Available energy and energy balance closure at four coniferous forest sites across Europe

Author(s) Moderow, U.; Aubinet, M.; Feigenwinter, C.; Kolle, O.; Lindroth, A.; Mölder, M.; Montagnani, L.; Rebmann, C.; Bernhofer, C.
Author(s) at UniBasel Feigenwinter, Christian ;
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The available energy (AE), driving the turbulent fluxes of sensible heat and latent heat at the earth surface, was estimated at four partly complex coniferous forest sites across Europe (Tharandt, Germany; Ritten/Renon, Italy; Wetzstein, Germany; Norunda, Sweden). Existing data of net radiation were used as well as storage change rates calculated from temperature and humidity measurements to finally calculate the AE of all forest sites with uncertainty bounds. Data of the advection experiments MORE II (Tharandt) and ADVEX (Renon, Wetzstein, Norunda) served as the main basis. On-site data for referencing and cross-checking of the available energy were limited. Applied cross checks for net radiation (modelling, referencing to nearby stations and ratio of net radiation to global radiation) did not reveal relevant uncertainties. Heat storage of sensible heat J H, latent heat J E, heat storage of biomass J veg and heat storage due to photosynthesis J C were of minor importance during day but of some importance during night, where J veg turned out to be the most important one. Comparisons of calculated storage terms (J E, J H) at different towers of one site showed good agreement indicating that storage change calculated at a single point is representative for the whole canopy at sites with moderate heterogeneity. The uncertainty in AE was assessed on the basis of literature values and the results of the applied cross checks for net radiation. The absolute mean uncertainty of AE was estimated to be between 41 and 52 W m−2 (10–11 W m−2 for the sum of the storage terms J and soil heat flux G) during mid-day (approximately 12% of AE). At night, the absolute mean uncertainty of AE varied from 20 to about 30 W m−2 (approximately 6 W m−2 for J plus G) resulting in large relative uncertainties as AE itself is small. An inspection of the energy balance showed an improvement of closure when storage terms were included and that the imbalance cannot be attributed to the uncertainties in AE alone.
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