Recent impact studies of satellite-derived wind products at the DWD

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

- Introduction
- General analysis and forecast impact of AMV wind vectors
- Monitoring and impact results of Meteosat-8/9 Meteosat5/7 GOES 10/11
- Quality and Impact of MTSAT-1R
- Quality estimations of the MODIS winds from NOAA/NESDIS
- Use of ASCAT scatterometer winds
- Summary
Global Model GME

- Operational NWP Model of DWD
- Gridpoint model, hexagonal triangular grid
- 40 km mesh size, 36870 grid points/layer
- 40 layers (hybrid, sigma/pressure)
- Prognostic variables: $p_s$, $u$, $v$, $T$, $q_v$, $q_c$, $q_i$, $o_3$
- Intermittent data assimilation (OI, 3-hourly) -> 3DVAR (PSAS) system
- Incremental digital filter initialization (P. Lynch)
- At 00 UTC and 12 UTC: forecasts for 174 hours
- At 18 UTC: forecasts for 48 hours
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)
  • 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 Impact Experiment

• Following an initiative by Mary Forsythe and Lars Peter Riishojgaard

• Data denial experiment with 3DVAR

• No use of geostationary and polar AMV wind vectors

• Winter period (12th Dez. 2007 – 12th January 2008)

• 00 UTC and 12 UTC forecasts
Difference of mean wind speed analysis and mean RMS of increments
Anomaly correlation coefficient for the Geopotential Height in 500 hPa
20071212 - 20080112

Crtl
Crtl without AMVs

9th Int. Winds Workshop

Alexander Cress
RMSV Wind Vector in 200 hPa
2007121212 - 2008011212

NH

SH

TR

Routine
Routine without AMVs

9th Int. Winds Workshop
Alexander Cress
OBS – FG Statistics for Meteosat-5 and Meteosat-7 wind speed
01 Dec. 2006 – 31 Dec. 2006 > 400 hPa
Deutscher Wetterdienst

Frequency distribution of obs – fg wind speed statistics

AMV Satellite: GOES 11 / WV cloudy wind speed [m]  Exp:
Date: 20080101 1800 - 20080110 1800
North: 90.00 SOUTH: -90.00 WEST: -180.00 EAST: 180.00
Level Max./Min: 35700.00 / 13700.00

AMV Satellite: GOES 12 / WV cloudy wind speed [m]  Exp:
Date: 20080101 1800 - 20080110 1800
North: 90.00 SOUTH: -90.00 WEST: -180.00 EAST: 180.00
Level Max./Min: 35700.00 / 13700.00

AMV Satellite: METEOSAT 7 / WV cloudy wind speed [m]  Exp:
Date: 20080101 1800 - 20080110 1800
North: 90.00 SOUTH: -90.00 WEST: -180.00 EAST: 180.00
Level Max./Min: 35900.00 / 13600.00

AMV Satellite: METEOSAT 9 / WV cloudy wind speed [m]  Exp:
Date: 20080101 1800 - 20080110 1800
North: 90.00 SOUTH: -90.00 WEST: -180.00 EAST: 180.00
Level Max./Min: 35900.00 / 12400.00
OBS minus FG statistics for AMV infrared wind speed
10 days in March 2007 > 400 hPA

Meteosat-8

Meteosat-9

9th Int. Winds Workshop  Alexander Cress
OBS minus FG statistics for AMV WVcloudy wind speed
10 days in March 2007

> 400 hPa
Anomaly correlation coefficient of the 500 hPa geopotential height
2007032412 – 2007042412 31 forecasts
Control (Routine with Meteosat-8) Exp (Routine with Meteosat-9)
Analysis and forecast impact of MTSAT-1R

- **Usage**
  - extratropics over oceans; tropics over oceans and land

  - IR between 1000 and 700 hPa and above 400 hPa
    - QI > 85
  - WVcloudy above 400 hPa
    - QI > 85
  - WVclear is not used
  - VIS below 700 hPa
    - QI > 85

- 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

- One month analysis and forecast experiment (June/July 2007)
First Guess Departure against QI Index for MTSAT-1R
Date: 2007061500 – 2007070500
Wind Speed [m/s] >400 hPa

Obs wind speed
Obs – fg bias
Obs – fg rms
OBS – FG Statistics for MTSAT-1R for July 2007
> 400 hPa  QI > 80

IR

WVcloudy

9th Int. Winds Workshop

Alexander Cress
OBS – FG Statistics for MTSAT-1R for July 2007
700 hPa - 400 hPa

IR QI > 80

IR QI > 90
Anomaly correlation coefficient
Date: 2007060912 - 2007070912

NH

SH

EU

Crtl
Crtl plus MTSAT-1R

9th Int. Winds Workshop

Alexander Cress
Use of MODIS winds from NOAA/NESDIS with QI Index

- **Usage**

  - Since Nov. 2005 DWD receives MODIS winds over GTS processed by NOAA/NESDIS

  - Use of MODIS winds over both, land and sea

  - IR above 1000 hPa, over Antarctica only over 600 hPa

  - WVcloudy above 600 hPa

  - QI Index for IR and WVcloudy > 65

  - FG check: asymmetric to remove negative OBS-FG bias

  - Thinning: 1 wind per pre-defined thinning box (60 km; 15 vertical layers). Data selection by highest noFirst Guess QI in a box

  - One month analysis and forecast experiment (NOV/ Dez. 2006)
Deutscher Wetterdienst

9th Int. Winds Workshop

Alexander Cress
06007 : ROUTINE with MODIS BUFR Winds
Time series of ANOC: GEOPOTENTIAL fct: 120 h
Period: 20061130 00 - 20061231 00

NH

TR

SH

EU

9th Int. Winds Workshop

Alexander Cress
• Motivation and Usage

MODIS polar winds are not available in time to be used in operational (main) run. Only available in update run

Direct broadcasting winds from Tromso, McMurdo ~ 100 minutes earlier

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 update cycle runs

Monitoring results show same quality as conventional MODIS winds

Experimental use of DB polar winds in the same way as conventional MODIS winds

Experiment: 23 days in November 2007
Use of scatterometer data at DWD

• 10 m wind vectors (most likely wind)

• QuikScat and ASCAT

• Global and regional

• Use of multiple wind solutions (planned)

• Experiments with OI and 3DVAR

- (u/v) most likely wind
  - coded as Pseudo-Buoy (Bufr)

- (u/v) more than one wind
  - coded as Bufr/netCDF

- colloc. with GME -FG/Ana
  - analyses of data quality

Read SCATT (25 km BUFR data)
Data from data base or file or ECMWF MARS System

Pre SCATT
- read in original Bufr
- data selection within analyses time window
- eliminates overlapping orbits
- computes KNMI rain flag; data flaging
- computes direction check; data flagging
- computes bias correction
- data selection based on quality control
- thinning
- output options: Bufr; netCDF, ascii

OI - Analyses
- (u/v) most likely wind
  - coded as Pseudo-Buoy (Bufr)

3DVAR - Analyses
- (u/v) more than one wind
  - coded as Bufr/netCDF

Offline Monitoring
- (u/v) most likely wind
  - coded as Pseudo-Buoy (Bufr)

9th Int. Wind Workshop

Alexander Cress
Deutscher Wetterdienst

Scatterometer Data Coverage
2008022500 +/- 1.5 H
ASCAT (red) QuikScat (blue)
ASCAT Scatterometer Statistics
10 m Windspeed [m/s]

Mean First Guess Departure (OBS-FC) (all)
EXP = rou
Time period: 20070901 00UTC - 20070917 06UTC, Hour = all

Mean First Guess Departure (OBS-FC) (OLdata)
EXP = rou
Time period: 20070901 00UTC - 20070917 06UTC, Hour = all

Units: m/s
min = -5.74
max = 25.11
mean = 0.22

Units: m/s
min = -5.73
max = 9.12
mean = 0.27
ASCAT wind vector cell quality

Date: 2007090100 – 2007091021

Date: 2007090100 – 2007091021

9th Int. Winds Workshop

Alexander Cress
Monthly Mean Difference between Control (Routine) and Control + Ascat data
Date: 2007070812 - 2007080812

Difference of Analyses

\[ \text{ANAM\_CME\_20 - ANAM\_6217\_2} \]

Difference of FG-ANA RMS

\[ \text{FG\_ANA\_RMS\_CME - FG\_ANA\_RMS\_6217} \]

9th Int. Winds Workshop

Alexander Cress
Anomaly correlation coefficient for sea level pressure
Period: 2007070812 – 2007080812

Northern Hemisphere

Southern Hemisphere

Crtl
Crtl plus ASCAT

Crtl
Crtl plus ASCAT
Time series of anomaly correlation coefficient for Europe
Mean sea level pressure
Start of the forecasts 00 UTC
Deutscher Wetterdienst

Deviation of u-wind component at 850 hPa of 3DVAR analysis to IFS analysis
Juni 2007
3DVAR with and without scatterometer data (QSCAT plus ASCAT)

Deviation of 850hPa u-wind to IFS analysis

9th Int. Winds Workshop

Alexander Cress
Summary I

• Despite extensive use of satellite radiances AMV wind vectors still a valuable observing system for the global data assimilation system at DWD

• AMVs change the model background significantly over large parts of the tropical and subtropical ocean areas

• The eastward zonal flow is decelerated over the tropical pacific

• Decreased wind speed analyses in the stratocumulus inversion regions over the Pacific and Atlantic oceans

• Negative impact of not using AMV wind vectors is most predominant on the southern hemisphere and in the Tropics

• Slightly positive benefit on both hemispheres using MET-8/9 winds in place of Met-7 AMVs
Summary II

• No negative impact was found by replacing GEOS10 and MET-5 winds by wind vectors from GOES11 or MET-5

• A positive impact of MTSAT-1R was assessed after a change in height assignment took place in 2007

• QI Index very helpful to filter out bad data

• MODIS winds have a positive impact on the analysis over the Arctic and Antarctic area

• Positive forecast impact of MODIS winds on both Hemispheres

• Direct broadcast winds very helpful to get polar winds earlier due to early cut-off time of the main forecast run
Summary III

• 10 Meter wind vectors of ASCAT can be used in all weather conditions.

• Rain flag algorithm of KNMI successful to eliminate rain contaminated QuikScat data

• ASCAT data smaller bias than QuikScat data. Therefore no bias correction

• Scatterometer data have positive impact on single analyses/forecasts

• General small positive impact on forecast quality for both Hemispheres, predominantly on the Southern Hemisphere

• Use of ASCAT data improved the forecast of a deep low pressure system off the Irish coast substantially

• Small structures are difficult to analyses due to broad scale error correlation functions