

# Recent improvements to the use of satellite sounding data in Met Office regional models

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## Introduction

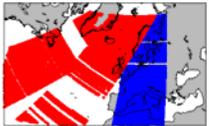
During the last year the North Atlantic European (NAE) configuration of the Unified Model has undergone several significant improvements to both the assimilation and forecast components. The model resolution has been increased to 12 km and the model domain is shown in **Figure 1**. The main data assimilation change has been the transition from 3D-Var to 4D-Var and this was found to improve the forecast scores of dynamical variables such as PMSL and wind. In addition, several changes have been made to the use of satellite sounding data which are outlined below. In each case the baseline system includes NOAA15 and NOAA16 AMSU-A & B data received from five EUMETSAT Advanced ReTransmission Service (EARS) stations (shown in **Figure 1**). Use of locally received data is important because the data cutoff for the NAE main forecast runs is two hours.



Figure 1. The NAE Domain. Ground stations from the EARS network are shown as stars

## 1. Introduction of NOAA-18 AMSU-A & MHS

Following on from the successful introduction of NOAA-18 in the Met Office global model we investigated the impact of using this data in the NAE. **Figure 2** shows the typical increase in data coverage caused by the inclusion of NOAA-18. This resulted in reduced temperature forecast errors



for both upper and lower regions of the troposphere throughout the forecast range. See **Figure 3** below. Additionally, forecasts of cloud cover were improved by 1.6% (expressed as an equitable threat score and verified using station reports)

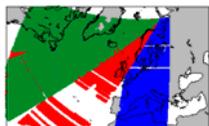


Figure 2: Typical ATOVS data coverage in the six hour assimilation window

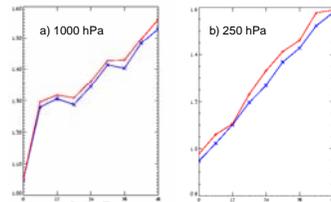


Figure 3: Forecast temperature errors compared. Red: NOAA-15 & 16 assimilated. Blue: NOAA-15, 16 & 18

## 3. Bias correction in the NAE

ATOVS data in the regional models use bias coefficients derived using statistics from the global model. This simplifies the updates required to the operational system but assumes that the biases between the global and regional models are small, which may not always be the case. Also there may be instruments that we wish to assimilate specifically in the NAE and so for this reason it is worth comparing the effectiveness of bias correction using NAE statistics. Since the bias correction scheme contains model predictor terms (currently upper and lower level thickness), it is necessary to compile statistics over the full climatology covered by the model. This was attempted by compiling statistics for a winter month and a summer month.

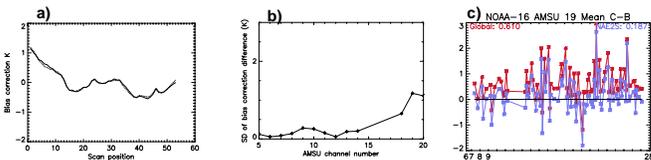


Figure 6: Bias correction coefficients derived from global and NAE models compared. a) Cross track dependency for AMSU-B channel 4. b) Difference in response to a range of typical model predictor values. c) Time series of the residual bias for AMSU-B ch4 using NAE forecasts as the background. Blue: NAE derived coefficients. Red: Globally derived coefficients

Figure 6a shows that the cross track bias determined from either model is almost identical. In 6b the difference in the response of the correction coefficients to a range of predictor values is greatest for the AMSU-B channels. Figure 6c shows that the performance of the NAE derived coefficients is generally better for AMSU-B channel 5, when compared with the NAE background

## Summary

- Both NOAA-18 and AIRS data resulted in forecast improvements and are now used in operational NAE assimilation
- Bias corrections can be computed from the NAE domain using a two season approach and this reduces the residual bias with respect to the NAE for humidity channels
- AMSU-B 150 GHz observations improve the low level humidity field. Further studies will examine the affect on thin cloud layers in more detail

## 2. First use of AIRS radiances

AIRS data have been assimilated into the operational Met Office global model since Summer 2004 and one of the main impacts has been improved near-surface humidity. Such improvements are also desirable in our regional models where one of the main forecast products is cloud cover, and so we have investigated the impact of AIRS in the NAE. The pre-processing step, which is identical to the global system, includes cloud detection using a combination of infrared and microwave channels. After rejection of cloudy scenes there is still a useful number of observations in each analysis cycle (**Figure 4**). In addition to this, data gaps will also be present as we currently do not receive AIRS via local reception.

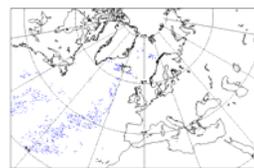


Figure 4: Typical AIRS coverage after cloud detection

SSM/I total column water vapour Observed - Background (Kgm<sup>-2</sup>)

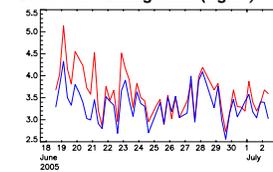


Figure 5: Time series of the fit to SSM/I estimates of water vapour. Red: control Blue: AIRS experiment

The most significant impact was an improved fit of the short-range forecasts to independent observations of water vapour from SSM/I (**Figure 5**). The SSM/I estimates are principally influenced by humidity in the boundary layer and so this result is consistent with AIRS impacts in the global model.

## 4. Impact of full resolution AMSU-B

As reported at ITSC-14, we have developed a scheme to quality control AMSU-B channels at full resolution, including channel selection based on the retrieved cloud liquid water in the field of view. This new scheme allows us for the first time to test the impact of the 150 GHz channel in our assimilation scheme. Forecast trials indicate that the short-range humidity field is improved, as verified by SSM/I (**Figure 7**) and HIRS data (not shown). Improvement to the precipitation field was found to be neutral, when verified by the UK radar network. However, the surface temperature field was degraded in several cases and these were found to be during cold nights when a thin low level cloud layer was present. In such cases the broad scale increments from arising from the microwave data tended to remove the narrow bands of cloud resulting in stronger surface cooling in the forecasts. An example is shown below.

SSM/I total column water vapour Observed - Background (Kgm<sup>-2</sup>)

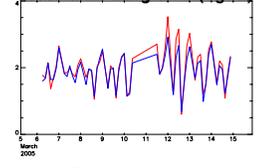


Figure 7: Time series of the fit to SSM/I estimates of water vapour. Red: control Blue: Full Resolution AMSU-B

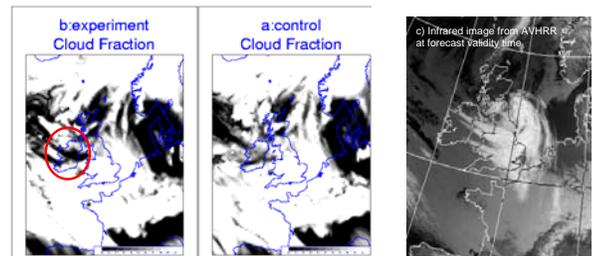


Figure 8: Comparison of the short-range cloud field for a) control and b) assimilation of AMSU-B at full resolution for a winter night time case. The experiment results in reduced cloud over Ireland, whereas in reality the low level cloud field is retained, as shown by the verifying infrared image



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