Analysis of above and below-canopy energy fluxes of an Alpine coniferous forest

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The processes that control the physical and chemical properties of the Earth's atmosphere are related to the rate at which heat and mass (such as carbon dioxide, water vapour, trace gases and pollutants) are exchanged between the Earth's surface and the atmosphere. Forests represent a significant fraction of the Earth's surface and play a crucial role in determining the characteristics of the atmosphere. In this study, we investigated how different wind circulation patterns (slope winds, Tramontana and Southerlies) influenced the overstory and understory energy balance of an Alpine coniferous forest (Renon, Italy) located in an area with complex topography and a mean slope of about 11° with a south aspect. Turbulent fluxes of sensible and latent heat were measured from August to October 2021 applying the Eddy Covariance (EC) technique by means of two EC systems installed above and below the canopy. For the above-canopy case, the tilt correction was applied to net radiation measurements and storage terms of sensible and latent heat were added to the overall energy exchange. The energy balance closure was assessed for each month (August, September and October 2021) and during different circulation patterns for clear-sky days. Furthermore, we investigated how the energy balance closure was related to different atmospheric turbulence and stability conditions. During slope wind days, the above-canopy turbulent fluxes of sensible and latent heat were sometimes found to be overestimated with respect to the available energy (AE), while during Southerlies and Tramontana the AE and the turbulent fluxes showed a better closure (energy balance ratio closer to 1). On the contrary, below-canopy fluxes were mostly underestimated under all wind circulations. We argue that the lack of closure of the energy balance might be due to the unaccounted contribution of non-turbulent fluxes and, in the below-canopy case, also to a footprint mismatch. In general, compared to slope wind circulation, synoptically driven winds determined higher turbulent mixing conditions across all hours, both overstory and understory.