Use of satellite winds at Deutscher Wetterdienst (DWD)

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- Introduction
- Atmospheric motion vector winds (geo and polar)
- MISR winds
- IODC experiments

Numerical Weather Prediction at DWD

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Global model GME

Grid spacing: 20 km

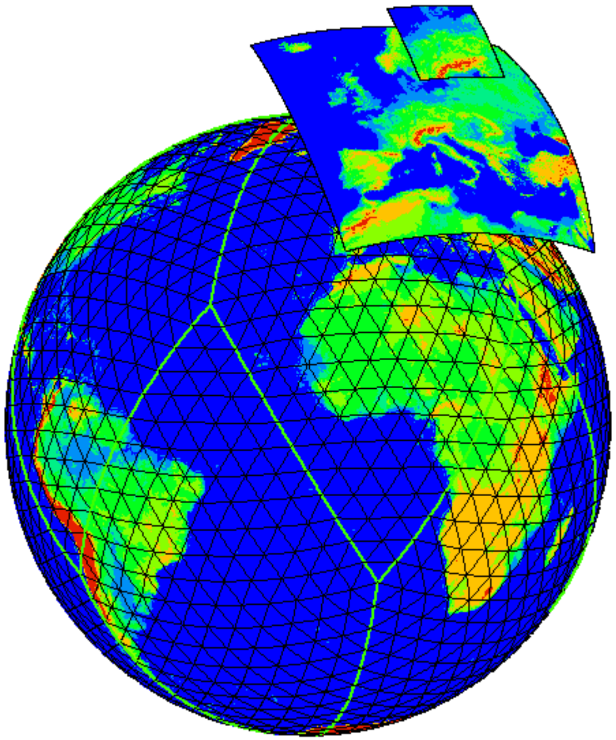
Layers: 60

Forecast range:

174 h at 00 and 12 UTC

48 h at 06 and 18 UTC

1 grid element: 778 km^2



COSMO-DE EPS

Pre-operational

20 members

Grid spacing: 2.8 km

Variations in:

lateral boundaries, initial conditions, physics

COSMO-EU

Grid spacing: 7 km

Layers: 40

Forecast range:

78 h at 00 and 12 UTC

48 h at 06 and 18 UTC

1 grid element: 49 km^2

COSMO-DE

Grid spacing: 2.8 km

Layers: 50

Forecast range:

21 h at 00, 03, 06, 09,

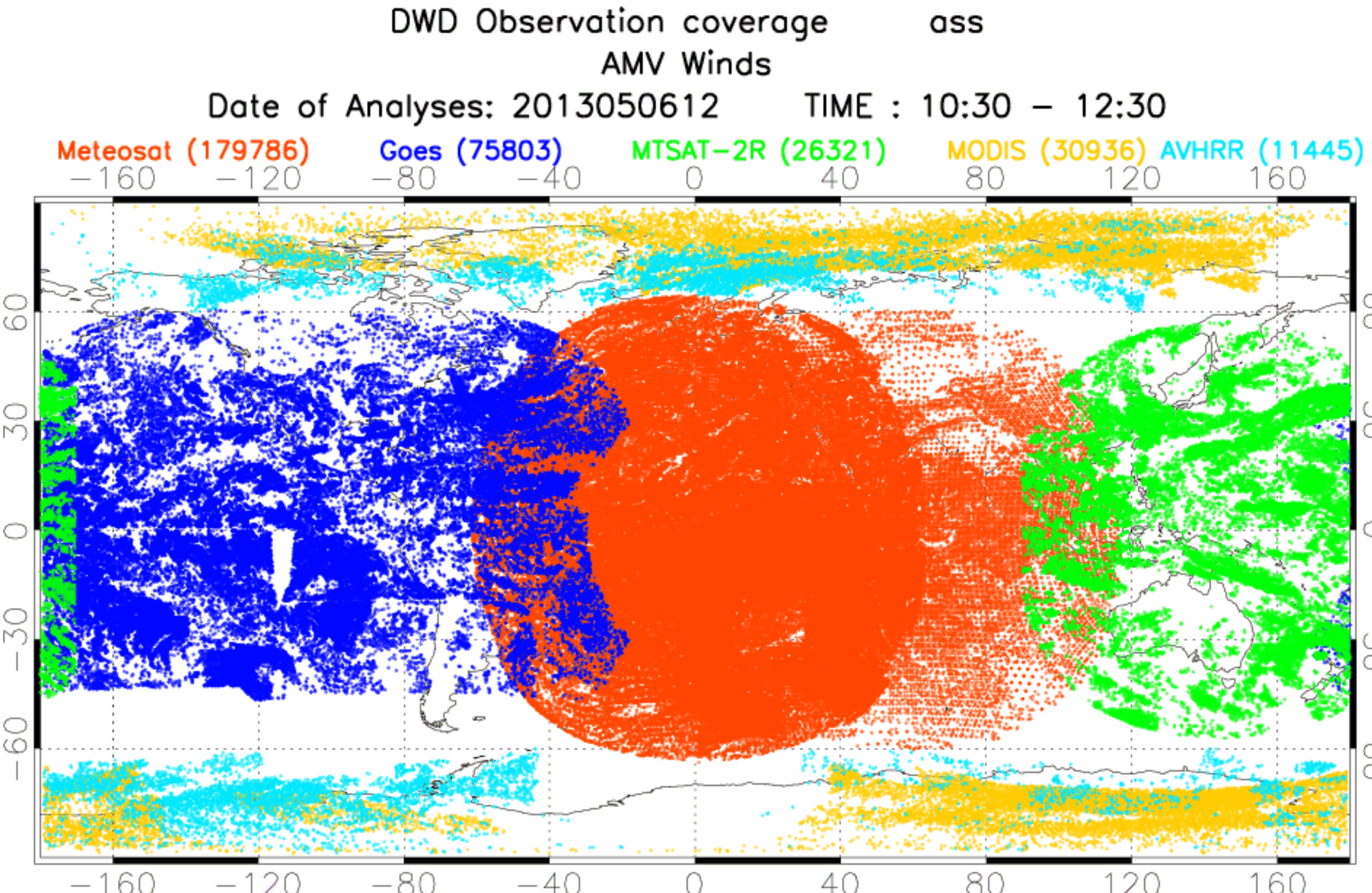
12, 15, 18, 21 UTC

1 grid element: 8 km^2

Usage of AMV winds at DWD

- Geostationary satellites (GOES 13/15; Eumetsat 7/10; MTSAT-2R)
  - extratropics and tropics over oceans and land
  - IR above 1000 hPa
  - WVcloudy above 400 hPa; WVclear is not used
  - VIS below 700 hPa
  - QI threshold blacklisting
  - FG check: asymmetric to remove negative OBS-FG bias
  - Thinning: 1 wind per pre-defined thinning box (200 km;15 vertical layers).
    data selection by highest noFirst Guess QI in a box

- Polar orbiting satellites (MODIS, AVHRR, DB MODIS, DB AVHRR)
  - over land and oceans
  - IR above 1000 hPa, over Antartica over 600 hPa
  - WVcloudy above 600 hPa
  - QI threshold blacklisting
  - FG check: asymmetric to remove negative OBS-FG bias
  - Thinnig: 1 wind per thinning box (~60 km; 15 vertical layers)


DWD Observation coverage ass
AMV Winds
Date of Analyses: 2013050612 TIME : 10:30 – 12:30
Meteosat (179786) Goes (75803) MTSAT-2R (26321) MODIS (30936) AVHRR (11445)
-160 -120 -80 -40 0 40 80 120 160
60 30 0 -30 -60

Eumetsat
CCC height assignment method

Before:

- Use of different height assignment methods for different cloud types, independently from feature tracking.
- AMVs assumend to be representative of winds at cloud top height.

Main changes:

- Use of CCC approach to better link the pixels used in the height assignment with those that dominate in the tracking
- Make direct use of pixel-based cloud top pressures from CLA product rather than generating AMV CTPs.

➢ Pre-operational monitoring showed significant improvements for medium and high level winds

➢ Increse in RMSVD of ~20% for IR and VIS winds at low levels in the Southern Hemisphere and Tropics

✓ Operational since Sep. 2012; patch for low level winds in April 2013

CCC height assignment method

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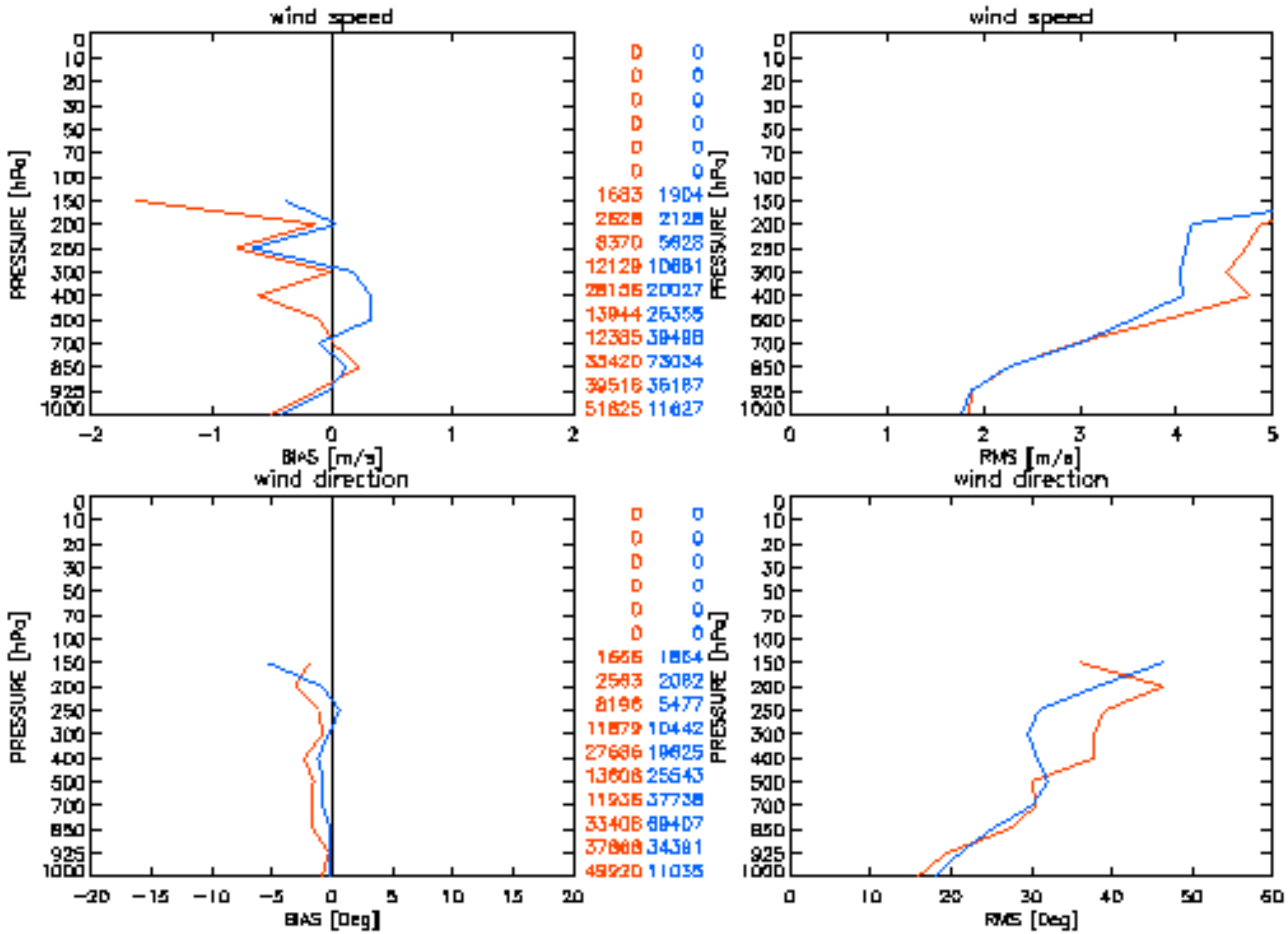

Figure 15: *Vertical profiles of infrared AMV wind speed bias (left) and rms (right) for the old AMV height assignment method (red) and the new CCC height assignment method (blue) for the period 05/06/2012 - 05/07/2012.*

CCC height

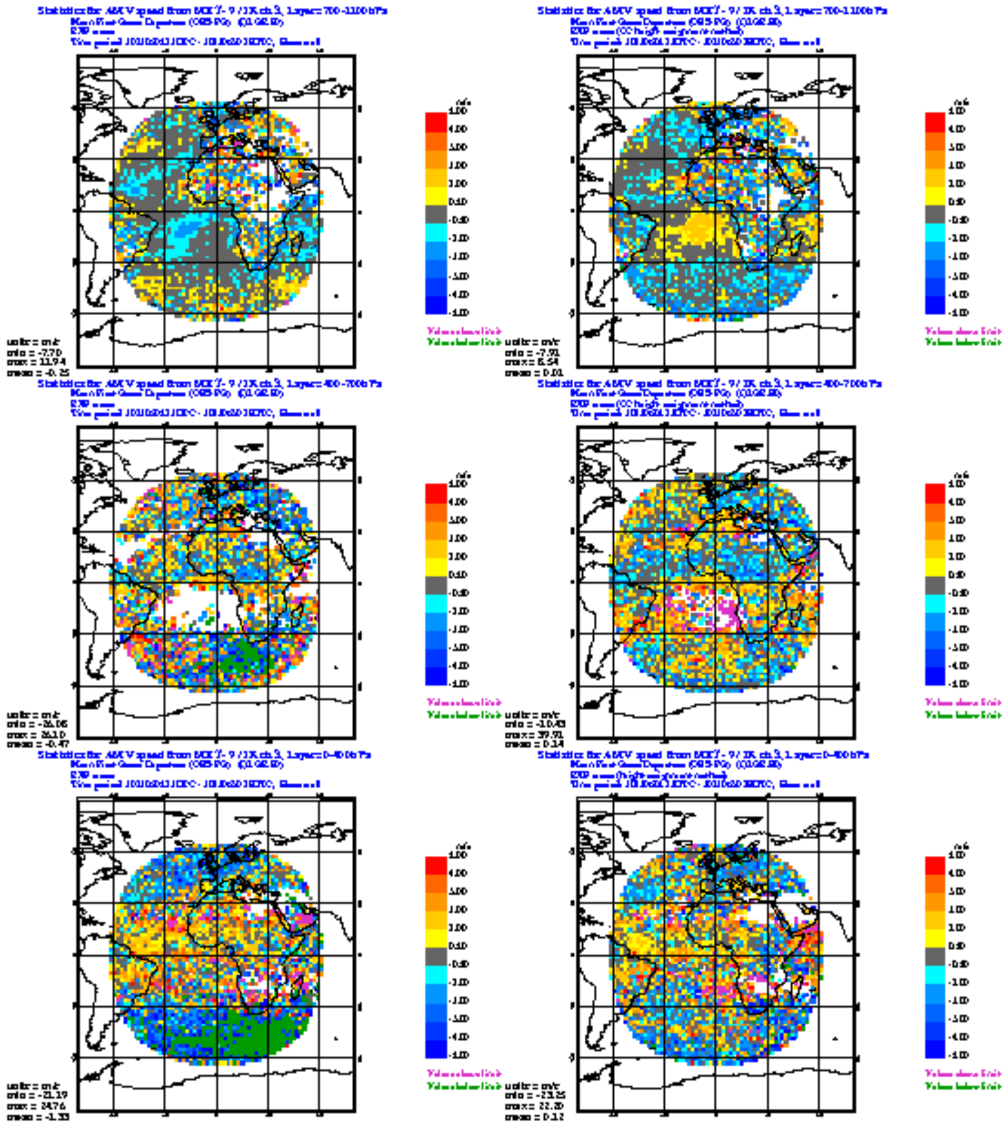

Figure 18: *Regional distribution of infrared AMV wind speed first guess departures for the old AMV height assignment method (left) and the new CCC height assignment method (right) for the lower (upper two panels), mid (middle panels) and lower (bottom two panels) levels and the period 05/06/2012 - 05/07/2012.*

AMVs: Monitoring of AMVs with ccc-method height assignment

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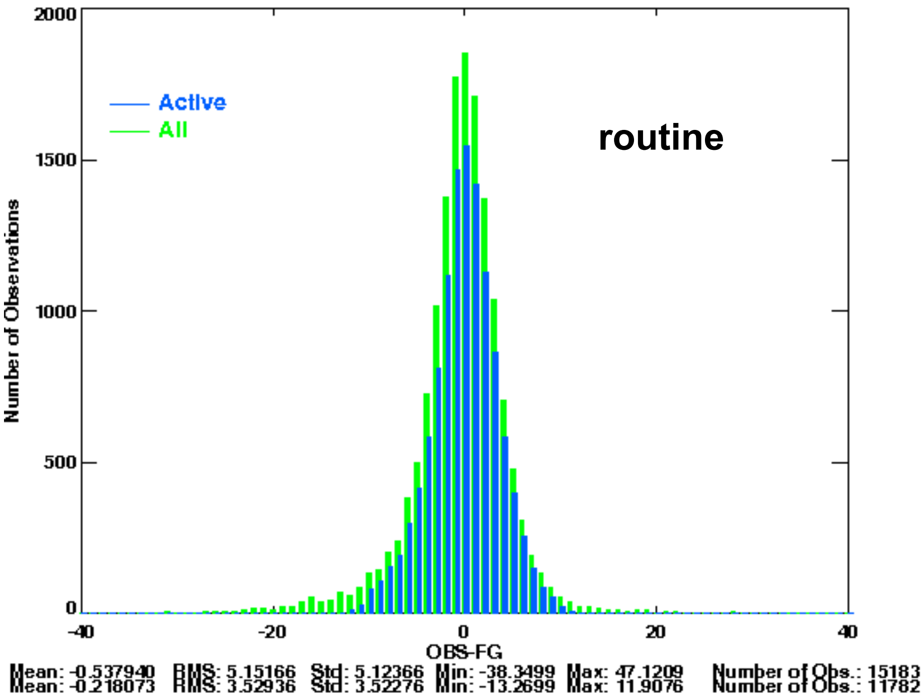
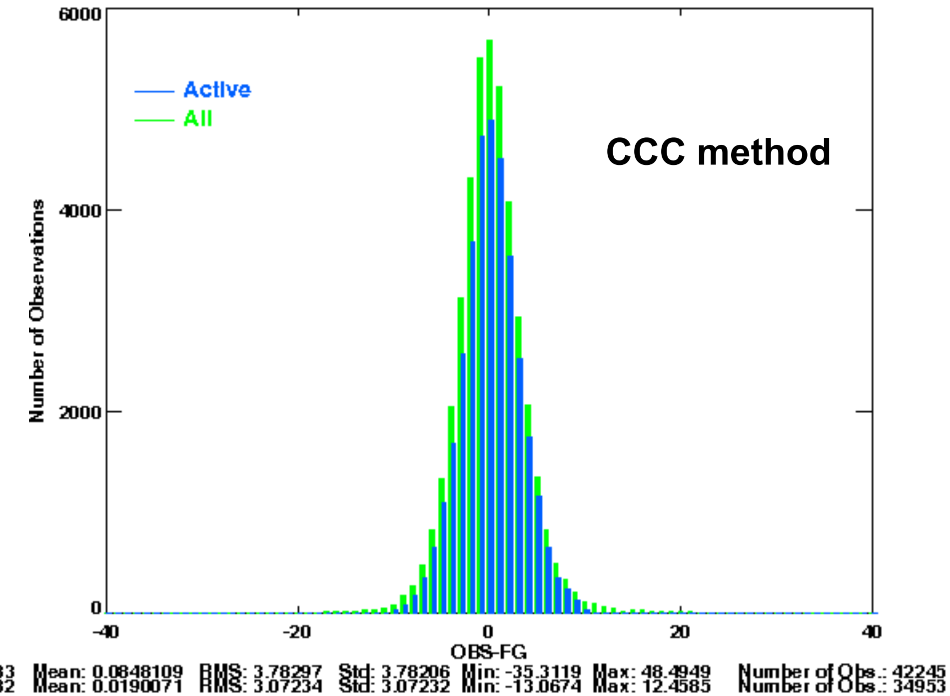
Meteosat 9
Medíum level (700 – 400 hPa) infrared winds QI > 80
2012060512 - 2012070518





- Better quality winds by using the CCC Height Assignment method for medium and high level winds
- Number of high quality winds (QI > 80) increases for medium level winds in case of CCC method
- Quality of low level winds in Tropics and Southern Hemisphere decreases slightly

Validation of MET-10 products (AMVs)

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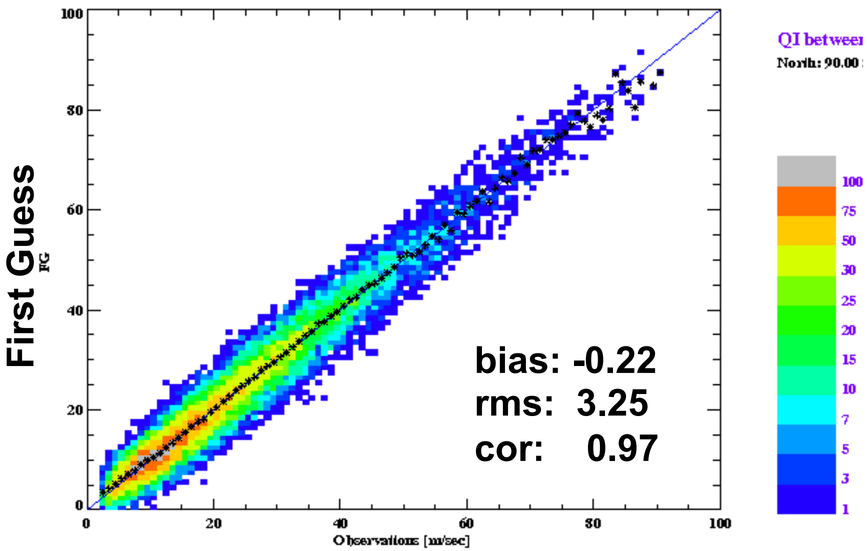
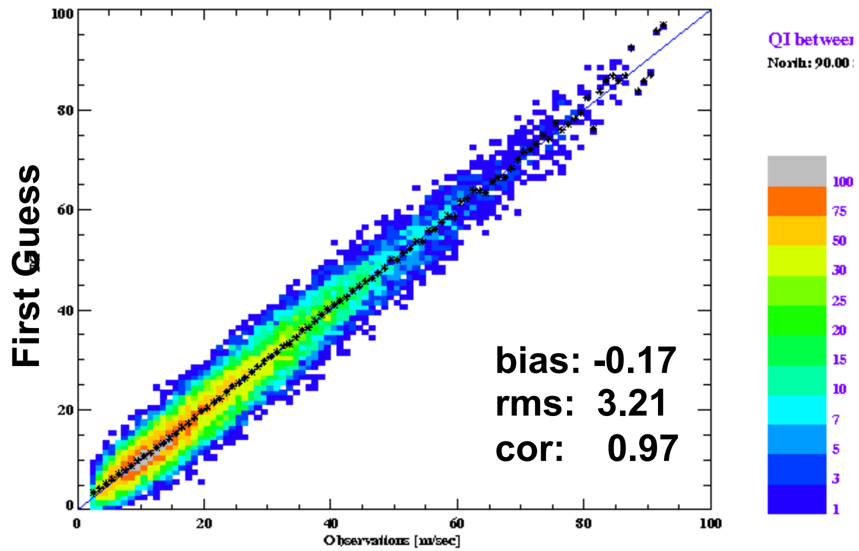
High level infrared AMV winds (used)
2012121800 - 2012122818

Meteosat-9



Observation

Meteosat-10



Observation

Quality of Meteosat-10 AMV
comparable to or slightly better than AMVs from Meteosat-9

METOP-B : AVHRR polar winds

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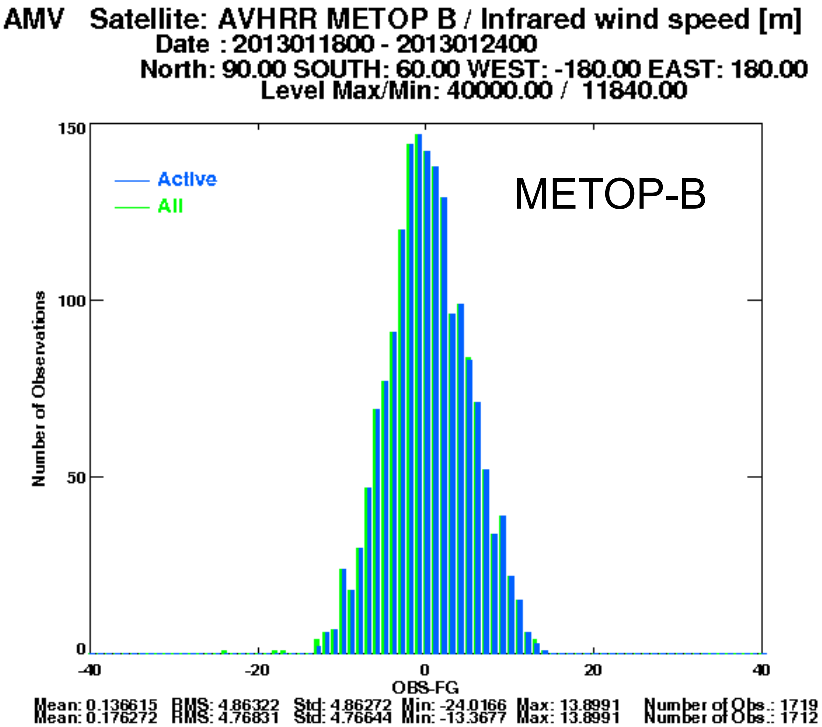
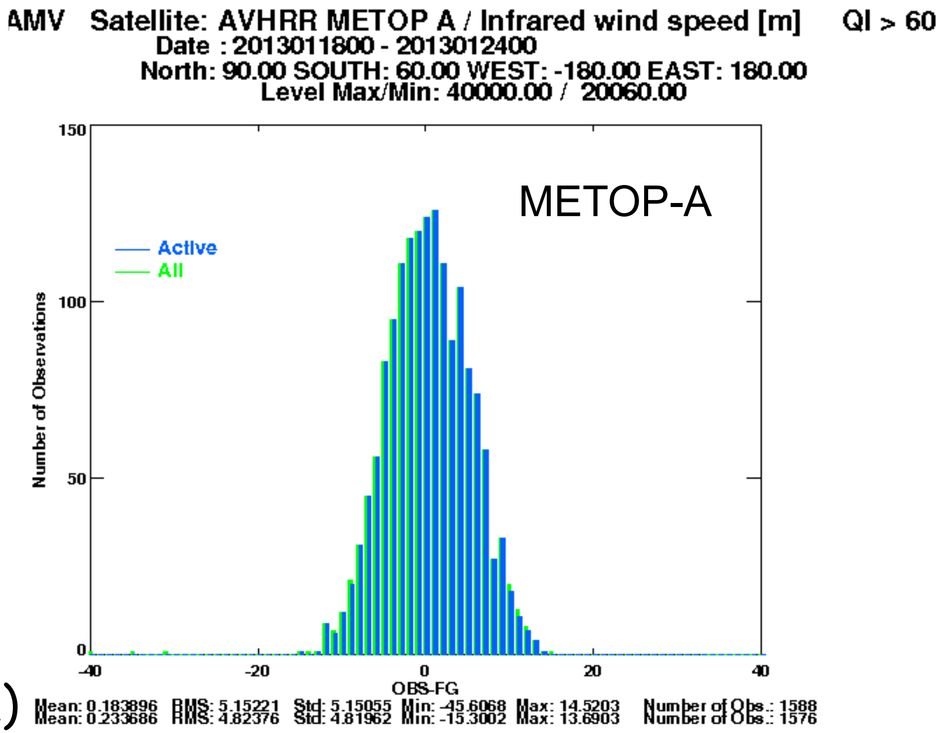
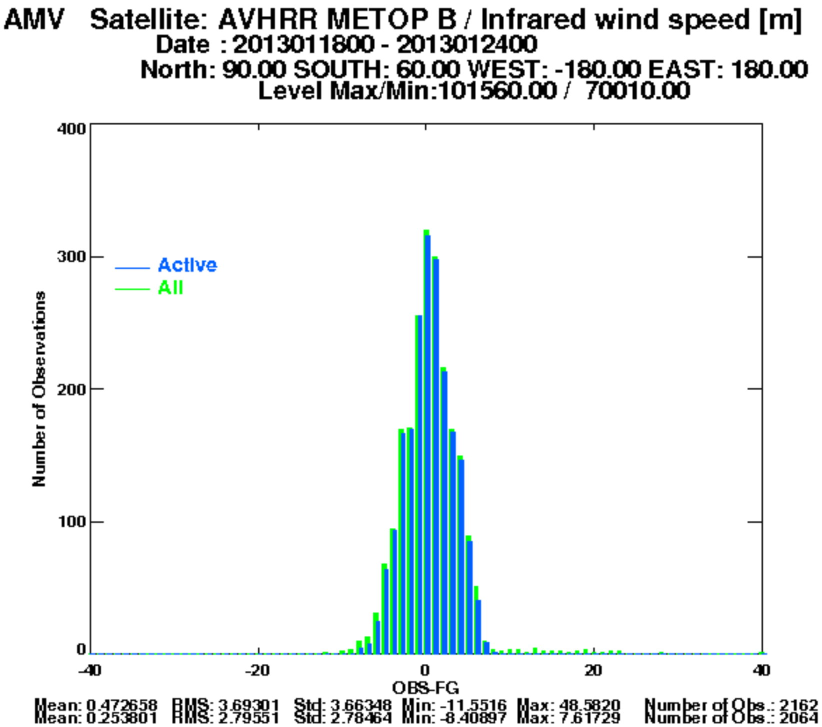


Test data 18.1. – 24.1.2013
IR 400 – 100 hPa
QI > 60

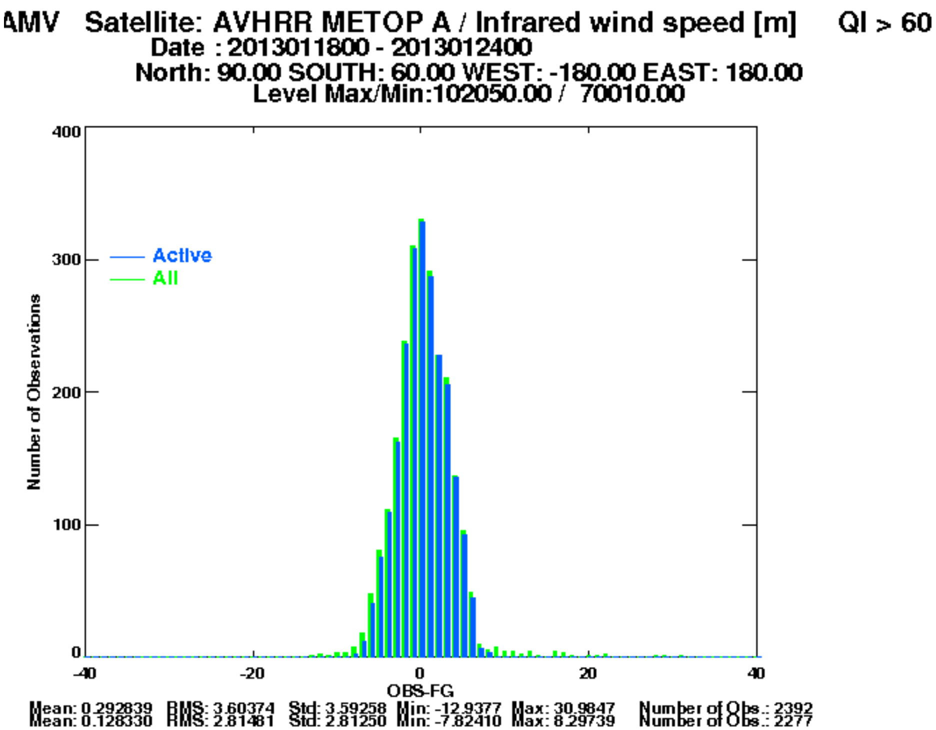


- ~10% more data
- highest at 118 hPa (METOP-A: 200hPa)
- slightly smaller bias (and stdv)

METOP-B : AVHRR polar winds



Test data 18.1. – 24.1.2013
IR 1000 – 700 hPa
Qi > 60



- ~10% less data
- slightly larger bias

New observation errors

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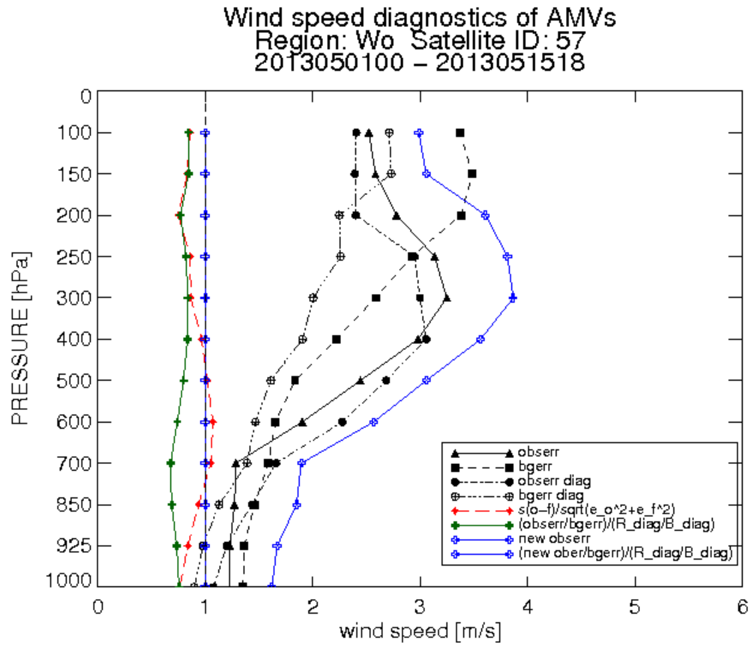
Diagnosis of observation, background error statistics in observation space



- After Desroziers et. al.
- Diagnose observation and background-error variance
- Compare diagnosed error variances with corresponding errors used in the assimilation

Results

- Background errors seems slightly overestimated and observation errors seem to be underestimated in the analysis
- More pronounced in case of polar winds
- Specification of observation errors more critical than background error
- Same differences between tropics, extra tropics and polar regions

AMV experiments

Exp: 9325/9327: Revised observation error after Desrozier

Exp: 9447/9456: Same as 9327 but with smaller sgm_fg (sgm_fg from 3 -> 2)

First guess check:

$$|obs - fg| < sgm\_fg * sqrt(obserr^2 + bgerr^2)$$

=> more outliers will be rejected

Both changes work global for all different AMVs (geo and polar)
Specified obserr different for different satellites

Meteosat 10 / infrared winds / global
2013050100 - 2013052518

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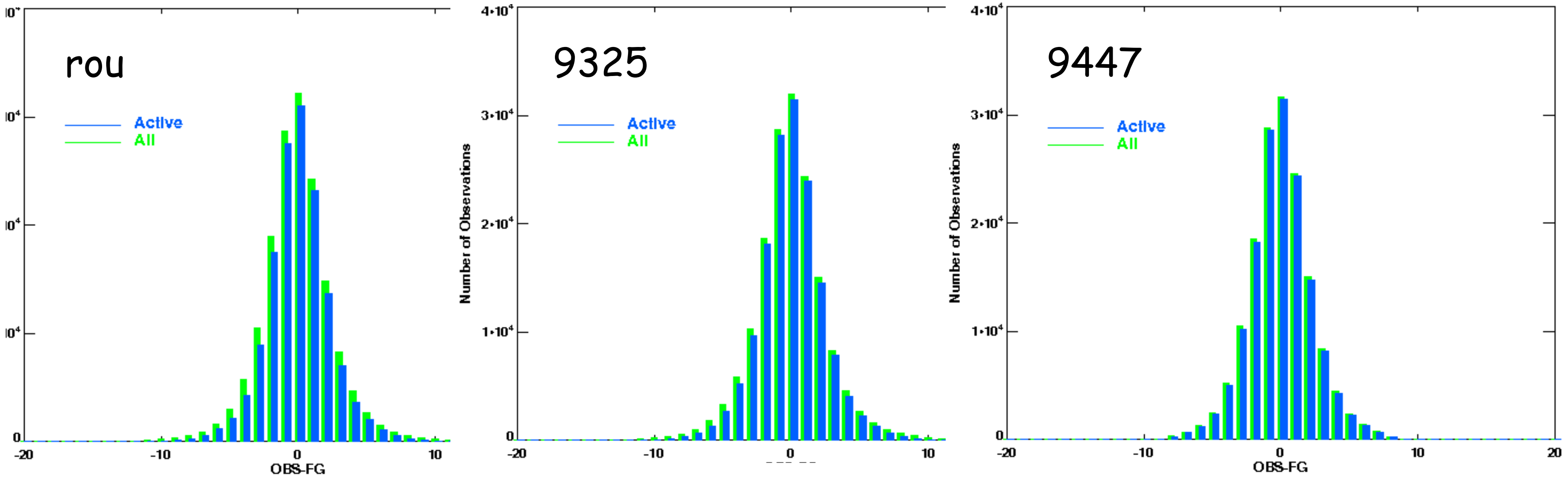

	bias	rms	stdv	min	Max	number
Routine	-0.15483 -0.14779	2.58512 2.26382	2.58049 2.25899	-14.3824 -12.0930	14.2424 12.7403	161348 145354
Exp.: 9325	-0.14741 -0.14919	2.65206 2.35778	2.64797 2.35305	-14.2836 -12.5968	14.1242 14.1242	162384 153181
Exp.: 9447	-0.13149 -0.13014	2.30296 2.26439	2.30011 2.26066	-9.75785 -9.75785	10.1495 10.1495	156711 153861

Mean analysis error difference 2013050112 – 2013053112

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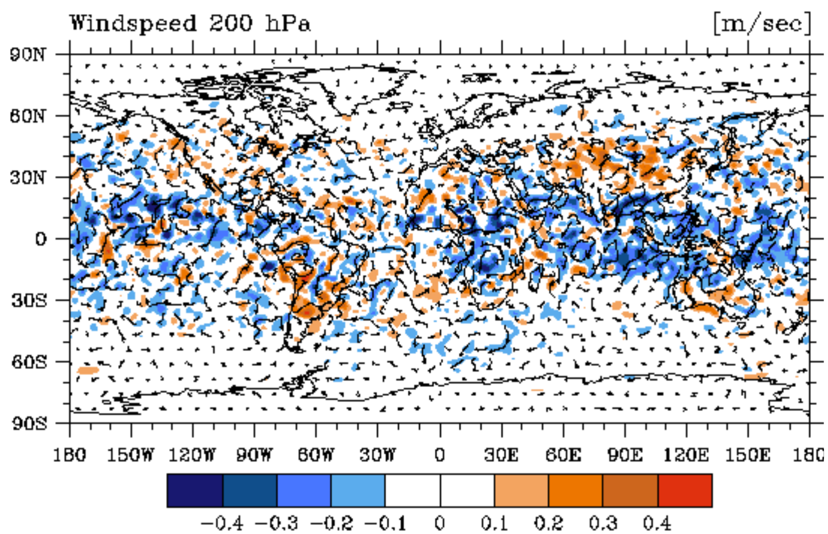
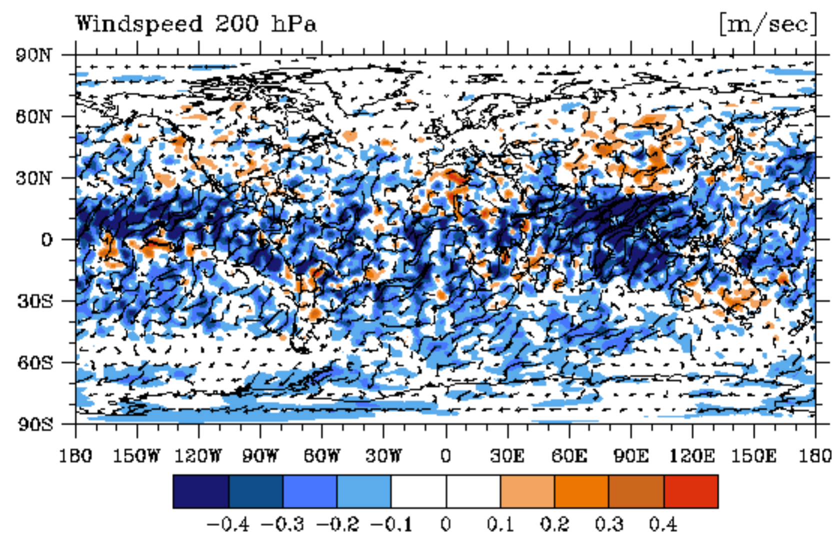
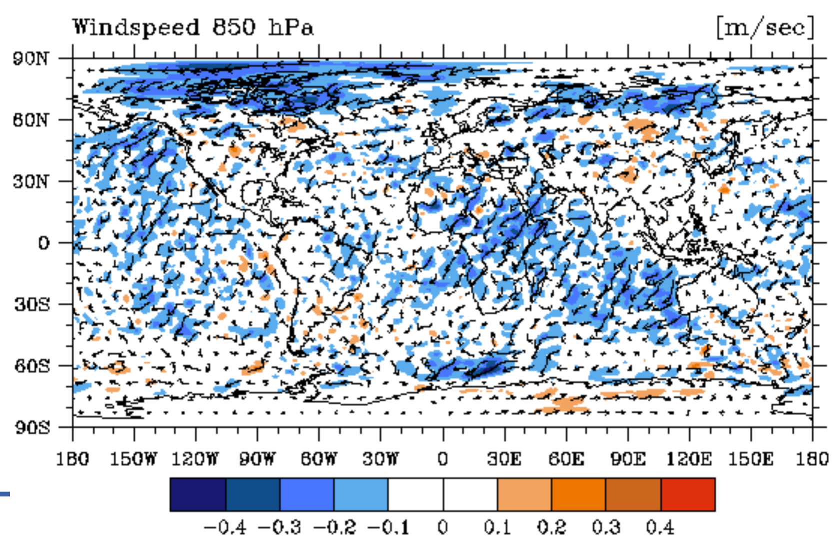
Mean Windspeed/Vector error difference (9325 - Ctrl)



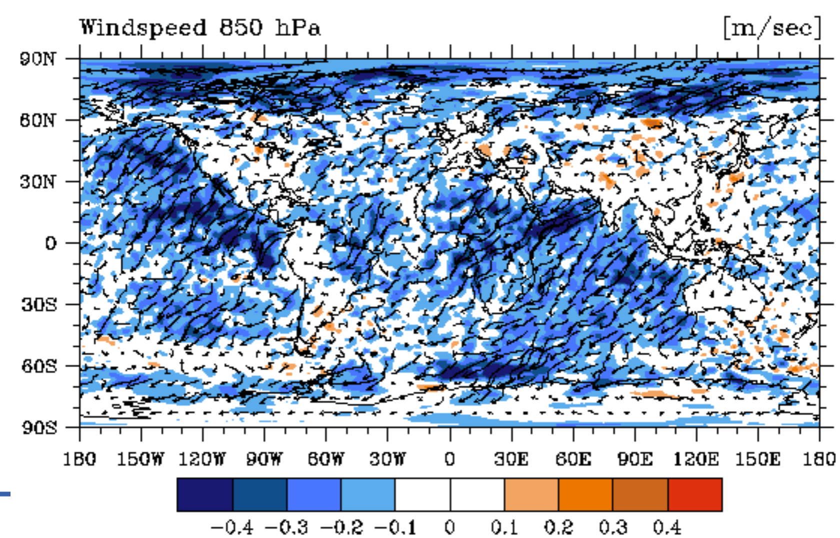
Mean Windspeed/Vector error difference (9447 - Ctrl)



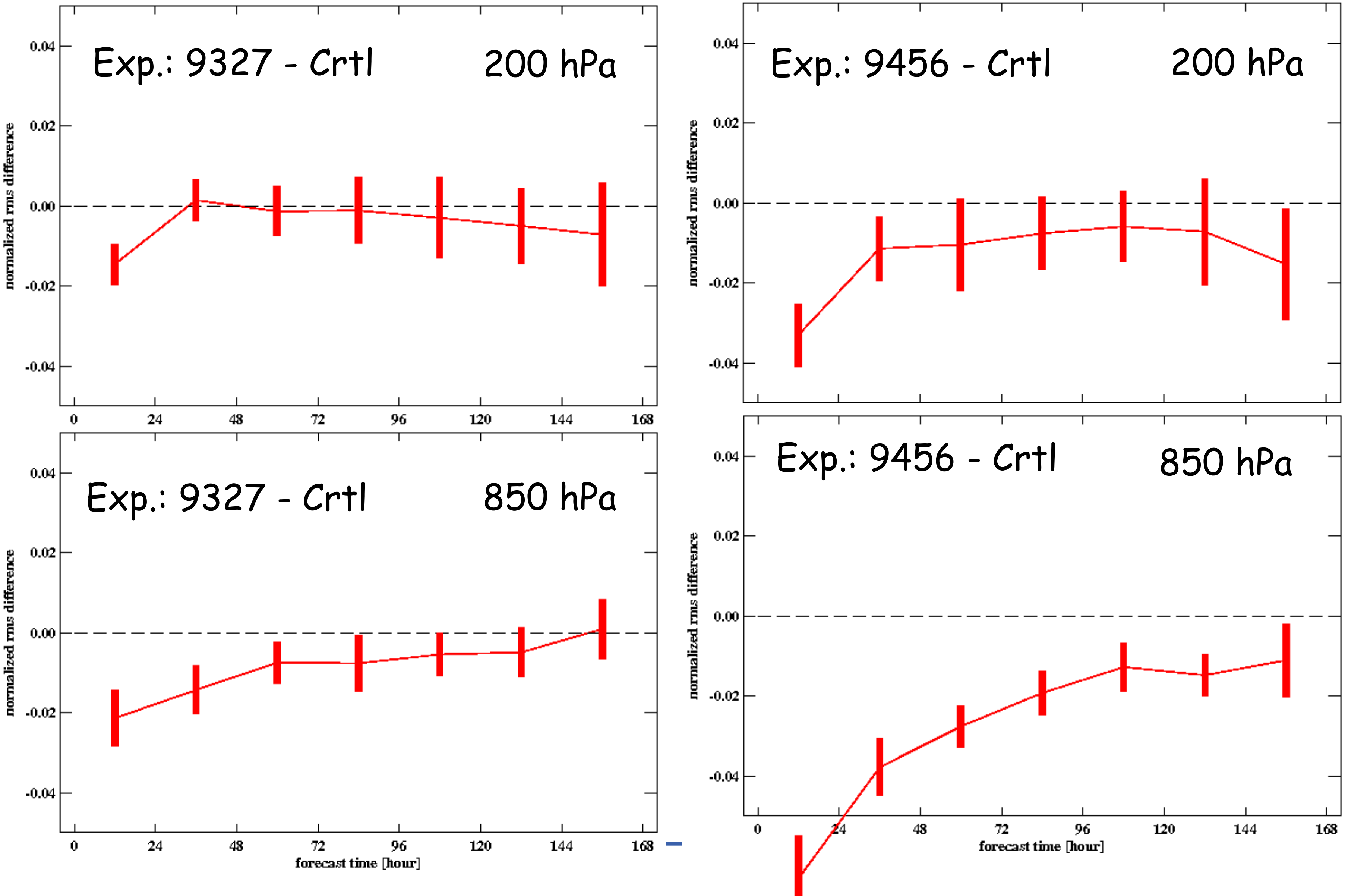
Mean Windspeed/Vector error difference (9447 - Ctrl)



Mean Windspeed/Vector error difference (9447 - Ctrl)



Forecast impact / wind speed
Normalized rms difference / tropics
2013050112 - 2013053112



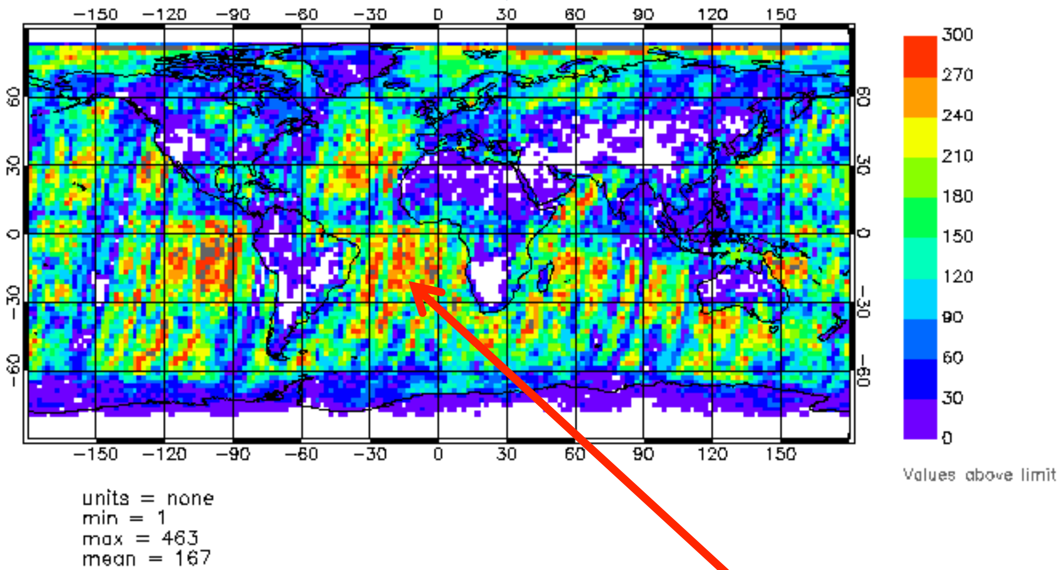
Evaluation of MISR winds test data

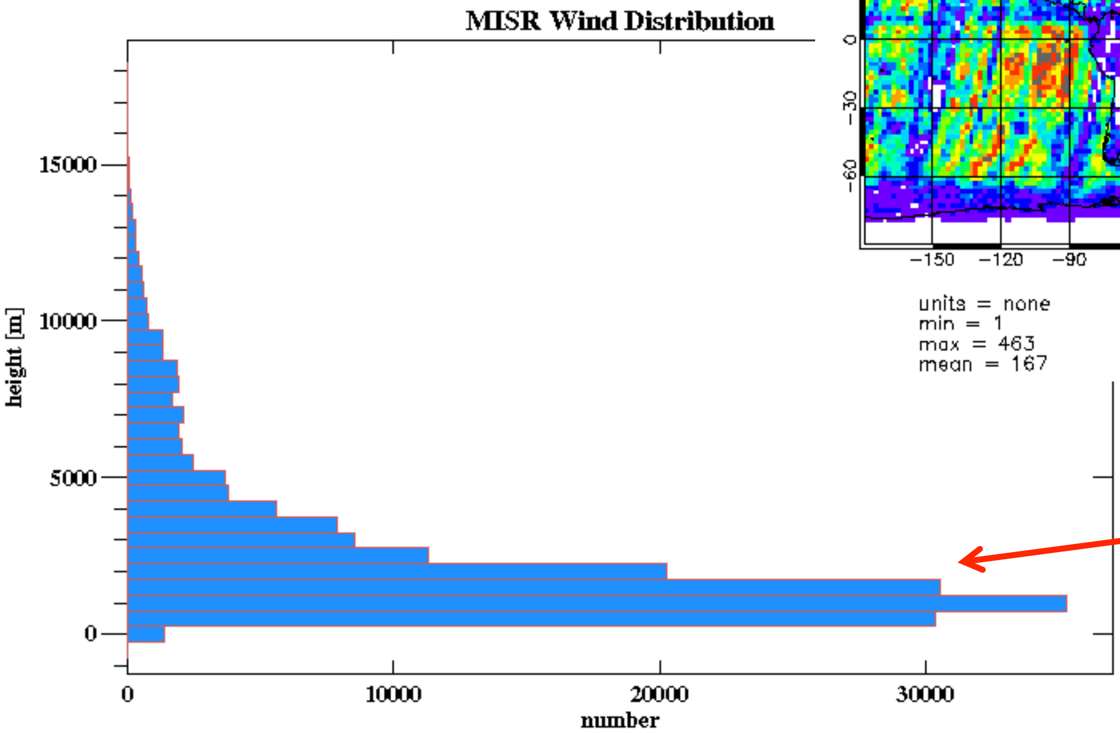
- Multi-angle Imaging SpectroRadiometer (MISR) instrument (TERRA)
- Employing nine fixed cameras pointing at fixed angles
- Provides wind speed and direction in visible channel

Monitoring of wind product on behalf of the Int. Wind Working Group and following SWG suggestion

- Use of the global assimilation and forecasting system of DWD
- Two monitoring periods:
  - Summer 2010: 15th August – 30th September 2010
  - Winter 2010/11: 01th December 2010 – 15th January 2011

Observation Coverage MIRS Winds





Most MISR winds found in the lower troposphere over Sea

MISR Winds Monitoring

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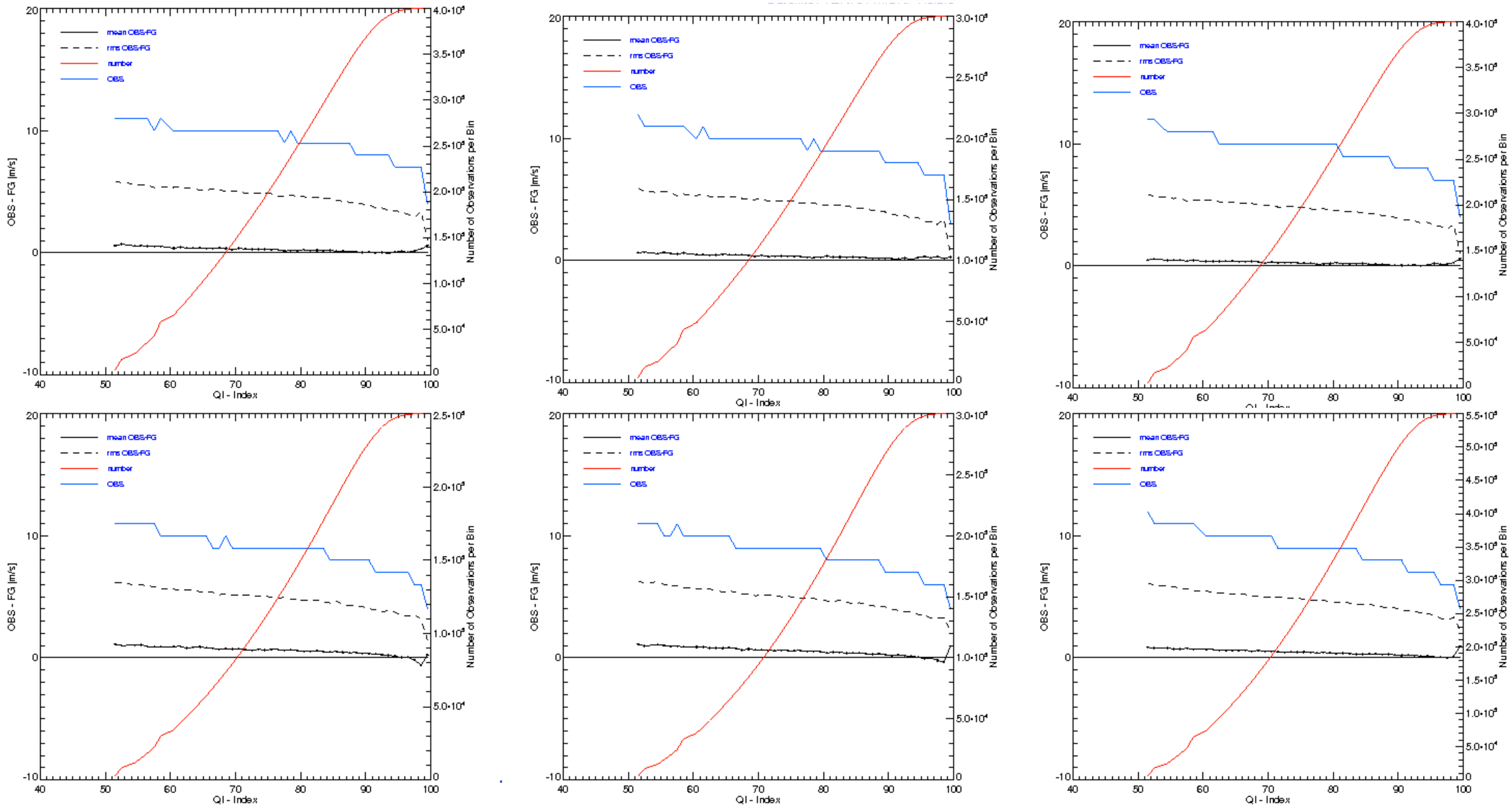
First Guess departures against MISR QI Index
visible / 1100 - 700 hPa

Obs - fg
Obs – fg stdv
Observation
Number per bin [%]

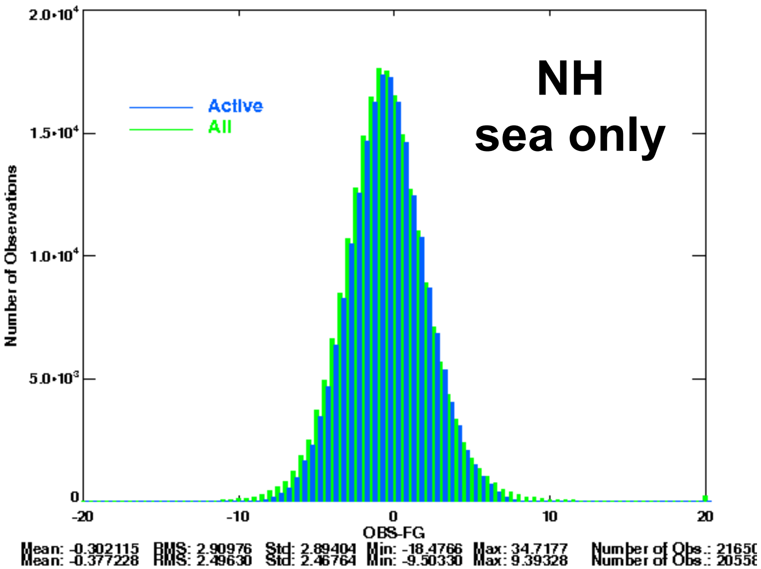
NH | Tr | SH

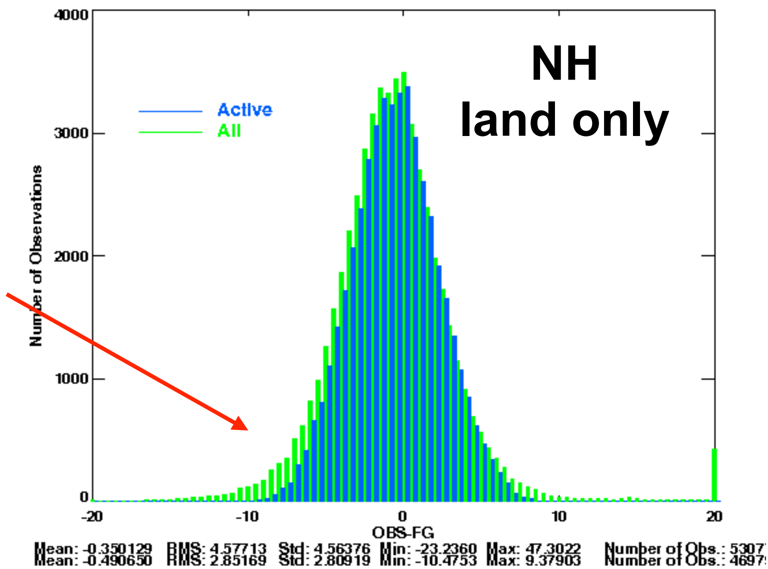
summer 2010 / winter 2010



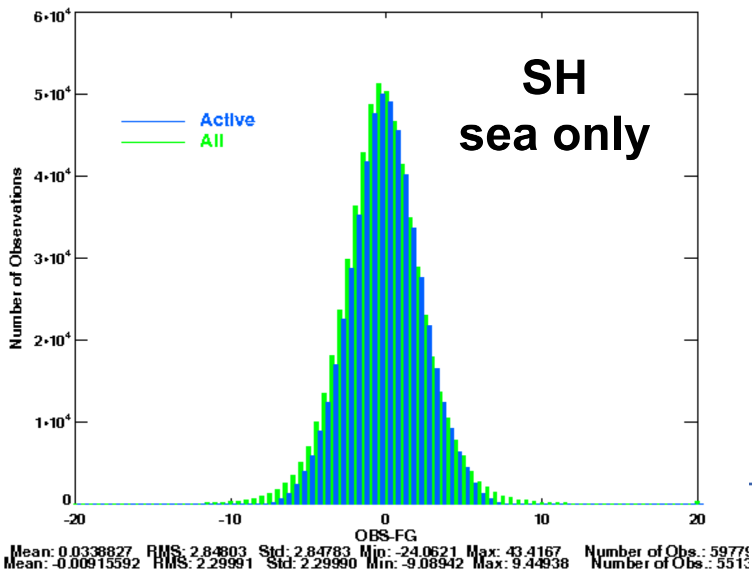
MISR winds monitoring

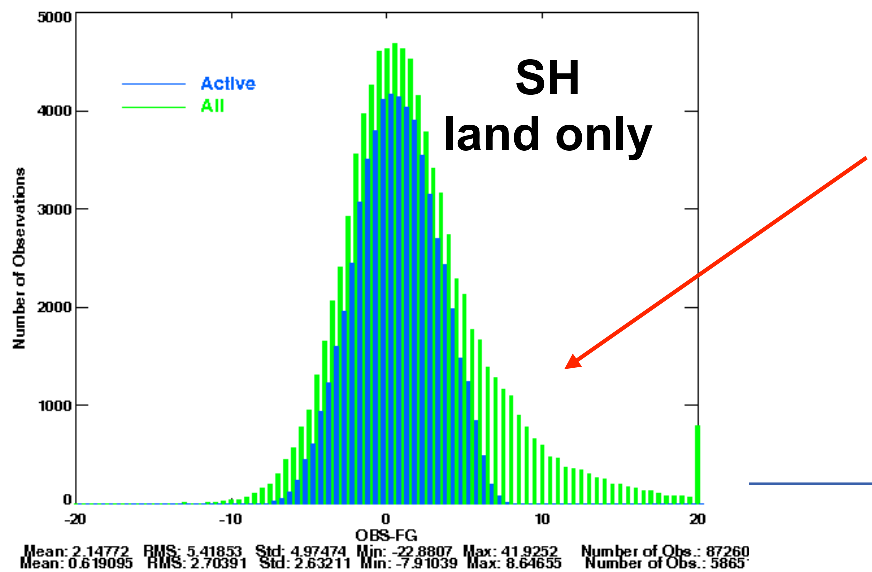
Deutscher Wetterdienst
Wetter und Klima aus einer Hand





Winter
QI > 80





MISR winds monitoring

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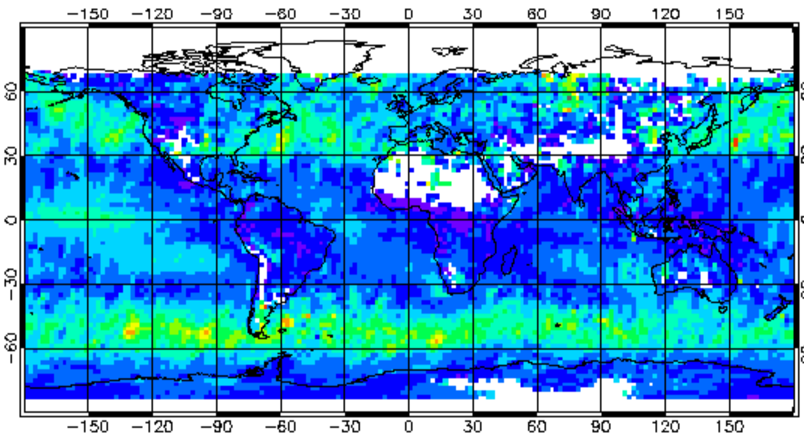
Wetter und Klima aus einer Hand

DWD

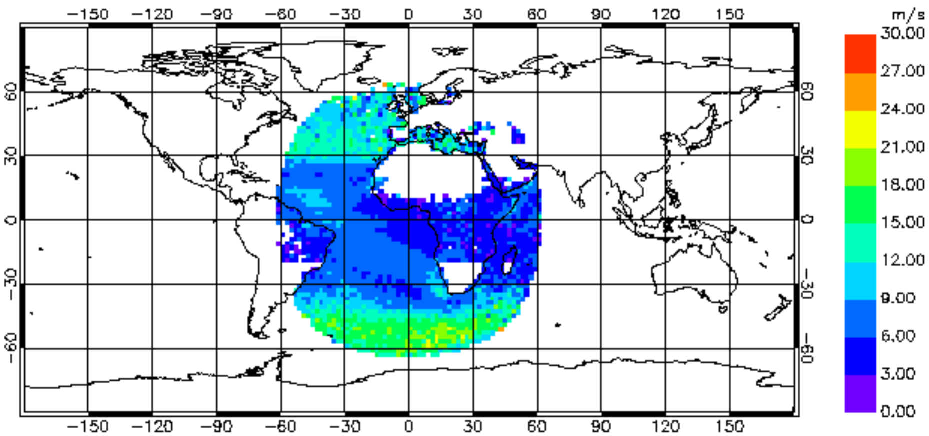
Wind Speed Observation
Visible 1100 – 700 hPa

Winter
QI > 80

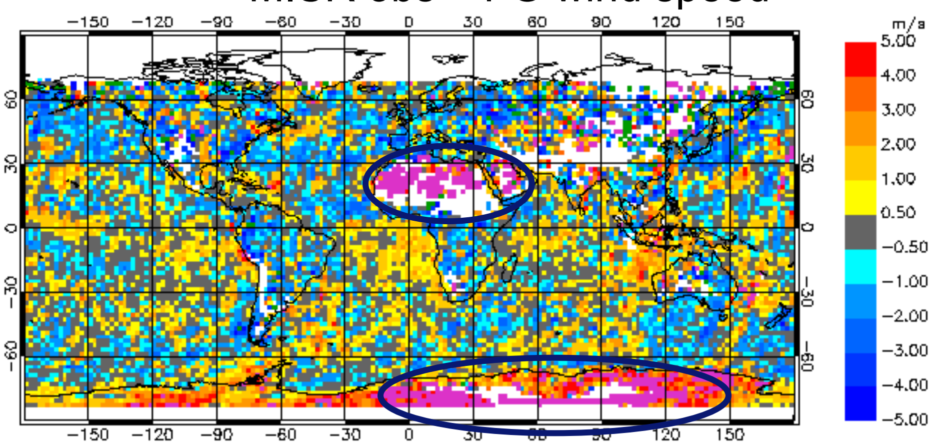
MISR



Meteosat 9



MISR obs – FG wind speed



Promising data source over sea

Problems visible over land
(esp. ice/desert)

QI currently a relatively week indicator of dataquality

MISR impact experiments

- Two test periods

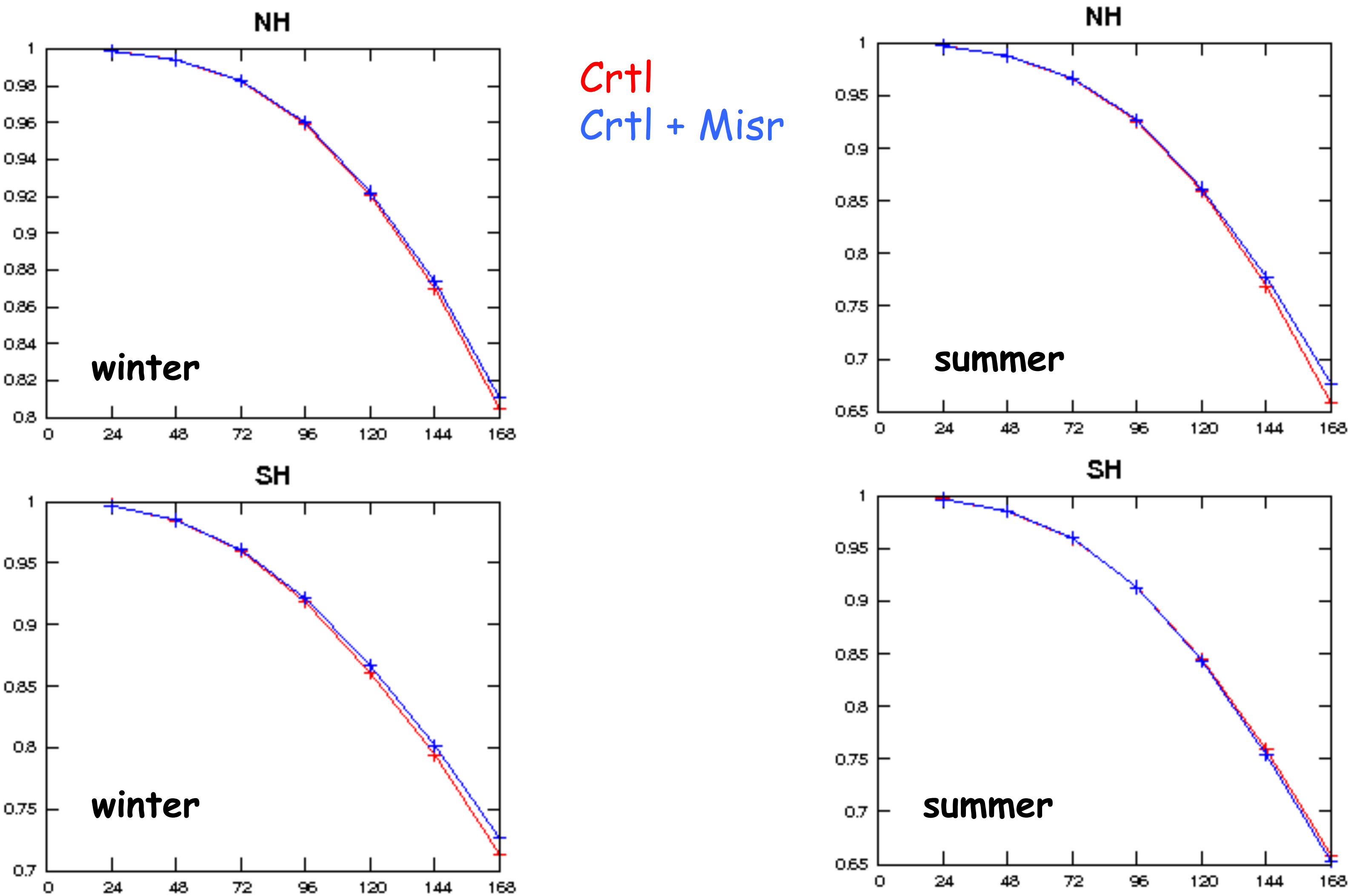
  - summer case: 15th Aug – 30th Sept. 2010
  - winter case: 1st Dez 2010 – 15th Jan. 2011

- Experiments:

  - Crtl (as routine without MISR winds)
  - Exp (as routine with MISR winds)

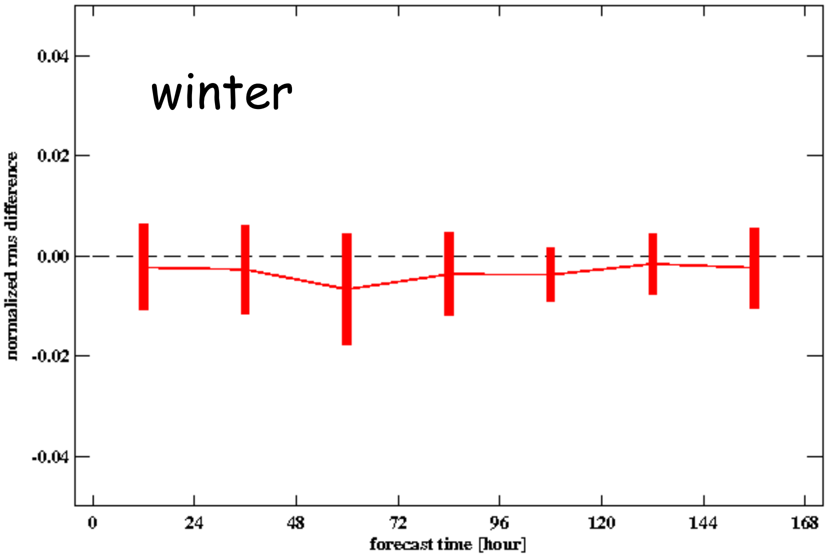
- Observation errors estimated after Dezroisier et. al.

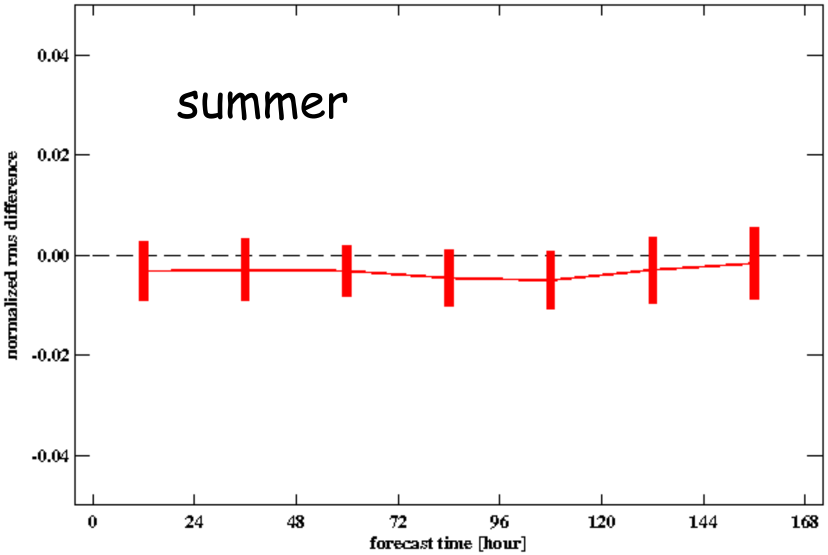
Anomaly correlation coefficient 500 hPa geopotential height



normalized rms difference
850 hPa wind vector

Tropics





- Positive impact of MISR winds throughout the whole forecast range
- Positive impact in summer and winter case
- Impact larger in lower atmosphere

Dedicated impact experiments

- IODC: GEO coverage of the Indian Ocean (Support for decision whether to extend the Meteosat IODC mission)

  - MET-7 denial experiment
  - MET-7 replaced by Chinese FY-2E

  - Winter period: 1.12.2012 – 31.01.2013

Exemple of monitoring results for MET-7 and FY-2E

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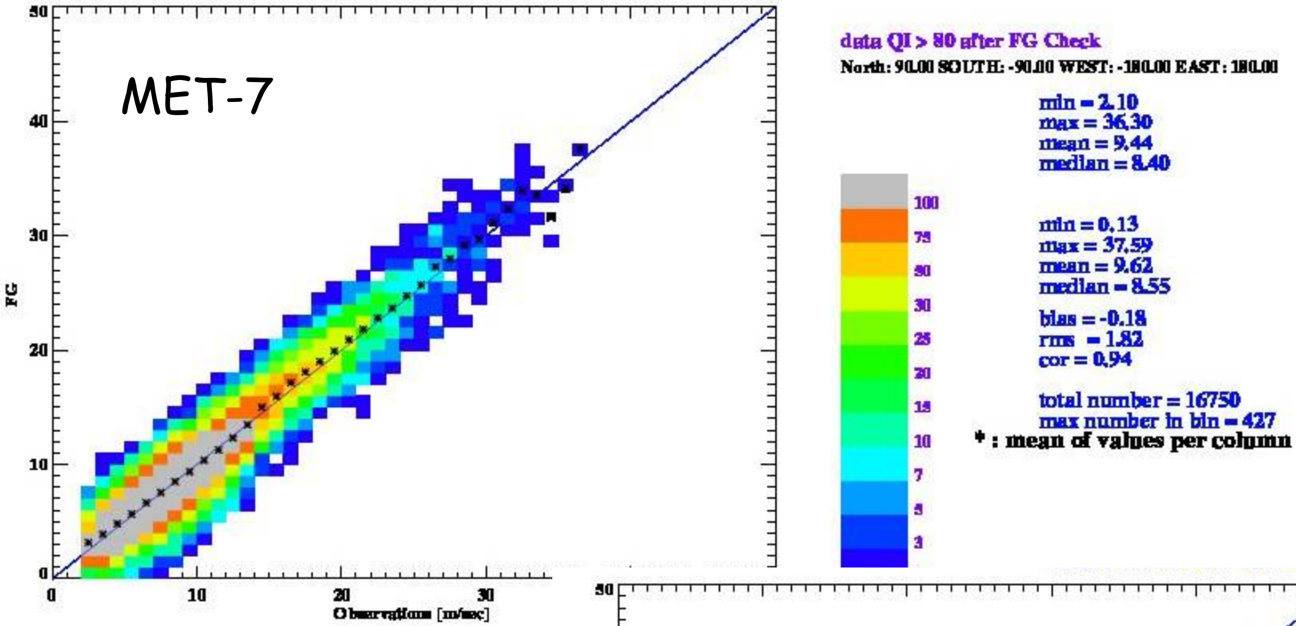
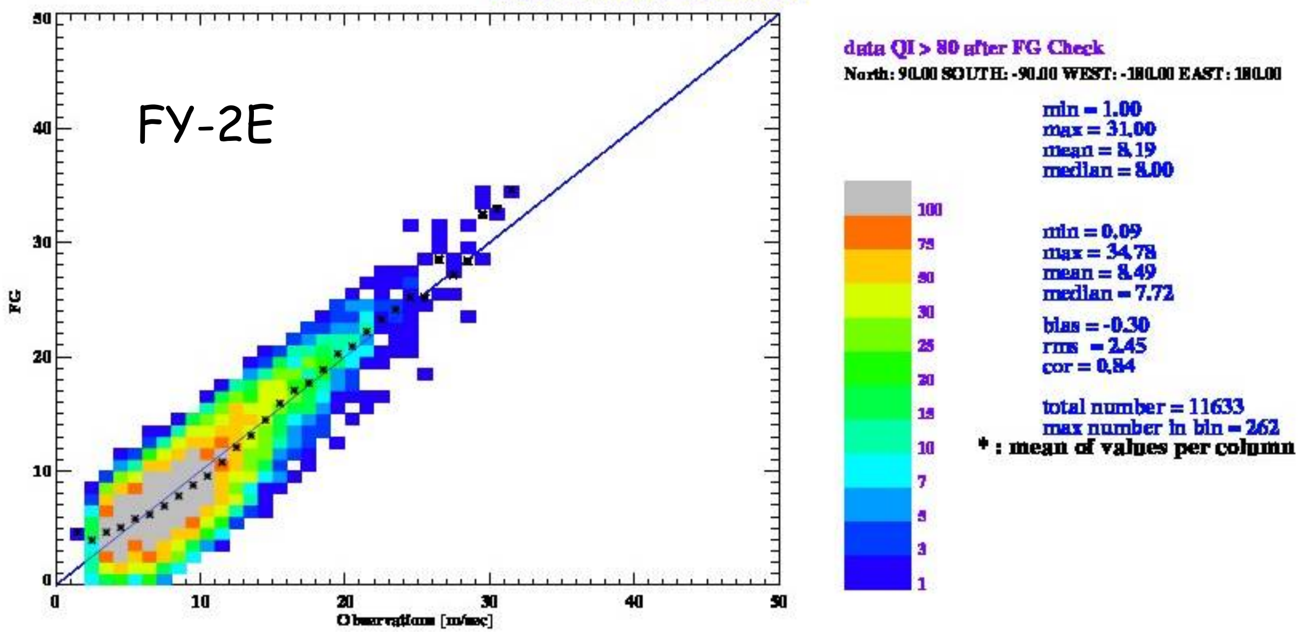


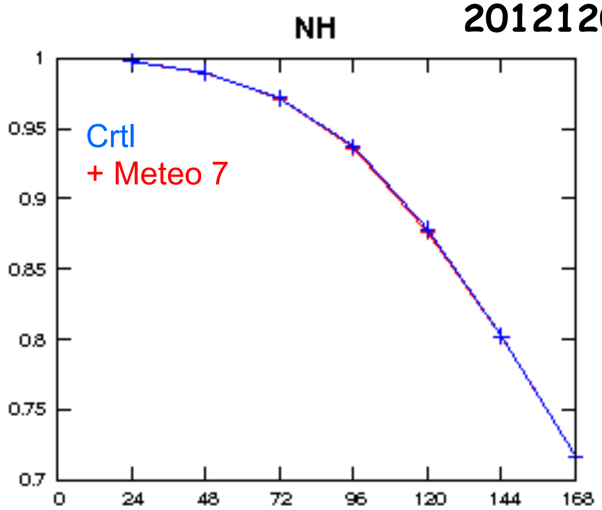
IR winds, QI > 80
1000 – 700 hPa
1.10. – 29.10.2012

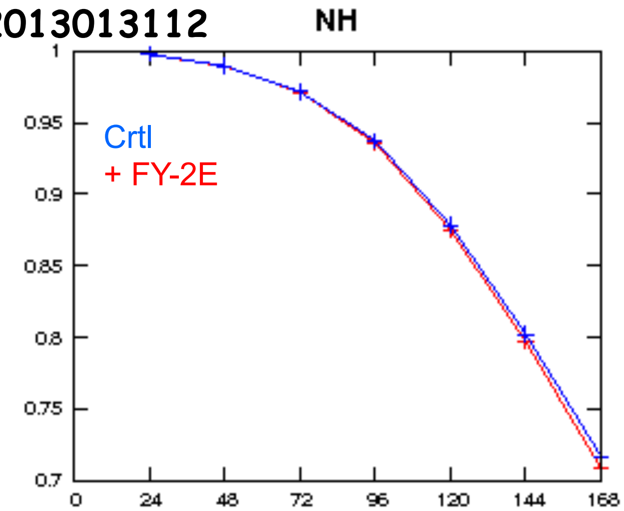
- Fewer winds
- Larger wind speed dependent biases
- Larger rms

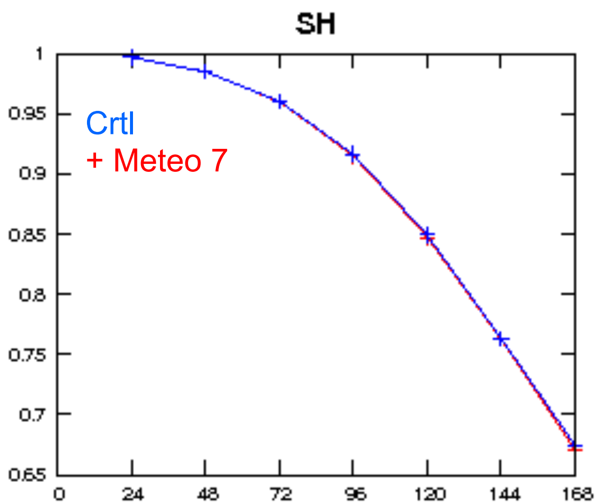


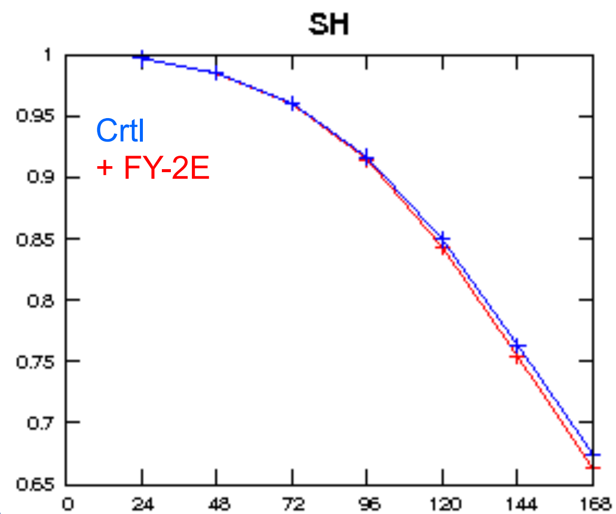
Scores: Crtl + Met7 / FY-2E
Geopotential Height 500 hPa

Winter period
2012120112 - 2013013112

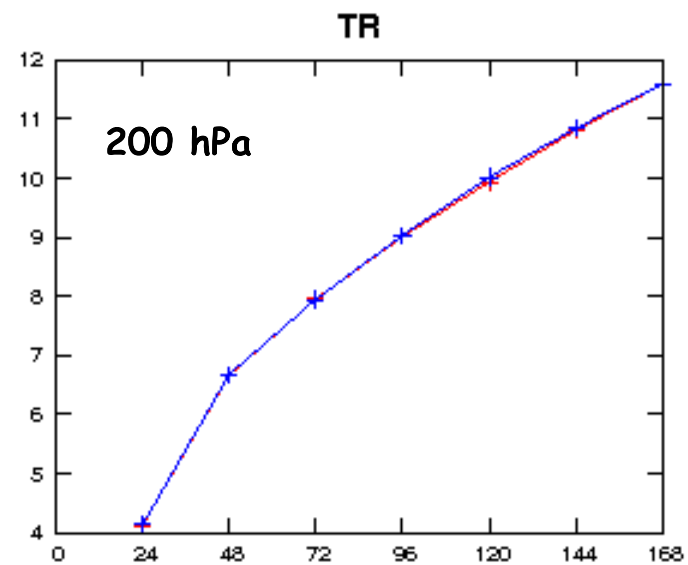


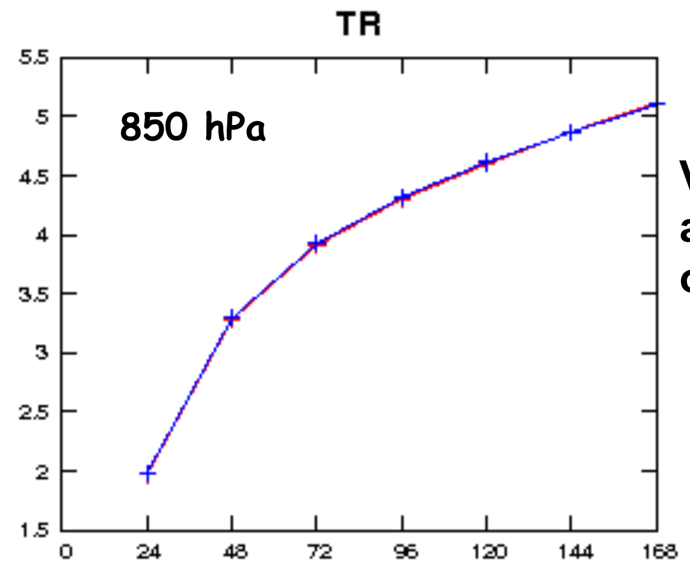




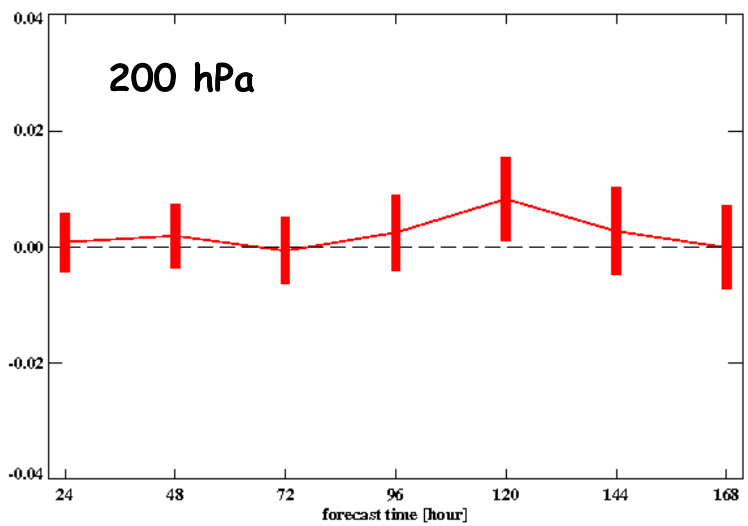


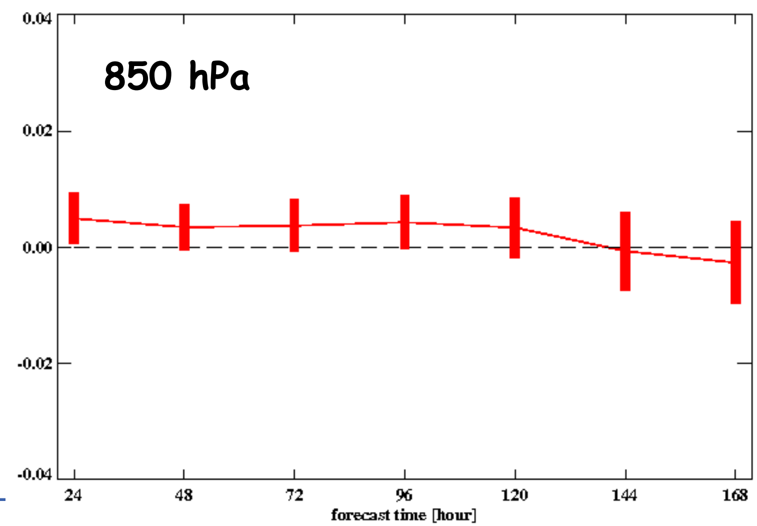
Scores: MET-7 denial
RMSV of Wind Vector in the Tropics



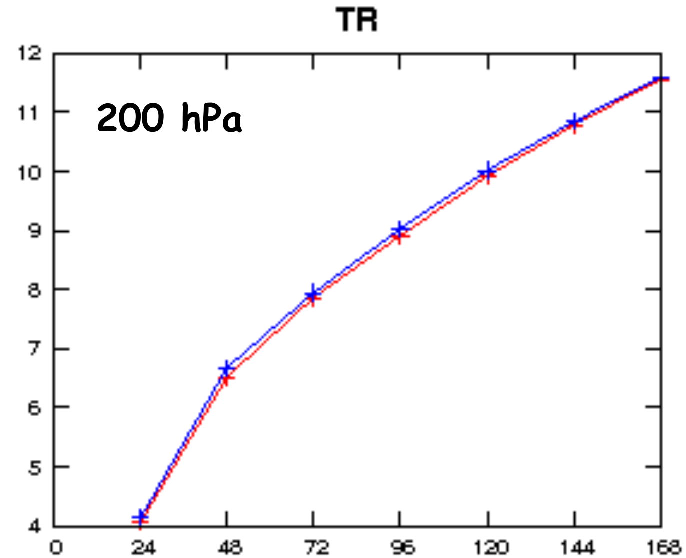


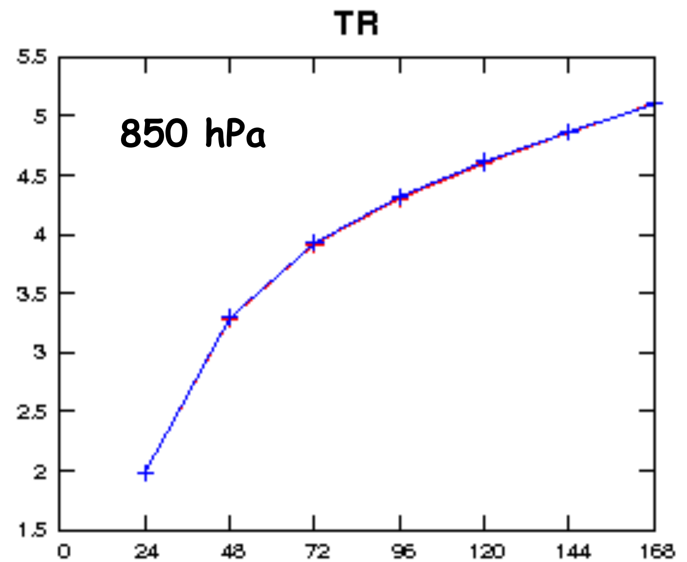
Verification against own analysis

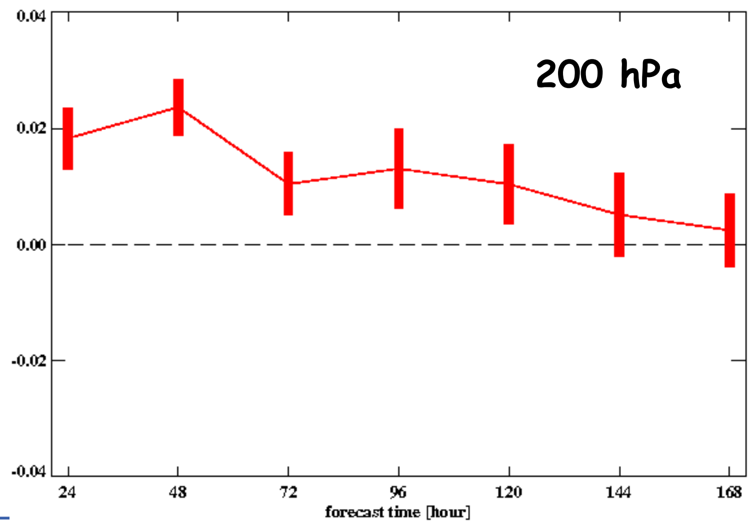


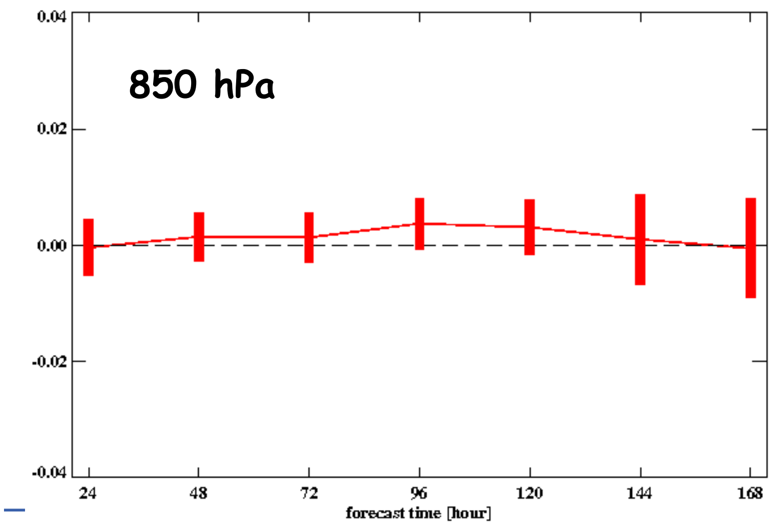


Scores: FY-2E replacing MET-7
RMSV of Wind Vector 850 hPa





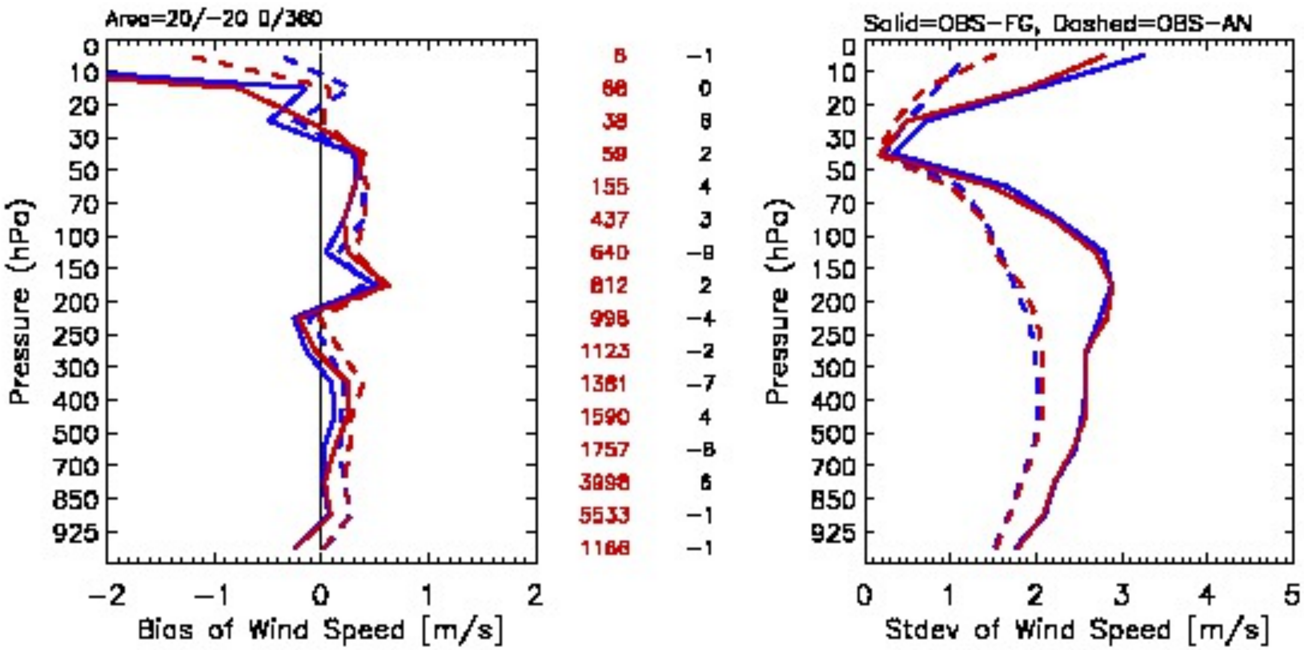




Verification against own analysis

IODC exp : FY-2E replacing MET-7
Statistics for PILOT wind observations

OBS – FG / OBS – AN for PILOT winds



Area: **Tropics**

MET-7 (Cntl)
FY-2E

Preliminary results:

- MET-7 AMVs have best quality according to monitoring statistics
- No IODC Meteosat AMVs lead to degraded analysis and forecast quality
- Use of Chinese FY-2E AMVs is currently no adequate substitute
  (data quality, no VIS winds, no WVclear-WVcloudy distinction)

Summary

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Wetter und Klima aus einer Hand
DWD

- METOP-B and MSG-3 (Met-10) AMVs show very good quality in our monitoring
  - operationell since beginning of May 2013

- CCC height assignment method improve the number and quality of AMVs in the middle and upper troposhere. After a revison of the method also the lower level AMVs are comparable to the old method

- Revised obs. Error and FG check leads to positive impact in the tropics and SH (smaller impact on NH and EU). Impact larger in lower troposphere.

- MISR winds over sea a promising new data source.
  - Still problems over Land (Sahara, Greenland, Antartica)
  - QI currently a relatively week indicator of data quality
  - Positive impact in both hemispheres larger in winter

- IOCD experiments:
  - MET-7 AMVs have best quality according to monitoring statistics
  - No IODC Meteosat AMVs lead to degraded analysis and forecast quality
  - Use of Chinese FY-2E AMVs is currently no adequate substitute (data quality, no VIS winds, no WVclear-WVcloudy distinction)