AMV Height Assignment with Meteosat-9: Current Status and Future Developments

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Organisation of this presentation

• Algorithm changes
• Best-fit analysis:
  – To study impact of algorithm changes,
  – To highlight some ‘features’
• Future developments
What has happened since 2006?

- February 2007: major algorithm changes
- 11 April 2007: Meteosat-9 became prime satellite
- March 2008: minor algorithm changes
- Ongoing: new image radiance definition
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Algorithm Changes (February 2007)

- Scenes analysis: dynamic clustering instead of ‘layering’
- AMV location moved to position with maximum local standard deviation (radiance)
- CO₂ height assignment methods: improved handling of forecast temperature inversions
- Use Semi-Transparency Correction (STC) methods for narrow selection of AMVs
- Do not apply Cloud Base Height Assignment if this places the AMV higher in the atmosphere
- Do not apply Inversion Height Correction if this places the AMV higher in the atmosphere
- Various smaller changes
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Scenes Analysis

• Consider 24 x 24 target area
• Select cloudy pixels
• Use cloud top height of each pixel (provided by CLA product)
Scenes Analysis

Old method:
• Layering
• Fixed boundaries at 100, 300, 500, 700, 900 hPa
Scenes Analysis

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Old method:
• Layering
• Fixed boundaries at 100, 300, 500, 700, 900 hPa
• A well-defined cloud scene is sometimes split into 2 separate scenes
Scenes Analysis

New method:
• Dynamic clustering
• Applies histogram analysis
• Fits Gaussian curve to each well-defined pixel cluster
• If multiple low-level scenes: merge
Height Assignment

- Select scene with coldest EBBT
- Apply all supported H/A methods:
  - EBBT,
  - CO$_2$-12.0 & CO$_2$-10.8
  - STC methods
- Select most appropriate method:
  1) CO$_2$-12.0
  2) EBBT
  3) STC
Impact of these changes

According to ECMWF:

• Overall neutral impact
• More low-level winds assimilated
• Better statistics for medium-level winds
Impact of these changes

Internal validation:
One can do a visual inspection . . .
Impact of these changes

Internal validation:
Or one can do a statistical analysis . . .
Impact of these changes

Internal validation:
Or one can do a statistical analysis . . .

Best-fit analysis, comparing AMVs with ECMWF forecast data
What is ‘best-fit’?

• Compare each AMV to forecast profile data at the same location.
• Identify the level at which the profile speed and direction match the AMV most accurately.
• Use forecast consistency.
• If this is a well-defined level, then accept it as a so-called ‘best-fit’ level.
• Some considerations:
  – Apply AMV quality threshold,
  – Is there a good match at all? ‘best-fit’ does not necessarily mean ‘good fit’.
But what is a ‘well defined level’?

- So we have identified a ‘best-fit’ level, but is it actually useful?
- That will only be the case when it is clearly distinct from all other levels.
- Let’s introduce the concept of ‘best-fit’ layer.
- A shallow ‘best-fit’ layer implies a well defined ‘best-fit’ level.
But what is a ‘well defined level’?

- If the ‘best-fit’ layer is very broad, then reject the collocation.
- A ‘best-fit’ layer being shallow is not sufficient; there should not be any secondary ‘best-fit’ levels.
The ‘best-fit’ algorithm

- Apply the same algorithm as we use to derive the AMV forecast consistency (S ≡ AMV, F ≡ forecast wind vector):

\[
Consistency = 1 - \left( \text{tanh} \left( \frac{|\vec{S} - \vec{F}|}{\text{MAX}(0.2 \cdot |\vec{S} + \vec{F}|, 0.01) + 1} \right) \right)^2
\]

- Values are in the range [0, 1],
- Value ~0: very poor consistency,
- Value ~1: very good consistency.
‘Best-fit’ layer

- Search for ‘best-fit’ layer = identification of pronounced peak in consistency profile.
- Maximum consistency must exceed $C_{\text{peak}}$.
- Consistency at base of peak must be lower than $C_{\text{base}}$.
- $C_{\text{peak}}$ defines existence of suitable peak,
- $C_{\text{base}}$ defines layer thickness.
Our ‘best-fit’ analysis

• Forecast profiles (+12 hours forecast).

• Intermediate AMV products.

• Very strict conditions:
  – QI at least 0.85,
  – ‘best-fit’ layer thickness of 110 hPa at most,
  – F/C consistency criteria:
    • Peak value at least 0.85,
    • Base value of 0.35.
Best-fit statistics

- February 2007
- November 2007
- Two aims:
  - Current performance of height assignment methods,
  - Performance improvement after algorithm changes.
Height Assignment Methods

• EBBT

• 2 CO₂ methods:
  – CO₂ - 12.0 (prime method)
  – CO₂ - 10.8

• 4 Semi-Transparency Correction (STC) methods:
  – STC - 6.2
  – STC - 7.3
  – IR / WV - 6.2
  – IR / WV - 7.3
'Best-fit' cases (IR-10.8, global)

February 2007

November 2007
‘Best-fit’ cases
(IR-10.8, global)

February 2007

November 2007
‘Best-fit’ cases (IR-10.8, global)

February 2007

Implies H/A ceiling of 200 hPa:
Tropopause problem?

November 2007
‘Best-fit’ cases (WV-6.2, global)

February 2007

November 2007
‘Best-fit’ cases (IR-10.8, Sahara, noon)

February 2007

November 2007
‘Best-fit’ cases (IR-10.8, Sahara, midnight)

February 2007

November 2007
Summary of collocation results

• General:
  – Average bias of + 50 hPa (200 - 350 hPa layer),
  – Strong positive bias above 150 hPa, probably related to problems with tropopause handling,
  – CO₂-10.8 performs better than CO₂-12.0,
  – STC methods show negative bias below 300 hPa.

• New algorithms:
  – Big improvement of CO₂ heights below 350 hPa (from large, negative bias to weak, negative bias),
  – Not so big improvement of STC heights below 350 hPa (from very large, negative bias to large, negative bias),
  – Sahara still problematic.
Interpretation of collocation results

Suggestions:
– Keep on trying to improve CLA cloud-top heights.
– Alternative method: consider pixels that contribute most to the peak in the cross-correlation surface (Ryo Oyama, Régis Borde).
What is next?

• Test alternative pixel selection:
  – Pixels that contribute most to the peak in the cross-correlation surface
• Investigate handling of tropopause
• Introduce height QI, based on inter-comparison of individual methods
• Expand AMV collocations:
  – For all individual methods,
  – Radiosonde & forecast data.
Thanks!