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 2013, GFDL scientists have co-authored over 45 peer-reviewed publications with external collaborators (excluding CICS co-authors) from the following institutions:

U.S. Federal and Federal-Sponsored

1. DOE Brookhaven National Laboratory, Upton, New York
2. DOE Program for Climate Model Diagnosis and Intercomparison (PCMDI), Lawrence Livermore National Laboratory, Livermore, California
3. NASA Goddard Institute for Space Studies, New York, New York
4. NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California
5. Naval Research Laboratory, Monterey, California
6. NCAR Earth System Laboratory, National Center for Atmospheric Research, Boulder, Colorado
7. NOAA National Climatic Data Center, and Cooperative Institute for Climate and Satellites, North Carolina State University, Asheville, North Carolina
8. NOAA National Marine Fisheries Service, Seattle, Washington
9. NOAA National Marine Fisheries Service, Northeast Fisheries Science Center, Narragansett, Rhode Island
10. NOAA National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu, Hawaii
11. NOAA National Marine Fisheries Service, Southwest Fisheries Science Center, Environmental Research Division, Pacific Grove, California

U.S. Non-Federal

1. Department of Earth and Environment, Boston University, Boston, Massachusetts
2. Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado
3. Department of Applied Physics and Applied Mathematics, Columbia University, New York, New York
4. Department of Earth and Environmental Engineering, Columbia University, Manhattan, New York
5. International Research Institute for Climate and Society, The Earth Institute of Columbia University, Palisades, New York
6. Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York
7. George Mason University, Fairfax, Virginia
8. School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Georgia
9. Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, Virginia
10. Program in Atmospheric and Oceanic Sciences, Princeton University, Princeton, New Jersey
11. Program in Science, Technology, and Environmental Policy, Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, New Jersey
12. Department of Environmental Sciences, Rutgers University, New Brunswick, New Jersey
13. Joint Institute for Regional Earth System Science and Engineering, University of California, Los Angeles, Los Angeles, California
14. Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California
15. Department of Mechanical Engineering, University of Colorado, Boulder, Colorado
16. International Pacific Research Center, School of Ocean and Earth Science and Technology, University of Hawaii, Honolulu, Hawaii
17. IIHR-Hydroscience and Engineering, The University of Iowa, Iowa City, Iowa
18. Department of Atmospheric and Oceanic Science, University of Maryland, College Park, Maryland
19. Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida
20. Department of Atmospheric, Oceanic, and Space Sciences, University of Michigan, Ann Arbor, Michigan
21. Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill, North Carolina
22. Department of Earth Sciences, University of Southern California, Los Angeles, California
23. Department of Geological Sciences, The John A. and Katherine G. Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas
24. Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas
25. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

International – Government, National, and International

1. Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), Italy
2. Institut Pierre-Simon Laplace (IPSL), Paris, France
3. Max Planck Institute, Germany
4. Met Office Hadley Centre, Exeter EX1 3PB, United Kingdom
5. National Oceanography Centre, Southampton, Southampton, United Kingdom

International - Non-Government

1. Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China
2. Departament d'Oceanografia Física, Institut de Ciències del Mar, CSIC, Barcelona, Spain
3. Universidad Complutense, and Instituto de Geociencias UCM, CSIC, Madrid, Spain
4. Laboratoire de Météorologie Dynamique, École Normale Supérieure, Paris, France
5. Geological Institute, Department of Earth Sciences, ETH Zurich, Zurich, Switzerland
6. Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland
7. Earth System Physics Section, International Centre for Theoretical Physics, Trieste, Italy
8. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan
9. Laboratoire de Physique, Lyon, France
10. Department of Earth and Planetary Sciences, McGill University, Montreal, Quebec, Canada
11. National Taiwan Normal University, Taipei, Taiwan
12. College of Urban and Environmental Sciences, Peking University, Beijing, China
13. School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea
14. Center for Earth System Science, Tsinghua University, Beijing, China
15. Climate and Environmental Physics, Physics Institute, University of Bern, Bern, Switzerland
16. Fisheries Centre, University of British Columbia, Vancouver, British Columbia, Canada
17. School of Environmental Sciences, The University of East Anglia, Norwich, United Kingdom
18. School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom
19. Institute of Oceanography, University of Hamburg, Hamburg, Germany
20. Climate Change Research Centre, University of New South Wales, Sydney, Australia
21. Department of Meteorology, University of Reading, United Kingdom
22. Atmosphere and Ocean Research Institute, University of Tokyo, Kashiwa, Japan
23. University of Toronto, Toronto, Canada
24. School of Earth and Ocean Sciences, and Department of Physics, University of Victoria, Victoria, British Columbia, Canada
25. Institute for Marine and Atmospheric Research Utrecht, Utrecht University, Utrecht, Netherlands
26. Willis Research Network, London, United Kingdom

NOAA Cooperative Institutes and Cooperative Agreement

The following is a brief description of the NOAA Cooperative Institutes with Princeton University and Columbia 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.

Princeton University's Cooperative Institute for Climate Science and Atmospheric and Oceanic Sciences Program – The relationship between GFDL and Princeton University dates back to before the founding of the Laboratory in 1955. The Laboratory's founding director, Joseph Smagorinsky, began his research career at Princeton University's Institute for Advanced Study. 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 the Cooperative Institute for Climate Science (CICS) fall into one of three tasks, and also within one of three themes. Task 1 is "Administrative Support" and is funded on the order of $100K annually. Task 2 supports post-doctoral scientists and graduate students that work collaboratively at GFDL with GFDL host scientists and has grown to be funded at more than $2.5M annually. Task 3 is independently funded 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 some is performed by scientists at other institutions.

The three themes are as follows:

1. Earth system modeling and analysis. The development and improvement of Earth system models, that is, models that simulate and aid the understanding of the present climate and Earth system, and that can be used to predict changes in the state of the climate and Earth system. An Earth system model includes components representing the dynamics of the atmosphere, the oceans, the cryosphere, the land its hydrology, and the physical, chemical and biological systems within and affecting these components.

2. Data assimilation. The development of capabilities to assimilate both physical and biogeochemical observations to produce an estimate of the current environmental state for use in Earth system modeling and the prediction of the future state of the climate.

3. Earth system model applications. The use of Earth system models to study the processes associated with long term climate change and variability, and to make predictions of the future state of the Earth system.

Columbia University's Cooperative Institute for Climate Applications and Research (CICAR) – In 2003, NOAA competitively selected Columbia University to host the Cooperative Institute for Climate Applications and Research and named GFDL as the NOAA host Laboratory. GFDL has funded its administrative expenses each year, on the order of slightly more than $100K, and has funded one significant two-year research project and one other small research project. Most of the research undertaken by CICAR for NOAA had been supported by the NOAA Climate Program Office. CICAR's period of performance ended in 2013.

University Corporation for Atmospheric Research (UCAR) – GFDL has been hosting UCAR scientists for more than a decade. In 2012, NOAA re-competed that cooperative agreement and the result was two grant awards, one managed by the National Weather Service and the other managed by the Climate Program Office. Scientists and scientific support are currently brought on through UCAR's Visiting Scientist Program, which is managed by the National Weather Service.

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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 2013 Funding
NOAA Climate Program Office	CORE – Global climate modeling including non-CO_2 greenhouse gases	V. Ramaswamy		71,646
NOAA Climate Program Office	CORE – Simulate influence of greenhouse gases on stratospheric temperatures and stratospheric processes	V. Ramaswamy		104,314
NOAA Climate Program Office	CORE – Continue incorporation of aerosol-cloud microphysics in global models to elucidate aerosol-cloud interaction effects	V. Ramaswamy		96,863
NOAA Climate Program Office	CORE – Modeling various field data, including Gulf of Mexico Atmospheric Composition and Climate Study, using chemical transport models and calculation of radiative forcing of aerosols for the government performance and results act measure"	Larry Horowitz, Hiram Levy		96,863
NOAA Climate Program Office	CORE – Model-observation comparisons to link emissions with aerosol properties	V. Ramaswamy		104,314
NOAA Climate Program Office	Ocean data assimilation	Anthony Rosati		41,495
Office of Naval Research	Improving hurricane weather research and forecasting and GFDN coupled models for transition to operations	Morris Bender	Isaac Ginis	40,000
NOAA Climate Program Office	Decadal climate prediction and abrupt change (was model development in fy09)	Brian Gross		1,768,000
NOAA Climate Program Office	NOAA environmental software infrastructure and interoperability – Implicit coupling of the community sea-ice model in GFDL models	V. Balaji		250,000

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	Fiscal Year 2013 Funding
NASA/Goddard Space Flight Center	General circulation model simulations of Martian dust storm activity	R. John Wilson		100,000
NASA/Goddard Space Flight Center	Toward GEOS-6 - A Non-hydrostatic Modeling Capability	S-J Lin	Max J. Suarez	5,000
NOAA Climate Program Office	Northeast shelf integrated ecosystem assessment	Charles Stock		2,000
NOAA Climate Program Office	Towards improving convection parameterization and the Madden-Julian oscillation in next-generation climate models	Ming Zhao	Xianan Jiang and Duane Waliser	33,482
NOAA Climate Program Office	A US national multi-model ensemble intra seasonal to interannual prediction system	Anthony Rosati		101,650
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	109,250
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		4,750
Department of Energy	Using atmospheric radiation measurement observations to evaluate cloud and convection parameterizations and cloud-convection-radiation interactions in the GFDL general circulation model	Leo J. Donner		354,903
NASA	Improved understanding of atmospheric processes via data assimilation	R. John Wilson		48,466
USGS	Modeling the effects of environmental change on crucial wildlife habitat	Keith Dixon	Colleen Caldwell and Kenneth Boykin	20,000
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		59,938

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	Fiscal Year 2013 Funding
NOAA Cliamte 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	133,812
NOAA Climate Program Office	CPT to improve cloud and boundary layer processes in global forecast system/climate forecast system	Jean-Christophe Golaz	Christopher Bretherton, Joao Teixeira, Hualu Pan	1,000
NOAA Climate Program Office	Collaborative research: representing calving and iceberg dynamics in global climate models	Robert Hallberg	David Pollar, Alistair Adcroft, Olga Sergienko, Jason Amundson, Leigh Stearns, Jeremy Bassis	1,000
NOAA Climate Program Office	Collaborative research: cloud macrophysical parameterization and its application to aerosol indirect effects	Jean-Christophe Golaz	Leo J. Donner, Ming Zhao, Yi Ming	370,957
NOAA	Skillful predictions of seasonal hurricane frequency, track, and landfall	Gabriel Vecchi and S-J Lin		2,770,179
NOAA Climate Program Office	Understanding and improving general circulation model simulations of MJO initiation over the tropical Indian Ocean using DYNAMO field observations	Leo J. Donner	Hailan Wang, Siegried Schubert	8,000
OAR	Seasonal-to-decadal climate predictions for marine resource management	Charles Stock	Michael Alexander, Kathy Pegion, Nicholas Bond, Yan Xue, Gabriel Vecchi	385,883
NOAA Climate Program Office	Impact of organic nitrate chemistry on air quality and climate: past, present and future atmospheres	Jingqiu Mao		392,881*

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	Fiscal Year 2013 Funding
National Science Foundation	G8 Initiative – ExArch: Climate analytics on distributed exascale data archives	Venkatramani Balaji		312,967*
National Science Foundation	CDI-Type II: Collaborative Research: Scaling up: Introducing commoditized governance into community Earth science modeling	Venkatramani Balaji		204,415*
National Science Foundation	Collaborative research: continuation and enhancement of MPOWIR	Sonya Legg		249,958*
Office of Naval Research	Numerical investigation of nonlinear internal wave generation and mixing in straits	Sonya Legg		498,420*
NASA Atmospheric Composition	Exploring emission versus climate drivers of tropospheric ozone variability and trends over northern mid-latitudes from space	Meiyun Lin	Owen Cooper	141,722*
State of Texas	Investigation of Global Modeling and Lightning NOx Emissions as Sources of Regional Background Ozone in Texas	Meiyun Lin	Chris Emery, William Koshak	9,810*
National Science Foundation	Collaborative research on quantifying the impacts of atmospheric and land surface heterogeneity and scale on soil moisture-precipitation feedbacks	Kirsten Findell	Benjamin Lintner, Pierre Gentine	301,692*

*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 2013 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:

CORE – Global climate modeling including non-CO_2 greenhouse gases

V. Ramaswamy

FY2013 Funding: $71,646

Abstract

Quantify the seasonal and spatial characteristics of the global-mean radiative and surface forcing due to the changes in non-CO2 greenhouse gases (methane, nitrous oxide, halocarbons and tropospheric and stratospheric ozone), considering the time periods 1950, 1980 and present. Analyze the influences due to overlap with water vapor, and study the spectral characteristics including the sensitivity to changes in temperature and moisture at different altitudes.

CORE – Simulate influence of greenhouse gases on stratospheric temperature and stratospheric processes

V. Ramaswamy

FY2013 Funding: $104,314

Abstract

Quantify the roles of well-mixed greenhouse gases, ozone and aerosols on the temperature evolution from the upper troposphere to the upper stratosphere (over the period 1979 to 2005) using the NOAA/GFDL climate model and satellite and radiosonde observations. Examine the Arctic and Antarctic polar seasonal stratospheric changes from the past to the present and into the 21st century. Investigate the ensuing stratospheric effects upon the troposphere. The above issues will be examined using climate model versions with prescribed and prognostic interactive ozone.

CORE – Continue incorporation of aerosol cloud microphysics in global models to elucidate aerosol-cloud interaction effects

V. Ramaswamy

FY2013 Funding: $96,863

Abstract

Evaluation of the results of the simulations with the new prognostic description of the interactions between aerosols and clouds will continue, with the aim being to determine the robustness of the estimate of the total aerosol forcing (accounting for direct and all indirect effects). In this regard, field observations as well as satellite observations of the relevant aerosol and cloud parameters will be employed. Both mixed-layer ocean and coupled

atmosphere-ocean model integrations will be employed to examine the consequences of this forcing and to determine the sensitivity of the climate system due to warm cloud-aerosol interactions

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CORE – Modeling various field data, including Gulf of Mexico atmospheric composition and climate study using chemical transport models and calculation of radiative forcing of aerosols for the government performance and results act measure

Larry Horowitz and Hiram Levy

FY2013 Funding: $96,863

Abstract

Simulations of chemistry-aerosol-cloud-climate interactions will be conducted using the GFDL AM3 atmospheric GCM. Initial development of coupled, interactive stratospheric chemistry, tropospheric chemistry, aerosol, cloud, and radiation modules has been completed. Simulations in AM3 will be used to:

- Reduce uncertainty in the characterization of the optical properties and direct radiative forcing due to greenhouse gases and aerosols.
- Continue evaluation of the simulation of tropospheric and stratospheric species in AM3, and conduct scientific investigations of chemistry-climate couplings.
- Quantifying the space-time distributions of species in the AM3, including differences arising due to the treatment of species as passive/active tracers, and as online/offline characterizations.
- Analyze the sensitivity of the online simulations to the feedbacks involving the model's radiation and thermodynamics. Determining the role of the feedbacks on dust and sea-salt aerosol emissions.
- Investigate aerosol-cloud interactions; estimate magnitude of aerosol indirect radiative forcing

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CORE – Model-observation comparisons to link emissions with aerosol properties

V. Ramaswamy

FY2013 Funding: $104,314

Abstract

Quantify the roles of the different aerosol species (sea-salt, dust, organic carbon, black carbon, sulfates) in the present-day global radiative forcing using the interactive aerosol module developed as part of the next-generation NOAA/GFDL Atmospheric Model. Evaluate the reliability by comparing against multiple observations concerning aerosol parameters

obtained from ground-based, in situ, field campaigns and satellite observations. Links between emissions from different sources and aerosol physical and optical properties will be evaluated, including influences due to hygroscopicity and internal mixing. The resulting effects on the radiative and surface forcing will be analyzed. The improvement due to the improved, self-consistent treatment of the interaction between aerosol emissions, meteorology, and radiative heating, in contrast to the usual prescribed aerosol distributions (e.g., AR4 models), will be assessed.

Ocean data assimilation

Anthony Rosati

FY2013 Funding: $41,495

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.

Improving hurricane weather research and forecasting and GFDN coupled models for transition to operations

Morris Bender

FY2013 Funding: $40,000

Abstract

GFDL has received Joint Hurricane Testbed (JHT) funding to continue to upgrade the operational version of its hurricane model for both the Navy (GFDN) and the National Weather Service. GFDN is now coupled in all ocean basins, with full 3-D ocean coupling. In addition, physics upgrades were transitioned to GFDN in 2013, to make the two versions of the model identical. Considerable effort was also made to track down a major coding error introduced by

Navy personnel that resulted in degraded model performance. As transition was made to a new computer system at the National Weather Service, a moratorium was put in place that prevented any operational models from being upgraded in 2013. Nevertheless, throughout the year, the GFDL hurricane group continued to develop a new high resolution version of the hurricane prediction system, which is currently planned for transition to operations at both the National Weather Service and the Navy in 2014. This model has shown significantly improved forecasts of storm intensity, both for stronger and weaker systems.

Decadal climate prediction and abrupt change

Brian Gross

FY2013 Funding: $1,768,000

Abstract

There is an urgent need to provide predictions and projections, based on the best possible science, that answer questions such as: What will Atlantic hurricane activity be like over the next decade? Will observed changes in the Arctic accelerate or moderate in coming decades? What are the prospects for ongoing drought over the southwestern U.S. in the coming years and decades? This need is driven in part by the recognition of the unusual nature of current and recent climate events, and by their potential to create significant socioeconomic and policy issues for the U.S. on local, regional, national, and international scales.

GFDL/NOAA is undertaking a research program to develop the capability to make the best possible predictions and projections on seasonal to decadal time scales. There is a recognition that decadal-scale changes are a result of both natural variability of the climate system and the response to changing radiative forcing. This research program addresses both processes. First, we have developed a unified seasonal to decadal prediction system. This system starts a model from the observed state of the climate system and predicts the evolution of the natural variability of the system on seasonal to decadal time scales. This includes prediction of phenomena on the seasonal to interannual time scale, such as El Nino/Southern Oscillation (ENSO), as well as phenomena on multi-annual to decadal scales, such as the Atlantic Meridional Overturning Circulation (AMOC). Our initial prediction system has shown significant skill in predicting multi-year to decadal-scale evolution of upper ocean conditions (and this is the same system that has shown substantial skill in the North American Multi-Model Ensemble for seasonal prediction). Ongoing work will investigate the extent to which our decadal predictive skill can be enhanced and translated to climatic impacts. There remains a fundamental research challenge to assess the inherent decadal-scale predictability of the climate system, and to develop optimal systems that can realize that predictability within a unified seasonal to decadal prediction system.

The second critical piece of our research program involves projecting changes in the climate system over the next several decades in response to changing radiative forcing. This effort especially targets the potential for changes in regional climate, including water resources and hydroclimate, as well as climate extremes, such as tropical cyclones. For this work we make use of large ensembles of simulations using new high-resolution coupled climate models recently developed at GFDL. These models provide a major leap forward in our ability to simulate regional climate and extremes, and thus provide a critical breakthrough in facilitating quantitative assessments of the risks of changes in regional climate and climate extremes over the coming decades.

The benefit to society from this research program will come from making available our best possible science-based predictions and projections of climate system changes over the coming decades, especially for regional climates and extremes. Quantifying the risks associated with multi-year to multi-decadal climate variations and change would be of enormous potential benefit across a range of sectors, from water resources to agriculture to shipping. In addition, such prediction and projection systems will provide a prototype warning and assessment system for the risk of abrupt climate change.

NOAA environmental software infrastructure and interoperability group - Implicit coupling of the community sea-ice model in GFDL models

V. Balaji

FY2013 Funding: $250,000

Abstract

One of the innovative aspects of the Flexible Modeling System (FMS) is a fast-slow coupling cycle. This method allows very fast equilibration of land and ocean surface layers with weather in the atmosphere. Based on the exchange grid technology (Balaji et al 2006) it allows a cross-component implicit coupling timestep. This permits a coupling timestep (typically 15 min for climate models) between atmosphere and ocean and land surfaces. This technology is currently being ported to the Earth System Modeling Framework (ESMF).

Under this proposal, we propose to extend this technology to the community sea-ice model CICE (Hunke and Lipscomb 2001). The steps include:

- re-architecting CICE to separate the fast thermodynamics from the slower elastic-viscous-plastic (EVP) dynamics. CICE does not currently separate fast and slow processes.

- demonstration of CICE coupling within FMS. This will be done using a standard set of "CORE-forced" ice-ocean coupled runs that are very well understood and studied. The ocean model used for these studies is the GFDL community ocean model MOM.

- using these runs as a benchmark, develop an ESMF-based ice-ocean coupled system using CICE and MOM for the purposes of showcasing fast coupling and exchange grid technologies in ESMF. Several community projects including the National Unified Operation Prediction Capability (NUOPC) have registered interest in this project.

General circulation model simulations of Martian dust storm activity

R. John Wilson

FY2013 Funding: $100,000

Abstract

The outstanding problem for simulating the present Mars climate is representing the spatial and temporal variability of aerosol and the feedbacks that connect dust raising and transport with the evolving atmospheric circulation. Interannual variability is dominated by episodic planet-encircling dust storms, which represent a spectacular radiative/dynamical feedback resulting from the mobilization and subsequent transport of dust. Another prominent aspect of the dust cycle is the emergence of large regional dust storm events that occur in the pre and post solstice periods of the northern hemisphere (NH) winter season. These events are initiated by midlatitude traveling waves in the NH that raise dust that is occasionally transported southward within low-lying channels into the southern (summer) hemisphere. These so-called flushing storms appear to be a relatively regular aspect of the dust cycle, although their impact varies from year to year. Local dust storm activity along the boundaries of the retreating CO2 polar caps is a basic feature of the dust cycle. To date, published efforts to simulate the main features of the dust cycle have been unsuccessful in yielding realistic interannual variability for major dust storms and have also failed to reproduce the more regular influence of flushing storms.

We propose to continue the development and utilization of a Mars General Circulation Model (MGCM) for gaining an improved understanding of the degree to which dynamical and radiative interactions between aerosols, the atmospheric circulation and the surface control the seasonal and interannual variability of the present climate. We will examine the contribution and response to dust raising by the various circulation elements such as the Hadley circulation, thermal tides, slope winds, transient waves and the CO2 condensation flow. We intend to identify and explore the sensitivities of the positive and negative feedback mechanisms within the climate system. Our simulations now include the influence of a finite reservoir of mobile dust. By imposing an inverse relationship between the surface stress threshold for dust lifting

and the depth of dust at the surface, we have introduced a potentially important negative feedback that enables the model climate system to organize the surface dust distribution in such a way as to support interannual variations in major dust storm events. Water ice clouds contribute to the atmospheric thermal balance and may play a notable role in structuring the polar vortex in which the traveling waves that initiate flushing storm events are embedded. Our goal is to carry out high resolution multiannual simulations of Martian climate that yield regional and planet-encircling dust storm with realistic spatial and temporal variability. It is anticipated that an improved understanding and parameterization of dust lifting and surface characterization will significantly aid the development of useful weather forecasting capability, which could assist mission planning and spacecraft operations. It is expected that the ability to represent the dust cycle in simulations of the current Mars climate will be an important step for evaluating the geologic history of dust deposits across the planet.

Towards GEOS-6 – A Non-hydrostatic modeling capability

Max J. Suarez and S-J. Lin

FY2013 Funding: $5,000

Abstract

We propose to implement and test a new cubed-sphere finite-volume, non-hydrostatic dynamical core developed at NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) for use in future Global Modeling and Assimilation Office (GMAO) atmospheric general circulation models. The core will be implemented under the MAPL software interface to the Earth System Modeling Framework (ESMF) used in GMAO systems. It will be tested at various resolutions in climate, numerical weather prediction (NWP), and data assimilation modes. We will evaluate the core's hydrostatic and non-hydrostatic options at resolutions from 15 to 50 km, and will compare the resulting non-hydrostatic implementations at the two centers using resolutions as close to cloud-resolving as computing resources will allow (~5km).

For the GMAO, this proposal prepares the pathway to the next generation GEOS-6 system. For GFDL it will provide additional resources for a more thorough evaluation of the core and particularly of its performance at very high resolution in a numerical weather prediction (NWP) setting using the GMAO's atmospheric data assimilation system. The non-hydrostatic finite volume dynamical core is already undergoing advanced testing at GFDL and a hydrostatic version using the same code base is being tested at GMAO.

This collaboration between GMAO and GFDL will further the interests of both parties in the Development of advanced climate and NWP models, and represents a key step in ensuring

NASA's ability to continue to analyze and assimilate high-resolution satellite data using state-of-the-art models.

Northeast shelf integrated ecosystem assessment

Charles Stock

FY2013 Funding: $2,000

Abstract

These funds are for travel by Charles Stock in support of the Northeast U.S. Shelf Integrated Ecosystem Assessment Effort. Dr. Stock is the GFDL contact point for efforts to incorporate climate information into Integrated Ecosystem Assessments in the Northeast U.S.

Towards improving convection parameterization and the Madden-Julian oscillation in next-generation climate models

Ming Zhao

FY2013 Funding: $33,482

Abstract

Tropical biases remain a significant problem in global atmosphere models, even at horizontal resolutions of 20-50 km. In addition to mean state errors, another glaring deficiency is the general absence of the 30-60-day Madden-Julian oscillation (MJO), which modulates the frequency of tropical cyclone genesis over several basins and interacts with the lower-frequency El-Nino Southern-Oscillation. It is thought that such errors stem mainly from deficiencies in convection parameterization, but the precise nature of these deficiencies remains unclear. In order to address such tropical problems, we propose to run and analyze a suite of short-term (10-day), high-resolution weather hindcasts, focusing on a 40-day period of enhanced MJO activity during the Year of Tropical Convection (YoTC) when special observational and assimilated datasets are available. The hindcasts will be perfomed using 4 different high-resolution atmospheric models (GEOS-5, CAM5, HiRAM, and WRF) as part of a multi-institutional collaborative research effort. The goal is to see how simulations of the MJO and other high-impact weather phenomena, as well as the mean state, are affected by either i) increases in model resolution (going from 50- down to 5-km horizontal grid spacing) or ii) the use of a "superparameterization" of convection at 50-km horizontal grid spacing. Hindcasts will also be generated with each of the models' convection schemes turned off, to see how the various schemes tend to improve (or degrade) their respective model's performance at high resolution. We hypothesize that models with more realistic convective processes will do better

at simulating the MJO, so our diagnosis of model output will include both process-level and global-scale aspects, and will compare these in order to test this hypothesis. Improved understanding of this convective process-global performance relationship will serve the overall goal of improved ability to simulate convection variability and the MJO in models used to predict changes in regional-scale climate and high-impact weather for the decades to come.

A US national multi-model ensemble intra seasonal to interannual prediction system

Benjamin Kirtman, James L. Kinter III, Dan Paolino, Michael K. Tippett, Anthony G. Barnston, Anthony Rosati, Kathy Pegion, Siegfried Schubert, Michele Reinecker, Max Suarez, Huug van den dool, Malaquias Pena Mendez, Jin Huang, Scott Weaver, Qin Zhang, Jon Gottschalck, Joe Tribbia, Don Middleton, Eric Wood

FY2013 Funding: $101,650

Abstract

The demand for and our ability to predict the seasonal variations of the Earth's climate dramatically increased from the early 1980s to the late 1990s. This period was bracketed by two of the largest El Niño events on record: the 1982-83 event, whose occurrence was unknown until after it was over; and the 1997-98 event, which was predicted up to six months in advance. This improvement was due to the convergence of many factors including a concerted international effort to observe, understand and predict tropical climate variability, the application of theoretical understanding of coupled ocean-atmosphere dynamics, and the development and application of models that accurately simulated the observed variability. The improvement led to considerable optimism regarding our ability to predict seasonal climate variations in general and El Niño/Southern Oscillation (ENSO) events in particular, and our ability to predict the impacts associated with these variations through many sectors of society.

In the late 1990s, our ability to predict tropical climate fluctuations reached a plateau with only modest subsequent improvement in forecast quality. Arguably, there were substantial qualitative forecasting successes - almost all the models predicted a warm event during the boreal winter of 1997/98, one to two seasons in advance. Despite these successes, there have also been some striking quantitative failures. For example, according to Barnston et al. (1999) and Landsea and Knaff (2000), the performance of many different prediction systems during the 1997-1999 ENSO episode was mixed. None of the models predicted the early onset or the amplitude of that event, and many of the dynamical (i.e., CGCM) forecast systems had difficulty capturing the demise of the warm event and the development of cold anomalies that persisted through 2001. Many models failed to predict the three consecutive years (1999–2001) of relatively cold conditions and the development of warm anomalies in the central

Pacific during the boreal summer of 2002, and accurate forecasts continue to be a challenge even at relatively modest lead-times (Barnston 2007; personal communication).

Despite, or perhaps because of this plateau of forecast skill, two notable changes in prediction strategy have emerged, largely based on multi-institutional international collaborations: (i) forecasts must include quantitative information regarding uncertainty (i.e., probabilistic prediction) and verifications must include probabilistic measures of forecast quality (e.g., Palmer et al. 2000; Goddard et al. 2001; Kirtman 2003; Palmer et al. 2004; DeWitt 2005; Hagedorn et al. 2005; Doblas-Reyes et al. 2005; Saha et al. 2006 among many others); and (ii) a multi-model ensemble strategy may be the best current approach for adequately resolving forecast uncertainty (Palmer et al. 2004; Hagedorn et al. 2005; Doblas-Reyes 2005; Palmer et al. 2008), although other techniques such as perturbed physics ensembles (this is currently in use at the UK Met Office for their operational system) or stochastic physics (e.g., Berner et al., 2008) have been developed. The first change in prediction strategy naturally follows from the fact that climate variability is chaotic or irregular and, because of this, forecasts must include some quantitative assessment of this uncertainty. More importantly, the climate prediction community now understands that the potential utility of climate forecasts is based on end-user decision support (Palmer et al., 2000; Morse et al. 2005; Challinor et al. 2005), which requires probabilistic forecasts that include quantitative information regarding forecast uncertainty. The second change in prediction strategy follows from the first, because, given our current modeling capabilities, a multi-model strategy is a practical and relatively simple approach for quantifying forecast uncertainty due to uncertainty in model formulation. In fact, as argued in Krishnamurti et al. 2000, Palmer et al. (2004), and Kirtman and Min (2009), the multi-model approach appears to outperform (on average) any individual model using a standard single model approach. No objective comparison between sophisticated single model methods such as stochastic physics or perturbed parameters and multi-model approaches has been made.

More recently there has also been a growing interest for forecast information on time scales beyond 10 days, but less than a season. For example, the Climate Prediction Center of the National Centers for Environmental Prediction (NCEP/CPC) in the United States currently makes “outlook” type forecasts for extended weather forecast ranges (i.e., two weeks). The NCEP/CPC *Global Tropical Hazards/Benefits Assessment* provides forecasts of anomalous tropical temperature and precipitation. The *U.S. Hazards Assessment* product, also issued by NCEP/CPC, includes outlooks of potential hazards in the U.S up to 16 days. At present such outlook-style forecast products are based on a subjective combination of various statistical and dynamical methods, although there is momentum to make the process more objective using realtime dynamic model forecasts (Gottshalck 2008). These activities demonstrate the demand for such forecast information and are implicitly based on the assumption the even longer lead (beyond two weeks) forecasts will be made in the future.

This sub-seasonal time scale is in many ways coupled to the seasonal time scale1 and is often viewed as a source of predictability for seasonal time scales, yet the mechanisms for predictability on this time scale are less well understood (as compared to say, ENSO) and forecast quality is expected to be lower than on the seasonal time-scale. Despite this, there is substantial evidence for dynamic sub-seasonal predictions that are of sufficient quality to be useful (e.g., Pegion and Sardeshmukh, 2011) and evidence that a multi-model approach will enhance forecast quality on this time scale.

The proposed research leverages an existing National Multi-Model Ensemble (NMME) team that has already formed and began producing routine real-time seasonal to interannual (ISI) predictions in August 2011, providing them to the NOAA Climate Prediction Center (CPC) on an experimental basis for evaluation and consolidation as a multi-model ensemble ISI prediction system. The experimental prediction system developed by this NMME team is as an “NMME of opportunity” in that the ISI prediction systems are readily available and each team member has independently developed the initialization and prediction protocol. We will refer to the NMME of opportunity as phase 1 NMME (or NMME-1).

The activity proposed here is to develop a more “purposeful NMME” in which the requirements for operational ISI prediction are used to define the parameters of a rigorous reforecast experiment and evaluation regime. This will be phase 2 NMME (or NMME-2). The NMME team will design and test an operational NMME protocol that will guide the future research, development and implementation of the NMME beyond what can be achieved based on the phase 1 NMME project.

The proposed activity will: i. Build on existing state-of-the-art US climate prediction models and data assimilation systems that are already in use in NMME-1 and ensure interoperability so as to easily incorporate future model developments; ii. Take into account operational forecast requirements (forecast frequency, lead time, duration, number of ensemble members, etc.) and regional/user specific needs. A focus of this aspect of the work will be the hydrology of various regions in the US and elsewhere in order to address drought and extreme event prediction; iii. Utilize the NMME system experimentally in a near-operational mode to demonstrate the feasibility and advantages of running such a system as part of NOAA’s operations; iv. Enable rapid sharing of quality-controlled reforecast data among the NMME team members, and develop procedures for timely and open access to the data, including documentation of models and forecast procedures, by the broader climate research and applications community.

The proposed activity will also include several NMME research themes: i.The evaluation and optimization of the NMME system in hindcast mode (e.g., assessing the optimal number of ensemble members from each model, how to best combine the multi-model forecasts, sources of complementary prediction skill, etc.), methodologies to recalibrate individual dynamical models prior to combination, and provision of probabilistic quantitative (rather than categorical) information. There will also be a thorough evaluation of the forecasts across multiple time scales (e.g., variability beyond week two); ii. Ocean and land initial condition sensitivity experiments; iii. The application of the NMME forecasts for regional downscaling and hydrological prediction.

The remainder of this proposal describes the ongoing NMME-1 and how the support requested here will be used to continue this effort, and our strategy for evaluating how the multimodel approach contributes to the forecast quality. We also describe how NMME-2 will evolve from NNME-1 and the coordinated research activities envisaged. Our data dissemination strategy is also described.

Understanding climate variations in the Intra-Americas Seas and their influence on climate extremes using global high-resolution coupled models

Gabriel A. Vecchi, Thomas Delworth, and Anthony Rosati

FY2013 Funding: $109,250

Abstract

We propose to use a hierarchy of GFDL high-resolution climate models to improve our understanding of the climate of the Caribbean Sea and Gulf of Mexico (“Intra-Americas Seas”, or “IAS”), including its influence on climate-scale variations and changes in Atlantic hurricane activity and North American drought. Because of the complex, multi-scale oceanographic, atmospheric and coupled air-sea phenomena that characterize the IAS region, we will focus on both atmospheric and oceanic climate, and their interactions. We will explore the sensitivity of the simulation of the mean climate and climate variations in the IAS to changes in resolution and parameterization in the context of the coupled GFDL high-resolution models. The role of remote influences on climate in the IAS will be explored, assessing oceanic and atmospheric teleconnections by performing “data override” and “partial coupling” experiments with the climate models. Analogous perturbations to the coupled model will be used to explore the influence of the IAS on remote climate through atmospheric and oceanic processes. We will focus particularly on the influence of the IAS on North Atlantic hurricanes and on drought over North America. Predictability of the climate variations and teleconnections from the IAS will be explored using initialized prediction experiments using the GFDL high-resolution modeling system.

The principal hypotheses to be tested are: i) increased resolution and high-order numerics in global coupled climate models improve simulation of mean climate and variations of the Intra-Americas Seas, ii) remote, large-scale factors (e.g., ENSO and the Atlantic Meridional Overturning Circulation) drive variations and changes in the IAS through atmospheric and oceanic bridges, iii) changes in oceanic circulation and atmospheric convection in the IAS have a detectable influence on remote oceanic and atmospheric conditions, iv) modeled climate variations in the IAS modulate North American drought and North Atlantic tropical cyclone activity in the North Atlantic, v) the improved representation of drivers of IAS variability (e.g., ENSO and AMM) and the mean climate of the IAS in higher resolution models leads to enhanced predictive capacity for regional climate due from initialization and response to radiative forcing. The proposed work should improve our understanding and ability to model a key area of the global climate system, and the model simulations performed in this study and analysis of them will be beneficial to the high-resolution climate model development.

Relevance to NOAA's long-term goal and to the competition: This work will contribute to NOAA's long-term goal of climate adaptation and mitigation through improving our ability to model, predict and understand climate extremes over North America. The IAS is a principal moisture source for rainfall over much of the southeastern and central US, provides a warm water energy source to tropical cyclones and is key in the development of tornadic activity over the US. Therefore improved understanding, modeling and prediction of this key region is necessary to understanding likely changes in droughts, landfalling tropical cyclones and tornadic activity over the US, and help inform adaptation strategies. Though the IAS is influential to climate and extremes, "state-of-the-art global models have very large mean bias and erroneous variability over the [IAS] region," according to the IAS Climate Processes (IASCliP) Modeling Working Group (Misra et al. 2010). This proposal seeks to use higher resolution models to help remedy this important limitation to our current modeling capability.

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

FY2013 Funding: $4,750

Abstract

Tropical intraseasonal variability (ISV, e.g. Madden-Julian Oscillation) exerts significant influences on global climate and weather systems including tropical cyclones (TCs). This serves as a critical basis of the "Seamless Prediction" concept by bridging the forecasting gap between

medium- to long-range weather forecast and short-term climate prediction. For extended range forecasts of TC activity on an intraseasonal time scale (10~60 days), most of current approaches are based on statistical models or downscaling techniques. Recently, with the development of high-resolution general circulation models (GCMs) with improved model physics, it has become possible for these GCMs to represent both ISV and hurricanes, leading to a new avenue for intraseasonal TC prediction by using dynamical models. Our recent analyses (Jiang et al. 2011b; Jiang et al. 2011a) of ISV and TC activity over the eastern North Pacific (ENP) based on simulations by the high resolution NOAA/GFDL HiRAM AGCM illustrate that the observed dominant ISV modes over the ENP are captured well in HiRAM; meanwhile, the observed relationship between ISV and TC activity over the ENP can also be faithfully represented in this model. Motivated by these encouraging results, we propose to use HiRAM, a leading edge model in terms its ISV-TC fidelity, to qualify the predictive skill and estimate the predictability for TCs across the Intra-Americas Sea (IAS) on intraseasonal time scales. The objectives of this proposed study are as follows: 1. Conducting hindcast experiments to fully evaluate the prediction skill of ISV over the IAS by the NOAA/GFDL HiRAM; 2. Analyze the HiRAM hindcast ensembles to estimate the intrinsic predictability of TC activity over the IAS; 3. Evaluate the role of ISV in characterizing the prediction skill of TCs over the IAS on intraseasonal time scales; 4. Explore the physical mechanisms associated with ISV modulation of TC formation over the IAS; 5. Using both HiRAM climate simulations and hindcasts, evaluate how model horizontal resolution and different physical parameterization specifications influence model skill in simulating / predicting ISV and TC activity. With a focus on the close linkage between TCs, one of the most disastrous extreme events, and ISV, a prominent climate mode with broad impacts over the IAS, this proposal directly addresses MAPP program's FY2012 goals of "modeling of Intra-Americas Sea climate processes associated with extremes over North America". Moreover, this proposed study is in great agreement with recommendations by the National Academy of Science's 2010 report "Assessment of Intraseasonal to Interannual Climate Prediction and Predictability" that "Many sources of predictability remain to be fully exploited by intraseasonal to interannual (ISI) forecast systems. To better understand key processes that are likely to contribute to improved ISI predictions, …, MJO influences on other important components of the climate system, such as tropical cyclone genesis should continue to be explored and exploited for additional predictability."

Using atmospheric radiation measurement observations to evaluate cloud and convection parameterizations and cloud-convection-radiation interactions in the GFDL general circulation model

Leo J. Donner

FY2013 Funding: $354,903

Abstract

This project uses observations of clouds, aerosols, and other atmospheric properties from the Department of Energy (DOE) Atmospheric System Research (ASR) program to evaluate and develop the treatments of clouds in climate models developed at the National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory (GFDL). The project focuses on variability in atmospheric dynamics, thermodynamics, and moisture that occurs on scales below those explicitly resolved in climate models, which must be parameterized in these models. ASR observations of this variability are used in the development and testing of new parameterizations of clouds, cloud properties, and their interactions with aerosols which attempt to predict the distributions of this variability.

Improved understanding of atmospheric processes via data assimilation

R. John Wilson

FY2013 Funding: $48,466

Abstract

Getting the "physics" behind the spatial, seasonal and local time distribution of aerosols right is crucial for being able to predict the observed thermal structure without ad hoc prescription. Since the forcing and response of the Martian atmosphere are both fast compared to a diurnal cycle, proper prediction of aerosol distribution (and hence forcing) is necessary to properly capture the true nature of the evolving three-dimensional motions. This is likely crucial for a range of dynamical and climate processes throughout the Martian system. For the same reasons, it is crucial information if we wish to estimate the true global state of the atmosphere from limited observations with any confidence (i.e. being able to use techniques like data assimilation to globally 'extrapolate' limited spacecraft observations). More fundamentally from a planetary science perspective, application of models to paleoclimate will only be preliminary until we have skill in predicting forcing of present day conditions. We propose to test a straightforward set of hypotheses about how the aerosol distributions (and forcing) are determined and to assess whether physical models of these processes can provide a more skillful prediction of Martian atmospheric forcing and resultant mean state than extant published models. In order to simplify and minimize ambiguity in comparison of models and

data we propose to use a GCM within a Data Assimilation (DA) framework. The DA system provides a powerful tool to help diagnose missing processes and test model hypotheses against data. We expect that this work will result in a much better understanding of how the Martian atmosphere maintains the observed aerosol forcing and the resultant atmospheric circulation – i.e. it is expected that this project will greatly increase our understanding of the baseline Martian climate. The proposed work is thus directly relevant to the goals of the Mars Exploration Program through the 2010 MEPAG Goals Document Objective A to "Determine the processes controlling the present distributions of … dust by determining the short- and long-term trends" (investigation 1) and "Understand how volatiles and dust exchange between surface and atmospheric reservoirs" (investigation 3). The work targets our core understanding of the atmosphere and climate and is therefore relevant to the NASA MFR program.

Modeling the effects of environmental change on crucial wildlife habitat

Keith Dixon, Colleen Caldwell and Kenneth Boykin

FY2013 Funding: $20,000

Abstract

The primary objective for this project is to assess how a set of projected climate and land use change scenarios may impact the distribution of key species and unfragmented habitat in the South Central US. The results of these assessments will be integrated into decision support tools. The project will include evaluation of the role that uncertainty and variable effects of climate change on wildlife distributions and habitat have in these tools. As such, the project will necessarily synthesize information using computer models from multiple disciplines associated with the environmental sciences, including those dealing with the physical climate, land use, wildlife ecology and conservation biology. Efforts at GFDL will focus on the computer modeling of the physical climate aspects of the project.

High-resolution hurricane modeling, adaptive mesh refinement, improved physical parameterizations, wave-ocean coupling, and hurricane-climate-change projections

Morris Bender, Timothy Marchok and S-J Lin

FY2013 Funding: $59,938

Abstract

The National Weather Service's version of the GFDL hurricane model was officially unfrozen in 2011. Since then the GFDL hurricane group has made several major upgrades to the operational version of the hurricane model. These have resulted in a significant reduction in forecast error, for both track and intensity. A new high resolution version of the hurricane

model has been developed in 2013, with improved physics, and is being tested for operational implementation in 2014. Preliminary results, run for the combined 2008-2012 Atlantic hurricane seasons, are demonstrating significant reduction in intensity errors particularly for the 2 to 5 day forecast time periods. These accomplishments have been possible through the continued close collaboration of scientists at GFDL, the University of Rhode Island, and the National Weather Service's Environmental Modeling Center (EMC) with some of these improvements transferred to the HWRF operational model as well.

In 2010, the GFDL hurricane group developed an ensemble prediction system based on the operational hurricane model, which has been run in near real time as one of the HFIP stream 1.5 model candidates. Considerable effort was made to identify a reasonable range of uncertainty in the specified hurricane initial structure, moisture, and SSTs as guidance in selection of the perturbation of the various ensemble members. The system continues to be improved every year with the ensemble mean showing statistically significant improvement for intensity prediction compared to the operational GFDL hurricane model. Through development of a user-friendly web site, focus has also been in availability of the product in real time to forecasters at the National Hurricane Center, who have used the ensemble model spread as important guidance in the forecast uncertainty. Finally GFDL scientists continue to provide key leadership in several of the HFIP teams including the model strategy and forecast verification teams. As part of their HFIP funded activity, they provide assistance to other model groups around the USA, in use of the GFDL hurricane tracker, which is the main hurricane tracking code adopted by HFIP for their entire stream 1.5 and stream 2.0 models. In addition, GFDL scientists use this tracker as a tool for detecting tropical cyclogenesis in various operational global models and their ensembles.

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

FY2013 Funding: $133,812

Abstract

We propose a collaborative study between GFDL, NCAR, and WHOI to greatly advance our understanding of simulated AMOC variability, the impact of that variability on the atmosphere (and climate), and the relevance of that variability to our ability to make decadal climate predictions. Our work is motivated by the role that AMOC is thought to play in decadal climate variability and prediction, and by the critical need to improve our understanding of mechanisms and assessing the fidelity and robustness of simulated AMOC variability against

limited observations. A major facet of this proposal is the synergy achieved through the coordinated efforts between the three institutions involved, building upon our existing, strong collaborations. In particular, the development of common metrics and the coordinated design and analysis of focused, sensitivity experiments using suites of models from NCAR and GFDL, the two leading U.S. climate modeling centers, and WHOI's contribution in analysis of mechanisms and climate impacts are critical aspects of the proposed work. This coordination and synergy will provide an accelerated pathway to assessing robustness of model results and underlying mechanisms that, we hope, will lead to improved decadal prediction capabilities. Our goals include investigating impacts of model resolution, parameterizations, biases, and mean states on AMOC variability; determining the impact of ocean eddies on simulated AMOC and its variability; investigating AMOC variability and mechanisms in the recent past; improving our understanding of how particular physical processes and climate state information may give rise to predictive skill related to AMOC variability and evaluating how model differences in simulating AMOC variability affect related decadal predictability. We will use our findings to evaluate the realism of proposed mechanisms and assess the applicability of our results to other IPCC AR5 models.

Climate Process Team to improve cloud and boundary layer processes in global forecast system/climate forecast system

Jean-Christophe Golaz, Christopher Bretherton, Joao Teixeira, Hualu Pan

FY2013 Funding: $1,000

Abstract

A Climate Process Team (CPT) is proposed to improve cloud and boundary layer processes in NCEP's Global Forecast System (GFS) and Climate Forecast System (CFS) models. The intended CPO program/competition is MAPP (Research to Advance Climate and Earth System Models). The CPT will be a multi-institution collaboration between the University of Washington (CPT lead PI: Christopher Bretherton), the Jet Propulsion Laboratory (PI: Joao Teixeira), NCEP's Environmental Modeling Center (PI: Hualu Pan), and GFDL (PI: Chris Golaz; Co-PI: Ming Zhao). It is a sequel to a current MAPP-funded CPT on the subtropical stratocumulus to cumulus transition that builds on progress already made by this CPT and addresses MAPP's goal of leveraging the involvement of multiple NOAA climate modeling centers within a limited budget. The primary goal is to simultaneously improve the cloud climatology, energy budget, and operational forecast skill of the GFS and the next-generation CFS. A secondary goal is to identify weather regimes where clouds are either forecast much better or much worse by GFDL global climate models vs. GFS, as a step toward improving cloud-related parameterizations in both models.

Our current CPT found that both the operational GFS and CFS severely under-predict cloud amount, water content, and cloud radiative impact over most of the globe, producing unacceptably large global and regional biases in the net top-of-atmosphere and surface energy budgets. Reducing these biases would provide a strong foundation for reducing systematic errors in extended-range and seasonal forecasts. Our current CPT developed a portable single-column version of the operational GFS, which was used to improve the boundary-layer and shallow cumulus parameterizations, modestly improving global cloud distributions. We also developed a new cloud fraction parameterization that somewhat increases GFS-simulated global cloudiness, and a new eddy-diffusivity mass-flux scheme for GFS that combines the simulation of turbulence and shallow cumulus convection. The proposed CPT will try to advance these first steps into a GFS version which has clouds whose radiative properties are simulated as skillfully as in leading climate models, while at the same time maintaining or improving conventional measures of weather forecast skill. Our strategy involves careful testing and improvement of the microphysics and precipitation parameterizations, single-column and global analysis of the fidelity of parameterized cloud-turbulence-precipitation interactions in the revised GFS, and detailed comparisons of cloud simulations in hindcasts by GFS and two GFDL models, AM3 and HiRAM.

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

FY2013 Funding: $1,000

Abstract

Iceberg calving accounts for approximately 50% of the ice mass loss from the Greenland and Antarctic ice sheets. By changing a glacier's geometry, calving can also significantly perturb the glacier's stress-regime far upstream of the grounding line (defined as the location where grounded ice goes afloat). This process can enhance discharge of ice across the grounding line and increase ice-sheet contribution to sea level rise. Once calved, icebergs drift into the open ocean where they melt, redistributing freshwater to the ocean and altering water mass properties. This affects the large-scale ocean circulation, by injecting freshwater and altering water geochemical composition by transporting sediments frozen at their base that originated at Antarctic and Greenland continents.

To date, there is neither a consistent representation of calving processes in the continental ice-sheet models nor a self-consistent representation of iceberg evolution and its effects on ocean circulation in global ocean models. The proposed Climate Processing Team aims to fill these gaps by (1) developing parameterizations of calving processes that are suitable

for continental-scale ice-sheet models that simulate the evolution of the Antarctic and Greenland ice sheets, and implement these parameterizations in the GFDL climate model and its stand-alone ice-sheet model component; (2) developing a physically based iceberg component for inclusion in the large-scale ocean circulation model and implement it in the GFDL coupled climate model and (3) compiling the data sets of the glaciological and oceanographic observations that are necessary to test, validate and constrain the developed parameterizations and models. New observational and modeling tools, including the widespread availability of abundant high-resolution satellite imagery and numerical models capable of simulating calving from outlet glaciers and ice shelves and subsequently track iceberg evolution, position us to make a significant advance in our understanding of ice sheet dynamics, sea level rise and associated climate feedbacks.

The proposed research is directly relevant to NOAA's long-term goal of Climate Adaptation and Mitigation. It addresses the NOAA objective *to improve scientific understanding of the changing climate system and its impacts*. Iceberg calving is a crucial component of the mass balance and dynamics of ice sheets, yet it remains poorly represented in ice sheet models. Moreover, success in predicting both sea level rise and the influence of increased freshwater discharge into the polar oceans over the coming centuries hinges on improving the representation of key physical processes, like calving, in ice sheet models. In addition, this research is relevant to the long-term goal *To understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond*, and it directly supports the planning requirements for NOAA's long-term goal to promote "Resilient Coastal Communities and Economies". Our focus on improvement of cryospheric processes (ice-sheet modeling) is aimed to improve NOAA's Earth System Models (Modeling, Analysis, Predictions, and Projections Program - Research to Advance Climate and Earth System Models, Priority Area 2).

Collaborative research: cloud macrophysical parameterization and its application to aerosol indirect effects

Jean-Christophe Golaz, Leo J. Donner, Ming Zhao, Yi Ming

FY2013 Funding: $370,957

Abstract

Our climate process team (CPT) project is designed to improve the parameterization of cloud macro-physics (i.e. subgrid variability relating to clouds) and aerosol indirect effects (AIEs). To do so, our project has, for the first time, implemented a parameterization based on subgrid multi-variate probability density functions (PDFs) into two standard-resolution General Circulation Models (GCMs). Those two GCMs are the Community Atmosphere Model (CAM) from the National Center for Atmospheric Research (NCAR) and the Atmospheric Model version

3 (AM3) from the Geophysical Fluid Dynamics Laboratory (GFDL). The parameterization we have implemented is called Cloud Layers Unified By Binormals (CLUBB, Golaz et al. (2002); Larson and Golaz (2005); Larson et al. (2012)). Simulations from the resulting global models, CAM-CLUBB and AM3-CLUBB, have been compared to satellite observations.

Implementing CLUBB in a GCM is in some respects a high-risk project, but there are several potential benefits. CLUBB departs substantially from extant GCM parameterizations. CLUBB treats shallow cumulus (Cu) and stratocumulus (Sc) boundary layer clouds using a single equation set. This unified treatment avoids the artificial categorization of boundary layer cloud types that exists in present-day GCMs. In addition, because CLUBB unifies the treatment of shallow Cu and Sc, it facilitates the unification of microphysics schemes in those cloud types. In present-day GCMs, one microphysics scheme is used in Sc clouds and another is used in shallow Cu clouds. This is unsatisfying from a theoretical standpoint, and it also complicates the analysis of AIEs. Finally, CLUBB also tightly couples turbulence and cloud thermodynamics. This facilitates the coupling of aerosol activation to updraft speeds and also the second (cloud-lifetime) AIE.

Our CPT has made substantial progress in the past two years. In that time, CLUBB has been implemented in two GCMs, is running stably with acceptable cost, and has been compared with existing and new satellite observations. The simulations are almost competitive with the simulation fidelity in the standard versions of the GCMs. The simulations are not perfect, however, and our research has uncovered some interesting interactions between the cloud macrophysics (CLUBB) and the cloud microphysics that relate to problems in the simulations. Understanding these interactions is expected to have implications beyond CLUBB. The interactions are being explored collaboratively by the entire CPT in several different ways. This includes detailed comparisons of the GCMs with and without CLUBB, comparisons to fine-scale large eddy simulation (LES) models, and novel comparisons to observations. One strength of the CPT has been these collaborations, which are essential for improving the formulation of GCMs.

We believe, based on current progress, that with a few years of development, CAM-CLUBB and AM3-CLUBB can produce competitive or superior simulations to CAM and AM3. Succeeding in this would move our CPT project beyond a demonstration of principle by providing improved GCMs for the use of the community. In addition, CLUBB's approach allows for further unification and generalization of GCM parameterizations in the future. For these reasons we request a two-year special creativity extension in funding.

Skillful predictions of seasonal hurricane frequency, track, and landfall

Gabriel Vecchi and S-J Lin

FY2013 Funding: $2,770,179

Abstract

Applying leading edge high-resolution models and statistical methodologies, and utilizing key information about atmospheric and oceanic conditions, NOAA will significantly extend its seasonal outlook capabilities for hurricanes. Specifically, NOAA will develop probabilistic predictions of the level of hurricane activity in various important regions, such as the east and Gulf coasts, with lead times of months. After careful evaluation for credibility and utility for NOAA stakeholders, this new capability will be transitioned to NOAA Operations. This would be a significant advancement over existing outlooks which predict the number of storms but do not indicate how many of those will affect the Nation's coasts. For example, the predictions that skillfully foresaw that 2010 was going to be an extraordinarily active season in the Atlantic did not provide information that there were going to be no hurricanes making US landfall. Improved outlooks with region-specific information, including estimates of hurricane frequency, tracks, the number of land falling hurricanes, and intensity, and backed by tests establishing their practical utility, will significantly increase the value of the outlooks to decisions makers who require long-lead time for making decisions. Types of users who could eventually benefit include government agencies, emergency managers, water resource managers, agriculture, the insurance industry and other financial sectors, private weather forecasters, and offshore petroleum production.

Understanding and improving general circulation model simulations of Madden-Julian oscillation initiation over the tropical Indian Ocean using DYNAMO field observations

Leo J. Donner, Hailan Wang, Siegfried Schubert

FY2013 Funding: $8,000

Abstract

Despite the numerous improvements made to General Circulation Models (GCMs) in recent years, current models continue to be deficient in simulating and predicting the Madden-Julian Oscillation (MJO), a leading tropical intraseasonal mode of variability that interacts with and influences a wide range of weather and climate phenomena. Particularly problematic is the simulation of the initial phase of the MJO over the tropical Indian Ocean – a deficiency that limits both forecast skill and the ability to simulate a wide range of scale interactions linked to the MJO. The Dynamics of MJO (DYNAMO) field campaign, which provided in-situ observations over the central tropical Indian Ocean during the period October 1, 2011-March 31, 2012, will

provide a unique opportunity to confront GCMs with in-situ observations, with the ultimate goal of improving GCM simulations and predictions of the MJO.

It is proposed to use in-situ observations collected during the DYNAMO field campaign and the NASA Goddard Earth Observing System Model, Version 5 (GEOS-5) model system, to better understand the key physical processes associated with the MJO initiation over the tropical Indian Ocean and identify the main model deficiencies in simulating the MJO initiation. First, we will use the latest GEOS-5 data assimilation system to produce the global high-resolution DYNAMO Reanalysis so as to place the DYNAMO in-situ observations in a global context. The DYNAMO Reanalysis will be analyzed to investigate the key physical processes associated with the MJO initiation over the tropical Indian Ocean, and assess the GEOS-5 Atmospheric GCM (AGCM) deficiencies through a detailed examination of the analysis increments that should largely reflect model bias. Second, we will perform a series of AGCM and coupled replay experiments, to investigate the relative roles of atmospheric processes, and the impact of air-sea interaction, for the MJO initiation over the tropical Indian Ocean. Third, a series of coupled MJO reforecasts will be performed to assess the contribution of the DYNAMO in-situ observations to an enhanced MJO forecast skill through improvements in atmospheric and oceanic initial conditions. The root cause(s) of GEOS-5 limited forecast skill will be assessed through in-depth case-study analyses of when and where in the early stages of the MJO life cycle the model begins to lose skill. Lastly, we will perform a series of GCM sensitivity experiments to investigate the model convective sensitivity to environmental moisture as well as to address model issues revealed in the above data diagnosis.

The above work with the GEOS-5 model will be coordinated with on-going modeling efforts at NOAA Geophysical Fluid Dynamics Laboratory (GFDL) that address the simulation of the MJO in the GFDL Atmospheric Model version 3 (AM3) and Coupled Model version 3 (CM3) models. It is anticipated that frequent interactions between Global Modeling and Assimilation Office (GMAO) and GFDL on lessons learned, as well as some joint model experimentation, will be key to achieving fundamental improvements that extend beyond any model-specific bias, and point to fundamental improvements in the representation of the MJO in both the GEOS-5 and GFDL GCMs.

The proposed work targets the focus area “Understanding and Improving Prediction of Tropical Convection using Results from the DYNAMO Field Campaign” solicited by FY 2013 NOAA Earth System Science (ESS) Program, and directly addresses the motivation and goal of the DYNAMO program. It will contribute to NOAA’s long-term goal of climate adaptation and mitigation through “Improved scientific understanding of the changing climate system and its impacts”.

Seasonal-to-decadal climate predictions for marine resource management

Charles Stock, Michael Alexander, Kathy Pegion, Nicholas Bond, Yan Xue, Gabriel Vecchi

FY2013 Funding: $385,883

Abstract

Most marine resource management decisions, including the setting of catch limits on commercial fish, are made on inter-annual to decadal time scales. Pioneering seasonal to decadal scale climate predictions developed at OAR's Geophysical Fluid Dynamics Laboratory (GFDL) and the NWS National Centers for Environmental Prediction (NCEP) have the potential to provide critical climate information for these decisions. The work proposed herein consists of three tasks essential for realizing this potential. The first task is to quantify and elucidate the mechanisms underlying the skill of GFDL and NCEP climate predictions for a suite of ecosystem relevant climate properties (e.g., temperature, salinity, stratification, seasonal wind shifts, upwelling indexes) with an emphasis on U.S. waters and adjacent ocean basins. The second task is to communicate the strengths, limitations and outputs of present seasonal to decadal predictions to key members of the OAR and NMFS communities during a workshop to be held at GFDL. The final task is to develop a small number of regional "proof-of-concept" applications with workshop partners. The proposed work will make important contributions to NOAA's over-arching goals of an informed society anticipating and responding to climate and its impacts, a healthy ocean, and resilient coastal communities and economies.

Impact of organic nitrate chemistry on air quality and climate: past, present and future atmospheres

Jingqiu Mao

FY2013 Funding: $392,881

Abstract

Global nitrogen cycling and transport are largely modulated by biogenic emissions through the production of organic nitrates. Understanding the formation, fate and processing of organic nitrates is not only essential for understanding the global nitrogen cycle, ozone budget and secondary organic aerosol (SOA) formation, but is also central to the global oxidation capacity and greenhouse gas lifetimes.

Laboratory and field measurements in past decade have made significant progress on our understanding of organic nitrates, including the yield and fate of isoprene nitrates, NO_3 reactions with isoprene and terpenes, and aerosol uptake of NO_3 and N_2O_5. However, very little of this progress has yet been incorporated into global chemistry models. We here propose to develop and incorporate into two global chemistry models a new chemical oxidation

mechanism for isoprene and terpenes, aiming to improve our understanding of organic nitrate chemistry, the impact of nighttime chemistry from BVOCs+NO_3 reactions, ozone chemistry, and global oxidation capacity. Our proposed work aims to answer the following specific scientific questions:

(1) How do biogenic emissions affect the processing and export efficiency of NO_x emissions through organic nitrates? What is the role of terpenes in global oxidation?

(2) What is the impact of nighttime processes, such as the isoprene+NO_3 and terpenes+NO_3 reactions and aerosol uptake of NO_3/N_2O_5, on daytime ozone, NO_y partitioning and nitrogen export efficiency?

(3) What is the response of tropospheric ozone to projected future changes in anthropogenic activities (e.g., NO_x emissions) and biogenic emissions? How do global OH concentrations and CH_4 lifetime respond to these changes?

(4) Does this new BVOCs oxidation chemistry lead to an improved understanding of pre-industrial levels of tropospheric ozone?

This proposal responds to the Earth System Science (ESS) Program "Atmospheric Chemistry, Carbon Cycle and Climate" as solicited in the FY2013 Climate Program Office funding opportunity. We are specifically targeting: "employ multiple NOAA datasets to focus on the elements of the nitrogen cycle that are relevant to stratospheric ozone and climate, including interactions between the nitrogen and carbon cycles." As nitrogen and carbon are two key components in climate system, this is essential to the long-time goal of "improved scientific understanding of the changing climate system and its impacts" in NOAA's Next-Generation Strategic Plan (NGSP).

Collaborative research: continuation and enhancement of MPOWIR

Sonya Legg

FY2013 Funding: $249,958*

Abstract

MPOWIR (Mentoring Physical Oceanography Women to Increase Retention) is a community-led program aimed at providing mentoring to junior women in physical oceanography in order to improve their retention in the field. Initiated in 2004, MPOWIR activities were first fully funded by federal agencies in the spring of 2007, and renewed in 2009. The objectives of the program, as determined by the community in a planning workshop in the fall of 2005 are: (1) to provide continuity of mentoring from a young woman's graduate career, through her postdoctoral years to the first years of her permanent job, (2) to establish a collective responsibility within the physical oceanography community for the mentoring of junior women in the field, (3) to provide a variety of mentoring resources and mentors on a

variety of issues, (4) to cast a wide net to avoid exclusiveness and (5) to open this mentoring program to all those who self-identify as a physical oceanographer. This proposal is for further continuation and enrichment of MPOWIR activities. Specifically, funds are sought to continue the following MPOWIR activities:

1. Pattullo conference: This biannual conference brings together about 25 junior women physical oceanographers, together with 12 senior physical oceanographers, both male and female, for a 2.5 day meeting focused on discipline-based mentoring.
2. Mentoring groups: Groups of ~6 junior women and 2 senior women physical oceanographers meet for a monthly teleconference, for the purpose of confidential, personalized mentoring.
3. MPOWIR website: The website serves as a repository of resources for mentoring and physical oceanography careers.
4. Databases and surveys: Regular surveys are conducted to assess the effectiveness of MPOWIR activities, determine community mentoring needs, and evaluate progress in retention.
5. Town hall meetings and socials: Events at the Ocean Sciences meeting facilitate networking between physical oceanographers and provide career development information to junior scientists.

The website and town hall meetings are open to all, and greater emphasis will be placed on making material available via the website, to ensure a gender-neutral benefit. Efforts to export the MPOWIR model to other disciplines and institutions will be undertaken via links with the Earth Science Women's Network, and through a new quarterly newsletter. Social media will be used to publicize MPOWIR activities, announcement and events.

Intellectual Merit: This proposed work, through its focus on the retention of women in the field of physical oceanography, will allow further capitalization on the investment the funding agencies and universities have made on the education of women students. Essentially, this proposed work seeks to stem the loss of intellectual capital for the physical oceanographic field, as well as other geoscience disciplines.

Broader Impacts: This proposed work aids efforts to create a scientific workforce whose diversity more closely matches that of the student population and that of the U.S. population as a whole, by aiding the retention of women in the field of physical oceanography and other geoscience

Numerical investigation of nonlinear internal wave generation and mixing in straits

Sonya Legg

FY2013 Funding: $498,420*

Abstract

Large amplitude barotropic tides flowing over tall steep topography can lead to the generation of large amplitude internal waves, possibly accompanied by local wave breaking. We propose to examine the parameters and processes which determine the character of the internal wave response to barotropic flow in a strait such as Luzon Strait, as well as the local breaking and mixing processes which may result, employing both 2-dimensional and 3-dimensional simulations with the MITgcm. Model simulations will be used to assist in the planning of the field experiment and in the interpretation of the field data (in cooperation with Jody Klymak and other field observationalists).

Investigation of Global Modeling and Lightning NOx Emissions as Sources of Regional Background Ozone in Texas

Meiyun Lin

FY2013 Funding: $9,810*

Abstract

ENVIRON and researchers from Princeton/GFDL and NASA/MSFC propose to investigate contributions from global transport and lightning NOx emissions to regional ozone in Texas. Our proposal directly addresses an AQRP research priority. As the US standard for ground-level ozone is lowered, sources contributing to uncontrollable “background” concentrations take on more significance in the total ozone budget. Regional models now include worldwide contributions by deriving boundary conditions from global models. Two popular global models (GEOS-Chem and MOZART) have been routinely coupled to the CAMx and CMAQ regional models, and a new global model (AM3) is quickly gaining attention for its ability to replicate observations of Asian transport and stratospheric intrusion in the western US. We propose to evaluate the sensitivity of regional model background ozone predictions to boundary conditions generated from these three global models. Additionally, natural contributions such as lightning NOx (LNOx), which are routinely omitted from regulatory modeling, are now being seriously considered for their contribution to background ozone. Approaches to develop LNOx emission

estimates for modeling remain simplistic, limited by the lack of routine in-cloud flash data. We propose to develop a proof-of-concept approach that uses lightning flash data obtained from both ground and aloft monitoring networks to generate reliable LNOx emission estimates for regional modeling, and to analyze ozone sensitivity to various assumptions and input parameters. The funding requested for this 9-month project is $145,712 to cover the collection of global model and lightning detection data, develop the necessary programming tools, and to conduct regional ozone modeling and sensitivity analyses.

Exploring emission versus climate drivers of tropospheric ozone variability and trends over northern mid-latitudes from space

Meiyun Lin

FY2013 Funding: $141,722*

Abstract

Tropospheric ozone, in addition to being an important greenhouse gas and a major source of the hydroxyl radical [Intergovernmental Panel on Climate Change, 2007], is an air pollutant detrimental to human health and crop and ecosystem productivity [The Royal Society, 2008]. The lifetime of ozone in the troposphere ranges from minutes to hours at the surface, and days to weeks (~22 days [Stevenson et al., 2006]) in the free troposphere. Therefore, ozone measured at a surface site is produced from precursors emitted on the local, regional and hemispheric scale, in addition to transport from the stratosphere [Stevenson et al., 2006; Reidmiller et al., 2009]. However, the relative contribution of local and distant sources to surface ozone varies with precursor emission rates that are changing globally and rapidly. Furthermore, synoptic conditions that influence the flux of stratospheric ozone into the troposphere and the transport of local and distant sources of anthropogenic ozone can vary on inter-annual time scales [Fusco and Logan, 2003; Voulgarakis, et al., 2010]. Following is a review of the current understanding of the relative influences of anthropogenic emissions and naturally varying transport pathways on tropospheric ozone, and our proposal to quantify these impacts using satellite retrievals of tropospheric ozone, in situ ozone measurements and a new global-scale chemistry-climate model.

Collaborative research on quantifying the impacts of atmospheric and land surface heterogeneity and scale on soil moisture-precipitation feedbacks

Kirsten Findell

FY2013 Funding: $301,692*

Abstract

This project studies the potential feedback between soil moisture and precipitation. A positive feedback would mean that enhanced soil moisture leads to enhanced precipitation, as a wetter surface provides a source of evaporation for subsequent rainfall. In that case, precipitation would lead to wetter soil, which would in turn lead to further precipitation, while a lack of precipitation could lead to a lack of soil moisture and hence further reductions in precipitation leading to prolonged drought. This study assesses the influence of atmospheric and land surface heterogeneity and spatial scale on soil moisture-precipitation coupling, principally at daily timescales, through two interconnected approaches: 1) diagnostic analysis of available observations, reanalysis products, and global climate model (GCM) output; and 2) conceptual modeling of land-atmosphere interactions using process-based idealized models expresed as analytic equations as well as atmospheric column models coupled to simple soil models (eg "bucket" models). A primary objective of this activity is the development of robust, physically-based metrics for quantifying and comparing intraday soil moisture/precipitation coupling in models and observations.

The issues addressed in this project have relevance to society as well as science, as drought duration and intensity have substantial consequences for agriculture. In addition, the project will support and train a postdoctoral researcher, thereby helping to support and train the next generation of scientists.

Climate analytics on distributed exascale data archives – ExArch

Venkatramani Balaji

FY2013 Funding: $312,967*

Abstract

Climate science demands on data management are growing rapidly as climate models grow in the precision with which they depict spatial structures and in the completeness with which they describe a vast range of physical processes. For the Climate Model Inter-comparison Project 5 (CMIP5), a distributed archive is being constructed to provide access to what is expected to be

in excess of 10 Peta-bytes of global climate change projections. The data will be held at 30 or more computing centre's and data archives around the world, but for users it will appear as a single archive described by one catalogue. In addition, the usability of the data will be enhanced by a three-step validation process and the publication of Digital Object Identifiers (doi) for all the data. For many users the spatial resolution provided by the global climate models (around 150km) is inadequate: the CORDEX project will provide data scaled down to around 10km. Evaluation of climate impacts often revolves around extremes and complex impact factors, requiring high volumes of data to be stored. At the same time, uncertainty about the optimal configuration of the models imposes the requirement that each scenario be explored with multiple models. This project will explore the challenges of developing a software management infrastructure which will scale to the multi-exabyte archives of climate data which are likely to be crucialto major policy decisions in by the end of the decade. Support for automated processing of the archived data and metadata will be essential. In the short term goal, strategies will be evaluated by applying them to the CORDEX project data.

CDI-Type II: Scaling up: Introducing commodity governance into community Earth science modeling

Venkatramani Balaji

FY2013 Funding: $204,415*

Abstract

This project will explore and develop virtual organizations (VOs) that support community Earth system modeling at currently inaccessible scales of participation, computing power, and scientific complexity. Organizing large, distributed modeling efforts, which encompass multiple scientific disciplines, is extremely difficult using traditional tools and management structures. Future modeling activities will benefit from the transfer of ownership from central institutions to VOs that minimize the dependence on the geographic and temporal proximity of their participants. The interdisciplinary project team will initiate VOs focused on hydrological and climate modeling, realized as science gateways in which commodity governance bodies create units of operation that can be combined to create aggregate entities. This model of emergent structure, which is suggested by on-line communities such as SourceForge and Wikipedia, is one in which complex systems are not just supported, but can also grow and evolve. The VOs will be supported by cyberinfrastructure that enables participants to perform research workflows: tools (repositories, visualization and analysis tools, collaborative spaces), scientific content

(models and datasets), and semantic capabilities (ability to annotate, describe, and reason). The roles of analogy, hierarchy, and proximity in navigating to a new organizational paradigm will be explored. Intellectual Merit: This is a deeply integrative effort that cuts across the three thematic areas of the solicitation in order to initiate a new organizational mode in Earth science modeling. It introduces an innovative construct, the commodity governance unit, which is a blending of computational and social structures. The proposed work synthesizes the ideas of a highly interdisciplinary team involving social scientists, cyberinfrastructure developers, and scientists working in hydrology, weather, and climate. It incorporates, integrates, and recasts diverse experiences and influences, from participation in social web sites to participation in the IPCC process. The project methodology encompasses actor and observer roles, challenging social scientists to document and measure cultural and organizational change, and challenging software development teams to incorporate feedback that includes historical, political, and cultural perspectives. The climate, weather, and hydrology applications that are the focus of this work are central to understanding and responding to climate change, one of the most significant challenges currently facing society. This project will expand the intellectual resources that can be brought to bear on the issues of environmental change by minimizing the requirement for temporal and spatial proximity during model development and evaluation. Broader Impacts: As tools for prediction, policy definition, and response to environmental events and change, Earth system models impact all of society. The proposed work revolutionizes the way the global community participates in modeling, by reducing or removing the temporal, spatial, managerial, and institutional constraints that have limited the size and diversity of communities capable of direct collaboration. Governance principles that have emerged in successful open communities will facilitate the incorporation of intellectual resources from across society into the modeling community, and encourage the participation of underrepresented groups. If successful, this work will enrich and advance the global response to environmental change, and influence the organizational structures of other computational and collaborative disciplines.

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*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.

The following is a listing of various research projects supported by other NOAA and Non-NOAA partners during the period 2009-2012. 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 09 Funding	FY 10 Funding	FY 11 Funding	FY 12 Funding
NOAA Climate Program Office	Decadal climate predictability and predictions: focus on the Atlantic	Thomas Delworth and Anthony Rosati	Multiple	118,454			
NOAA Climate Program Office	A collaborative investigation of the mechanisms, predictability and climate impacts of decadal-scale AMOC variability simulated in a hierarchy of models	Thomas Delworth and Anthony Rosati	Gokhan Danabasoglu (NCAR), John Marshall (MIT), Joseph J. Tribbia (NCAR)	565,000			
NOAA Climate Program Office	A CPT in southern ocean water mass transformation and the carbon cycle	John Dunne, Anand Gnanadesikan, and Robbie Toggweiler	Multiple	15,000	12,000		
NOAA Climate Program Office	Understanding discrepancies between satellite observed and GCM-simulated precipitation in response to surface warming	Gabriel Vecchi	Brian Soden (Univ. of Miami)	6,000	6,000		
NOAA Climate Program Office	Using VOCALS to develop and evaluate stratiform cloud parameterizations incorporating sub-grid vertical velocity variability	Leo J. Donner and Chris Golaz		112,461	116,000		
NOAA Climate Program Office	CORE – Global climate modeling including non-CO2 greenhouse gases	V. Ramaswamy		96,156	96,156	96,156	83,890
NOAA Climate Program Office	CORE – Global climate modeling including non-CO2 greenhouse gases	V. Ramaswamy		140,000	140,000	140,000	122,140

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 09 Funding	FY 10 Funding	FY 11 Funding	FY 12 Funding
NOAA Climate Program Office	CORE – Continue incorporation of aerosol-cloud microphysics in global models to elucidate aerosol-cloud interaction effects	V. Ramaswamy		130,000	130,000	130,000	113,415
NOAA Climate Program Office	CORE – Modeling various field data, including GoMACCS, Using chemical transport models and calculation of radiative forcing of aerosols for the GPRA measure	Larry Horowitz and Hiram Levy		130,000	130,000	130,000	113,415
NOAA Climate Program Office	CORE – Model-observation comparisons to link emissions with aerosol properties	V. Ramaswamy		140,000	140,000	140,000	122,140
NOAA Climate Program Office	Improving climate predictions by reducing uncertainties about CO2 fertilization of the terrestrial biosphere	John Dunne and Ronald Stouffer	Multiple	8,000	8,000		
NOAA Climate Program Office	Ocean data assimilation	Anthony Rosati		209,000	209,000	177,650	43,000
Office of Naval Research	Improving HWRF and GFDN coupled models for transition to operations	Morris Bender	Isaac Ginis	30,000	33,000	17,000	40,000
NASA/Goddard Space Flight Center	The synthesis of spacecraft data with a Mars global circulation model	R. John Wilson		98,959	102,621	106,429	
NASA/Goddard Space Flight Center	Development of standard implementation practices and productivity software for ESMF-based MAP systems	V. Balaji	Multiple	110,000			
NASA/Goddard Space Flight Center	Development and testing of a satellite simulator using climate model in support of GLORY mission	Paul Ginoux and V. Ramaswamy		35,000			

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 09 Funding	FY 10 Funding	FY 11 Funding	FY 12 Funding
Department of Energy	Using ARM observations to evaluate cloud and convective parameterizations and cloud-convective-radiation interactions in the GFDL atmospheric general circulation model	V. Ramaswamy		88,461	92000		
NOAA Climate Program Office	Using models to improve our ability to monitor ocean uptake of anthropogenic carbon	Anand Gnanadesikan	Keith Rodgers	60,000	60,000	60,000	40,000
NOAA Climate Program Office	Model development	Brian Gross		1,097,676			
NOAA Climate Program Office	Decadal climate prediction and abrupt change (was “Model development” in FY09)	Brian Gross			2,157,808	2,141,220	1,868,000
NOAA Climate Program Office	Developing FRE as a parallel and distributed workflow (GIP)	V. Balaji		499,500		250,000	250,000
NOAA Climate Program Office	CPT – Representing internal-wave driven mixing in global ocean models	Robert Hallberg		349,229			
NOAA Climate Program Office	CPT – Ocean mixing processes associated with high spatial heterogeneity in sea ice and the implications for climate process models	Robert Hallberg		349,229			
NOAA Climate Program Office	CPT – Cloud macrophysical parameterization and its application to aerosol indirect effects	Leo J. Donner		276,494	241,262		
NOAA Climate Program Office	NSF travel funding	Leo J. Donner	Arlene Fiore-Field		15,000		

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 09 Funding	FY 10 Funding	FY 11 Funding	FY 12 Funding
NOAA National Ocean Service	Modeling the effects of climate change and acidification on global coral reefs	John Dunne			130,000	135,000	135,000
NASA/Goddard Space Flight Center	General circulation model simulations of Martian dust storm activity	R. John Wilson			91,000	0	95,000
NASA/Ames Research Center	ARC MARS General Circulation Model	R. John Wilson			90,371		
NASA/Goddard Space Flight Center	Toward GEOS-6 – a non-hydrostatic modeling capability	S-J Lin	Max J. Suarez		92,625	96,330	204,374
NASA/Goddard Space Flight Center	Effects of global change on Asian pollution outflow and long-range transport	Larry Horowitz			27,744		
NOAA Climate Program Office	Earth system modeling	Brian Gross				1,000,000	
NOAA Climate Program Office	Northeast shelf IEA	Charles Stock				100,000	2,000
NOAA Climate Program Office	Towards improving convection parameterization and the MJO in next-generation climate models	Ming Zhao	Xianan Jiang and Duane Waliser			33,321	32,506
NOAA Climate Program Office	A US national multi-model ensemble ISI prediction system	Anthony Rosati	Gokhan Danabasoglu and John Marshall				105,000
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				110,000

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators	FY 09 Funding	FY 10 Funding	FY 11 Funding	FY 12 Funding
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					2,000
NASA	Coupling Mars' dust and water cycles: effects of cloud formation on dust lifting, vertical extent, and deposition processes	R. John Wilson					20,315
Department of Energy	Using ARM observations to evaluate cloud and convection parameterizations and cloud-convection-radiation interactions in the GFDL general circulation model	Leo J. Donner					124,532
USGS	A proposal to host the Department of the Interior's South-Central Regional Climate Science Center	Keith Dixon	Isaac Held and Ron Stouffer				47,510