

Inclusion of new data types in the Canadian data assimilation system

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Summary of the new components to be implemented

- AIRS radiance data (87 channels).
- SSM/I radiance data (+ eliminating AMSU-A ch3 and new cloud mask for AMSU-B).
- Going from RTTOV7 to RTTOV8.7 (and new vertical interpolator)
- Inclusion of high scan angle AMSU data.
- QuikScat oceanic surface winds (from KNMI).
- 3.9 micron AMV (nighttime low level winds).
- Dynamical bias correction for radiance data.

Current operational assimilation and forecast system

- ~35 km resolution global forecast model (GEM with 800x600 points and 58 eta levels).
- 4DVAR global assimilation with 6 hour window.
- 15 km regional forecast model over North America (58 eta levels).
- 3DVAR FGAT regional assimilation with 6 hour spin-up cycle launched from global cycle every 12 hours.

SSM/I: Radiances from all 7 channels onboard the DMSP13, DMSP14, and DMSP15* satellites

- Data**
Raw SSM/I file received through ftp link from NESDIS.
Nominal resolution of 25 km.
- Quality Control**
Removal of observation over land due to complexity of surface emissivity modeling.
Removal of data over ice and when CLW > 0.01 kg/m2.
- Bias Correction**
Scan position and air mass correction are applied.
- Thinning**
1 pixel per 200 km horizontal box.
- Assimilation**
Observation error variance is set to the total error statistic.
RTTOV8 is used as forward model or observation operator.

*data corrupted

Evaluation

Along with two 2 1/2 months global assimilation cycles with new data for summer and winter season, the proposed configuration was tested in parallel mode this winter from January 29 up to April 18 2008. Results shown compare the operational cycle (OPSLB) with the parallel cycle (PARGLB) that incorporated the above mentioned new satellite data and procedural changes.

Figures

Anomaly correlation compares difference between forecast and climatological values at model grid points, against the average value of the forecast anomalies over the domain of interest, with the average of the difference between analyzed and climatological values at model grid points, against the average of the analyzed anomaly over the domain of interest. A value of 0.6 is generally accepted as a lower limit of a useful model forecast.

Time series of forecast model variables (temperature) statistics (standard deviation) against observed values from radiosondes.

Summary of results

The impact of all individual modifications were extensively tested in both 3D-FGAT and 4D-Var experiments of at least 1 month. Several additional modifications were tested, but did not give sufficiently positive impact and were consequently not included in the final cycles. (NOT SHOWN)

The combined impact on the medium-range forecasts of the proposed modifications is consistently positive in all regions. The gain in predictability for the 5-day forecast is approximately 3-4 hours in winter 1-2 hours in summer during the test cycles.

The results shown here are for the current parallel cycle of the global model. A clear gain is noted for the anomaly correlation score over both north and south hemispheres. It is consistent with what was observed during experimental test cycles. The time series comparison of day to day performance of the geopotential field shows that the system with new data does regularly better the operational system, specifically over southern hemisphere where several busts seen at 500 hPa were avoided (although there are still episodes where this is not the case).

The regional model was also tested with the addition of the new data in experimental runs and in parallel mode. However the impact (NOT SHOWN) is not as large than in the global context partly due to the relatively short regional run cutoff (1h50).

Given the positive impact of the new data, The Canadian Meteorological Center will implement these changes to the operational system on ~May 7 2008.

Data volume increase per type (for a typical 6 hour period)

Operational system		New data	
RAOBS	50000	SSM/I	14000
Aircraft	55000	QuikScat	10000
Profilers	8000	AIRS	75000
Surface	13000		
GOES	5000		
SatWind	40000	SatWind	1500
AMSU-A	50000	AMSU-A	14000
AMSU-B	20000	AMSU-B	5000
Total	~240000	Total	~120000

➔ 50% Overall increase

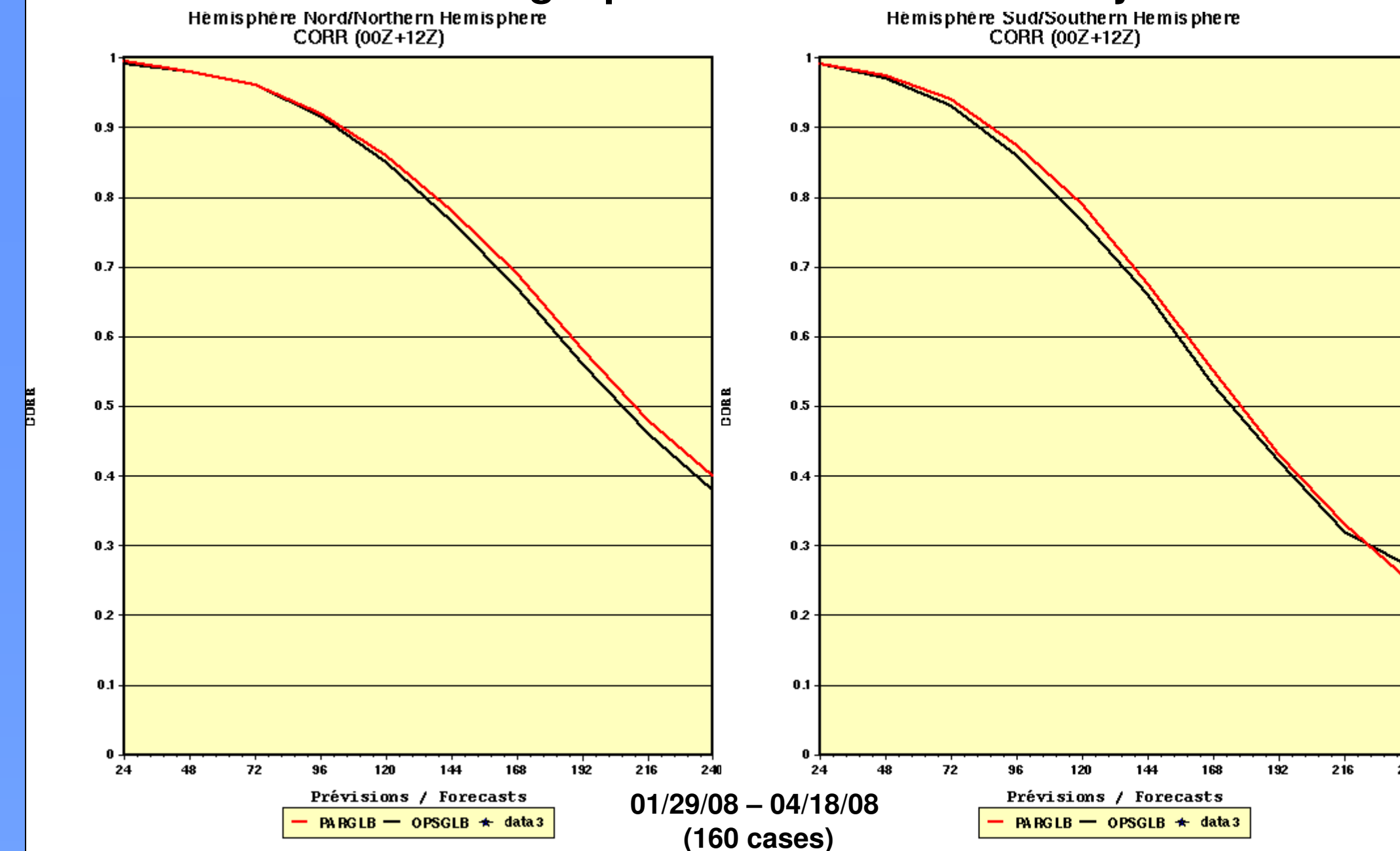
QuikSCAT: Surface wind derived from scatterometric measurements over water

- Data**
Near real time 10 m wind vector 100 km resolution from KNMI.
Data in BUFR format is gathered from ftp site.
- Quality Control**
KNMI Ambiguity removal www.knmi.nl/scatterometer/publications
KNMI quality indicator flag.
Accept winds speed > 4m/s.
- Assimilation**
Observation error of wind components is set at 1,7 m/s.

3.9µ AMV: atmospheric motion vectors from the near infrared channel onboard GOES satellites

- Data**
Received through GTS with similar processing than for other channels. This gives low level winds at night that complement the daytime low-level visible cloud drift observations.
- Thinning**
Horizontal resolution of 1.5 degrees.

Global model 500 hPa geopotential forecast anomaly correlation



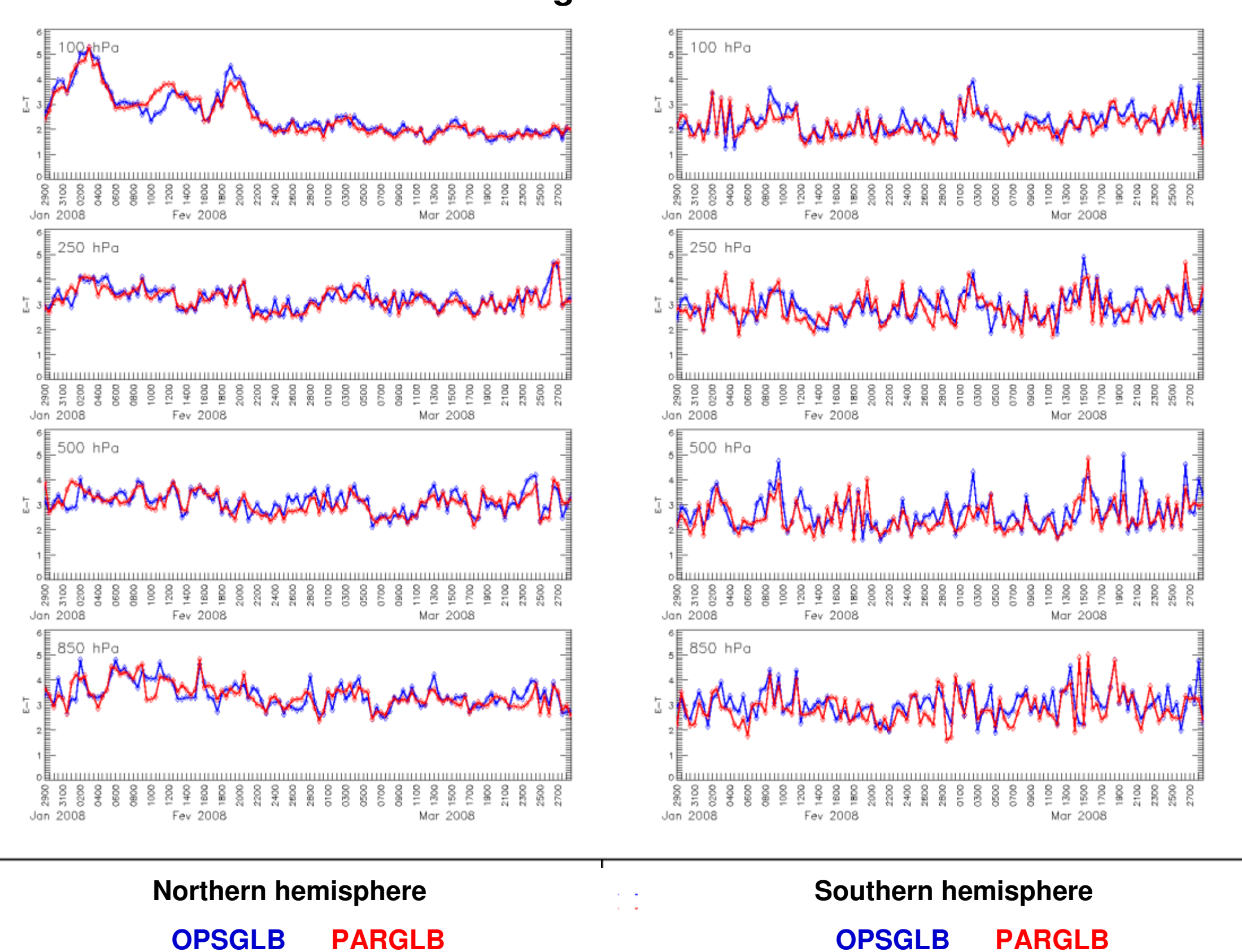
AIRS: Infrared hyper spectral radiances

- Data**
Subset of 281 channels received from NESDIS.
- Quality Control**
Radiance free cloud selection based on window channel and trial profile comparison.
In presence of cloud, only radiances sensing above cloud height estimated with CO2 slicing are kept.
No shortwave channel in daytime, no data over land/ice.
No data over water if surface emissivity <0.9
channel kept if NESDIS noise flag = 0.
- Channel selection: 87 channel**
4 highest peeking channels discarded at latitudes above 60 degrees North or South.
No/small contribution above NWP model top (10 hPa).
Good vertical sampling, low instrument noise.
Not or weakly affected by ozone or minor gases.
- Thinning**
250 km horizontal pixel selection.
- Assimilation**
Observation error variance is set to the total error statistic.
RTTOV8 is used as radiative transfer model with a new vertical interpolator.

Dynamical Bias Correction

- Online calculation of corrections for all radiance data every 6 hours of the global assimilation cycle based on the last 15 days. Correction applied on the next analysis
- Microwave**
Scan positions biases are removed and 2 air mass predictor are used with the Harris and Kelly scheme. Only ocean data is used for calculation.
- Infrared**
Observed brightness temperature as only predictor is used for the linear calculation of the correction. No ocean mask.

Global model 5 day forecast time series of the temperature standard deviation against radiosondes



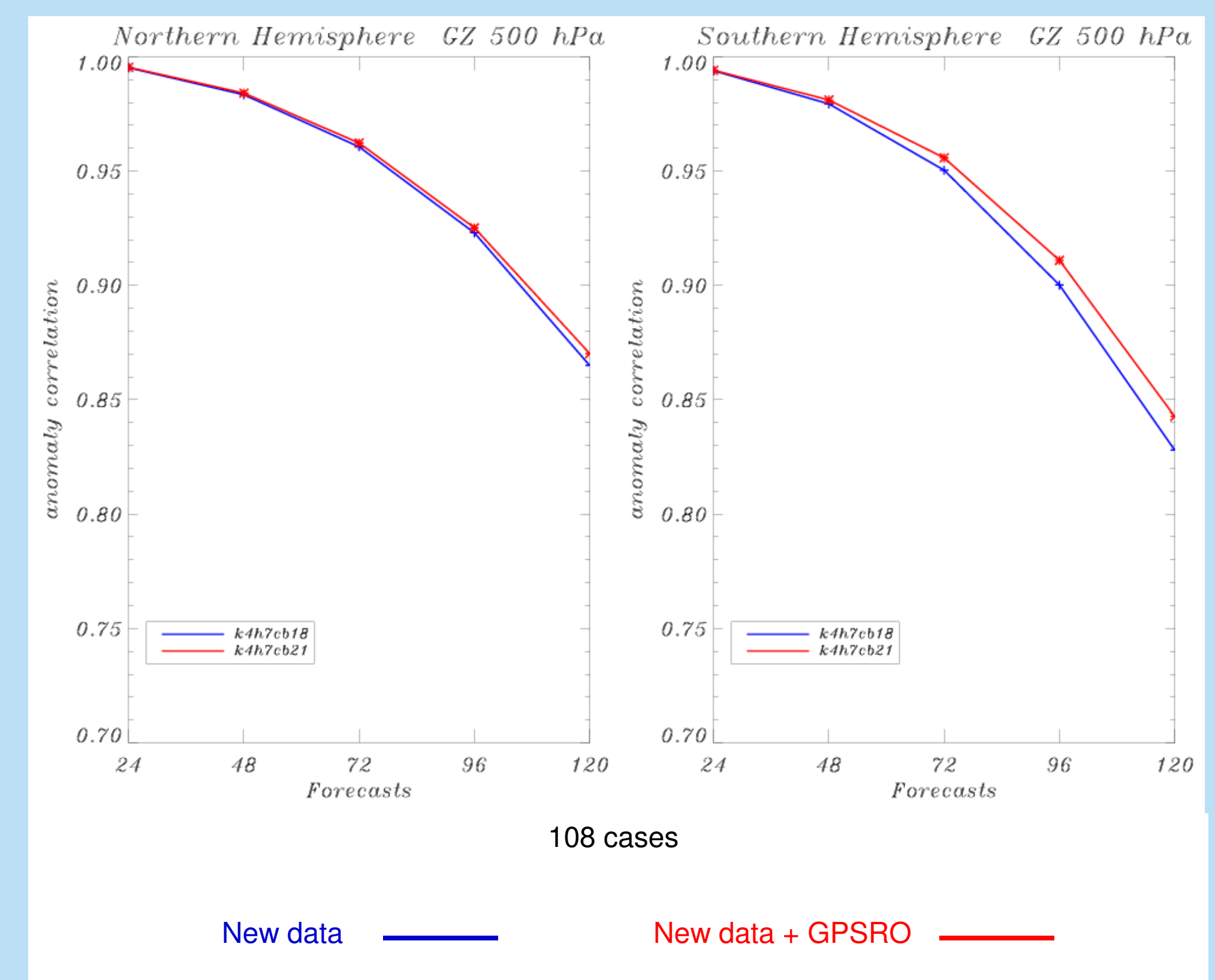
GPS RADIO-OCCULTATION IS NEXT DATA TYPE TO BE ASSIMILATED OPERATIONALLY

GPS RO Data in these experiments

- Satellites:
 - 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 ~25 data vertically (12000 assimilated data/step)
- Important:
 - All instruments are of the same type
 - There is no instrument-dependent calibration
 - GPSRO self-calibrates against SI
 - Only postprocessing & obs. operator could introduce bias
 - Although should be very small
- GPSRO assumed non-biased
 - Except at very low height (<2 km MSL)

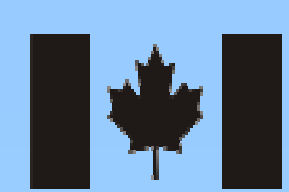
GPS RO data processing at EC

- Refractivity profiles versus MSL height (Level 2)
- Data thinning:
 - No more than 1 profile within 45 minutes and 300 km.
 - No more than 1 observation/vertical km (approximately 1 datum out of every 5, as profiles are usually received with 200m resolution)
- Vertical Clipping: Use data
 - above 4 km MSL
 - at least 1 km above background model surface
 - below model lid (10 hPa)
- Background Error Check
 - $-0.05 < (O-P)/P < 0.05$ where P is 6hr trial field
 - Translates approximately to accept
 - temperature innovations when lower than ~12 K
 - tropospheric moisture innovations lower than 25%



EVALUATION

Anomaly correlation for 108 winter cases during experimental winter cycle from December 27 2006 to February 18 2007 show predictability gain over both hemisphere. Improvement reaches 6 hours on day 5 for the southern hemisphere.
GPS-RO should be implemented operationally by end of summer 2008.



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