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Changes in snowpack energy balance during forest disturbance with focus on shortwave and longwave radiation

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Understanding the role of forest on snowmelt processes enables to better estimate snow storages at a catchment scale and contributes to higher accuracy of spring floods forecasting. A coniferous forest modifies snowpack energy balance by reducing the total amount of solar shortwave radiation (SWR) and enhancing the role of longwave radiation (LWR) emitted by trees. Both factors fundamentally influence snowmelt timing and snowmelt rates in forest environment. This study focuses on temporal and spatial variability of SWR and LWR in sites with different canopy structure. We were specifically focused on temporal changes in SWR and LWR in a disturbed forest affected by the bark beetle (Ips typographus). First experimental site was formed by the disturbed spruce forest (Sumava Mts., Czechia), two other reference sites were situated in an adjacent healthy spruce forest and open meadow. The canopy structure was described with hemispherical images, which we used to calculate the Leaf Area Index. The measurements of incoming and outgoing SWR and LWR were performed in all three sites equipped with CNR4 Net Radiometers (Kipp & Zonen) during three winter seasons (2015/16, 2016/17 and 2017/18). Besides SWR and LWR, sensible and latent heats and energy supplied by liquid rain were calculated for each site to describe the entire energy balance and the snowmelt process. The results showed that SWR is a major source of the energy in the open site, while LWR often constitutes a negative component of the snowpack energy balance. The total SWR in the healthy forest site was reduced by 94% compared to open area due to shading effect of the trees. In the disturbed forest site, SWR was reduced by 73% in winter 2015/16 and only by 42% in winter 2017/18 due to consecutive forest decay and thus the site became more open to SWR. On the contrary, LWR is the primary source of energy in forest environment during snowmelt. The net LWR (difference between incoming and outgoing LWR) constitutes a positive component of the snowpack energy balance in the healthy forest site (daily average 3.3 W.m-2), while the negative LWR balance (-20.5 W.m-2) was measured in the open site. Additionally, the forest decay also caused the significant decrease in net LWR from winter 2015/16 (-3 W.m-2) to winter 2017/18 (-12.9 W.m-2) in the disturbed forest site. The mentioned changes in SWR and LWR caused significantly slower snow ablation in the healthy forest site (by 32%) and in the disturbed forest site (by 7%) than in the open site. The results proved that changes in individual energy balance components after forest disturbance might lead to important consequences in snowmelt dynamics and therefore runoff.