Recent observing system experiments at The Met Office

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1. Global data denial trial

1.1 The Experiment

A data denial experiment was run for the period 20/9/99 - 19/10/99, using the versions of the forecast model and data assimilation scheme that were operational in December 2000. In order to reduce the computational cost, the model was run at reduced horizontal resolution (about 90 km compared with 60 km operationally) but at the operational vertical resolution of 31 levels. The impact of 'in-situ' observing systems (surface, aircraft, radiosondes), radiance data from Low Earth Orbiting satellites, and Atmospheric Motion Vectors (AMVs) from geostationary satellites was assessed. The following seven runs were performed:

1. All data.
2. All data less radiosondes.
3. All data less satellite radiances and AMVs (the no satellite data run).
4. All data less satellite radiances.
5. All data less AMVs.
6. All data less aircraft data.
7. All data less surface data (SYNOP, ships, buoys and marine platforms).

Note that the surface wind vectors from ERS were not used in any run, and surface wind speeds from one SSM/I satellite were used in both runs. Verification against radiosondes and the 'All data' analysis was performed.

1.2. Summary of key results

Impact of satellite data

- The benefit of satellite data is not always additive. For example, for 500 hPa height forecasts in the Southern Hemisphere, removing AMV data only causes a small degradation in forecast quality; removing only satellite radiance data has a larger effect; but removing both has a larger degradation than the sum of the two (see Figure 1).

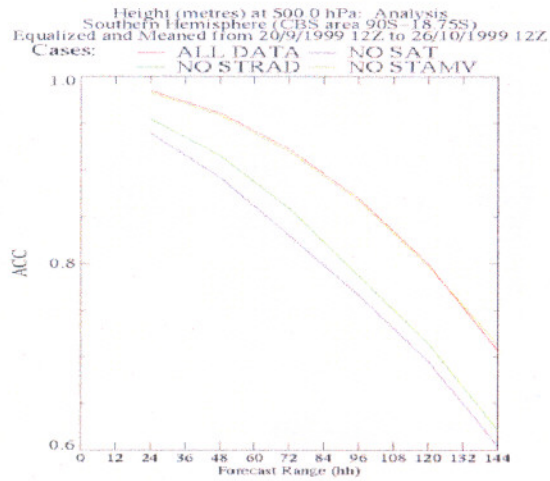

Fig. 1

- For 500 hPa height, in the Northern and Southern Hemisphere, satellite radiances have a larger impact than AMVs. In the tropics, AMVs have a larger impact up to 72 hours, but satellite radiances have a larger impact thereafter. Satellite data have negligible impact over Europe.
- For wind forecasts, satellite data have little impact in the Northern Hemisphere. In the tropics, AMV data are most important at short ranges, although satellite radiances have a larger impact at longer-range and at high levels. In the Southern Hemisphere satellite radiances are the most important data source, but removing all satellite data has a larger impact than removing satellite radiances and AMVs individually.
- For height verification, satellite data have a positive or neutral impact in most areas but a small negative impact in some. For example, at 250 hPa, removing satellite data reduces the bias in the tropics and thus reduces the RMS scores.

Impact of conventional data versus satellite data

- For height forecasts, satellite data have a similar benefit to radiosonde data in the Northern Hemisphere (see Figure 2). Satellite data have a much larger impact on height forecasts in the tropics and Southern Hemisphere than either radiosonde or aircraft data. Over Europe, radiosonde data have the biggest impact followed by aircraft.

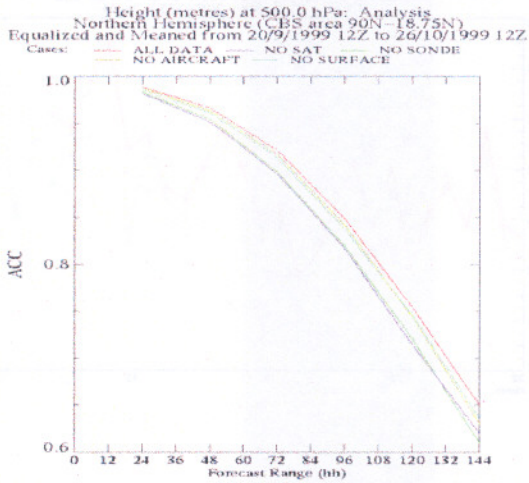

Fig. 2

- For wind forecasts, radiosonde data have a larger effect than satellite data and other data types in the Northern Hemisphere. In the Southern Hemisphere, satellite data clearly have the biggest impact on wind forecasts. In the tropics, radiosonde data and satellite data have a similar benefit except for 72-hour and 96-hour forecasts where satellite data are more beneficial. Over North America, Europe and Asia, radiosonde data have the largest impact on wind forecasts.
- The benefit of aircraft data is smaller than that of radiosonde or satellite data, but a benefit in height and wind forecasts of aircraft data can be clearly seen on a regional basis where there are large concentrations of aircraft data, for example, over Europe and North America.

Impact of surface data

- Removing surface data has a negligible effect on upper level wind forecasts, but causes a large deterioration in upper level height and mean sea level pressure forecasts, particularly in the tropics. The mean sea level pressure forecasts deteriorate in proportion to the amount of time the data are not assimilated.

The results quoted above are broadly in line with those found by *Bouttier and Kelly* (2001), although not identical. For example, the Met Office study shows a greater benefit of satellite data over Asia than was seen by the ECMWF study, possibly reflecting the use of extra radiance data over Siberia by the Met Office data assimilation scheme.

Although useful signals can be seen from a month's trial, it is recognised that other trials sampling different flow regimes should be carried out. This work is currently underway, using July 2001 and January 2002 data.

2. Recent improvements to satellite data processing

Development of ATOVS processing continued to deliver benefits in the operational NWP system during 2001, with three significant upgrades on February 13, April 18 and October 17. New ideas are also being developed under the research programme which promise to continue this trend of improvement in future years.

The most important of the three changes was the introduction of moisture information from AMSU-B. When NOAA-15 was launched in 1998 the temperature information was exploited quickly, but the moisture information could not initially be exploited both because of problems on the satellite and deficiencies in scientific understanding. In particular improved cloud detection and radiative transfer model accuracy were required. Work was undertaken in these areas resulting in a completely new scheme to distinguish thick cirrus (which is semi-transparent at the wavelengths observed by AMSU-B) from thin cirrus which is transparent at AMSU-B wavelengths. The impact of AMSU-B on moisture verification against radiosonde was significant, with substantial falls in RMS error at short range, especially in the tropics. For example the 500 hPa relative humidity error of the 24 hour forecast fell by 10% verified against tropical radiosondes (see Figure 3).

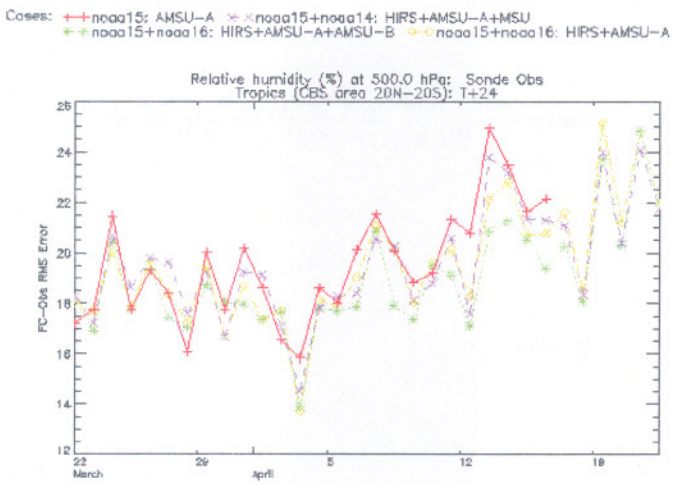

Fig. 3

Other important changes have included the introduction of NOAA-16 ATOVS observations, improved use of ATOVS over sea ice and in cloudy areas and the use of data from two SSM/I instruments.

Research activities continue to focus on improved use of ATOVS in cloudy areas, with studies of the analysis of cloud profiles from microwave sounding systems being undertaken, and on improved use of ATOVS over land by modelling and analysing the surface contribution to the observations more accurately.

Reference

Bouttier, F. & Kelly, G. (2001). Observing System Experiments in the ECMWF 4D-Var data assimilation system. *Q.J.R. Meteorol. Soc.*, **127**, 1469-1488.