The North American Monsoon Experiment
Forecast Forum

Prepared by the NAME Science Working Group

Draft v4.0:
The NAME Forecast Forum

Purpose:
To provide, for the North American Monsoon research and applications communities, an accessible, online forum, for the posting, distribution, monitoring and synthesis of intra-seasonal and seasonal precipitation forecasts of the North American Monsoon.

Principal Activities:
1. To monitor key indices of monsoon behavior
2. To monitor forecast skill of intra-seasonal to seasonal predictions of the North American Monsoon (NAM)
3. To make publicly available, a range of operational and experimental NAM intra-seasonal and seasonal precipitation forecast products
4. To link NAM monitoring activities with other monsoon monitoring activities such as that currently under development by NOAA Climate Prediction Center and the North American Monsoon climate research community
5. To link NAM monitoring and forecasting activities to the societal applications community that is cultivating improved uses and communication of monsoon information

Brief Rationale:
Since completion of the 2004 NAME Enhanced Observing Period NAME has entered into its principal modeling and prediction phase, and there is a clear need to demonstrate and assess warm season forecast skill, particularly as it relates to precipitation and streamflow. As a logical follow-on to NAM modeling activities coordinated under the NAME Model Assessment Program (NAMAP), there is an opportunity to provide a forum which consolidates and assesses, in real-time, the skill of intra-seasonal and seasonal monsoon forecasts. The NAME Forecast Forum has been designed to meet this opportunity. In fulfilling its stated purpose (above) the NAME Forecast Forum will help address a key milestone of the NAME research program which is to assess and improve the skill of warm season precipitation forecasts across much of North America. This document provides the basic details on how the Forum will operate. In order to maximize the participation of operational and research prediction groups in the U.S. and abroad, we have developed a relatively simple framework and suite of forecast indices which attempt to characterize major aspects of the North American Monsoon precipitation regime. While it is realized that additional, non-precipitation, metrics may also be of significant use and value, for now the Forum will remain focused on the monitoring and prediction of precipitation. All monitoring and forecasted data submitted to the forum will be made available to the public online through the NOAA/CPC ‘global monsoons monitoring’ web site which is now in operation. The timeline for NAME Forecast Forum activities will encompass the 2008 and 2009 monsoon seasons. The following pages outline the rationale for a small selection of monsoon precipitation indices and procedures for submitting forecast products to the Forum.
Development of North American Monsoon Precipitation Indices

Background:
Diagnostic research into the North American Monsoon precipitation regime has yielded significant insight into the spatial covariance structures of warm season precipitation anomalies across the southwestern parts of North America. Numerous works have attempted to regionalize, largely through EOF-type analyses, regions of warm season precipitation and streamflow coherence (c.f. Comrie and Glenn, 1998; Englehart and Douglas, 2002; Hu and Feng, 2002; Brito-Castillo et al., 2003; Gutzler, 2004; Gochis et al., 2006; Liebman et al., 2007). Many of these studies have exhibited significant consistencies in the spatial coherence of hydroclimatic variability. In a few cases the delineation of zones of regional coherence in rainfall and streamflow differ more substantially. While it is not the intent of this document to provide a thorough review and explanation for such differences, all of these studies differ to some degree with respect to analysis domains, periods of record, character of data (e.g. rain gauge vs. interpolated rainfall vs. streamflow) and analytical approaches. Depending on their respective periods of record, such regionalization studies may also be influenced by long-term changes in the multi-decadal variability of the coherence of rainfall anomaly patterns as discussed by Hu and Feng (2004 and 2007).

The purpose of this document is to put forward a suite of forecasted and monitored indices which can be used to:

a) simultaneously track monsoon precipitation behavior throughout the monsoon season
b) provide easy to use indices of precipitation for operational and research modeling groups in the creation of regionalized seasonal and subseasonal precipitation forecasts

Given that the vast majority of models engaging in seasonal forecast activities are global circulation models, there are practical limitations on the spatial resolution of the both the indices and the forecast data used to create an index. Therefore, the proposed suite of indices encompasses only the most basic structures of precipitation variability across southwestern North America. The index values will include average, anomaly and standardized precipitation index (SPI) values for each defined region.

We define the following regions for tracking and forecasting NAM precipitation variability:

Delineation of a general region of the NAM
1. This large-scale region attempts to encompass the entire locus of warm season convective activity commonly referred to as the North American Monsoon. Upon reviewing and synthesizing the studies above it was found that most NAM regionalization studies are fairly well encompassed by a general domain encompassing the southwest U.S. and the northwestern half of Mexico and including Baja California. (Note that Baja California is comparatively more dominated by the influence of tropical storms (c.f. Englehart and Douglas, 2001) than most other typical monsoon regions.) This general domain is similar to that
used in the composite analyses of Higgins et al., 1997 as well as the EOF study of Gutzler 2004 (his Figure 1). The region is significantly larger than the region 1 of Comrie and Glenn, 1998 (their Figure 4), and the NAME Tier I region where instrumentation was centered during the 2004 NAME Enhanced Observing Period. It is clear that this domain does not encompass all regions influenced by the North American Monsoon circulation, particularly with regards to its potential teleconnection effects. However, the area encompassed by this domain appears to be strongly modulated by the seasonal onset of warm season convective precipitation, often occurring in mid- to late-June and continuing through mid- to late-September.

![North American Monsoon Regional Domain](image)

**Figure 1. North American Monsoon Regional Domain**

*Delineation of NAM sub-regions*

Several of the above listed studies have attempted to identify various regions of precipitation coherence at daily, intra-seasonal and seasonal timescales. Some of the principal consistencies between findings are summarized as follows:

a) modal differences between monsoon rainfall (and streamflow) which divide the western slope of the SMO into North (northwest Mex.) South (southwest Mex.) regions [c.f. Hu and Feng, 2002, Fig. 2c; Brito-Castillo et al., 2003, Figs. 2a and b, Gutzler, 2004, Fig. 3b; Gochis et al., Figs. 4a and c]

b) modal differences between locations on the west vs. east side of the continental divide in both the southwest U.S. (Arizona vs. New Mexico) and in western Mexico (west vs. eastern slopes of the Sierra Madre Occidental) [c.f. Comrie and Glenn, 1998, Fig. 9; Englehart and Douglas, 2002, Fig. 6; Hu and Feng, 2002, Fig. 2b; Gutzler, 2004, Fig. 3b, Gochis et al., 2006, Fig. 4]

c) modal differences between the borderlands, Arizona and New Mexico (e.g. north of approx. 30° N latitude) and regions further south in Mexico [c.f. Comrie and Glenn, 1998; Hu and Feng, 2007]

d) the influence of tropical cyclones on the rainfall climatology of Baja California (Englehart and Douglas, 2001)
Based on these findings we define a limited selection of monsoon sub-regions which can be used to track and predict the regional coherence of precipitation variability within the N. American Monsoon domain. Given the practical limitations imposed by the coarse resolution of many global models we have attempted to define regions which, while preserving the statistical properties of rainfall coherence, will not adversely suffer from sampling deficiencies using global circulation model output. The sub-regions we define bound the following domains and are illustrated in Figure 2:

1) Northwest Mexico: nominally, from the continental divide west to the Gulf of California and from northern Sonora and Chihuahua (e.g. approx. 30° N latitude) south to approximately Mazatlan, Sinaloa
2) Arizona: from the Mogollon rim region southward to approx. 30° N latitude and from the continental divide in western New Mexico to the low desert region west of Phoenix
3) New Mexico: from the continental divide eastward to the Texas-Oklahoma border
4) Mexican Plateau: the eastern slope of the Sierra Madre Occidental from the continental divide east to the high deserts of eastern Chihuahua and Durango
5) Southwest Mexico: the coastal and highland regions of far southern Sinaloa, Nayarit, and Jalisco
6) Southern three-quarters of Baja California
7) Mouth of the Colorado River and low deserts of California, Nevada and Arizona
8) ‘Four Corners’ region of the Colorado Plateau

Figure 2. North American Monsoon Sub-Regional Domains
Forecast Forum Monitoring, Prediction and Verification Products:

This section contains prototypes of the Forecast Forum products that will be synthesized from monitoring and forecast data submitted to the forum. The goal is to provide a simple suite of graphical based monitoring, forecast and verification products that will be usable by the broader community. [NOTE: The figures shown here are for illustrative purposes and were constructed using either artificial or surrogate data and do not represent actual forecasts.]

Monitoring and Prediction Products:

1. Regularly updated rainfall accumulation plots for each regional index using the spatially-interpolated NOAA Climate Prediction Center (CPC) Unified Rain gauge Dataset (URD) as the key monitoring dataset. Both individual and multi-model or ensemble-mean index values will be plotted along with the monitoring (i.e. observed) data as shown below.

2. Time series of regionalized precipitation anomalies and regionalized values of SPI

3. Monthly and seasonal maps of single model and model multi-model composite anomalies, % of normal values (shown below) of forecasted regional indices. [NOTE: This product assumes that a model climatology (climate mean values) is available for the calculation of anomalies and/or % departures]:

![Example graph showing accumulated precipitation over time with different models and datasets compared to CPC URD.](image-url)
4. Maps of forecasted monthly and seasonal precipitation totals, anomalies and % of normal departures over the U.S.-Mexico domain similar to those currently generated by the CPC daily precipitation monitoring website (shown below):

EXAMPLE: Sub-region forecasts of % Normal JAS Precipitation

EXAMPLE: Forecasts of U.S. Mexico monthly and seasonal precipitation. [NOTE: this example figure is taken directly from the CPC daily precipitation monitoring website]

5. Sea surface temperature indices have long been implicated in variability in seasonal rainfall. Therefore, regularly updated sea-surface temperature indices
that have been documented to have a significant correlation with particular aspects of monsoon rainfall (e.g. N3.4, N1+2, NP, PDO, Gulf of California, AMO, Caribbean/Intra America Sea) will be monitored.

6. We also welcome the contribution of empirically-based or dynamically-based experimental forecasts, as well as shorter-term, or sub-seasonal forecasts (i.e. lead time of 1-4 weeks) for posting to the forum. While the products detailed in 1-5 above are expected to be standard products developed and distributed through the Forum we openly encourage investigators creating other types of monsoon precipitation forecasts (dynamical or empirical) to contact the forum if they are interested and willing to share their products openly. These products would likely be posted in a more generalized context to be determined at a later date.

Verification Products:
Following each monsoon season a brief post-hoc analysis of the previous monsoon season and its forecasts will be conducted. The purpose of this effort is to provide a more comprehensive assessment of the previous season’s monsoon and monsoon forecasts than what is possible in real-time. This effort will incorporate additional gauge-based datasets (e.g. NERN, simple NAME gauge data, additional co-op data from the U.S. and Mexico) in creating the verification dataset. It will performed during the intervening cool season and be made available online prior to the spring forecast cycle. Analyses of model performance may include but would not be limited to the following:

1. Monthly and seasonal NAM precipitation anomaly correlation maps as verified by the NOAA/CPC-URD seasonal (July-Aug-Sep) precipitation anomalies

2. Comparison of probability distribution functions of regionalized daily precipitation values between models and CPC-URD

3. Tabulated values of forecast bias and skill for each of the regions
Timeline for forecast submissions:

Ray et al (2007) recently identified major societal sectors that are both sensitive to variations in NAM hydroclimate and have a capacity to use and apply climate information. The authors identified natural hazards (e.g., drought, floods and fire), agriculture, public health and water management as four principal sectors in which climate plays a significant role in overall vulnerability. From this study a decision calendar was created which identifies the time periods of critical decision making activities related weather and climate in the North American Monsoon region.

Since one of the goals of the NAME Forecast Forum is to “link NAM monitoring and forecasting activities to the societal applications community” (see above), the Forecast Forum will operate on a timeline which is intended to be compatible, to the degree possible with the NAM annual decision calendar of Ray et al. Shown in the NAME Forecast Forum Product Timeline below are the planned creation and posting dates for the principal products to be disseminated through the forum beginning from the start of the 2008 calendar year. There will be two primary forecast cycles, the first in Jan-Feb-Mar and the second in Apr-May-Jun. These two periods, which generally encompass major operational prediction cycles at CPC and other centers, aim to provide both ‘long-lead’ (6-9 month) and ‘short lead’ (0-6 month) forecasts of the North American Monsoon. Any forecasts generated during these two periods can be submitted to the Forum using the guidelines outlined in the following section. Monthly or seasonal forecast products from these two lead periods will be accepted. Those wishing to submit shorter term forecasts (i.e. 1-4 week lead times) should contact the forum directly for details.
In addition to forecast submittal and posting two additional periods are specified on the timeline. The first period simply identifies the principal NAM monitoring period of Jun-Jul-Aug-Sep where the forum monitoring products will be updated regularly with observational data. The second period (Oct-Nov-Dec-Jan-Feb-Mar) identifies a period where a cursory review and evaluation of the previous monsoon season and forecasts is undertaken. This review will consist of the creation of a review document with a brief description of how various model forecast indices compared with their respective monitoring indices. The review document will be discussed and refined via a conference call between the forecast groups and the hosts of the forum from the NAME SWG and NOAA CPC. The final product of this review will be posted by Mar. of the following year so that users of next-year forecasts can assess how particular forecast products performed the previous monsoon.
Submission of Forecast Products/Data

The complete procedure for submitting forecasts to the Forum is currently under development and will be completed by the beginning of calendar year 2008. As indicated above the Forum will be hosted by NCEP/CPC and all products will be submitted directly to them. The general chain of activities will consist of individual modeling groups creating index values from their own model runs and then submitting these indices to the Forum directly. A gridded mask of the forecast zones will be made available on the Forum website. This mask will be a global 0.25x0.25 deg lat/lon grid with the appropriate regions designated above identified. Additional forecast plots such as spatially-distributed anomaly maps and similar products may be submitted as well but groups will need to contact the forum directly to arrange these submissions. At this time we have created the following outline which contains the basic steps in submitting a forecast.

*Draft Basic Steps to Submit NAM Forecasts to the Forum:*

1. Execute model runs and determine the appropriate lead time window using the Forum calendar above
2. Create spatially-averaged time-series values of forecasted precipitation using regional masks provided by the Forum
3. Submit time series of forecasted regionally-averaged precipitation to the Forum
4. For groups possessing model climatologies:
   a. create regionally-averaged values of the model climatological values
   b. create regionally-averaged values of forecast anomalies and ‘percent of normal’ precipitation
   c. create regionally-averaged values of forecasted SPI (optional but highly desired)
   d. submit time series of forecasted regional anomalies, ‘percent of normal’ and SPI values to the Forum.

Since this portion of the work plan is still under development we greatly welcome feedback on this plan. As stated above, we also welcome the contribution of empirically-based or dynamically-based experimental forecasts, as well as shorter-term, or sub-seasonal forecasts (i.e. lead time of 1-4 weeks) for posting to the forum. We openly encourage investigators creating other types of monsoon precipitation forecasts (dynamical or empirical) to contact the forum if they are interested and willing to share their products openly.
REFERENCES


12