A Sensitivity Study of Convection Parameterizations in MPAS-A Utilized in Conjunction with USEPA Physics Options

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1. Objective and Background

MPAS-A is the meteorological foundation of a next generation global air quality model being developed at the U.S. EPA to conduct retrospective air quality simulations. Accurate simulation of clouds and precipitation is essential for modeling photochemistry and aerosol processes. Now that several preferred EPA-developed physics schemes and options have been implemented into MPAS-A, the present study evaluates their use with selected combinations of convection parameterization scheme (CPS) and microphysics (MP) on different mesh resolutions.

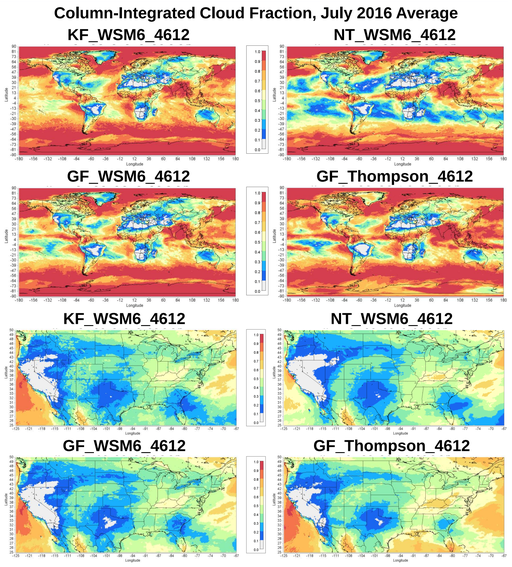
2. Approach

Specifications for 8 Simulations (4 CPS/MP pairs, 2 different meshes)

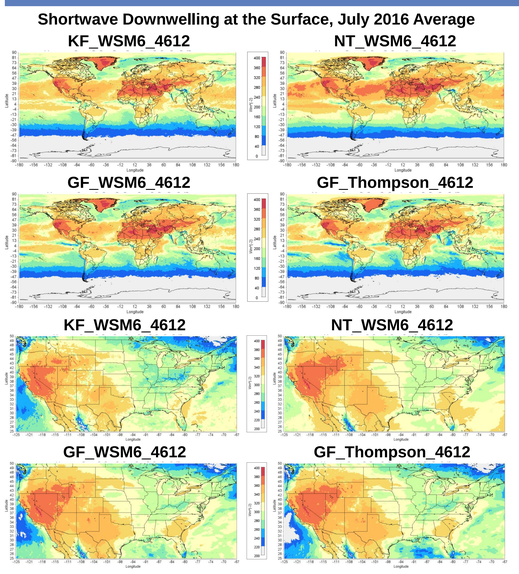
- Model: EPA-modified MPAS-A v6.0
- Surface Layer: Pleim (PSL)
- Land Surface Model: Pleim-Xiu (PX) with GFS soil nudging
- Land Use: MODIS 20-class on GMTED2010 topography
- Planetary Boundary Layer: Asymmetric Convective Model 2 (ACM2)
- Nudging: Grid analysis nudging FDDA, driven by 0.25°×0.25° GDAS/FNL
- Radiation: RRTMG shortwave and longwave radiation
- CPS & MP combination: •Mod-Kain-Fritsch (feedback to RRTMG, Bullock dynamic τ) & WSM6 (**KF_WSM6**)•New Tiedtke & WSM6 (**NT_WSM6**) as in 'mesoscale_reference' suite•Grell-Freitas & WSM6 (**GF_WSM6**)•Grell-Freitas & Thompson (**GF_Thompson**) as in 'convection_permitting' suite
- Grid: 92-25 km (**_9225**) & 46-12 km (**_4612**) variable resolution meshes
- Simulation Period: July 2016, with 10-day spin-up from 21 June 2016

3.1. Results: Cloudiness

The KF used here is based on KF from WRF v.3.9.1.1 and provides subgrid-scale cloudiness and condensates which are merged with the RH-based resolved clouds, producing more realistic cloud coverage to affect the radiation budget and precipitation in convective regimes. Note column-integrated cloud fraction only indicates the presence and areal extent of clouds within a model column and not cloud optical depth.

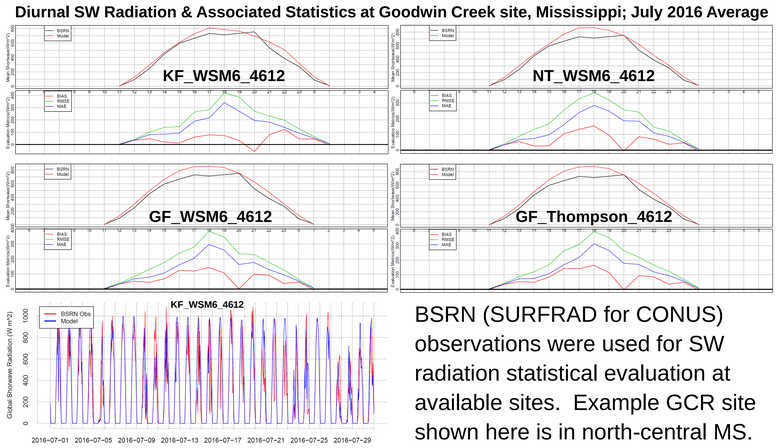


3.2. Results: Shortwave Radiation



Accounting for subgrid KF clouds reduces the surface radiation in convective regions as expected. For CONUS, KF_WSM6 reduced SW the most over land, despite not having the greatest overall integrated cloud fraction coverage. Thompson microphysics with GF produced slightly more cloudiness than GF_WSM6, also reflected here in the surface SW radiation. Note that all hours are included in this monthly average, which reduces the impact.

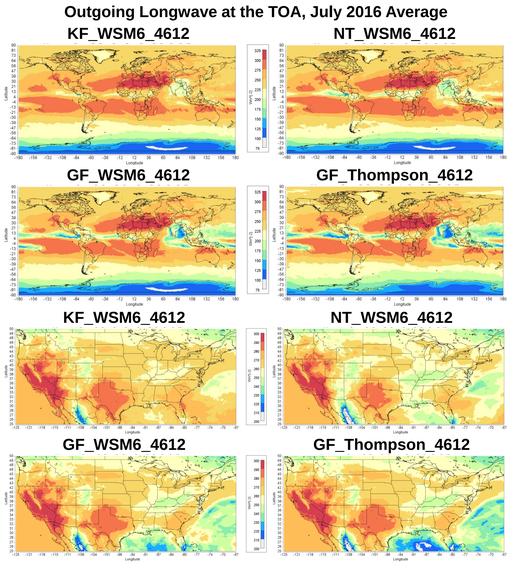
3.2. Results: Shortwave Radiation (cont'd)



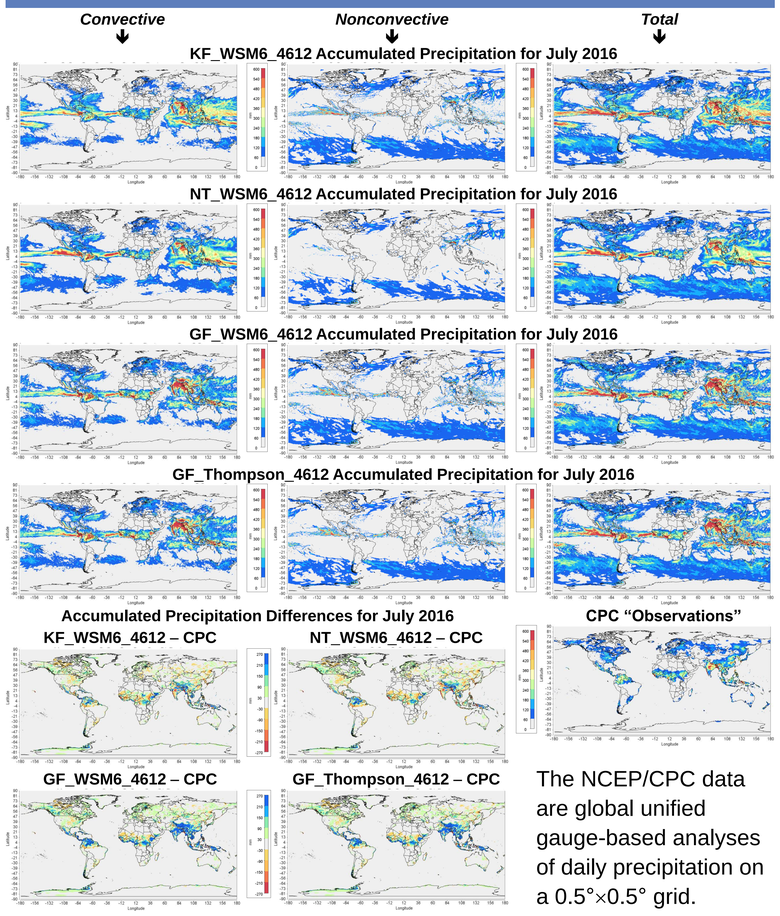
BSRN (SURFRAD for CONUS) observations were used for SW radiation statistical evaluation at available sites. Example GCR site shown here is in north-central MS.

3.3. Results: Longwave Radiation

More clouds generally mean less OLR at the top of the atmosphere, as seen here in the tropics for the slightly cloudier GF_Thompson compared to GF_WSM6 cases. Different from the CONUS SW result, CONUS OLR shows the least impact for KF_WSM6, but is more in agreement with its cloudiness shown in Section 3.1 (and significantly cloudier than the original KF included with MPAS-A).

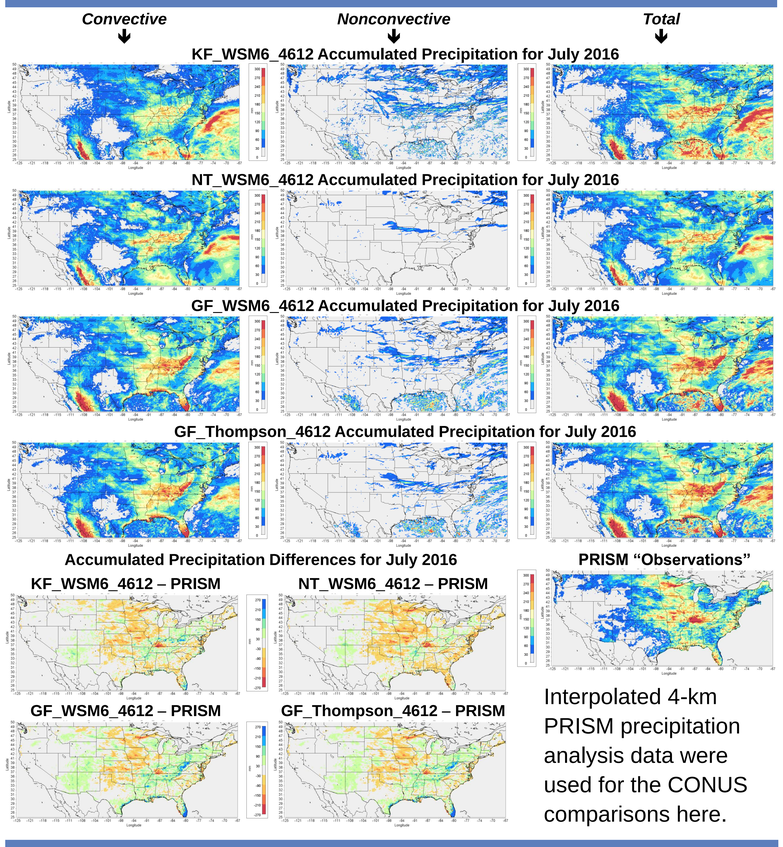


3.4. Results: Precipitation



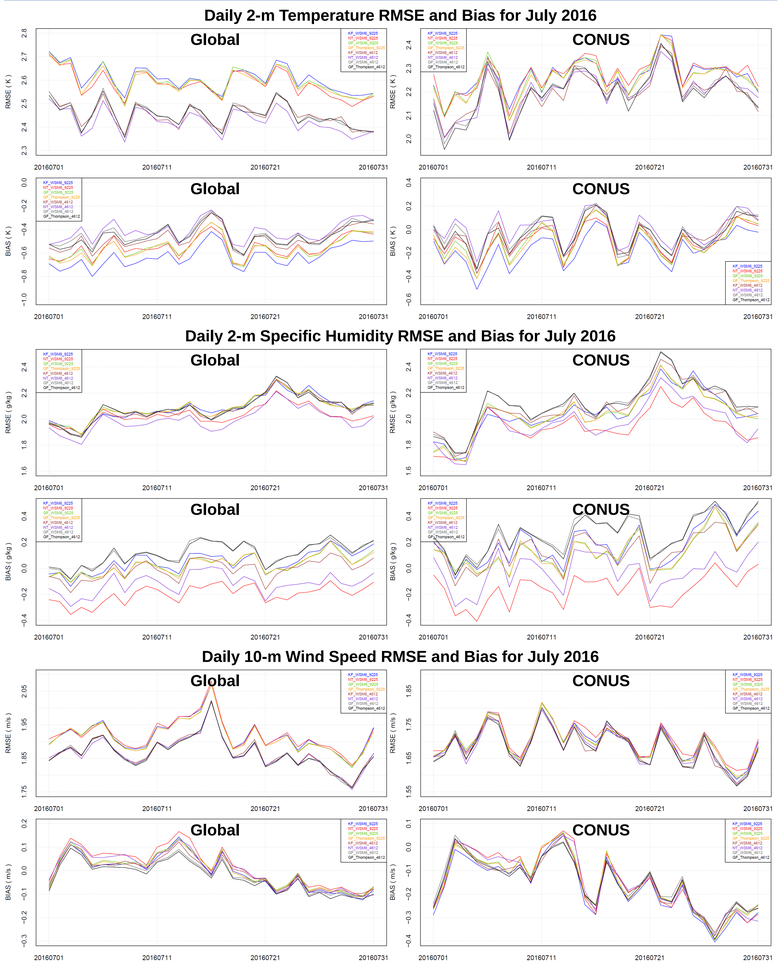
The NCEP/CPC data are global unified gauge-based analyses of daily precipitation on a 0.5°×0.5° grid.

3.4. Results: Precipitation (cont'd)



Interpolated 4-km PRISM precipitation analysis data were used for the CONUS comparisons here.

3.5. Results: Near-Surface Statistics



4. Conclusions

- Using the higher resolution 46-12 km mesh generally produced better results for this July 2016 study.
- The KF_WSM6 combination best simulated observed precipitation.
- Comparison with satellite observations is needed for over-water evaluation.