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Turbulent transport of energy across a forest and a semi-arid shrubland

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The role of secondary circulations has recently been studied in the context of well defined surface heterogeneity in a semi-arid ecosystem where it was found that energy balance closure over a desert-forest system and the structure of the boundary layer was impacted by advection and flux divergence. As a part of the CliFF (Climate Feedbacks and benefits of semi-arid forests, a collaboration between KIT, Germany and the Weizmann Institute, Israel) campaign, we studied the boundary layer dynamics and turbulent transport of energy corresponding to this effect in the Yatir forest situated in the Negev desert in Israel. The forest surrounded by small shrubs presents a distinct feature of surface heterogeneity, allowing us to study the differences between their interactions with the atmosphere above by conducting measurements with two EC stations and two Doppler LiDARs. As expected, the turbulence intensity and vertical fluxes of momentum and sensible heat are found to be higher above the forest compared to the shrubland. Turbulent statistics indicative of nonlocal motions are also found to differ over the forest and shrubland and also display a strong diurnal cycle. The production of turbulent kinetic energy (TKE) over the forest is found to be strongly mechanical, while buoyancy effects generate most of the TKE over the shrubland. Overall TKE production is much higher above the forest compared to the shrubland. The forest is also found to be more efficient in dissipating TKE. The TKE budget appears to be balanced on average both for the forest and shrubland, although the imbalance of the TKE budget, which contains the role of TKE transport, is found to be quite different in terms of their variation with atmospheric stability and diurnal cycles for the forest and shrubland. The effect of very large scale mesoscale motions are also directly quantified following a recent formulation by Banerjee and Katul, 2013, using the measured longitudinal velocity variances and boundary layer heights. The difference of turbulent quantities and the relationships between the components of TKE budget are used to infer the characteristics of turbulent transport of energy between the desert and the forest.