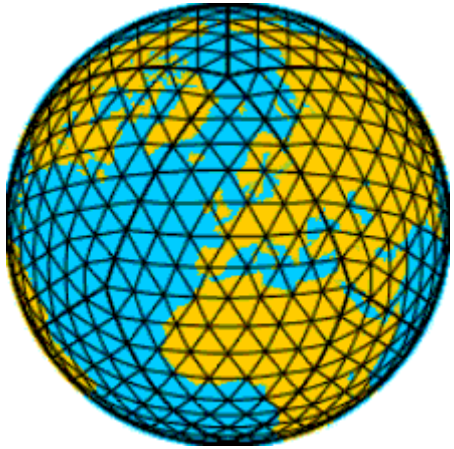
Deutscher Wetterdienst

Recent progress in using satellite winds at the German Weather Service

10th International Wind Workshop
Tokyo, JP, Feb. 22-26 2010
Alexander Cress

- Introduction
- Monitoring process
- AMV Impact Studies (Dec. 2007 – Jan. 2008)
- Use of AVHRR polar winds
- Impact of direct broadcasting polar winds
- Use or scatterometer data in COSMO EU
- Conclusions and Outlook

Global Model GME

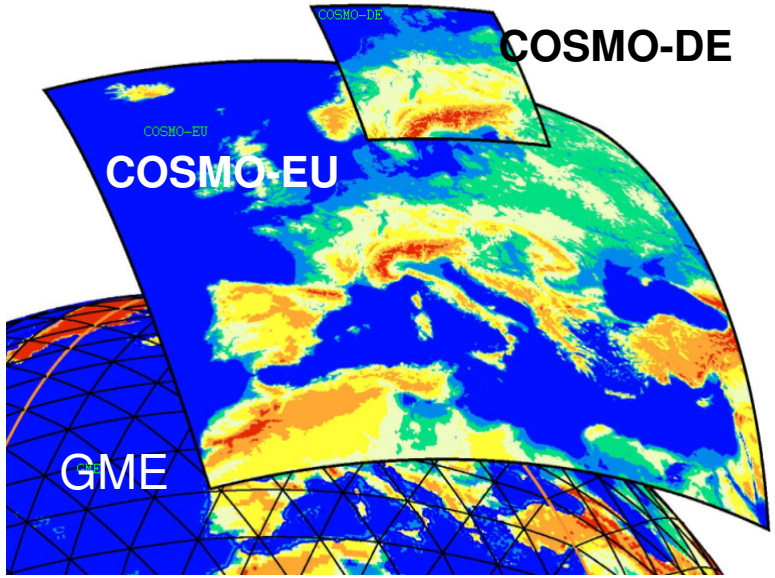


- Operational NWP Model of DWD
- gridpoint model, hexagonal triangular grid
- 30/40 km mesh size
- 60/40 layers (hyprid, sigma/pressure)
- prognostic variables: p_s, u, v, T, q_v, q_c, q_i, o_3
- 3DVAR (PSAS) system
- incremental digital filter initialization (P.Lynch)
- At 00 UTC and 12 UTC: forecasts for 174 hours
- At 06 UTC and 18 UTC: forecasts for 48 hours
  - ➢ Boundary values for local model

Lokal-Model COSMO-EU (LME) und COSMO-DE (LMK)

COSMO-EU (regional model): non-hydrostatic, rotated lat-lon grid, mesh-size: 7km
terrain-following hyprid coordinate with 40 layers up to 20 hPa
forecast range: 78 h every 6 hours
prognostic cloud ice, prognostic rain schemes
boundary values from GME

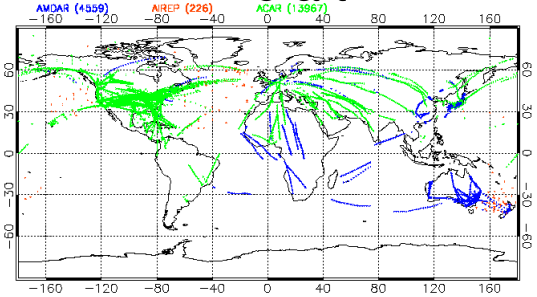
Analysis: continuous nudging scheme
observations: radiosonde, pilots, wind profiler, aircraft, synops, buoys, ships
cut-off: 2h30min
variational soil moisture analysis



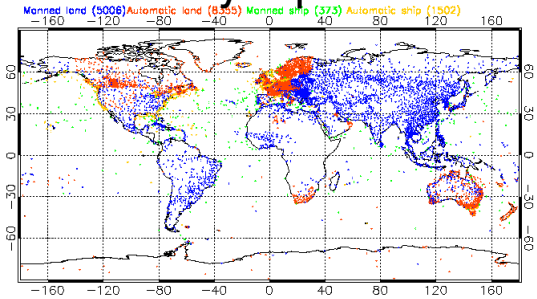
COSMO-DE (lokal model): similar to COSMO-EU
forecast range 18 h every 3 h
mesh-size: 2.8 km, explicit convection
latent heat nudging of radar reflectivities
boundary values of COSMO-EU

Observational Use in 3DVAR

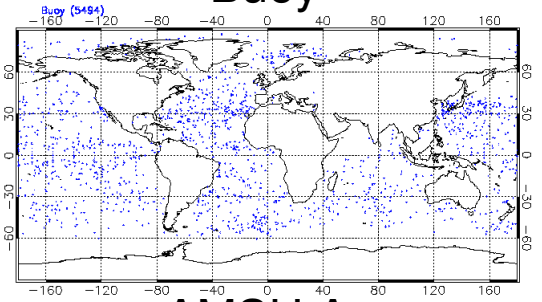
Aircraft



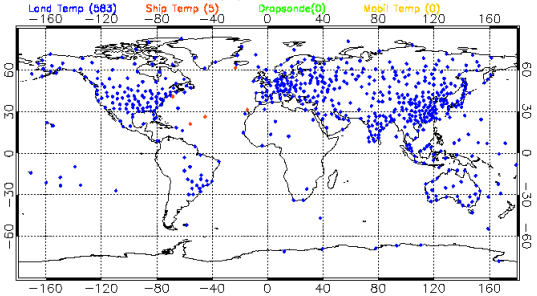
Synop



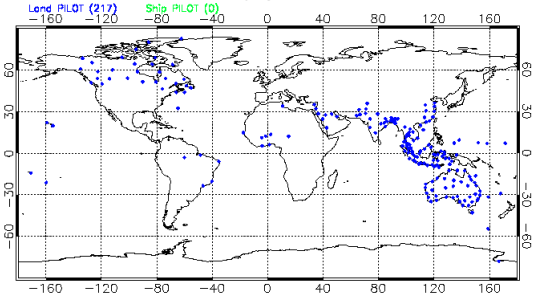
Buoy



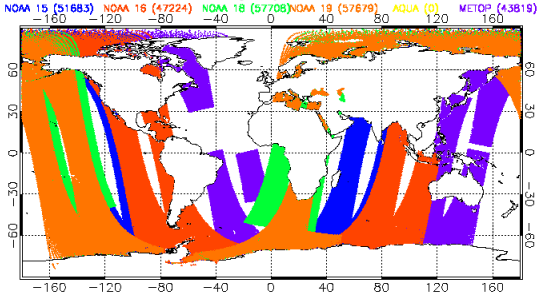
Radiosonde



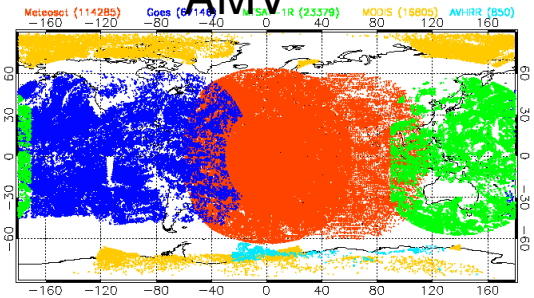
Pilot



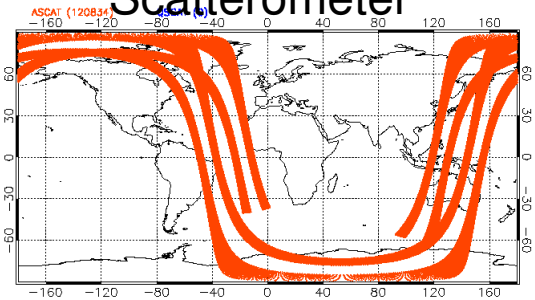
AMSU A



AMV



Scatterometer



Usage of AMV winds at DWD

- **Geostationary satellites (GOES 11/12; Eumetsat 7/9; MTSAT-1R)**
  - extratropics over oceans; 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)**
  - 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)

AMV data monitoring

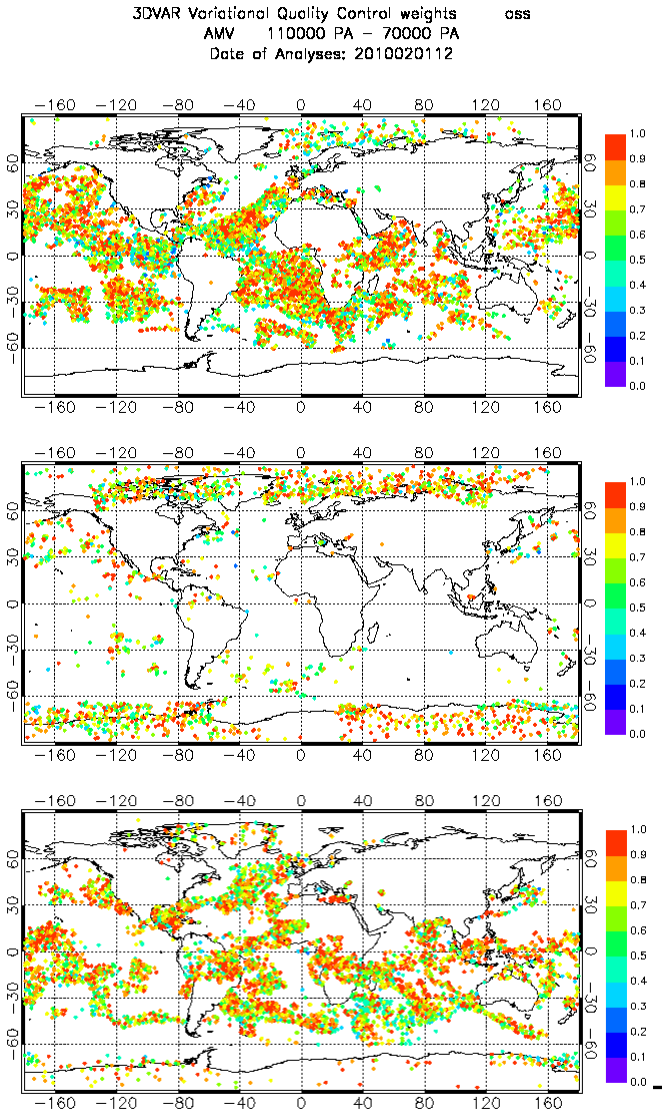
- Time evolution/geographical distribution of statistics for specific satellites over predefined areas/surfaces/channels/ flags/QI-Indexes

- Time series/Geo-plots/Hov-diagrams

- Regional distribution of 3DVAR weights

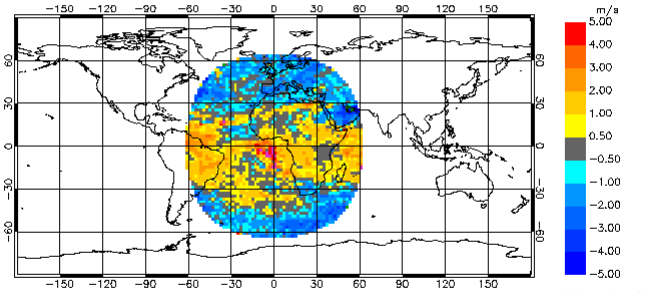
- Useful for quick and routine verification

- In case of conspicuousness: Switch of whole satellite or channel or region or increase QI thresholds etc.



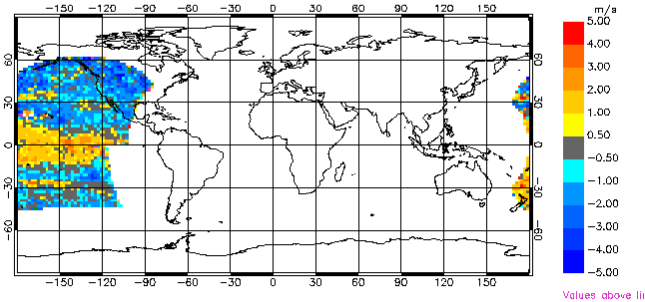
AMV data monitoring

Statistics for AMV speed from MET- 9 / WVcloud ch.1, Layer=0-400hF
Mean First Guess Departure (OBS-FG) (QI.GE.80)
EXP = rou
Time period: 20091201 00UTC - 20091231 21UTC, Hour = all



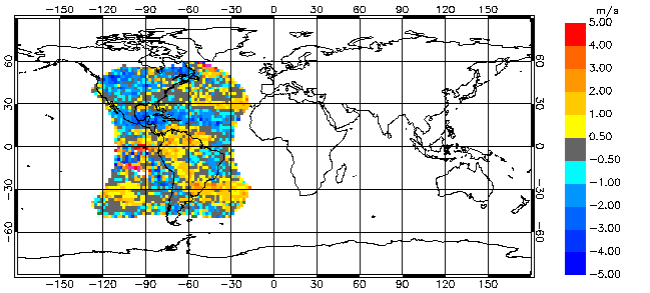
units = m/s
min = -10.22
max = 10.06
mean = 0.14

Statistics for AMV speed from GOES-11 / IR ch.1, Layer=0-400hPa
Mean First Guess Departure (OBS-FG) (QI.GE.80)
EXP = rou
Time period: 20091201 00UTC - 20091231 21UTC, Hour = all



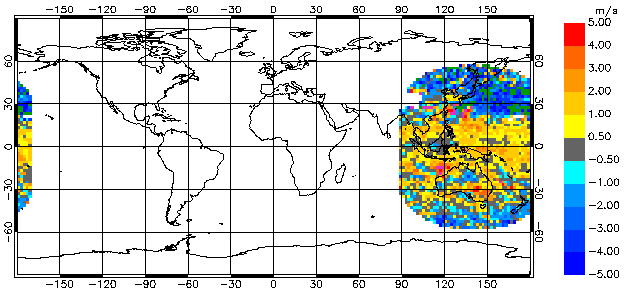
units = m/s
min = -7.90
max = 5.87
mean = -0.44

Statistics for AMV speed from GOES-12 / IR ch.1, Layer=0-400hPa
Mean First Guess Departure (OBS-FG) (QI.GE.80)
EXP = rou
Time period: 20091201 00UTC - 20091231 21UTC, Hour = all



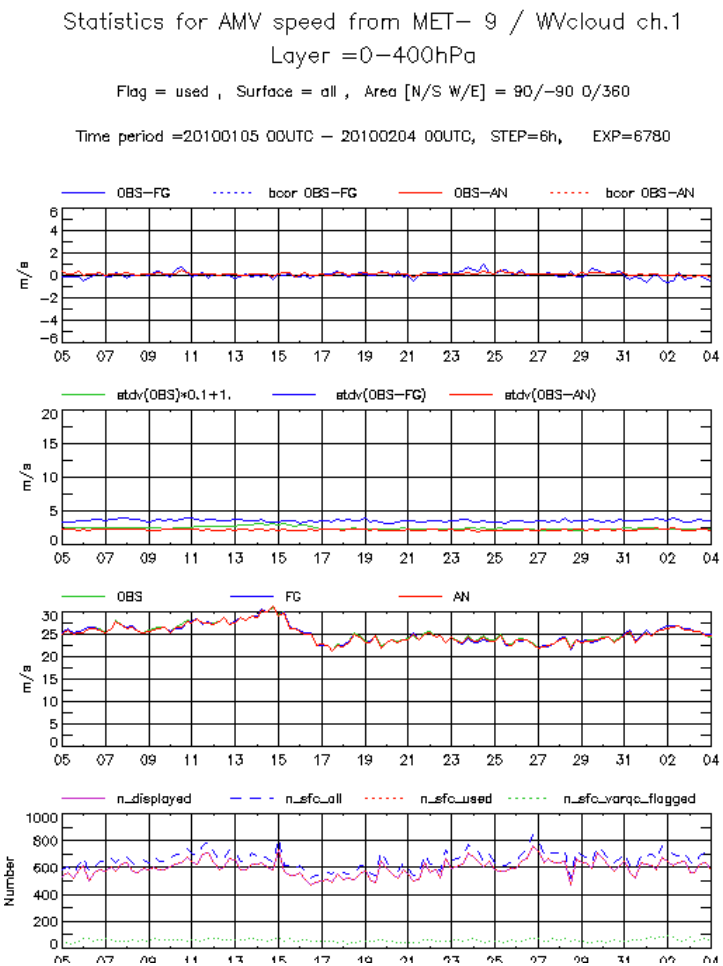
units = m/s
min = -6.05
max = 9.15
mean = 0.02

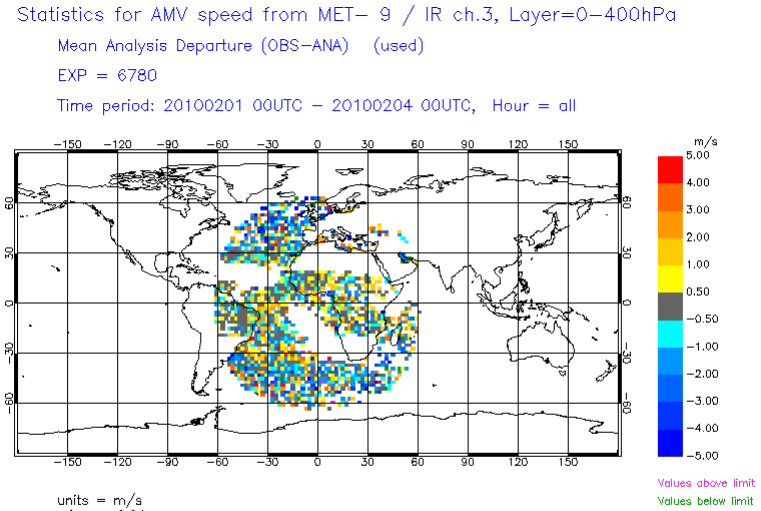
Statistics for AMV speed from MTSAT- 1 / IR, Layer=0-400hPa
Mean First Guess Departure (OBS-FG) (QI.GE.80)
EXP = rou
Time period: 20091201 00UTC - 20091231 21UTC, Hour = all

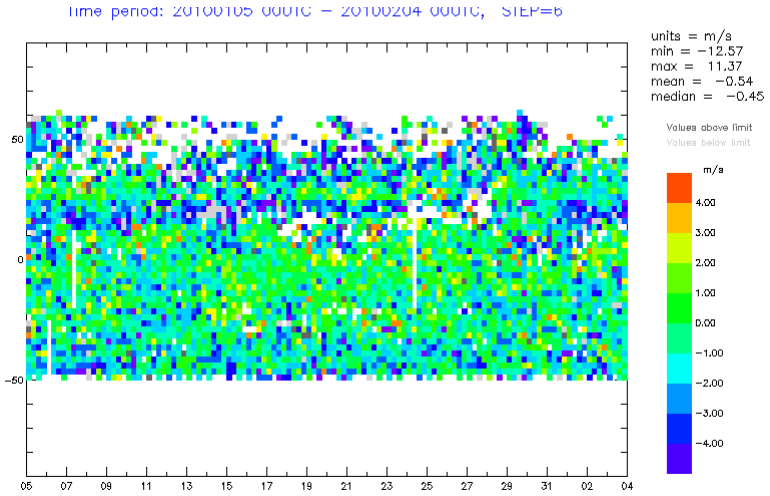


units = m/s
min = -14.92
max = 15.45
mean = 0.14

Deutscher Wetterdienst

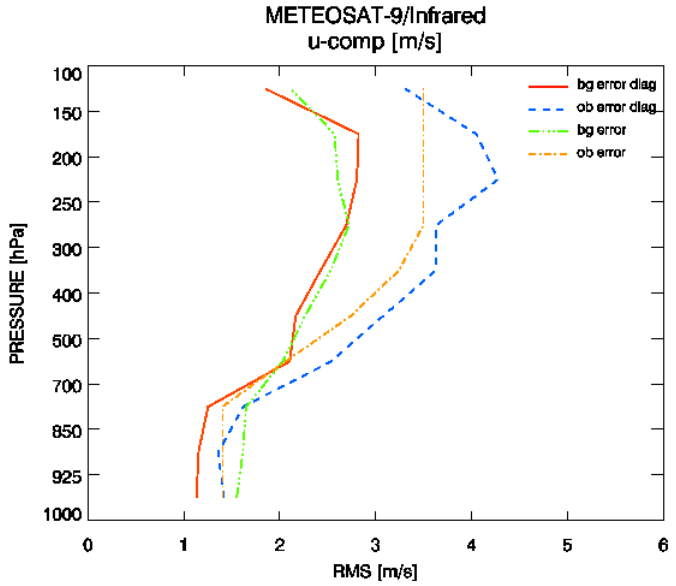






Diagnosis of observation, background error statistics in observation space

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



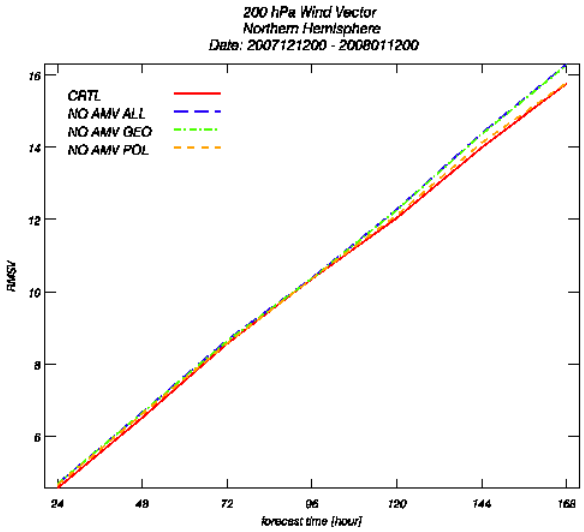
Results

- Background errors seems slightly overestimate 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

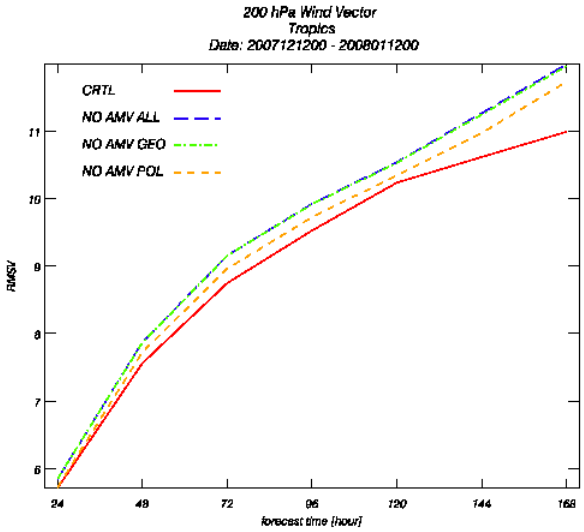
AMV Impact Experiment

- Following an initiative by Mary Forsythe and Lars Peter Riishojgaard
- Data denial experiment with 3DVAR
- No use of geostationary and/or polar AMV wind vectors
- Winter period (12th Dez. 2007 – 12th January 2008)
- 00 UTC and 12 UTC forecasts

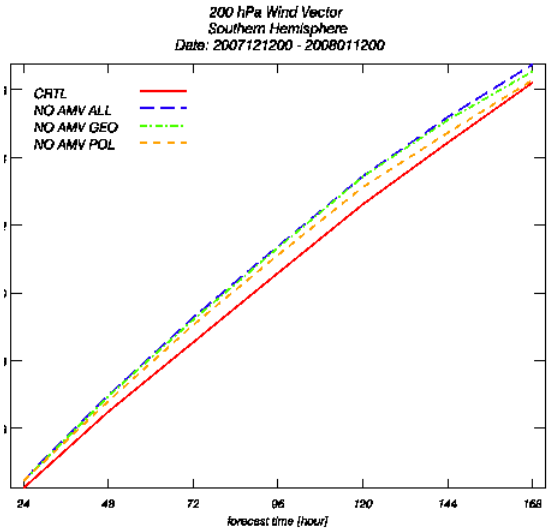
RMS of the 200 hPa Wind Vector
Date: 2007121200 - 2008011200



Northern Hemisphere

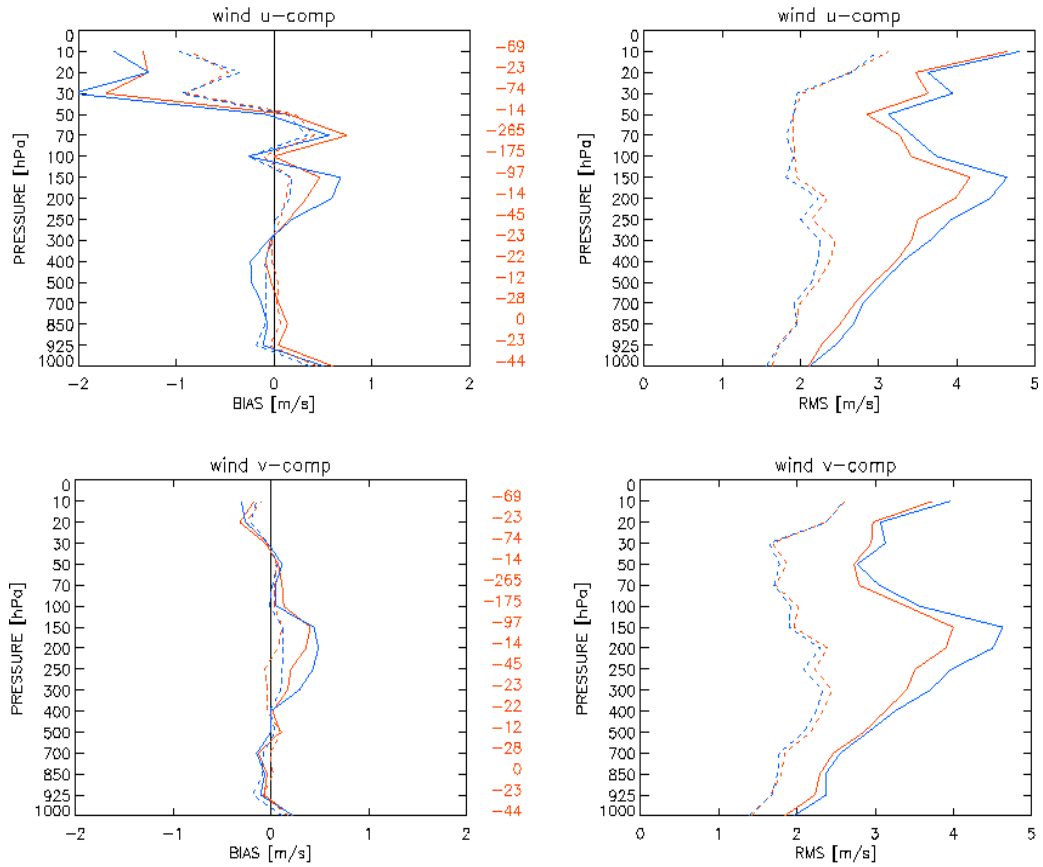


Tropics



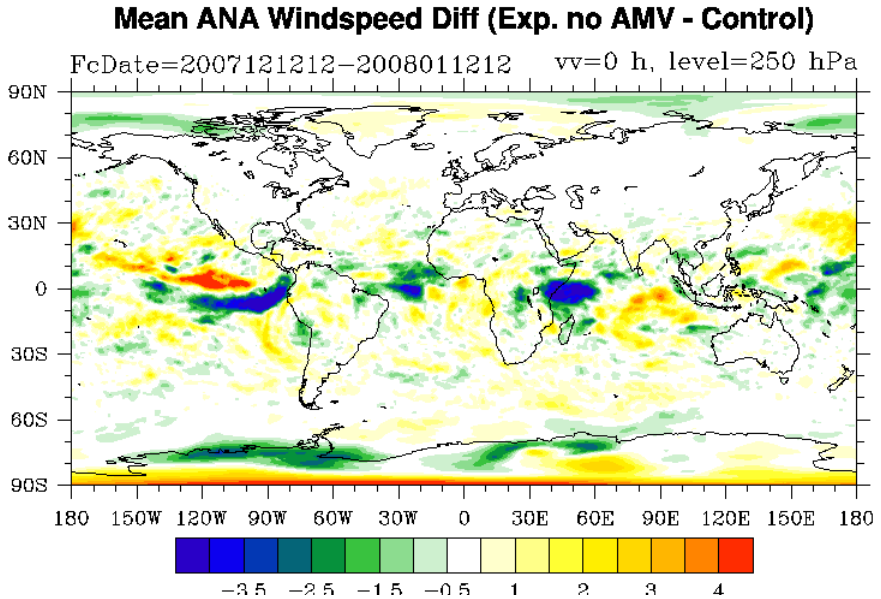
Southern Hemisphere

Radiosonde Verification (Tropics)
2007121200 – 2008011212
Obs – FG (full) Obs-Ana (dotted)

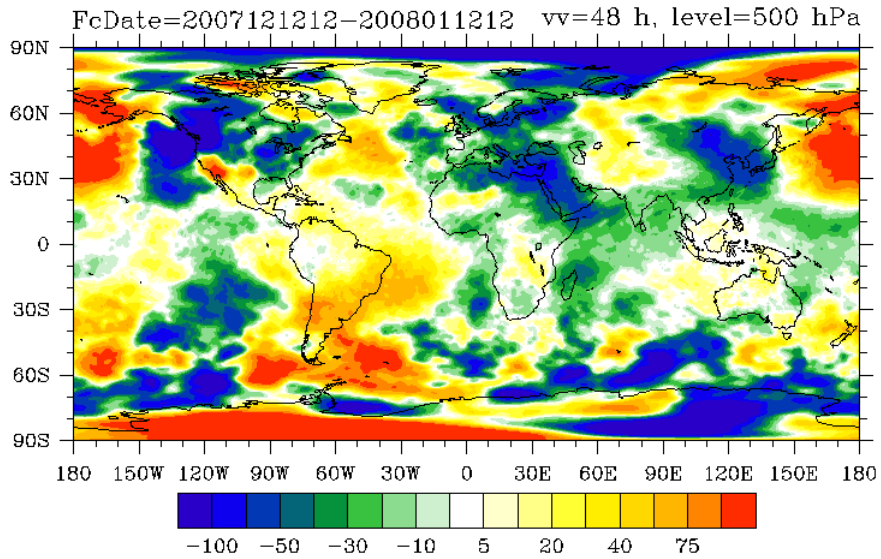


Control

No AMV

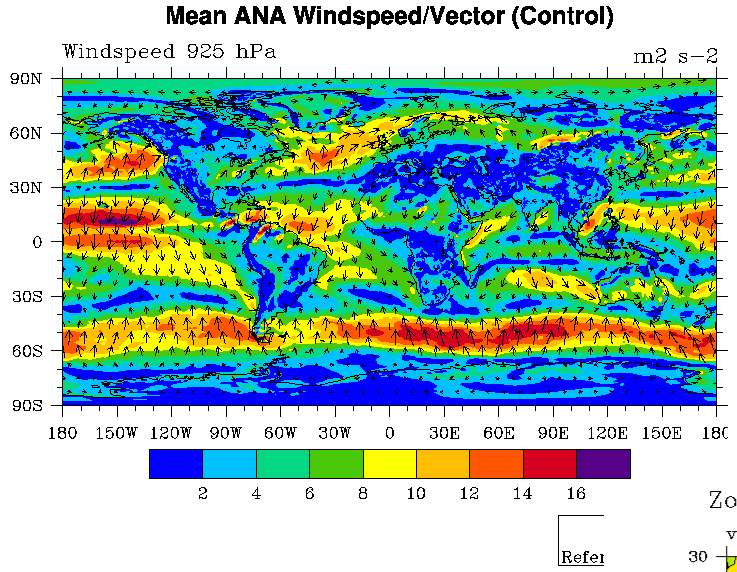


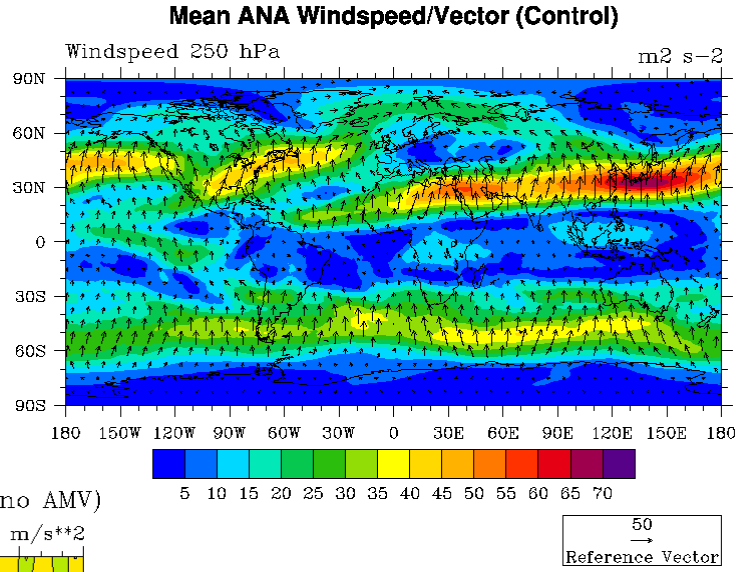
250 hPa windspeed

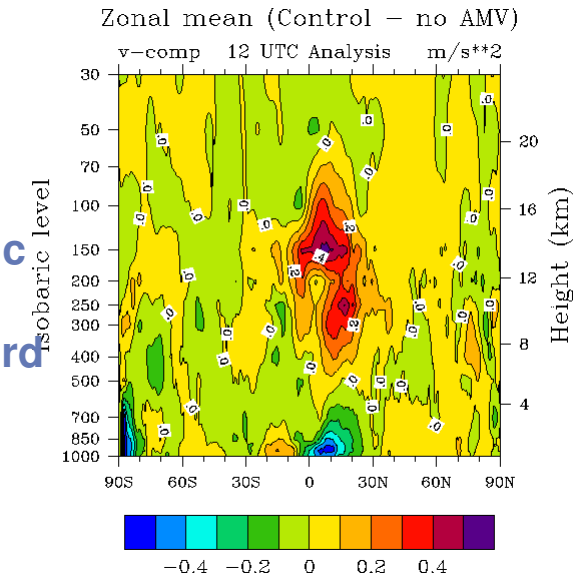


250 hPa geopotential height

Deutscher Wetterdienst







Using AMV winds

a) Stronger upper tropospheric northward wind speed

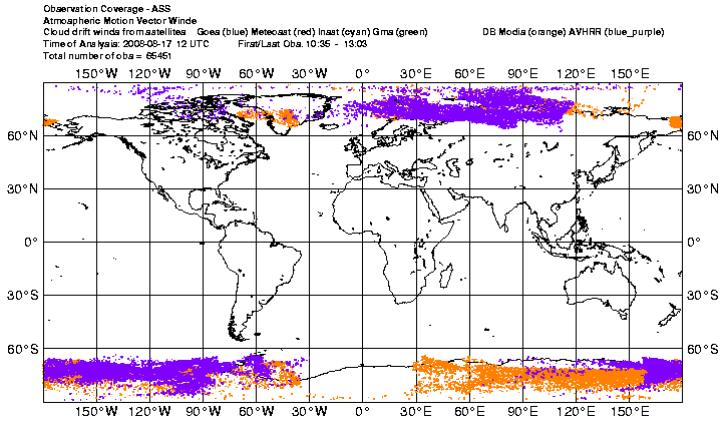
b) Stronger low level southward wind speed

Reduction of Hadley Circulation without using AMV winds ?

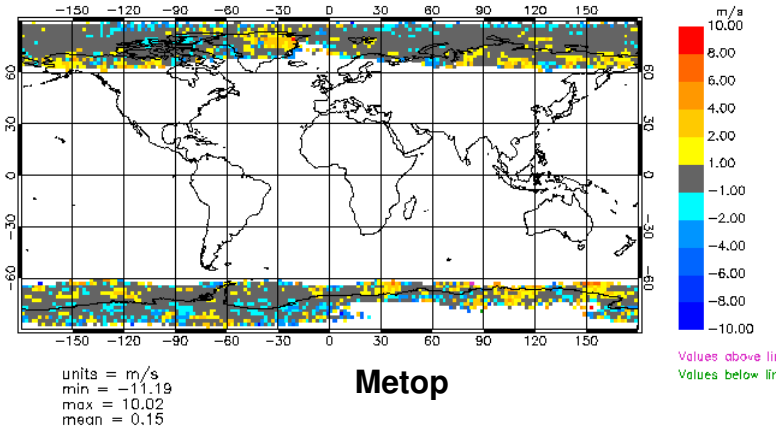
Deutscher Wetterdienst

Use of the polar AVHRR wind vectors in the global analyses system of DWD

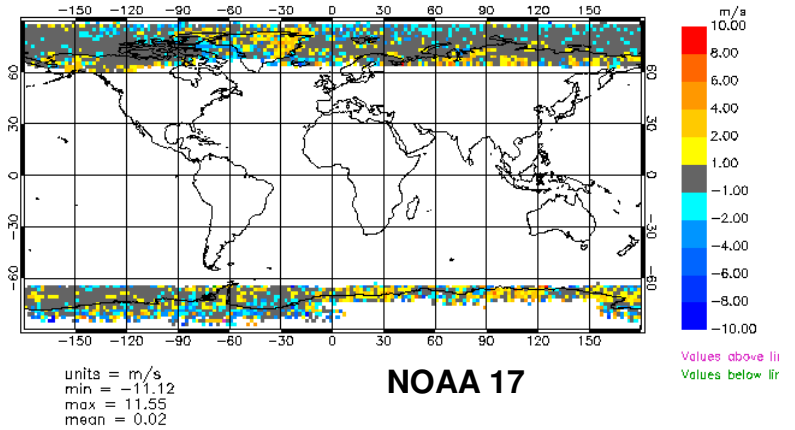
- **Polar regions with small observation density**
- **Polar regions show still large observation errors**
- **Polar lows have influence on weather regimes in Europe and North America**
- **Polar AMV winds from Terra and Aqua only Experimental**
- **No operational satellite programm planned for**
- **Derivation of AMV wind vectors in polar regions**
- **Deriation of wind vectors from polar orbiting**
- **NOAA satellites (15/16/17/18) and Metop**
- **Only infrared winds**
- **Height assigment more problematic than for Modis winds**



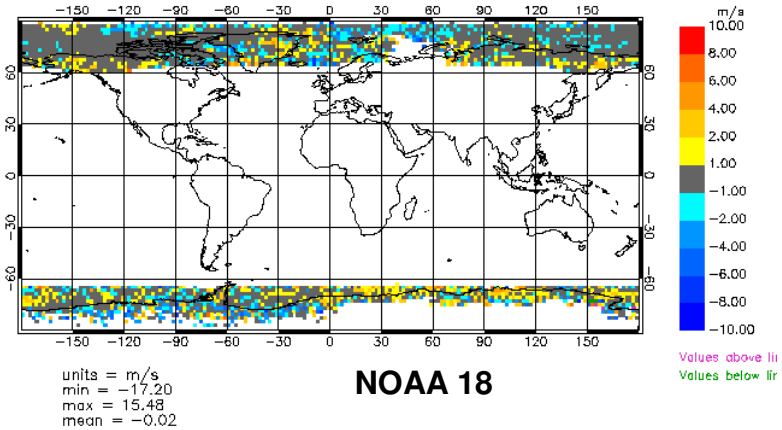
AVHRR OBS – FG Statistik
2008081400 – 2008083121
All Data mit QI > 65 700 hPa – 400 hPa



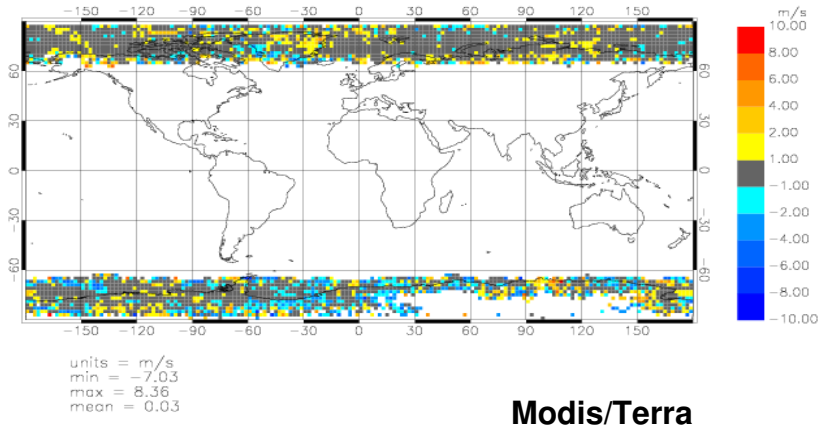
Metop



NOAA 17



NOAA 18

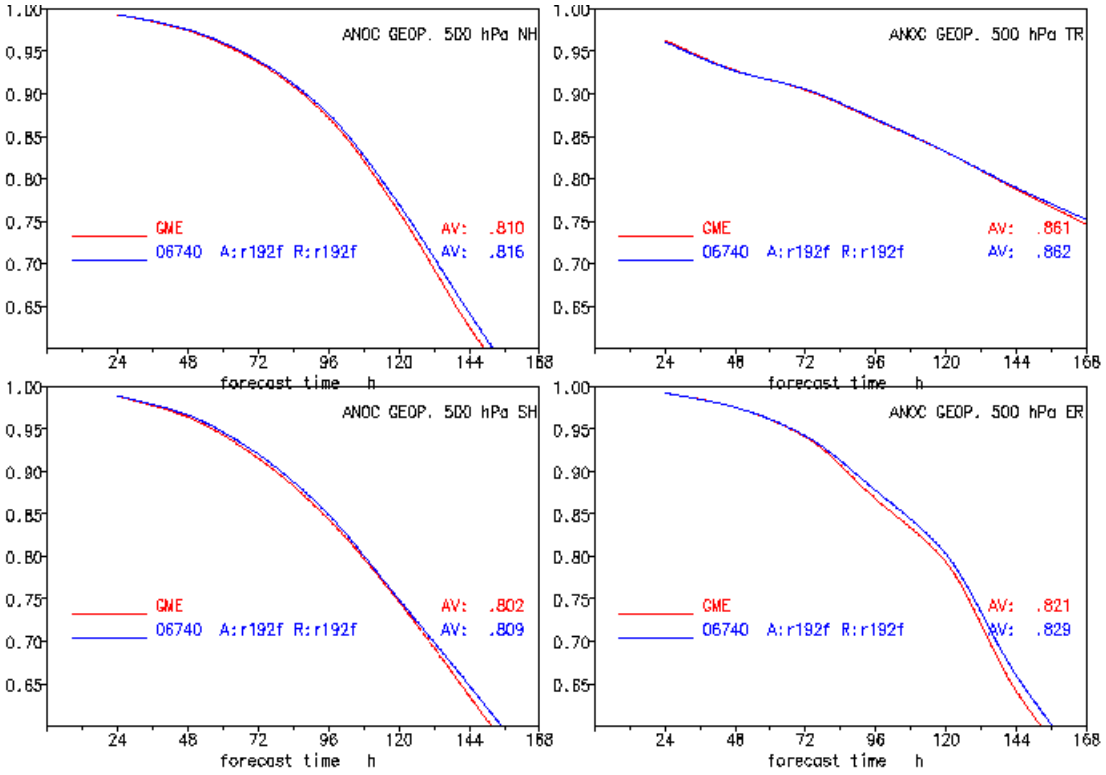


Modis/Terra

Anomaly correlation coefficient of the 500 hPa geopotential height

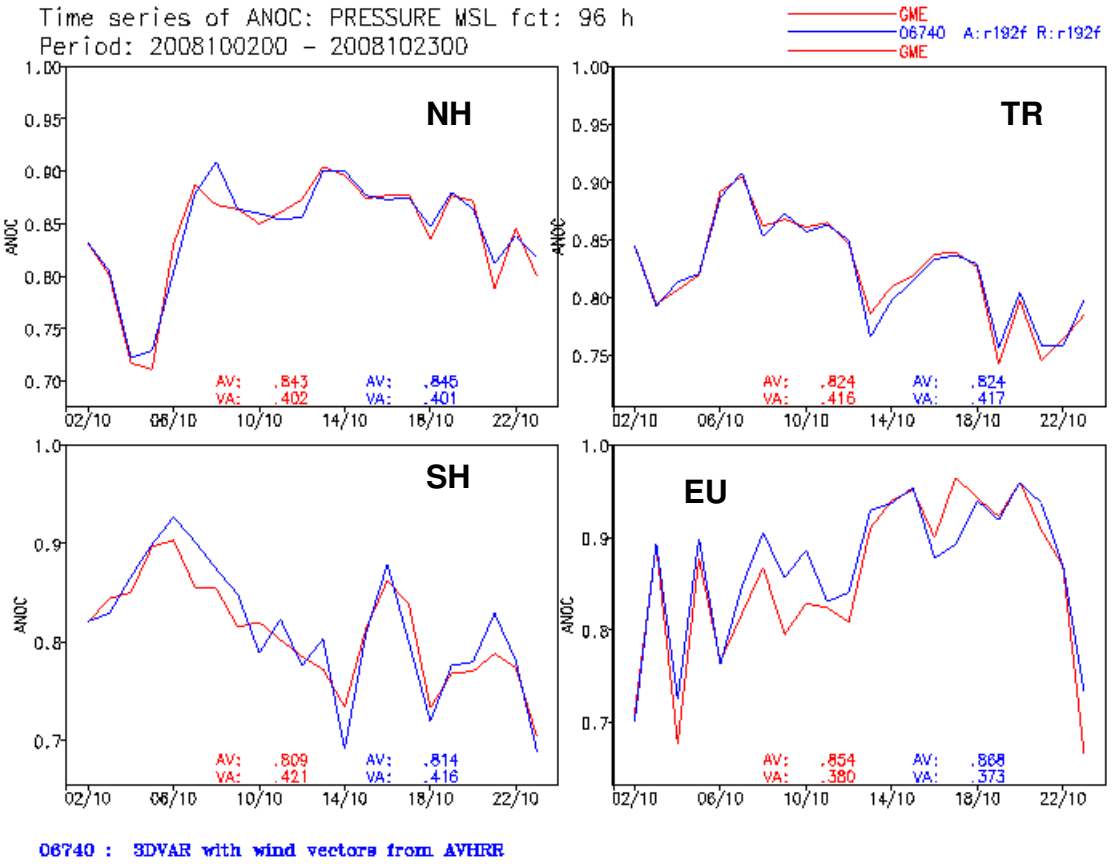
2008100200 – 2008102300 00 UTC 22 cases

Control (red) Exp. with AVHRR Winden (blau)



06740 : 3DVAR with wind vectors from AVHRR

Time series of anomaly correlation coefficients
96-h forecast of the 500 hPa geopotential height field
2008100200 – 2008102300 00 UTC



Routine
Exp. Mit AVHRR

Direct Broadcast MODIS Winds

Motivation

- **MODIS polar winds are not available in time to be used in assimilation of main run. Only available in assimilation run**

- **Direct broadcasting winds can be received much earlier ~ 100 minutes or more**

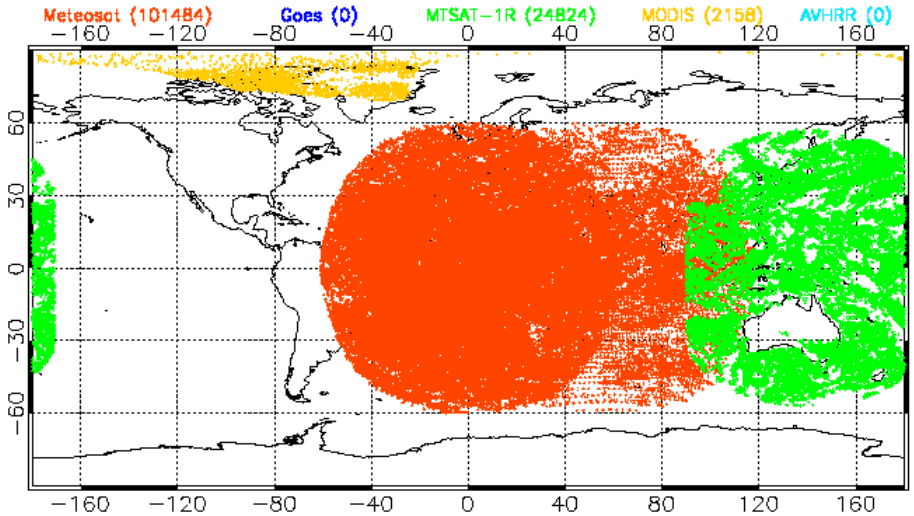
- **Winds from a variety of stations**
  - **Tromso - Terra Modis**
  - **Sodankyla - Terra Modis**
  - **Fairbanks - Terra Modis**
  - **McMurdo, Antartica - Terra/Aqua Modis**

- **Provide only partial coverage and only Terra can be received in the NH**

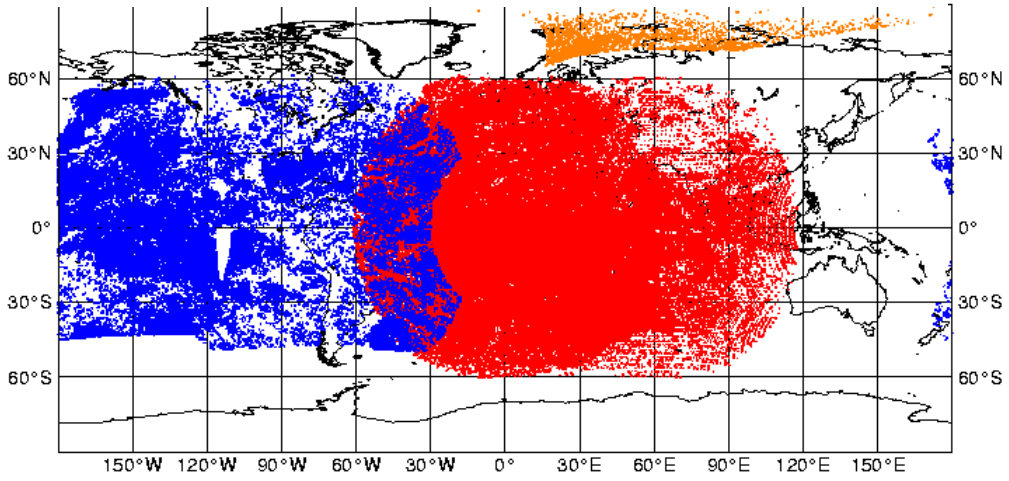
- **At DWD, no MODIS winds could be used in the main runs. Using DB winds, some polar winds can be used also in the main run. Additionally, more polar winds can be used in the assimilation**

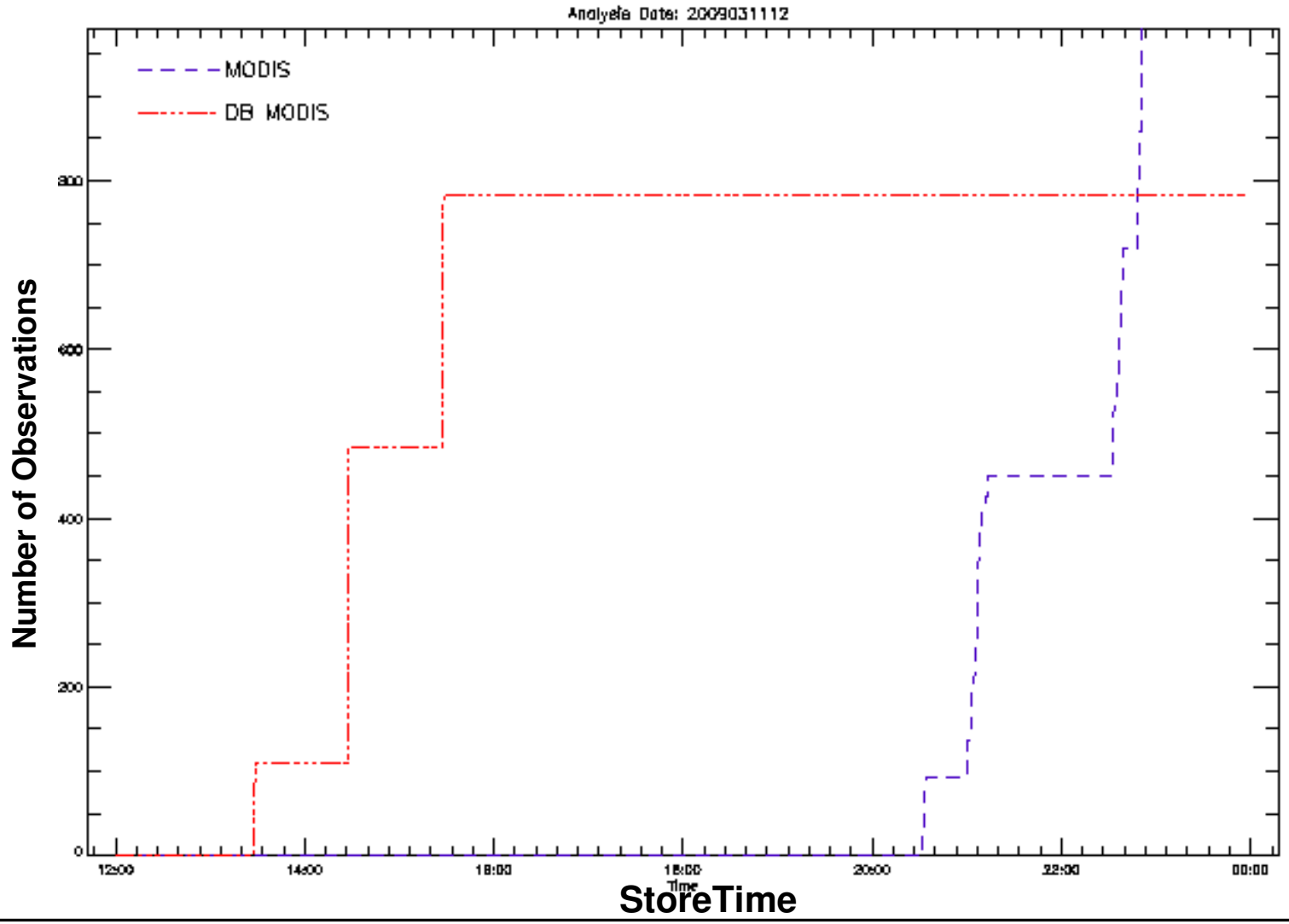
Data coverage

00 UTC



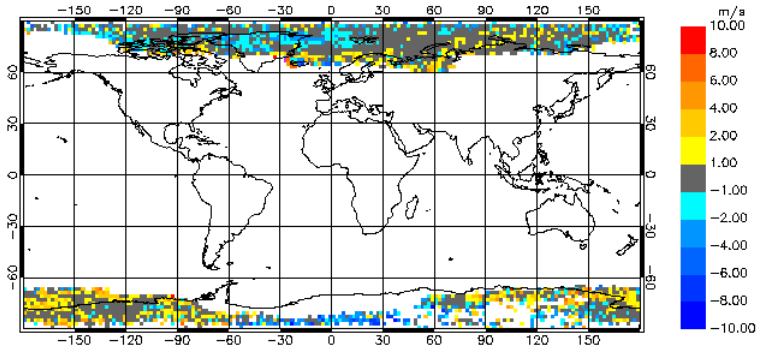
12 UTC




Analysis Date: 2009031112
MODIS
DB MODIS
Number of Observations
0
200
400
600
800
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time
StoreTime

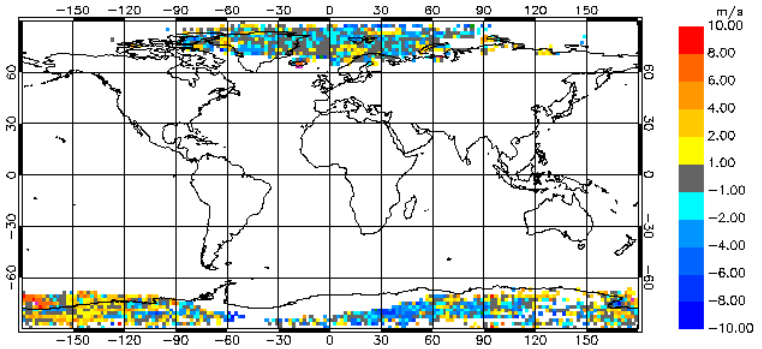
OBS –FG Statistics
Terra QI > 65
20090111 - 20090119

IR 700 – 400 hPa



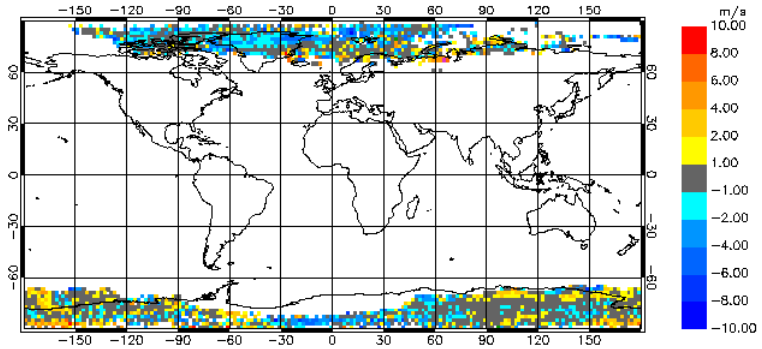
Mean: -0.05

IR 400 – 0 hPa



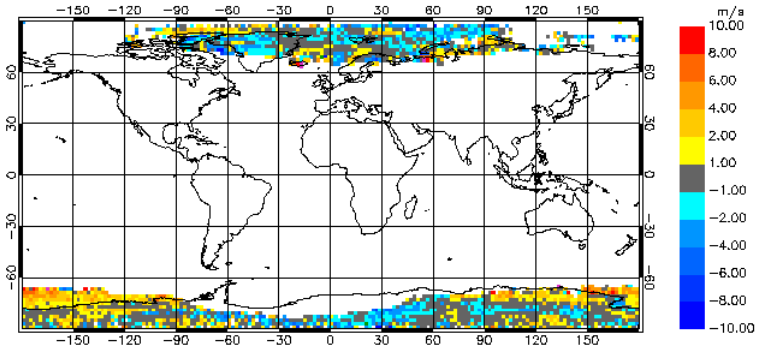
Mean: -0.13

WV 700 – 400 hPa

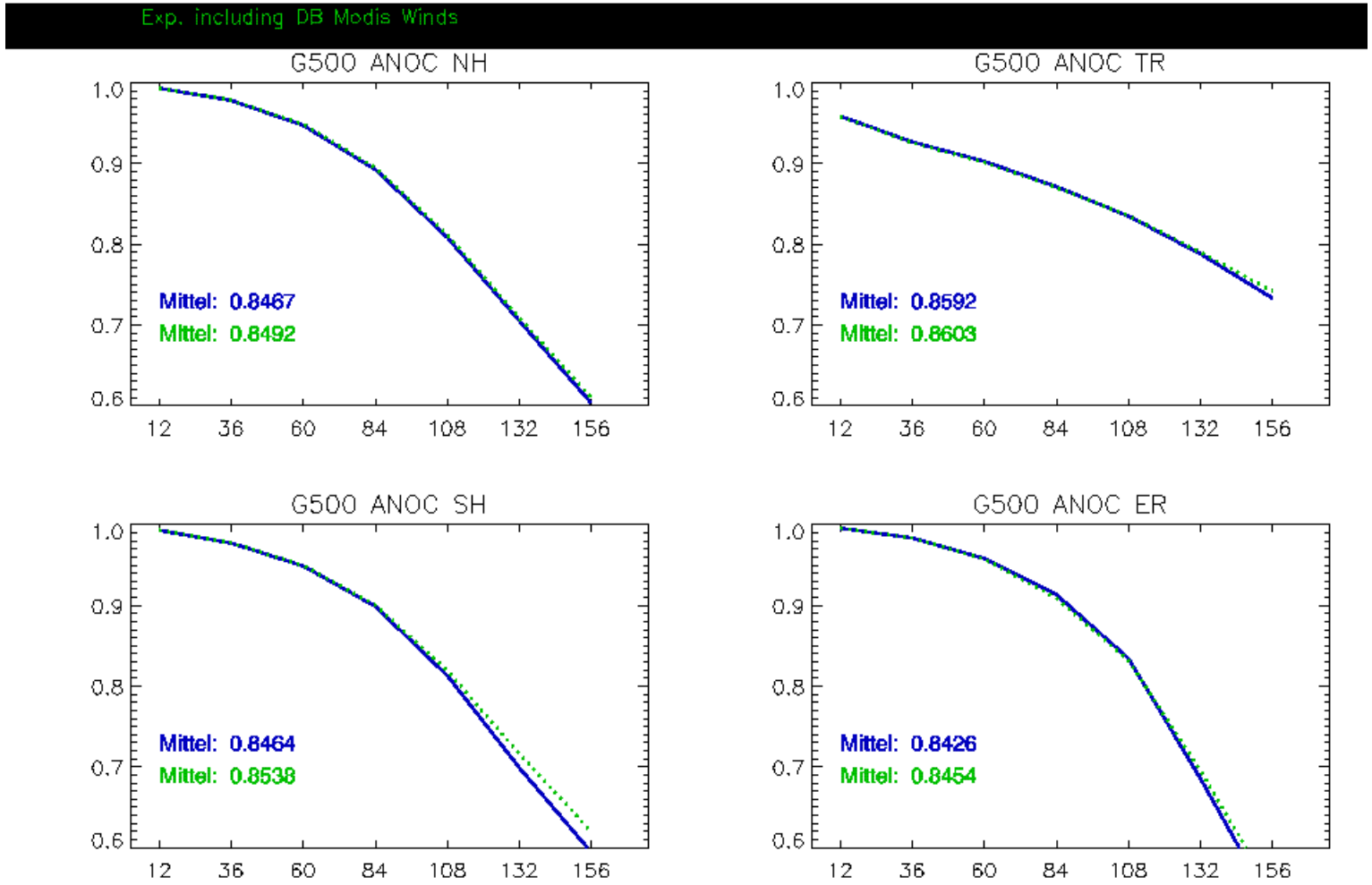


Mean: -0.26

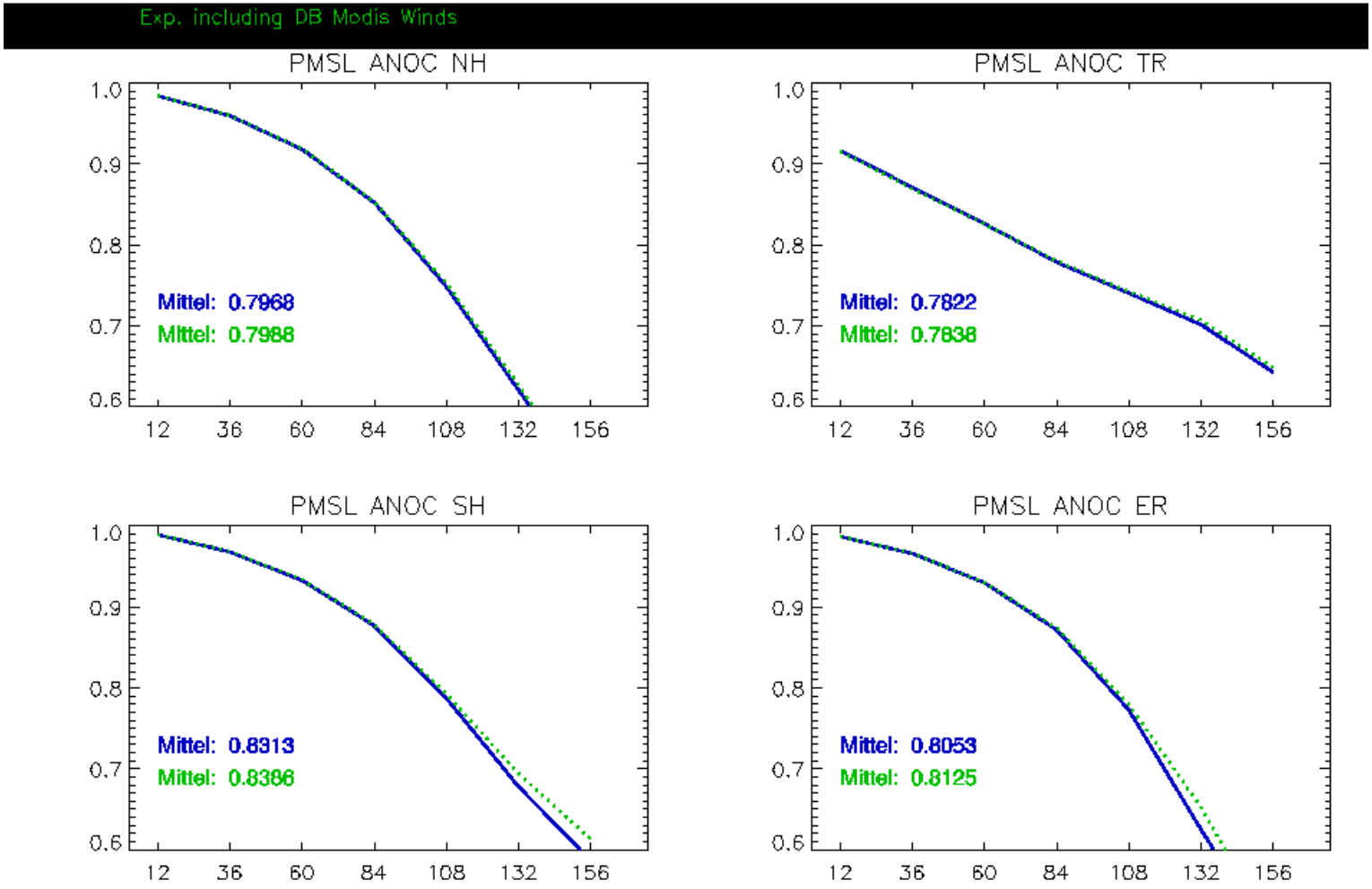
WV 400 – 0 hPa



Mean: 0.38



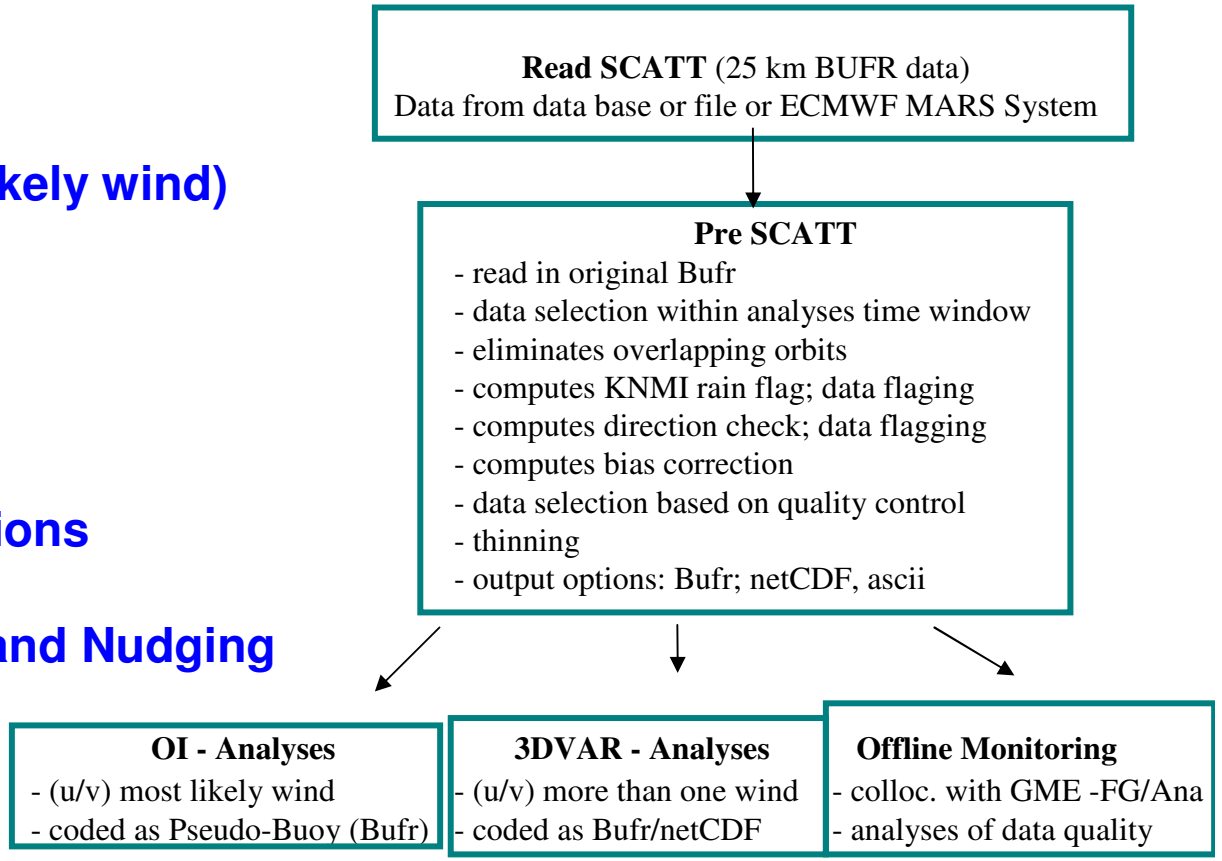
Mittelwerte der Scores im Zeitraum: 26.04.2009 00 UTC - 31.05.2009 00 UTC
GME r192f 06936



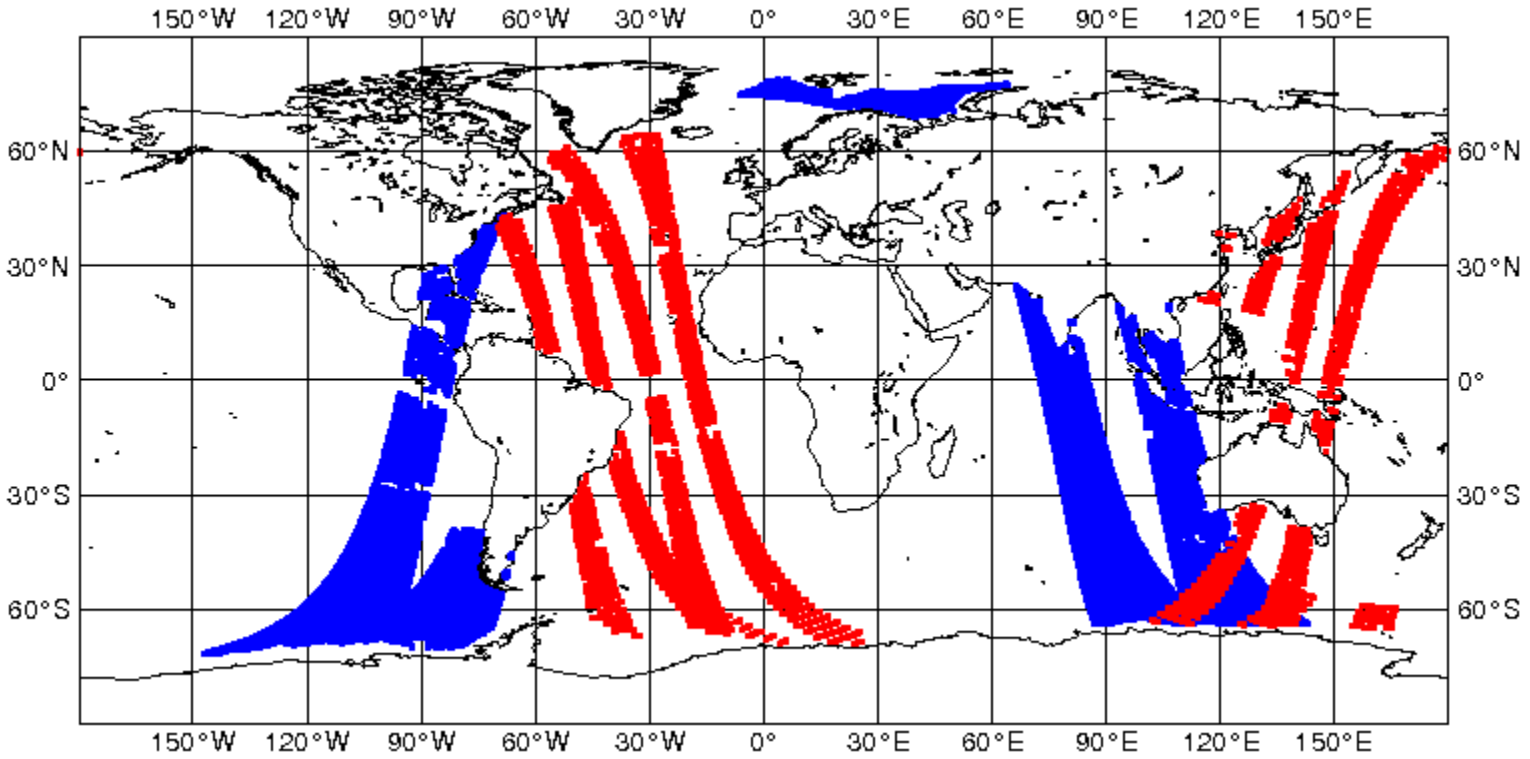
Mittelwerte der Scores im Zeitraum: 26.04.2009 00 UTC - 31.05.2009 00 UTC
GME r192f 06936

Use of scatterometer data at DWD

- 10 m wind vectors (most likely wind)
- QuikScat and ASCAT
- Global and regional
- Use of multiple wind solutions
- Experiments with 3DVAR and Nudging



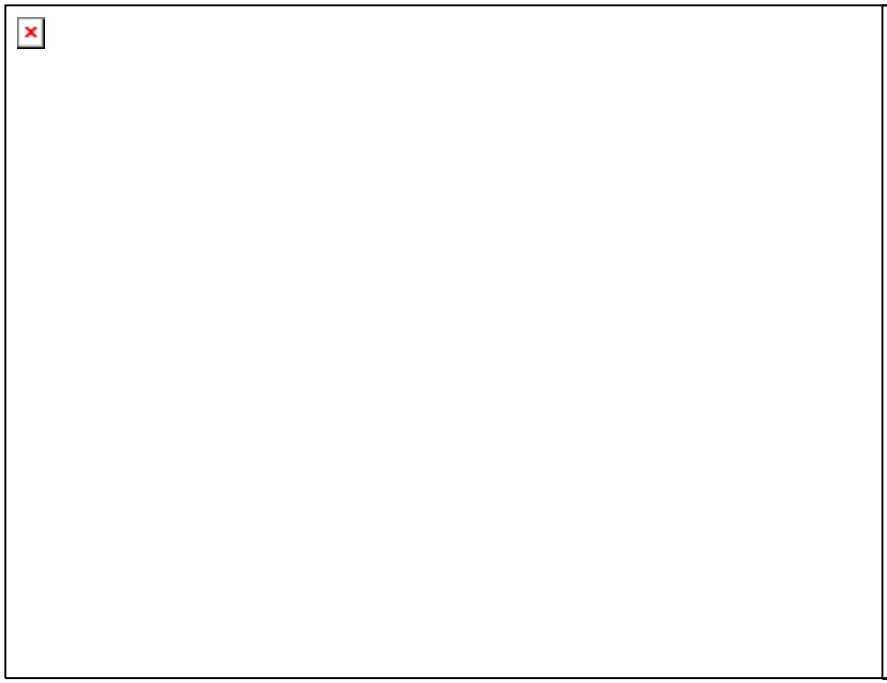
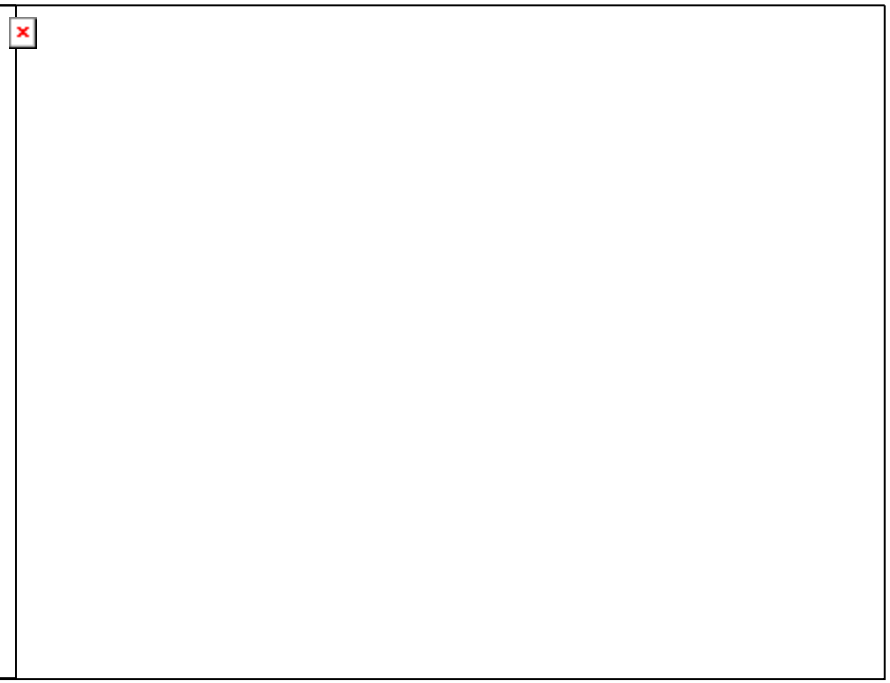
Scatterometer Data Coverage
2008022500 +/- 1.5 H
ASCAT (red) QuikScat (blue)



Scatterometer data in the Global Model GME

Tropical Storm 02B 2009052412 vv=12h

sea level pressure [hPa] / max windspeed [m/s]

Routine	Parallelroutine
	

Assimilation of Scatterometer Wind in COSMO-EU

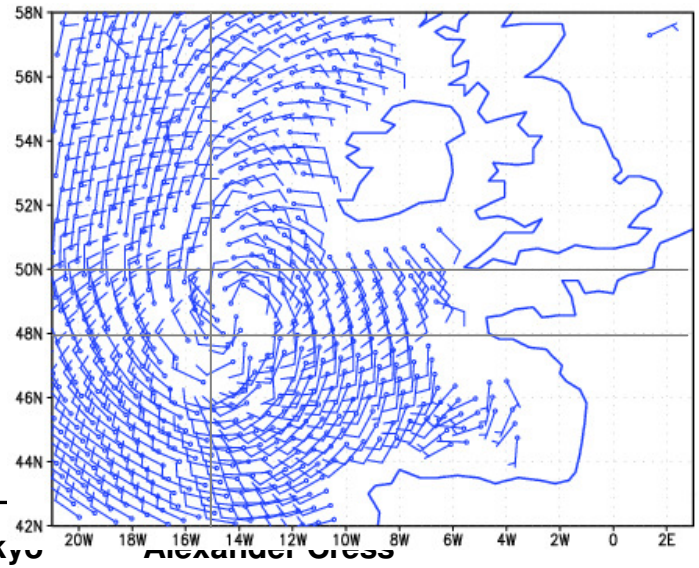
Heinz-Werner Bitzer (MetBw), Alexander Cress, Christoph Schraff (DWD)

- ➔ **nudging of scatterometer wind data technically implemented, taking into account all quality control / bias correction steps developed for use in GME**
- ➔ **idealised case studies: model rejects largest part of 10-m wind info unless mass field is explicitly balanced**

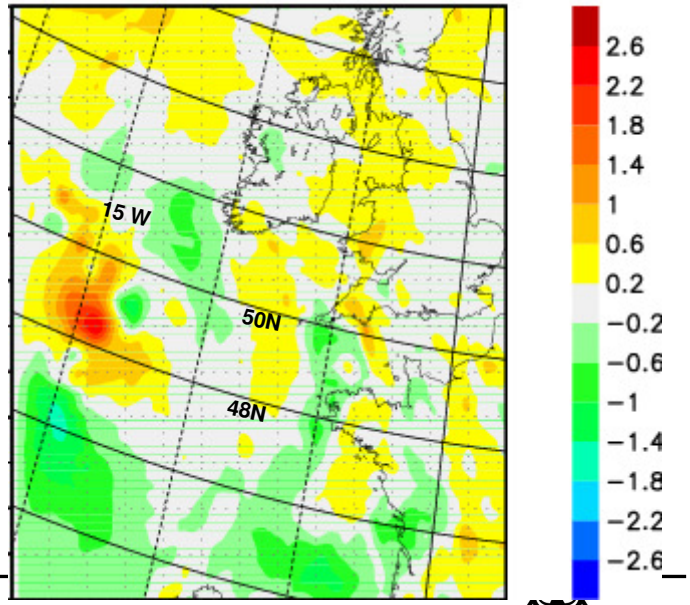
  → **derive surface pressure analysis correction in geostrophic balance with 10-m wind analysis increments (implies need to solve Poisson equation):**

  implemented, model now accepts data
- ➔ **first real case study computed**

QSCAT 19 June 2007, 6 – 9 UTC



Opr (no QSCAT) – Exp (QSCAT)
PMSL 19 June 2007, 9 UTC hPa

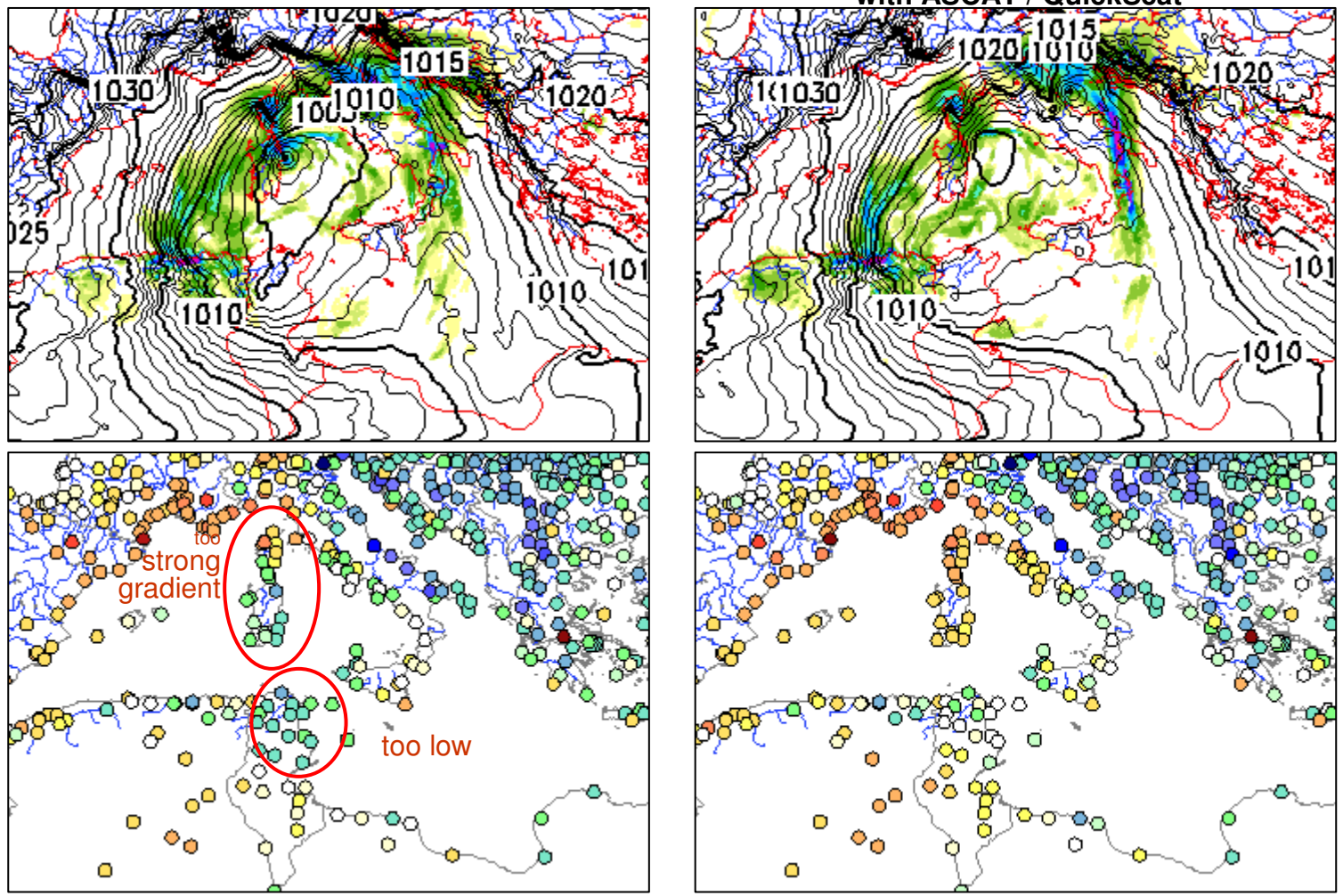


Deutscher Wetterdienst

COSMO-EU
9-h forecasts,
valid for
6 March 2008,
9 UTC

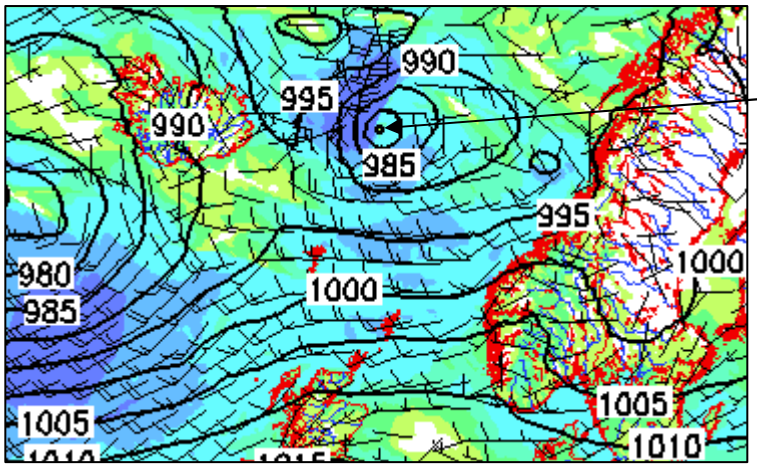
No scatt

with ASCAT / QuickScat

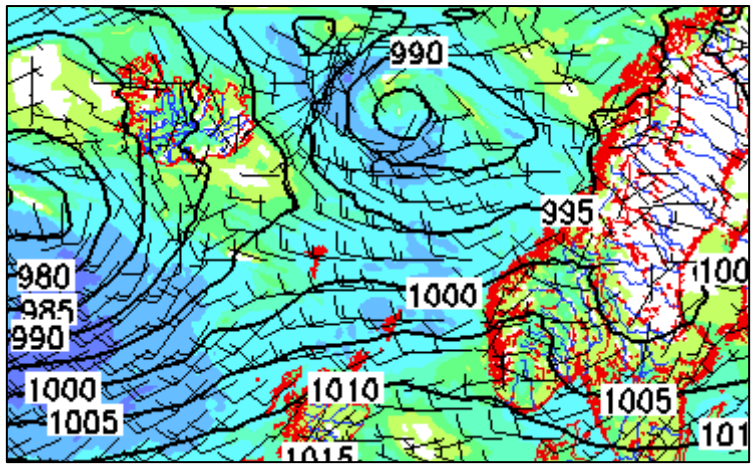


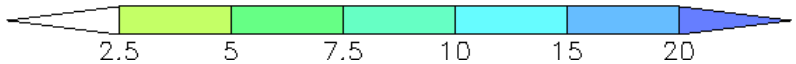
Deutscher Wetterdienst

COSMO-EU ana , no scatt



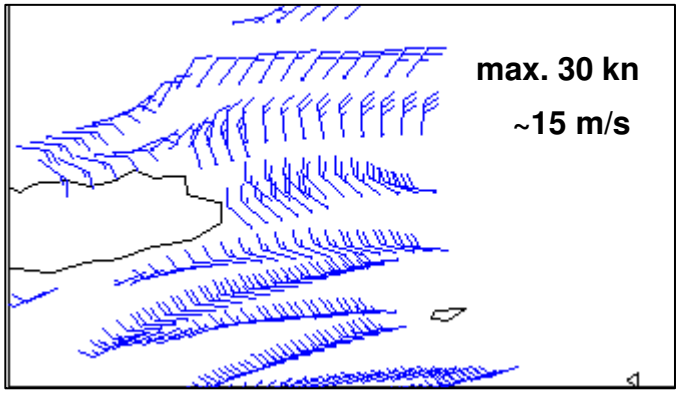
COSMO-EU ana with ASCAT/QuickScat



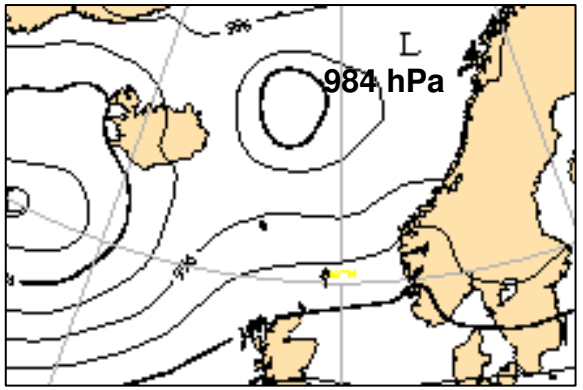


10-m wind [m/s]

ASCAT 28 Feb 08, 21 UTC ± 1.5h

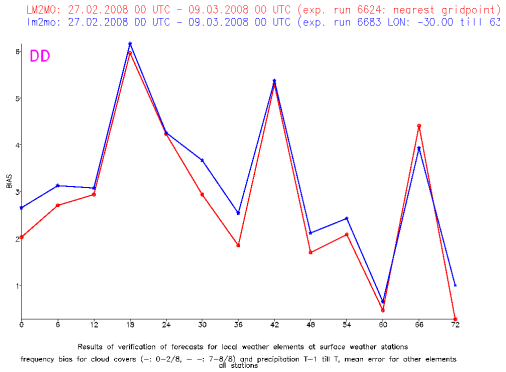


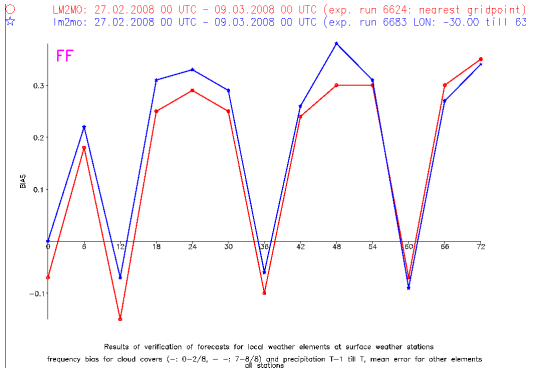
ECMWF analysis 29 Feb 08

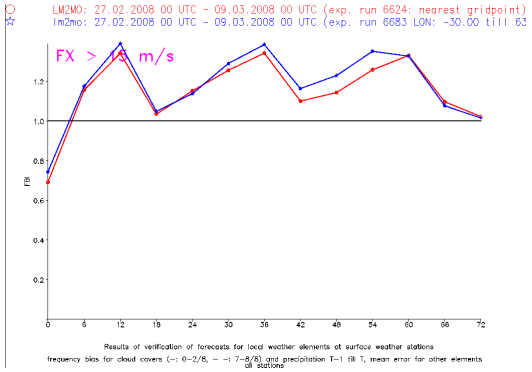


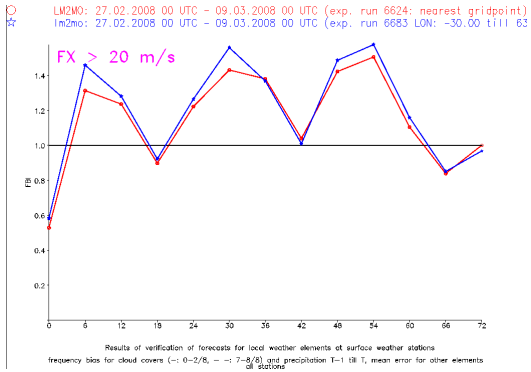
Deutscher Wetterdienst

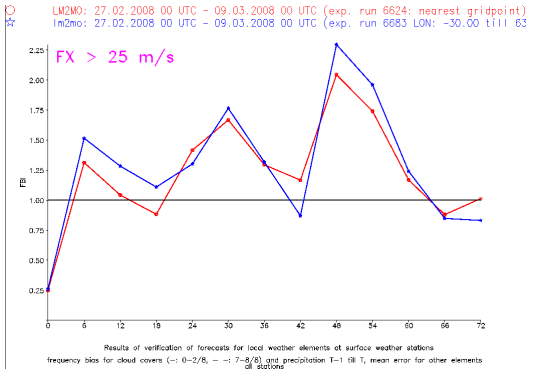
Compariosn of surface weather elements between COSMO-EU Routine and COSMO-EU experiment including Scatterometer data 27/02/2008 – 09/03/2008 00 UTC











Routine

Exp. with Scatt

Summary

- AMV wind vectors are a valuable data source for the 3DVAR at DWD
- Quality information of AMV's are very important
- AMV's intensify the tropical circulation (Hadley cells)
- Specification of observation and background error seems to be revised in the analyses
- Substantial benefit of AVHRR and DB MODIS polar winds
- Positive impact of scatterometer data in global and regional forecasts

Plans for the next years

- Continuation of work diagnosing the observation and background errors
- Use of additional polar wind products
- Monitoring the FY-2D AMV wind vectors
- Use of additional scatterometer data
- Use of HRW winds from MSG/HRV channel data in our COSMO modell
- Prepare for ADM mission


Thank you for
your
attention