Land-Atmosphere Coupling Studies Using the LIS-WRF System

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Project Description

Hypothesis:
Uncoupled systems (e.g., LDAS/LIS) or experiments (e.g., PILPS) may lead to inaccurate water and energy cycle process understanding by neglecting feedbacks due to Local Land-Atmosphere Coupling (‘LoCo’).

Objectives:
- To accurately understand, model and predict the role of LoCo in land–atmosphere interactions in the evolution of PBL/land fluxes and state variables.
- Develop a methodology to study factors controlling LoCo, using the coupled LIS-WRF system as a testbed to evaluate coupling diagnostics within community PBL and land surface models.

Contribution to the GEWEX-GLASS Community:
- Understanding and quantification of the processes controlling LoCo and their representation in offline, single-column, and fully-coupled models.
- Diagnostic approach that can be applied to any model (MERRA, MMF, GEOS-5) and observations.
- Determine the impact of the spatial and temporal scales of land surface physics and heterogeneities on convective initiation, clouds, and precipitation.
- Assess the impact of LoCo on assimilation of NASA observations into WEC predictions.

Diagnostic Framework

- The degree of LoCo between the land surface and PBL must be represented accurately in models, but remains largely undiagnosed due to the complex interactions and feedback processes present across a range of scales.
- A PBL-LS balance is created each day that depends on the nature and degree of L-A interactions in each coupled model.
- The diurnal evolution of:
  - 2m pot. temperature
  - 2m humidity can be used to diagnose the Surface and PBL (entrainment) fluxes
  - 600mb, 850mb reflect the heat and moisture equilibrium reached for a particular PBL + LSM coupling
  - Advection can be added as a third vector to quantify the full PBL budget and its locality.

Model and Experimental Design

Coupled LIS-WRF
- 1-km horizontal resolution
- NARR forcing
- 43 vertical levels (~42 m sfc)
- 3 PBL + 3 LSM configurations:
  - 9 combs of L-A coupling
- Case studies:
  - HOPPS, C99, Cabauw

LSMs in LIS
- Noah (NCEP)
- CLM (Community Land Model)
- 4 soil layers
- 10 soil layers (2 cm upper)
- NCEP operational
- Extensive canopy/wet soils
- 4 soil layers
- Tiled soil, canopy, snow surfaces

Future Work

Diagnostic Approach:
- Soil moisture perturbation experiments
- LIS-WRF to serve as testbed for GLASS/LoCo-experimented exctations
- NEWS 2006/7 extremes
- Single-column model testbed (WRF 1-D)

Extend methodologies:
- Convective initiation, clouds, precipitation & heterogeneity
- Mass-flux transport
- Larger scales and models (MERRA, GEOS-5, MMF)
- NASA observations:
  - Incorporate satellite remote sensing of PBL and LS properties into diagnostcs
- How does LoCo impact data assimilation in offline, single-column, and coupled models?
- EnKF in LIS-WRF: surface temperature, soil moisture, & snow cover