Bias Correction of RTFDDA Surface Forecasts

Presented by:
Daran Rife

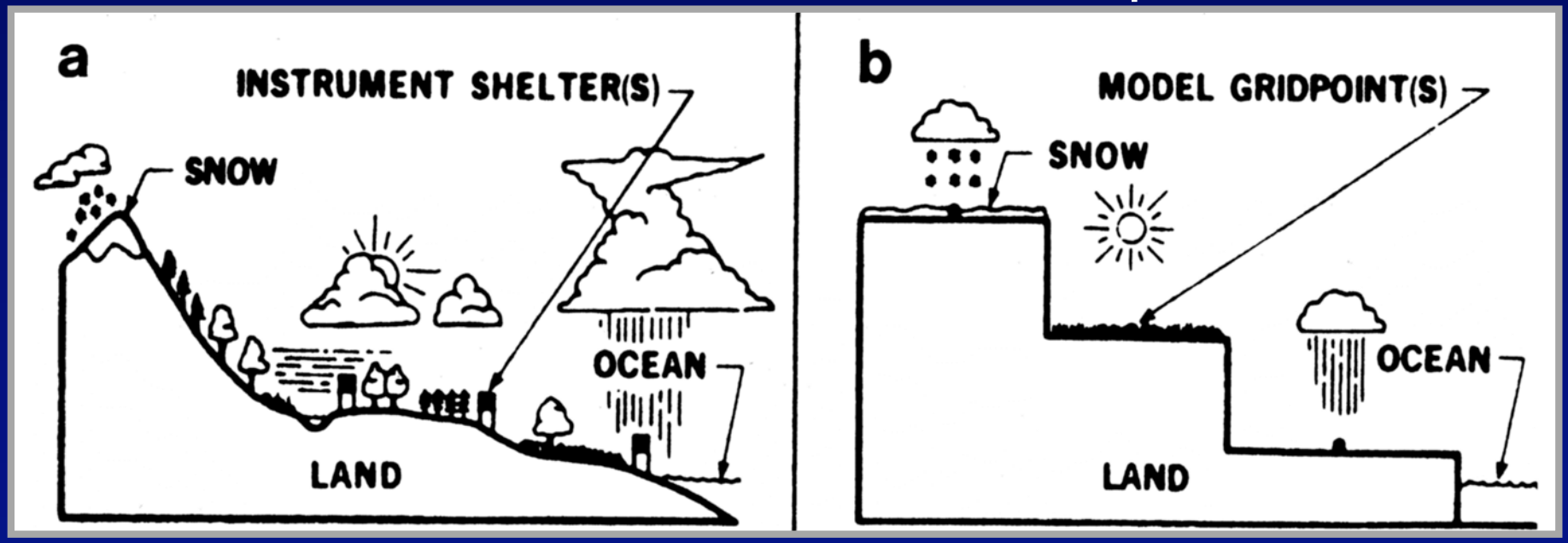
National Center for Atmospheric Research
Research Applications Laboratory
Boulder, Colorado

26 July 2006

Why implement a statistical correction?

Real world

Model representation



- Imperfect
- Small-scale features not resolved

Why Not Use a Traditional MOS Approach?

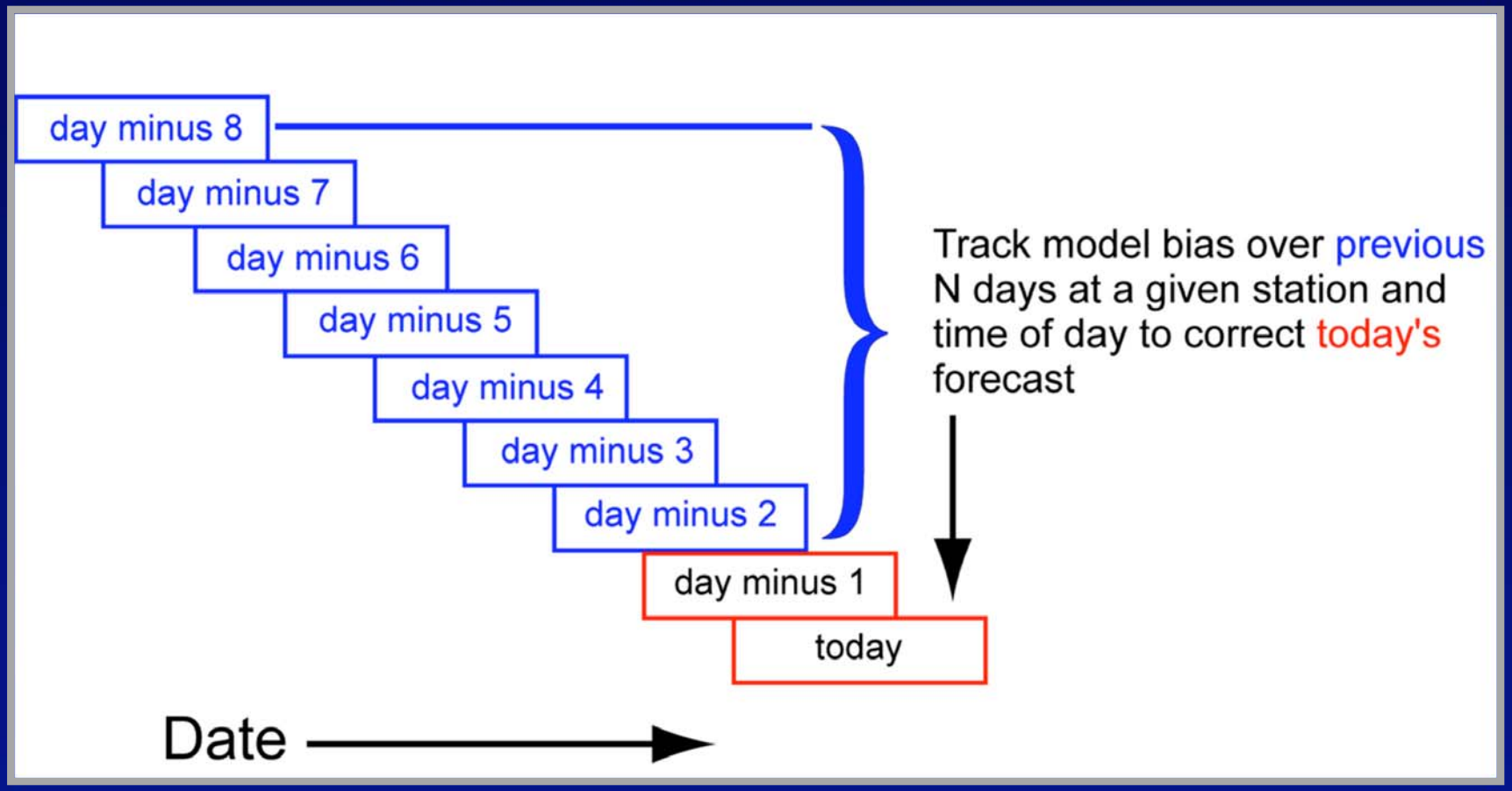
- Traditional MOS requires:
  - A “frozen” weather forecast model (no upgrades).
  - Lengthy data archive for “training” MOS equations.
- Implications:
  - MOS system must be completely “re-trained” whenever model is upgraded—difficult and very time consuming.

One Alternative

Running-mean bias correction

- Advantages:
  - Improve/upgrade model at any time.
  - Long data archive not needed.
  - Relatively easy to implement.
  - Significant increase in forecast accuracy.

Schematic of Point-wise Running-mean Bias Correction



Bias correction computed as function of station location and time of day

Bias Correction Provided for:

- 2 m AGL temperature
- 2 m AGL dew point temperature
- 2 m AGL relative humidity
- 10 m AGL wind direction
- 10 m AGL wind speed

Demo

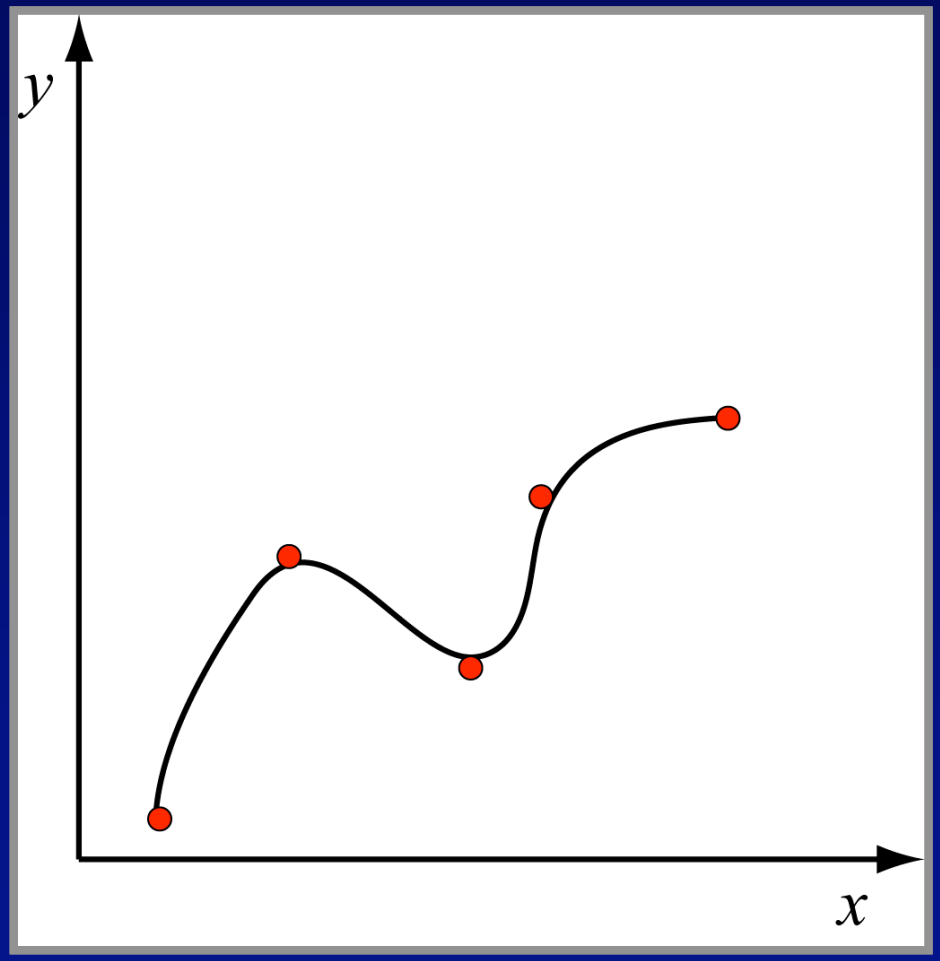
White Sands Missile Range

Bias Correcting the Gridded RTFDDA Forecasts

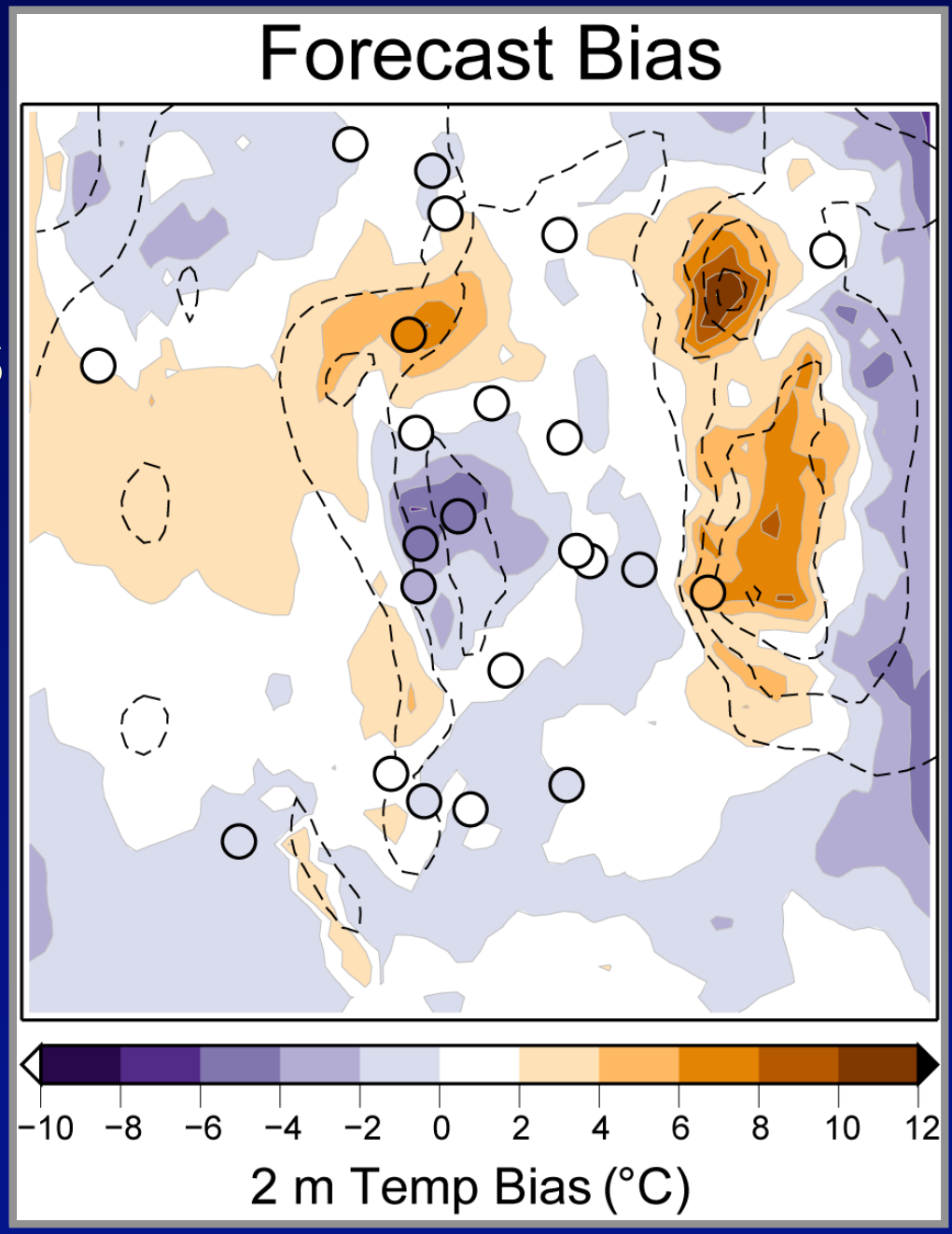
Outline

- How does the gridded bias correction scheme work?
- Example output from gridded bias correction system.
- Timeline for implementing gridded bias correction scheme into ATEC operations.

Motivation by Analogy: Curve Fitting



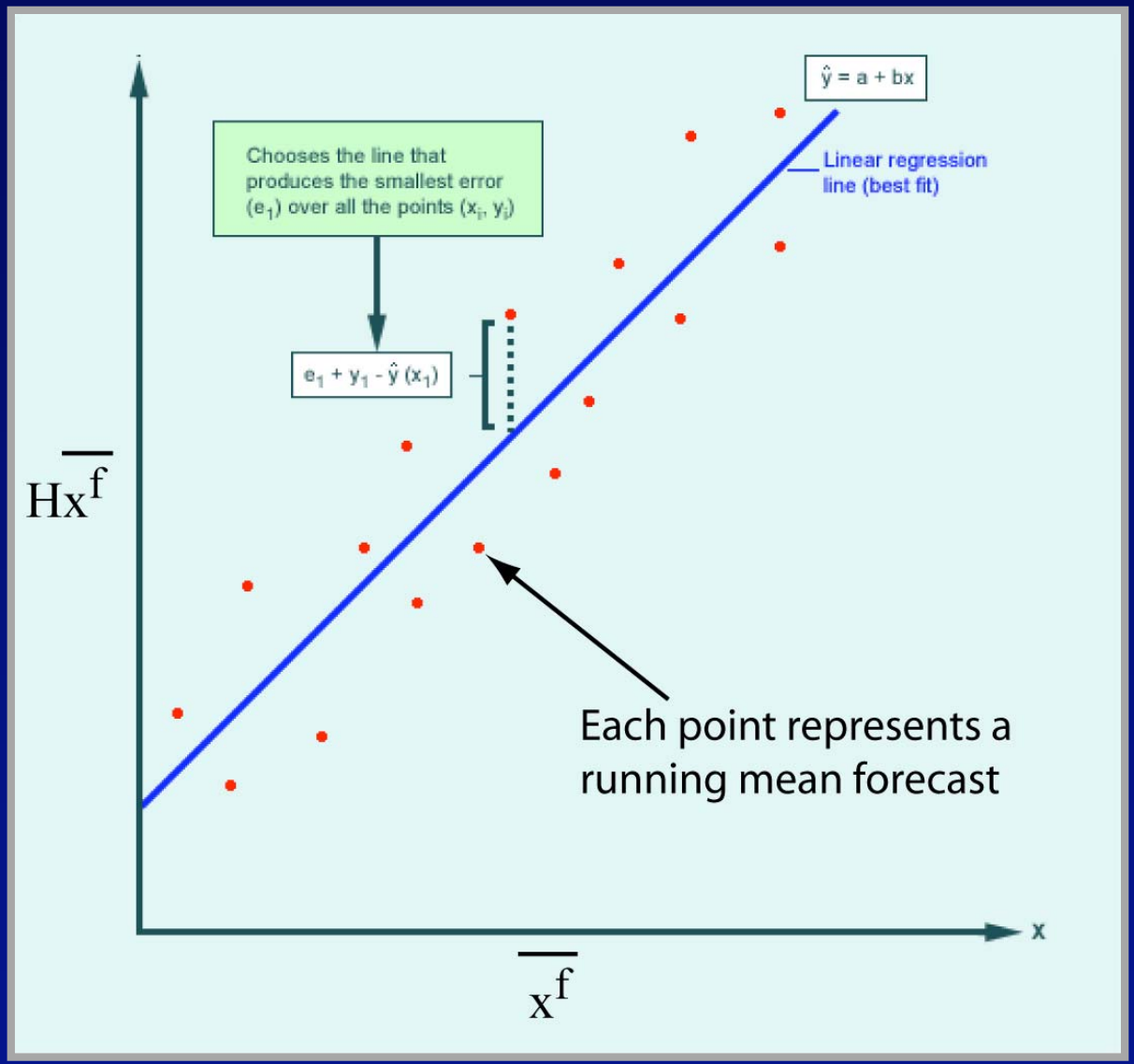
Estimating Forecast Biases Between and Away from Obs Locations



How Does the Gridded Bias Correction Scheme Work?

- STEP 1: Measure forecast bias at observation locations.
- STEP 2: Calculate coefficients of regression that describe the linear relationship between the running-mean forecast variables at the obs locations, and those at every point on the grid.

Calculating Coefficients of Regression

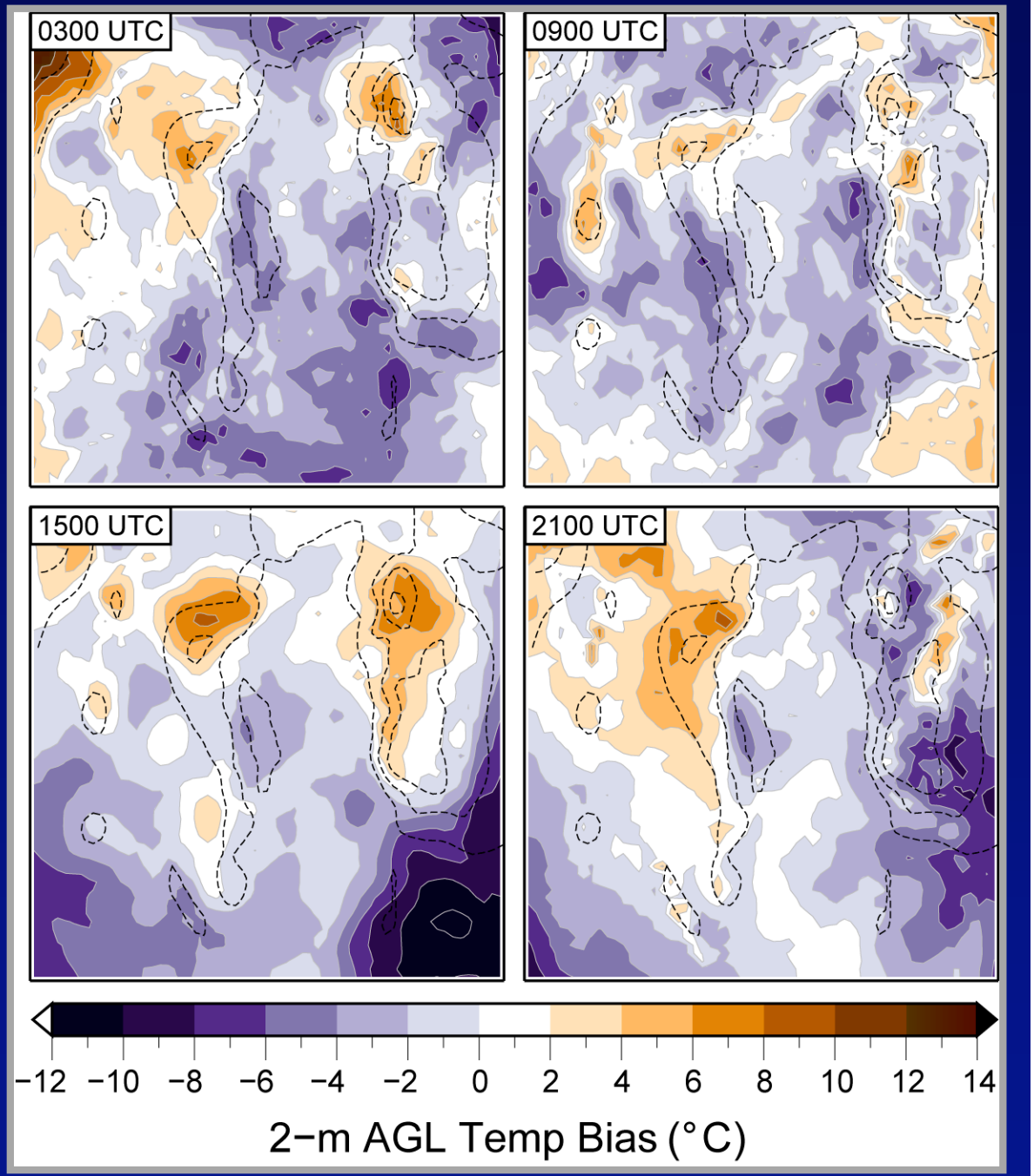


How Does the Gridded Bias Correction Scheme Work?

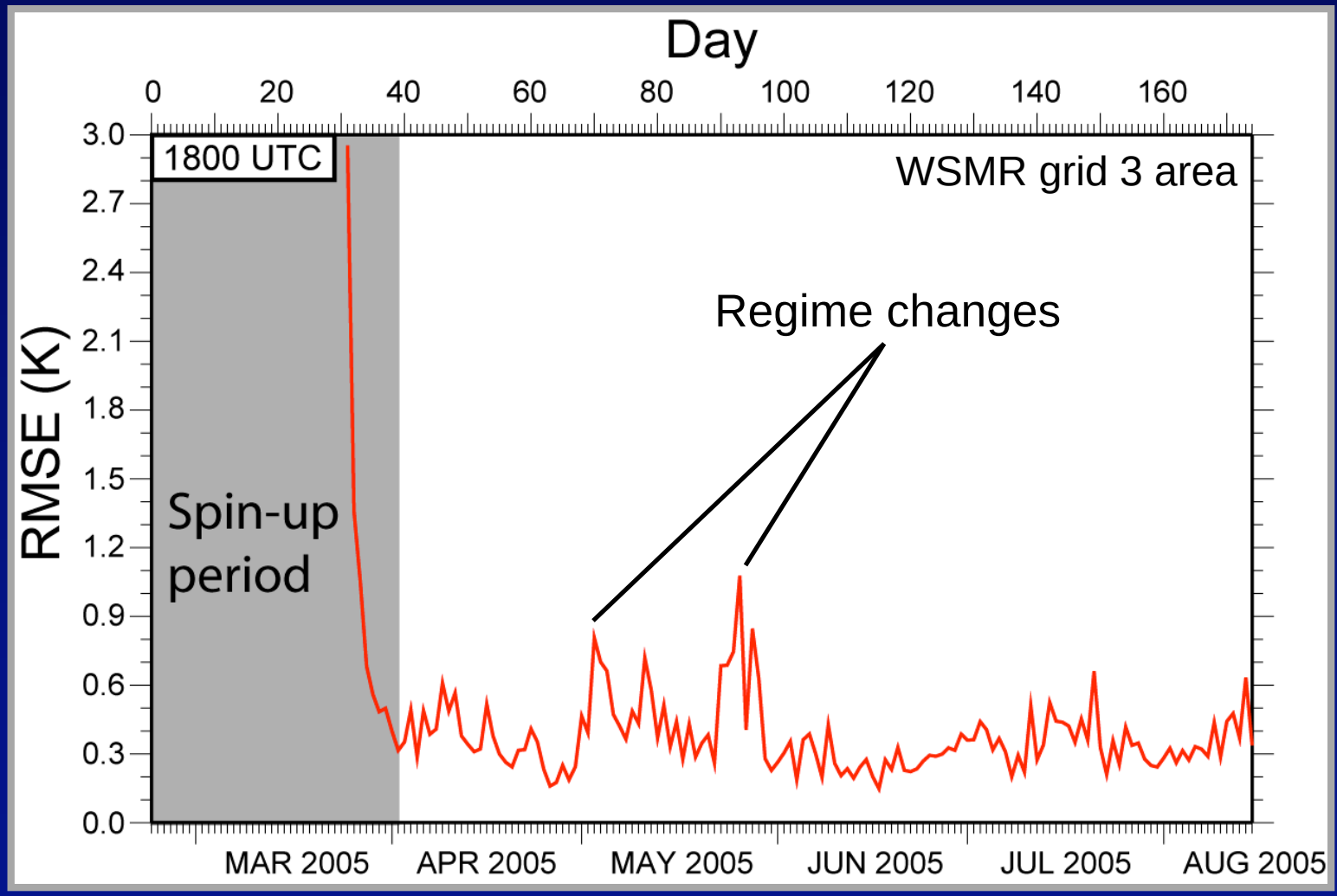
- STEP 1: Measure forecast bias at observation locations.
- STEP 2: Calculate coefficients of regression that describe the linear relationship between the running-mean forecast variables at the obs locations, and those at every point on the grid.
- STEP 3: Subtract bias from “raw” forecast to obtain a correction at each obs location.
- STEP 4: Use regression coefficients to “map” to corrections (at obs sites) onto the full grid.

Diurnal Evolution of Forecast Bias

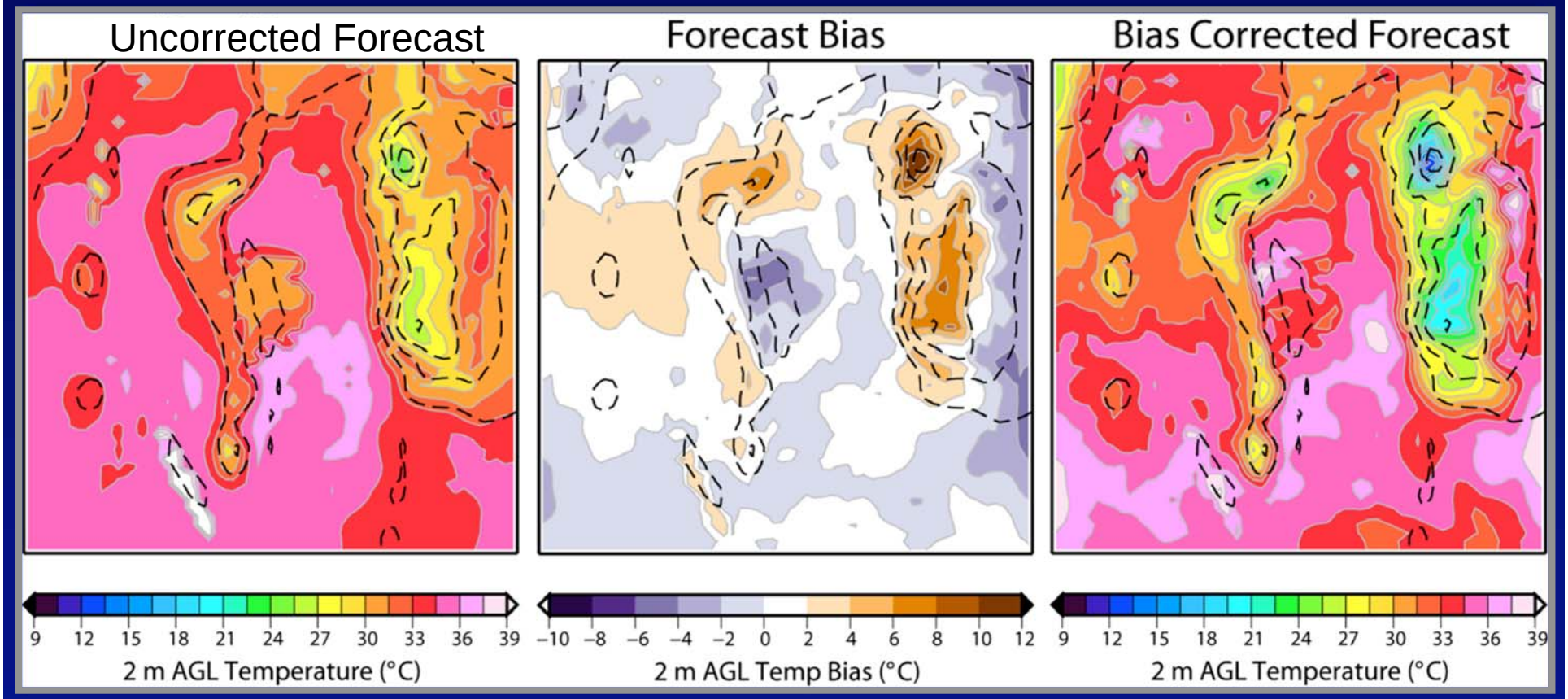
29 June 2005



How Well do Gridded Bias Estimates Fit the Observations?



Bias Corrected Forecast Grids



1800 UTC 29 June 2005

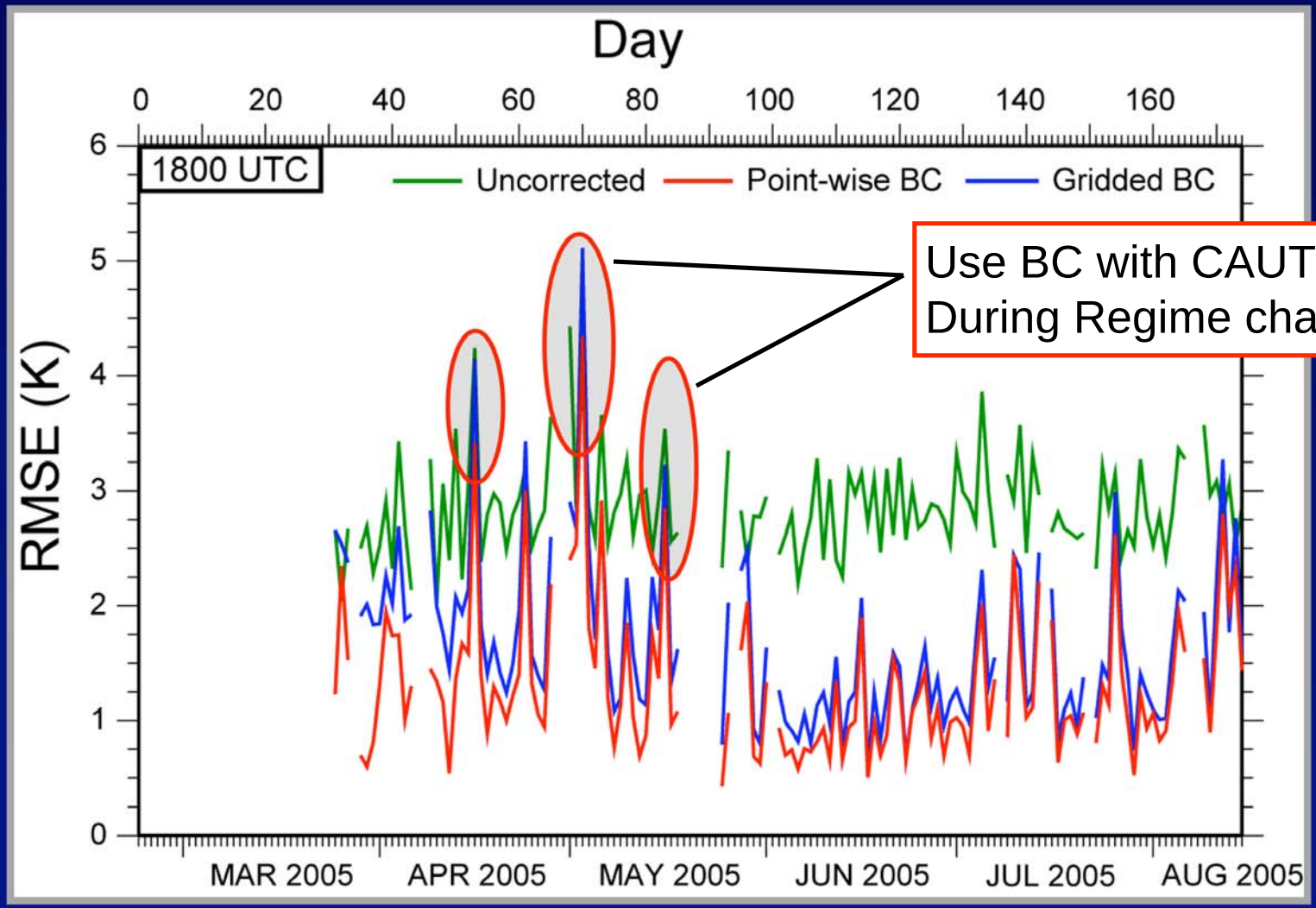
Advantage of Gridded Bias Correction Scheme

- Highly refined estimates of surface meteorological variables at all places on the range.

How Will ATEC Forecasters Benefit from Gridded Bias Correction Scheme?

- Substantially more accurate forecasts (on average).
- Use gridded BC to refine the GCAT climatographies that will be generated for each range.

How Much Are Forecasts Improved Through Bias Correction?



2-m AGL temperature over WSMR grid 3.

Timeline for Implementing Gridded Bias Correction into ATEC Operations

- FY06: Implement at ATC and DPG.
- FY07: Implement at other ranges where RTFDDA running.

Display of Bias Corrected Forecasts

- Web-based “Tabular Sites Data” tool
- Web-based “FDDA Image Viewer”.
- JViz?

Future Plans

- FY07-FY08: Develop/test method to bias correct the full 3D forecast grid.

Intelligent Use of Model Output

- Know the limitations of the model
- General limitations of NWP models:
  - Does not properly treat thin cloud layers.
  - Cannot adequately represent shallow nocturnal boundary layers (or shallow inversions).
  - Solutions near grid boundaries should be used with caution.
  - Models under-estimates the true amount of atmospheric variability (both spatial and temporal).

Limitations of NWP Models Continued)

- Does not account for shadows cast by terrain.
- Very-small-scale landscape features, such as a narrow canyon outlet or mountain pass, are not represented well (or at all) by the model.
- The model does not predict the production, movement, and concentration of atmospheric aerosols. Thus, it can't predict dust storms or how plumes of airborne dust will impact the sensible weather. Same thing is true for smoke plumes from forest fires.

These deficiencies lead to errors in the forecast. To the extent that these errors are systematic, the bias correction scheme can be used to remove them.

Intelligent Use of Model Output

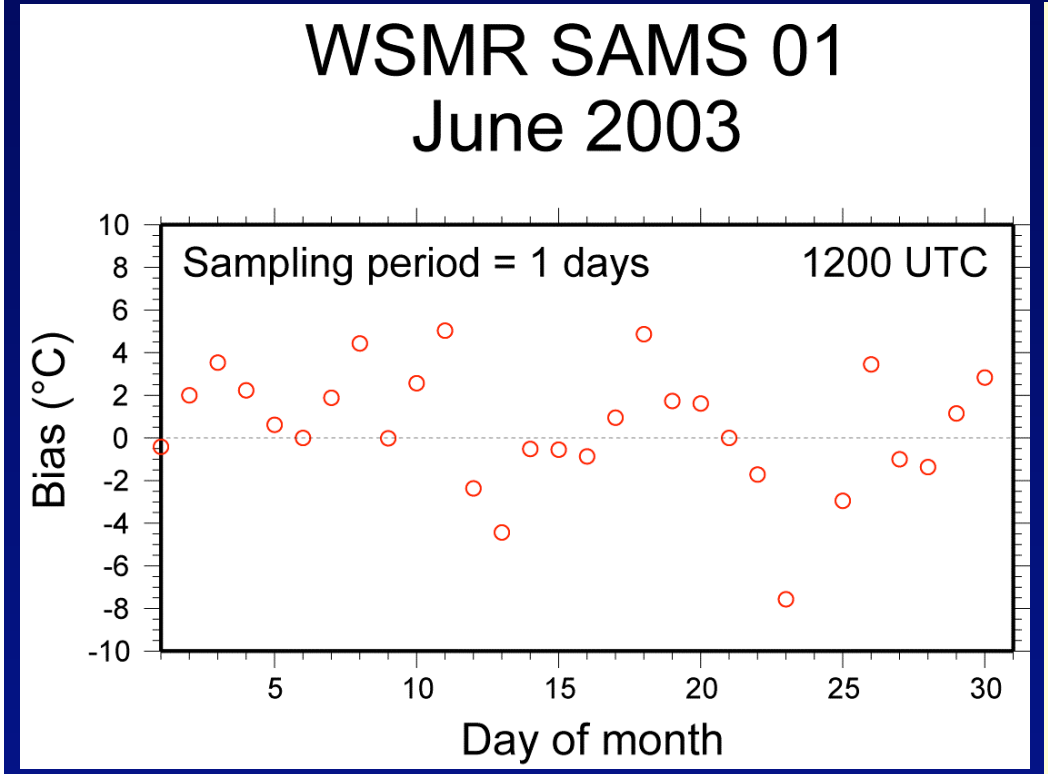
- Situations where the model output should be more closely scrutinized:
  - Does model snowfall/rainfall accumulation correspond well with what was observed?
  - Moist convection is very hard to predict.
  - The PBL conditions during the transition from daytime unstable to nighttime stable conditions (and the opposite transition) are very hard to predict.

GFS MOS Forecast for KELP EL, TX

KELP GFS MOS GUIDANCE 7/19/2006 1200 UTC

DT	/JULY 19		/JULY 20								/JULY 21								/JULY 22		
HR	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	06	12
N/X							74				98				72				100		75
TMP	89	93	95	89	83	80	76	84	91	95	95	89	83	78	74	83	92	97	97	85	77
DPT	53	51	49	49	51	52	53	55	52	49	47	48	49	50	51	54	53	50	48	50	53
CLD	BK	BK	BK	SC	SC	FW	FW	CL	FW	BK	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC
WDR	06	12	09	12	09	06	04	09	10	11	11	14	11	09	06	10	07	09	09	09	03
WSP	09	10	07	06	08	06	04	05	08	09	10	07	07	06	05	05	09	11	12	08	08
P06			11		11		9		5		9		10		5		5		10	6	3
P12							14				12				11				11		6
Q06			0		0		0		0		0		0		0		0		0	0	0
Q12							0				0				0				0		0
T06		24/	0	23/	0	8/	0	0/	0	11/	0	17/	0	9/	0	1/	0	20/	0	8/	0
T12				37/	0			8/	0			17/	0			9/	1		29/	0	
CIG	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
VIS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
OBV	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Why not use yesterday's bias to correct today's forecast?



Example:

Bias 11 June = +6 °C (too warm)
Bias 12 June = -3.5 °C (too cold)

Obs temp 12 June = 18 °C
Fcst temp 12 June = 14.5 °C

Correct the 12 June forecast using previous day's (11 June) bias:

BC = 14.5 °C – 6 °C = 8.5 °C

Our goal was to correct the Forecast toward the Observation, but…

We have made correction in the wrong direction!

How do we choose length of sampling period for computing bias correction?

Main Goal: produce the most accurate result on average

WSMR S05 for Aug 2003