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A new look at the atmospheric water cycle: measurements of water vapor and its main isotopologue using SCIAMACHY

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Water vapor is by far the most important greenhouse gas in the atmosphere. As a warmer atmosphere can contain more water vapor, a positive feedback effect with respect to climate change is expected. The distribution of water vapor is very inhomogeneous and variable, unlike that of other greenhouse gases. In the light of climate reconstructions and predictions, it is therefore crucial to better understand the water cycle and its response to past and present climate change. The relative abundance of the heavy water isotopologue HDO provides a deeper insight in the water cycle, as evaporation and condensation processes deplete heavy water in the gas phase. In the application of isotopologues, however, the space-borne retrieval of atmospheric water vapor isotopologues near the surface has so far been overlooked. We provide, for the first time (Frankenberg et al., Science 2009), global HDO/H2O abundances using the Scanning Imaging Absorption spectroMeter for Atmospheric CHartography (SCIAMACHY) instrument onboard ENVISAT. This allows for an entirely new perspective on the near-surface distribution of water vapor isotopologues. We are using the 2.3 micron (SWIR) window of SCIAMACHY, which is also used for the first time (Schrijver et al., AMT 2009) to derive total water vapor columns. Because of this wavelength range, and because SCIAMACHY is an absorption spectrometer, we are sensitive down to the lowest parts of the atmosphere where most of the water vapor resides. We further exploit a novel method to correct for the scattering effects of an ice layer on the SWIR detector and in order to further improve the accuracy of our HDO/H2O dataset, we derived an improved spectral linelist for H2O in the 2.3 micron window. The total water vapor columns have been validated with collocated ECMWF data and show good agreement. First results of atmospheric HDO/H2O show an expected latitudinal gradient, but also strong evaporation signals over the Red Sea and highly depleted values over mountain ranges. First comparisons with atmospheric General Circulation Models show that the observed high seasonality in HDO/H2O in the Sahel region is currently not well represented in the models. Such comparisons will add a new dimension to research into hydrological cycles.