Beating Uncertainties: Ensemble Forecasting and Data Assimilation

With Emphasis on Mountainous Terrain

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Personnel

- **Zhaoxia Pu** (University of Utah)
- **Group Members**
  Graduate students: Zhan Li (Materhorn), Hailing Zhang (NSF)
  Undergraduate Student: Chris Pace
- **Collaborators**
  Jim Steenburgh (University of Utah)
  Joshua Hacker (Naval Postgraduate School)
  David Whiteman, Sebastian Hoch, Eric Pardyjak (University of Utah)
  Others in Materhorn

Four research areas for Materhorn-M

(1) Quantifying spatial and temporal scales of error growth internal to a mesoscale model, and relating them to Initial Condition (IC) uncertainty;

(2) Determining whether the errors can be reduced by improving ICs or whether we are already near the limits of predictability imposed by chaos;

(3) Proposing and testing observations and strategies that will reduce the important IC errors while bringing us closer to predictability limits;

(4) Quantifying and characterizing the importance of model inadequacy in maintaining prediction errors that are not reduced as much as expected.

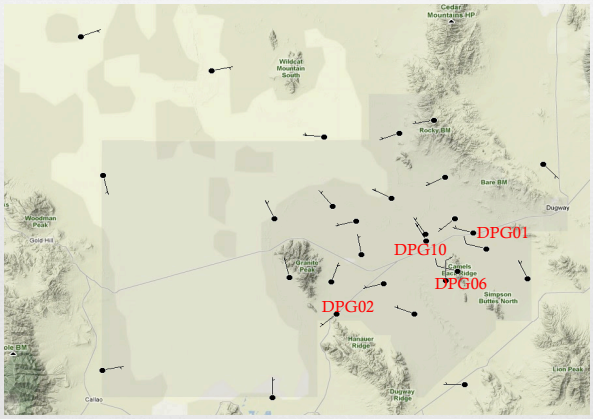
Background

- **Multiscale aspects of weather prediction in mountainous terrain (Jim Steenburgh)**
  - Uncertainties could come from all scales
  - IC uncertainties and model uncertainties should play roles in forecast uncertainties
- **Over mountainous terrain, near surface atmospheric processes (small scale) are understood the least**

Objective

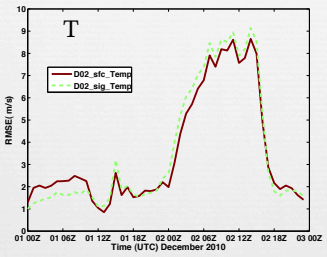
- **To what extent can data assimilation and ensemble forecasting reduce the uncertainties in near surface and boundary layer atmosphere over mountainous terrain?**

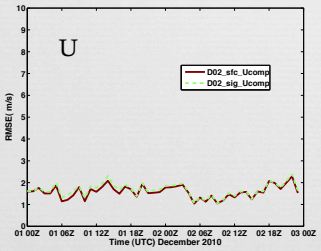
DPG Surface Mesonet Stations

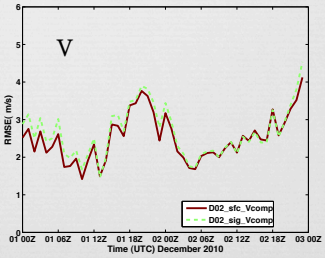


WRF model simulated surface temperature and winds vs. surface mesonet data

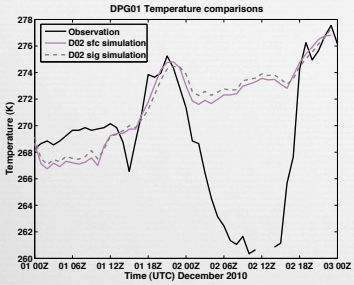
RMSE over DPG December 1-2, 2010

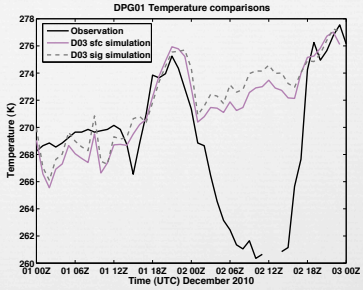






DPG01


DPG01 Temperature comparisons
Observation
D02 sfc simulation
D02 sig simulation
Temperature (K)
Time (UTC) December 2010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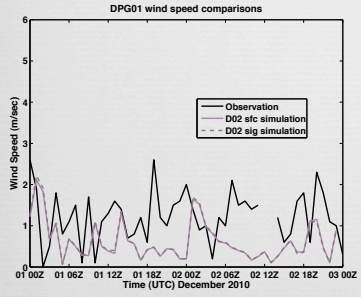
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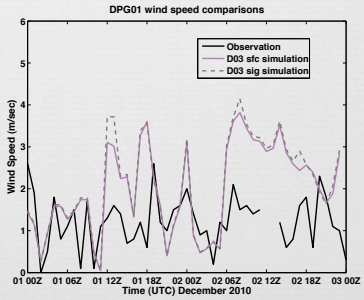
Observation
D02 sfc simulation
D02 sig simulation
Wind Speed (m/sec)
Time (UTC) December 2010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D03 sig simulation
Wind Speed (m/sec)
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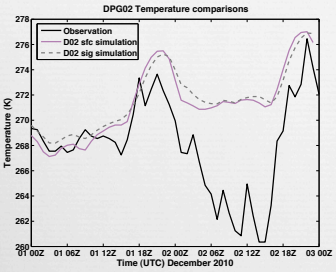
DPG02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Observation
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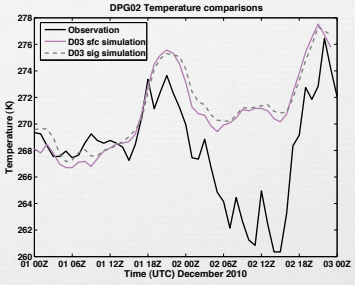
Temperature (K)
Time (UTC) December 2010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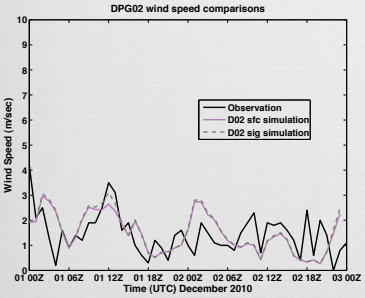
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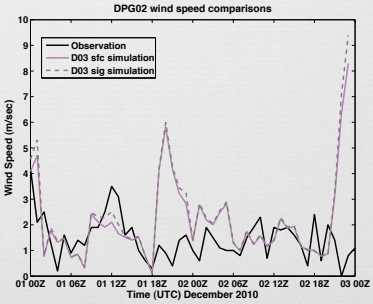
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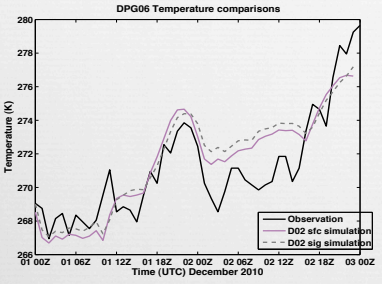
DPG06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Temperature (K)
Time (UTC) December 2010
Observation
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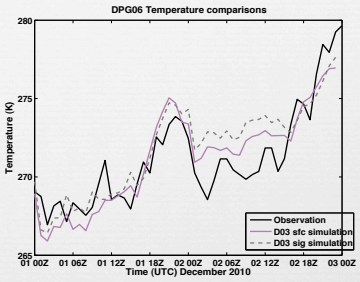
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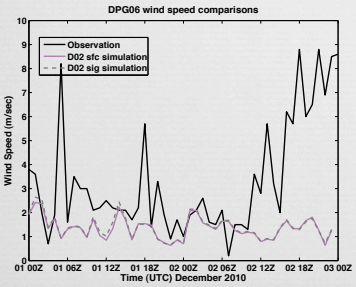
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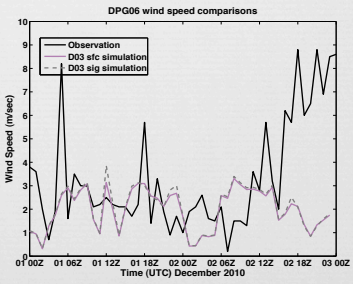
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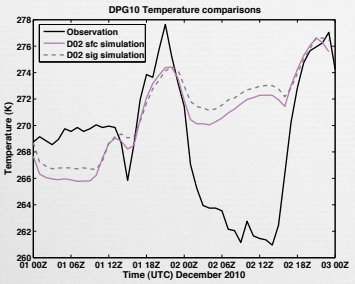
DPG10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Observation
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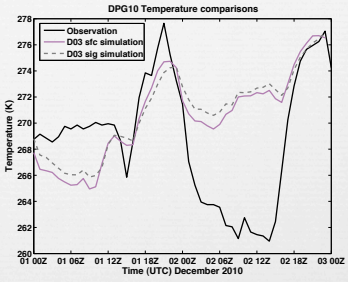
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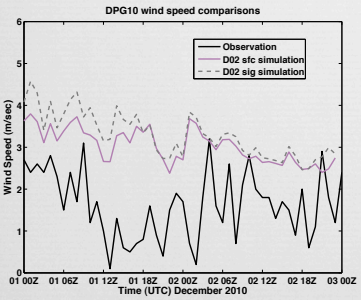
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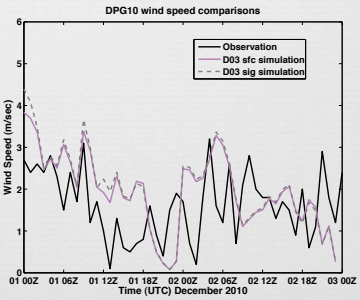
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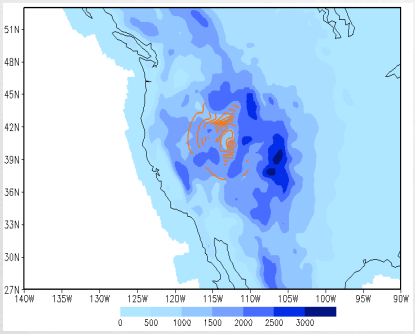
What we learned so far

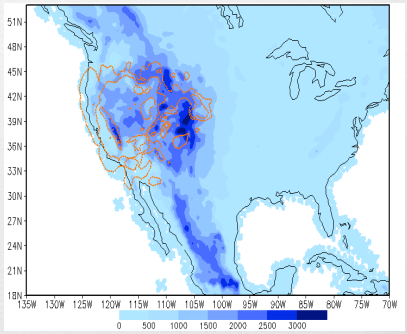
- Uncertainties in model initial conditions
- Uncertainties in representing diurnal variations
- Does increased resolution help??
- Lack of atmospheric boundary layer observations

Data assimilation over mountainous terrain

WRF/3DVAR



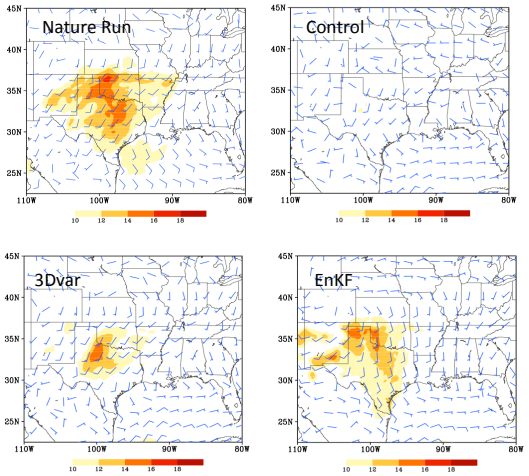
WRF/DART, EnKF



Pu and Zhang (2011)

Potentials of retrieving atmospheric PBL structure from surface observations

Wind speed and vectors: AGL 50m. 00 UTC 5 June 2008 (The first cycle of assimilation)



Pu and Zhang - EnKF/3DVar - 14th AMS Mesoscale Conference

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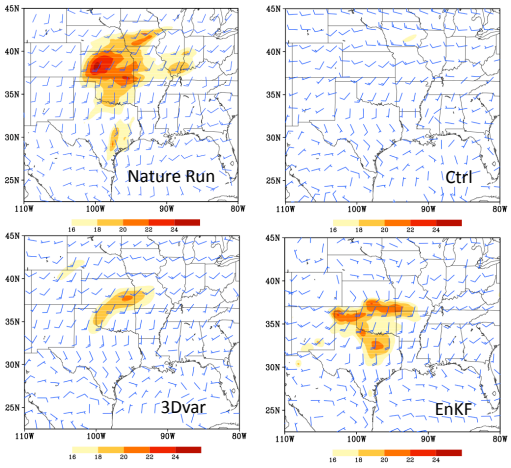

Pu and Zhang - EnKF/3DVar - 14th AMS Mesoscale Conference

Concluding remarks

Future work

- Evaluation of different data assimilation methods
- Dealing with mountainous terrain in data assimilation and ensemble forecasting
- Dealing with diurnal variation related model errors
- Resolution issues
- Ensemble forecasting based on ensemble data assimilation and parameter estimation

MATERHORN-X should provide a unique opportunity for evaluating data assimilation methods, validating ensemble forecasting, verifying numerical model and studying atmospheric processes over mountainous terrain.