1. Motivation, questions and strategy

Explicit connection can modify physics of land-atmosphere interaction (Holgenegger et al. 2009), yet the consequences of using cloud superparameterization (SP) for simulating the land-atmosphere interface in climate models have not been deeply explored. We have recently found that SP modifies the rainfall Triggering Feedback Strength (FFS, Findell et al. 2011) over North America and that SP amplifies the global Bowen ratio and its rate of increase under climate change simulations. Understanding why requires process level analysis on the diurnal timescale of flux partitioning / PBL feedback.

Questions: How does SP modify diurnal PBL energetics of the mean summer day? Does SP modify the sensitivity of PBL energetics to land surface conditions?

Strategy: Apply a Bettsian mixing diagram approach under the LoCo philosophy of Santanello et al. (2009). Compare climatologies of the mean summer day in SPCAM vs CAM simulations globally & against ARM Best-estimate data at SG.

2. SP adds complexity to LoCo 2-m mixing diagrams

Systematic effect observed over multiple land surfaces -- a stronger moistening/drying diurnal cycle in SPCAM than in CAM.

3. Details at ARM SGP imply SP alters atmospheric response vector.

SP introduces a deixis but exaggerated counter-clockwise rotation of the 2-m at- mospheric response vector in the 27-plane, from a morning heating-to-afternoon dry- ing-dominated regime.

Relative to ARM data, the di- urnal moisture cycle is too ex- treme in SP and an unrealistic "Atmospheric response" of early morning moistening occurs.

4. But actual bulk PBL energetics are insensitive to SP, 2-m state in LoCo is not a robust proxy for bulk PBL.

To ease comparison with data, the LoCo framework uses 2 meter conditions as a proxy for the bulk PBL.

But explicitly integrating SP conditions tells a different story. Comparing Figs. 1 & 3, the bulk PBL does not exhibit the systematic sensitivity to SP seen in Fig. 1, implying it is mostly a near-surface effect.

5. Robust effects of SP on near-surface PBL diurnal dynamics.

To investigate the effects of SP on the near-surface PBL, Fig. 2 shows differences in mixing diagram structure between SPCAM and CAM.

6. SP doesn’t modify PBL sensitivity to land surface moisture.

Explicit connection has the capacity to alter land-atmosphere feedback under certain meteorological re- gimes due to diurnal entrainment feedbacks affecting PBL dynamics. However, this does not lead to major emergent effects distinguishing the SPCAM. The sensitivity of bulk PBL surface moisture to land surface evaporative fraction in SPCAM mostly resembles that in CAM.

One regional effect of SP over the Central US is reducing the mean PBL moisture sensitivity to EF.

7. Take-home points

- We discover cloud superparameterization (SP) does not systematically modify bulk diurnal PBL energetics nor the atmospheric segment of land-atmosphere coupling as measured by the EF-sensitivity of diurnal PBL energetics.
- Although one regional effect is to reduce the mean PBL moisture sensitivity to EF over the Central US.
- We discover new effects of SP on near-surface diurnal variability in the PBL over most land surfaces:
  - SP strongly amplifies diurnal heating and especially moistening in the model layer immediately adjacent to the land surface. The lowest model level's state properties are less tightly coupled to overlying model levels than in the conventionally parameterized CAM.
  - Trapping of morning surface fluxes in the lowest model layer of the cloud resolving models occurs.
  - Compared to ARM data, the early morning moistening in SPCAM is unrealistic but the emergence of late morningsurface- amended drying is an improvement on the conventional CAM, albeit too exaggerated.
- Regarding the Lo-Co model intercomparison methodology of Santanello et al. (2009): Caution is advised in interpreting 2-m T and q as a proxy for PBL integrated energetics.
- Unfolding hourly time resolution in the surface/atmosphere decomposition method can be helpful, for us it helped pinpoint origins of an important near-surface effect of superparameterization on the PBL state.

References:

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