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The influence of DACCIWA radiosonde data on the quality of ECMWF analysis and forecasts

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An extensive field campaign was carried out in southern West Africa in June and July 2016 as part of the DACCIWA ("Dynamics-aerosol-chemistry-clouds interaction in West Africa") project. In addition to ground-based and research aircraft measurements, about 800 radiosondes were launched from eleven stations in Ivory Coast, Ghana, Benin, and Nigeria during the field campaign. Previous studies have already stressed that three-dimensional observations are of great importance for the correct representation of essential features of the West African Monsoon in the ECMWF (European Centre for Medium-Range Weather Forecasts) Integrated Forecasting System (IFS). Nonetheless, regular upper-air measurements are not available for most of the eleven stations. Therefore, the unprecedented measurements gathered during the DACCIWA field campaign provide a unique opportunity to evaluate the influence of radiosonde observations on the quality of the analysis and forecasts of the most recent model cycle of the ECMWF IFS (i.e. CY45r1, operational since June 2018). Two dedicated experiments were performed for this study. In one experiment all available (radiosonde) measurements were assimilated, while in the other DACCIWA radiosonde data were excluded from the assimilation. In the following, the experiments will be referred to as "DACCIWA" and "noDACCIWA", respectively. The latter experiment can be regarded as being very close to the status quo of the ECMWF operational analysis and forecasts for West Africa.

Mean 6-hourly differences between the "DACCIWA" and "noDACCIWA" analyses reveal that the impact of additional observations is largest for low-level winds and temperatures. When compared with the "noDACCIWA" analysis, weaker monsoon winds in the "DACCIWA" analysis lead to higher temperatures in parts of the study region due to a weaker cold air advection from the Gulf of Guinea. The strongest and statistically significant influences can be observed at night and downstream, i.e. north of stations in Ivory Coast and Ghana. Consistent with these nighttime biases, considerable differences are also found for low-level relative humidity, (low) cloud cover, and surface net radiation. Biases during daytime are generally much weaker, likely due to the effect of turbulent mixing in the boundary layer. In terms of the influence of DACCIWA radiosonde data on ECMWF forecasts, the improvement of the "DACCIWA" over the "noDACCIWA" predictions does not extend beyond lead times between 12 and 24 hours and is largely limited to temperature. This suggests that the main limiting factor for better ECMWF forecasts in West Africa is model error. It is hoped that the wealth of DACCIWA observations can contribute to a better understanding of the physical mechanisms involved in creating this model error in the future.