Evaluations of Prognostic Meteorological Models with Field Observations, with Focus on Meteorological Variables used in Dispersion Models

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Boundary layer (BL) variables needed by dispersion models

- **Operational needs** – Met model (e.g., MM5, WRF, RAMS) BL outputs can be fed directly to the dispersion model. For example SCIPUFF can accept surface fluxes, PBL height, and vertical profiles of winds, temperature, and turbulence (TKE)
- **Question** – For the same basic weather scenario, do the Met model BL outputs agree reasonably well with each other, with field data, and with the dispersion model internal parameterized formulas?

Two research studies summarized here

- **Hanna and Yang 2001**
  - MM5, RAMS (*SARMAP Central CA, OTAG Eastern US, LMOS*; all from Tesche and McNally)
  - OMEGA, COAMPS, MM5; Iraq 1991

- **Hanna et al 2010**
  - IHOP 2002 (OK, KS) MM5, WRF-NMM

Results of 2001 study with four models (MM5, RAMS, COAMPS, OMEGA) and four domains (SARMAP, OTAG, LMOS, Iraq)

- **For summer with mean winds of about 3 m/s:** Wind speed (WS) and wind direction (WD) typical <u>mean bias</u> is 1 m/s and 10°; <u>rmse</u> is 2 m/s and 60°

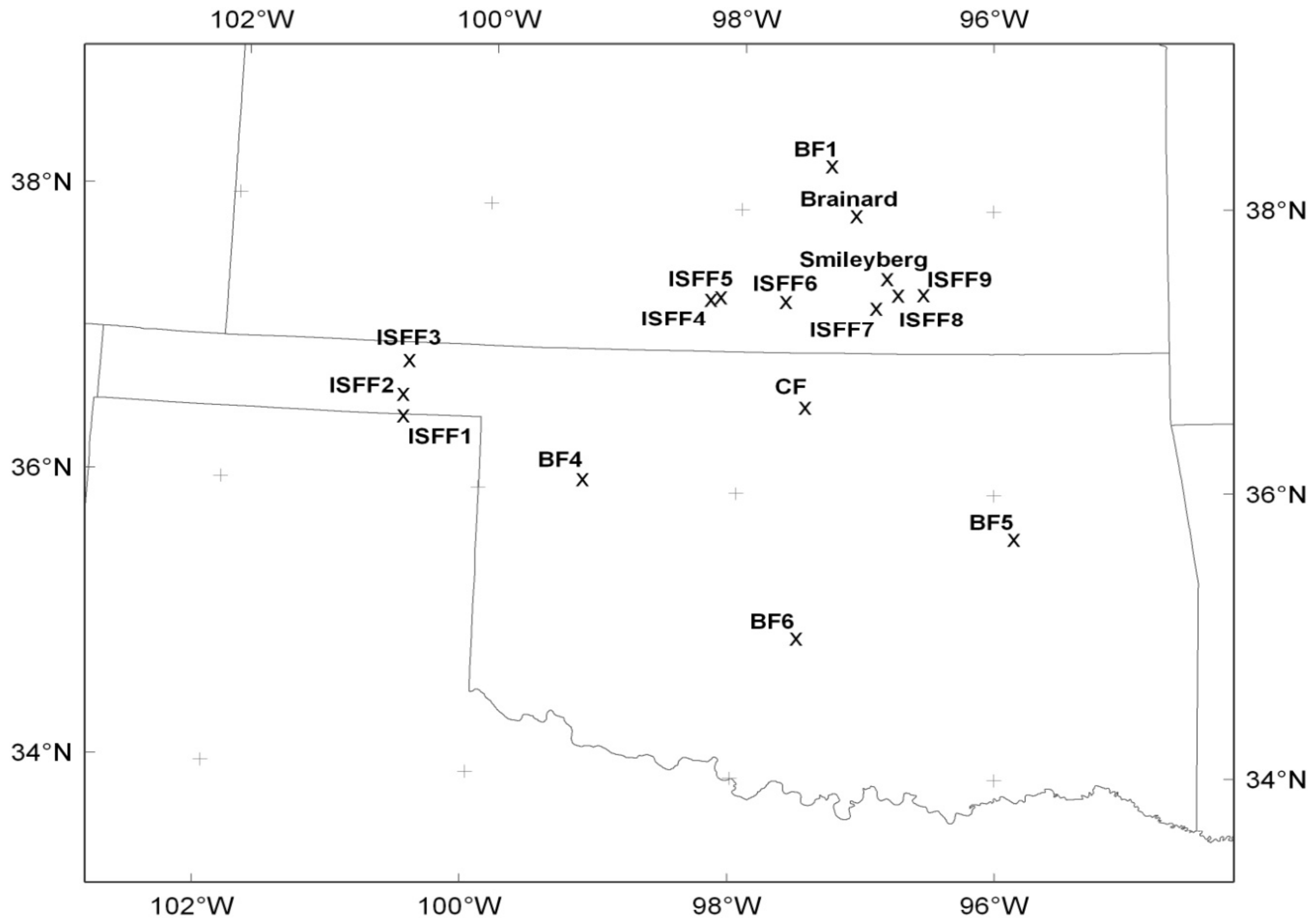
- **Vertical temperature gradients (dT/dz)** are generally underestimated for daytime capping inversions and nighttime ground-based inversions (probably due to inadequate resolution)

Three heavily instrumented test days from **I**nternational **H**2**O** **P**roject (**IHOP**) over southern great plains

- 3 May to 25 June 2002. The chief aim was improved characterization of the distribution of water vapor and its use to improve the prediction of convection.

- The 3 test days are “typical” with some clouds over part of the area and some scattered light rain.

IHOP Observing Sites

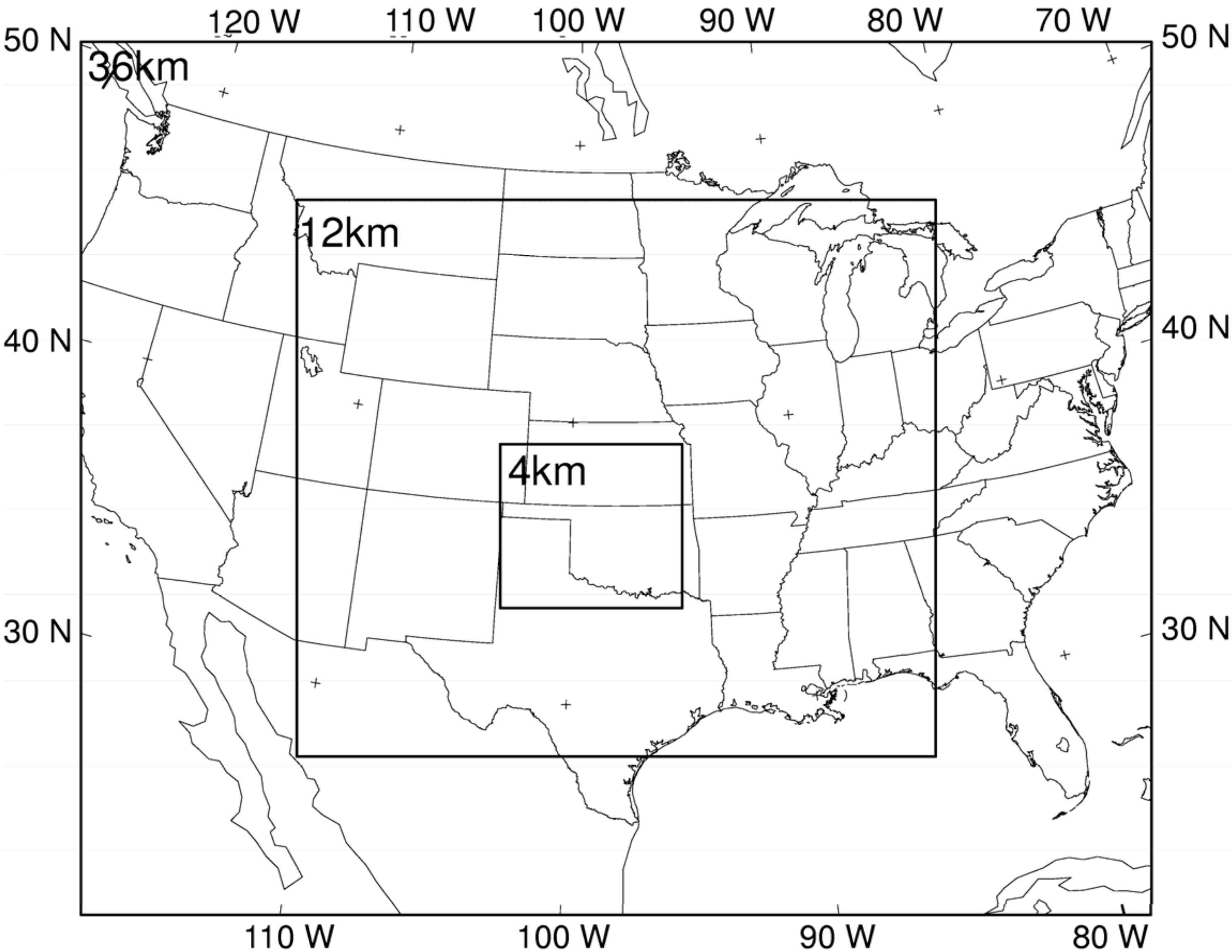


Met Models – MM5 and WRF-NMM

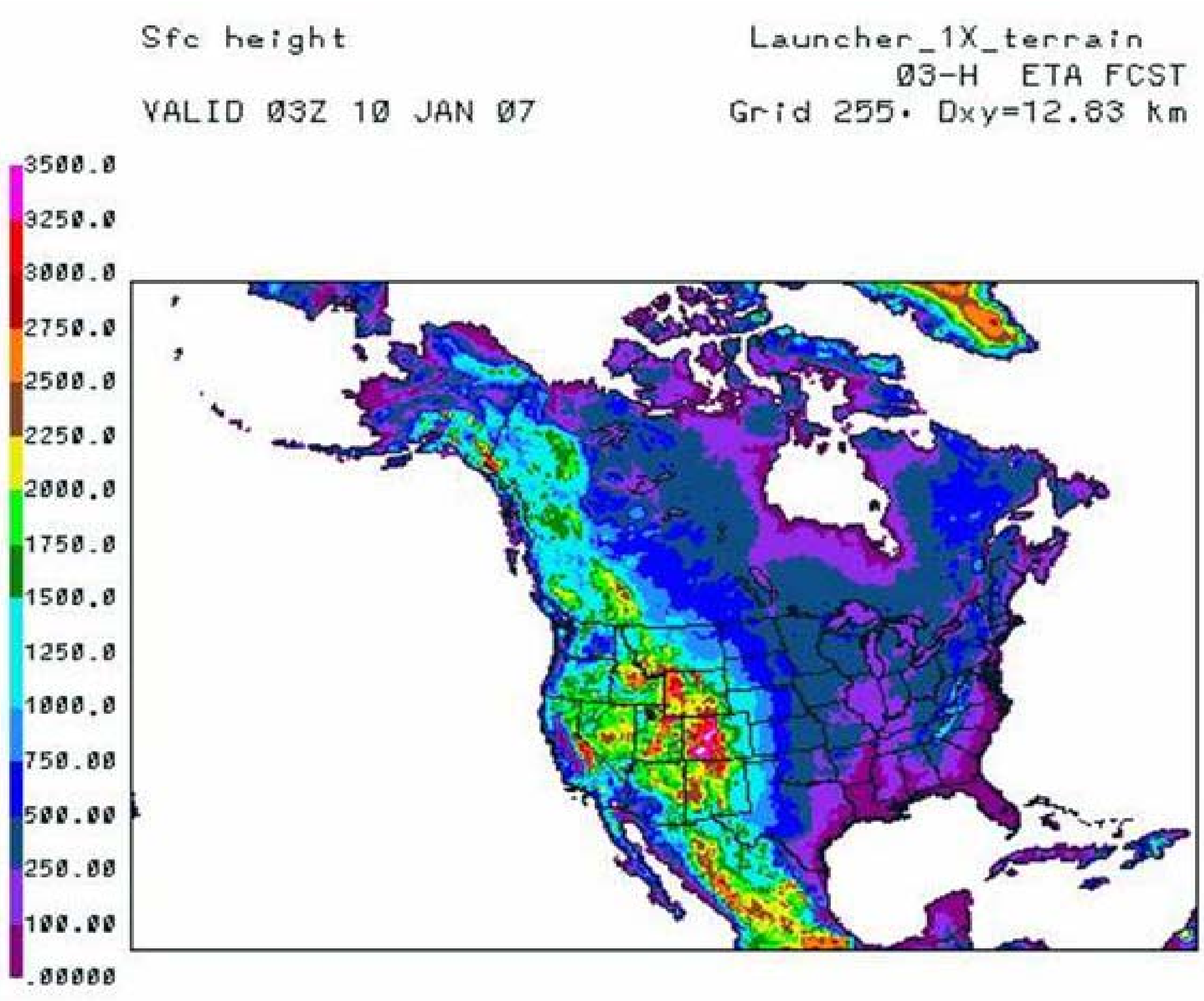
- **Penn State ran MM5 with a 36-12-4 km nested domain depicted on the next slide**

- **NCEP ran WRF-NMM with a 12 km grid for the domain on the slide after the MM5 slide.**

MM5 Modeling Domain



WRF-NMM Modeling Domain

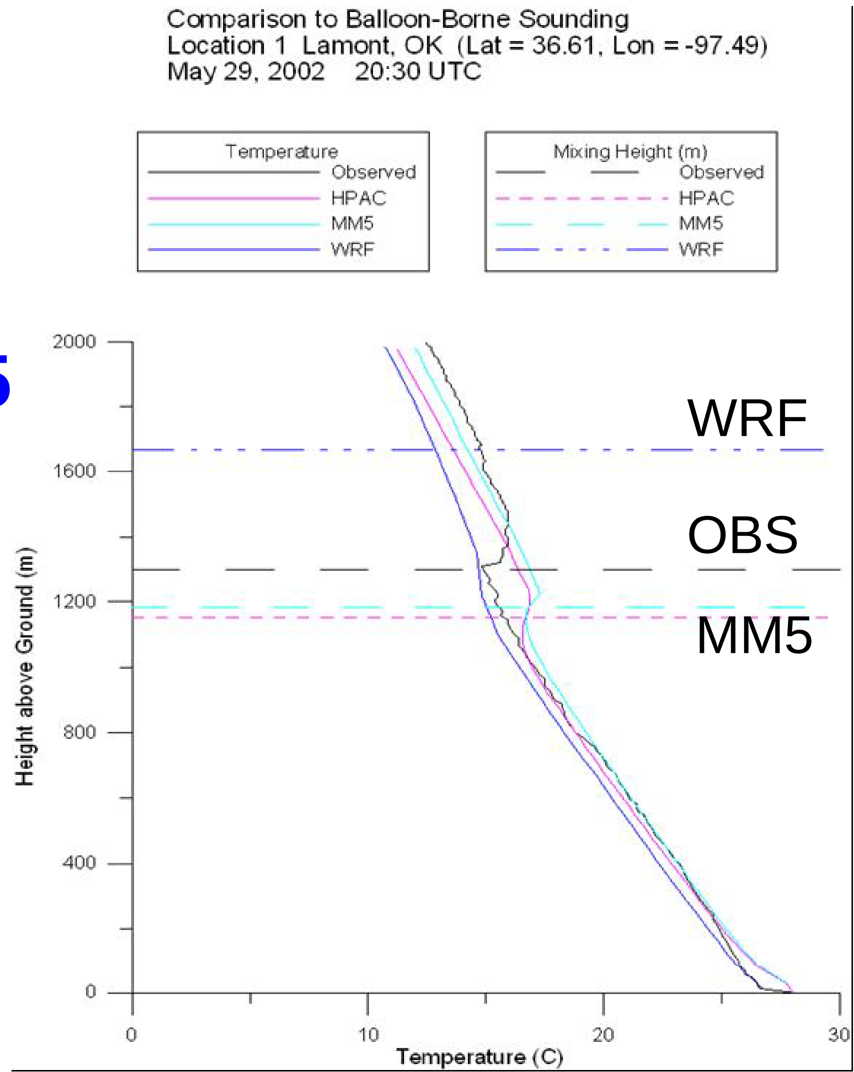


Vertical Profile Comparisons

- Made use of slow-rise radiosonde observations with much resolution in the BL
- Data from five sites for the three days at 3 hr intervals
  - Central Facility in Lamont OK
  - Hillsboro KS
  - Vici OK
  - Morris OK
  - Purcell OK

Example of daytime T profile and mixing depth comparison

OBS and MM5 Agree, WRF is 30 % high

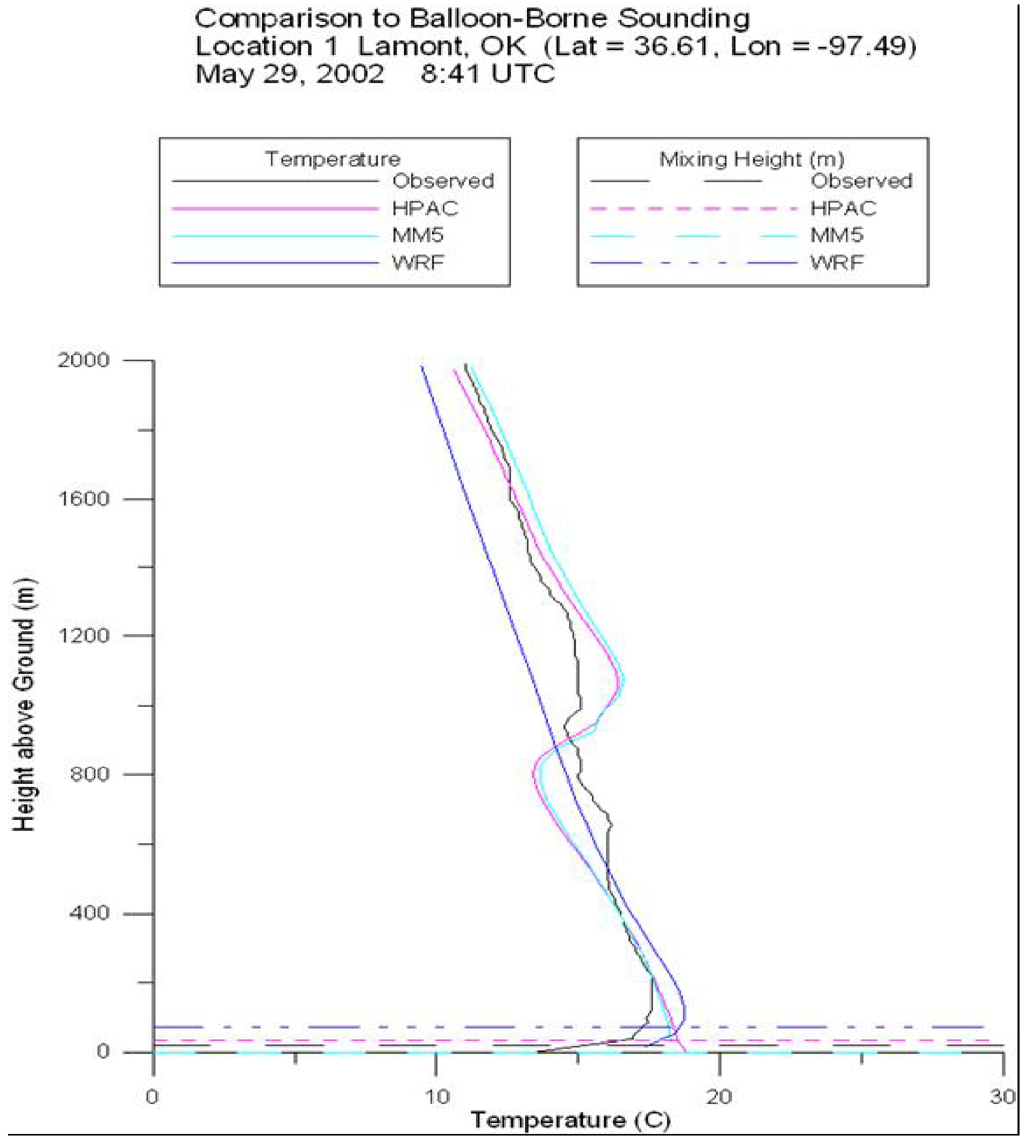


Example of nighttime T profile and mixing depth comparison

MM5 has elevated inversion; **WRF** does not.

WRF matches low level inversion;

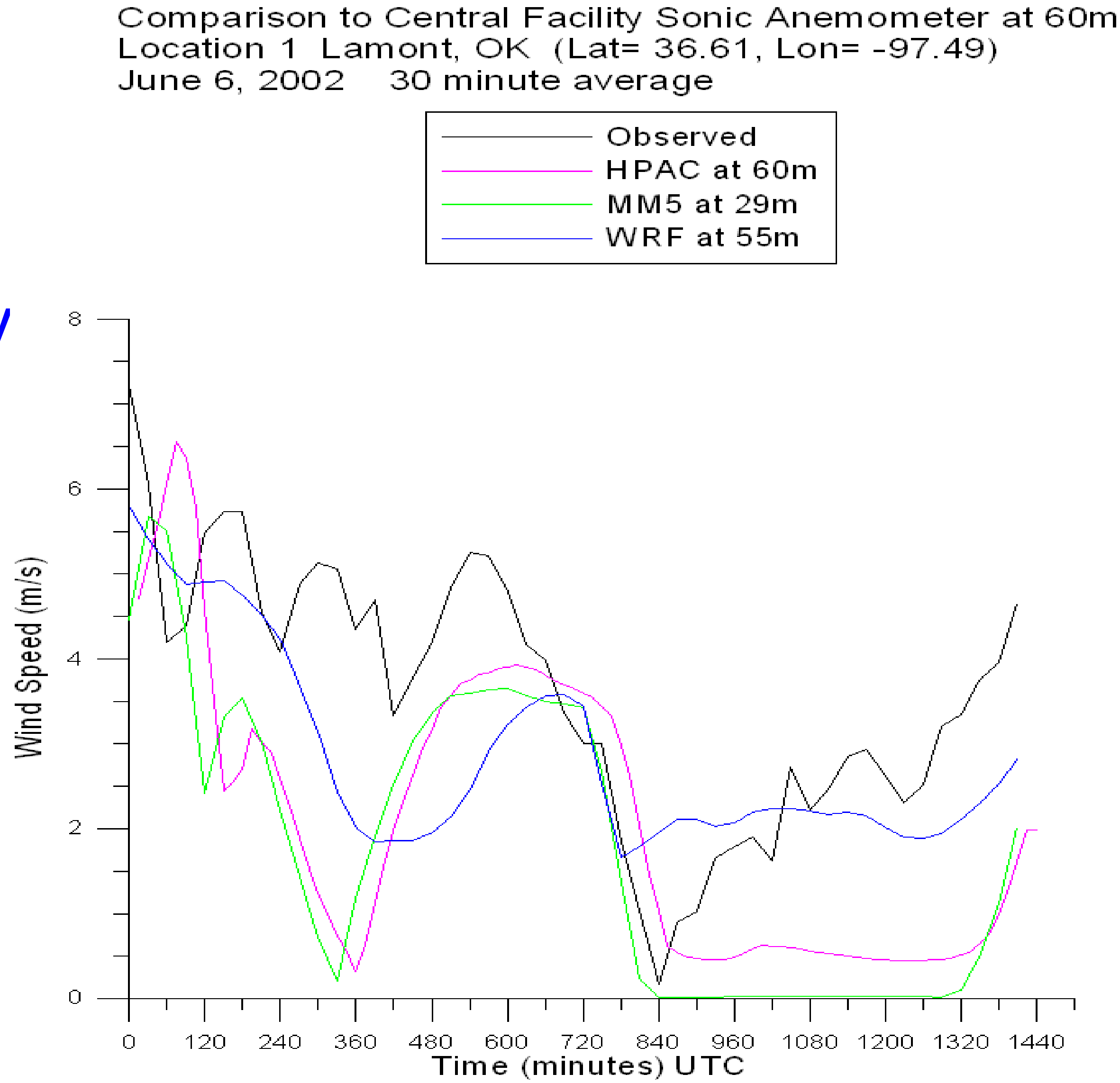
MM5 has no inversion (but it occurs later)



Time series of observed and simulated WS at Central Fac at z = 60 m on 6 June

Lots of variability

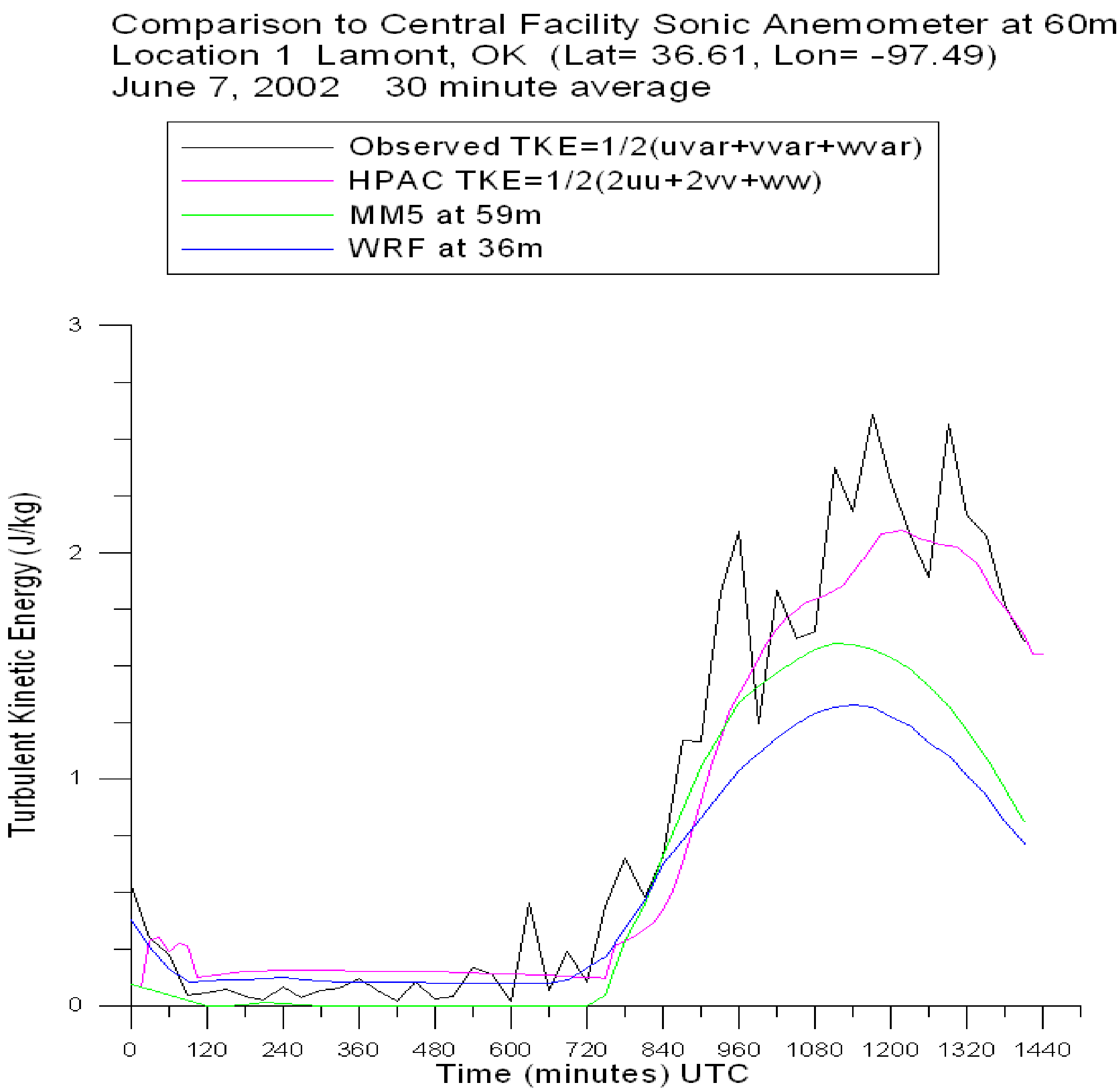
RMSE for WS = about 2 m/s



Time series of observed and simulated TKE at Central Fac at z=60 m on 7 June

Models better this day for TKE

HPAC OK in day; Fac 2 or 3 high at night



Conclusions

- Wind speed (WS) RMS error has a minimum (inherent uncertainty) of about 1 m/s, large biases occasionally happen, especially at night
- Wind direction RMS error is typically 20 to 60°but is clearly proportional to 1/WS
- Mixing depth has ±20 % error day, ±100 % night
- dT/dz in capping inversion underestimated by models
- Obs TKE agrees within a factor of two with model simulations during the day. At night, TKE agreement is not so good
- These results are in general agreement with the Seaman 2000 review paper

References

- Hanna, S. and R. Yang, 2001: Evaluations of mesoscale models' simulations of near-surface winds, temperature gradients, and mixing depths. J Applied Meteorol 40, 1095-1104.
- Hanna, S. + 10 coauthors, 2010: Comparison of observed, MM5 and WRF-NMM model-simulated, and HPAC-assumed boundary-layer meteorological variables for three days during the IHOP field experiment. Bound-Layer Meteorol 134 (2); 285-306.
- Seaman, N, 2000: Meteorological modeling for air quality assessments Atmos. Environ. 34, 2231-2259.