Assessment of Land Surface Hydrologic Predictability in the NAME Region Using a Derived Long-Term Land Surface Data Set

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3. Project Duration

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4. Introduction

The spatial and temporal variability of warm season precipitation over North America is, in general, poorly represented by the current generation of General Circulation Models (GCMs). However, there is recent evidence via modeling results of possible feedbacks between soil moisture and snow cover and the strength of the North American Monsoon system (NAMS). To date, it has not been possible to evaluate such relationships through data analysis, because soil moisture and snow cover data do not exist over a long enough time period, and do not span a sufficient spatial extent, to support such an effort. The central focus of this project is to produce the necessary data sets of observed and derived land surface variables, and to conduct exploratory data analyses to address directly questions related to the role of land feedbacks on the NAMS.

The Land Data Assimilation System (LDAS) project undertaken by GAPP has had as a principal objective the creation of more realistic initial conditions for weather and climate forecast models through the use of land surface parameterizations run off-line using observed forcings. The methods developed as part of LDAS are ideally suited to provide long-term surrogate data sets that can be the basis for evaluations of the role of the land surface in precipitation predictability over the NAMS region.

The overarching science question to be addressed by this research is "To what extent do soil moisture and snow anomalies affect the evolution of the North American Monsoon, and can such relationships (if any) be demonstrated using long-term derived soil moisture and snow data sets?". The proposed project has three objectives:

1) Extend the retrospective LDAS data set to cover all of NAME Tiers 1 and 2 for a period of approximately eighty years. Produce real-time LDAS data set over NAME Tiers 1 and 2.
2) Using the derived land surface data (especially soil moisture), undertake predictability studies to address the central science question associated with the role of the land surface in NAMS predictability. Test the resultant feedback mechanism by coupled modeling (RSM/VIC) experiments.
3) Utilize the derived land surface data set in conjunction with uncertainty analysis to evaluate regions and variables for which additional observations would be most valuable to address NAMS predictability.

The central science question and objectives will be addressed through four tasks. The first two tasks will utilize methods developed in creation of the 50-year LDAS retrospective data set to

extend a gridded 1/8 degree set of land surface forcings and derived land surface variables (precipitation, surface air temperature, downward solar and longwave radiation, wind, soil moisture, and land surface temperature) to cover all of NAME Tiers 1 and 2 for real-time and a period of 80 years. Task 3 will utilize the derived data sets, in conjunction with a range of prediction and diagnostic tools, to assess the relative role of land surface variables and SST in the evolution of the NAMS. And the resultant mechanism will be tested by the coupled model (RSM/VIC). Task 4 will utilize the forcing and derived land surface data sets in conjunction with a range of data analysis methods to evaluate uncertainty in the gridded retrospective surface fields, and to determine regions and variables for which additional observations would be most valuable.

5. Work in progress and accomplishments

The primary activities conducted to date are summarized below. Section 5.1 describes retrospective and real-time LDAS data set extension work, and Section 5.2 summarizes our data analysis work related to the role of antecedent land surface conditions in warm season precipitation over the NAM region.

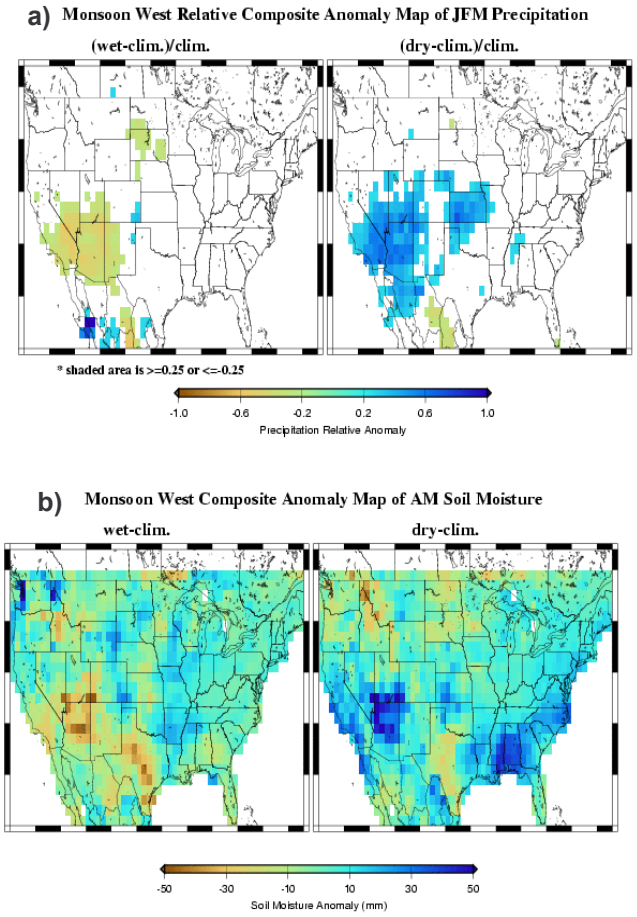

Figure 1: Monsoon west composite anomaly map a)Winter (JFM) precipitation b) Spring (AM) soil moisture

5.1 80-year retrospective and real-time LDAS data set extension

We are extending the retrospective LDAS data set to cover the period from the early 1920s through present for all of NAME Tiers1 and 2. We will also produce a real-time data set from spring 2004 through the end of the field campaign in late summer, 2004. The existing Maurer et al (2002) data set covers that portion of NAME Tiers 1 and 2 south to latitude 25 N (about 2/3 of Tier 1). However, the portion of the domain in Mexico was largely treated as "filler" or buffer zone in creation of the data set, recognizing that the quality of the data used was considerably less outside the continental U.S. We have assembled more complete precipitation data sets for Mexico, as well as streamflow data which will be used to verify the predicted surface water balance over selected river basins. For retrospective runs, the main sources of station data are ERIC2 (1940-1998; a product from Mexican Institute of Technology of Water (IMPTA) of the SEMARNAP) for daily precipitation and temperature data, and a CD produced by SMN (Servicio MeterorolÓgico Nacional, 2000) with some stations dating back to the 1920s. SMN daily historical precipitation data (provided

courtesy of Miguel Cortez Vázquez of SMN) are also a data source for 1995 – near real-time. We are presently combining these raw station data sets and gridding them to provide forcings for the VIC model. The real-time daily precipitation station data (about 800-1000 stations across Mexico) are being provided daily by SMN in connection with the North American Drought Monitoring Project. For the real-time LDAS implementation, we will use the Eta 4-D Data Assimilation System (EDAS) hourly temperature.

5.2 Relationship between antecedent land surface conditions and NAMS

Using monthly aggregates from the retrospective Land Data Assimilation System (LDAS) archive for the period 1950 to 1999 (Maurer et al, 2002), we have explored possible links between North American Monsoon System (NAMS) seasonal (JJAS) precipitation and pre-monsoon seasonal land surface conditions, including precipitation, temperature, soil moisture and snow cover anomalies. We have evaluated the possible effects of the previous winter and spring's land surface conditions in various subcontinental "predictor regions" on Monsoon West (Arizona and Western New Mexico) monsoon precipitation. We found a statistically significant inverse relationship with winter precipitation for the region consistent with Higgins et al. (1998) and Hu and Feng (2002). This inverse relationship varies in strength; over the second half of the 20th century it was strong during the 1965-1990 period, but weak otherwise. An inverse relationship between monsoon strength and the previous winter's snow accumulation in the mountainous part of the U.S. Southwest was found similar to the finding of Gutzler and Preston (1997) and Gutzler (2000). Based on this inverse relationship, we hypothesize a land surface feedback mechanism that (anomalously) high winter precipitation may lead to high spring soil moisture, low late spring and early summer air temperature, decreased land-sea temperature contrast, and weak monsoon circulation. Figure 1 shows that spring soil moisture reflects memory of the previous winter's precipitation, and this memory persists into June (not shown). However, our results show that this land memory contributes little to the magnitude of NAM precipitation. Unexpectedly, June surface air temperature is inversely related with the monsoon strength. It appears that atmospheric circulation patterns, rather than land-atmosphere feedback, is probably the main reason for this inverse relationship.

6. Future research

We intend to complete construction of the retrospective data set by March, 2004 and to have the real-time system implemented by April, 2004. During the first half of 2004, we will expand our retrospective land-atmosphere teleconnection work for most of the 20th century to determine the robustness of the relationships identified for the 1965-90 period. We will then shift the focus of our work from off-line to coupled model runs, where we can isolate various aspects of land-atmosphere and atmosphere-ocean interactions to better understand causality and possible sources of NAMS predictability. For this purpose, we will utilize either a new version of the NCEP Regional Spectral Model (RSM) which uses our VIC land surface scheme, or a climate version of MM5 in which Ruby Leung and colleagues at Pacific Northwest National Laboratory have implemented VIC.

7. References

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8. Presentations

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