Impact of the cumulus scheme on model initialization of convective storms

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Motivation

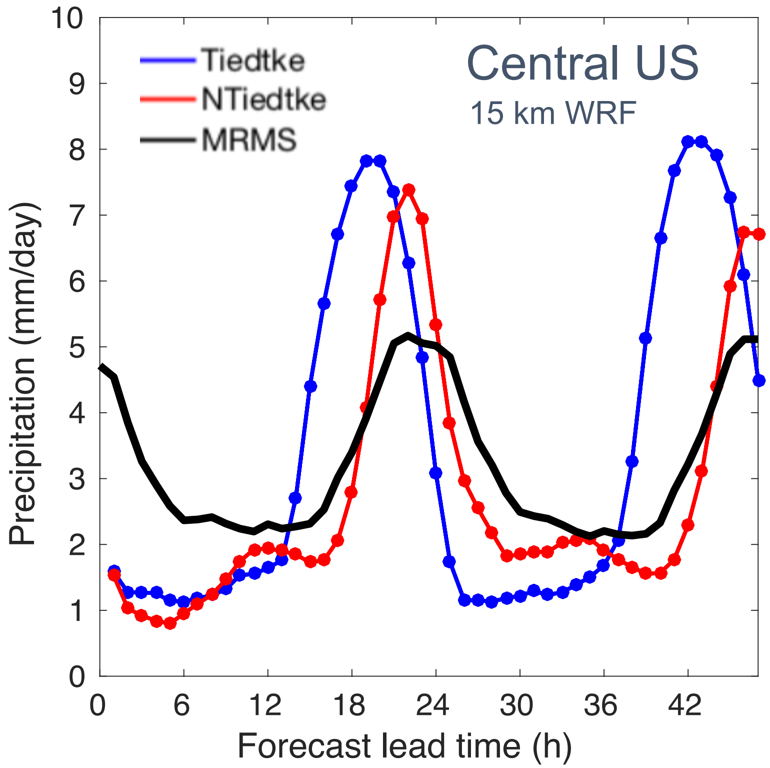
- The non-equilibrium convection parameterization (Bechtold et al., 2014) has been shown to improve the timing of the diurnal precipitation cycle.

- CAPE closure includes a diagnostic boundary-layer production term

- This representation was implemented in the New Tiedtke cumulus scheme* by Chunxi Zhang (2016).

- Does it improve the general model state? What impact do large-scale analyses generated with this new scheme have on 3 km forecasts?

Domain-averaged surface precipitation
48-h forecasts initialized at 00 UTC
from 1 to 15 June 2017



*non-equilibrium formulation is the default configuration since V3.9

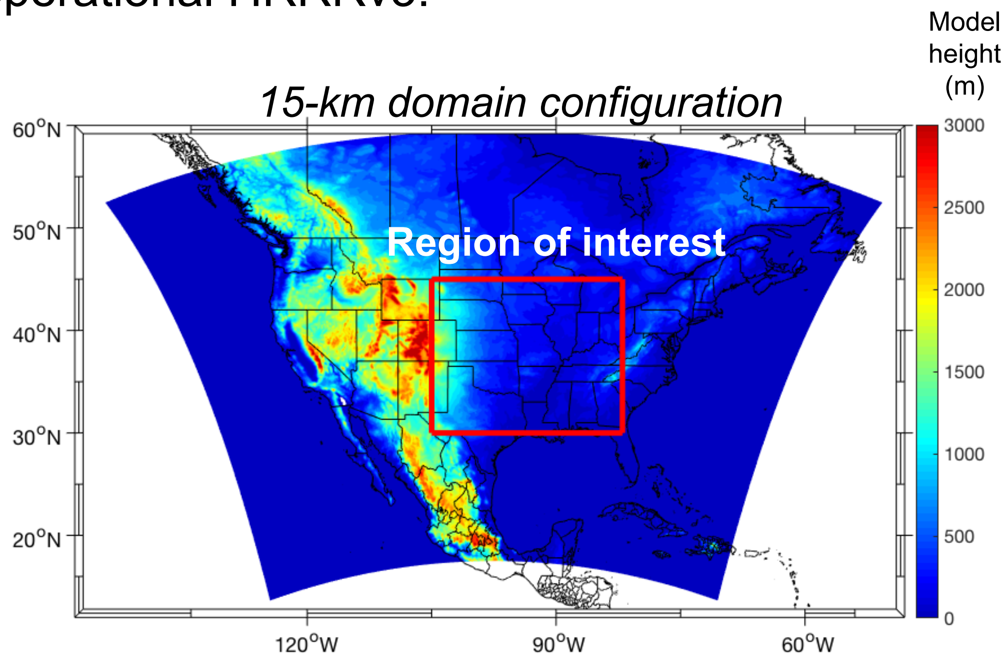
Two 15 km experimental *analysis* systems

- WRF-Data Assimilation Research Testbed (DART)
- 00 UTC 1 May to 00 UTC 15 June 2017
- Similar to NCAR Ensemble's real-time EnKF analysis system for HWT 2017
- 80 ensemble members; continuous-cycling; 6-hourly analyses; conventional observations
- Except physics suite adapted from operational HRRRv3:

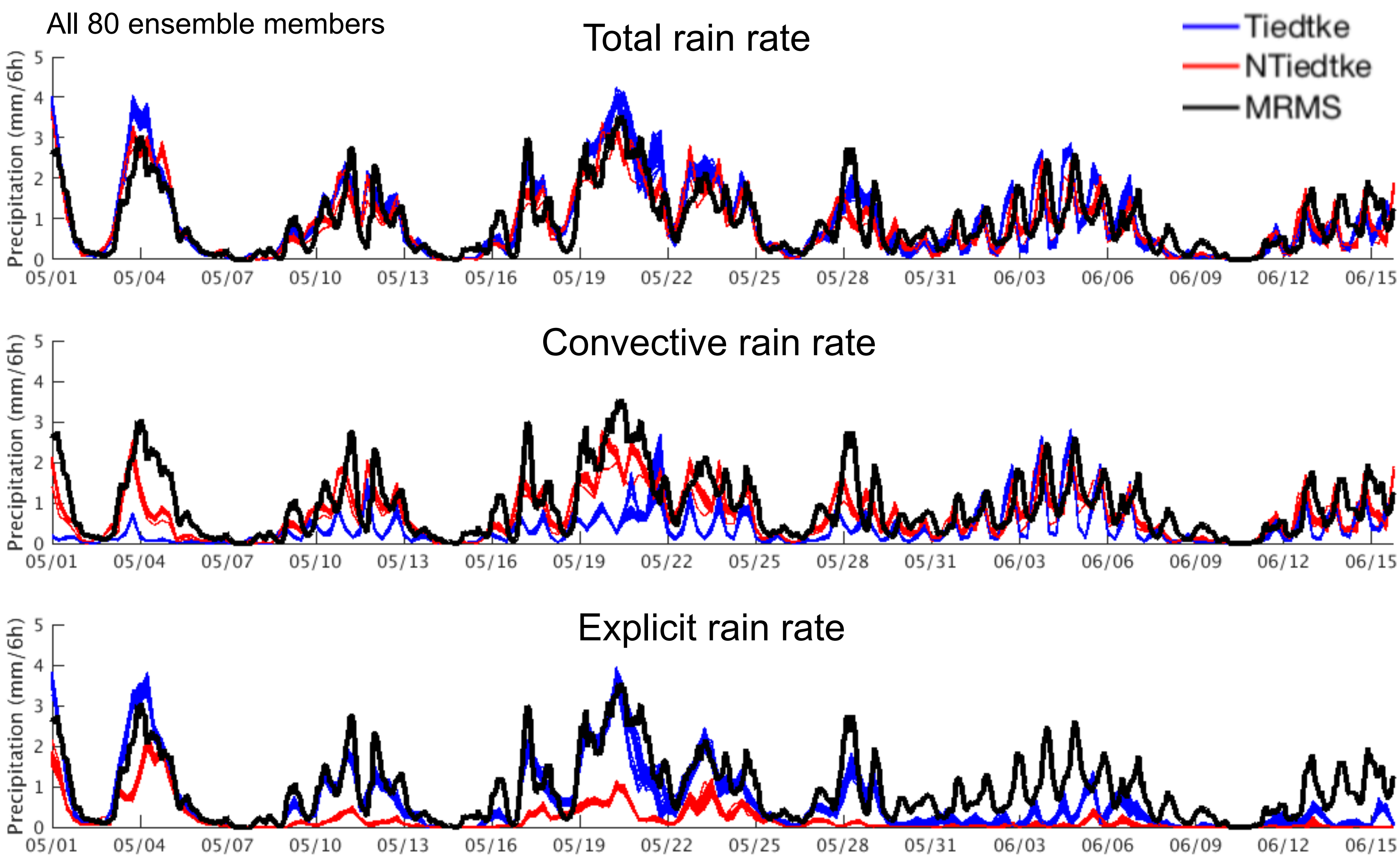
Thompson microphysics
MYNN-EDMF PBL scheme
RUC land-surface model
RRTMG short- and longwave radiation
  with aerosol and ozone climatologies

Cumulus scheme:
- **Modified Tiedtke from V3.8.1**
- **New Tiedtke (adapted from V3.9.1.1)**

15-km domain configuration

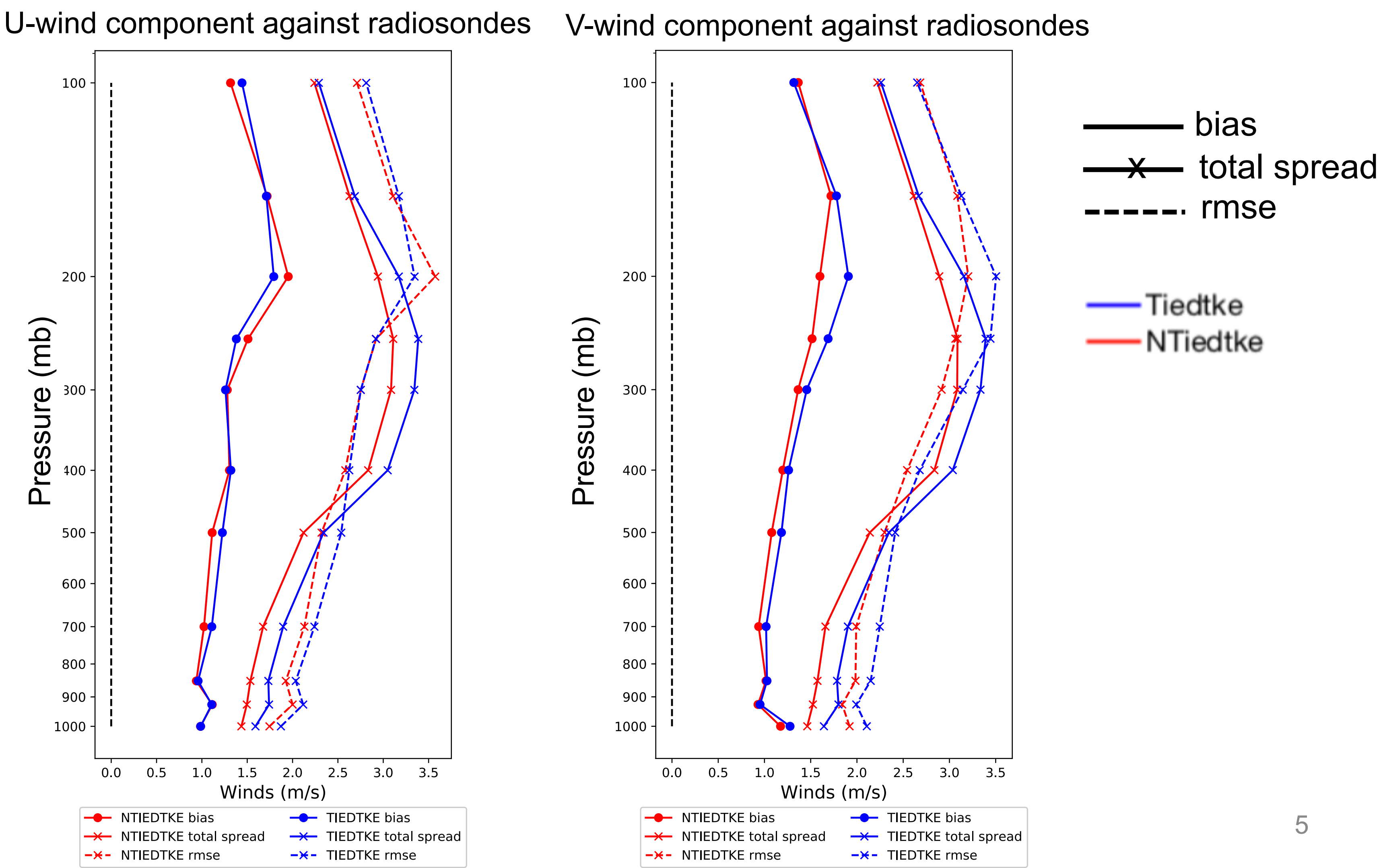


6-h forecast accumulated surface rain rate



Bias, spread, and RMSE of the 6-h forecast

00 UTC 1 May to 00 UTC 15 June 2017



Bias, spread, and RMSE of the 6-h forecast

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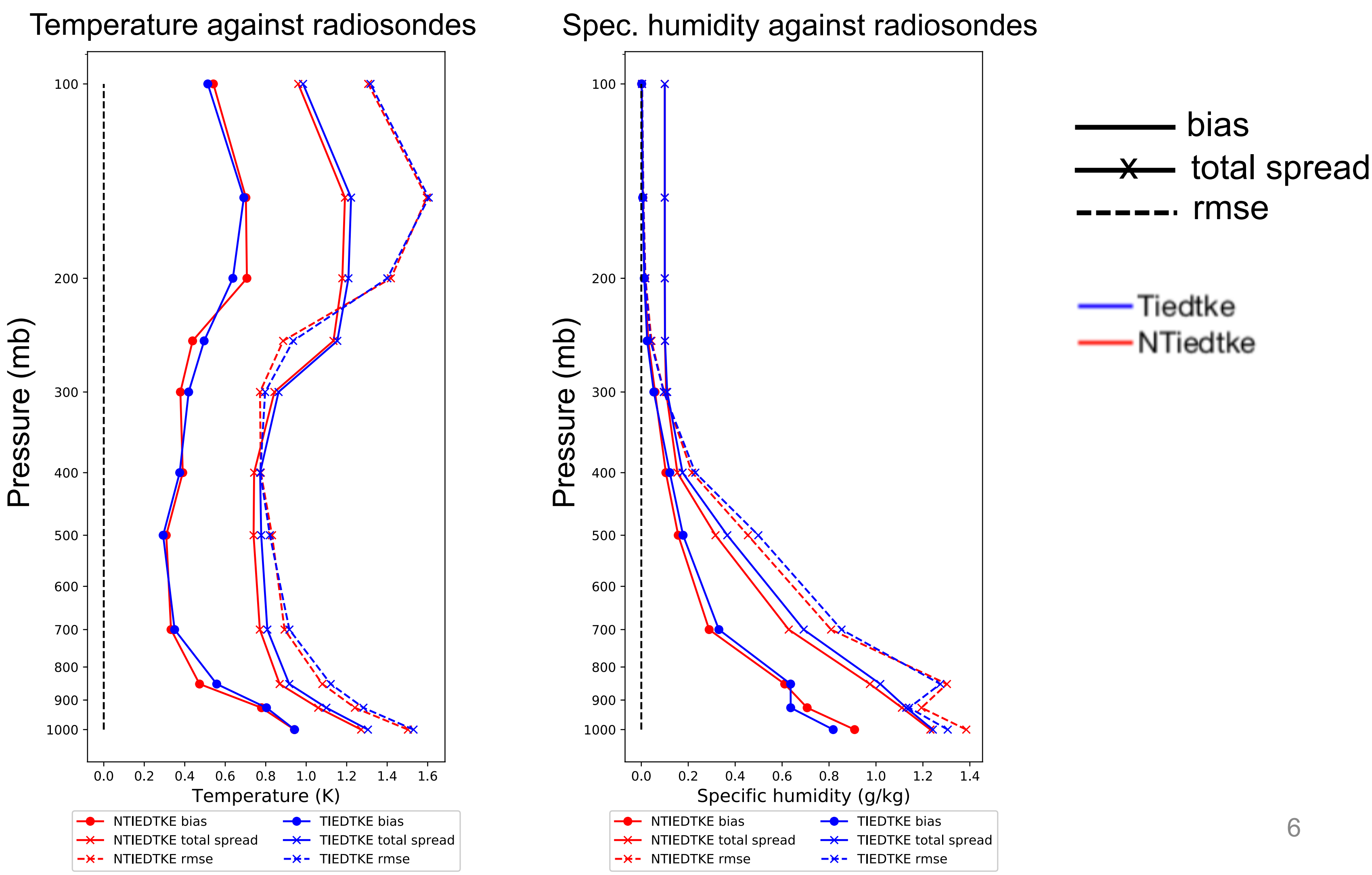
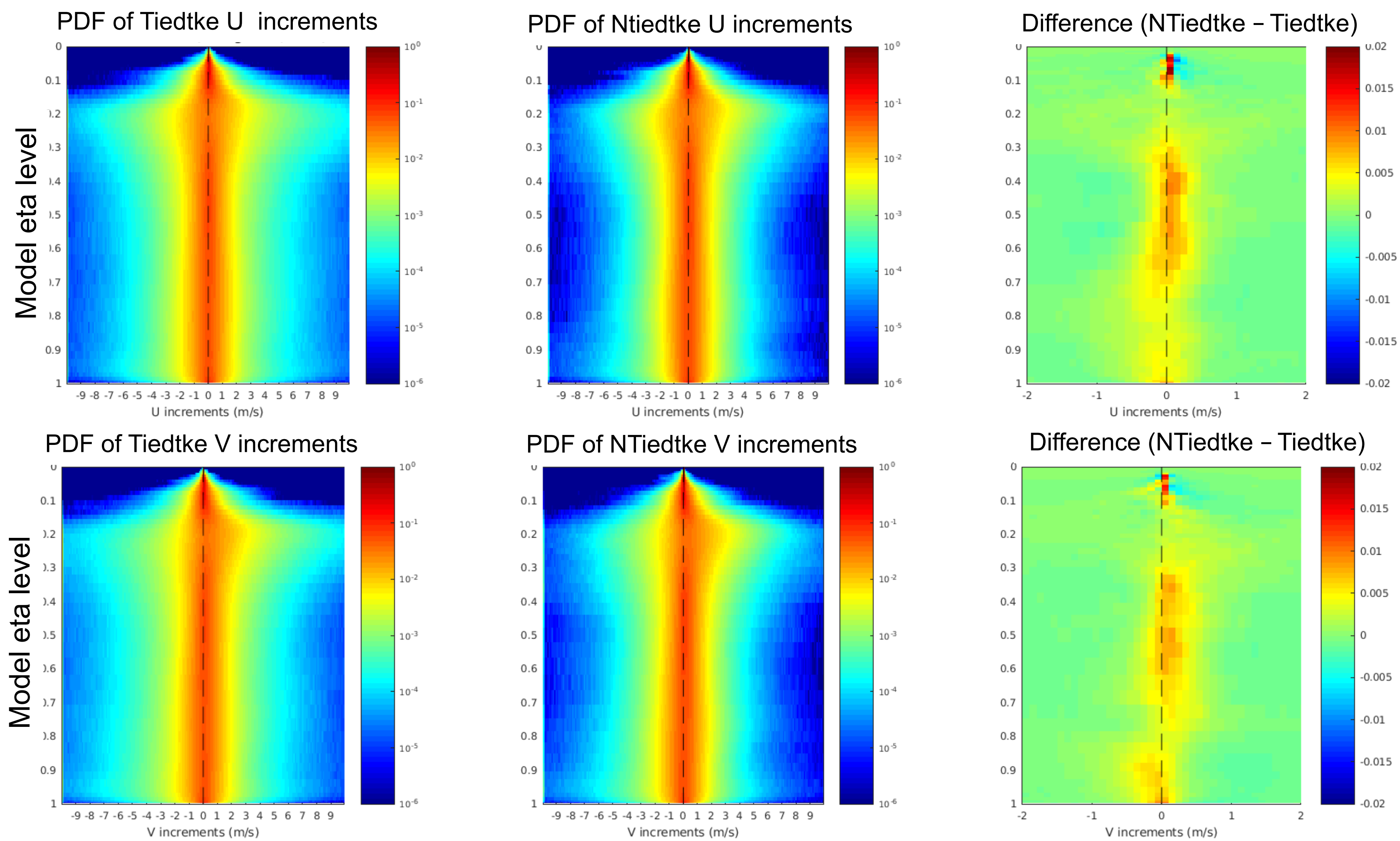


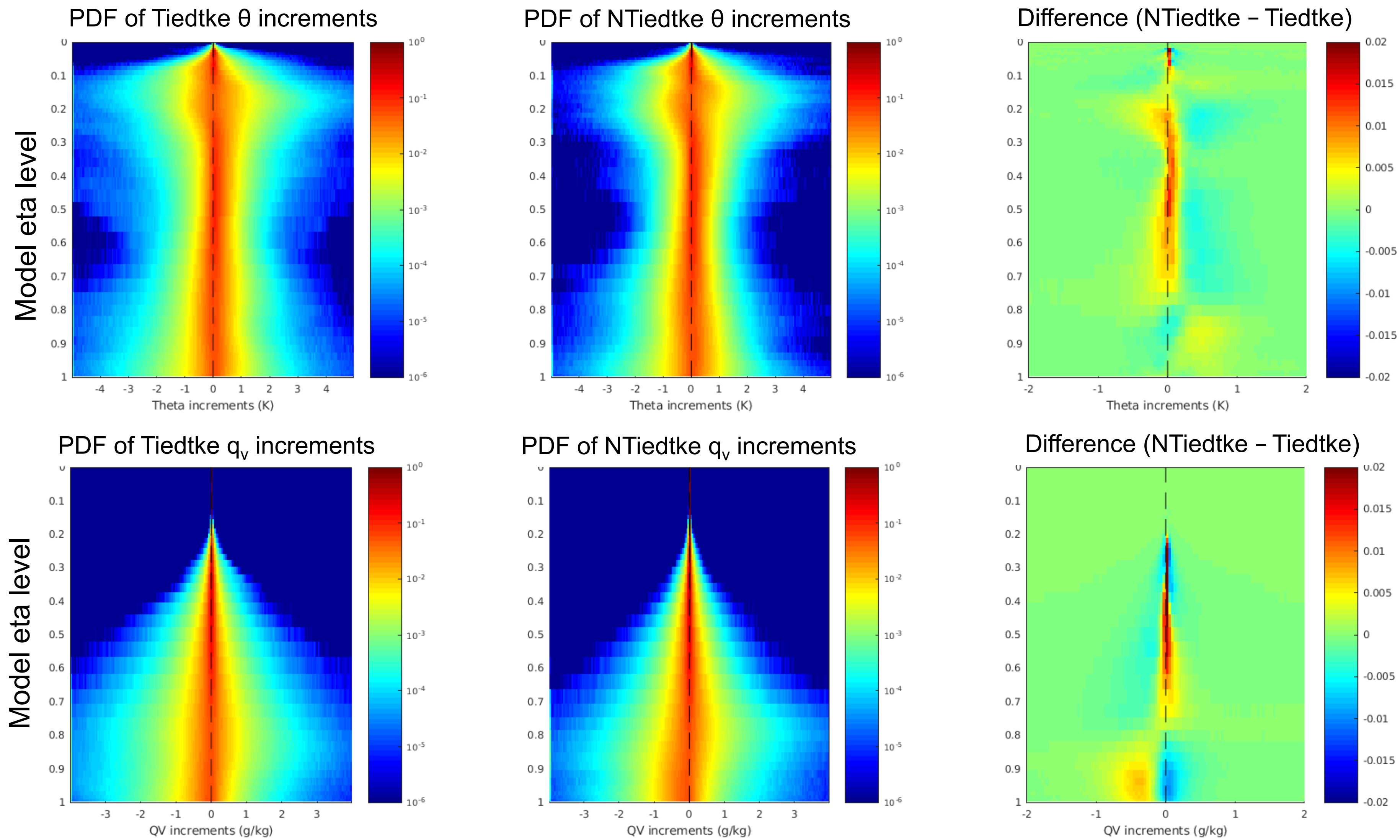
Reduced analysis increments (*u*, *v*)

00 UTC 1 May to 00 UTC 15 June 2017



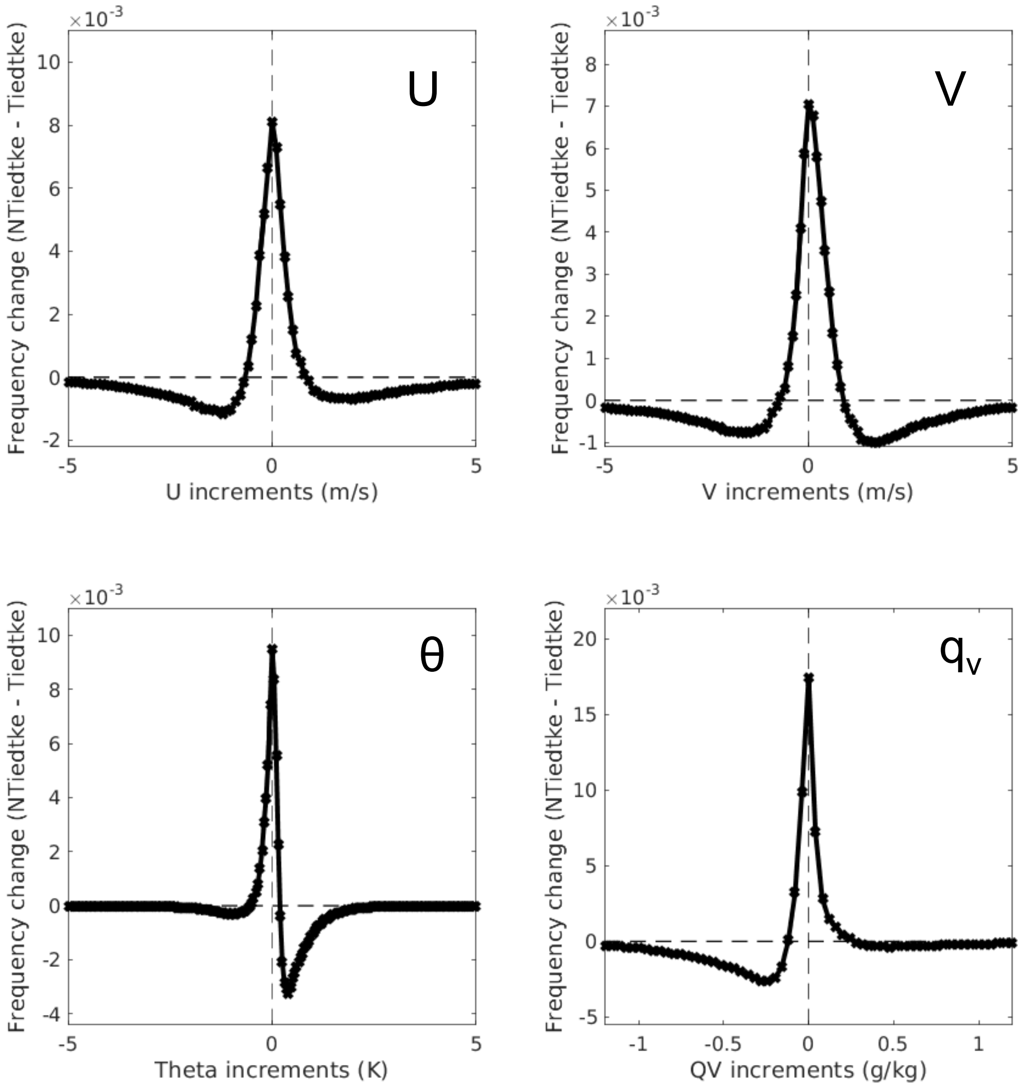
Reduced analysis increments (θ, q_v)

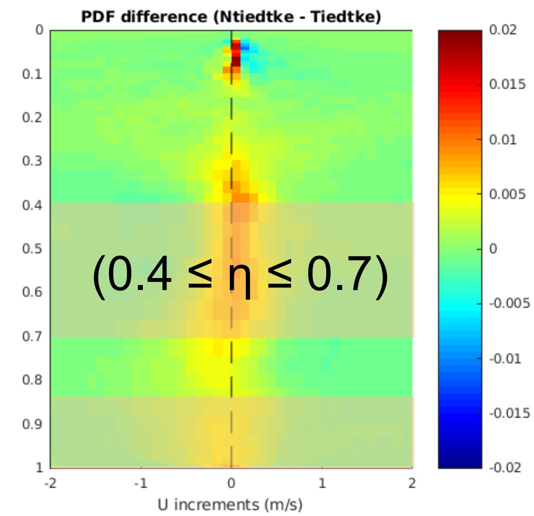
00 UTC 1 May to 00 UTC 15 June 2017



Layer-averaged mid-tropospheric differences

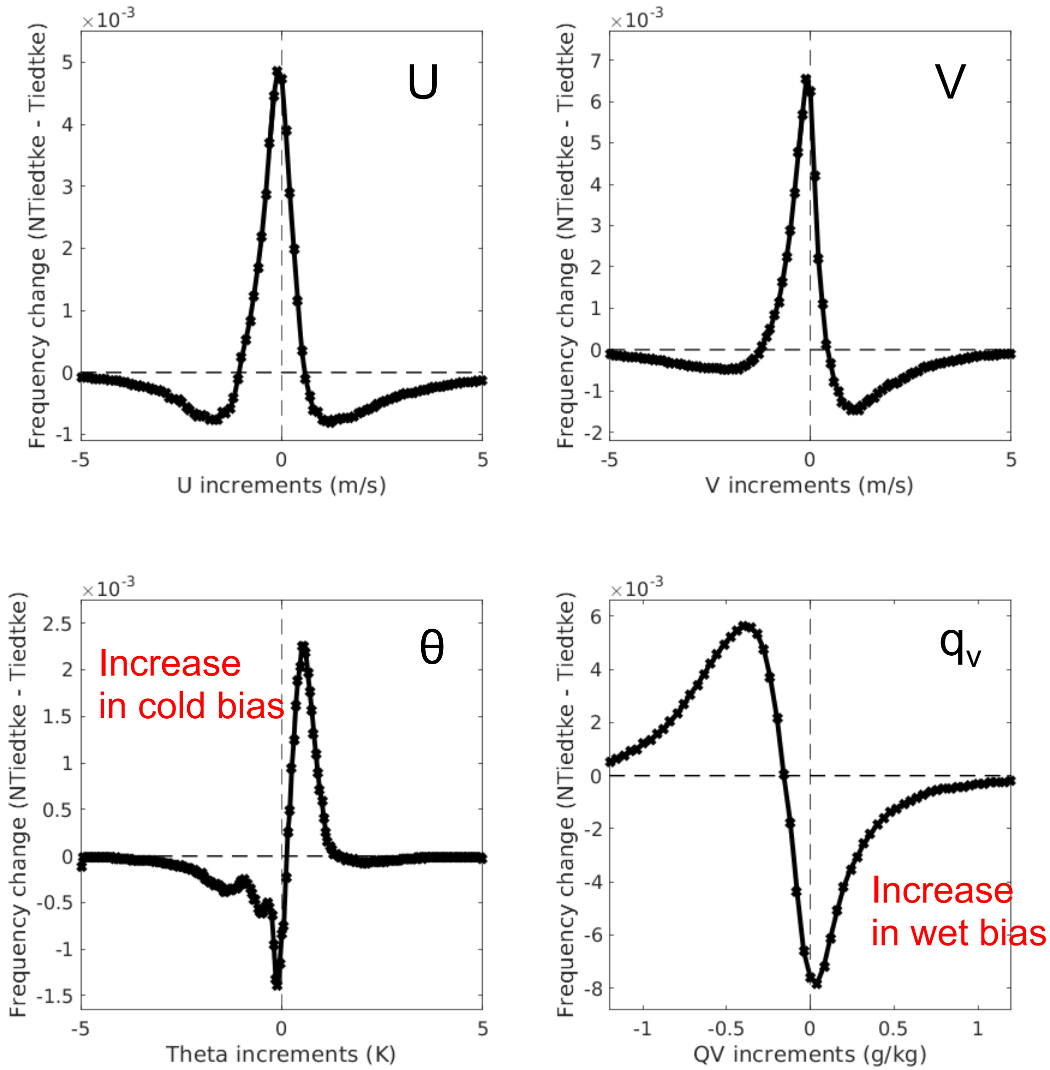
PDF differences (NTiedtke – Tiedtke)

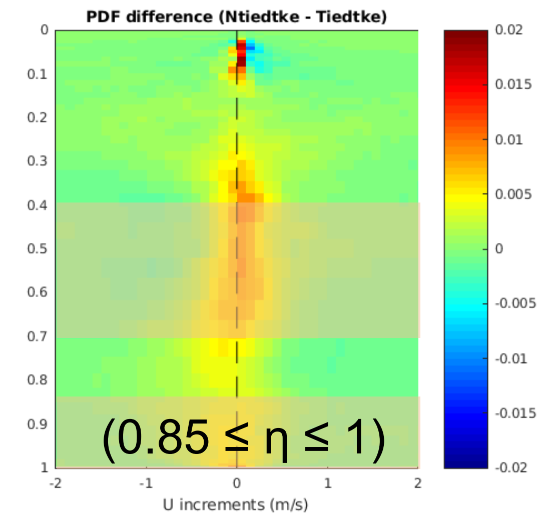




Layer-averaged near-surface differences

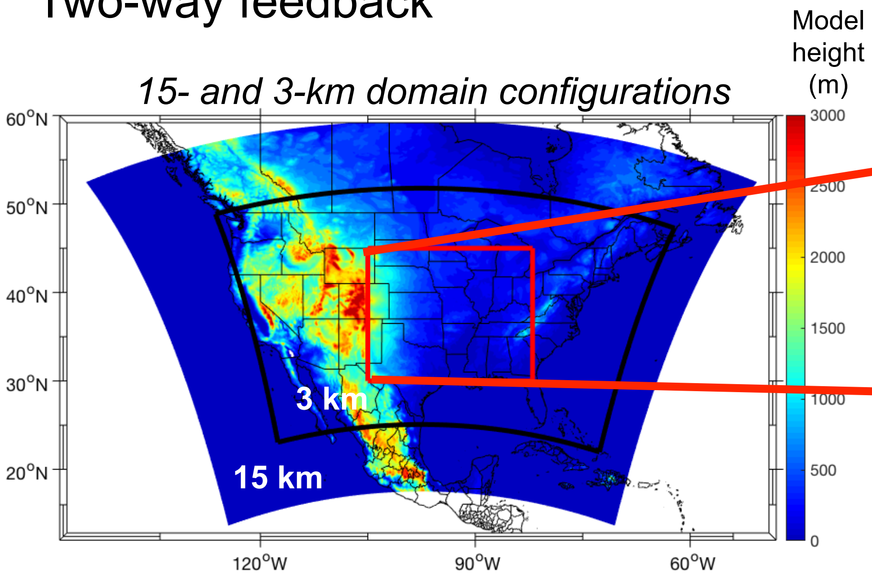
PDF differences (NTiedtke – Tiedtke)

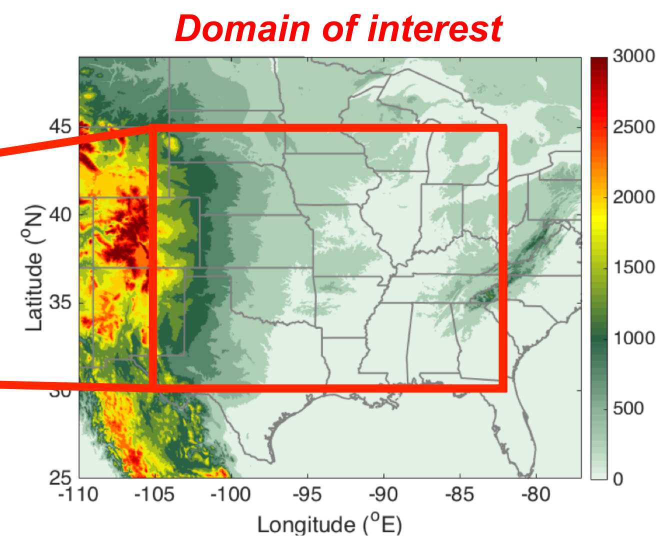


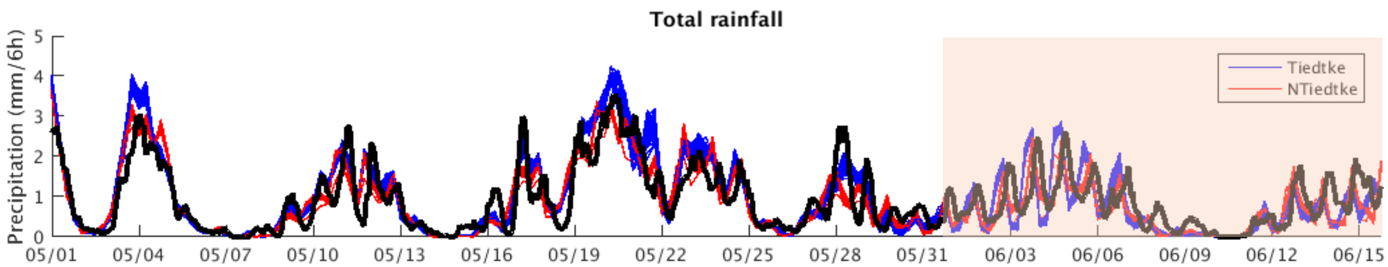


15/3 km experimental *forecast* system

- Period: 1 to 15 June 2017
- Deterministic 48-h forecasts initialized daily at 00 UTC
- Same physics as the analysis system (no cumulus scheme at 3 km)
- Two-way feedback



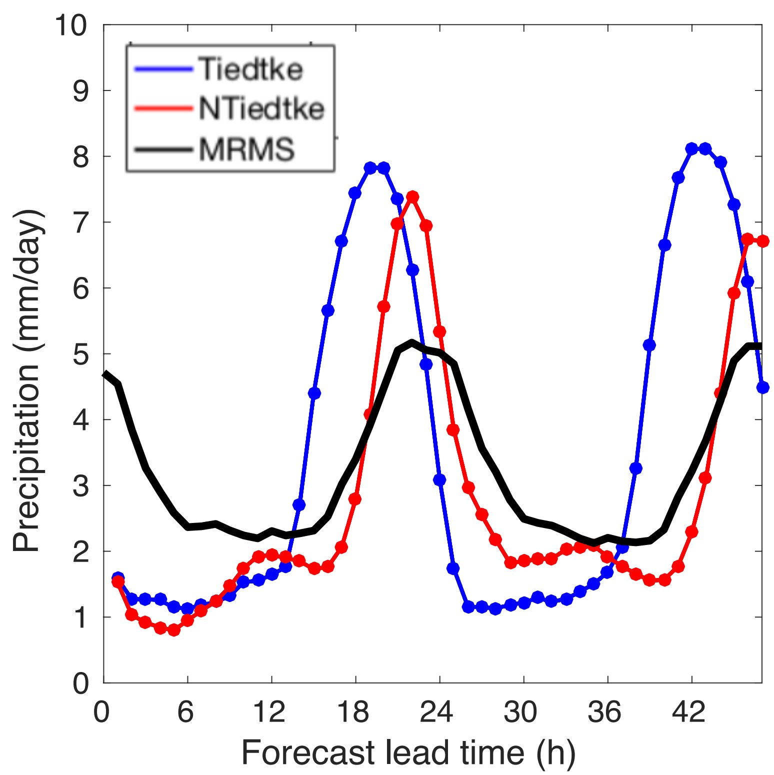




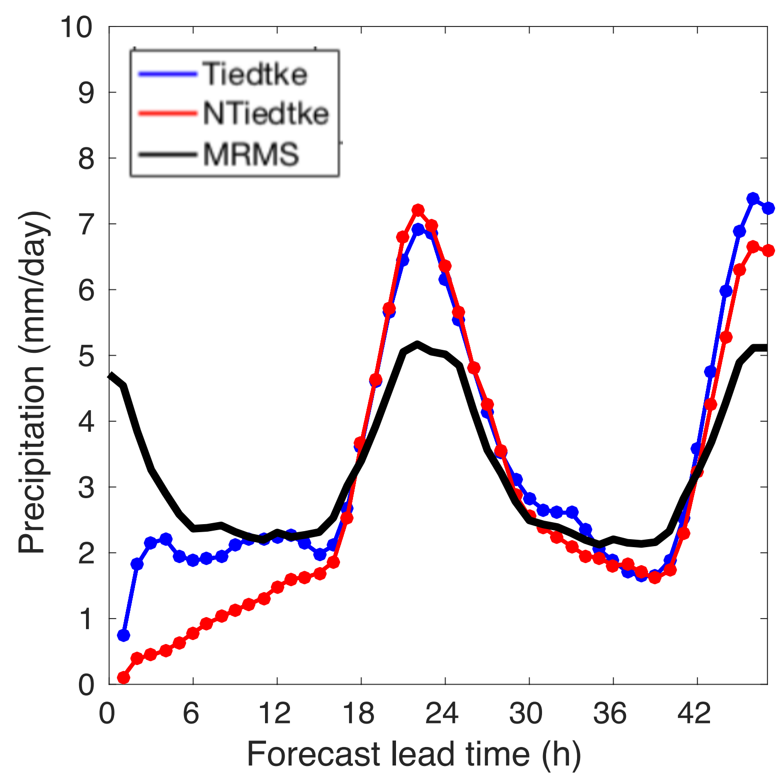
Impact of the cumulus scheme on 15/3 km forecasts

48-h forecasts initialized at 00 UTC
from 1 to 15 June 2017

Domain-averaged surface precipitation in a single-domain WRF 15 km

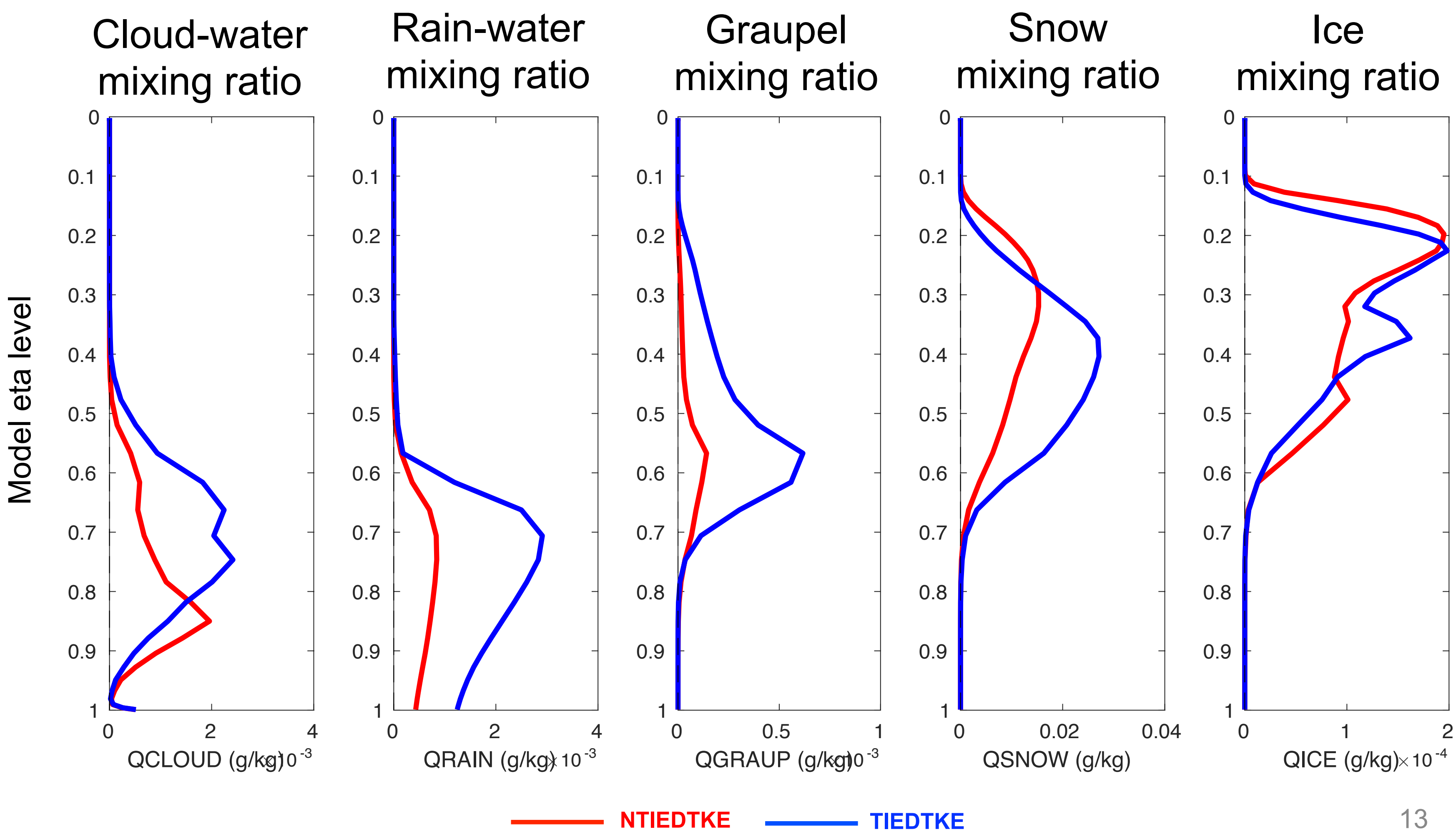


Domain-averaged surface precipitation in a nested WRF 3 km



Differences in the initial state

Vertical profiles of initial domain-averaged hydrometeor mixing ratios at 00 UTC



Next steps

- Based on our 6-hourly continuously-cycling WRF-DART system, we see slight improvements in the model state variables in the New Tiedtke cumulus scheme (as compared with the Tiedtke scheme), except for the near-surface cold and wet biases.

- A first look at the 3-km forecasts did not show large differences in the domain-averaged surface precipitation rates, except during 0-18 h, potentially due to how the microphysical processes are partitioned in the 15 km models.

- Next steps will include a more detailed analysis of the near-surface biases as well as the diurnal variation of the two model systems' performances.