Report on the Development of GSI-based WRF 4DVAR

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ABSTRACT

The Boulder repository GSI code is coupled with the WRF tangent linear adjoint model and the GSI-based WRF 4DVAR has been developed. Several experiments are conducted to validate this 4DVAR system and all results confirm the performance of the GSI-based 4DVAR system.

1. Upgrades of WRF tangent linear and adjoint model

To couple the WRF tangent linear and adjoint model (WRFPLUS) with GSI, the subroutine interfaces for WRF tangent linear and adjoint are constructed. Some other subroutines, such as save/read basic states, perturbations and adjoint forcing are also coded. Furthermore, the WRFPLUS has been upgraded to the latest WRF repository and the adjoint check can achieve 15-16 digital identical. Now, we are working on the parallelization of WRFPLUS.

2. Coupling GSI with WRFPLUS

A module named wrf_pertmod.F90, was coded to sever as the coupler or hub between GSI and WRFPLUS and is the only new add-on file in source codes. wrf_pertmod.F includes the interfaces to call WRF, WRF_TL and WRF_AD separately and also include the subroutines conducting the transfer for state variables from GSI space to WRF space and its adjoint, as well as the transfer from WRF space to GSI space and its adjoint.

At this moment, the GSI-based WRF 4DVAR can run with 1-processor parallel run due to the the undergoing WRFPLUS parallelization. We have tested the system on IBM with XLF compiler and Linux with PGI compiler.

3. Single Observation test

4DVAR approach has the capability to implicitly evolve the static background error statistics to flow dependent structure. Single observation is the best way to demonstrate the property of 4DVAR. The analysis time is 2000-01-25-00 and the 4DVAR time window is 6 hours. A single 500mb temperature at (32.5,-72, marked as a red star) is assimilated at the end of the time window on 2000-01-25-06. The Figure 1 shows the hourly increments between the 6-hour control run (from first guess) and analysis run (from 4DVAR analysis).

The analysis increment at 0h is located on the upstream and it evolved with time follow the wind stream. Eventually, at the end of time window, the increment arrive the observation location and the pattern of the increment has the flow dependent property.

4. 3-day real case

A 3-day CONUS domain, see Figure 2, are setup to run experiments to verify the performance of the GSI-based WRF 4DVAR system. The domain size is 47x32x28L, horizontal resolution is 135km; The Initial conditions and boundary conditions at every 6h are prepared from 2007-09-10-00 to 2007-09-13-00 and the initial conditions are the 12h forecast from NCEP FNL analysis; the NCEP GDAS prepbufr data will be used in assimilation.

We ran 3 experiments to compare the performance of the data assimilation. The first experiment is the CONTROL run without data assimilation, 48h forecast are made four times per day; The second experiment (3DVAR)is the 48h forecast from 3DVAR analysis four times per day; The third experiment (4DVAR) is the 48h forecast from 4DVAR analysis four times per day, Then, all the 48h forecasts are verified again the NCAR archived LITTLE_R format observation.

Figure 3 to Figure 11 show the profile RMSE from 0h to 48h forecast. At 0h, the 3DVAR gets the smallest profile RMSE overall as 3DVAR uses more observations in 0h that 4DVAR; At 6h, 4DVAR is the best , it is reasonable because 4DVAR uses the observations at 6h; In the subsequent forecast, 4DVAR experiment wins the verification and confirm our expectation. In the future, we will conduct higher resolution and longer period runs to further confirm the benefit of the 4DVAR.

List of Figures

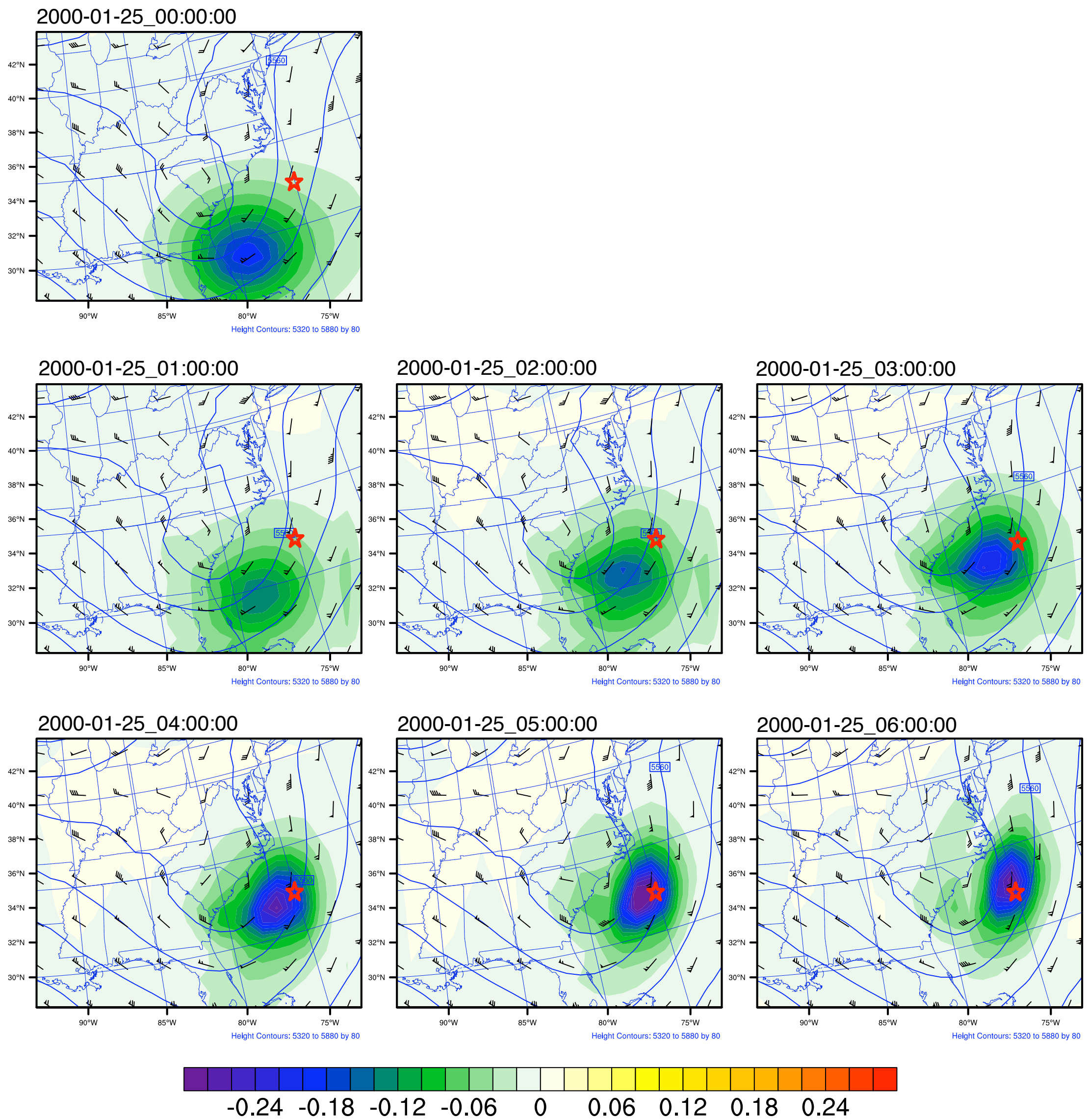

FIG. 1. Hourly increment evolution from 0h to 6h

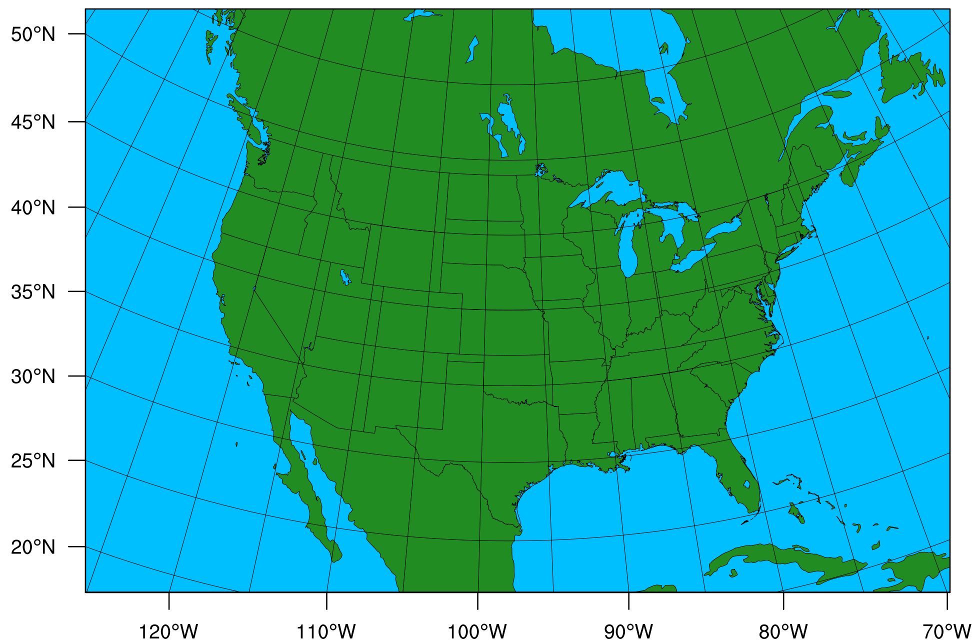

Fig. 2. domain configuration

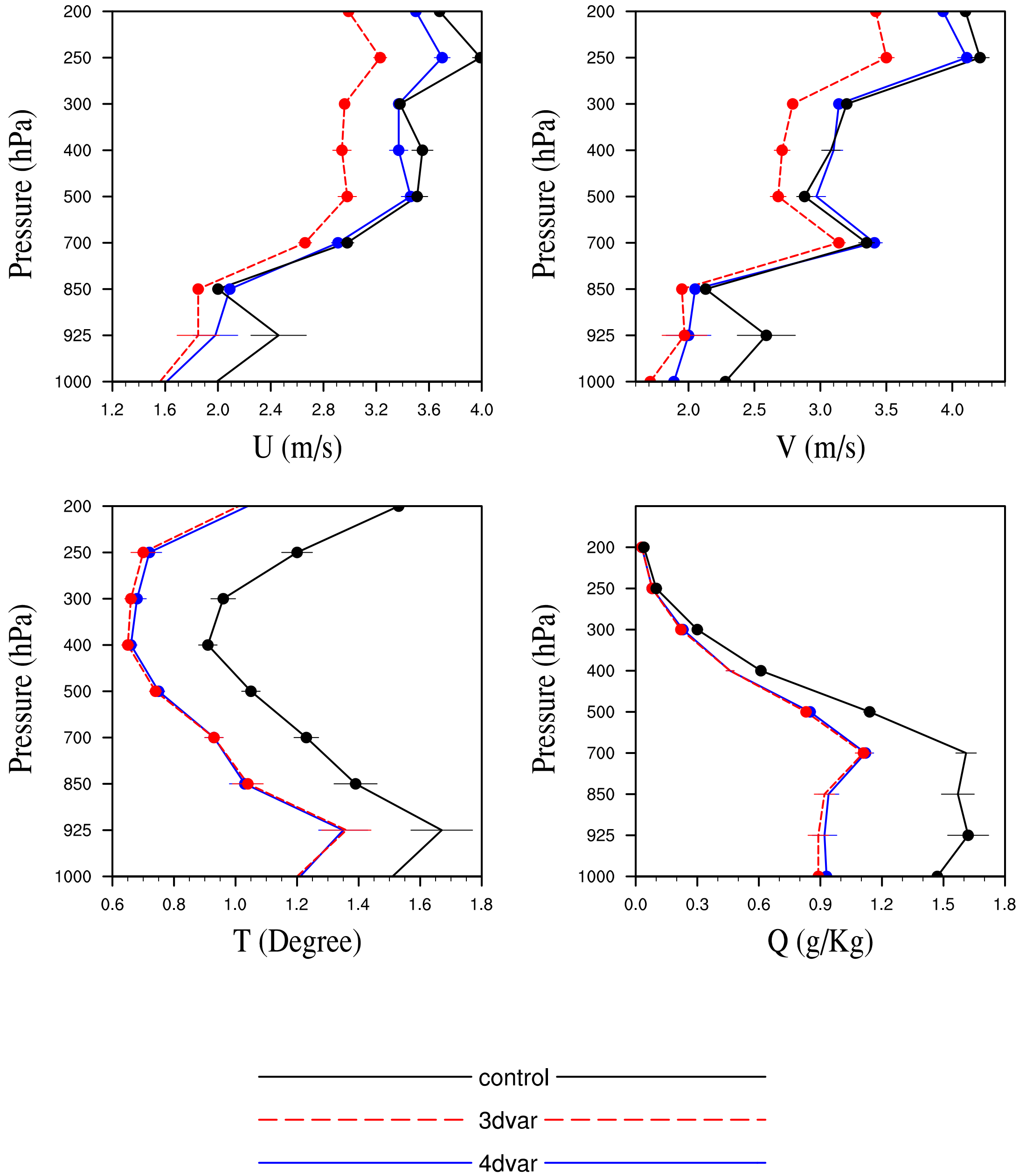

FIG. 3. Profile RMSE at 0h

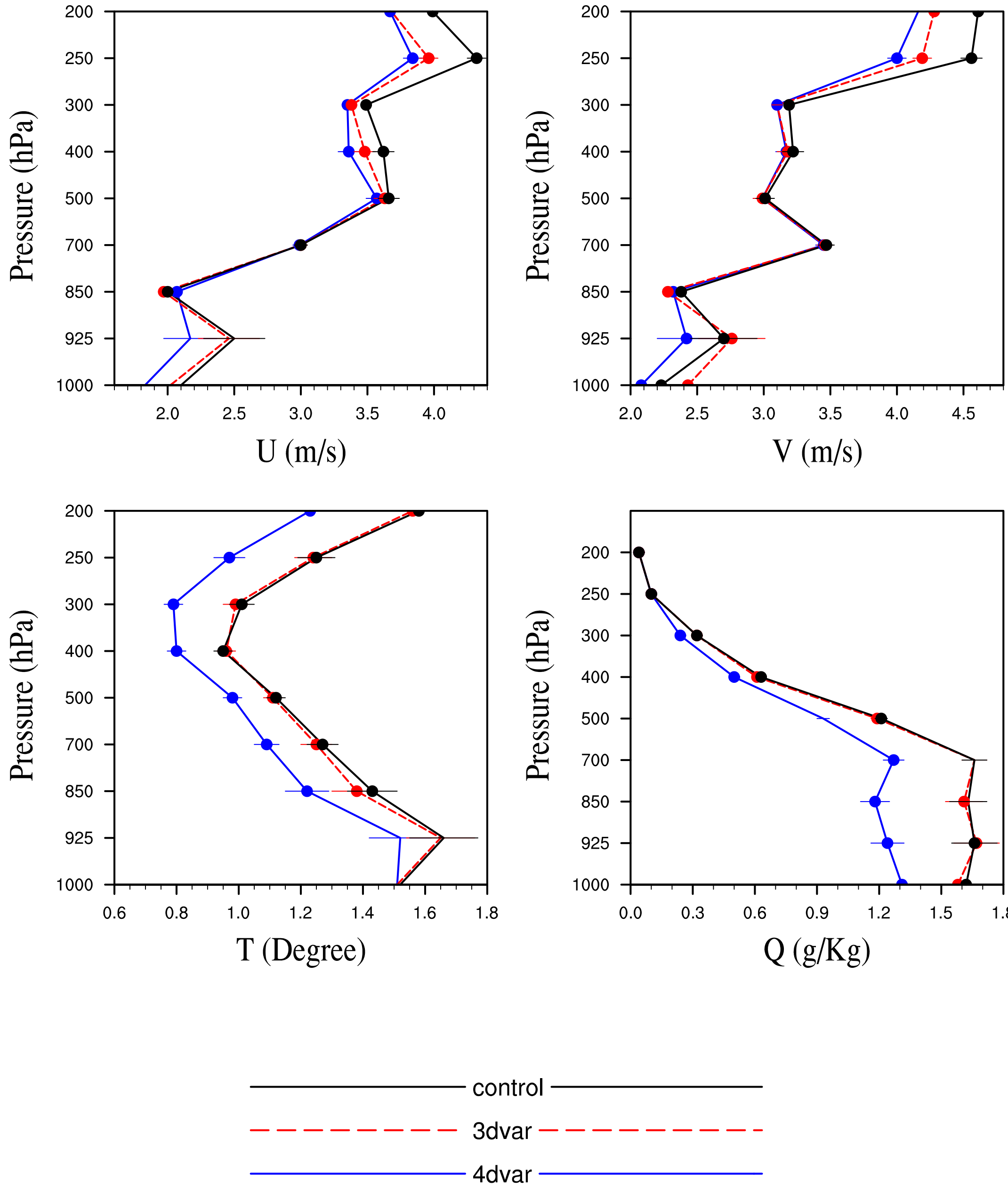

Fig. 4. Profile RMSE at 6h

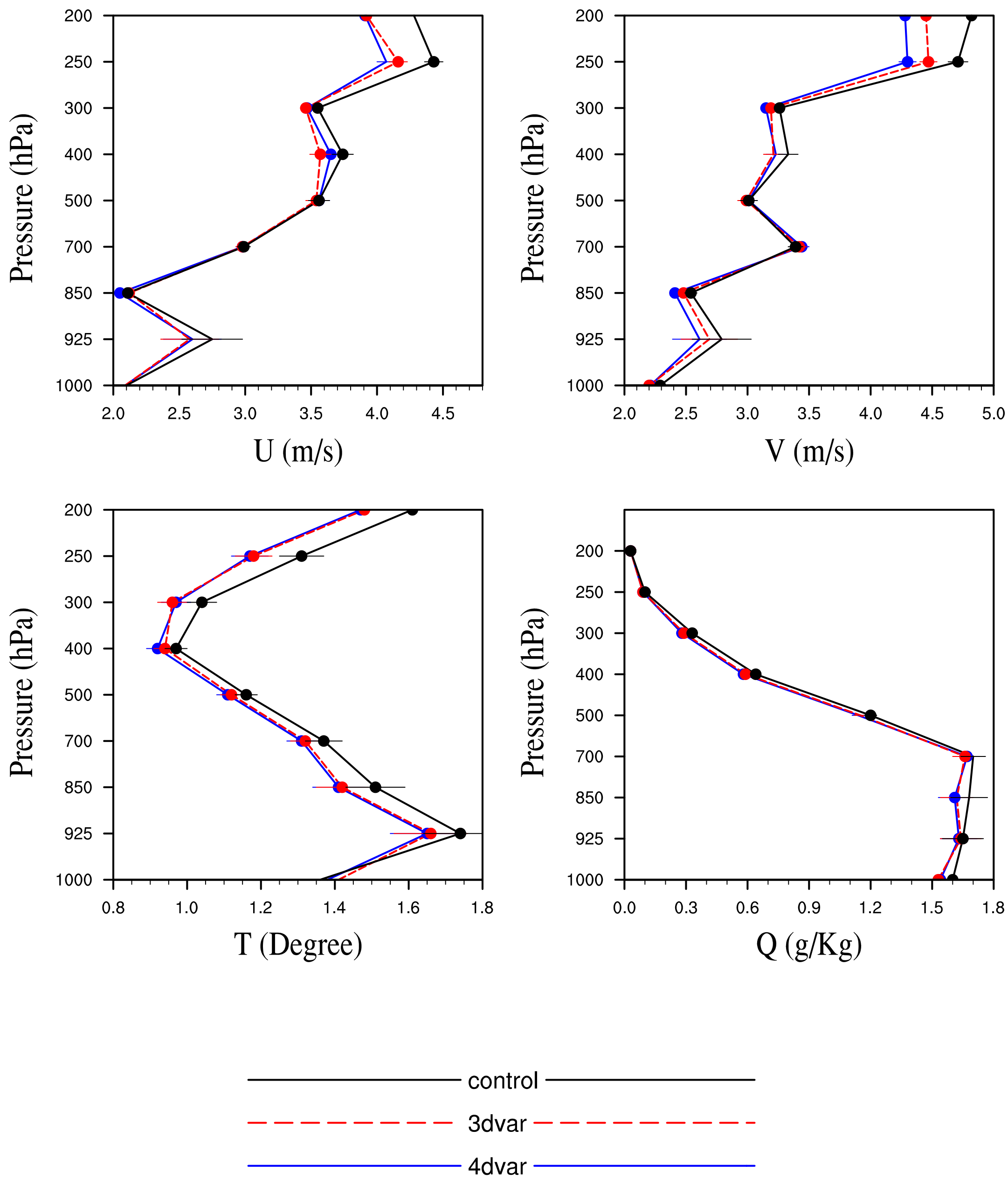

FIG. 5. Profile RMSE at 12h

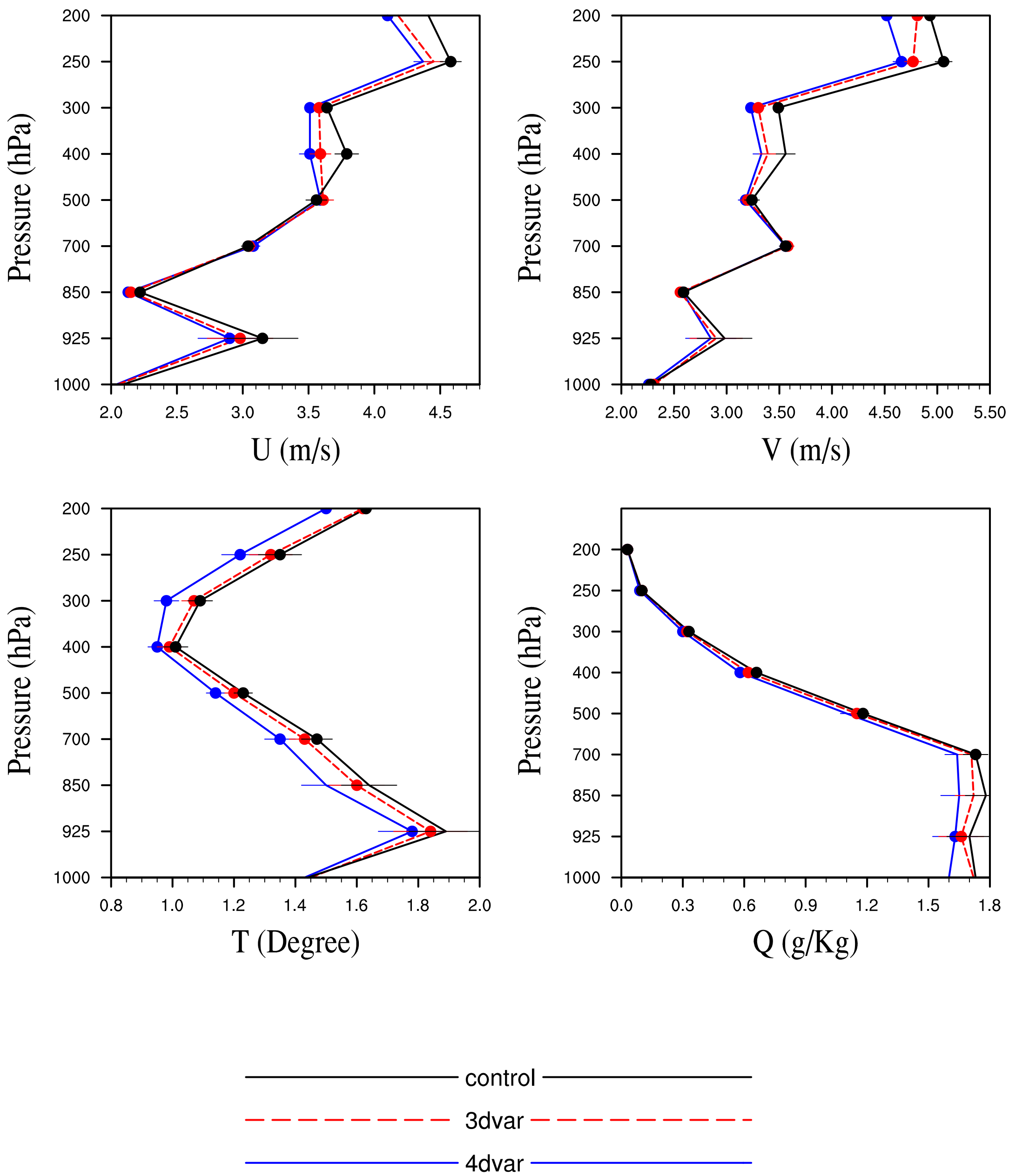

Fig. 6. Profile RMSE at 18h

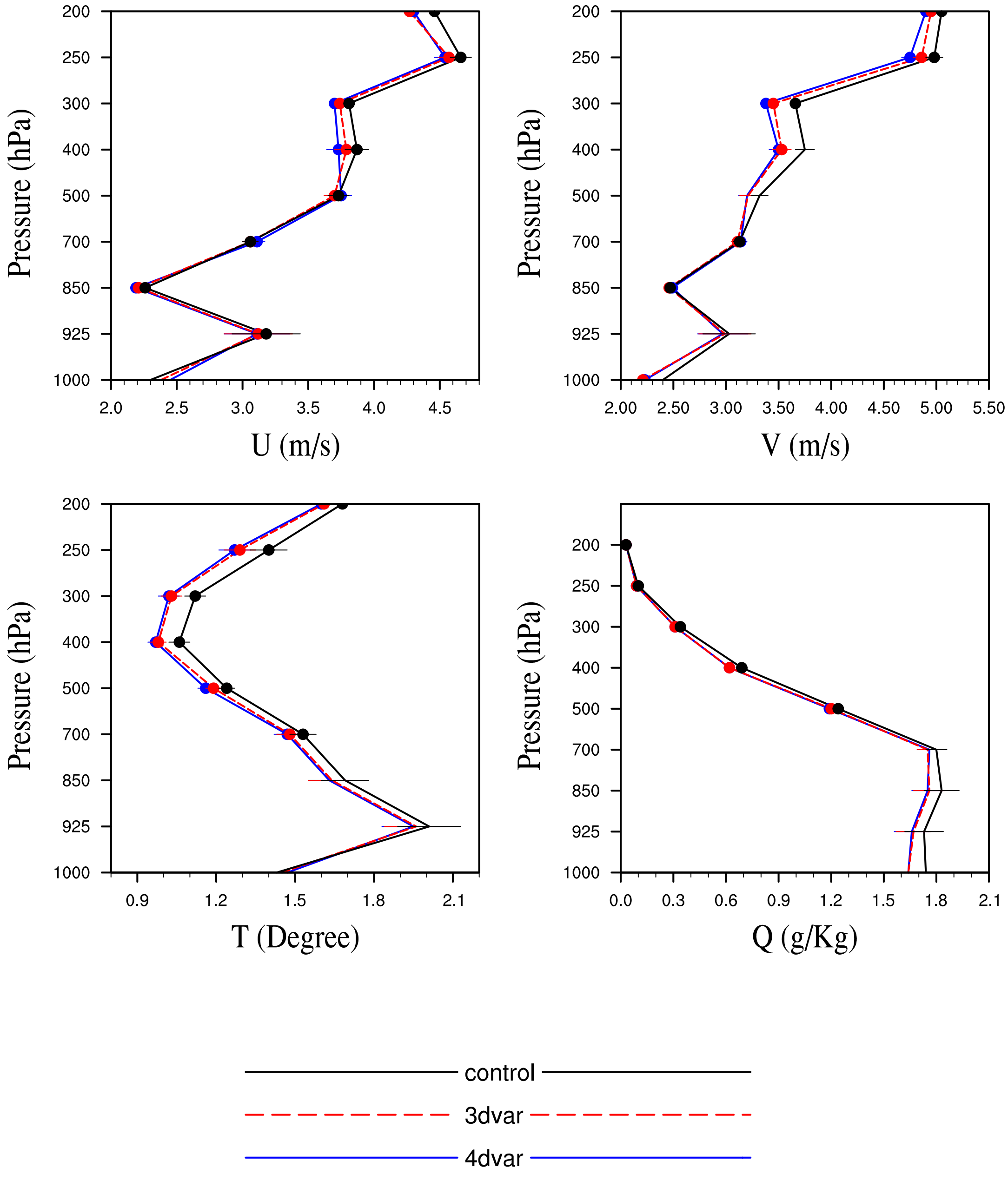

FIG. 7. Profile RMSE at 24h

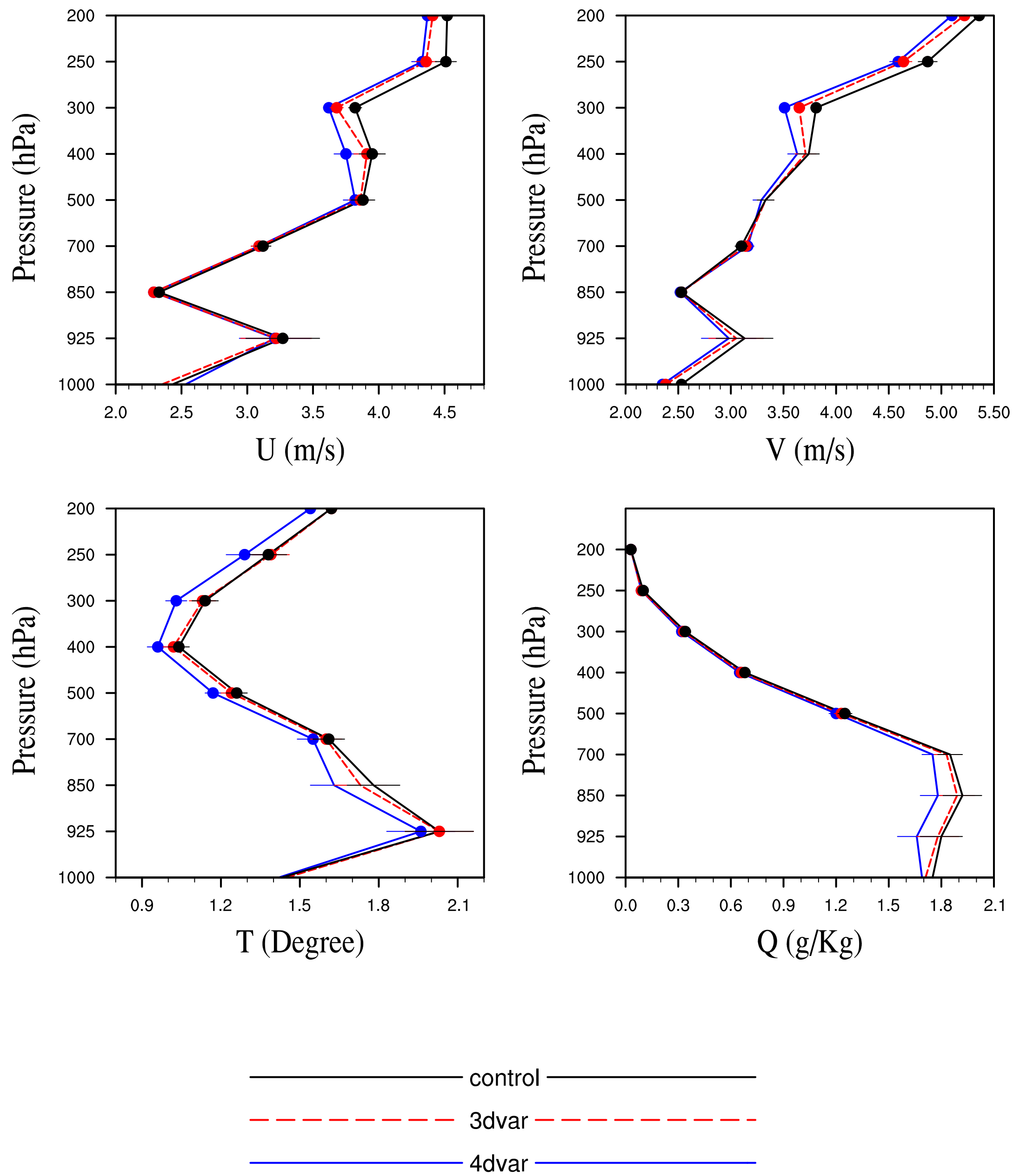

FIG. 8. Profile RMSE at 30h

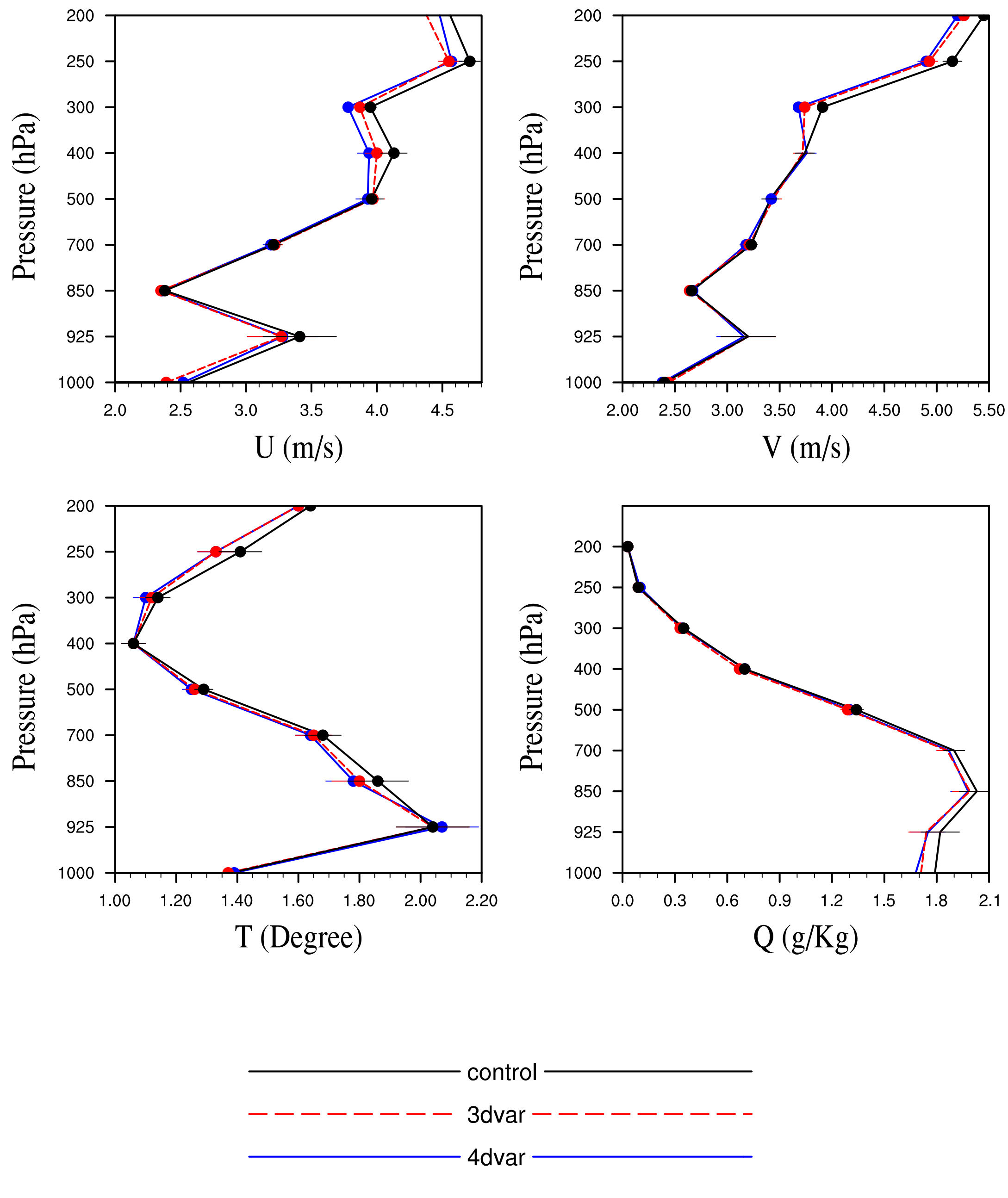

FIG. 9. Profile RMSE at 36h

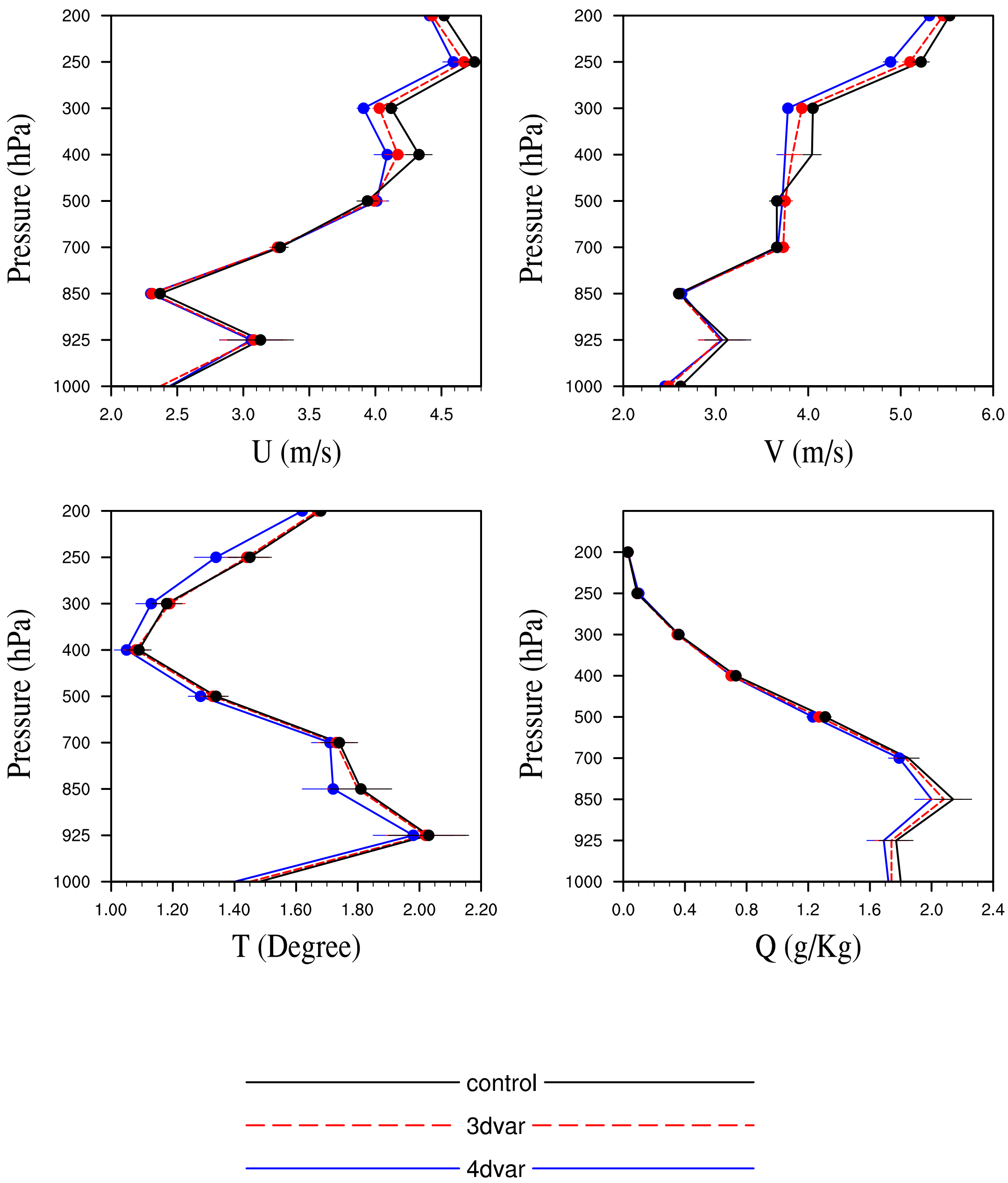

Fig. 10. Profile RMSE at 42h

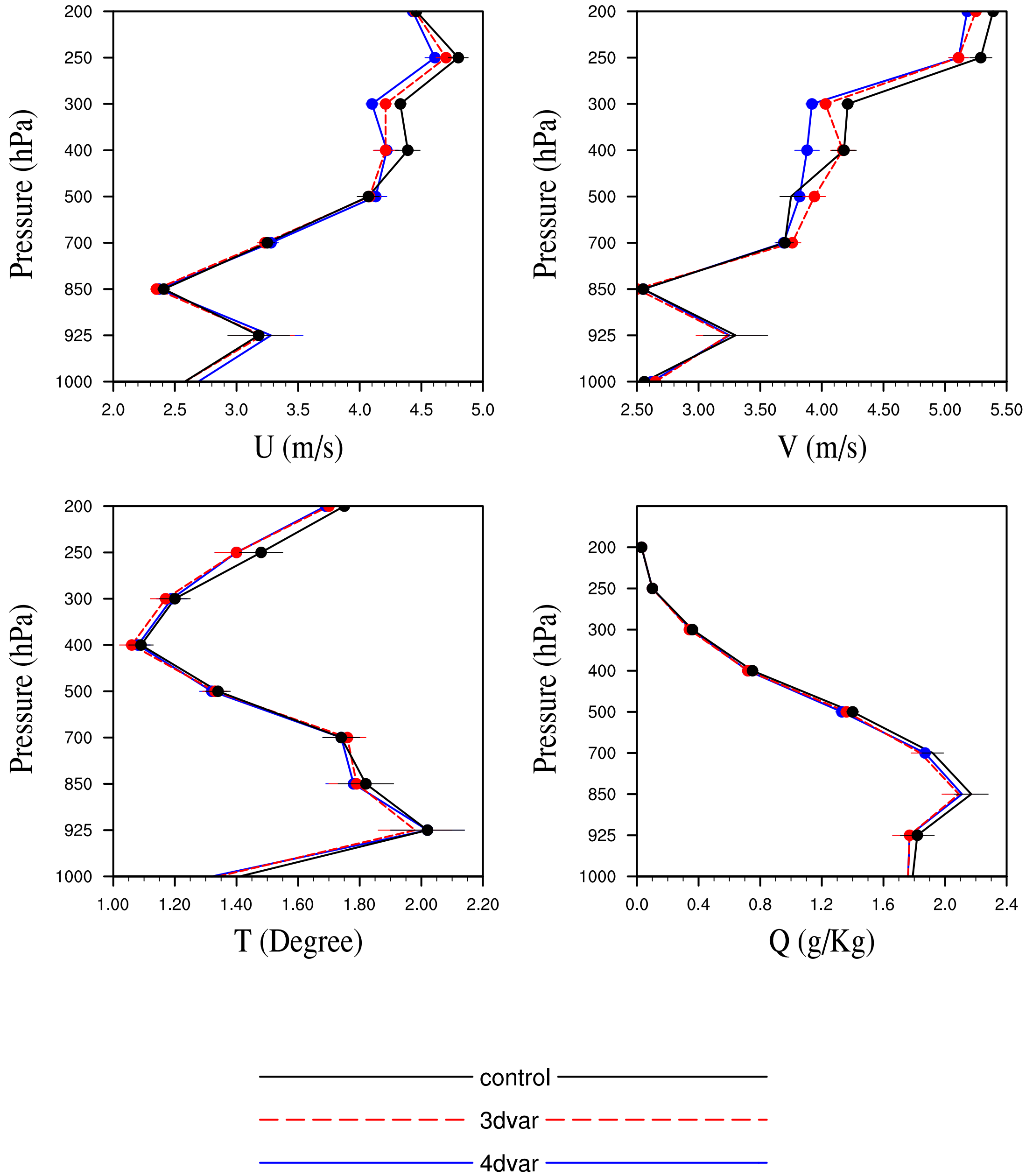

FIG. 11. Profile RMSE at 48h