Timeliness and impact of observations in the CMC global NWP system

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1 Introduction

The focus of this extended abstract is the impact of satellite data in CMC global NWP system in relation to the timeliness of the distribution of the observations. To satisfy operational requirements NWP centres such as the CMC must distribute short and medium range forecast to the users rapidly after the initial time.

CMC continuous assimilation cycle is a 6-hourly 3D-Var system. The observations cut-off times are T+9 hrs for 00 and 12 UTC analyses and T+6 hrs for the 06 and 18 UTC analyses. These relatively long cut-off times are used in order to wait for the arrival of most of the observations before doing the analyses. Operational forecasts are issued twice a day at 00 and 12 UTC. But the forecasts must be issued before the delay imposed by the final analyses of the assimilation cycle. So the global forecasts are made from an early analysis with a T+3 hrs observational cut-off time. Given the current reception time of some observations, especially circumpolar satellite observations, a reduced volume of observations is included in the analyses used for the operational forecast. Regional forecasts are produced from analyses with an even shorter cut-off time of T+1 hr 40.

CMC operational global forecast model has a horizontal resolution of 0.9° and 28 eta levels in the vertical. The analysis program is a 3D-Var assimilation program on model surfaces at a spectral resolution of T108. Background errors were obtained from the so-called 24-48 hr method. The observation quality control is done with a background check prior to the analysis and a variational QC during the analysis process itself.

During the last 3 years an important improvement in the quality of CMC short-term forecast has been obtained by the inclusion of ATOVS radiance observations from NOAA satellite. In the following sections, the results of observing system experiments, where one type of observation is completely removed from the assimilation, will illustrate the impact of such observations in CMC NWP system compared to conventional radiosonde observations.

Also, we have conducted an experiment to evaluate the impact of various observational cut-off times by running a series of assimilation cycles with more or less rapid updates. The volume of ATOVS radiance observations varies significantly when using short cut-off times, and the impact on the quality of the NWP is important.

2 Observing system experiments

During the year 2002, we have conducted a series of observing system experiments (OSEs) to evaluate the impact of various types of observations in the CMC NWP system. In these experiments one or more type of observation is removed from the assimilation and the impact on the forecast quality gives an indication of the value of that type of observation in the system. The evaluation was done on two 6-weeks period, winter: from 2001121800 to 2002012712, and summer: 2002061700 to 2002073112. During these two periods, we ran 6-day forecasts twice a day at 00 and 12 UTC, from the final analyses of the modified assimilation cycle.

Figure 1 shows a comparison of the impact of ATOVS radiances and conventional RAOBS soundings. For the Southern Hemisphere, clearly the impact of the satellite observations dominates over the rather sparse network of radiosonde sites. In CMC system, for the Northern Hemisphere, the RAOBS and ATOVS have a similarly important impact on the quality of the forecasts.

In the Tropics RAOBS and ATOVS observations also have a similar impact, but the impact obtained with the denial of all satellite data, ATOVS and AMVs, shows that satellite observations clearly dominate in that region. These results are partly related to the interactions between ATOVS and AMVs data, since loosing both types of observations has an impact larger than the sum of the impact of loosing these types of observation one at a time. The result is also true in the Southern Hemisphere, where the impact of loosing both AMVs and ATOVS is also more important.

3 Reception times and impact of cut-off times on NWP

The reception time of conventional observations does not usually suffer from excessive delays. The automated aircraft observations are received quite rapidly after observation time. Surface observations are also usually available in good number for the earliest analyses. Some of the radiosonde soundings are missing for the regional analyses with a short cut-off of T+1 hr 40, but given that it may take up to 1 hr 30 to complete the ascent, most are received at CMC in the expected time delay.

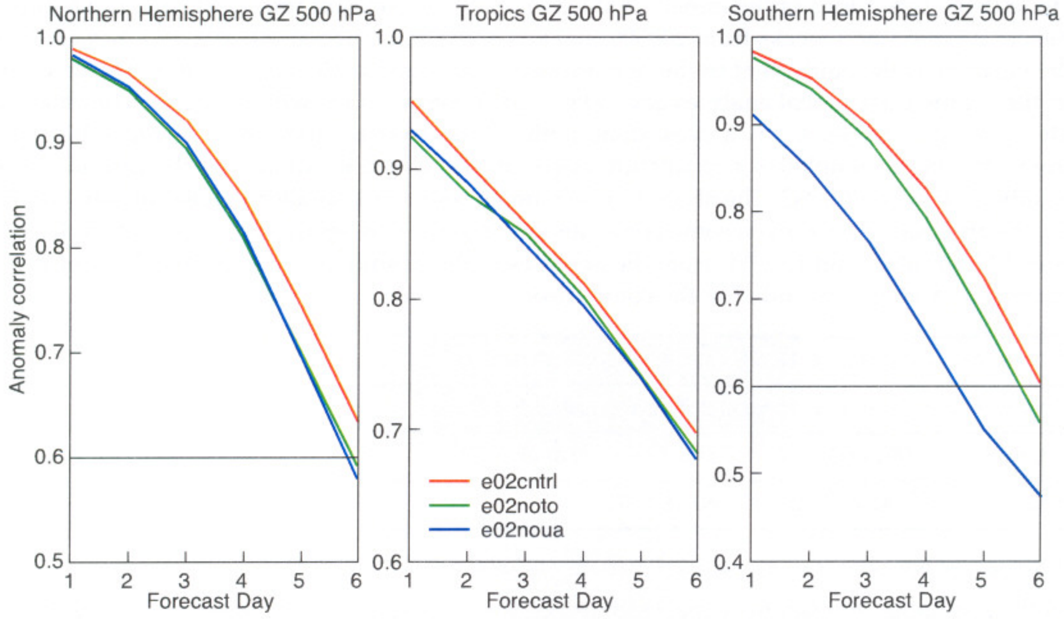

Fig. 1 Summer period impact of the removal of ATOVS vs. the removal of radiosondes, 6-day forecasts anomaly correlation of the 500 hPa geopotential heights for 3 latitudes bands; red line: control, blue line: no ATOVS and green line: no radiosonde observations.

For satellite data, the AMVs are normally available about one hour after observation time, since a triplet of images is needed to compute the winds; it is as fast as can be expected. The situation is different for circumpolar satellite data. For example, the availability of ATOVS data from NOAA satellites suffers from the fact that only 2 reception stations are currently used to gather the data. This situation results in blind orbits in which the data must be kept until the satellite comes back in view of one of the reception station. The blind orbits results in a delay of about 5 hours in the reception and processing of ATOVS data. Figure 2 shows an example for NOAA-15 satellite 06 UTC period. The data starts to be received a little less than one hour after the beginning of the period, but a 5-hour interruption occurs in the reception. At T+3 hrs only 40% of the data has been received and even at the longer T+6 hrs cut-off time of the assimilation cycle only about 50% of the data is available. Similar delays occur for all NOAA satellites at different period of the day.

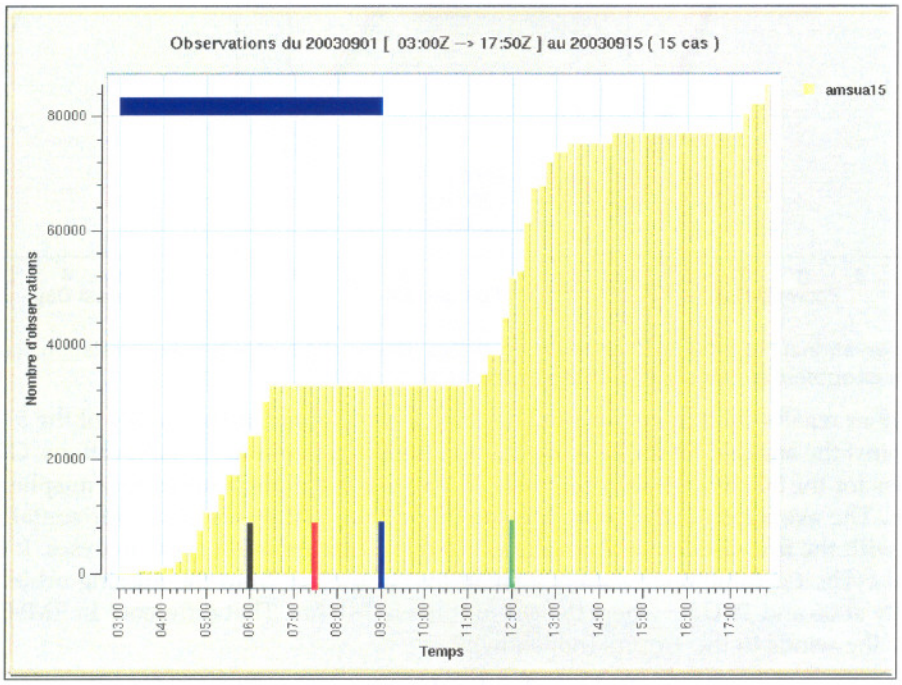

Fig. 2 Reception time of AMSU-A ATOVS observations, period 06 UTC and NOAA-15 satellite, average from 01 to 15 September 2003. The thick horizontal blue line represents the validity period of the observations, the ±3 hrs time window; the short vertical black line is the synoptic or analysis time, the red line the T+1 hr 30 cut-off time, blue line the T+3 hrs cut-off time and green line the T+6 hrs cut-off time.

In order to obtain a better idea of the impact of short observational cut-off times, we have run 4 different assimilation cycles for a period of 5 weeks from 2003083100 to 2003100412. The various cut-off times are listed in table 1 below. The G2 cycle is the equivalent to the operational assimilation cycle, G1 is a rapid update cycle using the observation files of the early global analyses and G0 is a quick update done with the observation files of the operational early regional analyses. G3 is a cycle done with a longer cut-off time of T+24 hrs, which should leave enough time to include a complete set of satellite observations, which is not always the case in the operational cycle, especially at 06 and 18 UTC. The shorter cut-off times result in a smaller volume of satellite observations available for the analyses. For G0 even some conventional observations are missing. For each cycle, we ran 6-day forecast every 12 hour at 00 and 12 UTC from the analyses of the assimilation cycles. A fifth set of forecasts, OPS, the operational forecasts, was included in the comparison.

G0: cut-off time: T+1 h 40 at 00 & 12 UTC at T+1 h 20 at 06 & 18 UTC.
G1: cut-off time: T+3 h 00 at 00 & 12 UTC at T+2 h 00 at 06 & 18 UTC.
G2: cut-off time: T+9 h 00 at 00 & 12 UTC and T+6 h 00 at 06 & 18 UTC.
G3: cut-off time: T+24 h 00 at 00, 06, 12 and 18 UTC

Table 1 List of the 4 assimilation cycles done with various cut-off times.

In general the evaluation follows the expected pattern; fewer observations included in the analyses results in a lower quality of the resulting forecasts. Figure 3 shows a comparison of the forecasts made from 3 of the assimilation cycles, the operational cycle G2, rapid update cycle G1 and the very early one G0. Similarly to the results obtained in the OSEs, the impact of the reduced volume of satellite observations is significant and larger in the Southern Hemisphere and the Tropics.

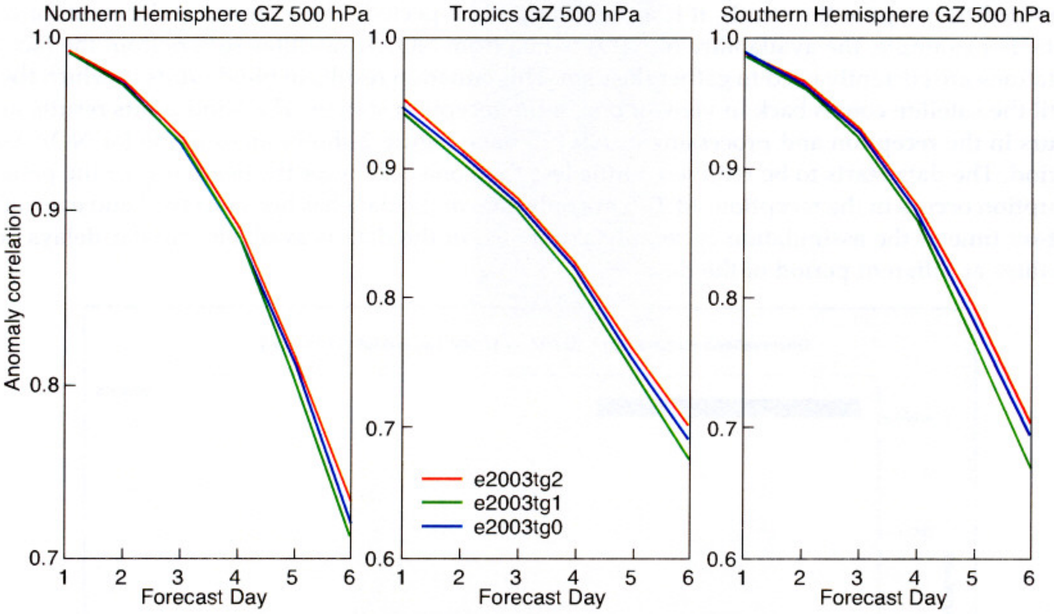

Fig. 3 Impact of observational cut-off time in assimilation cycles. Comparison of anomaly correlation scores for 6-day forecasts 500 hPa geopotential heights of 3 of the assimilation cycles.

Figure 4 shows other results from these experiments with a comparison of the quality of the 5 series of forecasts when verifying against the analyses of the cycle containing the largest volume of observations, G3. They are RMSE and BIAS time series for the 500 hPa 24-hour forecasts of temperature in the Southern Hemisphere throughout the 5-week verification. The averages for the series are shown on the right by the short horizontal lines. The lowest RMSE is obtained with the forecasts made from the G3 (red line) assimilation cycle analyses. It indicates that the current operational cycle, G2 (blue line), suffers a small loss of quality from the missing orbits of satellite data, which occurs mainly at 06 and 18 UTC where the cut-off time is T+6 hrs. That difference in RMSE was found to be more important for the winds in the Tropics (not shown).

Similarly the operational forecasts results (cyan line), suffers from a small loss of quality compared to the forecasts made with the analyses of the G2 cycle. Again, this is due to the reduced volume of observations in the early global analyses used to make these forecasts. This is one example of the cost in lost quality that we have to pay for operational NWP with short cut-off time.

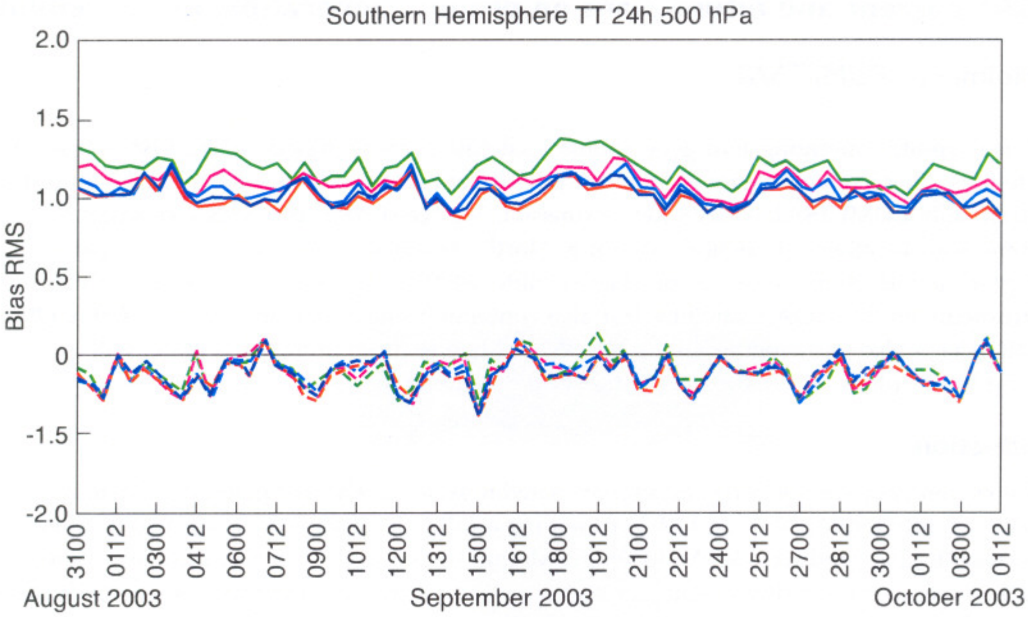

Fig. 4 Comparison of the 5 series of forecasts, 24-hour forecasts RMSE and BIAS of the temperature in the Southern Hemisphere, verification against analyses. Red: e2003tg3, blue: e2003tg2, cyan: e2003ops, magenta: e2003tg1, green: e2003tg0.

The quality of the forecasts falls more rapidly when using analyses from the global rapid update cycles as seen by the increased RMSE for the G1 and G0 cycles. The results of these experiments illustrate in different way the importance of the satellite data in CMC NWP suite and have shown that given the current delays in the reception of satellite data from the circumpolar satellites, the operational assimilation cycle set-up occasionally suffers from the lost data due to the T+6 hrs cut-off time. It also shows that the operational forecasts are affected by a small loss of quality due to the use of early analyses.

4 Conclusions

Satellite observations currently have a large impact on the quality of CMC NWP suite. In general, this impact dominates the other observing systems. Given the time delays in the reception of such data, we must maintain an assimilation cycle with relatively long cut-off times. The quality of operational forecasts, which must be issued from early analyses, suffers from the reduced volume of observations.

During next year the global forecast model horizontal resolution will be increased to about 35 km and the number of vertical levels to about 80. That change of forecast model will be coupled with the passage from a 3D-Var to a 4D-Var scheme in the operational assimilation cycle. Following these important modifications to the NWP suite, a very large increase in the volume of assimilated data is expected by the inclusion of new satellite data sets.

Planning and investment in timely reception and processing of satellite data is essential to realise the full potential of these observing systems in operational NWP suites.

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