

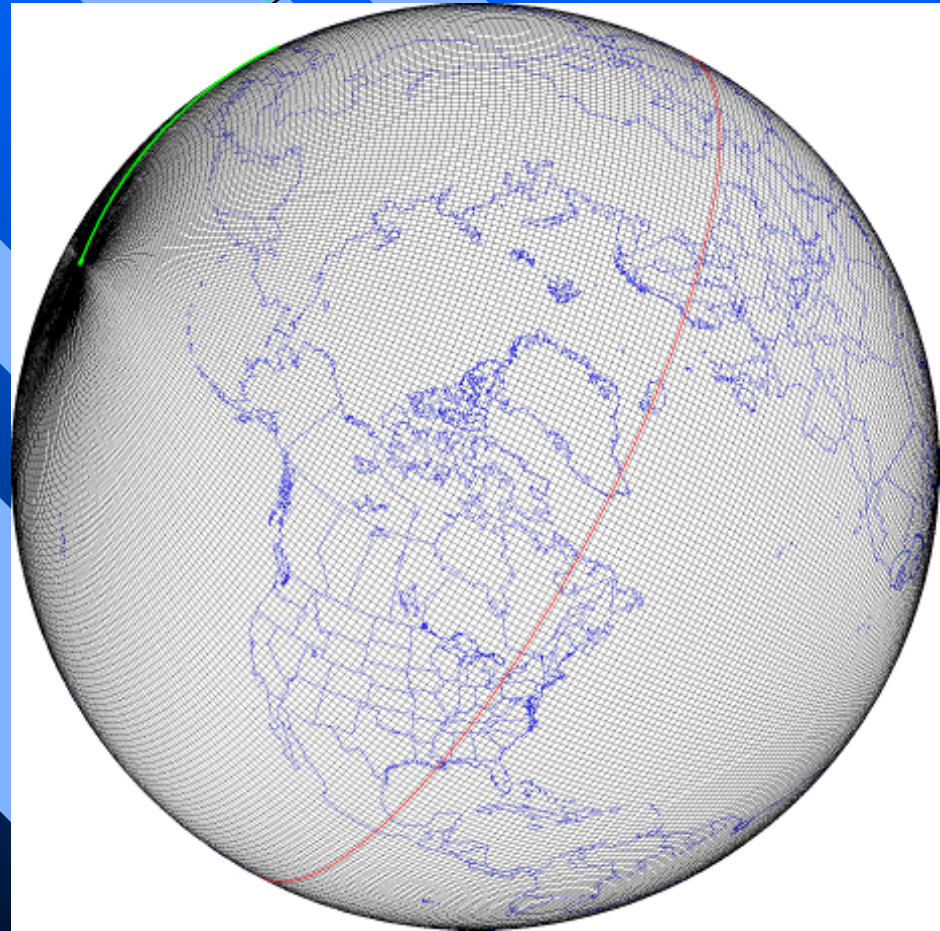
**The assimilation of AMSU-B
radiances in the CMC global data
assimilation system; their difficulties
relative to AMSU-A radiances and
their impact**

C. Chouinard, J. Hallé

Meteorological Service of Canada

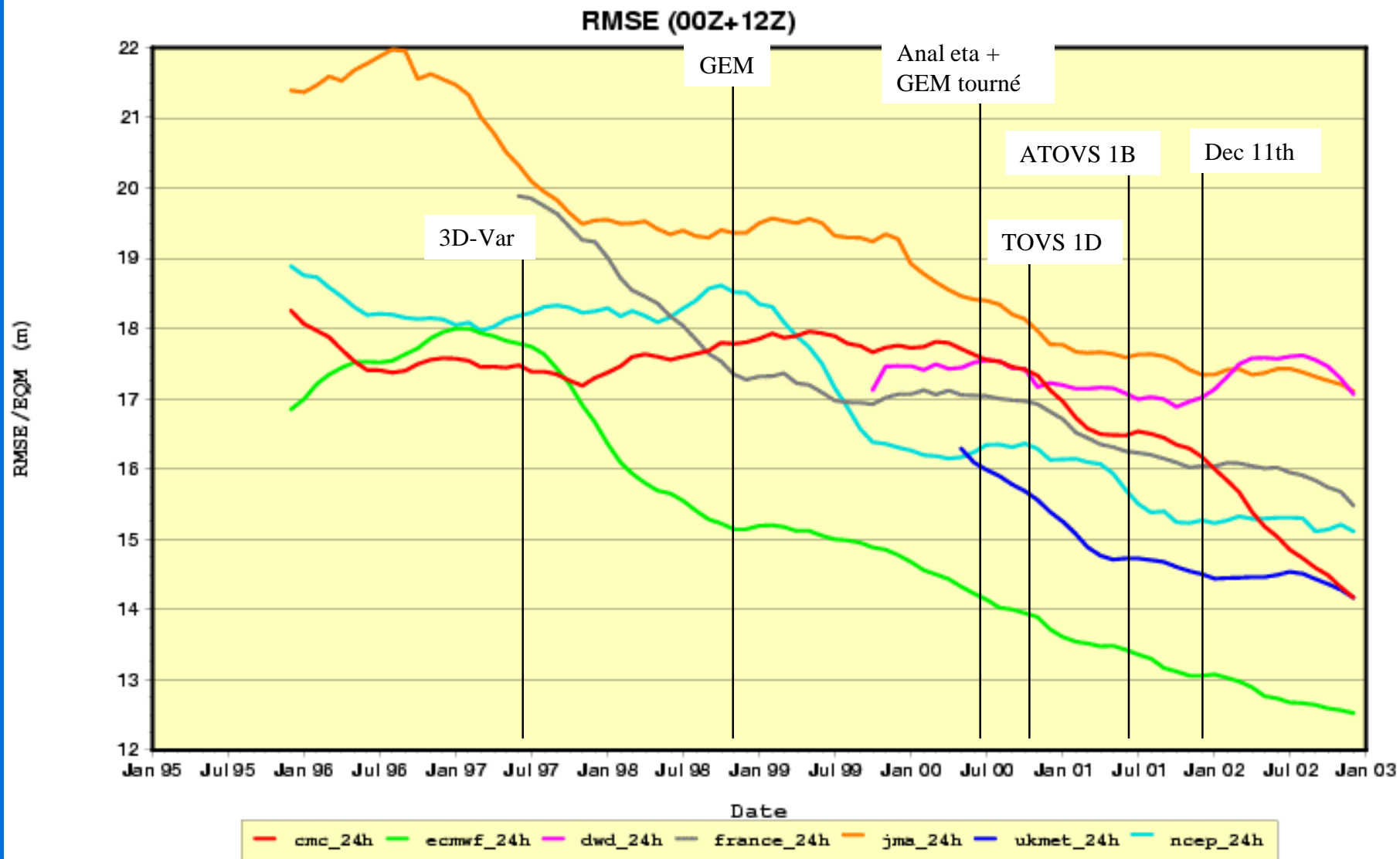
Medium- and long-range forecasts by the global version of the GEM (Global Environmental Multiscale) model

- uniform 0.9 degree lat-lon grid
- 28 **h** levels in vertical
- forecast to 144 h (12 UTC)
- forecast to 240 h (00 UTC),
- forecast to 360 h (Saturdays only)
- Operational since Oct. 14 1998



Comparison of the CMC 24h 500 hPa GZ to other NWP Centres Northern Hemisphere

VERIFICATION vs RADIOSONDES. GZ 500 hPa (24h)
Hémisphère Nord/Northern Hemisphere
Moyenne mobile de 12 mois / 12 Month Running Mean



3D-Var moisture analysis (Pre-AMSU-B)

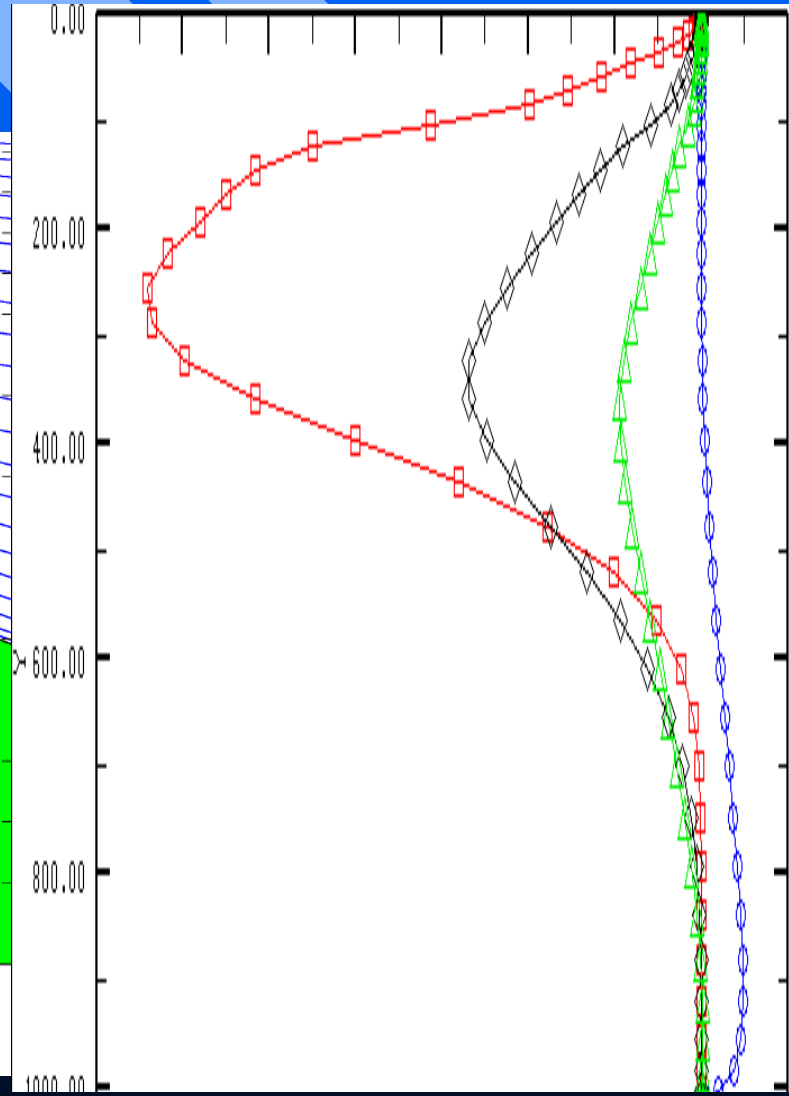
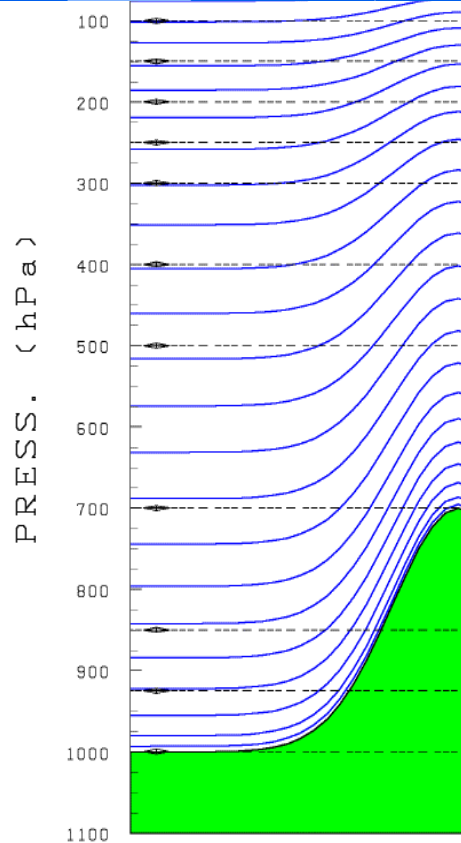
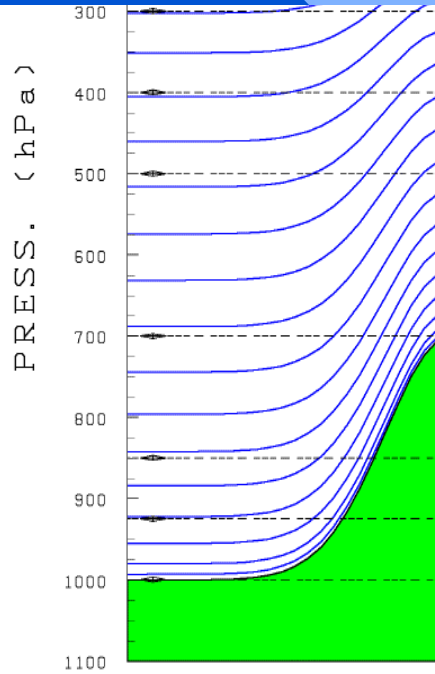
- direct assimilation of surface T, T-Td and ps
- RAOB T, T-Td, and winds at 27 levels
- added 3 ATOVS/AMSU-A (channels 3-5)
 - assimilated HUMSAT derived profiles of T-Td

Preparation of 3D-Var; raising the humidity analysis top

Sensitivity to Inq

Operational

New



Full resolution Innovations (O-P)

Date = 2003102600 NOAA-15/16/17 Brightness temperature O-P6hr

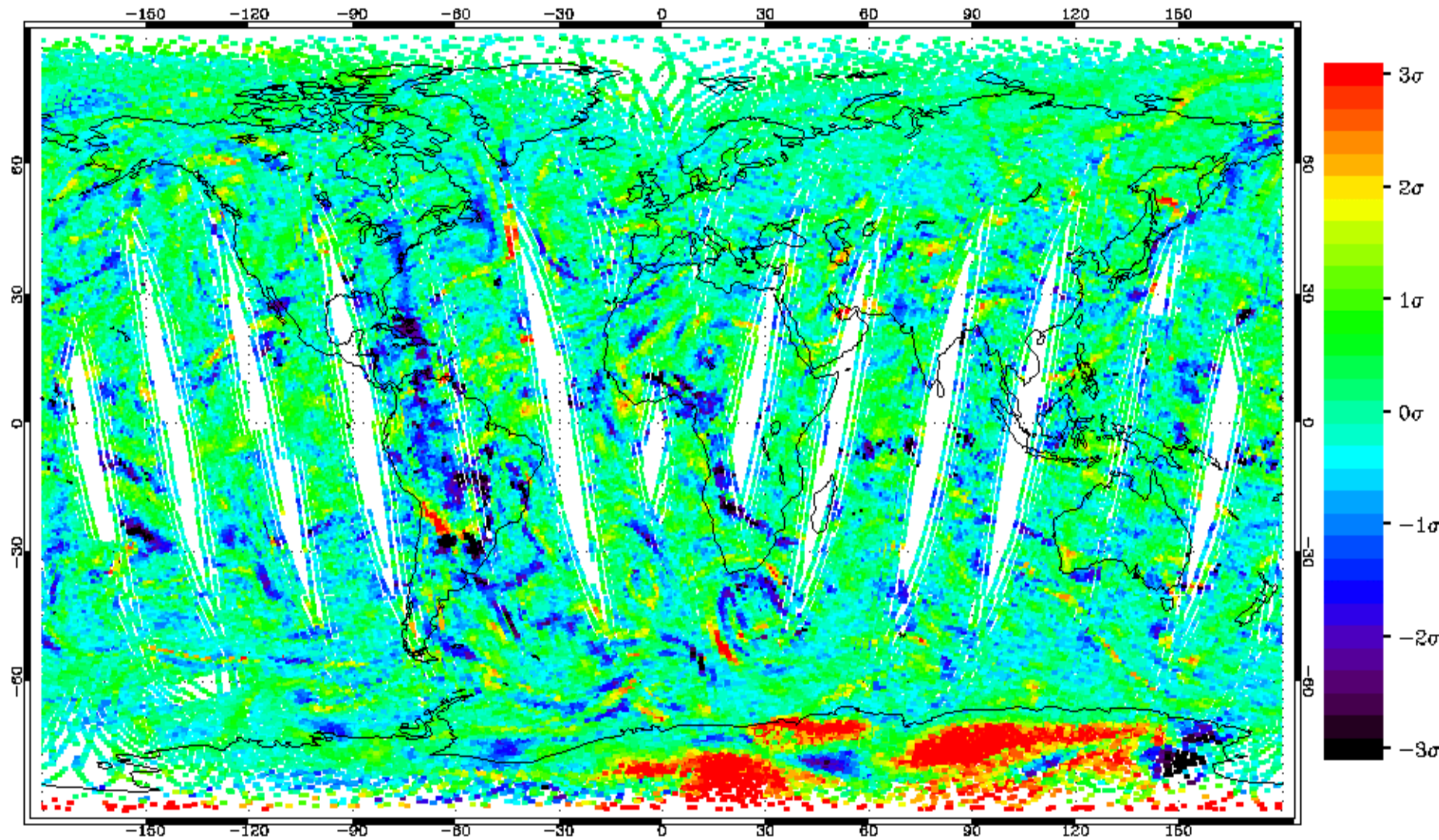
Nobs = 93470

Mean = 0.31

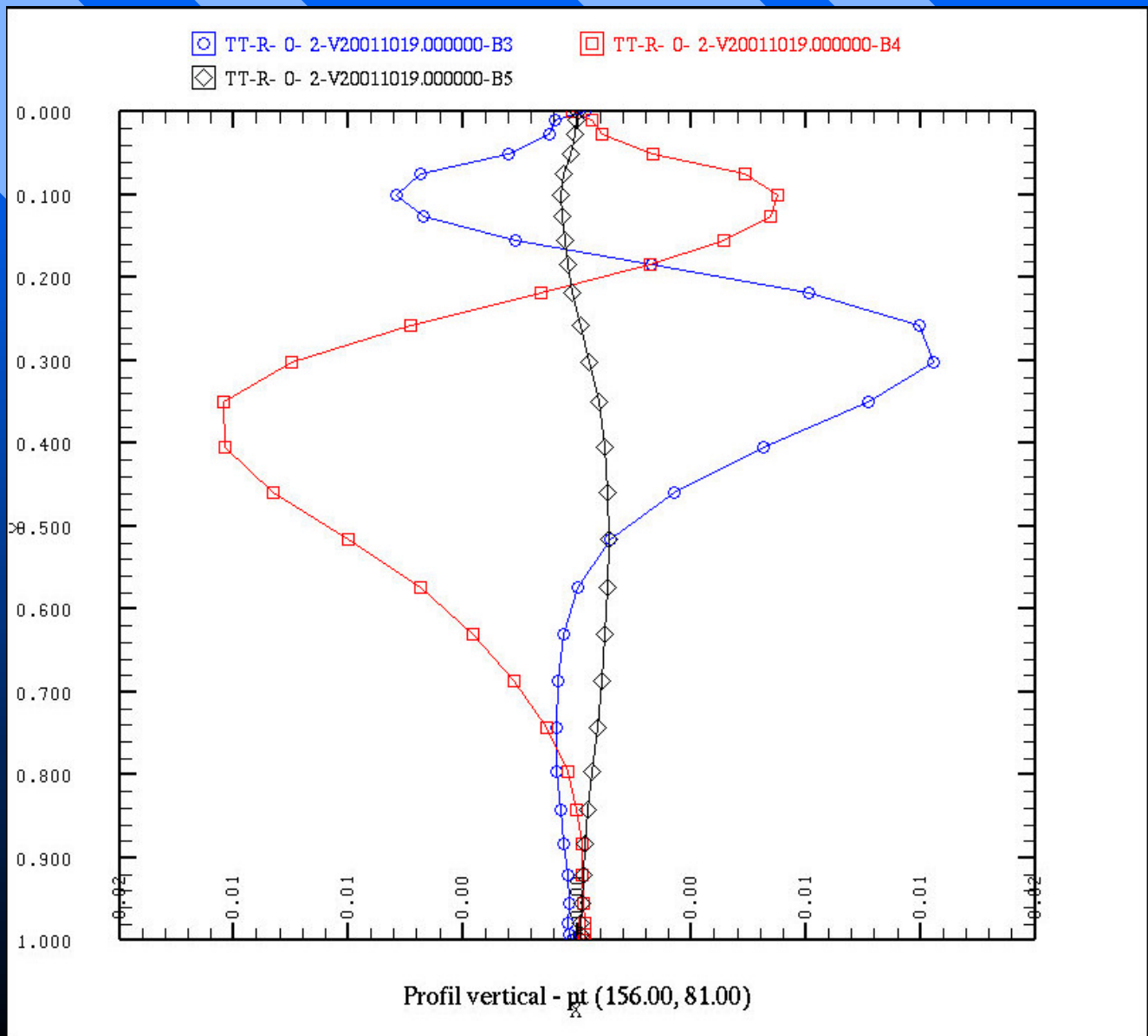
STDDEV = 4.25

% Reject = 37.3

Channel = AMSU-B-3



Sensitivity of AMSU-B to temperature



Procedure for direct assimilation of (AMSU-A/B) radiances in 3D-Var

- choose radiances for which radiative transfer is appropriate
- correct systematic errors of the fast radiative transfer model
- carefully select radiances for land/sea/ice
Example: land/ice; AMSU-A ch 6-10
 sea; AMSU-A ch 3-10
- QC and thin to equivalent NWP model resolution

Quality control - AMSU-A

- Gross check, i.e.. within physical limits.
- Grody cloud liquid water > 0.3 mm => AMSU-A 1-5, 15 rejected.
- Grody scattering index > 9 => AMSU-A 1-6, 15 rejected.
- Background check: $(O-P) > aS$, where S = error standard deviation
 $a = 4.0$, except
= 3.0 for AMSU-A 3 and
= 2.0 for AMSU-A 1-2 and 15.
- Any background check reject of a surface channel eliminates AMSU-A 1-5, 15.

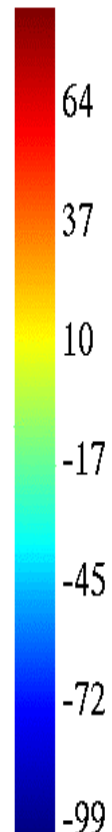
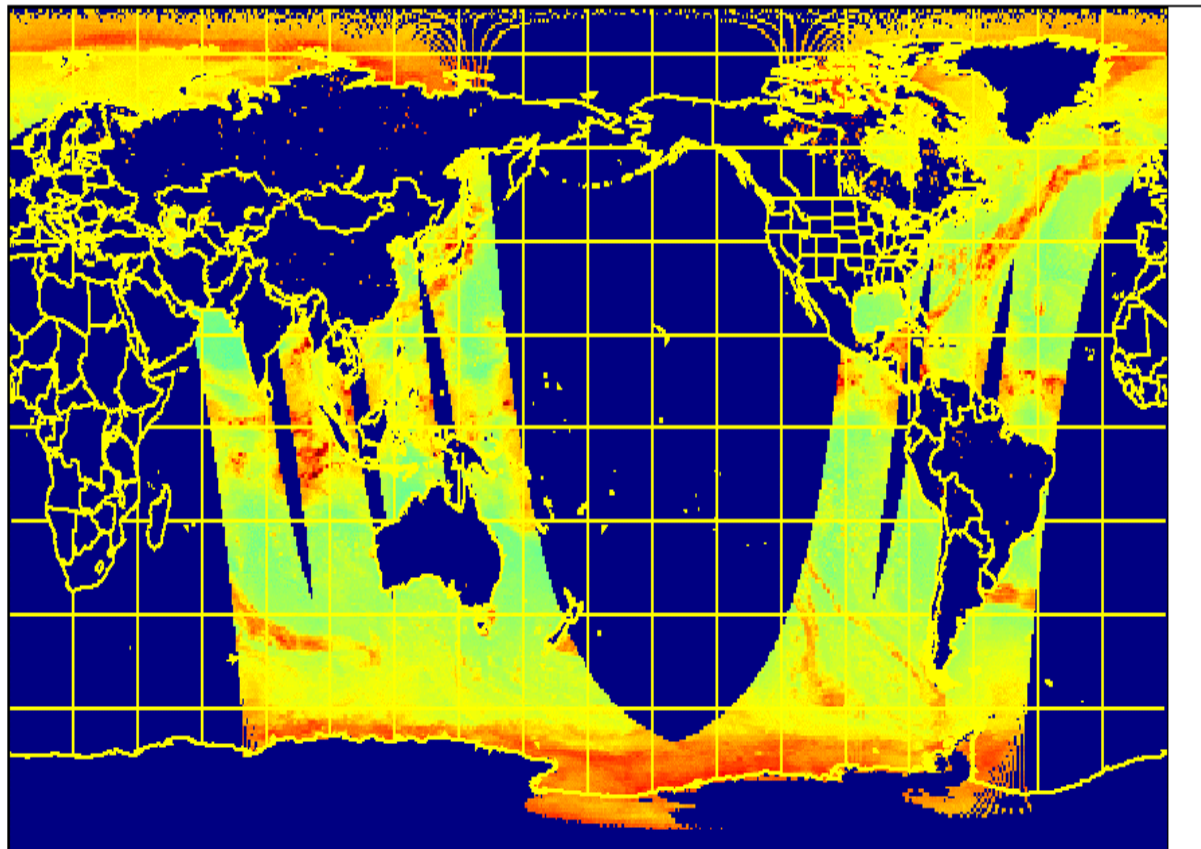
Quality control - AMSU-B (similar ones for AMSU-A)

12	Dryness index reject	Dryness index = $T_b(\text{AMSUB3}) - T_b(\text{AMSUB5})$ Reject if (dryness index) > 0 for AMSU-B 3, -10 for AMSU-B 4, -20 for AMSU-B 5	partial (AMSU-B 3-5)
13	Bennartz scattering index reject	Bennartz scattering index > 40 over sea-ice, or 15 over sea, or 0 over land.	full
14	innovation rogue check failure	$(y - H(x)) > \alpha * (\text{total error})$, where $\alpha = 2$ for AMSU-B 1, $\alpha = 3$ for AMSU-B 2 $\alpha = 4$ for AMSU-B 3-5	single

Scattering Index (Bennartz) to detect precipitation areas

SW (Scattering Index over Water)

Niveau: surface - Etiquette: N15 - Intervalle: 0 * 1.0e+00 sans unites



Champ valide 12:00Z le 28 octobre 2001

Final innovations (O-P) at analysis grid resolution

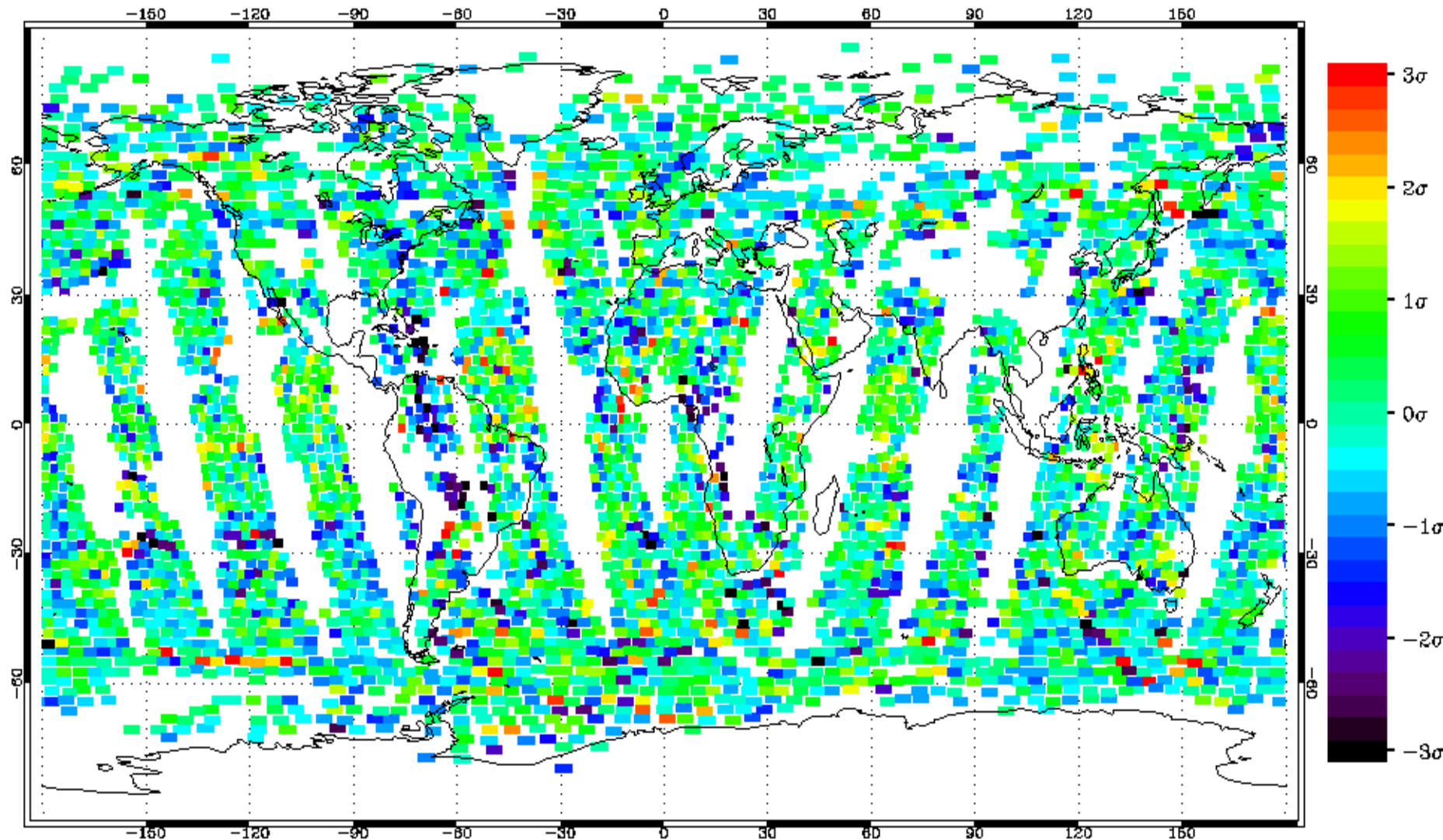
Date = 2003102600 NOAA-15/16/17 Brightness temperature O-P6hr

Nobs = 4985

Mean = -0.01

STDDEV = 2.90

AMSU-B-3

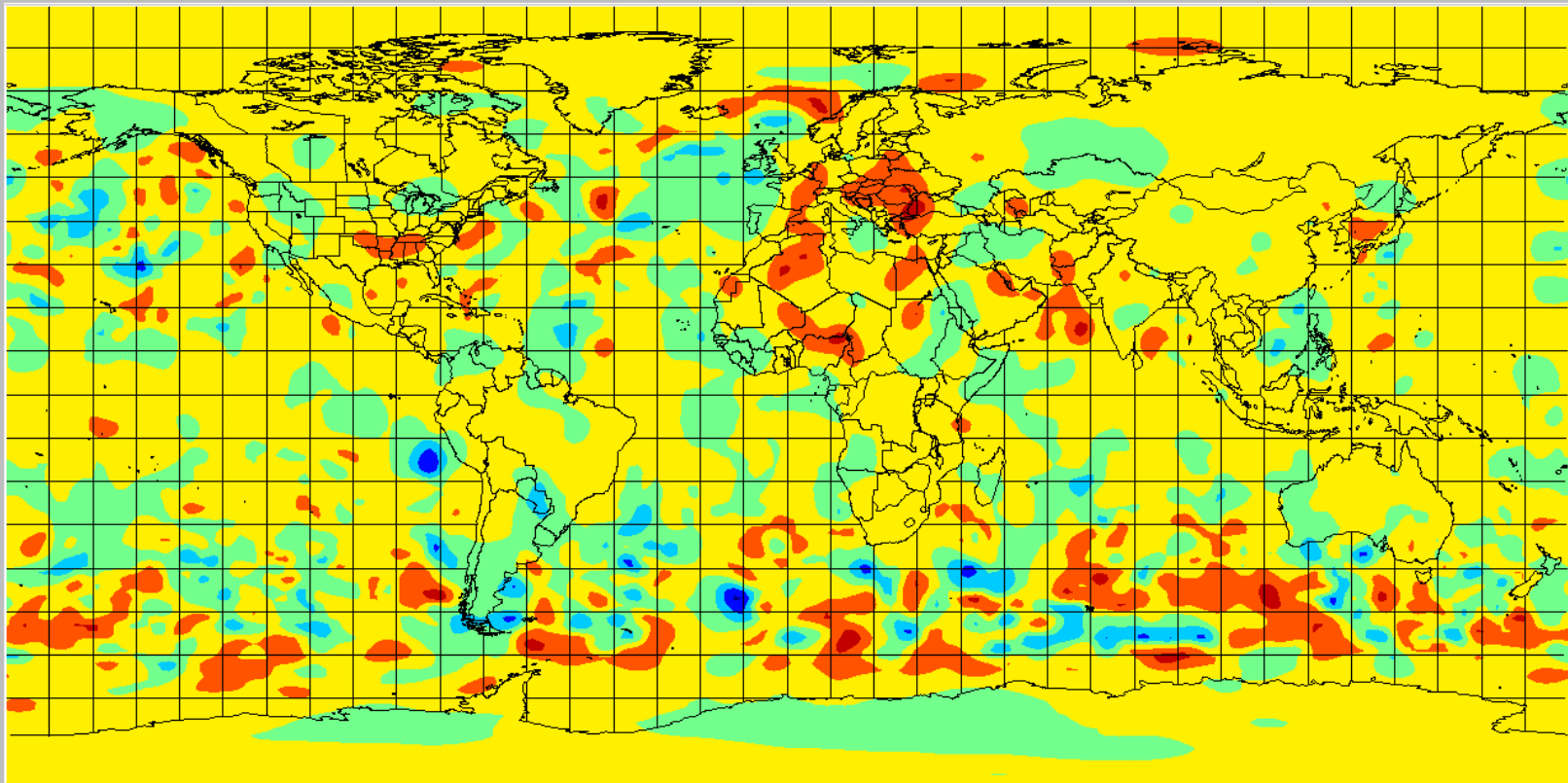


First analysis tests; AMSU-B data only

Moisture (lnq) corrections at 836 hPa

LQ

Niveau: 0.836000 hy - Etiquette: AMSUB940 - Intervalle: 0.2 * 1.0e+00 (???)



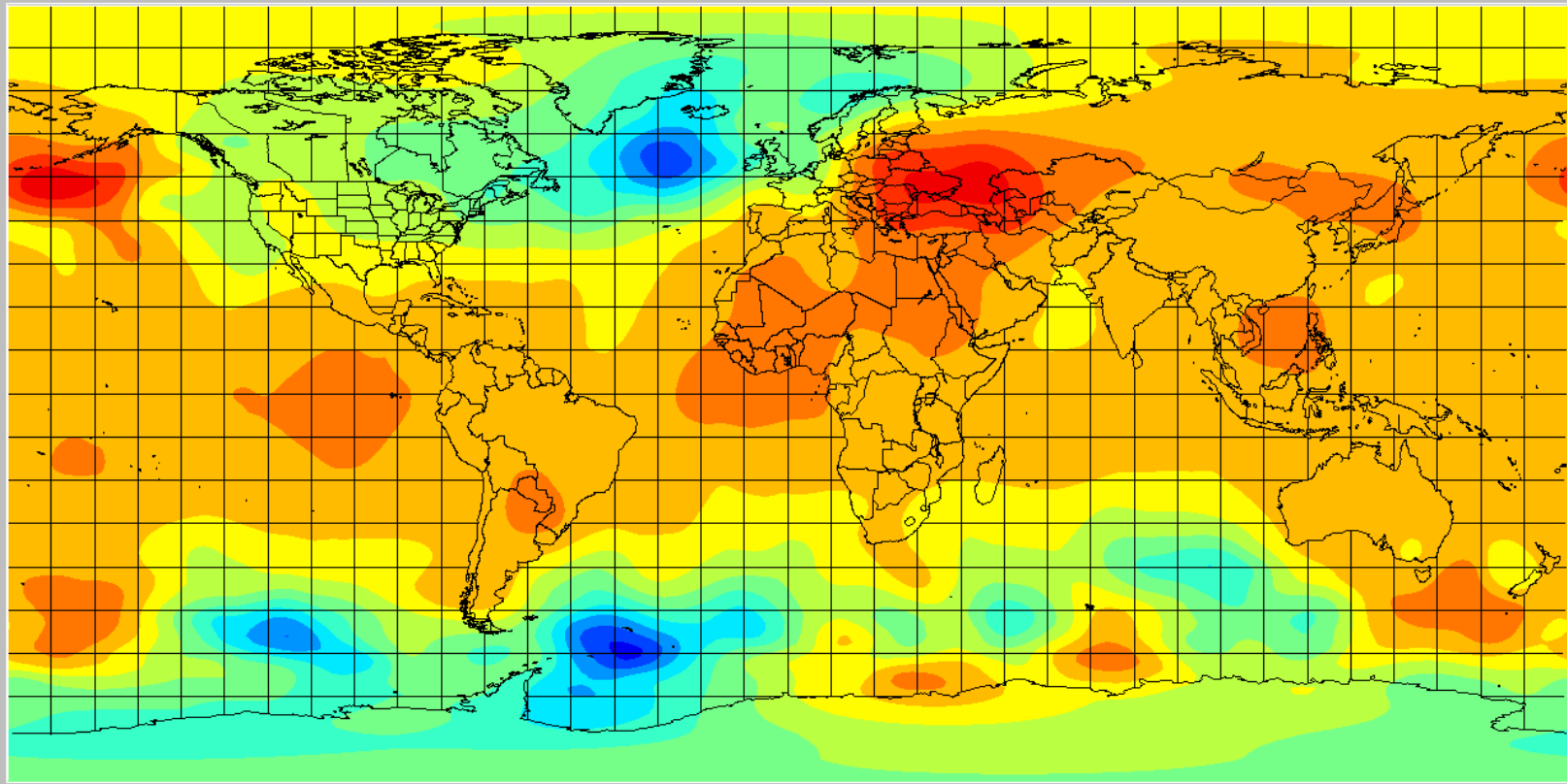
Residus valides 12.00Z le 04 fevrier 2002

First analysis tests; AMSU-B data only

Temperature corrections at 836 hPa

TT (Temperature de l'air)

Niveau: 0.836000 hy - Etiquette: AMSUB940 - Intervalle: 0.5 * 1.0e+00 deg C



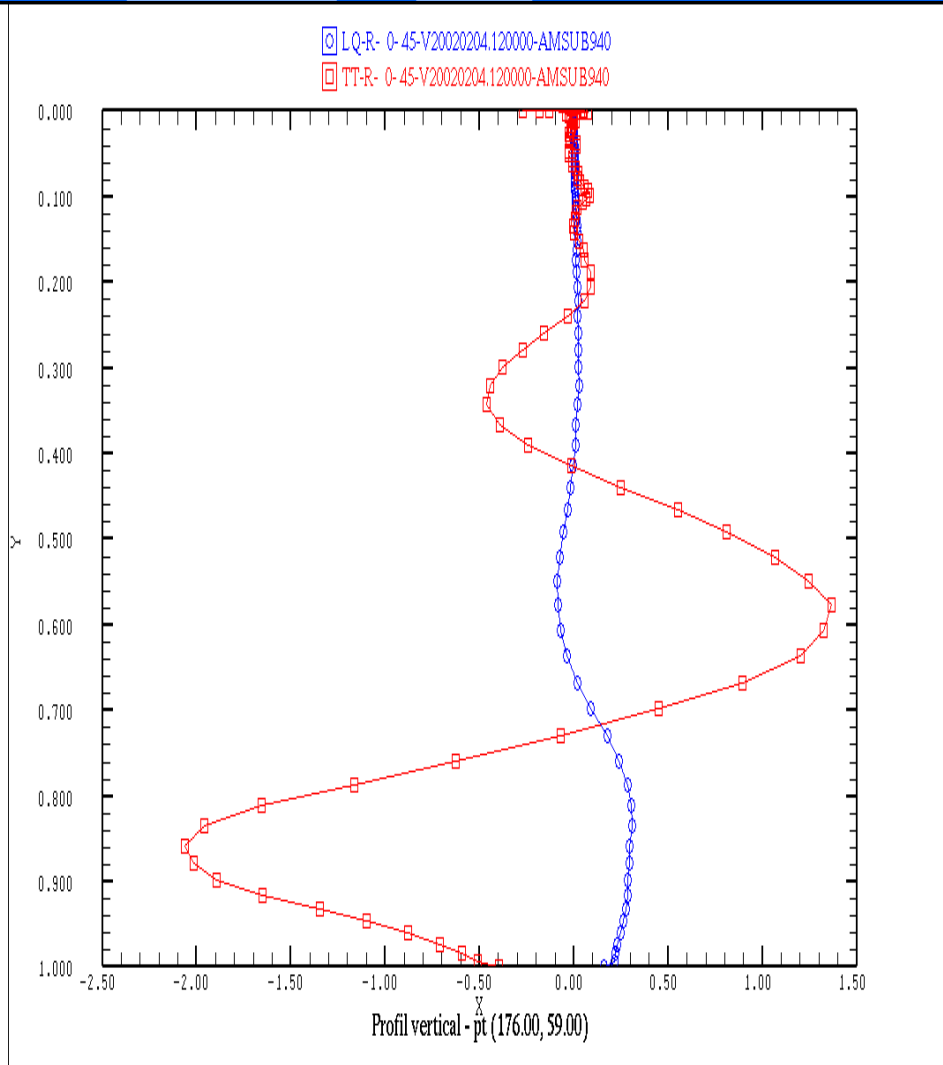
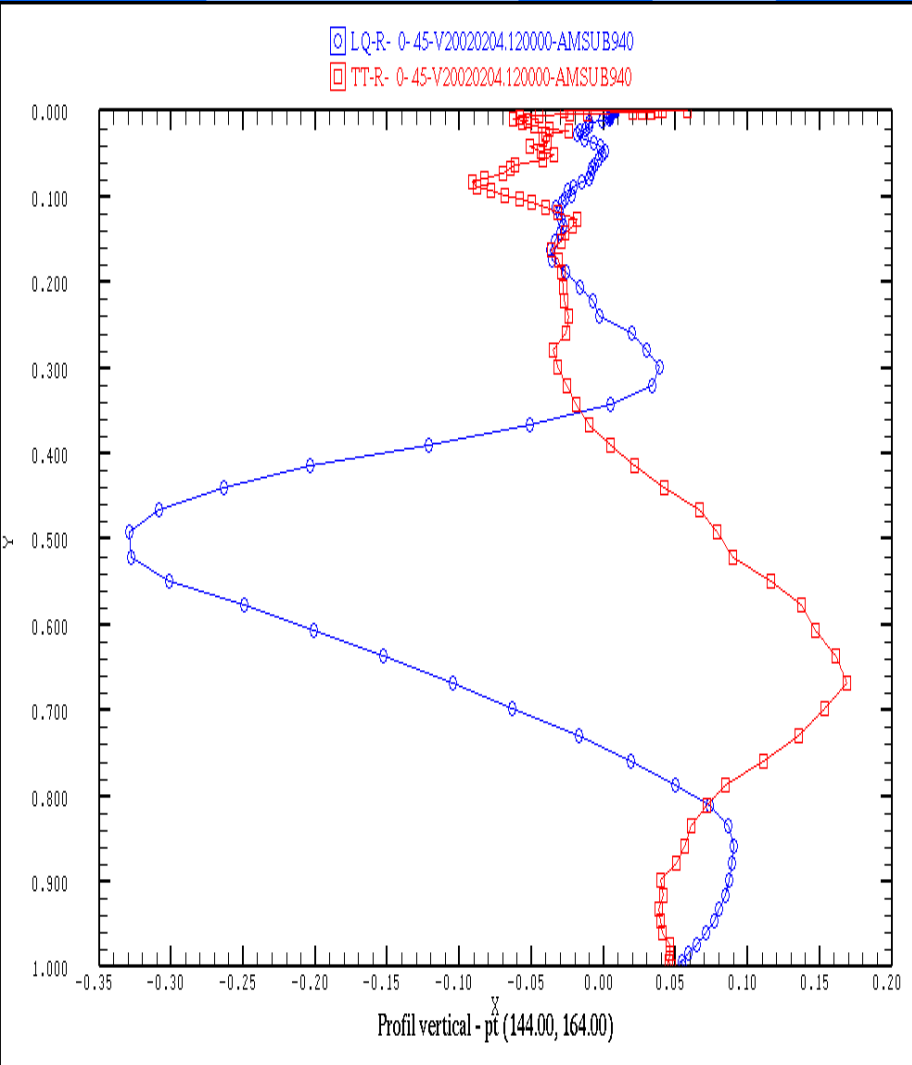
Residus valides 12.00Z le 04 fevrier 2002

First analysis tests; AMSU-B data only

Temperature and Inq correction profiles

Tropics

Extra-Tropics



Full analysis tests highlighting problems

AMSU-B5

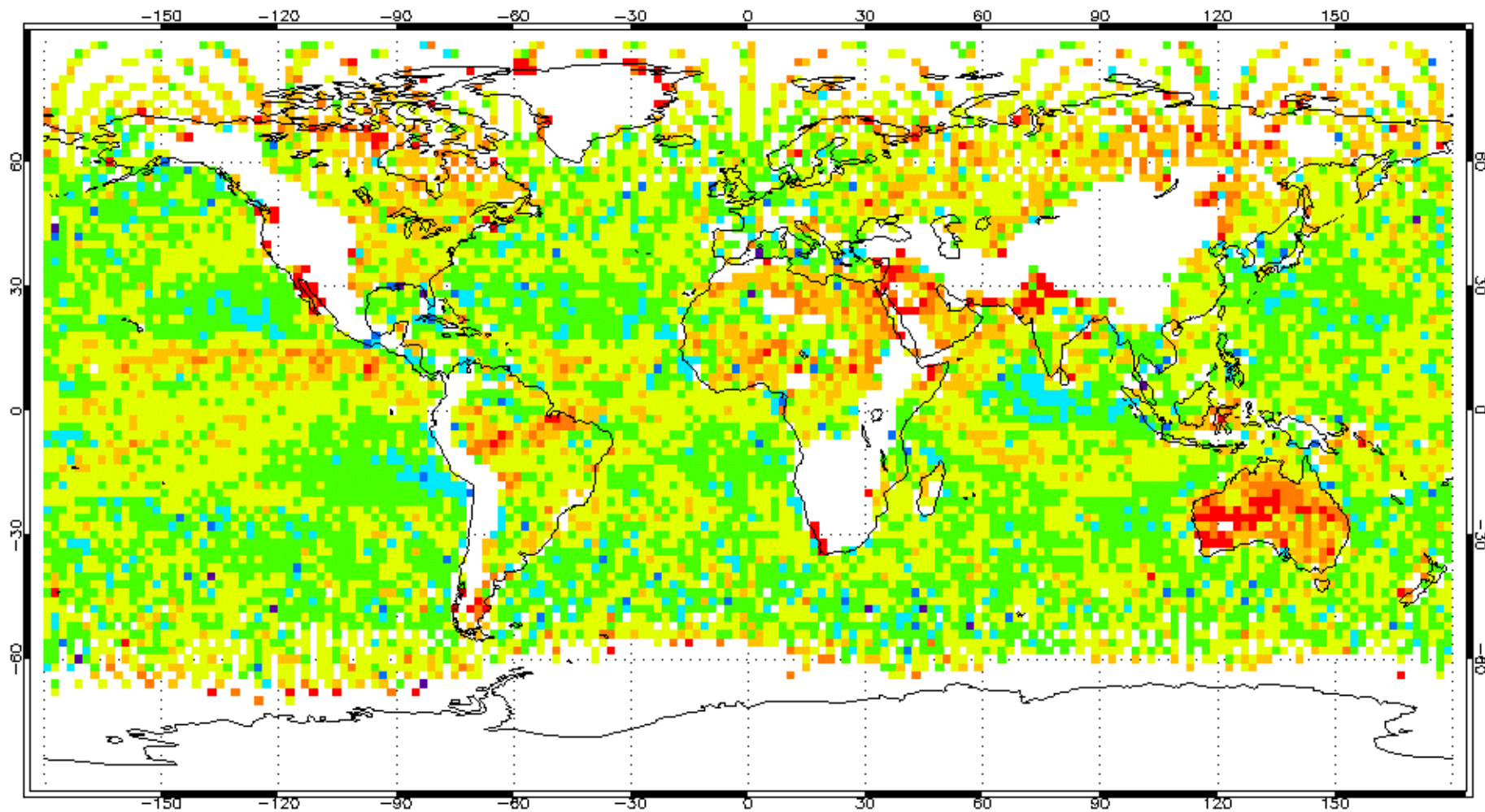
June 2003 NOAA-15/16/17 ATOVS AMSU-B-5 Brightness Temperature

O-P6hr of Assimilated radiances

Nbox = 10553 Mean = 0.15 σ = 0.63

Mean Brightness Temperature O-P (degree)

■ $< -3\sigma$ ■ $< -2\sigma$ ■ $< -1\sigma$ ■ $< -0\sigma$ ■ $> 0\sigma$ ■ $> 1\sigma$ ■ $> 2\sigma$ ■ $> 3\sigma$



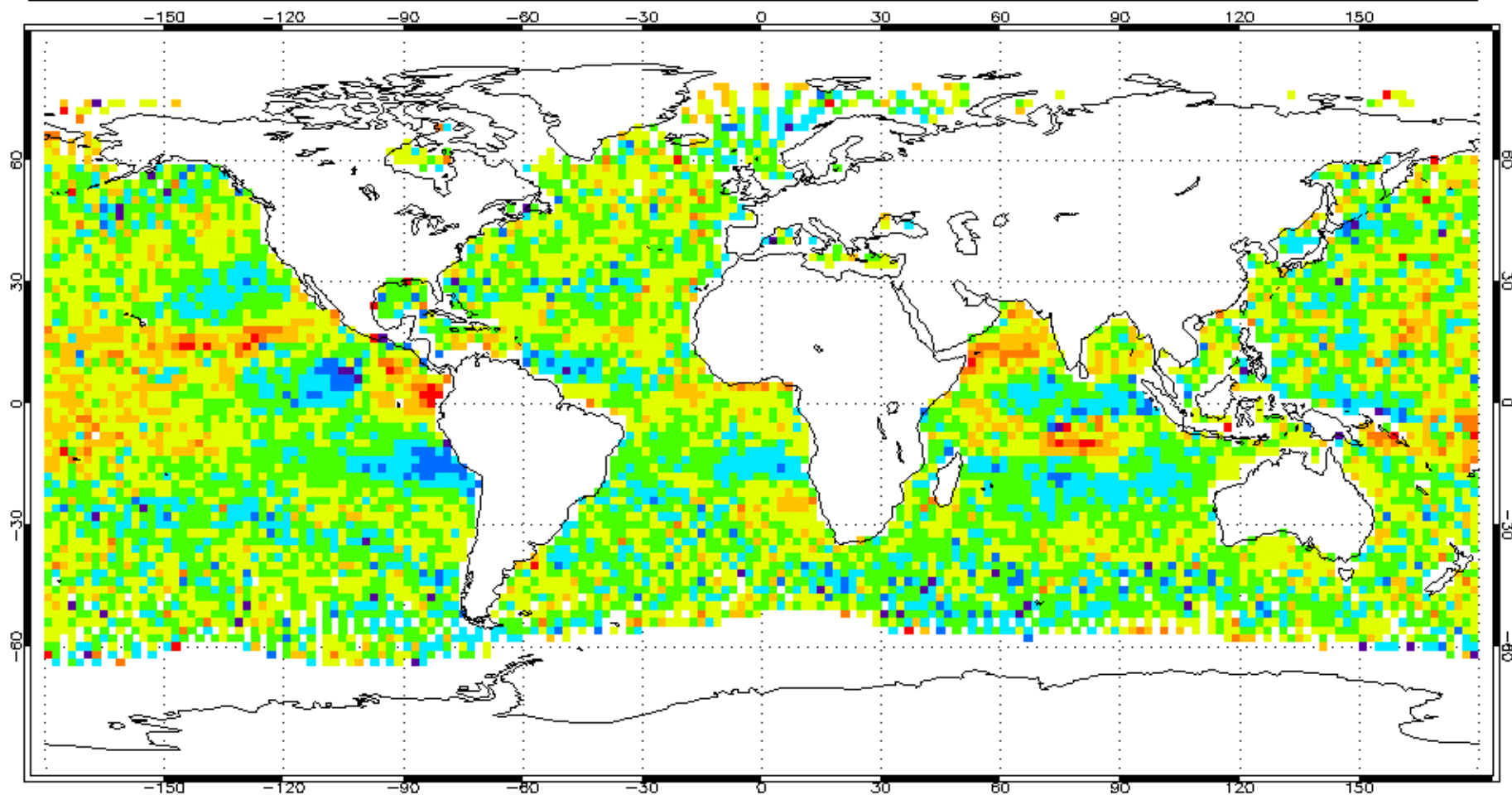
Corrections to problems with AMSU-B5

September 2003 NOAA-15/16/17 ATOVS AMSU-B-5 Brightness Temperature O-P6hr of Assimilated radiances

Nbox = 7306 Mean = -0.08 σ = 0.48

Mean Brightness Temperature O-P (degree)

■ $< -3\sigma$ ■ $< -2\sigma$ ■ $< -1\sigma$ ■ $< -0\sigma$ ■ $> 0\sigma$ ■ $> 1\sigma$ ■ $> 2\sigma$ ■ $> 3\sigma$



Biases over Eurasia in AMSU-B3

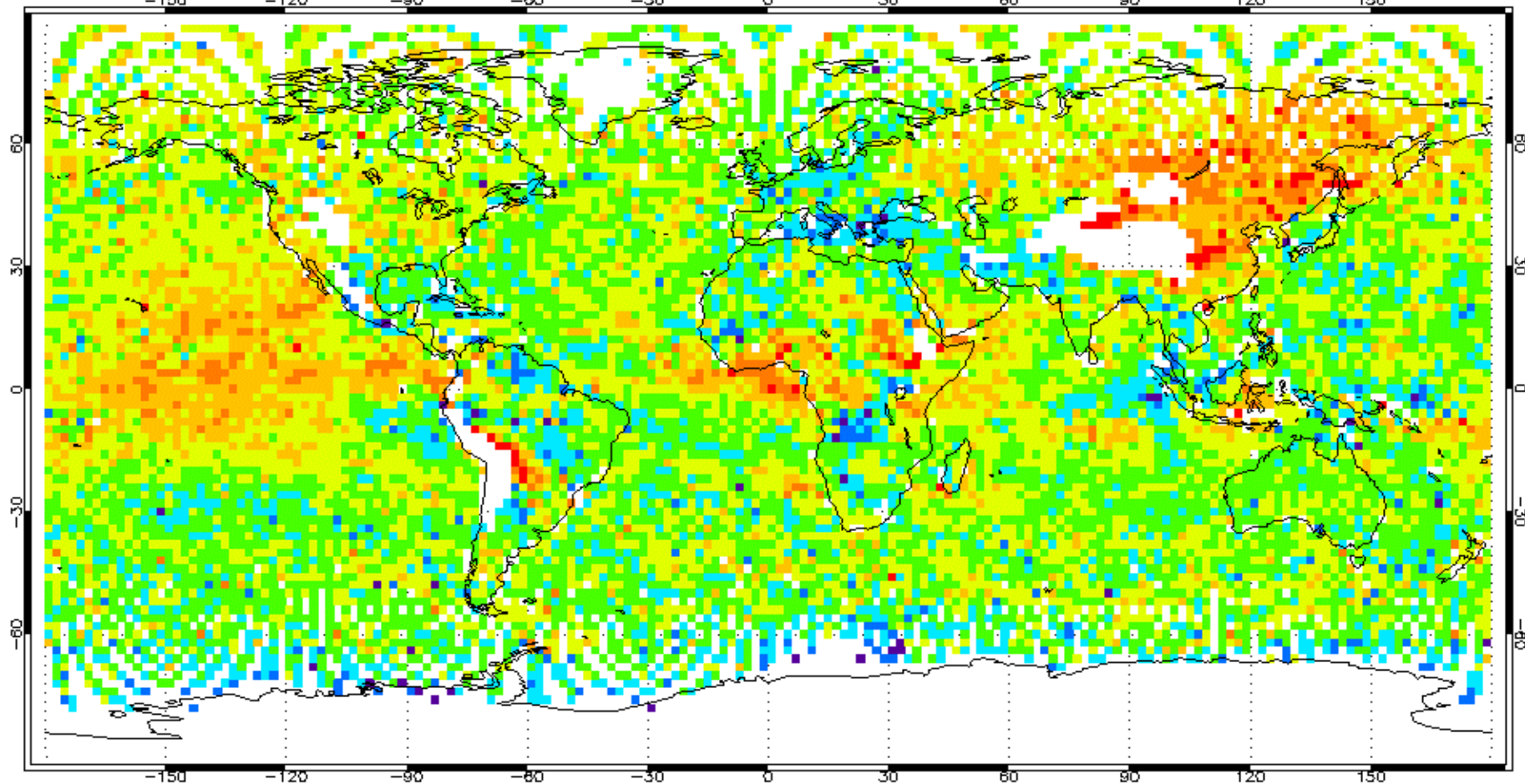
September 2003 NOAA-15/16/17 ATOVS AMSU-B-3 Brightness Temperature O-P6hr of Assimilated radiances

Nbox = 12167 Mean = 0.02 σ = 0.79

Mean Brightness Temperature O-P (degree)

■ $< -3\sigma$ ■ $< -2\sigma$ ■ $< -1\sigma$ ■ $< -0\sigma$ ■ $> 0\sigma$ ■ $> 1\sigma$ ■ $> 2\sigma$ ■ $> 3\sigma$

-150 -120 -90 -60 -30 0 30 60 90 120 150

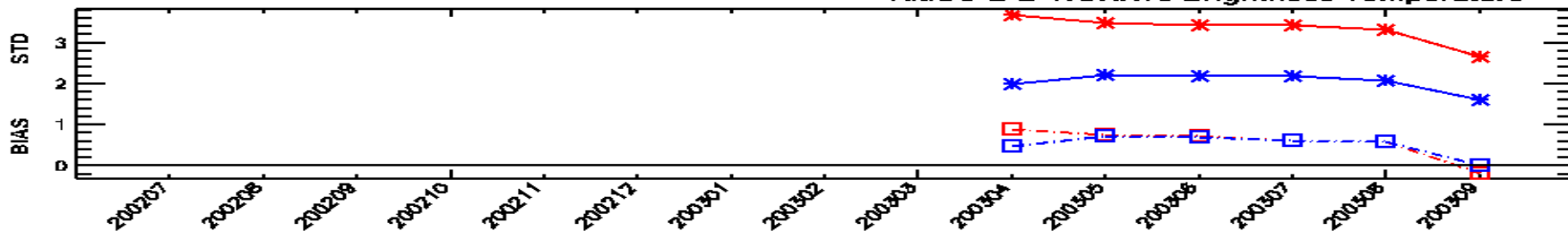


Radiance Monitoring (O-P/O-A)

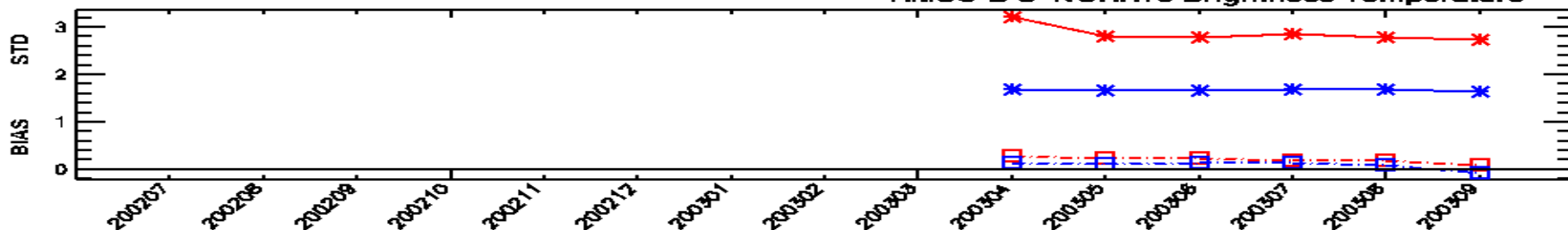
Monthly Means

O-P O-A

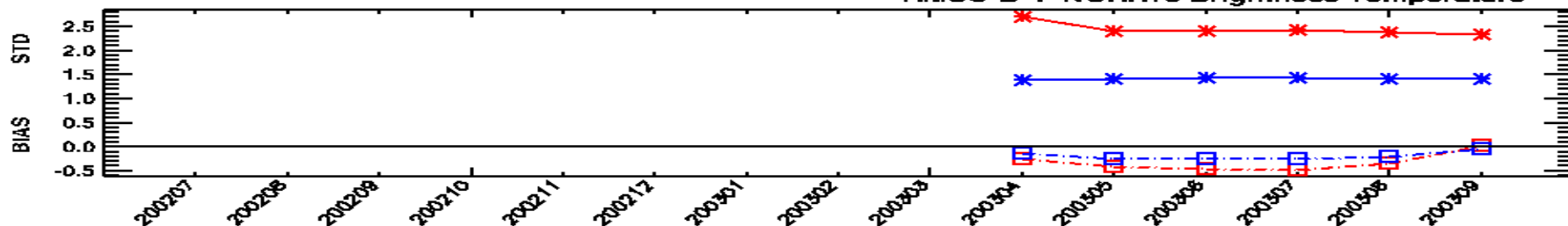
AMSU-B-2 NOAA16 Brightness Temperature



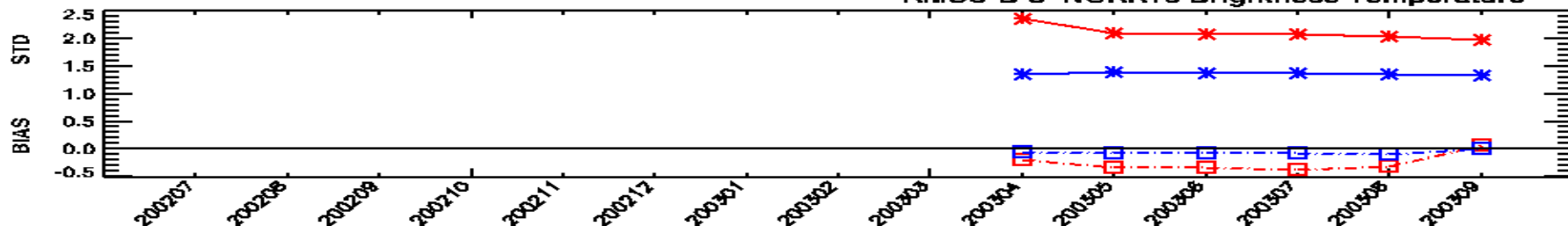
AMSU-B-3 NOAA16 Brightness Temperature



AMSU-B-4 NOAA16 Brightness Temperature



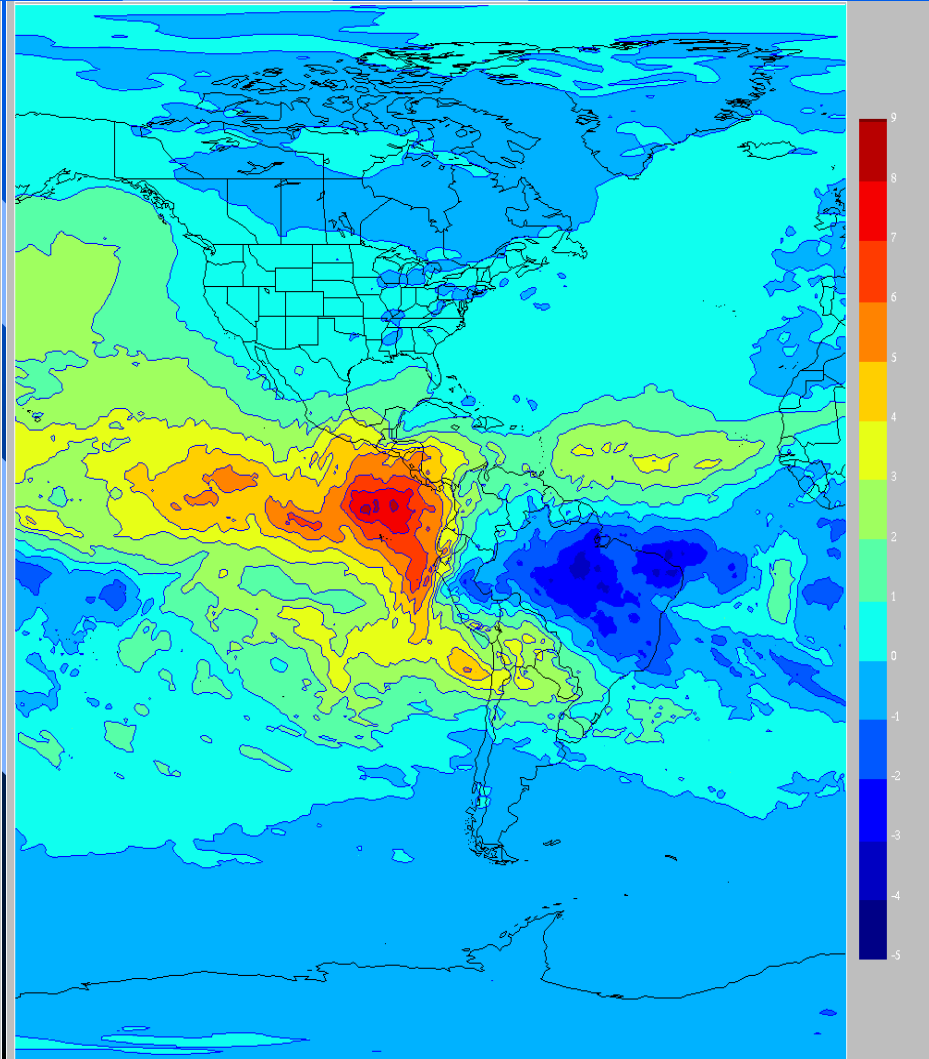
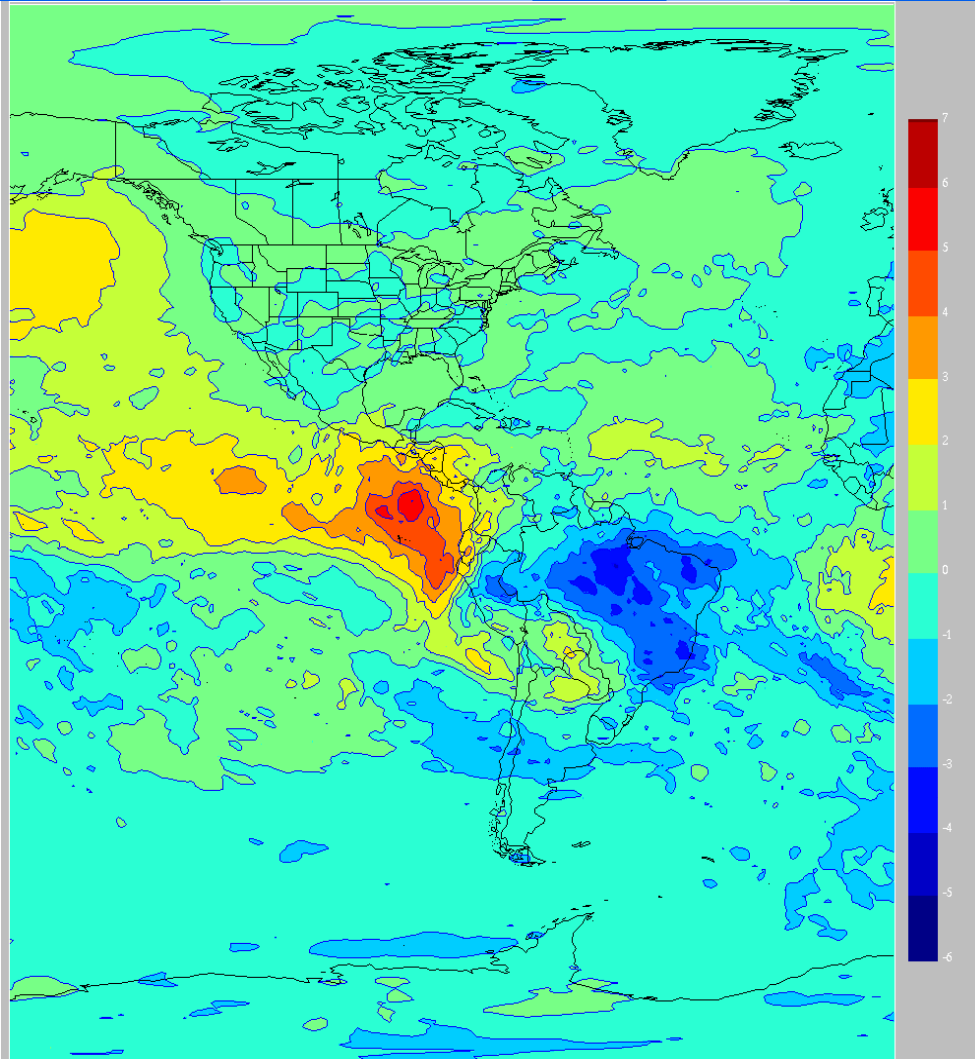
AMSU-B-5 NOAA16 Brightness Temperature



Independent verification; mean 250 hPa ES corrections relative to the operational CMC analysis

AMSU-B

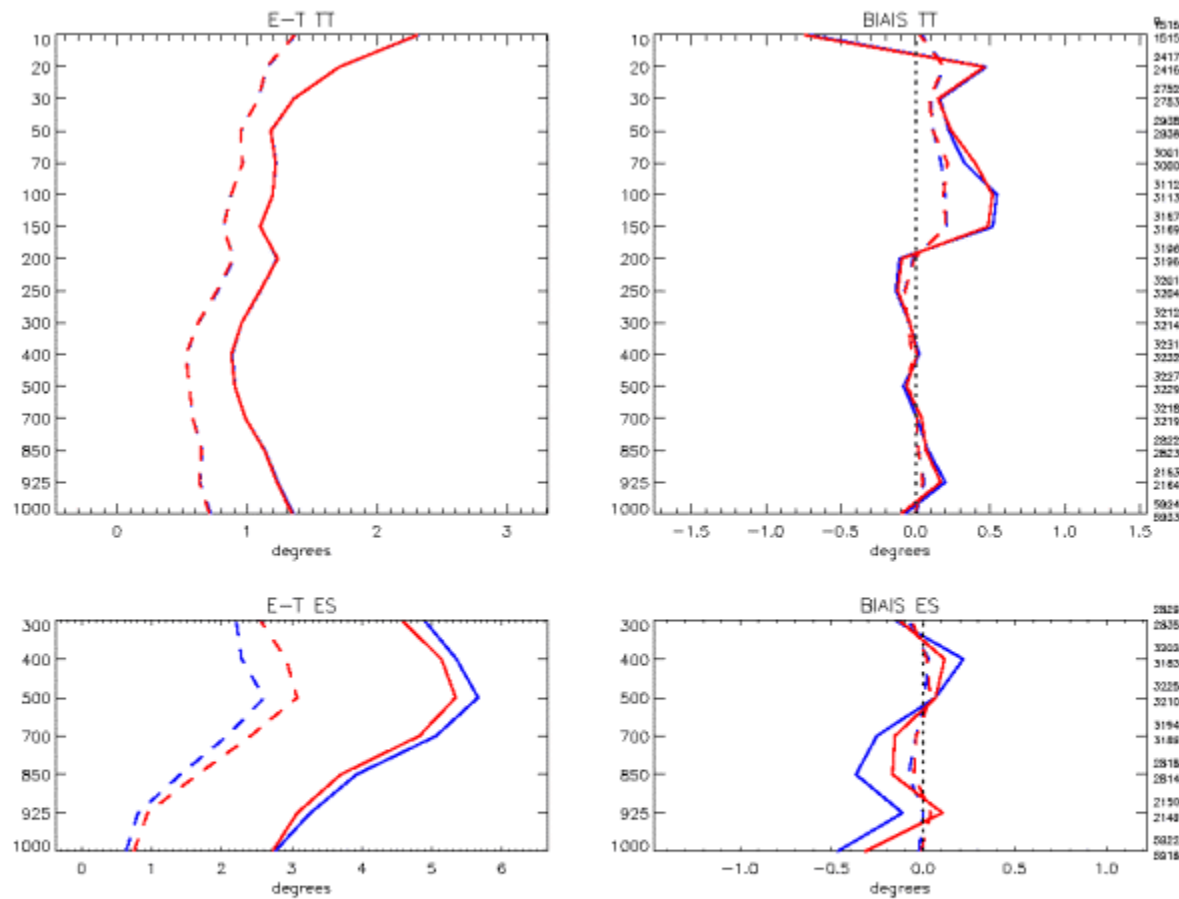
GOES 6.7m



Analysis Impact

O-P/O-A against NH radiosondes

Summer 2002



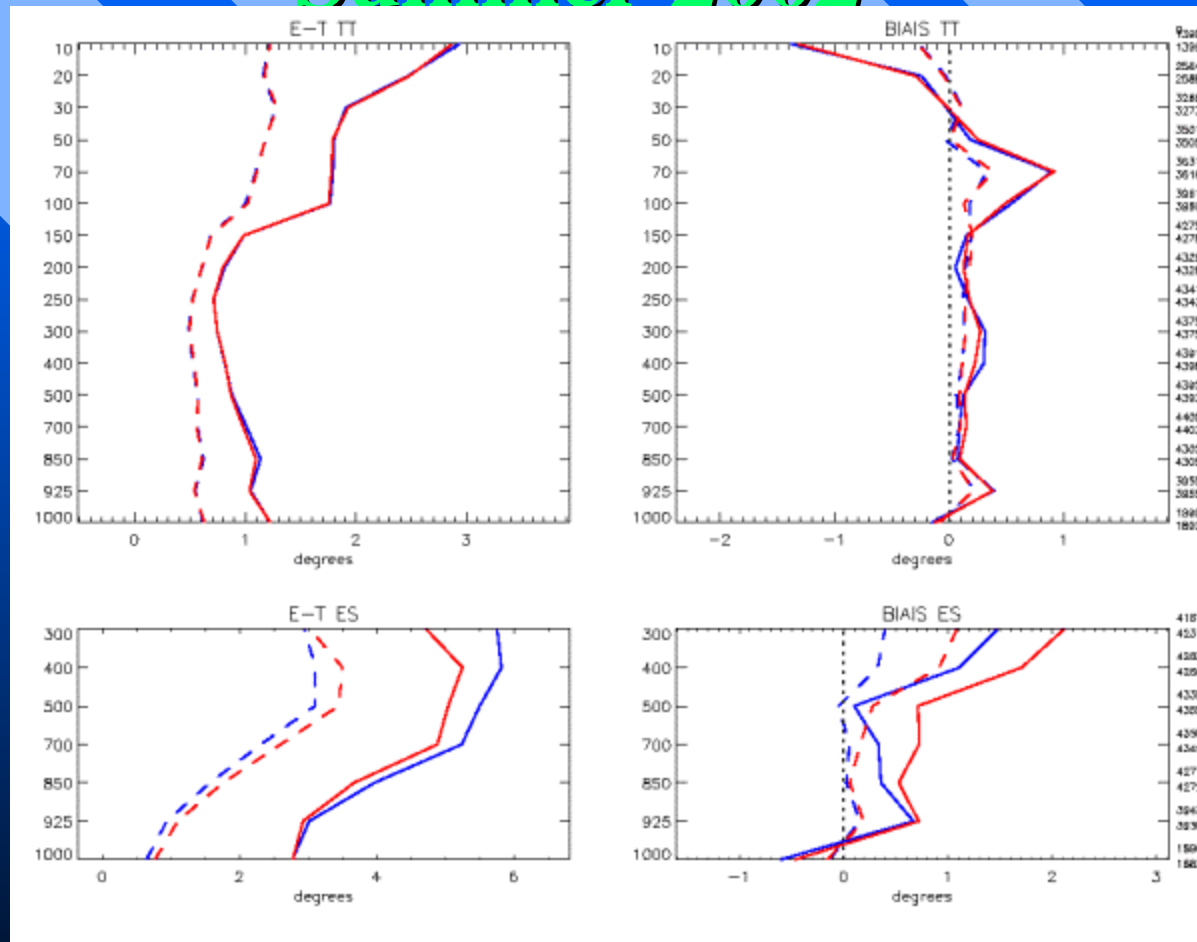
◇ ——— O-P m_ua020801_020930_000_e02a004.posv (122)
 □ - - - O-A m_ua020801_020930_000_e02a004.posv
 ◇ ——— O-P m_ua020801_020930_000_e02b004.posv (122)
 □ - - - O-A m_ua020801_020930_000_e02b004.posv

Type : O-P6hr O-A GZ TT ES
 Region : Hemisphere Nord
 Lat-Ion: (20N, 180W) (90N, 180E)
 Stat.

Analysis Impact

O-P/O-A against Tropical radiosondes

Summer 2002



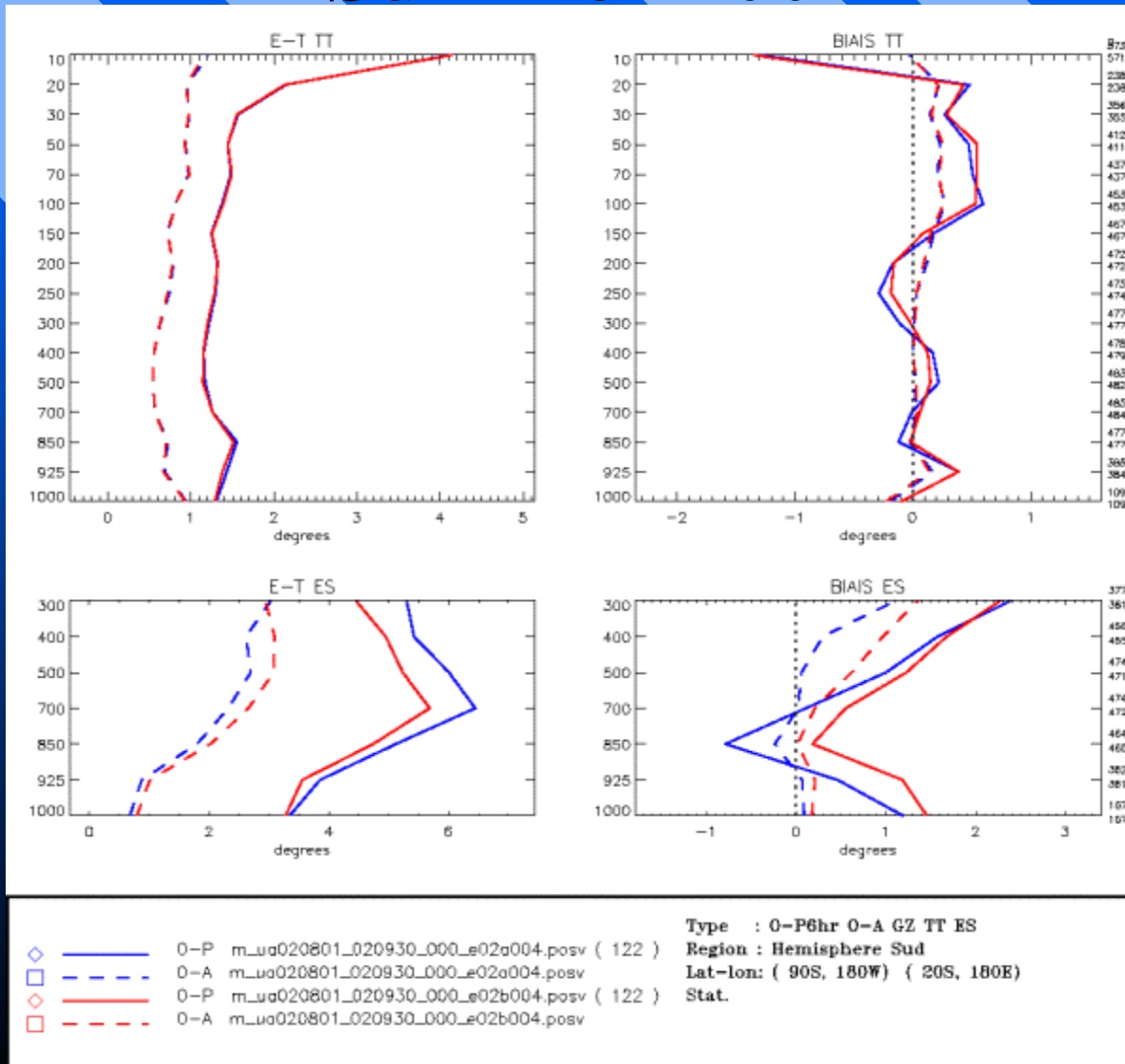
◇ ——— O-P m_u020801_020930_000_e02a004.posv (122)
 □ - - - O-A m_u020801_020930_000_e02a004.posv
 ◇ ——— O-P m_u020801_020930_000_e02b004.posv (122)
 □ - - - O-A m_u020801_020930_000_e02b004.posv

Type : O-P6hr O-A GZ TT ES
 Region : Tropiques
 Lat-Ion : (20S, 180W) (20N, 180E)
 Stat.

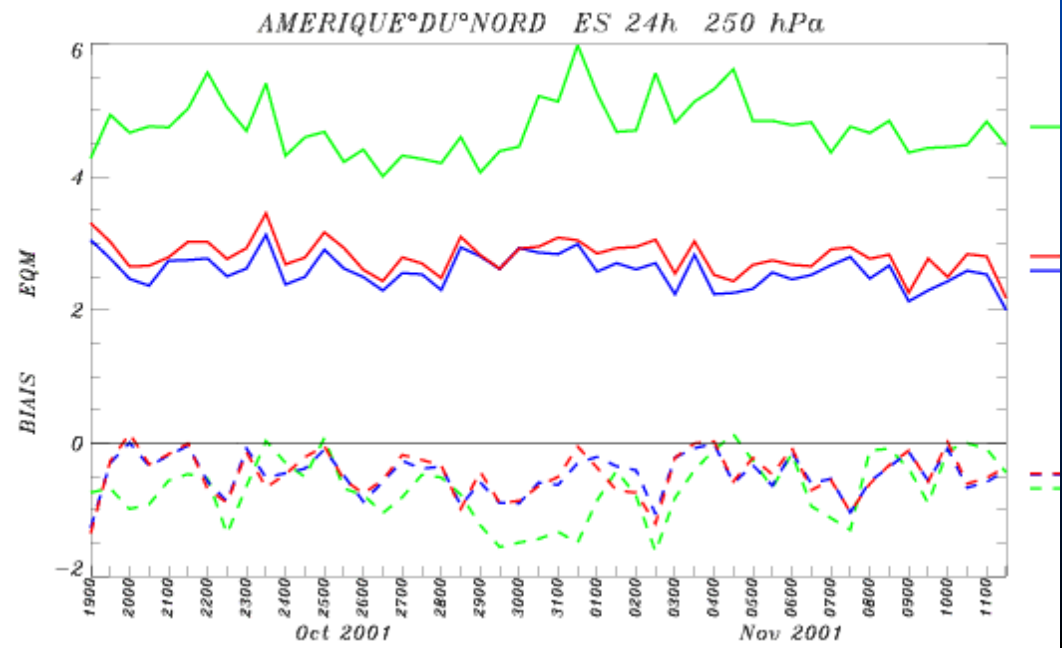
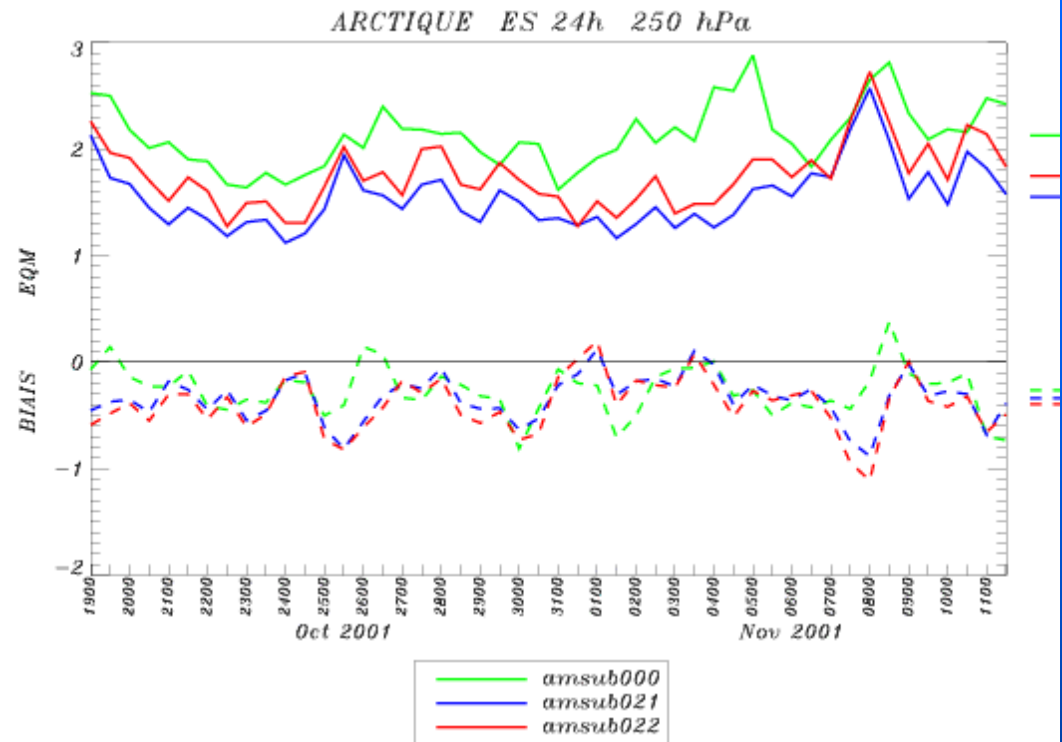
Analysis Impact

O-P/O-A against SH radiosondes

Summer 2002



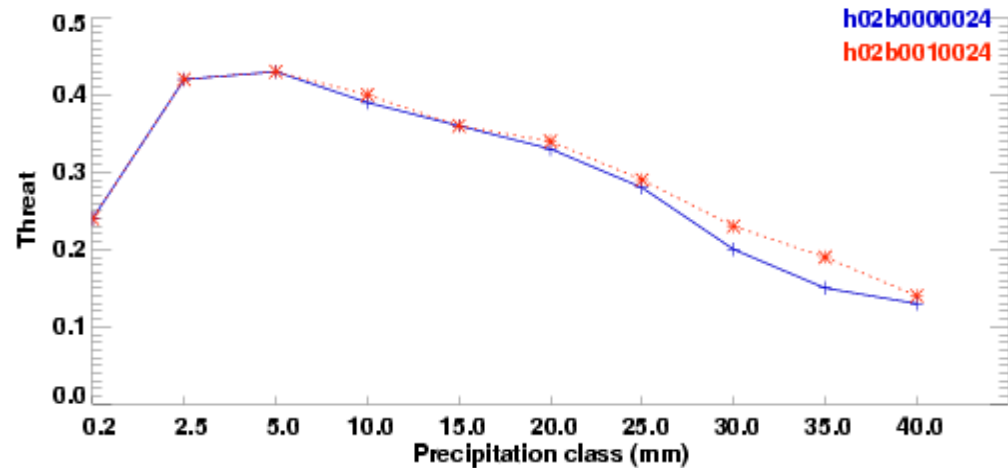
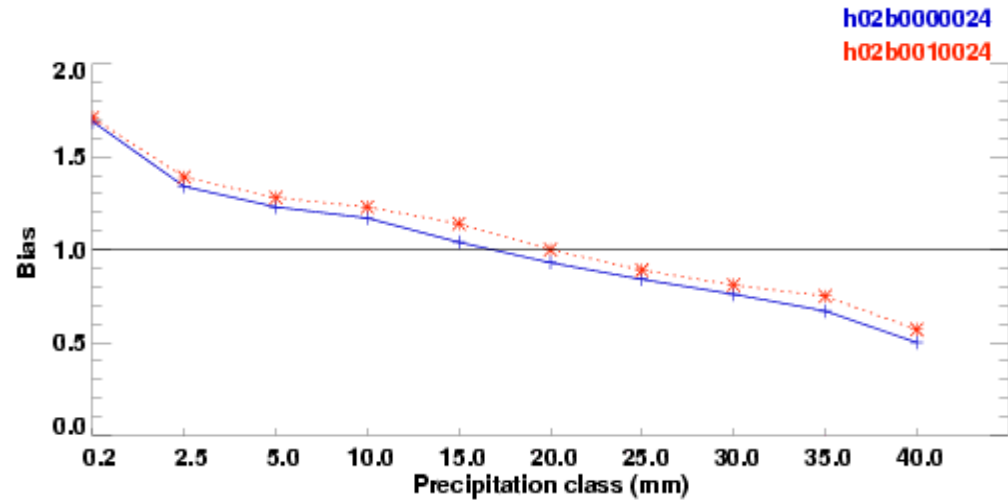
**Verifications
of 24-h
forecasts
against
analyses over
Arctic&NA;
(250 hPa ES)**



(00-24 h)
**Precipitation
 verification
 over NA
 Winter 2002**

24 hours precipitation forecast verification against observation

Synoptic network data for valid time 00-12z
 00 to 24 hours forecast North AMERICA
 Assimilation of AMSUB



Number of observation

22700	9045	5421	2600	1540	929	621	418	277	202
22700	9045	5421	2600	1540	929	621	418	277	202

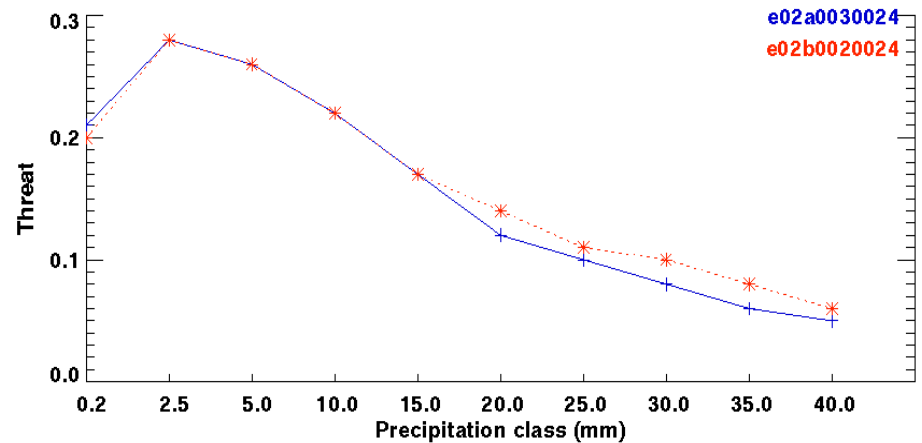
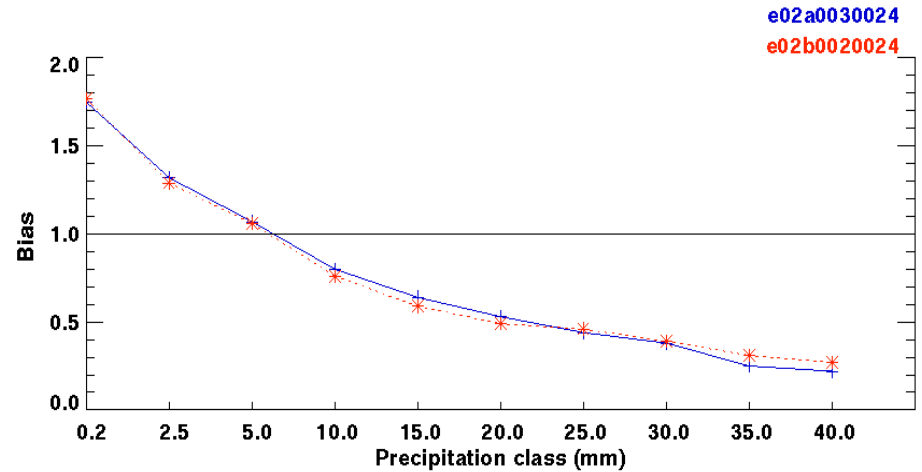
24 hours precipitation forecast verification against observation

Synoptic network data for valid time 00-12z

00 to 24 hours forecast North AMERICA

Assimilation of AMSUB

(00-24 h) Precipitation verification over NA Summer 2002

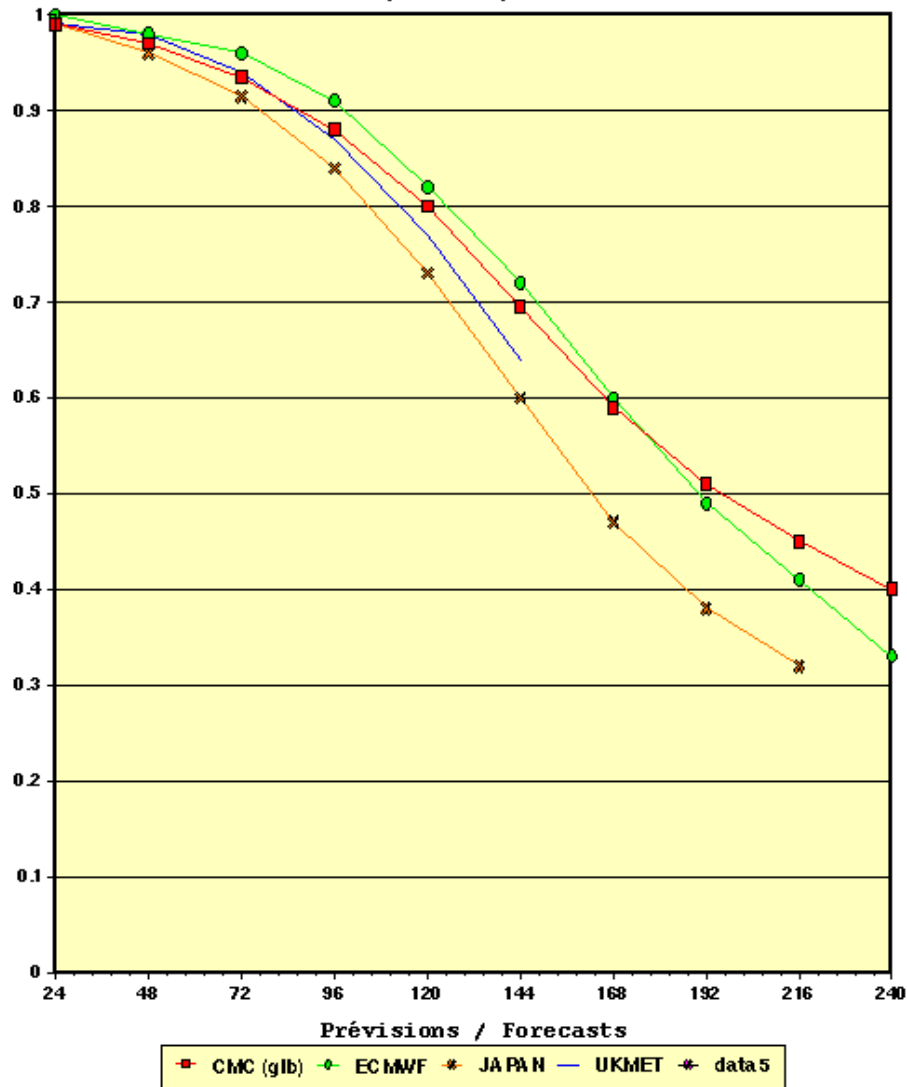


Number of observation

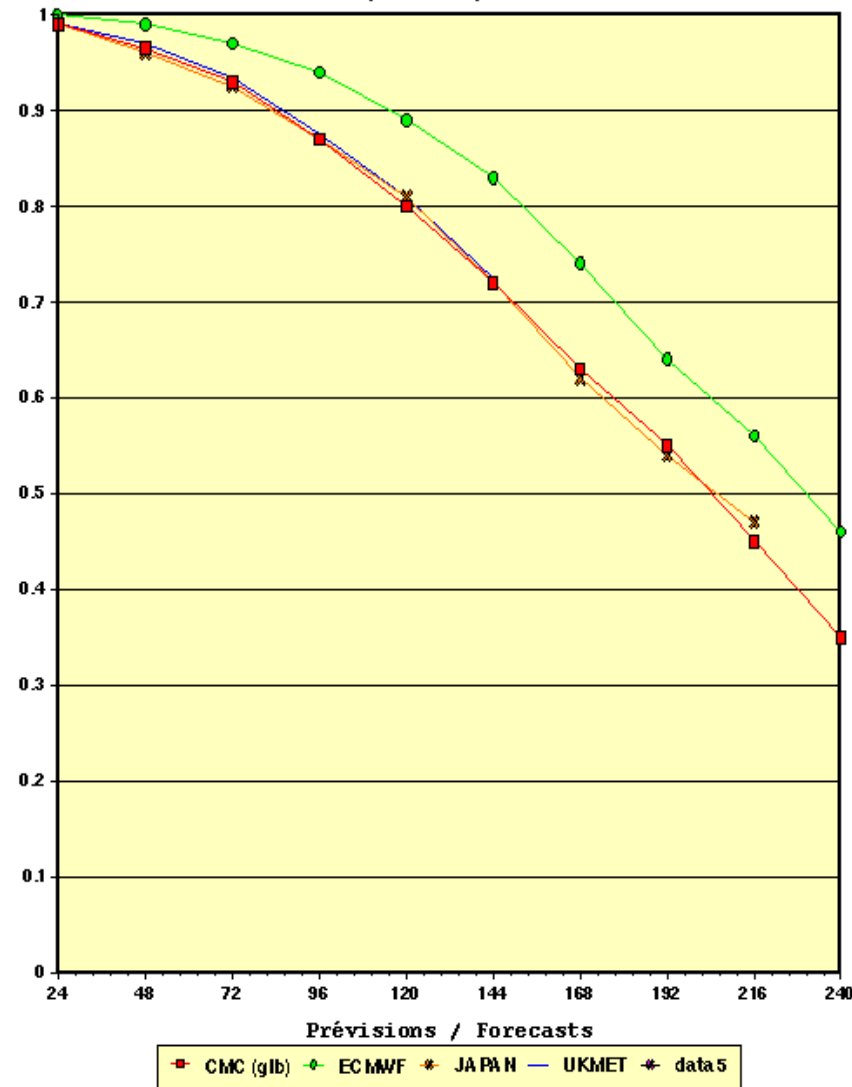
12286	6143	4091	2175	1391	894	571	391	296	229
12286	6143	4091	2175	1391	894	571	391	296	229

Anomaly correlation scores at 500 hPa at NWP Centres; September 2003

VERIFICATION vs ANALYSES
GZ 500 hPa 09/2003
Hémisphère Nord/Northern Hemisphere
CORR (00Z+12Z)



VERIFICATION vs ANALYSES
GZ 500 hPa 09/2003
Hémisphère Sud/Southern Hemisphere
CORR (00Z+12Z)



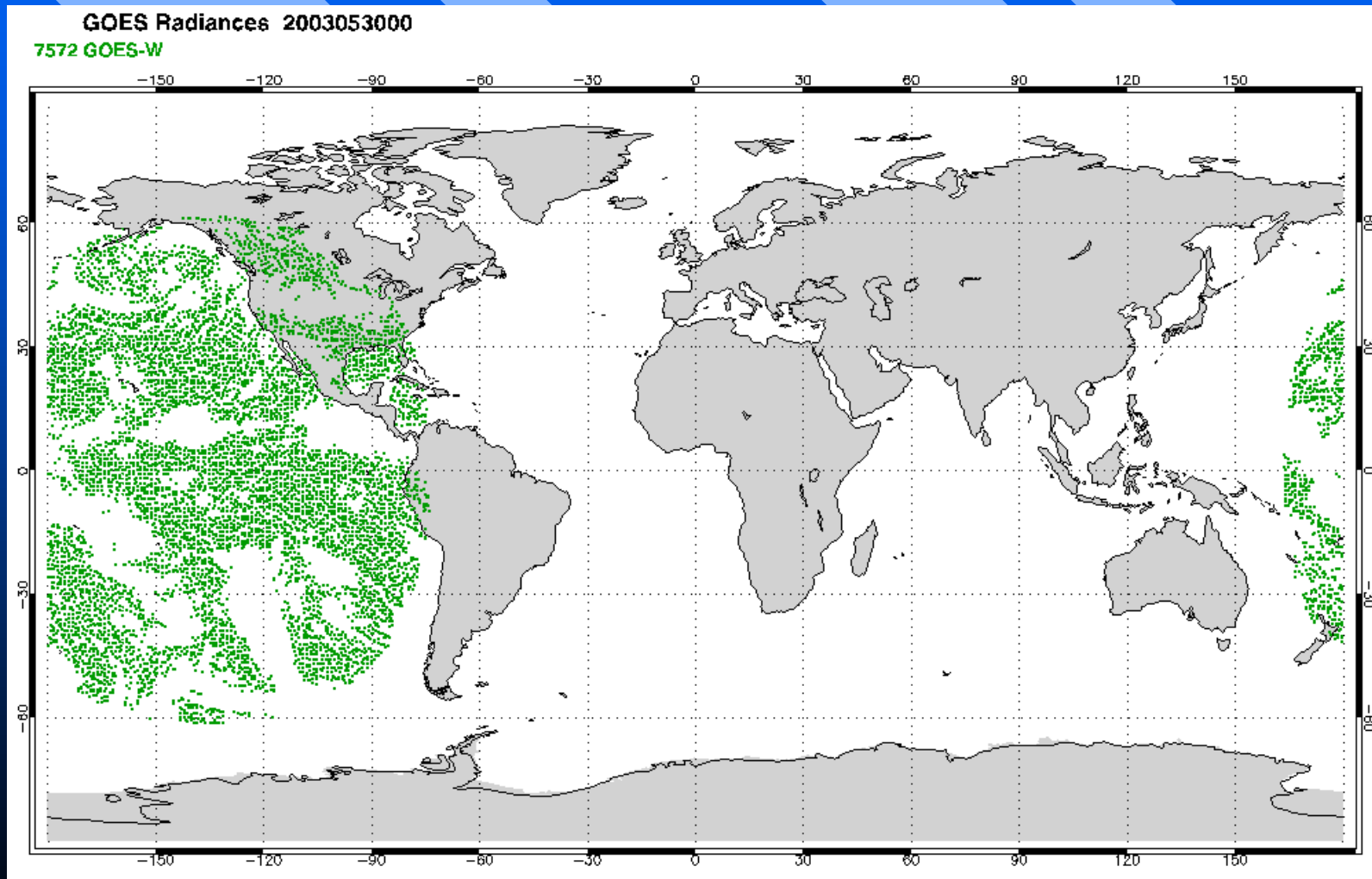
Conclusion

- The AMSU-B data of the NOAA-15, 16, and 17 platforms and the GOES 6.7 μ (see N. Wagner's poster) have a large impact on the moisture analyses of our global forecast system.
- The improvement of the upper and lower troposphere moisture analyses (250 & 850 hPa) persist through to 4 days of forecast and beyond with some positive impact on other variables such as winds and temperature.
- D. Anselmo's cross-validation of AMSU-B impacts with SSM/I TPW.

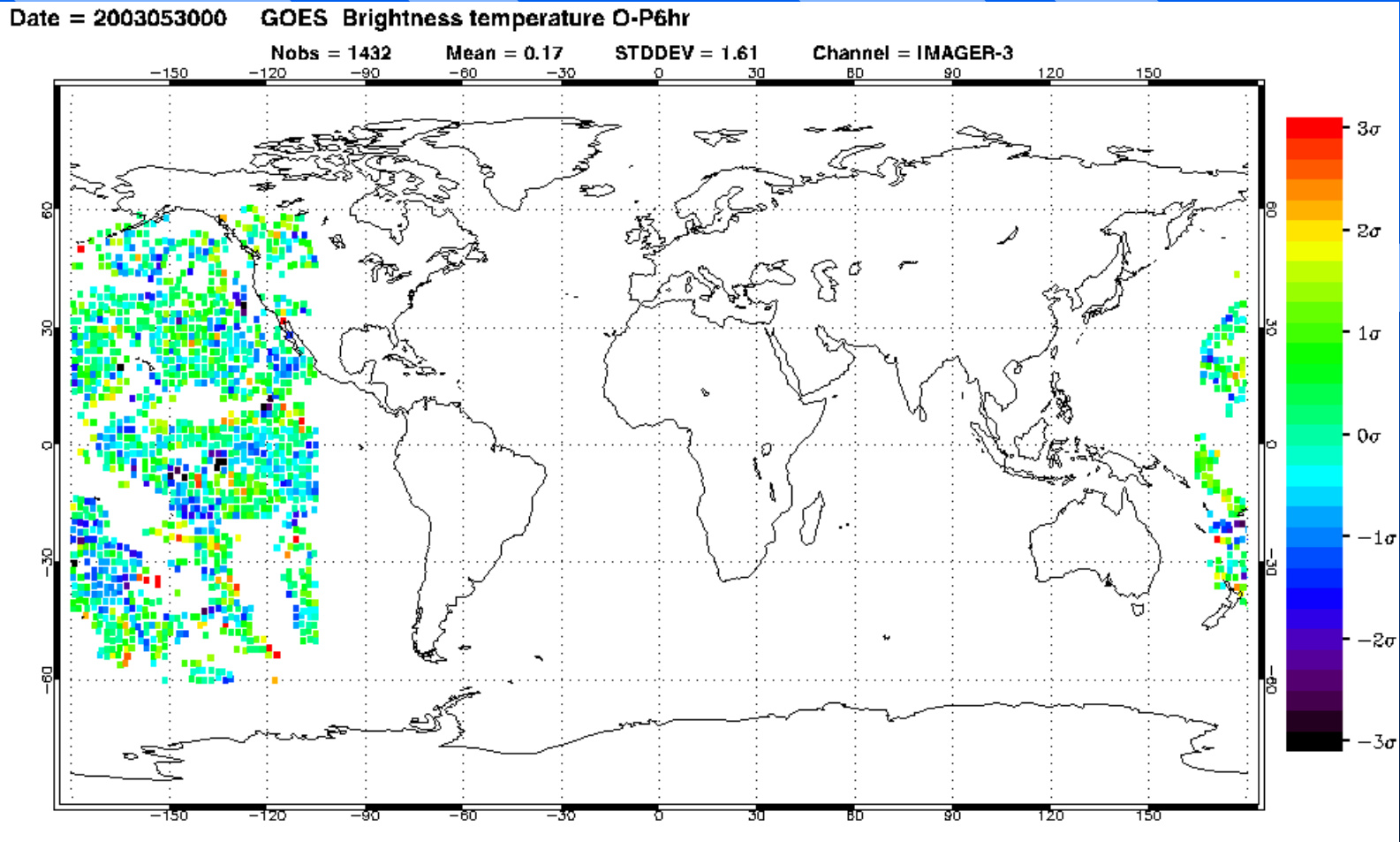
Future work in 3D-Var

- Regional Forecast System; done.
- QC-Var for TOVS data to increase the use of marginal data; Antarctica
- Raise the top of model and analysis from 10 hPa to 0.1 hPa in a hybrid vertical coordinate (AIRS project, stratospheric chemistry, support to Canadian Space Agency missions); still difficulties with moisture around and above 100 hPa; difficulties with RTTOV-7.
- IR radiances (2003 +)
 - assimilation of Meteosat and GMS
 - assimilation of AIRS and NOAA IR radiances
 - link the assimilation of Ts over land to soil moisture.

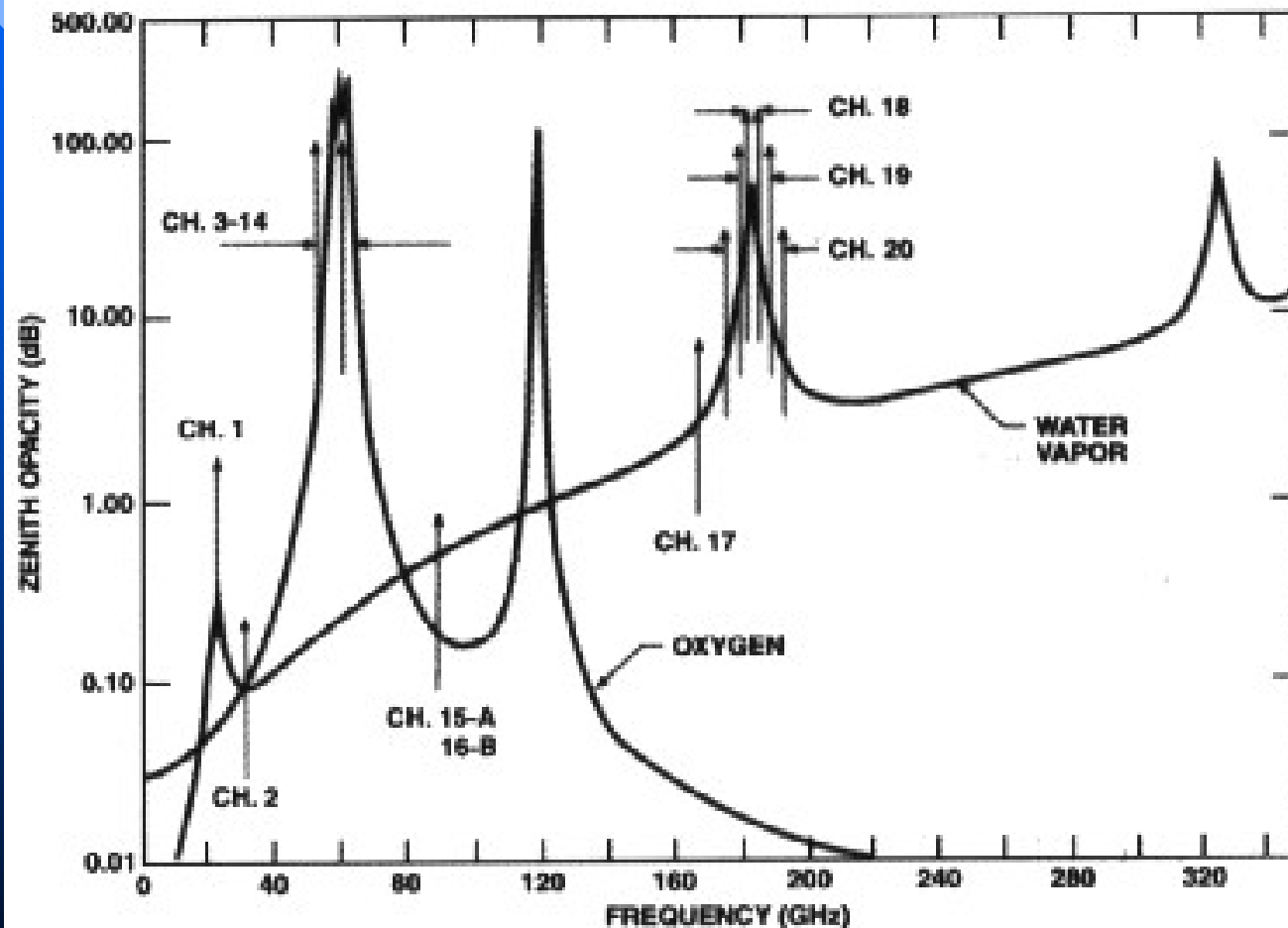
Coverage of GOES 6.7m radiances (GOES West only currently)



Final GOES 6.7m selection for analysis



Current AMSU-A and AMSU-B radiances of NOAA series



The channels selected for AMSU shown relative to the special characteristics of the atmosphere.