Comparison of WRF and Regional MPAS: Ensuring Consistent Physics Configurations

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With Special Thanks to Laura Fowler, Kelly Werner, Dave Gill, Jimy Dudhia and Joe Klemp

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Joint WRF and MPAS Users' Workshop

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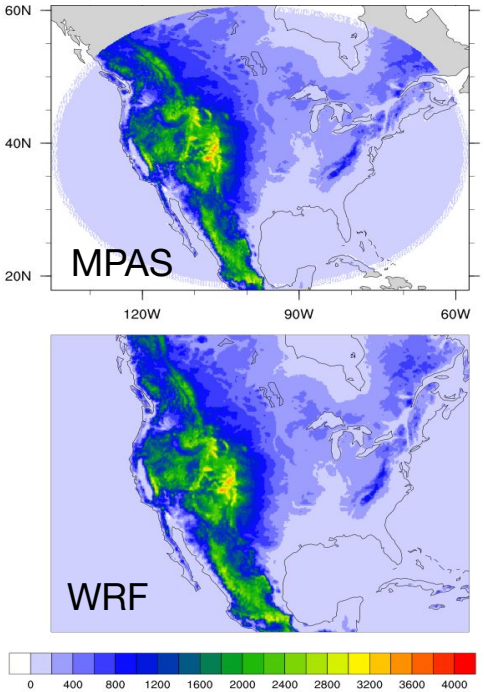
Motivation

- Regional configuration of MPAS has been available since MPAS V7.0
- **How do initialized short-range NWP forecasts from the two regional models compare?**
- While the model governing equations and time integration schemes used in WRF-ARW and MPAS are similar, there are differences in the two models including mesh/grid configurations, physics options and configurations, etc.

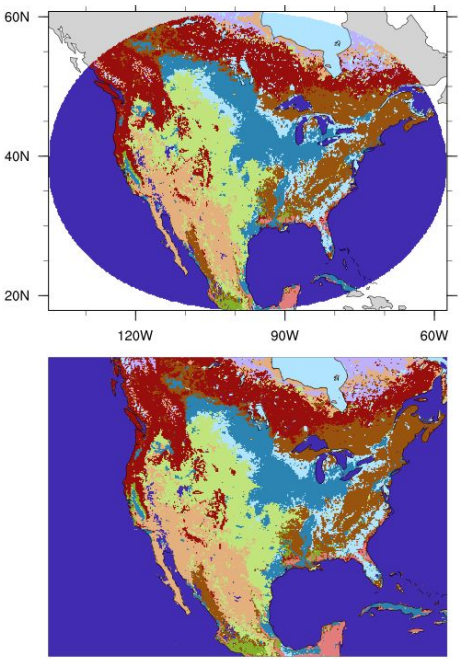
Experimental Set-up

Terrain (m)



GMTED 2010 dataset

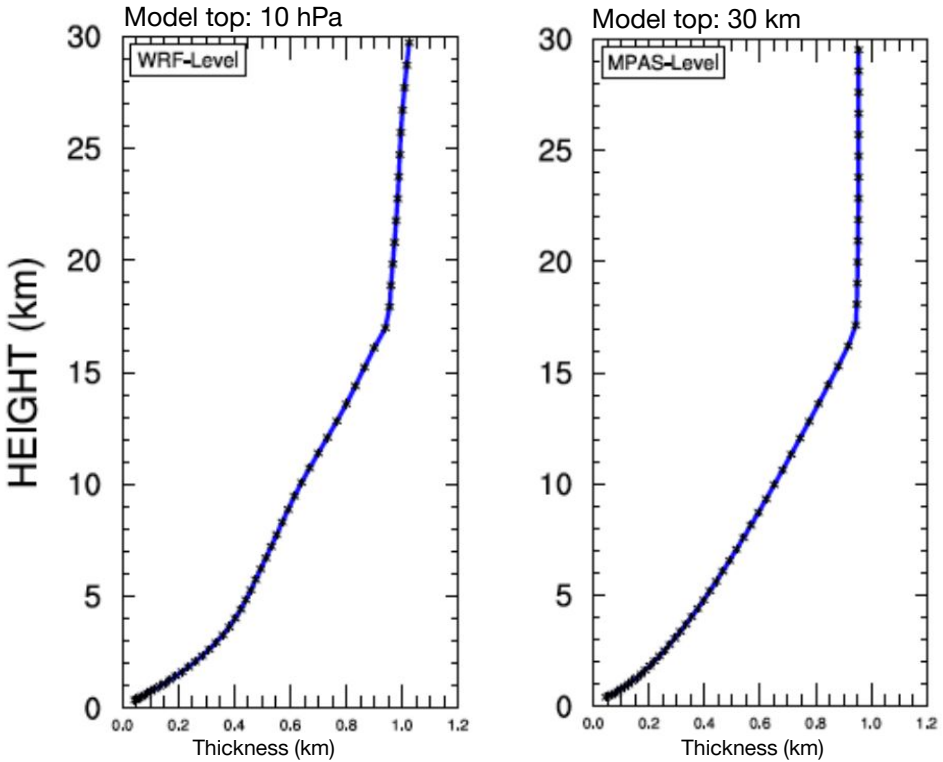
Landuse Type



MODIS 20-class dataset

Experimental Set-up

55 vertical levels



Physics Unification Effort

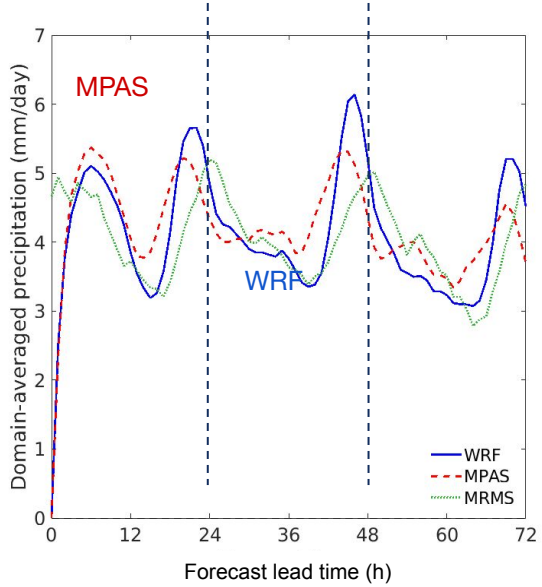
	MPAS V6.0	WRF V4.0.3
Physics suite	Mesoscale_reference	Tropical
	• Convection: New Tiedtke • Microphysics: WSM6 • Land surface: Noah • PBL: YSU • Surface layer: Monin-Obukhov • Radiation SW: RRTMG • Radiation LW: RRTMG	
Ozone	config_o3climatology = True	o3input = 2
Effective radii computed in microphysics	config_microp_re = True	use_mp_re = 1
Aerosol	No aerosol is considered	aer_opt = 0
Use snow albedo	sfc_snowalbedo = true	rdmaxalb=true
Sea ice	fractional_seaice =1	fractional_seaice = 1
Gravity wave drag	config_gwdo_scheme = off	gwd_opt = 0

Key Differences

15-km forecasts initialized at 00 UTC every 3 days using 0.25° GFS analysis with 3-h lateral boundary conditions from GFS

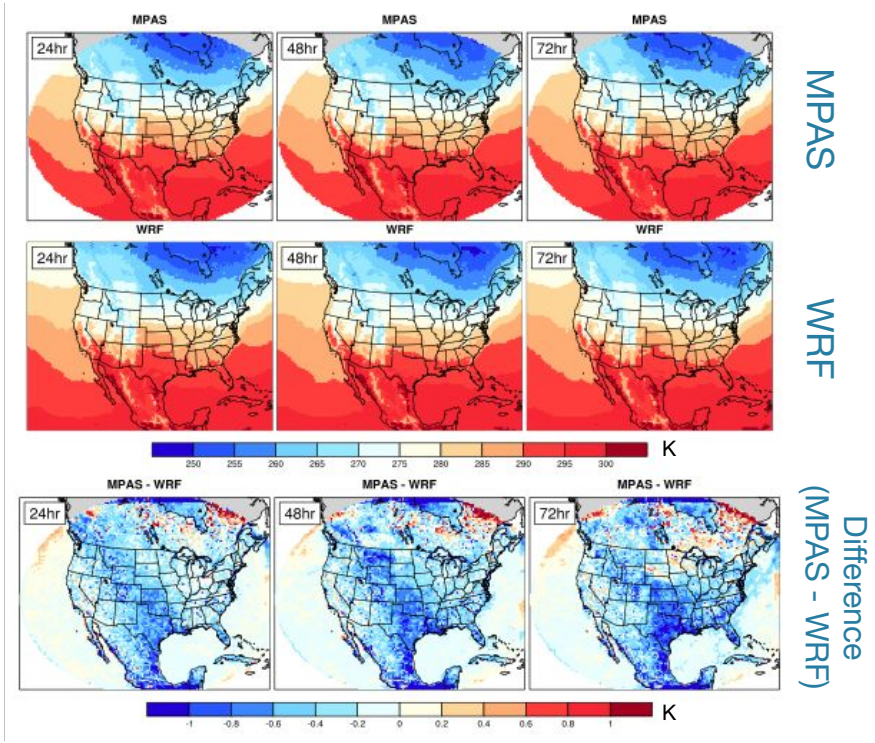
(1) Precipitation forecasts

20 April – 15 June 2017



(2) Near-surface (2-m) temperature forecasts

1 Feb – 30 March 2017



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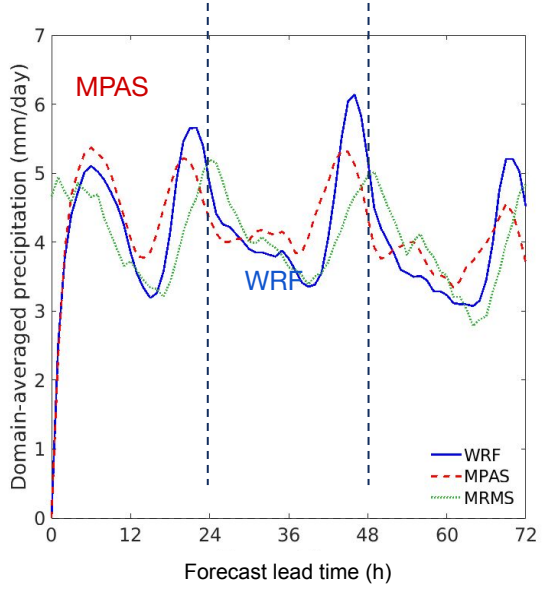

(2) Near-surface (2-m) temperature forecasts

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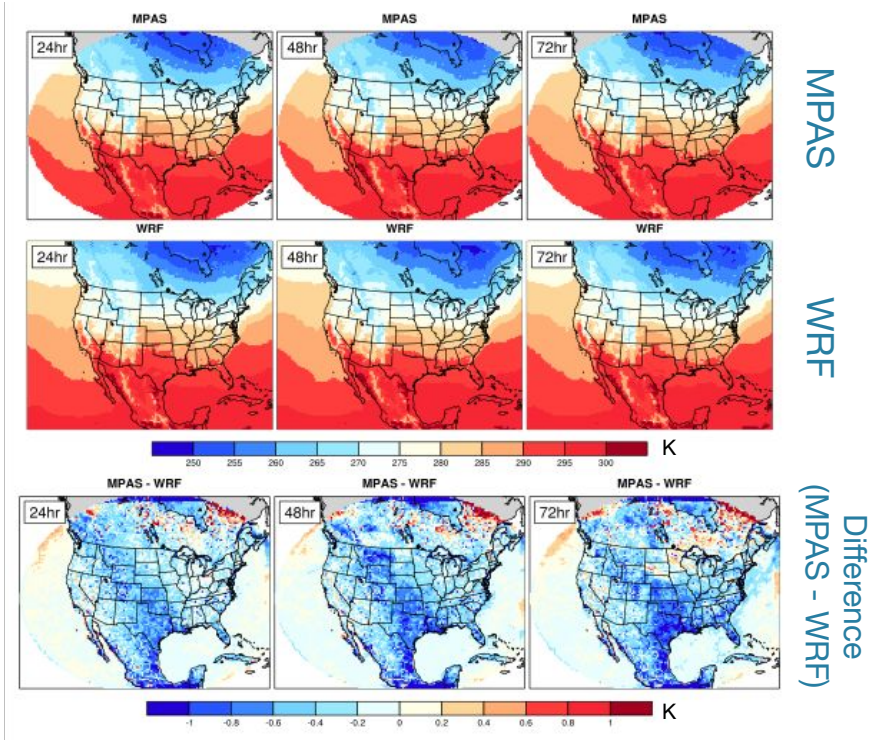
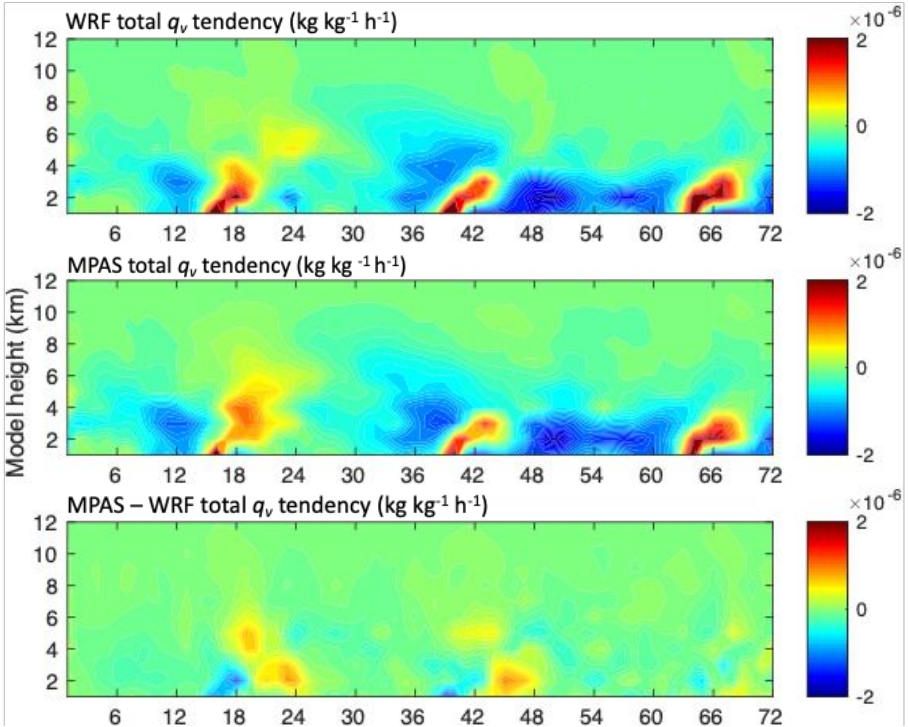
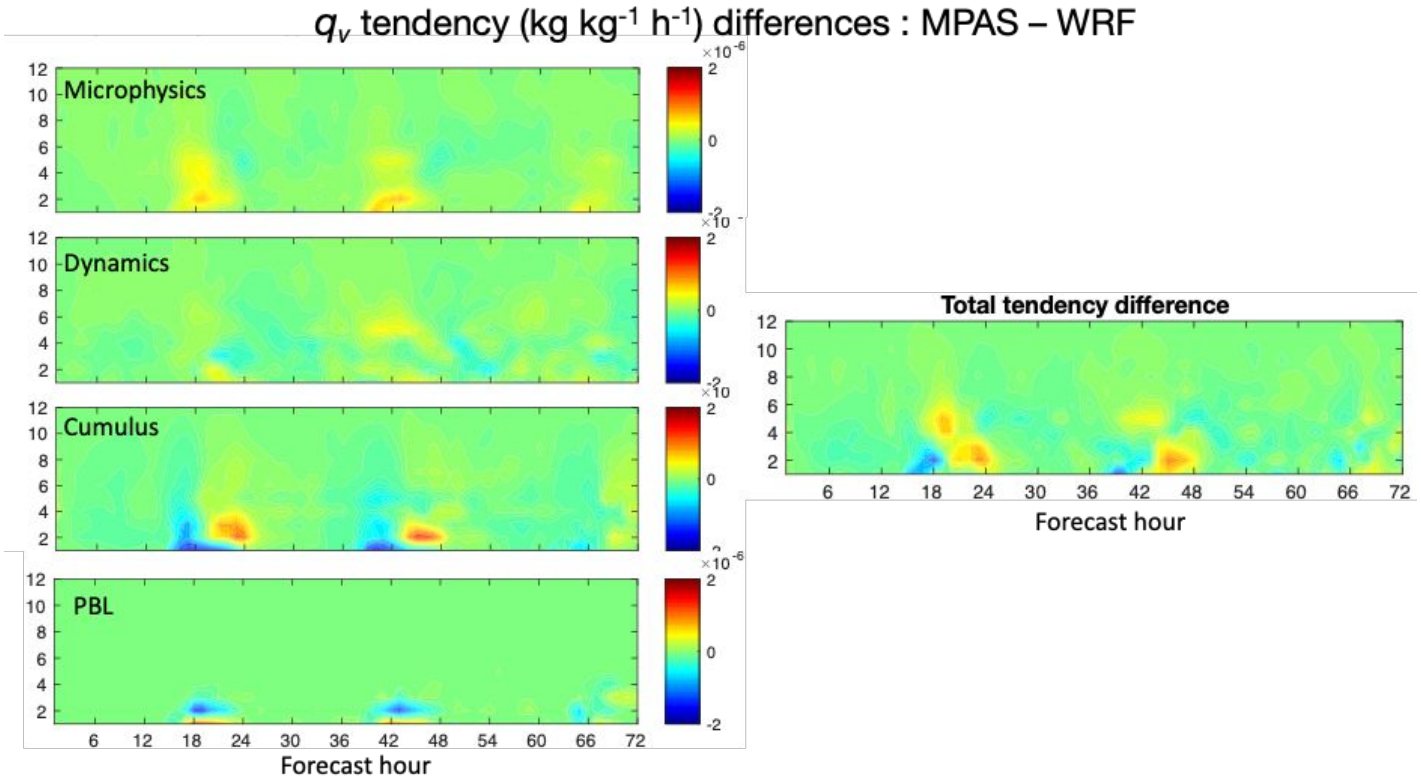


Spring Precipitation Forecasts

Moisture budget – 72-h forecast initialized 2017-06-04 00 UTC

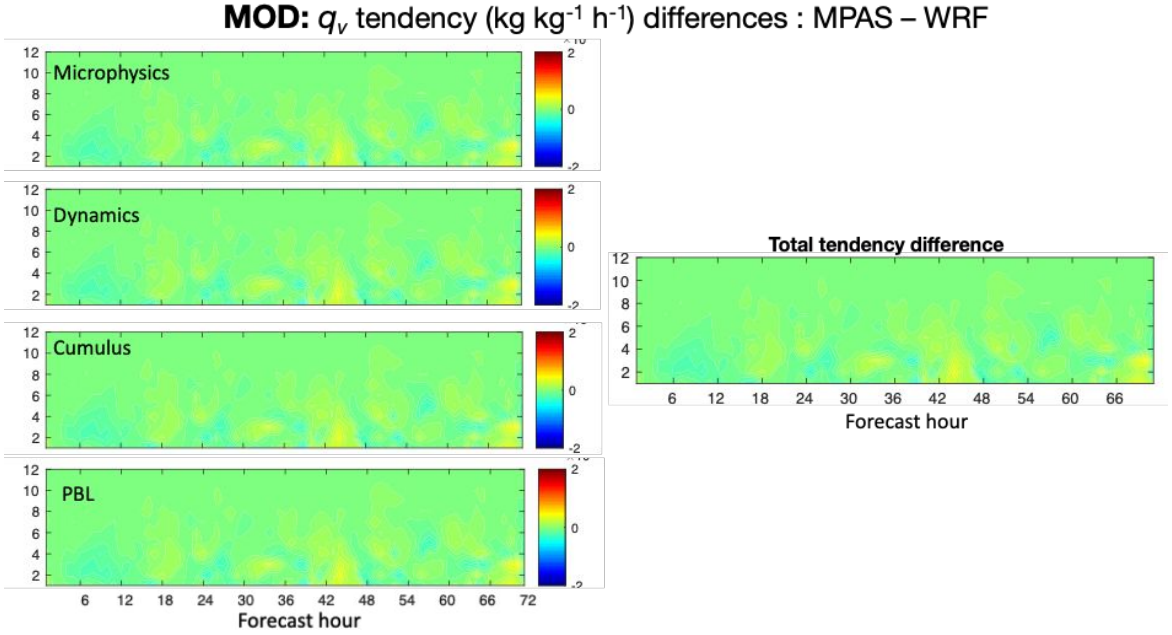


Spring Precipitation Forecasts



Spring Precipitation Forecasts

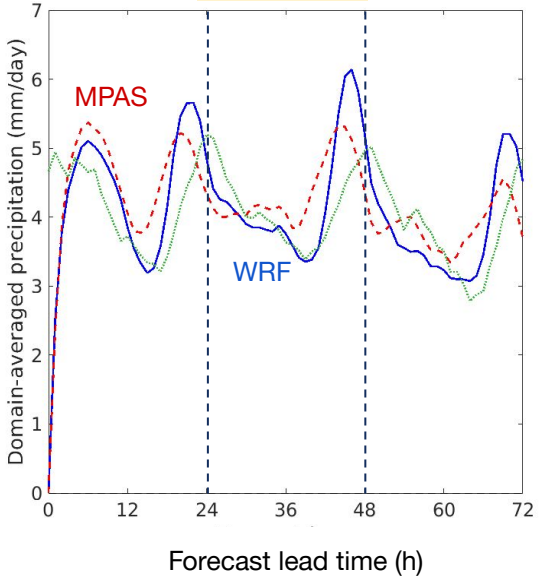
Differences were due to bugs in MPAS in the computation of the q_v and θ advection tendency forcing terms that are used as input to the cumulus scheme.



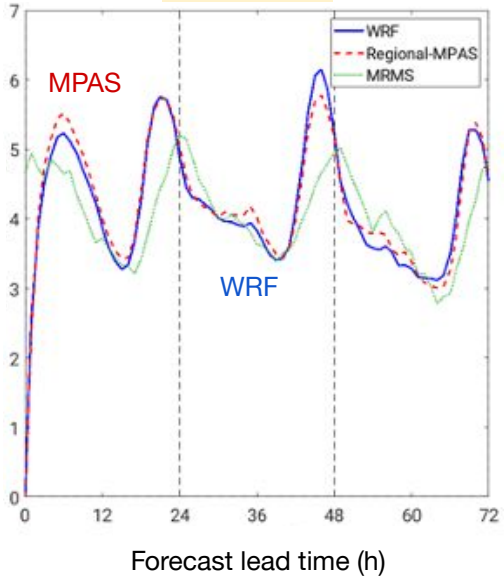
Spring Precipitation Forecasts

15-km Precipitation Forecasts
Initialized for the period 20 April – 15 June 2017

Before fix



After fix

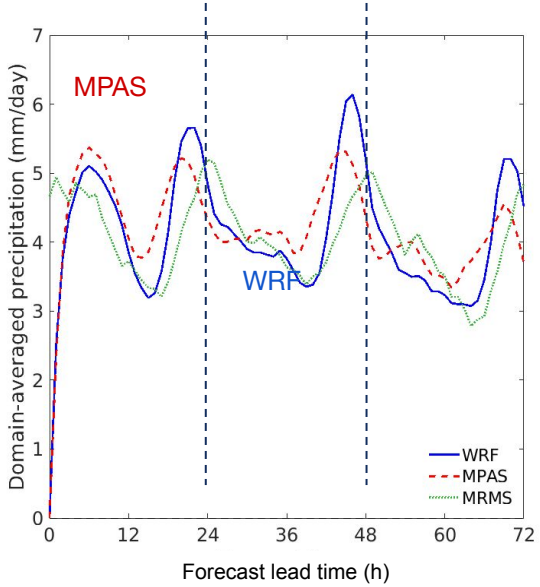


Key Differences

15-km forecasts initialized at 00 UTC every 3 days using 0.25° GFS analysis with 3-h lateral boundary conditions from GFS

(1) Precipitation forecasts

20 April – 15 June 2017



(2) Near-surface (2-m) temperature forecasts

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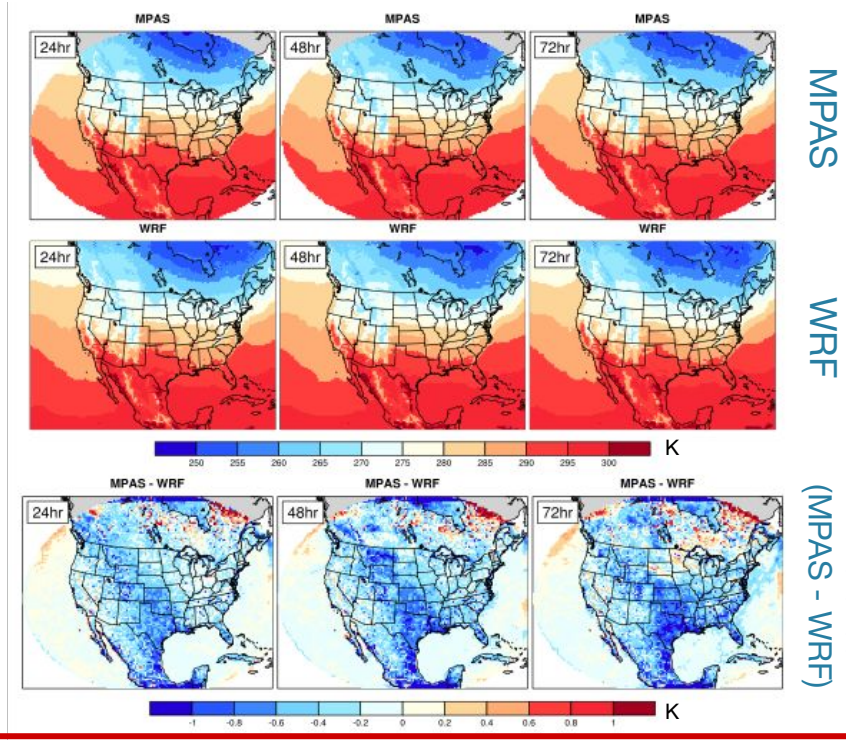
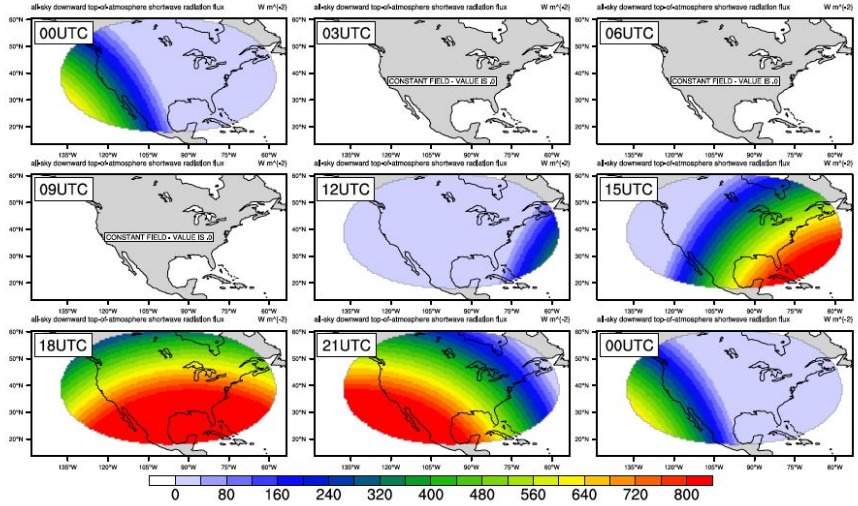


Near-surface Temperature Differences

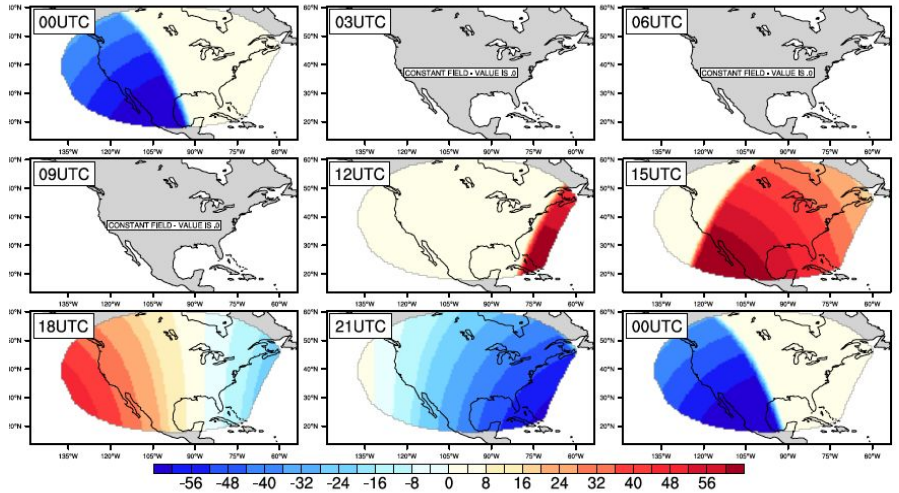
(1) Computation of the solar zenith angle

Definition of the local time for calculating the solar zenith angle was different (changed WRF to follow that done in MPAS)

MPAS Top-down Shortwave Radiation (W m^{-2})

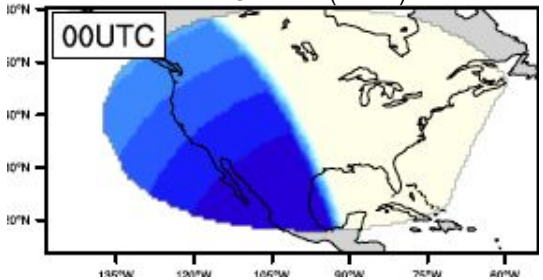


Difference, MPAS - WRF (W m^{-2})

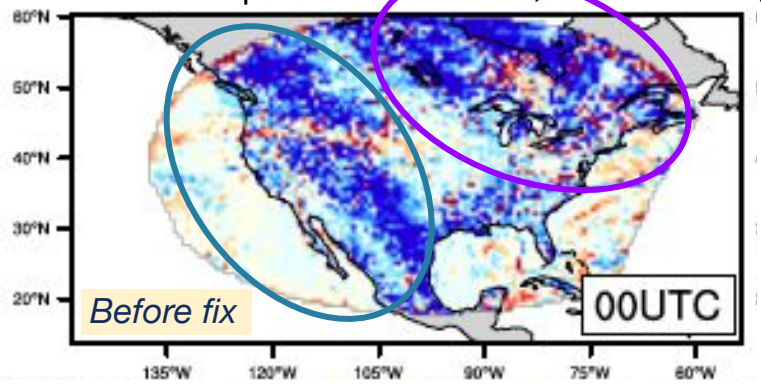


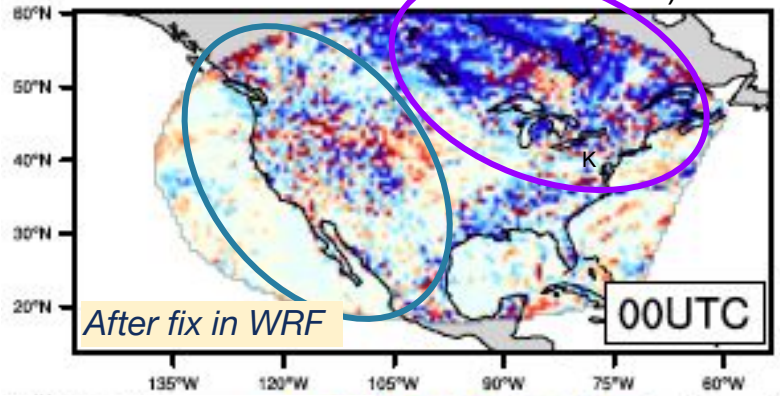
Near-surface Temperature Differences

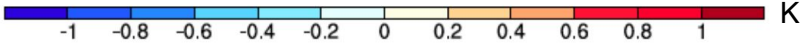
Difference in top-down shortwave radiation,
MPAS - WRF (W m^{-2})



2-m temperature difference, MPAS- WRF (24 h forecast initialized on 2017-02-01 00 UTC)



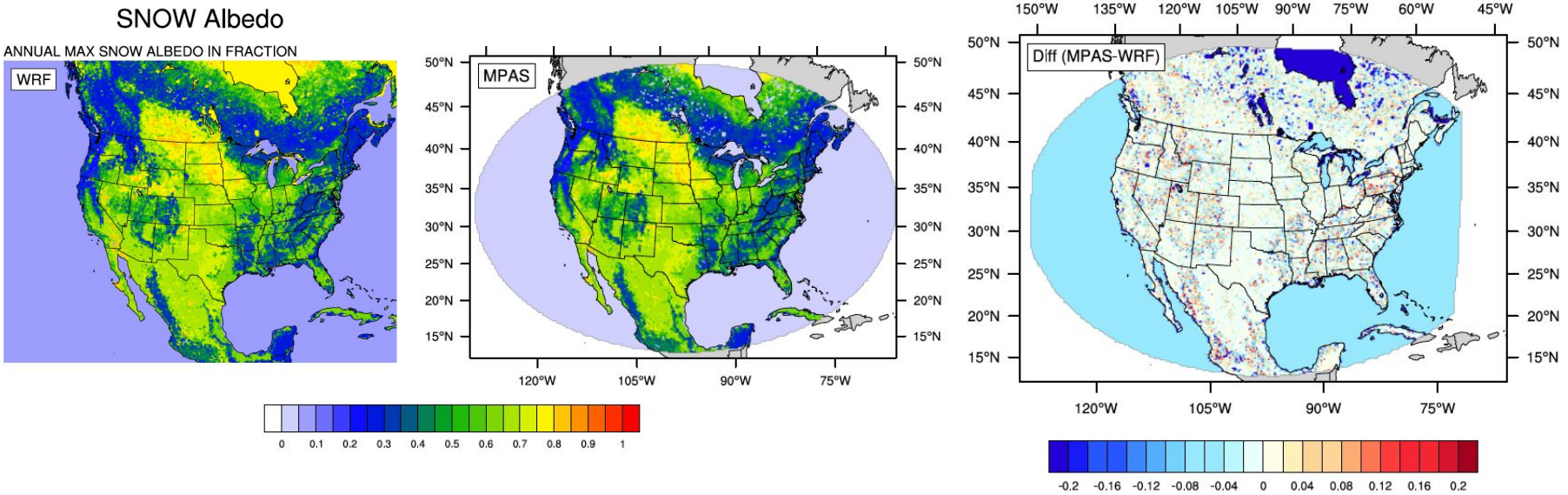




Near-surface Temperature Differences

(2) Snow albedo

Initialization of the annual maximum snow albedo variable over sea ice points



Near-surface Temperature Differences

(2) Snow albedo

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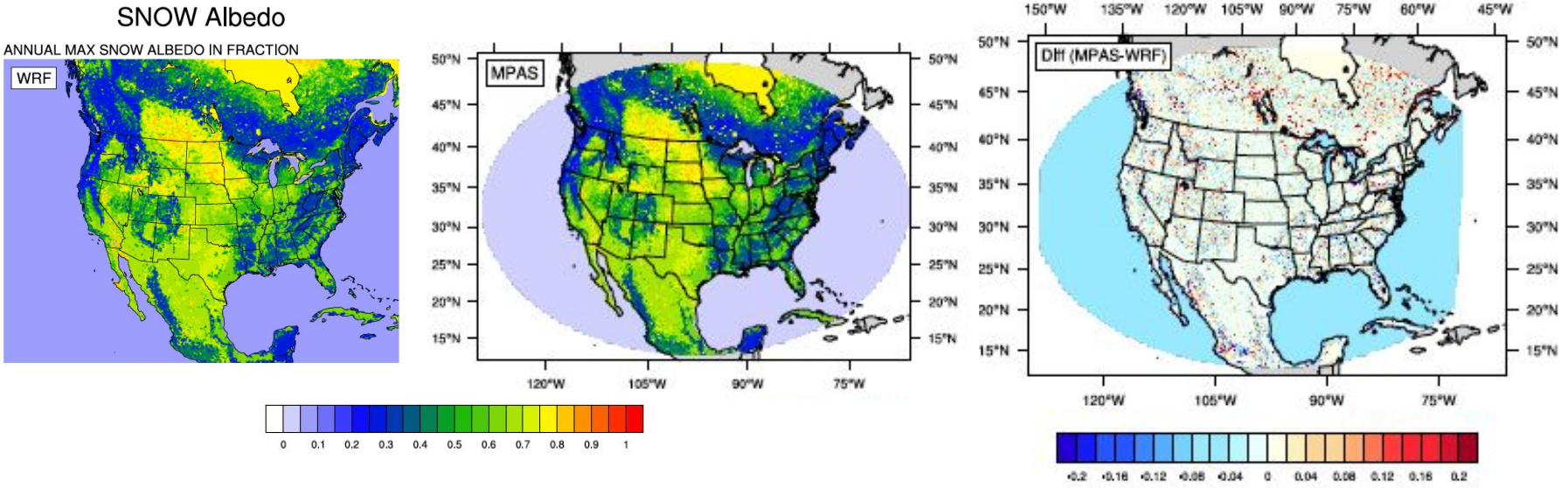
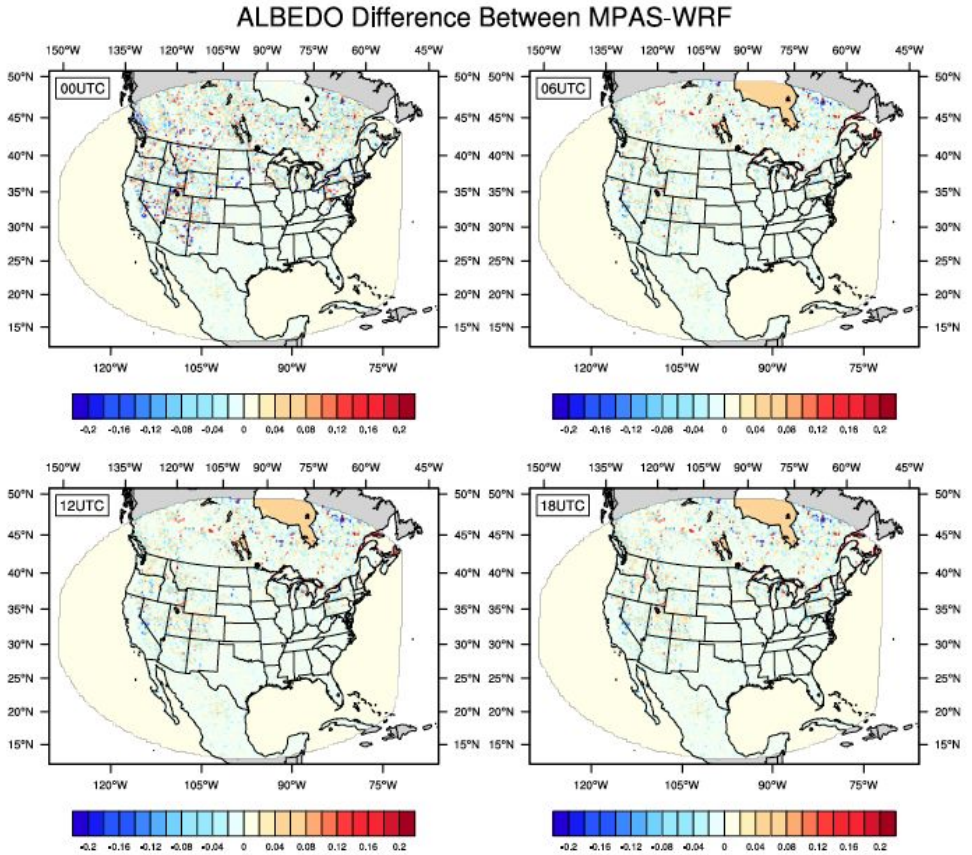


Near-surface Temperature Differences

(2) Snow albedo

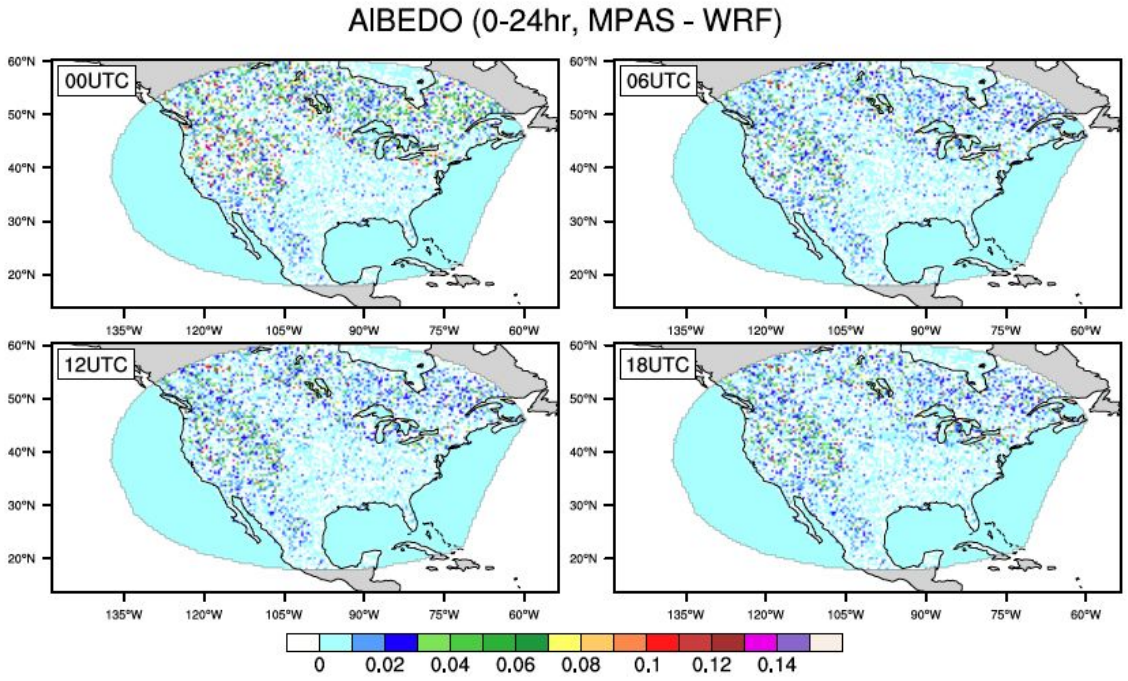
Default seaice albedo value in MPAS is now 0.65 (previously 0.80) and snow albedo is set to 0.75, consistent with that in WRF



Near-surface Temperature Differences

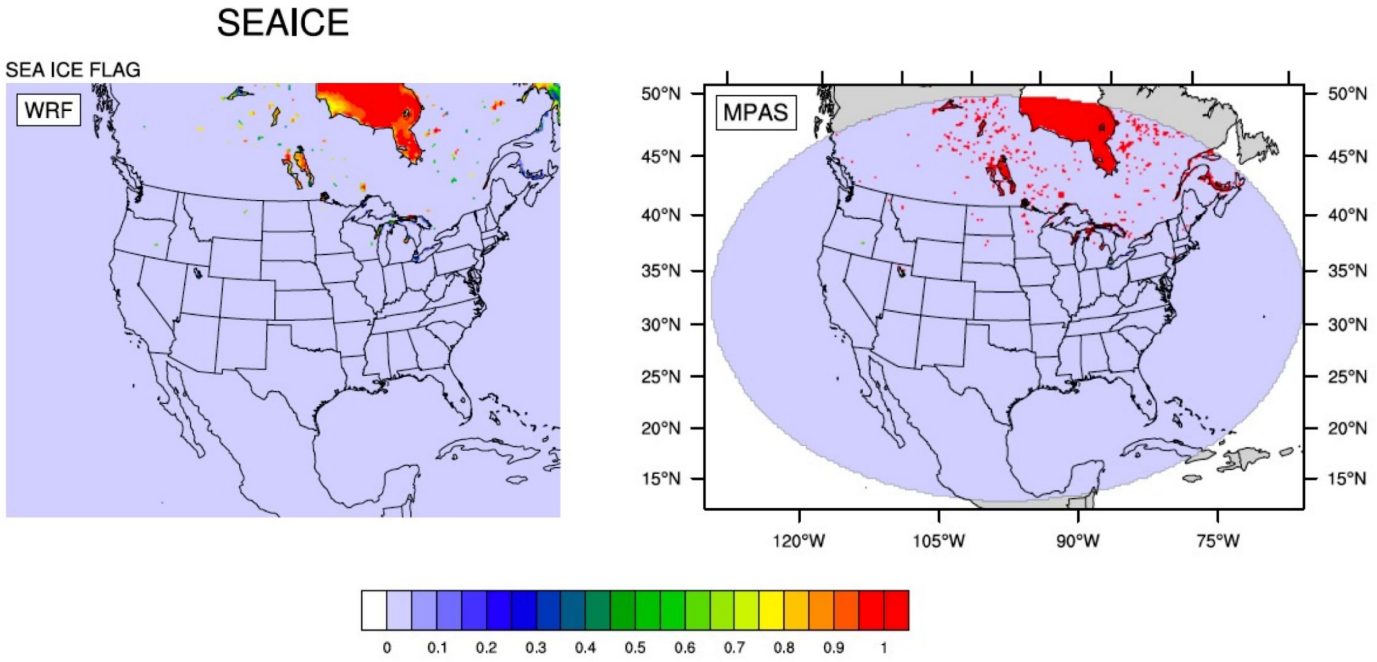
(2) Snow albedo

The default ‘seaice_albedo_opt’ is now set to using default snow albedo values (option 0) instead of a user-provided input albedo (option 2)



Near-surface Temperature Differences

(3) Sea ice definition when $T_{SST} \leqslant 100$ K (since WRF V3.5.1), instead of 271 K

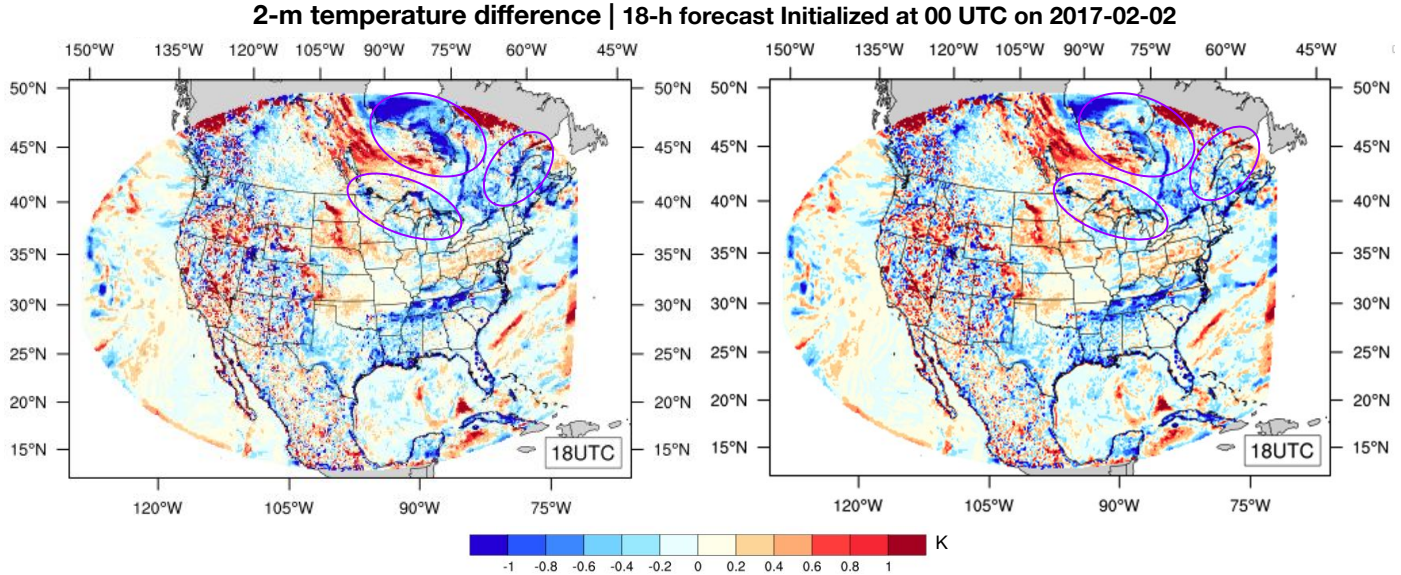


Near-surface Temperature Differences

(2) Snow albedo

- Initialization of the annual maximum snow albedo variable over sea ice points
- Default seaice albedo value in MPAS is now 0.65 and snow albedo 0.75, consistent with that in WRF
- Correction of the seaice_albedo_opt to 0 (sets to default values), and not 2

(3) Sea ice definition when $T_{SST} \leqslant 100$ K (since WRF V3.5.1), instead of 271 K



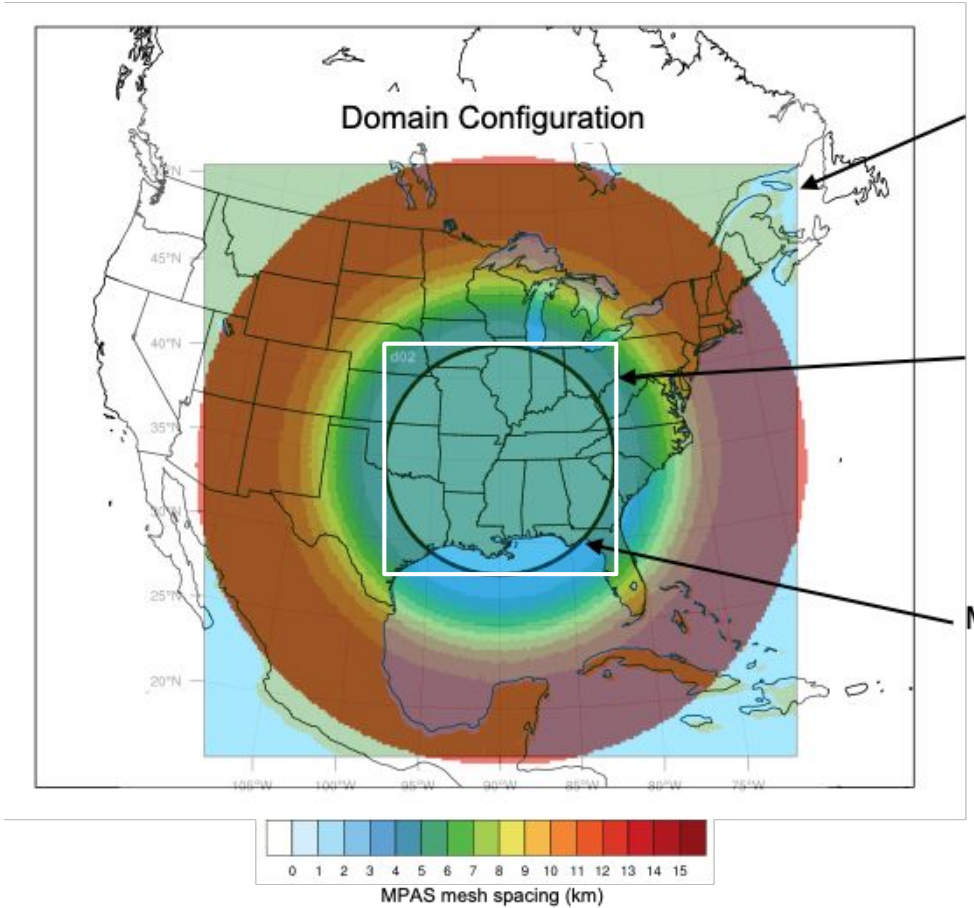
Summary

- Effort has been put into unifying the WRF/MPAS physics as well as uncovering subtle differences in the model physics configurations.
- This effort would greatly benefit from a shared physics repository (talk by L. Fowler on Tuesday).

	MPAS	WRF
Forcing terms to cumulus scheme	✔	
Solar zenith angle		✔
Snow albedo	✔	
Sea ice	✔	

Next Steps

(1) Rerun the two periods (spring and winter) with the model changes
(2) Similar tests at the convection-permitting resolution


Domain Configuration
d02
45°N
40°N
35°N
25°N
20°N
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MPAS mesh spacing (km)
WRF 15-km or 9-km domain, and also domain for full 3-km
WRF 3-km nest
MPAS 3-km region

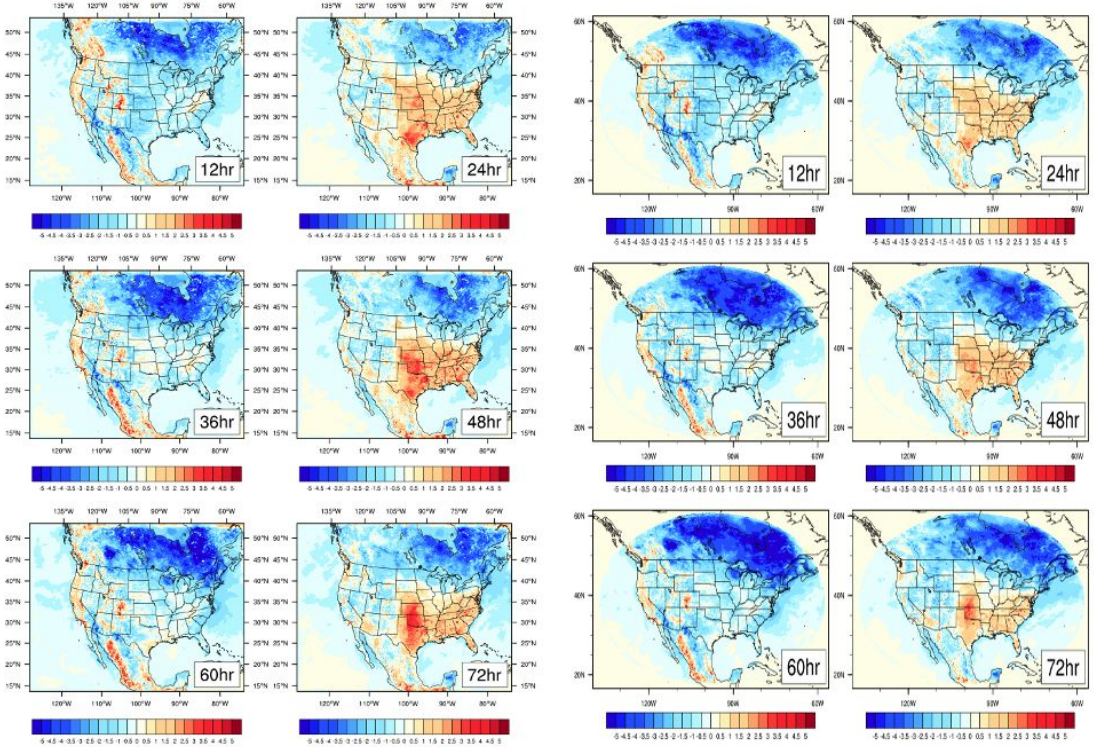
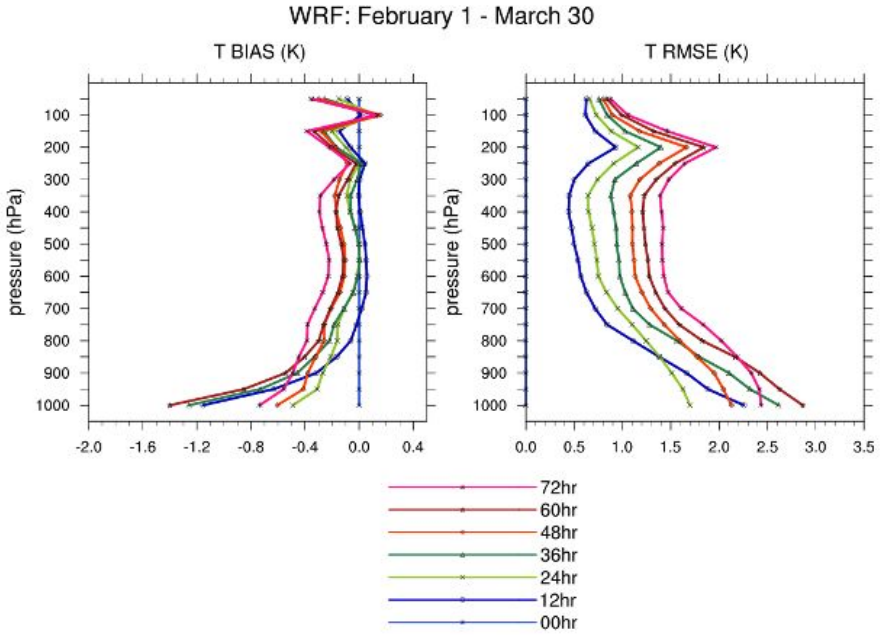
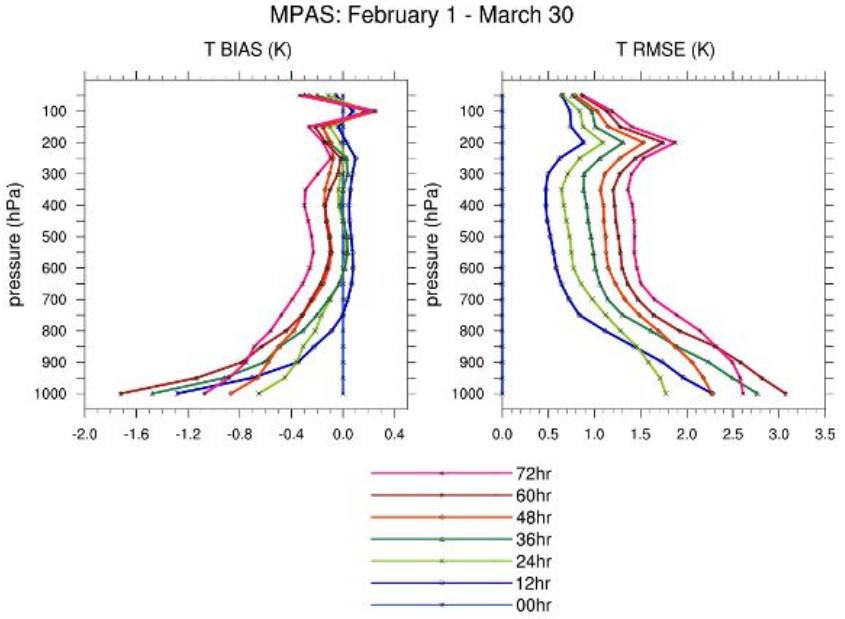


Fig. 3 Spatial distribution of 2m AGL temperature bias at various forecast lead time for all WRF and MPAS simulations during the period 1 February – 30 March 2017


WRF: February 1 - March 30
T BIAS (K)
T RMSE (K)
pressure (hPa)
100
200
300
400
500
600
700
800
900
1000
-2.0
-1.6
-1.2
-0.8
-0.4
0.0
0.4
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
72hr
60hr
48hr
36hr
24hr
12hr
00hr


MPAS: February 1 - March 30
T BIAS (K)
T RMSE (K)
pressure (hPa)
100
200
300
400
500
600
700
800
900
1000
-2.0
-1.6
-1.2
-0.8
-0.4
0.0
0.4
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
72hr
60hr
48hr
36hr
24hr
12hr
00hr