02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.C.a. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Carlos R Mechoso

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☒ Hispanic or Latino ☐ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☒ Other on file
- ☐ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

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PI/PD Name: Sang-Ki Lee

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

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PI/PD Name: Chunzai Wang

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:

Not Listed

REVIEWERS NOT TO INCLUDE:

Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 10-1	FOR NSF USE ONLY
NSF 10-1	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) AGS - GEO/ATM - Climate & Large-Scale Dynamics	

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				092530369	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS ☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☐ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE University of California-Los Angeles	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE 11000 Kinross Avenue Suite 102 LOS ANGELES, CA 90095-1406
AWARDEE ORGANIZATION CODE (IF KNOWN) 0013151000	
NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE	ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE
PERFORMING ORGANIZATION CODE (IF KNOWN)	

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS
☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 515,686	0 months		

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
  PHS Animal Welfare Assurance Number ________
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
  Exemption Subsection ________ or IRB App. Date ________
- ☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
  ____
- ☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT Department of Atmospheric Sciences	PI/PD POSTAL ADDRESS 7127 Math Sciences Building 405 Hilgard Avenue, Box 951565 Los Angeles, CA 900951565 United States
PI/PD FAX NUMBER 310-206-5219	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Carlos R Mechoso	PhD	1979	310-825-3057	mechoso@atmos.ucla.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

TPI 7025858

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 10-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☐

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 10-1

NSF 10-1

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

AGS - GEO/ATM - Climate & Large-Scale Dynamics

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

1041145

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
04/26/2010	1	06020000 AGS	5740	152764007	04/26/2010 5:01pm

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

590624458

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of Miami Rosenstiel School of Marine&Atmospheric Sci

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

4600 RICKENBACKER CSWY
KEY BISCAYNE, FL 33149-1098

AWARDEE ORGANIZATION CODE (IF KNOWN)

0015362010

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

PERFORMING ORGANIZATION CODE (IF KNOWN)

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: The Southern Subtropical Anticyclones**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 328,494	36 months	08/01/10	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

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☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
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____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
CIMAS

PI/PD POSTAL ADDRESS
4600 Rickenbacker Causeway

Miami, FL 331491098
United States

PI/PD FAX NUMBER
305-361-4412

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Sang-Ki Lee	PhD	1995	305-361-4521	s.lee1@miami.edu
CO-PI/PD Chunzai Wang	PhD	1995	305-361-4325	Chunzai.Wang@noaa.gov
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

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By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

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Certification Regarding Responsible Conduct of Research (RCR)
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By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

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* EAGER - EArly-concept Grants for Exploratory Research
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The Southern Subtropical Anticyclones

Principal Investigators: C. R. Mechoso (UCLA), Sang-Ki Lee (U. Miami/RSMAS), Chunzai Wang (NOAA/AOML)

Funding Period August 1, 2010 – July 31, 2013

Abstract

Intellectual Merit: According to a modern consensus, monsoon convection over the continents and orographic effects cooperate in the generation of zonally asymmetric features that characterize the subtropical anticyclones. Monsoon convection originates both Kelvin waves that propagate eastward and Rossby waves that propagate westward and poleward with associated subsidence that can be enhanced by diabatic and other effects. The midlatitude westerlies impinging on the western slope of mountain ranges induce equatorward flow that sinks along the isentropes contributing to subsidence in the eastern part of the subtropical oceans.

The generation of the subtropical anticyclones over the South Pacific and Atlantic Oceans pose additional challenges. First, in seasons other than the warm season the southern anticyclones are affected by convection in the *Northern Hemisphere* according to recent papers. Second, *equatorial dynamics* may play a larger role in the links between the southern anticyclones and convection over South America and southern Africa since these continental masses are bisected by the equator. Third, the warm season in South America and southern Africa also includes strong heat lows to the south of the strong convection, and the extent to which such *heat lows contribute to the subtropical highs* is unclear at the present time.

In view of these challenges, we propose to examine four outstanding and unresolved questions on the southern subtropical anticyclones: 1) *How is the South Atlantic anticyclone during the southern winter connected with the West African and Asian monsoons?* 2) *How significant are the interhemispheric influences of the Atlantic Warm Pool on the southeastern Pacific?* 3) *In the Southern Hemisphere, do atmospheric-ocean interactions contribute significantly to the links between monsoons and tropical highs?* and 4) *Has the recently reported change in the relationship between Atlantic and Pacific Niños affected the variability of the southern subtropical highs?* The project will use two coupled atmosphere-ocean general circulation models (NCAR and UCLA CGCMs), a steady-state two-level primitive equation atmospheric model linearized about a prescribed background flow, a linear, baroclinic, multi-level model, and a simple tropical atmosphere-ocean coupled model.

Broader Impacts: This proposal aims to reconcile different ideas on the generation and maintenance of the southern Atlantic and Pacific anticyclones, and to improve the understanding of these fundamental climate features and their variability. Such an improvement will provide guidance in work to obtain more successful simulations of the coupled atmosphere-ocean system and hence reduce systematic errors that affect climate models in the tropics and subtropics. Two students and one postdoc will be trained in work with a hierarchy of climate models.

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Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

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*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

RESULTS FROM PRIOR NSF SUPPORT

C. R. Mechoso received two relevant prior awards for scientific planning of the VAMOS (Variability of American Monsoon Systems) VOCALS Regional Experiment (VOCALS-REx). The PI was R. Wood (U. Washington): 1) ATM 0617283 VOCALS-REx Scientific Program Overview, and 2) ATM 0650551 Coordination and Planning for the VOCALS-REx. Activities are described in Wood et al. (2007), and Wood and Mechoso (2008).

S.-K. Lee received one relevant prior award to explore potential causes of a warm tropical Atlantic SST bias in the NCAR community climate system model simulation (ATM 0850897 What causes the tropical Atlantic SST bias in CCSM3? August/2009 – July/2012). The coPIs in this grant are C. Wang (NOAA/AOML), D. Enfield, and B. Kirtman (U. Miami/RSMAS).

1. Introduction

Persistent anticyclones cover the subtropical Pacific and Atlantic Oceans. The highest sea level pressures in these features are in the eastern parts of the basins, where large-scale subsidence balances strong low-level divergence. The anticyclones in the Southern Hemisphere are the least studied and least well observed; yet their eastern branches are integral components of fascinating climates characterized by complex interactions between the atmosphere and oceans. General circulation models of the coupled ocean-atmosphere system (CGCMs) exhibit serious systematic errors in the simulation of such climates. The models produce too warm sea surface temperatures (SSTs), erroneous southeast trade winds, and reduced upwelling and stratocumulus coverage.

The subtropical anticyclones have been studied in the framework of quasi-stationary waves. These waves are stronger in the wintertime Northern Hemisphere and linear models have been applied to gain insight on their generation by orographic and diabatic forcing (Charney and Eliassen 1949; Smagorinsky 1953; Nigam et al. 1986, 1988; Wang and Ting 1999). The linear effects of orography were found to be outweighed by those of diabatic heating, while extratropical heat sources were found to dominate over tropical ones. Quasi-stationary waves in the Southern Hemisphere are relatively weak throughout the year, and linear models perform less well (Valdes and Hoskins 1989; Wang and Ting 1999).

Rodwell and Hoskins (2001, hereafter RH01) presented a different paradigm on the generation and maintenance of the subtropical anticyclones in the warm season. Their arguments are based on a relatively simple atmospheric model forced with heating fields from reanalysis data. RH01 relates the subtropical highs to the monsoon circulations over the adjacent continents (see Fig.1). The equatorward portion of each anticyclone *to the east* of continents is interpreted as the Kelvin wave response to the monsoon heating, with a poleward-flowing low-level jet required for Sverdrup vorticity balance. A Rossby wave response to the monsoon heating over the continent interacting with the midlatitude westerlies produces adiabatic descent *to the west*, where Sverdrup balance demands the existence of an equatorward jet beneath the descent closing off the subtropical anticyclone on its eastern flank. Chen (2003) illustrated these concepts based on observational data. Accordingly, the summertime upper-level anticyclone/low-level heat low that characterizes a monsoon circulation is in spatial quadrature in longitude with ascent on the eastern side and subsidence on the western side over the eastern oceans, where extensive stratocumulus decks develop over cool waters brought to the surface by Ekman pumping associated with the equatorward low-level jet. The stratocumulus decks provide a radiative heat sink to the tropical atmosphere. In this sense, the climates along the eastern flank of the subtropical anticyclones – particularly in the southern Pacific and Atlantic – are tightly coupled atmosphere-ocean-land systems. In the winter season - when convective activity over the continents in the corresponding hemisphere is weak - the consensus is that orographic effects on the trade easterlies and midlatitude westerlies become dominant. The mountains block both the trades impinging on their eastern slope and the midlatitude westerlies impinging on their western slope and consequently induce poleward and equatorward flow closing the highs. Seager et al. (2003) identified air-sea interaction processes as important contributors to the strengthening of the summertime anticyclones in the eastern subtropical oceans. This is due to enhanced surface latent heat flux under subsidence drying, which helps maintain the cool SSTs and the strong SST gradient in the subtropics. They also linked the winter anticyclones to the splitting into individual cells of the subsiding branch of the Hadley circulation by the large-scale orography. The papers by RH01, Seager et al. (2003), and Chen (2003, 2005) have developed a modern consensus on the subtropical highs. Application of their concepts to the southern anticyclones is not straightforward, and a scenario built solely on them is *per force* an incomplete one.

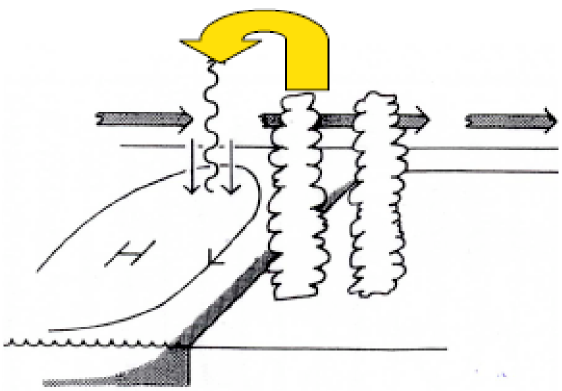

Figure 1. Schematic of connection between monsoons and highs to the west according to RH01 (from K. Nakamura)

Firstly, the arguments on the role of orography during the winter season are particularly pertinent to the South Pacific anticyclone since the Andes along the western coast of South America are high and have strong slopes. The situation is less clear with the South Atlantic anticyclone, since topography in southern Africa is lower and its blocking effect on the zonal flow is weaker and conceptually different (Richter and Mechoso 2004, 2006). Secondly, recent papers suggest important connections between the southern anticyclones and convection in seasons other than the warm season, but they refer to convection in the *Northern* Hemisphere. Richter et al. (2007), using an atmospheric GCM (AGCM), demonstrated that the better simulation of the African and Indian monsoons at their peak in the southern cold season contributes to better localize the South Atlantic anticyclone center in the eastern part of the ocean, consistent with the observation. In the southern spring, recent papers by C. Wang and collaborators (2006, 2010) have emphasized connections between the South Pacific subtropical high and convection over the Atlantic Warm Pool (AWP; warm surface water in regions comprising the Gulf of Mexico, Caribbean Sea, and the western tropical North Atlantic). These papers have demonstrated the establishment of interhemispheric connections through a regional Hadley circulation emanating from the AWP and sinking over the subtropical southeastern Pacific. Such Hadley circulation is strengthened (weakened) by anomalously large (small) AWPs. The interhemispheric connection helps explain why stratus clouds in the southeastern Pacific peak in the southern spring and not in the summer, when the South American monsoon system is in full strength. Thirdly, *equatorial dynamics* may play a larger role in the links between the southern anticyclones and convection over South America and southern Africa since the equator bisects those continental masses. Lastly, in South America and southern Africa the warm season is characterized by strong heat lows to the south of the strong convection. The extent to which such *heat lows contribute to the subtropical highs* is unclear at the present time. Miyasaka and Nakamura (2010, MN10 hereafter) suggested that the combination of low-level heating associated with the heat lows and strong longwave cooling

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over the stratocumulus decks results in sea-level pressure increases over the ocean to the west, thus potentially overlapping with RH01.

2. Goals and objectives of the proposal

The present proposal aims to reconcile different ideas on the generation and maintenance of the southern Atlantic and Pacific highs, gain a better understanding of these important climate features and their variability, and contribute to improve their simulation by CGCMs through identification of reasons for systematic model errors in the tropics. With these goals in mind, we plan to concentrate on four questions in the *framework of the coupled atmosphere-ocean system*:

- *How is the South Atlantic anticyclone during the southern winter connected with the West African and Asian monsoons?*
- *How significant are the interhemispheric influences of the Atlantic Warm Pool on the southeastern Pacific?*
- *In the Southern Hemisphere, do atmospheric-ocean interactions contribute significantly to the links between monsoons and subtropical highs?*
- *Has the recently reported change in the relationship between Atlantic and Pacific Niños affected the variability of the southern subtropical highs?*

The research proposed to answer each one of these questions is described separately in sections 3-6 below. The tools selected for the project (see the Appendix) are the National Center for Atmospheric Research (NCAR) Community Atmospheric Model (CAM) and Community Climate System Model (CCSM) (Collins et al. 2004; McCaa et al. 2004); University of California Los Angeles (UCLA) AGCM and CGCM (Ma et al. 2010a); a steady-state, two-level, linear primitive equation model developed by one of the PIs (Lee et al. 2009); the linear baroclinic model of Watanabe and Kimoto (2002); and a simple atmosphere-ocean coupled model of the tropical Pacific and Atlantic based on Zebiak and Cane (1987) and Zebiak (1993) as provided by S.-K. Lee. The research proposed justifies this model hierarchy. The NCAR models are widely applied in the community to climate studies and further evaluation of their performance will have broad benefits. In the UCLA models special care has been given to the physically-based representation of stratocumulus clouds and the successful representation of their properties and seasonal cycle (Konor et al. 2008). The simple models are appropriate for basic research on the different project components. The project participants are very familiar with all these models.

3. How is the South Atlantic anticyclone during the southern winter connected with the West African and Asian monsoons?

a. Background

In an effort to shed light on the mechanisms that determine the position and strength of the South Atlantic anticyclone in the southern winter, Richter et al. (2007) investigated an AGCM sensitivity to factors such as orography, SST, land surface properties, and model parameterizations. Their work demonstrated the existence of links between intensity and structure of the wintertime South Atlantic anticyclone and the summertime West African and Asian monsoons.

The issue to be examined in this project component is how these interhemispheric links are established. Wang et al. (2010) posed a similar question in their analysis of links between AWP convection and the Southeastern Pacific, and obtained an answer using the NCAR CAM version 3 (CAM3). They also used a simple, steady state, primitive equation, two-level model of the atmosphere linearized about background mean states from the zonally averaged NCEP/NCAR reanalysis between 120°W-40°W during the periods June-August and September-November (Lee et al. 2009). Forcing the simple model with idealized heating fields, they found that barotropic motions are produced near the heating source in the presence of a baroclinic zonal wind component (vertical zonal wind shear), and that such motions propagate to high latitudes in the presence of a barotropic component of the flow.

Figure 2 presents the baroclinic and barotropic components of the stream function response by the simple model of Lee et al. (2009) to the imposed heating in the AWP region during the southern spring. The baroclinic component shows a pair of anticyclones in the northeast and southeast Pacific, with a pattern indicative that Gill's dynamics is at work (e.g. Heckly and Gill 1984). The barotropic component shows a pattern of alternating high and low centers from the AWP across the equator to the high northern and southern latitudes.

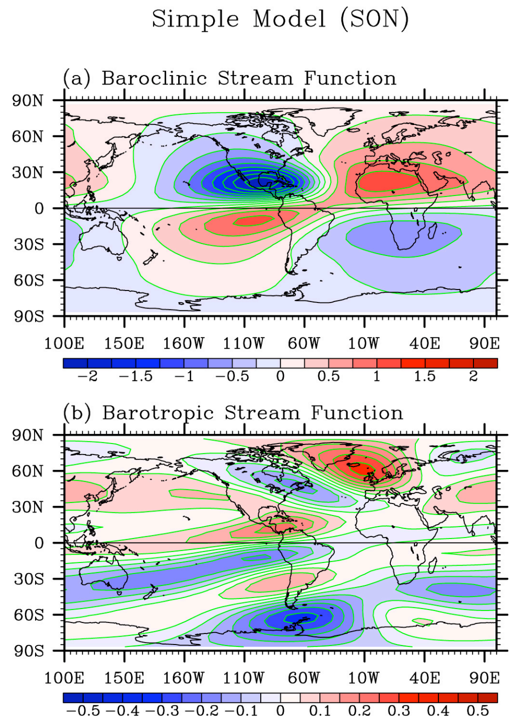

Figure 2: Baroclinic and barotropic stream functions (10^7 m^2/s) in response to a prescribed heating over the AWP region in the period Sep-Nov according to the simple model of Lee et al. (2009).

b. Proposed Research

We propose to investigate the mechanisms for propagation of the heat-induced signals from western tropical Africa and Southeast Asia to the subtropical Atlantic found by Richter et al. (2007), and study their sensitivity to the climatological zonal wind distributions. As in Wang et al. (2010), we will also use the two-level primitive equation model by Lee et al. (2009). The background model fields will be from the NCEP-NCAR reanalysis for June-August. Heating anomalies will be prescribed in the monsoon regions of Africa and Asia.

In the Lee et al. (2009) model, the background baroclinic and barotropic zonal wind distributions are defined as $\hat{U} = (U_1 - U_2)/2$ and $\bar{U} = (U_1 + U_2)/2$, respectively, where the subscripts 1 and 2 denote the upper and lower model layers. We will perform several model experiments with different background winds, including some with either no baroclinic or barotropic components (i.e., $\hat{U} = 0$ or $\bar{U} = 0$) over the Southern Hemisphere. In the AWP case, Wang et al. (2010) found that the background mean zonal winds have little effect on the local baroclinic response to the prescribed heating, but can strongly influence the propagation of barotropic signals. For example, if $\hat{U} = 0$ heat-induced baroclinic anomalies cannot interact with the background vertical wind shear to produce barotropic motions that propagate into the Southern Hemisphere. In addition, if $\bar{U} = 0$ the barotropic motions in the Southern Hemisphere are weak and confined to the low latitudes. We will examine whether the background zonal winds in the southern Atlantic sector are similarly important for the transmission of heating-induced signals to the southern subtropics. The paper by Richter et al. (2007) will provide guidance on the experiments with the simple model. The idealized heating anomaly will be centered around 10°N.

Richter et al. (2007) and Wang et al. (2010) used AGCMs for their research, i.e. they prescribed the time-varying SSTs. We propose to explore the connections in the southern winter between the South Atlantic anticyclone and convection associated with the West African and Asian monsoons *in the presence of atmosphere-ocean interactions*. Seager et al. (2003) and Huang and Shukla (2005) demonstrated the importance of these processes. CGCMs are the natural tools for this research, but these models have serious difficulties with the simulation of the seasonal cycle in the tropical oceans. In particular, it is not unusual for contemporary CGCMs to produce a SST gradient of the wrong sign along the equatorial Atlantic (Davey et al. 2002). A preferable alternative is a research approach based on an AGCM coupled to a slab ocean model (SOM). This procedure excludes ocean dynamics, but Carton at al. (1996) found that SST variability is no longer related to the thermocline depth poleward of about 7.5 S/N. Even for the main modes of variability in the off-equatorial tropical Atlantic, Dommenget and Latif (2000) found no major differences in simulations by a CGCM or an AGCM coupled to a mixed layer model; moreover, the interference between thermodynamic and dynamic coupling in the equatorial region seemed to be constructive. Trzaska et al. (2007) also successfully reproduced observed features of air-sea interactions in the South Atlantic using an AGCM coupled with a SOM.

We will therefore use the NCAR CAM3 either with or without a SOM to further explore whether the remote influence from the Northern Hemisphere is enhanced by changes in the SST underlying the South Atlantic anticyclone. The SOM domain will be confined to the South Atlantic in order to isolate features of air-sea interactions particular to this basin. We will work in both the seasonal ensembles and perpetual-month mode. That is, we will carry out ensemble simulations for a selected season (winter for the Southern Hemisphere) from slightly different boundary conditions or with all boundary conditions including downward short wave radiation at the top of the atmosphere and SST outside the coupled domain fixed to those corresponding to a particular month. A perpetual calendar month simulation is a standard feature of the CAM3 package. The number of ensemble members and length of runs will be such to ensure statistical significance of the results.

Two sets of CAM3 experiments are described in the following paragraphs. Design details may be revised based on our previous experience, and on what we will learn from the results with the simple model. The differences between control and hypothesis-testing experiments will be carefully analyzed.

(i) Control Experiments: In one of these experiments we will select the southern winter (northern summer) season. In the other, we will select the perpetual-July mode.

(ii) Hypothesis-Testing Experiments: In one of these experiments we will select the winter season in both hemispheres. In the other, we will select the perpetual-July mode for the Southern Hemisphere and perpetual-January mode in the Northern Hemisphere. This procedure results in reduced convection over the Northern Hemisphere continents (in its winter season) and replicates the propagation properties of the flow in the Southern Hemisphere (also in winter).

4. How significant are the interhemispheric influences of the Atlantic Warm Pool on the southeastern Pacific?

a. Background

Large-scale subsidence, extensive and persistent stratocumulus clouds, and cold SSTs characterize the southeastern tropical Pacific (SEP). Under the subsidence, surface winds evaporate water vapor from the ocean, but the atmospheric inversion prevents the moist air from rising to significant elevations. A thin layer of stratus or stratocumulus clouds forms at the base of the inversion and shields the ocean surface from solar radiation. The cold SSTs, light precipitation, and extensive stratocumulus cloud cover in the SEP are all integral parts of the inter-hemispheric asymmetry of the eastern tropical Pacific climate (e.g., Mitchell and Wallace 1992; Philander et al. 1996; Ma et al. 1996; Yu and Mechoso 1999).

The South Pacific subtropical high and subsidence over the SEP during the austral summer (boreal winter) are related to the monsoonal heating over South America as discussed in the Introduction to this proposal. During seasons other than the austral summer, however, when convective activity over South America is weaker, it is important to identify processes that can contribute to maintaining the subsidence over the SEP. Richter and Mechoso (2007) demonstrate that the westerly wind impinging on the Andes contributes to sinking along the equatorward sloping isentropes thus promoting subsidence over the SEP. This process must be at work in all seasons since the seasonal cycle of the subtropical jet is relatively weak in the Southern Hemisphere, but the effects might be primarily confined near the coastal region. Wang et al. (2010) posited that interhemispheric influence of the AWP contributes to maintaining the subsidence over the SEP during boreal summer and fall. Using observational data and NCAR community atmospheric model (CAM3) simulations, they presented support for this hypothesis by showing that an anomalously large (small) AWP during the boreal summer/fall results in a strengthened (weakened) regional Hadley-type circulation with enhanced descent (ascent) over the SEP.

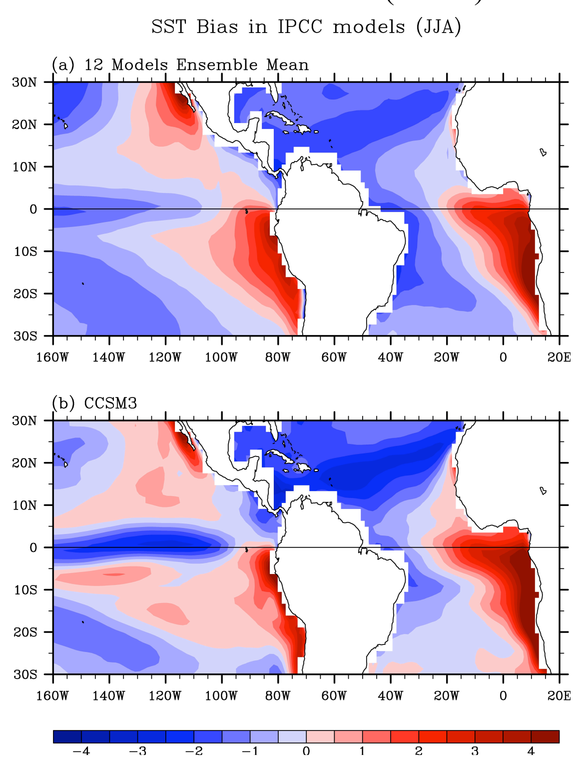

Figure 3. The tropical SST bias (simulated - observed) of IPCC models during boreal summer. The upper panel is from the ensemble average of IPCC models and the lower panel is from CCSM3. The total of twelve IPCC models are used to construct the ensemble mean. All IPCC model data are obtained from "the climate of 20th century" scenario. ERSST2 for the same period (1870-1999) is used for the observation.

The better understanding of subsidence in the eastern tropical oceans of the Southern Hemisphere is a major concern. Studies on the difficulties of CGCMs to properly capture both the eastern tropical Pacific and Atlantic climates have so far neglected consideration of the models success with the AWP and West African monsoon. These features, for example, might be the reason why the large stratocumulus decks in the Southern Hemisphere peak in the *spring* season while their Northern Hemisphere counterparts peak in the *summer* season (Klein and Hartmann 1993) being the latter more affected by the monsoons in the *same* hemisphere. They may also contribute to the well-known regional warm SST bias of 1~3°C and underestimated cloud coverage in the SEP reported by Mechoso et al. (1995), Davey et al. (2002), Deser et al. 2006, and de Szoeke and Xie (2008).

b. Proposed Research

We propose to further explore the interhemispheric influence of the AWP on the SEP beyond what was done by Wang et al (2010). There are three important and practical reasons for doing so. First, the findings in Wang et al. (2010) are based on a model with prescribed SST fields. This is a severe limitation in studies of the tightly coupled climate of the SEP where misrepresentation of atmosphere-ocean interactions is potentially important. Over the SEP, for example, the AGCM cannot answer whether the AWP-induced subsidence provides key contributions to cooling SSTs through the feedback between higher incidence of stratocumulus clouds due to increased lower tropospheric stability (LTS), lower SSTs and further increase of stratocumulus incidence (Klein and Hartmann 1993; Philander et al. 1996). Second, it is well known that almost all state-of-the-art CGCMs have serious difficulties with key variables in the SEP. What is less known is the cold bias of about 1~2^{o}C in the simulations by GCMs of the tropical North Atlantic, as shown in Figure 3 (also Misra et al. 2009). According to Wang et al. (2010) the cold SST bias in the tropical North Atlantic would weaken the regional Hadley-type circulation and associated descent over the SEP. Again, indications of such an important role of the AWP on the SEP would be missed by an AGCM since SSTs in this region would not be affected by the subsidence weakening. Third, AWP variability occurs on seasonal, interannual and multidecadal timescales in addition to long-term trends (Wang et al. 2008). In multidecadal time scale, variability in AWP extent is in phase with the Atlantic Multidecadal Oscillation (AMO). Since the climate response to the North Atlantic SST anomalies is primarily forced at low latitudes, the interhemispheric influence of the AMO on the SEP, if there is any, may operate through the mechanism of the AWP-induced regional Hadley-type circulation changes.

Several important remaining issues, therefore, remain on the subject of interhemispheric influences of the AWP on the SEP. Those issues can be distilled into three specific questions.

(1) How significant is the interhemispheric influence of the AWP on maintaining the South Pacific subtropical high in the austral winter (boreal summer)?
(2) Does the cold tropical Atlantic SST bias contribute to the warm SEP SST bias in CGCMs?
(3) Can the AMO affect the SEP through the AWP-induced regional Hadley-type circulation changes?

A list of model experiments is proposed in the following paragraphs to address these three questions. To bypass the CGCM difficulties mentioned above we will use CAM3 coupled with a slab ocean model and the CCSM3 in a special configuration.

(i) CAM3-SOM Experiments: A number of ensemble experiments will be performed with the CAM3 coupled with a SOM. In one set of experiments, the North Atlantic SSTs in the AWP region will be prescribed using climatological SSTs with and without the AWP feature, whereas SSTs outside of the AWP region are predicted. The AWP can be removed by preventing the SST anywhere inside the AWP region from exceeding 26^{o}C, the threshold SST for deep tropical convection (Wang et al. 2007). By comparing the ensemble experiments with and without the AWP, we will be able to address question (1). In another set of ensemble experiments, the North Atlantic SST will be specified using the observed SST composites for positive and negative phases of the AMO to address question (3).
(ii) CCSM3 Experiments: The CAM3-SOM experiments are aimed to understand the potential of air-sea thermal interactions in the SEP in further enhancing the AWP-induced subsidence over the region through the positive SST low-level cloud feedback (Philander et al. 1996). The next step will be to explore the relative importance of the SEP upper ocean dynamics using CCSM3. In one set of ensemble experiments, we will use the anomaly-coupled CCSM3 to strongly relax

the SSTs in the AWP region to those with and without the AWP. Similarly, in another set of ensemble experiments, the anomaly coupled CCSM3 will be used to strongly relax the North Atlantic SSTs to those of the positive and negative AMO phases. The last set of ensemble experiments is a special one, and is designed to address question (2). In this set we will use the original CCSM3, which has no anomaly-coupling algorithm implemented, with and without relaxing the tropical North Atlantic SSTs toward the observations. The objective of this work is to explore whether correcting the tropical North Atlantic SSTs reduces the warm SEP bias in the original CCSM3.

5. In the Southern Hemisphere, do atmospheric-ocean interactions contribute significantly to the links between monsoons and subtropical highs?

a. Background

We have recently demonstrated using both the UCLA AGCM (prescribed SSTs) and CGCM that the sensitivity of the southern warm season (Dec-Feb) climate to land surface processes is crucial to the successful simulation of the southern monsoon systems (Ma et al. 2010a). The AGCM uses either a simple land scheme (SLS) that specifies soil moisture availability or incorporates the Simplified Simple Biosphere Model (SSiB), which allows for consideration of soil and vegetation biophysical process. The most successful simulation in Ma et al. (2010a) was consistently obtained in the configurations with SSiB, in which continental monsoons are better reproduced both in intensity and pattern.

In the case of the South American monsoon system, improvement with a more advanced representation of land surface processes is not confined to the “hot spot” in Amazonia but extends to the heat low region in subtropical South America (Chaco Low). The regions along the lee of the Andes (South American low-level jet), Amazonia, and Chaco Low are also better simulated. Ma et al. (2010a) argued that the more successful depiction of the Chaco Low, which is controlled by local effects of land surface processes, decisively contributes to the improved model performance in the low-level flows over central South America and moisture transport from the Amazon basin to high latitudes. The better representation of the atmospheric column static stability and large-scale moisture convergence in tropical South America contributes to more realistic precipitation over the core monsoon region. The overall success in the simulation of SAMS with SSiB, therefore, is due to the combination effect of *both* local and non-local processes. This finding is supported by idealized AGCM experiments, in which the representation of surface processes is downgraded in selected region of South America.

Preliminary results with the UCLA CGCM (Ma et al, 2010b) reveal that the improvements are even more dramatic in the coupled atmosphere-ocean context as systematic errors in the tropics that plague such models are reduced with SSiB. The simulated annual mean precipitation and SST are improved, excessive westward extension of the equatorial cold tongue is reduced, and South Pacific Convergence Zone (SPCZ) is better positioned. In the tropical Pacific, the annual harmonic in the seasonal cycle of SST shows better phase and amplitude, and the frequency and amplitude of the interannual variability in SST are more realistic.

These results are qualitatively consistent with the expected influence of weaker continental monsoons on the equatorial Pacific climate found by Fu and Wang (2003) using a coupled atmosphere-ocean model with intermediate complexity. They are also consistent with the expected effects of improved diabatic heating over the continents on the subtropical highs and trade wind distributions. According to RH01 Rossby wave response to the more realistic, weaker monsoon heating over tropical South America with SSiB should result in decreased subsidence over the SEP, which would be less suitable for stratocumulus formation (since SSTs are the same in both runs). The impact expected from the MN10 mechanism is less clear. In the Chaco Low region, low-level heating increases with SSiB, while longwave cooling over the reduced stratocumulus decks may decrease. In addition, the equator bisects South America and strong convection during the warm season extends to very low latitudes. Thus, the South Pacific subtropical high can be more influenced by *equatorial dynamics* than its Northern Hemisphere counterpart. The response to a precipitation reduction near the equator – in reference to the AGCM with SLS - can be estimated from Gill's model of a localized tropical heat source (e. g., Bretherton and Sobel 2003). Accordingly, the impact would include increased trades in the eastern Pacific.

The CGCM results revealed the influence of other processes excluded in AGCMs. Stratocumulus incidence and extent are also better captured in the simulation with SSiB. The change of cloud incidence between the two simulations with SSiB and SLS is consistent with the change in static stability of the lower troposphere, which is defined as the potential temperature difference between 700 hPa and the surface (Klein and Hartman 1993). A close look at the reasons for the static stability difference revealed that it was due **both** to weaker subsidence and warmer SSTs along the Peruvian coastal region in the simulation with SSiB. Hence, atmosphere-ocean interactions strongly influence the results by allowing for establishment of positive feedbacks between stratocumulus and underlying SST. Stratocumulus incidence decreases in the SEP despite of weaker subsidence in the region as static stability of the lower atmosphere weakens primarily due to SST increase.

b. Proposed Research

The research in this project component aims to clarify the role of atmosphere-ocean interaction in the results presented in the previous sub-section and hence throw light on the contribution of coupled-atmosphere ocean processes to the links between monsoon and southern subtropical highs. Our approach will use both observational and reanalysis datasets, and both realistic and idealized simulations by the AGCM and CGCM. We have already completed the control simulations, which are 120 (20)-year long integrations of the CGCM (AGCM) with both SSiB and SLS. The following is a list of numerical experiments to be performed.

(i) CGCM coupled to SSiB globally except in South America *poleward* of 20°S, where the simple land surface scheme will be used. In this experiment (CGCM/SOUTH20S), surface fluxes are degraded in locations that include that of the Chaco Low. The corresponding experiment with the AGCM is already completed.

(ii) CGCM coupling to SSiB is performed everywhere, except over South America *equatorward* of 20°S. In this experiment (CGCM/NORTH20S) surface fluxes are degraded in central Amazonia. As in (i), the corresponding experiment with the AGCM is already completed.

(iii) CGCM coupled to SSiB globally except in the Western Hemisphere, where the simple land surface scheme will be used. In this experiment (CGCM/WEST) surface fluxes are degraded in locations that include those in which the Australian monsoon develops. This is an important case since the upgraded representation of surface processes also affects the simulation of the Australian monsoon and the Walker circulation. In the control simulation with the CGCM, the equatorial trade winds are weaker with SSiB in the central to western Pacific, which results in a more realistic oceanic equatorial thermocline and less exaggerated cold tongue than with SLS. A major improvement in CGCM performance in the tropical Pacific was achieved in this way.

(iv) CGCM coupled to SSiB globally except in the Eastern Hemisphere, where the simple land surface scheme will be used. In this experiment (CGCM/EAST) surface fluxes are degraded in locations that include those in which the West African monsoon develops. This is also an important experiment, which may help understand why the CGCM performs so poorly in the Atlantic.

(v) The experiments corresponding to (iii) and (iv), except with the AGCM (AGCM/WEST and (AGCM/EAST)

The AGCM experiments will be twenty-years long and use prescribed, time-varying, monthly mean SSTs from an observed climatology (Reynolds and Smith 1995). The CGCM experiments will be longer, and their precise duration will be determined by the preliminary results. Ensemble experiments will be carried out depending upon computer resources.

In order to better understand the AGCM and CGCM results, we propose to conduct a parallel investigation using a simpler model in an idealized framework. The linear baroclinic model (LBM) of Watanabe and Kimoto (2000) is very well suited to our objectives. It will be applied to examine the roles of three forcing mechanisms at work in this case, namely the Gill and RH01 Rossby wave responses to the reduced deep convection over the South America, and the MN10 response to the low-level heating over the Chaco Low, and their interactions that contribute to the improved simulation with SSiB of the summertime South Pacific high. The model will be integrated in time until steady state with multiple sets of prescribed diabatic heating profiles associated with the three forcing mechanisms. The heating profiles for the LBM will be obtained from the heating difference between the AGCM and CGCM simulations with SLS and SSiB.

6. Has the recently reported change in the relationship between Atlantic and Pacific Niños affected the southern subtropical highs?

a. Background

The southern subtropical highs are closely linked to tropical atmosphere-ocean dynamics. Diabatic-heating anomalies in the tropics modify the Hadley circulation and trade winds, and excite stationary barotropic Rossby wave trains that propagate into the extratropics (e.g., Karoly 1989; Berbery and Nogués-Paegle 1993; Robertson et al. 2000; Mo and Paegle 2001). Thus, a better understanding of the southern subtropical highs requires examination atmosphere-ocean dynamics in the tropics and its impacts on the extratropics. This brings the focus to El Niño/Southern Oscillation (ENSO) and its variability.

The tropical Pacific and Atlantic oceans host their own “El Niño” events peaking in boreal winter and summer, respectively (Philander 1990; Merle 1980; Zebiak 1993; Latif and Grötzner 2000). Chang et al. (2006) labeled the links between the Pacific and Atlantic El Niño events as “fragile” since they result from “destructive interference” between different mechanisms. The favorable mechanism, referred to as ENSO-Tropical-Warming (ETW), acts as the Pacific Niño induced warming of the entire tropics reduces evaporative cooling at the ocean surface (Chiang and Sobel 2002). The unfavorable mechanism, referred to as Thermocline-Feedback-Cooling (TFC), acts as enhanced trade winds in the Atlantic strengthen equatorial upwelling. What mechanism prevails depends upon the case.

Several recent papers suggest a dramatic change in the Pacific El Niño lead: Since the 1970’s Atlantic Niños seem to lead Pacific Niñas by about six months (Jury et al. 2002; Wang 2002; Melice and Servain 2003; Keenlyside and Latif 2007; Polo et al 2008). Rodriguez-Fonseca et al. (2009; hereafter RF09) present observational evidence of a change in Atlantic-Pacific Niños connection since the late 1960's in such a way that boreal summer Atlantic Niños alter the tropical circulation favouring the development of following-winter Pacific Niñas.

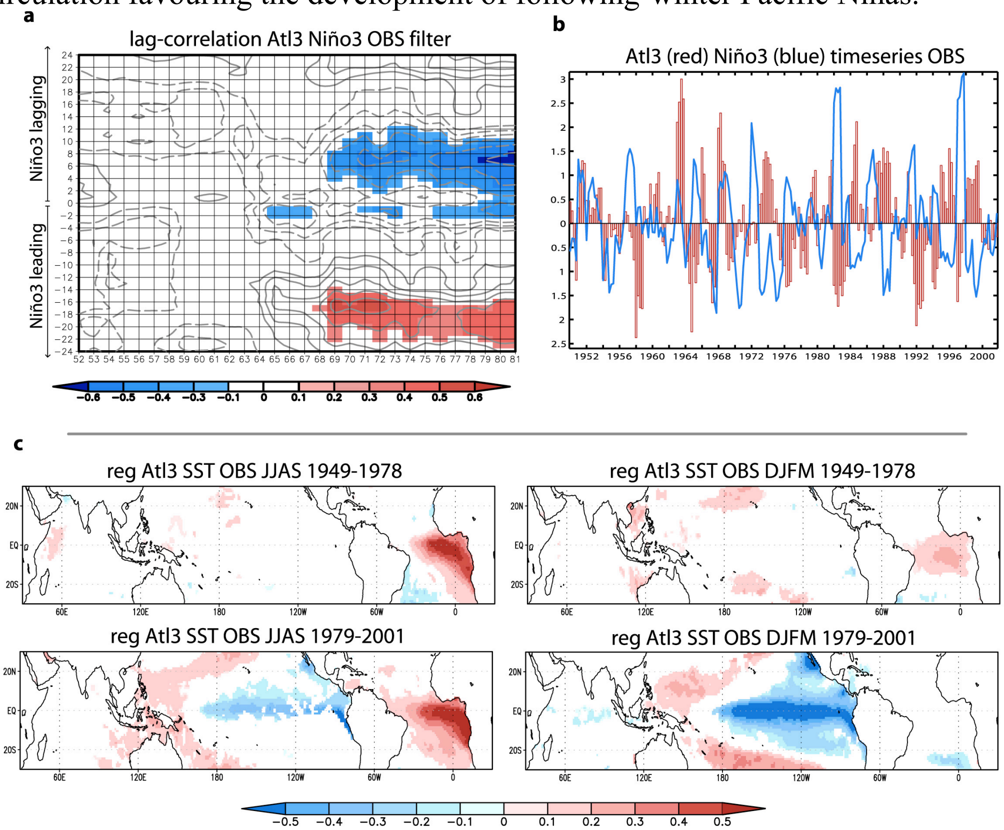

Figure 4. (a) Change in the Atlantic and Pacific Niños connection (RF09). Twenty year lead-lag correlation, running one year from 1952–1972 to 1981–2001, between the observed summer Atl3-index (June-September) and observed Nino3 index, for positive (from 0 to 24 months after summer) and negative (from 0 to 24 months before summer) lags. Only those regions for which the correlation between the Niño3 and the Atl3 index is 95% statistically significant under a t-test for the effective degrees of freedom are shaded. (b) Atlantic and Pacific Niños indexes time series. Observed summer (June-September) Atl3 standardized index (in red bars) and observed winter (December-March) Niño3 standardized index (in blue solid line) time series for the whole period 1950–2001. (c) Tropical Pacific SST response to summer Atlantic Niño for different time-periods. Observed anomalous SST (in °C) regressed onto the boreal summer Atl3 index (top) for the period 1949–1978 and (bottom) for the period 1979–2001, simultaneously (left) in summer and (right) in the following winter. Only those regions for which the correlation between the anomalous SST and the Atl3 index is 95% statistically significant under a t-test for the effective degrees of freedom are shaded.

Figure 4a shows significant negative correlations about 6-8 month lag with Atl3 leading from the late 1960's, in addition to the positive correlations at 12-18 months lag with Niño3 leading. All Pacific ENSO events after the 1960's are preceded by Atlantic events with the opposite sign (Fig. 4b). Before the 1970's, however, regressed maps of Indo-Pacific SST anomalies (Fig. 4c) onto the Atl3 index reveal no apparent relationship with Atlantic Niños in the previous summer (June-September). The presence of significant correlations at negative lags (Pacific leading) and at lag 0 in Fig. 4a is indicative of an influence of the Pacific on the Atlantic, as suggested by Chang et al. (2006) and others, although the precise mechanism responsible for the 12-18 month lag is unclear at the present time. A 6-8 month is reasonable since the Atlantic Niño is in its mature phase in June-September while the Pacific La Niña is in its mature phase in December-February. For positive lags, the correlations increase (from about 0.4 for negative lags to more than -0.6 for positive lags), suggesting that the Atlantic could have an active role in the enhancement of the Pacific ENSO events.

The interbasin links reported in the previous paragraph are supported by a relatively short observational record. Nevertheless, the analyses were performed using sound statistical techniques that support their significance. In addition, even though relations of precedence may vary with climate change, their better understanding will increase our knowledge of the interannual variability of the coupled atmosphere-ocean system. A short length of record is not a difficulty for the CGCM, since ensembles can be performed to address the statistical significance of the results. RF09 performed such ensembles integrations with an AGCM coupled with an OGCM of the tropical Indo-Pacific. The AGCM in RF09 is the International Centre for Theoretical Physics (ICTP), Trieste, Italy, version 40 (Kucharski et al. 2007, 2008), which is a spectral primitive-equation core and a set of simplified parameterization schemes. The OGCM is an extended 1.5 layer reduced-gravity model with a resolution of 2º long. by 1º lat. (Chang et al 1994). This efficient model (usually referred as Speedy) allowed for a validation strategy based on restricting atmosphere-ocean coupling to the Pacific and Indian Oceans and prescribing in the tropical Atlantic SST distributions corresponding to the period 1949 – 2002. In the ensemble simulations, Pacific La Niña events are correlated with previous summer Atlantic Niños after 1970, and not earlier. The correlation holds for all seasons, with maximum coefficients corresponding to the Atlantic Niño lead by 6 months. The mechanism (for the positive Atlantic phase) involves the strengthening of the Walker circulation with ascending branch over the Atlantic and descending branch over the central Pacific, in agreement with Wang (2006). The enhanced surface divergence in the latter region shallows the equatorial thermocline triggering coupled processes, and favouring the development of a Pacific La Niña. RF09 suggested that their results could be related to the reported 60's and 70's climate shifts.

These changes in the relationship between Atlantic and Pacific Niños can affect the variability of the southern subtropical highs through the mechanisms described earlier. In Figure 5, observed SST and SLP anomalies are regressed onto ATL3 index for the period 1949–1978 (left) and for the period 1979–2006 (right), simultaneously (center), with SST and SLP anomalies leading ATL3 by 3 months (top) and lagging by 3 months (bottom). According to Fig. 5, in the 1979-2006 period, the South Atlantic subtropical high weakened and the South Pacific strengthened during an Atlantic Niño. During the 1949-1978 period, the South Atlantic subtropical high also weakened but the South Pacific subtropical high remains practically unaffected during an Atlantic Niño. The recent changes in the relationship between Atlantic and Pacific Niños, therefore, have clearly affected the behavior of the South Pacific subtropical high.

b. Proposed Research

The main issues to be addressed are the mechanisms for connection between the Atlantic and Pacific Niños, the eventual variation of those mechanisms in time, and the impacts on the southern subtropical highs. We will start by verifying the mechanism proposed by Wang et al. (2006, 2009), which is based on feedbacks between the inter-basin SST gradient and the anomalous atmospheric flow across northern South America. Assume that there is a positive SST anomaly in the equatorial Atlantic. (A similar argument could be made starting from a negative SST anomaly in the eastern equatorial eastern Pacific.) The zonal SST gradient between the two equatorial ocean basins would induce a west-to-east pressure gradient in the atmospheric boundary layer (Lindzen and Nigam 1987). These would result in westerly wind anomalies across equatorial South America, which would extend eastward to the equatorial Atlantic further warming its surface through oceanic dynamics (e.g., Zebiak 1993; Carton and Huang 1994). In the Pacific side, the wind anomalies would increase the lower (upper) tropospheric divergence (convergence) in the equatorial eastern/central sector, and thus result in a local strengthening of the anomalous Walker circulation. This strengthening and the Bjerknes positive feedback between wind and SST anomalies would further decrease the SSTs and favor development of a Pacific cold event. Arguments of this type require careful examination since they involve complex feedbacks. Also, they do not consider the ENSO phase. In the recharge oscillator theory of ENSO (Jin 1997) anomalous easterlies in the equatorial Pacific would not trigger a Pacific La Niña unless the system is ready to discharge. In the "delayed oscillator" framework (Schopf and Suarez 1988; Suarez and Schopf 1988) the Atlantic El Niño could influence the ENSO locking to the seasonal cycle by modifying the tropical Pacific climate (Xiao and Mechoso 2009a, 2009b).

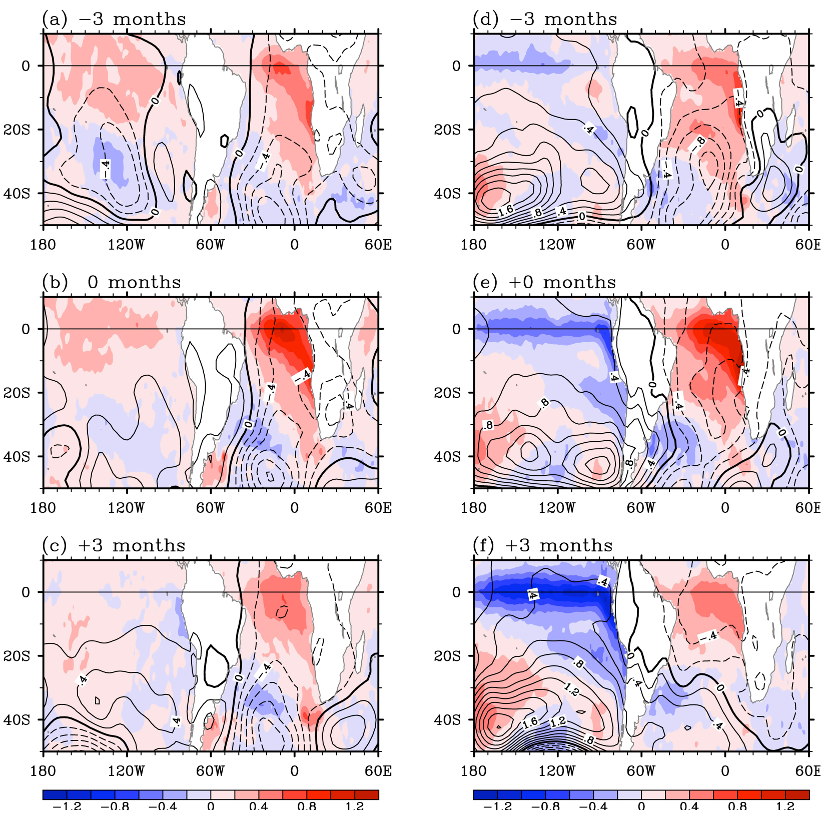

Figure 5. Observed SST and SLP anomalies are regressed onto ATL3 index for the period 1949–1978 (left) and for the period 1979–2006 (right), simultaneously (center), with SST and SLP anomalies leading ATL3 by 3 months (top) and lagging by 3 months (bottom).

The remaining question in the tropics is why the interbasin relationship changed after the 1970's? In this regard, we posit that the different mean states during the opposite phases of the Atlantic Multidecadal Oscillation (AMO) have changed the atmosphere-ocean interactions in the tropical oceans. Interannual variability in the tropics depends on the mean state (Meehl et al. 2001; van Oldenborgh et al. 2005; Wang and An 2002; Guilyardi 2006; Philip and van Oldenborgh 2006). Dong et al. (2006) explored the differences in low-level wind between the positive and negative phase of the AMO. They showed that the trades are reduced in the eastern equatorial Pacific, and increased in both the western equatorial Pacific and western equatorial Atlantic. In the Atlantic side, the increased trade winds uplift the equatorial thermocline favoring development of the zonal mode during the positive phase of AMO. In the Pacific side, the situation is more complex because of the sign change. To include consideration of the different AMO phases our period of study must extend for several decades. Gaining insight on the tropical problem would also help us to formulate concrete hypothesis on the behavior of the southern subtropical highs, which is our long-term objective

To fully investigate these issues, more detailed analyses of experiments such as those performed by RF09, which paid vary little attention to the ocean component, must be carried out. We propose to examine the correlative evolutions, along the equatorial Atlantic and Pacific, of SST, zonal wind stress, thermocline depth, atmospheric heating, and ocean heat content in RF09-type experiments but with a more advanced model (without flux correction), as described later in this section. The model experiments and analyses will focus on understanding in detail the processes during Atlantic Niño events and subsequent Pacific La Niña events. In designing the methodology to be used in the proposed research we carefully considered those used in Chang et al (2006) and RF09. Chang et al. (2006) performs simulations with the CCM3 forced with prescribed time-varying SSTs in the Pacific and with SSTs in the Atlantic that are provided by either 1) seasonally varying climatology, i.e. without interannual variability or any coupled mechanism, 2) a mixed-layer ocean model, i.e. without TFC, and 3) a reduced-gravity ocean model, i.e. with a reduced version of TFC. The technique in RF09 is based on an AGCM coupled to an Indo-Pacific OGCM, as described earlier. These techniques have both merits and demerits. In the Chang et al. (2006) the starting point is the Pacific lead; in RF09, the Pacific variability cannot feedback on the Atlantic. In order to consider an Atlantic lead and allow for Pacific feedbacks we propose to use a full CGCM in Tropical Pacific and Tropical Atlantic configurations, i.e. in which coupling is allowed in either ocean. We must get around, however, the serious difficulties of CGCMs with the simulation of the seasonal cycle in the Atlantic, as discussed above. This we will do by using the "anomaly-coupling" method, which was developed to bypass the contributions of climate drift in CGCM simulations and predictions (Kirtman et al. 1997). The idea is to steer the interface climatology of each CGCM component (atmosphere and ocean) to approximately follow the counterpart in either the observation or in an uncoupled simulation. Here we will take the latter approach, i.e. we will start by determining the uncoupled climatology of each CGCM component using forcings from observational data. In this project component we plan to use the UCLA CGCM version 7.1 as the main tool. (The Appendix describes our implementation of the anomaly-coupling method in the UCLA CGCM.) We will repeat selected experiments using the anomaly-coupled NCAR CCSM version 3 to cross-validate the UCLA CGCM simulations and thus to at least partially address model dependence of results. In order to gain more physical insight the physical processes involving Pacific-Atlantic interactions, we will also use a Zebiak and Cane (1987) type tropical atmosphere-ocean coupled model that is available to us.

A list of model experiments follows.

(i) Verification Experiments. Our first step will be to verify with our CGCM(s) the findings reported by RF09 with the ICTP model. The same simulations will be performed with similar model configuration (i.e. coupling restricted to the Pacific and Indian Ocean basins) and SSTs prescribed in the Atlantic for period 1949-2002.

(ii) Control Experiments. The objective of these control experiments (Control-AGCM and Control OGCM) is to produce the mean seasonal cycle for the runs in the anomaly-coupling mode. Thus, the control experiments will be performed with the CGCM components in the uncoupled mode. Control-AGCM will use the observed SSTs in the period 1949–2007, while Control-OGCM will use surface heat and momentum fluxes for the same period. Each experiment will consist of an ensemble of at least three multi-decadal integrations from slightly different initial conditions.

(iii) Hypothesis-Testing Experiments. The objective of these experiments will be to examine the different elements intervening in the proposed mechanisms for connection between the tropical oceans. The set up will be similar to RF09, with coupling restricted to the Tropical Pacific Ocean with SSTs prescribed elsewhere. In our approach, we will use anomaly-coupling with two sets of climatologies from the Control experiments covering periods for the positive and negative AMO phases (e.g., 1949-1965 and 1970-1995). Each experiment will consist of an ensemble of at least six integrations from slightly different initial conditions.

(iv) Cross-Validation Experiments. The objective of these experiments will be to examine the differences resulting from the assumption of a Pacific lead. The set up will be similar to Chang et al (2006), with coupling restricted to the Atlantic Ocean and SSTs prescribed elsewhere. We will use anomaly-coupling with two sets of climatologies from the Control experiments covering periods both for the positive and negative AMO phases. Again, each experiment will consist of an ensemble of at least six integrations from slightly different initial conditions.

(v) Simple Coupled Model Experiments. The CGCM experiments described above will help us to simulate and analyze the mechanisms that connect the Atlantic and Pacific Niños under different mean states, and also on the relationship between the Atlantic Niño and South Atlantic subtropical high. A simple coupled model will be used to obtain a basic insight on the results of CGCM experiments. The Pacific El Niño model of Zebiak and Cane (1987) will be combined with the Atlantic model of Zebiak (1993). The tropical Indo-Pacific box and tropical Atlantic box regions will be connected through a Gill-type atmosphere, but separated by the South American land mass. We will explore a phase locking mechanism of Pacific and Atlantic Niños under different parameter values including the mean states. For instance, we will examine cases in which the Atlantic Niño is subject to a damped oscillator or a self-sustained oscillator. In the case of damped Atlantic Niño, by adding noise signals with realistic amplitude, we will study if and how externally forced signals in the Atlantic can influence the Pacific El Niño. We will also explore a potential scenario that the observed lagged-correlation between the Pacific El Niño and Atlantic Niño is merely a by-product of Pacific El Niño leading its Atlantic counterpart.

6. Project personnel and work plan

The project is organized as two parallel efforts at UCLA and the Rosentiel School of Marine Sciences/U. Miami. C. R. Mechoso will lead the UCLA effort. Mechoso will be responsible for performing and organizing the analysis of the simulations with the UCLA GCM in its various versions. S.-K. Lee and C. Wang will lead the U. Miami/RSMAS effort, which will be responsible for performing and organizing the analysis of the simulations with the NCAR GCMs. The work with the simple models will be conducted by the graduate students in close coordination with the PIs of both institutions. The team members have been collaborating for several years and have on hand many resources for telecommunication at their institutions.

The budget at UCLA includes support for two graduate students and one summer month for Mechoso. The budget at U. Miami/RSMAS includes support for a part-time postdoc (8-months) and 3-months for S.-K. Lee in years 1 and 2, 5-months for S.-K. Lee in the year 3, and 1-month for a computer technician to help running the NCAR models.

7. Year-by-year summary of proposed work

Year 1: Tasks described in section 3b, both with the simple model of Lee et al. (2009) and NCAR CAM3 with and without the slab ocean model. Experiments described in section 5b with the UCLA GCMs.

Year 2: Experiments described in section 4b with the NCAR GCMs. Completion of tasks in Section 5b with the LBM model. Experiments

Year 3: Experiments described in section 6b both with the UCLA/NCAR GCMs and the simple model of the Cane-Zebiak type.

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Nigam, S., and, I. M. Held, 1988: Linear simulation of the stationary eddies in a GCM. Part II: The ‘‘mountain'' model. *J. Atmos. Sci.,* **45,** 1433–1452.

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Polo, I., B. Rodríguez-Fonseca, T. Losada, and J. García-Serrano, 2008: Tropical Atlantic variability modes (1979-2002). Part I: time-evolving SST modes related to West African rainfall. *J. Climate*, DOI 10.1175/2008JCLI2607.1 In Press.

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Richter, I. and C. R. Mechoso, 2006: Orographic Influences on Subtropical Stratocumulus. *J. Atmos. Sci.* **63**, 2585-2601.

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Rodriguez-Fonseca, B., I. Polo, J. Garcia-Serrano, T. Losada, E. Mohino, C. R. Mechoso, and F. Kucharski, 2009: Are Atlantic Niños enhancing Pacific ENSO events in recent decades? *Geophys. Res. Lett*., **36**, L20705, doi:10.1029/2009GL040048.

Robertson, A.W., C. R. Mechoso, and Y.J. Kim, 2000: The Influence of Atlantic Sea Surface Temperature Anomalies on the North Atlantic Oscillation. *J. Climate,* **13,** 122–138.

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van Oldenborgh, G. J., S. Y. Philip, and M. Collins, 2005: El Niño in a changing climate: A multi-model study, *Ocean Sci*., *1*, 81-95.

Wang, B., and S. I. An, 2002: A mechanism for decadal changes of ENSO behavior: Roles of background wind changes. *Climate Dyn.,* **18,** 475–486.

Wang, C., 2002: Atlantic Climate Variability and Its Associated Atmospheric Circulation Cells. *J. Climate,* **15,** 1516–1536.

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Wang, C., D. B. Enfield, S. -K. Lee, and C. Landsea, 2006: Influences of the Atlantic warm pool on Western Hemisphere summer rainfall and Atlantic hurricanes. *J. Climate*, **19,** 3011-3028.

Wang, C., S. -K. Lee, and D. B. Enfield, 2008: Climate response to anomalously large and small Atlantic warm pools during the summer. *J. Climate*, **21**, 2437–2450.

Wang, C., F. Kucharski, R. Barimalala, and A. Bracco, 2009: Teleconnections of the tropical Atlantic to the tropical Indian and Pacific Oceans: A review of recent findings. *Meteorologische Zeitschrift* (special issue), **18**, 445-454.

Wang, C., S. -K. Lee, and C. R. Mechoso, 2010: Interhemispheric influence of the Atlantic warm pool on the southeastern Pacific. *J. Climate*, **23**, 404-418.

Wang, H., and M. Ting, 1999: Seasonal cycle of the climatological stationary waves in the NCEP–NCAR reanalysis. *J. Atmos. Sci.,* **56,** 3892–3919.

Wang, C., S. -K. Lee and D. B. Enfield, 2007. Impact of the Atlantic Warm Pool on the Summer Climate of the Western Hemisphere . *J. Climate*, **20**(20), 5021-5040.

Wang, C., S. -K. Lee and D. B. Enfield, 2008. Atlantic Warm Pool Acting as a Link between Atlantic Multidecadal Oscillation and Atlantic Tropical Cyclone Activity. *Geochem. Geophys. Geosyst*., **9**, Q05V03, doi:10.1029/2007GC001809. (In the special issue of "Interactions between climate and tropical cyclones on all timescales")

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Watanabe, M., and M. Kimoto, 2000: Atmosphere-ocean coupling in the North Atlantic: A positive feedback. *Quart. J. Roy. Meteor. Soc*., **126**, 3343-3369.

Wood, R, and C. R. Mechoso, 2008: Southeastern Pacific Coupled Climate Field Experiment, EOS Transactions, p. 303, vol. **89**, 33.

Wood R., C. R. Mechoso, C. S. Bretherton, B. Huebert, R. Weller, 2007: The VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS). CLIVAR Variations, **5,** No 1.

Xiao, H. and C. R. Mechoso, 2009a: Correlative Evolutions of ENSO and the Seasonal Cycle. *J. Atmos. Sci.,* **66**, 1041-1049

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Yu, J. -Y., and C. R. Mechoso, 1999: Links between annual variations of Peruvian stratocumulus clouds and of SST in the eastern equatorial Pacific. *J. Climate*, **23**, 305-318.

Zebiak, S.E., and M.A. Cane, 1987: A Model El Niño–Southern Oscillation. *Mon. Wea. Rev*., **115**, 2262–2278.

Zebiak, S. E., 1993: Air–sea interaction in the equatorial Atlantic region, *J. Climate* **6,** 1567–1586.

C. Roberto Mechoso Biographical Sketch

April 2010 (www.atmos.ucla.edu/~mechoso)

C. Roberto Mechoso is Professor of Atmospheric Dynamics in the Department of Atmospheric and Oceanic Sciences at the University of California Los Angeles (UCLA). Mechoso's current research interests are ocean-atmosphere interactions, numerical weather prediction, meteorology aand climatology of the Southern Hemisphere, and high performance computing. He is author of more that 150 scientific publications in his fields of interest. The goal of his research is to increase the understanding of climate variability using analyses of highly realistic simulations with numerical models, complemented by studies with observational data. Targeted topics have been El Niño/Southern Oscillation and its impacts, American monsoon systems, stratospheric warnings, instabilities on atmospheric fronts, and distributing computing for climate modeling.

Professional Preparation

University of Uruguay, Electro-Mechanical Engineering, Engineer 1974; Princeton, University, Geophysical Fluid Dynamics, MA 1977, Ph.D. 1978.

Appointments

Professor of Atmospheric Dynamics, UCLA, since July 1991. Associate Professor of Atmospheric Dynamics, UCLA, July 1986 - June 1991. Assistant Professor of Atmospheric Dynamics, UCLA, July 1981 - June 1986. Adjunct Assistant Professor, UCLA, January 1979 - June 1981. Graduate Student, Princeton University, September 1975 - December 1978. Research Assistant, Geophysical Fluid Dynamics Program, Princeton University, January - August 1975. Lecturer (Fluid Mechanics and Continuum Mechanics), School of Engineering, University of Uruguay, 1968-1974. Directeur de Recherche, Ecole Polytechnique, France, October-November 2000. Distinguished Visitor, Universidad Complutense, Madrid, 2007.

Publications closely related to the proposed project

Mechoso, C. R., A. W. Robertson, N. Barth, M. K. Davey, P. Delecluse, P. R. Gent, S. Ineson, B. Kirtman, M. Latif, H. Le Treut, T. Nagai, J. D. Neelin, S. G. H. Philander, J. Polcher, P. S. Schopf, T. Stockdale, M. J. Suarez, L. Terray, O. Thual and J. J. Tribbia, 1995: The seasonal cycle over the Tropical Pacific in General Circulation Models. *Mon. Wea. Rev.*, **123**, 2825-2838.

Ma, C.-C., C. R. Mechoso, A. W. Robertson and A. Arakawa, 1996: Peruvian stratus clouds and the tropical Pacific circulation - a coupled ocean-atmosphere GCM study. *J. Climate*, **9,** 1635-1645.

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Rodriguez-Fonseca, B., I. Polo, J. Garcia-Serrano, T. Losada, E. Mohino, C. R. Mechoso, and F. Kucharski. 2009: Are Atlantic Niños enhancing Pacific ENSO events in recent decades? *Geophys. Res. Lett.* **36**, L20705, doi:10.1029/2009GL040048.

Wang, C., S. –K. Lee, and C. R. Mechoso, 2010: Inter-Hemispheric Influence of the Atlantic Warm Pool on the Southeast Pacific. *J. Climate*, **23**, 404-418.

Other relevant publications

Robertson, A. W. and C. R. Mechoso, 2000: Interannual and interdecadal variability of the South Atlantic Convergence Zone. *Mon. Wea. Rev*., **128**, 2947-2957.
Yu, J. -Y., and C. R. Mechoso, 2001: A coupled atmosphere-ocean GCM study of the ENSO cycle. *J. Climate*, **14**, 2329-2350.
Richter, I. and C. R. Mechoso, 2006: Orographic influences on subtropical stratocumulus clouds. *J. Atmos. Sci.* 63, 2585-2601.
Xiao, H., and C. R. Mechoso, 2009: Seasonal Cycle-El Niño Relationships: Validation of Hypotheses. *J. Atmos. Sci.* **66,** 1633-1653.
Xue, Y., F. De Sales, R. Vasic, C. R. Mechoso, A. Arakawa, and S. Prince, 2010: Global and temporal characteristics of seasonal climate/vegetation biophysical process interactions. *J. Climate*, **23,** 1411-1433.

Synergistic Activities

Mechoso chairs the Science Working Group of the WCRP/CLIVAR VAMOS-Ocean-Clouds-Atmosphere-Land-Systems (VOCALS) project of the Panel on the Variability of American Monsoon Systems (VAMOS). This is particularly relevant to the proposal since the program focuses on the South Eastern Pacific Climate. Mechoso is a member of International WCRP/ /CLIVAR Scientific Steering Group (SSG) and of the WCRP Drought Interest Working Group.

Collaborators

(i) *Collaborators:* A. Arakawa (UCLA), C. Bretherton (U. Wash.), A. Hall (UCLA), C. S. Konor (USC), J. Schubert (UCLA), R. Walterscheid (Aerospace), R. Wood (U. Wash), C. Wang (RSMAS), Y. Xue (UCLA).
(ii) *Graduate and Postdoctoral Advisors*: I. Orlanski (Geophysical Fluid Dynamics Laboratory, NOAA/Princeton University)
(iii) *Thesis Advisor and Postgraduate-Scholar Sponsor*: M. Chen, L. A. Drummond, J. D. Farrara, J.-H. Jung, K. Hines, A. Kitoh, C. S. Konor, M. Köhler, J.-L. Li, C.-C. Ma, G. Manney, A. Mariotti, I. Richter, A. W. Robertson, D. Sinton, R. Terra, L. Tseng, K. Yamazaki, H. H. Xeng, J.-Y. Yu, L. Zamboni
Number of graduate students advised: 10
Number of postgraduate scholars sponsored: 10

Biographical Sketches

Sang-Ki Lee
Cooperative Institute for Marine and Atmospheric Studies
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149
Phone: (305) 361-4521
Fax: (305) 361-4412
E-Mail: sang-ki.lee@noaa.gov
Web: http://www.aoml.noaa.gov/phod/people/sklee.html

(a) Professional Preparations:

Inha University (South Korea)	Oceanography	B.Sc.	1991
Old Dominion University	Oceanography	M.Sc.	1993
Old Dominion University	Oceanography	Ph.D.	1995
University of Miami	Climate studies	Post-Doc.	2002-2004

(b) Appointments:

2007 - present	Associate Research Scientist, Cooperative Institute for Marine and Atmospheric Studies, University of Miami
2002 - 2007	Assistant Research Scientist, Cooperative Institute for Marine and Atmospheric Studies, University of Miami
2002 - 2004	Postdoctoral Research Associate, Cooperative Institute for Marine and Atmospheric Studies, University of Miami
1996 - 2001	Research Engineer, Maritime Research Institute, Samsung Heavy Industries (South Korea)
1991 -1995	Graduate Research Assistant, Old Dominion University

(c) Publications

Five publications related to the proposed research

Lee, S.-K., D. B. Enfield and C. Wang, 2008. Why Do Some El Ninos Have No Impact on Tropical North Atlantic SST? Geophysical Research Letters, 35, L16705, doi:10.1029/2008GL034734.

Lee, S.-K. and C. Wang, 2008. Tropical Atlantic decadal oscillation and its impact on the equatorial atmosphere-ocean dynamics: A simple model study. Journal of Physical Oceanography, Vol. 38, No. 1, 193-212.

Lee, S.-K., D.B. Enfield and C. Wang, 2007. What drives seasonal onset and decay of the Western Hemisphere Warm Pool?. Journal of Climate, Vol. 20, No. 10, 2133-2146.

Lee, S.-K., D.B. Enfield, C. Wang, 2005. Ocean general circulation model sensitivity experiments on the annual cycle of Western Hemisphere Warm Pool. *J. Geophys. Res.,* 110, doi:10.1029/2004JC002640.

Lee, S.-K., G.T.Csanady, 1999. Warm Water Formation and Escape in the Upper Tropical Atlantic Ocean: Part II. A Numerical Model Study. *J. Geophys. Res*., 104, 29,573-29,590.

Five additional publications:

Lee, S.-K. and C. Wang, 2010. Delayed Advective Oscillation of the Atlantic Thermohaline Circulation. Journal of Climate, 23, 1254-1261.

Wang, C., S.-K. Lee and C. R. Mechoso, 2010. Inter-Hemispheric Influence of the Atlantic Warm Pool on the Southeastern Pacific. Journal of Climate, 23, 404-418.

Wang C. and S.-K. Lee, 2009. Co-variability of Tropical Cyclones in the North Atlantic and the Eastern North Pacific. Geophysical Research Letters, 36, L24702, doi:10.1029/2009GL041469.

DiNezio, P. N., A. C. Clement, G. A. Vecchi, B. J. Soden, B. P. Kirtman, and S.-K. Lee, 2009. Climate Response of the Equatorial Pacific to Global Warming. Journal of Climate, 22, 4873-4892.

Lee, S.-K., C. Wang and B. E. Mapes, 2009. A Simple Atmospheric Model of the Local and Teleconnection Responses to Tropical Heating Anomalies. Journal of Climate, 22, 272-284.

(d) Synergistic activities

Guest editor Progress in Oceanography, "Special issue: Gabriel T. Csanady volume", 2006.

(e) Collaborators & Other Affiliations

Collaborators and Co-Editors:

Brian Mapes (UM/RSMAS); George Halliwell (UM/RSMAS); Carlisle Thacker (NOAA/AOML); Jose Pelegri (CSIC/ICM); John Kroll (ODU)

Graduate Advisor:

Gabriel T. Csanady (retired)

Postdoctoral Advisors:

David B. Enfield (NOAA/AOML), Chunzai Wang (NOAA/AOML), Carlisle W. Thacker (NOAA/AOML)

Graduate students and Postdoctoral-Scholars advised:

Pedro DiNezio (UM/RSMAS), Hailong Liu (UM/RSMAS)

Biographical Sketches

Chunzai Wang
NOAA/AOML
Physical Oceanography Division
4301 Rickenbacker Causeway
Miami, FL 33149
Phone: (305) 361-4325
Fax: (305) 361-4412
E-Mail: Chunzai.Wang@noaa.gov

(a) Professional Preparations:

Ocean University of China	Marine Meteorology	B.Sc.	1995
Oregon State University	Atmospheric Sciences	M.Sc.	1991
University of South Florida	Physical Oceanography	Ph.D.	1982
University of South Florida	Climate studies	Post-Doc.	1995-1997

(b) Appointments:

2000 - present	Oceanographer, NOAA Atlantic Oceanographic and Meteorological Laboratory
1999 - 2000	Associate Scientist, CIMAS/RSMAS, University of Miami
1997 - 1999	Research Associate, College of Marine Science, University of South Florida
1995 - 1997	Postdoctoral Associate, College of Marine Science, University of South Florida

(c) Publications

Five publications related to the proposed research

Wang, C., S.-K. Lee, and C. R. Mechoso, 2010: Inter-hemispheric influence of the Atlantic warm pool on the southeastern Pacific. *J. Climate*, **23**, 404-418.

Wang, C., F. Kucharski, R. Barimalala, and A. Bracco, 2009: Teleconnections of the tropical Atlantic to the tropical Indian and Pacific Oceans: A review of recent findings. *Meteorologische Zeitschrift* (in a special issue), **18**, 445-454.

Wang, C., S.-K. Lee, and D. B. Enfield, 2008: Climate response to anomalously large and small Atlantic warm pools during the summer. *J. Climate*, **21**, 2437–2450.

Wang, C., S.-K. Lee, and D. B. Enfield, 2008: Atlantic warm pool acting as a link between Atlantic multidecadal oscillation and Atlantic tropical cyclone activity. *Geochem. Geophys. Geosyst.*, **9**, Q05V03, doi:10.1029/2007GC001809. (In the special issue of "Interactions between climate and tropical cyclones on all timescales".)

Wang, C., 2006: An overlooked feature of tropical climate: Inter-Pacific-Atlantic variability. *Geophys. Res. Lett.*, **33**, L12702, doi:10.1029/2006GL026324.

Five additional publications:

Wang, C., H. Liu, and S.-K. Lee, 2010: The record-breaking cold temperatures during the winter of 2009/10 in the Northern Hemisphere. *Atmos. Sci. Lett.*, accepted.

Wang, C., and S.-K. Lee, 2010: Is hurricane activity in one basin tied to another? *Eos*, **91** (10), 93-94, doi:10.1029/2009ES002729.

Wang, C., D.B. Enfield, S.-K. Lee, and C.W. Landsea, 2006: Influences of the Atlantic warm pool on Western Hemisphere summer rainfall and Atlantic hurricanes. *J. Climate*, **19**, 3011-3028.

Wang, C., and D. B. Enfield, 2001: The tropical Western Hemisphere warm pool. *Geophys. Res. Lett.*, **28**, 1635-1638.

Wang, C., 2001: A unified oscillator model for the El Niño-Southern Oscillation. *J. Climate*, **14**, 98-115.

(d) Synergistic activities

Editor, Journal of Geophysical Research (Oceans), 2009—Present.
Associate Editor, Journal of Climate, 2006—Present.
AGU Books Board (Representing Ocean Sciences and Climate), 2005—Present.
A member of the NOAA Environmental Modeling Team, 2008—Present.
Modeling group of the CLIVAR/VAMOS/IASCLIP (Intra-Americas Studies of Climate Processes) Program, 2008—Present.

(e) Collaborators & Other Affiliations

Collaborators and Co-Editors:

Annalisa Bracco (Georgia Institute of Technology); Antonietta Capotondi (Univ. of Colorado); Jame Carton (Univ. of Maryland); Mat Collins (Met Office/UK); David Enfield (AOML); Alexey Fedorov (Yale University); Eric Guilyardi (Univ. of Reading/UK); Ben Kirtman (Univ. of Miami); Fred Kucharski (Abdus Salam International Centre for Theoretical Physics/ Italy); Joël Picaut (LEGOS/France); Geert Jan van Oldenborgh (KNMI/Netherlands); Tim Stockdale (ECMWF/UK); Andrew Wittenberg (GFDL); Shang-Ping Xie (Univ. of Hawaii).

Graduate Advisor:

Robert Weisberg (Univ. of South Florida); Jeffrey Barnes (Oregon State Univ.)

Postdoctoral Advisors:

Robert Weisberg (Univ. of South Florida)

Graduate students and Postdoctoral-Scholars advised:

C. Shaji (New York Univ.); Sang-Ki Lee (Univ. of Miami); Ernesto Munoz (Univ. of Miami); Dongxiao Wang (Chinese Science of Academy); Weiqiang Wang (Univ. of Kiel), Hailong Liu (Univ. of Miami)

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **University of California-Los Angeles**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Carlos R Mechoso**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Carlos R Mechoso - PI**	0.00	0.00	1.00	$ 16,411	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	16,411	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (2) GRADUATE STUDENTS				58,396	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				74,807	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,240	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				78,047	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,255	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				1,500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				1,200	
5. SUBAWARDS				0	
6. OTHER				37,192	
TOTAL OTHER DIRECT COSTS				41,147	
H. TOTAL DIRECT COSTS (A THROUGH G)				120,694	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC calcated @ 54% (Rate: 54.0000, Base: 83502)**					
TOTAL INDIRECT COSTS (F&A)				45,091	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				165,785	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 165,785	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Carlos R Mechoso**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION: **University of California-Los Angeles**				FOR NSF USE ONLY		
				PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Carlos R Mechoso**				AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Carlos R Mechoso - PI	0.00	0.00	1.00	$ 17,232	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	17,232	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (2) GRADUATE STUDENTS				61,315	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				78,547	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,402	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				81,949	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,255	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				1,500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				1,200	
5. SUBAWARDS				0	
6. OTHER				37,192	
TOTAL OTHER DIRECT COSTS				41,147	
H. TOTAL DIRECT COSTS (A THROUGH G)				124,596	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC calcated @ 54% (Rate: 54.0000, Base: 87406)**					
TOTAL INDIRECT COSTS (F&A)				47,199	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				171,795	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 171,795	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: **Carlos R Mechoso**	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

TPI 7025858

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY					
ORGANIZATION: University of California-Los Angeles			PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Carlos R Mechoso			AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Carlos R Mechoso - PI	0.00	0.00	1.00	$ 18,093	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	18,093	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (2) GRADUATE STUDENTS				64,382	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				82,475	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,572	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				86,047	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,255	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				1,500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				1,200	
5. SUBAWARDS				0	
6. OTHER				37,192	
TOTAL OTHER DIRECT COSTS				41,147	
H. TOTAL DIRECT COSTS (A THROUGH G)				128,694	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC calcated @ 54% (Rate: 54.0000, Base: 91504)					
TOTAL INDIRECT COSTS (F&A)				49,412	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				178,106	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 178,106	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Carlos R Mechoso	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

TPI 7025858

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION **University of California-Los Angeles**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Carlos R Mechoso**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Carlos R Mechoso - PI	0.00	0.00	3.00	$ 51,736	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	3.00	51,736	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (6) GRADUATE STUDENTS				184,093	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				235,829	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				10,214	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				246,043	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				4,500	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				3,765	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				4,500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				3,600	
5. SUBAWARDS				0	
6. OTHER				111,576	
TOTAL OTHER DIRECT COSTS				123,441	
H. TOTAL DIRECT COSTS (A THROUGH G)				373,984	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				141,702	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				515,686	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 515,686	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $		
PI/PD NAME **Carlos R Mechoso**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

TPI 7025858

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Miami Rosenstiel School of Marine&Atmospheric Sci

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Sang-Ki Lee

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Sang-Ki Lee - Principal Investigator	3.00	0.00	0.00	$ 18,078	$
2. Chunzai Wang - Co-Principal Investigator	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	3.00	0.00	0.00	18,078	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1) POST DOCTORAL SCHOLARS	8.00	0.00	0.00	30,300	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	1.00	0.00	0.00	3,569	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				51,947	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				18,701	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				70,648	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Computer $ 3,000					
TOTAL EQUIPMENT				3,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				2,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				78,648	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 53.5000, Base: 75648)					
TOTAL INDIRECT COSTS (F&A)				40,472	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				119,120	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 119,120	$

M. COST SHARING PROPOSED LEVEL $ 0 — AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Sang-Ki Lee

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

1 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Miami Rosenstiel School of Marine&Atmospheric Sci

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Sang-Ki Lee

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Sang-Ki Lee - Principal Investigator**	3.00	0.00	0.00	$ **19,162**	$
2. **Chunzai Wang - Co-Principal Investigator**	0.00	0.00	0.00	**0**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	3.00	0.00	0.00	**19,162**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**1**) POST DOCTORAL SCHOLARS	8.00	0.00	0.00	**32,118**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	1.00	0.00	0.00	**3,783**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**55,063**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**19,843**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**74,906**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**3,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**2,000**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**2,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**79,906**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 53.5000, Base: 79906)**					
TOTAL INDIRECT COSTS (F&A)				**42,750**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**122,656**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **122,656**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Sang-Ki Lee

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

2 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Miami Rosenstiel School of Marine&Atmospheric Sci

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Sang-Ki Lee

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Sang-Ki Lee - Principal Investigator	5.00	0.00	0.00	$ 33,853	$
2. Chunzai Wang - Co-Principal Investigator	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	5.00	0.00	0.00	33,853	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	1.00	0.00	0.00	4,010	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				37,863	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				13,631	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				51,494	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				2,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				56,494	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 53.5000, Base: 56494)**					
TOTAL INDIRECT COSTS (F&A)				30,224	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				86,718	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 86,718	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Sang-Ki Lee

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

3 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION: University of Miami Rosenstiel School of Marine&Atmospheric Sci				FOR NSF USE ONLY — PROPOSAL NO.	DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Sang-Ki Lee				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Sang-Ki Lee - Principal Investigator	11.00	0.00	0.00	$ 71,093	$
2. Chunzai Wang - Co-Principal Investigator	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	11.00	0.00	0.00	71,093	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (2) POST DOCTORAL SCHOLARS	16.00	0.00	0.00	62,418	
2. (3) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	3.00	0.00	0.00	11,362	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				144,873	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				52,175	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				197,048	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 3,000					
TOTAL EQUIPMENT				3,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				9,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				6,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				6,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				215,048	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				113,446	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				328,494	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 328,494	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Sang-Ki Lee	FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Budget Justification

The project is organized as two parallel efforts at UCLA and the U. Miami's Rosentiel School of Marine Sciences (RSMAS). C. R. Mechoso will lead the UCLA effort. S.-K. Lee and C. Wang will lead the U. Miami/RSMAS effort. The team members have been collaborating for several years and have on hand many resources for telecommunication at their institutions.

The proposed research is extensive, thus we are requesting that the project lasts for a period of three years. The budget is developed from August 1, 2010 to July 31, 2013. Salary requests for U. Miami/RSMAS side include funds for a part-time postdoctoral researcher (8 months), S.-K. Lee (3 months), and a computer programmer (1 month) for years 1 and 2. For the year 3, U. Miami/RSMAS salary requests are for S.-K. Lee (5 months) and a computer programmer (1 month). C. Wang will work on this project for two months per year at no salary cost to the project. All model simulations will be performed using the high performance computing system at NOAA/HPCS, but a personal desktop computer for the postdoctoral researcher is budgeted in the first year. Two domestic trips attending scientific meetings for dissemination of scientific results and collaboration with other scientists is budgeted each year. Publication page charges (1.5 papers per each year) are also budgeted.

Current and Pending Support

UCLA	
The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.	
Investigator: ***C. Roberto Mechoso***	Other agencies (including NSF) to which this proposal has
Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support Project/Proposal Title: To improve modeling, simulation and prediction of the tropical climate with coupled GCMs Source of Support: NOAA - NA07OAR4310236 Total Award Amount: $348,226 Total Award Period Covered: 07/01/07 – 06/30/10 Location of Project: UCLA Person-Months Per Year Committed to the Cal: Acad: Sumr: 1.0	
Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support Project/Proposal Title: *Studies of Waves and Circulation Features in the Antartic Stratosphere Using Vorcore Data* Source of Support: NSF - ATM-073222 Total Award Amount: $461,977 Total Award Period Covered: 10/01/07 – 09/30/10 Location of Project: UCLA Person- Cal: Acad: Sumr: 1.0	
Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support Project/Proposal Title: To improve modeling, simulation and prediction of the tropical climate with the coupled atmosphere-ocean GCMs Source of Support: NOAA Total Award Amount: $444,349 Total Award Period Covered: 06/01/10 – 05/31/13 Location of Project: UCLA Person- Cal: Acad: Sumr: 1.0	

CURRENT AND PENDING SUPPORT – S.-K. LEE

Current

Title:	What Causes the Tropical Atlantic SST Bias in CCSM3?
PI:	S.-K. Lee (Lead PI)
Agency	National Science Foundation
Period:	1 August 2009 – 31 July 2012 (3 years)
Total Amt:	$366,322
Annual Effort	4 months
Location:	University of Miami-CIMAS

Title:	Improving Predictability of the Atlantic Warm Pool in Ocean Model for Assistance to Operational Hurricane Forecast
PI:	S.-K. Lee (Co-PI)
Agency	National Oceanic and Atmospheric Administration
Period:	1 August 2009 – 31 July 2011 (2 years)
Total Amt:	$184,600
Annual Effort	3 months
Location:	University of Miami-CIMAS

Title:	Diagnostic and Modeling Studies on Impacts, Mechanisms and Predictability of the Atlantic Warm Pool
PI:	S.-K. Lee (Co-PI)
Agency:	National Oceanic and Atmospheric Administration
Period:	1 June 2009 – 31 May 2012 (3 years)
Total Amt:	$350,200
Annual Effort:	1 months
Location:	University of Miami-CIMAS

Title:	Predicting the effects of climate change on bluefin tuna (Thunnus thynnus) spawning in the Gulf of Mexico using downscaled climate models
PI:	S.-K. Lee (Co-PI)
Agency	National Oceanic and Atmospheric Administration
Period:	1 April 2010 – 31 March 2011 (1 year)
Total Amt:	$93,345
Annual Effort	1 month
Location:	University of Miami-CIMAS

Title:	The Southern Subtropical Anticyclones (this proposal)
PI:	S.-K. Lee (Lead PI)
Agency	National Science Foundation
Period:	1 August 2010 – 31 July 2013
Total Amt:	$328,494
Annual Effort	3 months for the first two years and 5 months for the third year
Location:	University of Miami-CIMAS

CURRENT AND PENDING SUPPORT – C. WANG

Current

Title:	Diagnostic and Modeling Studies on Impacts, Mechanisms and Predictability of the Atlantic Warm Pool
PI:	C. Wang (Lead PI)
Agency:	National Oceanic and Atmospheric Administration
Period:	1 June 2009 – 31 May 2012 (3 years)
Total Amt:	$350,200
Annual Effort:	2 months
Location:	National Oceanic and Atmospheric Administration - AOML

Title:	Improving Predictability of the Atlantic Warm Pool in Ocean Model for Assistance to Operational Hurricane Forecast
PI:	C. Wang (Lead PI)
Agency	National Oceanic and Atmospheric Administration
Period:	1 August 2009 – 31 July 2011 (2 years)
Total Amt:	$184,600
Annual Effort	1 month
Location:	National Oceanic and Atmospheric Administration - AOML

Title:	What Causes the Tropical Atlantic SST Bias in CCSM3?
PI:	C. Wang (Co-PI)
Agency	National Science Foundation
Period:	1 August 2009 – 31 July 2012 (3 years)
Total Amt:	$366,322
Annual Effort	2 months
Location:	National Oceanic and Atmospheric Administration - AOML

Title:	The Southern Subtropical Anticyclones (this proposal)
PI:	C. Wang (Co-PI)
Agency	National Science Foundation
Period:	1 August 2010 – 31 July 2013
Total Amt:	$328,494
Annual Effort	2 months
Location:	National Oceanic and Atmospheric Administration - AOML

Pending

Title:	Application of Doppler Wind Lidar Observations to Improve Understanding and Prediction of Tropical and Extratropical Weather Systems
PI:	C. Wang (Co-PI)
Agency	The National Aeronautics and Space Administration
Period:	1 August 2010 – 31 July 2015
Total Amt:	$777,000
Annual Effort	2 months
Location:	National Oceanic and Atmospheric Administration - AOML

Facilities and Equipment

• The department maintains a fast (gigabit) network for high data transfer rates and connectivity amongst participating scientists.

• Printers (also for poster printing), scanner, backup facilities.

• The department also supports a full time system administrator and web programmer who provide support for research infrastructure on a limited basis and will assist in the configuration and maintenance of the data server requested for this project.

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.

Laboratory:

Clinical:

Animal:

Computer: A personal desktop computer in budgeted for the post doctoral associate in the first year.

Office:

Other:

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.

Postdoctoral Researcher Mentoring Plan for NSF Proposal

One postdoctoral researcher will be funded for 8-months per year during the first two years of the project. The postdoctoral researcher's development will be enhanced through the well-established program of mentoring activities at the University of Miami (UM). The goal of the mentoring program will be to provide the skills, knowledge and experience to prepare the postdoctoral researcher to succeed in his/her career path. To accomplish this goal, the postdoctoral researcher will be offered, through the school's dedicated Postdoctoral Programs Office, a series of intensive workshops involving a combination of lectures, discussions, readings, written exercises, and practical experiences to enhance his/her professional development. These events include workshops to enhance skills in Scientific Writing, Professional Skills and Ethics and Grant Writing. Specific elements of the mentoring plan will include:

- Working with the postdoctoral researcher to establish and implement a yearly individual development plan based on the process of UM's Rosenstiel School of Marine and Atmospheric Science (RSMAS).
- Seminars and workshops on how to identify research funding opportunities and write competitive proposals, offered by the UM's Postdoctoral Programs Office.
- Participation in a weekly seminar series with invited speakers who are leading scientists in the fields, sponsored by the Meteorology and Physical Oceanography (MPO) division of UM/RSMAS.
- Participation in NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML)'s informal research report seminars, in which all AOML scientists are expected to present their on-going research regularly.
- Participation in NOAA/AOML's visiting scientist seminars, which are offered irregularly at least once a month.
- Opportunities to network with visiting scholars who are leaders in our field by having individual one-on-one meeting and/or lunch/dinner with them when they participate in the UM/RSMAS's MPO weakly seminar series and NOAA/AOML visiting scientist seminars.
- Travel to at least one conference each year [e.g., AGU meeting] (travel funds are included in the budget), with the goal that the postdoctoral fellow presents a poster or oral presentation at the conference.
- Participation in journal clubs for graduate students and postdocs, in which participants meet by-weekly, along with one or more faculty facilitator, to discuss and critique recent journal articles in the field and to discuss how to write and submit journal articles.
- Participation in the weekly research group meetings, in which members will be expected to present their research regularly, and feedback will be given to help all members to develop their communication and presentation skills.
- Participation in NOAA/AOML's summer internship program to enhance his/her mentoring skills for undergraduate students.
- Opportunity to participate teaching both graduate and undergraduate students at UM/RSMAS.

Additionally, the PIs will help and work together with the postdoctoral researcher to produce high-quality scientific papers that list him/her as the first or a co-author. The PIs will also provide feedback on the scientific content and style of all manuscripts prepared by the postdoctoral researcher.

Success of this mentoring plan will be assessed by tracking the progress of the postdoctoral fellow through her/his individual development plan, interviews of the postdoctoral fellow to assess satisfaction with the mentoring program, and tracking of the postdoctoral fellow's progress toward his/her career goals after finishing the postdoc.

Appendix

1. The UCLA CGCM and the Anomaly Coupling Method

The UCLA CGCM configuration to be used in the proposed studies comprises the UCLA AGCM version 7.1 in its configuration with horizontal resolution of 2.5^{o} lon. by 4^{o} lat. and vertical resolution of 29 layers, coupled to the MIT OGCM in its configuration with horizontal resolution of 1° lon. by 0.3° lat. within 10° of the Equator increasing to 1° lat. poleward of 22°N and of 22°S and vertical resolution of 46 levels. The model's code is fully optimized and parallelized.

The atmospheric and oceanic components of the CGCM exchange information at time intervals set at the beginning of the run. The atmospheric component provides cumulative means between coupling instances of surface heat, momentum, and freshwater fluxes; the oceanic component of the CGCM provides the SST. The coupling interval in the model version used in this study is 24 hours. The "anomaly coupling" technique was originally developed in an attempt to minimize the contribution to the CGCM climatological drift by either predicted or simulated errors. The idea is to steer the interface climatology of each model component to approximately follow its counterpart in the observation. The first step in the procedure consists of splitting the field to be passed by each model into two parts 1) the part corresponding to the climatology as obtained in an uncoupled run with forcing from the observation, and 2) the remainder, which is defined as the anomaly. Next, the field to be passed is determined by adding this anomaly to the observed climatology. In short, the climatological parts of the fields exchanged between model components are replaced by those in the observation while leaving the anomalous parts without modification. Kirtman et al. (1997) provide details on the numerical procedure and verification of the method.

A priori, anomalies obtained with our anomaly coupling procedure can have a non-zero projection onto the mean climatology. We have verified *a posteriori* that this projection is negligible in runs experiments we have performed so far. In addition, we did not encounter any technical difficulties using the technique, and "initial shocks" and systematic "climate drifts" produced in the coupled system have been negligible.

2. NCAR Community Atmospheric Model and slab ocean model

The CAM3 is the latest version of a series of NCAR atmospheric GCM evolved from the widely used CCM3. The new features of CAM3 include the option to run with finite-volume dynamics or with semi-Lagrange dynamics while retaining the spectral Eulerian dynamical core as the default. The addition of two dynamic cores allows users to perform comprehensive model sensitivity tests, thus to minimize the model-dependency in climate process studies. The process of deep convection is treated with a plume ensemble scheme of Zhang and McFarlane (1995) and several changes have been made from its previous version in the model physics, such as the treatment of cloud-condensed water, evaporation of convective precipitation and explicit representation of fractional land and sea-ice coverage. See Collins et al. (2004) for details.

The standard CAM3 package includes a slab ocean model (SOM), which enables a fully interactive air-sea thermodynamic feedback essential to our WHWP forcing experiments (to be described in the next section). The ocean mixed layer contains an internal heat source, called a *Q*-flux, whose value is generally specified by a control run. For example, executing a control run using observed SSTs and sea ice distributions, the net surface heat flux over the ocean surface can be evaluated to yield the Q-flux:

$$Q\text{-flux} = \rho c_p H \frac{\partial \bar{T}_{obs}}{\partial t} - \bar{Q}_{net}\,, \tag{A1}$$

where $\bar{T}_{obs}$ is climatological SST, ρ and c_p are water density and specific heat of water, respectively, H is the annual mean mixed layer depth either fixed as a constant or obtained from the Levitus climatology, and $\bar{Q}_{net}$ is the climatological net surface heat flux extracted from the control run. Once the Q-flux is obtained, a coupled run can be executed updating the sea surface temperature using the slab heat budget equation:

$$\frac{\partial T}{\partial t} = \frac{Q\text{-flux} + Q_{net}}{\rho c_p H}\,, \tag{A2}$$

where T is the total mixed layer temperature, and Q_{net} is the net surface heat flux based on net radiative heat flux at the sea surface, air temperature, specific humidity and wind speed at 10m from the sea surface. The Q-flux can be interpreted as a crude representation of oceanic heat transport and heat exchange with deep-ocean that are required by the coupled system to retain a realistic annual cycle of SST. However, it must be prescribed for each coupled run and varies only seasonally, thus it is not an active player in coupled feedbacks. In the current version of CAM3 (version 3.1), the model SSTs must be either fixed with monthly data or computed using a slab ocean model. In order to use the full potential of the two SST schemes, the model code is modified in such a way that the SST can be specified in one geographic region and computed using the slab ocean model in other areas. For a detailed description of the latest CAM3, see Collins et al. (2004) and McCaa et al. (2004). We will perform our model experiments by using three model resolutions: T42 (2.8°×2.8° resolution), T85 (1.4°×1.4° resolution), and the finite volume dynamic core of 2.5°×2° resolution.

3. The NCAR Community Climate System Model version 3 (CCSM3)

CCSM3 is one of the most widely used global-scale climate models. It consists of four dynamical geophysical models (i.e., atmosphere, ocean, land and ice) linked by a central coupler. Each model component contains “active”, “data” and “dead” component versions allowing for a variety of “plug and play” options. The atmosphere, ocean, land and ice components of CCSM3 are the NCAR Community Atmospheric Model (CAM3), the CCSM Parallel Ocean Program (POP), the NCAR Community Land Model (CLM3), and the NCAR Community Sea Ice Model (CSIM5), respectively. CAM3 is the latest version of a series of NCAR atmospheric GCM evolved from the widely used CCM3. The process of deep convection is treated with a plume ensemble scheme of Zhang and McFarlane (1995) and several changes have been made from its previous version in the model physics, such as the treatment of cloud-condensed water, evaporation of convective precipitation and explicit representation of fractional land and sea-ice coverage. POP model is a level-coordinate oceanic GCM derived from earlier Bryan-Cox-Semtner models. POP model solves the three-dimensional primitive equations for fluid motions on the sphere under hydrostatic and Boussinesq approximations. Spatial derivatives are computed using finite-difference discretizations, which are formulated to handle any generalized orthogonal grid on a sphere. More technical details about CCSM3, CAM3, POP, CLM3, and CSIM5 can be found in Vertenstein et al. (2004a and b), Smith and Gent (2004), Collins et al.

(2004), Schramm et al. (2004). We will perform our model experiments using T42 (≈ 2.8°×2.8°) and T85 (≈ 1.4°×1.4°) resolutions for the atmospheric (and land) model. In both cases, the standard "gx1v3" resolution will be used for the ocean and ice models (40 vertical levels for the ocean model, 320 longitudes and 384 latitudes). The "T42_gx1v3" and "T85_gx1v3" resolutions are fully supported in the latest version of CCSM3. The so-called anomaly-coupling scheme of Kirtman et al. (1997) is currently implemented in the U. Miami/RSMAS version of CCSM3. All CCSM3 experiments will be carried out using the anomaly–coupled version.

4. The simple model of Lee et al. (2009)

This is a steady-state two-level primitive equation model, linearized about a specified background flow. Two levels (i.e., 250 mb and 750 mb) are recast as barotropic and baroclinic modes, respectively:

$$\overline{Y} = (Y_1 + Y_2)/2\,, \tag{A3}$$

$$\hat{Y} = (Y_2 - Y_1)/2\,. \tag{A4}$$

Y stands for any variable with subscripts 1 and 2 denoting values at the upper (250 mb) and lower (750 mb) levels, respectively. The baroclinic mode equations are greatly simplified by using the so-called weak temperature gradient approximation (i.e., thermal advection is neglected) following Gill (1980). In this study, the background mean flow is purely zonal and varies only in y-direction. Thus, the barotropic vorticity equation of Lee et al. (2009) can be simplified to:

$$\overline{U}\frac{\partial \overline{\zeta}}{\partial x} + \left(\beta - \frac{d^2\overline{U}}{dy^2}\right)\overline{v} = -r_0\overline{\zeta} + A_0\nabla^2\overline{\zeta} + F_{\overline{\zeta}}\,, \tag{A5}$$

where $\overline{v}$ denotes the barotropic meridional flow anomaly; □ is the barotropic background zonal flow; $\overline{\zeta}$ is the barotropic relative vorticity anomaly; β is the northward gradient of the vertical planetary vorticity; r_0 is the linear momentum damping coefficient for barotropic mode; A_0 is the momentum diffusion coefficient for barotropic mode. $F_{\overline{\zeta}}$ is given as

$$F_{\overline{\zeta}} = \hat{v}\frac{d^2\hat{U}}{dy^2} + \frac{d\hat{U}}{dy}\left(\frac{\partial \hat{u}}{\partial x} + \frac{\partial \hat{v}}{\partial y}\right) - \hat{U}\frac{\partial \hat{\zeta}}{\partial x}\quad, \tag{A6}$$

where $\hat{u}$ and $\hat{v}$ denote the baroclinic zonal and meridional flow anomaly components, respectively; $\hat{U}$ is the baroclinic background zonal flow; $\hat{\zeta}$ is the baroclinic relative vorticity anomaly. $F_{\overline{\zeta}}$ represents forcing terms involving the products of the background vertical shear and baroclinic wind anomalies. These are very important heat-induced forcing terms that produce barotropic flow anomalies, and collectively referred to as Rossby wave source in the literature (e.g., Sardeshmuku and Hoskin 1988). The barotropic disturbances are, however, remained trapped near the tropical heating source if □ ≤ 0. The barotropic background westerly wind (□ > 0) is required to radiate the head-induced barotropic signals to high latitudes [see equation 23 in Lee et al. (2009)].

The baroclinic zonal and meridional momentum equations and thermodynamic equation of Lee et al. (2009) can be rewritten as:

$$\overline{U}\frac{\partial \hat{u}}{\partial x}+\left(\frac{\partial \overline{U}}{\partial y}-f\right)\hat{v}=-\frac{\partial \hat{\phi}}{\partial x}-r_1\hat{u}+A_1\nabla^2\hat{u}+F_{\hat{u}}, \quad \text{(A7)}$$

$$\overline{U}\frac{\partial \hat{v}}{\partial x}+f\hat{u}=-\frac{\partial \hat{\phi}}{\partial y}-r_1\hat{v}+A_1\nabla^2\hat{v}+F_{\hat{v}}, \quad \text{(A8)}$$

$$\gamma\hat{\phi}+c_g^2\left(\frac{\partial \hat{u}}{\partial x}+\frac{\partial \hat{v}}{\partial y}\right)=-Q, \quad \text{(A9)}$$

where $\hat{\phi}$ is the baroclinic geopotential anomaly; f is the Coriolis parameter; r_1 is the linear momentum damping coefficient for baroclinic mode; A_1 is the momentum diffusion coefficient for baroclinic mode; c_g is the internal gravity wave speed; Q is proportional to the mass source (or sink) prescribed at the mid-level, but it should be interpreted as the heat source (or sink). Both and represent baroclinic forcing terms involving the products of the background wind shear and barotropic wind anomalies:

, (A10)

. (A11)

With the specified background zonal flows of and , we can solve the model equations (A3)–(A9) numerically by expressing the prognostic variables as truncated series of spherical harmonics. Since vectors such as horizontal wind fields have multiple values at the poles, the horizontal wind fields are represented in terms of the vertical component of relative vorticity and horizontal divergence prior to applying the numerical solution method. More details on the method of solution are given in Lee et al. (2009).

6. The Linear Baroclinic Model (LBM)

The LBM is the Center for Climate System Research, University of Tokyo/National Institute for Environmental Science (CCSR/NIES) AGCM linearized about a climatological mean basic state (Watanabe and Kimote (2000). Small et al. (2007) successfully used the LBM to study atmospheric responses to heating anomalies associated with the Central American midsummer drought. As in Small et al. (2007), the sigma coordinate LBM will be setup to have 20 vertical levels with orography at T42 resolution. The model will be then integrated in time until steady state with multiple sets of prescribed diabatic heating profiles associated with the three forcing mechanisms.

7. Simple Tropical Atmosphere-Ocean Couple Model for Pacific-Atlantic Basins

The Pacific El Niño model of Zebiak and Cane (1987) will be combined with the Atlantic Niño model of Zebiak (1993). The tropical Indo-Pacific box and tropical Atlantic box regions will be connected through the Gill Atmosphere, but separated by the South American land mass. We will explore a phase locking mechanism of Pacific El Nino and Atlantic Nino under different parameter values including the mean states. For instance, we will explore two cases where Atlantic Nino is subject to a damped oscillator or a self-sustained oscillator. In the case of damped Atlantic Nino, by adding realistic noise signals in the model, we will study if and how externally forced signals in the Atlantic can influence the Pacific El Nino. We will also explore a potential scenario that the observed lagged-correlation between the Pacific El Nino and Atlantic Nino is merely a by-product of Pacific El Nino leading Atlantic Nino. Another simple model of Lee and Wang (2008) will be also used to test a hypothesis that WES feedback in the South Atlantic can influence Atlantic Nino.