Abstract

Satellite derived Atmospheric Motion Vectors (AMVs) have given positive benefit to operational large-scale NWP forecasts for many years. Their use in Nowcasting has been limited due to the use of the large tracking box sizes that are used by operational AMV products. The NWCSAF AMV package allows local AMVs to be produced with smaller tracking boxes producing AMVs with scales that are more suitable for Nowcasting systems. Delays in the processing and reception of AMVs are also a problem for Nowcasting. Local AMVs can be produced within five minutes after the satellite image reception whereas the operational product may take up to 30 minutes.

The MSG NWCSAF software has been setup over the 1.5km UK model area and produces AMVs every 15 minutes. A set of OSEs is currently underway using the 4km UK model and 3DVAR data assimilation. In the near future OSEs will begin using the 1.5km UK hourly 4DVAR Nowcasting system.

1. Introduction.

This paper describes how the NWCSAF package (García, 2008) has been setup over the UK and some initial validation. An outline of the paper follows:

Section 2 gives a brief description of the Met Office convective scale forecasting systems, section 3 refers to the NWCSAF package, section 4 describes how the AMVs are monitored in real time, section 5 compares monthly AMV data together with other EUMETSAT AMV products, some initial forecast impact test are shown in section 6 and conclusions and future work are described in section 7.

2. Met Office mesoscale systems.

The Met Office is developing an hourly cycling 4D-Var high resolution (1.5km model, 3km data assimilation) NWP forecasting system for Nowcasting over southern England (Ballard et al. 2011) (for domain see Fig. 1 (right)). The data window is one hour and cut off is time 45 minutes. The boundary conditions are obtained from UKV model forecasts. The Met Office has an operational 4km model for the UK (UK4), since Dec 2005 and is running routinely the 1.5km UKV model, since summer 2010, both with 3hourly cycling 3D-Var and 6hourly forecasts to 36hours. These are based on the Met Office Unified Model and Variational data assimilation system (Lorenc et al., 2000) including latent heat nudging. All have 70 vertical levels. The UKV has a stretched boundary nested in the UK Global model and using 3km 3D-VAR over the whole domain. The data cut-off for the UKV cycles is about 2hours for the non-critical cycles at 00,06, 12,18UTC and shorter for the cycles producing the 36hours forecasts varying from 30mins for the 09UTC, and 55mins for 21UTC to 1hr 25mins for the 03UTC and 15UTC cycles.
The table below lists the current observations used for all data assimilation systems.

- Observation availability and temporal frequency.
  - Wind profiler (u, v) [15 min]
  - Doppler radar radial winds [10 min]
  - GPS (integrated humidity path) [15 min]
  - Scatterometer winds [~15 min]
  - Seviri radiances. [~15 min]
  - Seviri AMVs [~60 min]
  - Mops Cloud [15 min]
  - Mops Rain [15 min]


The High Resolution Wind (HRW) product from the NWCSAF package provides detailed sets of AMVs from up to seven MSG/SEVIRI channels: HRVIS, VIS06, VIS08, IR108, IR120, WV062 and WV073. Cloudy AMVs are extracted from all channels and in addition clear air AMVs from water vapour WV062 and WV073 channels. The AMVs are calculated for each MSG image slot every 15 minutes. The product includes pressure level information and a quality control flagging. In addition there is also an estimate of AMV’s error in probabilistic terms. The package has been developed by AEMET (Spanish National Weather Service) in the framework of the EUMETSAT Satellite Application Facility to support the Nowcasting and Very short range forecasting SAF (NWCSAF).

The NWCSAF MSG package has been configured over the UKV region and uses 15 minute MET9 imagery. The package uses a 512x512 pixel segment of the IR image and the HRVIS data is used also over the same region at full HRVIS pixel resolution.

In order to monitor the production and quality of the local UK AMVs two real time web interfaces to the AMV outputs have been setup.

(a) Fifteen minute monitoring.

Figure 2 shows the first website that allows the user to view each 15 minute slot of the last 24hr of production of NWCSAF(UK) products. Currently displayed is cloud type (left) and cloud height (right). Figure 3 shows an example of AMVs product produced each 15 minutes. These AMVs vectors are colour coded depending on sensor and level.
(b) Three hour monitoring using UK4 first guess.

The second web site has been designed to monitor the O-B differences using forecasts from the UK4 three hourly data assimilation system. Once the first guess for the next cycle is produced the observation processing (OPS) is run inputting AMVs for the last three hours together with the operational EUMETSAT AMV products received from the GTS. Figures 4 and 5 shows examples of the model vectors (yellow) and the AMVs (blue).

![Figure 4 upper level AMV blue UK4 model yellow SAFNWC (left) EUMETSAT (right)](image)

![Figure 5 lower level AMV blue UK4 model yellow SAFNWC (left) EUMETSAT (right)](image)

![Figure 6 examples statistical plots](image)

Figure 6 (left) shows an example of a scatter plot of wind speed for NWCSAF(UK) AMVs above 400 hPa. The x-axis is the UK4 model and y-axis the AMVs (red HRVIS green IR).
Figure 6 (right) shows a frequency distribution of wind speed for the standard deviations of the O-Bs for AMVs below 700 hPa (red HRVIS green IR).

5. Monthly monitoring.

The main purpose of the observation processing system (OPS), used at the beginning of all Met Office data assimilation systems, is to provide the Variational Analysis with a file of good data. OPS also produces an audit file containing entries for each observation. For each AMV observation this audit file includes entries for O-B departures, flags for acceptance or rejection and thinning, receipt and observed times, and also the level the of best fit of the AMV to the NWP wind profile. Statistical software is run routinely from these files to monitor the performance of the AMVs.

Figure 9 shows an example of a time series for NWCSAF(UK) AMVs, EUMETSAT M8 and M9 for all AMVs. All plots are computed for AMVs with QI values greater than .83. It had been found that with the NWPSAF AMVs a QI cut off setting for good data of .83 is too low. QI values of .93 for HRVIS AMVs and .97 IR AMVs are a better choice and still yield good geographical coverage.

Examples of density scatter plots using the UK4 model guess and AMVs are shown in figures 8, 9 and 10. AMVs are excluded with QI values below .93 for NWCSAF(UK) HRVIS, .91 for NWCSAF(UK) IR and .83 for all EUMETSAT AMVs. In the UK4 region there are very few EUMETSAT VIS AMVs and at upper levels there are no NWCSAF(UK) WV winds. WV AMVs now available in the latest NWCSAF package.
Figure 8 AMVs below 700 hPa Scatter plots using UK4 guess NWCSAF(UK) HRVIS (left) EUMETSAT IR(right)

Figure 9 AMVs below 700 hPa Scatter plots using UK4 guess NWCSAF(UK) IR (left) EUMETSAT IR (right)

Figure 10 AMV above 400 hPa NWCSAF(UK) HRVIS (top left) NWCSAF(UK) IR (bottom) METSAT WV(top right)
A further example of the use of the AMV statistical package is the Level of best fit plots (figure 11).

The NWCSAF(UK) winds at low levels appear to be higher than the first guess whereas at higher level the fit on average appears to be closer to the NWP model. It may be interesting to try resetting the AMV heights, at low levels, to the model values if the AMV heights are below the model boundary layer.

**Forecast Trials of PS27 UK4 suite**

**Total number of days = 16**

**Total number of cycles = 128**

**From 20111221 to 20120105**

**Validity Times for verification:** 0 600 1200 1800 UTC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control Data</th>
<th>Test Data</th>
<th>Test - Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ETS</td>
<td>Mean ETS</td>
<td>Wted ETS Diff</td>
</tr>
<tr>
<td>Surface Visibility</td>
<td>0.025</td>
<td>0.025</td>
<td>0.001</td>
</tr>
<tr>
<td>6 hr Precip Accum</td>
<td>0.299</td>
<td>0.333</td>
<td>0.038</td>
</tr>
<tr>
<td>Total Cloud Amount</td>
<td>0.287</td>
<td>0.297</td>
<td>0.091</td>
</tr>
<tr>
<td>Cloud Based Height (3/8 Cover)</td>
<td>0.204</td>
<td>0.212</td>
<td>0.085</td>
</tr>
<tr>
<td></td>
<td>Mean Skill</td>
<td>Mean Skill</td>
<td>Wted Skill Diff</td>
</tr>
<tr>
<td>Surface Temp</td>
<td>0.696</td>
<td>0.696</td>
<td>-0.007</td>
</tr>
<tr>
<td>Surface Wind</td>
<td>0.620</td>
<td>0.619</td>
<td>-0.030</td>
</tr>
<tr>
<td>Total Weighted Score (%)</td>
<td>37.719</td>
<td>37.947</td>
<td>-0.2% change</td>
</tr>
</tbody>
</table>

**Figure 12 Forecast scores UK4 model calculated over 6-36 hours**

### 6. Forecast evaluation

Two parallel trials were setup to study the impact of the SAF AMVs on the UK4 system. The control was an identical copy of the operational UK4 3DVAR and on average uses about 100 EUMETSAT AMVs in each three hourly cycle.
A test experiment was a copy of the control but replaced the EUMETSAT AMVs with those from the NWCSAF(UK). The AMV horizontal thinning was also reduced from 100km to 40km. AMVs were only used with QI values greater than .91 for HRV AMVs and .93 for IR AMVs. There was a factor of 10 increase in NWCSAF AMVs compared to the EUMETSAT AMVs for each analysis cycle.

The experiment was run for 16 days and the statistical results are shown in figure 12. Forecasts are run every second cycle up to 36 hours. The scores are evaluated using a set of UK stations using a weighting of six observed parameters during the forecast period. Averaged the 16 days it was found that three of the parameters have slightly improved whereas the other three are neutral.


The NWCSAF/MSG package has been successfully installed over the meso-scale UK domain and has been producing AMVs every 15 minutes for over twelve months. For the same overall quality the SAF package produces about ten times more AMVs than the operational EUMETSAT product.

Some initial data assimilation trials have been run and results are encouraging. More UK4 data assimilation trials are underway.

The NWCSAF package has been upgraded to produce cloudy and clear AMVs from the water vapour channels. At present we are evaluating these new AMVs.

Based on the studies (Lean et al. 2012) we will test various setting in the SAF package for target box size and QC tests. Also changes will be tested to the AMV observation operator in the Variational analysis.

The major aim of this project is to provide very rapid data to the Met Office 4DVAR Nowcasting system and Data assimilation trials will begin shortly.

References

Ballard Susan P, Bruce Macpherson, Zhihong Li, David Simonin, Jean-Francois Caron, Helen Butterly, Cristina Charlton-Perez, Nicolas Gaussiat & Lee Hawkes- Smith, Chiara Piccolo, Graeme Kelly, Robert Tubbs, Richard Renshaw Convective Scale Data Assimilation and Nowcasting, ECMWF, Seminar on Data assimilation for atmosphere and ocean, 6 - 9 September 2011

