Predictability and Data Assimilation Studies with Observations during MATERHORN Field Campaigns

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in collaborating with many others in MATERHORM science team

NATERHORN Investigator Meeting – III
University of Notre Dame
September 6, 2013

Background

The major objectives of MATERHORN-M

- **To evaluate model performance in predicting synoptic and local flows over mountainous terrain and thus [model evaluation]**

- **To improve predictability [data assimilation]**

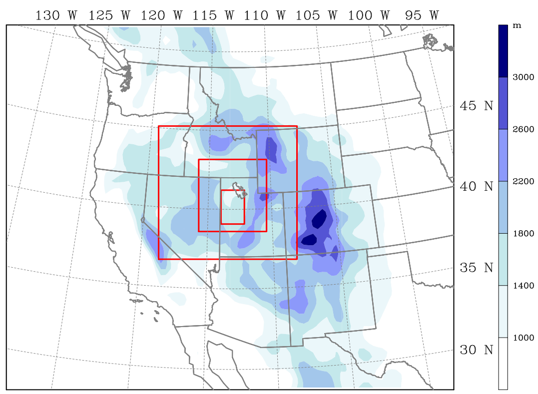
- **Two field experiments were conducted over Dugway Proving Ground (DPG), Utah during the fall 2012 (Sep. 21 – Oct. 20, 2012) and spring 2013 (May of 2013)**

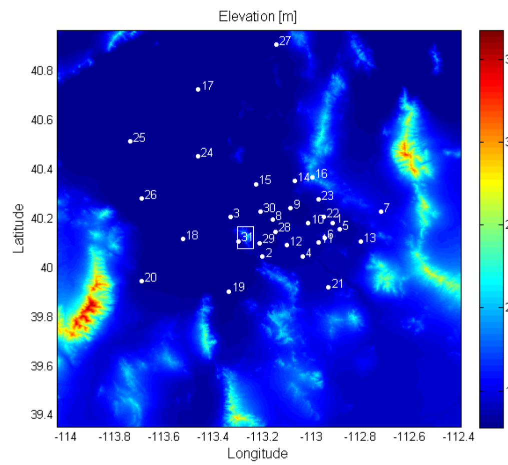
Our research emphases

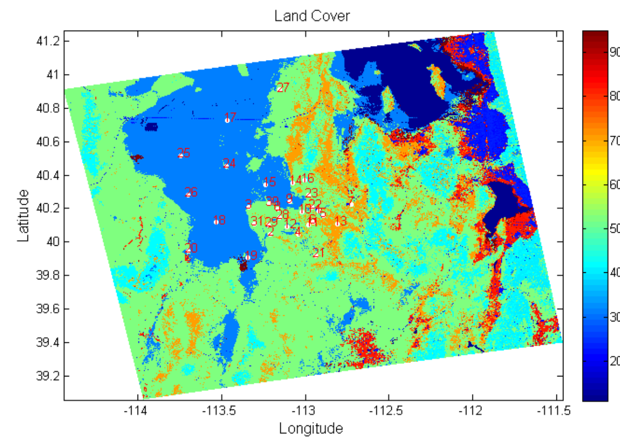
- **Evaluate WRF near-surface forecasts in regions of complex terrain**

- **Data assimilation and predictability**

Evaluate WRF near-surface temperature and wind forecasts







Major emphasis

- Weather Research and Forecasting model (WRF) real-time forecasts at 1.11 km horizontal resolution over Dugway Proving Ground (DPG)

Study periods:

- Pre-MATERHORN: 15 September - 14 October 2011
- MATERHORN
  - Fall 2012: September 25– October 25, 2012
  - Spring 2013: May 1 – May 31, 2013

Verification: against surface mesonet (SAMS) observations of 2-m temperature and 10-m wind and MATERHORN sounding observations

Evaluate WRF Surface Forecasts

Results from the Pre-Materhorn Cases

- Warm biases at night time and cold biases at day time are found in WRF forecasts.
- Under weak synoptic forcing, errors in near-surface temperature and winds depend on the diurnal cycle. Flow-dependent forecast errors are seen in stronger synoptic forcing cases, as the errors do not follow the diurnal pattern.
- Errors are presented in near surface wind and temperature even when the WRF is skillful at synoptic and mesoscale scales.

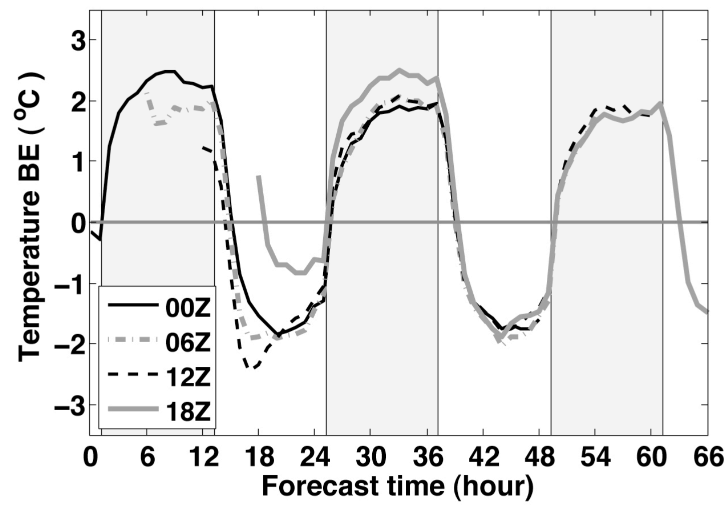


FIG. Bias error of simulated 2-m temperature from the 1.11-km domain over DPG with various initialization times. The forecasting period for all forecasts is 48 h. Statistics are based a month-long WRF real-time forecasts.

Related Publication: 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.

A real-time WRF forecast during the MATERHORN field program: Performance and evaluation with observations

Zhaoxia Pu, Xuebo Zhang, Hailing Zhang
Eric Pardyjak, W. James Steenburgh, Sebastian W. Hoch,
Jeff Massey, Matt Jeglum, David Whiteman
Department of Atmospheric Sciences, University of Utah

Dragan Zajic
Meteorological Division, Dugway Proving Ground

Yansen Wang
Army Research Laboratory

Stephan De Wekker
University of Virginia

Silvana DiSabatino and Harindra Fernando
University of Notre Dame

Univ. of Utah WRF real-time forecast during MATERHORN

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

UU Real-time WRF High-resolution Forecast

Model: WRF ARW; **IC/BC:** NCEP NAM

Contact: Prof. Zhaoxia Pu (Zhaoxia.Pu@utah.edu), Mr. Xuebo Zhang (Xuebo.Zhang@utah.edu)

Loop Mode: Adjust Speed: Pic No: 16

Change Field: 10m-Wind(m/s)

Select Domain: d04

Select time: 2013053118

Weather Links

Mesowest

UU AS Weather Center

Disclaimer: These products are experiment/research forecasts - they're not official forecasts. The products posted on this website are for research purpose only. All rights are reserved.

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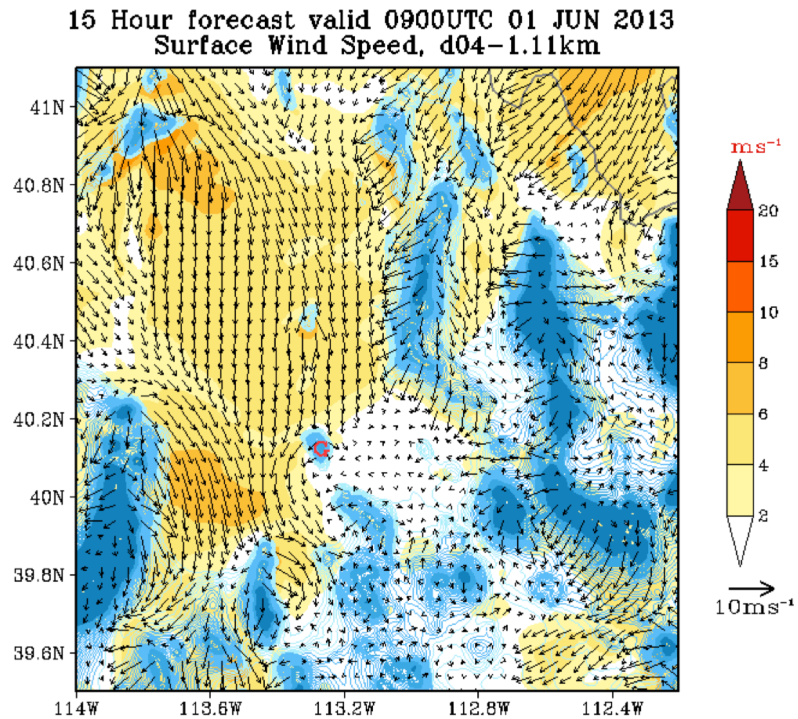


- To support field programs real-time
- To provide a useful database to evaluate WRF model's performance in predicting synoptic and local flows over mountainous terrain

WRF real-time forecasting

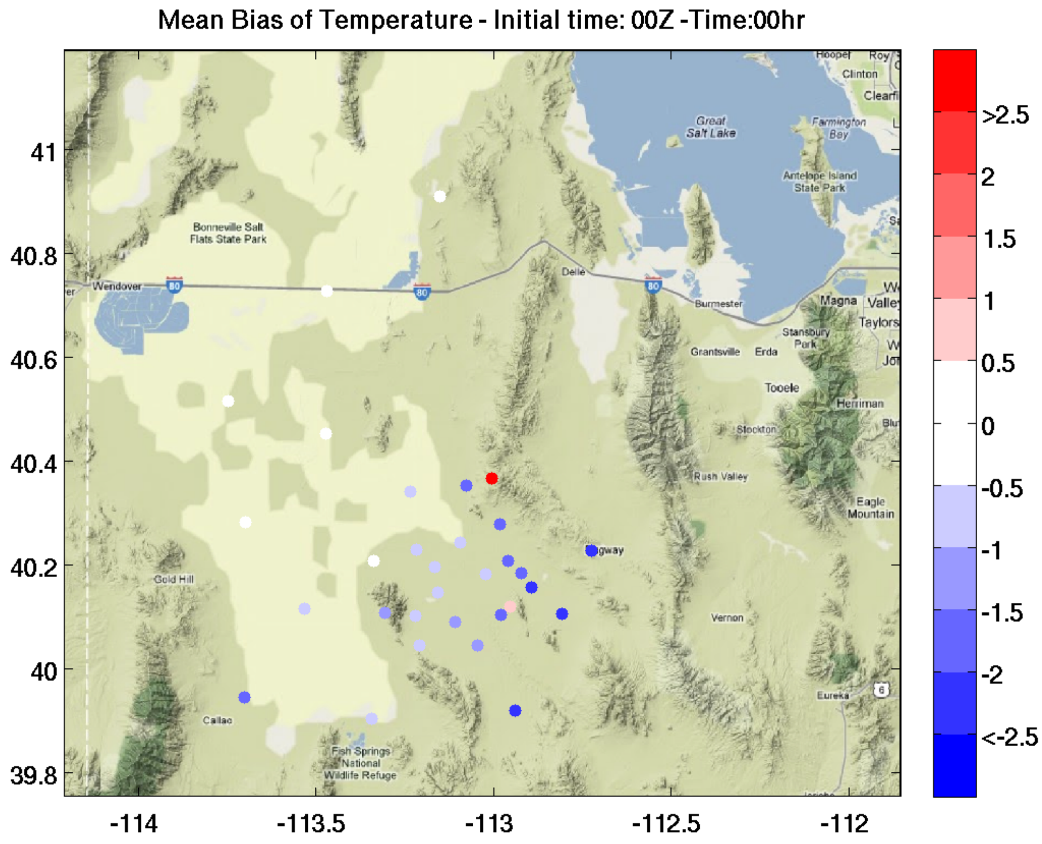
- **WRF model configuration**
  - WRF V3.3
  - Model horizontal resolution 30km/10km/3.3km/1.1 km
  - 4 sets of 48-h forecasts per day from 00Z, 06Z, 12Z and 18Z.

- **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

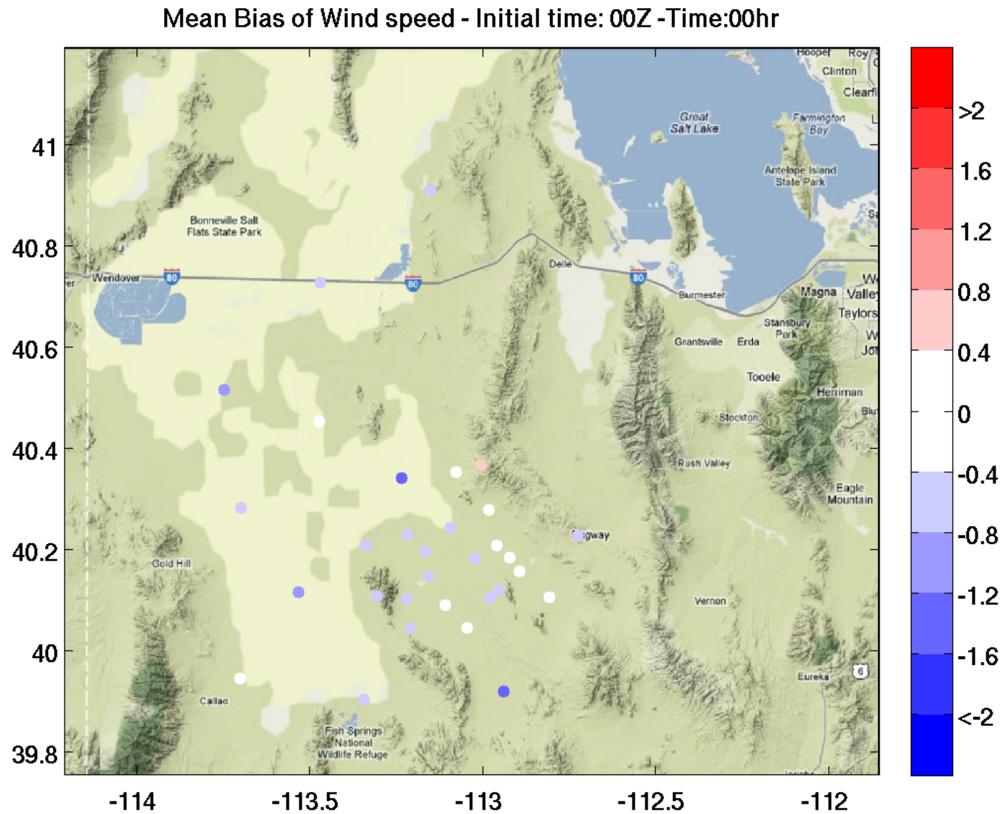
Overall Evaluation – fall 2012 campaign

Variation of Mean Bias with Forecast Time - Temperature



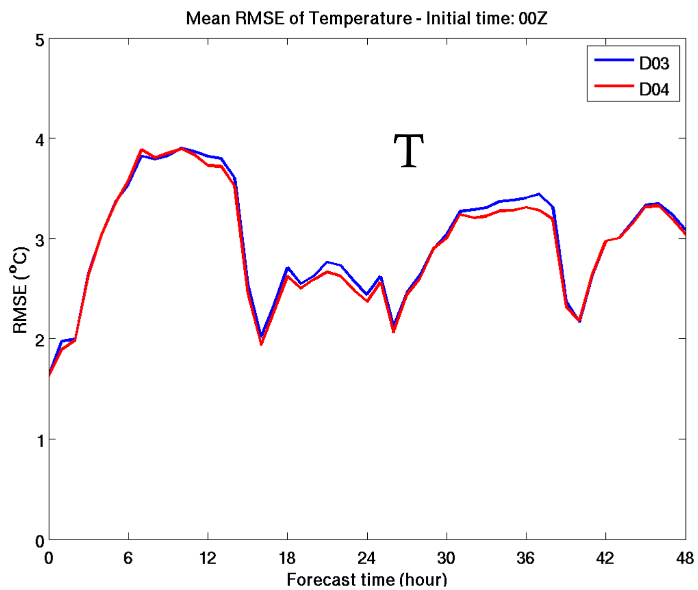
- **Warm bias during nighttime**
- **Cold bias during daytime.**

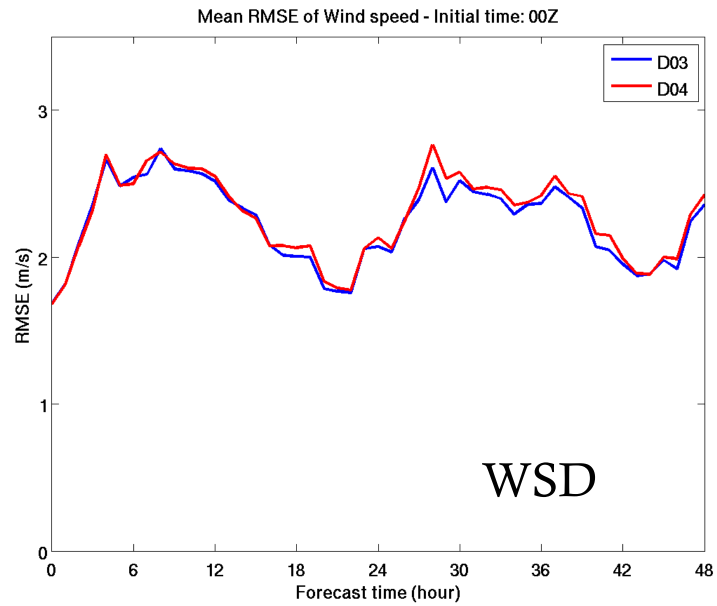
Variation of Mean Bias with Forecast Time – Wind speed

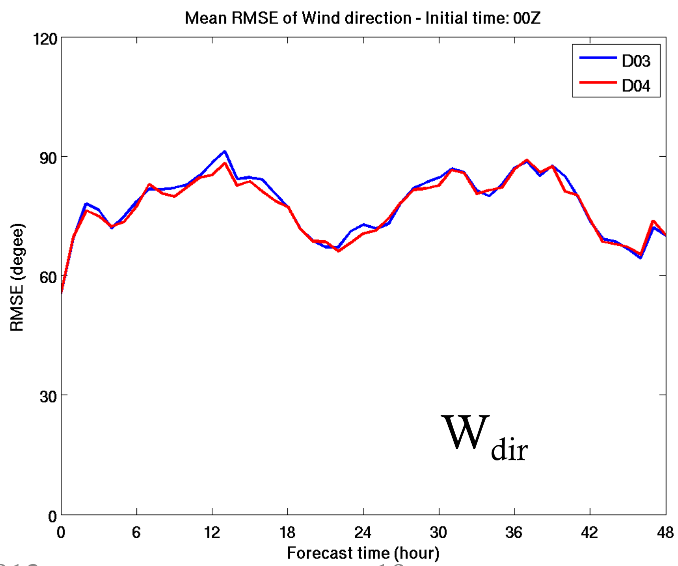


- **Statistically, wind speed bias is very small in most of stations.**

Mean RMSE (48 h forecast)



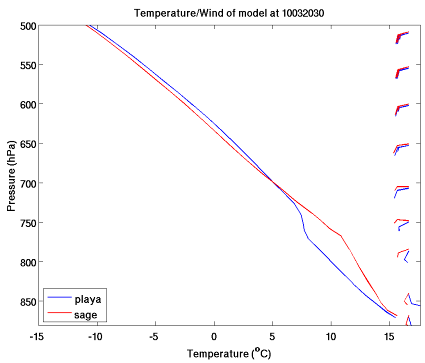


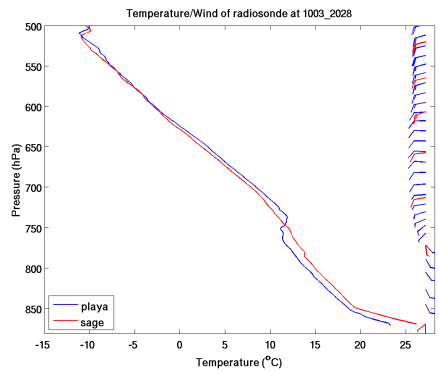


Sagebrush versus Playa

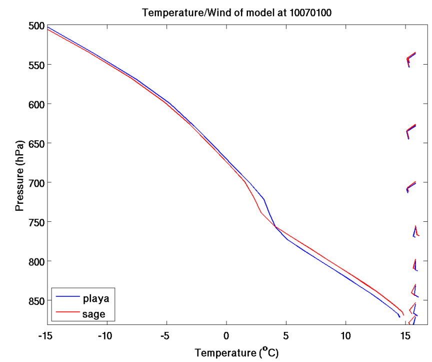
Model simulations vs. Radiosonde data of temp/wind

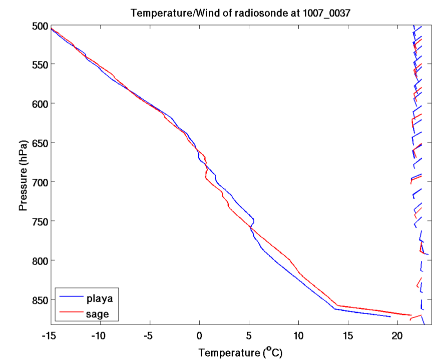
2030 UTC 3 Oct. 2012





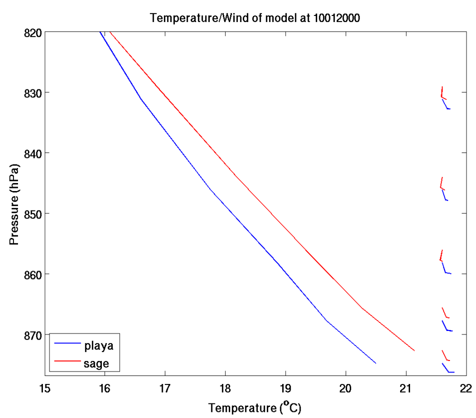
0030 UTC 7 Oct. 2012



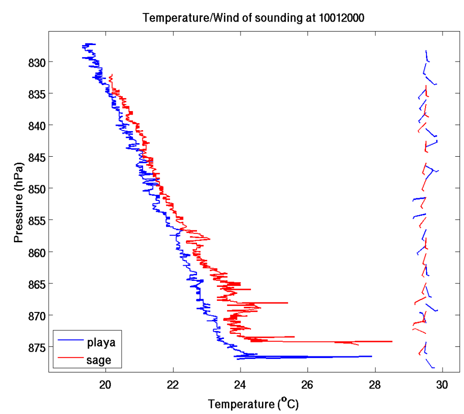


2000 UTC 1 Oct. 2012

Model simulations

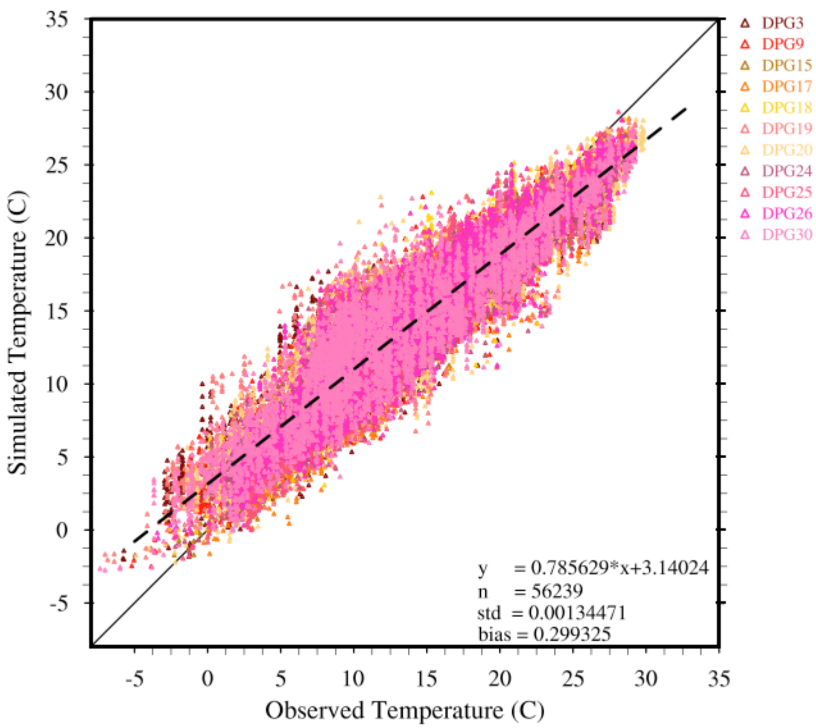


Tethersonde data of temp/wind

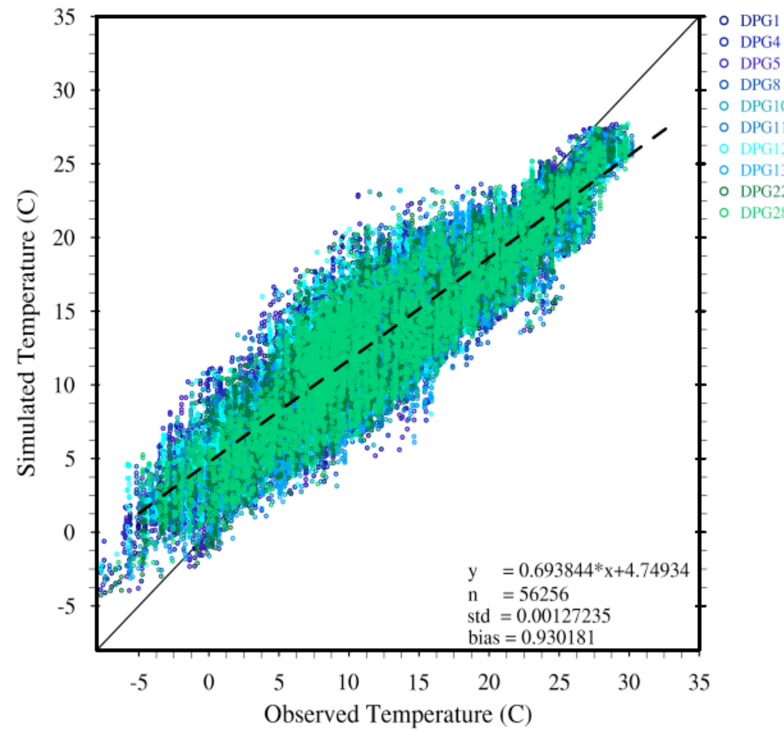


Sagebrush versus Playa

Surface obs. versus model simulated temperature - overall



Playa



Sagebrush

On-going and future work

- Additional evaluation/verification with MATERHORN observations (on-going)
- WRF large eddy simulations for selected IOP (s)
- Sensitivity to physical parameters (near-surface atmospheric, land-surface and soil states)

Data Assimilation and Predictability

Objectives

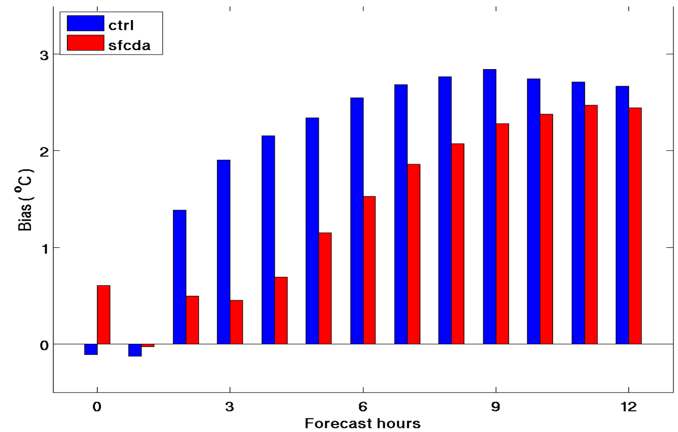
- Evaluate the impact of data assimilation on the predictability of atmospheric conditions over complex terrain
- Compare different data assimilation methods, such as ensemble Kalman filter (EnKF) and 3-dimensional variational data assimilation (3DVAR)

Major findings so far

- EnKF appears superior to the 3DVAR method over complex terrain
- Assimilation of surface mesonet observations results in positive impact on short-range forecasts.

Related publication

Pu, Z., H. Zhang, and J. A. Anderson, 2013: Ensemble Kalman filter assimilation of near-surface observations over complex terrain: Comparison with 3DVAR for short-range forecasts. *Tellus A,* 65,19620.



Assimilation of SAMS observations has significantly reduced the biases of surface temperature in 0-12 h forecast starting from Oct. 11, 2011

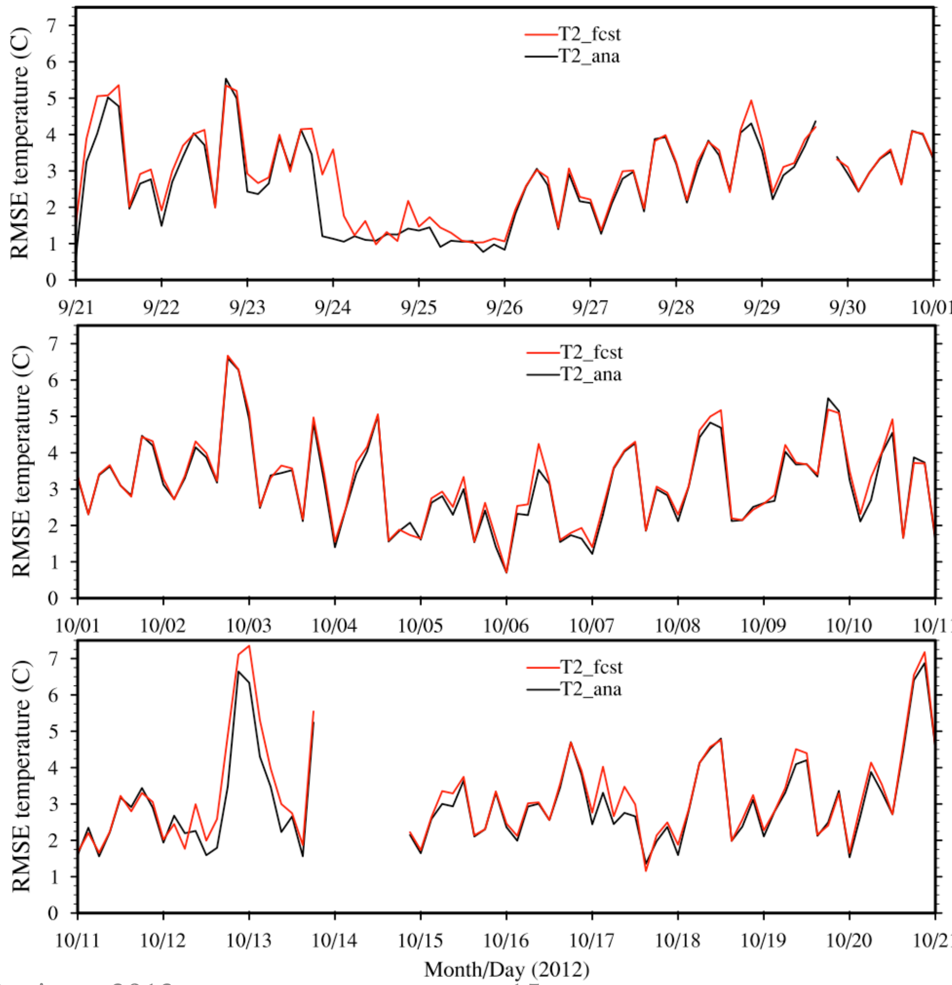
On-going work

- Study the predictability with ensemble Kalman filter assimilation of available conventional observations, surface mesonet observations along with observations collected during Materhorn filed experiments.

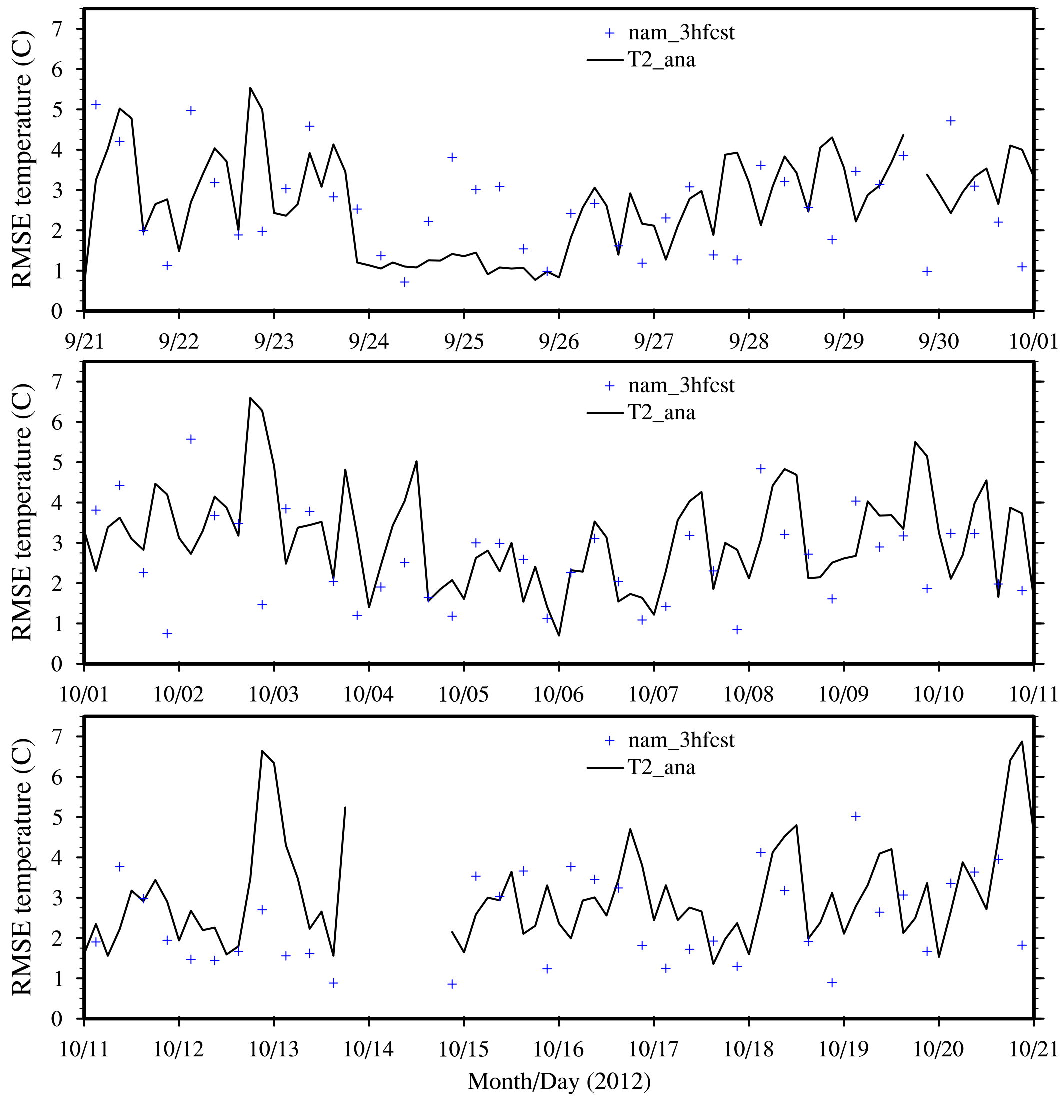
Assimilation of MATERHORN Observations

Ensemble Kalman filter data assimilation results
for MATERHORN fall 2012 field campaign
(WRF/DART with 60 ensemble members)

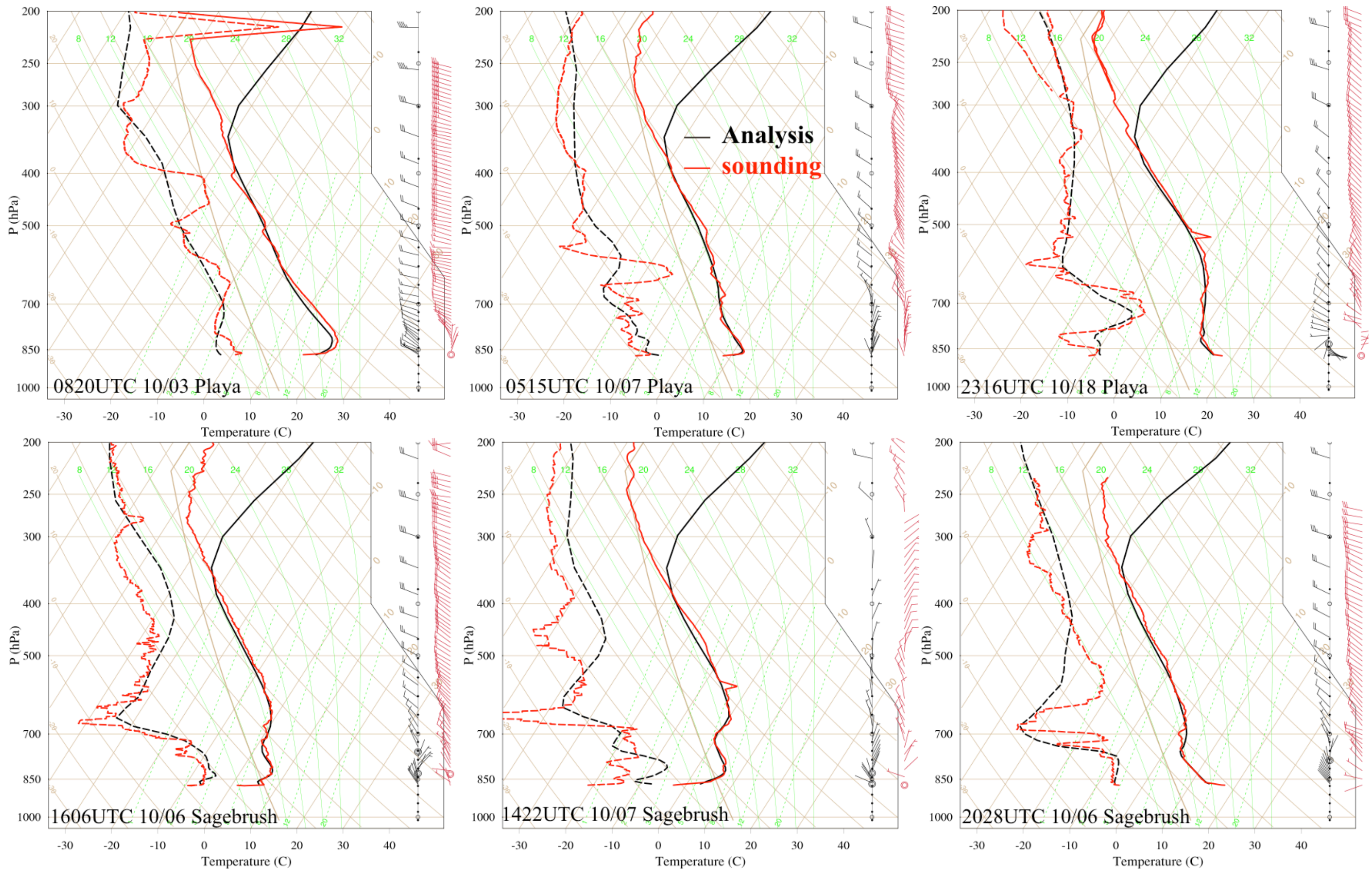
RMSE of Temperature



RMSE of Temperature: EnKF vs. NAM



Sounding vs. Analysis



Playa

Sagebrush

On-going and future work

- Evaluate the month-long EnKF analysis
- Case studies for IOPs
- Sensitivity experiments with additional observations
- Account for model errors