Evaluation of the real-time WRF forecasts during the Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) Program: Performance, comparison with observations and further implications

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Background

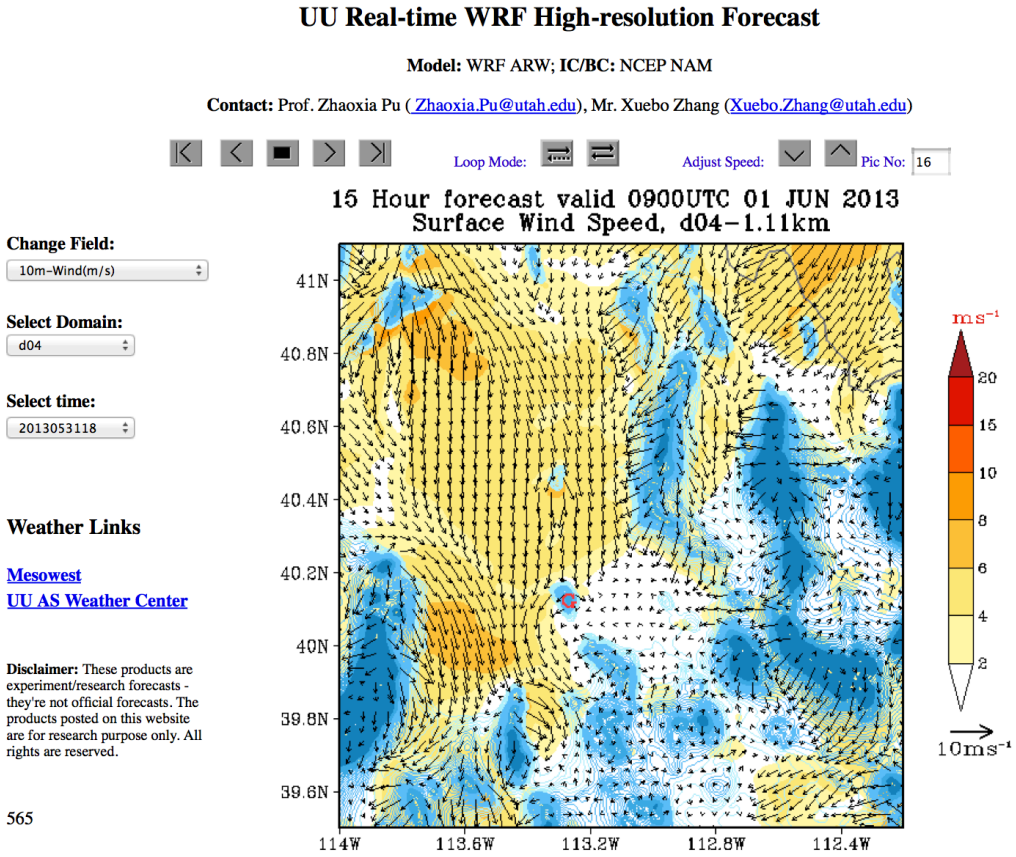
The Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) Program

- To evaluate model performance in predicting synoptic and local flows over mountainous terrain and thus to improve predictability

- Two field experiments were conducted over Dugway Proving Ground (DPG), Utah during the fall 2012 (Sep. 25 – Oct. 24, 2012) and spring 2013 (May of 2013)

Univ. of Utah WRF real-time forecast during MATERHORN

http://www.inscc.utah.edu/~pu

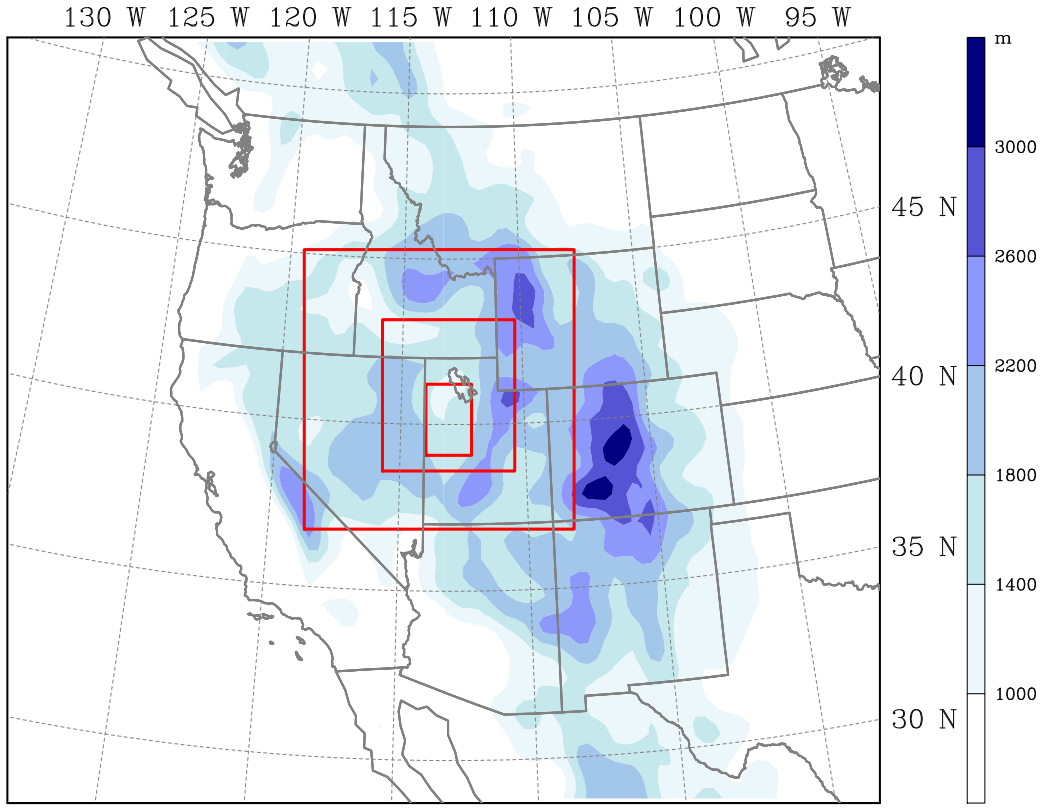


- To support decision making during field programs
- To provide a useful database to evaluate WRF model's performance in predicting synoptic and local flows over mountainous terrain

About this talk

- Summarize the performance WRF real-time forecasts
- Evaluating WRF forecasts with observations
- Ongoing and future work

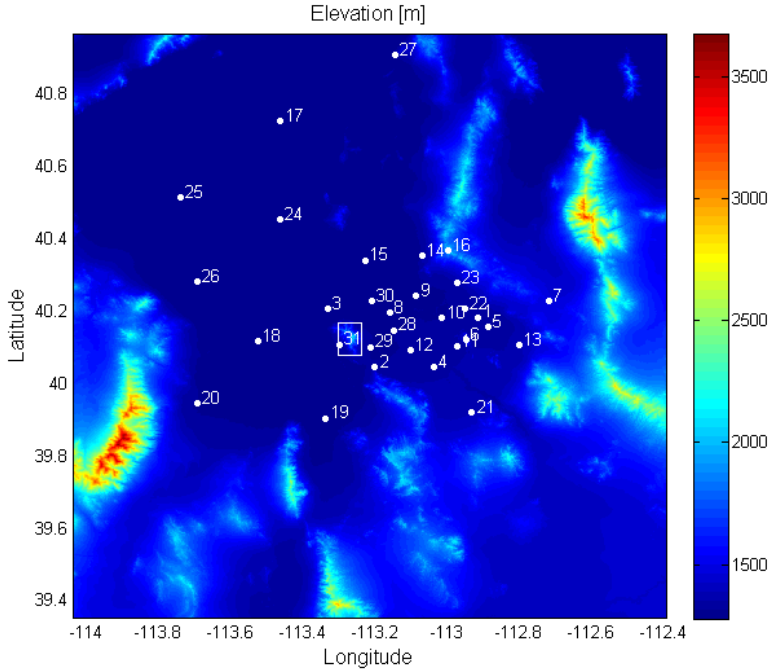
WRF model domains



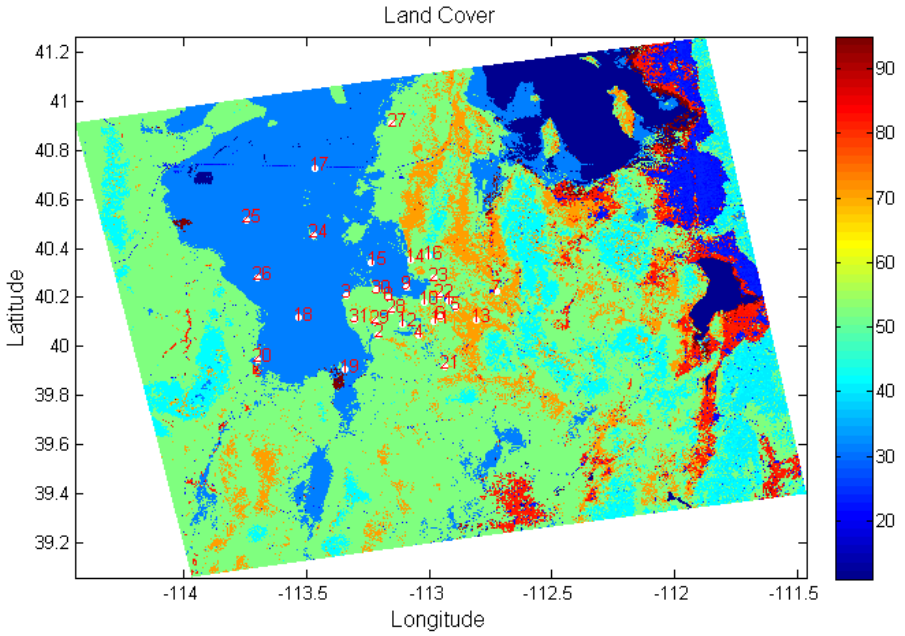
Horizontal resolution: 30km/10km/3.33km/1.11km

The inner most model domain
(Dugway Proving Ground)

Elevation (m) and SAMS



Land cover



WRF real-time forecasting

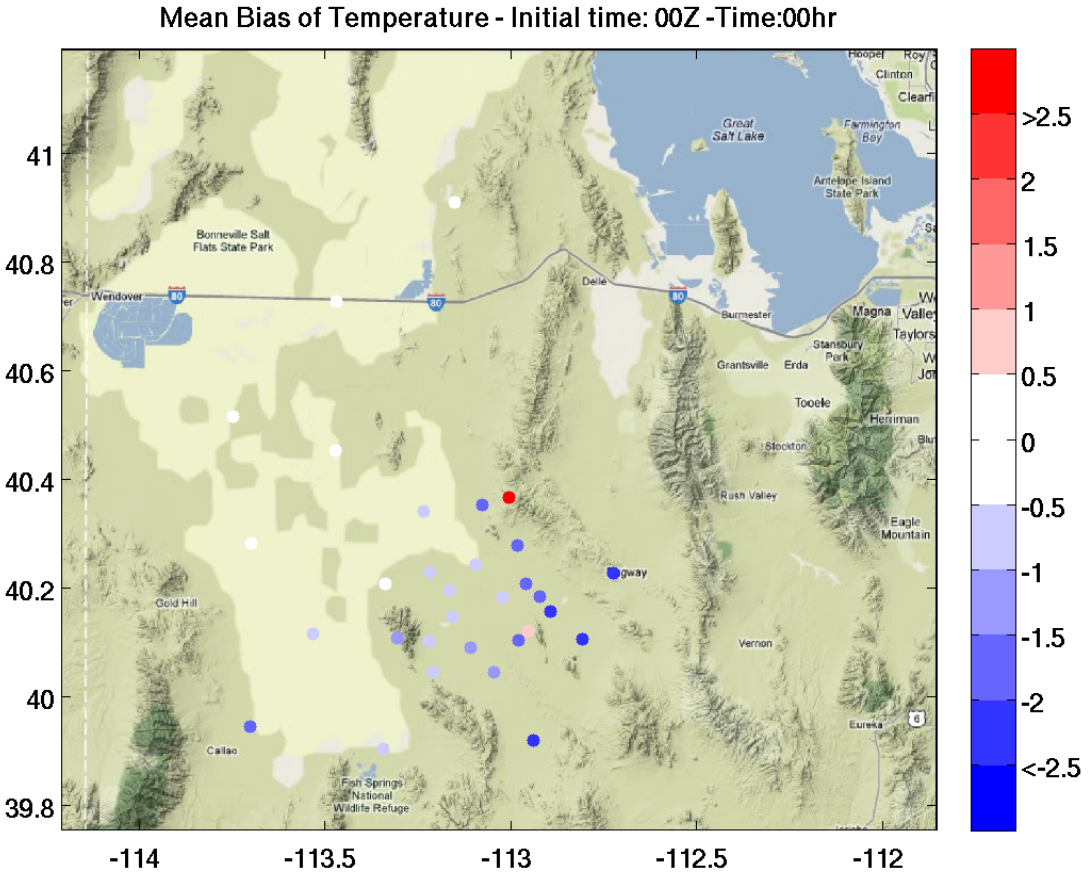
- **WRF model configuration**
  - WRF V3.3
  - Four **one-way** nested domains
  - Model horizontal resolution 30km/10km/3.3km/1.1 km
  - 4 sets of 48-h forecasts per day from 00Z, 06Z, 12Z and 18Z.
  - **Cold start** -- Initial and boundary conditions derived from the NCEP *North American Mesoscale* Forecast System (*NAM*)

- **Performed during MATERHORN fall 2012 and Spring 2013** to support the field program
  - Fall 2012 [Sep. 25 – Oct. 24, 2013] - 120 48-h forecast / 4 times per day
  - Spring 2013 [May 1-31, 2013] - 120 48-h forecast /4 times per day

- **Post-field evaluation is conducted** with the verification against
  - Surface Mesonet observations: 2-m temperature and 10-m wind [SAMS]
  - Sounding observations [Sagebrush and Playa] during IOPs
  - Lidar profiles over Granite mountain area during some IOPs

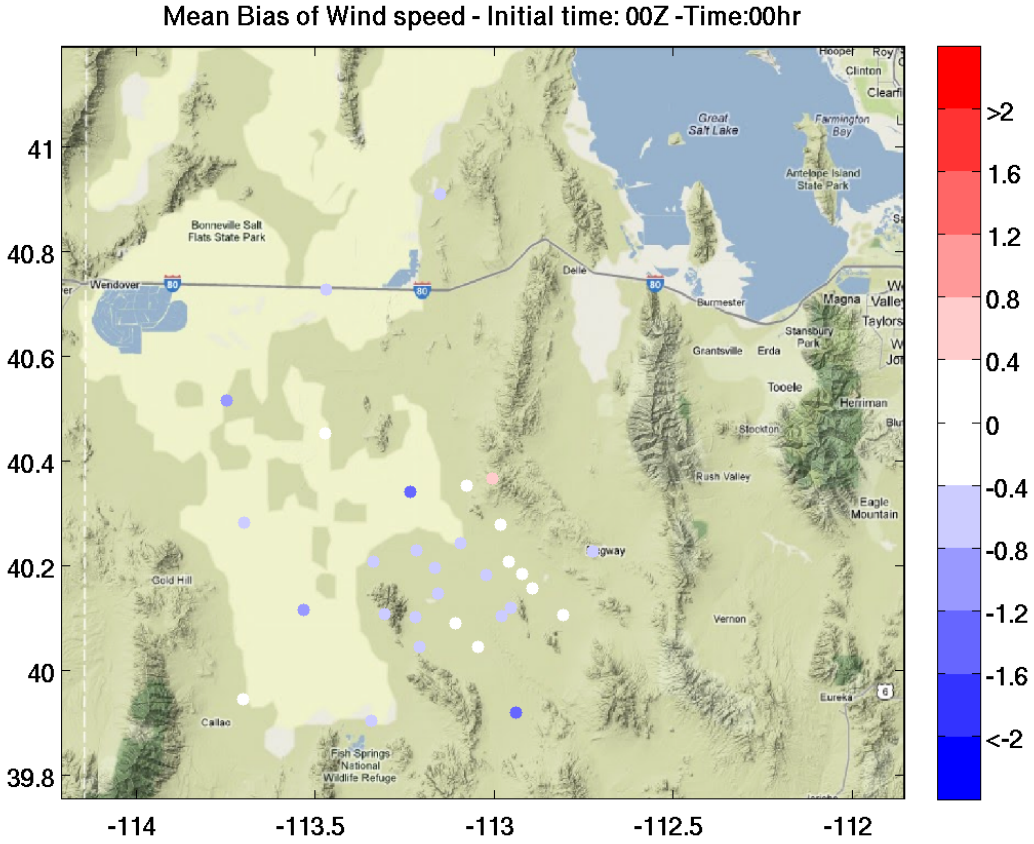
Overall Evaluation – fall 2012 campaign

Variation of Mean Bias with Forecast Time - Temperature



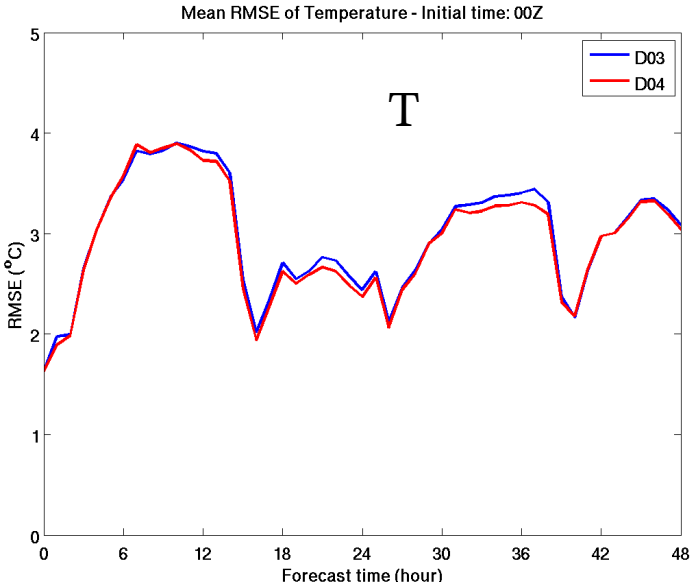
- **Warm bias during nighttime**
- **Cold bias during daytime.**

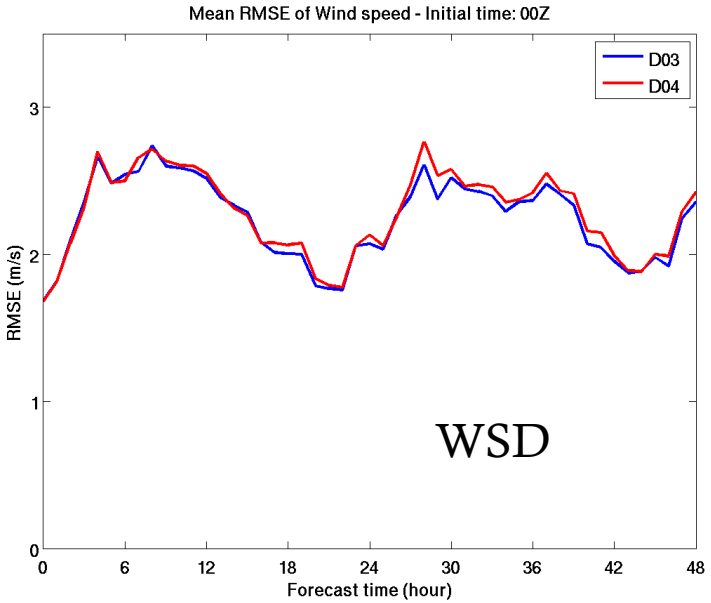
Variation of Mean Bias with Forecast Time – Wind speed

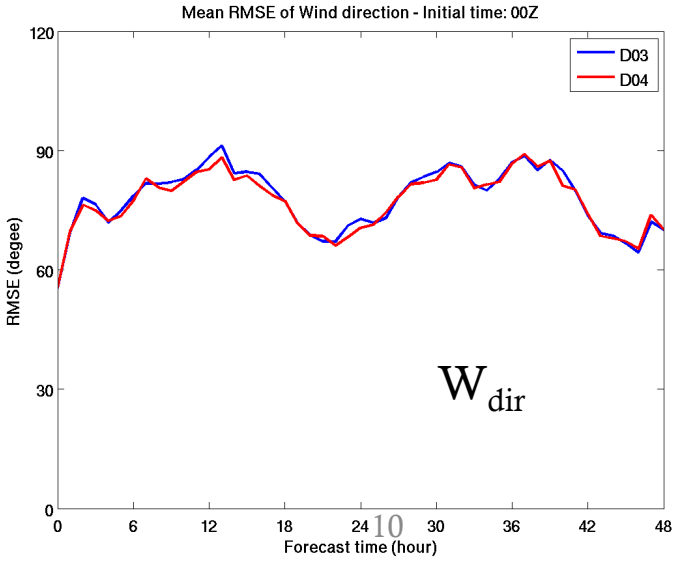


- **Statistically, wind speed bias is very small in most of stations.**

Mean RMSE (48 h forecast)







Overall evaluation - additional points

- Under weak synoptic forcings, forecast errors in surface variables remarkably depend on the diurnal cycle of the variables themselves.
- Flow-dependent forecast errors are seen in strong synoptic forcing cases, as the errors do not follow the diurnal pattern.
- The error patterns are independent of the model initialization time

See detailed evaluation for pre-Materhorn forecasts

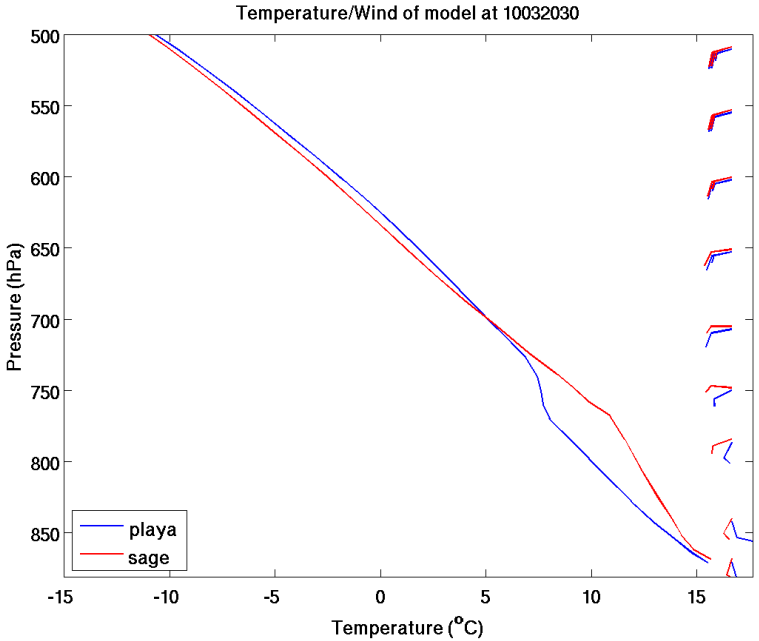
Zhang, H., Z. Pu and X. Zhang, 2013: Examination of errors in near-surface temperature and wind from WRF numerical simulations in regions of complex terrain. *Wea. Forecasting*, 28, 893-914.

Specific evaluation

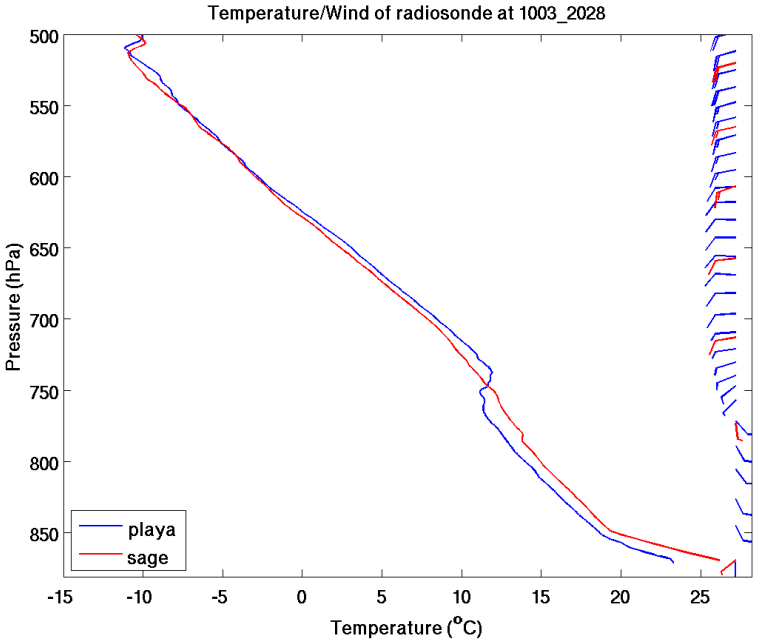
Sagebrush versus Playa

Sagebrush versus Playa
2030 UTC 3 Oct. 2012
Temperature/Wind

Model simulations

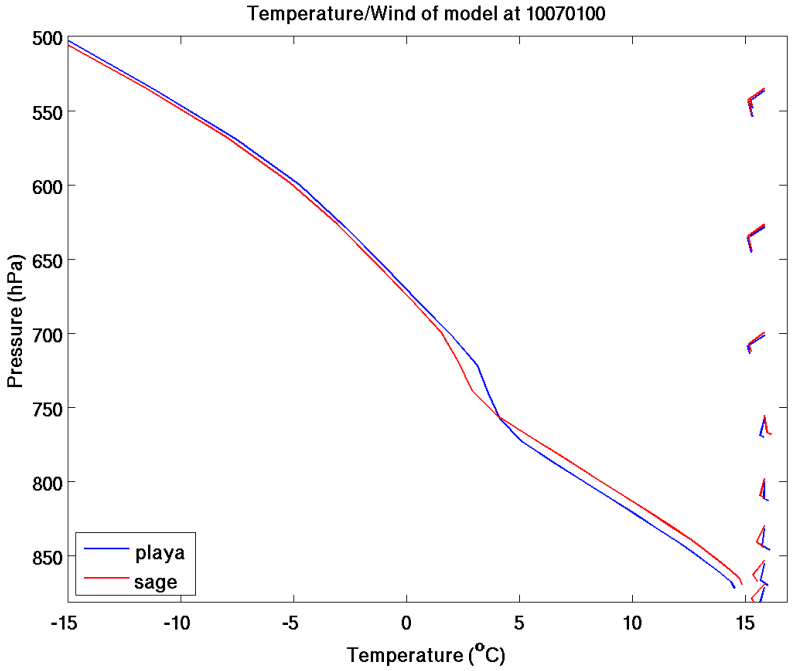


Radiosonde observations

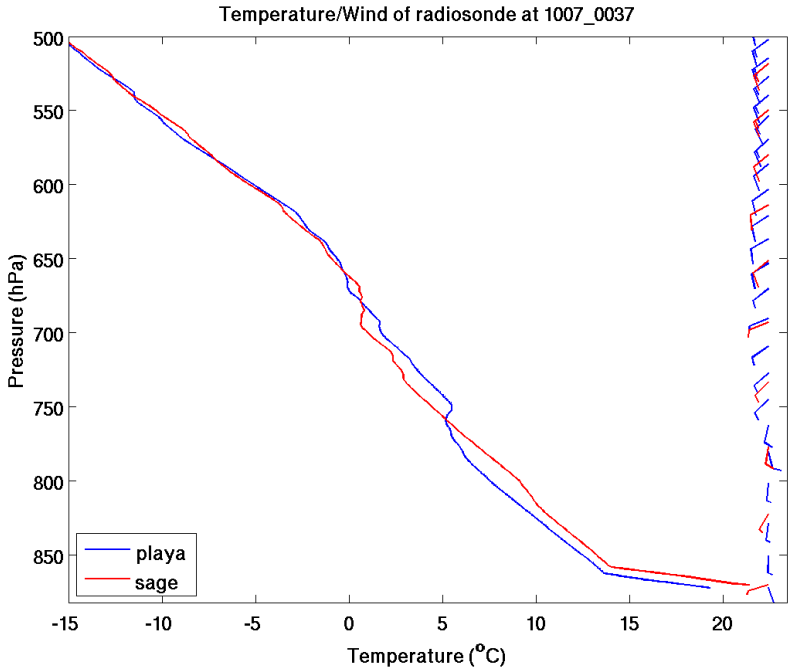


Sagebrush versus Playa
0030 UTC 7 Oct. 2012
Temperature/Wind

Model simulations

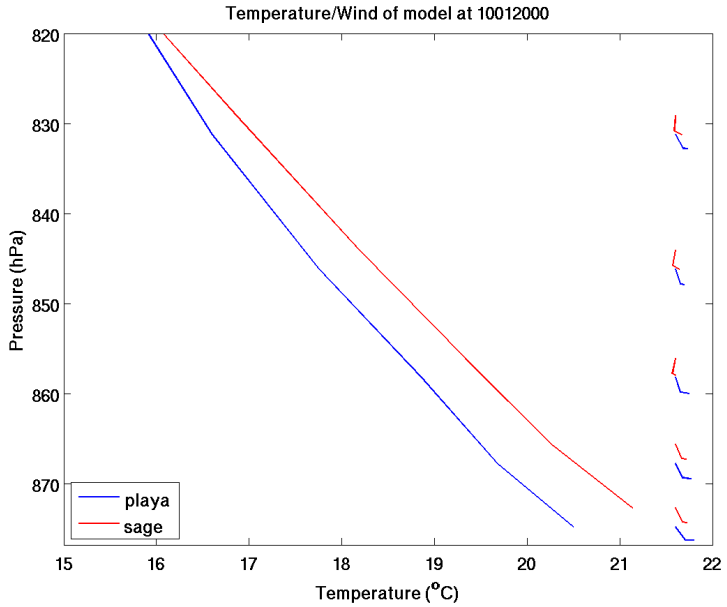


Radiosonde data of temp/wind

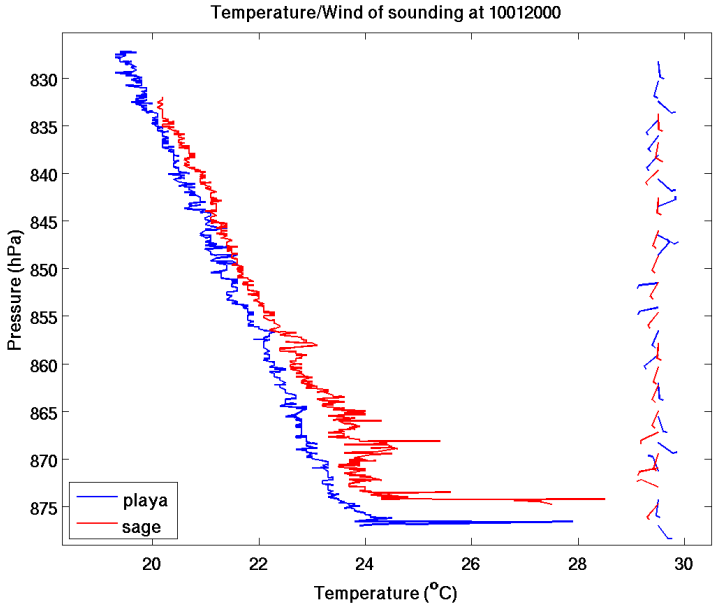


Sagebrush versus Playa
200 UTC 1 Oct. 2012
Temperature/Wind

Model simulations

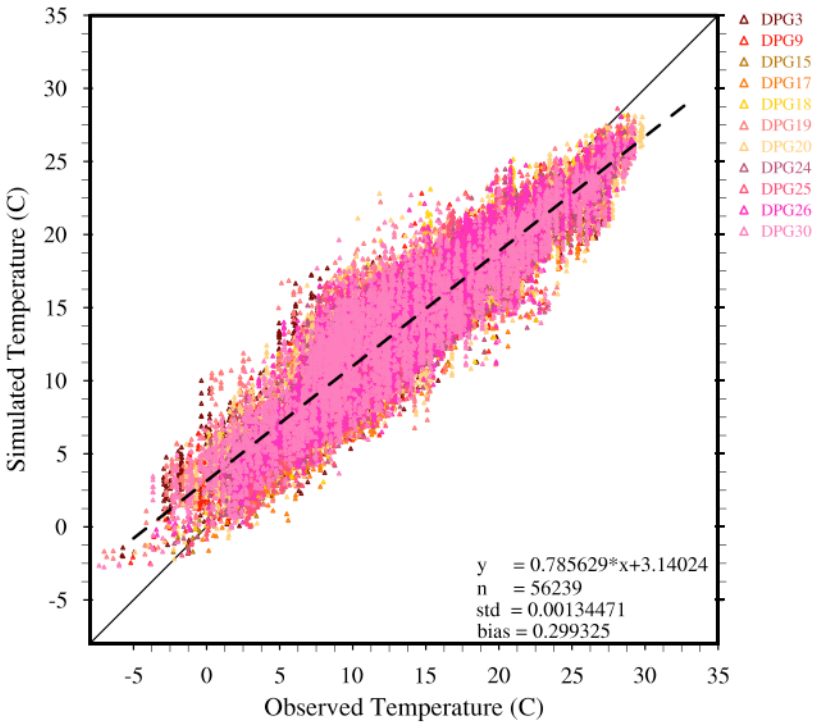


Tethersonde data of temp/wind

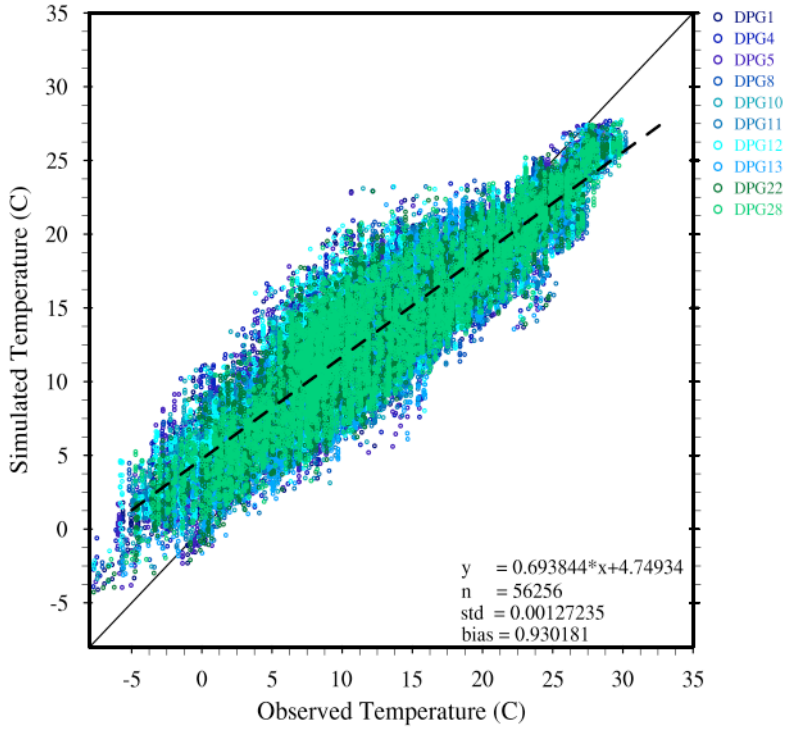


Sagebrush versus Playa

Surface obs. versus model simulated temperature - overall



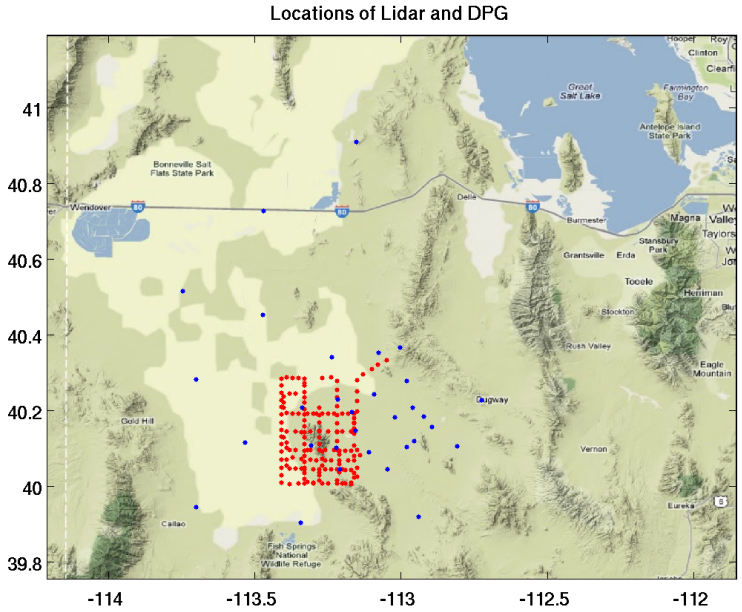
Playa

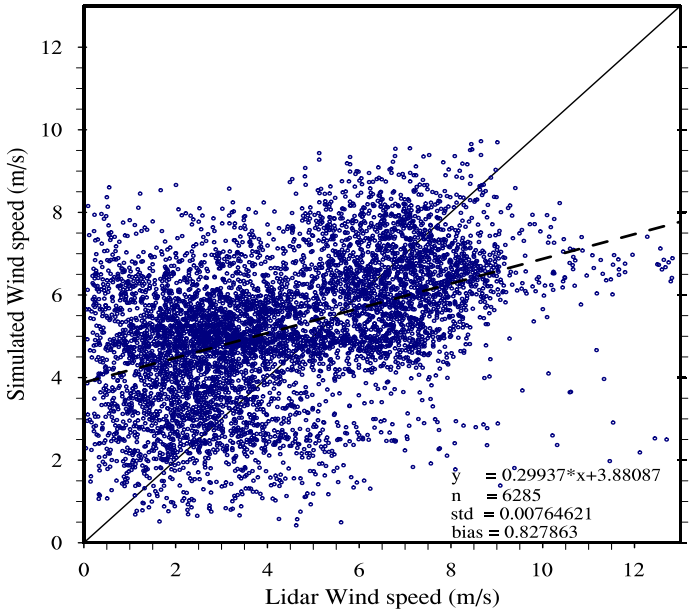


Sagebrush

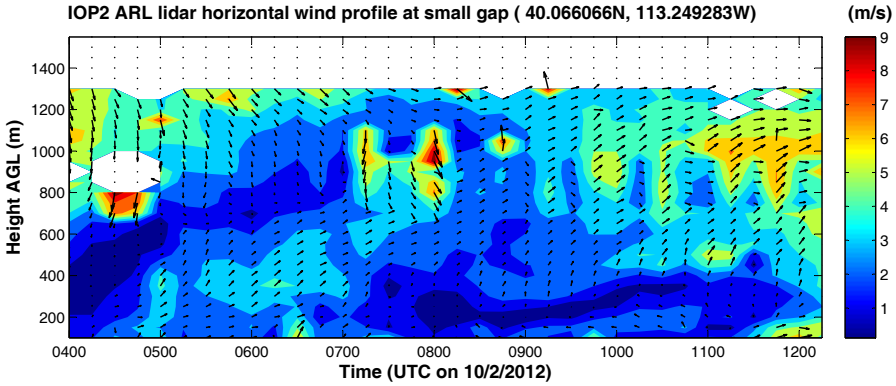
Compare with Lidar Observations

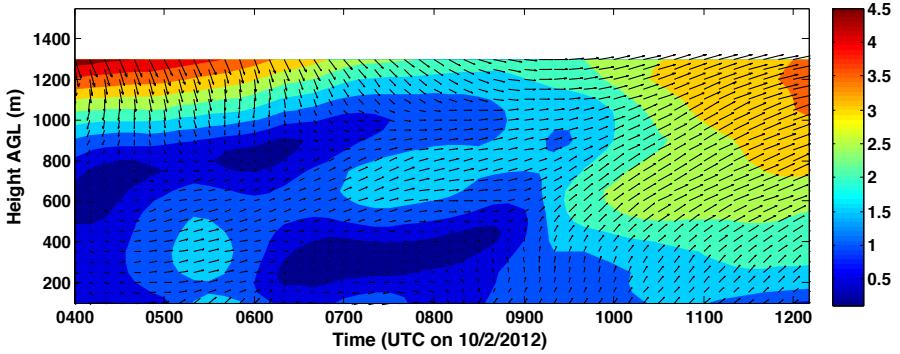
Oct. 6, 2012





IOP 2





Concluding remarks

- The real-time WRF forecasts provide useful information during the MATERHORN field campaigns

- The comparison between the WRF forecasts and observations is helpful for understanding of the error characteristics of WRF forecasts over mountainous terrain. In addition,

- It offers guidance to the additional numerical studies to explore improved predictability

On-going and future work

- Additional evaluation/verification with MATERHORN observations
- Data assimilation: Zhang and Pu (Paper # 16.5)
- Large eddy simulations
- Sensitivity to physical parameters (near-surface atmospheric, land-surface and soil states)

Acknowledgements

- DOD MURI Program and Materhron project managed by ONR
- NCAR WRF and WRFDA working group

Thank you!