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

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 km²

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 km²

COSMO-DE EPS
Pre-operational
20 members
Grid spacing: 2.8 km
Variations in:
lateral boundaries, initial conditions, physics

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 km²
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

Date of Analyses: 2013050612

TIME: 10:30 - 12:30

Meteosat (179786)

Goes (75803)

MTSAT-2R (26321)

MODIS (30936)

AVHRR (11445)
Eumetsat

CCC height assignment method

Before:
• Use of different height assignment methods for different cloud types, independently from feature tracking.
• AMVs assumed 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
- Increase 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
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.
Figure 18: Regional distribution of inferred 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 05/06/2018 - 05/07/2018.
AMVs: Monitoring of AMVs with ccc-method height assignment

Meteosat 9
Medium 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)

High level infrared AMV winds (used)
2012121800 - 2012122818

Meteosat-9
- bias: -0.22
- rms: 3.25
- cor: 0.97

Meteosat-10
- bias: -0.17
- rms: 3.21
- cor: 0.97

Quality of Meteosat-10 AMV comparable to or slightly better than AMVs from Meteosat-9
METOP-B: AVHRR polar winds

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

- ~10% more data
- highest at 118 hPa (METOP-A: 200 hPa)
- slightly smaller bias (and stdv)
Test data 18.1. – 24.1.2013
IR 1000 – 700 hPa
Qi > 60

• ~10% less data
• slightly larger bias
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 seem 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
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:
\[ |\text{obs} - \text{fg} | < sgm\_fg \times \sqrt{\text{obserr}^2 + \text{bgerr}^2} \]

=> 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

#### Results

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<th>stdv</th>
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#### Diagrams

- **rou**: Active vs. All
- **9325**: Active vs. All
- **9447**: Active vs. All
Mean analysis error difference
2013050112 - 2013053112

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

Exp.: 9327 - Crtl  200 hPa

Exp.: 9456 - Crtl  200 hPa

Exp.: 9327 - Crtl  850 hPa

Exp.: 9456 - Crtl  850 hPa
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: 15\textsuperscript{th} August – 30\textsuperscript{th} September 2010
  • Winter 2010/11: 01\textsuperscript{st} December 2010 – 15\textsuperscript{th} January 2011
Observation Coverage MIRS Winds

Most MIRS winds found in the lower troposphere over Sea.
MISR Winds Monitoring

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

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

NH
- Sea only
- Land only

SH
- Sea only
- Land only

Winter
QI > 80
MISR winds monitoring

Wind Speed Observation
Visible 1100 – 700 hPa

MISR
Meteosat 9

Winter
QI > 80

MISR obs – FG wind speed

Promising data source over sea

Problems visible over land
(esp. ice/desert)

QI currently a relatively week indicator of data quality
MISR impact experiments

• Two test periods

• Experiments:
  • Ctrl (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

- NH winter
- NH summer
- SH winter
- SH summer

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

- Fewer winds
- Larger wind speed dependent biases
- Larger rms
Scores: Crtl + Met7 / FY-2E
Geopotential Height 500 hPa

Winter period
2012120112 - 2013013112

NH

SH

Crtl + Meteo 7

Crtl + FY-2E

Crtl + Meteo 7

Crtl + FY-2E
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
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

- 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 troposphere. After a revision 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, Antarctica)
  - 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)