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 (1h)

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. Between 2005 and 2008, GFDL scientists have co-authored over 300 peer-reviewed publications with external collaborators (excluding CICS co-authors) from the following institutions:

U.S. Federal

1. DOD Naval Research Laboratory, Monterey, California
2. DOE Lawrence Livermore National Laboratory, Livermore, California
3. Environmental Protection Agency, Washington, DC
4. NASA Ames Research Center, Moffett Field, California
5. NASA Goddard Institute for Space Studies, New York, New York
6. NASA Goddard Space Flight Center, Greenbelt, Maryland
7. NASA Jet Propulsion Laboratory (JPL), Pasadena, California
8. NASA Langley Research Center, Hampton, Virginia
9. NOAA Atlantic and Ocneaographic and Meteorological Laboratory, Miami, Florida
10. NOAA, Earth Systems Research Lab, Boulder, Colorado
11. NOAA, Laboratory for Satellite Altimetry, Silver Spring, Maryland
12. NOAA National Marine Mammal Laboratory, Alaska Fisheries Center, Seattle, WA
13. NOAA, Pacific Marine Environmental Laboratory, Seattle, Washington
14. NOAA Regional and Mesoscale Meteorology Branch, Fort Collins, Colorado
15. NOAA Tropical Prediction Center, Miami, Florida
16. US Geological Survey, Bismarck, North Dakota, Corvallis, Oregon, Tucson, Arizona, and Reston, Virginia

U.S. Non-Federal

1. Albertus Magnus High School, Bardonia, New York
2. Bay Area Environmental Research Institute, Sonoma, California
3. Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada
4. Boston College, Chestnut Hill, Massachusetts
5. Brookings Institution, Washington, D. C.
6. California Institute of Technology, Pasadena, California
7. Center for Ocean–Land–Atmosphere Studies, Calverton, Maryland
8. Chevron-Texaco, San Ramon, California
9. College of William and Mary, Gloucester Point, Virginia
10. Colorado State University, Fort Collins, CO
11. Duke University, Beaufort, North Carolina
12. Florida State University, Tallahassee, FL
13. Forristall Ocean Engineering, Inc., Camden, Maine
14. Georgia Institute of Technology, Atlanta, Georgia
15. Harvard University, Cambridge, Massachusetts
16. International Research Institute for Climate Prediction, Columbia University, Palisades, NY
17. La Canada High School, La Canada, California
18. Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York, New York
19. Louisiana State University, Baton Rouge, LA
20. Massachusetts Institute of Technology, Cambridge, Massachusetts
21. Montana State University, Boseman, Montana
22. National Center for Atmospheric Research, Boulder, Colorado
23. New York University, New York, New York
24. NOAA Cooperative Institute for Research in Environmental Sciences, Boulder, Colorado
25. NOAA Joint Institute for the Study of the Atmosphere and Ocean, Seattle Washington
26. Old Dominion University, Norfolk, Virginia
27. Oregon State University, Corvallis, Oregon
28. Pennsylvania State University, University Park, Pennsylvania
29. RSA Systems, Altadena, California
30. Rutgers University, New Brunswick, New Jersey
31. SAIC at NOAA/NWS/Environmental Modeling Center, Camp Springs, Maryland
32. Scripps Institution of Oceanography, University of California, San Diego, California
33. Stanford University, Stanford, CA
34. Stevens Institute of Technology, Hoboken, New Jersey
35. Stony Brook University, Stony Brook, New York
36. Texas A&M University, College Station, Texas
37. University of Arizona, Tucson, Arizona
38. University of California, Berkeley, California
39. University of California, Los Angeles, California
40. University of California, Irvine, California
41. University of California, Santa Cruz, California
42. University of Chicago, Chicago, Illinois

43. University of Colorado, Boulder, Colorado
44. University of Georgia, Athens, Georgia
45. University of Hawaii, Honolulu, Hawaii
46. University of Illinois at Urbana–Champaign, Urbana, Illinois
47. University of Iowa, Iowa City, Iowa
48. University of Maryland Baltimore County, Baltimore, Maryland
49. University of Miami, Miami, Florida
50. University of Michigan, Ann Arbor, Michigan
51. University of Minnesota, Minneapolis, Minnesota
52. University of New Hampshire, Durham, NH
53. University of North Carolina at Chapel Hill, Chapel Hill, North Carolina
54. University of Rhode Island, Narragansett, Rhode Island
55. University of South Carolina, Columbia, South Carolina
56. University of South Florida, St. Petersburg, Florida
57. University of Texas at Austin, Austin, Texas
58. University of Utah, Salt Lake City, Utah
59. University of Washington, Seattle, Washington
60. University of Wisconsin—Milwaukee, Milwaukee, Wisconsin
61. Woods Hole Oceanographic Institution Joint Program, Woods Hole, Massachusetts
62. Yale University, New Haven, Connecticut

International - Government

1. Bureau of Meteorology Research Centre, Melbourne, Australia
2. Cooperative Research Centre for Catchment Hydrology, Clayton, Victoria, Australia
3. CSIRO Land and Water, Canberra, ACT, Australia
4. CSIRO Marine and Atmospheric Research, Hobart, Tasmania, Australia
5. CSIRO Marine and Atmospheric Research, Aspendale, Victoria, Australia
6. Danish Meteorological Institute, Copenhagen, Denmark
7. ETH Zurich, Zurich, Switzerland
8. Finnish Meteorological Institute, Helsinki, Finland
9. Frontier Research Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Yokohama City, Kanagawa, Japan
10. Hadley Centre for Climate Prediction and Research, Met Office, Exeter, United Kingdom
11. Institute for Environment and Sustainability, Ispra, Italy
12. Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy
13. Japan Science and Technology Agency, Kawaguchi, Japan
14. Max-Planck-Institute for Biogeochemistry, Jena, Germany
15. Max-Planck-Institut für Chemie, Mainz, Germany
16. Max-Planck-Institut für Meteorologie, Hamburg, Germany
17. National Institute for Environmental Studies, Tsukuba, Japan
18. NATO Undersea Research Centre, La Spezia, Italy
19. Royal Netherlands Meteorological Institute, De Bilt, The Netherlands

International - Non-Government

1. Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
2. Australian National University, Canberra, ACT, Australia
3. Center for Climate System Research, University of Tokyo, Tokyo, Japan
4. Dalhousie University, Halifax, Nova Scotia, Canada
5. Delft University of Technology, 2628 CA, Delft, The Netherlands
6. DLR Institute of Atmospheric Physics, Oberpfaffenhofen, Germany
7. Hebrew University of Jerusalem, Jerusalem, Israel
8. Institut für Ostseeforschung, Warnemünde, Germany
9. Laboratoire d'Optique Atmosphérique, CNRS, Université de Science et Technique de Lille, Villeneuve d'Ascq, France
10. Laboratoire des Sciences du Climat et de l'Environnement, UMR CEA-CNRS, CEA Saclay, Gif-sur-Yvette, France
11. Leibniz-Institut fuer Meereswissenschaften, Kiel, Germany
12. Macquarie University, NSW, 2109 Australia
13. National Taiwan Normal University, Taipei, Taiwan
14. Open University, Milton Keynes, UK
15. Oxford University, Oxford, UK
16. Risk Management Solutions, Ltd., London, United Kingdom
17. Seoul National University, Seoul, South Korea
18. SRM Institute of Science and Technology, Deemed University, Kattankulathur, India
19. Stockholm International Water Institute, Stockholm, Sweden
20. Tokyo Institute of Technology, Okayama, Japan and Yokohama, Japan
21. Universidad de la República, Uruguay
22. University of British Columbia, Vancouver, British Columbia, Canada
23. University of Cape Town, Rondebosch, Cape Town, South Africa
24. University of Edinburgh, Edinburgh, UK
25. University of Leeds, Leeds, UK
26. University of Liverpool, Liverpool, United Kingdom
27. University of Melbourne, Melbourne, Victoria, Australia
28. University of New South Wales, Sydney, New South Wales, Australia
29. University of Toronto, Toronto, Ontario, Canada
30. Utrecht University, Utrecht, The Netherlands

Significant current activities in which GFDL scientists are engaged include:

National

Brookhaven National Laboratory Project of Continuous Evaluation of Fast Processes in Climate Models
Department of Energy Atmospheric Radiation Measurement (ARM) Program
International Research Institute for Climate and Society (IRI, Columbia University)
National Aeronautics and Space Administration (NASA) Clouds in the Earth's Radiant Energy System (CERES)

National Center for Atmospheric Research Affiliate Scientist Program
National Center for Atmospheric Research Community Climate System Model Atmospheric Model Working Group
National Centers for Environmental Prediction (NCEP) Climate Test Bed and Multi-Model Ensemble (MME)
North American Regional Climate Change Assessment Program (NARCCAP)
US Climate Variability and Predictability (CLIVAR)
- Climate Process Teams (CPT) on
  - Low-Cloud Feedbacks
  - Gravity Current Entrainment
  - Eddy/Mixed-Layer Interaction
- Working Group on Drought
- Working Group on Decadal Prediction
- Working Group on the Madden-Julian Oscillation (MJO)

International

Aerosol Comparisons between Observations and Models (AeroCom)
Asian Pacific Climate Center (APCC) Programs in Seasonal Prediction
International Consortium of Atmospheric Research on Transport and Transformation Project (ICARRT)
International Geosphere-Biosphere Programme (IGBP)
VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS)
World Climate Research Programme
- Global Energy and Water Cycle Experiment (GEWEX) Could System Study (GCSS)
- Climate Variability and Predictability (CLIVAR) Program on Coordinated Ocean Reference Experiments (COREs)
- Chemistry-Climate Model Validation Activity (CCMVal)
- Coupled Model Inter-Comparison Panel (CMIP)
- Stratospheric Processes And their Role in Climate (SPARC)
- Climate and Cryosphere (CliC) Project

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 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 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, such as Johns Hopkins University, Rutgers University, the University of Maryland, and the University of New Hampshire. 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 – 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 is supported by NOAA Climate Program Office.

University Corporation for Atmospheric Research – GFDL has been hosting UCAR scientists for more than a decade through this Climate Program Office hosted Cooperative Agreement. Scientists and scientific support are brought on through the Visiting Scientist Program and the Joint Office of Scientific Support.

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, where appropriate, and funding entity. Funding amounts are available on the attached spreadsheet and details of any project are available upon request.

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators
NOAA Climate Program Office	Climate Processes Team (CPT) Collaborative Research: Interaction of Eddies with Mixed Layers	Robert Hallberg and Stephen Griffies	Raffaele Ferrari/MIT, Gokhan Danabasoglu/ NCAR, Glenn Flierl/MIT, Peter Gent/NCAR, William Large/NCAR, John Marshall/MIT, James McWilliams/UCLA, Kevin Speer/Florida State, Amit Tandon/Dartmouth, Leif Thomas/Stanford, Geoff Vallis/CICS
NOAA Climate Program Office	Decadal Climate Predictability and Preditions: Focus on the Atlantic	Thomas Delworth and Anthony Rosati	
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
NOAA Climate Program Office	A Climate Process Team in Southern Ocean Water Mass Transformation and the Carbon Cycle	John Dunne, Anand Gnanadesikan, and J. Robert Toggweiler	Jorge Sarmiento & Robert Key/CICS, Richard Feely and Chris Sabine/PMEL, Rik Wanninkhof/AOML, Scott Doney/WHOI, Joellen Russel/Univ. of Arizona, Mick Follows/ MIT
NOAA Climate Program Office	Understanding Discrepancies between Satellite-Observed and GCM-Simulated Precipitation Change in Response to Surface Warming	Gabriel Vecchi	Brian Soden and Otis Brown/Univ. of Miami

Continued on next page…

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators
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	
NOAA Climate Program Office	CORE - Global Climate Modeling Including Non-CO_2 Greenhouse Gases	V. Ramaswamy	
NOAA Climate Program Office	CORE - Simulate Influence of Greenhouse Gases on Stratospheric Temperatures and Stratospheric Processes	V. Ramaswamy	
NOAA Climate Program Office	CORE - Continue Incorporation of Aerosol-Cloud Microphysics in Global Models to Elucidate Aerosol-Cloud Interaction Effects	V. Ramaswamy	
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	
NOAA Climate Program Office	CORE - Model-Observation Comparisons to Link Emissions with Aerosol Properties	V. Ramaswamy	
NOAA Climate Program Office	Improving Climate Predictions by Reducing Uncertainties About CO_2 Fertilization of the Terrestrial Biosphere	John Dunne and Ronald Stouffer	Lars O. Hedin, Stephen Pacala, Elena Schevliakova, Steven Gerber/CICS, Joseph Wright/ Smithsonian Tropical Research Institute
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, and Tim Marchok	

Continued on next page…

Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators
NOAA NMFS	Comparative Analysis of Marine Ecosystem Organization (CAMEO): Building the Foundation - Climate Mechanisms Influencing Pacific Salmon Survival	John Dunne	
NOAA Climate Program Office	Ocean Data Assimilation	Anthony Rosati	
Office of Naval Research	Improving HWRF and GFDN Coupled Models for Transition to Operations	Morris Bender	Isaac Ginis/URI
NASA/Goddard Space Flight Center	Testing Climate Model Simulations of Cloud LifeCycle Dynamics Using NASA A-Train Measurements	Leo J. Donner	Brian Soden/Univ. of Miami
NASA/Goddard Space Flight Center	General Circulation Model Simulations of Martian Aerosol Transport and Climate	R. John Wilson	
NASA/Goddard Space Flight Center	Planetary Waves in the Martian Atmosphere: The Synthesis of MGS Data with a Mars Global Circulation Model	R. John Wilson	
NASA/Goddard Space Flight Center	The Synthesis of Spacecraft Data with a Mars Global Circulation Model	R. John Wilson	
NASA/Goddard Space Flight Center	Development of Standard Implementation Practices and Productivity Software for ESMF-Based MAP Systems	V. Balaji	Max J. Suarez, Arlindo daSilva, Michelle Rienecker, Franco Einaudi/ NASA/GSFC, Chris Hill/ MIT, Paul Schopf/COLA
NASA/Goddard Space Flight Center	Understanding the Mechanisms and Effects of Ice Nucleation in Tropical Cyclones	Paul Ginoux	Vaughan Phillips/CICS, Constantin Andronache/ Boston College
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	
NASA/Goddard Space Flight Center	Detection and Attribution of Spectral TOA Forcings and Feedbacks (CLARREO)	V. Ramaswamy	University of California/ Berkeley

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Funding Source	Proposal Title	GFDL Principal Investigator(s)	Co-Investigators
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	
University of Rhode Island	Coupled Tropical Cyclone-Ocean System	Morris Bender	Isaac Ginis/URI
NOAA Climate Program Office	Using Models to Improve Our Ability to Monitor Ocean Uptake of Anthropogenic Carbon	Anand Gnanadesikan	Keith Rodgers/CICS
NOAA Climate Program Office	Decadal Climate Predictions and Abrupt Change	V. Ramaswamy	

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 2008 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:

Collaborative Research: Interaction of Eddies with Mixed Layers

Raffaele Ferrari/MIT, Gokhan Danabasoglu/NCAR, Glenn Flierl/MIT, Peter Gent/NCAR, Stephen Griffies and Robert Hallberg/GFDL, William Large/NCAR, John Marshall/MIT, James McWilliams/UCLA, Kevin Speer/Florida State, Amit Tandon/Dartmouth, Leif Thomas/Stanford, Geoff Vallis/Princeton University

FY 2008 Funding: $114,183 Future Year Funding: $0

Abstract

The CPT-EMILE was created two years ago with the goal of formulating and testing in IPCC-class climate models parameterizations for the eddy transport in and near the surface boundary layer. The project was ambitious, but the team has made a very promising start. We used a combination of data and very high resolution numerical models to investigate eddy dynamics in the upper ocean. Using this body of work, we formulated a parameterization scheme for mesoscale eddy transport in the diabatic surface layer and a parameterization scheme for restratification driven by submesoscale eddies. Details of the work are given in the proposal. These two parameterization schemes have been implemented in the community

climate models and showed a large impact on the oceanic mean state, especially close to the surface. These modifications are likely to imply climate sensitivity in coupled models through the impact on air-sea exchange. We plan to explore some of the implications for coupled climate models in this coming year, but two additional years of funding are essential if the work is to come to full fruition.

Extension of the funding would allow the work to be completed in the following areas:

- completing the implementation of the new parameterizations in the ocean climate models at NCAR, GFDL, and MIT and studying their impact in coupled ocean-atmosphere models,
- comparing model outputs versus eddy statistics estimated from global data sets and from new data that will become available over the next three years from the CLIMODE and AESOP campaigns,
- completing the process studies of mesoscale-submesoscale interactions in the upper ocean with special emphasis on the roles of restratification, wind forcing, and frontogenesis,
- modifying the new parameterizations to account for new aspects of upper ocean physics only recently revealed by the team.

The CPT-EMILE has been active in a number of outreach activities. A web-site (http://cpt-emilie.org/) was created to advertise the research under way, workshop activities, and available positions. Ferrari is organizing a session on Eddy-Mixed Layer Interactions for the 13th Ocean Sciences Meeting to be held 20-24 February 2006 in Honolulu, Hawaii. The CPT-EMILIE met for workshops in Boulder, December 2003, and in Providence, November 2004. One more workshop is planned for March 2006. The workshops have been extremely useful to coordinate research activities and spin off new collaborations, so we plan to organize two more, if funding is extended.

This research here proposed is aimed at improving state of the art models of the atmosphere and ocean for studies of the climate of the Earth and how it might change in the future. Thus it is of great societal impact. The project will also contribute to the education of three young scientists, three post-doctoral fellows and one graduate student bridging between observations, theory, and modeling.

Decadal Climate Predictability and Predictions Focus on the Atlantic

Thomas L. Delworth and Anthony Rosati/GFDL

FY 2008 Funding: $176,923 Future Year Funding: $184,000

Abstract

There is currently limited understanding of the mechanisms of decadal climate variability, and of the potential predictability of the climate system on decadal time scales. Models currently used for decadal and longer climate change projections do not start their projections from the observed state of the ocean. Therefore, a potential source of skill for decadal climate change simulations is neglected. On the decadal scale, the relative roles of forced climate change and internal natural variability may be comparable. Thus, an improved understanding of decadal variability and predictability could lead to significant improvements of decadal scale climate projections. One potentially important region is the Atlantic, where multi-decadal scale warming has apparently led to increased hurricane activity. The relative contributions of anthropogenic forcing and internal variability to that increase of hurricanes is unknown, but it is precisely this question that is crucial for future estimates of hurricane activity.

We describe a systematic program of research activities whose aim is to (i) improve our understanding of the mechanisms of Atlantic decadal variability, (ii) evaluate potential predictability of the climate system, (iii) develop the necessary tools to make decadal climate predictions starting from observed ocean states, and (iv) conduct ensembles of decadal climate predictions starting from estimates of the observed state of the ocean. This research will be primarily conducted using GFDL s CM2.1 global climate model, as well as future climate models currently under development at GFDL. A crucial component of the research will be the further development and use of a novel assimilation technique recently developed at GFDL. The outcome of the research should be (i) an improved understanding of the mechanisms of Atlantic decadal variability, (ii) an evaluation of decadal scale predictability, (iii) a prototype system for making decadal climate predictions, including a newly developed assimilation system that will make state of the art estimates of the ocean from modern observational networks, and (iv) several ensembles of experimental decadal scale forecasts.

A Collaborative Investigation of the Mechanisms, Predictability and Climate Impacts of Decadal-Scale AMOC Variability Simulated in a Hierarchy of Models

Gokhan Danabasoglu/NCAR, Thomas L. Delworth/GFDL, John Marshall/MIT,
Anthony Rosati/GFDL, Joseph J. Tribbia/NCAR

FY 2008 Funding: $500,000 Future Year Funding: $565,000

Abstract

The Atlantic Meridional Overturning Circulation (AMOC) of the ocean is a singular feature of the general circulation thought to play a major role in maintaining the climate of the planet. There is an intense interest in developing nowcasting and projection systems for the AMOC because of (i) its association with variations in meridional ocean heat transport, North Atlantic sea surface temperatures and climatic variables such as air temperature, precipitation, drought and severe weather events such as hurricanes, (ii) its potential predictability, (iii) it's possible role in abrupt climate change particularly in response to anthropogenic forcing.

Motivated by this background, here we propose a collaborative study between NCAR, GFDL, and MIT to:

1. Characterize modeled AMOC variability and its climate impacts: past, present, and future,
2. Indentify the mechanism(s) of AMOC variability in the GFDL, MIT, and NCAR coupled models,
3. Explore the extent to which the AMOC is predictable by experimenting with prototype predictability systems initialized by ocean state estimates.

Our study is of particular importance because, as the community embarks on an ambitious program of study of the Atlantic climate variability, a theoretical underpinning analogous to that which motivated modeling and observations of ENSO, is still lacking. It is hoped that by capitalizing on the very significant efforts in coupled global climate modeling and state estimation methodologies at NCAR, GFDL, and MIT and drawing together their complementary strengths, we will make significant progress in each of the above foci areas.

A Climate Process Team in Southern Ocean Water Mass Transformation and the Carbon Cycle

Robert Key/Princeton University, Anand Gnanadesikan, John Dunne, and
Robbie Toggweiler/GFDL, Richard Feely and Chris Sabine/PMEL, Rik Wanninkhof/AOML,
Scott Doney/WHOI/NCAR, Joellen Russel/University of Arizona, Mick Follow/MIT

FY 2008 Funding: $15,000 Future Year Funding: $15,000

Abstract

Climate models are not systematically evaluated against the circulation of the Southern Ocean. This has resulted in IPCC models exhibiting huge ranges in quantities such as the transport of the Antarctic Circumpolar Current (ACC ~00 to 350 Sv; 1 Sverdrup = 10^6 m^3 s^{-1}) and the rate at which dense waters are transformed to light waters within the Southern Ocean (0 to 16 Sv). Unfortunately, published observations of such quantities differ widely as well, making it difficult for modeling groups to know what to aim for in terms of reasonable circulation. This is worrisome because the Southern Ocean is the primary sink for anthropogenic carbon dioxide and plays a central role in the long-term control of the "natural" carbon dioxide content of the atmosphere, with Southern Ocean water mass transformation, which brings old deep water into the upper ocean, playing a disproportionate role in both of these as well as on the magnitude of global biological production. The goal of this Climate Process Team is to evaluate the impact of biases of Southern Ocean circulation on the carbon cycle and to understand the causes for the biases. This will involve: 1. developing and analyzing a wide suite of diagnostics of Southern Ocean circulation to come up with the best possible climatology for the circulation; and 2. evaluating the relative impacts of wind, buoyancy forcing, mixing, and physical and biogeochemical model formulation on those aspects of Southern Ocean ventilation and biogeochemistry most important for the carbon cycle. This will require a combination of theoretical studies and model sensitivity studies.

Understanding Discrepancies between Satellite-Observed and GCM-Simulated Precipitation Change in Response to Surface Warming

Brian J. Soden/RSMAS University of Miami, Gabriel A. Vecchi/GFDL,
Otis Brown/RSMAS University of Miami

FY 2008 Funding: $6,000 Future Year Funding: $6,000

Abstract

All climate models predict that global precipitation will increase in response to surface warming. The rate at which global precipitation increases varies substantially among models,

but all models predict that it will increase more slowly (~1-3%/K) than the rate at which atmospheric water vapor increases (~7%/K). This disparity between the rate of moistening and rate of precipitation increase drives a weakening of the atmospheric circulation (Vecchi and Soden, 2007). The intermodel differences in the response of global precipitation to anthropogenic forcing are directly tied to differences in radiative cooling. However, the cause of intermodel differences in the response of radiative cooling to a warming climate are not understood.

Moreover, several recent observational studies (Allan and Soden 2007, Wentz et al. 2007, Zhang et al. 2007) suggest that precipitation may be increasing at a much faster rate than currently predicted by GCMs. These discrepancies appear at time-scales ranging from interannual, to decadal, to centennial and have important implications for future predictions of climate change, the reliability of the observing system and the monitoring of the global water cycle. If true, such a bias in model projections would have substantial repercussions - not only for the modeling of the atmospheric energy and water budgets, but also for the model projections of the response of the atmospheric and oceanic circulation to increased CO2. However, the veracity of the satellite-observed changes in precipitation remains in question due, in large part, to uncertainties in the retrieval of precipitation from passive microwave sensors.

We propose to better understand the cause of these discrepancies by performing a detailed comparison of SSMI observations and GFDL GCM simulations using a "model-to-satellite" approach in which model output is used to directly simulate the radiances which would be observed by the satellite under those conditions. The advantages of this strategy are that it avoids many of the assumptions that are required when performing retrievals and it provides a model-simulated quantity that is directly comparable to what is actually observed by the satellite. Any assumptions involved in the performing forward radiance simulation are made explicit and can be varied in a controlled framework to examine their sensitivity.

We propose to apply this strategy for comparing model-simulated microwave radiances from the GFDL GCM to the satellite-observed radiances from SSMI. The latest version of the GFDL GCM is well suited for this approach because it explicitly predicts many aspects of the hydrometeor profiles required for simulation of microwave radiances (e.g., the sub-grid distribution of rain rates, rain column heights, ratio of cloud liquid to rain water) and simulations are being performed with resolutions as high as ~30 km which is comparable to nadir footprint of the SSMI pixels. From this comparison we hope to better understand the cause of bias between observed and model-simulated precipitation response to a warming climate.

Using VOCALS to Develop and Evaluate Stratiform Cloud Parameterizations Incorporating Sub-grid Vertical Velocity Variability

Leo J. Donner and Jean-Christopher Golaz/GFDL

FY 2008 Funding: $109,059 Future Year Funding: $228,461

Abstract

We propose to participate in VOCALS Modeling and Regional Experiment (REx) using the GFDL GCM model. The representation of clouds and aerosols in the GCM and the interaction between them will be the focal point of our participation. VOCALS-REx collected data will provide a unique dataset to carefully evaluate GCM prediction of aerosols and clouds in the VOCALS study region. In turn, specific GCM experiments will be conducted to test some of the VOCALS-REx synergy hypotheses. Specifically, we plan to test the effect that anthropogenic aerosols exert on the GCM cloud field. We also intend to investigate whether a poor representation of the marine boundary layer clouds and coastal winds contribute to systematic coupled GCM errors.

Because the GFDL GCM climatology suffers from a negative cloud bias in the VOCALS-REx study region, we also propose to implement and test a new boundary layer cloud parameterization. A key feature of this new parameterization will be the incorporation of sub-grid variability of vertical velocity, temperature and moisture. In particular, the sub-grid vertical velocity information will allow for a more realistic treatment of the activation of clouds condensation nuclei (CCN) in stratiform clouds, and therefore a more realistic representation of the interaction between anthropogenic aerosols and clouds.

CORE - Global Climate Modeling Including Non-CO2 Greenhouse Gases

V. Ramaswamy/GFDL

FY 2008 Funding: $96,156 Future Year Funding: $288,460

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 Temperatures and Stratospheric Processes

V. Ramaswamy/GFDL

FY 2008 Funding: $140,000 Future Year Funding: $420,000

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/GFDL

FY 2008 Funding: $130,000 Future Year Funding: $390,000

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.

CORE - Modeling Various Field Data, Including GoMACCS, Using Chemical Transport Models and Calculation of Radiative Forcing of Aerosols for the GPRA Measure

L. Horowitz, H. Levy II/GFDL

FY 2008 Funding: $130,000 Future Year Funding: $390,000

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.

CORE - Model-Observation Comparisons to Link Emissions with Aerosol Properties

V. Ramaswamy/GFDL

FY 2008 Funding: $140,000 Future Year Funding: $420,000

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.

Improving Climate Predictions by Reducing Uncertainties in CO_2 Fertilization of the Terrestrial Biosphere

Lars O. Hedin/Princeton University, Joseph Wright/Smithsonian Tropical Research Institute,
Stephen W. Pacala, Elena Shevliakova and Stefan Gerber/Princeton University,
John P. Dunne and Ronald J. Stouffer/GFDL

FY 2008 Funding: $8,000 Future Year Funding: $16,000

Abstract

This proposal addresses one of the greatest uncertainties in our efforts to model the Earth's coupled carbon climate system: whether nutrient availability will limit the ability of tropical forests to serve as a terrestrial CO_2 sink. Recent evidence from models and field experiments suggest that, while poorly resolved, the terrestrial CO_2 sink might decrease or even become a source of carbon to the atmosphere, and thus further accelerate climate warming. Nutrient limitation of CO_2 fertilization in the tropics represents the single greatest source of uncertainty in the carbon cycle over the next half century. Resolution of this problem would be a major contribution by GFDL to the national debate about carbon mitigation, with substantial implications for policy options.

We propose to bring together a group of experimental, theoretical and modeling scientists to leverage our emerging understanding of plant response to CO_2 under nutrient limitation, with the goal of improving parameterization of the key processes that determine spatial and temporal variability of terrestrial carbon exchange within the GFDL dynamic land model LM3V.

Our goal is to develop a novel intellectual platform that links process-based field studies directly to the LM3V and GFDL Earth system model development. We will take advantage of the considerable observational, intellectual, and experimental infrastructure that exists within the Barro Colorado Island (BCI) research forecasts of the Smithsonian Tropical Research Institute in Panama. These forests represent an ideal model system for lowland tropical forecasts, with high diversity in species and land disturbance conditions, and soils that vary in nitrogen and phosphorus richness. Our proposed work is unique in that land models have not generally been

parameterized directly against observational and experimental data from lowland tropical forests.

To model the nutrient-dependence of CO_2 fertilization in the tropics, our strategy is to first characterize and parameterize the processes that generate and maintain nutrient limitations across tropical ecosystems. Second, we will parameterize the physiological and growth response of plants to variations in nutrient supply rates, using field-based experiments and observations. Third, we will evaluate the emergence of feedbacks between the coupled physical climate and terrestrial nutrient models.

We believe this platform offers a unique opportunity to reduce major scientific uncertainties about the terrestrial carbon sink, its dependence on nutrients, and its feedback onto the larger climate system.

High-Resolution Hurricane Modeling, Adaptive Mesh Refinement, Improved Physical Parameterizations, Wave-Ocean Coupling, and Hurricane-Climate-Change Projections

Morris Bender, S.-J. Lin and Tim Marchok/GFDL

FY 2008 Funding: $0 Future Year Funding: $400,000

(no abstract)

Comparative Analysis of Marine Ecosystem Organization (CAMEO): Building the Foundation - Climate Mechanisms Influencing Pacific Salmon Survival

John Dunne/GFDL

FY 2008 Funding: $50,000 Future Year Funding: $0

Abstract

The Office of Science and Technology of National Marine Fisheries Service (NMFS), and the Geophysical Fluid Dynamics Laboratory of Office of Oceanic and Atmospheric Research, are both a part of the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce. The mission of NMFS' Office of Science and Technology is to serve as the scientific focal point within NOAA Fisheries for the coordination, development and evaluation of science and technology strategies and policies, and its conservation and management mission. The mission of OAR's GFDL is to be a world leader in the experimental development of predictive tools and for the production of timely and reliable scientific knowledge and

assessments on natural climate variability and anthropogenic changes and the development of the required earth system models. GFDL works cooperatively in NOAA to advance its expert assessments of changes in national and global climate through research, improved models, and products.

Ocean Data Assimilation

Anthony Rosati/GFDL

FY 2008 Funding: $209,000 Future Year Funding: $627,000

(no abstract)

Improving HWRF and GFDN Coupled Models for Transition to Operations

Isaac Ginis/University of Rhode Island and Morris Bender/GFDL

FY 2008 Funding: $0 Future Year Funding: $63,000

Abstract

The forecast operations of both NOAA's Tropical Prediction Center and Navy's Joint Typhoon Warning Center require more accurate HWRF and GFDL/GFDN models as integral parts of the multi-model ensemble forecast efforts. We are requesting support, under the auspices of the Joint Hurricane Testbed (JHT) Program at NOAA, to further improve the performance of the operational HWRF model at the NOAA's National Centers for Environmental Prediction (NCEP) and the operational GFDN model at the Navy's Fleet Numerical Meteorology and Oceanography Center and provide assistance to NCEP and FNMOC in transitioning the model upgrades to operations.

The following are the major tasks to be undertaken:

GFDN model

- Increase spatial resolution from 1/12th to 1/18th degree in the inner mesh
- Couple with the WAVEWATCH III wave model
- Improve physics of the air-sea fluxes, including sea spray effects
- Implement NAVY's NCODA real-time ocean analysis in the Atlantic Basin

HWRF model

- Implement the new URI air-sea interface model (ASIM) coupled with the ESRL sea-spray model
- Assist in testing and evaluation of the improved HWRF-Wave-Ocean coupled system

This work will be conducted in close collaboration with our EMC and FNMOC colleagues, building directly upon our successful previous work on the improvements and operational implementation of the GFDL, HWRF and GFDN model upgrades. We will also collaborate with scientists at ESRL on the implementation of the ESRL sea-spray parameterization scheme.

Testing Climate Model Simulations of Cloud Lifecycle Dynamics Using NASA A-Train Measurements

Brian J. Soden and Leo J. Donner/GFDL

FY 2008 Funding: $5,000 Future Year Funding: $0

Abstract

Understanding the processes which control the water budget of the tropical upper troposphere is essential for the successful modeling of the Earth's climate. The feedbacks from upper tropospheric water vapor and cirrus represent some of the most important and most controversial within the climate system. Prediction of these feedback effects ultimately requires understanding the full lifecycle of tropical cloud systems and their impact on their impact on the moisture budget of the upper troposphere – from generation in deep convection to horizontal spreading and ultimate dissipation and conversion to vapor.

The basic premise of this proposal is that differences in cloud feedback between various versions of the GFDL and NCAR global climate models are manifest in their contrasting cloud lifecycles. By integrating NASA A-Train retrievals with Lagrangian trajectories from geostationary satellites we intend to test and ultimately improve the representation of tropical cloud lifecycles in these models and, in doing so, reduce uncertainty in their simulations of cloud feedback.

The proposed research involves an innovative method of combining NASA A-train and geostationary satellite data to quantitatively describe the lifecycle of tropical cloud systems and their subsequent impacts on the radiative and moisture budgets of the upper troposphere. The resulting Lagrangian data set will then be used to test different versions of the new GFDL and NCAR models which have been shown to exhibit a wide range of climate sensitivities and cloud

feedbacks. The primary tasks to be accomplished under this proposal are: (1) Develop Lagrangian-based products to compliment the more traditional Eulerian data streams by providing forward/backward trajectories and related Lagrangian diagnostics for cloud systems observed by the NASA A-Train satellites; (2) Use Lagrangian-based composites of NASA A-Train retrievals to characterize the radiative, macrophysical, and microphysical evolution of tropical cloud systems; (3) Use the Lagrangian information to assess the dependence of the detrained cirrus cloud properties upon the characteristics of the convective sources which generate them; (4) Evaluate the ability of the GFDL and NCAR Global Climate Models (GCMs) to simulate the relevant physical processes governing the observed lifecycle of tropical convective systems and their impact on the moisture and radiation budgets.

General Circulation Model Simulations of Martial Aerosol Transport and Climate

R. John Wilson/GFDL

FY 2008 Funding: $95,000 Future Year Funding: $0

Abstract

A continuing modeling effort is proposed to further 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 and the atmospheric circulation control the seasonal and interannual variability of the present climate. Interannual variability is dominated by episodic large dust storms that clearly represent a spectacular radiative/dynamical feedback resulting from the mobilization and subsequent transport of dust. These storms are a part of a seasonal variation in dust-raising activity and aerosol transport that strongly influences global atmospheric temperatures and the vigor of the atmospheric circulation. The potential interaction between water ice clouds and dust aerosol may have important consequences for the evolution of the spatial distributions of both water vapor and dust, particularly during the relatively cold northern hemisphere spring and summer seasons. The climate is thus responsive to the coupled seasonal variations in dust, water and CO_2 inventories, which are characterized by appropriate sources and sinks and linked by atmospheric transport.

This proposal builds on work undertaken at the Geophysical Fluid Dynamics Laboratory (GFDL/NOAA) in the development of a comprehensive MGCM that incorporates a microphysics-based description of the formation of water ice clouds, and a fully interactive calculation of radiative heating due to an evolving distribution of dust and water ice aerosols. The MGCM has been successfully applied to simulating aspects of the seasonal variation of atmospheric

temperatures and circulation, dust loading, water ice cloud formation, and dust and water vapor transport. We will continue to examine the contribution and response to dust-raising by the various circulation elements such as Hadley circulation, thermal tides, slope winds, transient waves and the CO_2 condensation flow.

A large volume of spacecraft data has been gathered that provides an unprecedented monitoring of the spatial and temporal variations of temperature, dust, water vapor and water ice aerosol. The synthesis of this data with climate modeling represents a comprehensive approach to characterizing and understanding the current Mars climate. These insights will also be critical for assessing how the climate may have evolved over geological history.

Planetary Waves in the Martian Atmosphere: The Synthesis of MGS Data with a Mars Global Circulation Model

R. John Wilson/GFDL

FY 2008 Funding: $90,427 Future Year Funding: $0

Abstract

Mars Global Surveyor observations indicate considerable variability in atmospheric structure that is associated with global scale thermal tides, stationary and transient waves. These observations include temperatures retrieved from Thermal Emission Spectrometer (TES) spectra and Radio Science occultations, density measurements derived from the Accelerometer Experiment, and wave clouds and dust fronts seen in imagery from the Mars Orbiter Camera (MOC). Thermal tides are particularly prominent in the Mars atmosphere and introduce a strong local time of day dependence on the temperature and wind fields. In addition to the usual sun-synchronous tides, longitudinal variations in topography can force nonmigrating (non-sun-synchronous) tides that are locked to the topography. These tides appear as diurnally varying upslope/downslope circulations within the near-surface boundary layer and are able to propagate up to aerobraking altitudes in the lower thermosphere. Midlatitude dust storms in the MOC imagery appear to be associated with traveling waves, while the zonal variation of water ice clouds is modulated by stationary waves. The proposed investigation will employ the NOAA/GFDL Mars General Circulation Model (MGCM) to study the relationship between retrieved temperatures (and densities) and the planetary scale wave structures in which they may be embedded. The MGCM has been successfully applied to simulating aspects of the seasonal variation of atmospheric temperatures and circulation, dust loading, water ice cloud formation, and dust and water vapor transport. The characterization of the spatial and seasonal variation of the atmospheric temperature structure is a fundamental aspect of the description of the Martian atmosphere. A complementary aspect of this research will be the further

refinement and validation of the dynamical and thermal processes in a Mars GCM that is becoming an increasingly powerful tool for describing and predicting the state of the atmosphere and for exploring present and past climate issues.

The Synthesis of Spacecraft Data with a Mars Global Circulation Model

R. John Wilson/GFDL

FY 2008 Funding: $0 Future Year Funding: $308,009

Abstract

Mars Global Surveyor (MGS) observations provide the basis for characterizing seasonal and interannual variability in atmospheric thermal structure, dust lifting activity, and cloudiness. The observations include temperatures retrieved from Thermal Emission Spectrometer (TES) spectra and Radio Science occultations, density measurements derived from the Accelerometer experiment, and clouds and dust fronts seen in imagery from the Mars Orbiter Camera (MOC). A significant limitation of the observations is the absence of direct information about the atmospheric circulation. Recently the TES retrievals of temperature and dust column opacity have been used as input to the UK Mars data assimilation system to derive a consistent set of thermal and dynamic fields for the three Mars years observed during the MGS mission. The proposal investigation will use this data set, referred to as the MGS Reanalysis, to document the variability of important components of the atmospheric circulation such as global scale thermal tides, stationary and transient waves. We will also employ the NOAA/GFDL Mars General Circulation Model (MGCM) to explore the relationship between spacecraft observations, the evolving atmospheric circulation and the resulting influence on water ice cloud formations, dust and water vapor transport, and aspects of dust lifting. The MGCM will also be used to identify and correct biases in the assimilation model that result from missing or incomplete physics and errors in the specification of the vertical distribution and radiative properties of aerosols. The characterization of the spatial and seasonal variation of the atmospheric circulation is a fundamental aspect of the description of the Martian atmosphere and climate. A complementary aspect of this research will be the further refinement and validation of the dynamical and physical processes represented in Mars GCMs, which are becoming increasingly powerful tools for describing and predicting the state of the atmosphere and for exploring present and past climate issues.

Development of Standard Implementation Practices and Productivity Software for ESMF-Based MAP Systems

Max J. Suarez, Arlindo daSilva/NASA/GSFC, V. Balaji/GFDL, Michele Rienecker/NASA/GFSC, Chris Hill/MIT, Paul Schopf/COLA, Franco Einaudi/NASA/GSFC

FY 2008 Funding: $105,000 Future Year Funding: $110,000

Abstract

Initial experience using the Earth System Modeling Framework (ESMF) has identified the need to standardize the way the framework is implemented in climate models and assimilation systems. Here, we propose to extend the framework by developing usage standards and software tools for building ESMF compliant components. The proposed developments will (1) facilitate the porting of existing codes to ESMF, (2) provide tools and a straightforward recipe for building new ESMF components, and (3) provide much greater interoperability between compliant components than between current ESMF compliant components. We also propose to implement the tools and standards being proposed in the GEOS-5 AGCM, one of the core systems of the MAP program, as well as in several other climate models. We anticipate that their use by other MAP investigators and by the MAP integration group will greatly facilitate the inclusion of diverse applications in MAP systems and enhance the compatibility of these systems and their products with those of other national and international efforts with which we will be collaborating.

Understanding the Mechanisms and Effects of Ice Nucleation in Tropical Cyclones

Paul Ginoux/GFDL, Vaughan Phillips/Princeton University, and Constantin Andronache/Boston College

FY 2008 Funding: $21,368 Future Year Funding: $0

Abstract

Our proposal will investigate the interactions between the tropospheric aerosols and clouds. This will utilize and extend the existing capabilities of an Explicit Microphysics Model (EMM) and a 3D Cloud-Resolving Model (CRM) with double-moment microphysics at GFDL.

Our goals are: (1) to analyze the correlations between satellite- and aircraft-data related to aerosols and cloud-cover properties, using TCSP observations; (2) to improve the EMM, which already has the unique capability of predicting particle properties (shape, bulk, density, size) without categorization assumptions and to predict the particle size distributions; (3) to improve the bulk microphysics scheme of the CRM, enabling it to predict the mass,

concentration and possibly certain properties of particles, with dependences of their nucleation and coagulation processes on the ambient turbulence and in-cloud electric fields; and (4) to answer scientific questions related to the role of cloud dynamics, electric fields, turbulence and other ambient conditions in the nucleation processes that provide the linkage between aerosol and ice particle properties in cirrus. Particular focus will be given to the competition between the homogeneous freezing of aerosol and that of cloud-droplets.

Development and Testing of a Satellite Simulator Using Climate Model in Support of the GLORY Mission

V. Ramaswamy and Paul Ginoux/GFDL

FY 2008 Funding: $0 Future Year Funding: $35,000

Abstract

We propose a 1-year project to develop and test a simulator of the Aerosol Polarimetry Sensor (APS) instrument in support of the GLORY mission to produce, from variables simulated with the GFDL climate model, aerosol properties that are consistent with the retrieved products, and can be compare with other ground-based and satellite products. Our objective is to combine the advantages of the different satellite instruments in the A-train constellation to better evaluate and constrain climate models, and to ultimately improve our understanding of the impacts of aerosol on climate.

Detection and Attribution of Spectral TOA Forcings and Feedbacks (CLARREO)

V. Ramaswamy/GFDL

FY 2008 Funding: $0 Future Year Funding: $274,573

Abstract

CLARREO has the potential to provide valuable new measurements that could help detect and estimate radiative forcings and feedbacks under clear sky conditions. The utility of CLARREO for the detection and quantification of cloud feedbacks remains an open issue. The feasibility of separating changes in clouds from changes in the rest of the climate system has not been determined. In solar wavelengths, the feasibility of isolating forcings and feedbacks in the data has yet to be tested. This is a particularly important issue given the large range and uncertainty in low-cloud feedbacks among the models assessed in the IPCC AR4. We propose to conduct a series of Observing System Simulation Experiments (OSSEs) to test the detection and

attribution of radiative forcings and feedbacks from the CLARREO data. One of our principal objectives is to quantify the improvement in detection and attribution skill relative to existing instruments.

Climate models treated as surrogates for the real Earth system are ideal tools for these feasibility studies. In climate models, unlike in the real system, it is easy to calculate the forcing terms for each individual radiatively active species, including the long-lived greenhouse gases, ozone, land-use change, and natural, anthropogenic, and volcanic aerosols. It is also possible to calculate the individual feedbacks associated with water vapor, lapse rate, surface albedo, and clouds. Climate models can be used to test whether these forcings and feedbacks can be separated and quantified using the CLARREO data, and if so what are the time scales for unambiguous detection and attribution. The latter question is related to the fidelity of the unforced natural variability in these models. An ensemble of models with a range of interannual variability is essential to avoid any systematic artifacts in the results.

We propose to conduct CLARREO OSSEs with three leading climate models analyzed in the IPCC AR4 that are already instrumented to compute forcings and feedbacks. In order to perform the OSSEs, we will add adding two new components to these models:

- Emulators for the shortwave and infrared CLARREO interferometers; and
- More advanced spectrally resolved treatments of surface spectral albedos.

The results from the instrument emulators will be treated as surrogate CLARREO data and reduced to estimate the forcings and feedbacks calculated directly from the model physics. Many climate models treat the interaction of solar radiation and the surface with relatively coarse spectral resolution. The improvements in land and ocean surface albedos will enhance the realism of the shortwave calculations for the OSSE.

The results from the OSSE will help answer several critical open questions, including:

1. Can the forcings from aerosols and land-use change and the feedbacks from snow and ice be detected and quantified using CLARREO data?
2. Can the indirect shortwave forcings from aerosol-cloud interactions and the feedbacks from clouds be detected and quantified using CLARREO data?
3. What are the implications of pixel size for the detection and quantification of forcings and feedbacks in clear-sky versus all-sky observations?
4. To what extent is it possible to isolate forcings and feedbacks associated with changes in specific species and processes in the CLARREO measurements?
5. Can the changes in and longwave feedbacks from low, middle, and high clouds be detected and quantified using the CLARREO infrared data?

Using ARM Observations to Evaluate Cloud and Convection Parameterizations and Cloud-Convection-Radiation Interactions in the GFDL Atmospheric General Circulation Model

V. Ramaswamy/GFDL

FY 2008 Funding: $84,000 Future Year Funding: $180,461

Abstract

This proposal summarizes research currently underway at GFDL to develop a new class of cloud and convection parameterizations based on sub-grid probability distribution functions (PDFs) of vertical velocity. These PDFs are subsequently used to generate PDFs of cloud microphysical properties. The approach has been implemented in the GFDL atmospheric model (AM) for deep convection, and a highly simplified implementation for droplet activation has been implemented for stratiform clouds. Together with the GFDL AM radiative transfer parameterization that is calibrated against 'bench-mark' computations, we will set up a platform for the analyses of the resulting cloud-convection-radiation interactions and the associated latent and radiative heating rates and fluxes against available ARM measurements and diagnoses.

The proposal requests an ARM-funded postdoctoral fellow to evaluate the parameterizations, test processes and investigate the interactions using ARM microphysical, radiation, and vertical velocity fields. Direct application of these observations to both general circulation model (GCM) and single-column models (SCMs) is proposed. We also propose use of large-eddy simulation (LES) and cloud-system-resolving models (CSRMs) as process-level models to understand the interactions among the different processes and to evaluate and develop the GCM parameterizations based on the improved understanding. We propose in particular the use of ARM data to evaluate and develop where necessary these process-level models.

We also propose that the ARM postdoctoral fellow co-ordinate AM tests of these parameterizations in the CCPP-ARM Parameterization Testbed (CAPT) program between GFDL and Program for Climate Model Diagnosis and Intercomaprison (PCMDI). Finally, given the availability of radiative heating rates and fluxes from ARM and the importance of accurate representation of them in both process and general circulation models, we propose that the ARM postdoctoral fellow employ ARM-observations to evaluate radiative heating rates in GFDL models, and compare them with the latent heating contribution in the diabatic heating of the atmosphere.

Coupled Tropical Cyclone-Ocean System

Morris Bender/GFDL and Isaac Ginis/University of Rhode Island

FY 2008 Funding: $28,000 Future Year Funding: $0

Abstract

This funding has been initiated to upgrade the 1-D coupling in the GFDN model to a full three-dimensional hurricane-ocean coupled system in the Pacific Ocean. GFDL will assist in the planning and development of the new coupled system in close collaboration with the research group at the University of Rhode Island (URI) led by Prof. Isaac Ginis.

GFDL scientist Morris Bender will assist in the transfer of the 3-D coupled model in the western Pacific to the current operational GFDN tropical cyclone prediction system. This will include development and modification of new scripts and source code where needed. GFDL scientist will transfer the new system to a Navy computer facility where extensive testing can begin.

Once the new system is in place in the Navy's computer facility, GFDL will evaluate the new 3-D tropical cyclone-ocean coupled model on a large number of cases in the west Pacific, spanning a multi-year sample.

GFDL scientists will assist FLEET personnel in the final transfer of the final 3-D coupled system to operations.

Using Models to Improve our Ability to Monitor Ocean Uptake of Anthropogenic Carbon

Anand Gnanadesikan/GFDL and Keith Rodgers/CICS

FY 2008 Funding: $60,000 Future Year Funding: $60,000

Abstract

There are two main tasks in using measurements to monitor the uptake of carbon dioxide by the ocean. The first task is the identification of the anthropogenic component of ocean carbon measurements along the Repeat Hydrography tracks. The second component is the extrapolation of the anthropogenic carbon inventory to the basin scale. For both cases, monitoring is complicated by variability in ocean circulation, and models provide an important tool in the development of novel methods to reduce uncertainty in estimates of ocean uptake of anthropogenic carbon. A major result thus far involves the role of large-scale planetary waves, which cause a horizontal light water rich in anthropogenic carbon. In a paper in press in

J. Geophys. Res., we show that this redistribution can be accounted for using altimetric measurements of sea surface height. Future work involves developing techniques to distinguish between changes in inventory due to adiabatic mechanisms like sea surface height from diabatic changes in ventilation. In the coming year we plan to examine output from the GFDL ESM2.1 in order to evaluate observational strategies for estimating ocean carbon uptake.

Decadal Climate Predictions and Abrupt Change

V. Ramaswamy/GFDL

FY 2008 Funding: $0 Future Year Funding: $1,097,000

Abstract

Utilize the new supercomputing resources that will be available as a result of the American Recovery and Reinvestment Act (ARRA) Climate Modeling and Data Records allocation to facilitate development and use of new climate model with high-resolution ocean (ocean grid sizing of 10-20 Km). These new ARRA computing resources will augment the NOAA R&D High Performance Computing System with required processing, data storage and analysis systems. This new hardware will facilitate running ensembles of high resolution model simulations for multiple decades. At this initial stage the ocean will be high resolution (as fine as 10 Km grid), but the atmosphere is medium resolution (100 Km grid).

A new data assimilation system will initialize state of the art climate models using data from the Global Ocean Observing System (GOOS), for routine production of initial conditions for decadal scale predictions. This requires three junior scientists with expertise in observational data and assimilation systems.

Development of coupled climate model with high-resolution ocean. This model will be called CM2.5 and is the target model to run for decadal predictions. It will require two project scientists for rigorous model evaluation and one technical support staff for optimizing code and managing integrations

Post doctoral support through the Cooperative Institutes will support modeling glaciers, and high resolution climate/carbon/ice/snow models with the intent to transition modeling results to NOAA's Geophysical Fluid Dynamics Lab (GFDL). This research will support implementation of a forecast capability for sea level rise and a better understanding of Arctic climate impacts.