Challenges in Satellite Data Monitoring

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1. Introduction

The amount of satellite data available for use in Numerical Weather Prediction (NWP) models has been steadily growing in the past decades. With satellite instruments like the Advanced InfraRed Sounder (AIRS) now being used in the ECMWF assimilation system, the amount of satellite data has increased massively and will continue to do so as more high-spectral resolution infrared instruments are on the horizon.

Because of its growing data volume and improvements in its usage in the ECMWF assimilation system, satellite data has surpassed radiosondes in being the most important element of the global observing system (GOS) in terms of forecast impact. Figure 1 shows the impact of various elements of the GOS on the skill of the ECMWF forecast for geopotential height at 500 hPa (Kelly 2004). The importance of satellite data over

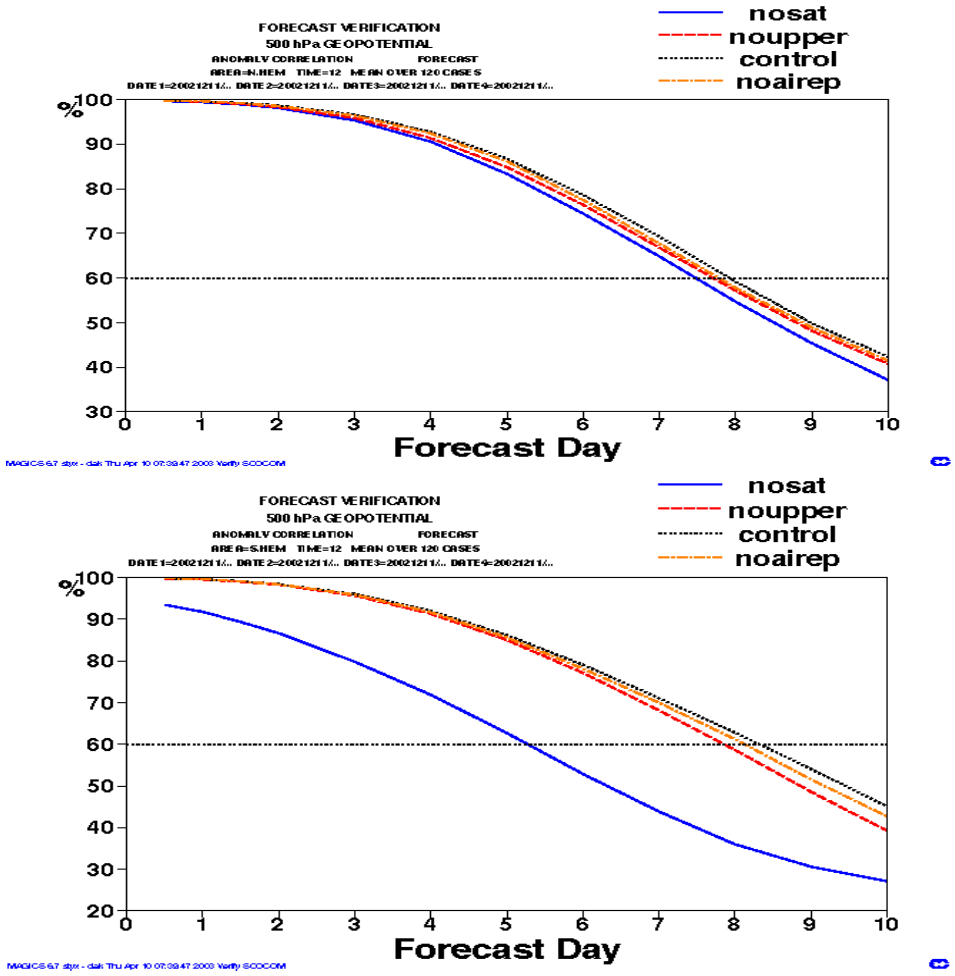

Figure 1 Verification scores (ACC) for geopotential height (500 hPa) gathered from a data impact study for Winter 2002/2003; black: control (all observations), orange: no aircraft data, red: no conventional sounding data, blue: no satellite sounding data; top northern hemisphere, bottom southern hemisphere (after Kelly 2004).

the southern hemisphere is clearly visible. More striking however is that even on the northern hemisphere, where many conventional data like radiosondes and aircraft observations are present, satellite data has the biggest impact on the forecast skill.

2. Satellite Data Monitoring at ECMWF

Having increased in data volume and importance for the ECMWF assimilation system, satellite data monitoring has become essential. The monitoring of satellite data at ECMWF is done on a daily (quasi real-time) and on a a-posteriori basis.

2.1. Daily monitoring

The impact of various elements of the global observing system on the ECMWF forecast model is assessed daily by analysts in the Meteorological Operations Section. His work is often triggered by problems in the forecast system. Inconsistent and/or bad forecasts might have arisen from large analysis increments, i.e. differences between the analysis (AN) and the FG. If that is the case, an in-depth investigation is done by the analyst on duty, trying to assess whether either the observation data or the FG was in error. This work is carried out within a synoptical framework, allowing the analyst to identify flow pattern related model errors or observation data problems.

2.2. Non-real time monitoring

At ECMWF, time series of data counts are routinely plotted and satellite observations are compared with model values from the ECMWF forecast system. Systematic differences (departures) between the first and the latter may either point to a problem with the satellite instrument or with the ECMWF forecast system. Apart from safeguarding the quality of the observation data, there is another purpose of a data monitoring system, namely the detection of systematic model errors. Having many independent multi-channel satellite instruments available that share the same, or partly the same, radiative properties one can deduce whether a departure is either instrument or model related.

Figure 2 shows on example of two different infrared channels that are on independent satellite instruments but have the same radiative properties, i.e. they are both sensitive for upper-tropospheric humidity. Both channels show large departures in the Inter-Tropical Convergence Zone (ITCZ) which suggests large model errors rather than systematic errors in the instruments.

Maps as shown in Figure 2 are available on ECMWF's satellite data monitoring web pages at http://www.ecmwf.int/products/forecasts/d/charts/monitoring/satellite. These pages feature statistics of many other satellite instruments can in the form of geographical maps of monthly means, time series of area averages, hovmöller diagrams, scatterplots etc.

3. Future Plans

As mentioned earlier, more high-spectral resolution sounding instruments will soon become available for assimilation into NWP models (e.g. IASI on METOP). This will increase the burden on satellite data monitoring as literally thousands of channels need to be monitored. A more automated type of monitoring would be desirable if not unavoidable. One could think of a system where an automated alert would be issued if, based on past statistics, satellite observations would seem to gradually drift away from the model. Apart from gradual drifts in the observation (or model) data one could think of other signals for which one would like to be alerted (e.g. values that fall outside the assumed distribution).

Further plans are the development of new tools for the operational real-time monitoring of satellite data. In this age of multi-spectral satellite instruments one would need a software application that could cope with large amounts of satellite data. More importantly, to be successful in an operational environment these tools

would need to be fast and have high levels of interactivity allowing the user to animate and overlay with model fields.

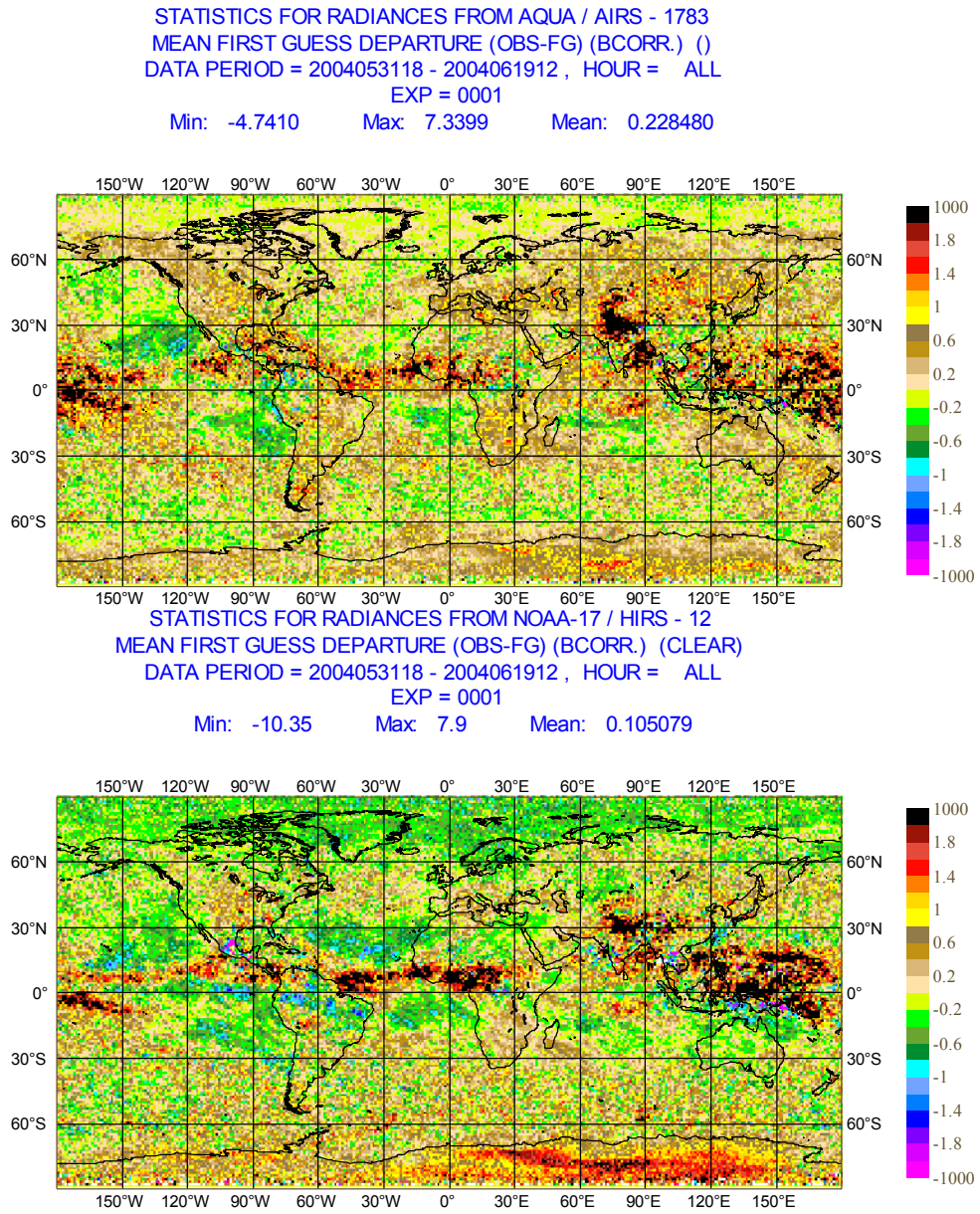

Figure 2 Mean First-Guess departures of AIRS channel 1783 (top) and HIRS channel 12 (bottom) for first 20 days of June 2004.

4. Reference

Kelly, G., 2004: OSEs of all main data types in the ECMWF operational system. In "Proceedings of the Third WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction". Alpbach, Austria, 9-12 March 2004, Edited by Horst Böttger, Paul Menzel and Jean Pailleux. WMO/TD NO. 1228