The Weather Research and Forecasting Model: 2022 Annual Update

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NCAR/MMM

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WRF Community Model Releases

- Version 1.0: WRF was first released December 2000
- Version 2.0: May 2004
- Version 3.0: April 2008
- Version 4.0: June 2018 (add hybrid vertical coordinate)
- Version 4.1: April 2019
- Version 4.2: April 2020
- Version 4.3: May 2021
  - 4.3.1 October 2021
  - 4.3.2 December 2021
  - 4.3.3 January 2022
- Version 4.4: April 2022

This talk highlights these releases

Outline

- Recap of new features in V4.3 (2021)
- Bug-fix releases since V4.3
- New in V4.4 (2022)
- Some release verification tests for V4.4

Recap: New Options in Version 4.3

- E-epsilon PBL scheme
  - *bl_pbl_physics=16*
  - Chunxi Zhang, NCEP
- NTU (National Taiwan University) microphysics
  - *mp_physics=56*
  - Tzu-Chin Tsai and Jen-Ping Chen (NTU)
- P3 new 3-moment 1-ice microphysics
  - *mp_physics=53*
  - Hugh Morrison (NCAR) and Jason Milbrandt (Environment Canada)
- GSL enhanced scale-aware orographic drag
  - *gwd_opt=3*
  - Mike Toy (GSL/NOAA)
- Implicit-Explicit Vertical Advection (IEVA)
  - *zadvect_implicit = 1*
  - Lou Wicker (NSSL)

Recap: New in V4.3

- Solar eclipse capability for RRTMG, Goddard, Dudhia SW
  - *ra_sw_eclipse=1*
  - Alex Montornès et al. (U. Barcelona, Spain)
- BEP and BEM multi-layer urban model extended to YSU PBL
  - Eric Hendricks et al. (NCAR/RAL)
- Local Climate Zone urban category capability in urban models consistent with WUDAPT (www.wudapt.org)
  - Andrea Zonato (U. Trento, Italy)
- Urban capabilities for green roofs and solar panels
  - Andrea Zonato and Cenlin He (RAL)
- NoahMP irrigation option
  - *opt_irr*
  - Prasanth Valayamkunnath (RAL visitor)
- Initial CTSM coupling capability
  - Negin Sobhani et al. (NCAR/CGD)

Recap: New in V4.3

- Vertical geopotential advection option
  - *phi_adv_z = 2*
  - Matthias Goebel (University of Innsbruck, Austria)
- Height-level output now can include pressure
  - *p_zl* in output
  - Jared Lee (RAL)
- MAD-WRF initial clouds
  - *madwrf_opt =1,2*
  - Pedro Jimenez at al. (RAL)
- Clear-sky 3d radiative tendencies for most schemes
  - *RTHRATLWC* etc in output
  - James Huppert (Penn State U)

Bug-Fix Releases Since V4.3

- V4.3.1 October 2021
  - The P3 3-moment (mp=53) scheme had problems in its V4.3 release that were fixed
  - The new photovoltaic panel urban option in V4.3 was fixed for its energy balance
  - Fix a Thompson aerosol (mp=28) surface flux problem (since V4.0) that gave inconsistent values based on nesting grid sizes to make this now independent of dx
  - For the greenhouse gas table option, new tables are provided for the annual variation in the CMIP6 SSP scenarios
  - Other minor ones detailed in
    - https://github.com/wrf-model/WRF/releases

Bug-Fix Releases Since V4.3

- V4.3.2 December 2021
  - Added time-varying greenhouse gas option to RRTMG shortwave options (these have relatively minor shortwave effects compared to longwave)
  - A test was introduced to stop certain combinations of PBL and LES schemes on nested grids (e.g. MYNN PBL). A workaround is posted for use of this combination.
    - https://github.com/wrf-model/WRF/issues/1514
  - Other minor ones detailed in
    - https://github.com/wrf-model/WRF/releases

Bug-Fix Releases Since V4.3

- V4.3.3 January 2022
  - Revision to PBL/LES test added in V4.3.2 to allow time series for certain options
  - Other minor ones detailed in
    - https://github.com/wrf-model/WRF/releases

Updates and Bug-fixes in V4.4

- Accumulated physics tendency output - *acc_phy_tend=1*
- Thompson aerosol scheme (mp=28) includes black carbon that is non-interacting with microphysics but allows a more complete radiation-aerosol interaction with this
- Thompson icloud=3 cloud fraction scheme has been updated
- All P3 microphysics options have been updated
- RRTMG radiation has a new cloud overlap option with a decorrelation length scale
- NoahMP LSM has many new options and is also now in a separate repository accessed as a submodule (separate talk)
- Minor updates to RUC LSM, MYNN sfc layer, Shin-Hong PBL
- The NMM dynamical core is no longer in the WRF code as of this release. This enabled clean-up related to dependencies.
- CMAQ 2-way coupling (see talk later)

More found at https://github.com/wrf-model/WRF/releases

Changed in V4.4: Greenhouse Gas Variation

- In V4.2 we made the CO2 year-dependent via an empirical function in the RRTMG longwave radiation (see my 2020 workshop update)
- We have also had since 2013 a compile-time option accessed via *-DCLWRFGHG* to use year-dependent tables of all major GHGs that are taken from IPCC scenarios such as RCP8.5
  - These span years 1765-2500
  - Available for CAM, RRTMG, RRTMG-Fast, and RRTM radiation
- In Version 4.4 we have brought the GHG table option into the standard code and made it the *default* for those options
  - New namelist option *ghg_input=1*
  - Old method still accessible with *ghg_input=0*
- More IPCC scenarios are available via the CAMtr files, or these can be customized for other cases (default now SSP2-4.5)
  - A1B, A2, RCP4.5, RCP6, RCP8.5, SSP1-1.9, SSP1-2.6, *SSP2-4.5*, SSP3-7.0, SSP5-8.5

New in V4.4: Shallow Water Roughness Length

- From Jimenez and Dudhia, JAMC 2018 *(shalwater_z0 = 1)*
- Shallow water with depths < 100 m has shoaling effects whereby the waves appear rougher for the same windspeed as compared to deeper water
- Unless accounted for, this leads to a systematic overestimation (up to 10%) of low-level windspeeds as detected in comparisons with a year of North Sea tower data (30 m water depth) in the above paper
- The option modifies the roughness length empirically fitted to the data as a function of windspeed (u*)
- Depth dependence (10-100 m) follows Taylor and Yelland (2001, JPO) and can use real bathymetry (through WPS) or fixed depth *shalwater_depth*

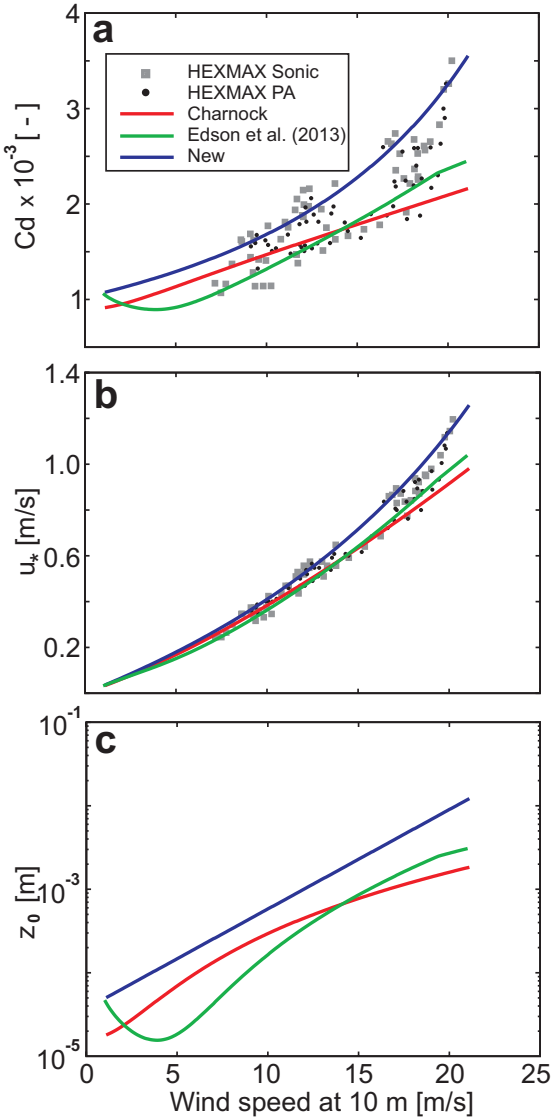
New Shallow Water Roughness Length

Jimenez and Dudhia, 2018

Drag Coefficient

Friction Velocity

Roughness Length



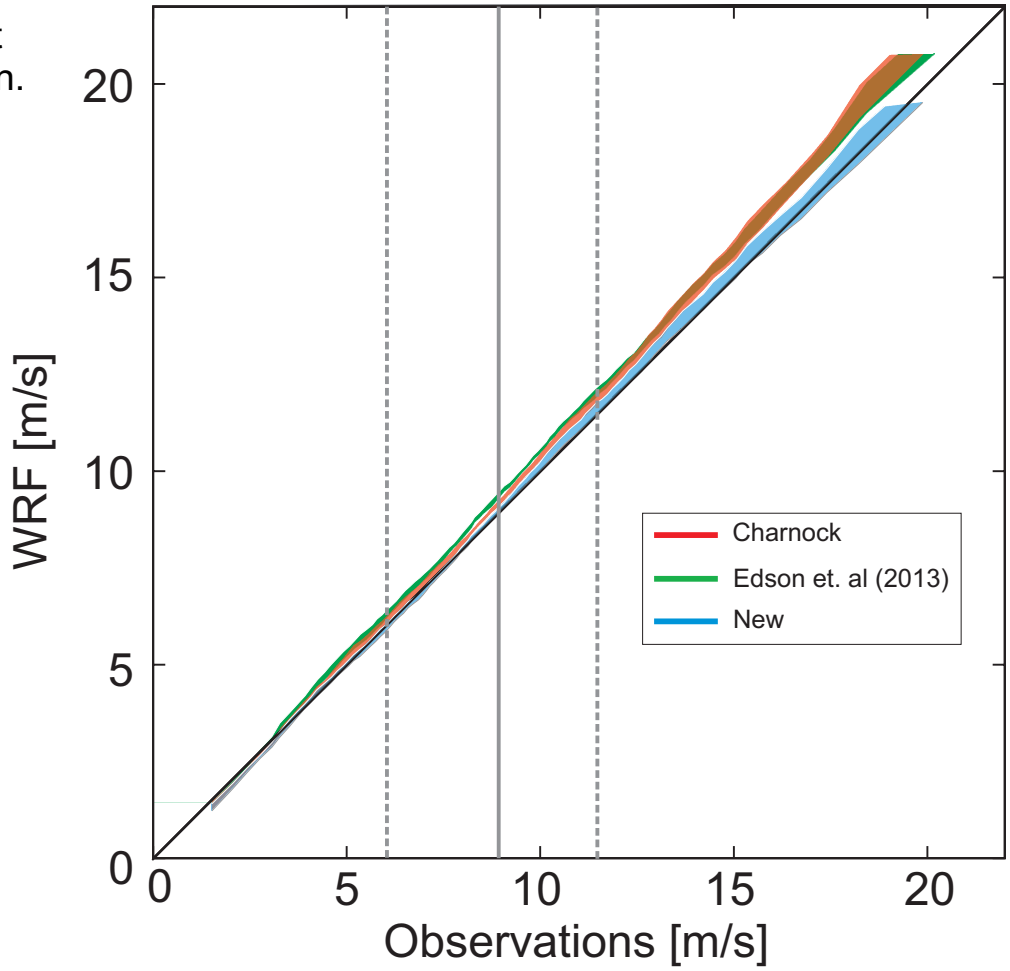
Comparison with field program data in shallow water (18 m depth, Dutch Noordwijk platform, HEXOS)

Note little sensitivity at low winds despite large z_0 difference

Percentile-percentile plot of wind-speed distribution. Dashed lines mark 25th and 75th percentile.

Old scheme has too many points with high winds. Above 1:1 line. Top percentiles are 5% faster.

New scheme matches observed distribution.



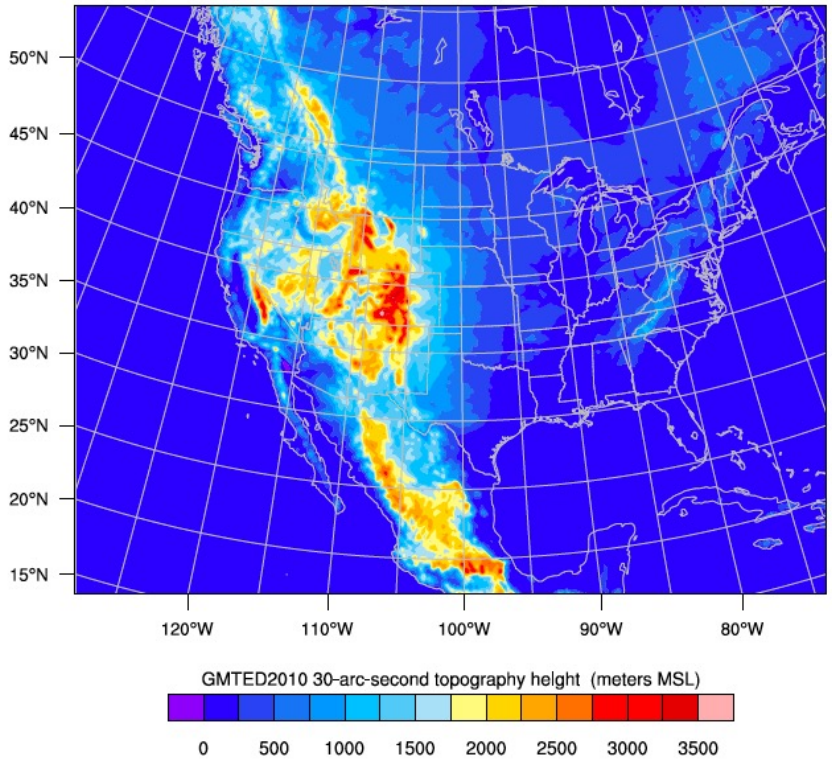
Spread is due to different PBL schemes

New in V4.4: Stochastic Ensemble Perturbations

- *Talks by Pedro Jimenez and Ju-Hye Kim (RAL)*
- WRF-Solar application was the focus
- Perturbations applied to selected physics suite but can be adapted to other options as the added code is outside the physics schemes
  - FARMS rad, MYNN pbl, Deng shcu, Thompson mp and cloud fraction, Noah LSM
  - Variables selected for perturbation were chosen for solar energy forecast sensitivity and differ for each scheme
- Pertubation is added to scheme inputs to provide perturbed tendencies and then subtracted again after scheme
- Perturbation code draws on existing stochastic functions in WRF and is customizable to each variable by magnitude, standard deviation, space and time scales

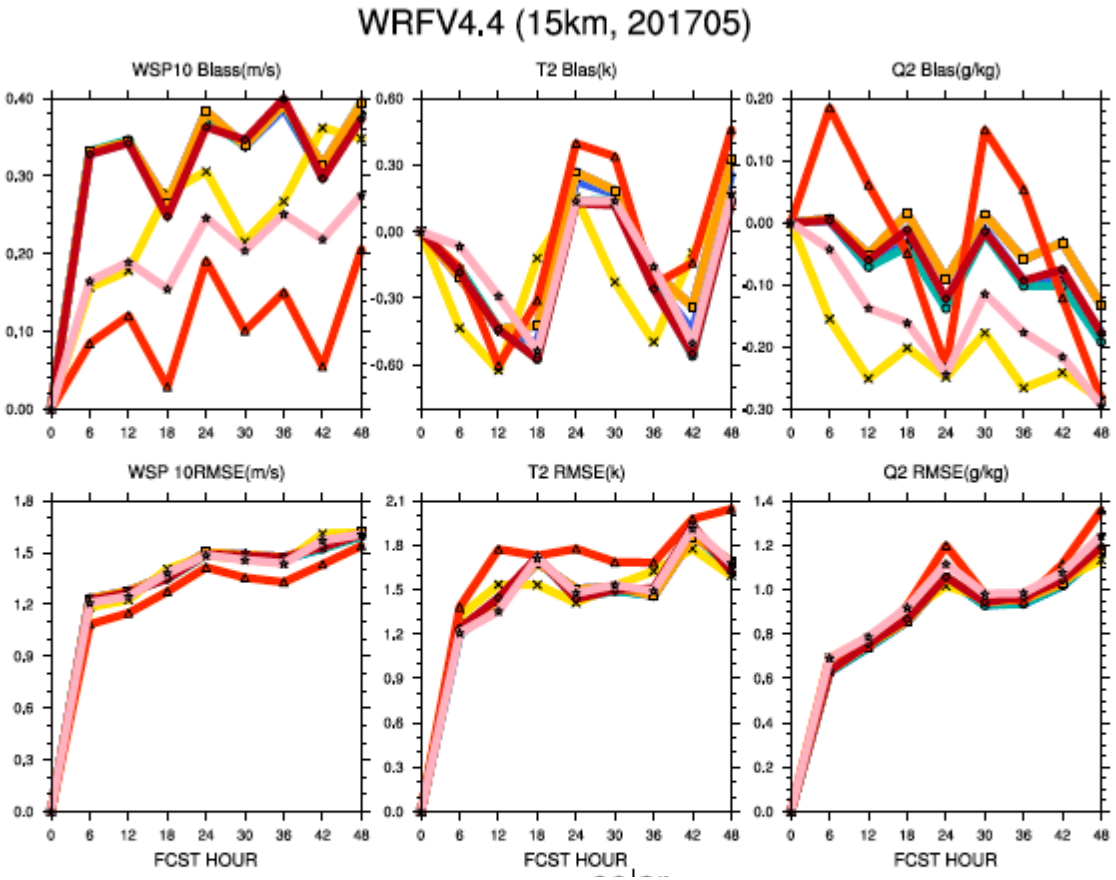
WRFv4.4 Tests and Verification

WRFV4.4 Test (DX = 15km 415 x 325 grids)



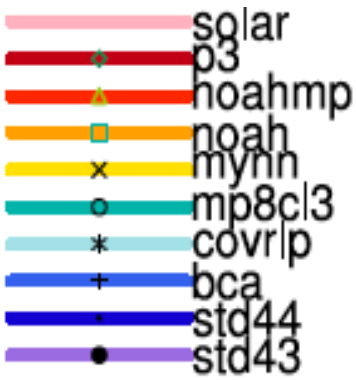
New and updated schemes/options that have been tested and verified

	radiation	cumulus	pbl	sfclay	surface	Microphysics
stdv4.3 stdv4.4 (base)	RRTMG	Tiedtke	YSU	Monin-Obukhov	Noah	WSM5
mp8cl3	Same as base except that the updated Thompson microphysics and cloud fraction schemes are used					
bca	Same as base except that aerosol-aware Thompson scheme with new black carbon data are used					
P3	Same as base except that updated P3 1-ice category, 1-moment cloud water scheme is used					
covrlp	Same as base except that rrtmg cloud overlap scheme is applied					
mynn	Same as base except that updated mynn sfclay scheme is used. PBL is changed to MYNN PBL, too.					
solar	WRF-solar EPS model is tested. Basic physics options are changed. MYNN PBL, Thompson microphysics, Deng shallow cu					
GHG	Run-time option of greenhouse gas is applied. All others the same as base.					
NoahMP	Same as base, except that NoahMP is used.					



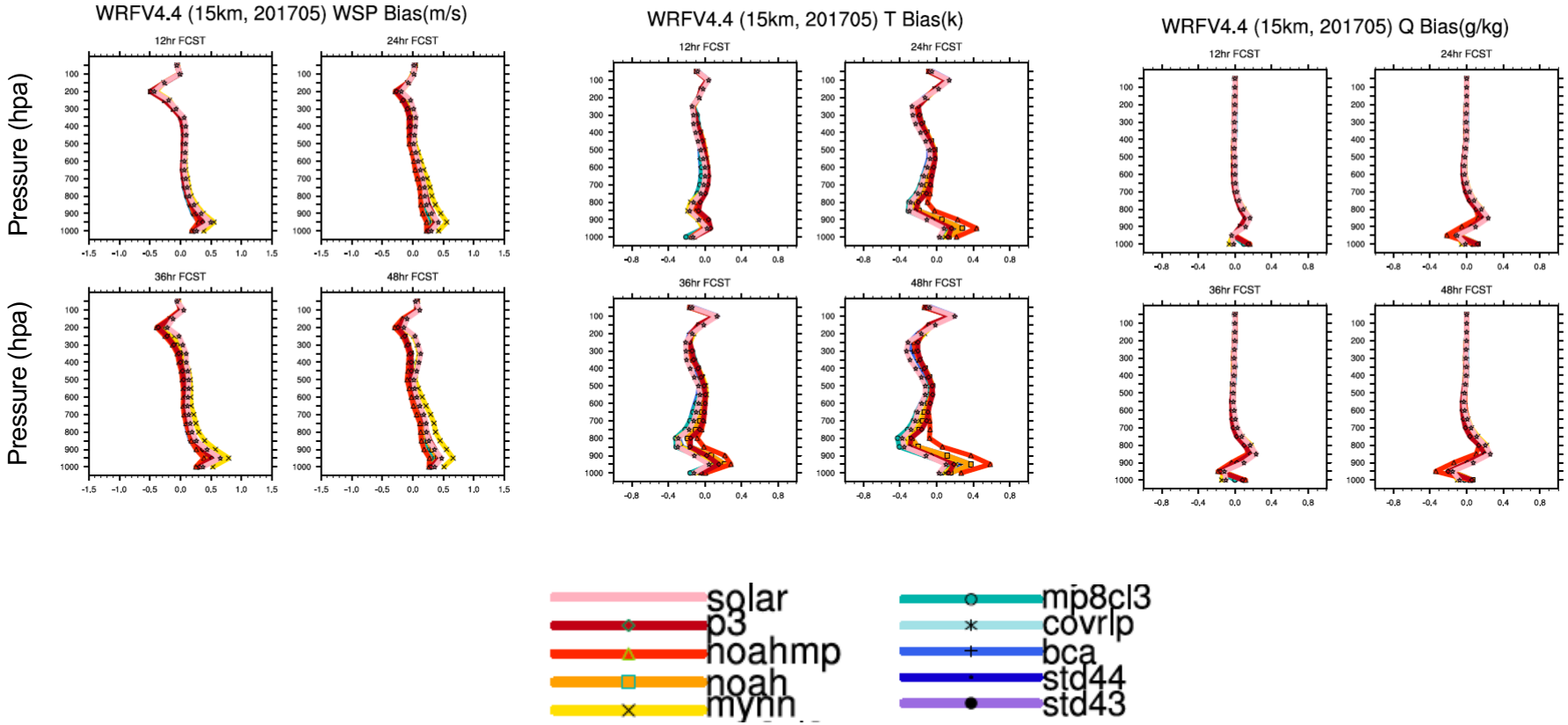
SPRING

00Z initializations

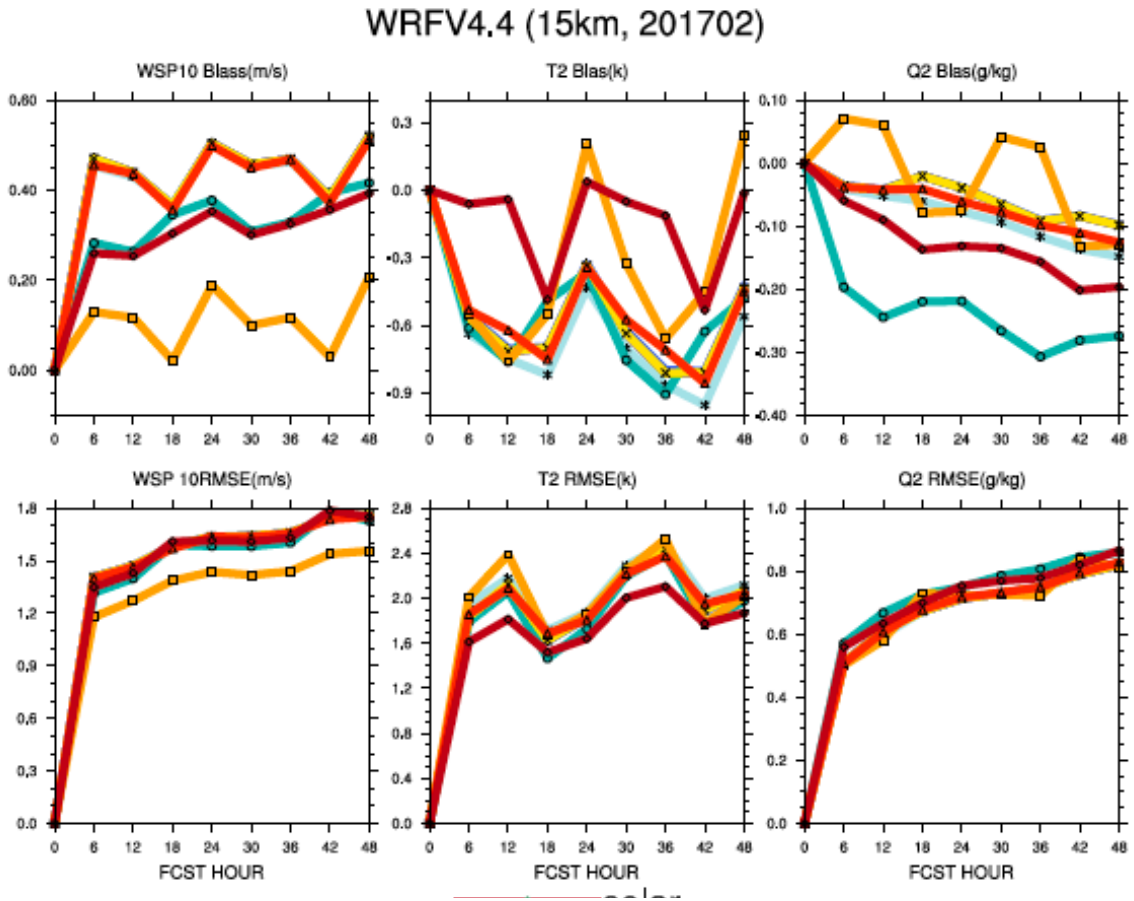


Note NoahMP has less wind bias

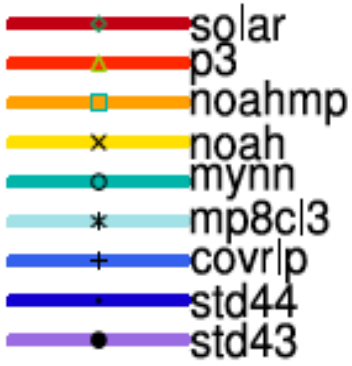
NoahMP moister at night



NoahMP slightly warmer PBL

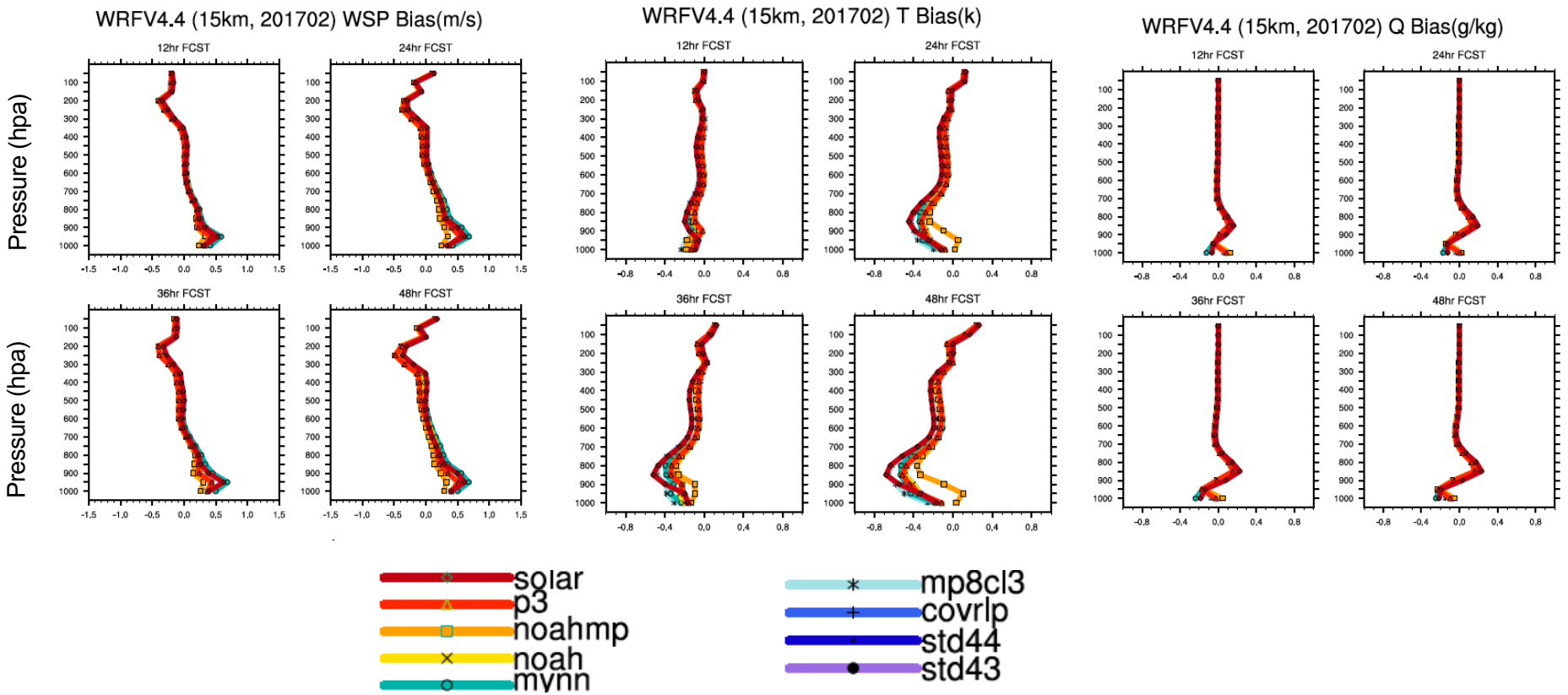


WINTER



NoahMP less wind bias

NoahMP moister, less mean bias

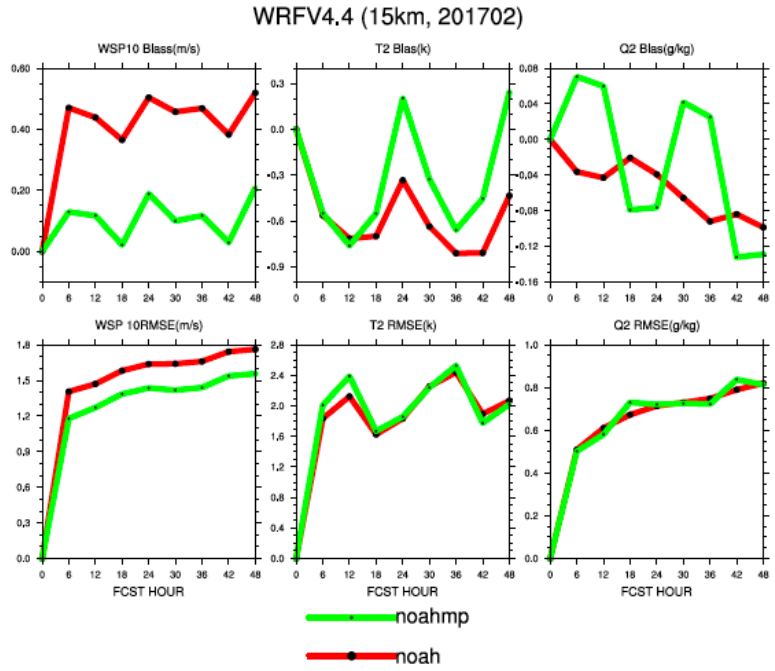


NoahMP warmer daytime PBL

Noah and NoahMP

NoahMP
warmer winter
2m T

WINTER



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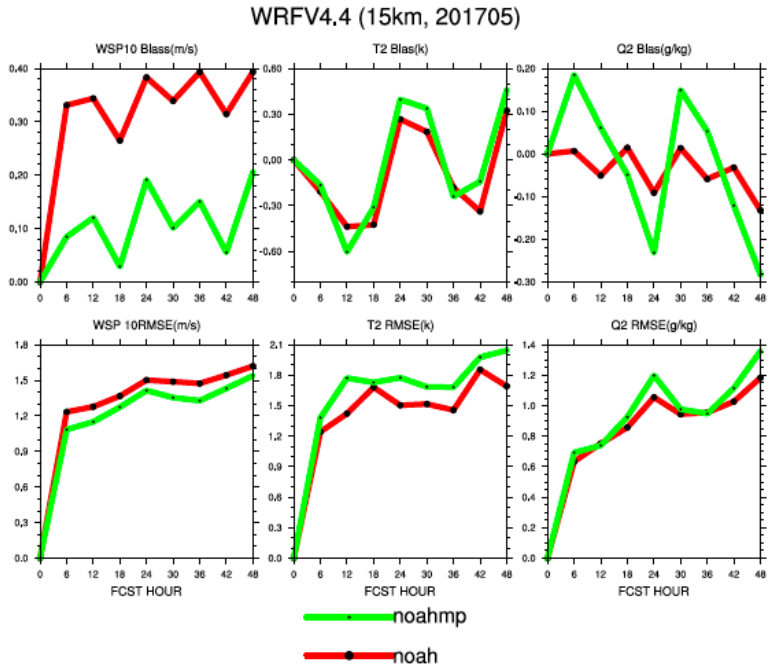
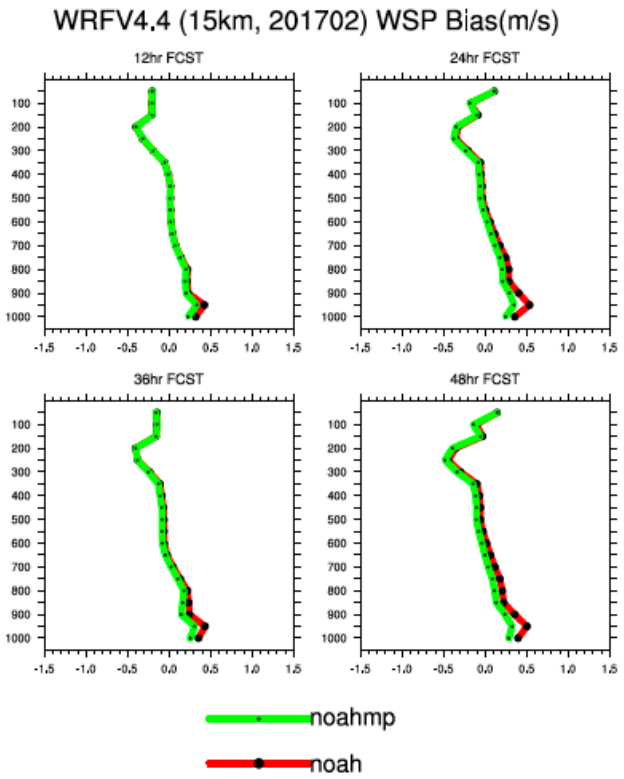
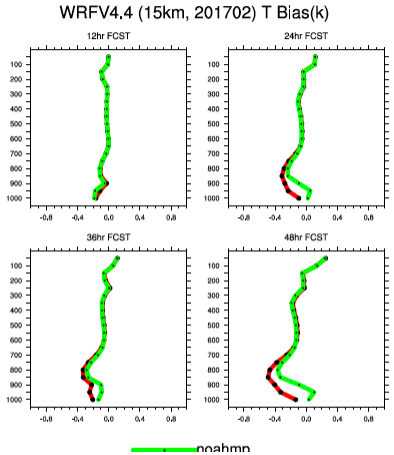


Wind speed bias difference is likely due to some higher roughness lengths in MPTABLE.TBL than in VEGPARM.TBL

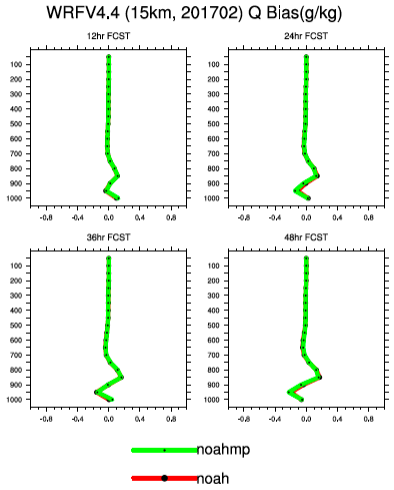
WINTER



NoahMP lower PBL wind



NoahMP warmer daytime PBL



Rainfall Comparisons

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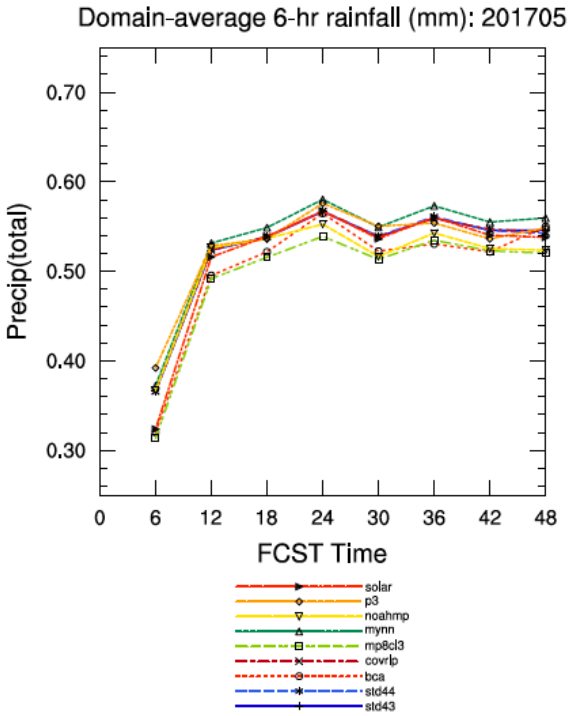

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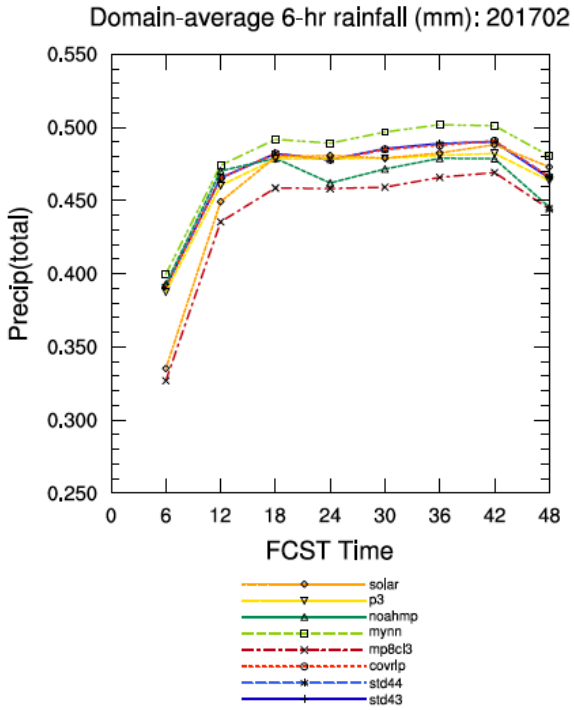
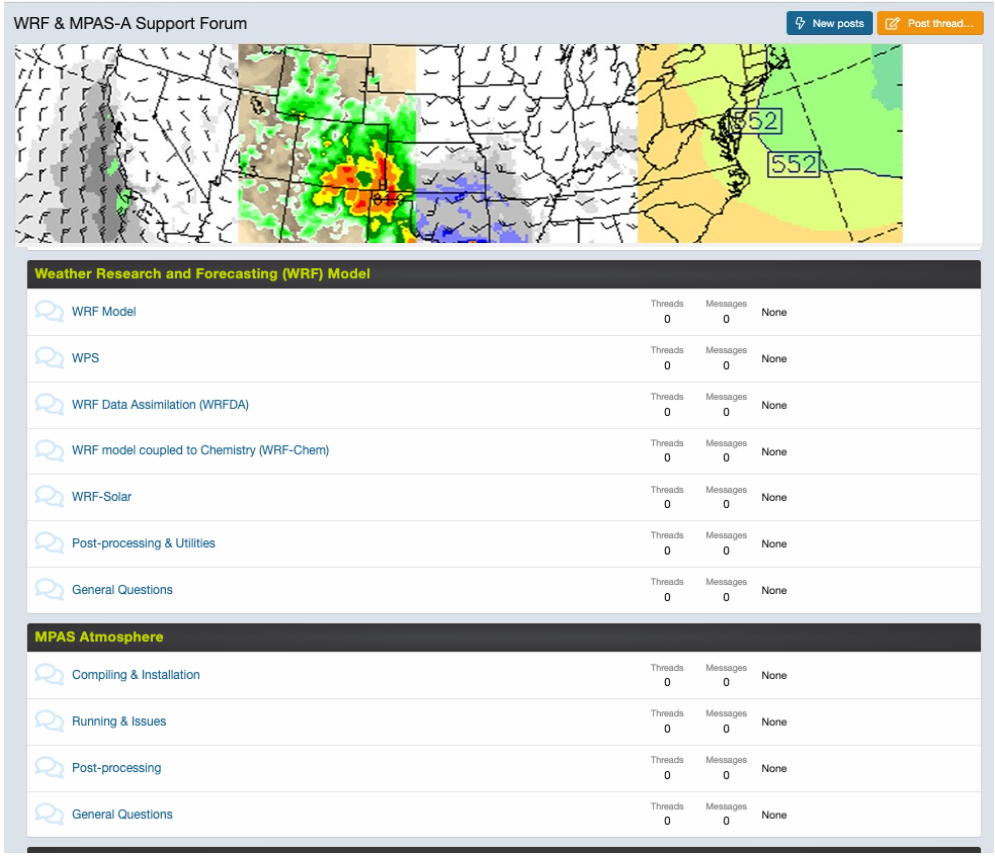


Main general feature is that tests with Thompson microphysics have longer spin-up time

New WRF/MPAS-A Support Forum

- Migrate from phpBB3 to Xenforo
- Fewer forums (categories) – cleaner and easier navigation
- Preserves all previous threads, attachments, and links
- Expected: June 23, 2022
  - Forum downtime June 21-22 for transition



Summary

Main new features in V4.4

- Shallow water roughness length
- Update to greenhouse gas default to use climatology
- New ensemble stochastic capability for WRF-Solar