Prediction Activities at NASA's Global Modeling and Assimilation Office

Siegfried Schubert

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The Global Modeling and Assimilation Office (GMAO) is a core NASA resource for the development and use of satellite observations through the integrating tools of models and assimilation systems. Global ocean, atmosphere and land surface models are developed as components of assimilation and forecast systems that are used for addressing the weather and climate research questions identified in NASA's science mission. More information about the GMAO may be found at http://gmao.gsfc.nasa.gov/

One of the key questions being addressed in NASA's science mission is how well transient climate variations can be understood and predicted. Advanced assimilation techniques are being developed to improve seasonal prediction skill by using the information in satellite altimetry and sea surface temperature. Techniques for utilizing soil moisture data are being developed based on research indicating that such data can significantly influence predictions of summertime precipitation over some continental regions (e.g., Koster et al. 2004). The GMAO contributes seasonal predictions to the consensus forecasts at NCEP, the International Research Institute for Climate Prediction (IRI), and the APEC Climate Center (APCC). The GMAO is exploring the impact of coupled prediction strategies and observations on prediction skill at sub-seasonal to decadal timescales, with a focus on identifying the role that specific observations play in extending prediction skill. High resolution versions of the global model and data assimilation system are being developed that enable the assimilation of high resolution satellite data and also provide new tools for exploring and predicting weather/climate linkages.

At weather time scales the GMAO is developing ultra-high (cloud-permitting) resolution global climate models capable of resolving high impact weather systems such as hurricanes. The ability to resolve the detailed characteristics of weather systems within a global framework greatly facilitates addressing fundamental questions concerning the link between weather and climate variability. Figure 1 illustrates how a recent version the GMAO atmospheric model (GEOS-5), run at 3.5km horizontal resolution, is able to simulate the fine structure of a strong hurricane as well as other detailed features of the global environment. The GMAO is conducting research to explore the linkages between tropical storm activity (tracks, frequencies and intensities) and the large-scale variability associated with the Madden Julian Oscillation (MJO), the El Niño Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and the Atlantic Multi-decadal Oscillation (AMO).

At sub-seasonal time scales, the GMAO is engaged in research and development to improve the use of land information (especially soil moisture), and in the improved representation and initialization of various sub-seasonal atmospheric variability (such as the MJO) that evolves on time scales longer than weather and involves exchanges with both the land and ocean. Figure 2, for example, shows the results from a series of hindcasts with an early version of the GEOS-5 coupled model that highlights the temporal variability of the predictability associated with the MJO, and the potential for skillful predictions beyond two weeks lead-time.

The GMAO has a long history of development for advancing the seasonal-to-interannual (S-I) prediction problem using an older version of the coupled atmosphere-ocean general circulation model (AOGCM). This includes the development of an Ensemble Kalman Filter (EnKF) to facilitate the multivariate assimilation of ocean surface altimetry (Keppenne et al., 2008; Rienecker et al., 2010), and an EnKF developed for the highly inhomogeneous nature of the errors in land surface models, as well as the multivariate assimilation needed to take advantage of surface soil moisture and snow observations (e.g., Reichle et al., 2008). Figure 3 shows a recent coupled AOGCM forecast for JJA of 2010. The results show an emerging La Niña event and a warm tropical Atlantic. The precipitation forecast indicates drought in the central United States, and the beginnings of an active hurricane season. Visit http://gmao.gsfc.nasa.gov/cgi-bin/products/climateforecasts/index.cgi for more information about the seasonal-to-interannual forecasts.

The importance of decadal variability, especially that associated with long-term droughts (e.g., Schubert et al. 2004), is well recognized by the climate community. An improved understanding of the nature of decadal variability and its predictability has important implications for efforts to assess the impacts of global change in the coming decades (e.g., Wang et al. 2009). In fact, the climate community has taken on the challenge of carrying out experimental decadal predictions in support of the IPCC AR5 effort. The GMAO is among the groups that have committed to carrying out the set of decadal hindcasts and forecasts as defined by CMIP-5 (http://cmip-pcmdi.llnl.gov/cmip5/). In carrying out these highly experimental predictions we will take advantage of our capabilities to replay the coupled model to an existing atmospheric reanalysis (going back to 1950), as well as, the work being done to assimilate historical ocean observations employing a weakly coupled (atmosphere-ocean) data assimilation technique.

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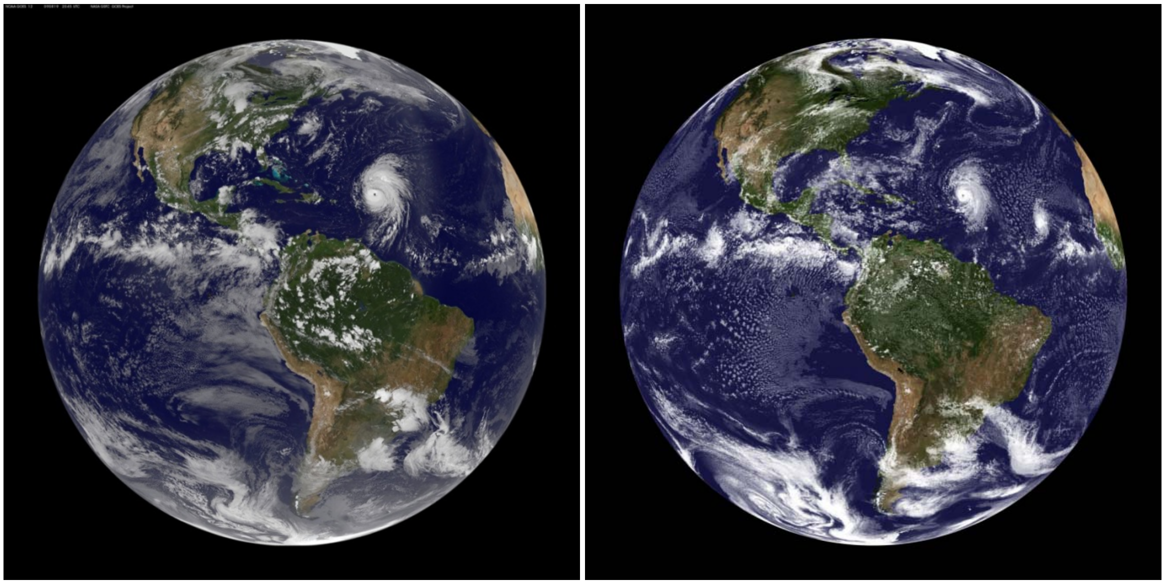

Figure 1: Left Panel: A GOES image of Hurricane Bill. Right panel: A 72-hour forecast of Hurricane Bill with a high resolution (3.5km) version of the GEOS-5 AGCM. The 72-hr forecast was initialized 2009-08-16 21z

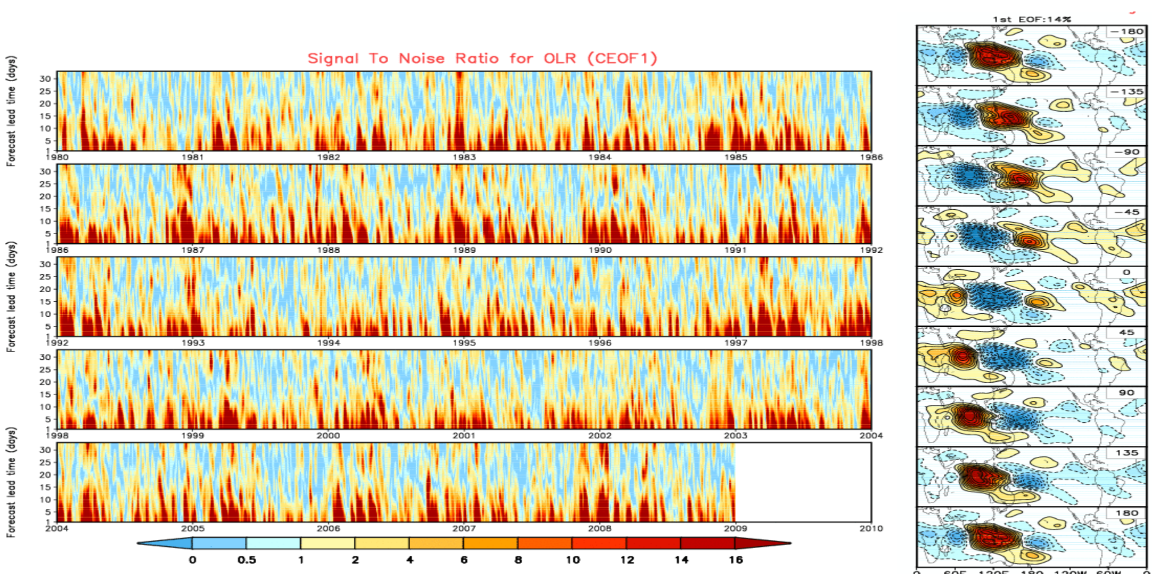

Figure 2: The results of a set of 6-month hindcast experiments with an early version of the GEOS-5 AOGCM initialized every day from 1980 through 2008. The panels on the left show the time series of the signal-to noise ratio of the OLR during the first month of each forecast for the first complex EOF (shown in the panels on the right) associated with the MJO.

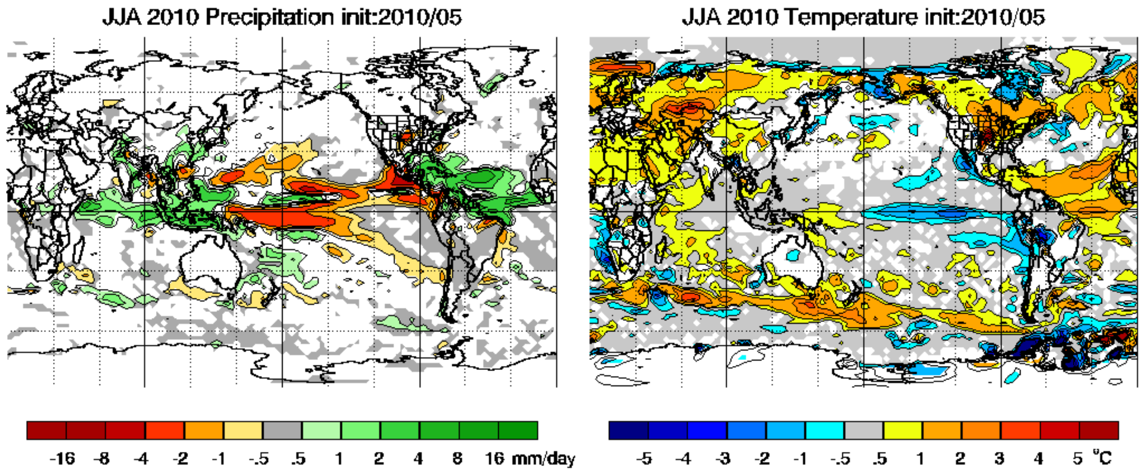

Figure 3: An example of an experimental seasonal (JJA) forecast carried out with the NASA/GMAO version 1 AOGCM (CGCMv1). The results are the ensemble averages of 18 ensemble members intialized on 1 May 2010. The left panel shows the precipitation anomalies, and the right panel shows the surface temperature anomalies.

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Summary

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At weather time scales the GMAO is developing ultra-high resolution global climate models capable of resolving high impact weather systems such as hurricanes. The ability to resolve the detailed characteristics of weather systems within a global framework greatly facilitates addressing fundamental questions concerning the link between weather and climate variability. At sub-seasonal time scales, the GMAO is engaged in research and development to improve the use of land information (especially soil moisture), and in the improved representation and initialization of various sub-seasonal atmospheric variability (such as the MJO) that evolves on time scales longer than weather and involves exchanges with both the land and ocean

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