Does the ATOVS RARS Network Matter for Global NWP?

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1.   Introduction

Along with other global numerical weather prediction centres, the Met Office routinely assimilates data from Regional ATOVS Retransmission (RARS) networks, such as the EARS service provided by EUMETSAT. Recently additional data has been made available for the Asia-Pacific and South American regions. In this study we investigate the forecast impact of using this data in addition to the standard global ATOVS datasets. We also examine the forecast benefit if all ATOVS data arrived in time to make the main forecast runs. This latter study gives insight into geographical areas in which extensions to the RARS network would be useful.

2.   Sources of ATOVS data

The main ATOVS data used at the Met Office are the global dumps arriving at the 1b level (antenna temperatures) from NOAA/NESDIS for NOAAs 15 to 18. Global MetOp data at the 1c level (brightness temperatures) arrives via EUMETCast. NOAA-18 1c data also is disseminated via this route and provides a level of robustness. In addition to these global streams, data from RARS stations arrives via ftp and EUMETCast at the 1c level.

Data from each RARS station is routinely checked for the following:

- Consistency of brightness temperatures against global equivalent

- Consistency of navigation against global equivalent

- Data delay (time between the observation and its arrival in the Met Office database)

- Robustness – how often does each station miss all available passes in 24 hours

Monitoring of the above is available on an external website (see Section 6). Figure 1 shows an example of the brightness temperature consistency check.

3.   Use of RARS data in Operations

During a six hour assimilation window the volume of RARS data (from 17 stations) is typically in excess of 200000 observations. This is a large amount of data and so a duplicate check is applied prior to quality control and 1D-Var retrievals. Within this check observations from the same satellite that are within 20 km apart are considered duplicates, from which the global data is given preference. Consequently the RARS data is used to fill in regions where the global data did not arrive in time. At each analysis time (0, 6, 12, 18 UTC) two assimilation/forecast runs are performed, a main run and an update. The main run is the most time critical as the forecasts go out to two days, and at 0 and 12 UTC, to five days. Currently the main run starts 2 hours 45 minutes after the nominal analysis time, i.e. the 12 UTC run starts at 14:45 UTC. At six hours after the nominal analysis time an update run is performed, whose purpose is to provide a six hour forecast for the next cycle. Because of the time constraint it is in the main run analyses that we expect RARS data to be of most use, although it will also be of benefit in the update analyses should the global stream suffer an outage.

Figure 2 shows the RARS data that has passed the duplicate check for a series of main run. Note the large amount of NOAA-16 data which is being supplied by RARS. This is because over 24 hours several orbits from this platform suffer appreciable delays via the global stream.

Once the duplicate check has been performed the global and RARS data streams are treated in an identical way through the pre-processing and assimilation, with the exception of channels from the HIRS instrument. These are rejected from RARS stations and not used in the assimilation step, due to the likelihood of missing calibration scans at the beginning and end
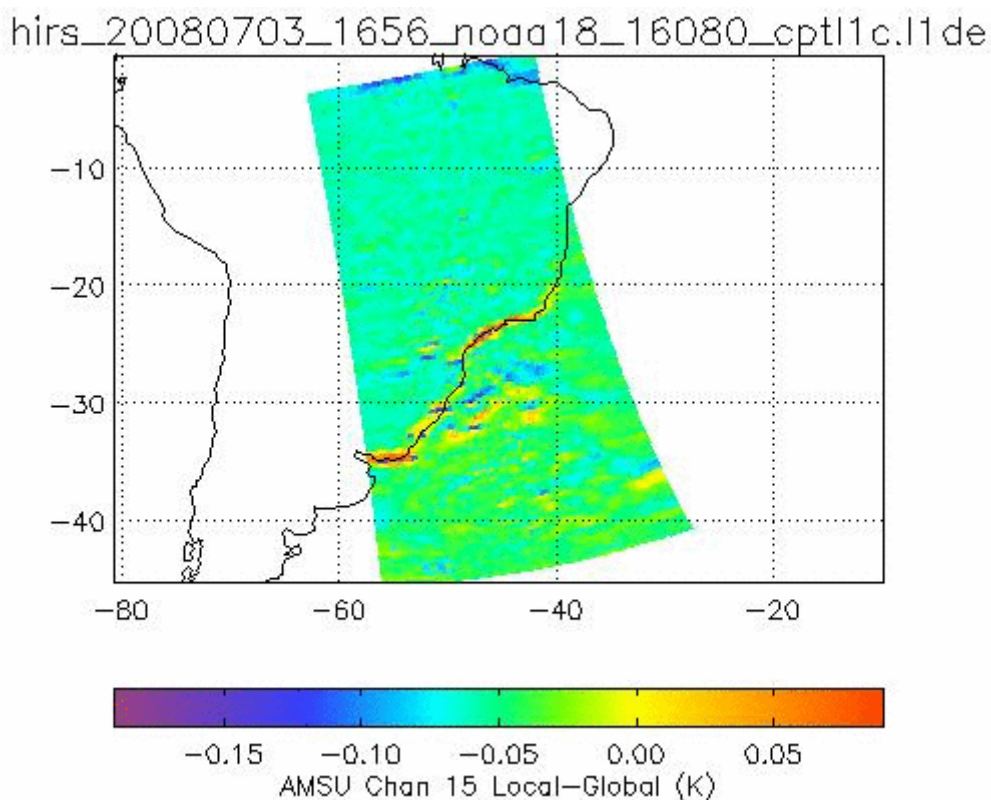

Figure 1: The brightness temperature difference between RARS and the corresponding global data for AMSUA channel 15 mapped to the HIRS grid. The RARS ground station is Cachoeira Paulista in Brazil.
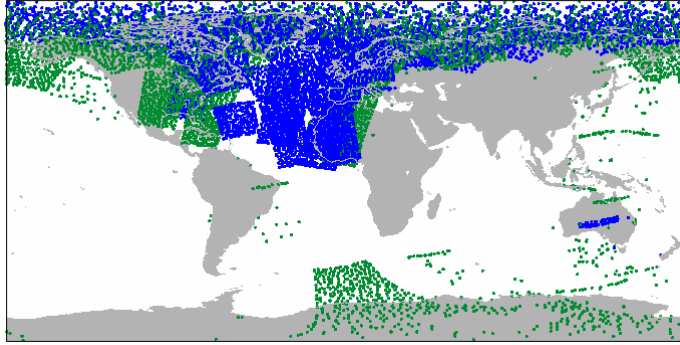
Figure 2: RARS data passing the duplicate check for 4 assimilation cycles. Key: Green NOAA-18, Blue NOAA-16.

of the overpass, which can lead to significant differences in the brightness temperatures between the global and local streams for this instrument. Figure 3 shows that typically around 25% of the satellite observations made during each assimilation window do not arrive in time via the global stream to make the main forecast runs, though on several occasions the loss can be in excess of 40%. The current network of RARS stations helps to fill in and typically recovers around 30% of the missing data.
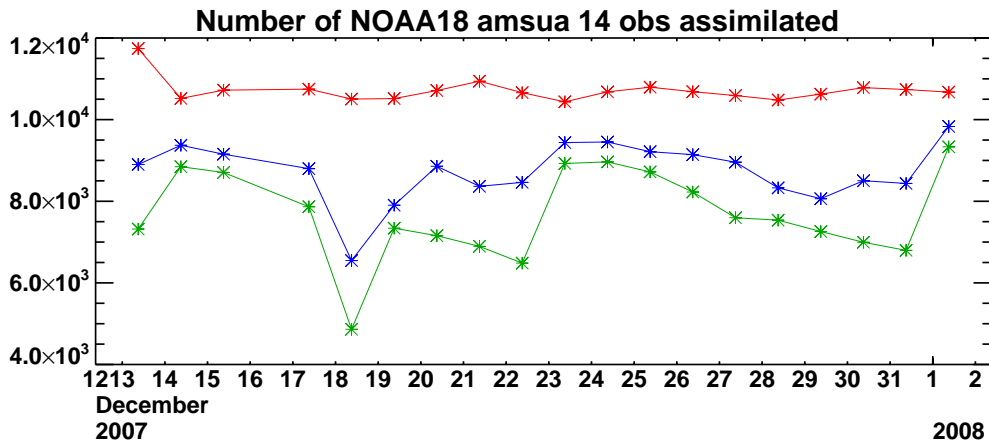

Figure 3: The number of ATOVS observations assimilated from the NOAA-18 platform for main forecast runs during mid December 2007 to early January 2008. Key: Green – data from global ATOVS dumps arriving in time, Blue- global dumps + 17 RARS stations, Red: ATOVS global data regardless of arrival time.

4. The Impact of RARS in NWP

4.1 Robustness

Whilst the dissemination from NESDIS of the global stream is very reliable, there are occasional outages. In these cases RARS provides a useful backup as demonstrated by Figure

4 which shows the last occasion during which the global stream from NOAA platforms was unavailable.
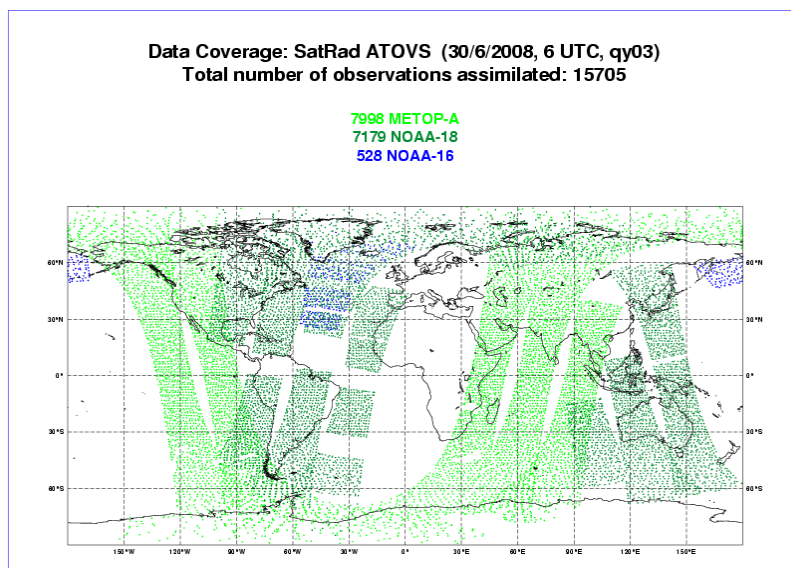

Data Coverage: SatRad ATOVS (30/6/2008, 6 UTC, qy03)
Total number of observations assimilated: 15705

7998 METOP-A
7179 NOAA-18
528 NOAA-16

Figure 4: An example of the amount of ATOVS data assimilated if the global stream from NESDIS was unavailable.

4.2 RARS Forecast Impact Experiments

In section 3 it was shown that a significant amount of ATOVS data is missing from the main forecast runs and so in the following section the impact of using this late data is investigated, along with an assessment of whether the RARS network can recover some of this impact.

This work follows on from an earlier study by Candy et al. (2004) which demonstrated that the late ATOVS data does have a useful forecast impact of between 1 and 4% in the 500 hPa height in the extra-tropics. The study also showed evidence that some of this impact was recovered by using data from the EARS network.

The investigation has been repeated as we now have a better distribution of RARS stations (Figure 5). However there are several factors which may result in a reduced impact from the late ATOVS data:

- 2004 study used AMSU data from three satellites (NOAAs-15, 16 & 17), in 2008 four satellites are assimilated (NOAA-16,17 (HIRS only),18 & MetOp-A).

- Svalbard downlink is now used for MetOp-A and certain orbits of NOAA-18 so timeliness of global stream improved for these platforms.

- In 2004 the sole satellite sounding information was provided by ATOVS, in 2008 AIRS, IASI & SSMIS are also operationally assimilated.

- In 2004 main run was started 2 hrs after analysis time, In 2008 this has been relaxed to 2 hrs 45 mins, so the amount of late data is reduced.
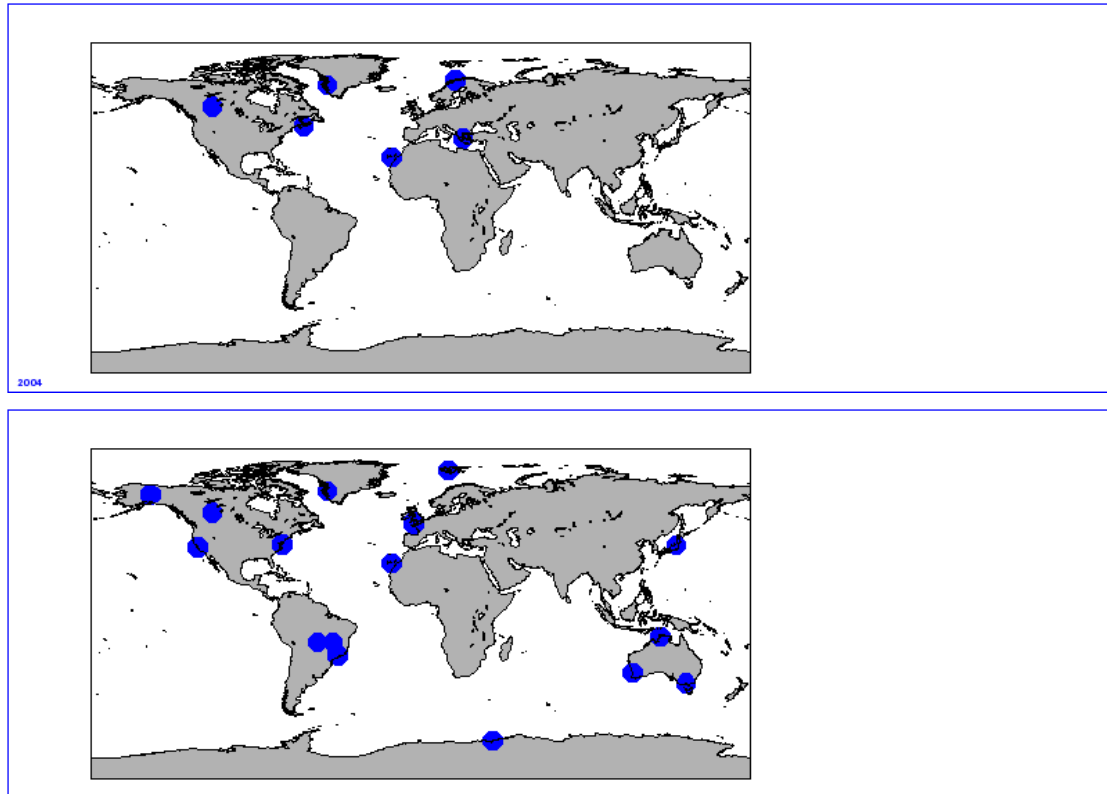
Figure 5: The RARS stations used in the 2004 study (top panel) and in the 2008 study (bottom panel)

A control run of the global assimilation and forecast system was performed during mid-December 2007 to mid-January 2008 in which observations were assimilated as in operations, apart from ATOVS, which only used data from the global stream. All data arriving beyond a certain time limit was not used in the assimilation. This was set to 2 hrs 45 mins after the analysis time of each main run and mimics the operational schedule. Hereafter this run is referred to as *ATOVSG*. Two experiment runs were then performed:

- *RARS.* As *ATOVSG* and also RARS data from 17 stations for NOAAs 16 & 18.

- *ALL ATOVS.* As *ATOVSG* but the time limit is ignored for ATOVS observations only, i.e. all observations in the global stream are used regardless of their arrival time.

The forecast impact of the *RARS* and *All ATOVS* experiments against the control is summarised in Figure 6. This shows the impact on pressure at mean sea level (PMSL) forecasts for both northern and southern extra-tropical regions. The impact of the late global stream data that does not make the main run forecasts is significant, particularly in the Southern Hemisphere. The impact from the current RARS network is smaller, although provides a useful impact at long range (beyond 72 hours) in the Southern Hemisphere. This impact is perhaps smaller than might be expected, however it should be noted that for the principle ATOVS satellites used at the Met Office the RARS service only supports NOAA16 & 18, as currently the MetOp satellite does not broadcast the HRPT stream.
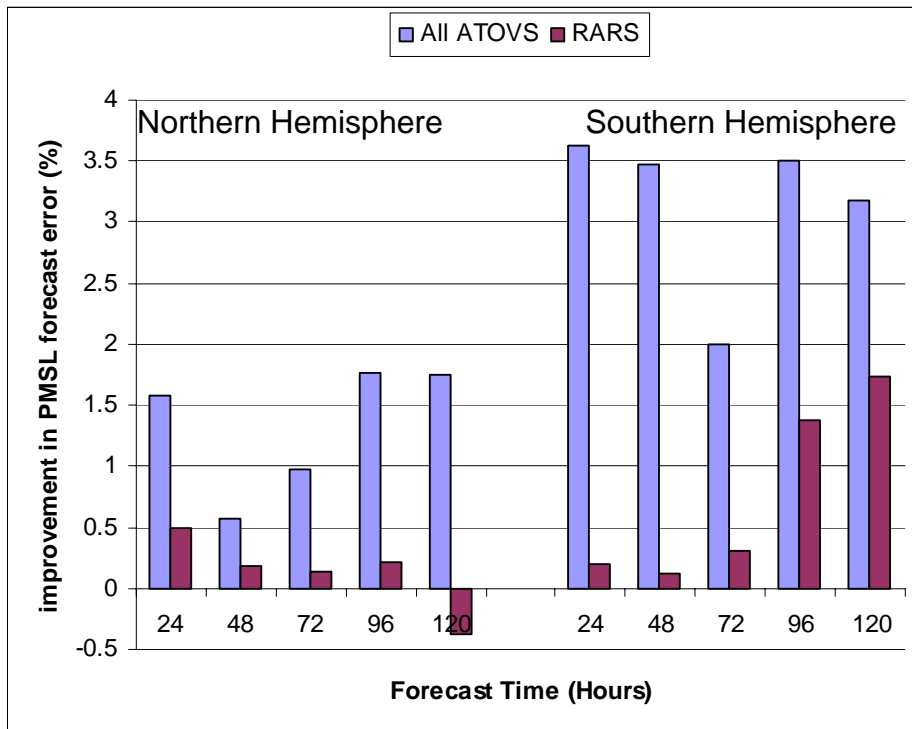
Figure 6: The forecast impact in the *All ATOVS* and *RARS* experiments.

Given the increasing number of RARS stations providing data it is instructive to examine the regions that are most sensitive to the late ATOVS data. In Figure 7 the RMS difference between the *All ATOVS* and *ATOVSG* main run analyses is shown. The largest differences are in the Southern Ocean and in the North Pacific regions and so it is potentially in these regions where further RARS stations would be of most benefit.
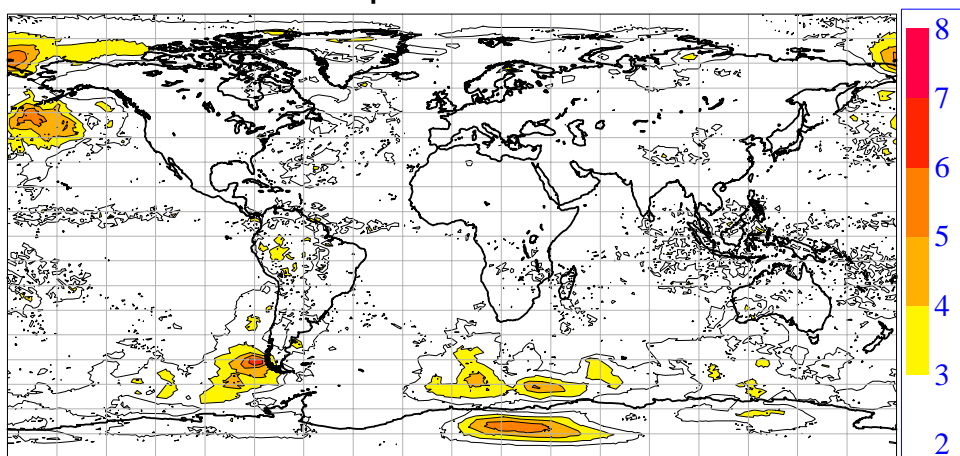

Figure 7: The RMS difference between the main run analyses at 12 UTC from the *All ATOVS* experiment and the *ATOVSG* control.

5.   Conclusions

The RARS network has grown considerably over the last four years and now contains stations in both hemispheres. Global coverage has grown from ~25% to ~60%. This increased coverage makes it a useful auxiliary source of data in global models, both for robustness should the global stream be interrupted, and to provide more observations in the time-critical main forecast runs.

Experiments carried out during winter 2007/08 demonstrated that the late ATOVS data which does not make the main forecast runs has a significant forecast impact, even in an assimilation system that uses sounding data from several diverse systems such as AIRS and SSMIS. This shows that timeliness of the sounding data is still an important issue and use of the RARS network helps to recover some of the lost impact, particularly in the Southern Hemisphere.

Analyses appear to be most sensitive to the late ATOVS data in the Southern Ocean and North Pacific regions. Data from Argentina and the Antarctic Peninsula are also now available, while further expansion is expected during 2008 and 2009 – e.g. Hawaii, Fiji and La Réunion. These will be added at the earliest opportunity to the 17 RARS stations already used in Met Office operations.

6.   References and Websites

B. Candy, A. Doherty, S. English & R. Saunders: 2004. The Use of EARS Data at The Met Office. *In Proc. of the 2004 EUMETSAT Meteorological Satellite Conference, Prague, Czech Republic.*

NWP SAF Regional and Global ATOVS intercomparison Website:
http://www.metoffice.gov.uk/research/interproj/nwpsaf/index.html