Observing System Experiments in the Dallas-Fort Worth Testbed

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Introduction

A 2009 report published by the National Research Council:

- Noted the inability to sufficiently observe the 3D mesoscale structure of the atmosphere
- Recommended that existing and new mesoscale networks be combined to form a nationwide "Network of Networks"

Global Science and Technology (GST) was selected to develop a system known as Mobile Platform Environmental Data (MoPED)

- Observations collected from trucks and other vehicles

Observing system experiments (OSEs) will be performed to assess the utility of assimilating MoPED data in high-resolution analyses and forecasts of convection

- Active vehicles collect observations every 10 seconds
- Goal: Determine optimal averaging time period for implementing MoPED observations in these OSEs

Data and Methodology

2, 3, 4, and 5 minute averages of air temperature, dew point temperature, and surface pressure are compared to 1 minute averages using a two-sided hypothesis test

- Data: 1950 to 2150 UTC on 5 November 2015 (truck CW14L)
- Null hypothesis is that the means for the 2, 3, 4, and 5 minute averages are not different from the respective means of the 1 minute averages
- Alternative hypothesis: the means are statistically different
- Level of significance = 90%
- Hypothesis test is performed using permutation testing
  - Number of permutations used for each test is 999

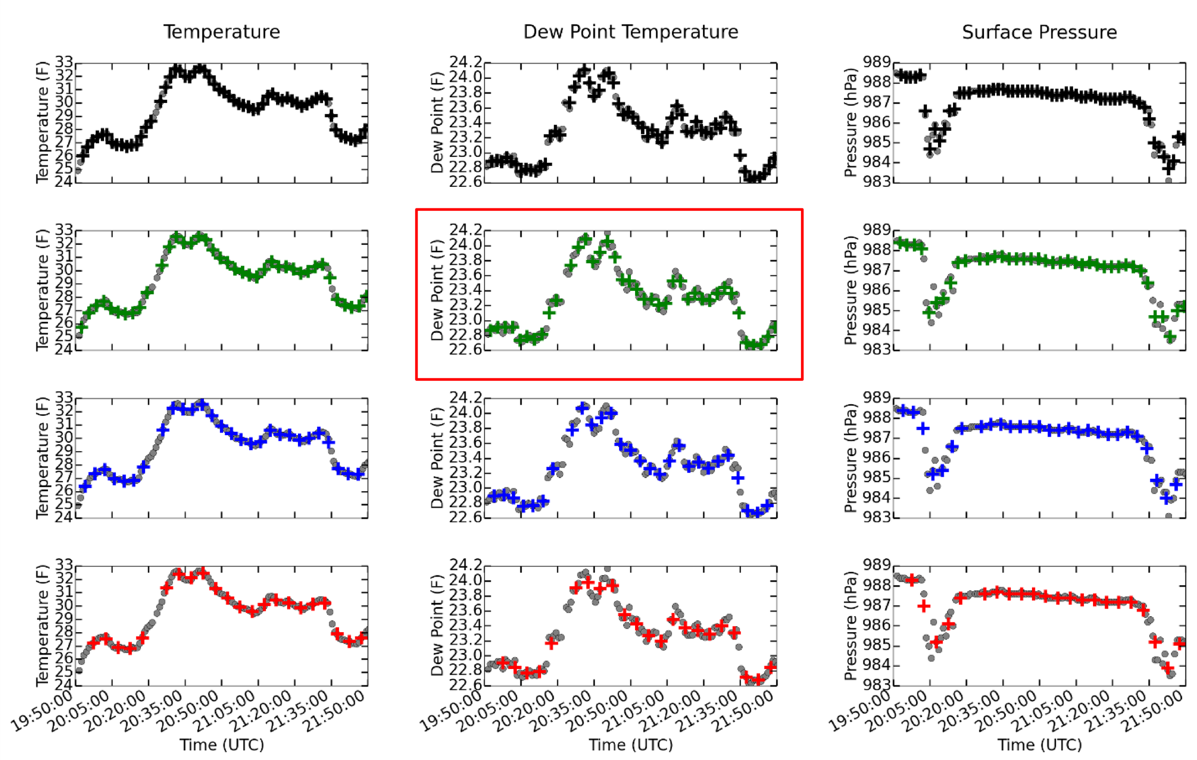

Figure 1: Thinned MoPED observations. The gray dots in each figure correspond to 1 minute averages of the respective variable. Black plus signs represent results of the two-minute averaging scheme, while green plus signs are for three-minute averages, blue plus signs represent four-minute averages, and red plus signs correspond to five-minute averages.

Results

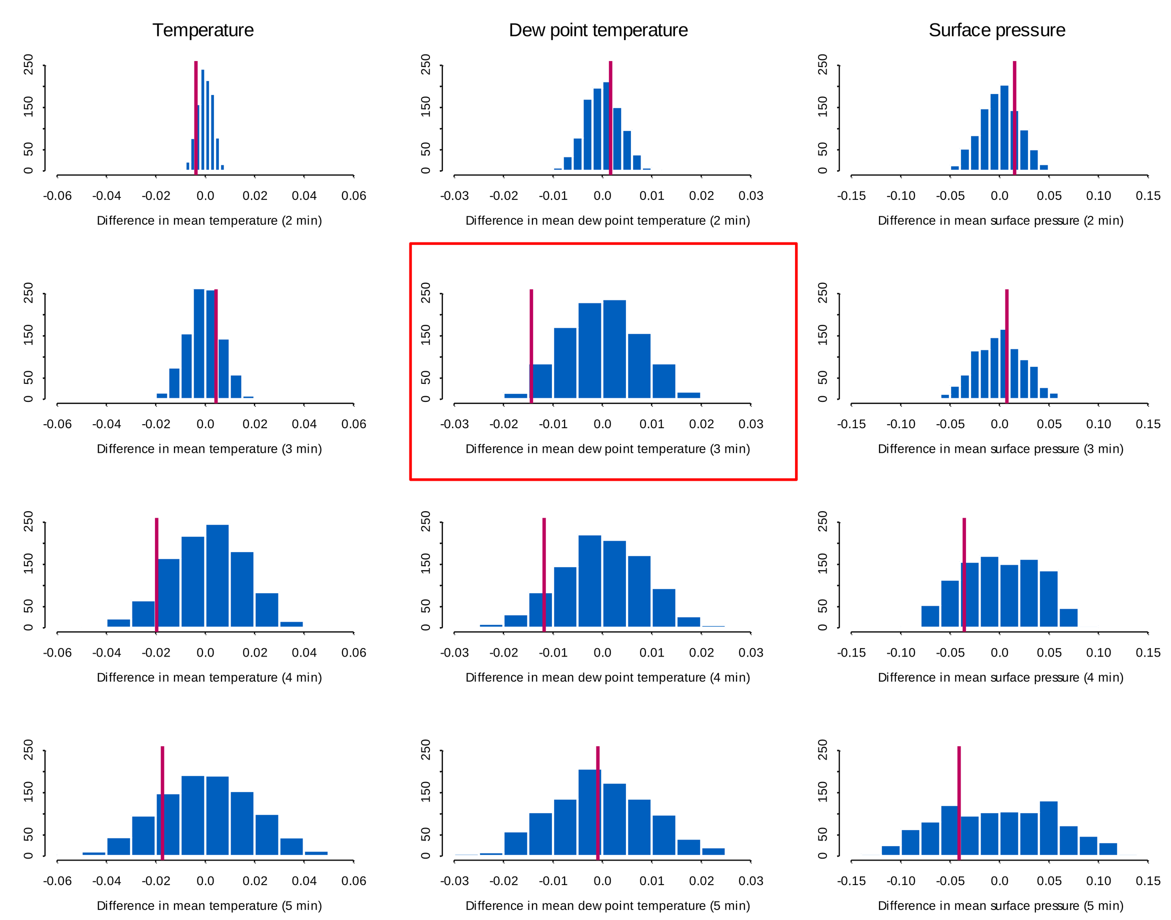

Figure 2: Results of the permutation test. The blue bars represent the differences in permutation means. The vertical red line represents the difference in mean between the two original datasets.

Table 1: Comparison of 1 min and 3 min averages (n = 39):

	Temperature	Dew point temp.	Surface pressure
Difference in sample means	0.005	**-0.015**	0.007
Standard deviation	0.0068	**0.0075**	0.0250
Two-sided p-value	0.524	**0.056**	0.832

Table 2: Comparison of 1 min and 4 min averages (n = 28):

	Temperature	Dew point temp.	Surface pressure
Difference in sample means	-0.019	-0.012	-0.036
Standard deviation	0.0149	0.0085	0.0385
Two-sided p-value	0.184	0.202	0.434

Dew point temperatures averaged using a 3-minute time interval are shown to be statistically different from 1-minute averages.

- No significant difference found for temperature and surface pressure

Tests of two further data sets (not shown) yielded different results

- Truck CW14L (1700 to 1800 UTC): 4-minute averages of surface pressure were shown to be statistically different
- Truck CW0W6 (1700 to 1810 UTC): 4-minute averages of dew point temperature demonstrated statistical significance

Future Work

- Differing results could be based upon environmental factors (e.g., air mass boundaries) and distance traveled by the vehicle (not considered in this study)
- In the future, an algorithm will be developed that factors in both the distance and time elapsed between observations.

WRF/3DVAR Cleburne, TX Tornadic Supercell Case Study

- Carlaw et al. [2015] found substantial impact from Weatherbug, CWOP, and GST MoPED surface observations on high-resolution analysis and forecast accuracy
- Case details:
  - -16 May 2013
  - -Supercell forms 0000 UTC-0100 UTC in Hood County
  - -Spawns EF3 tornado near Cleburne around 0215 UTC

Goal

- Determine impact of non-conventional observation types on cycled analyses and forecasts using 3DVAR and the WRF model.

Data and Methods

- Two nested domains (3 km and 400 m)

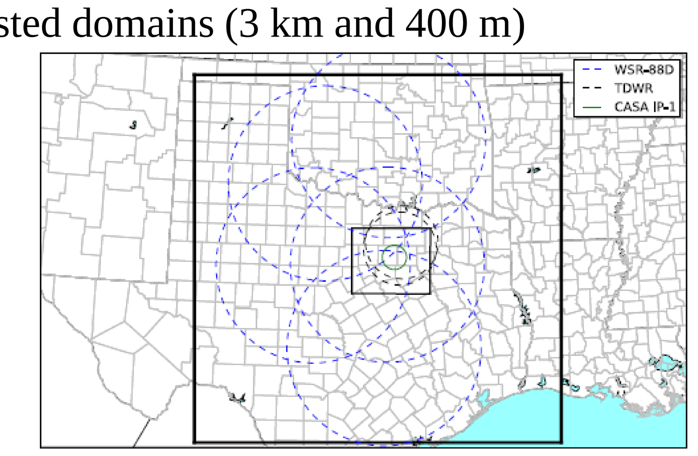

Figure 3: Coarse and fine grid domains with range rings from the assimilated radars

- 3DVAR/WRF cycled DA
- Hourly cycles on outer grid
- 5 minute cycles on inner grid
- Free forecast out from 0145 UTC (400m grid)

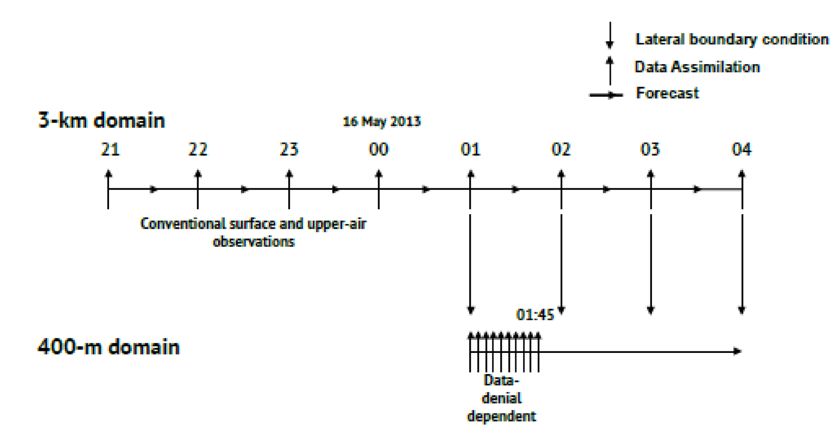

Figure 4: Depiction of data assimilation cycling logic

- Two separate experiments to examine impact of new observation types
- Examine differences in forecasted storm structure via reflectivity
- RMS error of analyzed near-storm thermodynamic environment

Experiment	Conventional	Non-Conventional
CTL	ASOS/AWOS, MDCRS, Mesonet, Wind Profilers, Raobs, Radars	GST MoPED, AWS Weatherbug, CWOP stations
NONEWSFC	ASOS/AWOS, MDCRS, Mesonet, Wind Profilers, Raobs, Radars	None

Results

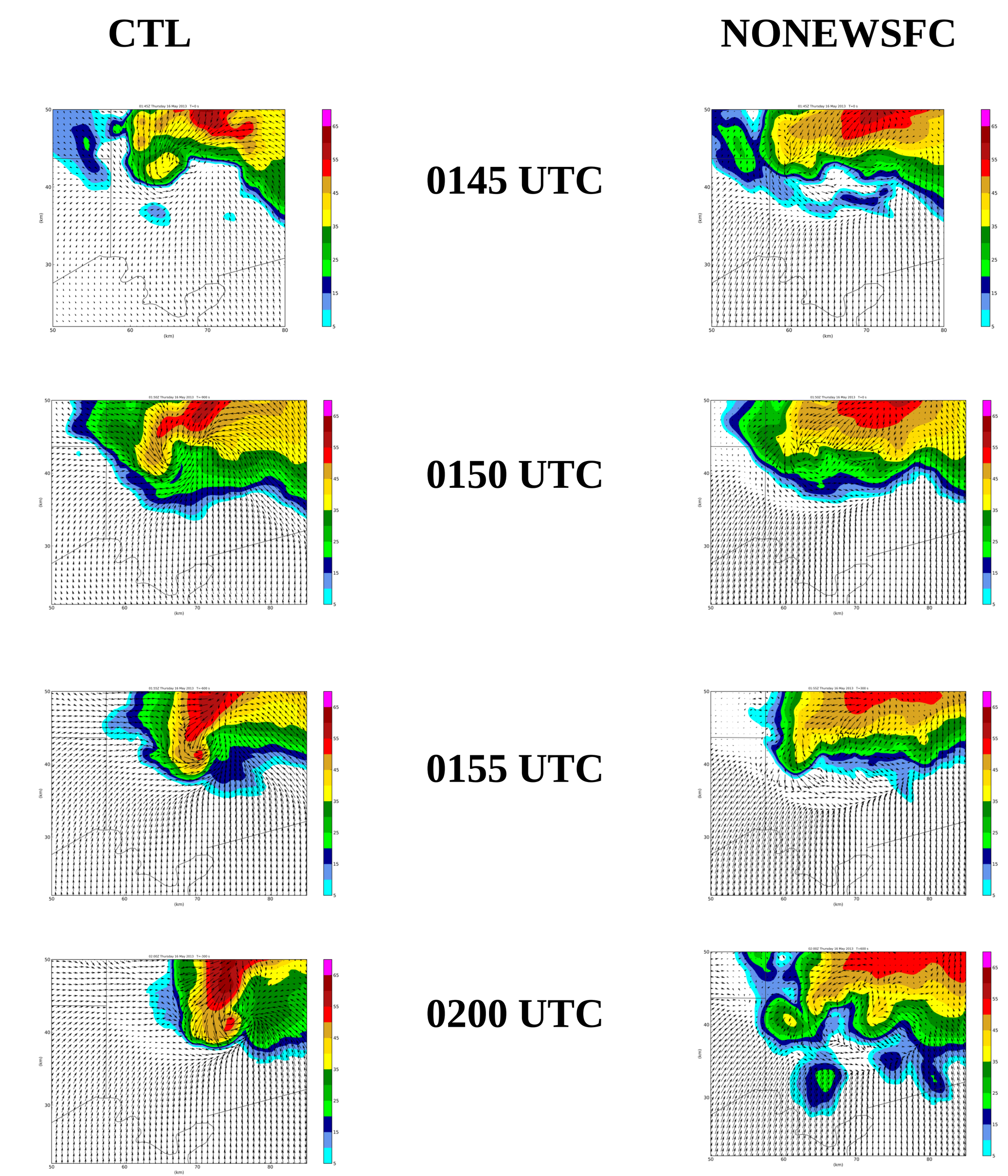

Figure 5: WRF Forecasted Z_H over Johnson County from control run (left) and data denial run (right)

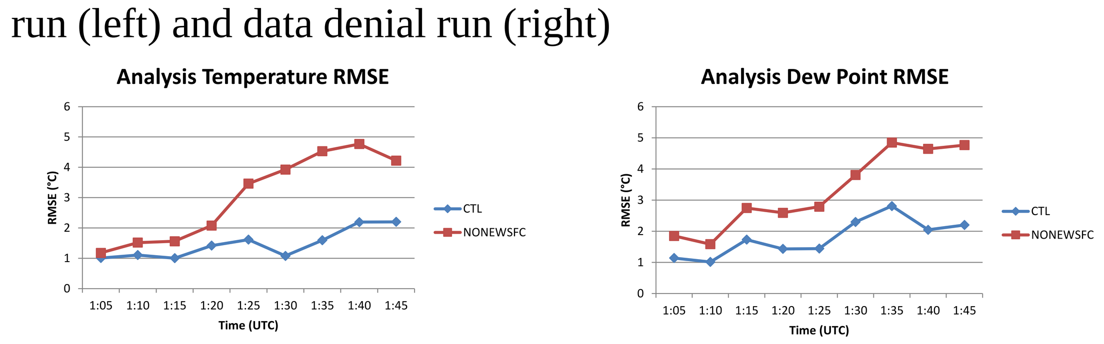

Figure 6: 3DVAR temperature (left) and dew point (right) analysis root mean squared error based on comparison with 10 independent ASOS sites in the Dallas/Fort Worth Metro area. Covers the DA cycling period on the 400m grid from 0100 UTC to 0145 UTC.

Conclusions

- Assimilation of non-conventional observations was found to improve the forecast structure of the supercell thunderstorm
- Error of temperature and dew point analyses reduced with addition of new observations
- WRF model shows similar sensitivity to non-conventional observations as ARPS model did for this case
- Future work will look at a more robust data set (i.e. month or longer period) to further assess the impact of these observations.
- EnKF data assimilation will be combined with WRF model simulations for future observing system experiments

Acknowledgements

This work is supported in part by the NWS Network of Networks, National Mesonet Project. DFW Testbed and CASA work is funded by NSF, NWS, NCTCOG. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the funding agencies. OU OSCER (Boomer) supercomputing resources were used for the numerical modeling experiments in this study.