Impact of combined AIRS and GPS-RO data in the new version of the Canadian global forecast model

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Gem-Strato: New model planned for late 2008

GOAL: raise model lid from 10 hPa to 0.1 hPa
+ improved physics + more satellite data assimilated

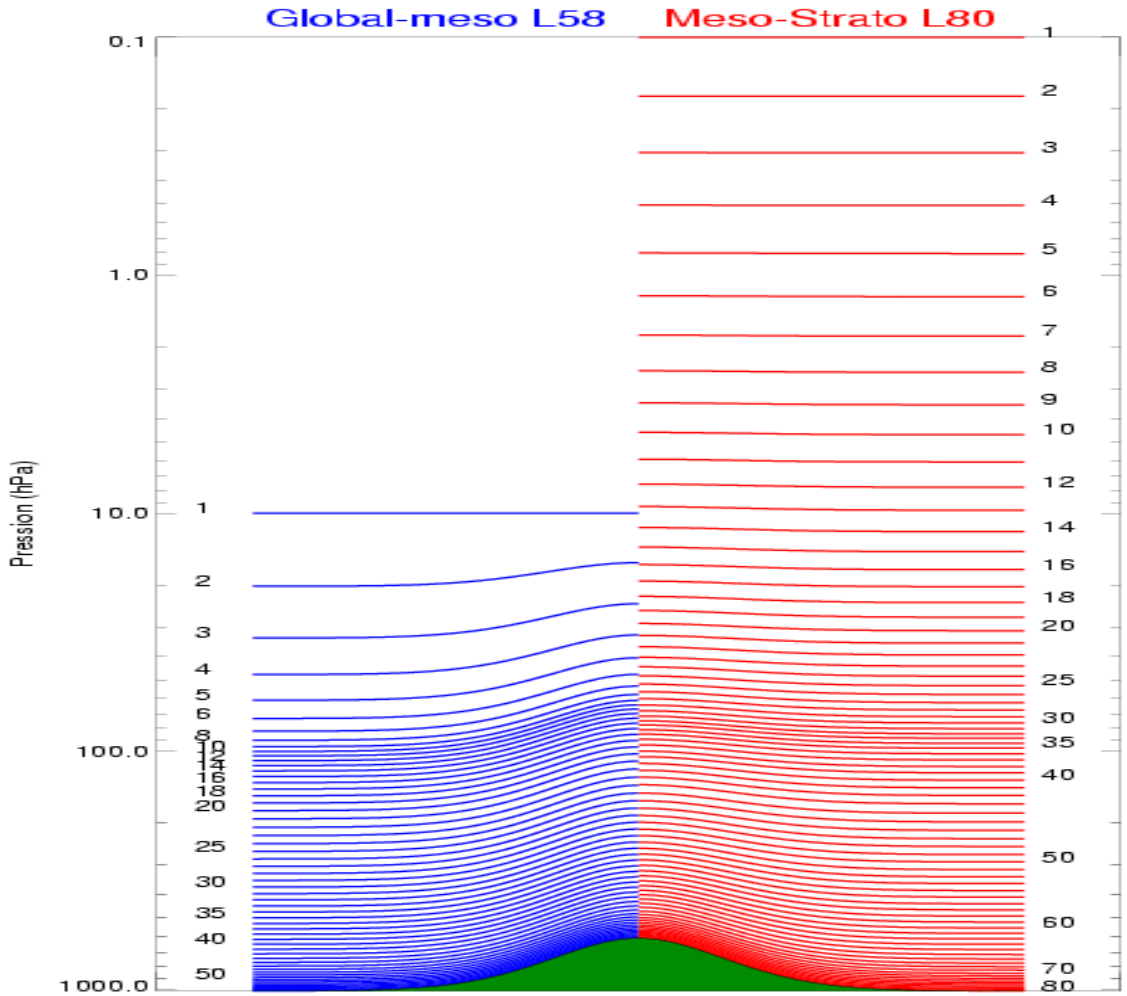
OUTLINE

- Model configuration changes
- Derivation of background error statistics
- Baseline Gem-Strato vs OPE with top at 10hPa
- Baseline GEM-Strato vs same + AIRS 87 (ch), Quickscat, SSMI
  as just implemented in OPE
- Add GPS-RO to above
- Add ~30 more AIRS channels allowed by higher top
- Conclusion

Model configuration changes

	Operational	GEM-Strato
No. of points In horizontal	800 x 600	800 x 600
Vertical coordinate	Eta (normalized sigma)	Hybrid
No. of levels in vertical	58	80
Top	10 hPa	0.1 hPa
Sponge del^2 at top (wind and temp)	4 levels	6 levels (to 1 hPa) No diffusion on mean zonal wind
Tropical sponge layer	4 levels From top to 50 hPa	8 levels From top to 3 hPa

New vertical coordinate

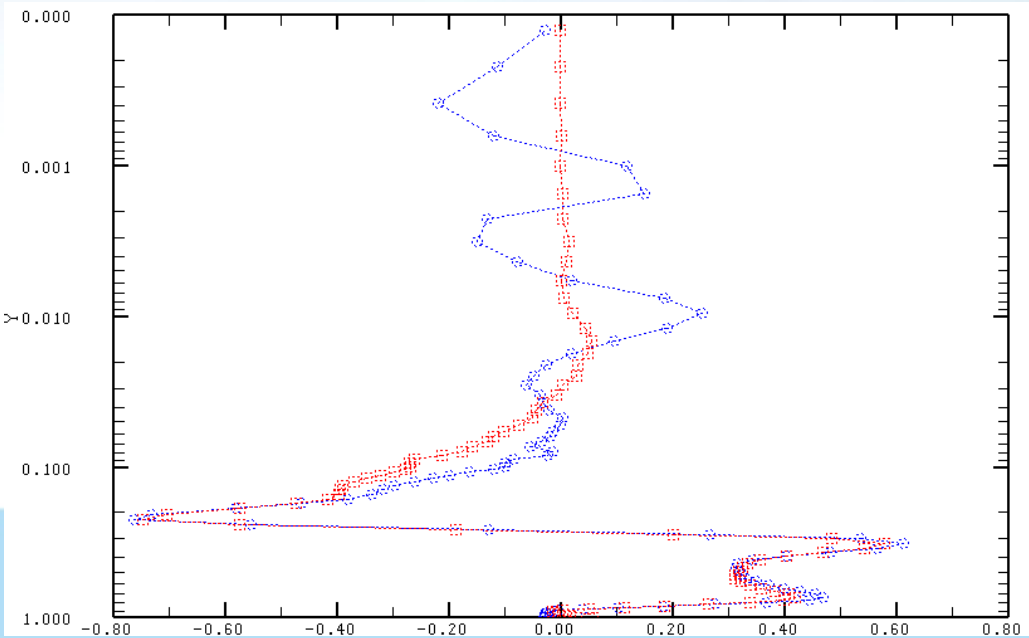


Physical parameterization changes

	Operational	GEM-Strato
Radiation	Fouquart/Bonnel (VIS) Garand (IR)	Li and Barker (CKD)
Non orographic GWD	No	HINES
Methane oxydation	No	**Yes**
Climatological Ozone	Kita and Sumi (1986)	Fortuin and Kelder (1998) under 0.3 hPa Haloe above 0.3hPa Mix at 0.3 hPa
Total cost	**1**	**1.5 - 1.8**

New background error covariances

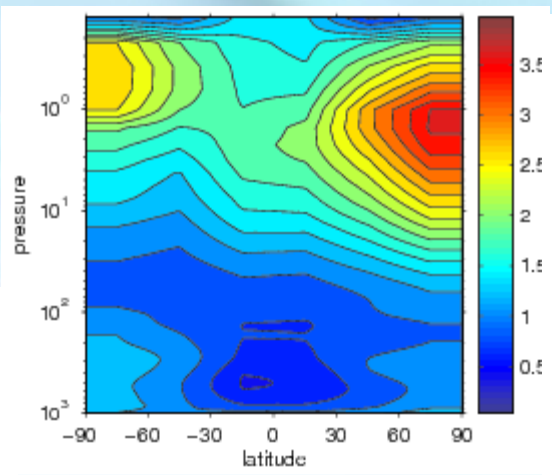
- As for operational system, background error covariances estimated using “NMC method”
- With current approach for modelling the geostrophic balance impossible to filter noisy correlations of “balanced temperature” (T_b) between troposphere and stratosphere
- New approach is to explicitly compute the vertical correlations for T_b so that they can then be localized with Hadamard product (also cross-term between T and U)
- Figure: analysis increment of temperature from only aircraft data (no data above ~200hPa) using: **old** and **new approach**



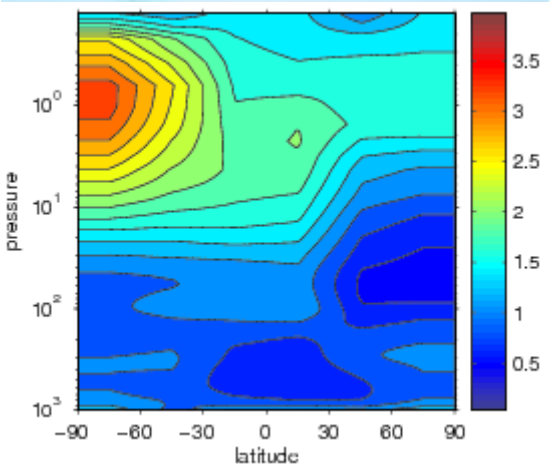
New background error covariances

- Variances adjusted to be consistent with MLS retrieved temperatures and radiosonde data T and U, except above 1 hPa where T variances reduced to avoid problems
- Ratio of unbalanced to total temperature stddev from 24h-48h forecast differences maintained
- Figures show T std and ratios: above 100 hPa SH less balanced, more divergent than NH and larger temperature variances in NH. Reverse in summer

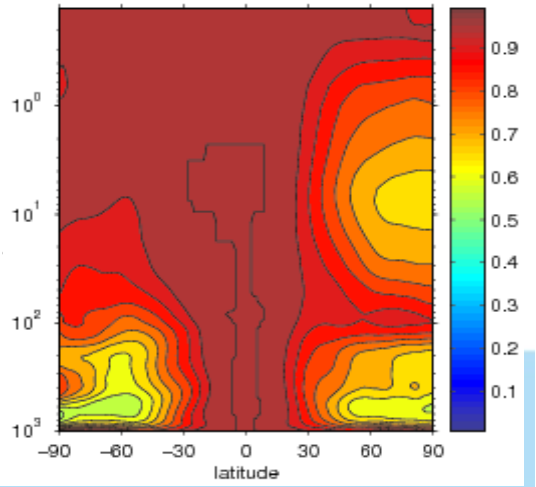
std T winter



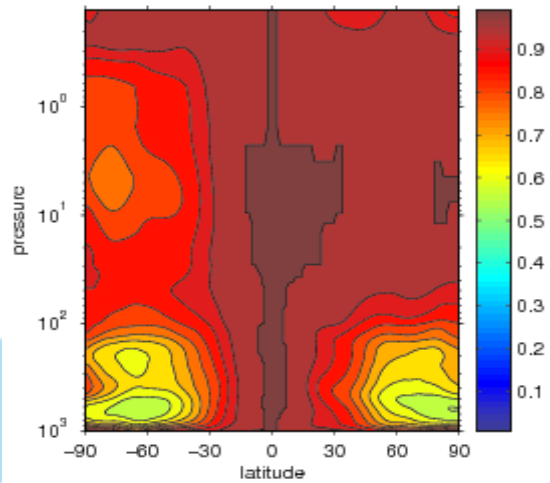
std T summer



std T_{unbal} / std T winter



std T_{unbal} / std T summer

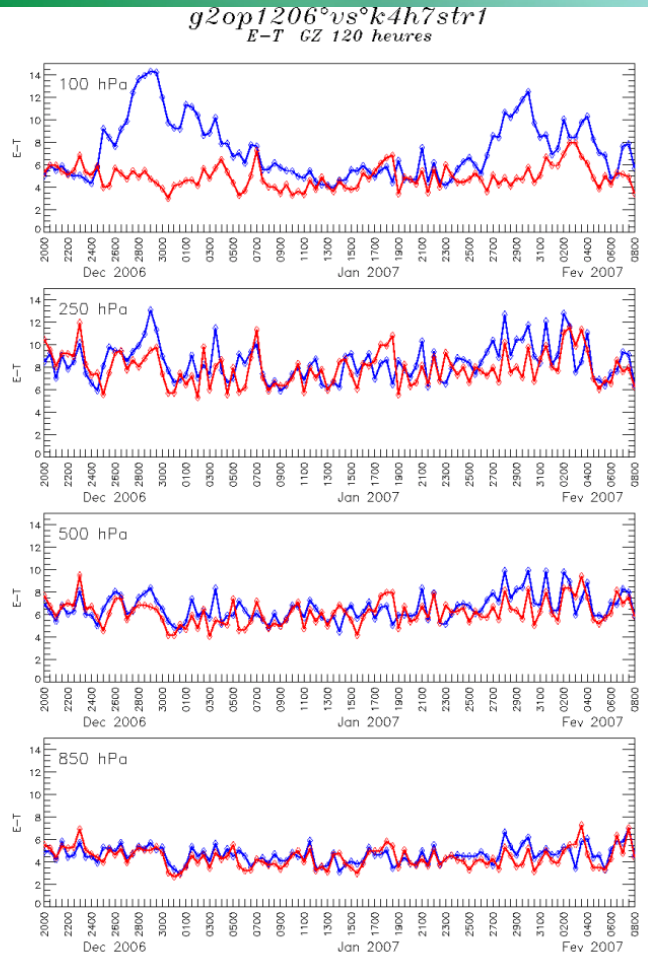


First 4D-var results Strato vs Operational

120-h Temp errors
vs raobs, NH

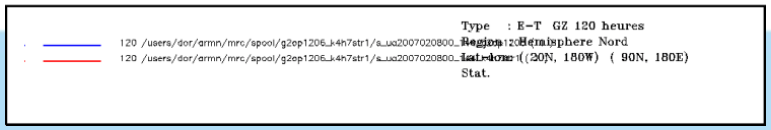
OPE: Top 10 hPa
Strato: Top 0.1 hPa

No AIRS, No GPS-RO

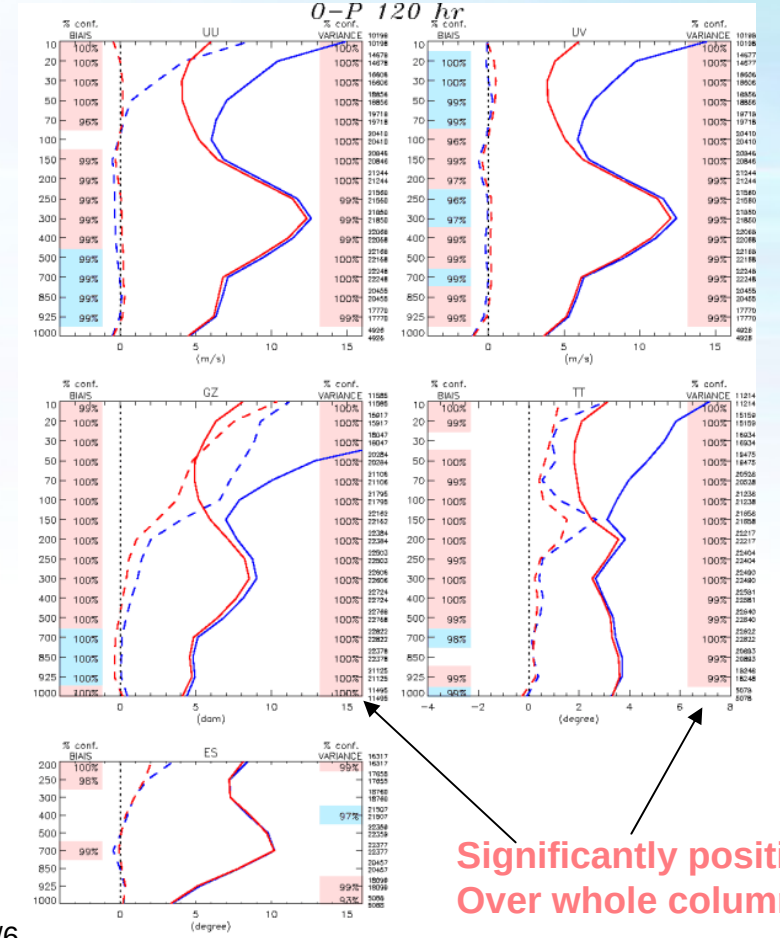


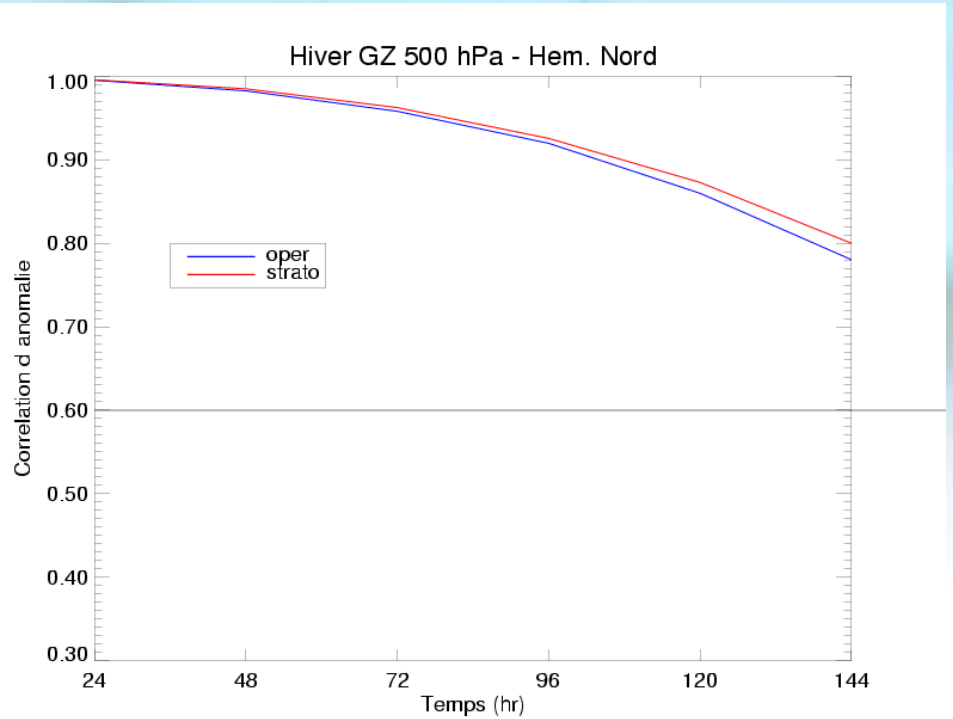
Note major improvement
For specific periods at
100 hPa with influence
at lower levels

6/6/2008



First 4D-var results Strato vs Operational NH

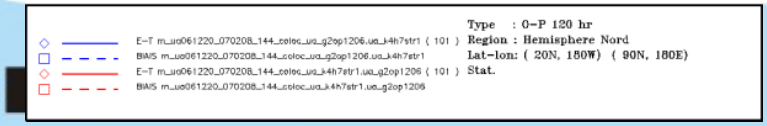




Gain of ~6h at days 5-6, 500 hPa

Significantly positive
Over whole column

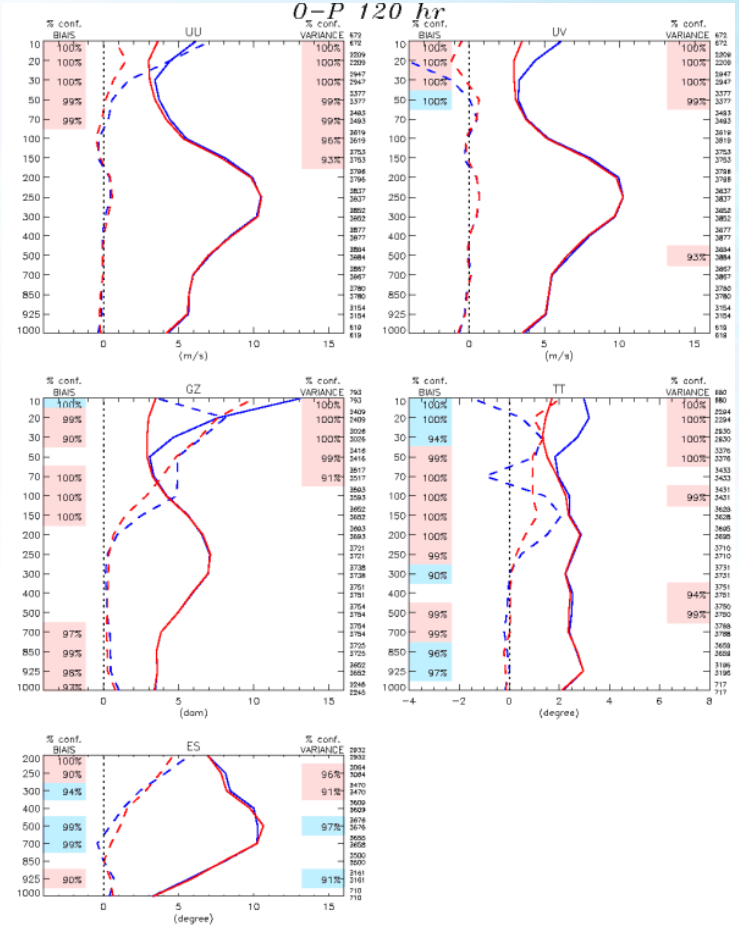
No AIRS, No GPS-RO



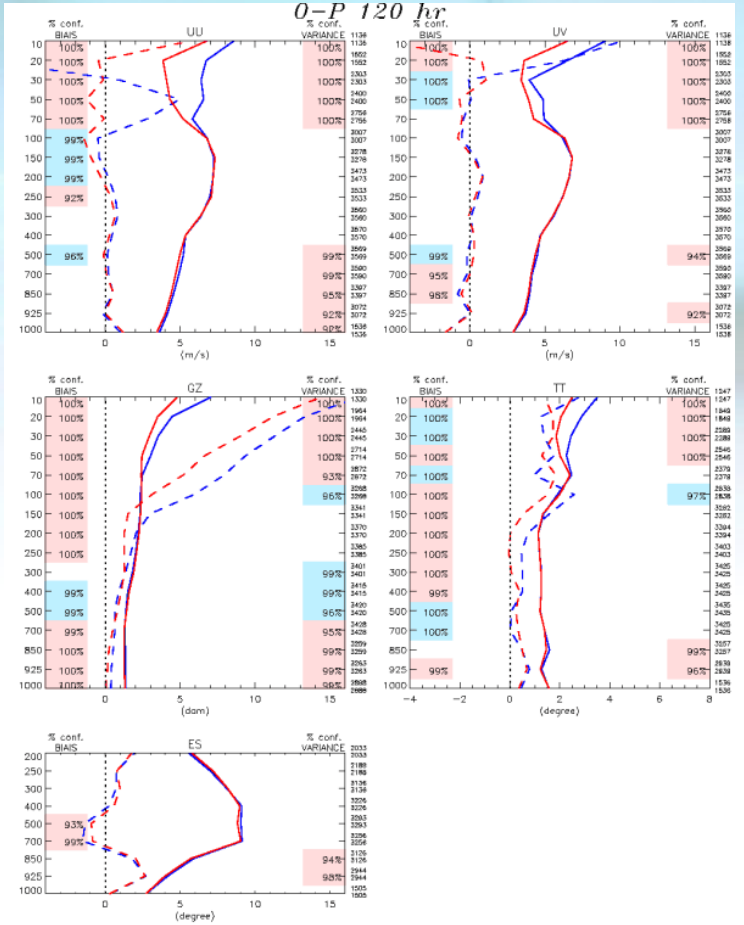
Canada

First 4D-var results Strato vs Operational TRO & SH

120-h SH



120-h TRO vs raobs



6/6/2

No AIRS, no GPS-RO

Next step: add new data types just implemented

- Baseline Gem-strato is satisfactory, but tested without new data types which are about to become operational … May 7 2008!

- Add new data recently implemented in OPE with top still at 10hPa

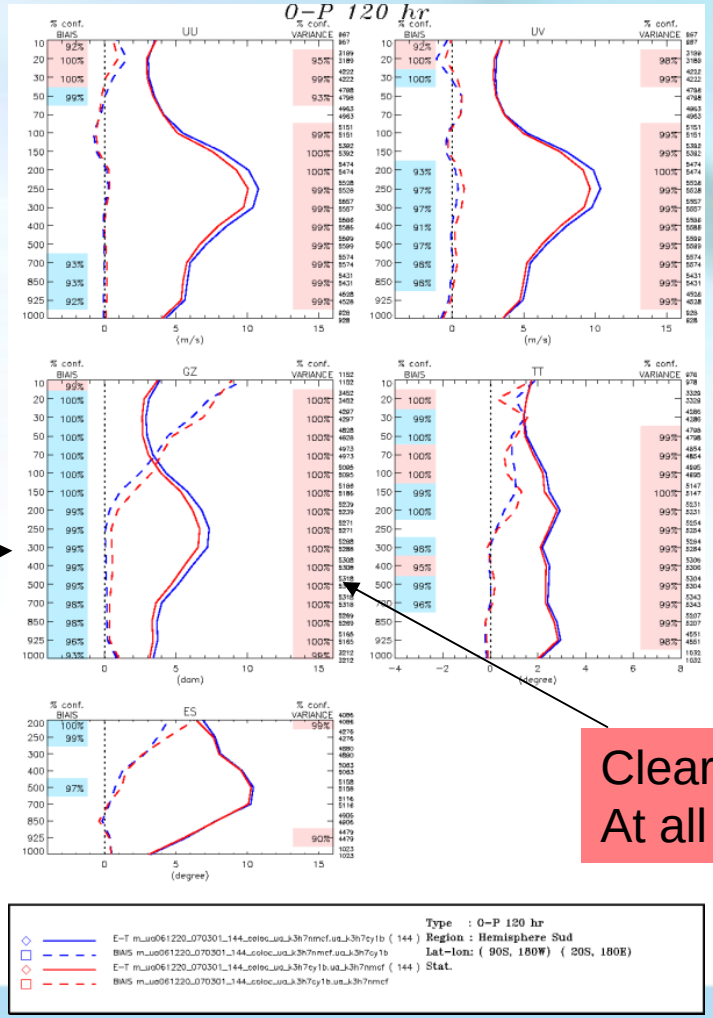
  - AIRS 87 channels
  - SSMI 7 channels from F13 and F14
  - Quickscat surface winds
  - Use all AMSU-A and AMSU-B scans (+25 % data)

- Off-line dynamical bias correction for all radiances (updated at every analysis using 15-day window)

See poster G. Debonde et al, on the impact of these new data
In current model with top at 10 hPa

Baseline strato vs same+ AIRS + SSMI + Quickscat (3D-var)

120-h SH



Negative impact on GZ bias It disappears in 4D Unexplained, but seems related to Ps.

Clear positive impact on SDs
At all levels for winds, temp, GZ

6/6/2008

Next step: add GPS RO

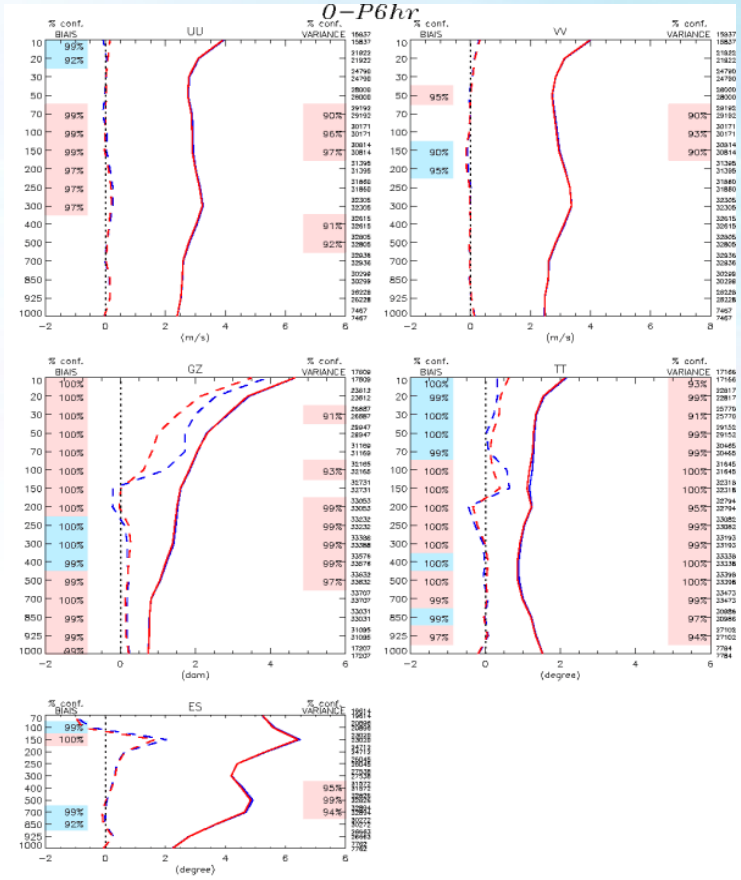
- Refractivity profiles assimilated from 4 to 40 km (~3 hPa) and at least 1 km above surface
- Satellites at time of tests:
  - CHAMP (1 satellite, aft antenna, ~150 profiles/day)
  - GRACE (1 satellite, aft antenna, ~150 profiles/day)
  - COSMIC (6 satellites, fwd & aft antennae, ~1500 profiles/day)

- Total: **~500 profiles/6h step**, excellent worldwide sampling (non repeating)
- Each profile contributes ~40 data vertically (vertical thinning at 1 km, original 200 m)
- All instruments are of the same type
- **Assumed non-biased**
- Background Error Check : -0.05< (O-F6h)/F6h <0.05 corresponds to about 12 K
- Obs error small: 0.5 to 1.5%, assigned dynamically

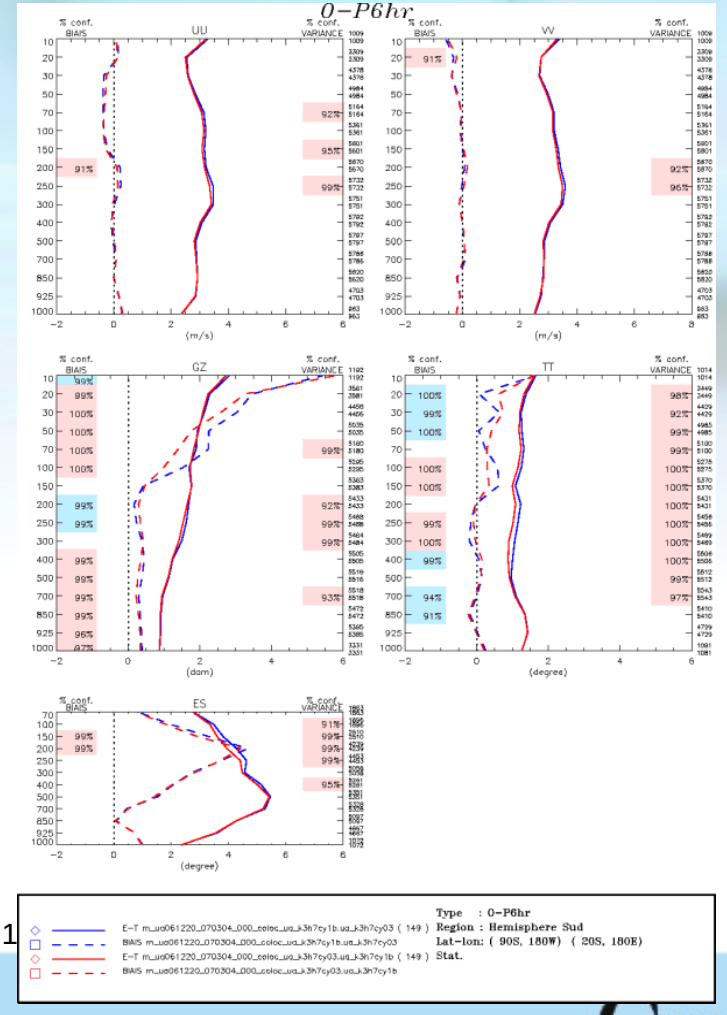
6-h validation with vs without GPS-RO, 3D-var

"with" includes AIRS,SSMI,Quickscat as used with top at 10 hPa

NH



SH



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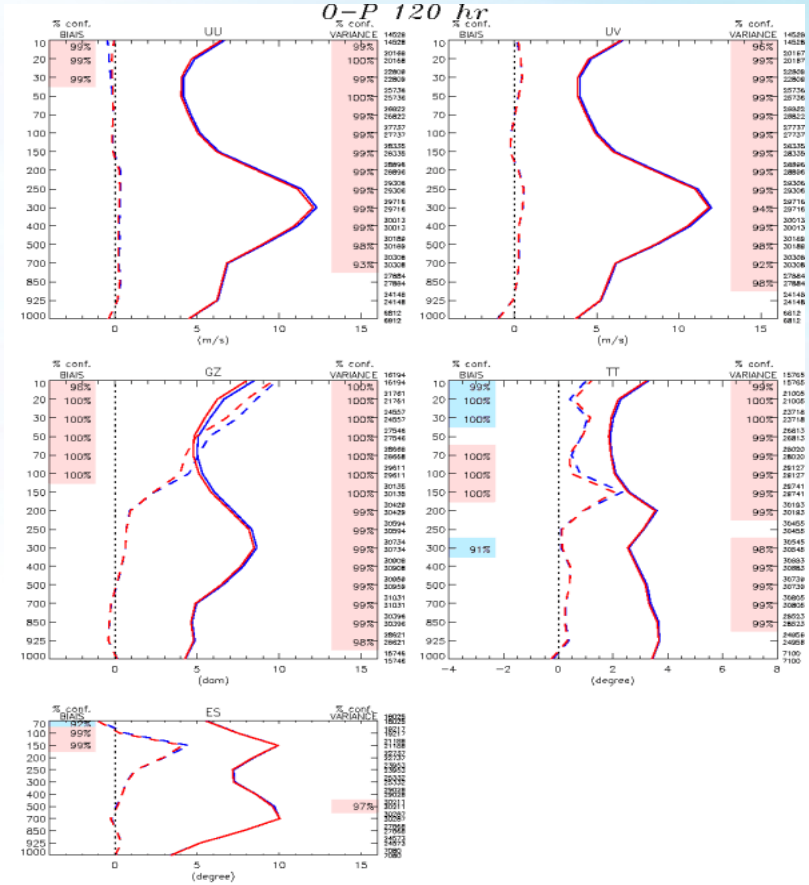
Based on 70-day winter cycle

Canada

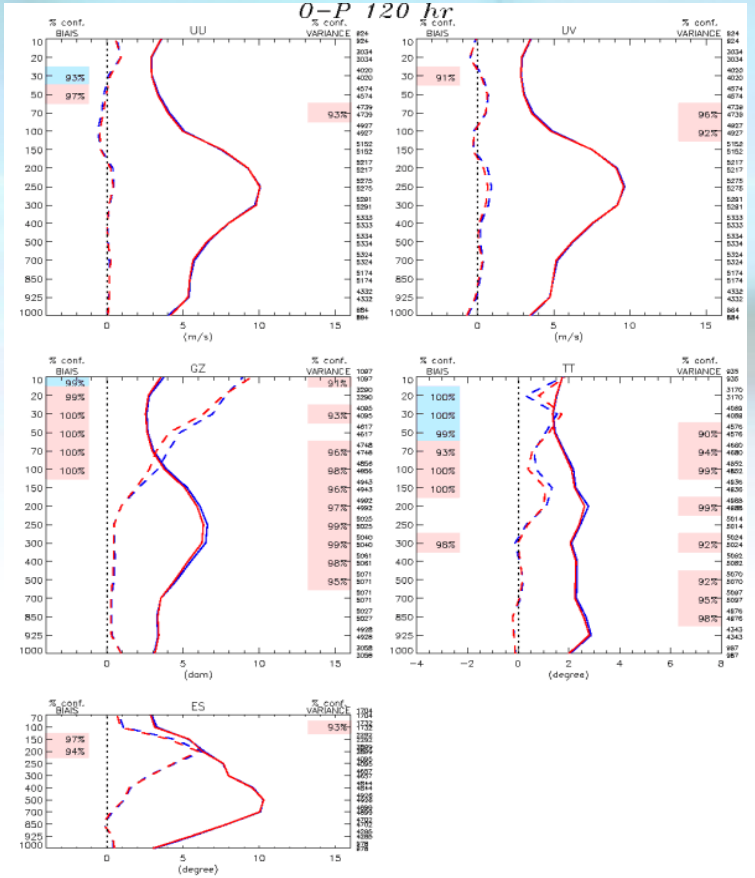
120-h validation with vs without GPS-RO, 3D-var anal cycle

"with" includes AIRS,SSMI,Quickscat as used with top at 10 hPa

NH



SH



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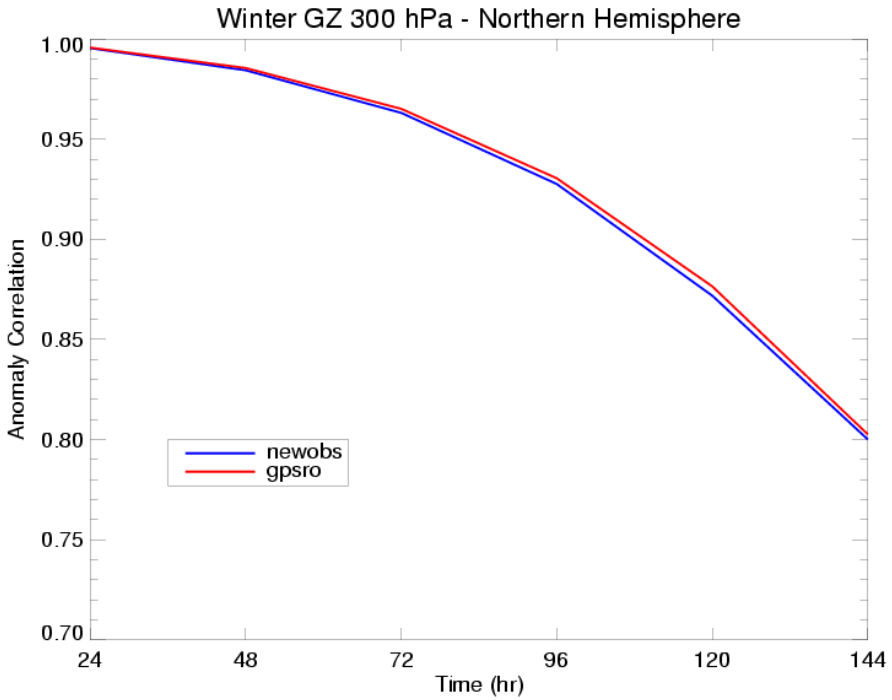
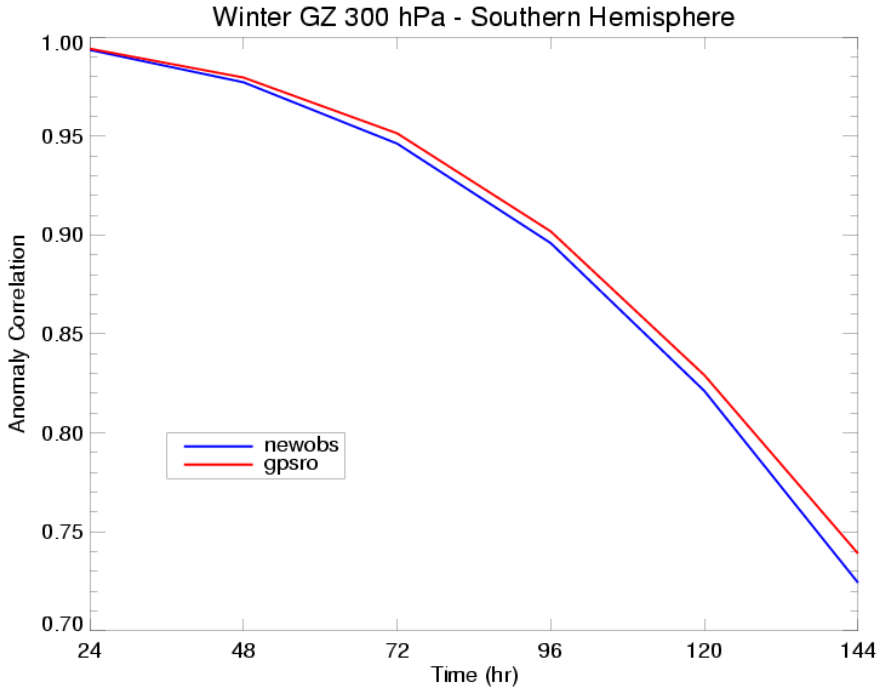
Based on 70-day winter cycle

Canada

Impact of GPS-RO (with, without) at 300hPa



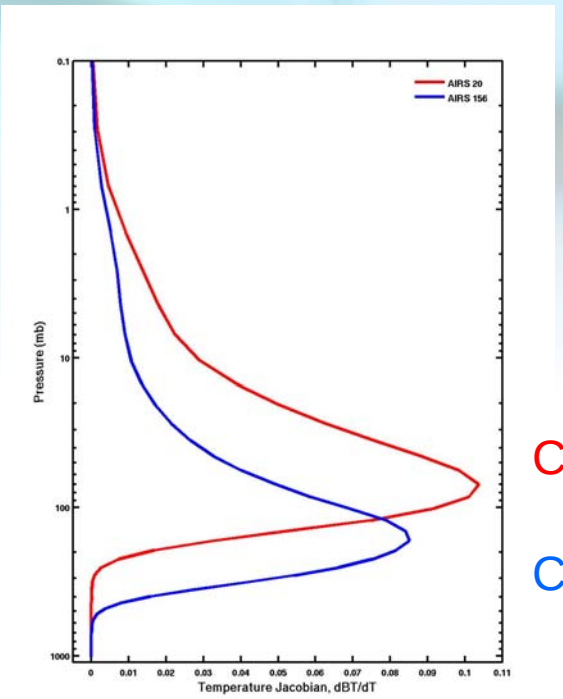


Gain of ~2 h HN and ~3-4 h HS at days 3 to 6

Based on 70-day winter cycle

Next step: additional AIRS allowed by higher lid

- Add 30 AIRS channels on top of current 87
- from # 20 to #204
- Highest is # 72 peaking at ~30 Hpa
- Previous highest was #156 with peak near 150 hPa
- Channels with significant contribution at model top not used

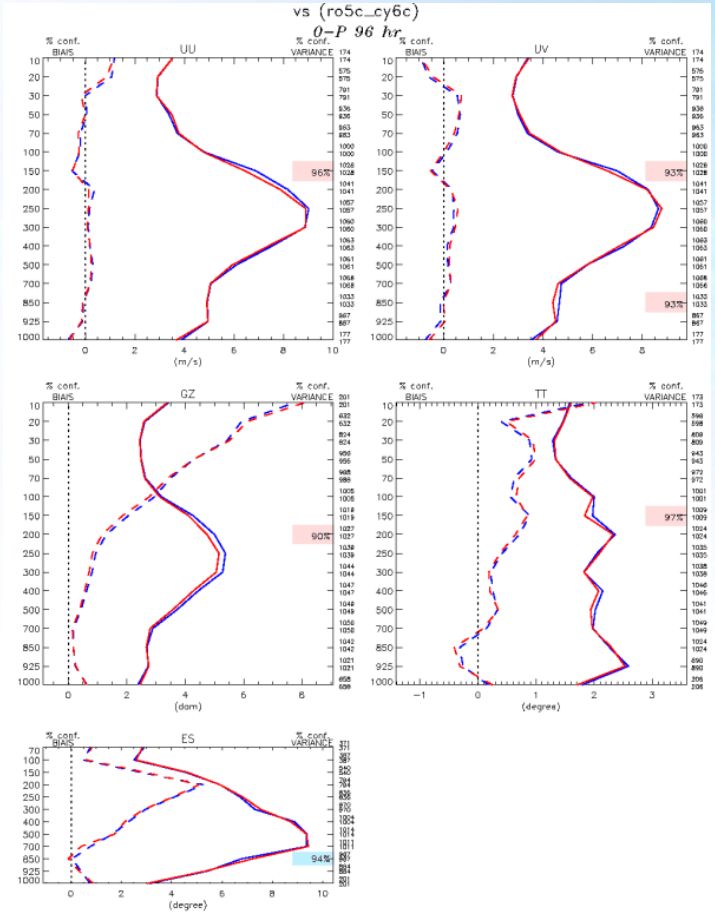


Ch 20

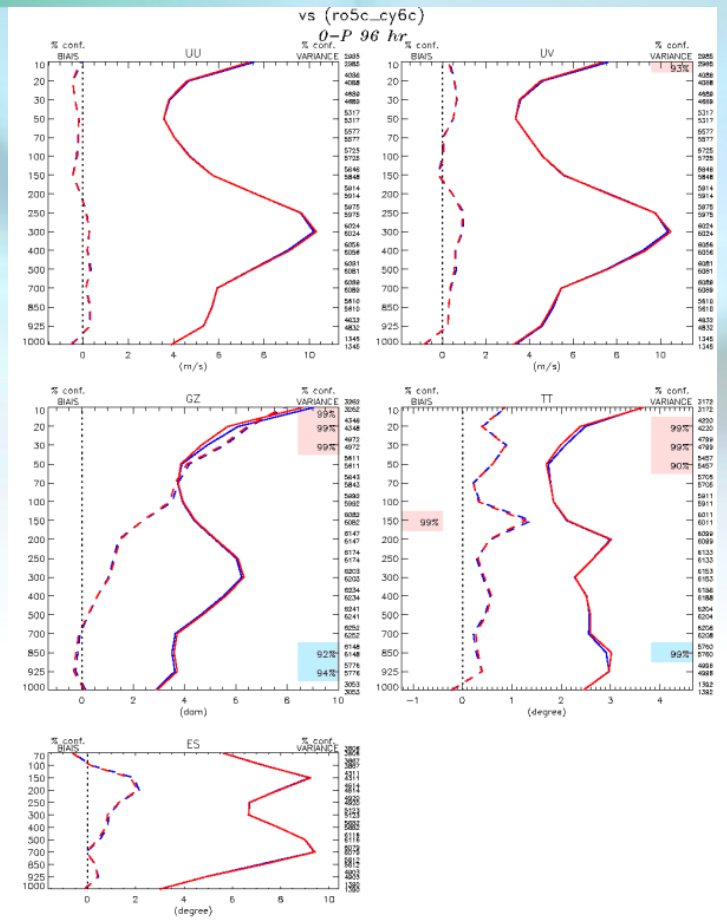
Ch 156

Additional AIRS channels: preliminary impact results (based on 28 96-h forecasts)

SH



NH



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Modest positive impact, stronger in SH

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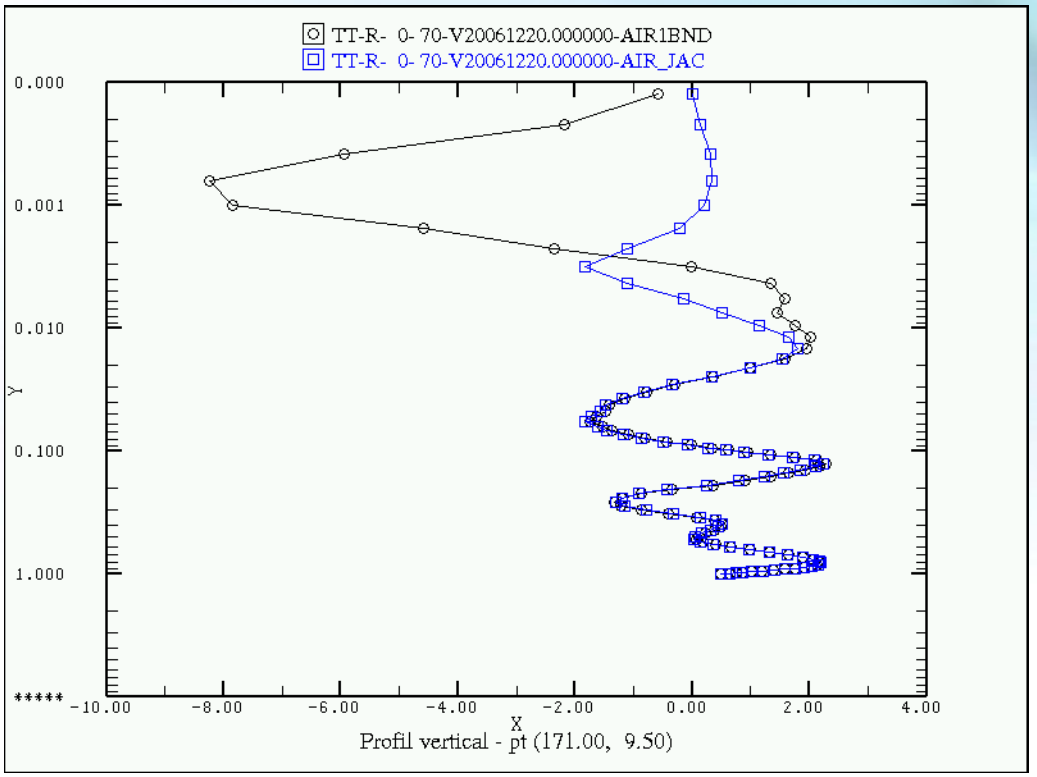
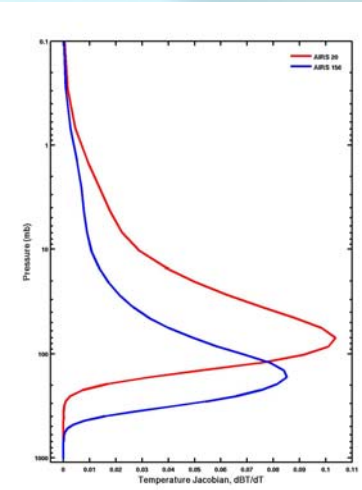
Issue: Tails of AIRS Jacobians may create large temperature increments in the stratosphere



Black: normal result of AIRS alone assimilation

Blue: effect of tail of Jacobian cut above 1 mb



0.1 hPa

1.0 hPa

10 hPa

Ch 20

Ch 156

6/6/2008

Ideal: top still higher and more observations above 5 hPa
Current position is not to cut tails, rely on AMSU-14 + GPSRO to control 0.1-10 hPa layer. GPS-RO up to 0.1 mb soon available.

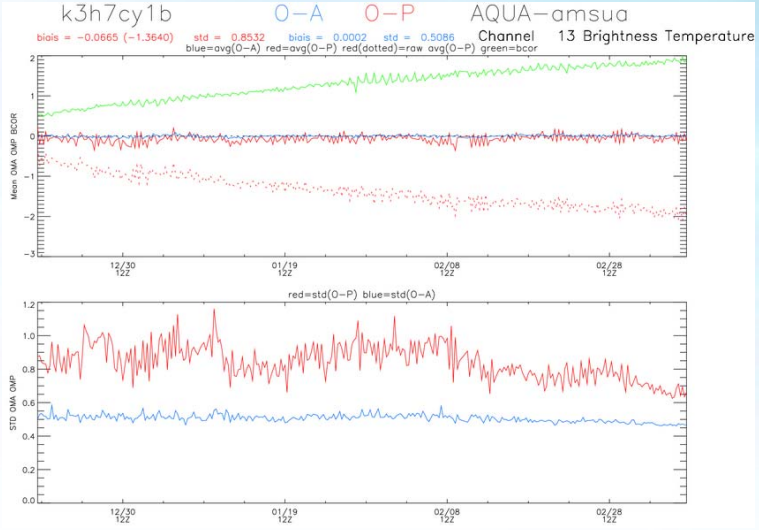
Issue: Drift with dynamic bias correction AMSU-A 11-14?

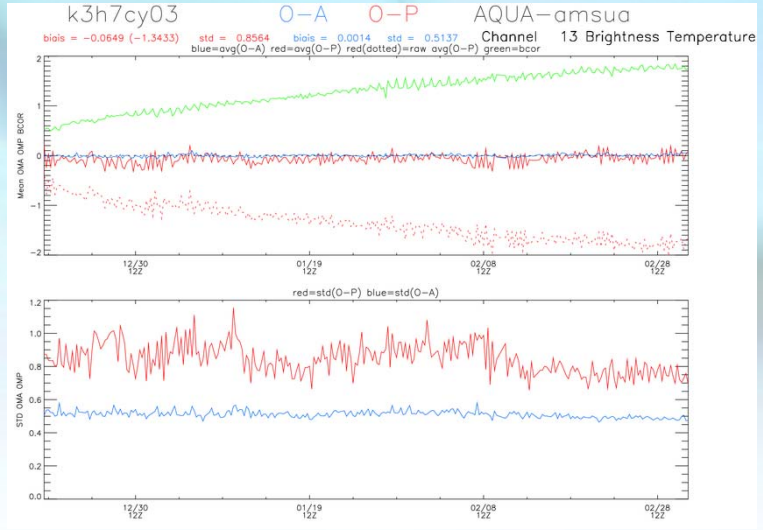
Dynamic BC ch 13 no GPSRO

same with GPSRO

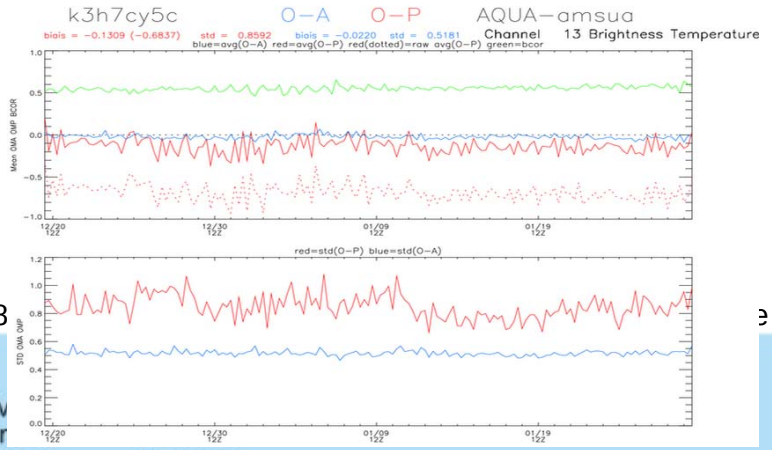
Bias

STD





Static BC ch 13 with GPSRO



Global BC _____

Global (O-P) ----------

System seems to drift with dynamic BC
GPSRO has little impact on ch 13 stats
Just a long cycle or real drift?
Current status: keep static BC for 11-14

Canada

Summary

Model lid raised to 0.1 hPa with:

- Improved model physics, hybrid coordinate
- Improved approach for background error statistics
- Use of GPSRO up to 40 km (soon 60 km)
- More AIRS channels (IASI soon !)

IMPACT:

- 6-12 hours of predictability gain at day 5, Geopotential 100 to 500 hPa
- Very large improvement above 200 hPa.

SYNERGY:

- Raising lid has highest impact in NH winter
- Adding AIRS has highest impact in SH for both seasons
- Adding GPSRO has similar impact in both hemispheres

ISSUES:

- Possible drift at model top with dynamical bias correction for AMSU-A 11-14
- AIRS tails can create large increments in stratosphere

Thank you!