Assessment of new AMV data in the ECMWF system

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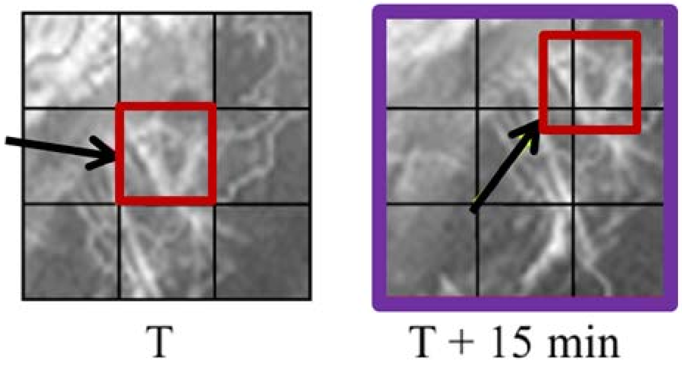
EUMETSAT Fellow Day, Darmstadt, 7th March 2016

Contents

- Overview of AMVs
- Assessment of Himawari-8
- Meteosat-11 initial investigation
- Metop Triplet product assessment
- Future plans

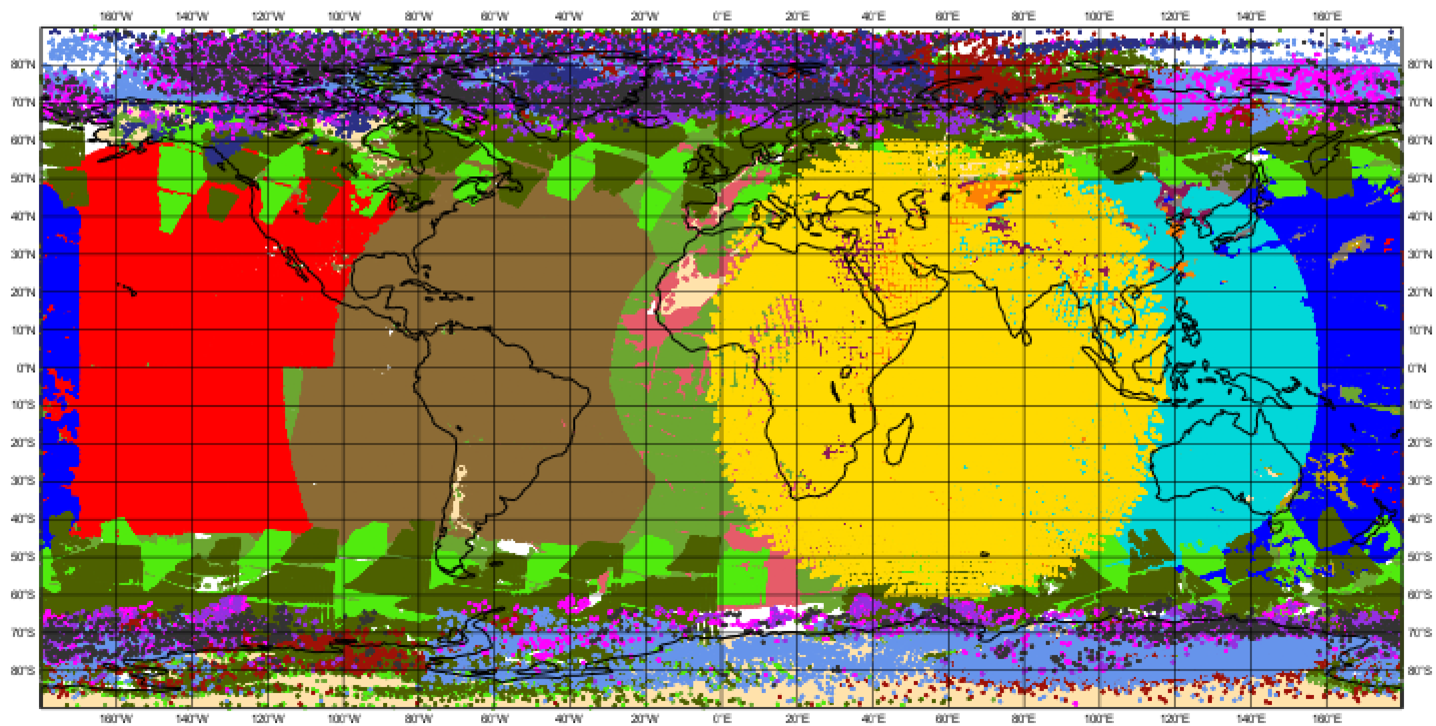
Atmospheric Motion Vector (AMV) derivation

1. Tracking
2. Height assignment
3. Quality control



All AMVs monitored – one cycle 12Z 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
FY-2E, FY-2G, INSAT-3D, Himawari-8, COMS-1, SNPP, TERRA



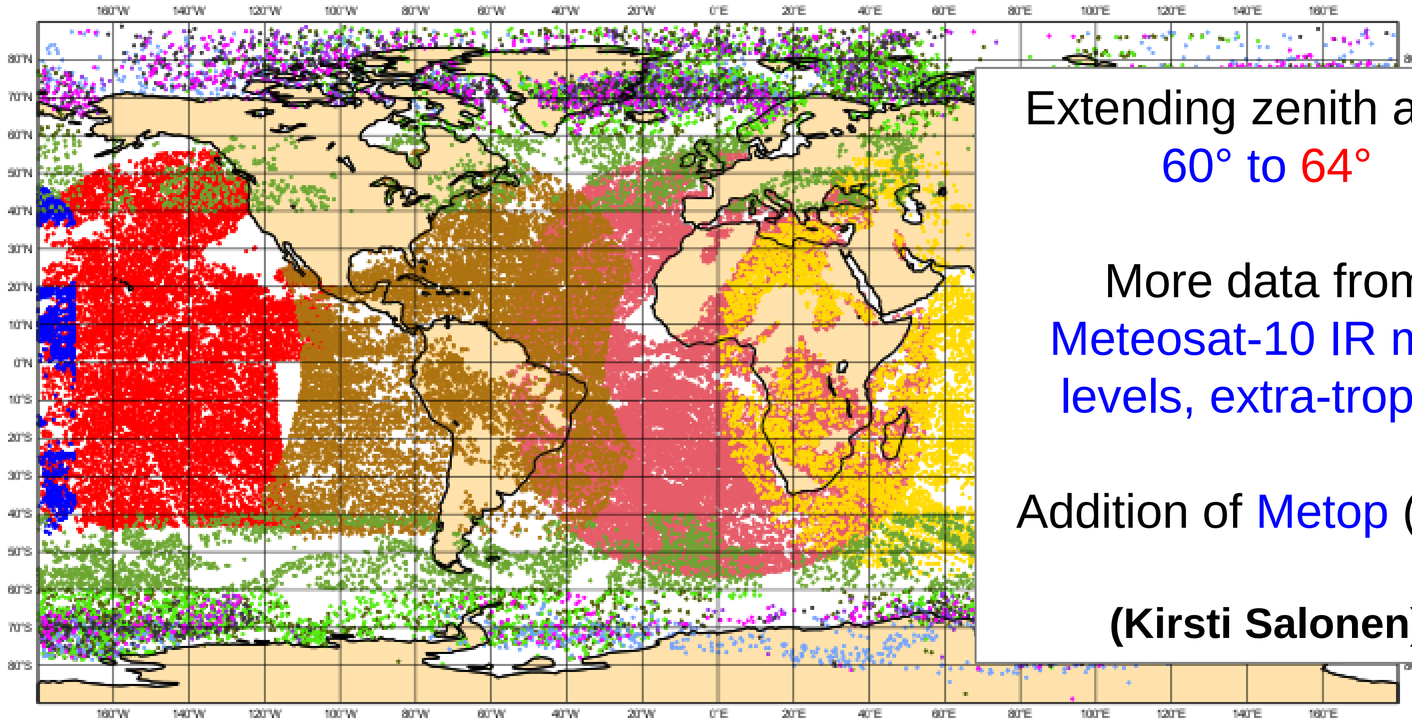
AMV processing at ECMWF

- 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)

Feature	Himawari-8/AHI	MTSAT-2/IMAGER
Location	140E	145E

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Location	140E	145E
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Full disk image	10 mins	24 mins
Total channels	16	5
Channels for AMVs	5	3

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 CO_2 and window channel in obs and simulated at different pressures)
  - Maximum likelihood estimation

Assessing Himawari-8 AMVs

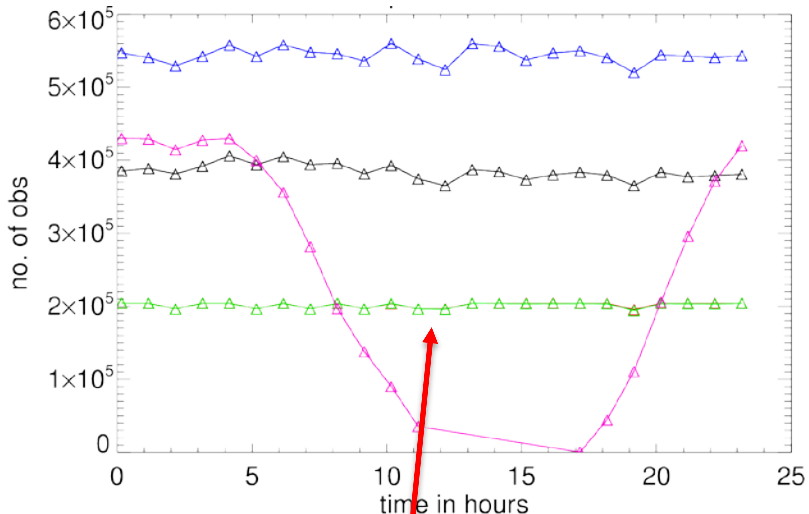
- Initial comparison of statistics with MTSAT-2
- Generate observation errors
- Determine potential configurations for assimilation
- Run assimilation experiments to test:
  - Impact on forecast
  - Impact on the fit of other observation sources to the model
- Implement in operations 15th March

Number of observations

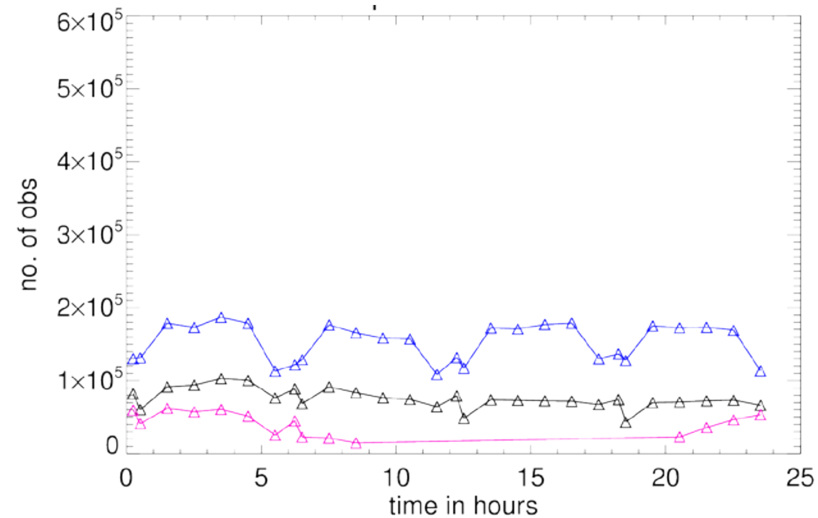
Much higher observation numbers

17th Nov – 13th Dec

Himawari-8



MTSAT-2 (all data)



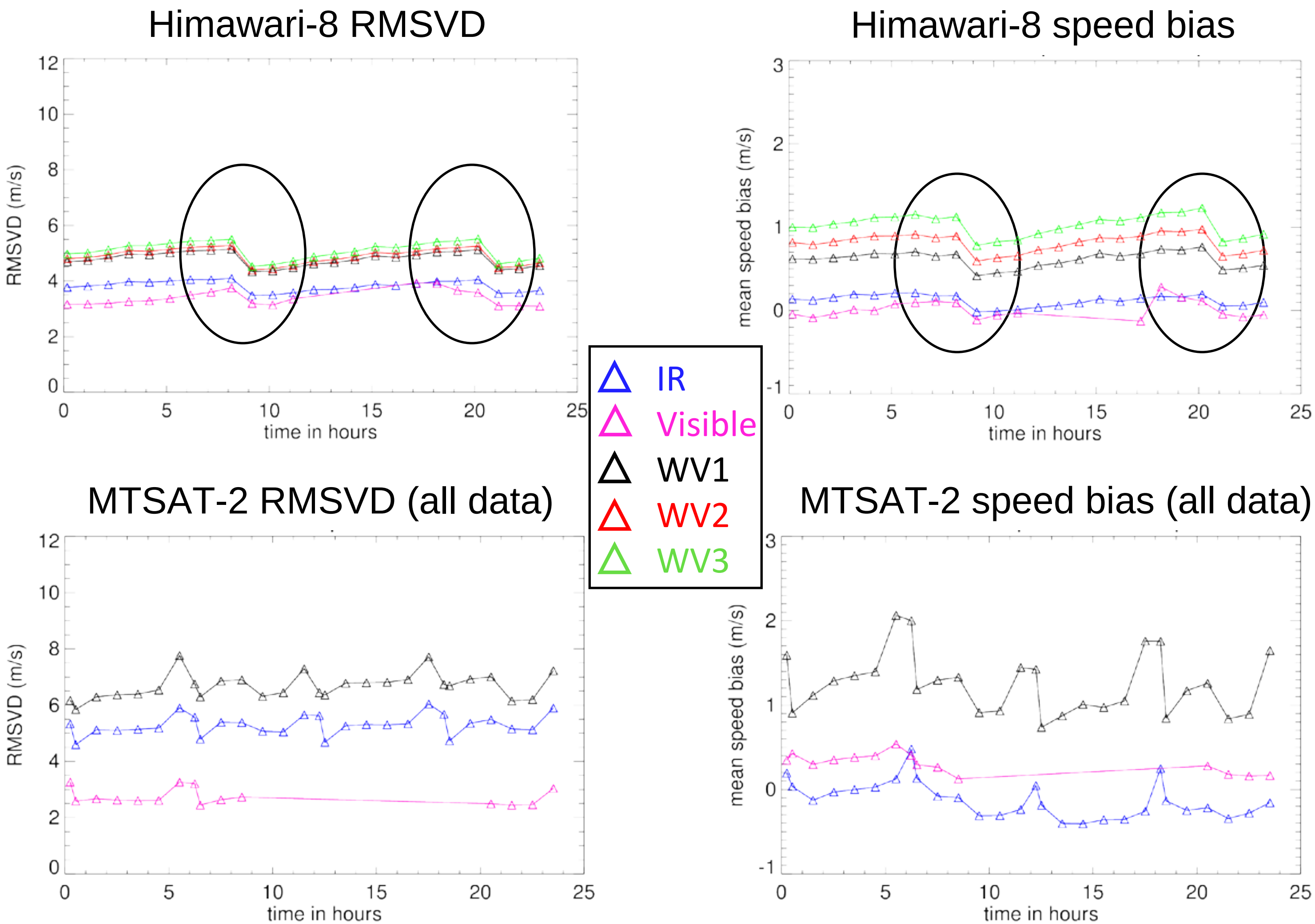
Cap on observation counts

6 hour cycle removed

△ IR (10.3µm)
△ Visible (0.64µm)
△ WV1 (7.35µm)
△ WV2 (6.95µm)
△ WV3 (6.25µm)

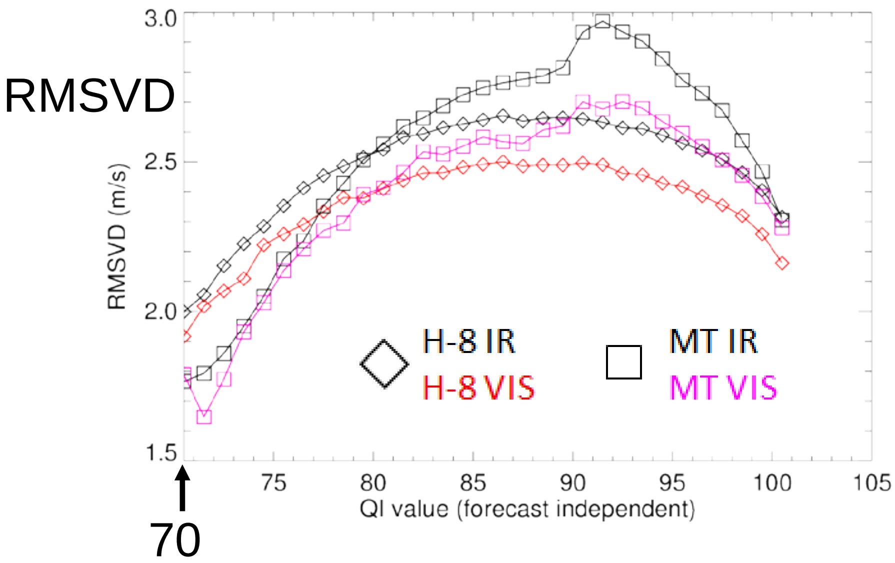
Initial results: time dependence

17th Nov – 13th Dec

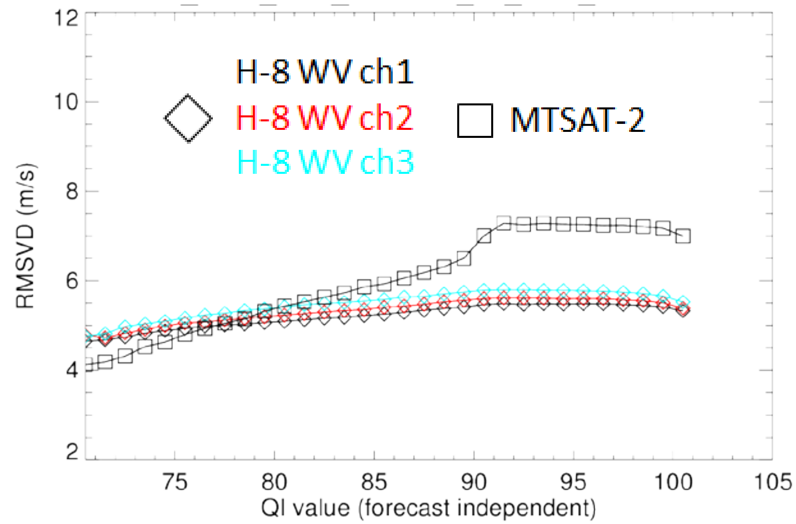


Initial results: Forecast independent QI

20-90S, >700hPa



All latitude, all pressure

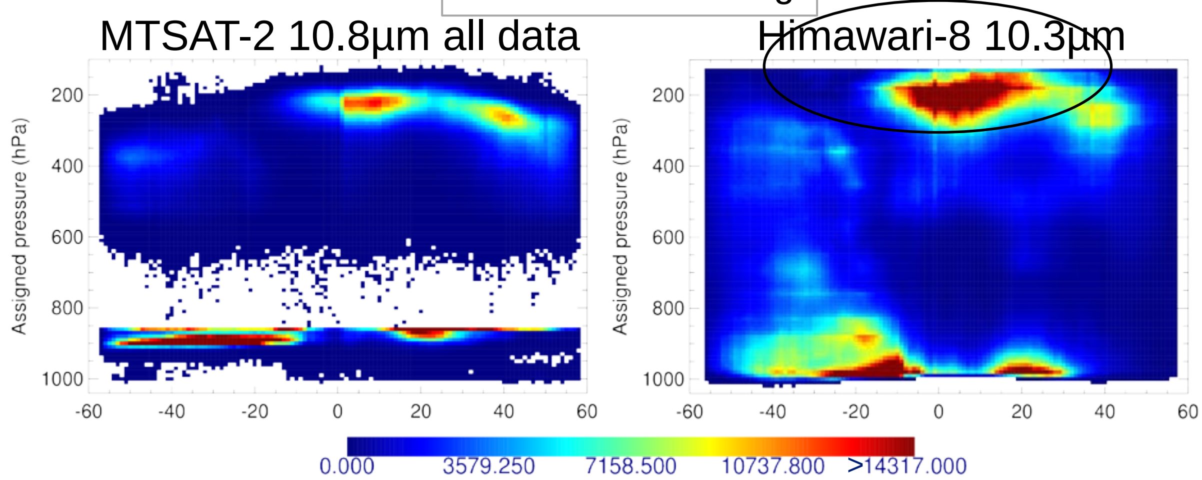


Decision to not apply QI threshold to Himawari-8

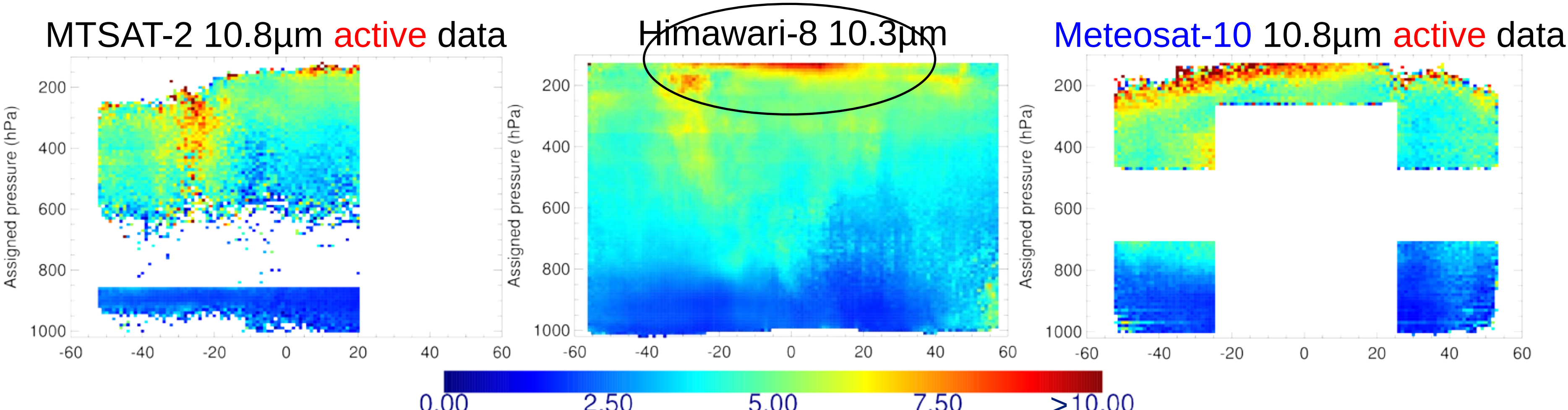
Zonal statistics:

Distribution of observations

19th June – 31st Aug



RMSVD



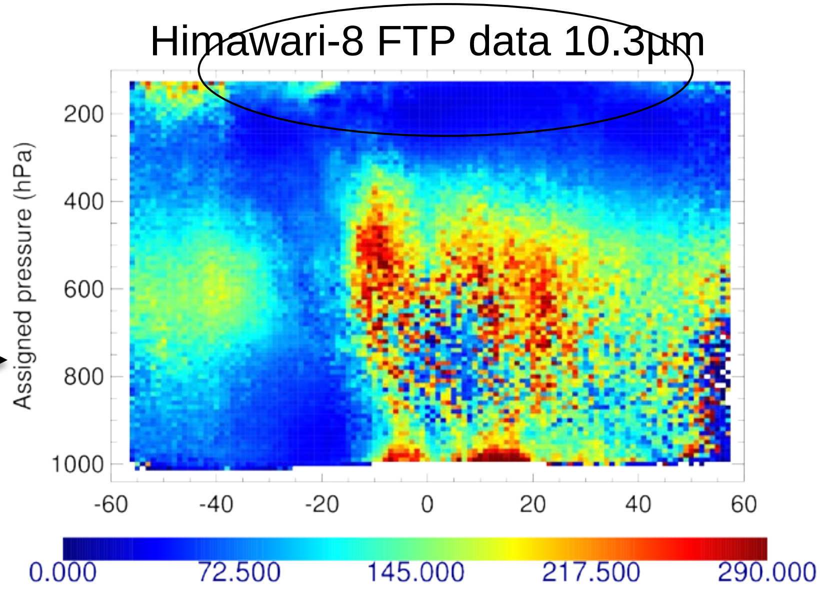
Observation errors

- 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)

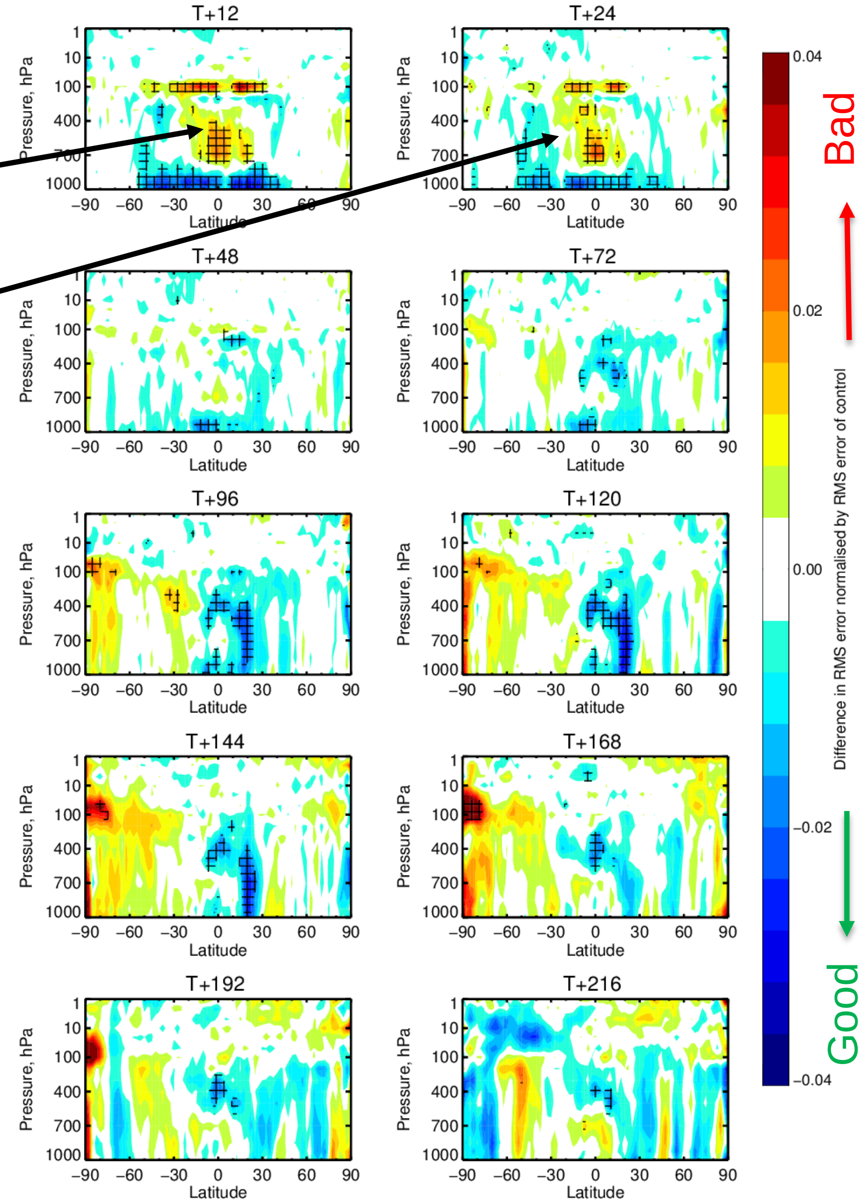


Assimilation experiments: initial configurations

- 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
  - Winter 17th Nov – 28th Feb 2016

Some positive…
…some not so positive

Most relaxed vs. ctrl (6 months)
Change in error in vector wind



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

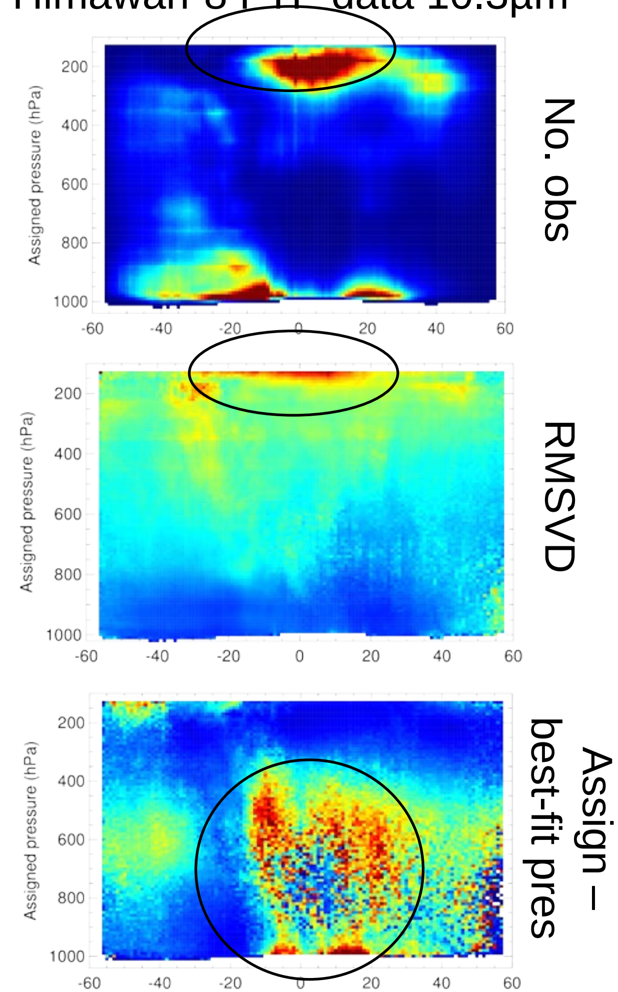
Even in most conservative have degradation in short term forecast scores

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

Himawari-8 FTP data 10.3µm



‘Super conservative’ configurations:

1. WV 6.95µm 150 < P < 400hPa

   Vis > 700hPa

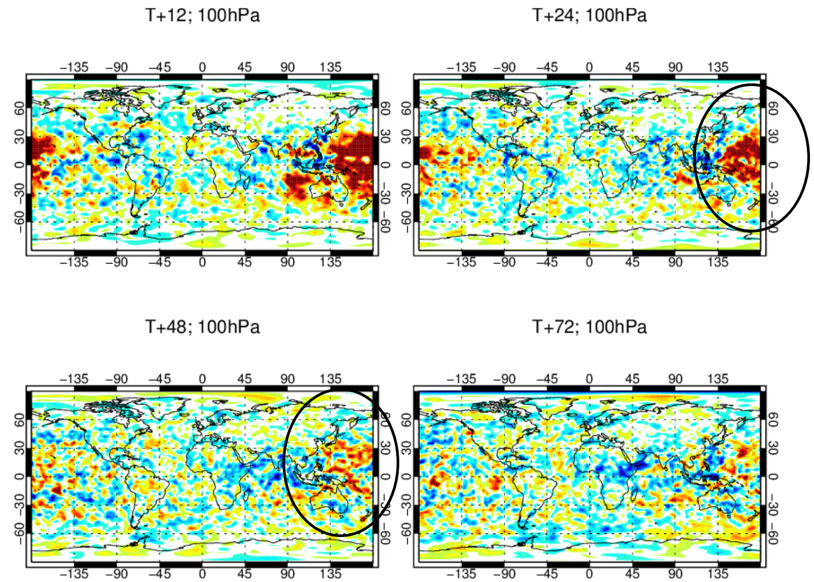
   IR > 150hPa

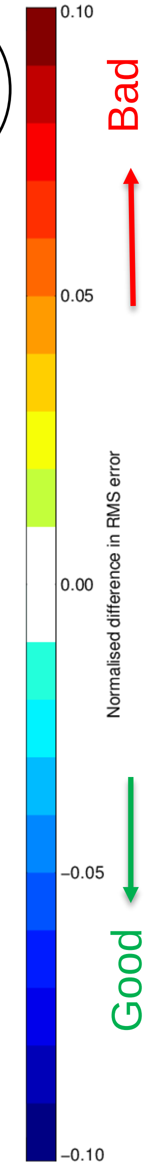
2. As above but IR screened in tropics > 300hPa

Impact on forecasts: change in error in vector wind

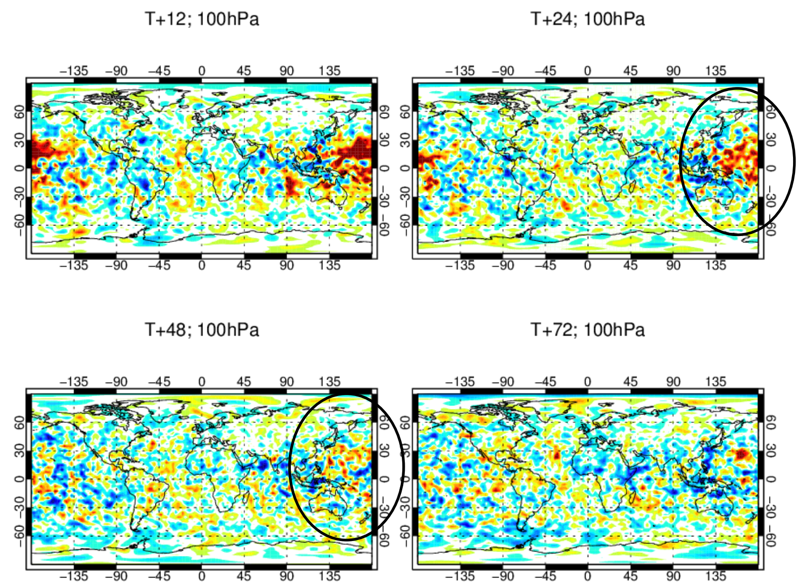
100hPa,
T+12 -> T+ 72

Original Conservative vs. ctrl

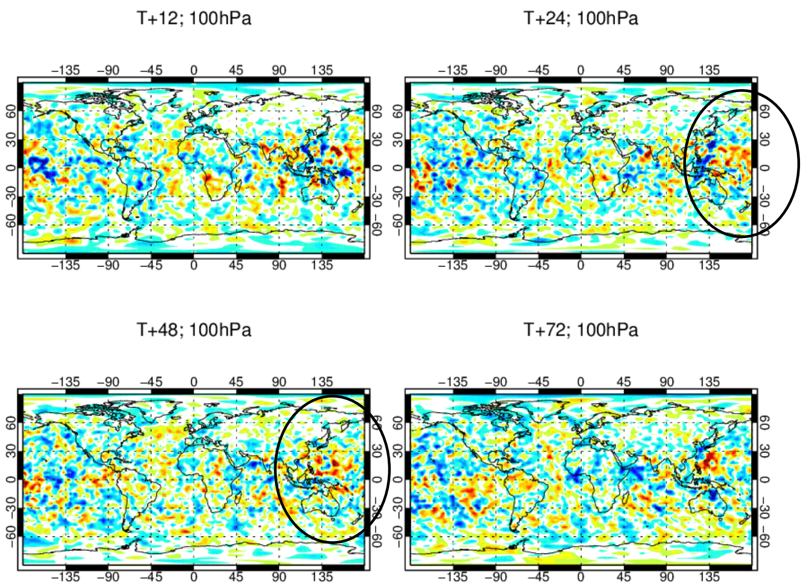




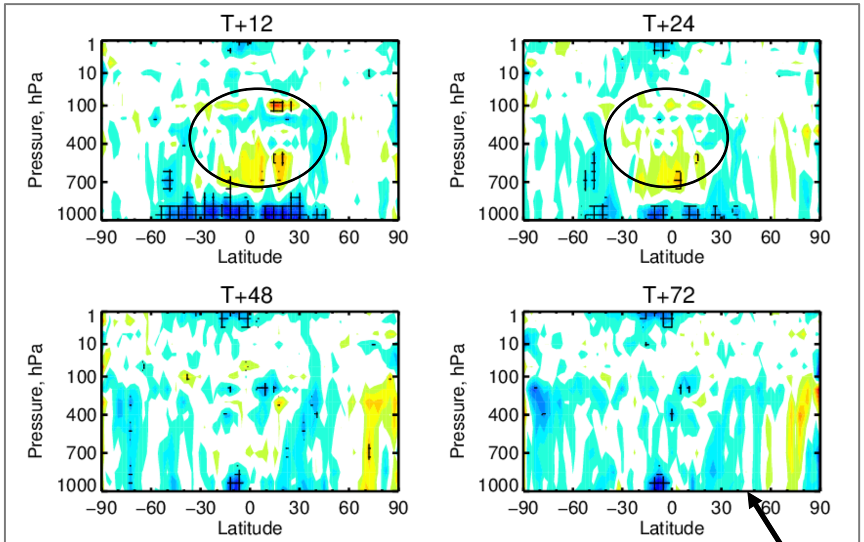
Super con. 1 (no high level) vs. ctrl

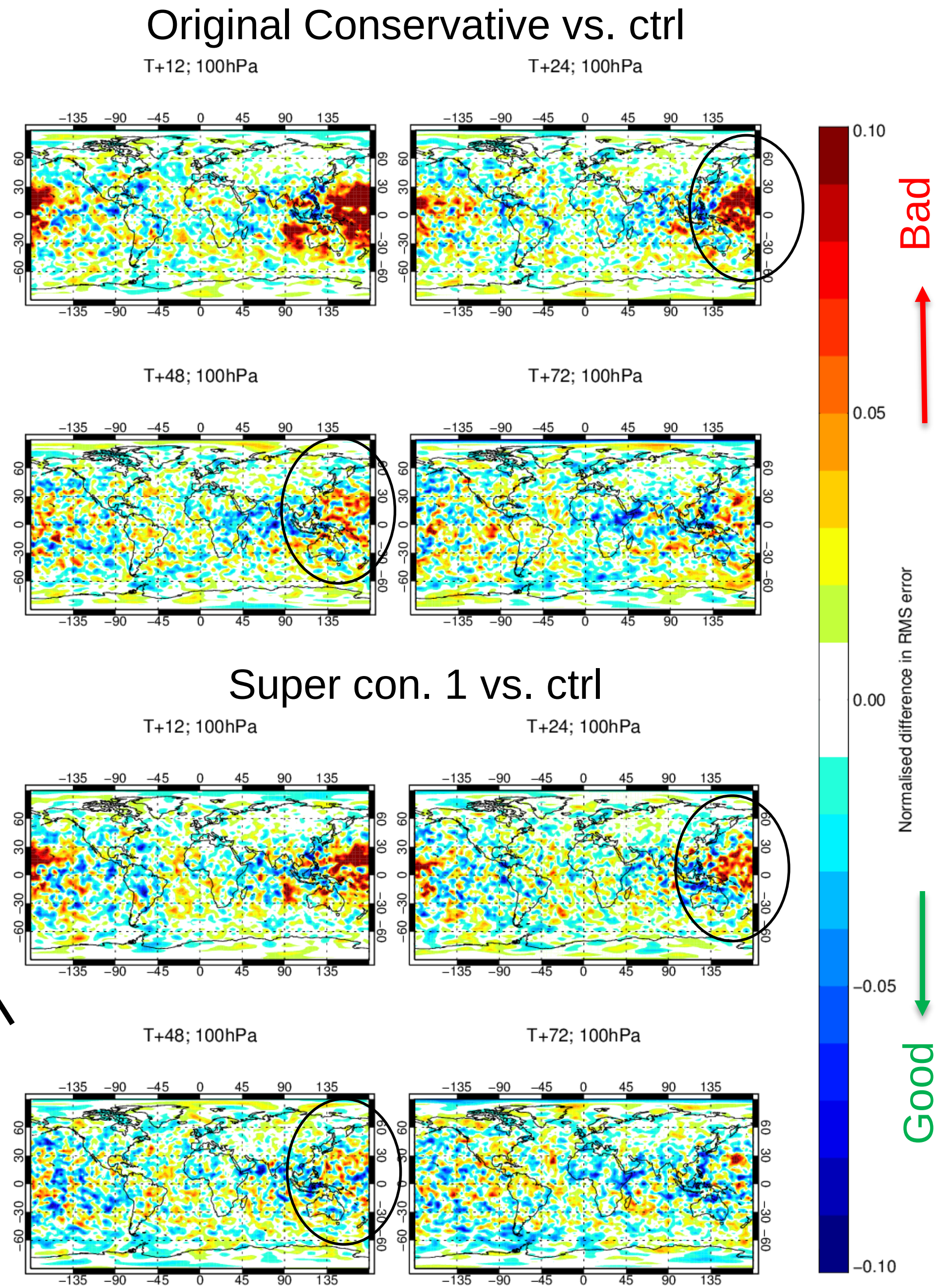


MTSAT-2 vs. ctrl



Impact on forecasts: change in error in vector wind

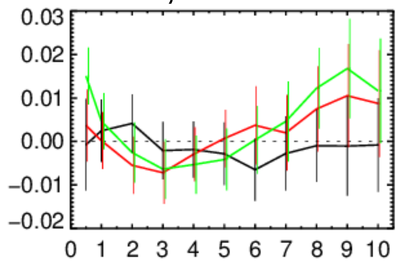




Forecast scores

Error in vector wind,
Tropics, summer and winter

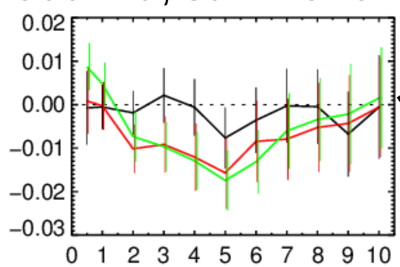
100hPa, summer only

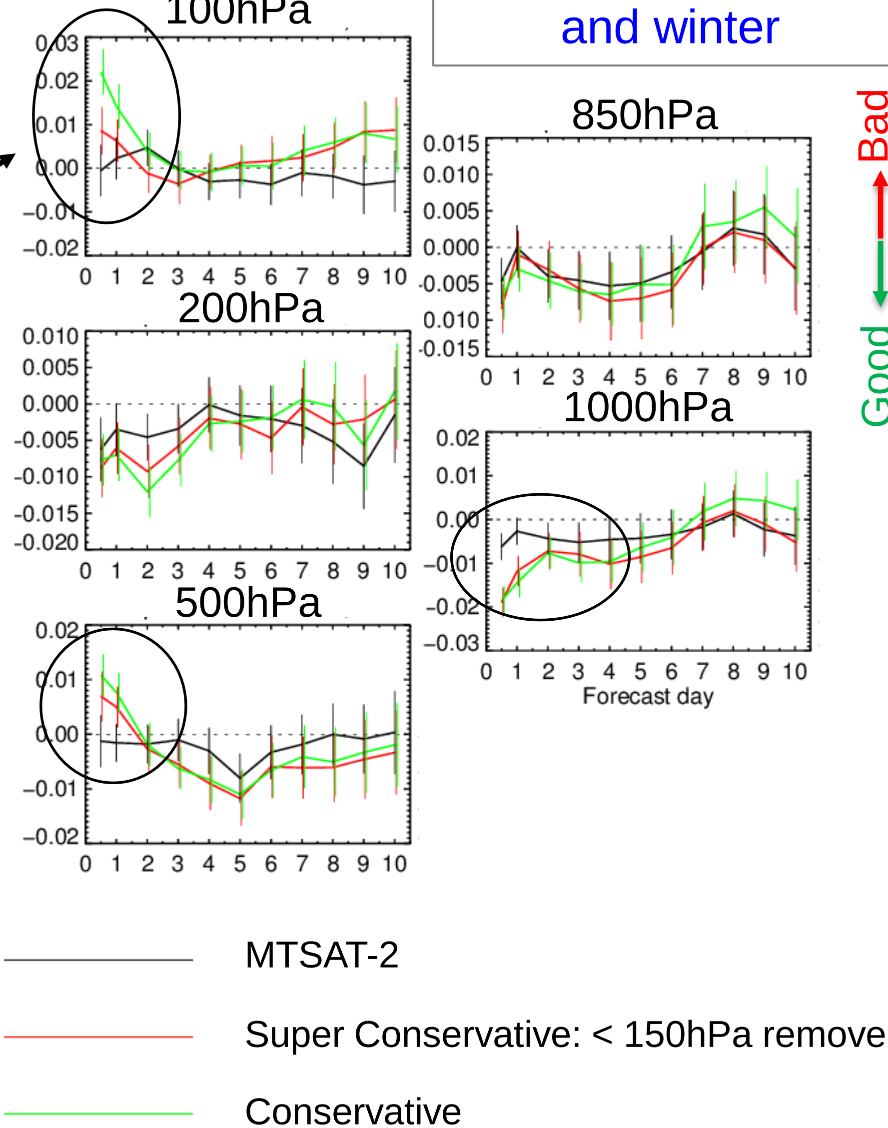


Mostly neutral -> positive

For other fields: mostly have similar behaviour to MTSAT-2

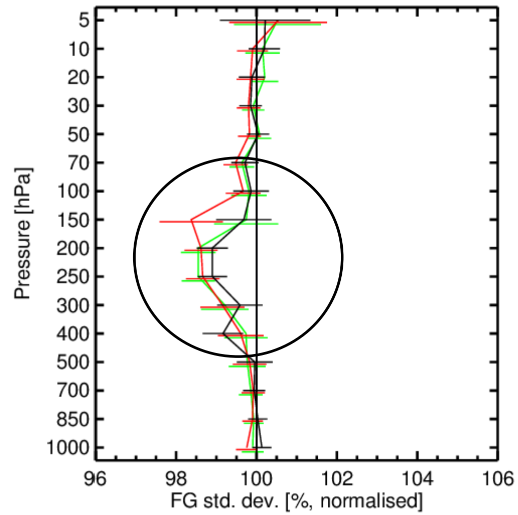
500hPa, summer only





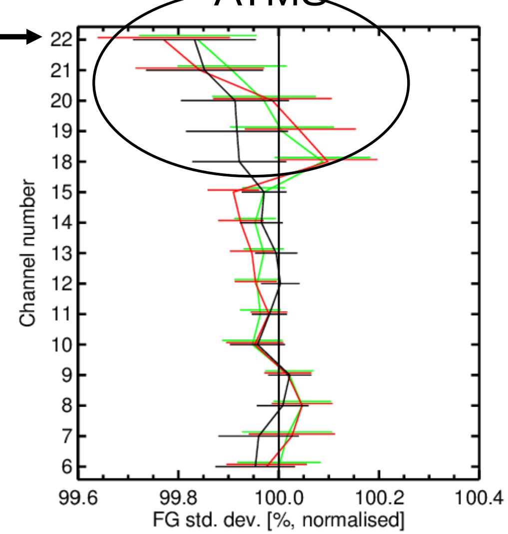
Fits of other observations to model background

AIREP AMprofiler EUprofiler
JPprofiler PILOT TEMP – U wind

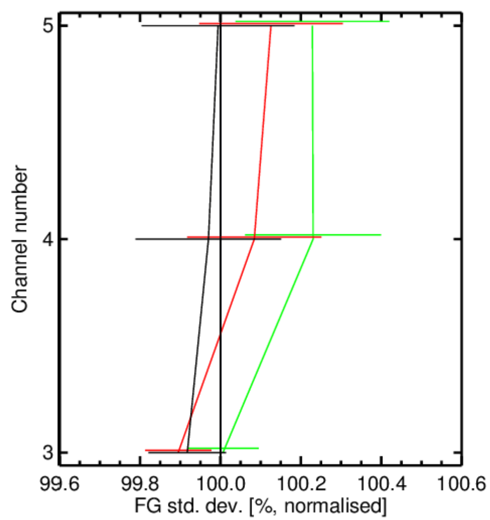


Highest
peaking

ATMS



MHS



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

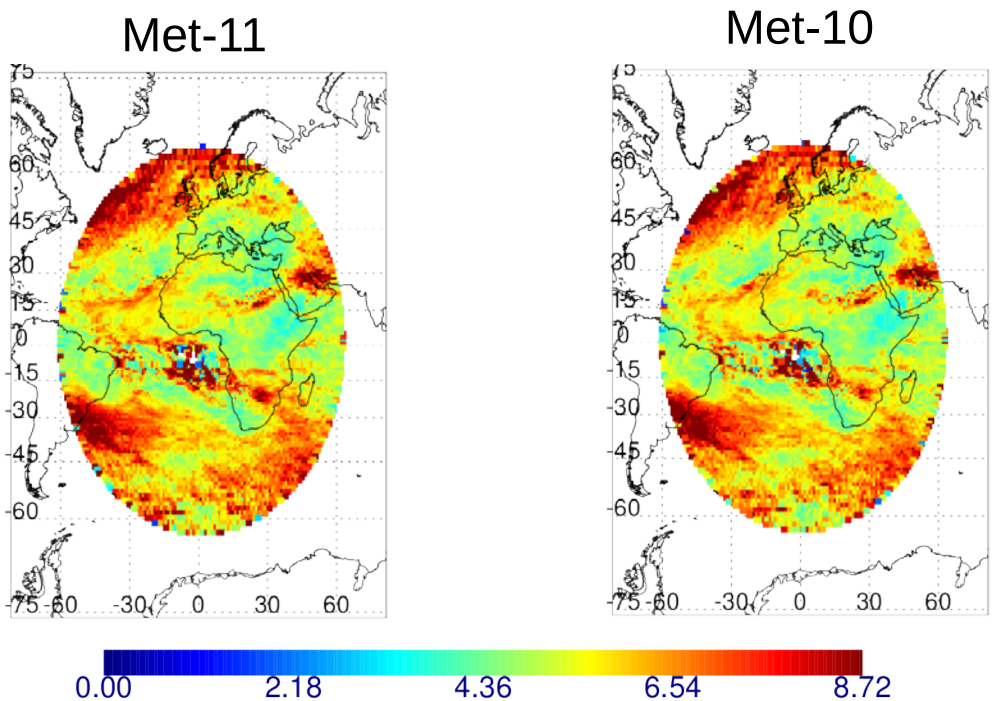
AMVs from Meteosat-11

- 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:

Channel type	Wavelength (μm)
Water vapour 1 (clear+cloudy)	6.25
Water vapour 2 (clear+cloudy)	7.35
Infrared	10.8
Visible	0.635
Visible (broad band, high res)	0.6-0.9

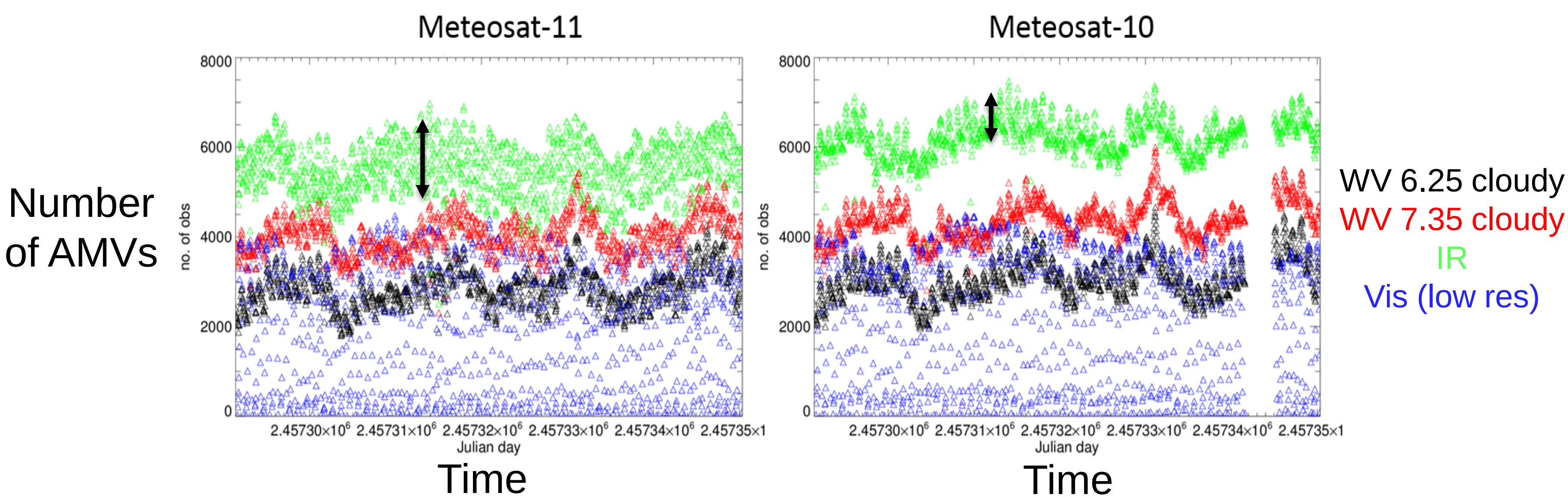
Good agreement

Vector difference,
IR
pressure < 400hPa



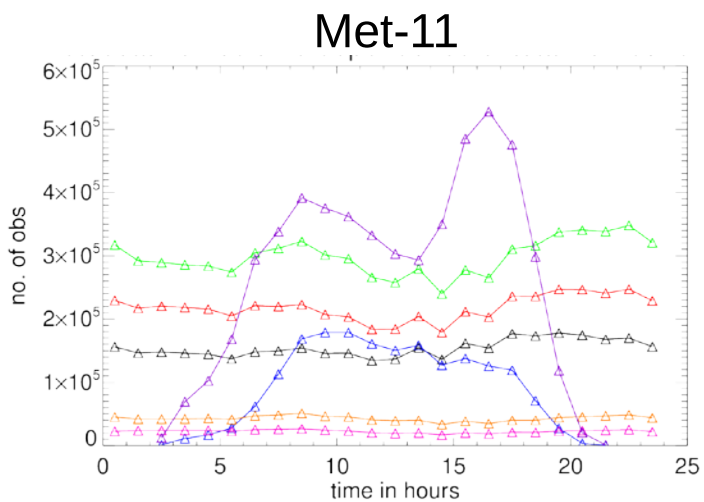
- Common large scale features
- Dependence on QI similar -> use same threshold at Met-10
- QI (forecast independent) > 85 applied before calculating statistics

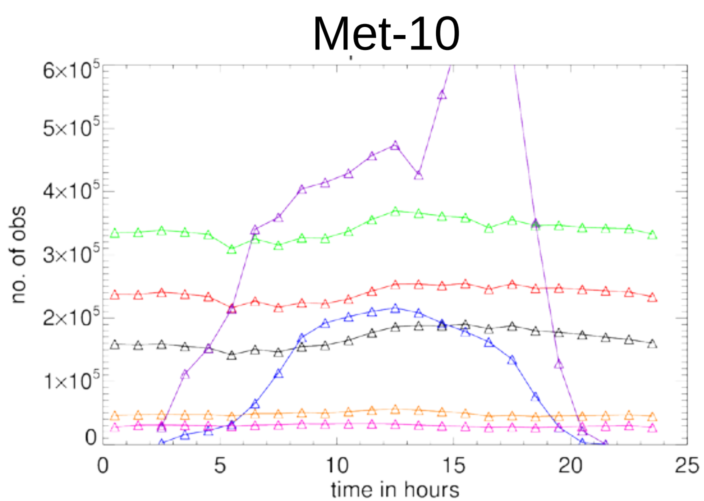
Time dependence

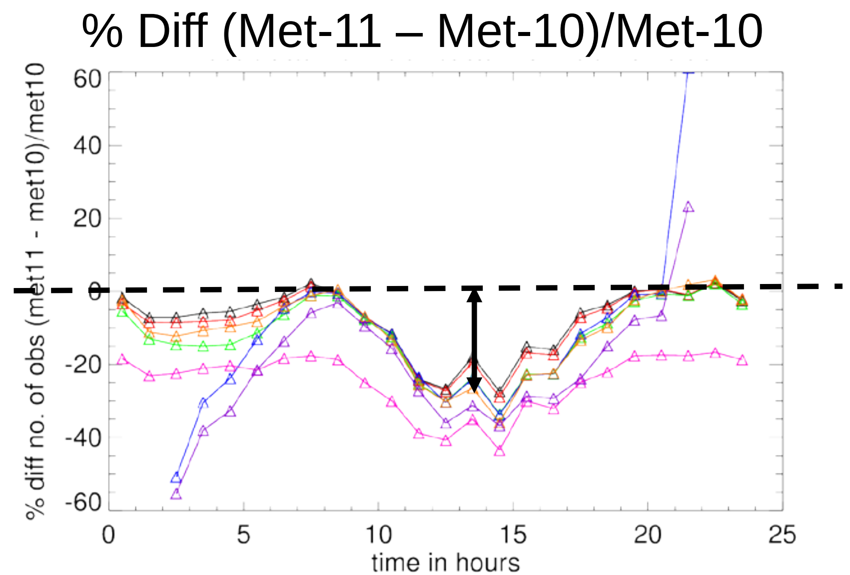


- Similar broad behaviour…
- …But more spread

Number of observations per hour



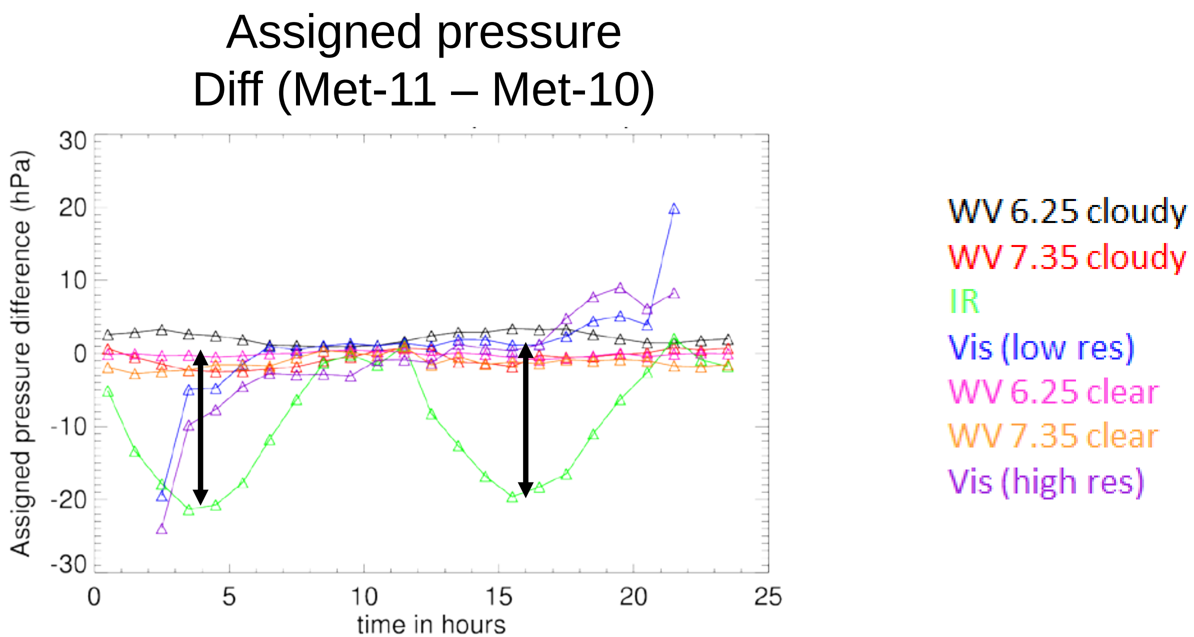




Fewer Met-11 during day

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

Difference in assigned pressure



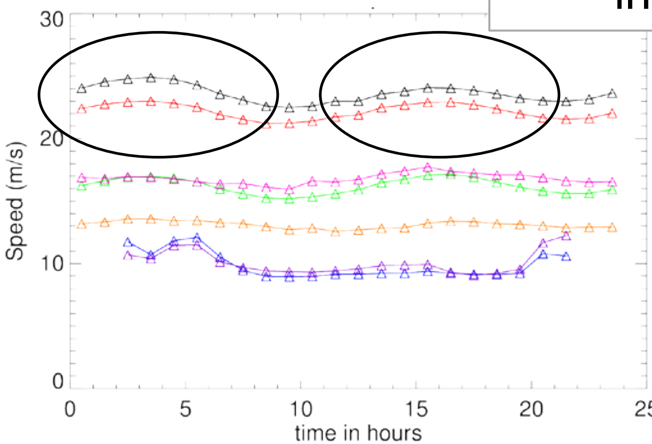
Good agreement apart from IR

If linked to orbit variation, why only IR affected?

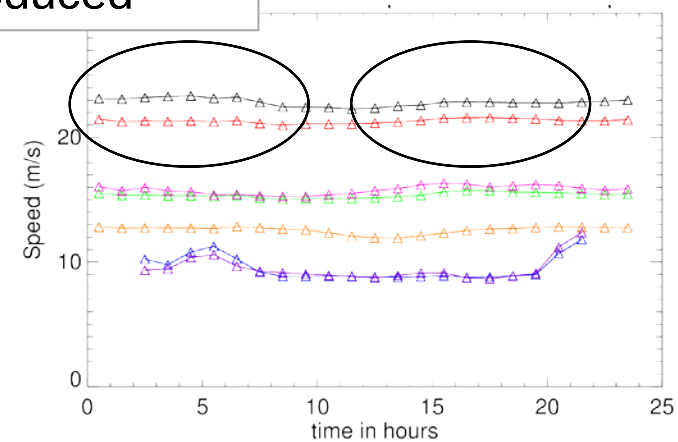
Sinusoidal variation

Sinusoidal variation introduced

Met-11



Met-10

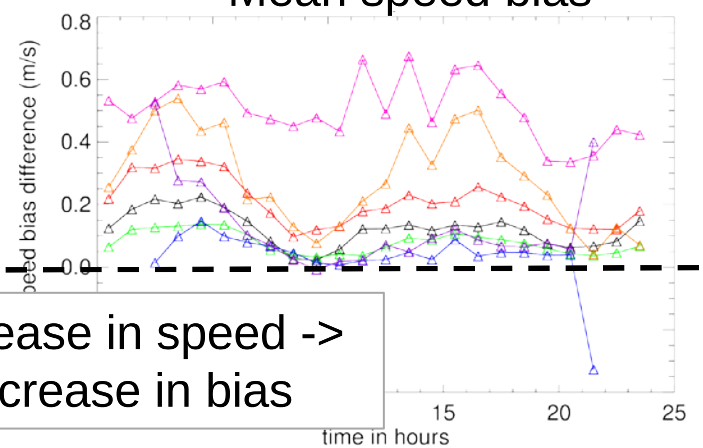


Mean speed

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

Diff (Met-11 – Met-10)

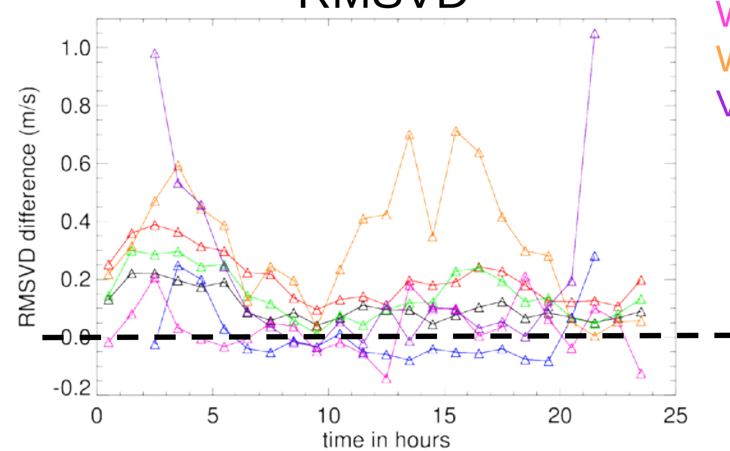
Mean speed bias



0.0

Increase in speed -> increase in bias

RMSVD



0.0

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 same satellite. Time apart ~ 100 mins. Polar only.

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

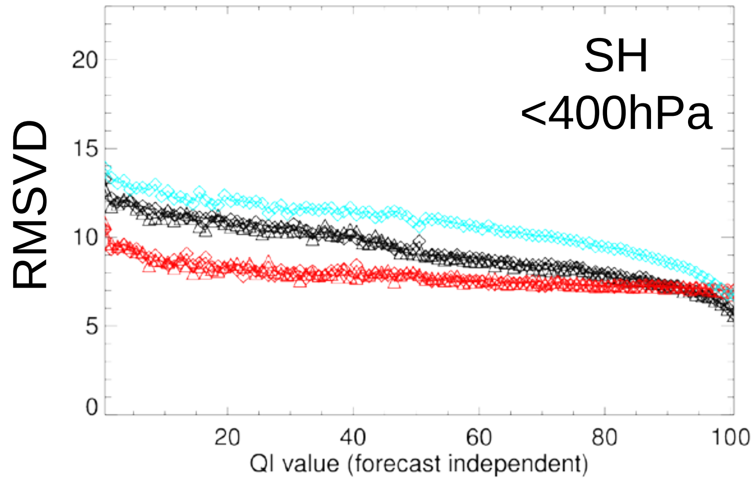
- **Triplet**: 2 images from closest orbits of different satellites. Third image used in **temporal consistency check**. Time apart ~ 50 mins. Polar only.

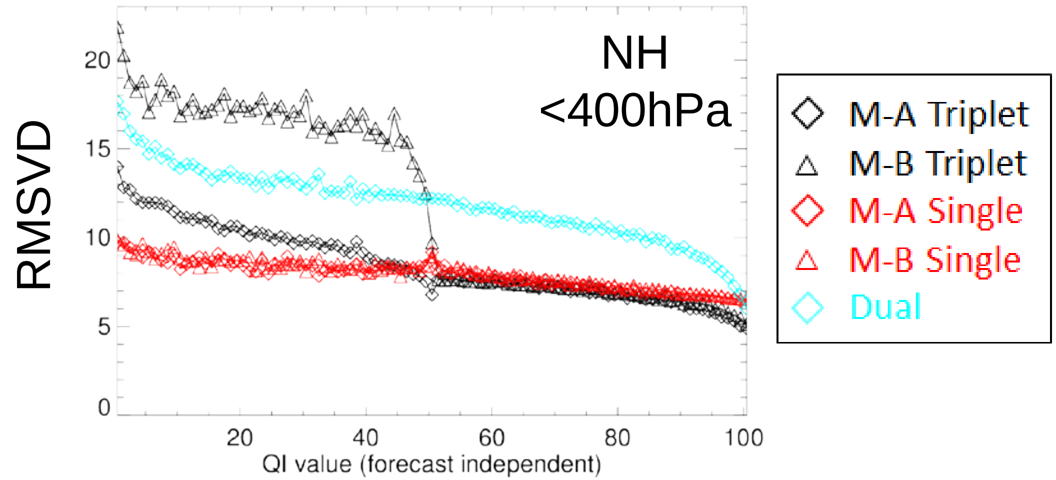
  -> more effective screening

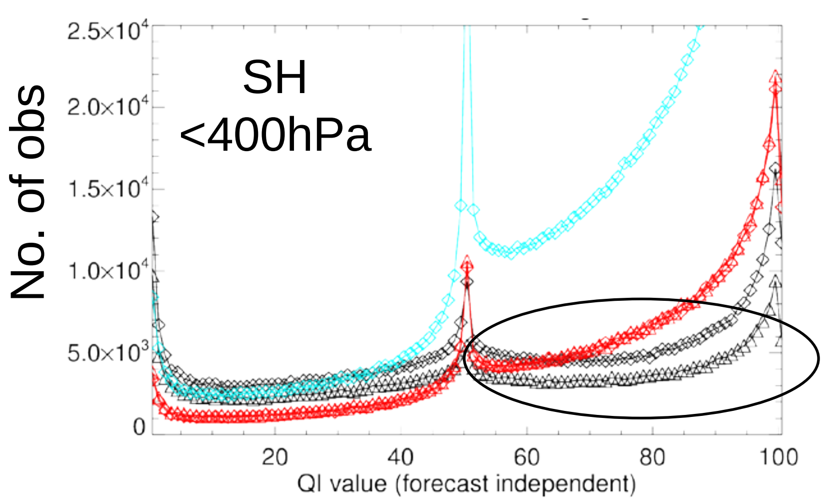
- Common processing applied
- Dual product latitude restricted to > 35° for comparison

Dependence on quality indicator

25th August – 24th Sept 2015





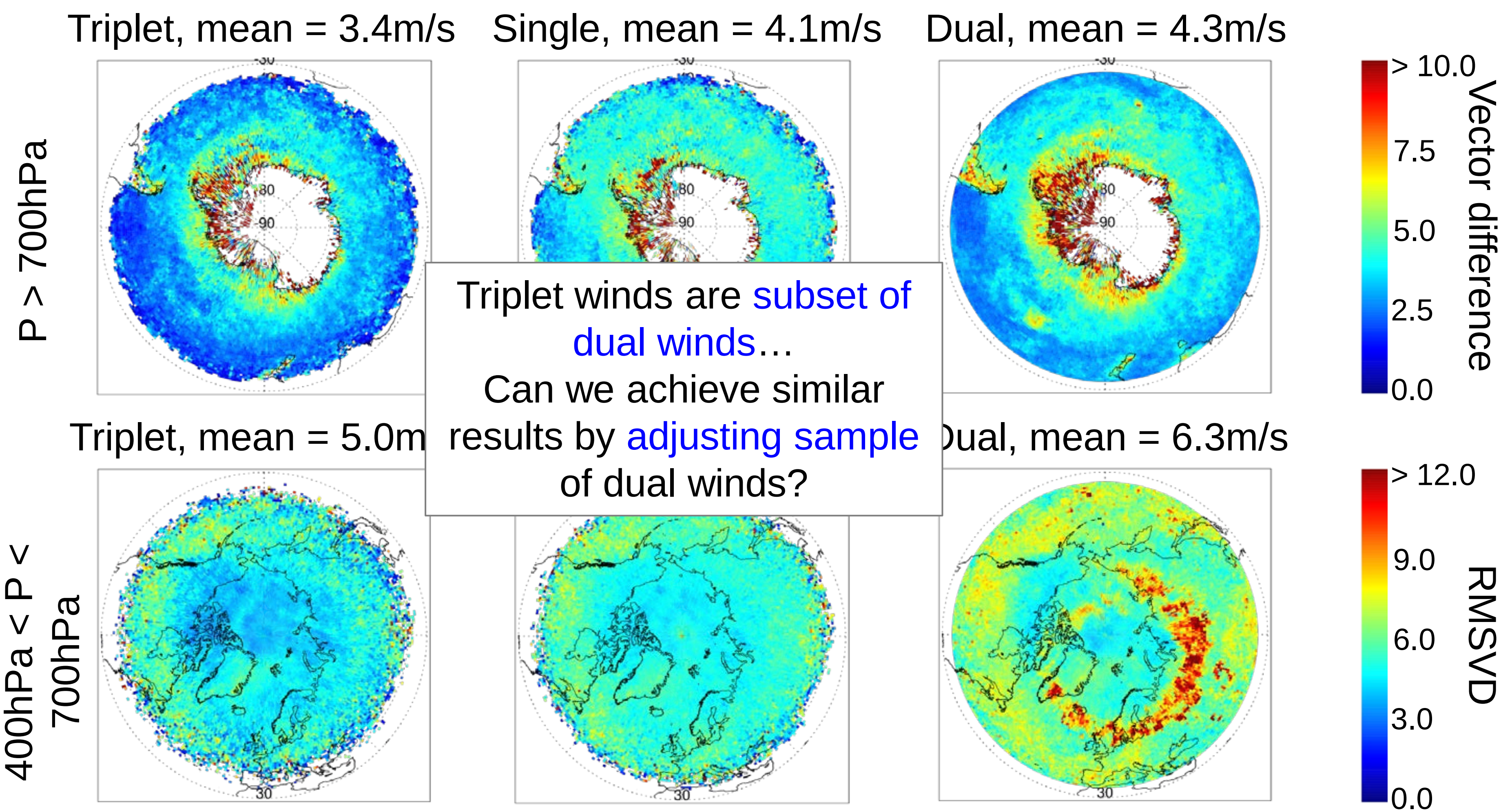


In a few search areas at specific times vector assigned exactly opposite direction. Assigned QI < 50.

Use QI ≥ 60 for subsequent analysis

Fixed in new operational release 2nd Dec 2015

Triplet vs. Single vs. Dual



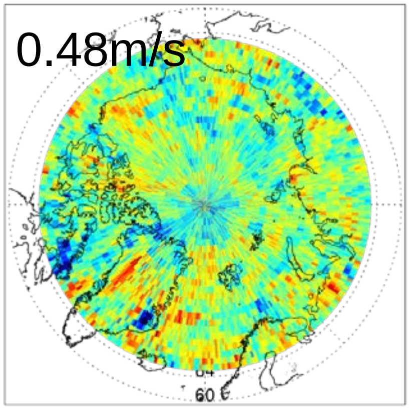
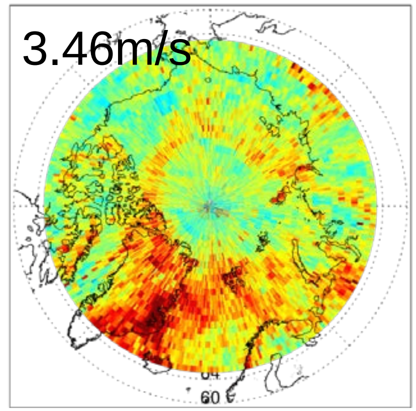
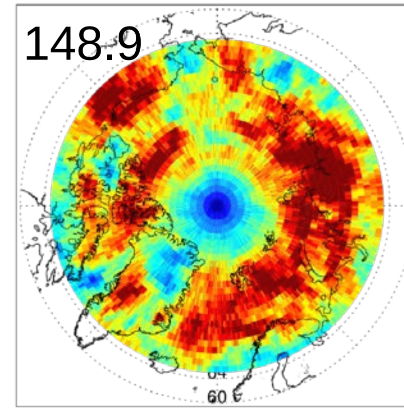
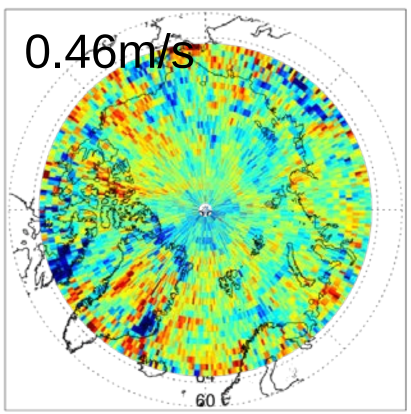
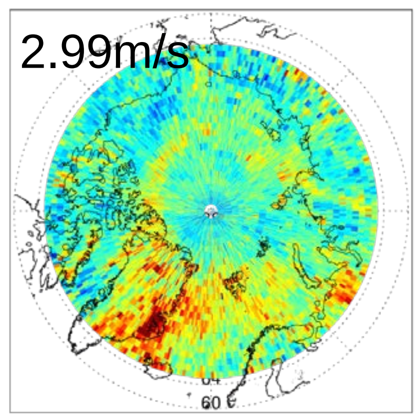
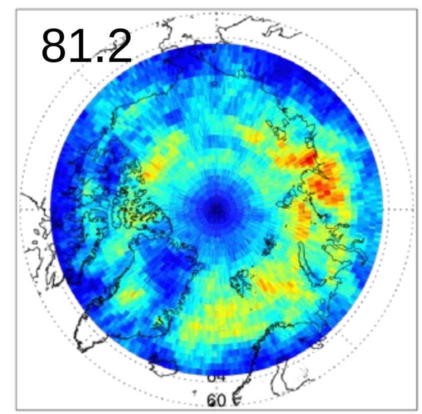
Triplet winds are subset of dual winds…
Can we achieve similar results by adjusting sample of dual winds?

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

P < 400hPa

	Mean speed bias	Standard deviation of speed bias	No. of obs
Dual QI ≥ 60			
Triplet QI ≥ 60			

<-1.49 -0.52 0.46 1.43 >2.40

<0.85 1.93 3.01 4.09 >5.17

0.000 62.500 125.000 187.500 >250.000

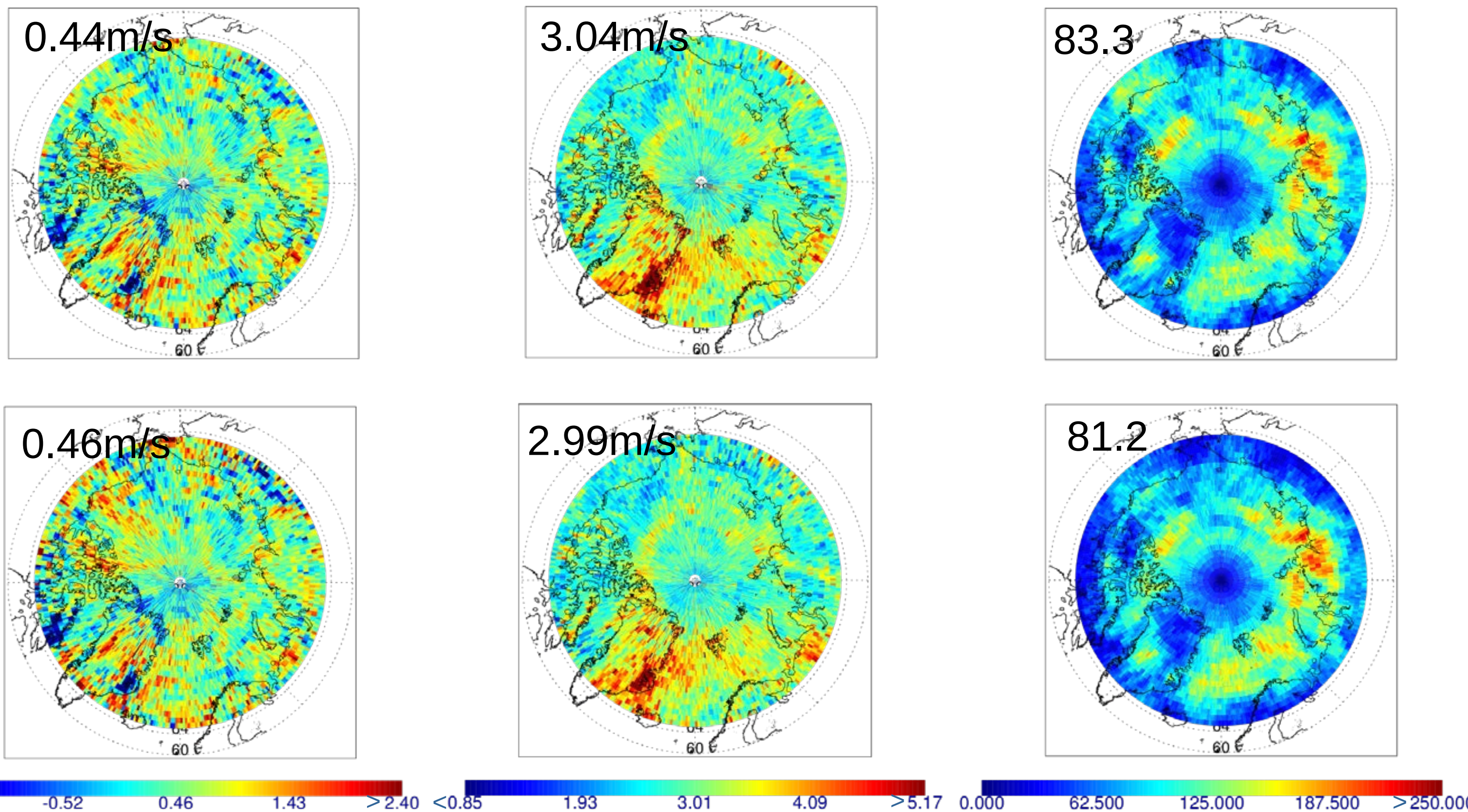
Changing QI thresholds

P < 400hPa

Mean speed bias | Standard deviation of speed bias | No. of obs

Dual QI ≥ 85

Triplet QI ≥ 60



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?