AMVs at the Met Office: activities to improve their impact in NWP

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11th International Winds Workshop, Auckland, 20-24 February 2012

Contents

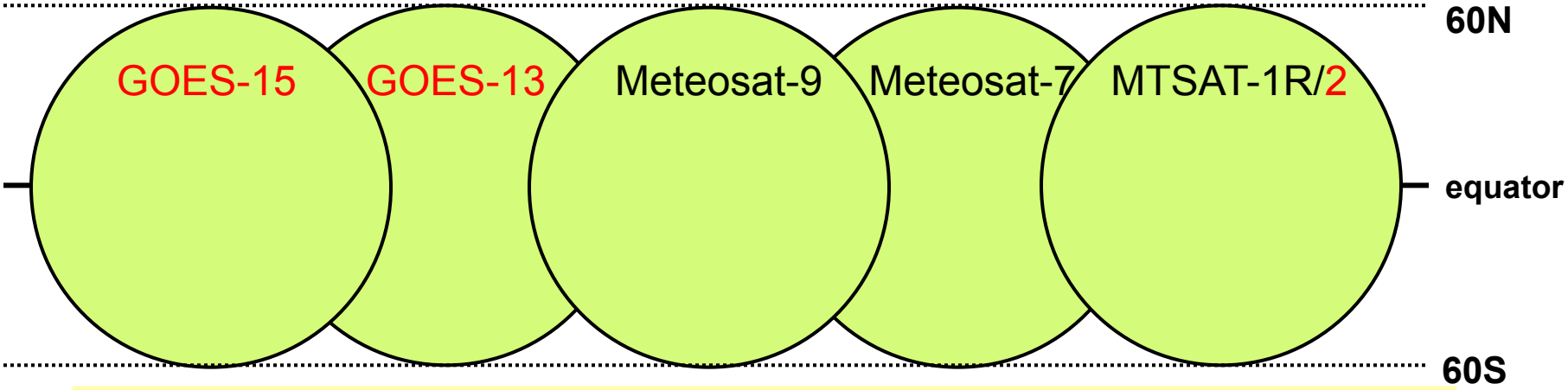
This presentation covers the following areas

- Current status
- Temporal Thinning
- Revisit observation errors / spatial blacklisting

Met Office AMV usage

Changes since the 10th International Winds Workshop

Terra, Aqua (NESDIS, Tromsø, McMurdo Stn, Sodankylä, Fairbanks)
NOAA 15/16/18/19 (CIMSS, Barrow, Rothera)
Metop-A (CIMSS)



Terra, Aqua (NESDIS, Tromsø, McMurdo Stn, Sodankylä, Fairbanks)
NOAA 15-19 (CIMSS, Barrow, Rothera)
Metop-A (CIMSS)

NB: JMA winds blacklisted over Christmas holidays 26/12 -17/1 due to satellite switchover on 26/12 – request that care is taken when considering when to make operational changes

Temporal thinning

AMV thinning strategy

Main approach to alleviate problems with spatially and temporally correlated error (another option is superobbing).

The most common question we get regarding our use of AMVs…

Why does Met Office have such strict time restrictions in our AMV QC?..

Current limitations

- Only use one wind in each spatial box in the 6 hour window

- Geostationary winds – only consider time slot nearest analysis e.g.

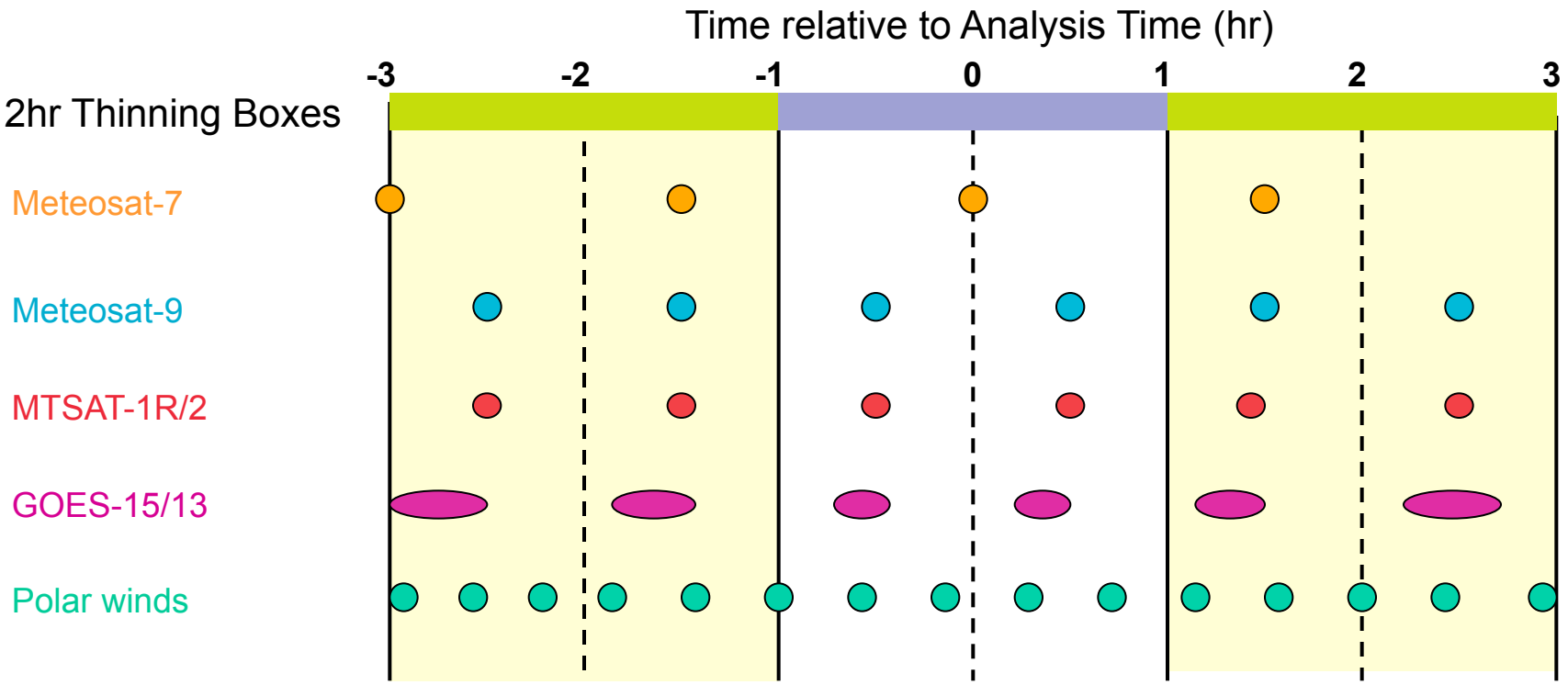
```
!-------------------------------------------------------------
! MSG IR, HRVIS, VIS 0.8 and cloudy WV 7.3
!-------------------------------------------------------------
! Infrared and water vapour (7.3 only)
 &Station Id='056',
   ObsTypes(1:2)='23613','23632',
   RejRep='F',RejUV='F',
   TimeStart=0,TimeEnd=40,
  ConfThres=80.,ThinRound='SATW' /
```

- Legacy from days of 3DVAR
- Previous experiments with removing the temporal blacklisting and instead using temporal thinning of 2/3 hr windows have led to negative impact (mainly SH)
- One of those things proving hard to move away from..

Increased temporal resolution of data

Now have hourly winds from MTSAT-2 (March 2011) and GOES-E/W (in test mode) – more even distribution throughout the assimilation window

Below illustrates when data arrives for different AMV types relative to the analysis time:



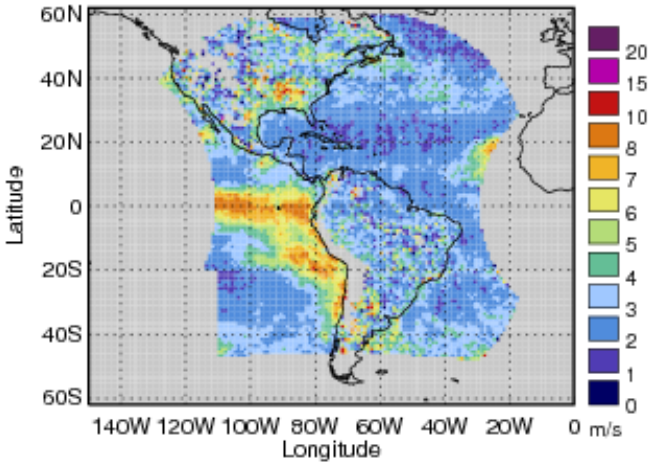
GOES hourly

Some differences in hourly and operational stream

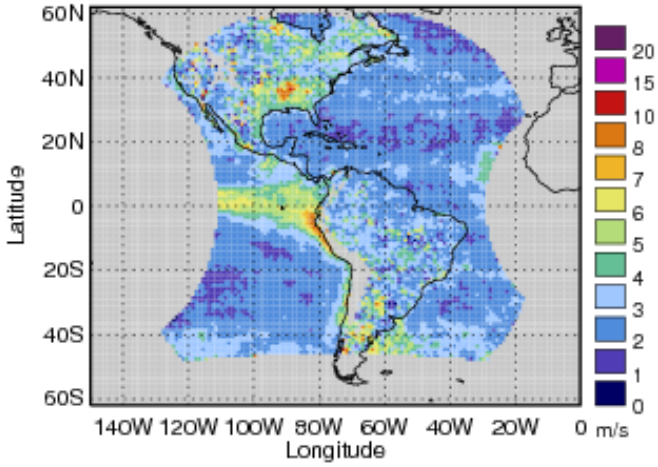
Significant improvement in low level RMS vector difference in the inversion region off the west coast of S. America

Methodology developed as part of the future GOES-R derivation scheme

GOES-13 VIS, Operational



GOES-13 VIS, Hourly



RMSVD - Nov 2011

Experiment setup

Period: 14/12/11 – 14/01/12 (31 days)

Control experiment:

- N320 4DVar L70 PS27
- Data as operations, but using new GOES hourly winds (i.e. future baseline when operational)
- Temporal blacklisting AMVs

Trial experiment:

- As control but with 2-hourly thinning of AMVs

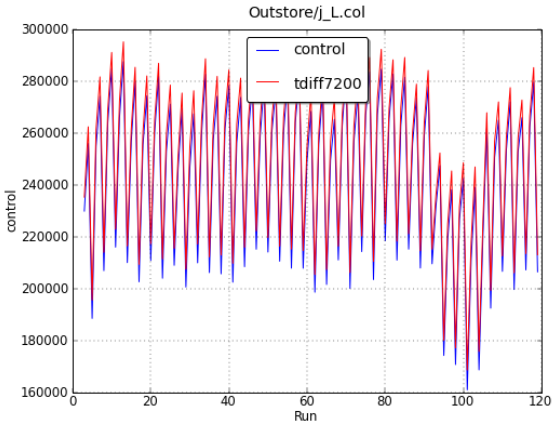
The choice of time window is compromise between using more data and avoiding the effects of temporally correlated error

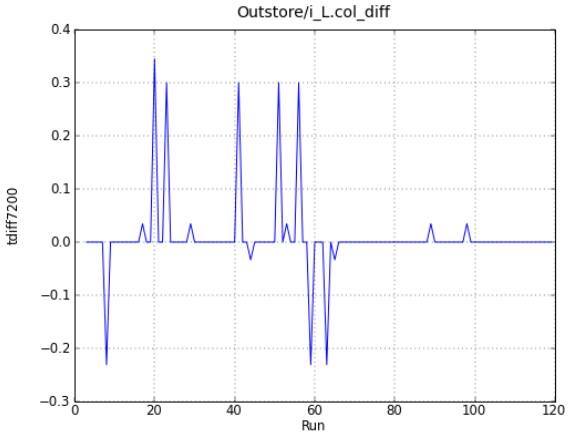
2-hourly gives about 3x number currently used

VAR stats

Control —

Trial —



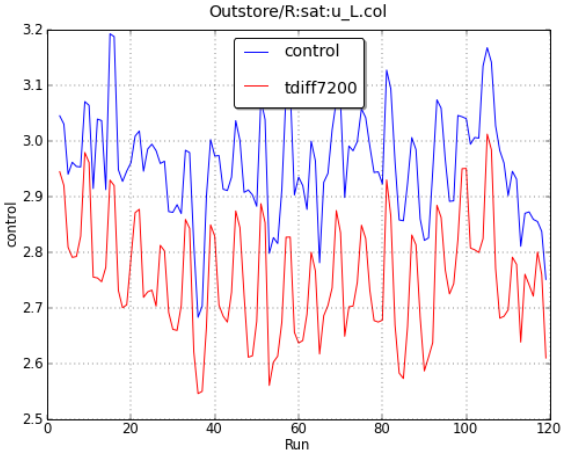


More iterations in trial

Slightly larger total penalty – expected due to increased number observations assimilated

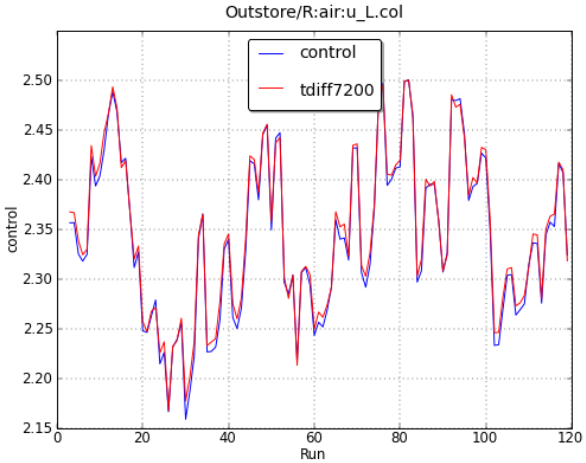
Few occasions when VAR takes longer to converge

RMS U m/s



Analysis fitting much closer to AMVs

RMS U m/s



Slightly worse fit to aircraft

Trial results - NWP Index

Weighted basket of skill scores with most weight on T+24 performance

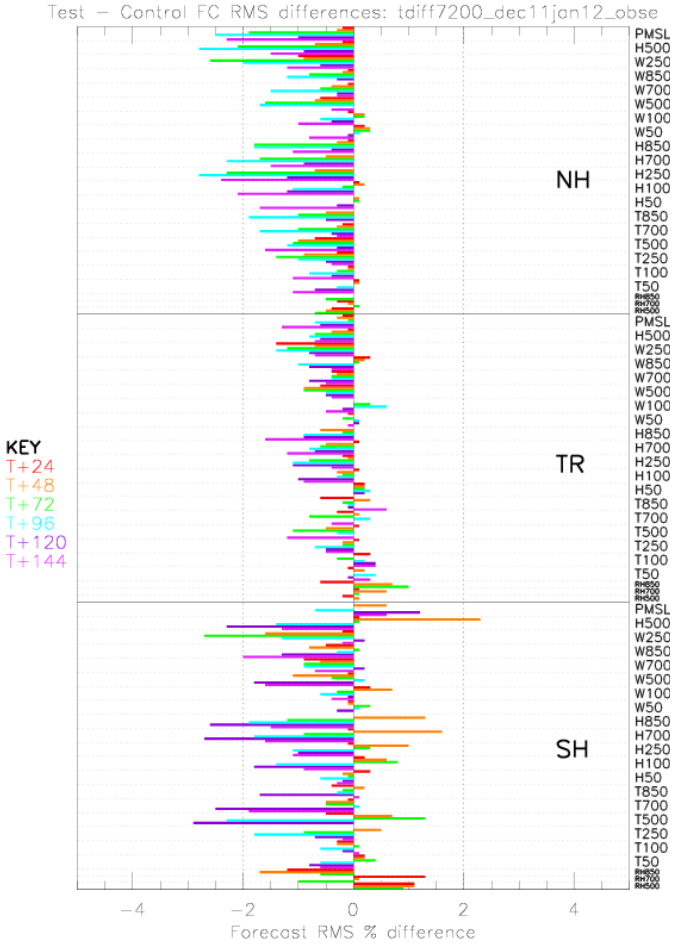
	vs Observations	vs Analyses
Season 1	+0.5	-1.7

NWP index positive versus observations, but strongly negative versus analysis

Biggest problem at T +24 in tropics and SH for wind and temps

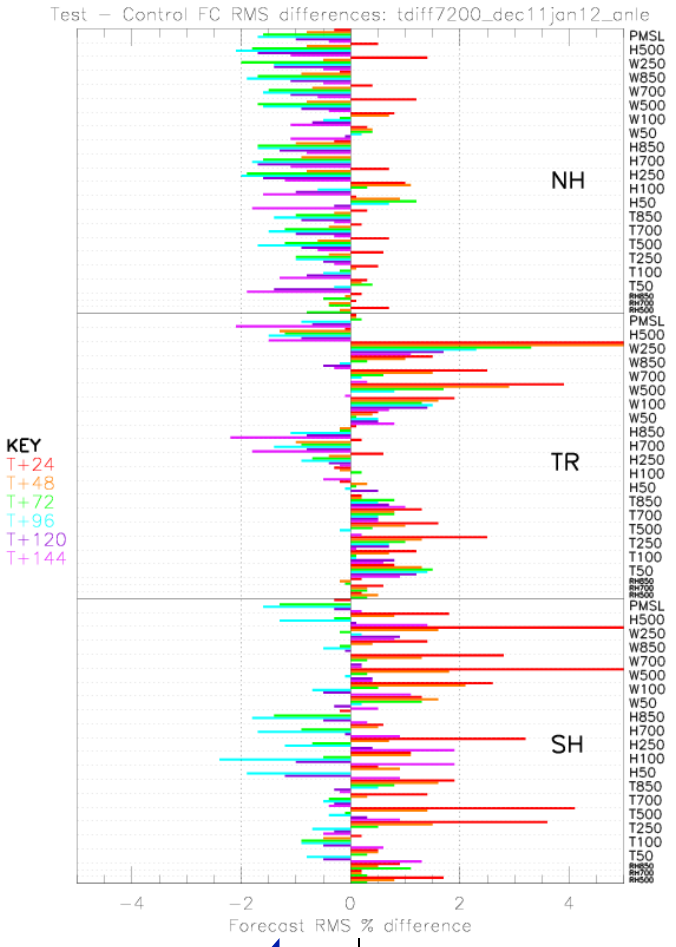
Especially large hits for W250

observations



Positive impact

analyses



Positive impact

What next

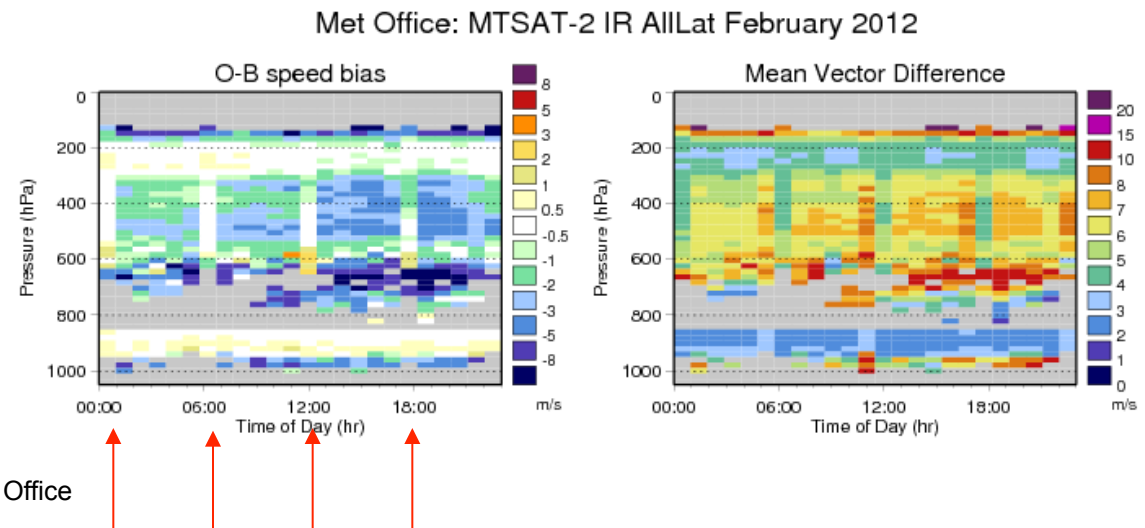
Try and understand negative impact versus analysis

• New background error covariances (ensemble rather than climatological) makes verifying against our own analysis more difficult.

• Poor scores could be due to the changes we have made to the character of the verifying analyses rather than a degradation of forecast quality. Verify against independent analyses e.g. ECMWF

Try different thinning windows?

Allow for temporal variation in bias e.g. MTSAT observed differences between the winds received at 0,6,12,18 (15/30 min imagery) and the intermediate time-slots (30/60 minutes)

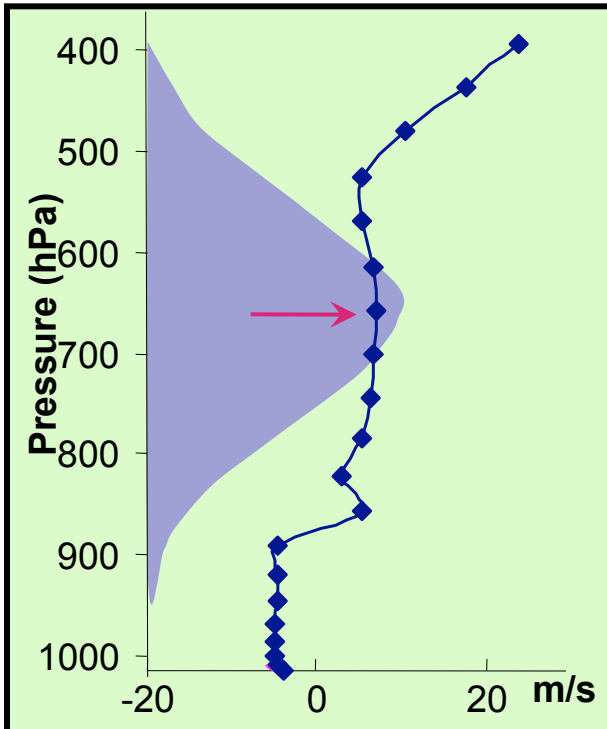


Revisit observation errors

Observation errors

New approach – operational since July 2008

Total u/v error = √ (u/v Error^2 + Error in u/v due to error in height^2)



shear

$$\text{Error in vector due to error in height} = \sqrt{\frac{\sum_i W_i (v_i - v_n)^2}{\sum_i W_i}}$$

Where

$$W_i = \exp\left(- \left[\frac{(P_i - P_n)^2}{2\text{Ep}^2} \right] dP_i \right)$$

Gaussian weights

i = model level
v_i = wind component on model level
v_n = wind component at observation location
p_i = pressure on model level
p_n = pressure at observation location
dP_i = layer thickness

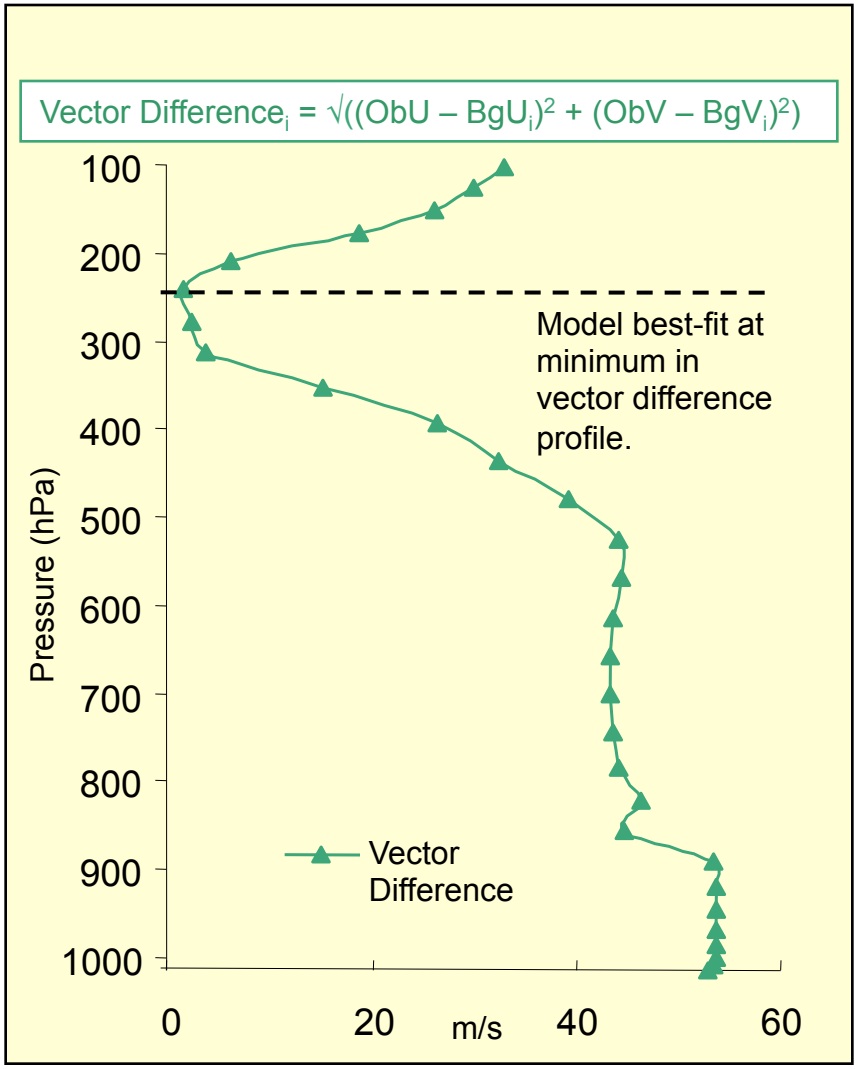
Summation over levels such that, for a given Ep, will have a larger error in high wind shear regions (down weight)

Future Ep from data producers → Until then estimate Ep using best-fit pressure stats as a guide… (Eu/v based on QI)

Calculating Ep

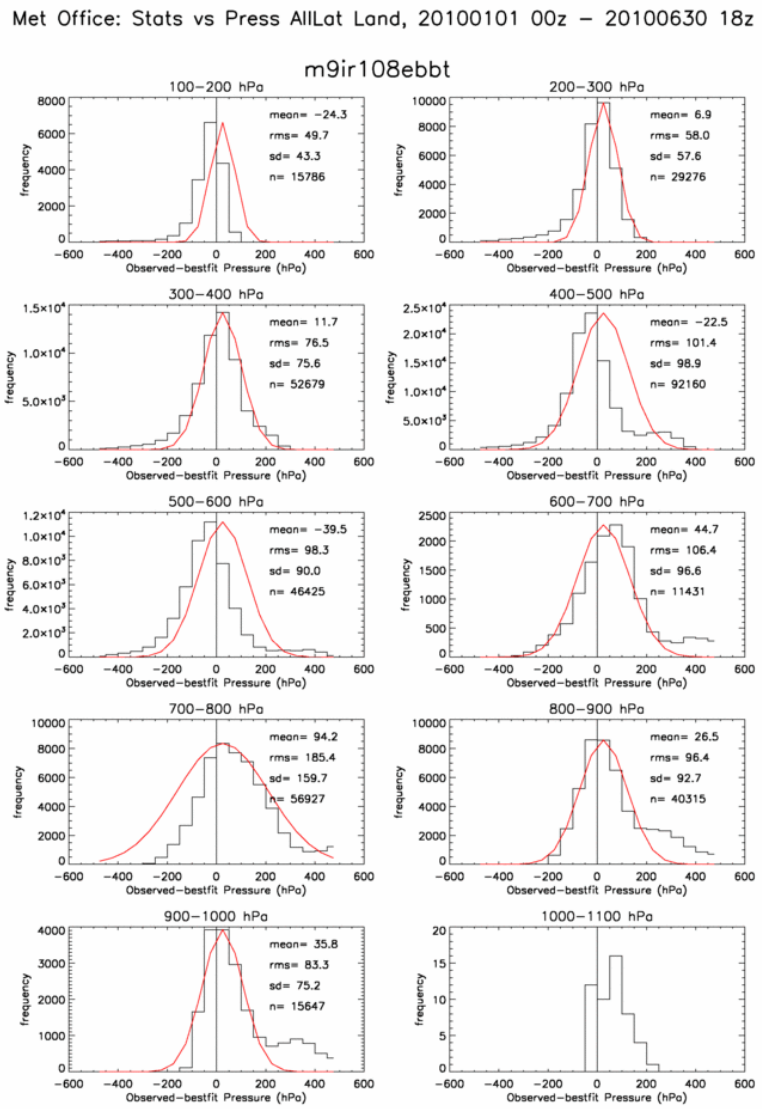
Set using look-up table dependent on (some of):
satellite / channel / height assignment method / surface type / latitude band and pressure level.

- Profiles reviewed to reflect changes over last 2 years using latest best-fit statistics
- Recalculated for 6 months of data, Jan-June 2010
- Primarily based on RMS difference between observed and best-fit pressure but also some manual tweaking; smoothing, artefacts, zonal plots



Calculating Ep

Example

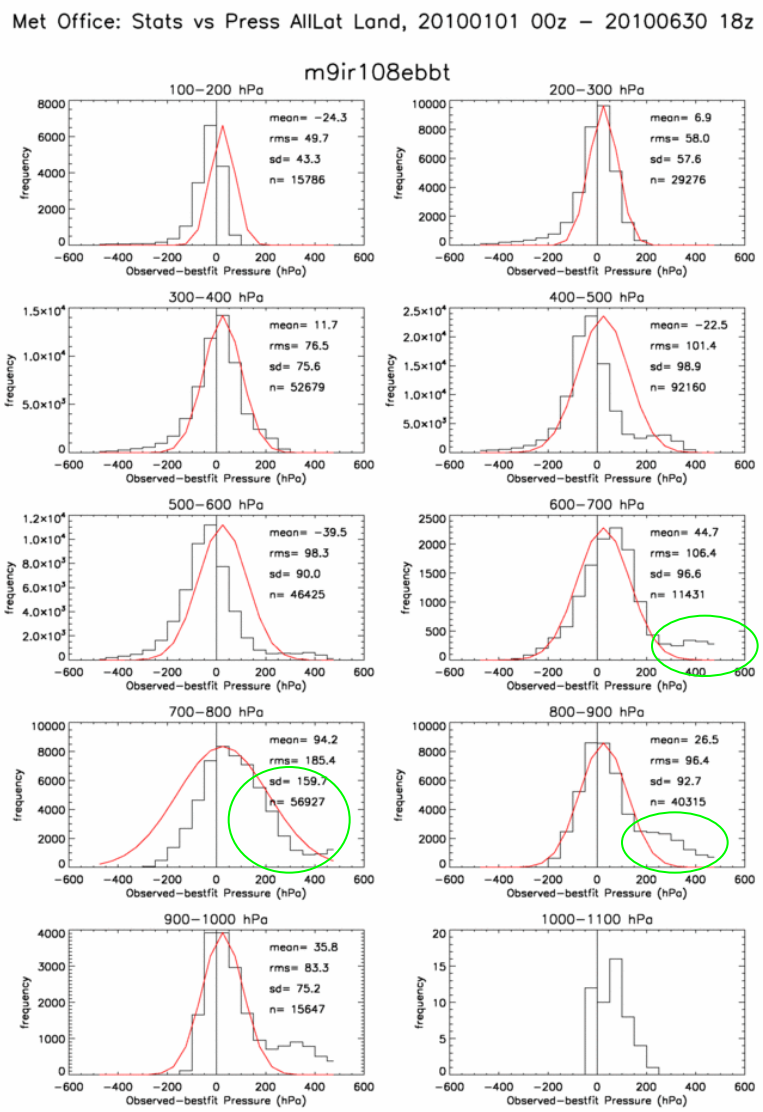


Example histograms for Meteosat-9 IR10.8 assigned using EBBT method over land

- Each plot shows the frequency versus observed – best-fit pressure calculated in 100 hPa bins (black)
- Red curve shows a fitted (scaled) Gaussian distribution
- Outliers (>2.5 standard deviations from the mean) removed

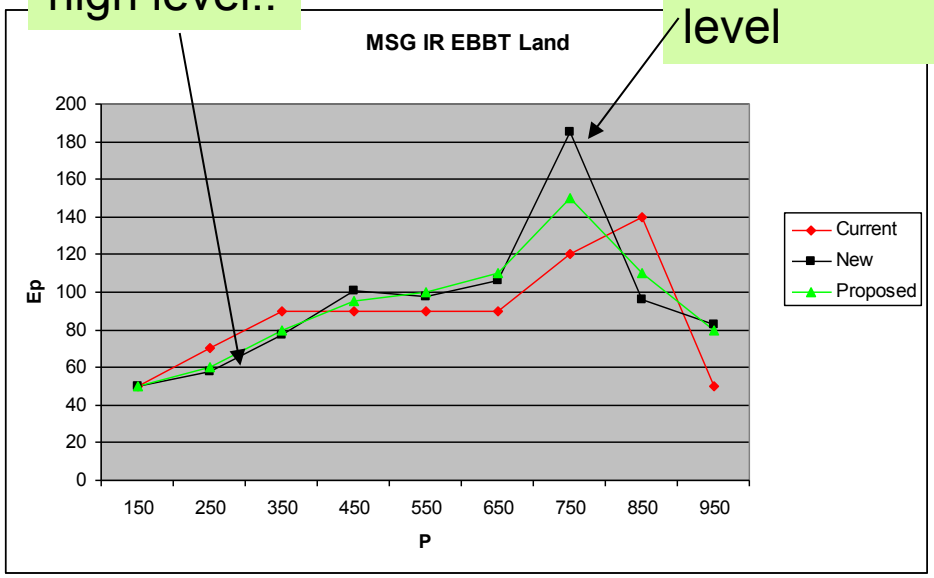
Calculating Ep

Example

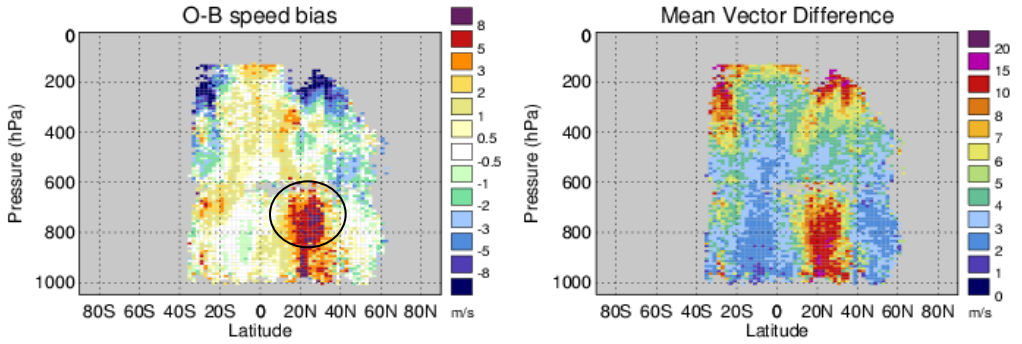


Reduce at high level..

.. inflate at mid-low level



Met Office: Meteosat-9 IR 10.8, April 2010 EBBT, land



Winds put lower than model best-fit pressure resulting in a fast O-B speed bias

Blacklisting and Ep - NWP Index

Trial periods: 15 Dec 2009 – 15 Jan 2010

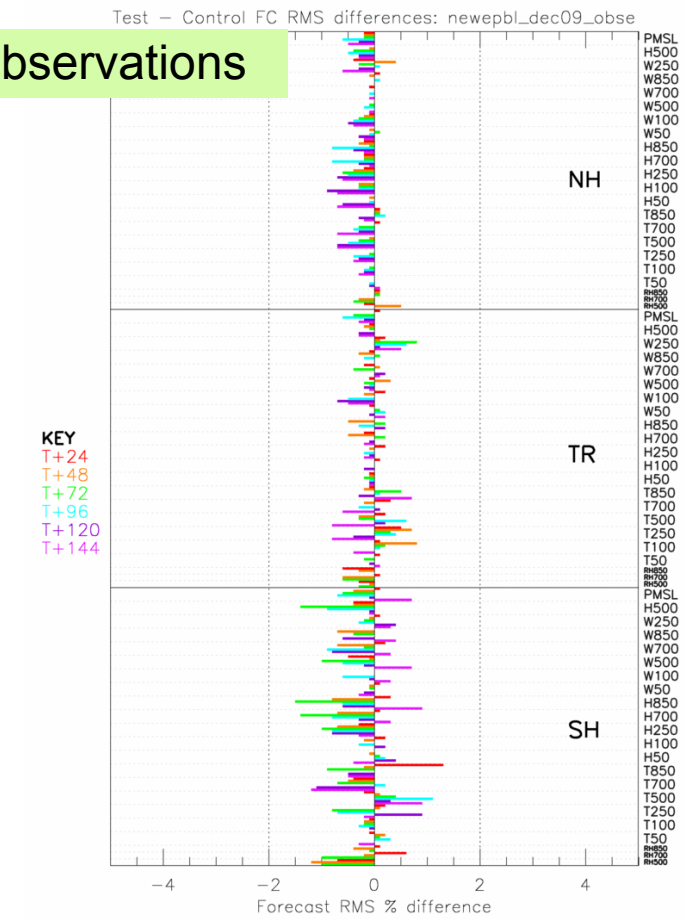
1 June 2010 - 30 June 2010

	vs Observations	vs Analyses
Season 1	**+0.1**	**+0.3**
Season 2	**+0.1**	**+0.2**

Combined package of updated observation errors and spatial blacklisting – neutral to small positive impact on NWP Index

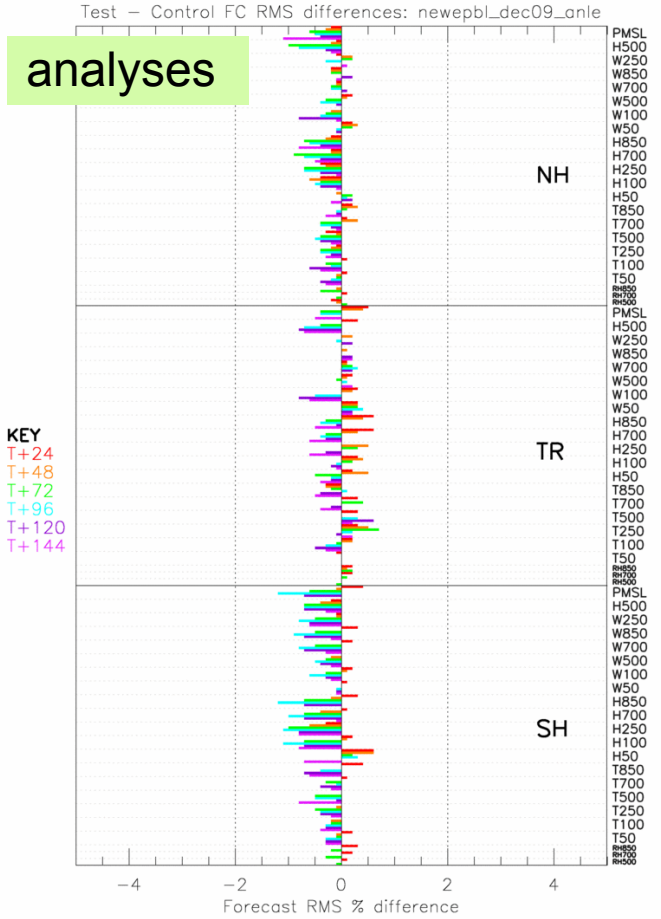
- **Operational since PS27, July 2011**

observations



Positive impact

analyses



Positive impact

Questions

Updated spatial blacklisting

Spatial Blacklisting

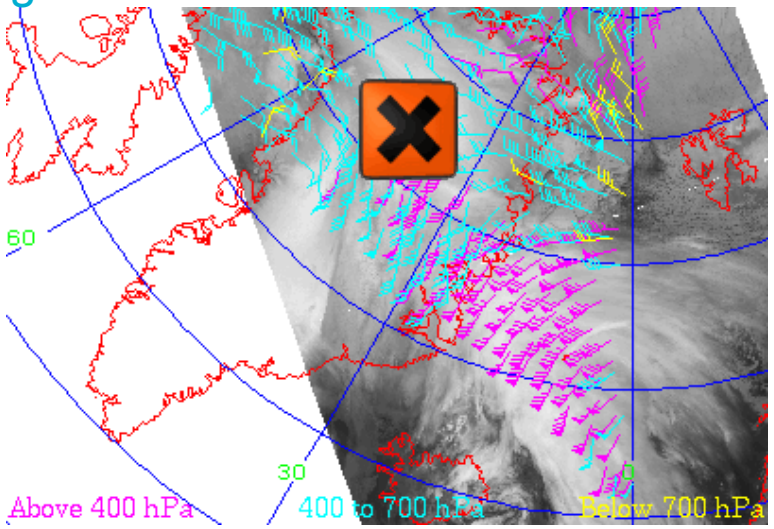
Balance between removing and down-weighting.

- Remove where consistently of poorer quality.

In recent years this has proved a hard area of the quality control to upgrade - previous go in 2007 gave small negative impact

- Idea is to remove winds where less reliable using O-B statistics, NWP SAF analysis reports, best-fit pressure and knowledge of derivation

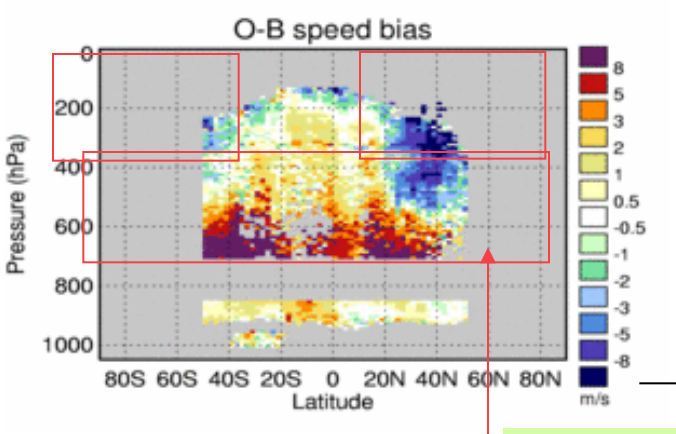
- But, also relax QC restrictions where winds show improvement e.g. producer derivation changes



Spatial Blacklisting

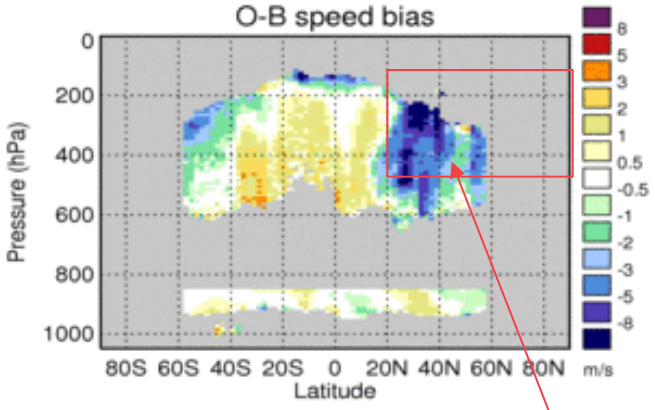
Remove some MTSAT rejections

e.g. in old scheme were rejecting all MTSAT IR mid level (fast bias) and in the extratropics at high level (jet slow bias)



IR January 2009

JMA derivation improvements



IR January 2012

Reject

Jet region rejections retained seasonally in NH

Spatial Blacklisting

Other examples

- Reset upper and lower pressure thresholds for all winds
- Introduce topographic checks – mountainous regions
- Implement CO2 slicing and WV intercept thresholds at mid level (Feature 2.9 AMV analysis reports)
- Implement satellite zenith angle checks for all Geostationary
- Retain MSG low level rejections over land NH (Feature 2.6 AMV analysis reports)
- etc

Combined package of updated observation errors and spatial blacklisting – neutral to small positive impact on NWP Index

- Operational since PS27, July 2011

	vs Observations	vs Analyses
Season 1	**+0.1**	**+0.3**
Season 2	**+0.1**	**+0.2**

Observation Errors

- Old scheme – errors only varied with pressure

Level (hPa)	1000	850	700	500	400	300	250	200	150
Error (m/s)	3.6	2.8	4.0	4.8	6.2	6.2	5.6	5.8	6.6

- **Individual observation error scheme** operational since July 2008
- Physically-based estimate - try to understand what the error sources are and attempt to quantify them

1) error in vector derivation
2) error in height assignment

} Assume independent

- Total error estimate

$$(\text{Total u/v error})^2 = (\text{Error in u/v})^2 + (\text{Error in u/v due to error in height})^2$$

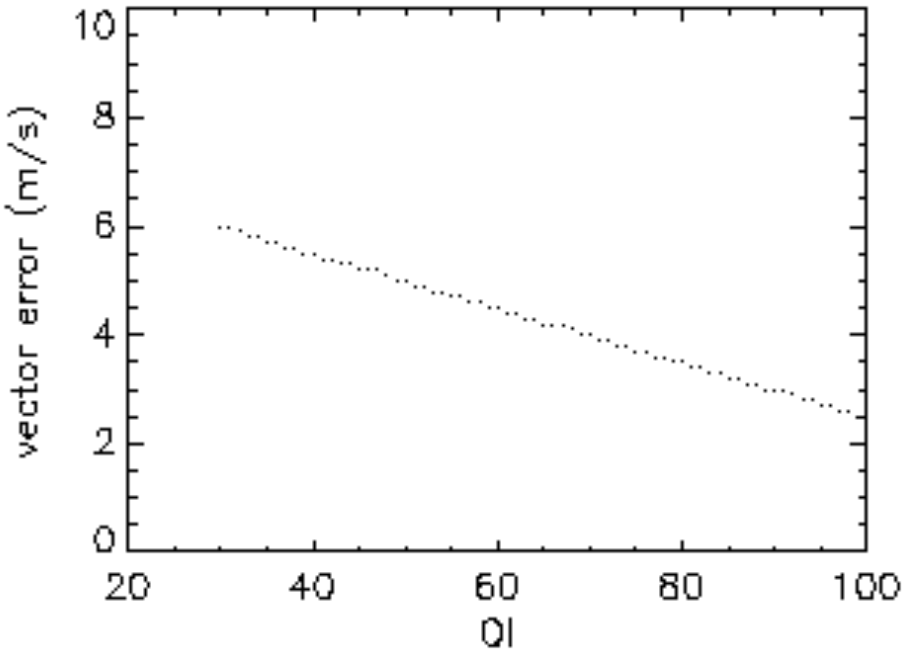
Inputs: error in HA, Ep, and error in u/v components, Eu, Ev

Hopefully these will be routinely provided with the AMVs by the producers using the information available during derivation. Alternatives..

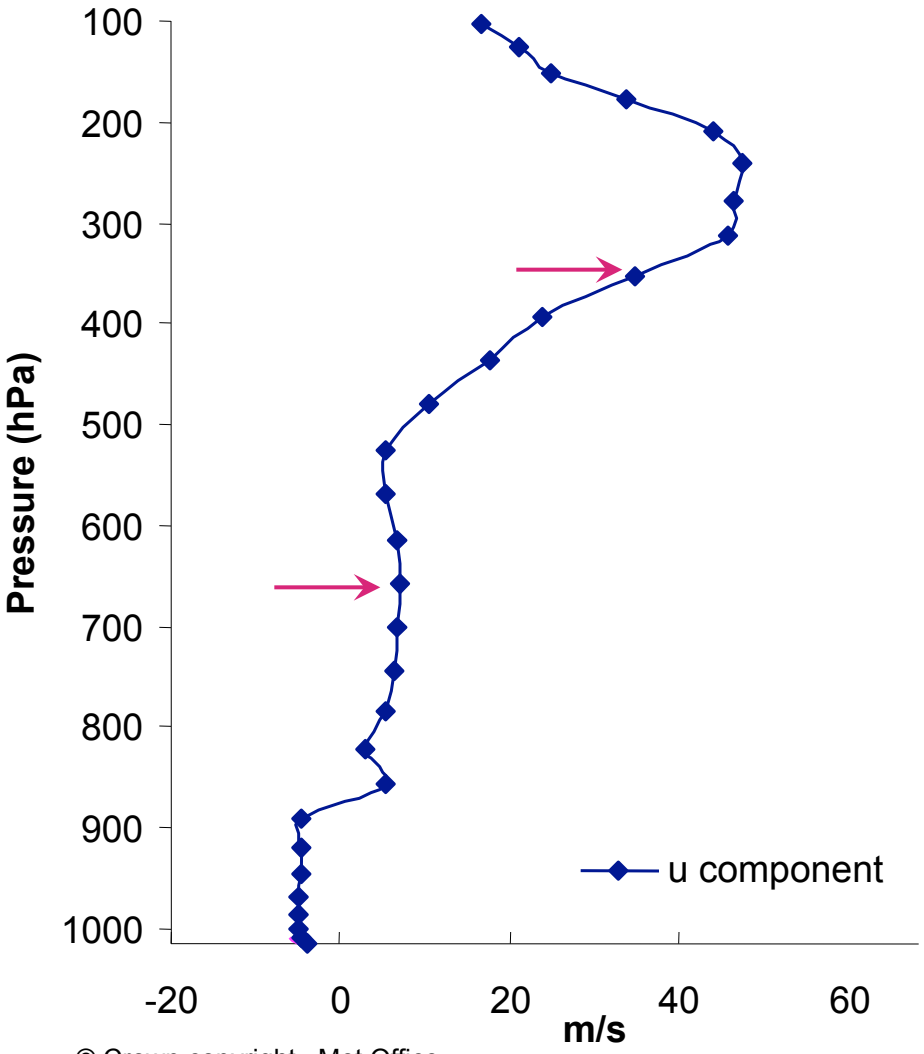
Vector error

Eu and Ev currently a function of model-independent QI, e.g.

$$Eu = a + b\frac{QI}{100}, \qquad Ev = Eu$$



Examples



P hPa	Eu m/s	Ep hPa	Total u error m/s
350	2	60	11.1
	2	80	12.9
	2	100	14.3
660	2	60	2.2
	2	80	2.6
	2	100	3.6

Height assignment error is not a problem in regions of low wind shear.

AMV thinning strategy

Current limitations

- Only use one wind in each spatial box in the 6 hour window, but AMVs available more frequently.
- Spatial box size of 2 degrees / 200 km is too big to capture some features of the flow – particularly in high resolution models.
- BUT we know the data has spatial and temporal error correlations so cannot simply throw data in at higher density.

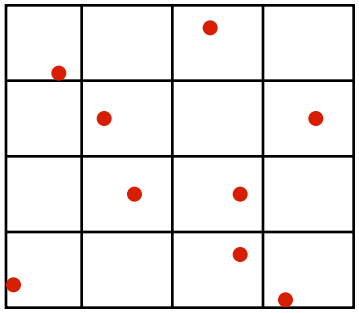
AMV thinning strategy

Proposed approach

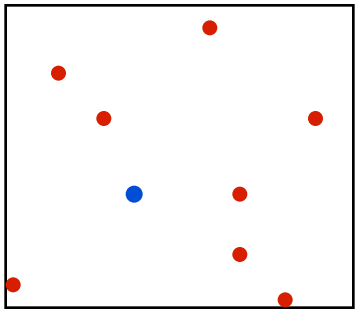
Introduce a 2-step thinning process

- Perform a fine scale thinning e.g. 50 km, 1 hour on all AMV observations. This will be the default thinning resolution
- Perform a second thinning round at coarser resolution e.g. 200 km, 3 hours, but only applying to boxes passing a certain criteria (e.g. more bland wind field, not sensitive areas...). Could use superobbing as an alternative for this step.

Aim to set up code to test this strategy and evaluate impact of using different criteria in step 2.



STEP 1

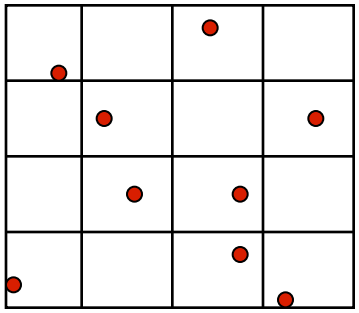


STEP 2

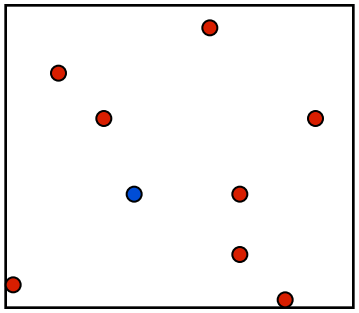
2. AMV thinning strategy

Decisions

1. What criteria should we use to decide if we should skip the second thinning round?
2. Should we thin or superob in the second round?
3. What box dimensions should we use for each step?
4. For thinning step(s), how do we select the observation (lowest observation error, closest to centre of box)?
5. If superobbing should we weight by observation error? Should we reduce the observation error?

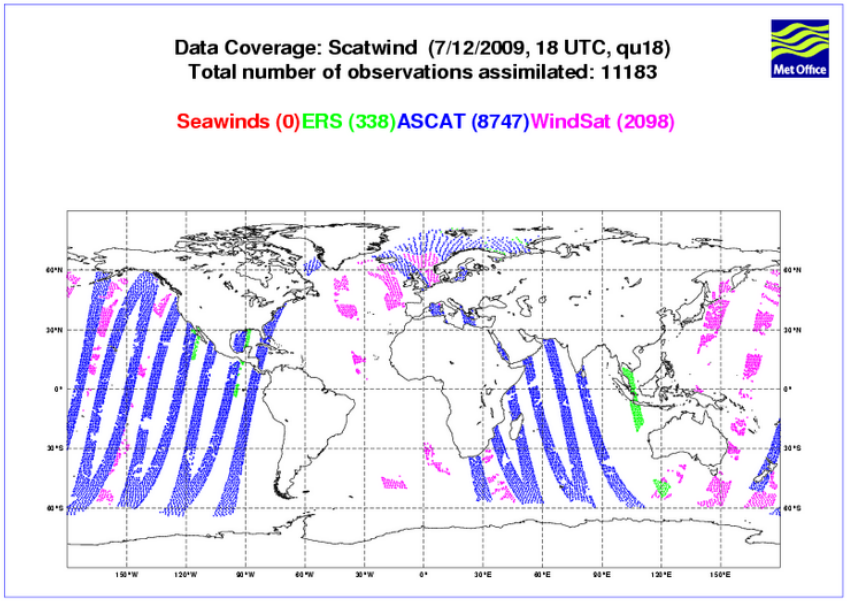


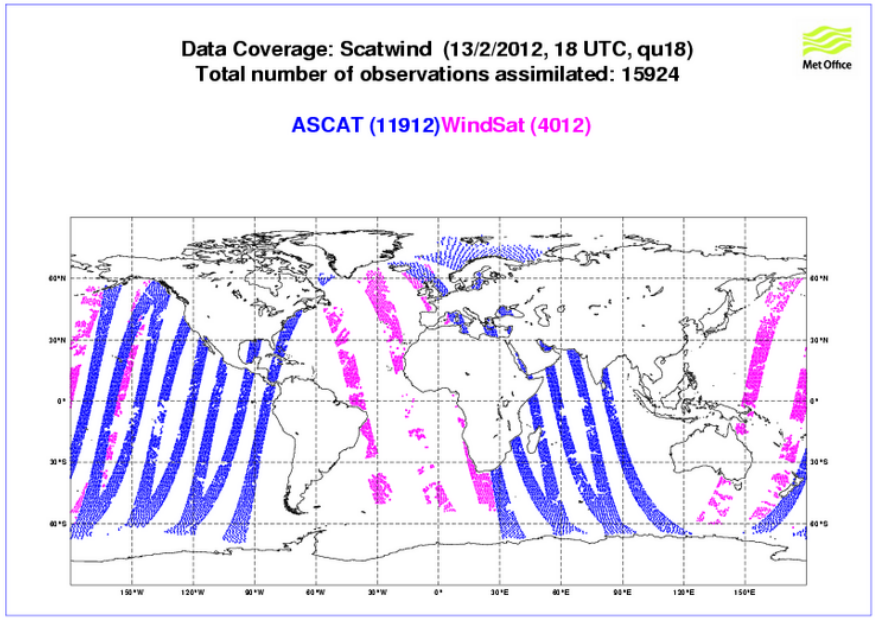
STEP 1



STEP 2

Met Office surface wind usage





20/07/11 Assimilate 12.5 km ASCAT in UK4/V.
Reduce thinning distance to 80 km in global.
05/07/11 End of ERS-2 mission.
02/11/10 WindSat assimilated in NAE model
15/06/10 Upgrade to new WindSat EDRs and update QC

LeoGeo winds

- Vectors are generated from either

single satellite

or by mixing

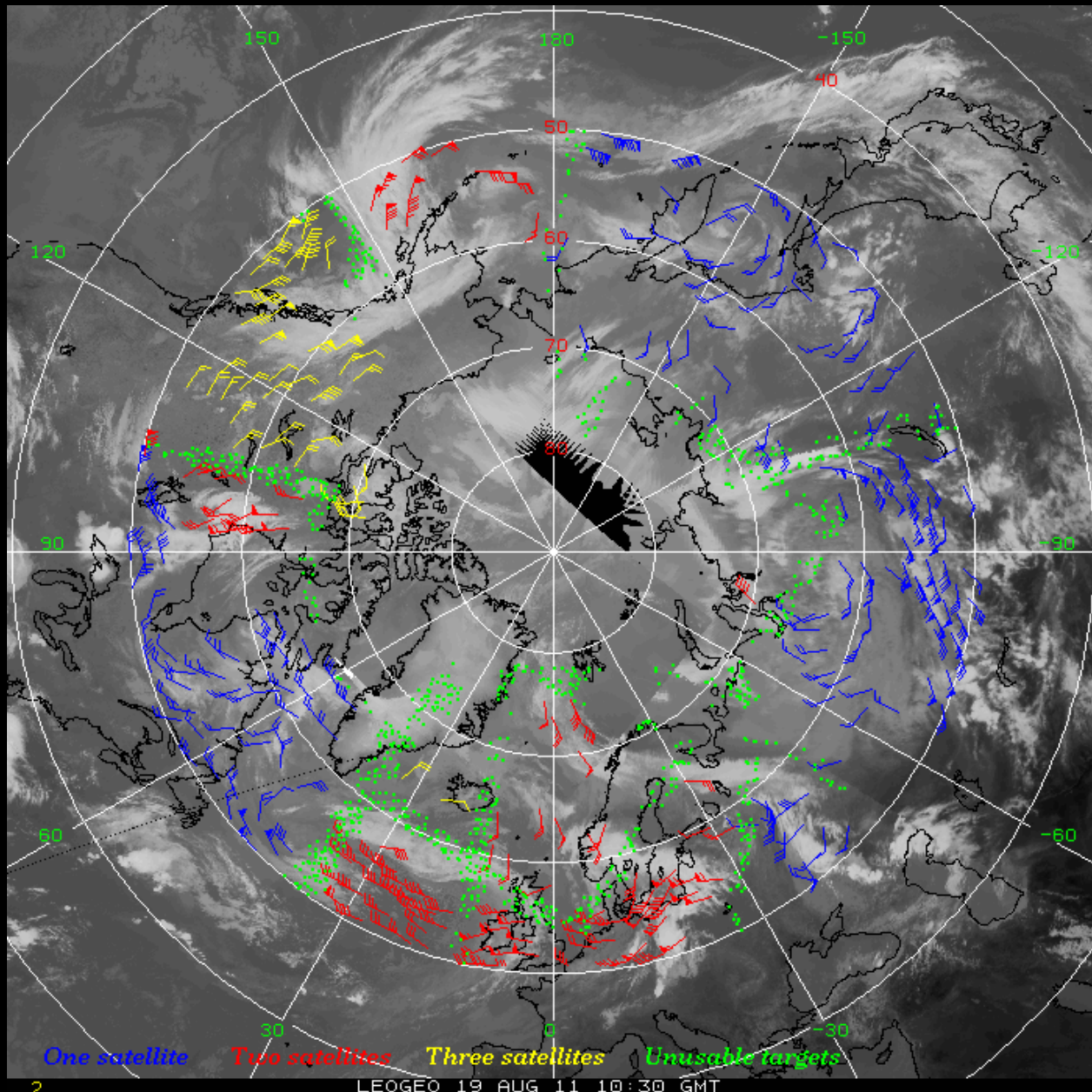
two or three satellites

- Tracking can use data from different satellites in the 3 images (accounts for the time and parallax information at each pixel)

But..

- Target/search box in each individual image must be from a single satellite

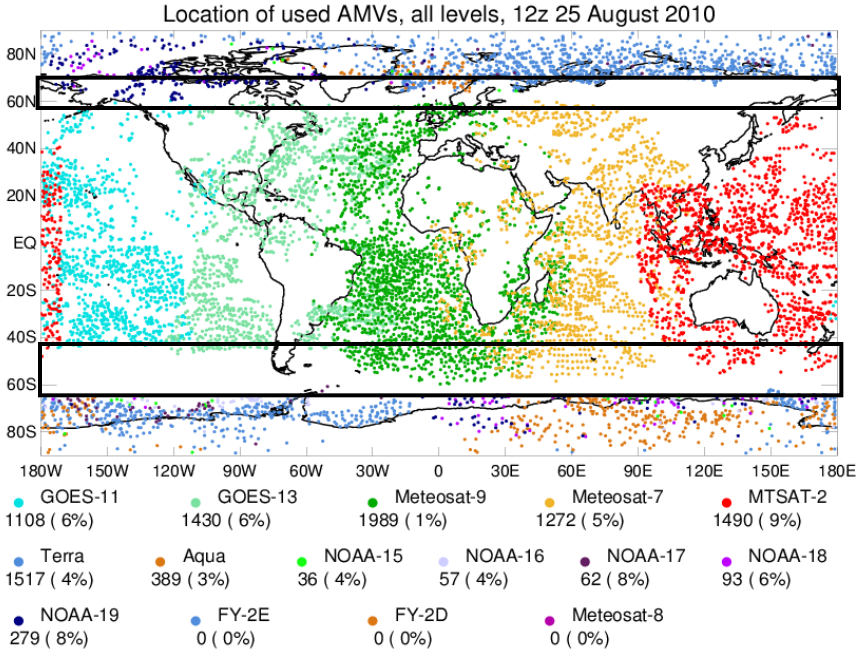
–> potential targets that cannot be tracked

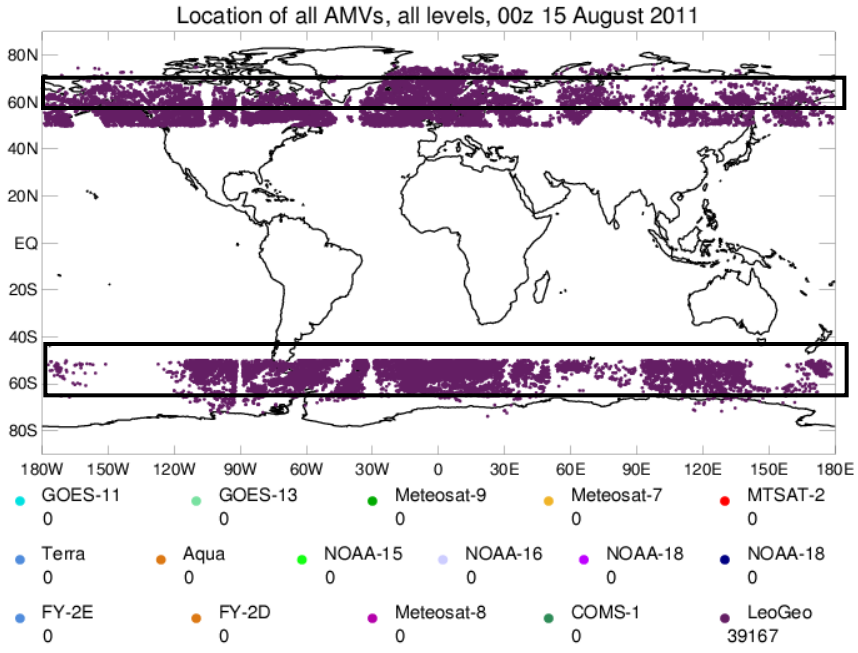


LeoGeo Coverage

Monitoring & initial analysis: 15 – 31 August 2011

- derived up to around 75 N/S

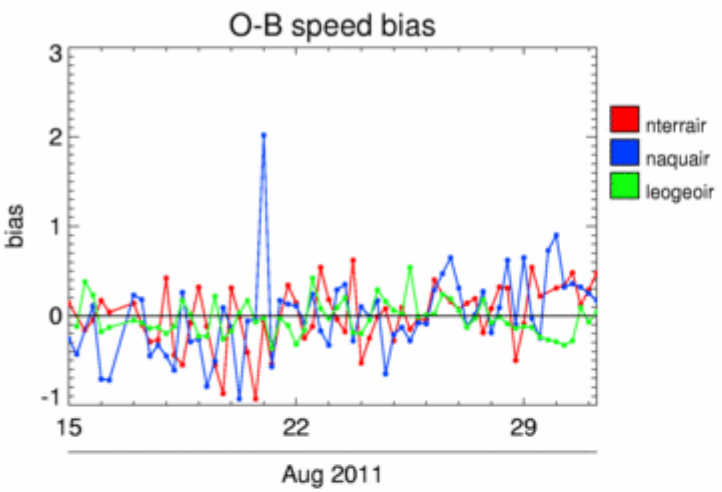


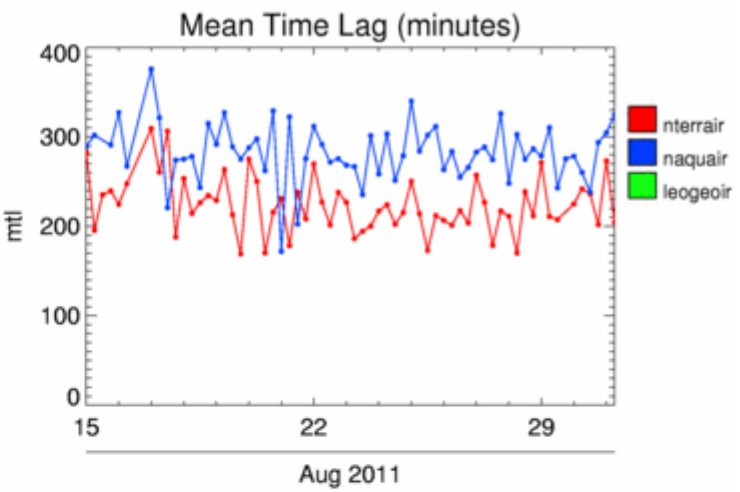


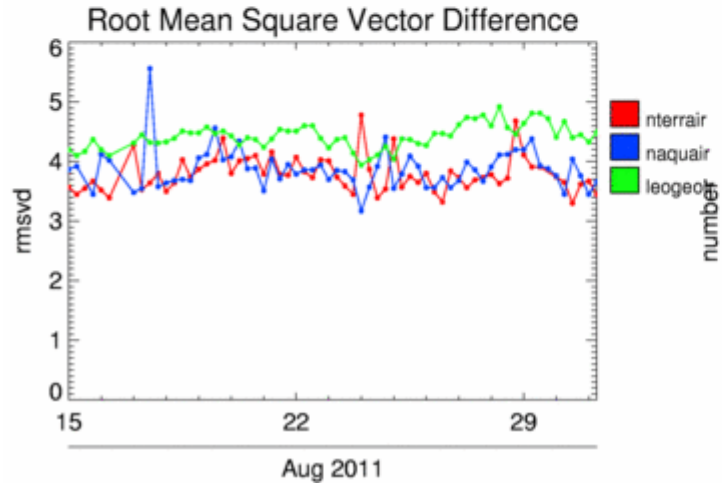
Monitoring

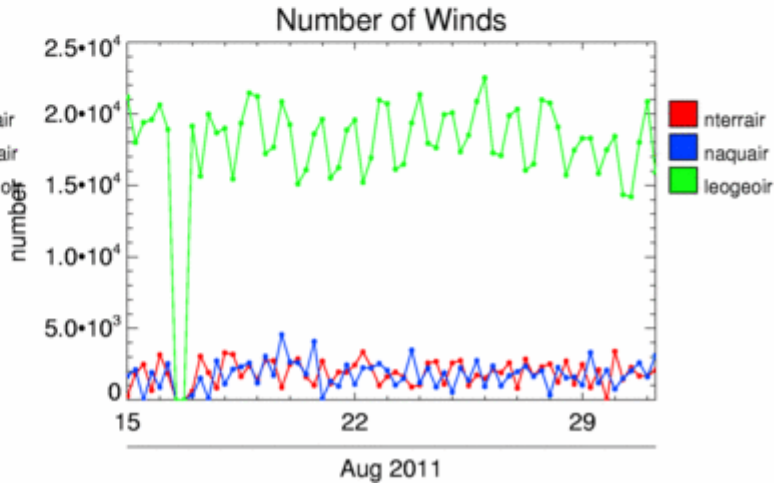
Time series, all levels, Northern Hemisphere, QI2>60

- Similar bias
- Small increase in RMS
- As expected, data volume is quite high as being derived every 15 mins.









Monitoring

Time series, all levels, Southern Hemisphere, QI2>60

- LeoGeo compares better with MODIS in SH