WRF "Obs-nudging" Updates, Verification and Plans for the Future Developments

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Thanks to the numerous modelers, engineers, forecasters, and managements at Dugway Proving Ground, Utah, and the National Center for Atmospheric Research at Boulder, Colorado.

Overview

- **WRF3.0 “obs-nudging” features and updates**
- **An introduction to Ensemble-RTFDDA**
- **“Obs-nudging” study with E-RTFDDA outputs**
  – MM5 versus WRF
  – NAM versus GFS
  – Impact of physics schemes and other model uncertainties
- **Comparison of WRF “obs-nudging” with community MM5 through a controlled case study**
- **Plans and on-going developments**

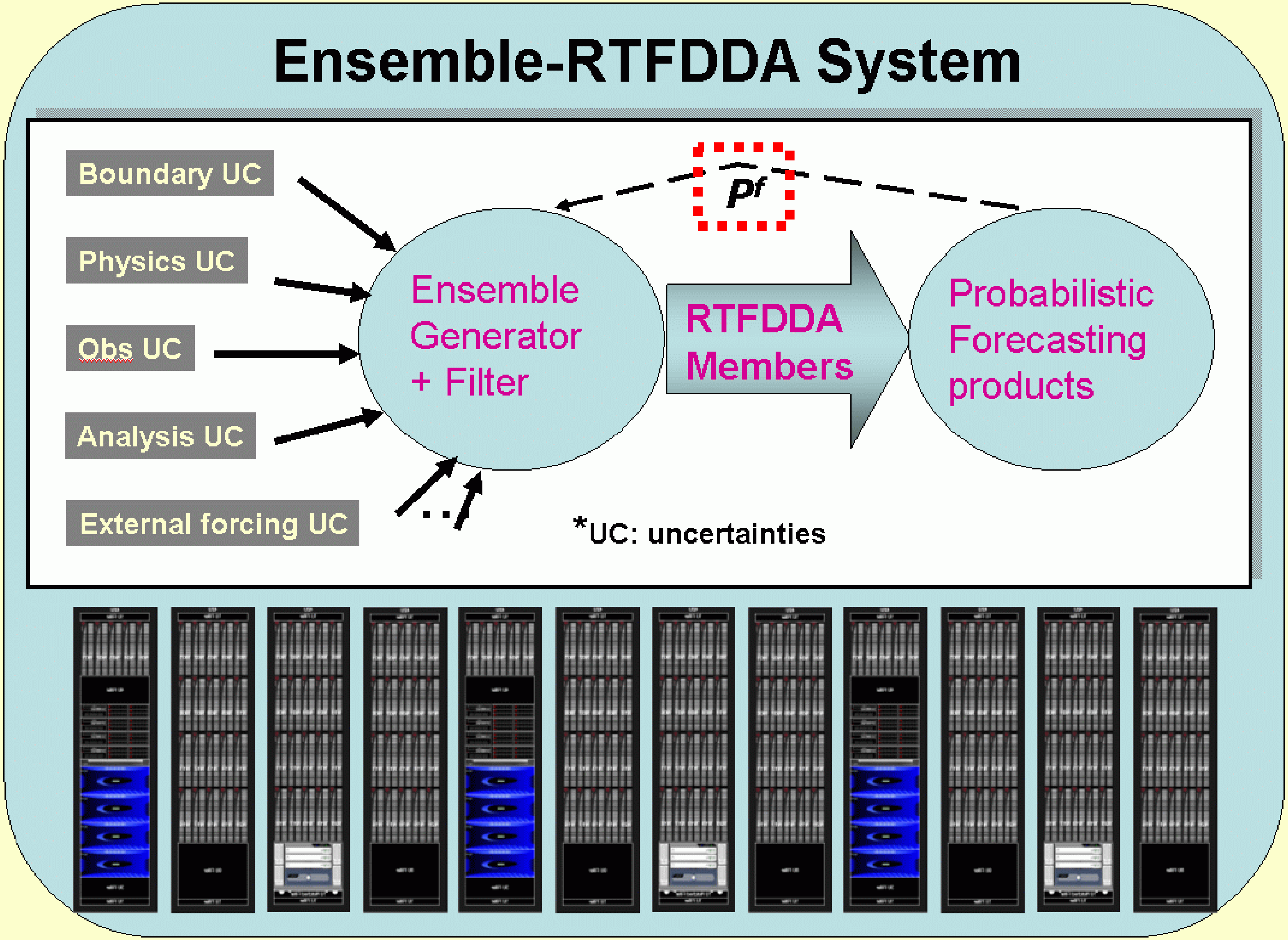
Features of Obs-nudging in WRF3.0

- Assimilate T, U, V and RH from any platforms
- Use different data weight algorithms for vertical profile-type data, point-wise upper-air observations, and surface observations
- Many built-in physically-based spatial weight constraints

New in WRF3.0:

- Assimilate different data for nested domains
- Permit domain-dependent influence radii and time windows, besides nudging coefficients
- Double-scan (mimic successive correction OA)
- Code/namelist/printout cleaning and adjustments
- Bug fixes and more

E-RTFDDA: an Ensemble of "Obs-nudging"

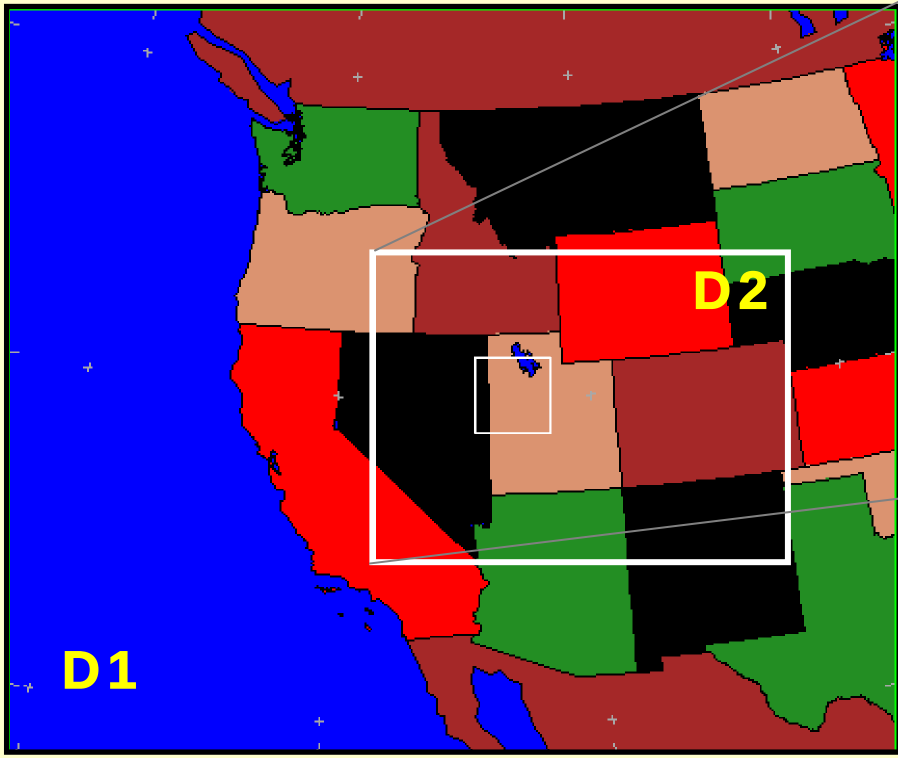


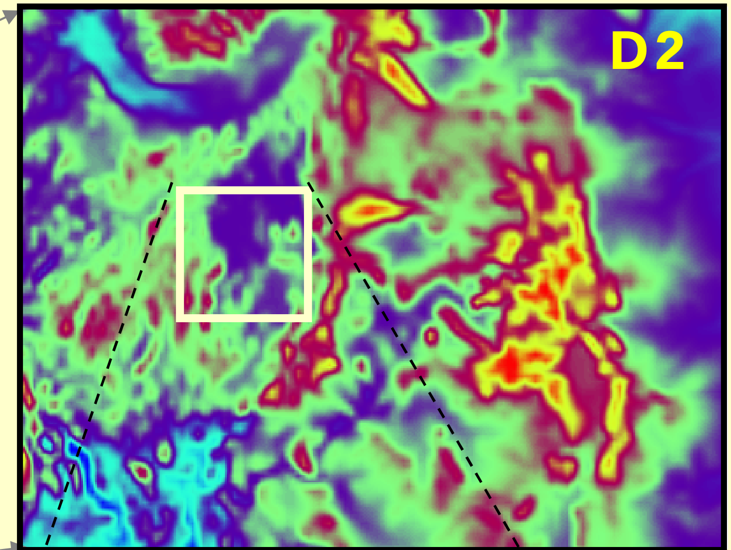
Description of 30 Members of DPG E-RTFDDA

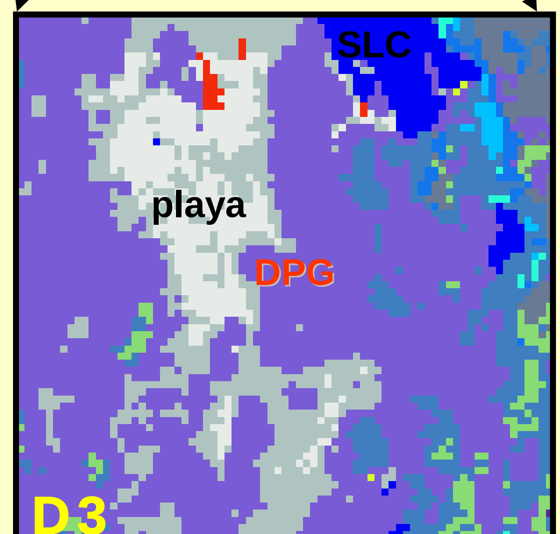
E#	LBC	WRF Members (15)
1	NAM	Control: WRF baseline physics
2	GFS	Control: WRF baseline physics
3	NAM	SLAB land surface
4	NAM	MYJ PBL
5	NAM	MYJ PBL + GD Cumulus
6	NAM	WMS6 microphysics
7	NAM	GD cumulus
8	GFS	Thomason microphysics
9	GFS	MYJ PBL + WMS5 microphysics
10	GFS	MYJ PBL
11	GFS	MYJ PBL + GD Cumulus
12	GFS	BMJ cumulus
13	GFS	BMJ cumulus in 3.3 km grid
14	GFS	GD cumulus in 3.3 km grid
15	GFS	KF cumulus in 3.3 km grid

E#	LBC	MM5 Members (15)
16	NAM	Control: MM5 baseline physics
17	GFS	Control: MM5 baseline physics
18	NAM	Simple cloud-effect radiation
19	NAM	ETA TKE PBL
20	NAM	Kain-Fritsch cumulus
21	NAM	Goddard microphysics
22	GFS	Betts-Miller cumulus
23	GFS	Reisner 3-ice microphysics
24	GFS	CCM2 radiation
25	GFS	GFS LBC Phase-uncertainty 1
26	GFS	Symmetric perturb to Member 25
27	GFS	GFS LBC Phase-uncertainty 2
28	GFS	Symmetric perturb. to Member 27
29	GFS	Correlated sounding perturbation
30	GFS	Symmetric perturb. to Member 29

E-RTFDDA Operation for Dugway Proving Ground



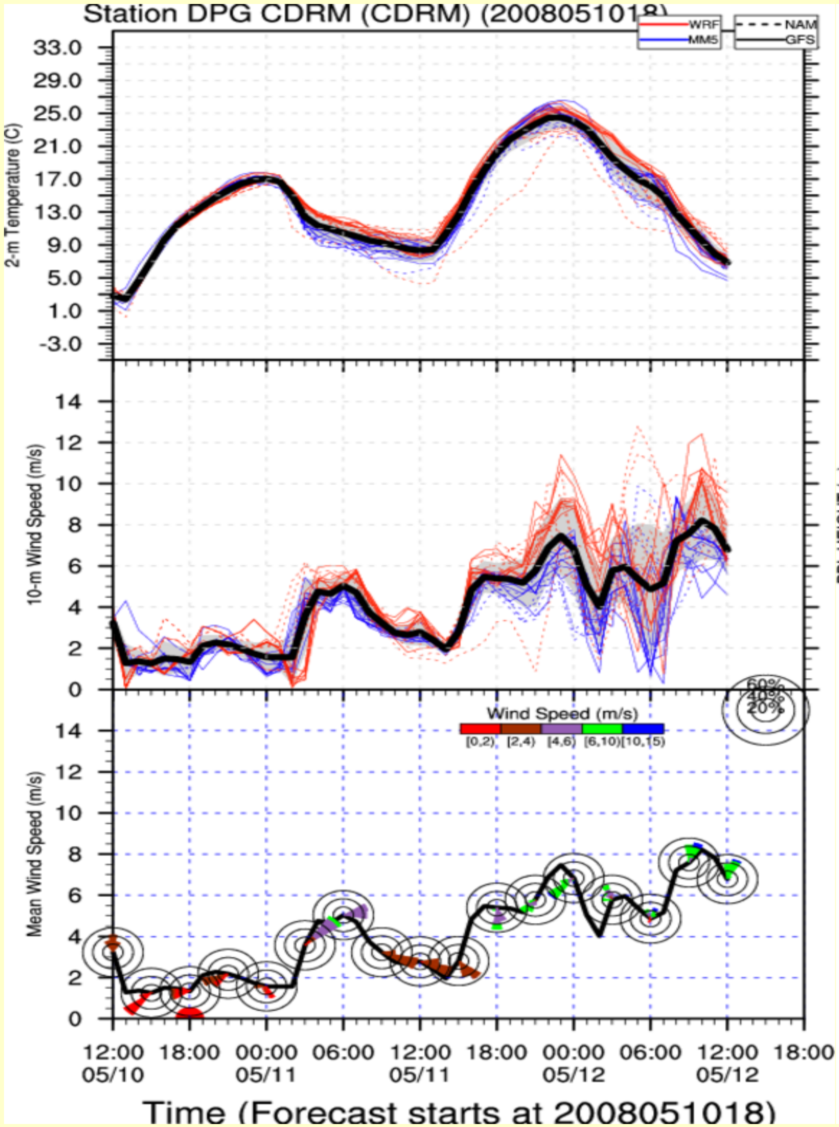


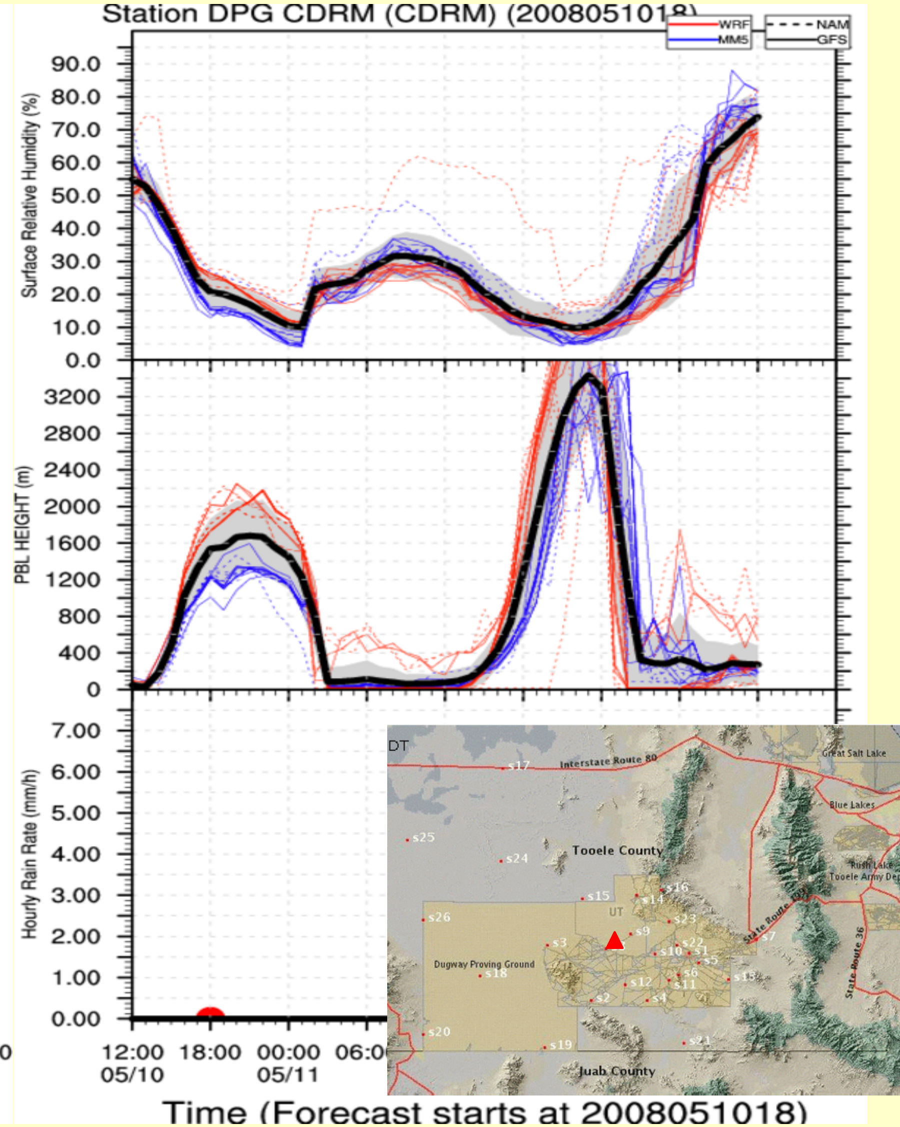


250 km
X
250 km

D1: map ΔX=30 km
D2: terrain ΔX=10 km
D3: land use ΔX=3.33 km

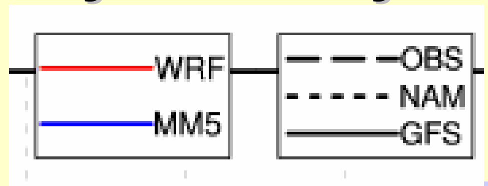
E-RTFDDA Spaghetti Meteograms

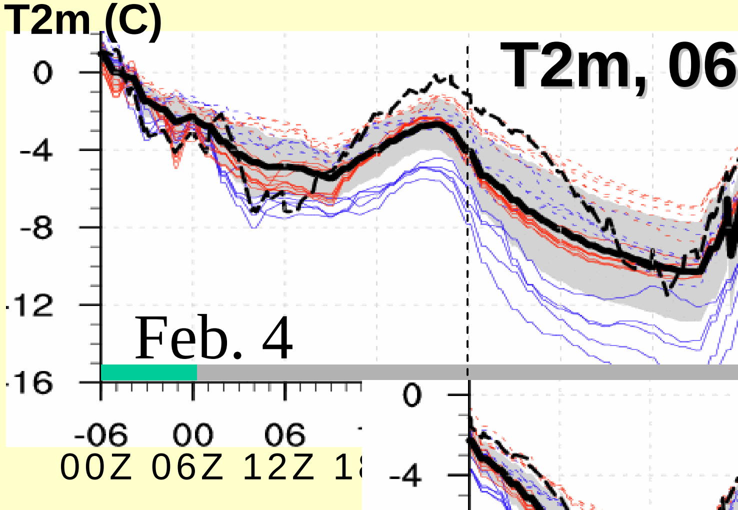


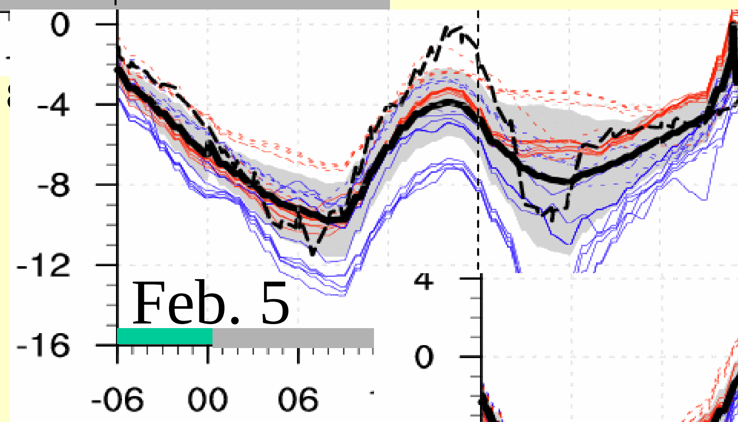


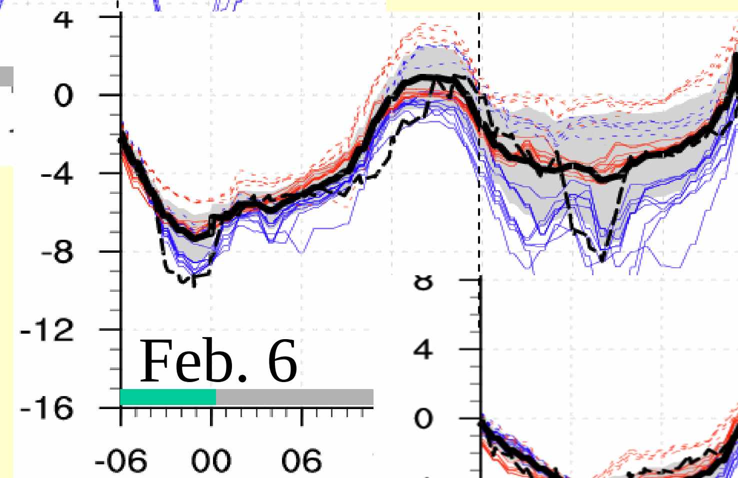
T2m, 06Z cycles daily for Feb 4,5,6 &7, 2008

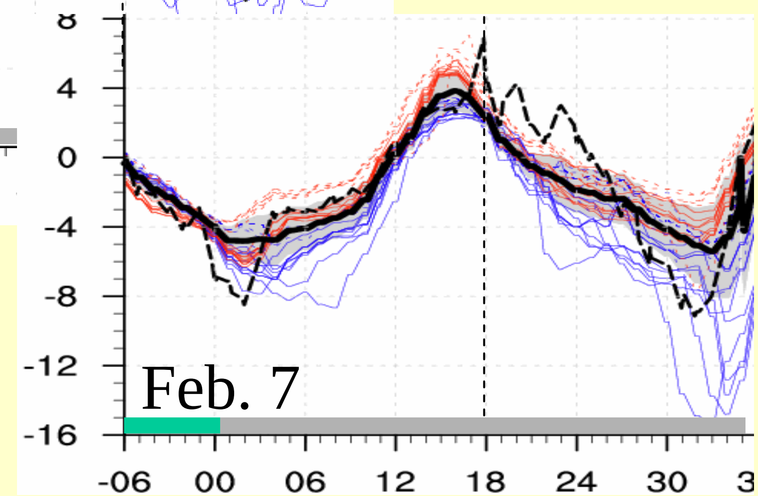
at DPG SAMS08











“Effective actions”

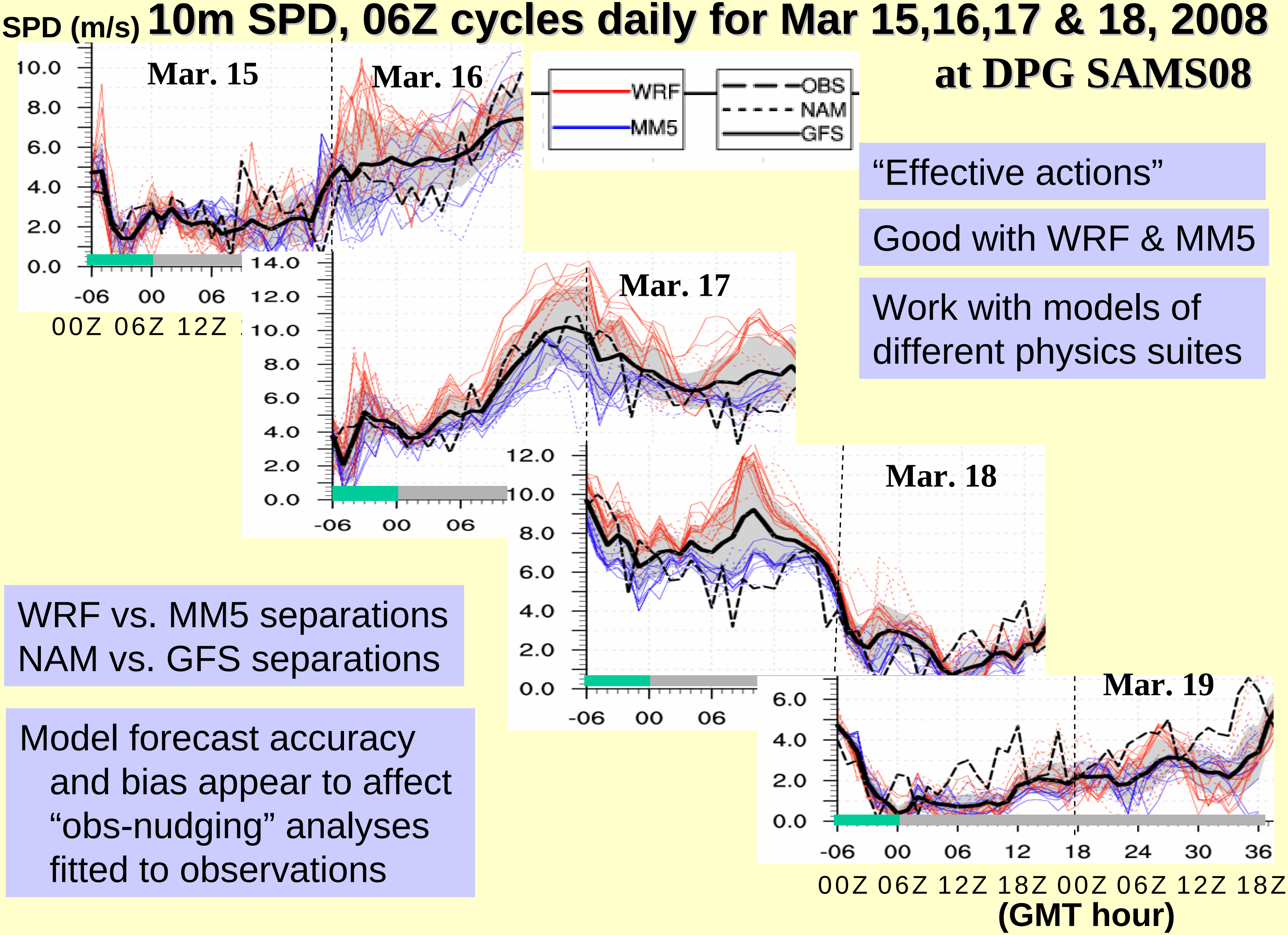
Good with WRF & MM5

Work with models of different physics suites

WRF vs. MM5 separations
NAM vs. GFS separations

Model forecast accuracy and bias appear to affect “obs-nudging” analyses fitted to observations.

10m SPD, 06Z cycles daily for Mar 15,16,17 & 18, 2008 at DPG SAMS08



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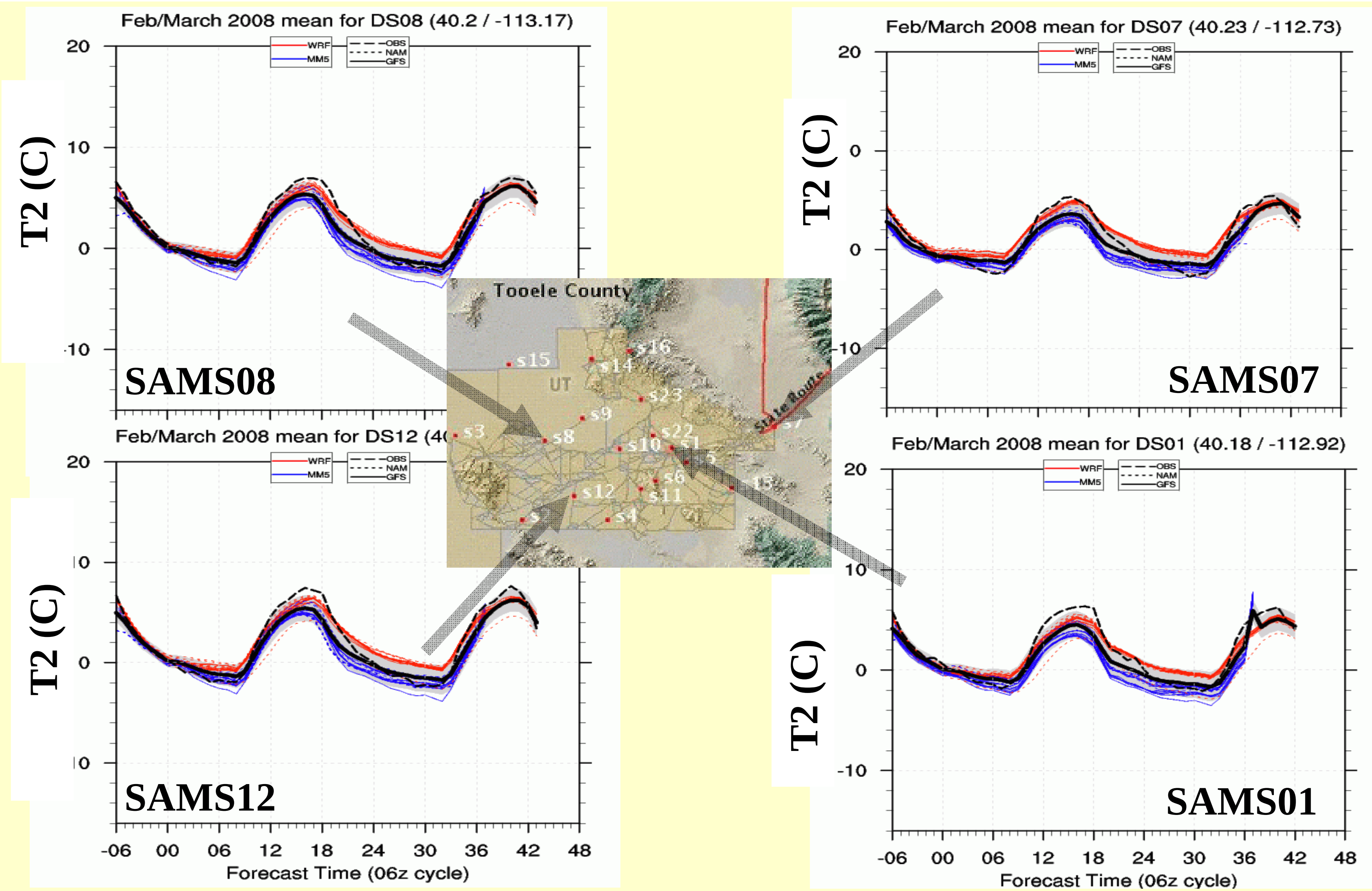
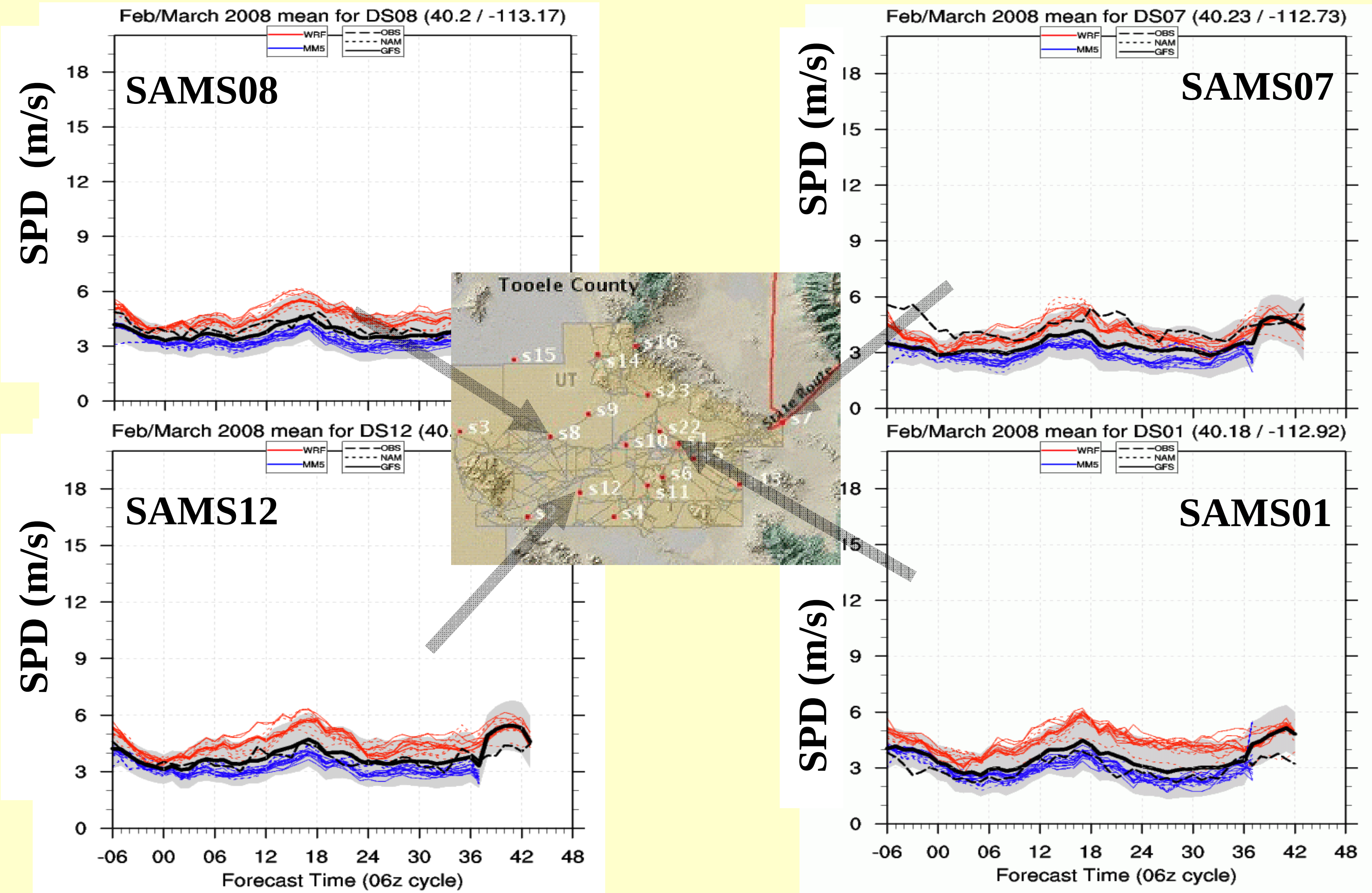
2008 Feb-Mar Mean: 2-m Temperatures



2008 Feb-Mar Mean: 10-m Winds

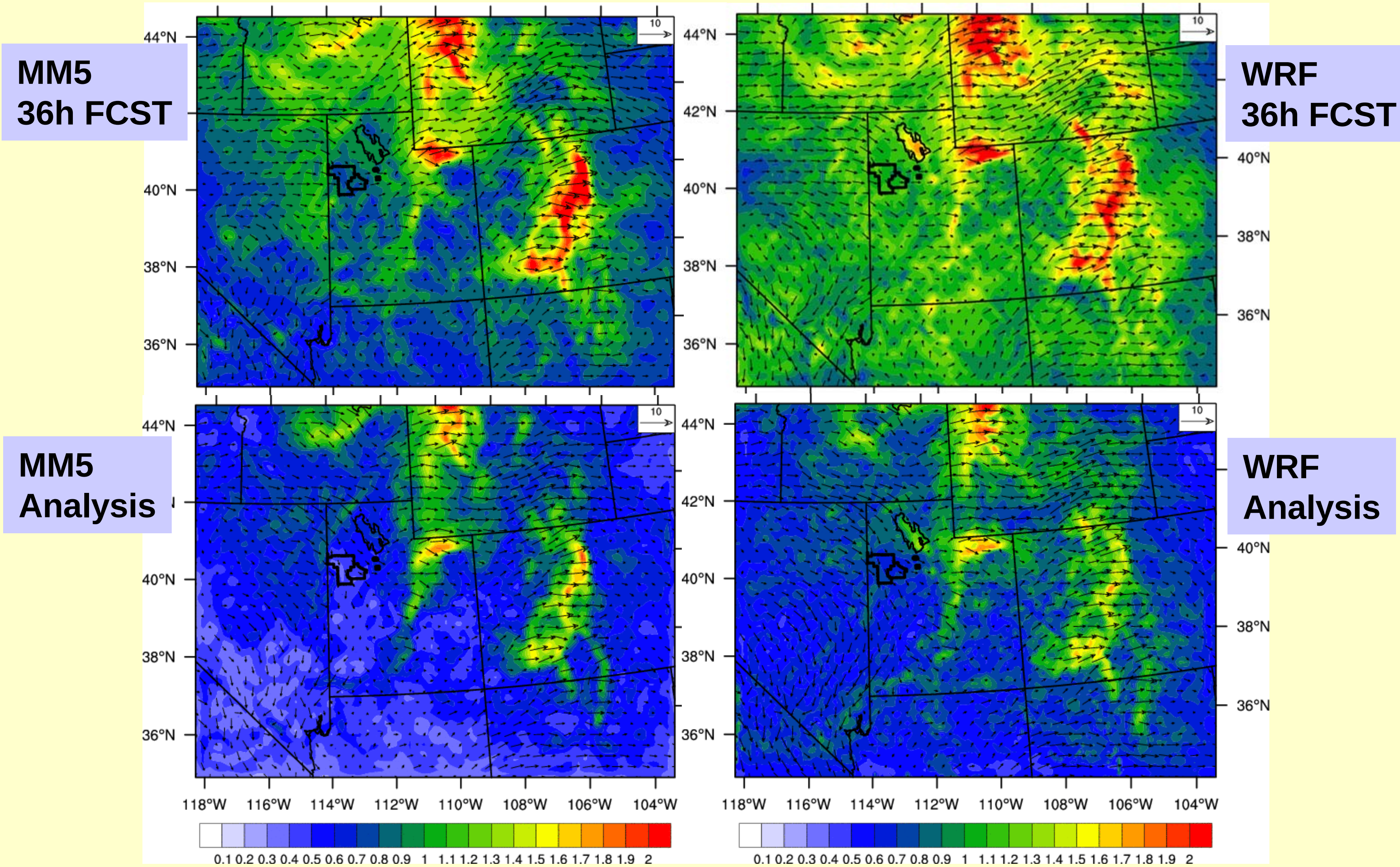
NCAR



Feb-Mar Mean of DPG E-RTFDDA Dom 2 Outputs

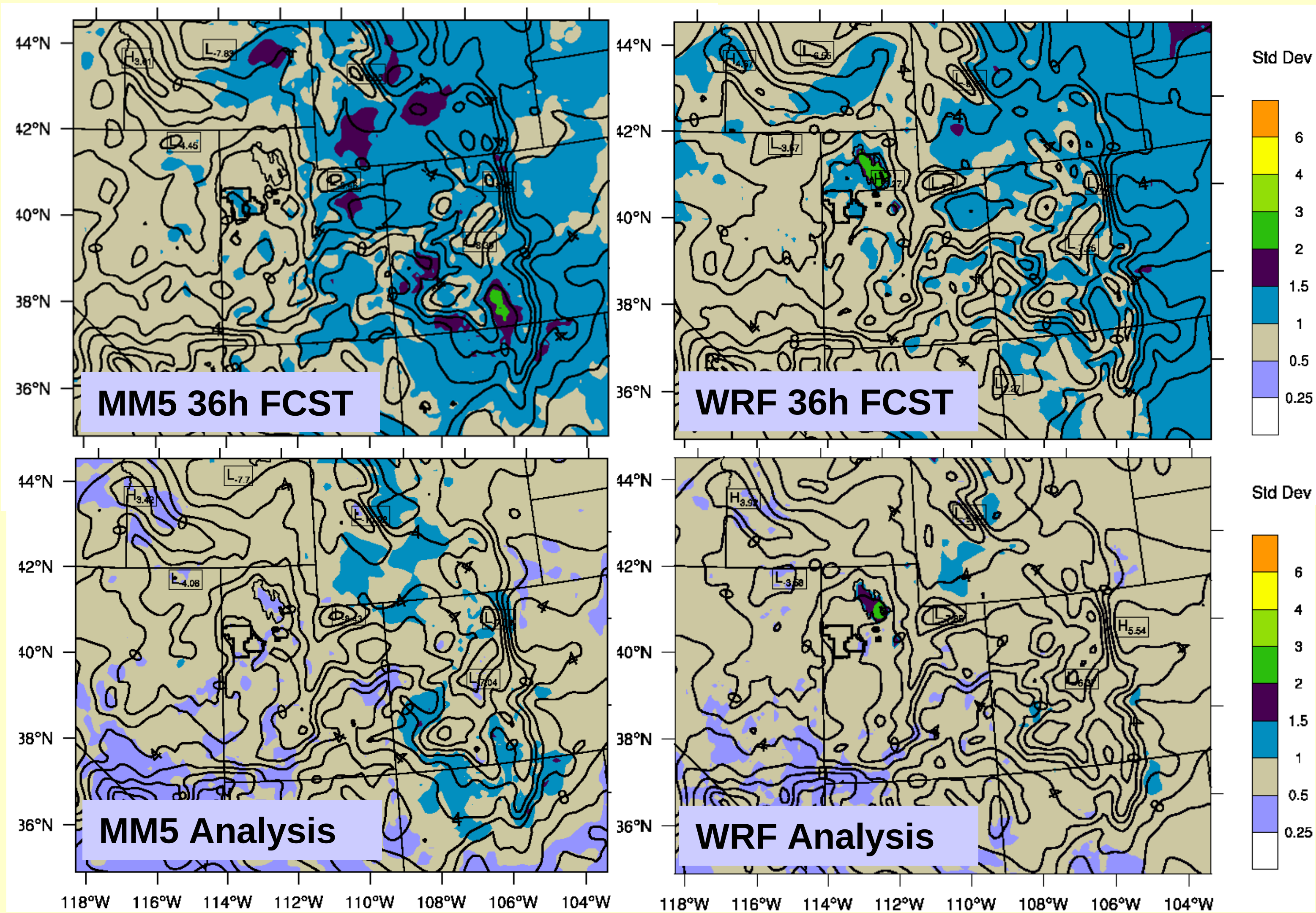
NCAR

Surface mean wind vector and wind speed STD (m/s), valid at 18Z



Feb-Mar Mean of DPG E-RTFDDA Dom 2 Outputs

Surface temperature and temperature STD (m/s), valid at 18Z



Controlled Comparison With Community MM5

- Cross Appalachian Tracer Experiment of 1983 (CAPTEX-83) Episode 1: 18-19 September 1983.
- Previously studied using MM5 by PSU
- Standard NCAR/NWS ADP radiosondes12 hourly and surface observations (3 hourly).

→ Set WRF with the same domain configuration ($\Delta x = 36$ km), ICs, BCs, Obs, physics suite and nudging parameters as used in MM5.

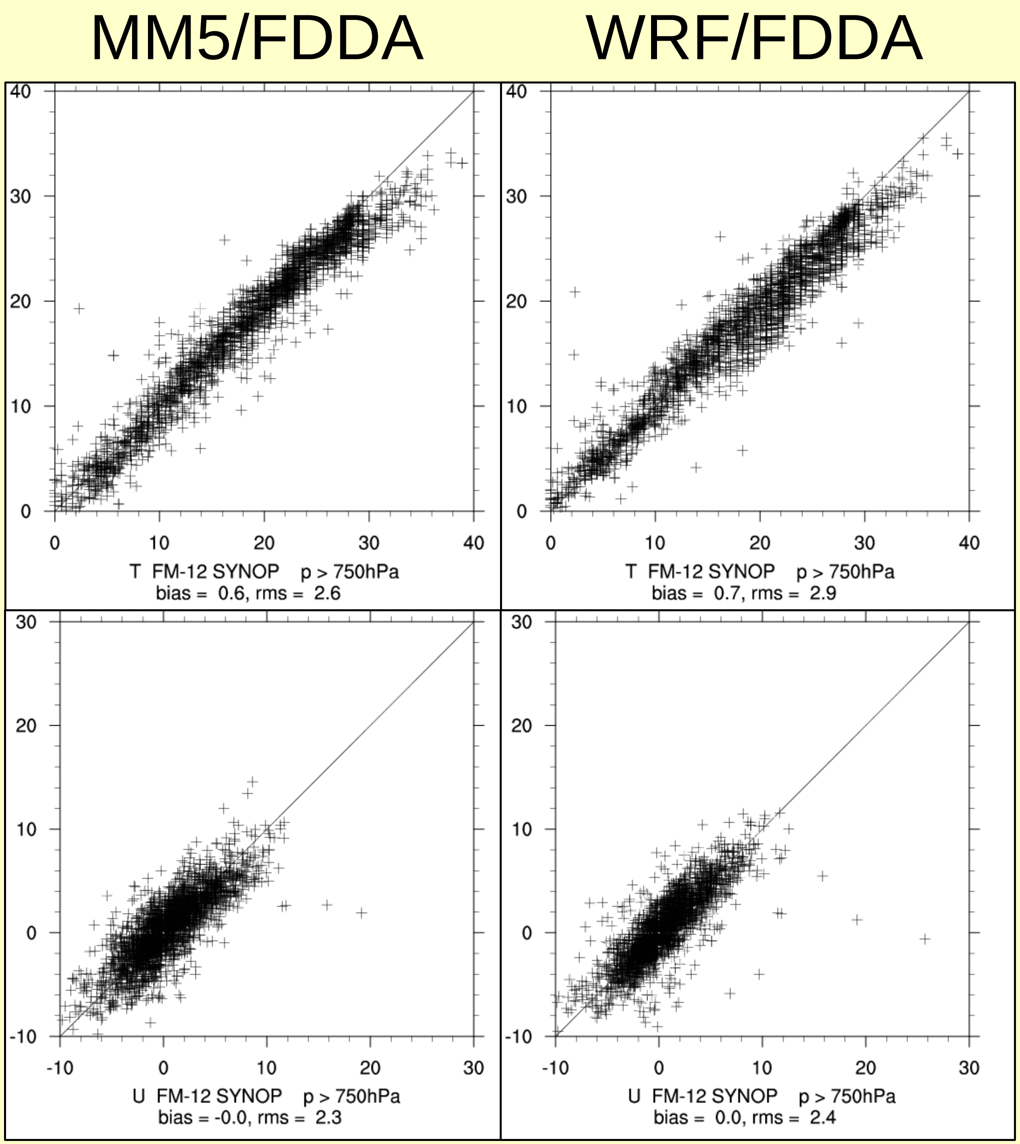
→ Used to systematically test the community WRF obs-nudging codes and algorithms

Fit to surface observations

Fcst (y) vs. obs (x)

2-m T

10-m U



Remarks from the controlled case study

- Valuable exercise to review/validate WRF obs-nudging scheme
- Help enhance the robustness of the WRF obs-nudging scheme for the broad community applications
- A showcase indicating the advantage of community involvement

Specific gains:

1. A utility program to pipe NCAR MSS ADP data to obs-nudging
2. Using sfc observations without sfc pressure
3. A flexibility for using height-based obs directly
4. A need to enhance the ability for enhance
5. Adjust for more intuitive namelist and diagnostic printouts
6. Dealing with more configurable domain options in WRF

Summary

Advantages of Obs-nudging

- Assimilate T, U, V and RH of all platforms
- Direct data-model interaction: simple, effective and flexible
- Based on the same foundational formulation as other DA schemes
- Continuous (model-nature) state synchronization

Obs-nudging Ensemble

- Real-time mesoscale data assimilation and prediction
- Systematic comparisons of MM5 versus WRF
- Impact of physics schemes and other model components
- R&D of 4D-EnKF using nudging and EnKF hybrid

Updates in WRF3.0

- Different obs for nested domains
- Domain-dependent influence radii and time windows
- “Double-scan” - multi-scale
- Code cleaning, bug fixes and
- Others

New Updates Coming Soon

- Accommodate the extra flexibility of WRF domains setting over MM5
- Height-based observation and incomplete surface data
- Utility program to ingest NCAR/NWS ADP data
- Adjusting space and time weights

Road Map for Obs-nudging Development

NCAR

Advanced Obs-nudging formulation

→ Build "proper" mesoscale ensembles - heterogeneous
→ Evaluate EnKF using the "proper" ensemble
→ Incorporate Kalman Gain to obs-nudging weights

Ensemble RTFDDA (NCAR / RAL) (Obs-nudging ensembles)

Improvement areas:
→ Spatial weights
→ Temporal weights
→ Diverse data sources

Hybrids:
→ 3DVAR
→ VDRAS
→ Grid-nudging FDDA

Basic Obs-nudging formulation