WRF Atmospheric Data Assimilation: lessons learned from ASR

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Outline

- Introduction of WRFDA System

- Seasonal variation of WRF model error at stratosphere

- Radiance bias correction strategy for regional DA

WRFDA (formerly WRF-Var): A community facility
## Barker et al. 2012, BAMS

- Developed and supported by NCAR/MMM with contributions from research community

- Include options for 3DVAR, 4DVAR, and hybrid Var/Ensemble
  - 3DVAR used for ASR

- Can assimilate conventional data, GPSRO (refractivity), satellite radiances, radar, precipitation (4DVAR only)
  - Variational bias correction (VarBC) for radiance DA

- Control variables
  - Stream function, unbalanced (velocity potential, T, Ps), and pseudo RH

- Not directly analyze T2m/Q2m/U10/V10
  - Those are WRF model diagnostic variables, not prognostic variables.
  - T2m/Q2m/U10/V10 obs used to analyze the lowest model levels' state.

Observations used in ASR

- Surface
  - U/V, T, Q, P: SYNOP, METAR, SHIPS, BUOY, SONDE_SFC,
  - U/V, T, Q, P: SYNOP, METAR, SHIPS, BUOY, SONDE_SFC,

  - U/V: QuikSCAT over ocean

- Upper air
  - PolarAMV, GeoAMV (U/V)
  - SOUND (U/V, T, Q), AIREP (U/V, T), PROFILER (U/V),

- GPS Radio Occultation (refractivity)

- _____

NCEP BUFR/PrepBufr data provided by Jack Woollen

observation coverage snapshot at 2007120100 with 3-h time window

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

✓ **More than 4000 surface stations**
✓ **Around 300 sounding stations**
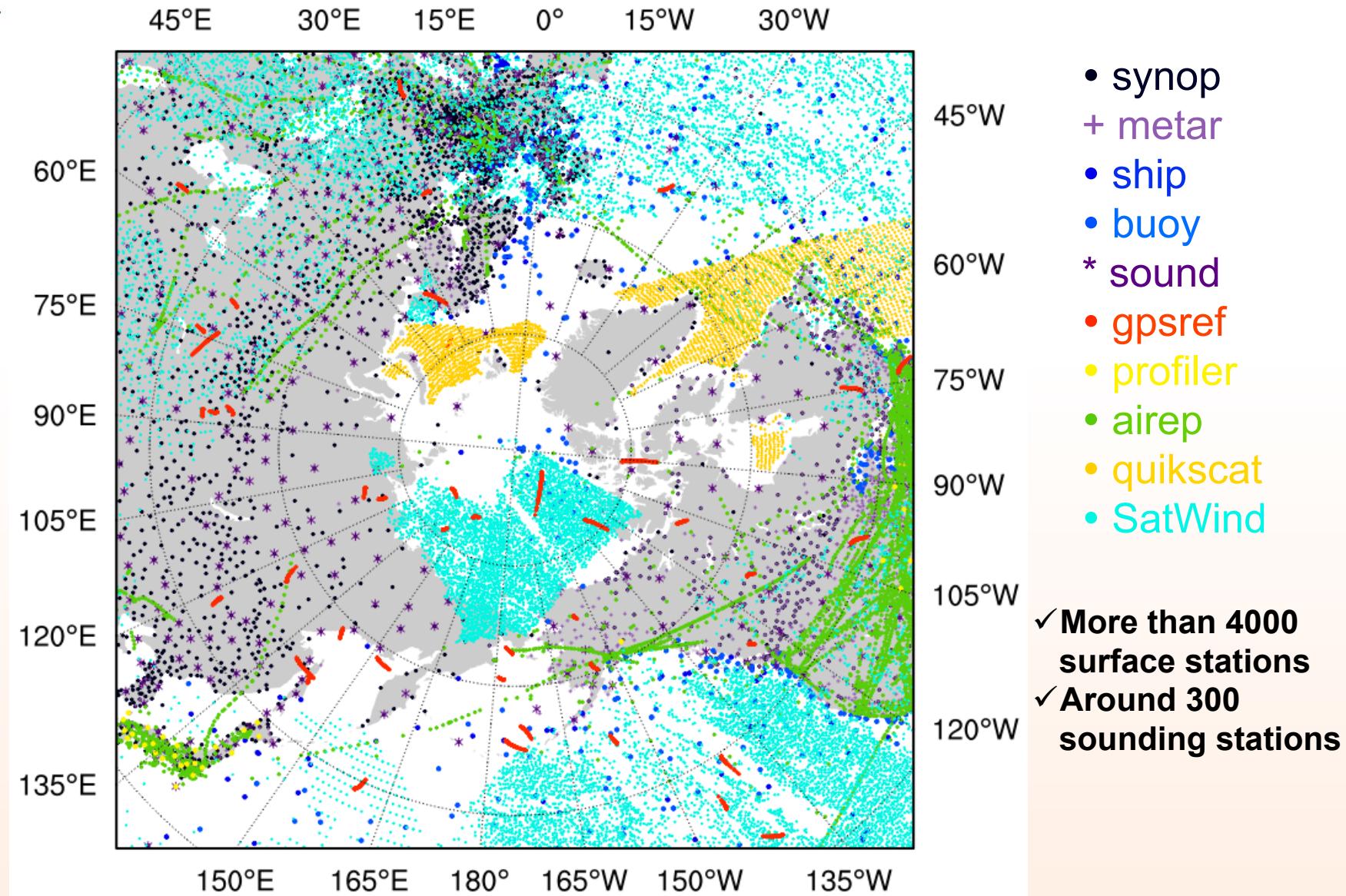
Seasonal variation of model forecast errors at stratosphere
(standard derivation statistics from 24h FC - 12h FC valid at same time)
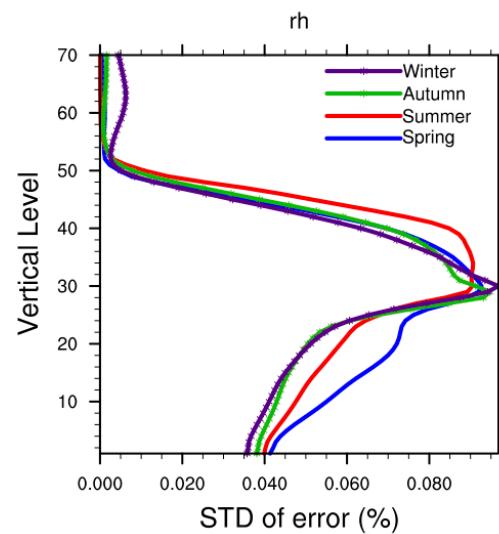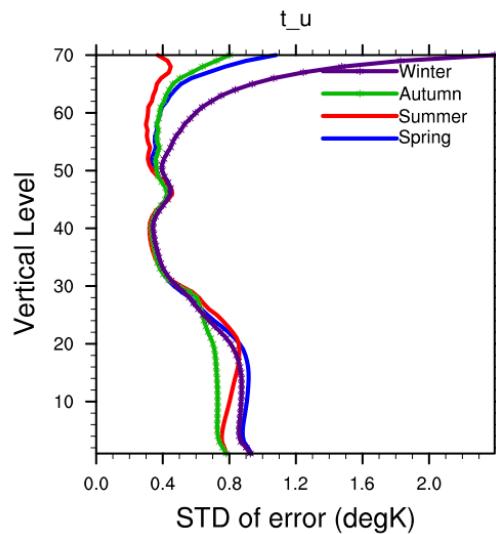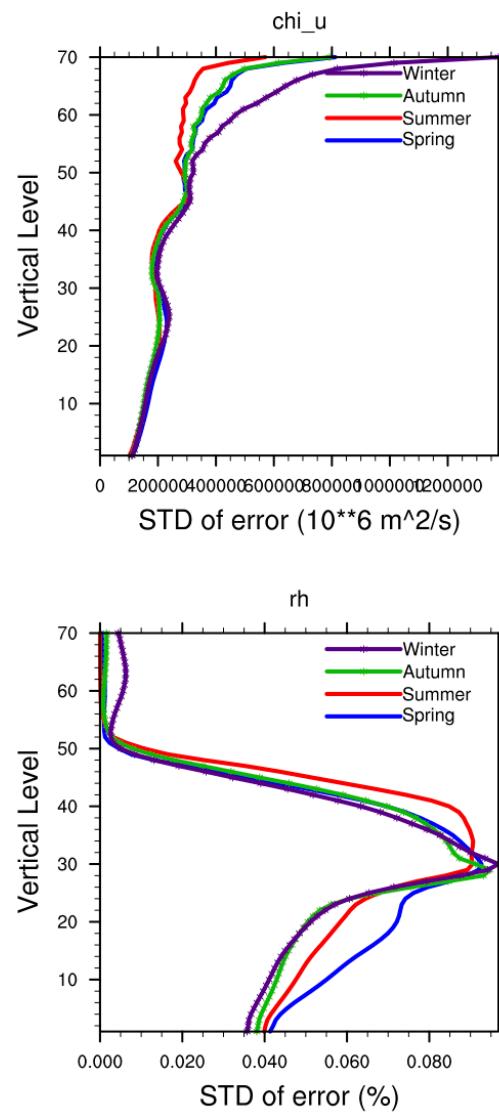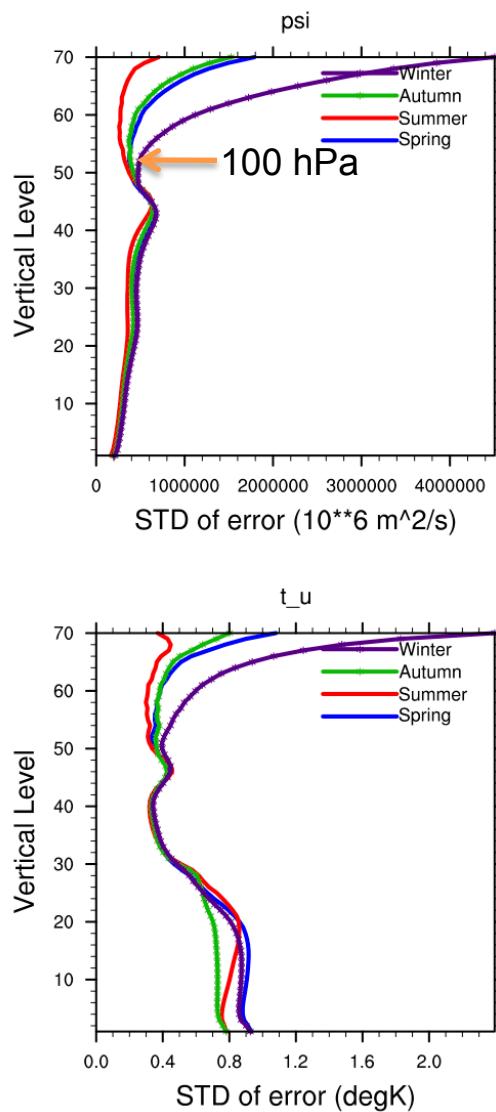
This is the basis for the background error covariance statistics.

Discontinuity caused by BEC change

50 hPa   RMSE
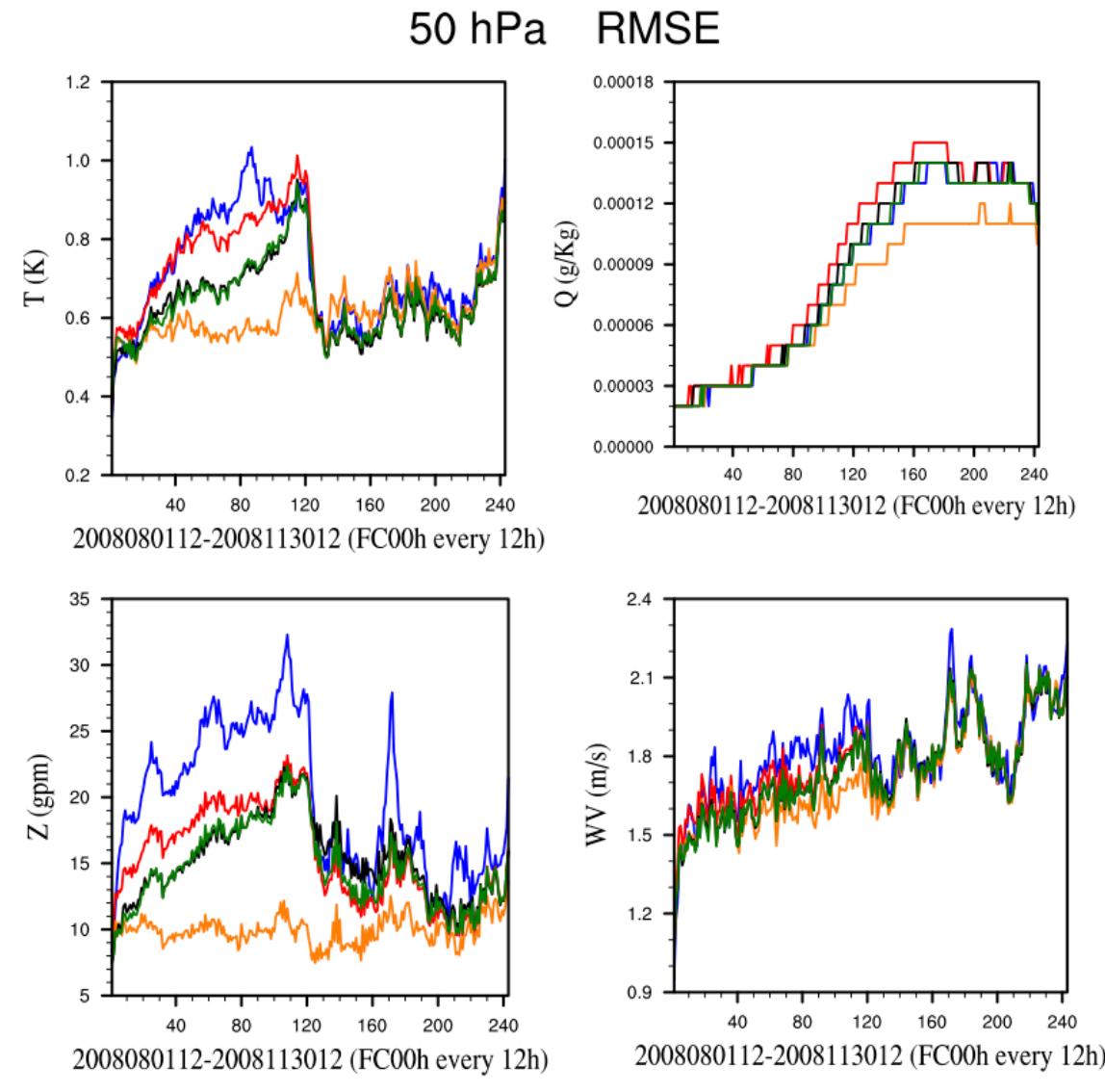
Compare to ERA-Interim.

One of reasons to use grid-nudging near the top.

Satellite 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 from 7 satellites

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

Data Availability

	LTAN (local time of ascending node)	Launch date	available date for ASR
NOAA-15	16:38:14	1998/05/13	Since the beginning
NOAA-16	20:00:43	2000/09/21	2001/01/24
EOS-2 (Aqua)	PM orbit	2002/05/04	2004/04/13
NOAA-17	19:45:41	2002/06/24	2002/09/11
NOAA-18	14:31:03	2005/05/20	2005/08/23
METOP-2	21:31:00	2006/10/19	2007/04/24
NOAA-19	13:31:47	2009/02/06	??

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

Bias Correction

stdv of O-B

noaa-15-amsub

noaa-16-amsub

2001/01/24

noaa-17-amsub

2002/09/11

noaa-18-mhs

2005/08/23

metop-2-mhs

2007/04/24

METOP-2
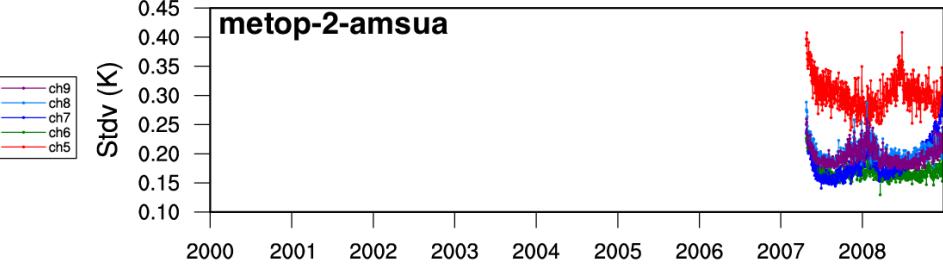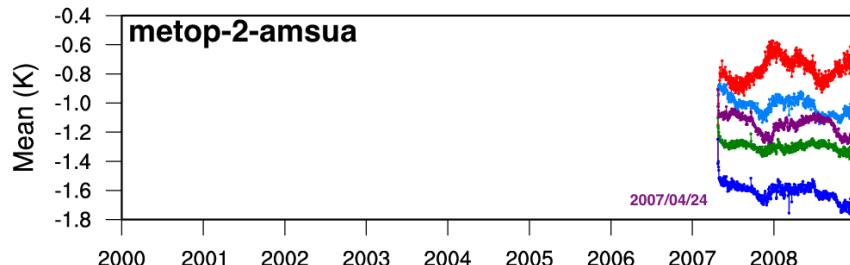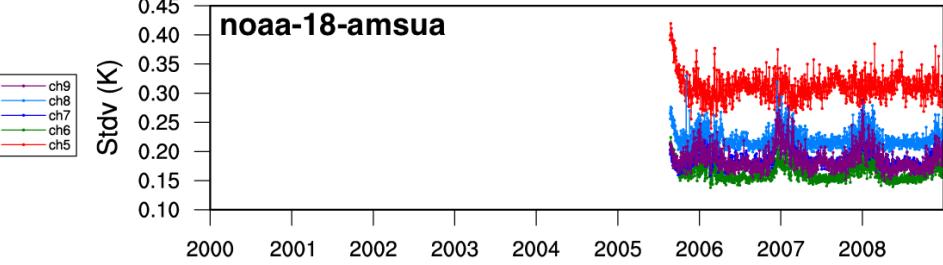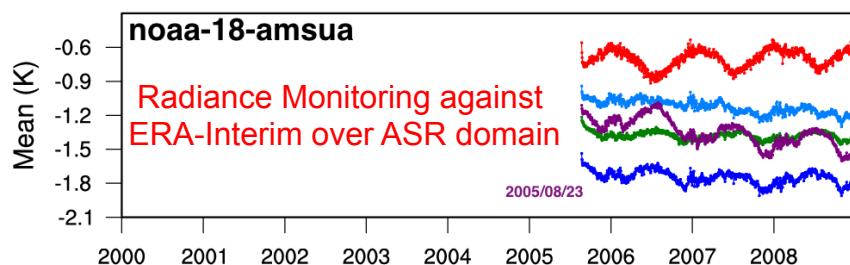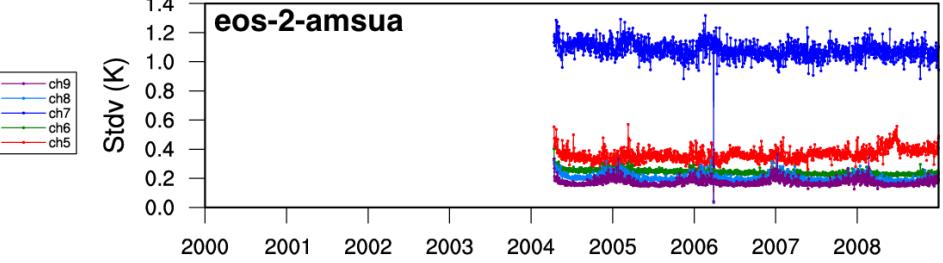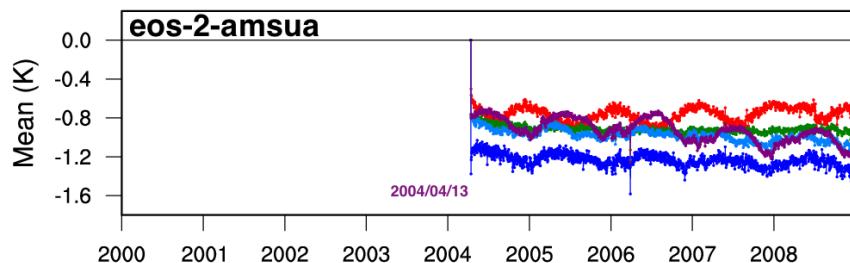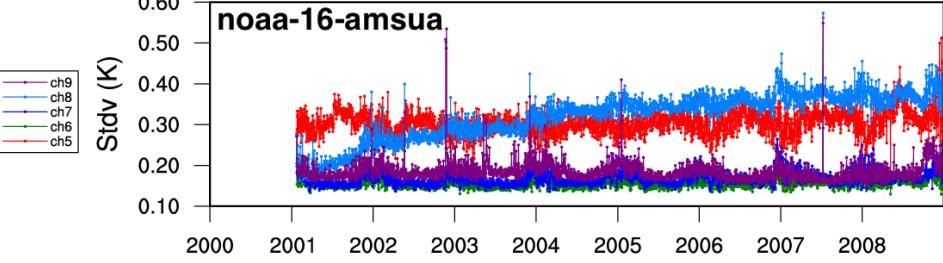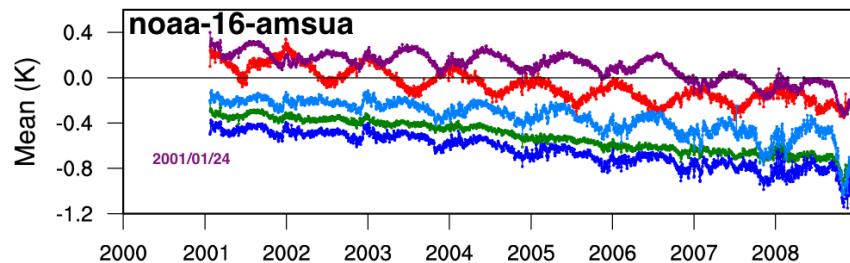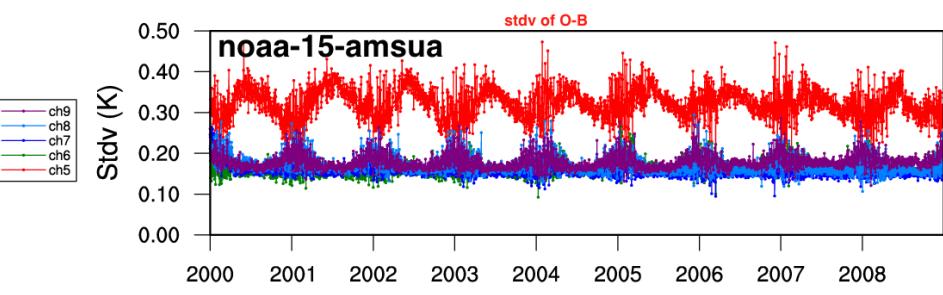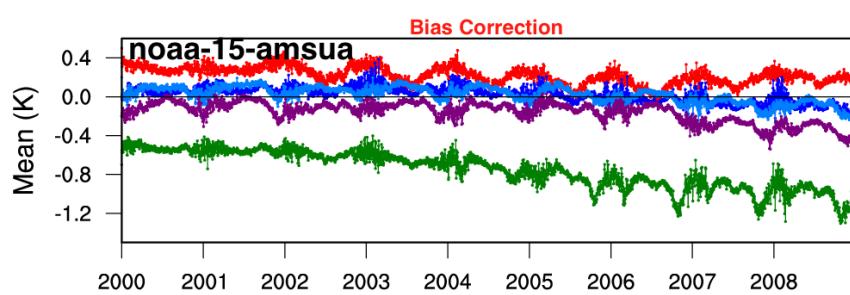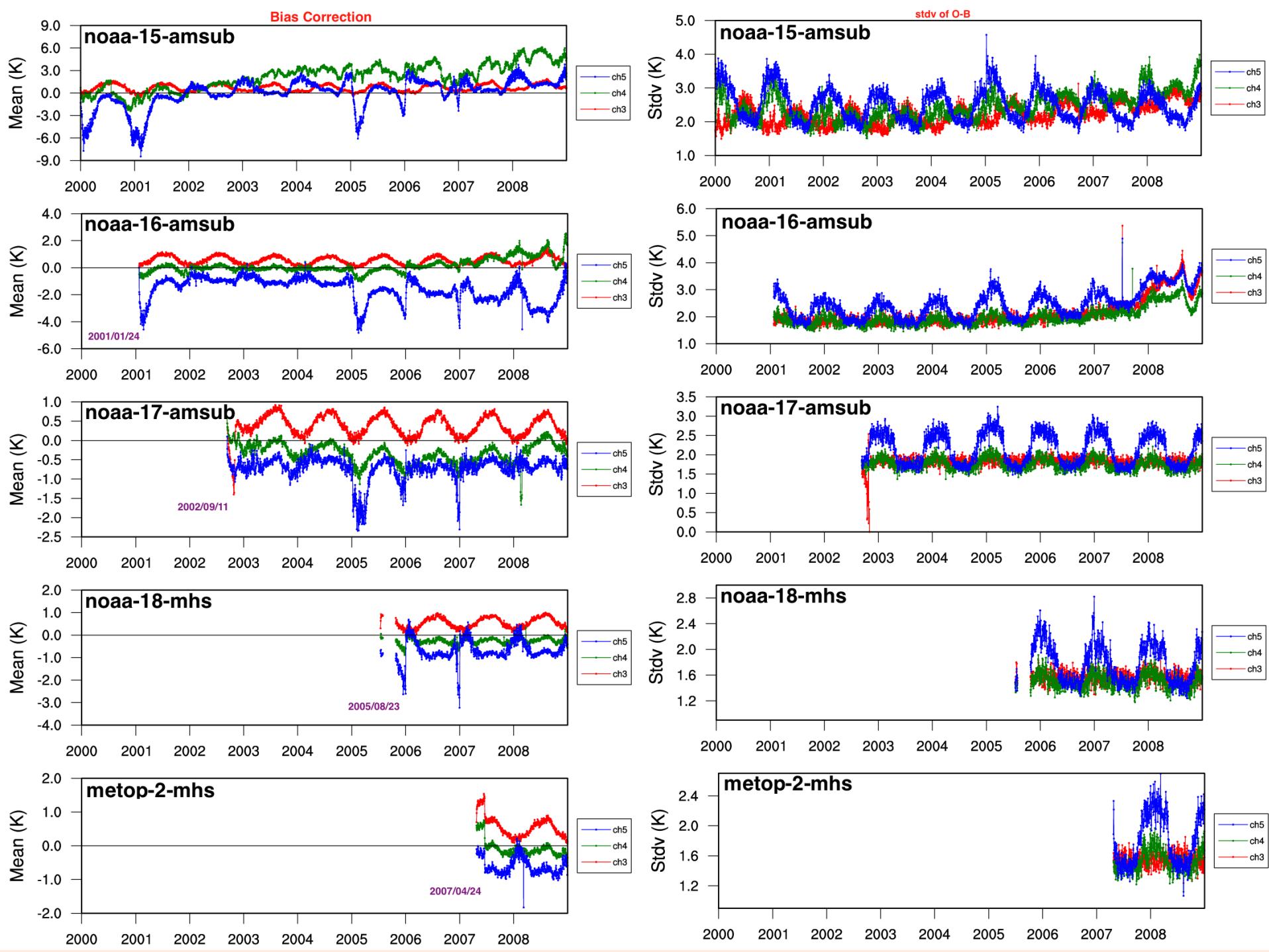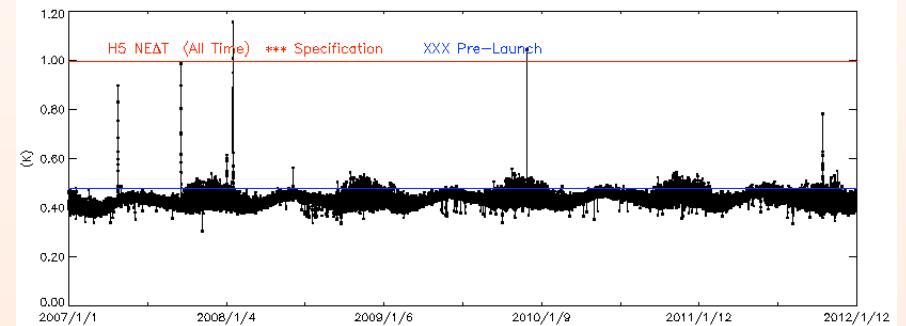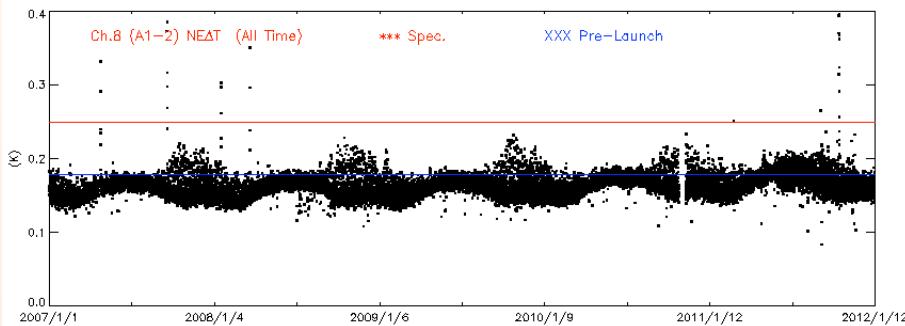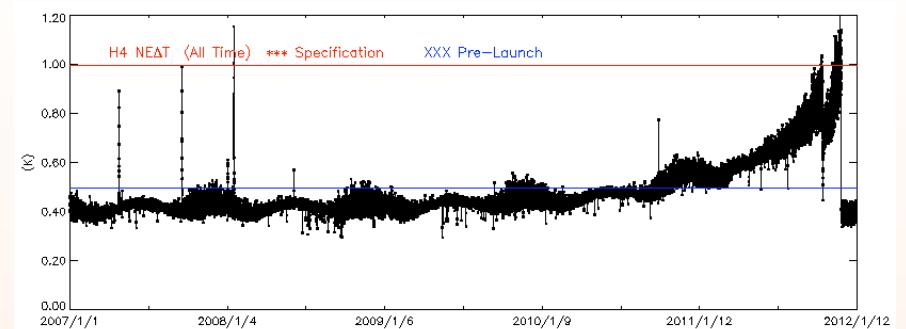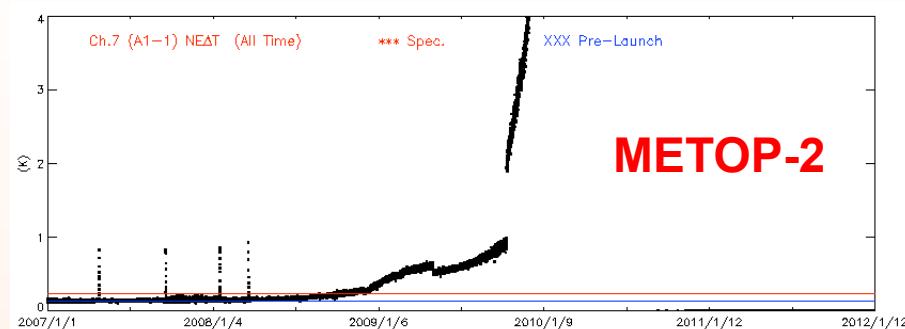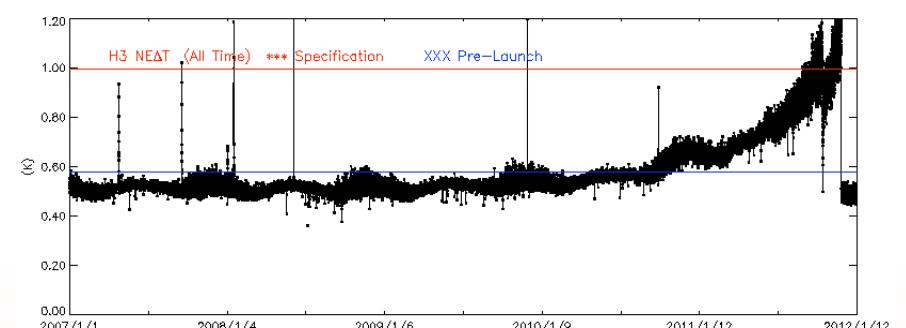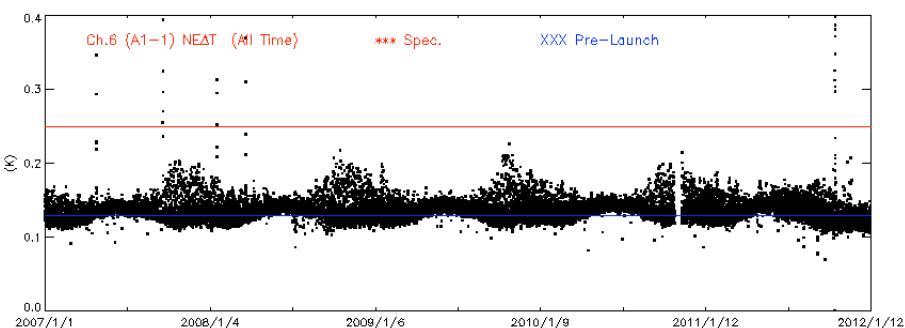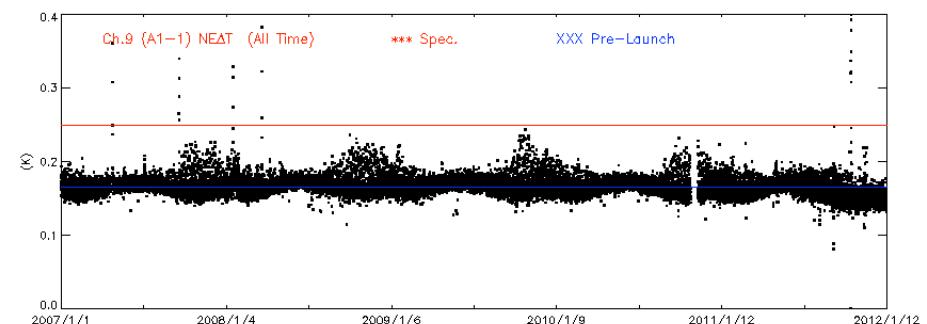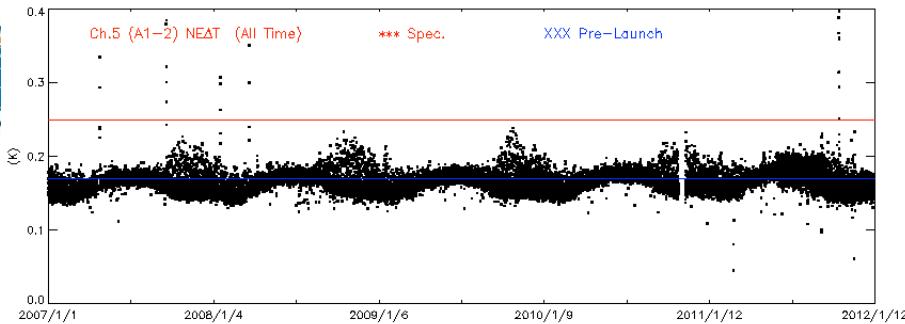
Radiance Monitoring against ERA-Interim
Global vs. Regional statistics
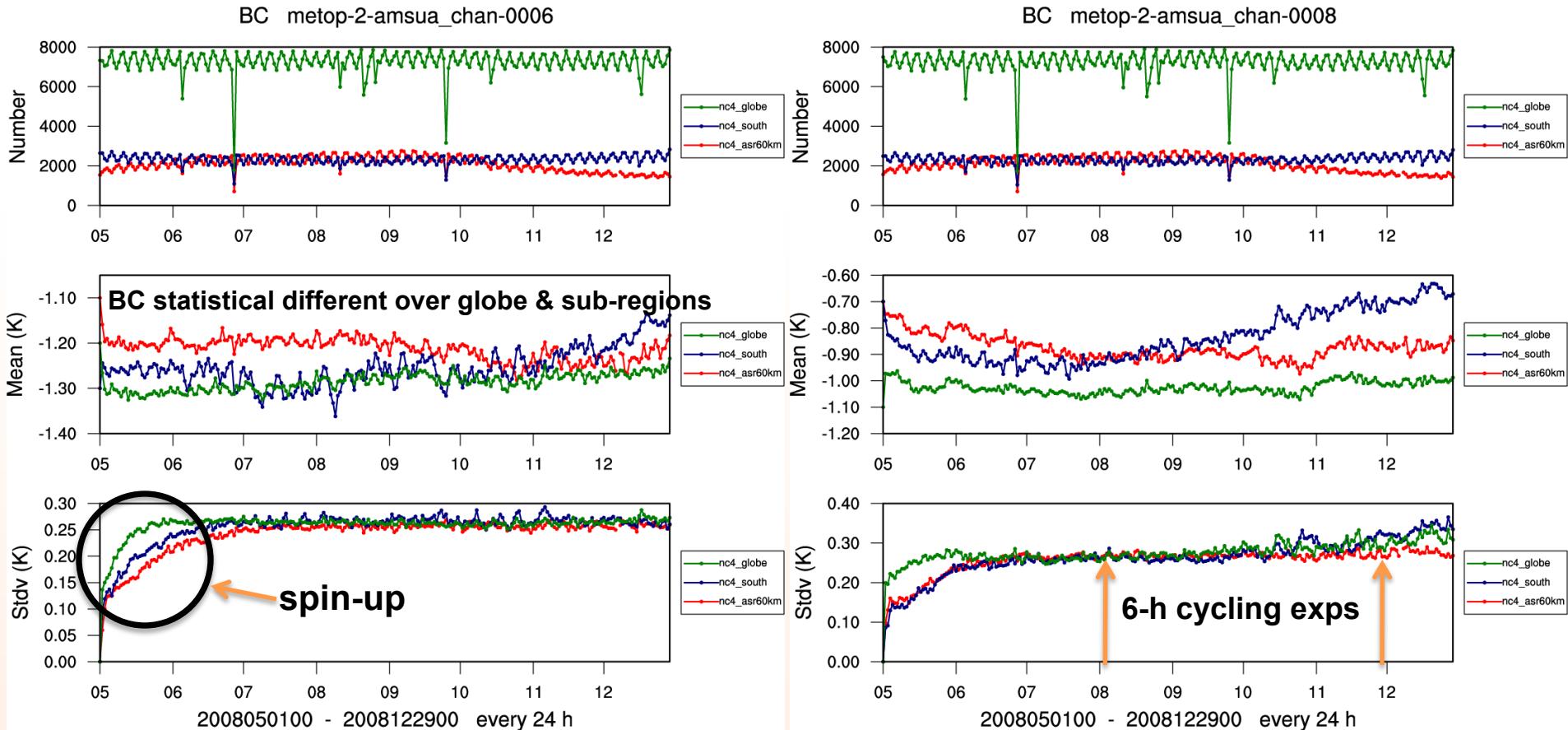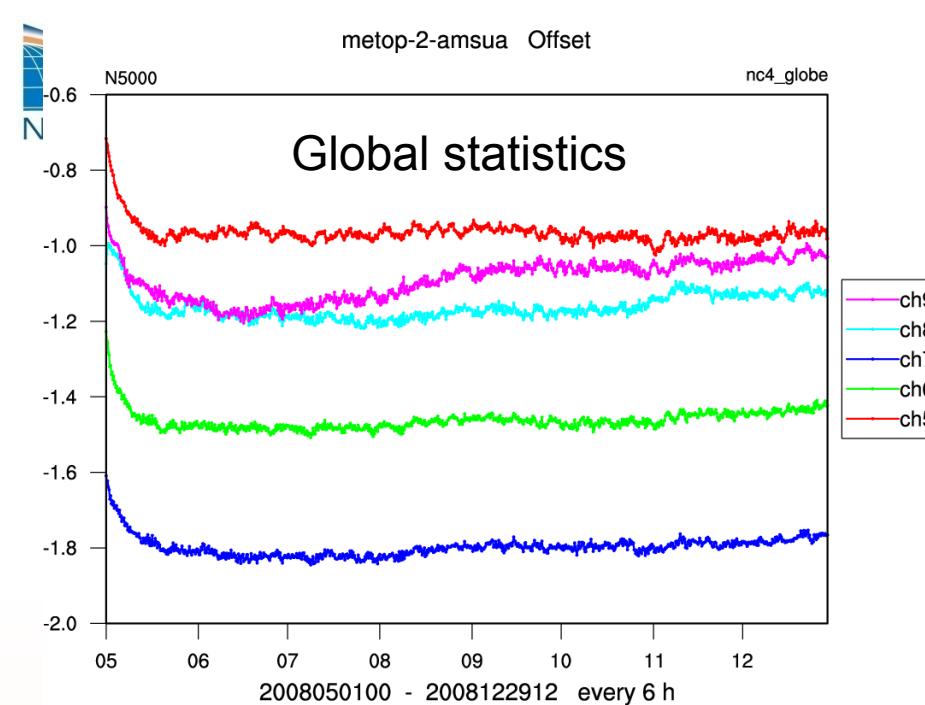
Bias correction coefficients:
"offset" evolution from global,
ASR-domain, South-Pole domain.
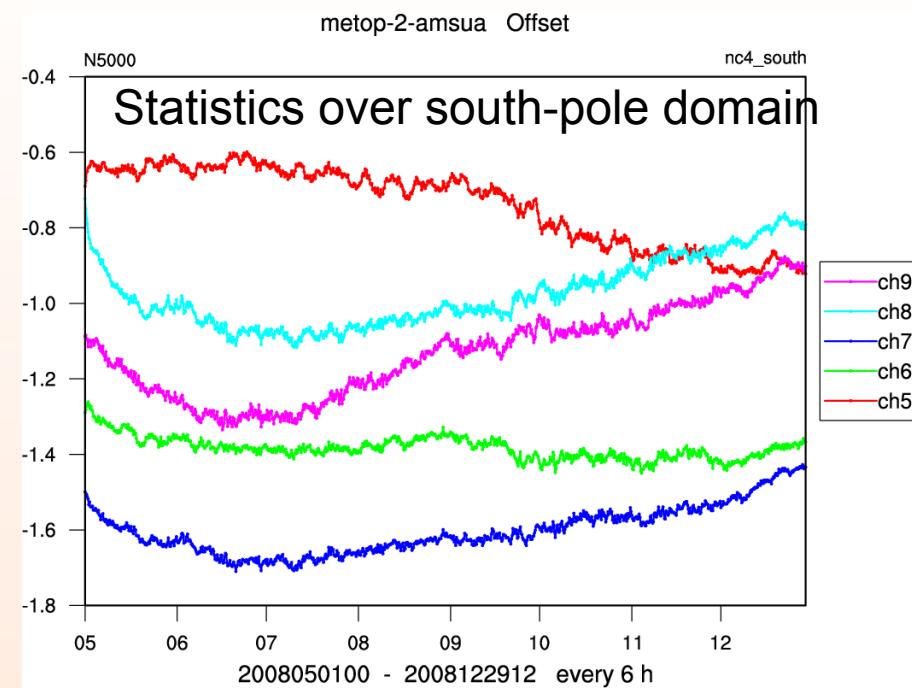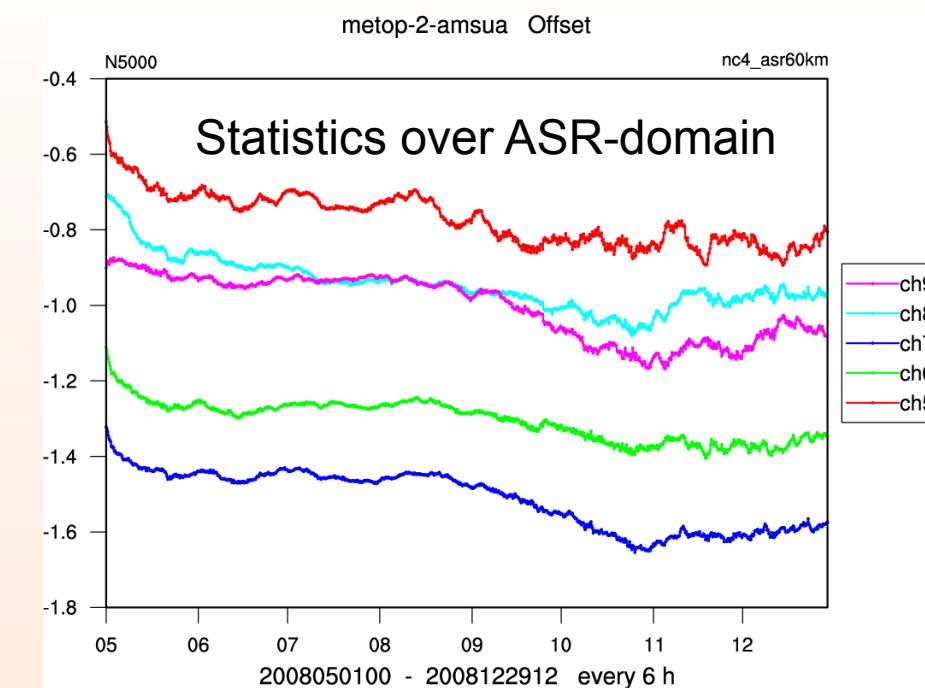
Bias correction sensitivity experiments

- Reduced resolution
  - 60km/57L/10hPa top, no grid-nudging on top, single domain

- 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.

  - **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

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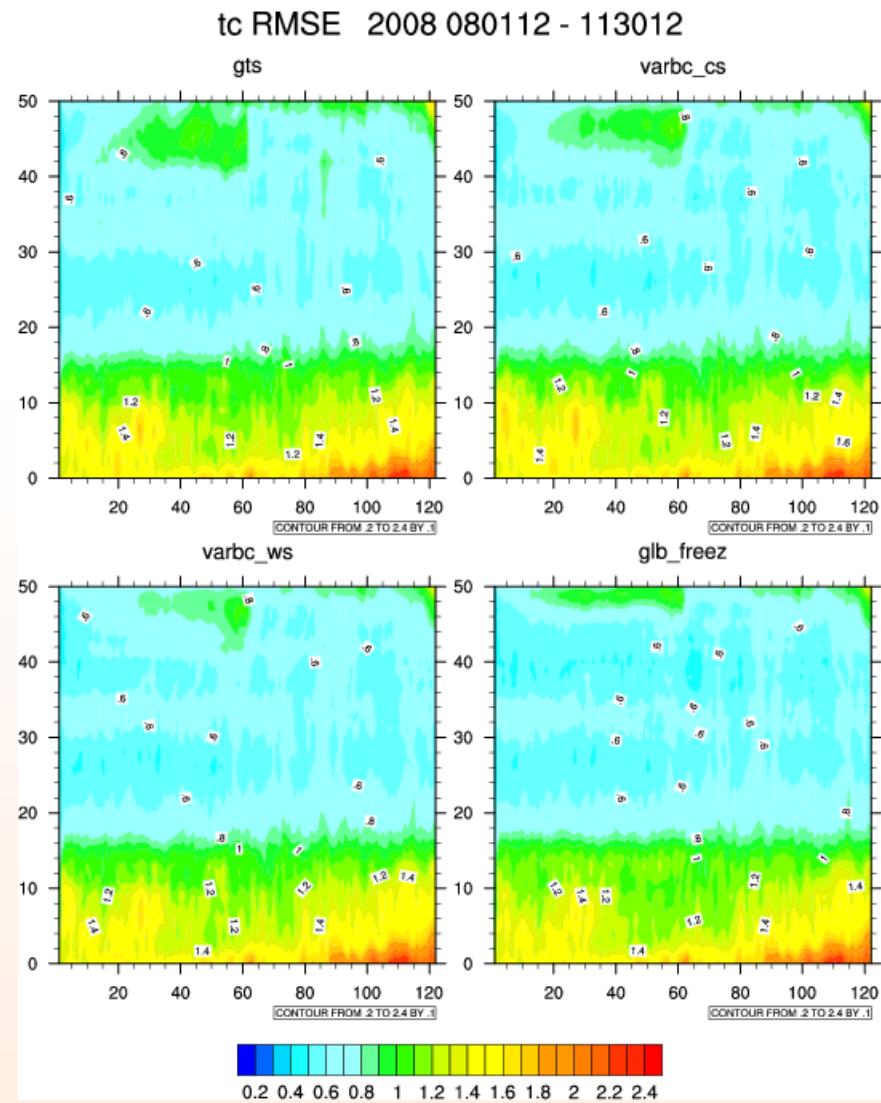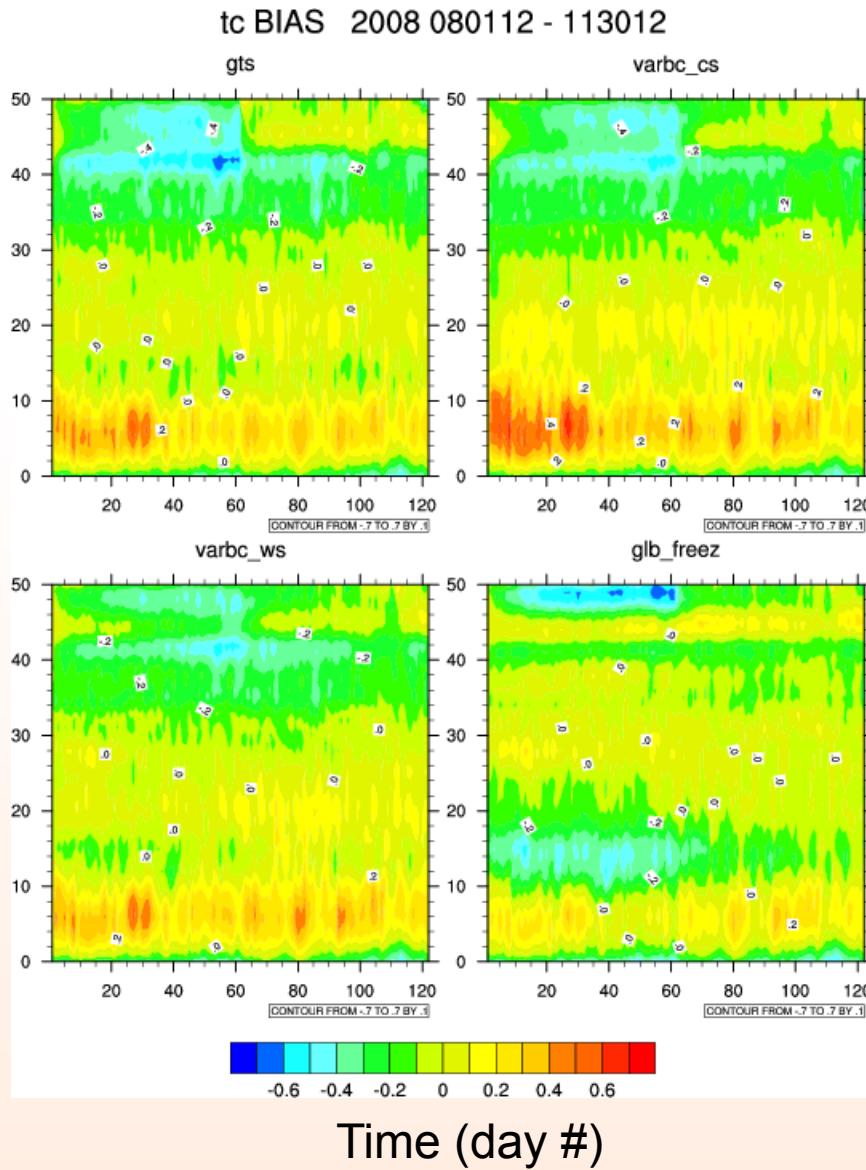
Q: analysis@12Z vs. ERA-Interim

QVAPOR BIAS   2008 080112 - 113012
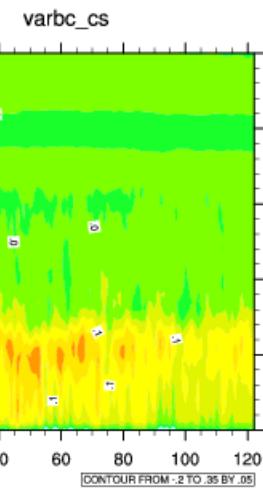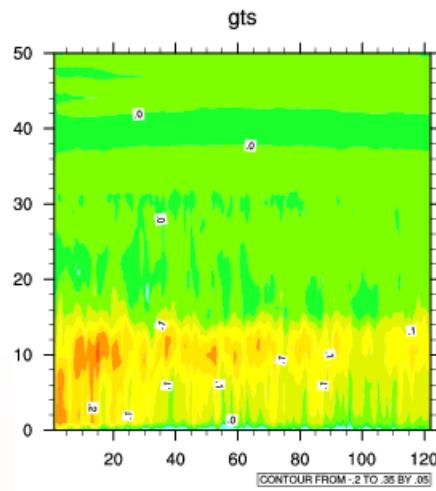
QVAPOR RMSE   2008 080112 - 113012
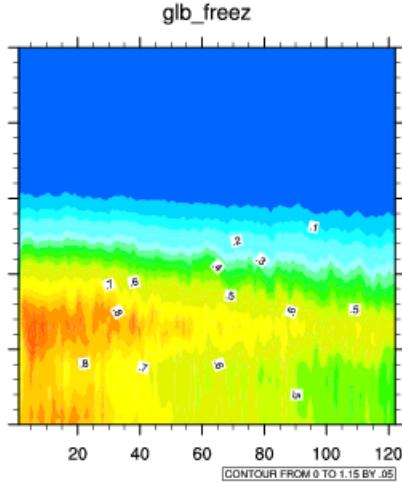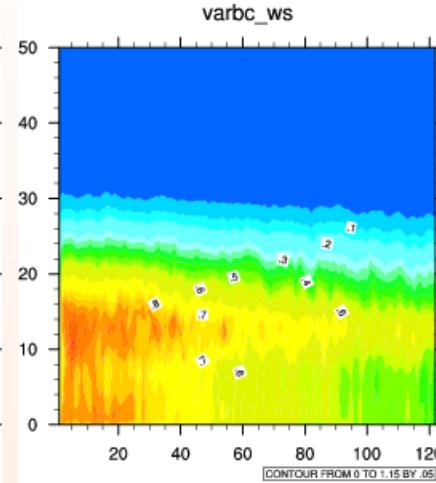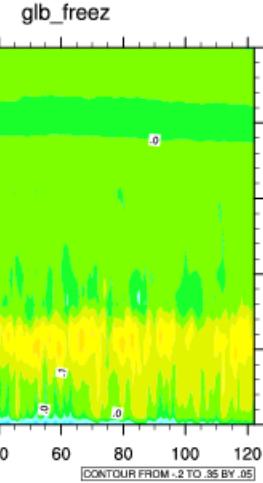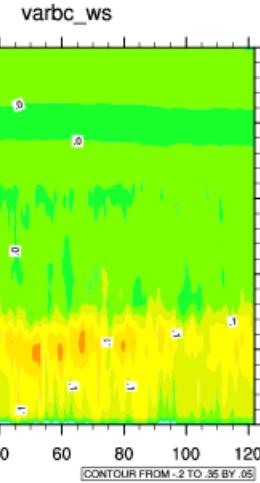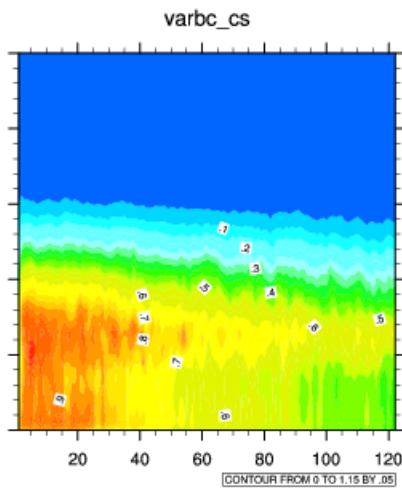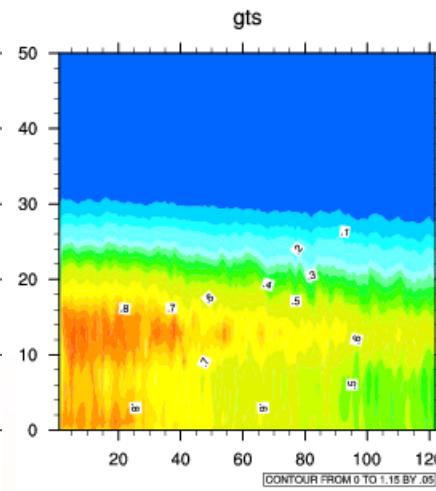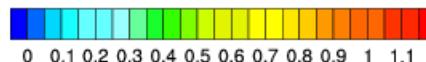
Z: analysis@12Z vs. ERA-Interim

z BIAS   2008 080112 - 113012

z RMSE   2008 080112 - 113012

Model Level

Time (day #)
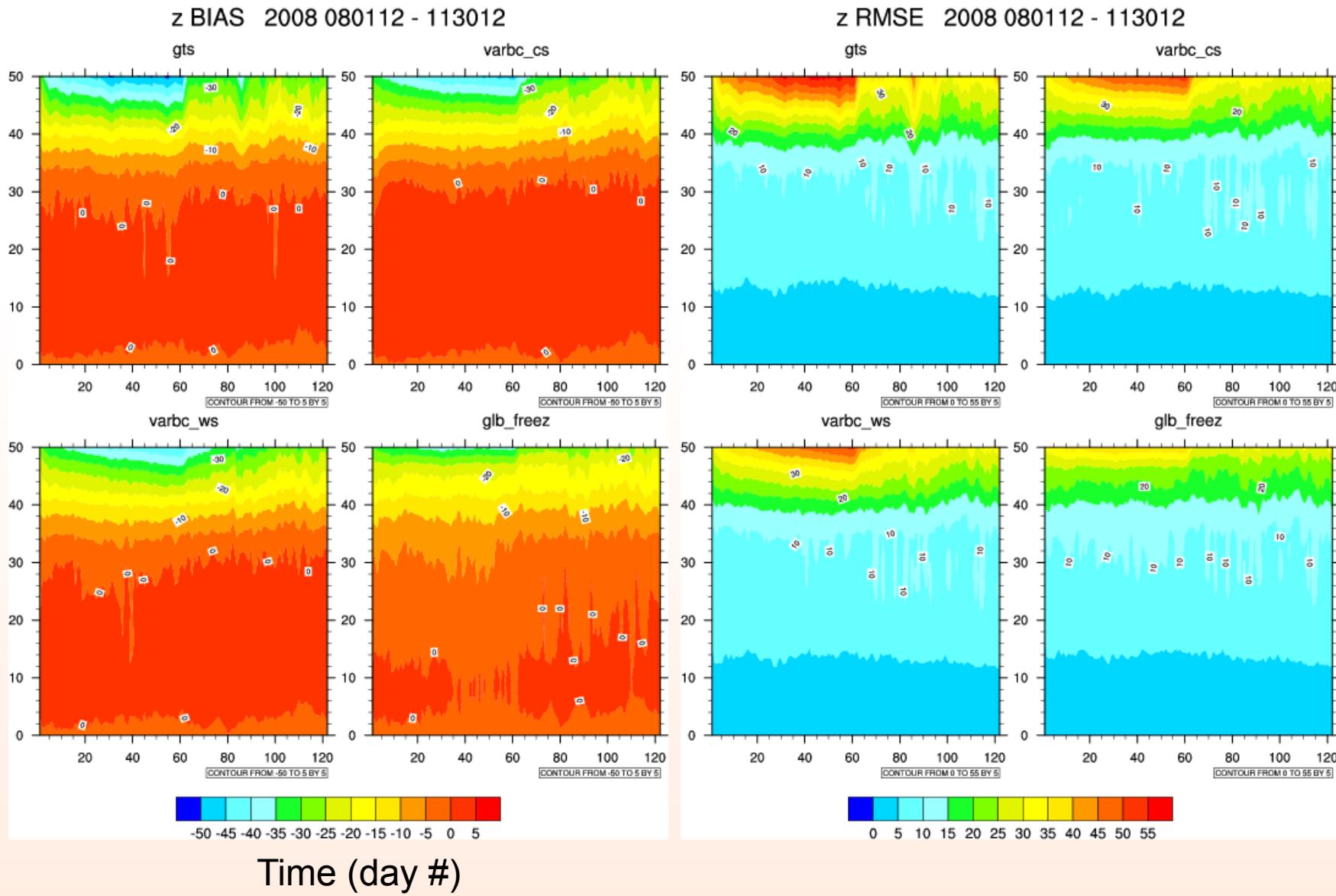
# T/Q bias: 24h FC@12Z vs. ERA-Interim
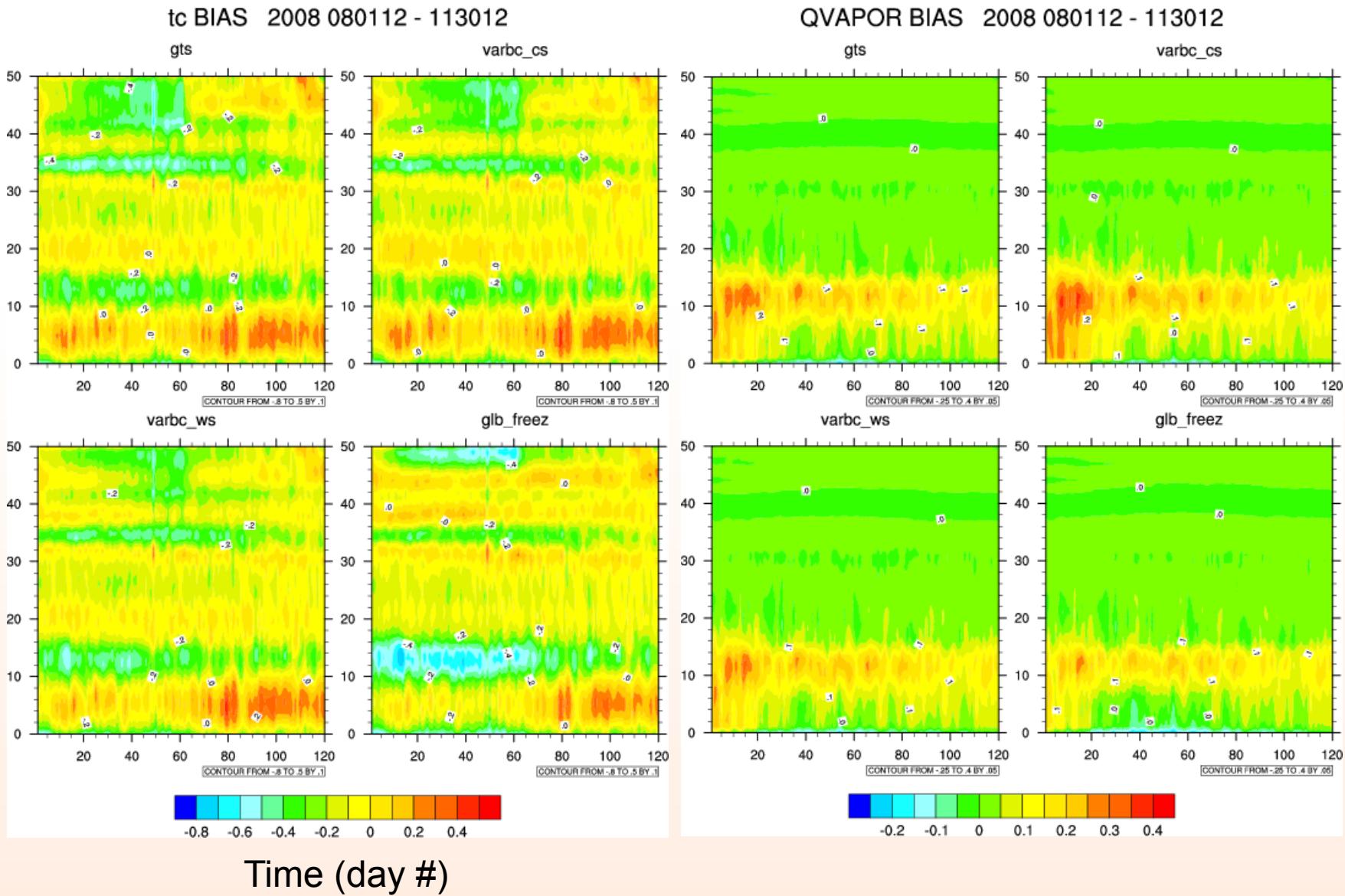
# Compare to ASCOS sounding
Aug. 3 ~ Sep. 7, 2008
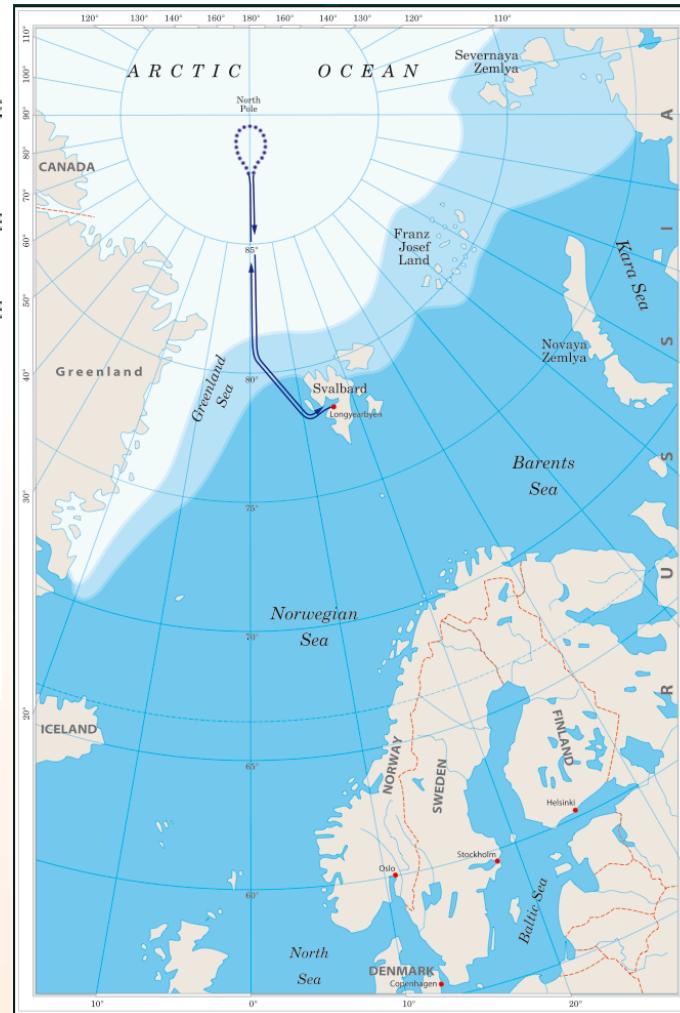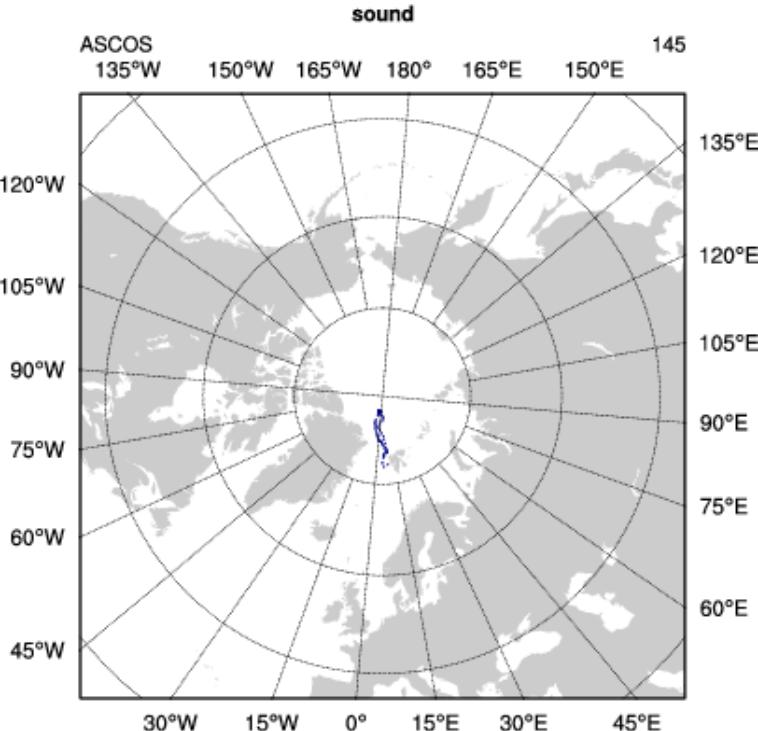
T/Q Analysis vs. ASCOS
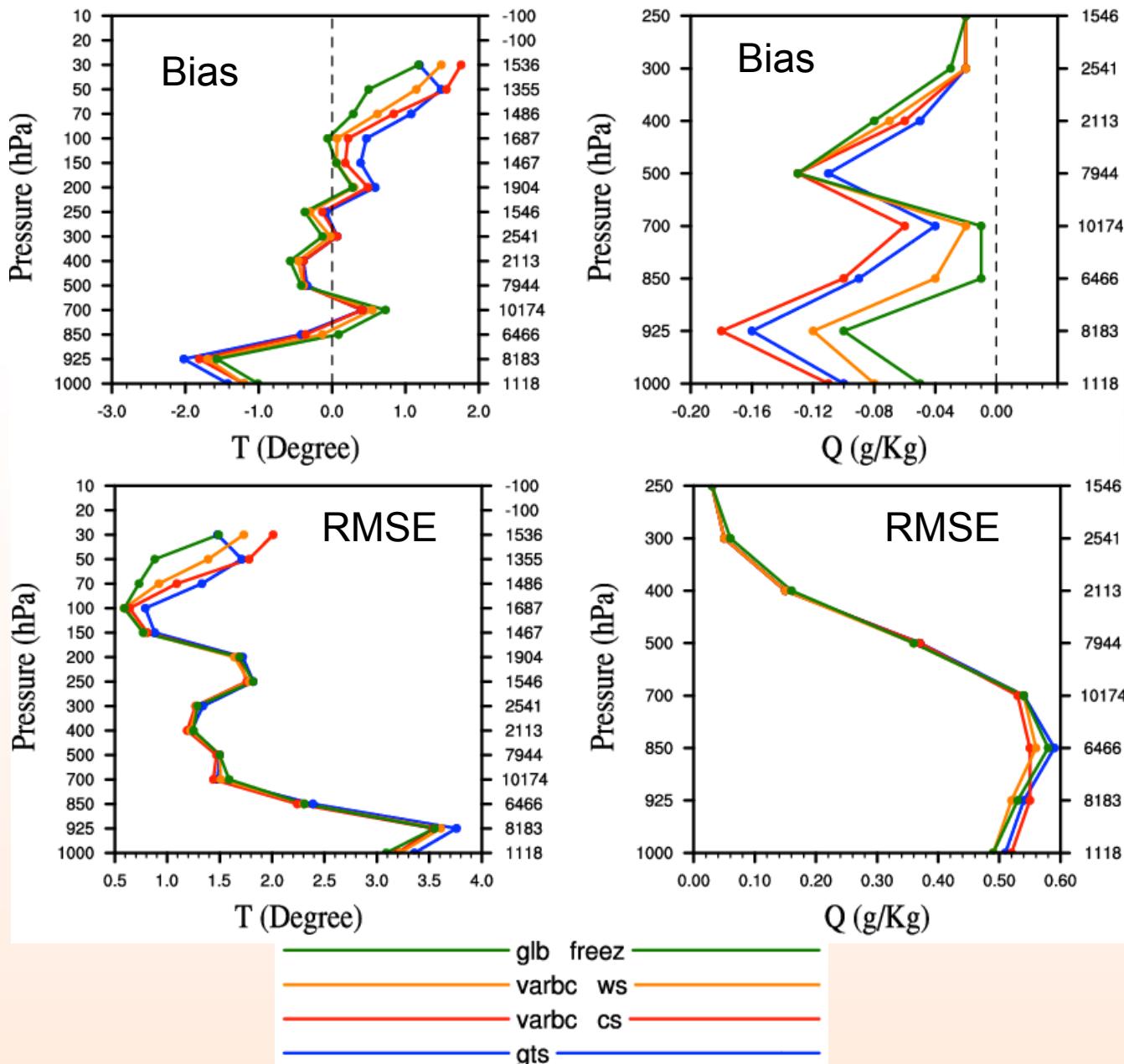
T/Q 24h FC vs. ASCOS
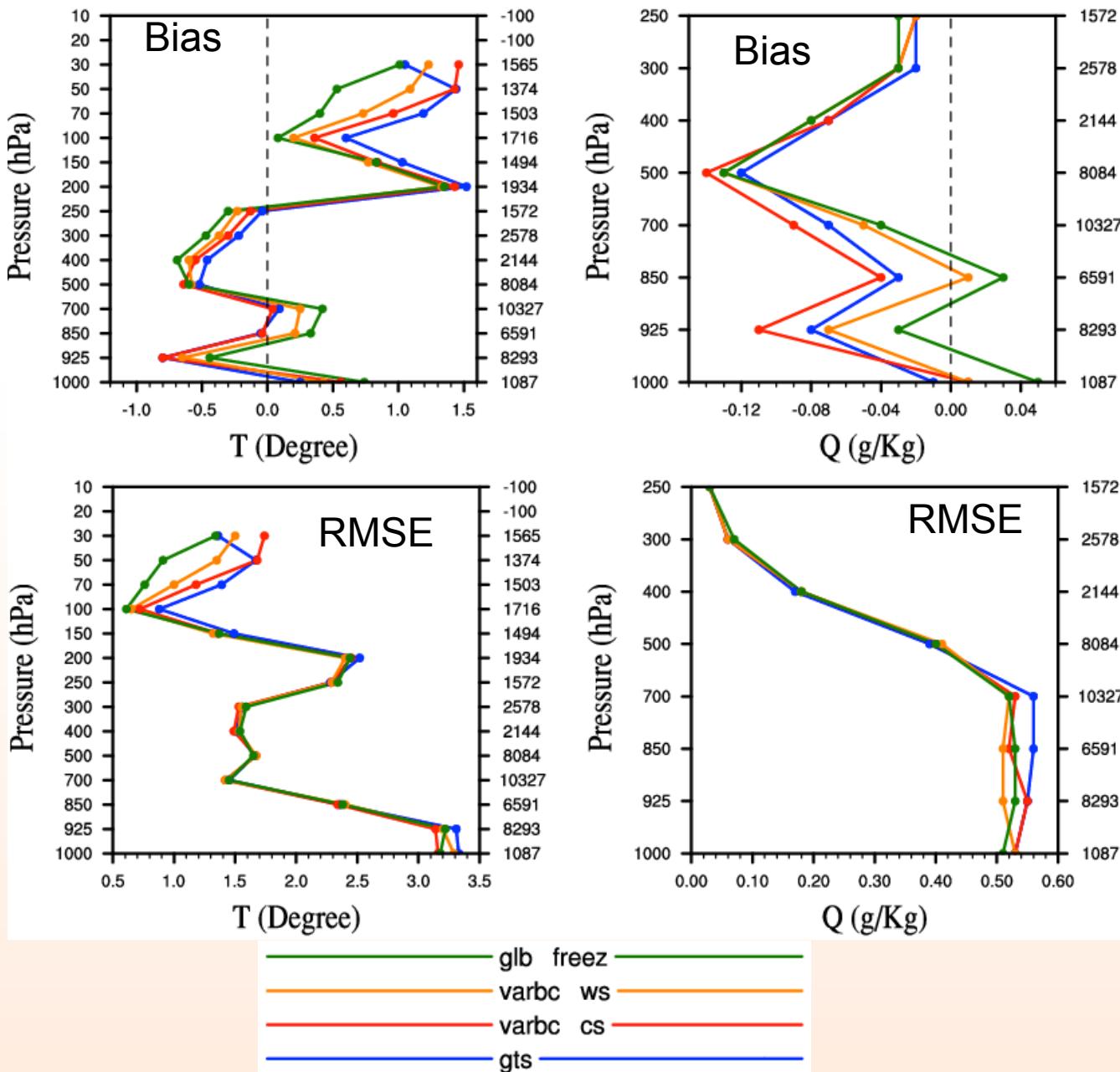
Plan for 10-km ASR production

- Diagnose 30km ASR-Interim and identify/fix the issues

- Implement in WRFDA radiance blacklist table used by ERA-Interim
    - Also refer to NESDIS instrument monitoring and NCEP radiance blacklist table
    - http://www.star.nesdis.noaa.gov/smcd/spb/icvs/
    - http://www.emc.ncep.noaa.gov/mmb/data_processing/Satellite_Historical_Documentation.htm

- Conservative usage of surface-sensitive channels
    - e.g., use AMSU-A ch5, AMSU-B/MHS ch5 only over water.

- Perform radiance monitoring run globally prior to ASR production
    - Pre-compute global BC coefficients statistics using ERA-Interim (in a 1°x1° grid) over the whole 11-year period.