Diagnosing the Land-Atmosphere Coupling in Reanalysis Products During Dry/Wet Extremes in the U.S. Southern Great Plains

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The strength of local land-atmosphere coupling ('LoCo') is a function of complex processes and feedbacks that require further understanding and quantification in prediction models, which ultimately impacts the simulation of sensible weather, turbulence, convective initiation, and precipitation across a range of scales. To this end, recent efforts under the GEWEX Global Land-Atmosphere System Study (GLASS) panel have developed a framework for diagnosing the strength and accuracy of LoCo that can be applied to any models or observations. This approach focuses on land-PBL interactions and feedbacks, and is premised on the idea that the daily variability of heat and moisture states and fluxes near the Earth's surface is reflective of both land surface (soil moisture) and atmospheric (boundary-layer depth) conditions. Therefore, the sensitivity of the coupled system can be quantified by simultaneously considering land and PBL processes, rather than one-at-a-time evaluation of individual variables that are typically performed.

LoCo diagnostics have since been developed, tested, and implemented using a unique NASA modeling system (LIS-WRF; Kumar et al. 2008) that includes a suite of atmospheric PBL schemes with a flexible, high-resolution land surface model interface (LIS) to evaluate the behavior of different land-atmosphere couplings. Results show that soil moisture anomalies lead to significantly different signatures of heat and moisture evolution, and highlight the potential utility of routine observations (e.g. 2-meter temperature and humidity) to be used as diagnostics of LoCo. Recent NASA Energy and Water Cycle Study (NEWS) and other community-based efforts (e.g. GEWEX-Landflux) have shown that current large-scale data and model products have significant uncertainty and spread in surface flux and other water and energy budget terms across global, continental, and regional scales. LoCo diagnostics can therefore be useful in diagnosing such products and lead to improvements in the proper translation of land surface states and anomalies (e.g. flood/drought) into atmospheric quantities (e.g. afternoon convection). To this end, the NEWS Integration Project on dry/wet extremes in the U. S. SGP has provided a collaborative foundation by which to apply LoCo diagnostics to reanalysis products such as MERRA and NARR in order to quantify their land-PBL coupling behavior.

In this study, LoCo diagnostics including the mixing diagram, PBL budget, evaporative fraction-PBL height, and LCL deficit approaches are applied to MERRA and NARR's mean diurnal cycles and observations from ARM-SGP during the summers of 2006 (dry) and 2007 (wet). Both MERRA and NARR perform quite well in terms of their land-PBL coupling relative to detailed in-situ observations. Even at monthly mean scales, the extreme dry/wet regimes and their impacts on 2-m T, q, surface heat and evaporative fluxes, and PBL growth and entrainment fluxes are all captured well by each, including the appropriate seasonal evolution.

Overall, results show how LoCo diagnostics can be applied across a range of scales and model products to gain insight on their relative and absolute behavior in terms of land-PBL coupling components. When comparing against the high-resolution regional (LIS-WRF) simulations with detailed land surface initialization, we see somewhat comparable results in the reanalysis products. This approach is now being repeated for other sites, regions, and case studies in order to further understand the coupling strength and behavior in MERRA, NARR, and other reanalyses versus that seen in-situ and remotely-sensed observations (e.g. AIRS).

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