Improving AMV impact in NWP

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Assimilation Changes

- Jul 08: New observation error scheme
- Nov 09: Stricter, symmetric background check
Nov 2008: Started assimilating WindSat winds
Nov 2009: Demise of Seawinds
WindSat helps to fill holes in scatterometer coverage

James Cotton looks after this work at Met Office
AMV data denial trials

Verification versus observations

12/12/07 – 12/01/08

NWP index = -0.9

N216
L50

15/12/09 – 15/01/10

NWP index = -0.8

N320
L70

Forecast RMS % difference
Contents

This presentation covers the following areas

- New AMV datasets – improving the coverage
- New AMV datasets – for high resolution NWP
- Options for improving the AMV assimilation
- Summary
New AMV datasets

Improving coverage
Closing the gap...

Incentive: not much other wind data in AMV data voids.

Useful for constraining polar front jets.
Closing the gap...

Possibilities:

- Increased geostationary coverage
  GOES in SH
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- Increased geostationary coverage
  GOES in SH

- Polar winds using only 2 images
  Metop AVHRR

Could completely close gap at least in NH, but lose temporal quality checks between derived vectors
Closing the gap...

Possibilities:

- Increased geostationary coverage
  GOES in SH

- Polar winds using only 2 images
  Metop AVHRR

- Multi-satellite polar winds e.g.
  Metop-A and Metop-B

?2012 -> for Metop-A/B, possibly earlier
for other less optimal configurations

Could completely close gap. Also
benefit from shorter image interval of 50
min rather than 100 min.
Closing the gap...

Possibilities:

- Increased geostationary coverage
  GOES in SH

- Polar winds using only 2 images
  Metop AVHRR

- Multi-satellite polar winds e.g.
  Metop-A and Metop-B

- Highly elliptical orbit

- Other winds datasets
  - ADM-Aeolus DWL
  - MISR follow-on

From Riishojgaard, IWW8 talk

?2016

Possible POLARSAT Canadian mission for 2 satellites.

See Louis Garand’s talk
New AMV datasets
For high resolution NWP
High resolution AMVs

Why are we interested?

- Current AMV products capture broad-scale flow.
- NWP moving to higher spatial resolution
  
  e.g. Met Office
  
  global 25 km
  
  regional 12 km
  
  UK 1.5 km
  
- Can we derive more useful AMV information for nowcasting or assimilation in high resolution models? Particularly to help with forecasting high impact weather events.
- Information available on smaller scales in the imagery (e.g. Purdom IWW8)
- Higher temporal resolution
  
  e.g. Meteosat-8 5 min interval imagery over Europe, GOES rapid scanning for severe weather

Examples of wind field resolution from Met Office operational models
1. Poorer low speed winds (limited by pixel resolution and image interval e.g. 4 km, 5 min -> 13.3 m/s to move one pixel).

2. May want to reduce dependence on existing quality control measures (spatial/temporal consistency, NWP forecast comparisons) – but risk of increased amount of poor quality data.

3. Spatial and temporal error correlations – currently handled by thinning, but would lose a lot of local flow information – how best to handle in NWP?
**Figure 1:** Met Office analysis chart for 1200 UTC 13 November 2009. A rapidly deepening low pressure system is moving north eastwards towards the UK.
High resolution AMVs
Case study – 13 November 2009

Enhanced wind speeds (35-45 m/s), Agree well with Met Office model background. Most have good QIs.

Meteosat-8 HRVIS

Meteosat-9 HRVIS

One wind (40 m/s), QI<45
AMV assimilation

Current status and future options
Key areas of AMV assimilation

- Blacklisting
- Thinning
- Background check
- Observation errors
- Observation operator

Analysis

Forecast
Blacklisting

Balance between removing and down-weighting. Remove where consistently of poorer quality.

Spatial

e.g. all winds above 100 hPa, all VIS winds above 700 hPa etc.
• How to set? based on limitations of derivation and O-B stats

QI thresholds
• Which QI or combination of QIs? preference model-independent QI
• How to select appropriate thresholds? QI versus stats plots, but ensure maintain reasonable coverage

Temporal thresholds
• Should we apply? remove timeslots affected by solar stray light

Speed thresholds
• Should we apply? remove slow winds (not well resolved)
Main approach to alleviate problems with spatially and temporally correlated error. Another option is superobbing.

- Choice of horizontal, vertical and temporal box dimensions - 200 km about right? Less experience setting optimal temporal dimension for use in 4D-Var.
- How to select observation to use? closest to centre of box, highest QI, lowest observation error
Background check

Safeguard to avoid assimilating data that is very different to the background.

• How to design test?
• Should it be symmetric / asymmetric?
• How strict should it be?
• Should we incorporate the check as part of initial QC or as part of VAR or both?
A good specification of the observation error is essential to assimilate in a near-optimal way.

Two independent sources

**Error in vector**
- Linked to accuracy of tracking step

**Error in height**
- Linked to accuracy of height assignment
- More problematic if large vertical wind shear

Currently assume uncorrelated errors – see Lars Isaksen’s talk later.
Observation errors

New approach – operational since July 2008

Total u/v error = \sqrt{(u/v \text{ Error}^2 + \text{Error in u/v due to error in height}^2)}

Error in vector due to error in height = \frac{\sqrt{\sum W_i(v_i - v_n)^2}}{\sum W_i}

where \[ W_i = e^{-\left(\frac{(p_i - p_n)^2}{2E_p^2}\right)} \times dP_i \]

Summation over levels with a significant \( W_i \)

- \( i \) = model level
- \( v_i \) = wind component on model level
- \( v_n \) = wind component at observation location
- \( p_i \) = pressure on model level
- \( p_n \) = pressure at observation location
- \( dP_i \) = layer thickness

For this we need an estimate of:

1. u and v error (\( E_u \) and \( E_v \))
2. height error (\( E_p \))

Ideally from data producers

Until then estimate \( E_p \) using best-fit pressure stats as a guide. \( E_u/v \) based on QI.
Observation errors
Assessing how well we are doing

Plan to retrial with revised Ep look-up table
Observation operator

Currently treat as point winds in space and time – may want to treat as a layer....

• Layer shape – Gaussian preferred
• Layer location relative to assigned height – centred / offset
• Layer width – how to set?
All Meteosat-9 IR 10.8 AMVs
9 Feb 00Z run

Biggest improvement seen for layer widths of 20-60 hPa
Observation operator

It is unlikely that the same layer width will be suitable for all Meteosat-9 IR 10.8 winds.

To get an upper limit of what might be possible, we also calculated O-B statistics where we allowed each observation to have its own best-fit layer width (defined as the layer in range 10-200 hPa giving minimum O-B vector difference).

<table>
<thead>
<tr>
<th></th>
<th>Mean Vector Difference m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single level</td>
<td>5.78</td>
</tr>
<tr>
<td>Minimum fixed layer - centred</td>
<td>5.47 (5%)</td>
</tr>
<tr>
<td>Minimum fixed layer - offset</td>
<td>5.53 (4%)</td>
</tr>
<tr>
<td>Best-fit layer - centred</td>
<td>4.07 (30%)</td>
</tr>
<tr>
<td>Best-fit layer - offset</td>
<td>3.62 (37%)</td>
</tr>
<tr>
<td>Best-fit single level</td>
<td>1.75 (70%)</td>
</tr>
</tbody>
</table>
Observation operator

Single level

O-B speed bias

50 hPa fixed layer

Best-fit layer

Standard deviation

All IR AMVs 16 Feb 00Z run
Summary
Summary

1. Improving AMV coverage
   • Reducing the gap between geo and polar
   • Improving timeliness of polar data

2. Increasing interest in high resolution AMV products as model resolution improves.
   • Not straight-forward
   • Need to review and optimise derivation and assimilation approach

3. Improving the AMV assimilation
   • Areas to consider include:
     • Blacklisting (space, time, QI, speed)
     • Thinning / Superobbing
     • Background check
     • Observation errors
     • Observation operator

4. Many of these tasks will benefit from producers and users working together.