The Weather Research and Forecasting Model: 2015 Annual Update

Jimy Dudhia

NCAR/MMM

Mesoscale & Microscale Meteorology

MMM

LABORATORY

WRF Community Model

- Version 1.0 WRF was released December 2000
- Version 2.0: May 2004
- Version 3.0: April 2008 (add global ARW version)
- … (major releases in April, minor releases in summer)
- Version 3.6: April 2014
  - Version 3.6.1: August 2014
- Version 3.7: April 2015

Physics Options Added in V3.6

- Spectral Bin Microphysics (mp_physics=30, 32, Khain, Lynn)
  - Fast and Full versions (4x33 and 8x33 bins)
- Thompson Aerosol-Microphysics coupling (mp_physics=28)
  - Climatology of water and ice nuclei and surface sources provided for WRF pre-processors
- Kain-Fritsch cloud fractions added to radiation (cu_rad_feedback=1, Alapaty et al., EPA)
  - Previously only Grell schemes had this option available
- Cloud fraction calculation method option for radiation
  - Previously two methods were tied to scheme choice

Physics Options Added in V3.6

- Improved aerosol input capability for radiation (Ruiz-Arias)
  - AOD map and aerosol properties can be input (aer_opt=2)
  - Previously only had climatology and WRF-Chem aerosols (aer_opt=1)
- Lake model (sf_lake_physics=1, 10-level model from CLM, Jiming Jin)
  - Fixed depth or global depth data available (FLake)
  - Can be used with any LSM
- Noah LSM sub-tiling (sf_surface_mosaic=1, Dan Li)
  - Sub-grid tiles of land-use category (mosaic_cat=4)

Changes for V3.6

- Surface layer (sfclay option 1) replaced by revised version (Jimenez et al. 2012, MWR)
- Option to mix other scalars and tracers using PBL's K-coefficient (scalar_pblmix=1, tracer_pblmix=1)
  - Only tracer on by default
- Cloud fraction method is now selectable with icloud=1,2
  - Old cldfra2 (Xu-Randall) is now icloud=1 (default)
  - Old cldfra (simple 1/0) is now icloud=2
- New 30" monthly leaf area index climatology for Noah and RUC LSMs (rdlai2d=.true., Barlage)
- New 15" 20-category MODIS landuse (Broxton, Zeng, UA)

Updates in V3.6.1 (August 2014)

- New lightning_option=3 added (B. Lynn)
  - Lightning Potential Index (m^2s^{-2}) calculated from w and microphysical variables
  - Options 1 and 2 are flash rates more suited to chemistry applications
- For hurricane options dissipative heating was commented out
  - based on evaluations of surface fluxes against observed estimates we think this term is much smaller (Shuyi Chen, U. Miami)
- Other bug-fixes as documented with release

New Options in V3.7

- New Tiedtke cumulus option (cu_physics=16)
  - Provided by C. Zhang (U. Hawaii)
  - More similar to ECMWF version(trigger, timescale, cloud differences)
- Multi-scale Kain-Fritsch cumulus scheme (cu_physics=11)
  - Provided by K. Alapaty and J. Herwehe (EPA)
  - Scale-dependent parameters and trigger
- Shin-Hong PBL scheme (bl_pbl_physics=11)
  - Provided by H. Shin (NCAR/ASP) and S. Hong (KIAPS)
  - Adapted to sub-kilometer usage

New Options in V3.7

- Top-down mixing option for YSU PBL (ysu_topdown_pblmix=1)
  - Provided by T. Wilson (UCLA)
  - Cloud-top radiatively driven downward convection added
- Optimized RRTMG radiation (ra_lw_physics=24, ra_sw_physics = 24)
  - Provided by J. Michalakes (NOAA) and M. Iacono (AER)
- New cloud fraction option (icloud=3)
  - Provided by G. Thompson (NCAR/RAL)
  - Larger cloud fractions and fractions even where RH < 100%

Updates in V3.7

- Diffuse, direct and direct normal solar radiation diagnostic outputs extended to CAM and FLG radiation options
- Revised MM5 sfclay scheme (sf_sfclay_physics=1) is now sped up by using look-up tables and faster convergence method for iteration
  - This may speed model up by 5% over V3.6
- Revised and old "MM5" surface-layer options (sf_sfclay_physics=1,91) over water now use COARE3.0 exchange coefficients instead of Carlson-Boland and reduced convective velocity for heat and moisture fluxes
- NoahMP and RUC LSMs updated
- Single-layer urban canopy model (sf_urban_physics=1) includes more water-related sub-options (e.g. oasis effect, urban irrigation, impervious layer)
- Orographic gravity wave drag (gwd_opt=1 with YSU PBL) now includes low-level flow blocking

Updates in V3.7

- Milbrandt microphysics updated
  - bug-fix for the V3.6 version, V3.5 was OK
- WSM, WDM and NSSL microphysics schemes now output effective radii for RRTMG radiation
- NSSL microphysics schemes updated
- Thompson microphysics scheme updated
  - initialization sped up using pre-generated look-up tables

Updates in V3.7

- SKEBS updated – cleaned up for easier customization (J. Berner)
- NWP diagnostics now include max hail size (G. Thompson)
- New vertical nesting option (K. Lundquist, LLNL)
- Dynamics: use_theta_m option added to improve LES (J. Klemp) [not yet for nested runs]
- Dynamics: use_q_diabatic option to improve updraft symmetry in strong advection cases (G. Bryan)

Updates in V3.7

- Lateral boundary fix for long-term drift issue
  - Specified points were only updated with tendencies leading to round-off drift for long simulations that showed up as boundary noise and streaks in upper winds
  - Fix is to specify value at end of time steps
- New idealized example cases for
  - Shallow convection (added in test/em_les directory)
  - Radiative-convective equilibrium (in test/convrad)

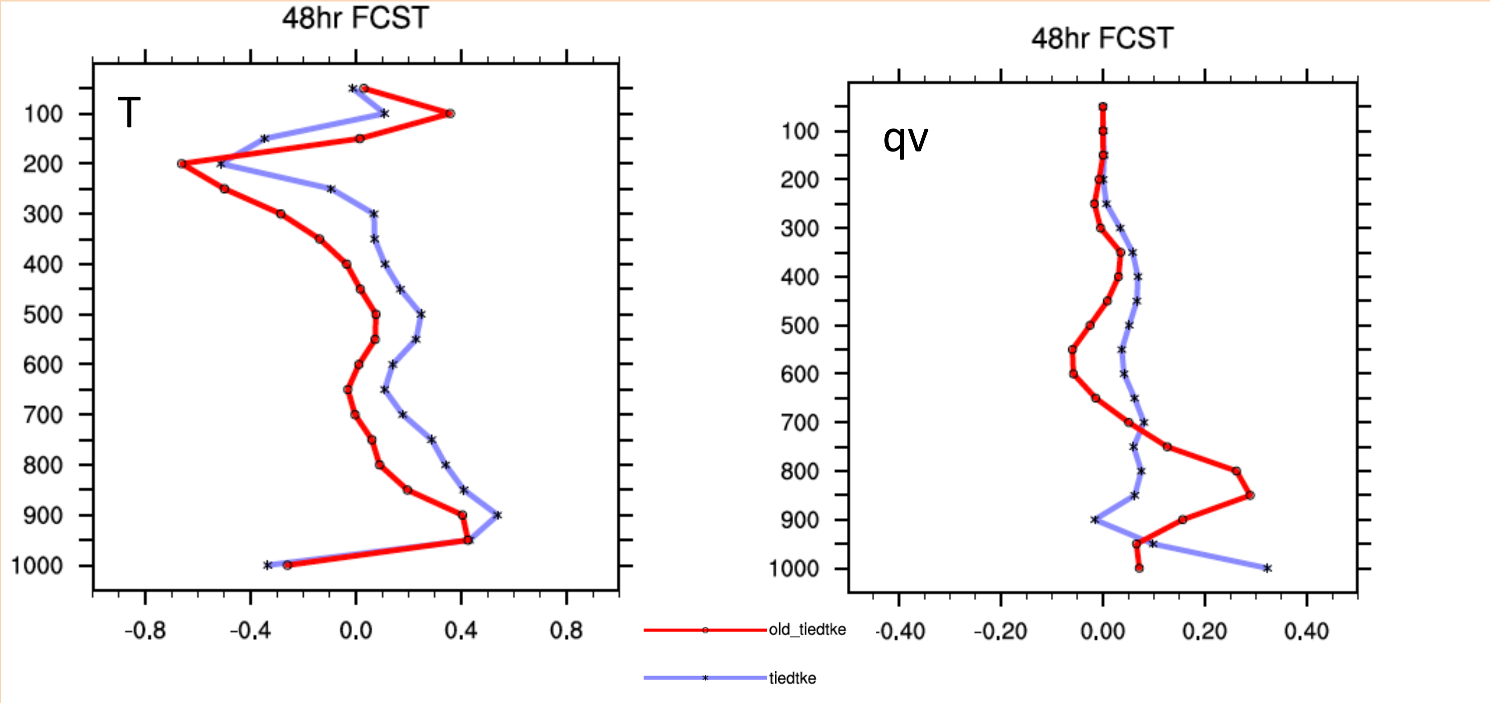
Updates in V3.7

- Configure selection format improved
- Memory reduction compared to V3.6 by "packaging" some extra 3d arrays that are only needed with one or few options

Examples of Changes

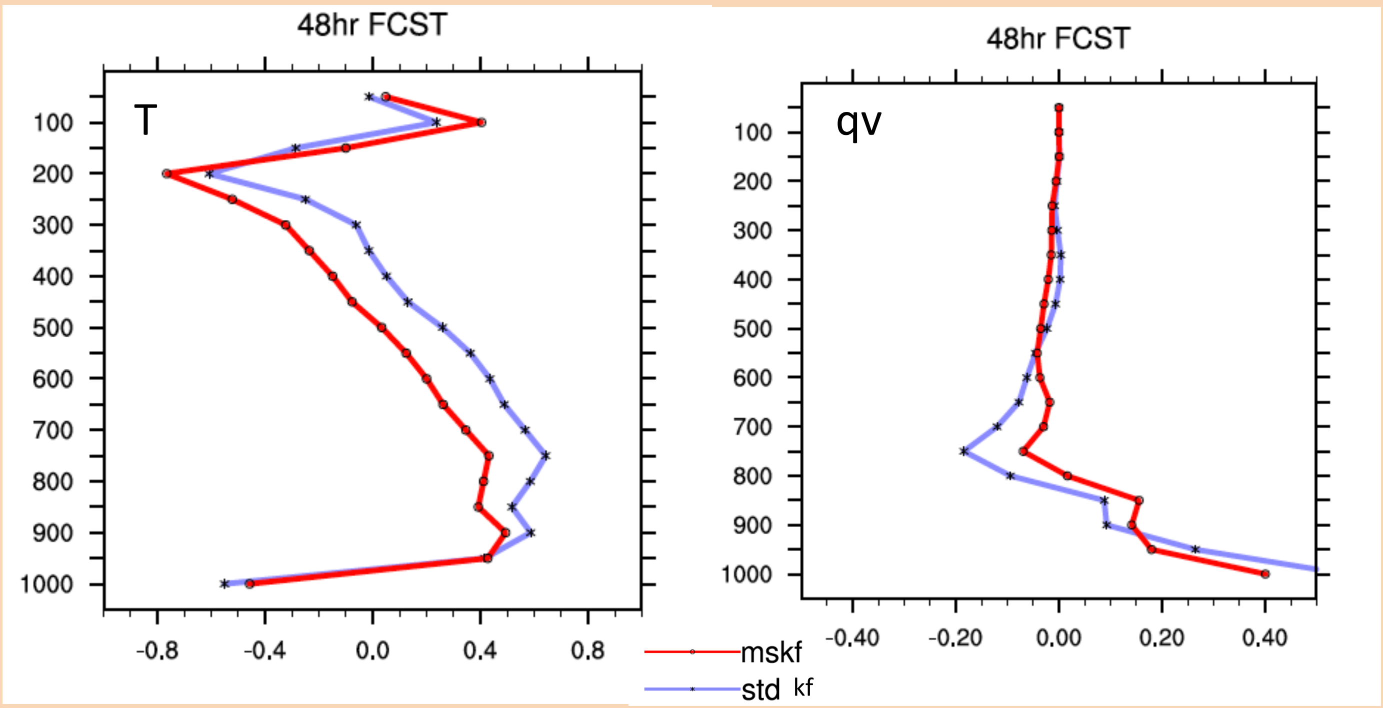
- 20 km, 28 cases, US domain, June 2010, 48-hr forecasts
- Note: Standard configuration in V3.7 gives essentially same results as V3.6.1
  - WSM5, KF, YSU PBL, RRTM LW, GSFC SW, Noah LSM
- Will show
  - Cumulus changes
  - Top-down mixing effect (new)
  - Gravity-wave-drag change (3.7 v 3.6.1)
  - New cloud fraction (icloud=3) effect (new)
  - Surface-layer flux change (3.7 v 3.6.1)
  - Thompson RRTMG feedback sensitivity (3 km)
  - Lateral boundary change (30-day run)

New versus old Tiedtke cu



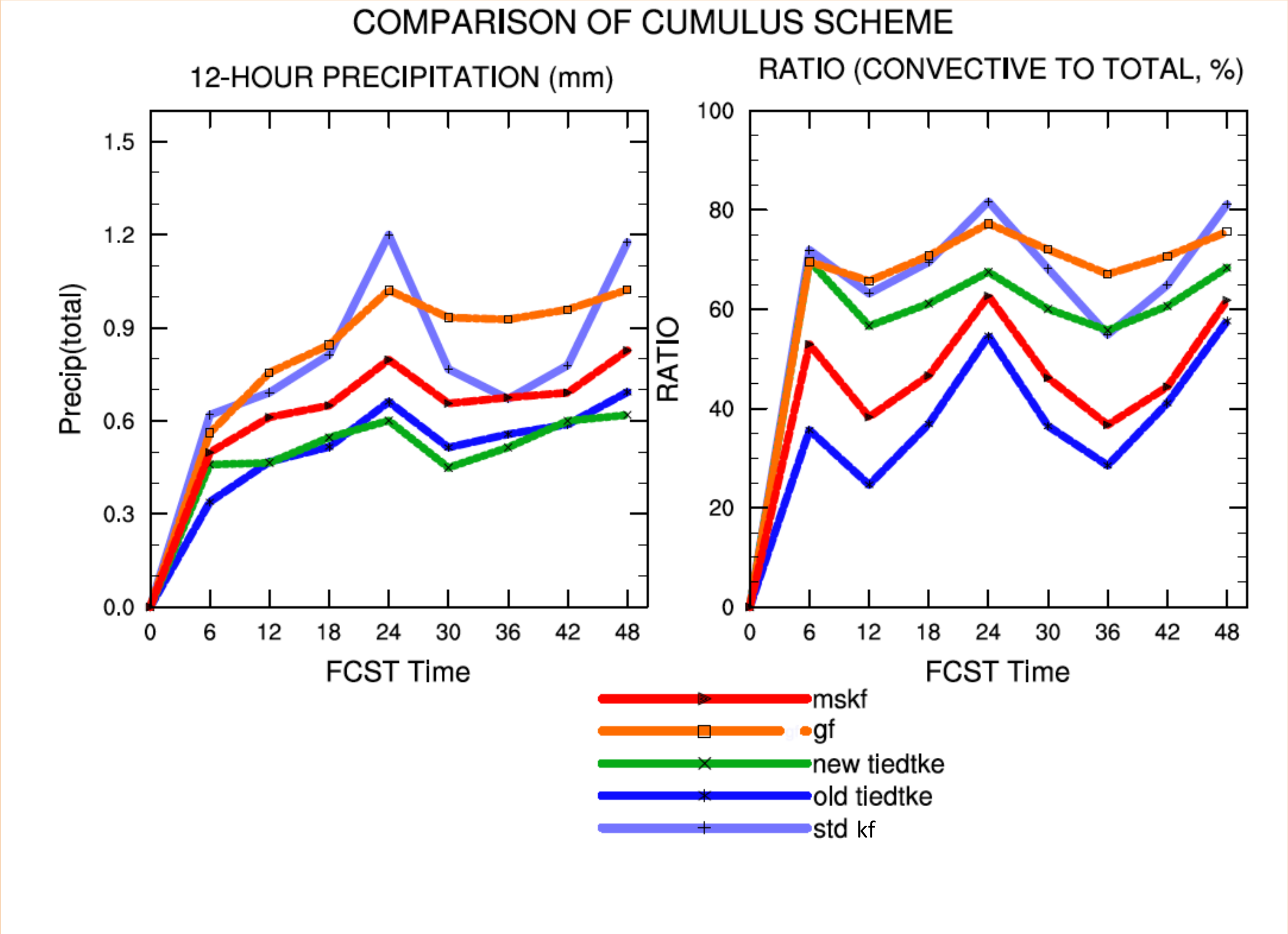
Newer Tiedtke increases warm bias, decreases low-level moist bias

MSKF versus KF cu



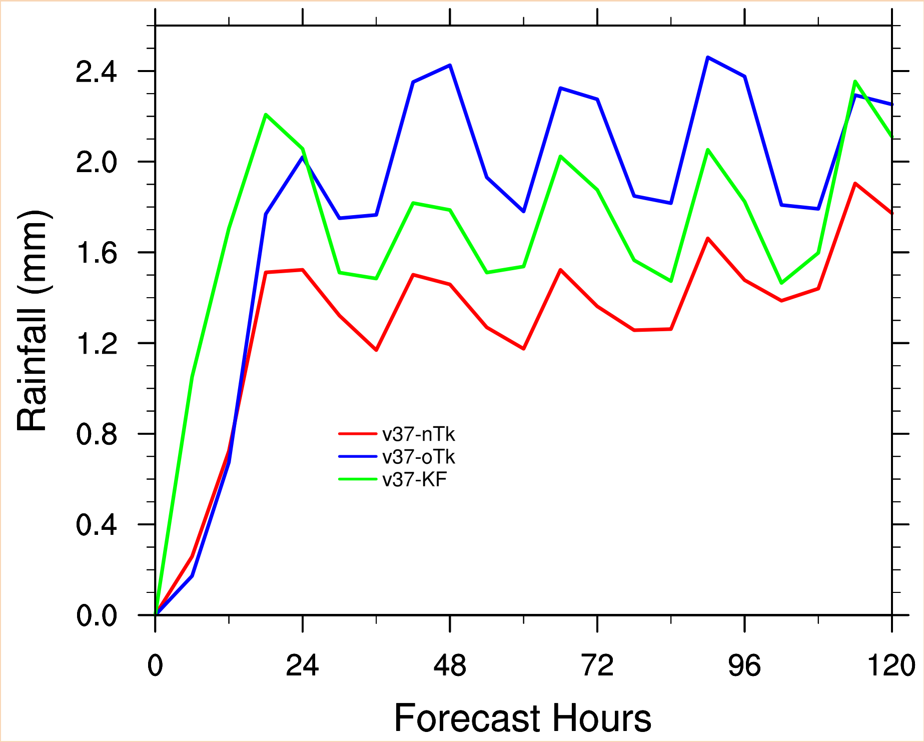
MSKF reduces warm bias, slightly less dry bias at low levels

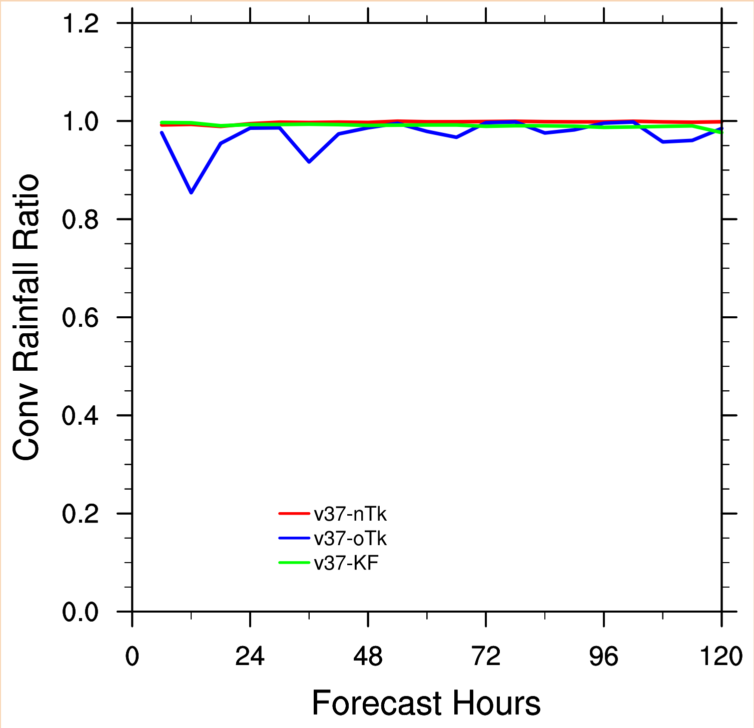
Precipitation

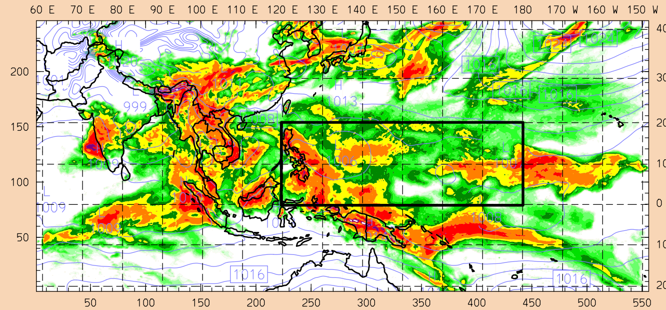


New Tiedtke similar precip, higher convective fraction, than old Tiedtke
MSKF less precip and less convective fraction than KF

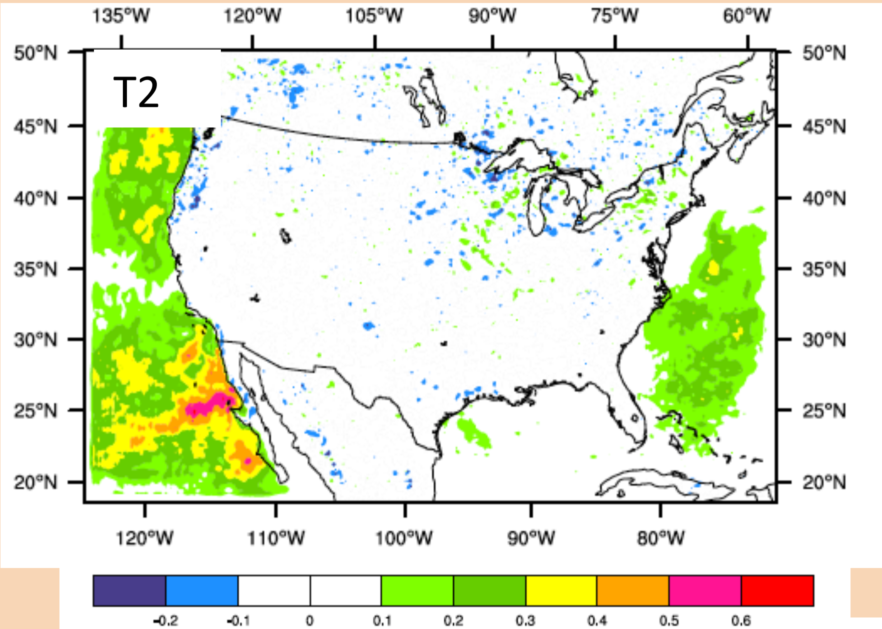
V3.7 new Tiedtke vs old Tiedtke and KF (DX=30 km)

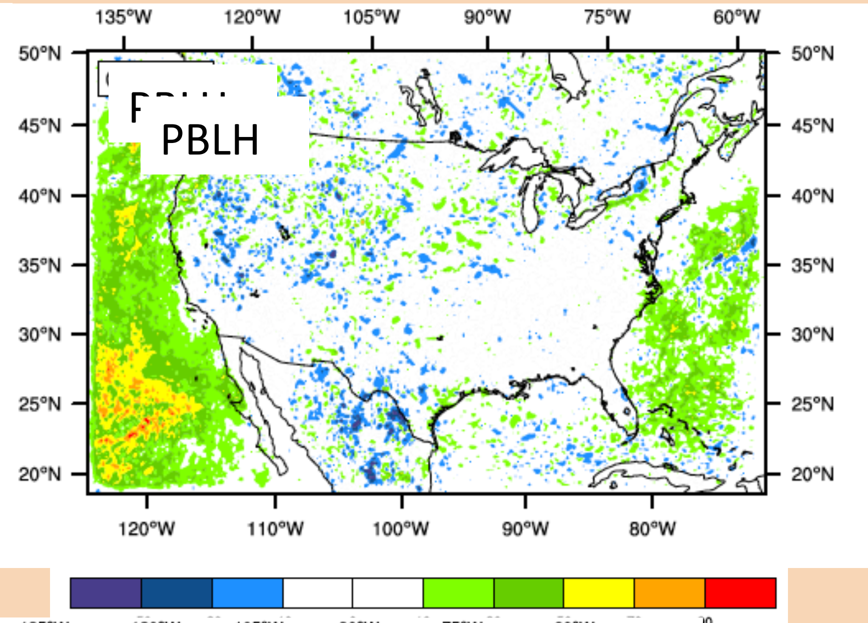


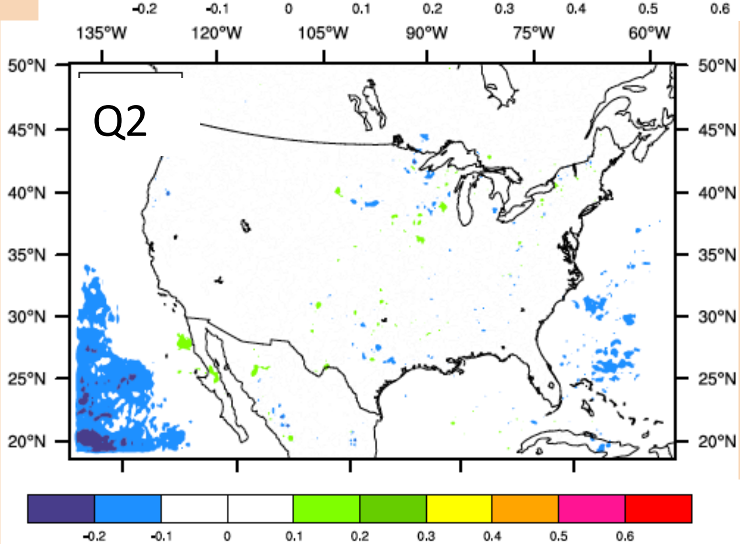


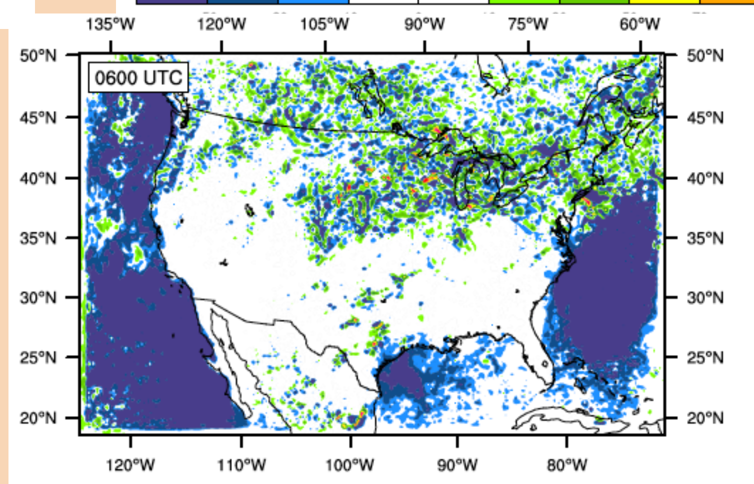


Top-Down Mixing in YSU PBL





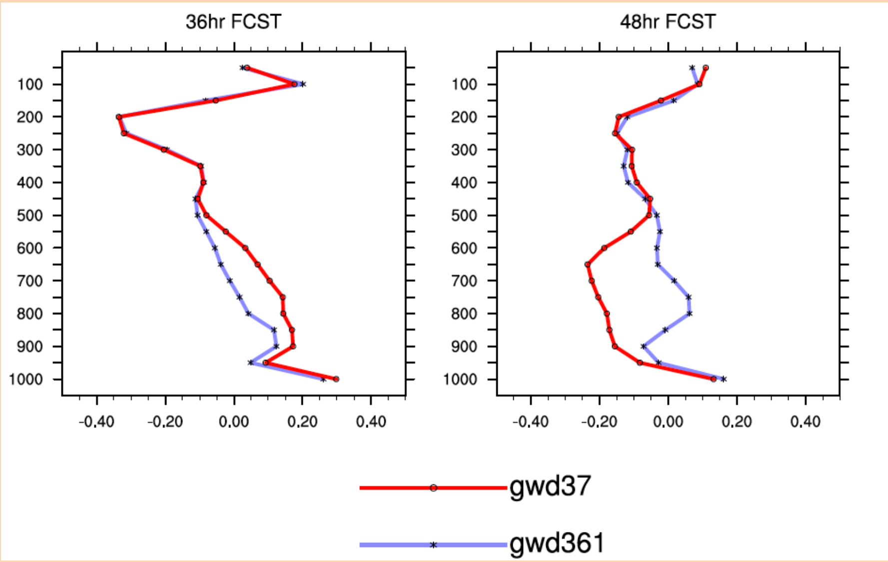




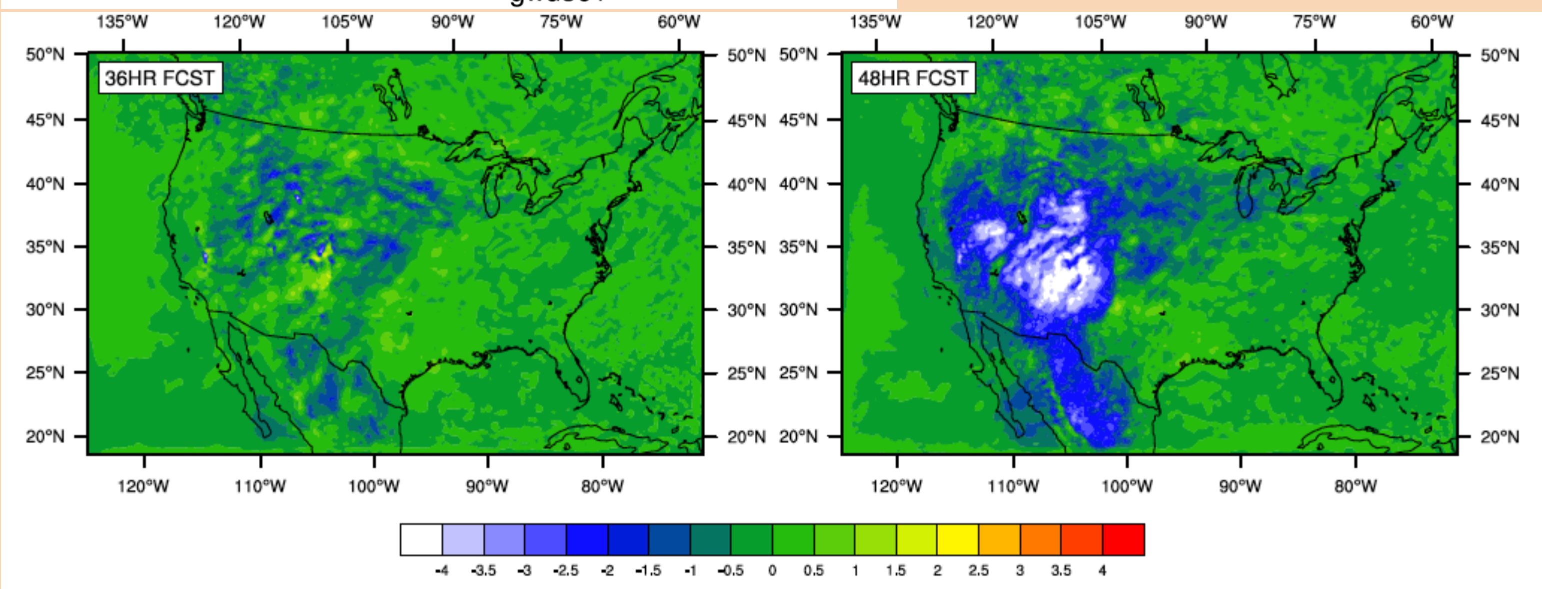
Integrated Cloud

Top-down mixing mostly affects stratocumulus regions – increases mixing – warms, dries and deepens PBL, reduces cloud ~50%

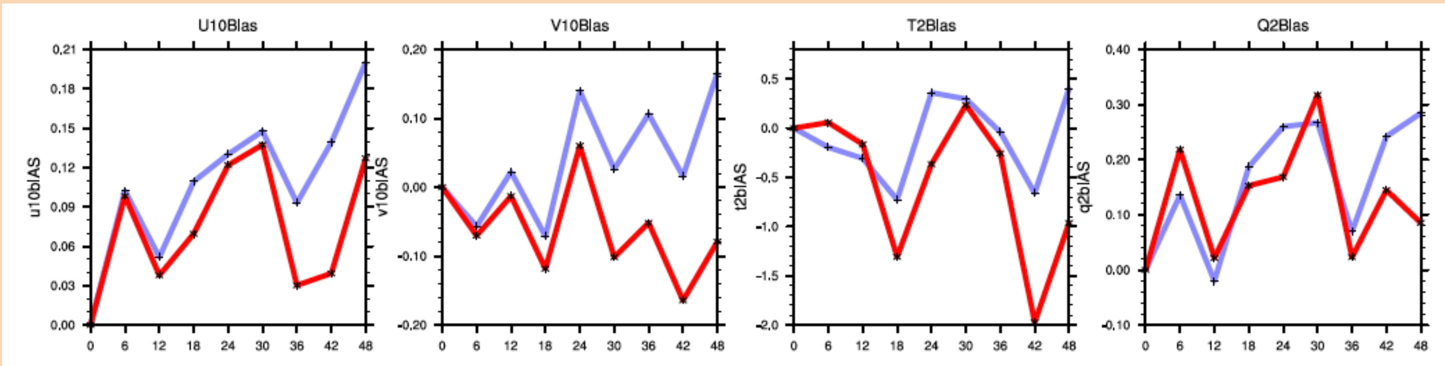
Gravity Wave Drag

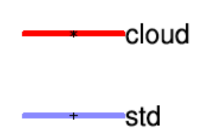


New scheme has flow-blocking effect that significantly reduces low-level winds, especially at 24 and 48 h (00Z)

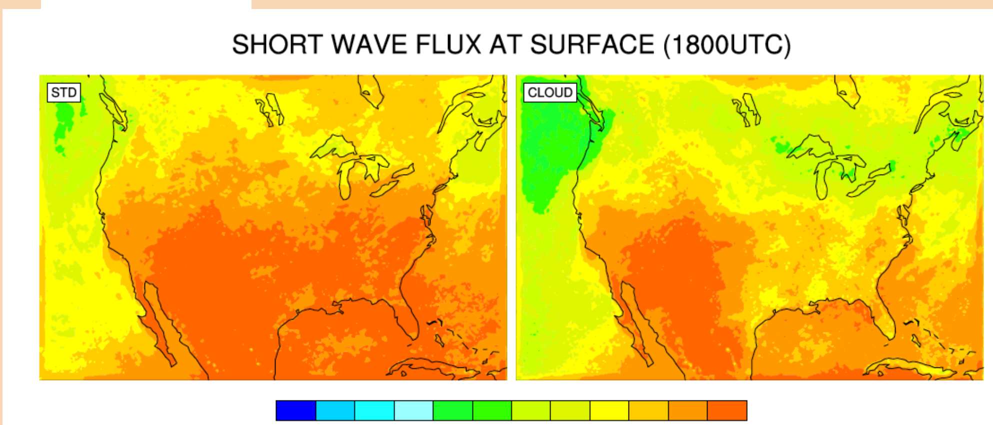


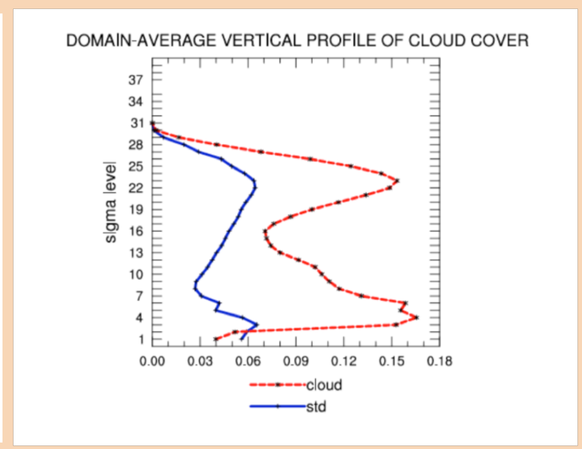
New Cloud Fraction (icloud=3)



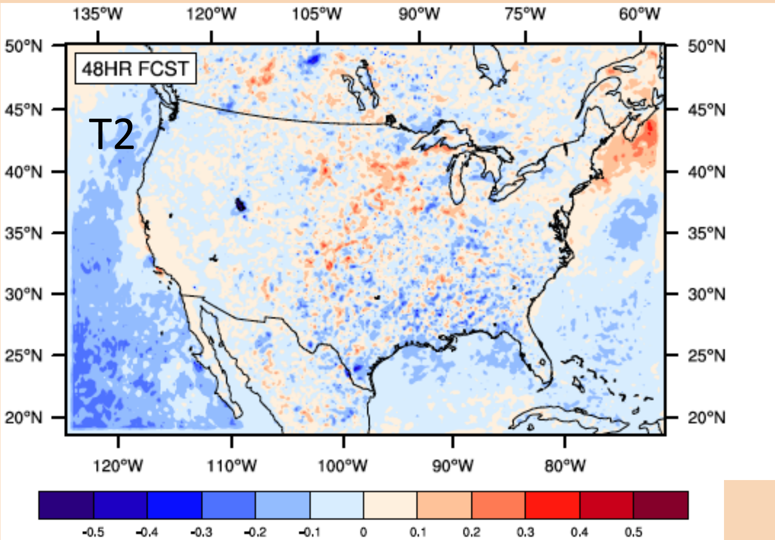


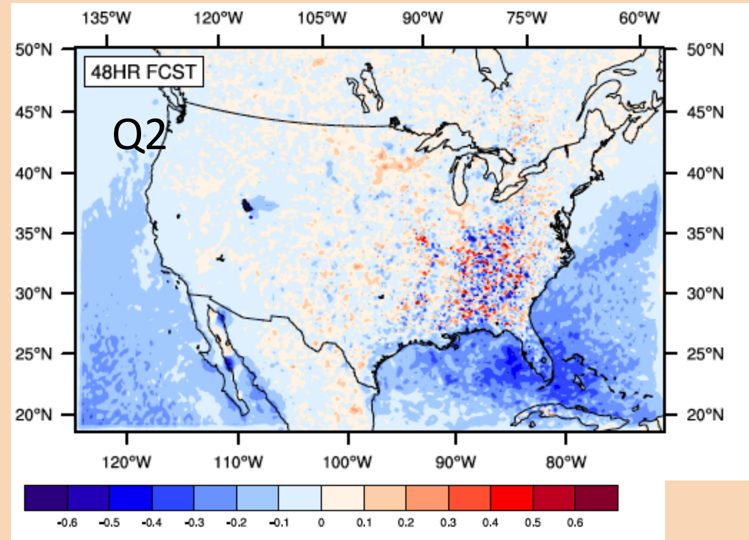
This option produces much larger cloud fraction than other options (may still need tuning before general use)





Modified Surface Layer



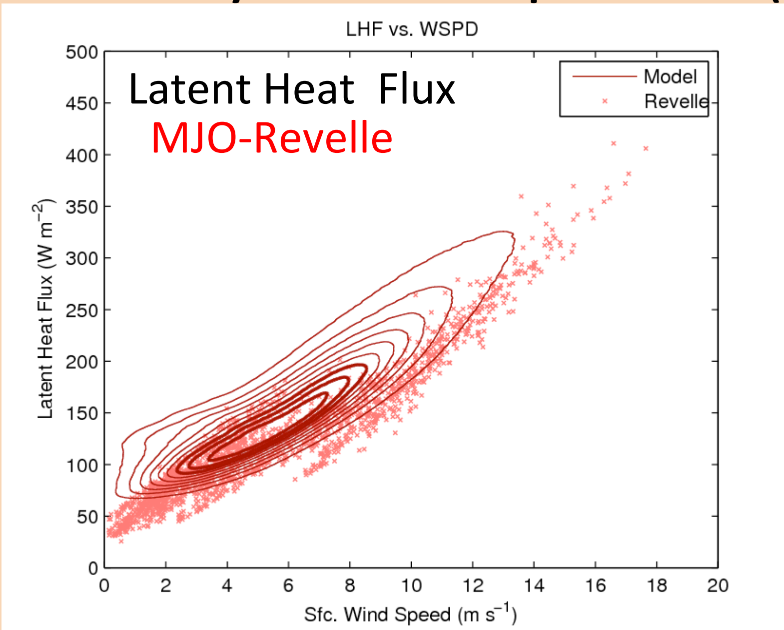


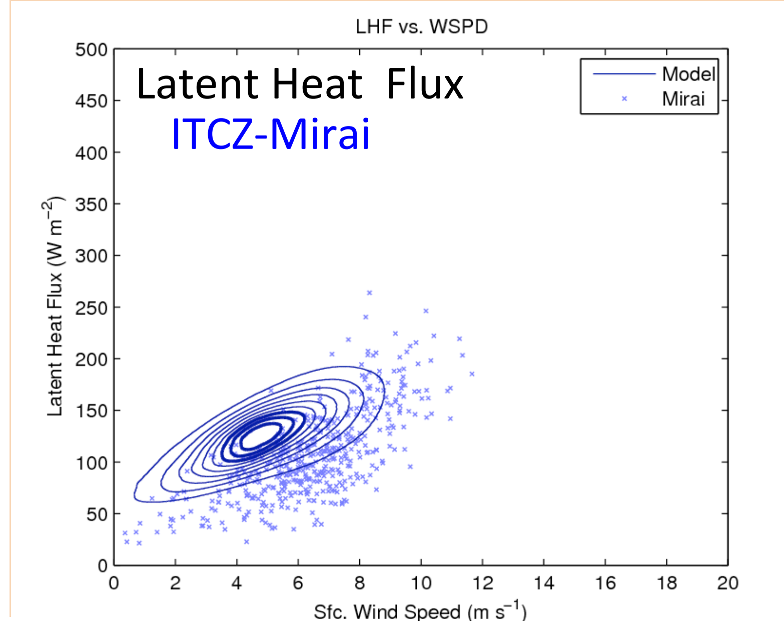
Differences in 2m T and Q.
Changing from Carlson-Boland to COARE3 and reducing VCONV over water leads to cooler and drier surface ocean

From U. Miami – VCONV change tested in coupled model – see talk 3.4 by A. Savarin

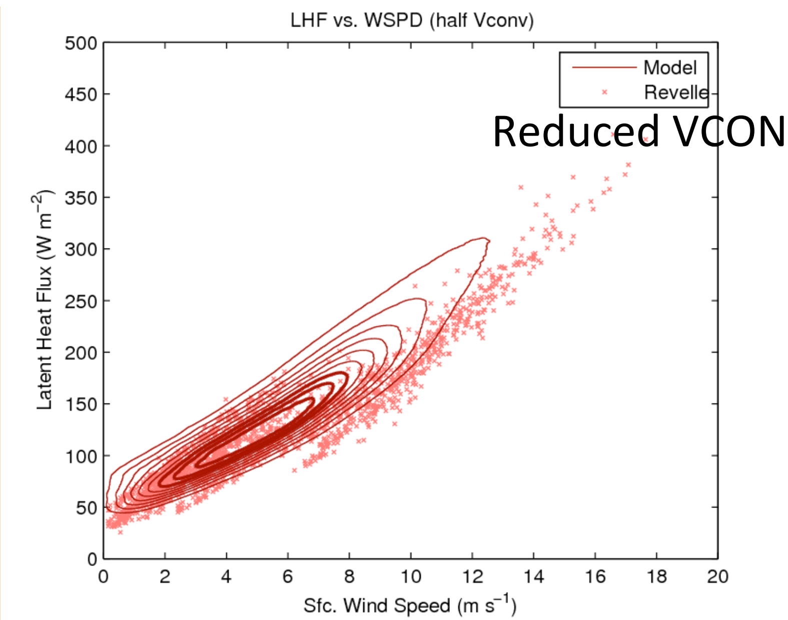
Correction of Model Bias due to Parameterized Convective Velocity in WRF Sfc/PBL

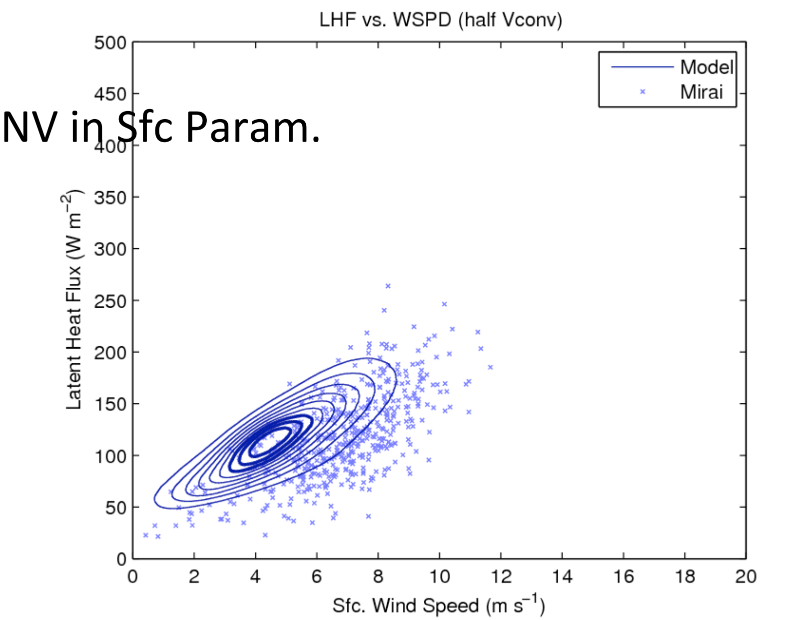
University of Miami Coupled Model (UWIN-CM) and DYNAMO Observations



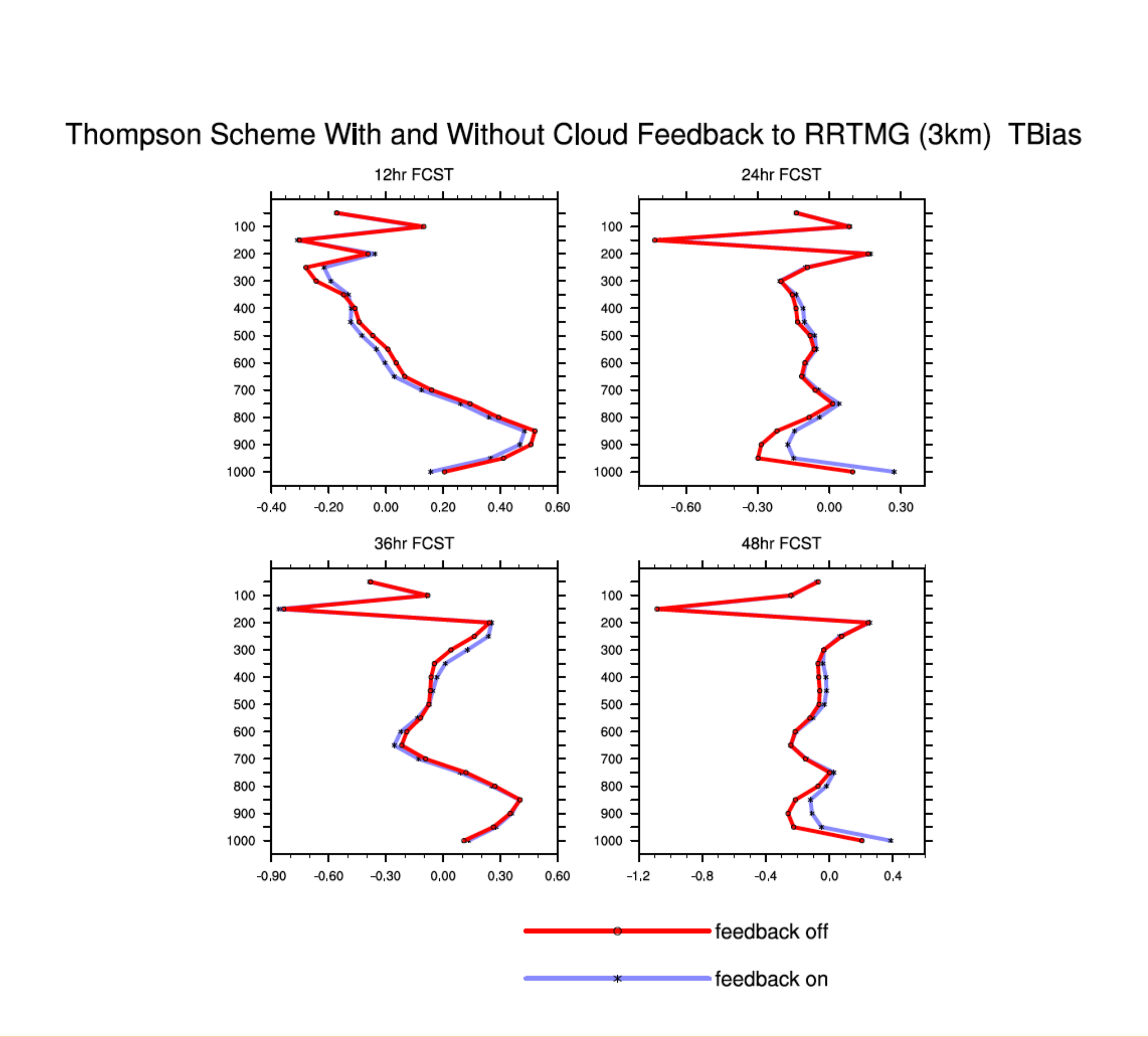


Reduced VCONV in Sfc Param.



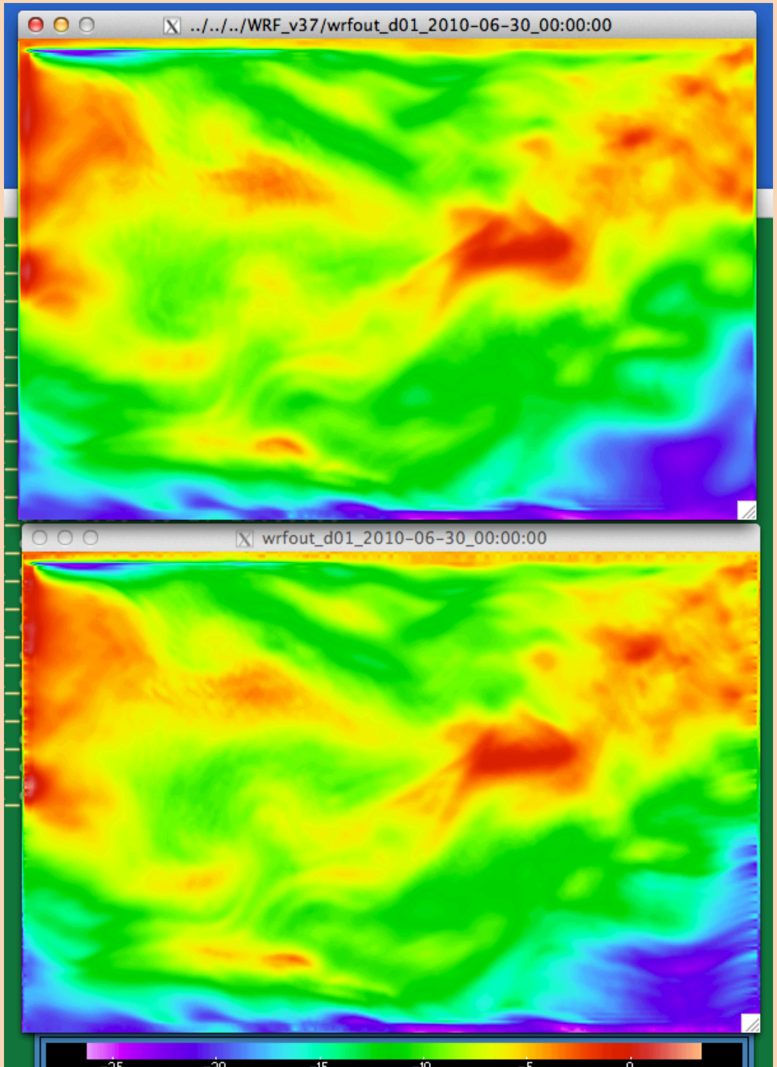


Thompson-RRTMG Interaction



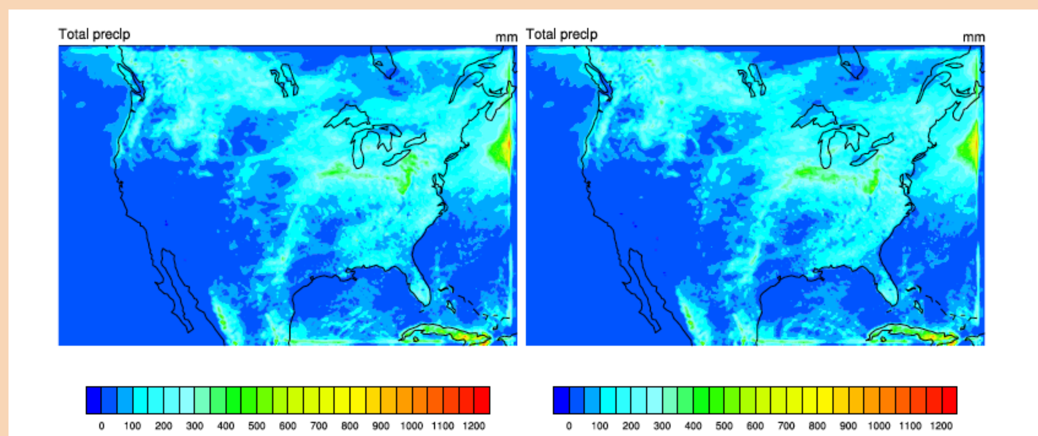
Feedback-on tends to be slightly warmer at lower levels 00Z in our June US 48-hr test cases. Longer term tests have been reported to show significant upper-level changes over time.

Lateral Boundary Condition



Continuous 30-day run shows effect of round-off drift on upper level U field – see southeast inflow boundary. Upper panel: fixed, lower panel: original.

This is normally not easy to see except in upper wind fields. Below precipitation shows little effect, but effect may increase with longer simulations.



New LBC Old LBC

Thanks

Credits:

Tests and Graphics: Ming Chen