UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE EFFECTS OF ATMOSPHERIC CONDITIONS ON THE SINGER

A DOCUMENT

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

DOCTOR OF MUSICAL ARTS

By

NICOLE MARIE VAN EVERY
Norman, Oklahoma
2016

THE EFFECTS OF ATMOSPHERIC CONDITIONS ON THE SINGER

A DOCUMENT APPROVED FOR THE
SCHOOL OF MUSIC

BY

_____
Dr. Eugene Enrico, Chair

_____
Mr. Kim Josephson

_____
Dr. Kevin Kloesel

_____
Dr. Frank Riddick

_____
Dr. Richard Zielinski

"Nicole, I applaud you for taking on this project. It is theoretically and practically important. We believe humidity is the biggest factor."

Dr. Ingo R. Titze
Vocal scientist and Executive Director
The National Center for Voice and Speech

"Of all musical instrument makers the voice builder is in greatest need for exhaustive and exact information about the instrument he makes, for the reason that the voice is of all musical instruments the most complicated in its method of tone production…The greatest need of the vocal profession is more information regarding the action of the human voice as a musical instrument."

John Redfield, American Mathematician
Music: A Science and an Art, 1928

ACKNOWLEDGMENTS

The idea for this research project was initially sparked by my lifelong passion for two subjects: singing and weather. When I moved to Norman to start my DMA in Voice at the University of Oklahoma in the fall of 2010, I knew I wanted to combine both of those passions to study something that often intrigued me, and something that I often heard other singers talk about (i.e. “I sound terrible today. There must be a front coming in.” or “This hall is too dry. I can’t perform here!”): how atmospheric conditions might affect the singing voice. Upon starting some preliminary research, I was surprised to find very little. Not one book or paper had been dedicated to the subject. Moreover, what little evidence there was gave conflicting information. This both excited and intimidated me. I knew the project would be large in scope and, because such little research existed, I would have to be determined and innovative in my approach to find evidence. My initial goals for this project were to include original experimental evidence in my final document. However, it became clear almost immediately that this step would be putting the cart before the horse. I decided to instead gather as much existing evidence as possible in order to grasp a better understanding of the subject’s heritage, and to provide a foundation for future research.

When I informally presented my topic idea to advisors at the School of Music, I was encouraged to run with it. I wanted support from the local professional weather community as well. I vividly remember driving to The National Weather Center in Norman one October morning that year to introduce my idea to Dr. Kevin Kloesel, the Director of the Oklahoma Climatological Survey and then-Associate Dean of the OU School of Meteorology. Kevin graciously welcomed my multi-disciplinary interests and

immediately opened his calendar to meet with me weekly to discuss how this project may be best approached. My connections with and support from Kevin and others at the NWC, including Dr. John T. Snow, would eventually lead to a position as Program Manager for the Office of Weather Programs and Projects (2012-2014), travel to locations such as Shanghai, Taipei, and Mexico City, to assist in the delivery of radar courses and international projects (2012-2014), and a chance to teach introductory meteorology courses for the School of Meteorology (2014-2016)—all experiences that would ultimately fortify and enhance my existing understanding of our atmosphere, and further help me in my research for this project.

I wish to express my appreciation to Kevin, for embracing my non-traditional ideas and supporting me in every step of this process. Your confidence in this opera singing "weather weenie" has meant so much! Thank you also to my School of Music committee members: Dr. Eugene Enrico, Prof. Kim Josephson, Dr. Frank Riddick, and Dr. Richard Zielinski. For your unwavering encouragement and enthusiasm, and for your backing of my unconventional topic, I am so grateful. The wisdom and expertise of each of you has been invaluable to me, not just in this research project, but also in all my musical endeavors at OU and beyond.

I would also like to thank Dr. Chris Fiebrich and the Oklahoma Mesonet for allowing me to borrow a temperature and humidity sensor package, and to Rebecca Tate for helping me with data collection. Thank you to Dr. Larry Mallett, Steven Eiler, and the OU School of Music for giving me the green light to set up that package in Sharp Hall during the month of April 2015. To the OU History of Science Collections Vault, thank you for retrieving historical literature for me on a regular basis, and thank you for

your patience on evenings when you had to remind me that you did, in fact, close for the night!

A big thank-you to my friend and fellow OU doctorate-degree earner Shannon Toll, who has spent many a day and night working on her dissertation alongside me. You've helped make this a fun process, with lots of laughs, and you've helped me keep things in perspective. We did it! I am grateful for my entire family—including my mom, Marie; my dad, Mark; my sister, Renee; and my grandparents, Larry, Dotta, James, and Lugenia—for your unending love and support from the very beginning. Finally, thank you to my best friend and husband, Matt Van Every. You are my inspiration every day.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The subject of atmospheric conditions and their potential effects on the human voice has been discussed for hundreds of years. However, perceptions are not consistent throughout history. Relatively recent books on the science of vocal pedagogy for singers include ways to protect the instrument from harsh atmospheric conditions, but very little research is used to back up common and vague statements such as "avoid exposure to cold, wet, or foggy weather" or "the singer's throat much prefers a spring rainy day to a cold crisp day in December." Furthermore, well-known singers have equally well-known aversions to singing in certain conditions. Yet, scientific explanation is staggeringly thin. Of the little scientific research conducted, very few use realistic atmospheric conditions, and even fewer use singers. Answers to questions about the voice's connection to atmospheric conditions are currently theoretical and diverse, demonstrating: 1) that many assume atmospheric conditions in one way or another do indeed affect the singer, but there are a variety of opinions regarding how and why, and 2) the necessity of universal clarification of these issues, using scientific information. Currently, no document has ever been solely dedicated to vocal health and atmospheric conditions. This study conducts an in-depth overview of theoretical and scientific evidence to produce such a text. It highlights the necessity—and serves as a catalyst—for further research in this little-studied field.

THE EFFECTS OF ATMOSPHERIC CONDITIONS ON THE SINGER

CHAPTER I: INTRODUCTION TO THIS STUDY

1.1 Purpose

The purpose of this document is to explicate the connection between certain atmospheric conditions and vocal health by means of compiling and investigating existing evidence from theoretical and scientific sources. As a whole, this document aims to serve singers by making available a comprehensive source of information concerning how vocal health may be affected by certain environments, thereby aiding in a deeper understanding of the instrument, and further aiding in the mitigation of potential hazards and discomforts. It is also anticipated that this document will be a catalyst for much-needed future research.

1.2 Need

Whether on the stage of a historic venue, on the covered platform of an open-air amphitheater, or in the cabin of a plane en route to the next performance, singers encounter many changing atmospheric conditions—both natural and artificial, most often with relatively short time for adaptation. And, perhaps more than most, a singer's success is heavily dependent upon the health of the instrument: the body itself. It is no secret to many singers that certain environments inevitably cause vocal distress. Yet, no comprehensive resources addressing this problem are currently offered. The need for this study is important because it makes available—for the first time—an intensive review of the potential connection between atmospheric conditions and the singer.

Vocal pedagogy books for singers often contain entire chapters devoted to the hygiene of the human voice.[1] Sections of such chapters include advice on how to protect the instrument from harsh atmospheric conditions. However, advice is sometimes inconsistent from source to source, and little research is available to back up common and vague statements such as "avoid exposure to cold, wet, or foggy weather"[2] and "the singer's throat much prefers a spring rainy day to a cold crisp day in December."[3]

While written evidence of a connection between the atmosphere and the voice may possibly date back over 4,000 years,[4] no body of work has ever been solely dedicated to the subject—one that continues to spark discussion today. Furthermore, recent dissemination of these ideas, whether for good or bad, has occurred in large part because of the Internet. A simple Web search of inquiries such as "Can singing in the cold permanently damage my voice?" and "Does humidity affect one's ability to sing?" will result in opinions from amateurs, vocal scientists, doctors, teachers, coaches, and professional singers, all weighing in with their thoughts about singing in differing

---

[1] For several specific examples, refer to: Friedrich S. Brodnitz, *Keep Your Voice Healthy: A Guide to the Intelligent Use and Care of the Speaking and Singing Voice* (New York: Harper & Brothers, 1953); Rachael Gates, L. Arick Forrest, and Kerrie Obert, *The Owner's Manual to the Voice: A Guide for Singers and Other Professional Voice Users* (New York: Oxford University Press, 2013); Jan E. Bickel, *Vocal Technique: A Physiologic Approach for Voice Class and Studio* (San Diego: Plural Publishing, Inc., 2008); Clifton Ware, *Basics of Vocal Pedagogy: The Foundations and Process of Singing* (Boston: McGraw-Hill, 1998); Barbara M. Doscher, *The Functional Unity of the Singing Voice*, 2nd ed. (Lanham, Maryland: The Scarecrow Press, Inc., 1994); Anthony F. Jahn, ed., *The Singer's Guide to Complete Health* (New York: Oxford University Press, 2013); Robert T. Sataloff and Ingo R. Titze, eds., *Vocal Health and Science: A Compilation of Articles from The NATS Bulletin and The NATS Journal* (Jacksonville: The National Association of Teachers of Singing, 1991); Norman A. Punt, *The singer's and actor's throat: the vocal mechanism of the professional voice user and its care in health and disease*, 3rd ed. (New York: Drama Book Specialists, 1979); Meribeth Bunch, *Dynamics of the Singing Voice*, 4th ed. (New York: Springer, 1997); Jean Westerman Gregg, "On Tension and Temperature," *The NATS Journal* 47, no. 3 (1991).

[2] Punt, *The singer's and actor's throat,* 59.

[3] Bickel, *Vocal Technique*, 114.

[4] Ilza Veith, trans., *Huang Ti Nei Ching Su Wen: The Yellow Emperor's Classic of Internal Medicine* (Berkeley: University of California Press, 1972).

environments. Current answers to such questions are often anecdotal and always diverse, demonstrating: 1) that many assume atmospheric conditions in one way or another do indeed affect the singer, but there are a variety of opinions regarding how and why, and 2) the necessity of universal clarification of these issues, using scientific information.

As another case in point, well-known singers have equally well-known aversions to singing in certain atmospheric conditions. Luciano Pavarotti rarely traveled without his famed scarves to keep his throat warm.[5] Aretha Franklin claimed her voice was affected by the cold while performing at the 2009 Presidential Inauguration.[6] Sherrill Milnes advises the singer to be aware of weather changes.[7] Judy Garland was reported to have run hot water to raise the humidity level in her hotel rooms.[8] Many singers refuse to perform in Las Vegas, where the dreaded "Vegas Throat" may occur.[9] These accounts are important, because they provide experiences from some of the most successful professional singers of this age.

More evidence is needed to support (or disprove) various claims so the vocal community may be like-minded and proactive about the potential effects of atmospheric conditions on the instrument. If a singer's profession relies upon the healthy function of the voice, then helping to fill the present chasm regarding this subject should be of great importance.

---

[5] "Pavarotti Issues Plea for Scarf," *Deseret News*, July 22, 1990, accessed October 20, 2014, http://www.deseretnews.com/article/113587/PAVAROTTI-ISSUES-PLEA-FOR-SCARF.html?pg=all.
[6] YouTube, "Larry King Live- Talks to Aretha Franklin About Her Hat During the Inauguration," accessed February 19, 2015, https://www.youtube.com/watch?v=7sZk2NKU_24.
[7] Karen Bell, "Sherrill Milnes talks to Performing Arts about caring for the voice," *Performing Arts & Entertainment in Canada* 27, no. 2 (1992): 7, accessed October 10, 2014, EBSCOhost.
[8] Gregg, "On Tension and Temperature," 42, 55.
[9] Kirk Baird, "Why 'Vegas Throat' Has Performers All Choked up," *Las Vegas Sun*, May 18, 2001, accessed October 10, 2014, http://www.lasvegassun.com/news/2001/.

1.3. Scope and Limitations

This document conducts an intensive study of extant thoughts, opinions, observations, and scientific research that can be used to explore the possible effects of atmospheric conditions on the singer. It does not include original scientific data. Because this subject has never been thoroughly explored from an extant-research angle, the author feels original, experimental evidence is premature at this stage of the study. Therefore, it is the author's intention to gather and compare current literature regarding the subject as a first step before future research commences. The scope of this subject is large; consequently, the information provided here is not exhaustive. The author recognizes there may be other atmospheric factors that could contribute to vocal distress not included in this particular study. This document does not include firsthand use of human subjects or any other living being. It is assumed the audience is familiar with the anatomy and physiology of the vocal apparatus; therefore, discussion of these topics is limited. Finally, this document is not meant to be a substitute for medical advice, diagnosis, or treatment.

1.4 Method and Structure

The evidence gathered for this document is separated into two main categories: theoretical, and scientific. The theoretical evidence, presented in Chapter III, thoroughly investigates thoughts, opinions, and observations found in extant writings that date from Ancient China through the twenty-first century, establishing that the subject of atmospheric conditions and vocal health has been discussed for centuries. If a manuscript is in a language other than English, the relevant portions have been

translated. Writings from vocal pedagogy texts, treatises and articles, and stories and testimonies from professionally diverse singers such as Luciano Pavarotti, Marilyn Horne, Aretha Franklin, Renèe Fleming, Beyoncé Knowles, Judy Garland, Enrico Caruso, and several others, are covered. Although the majority of these stories focus on how harsh atmospheric conditions adversely affected performances, some stories of no evident negative impacts under similar conditions are integrated as well. In addition, numerous online discussions about the atmosphere's effect on the voice are introduced. Tables that summarize these thoughts, opinions, and observations are included after each section. Effects on respiratory function will also be included as appropriate.

In Chapter IV, scientific research from the twentieth and twenty-first centuries is reviewed and compared to the aforementioned theoretical evidence, when possible. The information in this section is organized according to three atmospheric variables: temperature, humidity, and pressure. Both natural and artificial environments are discussed. Findings from a one-month gathering of temperature and humidity data within Paul F. Sharp Hall at the University of Oklahoma are also presented. The evidence in this chapter establishes the fact that, although some relevant scientific research has been conducted, much of it does not provide conclusive answers for the singer.

The document concludes with a summary of this study, as well as recommendations for much-needed future research, followed by the bibliography and appendices.

CHAPTER II: AN EXPLANATION OF THE RELATED LITERATURE

A thorough examination of atmospheric conditions and their specific relevance to the singer reveals a great void within the current realm of vocal pedagogy research. A representative selection of the available literature is briefly described in this chapter, and a full list can be found in the Bibliography.

2.1 Theoretical Evidence

Because historical context is important in establishing a foundation for this document's overall argument, the theoretical sources used for this study will span many thousands of years, beginning with those attributed to the Chinese Emperor Huang Ti (ca. 2650 B.C.) through those written in the twenty-first century. If a manuscript is in a language other than English, the relevant portions have been translated.

Most early evidence about the atmosphere's connection to the human voice is taken from writings that concern a much broader-studied topic: the connection between weather and human health (now known as the scientifically-accepted field of human biometeorology). The atmosphere's effect on man has been studied for millennia. According to ancient thought, illness was brought through changes in the winds and seasons.[10,11] Even today, scientists continue to investigate weather-driven causes for ailments and disease outbreaks around the world. Some of this thought deals with the human throat and chest—both of which are particularly apposite to a singer's vocal

[10]Francis Adams, trans., "On Airs, Waters, and Places," *The Internet Classics Archive*, accessed October 10, 2014, http://classics.mit.edu/Hippocrates/airwatpl.html.
[11] Veith, *Nei Ching*, 107. "Thus wind is the cause of a hundred diseases."

health. While some of the historical research may be dismissed as folly today, some of it continues to hold ground in the scientific community.[12]

The Yellow Emperor's Classic of Internal Medicine,[13] translated by Ilza Veith, is an interpretation of the ancient Chinese text titled *Nei Ching.* Attributed to Huang Ti (ca. 2650 B.C.), it is very likely the earliest-dated medical text still in existence. The theory within it remains the cornerstone of modern Chinese medicine even today. Of particular interest to this study are claims that cold impairs the lungs, and that an east wind impairs the throat and neck, among others.

The *Corpus Hippocraticum* contains 70 early medical works from Alexandrian Greece. Much of it is attributed to Hippocrates (ca. 460-377 B.C.), who was the first to credibly establish the marriage of meteorology and medicine. Within the *Corpus* is the philosophical essay *On Airs, Waters, and Places.*[14] In several passages of its 24 Parts, a direct correlation between the voice and atmospheric conditions can be found. For instance:

> Those (cities) that lie looking towards the rising of the sun, are naturally more healthy than those exposed to the north....In the first place, the heat and the cold are more moderate; the inhabitants are more blooming in complexion, and not so subject to disease; their **voice is clear**... (*Part V*)

[12] The scientific study of the atmosphere and its effects on living organisms is officially known as biometeorology. Refer to Chapter IV of this document for a more detailed discussion. Mounting evidence of correlations between disease and climate/weather are widely published. For more information, consult: National Research Council, *Under the Weather: Climate, Ecosystems, and Infectious Disease* (Washington, D.C.: National Academy Press, 2001); Randy J. Nelson et al., *Patterns of Stress, Immune Function, & Disease* (Cambridge: Cambridge University Press, 2002); and S.W. Tromp and W.H. Weihe, *Biometeorology*, *Vol. II, Part I* (Oxford: Pergamon Press, 1967).
[13] Veith, *Nei Ching.*
[14] Adams, "On Airs, Waters, and Places."

The essay also deems cities that lie exposed to the west, affected by the cold winds of the north, as unhealthy, wherein the temperature difference between morning and evening is very great. The inhabitants are apt to have **deep and hoarse voices.** *(Part VI)*. These and several other passages from the essay will be examined.

Frederick Sargent's *Hippocratic Heritage: A History of Ideas about Weather and Human Health*[15] is a seminal work detailing the long heritage of human biometeorology and bioclimatology. The Table of Contents is extremely useful as a foundation for further exploration into this history and includes ideas about weather and health dating from ancient thought through the latter half of the 20th century. The author found this source to be the most comprehensive historic overview in the biometeorological realm. A history of meteorological measurement is also included. The appendices are especially helpful in outlining specific ailments associated with differing seasons. Finally, additional potential resources abound in this source. A list of references is included at the end of each section of the book.

A Treatise on Vocal Physiology and Hygiene: With Especial Reference to the Cultivation and Preservation of the Voice[16] by William Gordon Holmes was published in 1879. Its chief aim was to "furnish persons who make an artistic or professional use of the vocal organs with a concise, but complete account of those scientific relations of the voice, physical and medical, which are generally only alluded to cursorily or passed over altogether in works on elocution and singing." Chapter V is dedicated to the Hygiene of the Voice and addresses the topic of climatic influences more than any other

[15] Frederick Sargent, II, *Hippocratic Heritage: A History of Ideas About Weather and Human Health* (New York: Pergamon Press, 1982).
[16] William Gordon Holmes, *A Treatise on Vocal Physiology and Hygiene: With Especial Reference to the Cultivation and Preservation of the Voice* (London: J & A Churchill, 1879).

pedagogical source found by the author. It also references a couple other applicable treatises with origins in France: Martial Brouc's *Hygiène philosophique des artistes dramatiques*[17] (1836), which discusses "disastrous consequences" for singers who perform in the open air; and Adolphe Méliot's *La Musique Expliquée aux Gens du Monde*[18] (1869), in which the author explores the idea that a singer's voice type has a direct correlation with climate. These latter two sources are also discussed in depth.

Because such little research on this topic exists, the author also feels it important to bring in current, up-to-date evidence from the singing community in the twentieth and twenty-first centuries. As stated above, a review of such evidence makes clear two points: 1) that many assume atmospheric conditions in one way or another do indeed affect the singer, but there are a variety of "opinions" regarding how and why, and 2) the necessity of universal clarification of these issues, using scientific information. While some of this evidence may lack academic piquancy, it is nonetheless important to include. The references used for this portion of the study include multiple passages, opinions, and personal accounts regarding atmospheric effects upon the singer. Newspaper articles and printed interviews, and informal online forums and blogs, will largely constitute these sources.

[17] Martial Brouc, *Hygiène philosophique des Artistes dramatiques* (Paris: A. Le Boyer et Comp., 1836), accessed November 4, 2014, http://hdl.handle.net/2027/nyp.33433011519950.
[18] Adolphe Méliot, *La Musique Expliquée aux Gens du Monde* (Paris: L. Marpon, 1869), accessed November 4, 2014, http://hdl.handle.net/2027/mdp.39015009592984.

2.2 Scientific Evidence

The majority of the sources used for this document's scientific discussion include experimentally based studies, which explore the possibility of direct correlations between the voice and atmospheric conditions through steps of the scientific method. Such studies did not exist until after 1950, and they are few in number. Of those that have been published, the focus is very narrow, and several variables and conditions are assumed. Moreover, the studies differ in the subjects and methods used.

As an example, a prominent study conducted by Katherine Verdolini, Ingo R. Titze, and David G. Druker[19] explores the effects of hydration on vocal fold tissue by manipulating relative humidity (RH) of the air. Six adult subjects were asked to sing after relatively long exposure (four hours) to each of three different conditions: no treatment (40%-55% RH), hydrated (85%-100% RH), and slightly dehydrated/dry (30-35% RH). However, desiccating drugs were administered during each subject's exposure to the latter two conditions: Dimetapp® during the slightly dehydrated/dry condition, and Robitussin® during the hydrated condition. The subjects were also allowed to drink water as much as they were able to comfortably tolerate in the hydrated condition. Therefore, this study does not conclusively explain the effects of atmospheric conditions alone.

The Effect of Relative Humidity of Inhaled Air on Acoustic Parameters of Voice in Normal Subjects,[20] a study published by Raphael Hemler et al. in a 1997 issue of *Journal of Voice*, is perhaps the most relevant scientific study concerning humidity and the singer to date. Eight healthy subjects inhaled air in three different air conditions for

[19] Katherine Verdolini, Ingo R. Titze, and David G. Druker, "Changes in Phonation Threshold Pressure with Induced Conditions of Hydration," *Journal of Voice* 4, no.2 (1990): 142-151, accessed September 8, 2011, http://dx.doi.org/10.1016/S0892-1997(05)80139-0.

[20] Raphael J.B. Hemler, George H. Wieneke, and Philippe H. Dejonckere, "The Effect of Relative Humidity of Inhaled Air on Acoustic Parameters of Voice in Normal Subjects," *Journal of Voice* 11, no. 3 (1997): 295-300, accessed September 8, 2011, http://dx.doi.org/10.1016/S0892-1997(97)80007-0.

10 minutes: dry (~2.1% RH), standard (~45% RH), and humidified (100% RH). They were then asked to sing a sustained /a/ of controlled pitch and loudness, which was analyzed for vocal discomfort. The researchers concluded that the human voice is very sensitive to decreases in relative humidity of inhaled air; even after short exposures to dry air, the subjects experienced vocal discomfort.

Direct Recordings of the Temperatures in the Tracheobronchial Tree in Normal Man[21] summarizes the findings of a study conducted by E.R. McFadden, Jr. et al., in which the temperature of the airways near the right lower lobe of the lung was measured in five normal subjects breathing air at subfreezing and ambient conditions. During rapid inspiration and inspiration of frigid air, the temperature of the distal airways fell and did not reach normal body conditions until the air moved deep into the periphery of the lung.

Also of use is *Oral Breathing Increases Pth and Vocal Effort by Superficial Drying of Vocal Fold Mucosa*[22] by Mahalakshmi Sivasankar and Kimberly Fisher in a 2002 issue of *Journal of Voice*, Vol. 16, No. 2. The researchers concluded that oral breathing superficially dehydrates the airway and therefore increases vocal effort, while nasal breathing increases the humidity of inspired air. While the latter breathing method is ideal for singers from a physiological standpoint, it is not always feasible when performing repertoire that leaves little time for anything but oral breathing.

[21] E.R. McFadden, Jr. et al., "Direct Recordings of the Temperatures in the Tracheobronchial Tree in Normal Man," *The Journal of Clinical Investigation* 69, no. 3 (1982): 700-705, accessed February 9, 2015, http://dx.doi.org/10.1172/JCI110498.

[22] Mahalakshmi Sivasankar and Kimberly V. Fisher, "Oral Breathing Increases Pth and Vocal Effort by Superficial Drying of Vocal Fold Mucosa," *Journal of Voice* 16, no.2 (2002): 172-181, accessed September 8, 2011, http://dx.doi.org/ 10.1016/S0892-1997(02)00087-5.

Bernhard Richter et al. conducted a study based on the climatic conditions of theater environments, titled *Working conditions on stage: climatic considerations.*[23] This study was published in the 2000 Vol. 25, No. 2 issue of *Logopedics, Phoniatrics, Vocology*. As the article correctly states, there is very little data about actual climatic conditions on stage. Temperature and humidity data were electronically gathered, as well as data regarding the fine dust content of the air. Information was collected during two opera performances and one spoken theater performance, to answer: 1) Does the use of a humidification unit improve stage conditions? 2) How does the data vary during a performance, with sporadic use of a humidifier? The primary findings of the study indicated that average temperatures and humidities of the performing space were improved with the use of a humidification unit. In addition, average dust levels were significantly lower when the humidification unit was used.

The Professional Voice and Airline Flight,[24] written by Robert J. Feder and published in Vol. 92 (1984) of the journal *Otolaryngology—Head and Neck Surgery* provides information about the temperature, humidity, and pressure conditions of airline cabins in-flight. This is useful in the document's section describing the effects of less-than-ideal atmospheric conditions encountered during a professional singer's travel.

[23] Bernhard Richter et al., "Working conditions on stage: climatic considerations," *Logopedics, Phoniatrics, Vocology* 25, no.2 (2000): 80-86.
[24] Robert J. Feder, "The professional voice and airline flight," *Otolaryngology – Head and Neck Surgery* 92, no. 3 (1984): 251-254.

2.3 Additional Sources

C. Donald Ahrens' *Meteorology Today: An Introduction to Weather, Climate, and the Environment*[25] is a widely used textbook among beginning meteorology students. While it thoroughly covers information regarding the Earth's atmosphere, it leaves out much of the mathematics that is often included in other meteorological textbooks. Therefore, the author feels this is a beneficial text for anyone not familiar with processes of the atmosphere. It is especially helpful in providing definitions for the terms used in this study. Also useful for defining terms is *The Oxford Dictionary of Weather,*[26] an A-Z guide specifically for weather and climate.

The National Centers for Environmental Information (NCEI, formerly the National Climatic Data Center) of the National Oceanic and Atmospheric Administration can be accessed at www.ncdc.noaa.gov.[27] This online database, generated by the NCEI of Asheville, North Carolina, contains the world's largest archived database of climate information. Records range from paleoclimatology data to data less than an hour old. Especially pertinent to this research is the ability to retrieve weather records from specific observing station locations within the United States in order to analyze conditions of outdoor performances. It is helpful, for example, to know the hourly temperature and humidity data for Washington, D.C. on January 20, 2009—the day Aretha Franklin claimed her voice was damaged by cold temperatures while singing at the Presidential Inauguration. This site is also useful for learning more about a common performance city's yearly average climate, which can be acquired via the

[25] C. Donald Ahrens, *Meteorology Today: An Introduction to Weather, Climate, and the Environment*, 7th ed. (Australia: Brooks/Cole, 2003).
[26] Storm Dunlop, *The Oxford Dictionary of Weather*, 2nd ed. (Oxford: Oxford University Press, 2008).

Annual Climatological Summaries. Weather Underground[28] is an additional excellent source for reviewing the historical meteorological data of specific locations around the globe.

Medical Climatology,[29] edited by Sidney Licht and Herman L. Kamenetz, is a book that contains several articles from doctors, professors, and climatologists, on a range of subjects. It begins with an essay titled "What is Weather," that provides a helpful overview of the Earth's atmospheric gases and other information about basic meteorological concepts. Following the first chapter are chapters about pollutants, aeroallergens, and the body's response to heat, cold, and altitude. It also includes a chapter on the history of medical climatology, which, like Sargent's book, is useful in researching historical thought about the subject.

Finally, although not directly discussed in this document, the author consulted numerous vocal pedagogy texts, focusing on the sections that discussed vocal hygiene as it pertains to the environment. While the majority of each pedagogy text can be considered scientific and highly technical, the sections that discuss atmospheric conditions are largely the opposite, often infused with opinion and/or continuation of popular beliefs. Very little scientific support is ever provided in support of advice, which is also often conflicting. For example, Nathan Punt advises singers to "avoid exposure to cold, wet, or foggy weather."[30] Jan Bickel claims "the singer's throat much prefers a spring rainy day to a cold crisp day in December."[31] Still other vocal pedagogy

---

[27] "Land-Based Station Data," *National Climatic Data Center*, https://www.ncdc.noaa.gov/data-access/land-based-station-data.
[28] "Historical Weather," Weather Underground, https://www.wunderground.com/history/.
[29] Sidney Licht and Herman L. Kamenetz, eds., *Medical Climatology* (Baltimore: Waverly Press, Inc., 1964).
[30] Punt, *The singer's and actor's throat*, 59.
[31] Bickel, *Vocal Technique*, 114.

texts make little mention of the atmosphere at all. This is not to point out flaws of current published works, but it is important to underline the fact that meteorological-related information within existing texts is not consistent or thorough, credits little to no scientific evidence, and is sometimes altogether absent.[32]

[32] The discussion of the environment's effect on vocal health within the vocal pedagogy realm is diverse and unique to each text. For just a very small sample of this diverse discussion, see FN 1.

CHAPTER III: A THEORETICAL PERSPECTIVE
ANCIENT CHINA – PRESENT DAY

The objective of this chapter is to lay an important foundation by first investigating humankind's thoughts, opinions, and observations about the connection between atmospheric conditions and vocal health, as they have been recorded throughout history. With this foundation, one can better uncover existing prevalent trends, which can assist in generating ideas for scientific research (see Chapter IV). The data in this chapter is non-statistical; rather, its gathering is purely exploratory and investigative.

Humankind has made connections between the atmosphere and its effects on the body, including the throat and chest, for millennia. Written evidence of this can be traced back to what is likely the earliest-dated medical text still in existence[33]: *Nei Ching*, the Classic of Internal Medicine, attributed to the Yellow Emperor Huang Ti (ca. 2650 B.C.).[34] This ancient Chinese writing gives particular significance to the atmospheric changes of the four seasons and their respective effects on overall human health. Although similar connections must have been made long before the *Nei Ching*, no earlier records are known to subsist. Yet, according to the late biometeorologist Frederick Sargent II, one can speculate about how the notion may have been conceived even in the early days of human life:

> Because it is probable that man has never been free of disease, the prevention and cure of sickness must have been a major concern. It is equally certain that early men were particularly anxious about successful production of their crops and that they were well aware that productivity was

[33] Another early text, The *Papyrus Ebers* from Egypt, dates around 1550 B.C. and contains references to phlegm in the throat and difficulty breathing, perhaps due to aeroallergens. Mark Jackson, *Asthma: A biography* (New York: Oxford University Press, 2009), 39.

[34] According to Veith, it is extremely difficult to associate the *Nei Ching* with a specific date. Researcher Dr. Wang Chi-min dates the text more likely around 1,000 B.C. Still others place its creation in the third century B.C., questioning the very existence of the mythical Yellow Emperor. Nevertheless, Veith states it is fair to assume that much of the text was "possibly handed down by oral tradition from China's earliest history." Regardless of its true date, the *Nei Ching* has served as the representative of Chinese medicine for at least nearly 2,000 years.

> linked to weather—rain, warmth, and sunshine at the appropriate seasons. Because these men understood neither natural atmospheric or biological phenomena nor causation of disease, they turned to supernatural agencies to intervene in their behalf and to magic and astrology to explain processes that were beyond their ken.[35]

Thanks to modern science, much more is known about atmospheric and biological phenomena in the present day. And, although the idea of a connection between the two may have originated through observations steeped in myth and superstition, relatively recent research has established scientific credibility in some medical disciplines (such as the seasonal transport of allergens and the unhealthfulness of pollutants). The scientific evidence will be discussed in more detail in Chapter IV. First, this chapter will lay an important foundation for this document's overall argument via a thorough examination of extant theoretical perceptions from Ancient China through the present day.

It should be noted that relevant medical documents written specifically for the vocalist did not appear until the nineteenth century. Therefore, earlier evidence is taken from writings that concern a much broader topic: the connection between weather and overall human health. Here, the author focuses only on passages that discuss the throat and the chest—the areas of the body particularly related to the singer. Cited passages include discussion on the effects of temperature, humidity, winds, seasons, fogs, pollutants, and allergens. If a manuscript is in a language other than English, the pertinent portions have been translated. While not claiming to be exhaustive, the author is confident the sources investigated for this chapter represent the majority of existing literature that gives mention to atmospheric conditions and vocal health. Although the

[35] Sargent, *Hippocratic Heritage*, 1.

sources for this review span thousands of years—and thousands of carefully combed pages—one very imperative piece of the puzzle is absent among them all: *universal, conclusive proof.*

3.1 Ancient China

"…The climate of the earth circulates within the throat…"[36]

As introduced above, the *Nei Ching* contains what is likely the earliest written evidence that mankind attributed diseases[37] and discomforts of the body (including those of the throat and chest) to the effects of atmospheric conditions. The theory within it remains the cornerstone of modern Chinese medicine even today, particularly within the first part, *Su Wên* ("Familiar Conversations"). Written in the form of a dialogue, it contains questions from the Yellow Emperor regarding health and healing, addressed to his minister, Ch'i-Po. The answers are strongly philosophical, not uncommon for early medicinal practice.[38] "Medicine was but a part of philosophy and religion, both of which propounded oneness with nature, i.e. the universe."[39] The text is based on the principle that humankind (the microcosm) is merely a fragment of the universe and therefore susceptible to the same natural laws that govern the waxing and waning of the world around it (the macrocosm).

[36] Veith, *Nei Ching*, 123.
[37] In ancient times, references to "disease" included even the sore throat and common cold.
[38] Veith, *Nei Ching*, v. According to Henry E. Sigerist, former Director of the Johns Hopkins Institute of the History of Medicine: "In all early civilizations…medical theory had a strongly philosophical character…China is no exception to the rule."
[39] Ibid, 10.

Out of this teaching came two concepts now very familiar to even the Western world: Yin and Yang.[40] Literally, the Chinese character for Yin (陰) means the "shady side of a hill;" its counterpart, Yang (陽), the "sunny side of a hill." These can be expanded to include atmospheric conditions. Yin represents cold, humidity, and darkness, while Yang represents their opposites: heat, dryness, and light. According to Ch'i-Po in the second chapter of the first book of *Nei Ching*, titled *Great Treatise on the Harmony of the Atmosphere of the Four Seasons with the (Human) Spirit*, "Yin and Yang, the two principles in nature, and the four seasons are the beginning and the end of everything and they are also the cause of life and death."[41] It is the imperative, delicate balance between the two that brings about optimum health. "Under this philosophy, the idea of a relation between weather and health first began to emerge in the mind of the author of *Nei Ching*."[42]

Careful review of the ancient text reveals numerous references to atmospheric influences on the throat and chest. Intriguingly, as subsequent sections of this chapter will illustrate, many of the observations presented below will emerge again in the medicinal doctrine of future physicians around the globe. Some of them remain familiar to Western medicine even today.

References in *Nei Ching*

> Book I:4 *Treatise on the Truth of the Golden Box:* "The east wind arises in Spring…there are disturbances in the throat and neck…The west wind arises in Fall; its sickness is located in the lungs…sickness resulting from the atmosphere of Spring is located in the head…"[43]

[40] Yin and Yang are the foundations of Taoism, which was formed by Fu Hsi, the Philosopher Emperor.
[41] Veith, *Nei Ching*, 104-105.
[42] Sargent, *Hippocratic Heritage*, 6.
[43] Veith, *Nei Ching*, 110.

In order to better understand the implications of the above passage, one must also bear geography and meteorology in mind. "The east wind arises in Spring…there are disturbances in the throat and neck…": Meteorologically speaking, the observation of the east wind arising in the spring is accurate. The climate of Mainland China has long been heavily influenced by a great seasonal wind reversal known as the Asiatic monsoon. As the rather large land mass heats during the warmer months of May through September, the land becomes warmer than the surrounding waters of the Pacific. This temperature difference results in an area of lower atmospheric pressure over the land, drawing in easterly and southeasterly winds from the ocean (see the right panel of Figure 1).[44] "The west wind arises in Fall; its sickness is located in the lungs…": In the fall, the process reverses. Wind generally blows outward from the continent, hence, a westerly wind (see the left panel of Figure 1). Thus, the easterly winds of the spring are humid, bringing most of China's annual rainfall. In contrast, the westerly winds of the fall are dry, bringing continental dust. "Sickness resulting from the atmosphere of Spring is located in the head…": According to an article in the 2014 *Shanghai Daily*, allergies are a common nuisance every spring for many inhabitants of China. "When pollen is present in the air, it can land in the eyes, nose…and begin an allergic reaction."[45]

While one must be careful in the interpretation of ancient textual meaning, it is interesting to re-approach Ch'i-Po's explanation with the meteorological facts in mind:

[44] Areas of higher pressure will generally always flow toward areas of lower pressure. This is known as the pressure gradient force, which is responsible for the initial movement of air. The wind reversal process as described above occurs frequently and can often be observed, for example, over a matter of hours in coastal areas and areas with adjacent large bodies of water (sea and land breezes).
[45] "Spring allergies are not to be sniffed at," *The Shanghai Daily,* April 14, 2009, accessed August 10, 2015, http://www.china.org.cn/health/2009-04/14/content_17604610.htm.

> "The **[humid]** east wind arises in Spring…there are disturbances in the throat and neck…The **[dry]** west wind arises in Fall; its sickness is located in the lungs…sickness resulting from the atmosphere of Spring is located in the head **[allergies]**."

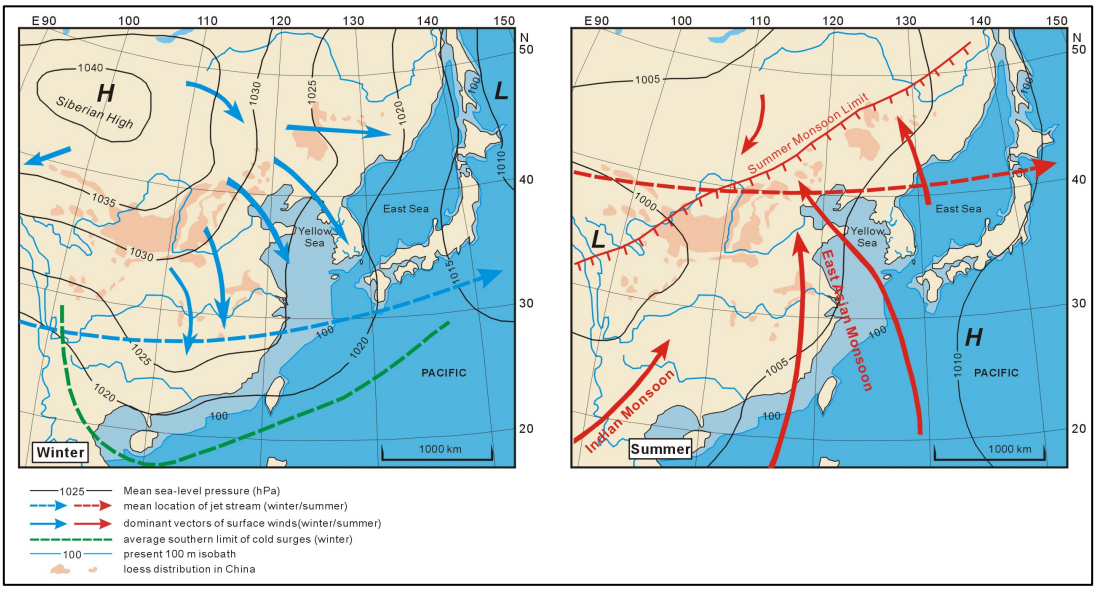


Figure 1. Asiatic Monsoon.[46]

Subsequent passages in the *Nei Ching* continue with this observation that humidity, cold, and dryness are injurious to the throat and lungs.

> Book 8:29: *Treatise on the Region of the Great Yin and on the Region of the Sunlight:* "Yang is related to the heavenly atmosphere and it controls the outside. Yin is related to the climate of the earth and it controls the inside…The throat is related to the heavenly atmosphere and the blockages are

[46] Sangheon Yi, "Holocene Vegetation Responses to East Asian Monsoonal Changes in South Korea," in *Climate Change: Geophysical Foundations and Ecological Effects*, eds. Juan Blanco and Houshang Kheradmand (InTech: Sept. 12, 2011), accessed October 24, 2015, *http://www.intechopen.com/books/climate-change-geophysical-foundations-and-ecological-effects" title="Climate Change - Geophysical Foundations and Ecological Effects">Climate Change - Geophysical Foundations and Ecological Effects*.

> related to the climate of the earth; thus Yang suffers through the wind, while Yin suffers through damp air."[47]

According to this passage, the blockages of the throat are related to the climate of the earth, which is also related to Yin. Yin represents cold and humidity. Therefore, one could interpret the above to mean: the throat suffers because of blockages caused by cold and humidity.

> Book 9:31 *Treatise on the Hot Sickness:* "When the illness is caused by the cold…the mouth is parched and very uncomfortable."[48]
>
> Book 1:3 *Treatise on the Communication of the Force of Life with Heaven:* "If one is injured in fall through humidity, it will rise to the upper part of the body and cause a cough…"[49]
>
> Book 2:7 *Treatise on Yin and Yang Treated Separately:* "Disobedience to the four seasons will surely manifest itself, and this manifestation will take the shape of an evil disease of the lungs, causing the people to pant and to breathe with difficulty."[50]
>
> Book 7:22 *Treatise on the Seasons as Patterns of the Viscera:* "When the disease is located within the lungs…one should avoid eating and drinking cold things and one should not wear chilly clothing."[51]
>
> Book 7:23 *Comprehensive Explanation of the Five Atmospheric Influences:* "…cold is injurious to the lungs…"[52]
>
> Book 2:5 *The Great Treatise on the Interaction of Yin and Yang:* "The powers of the earth create humidity in Heaven…and they give to the human voice the ability to

[47] Veith, *Nei Ching*, 234.
[48] Ibid, 241.
[49] Ibid, 109.
[50] Ibid, 129.
[51] Ibid, 202.
[52] Ibid, 207.

> sing...Humidity is injurious to the flesh, but wind counteracts humidity."[53]
>
> Book 3:9 *Treatise on the Six Regulations Governing the Manifestations of the Viscera:* "The [atmospheric] change affects the body and thus brings disease…"[54]

For the purposes of clarity and future comparison of other texts, the above selected *Nei Ching* passages are summarized in Table 1:

Type of Atmospheric Condition/Season	**Part of Body Affected**	**Resulting Condition**
Cold Temperature	Throat, Mouth, Lungs	*Negative Effects:* Suffering; Parched & uncomfortable; Injurious; Refrain from cold drinks & chilly clothing if ill
Humidity	Throat, Neck, Lungs	*Negative Effects:* Disturbances; Suffering; Cough
Dry Air	Lungs	*Negative Effects:* Disturbances
Spring	Head	*Negative Effects:* Sickness

Table 1. Summary of observations according to the *Nei Ching*

3.2 Ancient India

"Through excitement of the wind, the voice becomes dry, weak, and trembling."[55]

Hindu physicians were also among the earliest on record to link atmospheric conditions and human health, based on the macrocosmic-microcosmic principles associated with Áyurvedic medicine. According to Sargent, "this system sprang from a

[53] Ibid, 119.
[54] Ibid, 138.

tradition of medical magic that dates from the early part of the first millennium B.C."[56] Although the exact origins of Áyurvedic medicine are not known, the tradition was likely handed down by physicians for over at least a thousand years before being preserved in the texts of two men: Charaka and Suśruta. Their ancient writings, respectively named the *Charaka Samhitā* and the *Suśruta Samhitā*, are thought to date sometime around 400-200 B.C.[57]

Ancient Hindu medicine was based on the belief that the human body had a divine origin; it was a smaller representation (microcosm) of the greater divine (macrocosm), and was thus subject to the same forces. There were three basic principles responsible for the human body's regular function: air (wind), bile, and phlegm. An imbalance of one or more of these principles, partly brought on by weather and seasonal change, was unhealthy. From the *Suśruta*:

> Gale, windfall, sunshine, shade, moonshine, darkness, heat, cold, rain, day, night, fortnight, month, seasons, and solstices, etc. should be deemed as the eternal works of time, which, by virtue of their natural effects, contribute to the accumulation, augmentation, pacification or diminution of the deranged bodily [principles]…Like the seasons of the year the different parts of the day and night are marked by variations of heat, cold, etc.…the deranged bodily [principles] such as wind, bile, etc. naturally and spontaneously accumulate, aggravate, or subside during different parts of the day as they do in different seasons of the year.[58]

---

[55] A.C. Kaviratna, trans., *Charaka Samhitā* (Calcutta: G.C. Chakravarti, 1896), 1241.
[56] Sargent, *Hippocratic Heritage*, 7-8.
[57] Michael Dick, "The Ancient Ayurvedic Writings," *The Ayurvedic Institute*, 1998, accessed August 10, 2015, https://www.ayurveda.com/online_resource/ancient_writings.htm. The English translation of the *Suśruta* is more than 1,500 pages; the *Charaka* is more than 1,700.

Suśruta makes one of the earliest known references to wind-borne allergens:

> *Chapter VI. Characteristic Features of the Different Seasons of the Year and Their Influence on Health and Drugs (Ritucharyardhyayam):* "Sometimes the pollens of poisonous flowers or grasses, etc., wafted by the winds, invade a town or a village, and produce a sort of epidemic cough, asthma, catarrh…"[59]

He also writes several passages about the negative effects of cold temperature, citing it as the cause of the common cold. This correlation appears again and again not only throughout medical history, but it is also held to be true by many today.

> *CHAPTER XX: Salutary and Non-Salutary Effects of Regimen: The Effects of the Winds:* "The North wind is cold, crisp, mild…it increases the running secretions from the different orifices of the body (such as the nostrils etc.)."[60]

Specifically dealing with the throat:

> *Chapter XLV. Rules to Be Observed in Respect of Liquid Substances in General (Drava-Dravya-Vidhi-Madhyayam):* "The use of cold water should be avoided…in diseases of the larynx…"[61]
>
> *Chapter LIII. Symptoms and Medical Treatment of Hoarseness of Voice (Svara-Bheda-Pratishedha):* "[Hoarseness of voice is] aggravated by…exposure to cold…"[62]
>
> *Chapter L. Symptoms and Medical Treatment of Hiccough (Hicca-Pratishedha):* "Hiccough, cough, and asthma are

---

[58] K.K.L. Bhishagratna, ed., *An English Translation of the Suśruta Samhitā Based on Original Sanskrit Text, Vol. I* (Calcutta: K.K.L.B., 1907), 13.
[59] Ibid, 52. A *catarrh* is an inflammation of the mucous membranes, especially of the nose and throat.
[60] Ibid, 193.
[61] Ibid, 427.
[62] K.K.L. Bhishagratna, ed., *An English Translation of the Suśruta Samhitā Based on Original Sanskrit Text, Vol. III* (Calcutta: K.K.L.B., 1916), 335.

> the result of…residence in cold places, exposure to cold or dust or smoke or fire or wind…"[63]
>
> *Chapter LII. Symptoms and Medical Treatment of Cough (Kasa Pratishedha):* "Cough has its origin…by such causes as the entrance of smoke or of particles of dust (into the larynx and nostrils)…"[64]

Charaka's writings are similar in nature, identifying cold, dust, and wind as causes of disease:

> References within the *Charaka Samhitā*
>
> *Lesson I. Rasayana:* "Three such fruits of Piper longum should be taken (thrice a day)…with honey…Such a preparation is potent to cure…all diseases of the throat, hoarseness of voice…and all diseases that are born of excited wind and phlegm."[65]
>
> *Lesson VIII. The Treatment of Phthisis:* "Thus excited, the wind…when seated in the throat, it produces a tickling sensation there, as also a cough, hoarseness of voice…Through excitement of the wind, the voice becomes dry, weak, and trembling."[66]
>
> *Lesson XVII. The Treatment of Hiccup and Asthma:* "…hiccup and asthma [difficulty in breathing]…are characterized by (provoked) phlegm and wind…hear now what their originating causes are…By dust, by smoke, and by wind (entering the mouth and the nostrils), through residence (or stay) in cold places, and indulgence in (cold) water…The wind…entering the ducts that bear the vital breath…becomes provoked. Repairing to the chest, it then causes the phlegm to rise upward…When the wind, falling away from its normal course, getting into the ducts, seizing the throat and the head, and exciting the phlegm…His throat tickles; he speaks with great difficulty…he feels

[63] Ibid, 314.
[64] Ibid, 326.
[65] Kaviratna, *Charaka Samhitā*, 1049.
[66] Ibid, 1241.

> pleasure in things that are warm…This disease becomes aggravated by clouds, water, east-wind…"[67]

To summarize, the above *Samhitā* passages have been condensed into Table 2:

Type of Atmospheric Condition/Season	**Part of Body Affected**	**Resulting Condition**
North Wind, Cold	Chest, Throat	*Negative Effects:* Secretions (common cold); Hoarseness
Wind	Chest, Throat	*Negative Effects:* Tickling sensation; Cough; Hoarseness; Dryness; Weakness
Exposure to Dust, Smoke, Pollen	Chest, Throat	*Negative Effects:* Cough; Asthma; Diseases of the throat; Hoarseness; Phlegm

Table 2. Summary of observations according to Suśruta and Charaka

Although several of the above observations made by the Hindu and Chinese will be made again and again by future mankind, they are not supported conclusively by their writers. According to Sargent: "The differences they recorded do not stand critical scrutiny. If they had brought to bear the considerable knowledge of weather that they possessed, they could have developed the truly perceptive aphorisms we associate with the name of Hippocrates."[68]

[67] Ibid, 1483.

3.3 Ancient Greece

"When one comes into a city to which he is a stranger, he ought to consider its situation, how it lies as to the winds and the rising of the sun; for its influence is not the same whether it lies to the north or the south, to the rising or to the setting sun…For knowing the changes of the seasons…with the circumstances of each of these phenomena…he will succeed best in securing health, and will achieve the greatest triumphs in the practice of his art."[69]

It was in Greece[70], at the School of Cos, that a more well-rounded conception of medical meteorology was established. Hippocrates (ca. 460-377 B.C.), often referred to as the Father of Modern Medicine, was instrumental in formulating modern ideas about weather and health—ideas that far surpassed those expressed in Chinese and Hindu medicine. "Here we find for the first time the links between man's health and weather and climate fully and systematically developed…In fact, most present day writings on weather and health could easily, and without prejudice, be set within the framework established by Hippocrates some 2,400 years ago."[71] Although he did not have access to the meteorological and biological instruments of the future, his basic ideas are still used by many to this day. These ideas are passed down in what is now known as the *Corpus Hippocraticum*, which consists of about 60 ancient Greek medical texts, varied in content, age, and style. Although the texts strongly reflect the teachings of Hippocrates, most of them are not credited to one specific author. Yet, most scholars agree that Hippocrates was the author of those texts that concern weather and health,

---

[68] Sargent, *Hippocratic Heritage*, 34.
[69] Adams, "On Airs, Waters, and Places," Part I, II.
[70] Singing has been a popular and oft-practiced art in Greece for thousands of years, as depicted in Greek art and few surviving manuscripts. Evidence suggests that temperature in vocal hygiene was an important factor; the writings of Martial instructed vocalists to sip warm water in order to soften and sustain their voices, while Cicero advised the vocalist to avoid cold drinks. Holmes, *A Treatise on Vocal Physiology and Hygiene*, 30-31.
[71] Sargent, *Hippocratic Heritage*, 50-51.

most notably *On Airs, Waters, and Places*, and *Of the Epidemics I & III.*[72] Hippocrates was also one of the earliest scholars to write about the workings of the voice, recognizing the importance of the lungs, trachea, lips, and tongue in phonation. Here will begin a common thread, as will be seen in subsequent sections of this chapter: many of the scholars who are well known for their advancement of voice medicine are also the very same who are well known for their advancement of medical meteorology.

Hippocrates viewed the atmosphere as a whole—the combination of wind, temperature, and precipitation—as being the primary influence of health and disease. He also noted that the place in which one lived had a direct impact on health, including vocal health, for each location experienced a unique set of atmospheric conditions. This connection is especially communicated in *On Airs, Waters, and Places*:

> "A city that is exposed to hot winds (these are between the wintry rising, and the wintry setting of the sun), and to which these are peculiar, but which is sheltered from the north winds…the heads of the inhabitants are of a humid and pituitous constitution…owing to the phlegm running down from the head…"[73]

In other words: Those who reside in cities that are relatively warm and humid in the winter, and do not experience extremely cold air, may suffer from sinus problems (likely allergies).

> "Those [cities] which lie to the rising of the sun are all likely to be more healthy than such as are turned to the North, or those exposed to the hot winds, even if there should not be a furlong between them. In the first place, both the heat and cold are more moderate…the sun…dispelling the vapors which generally prevail in the

[72] Ibid, 48-49.
[73] Adams, "On Airs, Waters, and Places," Part III.

> morning…The inhabitants have clear voices…A city so situated resembles the spring as to moderation between heat and cold, and the diseases are few in numbers, and of a feeble kind, and bear a resemblance of the diseases which prevail in regions exposed to hot winds."[74]

In cities exposed to the east, heat and cold are more moderate and are considered healthier than cities exposed to hot or cold winds. Mists and fogs do not linger in the morning, as the rising sun dispels them quickly. Those who reside there have clear voices; diseases are few in number.

> "But such cities as lie to the west, and which are sheltered from winds blowing from the east, and which the hot winds and the cold winds of the north scarcely touch, must necessarily be in a very unhealthy situation…mist prevails commonly in the morning…for the sun does not shine upon the water until he be considerably raised above the horizon. And in summer, cold breezes from the east blow and dews fall; and in the latter part of the day the setting sun particularly scorches the inhabitants…Their voices are rough and hoarse owing to the state of the air, which in such a situation is generally impure and unwholesome, for they have not the northern winds to purify it; and these winds they have are of a very humid character…Such a situation of a city bears a great resemblance to autumn as regards the changes of the day, inasmuch as the difference between morning and evening is great."[75]

In cities exposed to the west, mists and fogs are common in the morning. Topographical features block the sun's rays until later in the day, when the sun has risen considerably above the horizon. As the sun sets in the west, the residents are scorched. The air is humid. The voices of those who reside there are rough and hoarse.

[74] Ibid, Part V.
[75] Ibid, Part VI.

In addition to being a keen observer of climatic conditions over the course of years, Hippocrates was a keen observer of the patient. He carefully recorded the symptoms and diseases experienced by populations under certain seasonal conditions. In Parts X and XV below, Hippocrates noted that, generally, a year with a rainy autumn, mild winter, and seasonable spring and summer produced a healthy constitution. Cold (from the northerly winds) and dry conditions in any season produced catarrhs, hoarseness, and coughs. Regions that were consistently mild but humid were deemed unhealthy; they produced rough voices.

> "And respecting the seasons, one may judge whether the year will prove sickly or healthy from the following observations…If there be rains in autumn; if the winter be mild, neither very tepid nor unseasonably cold, and if in spring the rains be seasonable, and so also in summer, the year is likely to prove healthy…but if the winter be southerly, showery and mild, but the spring northerly, dry, and of a wintry character…some have catarrhs beginning in the head and descending to the lungs…A spring that is northerly, dry, and cold…hoarseness is then constringed and contracted…if the summer is parched and northerly, but the autumn rainy and southerly …hoarseness …coughs…"[76]

> "As to the inhabitants of Phasis[77], their country is fenny, warm, humid, and wooded; copious and severe rains occur there at all seasons…Of all men they have the roughest voices, from their breathing an atmosphere which is not clear, but misty and humid…"[78]

[76] Ibid, Part X.

[77] Phasis was an ancient city once located near the current-day city of Poti, Georgia, on the east coast of the Black Sea. The area is known for its temperate, humid (63-93% RH annually), and rainy climate. Robert Henson, *The Rough Guide to Weather* (London: Rough Guides, Ltd., 2002).

> "In Thasos[79], about the autumn equinox, and under the Pleiades[80], the rains were abundant, constant, and soft, with southerly winds; the winter southerly, the northerly winds faint, droughts; on the whole, the winter having the character of spring. The spring was southerly, cool, rains small in quantity. Summer, for the most part, cloudy, no rain, the Etesian winds[81], rare and small, blew in an irregular manner. The whole constitution of the season being thus inclined to the southerly, and with droughts early in the spring, from the preceding opposite and northerly state…[In the spring] many had dry coughs without expectoration, and accompanied with hoarseness of voice."[82]

In summary, Hippocrates observed that the southerly, cool spring, accompanied by infrequent rainfall, produced dry coughs and hoarseness. Like the Chinese and the Hindu physicians, he also frequently observed that cold had a negative effect on the throat and chest:

> "For [ailments of] the throat, pour warm water over the head unless the weather be cold. Otherwise give meal as hot as possible…"[83]

> "Early in the spring, at the same time as the cold snaps which occurred…many suffered pain in the throat. Voices impaired."[84]

---

[78] Adams, "On Airs, Waters, and Places," Part XV.
[79] Thasos is the northernmost of the Greek Islands, located in the North Aegean Sea.
[80] In Hippocrates' time, it was customary to use the stars to mark the changes of the weather and the seasons. Sargent, *Hippocratic Heritage*, 50.
[81] The Etesians are northerly winds that blow in the summer, especially along the west coasts of southeast Europe. Henson, *The Rough Guide to Weather*, 226.
[82] Francis Adams, trans., "On Epidemics" Part I, *The Internet Classics Archive*, accessed October 10, 2014, http://classics.mit.edu/Hippocrates/epidemics.1.i.html.
[83] Wesley D. Smith, trans., "Epidemics" in *Hippocrates*, *Vol. VII* (Harvard University Press: Cambridge, Massachusetts, 1994), 83.
[84] W.H.S. Jones, trans., "On Epidemics" Part III, in *Hippocrates Collected Works* (Cambridge: Harvard University Press, 1868), accessed October 10, 2014, http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.01.0251%3Atext%3DEpid.%3Abook%3D3%3Achapter%3D2%3Asection%3D3.

"After the snow, southerly weather and rains came on…There was hoarseness and inflamed pharynxes."[85]

"There were coughs in winter, especially in southerly weather."[86]

"Coughs began around the winter solstice, on the fifteenth or twentieth day after frequent change between southerly weather and northerly with snow…[some had] inflammations of the throat…"[87]

References in *Aphorisms*[88]

"…if the north wind prevails, coughs, affections of the throat…occur."[89]

"If the summer be dry and northerly and the autumn rainy and southerly, headaches occur in winter, with coughs, hoarseness…"[90]

"The diseases of spring are…hoarseness, cough…"[91]

"Of winter…hoarseness, cough, pains of the chest…"[92]

"Cold things, such as snow and ice, are inimical to the chest, being provocative of coughs…and [colds]."[93]

References in *The Sacred Disease*

Part XIII. "…the south wind, suddenly coming on after north winds, loosens and relaxes the brain when it is braced and strong, so that the phlegm overflows…the body is immediately chilled, the patient loses the power of speech and does not breathe…the greatest enemy is winter…there

[85] Smith, "Epidemics," 97.
[86] Ibid, 205.
[87] Ibid, 269.
[88] Francis Adams, trans., "Aphorisms," *The Internet Classics Archive,* accessed October 10, 2014, http://classics.mit.edu/Hippocrates/aphorisms.html. An aphorism is an early form of statistical record, meant to be easily remembered by its reader.
[89] Ibid, Line 5.
[90] Ibid, Line 13.
[91] Ibid, Line 20.
[92] Ibid, Line 23.
[93] Ibid, Line 24.

> is a serious risk of the same thing happening in spring also…In summer the risk is least, as there are no sudden changes."[94]

Upon comparison of the passages above, it is clear that Hippocrates observed spring and winter as the most troublesome seasons for the voice. A summary of this section is included in Table 3:

Type of Atmospheric Condition/Season	**Part of Body Affected**	**Resulting Condition**
Spring: southerly, cool, damp	Upper Respiratory Tract, Lungs	*Negative Effects:* Dry cough; Hoarseness; Inflamed pharynx
Spring: northerly, cold, dry	Upper Respiratory Tract, Lungs	*Negative Effects:* Catarrh; Hoarseness; Pain in throat; Impaired voice
Spring: moderate and dry		*Positive Effects:* Clear Voices
Winter: southerly, mild, humid	Upper Respiratory Tract, Lungs	*Negative Effects:* Inflammations of the throat; Phlegmatic; Catarrhs; Hoarseness; Coughs; Chest pains
Winter: northerly, cold	Upper Respiratory Tract, Lungs	*Negative Effects:* Coughs; Affections of the throat; Hoarseness; Chest Pains
Cold things (i.e. snow, ice)	Lungs, Upper Respiratory Tract	*Negative Effects:* "Bad for chest;" Coughs; Colds
Misty, foggy locations	Vocal Tract	*Negative Effects:* Rough, Hoarse Voice

Table 3. Summary of observations according to Hippocrates

[94] W.H.S. Jones, trans., "The Sacred Disease" in *Hippocrates*, *Vol. II* (London: W. Heinemann, 1923).

3.4 Ancient Rome

"For in every instance, health in us is a due proportion of moist, dry, warm, and cold…"[95]

The Hippocratic tradition of medical meteorology pervaded Rome in a matter of centuries, brought to the city by Greek physicians. The most influential of these importers was Claudius Galen (ca. 130-200 A.D.), who is also well known for his seminal study of the human larynx. According to Green, "He was held in esteem by…[Flavius] Boethius the Consul in whose presence he performed dissections and demonstrated the organs of respiration and the voice."[96] Unfortunately, although frequently referenced, Galen's singular essay on the human voice is now lost.[97]

Galen began his medical studies at the age of 17, obtaining much of his early knowledge through extensive travel—undoubtedly becoming familiar with the writings of Hippocrates during this time. Ultimately, Galen's Hippocratic model of medicine was adopted by the Church and used for over twelve centuries, through the Middle Ages.[98] With the exception of a few Arabian physicians, there were no further advancements in medical meteorology until the Renaissance. Like Hippocrates, Galen identified atmospheric conditions as a primary cause of disease. Although his writings do not contain as much information pertaining directly to the voice, there are nonetheless a couple passages of interest:

---

[95] R.M. Green, *A Translation of Galen's Hygiene* (Springfield, IL: Thomas, 1951), 14.
[96] Ibid, xvii.
[97] Robert Thayer Sataloff. *Vocal Health and Pedagogy Volume I: Science and Assessment* (San Diego: Plural Publishing, Inc., 2006), 2. According to Sataloff, Galen is hailed as the founder of laryngology and voice science.
[98] Sargent, *Hippocratic Heritage*, 63-65.

> "Of…localities and seasons…the colder are more phlegmatic…"[99]
>
> "…throat roughness…also occurs from acrid vapours, dust or smoke…"[100]

A brief summary is included in Table 4:

Type of Atmospheric Condition/Season	**Part of Body Affected**	**Resulting Condition**
Cold	Upper Respiratory Tract, Lungs	*Negative Effects:* Phlegmatic
Smoke, dust	Throat	*Negative Effects:* Roughness

Table 4. Summary of observations according to Galen

3.5 Middle East

"Cold atmosphere…It has a very injurious effect on the trachea."[101]

While scholarly advancement in Western Europe waned during the Middle Ages until the advent of the Renaissance, physicians in the East studied and translated the texts of Hippocrates and Galen, notably. They also added their own observations about weather and health.[102] Rhazes the Experienced (ca. 850-923), known among

[99] Claudius Galen, "On the Natural Faculties," Book II, trans. Arthur John Brock, *The Internet Classics Archive*, accessed August 29, 2015, http://classics.mit.edu/Galen/natfac.2.two.html.
[100] Claudius Galen, *On Diseases and Symptoms*, trans. Ian Johnston (Cambridge: Cambridge University Press, 2006), 176.
[101] Avicenna, *The Canon of Medicine*, trans. Oskar Cameron Gruner (New York: AMS Press, Inc., 1973), 203, accessed August 29, 2015, https://archive.org/details/AvicennasCanonOfMedicine.
[102] Sargent, *Hippocratic Heritage*, 82.

vocal pedagogues for his writings about voice disorders, hoarseness, and voice and respiratory training,[103] wrote about seasonal allergies:

References in *The Sense of Smelling*[104]

> "When I read your description of Abu Zayd's illness, I realized what the cause is and why it gets worse in the spring, especially when smelling flowers. Therefore, I shall tell you what you need to know to prevent the illness. The patient ought to take note of the following points: …He should stay away from closed places, basements, and damp houses where the air is stuffy and dank…It is also good to breathe the vapors of hot water containing matricaria, menta sativa, pennyroyal, and worm seed. Also, before sleeping, the patient had better take substances that prevent secretion from pouring down into the chest since secretion pours into the chest when one is asleep, especially when one sleeps on the back for a long time. If such substances pour into the chest, the patient's voice will get hoarse; he will start coughing, become short of breath…Substances that strengthen the throat should be gargled with rosewater…Then a warm cloth must be put on head and chest, and the patient should stay in a house where cold air cannot get it…The illness is worse in people whose neck vessels are big and suffer when they smell flowers."

Avicenna (ca. 981-1037)[105] of Persia was well known for writing *The Canon of Medicine*, which was adopted as the standard medical text by numerous medieval universities. In it, he included detailed descriptions of voice production and disorders. His ideas on health strongly reflect those of Hippocrates; Thesis II of the *Canon* includes an entire section devoted to disease and climate.

> "The substance of the air is good when it is not contaminated with extraneous matter, such as the vapours

[103] Sataloff, *Vocal Health and Pedagogy*, 2.
[104] Abu Bakr Mohammad Ibn Zakariva al-Razi, "The Sense of Smelling," *FactBook*, accessed September 5, 2015, http://www.factbook.org/wikipedia/en/t/th/the_sense_of_smelling__book_.html.
[105] Sargent, *Hippocratic Heritage*, 83.

> [from marshes or lakes, or from canals or open sewers] or smoke and soot. It is open to the sky and, generally, is able to circulate freely round us…Air is good when it does not interfere with one's breathing or cause the throat to contract…"[106]

The avoidance of certain vapors, expressly those emanating from marshes or swamps, will be stressed often in future vocal hygiene texts. This idea of "mal'aria," or "bad air," had been around for centuries prior to the writings of Avicenna. It was a primary influence in the construction of ancient Roman theaters, as one example. The Roman Marcus Vitruvius Pollio (first century B.C.) is often credited as the father of architectural acoustics. In his *Ten Books on Architecture,* he states that architects should have a working knowledge of climates, air, and the healthiness and unhealthiness of theatrical sites. Keeping in mind that much ancient drama was sung, he writes in Book V Chapter III:

> "A site as healthy as possible should be selected for the theatre…if these winds come from marshy districts or from other unwholesome quarters, they will introduce noxious exhalations into the system…We must also beware that it has not a southern exposure. When the sun shines full upon the rounded part of it, the air, becoming shut up in the curved enclosure and unable to circulate, stays there and becomes heated; and getting glowing hot it burns up, dries out, and impairs the fluids of the human body."[107]

Avicenna also writes about cold and its effects on the throat. The last two passages below, especially, echo Hippocrates' observations about locations exposed to the east and west.

[106] Avicenna, *The Canon of Medicine*, 274.

The Effect of Unfavourable Changes in the Air: "Cold atmosphere…It has a very injurious effect on the trachea."[108]

The Influence of the Changes in the Quality of the Atmosphere; the Diseases Incident to the Several Seasons and Kinds of Weather: "The disorders of wintertime. These are chiefly phlegmatic in character…coryza[109] is common, and begins when the autumnal air is changing. Less common are: …hoarseness and sore throat."[110]

The Influence of Places of Residence on the Human Body: "Residence in easterly countries. When a district is exposed to the east, and is sheltered on the west, it is healthy and the climate is good. This is because the sun is high over it in the early part of the day, thus rendering the atmosphere clear. The purified air passes on and gentle winds blow over it in advance of the rising sun, their direction being corresponding."[111]

"Residence in westerly countries. When a district is exposed on the west, and is sheltered on the east, it does not receive the sun till late in the day, when the rays are already oblique. Hence the air never becomes rarefied or dry, but remains dense and humid. The prevailing winds are westerly and nocturnal. The climate of such places is therefore as of damp countries…Such districts are not as healthy as easterly ones, and they tend to become more unhealthy…to my thinking the climate has very bad characters, and this is because the sun's rays do not reach them until they are no longer strong enough to warm the atmosphere; and then the sun sets at once, and a cold night then suddenly sets in. As the air is of humid temperament in such countries, the inhabitants are liable to have husky voices, especially in autumn; for they are prone to catarrhs…"[112]

---

[107] Vitruvius, *The Ten Books on Architecture*, trans. Morris Hicky Morgan (Cambridge: Harvard University Press, 1914), 137-138, accessed November 4, 2014, http://academics.triton.edu/faculty/fheitzman/Vitruvius__the_Ten_Books_on_ Architecture.pdf.
[108] Avicenna, *The Canon of Medicine*, 203.
[109] Inflammation of the mucous membranes/congestion in the nasal cavity
[110] Avicenna, *The Canon of Medicine*, 294.
[111] Ibid, 330.

A summary of Avicenna's observations are illustrated in Table 5:

Type of Atmospheric Condition/Season	**Part of Body Affected**	**Resulting Condition**
Cold	Trachea	*Negative Effects:* Injurious
Winter	Upper Respiratory Tract, Lungs	*Negative Effects:* Phlegmatic; Coryza; Hoarseness; Sore throat
Residence in locations exposed to the west (air dense and humid)	Throat, Upper Respiratory Tract, Lungs	*Negative Effects:* Husky voices; Prone to catarrhs
Residence in locations exposed to the east (air dry and clear)		*Positive Effects:* Healthy constitution
Vapors from marshes, lakes, canals, sewers	Throat, Lungs	*Negative Effects:* Throat contracts; Difficulty breathing

Table 5. Summary of observations according to Avicenna

3.6 Scientific Beginnings

"…the Voice of Man, when by cold taken, groweth rugged, and…becometh hoarse."[113]

With the exception of physicians in the Middle East, there was not much advancement in medical meteorology after Galen until the intellectual awakening during the Renaissance. Beginning in the fourteenth century, man broke from the authoritarianism of the Church and started to question and explore the world around him. This humanistic philosophy sparked a growing interest in facts, proven through scientific method. The well-known natural philosopher, Francis Bacon (1561-1626), wrote: "Those…who aspire not to guess and divine, but to discover and know, who

[112] Ibid, 331.
[113] Francis Bacon, *Sylva Sylvarum, or a Natural History, in Ten Centuries* (London: J.R., 1765), accessed September 18, 2014, https://archive.org/details/sylvasylvarumorn00baco.

propose not to devise mimic and fabulous worlds of their own, but to examine and dissect the nature of this very world itself, must go to facts themselves for everything."[114] In his writings about atmospheric conditions and human health, Bacon included discussion of the voice itself, referring to temperature's influence:

References in *Sylva Sylvarum, or a Natural History, in Ten Centuries*:

> "A Bell if it have a Rift in it, whereby the sound hath not a clear passage, giveth a hoarse and jarring sound; so the Voice of Man, when by cold taken, groweth rugged, and (as we call it) furred, becometh hoarse."[115]
>
> "…greater heat, which may make the voice stronger..."[116]

From the two passages above, one can infer that, according to Bacon, cold air causes hoarseness, while heat causes strength in the voice.

Robert Boyle (1627-1691) was the first scientist to apply the study of natural phenomena to the inductive method of Bacon.[117] Among his many projects was extensive study about the properties of air; he recorded some of his observations in *The General History of Air*, which was published posthumously in 1692. The present-day National Oceanic and Atmospheric Administration (NOAA) Central Library, in cooperation with the Climate Database Modernization Program, the National Climate

[114] Francis Bacon, *The New Organon and Related Writings*, ed. F.H. Anderson (New York: Bobbs-Merrill Co., 1960), 23-24.
[115] Bacon, *Sylva Sylvarum,* 42.
[116] Bacon, *Sylva Sylvarum,* 43.
[117] Sargent, *Hippocratic Heritage*, 96.

Data Center (NCDC, now NCEI), and the NOAA 200th Celebration, has made the original document viewable to the public in electronic format. [118]

References in *The General History of the Air*

> "The continual use of the Air is so absolutely necessary to our Life; the good or bad Temperature of it is so important to our Health…"[119]

> "…I shall offer to your Consideration the Accidents that often happen to Men, by the mere Air, as…Colds, many of which indure a Man's Life-time; and which (with many bitter Infirmities that sometimes seize upon a Man, while standing, walking, or lying in the Air) are rarely or never felt or discerned at the Instant of the Approach or Insults upon a Man, nor yet accompanied with the Sense of any Excess in the Air for Heat or Cold at that time, and therefore not referable to any Cause in the Air…"[120]

> "…the particular Healthfulness and Unhealthfulness of Places, the evil Disposition of the Air, Evenings, Nights, and early in the Mornings, in some Parts more than in others; the super-abundant Moisture, excessive Winds, Droughts or other Seasons, proper to one Country, and not to be observed in another neighbouring to it; all these are rather to be allowed and referred to those Oders [*sic*], Vapors, and Exhalations…"[121]

> "Dr. C. chief Physician to the Ruffian Emperor, confirmed to me, that being in Russia in the Winter, when the Frost was very hard, and the East or North-East Wind blew cold, if he turned his Face toward the Wind, and walked against…he found himself unable to fetch his Breath, and almost stifled, as if the Air were very thick, or rather a great Stiffness brought upon the Organs of Respiration, whereby he was unable to move them as at other times, so that he was fain to turn his Head from the Wind that he might be able to fetch his Breath."[122]

---

[118] Robert Boyle, *The General History of the Air* (London: 1692), accessed December 19, 2015, http://docs.lib.noaa.gov/rescue/rarebooks_1600-1800/Qc161b691692.pdf.
[119] Ibid, ix.
[120] Ibid, 74.
[121] Ibid, 75.
[122] Ibid, 238.

In the document, Boyle also proposed that a network of thermometers be established to make records of an area's weather and climate, further aiding in determining what elements constituted healthfulness vs. unhealthfulness. The development and use of precise measurements by means of instrumentation began a vital step in the scientific research of the weather-health connection. Although devices for measuring atmospheric conditions had existed for thousands of years, the sixteenth and seventeenth centuries were important for the advancement of meteorological instrumentation.[123] Instruments such as the thermometer (measurement of temperature), mercury barometer (measurement of pressure), and hygrometer (measurement of moisture) were developed and improved by Galileo, Sanctorius, and Torricelli. Furthermore, not only did they prove to be invaluable in the measurement of meteorological phenomena, they also proved to be invaluable in the continued study of medical meteorology, ultimately providing quantifiable evidence in the atmosphere's connection to health in the twentieth century.

With the Enlightenment at the dawn of the eighteenth century, reason and specialization became all-important. Researchers began to narrow their focuses, specializing in very specific areas of study. While some specialized in areas such as tropical medicine, scientific measurement, and medical bacteriology, others turned to the subjects of hygiene and community health. Weather and climate were particularly emphasized in writings regarding such.[124] Published in 1733, John Arbuthnot's *An Essay Concerning the Effects of Air on Human Bodies* serves as a prime example. In it,

[123] The thermoscope, an early instrument for recording changes in air temperature, dates to at least the third century B.C. Rain gauges were used in India in the fourth century B.C., and wind vanes date back to ancient Greece. Sargent, *Hippocratic Heritage*, 117.
[124] Ibid, 171.

he stressed that "good air" was the key to optimal health. Included below are several examples in which he states the resulting qualities of hot, cold, dry, and/or moist air:

References in *An Essay Concerning the Effects of Air on Human Bodies*

> "First, as to Humidity, the least Quantity of it must produce a Cough; as for hot Air, the Lungs cannot bear Air that is hotter than the Animal Fluids. Heat and Moisture together, produce Putrefaction…Heating-Rooms…may be dangerous to the Lungs: On the contrary, Air intensely cold, by its Contact…produce Inflammations, which reign here in the Winter, and in many Countries upon cold Blasts…Air dry, and not intensely hot, must be favourable to the Lungs…"[125]

> "Cold both congeals the Fluids and constringeth the Solids…the natural Effect of which is a greater Secretion…through the Glands…especially from the Glands of the Head and Throat, are a natural Effect of Cold."[126]

> "Moisture relaxeth, unless it be combin'd with a greater Degree of Cold, which subducts so much of its relaxing Quality. The Inhabitants of cold and moist Countries are leucophlegmatick…The least Moisture taken in by the Windpipe immediately is rejected by Coughing."[127]

> "It is agreeable to Experience that watery Effluvia [fogs] are hurtful to the Glands of the Windpipe and the Lungs, and productive of Catarrhs."[128]

While the observations of these scientific thinkers are interesting, conclusive proof is still lacking.

---

[125] John Arbuthnot, *An Essay Concerning the Effects of Air on Human Bodies* (London: J. & R. Tonson, 1751), 116, accessed November 19, 2015, https://archive.org/stream/essayconcerninge00arbu/essayconcerninge00arbu_djvu.txt.
[126] Ibid, 161.
[127] Ibid, 166.
[128] Ibid, 200.

Type of Atmospheric Condition/Season	Part of Body Affected	Resulting Condition
Cold	Throat, Lungs	*Negative Effects:* Hoarse (Bacon); Stiffness of breath (Boyle); Inflammation, Secretions from head and throat (Arbuthnot)
Heat	Throat, Lungs	*Positive Effects:* Strength (Bacon) *Negative Effects:* If hotter than body temperature, unbearable for lungs (Arbuthnot)
Humidity	Throat	*Positive Effects:* Relaxes the throat, if not too cold (Arbuthnot)
Cold and Humidity Combined	Upper Respiratory Tract, Lungs	*Negative Effects:* Cough (Arbuthnot)
Heat and Humidity Combined	Lungs	*Negative Effects:* Dangerous (Arbuthnot)
Dry	Lungs	*Positive Effects:* Beneficial, if not too hot (Arbuthnot)

Table 6. Summary of observations according to Bacon, Boyle, and Arbuthnot

3.7 Vocal Hygiene and the Nineteenth Century

"The singer, on account of the susceptibility of his lungs to the influence of cold which the frequent use of his voice develops, must not spare any means of preserving those organs from the abrupt variations of temperature…Nothing produces catarrhal affections of the vocal organs more readily than cold."[129]

It is at this point in the historical review that relevant writings dedicated *solely* to the vocalist can be discussed. As pointed out earlier in this chapter, mankind had been interested about the workings of the voice for centuries. Galen, Hippocrates, Rhazes, and Avicenna provided "excellent descriptions of voice production and

[129] Ghislani Durant, *Hygiene of the voice: Its physiology and anatomy* (New York: G. Schirmer, 1870), 98-99, accessed November 4, 2014, http://hdl.handle.net/2027/mdp.39015005320430.

disorders."[130] Leonardo da Vinci, upon dissecting corpses, drew a detailed sketch of the human larynx in 1510[131]. Others, including Fabricius of Aquapendente (1537-1619), Marin Mersenne (1588-1648), Denis Dodart (1634-1707), and Johannes Müller (1801-1858) made some advancement in vocal production and acoustics.[132] However, it was not until the mid-nineteenth century that a deeper understanding of the inner workings of the voice was reached. In 1854, Manuel Garcia, Jr. developed an early, mirrored laryngoscope; for the first time, it was possible to study human vocal fold vibration during phonation. This led to the swift progression of writings on vocal pedagogy and vocal health. Now, in addition to discussing the anatomy and physiology of the vocal organ, writers introduced a topic that remains an important part of vocal texts even today: vocal hygiene—the personal care of the voice. The effects of atmospheric conditions are highly stressed in early writings, resonating with familiar clauses discussed in prior centuries. Also introduced are the climatic conditions of the theaters themselves. The references below are but a sample of the vocal hygiene output of the 1800s.

Ghislani Durant's *Hygiene of the voice: Its physiology and anatomy* was published in 1870. In Chapter IX, titled "Hygiene of the Voice," he discussed the atmosphere's influence on the vocal apparatus:

> "The precept of never exposing ourselves to cold or damp air immediately after any exercise in which the vocal organs have been violently exercised is of great importance. The world, known hoarseness of singers is a proverbial thing, and if sometimes it is an excuse, too often it is a reality. During the prevalence of cold weather, it is

[130] Sataloff, *Vocal Health and Pedagogy*, 2.
[131] Leonardo da Vinci's "Larynx and Leg" can be found in *Quaderni d'anatomia*, 1510.
[132] Holmes, *A Treatise on Vocal Physiology and Hygiene*, 101-109.

> only necessary to sing for a few minutes, and then expose ourselves immediately to the cold air to contract that hoarseness…Lyric or dramatic artists who are compelled on account of their profession, to remain during a greater or less period of time with portions of the body uncovered, may by certain precautions diminish in a great measure the injurious effects of cold. Thus, instead of remaining near a good fire until the moment before appearing on the stage, they should just warm themselves and then try to keep up that artificial warmth by some moderate exercise, such as walking up and down the room…A reaction takes place in the organism, which, unless the artist be very vigilant, and protect himself well against the influence of the surrounding atmosphere, may have a pernicious influence upon him."[133]
>
> "The singer, on account of the susceptibility of his lungs to the influence of cold which the frequent use of his voice develops, must not spare any means of preserving those organs from the abrupt variations of temperature. He can in a great measure protect himself by the use of flannel, which not only keeps his body warm, but renders the lungs and bronchial tubes less sensitive to cold…Nothing produces catarrhal affections of the vocal organs more readily than cold."[134]

In 1879, American doctor J. Solis Cohen, a lecturer on diseases of the throat and chest at Thomas Jefferson Medical College and on physiology and hygiene of the voice in the National School of Elocution and Oratory, wrote *The Throat and the Voice*.[135] In Chapter II, "Care of the Throat:"

> "There are few individuals who pass their lives without having been at some time affected with more or less sore throat. In variable climates sore throat is much more frequent than in equable climates. It is much more frequent, also, in localities where individuals are exposed to the irritating influences of particles of dust and other materials in the atmosphere, and which are inhaled in

[133] Durant, *Hygiene of the Voice*, 93-94.
[134] Ibid, 98-99.
[135] J. Solis Cohen, *The Throat and the Voice* (Philadelphia: Presley Blakiston, 1880).

> respiration…The most frequent exciting cause of diseases of the throat appears to be the direct action of cold upon the heated body…It is therefore necessary to avoid these sudden exposures. In cold weather, for instance, when the temperature in-doors is much higher than it is out of doors, one should not go into the open air directly from a warm room…"[136]

Also in 1879, British physician William Gordon Holmes wrote *A Treatise on Vocal Physiology and Hygiene with Especial Reference to the Cultivation and Preservation of the Voice*. Its chief aim was to "furnish persons who make an artistic or professional use of the vocal organs with a concise, but complete account of those scientific relations of the voice, physical and medical, which are generally only alluded to cursorily or passed over altogether in works on elocution and singing." Chapter V is dedicated to the Hygiene of the Voice and addresses the topic of climatic influences more than any other historical source found by the author. Near the beginning of the chapter, Holmes advised strongly that singers should breathe through the nose, for two reasons:

> "In the first place, the atmosphere is almost always much colder than the blood, and for this reason, if it were allowed to impinge in a direct current on the lining membrane of the air-passages or lung-cells, such a disturbance of function would be likely to ensure as would lead to inflammation of those parts. It is therefore indicated that the air, before arriving in the windpipe and lungs, should be warmed."[137]
>
> "In the next place, the atmosphere is full of impurities which ought to be eliminated from it before it passes into the interior of the body…The fine dust of metals and of minerals is mingled with the pollen grains of the highest orders of plants…marsh miasmata, etc.…The atmosphere

[136] Ibid, 19-22.
[137] Holmes, *A Treatise on Vocal Physiology and Hygiene*, 204-205.

> forms, therefore, a rich reservoir whence injurious matters may find their way…"[138]

Holmes then proceeded to state that nasal breathing, although recommended for singers in states of rest, is not possible during performance due to the nature of volume and speed with which air is needed. Because of this, the potential vulnerability to climatic variables is greatly increased:

> "But…in singing [it is] probably impossible, to avoid inspiring habitually through the open mouth…Under these circumstances the inside of the throat, and perhaps the lungs, may suffer in three ways, i.e., (1) from the coldness of the air, (2) from its drying influence as it rushes in a large body over the mucous membrane…and (3) from lodgment of dust. By such pernicious influences the mucous membrane is irritated and may become congested, whilst the muscles beneath lose their vigour and become relaxed. Hence arises sore and relaxed throat, which interferes with the activity of the vocal organs and deteriorates the qualities of the voice; or troublesome dryness, causing stiffness of the throat, may be produced with equally damaging results…"[139]

He added that singers should generally avoid singing in the open air, especially in cold or damp weather, which had been "proven" to lead to "disastrous consequences" for the voice.[140] Holmes' work also references a couple other applicable treatises, with origins in France: Paris physician Martial Brouc's *Hygiène philosophique des artistes dramatiques*[141] (1836), and Adolphe Méliot's *La Musique Expliquée aux Gens du Monde*[142] (1869). Of the two, Brouc's very early treatise on vocal hygiene—which

[138] Ibid, 205.
[139] Ibid, 206-207.
[140] Ibid, 209.
[141] Brouc, *Hygiène philosophique des Artistes dramatiques.*
[142] Méliot, *La Musique Expliquée.*

discusses in detail everything from what clothing performers should wear, to what temperature their bath water should be, to when to eat meals, and what types of food to avoid—contains the greatest reference to influences of the atmosphere: the first section of its first book is titled "Influence de l'air atmospherique," or "Influence of Atmospheric Air." As an English translation of the French document has yet to be produced, a rough translation of relevant passages follows:

Chapter I: Temperature

> First Article, General Considerations. "…it is most useful to the dramatic artist, who is bathed in all temperatures, at all levels of humidity, who is immersed in all its impurities…Just by how many and pressing reasons should he not strive to appreciate nature and to avoid the dangers?...Temperature, because of its intensity, has general and specific influences on human health…The action of the air does not stop at the visible surfaces of our body…"
>
> Second Article, Applications to the health of the dramatic artist. "It is mainly the theatre where he must bring extreme vigilance. Indeed in the rehearsals and performances. Behind the scenes the dangers grow…What a multitude of aisles, doors, cracks between the decorations through which air slips which are too small and too cold…On stage things sometimes take on a new face. A lifting of the curtain, the air of the room, warmed by the chandeliers and the respirations and bodily heat from the spectators, tends to keep in balance with that of the scene. They mingle soon and the air that is breathed is less pure than it was before, although it is at least a little warmer. But this state does not last long; the artist is soon forced to leave the stage to make room for new characters."
>
> "It would be hoped that, in winter, the stage and backstage were constantly kept at a temperature of six to ten degrees of Réaumur[143], during rehearsals or during performances,

[143] The Réaumur scale is a French temperature scale, set to 0 and 80 degrees for freezing and boiling water, respectively. Brouc advised that the stage, backstage, and lodges of performers should be kept at a temperature between 6-10 degrees Réaumur, or 45.5-54.5 degrees Fahrenheit.

and that lodges of the actors were heated to the same extent…These improvements have already been implemented in several theaters, among which we mention the great opera."

"If the lodge of the artist is far from the stage, and if it is necessary for him to go there, he should go there with speed and place a handkerchief in front of his mouth and nostrils, so that air, before entering, stays a few moments between the handkerchief and his face and thus permeates a certain amount of heat, and brings to his lungs a warm soothing fluid…Upon leaving the theater that evening, he should avoid speaking or singing, or staying too long exposed in the air of the street…"

Chapter II: Humidity

First Article: Descriptions of its effect on health. "If air has not been quickened by sunlight, if it hold in suspension too considerable amount of water, it becomes unhealthy…"

Second Article: Scientific considerations about it. "[Unfortunate] results generally belong only to extreme or prolonged humidity. However they may more or less occur under the influence of an average moisture, when continuous, or when the constitutions of the individuals who are exposed to it are predisposed. Moisture is always joined to the temperature. It is greater when it does not exceed certain high or low limits of the temperature scale; it becomes almost nil when the cold is excessive or when the heat is extreme, because then it is either solidified and reduced to ice or snow, or volatilized and reduced to fumes that rise in the higher regions of the atmosphere. In our climate and in many others, it is usually the humidity, combined with the temperature, that proves harmful…"

"The humidity varies over the land due to many circumstances. Each [artist] for his own safety should inquire into that of the city he inhabits, or places where he usually lives. In Paris, extreme humidity prevails during the two-twelfths of the year…"

Third Article: Application of previous data to the safety of theaters and health of artists. "If the air in the city where the artist is practicing is usually impregnated with a

> considerable amount of moisture, it will be certainly difficult to completely avoid the influence. In this unpleasant event, he will try to live in the highest area of this city. At home, he will take care in the summer to establish air currents…In winter, the heat of the fireplace…He should note the position of the theater in this city. If the theater is built on a hill, it is surrounded by a spacious site properly—if the openings there do not face the west wind (a more humid wind in France). He may therefore be reassured and know that the theater is as safe as necessary. If the theater is instead located in a shallow area, near a river or some swamp and surrounded by trees or is exposed to the aqueous breath of the west wind, he should complain on being forced to expose himself to such a place…Suppose that neither the city nor the theater are exposed to dangerous levels of moisture, because of its position or the nature of the objects around it, it remains true that the theater will be a successful stay in regards to humidity…To remedy humidity, raise the temperature of the air, and promote circulation, either backstage or in the dressing rooms…"

Chapter III: Wind and Harmful Fumes

> Fifth Article: Unsanitary causes in the theater itself. "Thus a theater should be placed under good hygienic conditions, with respect to winds from industries, etc. This is not all. The adverse effects that may result for the artist in breathing noxious gases, unhealthy vapors, do not exist only outside the theater. There are no less unpleasant products in the interior of the theater by unavoidable causes…The fats that burn in chandeliers, in the footlights, also spread unhealthy vapors…A certain amount of those black vapors, thick, will mingle in the air he breathes, altering more or less his perfection of the respiratory act, and irritate his lungs and larynx…"

Holmes also cites Adolphe Méliot's *La Musique Expliquée aux Gens du Monde* (1869). In it, Méliot proposed a theory that had not yet been explored. According to Méliot, climate was a primary influence in determining the actual fach of the voice itself. A rough translation of the original French text is below:

> "The climate has an influence on the voice. In hot countries the voices are more beautiful than in cold countries. Treble voices are also more common than low voices; in Italy there are more tenors than basses, and in Germany more basses than Tenors. Specifically in the country of France, Picardy provides the most beautiful and numerous bass voices. Languedoc, and especially Toulouse and its surrounding areas are famous for the tenor voice. Burgundy and Franche-Comté provide the most female voices."[144]

Holmes disregarded this theory, stating that history appears to indicate that musical gifts of the voice are ethnogenetic in their origin, and are therefore not dependent on climate.[145] He did, however, agree that differing climates have a profound effect on the health of the voice:

> *Hot Climates*.—"In excessively hot weather (80 to 90 degrees Fahr., or higher), if the air is dry, the skin is stimulated to provide a large quantity of perspiration and the body is kept cool by rapid evaporation. At the same time respiration is quickened because the rarefied air contains less oxygen, and a larger supply of it is therefore required for breathing purposes. The increased rush of the dry air through the vocal channels tends to parch the mucous membrane, an effect which may deteriorate the quality of the voice. Moreover, the heat relaxes the muscular system, so as to reduce the aptitude for exertion. Under these conditions, therefore, the voice may lose in power and purity. Should the air be unusually moist, although the parching effect is not present, the heat is more than ever depressing…It is only in hot weather that marsh miasmata are potent for harm. They arise from low-lying tracts of land covered with decaying vegetable matter, but cannot emanate so as to pervade the general atmosphere, unless aided by a temperature above 60 degrees Fahr. They…interfere, of course, with the artistic exercise of the voice…they can be avoided by living up hills, should there be any, in the infected districts…In hot climates the vicinity of the sea-coast is generally more healthful than the inland districts. The marine air has stimulating and tonic

[144] Méliot, *La Musique Expliquée,* 123.
[145] Holmes, *A Treatise on Vocal Physiology and Hygiene,* 248.

> properties…It contains the largest amount of oxygen, because, allowing for temperature, it has the greatest density; for, the sea level being the lowest, atmospheric pressure is there at its maximum. Its humidity is generally of an average measure according to the temperature…"[146]
>
> *Cold Climates*.—"Very cold weather (25 to 40 degrees Fahr.), if the air is dry, is invigorating. It renders the function of the lungs more active…The dryness of the atmosphere creates little tendency to parching of the air-passages, because it is counterbalanced by the cold which checks evaporation. On the whole, therefore, a cold, dry climate is favourable to vocal exercise, or at least is not injurious to the integrity of the voice. The combination of cold and damp is notorious for its pernicious influence on health, though why it should act so injuriously is not quite certain…But cold and damp also greatly exaggerate the liability to congestion of internal organs, and are prolific generators of inflammatory affections of the air-passages, such as quinsy, laryngitis, bronchitis, etc.…It has been asserted that the gravity of the voice is increased in a cold and humid atmosphere, but the statement needs proof. Retention of moisture in or about the vibrating portion of the vocal apparatus might, indeed, by increasing the density of the vocal bands, lower their tones. Singers certainly feel the effect of chill and damp weather, and are then seldom in good voice."[147]
>
> "Persons who are obliged to be out of doors in chilly and moist weather should be especially careful to breathe through the nose, as the air, being thus considerably warmed, will be enabled to carry off more watery vapour from the lungs. The mucous lining of the throat is also thus guarded from the ill effects of the cold…"[148]

Holmes cited an account in which the famous Italian contralto, Giuseppina Grassini (1773-1850), lost her upper range because of the "hygrometric influence of the climate"

[146] Ibid, 248-250.
[147] Ibid, 250-252.
[148] Ibid, 252.

upon traveling to England. Once she became acclimated, her voice regained its normal function.[149]

> *Temperate Climates.*—"The characteristic of most temperate climates is their variability, for, whilst their summer may be almost tropical, their winter is not unfrequently of polar severity…sudden changes of temperature to the extent of 20 or 30 degrees Fahr. may occur in the course of a single day. At one time dryness, and at another humidity of the air may be present…The hygienic qualities of temperate climates are in direct relation with their variability, and the rapid transitions from heat to cold are especially inducive of catarrhal and inflammatory maladies, such as usually result from taking cold. Diseases of the throat are, therefore, frequent, and the inhabitants have some difficulty in preserving the purity of voice required for its professional use."[150]

In 1884, Oskar Guttmann, in Chapter III of his writing titled *Gymnastics of the Voice*, wrote:

> "In the first place, the air we inhale must not be too cold and too raw; inflammation of the mucous membrane of the larynx, and especially of the vocal cords (hoarseness) is the usual consequence…After prolonged singing…the larynx should never be exposed internally or externally to cold air…It is easy to guard against either of these kinds of exposure; but this is generally not done, through want of precaution and through a false shame. It has been shown that most persons fail…because they have the insane belief that they are able to stand everything; that they must accustom the larynx to exposure, to cold air and the wind…Those, who are so careless, will have to stand the consequences…"[151]

---

[149] Ibid, 251.
[150] Ibid, 253-254.
[151] Oskar Guttmann, *Gymnastics of the Voice: Second English Edition* (Albany, New York: The Voice Press, 1884), accessed October 25, 2015, https://archive.org/stream/cu31924022418374/cu31924022418374_djvu.txt.

Also in 1884, voice teacher Emil Behnke and vocal surgeon Lennox Browne worked together to write *Voice, Song, and Speech: A Practical Guide for Speakers and Singers*:[152]

> *The Hygienic Aspect of Management of the Motor Portion – Respiration*. "…from Dr. Paul Niemeyer's 'Die Lunge:' … 'The *Air* we breathe *out* is warmer than when inhaled; of this we have a proof in winter when our lungs seem positively to be steaming; it carries water which we can condense on a cold pane of glass, and which in very cold weather freezes in our beards, on ladies' veils, etc.…' The necessity of always having fresh air is therefore self-evident. The question, then, of the purity of the air to be breathed is one of immeasurable importance, but one very generally neglected. The difference between the air of the practice-room of the singer in daylight and of the gas-heated and often dust-laden concert-room and theatre is undoubtedly the cause of many a failure and disappointment of both vocalist and entrepreneur…Supposing all that was necessary in breathing in air to the lungs was for the individual to take in a large amount at a time irrespective of considerations of temperature and dust, particles of organic and inorganic matter such as are always floating about in the atmosphere of cities and habitations, there would be no reason why he should not inhale with the open mouth; but since nature has provided, in the nostrils, an apparatus both from warming and filtering the air, it is important that this passage should be used, and that it should be quite open and unimpeded…we do not deny that for rapid half-breaths occasionally demanded by the singer or speaker, inspiration by the mouth is not only justifiable but unavoidable. Habitual practice, however, in mouth-breathing can only lead to great discomfort, if not to actual and direct mischief of the throat, windpipe, and chest; and such is very probable to result in the foggy and cold-damp weather of spring, autumn, and winter…Hence we see that from a health point of view, no less than from the singer's, the lungs must be well inflated with air of good quality."[153]

[152] Lennox Browne and Emil Behnke, *Voice, song, and speech: a practical guide for singers and speakers; from the combined view of vocal surgeon and voice trainer* (New York: G.P. Putnam's Sons, 1886), accessed November 4, 2014, http://www.archive.org/details/voicesongspeechp00browrich.
[153] Ibid, 102+.

The Hygienic Aspect of the Vibrating Element—The Larynx and the Vocal Ligaments. "Do not attempt to use the voice in unfavourable circumstances, as in the open air, especially if the weather be cold or raw, nor in a room impregnated with…smoke, foul air, or dust…After continued singing or speaking be careful to prevent exposure of the throat either externally or internally to the impressions of cold air. The same remark applies as to the necessity of guarding against sudden changes from hot to cold air even when the voice has not been used."[154]

The Daily Life of a Voice-User: "As to residence, it is all important that a singer should occupy a well-ventilated room…so that…he may get a draught of fresh air each day…It will be preferable that he live on a hill with a south aspect, and in a house in which every regard is had to the state of the drains, for the throat of a voice-user is always more or less in a state of congestion, and therefore always more liable than that of ordinary persons to receive the injurious impressions of any insanitary exhalations…Especially is this the case with singers going to a new city…Naturally the climate will vary very considerably with the country in which a singer may be called to reside, but it should be his study to assimilate the temperature, etc., of his temporary or permanent residence to that of his home or that of the last country which he has inhabited. Thus he will often require fires and closed doors at seasons when the regular inhabitants may prefer open windows, and *vice versa*...In this manner of residence there are individualities which may require to be humoured. Some persons breathe better in a smoky city than in the country. Some whom we have known always lose their voice at the seaside; some, subject to dry catarrhs, enjoy the soft air of a valley; others, of relaxed habit, require the invigoration of mountains. To many who gain their livelihood by their voice, attention cannot be given to these peculiarities all the year round, but at least all may observe them when they take a holiday."[155]

"In cold weather take a hot bath…one great quality of incalculable value to a singer, at least in this [London] climate, that of the hot dry air inspired while in the *callidarium*,[156] which is so useful in counteracting the

[154] Ibid, 128+.
[155] Ibid, 243+.
[156] A hot and steamy room

effects of the ordinary cold damp air of an English winter, or it might be said of three-fourths of the year in a British climate, on the mucous membrane of the respiratory tract."[157]

"We must repeat that it is necessary to protect not the mouth only, but nose and ears by loose cloud or veil against night air, dust, fog, and cold damp atmospheres."[158]

"…heated, ill-ventilated, or draughty atmospheres, as found in theatres, with the addition of dust of a more than usually irritating character…are all likely to deteriorate from functional activity, ease, and purity of the singer…"[159]

"The ordinary *sore throat or relaxed throat* hardly requires special description…It may be caused by changes of weather and temperature…Many such cases will be cured by a Turkish bath, which has doubtless an influence on the system…by the action of hot dry air on the mucous membrane, disordered through inhalation of cold damp atmospheres; for that is the kind of weather most productive of sore throats…in cases still rather more severe the patient may suck ice…or take an appropriate lozenge, such as the saline astringent made specially for us and sold by Roberts & Co."[160]

"It may generally be said that while dry air is desirable, dust is to be avoided. Also, without desiring to advocate pampering and coddling of a system subject to take cold easily, we earnestly advocate those liable thereto, especially if singers, to guard against the effects of night air, and changes of temperature incidental from exits from theatres, concert-rooms, and the like, by means of covering the mouth and nostrils, and by sufficient extra covering. A small amount of Vaseline, introduced into the nostrils by means of a camel's hair brush, acts admirably as a protective of a sensitive nasal mucous membrane against the injurious effects of irritating particles."[161]

[157] Ibid, 243+.
[158] Ibid, 249.
[159] Ibid, 262.
[160] Ibid, 272.
[161] Ibid, 285.

British pioneer of laryngology, Sir Morel Mackenzie (1837-1892), wrote *The Hygiene of the Vocal Organs: A Practical Handbook for Singers and Speakers*, published in 1888. He advised against singing in open air because of the "muggy English sky" of Britain.[162] In his chapter titled "Special Hygiene for Singers," he gave specific directions for clothing, stating the throats and chests of singers especially need protection:

> "The [chest] can hardly be kept too warm, but the [throat] should not be muffled up in the day time, unless the weather is bitterly cold. At night, however, and above all when coming out of a warm room or crowded theatre, the throat should be carefully wrapped up and the mouth should be kept shut. If there be marked proclivity to taking cold, or if the weather is foggy, a respirator is a useful safeguard."[163]
>
> "Amongst the external things to be most sedulously guarded against by the singer must be mentioned irritating atmosphere or vapours…danger of fog…dust, smoke…are all injurious…Sitting late in hot, stuffy rooms, where the calumet of peace makes the air thick with smoke, is especially pernicious, as the heat and irritation combined make the throat doubly sensitive to cold when the outer air has to be faced…"[164]
>
> "In wet or foggy weather, or when a cold east wind is blowing, a vocalist should not expose his larynx by going out of doors if he can help it; but in fine weather the outer air is a useful stimulant."[165]
>
> "Anything involving rapid motion through the air is in some measure bad for the throat, owing to the forcible impact of cold air on the pharynx, etc., and the necessary entrance into the air-passages of irritating particles of

[162] Morel Mackenzie, *The Hygiene of the Vocal Organs: A Practical Handbook for Singers and Speakers* (London: MacMillan & Co., 1888), 102.
[163] Ibid, 108.
[164] Ibid, 110-111.
[165] Ibid, 111.

> various kinds which may be floating about in the atmosphere."[166]

In 1898, American doctor Thomas Rumbold, in his monograph titled "The Hygiene of the Voice,"[167] wrote about the temperature of the stage:

> "Many good voices have been ruined by singing and speaking on a cold stage. An over-heated stage is nearly as injurious. It is preferable that the temperature of the stage should be pleasantly cool [65 to 70 degrees Fahr.] rather than pleasantly warm [~85 degrees Fahr.]…On a stage of the latter temperature, overheating is very apt to occur, whereas with a pleasantly cool stage this is far less likely. Every singer and speaker whose throat is weak, should remember that an overheating almost always results in a cold."[168]

The similar—and conflicting—perceptions of these nineteenth-century vocal hygienists can be more easily determined in Table 7.

[166] Ibid, 112.
[167] Thomas Rumbold, *The Hygiene of the Voice* (St. Louis: Witt Publishing Co., 1898).
[168] Ibid, 100.

Type of Atmospheric Condition/Season	**Part of Body Affected**	**Resulting Condition**
Cold	Upper Respiratory Tract, Throat, Lungs	*Negative Effects:* Dangerous; Hoarseness; Most frequent cause of disease; Sore throat; Disturbance of function (all); particularly dangerous if suddenly exposed (Cohen, Holmes)
Heat	Throat	*Positive Effects:* Creates beauty in voice (Méliot) *Negative Effects:* Voice may lose power and purity (Holmes); Overheating results in a cold (Rumbold)
Humidity	Upper Respiratory Tract, Throat, Lungs	*Negative Effects:* Dangerous; Hoarseness; Catarrhs; Unhealthy (Durant, Holmes, Brouc)
Dry	Throat, Lungs	*Positive Effects:* Beneficial (Browne, Behnke) *Negative Effects:* Irritating, Sore throat (Holmes)
Cold and Humidity Combined	Upper Respiratory Tract, Lungs	*Negative Effects:* Injurious, Hoarseness (Holmes, Browne, Behnke)
Heat and Humidity Combined	Upper Respiratory Tract, Throat, Lungs	*Negative Effects:* Harmful (Holmes)
Heat and Dry Combined	Throat	*Positive Effects:* Beneficial (Browne, Behnke) *Negative Effects:* Dryness, Quality of voice deteriorates (Holmes)
Cold and Dry Combined	Throat, Lungs	*Positive Effects:* Dry conditions at 25-40 degrees F = Invigorating, Lung function is more active, Favorable to vocal exercise (Holmes)
Dust	Upper Respiratory Tract, Throat, Lungs	*Negative Effects:* Irritating, Sore throat (Cohen, Holmes, Browne, Behnke)
Recommended Stage Conditions		45.5-54.5 degrees F (Brouc); 65-70 degrees F (Rumbold)

Table 7. Summary of observations according to Durant, Cohen, Holmes, Brouc, Méliot, Guttman, Browne & Behnke, Mackenzie, and Rumbold

3.8. Nineteenth-Century Products Devised to Protect the Singer from Atmospheric Conditions

"Everyone needs chest-strengthening Peps, because this novel breatheable medicine reaches every part of the throat and chest and gives just the help that is required to successfully resist the evil effect of bad weather."[169]

In addition to the steady increase of writings dedicated to vocal hygiene in the nineteenth century, numerous products—which claimed to protect vocalists from harsh atmospheric conditions—were developed, advertised, and sold. To help protect the delicacy of a female singer's throat and lungs from cold air and particulates (for it "should not be necessary for men if they did not shave and learned to breathe through the proper passages"[170]), Browne devised the fashionable respirator veil, sold by Messrs. Marshall & Snelgrove[171] (see Figure 2). Its creator declared the veil provided "protection from the Fogs and Cold of this capricious [London] climate." It consisted of a piece of plain, unspotted blonde with a double thickness of silk gossamer on the lower four inches. A thin layer of wire gauze was added to the part that covered the mouth and nostrils, so that it could be worn away from the face for comfort.[172]

In 1843, J.C. Ayer & Company introduced its first medicine: Cherry Pectoral.[173] A colorful advertisement card for the product, dated 1886, depicts weather-warning flags and reads: "Ayer's Cherry Pectoral Cures Coughs and Colds caused by Changes in the Weather." (See Figure 3) In 1850, John I. Brown & Son introduced Brown's

---

[169] The Peps Company, "The Peril in the Air," (C.E. Fulford Ltd, 1913), 7, accessed November 23, 2015, http://wellcomelibrary.org/player/b21539790#?asi=0&ai=1&z=-0.2231%2C-0.0414%2C0.7118%2C0.4879.
[170] Browne and Behnke, *Voice, song, and speech*, 107.
[171] Originally called the Royal British Warehouse, Marshall & Snelgrove was a department store in nineteenth-century London.
[172] Cohen, *The Throat and the Voice,* 21.

Bronchial Troches, "indispensible to speakers and singers."[174] Similar to that of Ayer's, an advertisement ca. 1875-1900 portrays weather-warning flags and begins: "Sudden changes in the weather cause coughs and throat troubles." (See Figure 4) Dr. De Jongh's Cod Liver Oil was said to relieve and eliminate "distressing symptoms in catarrh, dry cough, and humid or winter cough." (See Figure 5)

In June of 1913, the Peps Company released a booklet titled *The Peril in the Air* to advertise the advantages of taking their tablets for coughs and colds. Upon taking one or two before starting out in wet, cold, or foggy weather, the "rare" medicines sealed in each tablet were released and carried with the breath through the mouth, nasal passages, throat, bronchial tubes, and lungs. "Everyone needs chest-strengthening Peps, because this novel breatheable medicine reaches every part of the throat and chest and gives just the help that is required to successfully resist the evil effect of bad weather."[175] Page 9 of the booklet includes several testimonials from "distinguished users." The English contralto, Dame Clara Ellen Butt (1872-1936), and her husband, baritone Robert Henry Kennerley Rumford (1870-1957), remarked: "We have formed the very highest opinion of Peps, after using them regularly for some considerable time. They are quite unique in their invigorating effect on the throat and chest, and in their freedom from any irritating or relaxing effect on the vocal chords [*sic*]." (See Figure 6)

Among the multitude of seemingly harmless products of the mid-nineteenth to early-twentieth centuries were also those that, if used seriously today, would raise

---

[173] "J.C. Ayer & Co. and the Civil War," *Lowell Historical Society*, Oct. 24, 2011, accessed November 23, 2015, http://www.lowellhistoricalsociety.org/blog/2011/10/24/lhs-presentation-j-c-ayer-co-and-the-civil-war/.
[174] Despite Brown's claim, Thomas Rumbold described them as "injurious compounds." Rumbold, *The Hygiene of the Voice,* 95-96.
[175] The Peps Company, "The Peril in the Air," 7.

eyebrows. For example, numerous companies advertised throat lozenges and pastils infused with cocaine.[176] Also, Kerr's Chloride of Ammonium Inhaler claimed to be helpful in prevention of sore throats due to "voice use in cold or damp weather." The effects of cold were supposedly diminished by its use.[177] (See Figure 7) At present day, the Center for Disease Control (CDC) warns against exposure to ammonium chloride, as it irritates the eyes, nose, throat, lungs, and skin, and, in extreme cases, can result in coma.[178]

[176] Morel Mackenzie advised singers to take such medications containing one sixth of a grain of cocaine no more than one every half hour for two hours. Mackenzie, *The Hygiene of the Vocal Organs,* 154.
[177] According to Mackenzie in 1888, the device failed to prove effective for singers: "The Ammoniaphone, as it is absurdly called, was suddenly presented to an astonished world as a talisman only comparable to the magic rings and lamps of Oriental fiction…After carefully testing it on several individuals who were not informed as to the nature of the results to be expected, I can only say that in my hands at least [it] failed to produce any particular effect." Ibid*,* 155.
[178] "Occupational Safety and Health Guideline for Ammonium Chloride Fume," *U.S. Department of Health and Human Services*, 1992, accessed November 23, 2015, http://www.cdc.gov/niosh/docs/81-123/pdfs/0029.pdf.

THE RESPIRATOR VEIL

(See page 107 of this Work)

Supplies an efficient and long-sought for requirement by Ladies and others needing protection from the Fogs and Cold of this capricious climate.

Its simplicity and elegance alone should recommend it. In addition to this, Ladies will find that, when in use, it secures all the organs of respiration from cold, and unfavourable atmospheric influences.

It is free from the unsightly appearance of the ordinary respirator, and gives equal protection; the air being warmed when passing through the chambers which are formed by layers of gossamer throughout the border of the Veil.

To preclude the possibility of the Veil becoming damp from breath moisture, that portion which covers the most important organs (nose and mouth) is ingeniously stiffened by a specially prepared layer of wire gauze, that in no-wise interferes with the comfort of the wearer.

The Veil is also a safe protection from Dust, and can be worn equally well both in Summer and Winter.

It is also recommended to Ladies as being useful on leaving heated rooms, theatres, &c., and passing out into the night air. In foggy weather it will be found invaluable.

This combination of Veil and Invisible Respirator was prepared on the advice and suggestion of Mr. LENNOX BROWNE, and is generally recommended by most Members of the Faculty, see *Medical Times and Gazette*, *British Medical Journal*, *The Queen*, *Land and Water*, &c., &c.

PROTECTED BY REGISTERED TRADE MARK.

Price 5s. each, or by Post, 5s. 2d.

TO BE OBTAINED FROM

MARSHALL & SNELGROVE,

VERE STREET and OXFORD STREET, LONDON.

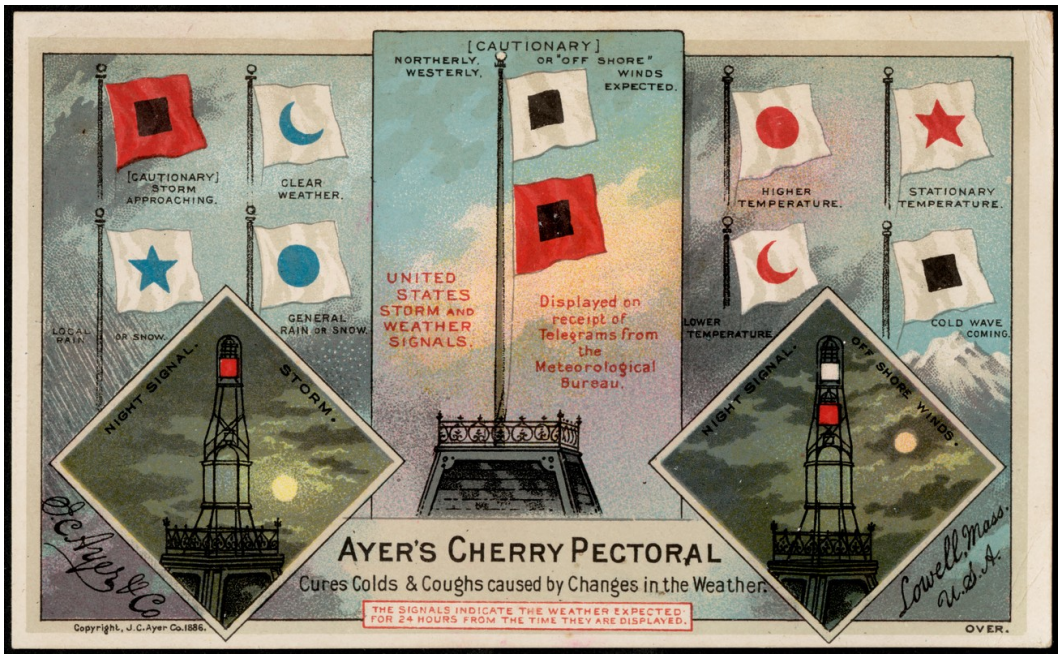
OR AT THEIR BRANCH STORES,

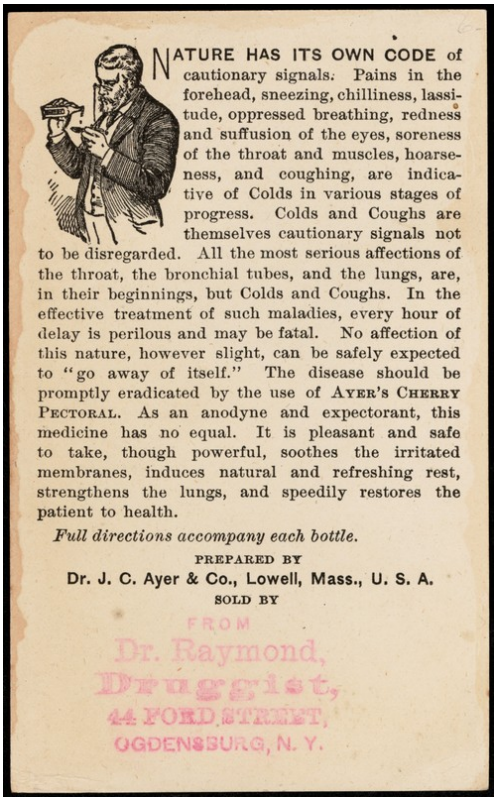
ST. NICHOLAS STREET, SCARBOROUGH, and
BOND STREET, LEEDS, YORKSHIRE.

Chemists and Druggists and the Trade supplied at Wholesale Rates.

Figure 2. The Respirator Veil.[179]

[179] Browne and Behnke, *Voice, song, and speech,* xxvii.





NATURE HAS ITS OWN CODE of cautionary signals. Pains in the forehead, sneezing, chilliness, lassitude, oppressed breathing, redness and suffusion of the eyes, soreness of the throat and muscles, hoarseness, and coughing, are indicative of Colds in various stages of progress. Colds and Coughs are themselves cautionary signals not to be disregarded. All the most serious affections of the throat, the bronchial tubes, and the lungs, are, in their beginnings, but Colds and Coughs. In the effective treatment of such maladies, every hour of delay is perilous and may be fatal. No affection of this nature, however slight, can be safely expected to "go away of itself." The disease should be promptly eradicated by the use of AYER'S CHERRY PECTORAL. As an anodyne and expectorant, this medicine has no equal. It is pleasant and safe to take, though powerful, soothes the irritated membranes, induces natural and refreshing rest, strengthens the lungs, and speedily restores the patient to health.

Full directions accompany each bottle.

PREPARED BY
Dr. J. C. Ayer & Co., Lowell, Mass., U. S. A.
SOLD BY

FROM
Dr. Raymond,
Druggist,
44 FORD STREET,
OGDENSBURG, N. Y.

Figure 3. Ayer's Cherry Pectoral Chromolithograph, 1886, front and back views.[180]

[180] Ayer & Co., *Ayer's Cherry Pectoral* (Lowell, Mass.: J.C. Ayer & Co., 1886) 12.4 x 7.4 cm trade card. [Author-owned]

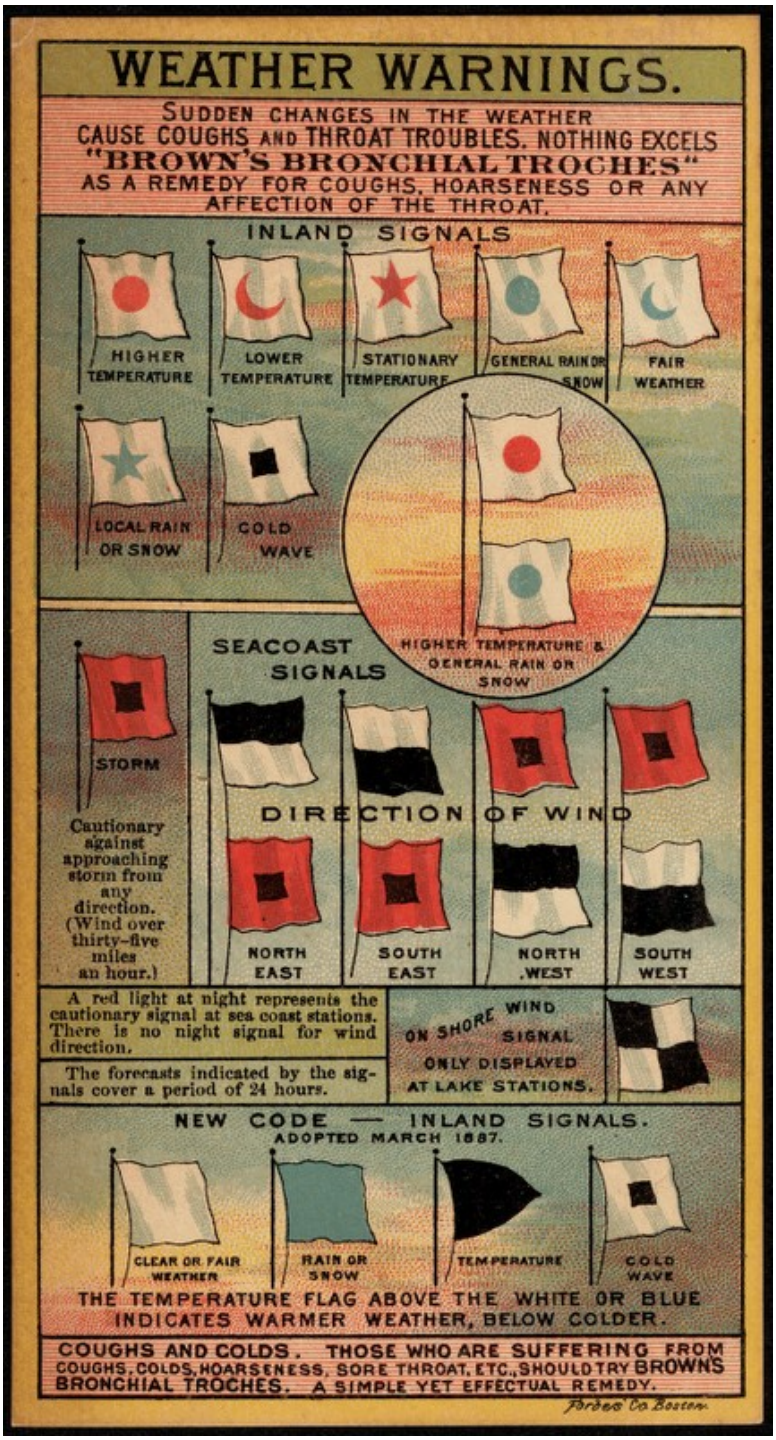


Figure 4. Brown's Bronchial Troches Chromolithograph, ca. 1875-1900, front view. [181]

[181] John L. Brown & Son, *Weather Warnings…An old world-renowned remedy for the relief and cure of colds, coughs, hoarseness, and all throat troubles…*Brown's bronchial troches (Boston: Forbes Lithograph Manufacturing Co., between 1875 and 1900) 15 x 8 cm. trade card. [Author-owned]

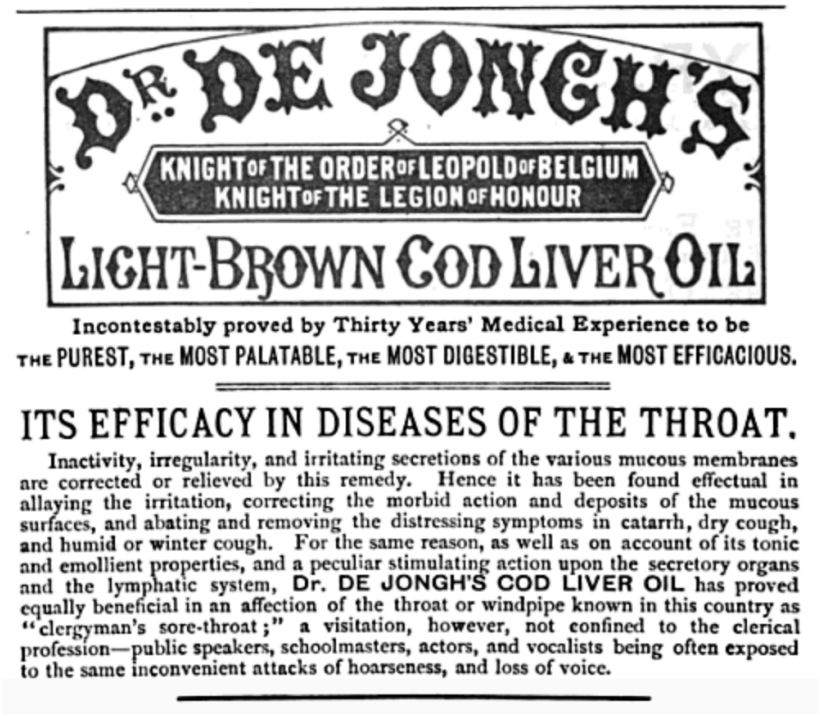


Figure 5. Dr. De Jongh's Light-Brown Cod Liver Oil Advertisement. Mid-nineteenth century.[182]

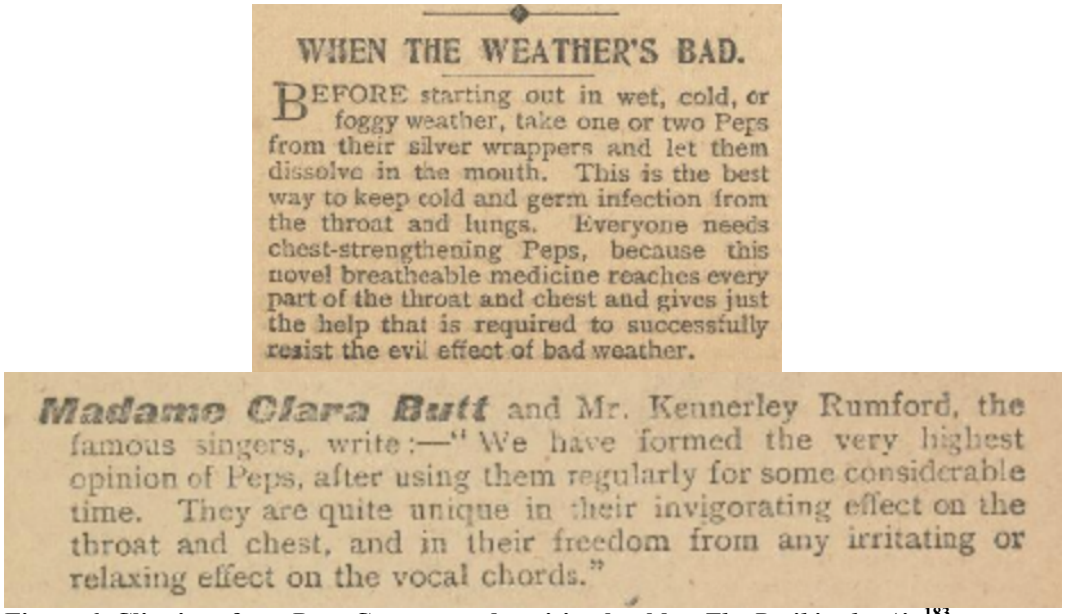


Figure 6. Clippings from Peps Company advertising booklet, *The Peril in the Air*.[183]

[182] Browne & Behnke, *Voice, song, and speech,* xxii.
[183] The Peps Company, "The Peril in the Air," 7, 9.

Figure 7. Kerr's Chloride of Ammonium advertisement, mid-nineteenth century.[184]

[184] Ibid, xxxiii.

3.9 The Twentieth and Twenty-First Centuries

"Be careful of weather changes—very hard on the voice."[185]

The claim that atmospheric conditions have an effect on the voice not only survives into the twentieth and twenty-first centuries, it finds new mediums in which to spread. With the advent of early technologies such as the phonograph disc record, radio, television, and cinema, music-lovers—who once had to attend live performances to hear their favorite compositions or singers—were now able to listen and watch from the comfort of their own homes and local theaters. The careers of early twentieth-century singers were propelled to new heights with the help of such technological advancements, spreading not only their music to a wider audience, but their anecdotes as well.

Numerous well-known and highly respected singers have written or spoken about their issues with performing in certain atmospheric conditions. These relatively recent stories are important to include in the research, because not only do they provide evidence from some of the most successful and respected singers of this age, they highlight the fact that this subject is still discussed—and disagreed upon—even today. Furthermore, for the first time in this historical review, specific dates and locations are given for some of these weather-affected performances. This information is crucial for quantitative comparison and analysis (see Chapter IV).

To renowned tenor Luciano Pavarotti (1935-2007), the avoidance of cold weather was of primary importance to the health of his instrument. In a 1999 interview

[185] Bell, "Sherrill Milnes talks to Performing Arts about caring for the voice," 7.

with National Public Radio, he said he tried to stay away from it altogether.[186] He was rarely seen without a large scarf wrapped around his throat: "When you go out, always protect your throat with a scarf!"[187] On February 10, 2006, he was widely criticized for lip-syncing *Nessun Dorma* during the opening ceremony of the Winter Olympics in Turin, Italy. According to the singer's manager, Terri Robson, the decision to pre-record the vocals was made because of the bitter cold weather, which made a live performance impossible. In an e-mail to the Associated Press, Robson wrote that Pavarotti's voice was "in great shape…but because of the extreme late-night temperature in Turin in February, for both him and the orchestra, it was decided that the only way to make it work was for him to pre-record."[188]

Pavarotti is not alone. In a 1981 *New York Times* article, mezzo-soprano Marilyn Horne (b. 1934) is cited as saying she doesn't walk anywhere in cold weather, in order to preserve her health.[189] In her more recent 2004 biography, *The Song Continues*, she recalls her time in the "boonies of West Germany," at the Gelsenkirchen Opera. "The climate ranged from fog to rain to snow and a film of just plain dirt hung like a mantle over the town. The winters were frightfully frigid; I had colds, colds, and more colds, plus bronchitis."[190] She also discussed the conditions during her performance at the 1993 Presidential Inauguration of Bill Clinton: "The Inauguration itself took place on a

---

[186] Neda Ulaby, "Profile: Luciano Pavarotti," *National Public Radio,* September 6, 2007, accessed September 8, 2011, http://www.npr.org/templates/story/story.php?storyId=14204641.
[187] Christian Owen, "Kallen Esperian: FACES of Memphis," *Style Blueprint*, November 9, 2014, accessed January 12, 2016, http://styleblueprint.com/memphis/everyday/kallen-esperian-faces-memphis/.
[188] Marta Falconi, "Pavarotti Lip-Synched Last Performance," *Huffington Post*, April 15, 2008, accessed September 8, 2011, http://www.huffingtonpost.com/2008/04/07/pavarotti-lipsynched-last_n_95502.html.
[189] Albin Krebs and Robert McG. Thomas, "Notes on People: Marilyn Horne and Her Victory Over Aggressive Viruses," *The New York Times*, January 21, 1981, accessed January 25, 2016, http://www.nytimes.com/1981/01/21/nyregion/notes-on-people-marilyn-horne-and-her-victory-over-aggressive-viruses.html.
[190] Marilyn Horne, *The Song Continues* (Fort Worth, TX: Baskerville Publishers, Inc., 2004), 93.

really cold January day. I was prepared. I had a wool suit and a cape made for the occasion. I was protected from the weather…"[191]

"Queen of Soul" Aretha Franklin (b. 1942) was perhaps not as protected for her own Inauguration performance for Barack Obama on January 20, 2009. In an interview the day afterward with CNN's Larry King, she revealed that she was extremely unhappy with her rendition of *My Country 'Tis of Thee*, thanks to the bitterly cold temperatures.

Excerpts from the Larry King Interview[192]

> King: *Is that a tough song to sing?*
>
> Aretha: *No, not at all, but yesterday it was. Mainly because of the temperature outside. I don't have to tell you, it was freezing, if you were there. Some singers it doesn't bother, and others it does. I don't care for it. It definitely affected my voice.*
>
> King: *One thing, with your magnificent voice, is it hard to sing outdoors?*
>
> Aretha: *It depends on the temperature. Yesterday, Mother Nature was not very kind to me. I'm going to deal with her when I get home…*

While Aretha chose to give a live performance over lip-syncing to a recording, cellist Yo-Yo Ma and his colleagues pre-recorded their piece two days earlier as a precaution against the subfreezing conditions. According to Ma: "We knew we couldn't have any technical or instrumental malfunction on that occasion. A broken string was not an option. It was wicked cold."[193] Aretha confessed she wished she had done the same. "I just hated that it was so cold. It wouldn't have been so bad if I hadn't sat

[191] Ibid, 214. The Inauguration ceremony was on January 20.
[192] YouTube, "Larry King Live- Talks to Aretha Franklin About Her Hat During the Inauguration."

outside for so long. By the time I had to sing, I was chilled…The cold weather isn't good for your voice. I should have [pre-recorded] my vocals. But I went ahead and did it live. That's me."[194]

Four years later, during Obama's second Presidential Inauguration on Monday, January 21, 2013, singer Beyoncé Knowles (b. 1981) received harsh public criticism for lip-syncing *The Star-Spangled Banner*. According to a Daily Mail article, she defended her choice to use a pre-recorded track; she was concerned the temperature would affect her voice: "Due to the weather…I did not feel comfortable singing live."[195] "Pavarotti mimed and it was freezing cold!"[196] Aretha gave a statement about the controversy, recalling her own difficulty at the first inauguration ceremony: "…having come face to face with 28, 22 degrees, I am not surprised she pre-recorded…for most singers that is just not good singing weather."[197]

In an article titled *Performing in Cold Weather Doesn't Just Affect Beyoncé* from AccuWeather, the advice of vocal coach Chris Beatty is cited:

> The main problem with colder weather for singers is dryness. Dryness in the vocal track is danger…breathe in through your nose instead of your mouth in order to give

---

[193] Daniel J. Wakin, "The Fingers Were Live, but the Music Wasn't," *The New York Times,* January 22, 2009, accessed January 14, 2016, http://www.nytimes.com/2009/01/23/arts/music/23band.html?_r=0.
[194] Tris McCall, "Aretha Franklin brings her signature soul to NJPAC," *nj.com*, March 28, 2013, accessed January 13, 2016, http://www.nj.com/entertainment/music/index.ssf/2013/03/aretha_franklin_brings_her_sig.html.
[195] Rebecca Nelson, "Beyoncé sings National Anthem Live for All the Haters at Super Bowl Press Conference," *Time*, January 31, 2013, accessed January 26, 2016, http://newsfeed.time.com/2013/01/31/watch-beyonce-sings-national-anthem-live-for-all-the-haters-at-super-bowl-press-conference/.
[196] Sarah Bull and Meghan Keneally, "'Pavarotti mimed and it was freezing cold!': Beyoncé's reasons for lip-synching at the inauguration," *DailyMail.com*, January 23, 2013, accessed September 30, 2014, http://www.dailymail.co.uk/tvshowbiz/article-2267348/Beyonce-backlash-Pavarotti-mimed-freezing-cold.html.
[197] Shushannah Walshe, "Aretha Franklin 'Really Laughed' About Beyoncé Lip-Sync Controversy," *ABC News*, January 22, 2013, accessed January 21, 2016, http://abcnews.go.com/Entertainment/beyonce-lip-sync-controversy-aretha-franklin-laughed/story?id=18289912.

> your breath a chance to warm up to your body temperature. Singers should wear a scarf and hat and arrive early to acclimate to their current weather conditions.[198]

Aretha would strongly disagree with Beatty's advice to arrive early: "Had I not had to sit that long, I had to sit for 45 or 30 minutes and it was much colder, it was in the 20s…I just wished I could have sung the moment I got there. If I could have walked on immediately and sung it wouldn't have affected my voice the way it did."[199] And, although Pavarotti would certainly agree with Beatty's advice to wear a scarf, not all singers have shared the same sentiment. Soprano Luisa Tetrazzini (1871-1940), in *The Art of Singing*, wrote: "Personally I never wear a collar and have hardened my throat to a considerable extent by wearing slightly cutout gowns always in the house, and even when I wear furs I do not have them closely drawn around my neck. I try to keep myself at an even bodily temperature, and fresh air has been my most potent remedy at all times…"[200] An 1895 article in *Warner's Magazine* even described the scarf as an "evil" to the singer:

> Singers, as a race, are given to coddling themselves, and one of the best ways of rendering one's self susceptible to colds is to be over-careful…even on the very coldest days, when you remove the boa [scarf], your neck will be unnaturally warm, if not moist with perspiration…By this unnatural and unnecessary protection you make that most important of all parts, your throat, so tender…the more you strengthen the throat by a wise disregard of molly-coddling, the better able it will be to stand the gyrations of our wonderful climate.[201]

---

[198] Molly Cochran, "Performing in Cold Weather Doesn't Just Affect Beyoncé," *AccuWeather*, January 24, 2013, accessed September 30, 2014, http://www.accuweather.com/en/weather-news/performing-in-cold-weather-doe/4715960.
[199] Walshe, "Aretha Franklin 'Really Laughed.'"
[200] Enrico Caruso and Luisa Tetrazzini, *Caruso and Tetrazzini on the Art of Singing* (New York: Dover Publications, Inc., 1975), 33.
[201] Karleton Hackett, "In My Studio," *Werner's Magazine: A Magazine of Expression* 17 (1895): 9.

Certainly, one must question: is a singer's negative reaction to certain atmospheric conditions purely physiological, or is there a psychological factor involved as well? Perhaps some singers are "hardened" to perform in certain environments that others are simply not? Soprano Renée Fleming (b. 1959), in her book *The Inner Voice: The Making of a Singer*, wrote: "So many factors contribute to the ease and well-being of the voice: the moisture in the air…altitude, change in climate…the weather."[202] While she acknowledges this, it doesn't seem to deter her from her performances. On Sunday, February 2, 2014, she sang the National Anthem at Super Bowl XLVIII in East Rutherford, New Jersey—the first open-air Super Bowl to be held in a cold-weather city. In the days leading up to the game, officials, players, fans, and performers alike were bracing themselves for the likely 30-degree temperatures. Halftime performer Bruno Mars discussed how he was going to keep warm in an interview with The Weather Channel: "Everyone's putting the fear of God in me like there's going to be a blizzard. I'm going to wear a beekeeper suit, I don't know. I'm not going to know until I get there…I'm not trying to hype myself up too much. I know it's going to be cold and I just got to face it."[203] In the same interview, singer Katy Perry, who went on to perform in the 2015 Super Bowl in Arizona, said: "The weather affects your vocal cords…I've been in some situations where it just like dries out your voice—the cold does. It's not where you shine your best, but you do what you have to do." Renée, however, was not worried about the weather, saying that her hometown of Rochester, New York, prepared her for singing in the cold. She said of the Super Bowl's forecasted

[202] Renée Fleming, *The Inner Voice: The Making of a Singer* (New York: Penguin Books, 2004), 204.
[203] Mesfin Fekadu, "Singing in the Cold: Bruno Mars Preps for the Super Bowl," *The Weather Channel,* January 2016, accessed January 22, 2016, http://www.weather.com/sports-recreation/superbowl/news/cold-super-bowl-bruno-mars-20131227.

temperatures: "As we're fond of saying, we Upstaters, even when we're in New York: 'Oh this is nothing.'"[204]

Cold temperature is not the only atmospheric condition discussed by many. Humidity, and the lack thereof, is another cited vocal health culprit. Humidity was a factor in Horne's work in Venice in 1956: "That September, the climate was not conducive to work. The sirocco[205] was up, and anyone who's ever lived through this thick, warm, damp wind knows how debilitating it is and how badly it affects people. The density and humidity is crushing; you simply cannot move let alone work."[206] The famous Italian tenor Enrico Caruso (1873-1921) wrote of his troubles with America's climate and dry rooms in his short treatise *The Art of Singing*:

> In common with most of the foreign singers who come to America, I have suffered somewhat from the effects of your barbarous climate, with its sudden changes of temperature, but perhaps have become more accustomed to it in the years of my operatic work here. What has affected me most, however, is the overheating of the houses and hotels with that dry steam heat which is so trying to the throat. Even when I took a house for the season I had difficulty in keeping the air moist.[207]

It has been reported that Judy Garland (1922-1969) would turn on the shower in her hotel room to raise the humidity level: "…upon arriving at her hotel, [she] would hang her clothes in the bathroom, turn on the hot shower, and sit in the steamy room while her clothes lost their wrinkles and the humidity would restore the feeling of ease

---

[204] Lorenzo Reyes, "Renée Fleming not worried about cold weather," *Democrat & Chronicle*, January 31, 2014, accessed January 22, 2016, http://www.democratandchronicle.com/story/sports/2014/01/30/rene-fleming-not-worried-about-cold-weather/5070855/.
[205] In the Mediterranean region, a warm, dust-laden, often humid southerly wind; particularly prevalent in spring and fall. Dunlop, *The Oxford Dictionary of Weather*.
[206] Horne, *The Song Continues*, 91.
[207] Caruso and Tetrazzini, *The Art of Singing,* 48-49.

to her singing voice…a good technique for warming the larynx and body as well."[208] Soprano Lilli Lehman (1848-1929) would breathe through a large sea sponge soaked in hot water to hydrate her vocal tract.[209]

Singers have been known to avoid certain dry-climate locations altogether. Las Vegas, Nevada, for example, is so notorious among vocalists that the term "Vegas Throat" has been coined. A *Las Vegas Sun* article sums up the problem well:

> In 1997 when U2 embarked on its world tour, the band looked no further than Sin City as the perfect site to kickoff the event…but the city isn't even on the band's concert schedule [anymore]. The unofficial reason for omission: The area's dry climate plays havoc on Bono's throat. Lest the lads from Ireland get a bad rap, it's not just a problem experienced by U2. Before Bon Jovi played the MGM Grand Garden Arena in April, band namesake and front man Jon Bon Jovi reportedly said he wouldn't perform in Las Vegas again because the dry air adversely affects his voice. The singer was so concerned with the area's lack of humidity, the use of backstage humidifiers was included in contract negotiations…Many celebrities who have performed at Paris Las Vegas, including Barry Manilow, Natalie Cole…have requested use of humidifiers. The machines proved so popular among entertainers that the MGM Grand Garden Arena had humidifiers built into the rooms backstage in case performers request them. For some, however, that's going too far. "I see people come into town so worried about drying up—they have humidifiers everywhere," famed crooner and Las Vegas resident Robert Goulet said. "Drink some water and use throat lozenges." Goulet added that it's not necessarily the climate that's the sole culprit behind Vegas throat, but the fact that today's singers were never properly trained in how to take care of their voices and how to sing…The combination is often too much for vocal cords to take. [210]

[208] Gregg, "On Tension and Temperature," 42, 55.
[209] Ibid.
[210] Baird, "Why 'Vegas Throat' Has Performers All Choked up."

According to NOAA's National Centers for Environmental Information (formerly NCDC), Las Vegas is one of the driest cities in the United States with an average annual relative humidity of just 30%, falling second only to Yuma, Arizona.[211] An in-depth discussion about potential optimum relative humidity levels as they pertain to vocal health is included in Chapter IV.

At the 2012 Israeli Opera Festival, held in the Judean Desert at the base of Mt. Masada, Israeli singer and third string cover Naama Goldman had to step in as the title role in *Carmen* after not one but two foreign singers were unable to perform due to the harsh desert conditions. Italian opera singer Anna Malavesi was forced to rest after being affected by a sandstorm during the previous day's rehearsal. Spanish opera singer Nancy Fabiola Herrara "was unable to continue singing [during the night of performance] because of the effect of Masada's dry conditions on her vocal chords [*sic*]."[212] Like the case of Renée Fleming, who was used to singing in cold temperatures because of her experience performing for years in her hometown of Rochester, New York, was Israel native Naama Goldman simply acclimated to the harsh desert conditions, unlike the traveling singers from Italy and Spain?

Acclimatization to quickly changing environments may be a key component to a singer's ability to perform in less than ideal conditions. In a *Back Stage West* article titled "Taking Your Voice On the Road," three Broadway singers gave their thoughts about the challenges of travel. Taylor Sternberg (*Jersey Boys*) said: "I'd say the biggest thing is going from climate to climate. Singing in Arizona is going to be different than

[211] "Extreme U.S. Climates," *The National Climatic Data Center*, accessed January 26, 2015, https://www.ncdc.noaa.gov/extremes/extreme-us-climates.php.
[212] Gil Zohar, "Israeli Diva Saves 'Carmen' at Masada," *Chicago Jewish Star*, June 29, 2012, accessed November 3, 2014, ProQuest.

singing in Florida. In Florida you walk outside and it's a personal humidifier 24/7, whereas you go to Arizona and it's very dry; you have to stay hydrated all the time. You've got to be protective of your voice and your health."[213] Gil Darnell (*The Real Monty*) agreed. "The environment changes with each location; not only is the city different, but the quality of the theatre and the housing can vary greatly. Air conditioning can play a big part in drying out the voice and creating problems, and allergies can act up in response to dusty theatres or new environmental conditions." Jen Talton (*Rent*) said: "The temperature is always different in every theatre—either way too hot or way too cold."

Although temperature and humidity are the most commonly discussed atmospheric variables, altitude is another factor of concern for many singers. At the prestigious Santa Fe Opera in New Mexico, which sits nearly 7,000 feet above sea level, numerous performers have expressed concern about the lack of oxygen. According to bass-baritone Luca Pisaroni (b. 1975), the altitude at Santa Fe requires adjustment:

> I always say, if you can sing a role here, you can sing it anywhere in the world. Obviously it takes much more in terms of energy, and you need to adapt to the fact that there is less oxygen than, for example, in New York…The first week, the only thing I do is to make sure that I have the same lung capacity that I normally have everywhere, because you do feel it. You walk two steps, and you are out of breath. Early in rehearsals, if the director asks you to walk across the stage, you start panting, and you wonder, 'Jesus, how am I going to sing this role?'[214]

[213] Michael Goodrich, "Taking Your Voice on the Road," *Back Stage West* 15, no. 15 (2008): 17, accessed October 10, 2014, EBSCOhost.

Dr. Paul De Stefano treats many of the Santa Fe Opera singers during the season. "Coming to an altitude of 7,000 feet is going to be significantly more stressful than singing at sea level, and even more stressful than singing at 5,000 feet, like say where Denver or Albuquerque would be."[215] David Holloway, Director of the Santa Fe Opera Apprentice Singers Program, often advises young singers about the effects of the high altitude when they arrive each summer. "I tell the young singers it's going to be three weeks before you start feeling like your old self. Some people do it quicker than that, and other people it takes even longer…whenever you're singing something, especially something that is long and sustained, you frequently have to find places to sneak breaths…"[216] Tenor Keith Jameson recalled his first summer coming to Santa Fe as an apprentice: "I was staying in a hotel that first week, and climbing the stairs, I was just out of breath and I thought 'What is this?'…I've known singers that have had oxygen backstage to help them get through certain performances because they were getting so light-headed." Jameson also discussed the challenges of the outdoor Adobe Theater: "The stage is open, at the back, to the elements, and so sometimes you have to deal with 40-degree weather…or high winds, or rain or storms that come through, so you sort of have to get used to it."[217] For soprano Natalie Dessay, however, the "thin air" is not a

---

[214] Eric Meyers, "Road Show: Luca Pisaroni in Santa Fe," *Opera News* 77, no. 9 (March 2013), accessed March 3, 2016, http://www.operanews.com/Opera_News_Magazine/2013/3/Features/Road_Show__Luca_Pisaroni_in_Santa_Fe.html.
[215] YouTube, "High Altitude Affects Singers at the Santa Fe Opera," *Santa Fe Public Radio*, accessed March 3, 2016, https://www.youtube.com/watch?v=yCGXjnjSqRI.
[216] Ibid.
[217] Ibid.

concern. "For me it's like Bob Beamon in the Mexico City Olympics.[218] It's a challenge, and I love singing at that elevation and in that beautiful setting."[219]

The sample of evidence in this section has shown that well-known singers cite certain atmospheric conditions as problematic to their performances. What about the general singing community? Today, the Internet has become a platform for numerous stories and advice from well-known performers and amateurs alike. In a March 2015 online forum, a conversation takes place between a new student of singing living in Argentina and an established voice teacher located in Seattle:[220]

> *Student:* "I have some problems because the summer is over and now we are in the autumn in Argentina, where I live…Every year I have the same issue: I have a hard time warming up my voice…I find that the cold weather doesn't let me have my full voice when practicing…I was wondering if anyone has the same problem and if there's any tip that could help me…"
>
> *Teacher:* "I don't think that cold weather really is the culprit. To blame your voice issues on the temperature outside or the weather is a bit unfounded…not proven to be a situation that affects people."

However, another search turns up another teacher's completely different opinion: "As the temperature plunges, singers and speakers need to take extra care…Having lived in temperatures ranging from 112 degrees [Fahr.] above to 55

[218] Long-jumper Bob Beamon set a record of 8.9 meters at the Mexico City Olympics in 1968. Many have said that the city's altitude (nearly 8,000 feet) contributed to this feat due to decreased air resistance.
[219] David Belcher, "The Altitude is Daunting, but the Soprano is Fearless," *The New York Times*, June 3, 2009, accessed March 3, 2016, http://www.nytimes.com/2009/06/07/arts/music/07belc.html?_r=0.
[220] "The Four Pillars of Singing – Warm-up for cold weather," *The Modern Vocalist World*, March 27, 2015, accessed June 3, 2015, http://www.themodernvocalistworld.com/topic/8372-the-four-pillars-of-singing-warm-up-for-cold-weather/.

degrees [Fahr.] below zero (Las Vegas, Northern MN, NYC, Chicago), I can tell you that when it comes to singing, temperature does matter."[221]

Any singer asking the question "Does weather affect my singing voice?" must undoubtedly be confused if consulting the Internet for an answer. A plethora of opinions and advice from amateurs, vocal scientists, doctors, teachers, coaches, and professional singers exists. While the majority of discussions agree that atmospheric conditions do affect the voice in one way or another, there are others who point out the unfounded nature of those claims. A small but telling sample of these conflicting perceptions via a simple Web search is presented below. The purpose of this particular evidence is merely to highlight the fact that so many views currently exist; again, universal scientific clarification is needed.

> ***Question:*** Can singing in cold weather permanently damage your voice? If so, how?[222]
>
> ***Answer #1:*** *Singing in cold weather can create tremendous strain to the vocal chords [sic] regardless of how well the voice was warmed up before the performance. Obviously such styles as choir or other methods relying on group harmonization rather than pure operatic expression in the voice will provide a greater endurance for the members involved than singers belting at maximum capacity. If anyone needs actual evidence just try for yourself and see how long your voice will last when frost is coming out of your mouth. I am a male vocalist who has been singing for years, hitting loud operatic notes from deep lows to even as high as a screeching parrot and cannot last in the cold for more than an hour before I start to crack and lose vibrato control. If you are performing under these conditions and must go on keep your volume at serious caution any decent*

[221] Chris Beatty, "Cold Weather Tips for Singers," *Ask the Vocal Coach Blog*, November 9, 2010, accessed June 3, 2015, http://vocalcoach.com/blog/2010/11/cold-weather-tips-for-singers/.
[222] Google Search, "Can singing in cold weather permanently damage your voice?" *Answer Bag,* accessed September 10, 2011, http://www.answerbag.com/q_view/12984#ixzz1J9nIyxGb.

singer will tell you that much. My advice, no matter how good your ability and strong your voice is-DO NOT DO IT!

Answer #2: *Well...if you're not careful, you could do some serious damage. I would suggest singing where you can be comfortable as this will always be best for your voice, but I've sung in -20-degree weather before (it was miserable! ...But I suppose anything for prestige...), so I guess if you're bundled up REALLY well and keep your body warm, you should be ok for a short period of time. Just watch what you do. Don't try anything too terribly strenuous as the cold will prevent your voice from being as supple as it normally would be.*

Answer #3: *I would assume not. Carolers do this and seem to retain decent voice quality, as do well-known singers in outdoor concerts.*

Question**:** Can cold temperatures diminish your singing range?[223]

Answer**:** *Yes, it can cause your voice to sound "tight" making you sharper and unable to hit your lower range. And then you get laryngitis, which is the singer's worst nightmare. Cold temperature has negative effects on any part of the body. Some maintain that overworking the voice in the cold can cause temporary to permanent damage, as I'm sure any cheerleader can attest to. Colder air is also much drier than room temperature air, and this can dry out the vocal cords and lungs (noticeable if running on a cold day). It is advisable to drink room-temp water while singing and avoid extremely cold temperatures.*

Question: Does singing in the cold weather affect the singing voice?[224]

Answer: *Singing in colder weather DOES affect your voice a lot actually. Cold temperatures constrict your vocal chords [sic] and dry the water in your throat. If you are going to a voice lesson, choir class, performance, or*

[223] Google Search, "Can cold temperatures diminish your singing range?" *Answer Bag,* accessed September 10, 2011, http://www.answerbag.com/q_view/11787#ixzz1J9oDNPB2.
[224] Google Search, "Does singing in the cold weather affect the singing voice?" *Yahoo Answers*, accessed September 10, 2011, http://answers.yahoo.com/question/index?qid=20091028102830AAHeLqE.

anything else dealing with singing, it's VITAL you keep your throat warm. Even one minute spent running to class in the cold CAN mess you up when singing. It's a crazy thing, I know, but true. Even though it seems too easy, scarves are a VERY effective way to do this. Plus they keep you nice, snuggly, and warm very well…Also, do NOT take deep breaths through your mouth. It's another VITAL piece of the puzzle. Breathe through your NOSE so you don't (like I said) freeze or dry up the water in your throat. Even talking counts as breathing in the cold, so just zip the lips until you're safely inside.

Question: Can the hot weather affect your singing voice?[225]

Answer #1: *…The number one thing you can do is to stay hydrated. If you don't drink water, your voice will dry up really fast especially if it is dry outside. Also, breathe with your mouth closed. It helps to prevent your voice from getting too dry.*

Answer #2: *Hot weather doesn't affect your voice at all. Cold weather yes…but not hot. If anything it makes singing easier because your jaw is looser…*

Answer #3: *Humid air might help, kind of acting like a humidifier, but I haven't heard of anything bad happening because of it just being hot.*

Question: Does the humidity affect one's ability to sing?[226]

Answer #1: *Yes, some people are more sensitive to drastic changes, a place too humid or too dry can affect in a positive or negative way your voice. I grew up in Puerto Rico, very humid country and my voice was always really good. Then I moved to Phoenix, and at the beginning my voice was really affected it no humidity there. I had to start drinking more water than usual and even some night I slept with a humidifier…so for my voice humidity is good! I am a professional opera singer, voice teacher and recording artist. Over 12 years of teaching experience.*

[225] Google Search, "Can the hot weather affect your singing voice?" *Yahoo Answers*, accessed September 10, 2011, http://au.answers.yahoo.com/question/index?qid=20090130202746AAFABr4.
[226] Google Search, "Does the humidity affect one's ability to sing?" *Yahoo Answers,* accessed September 10, 2011, http://answers.yahoo.com/question/index?qid=20060713182827AASdAfc.

Answer #2: *I know when it's really dry out my throat and all that fun stuff gets really dry. For me it's easier to warm up when it's more humid.*

Answer #3: *It affects the warmth and tone of one's voice. The more humid the air is, the better the sound carries and the more rich you sound.*

Answer #4: *Oh yes, humidity is good for the voice. By definition, humidity is just water in the air, so breathing in the humid air is good for your voice like drinking water is. Ever wonder why you sound so much better in the shower?*

Answer #5: *Yup. Ever noticed that it's harder to breathe when there's more water in the air? Imagine trying to sing! Also, very dry weather can be hard too.*

Question: I have to do a presentation on how the temperature of a room can affect how well you sing. I have been looking all over the Internet and so far haven't come across anything helpful. Please help.[227]

Answer: *It's an interesting question. As the air you breathe passes through the vocal cords, the quality of that air will have an effect on the voice. There are a few factors here: 1. A hot, dry room will have the effect of drying out the body generally, and the mucus linings of the throat and vocal cords themselves. 2. A hot, humid room will be slightly more beneficial for the voice (i.e. less drying) but will be more uncomfortable for the singer, sapping energy and making high intensity vocalising difficult. 3. A cold room may cause a degree of muscle contraction in the throat, constricting the voice and generally making it harder to sing. 4. Air conditioning removes moisture from the air, so although an air conditioned room may feel comfortable temperature-wise, it will often have a drying effect on the voice. A room at average temperature and humidity level will be the easiest to sing in - but how often do we get asked to sing in one of those?!*

[227] "Acting in Plays, Singing," *All Experts,* December 7, 2009, accessed September 10, 2011, http://en.allexperts.com/q/Acting-Plays-Singing-695/2009/12/HELP-9.htm.

Question: I am a professional singer living in the long-winter state of Vermont. This year due to a VERY active schedule (just released a new CD) and extra long periods of colds and flu, my voice has been taxed in new ways. My 1st question is humidifiers - pro or con? Some doctors and experts say you MUST have them to fight against the dry winter heat, other say they just breed bacteria and germs and bring on more troubles that they are worth. If you are "pro", then which is better a steam vaporizer, or a humidifier?...What should I do? What can save me? What is the best way to keep my voice supple, hydrated, lubricated, and happy?[228]

Answer: *The best way to keep your voice supple is to vocalize. Supple means flexible...To keep the voice hydrated drink two liters of water per day…I am "pro" hydrating the air and recommend a steam vaporizer in order to kill bacteria. Ideal humidity would be 60%. If on the road without a vaporizer, run a hot shower in the hotel room with the door open or place cups of water all over the heater…*

Discussion: *If you find yourself shying away from singing during certain weather conditions, you don't have to anymore. The tips below will show you how to avoid those singing blues when bad weather arrives. Believe it or not, the weather is a key factor in the success of your singing voice. Dry weather can cause you to have a "dry mouth" or "dry throat." Then there are temperature extremes—from extremely hot to freezing cold temperature. The extreme cold weather can cause colds, runny noses, the flu, and sore throat—all hindrances to your singing. The extreme hot weather can cause loss of breath and difficulty when holding long notes. High humidity, high pollen levels, etc.—all these can affect your singing in a negative way! With too much moisture in the air or high pollen levels, you might experience heavier breathing than usual, especially when singing…*[229]

---

[228] "Singing with a cold," *Mark Baxter Vocal Studios,* accessed September 15, 2011, http://www.voicelesson.com/free-vocal-help/q-and-a/singing-with-a-cold/.

[229] Bob Pardue, "Don't Get the Singing Blues Because of Bad Weather," *Ezine Articles*, May 1, 2007, accessed September 15, 2011, http://ezinearticles.com/?Dont-Get-the-Singing-Blues-Because-of-Bad-Weather&id=548346.

> ***Discussion:*** *Use a humidifier in your home. This is especially important in winter or in dry climates. 30% humidity is recommended.*[230]

> ***Discussion:*** *There are a lot of things that singers need to know in order to protect their voices, including…how certain weather conditions can interfere with your singing. The weather actually does have an impact on your voice. Hot and humid conditions can dry out your mouth and throat, making it difficult to sing. Humidity can also cause shortness of breath, making it near impossible to reach those high notes that you need. Warm weather also tends to come with pollen making allergies affecting the nose and throat. This will also make it harder to use your breathing techniques to sing. Sometimes singing and weather conditions do not mix well. Hydration, lots of rest, and good breathing should help with the heat and humidity. Fortunately, there are some tips to make it easier on yourself during the warm weather conditions. You should make sure that you are drinking even more water than usual to keep yourself well hydrated. The water should not be too warm and not too cold.*[231]

Finally, twentieth- and twenty-first-century vocal pedagogy texts are often consulted by singers for in-depth information about the workings of the vocal mechanism, and the best methods for employing healthy voice function. While much in these pedagogy texts can be considered scientific and technical, the sections that discuss vocal hygiene as it pertains to the environment are largely the opposite, often infused with opinion and/or continuation of popular beliefs. More often than not, no scientific support is given to back up conflicting statements such as "avoid exposure to cold, wet, or foggy weather"[232] or "the singer's throat much prefers a spring rainy day to a cold

[230] "Tips to Prevent Voice Problems," *National Institute on Deafness and Other Communication Disorders,* accessed September 15, 2011, *http://www.nidcd.nih.gov/health/voice/takingcare.htm.*
[231] "Using Breathing Techniques and Other Methods for Weather Conditions," *Large Mart,* accessed September 16, 2011, *http://www.largemart.com/singer/weather-and-singing-voice.htm.*
[232] Punt, *The singer's and actor's throat,* 59.

crisp day in December."[233] Still others make little mention of the atmosphere at all. This is not to point out flaws of current published works, but it is important to underline the fact that meteorological-related information within existing texts is not consistent or thorough, credits little to no scientific evidence, and is sometimes altogether absent.[234]

A summary of the conflicting perceptions from the professional and general singing communities discussed in this section is included in Table 8.

J. Chapter Summary

This chapter has illustrated that connections between vocal health and the atmosphere have been discussed for millennia. However, in researching the evolution of this subject's heritage, most of it seems to be based on conflicting theories and perceptions rather than facts. The author has found no conclusive evidence that points to a universal truth. While there seems to be a general consensus that certain atmospheric conditions do affect vocal health, there are also discrepancies in exactly which conditions are to blame, or how one is to protect against them. Furthermore, claims are often vague. "Avoid cold weather" and "avoid dry conditions" give no indication of exactly how cold or dry, for example. Is there a critical minimum and maximum range for optimum temperature and humidity levels during vocal performance? The evidence presented here highlights the need for clarification of these issues, using scientific information. As will be seen in the next chapter, while some scientific evidence is finally

[233] Bickel, *Vocal Technique,* 114.
[234] As discussed in Chapter II, the discussion of the environment and the singer is unique to each pedagogy text. For a list of several examples, refer to FN 1. However, this list should not be limiting to the reader. A comparison of most any selection of vocal pedagogy texts will reveal interesting opinions, inconsistencies, and differences in recommendations and delivery methods about atmospheric conditions (such as temperature, humidity, and pressure) and vocal health.

obtained with the help of vocal scientists and biometeorologists, the literature still leaves much to question.

Type of Atmospheric Condition/Season	**Part of Body Affected**	**Resulting Condition**
Cold	Throat; Upper Respiratory Tract	*Positive Effects:* Non-concerning, no proof that it is harmful *Negative Effects:* Damaging, Drying, Causes illness, Diminishes range, Strain
Heat	Throat; Jaw	*Positive Effects:* Makes singing easier, Loosens jaw *Negative Effects:* Drying, Exacerbates allergies, Harder to breathe Has no effect
Humidity	Throat; Upper Respiratory Tract	*Positive Effects:* Good, Causes sound to be richer *Negative Effects:* Crushing, Makes it harder to breathe, Harder to reach high notes
Dry	Throat	*Negative Effects:* Bad, worrisome
Altitude		*Positive Effects:* Non-concerning, a "fun" challenge *Negative Effects:* Concern due to lack of oxygen, Acclimatization needed, Breath is compromised
Recommended Humidity Level		30% 60%

Table 8. Summary of perceptions from the professional and general singing communities.

CHAPTER IV: A SCIENTIFIC PERSPECTIVE

The objective of this chapter is to present more reliable and objective evidence by investigating existing scientific research about the connection between atmospheric conditions and vocal health. It will focus on three specific atmospheric variables: temperature, humidity, and pressure. Although the current scientific output is much smaller in comparison to the evidence gathered in the previous chapter, it can be used in recommending future courses of action (see Chapter V). The data analysis here is largely numerical and statistical. In some cases, when possible, it will be used to test the validity of claims from the previous chapter. Several meteorological concepts will be addressed; a glossary of important terms is included in Appendix A for reference.

According to biometeorologist S.W. Tromp, "biometeorology is a young and at the same time a very old science, young by modern scientific standards, old if we consider the strong belief of man, from the earliest historic times to the present day, in the great influence of the weather and climate on man…"[235] From the first written evidence of a connection between atmospheric conditions and human health ca. 2650 B.C., it took nearly 4,600 years before the first solid scientific studies about the subject were published. Known as biometeorology, this relatively new field concerns the scientific study of the relationship between living organisms and the weather. Its importance was greatly enhanced after World War II, for three main reasons, according to Tromp: 1) Large-scale military operations, such as the war in the Western Desert in North Africa, required a thorough knowledge of meteorology and the effects of extreme weather and climatic conditions on the soldiers; 2) The rapidly developing space program had a great impact on the international recognition of biometeorology as a leading environmental science; and 3) The founding of the International Society of

[235] S.W. Tromp, *Biometeorology: The Impact of the Weather and Climate on Humans and Their Environment (Animals and Plants)* (London: Heyden & Son Ltd., 1980), 4.

Biometeorology in 1956 demonstrated the significance of the study of the effects of the physical environment on living organisms.[236]

While it is relatively simple to prove the influence of atmospheric conditions on plants, proving their effects on humans presents much more of a challenge.[237] When dealing with atmospheric conditions, numerous variables are involved (i.e. temperature, humidity, pressure). Pinpointing and isolating exactly which variables may cause ill effects inside the body, which in itself is a unique environment, is a great task. To help with this research, scientists in the 1930s developed climatic chambers in order to study the effects of isolated atmospheric variables on humans in a controlled environment. Researchers also began to use devices to record bodily functions under the natural conditions of the great outdoors.

Over the past several decades, enough evidence has mounted to indicate that certain atmospheric variables can in fact cause physiological changes in the human lungs, throat, and nose. For example, the effects of pollen, dust, and pollution are well

[236] Ibid, 5-6.
[237] Ibid, 54.

researched and widely accepted.[238] Numerous experiments have also addressed the effects of variables such as temperature and humidity, although their findings are not as conclusive or well known. Such studies are highly experimental, and it is difficult to estimate the significance of the results in physiological conditions. Moreover, not one specifically addresses the professionally trained singer. Nonetheless, for the vocalist, it is beneficial to possess awareness of these scientifically researched meteotropisms—correlations between changes in organisms with changes in the atmosphere. They can be used in comparison with singers' thoughts, opinions, and observations expressed throughout history, shedding light on the question: is there scientific evidence to support the perceptions? And, if not, what needs to be done in order to reach a universal truth?

[238] That allergens can present serious problems for the professional singer is widely accepted by the vocal community. Pollen from trees and other plants, fungus spores, and other microorganisms such as dust, can cause undesirable reactions in many. According to otolaryngologist and well-known vocal pedagogue Robert T. Sataloff, about one out of every five people in the United States suffers from allergies. "Understanding allergies is complex and important. It is a crucial issue for singers, since most of the symptoms caused by inhaled allergens affect the mucous membranes of the eyes, ears, nose, and throat." (Source: Sataloff and Titze, *Vocal Health and Science,* 94.) Because the actual effects and treatment of allergens have already been well documented and researched in the literature, they won't be covered in this study. However, it is important to very briefly highlight the atmospheric conditions that might exacerbate them. While atmospheric conditions definitely play a role in the presence and distribution of allergens, the relationship is a complicated one; complex factors include current season conditions, previous season conditions, type of allergen, and location. According to Dr. Warner Carr of the American College of Allergy, Asthma, and Immunology, rain often washes pollen away. However, it can also burst pollen particles and end up spreading allergens farther; and, rain aids in the growth of grass, plants, and trees, which in turn will increase their subsequent pollen production. Lack of rain can thus help allergy sufferers; drought makes it difficult for pollinating plants to grow. Yet, adding wind to the equation complicates matters. Dry conditions can actually make it easier for wind to pick up and infuse the air with pollen. Temperature is also a factor. Mild winters can often mean an early start to the allergy season, and warm springs can increase pollen counts. Late spring freezes can help lower them. Large day-to-day temperature fluctuations can also exacerbate the effects of aeroallergens. (Source: Linda Lam, "How Weather Impacts Spring Allergies," *The Weather Channel*, March 17, 2015, accessed March 4, 2016, https://weather.com/health/allergy/news/how-weather-impacts-spring-allergies.)

4.1 Temperature

As evidenced in Chapter III, temperature extremes are widely perceived as negative factors in vocal health and performance. Unfortunately, there currently exists little published scientific research directly addressing the effect of temperature on the human vocal tract itself, let alone for singers. Nonetheless, there is research in the biomedical field that can be relevant to this study. Largely extracted from broadly focused medical journals, these studies may also reveal methods and ideas for future research in the voice science community.

It should be noted: relative humidity, which is completely dependent upon temperature and an equally important factor, will be covered in the next section. Because discussion of humidity cannot be separated from discussion of temperature, its section will include additional points about heat and cold. This section will focus on studies that researched the effects of temperature only; the effects of humidity were neutralized and/or not mentioned.

In Chapter III, advice from vocal coach Chris Beatty instructed singers to "breathe in through your nose instead of your mouth in order to give your breath a chance to warm up to your body temperature."[239] It has long been assumed by many in the vocal community that ambient air, upon inhalation, is heated to body temperature (98.6 degrees Fahrenheit).[240] However, actual measurements have shown that, depending upon atmospheric conditions, expired air may actually be far from it. In a

[239] Cochran, "Performing in Cold Weather Doesn't Just Affect Beyoncé."
[240] See D. Garfield Davies and Anthony F. Jahn, *Care of the Professional Voice: A Guide to Voice Management for Singers, Actors and Professional Voice Users* (London: Routledge, 2004), 75; Brodnitz, *Keep Your Voice Healthy:* 17; H.K. Schutte, *The efficiency of voice production* (San Diego: Singular Publishing Group, Inc., 1980), 24; P.O.A.L. Davies, R.S. McGowan, and C.H. Shadle, "Practical Flow Duct Acoustics Applied to the Vocal Tract," in *Vocal Fold Physiology: Frontiers in Basic Science*, ed. Ingo Titze (San Diego: Singular Publishing Group, Inc., 1993), 93-142.

study by Paul Webb[241] from the Department of Physiology and Biophysics at the University of Washington School of Medicine, inspired and expired air peak temperatures were measured in 18 male subjects, using carefully placed thermocouples in the nasal airway to depths of 1, 5, and 9 centimeters. The subjects, breathing normally through the nasal passage only, inhaled air at room temperature (73.4 to 82.4 degrees F), cool temperature (41 to 46.4 degrees F), and cold temperature (-23.8 to -4 degrees F). Webb found that, although the results "demonstrated that inspired air was rapidly warmed in its course through the nose, at the back of the nose it was still several degrees below [98.6 degrees F]." In addition, the colder the temperature of the ambient inspired air, the colder the temperature of the air once it was expired (see Figure 8 and Figure 9).

AMBIENT AIR TEMPERATURE, °C.	NO. OF DETERMINATIONS	NO. OF SUBJECTS	DEPTH OF THERMOCOUPLE, CM.	INSPIRED AIR TEMPERATURE, °C.			EXPIRED AIR TEMPERATURE, °C.		
				Mean	S. D.	Spread	Mean	S. D.	Spread
23–28	23	8	1	24.7	±2.1	20.1–29.0	34.1	±1.6	30.5–37.2
			5	28.3	±2.8	23.0–33.7	35.3	±1.2	31.9–37.2
			9	31.7	±2.1	27.3–35.5	35.5	±0.3	34.1–37.4
5–8	13	6	1	11.8	±3.7	6.6–19.0	29.2	±2.6	24.6–34.1
			5	22.9	±3.6	15.3–32.5	33.3	±2.9	26.5–36.2
			9	30.0	±3.0	25.6–35.2	34.9	±1.2	31.2–36.3
−20–−31	14	10	1	−1.6	±4.7	−12.2– 7.0	26.2	±4.3	18.8–32.7
			5	15.8	±5.4	9.0–24.8	30.0	±3.5	21.0–33.5
			9	25.4	±3.4	18.7–32.2	31.9	±1.6	29.4–34.9

Figure 8. Results of inspired and expired air temperatures in degrees Celsius at the front, middle, and back of the nose in 18 resting subjects at 3 ambient temperatures.[242]

[241] Paul Webb, "Air Temperatures in Respiratory Tracts of Resting Subjects in Cold," *The Journal of Applied Physiology* 4 (1951): 378-382.

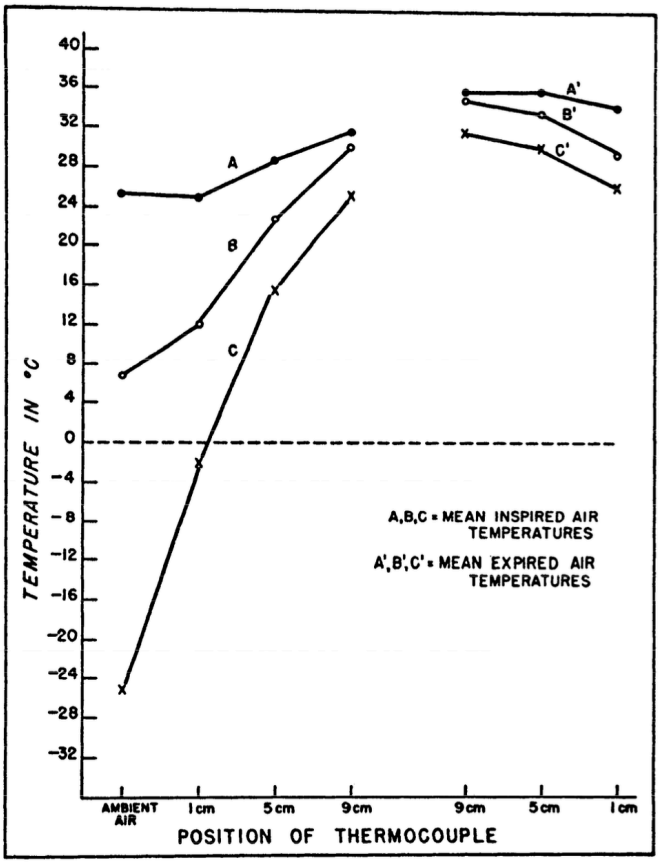


Figure 9. Mean peak temperature (degrees C) plot.[243]

Webb's study is interesting in that it demonstrates warming does take place rapidly within the tracheobronchial tree once ambient air enters. Even the coldest ambient air temperatures (-23.8 to -4 degrees F) were quickly warmed to 29.12, 60.44, and 77.72 degrees F at depths of 1, 5, and 9 cm, respectively. Results indicate that as the air continued to travel to the lungs, it was warmed considerably more. However, the final expiration values show that expired air in all temperature conditions rarely reached body temperature, and some were far below. What kind of effect, if any, do these temperatures have on the vocal mechanism, and is there a critical minimum ambient air

[242] Ibid, 380.
[243] Ibid, 381.

temperature for optimum vocal function? Furthermore, the above experiment involved nasal breathing and breathing at rest only. How would oral breathing affect the findings? Is there a significant difference when larger volumes of air are inspired, as in singing?

A study by E.R. McFadden, Jr. et al. provides possible answers to some of these questions. Published in a 1982 issue of the *Journal of Clinical Investigation* and titled *Direct Recordings of the Temperatures in the Tracheobronchial Tree in Normal Man*,[244] researchers discovered that, as the volume of cold air increases during inspiration, heat transfer takes place even deeper in the tracheobronchial tree. The subjects were five healthy, nonsmoking adult males who were "trained in the performance of respiratory maneuvers." A thermocouple was placed deep within the bronchi, about 49 cm from the opening of the nostrils. Each subject wore nose clips, so breathing was through the mouth only. They breathed room-temperature air (71.6 to 77 degrees F) and frigid air (-2.2 to 5 degrees F). During quiet breathing, most of the heating of the incoming air in both conditions took place in the upper airways as expected. However, when the volume of air inspired was increased during heavy breathing, and/or when the ambient air temperature was decreased, "the temperature of the distal airways progressively fell, and the point at which the incoming air reached body conditions moved deep into the periphery of the lung."[245] The volume of air inspired during heavy breathing was 30 to 60 liters per min, for four minutes. Assuming vital lung capacity is 5.5 liters per breathing cycle for male singers and 4 liters for female singers,[246] the volume of air

[244] McFadden, Jr. et al., "Direct Recordings of the Temperatures in the Tracheobronchial Tree in Normal Man."
[245] Ibid, 700.
[246] Jean Abitbol, *Odyssey of the Voice* (San Diego: Plural Publishing, 2006), 178.

inspired by the subjects in the study can be considered similar to the volume of air inspired during a four-minute aria or song. Figures 10 and 11 graphically show the study's results: *the higher the volume of air inspired, and the colder the air, the greater the temperature difference between inspired and expired air.* As the need to condition more air arose, the airways became less efficient heat exchangers.

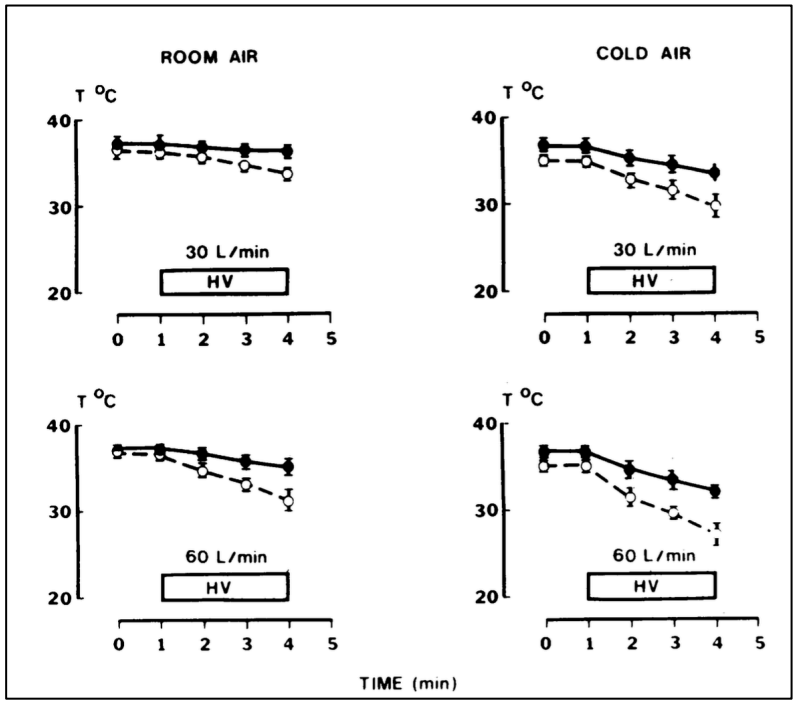


Figure 10. Changes in intra-airway temperatures during breathing 30 L/min and 60 L/min in room-temperature air and cold air. Open circles represent inspiration, closed circles represent expiration.[247]

[247] McFadden, Jr. et al., "Direct Recordings of the Temperatures in the Tracheobronchial Tree in Normal Man," 702.

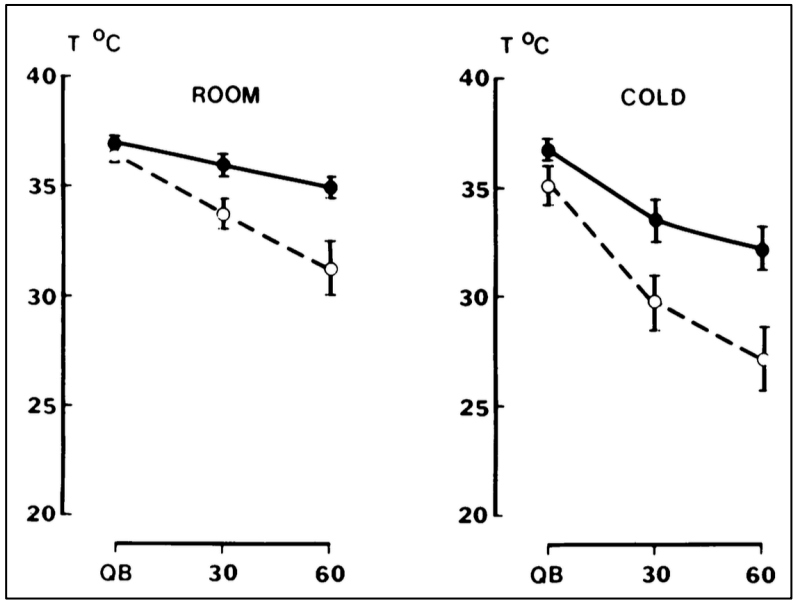


Figure 11. Comparison of the temperature (T) in both phases of respiration during the last minutes of quiet breathing (QB), and heavy breathing (30 and 60 L/min). Open circles represent inspiration, closed circles represent expiration.[248]

Measurements were made at only one location. Therefore, the overall relationship between the temperatures of inspired and expired air along the entire length of the tracheobronchial tree remained unknown at the time of this study. In 1985, McFadden worked with another team to thermally map the human airway by inserting a flexible probe with *multiple* thermistors into the tracheobronchial trees of six normal adult subjects (five males and one female). Similar to the 1982 study, results indicated that as the volume of air inspired increased, the temperature along the airway progressively decreased; these changes were considerably more profound in cold air. Interestingly:

> …when large minute ventilations are respired, the temperature in the esophagus adjacent to the trachea falls, suggesting that the capacity of the upper airway to condition inspired air may be overcome. In these

[248] Ibid, 703.

> circumstances, the point at which inhaled gas becomes heated to body temperature…appears to advance deep into the bronchial tree.[249]

Moreover, heat *loss* is shown to occur as the air moves from deep within the lung to the outside of the body during expiration: "From our data it appears that the air leaving the alveoli gradually undergoes a decrease in temperature as it passes through the bronchial tree, and this effect is dependent on the temperature and volume of the air that had previously been inspired."[250] It is also interesting that the temperature gradient between the glottis and the lung can be quite dramatic with cold air breathing:

> With room air [breathed at low volumes], the bulk of the conditioning takes place in the upper airways as expected; however, the colder the inspirate and/or the greater the [volume], the more other regions begin to participate. As this occurs, the temperature within the intrathoracic airways falls dramatically and large gradients develop between the glottis and the subsegmental bronchi, indicating a transfer of heat from airway walls to the airstream in these areas. The degree of cooling that occurs with the combination of high [volume] and frigid air can be substantial…The magnitude of this cooling would not have been apparent from the indirect measures of airway temperatures that have been used in previous investigations…gradients of [46.4 to 48.2 degrees F!] can exist between the lumena of these structures with cold air breathing.[251]

Based on these scientific studies alone, one could hypothesize that a singer breathing in cold air may indeed be affected vocally. Although the temperature of cold ambient air is quickly warmed when it enters the body, it does not reach bodily

---

[249] E.R. McFadden, Jr. et al., "Thermal mapping of the airways in humans," *The Journal of Applied Physiology* 58, no. 2 (1985): 564-570.
[250] Ibid, 569. The decrease in temperature during expiration is explained by heat being continuously given back up to the mucosa along the respiratory tract, which undergoes cooling to facilitate heat recovery.
[251] Ibid, 568.

conditions in the upper airways as many have thought. Rather, bodily conditions are not reached until the air is deep within the lung. Therefore, when relatively cold air passes over the larynx, it may temporarily cool the vocal mechanism enough to cause negative effects such as contractile function. But is there evidence that demonstrates exactly *how*—if at all—a cooled vocal mechanism may be affected?

According to a 2014 scientific study titled *Vocal Function and Upper Airway Thermoregulation in Five Different Environmental Conditions*, "There are long-held beliefs, particularly in the vocal performance arts, that the temperature of the air in which one is vocalizing will dramatically affect voice function…There has been no specific research effort to date to investigate whether there is any merit to these claims."[252] The authors of the study acknowledge the many challenges in obtaining reliable data in such an experiment on human larynxes in vivo.[253] Nonetheless, in the first experiment of its kind, they combined thermal environmental manipulation and temperature measurement methods of the upper airway to determine their effects on human voice function. Their hypothesis: that phonation threshold pressure (PTP) and perceived phonatory effort (PPE)[254] would increase during exposure to cold air, especially during oral breathing. However, their hypothesis was not supported by the

[252] Mary J. Sandage, Nadine P. Connor, and David D. Pascoe, "Vocal Function and Upper Airway Thermoregulation in Five Different Environmental Conditions," *Journal of Speech, Language, and Hearing Research* 57, no.1 (2014): 16-25, accessed September 8, 2011, EBSCOhost.
[253] A handful of experiments have been conducted on excised bovine and canine larynges, but their findings are not discussed in this document and are not verified to be true in human larynges. See: Donald S. Cooper and Ingo R. Titze, "Generation and Dissipation of Heat in Vocal Fold Tissue," *Journal of Speech and Hearing Research* 28 (June 1985): 207-215, accessed October 10, 2012, http://dx.doi.org/10.1044/jshr.2802.207; and Sandage et al., "Vocal Function," for more detailed descriptions.

results of their experiment, in which 15 participants breathed in air, through the nose and again through the mouth, at 59 degrees F (cold), 77 degrees F (thermally neutral), and 95 degrees F (hot), all at 40% relative humidity. "The three temperatures were selected to represent realistic outdoor temperatures in which extensive voice use may be required, that is, outdoor performance spaces during scheduled music and theater seasons."[255] After 20 minutes of exposure in each condition, the participants read passages at a comfortable loudness level. Resulting data showed no support for negative effects on the vocal mechanism in any of the temperature conditions.

The above study is important in that it lays design groundwork for future experiments to study how temperature changes might directly affect the vocal mechanism. It would be interesting to reproduce such a method with trained singers. It should be highly suggested that a more thermally challenging environment be used; 59 degrees F as a "cold" condition is likely not low enough. In addition, volume of air during inspiration/respiration should be increased, and sustained phonation on pitch should be employed to measure PTP and PPE effects.

4.2 Relative Humidity

Expressed as a percentage, relative humidity (RH) is the ratio of water vapor in a given mass of air (*w)* relative to the amount of water that air can hold at a given temperature (w_s). Put in simpler terms, the percentage is relative to the total amount of

---

[254] PTP and PPE are used in most investigations of environmental influences on vocal function. PTP = the minimum amount of subglottal pressure required for vocal fold vibration during phonation; it is thought to be directly proportional to vocal fold tissue viscosity. PPE = a psychological measure during phonation, or how hard the singer perceives he/she is working to produce phonation. To calculate PTP, use the equation (2k/T) (Bc) (w/2). See Verdolini, Titze, and Druker, "Changes in Phonation Threshold Pressure" for detailed information about how to calculate.

[255] Sandage et al., "Vocal Function," 20.

moisture air can hold. 100% RH means that air is completely saturated (therefore, it is not able to hold any more water vapor). RH is directly dependent upon temperature; the warmer the air, the more water vapor it can hold.

$$\text{RH} = w/w_s \; x \; 100\%$$

For the singer, air with low relative humidity has long been perceived to wreak havoc on vocal function. The vocal folds are surrounded by a thin mucosal covering. *In theory*, when one breathes in dry air, this mucosal covering dries out and becomes thick and viscous. Because of this increased viscosity, more subglottal pressure is required for the folds to vibrate properly during phonation, and more effort is thus necessary on the part of the vocalist (increased PTP and PPE). While numerous studies have been conducted to validate this theory, many of them include the simultaneous effects of other variables, such as fluid intake and the administration of mucolytic drugs. Furthermore, few of them use human subjects (excised animal larynxes are common), and of those that do, few subjects are professionally trained singers.[256] Therefore, much of the existing scientific research may not be conclusive in proving the effects of humidity conditions during singing.

[256] For more information on studies regarding hydration and vocal function (but not necessarily dealing with atmospheric conditions and/or humans), see: Julia Selby and Ginny Wilson, "Laryngographic Assessment of Voice Changes with Altered Hydration Status," *UCL Department of Phonetics and Linguistics,* accessed January 17, 2011, http://www.phon.ucl.ac.uk/home/shl10/julia/wilby.htm; Benjamin K. Finkelhor, Ingo R. Titze, and Paul L. Durham, "The effect of viscosity changes in the vocal folds on the range of oscillation," *Journal of Voice* 1, no. 4 (1988): 320-325, accessed September 8, 2011, http://dx.doi.org/10.1016/S0892-1997(88)80005-5; Raphael J.B. Hemler et al., "Laryngeal mucosa elasticity and viscosity in high and low relative air humidity," *Eur Auch Otorhinolaryngol* 258, no. 3 (2001): 125-129, accessed September 8, 2011, http://dx.doi.org/10.1007/s004050100321; Vishar Bhavsar, "An Essay on the Evidence Base of Vocal Hygiene," *Journal of Singing* 65, no. 3 (2009): 285-296.

As one example, a prominent 1990 study titled *Changes in Phonation Threshold Pressure with Induced Conditions of Hydration*, conducted by Katherine Verdolini, Ingo R. Titze, and David G. Druker, explores the effects of hydration on vocal fold tissue by manipulating the RH of the air.[257] Temperature conditions were not indicated. Six adult subjects were asked to sing after relatively long exposure (four hours) to each of three different conditions: no treatment (40%-55% RH), hydrated (85%-100% RH), and slightly dehydrated/dry (30-35% RH). However, desiccating drugs were administered during each subject's exposure to the latter two conditions: Dimetapp® during the slightly dehydrated/dry condition, and Robitussin® during the hydrated condition. The subjects were also allowed to drink water as much as they were able to comfortably tolerate in the hydrated condition. Although the lowest PTPs were recorded in the hydrated condition and the highest PTPs were recorded in the dry condition, due to the simultaneous use of drugs and water intake, this study does not conclusively explain the effects of atmospheric conditions alone.

A 2011 study by Verdolini and Titze, titled *Dependence of phonatory effort on hydration level*, exposed 12 vocally untrained subjects to three different conditions: 90% RH, 52% RH, and 23% RH, all at approximately 80 degrees F. Results again indicated an inverse relationship between PTPs and hydration level, especially with higher conversational pitches. However, similar to the researchers' 1990 study above, mucolytic and decongestant drugs were administered prior to inhalation of the conditions.[258]

---

[257] Verdolini, Titze, and Druker, "Changes in Phonation Threshold Pressure."
[258] Katherine Verdolini and Ingo R. Titze. "Dependence of phonatory effort on hydration level," *Journal of Speech & Hearing Research* 37, no.5 (1994): 1001, accessed September 8, 2011, JSTOR.

The Effect of Relative Humidity of Inhaled Air on Acoustic Parameters of Voice in Normal Subjects,[259] a study published by Raphael Hemler et al. in a 1997 issue of *Journal of Voice*, is perhaps the most relevant scientific study solely concerning atmospheric humidity and the singer to date. Eight healthy adult subjects orally inhaled air of three different controlled conditions for 10 minutes each: dry (~2.1% RH at ~74 degrees F), standard (~45% RH at ~77 degrees F), and humidified (100% RH at ~111 degrees F). They were then asked to sing a sustained /a/ of controlled pitch and loudness, which was analyzed for vocal discomfort. "Nearly all subjects reported unpleasant sensations in their airways and a subjective feeling of impaired voice production after inhalation of desiccated air. They reported a comfortable feeling after inhalation of the humidified air."[260]

Although the study's results provided strong evidence that dry air impedes vocal function, it is important to point out a disconnect between the extreme conditions used for the experiment and conditions that would likely be experienced during vocal performance. At 111 degrees F, air can hold a lot of water vapor. Outside of a steam room, a completely saturated environment (100% RH) is extremely rare at such high temperatures, let alone a likely performance condition. The heat index itself would be approaching 288 degrees F, which simply does not occur in most natural or artificial performance environments. Additionally, 2% RH at 74 degrees F is exceptionally dry and not likely, even in artificially heated indoor environments. A study using realistic conditions would be beneficial to the research. Finally, studies utilizing professionally

[259] Hemler, Wieneke, and Dejonckere, "The Effect of Relative Humidity of Inhaled Air on Acoustic Parameters of Voice in Normal Subjects."
[260] Ibid, 297. The researchers also analyzed perturbation measures (shimmer, amplitude, jitter, and pitch), and noise-to-harmonics ratios, following the subjects' exposure to the different air conditions.

trained singers are needed, as vocal function can vary considerably between such vocalists and those who are untrained.

The effects of nasal breathing should also be mentioned here. Many pedagogues have advocated for nasal breathing, for it has long been held that the nose will humidify inhaled air to 100% RH.[261] However, according to Webb, 100% RH "occurs only when the ambient air is hot and humid. Under other conditions expired air humidity is always less than 100%, the degree of desaturation depending on the water vapor content of the inspired air."[262] Even though the humidity of nasal-breathed air may be less than 100%, it is still greater than air breathed through the mouth. A 2002 study titled *Oral Breathing Increases Pth and Vocal Effort by Superficial Drying of Vocal Fold Mucosa*,[263] in which 20 normal subjects (mostly non-singers) inhaled air orally and nasally at ~20% RH, concluded that oral breathing superficially dehydrated the airway and increased vocal effort. Nasal breathing did not increase vocal effort. While the latter breathing method may be ideal for singers from a physiological standpoint, it is not always feasible when performing repertoire that leaves little time for anything but oral breathing. Nevertheless, the nose has been shown to filter and humidify incoming air, so singers should keep this in mind before and in between performances.

Regardless of the methods employed in the studies above, all do conclude that humidity levels likely affect vocal function in some way. A question that remains to be seen is whether or not there is a critical level of humidity for optimum vocal comfort and function, for singers especially.

---

[261] See FN 240.
[262] Webb, "Air Temperatures in Respiratory Tracts of Resting Subjects in Cold," 378.
[263] Sivasankar and Fisher, "Oral Breathing Increases Pth and Vocal Effort by Superficial Drying of Vocal Fold Mucosa."

4.3 Temperature and Humidity as They Pertain Specifically to Indoor Environments

It is important to dedicate a brief section specifically to temperature and humidity as they pertain to indoor environments and their effects on overall health, since singers most likely spend most of their time in homes, hotels, practice rooms, and performance halls. Indoor environments can differ drastically from outdoor environments, because of artificial heating and cooling. In the winter, for example, air inside a heated indoor space is often drier than that outdoors. *Unless a humidifier is utilized to increase humidity levels*, the inside air may be as low as 13% RH. The average RH of the Sahara Desert is 25%.[264] Why is indoor air so dry? Recall that warmer air can hold more water vapor. As cold air is drawn indoors and then heated, its water vapor content remains the same. Therefore, the ratio of water vapor present to the amount of water vapor necessary for saturation at warmer temperatures increases, and RH can decrease drastically.

If humidity levels are scientifically shown to affect vocal function in some way, then singers theoretically should, when possible, monitor the conditions of their indoor environments. While this is relatively easy to do in one's home, it is not always so in all places, especially if the location is short-term or unfamiliar. In a 2000 study titled *Working conditions on stage: climatic conditions*,[265] researchers highlight that there is very little quantitative data about actual climatic conditions on stage. In an effort to study temperature, humidity, and dust levels in an old, unhumidified, yet often-used German theater, they collected information during two opera performances and one

[264] Nicole LeWand, "Many Homes Are Drier Than the Sahara Desert," *NewsOK,* December 12, 1993, accessed March 1, 2016, http://newsok.com/article/2450798.
[265] Richter et al., "Working conditions on stage: climatic considerations."

spoken theater performance to answer two questions: 1) Does the use of a humidification unit improve stage conditions? 2) How does the data vary during a performance, with sporadic use of a humidifier? The primary findings of the study indicated that average temperatures and humidities of the performing space were improved with the use of a humidification unit—although the researchers stated that humidities greater than the 35-45% that were obtained in this study may be desirable for optimum vocal function. In addition, average dust levels were significantly lower when the humidification unit was used. Although conditions were theoretically improved, the performers were not asked about their perceptions, nor tested for vocal improvement, in this study.

The previous study inspired the author of this document to install a portable device in a hall where she often performs: Paul F. Sharp Concert Hall at the University of Oklahoma, in Norman. This hall is not equipped with a humidification system, and, in the opinion of the author, is often too dry for optimum vocal performance. The Oklahoma Mesonet supplied the device used for this data collection; it contained one temperature sensor and one humidity sensor, and was placed above stage right of the hall for the month of April 2015 (April 3-29). Temperature and humidity data were recorded every hour. A summary of the data is represented in Figure 13; see Appendix C for the entire data set. Interestingly, the temperature (effectively controlled by the building's indoor heating/cooling system) was relatively consistent during the entire data-gathering period, with a minimum of 65.48 degrees F, a maximum of 71.74 degrees F, and a monthly average of 70.25 degrees F. However, the RH fluctuated drastically, with a minimum of 18.2%, a maximum of 55.31%, and a monthly average

of 43.48%. This data shows that even in a temperature-controlled indoor environment, the RH can vary considerably if a humidification system is not used.

Prior to data collection, the author hypothesized that RH levels would be noticeably affected when the hall was full of audience members during performances. However, a later comparison of the data against the hall's April 2015 performance calendar revealed that the times of greatest RH fluctuation did not correlate with the times of the concerts. Therefore, the presence of human bodies within the hall did not have a noticeable effect on RH levels. A comparison of the RH data against the daily meteorological data for Norman, however, revealed some interesting correlations.

When the portable device was set up and turned on the morning of April 3, the humidity sensor immediately recorded a RH of 37.39%. As each hour passed, the RH decreased rapidly, reaching a minimum of 18.2% at 4 PM on April 4. The temperature did not fluctuate much more than one degree F during this period. What caused the RH to drop so dramatically? On April 3, Norman experienced a strong cold front moving through at approximately 6 AM, bringing with it relatively cold and dry air. (See Figure 12) Outside, temperature and dew point values fell quickly. This colder, drier air was eventually brought into the building, and therefore into Sharp Hall, every time doors were opened and closed. Because of the heating/cooling system, the temperature was quickly regulated. However, the decreased water vapor content of this heated air resulted in decreased RH values within the hall.

On April 5-6, RH within the hall increased rapidly, sometimes by 1% each hour, reaching RH values in the low to mid 50% range. What was happening outdoors to influence this change? Rain, and thus RH values of 100%. Similar correlations between

the data collected in Sharp Hall and the day-to-day weather changes of the external environment were found throughout the period. This mini-experiment has shown that the atmospheric conditions of indoor halls can indeed be influenced by external factors. Therefore, singers are not only at the mercy of day-to-day external atmospheric conditions during their outdoor performances, but can also be during their indoor performances as well—unless a humidification system is utilized.

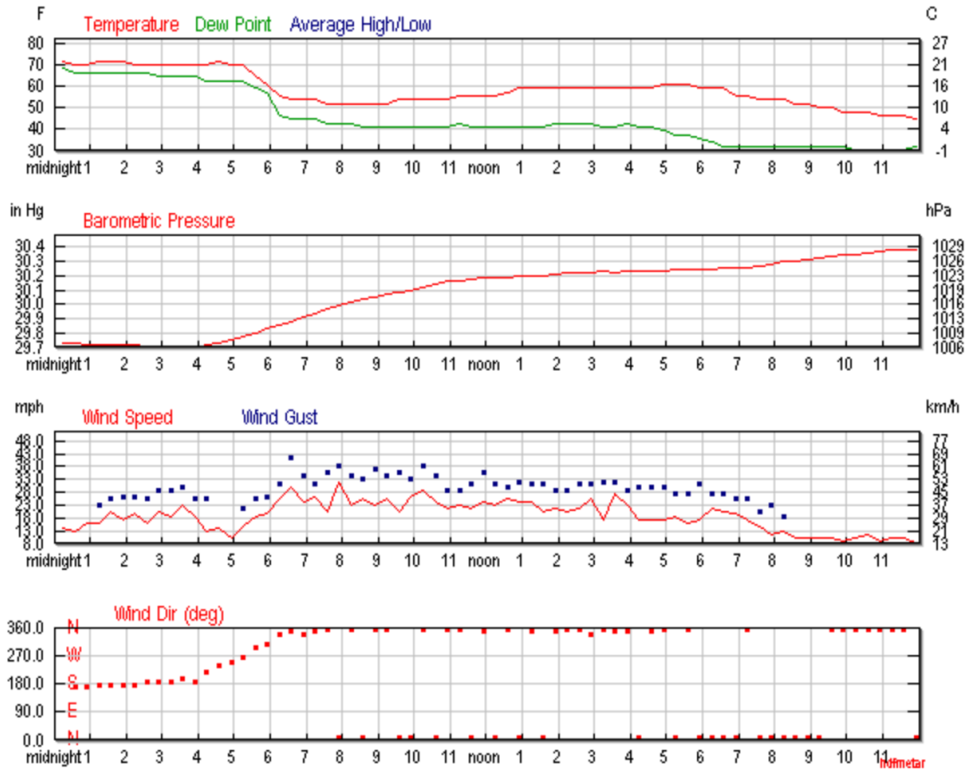


Figure 12. Hourly weather conditions in Norman OK on April 3, 2015.[266]

[266] "Weather History for KOUN, April 2015," https://www.wunderground.com/history/, accessed March 4, 2016.

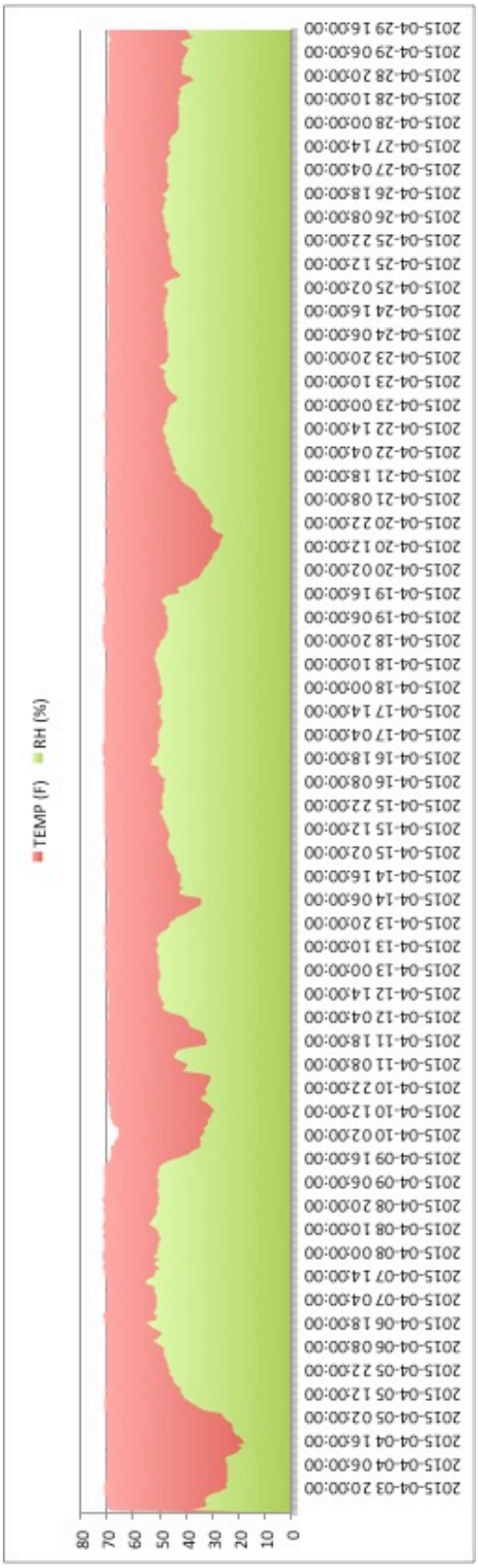


Figure 13. Temperature and RH data from Sharp Hall

Finally, singers should also keep in mind the conditions of their environment when traveling,[267] especially in airplanes. According to Robert J. Feder, in his article *The professional voice and airline flight*, cabin temperature is normally maintained at a comfortable 68-72 degrees F. However, the RH inside an in-flight cabin lies between just 5-10%. "Contrary to popular opinion, cabin air is not brought along on each flight in special tanks. Basically, cabin air is air from the external atmosphere that enters the aircraft by way of the jet engines…[it] is devoid of moisture and therefore almost totally lacking in humidity."[268] Also, at cruising altitudes of about 39,000 feet, most aircraft are pressurized at 7,500-8,000 feet above sea level, which can affect the body's ability to use oxygen efficiently, and can also affect the sinus cavity.[269] Feder recommends avoiding drying agents such as alcohol during flight, upping the intake of "mostly hot" fluids, and resting for at least 24 hours post-flight before a performance.

4.4 Altitude & Pressure

The atmosphere in which human life exists is a delicately balanced ocean of gases and particles.[270] With each inhaled breath of air, trillions of atoms and molecules that make up these gases and particles enter the body; each breath is mainly comprised of nitrogen (N_2—about 78% of the atmosphere at sea level) and oxygen (O_2—about 21% of the atmosphere at sea level). One may be accustomed to hearing "There is less oxygen at higher altitudes." As one travels to higher altitudes, atmospheric pressure decreases. Therefore, relative to lower altitudes, there is less air, and less oxygen,

[267] The exact amount of time it takes for a singer to acclimate to a new location is not known; more research in the field is needed.
[268] Feder, "The professional voice and airline flight."
[269] Pressure effects will be addressed in the next section.

making it harder for the body to use the gas efficiently. For example, in Denver, at about 5,280 feet (1.6 kilometers) above sea level (typically about 1000 millibars, or 760 millimeters of mercury), there is about 18% less O_2 for the singer to breathe than at sea level:

Using Dalton's Law of Partial Pressure:

$$\text{Pressure (P)} = 1000 \text{ mb } x \text{ } (.5)^{\text{height of Denver in km/5.6 km}}$$

$$P = 1000 \text{ mb } x \text{ } (0.5)^{1.6 \text{ km}/5.6 \text{ km}} = 820 \text{ mb}$$

$$820 \text{ mb } x \text{ } .21 = 172 \text{ mb} / 210 \text{ mb } x \text{ } 100\% = 82\%$$

$$100\%-82\% = 18\% \text{ less } O_2$$

Recall the singers who performed at the Santa Fe Opera, from Chapter III. In Santa Fe, there is 24% less O_2 than at sea level:

$$P = 1000 \text{ mb } x \text{ } (0.5)^{2.19 \text{ km}/5.6 \text{ km}} = 763 \text{ mb}$$

$$763 \text{ mb } x \text{ } .21 = 160 \text{ mb} / 210 \text{ mb } x \text{ } 100\% = 76\%$$

$$100\%-76\% = 24\% \text{ less } O_2$$

It is well documented in high altitude biometeorology that respiratory function can suffer at higher altitudes.[271] According to Tromp, the ability of an individual's body to transport and use O_2 during exercise begins to decrease significantly above an altitude of 5,250 feet, if the individual is unaccustomed to such an environment. High

[270] Ahrens, *Meteorology Today*, 1-3.

altitude effects of decreased partial oxygen pressure can include: increased lung ventilation, increased heart and pulse rate, asthma, bronchitis, cough, rhinitis, and migraines. In addition to the decreased partial pressure of O_2, the atmosphere at high altitudes is able to hold less water vapor relative to sea level. Because of this, air is often drier.

What is not as well researched about high altitudes is acclimatization; little is known about exactly how long it takes one to adjust to such environments. According to the International Society for Mountain Medicine, the body's adjustment process is a slow one, taking place over a period of days to weeks.[272] The body's response to acclimatization may be heavily dependent upon genetics, physical fitness, and hydration levels. And, once acclimatization is reached, although the effects of high altitude are reduced, they have not disappeared. At this time, although it is well known that the singer will have to work harder to sing their repertoire in higher altitudes, more scientific research may be needed to determine exactly how, and for how long, high altitude may affect overall vocal performance.

Considerably less is known about possible effects of minor daily changes in atmospheric pressure, for example, with the approach of low-pressure systems. According to Tromp, considerable changes in blood pressure have been observed during periods of rapid barometric fall or rise, accompanied by weather fronts and changing air masses.[273] In particular, people have often complained of sinus troubles, especially

---

[271] Tromp, *Biometeorology: The Impact of the Weather and Climate on Humans and Their Environment,* 108.
[272] "Normal acclimatization," *International Society for Mountain Medicine*, accessed March 3, 2016, http://ismm.org/index.php/normal-acclimatization.html.
[273] Tromp, *Biometeorology: The Impact of the Weather and Climate on Humans and Their Environment,* 108.

when already suffering from allergies or sinus pain[274]—although there is little to no scientific research to offer evidence here outside of situations during airline flight and scuba diving. "As such strong barometric changes are always accompanied by strong air turbulence and by changes in temperature and often by rainfall, hail, etc. it is difficult to determine the effect of the barometric fall alone."[275]

4.5 Comparing the Theory and the Science in Four Performances

Unfortunately, because specific atmospheric conditions are not mentioned in much of the theoretical evidence presented in Chapter III, it is difficult to accurately validate or disprove it with the existing scientific research presented in this chapter. "Avoid cold weather" gives no indication of exactly how cold, for example. One can, however, attempt to draw some connections through a bit of investigation. The author was able to find four specific-date performances where cold temperatures were explicitly cited as a concern or non-concern for each performer. The background of each performance has already been described in Chapter III: Luciano Pavarotti lip-syncing at the 2006 Opening Olympic Ceremony, due to cold temperatures; Aretha Franklin claiming the cold weather ruined her performance during the 2009 Presidential Inauguration; Beyoncé Knowles choosing to forgo a live performance at the 2013 Presidential Inauguration, citing cold temperatures; and Renée Fleming's non-concern

[274] Theoretically, according to Boyle's Law (which states pressure and volume are inversely related at a constant temperature), decreasing pressure (with the approach of a low, for example) will cause the sinus cavities to expand, much like an ascending balloon expands as it rises higher in the atmosphere (and thus into lower pressures). This "expansion" within the cavities may cause discomfort or even pain. Contraction, or squeeze, can also occur with approaching higher pressures. These effects are heightened when the sinus cavities are blocked, such as with a cold or allergies, because equal pressurization is unable to occur until the blockage is relieved.

[275] Tromp, *Biometeorology: The Impact of the Weather and Climate on Humans and Their Environment,* 108.

over her live performance during the 2013 Super Bowl Pregame, despite the media's hype about cold weather. Because the date, time, and location of each performance is known, meteorological data can be retrieved to determine the exact conditions during each performance for further analysis. For purposes of valid comparison, the criteria for selection of these performances included: 1) the performance must have been by a well-known professional singer; 2) the performance must have been in an open-air venue; and 3) similar atmospheric conditions must have been specifically cited as having affected or not affected the performer. In each of the four cases, because cold temperatures were the focus of concern/non-concern for the performers, comparison of temperatures will be stressed, although humidity and dew point will also be compared. The weather data analyzed for each case was recorded at surface observation stations located no more than fifteen miles from each performance site.[276]

Recall Aretha Franklin's performance during the January 20, 2009, Presidential Inauguration. Although she sang live, she claimed the cold temperatures ruined her rendition of *My Country 'Tis of Thee*. According to data recorded by a surface observation station at Washington, D.C.'s Ronald Reagan International Airport (KDCA), five miles from Capitol Hill, the overcast day's temperatures were about 10 degrees colder than normal averages; it was around 23 degrees F at the ceremony's 10 AM start. (See Figure 14) Video of her performance[277] shows that she breathed orally in between phrases. Using information from the scientific findings from above, it is likely that the cold ambient air entering Aretha's vocal tract was not reaching bodily

[276] Historical data for surface observation stations around the world can be accessed at https://www.wunderground.com/history/.

[277] YouTube, "Barack Obama Inauguration - Aretha Franklin - Sings 'America' My Country Tis Of Thee Jan 20, 2009," accessed March 10, 2016, https://www.youtube.com/watch?v=YsNHhJTZAM0.

conditions until it was well within her lungs. Whether or not this was in fact detrimental to her phonatory effort is in question.

Although Aretha did not cite dry conditions as a problem, it is important to consider them here as another possible negative factor in her performance. The RH was 55%; theoretically, it was in the "comfortable" range for a singer based on the studies above. However, the *dew point* was near 9 degrees F. Remember that cold air is able to hold less water vapor; it does not take much for very cold air to reach saturation. Therefore, although the RH was technically within "comfortable" limits according to the scientific literature, the actual water vapor content of the ambient air was extremely low. If one considers the equation RH = $w/w_s \ x \ 100\%$, one can determine the actual water vapor content of the ambient air that day:[278]

$$55 = w/2.61 \text{ g/kg} \ x \ 100$$

$$w = 1.44 \text{ g/kg}$$

For comparison, the actual water vapor content at room temperature (68 degrees F) with the same RH, 55%, is much higher:

$$55 = w/15 \text{ g/kg} \ x \ 100$$

$$w = 8.25 \text{ g/kg}$$

[278] At 23 degrees F, 2.61 g/kg of water vapor content is needed in order to reach saturation.

Therefore, because RH is *relative* to temperature and can be misleading in certain circumstances, dew point (which is independent of temperature) may actually be a more significant meteorological factor to consider when discussing atmospheric conditions and vocal function. However, it is not mentioned in any of the literature found for this study.

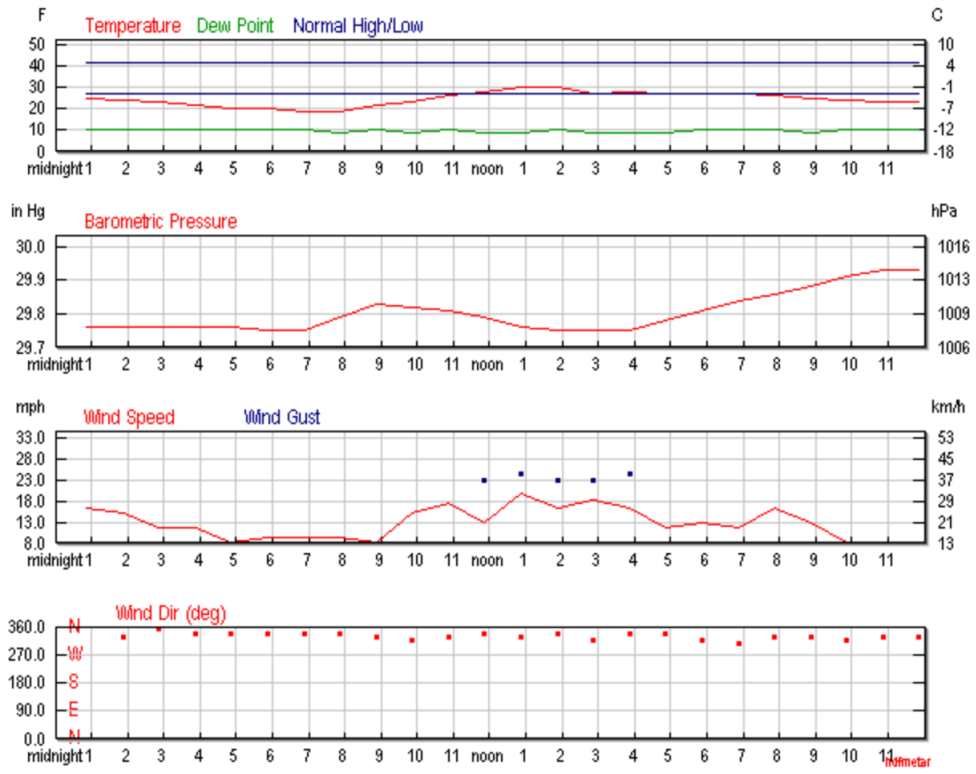


Figure 14. Hourly weather conditions during Aretha's performance on Tuesday, January 20, 2009, recorded at KDCA.[279]

Conditions were deemed too cold for Pavarotti to sing live at the February 10, 2006, Opening Olympic Ceremony in Turin, Italy. Data recorded by a surface-based

[279] "Weather History for KDCA, January 2009," accessed January 12, 2016, https://www.wunderground.com/history/.

weather observation station at the Turin Airport (LIMF), about 13 miles from the Stadio Olimpico performance site, reveals the temperature at the ceremony's 8 PM opening was near 37 degrees F. By the time Pavarotti took the stage over two hours later, the temperature was about 35 degrees F. The dew point was near 16 degrees F; relative humidity was 44%. (See Figure 15) Again, although dry conditions were not cited, the actual water vapor content of the air was relatively low:

$$44 = w/4.27 \text{ g/kg } x \text{ } 100$$

$$w = 1.87 \text{ g/kg}$$

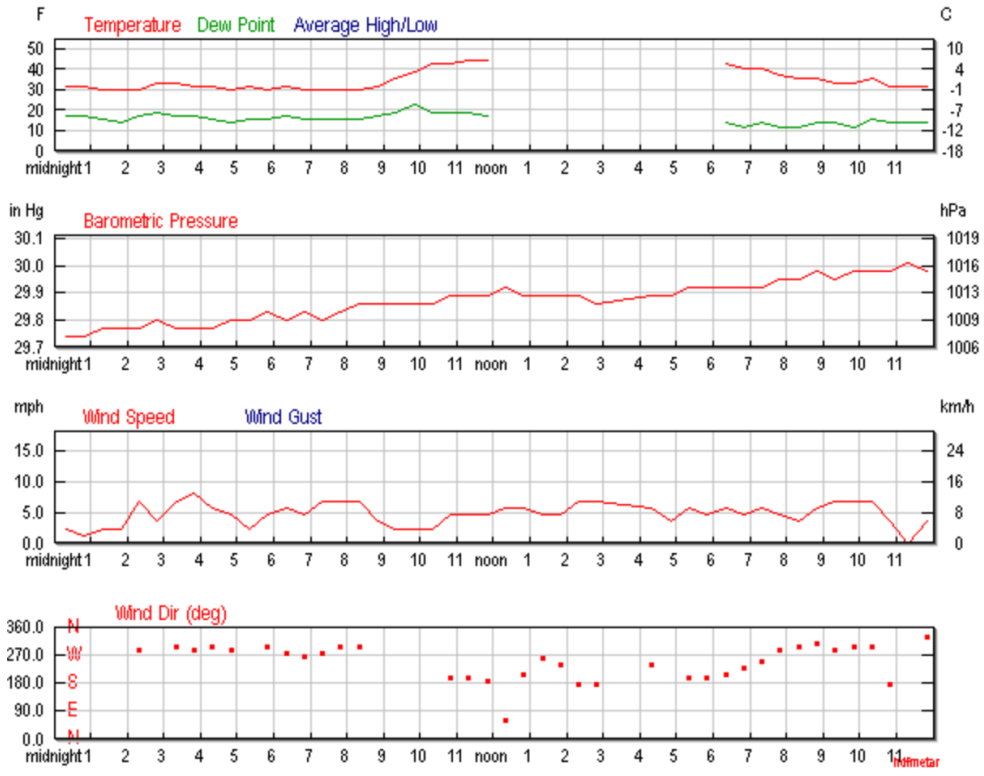


Figure 15. Hourly weather conditions during Pavarotti's performance on Friday, February 10, 2006, recorded at LIMF.[280]

[280] "Weather History for LIMF, February 2006," accessed January 12, 2016, https://www.wunderground.com/history/.

Beyoncé Knowles also chose to lip sync in lieu of a live performance at the January 21, 2013, Presidential Inauguration, citing cold weather as the reason for her decision. The temperature at the ceremony's 11:30 AM start was near 40 degrees F, but the southerly wind, which ranged between 7-10 mph, made it feel closer to 33 degrees.[281] The dew point was 21 degrees F; the humidity was 47%. (See Figure 16) Water vapor content this day was also low:

$$47 = w/5.21 \text{ g/kg } x \text{ } 100$$

$$w = 2.45 \text{ g/kg}$$

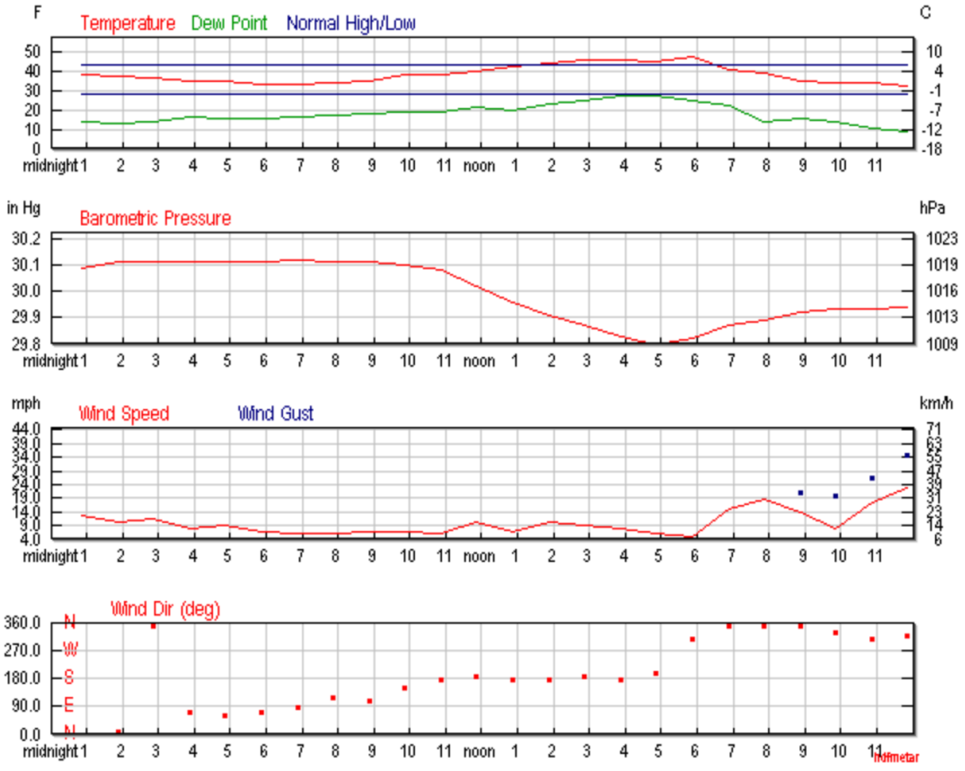


Figure 16. Hourly weather conditions during Beyoncé's performance on Monday, January 21, 2013, recorded at KDCA.[282]

[281] Wind chill as a factor is not discussed in this study. However, the combined effects of wind and temperature should be important considerations for future research.
[282] "Weather History for KDCA, January 2013," accessed January 21, 2016, https://www.wunderground.com/history/.

In contrast to the above three cases, Renée Fleming reported no vocal trouble during her live performance at the 2014 Super Bowl Pregame, although there was much media hype about the expected frigid conditions, as illustrated in Chapter III. In reality, the actual temperatures were much warmer than predicted just before kickoff at 6:30 PM. The surface observation station at Teterboro Airport (KTEB), about three miles from the MetLife Stadium, recorded a relatively balmy temperature of about 47 degrees F. The dew point was about 35 degrees F; the humidity was 63%. (See Figure 17) The water vapor content (4.3 g/kg) was relatively higher during her performance.

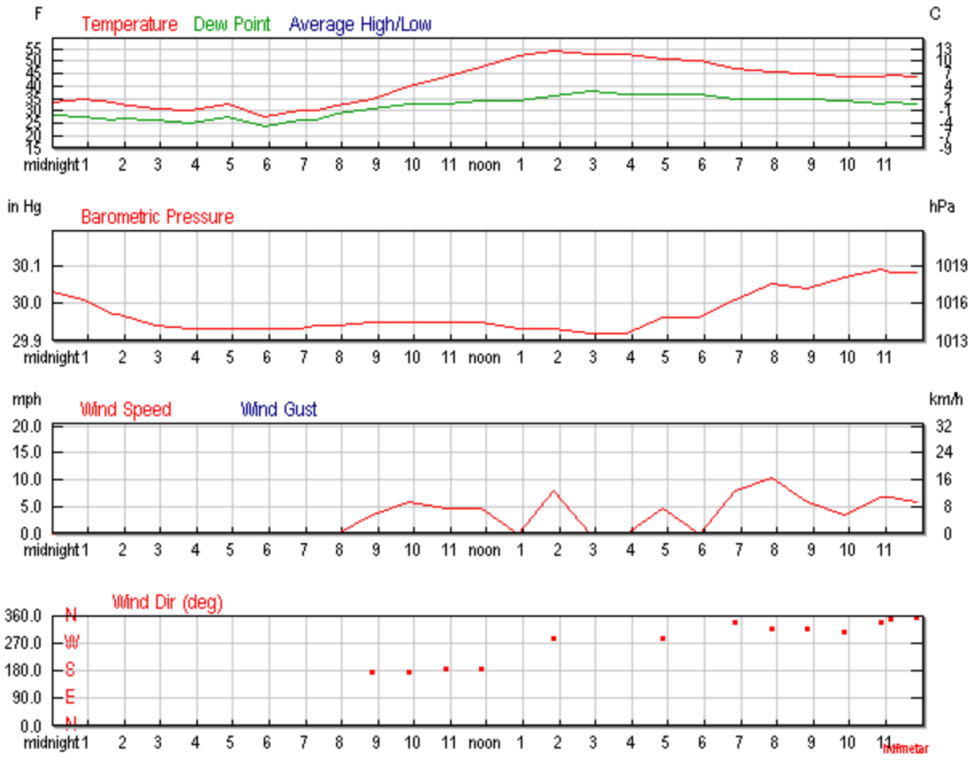


Figure 17. Hourly weather conditions during Renée's performance on Sunday, February 2, 2014, recorded at KTEB.[283]

[283] "Weather History for KTEB, February 2014," accessed January 22, 2016, https://www.wunderground.com/history/.

The above four performances have several situational variables in common: all were held in a winter month (January or February); all were held in a cold-weather city (Turin, Italy, Washington, D.C., or Rutherford, New Jersey); and all were surrounded by media buzz about cold temperatures. It is important to highlight that only two of the singers gave actual live performances in their respective conditions. To better explore any commonality or disparity in the atmospheric variables, graphs that interlay the data from all four events have been created (See Figures 18-21).

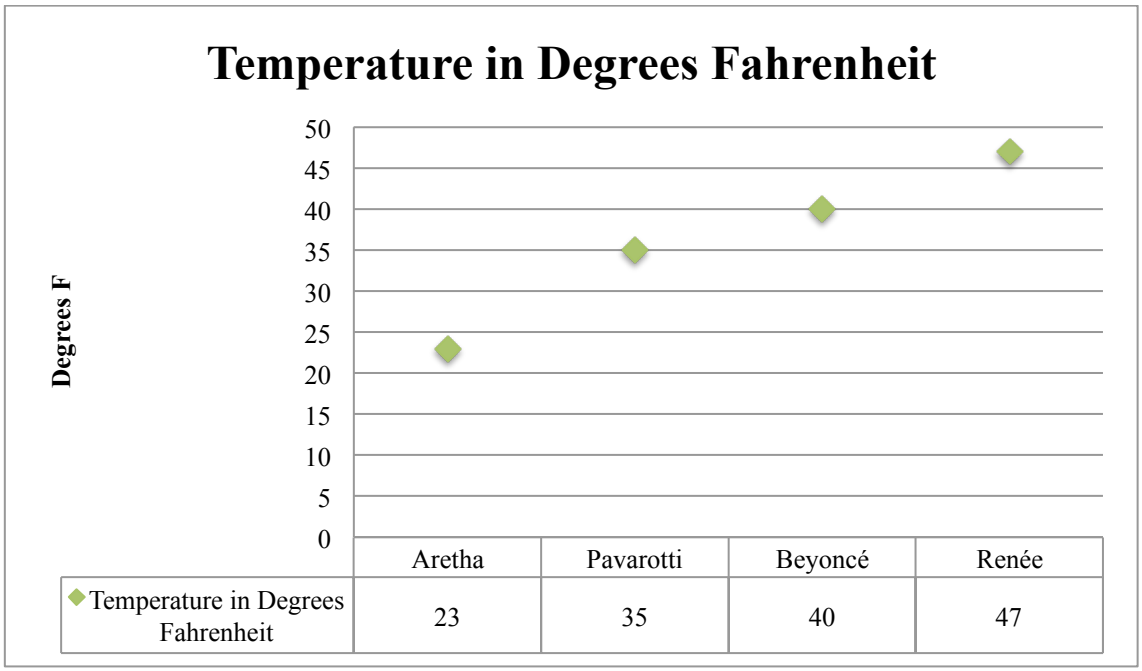


Figure 18. Approximate air temperature in degrees F during each performance. The two outside markers (Aretha and Renée) represent the live-sung performances. The two inside markers (Pavarotti and Beyoncé) represent the lip-synced performances.

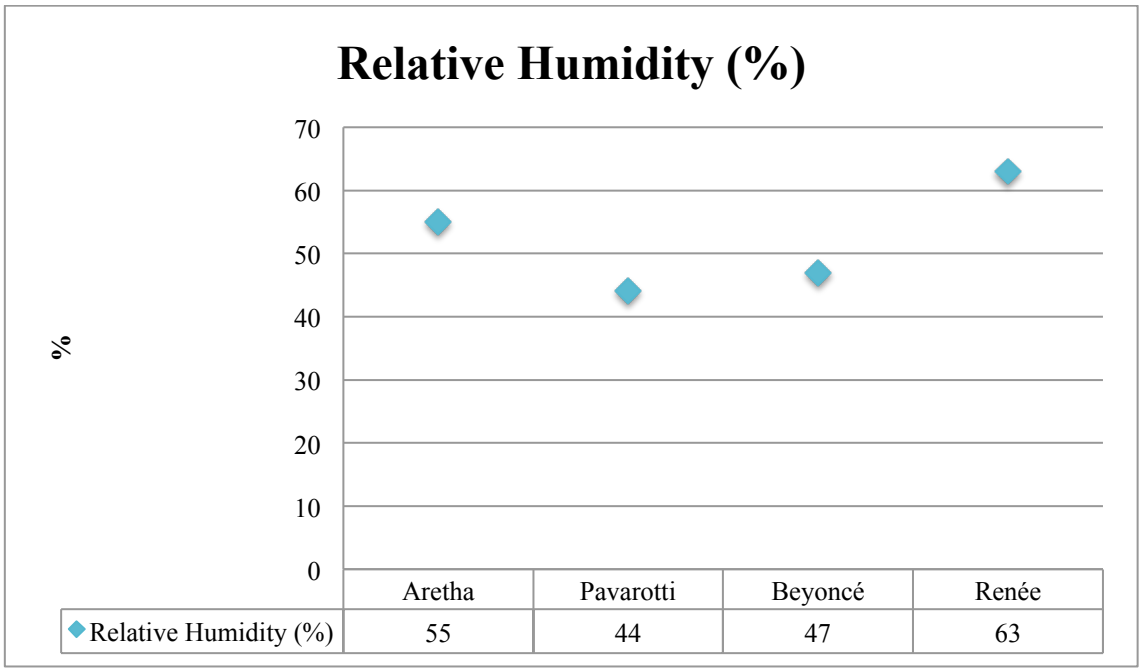


Figure 19. Approximate relative humidity during each performance. The two outside markers (Aretha and Renée) represent the live-sung performances. The two inside markers (Pavarotti and Beyoncé) represent the lip-synced performances.

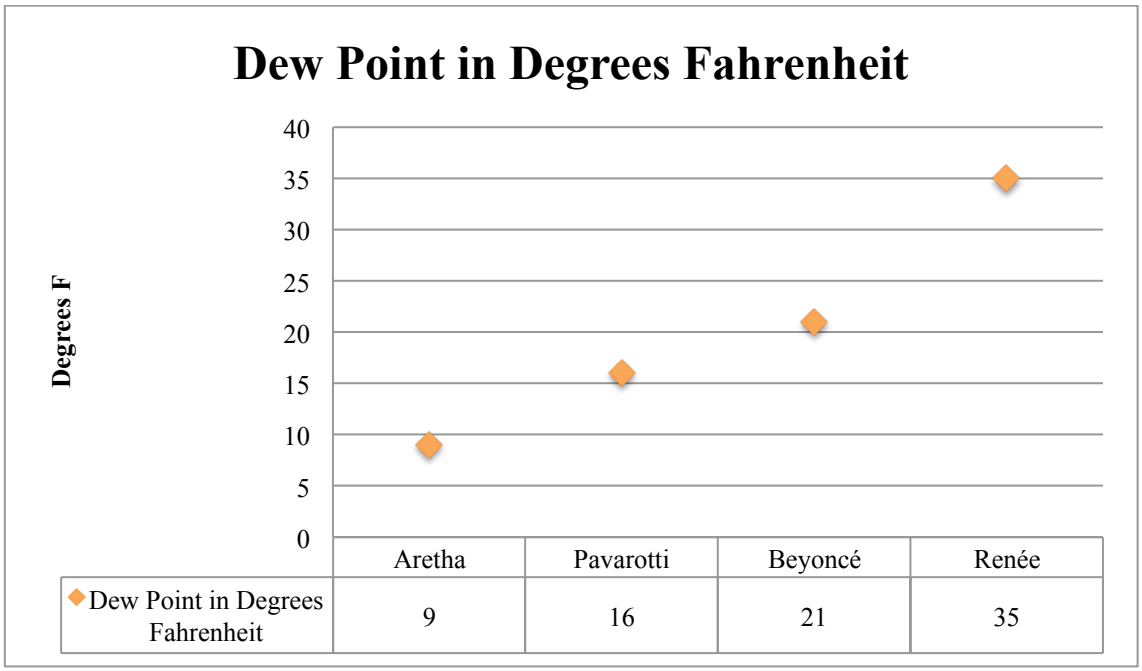


Figure 20. Approximate dew point temperature in degrees F during each performance. The two outside markers (Aretha and Renée) represent the live-sung performances. The two inside markers (Pavarotti and Beyoncé) represent the lip-synced performances.

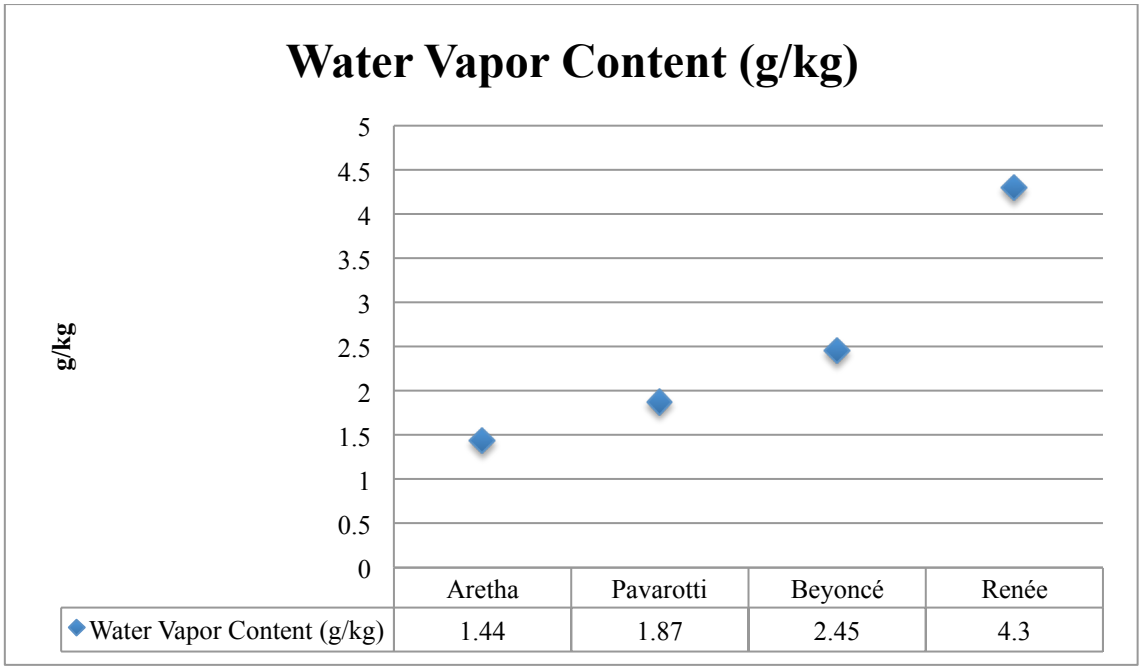


Figure 21. Approximate water vapor content in g/kg during each performance. The two outside markers (Aretha and Renée) represent the live-sung performances. The two inside markers (Pavarotti and Beyoncé) represent the lip-synced performances.

The data reveals that Aretha performed in not only the coldest conditions of the four, but also the driest. Renée performed in the warmest and most saturated. If the temperatures during Super Bowl night had been colder as initially expected, would Renée's performance have suffered? Or is she hardened to frigid temperatures because she has been used to them since childhood, as described in Chapter III? Would the other three performers have been able to give successful performances in the same conditions? Is the water vapor content of the ambient air a factor, perhaps overlooked by performers and researchers? More questions than answers remain. The above comparison highlights the fact that there is currently no uniformity of thought within the field. There is no hard and fast rule that suggests: "don't sing in 'these conditions,'" and there is little sharing of information within the vocal community. Several complex factors are likely involved, in addition to the ambient conditions. These may include acclimatization, and psychological and physiological components, all unique to the performer. Again, much more study is needed.

CHAPTER V: SUMMARY AND RECOMMENDATIONS

This study has explored the potential effects of atmospheric conditions on the singer's vocal function via a thorough investigation of existing theoretical and scientific literature. Chapter III revealed that the majority of this evidence is theoretical, and not much has changed in the community's approach to the topic since its earliest days of written existence. Although much of the information gathered strongly promotes that certain atmospheric conditions—cold temperatures and low humidities, especially—do affect the vocal mechanism, there are conflicting ideas as to what variable extremes produce negative/positive effects. Still others don't seem to be deterred by atmospheric conditions at all. Chapter IV explored scientific evidence in hopes of providing solid answers for a universal truth. However, the existing research, although helpful, leaves much to question. Simply put, the atmospheric-voice connection is a complex one, with many factors, and more research is needed to reach solid conclusions.

This document has contributed to the effort by compiling available evidence for the first time in the subject's history. The author sees this as a first step in a continuation of investigation. Now that it has been established that this topic is important among singers and needs universal clarification, persistent scientific research should be validated. Too few relevant experiments have been conducted to date, and not one has studied the effects of atmospheric conditions alone on the professional singer. While the author recognizes the difficulty in such data collection, she does not deem it impossible. Several methods are suggested here:

1) The collection of qualitative data via surveys. Although Chapter III outlines a large volume of opinions and perceptions, most of it is vague. It would be valuable to produce a survey that asks professional singers about their perceived vocal function in specific atmospheric conditions. An example of such a survey can be found in Appendix D.
2) Evaluation of PTP and PPE measures in controlled environments. The controlled temperature and humidity studies outlined in Chapter IV are helpful in providing experimental design information. However, the methods employed need to be altered. Professional singers and realistic atmospheric conditions should be used, and without additional variables such as fluid intake or drug administration. The effects of pressure/altitude can also be tested.
3) The use of technologies such as VoceVista.[284] Originally developed for teachers to analyze the singing voice, VoceVista is also used in vocal research and pathology to better determine sound color and amplification during singing. It is possible that such a technology could help determine any deviation from desirable vocal function in a variety of atmospheric conditions.
4) The development of a vocal index, and "vocal distress" maps for the professional singer. While this step is far down the line in future applications, if and when specific atmospheric variable ranges are proven for optimum vocal function, algorithms can then be used to create maps for the professional singer. Much like the daily "respiratory distress" or "aches and pains" maps currently available at Intellicast.com,[285] similar maps for "vocal distress" could be useful

[284] "Voce Vista," accessed March 20, 2016, http://www.vocevista.com/technology.html.
[285] "Health," *Intellicast*, accessed November 3, 2013, http://www.intellicast.com/Health/Default.aspx.

on a daily basis, for the traveling singer especially. See Appendix E for a sample of the current Intellicast maps.

To rephrase Tromp's quote from Chapter IV, the study of the effects of atmospheric conditions on the human voice is a young and at the same time a very old science. It is young by modern scientific standards, as much more research is needed in order to understand the full implications. It is old, if we consider the strong belief of humankind, from the earliest written evidence to the present day. This document serves as a step forward in the ongoing journey to reach a universal truth.

BIBLIOGRAPHY

Abitbol, Jean. *Odyssey of the Voice*. San Diego: Plural Publishing, 2006.

"Acting in Plays, Singing." *All Experts,* December 7, 2009. Accessed September 10, 2011. http://en.allexperts.com/q/Acting-Plays-Singing-695/2009/12/HELP-9.htm.

Adams, Francis, trans. "Aphorisms." *The Internet Classics Archive.* Accessed October 10, 2014. http://classics.mit.edu/Hippocrates/aphorisms.html.

-------. "On Airs, Waters, and Places." *The Internet Classics Archive.* Accessed October 10, 2014. http://classics.mit.edu/Hippocrates/airwatpl.html.

-------. "On Epidemics" Part I. *The Internet Classics Archive*. Accessed October 10, 2014. http://classics.mit.edu/Hippocrates/epidemics.1.i.html.

Ahrens, C. Donald. *Meteorology Today: An Introduction to Weather, Climate, and the Environment*. 7th ed. Australia: Brooks/Cole, 2003.

Al-Razi, Abu Bakr Mohammad Ibn Zakariva. "The Sense of Smelling." *FactBook*. Accessed September 5, 2015. http://www.factbook.org/wikipedia/en/t/th/the_sense_of_smelling__book_.html.

Arbuthnot, John. *An Essay Concerning the Effects of Air on Human Bodies*. London: J. & R. Tonson, 1751. Accessed November 19, 2015. https://archive.org/stream/essayconcerninge00arbu/essayconcerninge00arbu_djvu.txt.

Avicenna. *The Canon of Medicine*. Translated by Oskar Cameron Gruner. New York: AMS Press, Inc., 1973. Accessed August 29, 2015. https://archive.org/details/AvicennasCanonOfMedicine.

Bacon, Francis. *The New Organon and Related Writings*. Edited by F.H. Anderson. New York: Bobbs-Merrill Co., 1960.

-------. *Sylva Sylvarum, or a Natural History, in Ten Centuries*. London: J.R., 1765. Accessed September 18, 2014. https://archive.org/details/sylvasylvarumorn00baco.

Baird, Kirk. "Why 'Vegas Throat' Has Performers All Choked up." *Las Vegas Sun*, May 18, 2001. Accessed October 10, 2014. http://www.lasvegassun.com/news/2001/may/18/why-vegas-throat-has-performers-all-choked-up/.

Beatty, Chris. "Cold Weather Tips for Singers." *Ask the Vocal Coach Blog*, November 09, 2010. Accessed October 10, 2014. http://vocalcoach.com/blog/2010/11/cold-weather-tips-for-singers/.

Belcher, David. "The Altitude is Daunting, but the Soprano is Fearless." *The New York Times*, June 3, 2009. Accessed March 3, 2016. http://www.nytimes.com/2009/06/07/arts/music/07belc.html?_r=0.

Bell, Karen. "Sherrill Milnes talks to Performing Arts about caring for the voice." *Performing Arts & Entertainment in Canada* 27, no. 2 (1992):7. Accessed October 10, 2014. EBSCOhost.

Bhavsar, Vishar. "An Essay on the Evidence Base of Vocal Hygiene." *Journal of Singing* 65, no. 3 (2009): 285-296.

Bhishagratna, K.K.L., ed. *An English Translation of the Suśruta Samhitā Based on Original Sanskrit Text, Vol. I.* Calcutta: K.K.L.B., 1907.

-------. *An English Translation of the Suśruta Samhitā Based on Original Sanskrit Text, Vol. III.* Calcutta: K.K.L.B., 1916.

Bickel, Jan E. *Vocal Technique: A Physiologic Approach for Voice Class and Studio*. San Diego: Plural Publishing, Inc., 2008.

Boyle, Robert. *The General History of the Air*. London: 1692. Accessed December 19, 2015. http://docs.lib.noaa.gov/rescue/rarebooks_1600-1800/Qc161b691692.pdf.

Brodnitz, Friedrich S. *Keep Your Voice Healthy: A Guide to the Intelligent Use and Care of the Speaking and Singing Voice.* New York: Harper & Brothers, 1953.

Brouc, Martial. *Hygiène philosophique des Artistes dramatiques.* Paris: A. Le Boyer et Comp., 1836. Accessed November 4, 2014. http://hdl.handle.net/2027/nyp.33433011519950.

Brown, John I. & Son. *Weather Warnings…An old world-renowned remedy for the relief and cure of colds, coughs, hoarseness, and all throat troubles…*Brown's bronchial troches. Forbes Lithograph Manufacturing Co.: Boston [between 1875 and 1900]. 15 x 8 cm. trade card.

Browne, Lennox, and Emil Behnke. *Voice, song, and speech: a practical guide for singers and speakers; from the combined view of vocal surgeon and voice trainer*. New York: G.P. Putnam's Sons, 1886. Accessed November 4, 2014. http://www.archive.org/details/voicesongspeechp00browrich.

Bull, Sarah, and Meghan Keneally. "'Pavarotti mimed and it was freezing cold!': Beyoncé's reasons for lip-synching at the inauguration." *DailyMail.com*, January 23, 2013. Accessed September 30, 2014. http://www.dailymail.co.uk/tvshowbiz/article-2267348/Beyonce-backlash-Pavarotti-mimed-freezing-cold.html.

Bunch, Meribeth. *Dynamics of the Singing Voice*. 4th ed. New York: Springer, 1997.

Caruso, Enrico, and Luisa Tetrazzini. *Caruso and Tetrazzini on the Art of Singing*. New York: Dover Publications, Inc., 1975.

Cochran, Molly. "Performing in Cold Weather Doesn't Just Affect Beyoncé." *AccuWeather*, January 24, 2013. Accessed September 30, 2014. http://www.accuweather.com/en/weather-news/performing-in-cold-weather-doe/4715960.

Cohen, J. Solis. *The Throat and the Voice*. Philadelphia: Presley Blakiston, 1880.

Cooper, Donald S., and Ingo R. Titze. "Generation and Dissipation of Heat in Vocal Fold Tissue." *Journal of Speech and Hearing Research* 28 (June 1985): 207-215. Accessed October 10, 2012. http://dx.doi.org/10.1044/jshr.2802.207.

Davies, Garfield, and Anthony F. Jahn. *Care of the Professional Voice: A Guide to Voice Management for Singers, Actors and Professional Voice Users*. London: Routledge, 2004.

Davies, P.O.A.L., R.S. McGowan, and C.H. Shadle. "Practical Flow Duct Acoustics Applied to the Vocal Tract." In *Vocal Fold Physiology: Frontiers in Basic Science*, edited by Ingo R. Titze, 93-142. San Diego: Singular Publishing Group, Inc., 1993.

Dick, Michael. "The Ancient Ayurvedic Writings." *The Ayurvedic Institute*, 1998. Accessed August 10, 2015. https://www.ayurveda.com/online_resource/ancient_writings.htm.

Doscher, Barbara M. *The Functional Unity of the Singing Voice*. 2nd ed. Lanham, Maryland: The Scarecrow Press, Inc., 1994.

Dunlop, Storm. *The Oxford Dictionary of Weather*. 2nd ed. Oxford: Oxford University Press, 2008.

Durant, Ghislani. *Hygiene of the voice: Its physiology and anatomy.* New York: G. Schirmer, 1870. Accessed November 4, 2014. http://hdl.handle.net/2027/mdp.39015005320430.

"Extreme U.S. Climates." *The National Climatic Data Center*. Accessed January 26, 2015. https://www.ncdc.noaa.gov/extremes/extreme-us-climates.php.

Falconi, Marta. "Pavarotti Lip-Synched Last Performance." *Huffington Post*, April 15, 2008. Accessed September 8, 2011. http://www.huffingtonpost.com/2008/04/07/pavarotti-lipsynched-last_n_95502.html.

Feder, Robert J. "The professional voice and airline flight." *Otolaryngology – Head and Neck Surgery* 92, no. 3 (1984): 251-254.

Fekadu, Mesfin. "Singing in the Cold: Bruno Mars Preps for the Super Bowl." *The Weather Channel,* January 2016. Accessed January 22, 2016. http://www.weather.com/sports-recreation/superbowl/news/cold-super-bowl-bruno-mars-20131227.

Finkelhor, Benjamin K., Ingo R. Titze, and Paul L. Durham. "The effect of viscosity changes in the vocal folds on the range of oscillation." *Journal of Voice* 1, no. 4 (1988): 320-325. Accessed September 8, 2011. http://dx.doi.org/10.1016/S0892-1997(88)80005-5.

Fleming, Renée. *The Inner Voice: The Making of a Singer*. New York: Penguin Books, 2004.

"The Four Pillars of Singing – Warm-up for cold weather." *The Modern Vocalist World*, March 27, 2015. Accessed June 3, 2015. http://www.themodernvocalistworld.com/topic/8372-the-four-pillars-of-singing-warm-up-for-cold-weather/.

Galen, Claudius. *On Diseases and Symptoms*. Translated by Ian Johnston. Cambridge: Cambridge University Press, 2006.

-------. "On the Natural Faculties," Book II. Translated by Arthur John Brock. *The Internet Classics Archive*. Accessed August 29, 2015. http://classics.mit.edu/Galen/natfac.2.two.html.

Gates, Rachael, L. Arick Forrest, and Kerrie Obert. *The Owner's Manual to the Voice: A Guide for Singers and Other Professional Voice Users*. New York: Oxford University Press, 2013.

Green, R.M. *A Translation of Galen's Hygiene*. Springfield, IL: Thomas, 1951.

Hackett, Karleton. "In My Studio." *Werner's Magazine: A Magazine of Expression*, 1895.

"Health." *Intellicast.com.* Accessed November 03, 2014. http://www.intellicast.com/Health/Default.aspx.

Hemler, Raphael J.B., George H. Wieneke, and Philippe H. Dejonckere. "The Effect of Relative Humidity of Inhaled Air on Acoustic Parameters of Voice in Normal Subjects." *Journal of Voice* 11, no. 3 (1997): 295-300. Accessed September 8, 2011. http://dx.doi.org/10.1016/S0892-1997(97)80007-0.

-------, George H. Wieneke, Jean Lebacq, and Philippe H. Dejonckere. "Laryngeal mucosa elasticity and viscosity in high and low relative air humidity." *Eur Auch Otorhinolaryngol* 258, no. 3 (2001): 125-129. Accessed September 8, 2011. http://dx.doi.org/10.1007/s004050100321.

Henson, Robert. *The Rough Guide to Weather*. London: Rough Guides, Ltd., 2002.

"Historical Weather." *Weather Underground*. Accessed December 19, 2015. https://www.wunderground.com/history/.

Holmes, William Gordon. *A Treatise on Vocal Physiology and Hygiene: With Especial Reference to the Cultivation and Preservation of the Voice.* London: J & A Churchill, 1879.

Horne, Marilyn. *The Song Continues*. Fort Worth, TX: Baskerville Publishers, Inc., 2004.

Goodrich, Michael. "Taking Your Voice on the Road." *Back Stage West* 15, no. 15 (2008): 17. Accessed October 10, 2014. EBSCOhost.

Google Search. "Can cold temperatures diminish your singing range?" *Answer Bag.* Accessed September 10, 2011. http://www.answerbag.com/q_view/11787#ixzz1J9oDNPB2.

-------. "Can singing in cold weather permanently damage your voice?" *Answer Bag.* Accessed September 10, 2011. http://www.answerbag.com/q_view/12984#ixzz1J9nIyxGb.

-------. "Can the hot weather affect your singing voice?" *Yahoo Answers*. Accessed September 10, 2011. http://au.answers.yahoo.com/question/index?qid=20090130202746AAFABr4.

-------. "Does singing in the cold weather affect the singing voice?" *Yahoo Answers*. Accessed September 10, 2011. http://answers.yahoo.com/question/index?qid=20091028102830AAHeLqE.

-------. “Does the humidity affect one’s ability to sing?” *Yahoo Answers.* Accessed September 10, 2011. http://answers.yahoo.com/question/index?qid=20060713182827AASdAfc.

Gregg, Jean Westerman. “On Tension and Temperature.” *The NATS Journal* 47, no. 3 (1991): 42, 55.

Guttmann, Oskar. *Gymnastics of the Voice: Second English Edition.* Albany, New York: The Voice Press, 1884. Accessed October 25, 2015. https://archive.org/stream/cu31924022418374/cu31924022418374_djvu.txt.

Jackson, Mark. *Asthma: A biography*. New York: Oxford University Press, 2009.

Jahn, Anthony F., ed. *The Singer’s Guide to Complete Health*. New York: Oxford University Press, 2013.

J.C. Ayer & Co. *Ayer’s Cherry Pectoral cures colds & coughs caused by changes in the weather.* Lowell, Massachusetts [c.1886]. 8 x 13 cm trade card.

“J.C. Ayer & Co. and the Civil War.” *Lowell Historical Society*, Oct. 24, 2011. Accessed November 23, 2015. http://www.lowellhistoricalsociety.org/blog/2011/10/24/lhs-presentation-j-c-ayer-co-and-the-civil-war/.

Jones, W.H.S., trans. “On Epidemics” Part III. In *Hippocrates Collected Works*. Cambridge: Harvard University Press, 1868. Accessed October 10, 2014. http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.01.0251%3Atext%3DEpid.%3Abook%3D3%3Achapter%3D2%3Asection%3D3.

-------. “The Sacred Disease” in *Hippocrates*, *Vol. II*. London: William Heinemann, 1923.

Kaviratna, A.C., trans. *Charaka Samhitā*. Calcutta: G.C. Chakravarti, 1896.

Krebs, Albin, and Robert McG. Thomas. “Notes on People: Marilyn Horne and Her Victory Over Aggressive Viruses.” *The New York Times*, January 21, 1981. Accessed January 25, 2016. http://www.nytimes.com/1981/01/21/nyregion/notes-on-people-marilyn-horne-and-her-victory-over-aggressive-viruses.html.

Lam, Linda. “How Weather Impacts Spring Allergies.” *The Weather Channel*, March 17, 2015. Accessed March 4, 2016. https://weather.com/health/allergy/news/how-weather-impacts-spring-allergies.)

“Land-Based Station Data.” *National Climatic Data Center*. Accessed February 19, 2015. https://www.ncdc.noaa.gov/data-access/land-based-station-data.

LeWand, Nicole. “Many Homes Are Drier Than the Sahara Desert.” *NewsOK,* December 12, 1993. Accessed March 1, 2016. http://newsok.com/article/2450798.

Licht, Sidney, and Herman L. Kamenetz, eds. *Medical Climatology*. Baltimore: Waverly Press, Inc., 1964.

Mackenzie, Morel. *The Hygiene of the Vocal Organs: A Practical Handbook for Singers and Speakers*. London: MacMillan & Co., 1888.

McCall, Tris. “Aretha Franklin brings her signature soul to NJPAC.” *nj.com*, March 28, 2013. Accessed January 13, 2016. http://www.nj.com/entertainment/music/index.ssf/2013/03/aretha_franklin_brings_her_sig.html.

McFadden, Jr., E.R., D.M. Denison, J.F. Waller, B. Assoufi, A. Peacock, and T. Sopwith. “Direct Recordings of the Temperatures in the Tracheobronchial Tree in Normal Man.” *The Journal of Clinical Investigation* 69, no. 3 (1982): 700-705. Accessed February 9, 2015. http://dx.doi.org/10.1172/JCI110498.

-------, B.M. Pichurko, H. Frederick Bowman, Edward Ingenito, Steven Burns, Neil Dowling, and Julian Solway. “Thermal mapping of the airways in humans.” *The Journal of Applied Physiology* 58, no. 2 (1985): 564-570.

Méliot, Adolphe. *La Musique Expliquée aux Gens du Monde*. Paris: L. Marpon, 1869. Accessed November 4, 2014. http://hdl.handle.net/2027/mdp.39015009592984.

Meyers, Eric. “Road Show: Luca Pisaroni in Santa Fe.” *Opera News* 77, no. 9 (March 2013). Accessed March 3, 2016. http://www.operanews.com/Opera_News_Magazine/2013/3/Features/Road_Show__Luca_Pisaroni_in_Santa_Fe.html.

National Research Council. *Under the Weather: Climate, Ecosystems, and Infectious Disease.* Washington, D.C.: National Academy Press, 2001.

Nelson, Randy J., Gregory E. Demas, Sabra L. Klein, and Lance J. Kriegsfeld. *Seasonal Patterns of Stress, Immune Function, & Disease.* Cambridge: Cambridge University Press, 2002.

Nelson, Rebecca. “Beyoncé sings National Anthem Live for All the Haters at Super Bowl Press Conference.” *Time*, January 31, 2013. Accessed January 26, 2016. http://newsfeed.time.com/2013/01/31/watch-beyonce-sings-national-anthem-live-for-all-the-haters-at-super-bowl-press-conference/.

“Normal acclimatization.” *International Society for Mountain Medicine*. Accessed March 3, 2016. http://ismm.org/index.php/normal-acclimatization.html.

"Occupational Safety and Health Guideline for Ammonium Chloride Fume." *U.S. Department of Health and Human Services*, 1992. Accessed November 23, 2015. http://www.cdc.gov/niosh/docs/81-123/pdfs/0029.pdf.

Owen, Christian. "Kallen Esperian: FACES of Memphis." *Style Blueprint*, November 9, 2014. Accessed January 12, 2016. http://styleblueprint.com/memphis/everyday/kallen-esperian-faces-memphis/.

Pardue, Bob. "Don't Get the Singing Blues Because of Bad Weather." *Ezine Articles*, May 1, 2007. Accessed September 15, 2011. http://ezinearticles.com/?Dont-Get-the-Singing-Blues-Because-of-Bad-Weather&id=548346.

"Pavarotti Issues Plea for Scarf." *Deseret News*, July 22, 1990. Accessed October 20, 2014. http://www.deseretnews.com/article/113587/PAVAROTTI-ISSUES-PLEA-FOR-SCARF.html?pg=all.

The Peps Company. "The Peril in the Air." (C.E. Fulford Ltd, 1913), 7. Accessed November 23, 2015. http://wellcomelibrary.org/player/b21539790#?asi=0&ai=1&z=-0.2231%2C-0.0414%2C0.7118%2C0.4879.

Punt, Norman A. *The singer's and actor's throat: the vocal mechanism of the professional voice user and its care in health and disease*. 3rd ed. New York: Drama Book Specialists, 1979.

Redfield, John. *Music: A Science and an Art*. New York: Alfred A. Knopf Inc., 1928.

Reyes, Lorenzo. "Renée Fleming not worried about cold weather." *Democrat & Chronicle*, January 31, 2014. Accessed January 22, 2016. http://www.democratandchronicle.com/story/sports/2014/01/30/rene-fleming-not-worried-about-cold-weather/5070855/.

Richter, Bernhard, Erwin Löhle, W. Maier, B. Kliemann, and Katherine Verdolini. "Working conditions on stage: climatic considerations." *Logopedics, Phoniatrics, Vocology* 25, no.2 (2000): 80-86.

Rumbold, Thomas. *The Hygiene of the Voice*. St. Louis: Witt Publishing Co., 1898.

Sandage, Mary J., Nadine P. Connor, and David D. Pascoe. "Vocal Function and Upper Airway Thermoregulation in Five Different Environmental Conditions." *Journal of Speech, Language, and Hearing Research* 57, no.1 (2014), 16-25. Accessed September 8, 2011. EBSCOhost.

Sargent, Frederick, II. *Hippocratic Heritage: A History of Ideas About Weather and Human Health.* New York: Pergamon Press, 1982.

Sataloff. Robert Thayer. *Vocal Health and Pedagogy Volume I: Science and Assessment*. San Diego: Plural Publishing, Inc., 2006.

-------, and Ingo R. Titze, eds. *Vocal Health and Science: A Compilation of Articles from The NATS Bulletin and The NATS Journal.* Jacksonville: The National Association of Teachers of Singing, 1991.

Schutte, H.K. *The efficiency of voice production.* San Diego: Singular Publishing Group, Inc., 1980.

Selby, Julia, and Ginny Wilson. "Laryngographic Assessment of Voice Changes with Altered Hydration Status." *UCL Department of Phonetics and Linguistics.* Accessed January 17, 2011. http://www.phon.ucl.ac.uk/home/shl10/julia/wilby.htm.

"Singing with a cold," *Mark Baxter Vocal Studios.* Accessed September 15, 2011. http://www.voicelesson.com/free-vocal-help/q-and-a/singing-with-a-cold/.

Sivasankar, Mahalakshmi, and Kimberly V. Fisher. "Oral Breathing Increases Pth and Vocal Effort by Superficial Drying of Vocal Fold Mucosa." *Journal of Voice* 16, no.2 (2002): 172-181. Accessed September 8, 2011. http://dx.doi.org/ 10.1016/S0892-1997(02)00087-5.

Smith, Wesley D., trans. "Epidemics" in *Hippocrates*, *Vol. VII*. Harvard University Press: Cambridge, Massachusetts, 1994.

"Spring allergies are not to be sniffed at." *The Shanghai Daily,* April 14, 2009. Accessed August 10, 2015. http://www.china.org.cn/health/2009-04/14/content_17604610.htm.

"Tips to Prevent Voice Problems." *National Institute on Deafness and Other Communication Disorders.* Accessed September 15, 2011. *http://www.nidcd.nih.gov/health/voice/takingcare.htm.*

Tromp, S.W. *Biometeorology: The Impact of the Weather and Climate on Humans and Their Environment (Animals and Plants)*. London: Heyden & Son Ltd., 1980.

-------, and W.H. Weihe. *Biometeorology: Vol. II, Part I.* Oxford: Pergamon Press, 1967.

Ulaby, Neda. "Profile: Luciano Pavarotti." *National Public Radio,* September 6, 2007. Accessed September 8, 2011. http://www.npr.org/templates/story/story.php?storyId=14204641.

"Using Breathing Techniques and Other Methods for Weather Conditions." *Large Mart.* Accessed September 16, 2011. *http://www.largemart.com/singer/weather-and-singing-voice.htm.*

Veith, Ilza. *Huang Ti Nei Ching Su Wen: The Yellow Emperor's Classic of Internal Medicine.* Berkeley: University of California Press, 1972.

Verdolini, Katherine, and Ingo R. Titze. "Dependence of phonatory effort on hydration level." *Journal of Speech & Hearing Research* 37, no.5 (1994): 1001. Accessed September 8, 2011. JSTOR.

-------, Ingo R. Titze, and David G. Druker. "Changes in Phonation Threshold Pressure with Induced Conditions of Hydration." *Journal of Voice* 4, no.2 (1990): 142-151. Accessed September 8, 2011. http://dx.doi.org/10.1016/S0892-1997(05)80139-0.

Vitruvius. *The Ten Books on Architecture*. Translated by Morris Hicky Morgan. Cambridge: Harvard University Press, 1914. Accessed November 4, 2014. http://academics.triton.edu/faculty/fheitzman/Vitruvius__the_Ten_Books_on_Architecture.pdf.

"Voce Vista." *Voce Vista*. Accessed March 20, 2016. http://www.vocevista.com/technology.html.

Wakin, Daniel J. "The Frigid Fingers Were Live, but the Music Wasn't." *The New York Times*, January 22, 2009. Accessed November 10, 2014. http://www.nytimes.com/2009/01/23/arts/music/23band.html?_r=0.

Walshe, Shushannah. "Aretha Franklin 'Really Laughed' About Beyoncé Lip-Sync Controversy." *ABC News*, January 22, 2013. Accessed January 21, 2016. http://abcnews.go.com/Entertainment/beyonce-lip-sync-controversy-aretha-franklin-laughed/story?id=18289912.

Ware, Clifton. *Basics of Vocal Pedagogy: The Foundations and Process of Singing.* Boston: McGraw-Hill, 1998.

Webb, Paul. "Air Temperatures in Respiratory Tracts of Resting Subjects in Cold," *The Journal of Applied Physiology* 4 (1951).

Yi, Sangheon. "Holocene Vegetation Responses to East Asian Monsoonal Changes in South Korea." In *Climate Change: Geophysical Foundations and Ecological Effects*, edited by Juan Blanco and Houshang Kheradmand. InTech: Sept. 12, 2011. Accessed October 24, 2015. *http://www.intechopen.com/books/climate-change-geophysical-foundations-and-ecological-effects" title="Climate Change - Geophysical Foundations and Ecological Effects">Climate Change - Geophysical Foundations and Ecological Effects*.

YouTube. "Barack Obama Inauguration - Aretha Franklin - Sings 'America' My Country Tis Of Thee Jan 20, 2009." Accessed March 10, 2016. https://www.youtube.com/watch?v=YsNHhJTZAM0.

-------. “High Altitude Affects Singers at the Santa Fe Opera.” *Santa Fe Public Radio*. Accessed March 3, 2016. https://www.youtube.com/watch?v=yCGXjnjSqRI.

-------. “Larry King Live- Talks to Aretha Franklin About Her Hat During the Inauguration.” Accessed February 19, 2015. https://www.youtube.com/watch?v=7sZk2NKU_24.

Zohar, Gil. “Israeli Diva Saves ‘Carmen’ at Masada.” *Chicago Jewish Star*, June 29, 2012. Accessed November 3, 2014. ProQuest.

Works Referenced but Not Cited

Berke, Jacqueline, and Vivian Wilson. *Watch Out for the Weather.* New York: The Viking Press, 1951.

Bouma, J.J.S.H.J.W. “A short history of human biometeorology.” *Experientia* 43, no.1 (1987): 2-6. Accessed March 8, 2014. http://dx.doi.org/ 10.1007/BF01940345.

Feen, Diane. “Chilly Air Can't Squelch Warmth, Musical Brilliance of Renée Fleming.” *Boca Raton News*, March 09, 2010. Accessed September 08, 2011. http://www.bocaratontribune.com/bocaratonnews/2010/03/chilly-air-cant-squelch-warmth-musical-brilliance-of-renee-fleming/.

Haviland, Alfred. “The Iatrometeorology of Hippocrates.” *Association Medical Journal* 2, no. 61 (1854): 191-195. Accessed February 8, 2012. JSTOR.

Huber, Craig. “Singers, Others Suffer with ‘Vegas Throat.’” *FOX5 Vegas*. June 26, 2014. Accessed October 10, 2014. http://www.fox5vegas.com/story/25874173/singers-others-suffer-with-vegas-throat.

Kaiser, Manfred. *How the Weather Affects Your Health.* Australia: Michelle Anderson Publishing Pty Ltd., 2002.

Kals, W.S. *Your Health, Your Moods, and the Weather*. Garden City: Doubleday & Company, Inc. 1982.

Landsberg, Helmut E. *Weather and Health.* Garden City: Doubleday & Company, Inc., 1969.

Leydon, Ciara, Mahalakshmi Sivasankar, Danielle Lodewyck Falciglia, Christopher Atkins, and Kimberly V. Fisher. "Vocal Fold Surface Hydration: A review." *Journal of Voice* 23, no. 6 (2008): 658-665. Accessed September 8, 2011. http://dx.doi.org/10.1016/j.jvoice.2008.03.010.

Morgan, Michael D., and Joseph M. Moran. *Weather and People*. Upper Saddle River: Prentice Hall, 1997.

Munn, R.E. *Biometeorological Methods.* New York: Academic Press, 1970.

Palmer, Bruce. *Body Weather: How Natural and Man-Made Climates Affect You and Your Health.* Harrisburg: Stackpole Press, 1976.

Primiano, F.P., G.M. Saidel, F.W. Montague, K.L. Kruse, C.G. Green, and J.G. Horowitz. "Water vapour and temperature dynamics in the upper airways of normal and CF subjects." *European Respiratory Journal*, 1, no. 5 (1988): 407-414. Accessed February 9, 2015. http://erj.ersjournals.com/content/1/5/407.full.pdf+html.

"'Queen of Soul' Not Pleased with Performance at Inauguration." *CNN*, January 22, 2009. Accessed September 08, 2011. http://edition.cnn.com/2009/US/01/22/lkl.aretha.franklin/.

Richter, Bernhard, Erwin Löhle, Bettina Knapp, Matthias Weikert, Josef Schlömicher-Thier, and Katherine Verdolini. "Harmful Substances on the Opera Stage: Possible Negative Effects on Singers' Respiratory Tracts." *Journal of Voice* 16, no.1 (2002): 72-80. Accessed September 8, 2011. http://dx.doi.org/ 10.1016/S0892-1997(02)00074-7.

Rockingham, Graham. "A Valentine's Date with Pavarotti." *The Hamilton Spectator,* November 18, 2010. Accessed September 08, 2011. http://www.thespec.com/whatson-story/2100849-a-valentine-s-date-with-pavarotti/.

Sargent, Frederick, II. "A Survey of Human Biometeorology." *International Journal of Biometeorology* 9, no.1 (1965): 1-3. Accessed September 8, 2011. http://dx.doi.org/ 10.1007/BF02187303.

Sataloff, Robert T. *Professional Voice: The Science and Art of Clinical Care.* 2nd ed. San Diego: Singular Publishing Group, Inc., 1997.

Sterling, E.M., A. Arundel, and T.D. Sterling. "Criteria for Human Exposure to Humidity in Occupied Buildings." *ASHRAE Transactions* 91, no.1 (1985): 611-622. Accessed October 20, 2014. http://sterlingiaq.com/photos/1044922973.pdf.

Thomas, Pat. *Under the Weather: How the Weather and Climate Affect Our Health*. London: Fusion Press, 2004.

Titze, Ingo R. "Keeping It Moist." *The NATS Journal* 51 (1995): 39-40.

-------. *Principles of Voice Production*. Englewood Cliffs: Prentice Hall, 1994.

-------. "Unsolved Mysteries about Vocal Fatigue and Recovery." *Journal of Singing* 65, no.4 (2009): 449-450.

Voorhees, Irving Wilson. *Hygiene of the voice*. New York: The Macmillan Company, 1923. Accessed November 4, 2014. http://hdl.handle.net/2027/mdp.39015031040523.

Wallace, John M., and Peter V. Hobbs. *Atmospheric Science: An Introductory Survey.* New York: Academic Press, 1977.

APPENDIX A:
GLOSSARY OF METEOROLOGICAL TERMS AND DEFINITIONS

Air Mass	A large mass of air, usually hundreds to thousands of miles across and several miles high, with the same physical and chemical properties (i.e. maritime, continental, arctic, polar, tropical)
Barometer	Instrument used for measuring atmospheric pressure
Climate	The average atmospheric conditions that occur in a particular region over a specific and extended duration of time; derived from statistical information about meteorological elements including temperature, precipitation, wind speed, and humidity, collected over time
Dew point	The temperature at which a parcel of air reaches saturation, and at which condensation forms as cloud droplets, dew, mist, or fog
Elevation	The height of the ground above mean sea level
Front	The boundary between two different air masses (i.e. cold front, warm front)
Heat Index	A quality expressing discomfort, taking into account the combined effects of air temperature and relative humidity; when humidity is high on a hot day, the heat index is often higher than the actual air temperature—it *feels* hotter than it actually is due to the high moisture content of the air
High-Pressure System	In the northern hemisphere, a clockwise-turning system where the atmospheric pressure at sea level is higher than that of its surrounding locations; at its surface center, air sinks; is often associated with clear skies
Human Biometeorology	The study of the relationship between atmospheric conditions and human life

Humidity (Relative)	Expressed as a percentage, (RH) is the ratio of water vapor in a given mass of air *relative* to the amount of water that air can hold at a given temperature; the warmer the air, the more water vapor it can hold
Hygrometer	Instrument used for measuring atmospheric humidity
Low-Pressure System	In the northern hemisphere, a counter-clockwise-turning system where the atmospheric pressure at sea level is lower than that of its surrounding locations; at its surface center, air rises; is often associated with cold fronts, warm fronts, and stormy weather
Macroclimate	The climatic conditions that directly surround a living organism, both near Earth's surface, and in a limited space (i.e. a theater, a house)
Meteotropism	A correlation between a change in an organism and a change in the atmosphere
Millibar	(mb) A unit of atmospheric pressure, equal to 100 Pascals; standard atmospheric pressure at mean sea level is about 1,013.25 mb
Pressure	In meteorology, generally taken to be the force exerted by the hypothetical column of air extending from the surface to the outer limit of the atmosphere and subject to the Earth's gravitational attraction; measured by a barometer
Temperature	The degree of heat of a solid, liquid, or gaseous material; in meteorology, measured by a thermometer; Celsius, Kelvin, Fahrenheit are principal scales
Thermometer	Instrument used for measuring temperature
Weather	The state of the atmosphere on the short term (i.e. hour to hour, day to day, as opposed to climate's longer term); measure of changes of various parameters, such as temperature, humidity, wind, pressure, precipitation, etc.

APPENDIX B: A SUMMARIZING TABLE OF DOCUMENT EVIDENCE ATMOSPHERIC CONDITIONS AND THE VOICE

Atmospheric Condition	Perceived Negative Effects	Perceived Positive Effects	Scientific Research
Cold	Dangerous to the voice; causes dryness, hoarseness, coughs & colds, sore throat; disturbance of vocal function; can diminish range, cause strain, make it hard to breathe; refrain from cold drinks and chilly clothing	None found. Some perceive cold as non-concerning.	Cold air, when inhaled, does not reach bodily conditions until deep within the lung; more research needed to determine cold temperature's direct effect on the vocal mechanism
Heat	Voice may lose power and purity; overheating results in a cold; can make breathing difficult; exacerbates allergies	Creates beauty in voice, gives voice strength; makes singing easier, loosens jaw. Some perceive heat as having no effect.	No existing research found regarding heat's direct affect on vocal function
Humid	Dangerous and unhealthy; can cause hoarseness, cough, and congestion; can make breathing difficult	Causes sound to be richer, good for loosening the voice	Increased humidity has been shown to decrease effort during vocalization; however, more research is needed to determine effects during singing, and to determine optimum humidity range
Dry	Irritating, can cause sore throat; can cause disturbances in the lungs	Beneficial if not too hot; promotes healthy constitution	Increased dryness has been shown to increase effort during vocalization via a drying of the vocal fold mucosal covering; however, more research is needed to determine effects during singing
Cold and Humid Combined	Injurious; can cause hoarseness, dry cough, inflammation	None found, although many singers use cool mist vaporizers to relieve vocal ailments; depending on the source consulted, some vocalists recommend this type of treatment over steam heat, mostly because it does not promote mold/bacterial growth	No scientific research specifically dealing with cold *and* humidity found

Heat and Humid Combined	Harmful, dangerous; can cause inflammation, phlegm, hoarseness	None found, although many singers use steam heat to relieve vocal ailments; depending on the source consulted, some vocalists recommend this type of treatment over cool mist	Steam heat has been shown to be a beneficial hydration treatment (Verdolini et al., 1994)
Heat and Dry Combined	Dryness; quality of voice deteriorates	Beneficial; can cause clear voice, if temperature is moderate	
Cold and Dry Combined	Can cause hoarseness, pain in throat	Dry conditions at 25-40 degrees F = invigorating, lung function is more active, favorable to vocal exercise	
Altitude	Harder to breathe, sing long phrases; can cause tiredness, headaches, dehydration; additional oxygen may be needed	A "fun" challenge	Less oxygen is available at higher altitudes; affects respiration; more acclimatization studies needed
Dust, Smoke, Pollution	Can cause irritation, sore throat	None found	It is well accepted that these atmospheric particulates are harmful to the vocal/respiratory tract (see FN 238)

APPENDIX C: HOURLY TEMPERATURE AND HUMIDITY DATA COLLECTED IN APRIL 2015, PAUL F. SHARP CONCERT HALL, THE UNIVERSITY OF OKLAHOMA – TEXT FILE

TIME STAMP	TEMP (F)	RH
2015-04-03 11:00:00	68.666	37.39
2015-04-03 12:00:00	69.746	34.57
2015-04-03 13:00:00	70.16	32.97
2015-04-03 14:00:00	70.34	32.19
2015-04-03 15:00:00	70.394	32.73
2015-04-03 16:00:00	70.394	32.53
2015-04-03 17:00:00	70.304	32.12
2015-04-03 18:00:00	70.61	30.25
2015-04-03 19:00:00	70.664	27.37
2015-04-03 20:00:00	70.736	26.11
2015-04-03 21:00:00	70.682	24.58
2015-04-03 22:00:00	70.7	25.03
2015-04-03 23:00:00	70.592	24.35
2015-04-04 00:00:00	70.52	24.28
2015-04-04 01:00:00	70.358	24.55
2015-04-04 02:00:00	70.286	24.38
2015-04-04 03:00:00	70.196	24.58
2015-04-04 04:00:00	70.16	24.35
2015-04-04 05:00:00	70.124	24.65
2015-04-04 06:00:00	69.98	24.35
2015-04-04 07:00:00	70.088	24.52
2015-04-04 08:00:00	70.052	24.92
2015-04-04 09:00:00	69.818	24.79
2015-04-04 10:00:00	70.196	24.11
2015-04-04 11:00:00	70.142	22.28
2015-04-04 12:00:00	69.98	21.09
2015-04-04 13:00:00	69.764	19.46
2015-04-04 14:00:00	70.016	18.81
2015-04-04 15:00:00	70.016	21.02
2015-04-04 16:00:00	69.98	18.2
2015-04-04 17:00:00	69.998	18.95
2015-04-04 18:00:00	70.052	19.69
2015-04-04 19:00:00	70.268	20.27
2015-04-04 20:00:00	70.16	21.26
2015-04-04 21:00:00	70.124	22.17
2015-04-04 22:00:00	70.232	22.34
2015-04-04 23:00:00	70.466	22.31
2015-04-05 00:00:00	70.358	22.92
2015-04-05 01:00:00	70.466	24.14
2015-04-05 02:00:00	70.448	24.96
2015-04-05 03:00:00	70.412	25.81
2015-04-05 04:00:00	70.448	26.38
2015-04-05 05:00:00	70.466	30.49
2015-04-05 06:00:00	70.664	33.14
2015-04-05 07:00:00	70.592	34.97
2015-04-05 08:00:00	70.718	36.81

2015-04-05 09:00:00	70.628	38.34
2015-04-05 10:00:00	70.574	39.46
2015-04-05 11:00:00	70.628	40.2
2015-04-05 12:00:00	70.322	41.05
2015-04-05 13:00:00	70.25	41.8
2015-04-05 14:00:00	70.556	42.21
2015-04-05 15:00:00	70.484	42.11
2015-04-05 16:00:00	70.394	43.23
2015-04-05 17:00:00	70.358	44.11
2015-04-05 18:00:00	70.412	44.58
2015-04-05 19:00:00	70.43	45.03
2015-04-05 20:00:00	70.394	45.6
2015-04-05 21:00:00	70.304	45.98
2015-04-05 22:00:00	70.412	46.35
2015-04-05 23:00:00	70.394	46.38
2015-04-06 00:00:00	70.214	46.72
2015-04-06 01:00:00	70.196	46.55
2015-04-06 02:00:00	70.16	46.83
2015-04-06 03:00:00	70.25	47.33
2015-04-06 04:00:00	70.268	47.3
2015-04-06 05:00:00	70.178	48.01
2015-04-06 06:00:00	70.214	48.15
2015-04-06 07:00:00	70.322	48.08
2015-04-06 08:00:00	70.376	48.49
2015-04-06 09:00:00	70.304	49.13
2015-04-06 10:00:00	70.43	51.07
2015-04-06 11:00:00	70.7	52.7
2015-04-06 12:00:00	70.34	50.83
2015-04-06 13:00:00	70.358	50.39
2015-04-06 14:00:00	70.088	49
2015-04-06 15:00:00	70.016	50.05
2015-04-06 16:00:00	70.286	51.31
2015-04-06 17:00:00	70.196	52.22
2015-04-06 18:00:00	70.304	53.85
2015-04-06 19:00:00	70.862	55.31
2015-04-06 20:00:00	71.006	51.61
2015-04-06 21:00:00	71.078	50.8
2015-04-06 22:00:00	71.294	51.48
2015-04-06 23:00:00	70.97	52.6
2015-04-07 00:00:00	70.466	51.51
2015-04-07 01:00:00	70.25	51.14
2015-04-07 02:00:00	69.944	50.93
2015-04-07 03:00:00	70.25	51.1
2015-04-07 04:00:00	70.196	51.24
2015-04-07 05:00:00	70.052	51.07
2015-04-07 06:00:00	70.142	51.07
2015-04-07 07:00:00	70.43	51
2015-04-07 08:00:00	70.286	52.05
2015-04-07 09:00:00	69.422	51.99
2015-04-07 10:00:00	69.908	51.58
2015-04-07 11:00:00	70.16	53.48
2015-04-07 12:00:00	70.25	55.21
2015-04-07 13:00:00	69.998	54.4
2015-04-07 14:00:00	70.214	53.45

2015-04-07 15:00:00	70.664	51.95
2015-04-07 16:00:00	71.006	51.65
2015-04-07 17:00:00	71.168	51.17
2015-04-07 18:00:00	71.258	49.95
2015-04-07 19:00:00	71.618	50.93
2015-04-07 20:00:00	71.096	52.02
2015-04-07 21:00:00	71.114	51.1
2015-04-07 22:00:00	71.582	49.77
2015-04-07 23:00:00	71.366	52.7
2015-04-08 00:00:00	71.294	51.13
2015-04-08 01:00:00	71.312	50.52
2015-04-08 02:00:00	71.168	50.86
2015-04-08 03:00:00	71.114	50.52
2015-04-08 04:00:00	71.132	50.42
2015-04-08 05:00:00	71.042	50.08
2015-04-08 06:00:00	71.096	49.95
2015-04-08 07:00:00	71.258	50.02
2015-04-08 08:00:00	71.312	50.59
2015-04-08 09:00:00	70.952	50.49
2015-04-08 10:00:00	70.934	50.53
2015-04-08 11:00:00	71.24	51.92
2015-04-08 12:00:00	71.384	53.24
2015-04-08 13:00:00	71.42	53.65
2015-04-08 14:00:00	70.916	53.34
2015-04-08 15:00:00	71.222	52.53
2015-04-08 16:00:00	71.204	51.98
2015-04-08 17:00:00	71.204	50.9
2015-04-08 18:00:00	71.204	51.37
2015-04-08 19:00:00	71.6	50.93
2015-04-08 20:00:00	71.222	51
2015-04-08 21:00:00	71.204	50.69
2015-04-08 22:00:00	71.366	50.59
2015-04-08 23:00:00	71.33	50.49
2015-04-09 00:00:00	71.33	50.05
2015-04-09 01:00:00	71.024	50.25
2015-04-09 02:00:00	71.042	50.32
2015-04-09 03:00:00	70.826	51.07
2015-04-09 04:00:00	71.024	50.7
2015-04-09 05:00:00	70.916	50.36
2015-04-09 06:00:00	70.7	50.46
2015-04-09 07:00:00	70.718	50.49
2015-04-09 08:00:00	70.592	50.66
2015-04-09 09:00:00	70.844	50.9
2015-04-09 10:00:00	70.736	50.73
2015-04-09 11:00:00	70.538	50.49
2015-04-09 12:00:00	70.808	50.12
2015-04-09 13:00:00	70.826	49.71
2015-04-09 14:00:00	71.078	49.2
2015-04-09 15:00:00	69.872	47.61
2015-04-09 16:00:00	68.9	45.87
2015-04-09 17:00:00	68.54	42.21
2015-04-09 18:00:00	68.072	39.73
2015-04-09 19:00:00	68.45	38.23
2015-04-09 20:00:00	67.91	37.42

2015-04-09 21:00:00	69.044	35.04
2015-04-09 22:00:00	67.784	33.96
2015-04-09 23:00:00	66.956	34.57
2015-04-10 00:00:00	67.172	34.43
2015-04-10 01:00:00	65.966	35.01
2015-04-10 02:00:00	65.894	33.85
2015-04-10 03:00:00	65.498	33.38
2015-04-10 04:00:00	66.29	32.74
2015-04-10 05:00:00	65.48	33.28
2015-04-10 06:00:00	65.966	33.11
2015-04-10 07:00:00	67.55	31.92
2015-04-10 08:00:00	67.892	31.48
2015-04-10 09:00:00	68.144	31.85
2015-04-10 10:00:00	68.432	30.97
2015-04-10 11:00:00	68.558	30.87
2015-04-10 12:00:00	68.648	30.12
2015-04-10 13:00:00	68.738	29.54
2015-04-10 14:00:00	68.9	29.85
2015-04-10 15:00:00	68.936	30.83
2015-04-10 16:00:00	69.368	31.95
2015-04-10 17:00:00	69.17	33.41
2015-04-10 18:00:00	69.368	34.09
2015-04-10 19:00:00	69.422	33.89
2015-04-10 20:00:00	69.656	32.39
2015-04-10 21:00:00	69.782	32.33
2015-04-10 22:00:00	69.926	32.53
2015-04-10 23:00:00	69.998	31.75
2015-04-11 00:00:00	69.944	31.61
2015-04-11 01:00:00	69.908	31.65
2015-04-11 02:00:00	69.836	31
2015-04-11 03:00:00	69.728	30.76
2015-04-11 04:00:00	69.746	31.24
2015-04-11 05:00:00	69.764	34.63
2015-04-11 06:00:00	69.926	41.29
2015-04-11 07:00:00	69.818	40.07
2015-04-11 08:00:00	69.836	39.49
2015-04-11 09:00:00	69.764	39.22
2015-04-11 10:00:00	69.782	41.6
2015-04-11 11:00:00	69.89	44.11
2015-04-11 12:00:00	69.962	44.99
2015-04-11 13:00:00	70.052	44.31
2015-04-11 14:00:00	69.872	43.46
2015-04-11 15:00:00	69.836	41.53
2015-04-11 16:00:00	69.89	37.49
2015-04-11 17:00:00	69.854	32.7
2015-04-11 18:00:00	70.106	31.99
2015-04-11 19:00:00	70.196	31.85
2015-04-11 20:00:00	70.286	32.87
2015-04-11 21:00:00	70.034	32.84
2015-04-11 22:00:00	70.052	33.79
2015-04-11 23:00:00	70.16	34.63
2015-04-12 00:00:00	70.106	36.81
2015-04-12 01:00:00	70.016	38.44
2015-04-12 02:00:00	70.034	39.25

2015-04-12 03:00:00	69.89	39.32
2015-04-12 04:00:00	69.8	39.52
2015-04-12 05:00:00	69.764	41.77
2015-04-12 06:00:00	69.8	44.69
2015-04-12 07:00:00	69.818	46.72
2015-04-12 08:00:00	69.854	48.05
2015-04-12 09:00:00	69.746	49.03
2015-04-12 10:00:00	69.62	48.46
2015-04-12 11:00:00	69.638	48.46
2015-04-12 12:00:00	69.692	48.83
2015-04-12 13:00:00	69.62	49.51
2015-04-12 14:00:00	69.656	49.85
2015-04-12 15:00:00	69.782	50.25
2015-04-12 16:00:00	69.764	50.56
2015-04-12 17:00:00	70.016	50.29
2015-04-12 18:00:00	70.214	50.22
2015-04-12 19:00:00	70.322	50.19
2015-04-12 20:00:00	70.43	50.08
2015-04-12 21:00:00	70.646	49.78
2015-04-12 22:00:00	70.718	49.4
2015-04-12 23:00:00	70.538	49.88
2015-04-13 00:00:00	70.484	49.95
2015-04-13 01:00:00	70.358	50.22
2015-04-13 02:00:00	70.448	50.32
2015-04-13 03:00:00	70.394	50.25
2015-04-13 04:00:00	70.232	50.32
2015-04-13 05:00:00	70.268	50.66
2015-04-13 06:00:00	70.358	50.66
2015-04-13 07:00:00	70.43	50.73
2015-04-13 08:00:00	70.43	50.9
2015-04-13 09:00:00	70.322	51.17
2015-04-13 10:00:00	70.538	50.87
2015-04-13 11:00:00	70.61	50.56
2015-04-13 12:00:00	70.52	50.29
2015-04-13 13:00:00	70.484	50.93
2015-04-13 14:00:00	70.43	50.93
2015-04-13 15:00:00	70.7	50.19
2015-04-13 16:00:00	70.718	49.61
2015-04-13 17:00:00	70.898	48.9
2015-04-13 18:00:00	70.826	47.61
2015-04-13 19:00:00	70.664	46.14
2015-04-13 20:00:00	70.502	46.04
2015-04-13 21:00:00	70.394	46.15
2015-04-13 22:00:00	70.16	44.69
2015-04-13 23:00:00	70.16	43.26
2015-04-14 00:00:00	69.962	41.46
2015-04-14 01:00:00	69.998	40.03
2015-04-14 02:00:00	69.764	37.69
2015-04-14 03:00:00	69.818	36.26
2015-04-14 04:00:00	69.656	34.8
2015-04-14 05:00:00	69.638	34.26
2015-04-14 06:00:00	69.422	33.89
2015-04-14 07:00:00	69.458	34.4
2015-04-14 08:00:00	69.386	38.47

2015-04-14 09:00:00	69.656	41.63
2015-04-14 10:00:00	69.62	42.34
2015-04-14 11:00:00	69.962	41.43
2015-04-14 12:00:00	69.962	41.36
2015-04-14 13:00:00	70.07	42.51
2015-04-14 14:00:00	70.088	41.9
2015-04-14 15:00:00	69.962	42.07
2015-04-14 16:00:00	70.142	42.04
2015-04-14 17:00:00	70.25	41.94
2015-04-14 18:00:00	70.286	42.78
2015-04-14 19:00:00	70.322	43.09
2015-04-14 20:00:00	70.646	43.7
2015-04-14 21:00:00	70.826	43.46
2015-04-14 22:00:00	70.88	43.87
2015-04-14 23:00:00	70.844	43.77
2015-04-15 00:00:00	70.43	44.35
2015-04-15 01:00:00	70.16	45.03
2015-04-15 02:00:00	70.034	45.77
2015-04-15 03:00:00	69.944	46.11
2015-04-15 04:00:00	69.908	46.35
2015-04-15 05:00:00	69.854	46.69
2015-04-15 06:00:00	69.926	46.72
2015-04-15 07:00:00	69.8	47.03
2015-04-15 08:00:00	70.286	46.76
2015-04-15 09:00:00	70.52	46.35
2015-04-15 10:00:00	70.574	46.08
2015-04-15 11:00:00	70.862	46.35
2015-04-15 12:00:00	70.808	46.93
2015-04-15 13:00:00	70.718	46.79
2015-04-15 14:00:00	70.52	47.67
2015-04-15 15:00:00	70.736	47.78
2015-04-15 16:00:00	70.574	48.32
2015-04-15 17:00:00	71.078	48.86
2015-04-15 18:00:00	70.772	48.56
2015-04-15 19:00:00	70.844	49.54
2015-04-15 20:00:00	70.862	49.47
2015-04-15 21:00:00	71.096	48.83
2015-04-15 22:00:00	71.132	48.42
2015-04-15 23:00:00	71.078	48.76
2015-04-16 00:00:00	70.988	48.76
2015-04-16 01:00:00	71.042	48.86
2015-04-16 02:00:00	70.88	48.83
2015-04-16 03:00:00	70.934	48.79
2015-04-16 04:00:00	70.808	48.62
2015-04-16 05:00:00	70.898	48.52
2015-04-16 06:00:00	70.826	48.49
2015-04-16 07:00:00	70.718	48.42
2015-04-16 08:00:00	71.06	48.18
2015-04-16 09:00:00	71.006	47.98
2015-04-16 10:00:00	71.078	47.5
2015-04-16 11:00:00	71.114	49.44
2015-04-16 12:00:00	71.132	49.95
2015-04-16 13:00:00	71.204	50.39
2015-04-16 14:00:00	71.114	50.46

2015-04-16 15:00:00	71.132	50.73
2015-04-16 16:00:00	71.42	53.85
2015-04-16 17:00:00	71.402	52.53
2015-04-16 18:00:00	71.168	53.17
2015-04-16 19:00:00	71.15	51.78
2015-04-16 20:00:00	71.312	50.83
2015-04-16 21:00:00	71.726	51.07
2015-04-16 22:00:00	71.546	50.52
2015-04-16 23:00:00	71.456	50.08
2015-04-17 00:00:00	71.294	50.05
2015-04-17 01:00:00	71.276	50.22
2015-04-17 02:00:00	71.096	50.25
2015-04-17 03:00:00	70.934	50.29
2015-04-17 04:00:00	70.952	50.22
2015-04-17 05:00:00	70.79	50.32
2015-04-17 06:00:00	70.736	50.36
2015-04-17 07:00:00	70.772	49.91
2015-04-17 08:00:00	70.826	49.41
2015-04-17 09:00:00	70.826	48.79
2015-04-17 10:00:00	70.97	49
2015-04-17 11:00:00	70.808	49.27
2015-04-17 12:00:00	70.646	49.41
2015-04-17 13:00:00	70.88	49.64
2015-04-17 14:00:00	70.88	49.91
2015-04-17 15:00:00	70.844	49.88
2015-04-17 16:00:00	70.736	49.88
2015-04-17 17:00:00	70.826	50.05
2015-04-17 18:00:00	70.772	50.93
2015-04-17 19:00:00	70.862	50.08
2015-04-17 20:00:00	71.15	49.41
2015-04-17 21:00:00	71.042	49.27
2015-04-17 22:00:00	71.024	49
2015-04-17 23:00:00	71.096	49.34
2015-04-18 00:00:00	71.186	49.06
2015-04-18 01:00:00	71.132	49.1
2015-04-18 02:00:00	70.88	49.51
2015-04-18 03:00:00	70.628	49.61
2015-04-18 04:00:00	70.52	49.85
2015-04-18 05:00:00	70.502	50.02
2015-04-18 06:00:00	70.646	50.05
2015-04-18 07:00:00	70.466	50.08
2015-04-18 08:00:00	70.502	50.29
2015-04-18 09:00:00	70.232	50.83
2015-04-18 10:00:00	70.268	51.48
2015-04-18 11:00:00	69.98	51.34
2015-04-18 12:00:00	69.89	51.68
2015-04-18 13:00:00	69.926	52.02
2015-04-18 14:00:00	69.746	52.09
2015-04-18 15:00:00	70.142	51.41
2015-04-18 16:00:00	70.466	50.93
2015-04-18 17:00:00	70.682	50.87
2015-04-18 18:00:00	70.934	50.12
2015-04-18 19:00:00	71.114	49.71
2015-04-18 20:00:00	71.312	49.44

2015-04-18 21:00:00	71.582	48.99
2015-04-18 22:00:00	71.582	48.41
2015-04-18 23:00:00	71.654	47.9
2015-04-19 00:00:00	71.744	47.91
2015-04-19 01:00:00	71.6	47.16
2015-04-19 02:00:00	71.528	46.65
2015-04-19 03:00:00	71.276	46.85
2015-04-19 04:00:00	71.042	46.79
2015-04-19 05:00:00	71.024	46.96
2015-04-19 06:00:00	70.862	47.2
2015-04-19 07:00:00	70.844	47.23
2015-04-19 08:00:00	70.718	47.27
2015-04-19 09:00:00	70.52	47.33
2015-04-19 10:00:00	70.25	47.64
2015-04-19 11:00:00	70.016	47.91
2015-04-19 12:00:00	70.052	47.98
2015-04-19 13:00:00	69.998	49.1
2015-04-19 14:00:00	70.358	48.69
2015-04-19 15:00:00	70.664	47.81
2015-04-19 16:00:00	70.826	46.79
2015-04-19 17:00:00	70.772	42.61
2015-04-19 18:00:00	70.826	42.89
2015-04-19 19:00:00	70.934	43.6
2015-04-19 20:00:00	71.258	40.91
2015-04-19 21:00:00	71.24	38.98
2015-04-19 22:00:00	71.15	37.69
2015-04-19 23:00:00	71.186	35.48
2015-04-20 00:00:00	71.114	34.67
2015-04-20 01:00:00	71.132	34.5
2015-04-20 02:00:00	70.988	33.72
2015-04-20 03:00:00	70.754	33.31
2015-04-20 04:00:00	70.538	32.77
2015-04-20 05:00:00	70.502	31.58
2015-04-20 06:00:00	70.448	31.17
2015-04-20 07:00:00	70.466	30.49
2015-04-20 08:00:00	70.286	29.95
2015-04-20 09:00:00	70.034	29.95
2015-04-20 10:00:00	69.962	29.54
2015-04-20 11:00:00	69.872	28.69
2015-04-20 12:00:00	69.908	27.71
2015-04-20 13:00:00	69.926	26.86
2015-04-20 14:00:00	69.854	26.83
2015-04-20 15:00:00	69.854	26.86
2015-04-20 16:00:00	69.908	26.32
2015-04-20 17:00:00	69.962	25.53
2015-04-20 18:00:00	70.016	26.45
2015-04-20 19:00:00	69.818	28.79
2015-04-20 20:00:00	70.286	30.12
2015-04-20 21:00:00	70.664	30.32
2015-04-20 22:00:00	70.808	30.9
2015-04-20 23:00:00	70.61	30.22
2015-04-21 00:00:00	70.43	29.71
2015-04-21 01:00:00	70.484	30.19
2015-04-21 02:00:00	70.412	30.19

2015-04-21 03:00:00	70.214	30.49
2015-04-21 04:00:00	70.16	31.31
2015-04-21 05:00:00	70.07	32.56
2015-04-21 06:00:00	70.178	32.84
2015-04-21 07:00:00	70.142	34.33
2015-04-21 08:00:00	70.088	34.3
2015-04-21 09:00:00	70.016	34.74
2015-04-21 10:00:00	69.836	35.76
2015-04-21 11:00:00	69.746	35.76
2015-04-21 12:00:00	69.782	36.71
2015-04-21 13:00:00	69.836	37.15
2015-04-21 14:00:00	69.8	38.71
2015-04-21 15:00:00	69.782	40.58
2015-04-21 16:00:00	69.836	41.12
2015-04-21 17:00:00	69.998	41.7
2015-04-21 18:00:00	70.052	41.7
2015-04-21 19:00:00	70.052	43.43
2015-04-21 20:00:00	70.448	44.45
2015-04-21 21:00:00	70.79	43.43
2015-04-21 22:00:00	70.916	44.31
2015-04-21 23:00:00	70.79	44.48
2015-04-22 00:00:00	70.682	44.62
2015-04-22 01:00:00	70.61	44.96
2015-04-22 02:00:00	70.556	45.3
2015-04-22 03:00:00	70.448	45.67
2015-04-22 04:00:00	70.34	45.91
2015-04-22 05:00:00	70.358	45.91
2015-04-22 06:00:00	70.484	46.21
2015-04-22 07:00:00	70.394	46.59
2015-04-22 08:00:00	70.394	47.23
2015-04-22 09:00:00	70.394	47.57
2015-04-22 10:00:00	70.376	47.64
2015-04-22 11:00:00	70.286	47.81
2015-04-22 12:00:00	70.16	47.81
2015-04-22 13:00:00	69.98	48.96
2015-04-22 14:00:00	70.124	48.18
2015-04-22 15:00:00	70.322	48.86
2015-04-22 16:00:00	70.43	48.08
2015-04-22 17:00:00	70.304	47.78
2015-04-22 18:00:00	70.412	47.88
2015-04-22 19:00:00	70.772	47.71
2015-04-22 20:00:00	70.88	46.93
2015-04-22 21:00:00	70.7	47.2
2015-04-22 22:00:00	70.538	46.65
2015-04-22 23:00:00	70.484	46.59
2015-04-23 00:00:00	70.322	46.11
2015-04-23 01:00:00	70.16	45.16
2015-04-23 02:00:00	70.088	43.94
2015-04-23 03:00:00	69.98	43.23
2015-04-23 04:00:00	69.854	43.53
2015-04-23 05:00:00	69.98	44.55
2015-04-23 06:00:00	70.034	45.37
2015-04-23 07:00:00	70.124	46.08
2015-04-23 08:00:00	69.98	47.03

2015-04-23 09:00:00	69.926	47.54
2015-04-23 10:00:00	69.872	47.71
2015-04-23 11:00:00	69.818	47.64
2015-04-23 12:00:00	69.872	48.22
2015-04-23 13:00:00	69.8	48.35
2015-04-23 14:00:00	70.178	48.05
2015-04-23 15:00:00	70.088	47.81
2015-04-23 16:00:00	69.836	48.96
2015-04-23 17:00:00	69.998	50.15
2015-04-23 18:00:00	70.196	48.76
2015-04-23 19:00:00	70.43	47.33
2015-04-23 20:00:00	70.466	46.96
2015-04-23 21:00:00	70.538	46.66
2015-04-23 22:00:00	70.502	46.25
2015-04-23 23:00:00	70.484	46.59
2015-04-24 00:00:00	70.466	46.59
2015-04-24 01:00:00	70.322	46.76
2015-04-24 02:00:00	70.142	46.79
2015-04-24 03:00:00	69.926	46.83
2015-04-24 04:00:00	69.962	46.86
2015-04-24 05:00:00	69.8	46.89
2015-04-24 06:00:00	69.746	46.99
2015-04-24 07:00:00	69.656	47.1
2015-04-24 08:00:00	69.512	47.16
2015-04-24 09:00:00	69.53	47.2
2015-04-24 10:00:00	69.404	47.3
2015-04-24 11:00:00	69.314	47.67
2015-04-24 12:00:00	69.26	47.74
2015-04-24 13:00:00	69.206	48.05
2015-04-24 14:00:00	69.224	48.39
2015-04-24 15:00:00	69.368	48.46
2015-04-24 16:00:00	69.404	48.56
2015-04-24 17:00:00	69.296	48.46
2015-04-24 18:00:00	69.224	48.49
2015-04-24 19:00:00	69.494	48.39
2015-04-24 20:00:00	69.908	47.91
2015-04-24 21:00:00	70.124	47.5
2015-04-24 22:00:00	70.196	47.61
2015-04-24 23:00:00	70.232	47.16
2015-04-25 00:00:00	70.142	46.99
2015-04-25 01:00:00	70.07	46.89
2015-04-25 02:00:00	70.07	47.06
2015-04-25 03:00:00	69.836	48.42
2015-04-25 04:00:00	69.692	48.01
2015-04-25 05:00:00	69.656	46.96
2015-04-25 06:00:00	69.512	45.57
2015-04-25 07:00:00	69.458	42.95
2015-04-25 08:00:00	69.278	41.97
2015-04-25 09:00:00	69.368	43.4
2015-04-25 10:00:00	69.782	44.04
2015-04-25 11:00:00	70.16	44.72
2015-04-25 12:00:00	70.232	45.26
2015-04-25 13:00:00	70.34	45.43
2015-04-25 14:00:00	70.358	45.4

2015-04-25 15:00:00	70.484	45.74
2015-04-25 16:00:00	70.52	45.23
2015-04-25 17:00:00	70.61	45.98
2015-04-25 18:00:00	70.628	45.91
2015-04-25 19:00:00	70.52	46.35
2015-04-25 20:00:00	70.358	46.83
2015-04-25 21:00:00	70.502	46.89
2015-04-25 22:00:00	70.448	47.16
2015-04-25 23:00:00	70.538	46.76
2015-04-26 00:00:00	70.574	46.45
2015-04-26 01:00:00	70.556	46.35
2015-04-26 02:00:00	70.412	46.76
2015-04-26 03:00:00	70.304	47.4
2015-04-26 04:00:00	70.232	47.74
2015-04-26 05:00:00	70.232	47.91
2015-04-26 06:00:00	70.214	48.08
2015-04-26 07:00:00	70.178	48.25
2015-04-26 08:00:00	70.088	48.42
2015-04-26 09:00:00	69.908	48.46
2015-04-26 10:00:00	70.052	48.66
2015-04-26 11:00:00	69.818	48.69
2015-04-26 12:00:00	69.692	48.49
2015-04-26 13:00:00	69.566	48.29
2015-04-26 14:00:00	69.908	48.08
2015-04-26 15:00:00	70.754	47.95
2015-04-26 16:00:00	70.934	47.54
2015-04-26 17:00:00	71.078	47.4
2015-04-26 18:00:00	71.006	49
2015-04-26 19:00:00	71.132	47.91
2015-04-26 20:00:00	71.114	47.06
2015-04-26 21:00:00	71.204	46.62
2015-04-26 22:00:00	71.294	46.48
2015-04-26 23:00:00	71.042	47.16
2015-04-27 00:00:00	70.88	47.3
2015-04-27 01:00:00	70.574	47.2
2015-04-27 02:00:00	70.592	47.06
2015-04-27 03:00:00	70.556	47.03
2015-04-27 04:00:00	70.484	46.96
2015-04-27 05:00:00	70.394	46.55
2015-04-27 06:00:00	70.34	46.69
2015-04-27 07:00:00	70.196	47.23
2015-04-27 08:00:00	70.214	47.67
2015-04-27 09:00:00	70.106	47.5
2015-04-27 10:00:00	70.106	46.96
2015-04-27 11:00:00	70.016	46.18
2015-04-27 12:00:00	70.214	45.7
2015-04-27 13:00:00	70.628	46.18
2015-04-27 14:00:00	70.88	46.28
2015-04-27 15:00:00	70.826	46.48
2015-04-27 16:00:00	70.898	46.59
2015-04-27 17:00:00	70.88	46.28
2015-04-27 18:00:00	70.736	45.81
2015-04-27 19:00:00	70.808	45.16
2015-04-27 20:00:00	70.79	44.28

2015-04-27 21:00:00	70.646	43.46
2015-04-27 22:00:00	70.628	42.72
2015-04-27 23:00:00	70.628	42.51
2015-04-28 00:00:00	70.664	42.72
2015-04-28 01:00:00	70.7	42.92
2015-04-28 02:00:00	70.682	42.95
2015-04-28 03:00:00	70.7	42.85
2015-04-28 04:00:00	70.484	42.75
2015-04-28 05:00:00	70.43	42.92
2015-04-28 06:00:00	70.07	42.92
2015-04-28 07:00:00	69.998	42.55
2015-04-28 08:00:00	69.908	42.85
2015-04-28 09:00:00	69.71	43.26
2015-04-28 10:00:00	69.692	42.95
2015-04-28 11:00:00	69.8	42.65
2015-04-28 12:00:00	69.584	42.68
2015-04-28 13:00:00	69.242	41.63
2015-04-28 14:00:00	69.368	42.28
2015-04-28 15:00:00	69.53	42.82
2015-04-28 16:00:00	69.296	41.05
2015-04-28 17:00:00	69.62	40.1
2015-04-28 18:00:00	69.188	38.2
2015-04-28 19:00:00	69.278	36.91
2015-04-28 20:00:00	69.458	38.61
2015-04-28 21:00:00	69.332	41.05
2015-04-28 22:00:00	69.332	41.94
2015-04-28 23:00:00	69.44	41.56
2015-04-29 00:00:00	69.512	41.7
2015-04-29 01:00:00	69.368	41.36
2015-04-29 02:00:00	69.296	41.29
2015-04-29 03:00:00	69.278	40.95
2015-04-29 04:00:00	69.278	40.71
2015-04-29 05:00:00	69.332	40.2
2015-04-29 06:00:00	69.188	39.97
2015-04-29 07:00:00	69.224	39.19
2015-04-29 08:00:00	69.08	38.98
2015-04-29 09:00:00	69.134	39.93
2015-04-29 10:00:00	69.17	41.53
2015-04-29 11:00:00	68.954	41.63
2015-04-29 12:00:00	68.954	39.39
2015-04-29 13:00:00	68.738	37.15
2015-04-29 14:00:00	69.188	38.47
2015-04-29 15:00:00	69.584	39.15
2015-04-29 16:00:00	69.494	40.07

APPENDIX D: A SURVEY EXAMPLE

Section 1. Background Information

1. Please select the choice(s) that best describes you:
   - ○ I am a full-time professional singer.
   - ○ I am a professional singer with another occupation.
   - ○ I am a student of voice.
   - ○ I consider myself an amateur singer.
   - ○ I am a retired singer.
   - ○ Other (please specify) _____

2. How many years of professional singing experience have you had? _____

3. How many years of training have you had? _____

4. What is your gender?
   - ○ Male
   - ○ Female

5. What is your age? _____

6. Which of the following voice types is closest to yours?
   - ○ Soprano
   - ○ Mezzo-soprano
   - ○ Contralto
   - ○ Tenor
   - ○ Baritone
   - ○ Bass

7. *Primarily*, which type of genre do you sing?
    - ○ Classical/Opera
    - ○ Pop/Country/Rock
    - ○ Jazz
    - ○ Other (please specify) _____

Section 2. Geographic Information

8. Where do you currently live (city, state, country)? _____
    - ○ I prefer not to answer.

9. Where were you born (city, state, country)? _____
    - ○ I prefer not to answer.

10. Where have you spent most of your life? (city, state, country)?_____
    - ○ I move too often to answer this question.
    - ○ I prefer not to answer.

11. Do you/did you often travel to perform?
    - ○ Yes
    - ○ No

12. If you answered "Yes" to Question 11, please list the last three locations you performed (city, state, country).

    _____

    _____

    _____

Section 3. Atmospheric Conditions Information: Temperature

13. Please indicate your level of agreement: Air temperature can have an impact on my vocal performance.
    - ○ Strongly agree
    - ○ Agree
    - ○ Somewhat agree
    - ○ Disagree
    - ○ Strongly disagree
    - ○ No opinion
    - ○ I don't know

14. Please briefly explain your choice for Question 13.

_____

_____

_____

_____

15. Have you ever refused to/been unable to perform due to air temperature conditions (too hot or too cold)?
    - ○ Yes
    - ○ No

16. If you answered "Yes" to Question 15, please briefly explain. Give dates and locations if possible.

_____

_____

_____

_____

17. Have you ever requested that a performance space be heated or cooled to a specific air temperature?
    - ○ Yes
    - ○ No

18. If you answered "Yes" to Question 17, please briefly explain. What air temperature did you request?

_____

_____

_____

_____

19. What measures, if any, do you take to protect your throat/voice from cold temperatures? (check all that apply)
    - ○ I wear a scarf.
    - ○ I try to avoid going outdoors.
    - ○ Other (please explain) _____
    - ○ I don't think about protecting my throat/voice from cold temperatures.
    - ○ Cold temperatures do not affect my voice.

Section 4. Atmospheric Conditions Information: Humidity

20. Please indicate your level of agreement: Air humidity (moist or dry) can have an impact on my vocal performance.
    - ○ Strongly agree
    - ○ Agree
    - ○ Somewhat agree
    - ○ Disagree
    - ○ Strongly disagree
    - ○ No opinion
    - ○ I don't know

21. Please briefly explain your choice for Question 20.

_____

_____

_____

_____

22. Have you ever refused to/been unable to perform due to air humidity conditions (too moist or too dry)?
    - ○ Yes
    - ○ No

23. If you answered "Yes" to Question 22, please briefly explain. Give dates and locations if possible.

_____

_____

_____

_____

24. Have you ever requested that a performance space be humidified?
    - ○ Yes
    - ○ No

25. If you answered "Yes" to Question 24, please briefly explain.

_____

_____

_____

_____

26. What measures, if any, do you take to protect your throat/voice from dry conditions? (check all that apply)
    - ○ I use a warm mist humidifier.
    - ○ I use a cool mist humidifier.
    - ○ I increase my fluid intake.
    - ○ Other (please explain) _____
    - ○ I don't think about protecting my throat/voice from dry conditions.
    - ○ My voice is not affected by dry conditions.

Section 5. Atmospheric Conditions Information: Altitude

27. Please indicate your level of agreement: Altitude can have an impact on my vocal performance.
    - ○ Strongly agree
    - ○ Agree
    - ○ Somewhat agree
    - ○ Disagree
    - ○ Strongly disagree
    - ○ No opinion
    - ○ I don't know

28. Please briefly explain your choice for Question 27.

_____

_____

_____

_____

29. Have you ever refused to/been unable to perform due to high altitude?
    - ○ Yes
    - ○ No

30. If you answered “Yes” to Question 29, please briefly explain. Give dates and locations if possible.

_____

_____

_____

_____

31. Have you ever requested additional oxygen before, during, or after a performance?

- ○ Yes
- ○ No

32. If you answered “Yes” to Question 31, please briefly explain.

_____

_____

_____

_____

33. What measures, if any, do you take to protect your body from high altitude effects?

- ○ I give myself time to acclimate before a performance. How long?_____
- ○ I increase my fluid intake.
- ○ Other (please explain) _____
- ○ I don’t think about protecting my body from high altitude effects.
- ○ I am not affected by high altitude.

Section 6. Venue and Comfort Information

34. Which of the following venue types do you have experience performing in?
    - ○ Outdoor only
    - ○ Indoor only
    - ○ Both

35. If you have performed in both, which do you prefer?
    - ○ Outdoor
    - ○ Indoor
    - ○ No opinion

36. What is the reason for your answer in Question 35?

_____

_____

_____

_____

37. If you travel often to perform, are there specific locations (cities) that you dislike performing in because of the climate/weather?
    - ○ Yes
    - ○ No
    - ○ No opinion

38. If you answered "Yes" to Question 37, please briefly explain. List specific locations (cities) if possible.

_____

_____

_____

_____

39. Which of the following *temperature* ranges would you feel <u>comfortable</u> singing in? (select all that apply)
    - ○ 0-10 degrees Fahr.
    - ○ 11-20 degrees Fahr.
    - ○ 21-30 degrees Fahr.
    - ○ 31-40 degrees Fahr.
    - ○ 41-50 degrees Fahr.
    - ○ 51-60 degrees Fahr.
    - ○ 61-70 degrees Fahr.
    - ○ 71-80 degrees Fahr.
    - ○ 81-90 degrees Fahr.
    - ○ 91-100 degrees Fahr.
    - ○ Specific temperature range_____
    - ○ I don't know
    - ○ No opinion

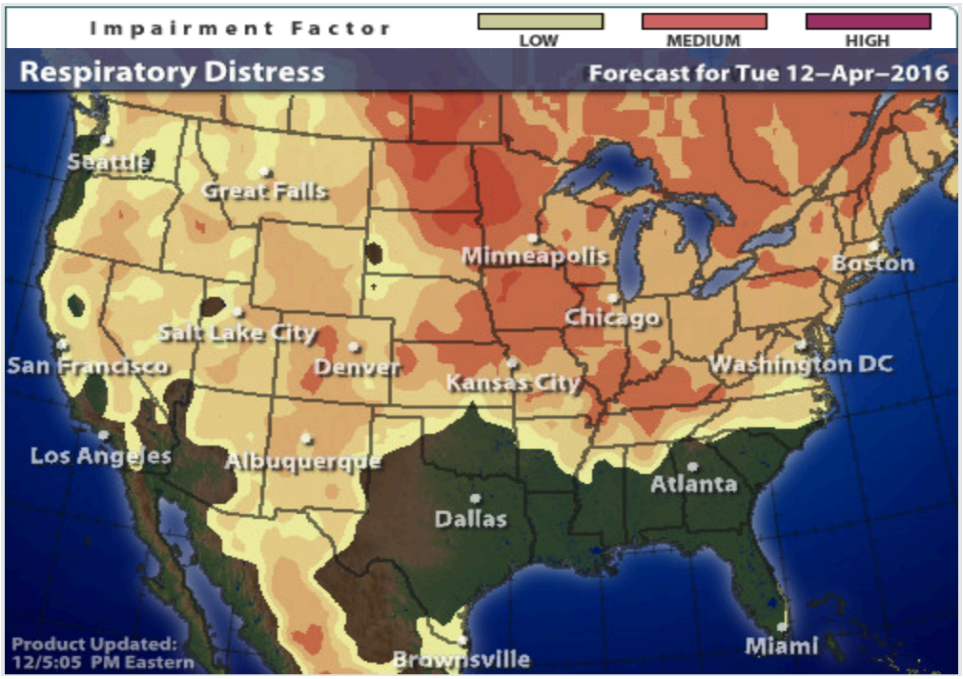
40. Which of the following *temperature* ranges would you feel <u>uncomfortable</u> singing in? (select all that apply)
    - ○ 0-10 degrees Fahr.
    - ○ 11-20 degrees Fahr.
    - ○ 21-30 degrees Fahr.
    - ○ 31-40 degrees Fahr.
    - ○ 41-50 degrees Fahr.
    - ○ 51-60 degrees Fahr.
    - ○ 61-70 degrees Fahr.
    - ○ 71-80 degrees Fahr.
    - ○ 81-90 degrees Fahr.
    - ○ 91-100 degrees Fahr.
    - ○ Specific temperature range_____
    - ○ I don't know
    - ○ No opinion

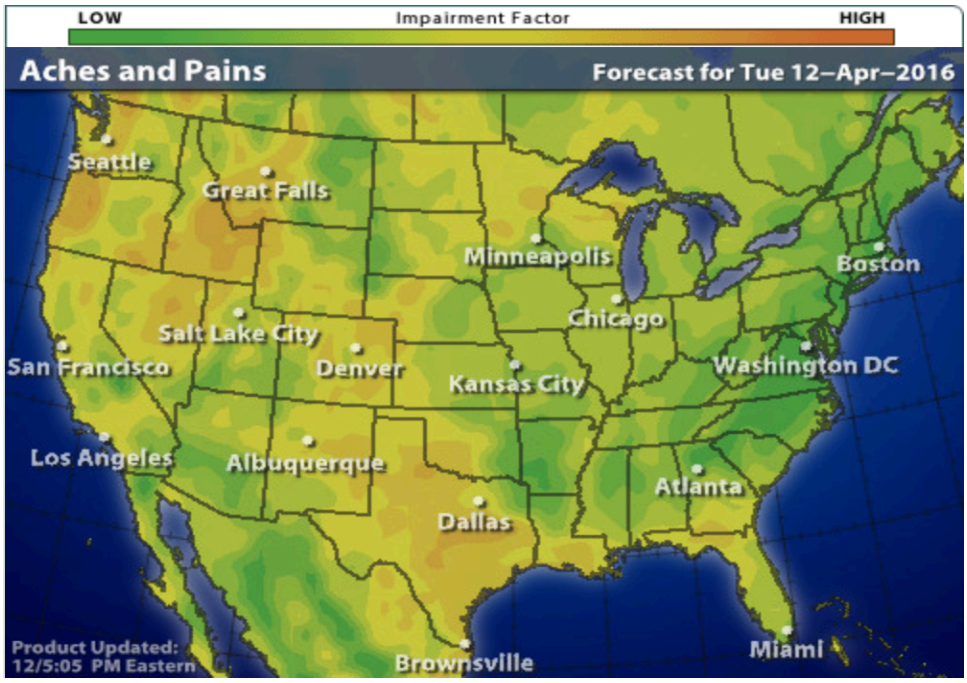
41. Which of the following *humidity* ranges would you feel comfortable singing in? (select all that apply)
    - ○ 0-10% Relative Humidity (RH)
    - ○ 11-20% RH
    - ○ 21-30% RH
    - ○ 31-40% RH
    - ○ 41-50% RH
    - ○ 51-60% RH
    - ○ 61-70% RH
    - ○ 71-80% RH
    - ○ 81-90% RH
    - ○ 91-100% RH
    - ○ Specific RH range _____
    - ○ I don't know
    - ○ No opinion

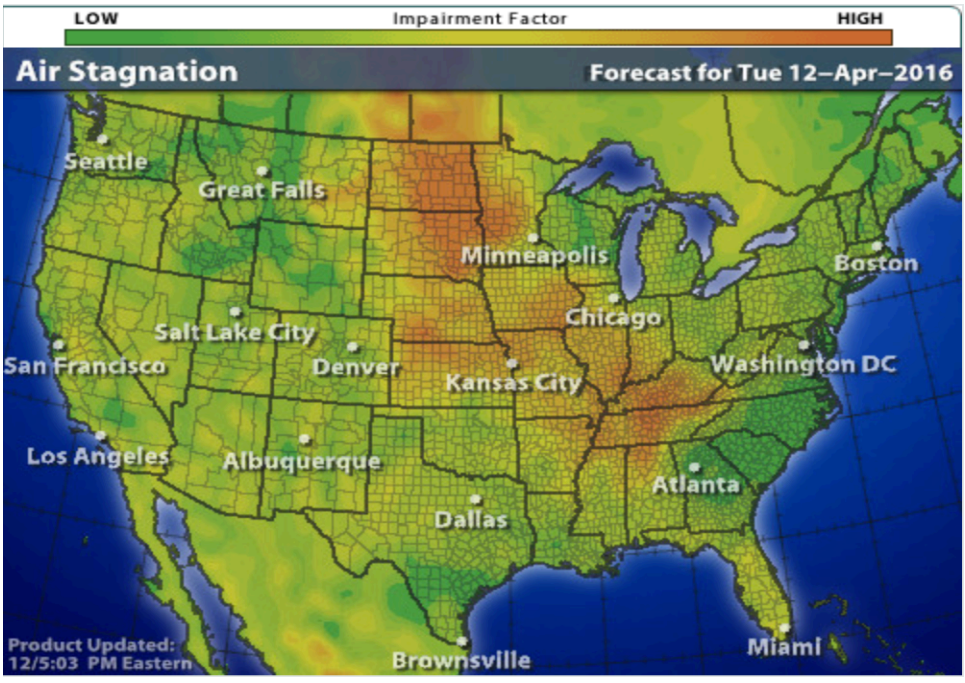
42. Which of the following *humidity* ranges would you feel uncomfortable singing in? (select all that apply)
    - ○ 0-10% Relative Humidity (RH)
    - ○ 11-20% RH
    - ○ 21-30% RH
    - ○ 31-40% RH
    - ○ 41-50% RH
    - ○ 51-60% RH
    - ○ 61-70% RH
    - ○ 71-80% RH
    - ○ 81-90% RH
    - ○ 91-100% RH
    - ○ Specific RH range _____
    - ○ I don't know
    - ○ No opinion

43. Are there any other specific situations in which weather and/or climate, including temperature and/or humidity conditions indoors and/or outdoors, affected your singing ability/performance? Please describe. If possible, include locations and dates. Feel free to use the back of this page if necessary.

APPENDIX E: SAMPLE OF MAPS FROM INTELLICAST.COM




LOW
Impairment Factor
HIGH
Aches and Pains
Forecast for Tue 12–Apr–2016
Seattle
Great Falls
Minneapolis
Boston
Chicago
Salt Lake City
San Francisco
Denver
Kansas City
Washington DC
Los Angeles
Albuquerque
Atlanta
Dallas
Product Updated:
12/5:05 PM Eastern
Brownsville
Miami


LOW
Impairment Factor
HIGH
Air Stagnation
Forecast for Tue 12–Apr–2016
Seattle
Great Falls
Minneapolis
Boston
Chicago
Salt Lake City
San Francisco
Denver
Kansas City
Washington DC
Los Angeles
Albuquerque
Atlanta
Dallas
Product Updated:
12/5:03 PM Eastern
Brownsville
Miami

MAP DESCRIPTIONS, TAKEN DIRECTLY FROM INTELLICAST.COM

Current Conditions Map: Composite National Current Weather Map displaying GOES-EAST Infra-red (IR) Satellite, WSI's NOWrad National Radar Mosaic and Current Surface Temperatures in Degrees Fahrenheit for Major Metropolitan Cities. Data is updated hourly to indicate current conditions.

Weather most often results from temperature differences from one place to another. On large scales, temperature differences occur because areas closer to the equator receive more energy per unit area from the Sun than do regions closer to the poles. On local scales, temperature differences can occur because different surfaces (such as oceans, forests, ice sheets, or man-made objects) have differing physical characteristics such as reflectivity, roughness, or moisture content.

Surface temperature differences in turn cause pressure differences. A hot surface heats the air above it and the air expands, lowering the air pressure. The resulting horizontal pressure gradient accelerates the air from high to low pressure, creating wind, and Earth's rotation then causes curvature of the flow via the Coriolis effect. The simple systems thus formed can then display emergent behaviour to produce more complex systems and thus other weather phenomena. Large-scale examples include the Hadley cell while a smaller scale example would be coastal breezes.

The strong temperature contrast between polar and tropical air gives rise to the jet stream. Most weather systems in the mid-latitudes are caused by instabilities of the jet weather. Weather systems in the tropics are caused by different processes, such as monsoons or organized thunderstorm systems.

The Respiratory Distress map shows areas where weather will potentially impact for the current day those with respiratory distress.

The Aches and Pains map shows areas where weather is likely to cause aches and pains. There has long been said to be a link between "rheumatic" pain and the weather. There appears to be no firm evidence in favour or against, but a 1995 questionnaire given to 557 people by A. Naser and others at the Brigham and Women's Hospital's Pain Management Center concludes that "changes in barometric pressure are the main link between weather and pain. Low pressure is generally associated with cold, wet weather and an increase in pain. Clear, dry conditions signal high pressure and a decrease in pain.

The Air Stagnation map shows areas where the atmosphere is likely to have more or less air stagnation for the current day. This affects air quality in that region, particularly in urban areas. Air stagnation is a phenomenon which occurs when the same air mass remains over an area for an extended period of time. Usually this is because light winds and a lack of precipitation cannot "clean" the air of pollutants, either gaseous (like ozone) or particulate (like soot or dust). In the United States, the National Weather Service issues an Air Stagnation Advisory when these conditions are likely to occur.