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 of 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 physical 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 LA interactions in each coupled model.
- The dural evolution of 2m potential temperature and humidity can be used to diagnose the Surface and PBL (entrainment) fluxes.
- Dryness ratios 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.

Coupled LIS-WRF

- 1-km horizontal resolution
- NARR forcing
- 43 vertical levels (~42m sfc)
- 3 PBL + 3 LSM combinations: 9 combos of LA coupling
- Case studies:
  - HOPPS, CIB, Cabauw

Land Information System

- Developed at NASA-GSFC
- Suite of LSMS with no cross-resolution, forcing, parameters
- Provides capability for improved initialization of land surface states
- Plug-in design supports model calibration and DA

Model and Experimental Design

PBLs in WRF

YSU: 0.806
MYJ:  -1.23
YSU: -3.25
MYJ:  -0.02
YSU: 0.635
MRF: 0.632
MYJ:  -1.23
YSU: 0.635
MRF: 0.69/0.35

Land-Atmosphere Coupling Studies

- Soil moisture perturbation experiments
- LIS-WRF to serve as testbed for GLASS/LoCo-directed experiments
- 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 diagnostics
    - How does LoCo impact data assimilation in offline, single-column, and coupled models?
    - EnKF in LIS-WRF: surface temperature, soil moisture, & snow cover

Future Work

Diagnostic approach:
- Soil moisture perturbation experiments
- LIS-WRF to serve as testbed for GLASS/LoCo-directed experiments
- 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 diagnostics
- How does LoCo impact data assimilation in offline, single-column, and coupled models?
- EnKF in LIS-WRF: surface temperature, soil moisture, & snow cover