Assimilation of MODIS wind data in the global NWP System of the German Weather Service

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Global measurements of wind field is essential to improve our knowledge of atmospheric 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 the 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 Artic 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 has become available, which provides polar wind fields. The winds are derived by tracking features in the IR window band at 11μm and in the water vapour (WV) band at 6.7μm 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 window, CO_2 slicing or the H_2O intercept method (Key et al., 2002). Results of the NOGAPS model are used as a first guess. MODIS data are available in areas north of 60^oN and south of 60^oS.

Using the global assimilation and forecasting system of the German Weather Service (DWD), two impact experiments - one summer (June 2003) and one autuum case (October 2003) - were conducted to estimate the potential benefit of the MODIS wind observations. In contrast to the operational use of AMW winds from geostationary satellites (only over oceans), the experiments used the MODIS wind observations over land and ocean. Due to problems with height assignment and topography (Key, 2002), the MODIS WV winds were used above 400 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.

Various aspects of the quality of MODIS data were investigated, such as frequency distributions or time series of differences between observations and first guess before and after the quality control. A good correspondence was found between the MODIS 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 stronger in the Southern Hemisphere than in the Northern Hemisphere. Comparing the two satellites Terra and Aqua, a higher OBS-FG bias 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 in data void areas. The overall impact on forecast quality is small but positve for Europe and the Northern Hemisphere and neutral for the Southern Hemisphere for the summer case, although periods can be detected, were using the MODIS wind data leads to a substantial improvement of the forecast quality (Fig. 2; end of the period). 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 midlatitude flow patterns is particularly intense. The relatively minor impact of the MODIS data on 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 indentify trackable features over the Antarctic continent.

References

Key, J.R. Santek, D. C.S. Velden, Bormann, N. 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.

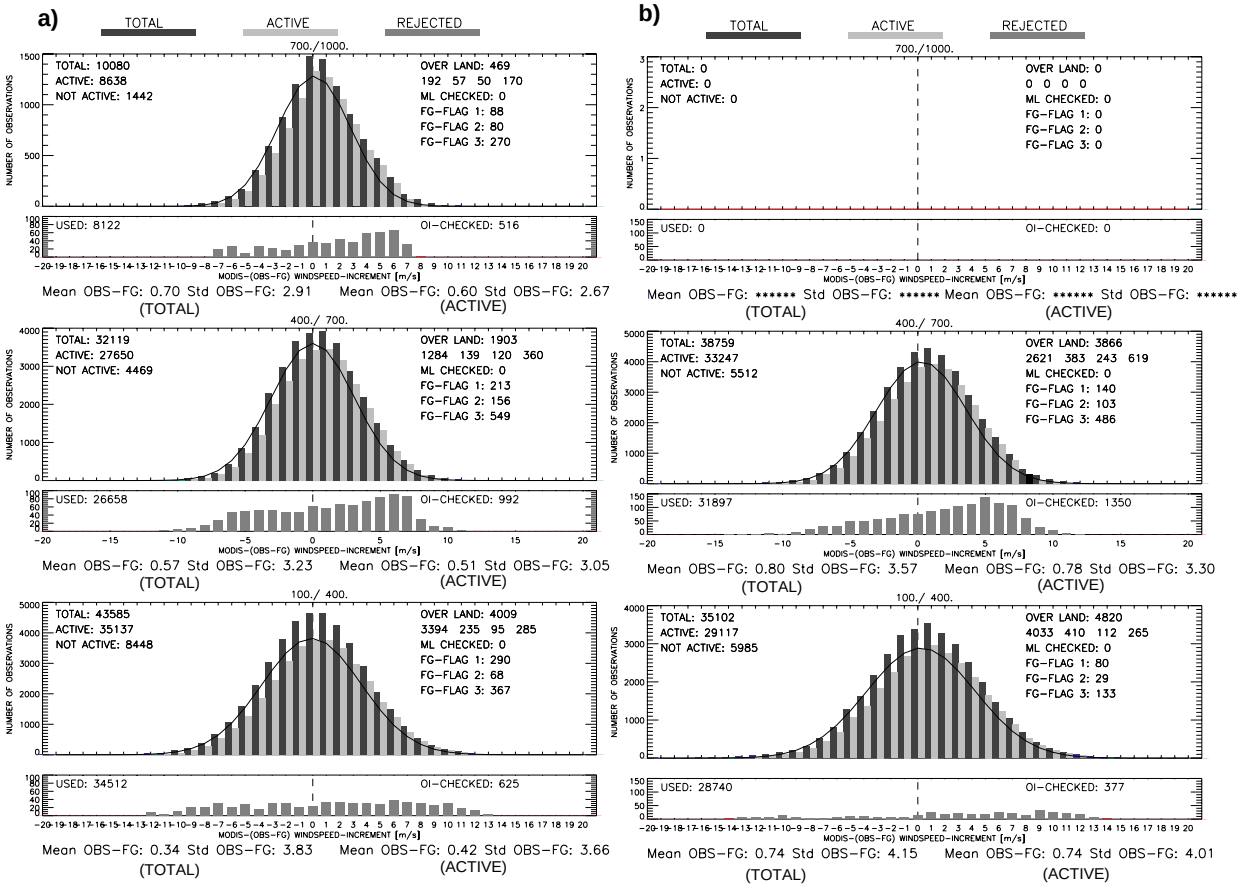

Figure 1: Frequency distribution of the difference between Modis windspeed (Terra and Aqua) and first guess, including quality control statistics for the summer case (June 12 to July 9, 2003) for all (Total, dark columns), active (after the quality control; light shaded columns) and used (after quality control and OI check, shaded columns in bottom picture) wind data, including the mean and standard deviation for all and active data, separated for the Northern (a) and Southern Hemisphere (b).

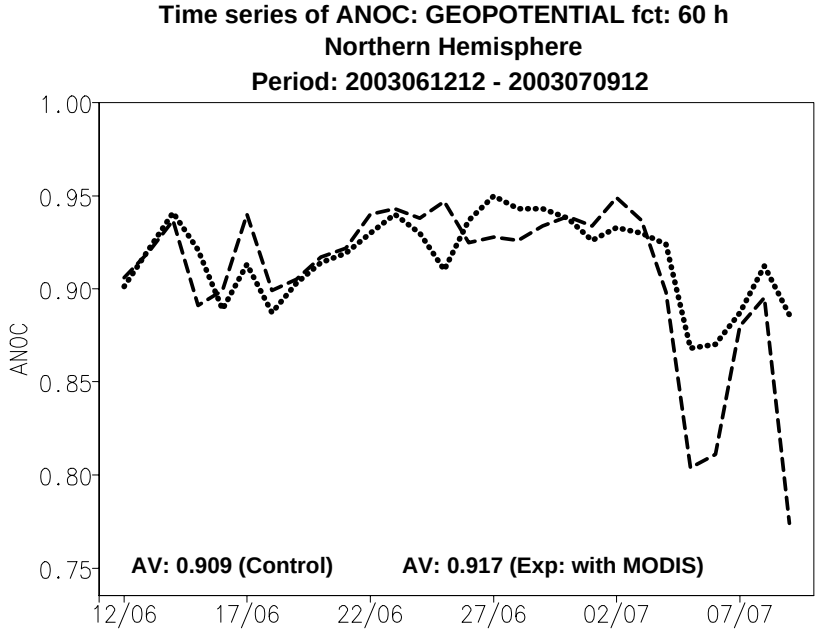

Figure 2: Time series of anomaly correlation coefficients of the 500 hPa geopotential height for the Northern Hemisphere at forecast time of 60h for control (dashed) and experiment (dotted) forecasts, including the MODIS wind data, from June 12 to July 9, 2003 12 UTC.