Assimilation Experiments with AMV data in HIRLAM

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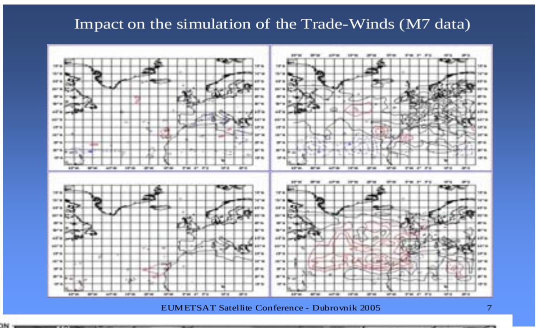
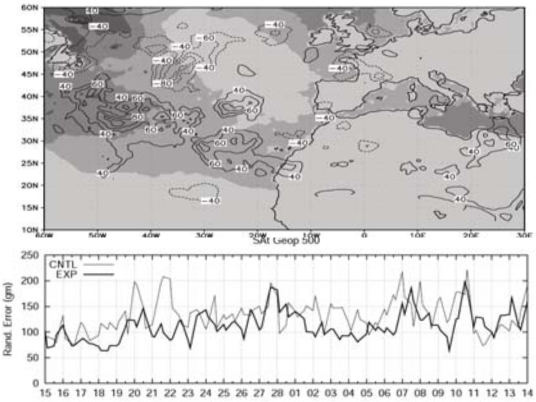
AMV (Atmospheric Motion Vectors) data are nowadays part of the baseline of atmospheric observations used in operational NWP. The coverage and quality of these data have increased continuously over the last years. All operators of meteorological satellites in geo-stationary orbit include AMV observations in their products catalogues, and there is a well established tradition of successful international co-ordination among them in this particular field. This co-ordination has led to better AMV data extraction algorithms and uniform coding and distribution procedures, all these things being very advantageous from the user´s standpoint. One significant step ahead in this time period has been the extension of the spatial coverage of these observations to the Polar regions and the availability of these Polar observations within a time schedule adequate for their exploitation in regional NWP systems. This achievement has been possible thanks to the imagery data acquired by the MODIS instrument which flies onboard the NASA EOS satellites, and the on-ground infrastructure deployed by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and other space agencies.



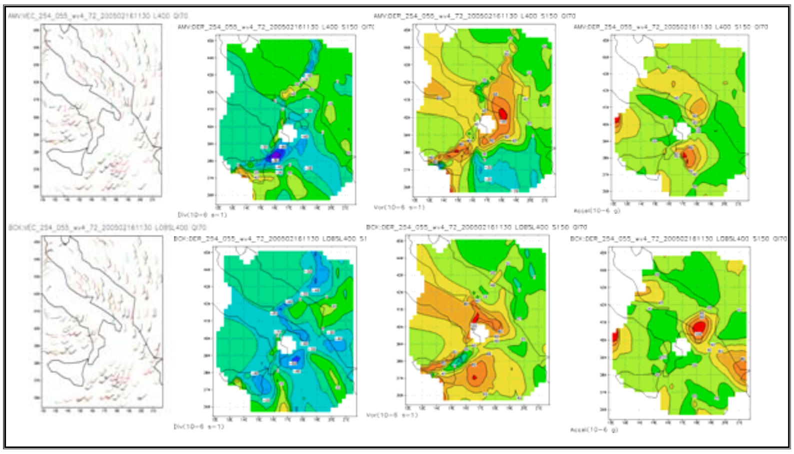


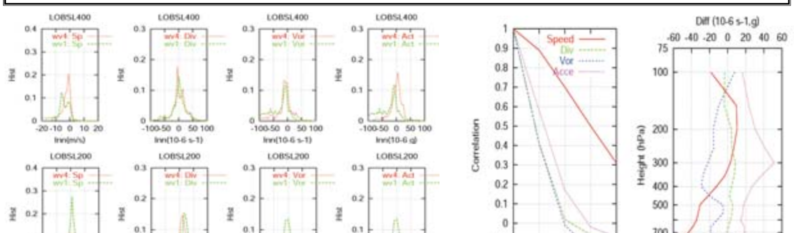
IMPACT STUDIES OVER THE NORTH ATLANTIC

The assimilation of METEOSAT AMV data has a clear impact on the way the HIRLAM model simulates the atmospheric dynamics in the North Atlantic region. Some results from different impact studies on a monthly scale that support this statement are shown along these lines. Right on the left one can see how the use in the analysis of M7 High Resolution Visible AMV vectors strengthens the Tradewind circulation during the Boreal Summer by a significant amount. The maps on the far left column correspond to wind speed at about 850 hPa, and the maps on the right column correspond to surface pressure, and in both cases the upper row is for the analysed fields and the bottom row for the +48H forecasts. The red areas delineate the zones where the impact on the monthly mean value is significant at the 0. 5% level.

Right below this figure another map showing the impact of M8 AMV data (all types) on the random difference between analyses and +24H forecasts is presented. Solid lines indicate a positive impact for the geopotential height at 500 hPa, while dashed lines contour areas where the opposite situation occurs. The shaded areas display monthly mean values of baroclinic instability as measured by the Eady maximum growth rate index averaged over a layer bounded by surface and 300 hPa, i.e., areas of maximum baroclinic activity during the period of the experiment (Boreal Winter). We can see that the positive impact is dominant at latitudes south of about 45 N and that these positive impact areas are located mainly downstream of high instability zones. This result shows that these data can improve the forecasts of transient baroclinic structures. The time series at the foot of the map corresponds to the spatial average of the impact parameter over an area west of 10W and south of 45N, i.e. over the area where the positive impact is more significant. The error reduction amounts to about 22%. These values are in line with results obtained by other researchers with the NOGAPS NWP system and AMV data from the NORPEX (North Hemisphere Pacific Ocean Experiment).

Verification of this impact by comparison with in-situ observations over Europe usually gives results positive but close to neutral. The low S/N ratios inherent to the O-F differences can surely explain part of this fact. In this respect, it is interesting to notice that the clearest verification results are usually obtained for parameters that, like geopotential and surface pressure, are calculated by addition of single level parameters (for these particular parameters and in an hydrostatic model through the hydrostatic equation and the tendency equation respectively), which allow for an enhancement in the S/N ratio.



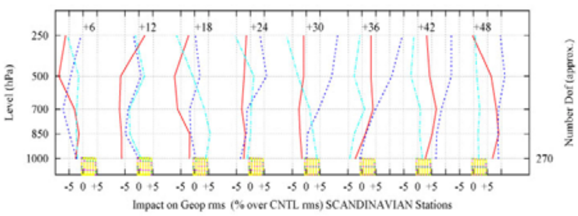


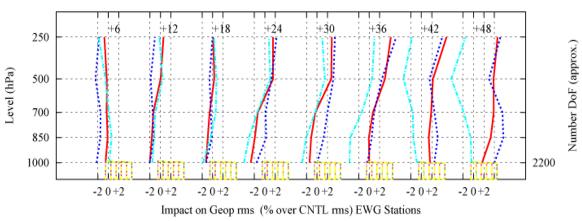
EXPERIMENTAL ASSIMILATION OF GEO-STATIONARY AMV DATA

The enhanced spatial and temporal resolutions of AMV data open up the door to new ways of assimilating these data. By carefully scanning the wind fields, it is already possible to find relatively shallow atmospheric layers with good horizontal coverage. On the right of these lines, one such case is shown. The upper row presents different horizontal wind related parameters (the wind itself, its divergence, vorticity and speed acceleration) calculated from the observations, and the lower row their model equivalents. The method uses Barne´s algorithm to generate grid fields from the scattered locations, and then the spatial and temporal differences are easily computed.

The case corresponds to a field extracted from the lower peaking M8 water vapour channel on the 16th of February 2005 about noon over the Italian Peninsula. Only vectors with quality index greater than 70 were retained and the colours of the barbs indicate to which time slot within the data assimilation window (here taken just 3 hours long) they belong. The atmospheric layer is centred at 400 hPa height and is about 50 hPa thick. The histograms below show statistics calculated from these "gridded observations", for this particular case. We see that the statistics for the channel "wv4" (red) look clearly better when compared with model equivalents from 400 hPa than from 200 hPa, while the opposite holds for the upper peaking M8 water vapour channel (green).

This exercise illustrates a possible application of this methodology as another way to tackle the long-standing "height assignment problem" in AMV data. By computing the vertical correlation from model fields, we see (plot on the far right) that, as expected, the differences de-correlate faster than the wind speed, and therefore they can point with more precision the level at which model and observations match better. Other avenue to follow is the possibility to assimilate directly these gridded observations which, although somewhat noiser, should in principle be free from bias.





IMPACT STUDIES OVER HIGH NORTHERN LATITUDES

Wind retrievals over the Polar Regions of the Earth by tracking clouds and moisture patterns on sequences of MODIS (Moderate Resolution Imaging Spectroradiometer) images have been produced since November 2003 at NOAA-NESDIS. Before that time, the technique was tested and developed at CIMSS (Co-operative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison). MODIS is embarked on the polar platforms EOS-I and EOS-II of NASA, also known as "Terra" and "Aqua". The success of this data coverage mission has raised support for its continuity when MODIS reaches the end of its operational life. Some alternatives considered are AVHRR imagery and AIRS radiance data.

Assimilation of MODIS data in HIRLAM has a clear positive impact on the random error of the mass-field. The upper panel on the left shows verification results for geo-potential for a set of Scandinavian stations on a monthly scale during the Boreal Winter. The quality of the impact improves markedly with height and forecast range (dotted blue lines). Although MODIS data in the North Hemisphere is extracted only at latitudes above 60 N, HIRLAM correctly propagates this information to lower latitudes and this positive impact is detectable as well for a verification area that comprises the whole of Europe (left, lower panel, dotted blue lines). Results for other seasons and parameters clearly advocate in favour of assimilating these data, in agreement with results from other research groups.

The joint assimilation of different observation types can however have a detrimental effect on the forecast skill (left, cyan dot-dashed lines). This problem arises from the lack of optimisation in the balances among the different control variables and in the relative weights given in the analyses to each observation type. Some caution is therefore necessary to avoid these "interference" effects.