DECISIONS Project Progress Report
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Project Title: Integrating Enhanced GRACE Water Storage Data into the U.S. and North American Drought Monitors

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Major Activities and Accomplishments

The goal of this project is to integrate terrestrial water storage data derived from NASA's Gravity Recovery and Climate Experiment (GRACE) satellites into the US and North American Drought Monitor products. These are two of the premier drought products used by governments and stakeholders. The major advantage of GRACE is its ability to detect changes in water stored below the surface, including groundwater. Currently, deep soil moisture and groundwater are not considered in the production of the Drought Monitors because large scale, reliable observations have not been available. In order to accomplish the goal, the GRACE data first must be assimilated into a land surface model, which will enable horizontal, vertical, and temporal downscaling of the coarse resolution GRACE data, and extrapolation to near-real time. Next, the assimilated groundwater and soil moisture fields will be systematically incorporated into the *objective blends* that constitute Drought Monitor baselines. After optimizing this process, several *a posteriori* measures of drought severity and stakeholder feedback will be used to quantify improvement in the Drought Monitors due to inclusion of assimilated GRACE fields.

In Year 1, two post doctoral associates were assigned to the project, Bailing Li and Rasmus Houborg. The latter was a new hire. Dr. Li has experience in assimilating GRACE data into the Catchment land surface model. She has led, with guidance from Drs. Ben Zaitchik, Rolf Reichle, and Matt Rodell, the extension of the GRACE data assimilation system (GRACE-DAS) domain from the Mississippi River basin to all of North America (Figure 1). This has been the most significant accomplishment to date. A major component of that effort was the production of GRACE-derived terrestrial water storage (TWS) anomaly time series for the major river basins of North America. We also have identified and resolved a critical issue regarding the dynamic range of total water storage in the Catchment model. We have purchased and installed a new high performance analysis server, which will be the platform for all of our GRACE-DAS simulations, and we are in the process of porting the code to it. Dr. Li is teaching Dr. Houborg to use GRACE-DAS, and he will soon become the lead research associate. We have determined the configuration for a 60-year Catchment model simulation, including meteorological forcing data and model parameters. This simulation will be used to generate a climatology of simulated groundwater and soil moisture, a necessary prerequisite to the integration of these fields into the Drought Monitor objective blends. The forcing for this long term simulation will be a combination of the Princeton 1948-2000 forcing dataset with the NLDAS 1996-present forcing

dataset. Thus another important accomplishment was enabling the GRACE-DAS to use these new forcing datasets as input.

We have had two teleconferences and several other communications with our partners at NOAA/NCDC, the University of Nebraska's National Drought Mitigation Center, and the University of California, Irvine. Outcomes of these teleconferences included significant progress on the details of the optimal technique for integrating the GRACE-DAS output into the Drought Monitor objective blends. Dr. Jay Lawrimore at NCDC is working with the principle developer of the objective blends to prepare to receive and utilize the GRACE-DAS output.

The project has already generated much interest. Preliminary results have been presented at several venues by Drs. Rodell, Zaitchik, and Reichle, including the annual meetings of the American Geophysical Union and American Meteorological Society, two meetings at the World Bank, a Group on Earth Observations (GEO) workshop, and local meetings with representatives from the USGS and the State Department.

Schedule Status

Because of the time required to set up the funding and subcontracts, to advertise for and hire a post doctoral associate, and to procure, install, and configure a high performance analysis server, the effective start date of the project was approximately 1 August, 2008. Thus we have just completed the third quarter of the project. Tasks for the first three quarters listed in the schedule in our proposal were the following:

1. Run GRACE-DAS over Mississippi basin 1996-present, NLDAS forcing.

Status: The critical point here was development of the ability to use NLDAS meteorological forcing, which has been completed. Furthermore, we determined that it would be necessary to generate a climatology based on a much longer period than 12 years, so we combined the Princeton 1948-2000 forcing dataset with the NLDAS dataset and enabled the GRACE-DAS to use it as input.

2. Small scale tests of new objective blends with GRACE data.

Status: After discussions with the Drought Monitor objective blends principle developer, Richard Tinker (NOAA), we determined that it would be most efficient to generate the 60-year climatology for all of North America before experimenting with the assimilated groundwater and soil moisture data as components of the objective blends.

3. Derive terrestrial water storage anomalies from GRACE for North American basins.

Status: Complete. We also have had discussions with GRACE principles at the University of Texas Center for Space Research, who have agreed to provide "quick look" (available within 2-3 weeks of the observation, rather than the standard 2-3 months) GRACE products to us on an experimental basis, with the hope that they will be useful for other applications projects as well.

4. Extend GRACE-DAS to North American domain.

Status: Complete (Figure 1).

5. Reconcile climatologies of GRACE-DAS and other blend components.

Status: See the note for Task 2. This will commence upon completion of the 60-year climatology.

Assessment of Project Development

Our progress is consistent with the schedule outlined in the proposal. There have been some changes, including the effective start date, the strategy for incorporating the GRACE-DAS

output into the objective blends, and development of the ability to use a longer forcing dataset. These are healthy developments which simply reflect the evolution of the project.

Project Management Metrics

Following is a list of project management metrics outlined in the proposal which are relevant at the current stage of the project. The performance of each is satisfactory, as described in earlier sections.

- Accomplishment of each milestone noted above
- Percentage of tasks starting and ending on schedule
- Number of days ahead or behind schedule for each task
- Budget is not being exceeded
- Time required to extend and optimize GRACE-DAS to North America
- Results presented and published

Planned vs. Actual Financial Activity

The project effectively began 10 months behind the proposed schedule. Given that, the budget is on track and funds are being burned at the appropriate rate. More details are available upon request.

Performance Measures

The most important early goal of the project has been completed on schedule: development of the ability to run GRACE-DAS over all of North America. Additional performance measures will be assessed later in the project when the GRACE-DAS results begin to be incorporated into the Drought Monitors.

Figures

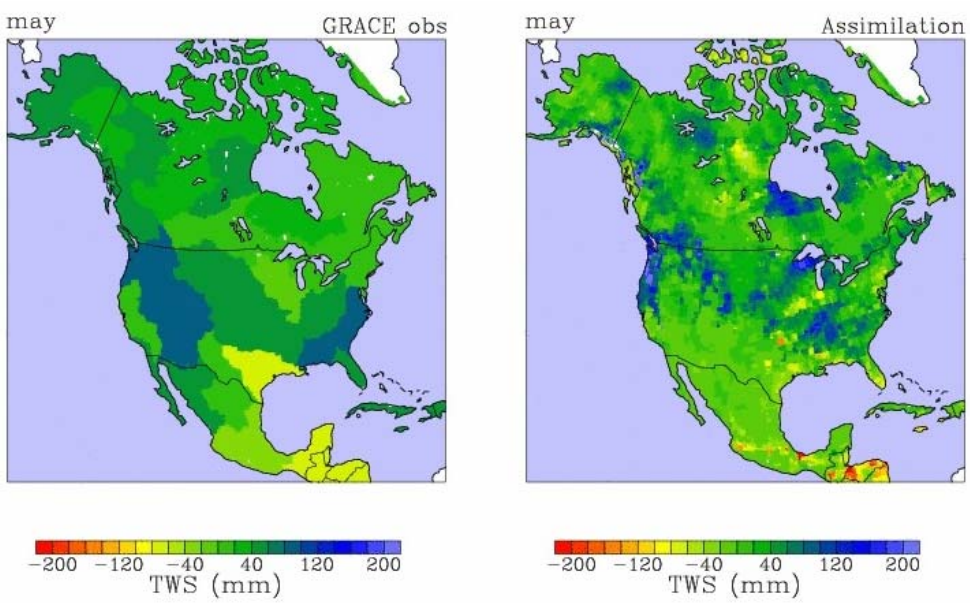

Figure 1: Basin scale terrestrial water storage anomalies (mm equivalent height of water) derived from GRACE (left) and output from the GRACE data assimilation system (right), for May 2003.