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A Boundary Layer Feedback Mechanism in GCM Simulations with an Elevated Blending Height

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Two 10-year long simulations were performed with the GEOS GCM to evaluate the impact on the resulting climate of using a land-atmosphere coupling (Extended Mosaic or EM) which results in a model blending which is elevated as compared to a standard Mosaic (M) land-atmosphere coupling. The focus of this presentation is on the differences between the two simulations over the eastern U.S. and eastern Asia in JJA, where a positive feedback loop (of different sign in the two different regions) is identified to explain the behavior.

The planetary boundary layer depth, sensible heat flux and canopy temperature are all higher in EM over the eastern U.S., (and in other regions as well, including southern Africa and southeast and northeast Asia), where the latent heat flux and the convective precipitation are lower. The direct result of the change in land-atmosphere coupling is an enhanced eddy diffusion in EM relative to M. In these regions, the enhanced eddy diffusion of heat and moisture is shown to generate higher temperatures and specific humidity aloft in the boundary layer, which result in this region in a lower relative humidity at those levels and the suppression of the precipitation. The lower precipitation results in drier soils and less evaporation, which acts to warm the canopy temperatures. The warmer skin temperatures, in turn, generate higher sensible heat flux and higher eddy diffusion. This completed the positive feedback.

A pattern of opposite sign is shown over a region in northern China and Mongolia, where the PBL depth, canopy temperature and sensible heat fluxes are all lower in EM, and the precipitation and evaporation are higher. In this region, the feedback pattern is manifest in connection with the higher mean evaporation rates over the deciduous forest. The enhanced eddy diffusion which results directly from the EM formulation enhances the temperature and humidity aloft, as occurs in the eastern United States.

The dominant role played by the moisture diffusion in this region, however, results in a higher relative humidity aloft, and enhances the precipitation in the EM simulation. This initiates the positive feedback of opposite sign.