Met Office

Migration to a Forecast Independent Quality Indicator and Further QC Changes @ Met Office

James Cotton, Mary Forsythe

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Motivation

- QC essential for NWP: remove data of “bad” quality, also data that cannot be simulated by NWP model
- AMVs supplied with Quality Indicator (QI) values
  - Spatial/temporal consistency
  - QI1 (*with* first-guess check against ECMWF, GFS, JMA,..)
  - QI2 (*without* first-guess check)
- Ideally observations independent from model.. but QI1 used thus far (protect from large HA errors)

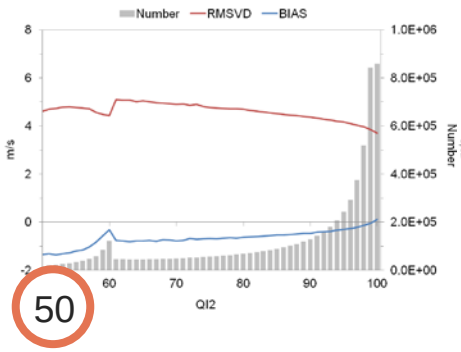
Aim

1) Migrate from QI1 to QI2 to remove check against (other centres) NWP forecast

2) Update thresholds

Does QI2 have skill?

GOES-13 IR



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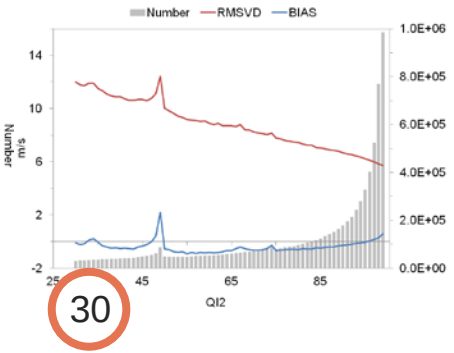
Met-10 IR



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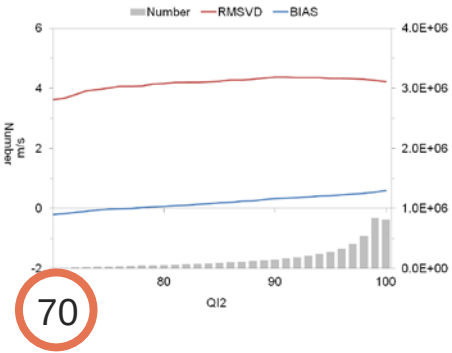
Him-8 WV



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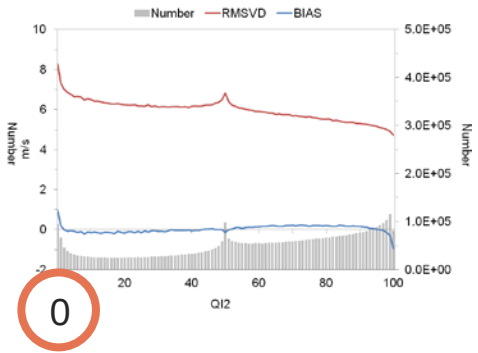
EUM Metop-B



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- Providers have different range of QI disseminated
- QI2 has greater proportion (than QI1) with very high QI values
- MSG has downward trend in RMSVD, but “spikes”
- GOES slight trend for QI > 60, Himawari flat

QI2 less useful at discriminating “bad” data..
But still useful for MSG

Met Office thresholds: before

Satellite	QI	Channel	Extra-tropics (High/Mid/Low)	Tropics
GOES-13/15	QI1	IR WV	85/80/80 80	90 90
Meteosat-8/10	QI1	IR VIS WV	85/80/80 65 80	90 90 90
Himawari-8	QI1		85	85
Metop (EUM)	QI1		80	-
VIIRS*	QI2		60	-
LeoGeo	QI1		70	-

- Use QI1 for all data, except VIIRS
- Vary by channel, latitude band, height level
- Very high QI1 threshold in the tropics..

Essentially assimilating ~NWP forecast information

Met Office thresholds: now

Satellite	QI	Channel	Threshold	Active?
GOES-13/15	QI2	All	50	N
Meteosat-8/10	“	“	85	Y
Himawari-8	“	“	70	N
Metop	“	“	60	Y
VIIRS	“	“	60	Y
Other polar	“	“	60	Y

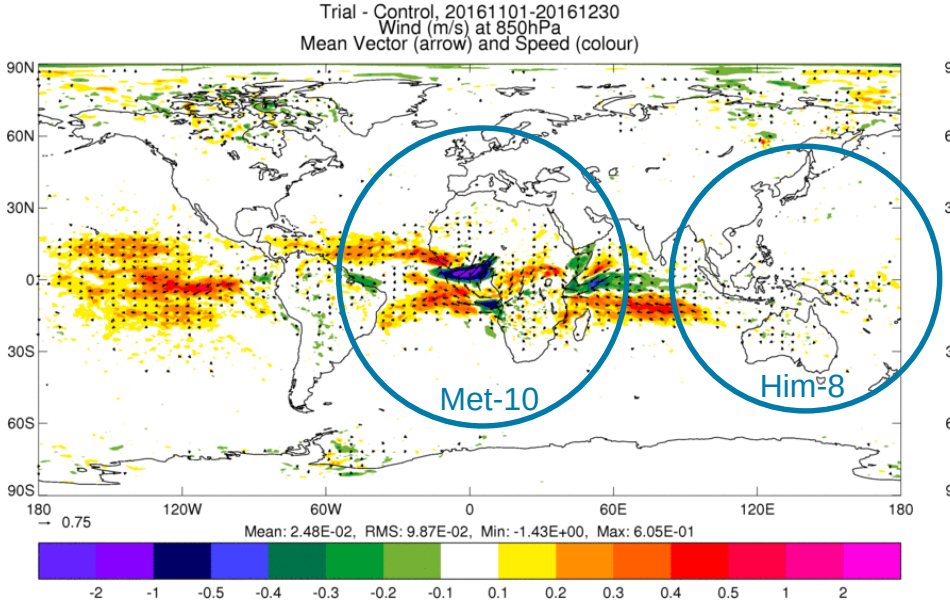
- Use QI2
- Vary only by satellite
- GOES and Himawari-8 – just prevent unexpected data with lower QI appearing

Impact experiment – round 1

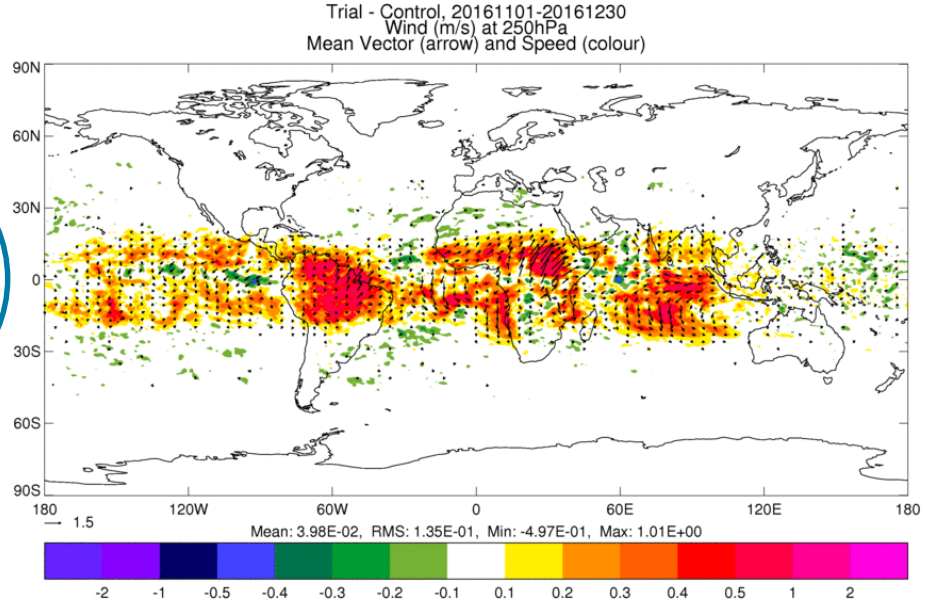
- “Relaxed” thresholds with QI2 allows 20% more AMVs used
- Large changes in mean tropical wind field at 850 hPa
- Background (T+6) u/v wind fit to AMVs is degraded by ~8%
  - ➢ Allowing larger innovations through
- Background fit to other obs is also slightly worse, including ~1% for SEVIRI radiances
- Forecast RMSE neutral vs observations, SH/NH 500 hPa height worse vs ECMWF analyses

Mean Wind Analyses

Experiment (QI2 “relaxed” thresholds) - Reference (QI1 strict thresholds)



Wind 850 hPa



Wind 250 hPa

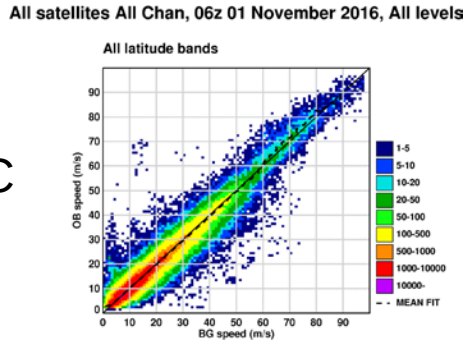
Changes largest for data where QI most useful –MSG , very little change in Himawari region

Tighten the background check

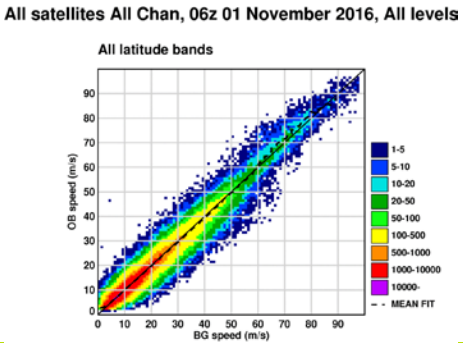
Can we ensure the *overall quality* of AMVs remains similar in migration from QI1 to QI2?

- Stricter QI2 thresholds aren't going to help
- Tighten background check against own model.. but we just removed model check via QI1??
- Not ideal, but our own model, tuneable, and currently quite relaxed

After QC



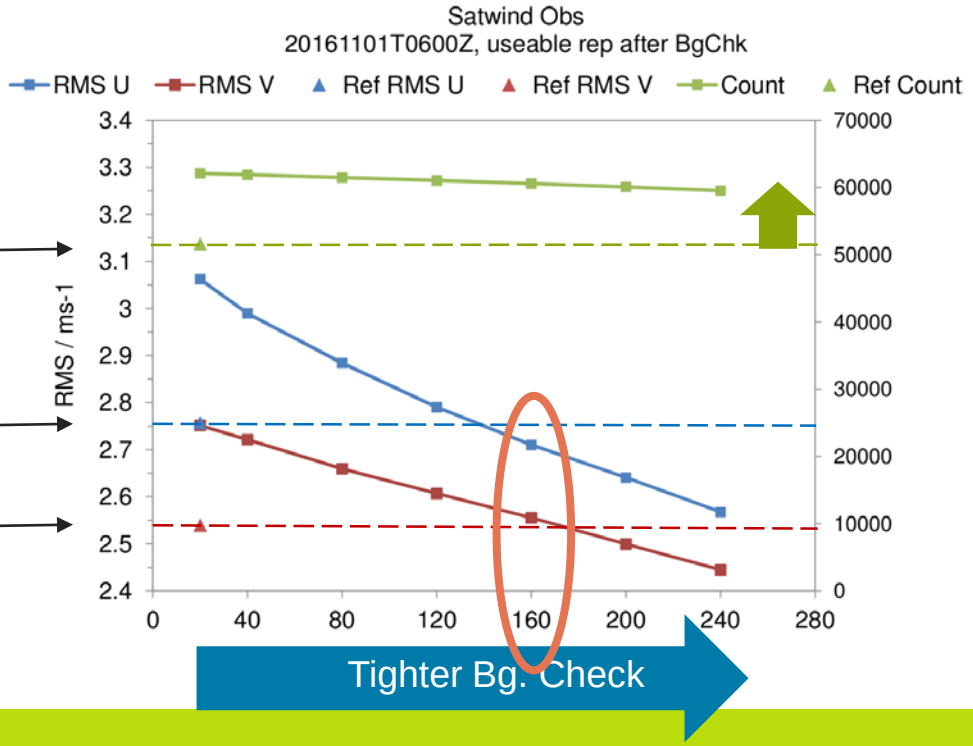
+ BgChk



RMS Sensitivity to Background check

Reference count

Reference RMS values

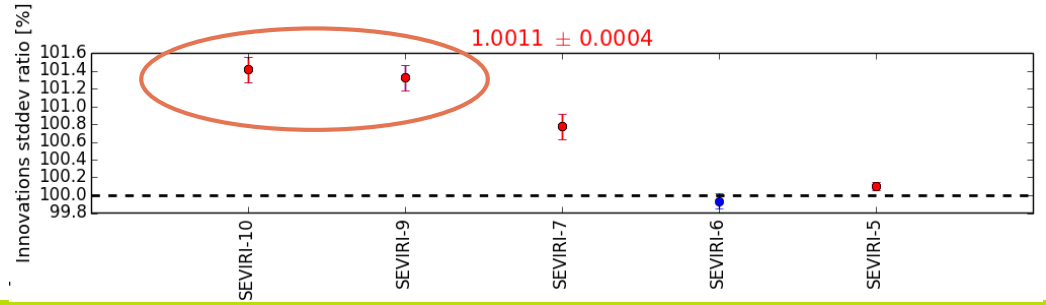


Stricter Bg. Check still allows many more AMVs vs QI1

Tightening background check efficient way to improve O-B

Impact experiment – round 2

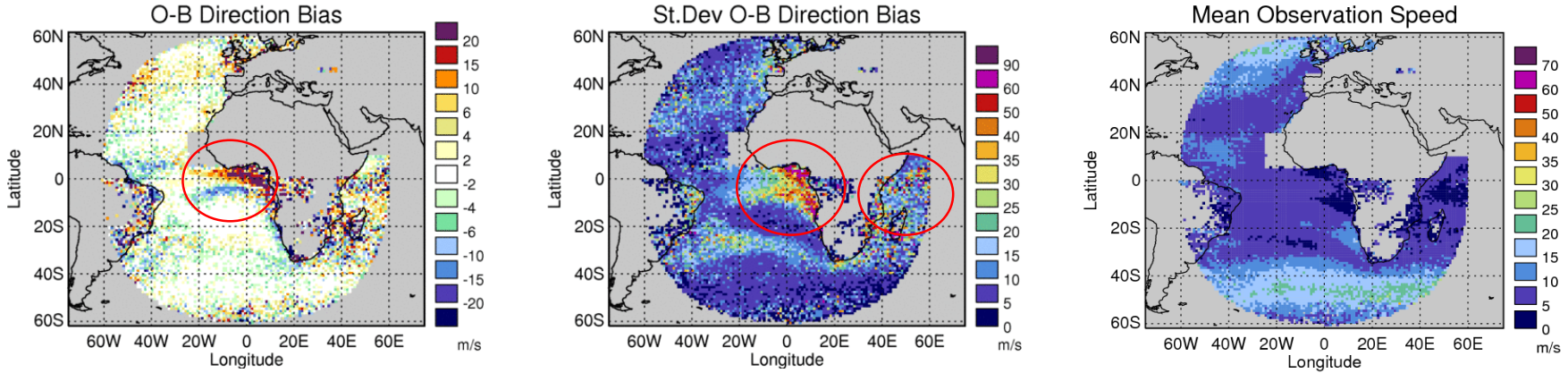
- Relaxed thresholds with QI2, but tighter BgCheck still allows 18-19% more AMVs (vs Ref)
- Background u/v wind fit to AMVs is now more similar
  - Reduced by 2% for u
  - Increased by 0.5% for v
- Background fit to other obs is neutral, except SEVIRI CSR channels 9 and 10 (surface)



QI2 “relaxed” thresholds, tighter Bg. Check vs. Reference

Wind direction O-B

Met Office: Meteosat-10 IR 10.8 II, December 2016



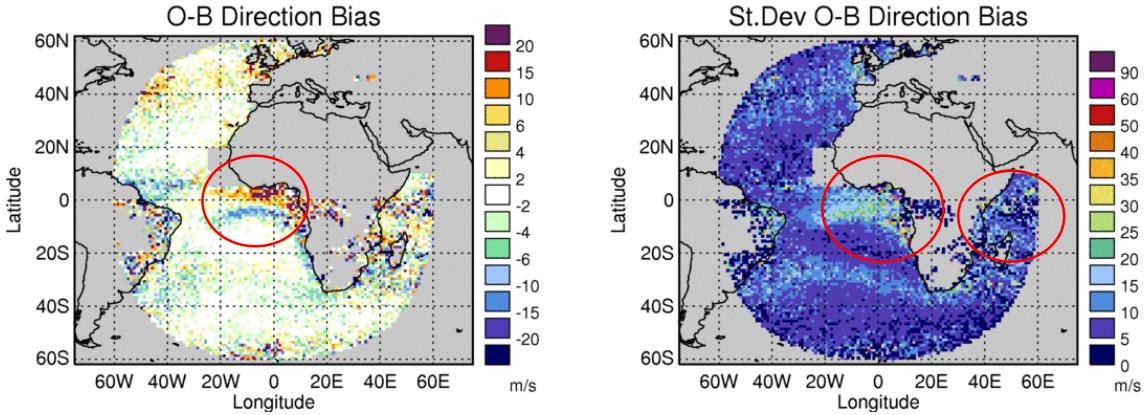
Degradation in SEVIRI-9/10 CSR linked to an increase in assimilated AMV O-B in same areas

- Indian Ocean and to the west of Africa near the equator

- low wind speed regions (average speed < ~5 m/s)

Wind direction O-B after min. speed

Met Office: Meteosat-10 IR 10.8 II, December 2016



After applying minimum speed check of 4 m/s

(AMV and model speed)

Impact experiment – round 3

- Relaxed thresholds with QI2, tighter BgCheck, and slow speed check still allows 11-13% more AMVs (vs Ref)
- Background u/v wind fit to AMVs remains similar to round 2
  - Reduced by 2% for u
  - Increased by 1.0% for v
- Background fit to Geo clear-sky radiance improved (versus experiment without speed check) for GOES, SEVIRI, AHI, but in summer season only..
- Forecast RMS errors mostly beneficial, esp. tropical winds 250 hPa

Met Office

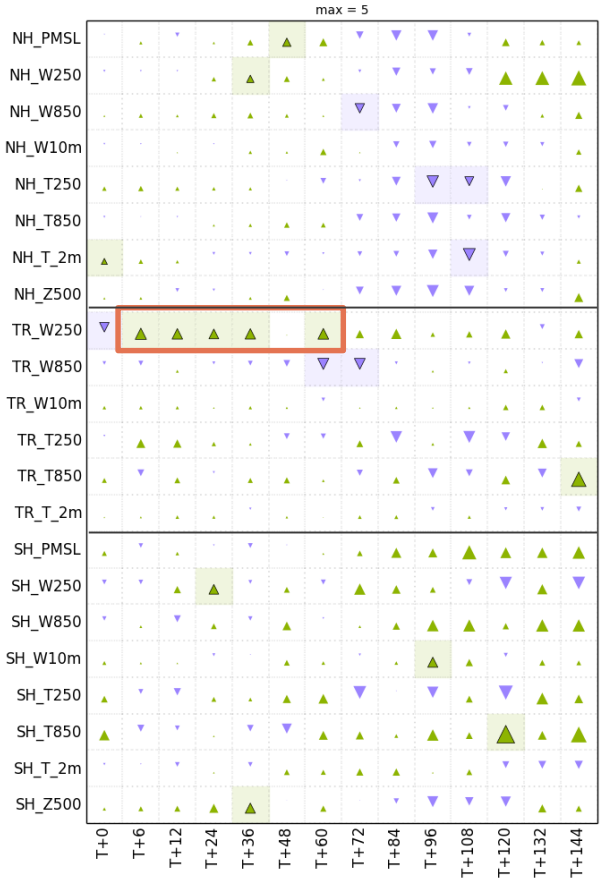
Forecast RMSE: Winter 2016/17

significant impacts

60 positive

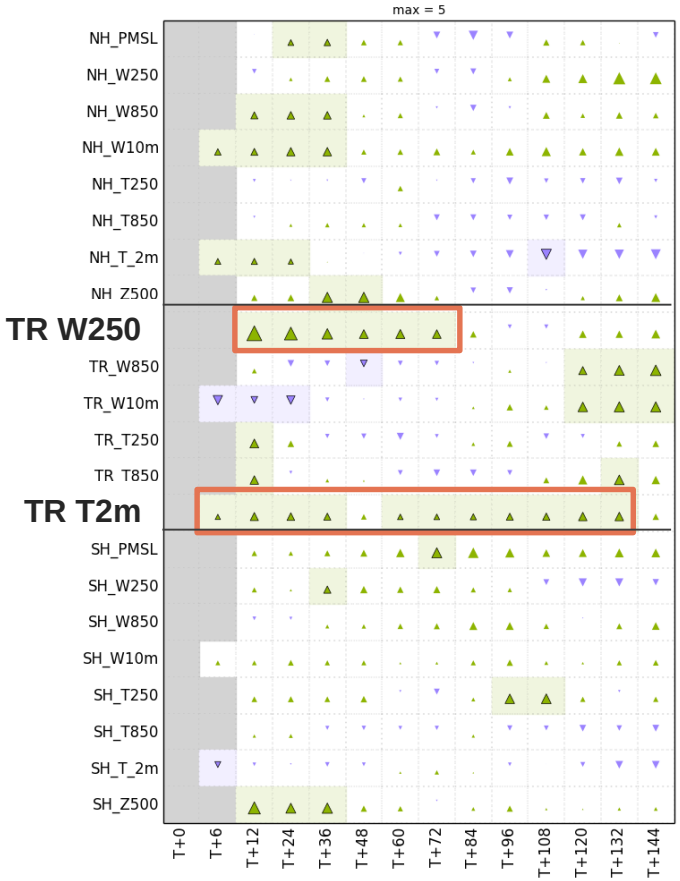
13 negative

% Difference (AMV Stretch vs. SA Package) : Overall 0.03%
Change in RMSE against observations for 20161124-20170130



Truth: Surface, Sonde, Aircraft (W250)

% Difference (AMV Stretch vs. SA Package) : Overall 0.07%
Change in RMSE against ECMWF analyses for 20161124-20170130



Truth: ECMWF

Met Office

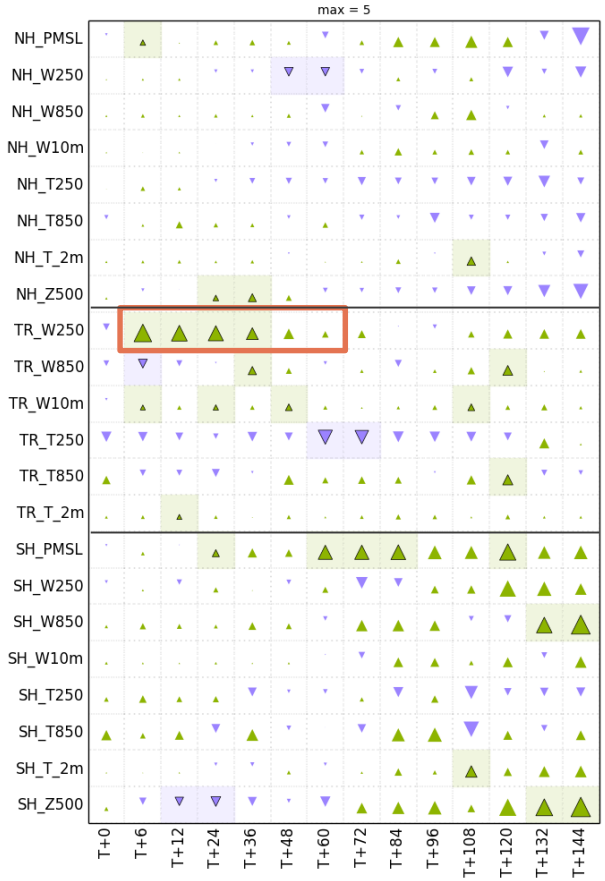
Forecast RMSE: Summer 2016

significant impacts

65 positive

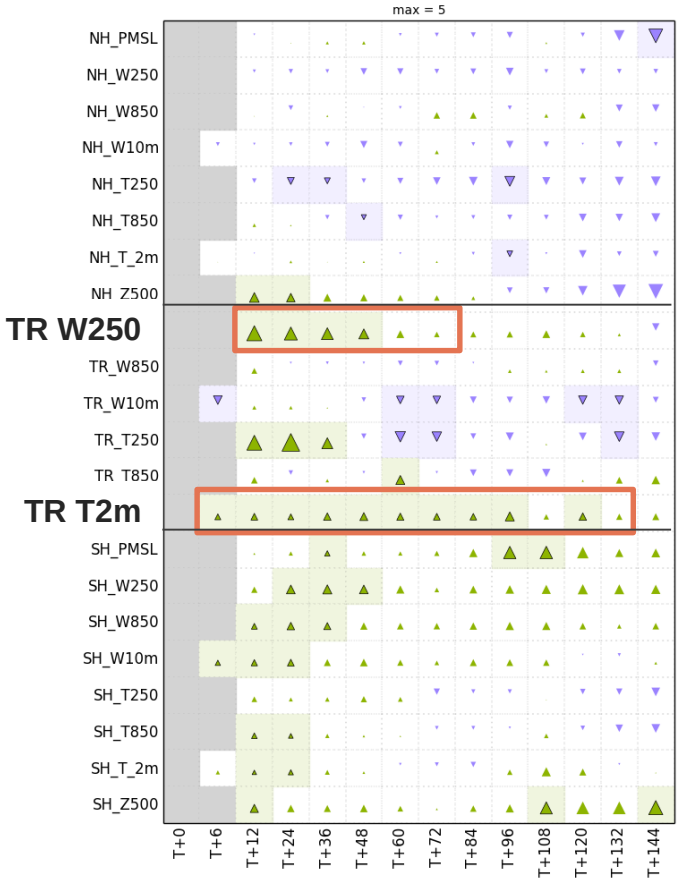
20 negative

% Difference (AMV Stretch vs. SA Package) : Overall 0.06%
Change in RMSE against observations for 20160709-20160930



Truth: Surface, Sonde, Aircraft (W250)

% Difference (AMV Stretch vs. SA Package) : Overall 0.03%
Change in RMSE against ECMWF analyses for 20160709-20160930



Truth: ECMWF

Conclusions I

- QI2 (without Fc) has little skill in discriminating ‘bad’ data
- Revised thresholds are much lower – no filtering applied for GOES and Himawari
- Allows much larger volume for assimilation, large change in low level wind analyses in tropics, but results in degraded O-B fit

- Needed to tighten check against Met Office background winds – remove small number of observations such that overall AMV O-B remains about the same in going from QI1 to QI2
- Found background fit to geostationary radiance (SEVIRI 9/10) still degraded - use minimum wind speed threshold to remove AMV and Bg. speeds < 4 m/s
- Forecast RMSE scores mostly beneficial – improvements seen for Winds 250 hPa in Tropics at day 1-2

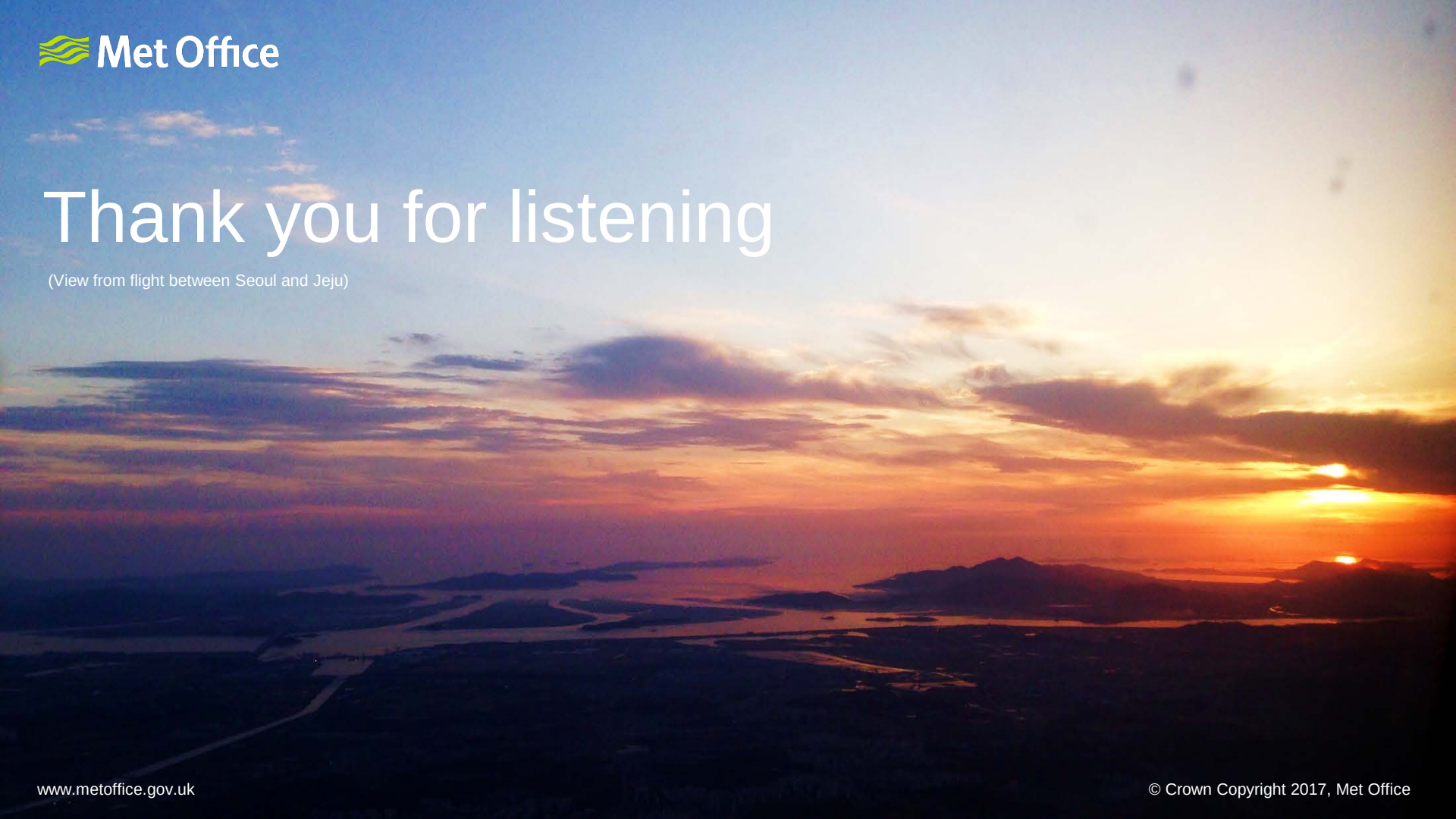
Conclusions II

- Changes operational with OS40, 13 Feb 2018
- For now we only have QI to work with, but with “new” AMV Bufr format we will have much more information supplied with the observations

  E.g. cloud top pressure error, optical thickness, OE cost,..

Thank you for listening

(View from flight between Seoul and Jeju)

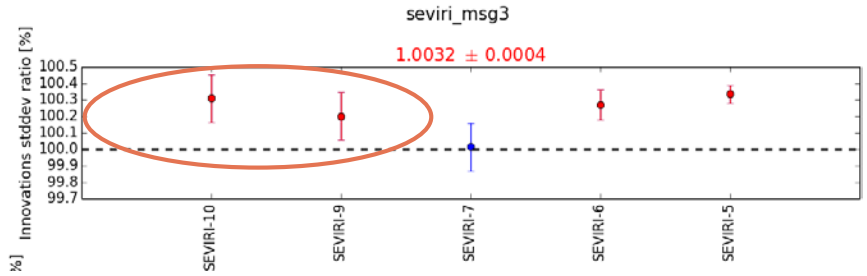


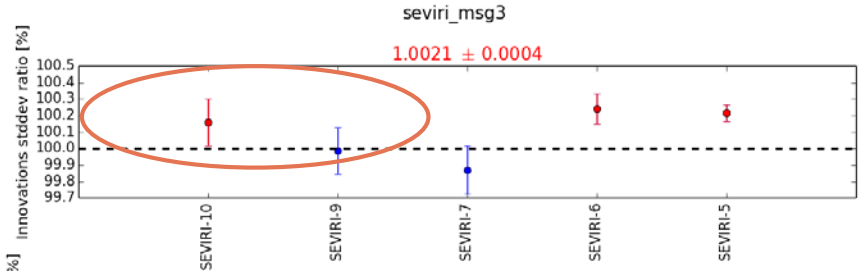
SEVIRI CSR O-B change vs reference

Without Min Speed Check

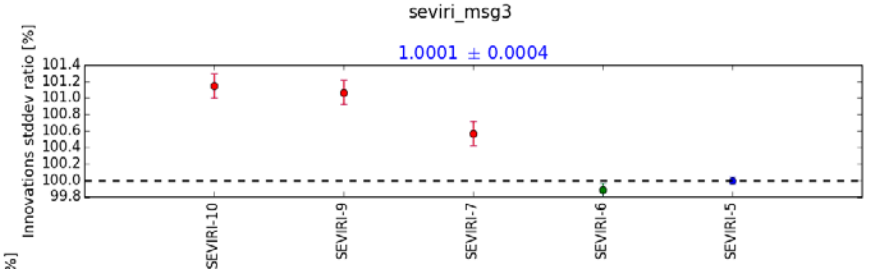
With Min Speed Check

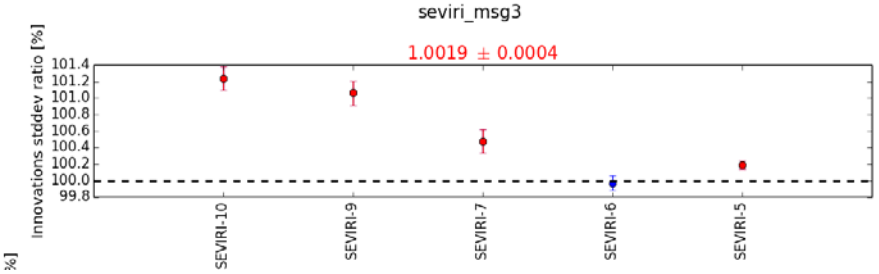
Summer





Winter





Bayesian background check

- ‘Good’ observations with normally distributed errors have Gaussian distribution with unbiased errors and variance V
- ‘Bad’ observations with gross errors have uniform density, k
- Background forecast assumed to have Gaussian errors

Let G denote the presence of gross errors, $\bar{G}$ denote the absence of gross errors

$$P(\bar{G}) = (1 - P(G))$$

The overall probability density of observed value y_o given background value y_b is

$$\begin{aligned} P(O) &= P(O \mid \bar{G})P(\bar{G}) + P(O \mid G)P(G) \\ &= N(y_o \mid y_b, V)(1 - P(G)) + kP(G) \\ &= \frac{1}{\sqrt{2\pi V}} \exp\left(\frac{-(y_o - y_b)^2}{2V}\right)(1 - P(G)) + kP(G) \end{aligned}$$

Variance of O-B values (excluding gross errors) $\quad V = \sigma^2 = {\sigma_o}^2 + {\sigma_b}^2$