The Impacts of Microphysics and Planetary Boundary Layer Physics on Model Simulations of U.S. Deep South Summer Convection

Eugene W. McCaul, Jr. (USRA)
Jonathan L. Case (ENSCO, Inc.)
Bradley T. Zavodsky (NASA/MSFC)
Jayanthi Srikishen (USRA)
Jeffrey M. Medlin (NOAA/NWS)
Lance Wood (NOAA/NWS)

26th Conference on Weather Analysis and Forecasting/22nd Conference on Numerical Weather Prediction at the 94th AMS Annual Meeting

Atlanta, GA
6 February 2014
Introduction/Motivation

• Accurate forecasting of convection (timing, intensity, mode, location) is forecast challenge for regional/local scale modeling
  – WFOs cite this as main forecast challenge in their local modeling efforts when running the Weather Research and Forecasting (WRF) Environmental Modeling System (EMS) framework
  – SPoRT’s data sets have been integrated into EMS and provide additional information on factors that contribute to convection in NWP models

• Composite results from a summer-long evaluation of forecasts with and without SPoRT data in 2012 revealed that both control and SPoRT forecasts exhibited a consistent under-prediction of precipitation coverage

• Motivation for this work is to better understand sensitivities to microphysics and PBL schemes within WRF to optimally configure SR WFO EMS for forecasting CI with SPoRT data

¹Medlin et al. (2012); 26th SLS P121
Model Configuration

• Using WRF-ARW core (via EMS)
  – 9-km outer/3-km inner domains
  – 40 vertical levels
  – 54s timestep
  – Initialized at 0600 UTC; 24h forecast
  – Initial and boundary conditions from GFS personal tile (0.205°)
  – Convective parameterization: Kain-Fritsch (only on outer domain)
  – Longwave radiation: RRTM
  – Shortwave radiation: Dudhia
  – Microphysics and PBL vary for an 8 x 3 matrix of runs

• Performed a control (CNTL; above configuration) and SPoRT (above configuration + 3 datasets at the right)

• SPoRT SST Composite
  – 2-km resolution
  – Generated twice daily
  – Provides details that allow model to account for over-ocean fluxes and seabreeze forecasting

• LIS
  – 3-km resolution
  – Run once daily (available every 3 hours)
  – Uses precipitation data and vegetation to predict soil characteristics that shape energy fluxes for weakly-forced convection

• SPoRT MODIS GVF
  – 1-km resolution
  – Generated once daily
  – Replaces coarse climatology to produce weather-of-the-day details that affect energy fluxes for weakly-forced convection
Convective initiation associated with a seabreeze front occurred between 1700 and 1800 UTC across southern AL and western FL.
Most combinations do not capture the CI in magnitude, intensity, or location.

Seabreeze appears to be pushed too far inland (AL/FL border instead of FL coast).

QNSE is most accurate PBL; NSSL is most accurate microphysics (this combo is best).

For this example, it appears that selection of proper microphysics scheme is more important.
• SPoRT data improves magnitude convection for all combinations
• Convection associated with seabreeze more to the south (more in line with observations) when SPoRT datasets are used for initialization compared to CNTL
• CI does appear in all 24 members, which is an improvement over CNTL
Evaluation of Land Surface

- Differences in land surface initialization appear to have played a major role in this event.
- Land surface features are very smooth with the GFS initialization.
- Soil moisture (SM) from LIS and SPoRT GVF provide greater detail of local features that can affect CI.
- GFS soil moisture exhibited a moist bias during this time and the inclusion of the LIS data dried out the soils in that region by an average of 10%.
- SPoRT GVF is slightly drier than CNTL especially in SW AL and SE MS.

![Diagram showing land surface features and soil moisture comparisons between CNTL and SPoRT models.](image)
Evaluation of 2m Temperature

- Drier, less vegetated land surface in SPoRT forecasts results in faster and heating of the land surface
- SSTs over Gulf of Mexico also appear to be cooler in SPoRT run (2-m temperature over water is on average about 1°C cooler than in control)
- Gradient between cooler SSTs (SPoRT: 27.8°C; CNTL: 28.9°C) and warmer land surface (SPoRT: 34.9°C; CNTL: 32.8°C) likely results in a stronger seabreeze, which results in the enhanced convection
MET Verification

• Warmer 2-m temperatures in SPoRT runs (bottom graph) in the hours leading up to convection are closer to observations than the CNTL (top graph)

• Pre-convection results appear to be independent of microphysics

• Results from MYJ and MYNN PBL schemes have similar pre-convection clustering of mean error with the SPoRT experiment closer to the observations than the CNTL (not shown)
One consideration that must be taken when dealing with operational forecasts is the time constraints involved with forecast delivery.

Both HGX and MOB currently use WSM6/MYJ, which is computationally cheapest.

QNSE appears to be best PBL scheme, but is also most computationally expensive.

Each forecast office will need to determine based on their resources and time of forecast delivery which option is feasible.
Summary/Future Work

• A control experiment initialized with large-scale land surface characteristics was compared to a SPoRT experiment using real-time SPoRT-LIS, MODIS GVF, and MODIS SSTs for a CI case study over Mobile
• Overall, SPoRT runs compare more favorably in timing, position, and intensity of initiated convection compared to CNTL
• Seabreeze more accurately represented in SPoRT run due to improved gradient in 2-m temperature
• Use of different land initialization datasets has larger impact on forecast than any differences between microphysics and/or PBL as evidenced by clumping of 2-m temperature
• Further evaluation on this case is needed to determine if u- and v-winds are improved with SPoRT datasets (further indication of seabreeze)
• Next step is to evaluate matrix results for 9 other cases to understand performance of different land surface initialization, microphysics, and PBL and generate cumulative statistics for more robust conclusions
• Results must be analyzed and compared to computational time constraints to then determine an optimal configuration to be used by WFOs for CI