CICAR

Columbia University in the City of New York
The Earth Institute at Columbia University
Lamont-Doherty Earth Observatory

Annual Performance Report

July 1, 2003 to June 30, 2004

For The

Cooperative Institute for Climate Applications and Research

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Palisades, New York 10964-8000

Prepared for:
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NOAA Research

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I. Preface:

a. Document Purpose

The Annual Report for the Cooperative Institute for Climate Applications and Research (CICAR), a Joint Institute funded by the National Oceanic and Atmospheric Administration Office of Oceanic and Atmospheric Research (OAR), is a requirement of the OAR Joint Institute Program. The CICAR annual report describes all actively funded research projects, education initiatives, and public information and outreach programs conducted under CICAR NOAA grant NA03OAR4320179 for the fiscal year ended June 30, 2004.

Looking forward to FY05 the CICAR annual report is also intended to give stakeholders a window to future research activity as well as CICAR's administrative and public outreach program development. As a key contributor to the OAR Joint Institute Program, CICAR research will, on a yearly basis, actively address NOAA's Strategic Goal to *Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond*.

b. Document Distribution

The CICAR Annual Report is distributed in hard and soft copy to the NOAA/OAR Joint Institute Program Office and is available in PDF version on both the OAR JI web site and the CICAR web site (debut fall '04). Copies of the report will be made available to the members of the Columbia University, Earth Institute, and Lamont-Doherty administrative and scientific communities as well as other interested agencies and individuals.

c. Document Contents

The 2004 CICAR Annual Report is a comprehensive written review of all administrative and research activity for the Institutes first year of operation that began July 1, 2003 and ended June 30, 2004.

II. The Cooperative Institute for Climate Applications and Research (CICAR)

a. Mission Statement

CICAR evaluates, understands, and predicts climate variability and change through the collection and analysis of modern and paleoclimate data and the use of Earth System models. We provide climate information to society through education and the development of applications and tools for assessing climate related risks.

b. Overview

CICAR, the Cooperative Institute for Climate Applications and Research was established in November 2003 as a research partnership between the National Oceanic and Atmospheric Administration and Columbia University In The City of New York. CICAR research themes are: (1) Earth System Modeling; (2) Modern and Paleoclimate Observations; and (3) Climate Variability and Change Applications Research.

CICAR's mandate brings together scientists from NOAA Laboratories, in particular the Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, and scientists of the Earth Institute at Columbia University, primarily the Lamont-Doherty Earth Observatory in Palisades, New York, to advance climate research, education, and outreach in support of NOAA's goals.

c. Structure

The Cooperative Institute for Climate Applications and Research (CICAR) is administered by Columbia University through its Lamont-Doherty Earth Observatory and is located at the Observatory's Palisades, New York campus. The CICAR consists of the Director, who is an official of Columbia University, an administrative staff, an Advisory Committee, and the scientific and support staff of the CICAR. The Geophysical Fluid Dynamics Laboratory (GFDL), a NOAA Research facility, is CICAR'S principal connection to NOAA.

The CICAR will have such internal organization as deemed necessary by the Director to meet its goals and carry out its programs. Initially, the Institute's principal research components will be NOAA GFDL and Columbia University's Lamont-Doherty Earth Observatory. Other research components may include, but are not limited to: the NOAA Office of Global Programs, the NOAA Climate Prediction Center (CPC), and the Earth Institute of Columbia University. In general, research undertaken will address critical environmental problems relative to the CICAR themes as identified by NOAA and / or Columbia University and will normally stress long-term collaboration.

d. CICAR Research Overview

The Cooperative Institute for Climate Applications and Research develops and promotes research to address a wide range of science and social topics consistent with the CICAR mandate. The project overviews appearing in the CICAR research section include observations and model development required for the prediction of seasonal-to-interannual and long-term climate variability, for developing better understanding of modern and paleo climates and their variability, and for the development of tools for providing climate information to society to assess risk and make decisions.

The CICAR program of research and education is designed to:

- Create a long-term research partnership between NOAA and the Columbia

University climate research community to enhance NOAA's research capabilities in the area of climate observations, modeling, and prediction.

- Contribute to NOAA's goal to enhance society's ability to plan and respond to climate variability and change by developing methods and tools for providing climate information to users and decision makers.
- Provide a basis for streamlining the administrative process for several established cooperative projects within Columbia University and NOAA – e.g. AbRupt Climate CHangE Studies (ARCHES), Climate Variability and Prediction program (CLIVAR), the IRI Applied Research Centers program, and the NOAA Climate and Societal Interactions program.
- Develop specific research projects that address critical research needs in:
  - Climate modeling and prediction
  - Modern and Paleoclimate research
  - Climate forecast applications research
- Improve the effectiveness of graduate-level education by expanding research opportunities available to graduates and undergraduates through participation in joint research projects.
- Identify opportunities and establish means to communicate climate research development to the public to facilitate broader understanding of climate related issues and their impact on society.

CICAR's research imperative is directly aligned with NOAA's mission goal to ***Understand climate variability and change to enhance society's ability to plan and respond***.

e. CICAR's Overall Operational Strategy by Task

The Institutes primary operational and research strategy is divided into four (4) tasks:

Task I: Administrative activities
Task II: Specialized science support activities
Task III: Proposed and currently funded individual projects
Task IV: Collaborative education program

III. CICAR Tasks

a. Task I: Administrative

Addresses the administrative functions of the Institute and supports the CICAR director and staff:

i. CICAR Administrative Staff

CICAR Director
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http://eesc.columbia.edu/faculty/hemming.html

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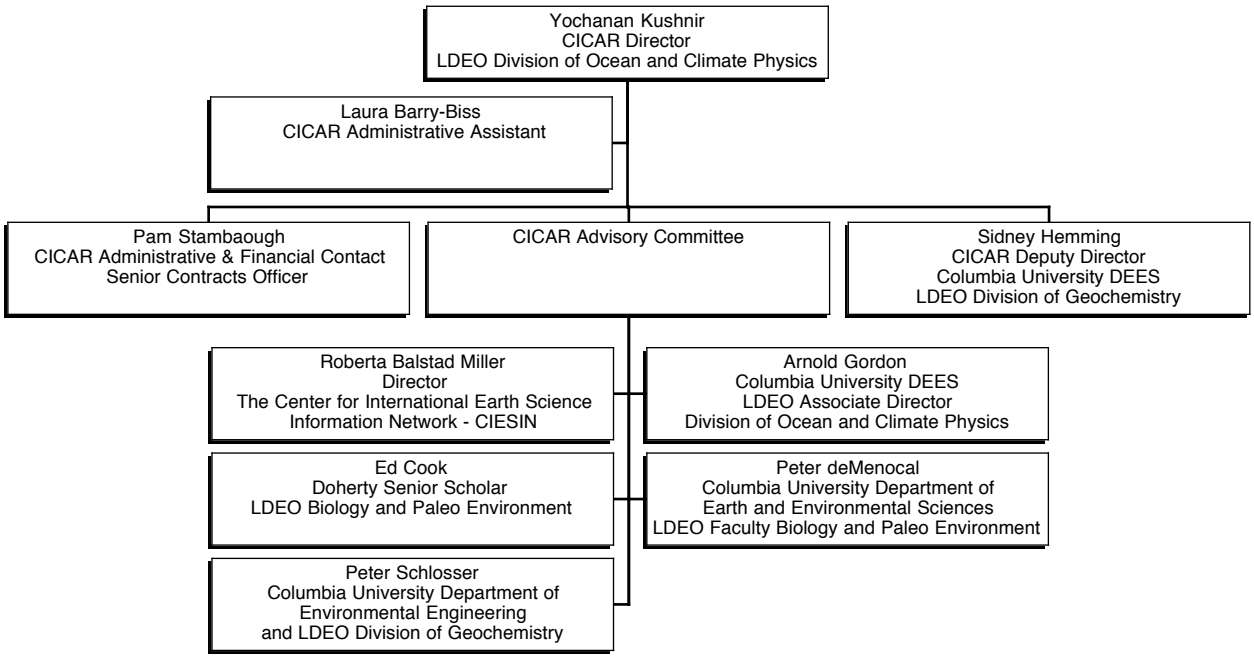
laurabb@ldeo.columbia.edu

ii. CICAR Advisory Committee

The CICAR Advisory Committee includes representation from the CICAR director and deputy director, the administrative staff, and senior scientists representing various Lamont-Doherty research divisions and affiliates as presented in the CICAR organization chart.

iii. CICAR Organization Chart:



iv. CICAR Administrative Activities July 1, 2003 – June 30, 2004

1. **CICAR Web Site Development**
    a. Format and Content in Review
    b. Go-live scheduled for Fall 2004
2. **Administrative Protocols**
    a. Constructed administrative interface between CICAR Administration and Lamont Central Administration to comply with Joint Institute requirements that differ from Columbia University routine proposal submission and award procedures.
3. **External and Hosted Activities**
    a. February 5, 2004: Hosted GFDL – LDEO Collaborative Research Discussion re:
        1. Broad Research Themes:
            a. Climate of the 19 to 21 Centuries and
            b. Climate of the Holocene with emphasis on the last 1000 years
        2. Presentation Outline:

a. GFDL plan for collaboration under CICAR
b. Lamont
    i. Climate Modeling Group projects
    ii. Ocean modeling projects
    iii. Paleo projects
    iv. Climate and sun forcing
    v. Tentative project proposals
c. GFDL
    i. IPCC runs
    ii. Carbon cycle modeling
    iii. Climate prediction

3. Discussion
    a. Defining project title and goals
    b. Formation of teams
    c. Action Plan

b. March 10, 2004: Hosted the first CICAR Advisory Committee Meeting
Discussion Outline:

1. CICAR administrative update:
    - Introduced new members of the committee and administrative support.
    - Described procedure for submitting projects under CICAR and annual reporting.
    - Discussed NOAA directives regarding transition of current projects.
2. New initiative for collaboration with GFDL:
    - Described pending proposal to fund postdocs and graduate students to conduct collaborative research on climate variability under natural and anthropogenic forcing.
3. Preparations for NOAA / JI Conference April 14-16 Silver Spring:
    - Particular focus on the NOAA 2005 budget and the specific issues CICAR should bring to the upcoming meeting.
4. Open Discussion on items 1 – 3:
    - The discussion addressed the current NOAA funding situation in particular its impact on the ARCHES project.
    - Annual CICAR Symposium: preliminary discussion regarding theme and structure
    - Public outreach: CICAR presence at LDEO Open House, CICAR Website, CICAR Newsletter and OAR “Hot Items” web page
5. On all relevant issues concerning the Institute, updates and reports are sent, via email, to the CICAR Advisory Committee members.

c. April 14 – 16, 2004: Attended the NOAA OAR JI Directors and Administrators Meeting in Silver Spring, MD.

b. Task II: Specialized Science Support Activities

This task provides for specialized support scientists that are employed by Columbia University (LDEO) but are located at the Geophysical Fluid Dynamics Laboratory (GFDL). These CICAR employees are hired to enhance the technical and scientific expertise at GFDL required to execute collaborative CICAR projects or to address specific needs that require specific expertise not available at GFDL. In the present 5-year budget cycle we propose to allow for five such support scientist positions. It should be noted that, to date, these slots have not been filled.

c. Task III: Individual & Collaborative PI Research Projects

This task encompasses the bulk of individual and collaborative PI research at LDEO / EI that is supported by grants from NOAA and complies with the themes of CICAR. It is comprised of currently funded research projects as well as new ones that strengthen the Institute research agenda in line with the themes. Task III represents the main thrust of the CICAR research agenda for the next five years.

i. CICAR's Overall Research Strategy by Theme

1. **Theme I:** *Earth System Modeling*

Research Goals:

- Develop computer models and methodologies to simulate and forecast climate variability / change
- Use computer models to study and understand the climate system evolution in the past, present, and future

2. **Theme II**: *Modern and Paleoclimate Observations*

Research Goals:

- Study Earth's climate history by developing, collecting, analyzing, and archiving paleoclimate data such as marine sediments, tree rings, corals, and glaciers
- Collect and analyze modern ocean observations to understand ocean processes and to improve ocean models

3. **Theme III:** *Climate Variability and Change Application Research*

Research Goals:

- Develop specific applications to provide climate information for decision makers in the areas of health, policy, water resources, and agriculture
- Study the communication between climate information providers and users in order to develop tools and methodologies that maximize the benefit of advances in climate science to society

ii. CICAR Research Activities from July 1, 2003 to June 30, 2004

1. Cicar Currently Funded Individual Research Projects Through June 30, 2004:

a. Dynamical Forecasting of ENSO: A Contribution to the IRI Network

2. Research Proposals Submitted Under CICAR But Not Funded As Of June 30, 2004:

a. Multivariate Approach to Ensemble Reconstruction of Historical Marine Surface Winds from Ship and Satellites

b. Atmospheric and Coastal Ocean CO2 Measurement Platform – SABSOON

c. Masters Program in Climate and Society

d. SOLAS OASIS Platform

e. Climate Change Data and Detection (CCDD) – Collaborative Research: Development of a Blended, Living Gridded Network of Drought Reconstructions for North America

f. The Consortium on Oceans Role in Climate (CORC) – AbRupt Climate CHangE Studies (ARCHES)

g. CLIVAR
   - South Atlantic Ocean-Atmosphere Interaction
   - The Role of Orography on the North American Monsoon Onset and Interannual Variability
   - Describing, Understanding, and Predicting Oceanic Precipitation Variations Associated with Tropical Atlantic Variability and the North Atlantic Oscillation
   - The Role of Ocean Dynamics In Tropical Atlantic SST

h. Understanding Climate Change from the Medieval Warm Period to the Greenhouse Future (Collaboration with GFDL)

3. Research Reports: For the reporting period from July 1, 2003 to June 30, 2004 one (1) research project was active.

a. *Dynamical Forecasting of ENSO: A Contribution to the IRI Network*
PIs: M.A.Cane, D.Chen, A.Kaplan

Research Addressing:

NOAA Strategic Goal 2: *Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond*

CICAR Theme I: *Modeling and Prediction*

i. **Project Overview:**
The goals of this research are to improve our ability to predict ENSO and to make that prediction as usable as possible to the forecasters at application centers, such as the International Research Institute for Climate Prediction (IRI) and the National Centers for Environmental Prediction (NCEP).
To accomplish these goals, Lamont-Doherty Earth Observatory researchers Mark A. Cane, Dake Chen, and Alexey Kaplan focused their attention on forecast system improvement, quantitative forecast error estimates, and ENSO predictability. LDEO researchers utilized past progress with emphasis on participating in the ocean data assimilation consortium, an activity of NOAA's Climate Dynamics and Experimental Prediction (CDEP) Applied Research Centers (ARCS), and on making the results usable to other participants of the IRI Network.

ii. **Research Goals**: To improve our ability to predict ENSO and to make our predictions as usable as possible to the forecasters at application centers. The efforts are focused on forecast system improvements, ENSO predictability, and data assimilation.

iii. **Educational Goals**: To train students and post docs in the exciting area of ENSO research and prediction.

iv. **Progress:**

a. ENSO predictability was studied based on unprecedented retrospective forecast experiment covering the past one and a half centuries; in April 2004 this work was published in *Nature* and reported by press agencies all over the world.

b. Contributions of observational error in initial conditions, of random atmospheric variability, and of model biases into the prediction error of Zebiak-Cane model were investigated.

c. Impacts of the small-scale ocean variability into the error in the initial ocean states obtained via data assimilation procedures were analyzed.

d. With regards to educational goals, (a) Alicia Karspeck, a graduate student supported by this grant, has defended her dissertation on the subject and received her Ph.D.; she will pursue her further work in this area in a post-doctoral position in JISAO at the University of Washington in Seattle; (b) Elizabeth Heller was selected as a finalist of the 2004 Intel Science Talent Search for her paper on the El Nino event of 1868; (c) postdoctoral position of Samar Khatiwala was

supported by this grant; he successfully made a transition to the research tenure track in the LDEO; (d) Alexey Kaplan delivered a lecture "El Nino Events: Predictions and Reconstructions" at the AMS sponsored teachers' workshop held in LDEO on February 28, 2004.

b. Publications

Chen, D., M. A. Cane, A. Kaplan, S. E. Zebiak and D. Huang, 2004: Predictability of El Niño over the past 148 years. *Nature*, **428**, 733-736, 2004.

Chen, D., S. E. Zebiak, M. A. Cane, 2004: Experimental forecast with the latest version of the LDEO model (March). *Experimental Long-Lead Forecast Bulletin*, **13**, 1, 12-14.

Chen, D., S. E. Zebiak, M. A. Cane, 2003: Experimental forecast with the latest version of the LDEO model (December). *Experimental Long-Lead Forecast Bulletin*, **12**, 4, 80-82.

Chen, D., S. E. Zebiak, M. A. Cane, 2003: Experimental forecast with the latest version of the LDEO model (September). *Experimental Long-Lead Forecast Bulletin*, **12**, 3, 12-14.

Hazeleger, W., R. Seager, M.A. Cane and N. Naik, 2004: How can tropical Pacific ocean heat transport vary*? J. Phys. Oceanogr.*, **24**, 1, 320-1,333.

Kaplan, A., M. A. Cane, D. Chen, D. L. Witter, R. E. Cheney, 2004: Small-scale variability and model error in tropical Pacific sea level. *J. Geophys. Res.*, **109**, C02001, doi:10.1029/2002JC001743.

Kaplan, A., 2004: Scaling of geostrophic kinetic energy to the spatial variance of sea surface heights *J. Atmos. Oceanic Technol., in review.* [Available at *http://rainbow.ldeo.columbia.edu/~alexeyk/Papers/Kaplan_jaot.pdf*].

Karspeck, A.R., R. Seager and M.A. Cane, 2004: Predictability of tropical Pacific decadal variability in an intermediate model. *J. Climate*, **18**, 2842-2850.

Mann, M.E., M.A. Cane, S.E. Zebiak and A. Clement, 2004: Volcanic and Solar Forcing of El Niño over the past 1000 years. *J. Climate*, in review.

Rienecker, M., S. Zebiak, J. Kinter, D. Behringer, A. Rosati, A. Kaplan, 2003: CDEP Consortium on Ocean Data Assimilation for Seasonal-to-Interannual Prediction (ODASI), NOAA 28th Climate Diagnostic and Prediction Workshop, Reno, Nevada, October 23.

Seager, R., A. Karspeck, M. Cane, Y. Kushnir, A. Giannini, A. Kaplan, B. Kerman, J. Velez, 2004: Predicting Pacific decadal variability. *In Ocean-atmosphere interaction and climate variability*, AGU, in press.

Shaman. J., M.A. Cane, A. Kaplan, 2004: The Relationship between Tibetan

Snow Depth, ENSO, River Dischange and the Monsoons of Bangladesh. *International Journal of Climatology*, in review.

d. Task IV: Collaborative Education Program

i. Collaborative Education Program Summary

Task IV of the research partnership between NOAA's Office of Atmospheric Research and Columbia University was created to facilitate three types of collaborative, educational activities under CICAR.

1. A postdoctoral program that is dedicated to provide opportunities for young, independent scientists to conduct research consistent with the CICAR themes and under the joint mentorship of NOAA (GFDL) and Columbia University (LDEO/EI) scientists.

2. A graduate research program for advanced graduate students that will support PHD thesis work consistent with the CICAR themes and under the joint mentorship of NOAA (GFDL) and Columbia University (LDEO/EI) scientists.

3. A visiting scholar program that will provide leading scientists from various national and international research institutes with the opportunity to visit LDEO and GFDL on a short-term basis to lecture the CICAR community and conduct collaborative research on the CICAR themes.

It is worth noting that preparation for the activities listed below (ii. Education) started before June 30, 2004 and the activities themselves will start in CICAR's second year.

ii. Education

1. GFDL – CICAR Collaborative:

A collaborative research initiative entitled *Understanding Climate Change From the Medieval Warm Period to the Greenhouse Future* was developed during CICAR's first budget year and will commence during the second part of 2004**.** Overall, this research program addresses the CICAR Themes of *Modeling and Prediction* and *Modern and Paleoclimate Observations*. Its goal is to model and understand the changes in global climate over the period from 1000AD to 2200AD and to put a future-warming scenario in the context of the recent, relatively well documented past. The program is designed to stimulate collaboration between LDEO and GFDL and to do that under the objective of providing joint mentorship to young investigators in the graduate study or post-doctoral stage of their career. Financing for this program is provided by GFDL from their overall research budget and will make it possible to fund six post-doctoral research scientists at various levels of support and three full-time graduate students at an advanced stage of their study.

2. M.A. Program in Climate and Society – Student Financial Aid and Research Awards 2004-2005
An education initiative addressing the CICAR Theme: *Climate Variability and Change Application Research*

Principal Investigator Mark Cane, G. Unger Vetlesen Professor of Earth / Climate Science at Columbia University, will direct a new twelve-month M.A. Program in Climate and Society to train professionals and academics to understand and cope with the impacts of climate variability and climate change on society and the environment. This rigorous program emphasizes the problems of developing societies and combines elements of established Columbia University programs in earth sciences, earth engineering, international relations, political science, sociology, and economics with unique classes in interdisciplinary applications specially designed for the program's students.

Graduates of the M.A. Program in Climate and Society will be prepared to address environmental issues from positions in government, business, academe, and nongovernmental organizations.

iii. Outreach

1. Community Based: *Looking Forward:* CICAR Outreach and Education

a. September 18, 2004: Community Festival: Columbia 250 Penultimate Celebration

First up on CICAR's 2004 public outreach program is the Columbia University New York City Community Festival slated for all-day Saturday, September 18. CICAR is participating as part of the Lamont-Doherty Earth Observatory Climate Change exhibit. The institute's director, Yochanan Kushnir, and his staff coordinated the efforts of Lamont scientists and students to produce a series of hands-on, kid-friendly demonstrations including a water salinity tank, coral specimens, tree rings, and computer customized weather print outs based on dates entered by participants (birthday, anniversary, etc.). Other images and materials include information on droughts, climate – past, present, and future, and tips for kids on what they can do to help protect the environment. All the displays and materials marry to the overarching exhibit theme Climate of the Last 1000 Years and are designed to involve, educate, and stimulate the public. New Yorkers of all ages are invited to Columbia's Community Festival, taking place on and around the University's Morningside and Barnard campuses.

b. October 9, 2004: The Lamont-Doherty Earth Observatory Annual Open House: Restless Earth

Saturday, October 9, 2004 CICAR will be hosting a tent at the Lamont-Doherty Earth Observatory Open House. The Observatory's grounds are

open to thousands of neighbors and students from surrounding communities in New York and New Jersey as researchers present their studies of this Restless Earth. As part of the institute's inaugural appearance, CICAR representatives will distribute and discuss various educational materials including NOAA posters and brochures; collateral information on other NOAA / CICAR funded research projects, and video presentations to the public. Open House exhibits, activities, demonstrations, and presentations are aimed at different ages and educational levels, from elementary school-age children, to college students, to those well versed in the earth sciences.

Guided forest hikes with an Observatory **dendrochronologist** explore tree ring science and how it reveals key information on forest ecology and past climates. **Seismologists, geologists, and tectonophysicists** discuss the dynamics of earthquakes, floods, landslides and severe storms, and how they have shaped the Earth. **Marine and paleo biologists** present exhibits on aquatic life, demonstrate satellite sensing of ocean biology, and present discoveries from the fossil record. How water and pollutants move in the ground is explored with Observatory **geochemists**, as well as rocks and what they tell us about the deep Earth. **Ocean and climate physicists** investigate climate phenomena in the atmosphere and ocean. **Marine geologists and geophysicists** discuss evidence for geologic impacts on climate, civilization, and mass extinctions. These are just a few of the many exhibits and presentations offered.

Visitors can explore science labs, educational opportunities in the earth sciences, and listen to earth science lectures, while enjoying the Observatory's 157-acre campus.

IV. Appendix

a. CICAR Principal Investigators

Name	Title
Anderson, Robert F.	Doherty Sr. Scholar
Balstad-Miller, Roberta	Sr. Research Scientist
Bond, Gerard	Doherty Sr. Scholar
Broecker, Wallace	Newberry Professor
Burckle, Lloyd	Adjunct Sr. Research Scientist
Cane, Mark	Vetlesen Professor Earth Climate Sci.
Chen, Dake	Doherty Sr. Research Scientist
Cook, Ed	Doherty Sr. Scholar
D'Arrigo, Rosanne	Doherty Sr. Research Scientist
DeMenocal, Peter	Associate Professor
Gordon, Arnold	Professor
Hemming, Sidney	Associate Professor
Ho, David	Doherty Associate Research Scientist
Houghton, Robert	Sr. Staff Associate
Kaplan, Alexey	Doherty Research Scientist
Krahmann, Gerd	Doherty Associate Research Scientist
Kushnir, Yochanan	Doherty Sr. Research Scientist
Lenhardt, Christopher	Sr. Staff Associate
Louchouarn, Patrick	Associate Professor
Martinson, Doug	Doherty Sr. Research Scientist
McGillis, Wade	Doherty Research Scientist
Naik, Naomi	Sr. Staff Associate
Ou, Hsien-Wng	Doherty Sr. Research Scientist
Peteet, Dorothy	Adjunct Sr. Research Scientist
Pitman, Walter	Special Research Scientist
Polvani, Lorenzo	Associate Professor
Robertson, Andrew	Research Scientist
Robertson, Robin	Doherty Associate Research Scientist
Sambrotto, Raymond	Doherty Research Scientist
Schlosser, Peter	Professor
Seager, Richard	Doherty Sr. Research Scientist
Smethie, William	Doherty Sr. Research Scientist
Sobel, Adam	Assistant Professor
Sustanto, Dwi	Doherty Associate Research Scientist
Ting, Mingfang	Doherty Sr. Research Scientist
Tremblay, Bruno	Doherty Associate Research Scientist
Visbeck, Martin	Adjunct Research Scientist
Yuan, Xiaojun	Doherty Research Scientist

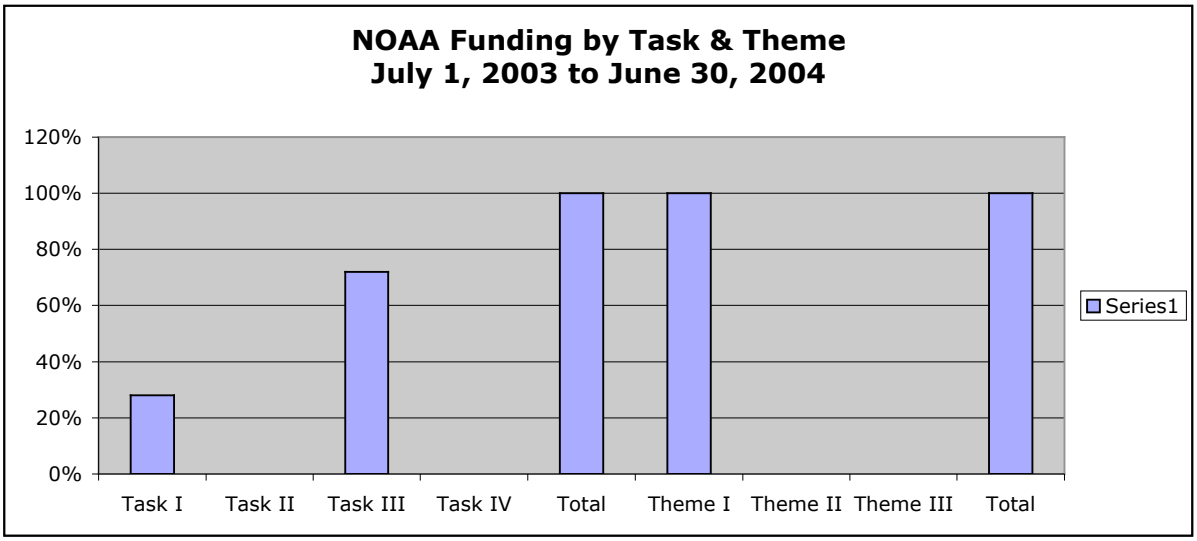
b. Lead Author Publication Table

	JI Lead Author			NOAA Lead Author			Other Lead Author		
	FY02	FY03	FY04	FY02	FY03	FY04	FY02	FY03	FY04
Peer Reviewed			4						4
Non Peer Reviewed		2	1					1	

c. The Cooperative Institute for Climate Applications and Research

Personnel Information Table

Category	Number	B.S.	M.S.	Ph.D.
Research Scientist	1			1
Visiting Scientist				
Postdoctoral Fellow	1			1
Research Support Staff	*1			1
Administrative	1	1		
Undergraduate Students				
Graduate Students	1	1		
Received less than 50% NOAA Support	12	3	2	7
TOTAL	**17**	**5**	**2**	**10**
Located @ Lab (identify Lab)				
Obtained NOAA employment within the last year	*1-GFDL			1

*Dr. Myriam Khodri
NOAA Geophysical Fluid Dynamics Laboratory
UCAR Visiting scientist postdoctoral fellowship working as part of the Climate Change Research Initiative (CCRI)
Accepted August 16, 2004
Start Date: October 1, 2004

d. NOAA Funding Bar Chart