Comparison of Morrison-Gettelman and Morrison Microphysics within WRF

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1. The CAM5.1 physics suite in WRF

The primary components of the CAM v5.1 physics suite are available in WRF as of v3.5. These have been implemented into WRF with the goal of making as few changes as possible to enable fair comparisons of the physics behavior between the WRF and CAM dynamical cores.

CAM Components in WRF

Category	Scheme Name
Longwave radiation	RRTMG-LW
Shortwave radiation	RRTMG-SW
Boundary Layer	Univ. of WA PBL
Deep convection	Zhang-McFarlane
Shallow convection	Univ. of WA Shallow Cumulus
Microphysics	Morrison-Gettelman w/ Park macrophysics
Aerosols*	3-Mode Modal Aerosol Module (MAM3)

* Trace gases & aerosols are turned off for the results shown here.

The following are still treated differently between WRF and CAM: gravity wave drag, the surface layer, trace gases, and particle settling.

2. Morrsion-Gettelman vs. Morrison MP

Upon first glance there are now two very similar microphysics schemes in WRF, both of which have Morrison in their name. However, the Morrison-Gettelman (MG) and Morrison (MOR) microphysics schemes are each designed for different purposes, and therefore have important differences between them. Morrison is designed for cloud and regional models with high resolution and short time steps while Morrison-Gettelman is designed for GCMs with coarse resolution and long time steps.

Significant Design Differences

Morrison-Gettelman	Morrison
Diagnostic condensate	Prognostic condensate
Arbitrary cloud fraction (0 to 1)	Binary cloud fraction (0 or 1)
No graupel/hail	Includes graupel/hail

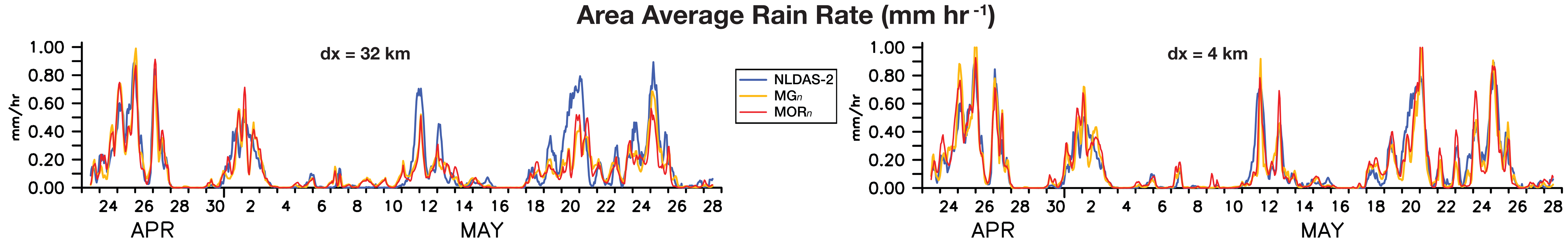
These, and other, differences lead to systematic differences in the behavior of each scheme.

3. Simulations

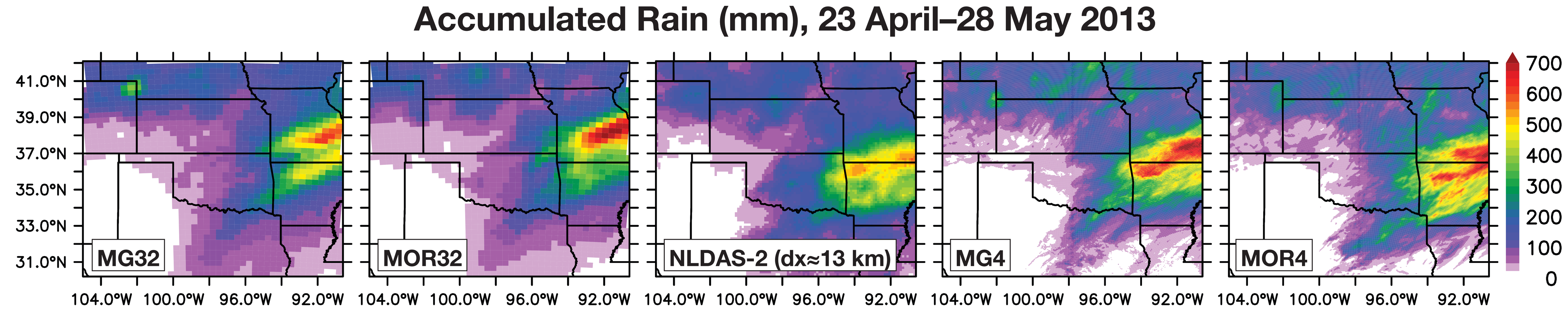
Two sets of simulations were done for both 32-km and 4-km grid spacings. Both sets used the CAM physics, above, but one set used Morrison-Gettelman microphysics (MG*n*) and the other used Morrison microphysics (MOR*n*), where *n* denotes the grid spacing. Deep convection is turned off at 4-km. Each simulation is a month long for the central United States during the MC3E field campaign.

4. Comparison between MG & MOR schemes for 32- and 4-km grid spacing

Area Average Rain Rate (mm hr^{-1})



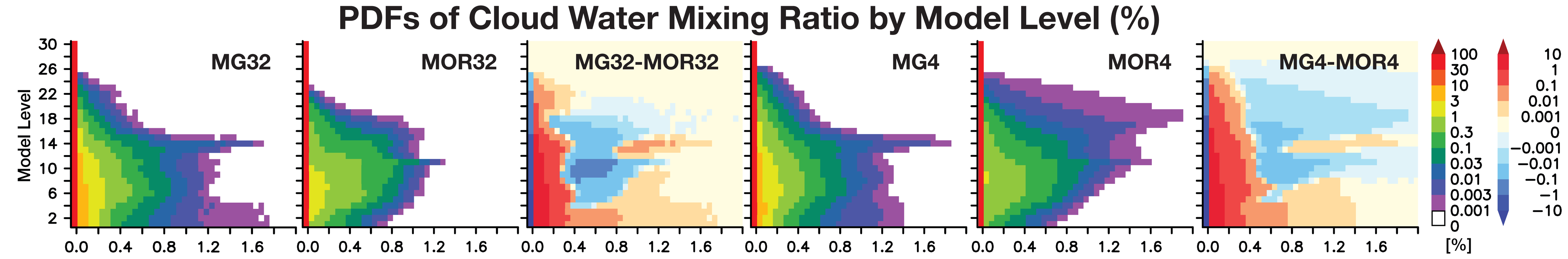
Accumulated Rain (mm), 23 April–28 May 2013



Rain amount is similar between MG and MOR, but MG spreads it over a larger area.

At higher resolution, rain increasingly concentrates in heavy regions for both schemes.

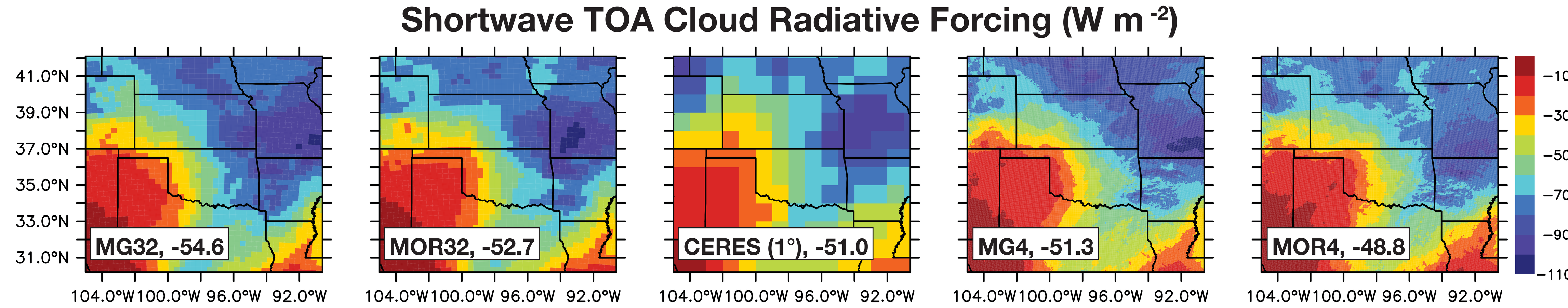
PDFs of Cloud Water Mixing Ratio by Model Level (%)



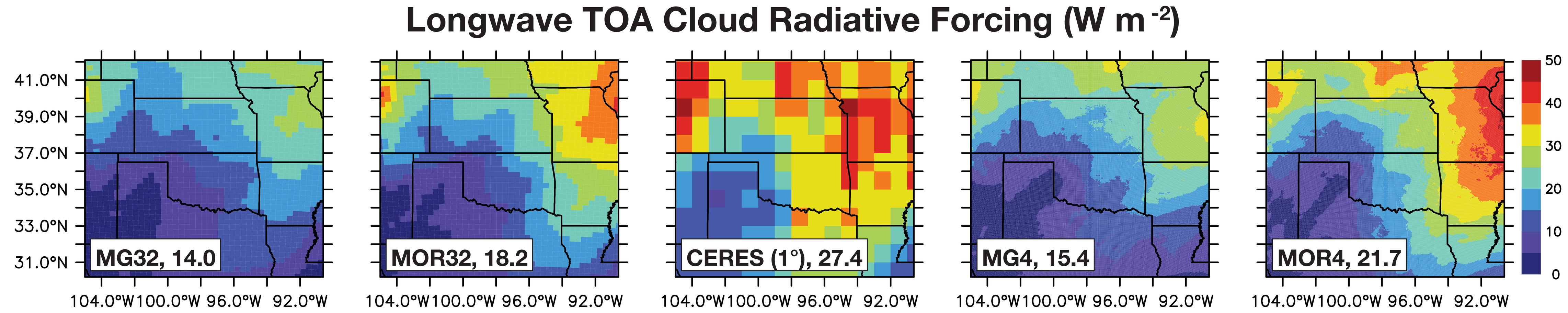
Compared to MOR, MG produces:

- less clear sky
- more low-density clouds
- more low-level clouds

Shortwave TOA Cloud Radiative Forcing (W m^{-2})



Longwave TOA Cloud Radiative Forcing (W m^{-2})



MG's more widespread clouds lead to stronger SW cloud forcing vs. MOR.

Tendency towards low-density clouds at lower levels with MG leads to weaker LW cloud forcing.

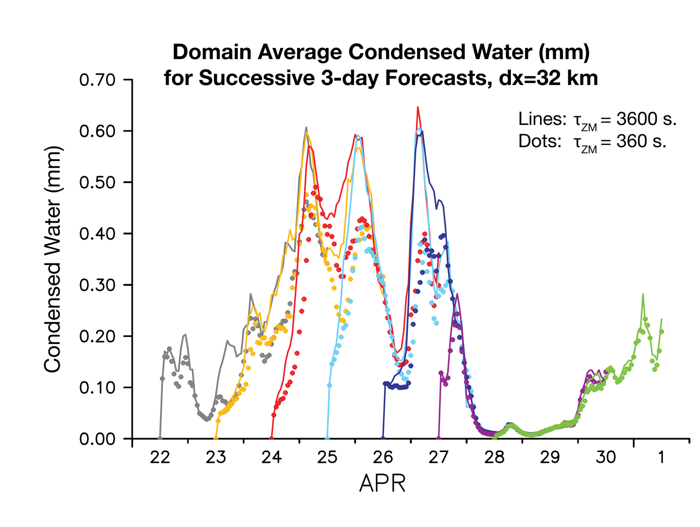
SW forcing is close to CERES obs., but LW forcing is too weak for MG & MOR.

5. Sensitivity to convective timescale

Results are sensitive to the Zhang-McFarlane convective timescale (τ_{ZM}). Plots in Sect. 4 use τ_{ZM}=3600 s.

A shorter timescale rains water out more quickly resulting in less clouds during the day and an enhanced diurnal cycle for precipitation.

Released v3.5 code has a dx-dependent τ_{ZM} that is untested.



References

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