

# OSCER State of the Center

**Henry Neeman, Director**

**OU Supercomputing Center for Education & Research  
A Division of OU Information Technology**

[hneeman@ou.edu](mailto:hneeman@ou.edu)



Wednesday September 23 2015  
University of Oklahoma





# Use Our Ugly Symposium Website!

Our ugly Symposium website

<http://symposium2015.oscer.ou.edu/>

has pretty complete agenda and speaker information, and is so ugly that it's actually reasonably optimized for handhelds like phones and tablets.

We encourage you to use it!



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Wed Sep 23 2015





# Preregistration Profile 2015

- **Organizations**: 78 preregistered (or speaking)
  - **Academic**: preregistered 36 institutions in 12 states (AR,IN,KS,LA,MO,ND,NE,NJ,OK,SD,TN,TX)
    - Includes 28 institutions in 8 EPSCoR states (AR,KS,LA,MO,ND,NE,OK,SD)
  - **Industry**: preregistered 28 private companies
  - **Government**: preregistered 9 agencies (federal, state)
  - **Non-governmental**: preregistered 6 organizations
- **Demographics**: 319 preregistered (and/or speaking)
  - 28% OU, 72% non-OU (or unknown)
  - 68% Oklahoma, 32% non-Oklahoma (or unknown)
  - 83% from EPSCoR states, 17% non-EPSCoR (or unknown)
  - 64% academic, 36% non-academic (or unknown)



# Attendee Profile 2002-2014

- Over 3300 attendees at the previous 13 Symposia
  - 69 in 2002, 225-325 per year thereafter, usually 275 $\pm$ 25
- Organizations: 312 through 2014
  - **Academic**: from 112 institutions in 27 US states & territories
    - 70 institutions in 14 EPSCoR jurisdictions
    - 32 institutions in Oklahoma
      - PhD-granting, masters-granting, bachelors-granting, community colleges, career techs, high school
      - Historically Black University, Tribal College, 3 Native American Serving Non-tribal Institutions
      - public, private, for-profit
  - **Industry**: attendees from 143 firms
  - **Government**: attendees from 37 agencies (federal, state, municipal, foreign)
  - **Non-governmental/nonprofit**: attendees from 20 organizations

# Symposium 2015 Sponsors: Thank You!

- Academic sponsor (1)
  - Great Plains Network
- Industry sponsors (17/18)
  - Platinum (1): Intel + HP
  - Gold (7): Arista Networks, **Brocade**/Lumenate, Dell, Mellanox Technologies, NVIDIA, **Quantum**, **Qumulo**
  - Silver (4): Cray, DataDirect Networks, SGI, Spectra Logic
  - Bronze (5/6): Adaptive Computing, Advanced Clustering Technologies, Aspen Systems, **Penguin**, **Pinnacle**/EMC

Thank you all! Without you, the Symposium couldn't happen. Over the past 14 Symposia, we've had a total of 84 companies as sponsors – and more than half have repeated (or were acquired by/merged with other sponsors).



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# Thanks!

## ■ OU IT

- OU CIO/VPIT Loretta Early
- Symposium committee: Josh Alexander (OU), Dana Brunson (OSU), Debi Gentis (OU), George Louthan (OII), Franklin Fondjo Fotou (LU), Joel Snow (LU), Karl Frinkle (SE), Evan Lemley (UCO)
- Symposium coordinator: Debi Gentis
- Sponsorship coordinator: Chance Grubb
- OSCER Operations Team: Dave Akin, Brett Zimmerman, Josh Alexander, Patrick Calhoun
- All of the OU IT folks who helped put this together

## ■ CCE Forum

- Jake Maurer, Kristin Livingston
- The whole Forum crew who helped put this together



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# Thanks: Plenary Speakers

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- Jim Kurose, NSF Computer & Information Science & Engineering Directorate
- Carl Grant (OU), Adrian Alexander (TU), Jennifer Fitzgerald (Noble), Mark Laufersweiler (OU), Robin Leech (OSU), Habib Tabatabai (UCO)
- Monica Martinez-Canales, Intel & Stephen Wheat, HP (Platinum sponsors)



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# Thanks: Gold Sponsor Speakers

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- Mickey Stewart, Arista Networks
- Dan DeBacker, Brocade Communications Systems Inc.
- DJ Spry, Dell
- Kashif Chauhan & D. Kent Snider, Mellanox Technologies
- Bob Crovella, NVIDIA
- Neal Wingenbach, Quantum
- Bob Collins, Qumulo



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# Thanks: Breakout Speakers

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1. Kate Adams, GPN
2. Dan Andresen, KSU
3. Joseph Babb, Tinker AFB
4. Dana Brunson, OSU
5. Eduardo Colmenares, MWSU
6. Nick Davis, OU Tulsa
7. Kendra Dresback, OU
8. Jim Ferguson, NICS
8. Karl Frinkle & Mike Morris, SEOSU
9. John Hale, Peter Hawrylak, Andrew Kongs, TU
10. Utkarsh Kapoor, OSU
11. Scott Lathrop, XSEDE/Shodor
12. David Monismith
13. Mukundhan Selvam, WSU
14. Dan Stanzione, TACC



# Thanks!

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To all of you for participating, and to those many of you who've shown us so much loyalty over the past 13 years.



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# Outline

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- OU
  - Resources
  - Accomplishments
- OCII/OneOCII



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# Resources





# OLD Dell Intel Xeon Linux Cluster

874 Intel Xeon CPU chips/6992 cores

Photo: Jawanza Bassue

412 dual socket/oct core Sandy Bridge 2.0 GHz, 32 GB

23 dual socket/oct core Sandy Bridge 2.0 GHz, 64 GB

1 quad socket/oct core Westmere, 2.13 GHz, 1 TB

15,680 GB RAM

~360 TB global disk

QLogic Infiniband

(16.67 Gbps, ~1 microsec latency)

Dell Force10 Gigabit/10G Ethernet

Red Hat Enterprise Linux 6

Peak speed: 110.6 TFLOPs\*

\*TFLOPs: trillion calculations per second



Just over 3x (300%) as fast as our 2008-12 supercomputer.

[boomer.oscer.ou.edu](http://boomer.oscer.ou.edu)

Just over 100x (10,000%) as fast as our first cluster supercomputer in 2002.



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# OLD Dell Intel Xeon Linux Cluster

874 Intel Xeon CPU chips/6992 cores

Photo: Jawanza Bassue

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Dell Force10 Gigabit/10G Ethernet

Red Hat Enterprise Linux 6

Peak speed: 110.6 TFLOPs\*

\*TFLOPs: trillion calculations per second



19% of the nodes are

“condominium” (owned by individual research teams): ~4x as many as all OSCER’s previous clusters combined.

[boomer.oscer.ou.edu](http://boomer.oscer.ou.edu)



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# Schooner: non-condominium nodes

- Compute nodes, non-condominium
  - 268 x R430, dual E5-2650v3 10-core 2.3 GHz, 32 GB RAM
  - 46 x R430, dual E5-2670v3 12-core 2.3 GHz, 64 GB RAM
- Accelerator-capable nodes, non-condominium
  - 28 x R730, dual E5-2650v3 10-core 2.3 GHz, 32 GB RAM
  - 8 x R730, dual E5-2670v3 12-core 2.3 GHz, 64 GB RAM
- Large RAM node, non-condominium
  - 1 x R930, quad E7-4809v3 8-core 2.0 GHz, 1024 GB RAM
- Accelerators, non-condominium
  - 6 x NVIDIA K20M
  - 24 x Intel Xeon Phi 31S1P
- Subtotal peak CPU speed, non-condominium: 266.57 TFLOPs



# Schooner: non-condominium other

- Interconnects
  - Infiniband: Mellanox FDR10 3:1 oversubscribed
  - Ethernet: GigE downlinks to nodes, 10GE uplinks to core
- Storage (user-accessible)
  - DataDirect Networks SFA7700X w/70 x 6 TB = ~300 TB useable
  - 6 x home/scratch 12 x 6 TB = ~291 TB useable





# Schooner: Old Condominium

As an experiment, we're transferring condominium nodes from Boomer over to Schooner.

- Compute nodes, condominium, old
  - 73 x R620, dual E5-2650 (Sandy Bridge), oct core, 2.0 GHz
- Accelerator-capable nodes, condominium, old
  - 6 x R720, dual E5-2650, oct core, 2.0 GHz
- Accelerators, condominium, old
  - 12 x NVIDIA M2075
  - 6 x NVIDIA K20M
- Storage, diskfull nodes, condominium, old
  - 4 x R720xd, 12 x 3 TB = ~19 TB useable each
- Subtotal peak CPU speed, old condominium: 20.22 TFLOPs



# Schooner: New Condominium

- Compute nodes, condominium, new
  - 6 x R430, dual E5-2650Lv3 12-core 1.8 GHz, 64 GB RAM
  - 39 x R430, dual E5-2670v3 12-core 2.3 GHz, 64 GB RAM
- Accelerator-capable nodes, condominium, new
  - 1 x R730, dual E5-2650v3 10-core 2.3 GHz, 32 GB RAM
  - 3 x R730, dual E5-2670v3 12-core 2.3 GHz, 64 GB RAM
- Accelerators
  - 8 x NVIDIA K20M
- Storage nodes, condominium, new
  - 1 x T630, 16 x 6 TB, 128 GB RAM, ~N TB useable each
  - 1 x T630, 16 x 8 TB, 128 GB RAM, ~N TB useable each
- Subtotal peak CPU speed, new condominium: 41.98 TFLOPs



# Schooner: Peak Speed

- Subtotal peak CPU speed, non-condominium: 266.57 TFLOPs
- Subtotal peak CPU speed, old condominium: 20.22 TFLOPs
- Subtotal peak CPU speed, new condominium: 41.98 TFLOPs
- Total peak CPU speed, public + old condominium + new condominium: 328.78 TFLOPs
- Schooner will be ~3 times as fast as Boomer.
- As on Boomer, roughly 19% of Schooner's peak speed will be condominium.



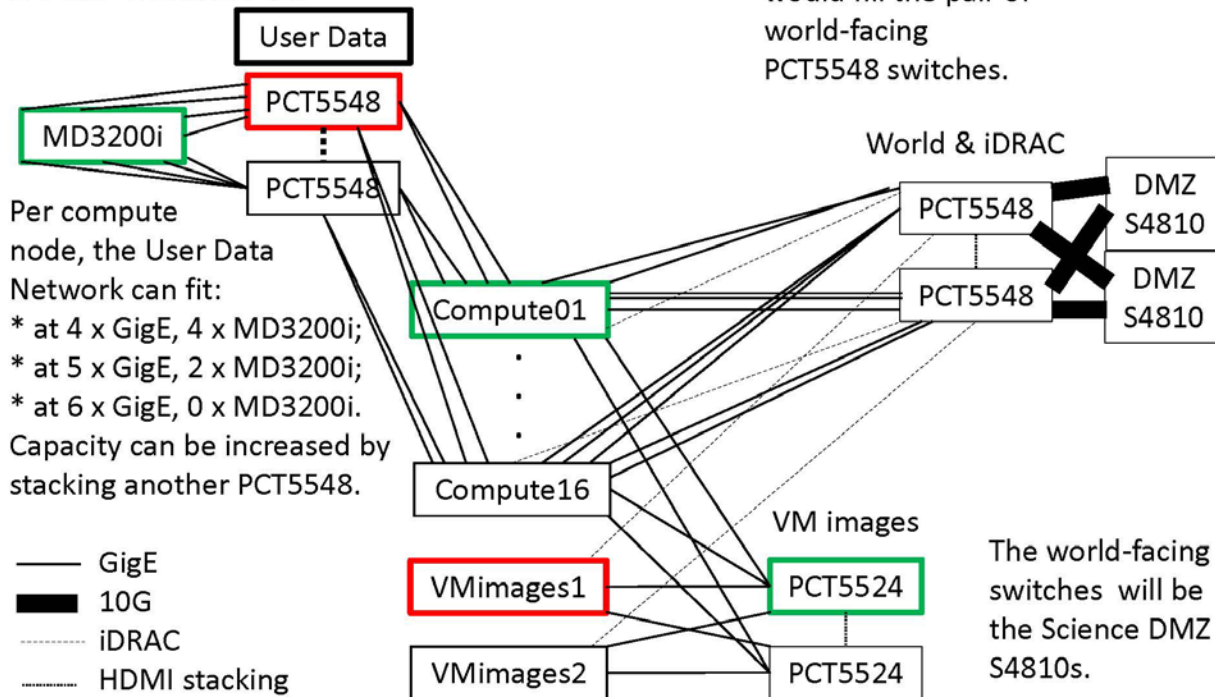
# OURcloud

## OU Research Cloud

(virtualized server pool)

Draft 4/23/2013

5 x GigE + 1 x iDRAC  
per compute node  
would fill the pair of  
world-facing  
PCT5548 switches.



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# OURcloud



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# Oklahoma PetaStore

A mix of disk and tape, available to researchers at OU (and statewide), with a unique business model that makes long term archival storage affordable.





# OSCER Personnel

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- Director: Henry Neeman
- Associate Director for Remote & Heterogeneous Computing: Horst Severini
- Manager of Operations: Brett Zimmerman
- Senior System Administrator: David Akin
- HPC Application Software Specialist: Josh Alexander
- Research IT Coordinator: Debi Gentis
- Petascale Storage Administrator: Patrick Calhoun
- Student Tech: Katy Franks
- Informatics: Mark Stacy



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# Accomplishments





# External Research Grants

1. J. van de Lindt, B. Ellingwood, A. Cerato, N. Wang, C. Nicholson et al, "NIST Center for Risk-Based Community Resilience Planning," \$1.37M
2. J. van de Lindt, A. Cerato, N. Wang, "A Risk-Informed Decision Framework to Achieve Resilient and Sustainable Buildings that Meet Community Objectives," NSF, \$380K
3. J. Straka, K. Kanak, "Challenges in understanding tornadogenesis and associated phenomena," NSF, \$750K
4. J. Straka, "Challenges in understanding tornadogenesis and associated phenomena (supplement)," NSF, \$29K
5. P. Kirstetter, B. L. Cheong, T.-Y. Yu, "Deployment of a Novel Solid-state Polarimetric Weather Radar for Hydrology," NSF, \$87K
6. B. L. Cheong, R. D. Palmer, "Development of a Novel Solid-State Polarimetric Weather Radar PX-10,000," Nanowave Technologies, Inc., \$550,000,
7. K. Nicholas, "Catalytic Deoxydehydration," DOE, \$438K
8. M. Libault, "CAREER: Exploring the Transcriptional Regulatory Networks Controlling the Early Stages of Legume Nodulation," NSF, \$1.1M
9. B. Shiau, D. Papavassiliou, J. Harwell, "Interfacially active SWNT/silica nanohybrids," Advanced Energy Consortium, \$419K
10. S. Crowell, B. Moore, Y. Luo, "Improved Parameterization of Carbon Cycle Models Across Scales Using OCO-2 Measurements of XCO2 and SIF," NASA, \$477K
11. B. Wawrik, "MGMIC: Metagenome Analysis for Corrosion Tracking," OU Biocorrosion Center, \$131K
12. B. Wawrik, A. Callaghan, "Development of Techniques for the Quantification of Functional Gene Expression Associated with Biocorrosion," OU Biocorrosion Center, \$37K
13. B. Wawrik, D. Bronk, "Collaborative Research: Determining Rates of Group-specific Phytoplankton and Bacterial Uptake of Inorganic and Organic Nitrogen by means of Stable Isotope Techniques," NSF, \$770K
14. A. Callaghan, B. Wawrik, J. Suflita, "Biochemistry and Genetics of Anaerobic Alkane Metabolism: Interrogation of Sulfate-Reducing Isolates and Enrichments Using Genome-Enabled and Proteomic Approaches," NSF, \$725K
15. B. Wawrik, "Determining Rates of Group-specific Phytoplankton and Bacterial Uptake of Inorganic and Organic Nitrogen by Means of Stable Isotope Techniques," NSF, \$10K

**OSCER-FACILITATED FUNDING TO DATE:**

**\$291M total, \$174M to OU**

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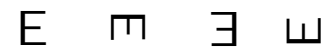


# External Research Grants (cont'd)

16. B. Wawrik, G. Sinclair, "Transcriptomic Response to Nutrient Depletion of Marine Dinoflagellates," Gordon and Betty Moore Foundation, \$70K in-kind
17. Joseph M. Suflita. Co-PIs: A. Callaghan, L. Gieg, Z. He, B. Wawrik, J. Zhou, "Extending Knowledge of Anaerobic Hydrocarbon Metabolism: Linking Metabolism, Functional Gene Molecular Markers and the GeoChip," ConocoPhillips, \$999K
18. A. Striolo, "Anti-Agglomerants Performance in Hydrates Management: Fundamental Insights," EPSRC, £330K
19. A. Striolo et al, "ShaleXenvironment," European Commission, €3M
20. A. Striolo, "Flow Transport in Shale Rocks," Halliburton, £69K
21. A. Striolo, D. Cole, "Nanopore Confinement of C-H-(O) Mixed-Volatile Fluids Relevant to Subsurface Energy Systems," DOE, £60K
22. A. Striolo, "Hydrates Inhibitor Research," Halliburton, £69K
23. A. Striolo, "Fracking Fundamentals," Marie Curie Career Integration Grant, €100K
24. J. Li, "Targeting Mosquito FREP1 Protein for Malaria Control," NIH, \$424K
25. J. Li, "CAREER: Genetic and Molecular Mechanisms of Parasite Infection in Insects," NSF, \$783K
26. D. Atkins, J. Li, "Memory T cell-mediated protecting against malaria," NIH, \$76K
27. J. Li, "Genomics analysis of Anopheles gambiae mosquitoes to Plasmodium falciparum parasite Infection," OCAST, \$135K
28. P. Klein, P. B. Chilson, E. Fedorovich, A. Shapiro, D. Turner, "Low-level jets in the nocturnal stable boundary layer: structure, evolution, and interactions with mesoscale atmospheric disturbances," NSF, \$984K
29. E. Bridge, "The Electronic Transponder Analysis Gateway (ETAG): An Animal Behavior Observatory," NSF, \$315K
30. B. Capogrosso-Sansone, "Multi-Worm Algorithm for Path Integral Quantum Monte Carlo in Ultracold Dipolar Gases, NSF, \$293K
31. K. Dresback, R. Kolar, "Performance Optimization of the Advanced Circulation (ADCIRC) Model," Intel Parallel Computing Center, \$300K
32. U. Hansmann, "Modeling the molecular mechanism of amyloid oligomer and fibril self assembly," OCAST, \$90K

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# External Research Grants (cont'd)

33. J. Wicksted, A. Knoedler et al, "Adapting Socio-ecological Systems to Increased Climate Variability," NSF, \$20M + \$4M Regents (total), \$7.0M + \$1.9M Regents (OU)
34. M. Engle et al, "Resilience and vulnerability of beef cattle production in the Southern Great Plains under changing climate, land use and markets," \$9.5M (total), \$1.9M (OU)
35. R. Palmer, G. Zhang, Y. Zhang, T. Yu, M. Yeary, S. Karimkashi, C. Fulton, B. Cheong, "Multi-Mission Phased Array Radar Risk Reduction: A Collaborative Effort with the ARRC at the University of Oklahoma," NOAA, \$1.5M
36. R. Palmer, G. Zhang, Y. Zhang, T. Yu, M. Yeary, Y. Hong, J. Crain, P. Chilson, "Next Generation Weather Radar Technology," NOAA, \$900K
37. R. Palmer, D. Bodine, S. Torres, B. Cheong, C. Fulton, "Understanding Polarimetric Radar Tornadic Debris Signatures Using Modeling, Simulations, and Field Measurements,," NSF, \$860K
38. A. Callaghan, "Elucidation of Alkene Metabolism in Two Sulfate-reducing Isolates via Metabolite Profiling and Transcriptomics," NSF, \$848K
39. D. LaDue, K. Kloesel, "REU Site: Research Experiences for Undergraduates at the National Weather Center," NSF, \$822K
40. J. Brotzge, M. Xue, N. Snook, Y. Jung, A. McGovern, "The Severe Hail Analysis, Representation, and Prediction (SHARP) Project," NSF, \$819K
41. L. Krumholz, J. Zhou, M. McInerney, J. Wall, "Characteristics of H2 Producing Biological Systems Operating at 1 nM H2 Concentration," DOE, \$819K (total), \$693K (OU)
42. P. Chilson, E. Fedorovich, R. Palmer, "Studies of the Atmospheric Boundary Layer Using Numerical Simulations Coupled With Radar/Sodar-Based Field Experiments," NSF, \$757K
43. M. Xue, K. Brewster, F. Kong, "Establishment of Precision Weather Analysis and Forecasting Systems (PWAFS) for the Jiangsu Province Meteorological Bureau (JSMB)," NRIET, \$505K
44. H. Neeman, D. Brunson, J. Deaton, S. Radhakrishnan et al, "CC-NIE: OneOklahoma Friction Free Network," NSF, \$500K
45. F. Kong, M. Xue, "Further Development of the Storm-Scale Numerical Weather Prediction Capability for Shenzhen Meteorological Bureau," Shenzhen, \$479K
46. E. Bridge, J. Kelly, "Optimizing Grassland Bird Conservation in an Era of Biofuel Production," USDA, \$466K

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# External Research Grants (cont'd)

47. R. Kolar, "Dynamic Integration of Natural, Human, and Instructure Systems for Hurricane Evacuation and Sheltering," NSF, \$456K
48. L. Ding, "Neuroimaging Study of Mental Fatigue," FAA, \$430K
49. U. Hansmann, "Development of Generalized-Ensemble Algorithms and their Application in Protein Studies," NSF, \$410K
50. L. Ding, "Large-Scale Computational Neuroimaging of Brain Electrical Activity," NSF CAREER, \$400K
51. P. Attar, "Optimal Spatiotemporal Reduced Order Modeling for Nonlinear Structural Dynamics," NSF, \$360K
52. B. L. Cheong, Y. Jung, G. Zhang,, "Support for X-band Solid-state Weather Radar Development," WeatherLink, \$334K
53. P. Vedula, P. J. Attar, "Fast simulations of turbulent flows based on spatiotemporal statistical information," NSF, \$330K
54. M. Xue, K. Brewster, F. Kong, "Development of a Short-Range Realtime Analysis and Forecasting System based on the ARPS for Taiwan Region Year 3 (IA#24) and Year 4 (IA #25)," NOAA, \$310K
55. E. Bridge, J. Kelly, X. Xiao, "Enhancing and disseminating miniaturized tracking technology for widespread use on small migratory songbirds," NSF, \$302K
56. J. Kelly, L. Gruenwald, P. Chilson, V. Lakshmanan, E. Bridge, "Advancing Biological Interpretations of Radar Data," NSF EAGER, \$299K
57. L. Ding, "High-Resolution Noninvasive Computational Neuroimaging," OCAST, \$283K
58. F. Kong, "Further Development to the Storm-Scale Numerical Weather Prediction Capability for Shenzhen Meteorological Bureau," SIATCAS, \$251K
59. R. Slatt, Consortium from 14 oil and gas company, \$245K
60. J. Brotzge, F. Carr, "Prototyping and Evaluating Key Network-of-Networks Technologies: Project Extension," NOAA, \$210K
61. Y. Jung, M. Xue, G. Zhang, "Development of a Polarimetric Radar Data Simulator for KLAPS," KMA, \$176K
62. J. Ruyle, "BRIGE: Investigation of Slot Antenna Recon figuration Mechanisms," NSF, \$175K
63. J. Brotzge, F. Carr, "CASA Warning System Innovation Institute," U Mass, \$160K

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# External Research Grants (cont'd)

64. J. Kelly, "Developing Innovative Tools to Use Weather Radar Data to Assess and Monitor Impacts of Existing and Future Energy Facilities on Aerial Faunas in California," CIEE, \$150K (total), \$49K (OU)
65. J. Brotzge, F. Carr, "Prototyping and Evaluating Key Network-of-Networks Technologies," NOAA, \$145K
66. T. Yu, Y. Wang, R. Palmer, B. Cheong, "Algorithm development for solid-state polarimetric weather radars," Toshiba, \$130K
67. M. Xue, K. Brewster, F. Kong, "Establishment of an Urban-Scale Weather Forecasting System (USWFS) for the Su Zhou Meteorological Bureau (SZMB)," \$127K
68. L. Ding, "Neurophysiological Assessment of Mental Fatigue and Cognitive Performance," FAA, \$115K
69. K. Dresback, R. Kolar, "Next Generation ADCIRC Tidal Database: Phase 2 - West Coast," DOD, \$75K
70. K. Dresback, R. Kolar, "Next Generation ADCIRC Tidal Database," NOAA, \$75K
71. P. Risser, J. Duckles, J. Bratton, NSF I-Corps, \$50K
72. R. Palmer, M. Yeary, "System and Software Engineering Support Services for CGI," CGI, \$46K
73. M. Yeary, M. Xue, "GRDS: Request to support a Native American Indian graduate student beginning his PhD within the CASA Engineering Research Center," NSF, \$32K

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# External Research Grants (cont'd)

74. I.Y. Akkutlu, J. Callard, C. Rai, C. Sondergeld, "OU Shale Gas and Unconventional Reservoir Research Cooperative," \$2.8M per year
75. J. P. Shaffer, T. Pfau, "A Rydberg Atom Electric Field Sensor," DARPA-ARO, \$1.18M (total), \$1.06M (OU)
76. Y. Luo, "Data Synthesis and Data Assimilation at Global Change Experiments and Fluxnet toward Improving Land Process Models," DOE, \$1.05M
77. F. Kong, M. Xue, K. Brewster, "Establishment of an Improved Numerical Weather Forecasting System for Chongqing Meteorological Service," Chongqing Institute of Green and Intelligent Technology, China, \$852K
78. G. Zhang, M. Xue, B. L. Cheong, T. J. Schurr, "Advanced Study of Precipitation Microphysics with Multi-Frequency Polarimetric Radar Observations and Data Assimilation," NSF, \$637K
79. J. P. Shaffer, "A Quantum Hybrid System for Linking Rydberg Atom Quantum Gates. NSF, \$465K
80. J. P. Shaffer, "Rydberg Atom Interactions and Collective Behavior," NSF, \$436K
81. J. P. Shaffer, "Interactions in Cold Rydberg Gases," NSF, \$422K
82. J. Cruz, "CIF: Small: Two-Dimensional Channel Modeling, Detection and Coding for Shingled Magnetic Recording," NSF, \$418K
83. M. Yuan, "Supplement to Developing and Evaluating the Effectiveness of the Location-based Offender Monitoring System for Offender Supervision," National Institute of Justice, \$396K
84. X. Wang, M. Xue, F. Kong, "Optimal Design of Multi-scale Ensemble Systems for Convective-Scale Probabilistic Forecasting," NSF, \$359K
85. F. Kong, M. Xue, "Further Development of the Storm-Scale Numerical Weather Prediction Capability for Shenzhen Meteorological Bureau," Shenzhen Institute of Advanced Technology, China, \$251K
86. J. Snow & F. Fondjo Fotou (Langston U), "MRI: Acquisition of a High Performance Computing Cluster for Research and Education," NSF, \$250K
87. M. Xue, K. Brewster, Y. Jung, "Advanced Data Assimilation and Prediction Research for Convective-Scale Warn-on-Forecast," NOAA, \$243K
88. I.Y. Akkutlu, "Multi-scale Characterization of Transport Phenomena in Shales for Improved Gas Recovery," Devon Energy, \$200K
89. M. Xue, R. McPherson, J. Brotzge, B. Moore, "Very High-Resolution Dynamic Downscaling of Regional Climate and Hydrology," USG, \$24K
90. J. Brotzge, F. Carr, "CASA DFW Testbed Enhancement: Task B of National Mesonet Program (NWP)," Earth Networks Inc., \$25K

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# External Research Grants (cont'd)

91. R. Voronov, "Intra-Thrombus Chemo-Transport and Local Stress Mechanics under Flow," American Heart Association Postdoctoral Fellowship, \$150K
92. X. Wang, M. Xue, "Improving High Resolution Tropical Cyclone Prediction using GSI-based Hybrid Ensemble-Variational Data Assimilation System for HWRF," NOAA, \$150K
93. I. Y. Akkutlu, "Molecular Theory of Capillarity in Kerogen - A Multi-component Approach to Predict Shale Gas/Liquid In-place and Transport in Nanopores," Devon Energy, \$150K
94. S. Dhall, L. Gruenwald, "Autonomous Database Partitioning using Data Mining for High End Computing," NSF, \$150K
95. M. Xue, K. Brewster, F. Kong, "Ensemble Simulation of GOES-R Proxy Radiance Data from CONUS Storm-Scale Ensemble Forecasts, Product Demonstration and Assessment at the Hazardous Weather Testbed GOES-R Proving Ground," NOAA, \$126K
96. M. Xue, K. Brewster, F. Kong, "Ensemble Simulation of GOES-R Proxy Radiance Data from CONUS Storm-Scale Ensemble Forecasts, Product Demonstration and Assessment at the Hazardous Weather Testbed GOES-R Proving Ground," NOAA, \$94K
97. K. Brewster, M. Xue, "High Resolution Data Assimilation for Trajectory Improvement," DOD-Air Force, \$79K
98. F. Kong, "CAPS support to the WRF Lightning Forecast Algorithm for the NOAA R3 effort," NOAA GOES-R/Universities Space Research Assn, \$48K
99. R. McPherson, M. Shafer, Y. Hong, "Utilization of Regional Climate Science Programs in Reservoir and Watershed Impact Assessments," OSU Water Resources Responses to Climate Change: Pilot Study, \$43K
100. P. Attar, "Numerical Simulation of a Membrane Micro Air Vehicle in a Gust Field, Ohio Aerospace Institute, \$35K
101. J.R. Cruz, "Signal Processing for Magnetic Recording Channels," Hitachi Global Storage Technologies, Inc., Director, \$30K
102. J.R. Cruz, "Equalization, Detection, and Coding Algorithms for Bit Patterned Media Recording," Advanced Storage Technology Consortium, \$17K
103. L. Sells, J. Goulden, H. Aboudja, "LittleFe grant," LittleFe project, \$2.5K
104. L. Sells, J. Goulden, "Early Adopter Grant," NSF/TCPP, \$2.5K

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# External Research Grants (cont'd)

105. B. Moore III et al, "Department of the Interior South-Central Regional Climate Science Center," US Dept of the Interior, \$3.5M (total), \$1.4M (OU)
106. A. Striolo, D. Resasco et al, "Center for Application of Single-Walled Carbon Nanotubes," DOE, \$1M
107. J. K. Shen, "CAREER: Electrostatic Mechanisms in Protein Stability and Folding, NSF, \$773K
108. Y. Kogan, "Parameterization of cumulus convective cloud systems in mesoscale forecast models," ONR, \$594K
109. X. Wang, M. Xue, F. Kong, "Optimal Design of Multi-scale Ensemble Systems for Convective-Scale Probabilistic Forecasting," NSF, \$395K
110. R. D. Palmer, T.-Y. Yu, "NMQ and WDSS-II for the KMA radar network: Real-time, effective, and integrated weather products," Space Environment Laboratory, Inc., \$361K
111. B. Grady, A. Striolo, "Novel Supramolecular Structures of Laterally Confined Amphiphilic Molecules," NSF, \$335K
112. D. Resasco, D. Papavassiliou et al, "Interfacially active SWNT/silica nanohybrids," Advanced Energy Consortium, \$331K
113. C. Y. Tang , R. Ramakumar, N. Jiang , "Control and Operation of Large-Scale Wind Farms in the Power System", NSF, \$231K
114. J. Shen, "Electrostatic Modulation of Protein Stability and Folding," NIH, \$1.4M
115. Y. Wang, "Theoretical Tools for Measuring Dark Energy from Galaxy Clustering," DOE, \$230K
116. F. Kong, M. Xue, "Further Enhancement to the Hourly Assimilation and Prediction System (HAPS) for Shenzhen Meteorological Bureau." Shenzhen Institute of Advanced Technology, Chinese Academy of Science, \$228K
117. P. Attar, P. Vedula, "Multi-fidelity Modeling and Simulation (M&S) Tool for Nonlinear Aeroelasticity," Advanced Dynamics, \$160K
118. B. Eskridge, "CDI-TYPE I: RUI: Emergent Hierarchies of Leaders in Multi-Robot Systems," NSF, \$159K
119. A. Striolo, "Mixed-Volatile Fluids Relevant to Subsurface Energy Systems," DOE, \$120K
120. P. Skubic, M. Strauss, "OU Contribution to the ATLAS Southwest Tier 2 Computing Center (Supplement)," NSF, \$110K
121. P. Attar, "High-Fidelity Computational Aeroelastic Solver Research," Ohio Aerospace Institute, \$53K
122. P. Skubic, M. Strauss, "OU Contribution to the ATLAS Southwest Tier 2 Computing Center (Supplement)," NSF, \$50K

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# External Research Grants (cont'd)

123. P. Skubic, M. Strauss, "University of Oklahoma Contribution to OSG Software Development," Brookhaven National Laboratory, \$50K.
124. P. Attar, "Computational Model Development and Experimental Validation Measurements for Membrane-Batten Wing," Ohio Aerospace Institute, \$43K
125. A. Striolo, "Reduced Carbon in Earth's Crust and Mantle I," Alfred P. Sloan Foundation, \$39K.
126. J. Gao, "Advancing Research on Realtime Weather-Adaptive 3DVAR Analyses with Automatic Storm Positioning and On-demand Capability," NOAA, \$36K
127. M. Xue, "Probabilistic Forecasting for Aviation Decision Aid Applications," Impact Technologies, \$20K
128. P. Attar, P. Vedula, "Towards Better Modeling and Simulation of Nonlinear Aeroelasticity On and Beyond Transonic Regimes," Advanced Dynamics, \$20K
129. P. Attar, P. Vedula, "High-Fidelity Computational Aeroelastic Models in Support of Certification Airworthiness of Control Surfaces with Freeplay and Other Nonlinear Features," Advanced Dynamics, \$9K

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# External Research Grants (cont'd)

130. H. Neeman, D. Brunson (OSU), J. Deaton (OneNet), J. He (Noble Foundation), D. Schoenefeld (TU), J. Snow (Langston U), M. Strauss (OU), X. Xiao (OU), M. Xue (OU), "Oklahoma Optical Initiative," NSF, \$1.17M
131. H. Neeman, M. Jensen, M. Strauss, X. Xiao, M. Xue, E. Baron, K. Dresback, R. Kolar, A. McGovern, R. Palmer, D. Papavassiliou, H. Severini, P. Skubic, T. Trafalis, M. Wenger, R. Wheeler (Duquesne U), "MRI: Acquisition of Extensible Petascale Storage for Data Intensive Research," NSF, \$793K
132. D. Resasco, J. Harwell, F. Jentoft, K. Gasem, S. Wang, "Center for Interfacial Reaction Engineering (CIRE)," DOE EPSCoR, \$2.4M (\$1.97M OU)
133. P. Skubic, M. Strauss, B. Abbott, P. Gutierrez, "Experimental Physics Investigations Using Colliding Beam Detectors at Fermilab and the Large Hadron Collider (LHC) (TASK A) 2010-2013 Renewal," DOE, \$2.8M
134. R. Palmer, Y. Zhang, G. Zhang, T. Yu, M. Yeary, Y. Hong, J. Crain, P. Chilson, "Next Generation Phased Array," NSSL, \$2M
135. P. Skubic, M. Strauss, B. Abbott, P. Gutierrez, "Experimental Physics Investigations Using Colliding Beam Detectors at Fermilab and the Large Hadron Collider (LHC) (TASK A) 2010-2013 Renewal-Revision," DOE, \$1.52M
136. D. Cole, Alberto Striolo, "Structure and Dynamics of Earth Materials, Interfaces and Reactions," DOE, \$1.5M (\$90K OU)
137. R. Sigal, F. Civan, D. Devegowda, "Simulation of Shale Gas Reservoirs Incorporating the Correct Physics of Capillarity and Fluid Transport," Research Partnership to Secure Energy for America (RPSEA), \$1.05M
138. M. Biggerstaff, J. Straka, L. Wicker, Zrnica, Zahari, "MRI Development of C-Band Mobile Polarimetric Weather Radars," NSF, \$989K (\$439K OU)
139. D. Resasco, D. Papavassiliou et al, "Carbon Nanotube Technology Center," DOE, \$925K
140. M. Saha, D. Papavassiliou, A. Striolo, K. Mullen, B. Grady, C. Altan, D. Resasco, "Experimental and theoretical studies of carbon nanotube hierarchical structures in multifunctional polymer composites," DoD-EPSCoR, \$897K
141. E. Mansell, J. Straka, C. Ziegler, D. MacGorman, "Numerical modeling studies of storm electrification and lightning," NSF, \$817K
142. E. Rasmussen, J. Straka, K. Kanak, "Collaborative Research: Challenges in understanding tornadogenesis and associated phenomena, \$755K (\$489K OU)
143. J. Straka, K. Kanak, "Challenges in tornadogenesis and associated phenomena," NSF, \$584K

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# External Research Grants (cont'd)

144. M. Xue, F. Kong, "Advanced Multi-Moment Microphysics for Precipitation and Tropical Cyclone Forecast Improvement with COAMPS," ONR, \$592K
145. J. Straka, K. Kanak, "Collaborative Research: Challenges in Understanding Tornadoogenesis and Associated Phenomena," NSF, \$515K
146. D. MacGorman, E. Mansell, C. Ziegler, A. Fierro, M. Xue, "Techniques for Assimilating Geostationary Lightning Mapper Data and Assessment of the Resulting Impact on Forecasts," NOAA, \$415K
147. M. Xue, F. Kong, K. Brewster, X. Wang, "A Partnership to Develop, Conduct, and Evaluate Realtime High-Resolution Ensemble and Deterministic Forecasts for Convective-scale Hazardous Weather: Moving to the Next Level," NOAA CSTAR, \$375K
148. M. Xue, K. Brewster, J. Gao, X. Wang, "Advanced Data Assimilation and Prediction Research for Convective-Scale 'Warn-on-Forecast,'" \$500K, NOAA
149. X. Wang, "Improving satellite radiance data assimilation using a hybrid ensemble-Gridpoint Statistical Interpolation (GSI) method for global numerical weather prediction," NASA, \$276K
150. X. Wang, M. Xue, "Improving NOAA operational global numerical weather prediction using a hybrid-ensemble Kalman filter data assimilation and ensemble forecast system," NOAA, \$207K
151. D. Resasco, D. Papavassiliou et al, "Interfacially active SWNT/silica nanohybrids," Advanced Energy Consortium (AEC), \$333K
152. D. Oliver, "Data analysis and inversion for mobile nanosensors," AEC, \$320K
153. R. Palmer, T. Yu, G. Zhang, M. Yearly, P. Chilson, Y. Zhang, J. Crain, "Advancements in Phased Array Weather Radar Research at OU," NOAA National Severe Storms Laboratory (NSSL), \$270K
154. A. Striolo, "The Emergent Behavior of Solid Nanoparticles at Oil-Water Interfaces: A Multi-Scale Thermodynamic Approach to Enable Bio-Oil Upgrade," NSF, \$238K
155. M. Xue, K. Brewster, F. Kong, "Development of a Short-Range Realtime Analysis and Forecasting System based on the ARPS for Taiwan Region," NOAA, \$200K
156. J. Straka, K. Kanak, "Formative dynamics of the mammatus clouds in thunderstorm cirrus," NSF, \$318K
157. M. Yearly, C. Tang, "Computationally Efficient Linear Transforms for Remote Sensing Systems," NSF, \$299K
158. A. Striolo, "Probing regular solution theory for mixed amphoteric/ionic surfactant systems by molecular dynamics simulations," ACS, \$100K

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# External Research Grants (cont'd)

159. K. Brewster, M. Xue, F. Kong, meteorology project, \$211K
160. M. Xue, meteorology project, \$120K
161. A. McGovern, "Learning to guide search in large state spaces," IBM DARPA, \$95K
162. J. Straka, K. Kanak, "Supplement: Challenges in tornadogenesis and associated phenomena (VORTEX2)," NSF, \$87K
163. F. Kong, M. Xue, "Establishment of an Experimental Real-Time Short-Term Storm Prediction System for Shenzhen Meteorological Bureau," \$58K
164. J. Straka, "Improved Understanding/Prediction of Severe Convective Storms and Attendant Phenomena through Advanced Numerical Simulation," NSF, \$58K
165. M. Xue, "Assimilation of NEXRAD Radial Winds in a Regional Mesoscale Model," Miss State U, \$79K
166. J. Cruz, R. Todd, "Medium-Density Parity-Check Codes for Tape Systems," INSIC, \$36K
167. M. Xue, D. Stensrud, J. Gao, "Advancing Warn on Forecast – Storm-scale Analysis of Vortex 2 Thunderstorms," NSSL, \$70K
168. P. Attar, "High-Fidelity Computational Aeroelastic Solver Research," Ohio Aerospace Institute, \$60K
169. J. Straka, K. Kanak, "Development of Unmanned Aircraft System for Research in a Severe Storm Environment and Deployment within the VORTEX 2," NSF, \$44K
170. J. Cruz, "Equalization, Detection, and Coding Algorithms for Bit Patterned Media Recording Channels," International Storage Industry Consortium (INSIC), \$35K
171. J. Cruz, R. Todd, "Signal Processing for Magnetic Recording Channels," private company, \$30K
172. P. Attar, P. Vedula, "Deterministic and Statistical Characterization of the Impact of Control Surface Freeplay on Flutter and Limit-Cycle Oscillation (LCO) using Efficient Computational Modeling," Advanced Dynamics, \$30K
173. P. Attar, P. Vedula, "Novel Reduced Order in time Models for Problems in Nonlinear Aeroelasticity," Advanced Dynamics, \$29K
174. F. Carr, J. Straka, "Severe storm research," Jonathon Merage Foundation, \$21K
175. F. Carr, J. Straka, "Severe storm research," Jonathon Merage Foundation, \$20K

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# External Research Grants (cont'd)

176. A. Striolo, "Electrolytes at Solid-Water Interfaces: Theoretical Studies for Practical Applications," DOE EPSCoR, \$450K
177. A. Striolo, Saha, "Experimental and Theoretical Studies of Carbon Nanotube Hierarchical Structures in Multifunctional Polymer Composites," DOD EPSCoR, \$450K
178. D. Cole (ORNL), A. Striolo, "Structure and Dynamics of Earth Materials, Interfaces and Reactions," DOE, \$1.5M (\$75K OU)
179. D. Papavassiliou, A. Striolo, "Effects of Hydrophobicity-Induced Wall Slip on Turbulence Drag and Turbulence Structure," NSF, \$230K
180. A. Striolo, D. Resasco, U. Nollert, "Understanding the Interactions between Carbon Nanotubes and Cellular Membranes," NSF, \$380K
181. M. Xue, Y. Hong, X. Hu (GSU), "Integrated Weather and Wildfire Simulation and Optimization for Wildfire Management," NSF, \$997K (\$483K OU)
182. Y. Hong, "Next Generation QPE: Toward a Multi-Sensor Approach for Integration of Radar, Satellite, and Surface Observations to Produce Very High-resolution Precipitation Data," NOAA/OAR/NSSL via CIMMS, \$83K
183. R. Palmer, Y. Hong, "Phased Array Technology for Weather Radar Applications," NOAA/OAR/NSSL via CIMMS, \$426K
184. Y. Hong, Baski (OSU), "Proactive approach to transportation resource allocation under severe winter weather emergencies," OK-DOT/OTC, \$261K (\$101K OU)
185. R. Palmer, Y. Hong, "Atmospheric Observations using PhasedArray Technology," \$340K
186. Y. Hong, "Toward Improved Flood Prediction and Risk Mitigation: Capacity Building for Africa," NASA, \$87K
187. Y. Hong, "Improving NASA Global Hazard System and Implementing SERVIR-Africa," NASA, \$272K
188. Y. Hong, "Link SERVIR-Africa Work to NASA Land Information System: Workshop Training and Data Assimilation of GRACE to NASA-OU Hydrologic Model," NASA, \$10K
189. R. Adler (NASA), Y. Hong, "Global Hazard (Flood-Landslide) Decision-Support System," NASA, \$900K
190. S. Schroeder, "CAREER: Advancing Viral RNA Structure Prediction," NSF, \$750K

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# External Research Grants (cont'd)

191. P. Attar, "High Fidelity Computational Aeroelastic Analysis of a Flexible Membrane Airfoil Undergoing Dynamic Motion," Ohio Aerospace Institute, \$35K
192. P. Attar, "Computational Model Development and Experimental Validation Measurements for Membrane-Batten Wing" Flexible Membrane Airfoil Undergoing Dynamic Motion," Ohio Aerospace Institute, \$43K
193. K. Droegemeier, F. Kong, P. Attar, "A Partnership to Develop, Conduct, and Evaluate Realtime High-Resolution Ensemble and Deterministic Forecasts for Convective-scale Hazardous Weather," NOAA, \$375K
194. M. Xue, G. Zhang, K. Brewster, F. Kong, "Prediction and Predictability of Tropical Cyclones over Oceanic and Coastal Regions and Advanced Assimilation of Radar and Satellite Data for the Navy Coupled Ocean-Atmosphere Mesoscale Prediction System," ONR/DOD EPSCoR, \$476K; OK Board of Regents \$100K
195. S. Ahalt, A. Apon, D. Lifka, H. Neeman, "NSF Workshop High Performance Computing Center Sustainability," NSF, \$49K (\$0 OU)
196. Y. Luo, S. Lakshmivarahan, "Development of a Data Assimilation Capability towards Ecological Forecasting in a Data-Rich Era," NSF, \$1.08M
197. Y. Luo, D. Schimmel (NEON), J. Clark (Duke U.), Kiona Ogle (U. Wyoming), S. LaDeau (Cary Institute of Ecosystem Study), "RCN: Forecasts Of Resource and Environmental Changes: Data Assimilation Science and Technology (FORECAST)," NSF, \$500K
198. J. Straka, K. Kanak, Davies-Jones, H. Neeman, "Challenges in understanding tornadogenesis and associated phenomena," NSF, \$854K
199. P. Risser et al, "A cyberCommons for Ecological Forecasting," NSF, \$6M (\$2.78M OU)
200. M. Xue, X. Wang, X. Li (OSU), R. Barnes, S. Sanielevici (PSC), H. Neeman, "Enabling Petascale Ensemble-Based Data Assimilation for the Numerical Analysis and Prediction of High-Impact Weather," NSF, \$1.2M (\$902K OU)
201. P. Skubic, B. Abbott, P. Gutierrez, M. Strauss, "ATLAS Southwest Tier 2 Computing Center," NSF, \$600K/year (\$60K/year OU)
202. Y. Hong, "Evaluation of NASA Global Hazard System," NASA, \$45K

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# External Research Grants (cont'd)

- 203. J Wicksted, F. Waxman et al, "Building Oklahoma's Leadership Role in Cellulosic Bioenergy," NSF EPSCoR, \$15M (\$5.7M OU)
- 204. D.S. Oliver, software, \$16.7M
- 205. K.K. Muraleetharan, G. Miller, and A. Cerato, "Understanding and Improving the Seismic Behavior of Pile Foundations in Soft Clays," NSF, \$1.15M (\$500K OU)
- 206. K. Droegemeier, F. Kong, "Multisensor Studies of Precipitation for Model Verification and Data Assimilation," U Minn, (\$7K OU)
- 207. K. Droegemeier, M. Xue, F. Kong, "Observing System Simulation Experiments for Airborne Weather Sensors," HRL, (\$33K OU)
- 208. M. Nollert, Scholarship, FD-OMRF, \$12K
- 209. R. Sigal, R. Philp, C. Rai., S. Shah, R. Slatt, C. Sondergeld, D. Zhang, energy company, \$1.9M
- 210. B. Grady, D. Schmidtke, A. Striolo, A. Cheville, D. Teeters, "Polymer Nanostructures on Solid Surfaces," \$208K (\$125K OU)
- 211. T. Conway, "E. coli Model Organism Resource," UN-Purdue, (\$685K OU)
- 212. R. Kolar, "Storm Surge Modeling in SE Louisiana - 2006," ARCADIS, (\$37K OU)
- 213. D. Cole (ORNL), A. Striolo, "Rates and Mechanisms of Mineral-Fluid Interactions at the Nanoscale," DOE, \$1.65M (total), (\$55K OU)
- 214. R. Kolar, "A Prototype Operational Modeling System for Waves, Coastal Currents, Inundation and Hydrologic Flooding for Eastern North Carolina," UN-UNC-CH, (\$209K OU)
- 215. R. Kolar, "A Coupled Regional-Coastal Ocean Model: HYCOM/CG-ADCIRC," DOD-NRL, (\$333K OU)
- 216. M. Xue, "Contribution to WRF Model Development by the Center for Analysis and Prediction of Storms," DOC-NOAA, \$821K
- 217. K. Marfurt, "Improving Geologic and Engineering Models of Midcontinent Fracture and Karst Modified Reservoirs Using 3-D Seismic Attributes," UKCRINC, (\$61K OU)
- 218. P. Attar, P. Vedula, "Novel, Optimal, Physics-based Reduced Order Models for Nonlinear Aeroelasticity," Advanced Dynamics, \$49K
- 219. S. Dhall, "Autonomous Data Partitioning using Data Mining for High Performance Computing," NSF, (\$125K OU)

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# External Research Grants (cont'd)

220. M. Xue, K. Brewster, J. Gao, "Ensemble-based Data Assimilation for Tropical Storms, and Realtime 3DVAR Analysis for Initial Proof of 'Warn-on-Forecast' Concept: Collaborative Research between CAPS and NSSL," DOC-NOAA, \$100,000
221. M. Xue, "Contribution to Model Development and Enhancement Research Team by the Center for Analysis and Prediction of Storms," DOC-NOAA, \$620K
222. M. Xue, K. Brewster, "Ensemble-based Data Assimilation for Convective Storms and Hurricanes," DOC-NOAA, \$100,000
223. S. Schroeder, "Discovering Satellite Tobacco Mosaic Virus Structure," OCAST, \$85K
224. S. Schroeder, "Computational Advances Toward Predicting Encapsidated Viral RNA Structure," Pharmaceutical Research and Manufacturer's Association of America, \$60K
225. R. Kolar, "Outer Boundary Forcing for Texas Coastal Models," Texas Water Development Board, \$20K
226. K. Milton, "Collaborative Research: Quantum Vacuum Energy", NSF, \$250K
227. A. McGovern, "Developing Spatiotemporal Relational Models to Anticipate Tornado Formation," NSF, \$500K
228. Y. Kogan, "Midlatitude Aerosol-Cloud-Radiation Feedbacks in Marine Boundary Layer Clouds", ONR, \$638K
229. J. Straka, K. Kanak, Davies-Jones, "Challenges in understanding tornadogenesis and associated phenomena," NSF, \$854K (total), \$584K (OU)
230. Y. Hong, "Improvement of the NASA Global Hazard System and Implement Server-Africa," NASA, \$272K
231. J. Antonio, S. Lakshmivarahan, H. Neeman, "Predictions of Atmospheric Dispersion of Chemical and Biological Contaminants in the Urban Canopy." Subcontract No. 1334/0974-01, Prime Agency DOD-ARO, Subcontract through Texas Tech University, Lubbock, TX, Sep. 29, 2000 to Nov. 3, 2001, \$75K
232. A. Striolo, "Electrolytes at Solid-Water Interfaces: Theoretical Studies for Practical Applications," OSRHE Nanotechnology, \$15K
233. D. Papavassiliou, "Turbulent transport in non-homogeneous turbulence," NSF, \$320K

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# External Research Grants (cont'd)

234. K. Droegemeier et al., "Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere," NSF, \$17M (total), \$5.6M (OU)
235. K. Droegemeier et al., "Linked Environments for Atmospheric Discovery (LEAD)," NSF, \$11.25M (total), \$2.5M (OU)
236. M. Strauss, P. Skubic et al., "Oklahoma Center for High Energy Physics", DOE EPSCoR, \$3.4M (total), \$1.6M (OU)
237. M. Richman, A. White, V. Lakshmanan, V. DeBrunner, P. Skubic, "Real Time Mining of Integrated Weather Data," NSF, \$950K
238. D. Weber, K. Droegemeier, H. Neeman, "Modeling Environment for Atmospheric Discovery," NCSA, \$435K
239. H. Neeman, K. Droegemeier, K. Mish, D. Papavassiliou, P. Skubic, "Acquisition of an Itanium Cluster for Grid Computing," NSF, \$340K
240. J. Levit, D. Ebert (Purdue), C. Hansen (U Utah), "Advanced Weather Data Visualization," NSF, \$300K
241. D. Papavassiliou, "Turbulent Transport in Wall Turbulence," NSF, \$165K
242. L. Lee, J. Mullen (Worcester Polytechnic), H. Neeman, G.K. Newman, "Integration of High Performance Computing in Nanotechnology," NSF, \$400K
243. R. Wheeler, "Principal mode analysis and its application to polypeptide vibrations," NSF, \$385K
244. R. Kolar, J. Antonio, S. Dhall, S. Lakshmivaran, "A Parallel, Baroclinic 3D Shallow Water Model," DoD - DEPSCoR (via ONR), \$312K
245. R. Luettich (UNC), R. Kolar, B. Vieux, J. Gourley, "The Center for Natural Disasters, Coastal Infrastructure, and Emergency Management," DHS, \$699K
246. D. Papavassiliou, M. Zaman, H. Neeman, "Integrated, Scalable MBS for Flow Through Porous Media," NSF, \$150K
247. Y. Wang, P. Mukherjee, "Wavelet based analysis of WMAP data," NASA, \$150K
248. E. Mansell, C. L. Ziegler, J. M. Straka, D. R. MacGorman, "Numerical modeling studies of storm electrification and lightning," \$605K

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# External Research Grants (cont'd)

249. K. Brewster, J. Gao, F. Carr, W. Lapenta, G. Jedlovec, "Impact of the Assimilation of AIRS Soundings and AMSR-E Rainfall on Short Term Forecasts of Mesoscale Weather," NASA, \$458K
250. R. Wheeler, T. Click, "National Institutes of Health/Predocorral Fellowships for Students with Disabilities," NIH/NIGMS, \$80K
251. K. Pathasarathy, D. Papavassiliou, L. Lee, G. Newman, "Drag reduction using surface-attached polymer chains and nanotubes," ONR, \$730K
252. D. Papavassiliou, "Turbulent transport in non-homogeneous turbulence," NSF, \$320K
253. C. Doswell, D. Weber, H. Neeman, "A Study of Moist Deep Convection: Generation of Multiple Updrafts in Association with Mesoscale Forcing," NSF, \$430K
254. D. Papavassiliou, "Melt-Blowing: Advance modeling and experimental verification," NSF, \$321K
255. R. Kol,ar et al., "A Coupled Hydrodynamic/Hydrologic Model with Adaptive Gridding," ONR, \$595K
256. D. Papavassiliou, "Scalar Transport in Porous Media," ACS-PRF, \$80K
257. M. Xue, F. Carr, A. Shapiro, K. Brewster, J. Gao, "Research on Optimal Utilization and Impact of Water Vapor and Other High Resolution Observations in Storm-Scale QPF," NSF, \$880K.
258. J. Gao, K. Droegemeier, M. Xue, "On the Optimal Use of WSR-88D Doppler Radar Data for Variational Storm-Scale Data Assimilation," NSF, \$600K.
259. K. Mish, K. Muraleetharan, "Computational Modeling of Blast Loading on Bridges," OTC, \$125K
260. V. DeBrunner, L. DeBrunner, D. Baldwin, K. Mish, "Intelligent Bridge System," FHWA, \$3M
261. D. Papavassiliou, "Scalar Transport in Porous Media," ACS-PRF, \$80K
262. Y. Wang, P. Mukherjee, "Wavelet based analysis of WMAP data," NASA, \$150K
263. R. Wheeler et al., "Testing new methods for structure prediction and free energy calculations (Predocorral Fellowship for Students with Disabilities)," NIH/NIGMS, \$24K
264. L. White et al., "Modeling Studies in the Duke Forest Free-Air CO2 Enrichment (FACE) Program," DOE, \$730K

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# External Research Grants (cont'd)

265. Neeman, Severini, "Cyberinfrastructure for Distributed Rapid Response to National Emergencies", NSF, \$132K
266. Neeman, Roe, Severini, Wu et al., "Cyberinfrastructure Education for Bioinformatics and Beyond," NSF, \$250K
267. K. Milton, C. Kao, "Non-perturbative Quantum Field Theory and Particle Theory Beyond the Standard Model," DOE, \$150K
268. J. Snow, "Oklahoma Center for High Energy Physics", DOE EPSCoR, \$3.4M (total), \$169K (LU)
269. M. Xue, F. Kong, "OSSE Experiments for airborne weather sensors," Boeing, \$90K
270. M. Xue, K. Brewster, J. Gao, A. Shapiro, "Storm-Scale Quantitative Precipitation Forecasting Using Advanced Data Assimilation Techniques: Methods, Impacts and Sensitivities," NSF, \$835K
271. Y. Kogan, D. Mechem, "Improvement in the cloud physics formulation in the U.S. Navy Coupled Ocean-Atmosphere Mesoscale Prediction System," ONR, \$889K
272. G. Zhang, M. Xue, P. Chilson, T. Schuur, "Improving Microphysics Parameterizations and Quantitative Precipitation Forecast through Optimal Use of Video Disdrometer, Profiler and Polarimetric Radar Observations," NSF, \$464K
273. T. Yu, M. Xue, M. Yeay, R. Palmer, S. Torres, M. Biggerstaff, "Meteorological Studies with the Phased Array Weather Radar and Data Assimilation using the Ensemble Kalman Filter," ONR/Defense EPSCOR/OK State Regents, \$560K
274. B. Wanner, T. Conway, et al., "Development of the www.EcoliCommunity.org Information Resource," NIH, \$1.5M (total), \$150K (OU)
275. T. Ibrahim et al., "A Demonstration of Low-Cost Reliable Wireless Sensor for Health Monitoring of a Precast Prestressed Concrete Bridge Girder," OK Transportation Center, \$80K
276. T. Ibrahim et al., "Micro-Neural Interface," OCAST, \$135K
277. J. Snow, "Langston University High Energy Physics," \$155K (LU)

**OSCER-FACILITATED FUNDING TO DATE:**

**\$291M total, \$174M to OU**

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# External Research Grants (cont'd)

278. L.M. Leslie, M.B. Richman, C. Doswell, "Detecting Synoptic-Scale Precursors Tornado Outbreaks," NSF, \$548K
279. L.M. Leslie, M.B. Richman, "Use of Kernel Methods in Data Selection and Thinning for Satellite Data Assimilation in NWP Models," NOAA, \$342K
280. J. Gao, K. Brewster, M. Xue, K. Droegemeier, "Assimilating Doppler Radar Data for Storm-Scale Numerical Prediction Using an Ensemble-based Variational Method," NSF, \$200K
281. E. Chesnokov, "Fracture Prediction Methodology Based On Surface Seismic Data," Devon Energy, \$1M
282. E. Chesnokov, "Scenario of Fracture Event Development in the Barnett Shale (Laboratory Measurements and Theoretical Investigation)," Devon Energy, \$1.3M
283. M. Xue, K. Brewster, J. Gao, "Study of Tornado and Tornadoic Thunderstorm Dynamics and Predictability through High-Resolution Simulation, Prediction and Advanced Data Assimilation," NSF, \$780K
284. A. Striolo, "Heat Transfer in Graphene-Oil Nanocomposites: A Molecular Understanding to Overcome Practical Barriers." ACS Petroleum Research Fund, \$40K
285. D.V. Papavassiliou, "Turbulent Transport in Anisotropic Velocity Fields," NSF, \$292.5K
286. D. Oliver, software license grant, \$1.5M
287. R. Broughton et al, "Assembling the Eutelost Tree of Life – Addressing the Major Unresolved Problem in Vertebrate Phylogeny," NSF, \$3M (\$654K to OU)
288. A. Fagg, "Development of a Bidirectional CNS Interface or Robotic Control," NIH, \$600K
289. M. Xue, J. Gao, "An Investigation on the Importance of Environmental Variability to Storm-scale Radar Data Assimilation," NSSL, \$72K
290. JV. Sikavistsas and D.V. Papavassiliou , "Flow Effects on Porous Scaffolds for Tissue Regeneration," NSF, \$400K
291. P. Skubic, M. Strauss, et al., "Experimental Physics Investigations Using Colliding Beam Detectors at Fermilab and the LHC," DOE, \$503K

**OSCER-FACILITATED FUNDING TO DATE:  
\$291M total, \$174M to OU**

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# External Research Grants (cont'd)

292. Y. Wang, "Science for the Euclid Mission", NASA/JPL, \$52K (2015)
293. D. LaDue, K. Kloesel, "EPSCoR Funded Participant in the National Weather Center Research Experiences for Undergraduates Program," Oklahoma EPSCoR, \$9K
294. V. Sikavitsas, D. Papavassiliou, "The influence of fluid shear forces, oxygen and nutrient mass transport in the development of bone grafts in perfusion bioreactors," OCAST,, \$45K
295. D. Schmidtke, D. Papavassiliou, "Development of a Miniature Right Heart Support Device," NIH, \$347K
296. D. Resasco, D. Papavassiliou, "Interfacially active SWNT/silica nanohybrids," Advanced Energy Consortium, \$688K
297. B. L. Cheong, T.-Y. Yu, R. .D. Palmer, "Instrumental Support for the Winter Experiment Campaign," SELab Inc, \$215K
298. E. Bridge, "CAREER: Unwrapping the Migratory Gene Package," NSF, \$760K
299. E. Bridge, "The Electronic Transponder Analysis Gateway (ETAG): An Animal Behavior Observatory," NSF, \$315K
300. E. Bridge, "An Open-Source Radio Frequency Identification System for Animal Monitoring," NSF, \$331K
301. R. McPherson, E. White, M. Shafer, D. Rosendahl, M. Richman, "Trends in cold temperature extremes and winter weather for the SPTC region," USDOT, \$132K
302. R. Palmer, B. Cheong, C. Fulton, J. Salarzar, M. Yearly, T.-Y. Yu, Y. Zhang,. "Meeting the Technical Challenges of the Multi-Mission Phased Array Radar," NOAA, \$1.65M
303. M. J. McInerney, L. Krumholz, Bioremediation of Chromium and Arsenic from Industrial Wastewater," Nat'l Academies of Science, \$162K
304. M. Coniglio (PI), C. Doswell III, R. J. Trapp
305. "Improved understanding of convective-storm predictability and environment feedbacks from observations during the Mesoscale Predictability Experiment (MPEX)," NSF, \$272K
306. Y. Kogan, "Parameterization of Cumulus Convective Cloud Systems in Mesoscale Forecast Models," ONR, \$267K
307. S. Schroeder, "Predicting Viral RNA Structures, Function, and Drug Targets from Sequence," OCAST, \$145K

**OSCER-FACILITATED FUNDING TO DATE:**

**\$291M total, \$174M to OU**

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# External Research Grants (cont'd)

308. L. Ding, "NRI-Small: Robot Assistants for Promoting Crawling and Walking in Children at Risk of Cerebral Palsy," NSF, \$1.135M
309. M. Elwood Madden, G. Soreghan, A. Callaghan, J. Volz, M. Nannny, "Acquisition of a High Resolution Raman Mapping Microscope," NSF, \$294K
310. E. Baron, "Collaborative Research: Three-Dimensional Simulations of Type Ia Supernovae Constraining Models with Observations," NSF, \$26K
311. H. Neeman, K. Brewster, A. McGovern, H. Severini, T. Yu, M. Atiquzzaman, G. Creager, B. George, Z. Gray, S. Radhakrishnan, P. Skubic, M. Strauss, X. Xiao, M. Xue, "A Model for Advanced Cyberinfrastructure Research and Education Facilitators," NSF, \$400K
312. E. Lemley, G. Qian, "MRI: Acquisition of a High Performance Computing Cluster for Research at a Predominantly Undergraduate Institution," NSF, \$305K
313. R. Floyd, J. Pei, "Understanding the Behavior of Prestressed Concrete Girders after Years of Service," OK DOT, \$327K
314. G. Zhang, S. Arani, "Polarimetric Phased Array Radar Research in Support for MPAR Strategy," NOAA, \$438K
315. A. Fierro, M. DeMaria, E. Mansell, C./ Ziegler, D. MacGorman, A. Schumacher, R. Brummer. "Using total lightning data from GLM/GOES-R to improve real-time tropical cyclone genesis and intensity forecasts," NOAA, \$268K (\$123K to OU)
316. U. Hansmann, "Folding, Mis-folding and Aggregation of Proteins," NIH, \$887K
317. G. R. Keller, S. Holloway, D. Devegowda, K. Crain, A. Holland, A. Ghassemi, "4D Integrated Study Using Geology, Geophysics, Reservoir Modeling and Rock Mechanics to Development Assessment Models for Potential Induced Seismicity Risk,," \$1.478M
318. J. Gao, D. Stensrud, X. Wang, "Assimilation of Doppler Radar Data with an Ensemble-based Variational Method for Storm-scale NWP," NSF, \$481K
319. M. Soe (RSU), "Unitary Qubit Lattice Algorithms for Quantum Turbulence with Non-Abelian Vortices," NSF, \$75K,

**OSCER-FACILITATED FUNDING TO DATE:**

**\$291M total, \$174M to OU**

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# External Research Grants (cont'd)

- 320. J. Cruz, "Two-Dimensional Channel Modeling, Detection and Coding for Shingled Magnetic Recording," NSF, \$419K,
- 321. J. Shaffer, "Laser Stabilization System for Rydberg Atom Physics," Army Research Office, \$75K

**OSCER-FACILITATED FUNDING TO DATE:  
\$291M total, \$174M to OU**

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# External Funding Summary

- External research funding facilitated by OSCER (Fall 2001- Fall 2015): **\$291M total, \$174M to OU (60%)**
- Funded projects: **OVER 300**
- **134** OU faculty and staff in **21** academic departments and **6** non-academic units
- Comparison: Fiscal Year 2002-15 (July 2001 – June 2015):  
OU Norman externally funded research expenditure: \$1.07B

Since being founded in fall of 2001, OSCER has enabled research projects comprising almost

**1 / 6 of OU Norman's total externally funded research expenditure, with an 8-to-1 return on investment.**



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# Publications Facilitated by Research IT

- Publications facilitated by Research IT resources

- **2015: 155** (so far)
- 2014: 188
- 2013: 215
- 2012: 284
- 2011: 206
- 2010: 142
- 2009: 107
- 2008: 109
- 2007: 77
- 2006: 88
- 2005: 64
- 2004: 28
- 2003: 9
- 2002: 8
- 2001: 3

**TOTAL SO FAR: 1683 publications**

[http://www.oscer.ou.edu/papers\\_from\\_rounds.php](http://www.oscer.ou.edu/papers_from_rounds.php)

Includes 34 MS theses, 37 PhD dissertations.



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# OU Supercomputing Club & Team

- In the past couple of years, OSCER operations team member Josh Alexander decided he wanted OU students to compete in the SC supercomputing conference's Student Cluster Challenge.
- So, with the help of people in CS and ECE, he founded a team, they submitted a proposal to SC14 -- and got in!
- Founding the team led to founding the Sooner Supercomputing Club last year.
- This is the only effective way we've seen at OU to get students motivated to learn HPC.



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Oklahoma  
Cyberinfrastructure  
Initiative

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2008-13

# OK Cyberinfrastructure Initiative

- All academic institutions in Oklahoma are eligible to sign up for free use of OU's and OSU's centrally-owned CI resources.
- Other kinds of institutions (government, non-governmental) are eligible to use, though not necessarily for free.
- Everyone can participate in our CI education initiative.
- The Oklahoma Supercomputing Symposium, our annual conference, continues to be offered to all.
- Triggered by OK's NSF EPSCoR RII Track-1 2008-13.



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OneOklahoma Cyberinfrastructure Initiative



# OCII Goals

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- **Reach** institutions outside the mainstream of advanced computing.
- **Serve** every higher education institution in Oklahoma that has relevant curricula.
- **Educate** Oklahomans about advanced computing.
- **Attract** underrepresented populations and institution types into advanced computing.



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# OneOCII Strategy

- OneOCII doesn't exactly have a strategy; it'd be more accurate to say we have an approach:
  - Every CI project in the state is part of the larger whole.
  - Each new project advances a subset of OneOCII.
  - Not all parts of OneOCII advance at the same time.
  - Everyone works together on everything.



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# OCII Service Methodologies Part 1

- **Access (A)**: to supercomputers and related technologies (20 OK academic institutions to date).
- **Dissemination (D)**: Oklahoma Supercomputing Symposium – annual advanced computing conference (25 OK academic institutions to date).
- **Education (E)**: “Supercomputing in Plain English” (SiPE) workshop series: 11 talks about advanced computing, taught with stories, analogies and play rather than deep technical jargon. Have reached 248 institutions (academic, government, industry, nonprofit) in 47 US states and territories and 10 other countries (14 OK academic institutions to date).



# OCII Service Methodologies Part 2

- **Faculty/Staff Development (F)**: Workshops held at OU and OSU on advanced computing and computational science topics, sponsored by the National Computational Science Institute, the SC supercomputing conference series, the Linux Clusters Institute, the Virtual School for Computational Science & Engineering. Oklahoma is the only state to have hosted multiple events sponsored by each of these (18 OK academic to date).
- **Outreach (O)**: “Supercomputing in Plain English” (SiPE) overview talk (24 OK academic to date).
- **Proposal Support (P)**: Letters of commitment for access to OCII resources; collaborations with OCII lead institutions (4 OK academic, 1 nongovernmental).



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# OCII Service Methodologies Part 3

- **Technology (T)**: Got or helped get technology (e.g., network upgrade, mini-supercomputer, hi def video camera for telepresence) for that institution (14 OK academic to date).
- **Workforce Development (W)** – (36 OK academic)
  - Oklahoma Information Technology Mentorship Program (OITMP)
  - “A Day in the Life of an IT Professional” presentations to courses across the full spectrum of higher education.
  - Job shadowing opportunities and direct mentoring of individual students.
  - Institution Types: high schools, career techs, community colleges, regional universities, PhD-granting universities.
- Special effort to reach underrepresented populations: underrepresented minorities, non-PhD-granting, rural



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# OCII Institution Profile

To date, OCII has served 100 Oklahoma institutions, agencies and organizations:

- 52 OK academic (2 more booked this semester)
- 48 OK non-academic



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# OCII Institution Profile

To date, OCII has served 100 Oklahoma institutions, agencies and organizations:

- 52 OK academic
  - Universities & Colleges
    - 3 comprehensive PhD-granting
    - 20 regional non-PhD-granting
  - Community Colleges: 10
  - Career techs: 13
  - Secondary schools: 4
  - Public school systems: 2
- 48 OK non-academic



OSCAR State of the Center Address  
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# OCII Institution Profile

So far, OCII has served:

- 52 OK academic
  - 9 Minority Serving Institutions
  - 15 other institutions with above state average and national average for one or more underrepresented minorities
- 48 OK non-academic

## Minority Serving Institutions

- Oklahoma's only Historically Black College or University
  - Langston U (Langston)
- Native American Serving Non-tribal Institutions
  - East Central U (Ada)
  - Northeastern Oklahoma A&M College (Miami)
  - Northeastern State U (Tahlequah)
  - Southeastern Oklahoma State U (Durant)
- Tribal Colleges
  - College of the Muscogee Nation (Okmulgee)
  - Comanche Nation College (Lawton)
  - Pawnee Nation College (Pawnee)
- Other Minority Serving Institution
  - Bacone College (Muskogee)





# OCII Institution Profile

To date, OCII has served 100 Oklahoma institutions, agencies and organizations:

- 52 OK academic institutions
- 48 OK non-academic organizations
  - 16 commercial
  - 19 government
  - 2 military
  - 11 non-governmental



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# OCII Academic Institutions

1. **Bacone College (MSI, 25.0% AI, 29.8% AA): T**
2. **Cameron U (16.6% AA): A, D, E, F, O, T, W**  
*Taught advanced computing course using OSCER's supercomputer (multiple times).*
3. Canadian Valley Tech Center: W
4. Chisholm Trail Tech Center: W
5. **College of the Muscogee Nation (Tribal): O, T**
6. **Comanche Nation College (Tribal): D, O, T**
7. DeVry U Oklahoma City: D, F, O
8. **East Central U (NASNI, 16.9% AI, rural): A, D, E, F, O, P, T, W**  
*Taught advanced computing course using OSCER's supercomputer.*
9. **Eastern Oklahoma State College (24.9% AI): W**
10. Eastern Oklahoma County Tech Center: W
11. Elgin Middle School: O (tour only)
12. Francis Tuttle Tech Center: D, T, W
13. **Gordon Cooper Tech Center (13.5% AI, nonmetro): D, O, W**
14. **Great Plains Tech Center (11.5% AI): W**
15. **Kiamichi Tech Center (18.5% AI): T, W**
16. **Langston U (HBCU, 77.2% AA): A, D, E, F, O, P, T, W**  
*NSF Major Research Instrumentation grant for supercomputer awarded in 2012.*

Note: Langston U (HBCU), East Central U (NASNI) and U Central Oklahoma are the only non-PhD-granting institutions to have benefited from every category of service that OCII provides.

Average: ~3 (mean 3.5, median 3, mode 1)

AA = African American (7.7% OK population, 13.2% US population)

AI = American Indian (9.0% OK, 1.2% US)

H = Hispanic (9.6% OK, 17.1% US)

ALL = 26.3% OK, 31.5% US

HBCU: Historically Black College or University

NASNI = Native American Serving Non-Tribal Institution

MSI = Minority Serving Institution



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# OCII Academic (cont'd)

17. Lawton Christian School (high school): W
18. Metro Tech Centers (29.3% AA): D
19. Mid-America Tech Center: D, W
20. Mid-Del Public Schools: D
21. Moore Norman Tech Center: D, W
22. Northeast Tech Center (21.5% AI): W
23. Northeastern Oklahoma A&M College (NASNI, 22.6% AI): T, W
24. Northeastern State U (NASNI, 22.4% AI, nonmetro): A, D, E, F, O, T, W  
*Taught computational chemistry course using OSCER's supercomputer (multiple).*
25. Northwestern Oklahoma State U: A, F, O
26. Oklahoma Baptist U (nonmetro): A, D, E, F, O, T, W
27. Oklahoma Christian U: O, W
28. Oklahoma City Community College: O, T, W
29. Oklahoma City U: A, D, E, F, O, T, W  
*Educational Alliance for a Parallel Future mini-supercomputer proposal funded in 2011.  
Taught advanced computing course using OSCER's supercomputer (multiple).*
30. Oklahoma Panhandle State U (rural): A, D, O, W
31. Oklahoma School of Science & Mathematics (high school): A, D, E, O, W
32. Oklahoma State U (PhD): A, D, E, F, O, P, T, W  
*NSF Major Research Instrumentation proposal for supercomputer funded in 2011.*
33. Oklahoma State U Institute of Technology (community college, 19.9% AI): W  
Average: ~3 (mean 3.5, median 3, mode 1)

AA = African American (7.7% OK population, 13.2% US population)

AI = American Indian (9.0% OK, 1.2% US)

H = Hispanic (9.6% OK, 17.1% US)

ALL = 26.3% OK, 31.5% US

HBCU: Historically Black College or University

NASNI = Native American Serving Non-Tribal Institution

MSI = Minority Serving Institution



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# OCII Academic (cont'd)

34. **Oklahoma State U OKC (16.0% AA, community college): O, T, W**
35. **Oral Roberts U (17.7% AA): A, F, O, W**
36. **Panola Public Schools: D**
37. **Pawnee Nation College (Tribal): T**
38. **Pontotoc Tech Center (41.6% AI): T, W**
39. **Rogers State U (12.9% AI): A, D, F, O**  
*Taught computational chemistry course using OSCER's supercomputer.*
34. **Rose State College (18.0% AA): F, W**
35. **Sequoia High School (Tribal): W**
36. **St. Gregory's U (nonmetro): A, D, E, F, O**
37. **Southeastern Oklahoma State U (NASNI, 21.0% AI, nonmetro): A, D, E, F, O, T, W**  
*Educational Alliance for a Parallel Future mini-supercomputer grant funded in 2011*
44. **Southern Nazarene U (16.0% AA): A, D, F, O, P, T, W**  
*Taught computational chemistry course using OSCER's supercomputer.*
45. **Southern OK Tech Center (10.7% AI): T, W**
46. **Southwestern Oklahoma State U (rural): A, D, E, F, O, T, W**  
*Taught advanced computing course using OSCER's supercomputer (multiple).*
47. **Tulsa Community College: F, W**
48. **U Central Oklahoma: A, D, E, F, O, P, T, W**  
*NSF Major Research Instrumentation proposal for supercomputer submitted in 2011-13.*
49. **U Oklahoma (PhD): A, D, E, F, O, P, T, W**  
*NSF Major Research Instrumentation grant for large scale storage funded in 2010*
50. **U Phoenix: D**
51. **U of Science & Arts of Oklahoma (11.7% AI): A, O**
52. **U Tulsa (PhD): A, D, E, F, O, P, T, W**  
*Taught bioinformatics course using OSCER's supercomputer.*

Average: ~3 (mean 3.5, median 3, mode 1)

AA= African American (7.7% OK population, 13.2% US population)

AI = American Indian (9.0% OK, 1.2% US)

H = Hispanic (9.6% OK, 17.1% US)

ALL = 26.3% OK, 31.5% US

HBCU: Historically Black College or University

NASNI = Native American Serving Non-Tribal Institution

MSI = Minority Serving Institution



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# OCII Non-academic

## ■ Commercial (16)

1. Andon Corp : D, F
2. Chesapeake Energy Corp : D
3. Creative Consultants : D
4. Fusion Geophysical: D
5. Indus Corp: D, E
6. Information Technologic: D
7. KANresearch: D
8. KeyBridge Technologies: D
9. Lumenate: D
10. OGE Energy Corp: D
11. Perfect Order (now defunct): D
12. PowerJam Production Inc: D
13. Versatile: D
14. Visage Production Inc: D, E
15. Weather Decision Technologies Inc : A
16. Weathernews Americas Inc.: A, D

## ■ Government (19)

1. City of Duncan: D
2. City of Edmond: D
3. City of Nichols Hills: D
4. City of Tulsa: E
5. NOAA National Severe Storms Laboratory: A, D, E, F
6. NOAA Storm Prediction Center: D
7. NOAA National Weather Service: D
8. NOAA Radar Operations Center: D
9. OK Climatological Survey: D
10. OK Department of Health: D, E
11. OK Department of Human Services: D, E
12. OK Department of Libraries: D
13. OK Department of Mental Health and Substance Abuse Services: D
14. OK Office of State Finance: D
15. Oklahoma State Chamber of Commerce: D
16. OK State Regents for Higher Education: A, D, T
17. OK State Supreme Court: D
18. OK Tax Commission: D
19. Tulsa County Court Services: D





# OCII Non-academic (cont'd)

- Military (2)
  1. Fort Sill Army Base: E
  2. Tinker Air Force Base: A, D, E, F, O
- Non-governmental/non-profit (11)
  1. American Society of Mechanical Engineers, Oklahoma City chapter: O
  2. Engineering Club of Oklahoma City: O
  3. Lions Club of Norman OK: O
  4. Lions Club of Shawnee OK: O
  5. Norman Science Café: O
  6. Oklahoma EPSCoR: D
  7. Oklahoma Historical Society: D
  8. Oklahoma Innovation Institute/Tulsa Research Partners: A, D, E, O, P
  9. Oklahoma Medical Research Foundation: A, D, P
  10. Oklahoma Nanotechnology Initiative: D
  11. Samuel Noble Roberts Foundation (**rural**): A, D, E, F, T



# OCII Outcomes: Research

- External research funding to OK institutions facilitated by OCII lead institutions (Fall 2001- Summer 2015): **over \$174M**
- Funded projects facilitated: **over 300**
- OK faculty and staff: **over 130** in **~20** academic disciplines
- Publications facilitated: **over 1600**



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# OCII Outcomes: Research

- Specifically needed OCII just to be funded: **over \$43M**  
(OneOCII necessary but far from sufficient)
  1. NSF EPSCoR RII Track-1 (2008-13): \$15M to OK
  2. NSF EPSCoR RII Track-1 (2013-18): \$20M to OK (+\$4M Regents)
  3. NSF EPSCoR RII Track-2: \$3M to OK
  4. NSF EPSCoR RII C2: \$1.17M to OK
  5. NSF MRI (OU): \$793K
  6. NSF MRI (OSU): \$908K, \$951K
  7. NSF MRI (Langston U): \$250K
  8. NSF CC-NIE (OU, OSU, LU, OII, OneNet): \$500K
  9. NSF MRI (UCO): \$305K
  10. NSF CC\*IIE (OU): \$400K
  11. NSF CC\*IIE (GPN, OneNet, others): \$130K
  12. NSF MRI (TU): \$180K



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# OCII Outcomes: MRI Grants

- NSF Major Research Instrumentation for CI: **over \$2.5M**
  - NSF MRI (OU): \$340K, 2003; \$793K, 2010; submitting 2016
  - NSF MRI (OSU): \$908K, 2011; \$951K, 2015
  - NSF MRI (Langston U): \$250K, 2012
  - NSF MRI (UCO): \$305K, 2014
  - NSF MRI (TU): \$180K, 2015
- How do we stack up (since 2001 when OSCER was founded)?
  - OK: 15.5% of funding, 11% of PIs, 13% of awards
  - OU: 13.5% of funding
    - Among units, IT is 4<sup>th</sup> in number of awards, 4<sup>th</sup> in total funding.
    - Among PIs, Neeman is 1<sup>st</sup> in awards and 1<sup>st</sup> in funding (13.5%).
  - OSU: 18.5% of funding
  - Langston U: 100% of funding
  - UCO: 70% of funding; Lemley is 1<sup>st</sup> in funding

# OCII Outcomes: Education

## Teaching: 9 institutions including 3 MSIs

- Teaching/taught parallel computing using OneOCII resources:
  - Cameron U – multiple times
  - East Central U (NASNI)
  - Oklahoma City U – multiple times
  - Southwestern Oklahoma State U
- Taught parallel computing via LittleFe baby supercomputer and OneOCII resources:
  - Southeastern Oklahoma State U (NASNI) – multiple times
- Taught computational chemistry using OSCER resources:
  - Northeastern State U (NASNI) – multiple times
  - Southern Nazarene U
  - Rogers State U – multiple times
- Taught Bioinformatics using OCII resources:
  - U Tulsa – 2 semester sequence



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# OCII Outcomes: Resources

7 institutions including 2 MSIs, plus C2 institutions

- NSF Major Research Instrumentation grants: \$1.95M
  - OU: Oklahoma PetaStore, \$793K (in production)
  - Oklahoma State U: Cowboy cluster, \$909K (in production)
  - Langston U: cluster, \$250K (recently deployed)
  - U Central Oklahoma: cluster, \$305K (just awarded)
  - **NEW! U Tulsa**: cluster, \$180K (just awarded)
- LittleFe baby supercomputer grants (\$2500 each)
  - OU: Ron Barnes
  - Oklahoma City U: Larry Sells & John Goulden
  - Southeastern Oklahoma State U: Mike Morris & Karl Frinkle
- Networking: C2 grant: \$1.17M, CC-NIE grant \$500K



# OK Optical Initiative (NSF EPSCoR C2)

## ■ Hardware

- Statewide Ring upgrade: replaced routed mux/demuxes with Reconfigurable Optical Add Drop Modules: much less expensive and much more straightforward to add new 10G circuits.
- Institutional upgrades
  - OU and OSU: cluster upgraded to 10G shared from GigE (10X), then upgraded to 20G (2 x 10G) dedicated (20X), which is connected to Internet2's 100G Innovation Platform backbone.
  - OU: mini-Science DMZ.
  - U Tulsa: upgraded to GigE from 200 Mbps (5X).
  - Samuel Roberts Noble Foundation: (private non-profit research institutions): upgraded to GigE from 45 Mbps for research (22X), 100 Mbps for commodity (2X)







# OK Optical Initiative (NSF EPSCoR C2)

- Hardware (continued)
  - Institutional Upgrades (continued)
    - Langston U (Oklahoma's only Historically Black College or University): upgraded to 10G from 100 Mbps (100X) for research.
    - Bacone College (Minority Serving Institution): campus backbone upgraded to 100 Mbps with GigE core from 10 Mbps (10X upgrade).
    - College of the Muscogee Nation (Tribal): network core for new residence hall.
    - Comanche Nation College (Tribal) distance learning system.
    - Pawnee Nation College (Tribal) Internet radio station, distance learning system, campus backbone upgrade to GigE.
  - OK IT Mentorship Program





# OK Optical Initiative Side Effects

- 100G connection to Internet2's Innovation Platform
- OU+OSU Shared Services initiative: leveraging C2 investments to create enterprise IT collaborations both within and between the institutions.
  - OU Virtual data center – highly robust
  - Virtualized services
  - Substantial savings from shared infrastructure and shared purchasing vehicles.
  - **NOT AT ALL FUNDED BY C2.**
  - But, leverages C2 capabilities – if not for the C2, Shared Services would have had to make the exact same investments in the state ring.



# OCII HPC (2008-12)

---

Just over 40 TFLOPs of HPC capacity across the state:

- OU: 34.5 TFLOPs (internally funded)
- OSU: 6.3 TFLOPs (internally funded)



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# Education, Outreach, Training, etc

- Education
  - Supercomputing in Plain English (SiPE)
- Outreach
  - SiPE Overview Talk, Cyberinfrastructure tours
- Training
  - Various technology trainings (run by vendors)
- Faculty/Staff Development
  - Summer workshops
- Workforce Development
  - Oklahoma IT Mentorship Program



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# Supercomputing in Plain English

- **FREE and OPEN TO ALL**
- Provided every other spring (upcoming Spring 2015)
- Available LIVE via videoconferencing
- Topics <http://www.oscer.ou.edu/education/>
  1. Overview: What the Heck is Supercomputing?
  2. The Tyranny of the Storage Hierarchy
  3. Instruction Level Parallelism
  4. Stupid Compiler Tricks
  5. Shared Memory Multithreading
  6. Distributed Multiprocessing
  7. Application Types and Parallel Paradigms
  8. Multicore Madness
  9. High Throughput Computing
  10. GPGPU: Number Crunching in Your Graphics Card
  11. Grab Bag: Scientific Libraries, I/O Libraries, Visualization



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# SiPE Participants

- 362 institutions, firms, agencies and organizations in 51 US states & territories and 17 other countries
  - Academic: 251 institutions in 51 US states & territories and 15 other countries
    - 88 institutions in 26 EPSCoR jurisdictions
      - 16 institutions in Oklahoma
  - Industry: 49 firms in the US and 4 other countries
  - Government: 44 – US federal and state plus 7 other countries
  - Non-Governmental: 18 (US and 1 other country)
- Missing US states & territories
  - EPSCoR states: RI, VT
  - EPSCoR territories: Guam (no PhD-granting)
  - Other territories: American Samoa, Northern Marianas Islands (community colleges only)



# Outreach: Presentations & Tours

## Courses at OU

1. Chem Engr: Industrial & Environmental Transport Processes (D. Papavassiliou)
2. Engineering Numerical Methods (U. Nollert)
3. Math: Advanced Numerical Methods (R. Landes)
4. Electrical Engr: Computational Bioengineering (T. Ibrahim)

## Research Experience for Undergraduates at OU

1. Ind Engr: Metrology REU (T. Reed Rhoads)
2. Ind Engr: Human Technology Interaction Center REU (R. Shehab)
3. Meteorology REU (D. Zaras)

## External

1. American Society of Mechanical Engineers, OKC Chapter
2. Engineering Club of Oklahoma City
3. Association for Computing Machinery (ACM) Special Interest Group on Computer Science Education (SIGCSE) 2010
4. Oklahoma State Chamber of Commerce
5. National Educational Computing Conference 2006 (virtual tour via videoconference)
6. Norman (OK) Lions Club
7. Society for Information Technology & Teacher Education conference 2008, 2009, 2010
8. Axiom Conference on Applied Research in Information Technology 2008
9. Shawnee (OK) Lions Club
10. Oklahoma Louis Stokes Alliance for Minority Participation (@ OSU) 2010 (Keynote)
11. Norman (OK) Science Café
12. Tech Forum Texas 2010
13. Texas Computer Education Association 2011
14. Tinker Air Force Base
15. Consortium for School Networking 2011
16. Consortium for Computing Sciences in Colleges 2011 (Keynote)
17. SC07-13

## Other Universities

1. SUNY Binghamton (NY)
2. Bradley University (IL)
3. Cameron University (OK)
4. The Citadel (SC)
5. College of the Muscogee Nation (OK)
6. Comanche Nation College (OK)
7. DeVry University (OK)
8. East Central University (OK)
9. El Bosque University (Bogota Colombia)
10. Southwestern University (TX)
11. Langston University (OK)
12. Louisiana State University
13. Midwestern State University (TX)
14. Northeastern Oklahoma State University
15. Northwestern Oklahoma State University
16. Oklahoma Baptist University
17. Oklahoma City University
18. Oklahoma State University x 2
19. Oklahoma State University – OKC
20. Oral Roberts University (OK) x 2
21. Rogers State U (OK)
22. Philander Smith College (AR)
23. St. Gregory's University (OK) x 2
24. Southeastern Oklahoma State University x 2
25. Southern Nazarene University (OK)
26. Southwestern Oklahoma State University x 2
27. Texas A&M-Commerce
28. University of Arkansas Fayetteville
29. University of Arkansas at Little Rock
30. University of Arkansas at Pine Bluff
31. University of Central Oklahoma
32. University of Oklahoma-Tulsa
33. University of Science & Arts of Oklahoma
34. University of Texas Brownsville
35. University of Tulsa (OK)

## High Schools and High School Programs

1. Oklahoma School of Science & Mathematics x 2
2. Oklahoma Christian University's Opportunity Bytes Summer Academy
3. Dept of Energy National Scholarship Finalists
4. Ardmore High School (OK)
5. Elgin Middle School



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# Fac/Staff Dev: Summer Workshops

- National Computational Science Institute workshops
  - Intro to Parallel Programming & Cluster Computing weeklong: summer 2004, summer 2005, summer 2008, summer 2009, summer 2012
  - Intro to Parallel Programming & Cluster Computing daylong: fall 2003, fall 2007-11
  - Intermediate Parallel Programming & Cluster Computing weeklong: summer 2010, summer 2011
    - LittleFe baby supercomputer buildout (summer 2011 – first ever anywhere; summer 2012)
  - Computational Chemistry for Chemistry Educators weeklong: summer 2009, summer 2011
  - Many of these were co-sponsored by Oklahoma EPSCoR (2008-2012) and/or the SC Education Program (2007-9, 2011)



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# Fac/Staff Dev: Summer Workshops

- Linux Clusters Institute workshops: June 2005, Feb 2007
  - Selected to host the next LCI workshop (2015)
- Virtual School for Computational Science & Engineering weeklong
  - 2012: Programming Heterogeneous Parallel Computing Systems; Proven Algorithmic Techniques for Many-core Processors (both on GPU computing)
  - 2013, 2015: Data Intensive Summer School (big data)
- Software Carpentry Bootcamp (2013): Python, scripting, version control etc
- Bioinformatics weeklong (2012, 2015)
- SUMMARY: Every summer 2004-2015 except 2006, 2007.



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# OK IT Mentorship Program

The Oklahoma Information Technology Mentorship Program is sending networking professionals to universities, colleges, career techs and even a high school statewide.

These professionals will give talks on the practicalities of being a networking professional – what that career choice means day by day.

We also provide both live and virtual job shadowing opportunities – students can follow networking professionals around to see what their work looks like, either in person or via Twitter and Facebook.

So far we've done over 100 events for 39 institutions.



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OneOklahoma  
Cyberinfrastructure  
Initiative  
2013-18

---

# OneOklahoma Cyberinfrastructure Initiative

• OPSU

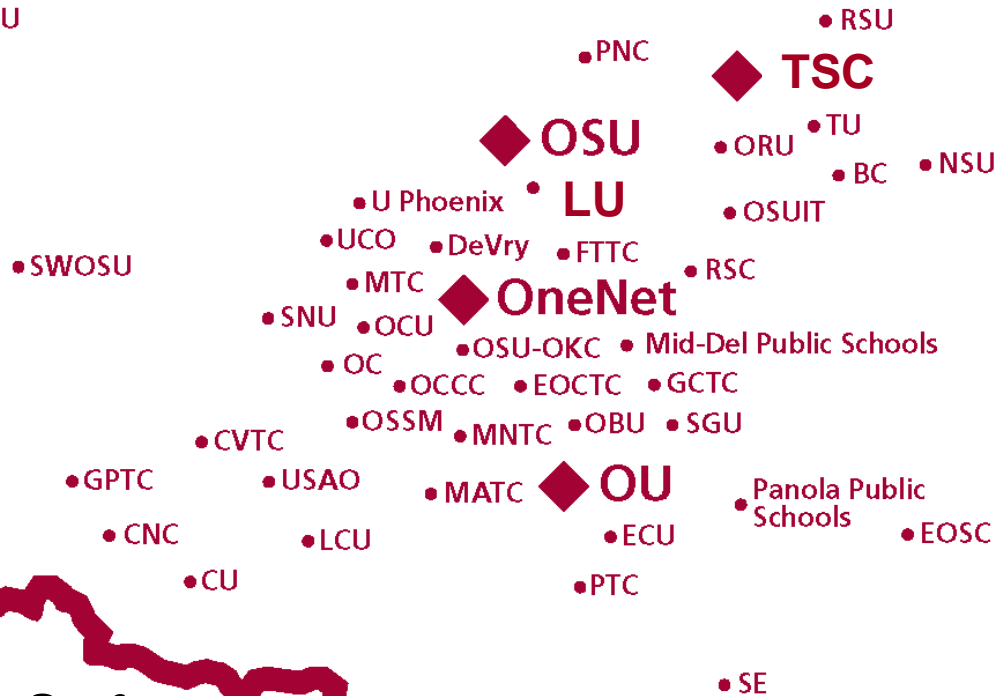
• NWOSU

• RSU

## 2013-18

Resource Providers: OU, OSU, TSC, Langston (HBCU, HEP)

- All OCII Services
- Informatics: Research facilitators (NOT researchers) who embed in specific research teams . Expands Informatics team from just OU to OSU, available to others statewide.
- cyberCommons: adaptable Big Data environment developed under OK-KS Track-2 (2009-13).
- Data Stewardship Initiative: collaboration among CI and Libraries.
- OK STEM Mentorship Program: extended OK IT Mentorship Program to other STEM disciplines.



**So far:**  
**52 OK academic**  
**48 OK non-academic**

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# NEW! OneOCII

All of OCII, plus:

- Informatics professionals: research facilitators embedded in specific research projects (and largely funded by them)
- CyberCommons (from old NSF EPSCoR RII Track-2 grant)
  - Software platform for end-to-end research workflow support
- Physical resources
  - Research Cloud: research teams can buy virtual servers
  - Hadoop cluster
- Data Stewardship Initiative (led by Libraries)
- Oklahoma STEM Mentorship Program (not just IT) – already 20 institutions signed up, including 3 new



# NSF EPSCoR RII Track-1

- “Adapting Socio-ecological Systems to Increased Climate Variability”
- OU, OSU, U Tulsa, Noble Foundation
- \$24M (\$20M NSF, \$4M State Regents) over 5 years
- Includes just under \$1M for Informatics
  - OU: heavy in Year 1 and first half of Year 2, light thereafter
  - OSU: nothing in Year 1 and first half of Year 2, 1 FTE thereafter
  - Sustainability plan, in place, guarantees at least through 2021



# OneOCII HPC

Over 200 TFLOPs of HPC capacity across the state  
(5X increase from 2008-12)

- OU: 110.6 TFLOPs, acquired 2012 (internally funded)
- OSU: 48.8 TFLOPs, acquired 2012 (NSF MRI)
- Langston U: 8 TFLOPs CPU, 18.72 TFLOPs GPU, acquired 2013 (NSF MRI)
- Tandy Supercomputing Center (Tulsa): 34.56 TFLOPs, acquired 2013 (independently of OCII/OneOCII)
- UCO: 30+ TFLOPs



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# OK STEM Mentorship Program

- Already have presenters signed up for:
  - Agriculture
  - Earth Sciences
    - Atmospheric Sciences: Meteorology
    - Ecological Sciences: Ecology, Rangeland Ecology, Urban Ecology
    - Geographical Sciences: Geography, Geographic Information Systems
  - Engineering: IT/CS
  - Libraries
  - Life Sciences: Plant Biology
  - Social Sciences: Anthropology, Economics, Political Science



Advanced  
Cyberinfrastructure  
Research & Education

---

Facilitators  
2015-16

# History

- March 2012: Clemson U creates “Condo of Condos” initiative.
- Apr 2013: Clemson U submits “Condo of Condos” proposal, including ACI-REFs and networking hardware:
  - 13 institutions, 4 years, \$33M+
- March 2015: Proposal partially funded, ACI-REFs only:
  - 6 institutions (not OU), 2 years, \$5.3M
- Apr 2015: OU submits ACI-REF CC\*IIE proposal.
- Sep 2015: NSF announces OU ACI-REF grant.
  - 2 years of 1.0 FTE (Oct 2015 – Sep 2016)
  - 2 summer workshops (2015, 2016) on how to be an ACI-REF



# What's an ACI-REF?

- An Advanced Cyberinfrastructure – Research & Education Facilitator (ACI-REF) works directly with research teams to adopt advanced cyberinfrastructure into their research and education.
- OSCER personnel have been providing a low-intensity version of this service since the beginning.
- OU Informatics personnel have been providing a high intensity version since fall 2010.
- OU's ACI-REF FTE focuses on high end networking, especially SDN via OFFN.



# ACI-REF Grant Objectives #1

- Data-Intensive Research Facilitation: Via Software Defined Networking (SDN) across OFFN, facilitate end-to-end management, by researchers, of high bandwidth/high performance data flows through a distributed hierarchy of open standards tools, providing researchers with a new layer of transparency into network transport at OU, among OneOCII institutions, and with ACI-REF members.
- Oklahoma ACI-REF project: Lead and facilitate adoption of the ACI-REF approach across Oklahoma, leveraging extant and emerging capabilities within OneOCII.



# ACI-REF Grant Objectives #2

- National training regime: Provide a “virtual residency” program for Campus CI Engineers and other ACI-REFs, open to not only CC\*IIE awardees and ACI-REF members but any institution that needs.
- Research Experiences for Undergraduates (REU)  
Sites/Supplements: Foster undergraduate research at OU via a culture of integrating REU sites and supplements into STEM research, including by all research themes on the ACI-REF grant.



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# Research Projects Part 1

- High Energy Physics
  - also on on DOE EPSCoR, C2, PetaStore, OFFN
  - 8 Gbps
  - \$1.7M current, \$1M pending/planned
  - 7 faculty, 2 staff, 4 postdocs, 9 grad students
- Spring Realtime Storm Forecasting Experiment (CAPS)
  - also on C2, PetaStore, OFFN
  - 12 Gbps
  - \$2.5M current, \$1M pending/planned
  - 6 faculty, 10 staff, 20 grad students
- Weather Radar (ARRC)
  - also on PetaStore, OFFN
  - 1.9 Gbps
  - \$10M current, \$30M pending/planned
  - 16 faculty, 7 staff, 16 postdocs, ~60 grad students, ~10 undergrads



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# Research Projects Part 2

- Tornado Models (IDEA)
  - also on EPSCoR RII Track-2, PetaStore, OFFN
  - 0.6 Gbps
  - \$600K current, \$500K pending/planned
- Warn on Forecast (CIMMS): NEW!
  - 0.5 Gbps
  - \$677K current
  - 12 staff, 4 postdocs, 3 grad students
- Ecological Informatics (EOMF)
  - also on EPSCoR RII Track-2, OFFN
  - 0.2 Gbps
  - \$5M current, \$8M pending/planned
  - 1 faculty, 3 staff, 3 postdocs, 7 grad students, 1 undergrad



# Research Projects Part 3

- Data Networks (CS)
  - also on OFFN
  - \$720K current
  - 2 faculty, 3 grad students
- TOTALS
  - 23 Gbps
  - \$21 current, \$40M pending/planned
  - 33 faculty, 34 staff, 27 postdocs, ~108 grad students, ~14 undergrads



**ACI-REF**

**Virtual Residency**

---



# ACI-REF Virtual Residency

- First week of June
- 50 participants (28 onsite, 22 videoconferenced)
  - 39 institutions
  - 26 states and territories
  - 21 institutions in 12 EPSCoR jurisdictions
  - 5 Minority Serving Institutions,
  - 5 non-PhD-granting institutions



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# Virtual Residency Structure

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- Plenaries
- Breakout sessions in two tracks
  - Computational & Data-Enabled Science & Engineering
  - Software Defined Networking
- Practica



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# Plenary Topics

- Introduction to Research Cyberinfrastructure Consulting
- How to Give a Cyberinfrastructure Tour
- Effective Communication: How to Talk to Researchers About Their Research
- Cyberinfrastructure User Support (slides provided by Memo Belgin)
- Faculty: Tenure, Promotion, Reward System (Prof. Bruce Mason, OU Physics)
- Using Videoconferencing and Collaboration Technologies for Consulting (S. Patrick Calhoun, OSCER & JUB Sheriff, OU IT)
- Writing Grant Proposals (Linda Mason, Oklahoma State Regents for Higher Education)



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# Plenary Topics (cont'd)

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- The Shifting Landscape of CI Funding Opportunities (Dr. J. Barr von Oehsen, Clemson U)
- So You Want to Write a Cyberinfrastructure Proposal
- Stories from the Trenches



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# CDS&E Breakout Track

- Deploying Community Codes (Josh Alexander, OSCER)
- Practicum: Real Users and Their CDS&E Research:  
Prof. Amy McGovern, OU Computer Science
- Benchmarking & Tuning (Brett Zimmerman, OSCER)
- Practicum: Real Users and Their CDS&E Research  
(Prof. Randy Kolar & Dr. Kendra Dresback, OU Civil Engr)
- “Speed Dating:” Real Users and Their CDS&E Research  
(multiple STEM research teams)
  - Two sessions (Tue & Thu)



# CDS&E Breakout Track

---

- Finding and Provisioning Remote Resources
  - XSEDE: Jeff Pummill, University of Arkansas
  - Open Science Grid:
    - Horst Severini, OSCER/OU High Energy Physics
    - Elizabeth Prout, Indiana University (via video)
    - Rob Gardner, University of Chicago (via video)



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# SDN Track

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- OpenFlow lecture
- OpenFlow lab
- Exploring Open Daylight lecture
- Exploring Open Daylight lab
- Practica: Real Users' High Bandwidth Research (High Energy Physics, Warn on Forecast)
- The Software in SDN lecture
- The Software in SDN lab





# Acknowledgements

Portions of this material are based upon work supported by the National Science Foundation under the following grants:

- Grant No. EPS-0814361, “Building Oklahoma's Leadership Role in Cellulosic Bioenergy”
- Grant No. EPS-1006919, “Oklahoma Optical Initiative”
- Grant No. OCI-1039829, “MRI: Acquisition of Extensible Petascale Storage for Data Intensive Research”
- Grant No. OCI-1126330, “Acquisition of a High Performance Compute Cluster for Multidisciplinary Research”
- Grant No. ACI- 1229107, “Acquisition of a High Performance Computing Cluster for Research and Education”
- Grant No. EPS-1301789, “Adapting Socio-ecological Systems to Increased Climate Variability”
- Grant No. ACI-1341028, “OneOklahoma Friction Free Network”
- Grant No. ACI-1429702, “Acquisition of a High Performance Computing Cluster for Research at a Predominantly Undergraduate Institution”
- Grant No. ACI-1440774, “Leveraging Partnerships Across the Great Plains to Build Advanced Networking and CI Expertise”
- Grant No. ACI-1440783, “A Model for Advanced Cyberinfrastructure Research and Education Facilitators”



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# Acknowledgements

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Dell provided seed systems for the OU Research Cloud (“OURcloud”) and the OU Science DMZ.



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# Symposium 2015 Sponsors: Thank You!

- Academic sponsor (1)
  - Great Plains Network
- Industry sponsors (17/18)
  - Platinum (1): Intel + HP
  - Gold (7): Arista Networks, **Brocade**/Lumenate, Dell, Mellanox Technologies, NVIDIA, **Quantum**, **Qumulo**
  - Silver (4): Cray, DataDirect Networks, SGI, Spectra Logic
  - Bronze (5/6): Adaptive Computing, Advanced Clustering Technologies, Aspen Systems, **Penguin**, **Pinnacle**/EMC

Thank you all! Without you, the Symposium couldn't happen. Over the past 14 Symposia, we've had a total of 84 companies as sponsors – and more than half have repeated (or were acquired by/merged with other sponsors).



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# Thanks!

## ■ OU IT

- OU CIO/VPIT Loretta Early
- Symposium committee: Josh Alexander (OU), Dana Brunson (OSU), Debi Gentis (OU), George Louthan (OII), Franklin Fondjo Fotou (LU), Joel Snow (LU), Karl Frinkle (SE), Evan Lemley (UCO)
- Symposium coordinator: Debi Gentis
- Sponsorship coordinator: Chance Grubb
- OSCER Operations Team: Dave Akin, Brett Zimmerman, Josh Alexander, Patrick Calhoun
- All of the OU IT folks who helped put this together

## ■ CCE Forum

- Jake Maurer, Kristin Livingston
- The whole Forum crew who helped put this together



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# Thanks: Plenary Speakers

---

- Jim Kurose, NSF Computer & Information Science & Engineering Directorate
- Carl Grant (OU), Adrian Alexander (TU), Jennifer Fitzgerald (Noble), Mark Laufersweiler (OU), Robin Leech (OSU), Habib Tabatabai (UCO)
- Monica Martinez-Canales, Intel & Stephen Wheat, HP (Platinum sponsors)



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# Thanks: Gold Sponsor Speakers

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- Mickey Stewart, Arista Networks
- Dan DeBacker, Brocade Communications Systems Inc.
- DJ Spry, Dell
- Kashif Chauhan & D. Kent Snider, Mellanox Technologies
- Bob Crovella, NVIDIA
- Neal Wingenbach, Quantum
- Bob Collins, Qumulo



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# Thanks: Breakout Speakers

1. Kate Adams, GPN
2. Dan Andresen, KSU
3. Joseph Babb, Tinker AFB
4. Dana Brunson, OSU
5. Eduardo Colmenares, MWSU
6. Nick Davis, OU Tulsa
7. Jim Ferguson, NICS
8. Karl Frinkle & Mike Morris, SEOSU
9. John Hale, Peter Hawrylak, Andrew Kongs, TU
10. Utkarsh Kapoor, OSU
11. Scott Lathrop, XSEDE/Shodor
12. David Monismith
13. Mukundhan Selvam, WSU
14. Dan Stanzione, TACC



# Thanks!

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To all of you for participating, and to those many of you who've shown us so much loyalty over the past 14 years.



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# Such a bargain!

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- If you want your t-shirt and your power bank, all you have to do is give us a completed evaluation form!
- It's that easy!
- What a bargain!



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# To Learn More

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<http://www.oscer.ou.edu/>

<http://oneocii.okeyscores.org/>



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**Thanks for your  
attention!**

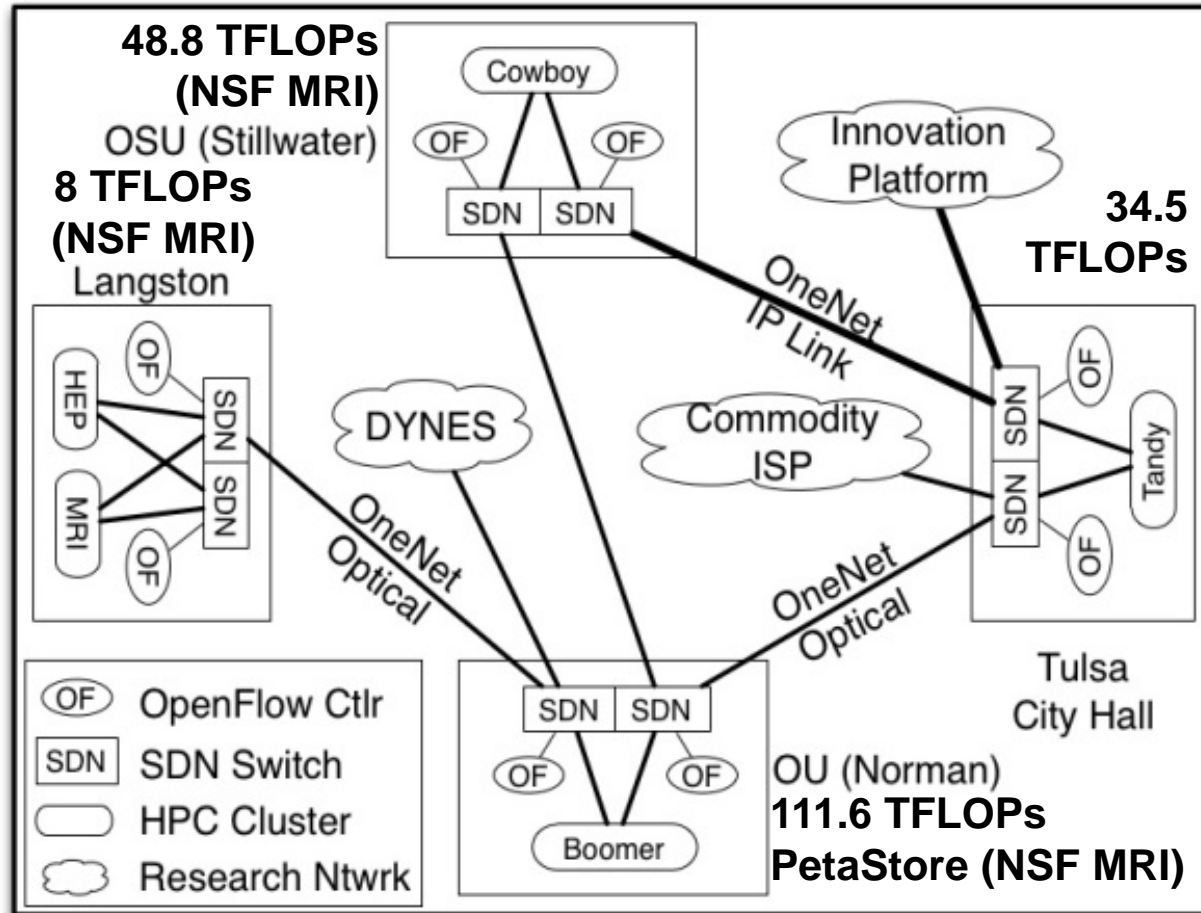
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**Questions?**

OneOklahoma  
Friction Free  
Network  
2013-15

---

# NSF CC-NIE Grant



## OneOklahoma Friction Free Network (OFFN)

- Multi-institutional Science DMZ
- Software Defined Networking
- Dedicated 10G among the participating sites
- Aggregate compute: just over 200 TFLOPs (peak)



# Objectives

---

1. Deploy and maintain, at the four institutions, a research-only network consisting of institutional last mile components that are independent of enterprise networks, with its internal hub collocated with OneNet.
2. Apply Software Defined Networking (SDN) across OFFN, facilitating end-to-end management, by researchers, of high bandwidth/high performance data flows through a distributed hierarchy of open standards tools, giving researchers a new layer of transparency into network transport.
3. Provide these capabilities – OFFN's in particular and OneOCII's in general – to all relevant researchers and educators statewide, and facilitate their use.



# Initial Science Drivers

- High Energy Physics (ATLAS, DØ): OU, LU, OSU
- Real Time Numerical Weather Prediction: OU
- Weather Radar: OU
- Bioinformatics: OSU
- Ecological Informatics: OU (added after grant started)
- ... with more to come.

Identified aggregate bandwidth: 23+ Gbps (when everything is going full tilt at the same time)



# Science Driver: High Energy Physics

- Senior Personnel
  - H. Severini (OU)
  - P. Skubic (OU)
  - J. Snow (LU)
  - M. Strauss (OU)
- Oklahoma Center for High Energy Physics (OCHEP)
- Funding: \$1.7M current, \$1M planned (NSF, DOE, Fermilab)
- 7 faculty, 2 staff, 4 postdocs, 3 graduate students
- Identified bandwidth need: up to 8 Gbps sustained



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# Science Driver: High Energy Physics

- OU and LU already do a lot of ATLAS computing (data analysis and Monte Carlo simulation).
- OU, LU and OSU constitute the Oklahoma Center for High Energy Physics (OCHEP).
  - OSU physicists aren't doing computational.
- OU, LU and U Texas Arlington constitute the NSF's ATLAS Southwest Tier2 Center (SWT2), which is consistently in the top 3 most productive US academic Tier2 sites (OU is consistently #6-#8 most productive US academic institution).
- OSU and TSC have agreed to provide their idle cycles for ATLAS jobs, but will kill them off in favor of local jobs.



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# Science Driver: Weather Prediction

- OU Center for Analysis & Prediction of Storms (CAPS)
- Senior Personnel
  - M. Xue (CAPS Director and faculty in OU's School of Meteorology)
  - K. Brewster (CAPS Associate Director)
- Funding: \$2.5M per year current, \$1M per year planned (NSF, NOAA)
- 6 faculty, 10 staff, 20 graduate students
- Identified bandwidth need: 12 Gbps sustained (during the annual Spring Realtime Storm Forecasting Experiment, mid-March – mid-June)



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# Science Driver: Weather Radar

- Advanced Radar Research Center (ARRC)
- Senior Personnel: Tian-You Yu et al
- Funding: \$10M current, \$5M pending, \$25M planned (NOAA, NSF, NASA, industry)
- 15 faculty, 2 staff, 11 postdocs, ~60 graduate students, ~10 undergraduates
- Identified bandwidth need: 1.9 Gbps sustained



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# Science Driver: Bioinformatics

- OSU Bioinformatics program
- Senior Personnel Elshahed (OSU), Hoyt (OSU)
- Funding: \$6.1M current, \$4.4M pending (NSF, NIH, USDA, DOD, US Army, OCAST, OK Ag Experiment Station)
- 14 faculty, 6 postdocs, 35 graduate students
- Identified bandwidth need: likely 1.6+ Gbps – lesser of (a) bandwidth of OSU HPC cluster disk or (b) bandwidth of Oklahoma PetaStore disk



# Network Deployment Goals

- Provide a proven, commercial off-the-shelf (COTS) hardware platform backed with vendor support.
- Realize the Science DMZ goals through the use of a truly independent network at each campus site.
  - The network deployment will consist of dedicated optical pathways to the optical transport provider (OneNet), as well as to the local campus backbone where desired.
- Deploy a fully virtualized infrastructure, to be used simultaneously by multiple research entities, presented to each entity as a dedicated “slice” of the overall resource.
- Leverage federation to provide oversight and visibility into the operations of the virtualized platform.



# Network Deployment Goals (cont'd)

- Realize the full potential of OFFN through awareness, training, site-specific hand-off, and communities of support for OFFN adopters.

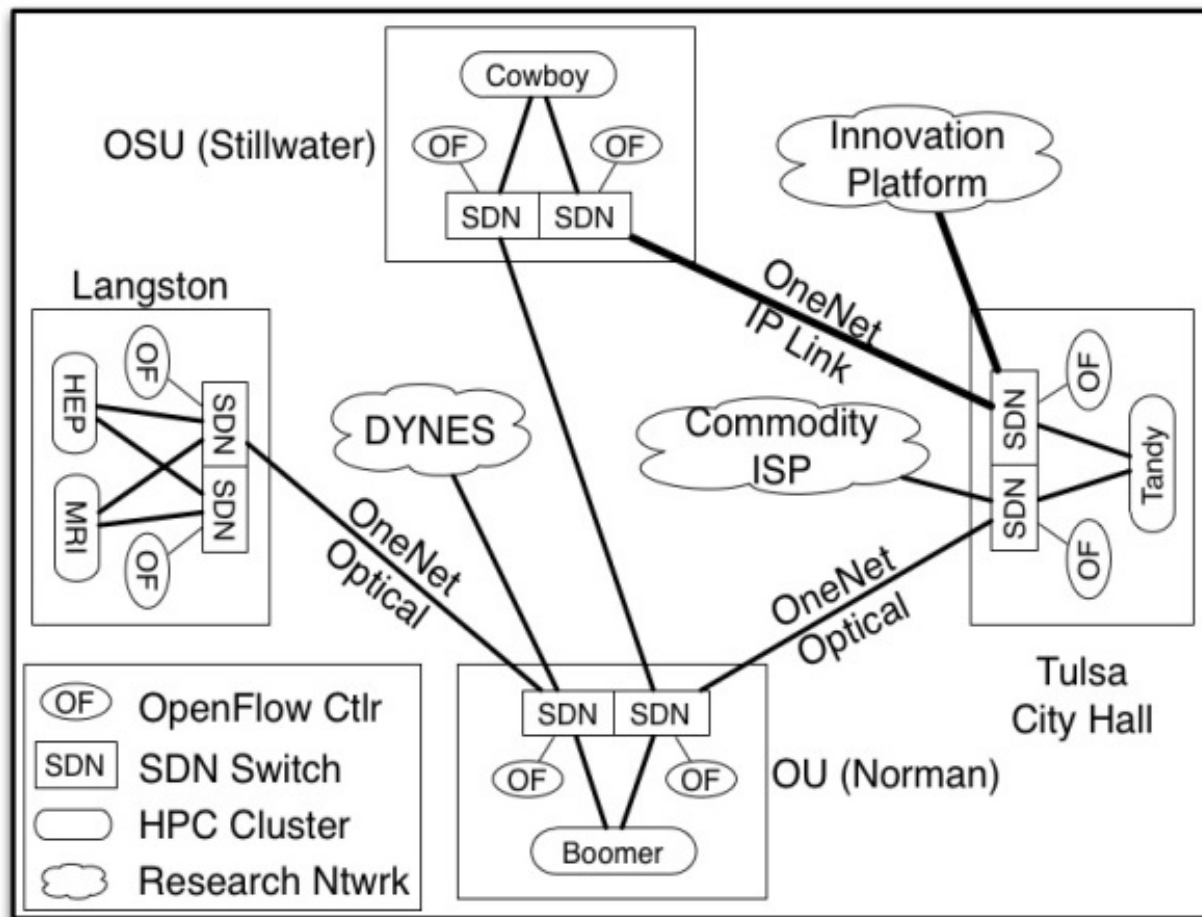


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# State Diagram (Conceptual)



# State Diagram (Logical)







# Institutional Design

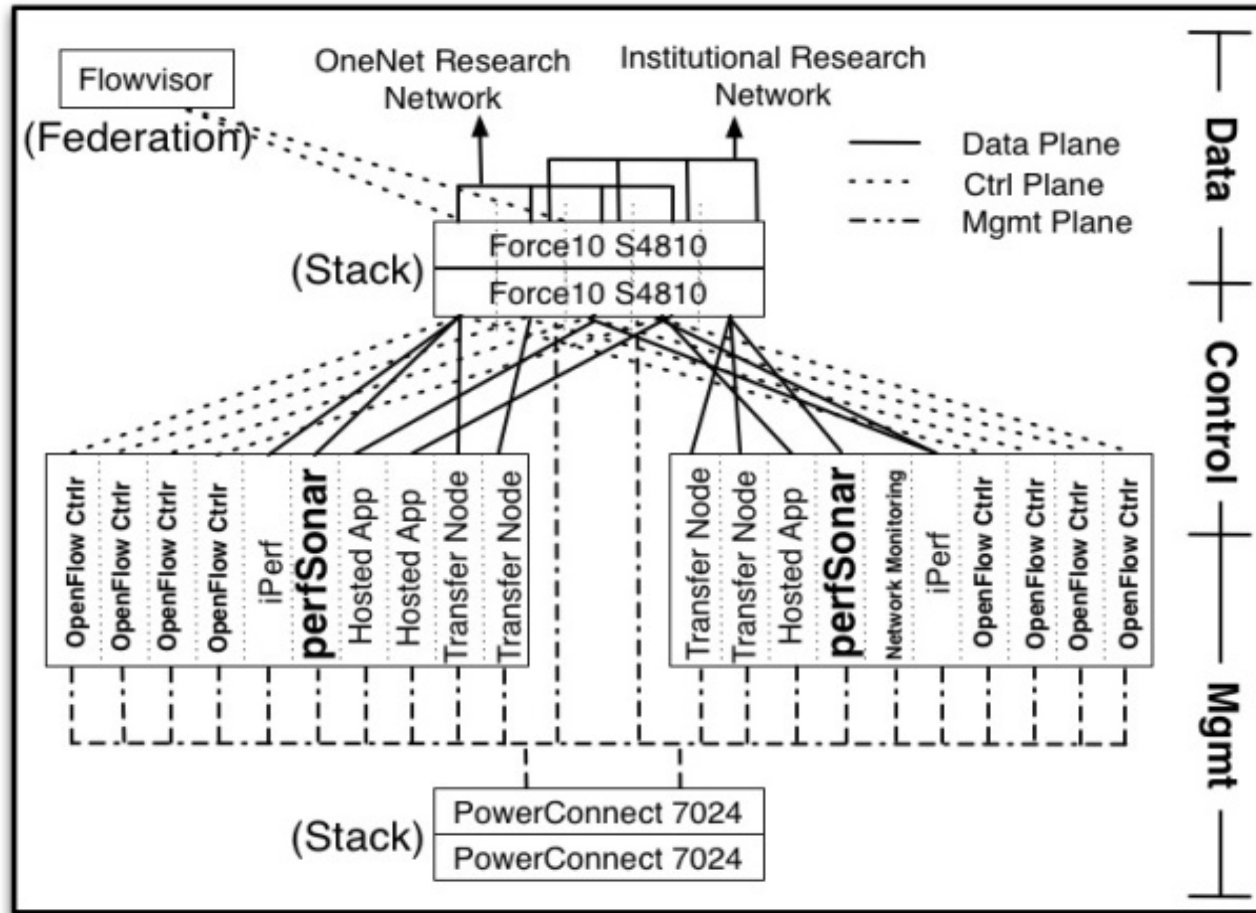
- SDN switches provide a virtualized data plane resource, to effectively and efficiently forward Ethernet traffic based on rules configured on the SDN controller. (Note that TSC will use a 24-port SDN-capable Brocade linecard instead.)
- Platform support switches provide the connectivity required for out-of-band management functions, including server lights-out management, SDN switch component management, and Virtual Machine (VM) host management.



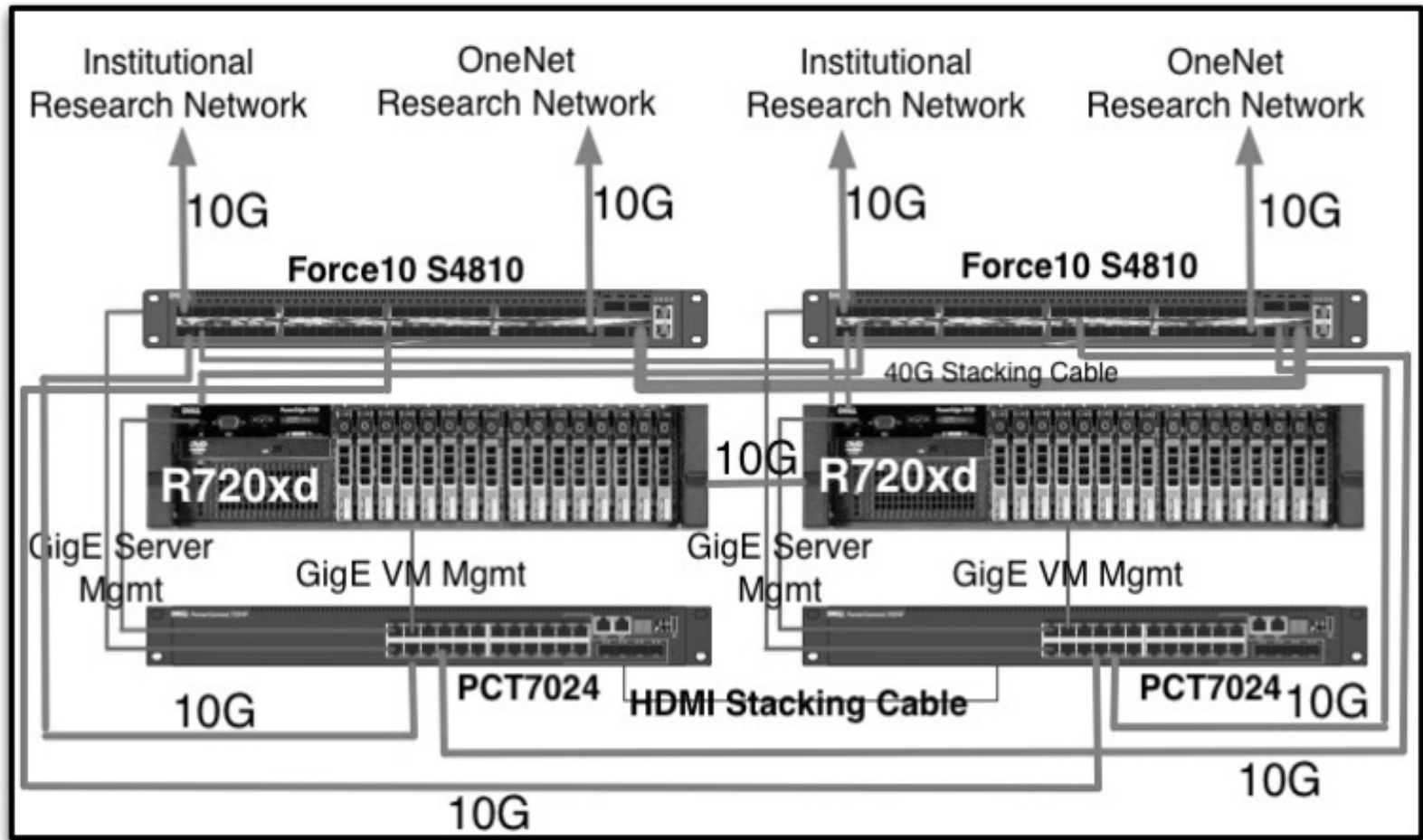
# Institutional Design (cont'd)

- Servers provide multiple virtualized SDN controller resources, plus a virtualized platform for providing performance toolsets, management and monitoring utilities, and data transfer tools (e.g., perfSonar).
- Software (all Open Source and/or free)
  - OS virtualization platform (Xen, VirtualBox or Qemu)
  - Linux host and guest OS (Fedora or CentOS)
  - SDN controller (Beacon or Floodlight)
  - Performance testing (iPerf and the PSPPerformance Toolkit)
  - Monitoring (Cacti or Nagios)

# Institutional Diagram (Logical)



# Institutional Diagram (Physical)





# External Connectors

- **Innovation Platform**: OneNet has secured a 100G connection onto Internet2's Innovation Platform (IP).
  - OSU has dedicated connectivity to connect to the IP at 100G.
  - OU is deploying 2 x 10G with Layer-2 and Layer-3 transport services, from OU to OneNet, connecting directly into the same OneNet chassis as the IP. Under OFFN, researchers statewide will straightforwardly be able to access the IP via OU and OSU.
- **DYNES**: OU hosts a “static” DYNES site deployment.
  - Primarily implemented as a dedicated path tool for OUHEP's SWT2 cluster to receive large datasets from LHCOne.
  - Can easily be migrated to the 4PP Science DMZ.



# External Connectors (cont'd)

- **XSEDE**: OU's already-funded plan to connect to the Innovation Platform can also facilitate connection to XSEDEnet at no additional charge, by OneNet simply setting aside 10 Gbps of the 100 Gbps connection into the Innovation Platform (subject to OneNet's and XSEDE's approval).
- **PlanetLab** provides an overlay services network that can be decomposed into tangible resource pools used for network experimentation. Both OU and OSU provide dedicated PlanetLab hardware resources.



# Acknowledgements

Portions of this material are based upon work supported by the National Science Foundation under the following grants:

- Grant No. EPS-0814361, “Building Oklahoma's Leadership Role in Cellulosic Bioenergy”
- Grant No. EPS-1006919, “Oklahoma Optical Initiative”
- Grant No. OCI-1039829, “MRI: Acquisition of Extensible Petascale Storage for Data Intensive Research”
- Grant No. OCI-1126330, “Acquisition of a High Performance Compute Cluster for Multidisciplinary Research”
- Grant No. ACI- 1229107, “Acquisition of a High Performance Computing Cluster for Research and Education”
- Grant No. EPS-1301789, “Adapting Socio-ecological Systems to Increased Climate Variability”
- Grant No. ACI-1341028, “OneOklahoma Friction Free Network”
- Grant No. ACI-1429702, “Acquisition of a High Performance Computing Cluster for Research at a Predominantly Undergraduate Institution”
- Grant No. ACI-1440774, “Leveraging Partnerships Across the Great Plains to Build Advanced Networking and CI Expertise”
- Grant No. ACI-1440783, “A Model for Advanced Cyberinfrastructure Research and Education Facilitators”



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# Acknowledgements

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Dell provided seed systems for the OU Research Cloud (“OURcloud”) and the OU Science DMZ.



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- Symposium coordinator: Debi Gentis
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- OSCER Operations Team: Dave Akin, Brett Zimmerman, Josh Alexander, Patrick Calhoun
- All of the OU IT folks who helped put this together

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- Jim Kurose, NSF Computer & Information Science & Engineering Directorate
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