Recent progress in using satellite winds at the German Weather Service

Alexander Cress, Heinz Werner Bitzer
German Weather Service , Offenbach am Main, Germany, email: Alexander.Cress@dwd.de

- **Introduction**
- **Recent changes in the use of AMV observations**
- **AMVs over land**
- **AMV impact study**
- **Use of Scatterometer data (Ascat, Oceansat-2)**
- **Height correction of AMVs with airborne lidar and droposonde observations**
- **Conclusions and Outlook**

Numerical Weather Prediction at DWD

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Global model GME

Grid spacing: 30 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

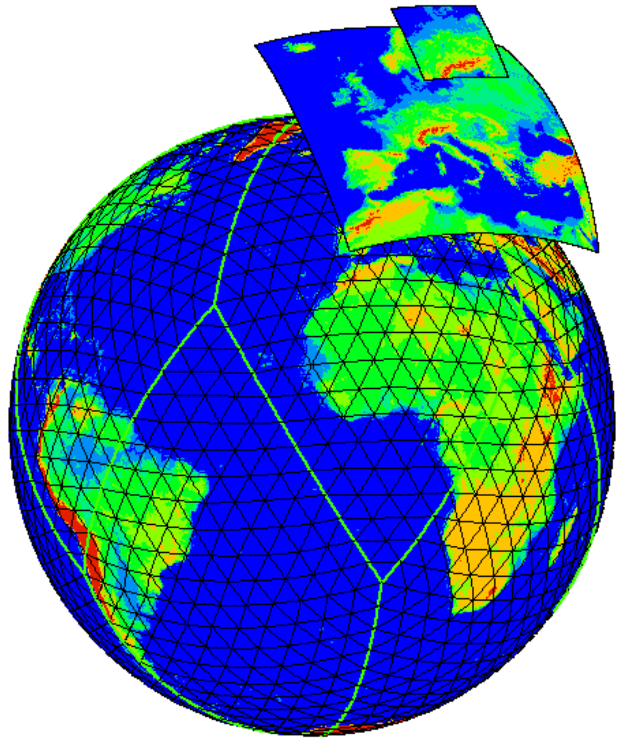
Pre-operational

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

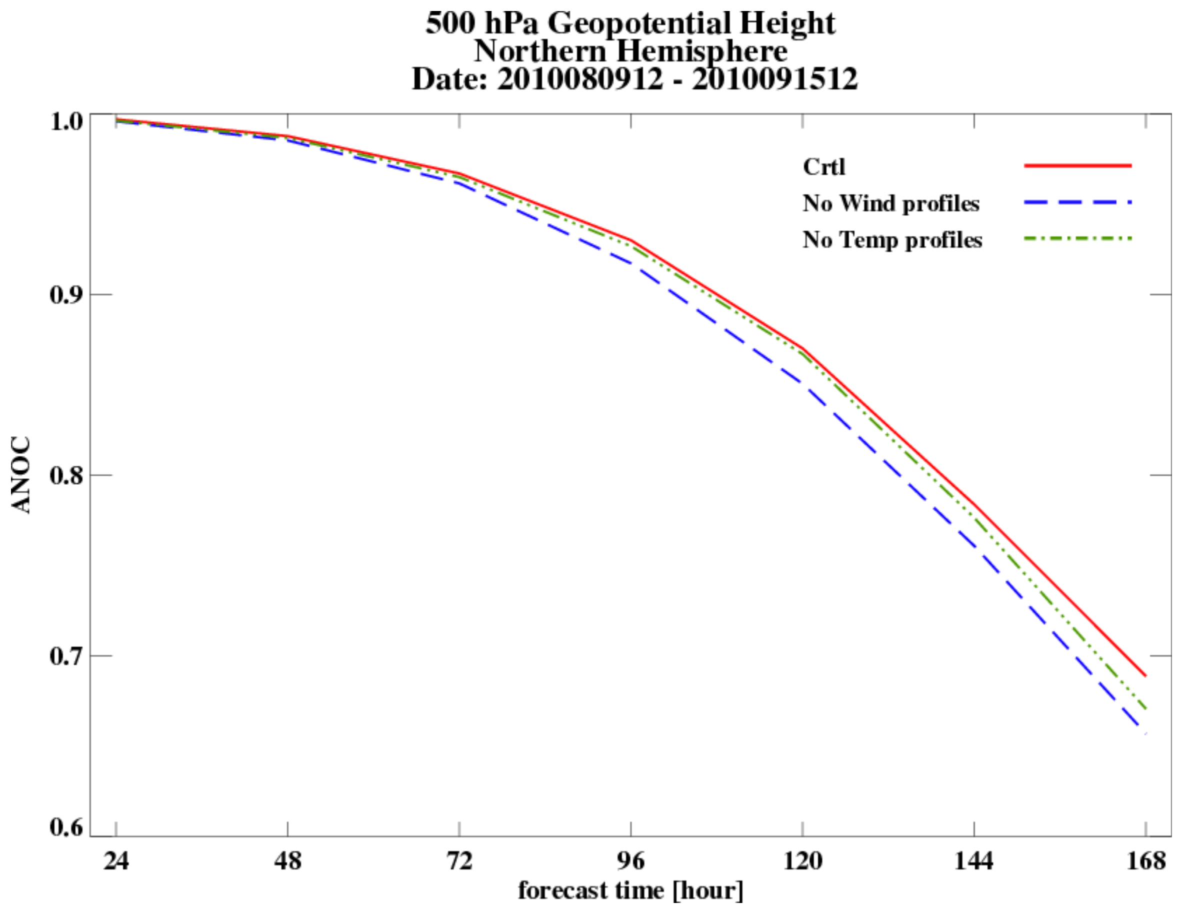
Assimilation schemes

- Global: 3DVAR PSAS
  - Minimzation in observation space
  - Wavelet representation of B-Matrix
    - seperable 1D+2D Approach
    - vertical: NMC derived covariances
    - horizontal: wavelet representation
  - Observation usage: *Synop, Temp/Pilot, Dropsonde, AMV, Buoy, Scatterometer, AMUSU-A/B, Aircraft, Radio Occultation*
  - Time window: 3 hours
- Local:
  - Continous nudging scheme and latent heat nudging
  - Time windows: 0.5 – 1 hour
  - Observation usage: *Synop, Temp/Pilot, Dropsonde, Buoy, Aircraft, Scatterometer, Windprofiler, Radar precipitation*

Usage of AMV winds at DWD

- Geostationary satellites (GOES 13/15; Eumetsat 7/9; 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)

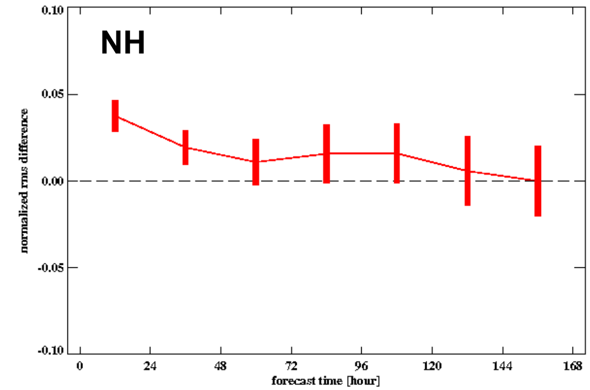
Motivation

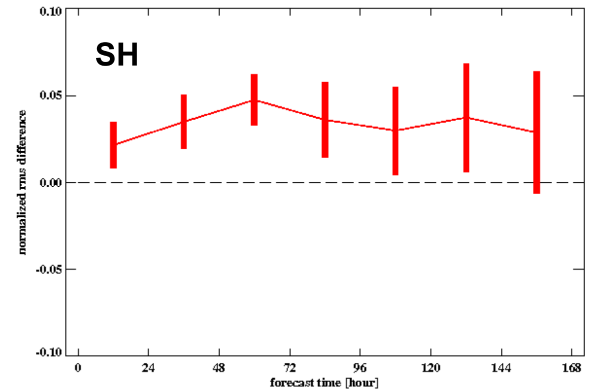

500 hPa Geopotential Height
Northern Hemisphere
Date: 2010080912 - 2010091512
Crtl
No Wind profiles
No Temp profiles
ANOC
1.0
0.9
0.8
0.7
0.6
24
48
72
96
120
144
168
forecast time [hour]

AMV impact study

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- ➔ Summer and winter period
- ➔ Exp. NoAMV/NoPolarAMV/NoScat
- ➔ AMV Impact larger for summer than winter
- ➔ Impact highest in Tropics and SH
- ➔ Impact is smaller on NH
- ➔ Impact higher in upper troposhere
- ➔ Impact detectable up to 5 days in summer and up to 3 days in winter on NH
- ➔ On SH impact is seen over the whole forecast range
- ➔ In tropics strong impact in the first 72 hours
- ➔ Strong impact of PolarAMVs seen over Antarctica
- ➔ Only small impact of northern polar region
- ➔ ASCAT data showed a strong impact on psml and 850 wind vector in the NH but almost no impact on thr SH.



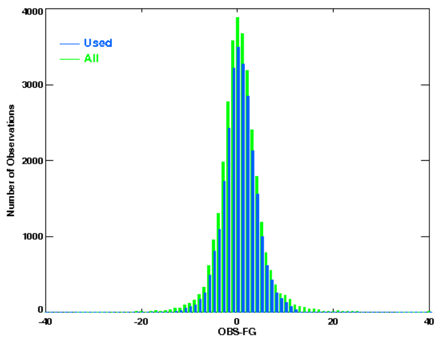


MTSAT-1R ⇨ MTSAT-2R

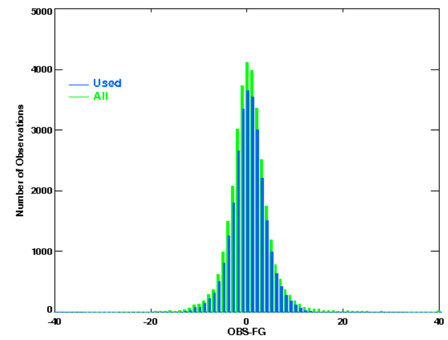
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Comparision between MTSAT-1R and MTSAT-2R
- Test period : June 2010
- Compared to First Guess field
- No significant difference in quality between MTSAT-1R and MTSAT-2R
- Operational use since autumm 2010

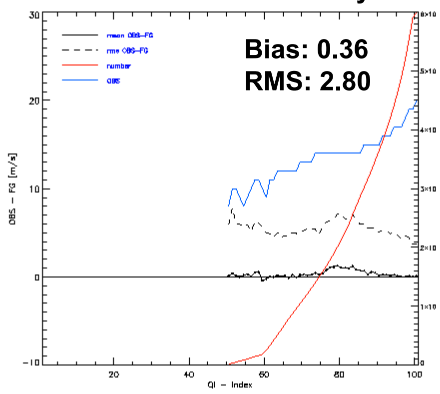
MTSAT-1R/infrared
400 – 100 hPA



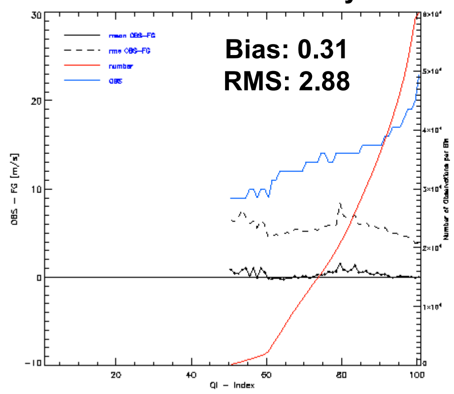
MTSAT-2R/infrared
400 – 100 hPA



MTSAT-1R/wvcloudy



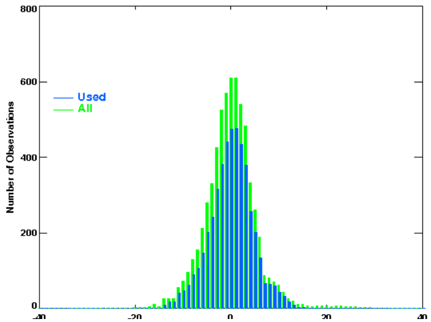
MTSAT-2R/wvcloudy



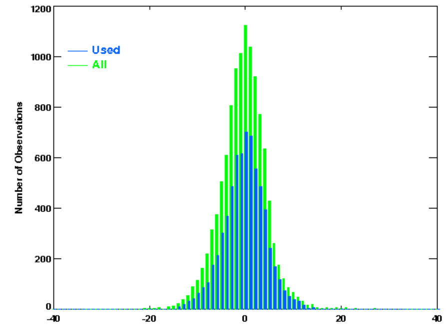
GOES 11 ⇨ GOES 15

- Comparision between GOES 11 and GOES 15
- Test period : Nov 2011
- Compared to First Guess field
- No significant difference in quality
- Operational use since Dez. 2011

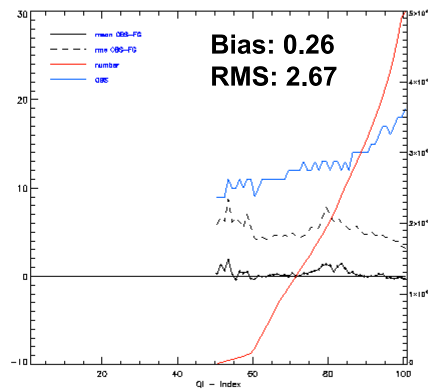
GOES 11 wvcloudy
100 – 400 hPa



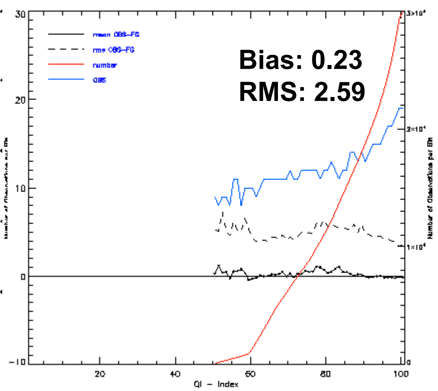
GOES 15 wvcloudy
100 – 400 hPa



GOES 11 infrared
100 – 400 hPa

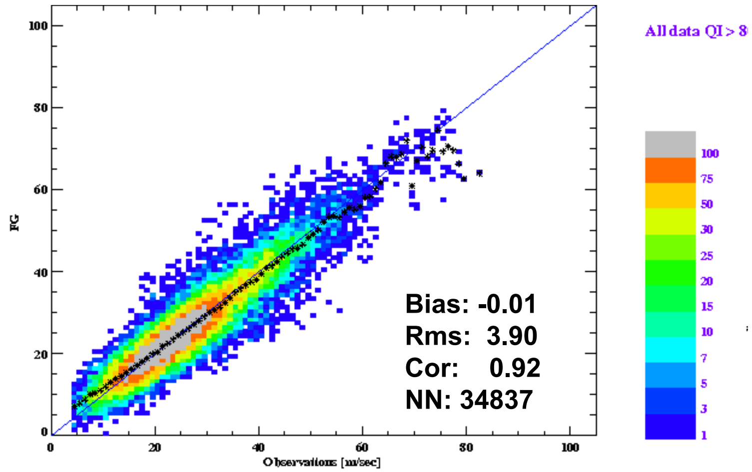
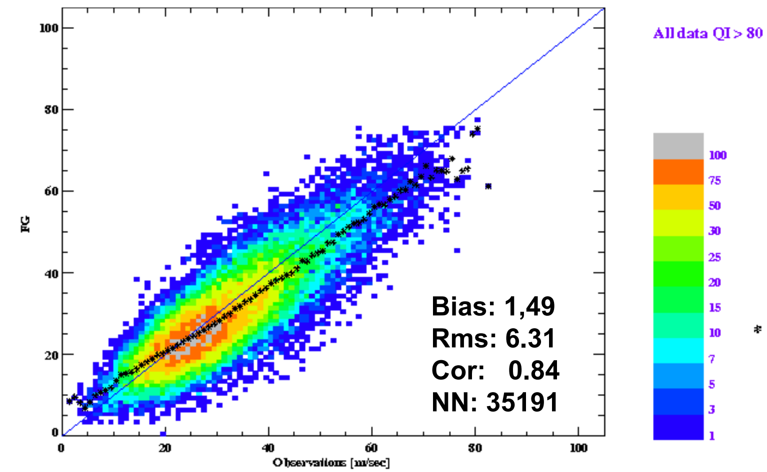
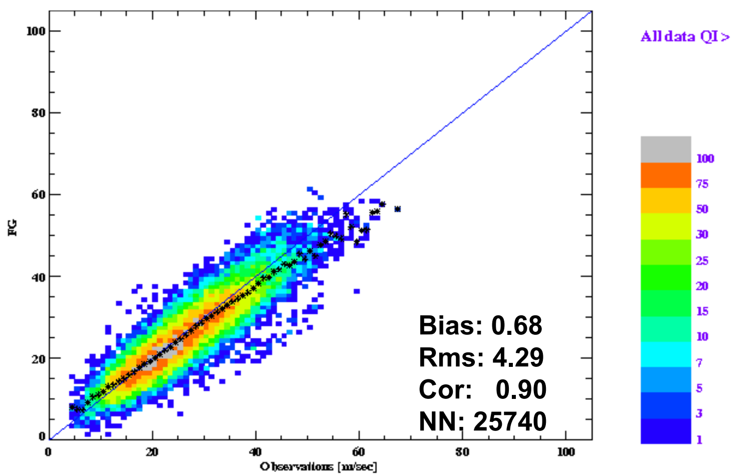
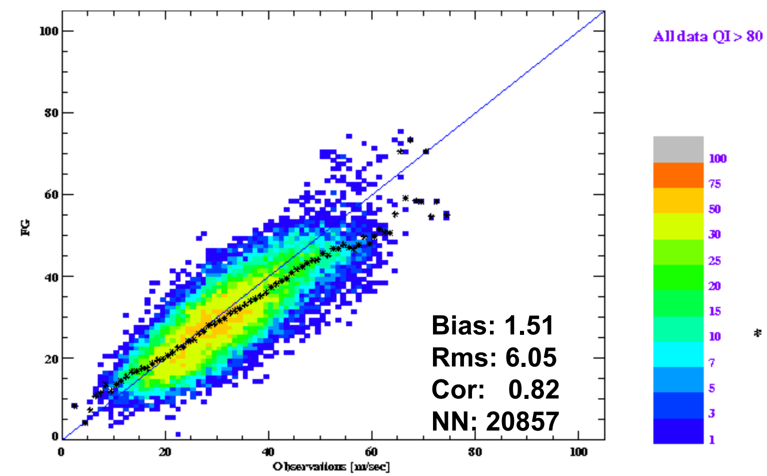


GOES 15 infrared
100 – 400 hPa



Comparison AVHRR Metop NOAA ⇨ Eumetsat Dec 11 – Jan 12

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

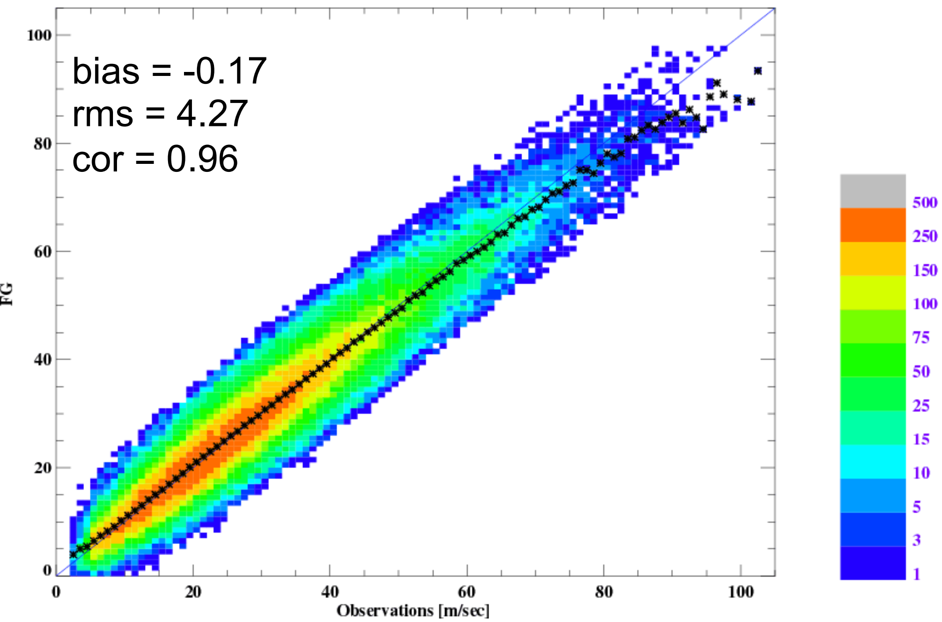
	NOAA	Eumetsat
Arctic		
Antarctica		

Data quality AMVs over land

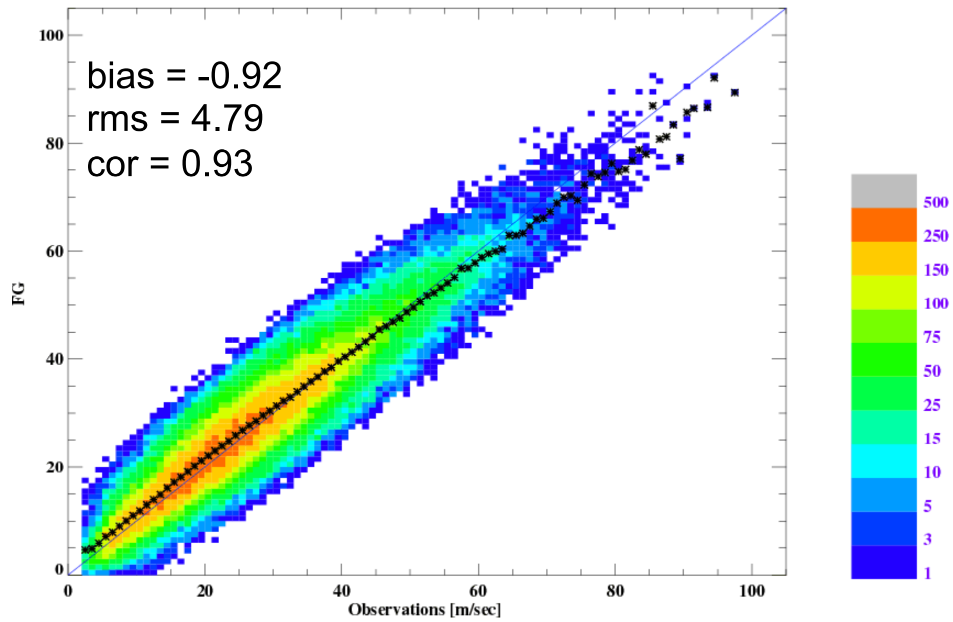
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Wind speed [m/sec]
Level: 100 – 400 [hPa]
Period: 2011040100 - 2011043118

AMVs over sea



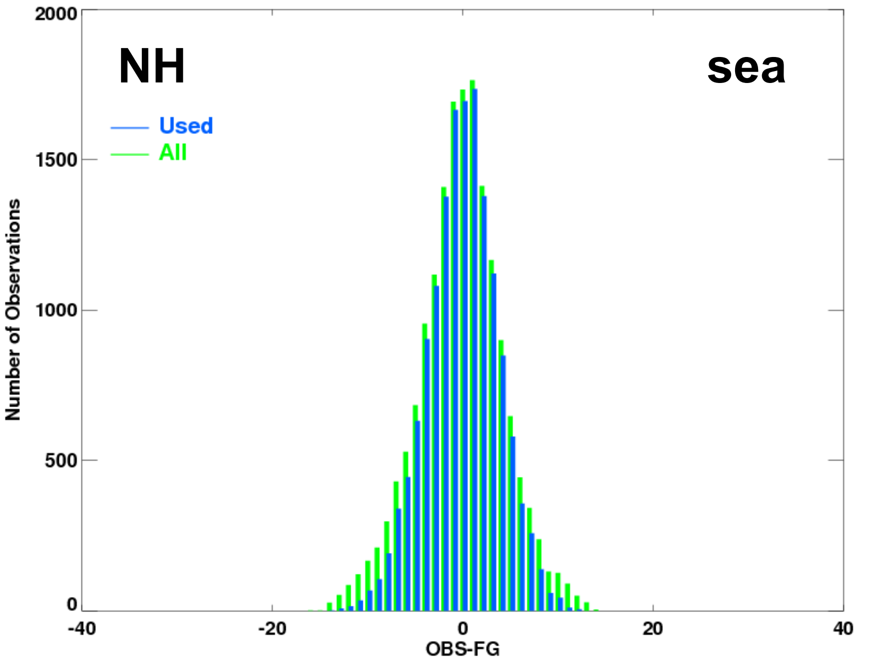
AMVs over land



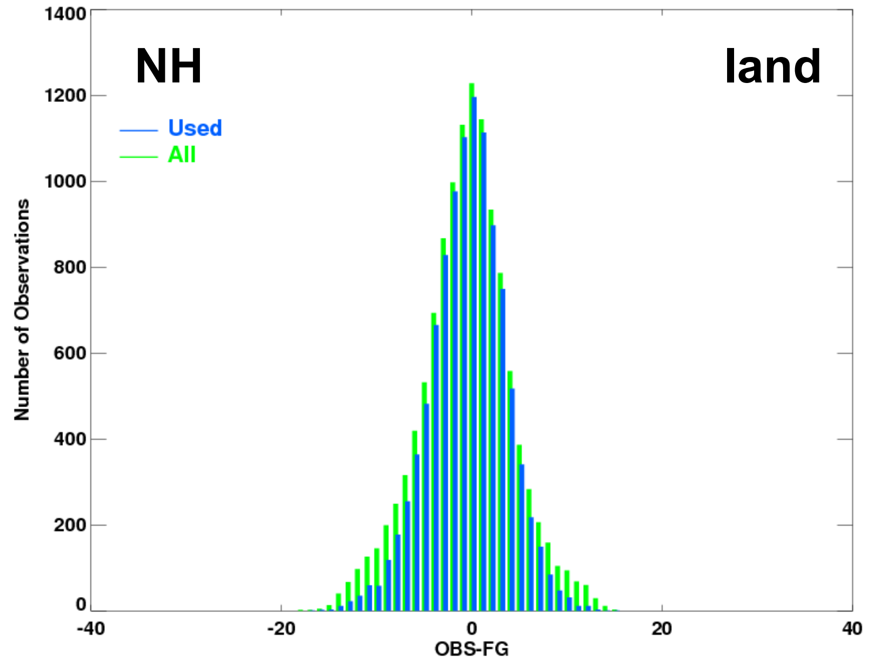
Data quality AMVs over land

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Meteosat 9 wvCloudy
Level: 400 hPa – 100 hPa



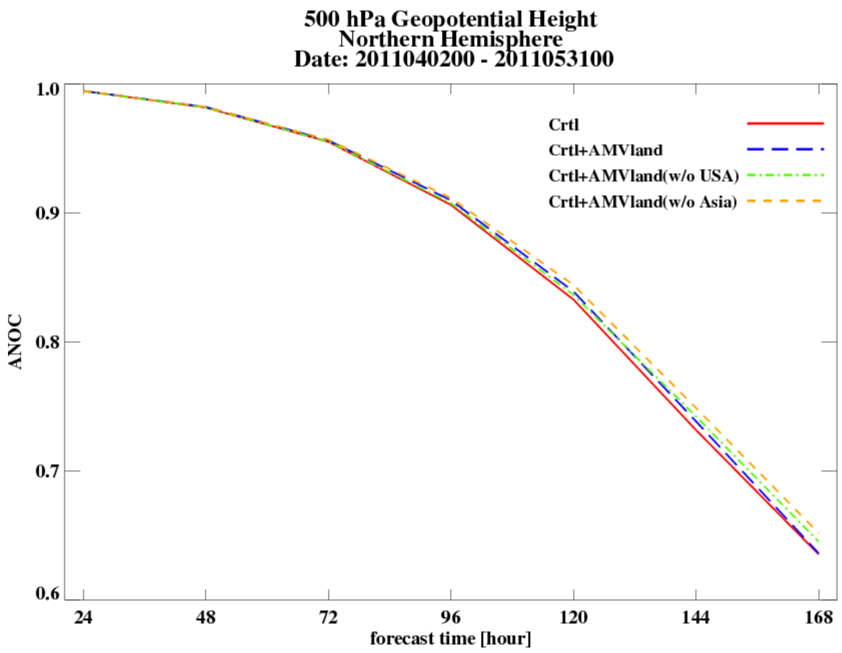
Mean: -0.256664 RMS: 4.40063 Std: 4.39327 Min: -15.5761 Max: 14.3412 Number of Obs.: 16
Mean: -0.193501 RMS: 3.68225 Std: 3.67729 Min: -13.5442 Max: 11.9825 Number of Obs.: 15

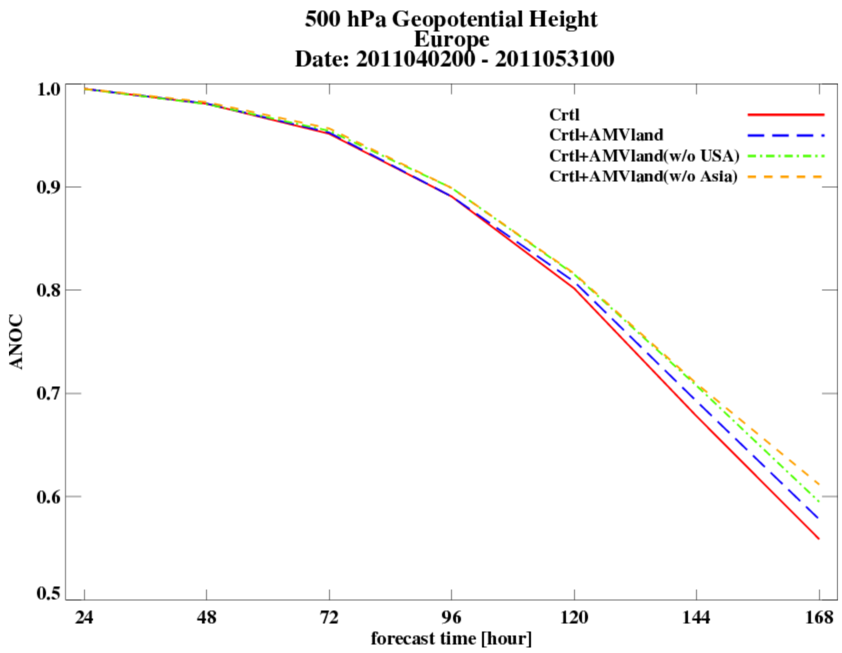


Mean: -0.631429 RMS: 4.75976 Std: 4.71789 Min: -18.4034 Max: 15.2449 Number of Obs.: 11953
Mean: -0.589578 RMS: 3.96827 Std: 3.92442 Min: -16.9579 Max: 15.2449 Number of Obs.: 10527

- AMVs over land comparable to AMVs over sea for upper troposphere
- For the lower troposphere, AMVs over land above deep orography problematic
- On average bias for AMVs over land 0.5 m/s higher in upper troposphere increasing to 1 m/s in lower troposhere. RMS comparable

AMV over Land Impact

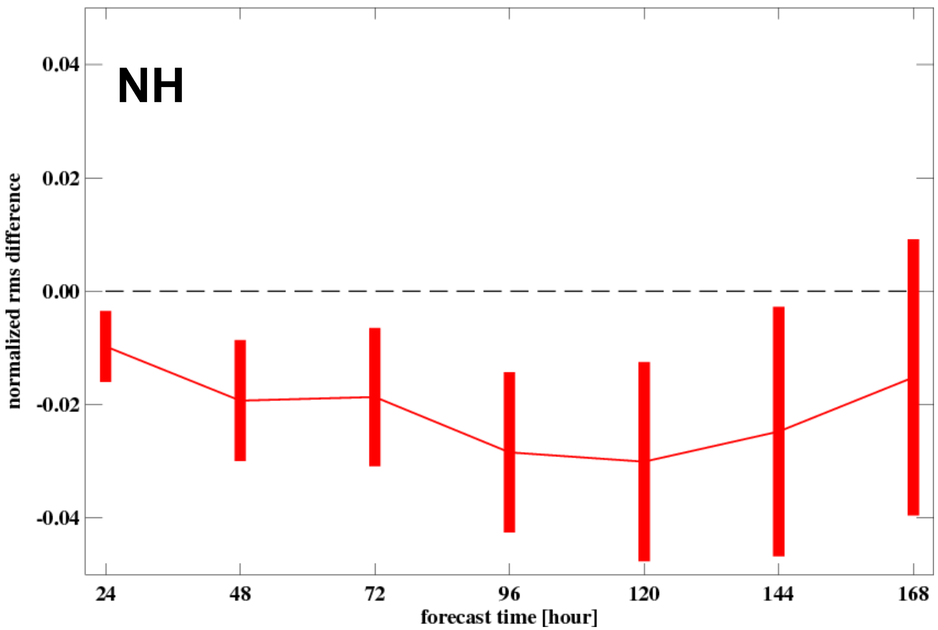


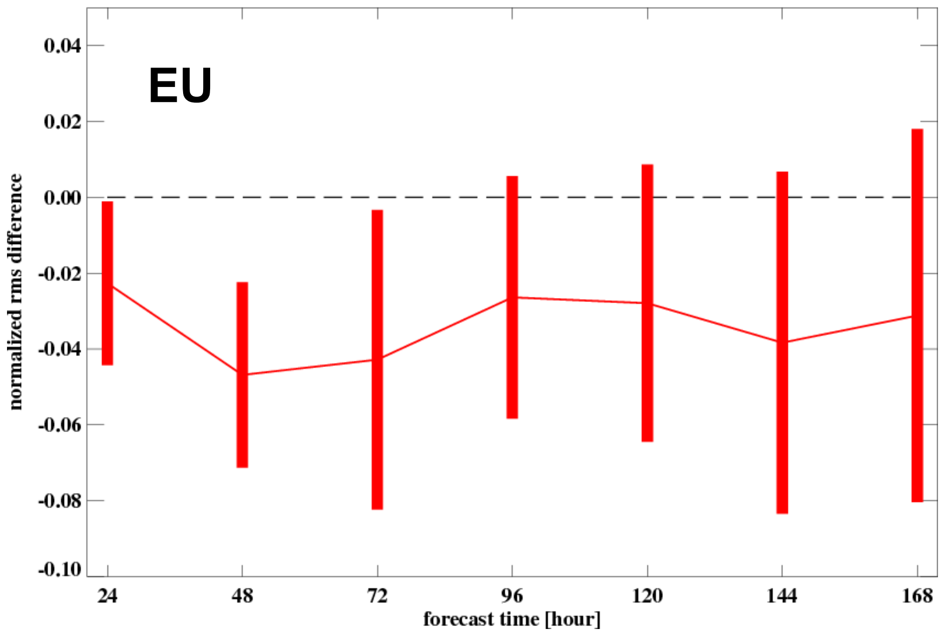


AMV over land
Normalized rms difference

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Experiment period: 2011040200 - 2011052400





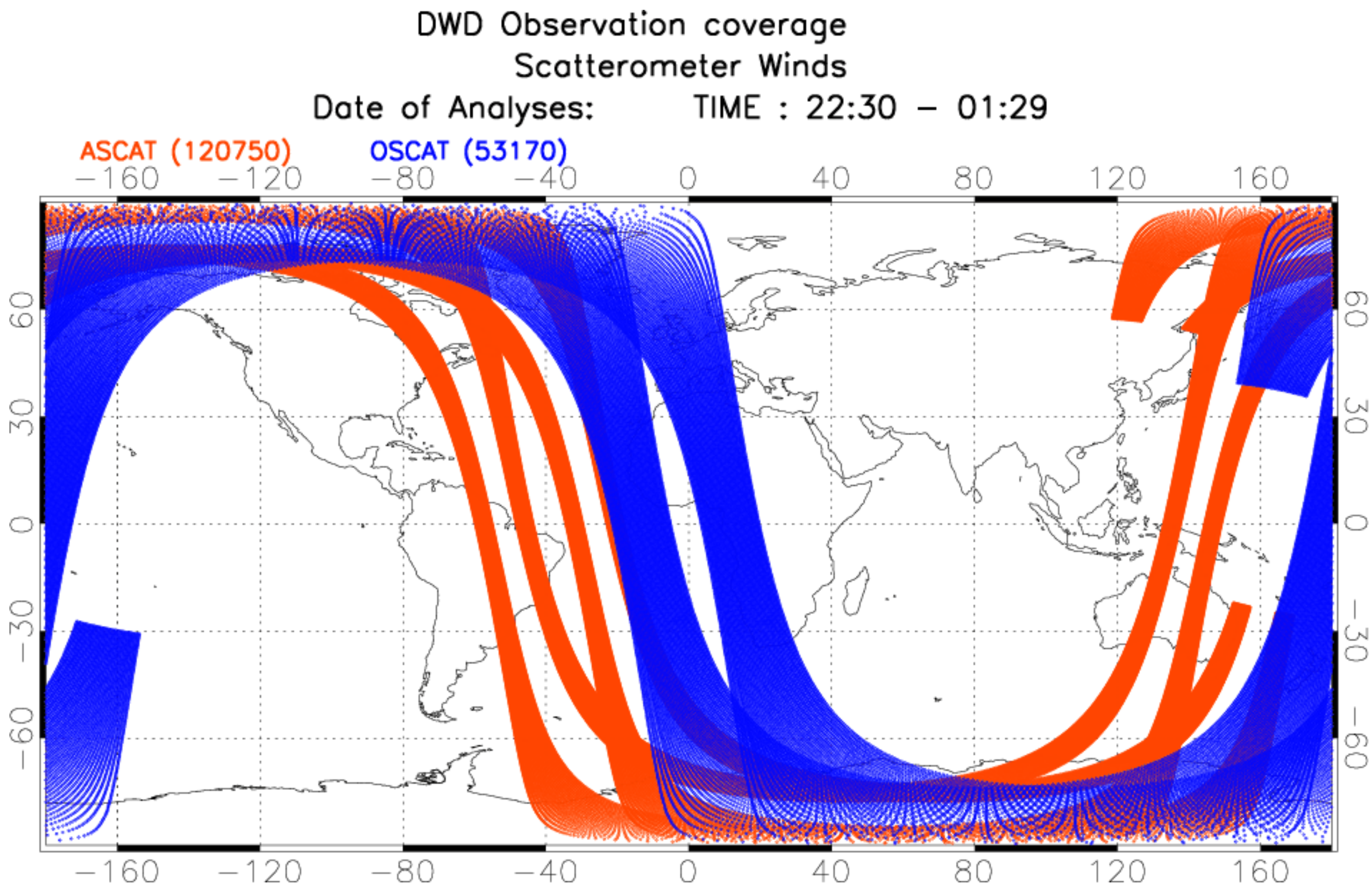
- Experiment with AMVs over land but without Asian AMVs
- Verified against own analysis
- Forecast impact positiv for all forecast times on Northern Hemisphere and Europe
- Neutral impact on Southern Hemisphere

Scatterometer

- Scatterometer provides ocean wind vectors from backscatter triplets or quadruplets using a geophysical model function
- Ku band (QuikScat,Oceansat-2) or C band radar systems (ERS 2, ASCAT)
- Radar backscatter depends on sea surface waves
- Quality control important (Rain flagging, land/ice flagging etc.)
- How to spread information into the vertical ?
- Representation of Boundary layer physics over oceans important
- Several future missions planned (Windsat, Metop-B, CFOSAT, HY-2A, Microwave Temperature and Wind Mission

Scatterometer

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

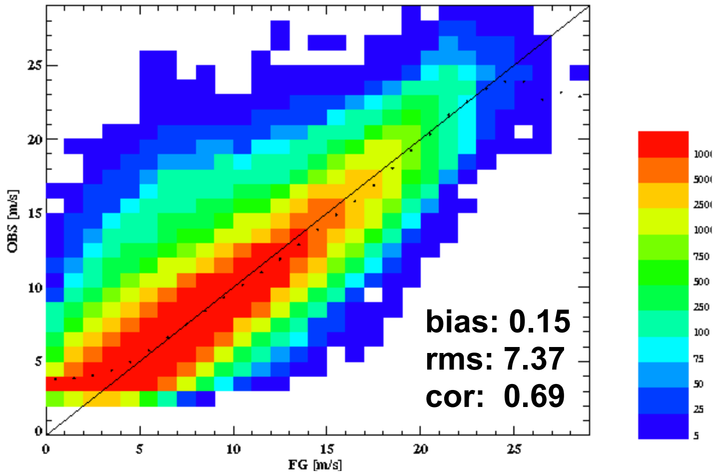


OSCAT Data Quality

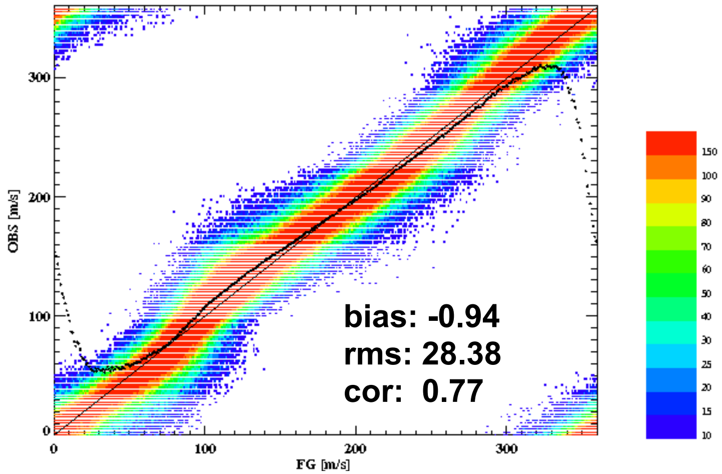
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

All data

windspeed

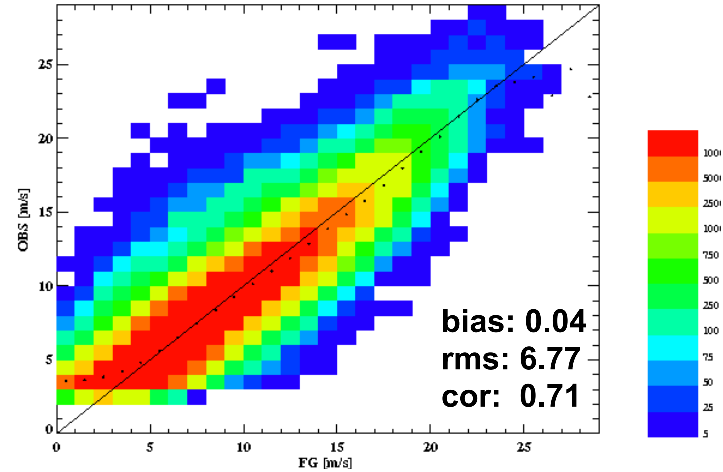


winddirection

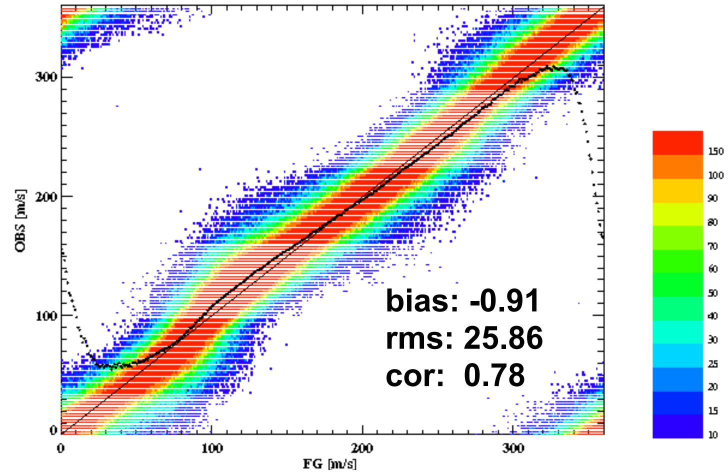


Flagged data removed

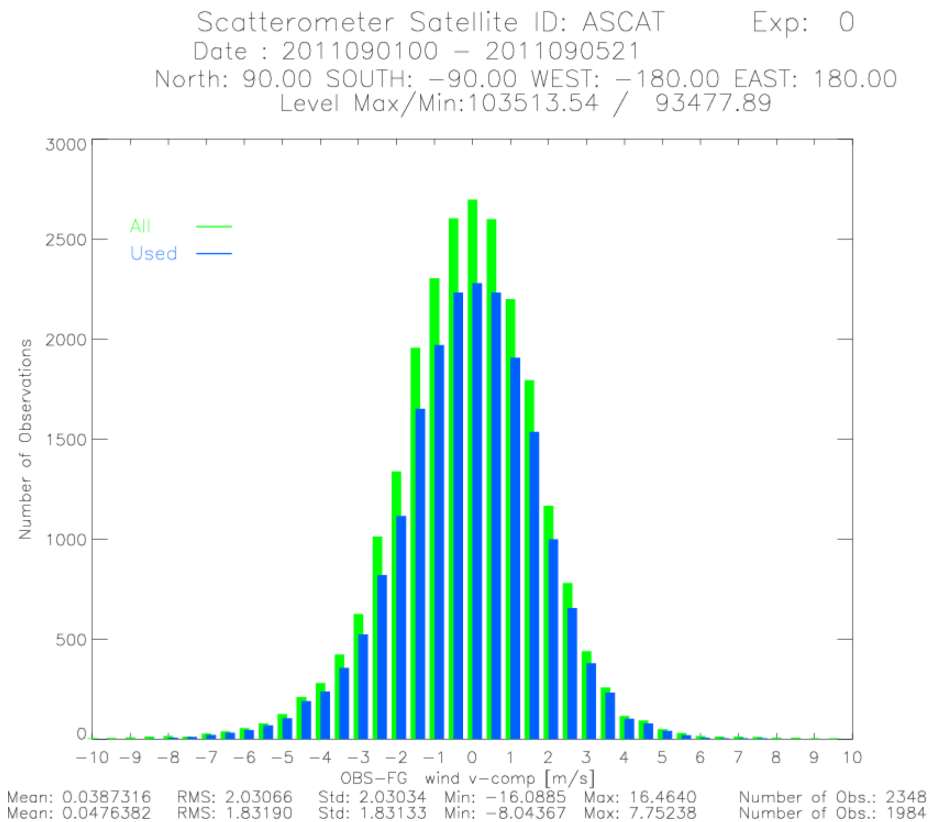
windspeed

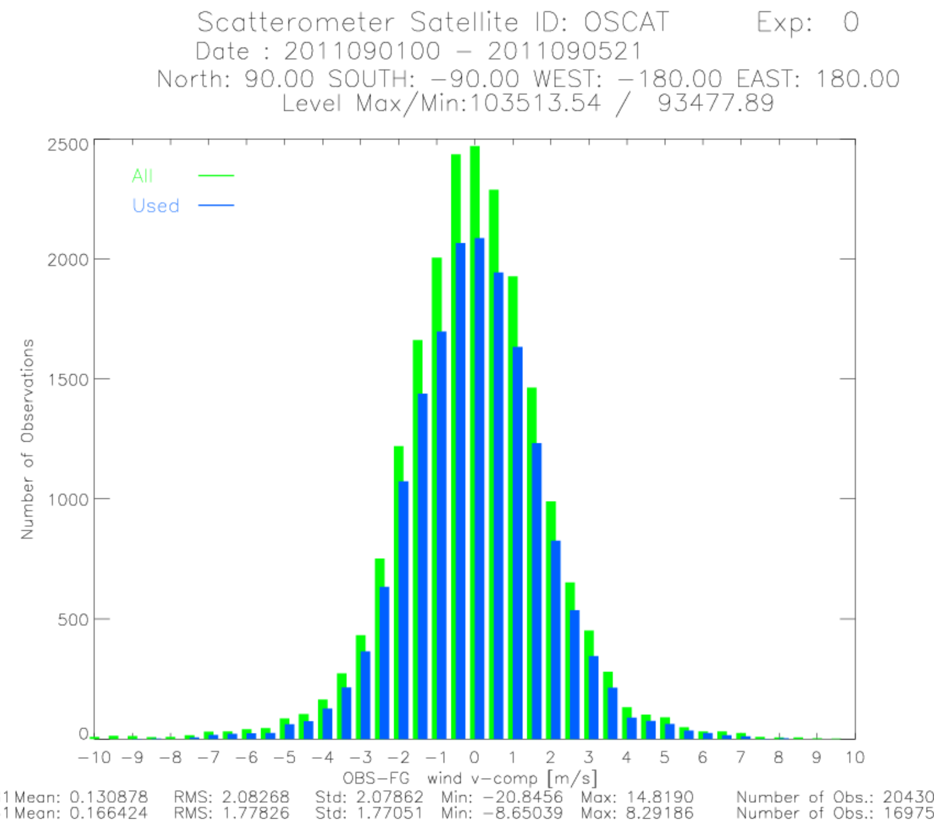


winddirection



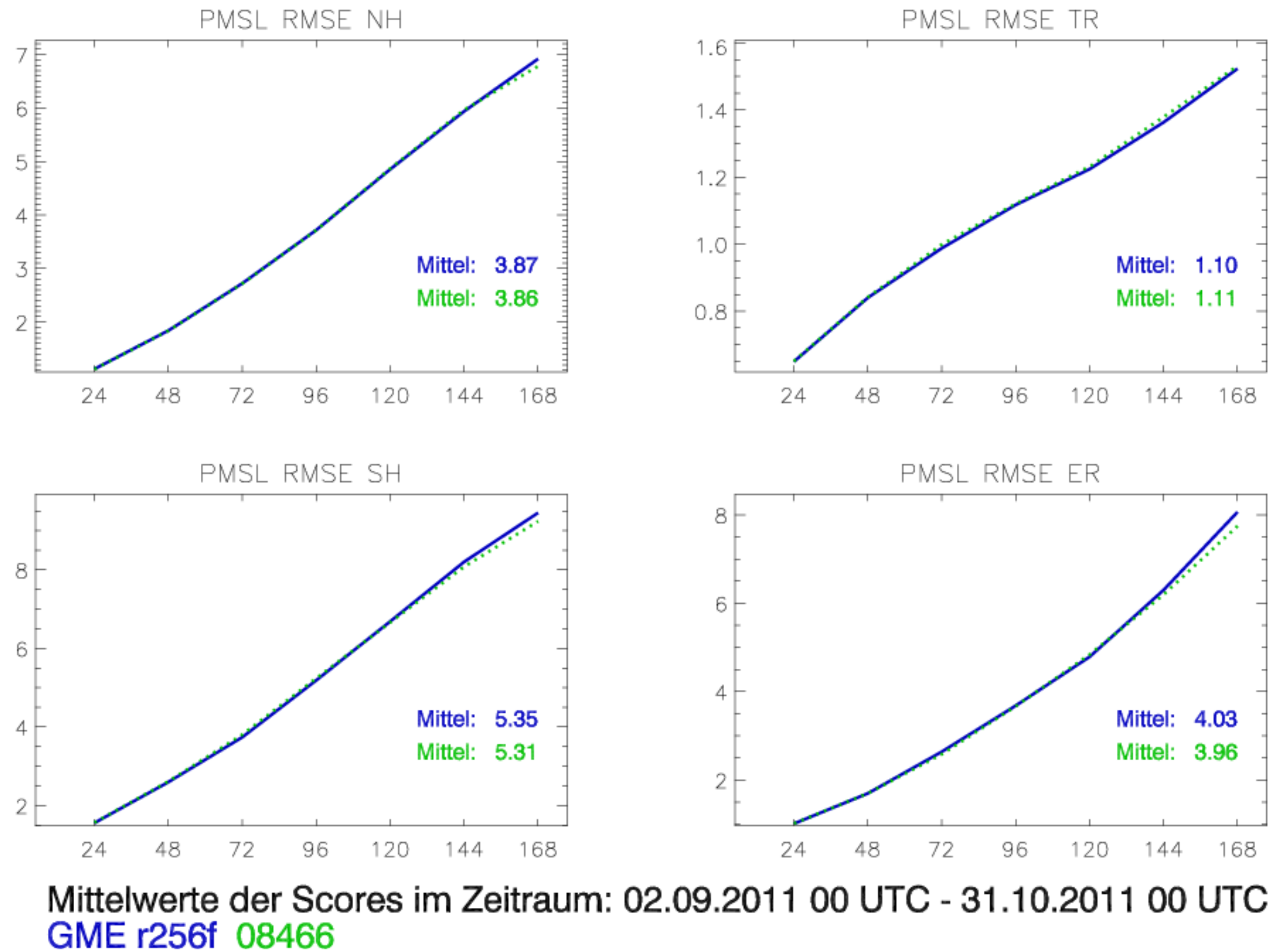
Oscat data quality





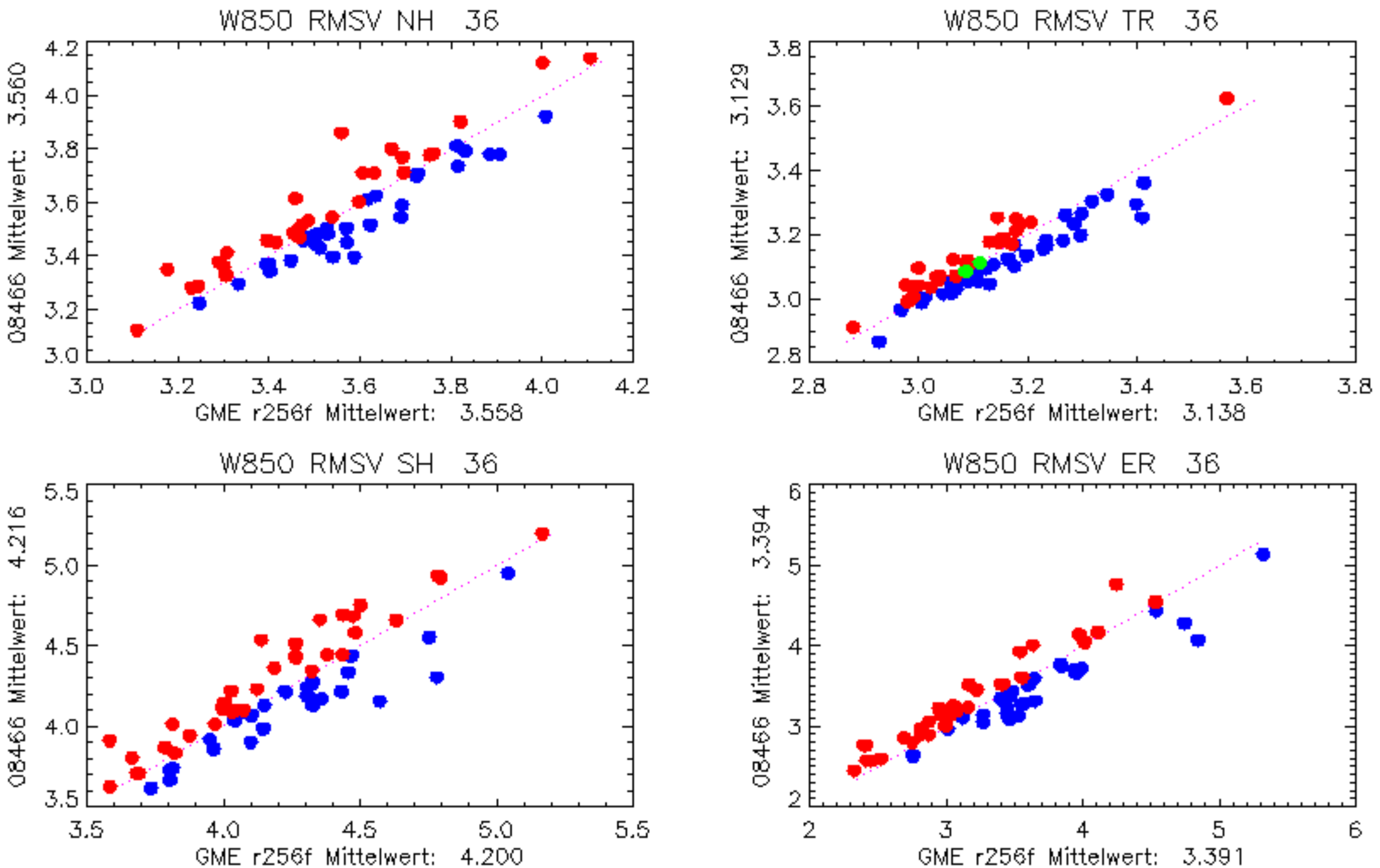
Oscat impact

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Oscat impact

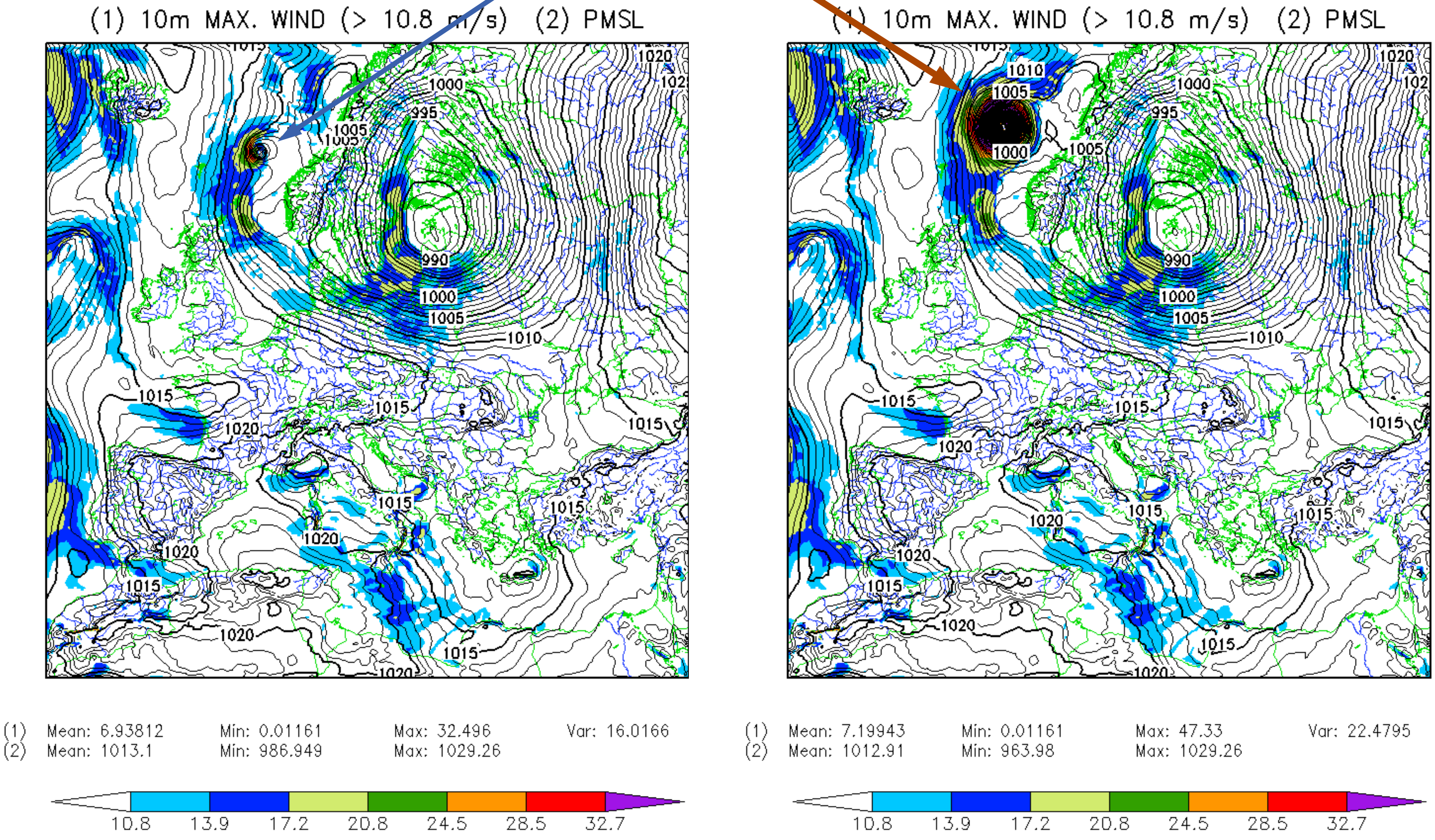
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Scatterdiagramm der Scores im Zeitraum: 02.09.2011 12 UTC - 31.10.2011 12 UTC

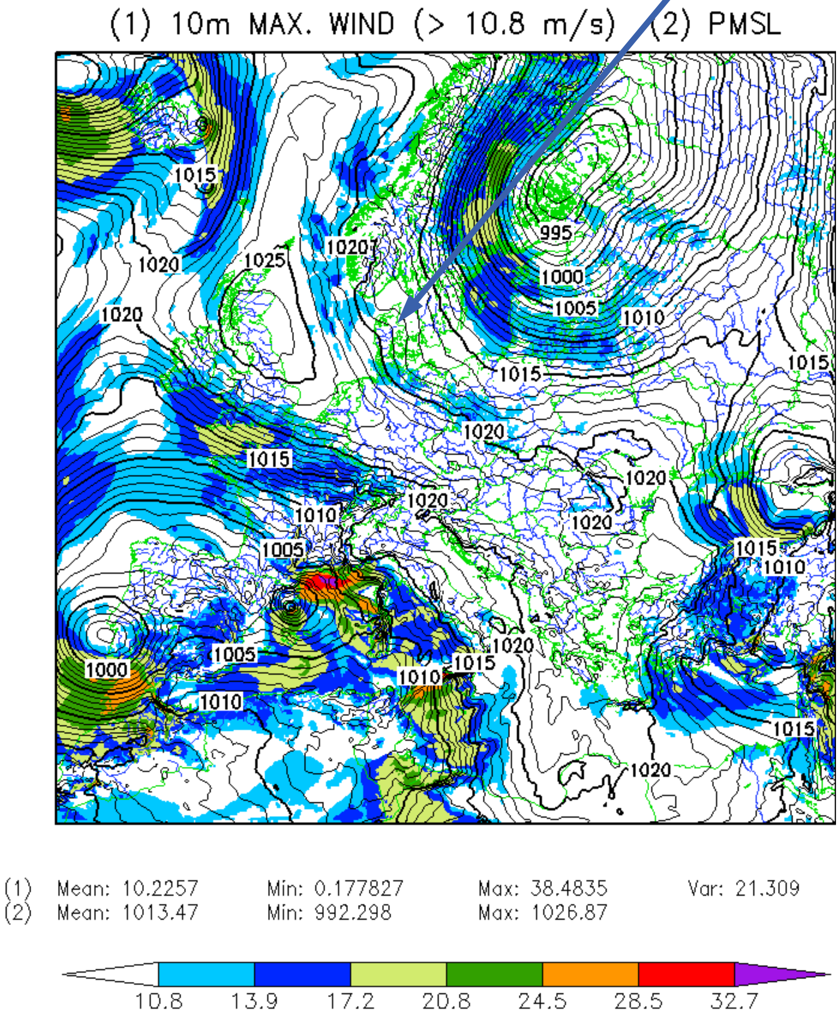
Erroneous low pressure system caused
By a malfunctional bouy

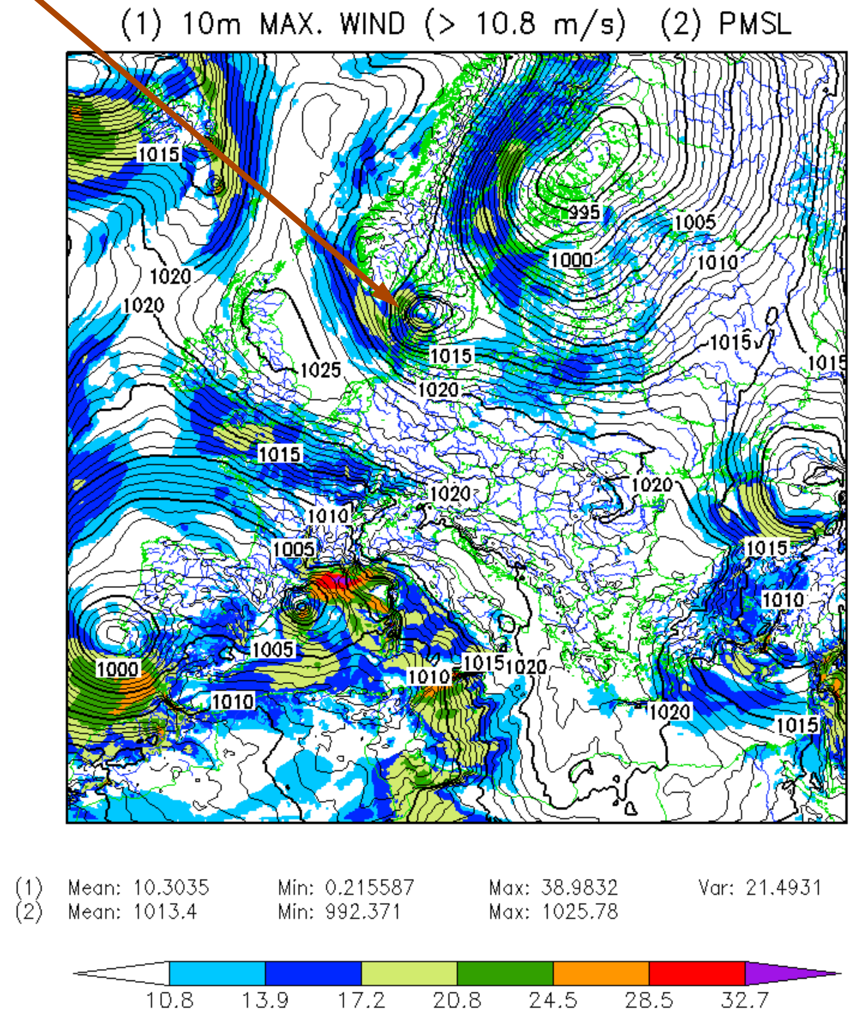
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



36 hour forecast

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD

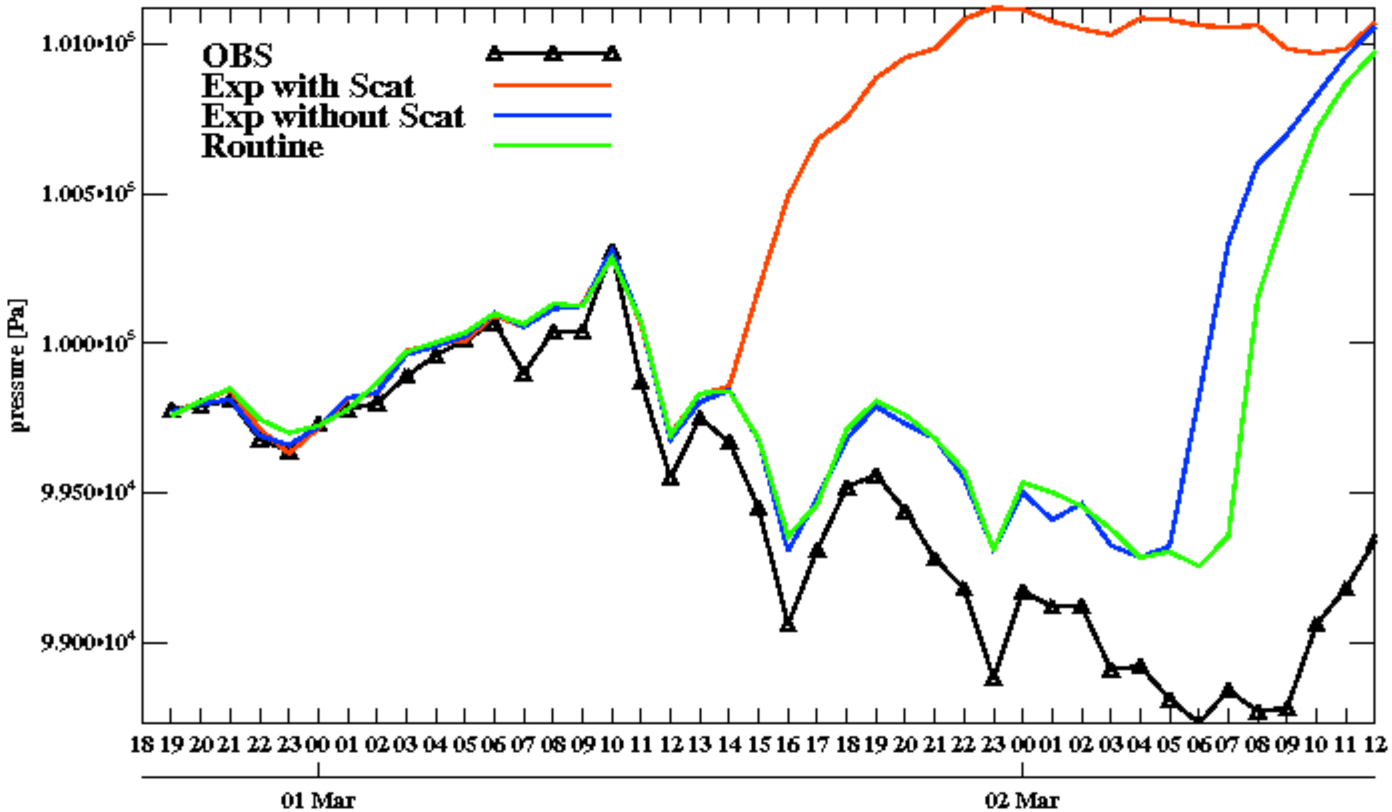




Time series of sea level pressure observation and analysis at bojie (63643) location

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

01 March – 02 March 2010

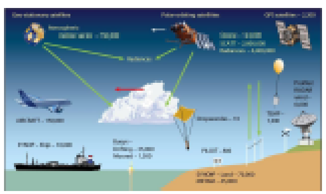


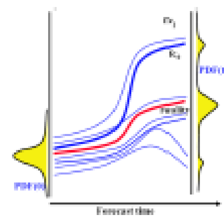
Hans Ertel Center for data assimiliation
established at Univ. Munich and DLR, sponsored by DWD

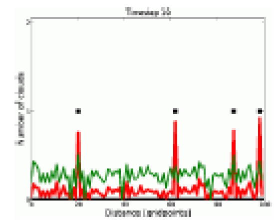
Goals

- Fundamental research in the areas of data assimilation (DA) and ensemble forecasting
- Training of young researchers and students
- Methods to assess the analysis and forecast impact of observations in the KENDA-COSMO system
- Methods to use additional satellite observations for NWP
- Methods to improve the representation of forecast uncertainty in the KENDA-COSMO system
- Robust data assimilation methods for strongly non-linear systems with non-Gaussian error statistics

Research areas







Observation impact

Tools to quantify the analysis and forecast impact of observations in EnDA

Monitoring of observations

Optimized use of observations

Satellite observations

Direct assimilation of MSG SEVIRI VIS+NIR radiances in KENDA

AMV height correction with lidar observations

(Lightning)
(ADM-Aeolus)

Ensemble forecasts

Improved representation of forecast uncertainty

KENDA initial perturbations

Flow-dependence and impact time of perturbations

DA methods

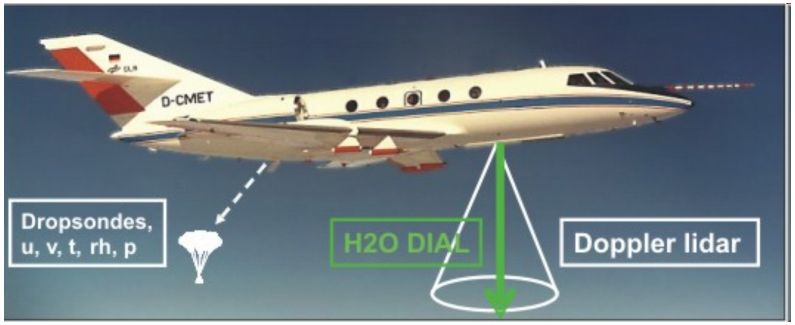
Methods for convective-scale DA

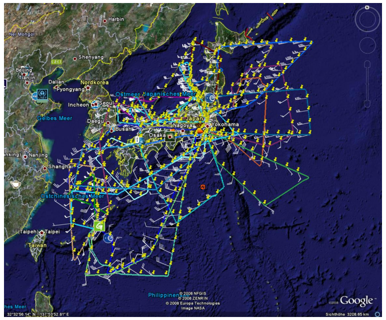
Idealized tests with non-Gaussian error statistics (toy models)

Robust methods for highly non-linear systems

Height correction of atmospheric motion vectors with airbourne lidar observations

Martin Weissmann, Kathrin Folger und Heiner Lange



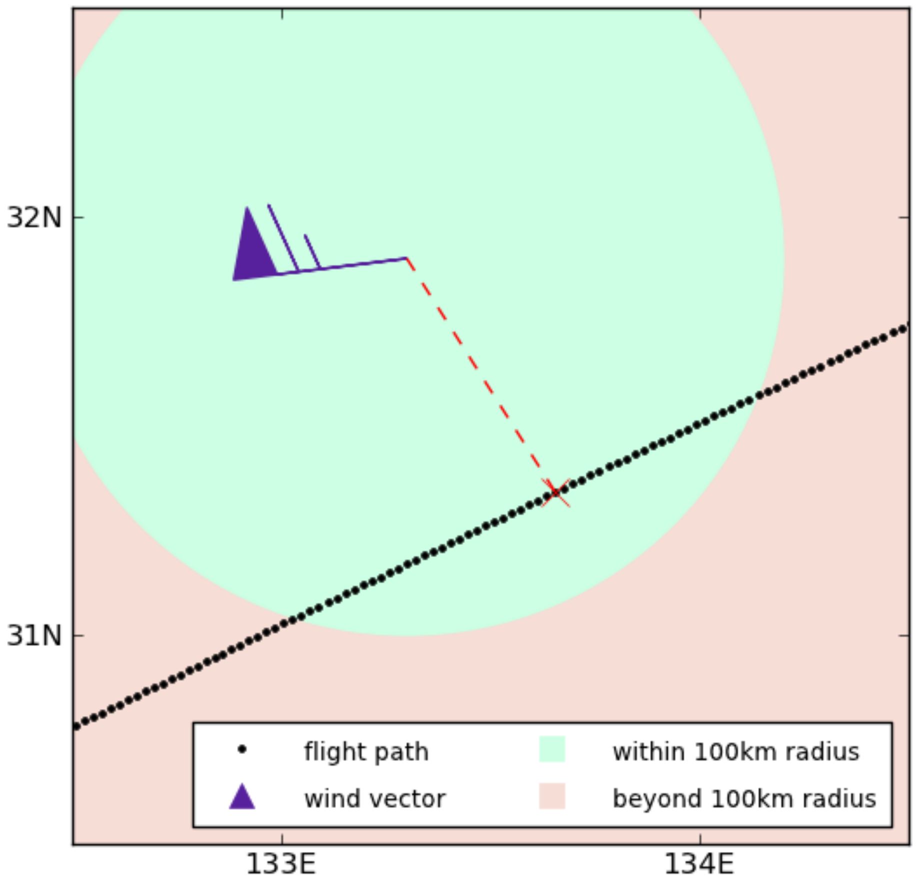


Goals: Shifting the height of estimated AMVs to cloud heights detected by an lidar during T-PARC
Evaluationg the reduction of AMV wind error through the height correction with dropsonde observations
Developing a correction algorithm that could adjust AMV heights with satellite lidar observations in the future

Data base: T-PARC ~60 hours, Drops, Lidar Backscatter, CIMMS Geo AMVs

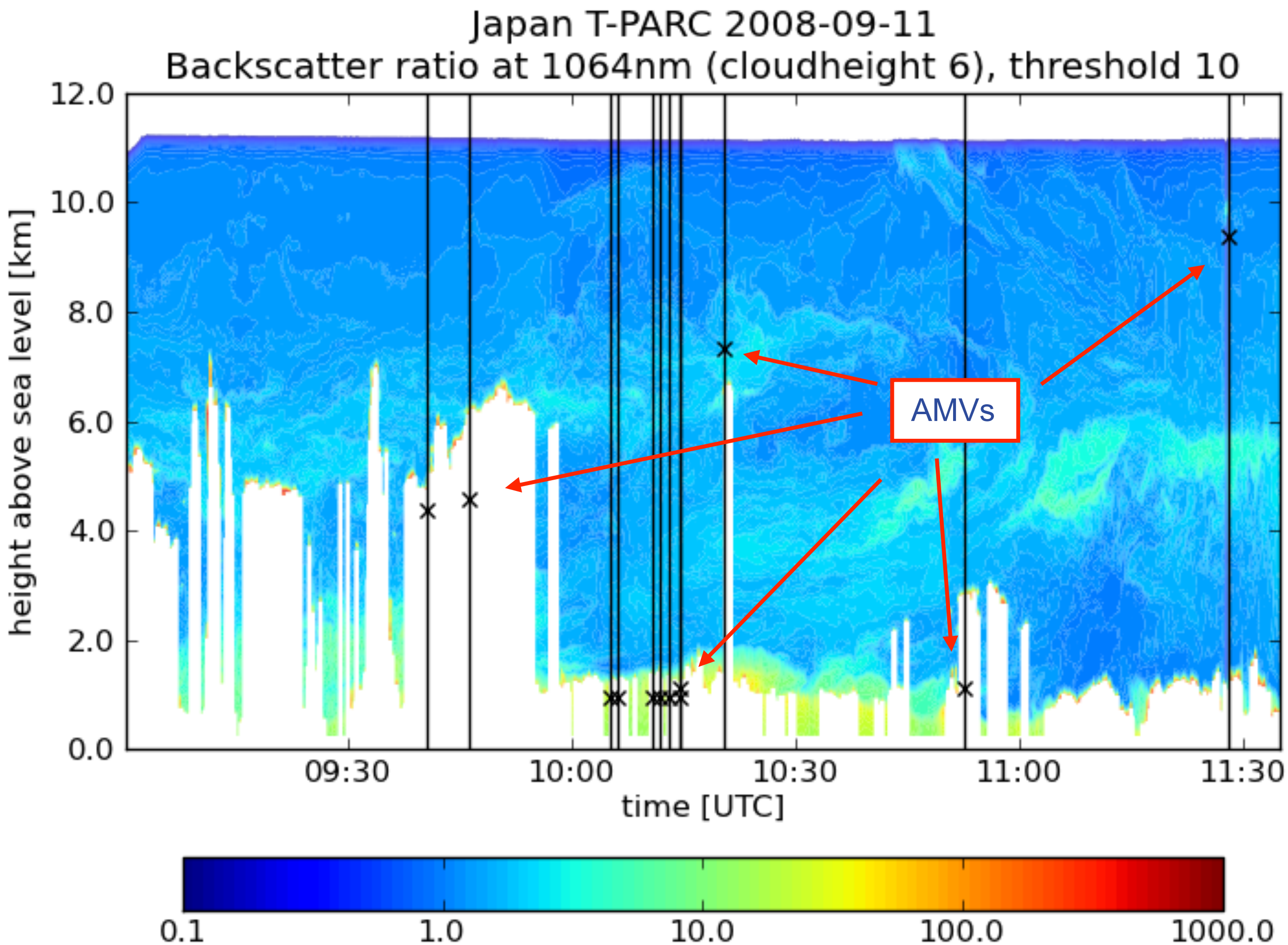
Steps: Cloud height detection, correction, verification mit Dropsonde data (for T-PARC AMVs)

Conditions

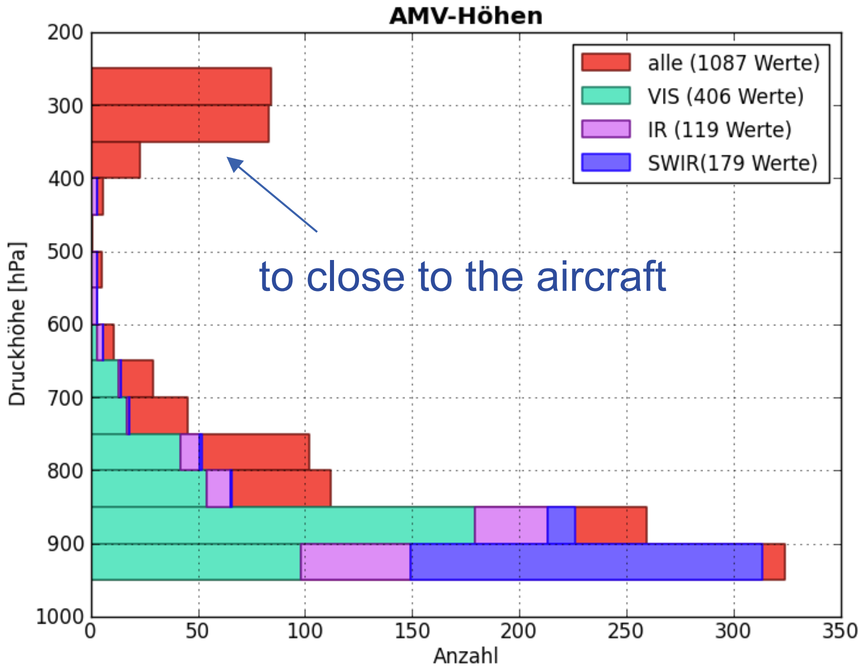


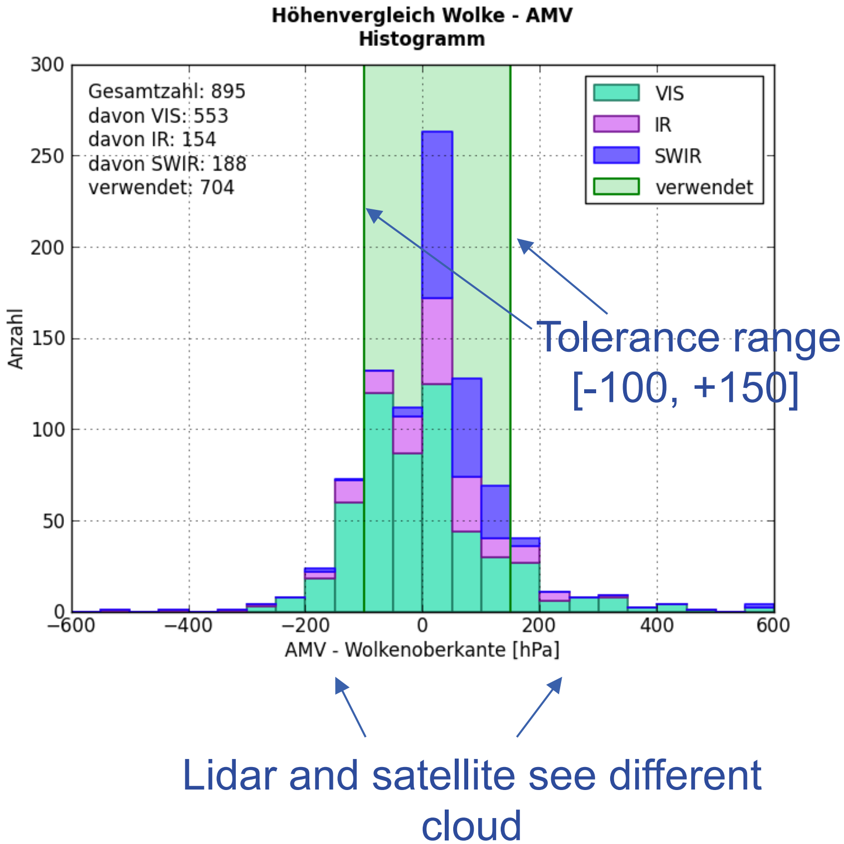
- less than 100 km distance
- less than 60 min. time difference
- no WV (only IR/SWIR/VIS)
- AMVs 150 hPa below flight height
- dropsonde within 100 km distance

measurement example



Comparable AMV – Lidar clouds





General appraoch

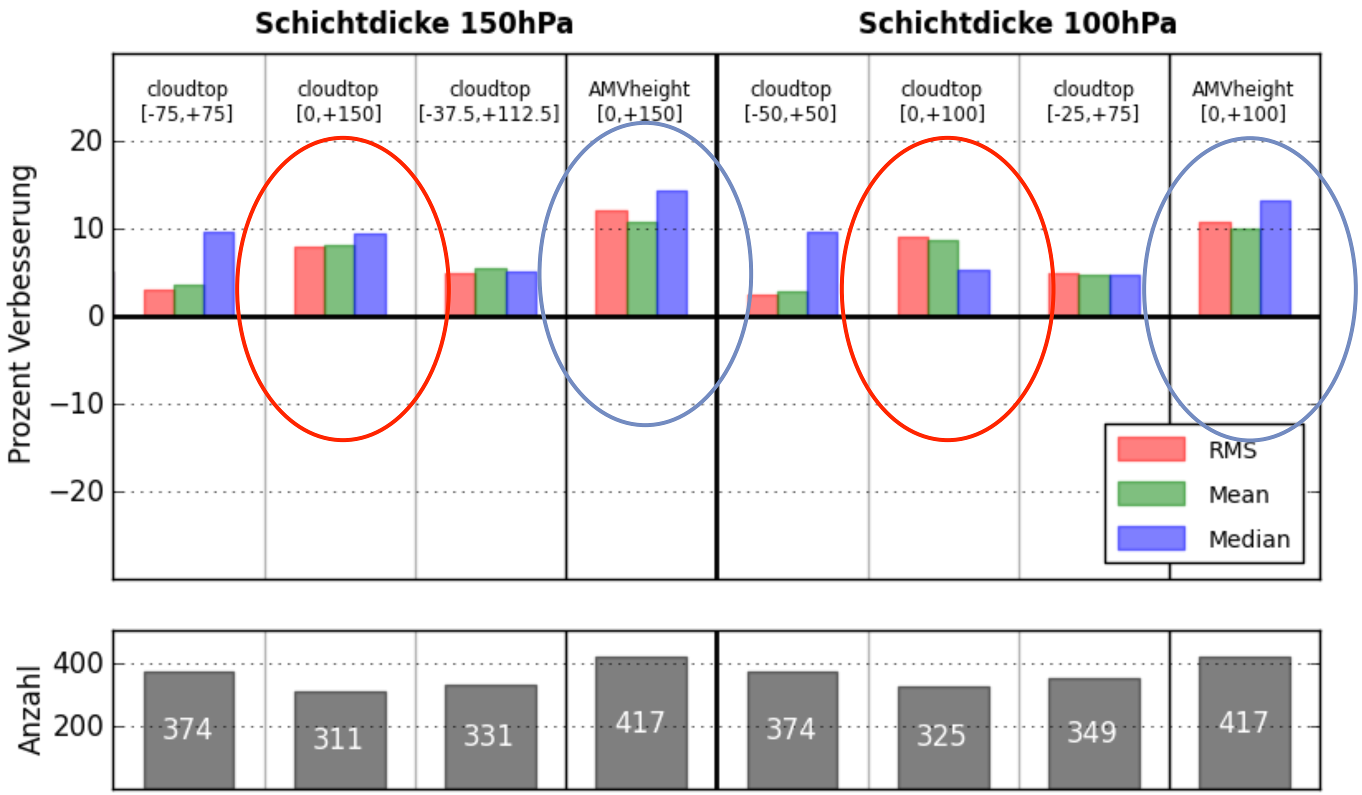
- **Assumption:** AMV winds are representative of a layer wind
- **Method:** Compare the AMV wind mearsurement with dropsonde layer winds

X = AMV wind minus dropsonde layer wind
[+75,-75 hPa around AMV height]

Y = AMV wind minus dropsonde layer wind
[+0,-150 hPa below/around lidar cloud]

Compute the relative improvement : (X-Y)/X * 100 [%]

Results for all AMVs



- Improvement with Lidar: 5-10%
- Systematic height assignment error
- Improvement 10% if compared layer winds 100-150 hPa below AMV
- Results are dominated by VIS winds

Conclusions I

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Wind information are very important in our assimilation system
- AMVs important contribution to the global observation system
- Impact of AMVs stronger in summer period than in winter
- Impact is high on the Southern Hemisphere and Tropics and smaller on the Northern Hemisphere
- Strong impact of polar AMVs over the southern polar regions
- Use of MTSAT-2R and GOES 15 winds operationally
- Metop AVHRR winds derived from Eumetsat show higher bias and RMS compared to winds derived from NOAA
- Use of AMVs over land show a strong positive impact

Conclusions II

- Quality of Oceansat-2 winds comparable to ASCAT winds
- Small positive impact of Oceansat-2 scatterometer winds
- Scatterometer winds help to stabilize the COSMO analysis and forecasts
- Small positive impact also in COSMO regional model
- Program started to analysis and improve the height assignment of AMVs with the help of lidar and dropsonde cloud height and wind observations
- Assimilation of height corrected AMV winds or AMV winds as layer winds