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Airborne Lidar Observations of Water Vapor Variability in the Tropics

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Thanks to the capability of performing targeted, simultaneous measurements of atmospheric backscatter and water vapor in regions of particular interest, an airborne water vapor lidar can help elucidate the complex interactions between water vapor, clouds and circulation in the tropics. The DLR WALES (Water vapor Lidar Experiment in Space) lidar was therefore operated on board the German research aircraft HALO during the NARVAL campaigns in December 2013 and in August 2016 in the Northern Atlantic Trades. The measurements show that high horizontal and vertical variability of humidity is omnipresent. The variability mainly stems from the presence of dry regions in the cloud and sub-cloud layers, and from vertical transport of moisture through the cloud layer by shallow convection in the trades, and by deep convection in the ITCZ. It poses challenges to climate models because it influences radiation, thus generating secondary circulations between radiatively heated and cooled regions. Out of the wealth of about 30 winter and 60 summer flight hours totaling 75,000 km of data over the Tropical Atlantic Ocean east of Barbados, several representative lidar segments from different flights are presented, together with satellite imagery and dropsonde profiles. Main advantages of lidar are the capability to detect small-scale vertical moisture gradients and thin dry layers, given the vertical WALES resolution of 300 m, and the capability to obtain profiles within cloud gaps of 3 km minimum size. These unique remote sensing characteristics allow unprecedented insights into water vapor distributions in the vicinity of shallow (trade clouds) and deep convection (ITCZ). Combining the lidar data with the HALO HAMP radar profiles allows comprehensive comparisons with model results such as the high-resolution ICON simulations that are available at the MPI for Meteorology for the campaign periods. Foreseen are comparisons of basic moisture statistics along the flights, and of cross-sections in moisture space that are sorted from the driest water column to the wettest, in which cloud fraction can be represented as an additional variable. First related findings will be presented.