Abstract

Satellite derived Atmospheric Motion Vectors (AMVs) have given positive benefit to the Global and Regional NWP forecasts for many years. Their use in Nowcasting and mesoscale forecasting systems has been limited due to the use the number of pixels used in the AMV tracking boxes and their timeliness. This NWCSAF package allows AMVs to be produced with smaller tracking boxes with scales that are more suitable for these systems. The NWCSAF package can be run locally over a small region and provide AMVs within a few minutes of the satellite image reception.

The MSG NWCSAF software has been setup on a MetOffice Linux sever. It runs over the UKV region and produces AMVs every 15 minutes or ten minutes (rapid scan mode).

A study (Lean et al., 2014) suggests lowering the AMV heights of the upper level AMVs can reduce the speed bias. This height reduction has be tested and is now included in the operationally use of the local AMVs in the UKV assimilation.

A series of data impact tests have been run with the UKV 1.5 km 3DVAR data assimilation system. Forecasts including the local AMVs show a positive impact for cloud and precipitation. An additional NWCSAF AMVs have been produced using rapid scan MSG images. These AMVs have been input into the 1.5km UK hourly 4DVAR Nowcasting data assimilation.

INTRODUCTION.

Large scale NWP has used AMVs are available on the GTS from the major satellite providers. These products have been tailored to meet the needs of large scale NWP and generally ignore the mesoscale atmospheric flow. Another disadvantage of the operational products is the time delay, these products reach the user generally between 30 and 60 minutes is ok for global systems but for Nowcasting system to often too late.

With the previous comments in mind the Nowcasting SAF (funded by EUMETSAT) with the help of EUMETSAT AMV team have produced a very flexible software package which can be tailored to the user’s own requirements. The user can limit the geographical region processed in order to produce the AMVs very quickly. The pixel box size can also be selected to match the scales in the NWP system.

UK MESOSCALE DOMAINS

The Met Office has an operational 1.5km UK model both with 3hourly cycling 3D-Var and forecasts run to 36 hours. These are based on the Met Office Unified Model (Davies et al., 2005) and variational data assimilation system (Lorenc et al., 2000, Rawlins et al., 2007) including latent heat nudging (Macpherson et al., 1996, Jones & Macpherson, 1997, Dixon et al., 2009) and direct variational assimilation of a 3D cloud analysis via associated relative humidity along with conventional data. Both have 70 vertical levels. The UKV is 1.5km resolution over the UK with a 4km stretched boundary conditions from the MetOffice Global Model.
In order to investigate the use of NWP for nowcasting, the Met Office has developed an hourly cycling high resolution (1.5km) NWP forecasting system over southern England (for domain see Figure 1) nested in the latest available UKV forecasts for boundary conditions.

This system can use either 3D-Var or 4D-Var along with latent heat nudging and moisture nudging (Macpherson et al., 1996, Jones & Macpherson, 1997, Dixon et al., 2009). The system current assimilates the 3D cloud cover analysis via the moisture nudging rather than direct variational assimilation now used in the UKV and UK4 systems. Although 4D-Var takes more time than 3D-Var to run the aim is to investigate the benefit of assimilation of high time-frequency sub-hourly data. The 3D-Var has been run with either 1.5km or 3km resolution analysis grid whilst the 4D-Var has been run only on a 3km grid to save CPU time.

**GOAL OF HIGH RESOLUTION WINDS (HRW) PRODUCT**

The High Resolution Winds product (Garcia-Pereda, J., 2008) aims to provide, for near real time meteorological applications, detailed sets of Atmospheric Motion Vectors (AMVs) from Meteosat Second Generation (MSG) satellite, considering up to seven MSG/SEVIRI channel data (HRVIS, VIS06, VIS08, WV062, WV073, IR108, IR120) throughout all hours of the day, as a dynamic information in the SAFNWC/MSG package. The product includes pressure level information, and a quality control flagging giving some indication of its error in probabilistic terms, with auxiliary indicators about how the product was determined. Since HRW v4.0 in the year 2013, HRW product provides also trajectories considering the successive tracking of the same tracers in consecutive images.

The package has been developed by AEMET in the framework of the EUMETSAT Satellite Application Facility ot support to Nowcasting and Very short range forecasting (NWC SAF). This product is useful in Nowcasting applications, used in synergy with other data available to the forecaster. For example, in the watch and warning of dangerous wind situations, in the monitoring of the general flow, of low level convergence (when and where cumulus start to develop), of divergence at the top of developed systems, or other cases of small scale circulation or wind singularities.

High Resolution Winds output is similar to other products calculating Atmospheric Motion Vectors: the winds, trajectories and all parameters related to them are calculated at a level 2 of processing. No level 3 of processing (as a grid interpolation or a meteorological analysis based in the HRW output) is included.
THE HRW (EXECUTION) STEP

The execution step is the processing of SEVIRI images with HRW algorithm in the region defined by the user. The HRW running time scheduling relies on the programmed Task Definition File. This process consists in the running of the command along with the required parameters (slot, region file and model configuration file) by the Task manager. A single cycle in the UK domain takes less than a few minutes to produce AMVs from up to six MSG channels.

SUITE MONITING

Products from the real time SAFNWC package can be monitored on MetOffice web site within a few minutes after their products are available.

The imagery and cloud products (Figure 2) can be selected for each time slot and the imagery can be superimposed with upper or lower level AMVs. Different AMVs types are colour coded for identification.

Figure 2 Example of Real time AMV monitoring

Comparison with UKV guess

The UKV 36 hr forecast model provides forecasts valid between +2 +3+4 hours to monitor UK AMVs. The results are again shown on a MetOffice site and examples of plots are shown in figures 3 and 4.
Figure 3 Scatter plots  
left UK AMV (blue IR, red WV yellow VIS)  
right UK AMV (red) EUMET AMV (green)  

UK4 3hr monitoring  
left UK AMV right EUM AMV  

Figure 4 UK AMVs (left) EUMETSAT AMVs (right) yellow UKV guess blue AMV
Table 1 Monthly monitoring (NWPSAF) web site

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Note: from march clear improvement in BIAS and STD for UK AMVs

Table 1 Monthly monitoring (NWPSAF) web site

Monthly statistics.

AMV departures (observation minus UKV model first guess) are used for UK AMV monthly monitoring. Plots are found the external NWPSAF web (nwpsaf.eu).

In March 2014 the heights of the upper level UK AMVs were lowered by 40 hPa. The results are shown in Table 1. There is clear reduction in the UK AMV bias and improved STD against the UKV model after February 2014.

FORECAST IMPACT

The NWCSAF AMV package (v2011) (IR and VIS channels only) was initially setup in research mode and some NWP trials were run using the UK4 data assimilation PS28 suite for 28 days. The results were essentially neutral. A further set of 7 day trials were run with various settings of the time and space thinning parameters. The UK AMVs appeared to degrade if the area thinning was reduced below 20km and if the time window was larger than one hour. In addition the sensitivity to various setting of AMV QI were tested. Two QI values were chosen (.93 for IR winds and .96 for visible AMVs).

A new version of the NWCSAF package was received (v2012) which now allowed AMVs to be calculated from addition MSG channels including the water vapour channels. A revision of the internal QI in the new package required a retuning of the QI values used for selection a data for assimilation.

Following this a series of three 40day trials were run to test the area (20km and 10km) and temporal thinning (30min and 60min) with the UKV PS31 suite. The best combination of UKV suite was 20km and 30min thinning. This experiment was extended to 47 days and the results are shown Figures 5-7. Based on these results UK AMV were introduced into the operational MetOffice UKV system.

An additional data impact experiment was run with the UKV data assimilation system to test the lowered (40hPa) upper level heights. The standard UK Index scores showed neutral impact but there was a clear improvement in the six hour forecast, Figure 7.
**UK Index Metric for forecast verification**

<table>
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<th>Element</th>
<th>ETS Threshold</th>
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<tr>
<td>1.5m Visibility</td>
<td>200m, 1000m, 5000m</td>
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<tr>
<td>6 hour ppt accumulation</td>
<td>0.5mm, 1.0mm, 4.0mm</td>
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<tr>
<td>Cloud Cover</td>
<td>0.3, 0.6, 0.8</td>
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<tr>
<td>Cloud Base Height</td>
<td>100m, 500m, 1000m</td>
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<tr>
<td>1.5m Temperature</td>
<td>1-RMSE (RMS)/ppt</td>
</tr>
<tr>
<td>10m wind</td>
<td>1-RMSE (RMS)/ppt</td>
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- ETS Equitable Threat Score
- RMS root mean square
- Weighted Basket of Indices
- ETS elements
- Combo of ETS & RMS scores

<UK4 Impact trials verified to T+24 at 00, 06, 12, 18 UTC

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**The best of three UKV 40 day trials extended to 47 days**

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**Figure 5 Forecast Verification Parameters**

**Figure 6 Forecast Verification**
Final comments

In January 2014 the locally produced AMVs above 400 hPa, from the NWCSAF package replaced the EUMETSAT AMVs in the operational UKV data assimilation suite at the MetOffice.

In March 2014 the UK AMVs above 400 hPa have their assigned heights reduced by 40 hPa.

The use of UK AMVs down to 850 hPa over sea has been successfully tested and was introduced in July 2014 to operational UKV data assimilation.

Plans are now underway to test UK AMVs in an hourly cycling version of the UKV data assimilation.

In the near future the impact of NWCSAF UK AMVs from rapid scan data will be tested within the 4DVAR in the hourly UKV data assimilation system.
References


Garcia-Pereda, J., 2008: Evolution of high resolution winds product (hrw), at the satellite application facility in support to nowcasting and very short range forecasting (safnwc). Proceedings, Ninth International Wind Workshop, Annapolis, MD.

Lean P, Kelly G A, Migliorini S Characterizing AMV height assignment errors in a simulation study (2014) in his volume..
