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Observational analysis of the atmosphere–land surface interactions over the TERENO pre-alpine region

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Abstract

In order to examine the variability of heat fluxes and energy partitioning over complex terrain in the TERrestrial ENvironmental Observatories (TERENO) pre-alpine region, the turbulent heat fluxes and moisture at the surface layer were calculated using the eddy covariance technique. To better understand the principle characteristics of the land-surface energy balance, monthly and seasonal variations of radiation components, heat fluxes and moisture contents in the region, the measurements obtained from three eddy-covariance towers from January 2013 to December 2014 were analyzed. The diurnal, monthly and seasonal variations observed in all the radiation components as a result of the seasonal variation in the solar radiation. The diurnal variations in shortwave radiation were larger than those of longwave radiations. The highest daily value of incoming shortwave radiation (ISR, 344.2 W/m2), incoming longwave radiation (ILR, 389.3 W/m2) and outgoing longwave radiation (OLR, 439.2 W/m2) were measured in summer, while the highest daily value of outgoing shortwave radiation (OSR, 120.7 W/m2) occurred in winter due to the snow cover in the region. The ISR and OLR had the strongest seasonal and interannual variability, in particular during the summertime. The maximum (extreme) surface albedo value was measured in winter 2013 due to the heavy snowfall event. By contrast, it was lower during the warm seasons because of a darker surface (i.e. high vegetation fraction and wetter soil). The seasonal variation of the sensible heat flux (H) was stronger than that of the latent heat flux (LE) in winter, while LE had a stronger variation in summer and considered as the main consumer of available energy in summer, while the soil heat flux (G) indicated the least variation over the experimental time. In addition, the range of the seasonal diurnal cycle of net radiation (Rn) increased from winter to summer and decreased in-turned position indicating a high variation of Rn in summer and weak in winter, as well. Therefore, the highest seasonal diurnal variations observed in Rn, followed by LE and H, and also the lowest one found in G, whereas the nocturnal ones were negligible. The soil moisture was highly depended on the precipitation, while it was mostly frozen during winter and rather dry over the summertime periodically. The maximum surface energy rate found at the Fendt site and reached 0.655, while the lowest one observed in Rottenbuch with a value of 0.558 as well as the minimum R2 between the turbulent fluxes and available energy was found at the Graswang site. The energy imbalance problem was identified and the residual was about 18%, 15% and 23% of the available energy at the Fendt, Graswang and Rottenbuch sites, respectively and the reasons are discussed.

Key words: Heat fluxes variability, energy balance, soil moisture availability, southern Germany