Motivation
How much do subgrid-scale land-atmosphere interactions affect the simulation of grid-mean cloud cover and liquid water content of shallow clouds in regions like central U.S. and Amazon in climate models?

Approach
- We performed nested WRF LESs of summertime shallow convection over ARM SGP with interactive land surface (Noah model) and realistic initial/boundary conditions. (CONTROL)
- A 3-nest setup is used. The two inner domains (d02 and d03) are LES domains and comparable in size to typical climate model grid boxes.

Responses in TRANSPARENT_CLD
- Responses in AVE_SFC_HEAT and AVE_SFC_RAD are comparable in magnitude, suggesting the dominance of cloud shading-induced heterogeneities in our cases. But responses in AVE_SFC_HEAT and AVE_SFC_RAD are smaller than those in TRANSPARENT_CLD.
- Negative mean surface heat flux responses suggest that negative feedbacks through domain-scale land-atmosphere coupling can constrain the impact of land–atmosphere interactions at smaller scales.

Control simulations
- Three cases are examined:
  Aug 8, 2006, BR~1.68, ~3 m/s sfc wind; May 14, 2007, BR~0.45, >10 m/s sfc wind; May 16, 2008, BR~0.61, 3~5 m/s sfc wind.

Responses in the averaging experiments
- AVE_SFC_RAD – CONTROL shows consistent increase in cloud water content in almost all cases.
- Responses in AVE_SFC_HEAT and AVE_SFC_RAD are comparable in magnitude, suggesting the dominance of cloud shading-induced heterogeneities in our cases. But responses in AVE_SFC_HEAT and AVE_SFC_RAD are smaller than those in TRANSPARENT_CLD.
- Negative mean surface heat flux responses suggest that negative feedbacks through domain-scale land-atmosphere coupling can constrain the impact of land–atmosphere interactions at smaller scales.

Summary
- Cloud shadows at the surface have a clear impact on the strength of shallow convection and shallow cloud water content under realistic winds and surface conditions. This impact depends sensitively on the solar incidence angle.
- For a climate model grid box, subgrid-scale heterogeneities induced by cloud shadows can be as important as those due to more static features in land use/cover or soil temperature/moisture for the simulation of grid mean shallow cloud properties.


This research was supported by the U.S. DOE's ASR Program via the ICLASS SFA.

CONTACT: Heng Xiao, Heng.Xiao@pnnl.gov, P.O.Box 999, Richland, WA 99352