USE OF GLOBAL ATOVS AND SSMI OBSERVATIONS AT MÉTÉO-FRANCE

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1 INTRODUCTION

Preprocessed NOAA-15 radiances from NESDIS are currently being used in the four-dimensional variational (4DVar) assimilation system of ARPEGE, the global numerical weather prediction model operational at Météo-France. The current analysis scheme consists of applying a one-dimensional variational (1DVar) assimilation system to the pre-processed radiances to obtain quality control flags, vertical profiles of temperature and humidity and surface temperature. The radiances are then injected into 4DVar together with the surface temperature and the retrieved profiles above the top of the model (5 hPa). More details are to be found in Rabier *et al.* (2001). As a first illustration of the use of ATOVS data at Météo-France, the impacts on analysis and forecast of additionally using NOAA-16 data will first be presented (Section 2). NESDIS preprocessed data undergo significant preprocessing consisting mainly in instrument collocation and creation of flags. This process can introduce complicated random and systematic errors in the data that are not present in the raw radiances. With the advanced data assimilation schemes such as 4DVar this preprocessing step can be bypassed and consequently more information is expected to be extracted from the data. The assimilation of ATOVS raw radiances at Météo-France is under investigation; the first results are presented in Section 3. Another development at Météo-France concerns the experimental assimilation of total column water vapour and surface wind speed over the ocean derived from the SSM/I one-dimensional variational (1DVar) scheme developed at ECMWF. The impact of both retrieved products on analysis and forecast will be presented in Section 4. All experimental assimilations are performed using a model with a quadratic truncation of 199 wavenumbers, 31 hybrid coordinate vertical levels from the surface up to about 5 hPa and a spherical geometry with France as the pole (stretching factor of 3.5), i.e. 19 km horizontal resolution over France and 234 km at the Antipodes. The assimilation is performed at low resolution in three steps, namely truncation of 42, 63 and 95 wavenumbers. This was the operational configuration of the global model at Météo-France before 16th January 2002.

2 ADDITION OF NESDIS NOAA-16 DATA

Since 21 May 2001 NOAA-16 data are operationally processed at NESDIS and received at Météo-France at a 120 km horizontal resolution. An experimental assimilation and forecast suite has been run from the operational configuration to assess to which extent these new data are beneficial to the model. Once in the system the data are thinned to a final horizontal resolution of 250 km. Bias correction coefficients for NOAA-16 data have been computed following the method developed in Harris and Kelly (2001) which contains a dual bias correction with respect to the scan position as well as to the air-mass similarly to what is done for NOAA-15 data. The assimilation of NOAA-16 data on top of NOAA-15 data was found to behave better than the assimilation of NOAA-15 data only on a 19-day period in July 2001, especially in the medium-range as illustrated by the difference in 300 hPa geopotential height performance at day four in Figure 1. A significant impact can also be seen occasionally in the short range (see Figure 2).

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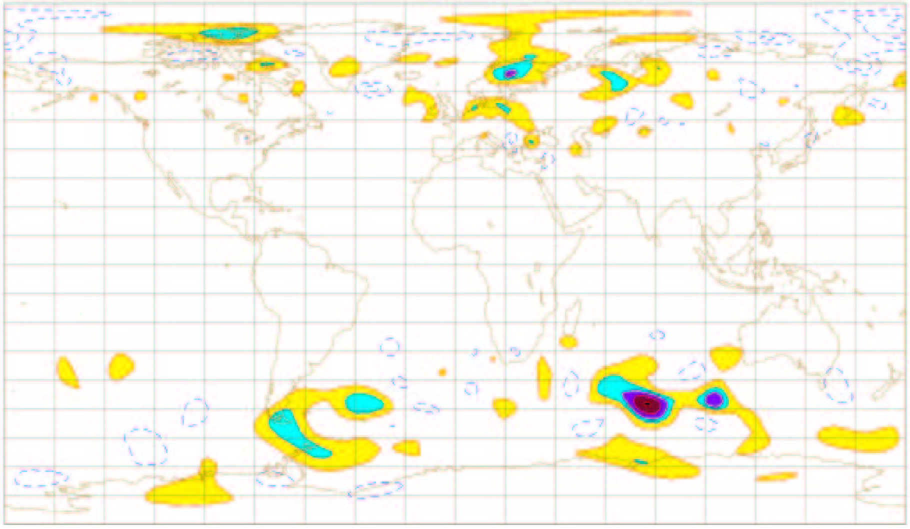


Figure 1: 300 hPa geopotential height difference between the 96-hour forecast root-mean-square error from the experiment with only NOAA-15 ATOVS data and from the experiment with NOAA-15 and NOAA-16 ATOVS data, averaged over 19 days of assimilation (1-19 July 2001). Contour interval is 10 m. Shaded surfaces represent positive differences greater than 10 m, showing a significant improvement brought by NOAA-16 data.

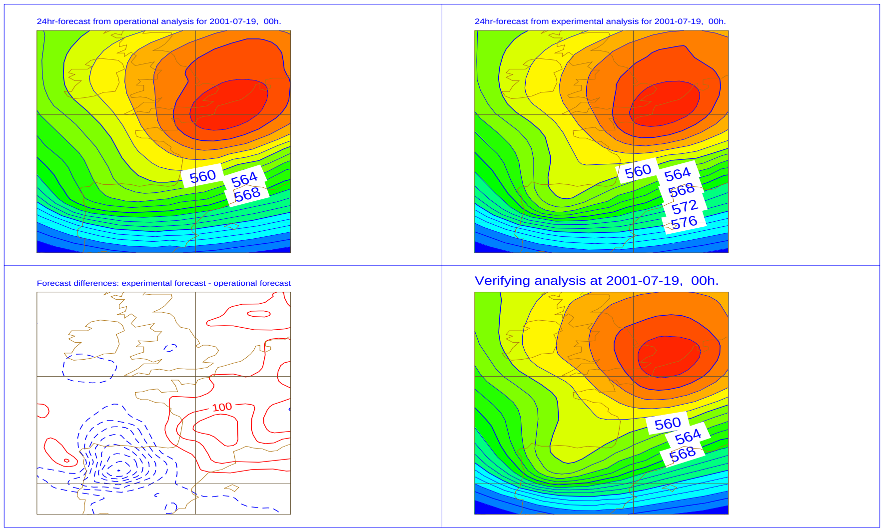


Figure 2: 500 hPa geopotential height 24-hour forecast without and with NOAA-16 (top left and right panels respectively), difference between experiment with and experiment without NOAA-16 (bottom left panel with contour interval of 50 mgp, positive values in dashed line and negative in solid line) and operational verifying analysis (bottom right panel), showing a benefit from NOAA-16 data in representing the trough.

3 USE OF ATOVS RAW RADIANCES

The assimilation of ATOVS raw radiances without collocation and 1DVar inversion is currently under investigation. Major developments in that respect concern the extrapolation of model fields above the top of the model as an input to the radiative transfer model, the radiance bias correction, the optimal density of observations and the quality control.

The radiative transfer code currently being used (RTTOV, Saunders *et al.* 1998) requires the vertical temperature on 43 pressure levels. Under the top of the model, profiles are interpolated to RTTOV pressures levels. Above the top of the model (about 5 hPa until 16th of January 2002) an extrapolation of the profiles using a regression algorithm (Clément Chouinard, personal communication) which extrapolates the departure from a reference profile (see Figure 3) has been tested. Regression coefficients are obtained using statistics over a dataset based on rockets, satellite and perfect gas theory.

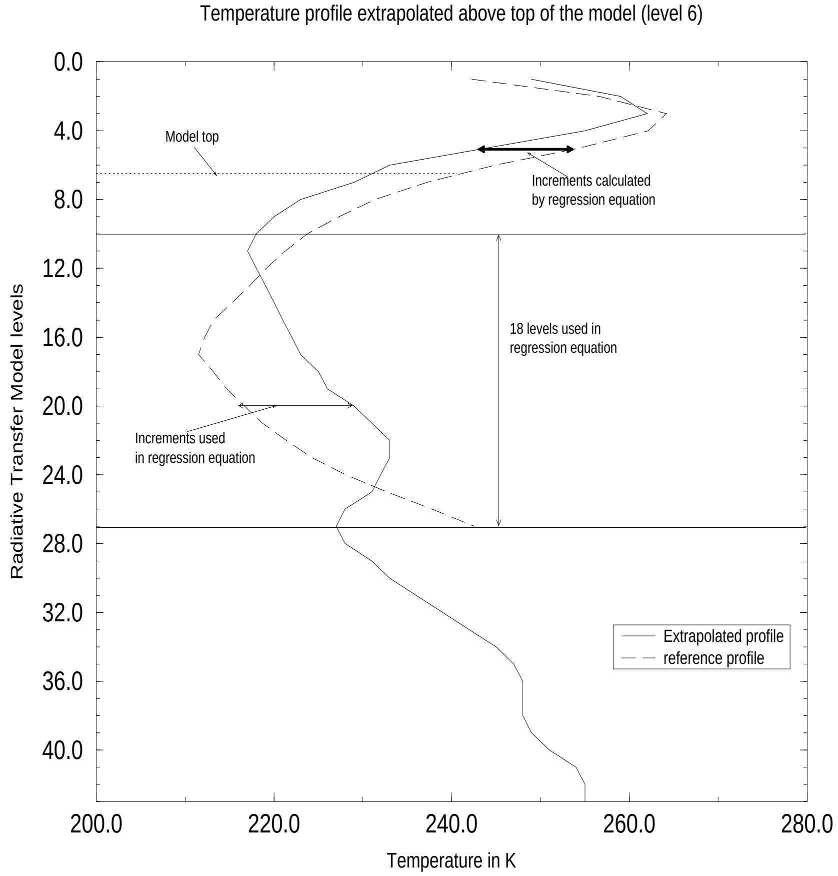


Figure 3: Extrapolation of the the temperature profile above the top of the model.

An horizontal thinning is performed to ensure a minimum distance of about 200 km between observations. Cloud and precipitation detection is necessary as in the first case temperature and humidity information cannot be extracted from the cloud contaminated infrared HIRS measurements and in the second case lower microwave channels are too sensitive to rain to be used in presence of precipitation in the field of view. The detection is done by comparing the observed to the background radiances in HIRS window channel 8 and channel 12 for cloud detection and in AMSUA-4 window channel radiance. Bias correction coefficients have been computed following the method developed in Harris and Kelly (2001).

The assimilation of raw radiances was found to behave better than the assimilation of preprocessed radiances on a 11-day period in April 2001, especially in the medium-range as illustrated by the difference in 300 hPa geopotential height performance at day four in Figure 4. On a global scale raw radiances enable the 300 hPa geopotential height forecast rms error to be reduced by about 3.3% (1.9 m absolute difference). In this experiment only AMSUA from NOAA-15 have been used, as HIRS instrument on board the same platform encountered some technical problems. Further experiments will be performed with both instruments and both available satellites (NOAA-15 and NOAA-16).

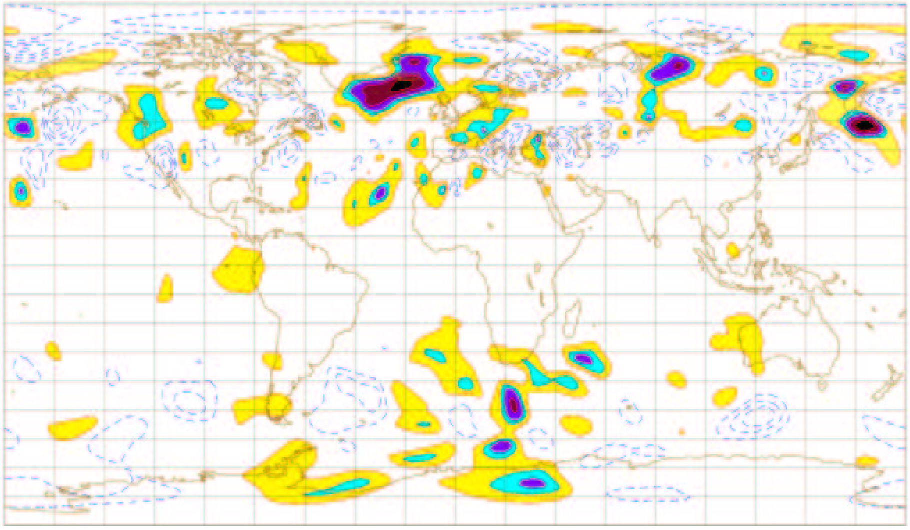


Figure 4: 300 hPa geopotential height difference between the 96-hour forecast root-mean-square error from the experiment with ATOVS preprocessed data and from the experiment with ATOVS raw radiances, averaged over 11 days of assimilation. Contour interval is 10 m. Shaded surfaces represent positive differences greater than 10 m, showing a significant improvement brought by the raw radiances.

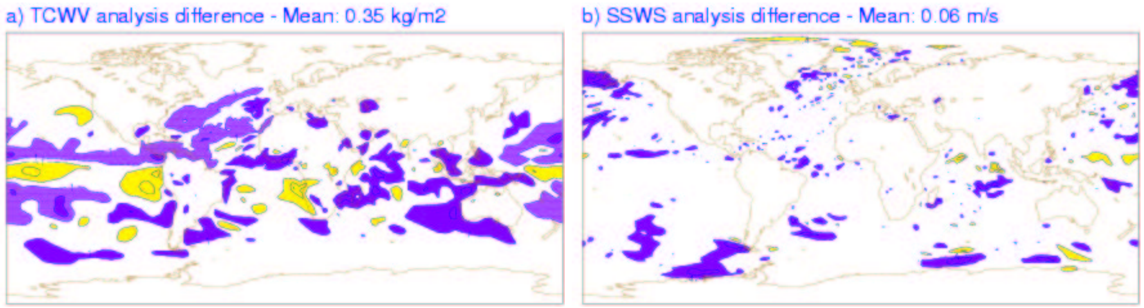
4 USE OF SSM/I DATA

Experimental assimilation of total column water vapour (TCWV) and surface wind speed (SSWS) over the ocean, derived from the 1DVar inversion (see Phalippou (1996) for description of the method developed at ECMWF and Gérard and Saunders (1999) for assimilation of TCWV at ECMWF) has been investigated at Météo-France. An horizontal thinning of the 1DVar products has been performed, i.e. 250 km for TCWV and 125 km for SSWS. The observation errors are derived from the 1DVar error covariance matrix and are such that an equivalent global weight is given to both model and observations between extreme values, whereas the TCWV observation errors are higher than the model errors below 10 kg m^{-2} and above 60 kg m^{-2} and the weight given to SSWS observations is weaker for SSWS lower than 6 m s^{-1} and higher for values above 12 m s^{-1}.

Assimilation experiments of these data over a two week period (1-15 January 2000) have been performed together with a control run where no SSM/I data is used. These experiments show a global moistening of the model analysis in the Northern Hemisphere (1.5% increase), in the Southern Hemisphere (2.2% increase) and in the Tropics (0.9% increase), as shown in Figure 5.a. However a drying is to be noticed in the dry tongues located off the western coasts of subtropical continents. Moreover a better coherence between first guess and analysis is noticeable as these data help to reduce the global difference between first guess and analysis. As for the assimilation of SSWS, it tends to strenghten the analysis surface wind speed in the Tropics (1.4% increase), in the Southern Hemisphere (1.2% increase) and in the Northern Hemisphere (1.1% increase), as shown in Figure 5.b. Moreover, the SSM/I data seem to be beneficial to the reproduction of cyclone intensity and position. Even though the effect of assimilating SSM/I TCWV and SSWS remains in the forecasts for up to 96 hours, no significant impact is seen in the mean forecast performance.

5 SUMMARY AND PERSPECTIVES

Several experiments were performed investigating the impact of satellite data in the French global model. NOAA-16 preprocessed radiances from NESDIS were found to have a positive impact on forecast performance on top of NOAA-15 data. ATOVS raw radiance assimilation experiments also showed some improvements in the quality of the subsequent forecasts. To improve the analysis scheme, some tunings are necessary, especially for observation error, surface skin temperature error and thresholds used for cloud and precipitation detection.


a) TCWV analysis difference - Mean: 0.35 kg/m2

b) SSWS analysis difference - Mean: 0.06 m/s

Figure 5: (a) TCWV and (b) SSWS analysis differences between the experiment with SSM/I data and the experiment without. Units are in (a) kg m^{-2} and (b) m s^{-1} and mean difference values are indicated at the top of each panel. Contour lists are -3/-1/1/3 kg m^{-2} for TCWV (a) and -0.8/-0.4/0.4/0.8 m s^{-1} for SSWS (b). Dark shaded surfaces represent positive differences, light shaded surface represent negative differences.

It is also more appropriate to calculate regression coefficients used in extrapolation for different latitudes. Work will be continuing in this area, until operational implementation.

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