Atmosphere and surface analysis over north polar region using WRF/WRFDA

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Outline

- Arctic System Reanalysis: analysis/forecast cycle
- Importance of radiance monitoring
- Preliminary evaluation of results from a 2-year test
  - GPSRO impact
  - Radiance impact
  - Compare ASR-60km to ERA-Interim

3D Variational data assimilation formulation

- 3DVAR is to minimize a cost function

$$J(x) = \frac{1}{2}(x - x_b)^{\mathrm{T}} \mathrm{B}^{-1}(x - x_b) + \frac{1}{2}[H(x) - y]^{\mathrm{T}} \mathrm{R}^{-1}[H(x) - y]$$

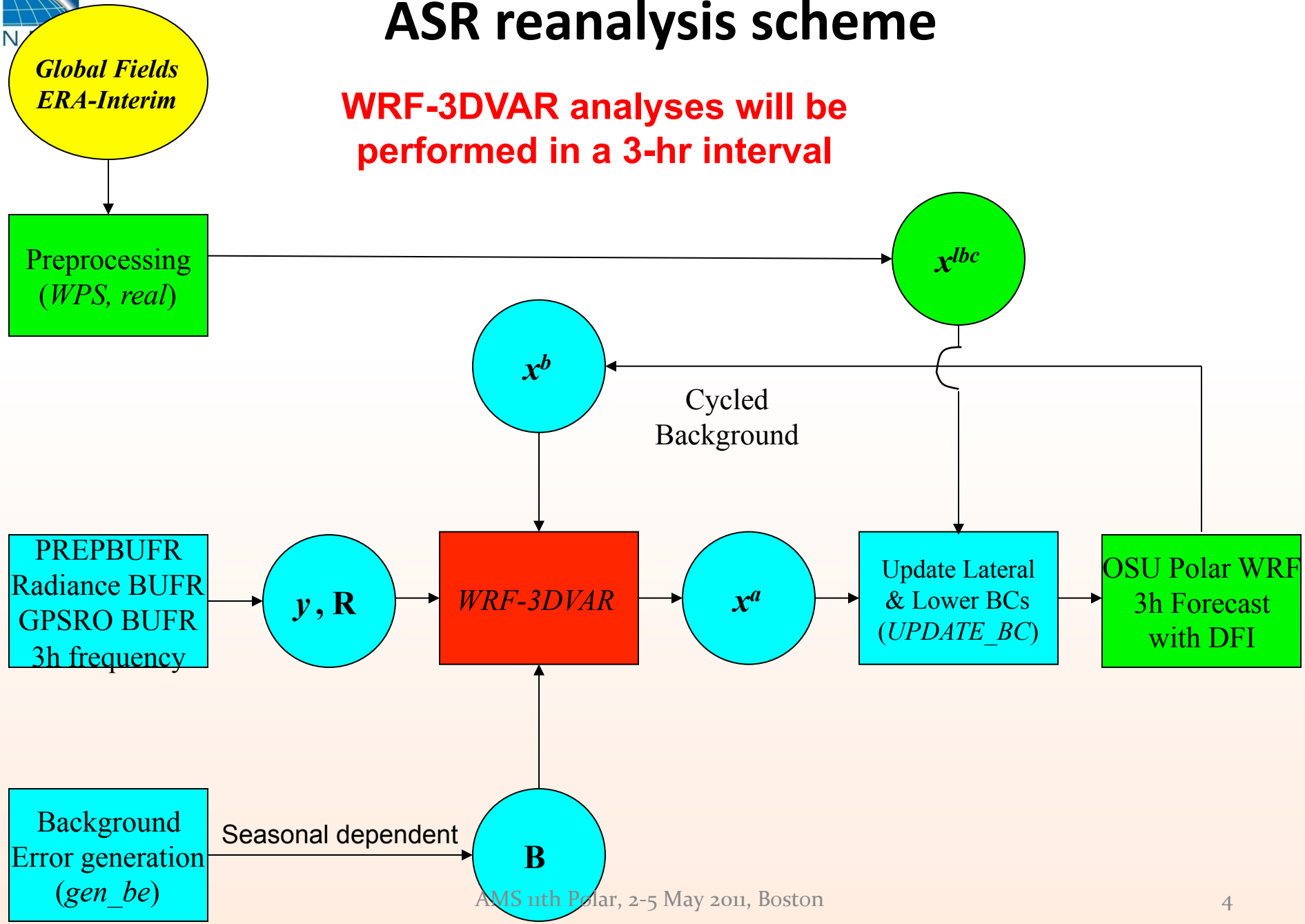
which measures the weighted distance of the model state x to the model "background" x_b and the observations y.

Contribution to the final analysis from x_b and y is determined by the background and observation error covariances B and R.

H is "observation operator", which transforms the model state to observation space.

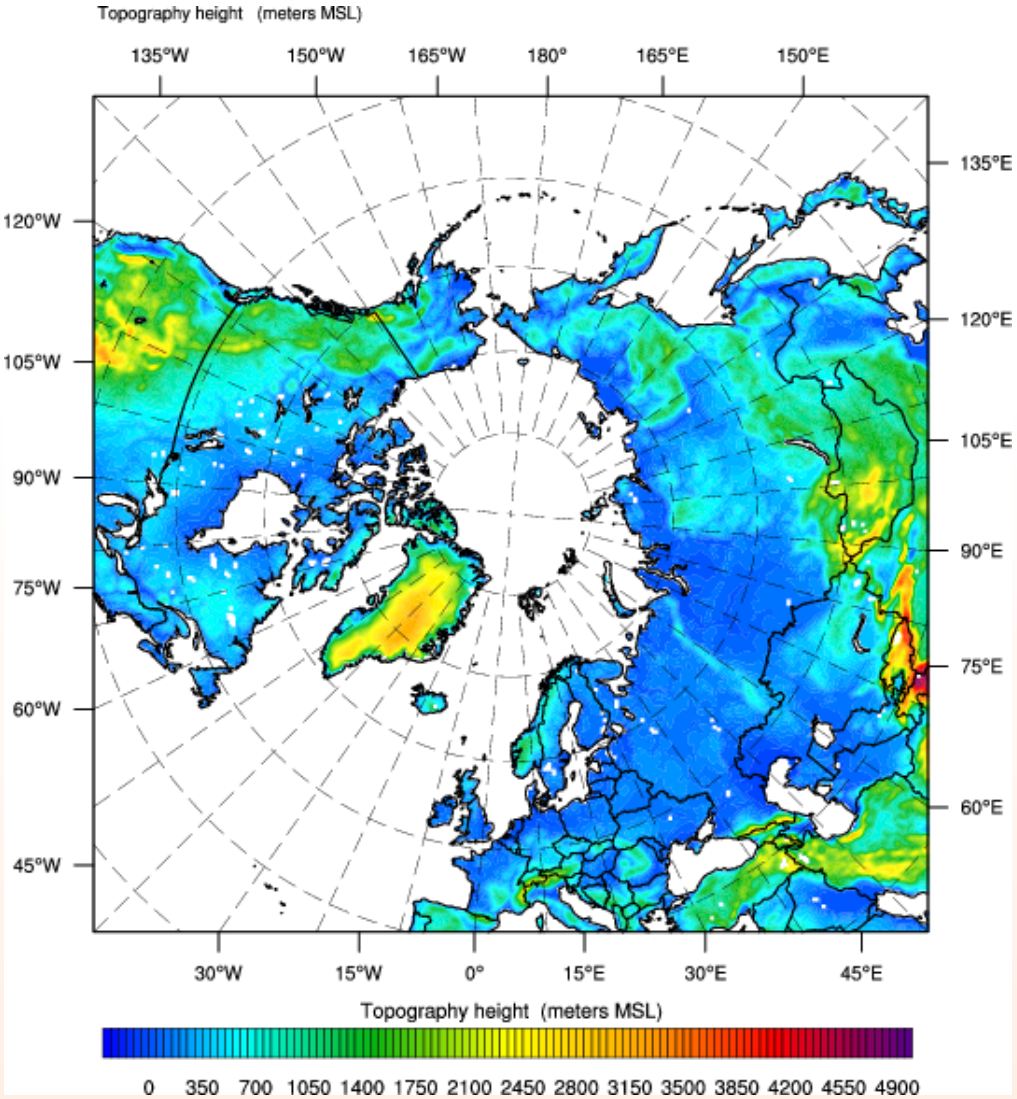
ASR reanalysis scheme

WRF-3DVAR analyses will be performed in a 3-hr interval

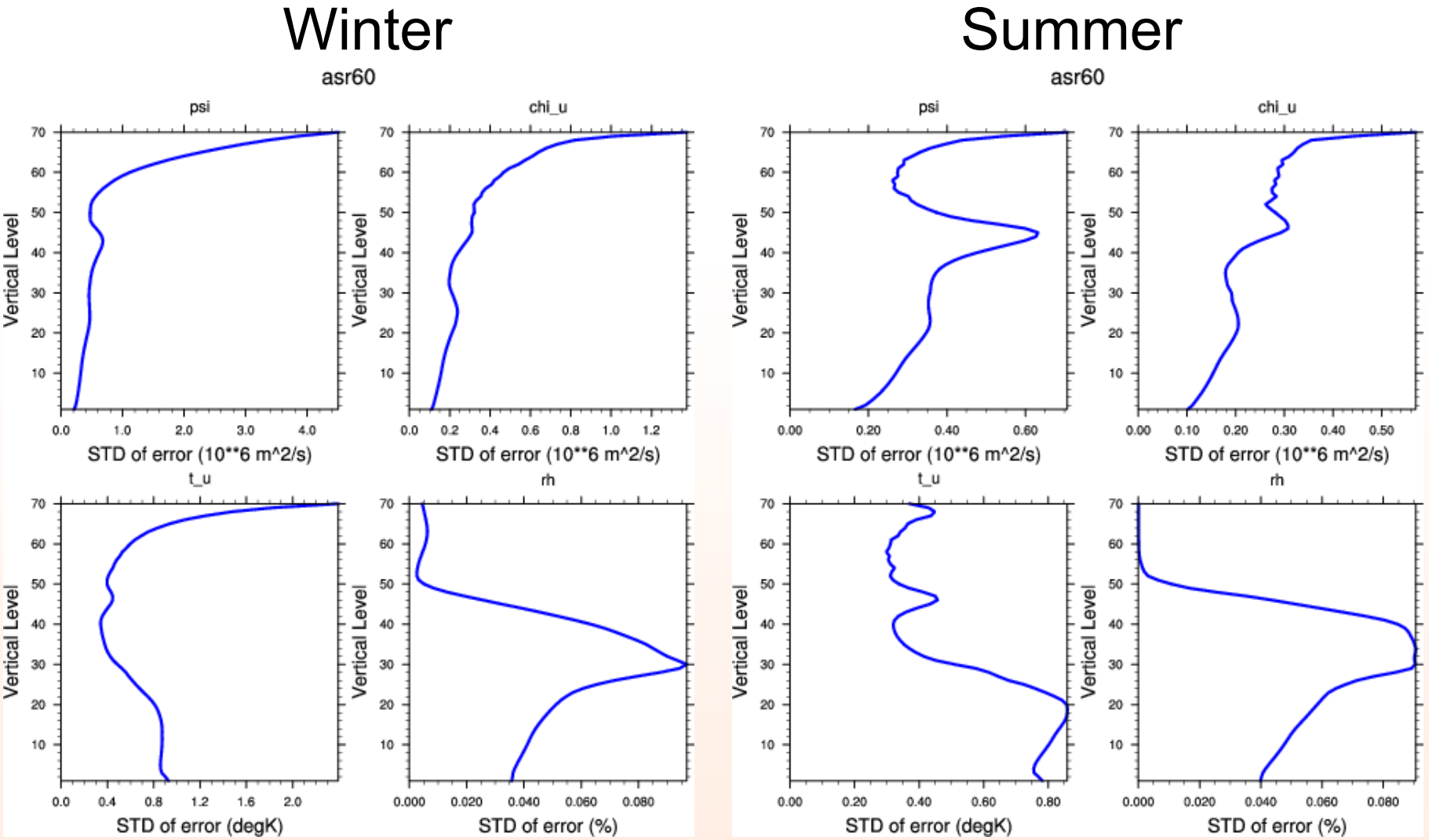


WRF model configuration

- Polar WRF
  - WSM5
  - RRTMG
  - MYNN2.5
  - NoahLSM
  - Fractional Sea ice
  - GWD
  - DFI
  - No Nudging
  - Polar projection
  - 60km/10hPa top
  - 180*180*71L



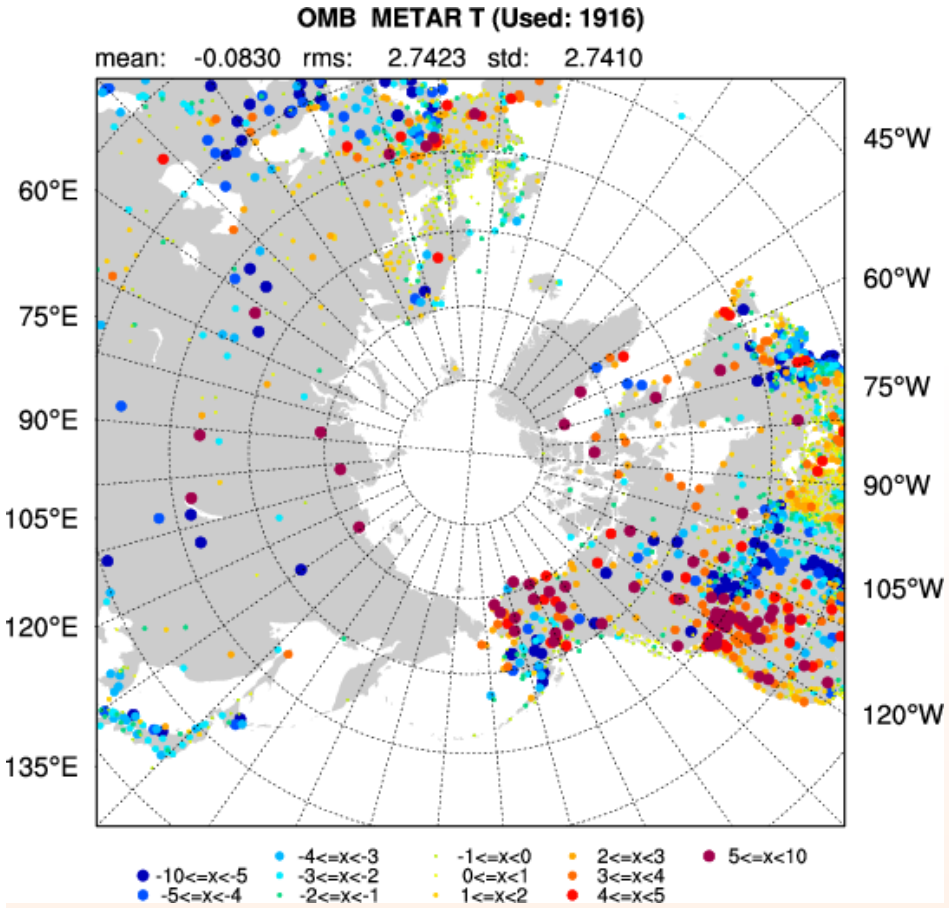
Background error statistics from NMC method (basically 24h FC - 12h FC valid at same time)

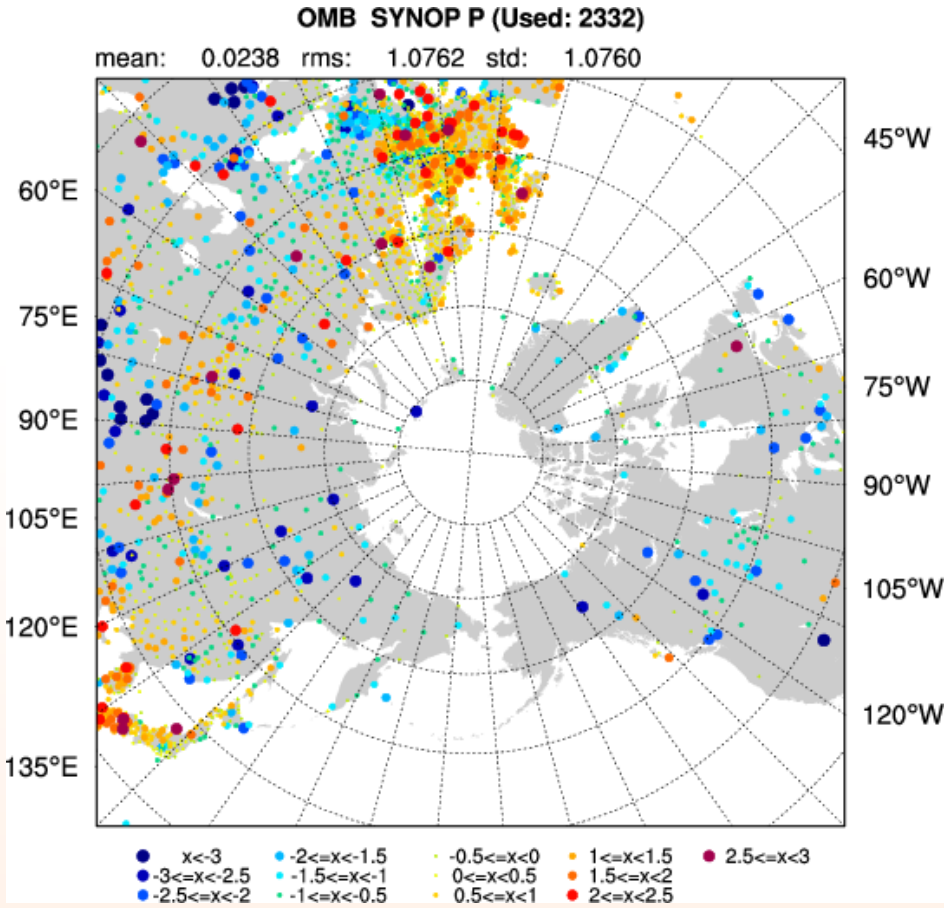


Observations used in ASR

- Surface
  - U/V, T, Q, P: SYNOP, METAR, SHIPS, BUOY, SONDE_SFC,
  - U/V: QSCAT
- Upper air
  - SOUND (U/V, T, Q), AIREP (U/V, T), PROFILER (U/V), GEOAMV (U/V)
- GPS Radio Occultation (refractivity)
  - Use data between 2km~18km
- Microwave radiances from polar satellites
  - Brightness temperature

Typical land surface stations: 2007010103





More than 4000 stations used.

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MW radiance data used (2000~)

	AMSU-A	AMSU-B	MHS
NOAA-15	X	X	
NOAA-16	X	X	
NOAA-17		X	
NOAA-18	X		X
NOAA-19	X		X
METOP-2	X		X
EOS-2 (Aqua)	X		

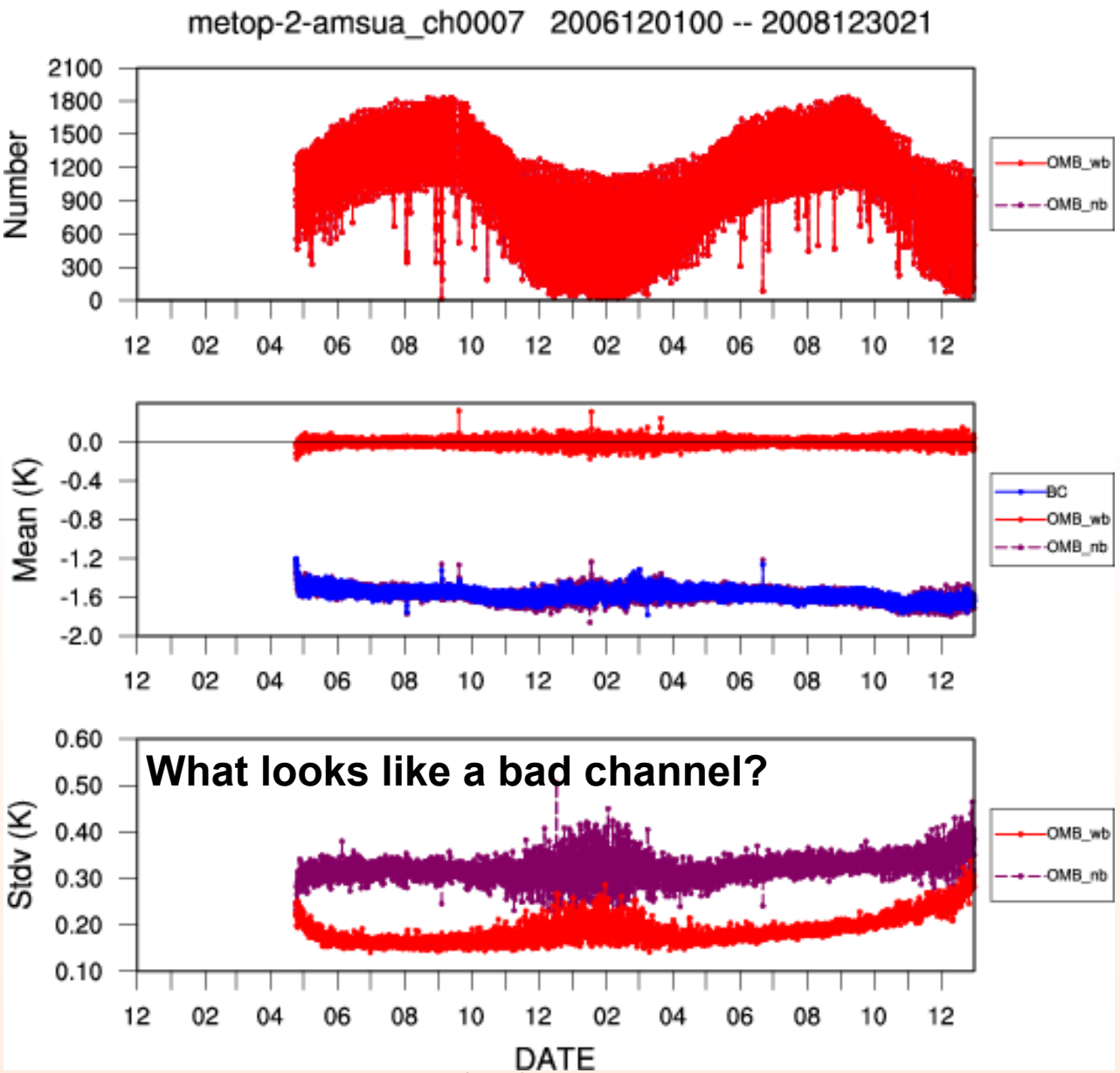
Total 12 sensors

AMSU-A: assimilate channels 5~9.
AMSU-B/MHS: assimilate channels 3~5.

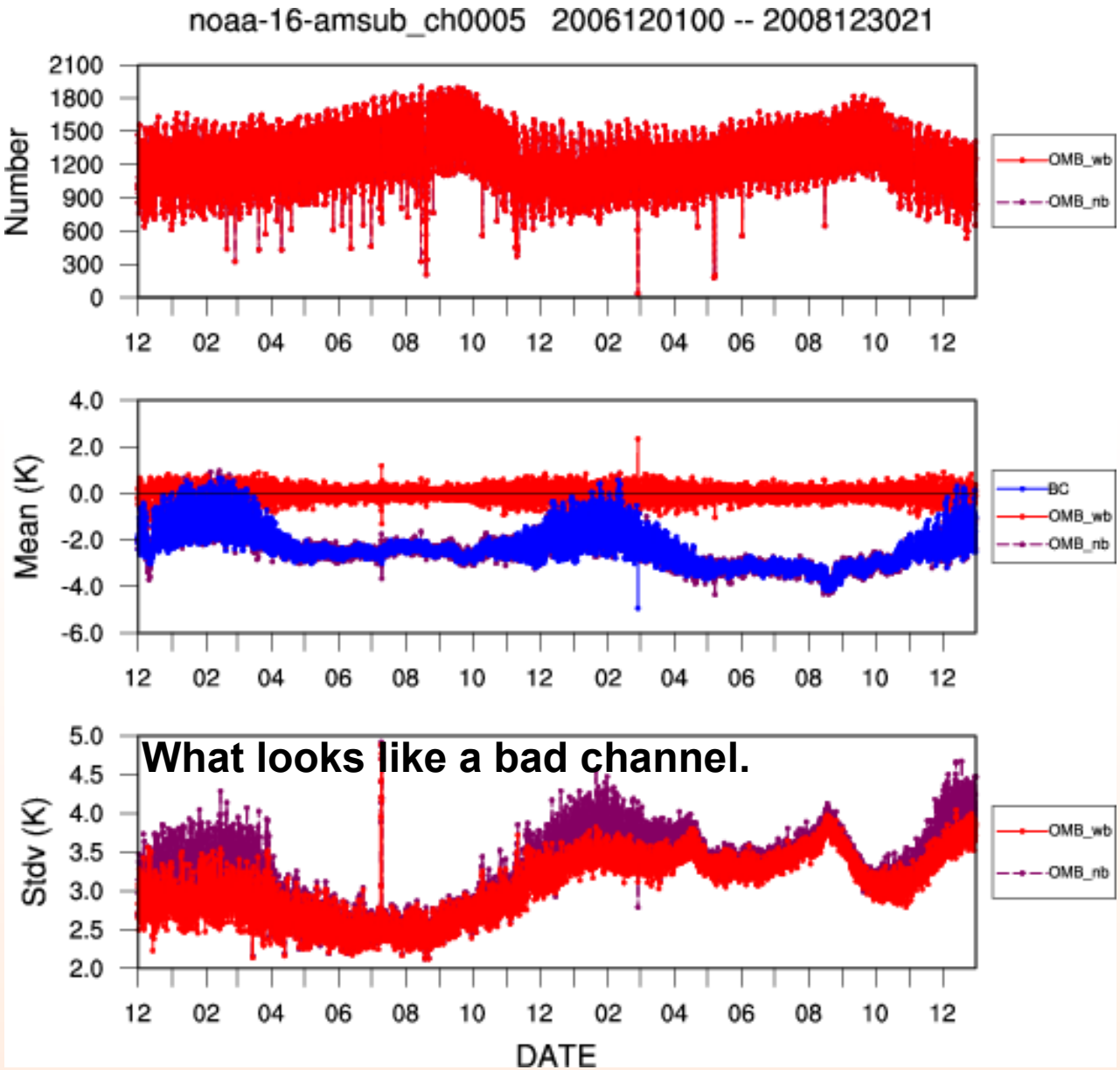
Data availability depends on year.

Need to carefully do sensor/channel selection and bias correction.

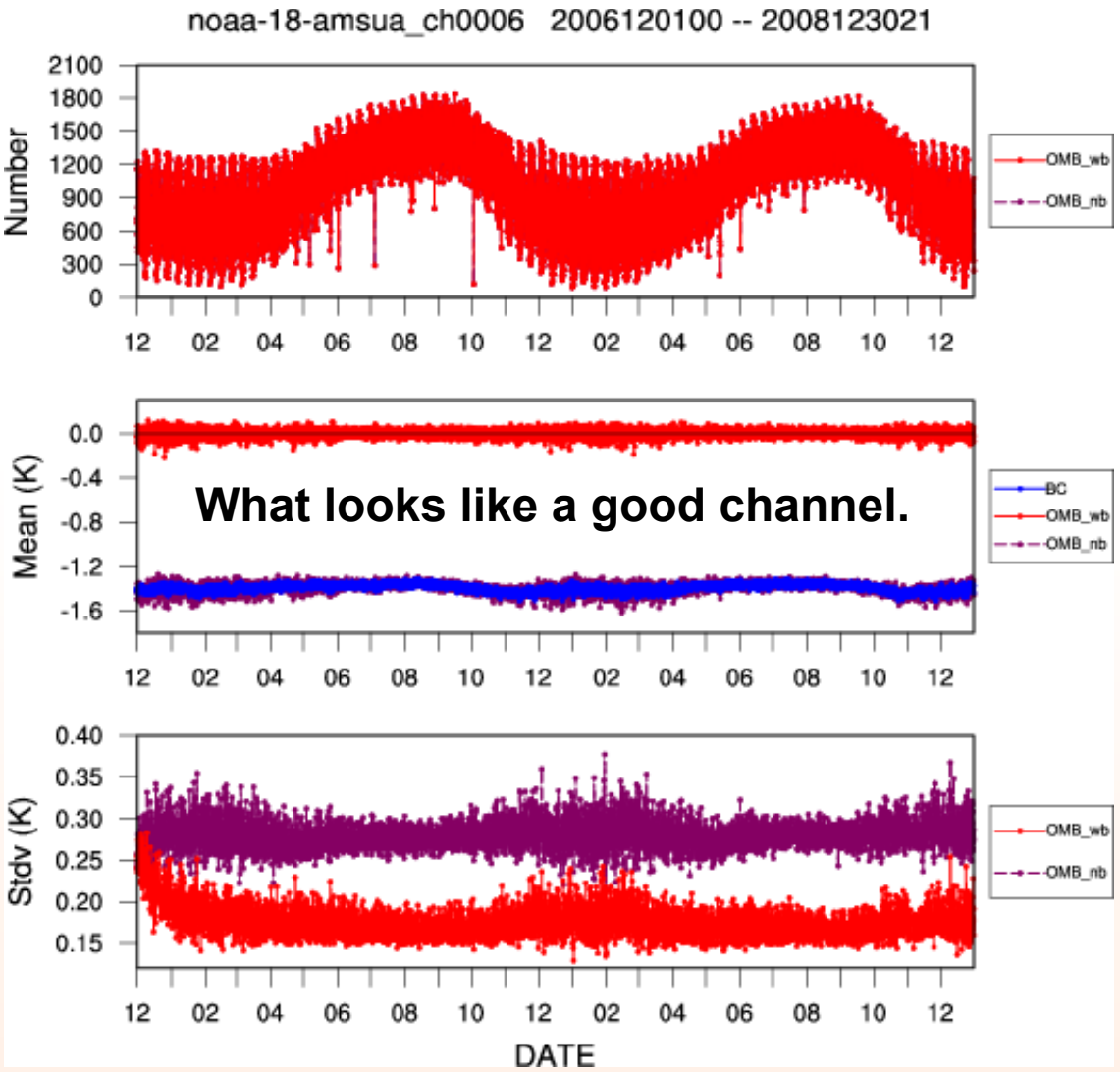
data monitoring before DA: vs. ERA



data monitoring before DA

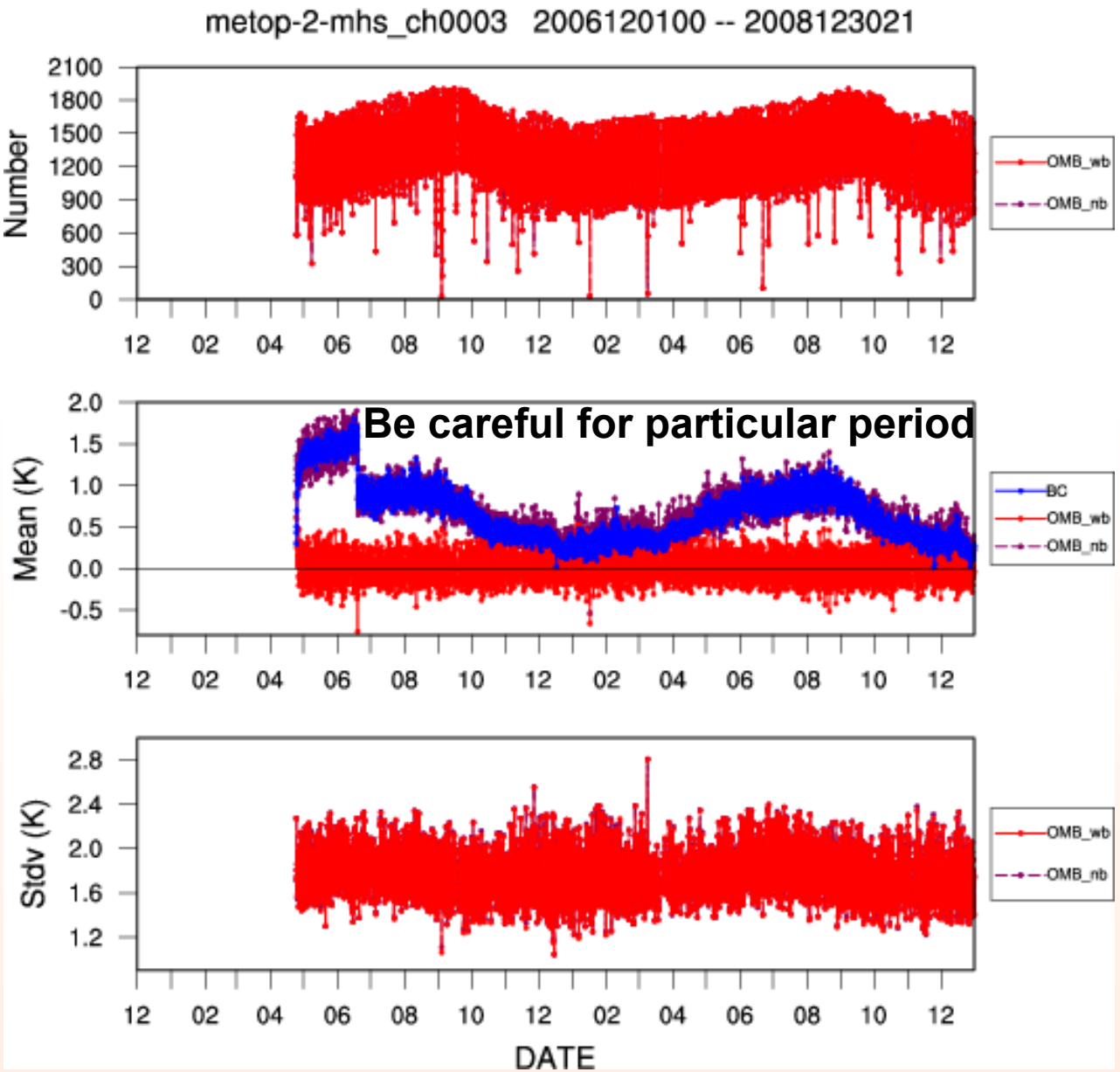


data monitoring before DA



Need spin-up to make bias correction stable.

data monitoring before DA



Decision from 2-yr radiance monitoring

- Turn-off following sensors/channels
  - Noaa-16-amsua ch-9 (according to NCEP Jack Woolen's table, not from monitoring)
  - Metop-2-amsua ch-7
  - Noaa-17-amsub ch-4
  - Noaa-15/16-amsub all channels

A radiance monitoring run from 2000 has been done to guide sensor/channel selection for OSU production run.

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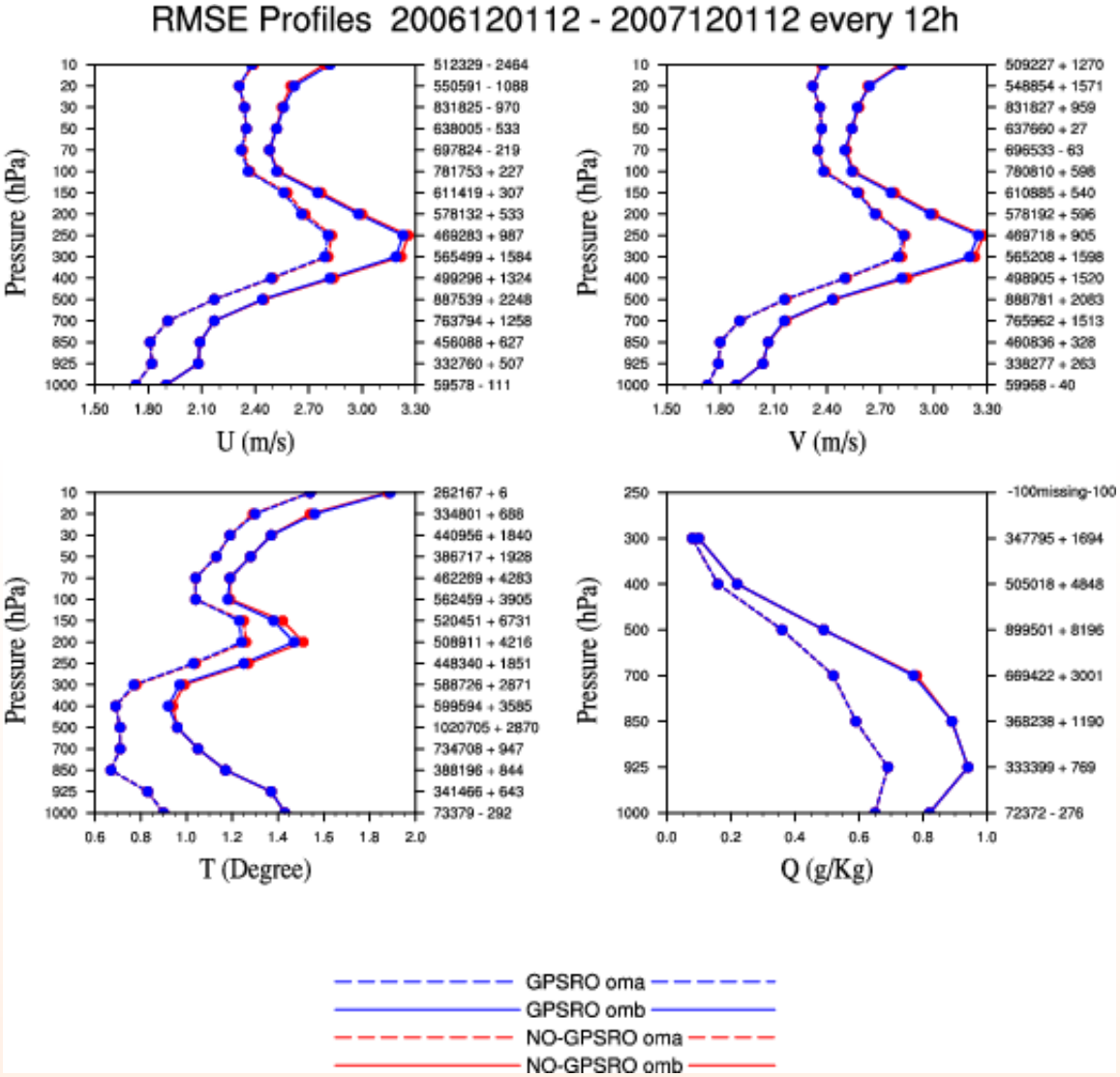
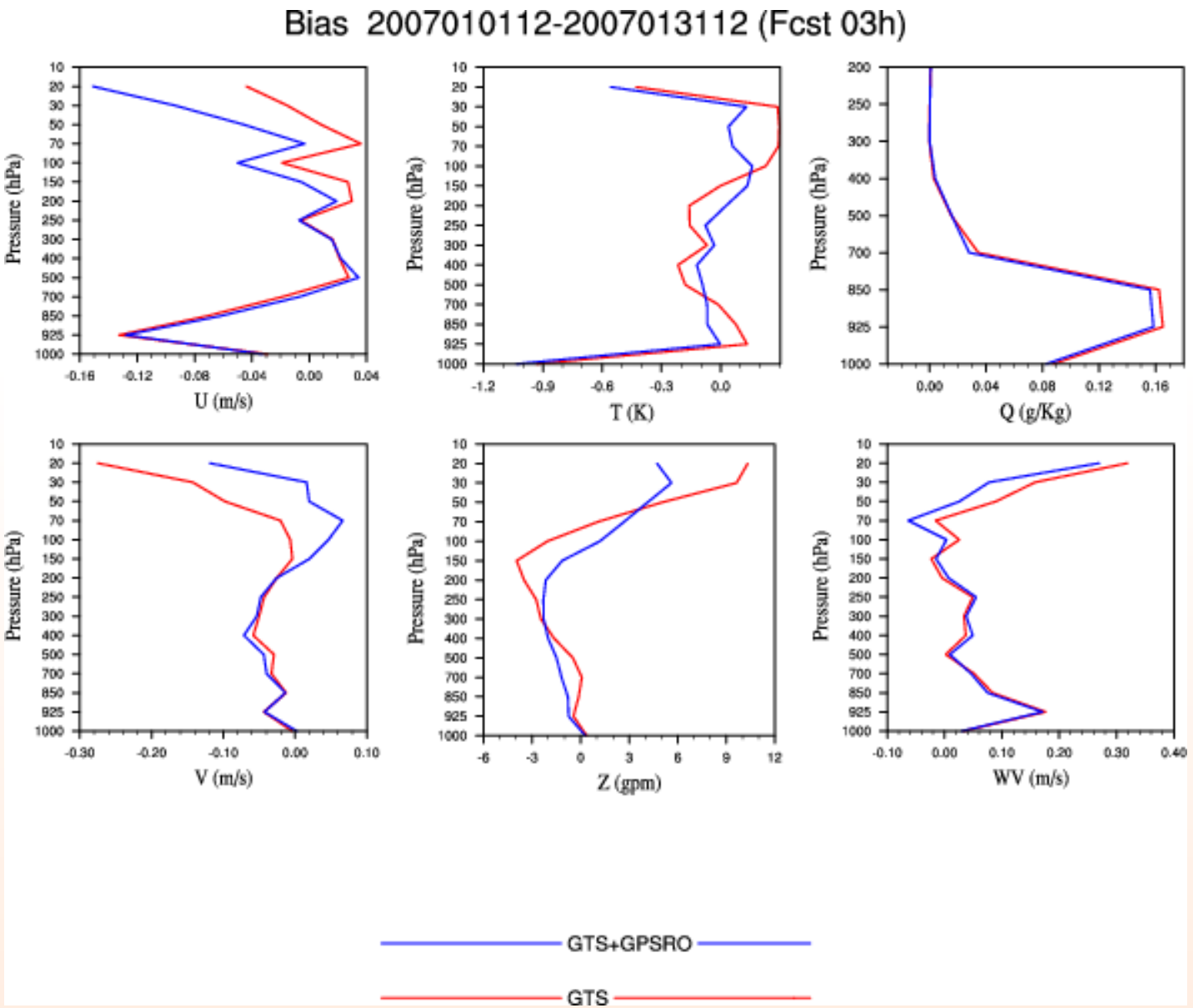
GPSRO impact: 1-yr Sound OMB/OMA

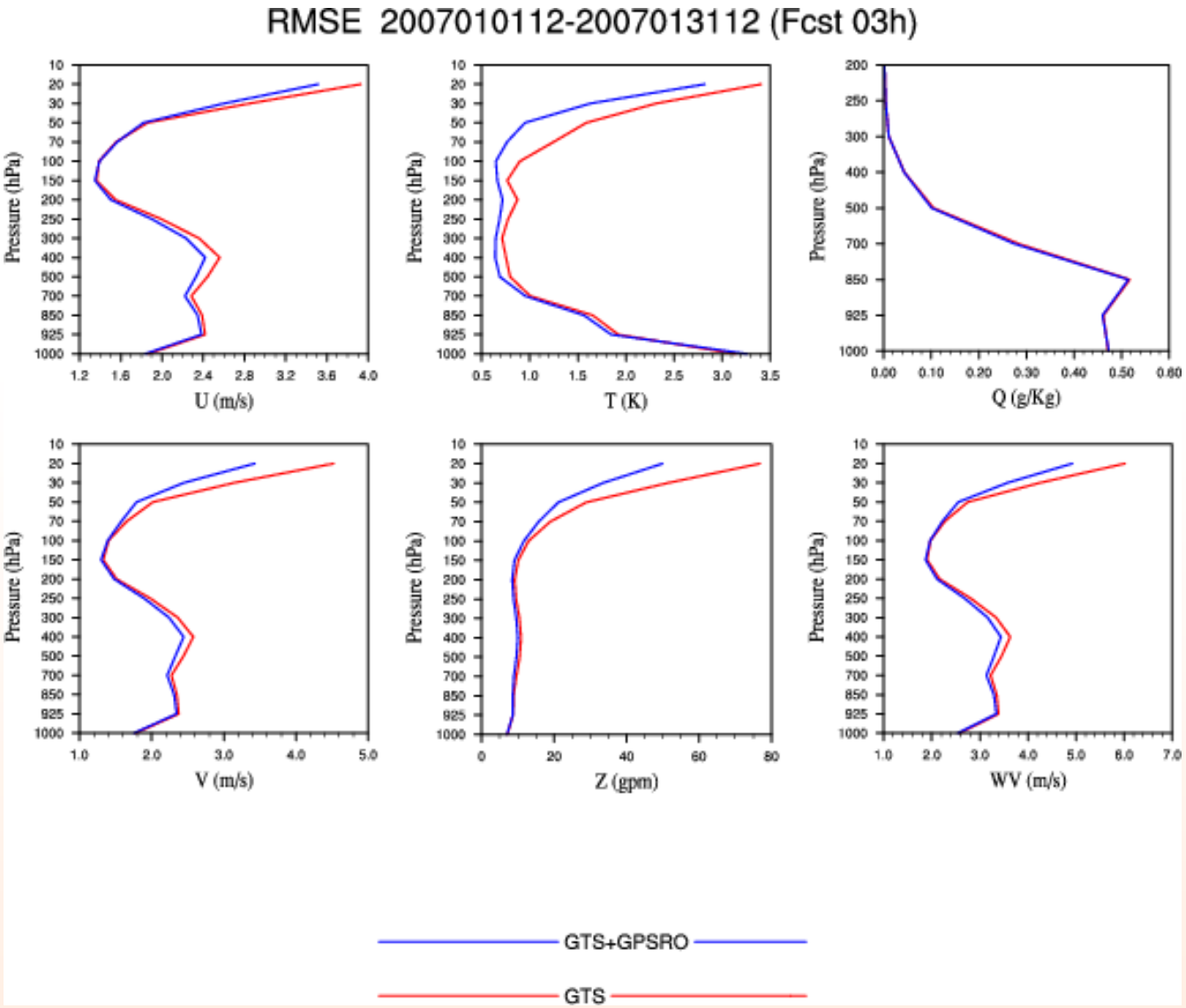


Adding GSPRO leads to more sound obs used, indication of better 3-h forecasts.

GPSRO impact: 3h forecasts vs. ERA-I analysis



GPSRO impact: 3h forecasts vs. ERA-I analysis



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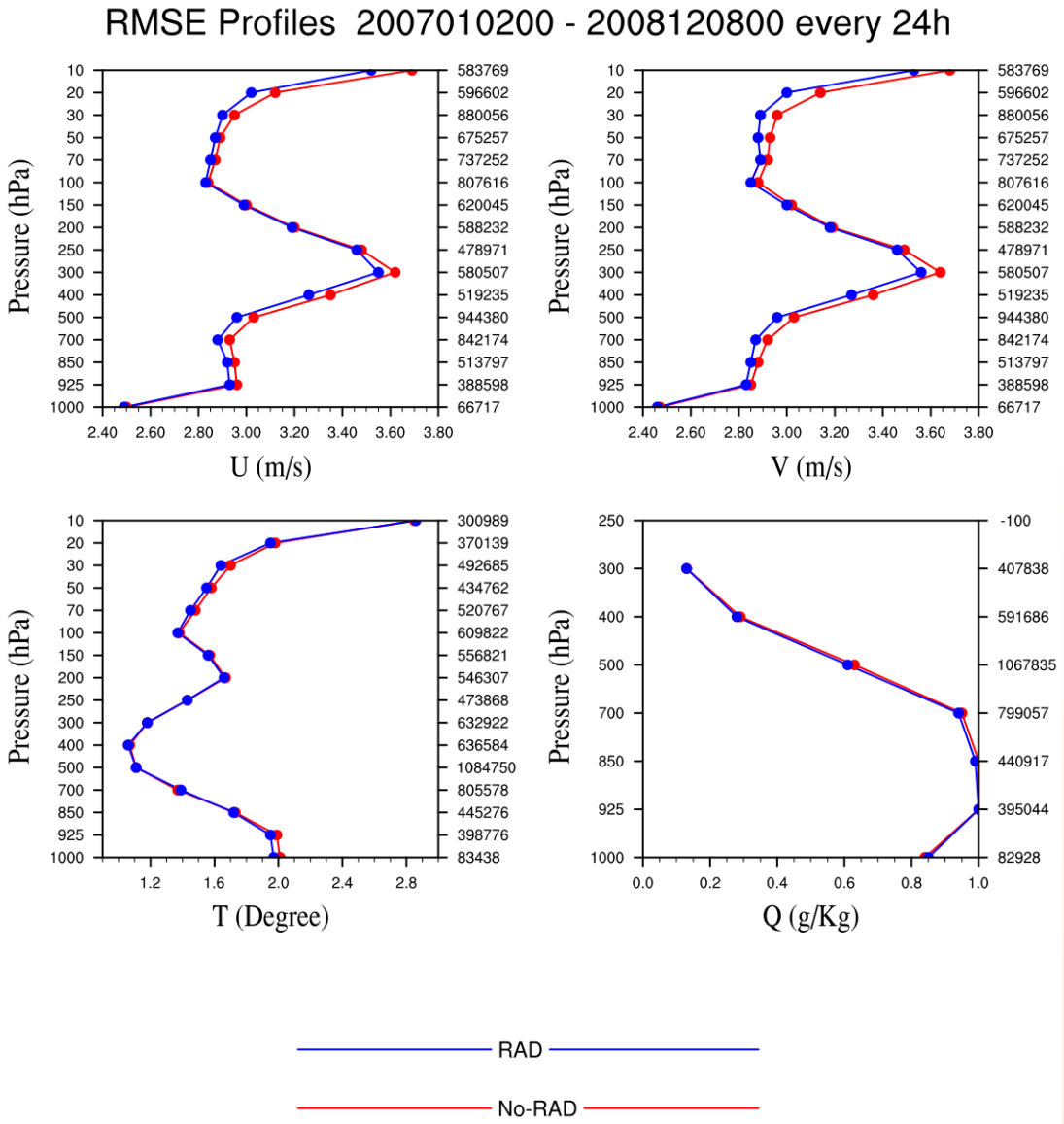
Radiance impact: 3h forecast vs. Sound



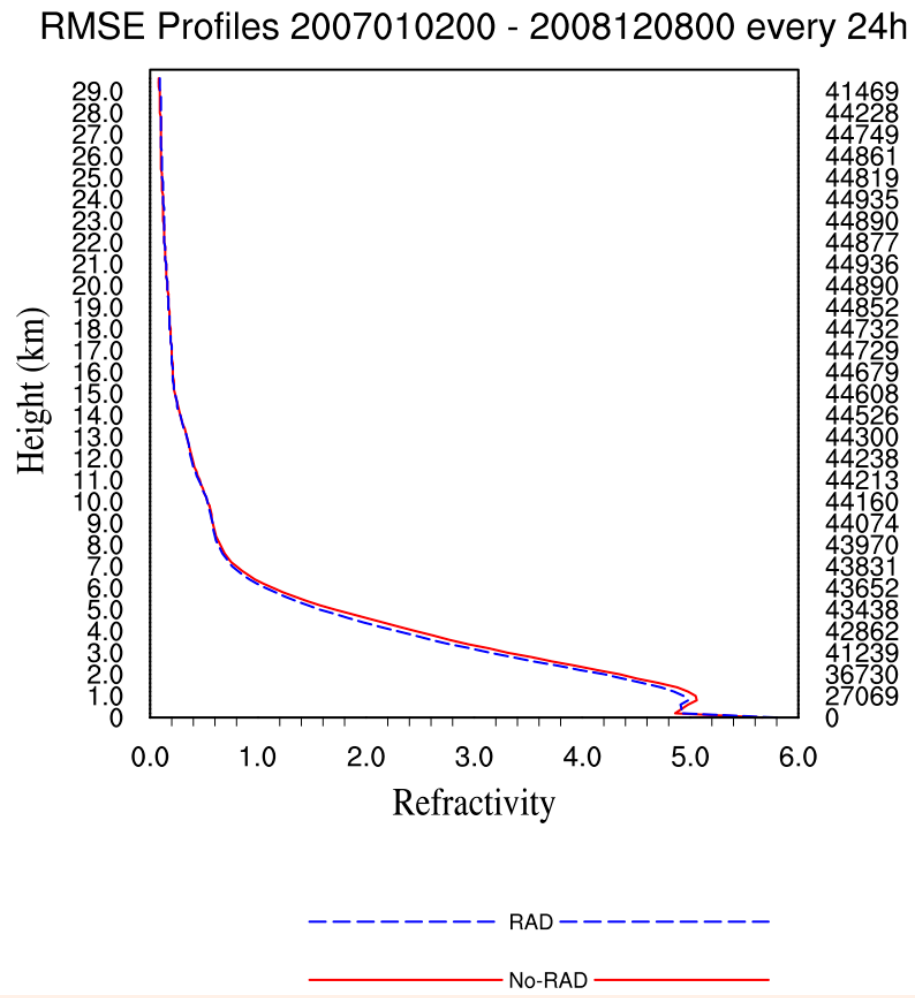
2-yr aggregated statistics.

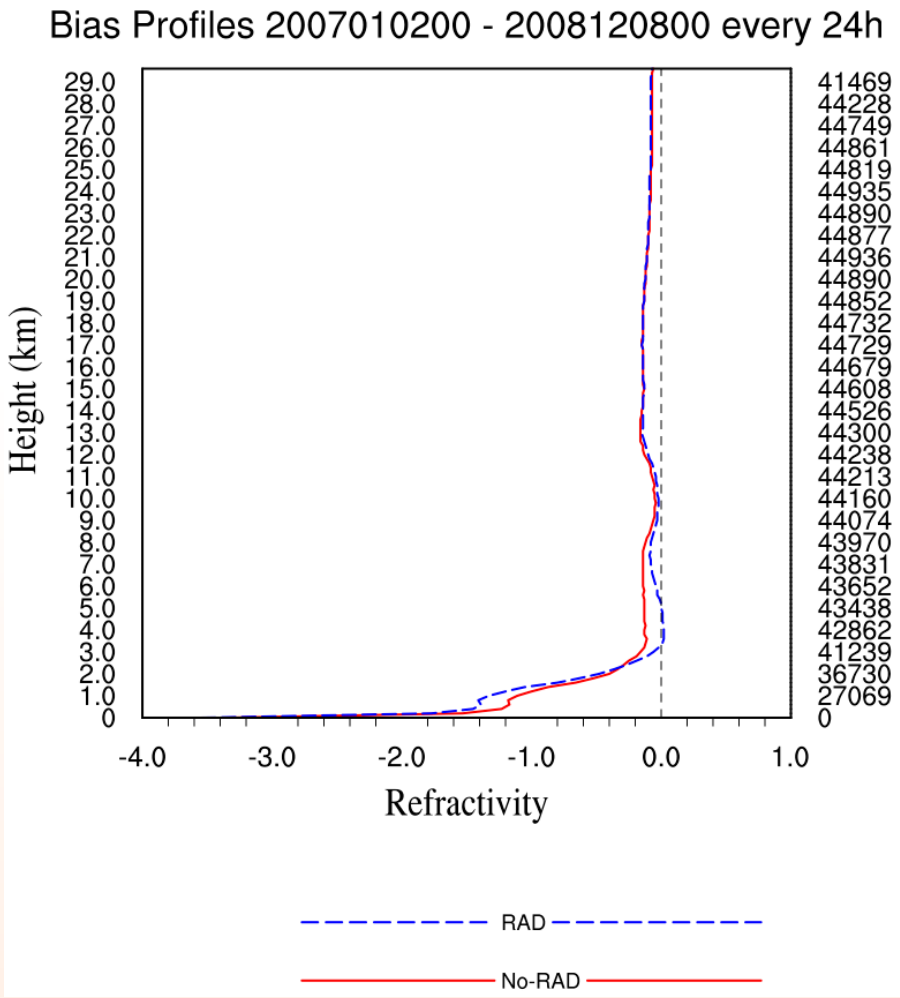
Forecasts valid at 00 Z,

i.e., initialized from analyses at 21 Z, when very few sounding obs available.

NOTE: both exps. Include GPSRO data.

Radiance impact: 3h forecast vs. GPSRO





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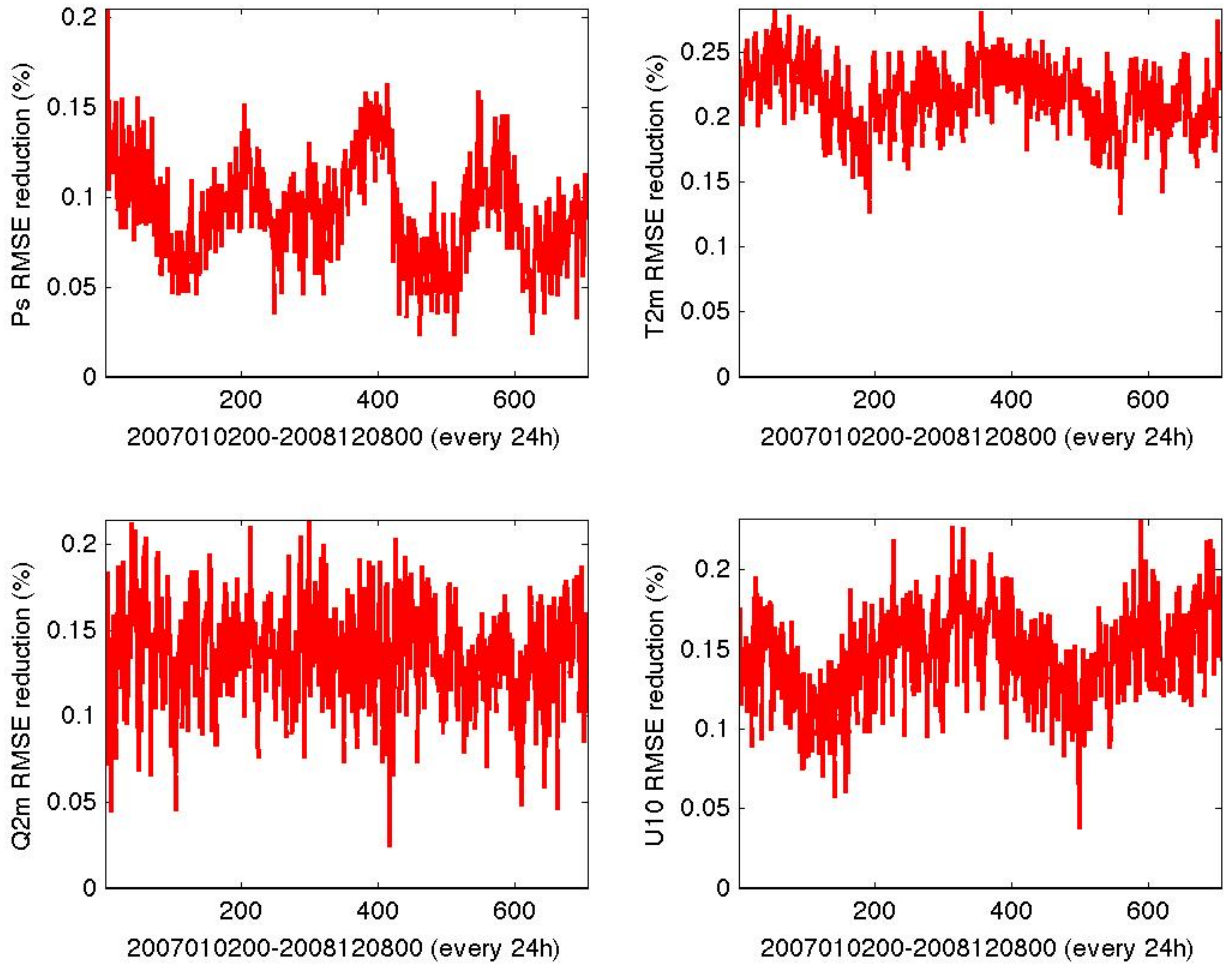
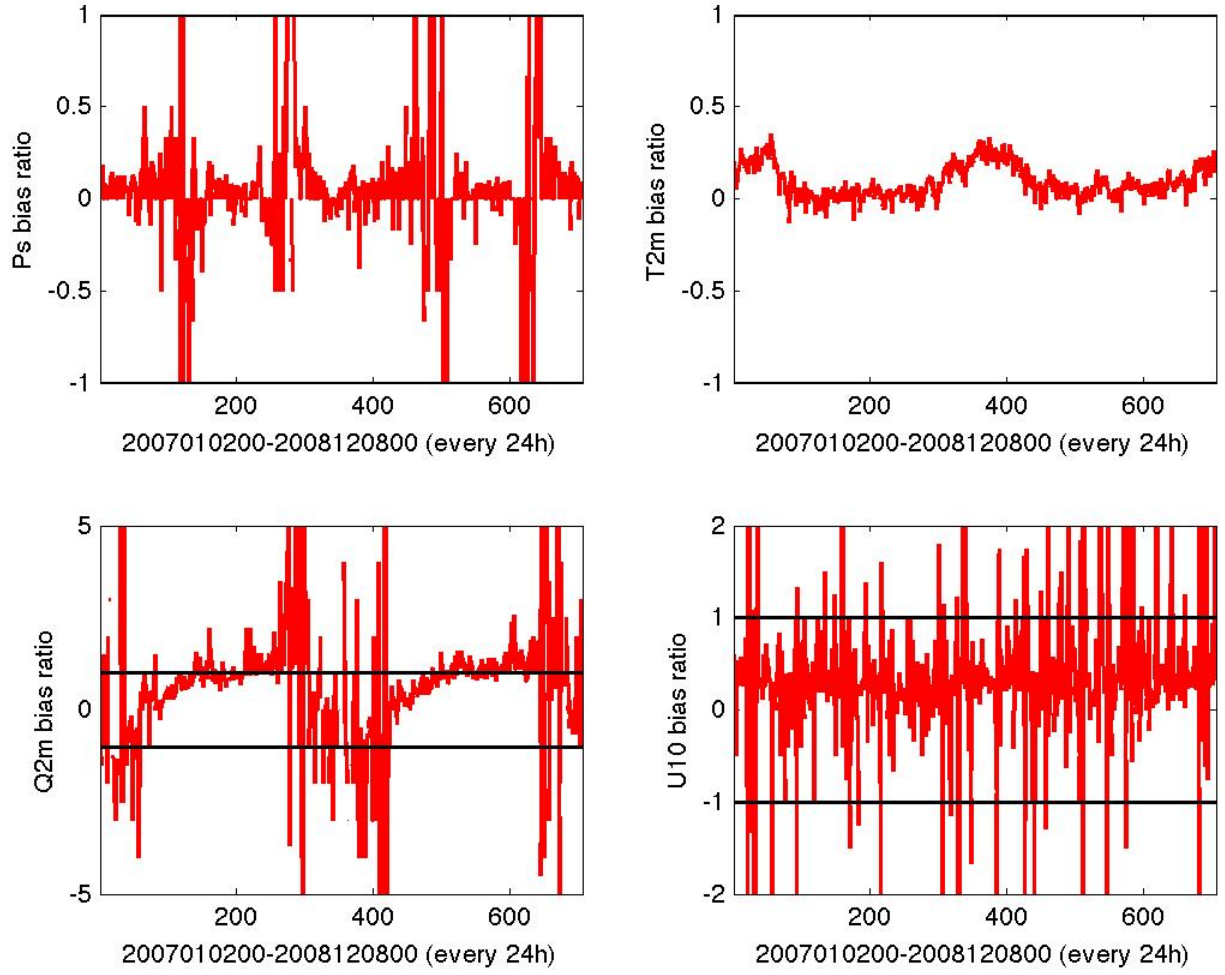
ASR-60km vs. ERA-Interim: against SYNOP

[rmse(ERA)-rmse(ASR)] / rmse(ERA)

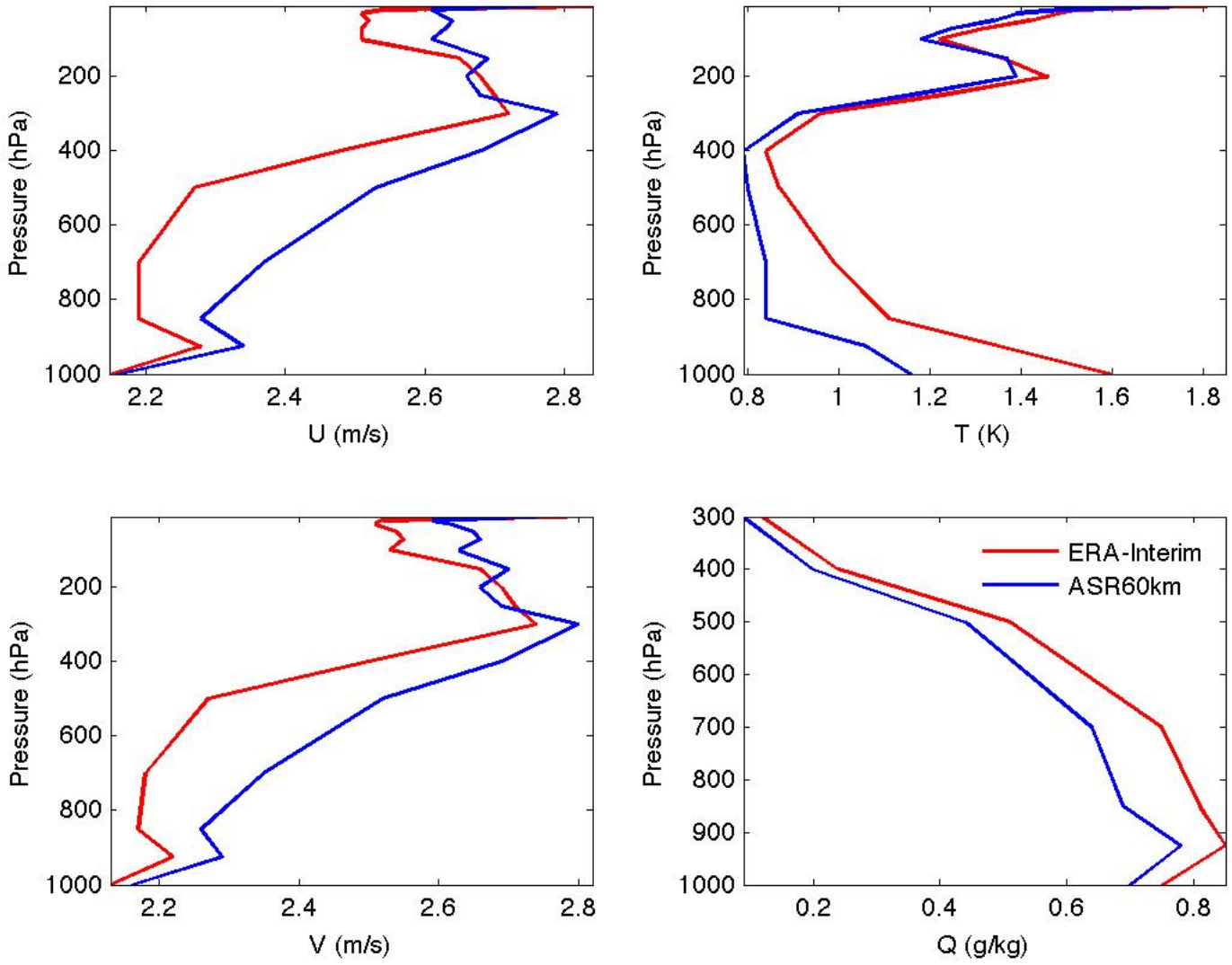


ASR-60km vs. ERA-Interim: against SYNOP

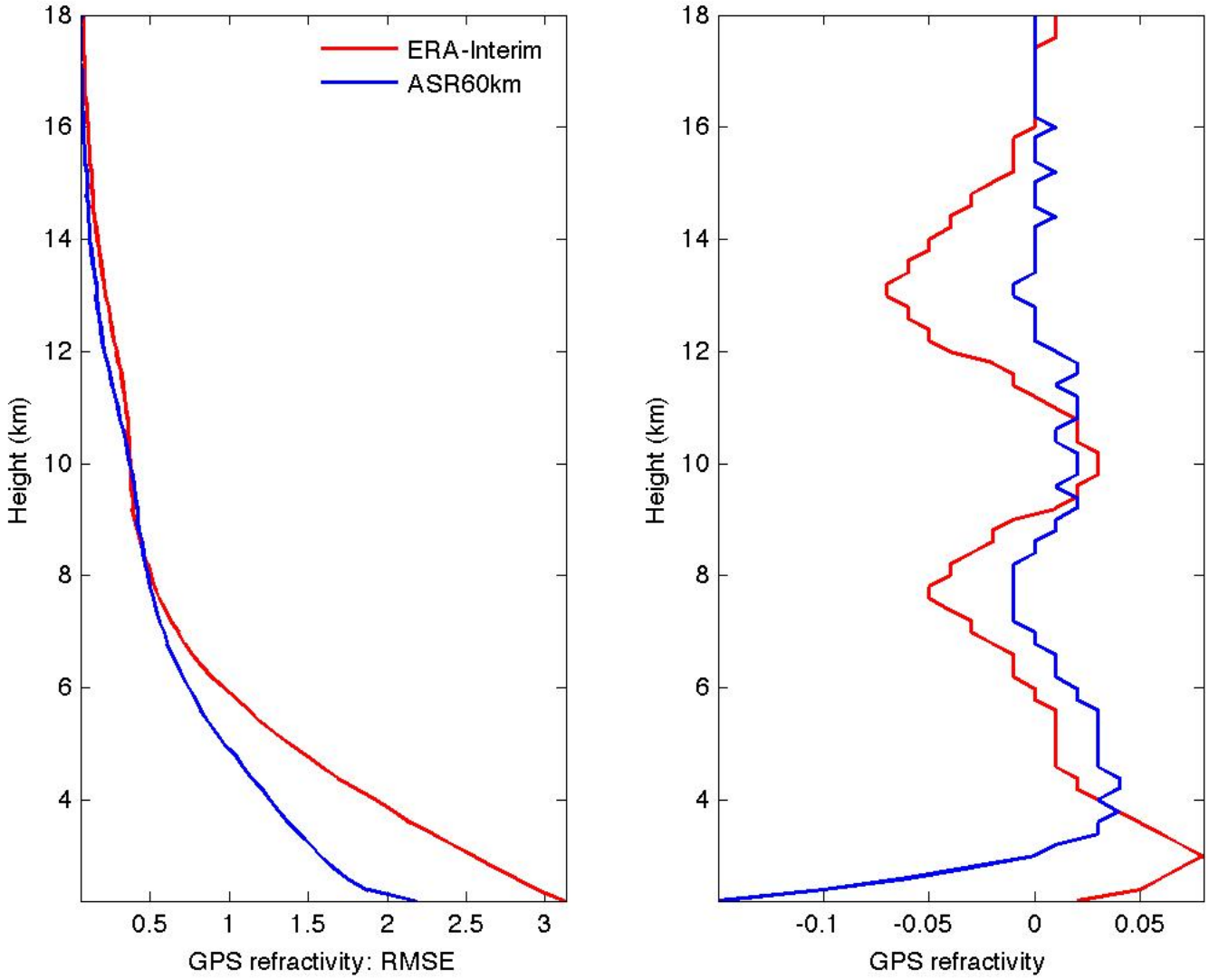
bias(ASR) / bias(ERA)



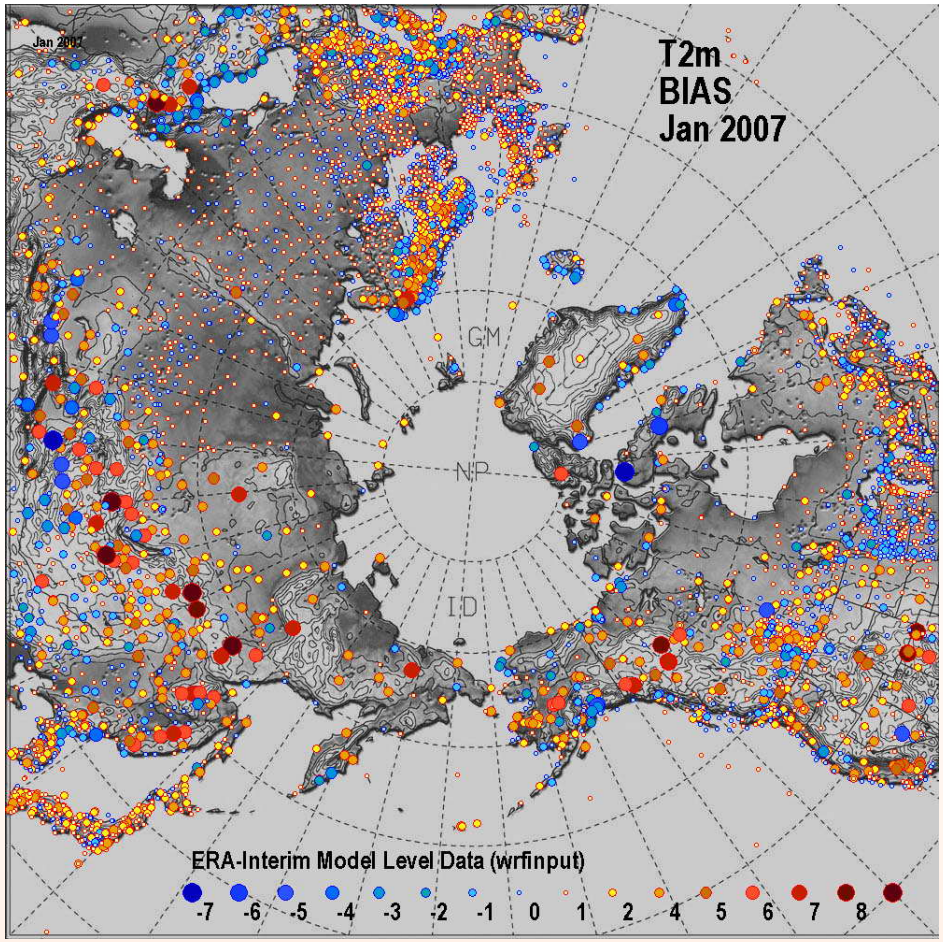
ASR-60km vs. ERA-Interim: against SOUND



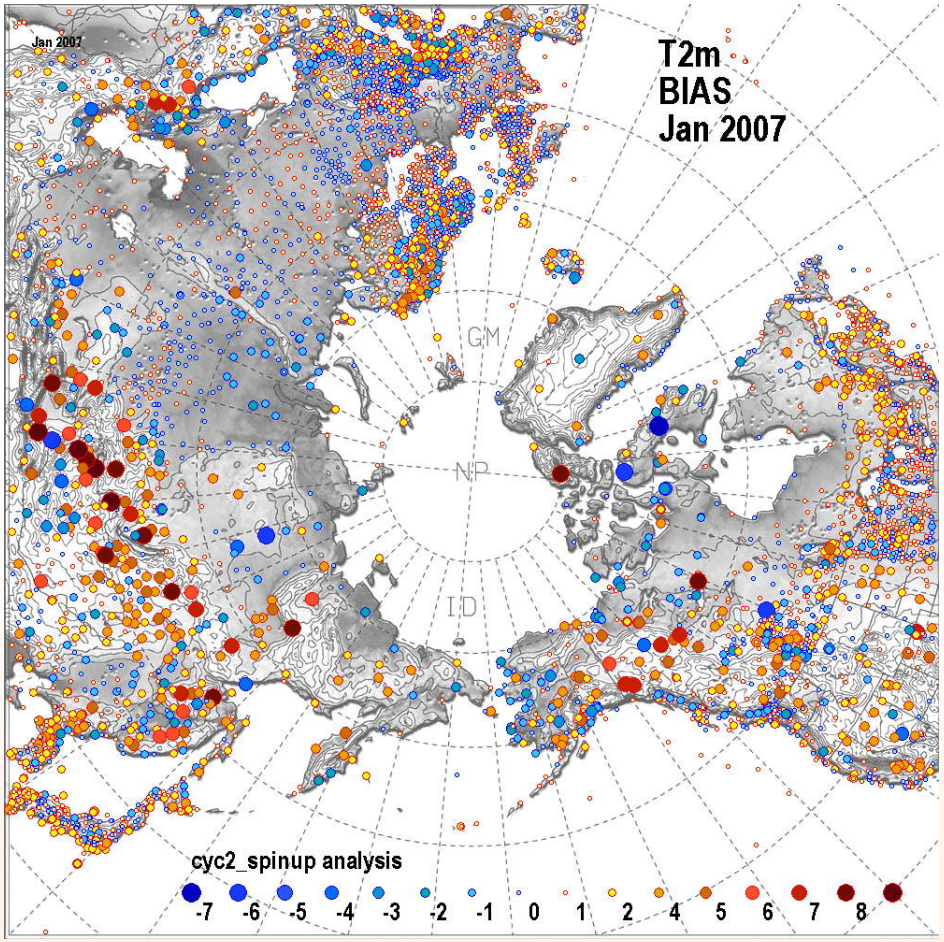
ASR-60km vs. ERA-Interim: against GPSRO



ASR-60km vs. ERA-Interim: T2m



ERA-Interim



ASR-60km

Summary

- Careful radiance sensor/channel selection and bias correction through monitoring is critical to get positive impact from radiance data.

- ASR reanalysis fits well to surface Ps/T2m/U10/V10 and upper-air T/Q

- Need some further work to improve fitting to Q2m and upper-air wind