Poster #V66

Evaluation of Vertical Resolution Impacts on Convection Allowing Regional Forecast

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1. Objectives

- Vertical resolution is less examined for convective scale weather prediction compared to the horizontal resolution
- Will increasing the vertical resolution help to improve the convective scale weather forecast?
- Design and evaluate vertical level configurations for the next generation convective scale weather forecast system to:
  - resolve important boundary layer processes
  - extend upper levels high enough for future satellite data assimilation
  - chose a configuration that does not increase computing expenses significantly
- Three vertical level configurations are proposed by:
  - Extending the model top of NSSL-MPAS realtime experiments from 26 km to 42 km
  - Converting the FV3-based RRFS sigma-pressure hybrid levels into z level
  - Converting the operational GFS sigma-pressure hybrid levels into z level
- The performance of proposed vertical level configurations is tested and evaluated for 15 early spring cases with MPAS

2. Regional convective scale MPAS system set up

- Dynamic core: MPAS limited area model (LAM) on a horizontal 3 km CONUS grid
- Vertical z levels as in Fig. 1; lowest model level on ~8-10m above sfc; model top at 42 km
- Dynamics: Timestep: 20 seconds; number of acoustic steps per full RK step=2; the number of RK steps per split transport step=3
- Physics: Cumulus convection: None; Microphysics: Thompson MP; Radiation: RRTMG LW and SW; GWD; PBL and surface: MYNN; LSM: RUC
- No DA
- IC and LBC: IC is from GFS high resolution grib2 (L127+ 13 km dx); LBC is from GFS grib2 every 3 hours

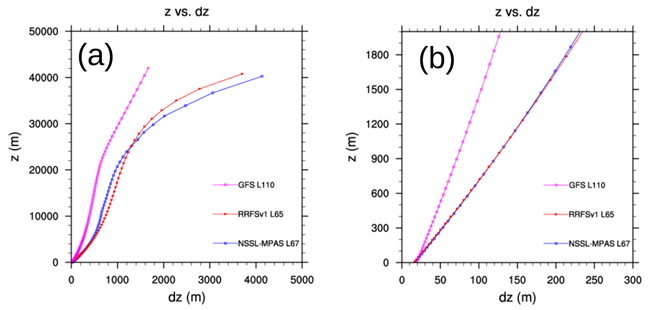


Fig. 1. vertical resolutions (z-delta z) tested and evaluated: (a) full depth; (b) zoomed in low levels



Fig. 2. MPAS domain over CONUS (3 km)

3. MPAS experiments and verification

- RRFS retrospective experiments
  - 15 early spring cases: initialized 2024/03/14 to 2024/04/11 at 00Z every other day; 36 hours forecast
- Evaluation metrics using MET/METplus:
  - Bias-corrected rmse and bias of
  - surface T(2m)/U(10m)/V(10m)/DPT(2m)/PRMSL hourly
  - T/U/V/RH/HGT profiles
  - verified against NDAS/prepbufr over CONUS hourly (sfc) of 12 hourly (upper air)
  - Precipitation fractions skill score (FSS)+frequency bias verified against CCPA over CONUS (6 hourly accumulation)
- Model instability:
  - 15/15 cases successful for NSSL-MPAS-L67; 14/15 cases successful for RRFSv1-L65; 9/15 cases successful for GFS-L110
  - Comparison was on 8 cases with all three vertical level experiments ran successfully

4. Results

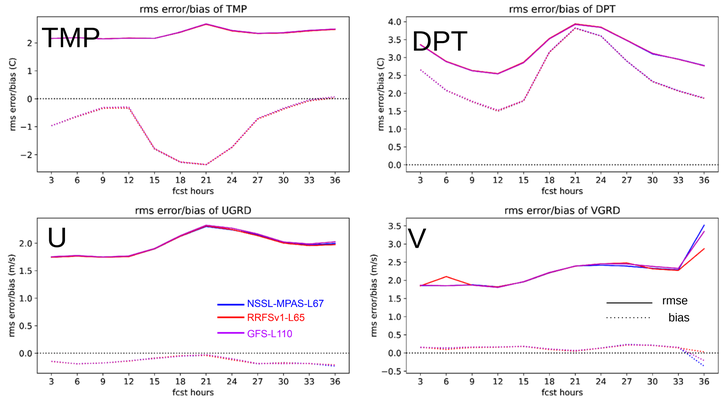


Fig. 3. bias-corrected rmse and bias for 2m temperature, dew point, 10m u and v for three vertical level configurations experiments over CONUS, aggregated over 8 cases. Solid is RMSE and dashed is bias

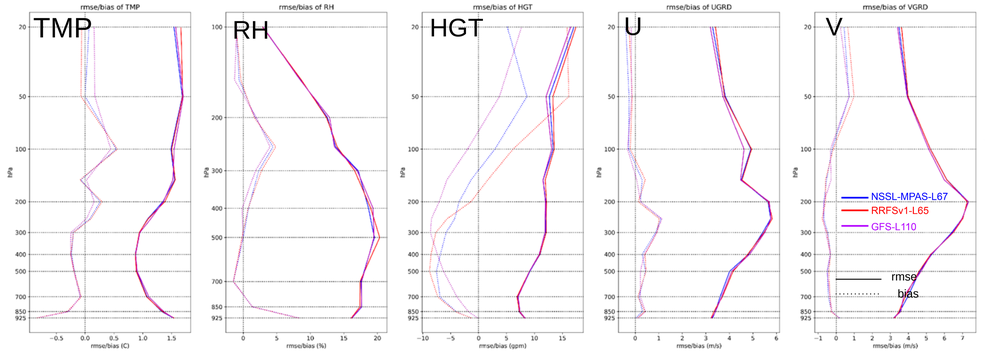


Fig. 4. bias-corrected root-mean-square error and bias for temperature, relative humidity, geopotential height and u, v winds for three vertical levels configurations experiments over CONUS, averaged every 12 hours from 12 to 36 hours and aggregated over 8 cases. Solid is RMSE and dashed is bias

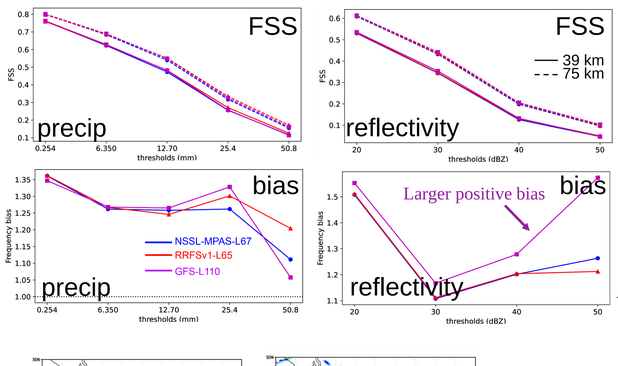


Fig. 5. 6-hour precipitation accumulation and composite reflectivity fractions skill scores (FSS) and frequency bias (FB) of three vertical levels configurations experiments over CONUS for various thresholds. Precip FSS/FB is averaged every 6 hours from 6 to 36 hours. Reflectivity FSS/FB is averaged every 3 hours from 3 to 36 hours and aggregated over 8 cases. Solid is FSS at neighborhood size of 39 km and dashed is at 75 km.

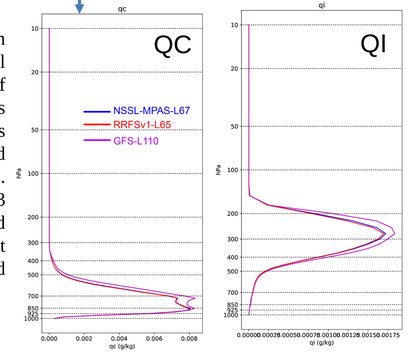


Fig. 6. Time-domain averaged cloud water and cloud ice mixing ratio for 2024/03/24/00

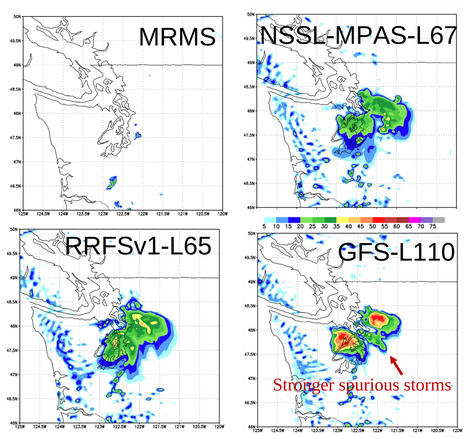


Fig. 7. 27 hours composite reflectivity (dBZ) forecasts of three vertical level configurations experiments initialized at 2024/03/24/00, along with the MRMS observations at 2024/03/25/03.

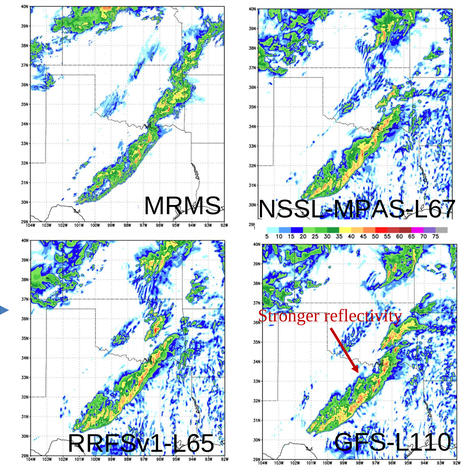


Fig. 8. 30 hours composite reflectivity (dBZ) forecasts of three vertical level configurations experiments initialized at 2024/03/24/00, along with the MRMS observations at 2024/03/25/06.

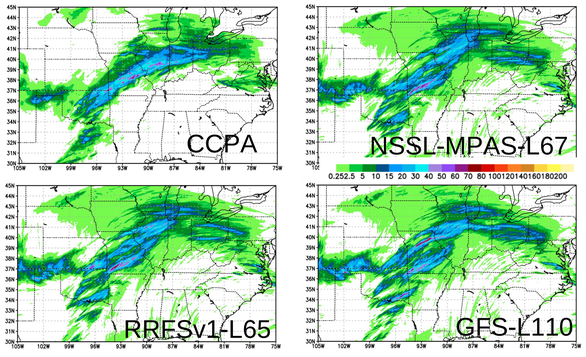


Fig. 9. 30 hours 6-hourly precipitation forecasts (mm) of three vertical levels configurations experiments initialized at 2024/04/01/00, along with the CCPA observations at 2024/04/02/06.

5. Conclusions

- Three different vertical level configurations were tested and evaluated for convective scale regional forecasts with the MPAS model for early spring cases over CONUS
- Similar stats are found between NSSL-MPAS-L67 and RRFSV1-L65 in sfc, upper air, rain and reflectivity; NSSL-MPAS-L67 improves on geopotential height bias
- GFS-L110 tends to overpredict reflectivity with spurious storms sometimes, which may be related to more cloud ice/water and condensation (Aligo et al. 2009)
- Doubling vertical resolutions does not always lead to an improvement of the forecasts (GFS-L110); more tuning is needed to control instability

Aligo, E. A., W. A. Gallus , and M. Segal, 2009: On the Impact of WRF Model Vertical Grid Resolution on Midwest Summer Rainfall Forecasts. Wea. Forecasting, 24, 575–594