Quantifying the atmospheric boundary layer evolution during a 2020 heat wave over western Germany

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During June 2022 surface air temperatures across most of Europe were above the 1991-2020 average and daily maximum temperatures reached over 40 ºC over southern Europe (according to Copernicus.eu). Unusually high temperatures were also reached in Germany, where heat waves took place with over 35 ºC. In the Jülich Observatory for Cloud Evolution (JOYCE), these extreme temperature and humidity conditions were registered. JOYCE combines a rather unique set of ground-based remote sensing instruments that provide information about Boundary Layer thermal structure. The present investigation utilizes some of those measurements to diagnose total mean flux of heat and moisture within the Boundary Layer. In order to analyze the daily evolution of these fluxes during a heat wave, we utilize measurements of temperature and humidity from an Atmospheric Emitted Radiance Interferometer (AERI) and plot them in the mixing diagram approach, i.e., in an energy space (Lq versus $C_p\Theta$, where L is the latent heat of vaporization and C_p is the specific heat). Additionally, we quantify, in a 2D vector representation, the contributions of surface, advection and entrainment fluxes to the total mean flux. Estimates of horizontal temperature and humidity advection are obtained from measurements of the 30º elevation scan of a Microwave Radiometer (MWR) and from wind velocities measured by a Doppler Lidar. Additionally, surface flux measurements from the Integrated Carbon Observation System (ICOS) in a near by station in Selhausen are utilized to quantify the contribution of these surface fluxes in the mixing diagram. The total mean flux shows a daytime evolution with both sensible and latent heat components observed in days before the heat wave; whereas a high sensible heat flux dominates during the heat wave and the advective contribution becomes more important when the heat wave ends. We discuss the daily evolution of these fluxes, as well as the implementation of the mixing diagram approach for their study utilizing measured quantities. The present investigation can shed light on the Land-Atmosphere interaction and the closure of the surface energy and water budgets. Furthermore, understanding how the surface conditions can affect the atmospheric variables is valuable for a better characterization, and subsequent prediction, of extreme events such as heat waves in a warming climate.