Collaboration with other national and international research groups, both inside and outside of NOAA including Cooperative Institutes and universities, as well as reimbursable support from NOAA and non-NOAA sponsors

Collaboration at its essence is individuals choosing to work together to achieve more collectively than they could individually – the whole is greater than the sum of the parts. In some instances GFDL staff seeks to work with others and, similarly, in other instances GFDL researchers are sought as a research partner. It is all about seeking to leverage research capabilities and strengths through appropriate partnering. This section is divided into three logical segments. The first lists GFDL's national and international collaboration partners, the second briefly describe GFDL's Cooperative Institute and Cooperative Agreement research partners, and the third lists as a table and then provides abstract level information about outside funded research underway at GFDL.

National and International Collaborations

GFDL scientists collaborate with other scientists around the country and the world. During 2018, GFDL scientists have co-authored over 61 peer-reviewed publications with external collaborators (excluding CICS-P/CIMES co-authors) from the following institutions:

U.S. Federal and Federal-Sponsored

1. DOD/Navy/ONR/Naval Research Laboratory/Marine Meteorology Division, Monterey, CA
2. DOE/ Lawrence Berkeley Laboratory, Berkeley, Richland, WA
3. DOE/ Pacific Northwest National Laboratory, Richland, WA
4. DOE/Lawrence Livermore National Laboratory, Livermore, CA
5. DOE/Los Alamos National Laboratory/Fluid Dynamics and Solid Mechanics, Los Alamos, NM
6. DOE/Oak Ridge National Laboratory/Computing and Computational Sciences Directorate, Oak Ridge, TN
7. NASA Ames Research Center, Moffett Field, CA
8. NASA Goddard Space Flight Center, Greenbelt, MD
9. NASA Langley Research Center, Hampton, VA
10. NOAA/ National Severe Storms Laboratory, Norman, OK
11. NOAA/ Pacific Marine Environmental Laboratory, Seattle, WA
12. NOAA/NESDIS/Office of Satellite Technology and Research/Advanced Satellite Products Branch, Madison, WI
13. NOAA/NMFS/Northeast Fisheries Science Center, Woods Hole, MA
14. NOAA/NMFS/Southwest Fisheries Science Center, Monterey, CA
15. NOAA/NOS/National Centers for Coastal Ocean Science, Silver Spring, MD
16. NOAA/NWS/NCEP/Climate Prediction Center, College Park, MD

17. NOAA/NWS/NCEP/Climate Prediction Center, Silver Spring, MD
18. NOAA/NWS/NCEP/Environmental Modeling Center, College Park, MD
19. NOAA/NWS/NCEP/National Hurricane Center, Miami, FL
20. NOAA/OAR Office of Weather and Air Quality (OWAQ), Silver Spring, MD
21. NOAA/OAR/Atlantic Oceanographic and Meteorological Laboratory, Miami, FL
22. NOAA/OAR/Earth System Research Laboratory/Physical Sciences Division, Boulder, CO
23. NOAA/OAR/Pacific Marine Environmental Laboratory, Seattle, WA
24. US Environmental Protection Agency, Washington DC
25. US Environmental Protection Agency/National Exposure Research Laboratory/Computational Exposure Division, Research Triangle Park, NC
26. US Environmental Protection Agency/Region VIII, Denver, CO
27. US Geological Survey, Reston, VA
28. US Naval Research Laboratory, Washington DC.

U.S. Non-Federal

1. Atmospheric and Environmental Research, Inc., Lexington, MA
2. Atmospheric and Oceanic Sciences Department, University of Wisconsin-Madison, Madison, WI
3. Atmospheric and Oceanic Sciences Program, Princeton University, Princeton, NJ
4. Atmospheric Sciences Program, Department of Geography, The Ohio State University, Columbus, OH
5. Atmospheric Sciences Research Center, University at Albany, State University of New York, Albany, NY
6. Bren School of Environmental Science & Management, University of California at Santa Barbara, Santa Barbara, CA
7. Byrd Polar and Climate Research Center, The Ohio State University, Columbus, OH
8. Center for Analysis and Prediction of Storms, University of Oklahoma, Norman, Oklahoma
9. Center for Earth and Environmental Science, University at Plattsburgh, State University of New York, Plattsburgh, NY
10. Center for Environmental Medicine, Asthma, and Lung Biology, University of North Carolina, Chapel Hill, NC
11. Center for Global and Regional Environmental Research & Department of Chemical and Biochemical Engineering & Interdisciplinary Graduate Program in GeoInformatics, University of Iowa, Iowa City, IA
12. Center for Ocean–Land–Atmosphere Studies, George Mason University, Fairfax, VA
13. College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR
14. Cooperative Institute for Climate Science, Princeton University, Princeton, NJ
15. Cooperative Institute for Mesoscale Meteorological Studies, and School of Meteorology, University of Oklahoma, Norman, OK
16. Courant Center for Atmosphere Ocean Science, New York University, New York
17. Davidson Laboratory, Stevens Institute of Technology, Hoboken, NJ
18. Department of Applied Physics and Applied Mathematics, Columbia University, New York, NY
19. Department of Atmospheric and Oceanic Science, University of Colorado Boulder, Boulder, CO

20. Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, CA
21. Department of Atmospheric Science, and School of Environmental Sustainability, Colorado State University, Fort Collins, Colorado
22. Department of Atmospheric Sciences, University of Hawaii at Mānoa, Honolulu, HI
23. Department of Atmospheric Sciences, University of Miami
24. Department of Atmospheric Sciences, University of Washington, Seattle, WA
25. Department of Atmospheric, Oceanic, and Earth Sciences and Center for Ocean-Land-Atmosphere Studies, George Mason University, Fairfax, Virginia
26. Department of Biological and Environmental Engineering, Cornell University, Ithaca, NY
27. Department of Biological Sciences, Center for Ecosystem Science and Society (ECOSS), Northern Arizona University, Flagstaff, AZ
28. Department of Biological Sciences, Purdue University, West Lafayette, IL
29. Department of Chemistry and Biochemistry, University of Maryland, College Park, MD
30. Department of Chemistry, University of California, Irvine, CA
31. Department of Civil & Environmental Engineering, University of Washington, Seattle, WA
32. Department of Civil & Environmental Engineering, University of California Los Angeles, Los Angeles, CA
33. Department of Civil and Environmental Engineering, Duke University, Durham, North Carolina
34. Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ
35. Department of Civil, Construction, and Environmental Engineering, University of Alabama, Tuscaloosa, AL
36. Department of Earth and Atmospheric Sciences, Cornell University, Ithaca, NY
37. Department of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA
38. Department of Earth and Atmospheric Sciences, University of Houston, Houston, TX
39. Department of Earth and Environment, Boston University, Boston, Massachusetts
40. Department of Earth and Environmental Engineering, Columbia University, New York, NY
41. Department of Earth and Environmental Science, University of California, Berkeley, CA
42. Department of Earth and Environmental Sciences, and Department of Applied Physics and Applied Mathematics, Columbia University, New York, New York
43. Department of Earth and Planetary Sciences, Northwestern University, Evanston, IL
44. Department of Earth System Science, Stanford University, Stanford, California
45. Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA
46. Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafeyette, IN
47. Department of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI
48. Department of Earth, Ocean, and Atmospheric Science, Florida State University, Tallahassee, FL
49. Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN
50. Department of Environmental Sciences, Environmental & Natural Resource Sciences Building, Rutgers University, New Brunswick, NJ
51. Department of Environmental Toxicology, University of California, Davis, CA

52. Department of Geography, University of California, Santa Barbara, CA
53. Department of Geological Sciences, University of North Carolina Chapel Hill, Chapel Hill, NC
54. Department of Geology & Geophysics, Yale University, New Haven, CT
55. Department of Geosciences, University of Arizona, Tucson, AZ
56. Department of Global Ecology, Carnegie Institution for Science, Stanford, CA
57. Department of Marine Sciences, University of North Carolina at Chapel Hill, Chapel Hill, NC
58. Department of Marine, Earth, and Atmospheric Science, North Carolina State University, Asheville, NC
59. Department of Mathematical Sciences, Worcester Polytechnic Institute, Worcester, MA
60. Department of Meteorology, Pennsylvania State University, University Park, PA
61. Department of Natural Resources and the Environment, University of New Hampshire, Durham, NH
62. Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA
63. Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI
64. Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham, NC
65. Environmental Defense Fund, Washington DC
66. Geography Department, University of California, Berkeley, CA
67. Geophysical Institute and Department of Chemistry, University of Alaska Fairbanks, Fairbanks, AK
68. Graduate School of Oceanography, University of Rhode Island, Narragansett, RI
69. Institute for Geophysics, University of Texas at Austin, Austin, TX
70. International Research Institute for Climate and Society (IRI), Earth Institute, Columbia University, Palisades, New York
71. Iowa Institute of Hydraulic Research (IIHR)-Hydroscience & Engineering, University of Iowa, Iowa City, IA
72. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA
73. John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA
74. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY
75. Marine Fisheries Division, Connecticut Department of Energy and Environmental Protection, Old Lyme, CT
76. National Center for Atmospheric Research (NCAR), Boulder, CO
77. Princeton Environmental Institute, Princeton University, Princeton, NJ
78. School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA
79. School of Forestry & Environmental Studies, Yale University, New Haven, CT
80. School of Global Environmental Sustainability, Colorado State University, Fort Collins, Colorado
81. School of Marine and Atmospheric Sciences, Stony Brook University, State University of New York, Stony Brook, NY
82. Scripps Institution of Oceanography, University of California at San Diego, La Jolla, CA
83. Sierra Nevada Research Institute, University of California, Mercede, CA
84. University of Illinois at Urbana-Champaign, Urbana, IL
85. Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, NJ

86. Woods Hole Oceanographic Institution, Massachusetts Institute of Technology, Woods Hole, MA

International – Government, National, and International

1. Agenzia Nazionale per le Nuove Tecnologie, l'energia e lo Sviluppo Economica Sostenible (ENEA), Bologna, Italy
2. Barcelona Supercomputing Center, Barcelona, Spain
3. Center for Climate Physics, Institute for Basic Science (IBS), Busan, South Korea
4. Central Weather Bureau, Taipei, Taiwan
5. Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Pune, India
6. CNRM, Centre National de Recherches Météorologiques, Toulouse, France
7. Commonwealth Scientific Industrial Research Organization, Oceans and Atmospheres, Hobart, Australia
8. Council of Agricultural Research and Economics (CREA), Research Centre for Forestry and Wood, Arezzo, Italy
9. Estellus, and Laboratoire de l'Etude du Rayonnement et de la Mati ere en Astrophysique, CNRS, Observatoire de Paris, Paris, France
10. Federal Environment Agency (UBA), Oberried, Germany
11. Hong Kong Observatory, Kowloon, Hong Kong
12. India Meteorological Department, New Delhi, India
13. Indian Institute of Tropical Meteorology, Pune, India
14. Instituto Nacional de Pesquisas Espaciais (INPE), Sao Paulo, Brazil
15. Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan
16. Laboratoire de Meterologie Dynamique (LMD/IPSL), Paris, France
17. Laboratoire de Sciences de Climat et Environnement (LSCE), Saclay, Paris, France
18. Max-Planck Institut fur Meteorologie, Hamburg Germany
19. Meteorological Research Institute, Tsukuba, Japan
20. UK Meteorological Office – Hadley Centre, Exeter, UK
21. National Typhoon Center, KMA, Jeju, Republic of Korea
22. Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan
23. Royal Netherlands Meteorological Institute, De Bilt, Netherlands
24. Shanghai Typhoon Institute, China Meteorological Administration, Shanghai, China
25. State Key Laboratory of Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute for Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

International - Non-Government

1. Center for Earth System Science, Tsinghua University, Beijing, China
2. Center for International Climate and Environmental Research (CICERO), Oslo, Norway
3. Center für Erdsystemforschung und Nachhaltigkeit, Universität Hamburg, Hamburg, Germany
4. Center of Excellence for Climate Change Research, Department of Meteorology, King Abdulaziz University, Jeddah, Saudi Arabia
5. Centre for Marine Socioecology, University of Tasmania, Hobart, Australia
6. Centre for Ocean Life, Technical University of Denmark (DTU-Aqua), Denmark
7. Centre for Research in Earth and Space Science, York University, Toronto, Canada
8. Christian-Albrechts University of Kiel, Kiel, Germany
9. Climate and Environmental Physics, Physics Institute, University of Bern, Bern, Switzerland
10. Climate Change Research Centre, University of New South Wales, Sydney, Australia
11. Department of Chemistry, University of Cambridge, Lensfield Road, Cambridge, UK
12. Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong
13. Department of Earth and Environmental Sciences, Chonbuk National University, South Korea
14. Department of Earth and Planetary Sciences, McGill University, Montreal, Canada
15. Department of Earth Sciences, University of Oxford, Oxford, United Kingdom
16. Department of Earth System Sciences, Tsinghua University, Beijing, China
17. Department of Environmental Science and Engineering, Fudan University, Shanghai, China
18. Department of Environmental Systems Science, Institute for Environmental Decisions, and Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland
19. Department of Meteorology, NCAS/University of Reading, Reading, UK
20. Department of Oceanography, Dalhousie University, Halifax, Canada
21. Department of Physical Geography, Faculty of Geosciences, Utrecht University, Utrecht, Netherlands
22. Department of Statistics, University of Bologna, Bologna, Italy
23. Department of Water Management, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, Netherlands
24. Department of Earth, Ocean and Ecological Sciences, University of Liverpool, Liverpool, UK
25. Dirección de Meteorología e Hidrología, Asunción, and Facultad Politécnica, Universidad Nacional de Asunción, San Lorenzo, Paraguay
26. Divecha Centre for Climate Change, Indian Institute of Science, Bangalore, India
27. Division of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Sapporo, Japan
28. Division of Physical Sciences and Engineering, King Abdullah University of Science and Technology, Saudi Arabia
29. Earth Sciences, Department Barcelona Supercomputing Center (BSC-CNS), Barcelona, Spain
30. Earth System Physics Section, International Centre for Theoretical Physics, Trieste, Italy

31. ECMWF (European Centre for Medium Range Forecast), Reading, United Kingdom
32. Eurasia Institute of Earth Sciences, Istanbul Technical University, Istanbul, Turkey
33. Finnish Meteorological Institute, Helsinki, Finland
34. First Institute of Oceanography, State Oceanic Administration, Qingdao, China
35. Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici, Bologna, Italy
36. GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
37. Geophysical Institute, University of Bergen, Bergen, Norway
38. Grantham Institute & Department of Physics, Imperial College London, UK
39. Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland
40. Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia
41. Institute for the Oceans and Fisheries, The University of British Columbia, Vancouver, CA
42. Institute of Physics and Meteorology, University of Hohenheim, Stuttgart, Germany
43. International Council for the Exploration of the Sea, København V, Denmark
44. Lancaster Environment Centre, Lancaster University, Lancaster, United Kingdom
45. LOCEAN/IPSLSorbonne Universités (UPMC)-CNRS-IRD-MNHN, Paris, France
46. Mathematics and Physical Sciences, University of Exeter, Exeter, UK
47. Max Planck Institute for Biogeochemistry, Jena, Germany
48. Max Planck Institute for Meteorology Hamburg, Germany
49. McGill University, Montreal, Canada
50. Meteorology and Air Quality Group, Wageningen University, Wageningen, Netherlands
51. Ministry of Education Key Laboratory for Earth System Modeling, Department of Earth System Science, and Joint Center for Global Change Studies (JCGCS), Tsinghua University, Beijing, China
52. Nagoya University, Furocho, Chigusa-ku, Nagoya, Japan
53. National Institute for Environmental Studies (NIES), Tsukuba, Japan
54. National Oceanography Centre, University of Southampton, Southampton, UK
55. NERC (Natural Environment Research Council) Centre for Ecology and Hydrology, Environment Centre Wales, Bangor, United Kingdom
56. Research Center for Advanced Science and Technology, University of Tokyo, Tokyo, Japan
57. Research School of Earth Sciences and ARC Centre of Excellence for Climate System Science, Australian National University, Canberra, Australia
58. Royal Netherlands Meteorological Institute, De Bilt, Netherlands
59. School of Earth & Environmental Sciences, University of Wollongong, New South Wales, Australia
60. School of Earth and Environment, University of Leeds, Leeds, United Kingdom
61. School of Earth and Environmental Sciences, Seoul National University, Seoul, South Korea
62. School of Energy and Environment, City University of Hong Kong, Hong Kong, China
63. School of Earth Sciences, University of Melbourne, Victoria, Australia
64. School of Environmental Science, University of East Anglia, Norfolk, United Kingdom
65. School of Geographical Sciences, University of Bristol, Bristol, United Kingdom
66. School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom
67. Scottish Association for Marine Science, Oban, United Kingdom

68. Uni Research Climate, Bjerknes Centre for Climate Research, Bergen, Norway
69. United Nations Environment Programme World Conservation Monitoring Centre, Cambridge, United Kingdom
70. Universidad Complutense de Madrid, and Instituto de Geociencia, Centro Mixto del Consejo Superior de Investigaciones Científicas, Madrid, Spain
71. University of New South Wales, Australia.
72. University of Oslo, Oslo, Norway
73. Wegener Center for Climate and Global Change and Institute for Geophysics, Astrophysics, and Meteorology (IGAM)/Institute of Physics, University of Graz, Austria

NOAA Cooperative Institutes and Cooperative Agreement

The following is a brief description of the NOAA Cooperative Institutes with Princeton University for which GFDL is the host, as well as of the NOAA Cooperative Agreement with the University Corporation for Atmospheric Research through which GFDL is able to bring on-board post-doctoral scientists, visiting scientists, and scientific support.

On July 1, 2018, NOAA and Princeton University embarked upon a new collaborative partnership through the Cooperative Institute for Modeling the Earth System (CIMES). This is a new ten-year cooperative agreement grant award that consists of a five-year base period and a five-year option period that extends through June 30, 2028. The previous award to Princeton University, the Cooperative Institute for Climate Science (CICS-P), had a period of performance that concluded June 30, 2018, but was subsequently extended through June 30, 2019, to allow for a smooth transition to the new CIMES award. Though both CIMES and CICS-P, and their predecessors, GFDL has partnered with Princeton University's Atmospheric and Oceanic Sciences Program since 1968 to educate the next generation of scientists as well as to partner on scientific research projects of mutual interest. The relationship between GFDL and Princeton University dates back to before the founding of the Laboratory.

The Laboratory's founding director, Joseph Smagorinsky, began his research career at Institute for Advanced Study at its campus adjacent to Princeton University. In 1955, the Laboratory was formally established in Washington, DC, but then later returned to Princeton University in 1968 following a competitive process and the construction of a suitable facility. GFDL has been in its current facility ever since.

Current activities sponsored at CIMES fall into one of three tasks, and also within one of three themes. Task 1 is administration, education, and outreach and is funded annually based on a percent of research dollars committed to Tasks 2 and 3, currently 4.6%. Task 2 supports post-doctoral scientists, associate research scholars, research scholars, research faculty, visiting scientists, and graduate students who work collaboratively at GFDL with GFDL host scientists and has grown to be funded at about $6M annually. Task 3 is independent research and is funded on the order of $0.5M annually. Most of the research under Task 3 is performed by scientists at Princeton University's Main Campus, but may be performed by Princeton University partner scientists at other institutions.

CIMES research centers around the following three themes:

1. *Earth System Modeling:* Developing and improving Earth System Models (ESMs), numerical models which simulate the climate and earth system, and allow prediction of the future evolution of this system. These models include the dynamical, physical, chemical and biological components of the atmosphere-ocean-land system and the coupling between them.

2. *Seamless Prediction Across Time and Space Scales:* Applying the ESMs to predictions on time-scales from days to centuries and over spatial scales from those of extreme events to global scales, making

use of the same flexible code-base. We focus on two different aspects of prediction across time and space scales, the very high-resolution modeling necessary to resolve extreme weather phenomena, and the predictability of different weather and climate phenomena.

3. Earth System Science: Analysis and Applications: Using ESMs to understand the impacts of environmental variations and changes on pressing problems of relevance to society, including marine ecosystems, weather extremes, drought, and air quality.

GFDL has been hosting scientists and research support staff of the University Corporation for Atmospheric Research (UCAR) for twenty-five years and is currently sponsoring 20 such staff who work collaboratively at GFDL on projects of mutual interest.

GFDL partners with UCAR through its Cooperative Programs for the Advancement of Earth System Science (CPAESS). CPAESS was created in February 2016, from the merger of two of UCAR's former programs, the Joint Office of Science Support (JOSS) and the Visiting Scientist Programs (VSP). CPAESS is providing an extensive portfolio of organization and management services for the broad Earth science community. Its works collectively toward the advancement of scientific research for the benefit of society.

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Reimbursable Research Projects at GFDL

The following is a listing of various research projects currently underway that are being supported by other NOAA and Non-NOAA partners. It identifies the project title, GFDL scientist, other scientist, funding amount, and where appropriate, funding entity. Details on any project are available upon request.

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	Fiscal Year 2018 Funding
NOAA Climate Program Office	Ocean Data Assimilation*	Xiaosong Yang		59,684
NOAA Climate Program Office	An Open Framework for Process-Oriented Diagnostics of Global Models - MAPP	Yi Ming	John Krasting and Ming Zhao	50,000
NOAA Climate Program Office	Northeast shelf integrated ecosystem assessment	Charles Stock	Andrew Ross	100,000
NOAA Climate Program Office	Observing and Understanding Processes Affecting the Propagation of Intraseasonal Oscillations in the Maritime Continent Region (Ming Zhao)	Ming Zhao	Xianan Jiang, Duane Waliser, Baoqiang Xiang	48,243
NOAA Climate Program Office	Develop infrastructure and technological advancements for core modeling elements	Whit Anderson		399,600
NOAA Climate Program Office	US Clivar Travel Support	Andrew Wittenberg		4,341
NOAA OAR/OWAQ	FACETS	Tom Delworth and Sarah Kapnick	Nathaniel Johnson	250,000
NOAA/OCIO	SENA (Software Engineering for Novel/Architecture*	Venkatramani Balaji		790,000
NOAA Climate Program Office	ENSO Blog*	Nathaniel Johnson		10,000
NOAA Climate Program Office	The North American Multi-Model Ensemble (NMME) Phase II	Sarah Kapnick and Thomas Delworth		120,000
NOAA Climate Program Office	ALE Project	Robert Hallberg		182,471

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	Fiscal Year 2018 Funding
United States Geological Survey	USGS/SC USGS/SC-CSC Consortium	Keith Dixon		54,051
NASA / GSFC	High Mountain Asia	Sarah Kapnick	Paul Ginoux	172,752
NASA / GSFC	Detection and Attribution of Dust Sources to Understand Dust Effects on Climate and Air Quality	Paul Ginoux		89,996

*The recipient for this reimbursable agreement is not GFDL, though the funds, computer time, or both, further GFDL's mission and may have resulted in additional staffing at GFDL.

On the pages that follow are abstracts for the current projects, where available. Funding indicated is the amount of funds to be sent by the funding source to GFDL in FY 2018 and future years, and is not a cumulative total of funding to be sent by the funding source to all institutions or for all years:

Ocean Data Assimilation

Xiaosong Yang

FY2018 Funding: $59,684

Abstract

Estimating the state of the Earth System is critical for monitoring our planet's climate and for predicting changes to it on time scales from months to decades. Toward these ends, the vast number of atmospheric observations and the growing number of ocean observations must be combined with model estimates of the state of the Earth System by means of data assimilation systems. This project explores the development of new data assimilation techniques using state-of-the-art coupled climate models and applies these techniques to detecting climate change, improving forecasts on seasonal to interannual time scales while providing estimates of their uncertainty, and improving our understanding of predictability at decadal time scales in order to provide a foundation for the development of a NOAA capability for decadal forecasts. This capability will provide the Nation's decision and policy makers with the best possible climate information on critical problems such abrupt climate change, changes in hurricane activity, drought, and sea-level rise.

An Open Framework for Process-Oriented Diagnostics of Global Models

Yi Ming, John Krasting, and Ming Zhao

FY2018 Funding: $50,000

Abstract

There is a need to identify targeted improvements to the fidelity of models for the Earth System and its variability. Process-oriented diagnostics characterize a physical process in a manner related directly to mechanisms essential to its simulation, and thus provide valuable guidance for model improvement. An organizational framework that integrates such diagnostic development projects aids accessibility by modelers. Work Summary: The proposed Type 1 team will expand an open framework to entrain process oriented diagnostics developed by multiple research teams into the development stream of the modeling centers. Building on work by the previous Type 1 team project, it will coordinate Type 2 individual projects through an Application Programming Interface (API) for process-oriented diagnostics. Modules under this protocol will compare any development model version to observations, while leveraging analysis of the Coupled Model Intercomparison Project Phase 6 (CMIP6) ensemble to place these diagnostics in a multi-model context. The CMIP6 ensemble will be used in the framework to aid the model developer in identification of poorly represented physical pathways. The API will permit comparison of multiple model runs from CMIP6 models or perturbation/ensemble runs of individual models. The lead PI team maintains consistency with the previous Type 1 team while expanding representation from the Geophysical Fluid Dynamics Laboratory (GFDL) model

development and diagnostics teams and from the Program for Climate Model Diagnosis and Intercomparison (PCMDI) to leverage community data standards and enhance coordination of metrics and diagnostics development across agencies. A task force will be created, modeled on the current Model Diagnostics Task Force, which will emphasize proactively reaching out to PIs of Type 2 proposals funded under this MAPP call. A key ingredient in ensuring that diagnostics are useful to the development teams is feedback from these teams and from other groups. Task Force members will be invited to present their diagnostic development plans early, to coordinate with expansion of the API. The interaction will promote common standards and tools, fostering diagnostics modules that are well targeted and implemented for ease of coordination both within the Task Force and with national and international efforts. Self-documentation and community data and metadata protocols will be included in the API. The task force will also coordinate synthetic publications. The Type 1 Team will also develop tools and additional process-based diagnostics in key areas complementing Type 2 proposals, including tools to assist modelers in navigating trade-offs among multiple observational constraints. Diagnostics for basin-scale heat uptake and sea level change will be standardized. Diagnostics for feedback mechanisms in regional hydroclimate extremes including cloud feedbacks will be developed, complemented by parameter-perturbation experiments with the GFDL model that will be made available to the Type 2 teams. Diagnostics will be brought into the framework for processes affecting temperature and precipitation distribution tails, including advanced convective diagnostics and moist-static energy diagnostics. Relevance to competition: This proposal directly addresses the call for the “Modeling, Analysis, Predictions, and Projections (MAPP) Competition 2: Addressing Key Issues in CMIP6-era Earth System Models” by developing a Type 1 core team to lead integration of projects on process oriented diagnostics. It proposes a code and data sharing framework that facilitates integration of these into the development path of modeling centers, scientific development of new process oriented diagnostics, and protocols to engage and synthesize the efforts of Type 2 projects in model evaluation, as well as plans for the dissemination of this information. It addresses NOAA's long-term climate goals by strengthening foundational capabilities, combining observations with modeling and prediction, and communication of scientific understanding.

Northeast Shelf Integrated Ecosystem Assessment

Charles Stock

FY2018 Funding: $100,000

Abstract

The purpose of this project is to apply GFDL’s high-resolution climate/earth system models to understand climate impacts on marine resources on the Northeast U.S. shelf and develop statistical downscaling approaches for Northeast U.S. estuaries.

Influences of the Maritime Continent on the Eastward Propagation of the Madden-Julian Oscillation

Ming Zhao, Xianan Jiang, Duane Waliserm and Baoqiang Xiang, with Collaborator Shian-Jinn Lin

FY2018 Funding: $48,243

Abstract

This proposal addresses the cause of the mean square error (MSE) bias in models, with a focus on diurnal cycle and air-sea coupling. The approach is to examine how cumulus momentum transport could damp Madden-Julian Oscillation (MJO) propagation across the Maritime Continent (MC). Will utilize diurnal cycle sensitivity experiments with CM4 (vs. AM4) by holding solar radiation constant, flattening terrain, removing MC, etc. This approach works with GFDL coupled and atmosphere-only models (~25-50 km) and Sub-seasonal-to-Seasonal (S2S) models and probes the sensitivity of propagation to air-sea interaction in models and to the coupling frequency (hourly to daily), and also uses Years of the Maritime Continent (YMC) data and satellite/reanalysis data (2017-2019). This effort proposes comparing coupled and uncoupled model frameworks, and may help with further coupled model development. Also, also GFDL is actively involved in the effort. The proposal contains a nicely comprehensive catalog of the reanalysis, and datasets they will use. The PIs and staff are strong scientists with impressive records. There is a strong link to S2S topics. However, it's not clear how unique this work is (e.g., flattening terrain, etc.) and what will be gained by so many sensitivity experiments. The focus on one mechanism may limit the impact, but it certainly will reveal model deficiencies. The PIs should take this into consideration when starting this project. Also, this is a very ambitious amount of work proposed for a 3 year project. Overall, this proposal will advance the understanding of the MJO in the Maritime Continent region and aid future model development.

OAR Software Engineer

Whit Anderson

FY2018 Funding: $399,600

Abstract

This project is to develop infrastructure and technological advancements for core modeling elements developed using FMS at GFDL as the foundation upon which a wide range of physical, chemical and biological representations have been built. These modeling elements provide a rich suite of models ranging from idealized dynamical models to full Earth System Models with interactive marine and terrestrial ecosystems, for the purpose of studying the climate and its response to forces, including anthropogenic. To this end, this will support efforts

that will use state-of-art procedures and methods for community-based software development, and will maintain rigorously tested (regression testing of conformance to known answers; and computational performance) master installations at GFDL/Princeton University. Of particular importance is conformity with ongoing code development at GFDL, and to this end these efforts will closely interact with the model development team at GFDL.

Forecasting a Continuum of Environmental Threats (FACETS)

Sarah Kapnick and Tom Delworth

FY2018 Funding: $250,000

Abstract

The purpose of this funding is to host a postdoctoral research associate at the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) to conduct studies on the predictability of seasonal hydroclimate extremes. This researcher is expected to leverage available observational and dynamical forecast model data to study the causes and predictability of hydroclimate extremes, including droughts, pluvials, and tropical cyclone impacts, over North America on seasonal timescales. The research would entail a focus on determining the viability of developing probabilistic hazard outlooks for seasonal hydroclimate extremes.

SENA – Software Engineering for Novel/Architecture

V. Balaji

FY2018 Funding: $790,000

Abstract

NOAA models are currently written to maximize efficiency on scalar computer architectures. It is expected that architectures based on fine-grained computing technologies will be replacing current architectures in the near future. NOAA must prepare mission critical applications to efficiently execute on next generation HPC architectures while maintaining performance levels on the current HPC. This is for the re-coding of these applications to run on fine-grained architectures.

ENSO blog writing and editing services

Nathaniel Johnson

FY2018 Funding: $10,000

Abstract

The purpose of this project is to collaborate with NOAA's Climate Prediction Center and Climate Program Office on writing and editing tasks for the ENSO Blog, published bi-weekly in NOAA Climate.gov's "News & Features" section. Specifically, will provide subject matter expertise and editorial assistance in the development of blog articles and associated maps and data visualizations to be published in Climate.gov.

North American Multi-Model Ensemble (NMME)

Sarah Kapnick and Tom Delworth

FY2018 Funding: $120,000

Abstract

This will support a full-time support scientist to facilitate the routine operation of the GFDL prediction system and to transmit the model predictions to the National Weather Service's Climate Prediction Center, travel expenses to scientific meetings relevant to the prediction activity, and page charges for related publications. This activity includes routine prediction simulations and development of next-generation prediction systems, as well as the monthly experimental predictions.

ALE Project

Robert Hallberg

FY2018 Funding: $182,471

Abstract

This project will take the key steps to evaluating the suitability of MOM6 as a successor to HYCOM in operational Earth System Predictions by both the Navy and NOAA, and for identifying those capabilities and features of HYCOM that should be incorporated into MOM6 to form the basis for a National Global Ocean Modeling capability, in support of the overarching Earth System Prediction Capability goals.

USGS/SC-CSC Consortium

Keith Dixon

FY2018 Funding: $54,051

Abstract

As a world-leader in weather and climate modeling, GFDL specializes in building and interpreting state-of-the-art computer-based models relevant for society. GFDL researchers bring to the SC-CSC consortium expertise that helps insure in-depth understanding of the robustness and limitations of climate predictions and projections across times scales spanning seasons to centuries – projections that subsequently are used in impact studies, response modeling applications, and to develop stakeholder guidance. Within the SC-CSC community, GFDL's physical climate and modeling expertise is unique in this regard, filling a niche that markedly enhances the science–based foundation upon which SC-CSC products are built.

High Mountain Asia

Sarah Kapnick and Paul Ginoux

FY2018 Funding: $ $172,752

Abstract

High Mountain Asia (HMA) is also known as the "Third Pole" due to it possessing the highest concentration of ice and snow outside of the Polar Regions. Under climate forcing, the timing and amount of snowfall over the region will be altered, which can change the regional water budget irrespective of changes in glacier and snowmelt runoff caused by warming temperatures. Complicating matters, snow and ice in the region is not pure; dust deposition in HMA can alter the surface albedo and influence cryosphere melt dynamics and feedback on broader circulation. We propose the integration of dust satellite products (TOMS/OMI, MODIS and SeaWiFS) with global climate model simulations to quantify dust deposition events to explore year-to-year climate variability, the role of dust and surface albedo on the hydroclimate, and future hydroclimate of HMA. We will use a global atmospheric chemistry model, AM3 (at 50 km atmospheric resolution) and a high-resolution coupled global climate model, FLOR (also at 50 km atmospheric resolution). AM3 has previously been shown to be effective in reproducing dust transport in remote regions (Li et al. 2010). The atmospheric model resolution and physics in FLOR has previously been shown to be effective in representing the hydroclimate seasonal cycle of HMA (Kapnick et al. 2014). This 3-year project can be broken down into 3 main phases:

1. We will develop a unique high-resolution database containing aerosol products from satellite data and AM3 simulations. With this database we propose to map for the first time the frequency and origin of aerosol events for the last 36 years over the entire HMA.

Presently, aerosol loading and dust in particular are not available at resolutions below 1° on a mapped latitude/longitude grid; we will provide this information at high resolution (0.1°) on a mapped uniform grid for all products for ease of use for comparison and analysis without further post processing.

2. Using the satellite record combined with atmospheric chemistry modeling to track aerosol deposition, we will implement a parameterization for the effect of aerosol deposition on the HMA cryosphere to explore feedbacks and sensitivities in the HMA hydroclimate. We will release GCM data at 50 km resolution over the region with and without aerosol deposition included for the historical record and also make available a long control simulation with constant forcing. Comparisons between these different simulations will allow us to rigorously quantify for the first time the role of aerosol deposition altering surface albedo and its effect on regional hydroclimate in the historical record.
3. We will use the results of stages one and two to implement the observations-based model parameterization for the aerosol deposition influence on surface albedo to force a future projection simulation through 2100. When compared with projections without aerosol deposition, we can quantify the role of aerosols and surface albedo on future climate sensitivity and feedbacks. We expect that the regional hydroclimate sensitivity of the cryosphere will increase as a result of temperatures rising above freezing more often and changes in deposition leading to increased melt. This data set will be useful for others wishing to utilize GMELT to improve hazard mitigation planning and policy tools relating to regional changes in water resources over the next 1-100 years. Y18 Funding: $172,752

Detection and Attribution of Dust Sources to Understand Dust Effects on Climate and Air Quality

Paul Ginoux

FY2018 Funding: $89,996

Abstract

Dust is one of the most abundant aerosol in the atmosphere, and through its interactions with radiation, cloud microphysics, and gas phase chemistry, it affects air quality and climate. However, very little effort is spent on improving dust source inventories. Most aerosol and climate models are still using the TOMS based source function by Ginoux et al. (2001), or some of its variant. This old source inventory provides satisfactory results for sources in arid regions, but dust emission is not confined to deserts. It is also observed in rural areas of temperate zones. It was noted in the IPCC assessment report (AR5) that “Anthropogenic, including road dust and mineral dust due to human land use change, remain ill quantified although some recent satellite

observations suggest the fraction of mineral dust due to the latter source could be 20 to 25% of the total (Ginoux et al., 2012a, 2012b)". Dust was the only aerosol with an anthropogenic contribution for which no scenario of emission was considered during IPCC AR5. The dust sources inventory of Ginoux et al. (2012a) derived from Aqua MODIS Deep Blue Collection 5.1 aerosol products provides the first satellite based high resolution (0.1^ox0.1^o) inventory including the contribution from agriculture. This dust source inventory has been used by multiple agencies (NASA GSFC, NASA GISS, NOAA NWS, NRL, USAF, EPA) for research and dust forecasting. The prediction skill scores were significantly improved in some areas while others not. The lack of uniform improvement comes from the additional dependency of dust emission on the velocity threshold of wind erosion and dust mobilization, especially for vegetated areas such as cropland. As this threshold is difficult to constrain, modelers tend to use fixed values. Another issue is that Collection 5.1 aerosol products are retrieved only over bright surfaces, neglecting significant portion of land-use and periglacial sources. Although dust from periglacial sources is well documented, such as for Alaska and Iceland, and may be the major source of dust in high latitude, it has been neglected. Furthermore, they may be increasing with retreating glacier due to global warming.

Building on our experience to detect, attribute and constrain dust emission for transport and climate models, we propose to process Aqua MODIS Deep Blue Level 2 Collection 6.0 with Ginoux et al (2012a) algorithms to provide a quality assured global dust inventory at 0.1^ox0.1^o resolution (CMIP6 recommended) with the anthropogenic fraction of dust from pasture, cropland. In addition, we will provide the first global monthly varying threshold velocity of wind erosion, and the set of parameters used to constrain it, including observed (re-analysis) meteorological fields, satellite based vegetation, soil moisture, crop classification, and irrigation. In the second part the regional contrast of dust emission to each of these parameters will be analyzed after validation by comparing simulated aerosol properties with ground-based and satellite observations. We will take advantage of the extended coverage of this new inventory to study the effects of high-latitude peri-glacial dust sources on ice cloud microphysics and longwave radiation. The third part will focus on understanding the interactions of anthropogenic dust with other aerosol components. In particular, we propose to quantify the impact of natural and anthropogenic dust on climate and air quality through the heterogeneous reactions of HNO_3, H_2SO_4, and SO_2 on dust.

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Reimbursable Research Projects at GFDL

The following is a listing of various research projects supported by other NOAA and Non-NOAA partners during the period 2014-2017. It identifies the project title, GFDL scientist, other scientist, funding amount, and where appropriate, funding entity. Details on any project are available upon request.

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
NOAA/OAR/NWS	High-resolution hurricane modeling, adaptive mesh refinement, improved physical parameterizations, wave- ocean coupling, and hurricane-climate-change projections	Morris Bender, S-J Lin, Tim Marchok		85,000			
NOAA Climate Program Office	A collaborative multi-model study: understanding Atlantic meridional overturning circulation variability mechanisms and their impacts on decadal prediction	Thomas Delworth, Anthony Rosati, Rym Msadek	Gokhan Danabasoglu, Young- Oh Kwon, Alicia Karspeck, Joseph Tribbia, Steve Yeager, Claude Frankignoul	281,120			
NOAA Climate Program Office	Understanding and Improving GCM Simulations of MJO Initiation Over the Tropical Indian Ocean Using DYNAMO Field Observations	Leo J. Donner	Hailan Wang, Siegfried Schubert	12,000			
NOAA Climate Program Office	Collaborative Research: Representing Calving and Iceberg Dynamics in Global Climate Models	Robert Hallberg	David Pollard, Alistair Adcroft, Olga Sergienko, Jason Amundson, Leigh Stearns, Jeremy Bassis	12,000	12,000	13,000	
USACE	Analysis of Wave and Surge Effects	Thomas Knutson	P. Duffy, J. Arnold, M. Wehner	135,000			

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
NWS R2O NGGPS	Development and Evaluation of the GFDL Finite-Volume Dynamical Core on the Cubed-Sphere (FV3) for the Next Generation Global Prediction System (NGGPS)	S-J Lin and Lucas Harris	Henry Juang		800,000	700,000	1,394,560
NWS R2O NGGPS	Subseasonal Hurricane Prediction in a Prototype Variable-Resolution Global NGGPS Model	Lucas Harris	S-J Lin and Jan-Huey Chen		129,152		
NWS R2O NGGPS	Implementation and Testing of Regional and Global Dust Forecasting	Paul Ginoux			191,300		
NOAA Climate Program Office	Reactive Nitrogen Biogeochemical Cycling in the GFDL ESMs	Larry Horowitz	Elena Shevliakova, Duncan Menge, Richard Conant, Donald Zak, Jennifer Murphy, Karen Cady-Pereira		368,000	358,000	344,000
NOAA Climate Program Office	Atlantic Basin Tropical Cyclone Database Reanalysis and Estimation of "Missed" Major Hurricane and Overall Activity	Gabriel Vecchi	Frank Marks, Christopher Landsea		44,462	45,538	
NOAA Climate Program Office	Development of a Framework for Process-Oriented Diagnosis of Global Models	Yi Ming	Eric D. Mahoney, Andrew Gettelman, J. David Neelin		134,394	139,051	143,904
NOAA Climate Program Office	Diurnal Metrics for Evaluating GFDL and Other Climate Models	Chris Golaz	Aiguo Dai, Junhong Wang, Ming Zhao		6,776	6,776	6,776

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
NOAA Climate Program Office	Assessing the Impact of Model Formulation and Resolution on Arctic Sea Ice Variability	Rym Msadek, Gabriel Vecchi, Michael Winton			264,647	136,175	
NOAA Climate Program Office	Towards an Improved Understanding of the Initiation & Propagation of the Madden-Julian Oscillation	Ming Zhao	Xianan Jiang, Duane Waliser, Bin Wang, Richard Johnson		199,442	137,516	
NOAA Climate Program Office	The North American Multi-Model Ensemble (NMME) - Phase II	Gabriel Vecchi			120,000	120,000	120,000
NOAA Climate Program Office	Evaluation of Warm Cloud Microphysical Processes in Global Climate Models with Multi-Sensor Satellite Observations	Chris Golaz	Huan Guo, K. Suzuki		52,972	54,203	55,473
NOAA Climate Program Office	Metrics for General Circulation Model Biases in Extratropical Cyclones Clouds and Precipitation: Evaluating Their Skill and Identifying Processes to be improved	Chris Golaz and Leo J Donner	James Booth, Catherine Naud, Zhengzhao Luo		10,000	10,000	10,000
NOAA Climate Program Office	Process-Oriented Diagnosis and Metrics Development for the Madden-Julian Oscillation Based on Climate Simulations	Ming Zhao	Xianan Jiang, Eric Mahoney, S-J Lin		22,980	23,900	26,857
OCIO	Software Engineering for Novel Architectures (SENA)	V. Balaji			818,955	790,000	790,000
NWS	Tapes for Siebers	Siebers					250,000

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
NWS CPO	Coupled-Wave - Ocean System for NCEP's Global Forecast System (MAPP) (Griffies)	Griffies				12,000	12,000
NOAA Climate Program Office	ALE	Robert Hallberg					64,750
NOAA Climate Program Office	Nat Johnson ENSO blog	Nat Johnson					10,000
NOAA Climate Program Office	Observing and Understanding Processes Affecting the Propagation of Intraseasonal Oscillations in the Maritime Continent Region (Ming Zhao)	Ming Zhao	Xianan Jiang, Duane Waliser, Baoqiang Xiang				91,559
NOAA Climate Program Office	A North American Multi-Model Ensemble (NMME) ISI Prediction System	Gabriel Vecchi	Benjamin Kirtman, Siegfried Schubert, Joe Tribbia, Huug van den Dool, Malaquias Pena Mendez, Michael Tippett	100,000			
NOAA Climate Program Office	Evaluating How Dry Deposition Influences Eastern US Ozone Aerosols and Precursors	Larry Horowitz	Serguey Malyshev, Jingqiu Mao, Elena Shevliakova, Vaishali Naik, Paul Ginoux	40,355	51,720	53,155	

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
NOAA Climate Program Office	Understanding Tropical Pacific Biases in Climate Simulations and Initialized Predictions	Andrew T. Wittenberg	Gabriel A. Vecchi, Thomas L. Delworth, Yan Xue, Arun Kumar	226,993	130,796	7,075.00	
NOAA Climate Program Office	Ocean Indices and Indicators in the Tropical and South Atlantic Ocean	Rong Zhang	Gustavo Jorge Goni, Shenfu Dong, Marlos Goes, Francisco J. Beron-Vera	26,118	27,275		
NOAA Climate Program Office	Process Level Investigation of the Role of Convection and Cloud Parameterization in Tropical Pacific Bias	Ming Zhao	J.-C. Golaz, Y. Ming, S-J Lin, I.M. Held, S. Fueglistaler	365,816	177,439	14,000	
NOAA Climate Program Office	Ocean data assimilation	Anthony Rosati		60,000	60,900	60,900	59,684
Office of Naval Research	Improving HWRF and GFDN coupled models for transition to operations	Morris Bender	Isaac Ginis	40,000			
NOAA Climate Program Office	Using models to improve our ability to monitor ocean uptake of anthropogenic carbon	Anand Gnanadesikan	Keith Rodgers	40,144	40,746	40,746	20,000
NOAA Climate Program Office	NOAA environmental software infrastructure and interoperability (NESII) – Implicit coupling of the community sea-ice model in GFDL models	V. Balaji		125,000	80,000	83,200	86,528

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
NOAA Climate Program Office	CPT to Improve Cloud and Boundary Layer Processes in GFS/CFS	Jean-Christophe Golaz	Christopher Bretherton, Joao Teixeira, Hualu Pan	47,000	48,000	48,000	
NOAA Climate Program Office	Northeast shelf IEA	Charles Stock			18,000	190,000	100,000
NOAA Climate Program Office	Understanding climate variations in the Intra-Americas Seas and their influence on climate extremes using global high-resolution coupled models	Gabriel Vecchi	Thomas Delworth and Anthony Rosati	120,000			
NOAA Climate Program Office	Modulation of tropical cyclone (TC) activity over the Intra- Americas Sea by intraseasonal variability: implications for dynamical TC prediction on intraseasonal time scales	Ming Zhao	Xianan Jiang and Duane Waliser	50,000	100,000		
National Science Foundation	Energetically consistent, resolution aware, parameterization of mesoscale eddies in the ocean	Alistair Adcroft			86,421	139,733	137,983
Depart. Of Energy	Dream: Distributed Resources for the Earth System Grid Federation Advanced Management	V. Balaji				300,000	300,000
NOAA	Process Level Investigation of the Role of Convection and Cloud Parameterization in Tropical Pacific Bias in GFDL Next Generation Global Climate Models	Stephan Fueglistaler	Ming Zhao	33,039	33,039	33,045	

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
National Science Foundation	Global Atmospheric Modeling Hierarchy Development	Isaac Held	Stephan Fueglistaler				144,025
National Science Foundation	Dynamics of the Orkney Passage Outflow	Sonya Legg			30,075	30,681	23,464
National Science Foundation	Continuation and Enhancement of MPOWIR	Sonya Legg		27,764	85,130	30,318	106,746
Office of Naval Research	Numerical investigation of non-linear internal wave generation and breaking in straits	Sonya Legg		126,446			
NASA Prime	Exploring emission versus climate drivers of tropospheric ozone variability and trends over northern midlatitudes from space	Meiyun Lin		69,665	68,626		
NASA	Statistics for Stratospheric Influence on Surface GHGs during NASA's North American Field Campaigns: A Study with Aircraft & Satellite Data and High-Resolution Global Models	Meiyun Lin		31,026	34,734	35,691	
Clark County Dept. of Air Quality	Characterizing Daily-to-yearly Variability in High-ozone Events from Regional Pollution Versus Stratospheric Intrusion	Meiyun Lin	Larry Horowitz				142,605

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
NOAA	Impact of Organic Nitrate Chemistry on Air Quality and Climate: Past, Present, and Future Atmospheres	Jingqiu Mao		128,003	137,835		
National Science Foundation	Southeast Atmosphere Studies Workshop: Intensive Observation Period Modeling to Improve Mechanistic Representation of Trends	Jingqiu Mao			20,000		
University of Miami	Fisheries and the Environment (FATE): A New Zooplankton Community Index and Recruitment Model to Improve Understanding of the Stock-Recruit Relationship for Western Atlantic Bluefin Tuna	Barbara Muhling			28,454		
NOAA	Using Models to Improve our Ability to Monitor Ocean Uptake of Anthropogenic Carbon	Keith Rodgers		40,144	40,746	40,746	20,000
NOAA	Representing Calving and Iceberg Dynamics in Global Climate Models	Olga Sergienko		145,000	150,000	155,000	
University of California, San Diego	Dynamic Response of the Ross Ice Shelf to Wave-induced Vibrations	Olga Sergienko		13,533	14,085	14,648	
Princeton-CMI BP	A Carbon Mitigation Initiative at Princeton University (BP CMI) - PD Fellowship (Pacala)	Elena Shevliakova				100,000	100,000

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
National Science Foundation	Energy Pathways and Scale Interactions in the Ocean	Geoffrey Vallis		121,732	125,957		
National Science Foundation	Dynamics of the Midlatitude Circulation and Implications for a Changing Climate	Geoffrey Vallis		209,360			
NOAA	Skillful Predictions of Seasonal Hurricane Frequency, Track and Landfall	Jorge Sarmiento	Gabriel Vecchi and Shian-Jiann Lin	501,071	895,669	828,548	544,891
NOAA	Non-hydrostatic Global Models: GFDL HiRAM	Jorge Sarmiento	Shian-Jiann Lin	107,571	108,231	45,097	
Department of Energy	Radiative Forcing Model Intercomparison Project (RFMIP)	V. Ramaswamy		82,510	84,849	87,258	
NASA /GSFC	Detection and Attribution of Dust Sources	Paul Ginoux		92,297	103,306	132,221	89,996
NASA /GSFC	High Mountain Asia	Sarah Kapnick	Paul Ginoux			133,942	138,752
NASA / GSFC	Improved understanding of atmospheric processes via data assimilation	John Wilson		48,466	50,404		
NASA / GSFC	Coupling Mars Dust and Water Cycles	John Wilson		19,000	9,000		

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 14	FY 15	FY 16	FY 17
United States Geological Survey	Statistical Downscaling of GCM Output	Keith Dixon		47,804	48,102	48,403	48,707
United States Geological Survey	Statistically Downscaled Climate Projections	John Lanzante		67,650			
United States Geological Survey	Climate Variability and Change	John Lanzante		16,784			
NASA	Use of Cloudsat and A-Train Multi-Sensor Satellite Observations to Improve Representation of Aerosol Effect on Precipitation in Climate Models	Chris Golaz	Yi Ming	14,860	14,860	14,860	
NASA	Mars Atmosphere & Aerosol Reanalysis	John Wilson		61,903	63,662		
NASA	Contribution to Anthropocene Radiative Forcing and Climate by Anthropogenic Sources of Soil Dust Aerosol	Paul Ginoux			12,000	7,000	
United States Army Corps of Engineers	Analysis of Wave and Surge Effects	Thomas Knutson	Morris Bender	135,000			
United States Geological Survey	Sensitivity of Statistically Downscaled Climate Projections	Keith Dixon		47,804	85,000	52,160	
United States Geological Survey	Modeling the effects of environmental change on crucial wildlife habitat	Keith Dixon		20,000	20,000		

*The recipient for this reimbursable agreement is not GFDL, though the funds, computer time, or both, further GFDL's mission and may have resulted in additional staffing at GFDL.