3.3 PBL AND OZONE VERIFICATION IN NAM-CMAQ MODELING SYSTEM AT NCEP

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1. INTRODUCTION

NOAA/EPA air quality forecast capability has been implemented at NWS (Davidson et al, 2004; Otte et al, 2004). The current version of the linked model system uses WRF/NMM model as the meteorological driver and the CMAQ model for predicting reactive transport of chemical species. In operational mode, the system provides 48-hours ozone forecasts twice a day for the Eastern US domain, for 06Z and 12Z initial times. In experimental and developmental modes, the system also makes ozone predictions for larger continental US domain, and provides aerosol predictions (McQueen et al, 2005). Since PBL height is one of key parameters in air quality modeling determining extent of turbulence and dispersion of pollutants, it is extremely important to estimate accuracy of PBL predictions in meteorological model. In this study, the PBL heights forecasts from WRF/NMM model are verified. Since boundary layer measurements are usually undertaken for specific episodes in different field studies but they do not exist on regular basis, radiosonde data are used for PBL height estimation in this study. Wind, temperature and moisture profiles determine the extent of boundary layer. Also, for the 15 days period of TexAQS experiment, the model is verified with observational PBL heights derived from profiler data.

2. METHOD

In PBL height calculations, WRF/NMM model utilizes turbulent kinetic energy (TKE) scheme, whereas the 'observational' PBL is computed from radiozonde profiles using critical Richardson number approach (Vogelezang and Holtslag, 1996). Bulk Richardson number is computed for each layer in radiosonde profile. Critical Ri_{CR} = 0.25 is used to determine the top of boundary layer. Since fluxes measurements do no exist in radiosonde data they are set to be zero in surface layer calculations.

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3. EVALUATION FOR DIFFERENT REGIONS

PBL height verification is done for Eastern and Western parts of the US. It is clearly seen in Fig.1 that for the period of July-August 2006, Western US has significantly deeper boundary layer than Eastern US. Besides WRF/NMM, Eta 32 km model is also evaluated. Both models over predict PBL height. Over the East, over prediction is larger in WRF/NMM model than in Eta; over the West WRF/NMM seems to provide better results. Both regions are slightly improved with introducing the updated version of WRF/NMM. PBL over prediction over Western domain could be a potential reason for significant ozone under prediction in California found in AQ forecast system in Summer 2006 , illustrated in Fig. 2.

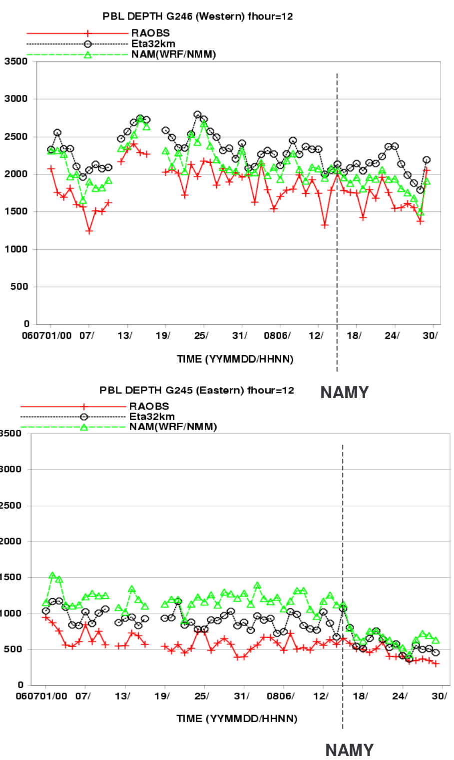

Fig.1: WRF/NMM, Eta32 and RAOBS PBL depth for Western (a) and Eastern (b) sub-domains for July-August 2006. NAMY line indicates the update of WRF/NMM model.

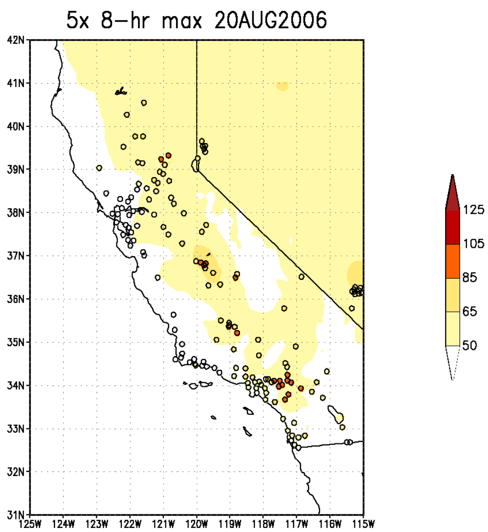

Fig. 2: Surface ozone concentration (ppb): CMAQ forecast (field) and AIRNOW observations (circles) for 20 August, 2006.

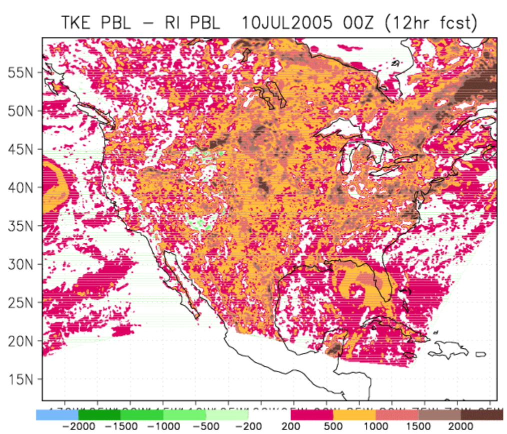

Fig. 3: Difference (m) between WRF/NMM PBL heights derived from TKE scheme and recomputed using Richardson number approach.

4. TKE and RI NUMBER APPROACHES

For the method verification, the Richardson number approach was also applied to model output. In this experiment, the model still uses TKE approach for internal boundary layer scheme, but PBL heights are recalculated from model profiles of wind, temperature and moisture the same way as the RAOBS algorithm utilizes the calculations. A sample of differences between internal PBL heights and estimated from output profiles with critical Richardson number criteria is provided in Fig.3. Almost over the whole domain, the TKE PBL is deeper than the Richardson number PBL.

5. TEXAQS PBL HEIGHTS

In TexAQS 2006, profiler data are used to provide an accurate estimation of PBL heights during the experiment. In this study, PBL heights for five stations derived from profiler observations are compared with the WRF/NMM predicted PBL heights. Fig.4 shows the location of two profiler stations as well as one radiosonde located close to one of the profilers. For all five stations, most of time the model predicts higher PBL than the measurements report. As one can see from Fig.5, the model fits well the observations during the period of growing boundary layer but provides significantly higher daily peaks. Also, sometimes different forecast hours in the model predict different PBL maxima for the same verification time. From profiler and RAOB comparison, the radiosonde seems to provide lower PBL than the profiler does, but it should be taken into account that radiozonde data are available only twice a day – 00z and 12z, and boundary layer is usually passes its maximum and begin to destroy when RAOBS estimations could be applied. PBL over prediction (Fig. 6) as well as land and ocean boundary layer differences could be one of the reasons of ozone under prediction and displacement shown in Fig.4.

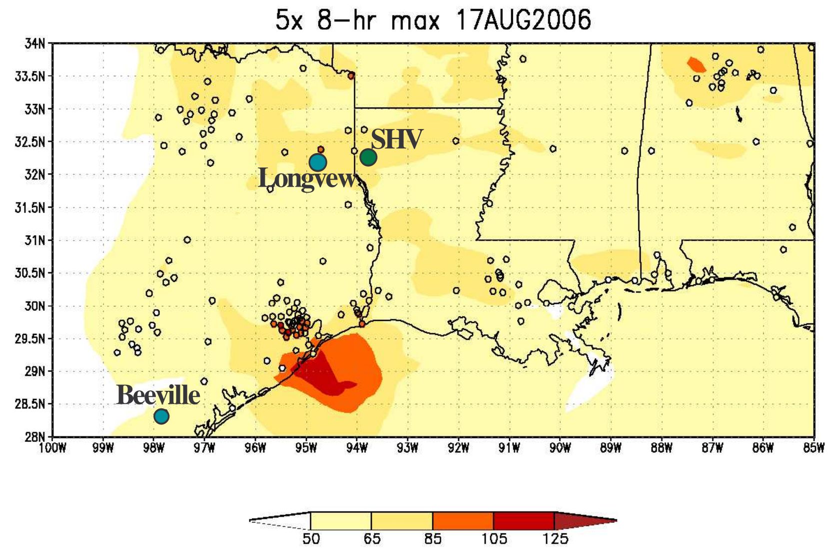

Fig. 4: Surface ozone concentration (ppb): CMAQ forecast (field) and AIRNOW observations (circles) for 17 August 2006.

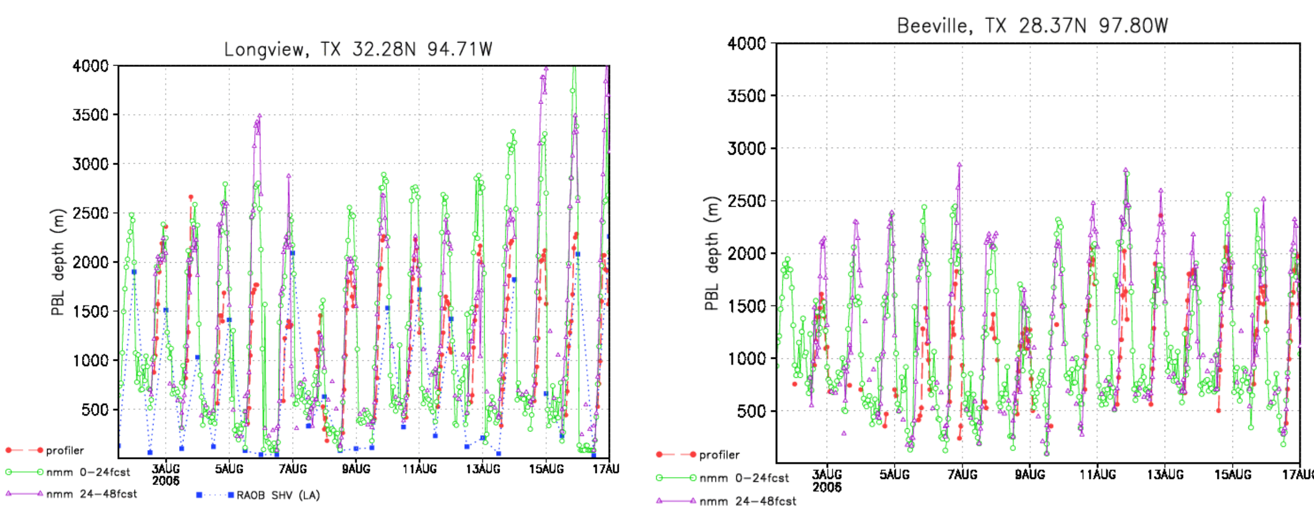

Fig. 5: Time series of PBL heights forecasted in WRF/NMM (green and purple) and derived from profiler (red) and radiosonde (blue): Longvew (a) and Beeville (b).

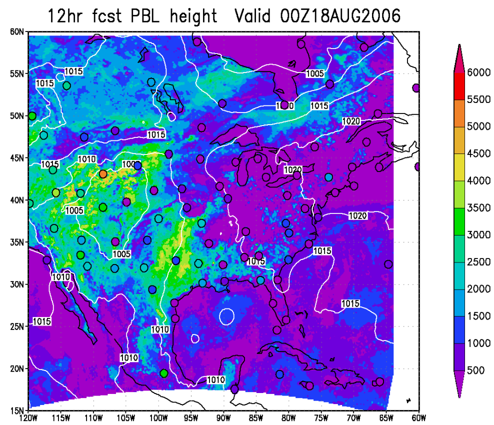

Fig. 6: PBL height (m): WRF/NMM 12h forecast (field) and RAOBS estimations (circles). Valid at 00Z 18 August 2006.

6. SUMMARY

PBL heights from WRF/NMM and ETA models are verified for summer 2006 period with RAOBS observations. WRF/NMM model is also verified with PBL heights provided by profiler measurements during 15 days period of TexAQS experiment. For geographical regions, WRF/NMM produces higher than ETA boundary layers over Eastern US, and lower over Western US. Both models produce higher PBL than the RAOBS observations estimate. Richardson number approach used for model PBL height recalculations provides better agreement with RAOBS estimations. Updated WRF/NMM (NAMY) provides small improvement in PBL heights. In TexAQS experiment, the WRF/NMM model produces deeper boundary layer than the observations report. PBL heights computed from profiler data (TexAQS/Longview) are similar to RAOBS(SHV) data, although the profiler fits the model results better.

7. ACKNOWLEDGMENTS AND DISCLAIMER

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8. REFERENCES

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