AMV impact studies at the Met Office

James Cotton, Mary Forsythe, Francis Warrick, Richard Marriot

12th International Winds Workshop, Copenhagen, 16-20 June 2014

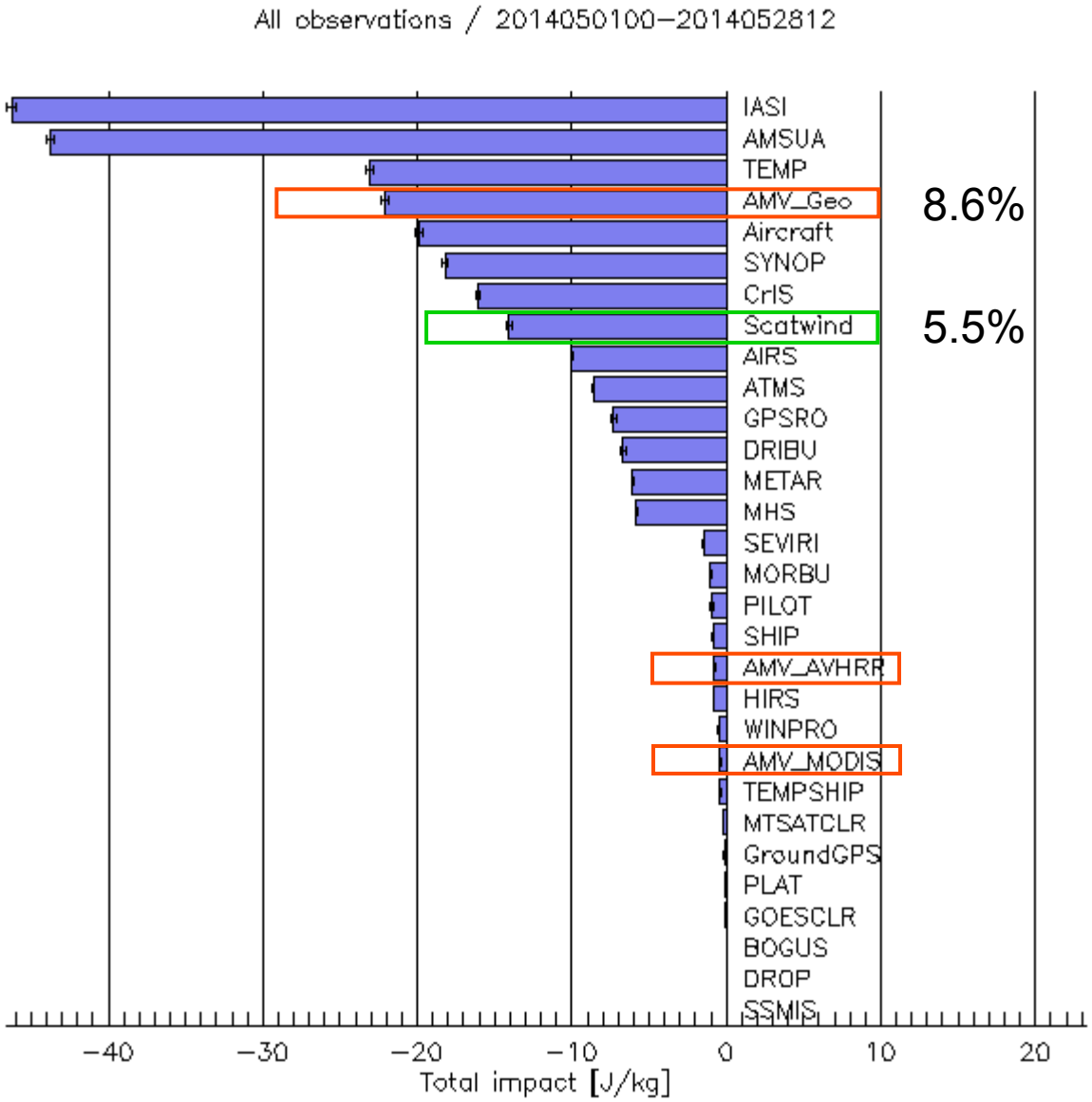
Overview

1. Forecast Sensitivity to Observations
2. MSG low level winds
3. Filling the gap
4. IODC investigation

Forecast Sensitivity to Observations (FSO)

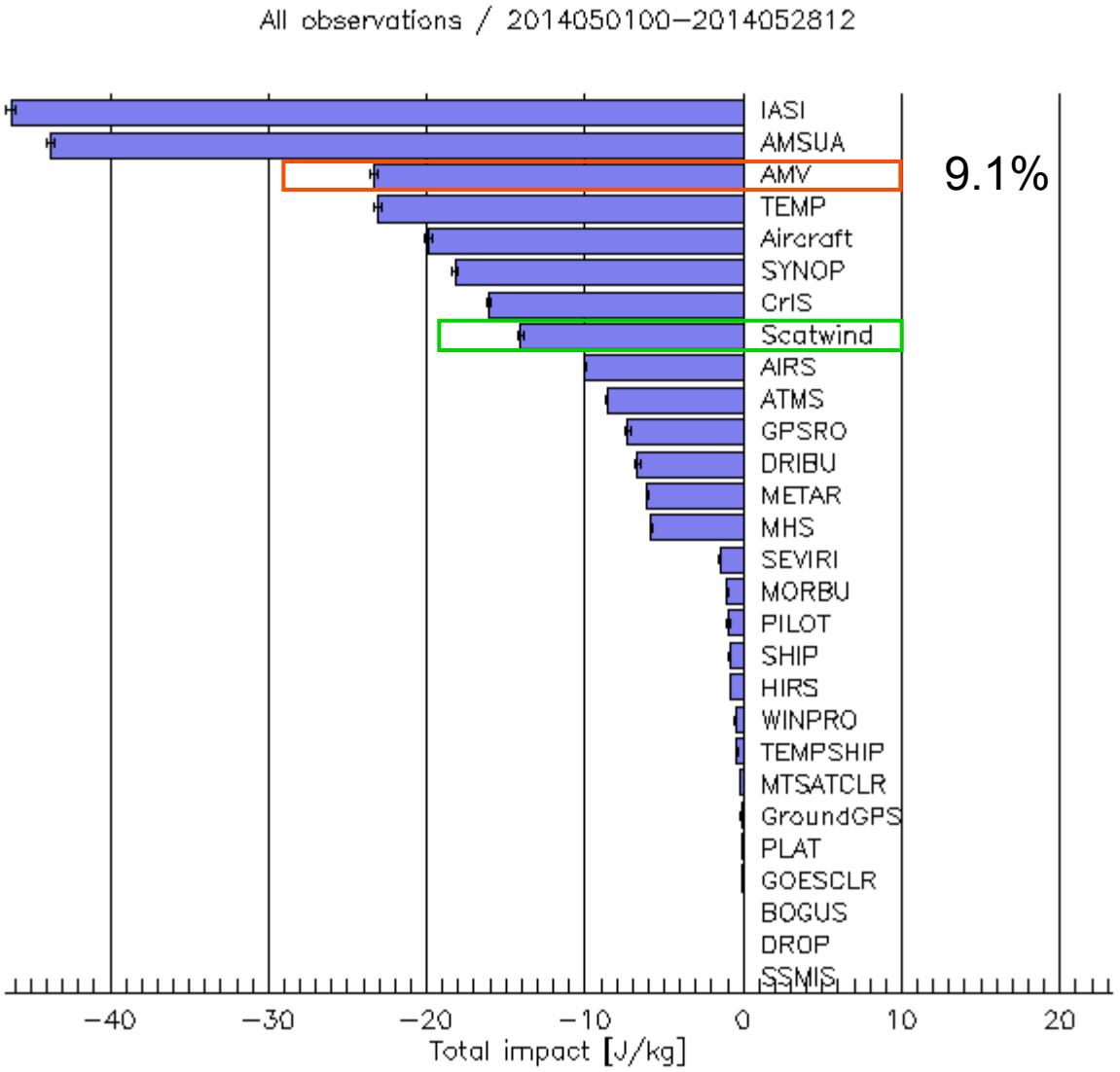
Impact on 24-hr forecast error - FSO

- Global FSO impacts now being calculated on routine basis in NRT
- Example from May 2014
- Moist total energy norm
- Surface to 150 hPa



Impact on 24-hr forecast error - FSO

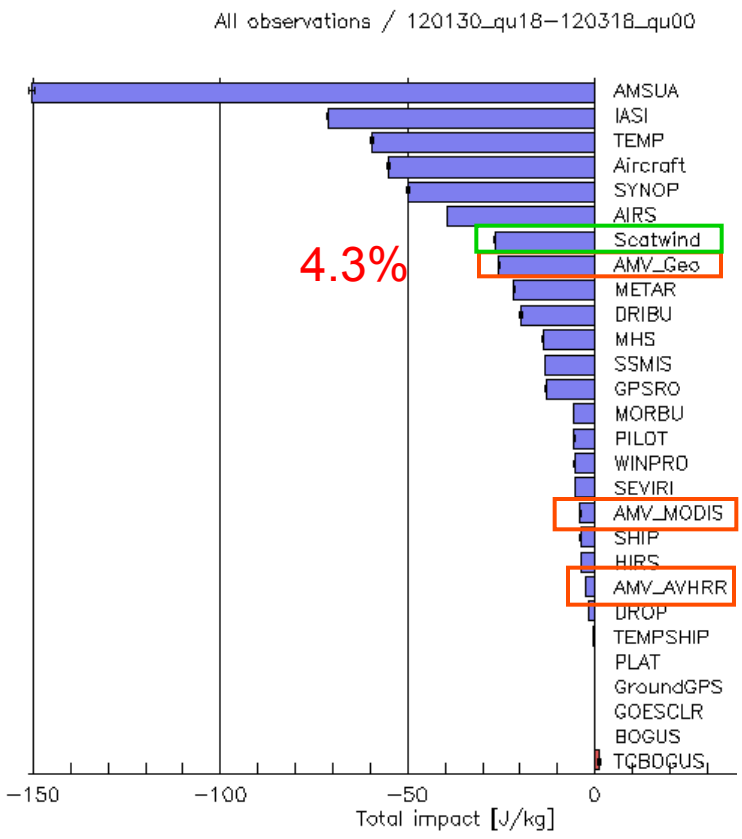
- Global FSO impacts now being calculated on routine basis in NRT
- Example from May 2014
- Moist total energy norm
- Surface to 150 hPa



Impact on 24-hr forecast error - FSO

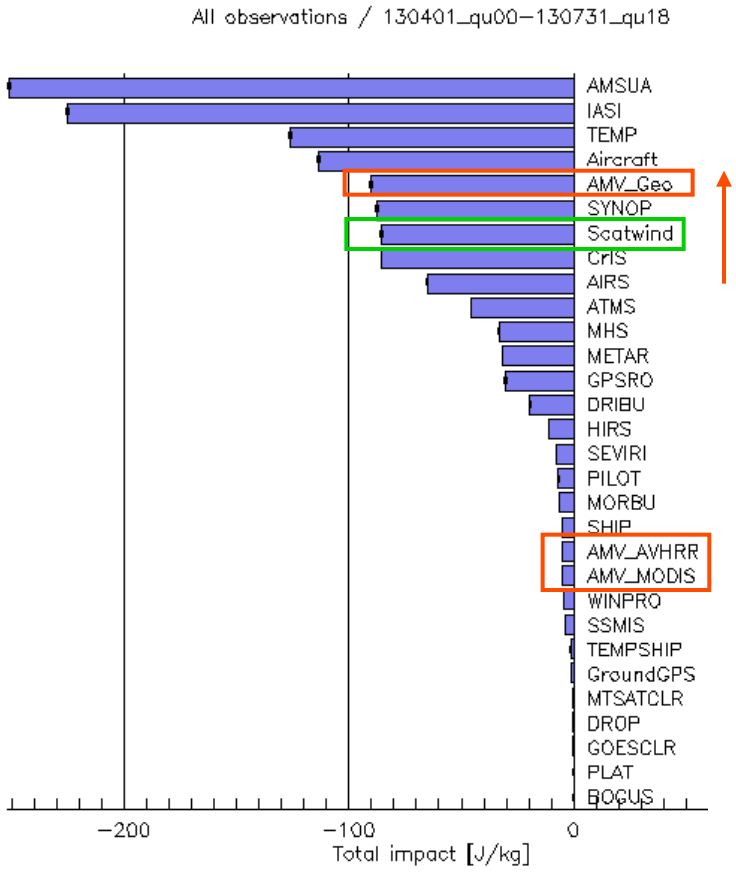
PS30-like

Jan-Mar 2012



PS32-like

Apr-July 2013

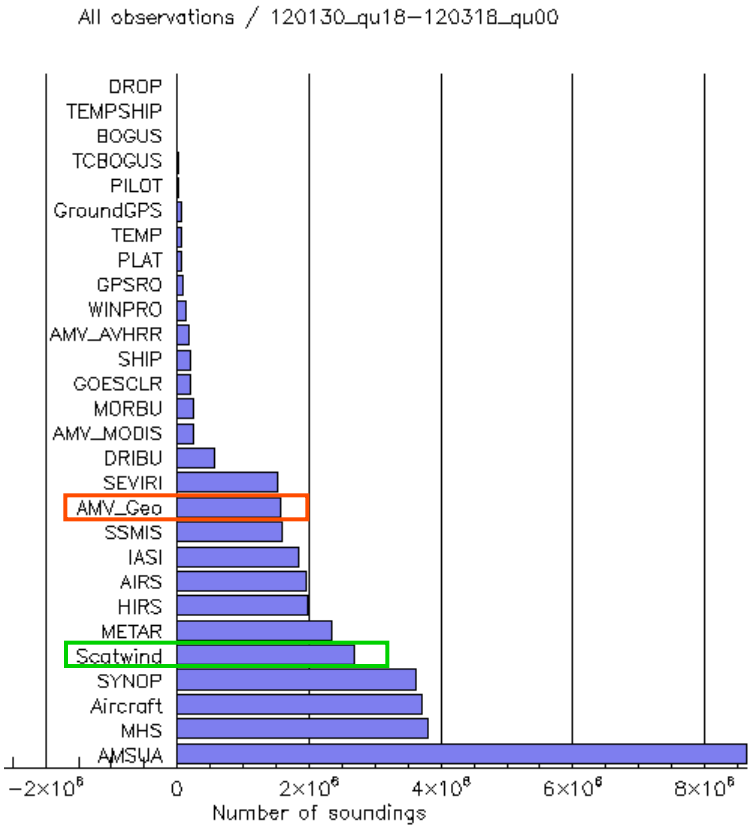


Contributions to the total observation impact on a moist 24-hour forecast-error energy-norm (courtesy of Richard Marriot)

Number of ‘soundings’

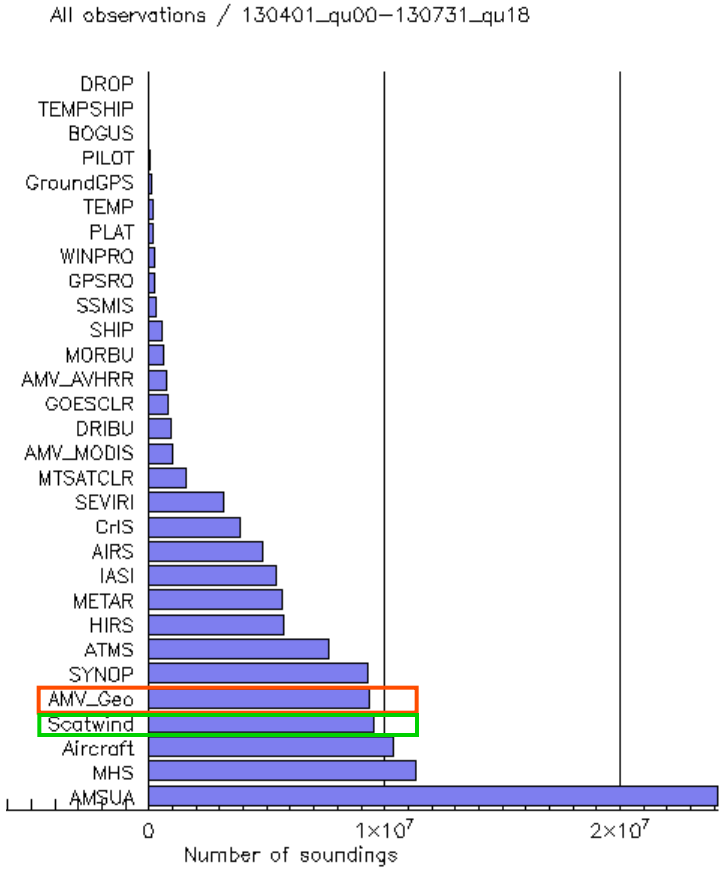
PS30-like

Jan-Mar 2012



PS32-like

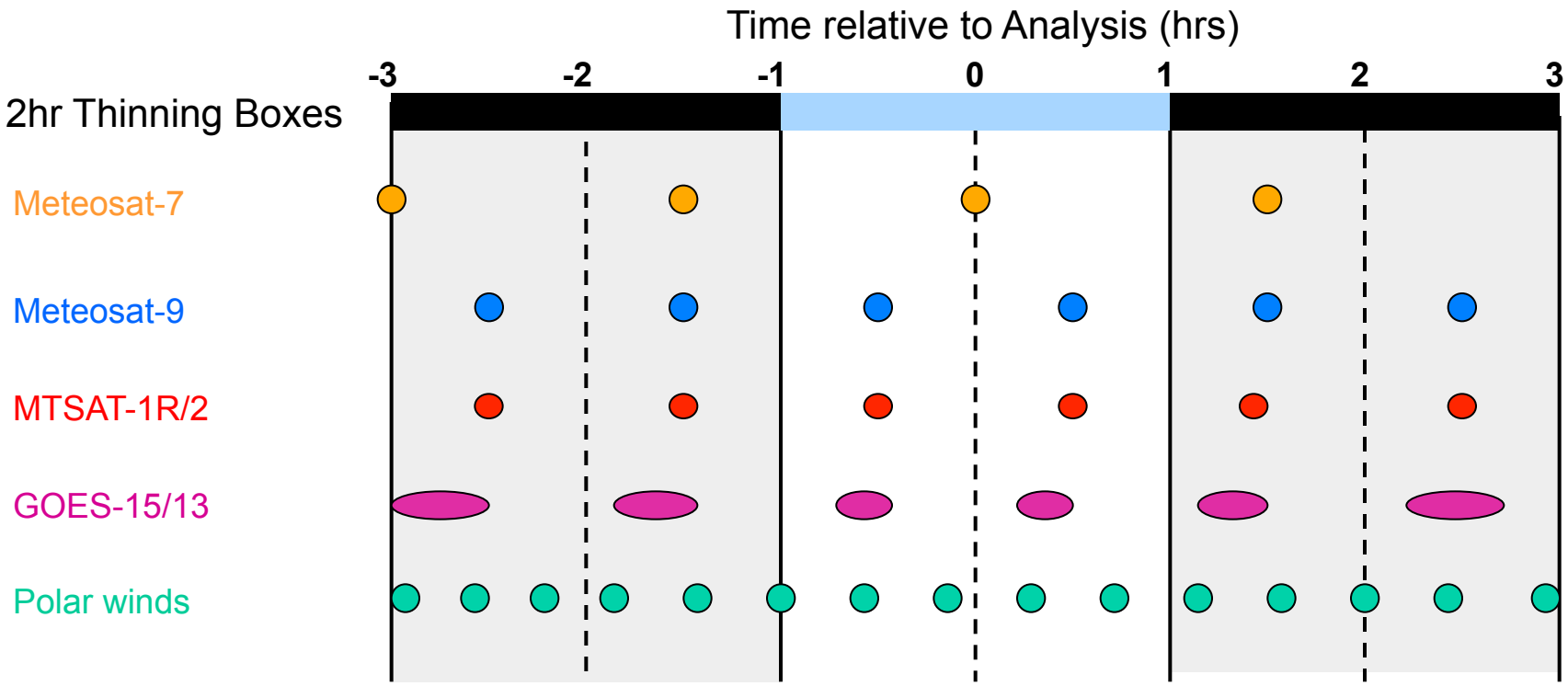
Apr-July 2013



i.e. num wind vectors (u/v pair) for AMV and Scatterometers

Implementation of temporal thinning

- Previously used one wind in each spatial box in the 6 hour window
- From PS31 (January 2013) assimilate in 2-hourly time slots
- 2-3x number of winds

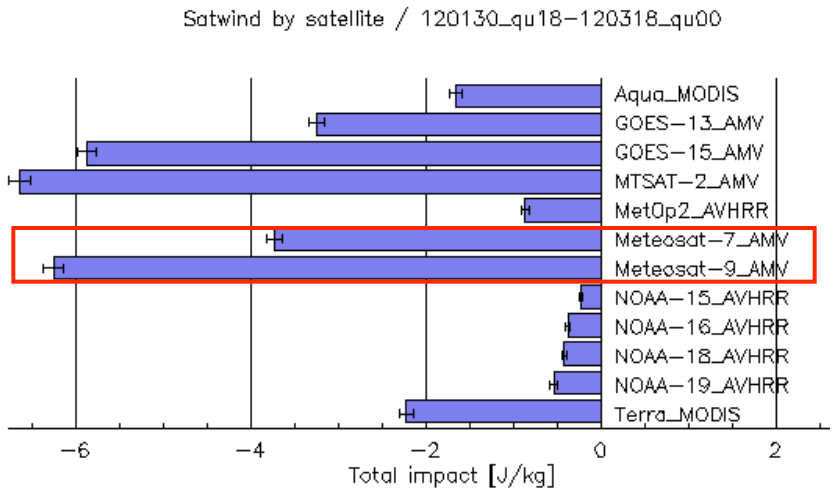


Change in MSG impact

AMV impact by satellite

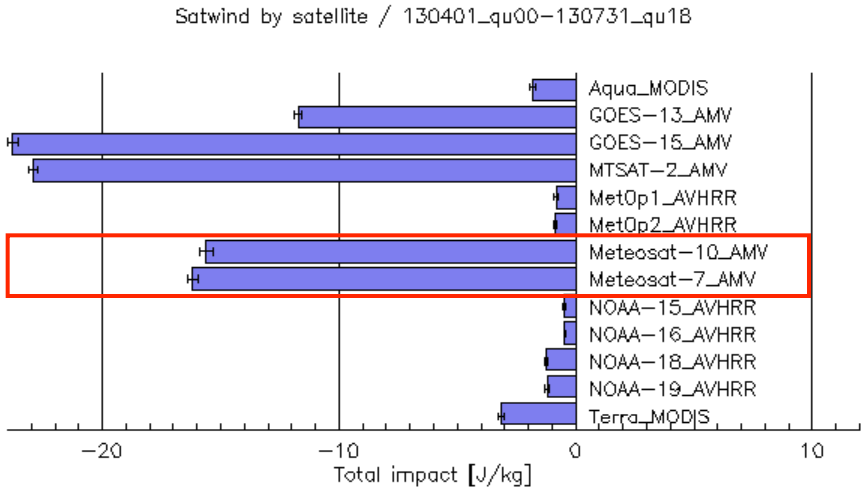
PS30-like

Jan-Mar 2012



PS32-like

Apr-July 2013



- Observed significant drop in relative impact of MSG following blacklist of low level IR and visible channel winds
- Contribution similar to Meteosat-7

EUMETSAT CCC winds

EUMETSAT CCC winds

Main changes

- Cross Correlation Contribution (CCC) method (Borde and Oyama, 2008)
- Maintain closer link between the pixels used in the height assignment with those that dominate in the tracking
- Makes direct use of pixel-based cloud top pressures from CLA product rather than generating AMV CTPs

Pre-operational monitoring showed

- Significant improvements e.g. high level in the jet regions.
- Increase in RMSVD of ~0.6 m/s (20%) for IR and VIS winds at low levels

CCC data became operational on 5 September 2012

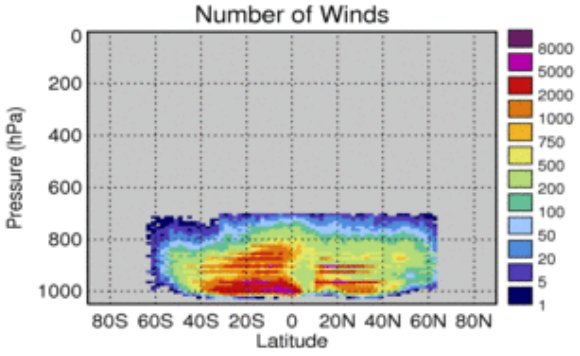
- Decided to blacklist the low level MSG data (16 Oct 2012)
- EUMETSAT ‘fix’ for low level data implemented 16 Apr 2013. Impact?

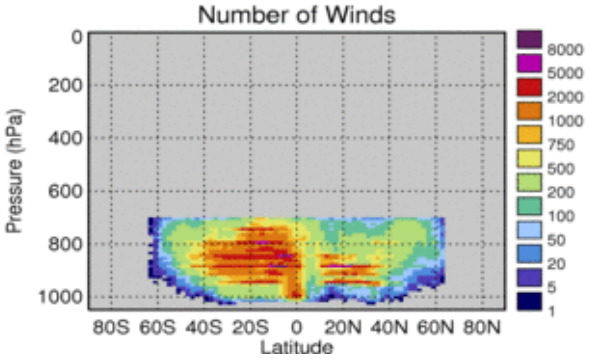
Parallel monitoring - June 2012

VIS 0.8, Oper (pre-CCC), QI2>80

VIS 0.8, CCC, QI2>80

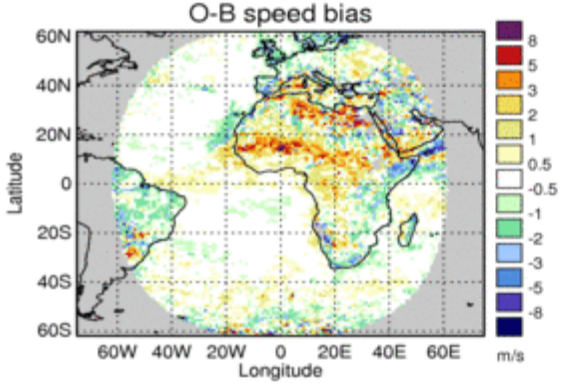
CCC higher

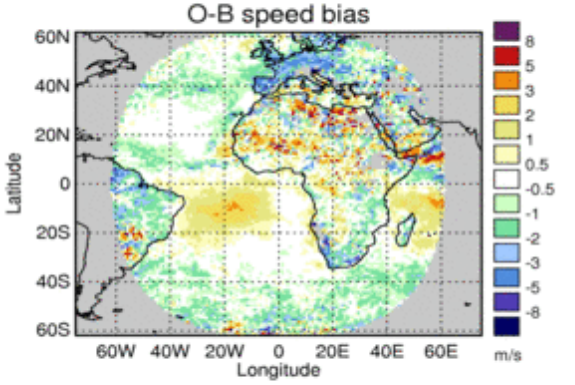




Positive speed bias 0-30°S

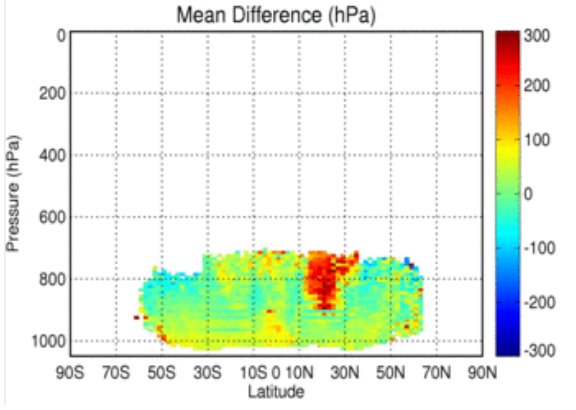
Negative bias mid latitudes/ Europe

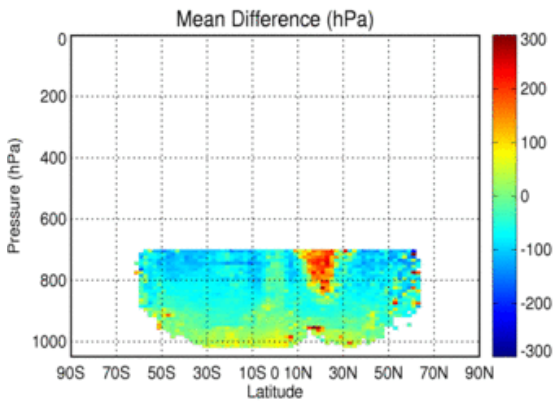




Assigned minus best-fit pressure

- Negative, 'high' height bias
- Shift to higher levels not in agreement with model





Impact experiment at ECMWF

Courtesy Kirsti Salonen (ECMWF)

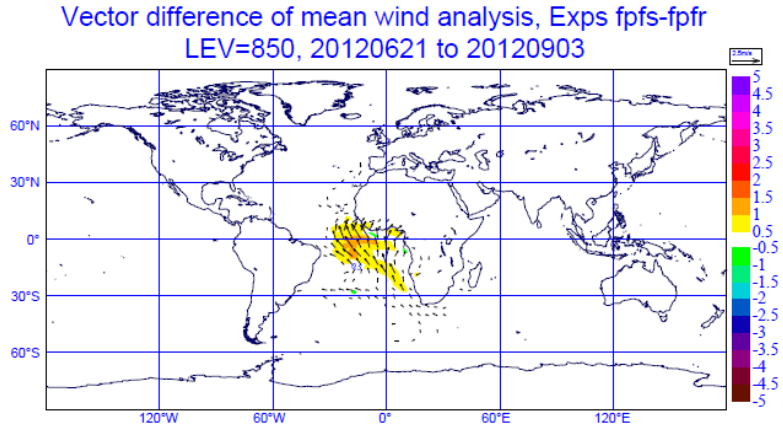


Figure 12: Difference in the mean wind analysis at 850 hPa between the CCC experiment and the Control. Shading indicates the difference in mean wind speed [m/s]. The considered period is 21 June - 3 September 2012.

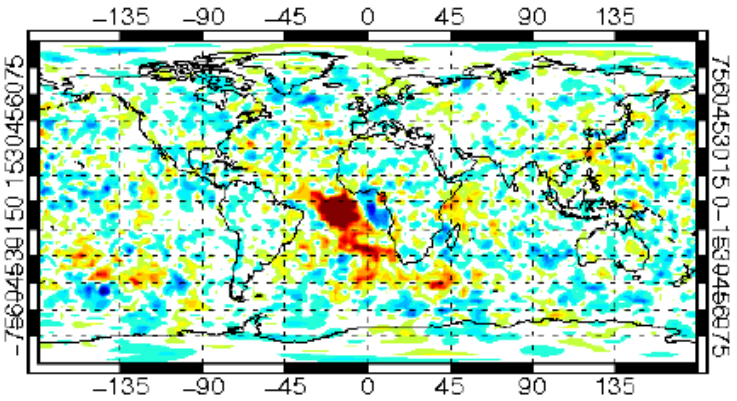


Figure 16: Map of the normalised rms difference between the CCC ensperiment and the Control for 48-hour wind forecast at 850 hPa level. Blue shades indicate positive impact and green and red shades negative impact from using the CCC AMVs.

Significant difference in mean wind analysis at low levels (850 hPa)

- CCC AMVs tends to strengthen the mean wind field
- Same region as the increase in positive speed bias for CCC winds

Negative impact on forecasts

-> blacklist the low level MSG winds (Sept 2012)

Update for low level HA

Height difference mainly occurs in regions with a low level temperature inversion (Borde et al, 2013).

• Due to difference in the way the inversion correction is applied in CLA algorithm compared to the pre-CCC AMV algorithm

Pre-CCC

• If final EBBT height below 650 hPa and above an inversion then corrected to base of inversion layer

CCC

• If EBBT CTH below 650 hPa + temperature inversion is found then height is corrected to 1/3 way above base of inversion layer

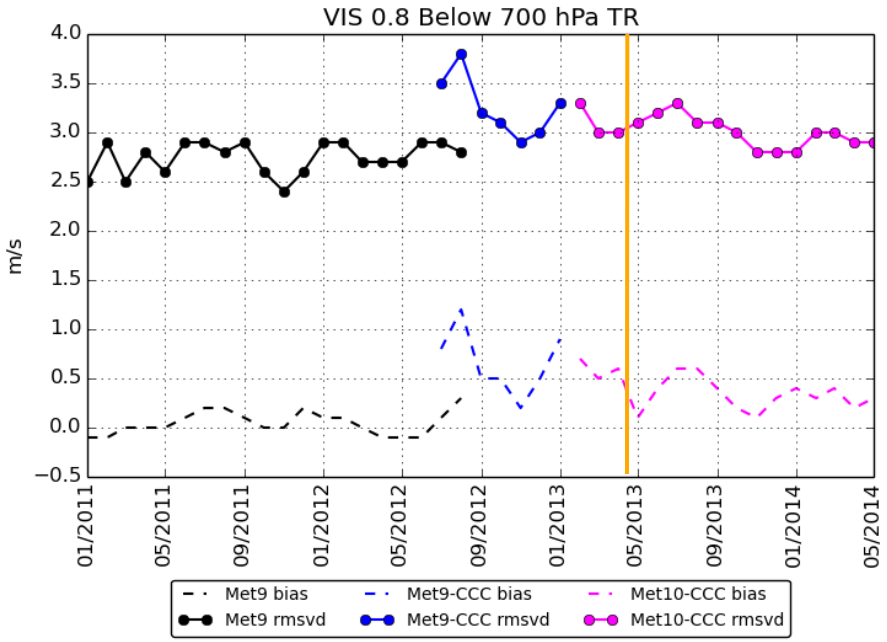
• CTH can be corrected upwards as well as downwards

Derivation updated on 16 April 2013 so more consistent with old inversion scheme

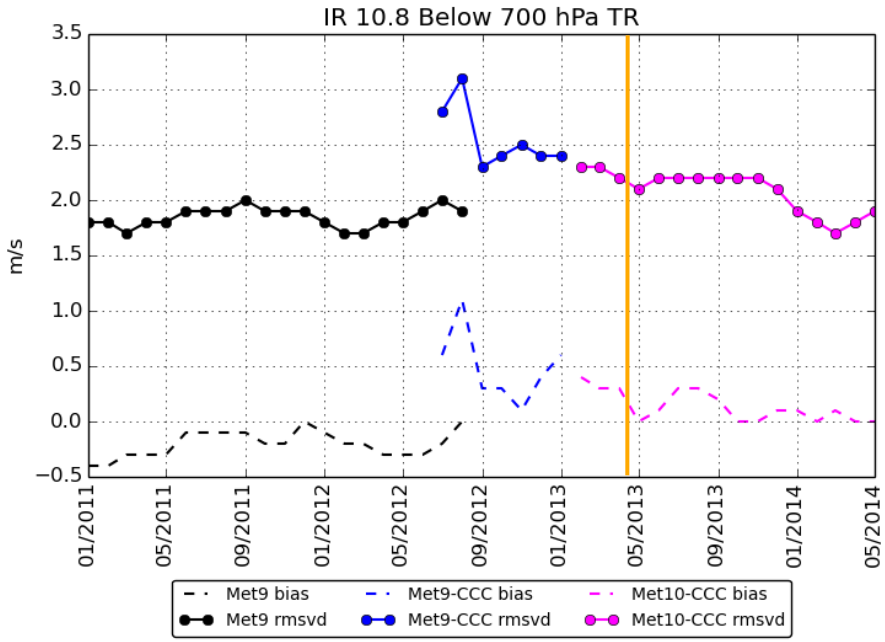
CGMS Time series

Tropics

VIS 0.8



IR 10.8



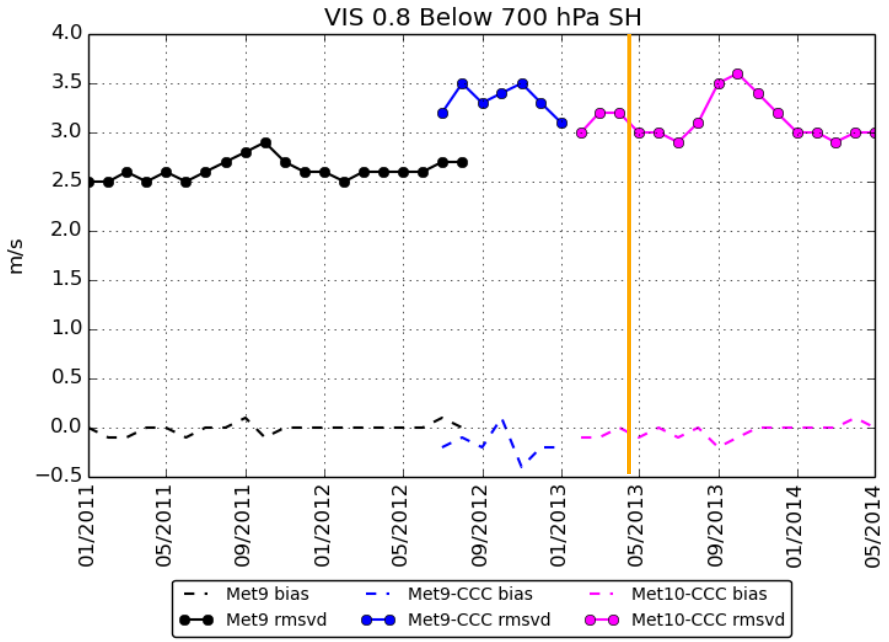
Met-9 -> Met-9 CCC -> Met-10 CCC

QI1 > 80 (IR) or QI1 > 65 (vis)

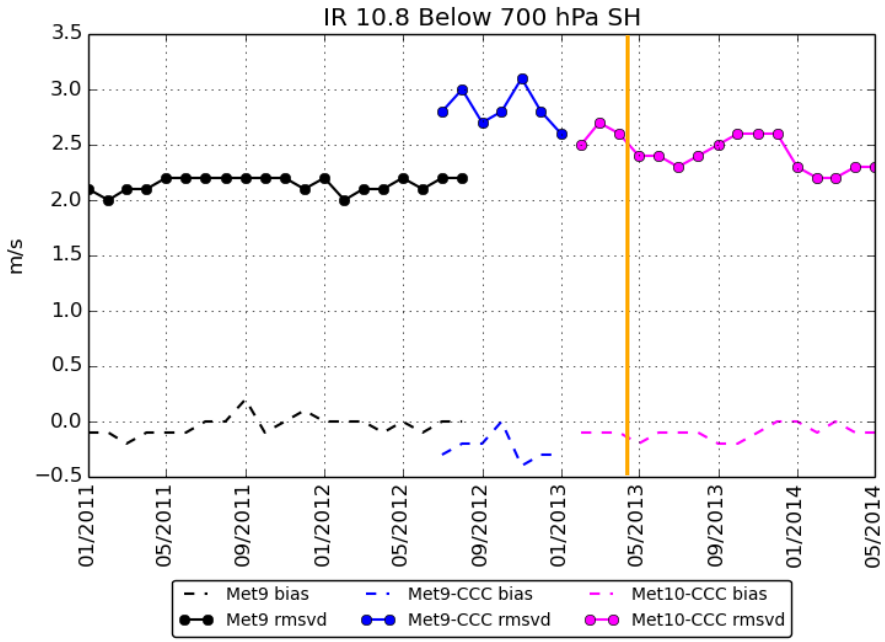
CGMS Time series

Southern hemisphere extra-tropics

VIS 0.8



IR 10.8



Met-9 -> Met-9 CCC -> Met-10 CCC

QI1 > 80 (IR) or QI1 > 65 (vis)

Assimilation Experiment

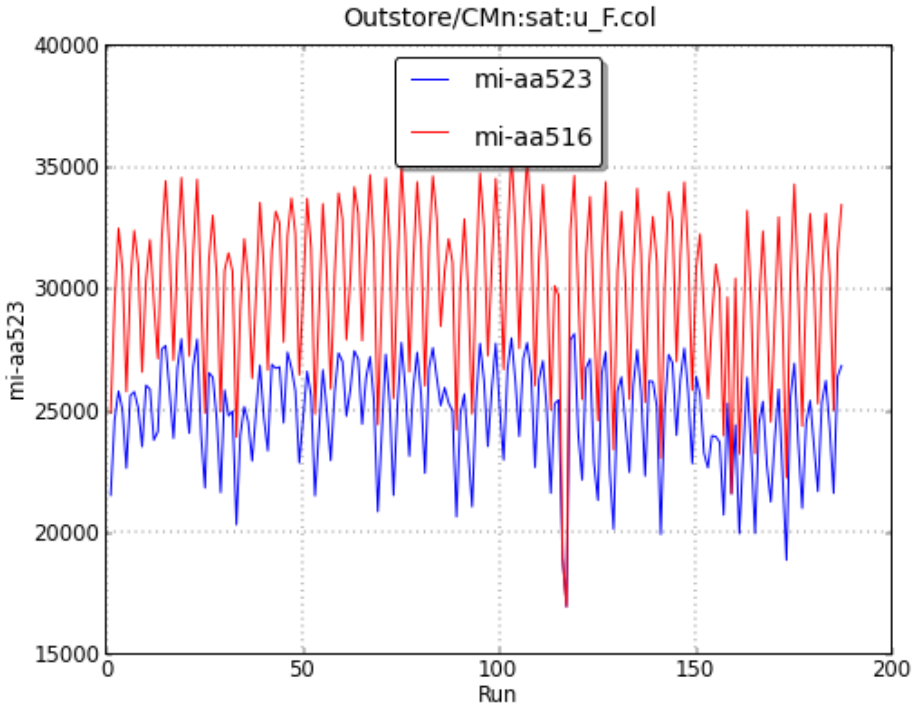
45-day experiment to assess impact of reintroducing low level MSG winds to operations

- 10 July 2013 to 25 Aug 2013
- Control: No Met-10 AMVs below 700 hPa
- Trial: Assimilate Met-10 IR, VIS, HRVIS below 700 hPa
- PS32 configuration, N320 L70, 4D-Var (N108-N216)

Number of AMVs assimilated

Control

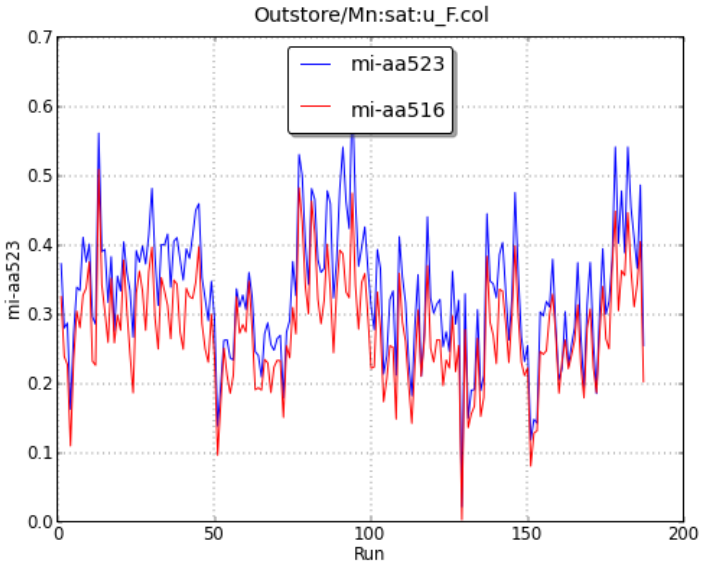
Trial



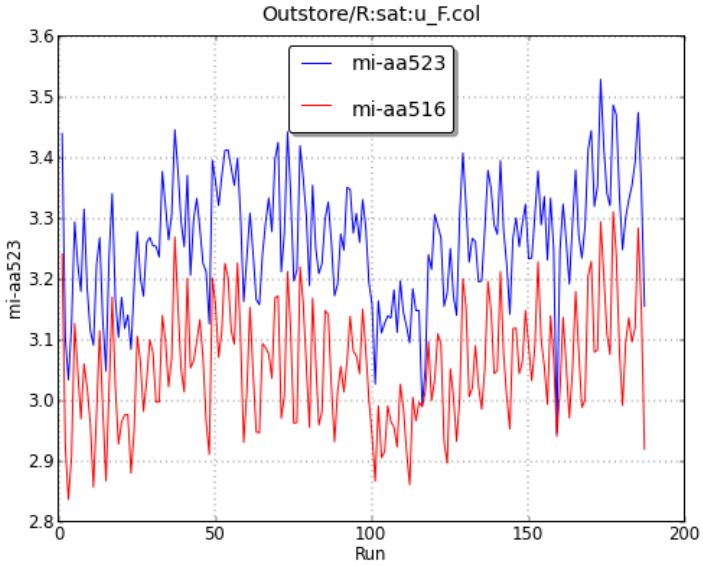
20% increase in AMV observations assimilated (from avg. 24,800 to 30,000)

AMV zonal wind component O-B

Mean u-wind O-B



RMS u-wind O-B



Control

Trial

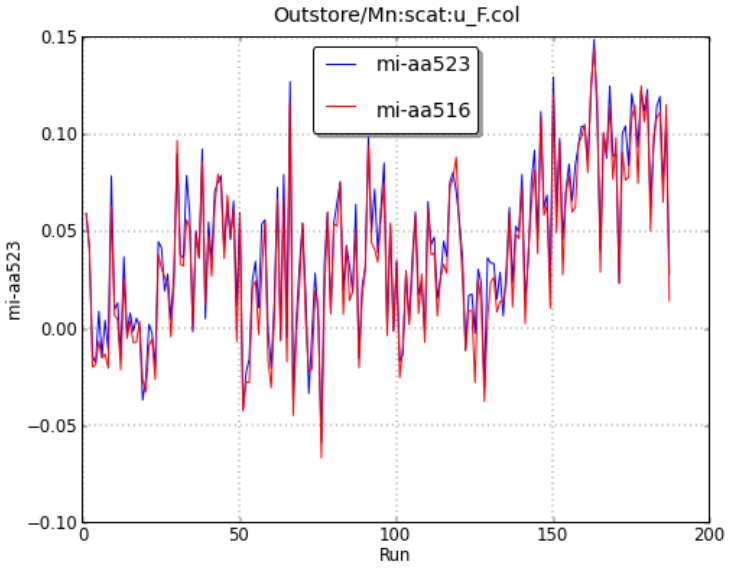
- RMS O-B ~ 0.2 m/s (6%) lower when the low level MSG winds are included. Mean O-B also shows a small improvement
- Similar results for O-A

Scatterometer zonal wind O-B

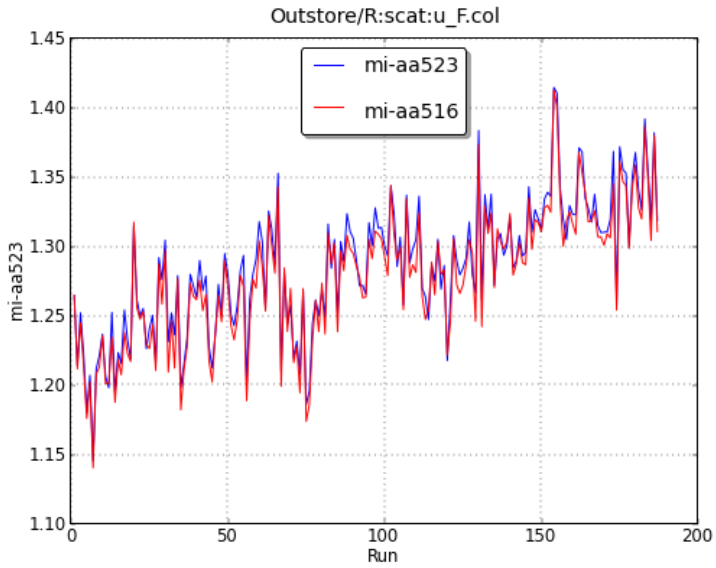
Control

Trial

Mean u-wind O-B



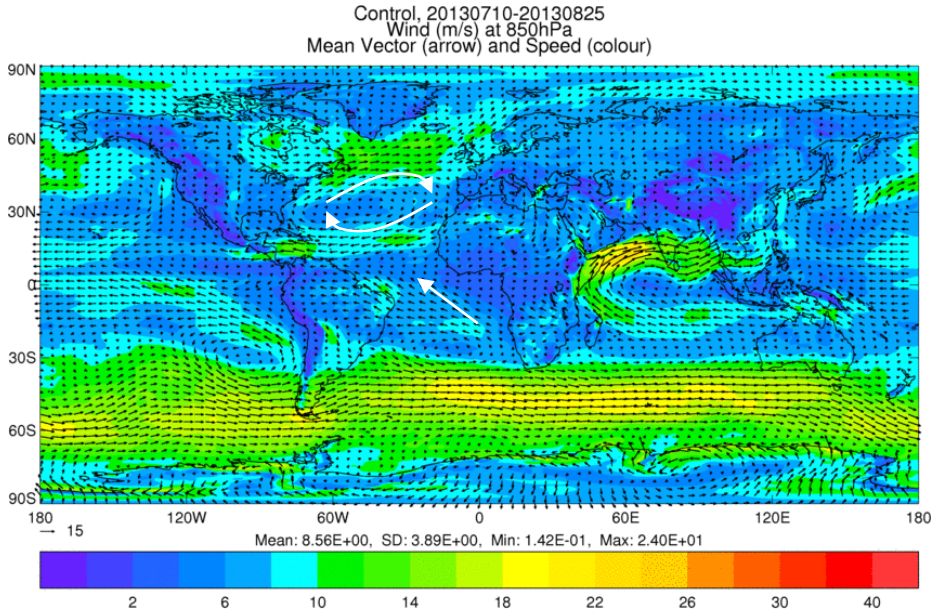
RMS u-wind O-B

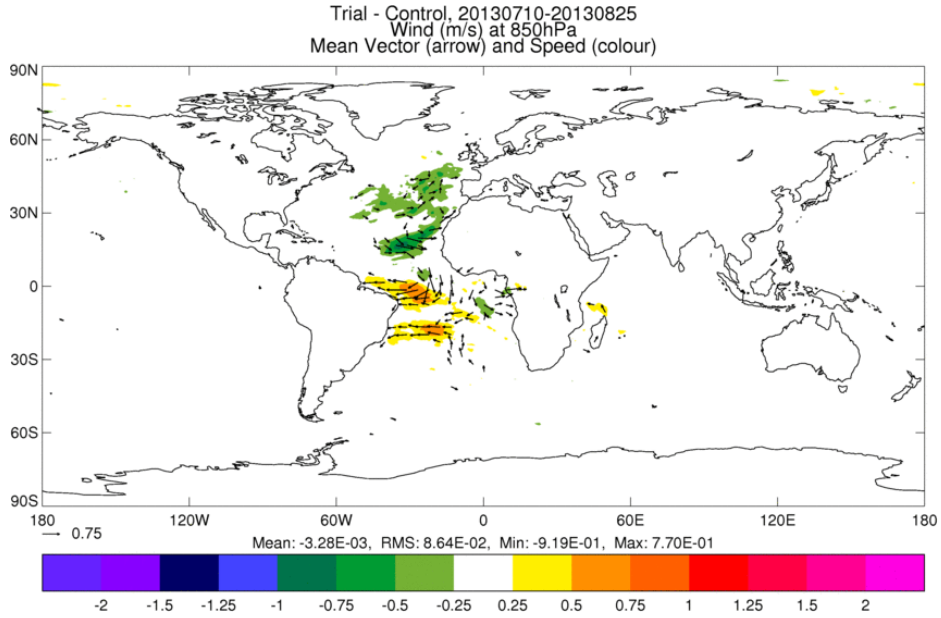


- RMS O-B for scatterometer winds also slightly lower in the trial (0.5% reduction for U and V)

Impact on wind analysis

850 hPa wind field, averaged over trial period



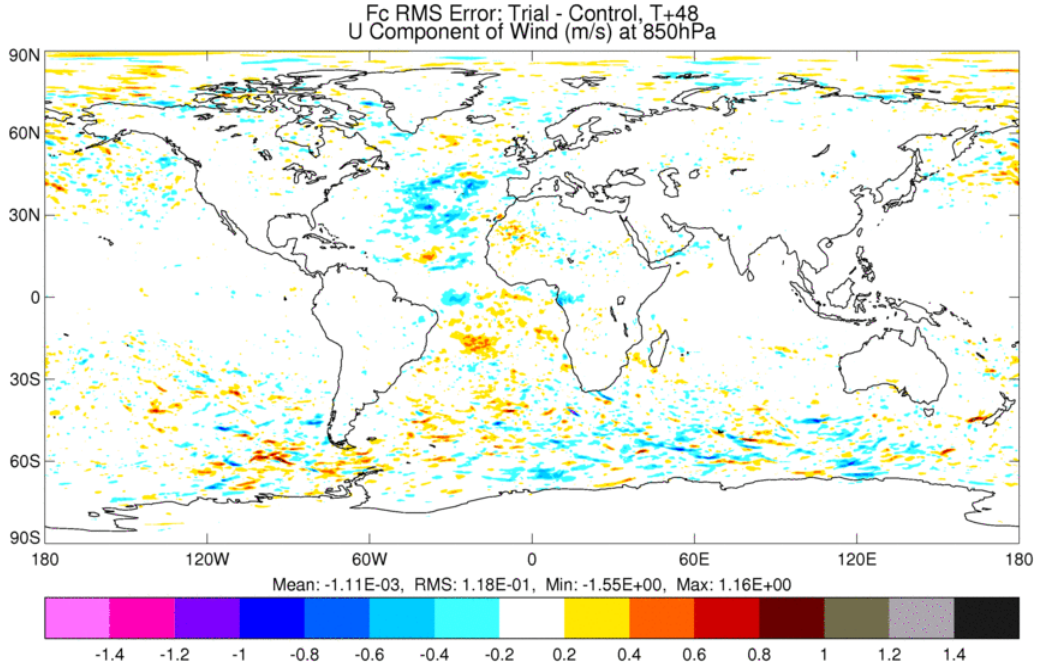


Diff: Green-blue indicates wind speeds are slower in the trial, yellow-red where they are faster.

- Trade winds in tropical South Atlantic increase by up to 0.7 m/s
- Slower in North Atlantic by up to 0.9 m/s

Impact on 850 hPa wind forecasts

Zonal wind: T+48 RMS error



blue: positive impact

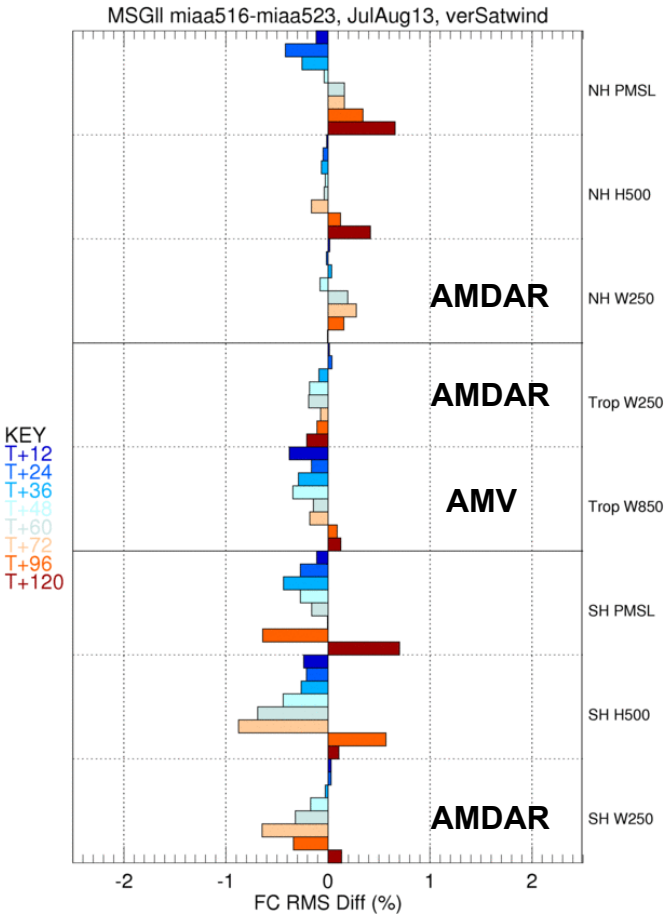
yellow-red: negative impact

- Small region of negative impact ~ 20°S
- North Atlantic shows a widespread region of positive impact

Change in forecast RMS (NWP Index)

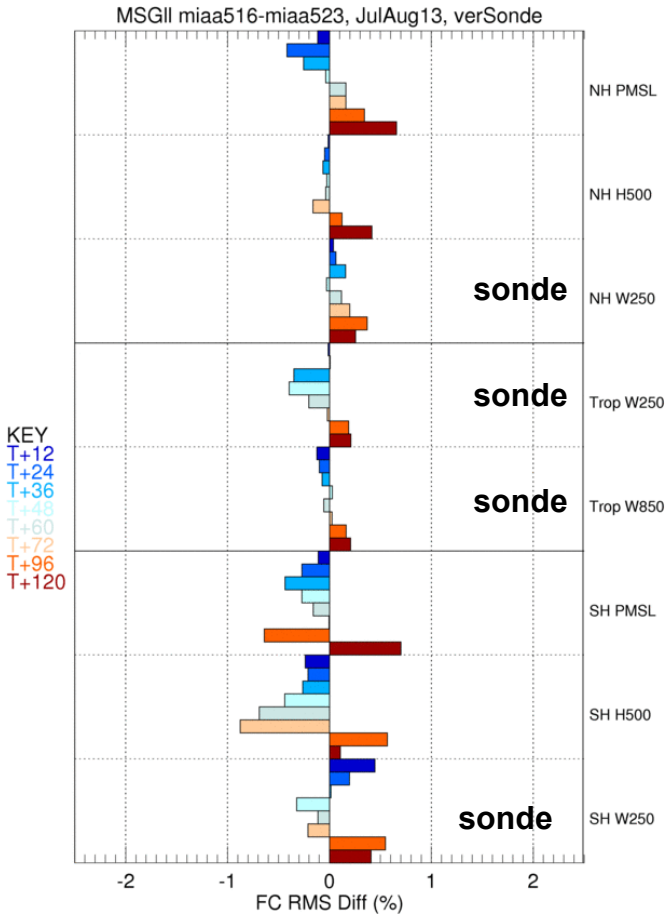
- Mixed impacts for PMSL in NH
- Tropical winds rather neutral
- Improvements for most forecast ranges in SH

Standard (**-0.11**)



Positive impact ←

Alternative (**-0.13**)



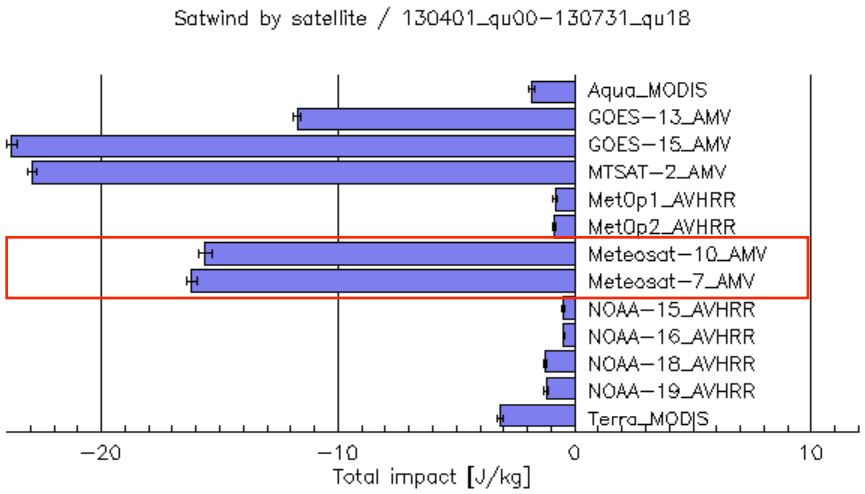
Positive impact ←

Change in MSG impact (II)

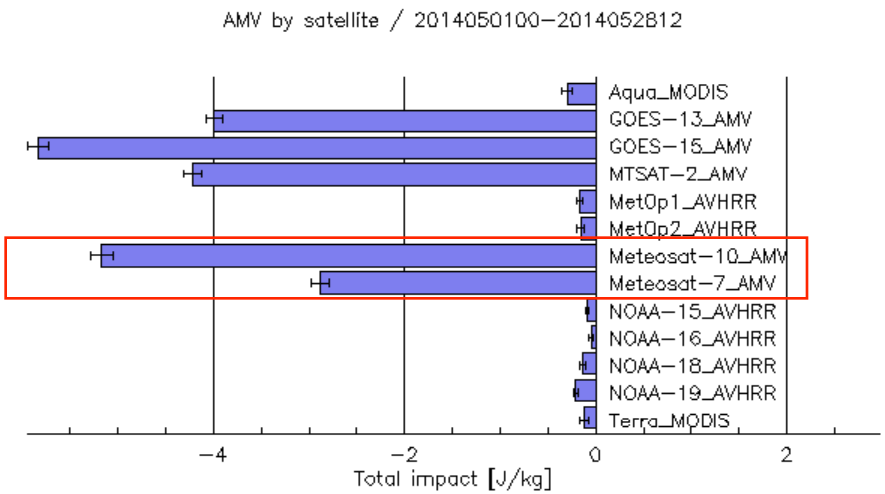
AMV impact by satellite

PS32-like

Apr-July 2013



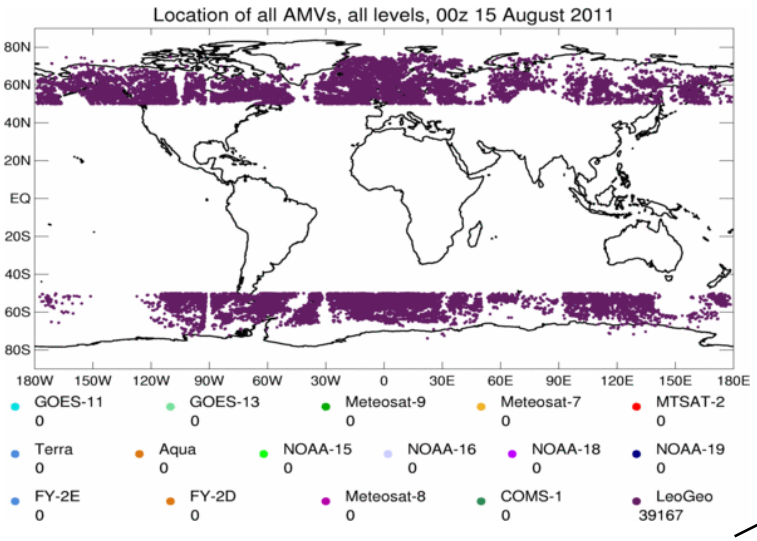
May 2014

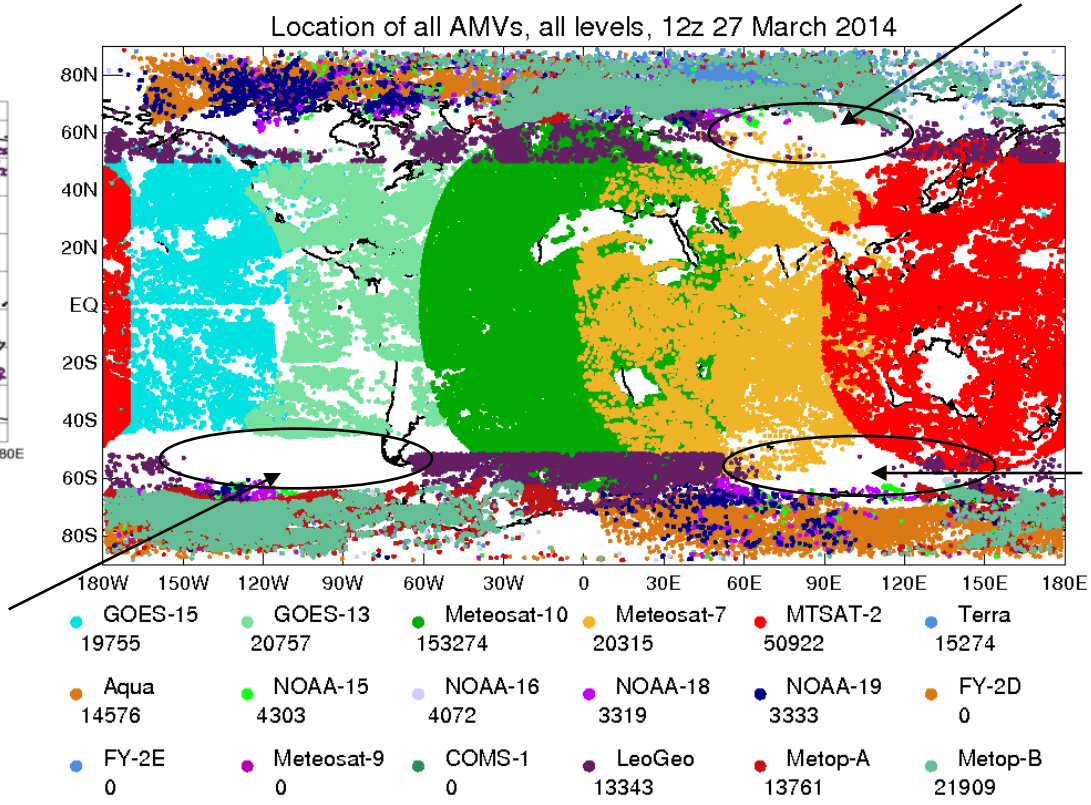


Meteosat-10 impact restored following reintroduction of low level winds in January 2014

Filling the gap

LeoGeo mixed satellite winds



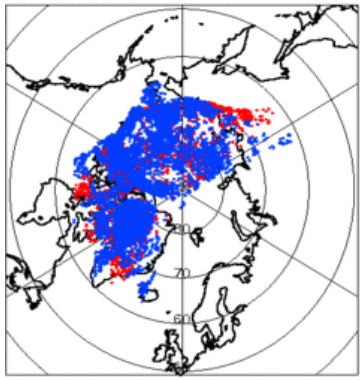


- LeoGeo provides less complete coverage than seen in previous analyses
- Loss of GOES-12 (South America) and removal of Met-7, FY-2E (?)
- Assimilation trials ongoing with BUFR data

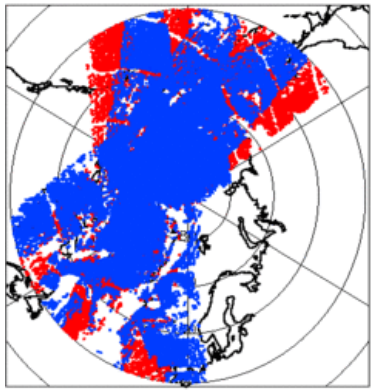
EUMETSAT Metop winds

EUMETSAT data reaches as far as 50° N/S.
CIMSS data is polewards of ~65°

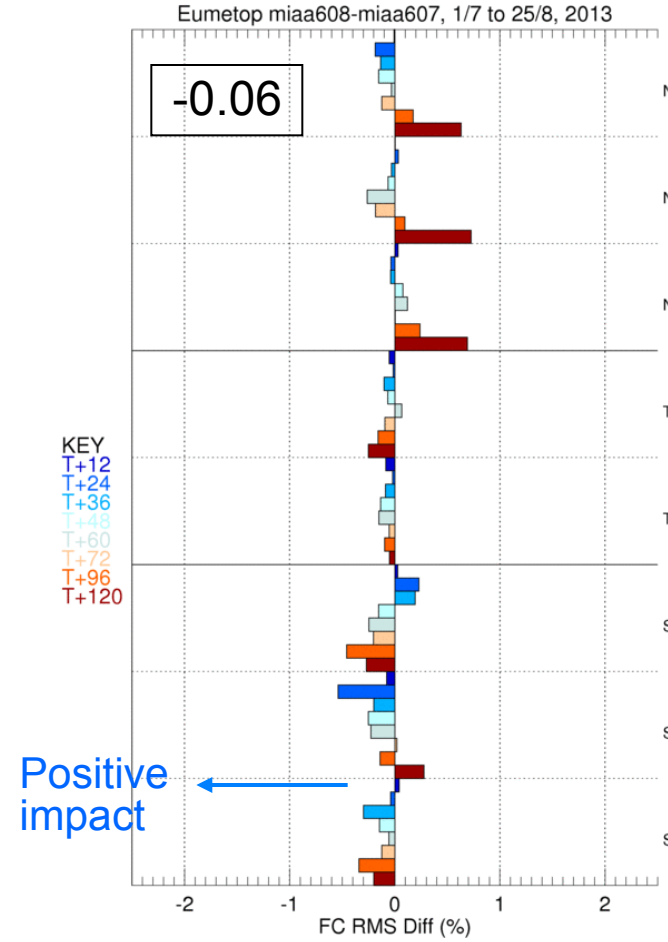
CIMSS Metop-A/B



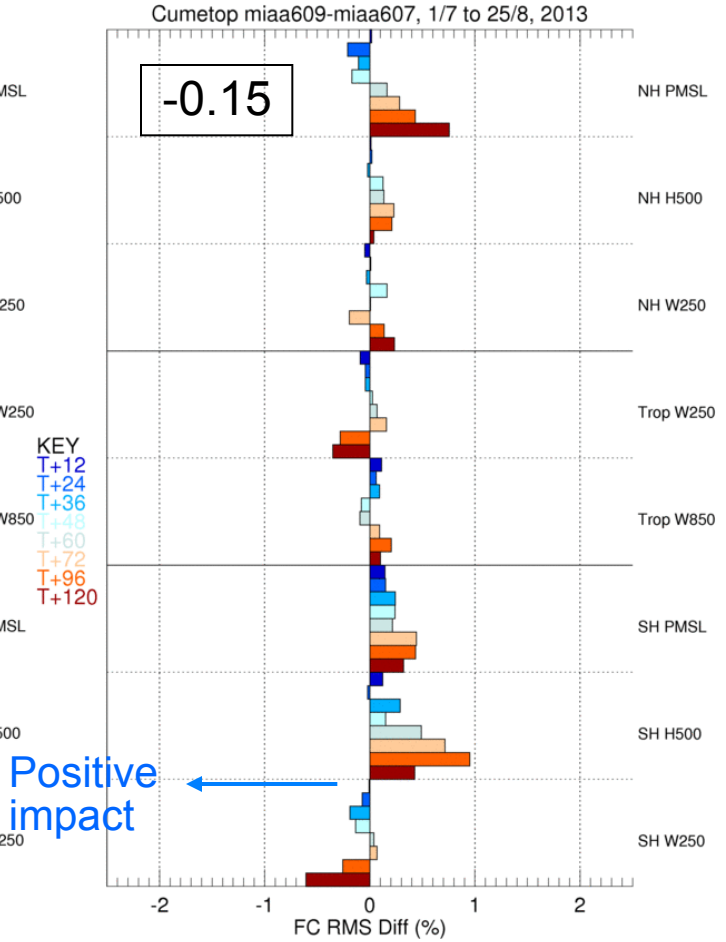
EUM Metop-A/B



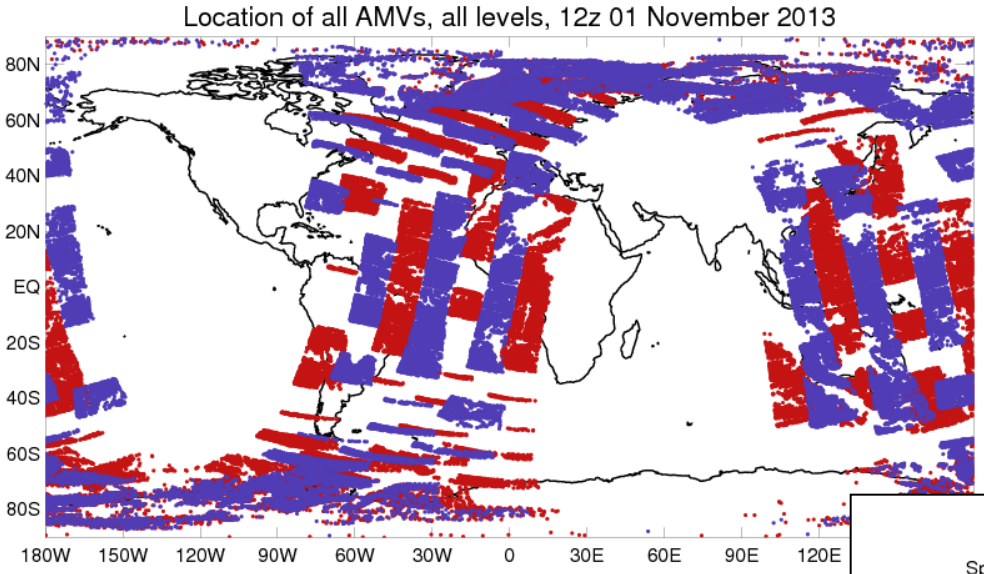
EUMETSAT vs NoPolar

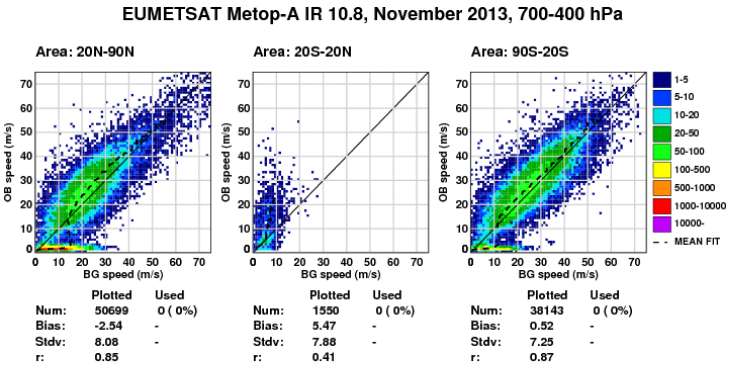


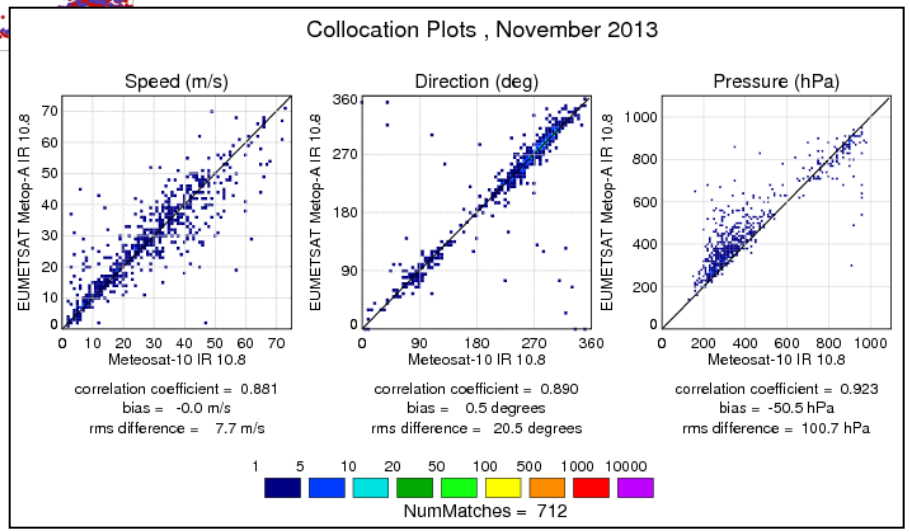
CIMSS vs NoPolar



Dual Metop-A/B winds





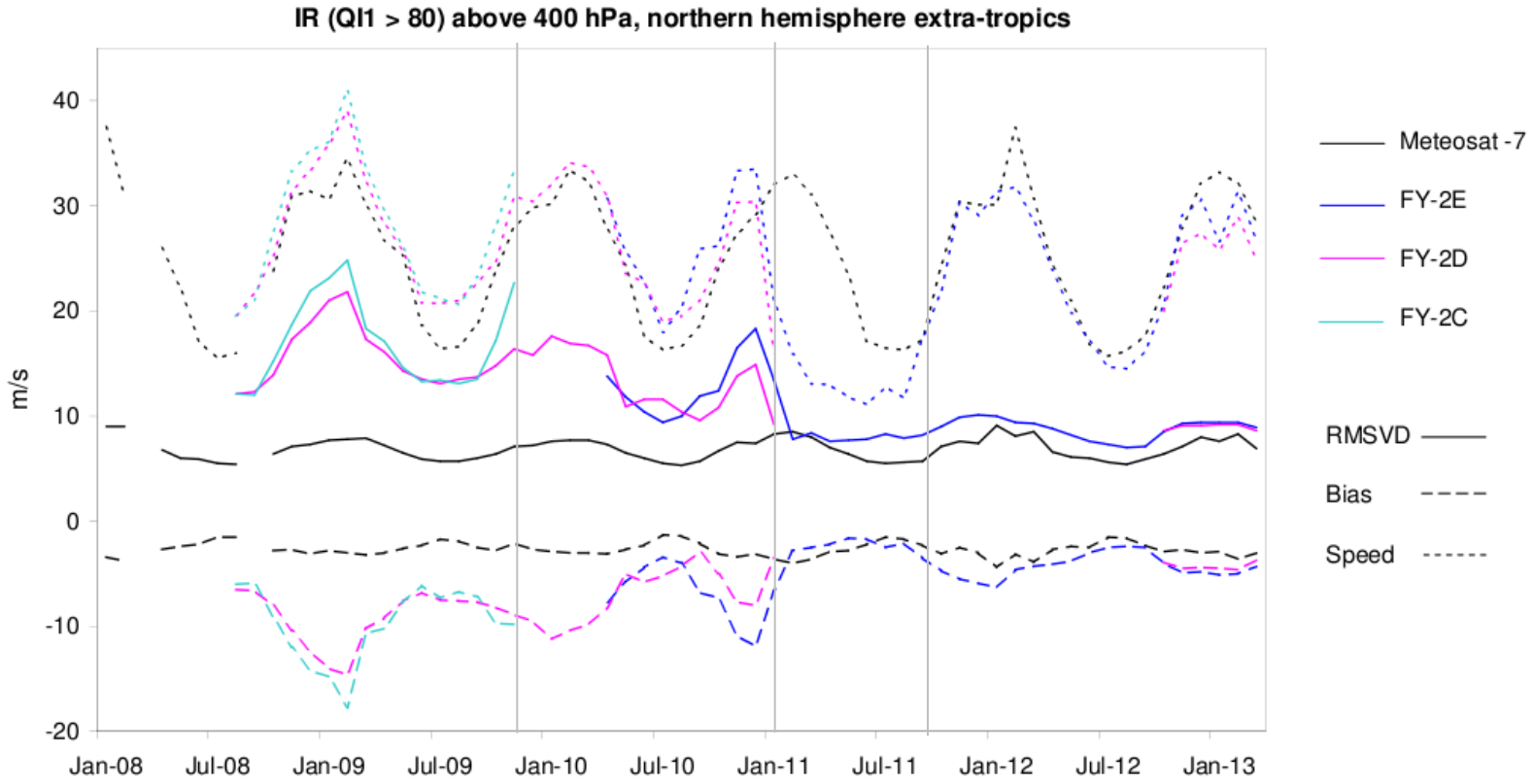


Collocation with Meteosat-10

- Good vector agreement
- More differences in height (HA limitations for AVHRR)

Indian Ocean intercomparison

Indian Ocean inter-comparison



Report available from NWP SAF investigation web page

http://nwpsaf.eu/monitoring/amv/investigations.html

Summary

- Latest FSO statistics show AMVs are having a substantial positive impact on Met Office global NWP
- Low level MSG winds show some improvement following update in April 2013. O-B's perhaps not back to pre-CCC levels.
    - Reinstating the data gives some improvement in forecast RMS scores
    - AMV O-B and O-A fit improved and small benefit for scatterometer O-B
    - Reinstated to operations 21 January 2014
- Trials with LeoGeo and EUMETSAT Metop winds ongoing
- IODC inter-comparison report published on NWP SAF website

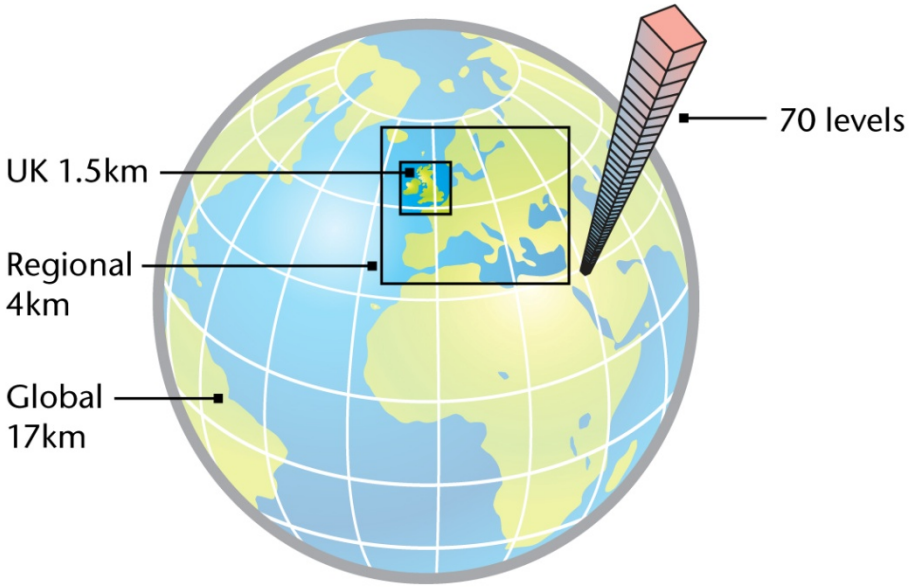
Met Office

Thank You
Questions?

Met Office NWP model suites

Global and MOGREPS-G

- 25-km in mid latitudes (17-km from July 2014)
- 70 levels (80-km model top)
- Hybrid 4D-Var (60-km)
- Analysis times: 0,6,12,18 Z
- T+67 forecast twice/day
- T+168 (7 day) forecast twice/day
- 12-member EPS - 32 km 4x/day T+168



Euro4

- 4.4 km, 70 levels (40-km model top)
- Global downscaler
- T+60 forecast twice/day
- T+120 (5 day) forecast twice/day

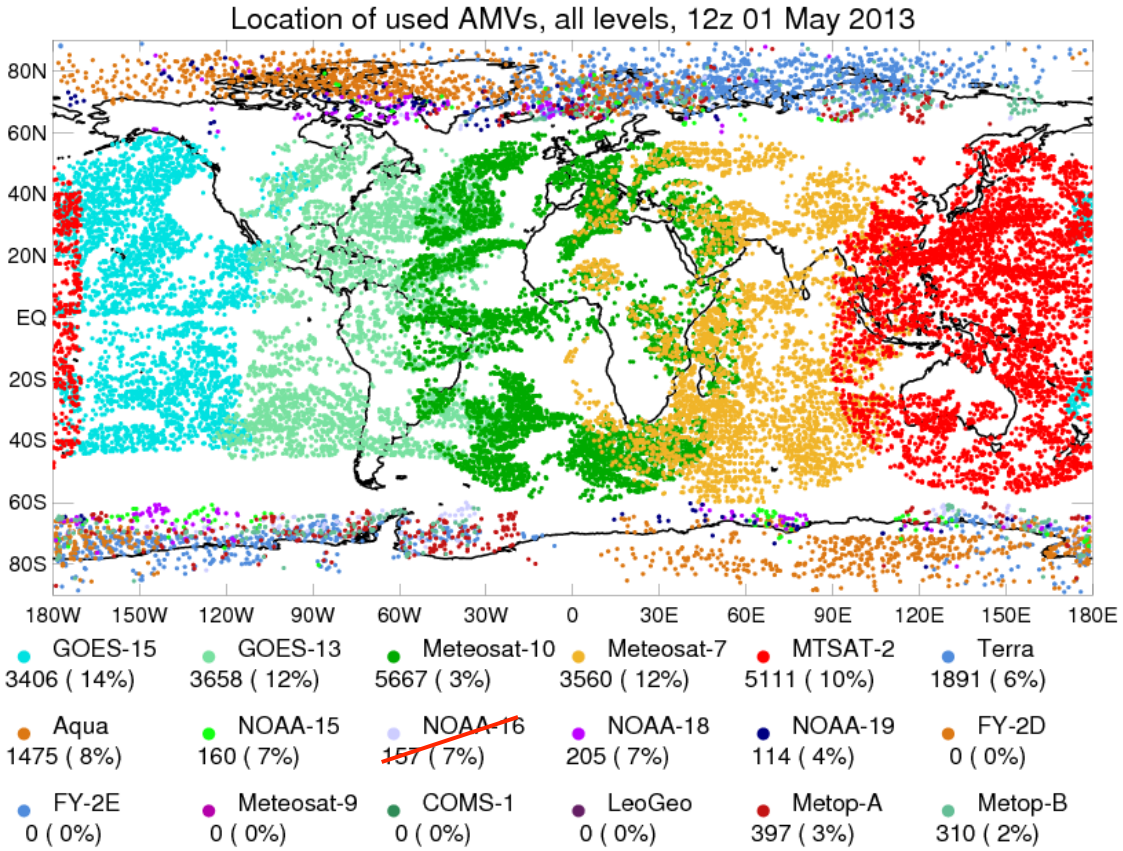
UKV and MOGREPS-UK

- 1.5-km, 70 levels (40-km model top)
- 3D-Var (3 hourly)
- T+36 hr forecast 8/day
- 12-member EPS - 2.2 km 4x/day 36h

MOGREPS = Met Office Global Regional Ensemble Prediction System

Current operational use of AMVs

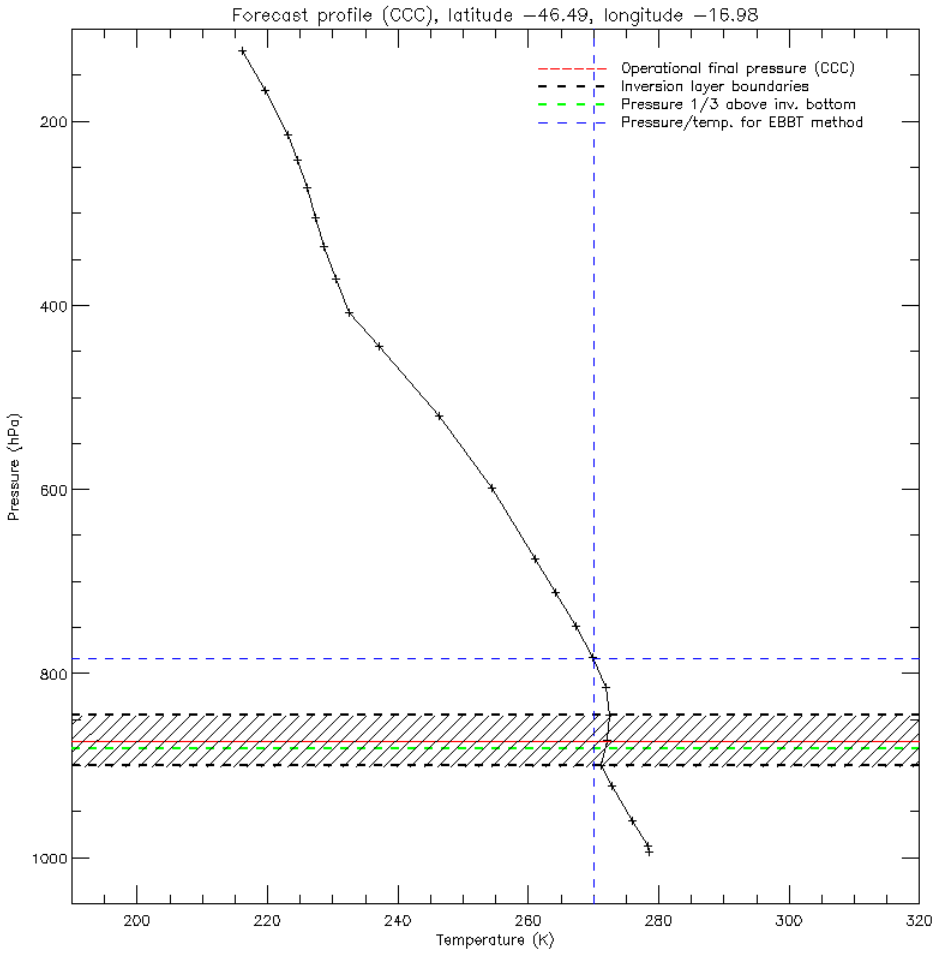
Using data from 5 geostationary and 7 polar platforms



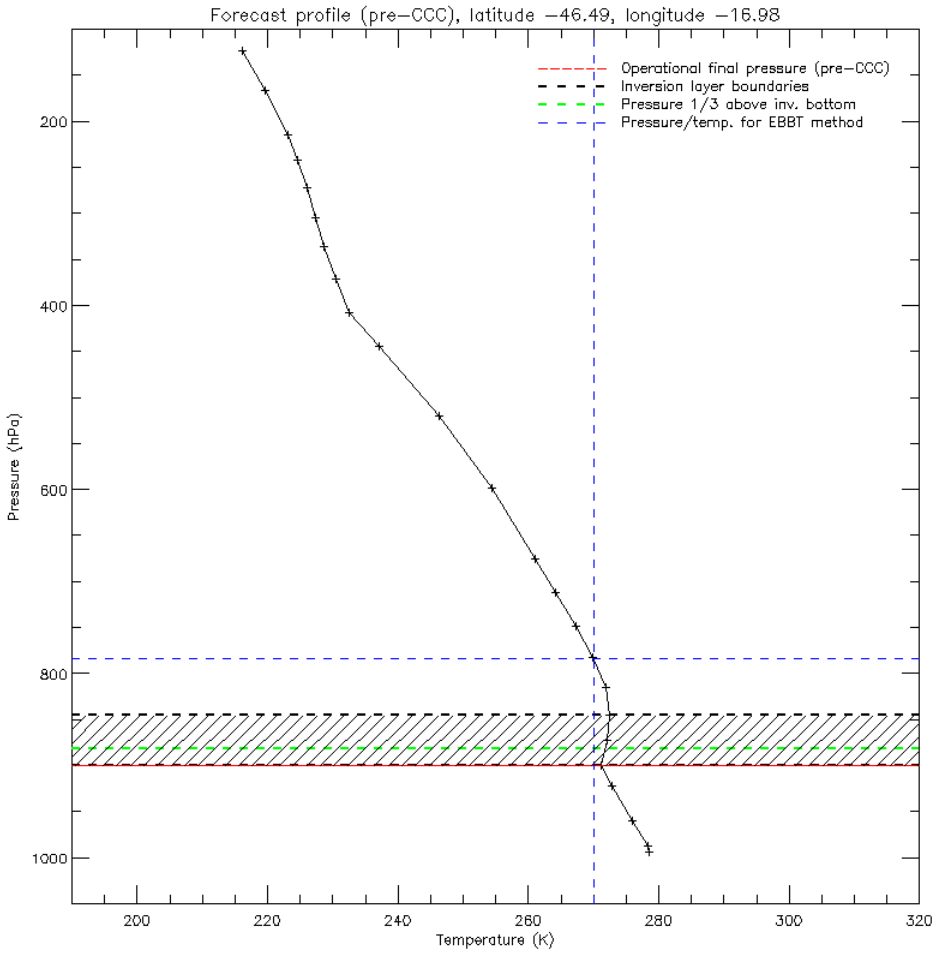
EUMETSAT	Met-10, Met-7
JMA	MTSAT-2
NESDIS	GOES-13/15, Aqua/Terra MODIS
CIMSS	NOAA-15/~~16~~/18/19 AVHRR, Metop-A/B AVHRR

EBBT CTH above inversion

CCC



Pre-CCC



Courtesy Regis Borde (EUMETSAT)

Impact of low level update

Met-10 visible 0.8, QI2 >80

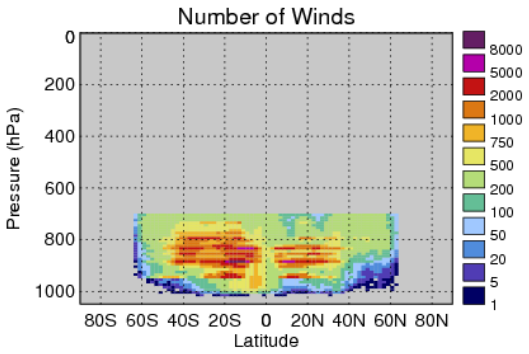
Updated AMVs assigned lower in atmosphere

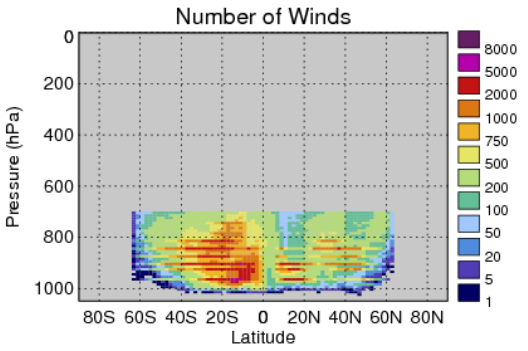
Reduced positive speed bias in tropical Atlantic.

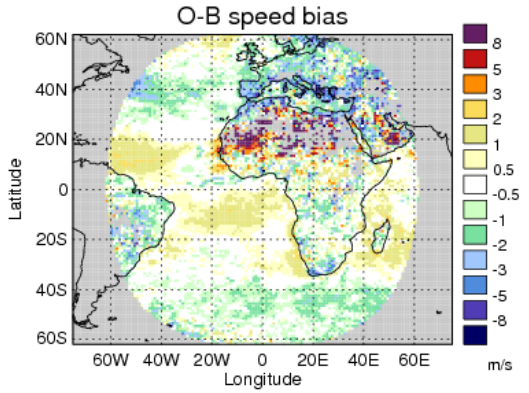
Negative speed bias in mid-latitudes also improved.

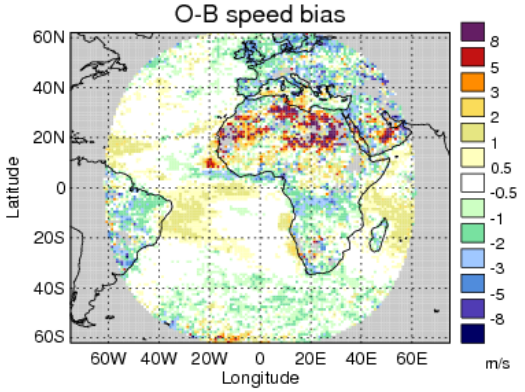
CCC: month prior

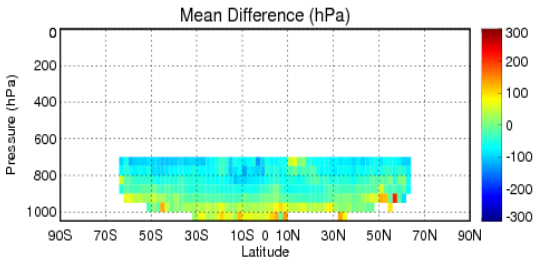
updated-CCC: month after

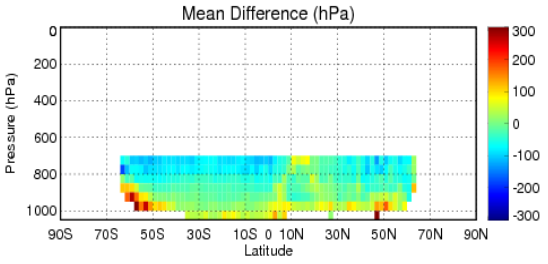








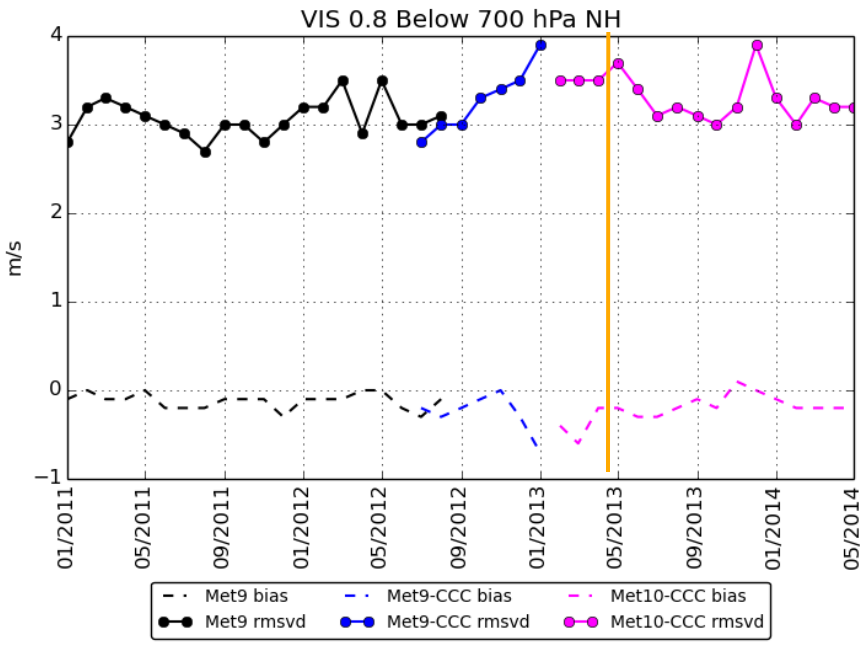




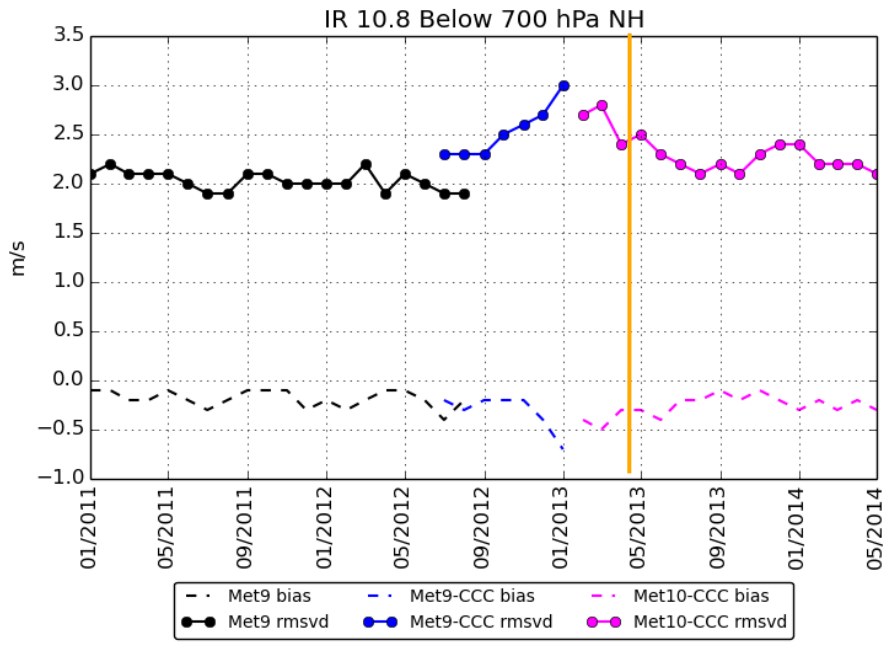
CGMS Time series

Northern hemisphere extra-tropics

VIS 0.8



IR 10.8



Met-9 -> Met-9 CCC -> Met-10 CCC

QI1 > 80 (IR) or QI1 > 65 (vis)

Wind verification in VER

Global NWP index verification

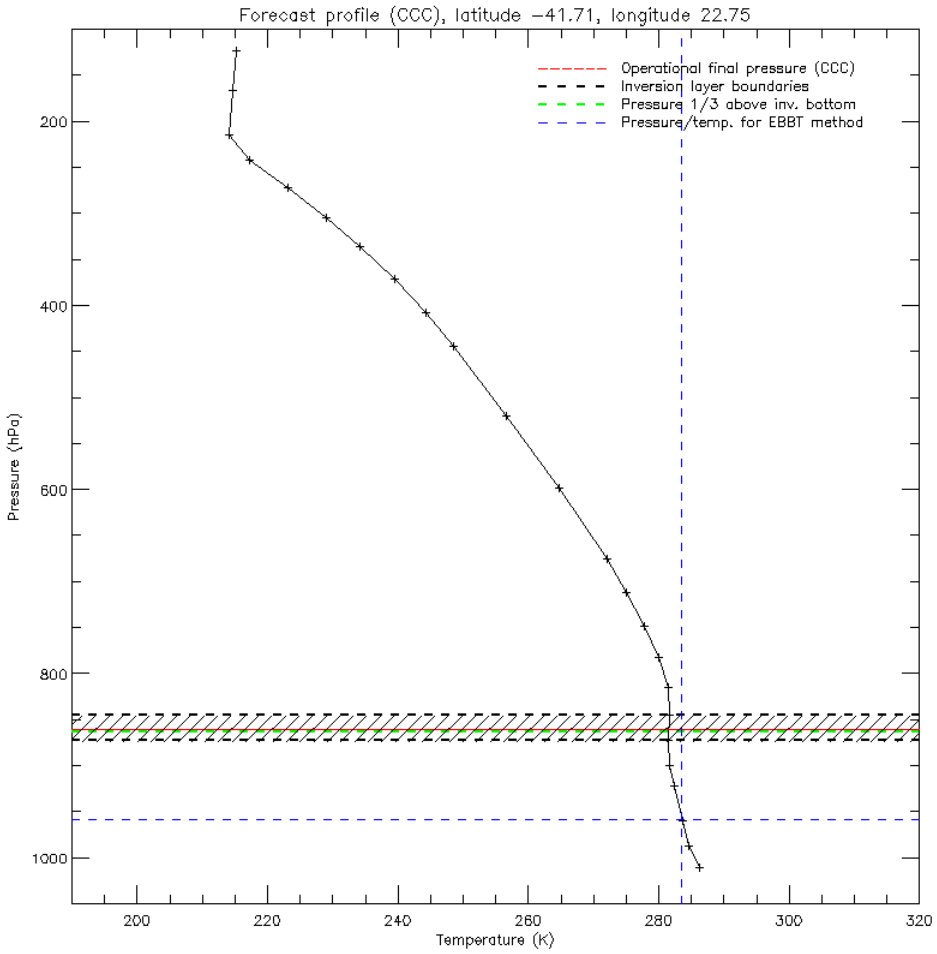
- 250 hPa wind against AMDARS
- 850 hPa wind against AMVs (tropics only)
- Other heights in extended index verified against sondes

AMV observations used to verify the forecasts are those that were assimilated in operations at the time.

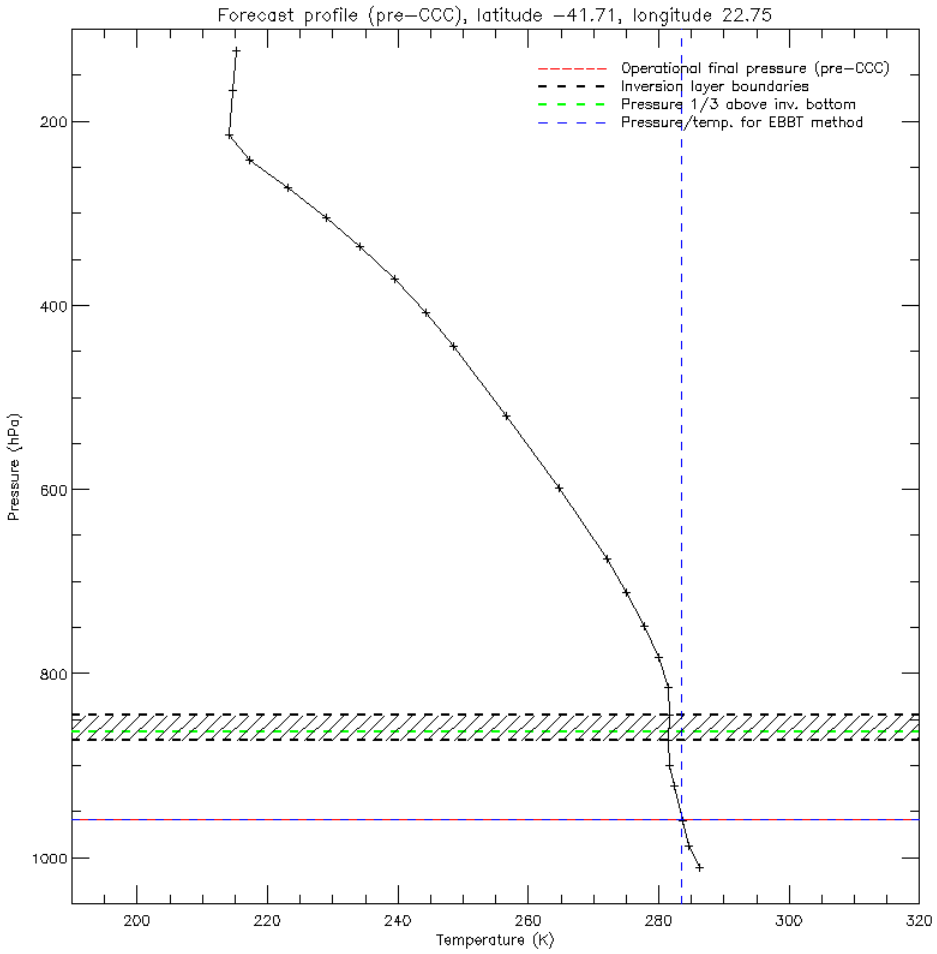
- The low level MSG winds are blacklisted so have fewer observations to verify against in the region where we are adding AMVs back in.
- Still some coverage in this region from GOES-13 and Met-7.
- Alternatively, the VER system also allows the option to verify all wind scores against Sondes

EBBT CTH below inversion

CCC



Pre-CCC

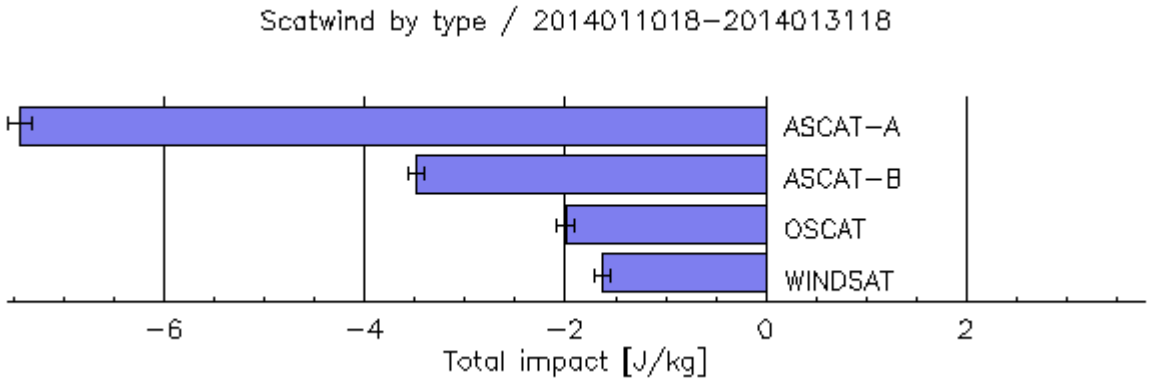


Courtesy Regis Borde (EUMETSAT)

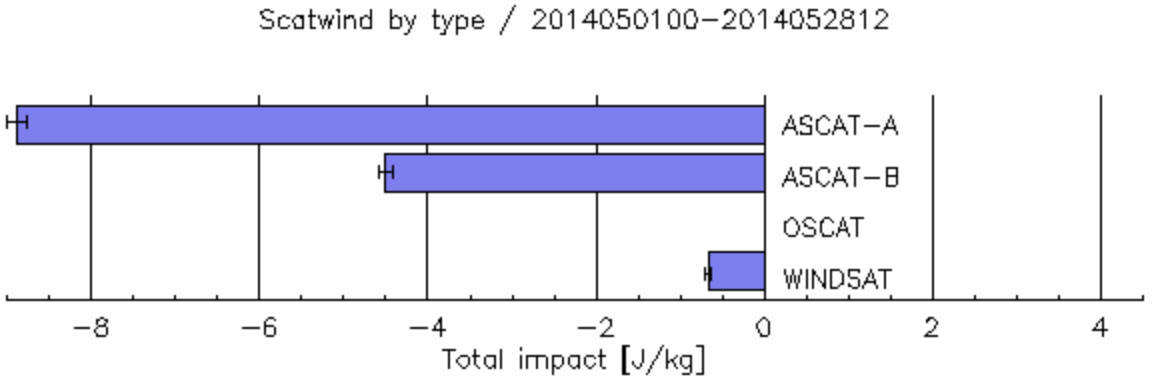
Scatwind FSO

Impact by satellite

January 2014



May 2014



Operational changes 2013

- Emergency: GOES-13/14
- Seasonal: MTSAT
- Derivation updates: [GOES hourly product implementation delayed]
- New satellites/transitions: Meteosat-10, Metop-B, MTSAT-1R/2
- Assimilation changes: temporal thinning, QC, blacklisting

Type of Change	PS31	Routine	Routine	Routine	Routine	Emerg.	Emerg.	Routine	Routine	Routine	Routine	Routine
Date	**Jan-13**	**Jan-13**	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Jun-13**	**Jun-13**	**Aug-13**	**Oct-13**	**Nov-13**	**Dec-13**
Global / CAM	2-hourly thinning	Switch Met-9 to Met-10, Reinstate MTSAT-2	Add CIMSS Metop-B AVHRR winds	Update Met10 QC for WV winds	Revert MTSAT seasonal blacklist in NH jet region	Reject GOES-13	Accept GOES-14	Reinstate GOES-13	Update Met-7 QC	Reject Terra WV winds	Use MTSAT-1R instead of MTSAT-2 Remove mid level	Blacklist MTSAT-2 over xmas
NAE		Switch Met-9 to Met-10		Update Met10 QC for WV winds		Reject GOES-13	Accept GOES-14	Reinstate GOES-13	Update Met-7 QC	Reject Terra WV winds	Remove mid level MSG WV winds	
UK		Switch Met-9 to Met-10		Update Met10 QC for WV winds							Remove mid level MSG WV winds	