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Tracking atmospheric boundary layer dynamics with water vapor D-excess observations

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Stable isotope water vapor observations present a history of hydrological processes that have impacted on an air mass. Consequently, there is scope to improve our knowledge of how different processes impact on humidity budgets by determining the isotopic end members of these processes and combining them with in-situ water vapor measurements. These in-situ datasets are still rare and cover a limited geographical expanse, so expanding the available data can improve our ability to define isotopic end members and knowledge about atmospheric humidity dynamics. Using data collected from an intensive field campaign across a semi-arid grassland site in eastern Australia, we combine multiple methods including in-situ stable isotope observations to study humidity dynamics associated with the growth and decay of the atmospheric boundary layer and the stable nocturnal boundary layer. The deuterium-excess (D-excess) in water vapor is traditionally thought to reflect the sea surface temperature and relative humidity at the point of evaporation over the oceans. However, a number of recent studies suggest that land-atmosphere interactions are also important in setting the D-excess of water vapor. These studies have shown a highly robust diurnal cycle for the D-excess over a range of sites that could be exploited to better understand variations in atmospheric humidity associated with boundary layer dynamics. In this study we use surface radon concentrations as a tracer of surface layer dynamics and combine these with the D-excess observations. The radon concentrations showed an overall trend that was inversely proportional to the D-excess, with early morning entrainment of air from the residual layer of the previous day both diluting the radon concentration and increasing the D-excess, followed by accumulation of radon at the surface and a decrease in the D-excess as the stable nocturnal layer developed in the late afternoon and early evening. The stable nocturnal boundary layer was associated with high radon concentrations and low D-excess. Interestingly the intermittent turbulence that brought low radon air to the surface from above the stable surface layer was associated with increases in the D-excess. These observations have shown that the D-excess in water vapor can be used to study moisture variability associated with atmospheric boundary layer dynamics on diurnal time scales. However, without knowledge of all isotopic end members, it is difficult to quantify the sources of moisture.