On the bias-correction strategy of radiance data assimilation with a limited-area model

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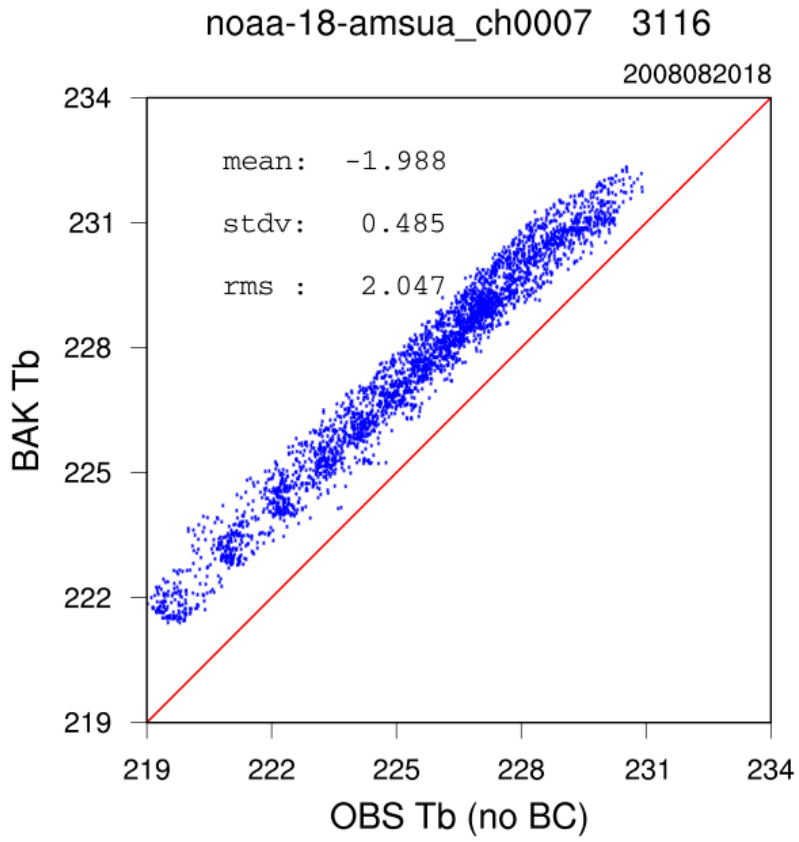
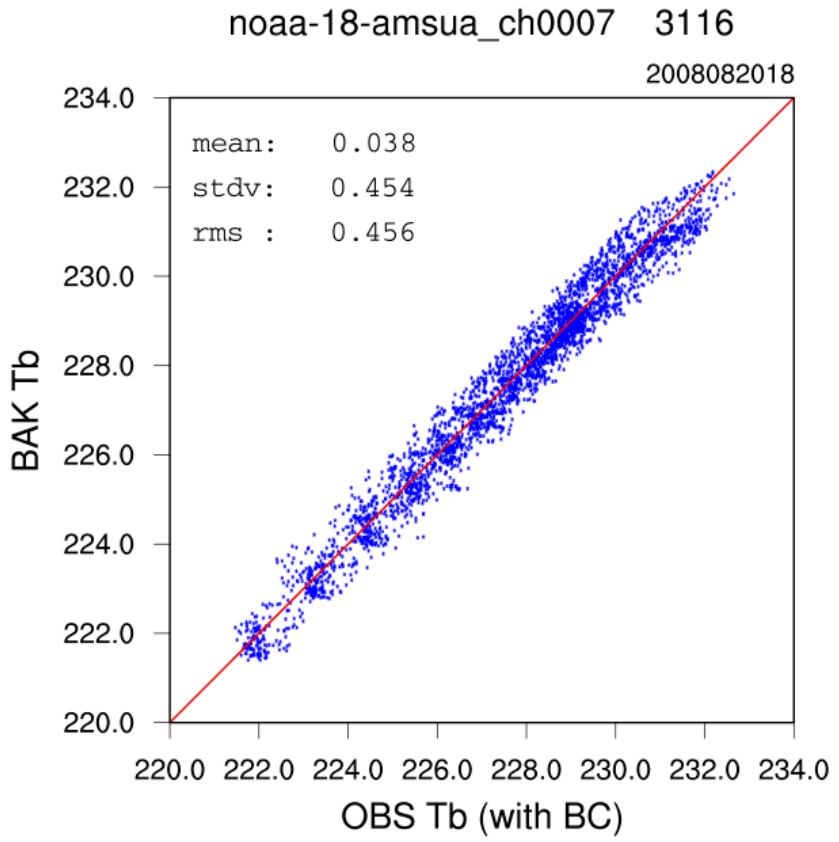
NCAR/NESL/MMM

What looks like radiance bias





Variational Bias Correction (VarBC) in WRFDA (T. Auligné)

Modeling of errors in satellite radiances:

$$y = H(x_t) + B(\beta) + \varepsilon$$

$$\begin{cases} \langle \varepsilon \rangle = 0 \\ B(\beta) = \sum_{i=1}^{N} \beta_i p_i \end{cases}$$

Bias-correction coefficients

Predictors:
- Offset (i.e., 1)
- 1000-300mb thickness
- 200-50mb thickness
- Surface skin temperature
- Total column water vapor
- Scan, Scan^2, Scan^3

Bias parameters can be estimated within the variational assimilation, jointly with the atmospheric model state (Derber and Wu 1998) (Dee 2005) (Auligné et al. 2007)

Inclusion of the bias parameters in the control vector : $x^T \rightarrow [x, \beta]^T$

J_b: background term for x J_o: corrected observation term

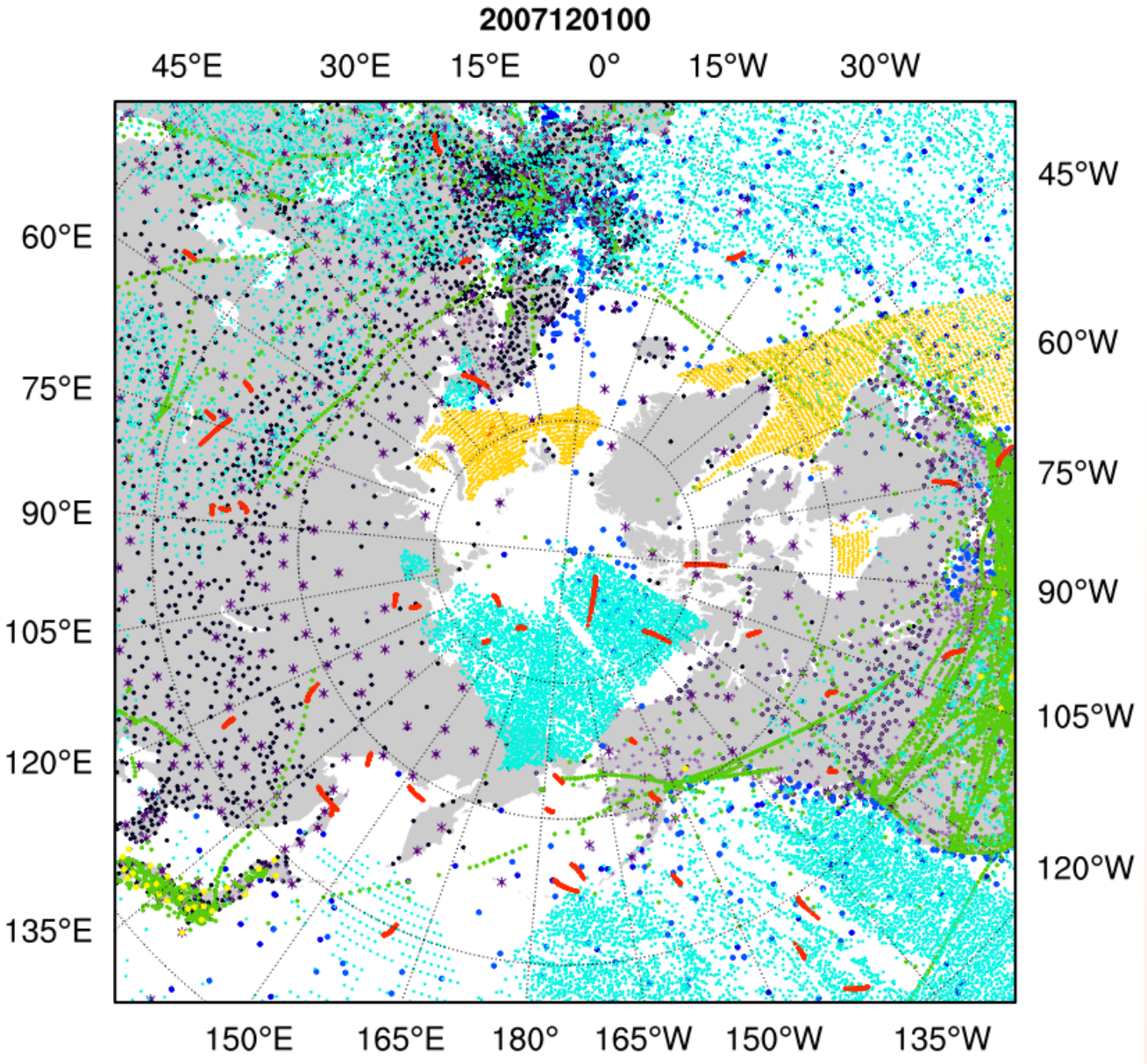
$$\mathbf{J}(\mathbf{x},\beta) = (\mathbf{x_b} - \mathbf{x})^{\mathrm{T}} \mathbf{B}_{\mathbf{x}}^{-1} (\mathbf{x_b} - \mathbf{x}) + \left[\mathbf{y} - H(\mathbf{x}) - B(\beta)\right]^{\mathrm{T}} \mathbf{R}^{-1} \left[\mathbf{y} - H(\mathbf{x}) - B(\beta)\right] + (\beta_{\mathbf{b}} - \beta)^{\mathrm{T}} \mathbf{B}_{\beta}^{-1} (\beta_{\mathbf{b}} - \beta)$$

J_p: background term for β

«Optimal » bias correction considering all available information

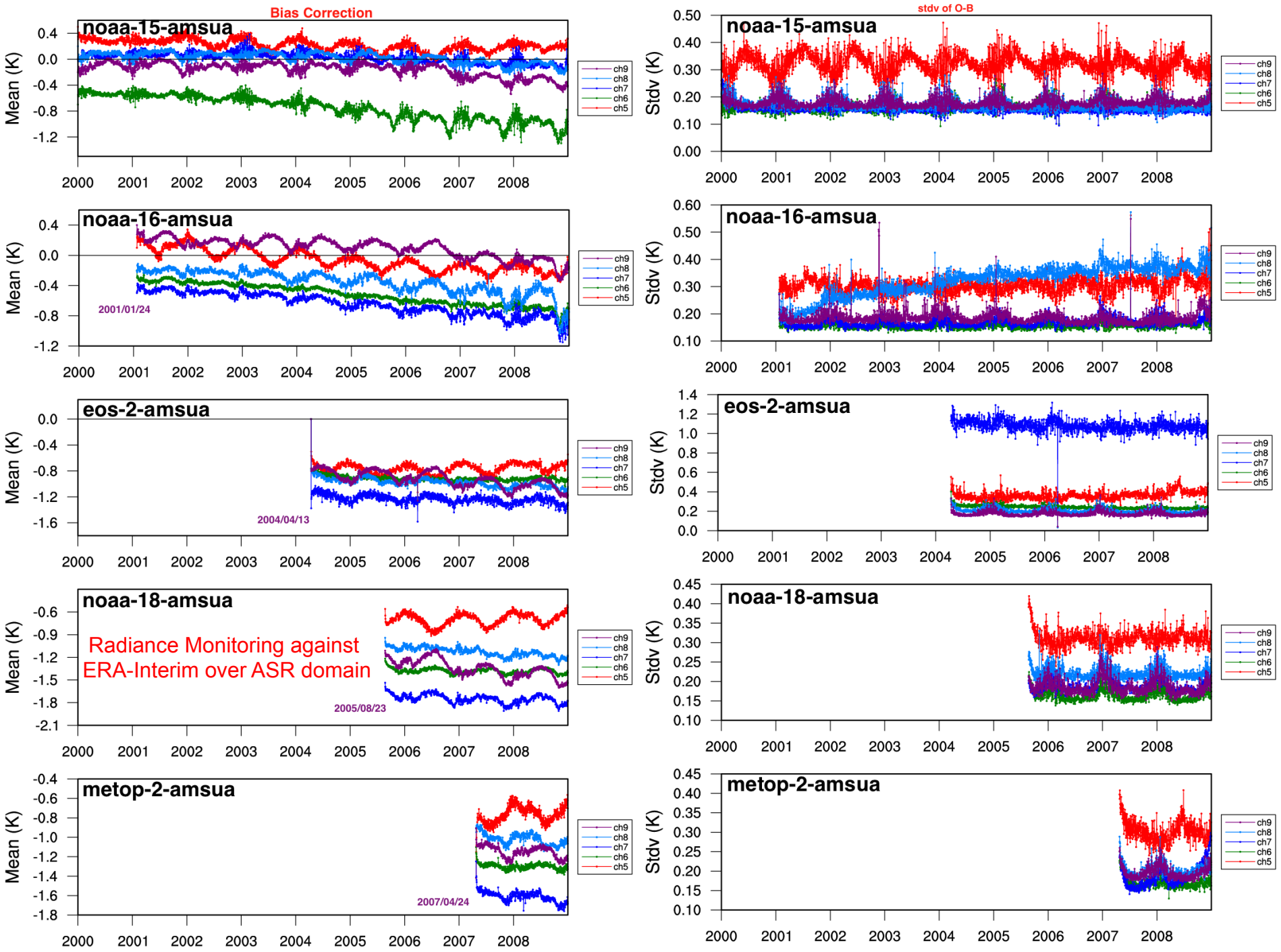
Can be used for radiance **offline monitoring** by removing J_b term and other obs., and using some analysis fields as reference.

Domain used in this study (and for Arctic Reanalysis)



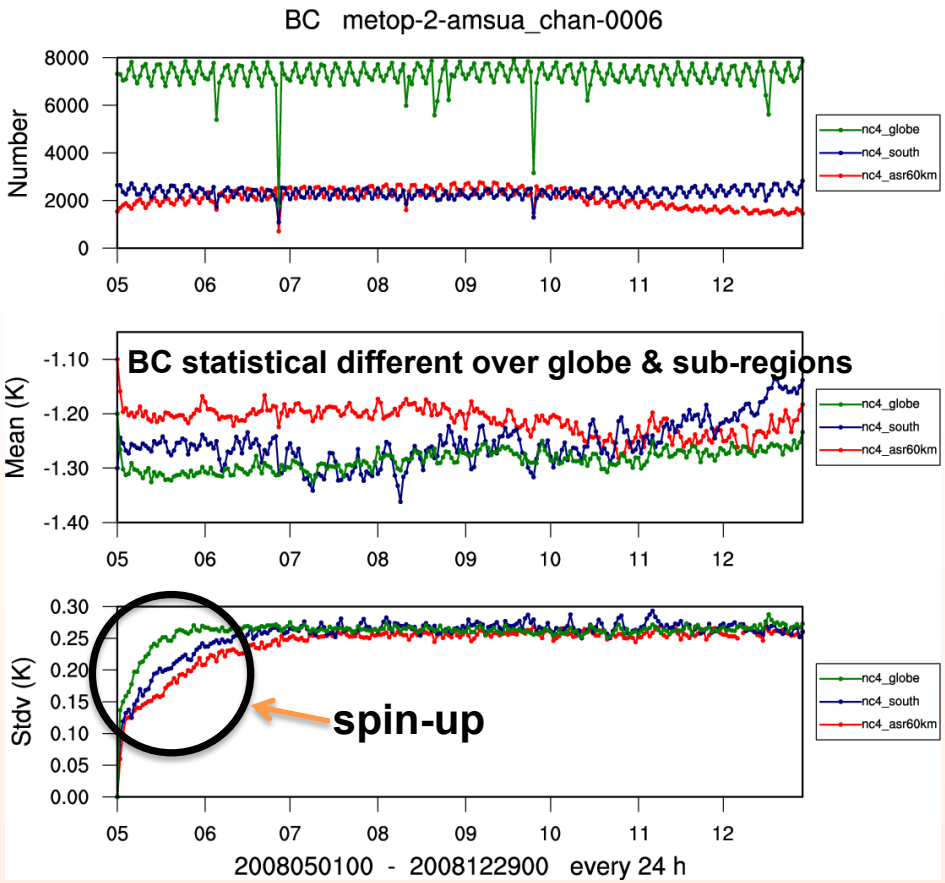
- synop
+ metar
- ship
- buoy
* sound
- gpsref
- profiler
- airep
- quikscat
- SatWind

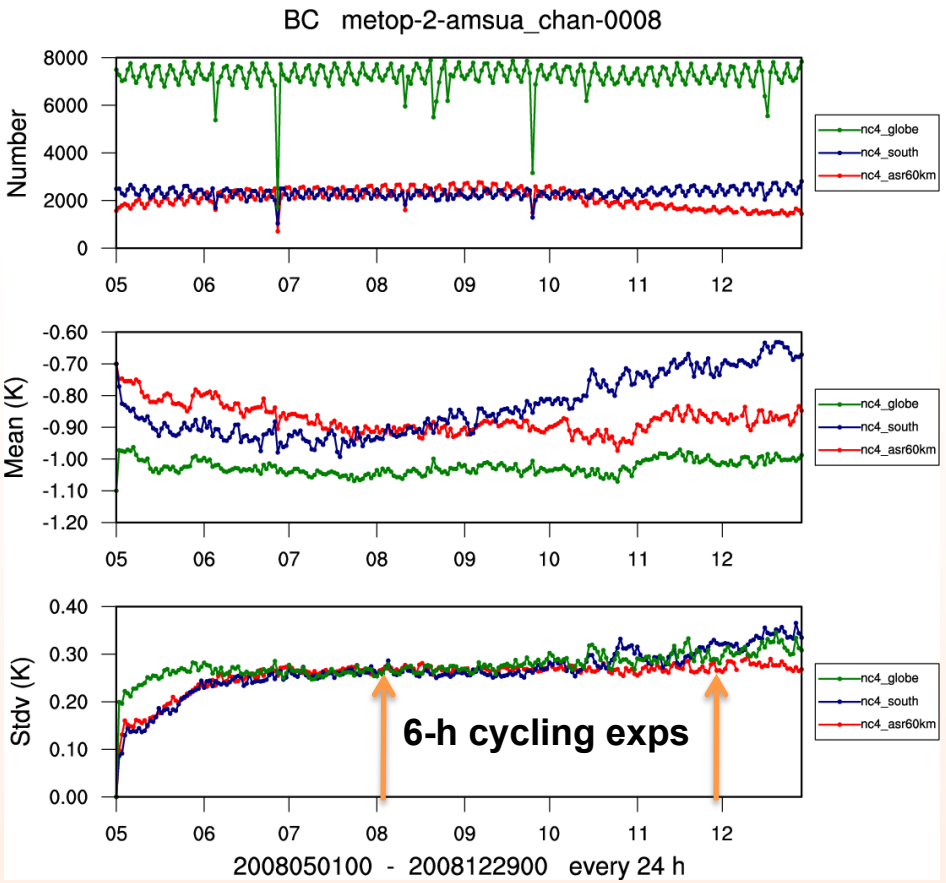
✓**More than 4000 surface stations**
✓**Around 300 sounding stations**


Bias Correction
stdv of O-B
noaa-15-amsua
noaa-16-amsua
2001/01/24
eos-2-amsua
2004/04/13
noaa-18-amsua
Radiance Monitoring against
ERA-Interim over ASR domain
2005/08/23
metop-2-amsua
2007/04/24
Mean (K)
Stdv (K)
ch9
ch8
ch7
ch6
ch5

Radiance Monitoring against ERA-Interim

Global vs. Regional statistics





Bias correction sensitivity experiments

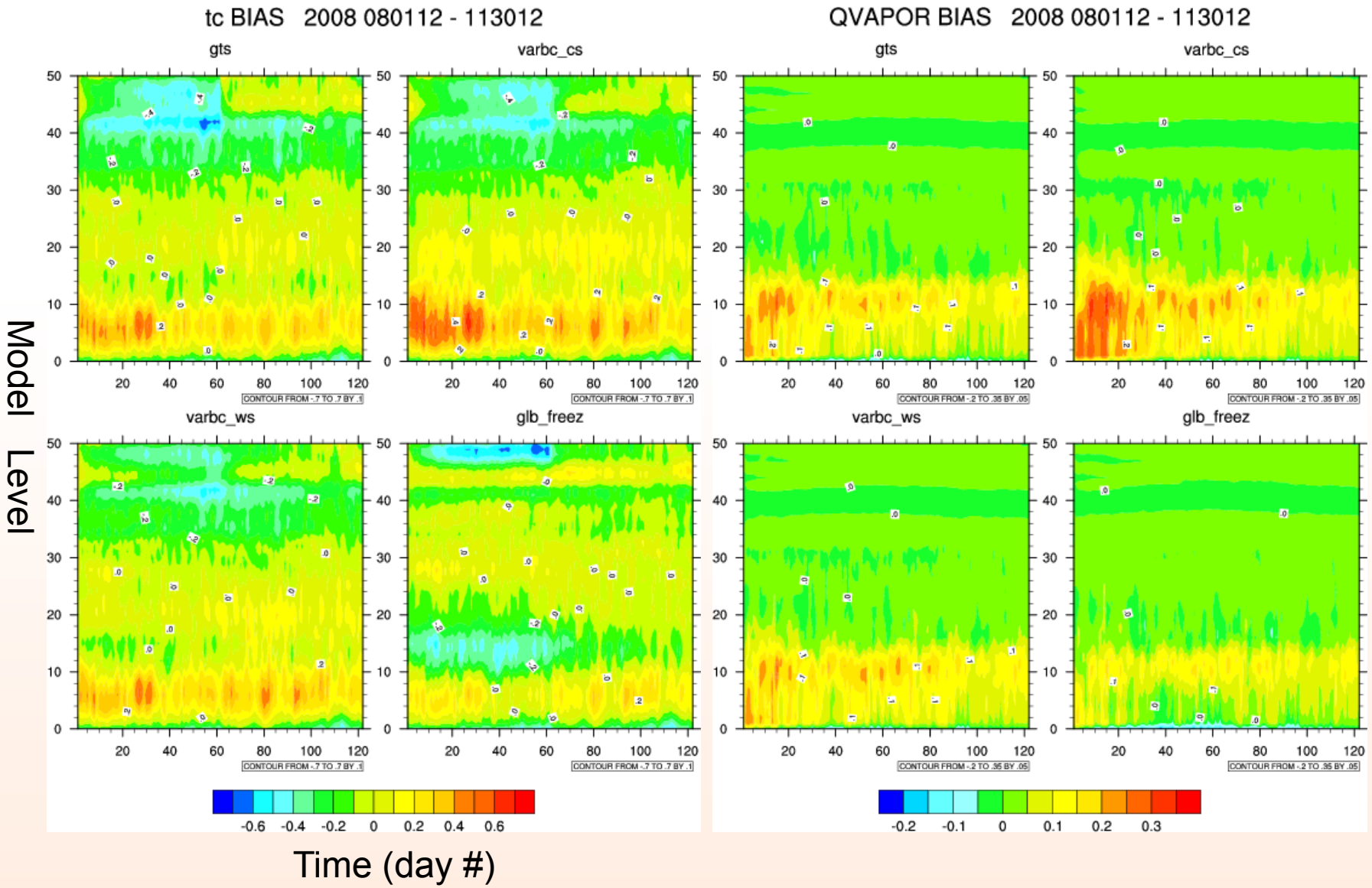
- model resolution
  - 60km/57L/10hPa top.

- 4 experiments
  - **gts**: Non-radiance data assimilated

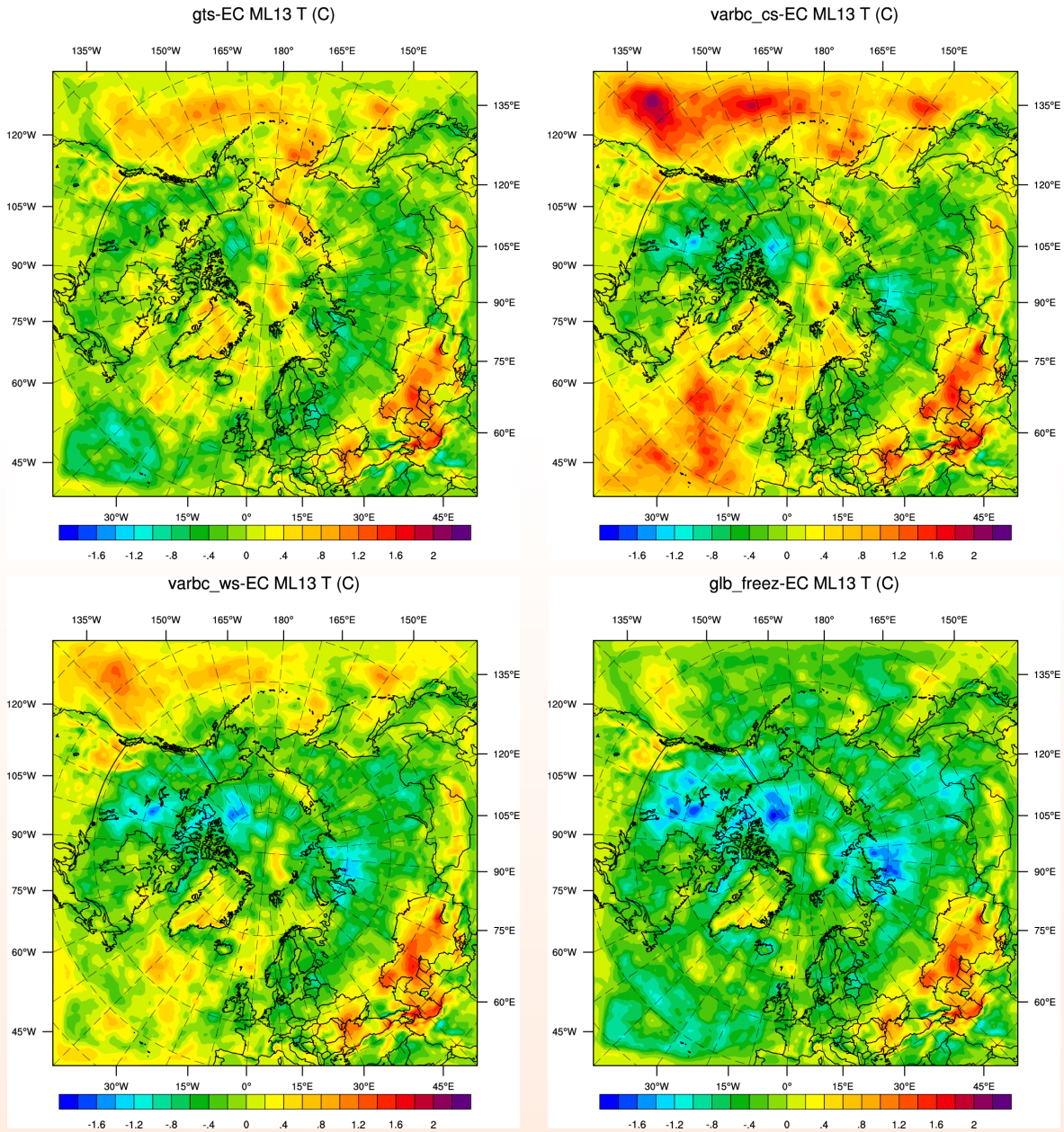
exps with conventional data and AMSU-A radiances assimilated

- **varbc_cs**: uses "cold-start" VarBC coeffs at the beginning of cycles, i.e., no knowledge of coeffs. (default setting in WRFDA)
- **varbc_ws**: uses "warm-start" VarBC coeffs at the beginning of cycles, i.e., **regional** spun-up coefffs from May~July.
- **glb_freez**: turn-off VarBC, but update BC coeffs each cycle from **global** statistics (similar scenario at NWP centers running both global and regional model)

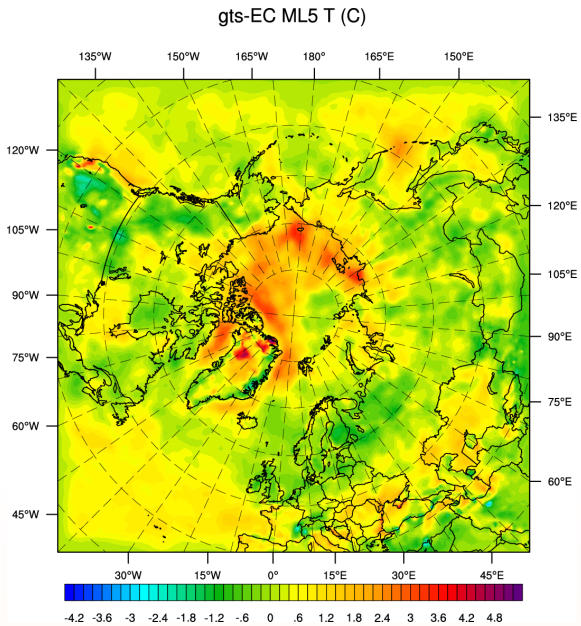
T/Q: analysis@12Z vs. ERA-Interim

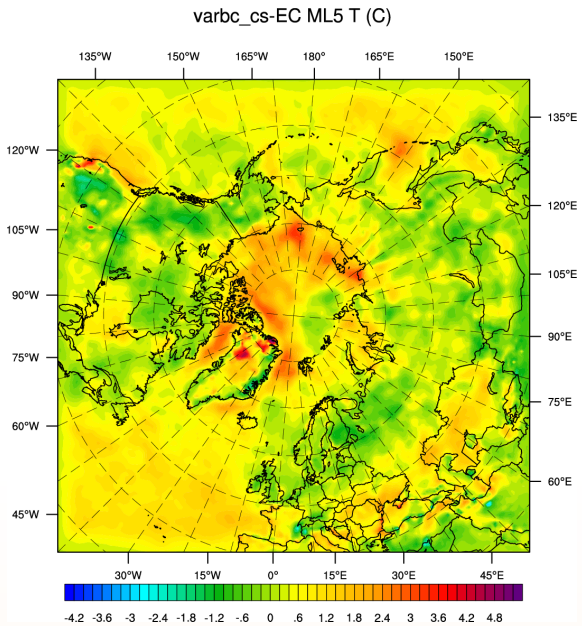


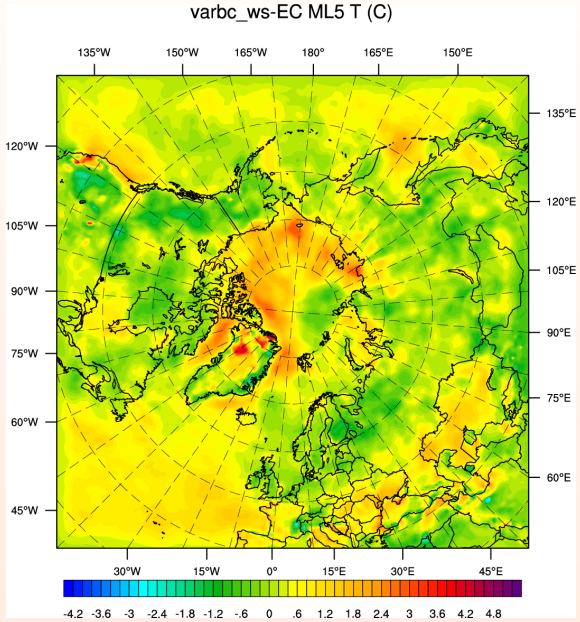
T bias @model level 13 (~2 km) in August

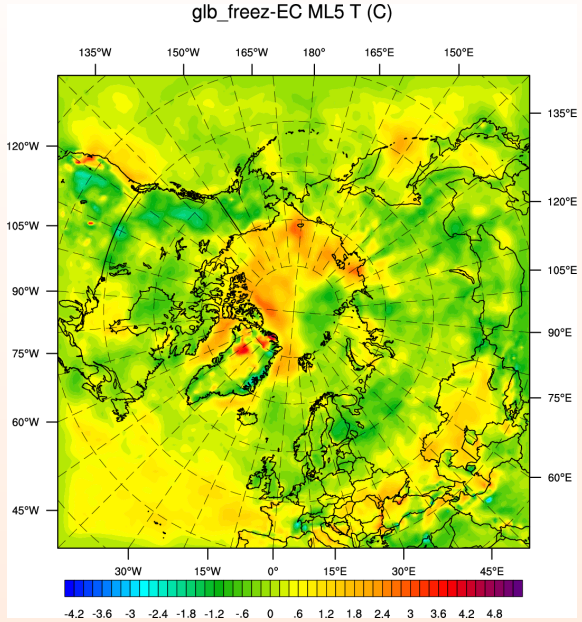


T bias @model level 5 in August

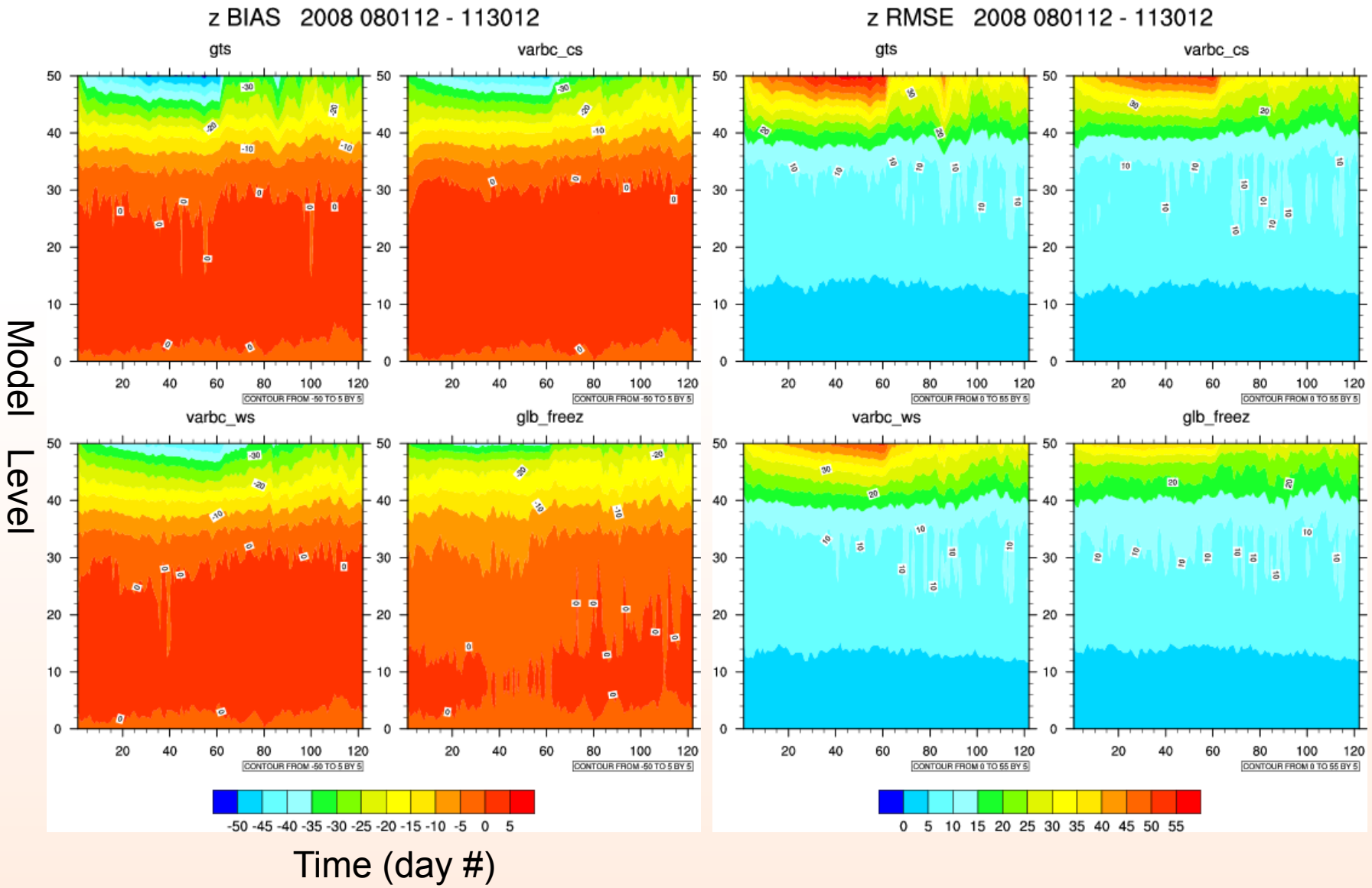




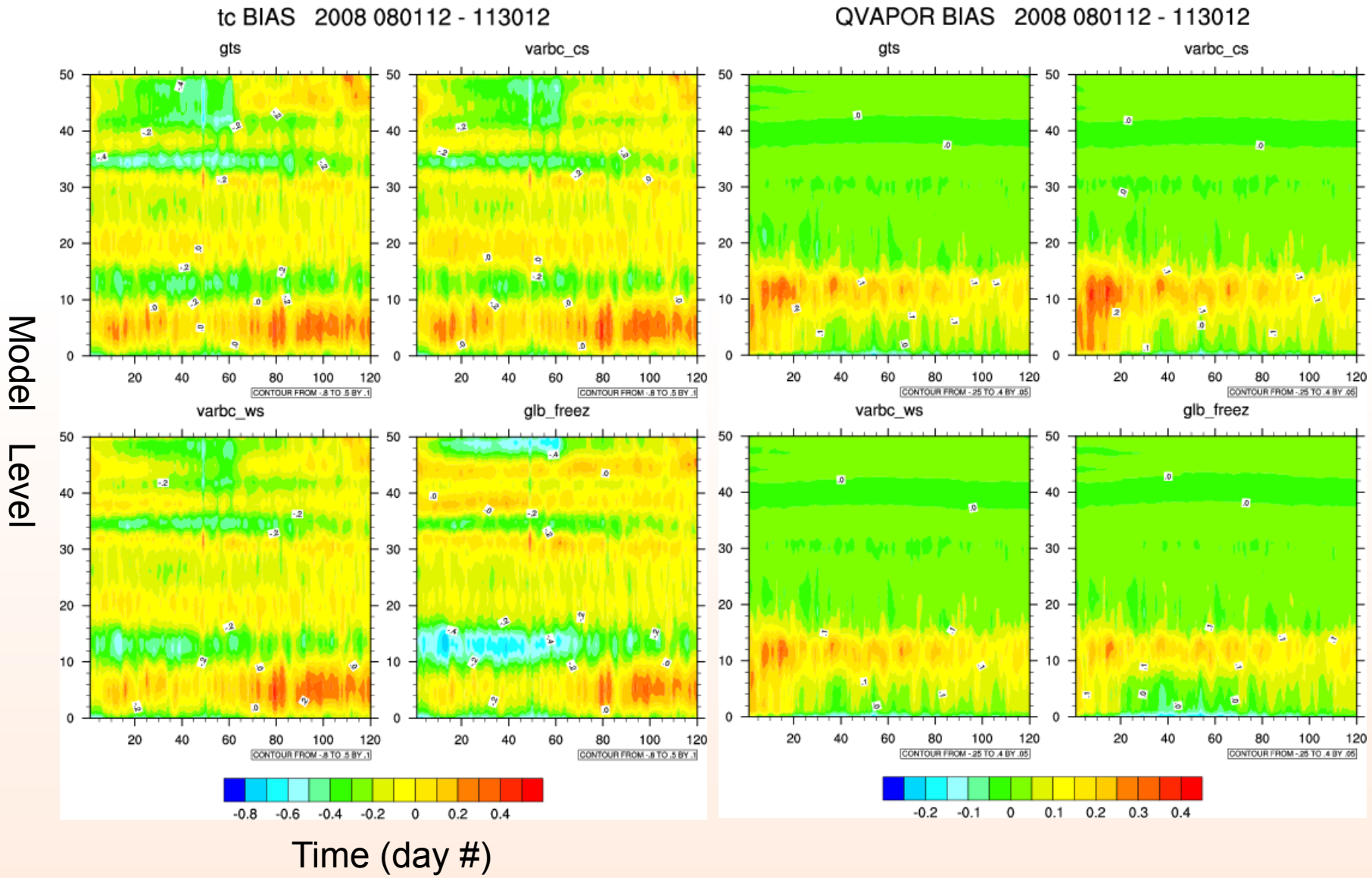




Z: analysis@12Z vs. ERA-Interim

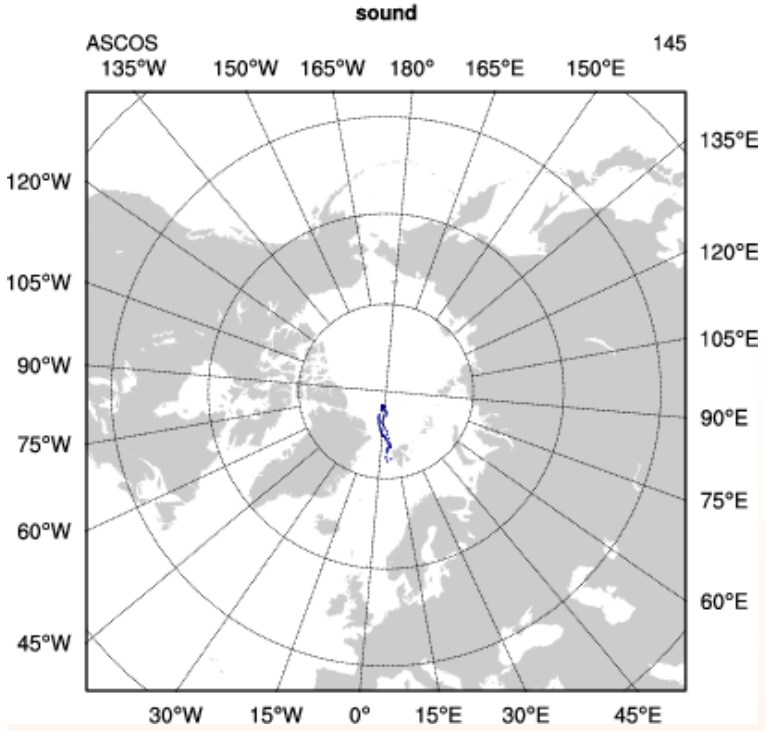


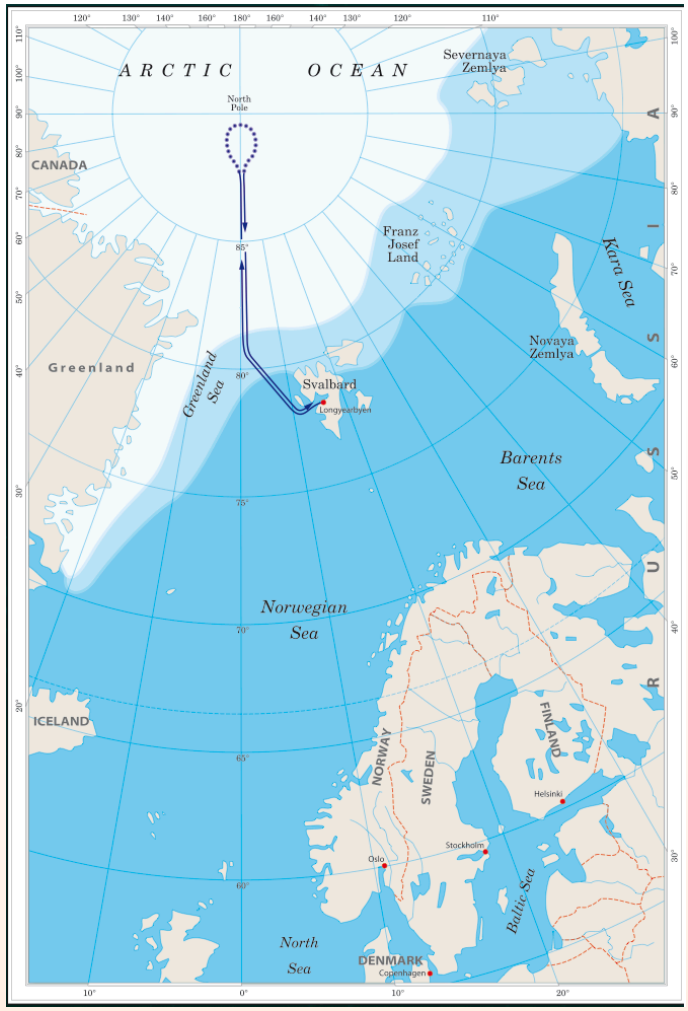
T/Q bias: 24h FC@12Z vs. ERA-Interim



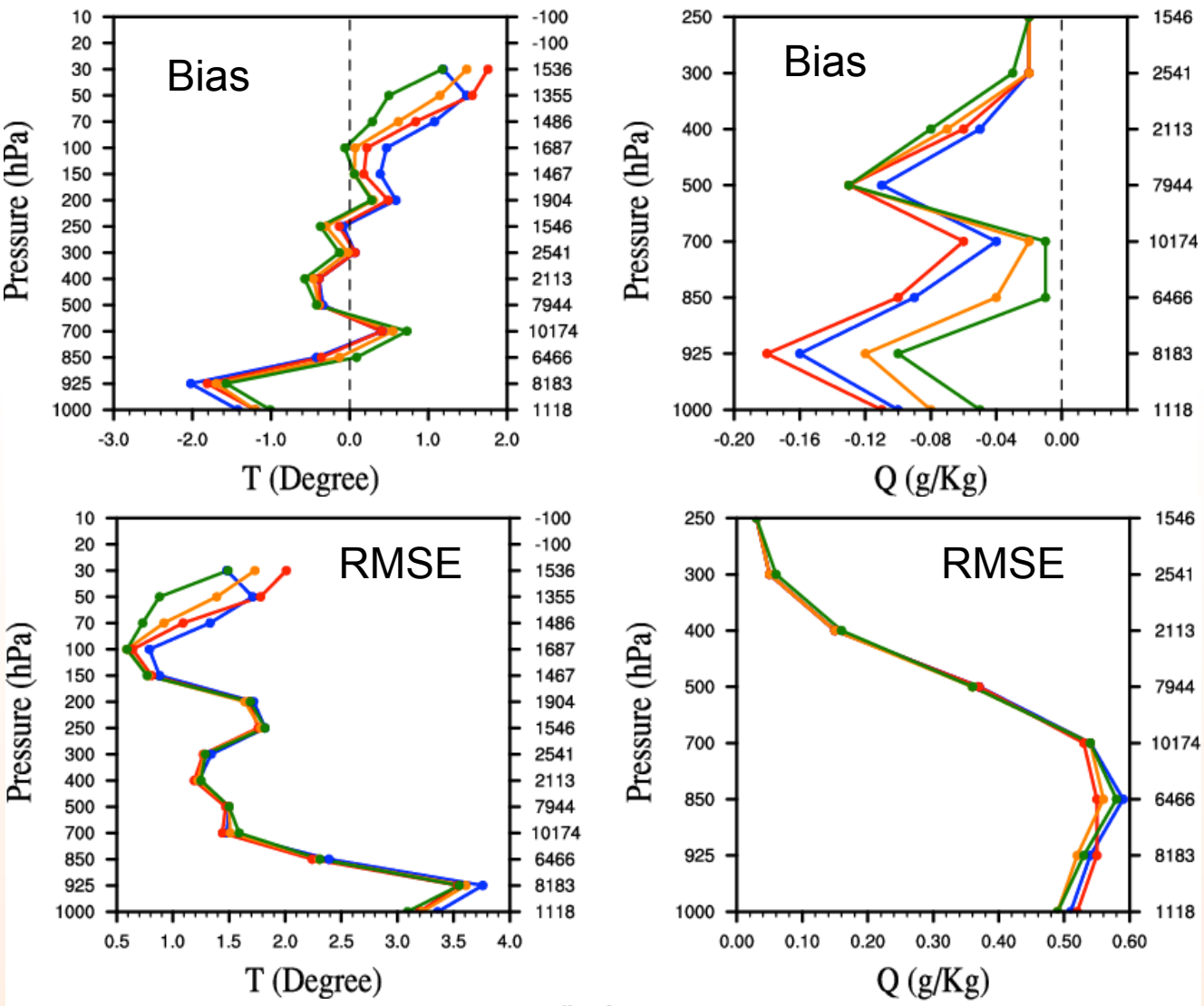
Compare to ASCOS sounding

Aug. 3 ~ Sep. 7, 2008

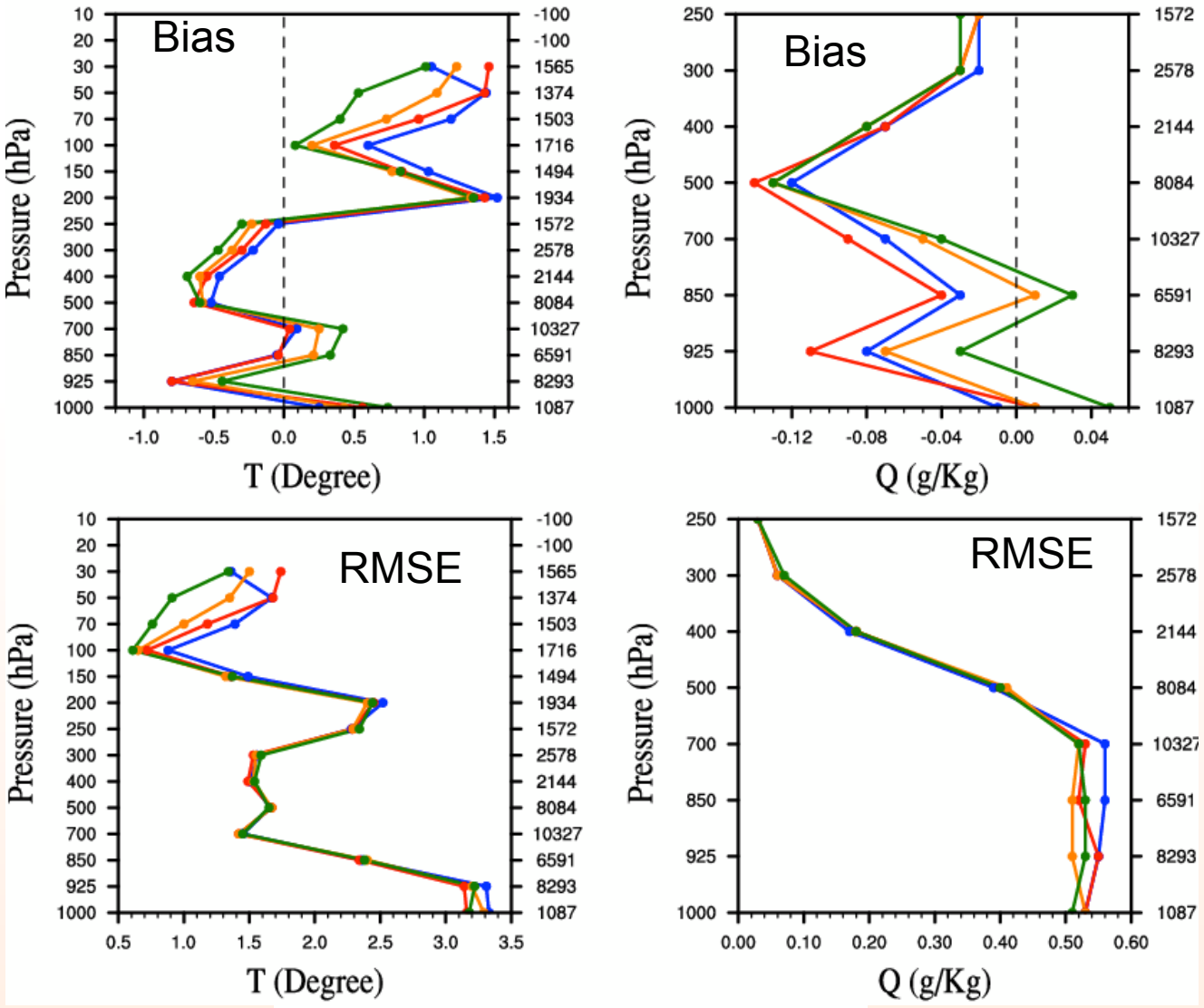




T/Q Analysis vs. ASCOS

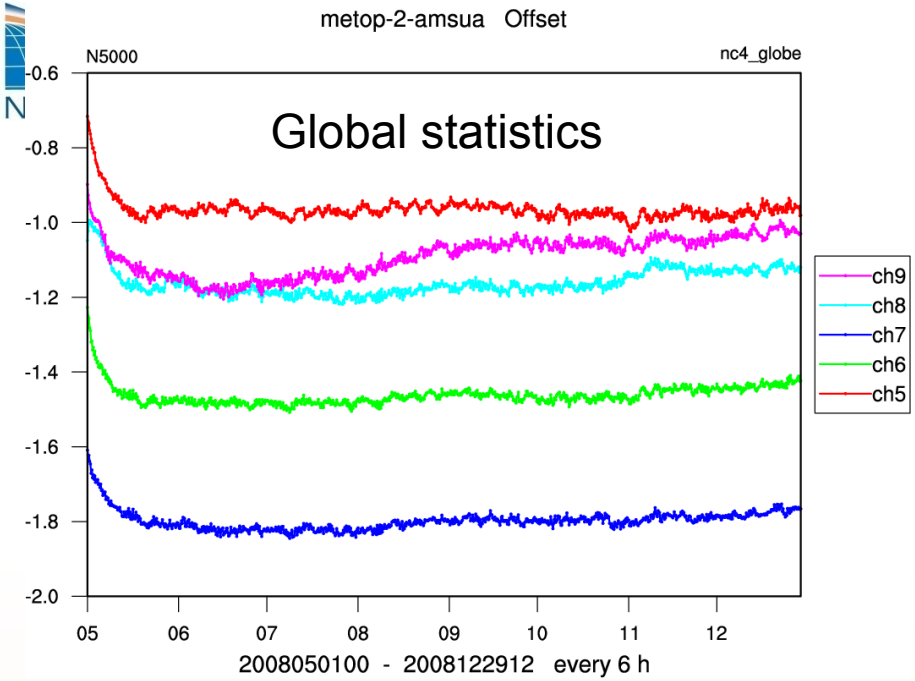


T/Q 24h FC vs. ASCOS

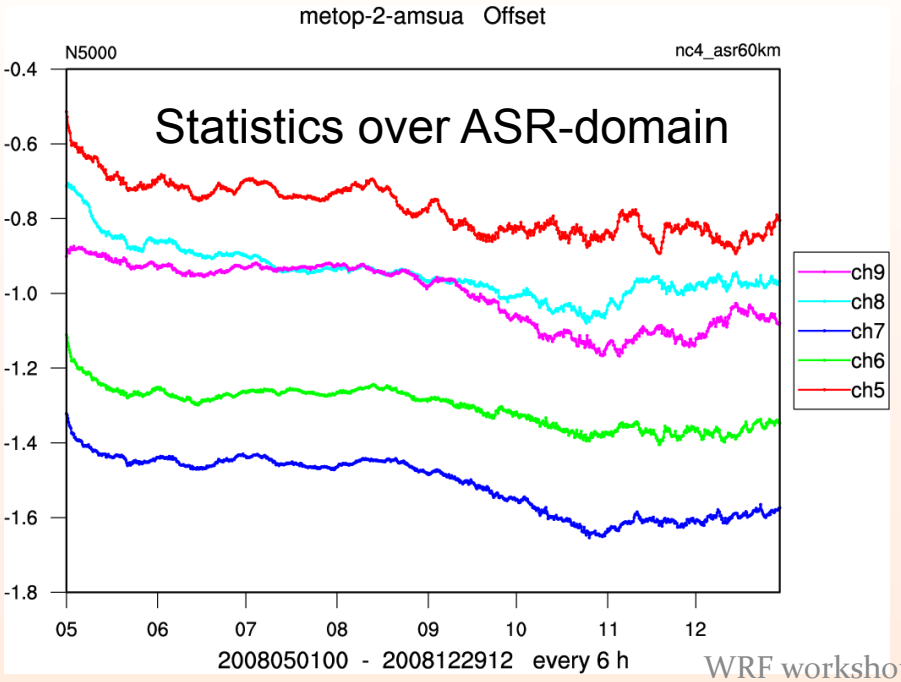


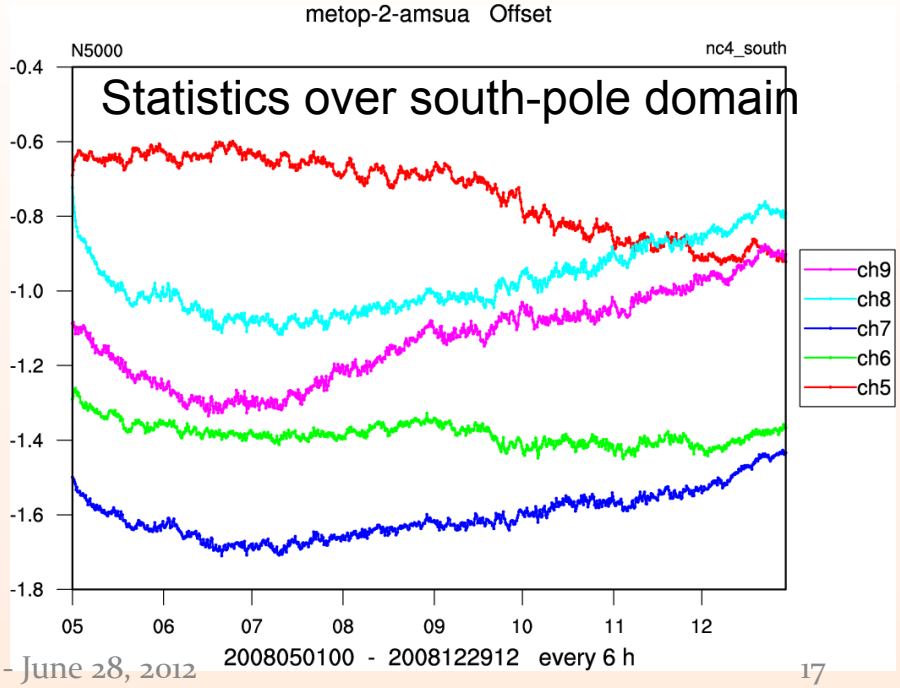
Summary

- Need month-long spin-up to obtain useful bias correction coeffs.
- Warm-start VarBC over regional domain is beneficial
  - Particularly over regions without soundings (e.g., ocean, sea ice)
- Need more investigation on using global vs. regional BC statistics for regional radiance DA.



Bias correction coefficients:
"offset" evolution from global, ASR-domain, South-Pole domain.





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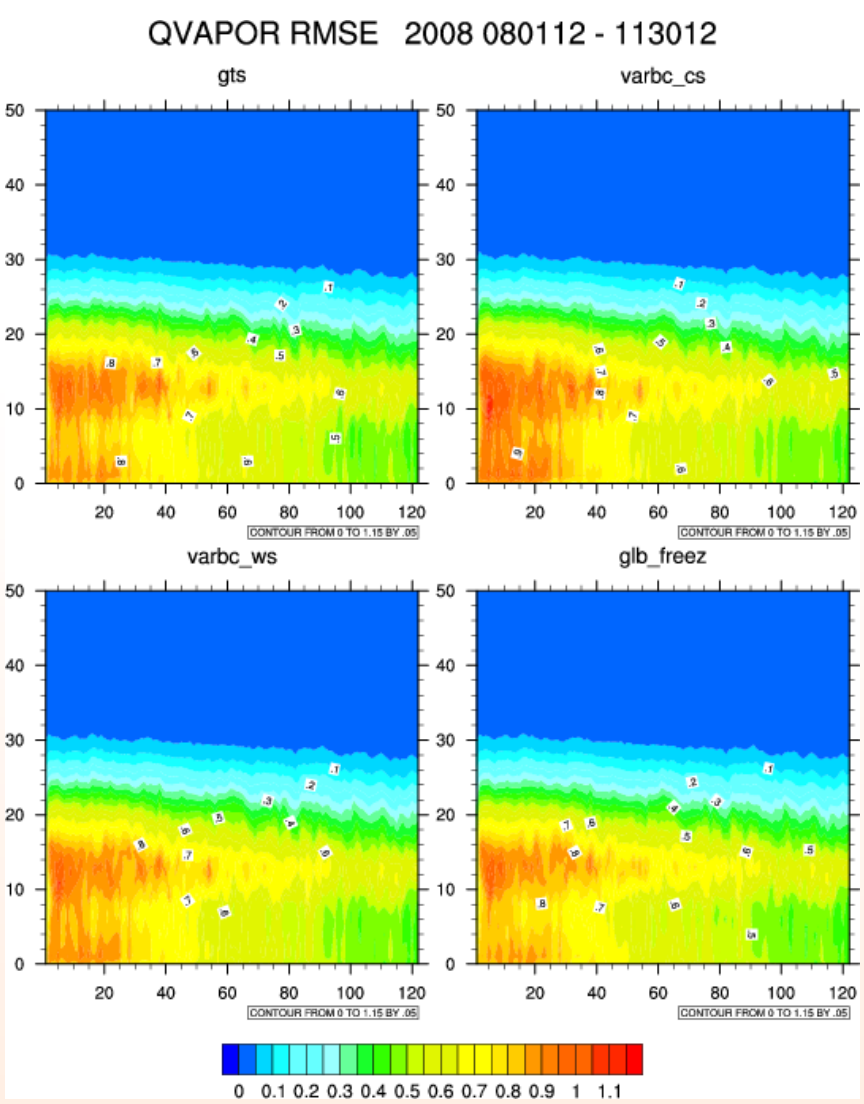
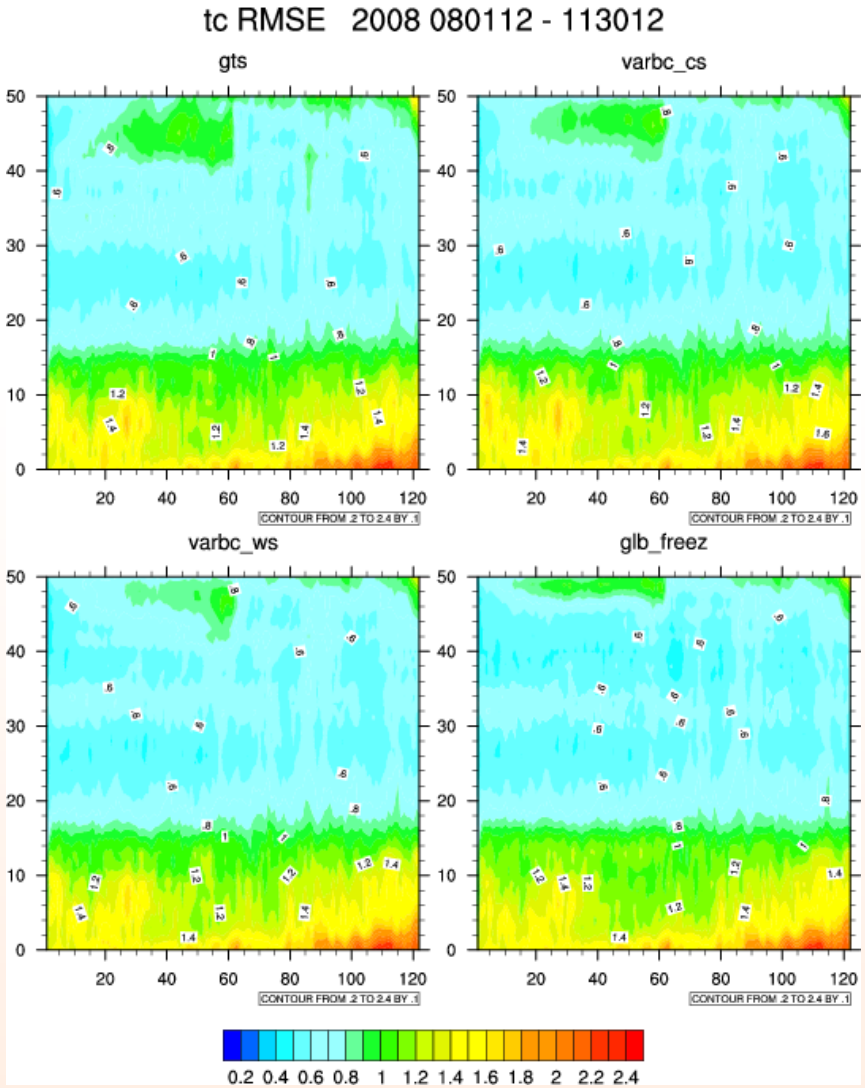
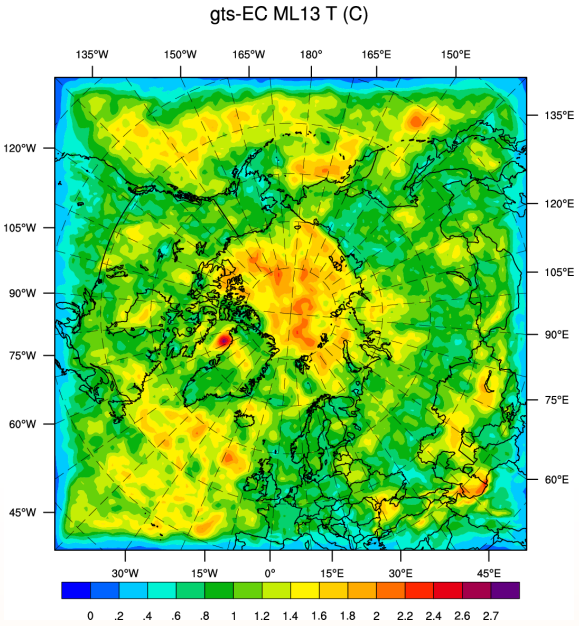
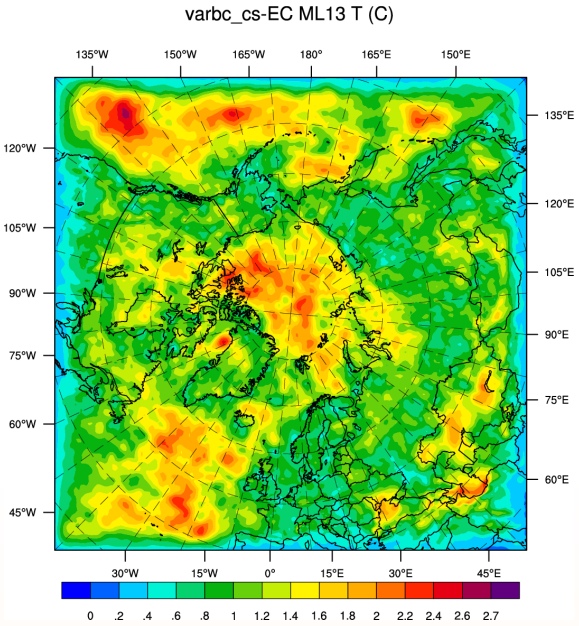
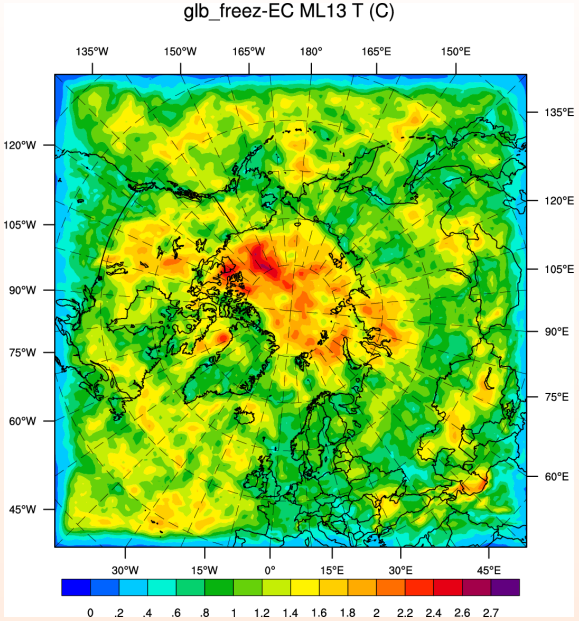


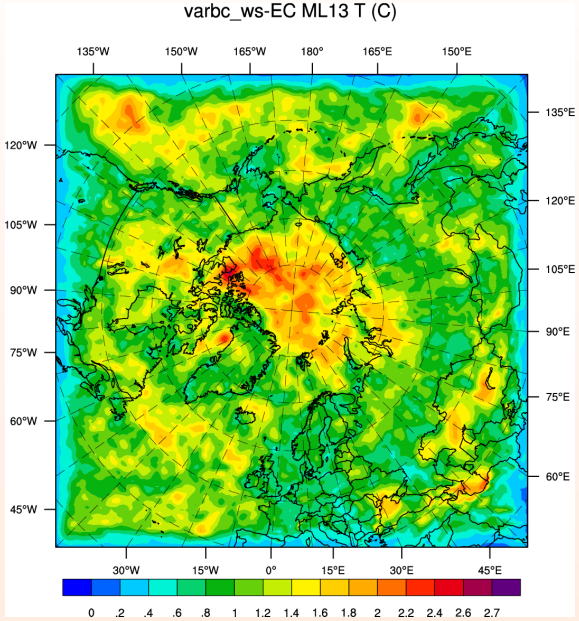


T rmse @model level 13 (~km)









T rmse @model level 5 (~km)