The Weather Research and Forecasting Model: 2018 Annual Update

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2018 Joint WRF/MPAS Users' Workshop

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 3.8: April 2016
- Version 3.9: April 2017
  - 3.9.1.1: August 2017
- Version 4.0: June 2018

Outline

- Recap of new features in V3.9
- New features in V4.0
- New user support forum

Recap: new in V3.9 (April 2017)

- Highlights
  - Introduction of physics suites
  - Hybrid vertical coordinate option
  - Predicted Particle Property (P3) microphysics
  - Stochastic physics options
  - NoahMP urban and crop capabilities
  - New 30” global soil dataset

New in V4.0

- Hybrid coordinate integrated into code
  - Previously was compile-time pre-processor generated replacements of 2d [$\mu(i,j)$] with more general 3d [$\mu(i,j)C_1(k)+C_2(k)$] form
  - Now code is explicitly replaced
  - Old coordinate is an option
- θ_m replaces θ as prognostic variable
  - Previously use_theta_m switch activated conversions before and after the dynamics code
  - Now used in wrfinput and boundary files

New in V4.0

- New method of automatically setting vertical levels in *real.exe* via stretching factors
- Idealized cases mostly combined into a single *module_initialize_ideal.F*
  - Also work with hybrid coordinate and θ_m

Additions to existing physics

- Predicted Particle Property (P3) microphysics
  - Introduce a 2nd free category option (*mp_physics=52*)
- Thompson-Eidhammer Aerosol Aware microphysics
  - Dust emission added (*dust_emis=1*)
  - Surface aerosol emission modified
- Multi-Scale Kain-Fritsch cumulus scheme (from NCSU/EPA)
  - Prescribed climatological aerosol capability added to MSKF cumulus along with internal microphysics (*aercu_opt=1,2*)
  - Specialized aerosol version of Morrison microphysics (*mp_physics=40, aercu_opt=2*)
- NSSL microphysics updated
- Morrison microphysics
  - New switch: *morr_rimed_ice = 1* (hail now default)
- WRF-Fire significantly updated (RAL)

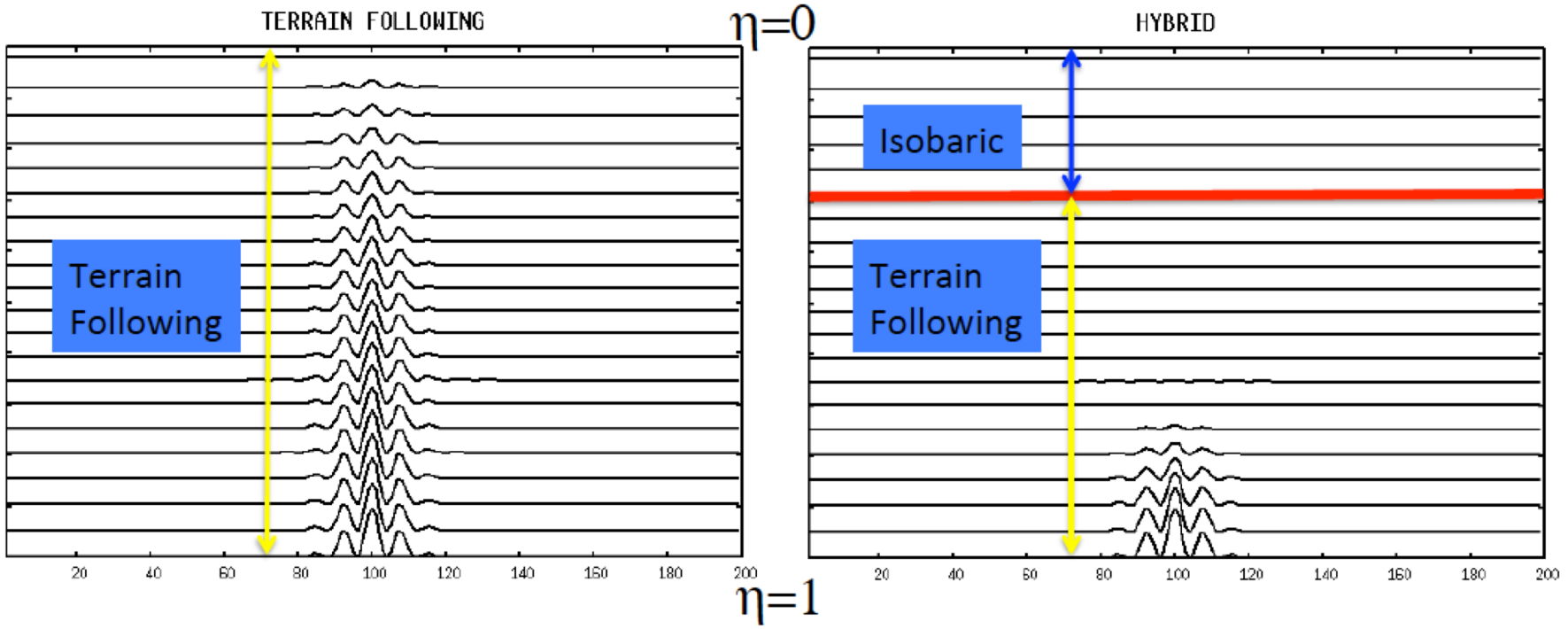
Additions to Physics

KIAPS (Korea) contributions

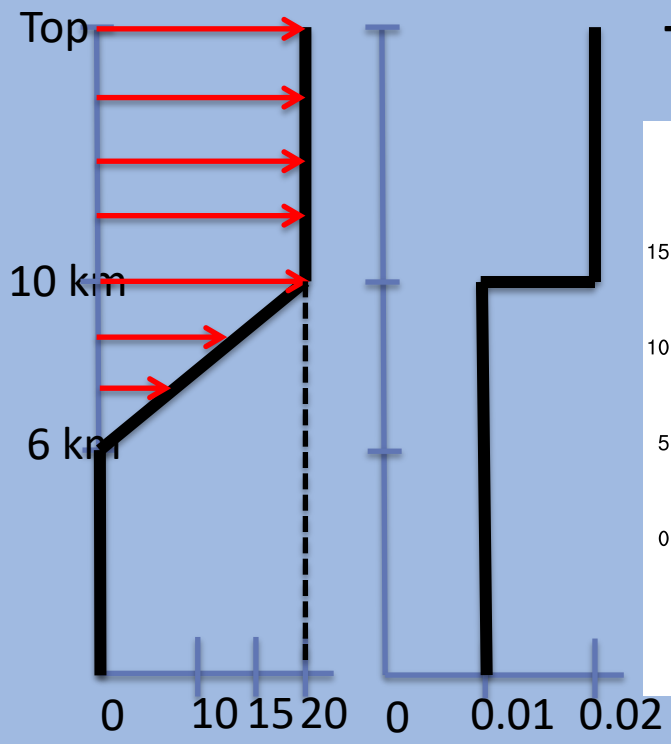
- RRTMG-K: a version of RRTMG that combines MCICA calculations in longwave and shortwave and reduces computational cost (*ra_lw_physics=14, ra_sw_physics=14*)
- KSAS: a scale-aware version of NSAS (replacement for *cu_physics=14*)
  - Note this needs *shcu_physics=4* to activate NSAS shallow convection because it is a deep-only scheme
- WDM6 (*mp_physics=16*) now distinguishes autoconversion rates over land and water

Hybrid Vertical Coordinate

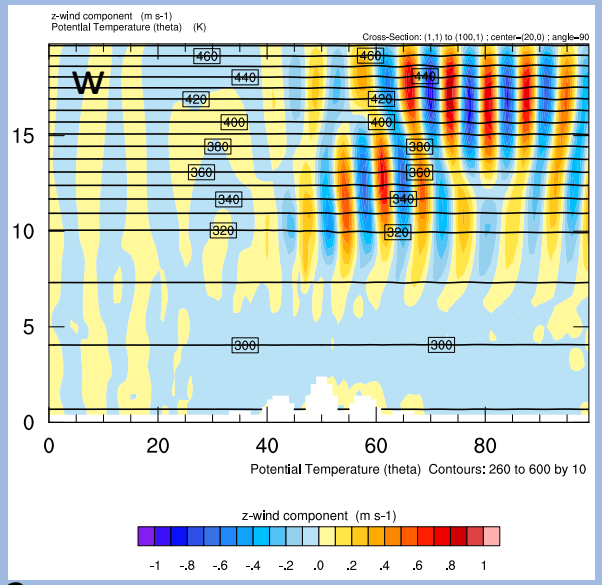
- New hybrid vertical coordinate option in V3.9
- Isobaric at top means less noise in upper-air output over mountains



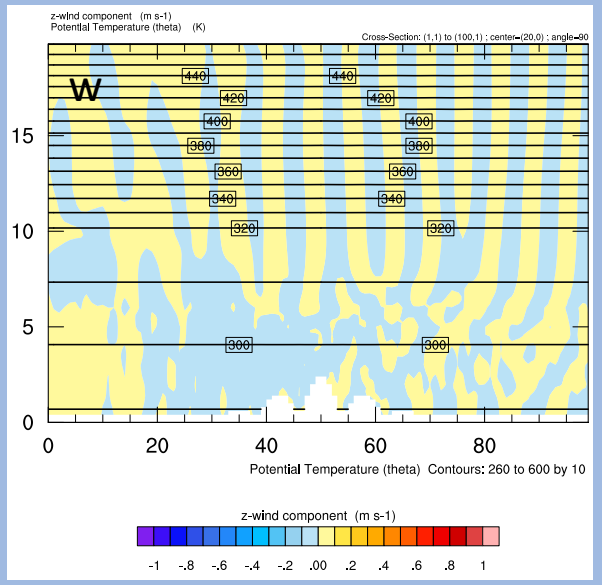
Hybrid Vertical Coordinate



Terrain Following



Hybrid Coordinate



dx=1 km, dz=500 m
ht=2000 m, top= 20 km
η_c=0.3, 5 hrs

- In this 2d test, all the flow is above the terrain.
- Terrain following coordinate shows response to coordinate in vertical motion (max < 1 m/s).
- Hybrid coordinate correctly shows no significant response.

θ_m replaces θ

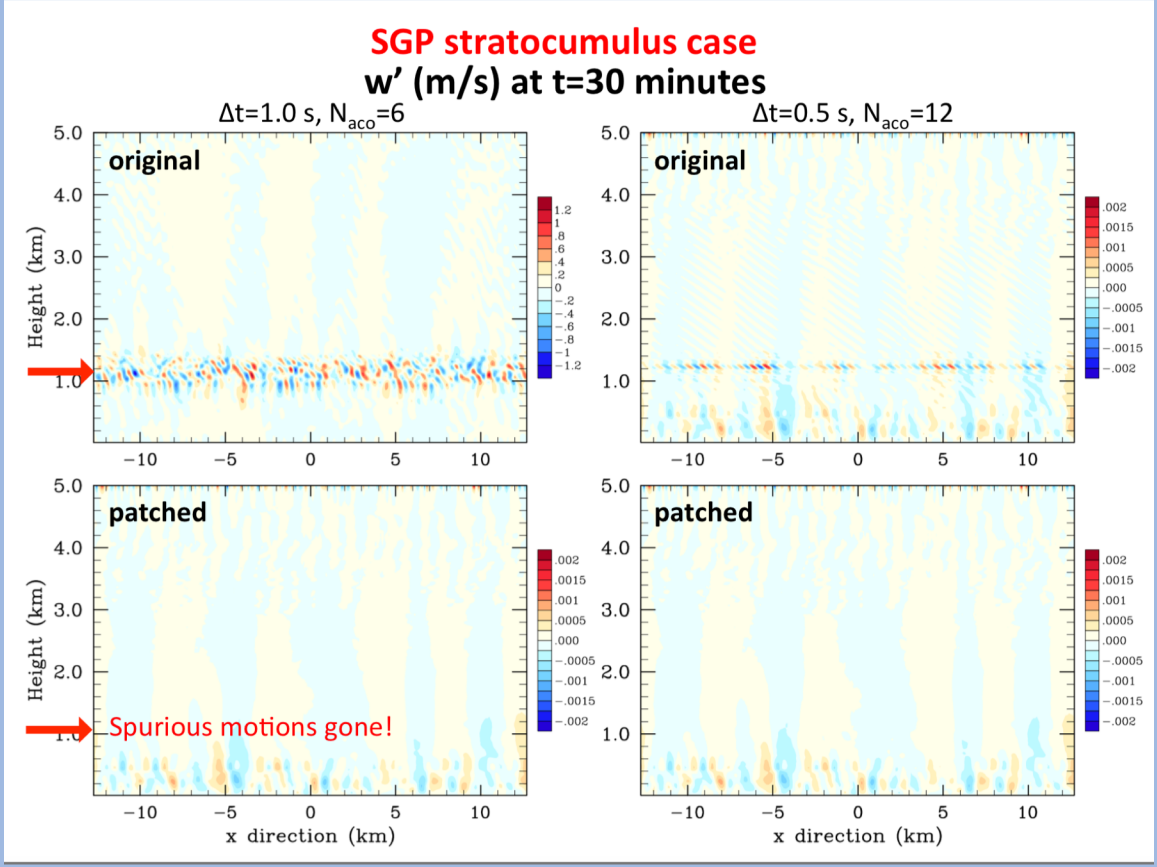
- $\theta_m = \theta\ (\ 1 + R_v/R_d\ q_v\ ) \approx \theta\ (\ 1 + 1.61\ q_v\ )$
- Note this is not θ_v
- θ_m is more closely related to pressure through

$$p = p_0(R_d\rho_d\theta_m/p_0)^\gamma$$

where $\gamma = c_p/c_v \approx 1.4$

- This was the variable in a previous height version of WRFV1 and in the current height-based MPAS
- Found to have advantages in sharp q gradients
- Note that for backward compatibility we still carry the old $\theta - 300$ as *T* in the model output and *THM* is θ_m-300
- Initial and Boundary files in V4.0 contain θ_m
- *use_theta_m = 0* can be used to revert to dry theta

θ_m replaces θ

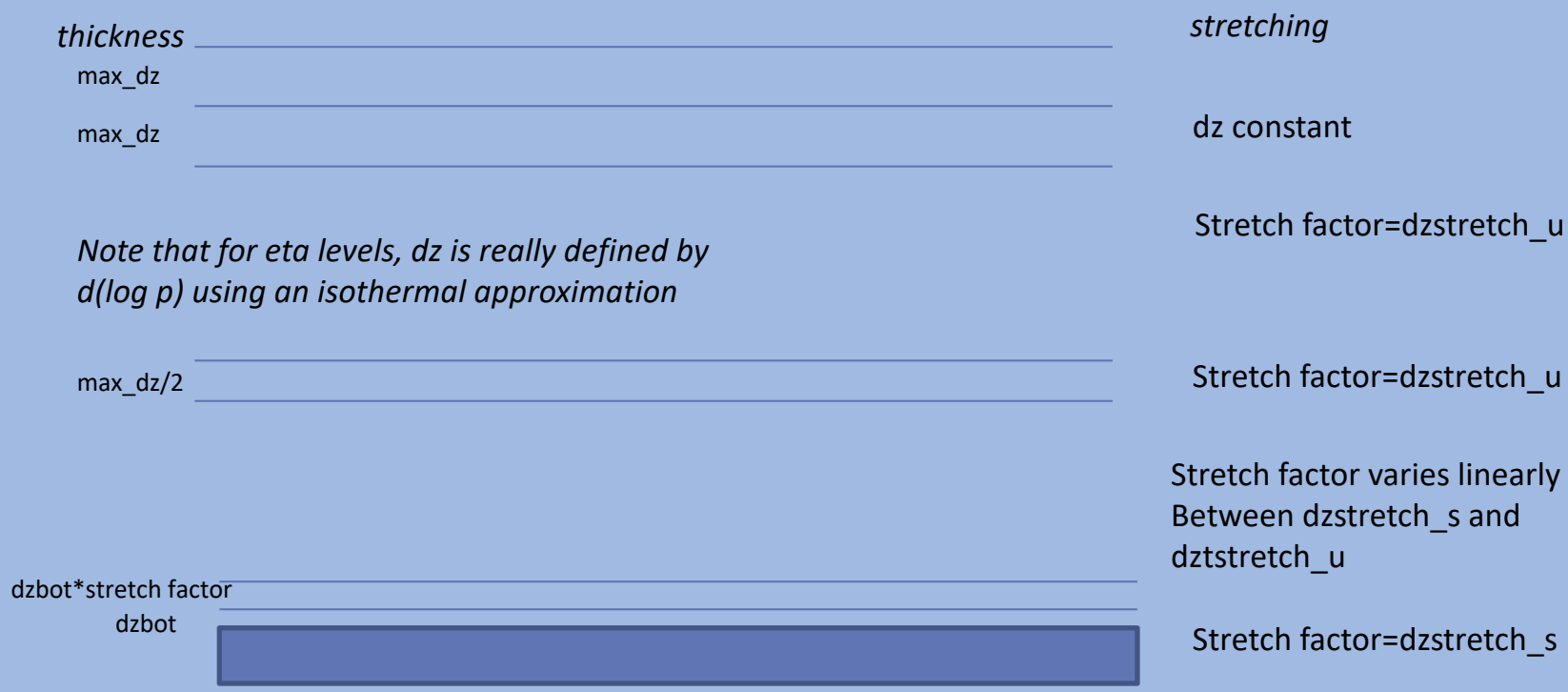


Test case – Xiao et al. (PNNL) 2015 workshop
LES with sharp moisture gradient

Model Levels

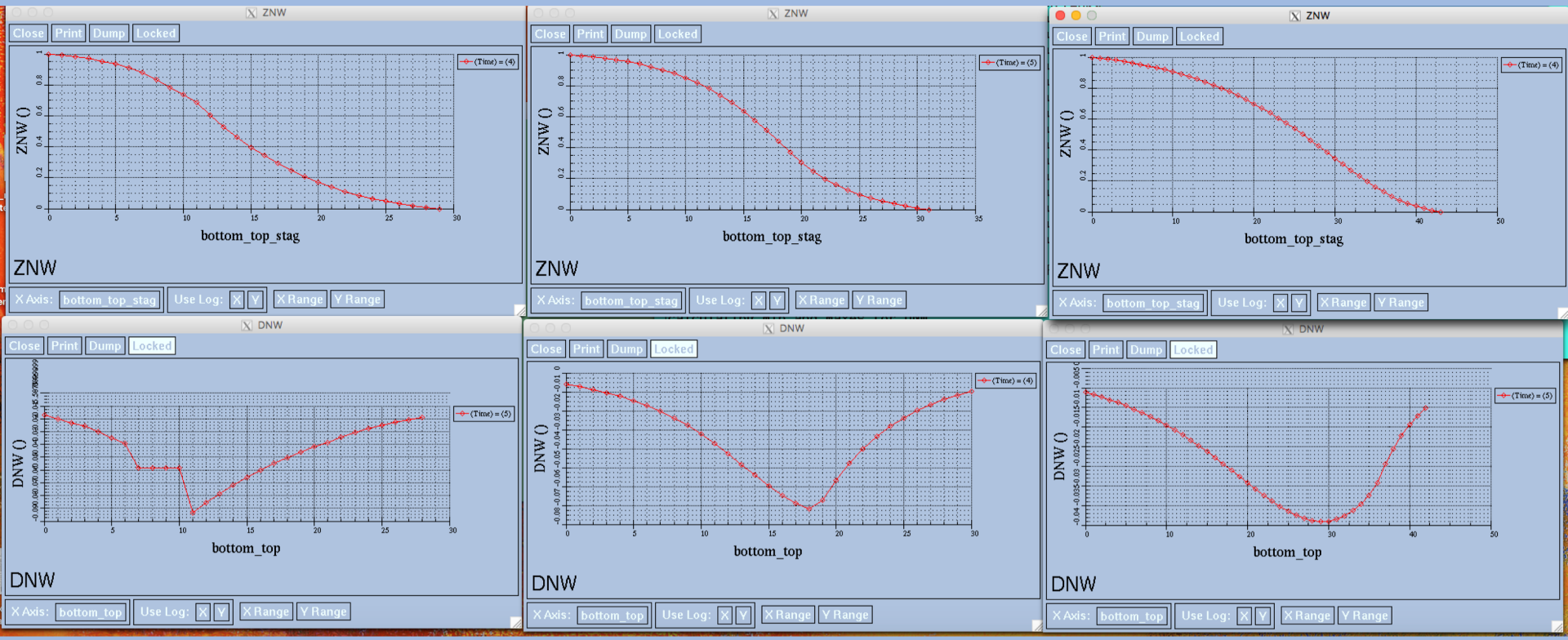
- New method of calculating levels with stretching function for real-data cases (smoother variation in thickness, more customizable)
- *auto_levels_opt=1* old method
  - Specified lower levels and constant height at top (*max_dz*)
- *auto_levels_opt=2* (default) new method
  - Lower (*dzstretch_s)* and upper (*dzstretch_u*) stretching factors (defaults 1.3 and 1.1)
  - Lowest level thickness (*dzbot*, default = 50 m)
  - Maximum thickness (*max_dz*, default = 1000 m)

Parameters for auto_levels = 2



Example of New and Old Levels

Eta values (upper) and eta thickness (lower)



Old 28 levels

New 32 levels
dzstretch=1.2

New 44 levels
dzstretch=1.1

Noah and NoahMP Updates

NoahMP

- New Gecros crop model (*opt_crop=2*)
- Improved groundwater (*opt_run=5*)
- New soil composition dataset (*opt_soil=3* and *opt_pedo=1*)
  - Continuous sand/clay percentages instead of categories – 30” global dataset

Noah and RUC

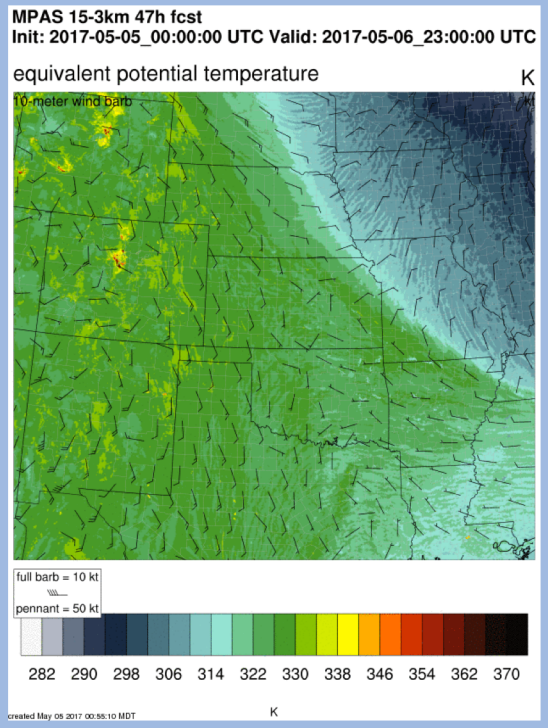
- New monthly albedo dataset improves global resolution and based on more up to date MODIS

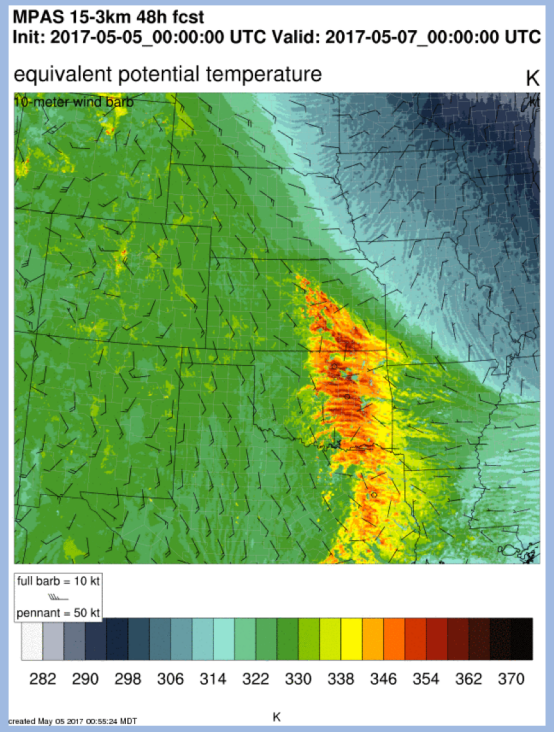
Urban in Noah and NoahMP

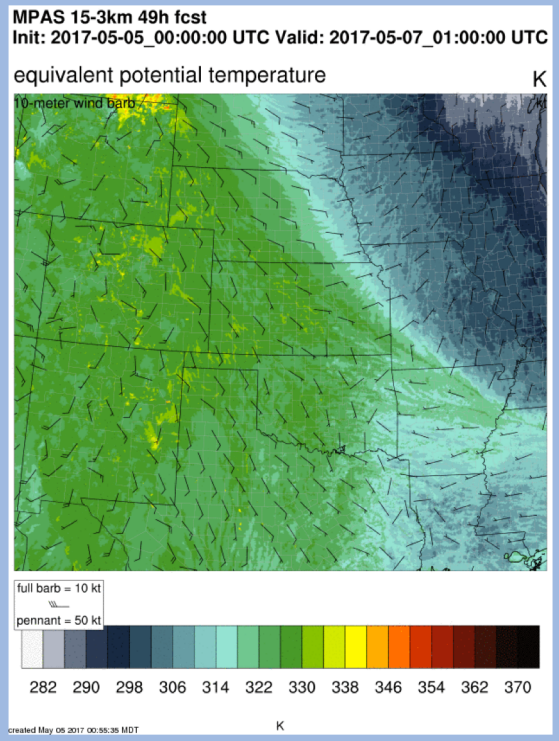
- Hi-res NLCD-based urban fraction for US available for geogrid

Improvements and Bug Fixes

- 2-meter Q diagnostic (Q2)

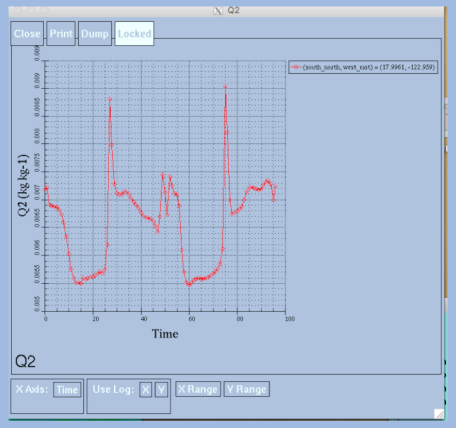






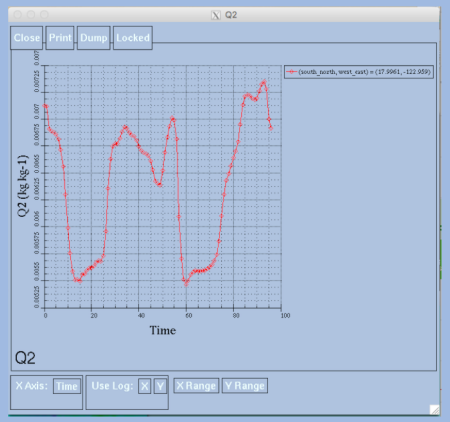
Problem: flash of high Q2 at transition times
This occurs in regions of vegetation and low wind-speed

Q2 Diagnostic Fix



Time series at a point. Spikes at sunset (left) are removed by fix (right)

Fix is to limit Q2 below 5% above lowest level QVAPOR (does not affect other results)



Lowest level QVAPOR (left) shows no spikes

Rationale: Q2 is estimated from surface exchange coefficient, effective QSFC, and latent heat flux. This is OK *unless* the latent heat flux also includes a significant fraction not from the surface flux (e.g., evapotranspiration) which leads to overestimation of Q2 especially if exchange coefficient is small as occurs in weak winds at sunset.

Bug Fixes

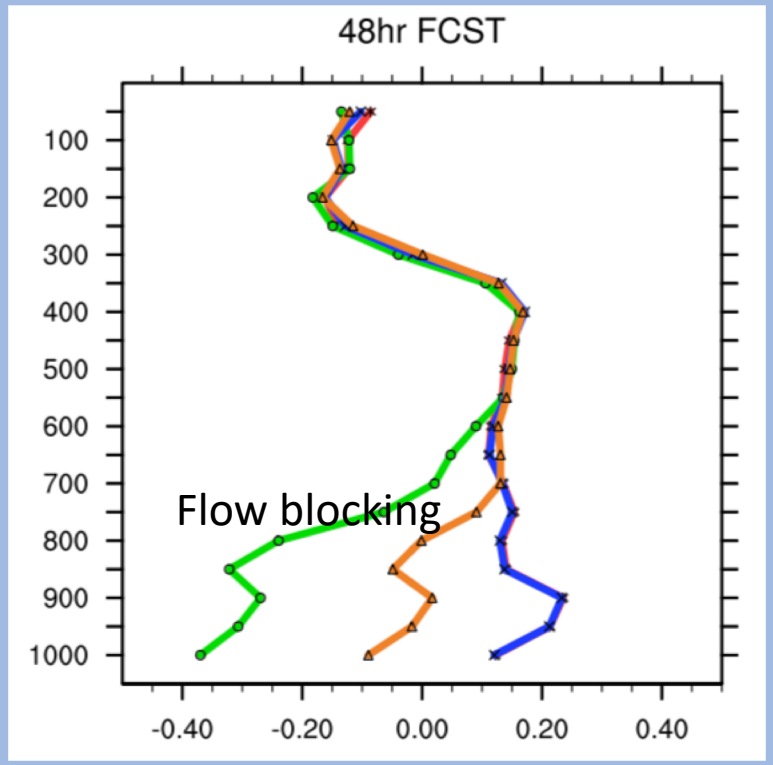
- Since V3.9 nests have not had ozone effects in shortwave scheme – fixed in V4.0
- Since V3.9 suites will use ozone profile instead of preferred o3input=2 (monthly global climatology) – fixed in V4.0
- Full list of bug fixes and updates posted at

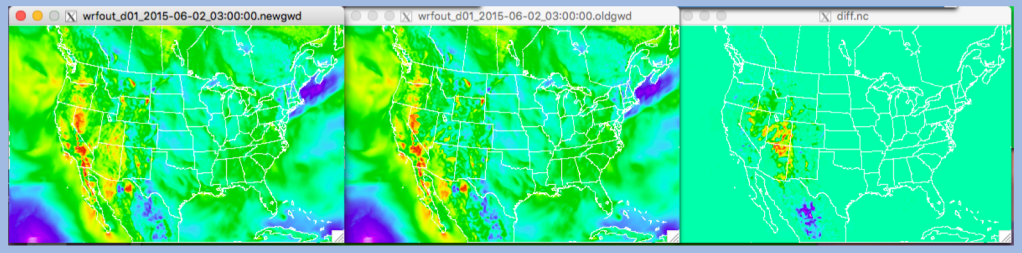
http://www2.mmm.ucar.edu/wrf/users/wrfv4.0/updates-4.0.html

Gravity Wave Drag

- Previously use was limited to grids that are approximately W-E and S-N oriented because orographic data from geogrid was provided relative to lat/long
- In V4.0 we can apply it with any grid orientation because we locally rotate the winds and tendencies before and after GWD is applied
- In V4.0 a fix was made to improve flow-blocking at low levels (GSD and KIAPS) – this reduces the effect in our tests

U Bias 2016 January 15 km tests





GWD off V3.9 (red), V4.0 (blue)
GWD on V3.9 (green)m V4.0 (orange)

Other New Features

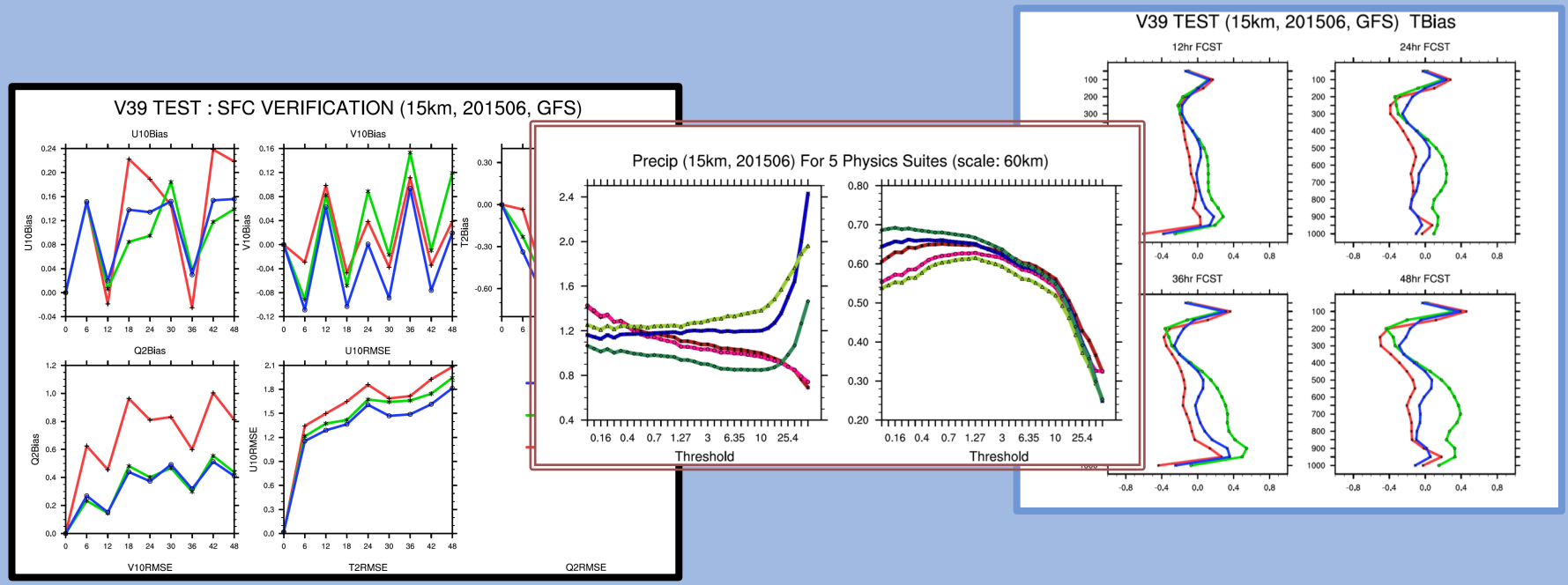
- *netcdf4* compressed output can be used if available
- Auxhist stream h1 allows output of total fields instead of separate base state and perturbation - ongoing, further work needed
  - 3d pressure, geopotential height, pressure, temperature, wind speed and true direction, 2d mean sea-level pressure
- Namelists cleaned up (some unneeded items removed)

Other New Features

- *diff_6th_slopeopt=1* reduces or turns off 6th order filter near steep slopes
  - Also can now select which 4d arrays to apply this filter
- Spectral nudging now includes water vapor as an option
- MM5 surface layer (*sf_sfclay_physics =1, 91*)
  - Add Zilitinkevitch option for thermal roughness length (*iz0tlnd=2*) – Czil=0.1
- MYJ surface layer (*sf_sfclay_physics =2*)
  - now works with LES
    - Momentum u* (*ustm*) was needed separately from *ust*
- Clear-sky surface direct and diffuse component added (previously just all-sky)

Release Testing

- 15 km – June 2016 and January 2015 – 28 cases each, test new suites, new and changed options and “standard configuration” new version against previous version (YSU, RRTMG, WSM5, Noah, KF)
- No hi-res or precipitation verification yet



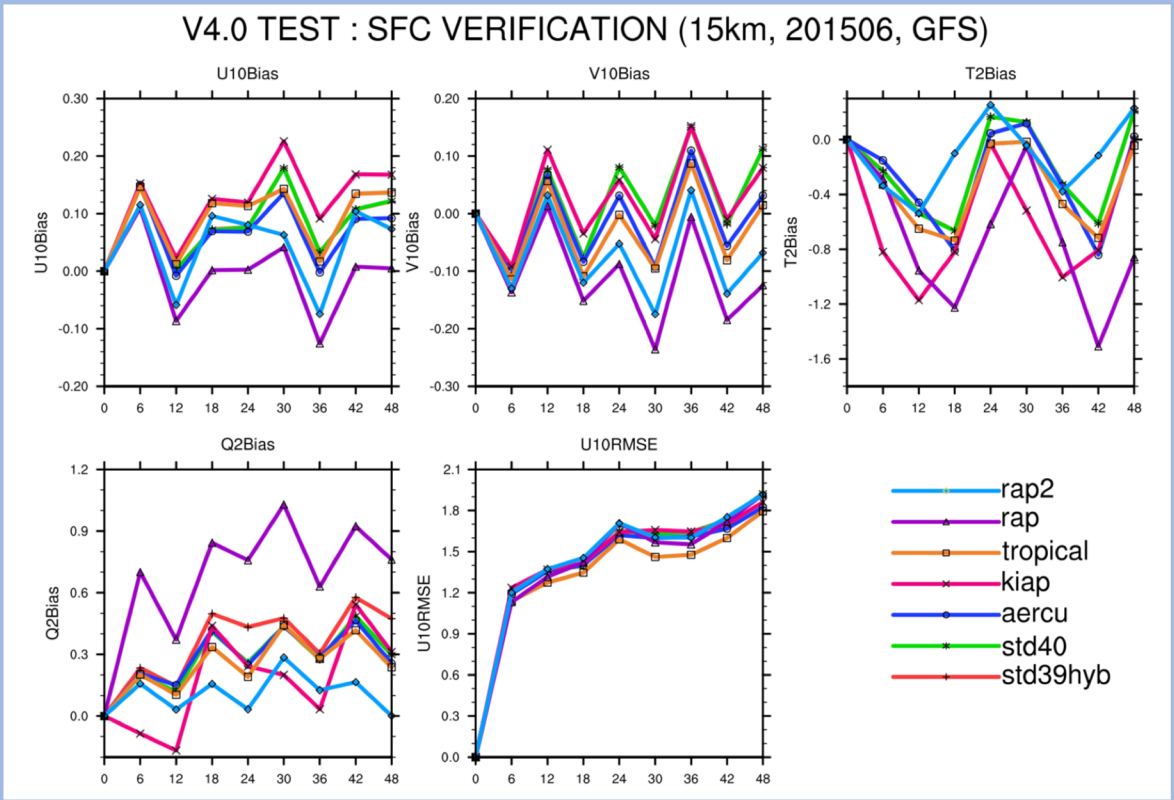
Test Suites

	Microphysics	Cumulus	Radiation	PBL	LSM
STD	WSM5	KF	RRTMG	YSU	Noah
Tropical	WSM6	New TDK	RRTMG	YSU	Noah
CONUS	Thompson	TDK	RRTMG	MYJ	Noah
KIAPS	WDM6	KSAS/NSASsh	RRTMK	YSU	Noah
RAP2 (RAP/Noah)	Thompson-aero	GF	RRTMG	MYNN	Noah
RAP*	Thompson-aero	GF	RRTMG	MYNN	RUC
AerCu	Morrison-aero	MSKF	RRTMG	YSU	Noah

* We show RAP2 because LSM initialization is with GFS soil

Surface Verification

June 2016 15 km US domain

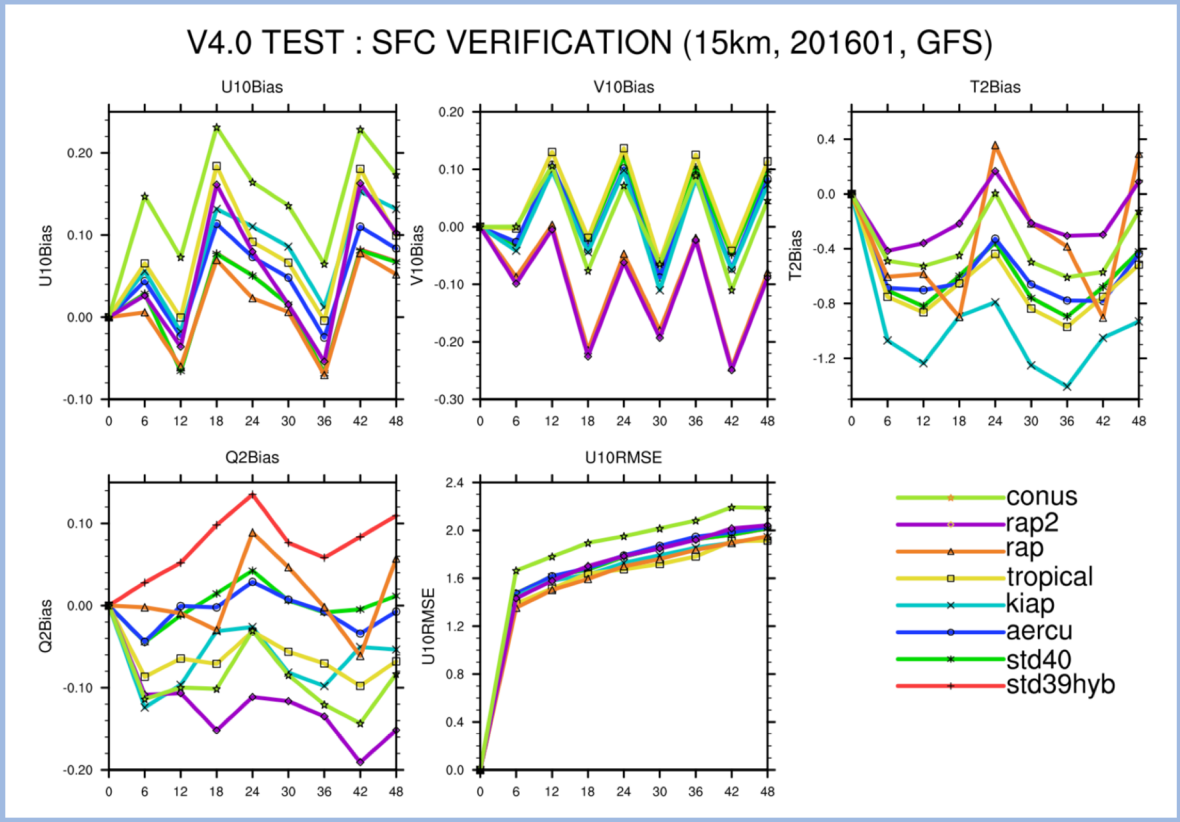


Summer versus GFS analysis

- RAP cool and moist bias but RAP2 better (RUC versus Noah LSM with GFS soil)
- For 2m T V4.0 has less negative bias than V3.9
- Hybrid coordinate test also shows no difference from STD

Surface Verification

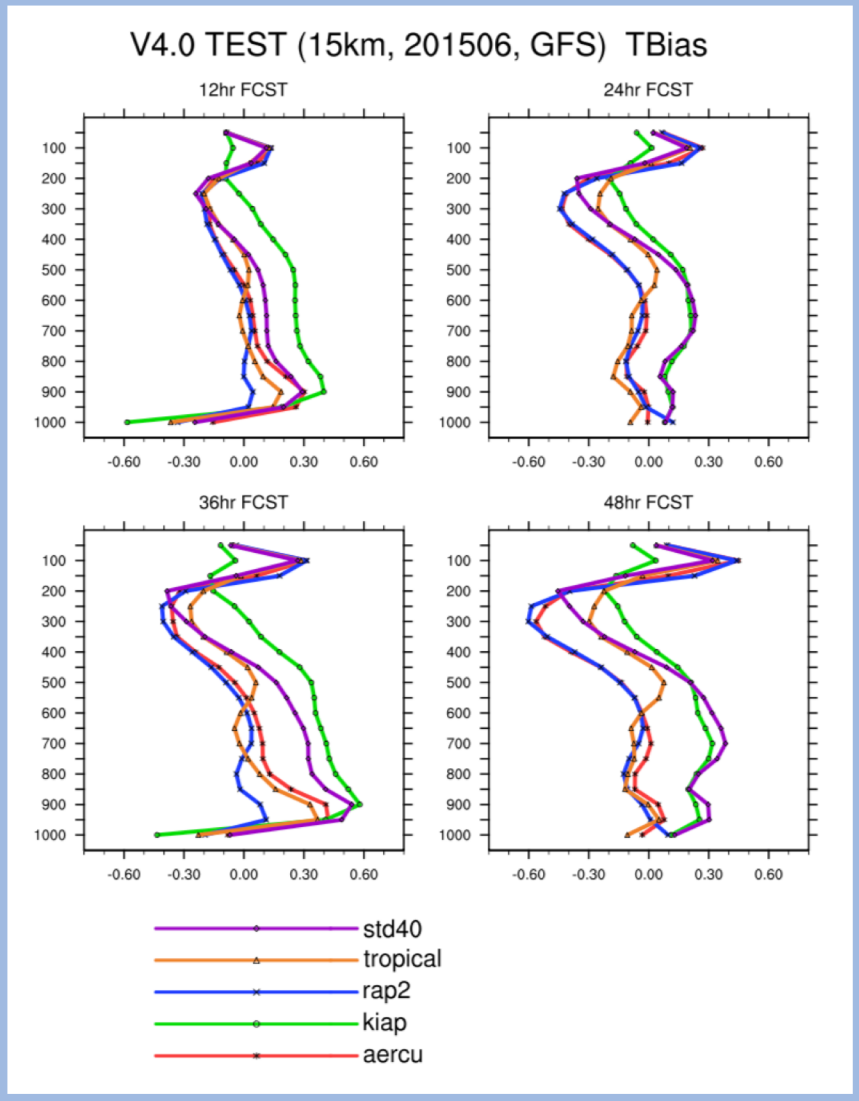
January 2016 15 km US domain

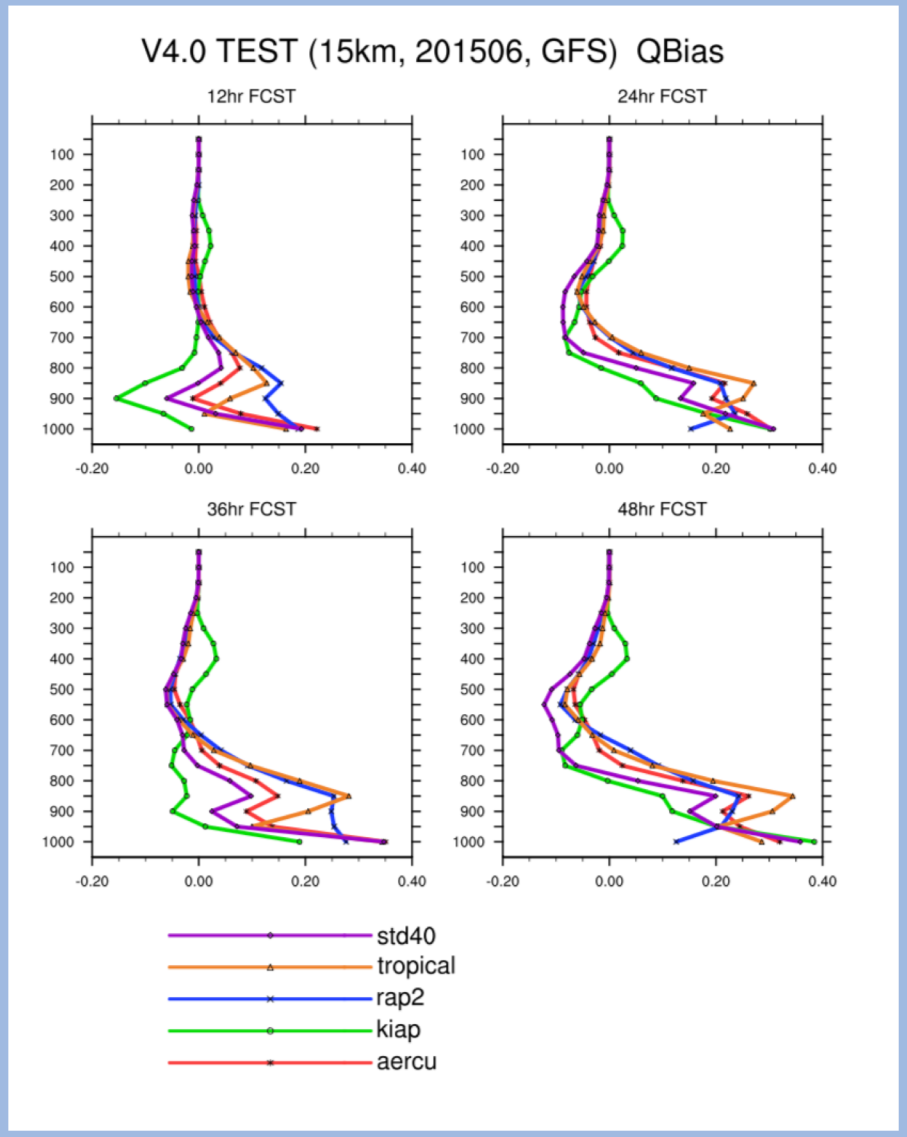


Winter versus GFS analysis

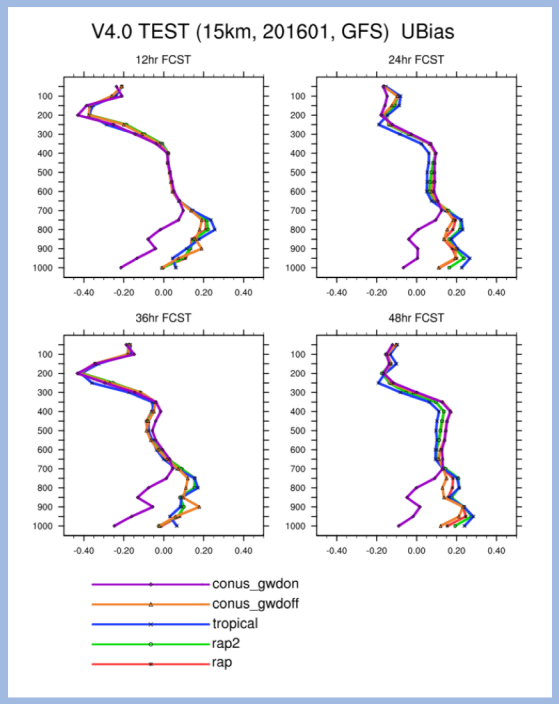
- RAP and RAP2 stand out with low 10 m V bias
- CONUS has higher 10 m U bias
- For 2m T KIAPS is cooler
- For 2m Q RAP2 drier and V3.9 moister

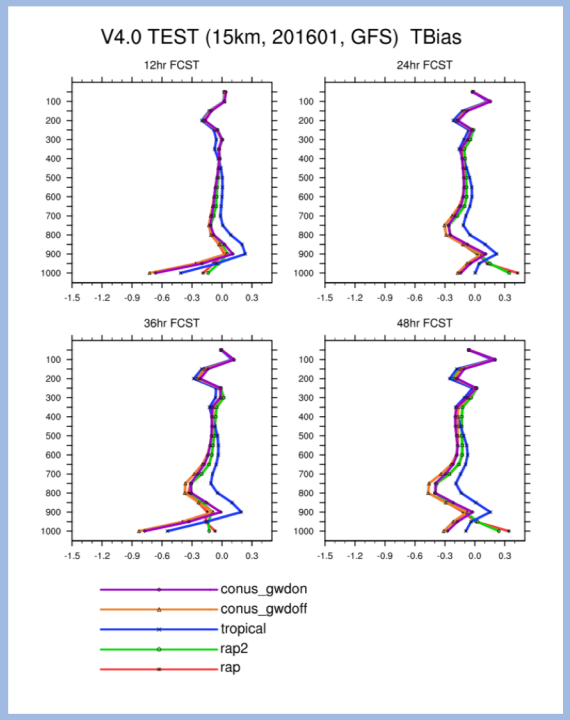
Profile Verification: Summer V4.0

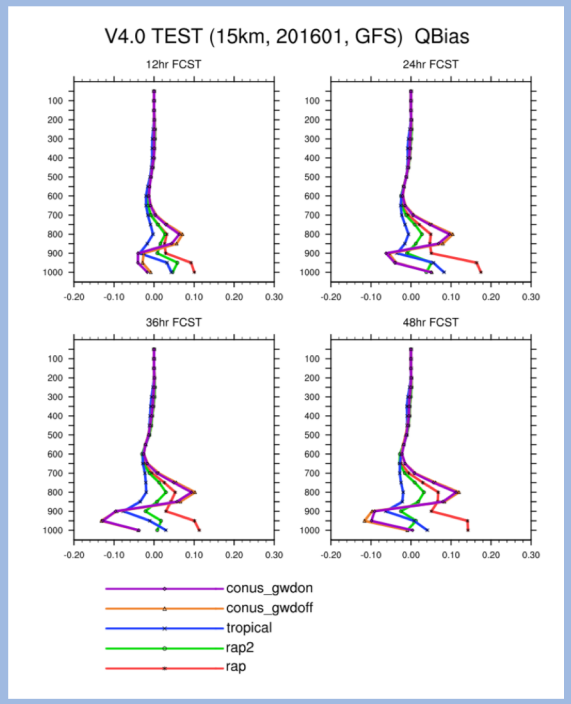




Profile Verification: Winter V4.0







Includes CONUS GWD on and off – note GWD effect

WRF and MPAS

- WRF and MPAS now share same code in a physics suite
  - *'tropical'* suite in WRF *='mesoscale reference'* in MPAS
  - Aim is to share a repository
- Releasing github versions of WRF and MPAS
- WRF and MPAS user support will soon move to a web-based forum (more discussion this afternoon)
  - Users will have access to previous questions and answers
  - Categories for questions (e.g. WPS, WRF, MPAS, compiling, runtime, general)
  - Page maintained by NCAR
  - Monitored and moderated by wrfhelp/mpashelp
  - Email help will be phased out
    - However mechanism needed for offline iterations, data transfers

End

Thanks to Ming Chen and Wei Wang