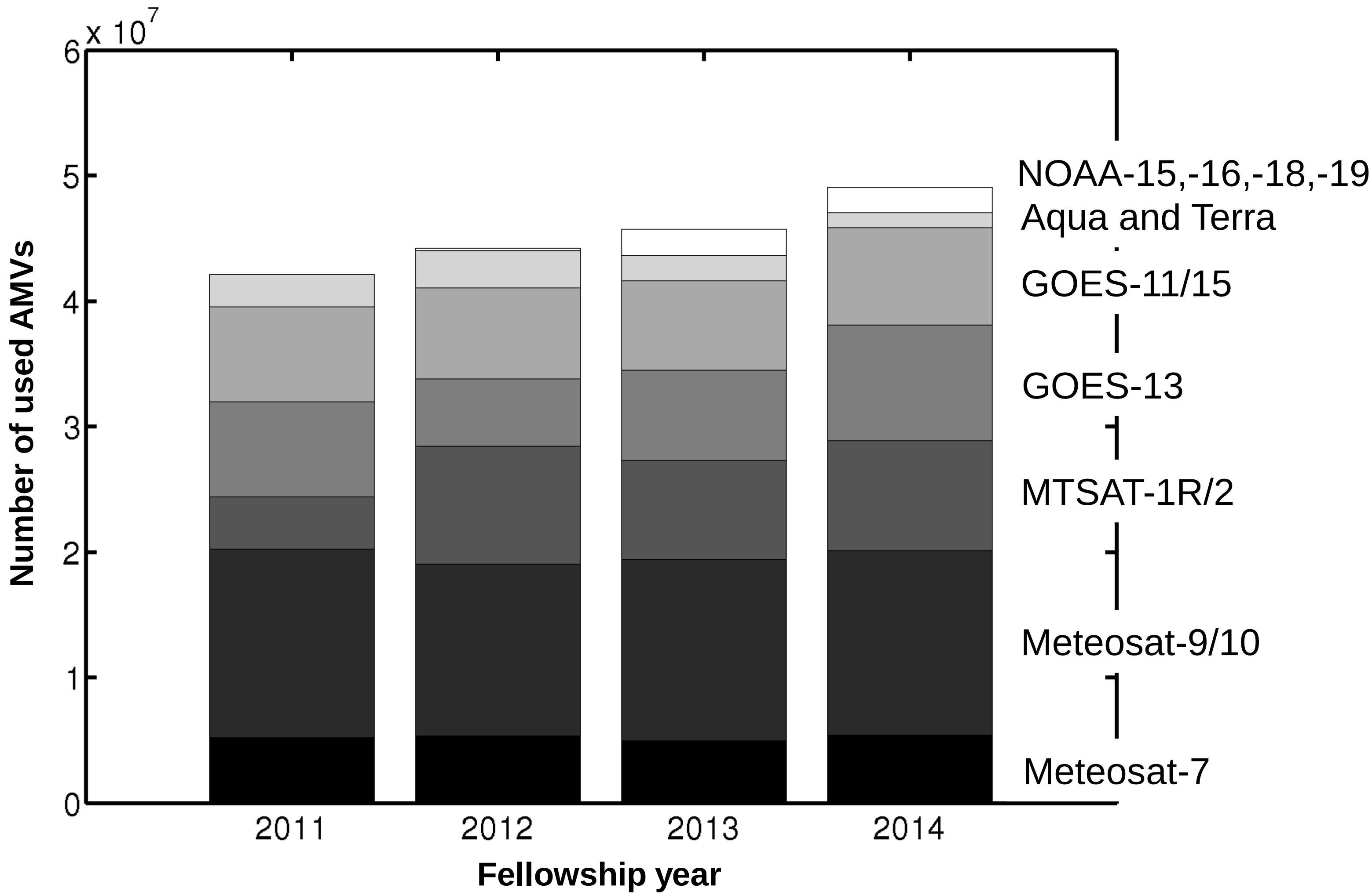
AMVs in the ECMWF system:

Highlights of the operational and research activities

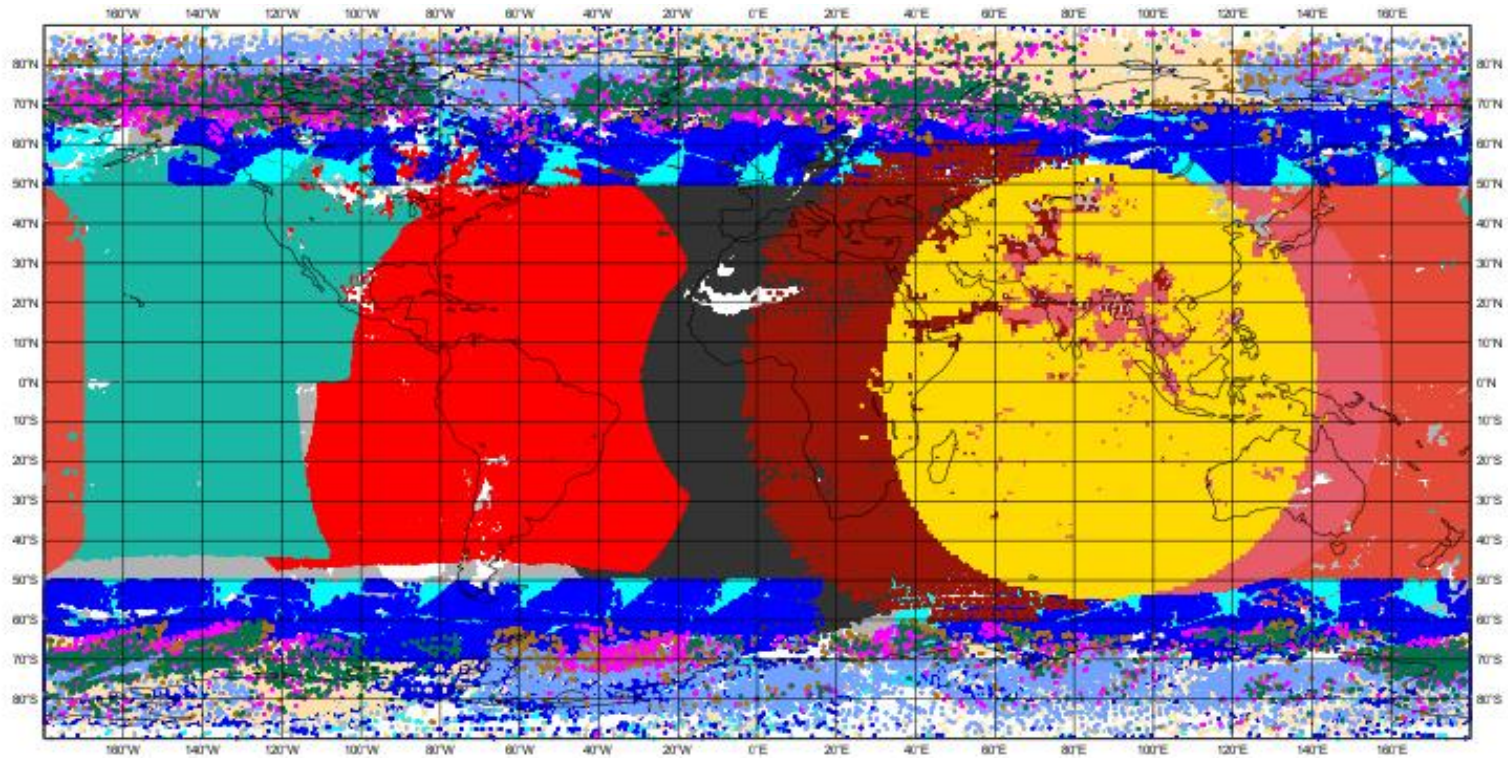
Kirsti Salonen and Niels Bormann

Look back: how the use of AMVs has evolved



AMV sample coverage: monitored

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

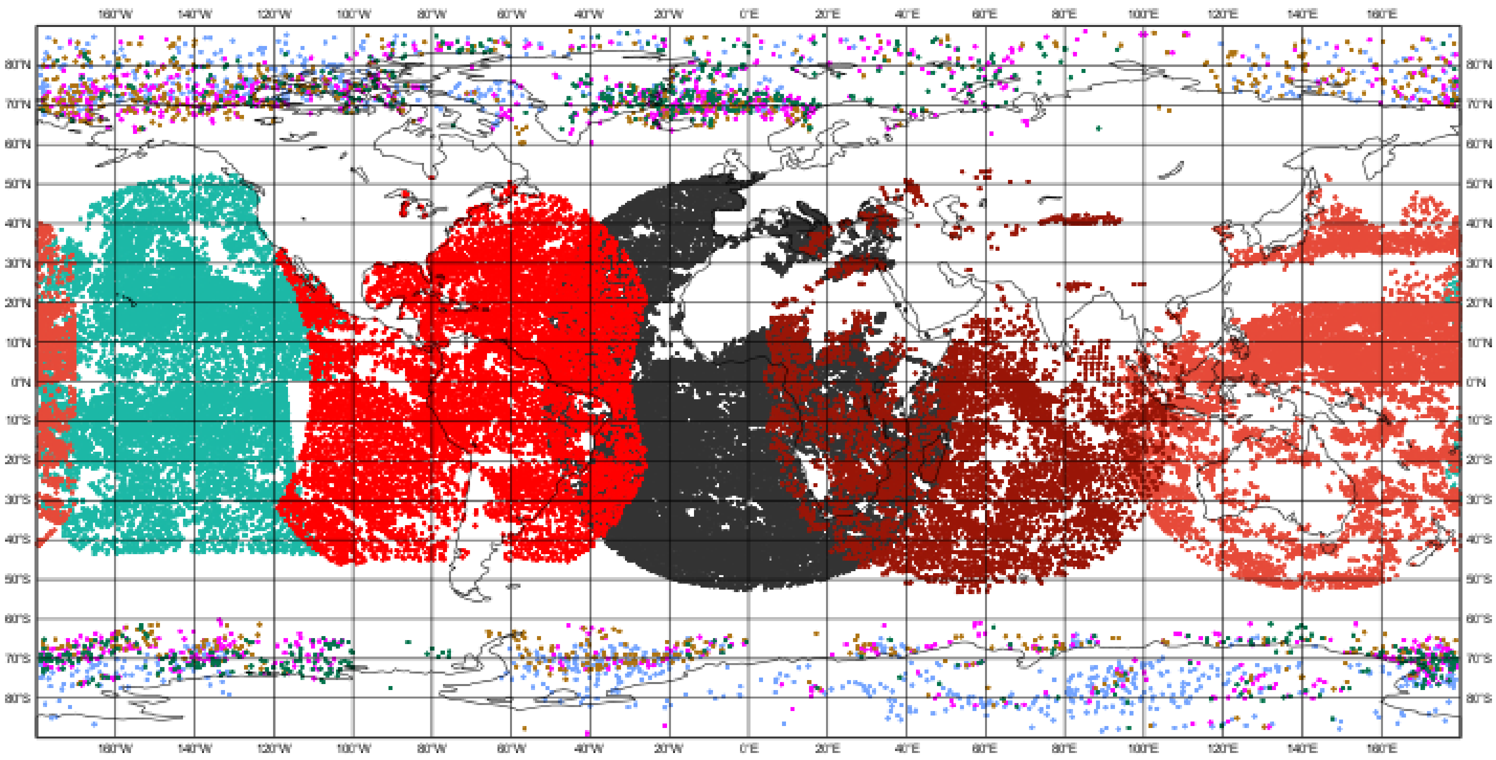


AMV sample coverage: active

GOES-15 | GOES-13 | MET-10 | MET-7 | MTSAT-2

NOAA-15 | NOAA-18 | NOAA-19

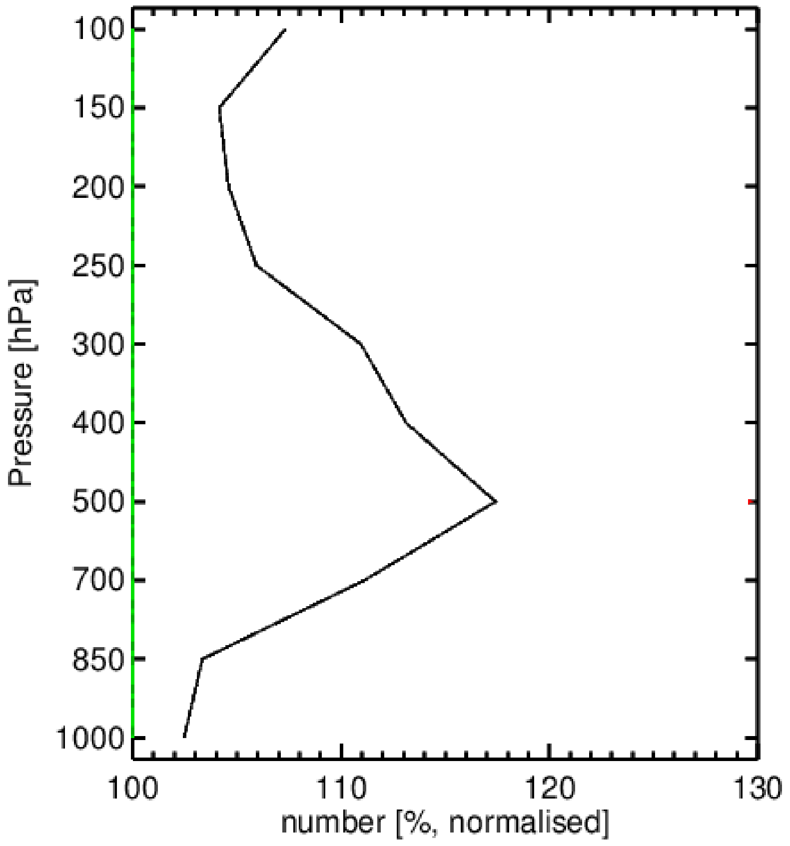
AQUA



Revising the blacklisting decisions

- **Motivation:**
  - **Improvements in the AMV processing.**
  - **Use of situation dependent observation errors.**
- **Relaxations:**
  - **Satellite zenith angle 60° -> 64°**
  - **Blacklisting of Meteosat-10 AMVs at midlatitudes 460 – 700 hPa removed.**

Change in the NO. of obs



Sample coverage, operational blacklist

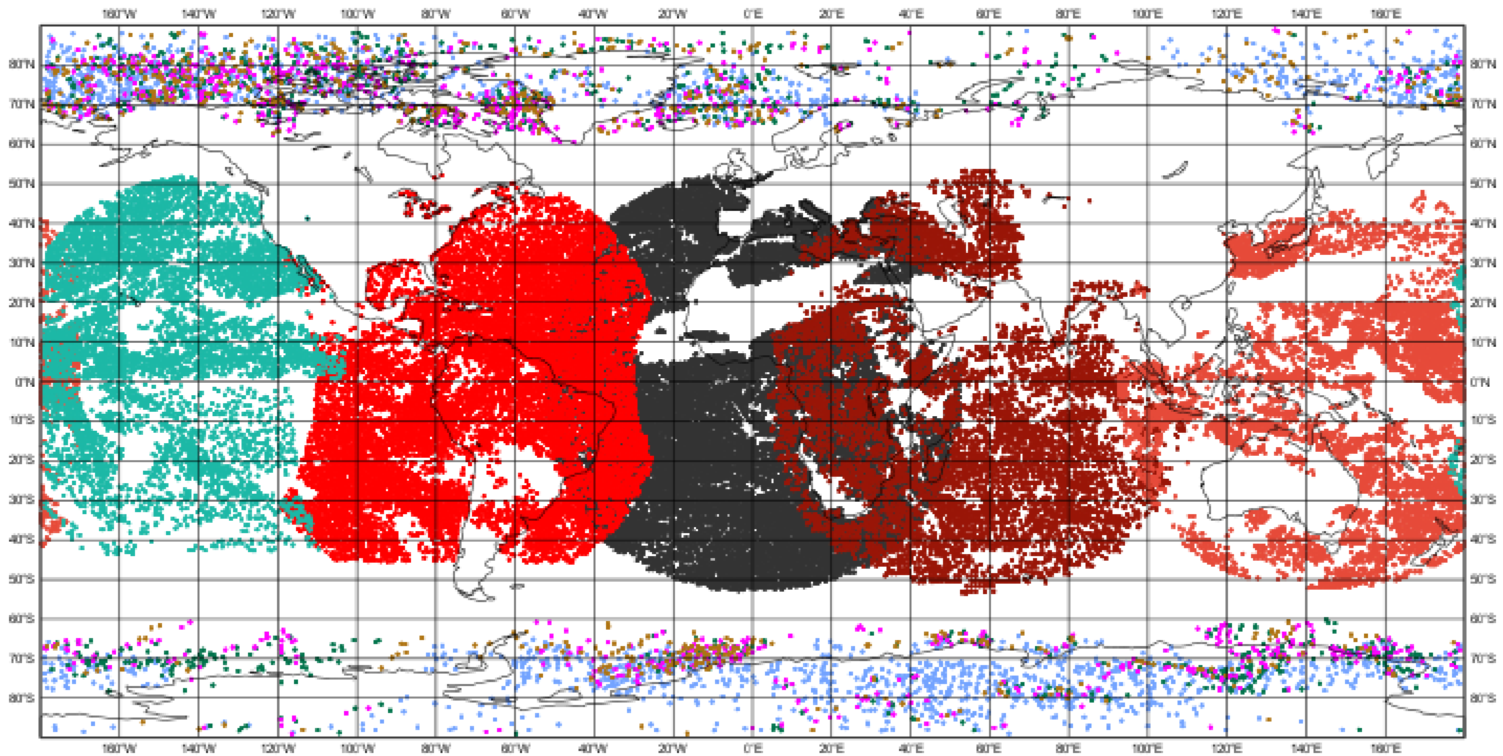
GOES-15
NOAA-15
AQUA

GOES-13
NOAA-18

MET-10
NOAA-19

MET-7

MTSAT-2

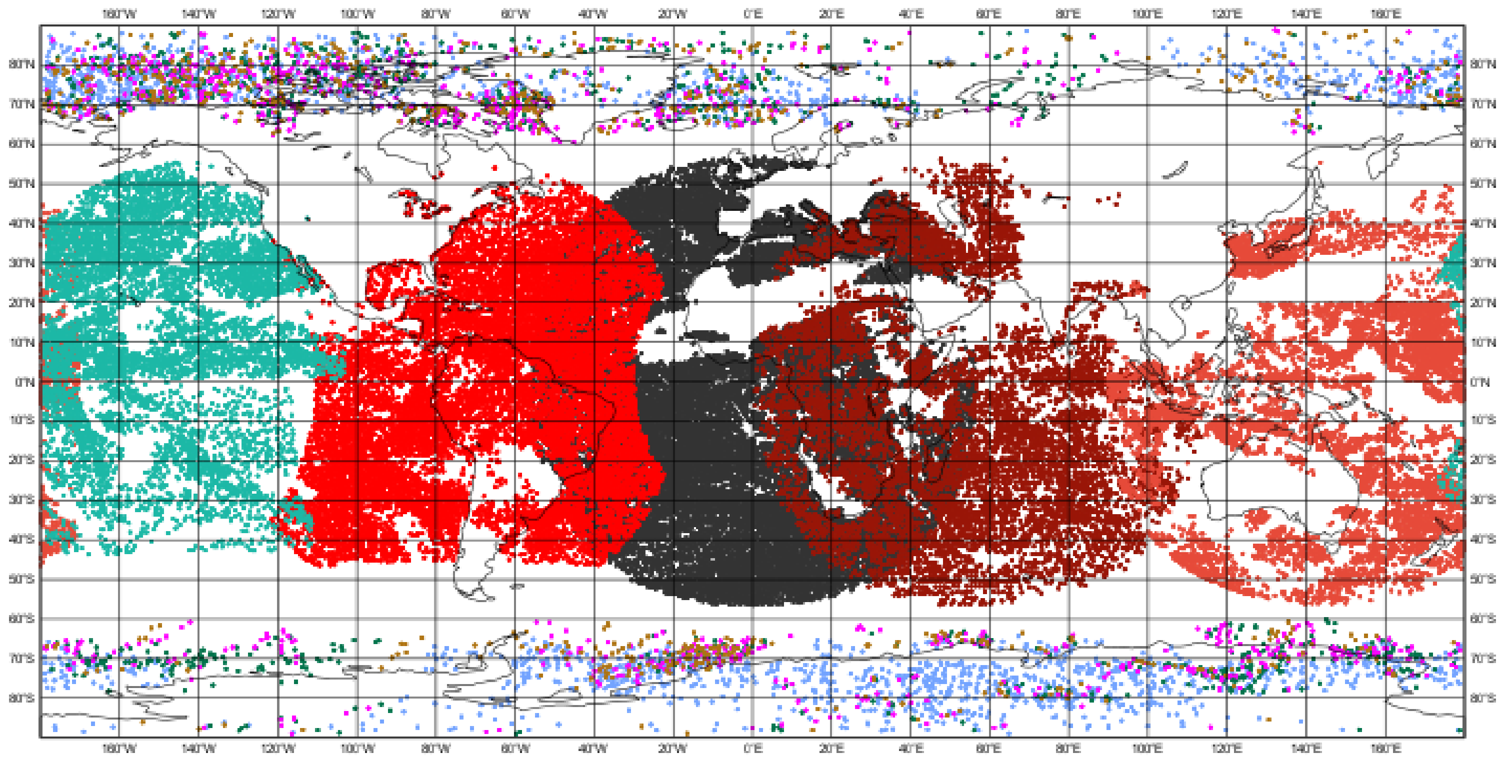


Sample coverage, revised blacklist

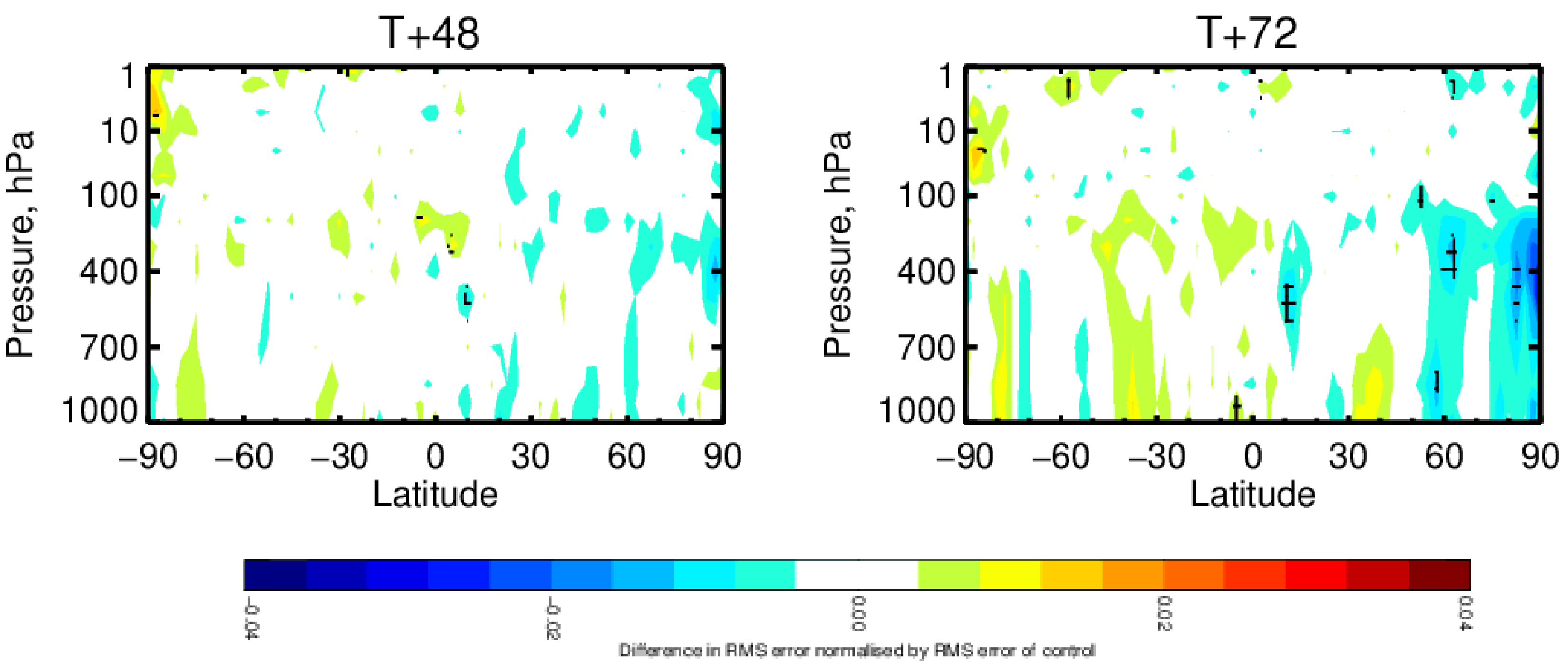
GOES-15 | GOES-13 | MET-10 | MET-7 | MTSAT-2

NOAA-15 | NOAA-18 | NOAA-19

AQUA



Forecast impact: normalised difference of the RMS wind error



Positive impact

Negative impact

Potential to further reduce the gap:

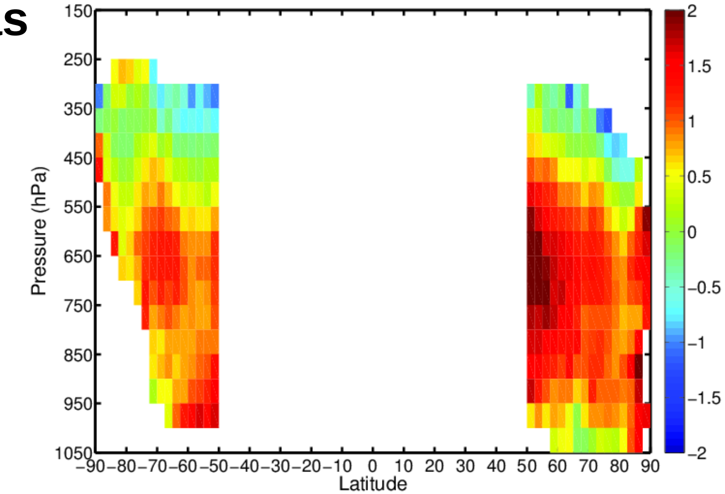
Metop AMVs

- 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, 27th May 2014
  - Centres of target box used as reference points when computing the wind
  - The window search size depends on the expected displacement

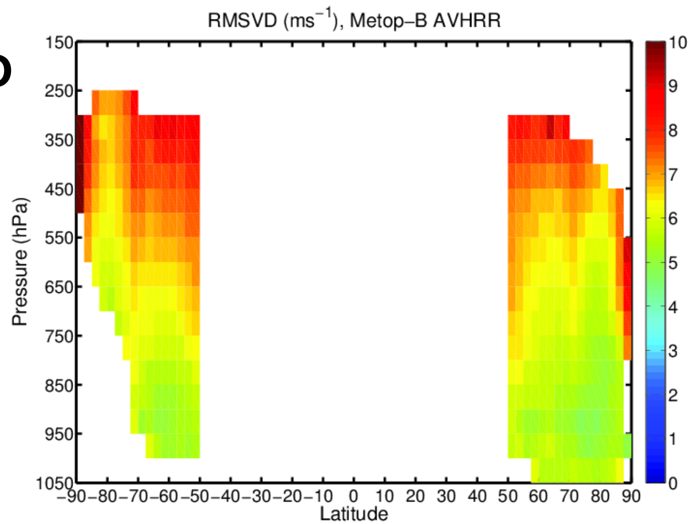
Single Metop AMVs

27.3-26.5.2014

Bias

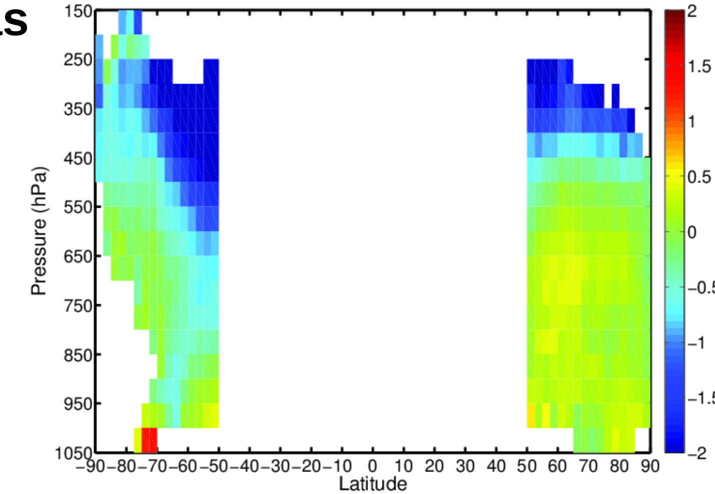


RMSVD

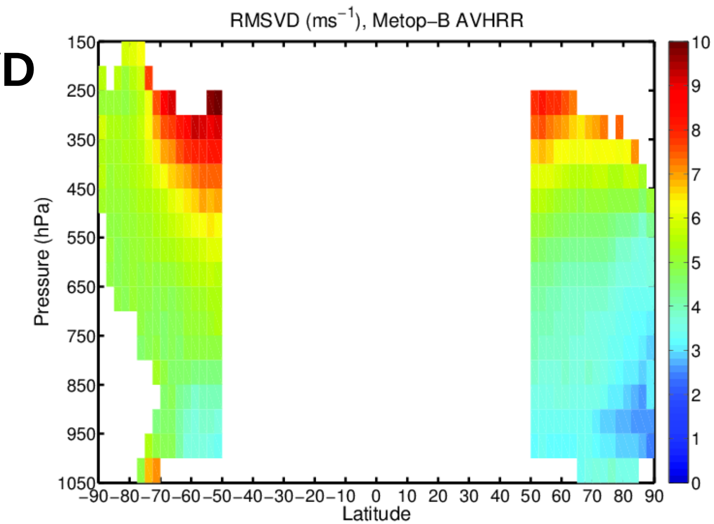


28.5-27.7.2014

Bias



RMSVD

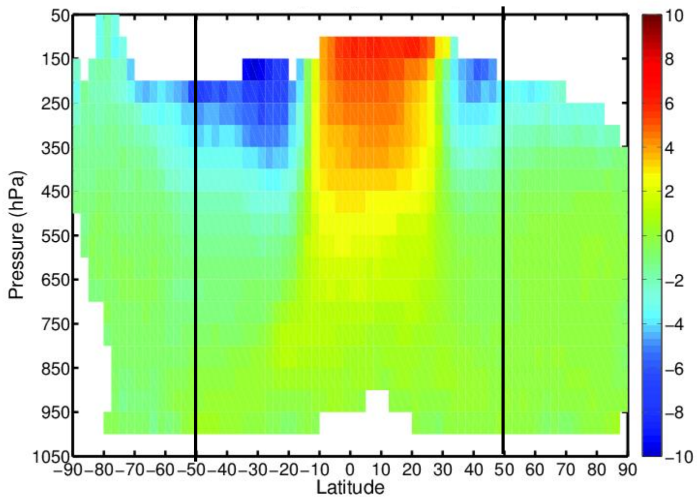


dual Metop AMVs

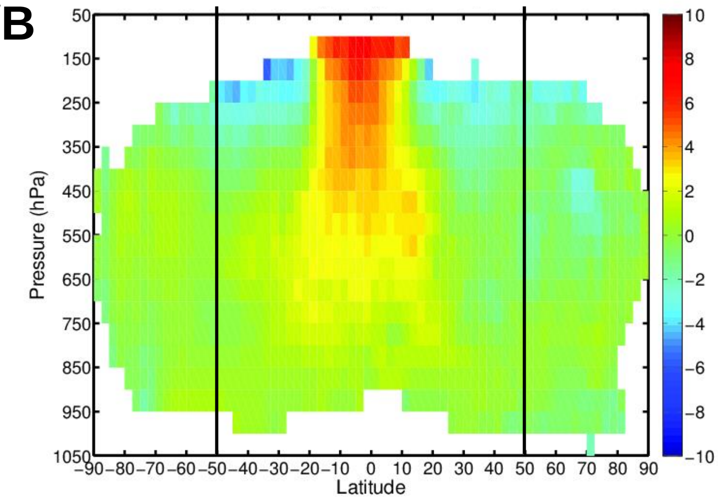
Bias, 31.7-5.10.2014

Bias, 5.12.2014-4.1.2015

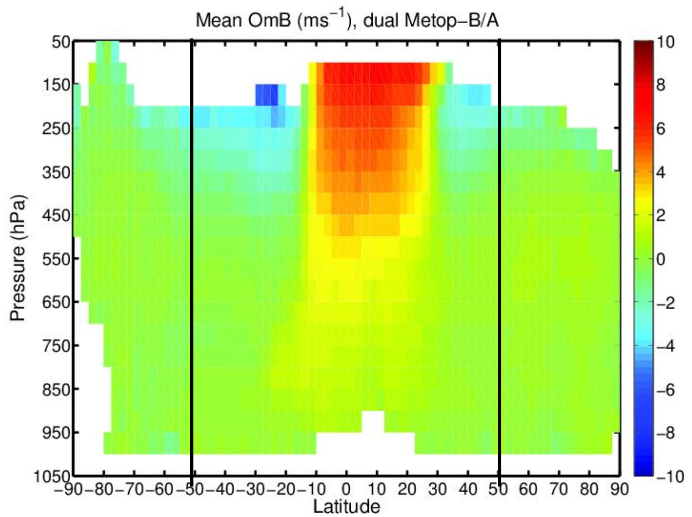
A/B



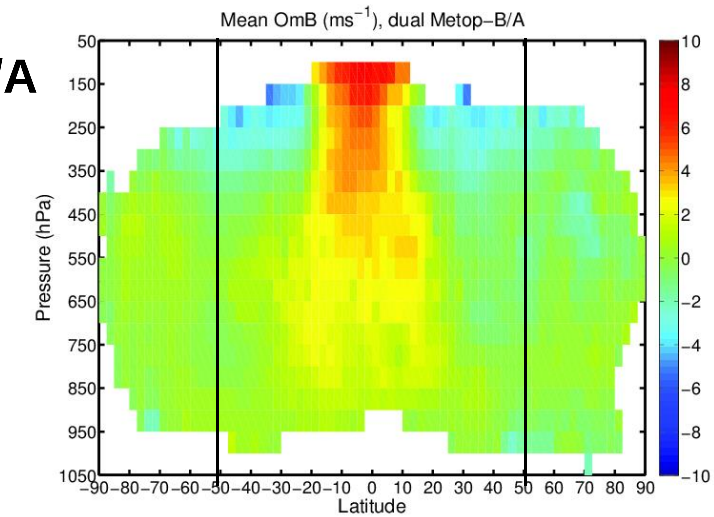
A/B



B/A



B/A



Upcoming changes and new AMVs

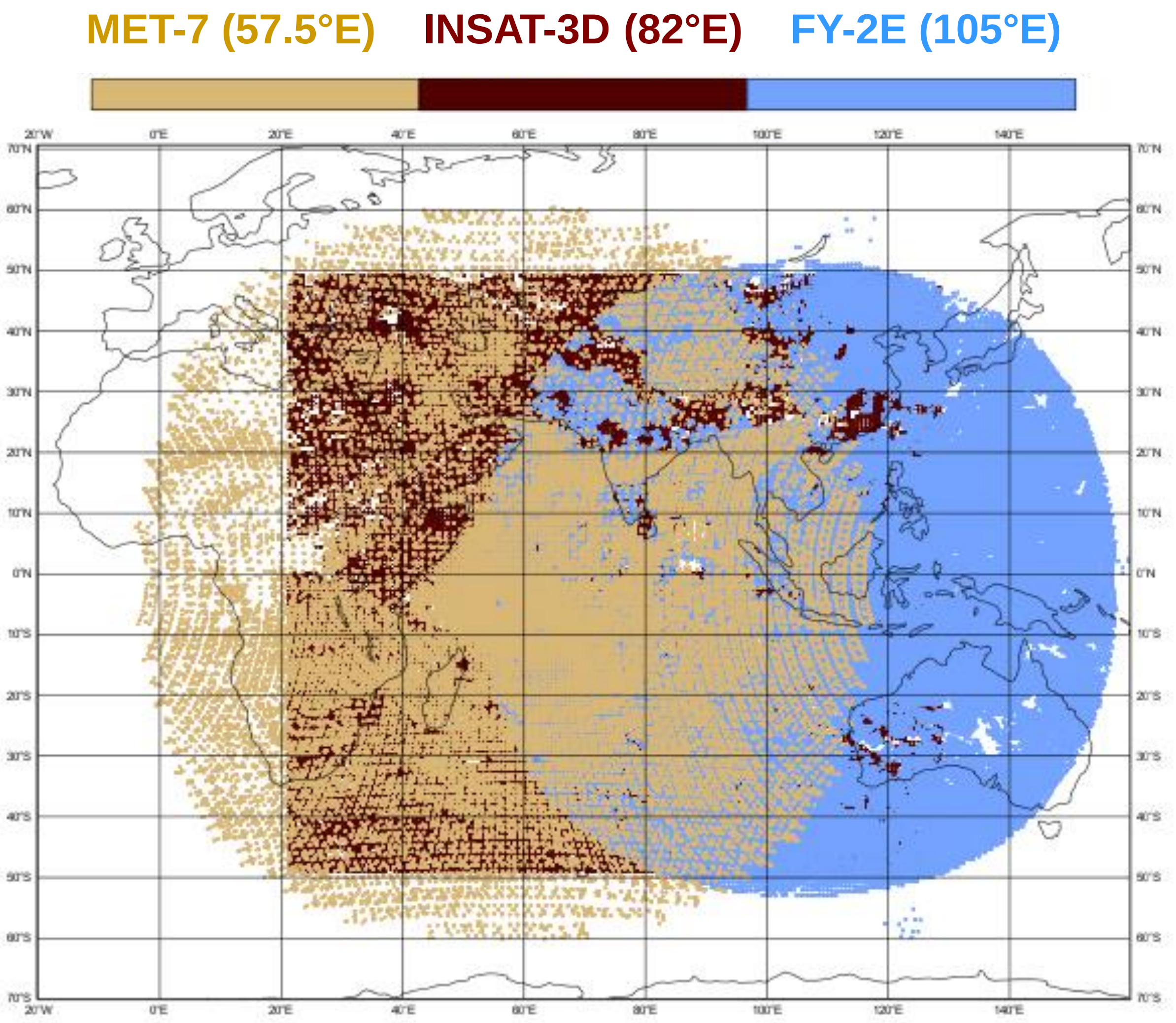
- Himawari-8 will replace MTSAT-2, summer 2015.
- Preparations for GOES-R AMV processing.
- ECMWF IFS cycle 41r2
  - INSAT-3D, COMS, VIIRS AMVs to operational monitoring.
  - Relaxation of the blacklisting

AMVs over the Indian Ocean

ECMWF

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.



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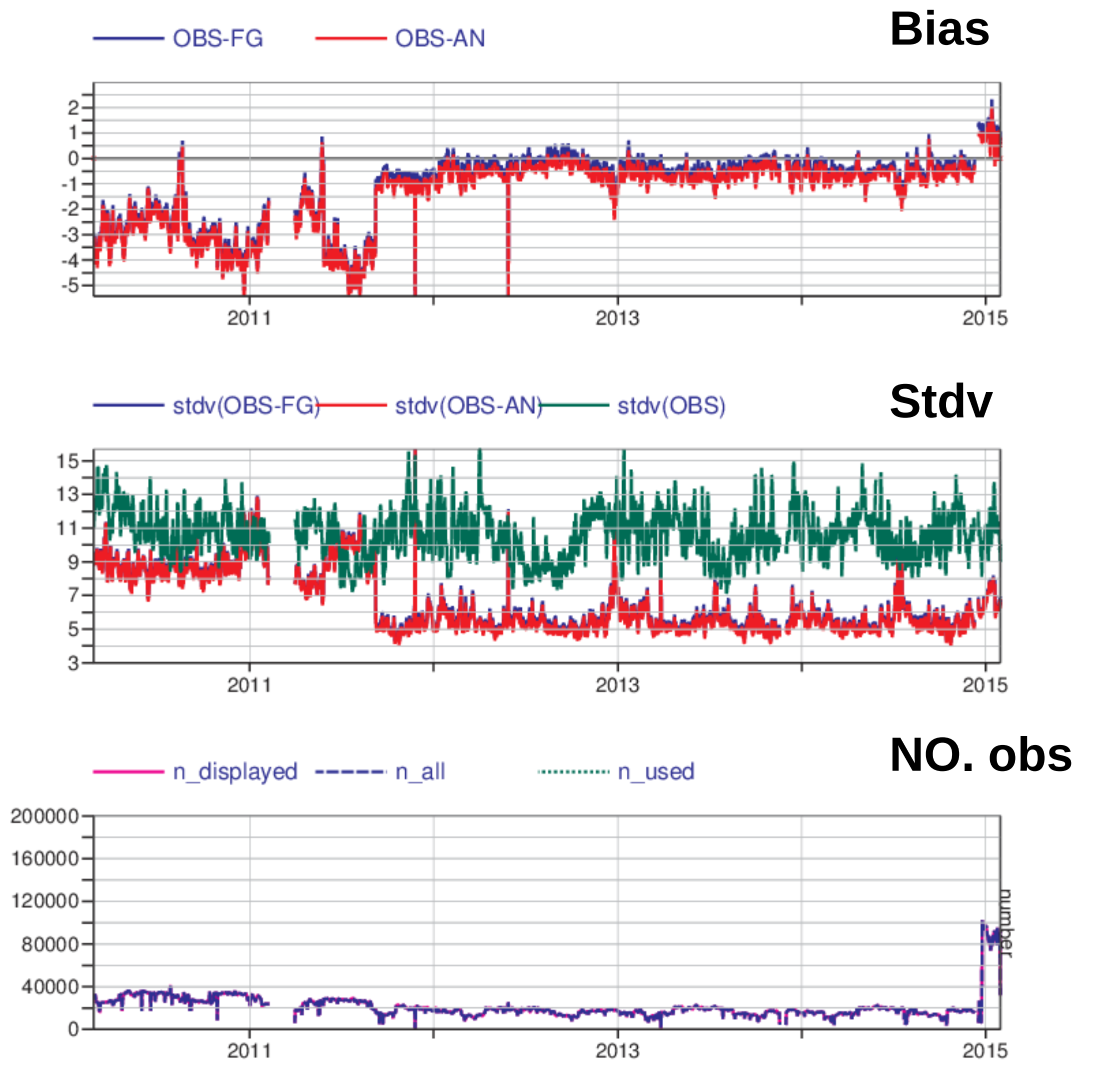
FY-2E

- 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.

Mixed WV AMVs, high levels



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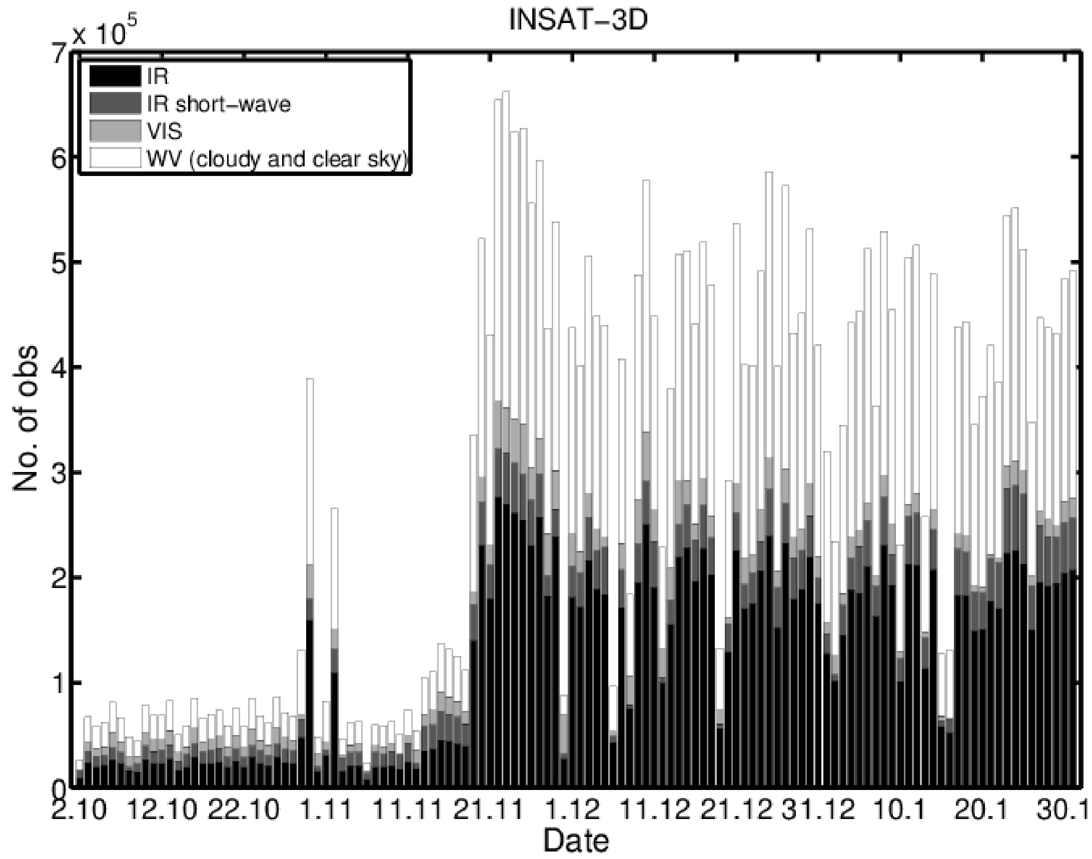
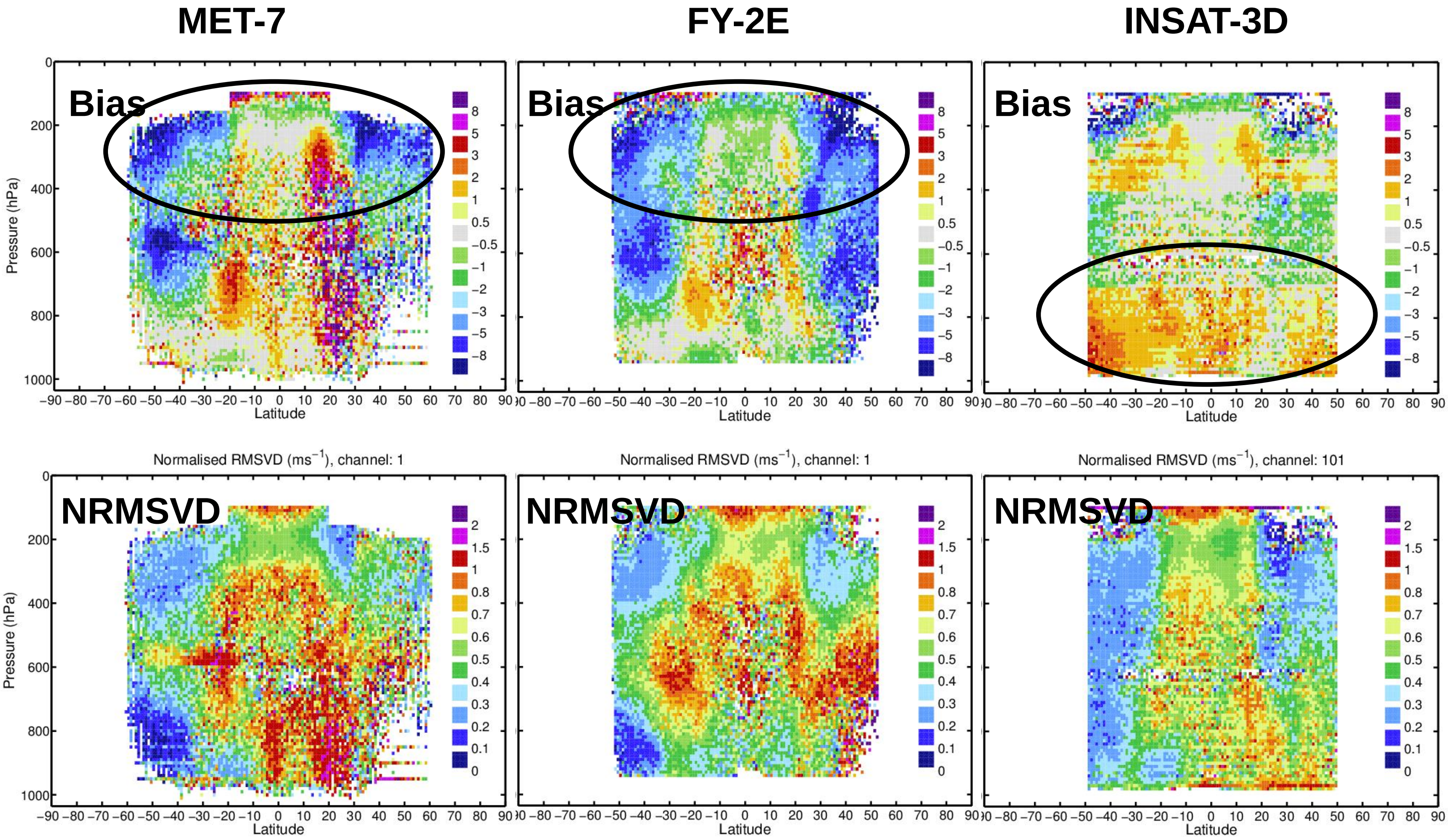
INSAT-3D

- 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.

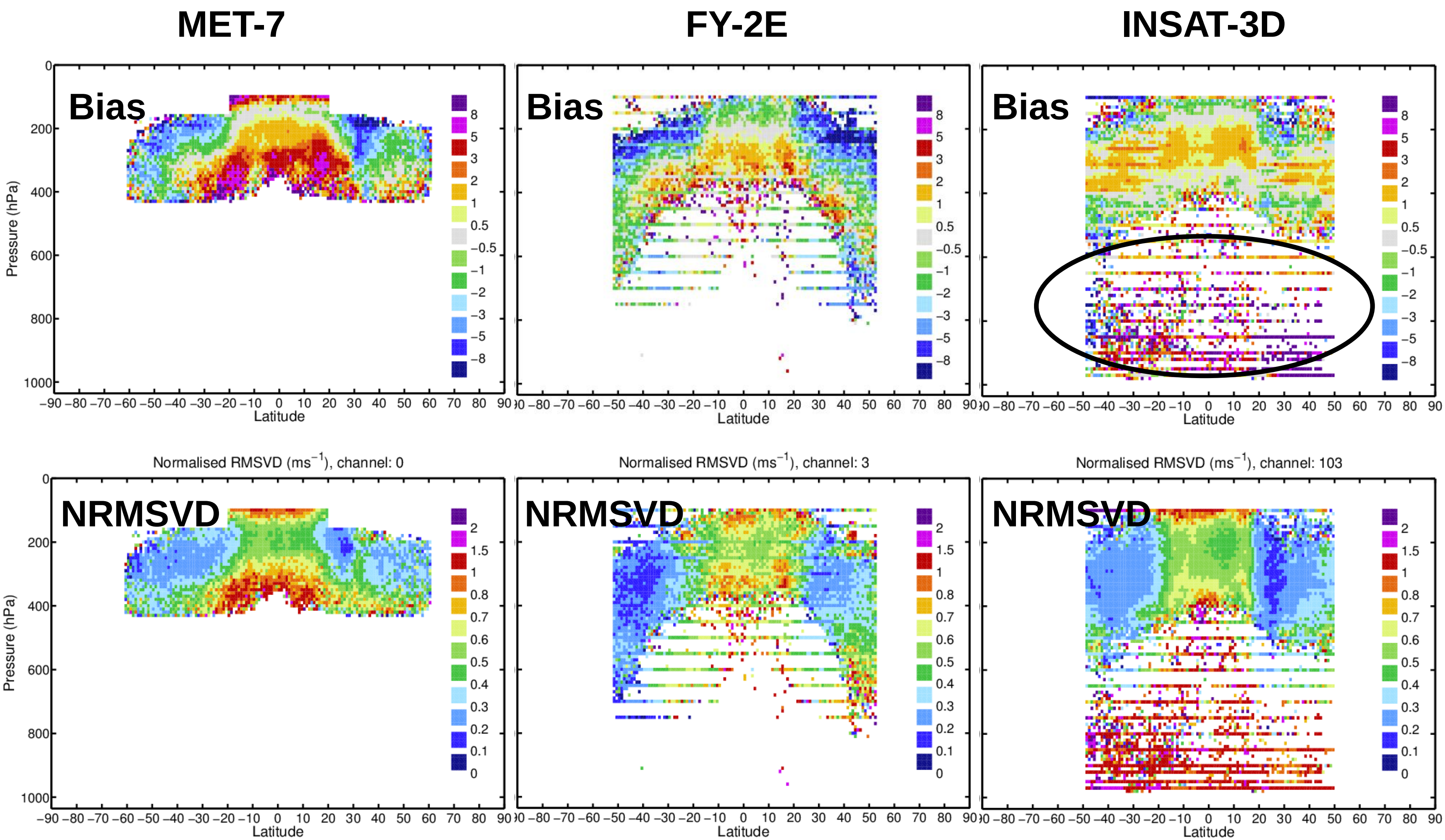


ECMWF

Comparison of the data quality: IR



Comparison of the data quality: WV



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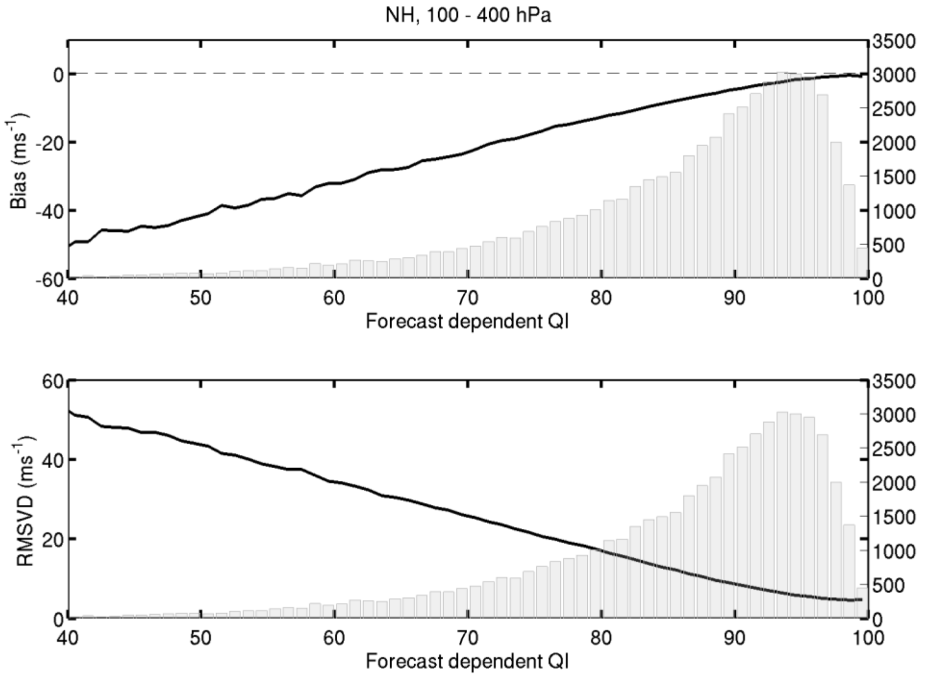
Experimentation with MET-7 and FY-2E

- Summer season 2.8-31.10.2013 and winter season 1.1-31.3.2014.
- ECMWF CY40r2, T511, 137 levels, 12-hour 4D-Var.
- <u>Control</u>
  - All operationally assimilated conventional and satellite observations used except MET-7 AMVs and clear sky radiances.
- <u>MET-7</u>
  - Similar to Control but MET-7 AMVs and CSRs are used.
- <u>FY-2E</u>
  - 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**



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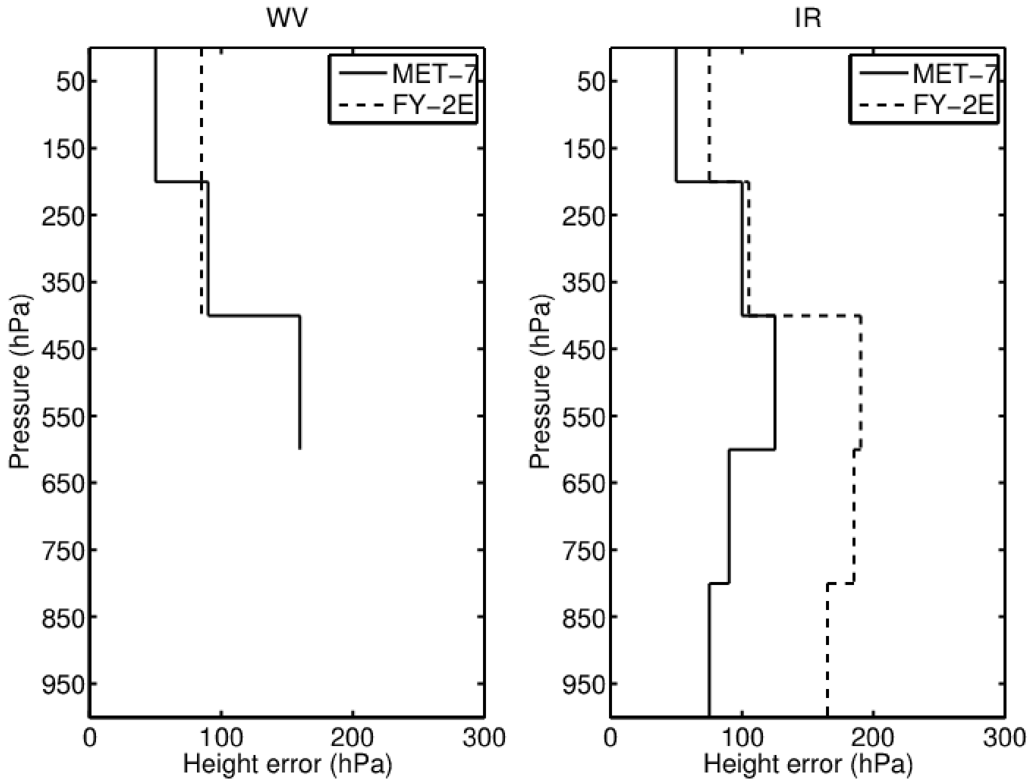
Observation errors

- Height errors estimated from best-fit pressure statistics.
- Tracking errors 2-3 m/s depending on height, similar to other GEO satellites.



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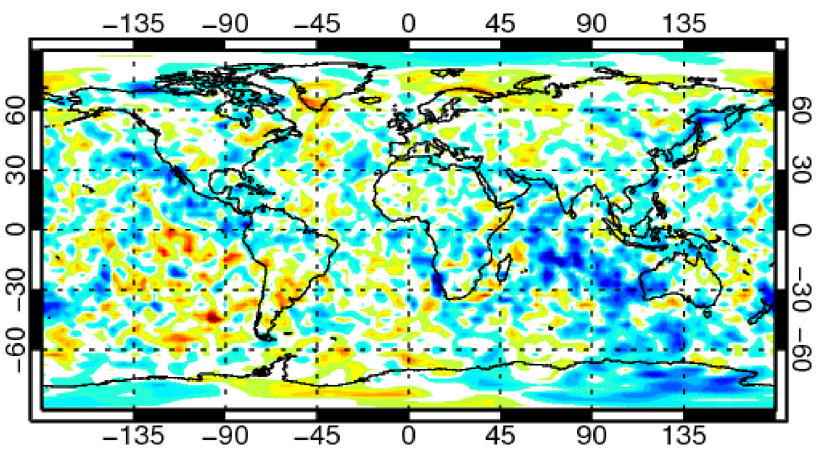
Forecast impact: normalised difference of the RMS wind error

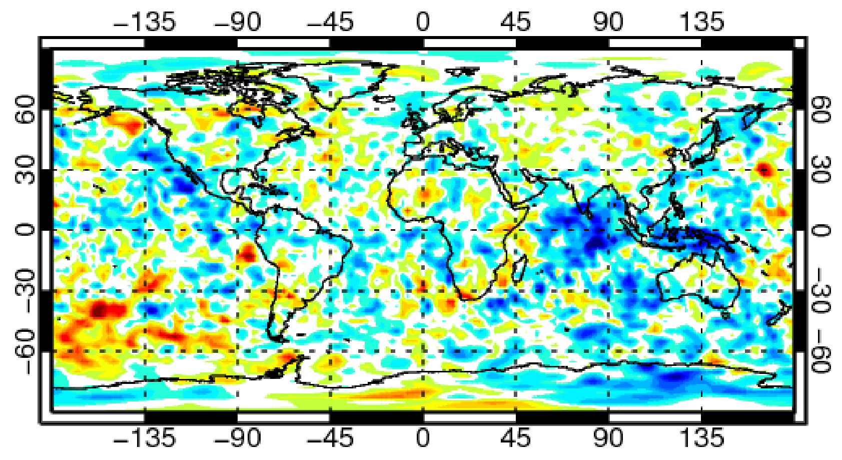
MET-7

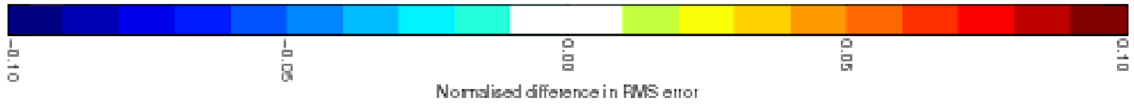
T+72; 200hPa



FY-2E

T+72; 200hPa





Positive impact

Negative impact

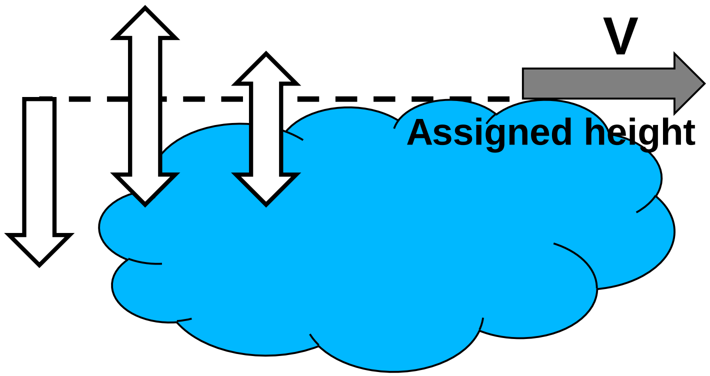
Conclusions

- 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

ECMWF

Alternative interpretations of AMVs



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

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

(2) Weissman et al, 2013: Height Correction of Atmospheric Motion Vectors Using Airborne Lidar Observations. JAMC, 52, 1868-1877.

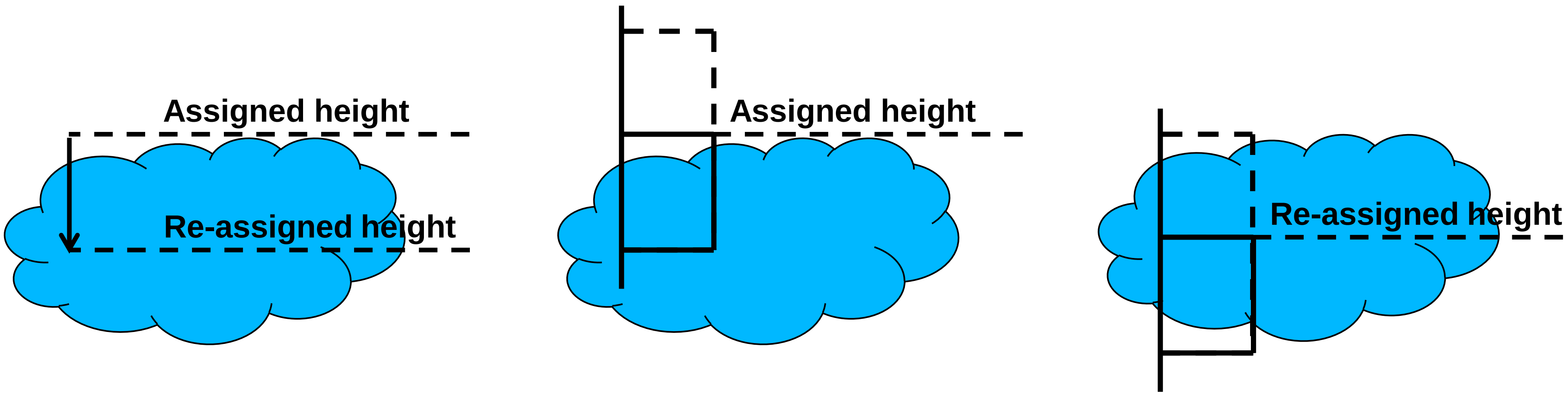
(3) Hernandez-Carrascal and Bormann, 2013: Atmospheric Motion Vectors from Model Simulations. Part II: Interpretation as Spatial and Vertical Averages of Wind and Role of clouds. Accepted to JAMC.

Approaches under investigations

1. Single-level with heigth re-assignment

2. Boxcar averaging centrered or below

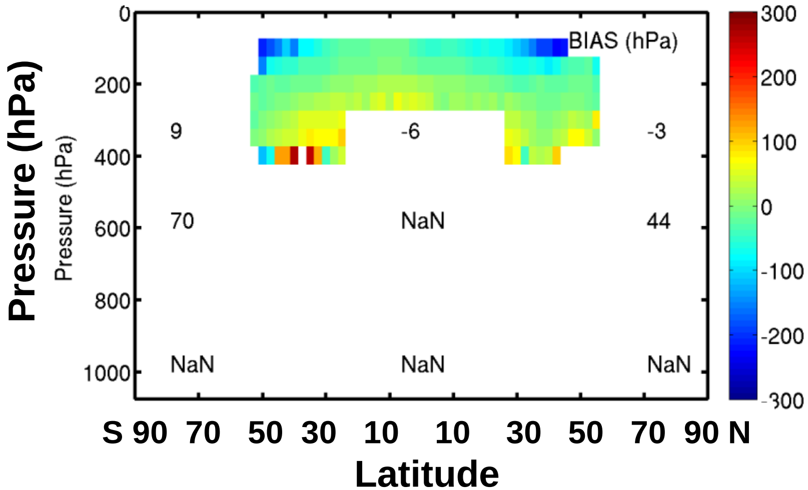
3. Boxcar averaging centrered/below with height re-assignment



Summay: experimenting with layer averaging

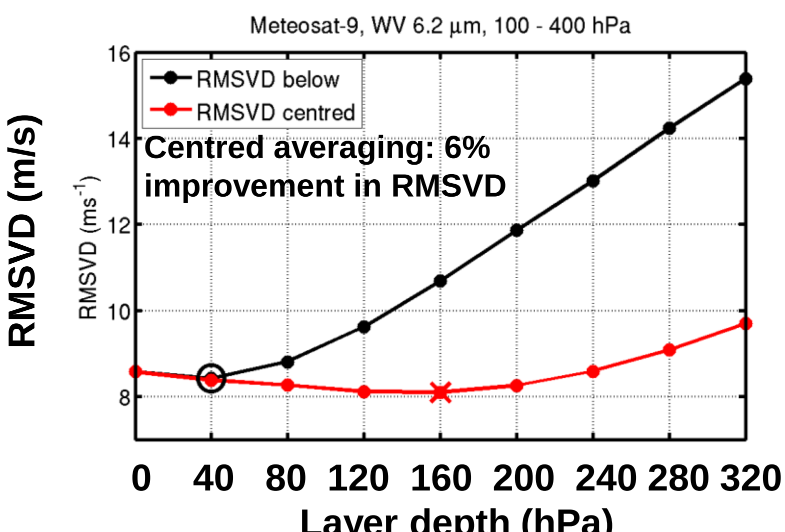
METEOSAT-9 WV, high levels

Best-fit pressure bias



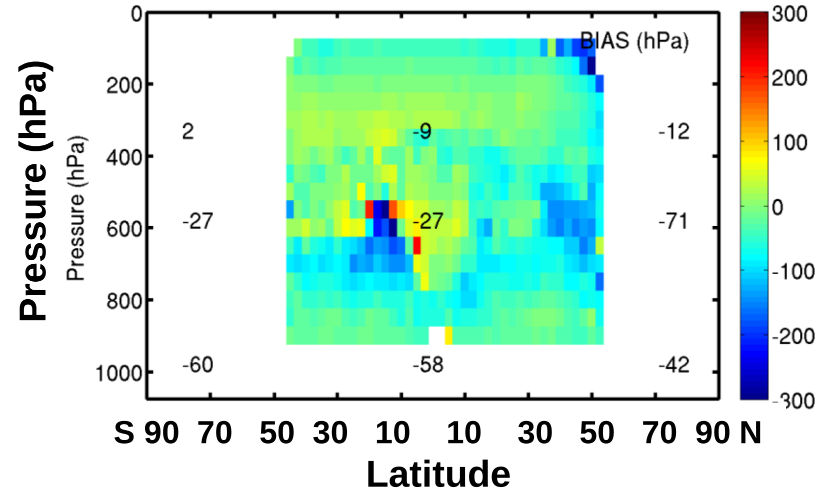
Assigned p lower in the atmosphere than best-fit p

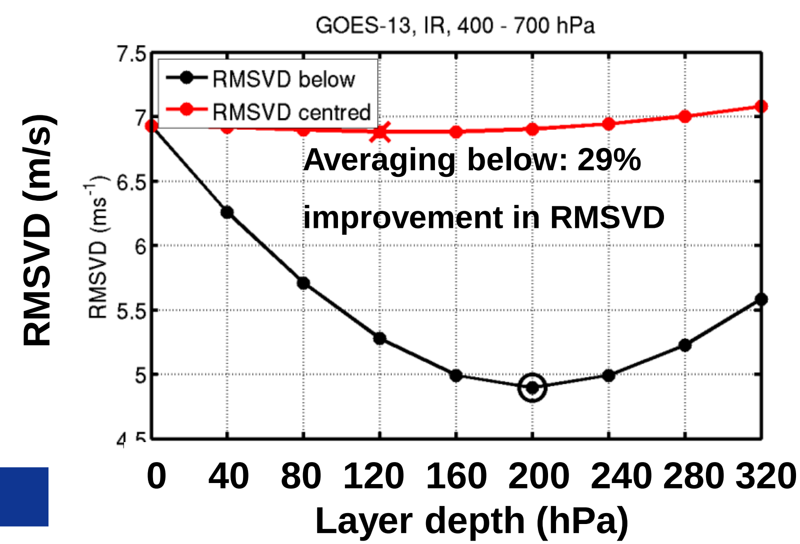
Assigned p higher in the atmosphere than best-fit p



GOES-13 IR, mid levels

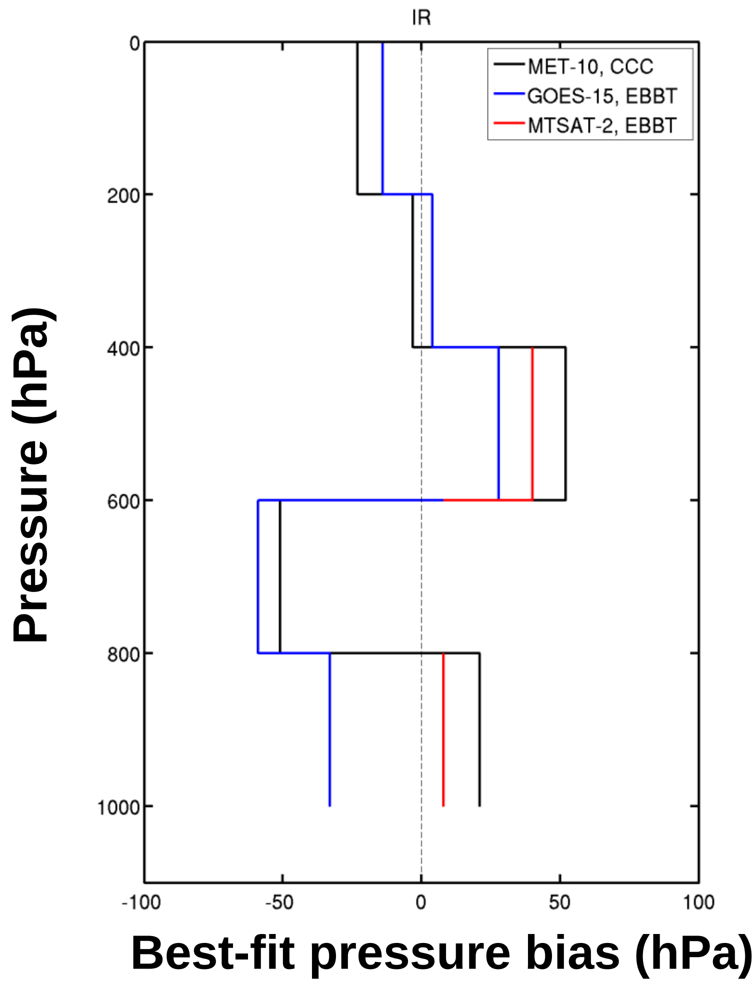
Best-fit pressure bias





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.

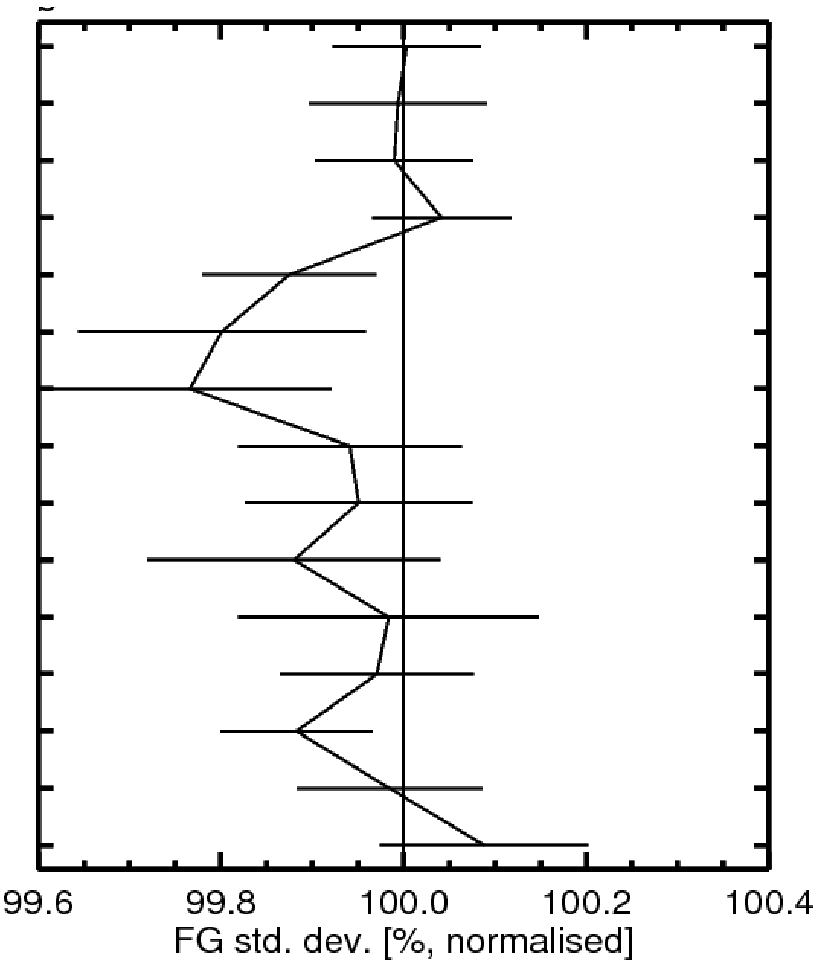


Data assimilation experiments

- Control: single-level observation operator
- Experiments with
  - Boxcar centred averaging 120 hPa
  - Boxcar averaging 40 hPa below
  - Re-assignment and single-level observation operator
- Winter period, 1.12.2013 – 28.2.2014.
- 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.



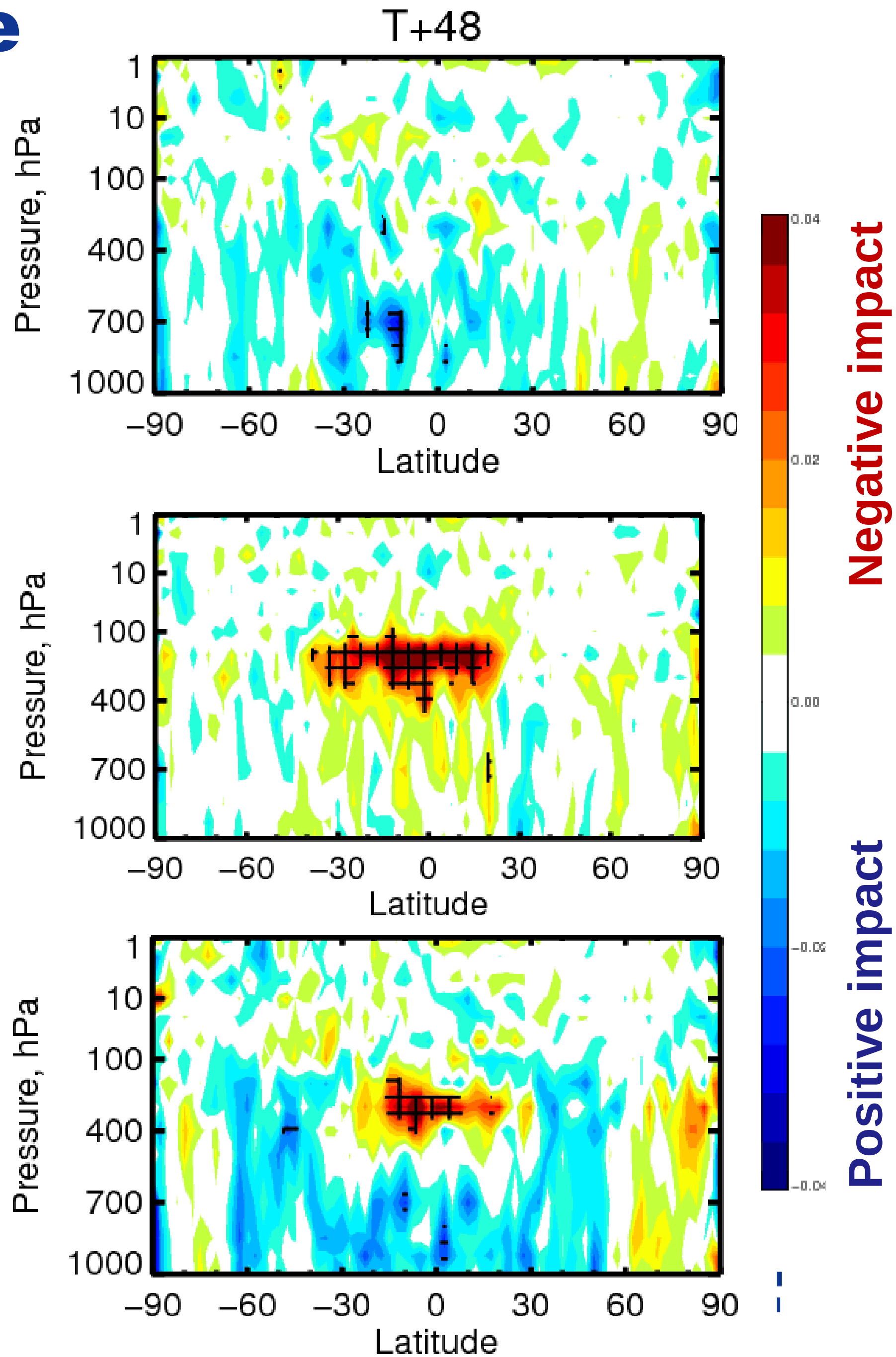
ECMWF

Normalised difference in VW RMS error

Single level observation operator with height re-assignment

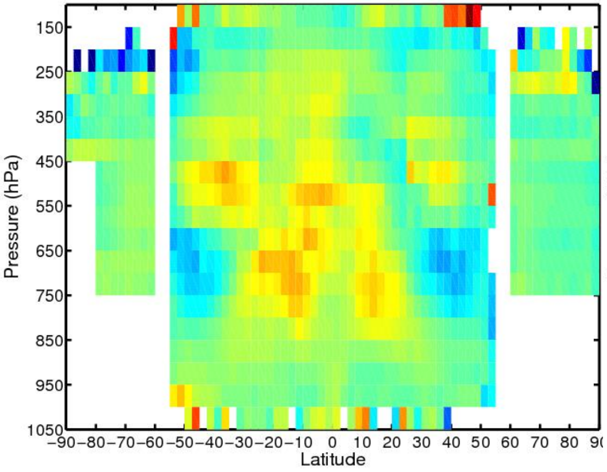
Centred averaging 120 hPa

Averaging below 40 hPa

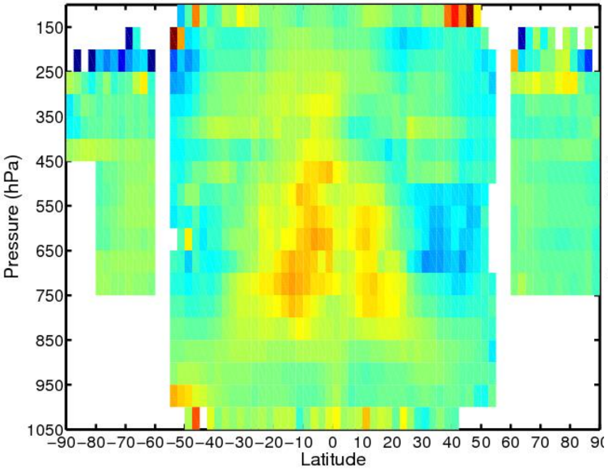


OmB bias for wind speed

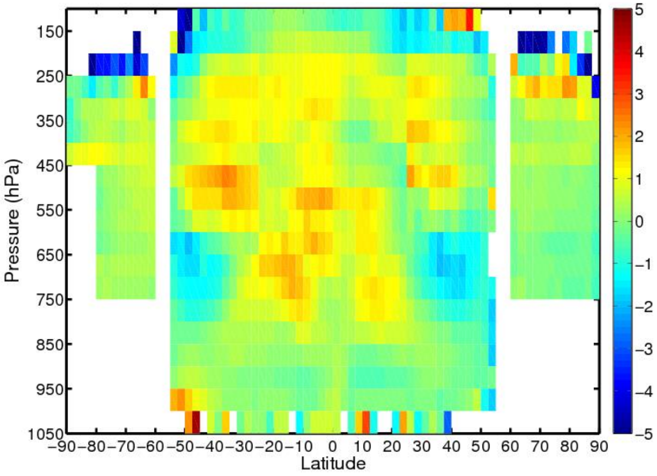
Single-level observation operator



Single-level with heigth re-assignment



Layer averaging 40 hPa below



ECMWF

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.