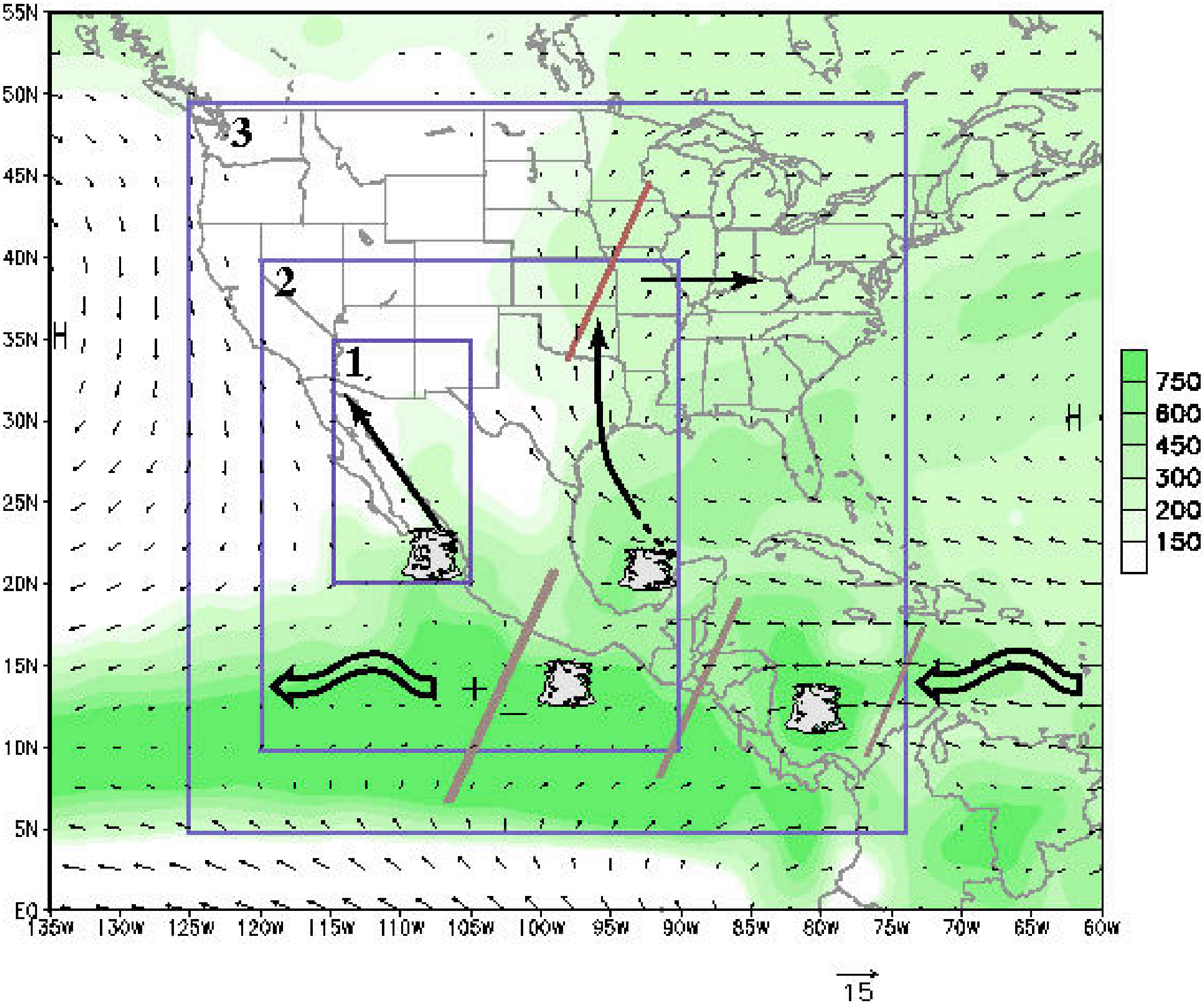

COVER

Schematic illustrating the multi-tiered approach of the North American Monsoon Experiment (NAME). The schematic also shows mean (July-September 1979-1995) 925-hPa vector wind and merged satellite estimates and raingauge observations of precipitation (shading) in millimeters. Circulation data are taken from the NCEP/ NCAR Reanalysis archive.

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Preface

Previous research has demonstrated potential for the prediction of warm season precipitation over North America. Recent advances in the monitoring and modeling of ENSO-precipitation relationships and in the diagnosis and understanding of the role of coupled ocean-atmosphere-land surface interactions in the continental hydrologic cycle have promoted the idea that there is a deterministic element in the year-to-year variability of precipitation, particularly during the cold season. To date, however, the climate community has not been very successful in extending our understanding of these broad precipitation relationships to improved operational prediction of warm season precipitation - this despite new research that has demonstrated potential predictability of warm season precipitation over North America. This is due in part to constraints imposed by our observational database, which is limited in spatial extent and temporal resolution, and which is often not available in real time for use as initial and boundary conditions in climate prediction. These problems are of particular concern over Latin America, where observations are more limited than over the United States.

In this document we develop these concepts more fully, in particular by outlining the science issues associated with gaps in our understanding of the North American Monsoon System (NAMS). Plans for field work that would target those gaps, and result in the improved understanding necessary to advance warm season precipitation prediction are presented. The document emphasizes the interactive combination of ocean-forced atmospheric circulation anomalies and land-atmosphere feedbacks that make climate diagnostics and prediction especially challenging in the NAMS domain. A multi-scale (tiered) approach to the field work is proposed, in which each tier has a specific research focus aimed at determining the sources and limits of warm season precipitation predictability on seasonal-to-interannual timescales. These efforts will benefit from strong links with several CLIVAR-led and GEWEX-led programs whose observations will place these process studies in a broader spatial and temporal context.

This document was compiled by the NAME Science Working Group (SWG), whose members are listed on page 1. This version includes recent progress on the NAME 2004 Enhanced Observing Period (Part 4) and on the NAME Modeling and Data Assimilation strategy (section 3.3). This progress stems in part from several previous NAME SWG planning meetings including Palisades, New York (October 2000), La Jolla, California (October 2001), Washington D.C. (October 2002), Puerto Vallarta, Mexico (November 2003) and Tucson, AZ (April 2004). The NAME Modeling and Data Assimilation Strategy (section 3.3) stems from a NAME Modeling and Data Assimilation Workshop in College Park, MD (June 2003). Additional discussions held at meetings and workshops on the Variability of the American Monsoon System (VAMOS) element of CLIVAR, US CLIVAR Pan American research and the GEWEX America Prediction Project (GAPP) have helped to shape this document. For additional information, the reader is referred to the NAME WWW page at the URL: http://www.joss.ucar.edu/name. Readers are also referred to the Pan American Science Prospectus and Implementation Plan, available at http://www.atmos.washington.edu/gcg/Clivar3/ and the GEWEX America Prediction Project Science Plan and Implementation Strategy.

Summary

The North American Monsoon Experiment (NAME) is an internationally coordinated, joint CLIVAR-GEWEX process study aimed at determining the sources and limits of predictability of warm season precipitation over North America, with emphasis on time scales ranging from seasonal-to-interannual. It focuses on observing and understanding the key components of the North American monsoon system and their variability within the context of the evolving land surface-atmosphere-ocean annual cycle. It seeks improved understanding of the key physical processes that must be parameterized for improved simulation with dynamical models. NAME employs a multi-scale (tiered) approach with focused monitoring, diagnostic and modeling activities in the core monsoon region, on the regional-scale and on the continental-scale. NAME is part of the CLIVAR/VAMOS program, US CLIVAR Pan American research, and the GEWEX America Prediction Project (GAPP).

The scientific objectives of NAME are to promote a better understanding and more realistic simulation of:

- warm season convective processes in complex terrain (Tier 1);
- intraseasonal variability of the monsoon (Tier 2);
- the response of the warm season atmospheric circulation and precipitation patterns to slowly varying, potentially predictable oceanic and continental surface boundary conditions (Tier 3);
- the evolution of the North American monsoon system and its variability.

To accomplish these objectives, planning has proceeded with the intent of developing:

- empirical and modeling studies plus data set development and enhanced monitoring activities that carry on some elements of the existing PACS program and the US CLIVAR/GEWEX Warm Season Precipitation Initiative (2000-2004);
- the NAME 2004 field campaign, including build-up, field, analysis and modeling phases;
- empirical and modeling studies in the joint NOAA CPPA program (2004+).

In addition to significant improvements in short-term climate prediction, NAME will lead to joint international experience with Mexican and Central American scientists in the exploitation of in situ and satellite data, advancements in high-resolution climate models, advancements in the development of the climate observing system, and the production of consistent climate data sets over the Americas.

An online version of the NAME Science and Implementation Plan is available from the NAME WWW page at the URL: http://www.joss.ucar.edu/name/

1. NAME AND ITS SCIENTIFIC OBJECTIVES

1.1 Rationale

State-of-the-art climate models do not accurately represent the spatial distribution and temporal variability of warm season precipitation over North America. There are many processes and feedbacks operating within the atmosphere, at the surface, and below the surface that are not represented in the models. These deficiencies are the motivation for the North American Monsoon Experiment (NAME), an internationally coordinated effort to determine the sources and limits of predictability of warm season precipitation over North America, with emphasis on time scales ranging from seasonal-to-interannual. This goal is motivated by recent advances in our understanding of ENSO-precipitation relationships and of the role of the land surface memory component in the continental hydrologic cycle which, when viewed collectively, suggest a deterministic element in the year-to-year variability of summertime precipitation over North America.

A fundamental and necessary first step towards improving warm season precipitation prediction is the clear documentation of the major elements of the warm season precipitation regime and their variability within the context of the evolving land surface-atmosphere-ocean annual cycle. Monsoon circulation systems, which develop over low-latitude continental regions in response to seasonal changes in the thermal contrast between the continent and adjacent oceanic regions, are a major component of continental warm season precipitation regimes. The North American warm season is characterized by such a monsoon system [hereafter referred to as the North American Monsoon System or NAMS]. The NAMS provides a useful framework for describing and diagnosing warm-season climate controls and the nature and causes of year-to-year variability. A number of studies during the past decade have revealed many of the major elements of the NAMS, including its context within the annual cycle and some aspects of its variability. Its broadscale features and variability are described together with a literature review in Appendix A.

NAME will exploit available and enhanced observations and synthesize these into a complete depiction of the NAMS. A range of models will be used to assess our capability to simulate the evolution of the warm season precipitation regime, its variability and feedbacks. These studies will enhance our physical understanding and identify deficiencies in our observational and modeling capabilities. While there has been considerable progress in recent years, clearly we do not yet have the capability to produce accurate precipitation forecasts during the warm season (particularly on intraseasonal-to-seasonal time scales). This leads to a number of general questions that must be addressed in order to move forward:

- How is the evolution of the warm season (May-October) atmospheric circulation and precipitation regimes over North America related to the seasonal evolution of oceanic and continental boundary conditions?
- What are the interrelationships between year-to-year variations in warm season

boundary conditions, the atmospheric circulation and the warm season precipitation patterns?

- What are the significant features of and interrelationships between the anomaly-sustaining atmospheric circulation and the boundary conditions that characterize large-scale long-lasting continental precipitation (and temperature) anomaly regimes?

- What are the dynamical linkages between the NAMS domain and the larger-scale climate system across North America and nearby oceans on seasonal-to-interannual time scales?

In each of these questions the term "boundary conditions" refers to both the land surface and the oceans. Thus, a question that encompasses each of the above questions is:

- What are the relative roles of remote boundary forcing (particularly tropical Pacific SST), local and regional sea and land surface forcing (e.g. Gulf of California SST and soil moisture) and internal atmospheric dynamics in the seasonal-to-interannual variability of warm season precipitation over North America?

In light of such critical questions, the time has come to introduce a comprehensive program that measures the suite of coupled atmospheric, land surface and oceanic parameters that collectively characterize the warm season precipitation regime and its variability. There are several additional factors indicating that this is an appropriate time for NAME: (1) Several global operational centers (e.g. NCEP and ECMWF) are able to provide consistent large-scale forcing as well as local analyses to support such an effort; (2) the NCEP Regional Reanalysis project and the Land Data Assimilation System (LDAS) products are available; and (3) there is a synergy with several other programs, ongoing and planned, including VAMOS/MESA, PACS, GAPP and CEOP.

1.2 Objectives

It is clear that we do not have the basic understanding of the NAMS required for skillful seasonal-to-interannual predictions of warm season precipitation. NAME is planned to address this lack of understanding. The scientific objectives of NAME are to promote a better understanding and more realistic simulation of:

- warm season convective processes in complex terrain (Tier 1);
- intraseasonal variability of the monsoon (Tier 2);
- the response of the warm season atmospheric circulation and precipitation patterns to slowly varying, potentially predictable oceanic and continental surface boundary conditions (Tier 3);
- the evolution of the North American monsoon system and its variability.

In addition to these scientific objectives, NAME researchers will interact with applications, assessment, and human dimensions researchers on the potential use of NAME science by end users.

Achieving these objectives will require improved empirical and modeling studies of the monsoon system and its variability, sustained observations of the atmosphere, ocean and land and enhanced observations over portions of the core monsoon region, combination of the observations and numerical models through data assimilation, and high-resolution coupled model runs with various combinations of the relevant boundary forcing parameters.

An implementation plan is presented here that includes high intensity process studies to be concentrated within one month, investigations of processes that span the monsoon season or an annual cycle (~4 to 18 months), and monitoring to be sustained for two (or more) years. Specific activities for an enhanced observing period during the summer of 2004 is presented to illustrate that the scientific objectives of NAME can be met. NAME process studies will constitute a multi-scale approach in space and time (Fig. 1). The enhanced observations during the summer of 2004 are focused in the core monsoon region and on the regional-scale, and to a lesser extent on the continental-scale.

The current plan is not meant to be exclusive, and additional field efforts are encouraged. Further extensions of NAME field work are being sought through international collaboration facilitated by VAMOS and US CLIVAR Pan American research.

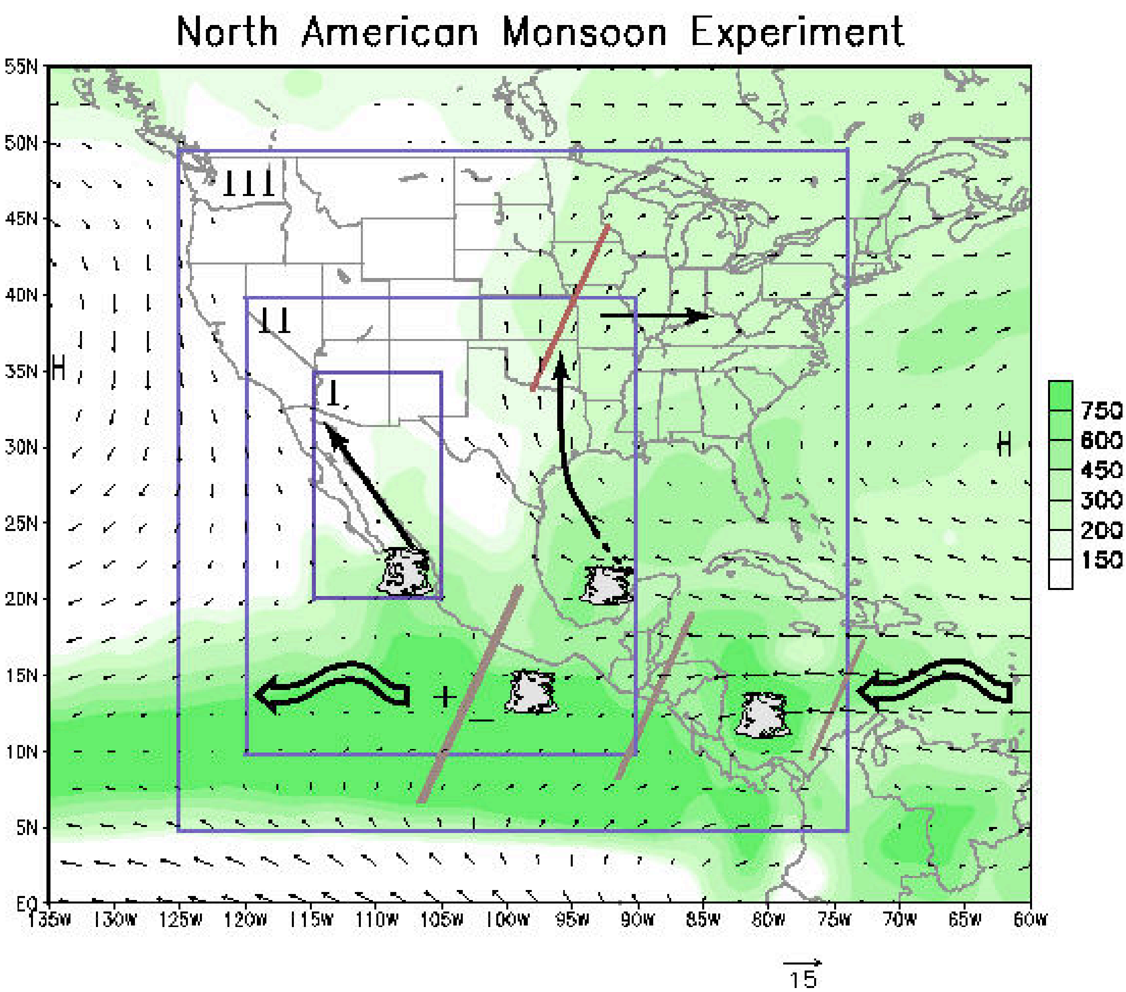


Figure 1. Schematic Illustrating the multi-tiered approach of the North American Monsoon Experiment (NAME). The schematic also shows mean (July-September 1979-1995) 925-hPa vector wind and merged satellite estimates and raingauge observations of precipitation (shading) in millimeters. Circulation data are taken from the NCEP/ NCAR Reanalysis archive.

1.3 Anticipated Benefits and Milestones

The NAME Program will deliver the following:

- Observing system design for monitoring and predicting the North American monsoon system;
- More comprehensive understanding of North American summer climate variability and predictability;
- Strengthened multinational scientific collaboration across Pan America;
- Measurably improved climate models that predict North American monsoon variability months to seasons in advance.

Some milestones that will be used to track progress in operational summer prediction include:

- Benchmark and assess current global and regional model simulations of the North American monsoon (2004);
- Evaluate the impact of additional data from the NAME 2004 field campaign on operational analyses and forecasts (2006);
- Simulate the initiation of regular deep convection (i.e. monsoon onset) to within a week of its observed initiation (2006);
- Simulate the diurnal cycle of observed precipitation to within 20% on a monthly averaged basis (2007);
- Reproduce the magnitude of the observed afternoon peak of latent and sensible heat fluxes to within 20% on a monthly averaged basis (2008)

1.4 Endorsements

NAME is the North American implementation of the WCRP CLIVAR/VAMOS program (the South American implementation is Monsoon Experiment South America or MESA). NAME has been endorsed by the U.S. CLIVAR Scientific Steering Committee as a warm season process study of the North American monsoon under the U.S. CLIVAR Pan American Panel. In addition, NAME is part of the GEWEX Americas Prediction Project (GAPP) Science and Implementation Plan. Finally, NAME has been endorsed by the NOAA/National Weather Service Science and Technology Committee

1.5 NOAA ISIP and CPPA Programs

Recently the NOAA PACS and GAPP programs merged to form the Climate Prediction Program for the Americas (CPPA). CPPA is the research component of the new NOAA Intraseasonal-to-Interannual Prediction (ISIP) program. NAME objectives are closely linked with those of CPPA and hence NAME is the first field campaign to be supported by CPPA. The CPPA interest in NAME is to improve intraseasonal to interannual climate forecasts for the warm season. CPPA will continue to support warm season precipitation diagnostic and modeling studies through NAME after 2004. More information about these programs is found in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session1/Huang2.htm

1.6 GAPP and NAME

The North American Monsoon Experiment (NAME) provides one of the principal operational foci for the implementation of the GEWEX Americas Prediction Project (GAPP) research on warm season precipitation. NAME has a major emphasis on the role of the land surface and the role of the Great Plains and Gulf of California low-level jets. NAME integrates GAPP interests with studies of the role of oceanic forcing of continental climate anomalies, since ocean memory components evolve slowly and are to some degree predictable in their own right, and warm season correlations between SST and continental precipitation are at least marginal. Specific aspects of NAME's contribution to GAPP are discussed in the GAPP Science and Implementation Plan.

NAME research on warm season precipitation will contribute to the North American component of the Coordinated Enhanced Observing Period (CEOP). CEOP and NAME are coherent in terms of timing (2004 is the CEOP second annual cycle period). A key issue for CEOP is an international commitment and cooperation on data collection and exchange. NAME has very strong international collaboration between the US and Mexico, and between both GEWEX and CLIVAR. Other anticipated benefits of a strong NAME-CEOP linkage include joint international experience in the exploitation of new in situ and satellite data; the production of consistent data sets that can act as test beds for the validation of numerical model products and remote sensing data; advancements in coupled model development over land and ocean areas; and advancements in the development of the climate observing system.

1.7 Other Linkages

In addition to linkages discussed in sections 1.4-1.6, NAME will maintain strong ties to:

- Other monsoon-related projects, such as the international CLIVAR VAMOS Monsoon System South America (MESA) program, and CLIVAR/GEWEX sponsored studies of the Asian monsoon systems. These ties will be facilitated greatly through joint research efforts supported by the CPPA program;

- The U.S. and International CLIVAR programs, which are conducting considerable warm season precipitation research over the oceans (e.g. EPIC, VOCALS), complementing GAPP's emphasis on continental precipitation;
- NASA's Global Precipitation Monitoring Project to strengthen long-term precipitation monitoring activities;
- The NOAA RISA programs, which will help NAME ascertain promising targets for enhanced precipitation monitoring, prediction, and information dissemination;
- NRCS and USGS, for more extensive land surface data sets; and
- The DOE ARM program for high-quality data on cloud and radiation variability that would enhance NAME research on warm season precipitation.

2. SCIENTIFIC BASIS FOR NAME

2.1 North American Warm Season Precipitation Regime

Over southwestern North America there is a continental-scale monsoon-like circulation regime that is associated with the summertime precipitation climatology of the region. While some aspects of the seasonally varying climate over the southwest U.S., Mexico and Central America have been well described (see Appendix A for a literature review), others have not. Large-scale patterns of drought and streamflow anomalies have been empirically linked to potentially predictable Pacific SST anomalies on interannual to decadal time scales. Links between the summer monsoon in southwestern North America and summertime precipitation in the Great Plains of the United States may have predictive value at the seasonal time scale.

The structure of the low-level circulations that supply moisture from the tropics along the Gulf of California and from the Gulf of Mexico, the precipitation patterns and associated divergent circulations, and the moisture and energy budgets over the core North American monsoon region remain largely unvalidated and incompletely understood. Dynamical understanding of the seasonal march of rainfall and its variability over Mexico and Central America is incomplete. The meteorological observation and analysis system for this region must be improved to describe and understand relationships among low-frequency anomalies of the warm season precipitation regime and the nature and frequency of significant weather events such as hurricanes and floods.

Precipitation is an intermittent stochastic process. Individual precipitation events occur in association with synoptic, diurnal, and mesoscale atmospheric circulation systems. The number and / or intensity of these events over a month or season can vary substantially from year to year. Part of this time-averaged variability appears to be a response to subtle variations in the distribution of tropical SSTs, but the mid-latitude response to tropical ocean anomalies is regionally and seasonally dependent. Large seasonal-to-interannual variations in the advective moisture supply from the oceans to the North American continent help to govern the warm season precipitation regime.

There is also persuasive evidence that potentially predictable anomalies of soil moisture, snow cover and vegetation may play an important role in the seasonal variability of North American warm season precipitation patterns. Because these land surface anomalies are themselves largely determined by fluctuations of precipitation, it has been suggested that there are important feedbacks between the atmosphere and land surface that can be either positive (in which case climate anomalies are self-sustaining) or negative (self-suppressing). Diagnosis of these feedback pathways will require significant advances in the quality of observations and modeling of the NAMS domain.

2.2 Role of Oceanic Forcing of Continental Climate Anomalies

The land and ocean surface memory components of the climate system evolve more slowly than the individual precipitation-producing circulation systems and are to some degree predictable in their own right (see Appendix A). Prospects for improved prediction on seasonal-to-interannual time scales hinge on the inherent predictability of the system, and our ability to quantify the initial states and forecast the evolution of the surface forcing variables (i.e. SST, vegetation and soil moisture).

The influence of tropical SST anomalies on North American climate is statistically most obvious during the cold season, but warm season correlations between SST and continental-scale precipitation are at least marginal. The climate system exhibits some simplicity in the form of a few phenomena that are the building blocks to progress in climate forecasting. The El Niño/ Southern Oscillation (ENSO) phenomenon is the major source and best understood of these. Climate research has identified several additional oceanic and atmospheric phenomena that establish global climate patterns, including the Pacific Decadal Oscillation (PDO), and the Madden-Julian Oscillation (MJO). The PDO, like ENSO, can cause systematic changes in the large-scale circulation patterns that lead to regional changes in the number and intensity of storms. The MJO, when it is active, dramatically increases the intraseasonal variability in the tropics and subtropics. The relative influences of these modes of variability on the warm season precipitation regime over North America are not well understood.

Recent research has shown that low-frequency variability in U.S. summer rainfall is associated with multidecadal variability in the North Atlantic SST. For example, the North Atlantic warming (roughly 1930-1965) included two of the most well known droughts (the 1930's Dust Bowl and the 1950s drought). The North Atlantic variability is also associated with important changes in the winter correlation patterns between U.S. rainfall and ENSO. Much of our empirical knowledge of ENSO rainfall effects over the U.S. have been obtained during the recent period of North Atlantic cooling (roughly 1969-1994). However, very little is known about how this low-frequency SST variability interacts with the interannual fluctuations of the North American Monsoon.

The role of the Intra-Americas Sea (IAS) region (from roughly 55°W to the Americas, and roughly 5°N to 30°N, i.e., the Caribbean Sea, Gulf of Mexico, Straits of Florida, and adjacent waters of the North Atlantic) in modulating warm season precipitation prediction over North America is uncertain. Of interest to NAME is the possibility for strong interactions between the IAS, the eastern Pacific warm pool region and southwestern North America. In addition, improved warm season precipitation prediction over the U.S. Great Plains may be contingent on a better understanding of the hydrologic cycle of the IAS region. Though the hydrologic cycle of the IAS has not received much attention to date, some of its oceanic and atmospheric components are beginning to come into focus.

2.3 Role of Land Surface-Atmosphere Interactions

The relative importance of the land and ocean influences on North American precipitation changes with the seasons. The influence of the land surface is strongest during the warm season, when the continents are warmer than the surrounding oceans and surface evaporation is large and varies greatly as a function of terrain and vegetative cover. It should be noted that the influence of SST anomalies on cold season precipitation can indirectly affect warm season rainfall, since they play a role in determining the initial springtime soil moisture conditions and vegetative cover, which in turn can feed back upon the climate during the warm months through their influence on surface air temperature and evaporation.

The land surface has many memory mechanisms beyond soil moisture, especially over the western US. Snow extends surface moisture memory across winter and spring. Vegetation in semi-arid regions is a seasonally evolving, interannually variable atmospheric boundary condition that affects momentum transfer, radiation, heat and moisture fluxes.

In addition, aerosols are an important atmospheric constituent in southwestern North America. Circulation is often weak and anthropogenic sources from urban areas attenuate and reflect shortwave radiation. Fires (both natural and man-made) and their associated particulates have pronounced seasonal and interannual variability. Dust is an important factor in the spring and early summer. In addition, there exist large and variable radiative impacts as well as anthropogenically-driven trends in aerosols in the region, which must be understood. For example, what impact would the additional absorption and scattering have on the regional climate?

It is important to recognize that, depending on the variable and the time of the year, the evolution of particular surface forcing variables may not be slow. For example, in western Mexico the vegetation type and fractional vegetation coverage changes dramatically in just a few weeks during the onset of the summer monsoon. Observations from the Oklahoma Mesonet indicate that soil moisture can change dramatically with one heavy rainfall event.

As indicated above, the surface hydrology of western North America plays a fundamental but inadequately understood role in the warm season precipitation regime. The complex terrain and semi-arid conditions of this region stand in stark contrast to the Mississippi Valley which was the focus of the GEWEX Continental-scale International Project (GCIP). For example, in Southwest North America lush natural vegetation exists primarily in narrow strips along the banks of rivers in the middle of arid deserts. A proper characterization of large-scale evapotranspiration must somehow resolve these one-dimensional ribbons of vegetation, which can be much narrower than the typical footprint of an AVHRR-based vegetation scene. Consideration of such questions will make the surface hydrological component of NAME dramatically different than was the case for GCIP, making NAME an excellent complement to GCIP and focus for GAPP.

Soil moisture also varies much differently in the arid NAMS domain compared with the more mesic GCIP region. Soil type and vegetation cover depend strongly on the surface elevation and slope aspect, both of which are tremendously variable over short distances in regions of complex terrain. Runoff is highly channelized. The short duration of most warm season precipitation episodes, combined with intense solar radiation, make for intense but short-lived episodes of surface evaporation following rainstorms. For all of these reasons, the surface hydrology component of NAME will provide a severe test of land surface models and will facilitate the continued progress on these models accomplished in GCIP. More complete and detailed analysis of surface hydrology and soil moisture will be a fundamental component of NAME research.

2.4 Role of Low-Level Jets

The Great Plains low-level jet (GPLLJ) plays a critical role in the summer precipitation and hydrology of the central US while the Gulf of California low-level jet (GCLLJ) contributes to the summer precipitation and hydrology in the southwestern U.S. and Mexico (Fig. 2). Developing a better understanding of both of these jets is of critical importance to NAME.

The GPLLJ transports considerable moisture from the Gulf of Mexico and eastern Mexico into the central US. It is controlled by large-scale dynamics, the strength and size of the energy sources over the Gulf of Mexico and the Intra-Americas Sea, and land surface effects, including vertical motion induced by topography, elevated heat source and dynamic effects over the Rocky Mountains, radiation balances on the land, and temperature contrasts between the land and the Gulf of Mexico. The diabatic effects of land in this regional circulation must be understood and modeled. For example, nocturnal dynamic and thermodynamic factors may be mutually reinforcing, thus contributing to the strength of the moisture convergence into the Mississippi River Basin during the night and early morning.

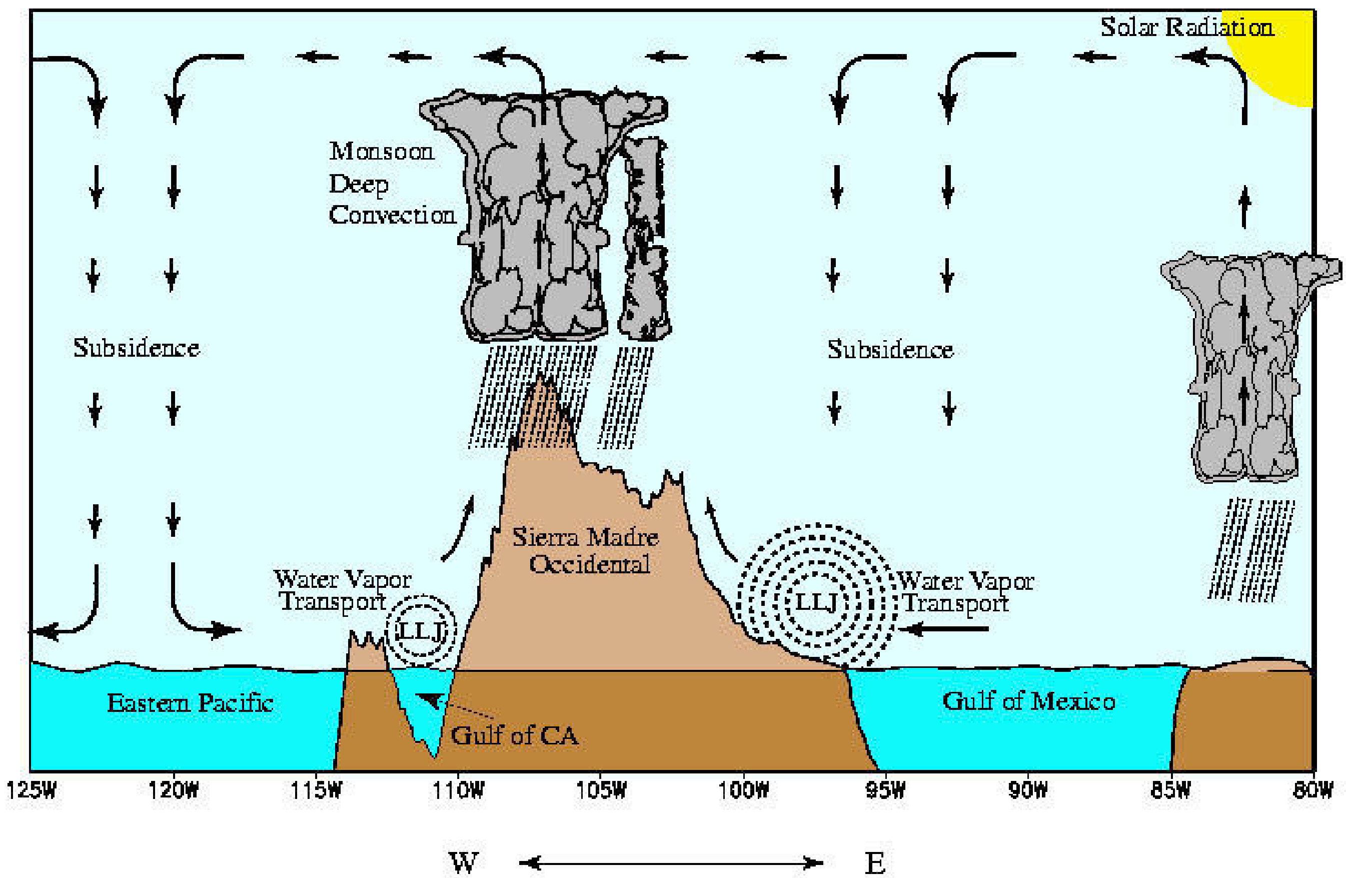


Figure 2. Schematic vertical (longitude-pressure) cross section through the North American Monsoon System at 27.5°N. Topography data was used to establish the horizontal scale and NCEP/NCAR Reanalysis wind and divergence fields were used to establish the vertical circulations.

The GCLLJ is inextricably linked to Tropical Easterly Waves (TEWs) and Gulf of California moisture surge events that play a critical role in the intraseasonal variability of the monsoon along the west coast of Mexico and in the southwest U.S. Most of the moisture in the lower troposphere (below 850-hPa) over the southwestern U.S. (west of the continental divide) arrives with the GCLLJ, while most of the moisture at higher levels arrives from over the Gulf of Mexico. Difficulties in explaining the observed precipitation distribution and its timing, have been due, in part, to the fact that Baja California and the Gulf of California have not been properly resolved in models and reanalyses in the past.

2.5 Links to Applications, Assessment, and Human Dimensions Research

There is an active community of researchers in the NAME region who are undertaking studies on the applications of climate and weather information in the American Southwest, on the sensitivity and vulnerability of people in the region to climate variability, and on the usability of forecasts in the region. An assessment of the impacts, information needs, and issues for policymaking has been made for the U.S. However, the North American Monsoon crosses national boundaries, so any effort to understand its impacts and interactions with society must extend beyond the U.S. southwest. Several institutions focus on these issues in the multinational monsoon region, including the Climate Assessment Project for the Southwest (CLIMAS), based at the University of Arizona, the Western Regional Climate Center, and the international Cooperative Research Networks (CRN) funded by the InterAmericas Institute (IAI).

There is an opportunity for NAME to link to this community and interact to improve the potential of NAME research to address societal needs. This interaction between NAME and applications, assessment, and human dimensions research can contribute to improvements in the flow of climate information from producers to users, and produce experimental products and information specific to identified needs of users in the region.

These research and applications efforts have identified a number of sectors and user groups for whom information is important on summer precipitation and temperature, and the monsoon in particular. These include reservoir managers, fire managers, dryland farmers, ranchers, small agricultural producers, and urban water users. Water scarcity related to climate variability is also important to the rural poor of the region. Surveys conducted with stakeholders in the region provide valuable information about the needs of certain users for information, and including specific lead times, and variations in information needs across the year.

Decision makers' needs and related information pertaining to timing and content of information provision vary greatly from one user to another, often within the same sector. Interaction with NAME researchers will allow applications researchers to further develop and refine calendars for the Southwest, as well as to establish a process for determining what information should be routinely furnished for the Southwest, when and how. Jointly, NAME researchers and applications researchers can contribute to development of climate services for the region, building on NAME research.

Several institutions in the region have a focus on regional studies related to climate variability, and are involved in routine or pilot activities to disseminate climate information to users and evaluate its influence and usability. Since inception in February 1998, CLIMAS has focused on integrating regionally relevant climate and hydrologic research with analysis of stakeholder sensitivities and vulnerabilities to climate and its impacts. CLIMAS has begun to develop a formal mechanism to provide climate services specifically tailored for users in the desert Southwest. Three other institutions have experience with applications studies in the monsoon region: the Desert Research Institute has a long history of arid lands studies; the Western Regional Climate Center has extensive experience with user services; and the NOAA Climate Diagnostics Center has been interacting with users via climate briefings to targeted user communities. In addition, the NOAA Office of Global Programs Economics and Human Dimensions Program has funded a number of studies in the region. In the multinational context of the monsoon, the IAI has funded several collaborative research projects in Mexico and Central America focusing on the impacts of climate variability on disaster risks in the region. These projects, as well as others of the IAI and the International Research Institute for Climate Prediction, could provide opportunities for international collaboration on applications of monsoon information.

3.0 THE NAME PROGRAM

A brief discussion of the general nature of NAME research is followed by a more in depth discussion of NAME research questions and activities.

3.1 Nature of the Research

The NAME objectives will be addressed by a symbiotic mix of diagnostic, modeling and prediction studies together with enhanced observations. This research activity will necessarily be diverse because it seeks to answer scientific questions relating to several different coupled processes and phenomena. However, there is a substantial similarity in the methods that will be used to achieve these objectives.

Diagnostic studies will provide an improved description and understanding of the nature and variability of the NAMS. This includes the identification of spatially and temporally coherent relationships between the land and atmosphere which have implications for prediction, and need to be further explained through subsequent model experiments. Conversely, the model experiments will provide a deeper understanding of dynamic and thermodynamic processes and thus allow a broader interpretation of the empirical results.

As part of its overall effort, the NAME will contribute to the development of improved land surface and hydrologic models as well as improved land-atmosphere coupled models. Ultimately, there is a need to evaluate the ability of coupled models to describe and predict climate and hydrologic variables at regional scales. In general, such tests will require multi-member ensemble experiments with high resolution, coupled models using well-specified observations of atmospheric forcing as model boundary conditions. In regions where the surface forcing of the atmosphere varies on spatial scales of less than a few hundred kilometers, the current resolution of GCMs is inadequate to resolve the detailed variability required for application to water resource problems on the catchment scale. On the other hand, higher resolution regional mesoscale models (RMMs) cannot reflect the full planetary forcing, but can more accurately represent the effects of regional gradients associated with features such as coastlines, orography, land use, soil and vegetation type.

In some cases NAME studies will be "event oriented", i.e. studies "indexed" to the life cycles of specific events. As a consequence, the spatial domain of these studies will necessarily range from mesoscale to continental-scale. Some studies will require a full latitude perspective over the North American sector, from the ITCZ to at least the middle latitude storm track. These studies will be carried out in tandem with land surface model experiments and land data assimilation experiments, and will benefit from multi-year regional reanalyses and retrospective soil moisture analyses.

NAME will develop a variety of basic data sets and data products, which will be distributed primarily from the established data distribution centers (e.g.UCAR/JOSS, NCDC, CDC) and via the data management activities of US CLIVAR Pan American research, CLIVAR/VAMOS and GAPP. Where augmentation is required, it will be accomplished by an expansion of the data management activities of these programs.

3.2 Multi-Scale Framework

A multi-scale (tiered) approach to the analysis, diagnostic and model development activities of NAME is recommended (Fig. 1). NAME will include focused activities in the core monsoon region, on the regional-scale and on the continental-scale, which for convenience are referred to as Tier 1, Tier 2, and Tier 3 respectively. Each tier has a specific research focus aimed at improving warm season precipitation prediction, and activities related to each tier will proceed concurrently. The core monsoon region will include reference networks (e.g. wind profiler / radar and raingauge networks), which are well instrumented regions of small to intermediate scale distributed around the Gulf of California, Baja California and western Mexico. These sites will provide data for climate monitoring, model validation and for research in land area and hydrologic processes. Details of the observing system enhancements recommended for the NAME field campaign are discussed in section 4.4.

In the following, focused research questions for each tier are stated and used to illustrate the nature of the research activity that will be undertaken.

3.2.1 Core Monsoon Region

A primary objective of Tier 1 activities is to resolve the wind, temperature, and moisture fields at fine spatial and temporal scales around the Gulf of California, sufficient to develop stable monthly means during the summer. There is also an emphasis on the synoptic-scale (and regional scale) signal associated with Gulf of California surge events. The principal scientific questions are:

- How are low-level circulations along the Gulf of California / west slopes of the Sierra Madre Occidental related to the diurnal cycle of moisture and convection?
- What is the relationship between moisture transport and rainfall variability (e.g. forcing of surge events; onset of monsoon details)?
- What is the typical life cycle of diurnal convective rainfall? Where along the western slope of the Sierra Madre Occidental is convective development preferred?
- What are the dominant sources of precipitable moisture for monsoon precipitation over southwestern North America?
- What are the fluxes of energy and water from the land surface to the atmosphere across the core monsoon region, and how do these fluxes evolve in time during the warm season?

None of the earlier field campaigns in southwestern North America (e.g. SWAMP 90, EMVER 93) have emphasized the large-scale coupling of the low-level circulations along the Gulf of California to those along the western slopes of the SMO. To anyone who has monitored this region on a daily basis during the warm season, it is clear that this coupling is intimately related to the diurnal cycle of moisture and convection along the western slopes of the SMO and along the Gulf of California. Because the amplitude of the diurnal cycle is regime dependent, it is important to understand the nature of the relationship between the diurnal cycle and the seasonally varying atmospheric circulation and precipitation patterns. The core monsoon region is uniquely suited for studies of the role of the diurnal cycle because it is a region where the amplitude of the diurnal cycle far exceeds the amplitude of the annual cycle.

Most modelers agree that the diurnal cycle, and related processes and feedbacks are poorly represented in models (both RMMs and GCMs). An especially serious problem is the poor coupled model simulations of warm season precipitation over and near tropical and subtropical land areas (e.g. McAvaney 2001) such as the NAME core monsoon region. However, this is true not only over the core monsoon region, but also at most locations over

North America during the warm season (e.g. the southeastern United States). Although indirect estimates of many of the low-level circulation features are provided by satellite remote sensing techniques (e.g. cloud-track winds and the diurnal cycle of cloud cover), these analyses have deficiencies and require calibration. Better documentation of the horizontal and vertical structure of these circulation features and their relationships to convection is critical.

Diagnostic and modeling studies are required to describe and understand the structure of the low-level circulations that supply moisture from the tropics along the Gulf of California, the precipitation patterns and associated divergent circulations, and the moisture and energy budgets over the core North American monsoon region. Available in situ and satellite remote sensing data can be used to help guide these analyses. However, improved data are needed to describe the moisture fluxes over the region with sufficient spatial and vertical resolution to clearly distinguish between different models (meso-Eta, MM5, NCEP reanalyses, etc). This needs to be done over a larger portion of the Gulf of California than has been done in previous field campaigns. There are also large differences between reanalysis moisture fluxes and observed (radiosonde-based) fluxes in the 1000-850 hPa layer in the core monsoon region. For example, the reanalyses would suggest that moisture influx from the tropical pacific is very important in the rains over NW Mexico while observations suggest that this influx is less important.

The meteorological observation and analysis system for the core monsoon region must be enhanced in order to resolve the low-level circulations, the diurnal cycle and the coupling with the earth's surface. Regional mesoscale models and assimilation systems (such as the Eta Model Data Assimilation System (EDAS)) can be used to guide enhanced monitoring activities. Enhancements to the radiosonde and pilot balloon networks over Mexico, the wind profiler / radar network in the core monsoon region, transects of recording raingauges from the Gulf of California to the SMO, automatic meteorological stations (wind, surface air temperature, dewpoint, sea-level pressure, and precipitation), instrumentation (e.g. radiometers) to calculate surface energy budgets and fluxes, and research aircraft operations are recommended during the NAME field campaign (see Part 4 for a scientific justification and details).

High resolution models and analyses are required to examine the separation between water vapor east of the continental divide, which clearly originates from the Gulf of Mexico / Caribbean Sea, and moisture over the Sonoran Desert that appears to originate from the Gulf of California. Additional studies using high-resolution mesoscale models and analyses are needed to describe and understand linkages between the sea breeze / land breeze phenomenon and the intense afternoon and evening precipitation along the west slopes of the SMO and the morning precipitation near the coastline and over the Gulf of California. Modeling studies of the diurnal cycle of convection are also required, in particular, to determine the effects of model resolution and changes in physical parameterizations on precipitation in the core monsoon region.

NAME will exploit GCIP/GAPP experience with MOdel Location Time Series (MOLTS) for model validation and water budget studies. MOLTS are model output at specific locations, such as upper air sounding sites or in situ observation sites. MOLTS have been available since

April 1995 from the NCEP Eta model. Currently, there are ~1200 Eta MOLTS, each of which includes an extensive array of upper air and surface parameters (many of which are not available on the regular Eta grid). Within the framework of the GEWEX Combined Enhanced Observing Period (CEOP), NAME has proposed a few additional MOLTS sites to coincide with the upper air sounding sites in the NAME domain over Mexico and in the Intra-Americas Sea region. We note that many of the upper air sounding sites within the NAME domain are already MOLTS sites, but there are ~25 sites that are not (including the proposed PIBAL sites and the PACS Sonet sites). These data will be used for model validation studies, and for closing regional water budgets (i.e., over the Intra-Americas Sea, Gulf of Mexico or Mexico).

Observations strongly suggest that mean moisture fluxes over the northern Gulf of California (e.g. Puerto Penasco) are larger than over the Central Gulf, near Empalme. This feature is not resolved by current analyses. While it is a relatively small-scale feature in terms of climate considerations, nevertheless it would be a good test of the quality of a data assimilation scheme to reproduce it. It is unclear, however, whether these transports are due to higher winds at Puerto Penasco or a deeper moist layer (which the CEDO radiosonde data from EMVER and other field observations do not suggest). Enhancements to the in situ sounding network around the northern Gulf of California region are needed to answer this question.

An important goal of the NAME field phase is to gather sufficient observations to determine the importance of vegetation-atmosphere feedbacks in moving the precipitation maximum towards the Gulf of California throughout the summer. The pattern of monsoon precipitation evolves from the high peaks of the SMO (June) to the foothills (July) and finally to the coastal areas and southern Baja California (August and September). It is unclear whether this is a response to land-sea thermal contrast (the land cools from June to Sept while the ocean warms) or a response to changes in vegetation. Micro-meteorological measurements and accurate measurements of the land-sea diurnal circulations will be needed to address these question.

Diagnostic studies and coupled model runs, with various combinations of the relevant boundary forcing parameters, are required to determine the relative contributions of Gulf of California SSTs, soil moisture and vegetation to warm season precipitation variability in the core monsoon region. Studies with stand alone hydrological models, using observed and model-calculated forcing, are also required to investigate the influence of topography-dependent precipitation on the hydrological response of watersheds. Multi-member ensemble experiments with high-resolution regional coupled models are also needed for areas with marked topography to calculate topography-dependent precipitation probability distribution functions (PDFs) for validation against observed PDFs.

At present, we know relatively little about land surface conditions and fluxes over most of the NAMS region (Arizona and New Mexico are the exception, although the data is still relatively sparse). Measurements of latent/sensible heat flux and net radiation at strategically located towers would provide the critical information needed to understand how the land surface state evolves throughout the monsoon season. NAME recommends that these towers be co-located with radiosonde stations as part of the enhanced radiosonde network. The surface flux data obtained from the towers would provide important ground truth for more spatially extensive satellite estimates. This is an important step in understanding the coupled land-atmosphere system.

Much of the NAMS domain is characterized by a heterogeneous, highly variable terrain and vegetation. For example, there are many densely vegetated ribbons along rivers (~1 km wide in some places) that may account for a substantial fraction of the evapotranspiration of the region. Characterizing the surface fluxes here is challenging, but critical for understanding and simulating the hydrologic cycle in southwestern North America.

Considering the sparse observing network and the high spatial variability of the land surface across the NAMS domain, the only feasible way to derive comprehensive estimates of land surface characteristics is via satellite estimates. An important goal for NAME will be to motivate improvements in satellite-based characterization of soils and vegetation and associated estimates of sensible and latent heat fluxes. Many operational satellite data products are limited in spatial resolution, a critical problem for NAME. New satellite instruments, such as ASTER on EOS-AM1, promise spatial resolution of 10s of meters. Such resolution will be important for characterization of important hydrological parameters in areas of sharp gradients, e.g. river valleys and mountainous regions.

3.2.2 Regional-Scale

Tier 2 focuses on regional-scale features over southwestern North America and the warm pool region to the southwest of Mexico. The goal of activities in this region is an improved description and understanding of the major factors contributing to intraseasonal variability of the monsoon. The principal scientific questions are:

- How important are interactions between Tropical Easterly Waves and Gulf of California moisture surges in the prediction of monsoon precipitation?

- What is the nature of the relationship between the MJO, tropical cyclone activity and monsoon precipitation?

- What portion of the skill of summer precipitation forecasts, in addition to that already harvested from ENSO, will arise from an ability to forecast MJO activity over a season?

- What is the physical setting for the bimodal distribution (i.e. wet-dry-wet) in warm season precipitation over Mexico and Central America and what factors influence its interannual variability?

It is possible to identify many phenomenological factors that produce variability within a monsoon season on time scales of a few days to a few weeks (e.g. synoptic-scale disturbances, monsoon troughs, mid-latitude effects and quasi-periodic oscillations). NAME will focus on Tropical Easterly Waves (TEWs), Gulf of California moisture surges and their interactions, since these disturbances appear to have a significant influence on monsoon rainfall over a season. A primary focus for NAME will be on the extent to which these influences are predictable.

The role of the MJO in modulating the monsoon, as well as linkages between the MJO, tropical cyclones and monsoon precipitation will be investigated. NAME will also examine the physical mechanisms contributing to interannual variability in active (break) monsoons and the pronounced double peak structure in precipitation over Mexico and Central America.

An important goal of the NAME field phase is to gather sufficient data to determine the importance of gulf surges in transporting moisture up the Gulf. In particular, do they really enhance rainfall in the mean, or do they just rearrange the distribution of rainfall? What larger-scale circulations generate the surges, and through what processes? How are these relevant to climate-scale issues? In addition, diagnostic studies are needed to examine the structure of the TEWs and Gulf of California surge events, their frequency of occurrence, their linkages, and the temporal evolution of the associated moisture transport. Other important issues include the fraction of TEWs that produce Gulf surges, the physical mechanisms responsible for this linkage, and the role of boundary forcing.

Another aspect of the linkages between TEWs and Gulf of California moisture surges that has not been explored systematically is the extent to which they might influence the interannual variability (i.e. onset and intensity) of the monsoon, especially over northwestern Mexico and the southwestern U.S. High resolution mesoscale models and coupled ocean-atmosphere-land models that accurately simulate these disturbances are also needed. In order to be useful, the models must reproduce the common weather characterisitics of these disturbances (e.g. in the case of the moisture surge events this includes a rise in dewpoint temperature, a decrease in the diurnal temperature range, a windshift with an increased southerly wind component, and increased cloudiness and precipitation) which can be validated against in situ and satellite remote sensing data.

The intraseasonal variability of monsoon precipitation over North and Central America is also related to the eastward progression of intraseasonal oscillations (such as the MJO) around the global tropics. Of tremendous practical significance is the fact that there is a coherent relationship between the phase of the MJO and the points of origin of tropical cyclones in the western Pacific, eastern Pacific and Atlantic basins, suggesting that the MJO modulates this activity. The precise nature of this relationship remains elusive. NAME studies will address the following questions:

- How does the phase of the MJO relate to the frequency and intensity of hurricanes and tropical storms in the eastern Pacific and Atlantic basins?

- What fraction of the summer rainfall over the Americas is due to tropical storms and hurricanes?

- Does interannual-to-interdecadal variability of the MJO contribute to tropical cyclone frequency and intensity?

Coastally trapped disturbances that originate from the TEW forcing may provide a conduit between the tropical east Pacific and the mid latitudes through episodic gulf surges. This provides a natural link between EPIC and NAME. Also, since the phase of the MJO seems important in forcing the pre-surge lows in the southern Gulf of California, there is a global and intraseasonal scale aspect to this problem. Thus, there is a natural connection between the NAMS and ENSO, since the latter effects the MJO.

While ENSO-related impacts on the NAMS are reasonably well documented, MJO-related impacts on the NAMS as well as the relative influences of the MJO and ENSO are not well understood. Thus, it is also important to determine the relationships between the MJO, ENSO, and monsoon precipitation. This includes investigations of the regional dependence of ENSO-related and MJO-related impacts on summer rainfall, in particular to determine under what circumstances these impacts are in the same (opposite) sense. Statistical relationships between temporal indices of these modes and the frequency of various kinds of significant weather events (e.g. floods, droughts, heat waves) should be examined to obtain detailed information on the climatic signatures of these modes. This includes studies of the role of Pacific tropical storms, which can contribute a major fraction of annual rainfall to inland areas of Mexico and the southwestern U.S. (in a manner analogous to the Bengal and Arabian cyclones in the Indian monsoon).

Because the relative influences of the MJO and ENSO on the warm season precipitation regime over North America are not well understood, NAME includes a series of empirical predictability studies aimed at determining the fraction of the systematic (i.e. predictable) portion of warm season precipitation variability that arises from knowledge of MJO activity over a season (i.e. both seasonal prediction of aggregate MJO activity and prediction of individual MJO episodes). Results from empirical studies will be used to evaluate the ability of models to simulate intraseasonal aspects of the monsoon circulations and the associated precipitation patterns. By necessity, attention must also be placed on the ability of these models to capture the MJO and its associated impacts.

Diagnostic and modeling studies are required to investigate the role of the ITCZ/cold-tongue complex and the warm pool off the west coast of southern Mexico and Central America in warm season precipitation variability over the core monsoon region. Of particular interest is the evolution of the midsummer drought and the pronounced double peak structure in summer precipitation over Mexico and Central America. The extent to which TEWs influence this evolution is also of interest. New in situ and satellite data sets from EPIC also provide an opportunity to understand and improve the simulation of relationships between SST, surface wind stress, precipitation and cloudiness over the eastern Pacific region.

It is likely that the predictability of monsoon precipitation on intraseasonal time scales is related to the occurrence and evolution of low latitude disturbances (e.g. TEWs, tropical cyclones and the MJO) in the region between the equator and 20°N. In order to properly resolve these features, models must extend to the deep tropics (near the equator) and westward to at least Hawaii. Since 1998 NCEP has archived output from the operational 32-km Eta model on a grid that extends to the equator and westward to Hawaii, though this output has not been available to projects such as GCIP, which relied on the mainline 40-km Eta output grid (known as GRID 212) . NAME recognizes that populating an Eta archive with output from the full domain increases the archive volume. However, building such an archive at full resolution on the output grid (known as GRID 221) will not only serve the scientific objectives of NAME, but will also have broad appeal for many GAPP and VAMOS projects.

3.2.3 Continental-Scale

Tier 3 focuses on aspects of the continental-scale monsoon and its variability. Here the goal is an improved description and understanding of spatial / temporal linkages between warm season precipitation, circulation parameters and the dominant boundary forcing parameters. NAME views the continental-scale Tier as an important framework for collaboration amongst the CLIVAR and GEWEX communities on problems involving the fully coupled ocean-atmosphere-land system. Among the questions that will be addressed by NAME are the following:

- How is the evolution of the warm season precipitation regime over North America related to the seasonal evolution of the boundary conditions?
- What are the interrelationships between year-to-year variations in the boundary conditions (both land surface and adjacent sea surface), the atmospheric circulation and the continental hydrologic regime?
- What are the links, if any, between the strength of the summer monsoon in southwestern North America and summertime precipitation over the central United States?
- Can numerical models reproduce the observed summer precipitation in average years and years with ENSO/PDO influence?
- How much of the seasonal predictability of large-scale warm season precipitation anomalies can be downscaled to local precipitation variability?

- What are the relationships between extreme weather events (e.g. floods, droughts, heat waves, hurricanes), climate variability and long-term trends?

Diagnostic studies that enhance our dynamical understanding of the seasonal march of the monsoon and its variability over Mexico and Central America are critical. An important requirement of the NAME field phase is to gather sufficient data to describe the life cycle of the monsoon (i.e. onset, maintenance and demise), which has never been well described in the past. The regional onset and demise phases are relatively rapid, and can probably be described by the basic sounding network with suitable enhancements (see section 4.4).

Prediction of the detailed distribution of continental precipitation is a challenging task since it requires the skillful modeling of the subtle interplay between land surface and oceanic influences such as the complicating influences of terrain and coastal geometry. While resolution of global models continues to increase with enhancements in computational capability, there is also a need for higher resolution mesoscale models and multi-year assimilated data sets to address the issues above. Previous efforts of CLIVAR (e.g. PACS) and GEWEX (e.g. GCIP) provide a strong foundation for these studies and offer tremendous opportunities for coordination and collaboration. Sufficient observational data are needed to clearly distinguish between the models. This is a primary motivation for the NAME 2004 Enhanced Observing Period (Part 4).

Additional analyses of existing in situ data and satellite remote sensing data sets are required to investigate statistical relationships with boundary forcing parameters (e.g. SST, soil moisture and vegetation cover) and to examine the interannual variability of such relationships. This includes studies that elucidate how the relative importance of the land and ocean influences on North American precipitation change with the seasons. Statistical studies are also needed to search for predictability between observed boundary forcing anomalies and subsequent circulation and precipitation anomalies.

Coupled ocean-atmosphere-land modeling and predictability studies are needed to determine the extent to which links between the summer monsoon in southwestern North America and summertime precipitation in the Great Plains of the United States have predictive value at the seasonal time scale. This includes studies of links between the strength of the summer monsoon and major flood (drought) episodes over the central United States. A critical aspect of this problem is the extent to which energy sources over the Gulf of Mexico / Intra-Americas Sea control GPLLJ variability. Numerous studies have demonstrated a coherent linkage between the GPLLJ and warm season precipitation variability over the U.S. Great Plains. Numerical experiments using coupled models with specified observed boundary conditions (e.g. observed SSTs over the Gulf of Mexico / Intra-Americas Sea; soil moisture over the Great Plains) are required to investigate whether models can reproduce statistically significant predictive relationships. Multi-member ensemble integrations with high-resolution coupled models, with and without interactive boundary forcing, are needed to determine the relative sensitivity of the models to changes in SST -vs- land memory processes.

Assuming that the studies described above are successful, season-long integrations using coupled models are also required to investigate whether such models can successfully simulate the evolution of the boundary conditions as well as the associated warm season climate and hydrologic response at seasonal time scales. This includes average years, and years with significant ENSO/PDO episodes. This also includes investigations of the lagged response, e.g. of the influence of boundary forcing during the preceding winter and spring on the onset and intensity of the subsequent summer monsoon.

Southwestern North America is characterized by complex terrain and correspondingly sharp gradients in vegetation, and warm season precipitation in this region results principally from deep convective thunderstorms. These features of the warm season precipitation regime motivate the need for improved high-resolution modeling. For assessments of predictability, it will be important to ascertain the extent to which the large-scale anomalies that are the customary focus of seasonal predictive efforts are expressed on the smaller scales of importance for land surface hydrology. Skillful downscaling of climate anomalies will be a necessary component of useful seasonal forecasts in this region.

The seasonal forecasting community is beginning to recognize that other effects besides ENSO, i.e. other leading patterns of climate variability (MJO, PDO, AO) and long term trends, impact a season's climate and weather and need to be accounted for. It is increasingly clear that a better understanding of the linkages between weather and climate is needed since many decision making processes are directly tied to weather "events". It is the yet largely unexplained relationships between extreme weather events, climate variability, and long-term trends that are likely to have the most direct impacts on society. A better understanding of these relationships will only come from additional diagnostic studies and numerical experimentation that determine how the leading patterns of climate variability regulate the numbers of daily weather extremes, how changes in daily weather extremes are related to long-term trends, and how climate variability is related to long-term trends. Such studies will serve to focus attention on the physical phenomena that climate variability and climate change models must be able to simulate in order to be deemed credible for use in weather and climate forecasts and assessments. For NAME these studies should emphasize extreme weather events during the warm season (e.g. hurricanes, floods, droughts), though extreme weather events during the cold season are also of interest.

It is the responsibility of agencies such as NOAA to provide the best possible guidance regarding future climate variations and trends. Integrated modeling, i.e. modeling that brings together the climate variability, climate change and weather communities, will serve as the primary tool with which to create the necessary products. Yet at the present time the weather, climate variability and climate change modeling efforts are largely unrelated, for the most part uncoordinated, and hence there is little technology transfer between the efforts. The studies outlined above should demonstrate that linkages between climate variability, climate change and weather extremes are pervasive, and hence that stronger collaboration between the modeling communities is needed. This might include systematic comparisons of weather and climate models for forecast lead times beyond about a week, when climate forcing impacts begin to dominate over the initialization used in weather forecasting.

3.3 NAME Modeling and Data Assimilation

This subsection presents a strategic overview of NAME modeling, data assimilation and predictability activities. A strategy is outlined for accelerating progress on the fundamental modeling issues pertaining to NAME science goals. The strategy takes advantage of NAME enhanced observations, and should simultaneously provide model-based guidance to the evolving multi-tiered NAME observing program.

The overarching goal of NAME is to improve seasonal-to-interannual predictions of warm season precipitation over North America. Central to achieving this goal are improved observations, and improvements in the ability of models to simulate the various components and time scales comprising the weather and climate of the North American Monsoon System.

The NAME region represents a unique challenge for climate modeling and data assimilation. It is a region marked by complex terrain and characterized by a wide range of phenomena including, a strong diurnal cycle and associated land-sea breezes, low level moisture surges, low level jets, tropical easterly waves, intense monsoonal circulations, intraseasonal variability, and continental-scale variations that link the different components of the monsoon. In fact, the NAMS exhibits large-scale coherence in the form of several known phenomena that have an important impact on intraseasonal to decadal time scales. Hence there are building blocks to serve as the foundation for climate forecasting. The El Niño/ Southern Oscillation (ENSO) phenomenon is the best understood of these phenomena, but previous research on the NAMS has also identified several others, including the Madden-Julian Oscillation (MJO), and the Pacific Decadal Oscillation (PDO). The relative influences of these phenomena on the warm season precipitation regime over North America are not well understood. Conversely, the large scale convective maximum associated with the monsoon affects circulation elsewhere, as shown by the relationship between the strength of deep convection and the amplitude and location of the summer subtropical High to the west. Similarly, intraseasonal and interannual fluctuations of monsoon rainfall in the Tier-1 region fluctuate out-of-phase with summer rainfall across the central United States; at present the mechanisms for this feature remain unclear.

Prospects for improved prediction on seasonal-to-interannual time scales hinge on the inherent predictability of the system, and our ability to quantify the initial states and forecast the evolution of the surface forcing variables (e.g. SST and soil moisture). In addition to understanding the role of remote SST forcing such as that associated with ENSO and the North Pacific, we must understand the nature and role of nearby SST anomalies such as those that form in the Gulf of California. The land surface has many memory mechanisms beyond soil moisture, especially over the western US. Snow extends surface moisture memory across winter and spring. Vegetation in semi-arid regions, which shows pronounced seasonal and interannual variability, acts as an atmospheric boundary condition that affects momentum transfer, radiation, heat and moisture fluxes.

The NAME modeling strategy outlined below recognizes three distinct, but related, roles that observations play in model development and assessment. These are (1) to guide model development by providing constraints on model simulations at the process level (e.g. convection, land/atmosphere and ocean/atmosphere interactions); (2) to help assess the veracity of model simulations of the various key NAMS phenomena (e.g. low level jets, land/sea breezes, tropical storms), and the linkages to regional and larger-scale climate variability; and (3) to provide initial and boundary conditions, and verification data for model predictions.

The following subsections briefly discuss the multi-scale model development strategy, the role of data assimilation in addressing the larger-scale NAMS modeling issues, and the role of global models in addressing the global-scale linkages and the NAMS prediction problem. All of these activities will be coordinated by the NAME Modeling-Observations Team as described below.

Modeling-Observations Team

To accelerate progress on achieving NAME's objectives, NAME has organized a modeling-observations team that is charged with:

- Providing guidance on needs and priorities for NAME 2004 field observations;
- Identifying the path to improved warm season precipitation prediction;
- Identifying additional process studies necessary to reduce uncertainties in coupled models.

The NAME team conducted a North American Monsoon Assessment Project "NAMAP" involving 6 global and regional modeling groups. Interested users can access the NAMAP simulations via the NAMAP Data Mangement Page at UCAR/JOSS:

http://www.joss.ucar.edu/name/namap/index.html

Results are summarized in an Atlas (Gutzler et al. 2004) that is available on the NAME web page at the URL:

http://www.cpc.ncep.noaa.gov/research_papers/ncep_cpc_atlas/11/index.html

Results serve as a benchmark and guide for NAME 2004 enhanced observations. It is anticipated that a NAMAP2 follow on activity will focus on simulations of the summer of 2004 after the NAME 2004 EOP.

In order to identify the path to improved warm season precipitation prediction, the team assembled a "White Paper" entitled "NAME Modeling and Data Assimilation: A Strategic Overview" that will serve as a roadmap for NAME modeling, data assimilation and analysis, and predictability and forecast skill activities. The "White Paper" discusses in considerable detail the strategy that NAME will pursue to make progress towards NAME's guiding goal (improved warm season precipitation forecasts on intraseasonal-to-interannual time scales). While a few important aspects of the "White Paper" are summarized below, it is strongly recommended that the reader refer to the current version of the paper, which is available on the NAME webpage at the URL:

http://www.joss.ucar.edu/name/science_planning/name_modeling.doc

<u>Multi-scale Model Development</u>

NAME multi-scale model development activities presume that deficiencies in how we model "local" processes that modulate deep convection are the leading factors limiting precipitation forecast skill in both global and regional models during the warm season. In order to achieve the desired improvements, NAME will focus on

- moist convection in the presence of complex terrain and land/sea contrasts;
- land/atmosphere interactions in the presence of complex terrain and land/sea contrasts;
- ocean/atmosphere interactions in coastal regions with complex terrain.

The detailed strategy that is used to tackle the three process-level issues listed above is presented in the NAME modeling and data assimilation "White Paper". Improvements on these "process-level" issues will require both fundamental improvements to the physical parameterizations, and improvements to how we model the interactions between the local processes and regional and larger scale variability in regional and global models. In short, model development efforts must take on a multi-scale approach. As such, we require information about the NAMS and related variability that extends across all Tiers (1,2,3) and beyond to include global scales.

NAME development efforts are envisaged to be both "bottom–up" (i.e. process-level modeling that is scaled-up to address parameterization issues in regional and global models) and "top-down"(i.e. regional and global models are scaled-down to address issues of resolution and the breakdown of assumptions that are the underpinnings of the physical parameterizations).

Some important issues for global modeling efforts are summarized in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session5/schubert.htm

Some important issues for regional modeling are summarized in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session5/Berbery.htm

Some mesoscale modeling applications designed to improve predictions in the Gulf of California are summarized in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session5/farfan.htm

A key focus of the NAME modeling effort will be on improving the representation of the diurnal cycle. The diurnal cycle is important to the NAME region for the following reasons:

- There are strong diurnal signals in many key variables such as precipitation and convection, low-level winds, moisture transport, and surface temperature, etc.;
- Many physical processes crucial to the NAMS operate on the diurnal timescale, such as sea/land breezes, and land-atmosphere interactions through surface evaporation, vertical transport of water vapor by deep convection, etc.;
- The diurnal cycle is modulated by processes on local scales (surface conditions), regional scales (coastal land-sea contrast), and the large scale (the circulation), and thus is a universal problem for all three NAME tiers;
- The presence of complex terrain further complicates the mechanisms for the diurnal cycle. Current models have difficulty simulating the diurnal cycle so it is an important problem for multi-scale modeling.

As we move beyond Tier 1, we need to consider the large regional differences within the broader-scale NAM region including differences in terrain, land surface conditions, and the basic climatology. In particular, efforts should be geared to understanding and improved modeling of the differences between the representation of organized convection in the coastal terrain of NAME, its representation over the Great Plains in the presence of a strong low-level jet, and its representation over the relatively wet land surface conditions of the eastern United States. Here too the diurnal cycle will likely play a central role, especially in terms of its interaction with topography, the land surface, and with the large-scale flow. Addressing and verifying such large-scale interactions and regional differences will require that the NAME Tier 1 observations are put in the context of other in situ and remote observations. This is best accomplished through data assimilation.

<u>Climate Process and modeling Team</u>

NAME is currently organizing a Climate Process and modeling Team (CPT) whose phenomenological focus is the diurnal cycle of convection in complex terrain; the team is currently identifying one or two key physical processes that are deficient in global and regional models (e.g. orographic forcing of deep convection). Efforts are being made to make sure that these activities are consistent with CPPA objectives and with the emerging NOAA ISIP program (see section 1.5).

More information about the Climate Process and modeling Team framework is available on the NAME webpage in a Powerpoint presentation at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session1/Ji.htm

Multi-tier Synthesis and Data Assimilation

The observations obtained from the NAME 2004 field campaign should provide valuable new insights into the mechanisms and phenomena of the monsoon in the Tier 1 region and, will help to improve the representation of key physical processes in models. Nevertheless, in order to pursue a true multi-scale modeling strategy, we require information about the monsoon that extends well beyond the Tier 1 region. Data assimilation enhances the value and extends the impact of the Tier 1 observations to allow NAME to address issues of model quality and monsoon variability on scales that extend across the greater NAM region. In addition, data assimilation can provide an important framework for quantifying the impact of observations, and for assessing and understanding model deficiencies.

The basic goal is the creation of the best possible research quality assimilated data sets for studying the NAM region and its interactions with the large-scale environment. It is expected that this effort will rely primarily on regional data assimilation systems with some limited work done with global systems. The former have the potential to provide high resolution, and spatially and temporally more complete (compared with the Tier 1 observations alone), estimates of the various NAMS phenomena such as Gulf surges, low level jets, and tropical easterly waves, while the latter provide information (at a somewhat lower resolution) about linkages between the greater NAMS and global-scale climate variability and the role of remote boundary forcing. Additionally, we anticipate that off-line land data assimilation systems, as well as, simplified 1-dimensional land/atmosphere and ocean/atmosphere data assimilation systems will provide invaluable “controlled” environments for addressing issues of land-atmosphere and ocean-atmosphere interactions and model errors.

Current and proposed global and regional reanalysis activities will be critical in this process. Regional data assimilation (e.g. the NCEP Regional Reanalysis and the real-time R-CDAS) will be critical for improved understanding of key components of the NAMS (e.g. surges, jets). Global data assimilation will be critical for linkages to the large scale and the roles of remote boundary forcing.

The specific NAME objectives are:

- To better understand and simulate the various components of the NAM and their interactions;
- To quantify the impact of the NAME observations;
- To identify model errors and attribute them to the underlying model deficiencies;
- To identify model deficiencies in the representation of moist processes.

The strategies that NAME will use to achieve these objectives are given in the NAME modeling and data assimilation "White Paper".

Current real-time monitoring, data assimilation, forecast and modeling activities and products are found on the NAME WWW page under "Science" at the URL:

http://www.joss.ucar.edu/name/

Predictability and Global-scale Linkages

One of the key measures of success of the NAME program will be the extent to which predictions of the NAMS are improved. The prediction problem for NAME is rather broad and includes time scales ranging from diurnal to weather to interannual. While regional models will play an important role, dynamical predictions beyond more than a few days are potentially influenced by (and interact with) global climate variability, so that global models and data assimilation become increasingly important. In fact, it is likely that global-scale variability and the slower components of the boundary forcing (e.g. SST and soil moisture) will provide the main sources of predictive skill in this region on subseasonal and longer time scales.

The key issue to be addressed here is to determine the extent to which model improvements made at the process level (e.g. convection, land/atmospheric interaction), and associated improvements made in the simulation of regional-scale phenomena (diurnal cycle, basic monsoon evolution, low level jets, moisture surges etc), validated against improved data sets, ultimately translate into improved dynamical predictions. Additionally, we wish to determine the impact on predictions of improved initial and boundary conditions, though this would initially be rather limited to focus on the period of available NAME observations (the 2004 field campaign). For example, how sensitive are model simulations of NAMS precipitation (and the components of the large scale circulation driven by monsoonal convection) to accurate specification of SSTs in the Gulf of California, Gulf of Mexico, or east Pacific?

We envision that a number of "hindcast" experiments will be carried out, utilizing existing multi-year regional and global assimilated data sets. The NAME 2004 enhanced observing period will serve as an important case study to assess the direct impact of the enhanced observing system for initializing and forcing the models.

These activities will allow NAME to address key questions (ultimately critical for improved warm season precipitation prediction). Specific objectives of NAME Predictability Research are:

- to examine whether the observed connections between the leading patterns of global climate variability (e.g. ENSO, MJO) and the NAMS are captured in global models;
- to determine the predictability and prediction skill over the NAMS region associated with the leading patterns of climate variability;
- to investigate the impacts of anomalous continental and oceanic conditions in regional and global models;

- to determine the impact of land-atmosphere interaction like soil moisture feedback and changes of vegetation during the monsoon;
- to compare the relative influences of local and remote SST forcing on predictive skill in the NAME region;
- to assess the advantage of increased resolution (either global or locally enhanced - for example by embedding regional high-resolution models in global models).

Several broader cross-cutting themes also warrant attention. These include studies that examine the relative importance of oceanic and land-surface boundary forcing, and studies to quantify error growth due to model errors and those due to the uncertainties in analyses and boundary conditions. For many of the above issues, it will be useful to consider collaborative multi-nation/multi-model experimental prediction efforts.

Seasonal precipitation and temperature forecasts are available from several centers (including IRI, CPC, CDC) on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/

Some important issues for climate and seasonal forecasts are summarized in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session5/schemm.htm

NAME Modeling and Data Assimilation "Roadmap"

A "Roadmap" that ensures the synchronization of the NAME observing program with the modeling and data assimilation efforts is presented in the "White Paper" discussed earlier. The objective is to facilitate a timely two-way flow of information so that the modeling and data assimilation activities provide guidance to the evolving observing program, and that the observations provide information for advancing model development. The "Roadmap" (as of May 2004) is as follows:

- Model and Diagnostic Activities
  - *NAMAP (benchmark simulations of 1990 monsoon) – Gutzler et al. (2004)*
  - *NAMAP2 (simulations of 2004 monsoon) – proposed*
- Data Assimilation
  - *NCEP high resolution North American climate analysis system – R-CDAS (Mo and Higgins)*
  - *NAME 2004 data impact studies – (Mo and Higgins)*
  - Model and Forecast System Development
  - *Diurnal Cycle Experiments – multiyear simulations in AGCMS (Schubert et al.)*
  - *NAME CPT (diurnal cycle of convection in complex terrain) – proposed*

- Experimental Prediction
    - *Sensitivity to SST and soil moisture*
    - *Subseasonal prediction (e.g. MJO)*
    - Climate Prediction Product Development and Applications
    - *Assessments (North American drought monitor, hazards)*
    - *Forecasts (North American seasonal and subseasonal)*

NAME milestones that will be used to track progress in operational summer prediction are listed in section 1.3.

NAME Modeling Issues

There are numerous modeling issues under consideration by the NAME community:

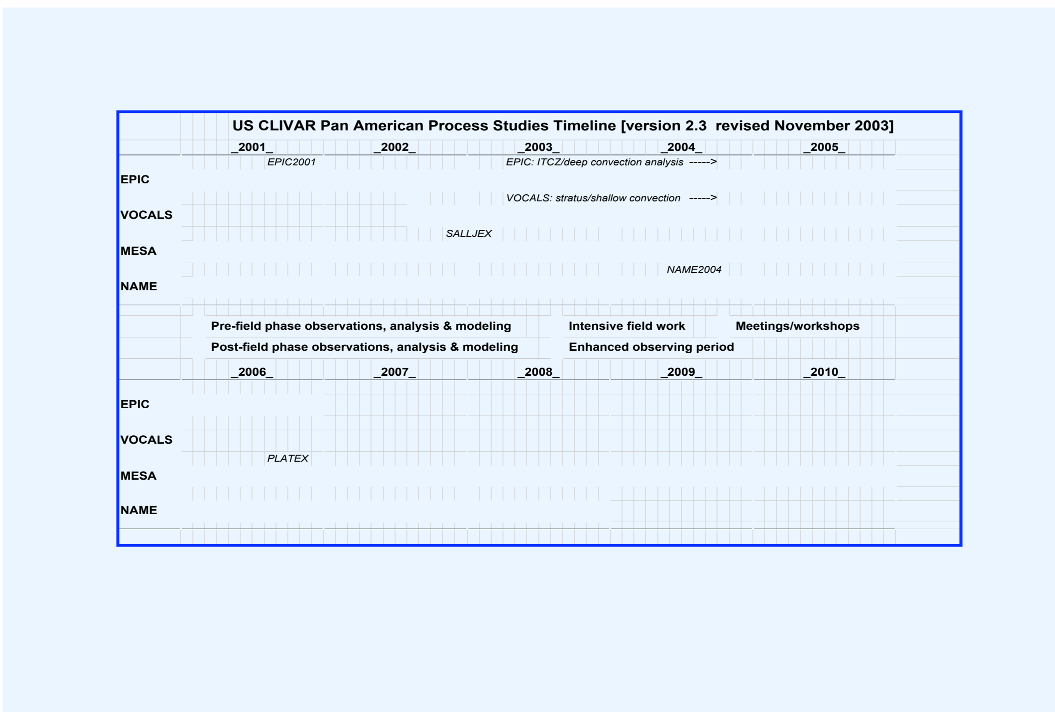
- How do we expand participation in NAME Modeling activities?
    - *Representatives to WGSIP, THORPEX, others?*
- How do we develop the NAME CPT?
    - *NCEP Hydromet Testbed*
- How do we develop joint NAME-MESA-VOCALS modeling activities?
    - *Experimental prediction activities that include the Americas*
- How do we develop the linkage between NAME modeling and applications (e.g. hydrology)?
    - *NAME Hydromet group partners with IRI on a regional project*
- Which climate prediction products should NAME pursue?
    - *North American seasonal forecasts and drought monitor*

3.4 Timeline

NAME field activities include planning, preparations, data collection, principal research and data management phases during an eight-year "life-cycle". These activities are focused on the NAME 2004 Enhanced Observing Period (EOP). A schedule divided into the major phases is as follows

NAME PHASES	00	01	02	03	04	05	06	07	08
Planning:	-------------------|								
Preparations			-------------------|						
Data Collection			- - - - - - - - --------------|						
Principal Research				--------------------------------------|					
Data Management			---|						

NAME is one of several process studies under the U.S. CLIVAR Pan American panel. The U.S. CLIVAR Pan American Process studies timelines (as of November 2003) are as follows:



NAME Planning began in the spring of 2000 at the CLIVAR/VAMOS Panel meeting in Santiago, Chile. A North American Monsoon System (NAMS) working group was formed and charged with developing cooperative international research to investigate the North American Monsoon System. It identified enhanced monitoring and field studies of the low-level circulation features in the core monsoon region (especially as they relate to precipitation) as key priorities. These priorities were subsequently endorsed in the international arena by the CLIVAR/VAMOS Panel (June 2000) and in the U.S. national arena by the US CLIVAR Pan American Panel (July 2000). A NAME Science Working Group (SWG) was organized (May 2000) to develop this document and a NAME Planning Workshop was held (Oct. 2000) to discuss and coordinate plans for NAME implementation. Subsequent meetings of the NAME SWG have been aimed at refining the NAME implementation plan, particularly for the field campaign during the summer of 2004 and developing the NAME modeling and data assimilation activities.

The NAME Data Collection phase encompasses the EOP, which will occur during the summer of 2004. This period has been identified as providing an excellent opportunity to carry out NAME data collection activities because:

- A new generation of remote sensing satellites will be available to provide unprecedented enhancement of observing capabilities to quantify critical atmospheric, surface, hydrologic and oceanographic parameters.

- Several NWP centers are able to run their coupled modeling systems to provide dynamically consistent data sets over the NAMS domain.

- Other CLIVAR-led and GEWEX-led field experiments are planned during this period.

The NAME Principal Research phase will continue for several years following the data collection phase. During this phase the coordinated and cooperative research efforts (i.e. diagnostic and modeling studies), which were the principal drivers of NAME field activities, will provide inputs to the Data Management efforts to ensure that the composite data set resulting from NAME will be archived in a manner useful to participants and other interested users. It is envisioned that a NAME Science Conference will bring this phase of NAME to a close in 2008.

3.5 Project Structure

NAME research is overseen and directed by a Science Working Group (SWG) that has been appointed by the International CLIVAR VAMOS panel. The SWG is charged with developing and leading cooperative international research to achieve the science objectives of NAME. It is made up of scientists who are involved in the process study research and are committed to the success of the project. The current members of the SWG (as of September 2004) are as follows:

Name	*Affiliation*	*Service Through*		*Name*	*Affiliation*	*Service Through*
Jorge Amador	UCR	2006		Bob Maddox	UAZ	2006
Hugo Berbery	UMD	2007		Kingtse Mo	CPC	2006
Miguel Cortez	SMN	2006		Francisco O'Campo	CICESE	2006
Art Douglas	Creighton U	2007		Erik Pytlak	NWS	2006
Michael Douglas	NSSL	2005		Andrea Ray	CDC	2006
Dave Gochis	NCAR/RAP	2006		Jae Schemm	CPC	2007
Wayne Higgins (Chair)	CPC	2006		Siegfried Schubert	NASA	2005
Dick Johnson	CSU	2006		Chris Watts	IMADES	2007
Dennis Lettenmaier	UW	2006		Chidong Zhang	RSMAS	2005
Rene Lobato	IMTA	2007				

The NAME SWG is organized in the following manner:

• The SWG identifies nominations for new members and submits them to the VAMOS Panel for review and approval.

The NAME Program is implemented in the following manner:

• NAME research is implemented by funding agencies and institutions in the participating countries.

• In the US, NAME plans will be evaluated by the CLIVAR Pan American Panel for implementing the US CLIVAR contributions to NAME. This includes advising the US CLIVAR SSC and funding agencies on the balance between NAME and other PanAm research. Similarly, the GAPP SAG will evaluate NAME Plans and advise the US funding agencies on their importance relative to other GAPP endeavors.

The SWG has established the NAME Forecast Operations Centers (FOC's), organized jointly between the National Weather Service (Tucson WFO as lead) and the Mexican Weather Service (Mexico City). The NAME FOC director will coordinate planning and preparations for the Tucson NAME FOC, and direct Forecaster Support activities for the NAME 2004 EOP. The NAME FOC's have rotational teams of forecasters from the NWS, SMN, and NCEP (HPC, SPC, TPC and CPC) as well as private and retired forecasters. In support of the FOC, NAME is organizing a composite precipitation dataset that includes a wide variety of precipitation estimates (gauge, satellite, radar, multi-sensor) for intercomparison studies and forecast verification during NAME 2004.

The VAMOS/NAME Project Office has been established at the UCAR Joint Office for Science Support (JOSS). The Project Office will (i) provide the requisite infrastructure for the design and implementation of the NAME 2004 field campaign, (ii) manage the NAME program field operations (including relevant communications) for the accomplishment of the NAME scientific objectives; (iii) provide scientific data management services to NAME, including data collection and dissemination; and (iv) provide specialized logistics support for the implementation of NAME, including administrative and fiscal support, workshop/conference/educational and specific training coordination and implementation.

More information about Project Office activities is available on the NAME webpage in a Powerpoint presentation at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session1/Emmanuel.htm

The VAMOS/NAME Project Office has established the NAME International Support Team (INPST) to achieve the tasks outlined above. Current membership of the team:

Arthur Douglas
Department of Atmospheric Science
Creighton University

Daniel Breed
NCAR/MMM
breed@ncar.ucar.edu

Dave Gochis
NCAR/RAP
gochis@rap.ucar.edu

C. B. [Gus] Emmanuel

René Lobato Sánchez
IMTA
rlobato@tlaloc.imta.mxsonora@creighton.edu

José Meitín
OGP/NOAA & JOSS/UCAR
meitin@ucar.edu

Francisco Ocampo Torres
CICESE
ocampo@cicese.mx

Armando Rodríguez Davila

JOSS/UCAR
cbe@ucar.edu

SMN
arodriguez@mailsmn.cna.gob.mx

4.0 NAME 2004 ENHANCED OBSERVATION PERIOD

4.1 Background

Extensive voids in the operational observing system have prompted field programs in southwestern North America in the past. For example, the structure and variability of the low-level jet in the Gulf of California, and the North American monsoon were studied during SWAMP-90, and EMVER-93, respectively. Collaborations between Mexican and U.S. scientists were instrumental in the success of these programs.

None of the earlier field campaigns have emphasized the large-scale coupling of the low-level circulations along the Gulf of California to those along the western slopes of the SMO. Better documentation of the horizontal and vertical structure of these circulation features and their relationships to convection is critical. The need for better documentation of these features is part of the motivation for enhanced monitoring activities in the core monsoon region. One of the primary goals of the NAME 2004 EOP is improved monitoring and modeling of the relationship between low-level circulation features and the diurnal cycle of moisture transport and precipitation. The core monsoon region is uniquely suited for this purpose because it is a region where the amplitude of the diurnal cycle far exceeds the amplitude of the annual cycle. The SMO and Rockies extend from the tropics to the high latitudes, and both are significantly higher than the low-level circulations (including the GCLLJ and the GPLLJ). The SMO rises rather abruptly from the Gulf of California to elevations exceeding 3000 m. The GCLLJ and associated nocturnal precipitation maxima have been well documented over the northern Gulf and southwestern United States, but the relevance of the low-level circulation features to conditions further east along the SMO is not well known.

4.2 Status

The NAME 2004 EOP will operate for a period of 4 summer months (JJAS 2004) to coincide with the peak monsoon season and maximum diurnal variability. NOAA's Office of Global Programs (OGP) has funded approximately 15 NAME 2004 Field Projects (see section 4.4 for details). NSF is funding the deployment of the S-POL polarimetric radar, 3 Integrated Sounding Systems (ISSs) and 1 mobile sounding system (GLASS). NASA and USDA are supporting the NAME Soil Moisture Field Campaign (SMEX-04). The National Weather

Service is funding 360 additional soundings at WFO's in the Southwest in support of NAME Intensive Observing Period (IOP) days. DOD/Army and NOAA/OGP are jointly funding additional soundings at Yuma, AZ.

As the details of each funded project emerge, they have been incorporated into this plan. However, in many cases full details are found on the NAME WWW page, usually in meeting presentations (all of which are available). An online mapping tool has also been developed in the NAME Hydrometeorological Working Group (NHWG). This tool facilitates communication and information dissemination about the locations and measuring protocols to be followed during the 2004 EOP.

The NAME Forecast Operations Center forecaster rotation will occur from June 21-August 31, 2004 during which time daily briefings, discussions and forecasts will be available. During this period there will be up to 20 IOP days. The NAME FOC Science Director will be key to decision making relative to the IOP's. The NAME Science Director duties will include scientific oversight on behalf of the NAME SWG, advice to the NAME Operations director on consistency of operations with NAME scientific objectives, and adjudication when necessary among competing or conflicting daily operations plans. The NAME FOC Science Director rotation will consist of PI's from the US and Mexico, who will participate for 2 week stints with overlap. Details on all of these issues are discussed below.

4.3 Region of Focus

For the core monsoon region the study area should be sufficiently large to encompass the major portions of key features, including the land breeze / sea breeze circulation, the mountain / valley circulation, the GCLLJ and the precipitation patterns along the SMO. It should also encompass the region of largest diurnal variability in moisture transport and precipitation. Berbery (2001) used EDAS analyses to show that the largest diurnal variability in wind and moisture transport is within a few degrees of 25° N, over Sonora and Sinaloa. Based on these considerations, the study area for the core monsoon region was chosen (Fig. 1).

The region is larger than that occupied by any single feature. It is also important to keep in mind that the low-level circulation features and precipitation patterns of interest here are influenced by the large-scale circulation. Thus, it is necessary to measure the atmospheric characteristics over a substantially larger region than that covered by the core monsoon region, and this is an important point of intersection with the other NAME Tiers. Although in principal it would be desirable to describe the atmospheric conditions over all of North America to the degree that NAME aspires, this is not practical. The NAME network configurations discussed below are a compromise between the need to describe the features of interest and the limited resources available.

4.4 Instrument Platforms

Proposed NAME 2004 instrument platforms include the NAME Tier 1 Instrumentation and regional enhancements (Tiers 1 and 2). The NAME Tier 1 network includes wind profilers, radars (SMN and NCAR S-Pole), radiosondes, research vessels, buoys, event logging raingauges, in situ soil moisture sensors, and research aircraft operations. Regional enhancements include radiosondes in Mexico and in the Southwest United States, a network of PIBALS and a cooperative network of simple raingauges. Some enhanced monitoring activities (e.g. simple raingauge network; event logging raingauge network) will operate before, during and after the NAME 2004 Field Campaign. It will be important to assess which components of the enhanced observing system should be maintained to meet PACS and GAPP science goals, as well as the goals established by other programs or agencies.

A list of funded NOAA NAME 2004 EOP Projects, including PI contacts, proposal titles and instrumentation, is found on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/name_2004_funded.html

This list does not include funded activities supported by NSF (e.g. the NAME Tier 1 radar network), NASA/USDA (e.g. Soil Moisture Field Experiment (SMEX-04)), nor does it include any of the NAME modeling and diagnostic activities supported by NOAA CPPA.

A NAME "EOP Expendables" spreadsheet has been maintained to keep a running accounting of EOP expendables (principally sondes) that have been budgeted during the EOP. In addition, a NAME "Master EOP" spreadsheet is a tabulation of all known instrument platforms. A particular interest is GTS availability, since data must be made available to the national centers for real-time assimilation. Both of these spreadsheets have been kept up to date and are maintained on the NAME WWW page.

The NAME 2004 EOP Instrument Platforms are summarized in Fig. 3.

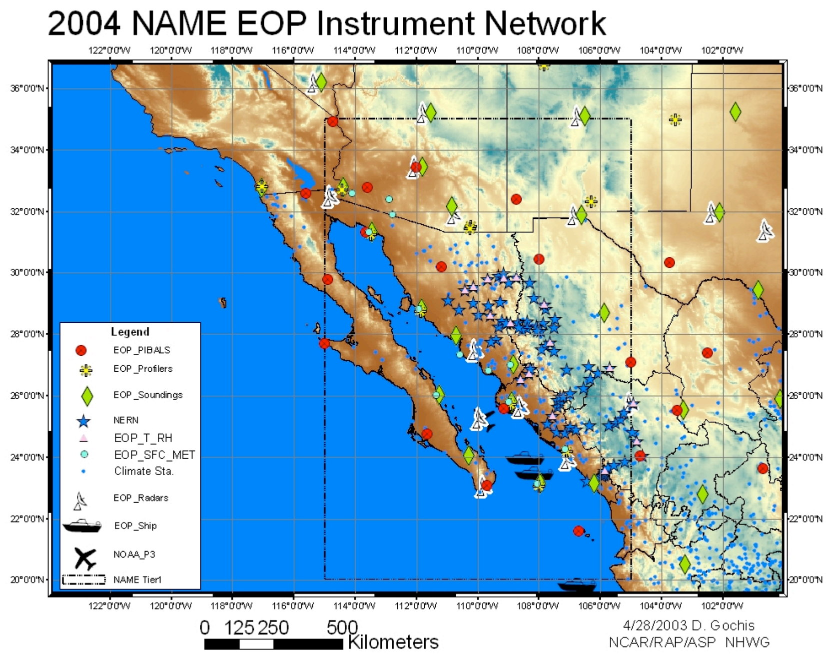


Figure 3. Summary of NAME 2004 EOP instrument platforms.

For convenience brief summaries of the major platforms in Figure 3 are given below. Where appropriate the summaries include tables listing individual activities and appropriate e-mail contacts. Readers are encouraged to contact the PI's for more detailed (and up to date) information, including specific scientific objectives, timelines, data dissemination plan, etc. A Powerpoint presentation that synthesizes much of this information is found on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/hydromet/OverviewAll/

4.4.1 Surface Meteorology

NAME 2004 surface meteorology observations are summarized in Fig. 4.

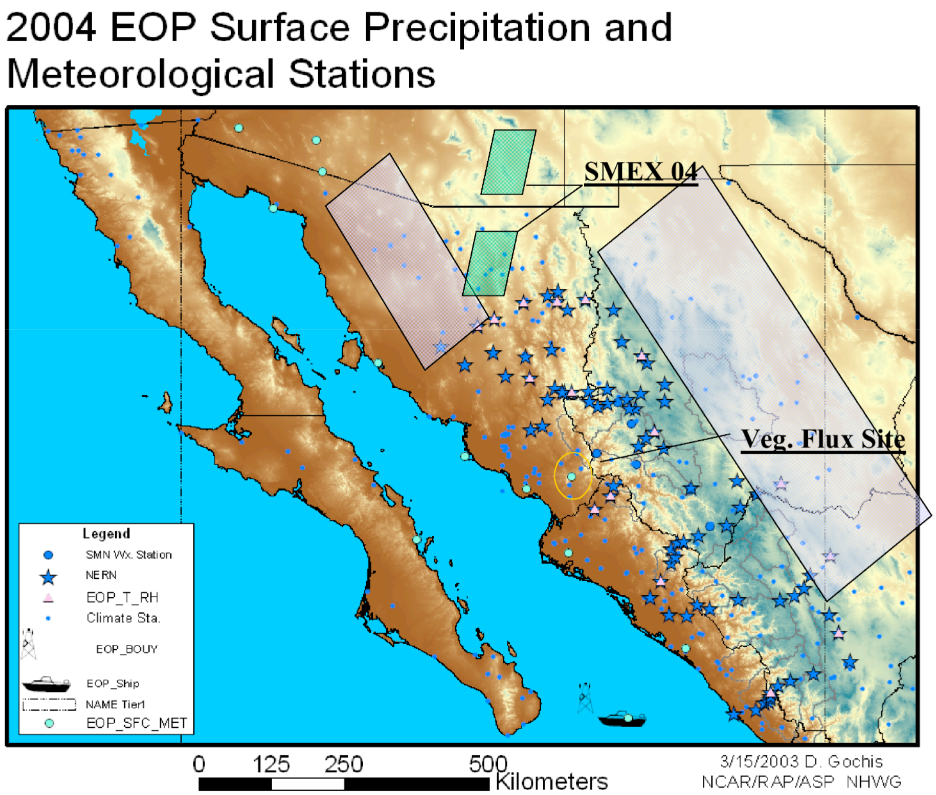


Figure 4. Summary of NAME 2004 EOP surface precipitation and meteorological instrumentation.

The individual activities that make up the surface meteorology component of the network are listed in the following Table:

Platform / Data	*Location*	*Contacts*
Raingauges (event)	Multiple	J. Shuttleworth (shuttle@hwr.arizona.edu) C. Watts (watts@cideson.mx) D. Gochis (gochis@rap.ucar.edu) J. Garatuza (garatuza@hwr.arizona.edu)
Raingauges (simple)	Multiple	R. Lobato (lobato@tlaloc.imta.mx) W. Higgins (Wayne.Higgins@noaa.gov) E. Yarosh (Evgeney.Yarosh@noaa.gov) W. Shi (Wei.Shi@noaa.gov)
Sfc. Temp/RH	Multiple	A. Douglas (Sonora@Creighton.edu)

		D. Gochis (gochis@rap.ucar.edu)
Wx. Stations	Southern Arizona	A. Jamison (Austin.Jamison@noaa.gov)
Flux Tower / Vegetation	Foothills of SMO	M.Douglas (Michael.Douglas@noaa.gov) C. Watts (watts@cideson.mx)
Flux Tower	Foothills of SMO	C. King (Clark.W.King@noaa.gov)
Oceanic Fluxes	Gulf of California	V. Magaña or Mex. Navy
Oceanic Fluxes	Gulf of California	S. Rutledge (rutledge@atmos.colostate.edu) C. Fairall (Chris.Fairall@noaa.gov)
Soil moisture sensors Aircraft (NASA DC-10)	Remote sensing validation	D. Lettenmaier (dennisl@u.washington.edu) T. Jackson (tjackson@hydrolab.arsusda.gov) J. Shuttleworth (shuttle@hwr.arizona.edu)
Hydrometeorology	Integrated network	D. Gochis et al. (gochis@rap.ucar.edu)

Raingauges (event)

This network (referred to as the NAME Enhanced Raingauge Network or NERN) includes 100 event logging, tipping bucket raingages. They have been installed in 6 major east-west transects traversing the Sierra Madre Occidental. The network will contribute to a major improvement in topographic and temporal sampling of precipitation in the region. The network was installed during 2002-2003, and will remain in operation through the spring of 2006. Data is not available in real-time. It is anticipated that the CNA will continue to operate these new gauges after NAME has been completed.

Practical design constraints, an action plan, a data dissemination plan, instrumentation for the raingauge network, and preliminary results are summarized in Gochis et al. (2003a; 2003b) on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/documentation/publications.html

Contacts: Dave Gochis (gochis@rap.uar.edu), Chris Watts (watts@cideson.mx), and Jaime Garatuza (garatuza@hwr.arizona.edu)

Raingauges (simple)

This activity will install a cooperative observer network of roughly 1000 simple accumulation gauges in 2 data sparse regions of Northcentral and Northwestern Mexico. The network will provide daily accumulated rainfall and will provide improved spatial representation of precipitation in these regions. The network will be installed during the winter and spring of 2004 and maintained by IMTA. Data is not available in real-time. It is anticipated that the SMN will continue to operate the network after NAME has been completed.

Some details of the network are given in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Lobato.htm

Contacts: Rene Lobato (lobato@tlaloc.imta.mx), Wayne Higgins (Wayne.Higgins@noaa.gov), Evgeney Yarosh (Evgeney.Yarosh@noaa.gov), and Wei Shi (Wei.Shi@noaa.gov)

Augmented Surface Temperature and Humidity Measurements

This activity will install 16 recording temperature and humidity sensors. They will be deployed along SMO transects in collaboration with the NERN (above) and CNA/SMN observatories. The network will help elucidate temperature and relative humidity profiles along the Sierra Madre Occidental. Data from the network is not available in real time.

Contacts: Art Douglas (sonora@creighton.edu) and Dave Gochis (gochis@rap.ucar.edu)

Augmentation of Southern Arizona ALERT Network

This activity will establish three additional ALERT automated weather stations in southwestern Arizona. They will contribute to improved monitoring in the data-sparse border region. Surface parameters to be monitored include temperature, relative humidity, sea level pressure, wind speed and wind direction, and event precipitation. These stations will be maintained by the NWS and will provide real-time and GTS availability.

Contact: Austin Jamison (Austin.Jamison@noaa.gov)

Flux Tower

This activity will include flux tower, sounding and tethersonde measurements over a deciduous forest site in the SMO foothills. The instrumented dry-forest tower will include measurements of humidity, temp, momentum fluxes and radiation. The activity will also involve some (~100) simple and fewer (~10) digital recording raingauges, surface met stations and some PIBAL measurements. The surface flux data would provide important ground truth for model validation. Data are not available in real time.

Contacts: Mike Douglas (Michael.Douglas@noaa.gov), and Chris Watts (watts@cideson.mx)

Oceanic Fluxes

Surface meteorological and oceanographic measurements from a Mexican research vessel, including air-sea radiative and turbulent flux instrumentation. Some data available in real-time via GTS.

Contacts: Steve Rutledge (rutledge@atmos.colostate.edu) and Chris Fairall (Chris.Fairall@noaa.gov)

NAME Soil Moisture Field Campaign SMEX-04

SMEX04 will deliver multiscale measurements and validation of near surface soil moisture. There are 2 target areas: Walnut Gulch, Arizona and northern Sonora, MX. SMEX 04 elements include in-situ soil moisture networks (5-cm), precipitation, and micromet measurements (north and south sites), aircraft mapping (NASA P-3), intensive sampling concurrent with aircraft mission and satellite products. Data is not available in real-time.

An experiment plan, key objectives, instrumentation and products are described in detail on the SMEX04-NAME WWW page at http://hydrolab.arsusda.gov/smex04/

A recent Powerpoint presentation on SMEX04 is available on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session1/Lettenmaier.htm

Contacts: Tom Jackson (tjackson@hydrolab.arsusda.gov) and Dennis Lettenmaier (dennisl@u.washington.edu)

Hydrometeorology

The NAME Hydrometeorology Working Group (NHWG) will build a unified, quality controlled hydrographic data archive consisting of the NAME enhanced observations and existing Mexican observations (includes streamflow, soil moisture, topographic data and vegetation fields). Data will be archived using standardized data formats with metadata. The activity will inventory and document the availability and quality of current hydrographic and physiographic data over Mexico and the southwestern United States. To the degree possible, cost-effective recommendations for obtaining critical but unavailable data during NAME will be made. The NHWG is also building a NAME Hydromet MapServer to overlay various fields and datasets. A "white paper" describing the mission of the NHWG is located on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/documentation/NHWG_Doc_01_23_03.doc

Other activities of the NHWG are summarized on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/hydromet/index.html

4.4.2 Radar

NAME 2004 radar observations are summarized in Figure 5.

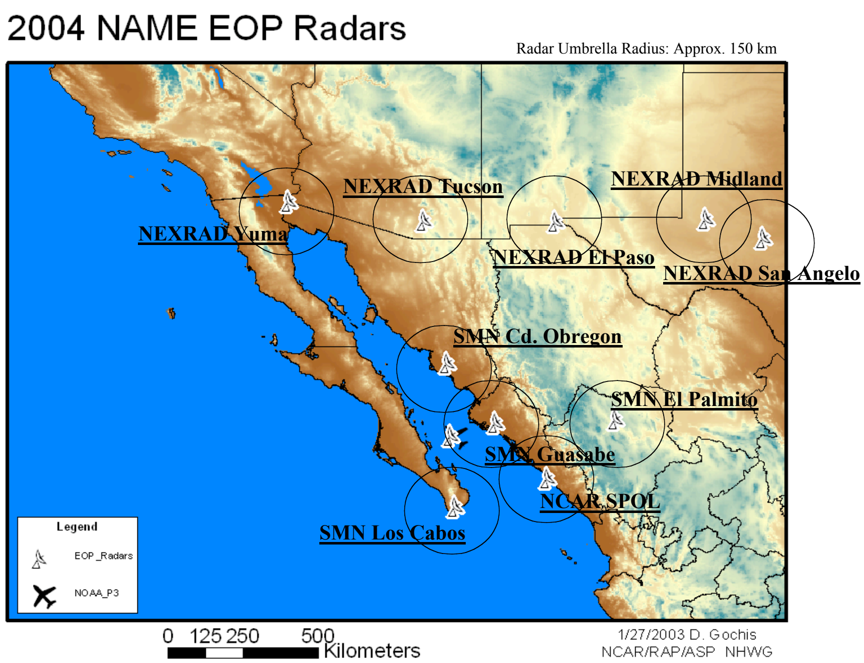


Figure 5. NAME 2004 EOP Radars.

The individual activities which make up the radar component of the network are listed in the following Table:

Platform / Data	*Location*	***Contacts***
Upgraded SMN Radars	Multiple	T. Lang (tlang@atmos.colostate.edu) R. Carbone (carbone@ucar.edu)
NCAR S-POL Radar	Sinaloa	S. Rutledge (rutledge@atmos.colostate.edu) R. Carbone (carbone@ucar.edu)
NOAA P-3 X-Band Radar	Multiple / GOC	S. Rutledge (rutledge@atmos.colostate.edu)

SMN Radars

SMN C-band Doppler radar data will be collected, quality controlled and calibrated at 4 locations in NW Mexico: Cd. Obregon, Guasabe, Los Cabos, El Palmito. The SMN radars will provide important data to address storm structure, climatology, and hydrological applications. Products will include composite reflectivity, velocity and rainfall data sets. Data will be saved via planned digitization upgrades. Operations will be conduted 24 hours/day, 7 days/week during the NAME 2004 EOP. SMN radars will have a 15-minute cycle (matched w/ S-POl) with pre-programmed 360° volumes w/ 7.5-min period. There will be oversight by Arturo Valdez-Manzanilla & NCAR. Doppler reflectivity will be available in real-time where internet service is available. An NCAR/RAP TITAN storm detection and tracking algorithm may be used. There will be coordination with NERN raingages.

The SMN upgrades at Cd. Obregon, Guasabe, Los Cabos, El Palmito will be completed by mid-June, 2004.

Contacts: Tim Lang (tlang@atmos.colostate.edu); Rit Carbone (carbone@ucar.edu)

NCAR S-POL

The NCAR/NSF S-POL radar will be deployed north of Mazatlan during the NAME EOP. The S-POL is an S-band, dual-linearly polarized, Doppler radar that provides superior rain estimates to conventional radars and that can distinguish between hydrometeor types. Radar observations will be used to document the horizontal distribution of rainfall amount and intensity, document storm morphology, document the diurnal cycle of rainfall and convection, identify 2-D airflow features (e.g. gust fronts, sea breezes, etc.) and identify hydrometeors to aid verification of models. These objectives complement and supplement those described for surface meteorology (especially the raingauge networks) and the atmospheric profiling

The S-POL will be operated 24-hours/day, 7 days/week for 6 weeks (July 1-August 15). It has a 15-minute cycle w/ 360° vol, PPI, and RHI sectors. It will be staffed by NCAR and CSU.Doppler reflectivity will be available in real-time. There will be coordination with NERN raingages. Real-time radar data will be provided to the NAME FOC's.

The objectives, scientific questions, instrumentation and data dissemination plans for radar observations are found on the NAME WWW page in a Powerpoint presentation at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session3/Lang.htm

and in a "white paper" entitled "NAME Tier 1: Radar-Profiling-Sounding Network" at the URL:

http://www.joss.ucar.edu/name/documentation/Tier 1_radar_whitepaper_NAME.new.pdf

Contacts: Steve Rutledge rutledge@atmos.colostate.edu), Rit Carbone (carbone@ucar.edu)

NOAA P-3 X-Band Doppler Radar

A NOAA P-3 X-BAND Doppler Radar will be used for roughly 80 hours (72 research hours) to provide radar coverage of convective systems over the GOC and SMO. Dual-Doppler and in situ microphysical data will be collected. These will be event-based flights, hence there will not be 24-hour coverage. CSU personnel will oversee in-flight radar data acquisition.

Objectives, scientific questions, instrumentation and data dissemination plans for aircraft radar observations are found on the NAME WWW page in a Powerpoint presentation at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session3/Lang.htm

4.4.3 Atmospheric soundings and profiling

NAME 2004 atmospheric soundings and profiling observations are summarized in Fig. 6.

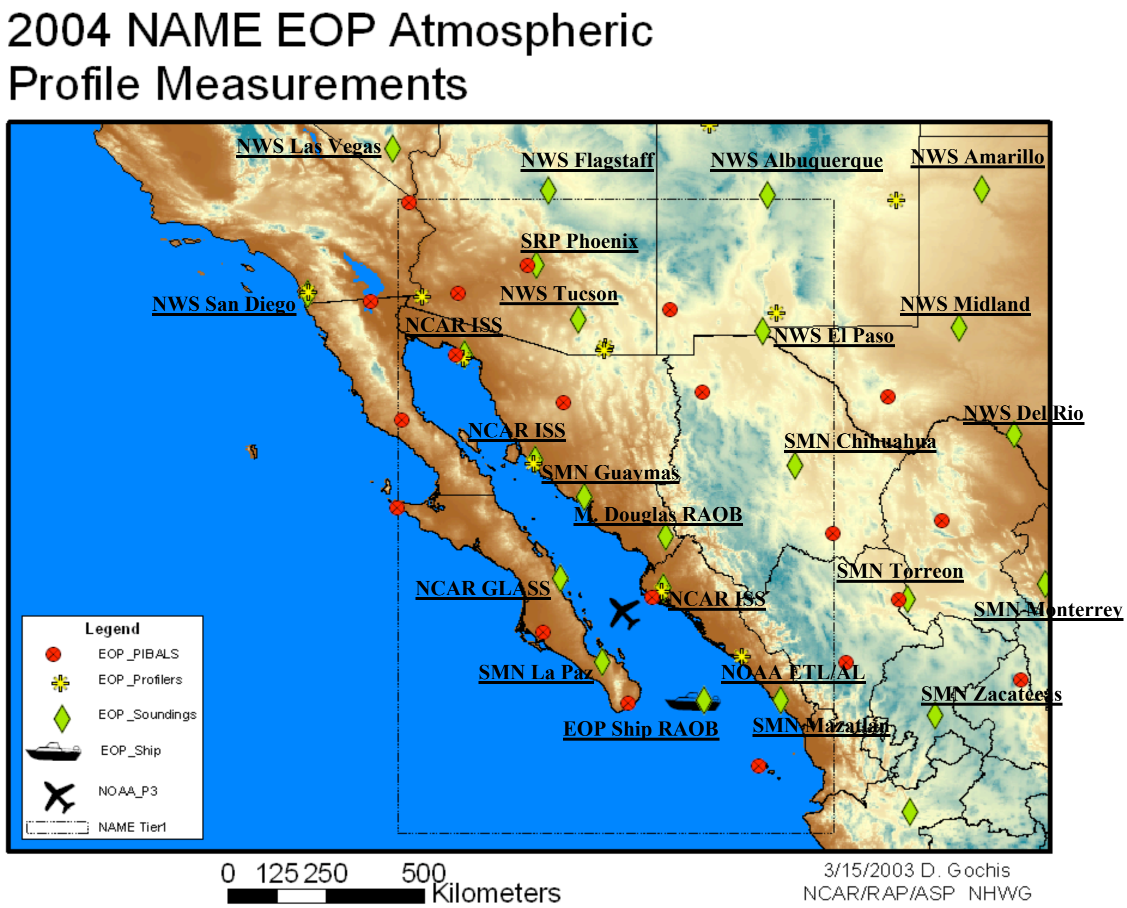


Figure 6. NAME 2004 EOP atmospheric profile measurements.

The individual activities which make up the atmospheric profiling component of the network are listed in the following Table:

Platform / Data	Location	Contacts
NWS Soundings	Multiple	J. Zhou (Jiayu.Zhou@noaa.gov) W. Higgins (Wayne.Higgins@noaa.gov)
SMN Soundings	Multiple	A.Douglas (sonora@creighton.edu) M. Cortez (mcortez@mailsmn.cna.gob.mx)
Pilot Balloons / Powersondes	Multiple	M. Douglas (Michael.Douglas@noaa.gov)
Wind profile / Sounding	Multiple	C. King (Clark.W.King@noaa.gov) L. Hartten (lhartten@al.noaa.gov) M. Ralph (Marty.Ralph@noaa.gov)
Integrated Sounding Systems	Multiple	R. Johnson (johnson@atmos.colostate.edu R. Carbone (carbone@ucar.edu)
Precipitation and vertical wind profiling	1 Coastal Site nr SPOL 1 Mountain Site	C. Williams (cwilliams@al.noaa.gov) A.White (allen.b.white@noaa.gov)
Oceanic Soundings	Gulf of California	S. Rutledge (rutledge@atmos.colostate.edu) C. Fairall (Chris.Fairall@noaa.gov)
Puma or Mexican Navy ship	Gulf of California	V. Magaña (victormr@servidor.unam.mx) Mexican Navy

NWS Soundings

The NWS will provide additional GPS radiosonde launches on twenty Intensive Observing Period (IOP) days from June to August 2004. The additional radiosonde releases will contribute to improved understanding of the diurnal cycle of winds and moisture in the region on IOP days during NAME 2004. The NWS contribution is 360 radiosonde releases of two additional soundings (0600Z, 1800Z) in addition to the routine soundings (0000Z, 1200Z) per IOP day at 9 WFO sites:

Western Region: San Diego, CA; Las Vegas, NV; Flagstaff, AZ; Tucson, AZ
Southern Region: Albuquerque, NM; El Paso, TX; Midland, TX; Del Rio, TX; Amarillo, TX.

The NWS will include labor to accommodate the additional releases. Data will be available in real time via the GTS.

Details about the NWS contribution are available in 2 Powerpoint presentations:

http://ftp.nws.noaa.gov/ost/climate/PPT_S&TCommittee.ppt

http://ftp.nws.noaa.gov/ost/climate/name_higgins_S&TCommittee.pdf

Contacts: Jiayu Zhou (Jiayu.Zhou@noaa.gov), Wayne Higgins (Wayne.Higgins@noaa.gov)

Yuma Soundings

The U.S. ARMY/DOD has partnered with NOAA/OGP to support 2x daily GPS radiosonde launches at Yuma, AZ during the NAME EOP, July 1 – August 15, 2004. Data will be available in real-time and available for upload to the GTS.

Contact: Bob Maddox (maddox@atmo.arizona.edu)

SMN Soundings

NOAA and the SMN will collaborate to provide enhanced GPS radiosonde observations in Mexico during the NAME 2004 EOP. The additional soundings will help to resolve the wind, moisture and temperature fields at appropriate spatial and temporal scales, sufficient to develop stable monthly means during the monsoon. The additional soundings will be very useful for model validation studies, data assimilation and reanalysis activities. The major activities and contributions are:

- Supplemental soundings will be taken at seven SMN radiosonde sites (La Paz, Empalme, Chihuahua, Mazatlan, Torreon, Monterrey, Zacatecas), twice (2X) daily during the EOP, increasing to six (6X) daily during 20 IOP days;
- A dedicated server has been established at SMN in Mexico City for the relay of Mexican data to JOSS and NCEP (radiosonde data will be available in real time via the GTS);
- A position will be established for data assimilation coordination at NCEP, with visiting scientists from SMN and the US;
- Exchange visits have been arranged for FOC scientists to go to SMN during the NAME 2004 EOP;
- Exchange visits have been arranged for SMN scientists to go to NWS Tucson during the NAME 2004 EOP

The SMN contribution to NAME also includes the exchange of real-time data from its observational networks (79 synoptic stations) and the exchange of historical data bases in digital form. An effort is being made to get 16-18 Mexican Navy stations into the NAME datastream.

Contact: Art Douglas (sonora@creighton.edu), Miguel Cortez (mcortez@mailsmn.cna.gob.mx)

Central American Soundings

NOAA OGP (CPPA program) is coordinating with the NASA Tropical Cloud Systems and Processes effort to provide enhanced daily soundings from San Jose, Costa Rica during NAME.

The schedule calls for 4x daily soundings from June 16 to September 9. In addition, NOAA/OGP is coordinating with NOAA/NHC and the Belize Wx Service (Dr. Carlos Fuller) for 2x daily soundings at Belize City from June 20 – September 20, 2004.

Pilot Balloons / Powersondes

A regional network of Pilot Balloons (PIBALs) at up to 20 sites will be established in support of the NAME 2004 EOP. The PIBAL's will provide lower atmospheric profiles of temperature, relative humidity, wind speed and wind direction. PIBALS are grouped to satisfy particular NAME Tier 1 objectives, including improved estimates of moisture flux from the eastern Pacific Ocean into the NAME Tier 1 domain, an improved description of tropical wave variability over central Mexico and south of the Gulf of California, and an improved description of variations of the quasi-permanent heat low over the southwestern desert of the US and northwestern Mexico. Soundings will be made twice-daily at all stations, 3 times daily at most stations, and 4 or more times daily at a selected subset of sites during NAME 2004 IOP's. Implementing the network involves substantial training of SMN observers and collaboration with other institutions in the region. Many sites will be available in 2-3 hr delayed reception.

The activity also includes omegasonde (RS-80N) soundings at Bahia Tortugas and Puerto Peñasco and powersonde flights at Puerto Peñasco (or Obregon).

A Powerpoint presentation that describes the scientific objectives, instrumentation, measurement strategies, and data dissemination plan is found on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session3/Douglas_Pibal.htm

Note: these activities are in addition to current sustained monitoring activities in the region (partially funded by NOAA) as discussed on the PACS-SONET web page:

http://www.nssl.noaa.gov/projects/pacs

Contact: Mike Douglas (Michael.Douglas@noaa.gov)

Wind Profile / Sounding

A 915 MHz UHF wind profiler array will be deployed to conduct boundary layer, flux and soil moisture studies for NAME. Instrumentation will include windprofilers with RASS, 10 m meteorological towers, and soil moisture measurements at Obregon and wind profiler and GPS soundings at Puerto Penasco.

Contacts: Clark King (Clark.W.King@noaa.gov), Leslie Hartten (lhartten@al.noaa.gov) and Marty Ralph (Marty.Ralph@noaa.gov)

Integrated Sounding Systems

Three NCAR Integrated Sounding Systems (GPS sounding system, 915 MHz wind profiler, RASS, and surface meteorology station) will be deployed at Puerto Peñasco, Kino Bay, and Los Mochis. One NCAR GLASS system (GPS sounding system and surface meteorology station) will be deployed at Loreto. These systems will permit up to 6 soundings per day on NAME 2004 IOP days. Data will be available in real-time via the GTS. Sites will be installed from south to north and will be online starting near the end of June 2004. The ISS sounding network is designed to determine surge initiation mechanisms, mechanisms for the diurnal cycle of convection, air-sea exchanges and atmospheric budgets.

Scientific objectives, practical design constraints, instrumentation and a data dissemination plan, are summarized in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session3/Johnson.htm

Contacts: Dick Johnson (johnson@atmos.colostate.edu)

Precipitation and vertical wind profiling

The microphysical properties of monsoon precipitation will be retrieved at a coastal site (near Mazatlan, SIN). The site is 40 km NW of the S-POL radar. The site will include a 915 MHz vertical windprofiler with RASS, a 449 MHz vertical air motion profiler and a surface disdrometer. The S-band profiler will observe hydrometeors larger than ~0.5 mm from ~100 meters to ~15 km. The vertical air motion profiler will provide estimates of the air motion from ~300 meters to the freezing level. In addition, this site will include a 915 MHz wind profiler (see Windprofile / Sounding activity above) that will estimate the horizontal wind motions from ~100 meters to 4-to-5 km. The site will be in operation from May 28 – September 30, 2004, with partial operation thereafter through 2006. Some data will be available in real-time.

Contacts: Chris Williams (cwilliams@al.noaa.gov), Allen White (allen.b.white@noaa.gov) and Clark King (clark.king@noaa.gov).

GPS Integrated Water Profiles

NSF and NOAA OGP are jointly funding the installation and operation of 7 GPS integrated water profile stations in Mexico for NAME. These sites will measure column water vapor and surface meteorology conditions. The sites will include GPS receiver, barometer, thermometer, hygrometer,anemometer & web cam. The sites will aid in our understanding of the relationship between precipitable water and precipitation.

Contact: Rob Kurzinski (kursinski@atmo.arizona.edu)

4.4.4 Aircraft

NOAA P-3

NOAA P-3 flights will examine moisture fluxes and mesoscale circulations associated with the North American monsoon system. NAME has 80 budgeted flight hours, 72 for actual mission time. Principal objectives include mean moisture flux field estimation over the NAME tier 1 domain (6 flights, 45 h), vertical and horizontal variations of the low-level jet and the associated moisture flux variability (2 flights, 15h), and others (2flights, 10h) possibly including genesis of gulf surge events, or mesoscale convective systems. Airborne instrument package includes flight level temperature, specific humidity, pressure, and horizontal wind components. In addition, there is a dropwinsonde capability and X-band Doppler radar. The principal base of operations for NOAA P-3 flights is Mazatlan. The start date for the aircraft operations is July 1st, 2004. The flight operations will continue until August 15th, or until the allotted aircraft hours are used. Some data will be available in real time.

Contact: Mike Douglas (Michael.Douglas@noaa.gov).

4.4.5 Oceanographic

Oceanic Fluxes

Surface and PBL meteorological and ocean atmosphere flux measurements will be made from the research vessel BI-03 R/V ***ALTAIR*** (Mexican Navy). The Altair will remain at the mouth of the Gulf of California (108W, 23.5N) during 2 cruises (July 5-July 22) and (July 25-Aug. 12). Instrumentation will include inertially stabilized 915 MHz wind profiler, cloud ceilometer, Vaisala RS-90 rawinsondes (up to 6-8 times daily during NAME IOP days and available in real-time via the GTS), and CTD ocean profiles

Some preliminary plans are found in a Tier 1 Radar, Profiling and Sounding Network "white paper" on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/documentation/Tier1_radar_whitepaper_NAME.new.pdf

and at the URL:

http://olympic.atmos.colostate.edu/name/RHBwhitepaper.htm

Contacts: Chris Fairall (Chris.Fairall@noaa.gov), Steve Rutledge (rutledge@atmos.colostate.edu), Rob Cifelli (rob@atmos.colostate.edu), Steve Nesbitt (snesbitt@radarmet.atmos.colostate.edu), Walt Petersen (walt@olympic.atmos.colostate.edu), Gus Emmanuel (cbe@ucar.edu).

Gulf of California SST and Soundings

The role of oceanic processes on the Gulf of California SST evolution during the NAME 2004 EOP will be examined. Two 17 day cruises in June and August are planned. Instrumentation includes current meter moorings, drifters, surface meteorology stations, CTDs every 10 km, and 4x daily atmospheric soundings. In addition, there will be continuous SST and surface meteorology measurements during the cruises. Surface drifter deployment will be in the lower Gulf of California (12 each cruise).

Scientific objectives, a platform description, measurement strategies, and cruise details are summarized in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Cavazos.htm

Contacts: Mike Douglas (Michael.Douglas@noaa.gov), Emilio Beier (ebeier@oce.orst.edu), David Mitchell (mitch@dri.edu), D. Ivanova (dorothea@sage.dri.edu) and Peter Guest (pguest@nps.navy.mil).

4.5 IOP Protocols

Aircraft-related and non-aircraft-related IOP protocols have been established by the NAME SWG. IOP events have been prioritized based on their likelihood of success in accomplishing particular IOP objectives. An IOP calls table, which tabulates the various IOP events and ranks them according to research priority is maintained on the NAME WWW page. This table was agreed upon by SWG consensus at NAME SWG-6 in Tucson, AZ. Not all resources (aircraft or non-aircraft) have been specifically allocated. Thus, this table will help rotating directors keep track of available resources and science priorities.

An IOP Protocols powerpoint file describes the various aircraft and non-aircraft related IOP's listed in the IOP calls table. The latest version of this powerpoint file is maintained on the NAME WWW page. For convenience, the IOP protocols (as of this writing) are stated below:

NOAA P-3 Aircraft related IOP Missions

(1) Mean Moisture Flux over Tier I (6 flights; 42 hrs)

Purpose: To describe the influx of moisture from the Pacific into the NAME Tier 1 domain under strong, normal, and weak conditions. Flights from far offshore of Baja California to well south of Baja California, but also including flights over the GOC for comparative observations.

(2) Structure of GOC LLJ (2 flights; 14 hrs)

Purpose: To describe the horizontal and vertical structure of the GOC LLJ, especially over the northern GOC and to measure the overland conditions in NW Mexico. Flights over Northern GOC and NW Mexico.

(3) Genesis / Propagation of Gulf Surges (2 flights; 14 hrs)

Purpose: To describe the synoptic environment associated the genesis and propagation of Gulf Surges (most likely in concert with non-aircraft IOP) Flights over Southern and Central GOC region.

(4) Middle- and Upper-Level Easterly Inverted Troughs

Location: Northern and Central Mexico

(5) Inland Penetration of Sea / Terrain Circulation, PBL Evolution and Convective Development over SMO

Location: Central SMO inland to plateau rim

(6) Mesoscale Convective Complexes and Residuals:

Purpose: To focus on MCCs at the mouth of the Gulf of California. Missions depend on good forecasts.

Location: Southern end of GOC.

<u>Non-aircraft related IOP Missions</u>

(1) Baseline Monsoon Days

Purpose: To characterize the "mean" moisture flux field over the NAME Tier I region on days without propagating disturbances.

(2) Gulf Surges

Purpose: To monitor the genesis and propagation of Gulf Surges using one or two missions lasting 1-3 days, with emphasis on the diurnal cycle. The most dependable of these are associated with Tropical Storms moving toward or a bit SW of Baja. If such a situation develops, it should be quite doable to call a Gulf Surge IOP and plan the P-3 missions (if appropriate) before the actual onset of the surge.

(3) Suppressed Monsoon Days

Purpose: Compare amplitude of anomalies in suppressed conditions to enhanced conditions (e.g. in the pre-surge -vs- post surge environment), with emphasis on the diurnal cycle.

(4) Onset of the Monsoon

Purpose: To document the arrival of 2004 monsoon.

(5) Easterly Waves and Plateau Moisture Convergence

Purpose: Investigate moisture budget of NAME Tier 2 relative to movement of an easterly wave westward from GOM, with emphasis on the diurnal cycle.

4.6 Science Director Rotation

The NAME Science Director rotation will span the period June 21-September 1. Science Director tours are on site in Tucson, AZ (at the NAME Forecast Operations Center) for 10 consecutive days. There will be an overlap of two duty days on the tours. Jose Meitin and Gus Emmanuel will serve as Operations Directors throughout the period June 21 – September 1. The NAME Science Director rotation (please note: contingent on observational resources) is as follows:

June 21-30: Dave Gochis
June 29-July 8: Art Douglas
July 7-July 16: Dick Johnson
July 15-July 24: Brian Mapes
July 23-August 1: Rene Lobato
July 31-August 9: Bob Maddox
August 8 -August 17: Miguel Cortez
August 16-August 25: Mike Douglas
August 24-September 1: Dave Stensrud

The "General Responsibilities" of the NAME Science Director are:

- to provide scientific oversight on behalf of the NAME SWG and NAME PIs;
- to advise the NAME Operations Director on consistency of operations with NAME scientific objectives;
- to ensure that all priority IOP missions are achieved by the end of the EOP;
- to adjudicate when necessary among competing or conflicting operations plans; and
- to provide continuity of oversight during the EOP via overlapping duty schedule

The "Specific Duties" of the NAME Science Director are:

- to keep a normal duty schedule (morning to afternoon/evening) and to adjust the schedule as needed for night aircraft operations;
- to monitor the status of daily operations (aircraft, IOP soundings, receipt of data on GTS, etc.) in coordination with the NAME Operations Director, the NAME Monitoring Director and the FOC (including the evolving weather situation);
- to review the status of aircraft and non-aircraft IOPs completed to date (and to update the IOP Priorities Table and EOP Expendables Table accordingly;
- to attend the 2100 UTC weather briefing;
- to decide, in consultation with Ops Director, Flight Ops, NAME PIs present or otherwise available, and Mission Scientist, whether an IOP should be called for the next day (aircraft IOP with or without supplemental soundings, or non-aircraft IOP with supplemental soundings). This step should be done judiciously so as to minimize the potential for cancellations.

  IF YES: Define backup IOPs; Develop action plan for next 24-36 h; Coordinate next morning discussions (if necessary); Ensure notification of NWS/SMN Forecast Offices; Place sounding sites on standby (as needed); Complete JOSS Science Director Summary at the end of the day; Fill out extended IOP operations section in JOSS/NAME data catalog:

  http://www.joss.ucar.edu/name/catalog/other/forms/

  IF NO: Consider potential requirements for IOP on Day 2 (aircraft/soundings) and notify appropriate groups; Complete JOSS Science Director Summary at the end of the day; Fill out simple non-IOP operations section in JOSS/NAME Data Catalog:

  http://www.joss.ucar.edu/name/catalog/other/forms/

- If weather conditions dictate, then call-up of an IOP as soon as possible; place sounding sites on notice (at any time of day) for IOP soundings in 24 h;
- Debrief Mission Scientist (as needed) to refine future mission planning;
- Brief next Science Director at end of assignment.

4.7 NAME Forecast Operations Centers

Structure and Function

NAME forecast operations will be located in the NWS Tucson Weather Forecast Office Conference Room. Daily weather briefings to the NAME Science Director, and others on site, will be conducted in a classroom at the University of AZ Atmospheric Science Department. JOSS and NWS Tucson will provide forecasting and communication capabilities required for daily operations, and interactions with the SMN Forecast Operations Center, the JOSS Project Director and the NCEP Centers. University of Arizona Atmospheric Science will provide building access, office/work space and internet connectivity for scientists and students working on site in Tucson, as well as making the briefing room available for the entire NAME 2004 EOP period. The TUS FOC Operations Plan will be available on the NAME WWW page around June 1, 2004.

Forecasting Plans

Daily forecasts through the NAME 2004 EOP will be issued. There will be one or two forecast shifts per day depending on weather and EOP/IOP status. Daily forecast coordination between the Tucson FOC, the SMN and NCEP will occur (see below). Forecasts will focus on synoptic and large mesoscale features, and associated weather phenomena for tomorrow, with updates as needed during IOP'S. Daily briefings to the NAME Science Director will be given by the operational forecast staff. The primary forecast graphics and accompanying discussions will be uploaded onto the JOSS NAME catalog and daily forecast briefings will be given from the catalog. Monsoon discussion forms, to be prepared by daily forecasters, are located in the JOSS/NAME catalog at:

http://www.joss.ucar.edu/name/catalog/other/forms/

A zone forecasting exercise for day 2 QPF (12Z tomorrow to 12Z the day after tomorrow) for 9 NAME zones in the U.S. and Mexico (covers Tier 1) will be conducted during the summer of 2004. The exercise will take place much the way it did in the summer of 2003, except that all NAME forecasters will be encouraged to participate on a daily basis (whether or not they are in Tucson). Forms for the NAME zone forecasting exercise are located in the JOSS/NAME catalog at:

http://www.joss.ucar.edu/name/catalog/other/forms/

Forecasters are required to obtain a password from the NAME Operations Director.

Several exchange visits, involving SMN and NWS forecasters involved in NAME are planned during June -August 2004.

Staffing

The forecaster selection process began in mid-January 2004 with a Call-For-Forecasters. All interested individuals and organizations were encouraged to apply. Volunteers were asked to indicate when they would be available to work on site at Tucson. A small panel was convened to screen the list of volunteers and determine a forecasting duty schedule based upon experience, interest, and availability. Volunteers for the exchange visits were selected early in the process to aid the NWS foreign travel process.

The NAME forecast team includes forecasters from a variety of organizations to staff operational shifts during summer 2004 and / or visit for collaborations, including NWS WFOs in the Western and Southern Regions, Federal and Private Organizations (e.g., SRP, NSSL, Vaisala/GAI), Universities, NCEP Centers (Hydrologic Prediction Center; Tropical Prediction Center; Climate Prediction Center; Storms Prediction Center) and the SMN. A calendar with forecaster shift schedules has been compiled for June-August, 2004 and is available on the NAME web page.

Daily Coordination

Daily coordination calls will occur during NAME 2004. The conference calls will be daily from June 21-August 31. The calls will be led by the FOC briefing forecaster of the day. The participants will include: the SPC Day 2 outlook forecaster, the NHC Eastern Pacific forecaster, the HPC Day 2 forecaster, the HPC medium range forecaster, and the CPC Monitoring Director (Mon-Fri only). The call will take place at 1630 UTC.

The call agenda (15 minute limit) will be organized roughly as follows: (1) FOC - overview of Day 2 and 3; (2) SPC - overview of severe thunderstorm threat over Tier I ; (3) NHC - overview of tropical cyclone threats to Tier I and adjacent areas of Tier II within the next 72 hours; (4) HPC - Day 2 forecaster (QPF over Tier I in Day 2) and Medium range forecaster (QPF over Tier I in Days 3-5, with emphasis on Day 3); (5) CPC - overall monsoon flow pattern over Tier I in the day 6-10 period.

CPC/HPC Personal Briefing Sequence

A personal briefing web page has been designed for use by North American Monsoon Experiment (NAME) forecasters during NAME 2004. This page has the following advantages for the forecaster: (1) Easy access to a myriad of weather and climate tools in a convenient "one-stop shop" location; (2) Ideal format for use in daily coordination with other centers; (3) Convenient JavaScript drop-down menu for easy access to forecast products; (4) Menu divided into logical sub-categories for quick location of a particular forecast tool of interest; (5) Designed for use by forecasters operating under strict time constraints.

The page was constructed in collaboration with all of the NAME forecasters, the Tucson WFO and the NCEP Centers. The location of NAME Forecaster Briefing Page:

http://www.cpc.ncep.noaa.gov/NAME/NAME.html

NAME CPC Monitoring Director Rotation

The NAME 2004 CPC Monitoring Director rotation will occur from early June through late August, 2004. The CPC Monitoring Director will have the following general responsibilities:

(1) Review and update daily GDAS, EDAS and observed NAME 04 monitoring products posted on the JOSS/NAME WWW page during the early AM (prior to 1500UTC).

(2) Participate in the FOC-SMN-NCEP daily coordination calls (Monday-Friday, 1630UTC). The calls are limited to 15 minutes total.

(3) Fill out the NCEP/CPC Monitoring log in the JOSS/NAME Catalog once per week (on Friday), the contents of which will include a list of missing NCEP analysis products for the week, and a written summary of interesting, monsoon-related features as captured by NCEP monitoring products (includes limited comparisons to observations if desired). The location of this form in the JOSS/NAME catalog is:

http://www.joss.ucar.edu/name/catalog/other/forms/

The NAME 2004 CPC Monitoring Director Rotation is as follows:

Week 1: 6-12 June	Marco Carrera
Week 2: 13-19 June	Kingtse Mo
Week 3: 20-26 June	Randy Schechter
Week 4: 27 June-3July	Wayne Higgins
Week 5: 4-10 July	Anthony Artusa
Week 6: 11-17 July	Wayne Higgins
Week 7: 18-24 July	John Janowiak
Week 8: 25-31 July	Tim Eichler
Week 9: 1-7 August	Evgeney Yarosh
Week 10: 8-14 August	Scott Handel
Week 11: 15-21 August	Wei Shi
Week 12: 22-28 August	Tom Eichler

Composite Precipitation Dataset

A NAME Composite precipitation dataset has been organized for QPF forecast verification and for intercomparison studies. The dataset includes a suite of precipitation estimates (gauge, satellite, radar, multi-sensor, operational analyses). Protocols for this contribution were established in May 2003. This is a no cost contribution of data by roughly a dozen participating groups. UCAR/JOSS is hosting the dataset on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/verify/

4.8 Field Operations and Procedures

NAME 2004 field operations and procedures are coordinated by the NAME Project Office and the NAME SWG. The goal is to define requirements for, and conduct the day-to-day operations, to satisfy the data collection objectives of NAME.

The NAME Field Operations Plan includes a summary of the scientific objectives to be met during the field phase, describes the Tucson Forecast Operations Center (FOC) venue, describes the day-to-day operational procedures, describes the decision making process, specifies the forecast services available, describes the research platforms and research systems available, specifies and describes the communications and support systems required, specifies the data/data catalog availability at the FOC and specifies the necessary logistics (clearances, immigration/customs, etc.). The NAME Field Operations Plan is found under "Logistics and Support" on the NAME WWW page. A Powerpoint presentation that discusses the NAME Field Operations Center concepts in detail is found on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session4/Emmanuel.htm

Daily Operations Meeting

The daily operations meeting, chaired by the Operations Director, will begin at 1400 hours, local time, each day with an operational decision by 1600 hours. The meeting will start with a thorough review and discussion of the weather forecast for the next 24-48 hours, and extended outlook to 72 hours. This will be followed by a status report of the NAME experimental sites and platforms (aircraft and ship), availability of expendables and IOPs. The NAME Science Director on duty and the Operations Director, in consultation with PIs present, will determine the requisite operations for the next 24-48 hours and communicate this information to the sites and platforms. The Operations Director will monitor the field operations for compliance and keep the Science Director apprised of any discrepancies and system failures.

4.9 The NAME Field Catalog

The NAME On-line Field Catalog includes forecast discussions, mission reports, operations summaries, status reports, quicklook analysis products and report authoring tools. The operational products display includes satellite, surface, model analyses, upper-air soundings, buoy data and other marine products. The research products display includes aircraft, upper-air soundings, radar products and marine products. NAME IOP's will include special analysis products, science, operations and mission summaries, flight tracks, ship position, preliminary products and quick-look data analyses. The NAME On-line Field Catalog is found under "Data Management" on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/catalog/

4.10 NAME Data Management and Policy

The NAME Data Management page is found on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/dm/name_dm_index.html

This page includes a master table of all NAME data sets (with links and platform information) as well as links to the CODIAC Interactive Data Management System and the NAME On-line Field Catalog. The page also includes data submission guidelines and instructions, and the NAME data policy. Finally, the page includes links to a number of related projects (e.g. SALLJEX, etc.).

An overview of the NAME Data Archive is discussed in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session4/Meitin.htm

4.11 International Partnerships

SMN participation in NAME

The SMN envisions NAME as an opportunity to improve understanding of the climate of Mexico, to increase the capacity to predict warm season rainfall, to train operational forecasters, observers and technicians, and to share historical and near real-time data and products.

Prior to the NAME 2004 EOP, the SMN willpromote NAME inside the SMN and within CNA regional offices, contact Mexican climate agencies (CFE, local governments, universities), inspect and maintain observational networks and train forecasters, observers, and technicians as necessary.

The SMN has committed most of its 2004 annual training budget to NAME related activities (e.g 2-3 week training course in México City; exchange visits with NWS). The SMN is working with the Federal Electrical Commission (CFE) to locate suitable sites for NAME instrumentation.

During the NAME 2004 EOP , the SMN will

- provide SMN Meteorological Infrastructure (79 synoptic stations; 16 radiosonde sites; 74 automated weather stations; 12 radars (4 in northwestern Mexico);
- provide historical and near real-time data (e.g. digitize hourly information from synoptic stations);
- coordinate a NAME working group (meteorologists, observers, and technicians);
- participate in the joint Forecast Operations Centesr (Tucson-Mexico City).

Details about SMN participation in NAME are found in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Cortez.htm

At the present time there are 74 Automatic Weather Stations (AWS's) working with near real time data on the Internet. The number may climb to 84 during NAME, though the only new one in NW Mexico is at Hermosillo. Measurements (averages or accumulations) are at 10 minute intervals. The internet time lag is between 15 and 75 minutes, depending on the actual time of transmission. Variables include temperature, pressure, relative humidity, precipitation, solar radiation, wind (magnitude, direction), and gust wind (magnitude, direction).

There may be other AWS's available, including 25 operated by SEMAR (Mexican military Navy), 10 operated by GASIR-CNA (Surface Hydrology & River Engineering), 44 operated by CILA (International Boundary and Water Commission-Mexican side) on the Texas-Mexico border, 7 in an agromet network near Hermosillo and 10 in an agromet network near Caborca.

There are 83 surface synoptic stations. Nominally, measurements are taken every hour, and transmission is every 3 hours ("Pen and paper" recording instruments). Many observatories are short staffed, including many of the sites in NW Mexico.

Currently there are 15 radiosonde stations (co-located with observatories except for Cancun).

A Powerpoint presentation that summarizes the current status of data facilities in Mexico is found on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Rosengaus.htm

IMTA participation in NAME

IMTA will select and instruct cooperative observers (ranches, schools, health clinics, public facilities, etc.) and install a cooperative network of simple raingauges in data sparse regions of Northwest and North Central México. Data will be collected on a monthly basis, digitized and quality controlled. A Web accesible database will be developed for data distribution. Original data cards will be collected at the end of the monsoon season. If successful, the SMN will take over this network after the NAME 2004 EOP. Data will be incorporated into CPC's historical daily Mexican precipitation database for analysis and dissemination. Comparative and diagnostic studies are planned to investigate the quality of the new precipitation analyses.

Details about IMTA participation in NAME are found in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Lobato.htm

CICESE and UABC participation in NAME

CICESE and UABC will participate in an investigation of the role oceanic processes on the Gulf of California SST evolution during NAME 2004 and in a study of convective patterns over Baja, including characteristics of convective phenomena and behavior of landfalling tropical cyclones. CICESE is also collaborating with University of Washington to extend the retrospective LDAS data set to cover Tiers 1, 2 and 3 for ~ 50 yrs and to use the derived LDAS to undertake predictability studies that investigate the role of land-surface feedbacks in the monsoon region.

Details about CICESE and UABC participation in NAME are found in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Cavazos.htm

University of Vera Cruz participation in NAME

Several universities, including the University of Vera Cruz have emphasized that it is important for NAME PI's to engage the university community in México. It is a win-win situation since several of the NAME PI's are seeking additional field support and many university students are eager to participate.

It is important to identify NAME PI needs for operations personnel in both countries (including student trainees such as those from University of Vera Cruz), costs for them to participate, logistical issues related to their participation, and make this information available to NAME PIs who require these resources.

Subsecretaria de la Marina, Armada de Mexico

Data and meteorological equipment available from the Mexican Navy, including 27 automatic meteorological stations (17 on islands) that report 10 minute data, should be obtained and incorporated into the NAME catalog at UCAR JOSS. The ten minute data is sent from the Mexican Navy to the SMN via satellite link.

Details about these datasets are found in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Aguilar.htm

Central American collaborative interests

The NAME SWG is finalizing plans for additional soundings at Belize City and San Jose, Costa Rica during the NAME EOP. Given the importance of the Caribbean low-level easterly jet in the westward and northward transfer of momentum and moisture, and the interaction of the low-level jet with easterly waves, these are considered to be very important data. Belize and Costa Rica SMNs will provide balloons and hydrogen for twice daily radiosonde observations during the NAME EOP and will cover the costs associated with field personnel.

Central American Collaborative interests are summarized in a Powerpoint presentation on the NAME WWW page at the URL:

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Amador.htm

Regional CNA Offices in Northwest Mexico

CNA operates a system of dams in NW Mexico, with 147 Climate Stations, 6 Surface Observatories, 1 radiosonde station and 1 Doppler radar. Additional collaboration to determine which stations are critical for NAME is necessary. For more information, see

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Lagarda.htm

UNAM participation in NAME

The UNAM oceanographic vessel El Puma will cruise from 3-15 August, 2004 near 108 W, 20 N. Meteorological observations on board include radiosondes (Vaisala Digicora), Weather pack and Davis Stations, tethersonde balloon, radiometers (short and long wave, upwelling and downwelling radiation), precipitation gauges, and satellite images receiver. Oceanographic measurements include a thermosalinometer and CTD. El Puma is based in Mazatlan, Sinaloa. It has 3 labs with computers, telephone, room for 21 scientists, a reading room, and can navigate for up to 20 days. For more information, see

http://www.joss.ucar.edu/name/science_planning/SWG5/BROWSE/Session2/Magana.htm

4.12 NAME *"Teachers in the Field"*

NAME will have two *NOAA "Teachers in the Field"* during the NAME 2004 Field Campaign. Teachers in the Field will participate in the NAME 2004 Enhanced Observing Period, travel to Arizona and Mexico, and teach her/his classes via near real-time Web broadcasts. The NAME Teachers in the Field will participate in NAME aircraft, ship and FOC activities, and help develop teaching materials.

One of the NAME "Teachers in the Field" is Rhonda Feher, an elementary school teacher from Kayenta, Arizona. Her school is located on the Navajo Nation Reservation . Selection of a teacher from Mexico is in progress.

4.13 NAME K-12 Education Component

The NAME SWG has been asked to compile an "Education Module" for use by K-12. The module will take the form of a NOAA "Reports to the Nation". More information is available on the NOAA/OGP WWW page at the URL at http://www.ogp.noaa.gov/

APPENDIX A: THE NORTH AMERICAN MONSOON SYSTEM

A.1 Life Cycle

The life-cycle and large-scale features of the NAMS can be described using terms typically reserved for the much larger Asian Monsoon system; that is, we can characterize the life-cycle in terms of development, mature and decay phases. The development (May-June phase) is characterized by a period of transition from the cold season circulation regime to the warm season regime. This is accompanied by a decrease in mid-latitude synoptic-scale transient activity over the conterminous United States and northern Mexico as the extratropical storm track weakens and migrates poleward to a position near the Canadian border by late June (e.g. Whittaker and Horn 1981; Parker et al. 1989). During this time there are increases in the amplitude of the diurnal cycle of precipitation (e.g. Wallace 1975; Higgins et al. 1996) and in the frequency of occurrence of the GPLLJ (e.g. Bonner 1968; Bonner and Paegle 1970; Augustine and Caracena 1994; Mitchell et al. 1995; Helfand and Schubert 1995; Higgins et al. 1997a). The onset of the Mexican Monsoon (Douglas et al. 1993; Stensrud et al. 1995) is characterized by heavy rainfall over southern Mexico, which quickly spreads northward along the western slopes of the SMO into Arizona and New Mexico by early July (Fig. 7). Precipitation increases over northwestern Mexico coincide with increased vertical transport of moisture by convection (Douglas et al. 1993) and southerly winds flowing up the Gulf of California (Badan-Dagan et al. 1991). Increases in precipitation over the southwestern United States coincide with the development of a pronounced anticyclone at the jet stream level (e.g. Okabe 1995), the development of thermally induced trough in the desert Southwest (Tang and Reiter 1984; Rowson and Colucci 1992), northward displacements of the Pacific and Bermuda highs (Carleton 1986; 1987), the formation of southerly low-level jets over the Gulf of California (Carleton 1986; Douglas 1995), the formation of the Arizona monsoon boundary, and increases in eastern Pacific SST gradients (Carleton et al. 1990); and increased variability of the easterly low-level jet and convective activity in the Caribbean (Amador et al. 2000). From June to July there is also an increase in SLP over the southwestern United States (Okabe 1995) and a general height increase in mid-latitudes associated with the seasonal heating of the troposphere. The largest increases in height occur over the western and southern United States and are likely related to enhanced atmospheric heating over the elevated terrain of the western United States and Mexico, and increased latent heating associated with the development of the Mexican Monsoon. The resulting middle and upper tropospheric “monsoon high” is analogous to the Tibetan High over Asia (e.g. Tang and Reiter 1984) and the warm season Bolivian High over South America (e.g. Johnson 1976).

During the mature (July-August) phase the NAMS is fully developed and can be related to the seasonal evolution of the continental precipitation regime. The monsoon high is associated with enhanced upper tropospheric divergence in its vicinity and to the south, and with enhanced easterlies (or weaker westerlies) and enhanced Mexican Monsoon rainfall (Douglas et al. 1993). To the north and east of the monsoon high, the atmospheric flow is more convergent at upper levels and rainfall diminishes from June to July in the increasingly anticyclonic westerly flow (e.g. Harman 1991). Surges of maritime tropical air northward over the Gulf of California are linked to active and break periods of the monsoon rains over the deserts of Arizona and California (Hales 1972). The mature phase has also been linked

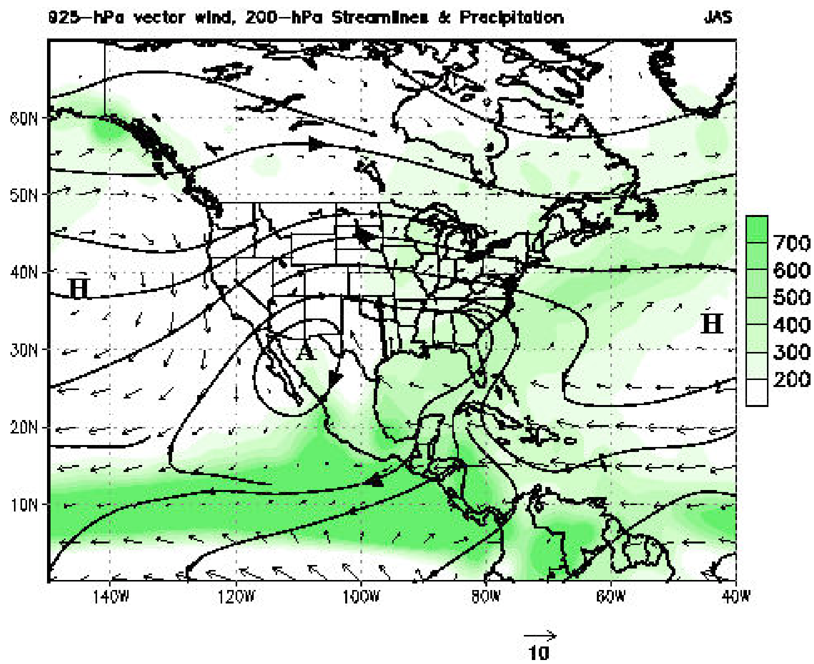


Figure 7. Mean 925-hPa vector wind (units: m s^{-1}), 200-hPa streamlines, and merged satellite estimates and station observations of precipitation (shading) for July-September 1979-1995. Circulation data are taken from the NCEP/NCAR Reanalysis. The position of the North American Monsoon System anticyclone is indicated by “A”. The Bermuda and North Pacific subtropical high pressure centers are indicated by “H”. Precipitation amounts are in mm. The approximate location of the Great Plains low-level jet is indicated by the heavy solid arrow.

with increased upper-level tropospheric divergence and precipitation in the vicinity of an "induced" trough over the eastern United States.

The decay (September-October) phase of the NAMS can be characterized as the reverse of the onset phase, although the changes tend to proceed at a slower rate. During this phase the ridge over the western United States weakens as the monsoon high retreats southward and Mexican Monsoon precipitation diminishes. The decay phase is also accompanied by an increase in rainfall over much of the surrounding region (Okabe 1995).

Numerous authors have attempted to identify the primary source of moisture for the summer rains over the southwestern United States. Bryson and Lowery (1955) suggested that horizontal advection of moist air at middle levels from the east or southeast around a westward extension of the Bermuda high might explain the onset of summer rainfall over the southwest; this was later corroborated by Sellers and Hill (1974). Several authors (Hales 1972, 1974; Brenner 1974; Douglas et al. 1993) expressed skepticism for this type of explanation since moisture from the Gulf of Mexico would first have to traverse the Mexican Plateau and SMO before contributing to Arizona rainfall. Rasmusson (1966; 1967) was among the first to show a clear separation between water vapor east of the continental divide, which clearly originates from the Gulf of Mexico / Caribbean Sea, and moisture over the Sonoran Desert that appears to originate from the Gulf of California. Schmitz and Mullen (1996) examined the relative importance of the Gulf of Mexico, the Gulf of California and the eastern tropical Pacific as moisture sources for the Sonoran Desert using ECMWF analyses. They found that most of the moisture at upper levels over the Sonoran desert arrives from over the Gulf of Mexico, while most of the moisture at lower levels comes from the northern Gulf of California.

Berbery (2001) used EDAS analyses to show that the diurnal cycle in moisture flux divergence over the core monsoon region is related to the diurnal cycle in the sea breeze / land breeze circulation. In particular, the afternoon seabreeze is associated with strong moisture flux divergence over the Gulf of California and strong moisture flux convergence over the west slopes of the SMO leading to intense afternoon and evening precipitation (Fig. 8). At night the land breeze develops leading to moisture flux convergence near the coastline and over the Gulf of California where morning precipitation often develops.

A.2 Continental-Scale Precipitation Pattern

The onset of the summer monsoon rains over southwestern North America has been linked to a decrease of rainfall over the Great Plains of the U.S. (e.g., Tang and Reiter 1984; Douglas et al. 1993; Mock 1996; Higgins et al. 1997b) and to an increase of rainfall along the East Coast (e.g., Tang and Reiter 1984; Higgins et al. 1997b). Okabe (1995) has shown that phase reversals in this continental-scale precipitation pattern are related to the development and decay of the monsoon. Changes in the upper-tropospheric wind and divergence fields (mean vertical motion) are broadly consistent with the evolution of this precipitation pattern (Fig. 9) (Higgins et al. 1997b).

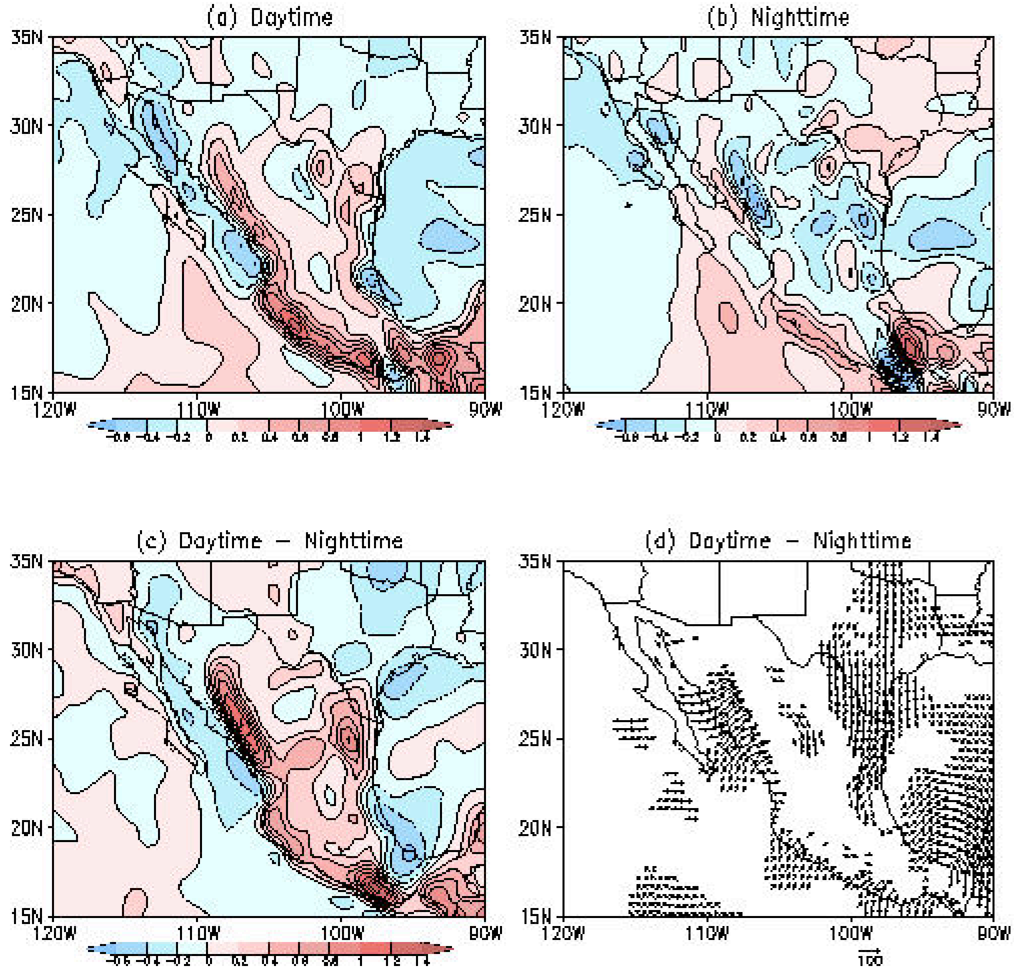


Figure 8. Moisture flux convergence during (a) daytime, (b) nighttime , (c) their difference and (d) daytime minus nighttime difference in moisture flux. Daytime is defined as 18-24 UTC (11 a.m.-5 p.m. local time). Nighttime is defined as 6-12 UTC (11 p.m.-5 a.m. local time). Contour intervals in (a)-(c) are 0.2 mm $hour^{-1}$ and positive values are shaded. The standard vector length is 100 kg $(m\ s)^{-1}$ and values smaller than 30 kg $(m\ s)^{-1}$ are masked. (From Berbery 2001)

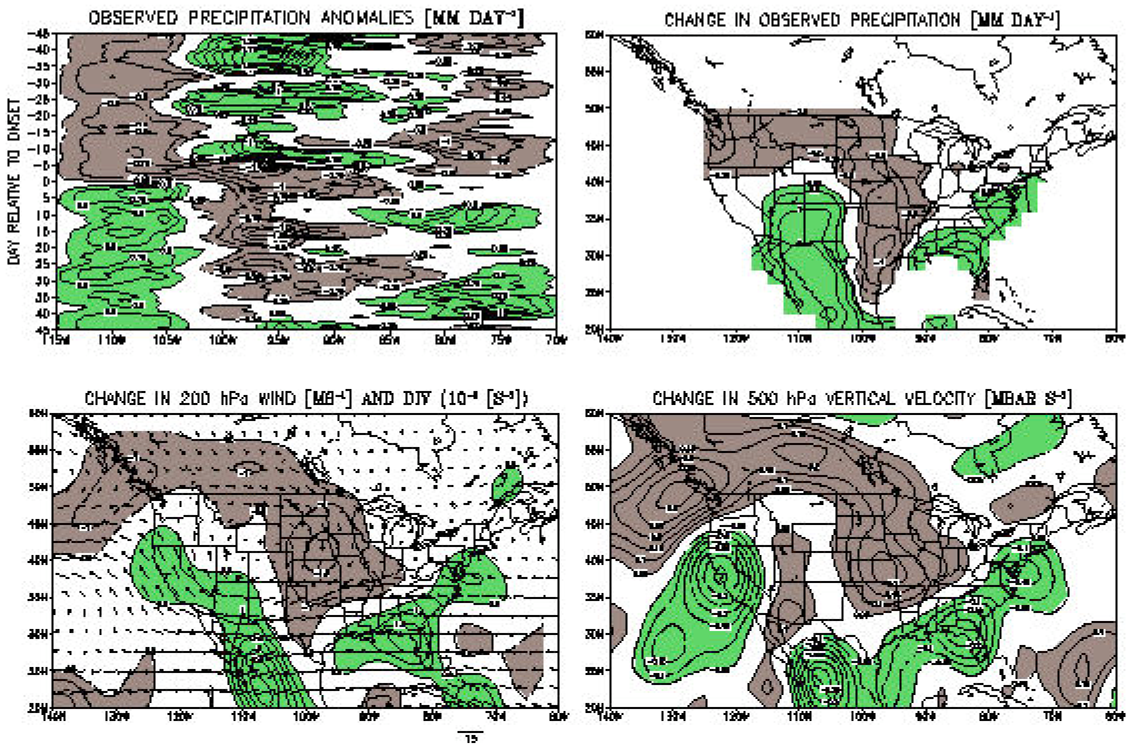


Figure 9. Top Left: Longitude-time diagram of the composite mean (1963-94) observed precipitation anomalies (departures from the JJA 1963-94 time mean) averaged between 34N and 38N. Results are shown for a 3-day running mean. Top Right: Map of observed precipitation represented as the composite mean (1963-94) difference between the 45-day period after onset (day 0 to day +44) and the 45-day period before onset (day -45 to day -1). In previous two figures, the contour interval is 0.25 mm/day, the zero contour is omitted for clarity, and values greater than 0.25 mm/day (less than -0.25 mm/day) are shaded dark (light). Bottom Left: Map of NCEP 200-hPa wind (units: m/s) and divergence (units: 1.0e-6/s). The contour interval is 0.5e-6/s. Bottom Right: Map of NCEP 500-hPa vertical velocity (units: microbar/s) represented as the composite mean (1979-94) difference between the 45-day period after onset (day 0 to day +44) and the 45-day period before onset (day -45 to day -1). The contour interval is 0.05 microbar/s.

Recently, Higgins et al. (1998) demonstrated that interannual variability of the continental-scale precipitation pattern closely mimics the seasonal changes associated with the development of the NAMS, suggesting that summer drought (flood) episodes in the central U.S. are linked to an amplification (weakening) of the NAMS and, in particular, to the intensity of the monsoon anticyclone over the southwestern U.S. It is important to determine to what extent this pattern is captured in global and regional models.

A.3 Interannual Variability

There is a growing body of modeling and observational evidence that slowly varying oceanic boundary conditions (i.e., SST, sea ice) and land boundary conditions (e.g. snow cover, vegetation, soil moisture and ground water) influence the variability of the atmospheric circulation on time scales up to seasonal and annual (e.g. Yasunari 1990; Yasunari et al. 1991; Yasunari and Seki 1992). Within the context of the NAMS, Higgins et al. (1998) showed that wet (dry) summer monsoons in the southwestern U.S. tend to follow winters characterized by dry (wet) conditions in the southwestern U.S. and wet (dry) conditions in the northwestern U.S. (Fig. 10). This association was attributed, at least in part, to the wintertime pattern of Pacific SST anomalies (SSTA) which provide an ocean-based source of memory of antecedent climate fluctuations.

A number of studies have considered the simultaneous relationship between SST in the tropical Pacific and NAMS rainfall. Harrington et al. (1992) found significant correlations between the phase of the southern oscillation and AZNM precipitation. Hereford and Webb (1992) suggested a relationship between increased summer precipitation in the Colorado plateau region and the warm phase of ENSO. During the summer season other studies have argued that more localized SSTA are important. Carleton et al. (1990) showed that the Southwest Monsoon is negatively correlated with SSTA along the northern Baja coast while Huang and Lai (1998) found positive correlations with SSTA over the Gulf of Mexico. Ting and Wang (1997) found that SSTA in the North Pacific may also influence precipitation over the central United States.

Another possibility is that both winter and summer precipitation regimes are influenced by coherent patterns of SSTA that persist from winter to summer. Namias et al. (1988) emphasized that persistent SSTA patterns in the North Pacific are often associated with persistent atmospheric teleconnection patterns. They identified the region in the midlatitudes of the central North Pacific (near 40^{o} N) as being an important area where SSTA have an effect on circulation anomalies downstream over the U.S. Of particular relevance for the NAMS is the work of Carleton et al. (1990) who demonstrated that anomalously wet (dry) summers in Arizona tend to follow winters characterized by the positive (negative) phase of the Pacific-North America teleconnection pattern.

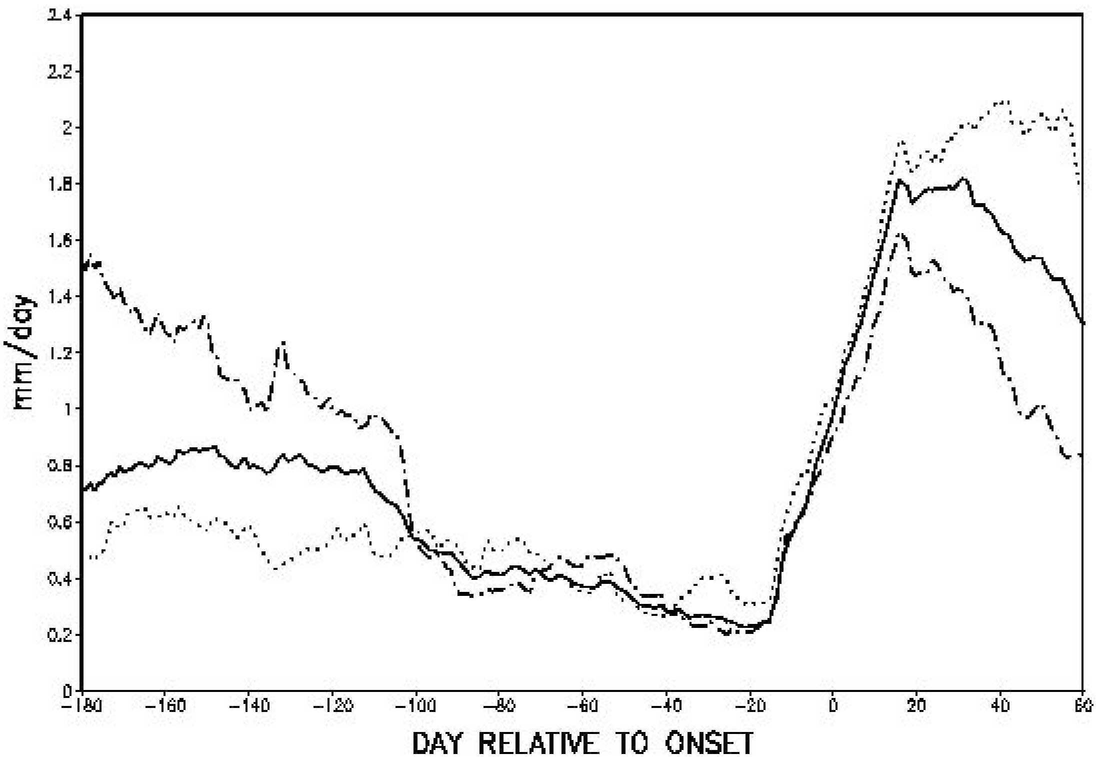


Figure 10. Composite evolution of the 30-day running mean area average precipitation (units: mm/day) over Arizona and New Mexico for wet monsoons (dotted line), dry monsoons (dot-dashed line) and all (1963-94) monsoons (solid line). The average date of monsoon onset is July 1 for wet monsoons, July 11 for dry monsoons and July 7 for all monsoons (defined as day 0 in each case).

Monsoonal rains are also influenced by changes in land-based conditions that provide memory of antecedent hydrologic anomalies. Observational and modeling evidence indicates that the springtime snowpack across Eurasia modulates the amplitude of the Asian monsoon rains in the following summer, such that heavy snowpack leads to a weak monsoon, and light snowpack leads to a strong monsoon (e.g., Barnett et al. 1989; Vernekar et al. 1995; Yang et. al 1996). Gutzler and Preston (1997) found an analogous relationship in North America such that excessive snow in the west-central U.S. leads to deficient summer rain in the Southwest and deficient snow leads to abundant summer rain.

Seasonal weather prediction has also been shown to be dependent, at least in portions of the land, on the soil moisture at the beginning of the growing season (Pielke et al. 1999) and the feedback between vegetation growth and rainfall (Eastman et al. 2000, Lu et al. 2000). This feedback may explain why correlations between ocean SSTs and rainfall over the Great Plains and southwest United States deteriorate during the warm season (Castro et al. 2000a). The inclusion of models of the vegetation response to weather, and the subsequent feedback to rainfall and other weather variables, therefore, may improve seasonal weather prediction. To accomplish this goal, however, soil physics and vegetation dynamics must be included as seasonal weather variables in the same context as rainfall, temperature, and other atmospheric variables.

A.4 Decadal Variability

Latif and Barnett (1996) discussed two types of decadal variability in the North Pacific that may be relevant for the NAMS. The first is associated with the recent climate shift in the North Pacific in the mid-1970s (e.g. Trenberth and Hurrell 1994; Miller et al. 1994; Graham et al. 1994) which many authors agree is a manifestation of atmospheric forcing driving ocean variations. The second type is more oscillatory, and involves unstable ocean-atmosphere interactions over the North Pacific as originally hypothesized by Namias (1959). Namias argued that SSTA in the North Pacific influence the atmospheric transients, hence the mean westerly flow in such a way as to reinforce the original SSTA. Recent coupled GCM and observational studies (e.g. Latif and Barnett 1994; 1996) have implicated Namias's hypothesis in the decadal variability of the North Pacific-North American sector.

In a recent study Higgins and Shi (1999) argued that the summer monsoon in the southwest U.S. is modulated by longer term (decade-scale) fluctuations in the North Pacific SSTs associated with the Pacific Decadal Oscillation. They found that the mechanism relating the North Pacific wintertime SST pattern to the summer monsoon appears to be via the impact of variations in the Pacific jet on west coast precipitation regimes during the preceding winter . This mechanism affects local land-based sources of memory in the southwestern U.S., which in turn influence the subsequent timing and intensity of the summer monsoon. These results are consistent with recent results of Castro et al. (2000b).

Occasionally long-term (decade-scale) periods of persistent drought or rainy conditions occur in the southwestern U.S. The reasons for such climate anomalies are poorly understood, and the modulation of interannual variability by longer term climate fluctuations also needs to be examined as part of the broader effort to develop useful short-term climate prediction capabilities. At the present time it is unclear whether any of the links between the monsoon in the southwestern U.S. and antecedent conditions are robust enough to have a positive impact on the predictability of warm season precipitation. Nevertheless, these relationships need to be described and sorted out.

A.5 Intraseasonal Variability

The intensity of the seasonal mean monsoon is influenced by the nature of the variability within the monsoon season. Previous attempts to relate rainfall anomalies for the monsoon season to the date of onset of the Indian monsoon (e.g. Dhar et al. 1980) have generally shown little relationship indicating that the intraseasonal variability of monsoon rainfall is quite large. In other words, a season with deficient monsoon rainfall does not imply an absence of rainfall for the whole season, but rather prolonged periods of reduced rainfall often referred to as "break" monsoons; prolonged periods of enhanced rainfall are referred to as "active" monsoons. Douglas and Englehart (1996) demonstrated that a dominant mode of variability of summer rainfall in southern Mexico and Central America was a tendency for an alternating wet-dry-wet period in the July-August-September time frame. This pronounced double peak structure is also observed in diurnal temperature range equatorward of the tropic of cancer (Fig. 11), but the physical setting responsible for this variability within the monsoon season remains elusive as does its interannual variability. The double peak structure in precipitation extends southwestward over the warm pool region of the eastern tropical Pacific. Recent evidence indicates that the trade winds, evaporation and precipitation patterns over the warm pool region modulate the sea-surface temperatures in a manner consistent with the double peak structure, hence the mid summer break (Magaña et al. 1999).

Stensrud et al. (1995) showed that a mesoscale model can simulate the observed features of the NAMS, including southerly low-level flow over the Gulf of California, the diurnal cycle of convection, and a low-level jet that develops over the northern end of the Gulf of California. One particularly important mesoscale feature that the model reproduces is a gulf surge, a low-level, northward surge of moist tropical air that often travels the entire length of the Gulf of California. Common characteristics of these disturbances (Hales 1972 and Brenner 1974) include changes in surface weather (a rise in dewpoint temperature, a decrease in the diurnal temperature range, a windshift with an increased southerly wind component, and increased cloudiness and precipitation). Gulf surges appear to promote increased convective activity in Arizona and are related to the passage of TEWs across western Mexico (Fig. 12; Stensrud et al. 1997; Fuller and Stensrud 2000).

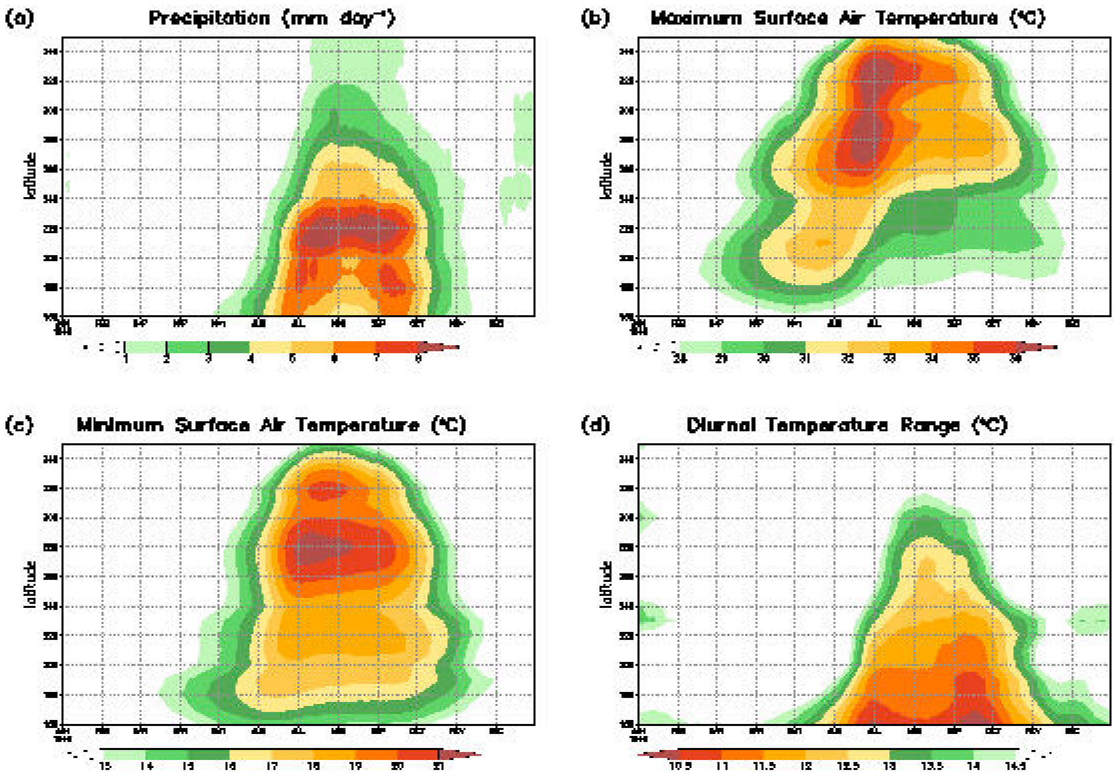


Figure 11. Time-latitude sections of the mean (1961-1990) annual cycle of (a) precipitation, (b) maximum surface temperature, (c) minimum surface temperature, and (d) diurnal temperature range (i.e. the difference between (b) and (c)). Data are averaged zonally over west coast land points at each latitude.

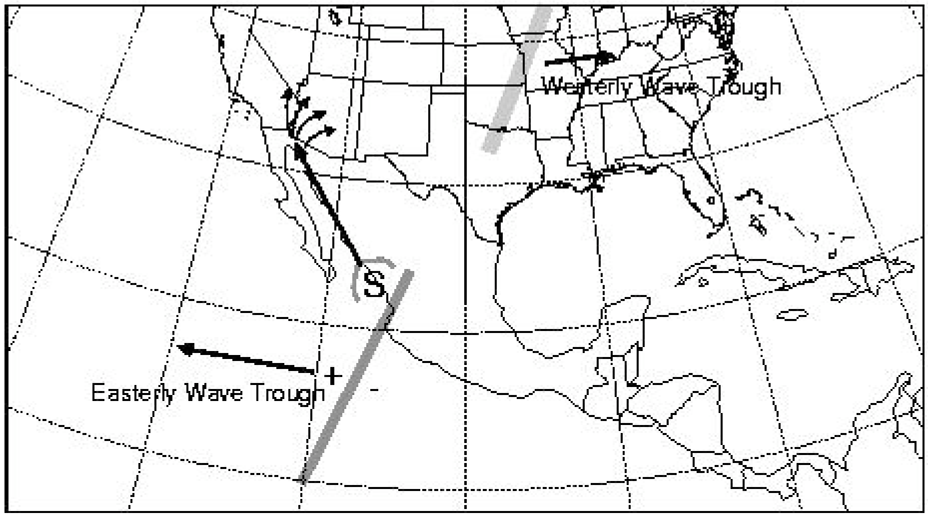


Figure 12. Conceptual model of the initiation and propagation of gulf surge events as suggested by Stensrud et al. (1997). Letter S denotes the area of surge initiation, with the diagonal arrow indicating the direction of surge propagation. The +/- indicate regions of upward / downward motion associated with the easterly wave trough, while the arrow indicates the direction of movement of the trough (from Fuller and Stensrud, 2000).

Mesoscale low-pressure systems at the southern end of the Gulf of California may also be important in triggering gulf surges. In many cases, these lows result from northward excursions of the ITCZ in the east Pacific. Zehnder et al. (1999) hypothesize that easterly waves approach from the Caribbean and perturb the ITCZ from it's climatological mean position at 10°N. They also describe a case of an eastern Pacific tropical cyclone that formed on the eastern edge of the perturbed ITCZ. The response of the ITCZ to the easterly wave forcing may depend on the phase of the MJO. In particular, the westerly phase of the MJO may result in a larger vorticity of the ITCZ, consistent with Zehnder et al. (1999).

One aspect of the connection between gulf surges and TEWs that has not been explored systematically is the extent to which it might influence the interannual variability in the onset and intensity of the monsoon. Since TEWs and Gulf surges are most active during the summer months, they are most likely to play a role in the onset of the monsoon in the southwestern US, which typically begins in early July. In addition, the extent to which TEWs might help explain the midsummer transitions over southern Mexico and central America also needs to be explored.

In a recent study Higgins and Shi (2001) separated the dominant modes of intraseasonal and interannual variability of the NAMS in order to examine MJO-related and ENSO-related influences on U.S. weather during the summer months. They found a strong relationship between the leading mode of intraseasonal variability of the NAMS, the MJO, and the points of origin of tropical cyclones in the Pacific and Atlantic basins (Fig. 13) which should be examined further.

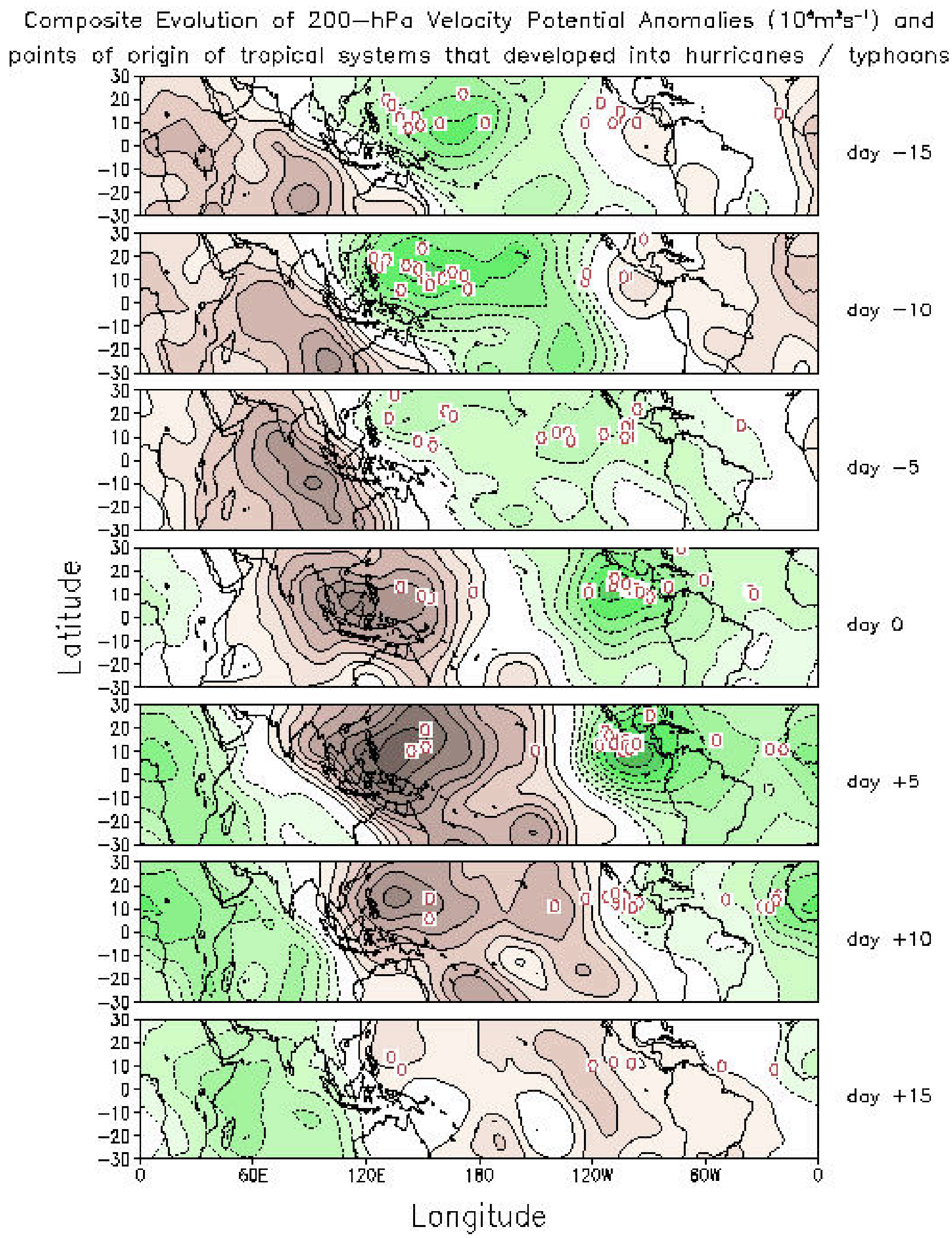


Figure 13. Composite evolution of MJO events during the summer months together with points of origin of tropical cyclones that developed into hurricanes / typhoons (open circles). The green (brown) shading roughly corresponds to regions where convection is favored (suppressed) as represented by 200-hPa velocity potential anomalies. Composites are based on 21 events over a 19 summer period. Hurricane track data is for the period JAS 1979-1997. Points of origin in each panel are for different storms. Contour interval is 0.5×10^6 m^2 s^{-1}, negative contours are dashed, and the zero contour is omitted for clarity.

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List of Acronyms

ALLS: American Low-Level Jets
AMIP: Atmospheric Model Intercomparison Project
AO: Arctic Oscillation
ASIMET: Air Sea Interaction - METeorology
CCM: Community Climate Model
CDC: Climate Diagnostics Center
CEOP: Coordinated Enhanced Observing Period
CLIVAR: Climate Variability, a WCRP research program
CLLJ: Caribbean Low-Level Jet
CMAN: Coastal-Marine Automated Network
COADS: Coupled Ocean-Atmosphere Data Set
COMPS: Coastal Ocean Monitoring and Prediction System
CPC: Climate Prediction Center
ECMWF: European Center for Medium Range Weather Forecasts
EDAS: Eta-model Data Assimilation System
EMVER-93**:** Experimento Meteorologico del Verano de 1993
ENSO: El Niño Southern Oscillation
EOP: Enhanced Observing Period
EPIC: Eastern Pacific Investigation of Climate
ERS: European Remote Sensing Satellites
GAPP: GEWEX America Prediction Project
GCIP: GEWEX Continental-Scale International Project
GCM: General Circulation Model
GEWEX: Global Energy and Water Experiment
GOES: Geostationary Operational Environmental Satellite
GPLLJ: Great Plains Low-Level Jet
GPS: Global Positioning System
IAS: Intra-Americas Sea
IOP: Intensive Observing Period
ITCZ: Inter Tropical Convergence Zone
IPST: International Project Support Team
IR: Infrared
IRI: International Research Institute
LDAS: Land Data Assimilation System
MESA: Monsoon Experiment South America
MJO: Madden-Julian Oscillation
NAME: North American Monsoon Experiment
NAMS: North American Monsoon System
NAO: North Atlantic Oscillation
NASA: National Aeronautics and Space Administration
NCAR: National Center for Atmospheric Research

NCDC: National Climatic Data Center
NCEP: National Centers for Environmental Prediction
NDBC: National Data Buoy Center
NOAA: National Oceanic and Atmospheric Administration
NVAP: NASA Water Vapor Project
NSF: National Science Foundation
OGP: Office of Global Programs
PACS: Pan American Climate Studies
PACS-SONET: Pan American Climate Studies Sounding Network
PDF: Probability Density Function
PDO: Pacific Decadal Oscillation
QSCAT: NASA's Quick Scatterometer
RASS: Radio Acoustic Sounding
RMM: Regional Mesoscale Model
RPV: Remotely Piloted Vehicle
SEAKEYS: Sustained Ecological Research Related to Management of Florida Keys Seascape
SLP: Sea-Level Pressure
SMO: Sierra Madre Occidental
SSMI: Special Sensor Microwave Imager
SST: Sea Surface Temperature
SSTA: Sea Surface Temperature Anomalies
SWAMP-90: Southwestern American Monsoon Project 1990
SWG: Science Working Group
TEW: Tropical Easterly Wave
TOVS: TIROS Operational Vertical Sounder
TRMM: Tropical Rainfall Measuring Mission
UHF: Ultrahigh Frequency
VAMOS: Variability of the American Monsoon System, an element of CLIVAR
VEPIC: VAMOS/EPIC
VOS: Voluntary Observation Ships
WFS: West Florida Shelf
WHWP: Western Hemisphere Warm Pool