AMVs in the ECMWF system:
Highlights of the operational and research activities

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Look back: how the use of AMVs has evolved

Number of used AMVs

Fellowship year

2011 2012 2013 2014

NOAA-15,-16,-18,-19
Aqua and Terra

GOES-11/15

GOES-13

MTSAT-1R/2

Meteosat-9/10

Meteosat-7

EUMETSAT Fellow day, 9th March 2015
AMV sample coverage: monitored

- GOES-15
- NOAA-15
- AQUA
- INSAT-3D
- GOES-13
- NOAA-18
- TERRA
- dual METOP-A/B, -B/A
- MET-10
- NOAA-19
- METOP-A
- MET-7
- FY-2D
- METOP-B
- MTSAT-2
- FY-2E
- VIIRS

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AMV sample coverage: active

GOES-15  NOAA-15  AQUA
GOES-13  NOAA-18
MET-10   NOAA-19
MET-7    MTSAT-2
Revising the blacklisting decisions

- **Motivation:**
  - Improvements in the AMV processing.
  - Use of situation dependent observation errors.

- **Relaxations:**
  - Satellite zenith angle $60^\circ \rightarrow 64^\circ$
  - Blacklisting of Meteosat-10 AMVs at midlatitudes 460 – 700 hPa removed.
Sample coverage, operational blacklist

GOES-15  GOES-13  MET-10  MET-7  MTSAT-2
NOAA-15  NOAA-18  NOAA-19
AQUA
Sample coverage, revised blacklist

GOES-15
NOAA-15
AQUA

GOES-13
NOAA-18

MET-10
NOAA-19

MET-7

MTSAT-2

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Forecast impact: normalised difference of the RMS wind error

Positive impact

Negative impact
Potential to further reduce the gap:

Metop AMVs

- Metop-A and Metop-B AMVs have coverage up to 50°S/N
- Dual Metop AMVs have global coverage
- Latest changes in the AMV processing, 27\textsuperscript{th} May 2014
  - Centres of target box used as reference points when computing the wind
  - The window search size depends on the expected displacement
Single Metop AMVs

27.3-26.5.2014

Bias

RMSVD

28.5-27.7.2014

Bias

RMSVD

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dual Metop AMVs

Bias, 31.7-5.10.2014

A/B

Bias, 5.12.2014-4.1.2015

A/B

B/A
Upcoming changes and new AMVs

- Himawari-8 will replace MTSAT-2, summer 2015.
- Preparations for GOES-R AMV processing.
- ECMWF IFS cycle 41r2
  - INSAT-3D, COMS, VIIRS AMVs to operational monitoring.
  - Relaxation of the blacklisting
AMVs over the Indian Ocean
MET-7

- MET-7 currently the prime satellite over the Indian Ocean.
- IR, cloudy WV, VIS AMVs available 1.5-hourly.
- Reaching the end of its lifetime.
- Plans to move MET-8 over the region.
**FY-2E**

- IR and mixed WV AMVs available 6-hourly.
- Long term monitoring indicates significant improvements in the data quality.
- No separation between cloudy and clear sky WV AMVs.
- Forecast dependent and independent QI set to same value.
INSAT-3D

- IR, mixed WV and VIS AMVs, available with varying time intervals.
- Became recently available in the GTS.
- No separation between cloudy and clear sky WV AMVs.
- QI information currently not very useful.
Comparison of the data quality: IR

MET-7

FY-2E

INSAT-3D

Bias

Normalised RMSVD (m s\(^{-1}\)), channel: 1

NRMSVD

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Comparison of the data quality: WV

MET-7

FY-2E

INSAT-3D

Bias

Normalised RMSVD (ms⁻¹), channel: 0

Normalised RMSVD (ms⁻¹), channel: 3

Normalised RMSVD (ms⁻¹), channel: 103

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Experimentation with MET-7 and FY-2E

- Summer season 2.8-31.10.2013 and winter season 1.1-31.3.2014.
- ECMWF CY40r2, T511, 137 levels, 12-hour 4D-Var.
- **Control**
  - All operationally assimilated conventional and satellite observations used except MET-7 AMVs and clear sky radiances.
- **MET-7**
  - Similar to Control but MET-7 AMVs and CSRs are used.
- **FY-2E**
  - Similar to Control but FY-2E IR and mixed WV AMVs are used. CSRs not available.
Data selection for FY-2E

- **QI criteria**
  - Forecast dependent QI, limits vary from 80 in tropics to 90 at midlatitudes high and mid levels.
  - Blacklisting and thinning similar to other geostationary satellites.
    - WV winds below 400 hPa
    - All AMVs over land below 500 hPa
Observation errors

- Height errors estimated from best-fit pressure statistics.
- Tracking errors 2-3 m/s depending on height, similar to other GEO satellites.
Forecast impact: normalised difference of the RMS wind error

MET-7

T+72; 200hPa

FY-2E

T+72; 200hPa

Positive impact

Negative impact
Conclusions

- Maintaining AMV coverage over the Indian Ocean region is very important.
- FY-2E and INSAT-3D show promising data quality, comparable to MET-7. However,
  - No separation between clear sky and cloudy WV AMVs
  - No CSR/ASR
  - FY-2E AMVs available only 6-hourly
  - Some technical issues
- Forecast impact from MET-7 and FY-2E neutral to positive.
- Impact studies with INSAT-3D AMVs to be done.
Alternative interpretations of AMVs
Alternative interpretations of AMVs

- Interpreted as single-layer observations even though clouds have vertical extent.
- Comparison to radiosonde\(^{(1)}\) and lidar\(^{(2)}\) observations and results from simulation framework\(^{(3)}\) suggests benefits from
  - Layer averaging
  - Interpreting as single level wind but within the cloud

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(1) Velden and Bedka, 2009: Identifying the Uncertainty in Determining Satellite-Derived Atmospheric Motion Vector Height Attribution. JAMC, 48, 450-463.


(3) Hernandez-Carrascal and Bormann, 2013: Atmospheric Motion Vectors from Model Simulations. Part II: Interpretation as Spatial and Vertical Averages of Wind and Role of clouds. Accepted to JAMC.
Approaches under investigations

1. Single-level with height re-assignment

2. Boxcar averaging centered or below

3. Boxcar averaging centered/below with height re-assignment
**Summay: experimenting with layer averaging**

**METEOSAT-9 WV, high levels**

**Best-fit pressure bias**

- Assigned pressure lower in the atmosphere than best-fit pressure.

**GOES-13 IR, mid levels**

**Best-fit pressure bias**

- Assigned pressure higher in the atmosphere than best-fit pressure.

**Meteosat-9, WV 6.2 μm, 100 - 400 hPa**

**Centred averaging:** 6% improvement in RMSVD

**GOES-13, IR, 400 - 700 hPa**

**Averaging below:** 29% improvement in RMSVD
Height re-assignment

- Use long-term bias statistics in the observation operator design to take into account systematic height assignment errors.
- Based on model best-fit pressure statistics. Bias varies typically between ±50 hPa.
- First trial: bias statistics defined separately for all satellites, channels, height assignment methods, vary with height.
Data assimilation experiments

- Control: single-level observation operator
- Experiments with
  - Boxcar centred averaging 120 hPa
  - Boxcar averaging 40 hPa below
  - Re-assignment and single-level observation operator
- IFS CY40r1, T511, 137 levels, 12-hour 4D-Var. All operationally used conventional and satellite observations used.
Promising results: single-level observation operator and re-assignment

- Normalised change in the standard deviation of background differences from radiosonde, pilot, aircraft and wind profiler observations.
Normalised difference in VW RMS error

Single level observation operator with height reassignment

Centred averaging 120 hPa

Averaging below 40 hPa
OmB bias for wind speed

Single-level observation operator

Single-level with height re-assignment

Layer averaging 40 hPa below
Conclusions so far

- Layer averaging can bring up to 30% reductions in RMSVD, typically 5-10%.

- Results from the first data assimilation experiments indicate:
  - Benefits from taking into account the systematic height errors
  - Degradation in the forecast quality above 400 hPa when layer averaging is used.
Ongoing work

- Co-operation with Hans-Ertel-Centre for Weather Research
  - Investigate similarities and explain differences in the systematic height error estimates based on best-fit pressure bias and lidar height corrections.
- More experimentation is required.