IMPACT OF MODIS WINDS ON THE GLOBAL NWP SYSTEM OF THE GERMAN WEATHER SERVICE

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ABSTRACT

Global wind field measurements are essential to improve our knowledge of atmos-pheric dynamics, including atmospheric transport processes of energy, water and airbourne particles. Unfortunately, coverage of wind observations is rather poor over the oceans and the polar regions. Only a few regular wind measurements are made along coastal areas of the Arctic, Antarctica and the interior of Canada, Alaska, Russia and Northern Europe, but there is little or no coverage of the interior of Antarctica, Greenland or the Arctic Ocean. Poor knowledge of the polar wind field is a major cause of larger than normal analysis and forecast errors in these regions, leading to occasional forecast “busts” in areas like Europe, influenced by synoptic disturbances originating in polar regions.

Recently a new satellite-derived wind product, developed at the Cooperative Institute for Meteorological Satellite Studies (CIMSS), has become available, which provides information on polar wind fields. The winds are derived by tracking features in the IR window band at 11 µm and in the water vapour (WV) band at 6.7 µm from the Moderate Resolution Imaging Spectrodiameter (MODIS) instrument on board the polar-orbiting satellites Terra and Aqua. Wind vector heights are assigned by using either the IR windows, CO_2 slicing or the H_2O intercept method (Key et al., 2002). Results of the NOGAPS model are used as a first guess wind field. MODIS winds are available in areas north of 65^o N and 65^o S.

1. EXPERIMENT SETUP

Using the global assimilation and forecasting system of the German Weather Service (DWD), two impact experiments – one in summer (June 2003) and one in autumm (October 2003) – were conducted to estimate the potential benefit of the MODIS wind observations. In contrast to the operational use of AMV winds from geostationary satellites (only over oceans), the experiments used the MODIS winds over land and oceans. Due to problems with height assignments and topography (Key et al., 2002), the MODIS WV winds were used above 550 hPa only and the MODIS IR winds over Antarctica above 550 hPa only. The winds were thinned to 70 km resolution and quality controlled in the same way as the AMV winds of the geostationary satellites. As a control run, the operational assimilation and forecast system at DWD were used, with a variety of conventional (radiosondes, aircraft, synops, buoys) and satellite (SATOB, SATEM) data.

2. RESULTS OF IMPACT STUDIES

A good correspondence was found between MODIS wind statistics and similar statistics for AMV winds from geostationary satellites (Fig. 1). Obviously, there is a positive bias between observations and model (model too slow), which is more pronounced in the Southern Hemisphere than in the Northern Hemisphere.

Comparing the two satellites Terra and Aqua, higher background and analyses departures could be found for Aqua, especially over Antarctica (not shown).

The MODIS winds have a large impact on the DWD polar analysis by introducing analysis increments into data void areas (Fig 2). For both assimilation periods the differences are largest over the Asian part of the Artic region, Greenland and Antarctica, with differences up to 5 m/s in higher levels of the atmosphere. In summer, the MODIS winds act to strengthen the cyclonic circulation in the Artic region and in the inner Antarctic peninsula. In autumn, only the Artic region shows a significant signal (not shown).

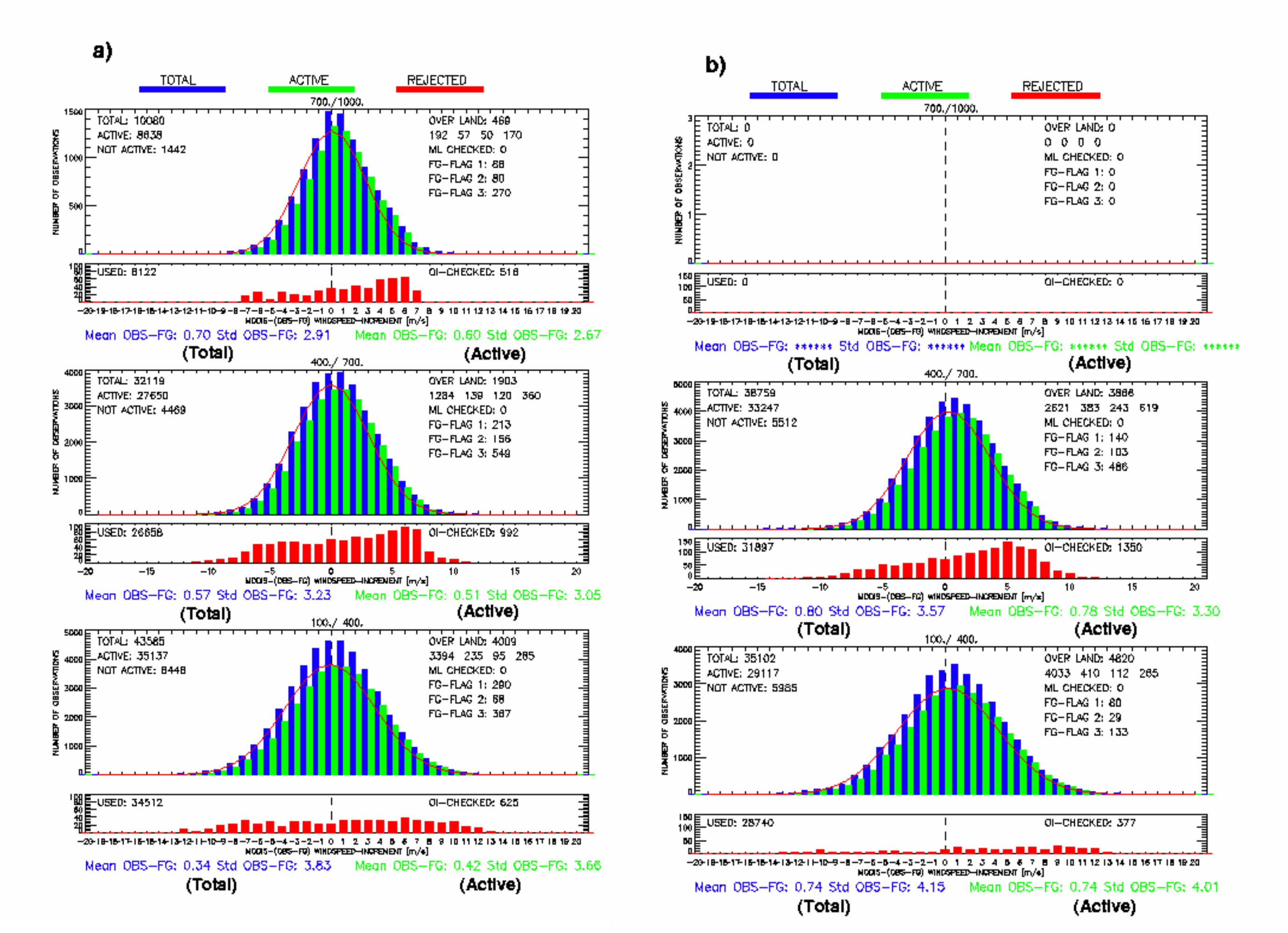

Figure 1: Frequency distribution of the difference between Modis (Terra and Aqua) and first guess windspeed including quality control statistics for the summer case (June 12 to July 9, 2003) for all (total; blue columns), active (after the quality control; green columns) data, including the mean and standard deviation for all and active data, separated for the Northern (a) and Southern Hemisphere (b). The red columns depict the data which were rejected by the OI check .

The overall impact on forecast quality is significantly, positive for Europe and the Northern Hemisphere and neutral for the Southern Hemisphere for the summer experiment (Fig. 3). In the Northern Hemisphere, using the MODIS wind data leads to an improvement of forecast quality of up to 12 hours. The autumm case shows the opposite behaviour; a neutral impact for Europe and the Northern Hemisphere and a small positive impact for the Southern Hemisphere (not shown). Obviously, the impact on forecast quality depends strongly on season and occasions in which the interaction between polar and mid-latitude flow patterns is particularly intense (Fig. 4: end of period). The relatively minor impact of the MODIS data on the forecast quality of the Southern Hemisphere could be connected to height assignment problems over high topography or conditions such as low-level thin stratus, which make it difficult to identify trackable features over the Antarctic continent.

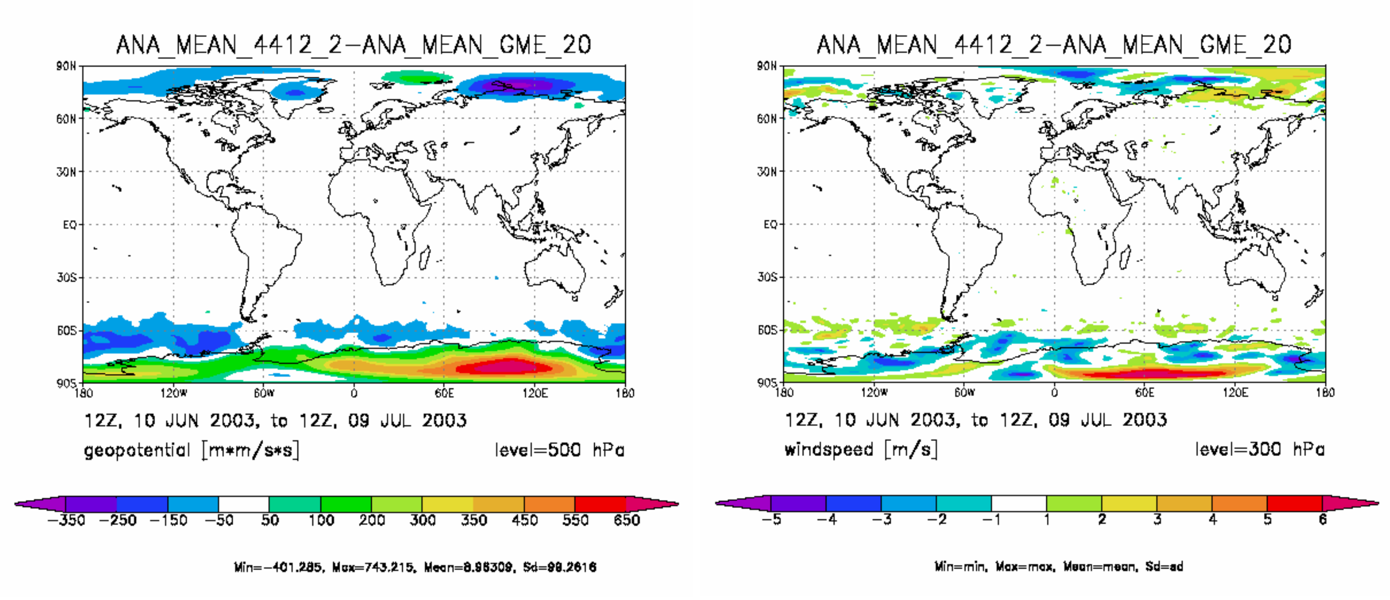

Figure 2: Difference of mean 500 hPa geopotential height (left) and wind speed analyses in 300 hPa (right) between the MODIS experiment and the Control run for June – July 2003.

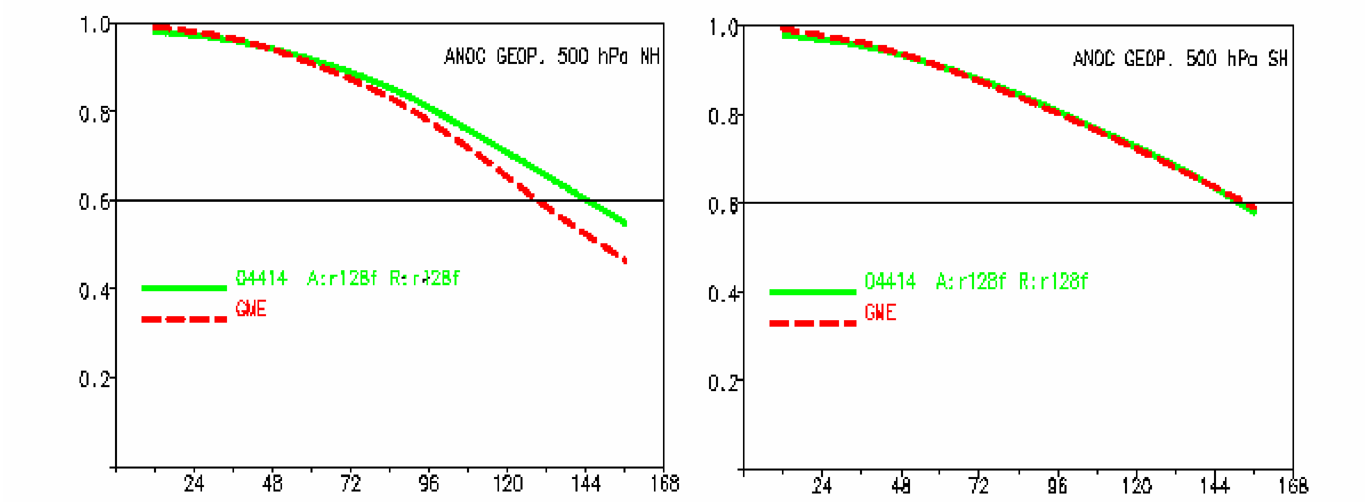

Figure 3: Anomaly correlation coefficient versus forecast time for the 500 hPA geopotential height for the Control forecast (red, without Modis winds) and for an experiment using Modis winds (green) averaged over 23 cases (18 June – 9 July, 2003).

3. RESULTS OF THE MOSAP PERIOD

Polar wind measurements from MODIS provide information in the data sparse polar regions and therefore have the potential to improve the analysis and forecast quality of global NWP systems. In the last years several centers have used the MODIS winds with mixed results. In an attempt to improve our knowledge of using this wind product and to identify possible sources of errors, the MODIS Special Acquisition Period (MOWSAP) were established for November 2003 – January 2004. During that period MODIS winds became available form NOAA/NESDIS and CIMSS. The main differences between both wind derivations are: NOAA/NEDIS use the GFS model as first guess with higher time resolution and shorter forecast times. Also they provide winds at the crossing day boundary.

The winds derived from CIMSS and NOAA/NESDIS for both satellites Terra and Aqua were monitored and compared for January 2004 and their impact on the NWP system of DWD is estimated. As an example, Figure 5 compares the background and analysis wind speed departures of the MODIS winds derived by

CIMSS (left) and NOAA/NESDIS (right) for the Terra satellite over the Artic area in the upper troposphere. Obviously, the NOAA/NESDIS winds show a much better agreement with the model background and analysis compared to the CIMSS winds. This is also true for the water vapor cloudy winds from Terra over the Artic region and Antarctica. Figure 6 shows the same results for the water vapor cloudy winds from the Aqua satellite over Antarctica. Again, the fit between the model analysis and background and the observations is much closer in case of the NOAA/NESDIS winds. Also the number of outliners (peaks in the time series) are reduced by using the MODIS winds form NOAA/NESDIS.

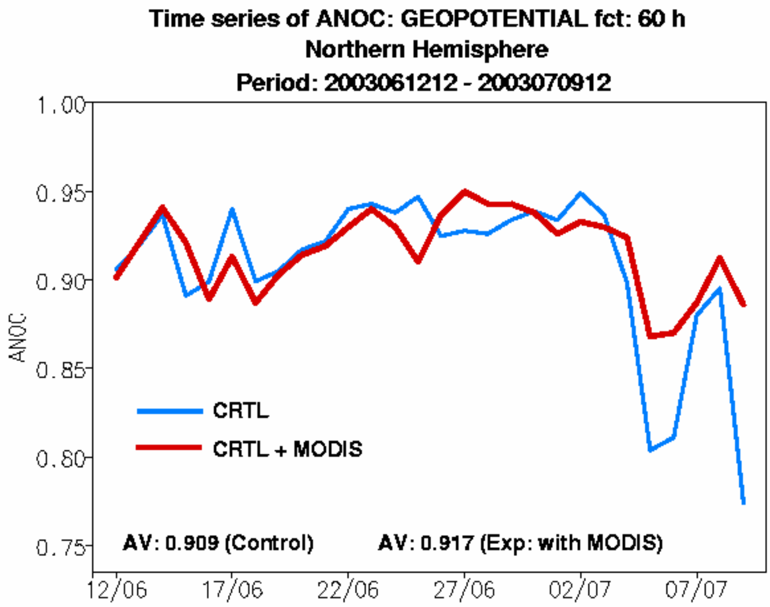

Figure 4: Times series of anomaly correlation coefficient of 60 h geopotential height forecasts in 500 hPa averaged over the Northern Hemisphere for the period 12 June – 09 July 2003 for the Control (blue) and the experiment using MODIS wind data in addition (red).

The assimilation of the MODIS winds derived by NOAA/NESDIS has a notable impact on the mean polar analysis compared to the CIMSS polar winds. For the January 2004 study period differences are largest over the polar region of the Southern Hemisphere. In general, MODIS winds from NOAA/NESDIS seems to strengthen the cyclonic circulation of both polar areas, with mean differences in wind speed of up to 2 m/s. As depicted in Figure 7, there is a substantial improvement in the mean fit of the analysis to the background (reduction of RMS) by using the MODIS winds of NOAA/NESDIS , indicating a higher quality of the observed wind fields The forecast impact of the MODIS winds derived by NOAA/NESDIS compared to the MODIS winds derived by CIMSS is small but positve on both Hemispheres.

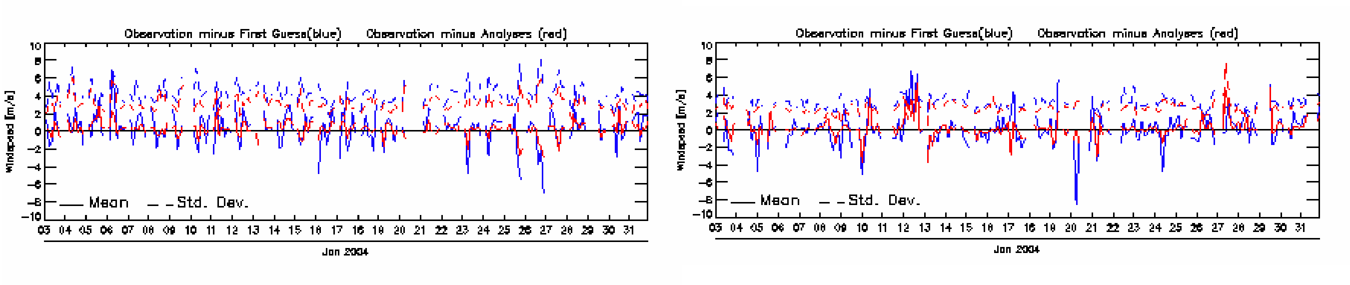

Figure 5: Time series of first guess (blue) and analysis (red) increments between MODIS winds from Terra derived by CIMSS (left) and NOAA/NESDIS (right) for the infrared chanel averaged over the Artic region

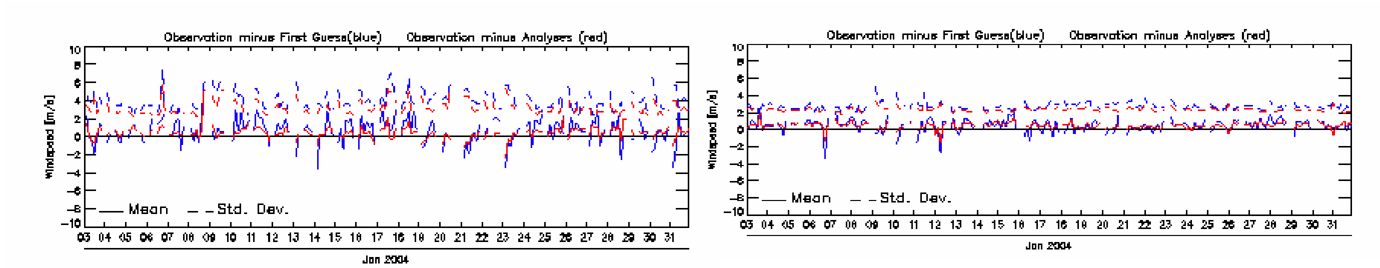

Figure 6: Time series of first guess (blue) and analysis (red) increments between MODIS winds from Aqua derived by CIMSS (left) and NOAA/NESDIS (right) for the water vapour chanel averaged over the Antarctica.

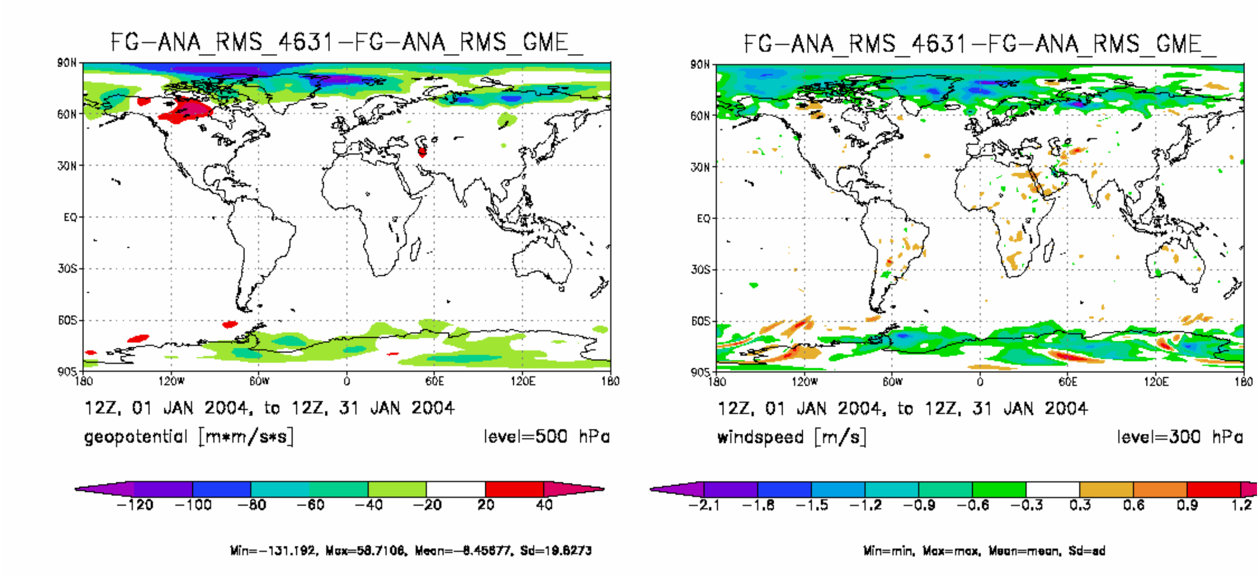

Figure 7: Difference of the mean rms difference between first guess and analysis for the 500 hPa geopotential height (left) and the wind speed in 300 hPa (right) for the experiment using MODIS winds derived by NOAA/NESDIS and the control run using MODIS winds derived by CIMSS.

4. REFERENCES

Key, J.R., Santek, D. C.S., Velden, Bormann, Thepaut, J.-N., Riishojgaard, L.P. Zhu, Y., Menzel, W.P., 2002: Cloud-drift and water vapor winds in the polar regions from MODIS. *IEEE Transactions on Geoscience and Remote Sensing*, 41, 482-492.