The impact of different configurations on forecasting extreme events with the Unified Forecast System

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Motivation

To investigate the
- Impact of code update,
- Update of different horizontal/vertical resolutions,
- Impact of different physics suites

Methods

- The study is focused on the CONUS domain and uses the UFS Short-Range Weather (SRWeather) Application.
- The physics suites used in this study include GFS v15.2, GFS v16, GFS v17α, and RRFS v1α.
- The results are tested with different configurations, such as the version of the code base, model grid spacing (13km vs 3km, 64 levels vs 127 levels), and the physics suite employed.
- The model forecasts are verified against station observations and analysis data.

Physics schemes and model settings in the experiments

	GFSv15.2	GFSv16	GFSv17α	RRFSv1α
Deep convection	SA-SAS	SA-SAS	SA-SAS	n/a
Shallow convection	MF(sa)	MF(sa)	MF(sa)	MYNN-EDMF
Microphysics	GFDL	GFDL	GFDL	AA-Thompson
Saturation adj.	True	True	True	False
PBL/Turbulence	K-EDMF	Moist SA-TKE-EDMF	Moist SA-TKE-EDMF	MYNN-EDMF
LSM	Noah	Noah	NoahMP	NoahMP
GWD	uGWP	uGWP	uGWPv1	uGWP
Radiation	RRTMG	RRTMG	RRTMG	RRTMG
d4_bg	0.15	0.15	0.15	0.15
vtdm4	0.075	0.075	0.075	0.075
sponge	30	10	10	24
tau	5	10	10	5
hord_mt	6	5	5	6
hord_vt	6	5	5	6
hord_tm	6	5	5	6
hord_dp	-6	-5	-5	-6

Impacts of code update and vertical resolution

- Initialized at Feb 03, 2020 12z, valid at Feb 06, 12z. (Fig. 1).
- Results from the latest version (develop branch) are slightly better than from the public release (SRW App v1.0).
- Increasing the number of levels further improves the results (Fig. 2).
- GFS v16 with 127 levels is better than GFS v16 with 64 levels with a larger area of cold air. Cold air area of v17α with 127 levels is reduced/degraded compared to v16 with 127 levels (Fig. 3)

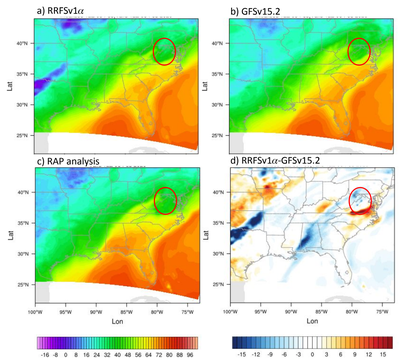

Fig. 1 2-m temperature valid at 12z, Feb. 6, 2020 for a) RRFSv1α, b) GFSv15.2, c) RAP analysis, and d) RRFSv1α - GFSv15.2. The unit is k.

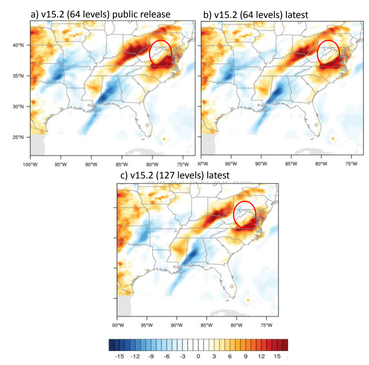

Fig. 2 Difference plots from RAP Analysis (model - RAP analysis) for 2-m temperature (k)

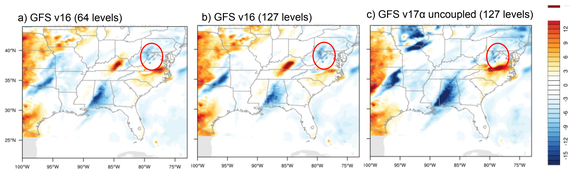

Fig. 3 Difference plots from RAP analysis for 2-m temperature (k).

Impact of horizontal resolution

- Results from the latest version with 127 vertical level.

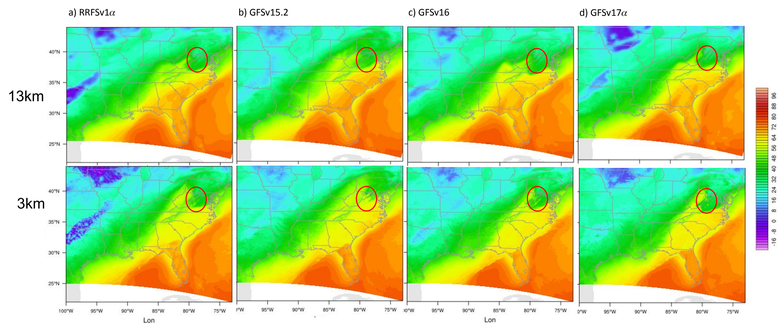

Fig. 4 2-m temperature (k).

T2 Bias for 13km and 3km

- The 2-m temperature is compared with surface station observations and the simulation error (model minus observations) for each station is calculated (Fig. 5).
- More stations have a positive error for the results for 3-km grid spacing than that of 13-km grid spacing. This is consistent with the northward shift in the 2-m temperature field (Fig. 4).

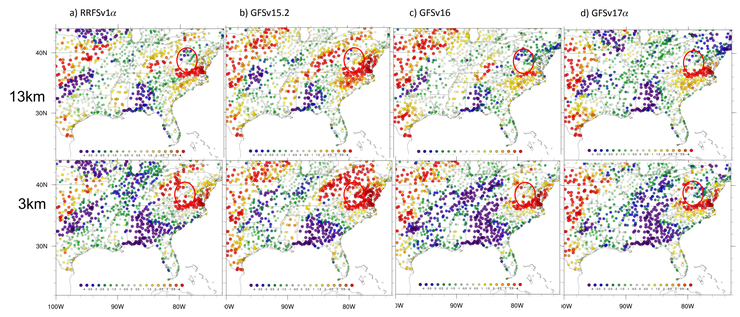

Fig. 5 Surface 2m temperature error. The unit is k.

Sensitivity test

- The cold air shifts northward when the land surface model is changed from NoahMP to Noah (Fig. 6).
- The temperature tendencies due to MP and PBL show big changes at lower levels (Fig. 7).

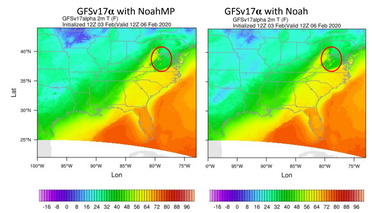

Fig. 6 Surface 2-m temperature a) GFSv17α with NoahMP, anb b) GFSv17α with Noah. The unit is k.

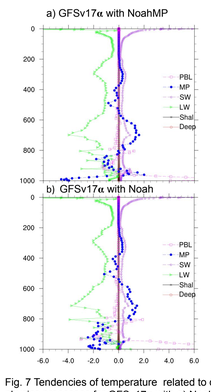

Fig. 7 Tendencies of temperature related to different physics processes for GFSv17α with a) NoahMP, and b) Noah. The unit is k/day.

Summary

- We performed experiments with the UFS Short-Range Weather Application using the latest code and more vertical levels to show
  - Improvements for the Cold Air Damming case with GFS v16
  - Degradation for (uncoupled) GFS v17α
- Results from 3-km horizontal grid spacing show that the cold air is shifted northward (degradation) for GFS v15.2 and GFS v16, but not for GFS v17α. The comparisons between model results and station observations confirms that.
- Sensitivity tests with GFS v17α show that changing land surface model from NoahMP to Noah can cause the northward shift of the cold air.

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