Recent Changes in the Derivation of Geostationary AMVs at EUMETSAT

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Summary

Introduction to EUMETSAT's geostationary AMVs

Recent changes:

- Cross-Correlation Contribution (CCC) method
- Best-fit pressure

Current developments:

- Optimal Cloud Analysis (OCA)
- Nested tracking

Future work

Introduction to EUMETSAT's geostationary AMVs

Meteosat satellites currently in operation

Meteosat-10: launched on 5 July 2012 as MSG-3, located at 0° East. It supports the Meteosat Prime Service (Full Earth Scanning, FES).

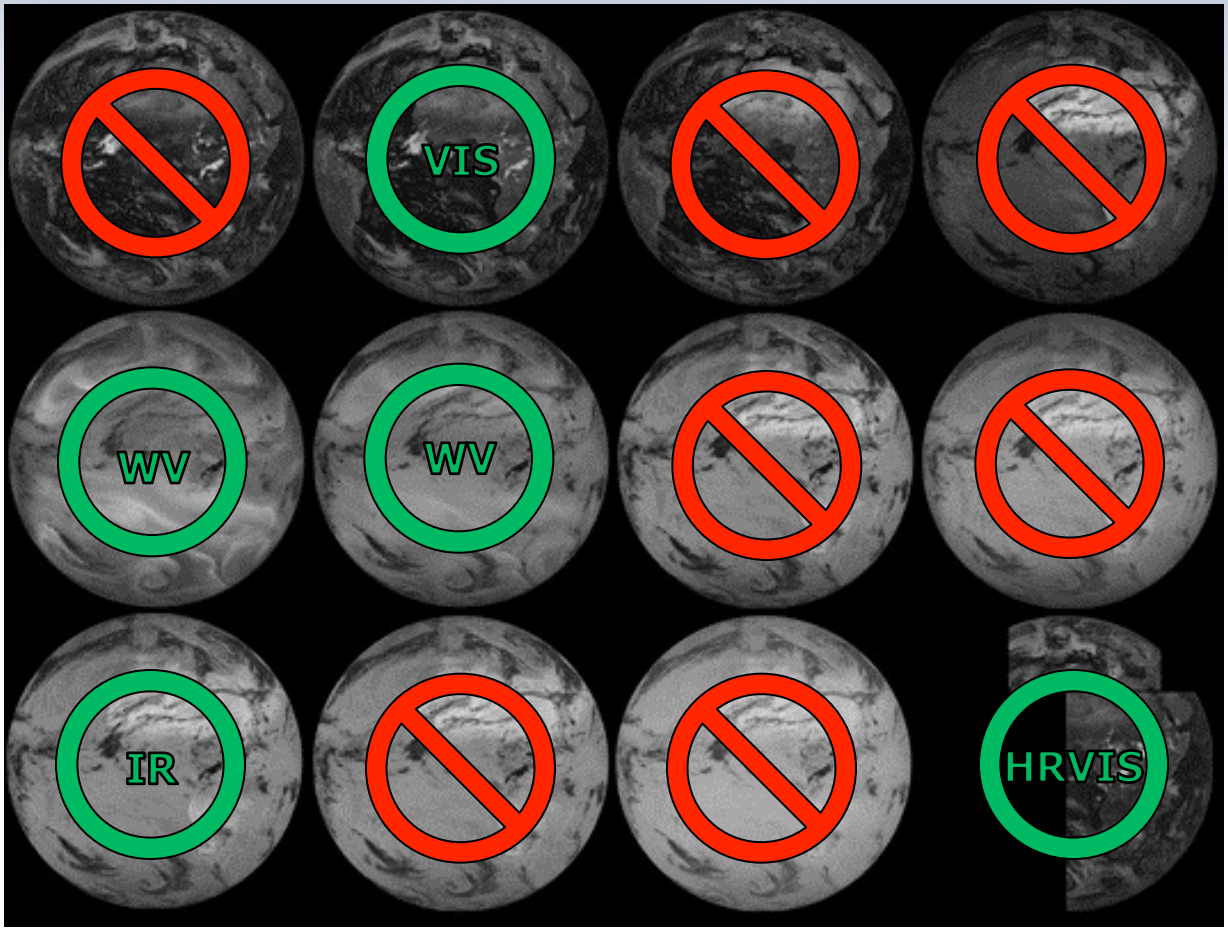
Meteosat-9: launched on 21 December 2005 as MSG-2, located at 9.5° East. It supports the Rapid Scanning Service (RSS).

Meteosat-8: launched on 28 August 2002 as MSG-1, located at 3.5° East. It is a backup for Meteosat-10 and, with lower priority, Meteosat-9.

Meteosat-7: launched on 2 September 1997, located at 57.5° East. It supports the Indian Ocean Data Coverage (IODC) service.

Introduction to EUMETSAT's geostationary AMVs

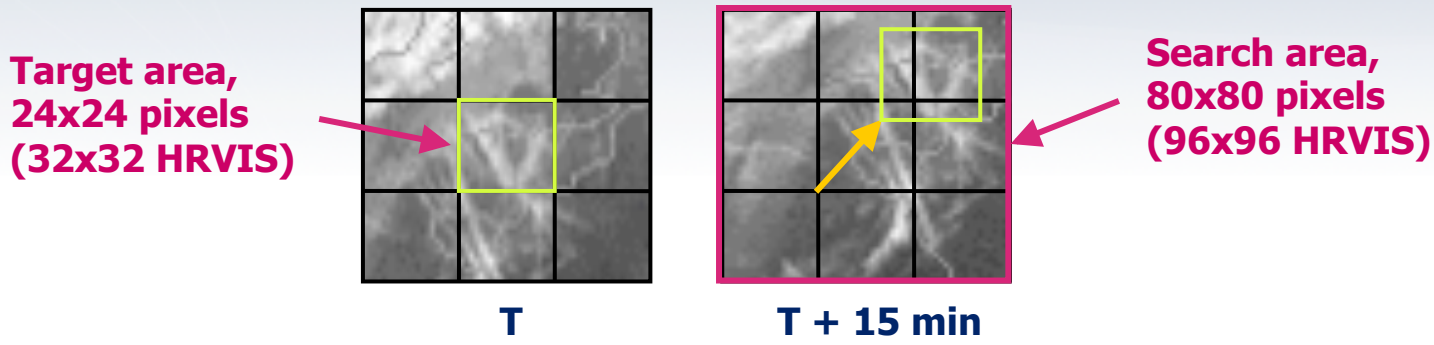
MSG SEVIRI channels



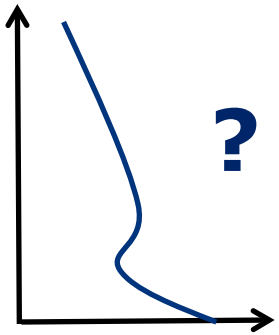
Introduction to EUMETSAT's geostationary AMVs

AMV derivation process

1. Tracking



2. Height assignment



3. Quality control

Summary

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Recent changes
Latest MSG MPEF releases

- **Release 1.5.3, September 2012**
  - Introduction of CCC method for the AMV height assignment
  - → Statistics of AMVs improved at high and mid levels, degraded at low levels
- **Patch for low-level winds, February 2013**
  - → Statistics of AMVs slightly better at low levels
- **Release 1.5.4, September 2013**
  - AMVs extracted at low levels in WV channels set to a poor QI
  - Introduction of the best-fit pressure calculation
  - Introduction of OCA product (2 layers, hourly), not yet used for AMVs

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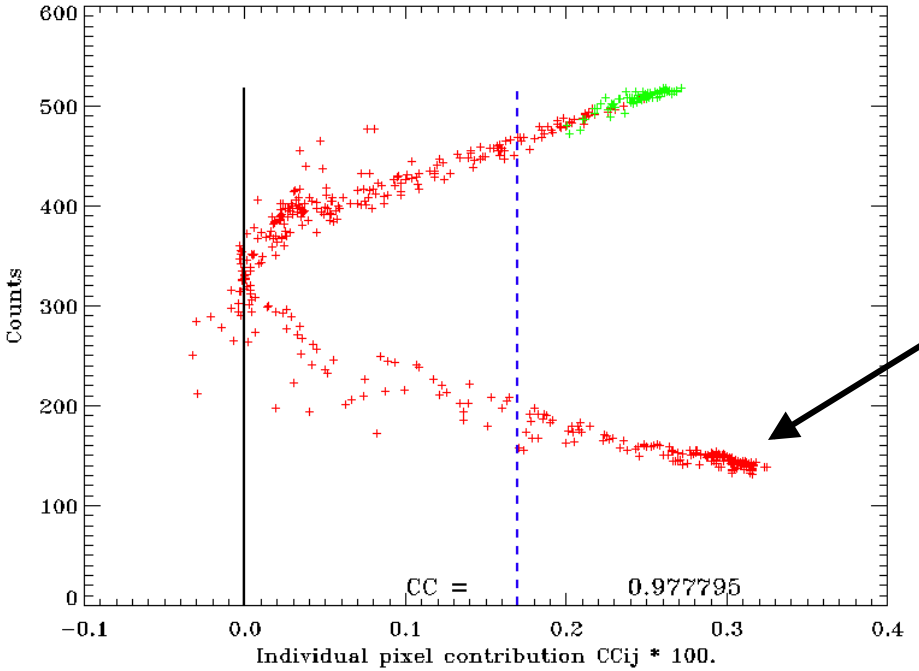
Cross-Correlation Contribution (CCC) method

Mathematical formulation

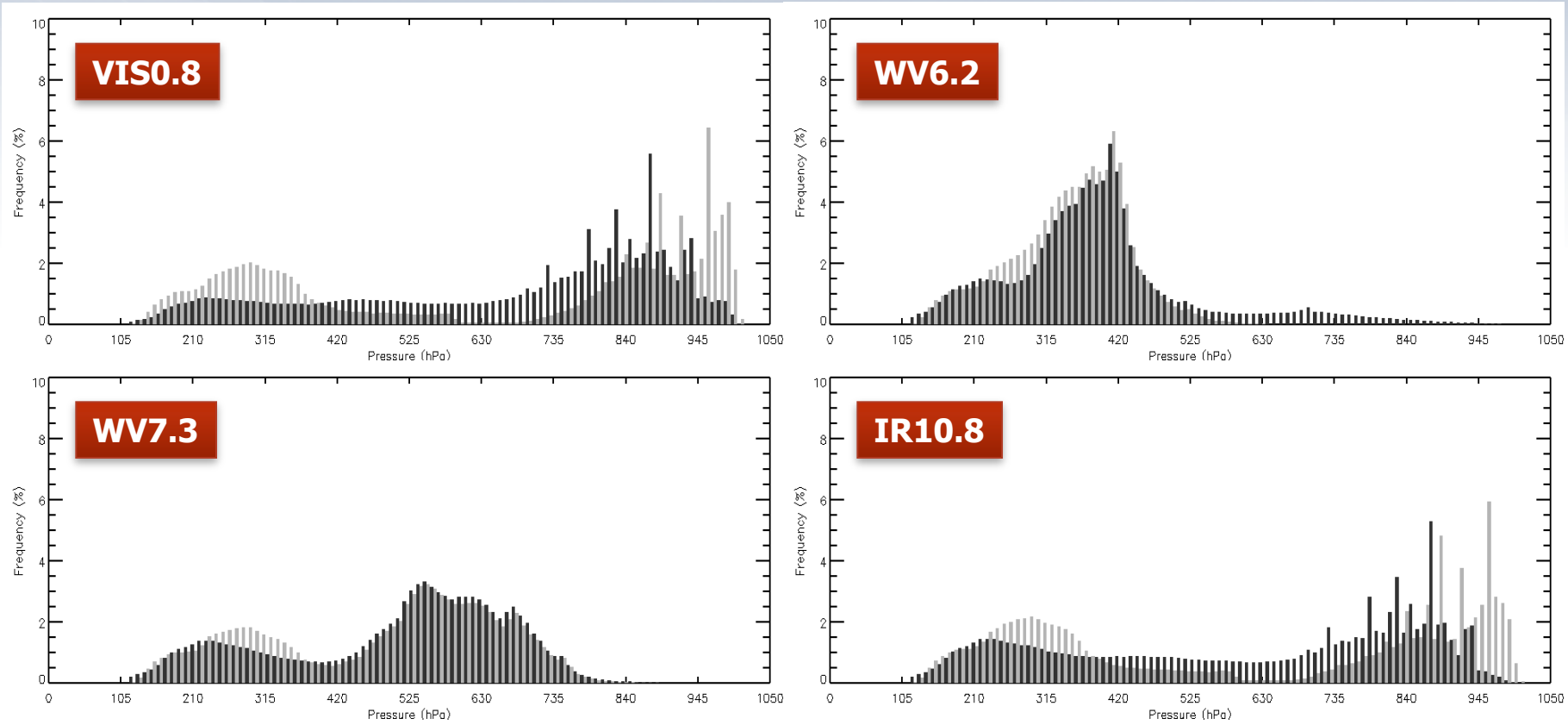
$$CC(m,n) = \frac{1}{M \cdot N} \sum_{i=1}^{M} \sum_{j=1}^{N} \frac{a_{i+m,j+n} - \bar{a}(m,n)}{\sigma_a(m,n)} \cdot \frac{b_{ij} - \bar{b}}{\sigma_b}$$



$$P = \frac{\sum_{\substack{cold\_branch \\ CC_{ij} > CCij\_thr}} CC_{ij} \cdot CTH_{ij}}{\sum_{\substack{cold\_branch \\ CC_{ij} > CCij\_thr}} CC_{ij}}$$

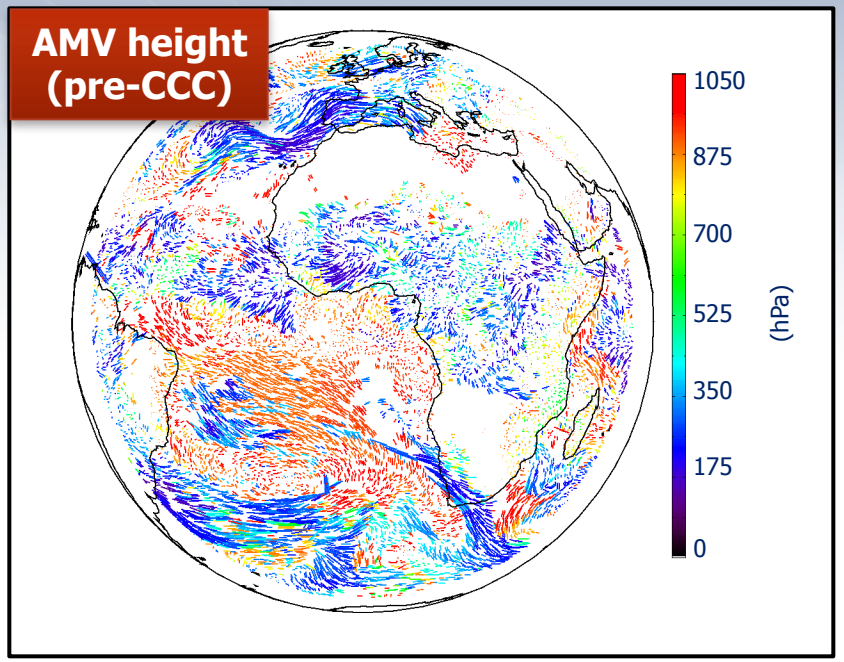
Cross-Correlation Contribution (CCC) method

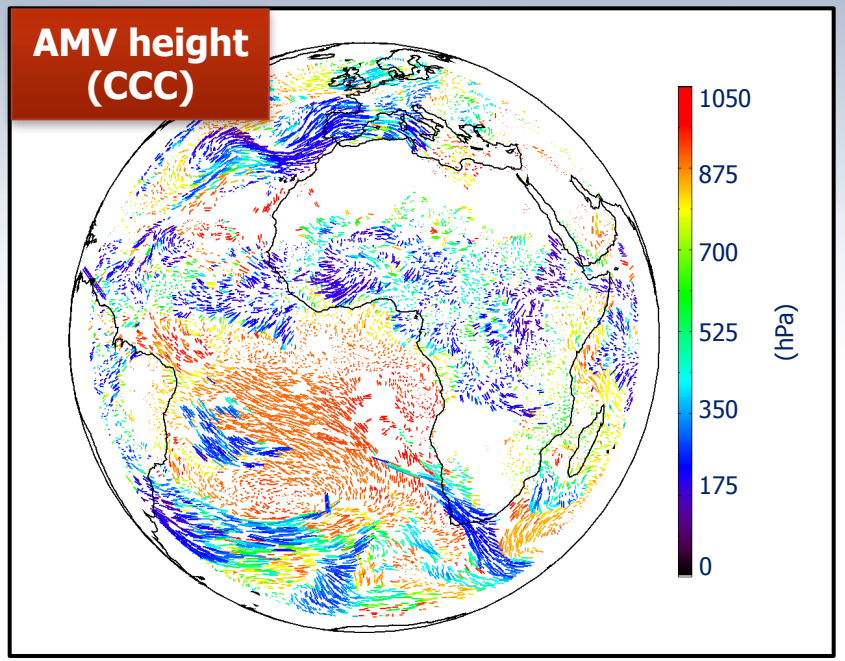
Histograms of height frequency per channel

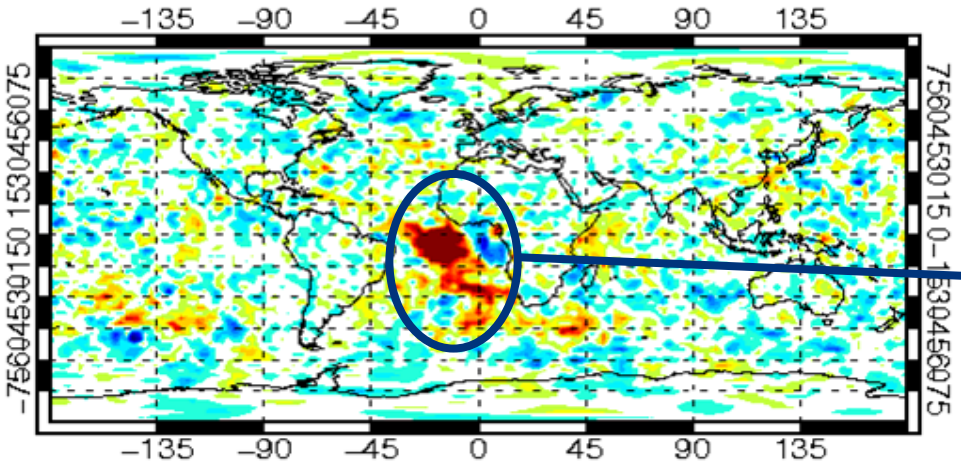


Cross-Correlation Contribution (CCC) method

Low-level cloud problem







Normalised RMS difference between CCC and control experiment for 48-hour wind forecast at 850 hPa

Negative impact

gmv INNOVATING SOLUTIONS

EUMETSAT

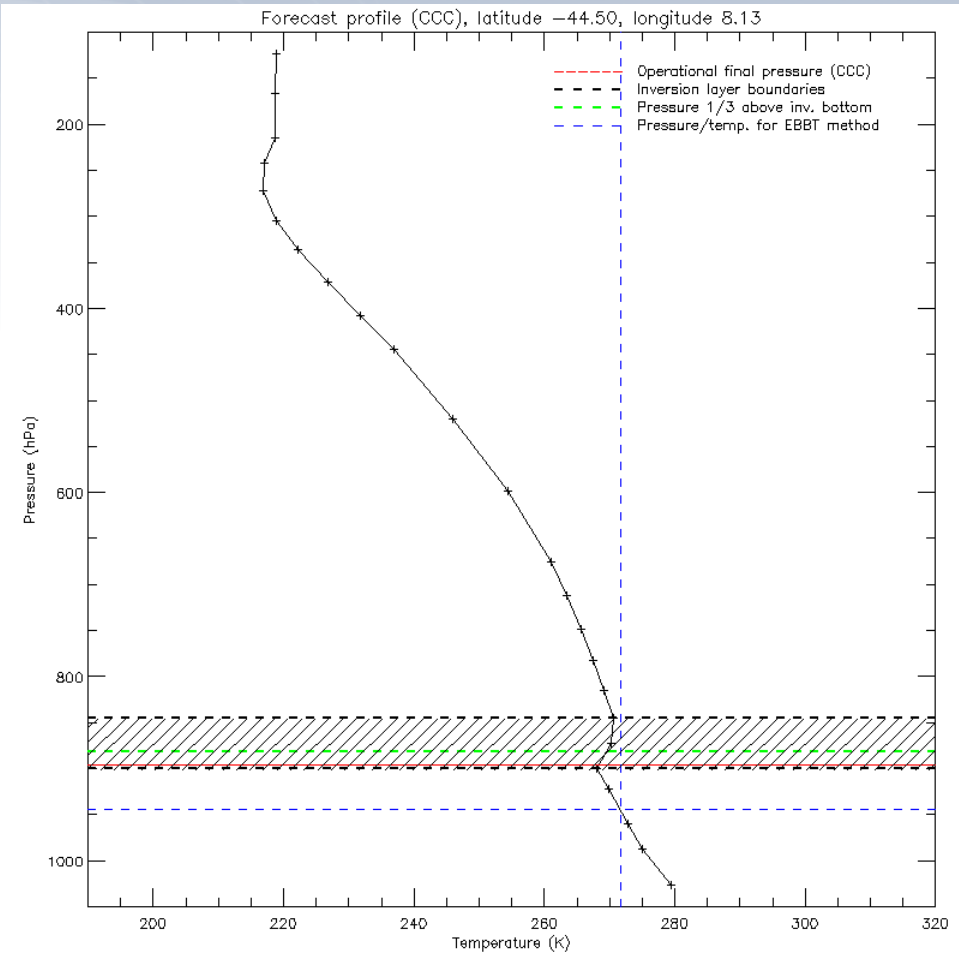
Cross-Correlation Contribution (CCC) method

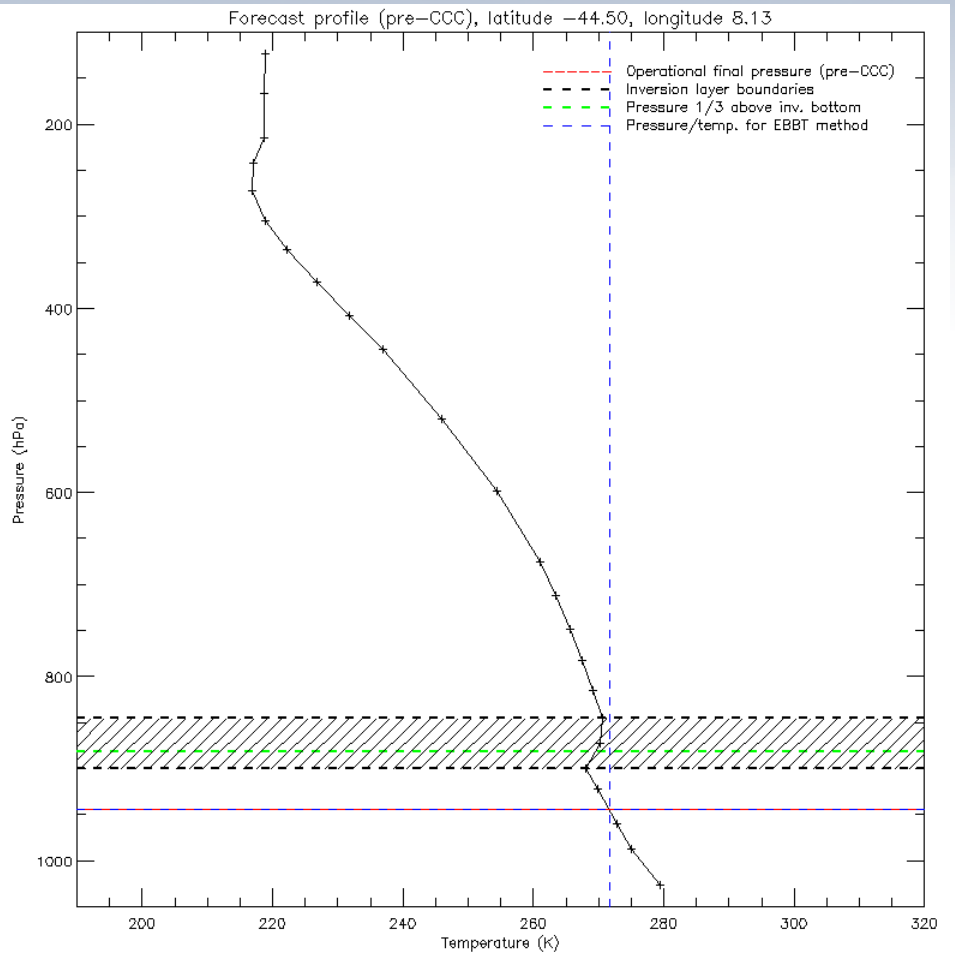
Speed bias per channel for June 2012

Region	Algorithm	IR10.8				VIS0.8	WV6.2	WV7.3	
		ALL	HGH	MID	LOW	LOW	HGH	HGH	MID
GLO	OPE	-1.54	-1.97	-1.46	-0.39	-0.30	-0.94	-1.54	-0.30
	CCC	-1.41	-1.71	-1.15	-0.79	-0.67	-0.75	-1.10	0.71
NH	OPE	-1.81	-2.28	-1.73	0.05	0.11	-1.03	-1.71	-0.36
	CCC	-1.60	-2.08	-1.23	-0.65	-0.46	-0.85	-1.29	0.50
SH	OPE	-1.70	-2.16	-0.17	-0.48	-0.65	-1.55	-2.10	0.70
	CCC	-1.28	-1.54	-0.57	-0.86	-0.77	-0.82	-1.25	1.64
TRO	OPE	-0.71	-0.60	-0.67	-0.83	-0.63	-0.31	-0.59	-0.41
	CCC	-0.94	-0.93	-0.93	-0.95	-0.89	-0.42	-0.47	-0.51

Cross-Correlation Contribution (CCC) method

Forecast profile comparison





Cross-Correlation Contribution (CCC) method

Low-level cloud solution: re-introduction of an inversion correction algorithm

1. Each pixel has a height provided by the CLA/CTH product

2. CCC computes an average height for each target area (based on the pixels that contribute the most to the tracking)

3. In case of temperature inversion, the height is set to 1/3 of the inversion strength above the inversion layer bottom

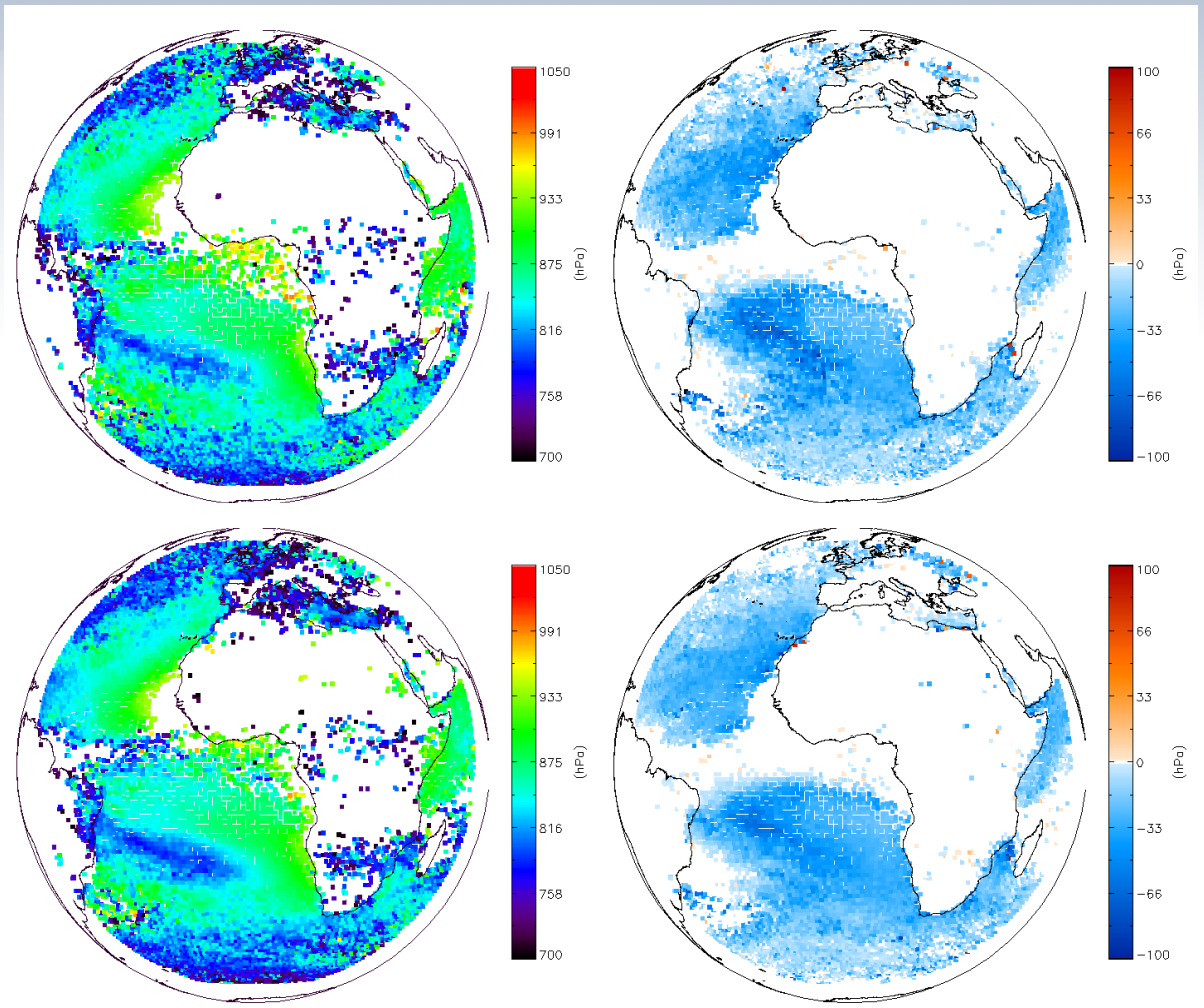
4. If the EBBT pressure is larger than the inversion corrected pressure, then the EBBT pressure is used instead

Cross-Correlation Contribution (CCC) method

Average CCC height (left) and height difference (right), Feb. 2013 (QI > 85)

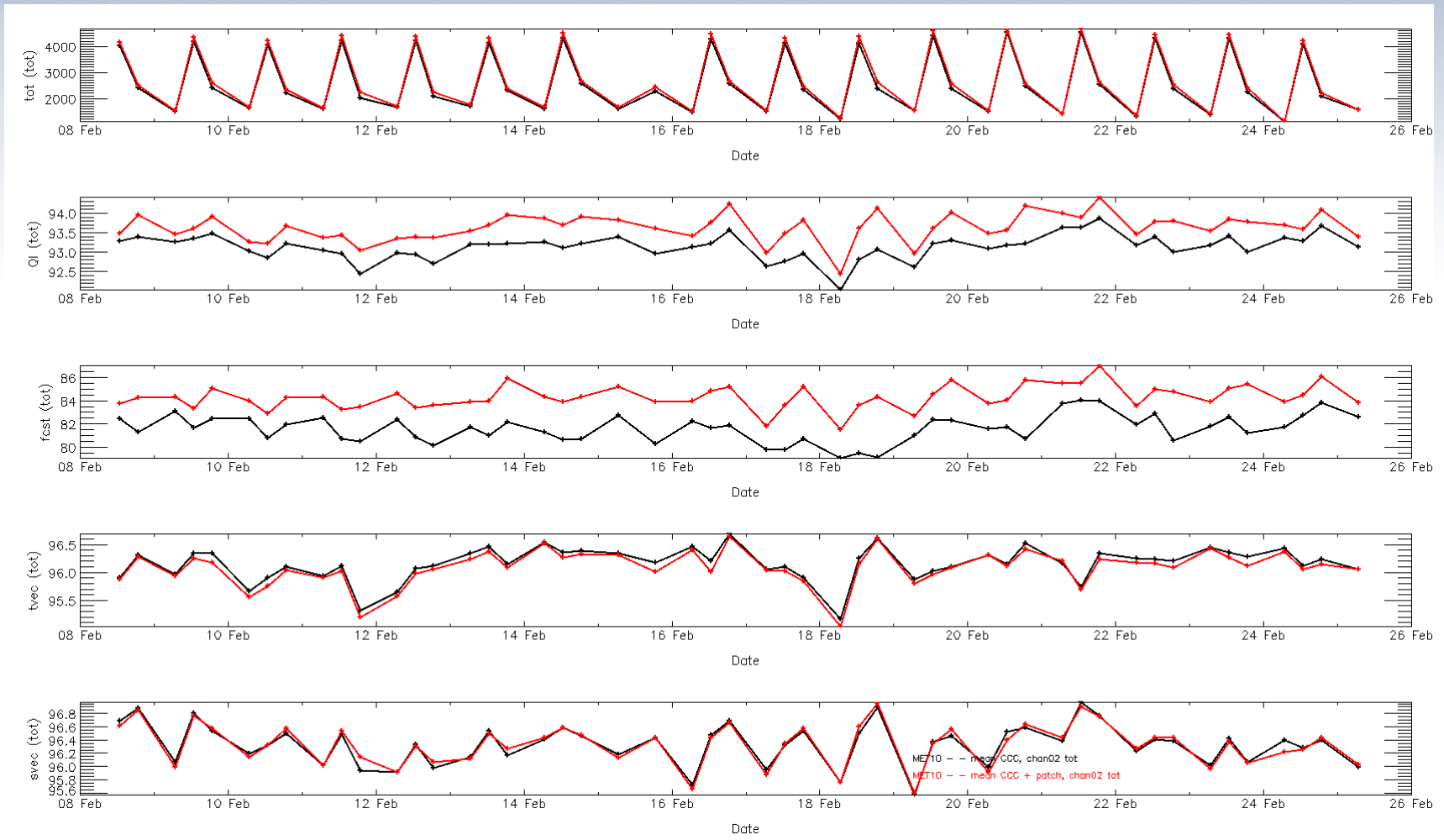
VIS0.8

IR10.8



Cross-Correlation Contribution (CCC) method

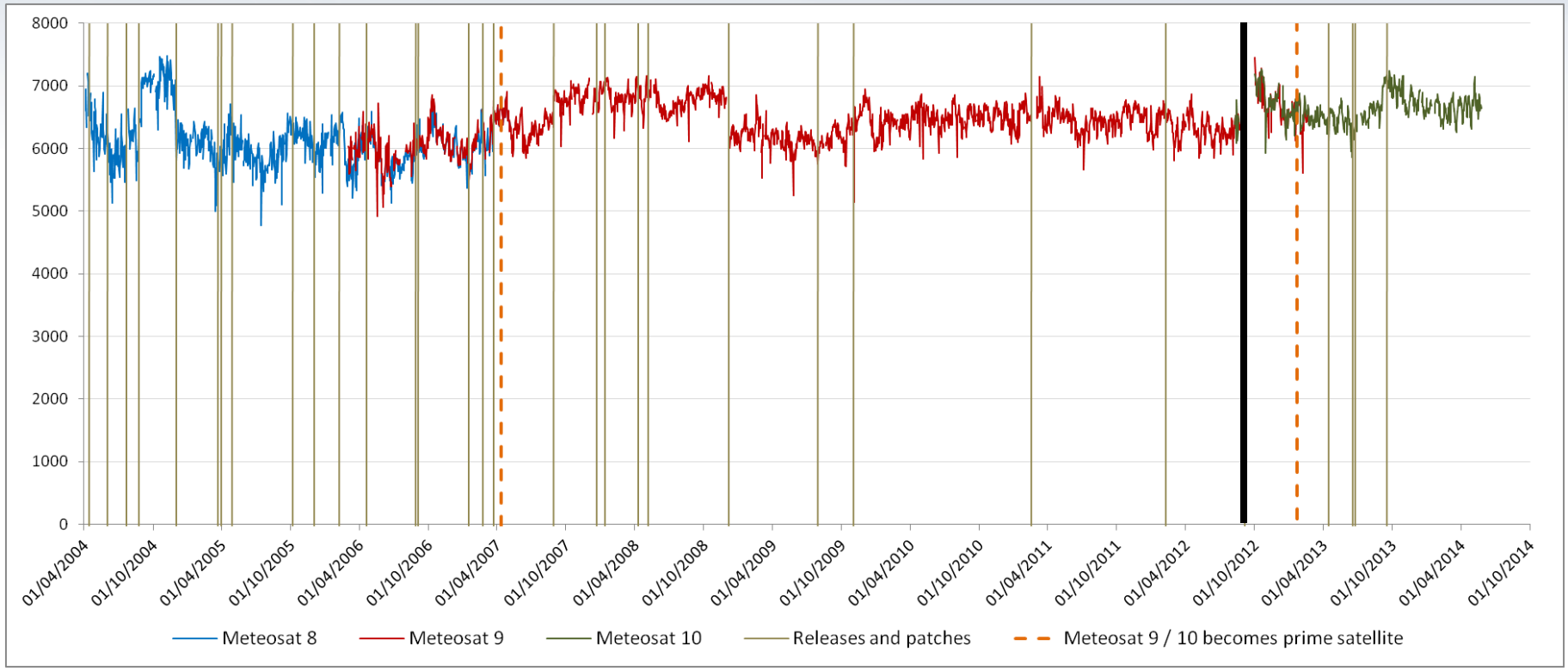
Impact on QI of VIS0.8 low-level winds, Feb. 2013 (QI > 85)



Cross-Correlation Contribution (CCC) method

Long-term statistics (I)

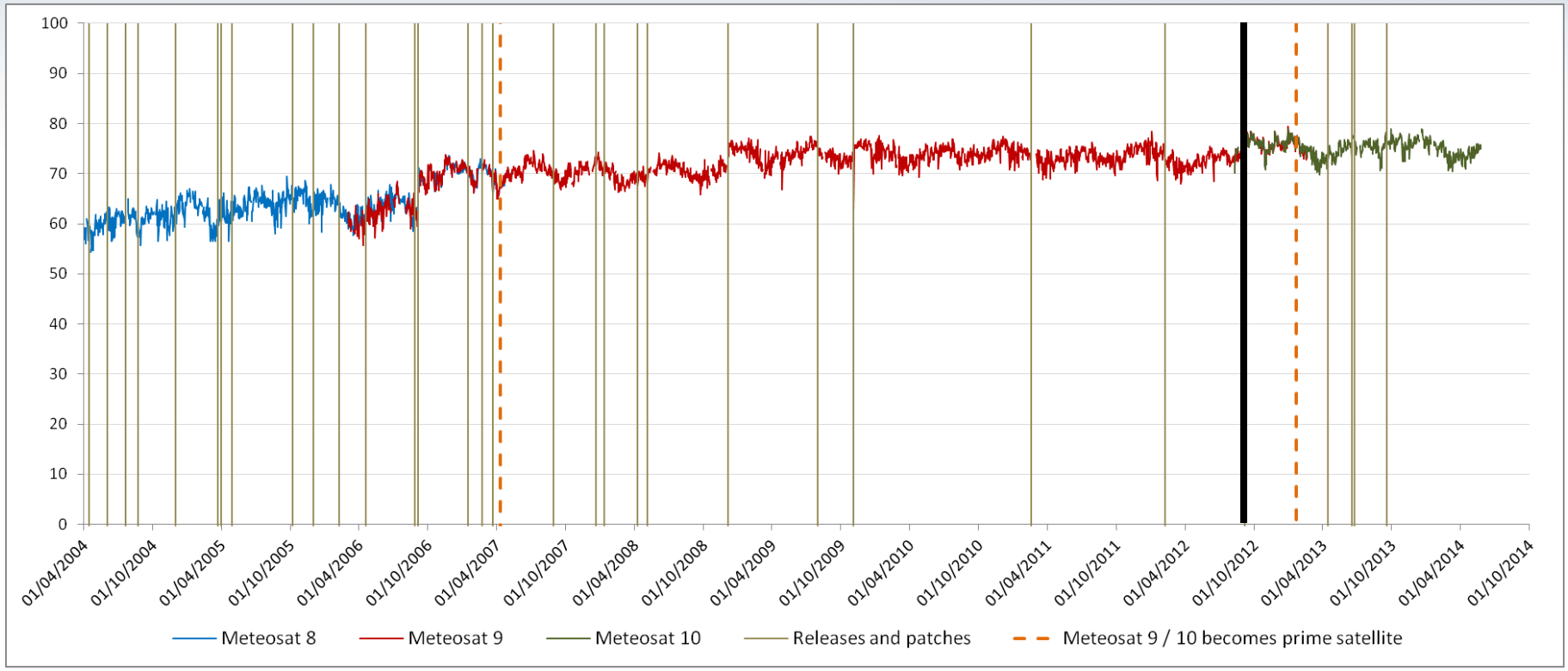
Number of AMVs, channel 02 (VIS 0.8 µm)



Cross-Correlation Contribution (CCC) method

Long-term statistics (II)

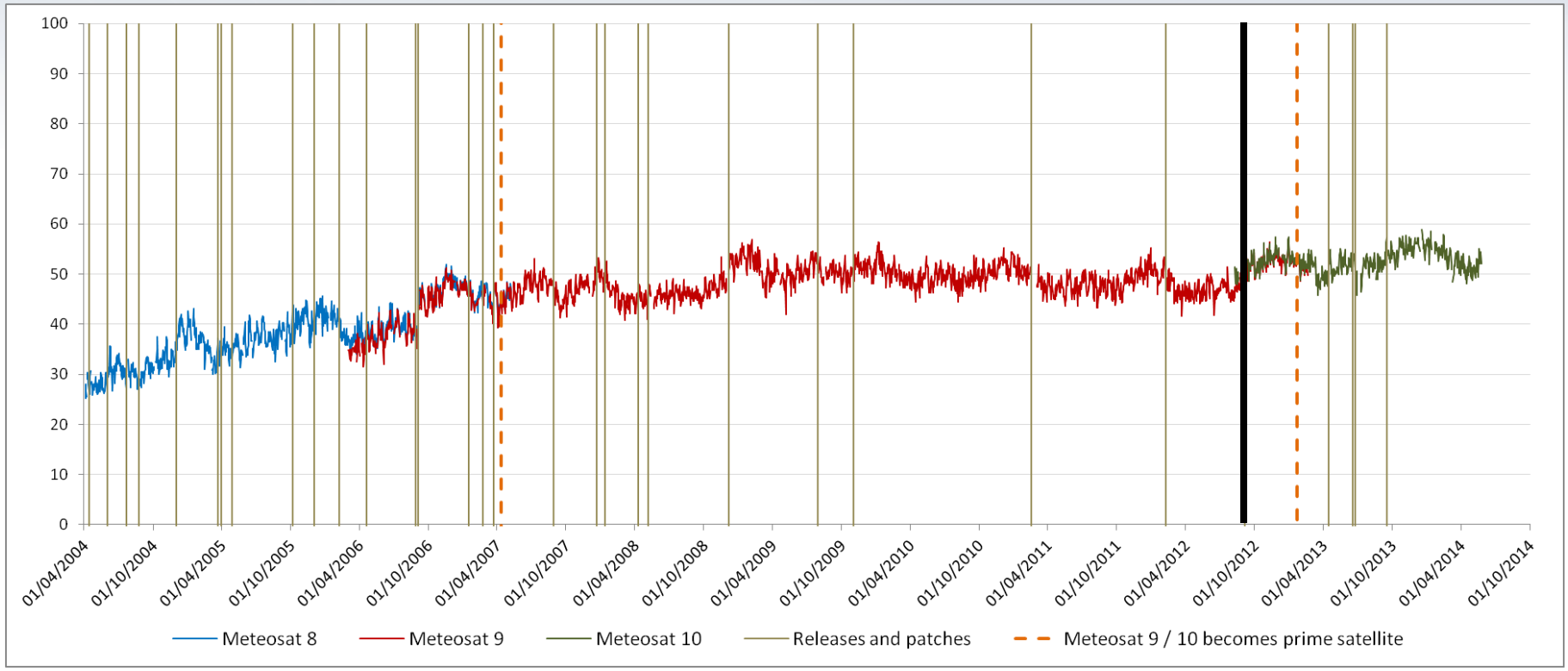
Spatial vector consistency, channel 02 (VIS 0.8 µm)



Cross-Correlation Contribution (CCC) method

Long-term statistics (III)

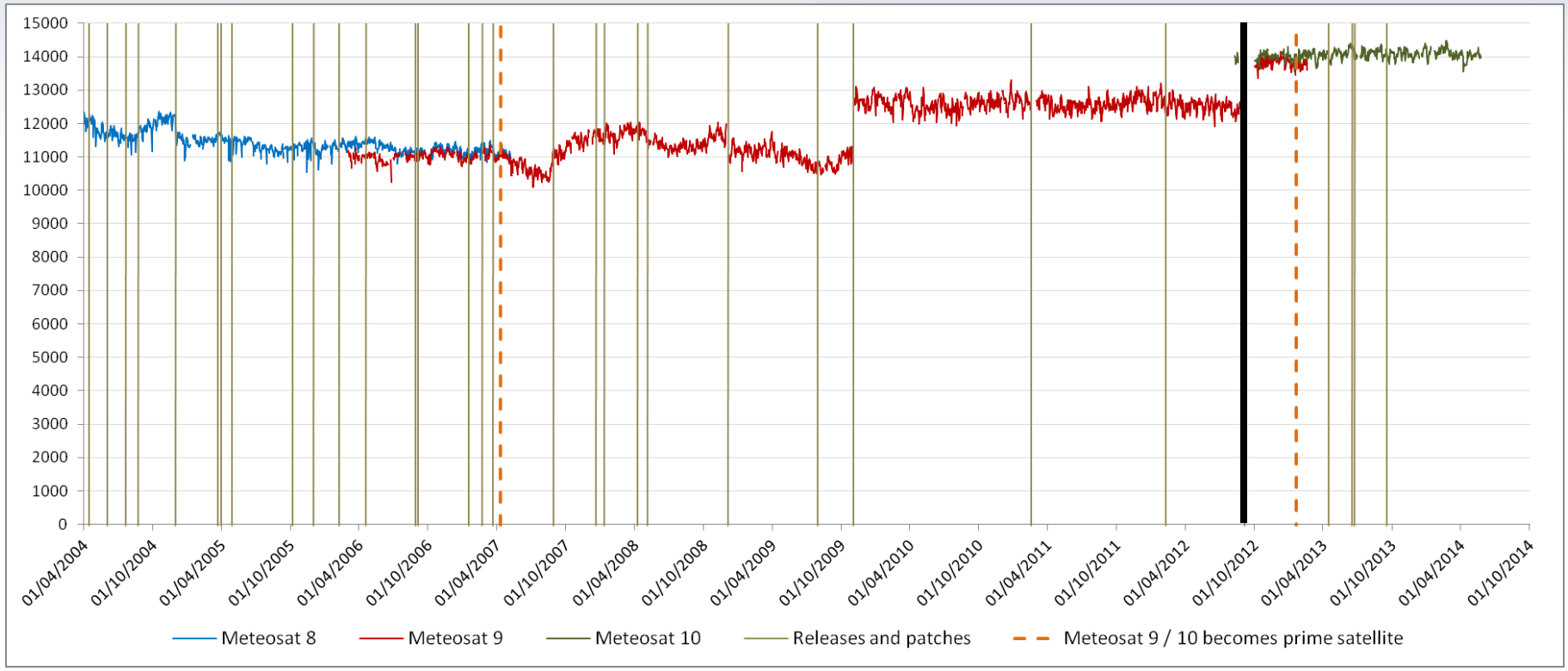
Forecast consistency, channel 02 (VIS 0.8 µm)



Cross-Correlation Contribution (CCC) method

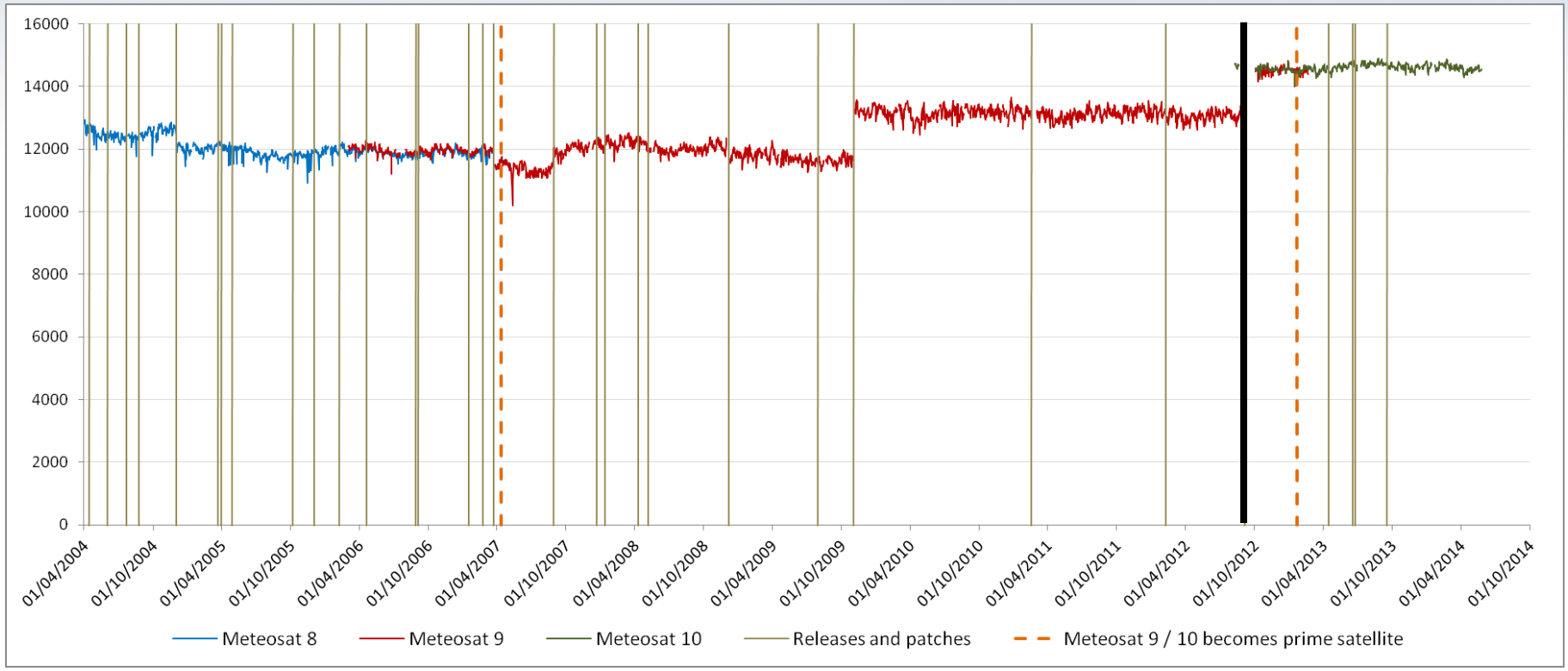
Long-term statistics (IV)

Number of AMVs, channel 05 (WV 6.2 µm)



Cross-Correlation Contribution (CCC) method
Long-term statistics (V)

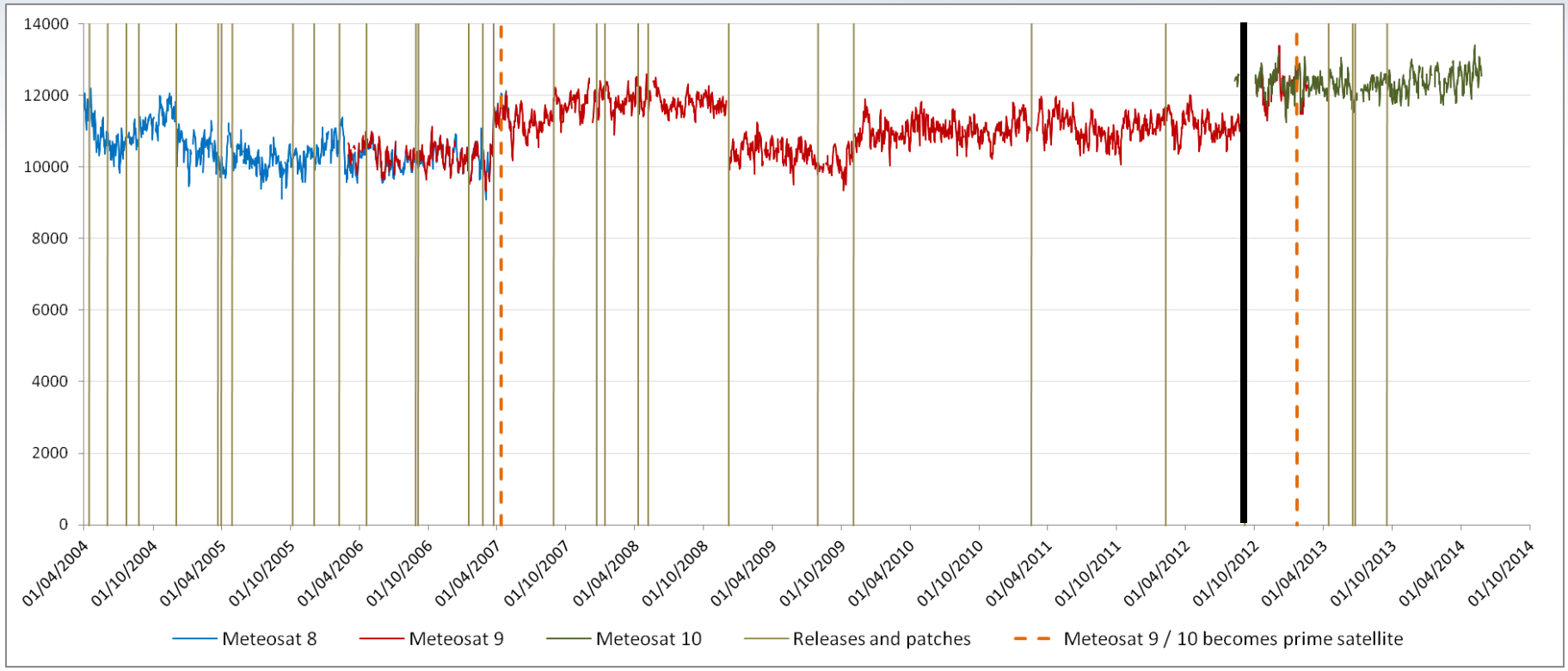
Number of AMVs, channel 06 (WV 7.3 µm)



Cross-Correlation Contribution (CCC) method

Long-term statistics (VI)

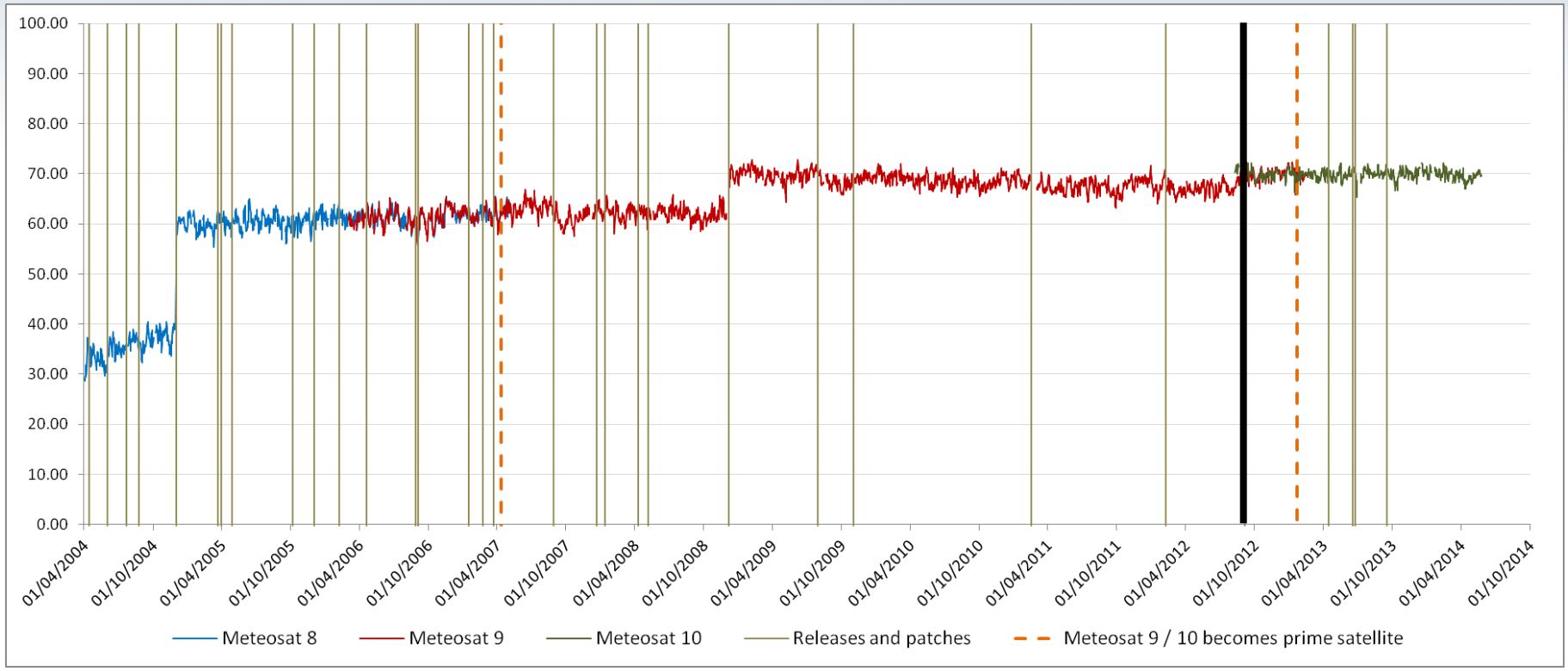
Number of AMVs, channel 09 (IR 10.8 µm)



Cross-Correlation Contribution (CCC) method

Long-term statistics (VII)

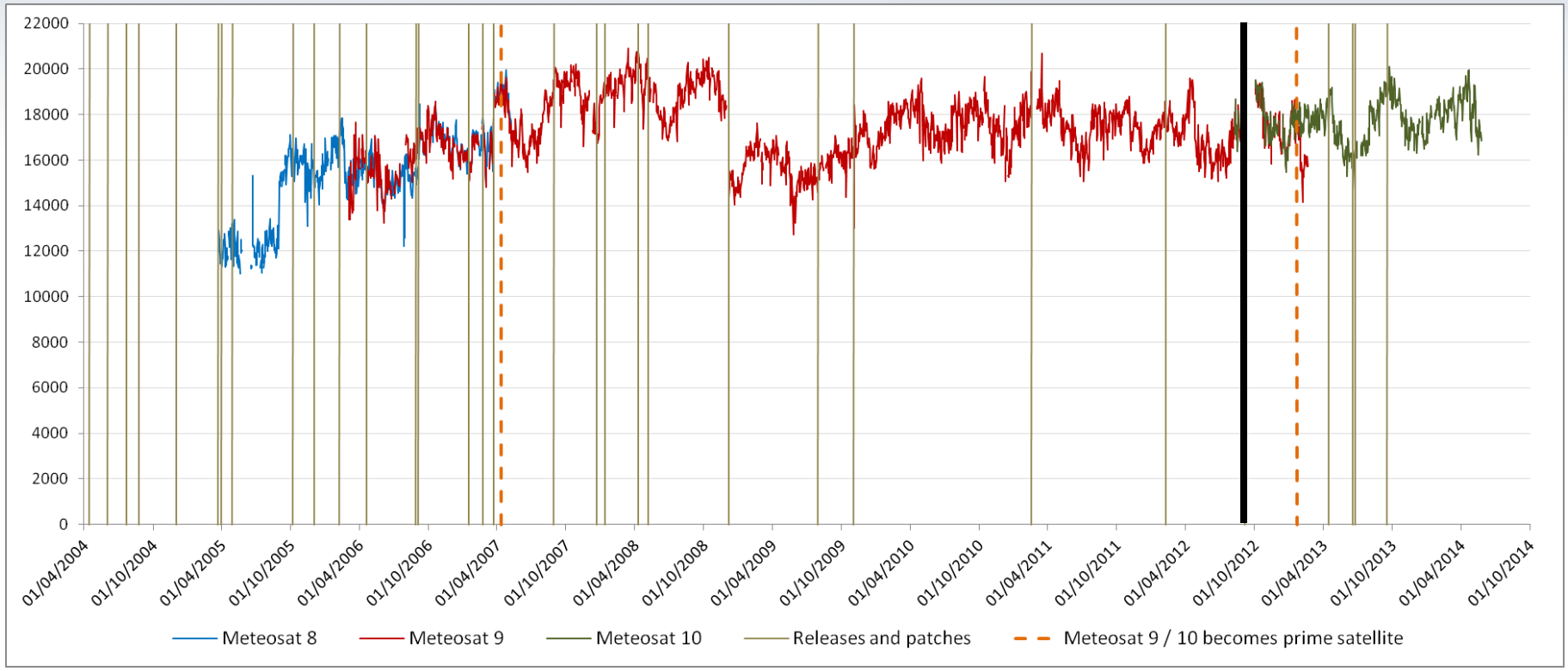
QI including forecast consistency, channel 09 (IR 10.8 µm)



Cross-Correlation Contribution (CCC) method

Long-term statistics (VIII)

Number of AMVs, channel 12 (HRVIS)



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Best-fit pressure

Recommendation IWW11.15. Definition and computation (from MET Office)

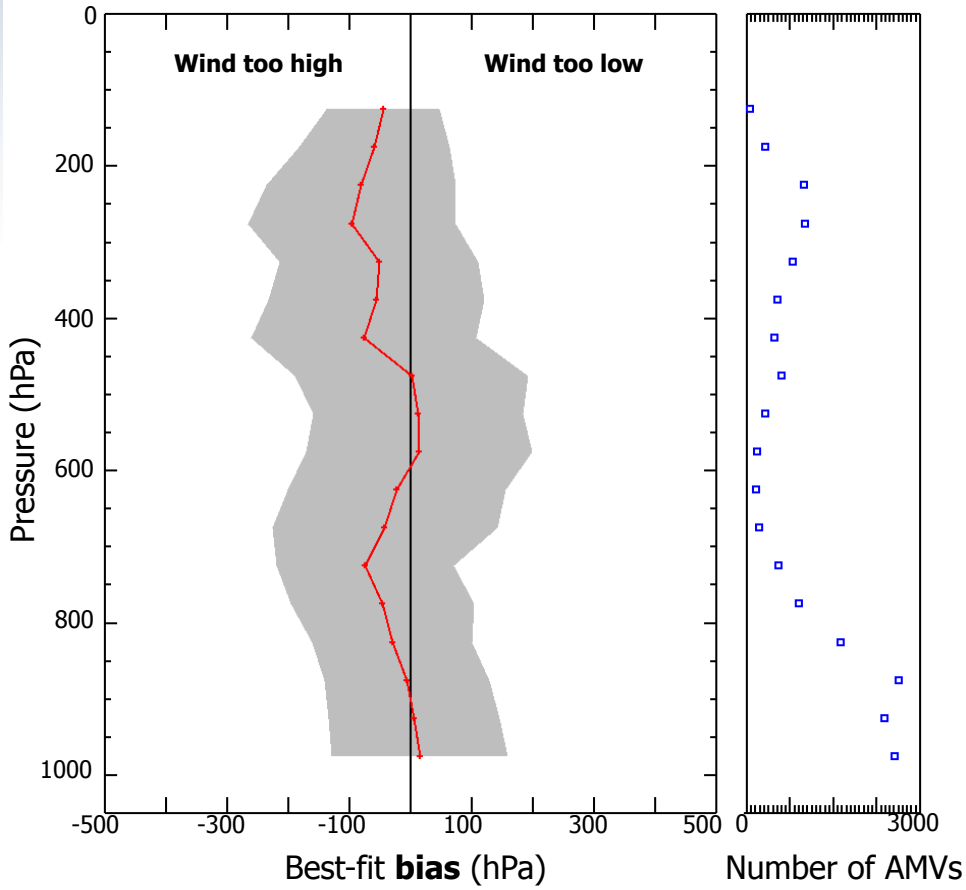
"*The **best-fit pressure** is the height where the vector difference between the observed wind and the model forecast wind is the smallest.*"

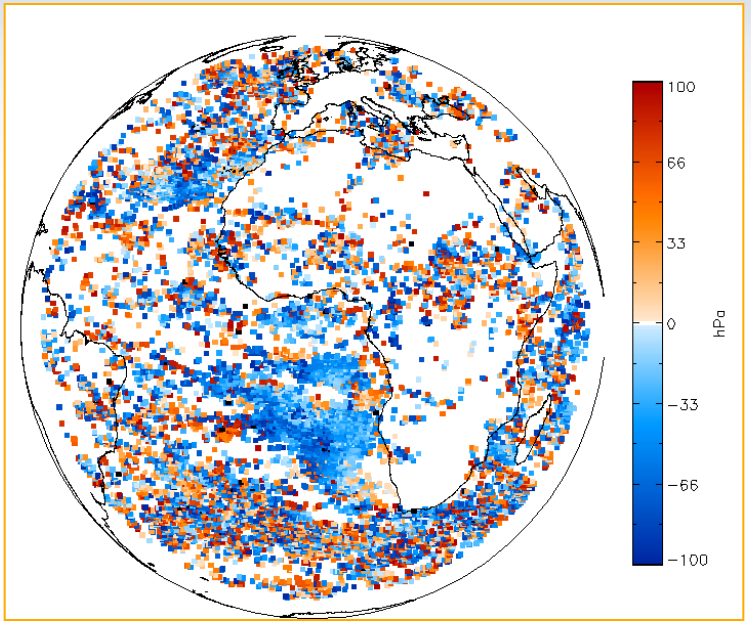
1. The U and V wind components are extracted from the forecast profile.
2. The minimum vector difference w.r.t. the model forecast is computed.
3. A parabolic fit is used in order to find the best-fit pressure.
4. The best-fit U and V components are computed by linear interpolation.
5. The best-fit pressure is valid only if:
    - The minimum vector difference is smaller than 4 m/s.
    - The vector difference is larger than the minimum plus 2 m/s outside the band +/- 100 hPa from the best-fit pressure.

Best-fit pressure

CCC – best-fit height, 5 September 2013 (I)

VIS0.8

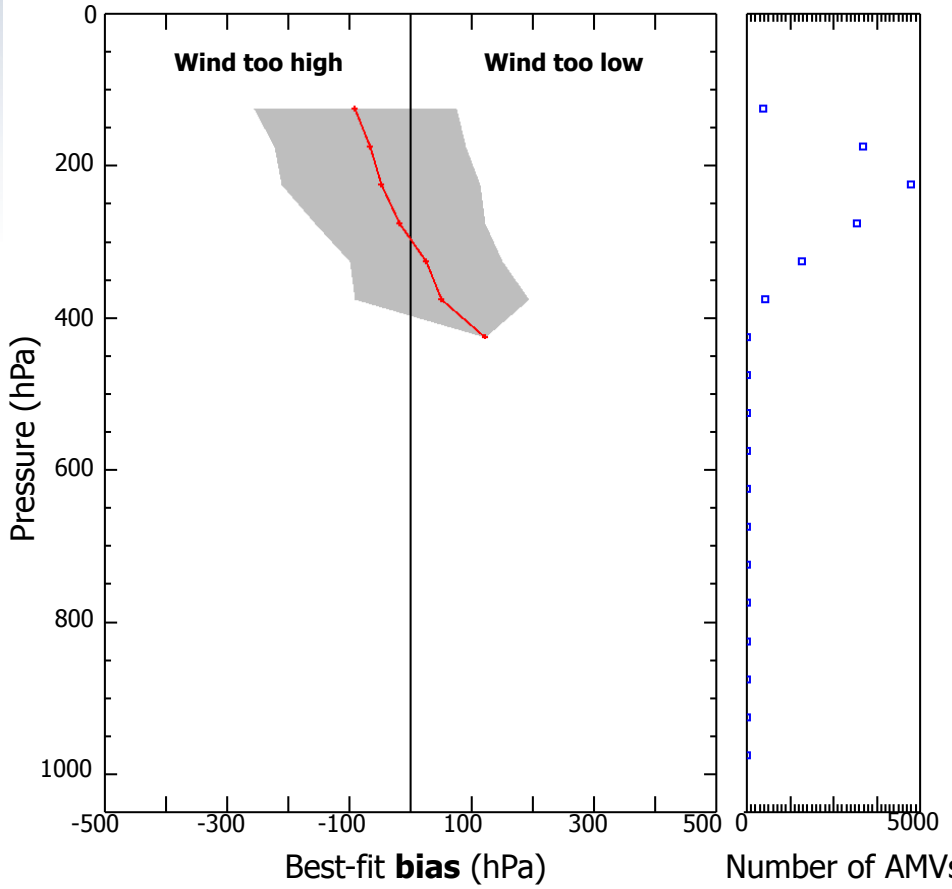


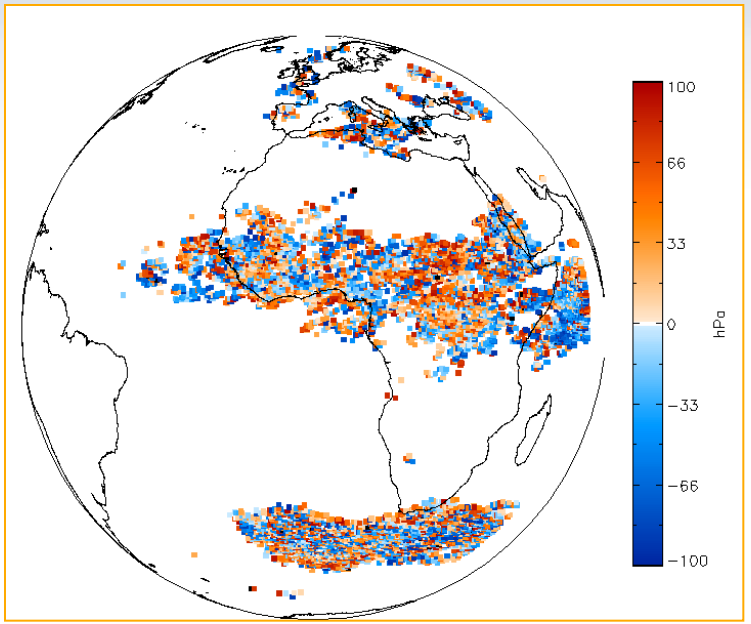


Best-fit pressure

CCC – best-fit height, 5 September 2013 (II)

WV6.2

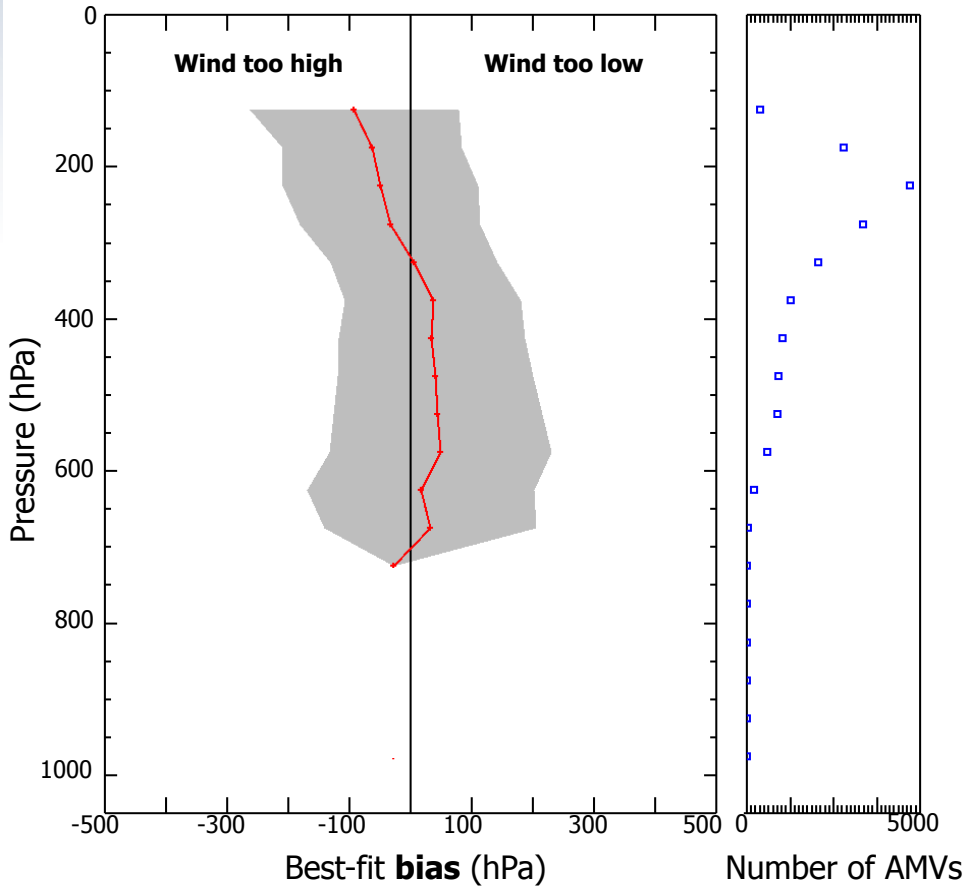


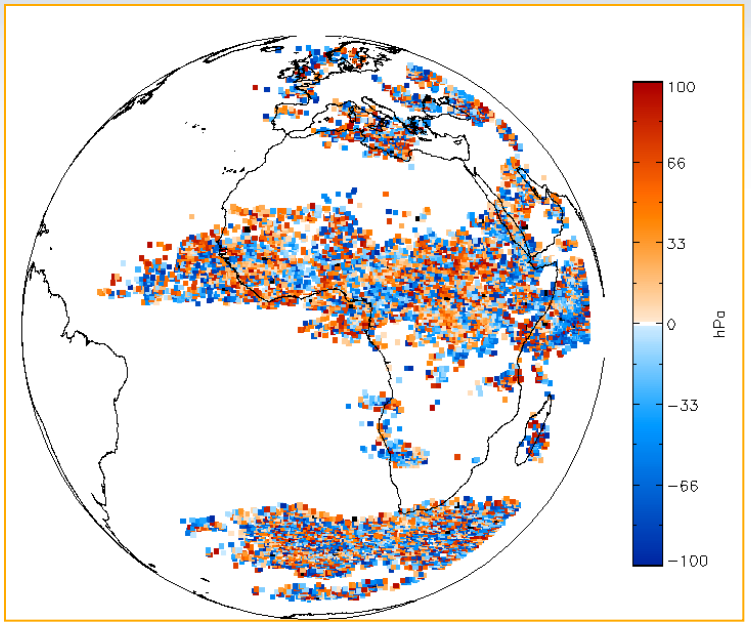


Best-fit pressure

CCC – best-fit height, 5 September 2013 (III)

WV7.3

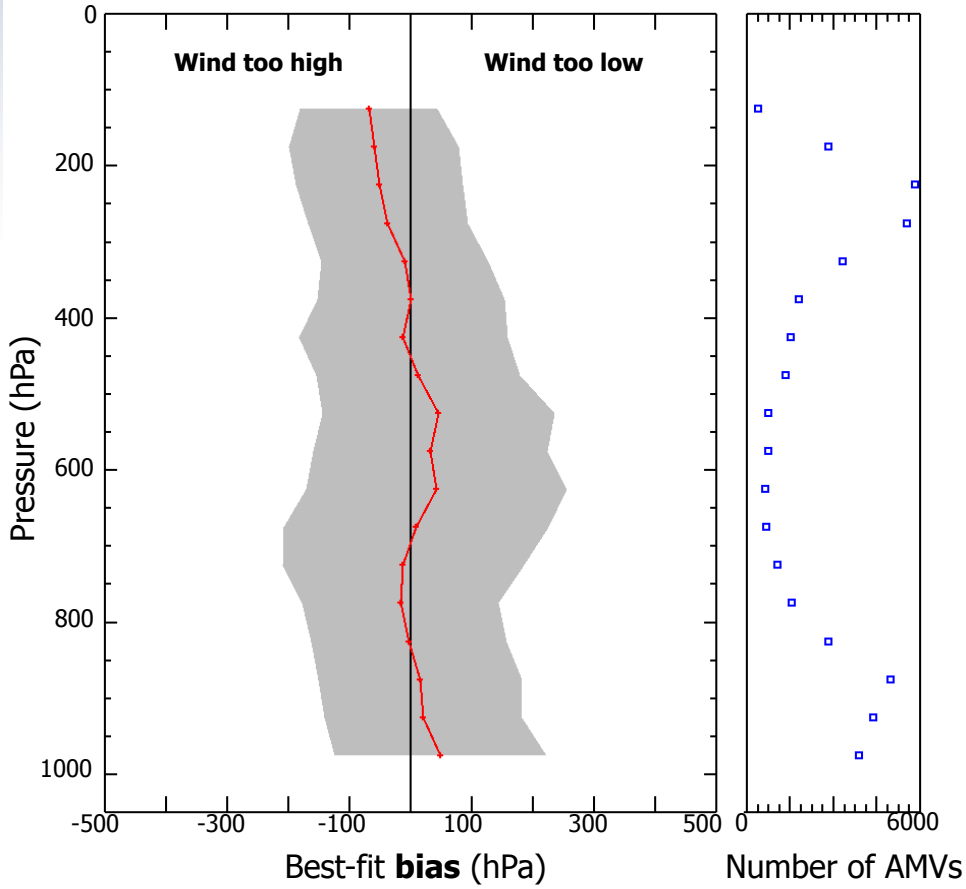


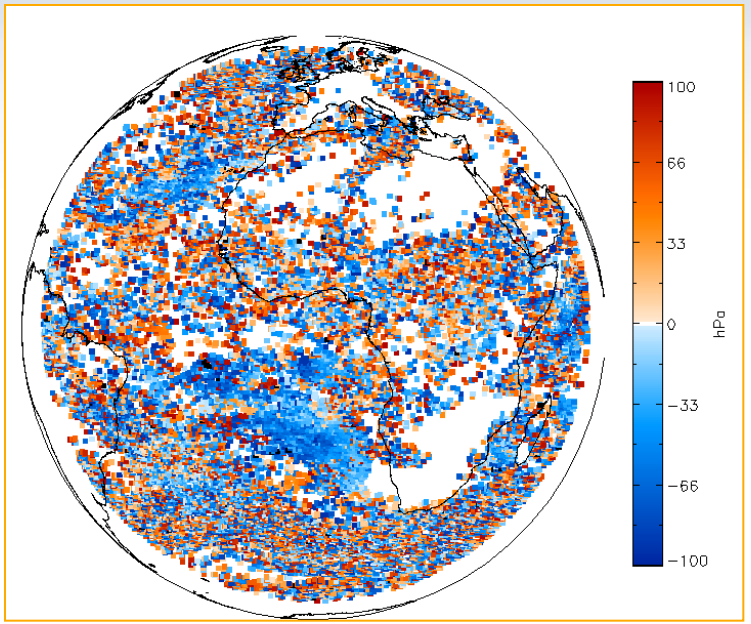


Best-fit pressure

CCC – best-fit height, 5 September 2013 (IV)

IR10.8





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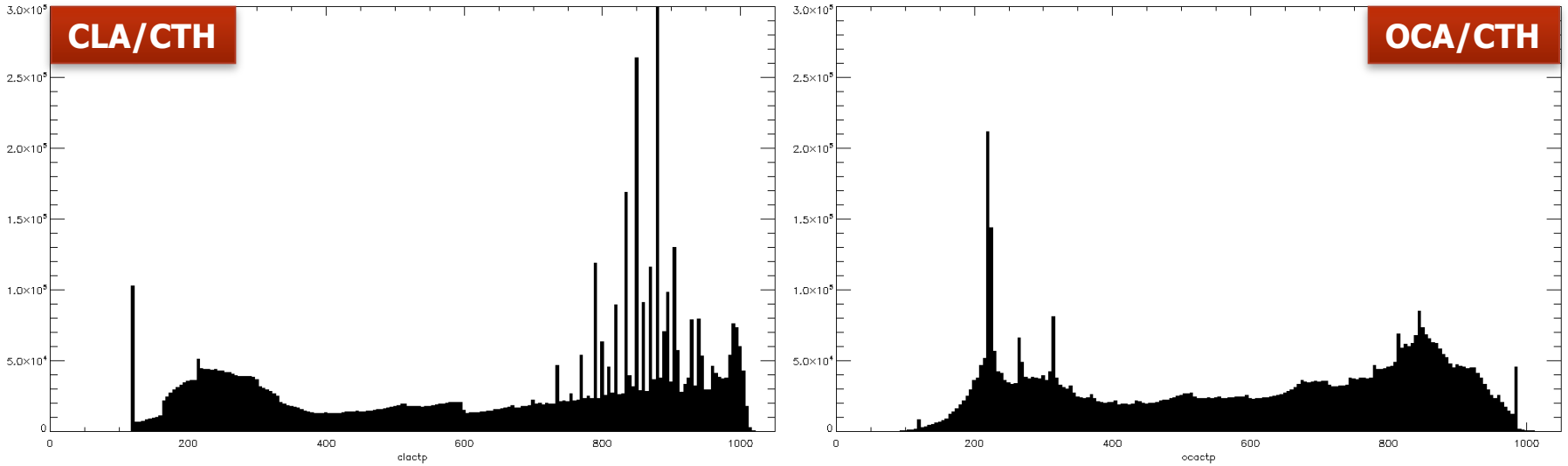
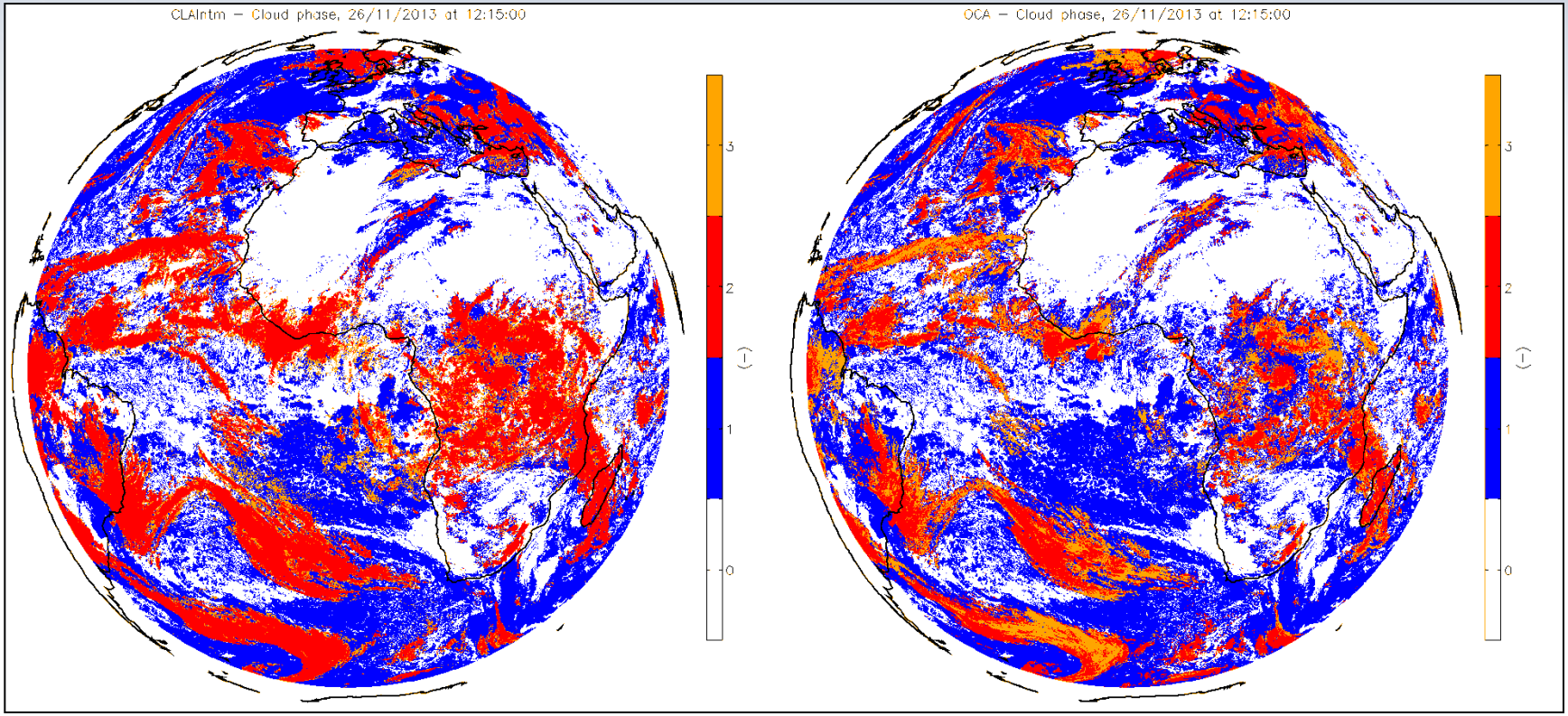
Optimal Cloud Analysis (OCA)
Introduction to OCA

- **OCA**: **Optimal Cloud Analysis** algorithm developed at EUMETSAT.
- Latest version uses two layers. Cloud-top height is computed for both.
- Microphysics parameters are computed: cloud phase, cloud effective radius, cloud optical thickness, etc.



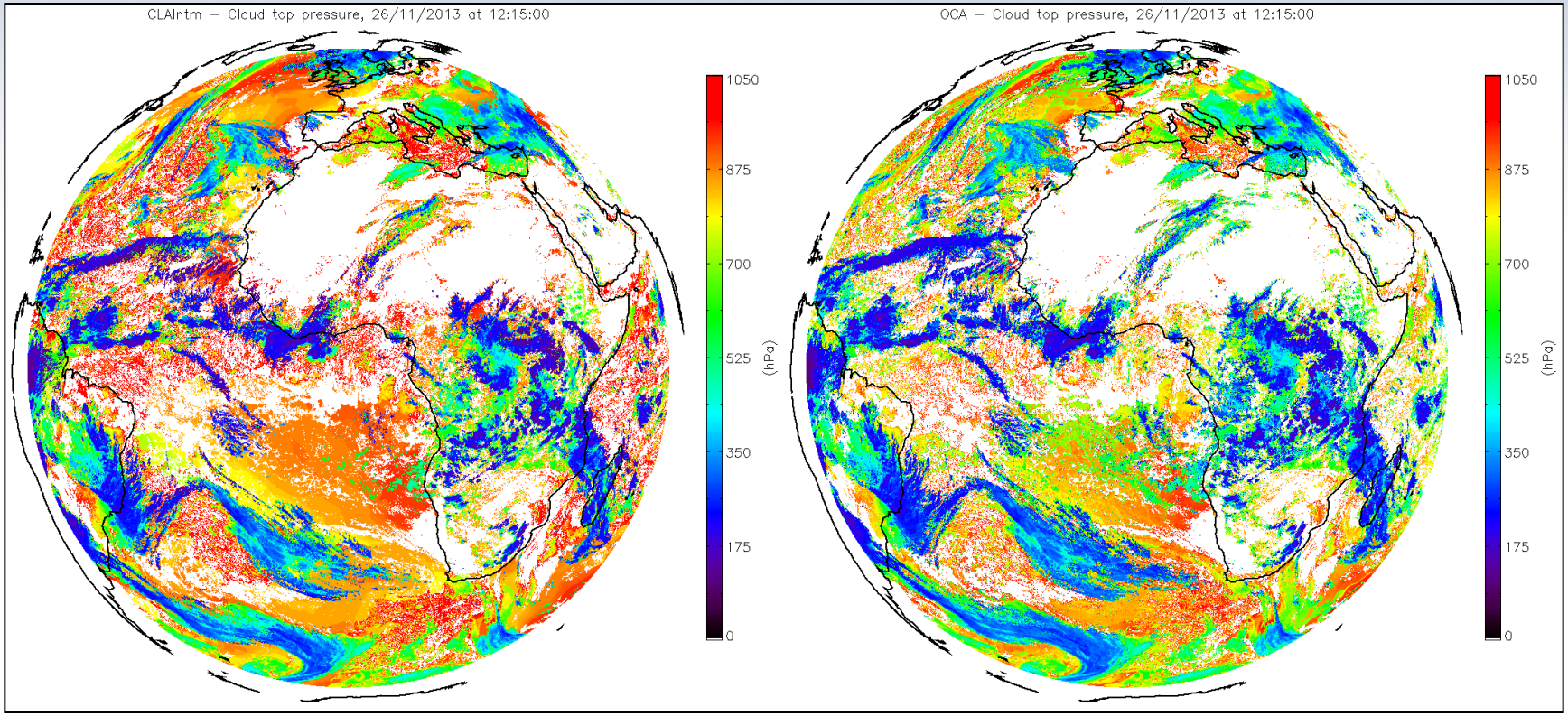
Optimal Cloud Analysis (OCA)

Cloud phase: CLA vs. OCA, 26 November 2013



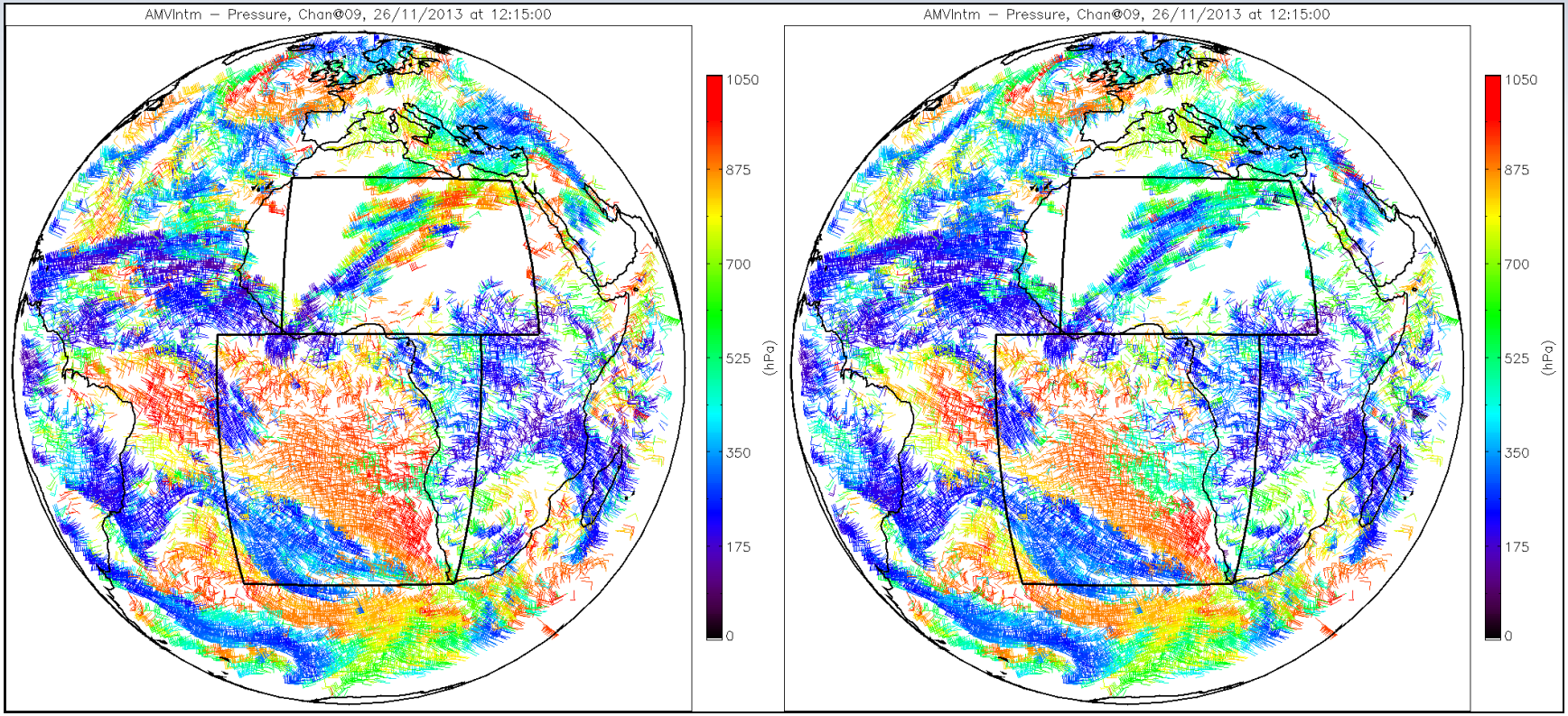
Optimal Cloud Analysis (OCA)

Cloud-top pressure: CLA vs. OCA, 26 November 2013



Optimal Cloud Analysis (OCA)

AMV Intermediate Product: CLA vs. OCA, 26 November 2013



Optimal Cloud Analysis (OCA)

AMV statistics: CLA vs. OCA, 26 November 2013

1. Winds with vs. without applied inversion (whole globe)

	CLA	OCA	DIFF
Mean overall QI (inversion points)	36.26	36.95	+0.69
Mean forecast QI (inversion points)	54.38	57.62	+3.24
Mean overall QI (other points)	33.86	34.32	+0.46
Mean forecast QI (other points)	49.21	48.62	-0.59

2. Central inversion area (lat. [-35º,5º], lon. [-20º,20º])

	CLA	OCA	DIFF
Mean overall QI	32.78	34.39	+1.61
Mean forecast QI	46.05	50.28	+4.23

3. Jet area (lat. [5º,30º], lon. [-10º,30º])

	CLA	OCA	DIFF
Mean overall QI	27.82	31.44	+3.62
Mean forecast QI	33.10	34.90	+1.80

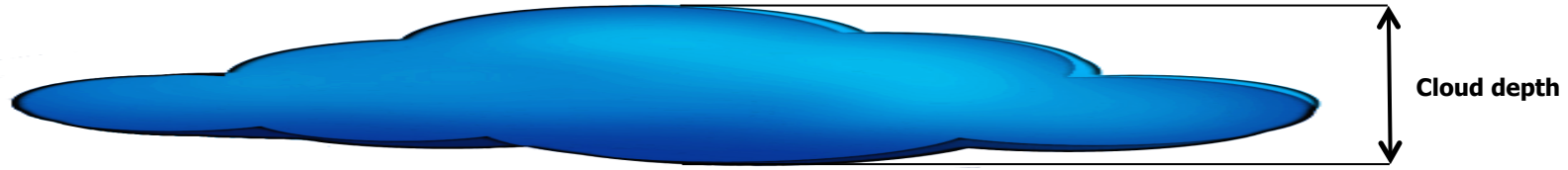
Optimal Cloud Analysis (OCA)

Use of microphysics parameters to set the AMV height

The cloud geometrical depth can be estimated from OCA parameters:

- Meerkötter and Bugliaro:

$$\Delta z_{cloud} = \frac{\sqrt{1.11 \cdot \tau \cdot r_{eff}}}{C_w}, \quad C_w = 4.488 \cdot 10^{-5} \cdot T_{cloud} - 0.010494$$



Alternatively:

- Liquid water path: $LWP = (5/9) \cdot \tau \cdot \rho \cdot r_{eff}$
- CCC weighted average optical thickness, $\Delta\tau$

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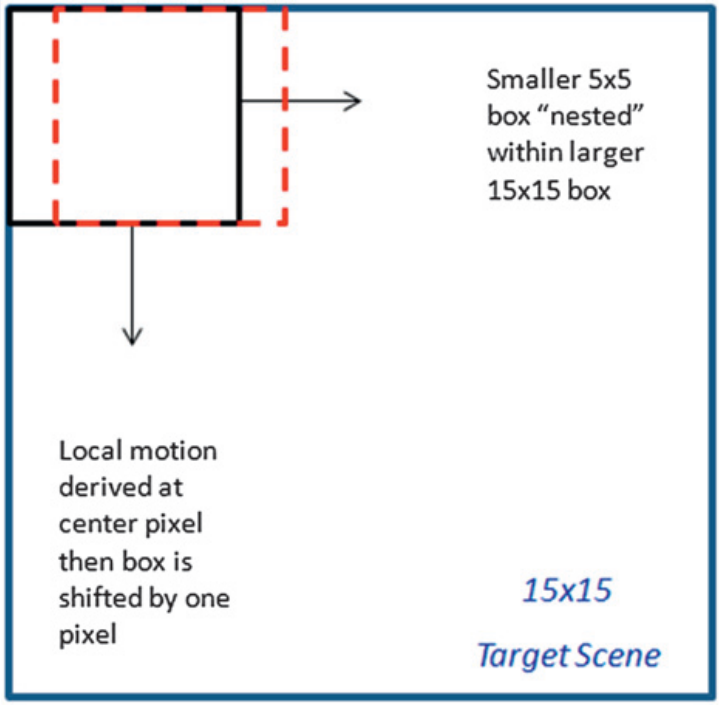
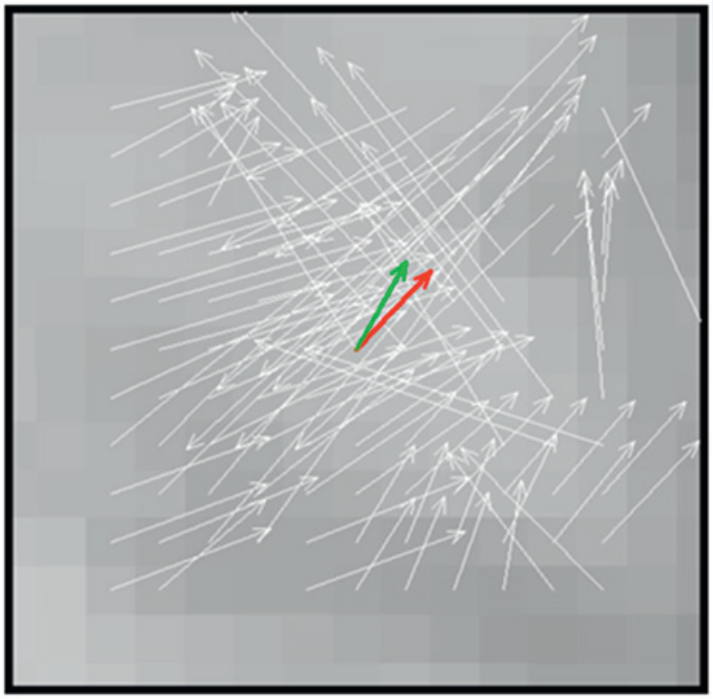
Nested tracking
Algorithm principles (image courtesy of Bresky et al.)

Small box nested within larger box

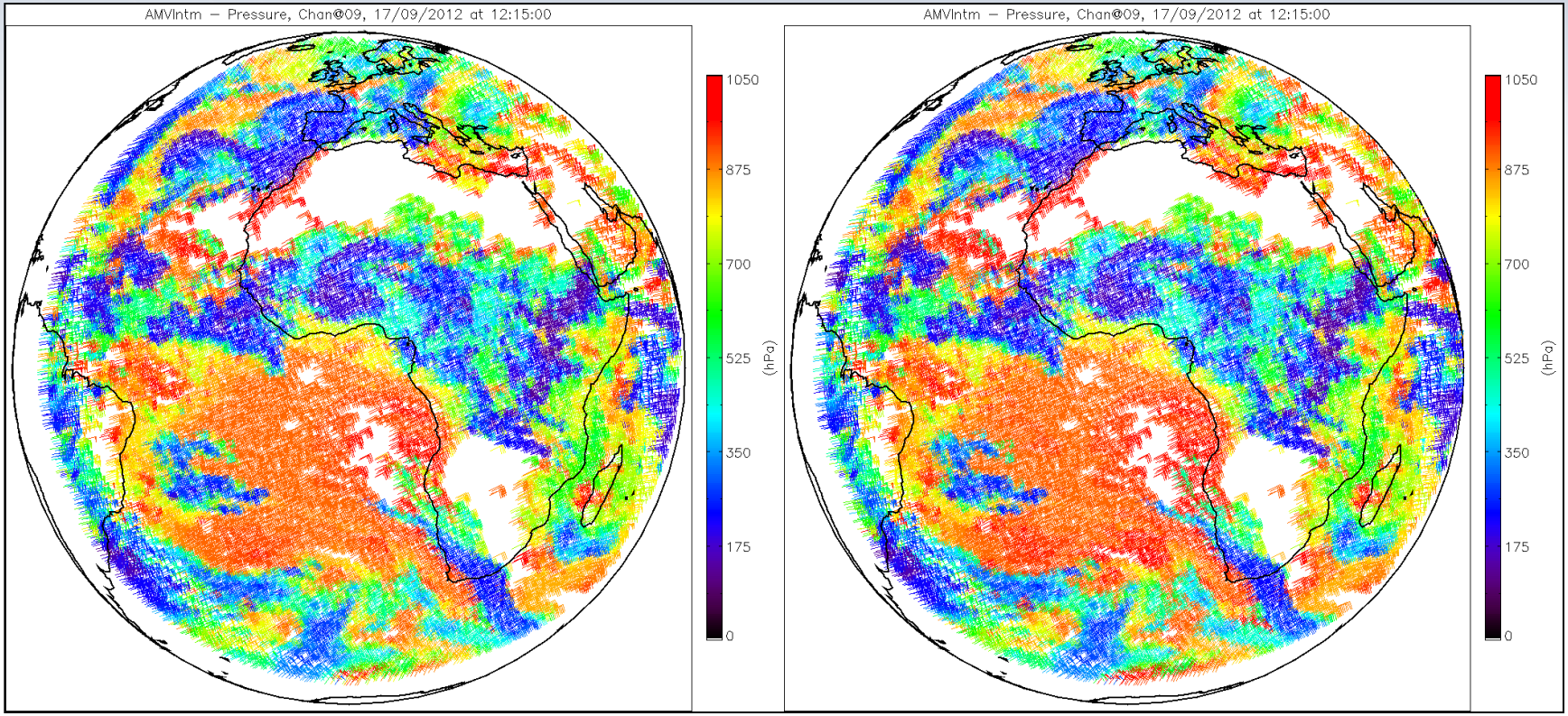


Vector displacements



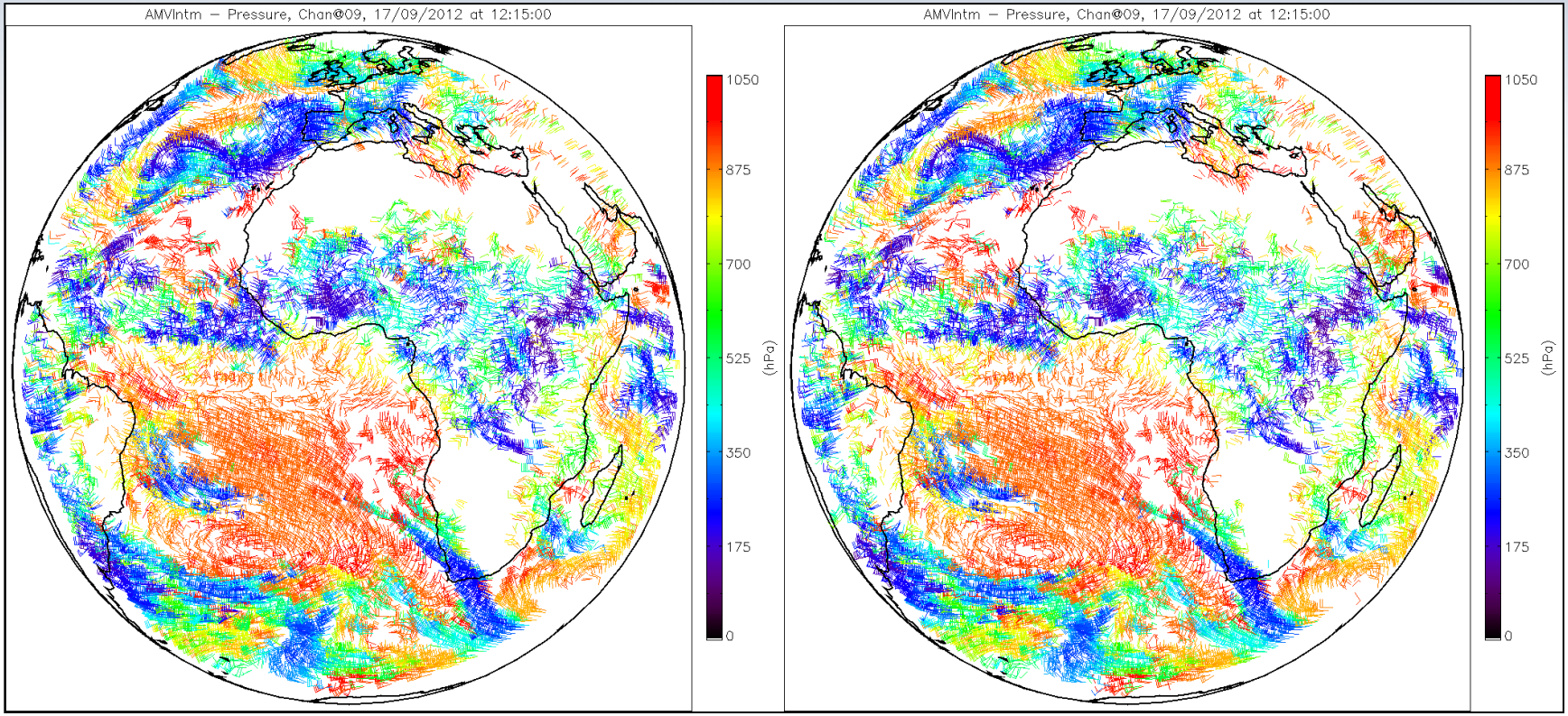
Nested tracking

Preliminary results: CCC vs. Nested Tracking (tracking case)



Nested tracking

Preliminary results: CCC vs. Nested Tracking (nominal case)



Nested tracking

Comparison between NESDIS and EUMETSAT winds, 1 to 7 November 2013

VIS10.8 All winds	NESDIS (Nested tracking) 19x19 box (HH-15, HH, HH +15)	EUMETSAT (CCC) 24x24 box (HH, HH+15, HH+30, HH+45)
Vector RMSE (m/s)	7.29	7.93
Standard Deviation (m/s)	4.48	4.92
Speed Bias (m/s)	-0.61	-2.32
Speed (m/s)	18.75	17.46
Average pressure (hPa)	438	415
Sample	4261	4261

VIS10.8 All winds	NESDIS (Nested tracking) 23x23 box (HH, HH+15, HH+30) No accel. / gross error checks	EUMETSAT (CCC) 24x24 box (HH, HH+15, HH+30, HH+45)
Vector RMSE (m/s)	8.45	8.34
Standard Deviation (m/s)	5.46	5.26
Speed Bias (m/s)	-0.51	-2.12
Speed (m/s)	18.73	17.71
Average pressure (hPa)	445	419
Sample	3323	3323

Summary

Introduction to EUMETSAT's geostationary AMVs

Recent changes:

- Cross-Correlation Contribution (CCC) method
- Best-fit pressure

Current developments

- Optimal Cloud Analysis (OCA)
- Nested tracking

Future work

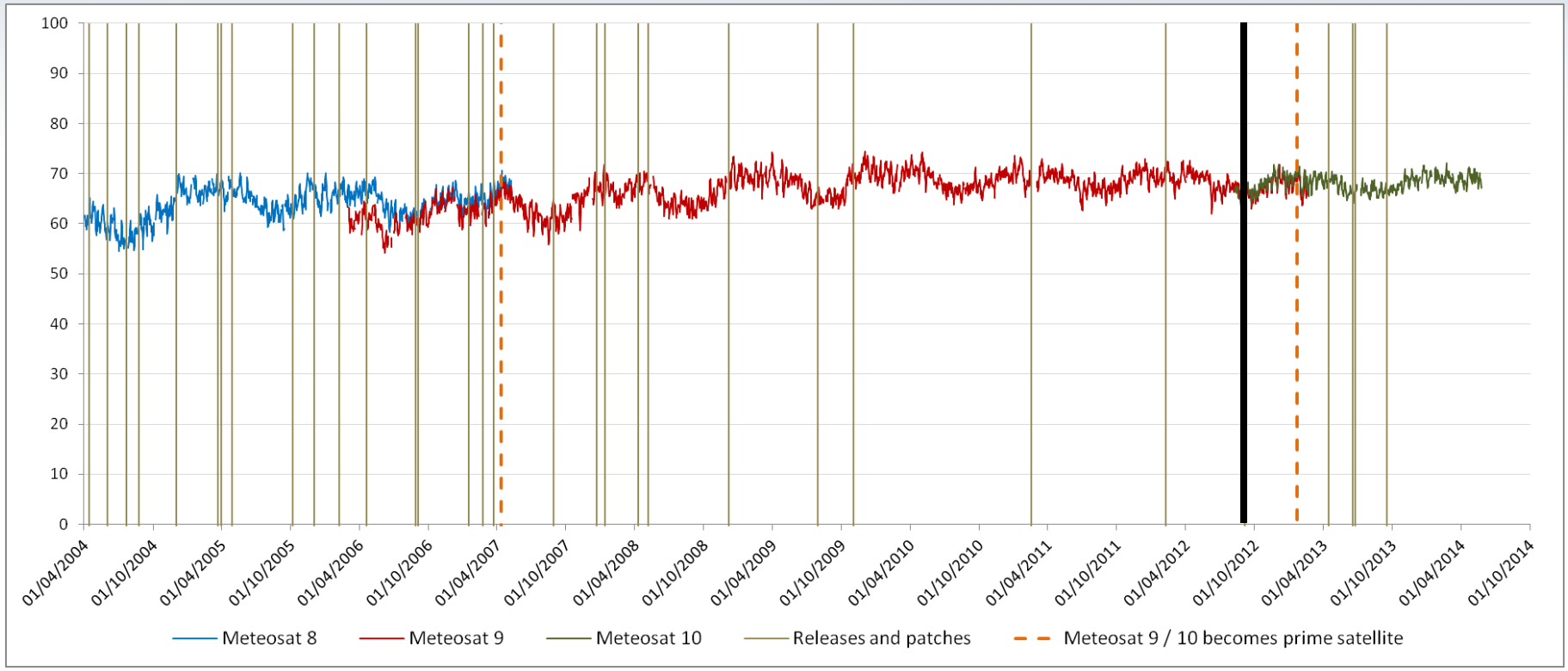
Future work

- **MFG**
  - Introduction of CCC method for the AMV height assignment (December 2015)
  - Divergence product (December 2015)
- **MSG**
  - Use OCA to set AMV height (dependant on OCA availability every 15 min.)
  - Change WV AMV height assignment in clear-sky conditions (December 2015)
  - Continue investigation on nested tracking scheme
- **MTG**
  - MTG FCI: prototyping activities using proxy data
  - MTG IRS: revisit the potential of optical flow methods applied to humidity fields (IASI data and/or proxy data). External study should start in 2014

Thank you!

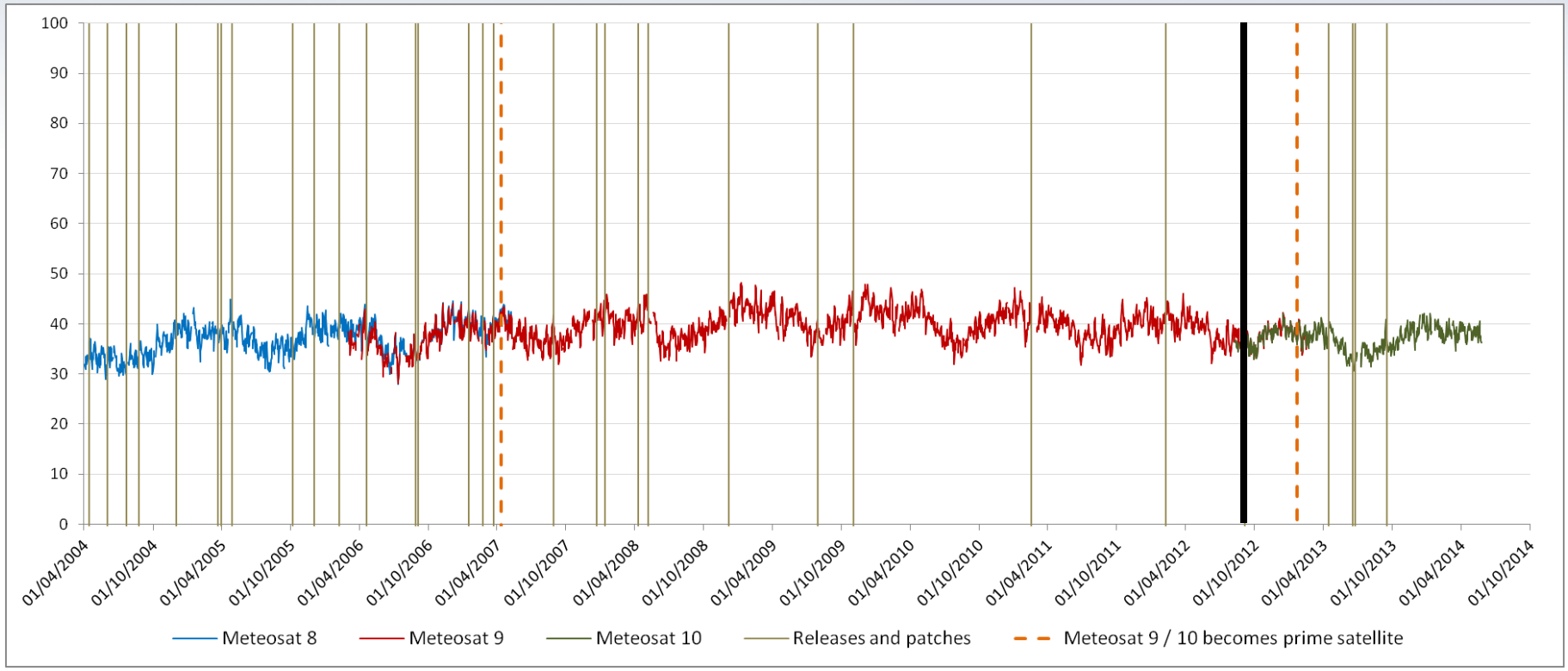
Cross-Correlation Contribution (CCC) method

Spatial vector consistency, channel 05 (WV 6.2 µm)



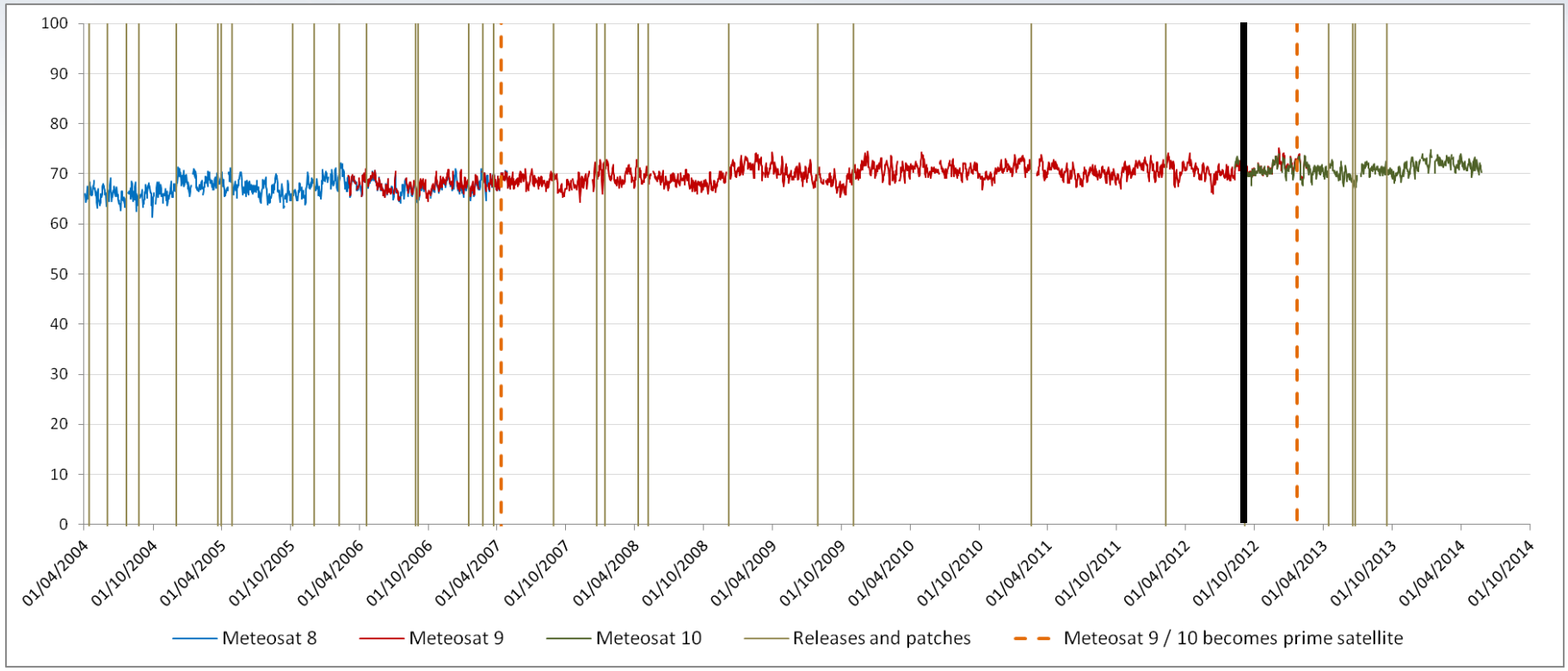
Cross-Correlation Contribution (CCC) method

Forecast consistency, channel 05 (WV 6.2 µm)



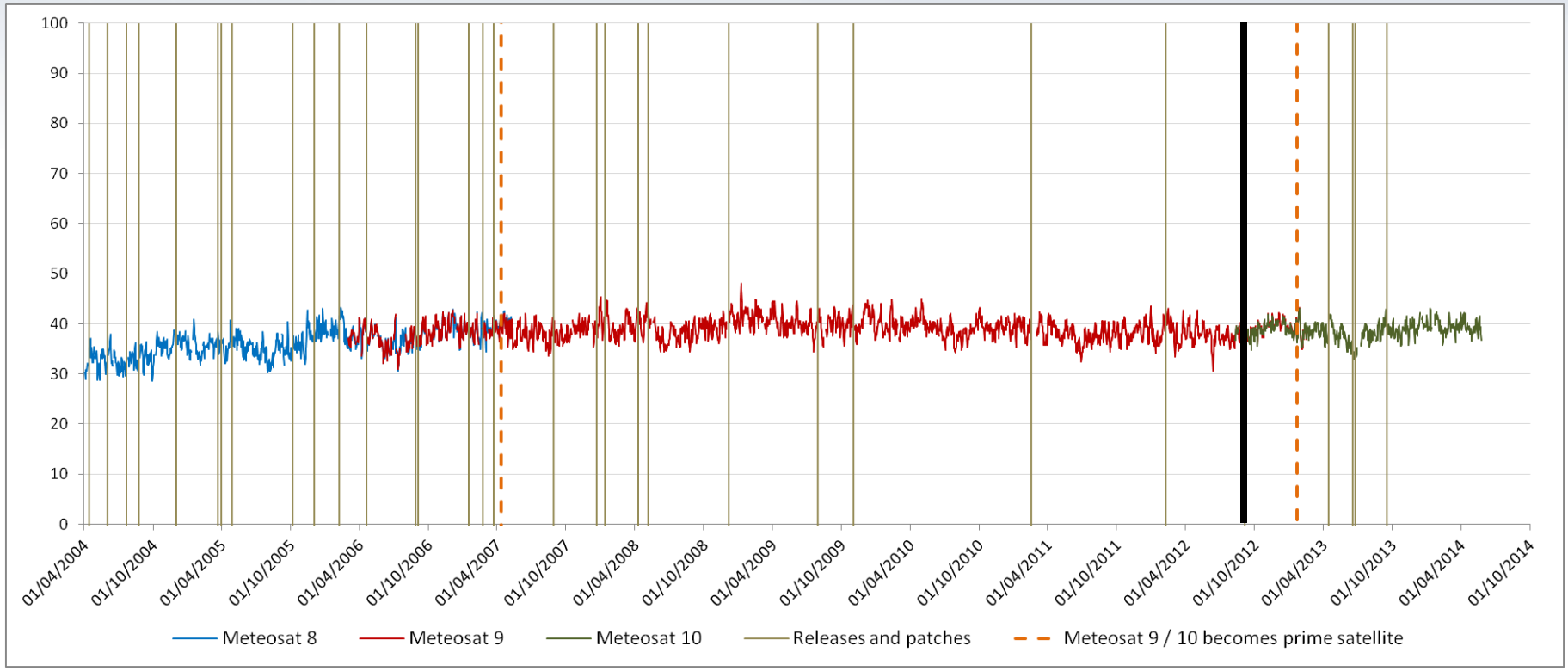
Cross-Correlation Contribution (CCC) method

Spatial vector consistency, channel 06 (WV 7.3 µm)



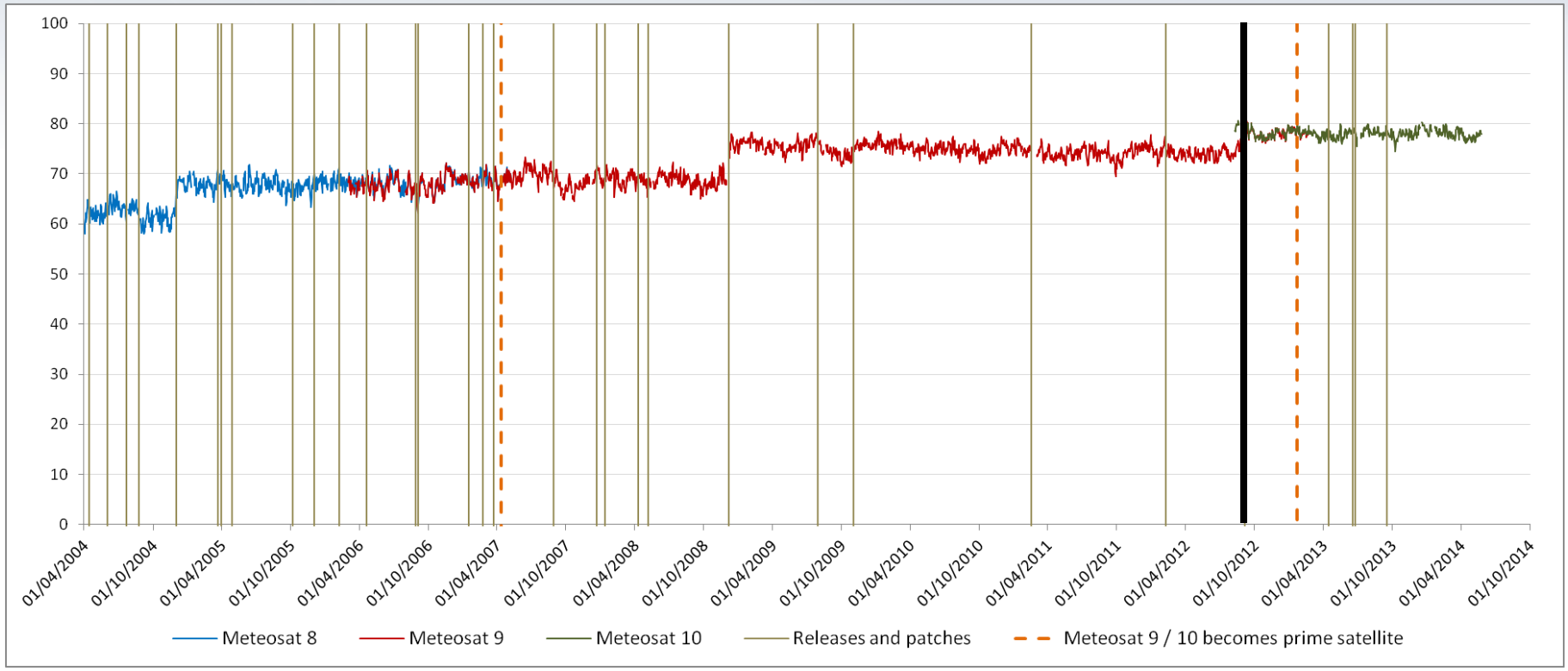
Cross-Correlation Contribution (CCC) method

Forecast consistency, channel 06 (WV 7.3 µm)



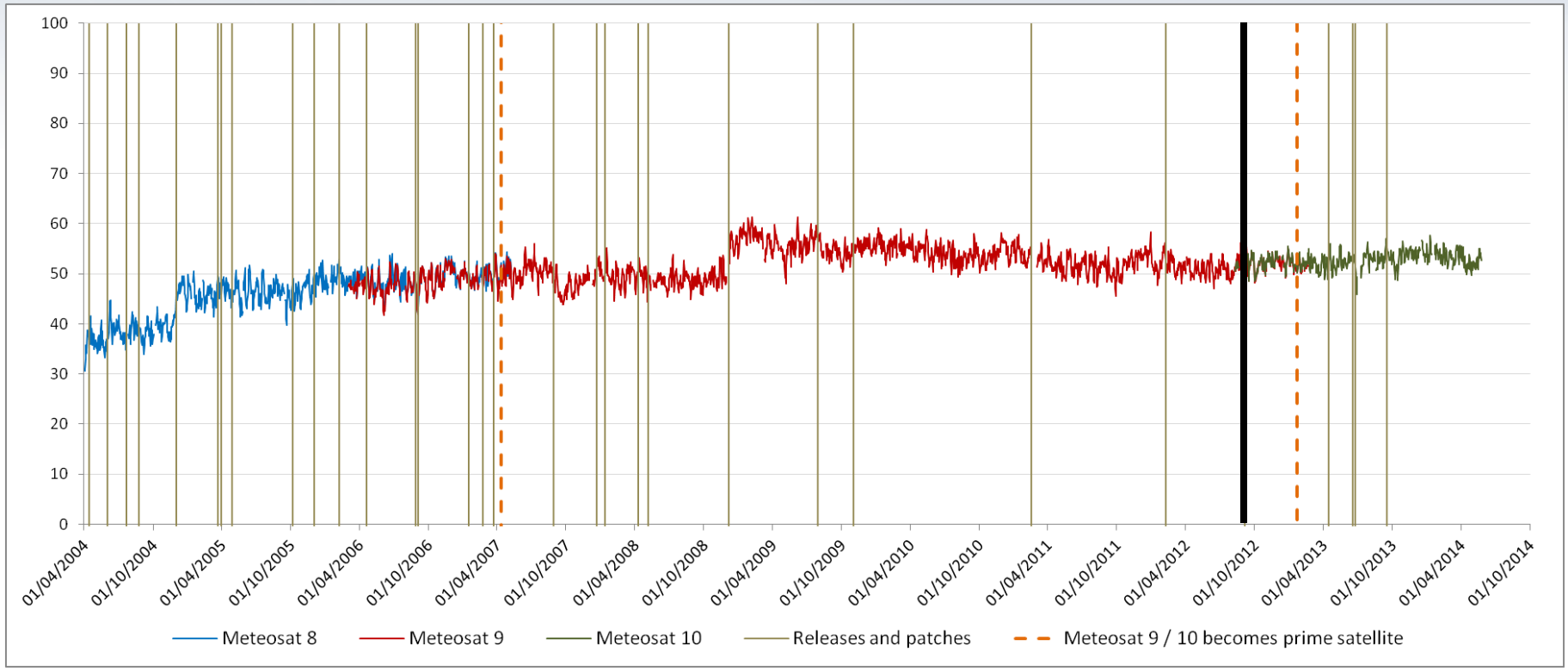
Cross-Correlation Contribution (CCC) method

Spatial vector consistency, channel 09 (IR 10.8 µm)



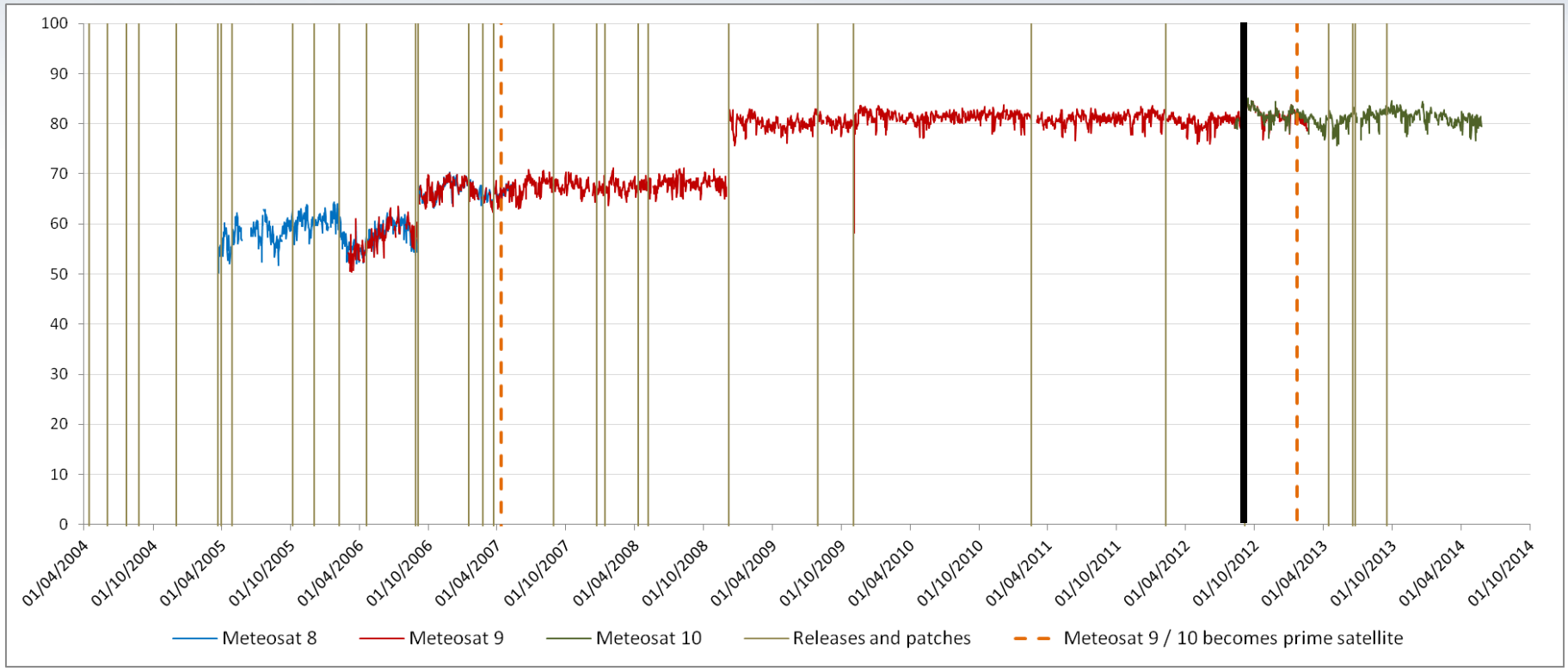
Cross-Correlation Contribution (CCC) method

Forecast consistency, channel 09 (IR 10.8 µm)



Cross-Correlation Contribution (CCC) method

Spatial vector consistency, channel 12 (HRVIS)



Cross-Correlation Contribution (CCC) method

Forecast consistency, channel 12 (HRVIS)