An Update on the Operational Use of Satellite Sounding Data at the Met Office

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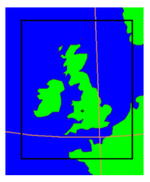
Operational System

Forecast Model

- Non-hydrostatic model with height as the vertical co-ordinate
- Global forecast model resolution ~25km (~17km from May 2014)
- Analysis resolution ~60km (~40km from May 2014)
- 70 levels in the vertical, model top is at 80 km (40km for LAMS)
- Global Main Forecast runs begin with cut off of 2 hours 45 minutes (update run cut off: 6 hours 15 minutes)

Other domains include:



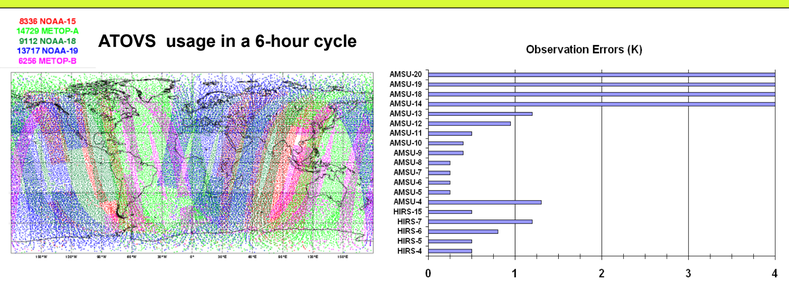
UKV 1.5 km model

Assimilation Scheme

- ***Observations Pre-processor***. Includes data thinning, bias correction (where necessary) & Bayesian quality control. For satellite radiance measurements a 1D-Var step is included to retrieve parameters such as skin temperature, cloud cover and surface emissivity, which are then used in 4D-Var.
- ***4D-Var***. Inner loops contain linear Perturbation Forecast model. Assimilation time window is six hours for global model (Rawlins *et al*, 2007). Forecast error covariance matrix derived from a coupled global ensemble blended with climatological covariances.

Microwave Sounders

Current Configuration



Channels Assimilated

	AMSU-A	AMSU-B / MHS	HIRS (clear only)
Metop-A	4-6, 8-14	3-5	4-7,11,12,15
Metop-B	4-14	3-5	4-7,11,12,15
NOAA-19	4-7, 9-14	3-5	---
NOAA-18	4-14	3-5	---
NOAA-15	5, 7-10, 12, 13	---	---

What's New Since ITSC-18

- Switch to RTTOV-9 (Parallel Suite 30, August 2012)
- Introduction of variable observation errors for AMSU-4 & 5 and HIRS 6 & 7 (PS31, January 2013)
  - ➢ R matrix constructed from errors due to instrument noise, clear air RT model errors, scan angle dependent uncertainties due to surface emission & cloud effects.
  - ➢ Some benefit (~1%) to SH forecasts (see Figure 1, right).
- Withdrawal of AMSU -1 & 2 (PS31, January 2013)
  - ➢ Anomalously large increments (in T) near SH ice edge.
  - ➢ Data denial gave benefit.
- Introduction of MetOp-B ATOVS (January 2013)
  - ➢ Data Thinned together with MetOp-A.
- Introduction of ATMS (PS32, May 2013)
  - ➢ Channels 6-15 (**R** = 0.35K) & 18-22 (**R** = 4K).
  - ➢ Positive impact (1-2%) in SH (Figure 2 – top).
  - ➢ Striping effects evident, due to 1/f noise in preamplifier (Fig 2).

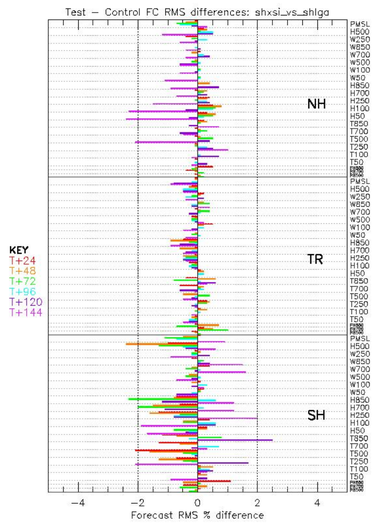


Figure 1. Forecast verification for variable observation error change (AMSU-4 / 5 & HIRS-6 / 7). Verification is relative to observations. Changes in RMSE shown for forecast day 1 to day 6 in NH, Tropics and SH.

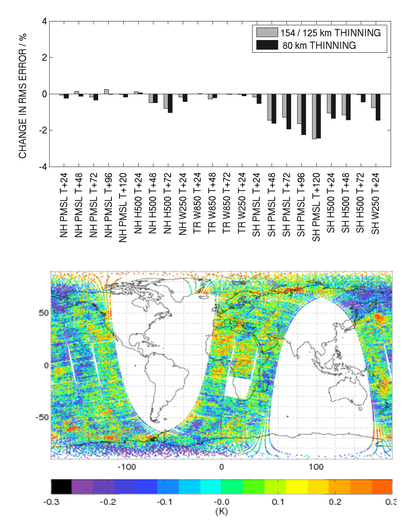


Figure 2. (Top) ATMS forecast verification when ATMS introduced into a full observing system. (Bottom) ATMS channel 8 (54.94 GHz) first guess departures, illustrating striping effects due to 1/f noise. See Doherty *et al* 2012, 2014

Advanced IR Sounders

AIRS

- Warmest field of view dataset used
- 1D-Var analysis of cloud top pressure and cloud fraction. Assimilate cloudy radiances with Jacobians peaking above cloud top
- Sea: 140 channels assimilated
- Land: 46 channels assimilated
- Observation errors:

  Temp sounding channels 1K
  Water vapour band 4K
  Window channels 1K

IASI

- 1 pixel from 4 chosen using most homogeneous field of view from AVHRR
- 1D-Var analysis of cloud top pressure and cloud fraction. Assimilate cloudy radiances with Jacobians peaking above cloud top
- Surface emissivity and skin temperature analysed in 1D-Var
- Sea: 138 channels assimilated
- Land: 131 channels assimilated by night (high-peaking channels only by day.)
- Inter-channel correlations are accounted for. Diagonal error values (see Figure 5) are used:

  Temp sounding channels ~0.4 K
  Water vapour band ~0.8 K
  Window channels ~0.4 K

What's New Since ITSC-18

- **Introduction of S-NPP CrIS (May 2013)**
  - ➢ Excellent data quality, especially radiometric sensitivity. STD (O-B) for clean stratospheric channels ~0.15K .
  - ➢ 1 fov (warmest) from field of regard
  - ➢ 1D-Var analysis of cloud top pressure and cloud fraction
  - ➢ 134 channels (76 temperature, 45 water-vapour, 13 surface)

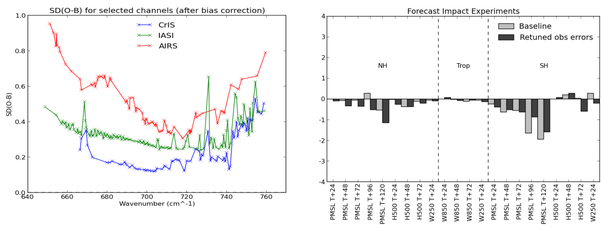


Figure 3. (Left) departure statistics for CrIS, AIRS and IASI, illustrating excellent radiometric performance of CrIS. (Right) forecast verification for CrIS assimilation experiments, showing results for conservative observation errors (0.5K, 1-2K, 4K for lower atmospheric T-sounding, other T-sounding and water vapour sounding channel respectively), and retuned errors (R=2×STD(O-B)). See Smith *et al*, 2014.

- **Introduction of MetOp-B IASI** (February 2013)
  - ➢ Excellent data quality. Modest forecast improvements (see Figure 4)
  - ➢ Thinned together with MetOp-A IASI initially. (23% more IASI data)
- **Treatment of correlated errors for IASI** (PS31, January 2013)
  - ➢ Errors diagnosed using method of Desroziers, then **R** reconditioned.

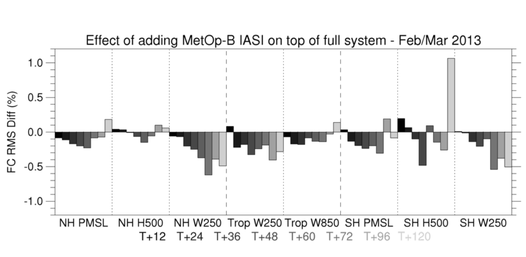


Figure 4. Forecast verification for the introduction of MetOp-B IASI in a full system. Verification is relative to observations. Changes in RMSE shown for forecast day 1 to day 5 in NH, Tropics and SH. See Cameron *et al*, 2013

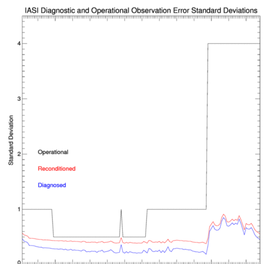


Figure 5. Diagonal elements of IASI R matrix for operational, diagnosed and reconditioned matrices. See Weston *et al*, 2013

What's Next / Work in Progress

- **ATOVS**. Dynamic emissivity retrieval over land. New radiative transfer coefficients - based on revised channel centre estimates. Use of diagnosed observation errors.
- **AIRS**. Use of diagnosed error covariances.
- **AIRS / IASI / CrIS**. Active ozone and CO_2 fitting in 1D-Var, leading to reduced biases.
- **All instruments**. Introduce updated error covariance matrix for 1D-Var scheme created via randomisation method. Introduction of VarBC.
- **CrIS.** More aggressive use over land**.** Surface emissivity retrieval over land**.** Use of diagnosed error covariances.
- **ATMS**. Review bias corrections. Improved treatment of striping and reflector emissivity.
- **SSMIS**. Assimilation of F17 and / or F18 radiances, and assessment of F-19. Improved orbital bias correction in VarBC. Use of channels affected by Zeeman splitting.
- **FY-3**. Assessment and assimilation of data from FY-3B and FY-3C.
- **AMSR-2**. Assessment and assimilation of GCOM-W AMSR-2 data.

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