Modeling Convection Using the Tiedtke Cumulus Scheme at Different Grid Sizes

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Motivation

- Cumulus scheme is an important model component in many applications.
- A CPS is specially important in models like MPAS where the model grid sizes are variable across the globe.
- In WRF model, there are versions of 'scale-aware' cumulus schemes for Grell-Freitas, Kain-Fritsch and SAS.
- The new Tiedtke scheme (contributed to WRF from University of Hawaii) has shown good performance in MPAS in grid sizes greater than 15 km (See poster #27).
- There is a need to develop a version of this Tiedtke scheme to be scale-aware, so that it can be used for applications in MPAS where grid sizes go from tenth of kilometers to a few kilometers.

Approaches

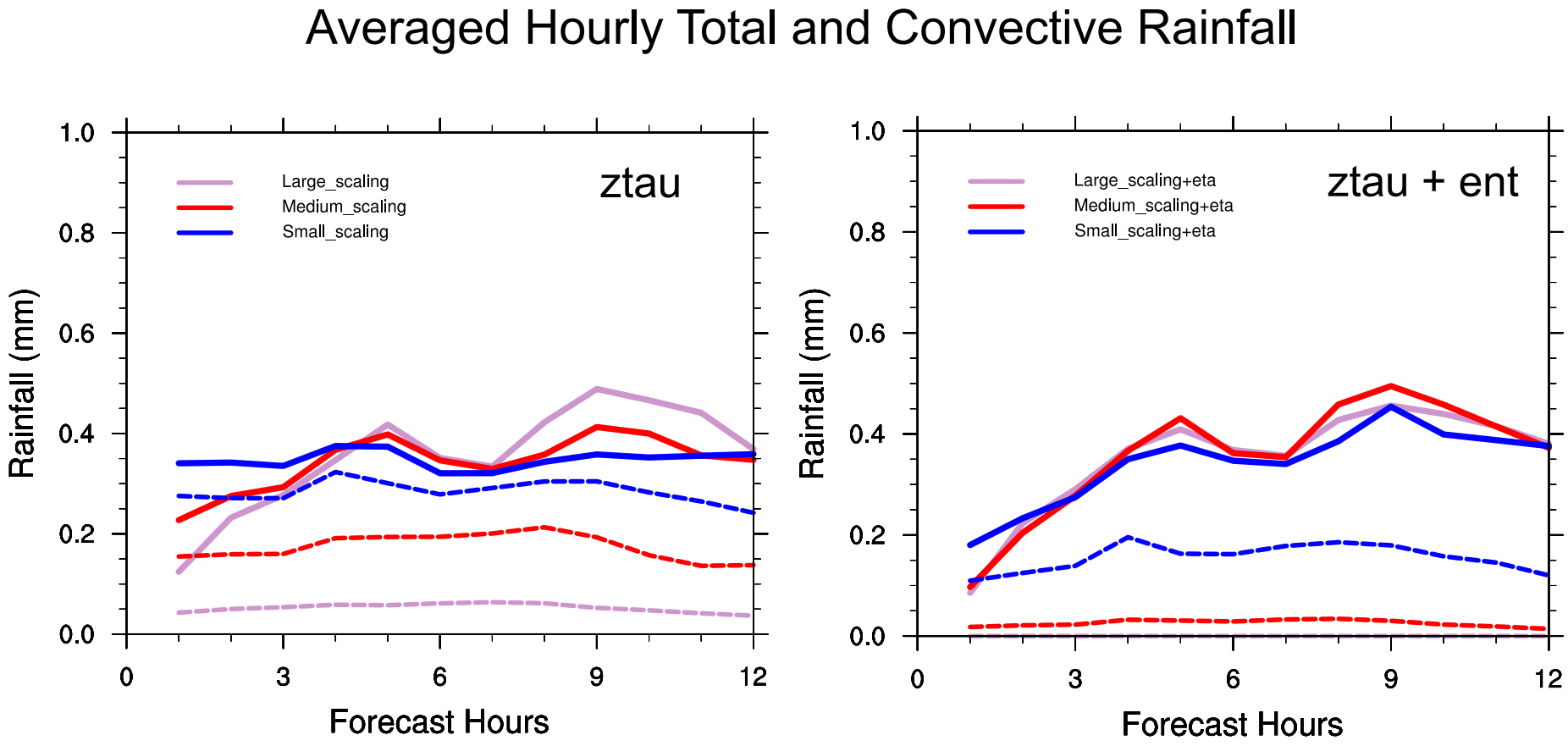
- In Grell-Freitas, the scaling is related to entrainment, and applied to the mass flux (Grell and Freitas 2014)
- In a version of the Simplified Arakawa-Schubert Scheme (SAS) scheme, the scaling is applied to cloud mass flux, CIN (part of triggering condition) and convective cloud water detrainment (Kwon and Hong 2017)
- In Kain-Fritsch scheme, the scaling is applied to convective adjustment time scale, and (min) entrainment (Zheng et al. 2016)
- In the Tiedtke scheme in IFS, a scaling is applied to the convective adjustment time scale (ECMWF Physics Doc for CY43R3)

The objective is to reduce effect of the CPS (surface rainfall as well as atmospheric heating and drying).

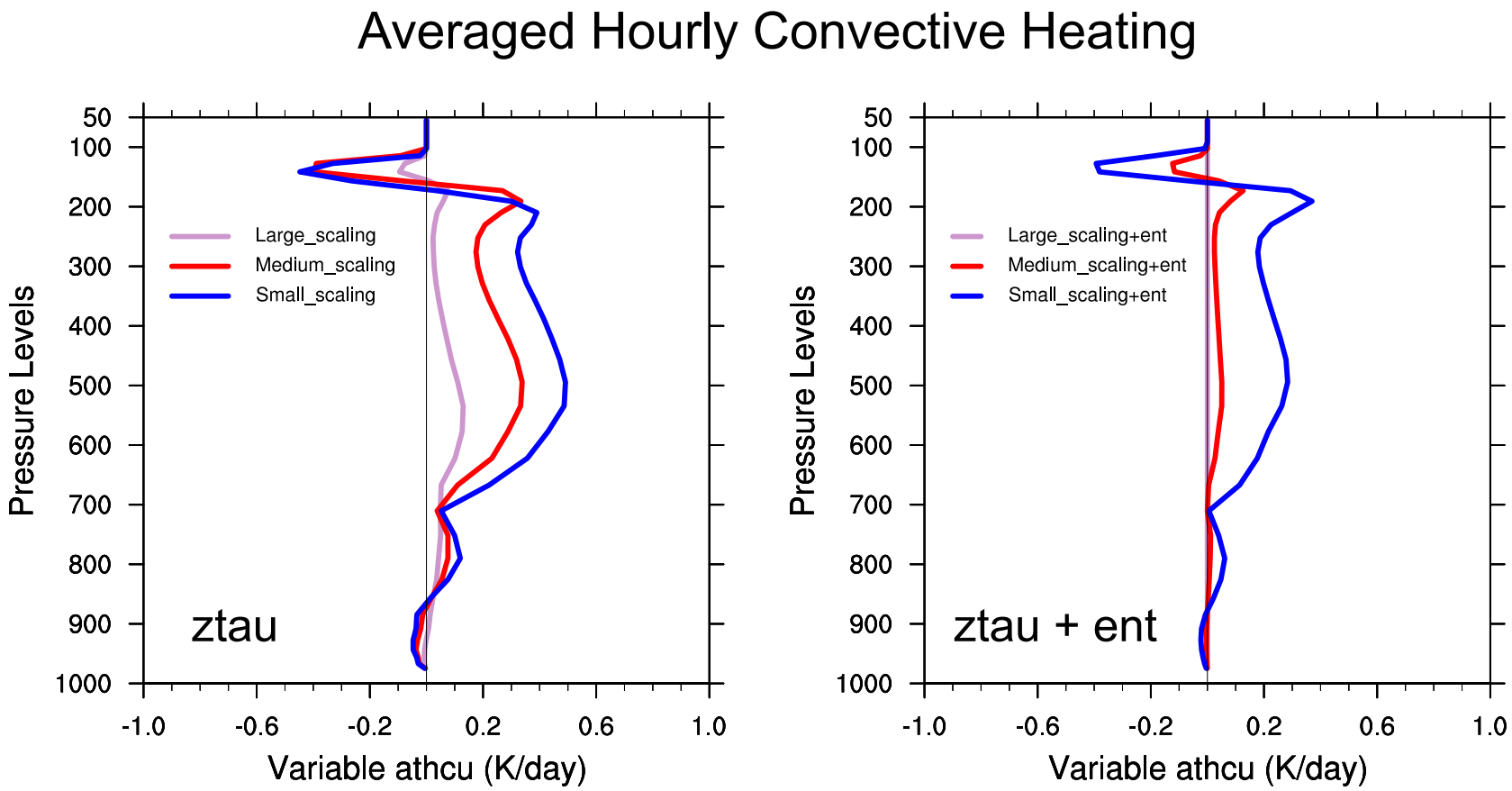
Approach in This Work

- Following the above ideas:
  - Consider scaling of convective adjustment time scale (ztau) and/or entrainment (ent) for convection initiation, and mid-level convection mass flux
  - First we test the effectiveness of modifying each parameters using specified values at 3 km in WRF
  - The values are chosen to be across a wide range (30 for large, 7 for medium, and 3 for small)

Sensitivity to ztau and ent

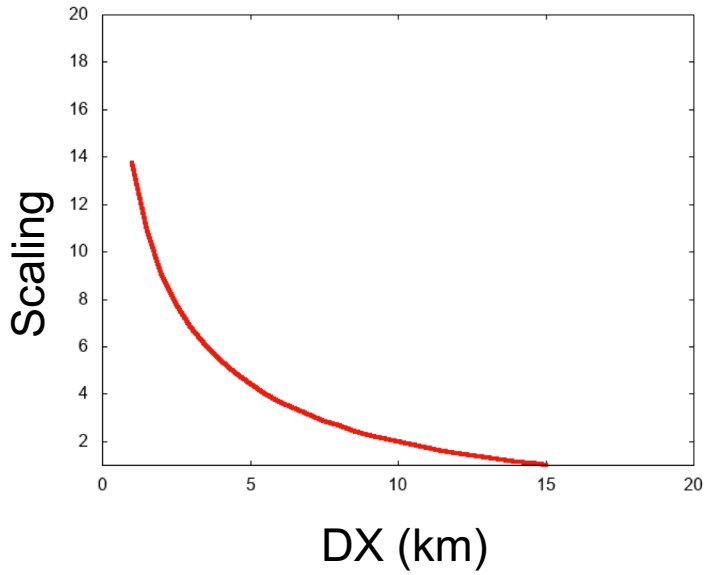


Sensitivity to ztau and ent



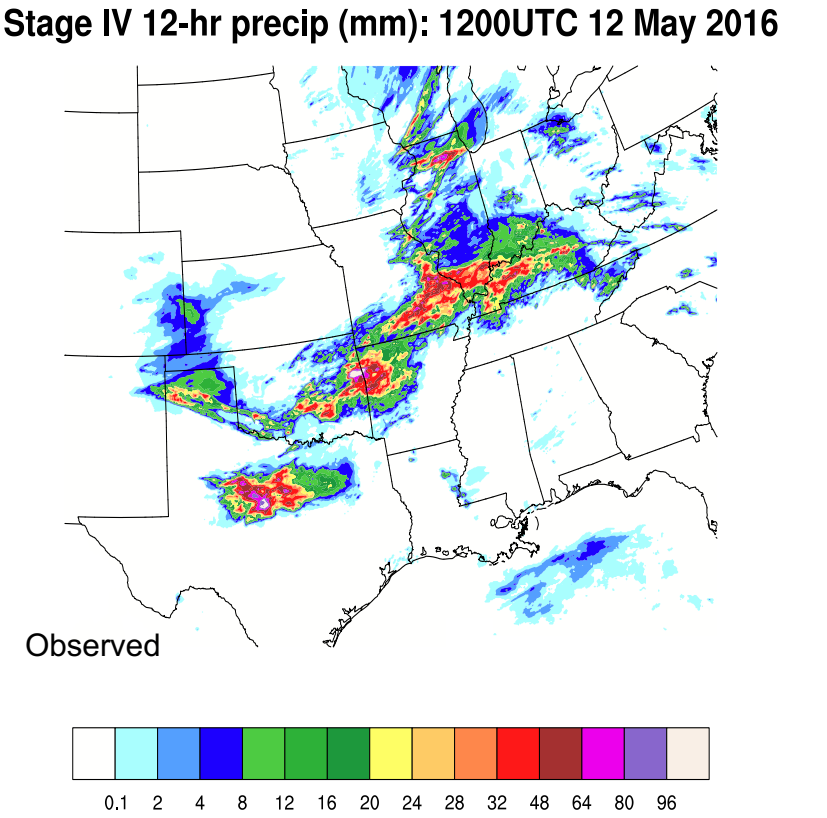
Approach in This Work

- A scaling function is constructed to give the desired value at about 3 km
- This scaling is tested in three cases:
  - A CONUS convection case
  - A Western Pacific Basin typhoon case (Soudelor)
  - A convective case near Singapore



CONUS Convection Case: May 12, 2016

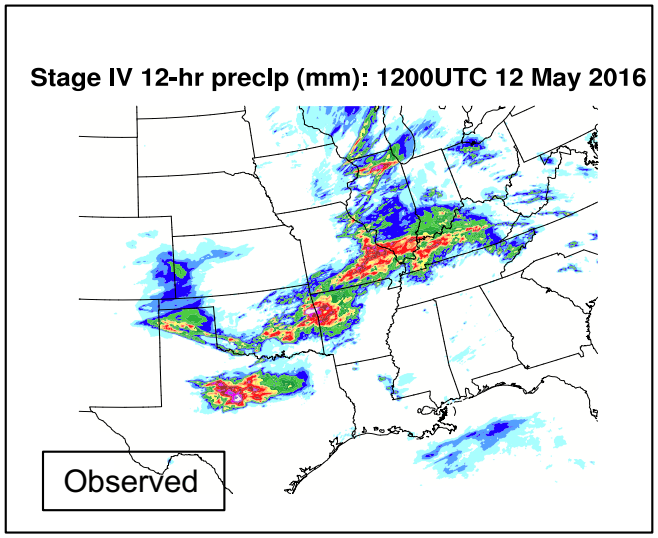
- IC from one of the NCAR ensemble members
- BC: 3-hourly GFS
- Domain: 3 km, 621x541x40
- 12 h forecast starting 0000 UTC, 5/12/16

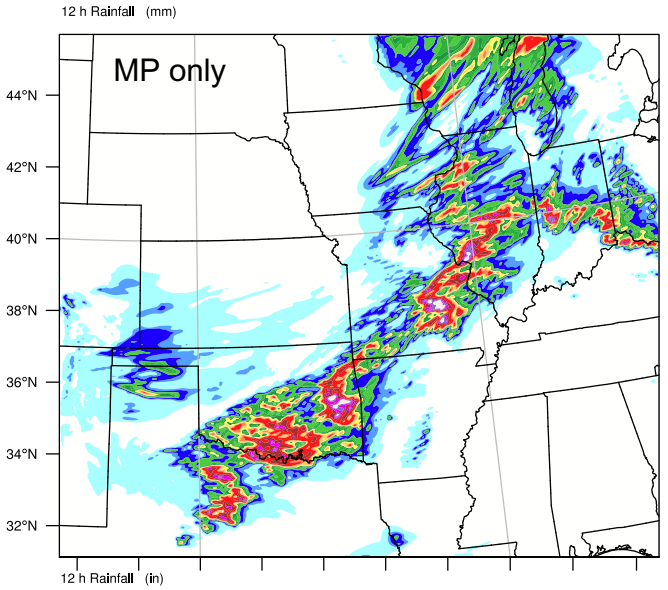


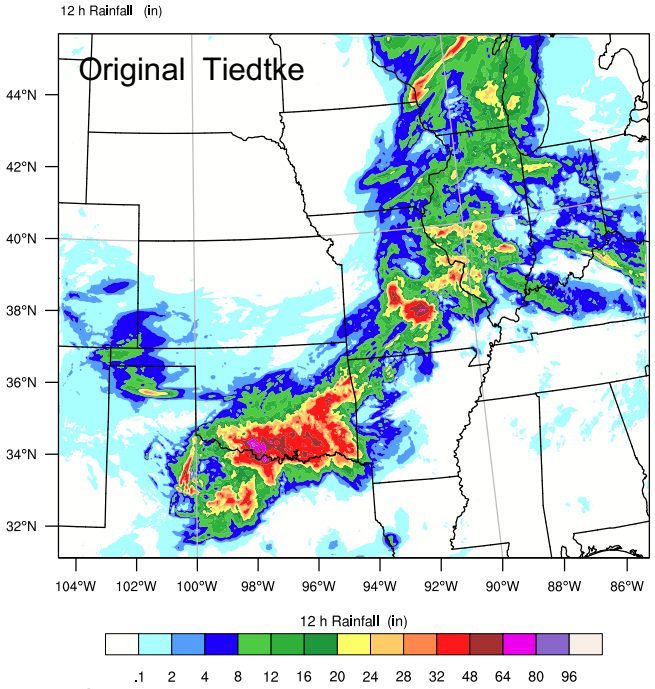
(Courtesy of M. Chen)

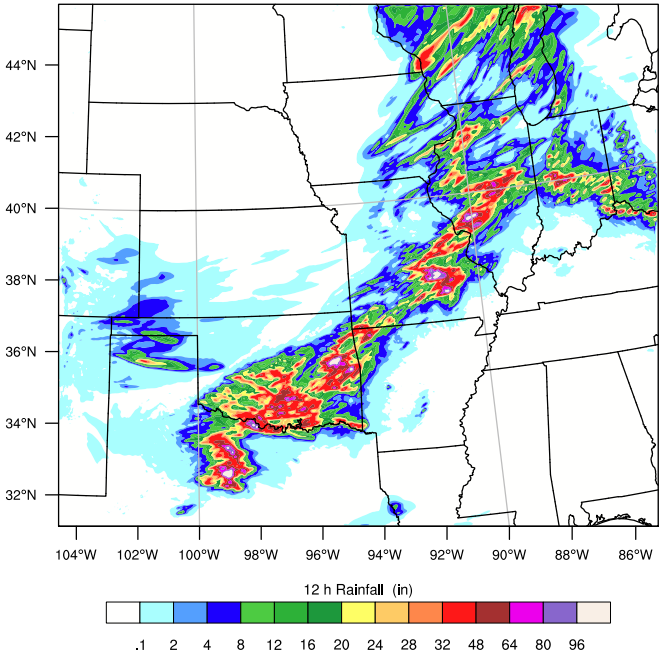
CONUS Convection Case: May 12, 2016

0-12 h rainfall



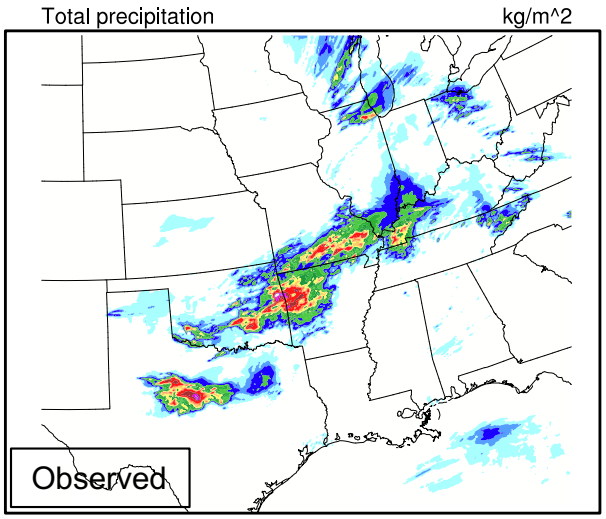


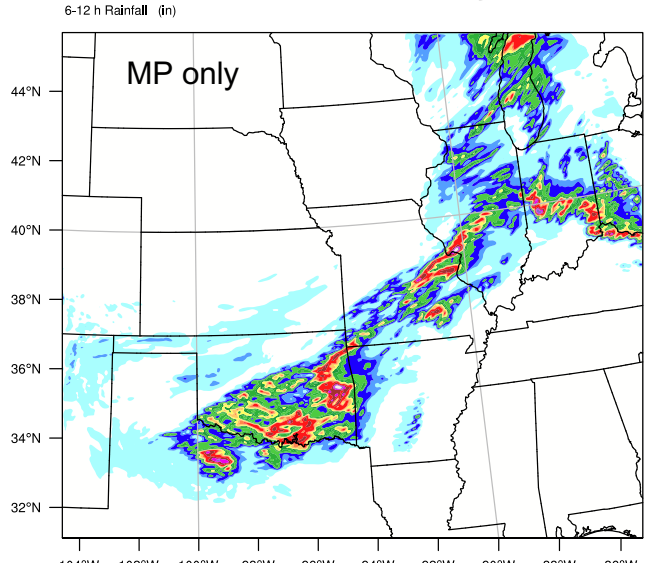


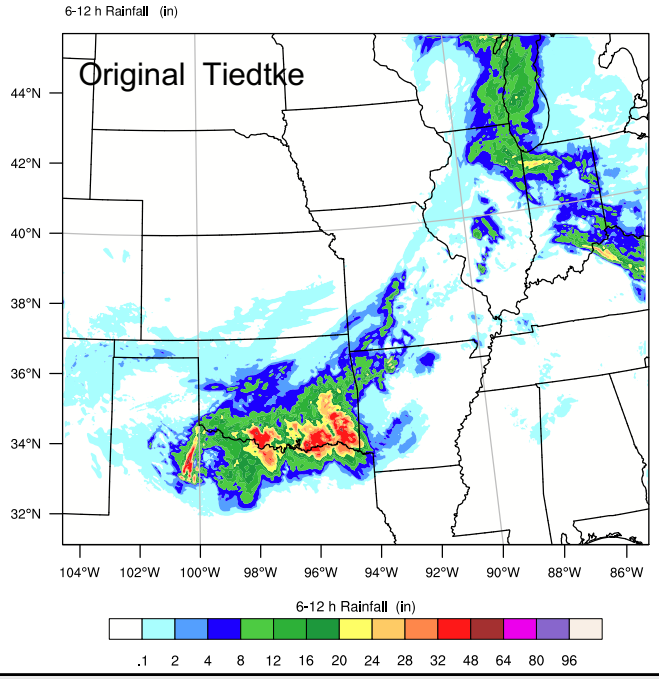


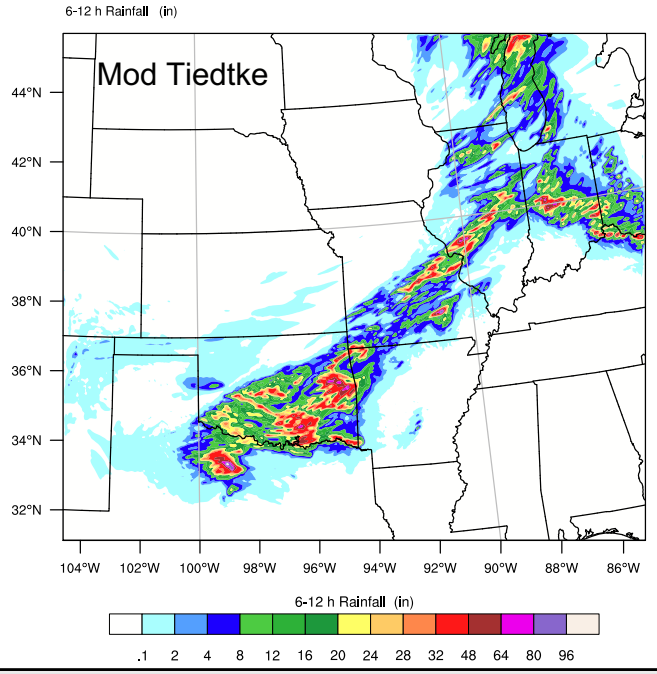
CONUS Convection Case: May 12, 2016

6-12 h rainfall

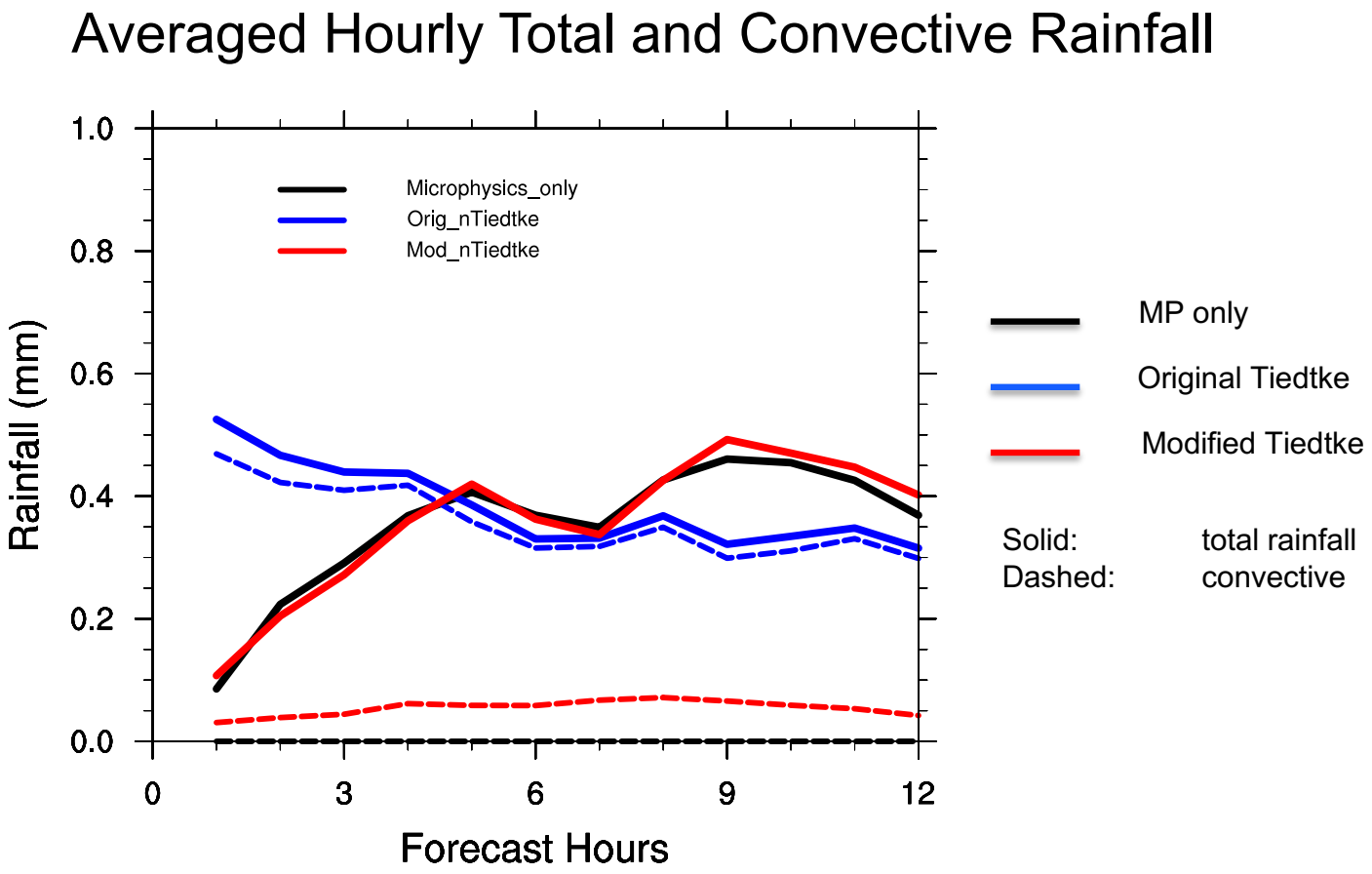








CONUS Convection Case: May 12, 2016



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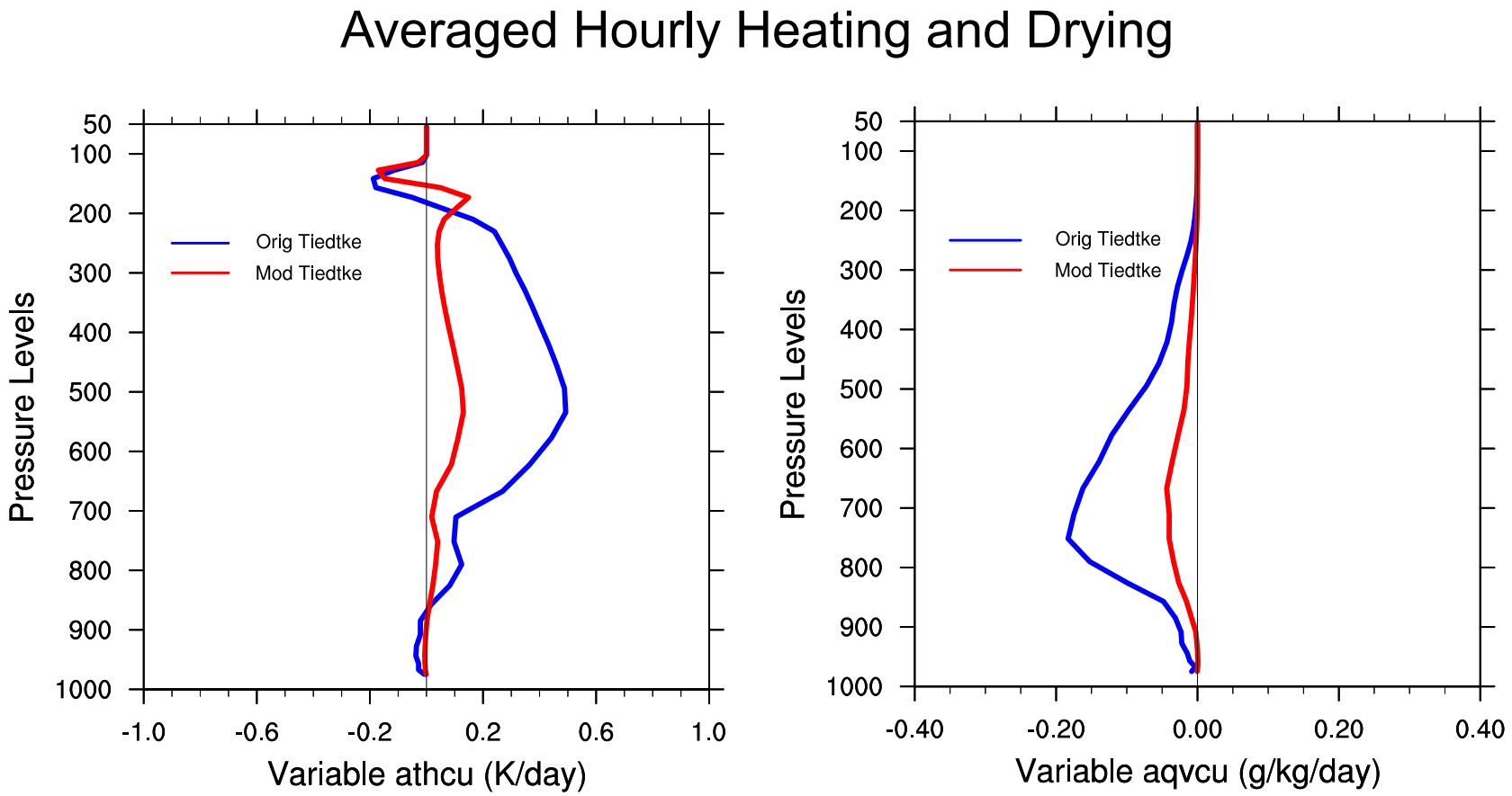
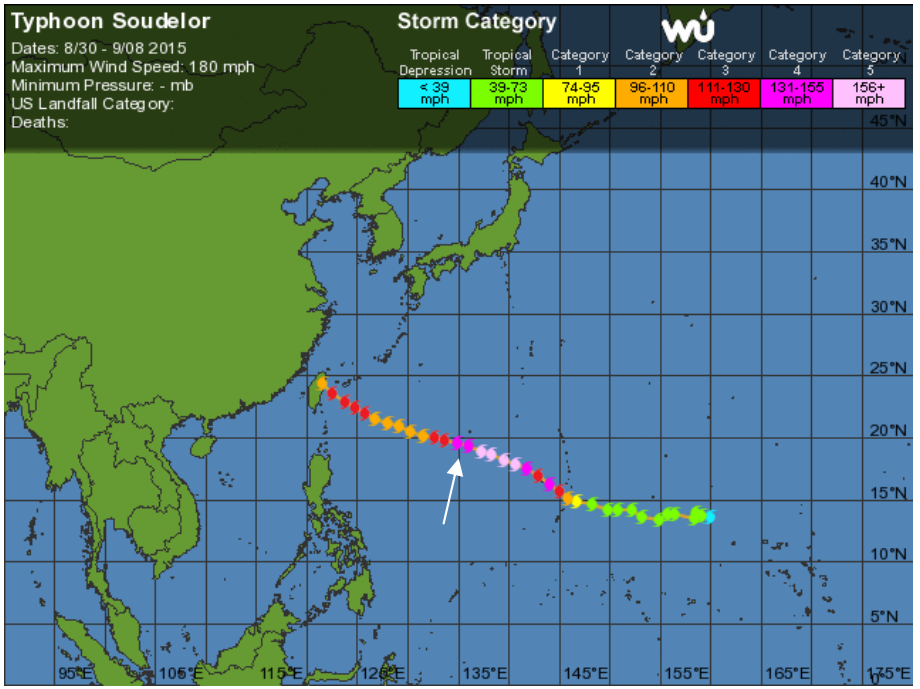


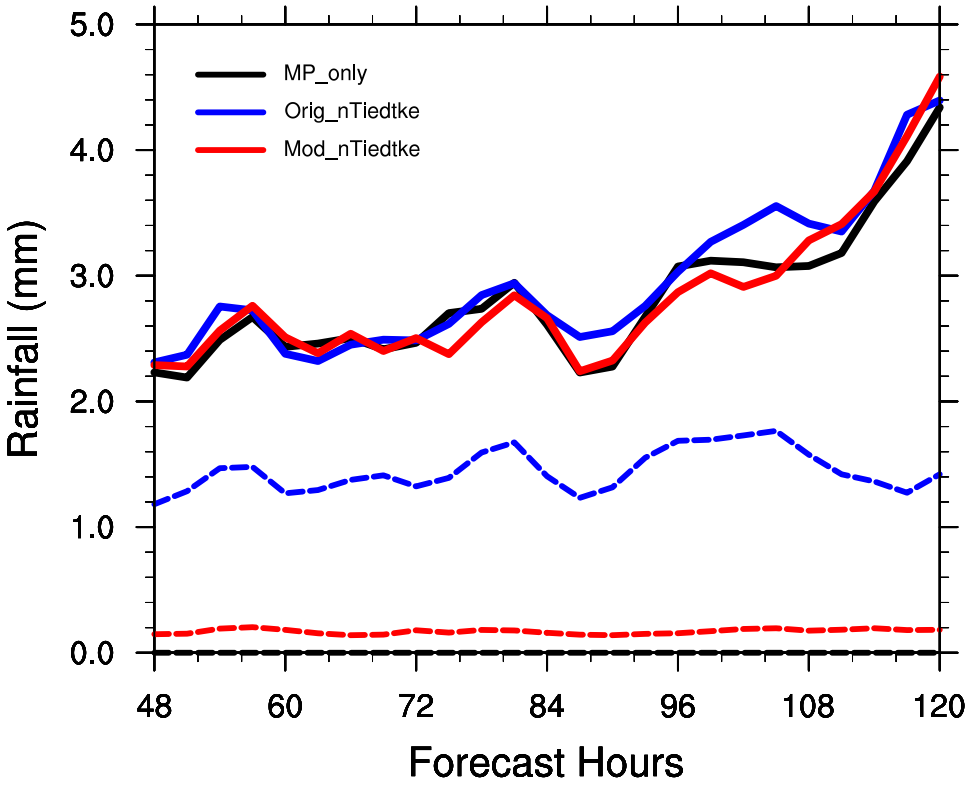
Typhoon Soudelor: August 3, 2015

- Cold start from GFS
- 15/3 km (CWB operational configuration)
- 120 h forecast from 0000 UTC 20150803 (marked by the white arrow)



Typhoon Soudelor: August 3, 2015

Averaged 3 hourly rainfall in a sub-domain



MP only

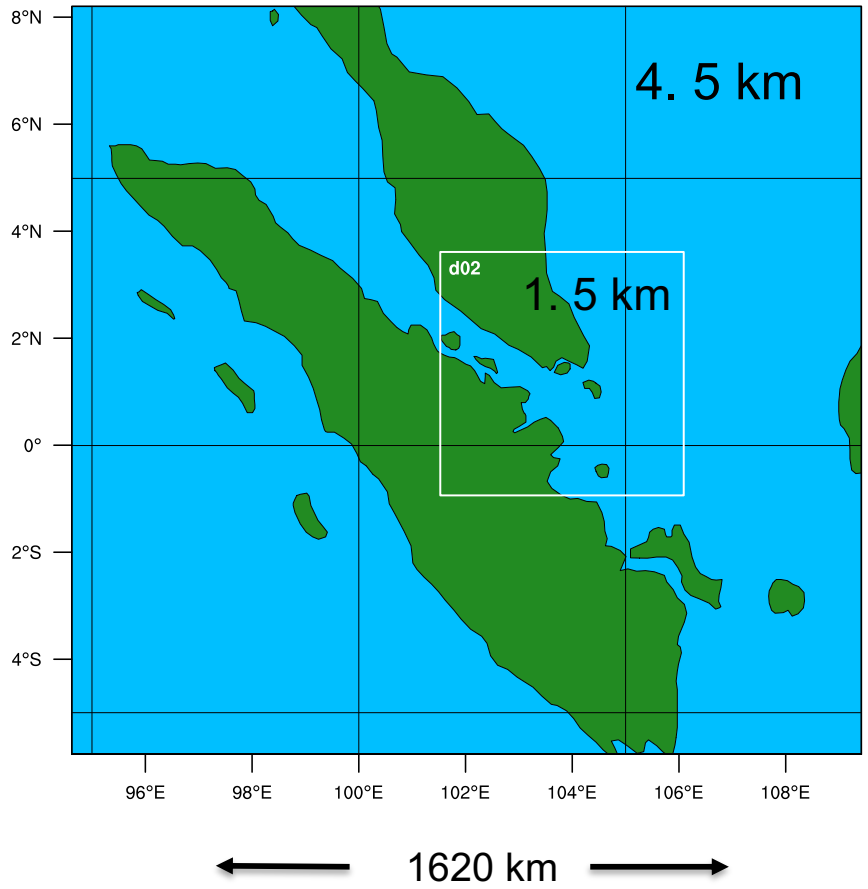
Original Tiedtke

Modified Tiedtke

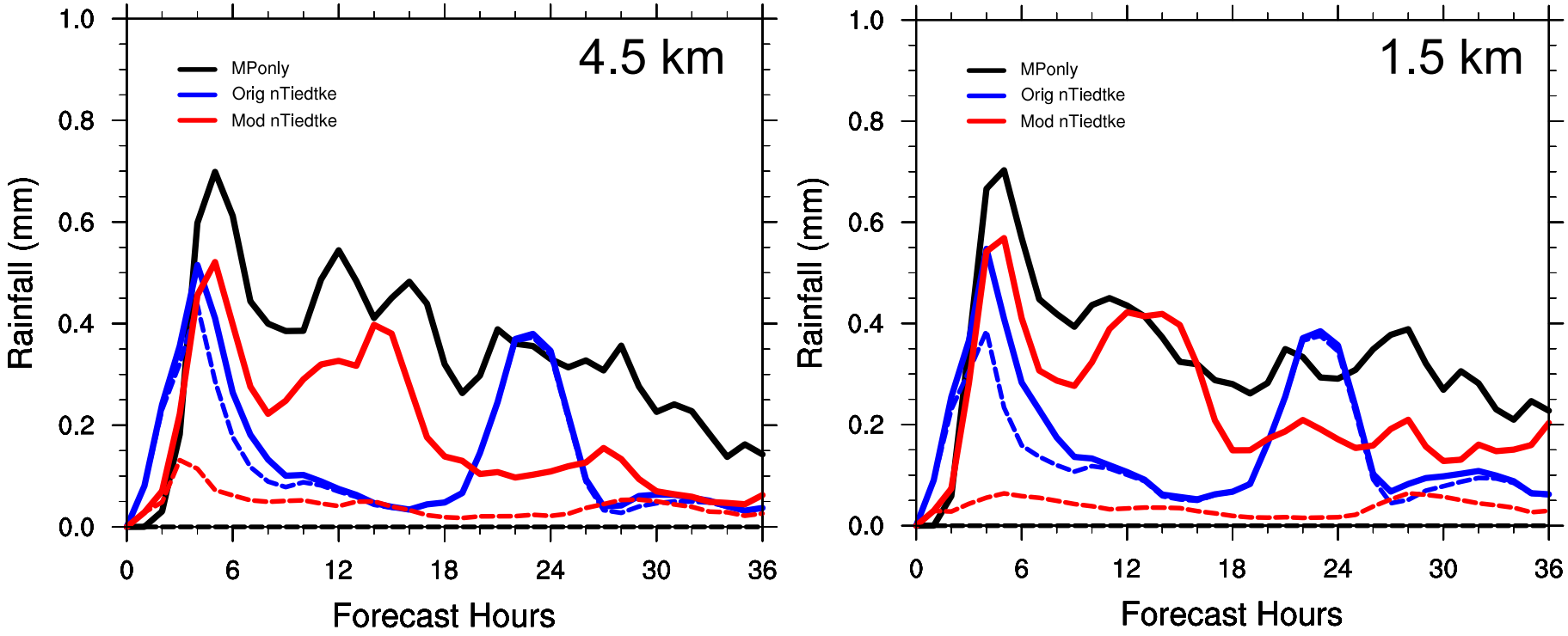
Solid: total rainfall
Dashed: convective

Tropical Convection: January 26, 2016

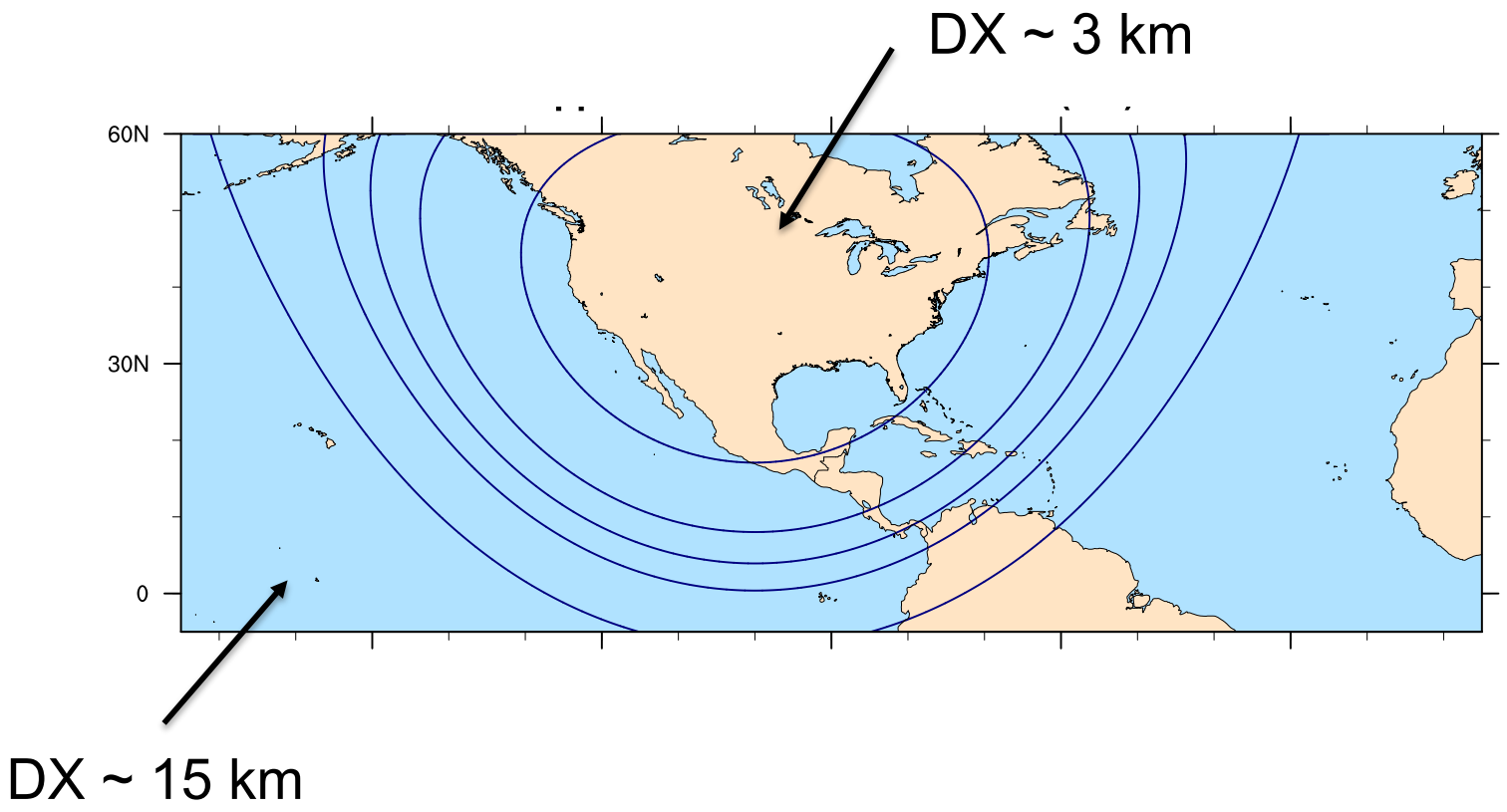
- Cold start from GFS
- Two domain at 4.5 and 1.5 km
- 36 h forecast from 0000 UTC 20160126



Tropical Convection: January 26, 2016

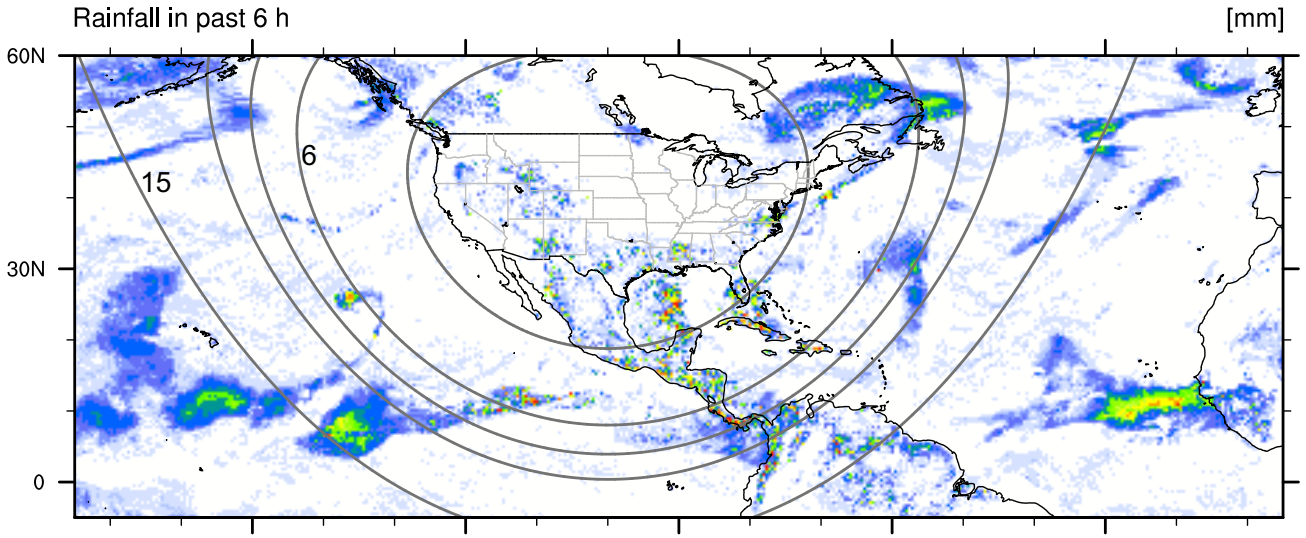


Test in MPAS (15-3 km)

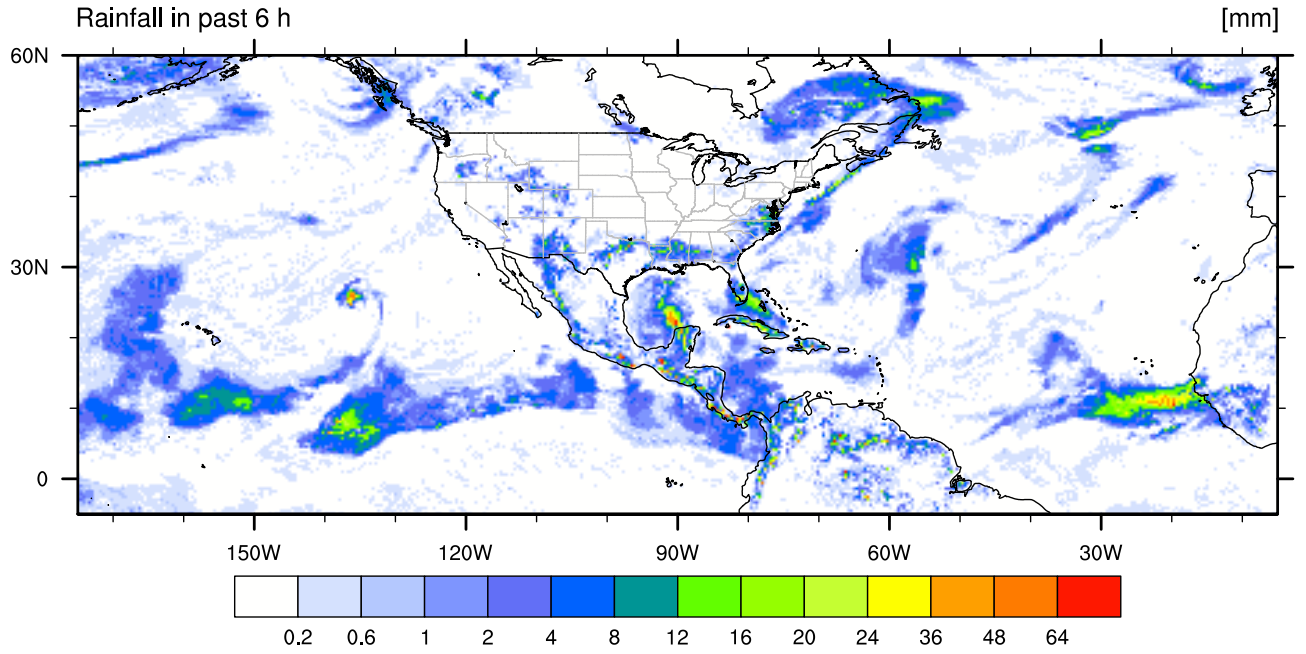


Test in MPAS: 6 hourly total rain

15-3 km

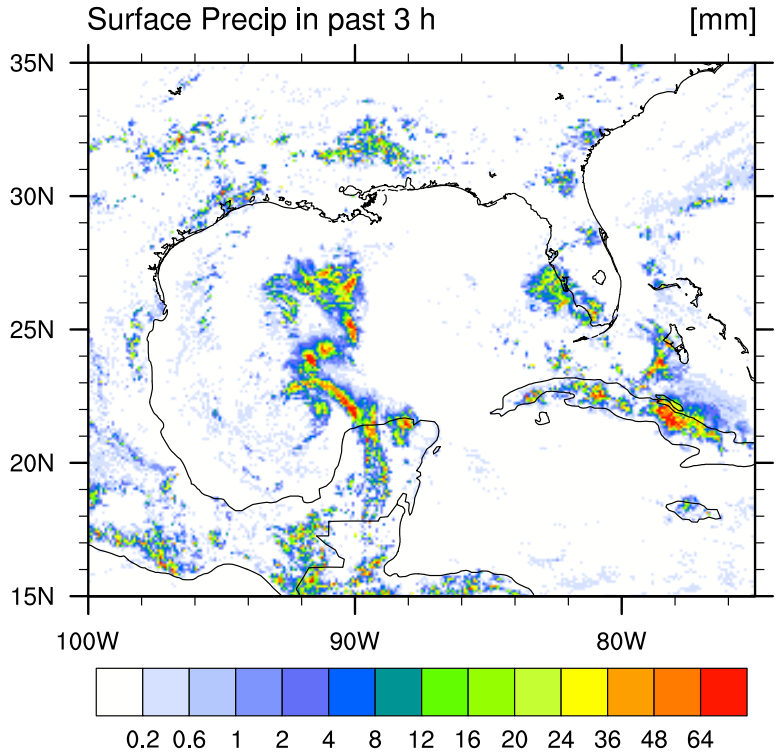


15 km

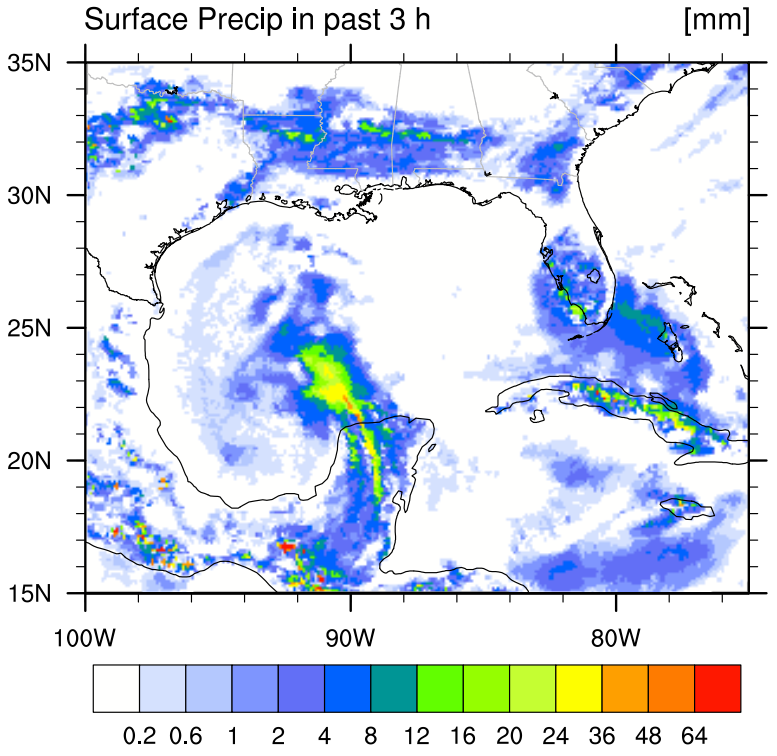


Test in MPAS: 3 hourly total rain

15-3 km



15 km



Summary and Future Work

- This is still work in progress;
- By scaling the convective adjustment time scale and entrainment for convective initiation, it is able to reduce the effect of CPS;
- There is larger sensitivity in tropical convection whether a CPS is partially active;