Assessment of new AMV data in the ECMWF system

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• Overview of AMVs
• Assessment of Himawari-8
• Meteosat-11 initial investigation
• Metop Triplet product assessment
• Future plans
Atmospheric Motion Vector (AMV) derivation

1. Tracking
2. Height assignment
3. Quality control
All AMVs monitored – one cycle 12Z 16\textsuperscript{th} Feb

- Metop A
- Metop B
- Dual Metop A/B
- GOES-13
- GOES-15
- MTSAT-2
- Met-7
- Met-10
- AQUA
- NOAA-15
- NOAA-18
- NOAA-19
- FY-2E
- FY-2G
- INSAT-3D
- Himawari-8
- COMS-1
- SNPP
- TERRA
AMV processing at ECMWF

• Apply blacklisting
  – QI thresholds (forecast dependent or forecast independent)
  – Channel selection, regional screening etc.

• First guess check

• Thinning
  – 200x200km
  – 50-175hPa boxes (vertical extent varies with height)
  – 30 mins
All AMVs used - one cycle 12Z 16th Feb

Metop A ☑️ Metop B ☑️ Dual Metop A/B ☑️ GOES-13 ☑️ GOES-15 ☑️ MTSAT-2 ☑️
Met-7 ☑️ Met-10 ☑️ AQUA ☑️ NOAA-15 ☑️ NOAA-18 ☑️ NOAA-19 ☑️

Closing gap with dual Metop

Extending zenith angle 60° to 64°

More data from Meteosat-10 IR mid-levels, extra-tropics

Addition of Metop (Feb)

(Kirsti Salonen)
New data

- From new satellites and improved existing products
  - Himawari-8
  - Meteosat-11 (test data)
    - VIIRS
    - COMS
    - INSAT-3D
    - Metop single and dual product
    - Metop triplet product
  - FY-2E
  - FY-2G

Monitored; analysis ongoing

In operations 4th Feb

Monitored
Himawari-8
Replacing MTSAT-2

- Himawari-8 launched Oct 2014
- AMV data received at ECMWF in June 2015
- MTSAT-2 AMVs only available to end March
- Advanced Himawari Imager (AHI)

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<tr>
<td>Total channels</td>
<td>16</td>
<td>5</td>
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<td>Channels for AMVs</td>
<td>5</td>
<td>3</td>
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New tracking and height assignment methods

• Tracking:
  – Small and large target boxes
  – Final vector from average of small and large
  – QC uses small-to-small and large-to-large vectors

• Height assignment
  – Fitting radiances and motion vector
  – Based on carbon dioxide slicing (compares ratio of cloudy-clear radiances for CO₂ and window channel in obs and simulated at different pressures)
  – Maximum likelihood estimation
Assessing Himawari-8 AMVs

• Initial comparison of statistics with MTSAT-2
• Generate observation errors
• Determine potential configurations for assimilation
• Run assimilation experiments to test:
  – Impact on forecast
  – Impact on the fit of other observation sources to the model
• Implement in operations 15th March
Number of observations

Much higher observation numbers

17\textsuperscript{th} Nov – 13\textsuperscript{th} Dec

Cap on observation counts

6 hour cycle removed

Himawari-8

MTSAT-2 (all data)

△ IR (10.3\,\textmu m)
△ Visible (0.64\,\textmu m)
△ WV1 (7.35\,\textmu m)
△ WV2 (6.95\,\textmu m)
△ WV3 (6.25\,\textmu m)
Initial results: time dependence

Himawari-8 RMSVD

MTSAT-2 RMSVD (all data)

Himawari-8 speed bias

MTSAT-2 speed bias (all data)

17th Nov – 13th Dec
Initial results: Forecast independent QI

20-90S, >700hPa

All latitude, all pressure

Decision to not apply QI threshold to Himawari-8
Zonal statistics:
Distribution of observations

MTSAT-2 10.8µm all data
Himawari-8 10.3µm

RMSVD

MTSAT-2 10.8µm active data
Himawari-8 10.3µm
Meteosat-10 10.8µm active data

19th June – 31st Aug
Observation errors

- Situation dependent errors combination of:
  \[ \sqrt{(\text{Tracking error})^2 + (\text{Height error})^2} \]

  - Represented by std. dev. (O-B) for wind speed where small error in height assignment. Same values used across geo satellites.
  - Involves error in height assignment represented by std. dev. (assigned - best-fit pressure)
Assimilation experiments: initial configurations

• Consider how much new information we can add

• Range from conservative (close to MTSAT-2 set up) -> relaxed (almost all data)

• Control: No MTSAT-2

• 2 seasons:
  – Summer 19th June – 30th Sept 2015
Some positive…
…some not so positive

Negative impact esp. in short range mid level tropics and ~100hPa

Even in most conservative have degradation in short term forecast scores

Mixed impact on fit of observations to model background (T+12 forecast)
Assimilation experiments: refined configurations

- Big % change in no. of AMVs at higher levels
- Elevated RMSVD at lowest pressure
- Degraded best-fit pressure statistics in IR tropics

‘Super conservative’ configurations:
1. WV 6.95µm 150 < P < 400hPa
   Vis > 700hPa
   IR > 150hPa
2. As above but IR screened in tropics > 300hPa
Impact on forecasts: change in error in vector wind

100hPa, T+12 -> T+72

MTSAT-2 vs. ctrl

Super con. 1 (no high level) vs. ctrl

Original Conservative vs. ctrl
Impact on forecasts: change in error in vector wind

Original Conservative vs. ctrl
T+12; 100hPa
T+24; 100hPa
T+48; 100hPa
T+72; 100hPa

Super con. 1 vs. ctrl
T+12; 100hPa
T+24; 100hPa
T+48; 100hPa
T+72; 100hPa
Forecast scores

100hPa, summer only

Mostly neutral -> positive
For other fields: mostly have similar behaviour to MTSAT-2

500hPa, summer only

Error in vector wind, Tropics, summer and winter

100hPa, 200hPa, 500hPa, 850hPa, 1000hPa

MTSAT-2
Super Conservative: < 150hPa removed
Conservative
Fits of other observations to model background

AIREP AMprofiler EUprofiler
JPprofiler PILOT TEMP – U wind

Highest peaking

ATMS

MTSAT-2

Super Conservative: < 150hPa removed

Conservative
Conclusions

• Initial comparison showed very promising results
• Many AMVs added to system
• Attempts to use more channels/coverage produced some positive, some negative impacts
• Stricter thresholds reduced some negative impacts
• Proposal:
  Initially use very conservative set up
  Explore further options for optimal way to introduce more data
Assessment of pre-operational Meteosat-11 data
Timeline

- Launched 15th July 2015
- Geostationary orbit at 3.4°W (Meteosat-10 at 0°)
- High inclination orbit of ~3° -> N-S latitudinal displacement of ~6°
- Storage of test data at ECMWF 25th Sept – 24th Nov 2015
- 16th Dec 2015 commissioning phase finished
- Satellite now in in-orbit storage
- Planned restart 2018…
- …can be quickly reactivated
AMVs from Meteosat-11

- Carries same instruments as Meteosat-10
- AMVs from Spinning Enhanced Visible Infra-Red Imager (SEVIRI)
- Data re-projected onto Met-10 field of view
- Same processing
- Same channels available for AMVs:

<table>
<thead>
<tr>
<th>Channel type</th>
<th>Wavelength (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water vapour 1 (clear+cloudy)</td>
<td>6.25</td>
</tr>
<tr>
<td>Water vapour 2 (clear+cloudy)</td>
<td>7.35</td>
</tr>
<tr>
<td>Infrared</td>
<td>10.8</td>
</tr>
<tr>
<td>Visible</td>
<td>0.635</td>
</tr>
<tr>
<td>Visible (broad band, high res)</td>
<td>0.6-0.9</td>
</tr>
</tbody>
</table>
Good agreement

Vector difference, IR pressure < 400hPa

• Common large scale features
• Dependence on QI similar -> use same threshold at Met-10
• QI (forecast independent) > 85 applied before calculating statistics
Time dependence

- Similar broad behaviour…
- …But more spread
Number of observations per hour

Met-11

Met-10

% Diff (Met-11 – Met-10)/Met-10

Fewer Met-11 during day
Difference in assigned pressure

Assigned pressure
Diff (Met-11 – Met-10)

- Good agreement apart from IR
- If linked to orbit variation, why only IR affected?

WV 6.25 cloudy
WV 7.35 cloudy
IR
Vis (low res)
WV 6.25 clear
WV 7.35 clear
Vis (high res)
Sinusoidal variation

Mean speed

Diff (Met-11 – Met-10)

Mean speed bias

RMSVD

Increase in speed -> increase in bias

WV 6.25 cloudy
WV 7.35 cloudy
IR
Vis (low res)
WV 6.25 clear
WV 7.35 clear
Vis (high res)
Summary

• Large scale characteristics similar to Met-10
• Overall data shows no major problems…
• … but good to understand differences
  – Variation in orbit introducing sinusoidal patterns?
  – Could re-projection be causing any effects?
  – Change in AMV numbers
• Re-evaluation when instrument reactivated
Metop triplet product
The Metop AMV products

- **Single**: 2 images of consecutive orbits from the same satellite. Time apart ~ 100 mins. Polar only.

- **Dual**: 2 images from closest orbits of different satellites. Time apart ~ 50 mins. Global.

- **Triplet**: 2 images from closest orbits of different satellites. Third image used in temporal consistency check. Time apart ~ 50 mins. Polar only.

  -> more effective screening

- Common processing applied
- Dual product latitude restricted to > 35° for comparison
Dependence on quality indicator

In a few search areas at specific times vector assigned exactly opposite direction. Assigned QI < 50.

Use QI ≥ 60 for subsequent analysis

Fixed in new operational release 2\textsuperscript{nd} Dec 2015
Triplet vs. Single vs. Dual

Triplet, mean = 3.4 m/s  Single, mean = 4.1 m/s  Dual, mean = 4.3 m/s

Triplet winds are subset of dual winds… Can we achieve similar results by adjusting sample of dual winds?

400 hPa < P < 700 hPa

Triplet, mean = 5.0 m/s  Single, mean = 5.4 m/s  Dual, mean = 6.3 m/s

P > 700 hPa

RMSVD

Vector difference

> 10.0

> 12.0

0.0

5.0

7.5

10.0

0.0

3.0

6.0

9.0

12.0

ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS
Changing QI thresholds

• Find QI value where no. of dual winds closest to no. of triplet winds QI ≥ 60.

• Compare:
  – Dual winds: QI ≥ 85
  – Triplet winds: QI ≥ 60
Changing QI thresholds

<table>
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<tr>
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<th>Mean speed bias</th>
<th>Standard deviation of speed bias</th>
<th>No. of obs</th>
</tr>
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<tbody>
<tr>
<td>Dual QI ≥ 60</td>
<td>0.48 m/s</td>
<td>3.46 m/s</td>
<td>148.9</td>
</tr>
<tr>
<td>Triplet QI ≥ 60</td>
<td>0.46 m/s</td>
<td>2.99 m/s</td>
<td>81.2</td>
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Changing QI thresholds

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<td>0.44 m/s</td>
<td>3.04 m/s</td>
<td>83.3</td>
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P < 400hPa
Summary

• Assessment revealed issue with low QI Metop B in NH (now fixed)
• Triplet winds look sensible
• Performance similar to single winds for QI ≥ 60 and improved over dual winds
• Potential to raise QI threshold of dual winds to achieve similar quality in polar regions
Future plans

• Continue refining Himawari-8 configuration
• Complete assessment VIIRS in preparation for operational use
• Assessment of new Optimal Cloud Analysis product for height assignment (Meteosat satellites)
• Continue research into single layer height assignment
Thank you for listening!
Any questions?