Interactive precipitation feedbacks in an unforced, single-column model

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1. Introduction and Motivation

•Single-column models (SCMs) are a computationally inexpensive way of evaluating feedbacks between soil moisture and precipitation. The simplicity of SCMs encourages exploration of a wide range of parameter space of governing factors.

•SCMs have the ability to isolate the effects of parameterizations on the behavior of boundary layer properties, precipitation, and soil moisture.

•This study focuses on the boundary layer and precipitation outcomes associated with different convective parameterizations and values of large-scale vertical motion. We evaluate the ability of the simple SCM framework to represent precipitation behavior, both in terms of amount and temporal variability.

2. Methodology

•WRF ARW model 3.1 run in SCM configuration for perpetual July 1st conditions in Topeka, Kansas

•Initial conditions based on early July sounding from Topeka, KS, assumed to be representative of summer conditions

•Noah land surface model (LSM)

•Shortwave and longwave radiation

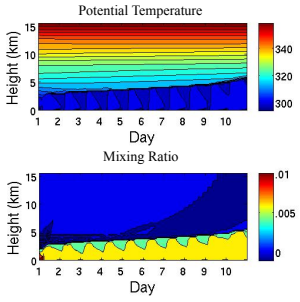
•Parameterized deep convection

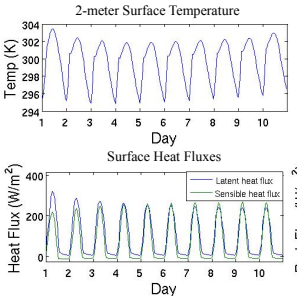
•Imposed large-scale vertical motion

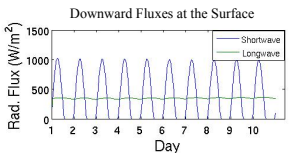
•Soil temperature and moisture initial conditions based on Atmospheric Radiation Measurement Program (ARM) measurements

•Conducted sensitivity experiments varying convective parameterization and large-scale vertical motion

3. Clear-sky Run





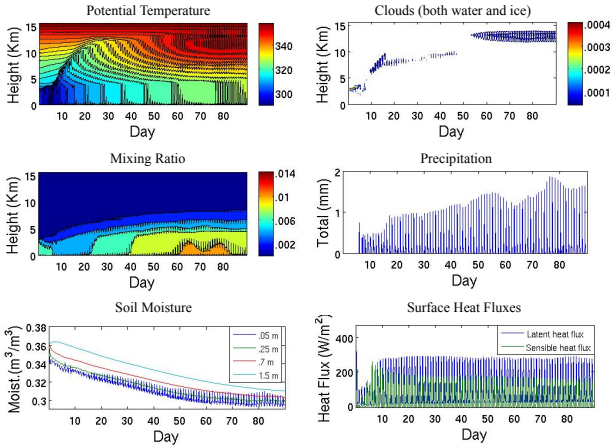


•10-day simulation

• w_{ls} = –0.6 cm s^{-1} (subsidence)

•Evaluating ability of model to produce a reasonable multi-day simulation of clear-sky conditions (no precipitation)

4. Interactive simulation with precipitation



•Perpetual July shortwave radiation

•Three-month simulation

•Betts-Miller-Janjic (BMJ) convective scheme

•Large-scale vertical motion w_{ls} = –0.4 cm s^{-1}

Results

•Surface heat fluxes are reasonable given that it rains almost every day

•Total precipitation over the three-month period is reasonable, but too frequent

•Model establishes a radiative-convective equilibrium (RCE) state, but with temperatures at the surface and aloft that are too warm

•Warm air aloft is mixed to the surface by the convective parameterization

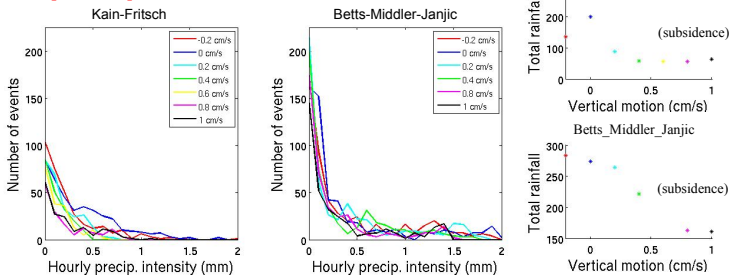
•Results suggest a need to nudge the free troposphere the initial atmospheric sounding in order to maintain reasonable temperatures

5. Effect of subsidence on precipitation behavior

•Sensitivity of precipitation distribution to large-scale vertical motion is most evident using the Kain-Fritsch parameterization.

•Sensitivity of total precipitation is greatest for the Betts-Middler-Janjic parameterization.

•Betts-Middler-Janjic produces the most reasonable total precipitation amounts



6. Summary and future work

•The model responds predictably to large-scale vertical motion forcing; precipitation totals mimic what would be expected for increased subsidence.

•Total precipitation in the Kain-Fritsch convective parameterization is too small relative to observations

•Betts-Middler-Janjic convective parameterization overestimates surface and free-troposphere temperatures but yields reasonable values of total precipitation over the three-month simulation.

•The free tropospheric temperature profile must be nudged to the initial sounding in order to maintain reasonable surface temperatures.

•Future simulations will explore the sensitivity of convective precipitation frequency and magnitude to a wide range of environmental parameters and WRF convective parameterizations..