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Evapotranspiration and CO_2 exchange of wet and snow-loaded canopy in an evergreen temperate coniferous forest

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Learning about the gas exchange dynamic (evapotranspiration and photosynthesis) relating to precipitation and leaf wetness is important for understanding the forest hydrological and carbon sink function. Precipitation can lead to the change in meteorological factors, depression on leaf gas exchange as well as increasing CO_2 emission from soil. However, few studies fully consider the effect of these changes in ecosystem scale.

This study conducted continuous eddy covariance measurement over a temperate evergreen Japanese cypress forest canopy in the Asian monsoon area from 2016 to 2019. By applying the eddy covariance method with the enclosed path gas analyzer, evapotranspiration and CO_2 exchange from the canopy to the atmosphere during and after rainfall and snow are precisely monitored. The chamber method is used to simultaneously measure the soil respiration. Especially, to reveal the mechanism of wet canopy gas exchange mechanism, a SVAT multilayer model with two rainfall interception solution (Model 1: free gas exchange with interception only by the adaxial surface; Model 2: no gas exchange with interception by both surfaces) is applied to figure out the interception distribution over the leaf surface.

The annual average daytime latent heat flux (λE) was 70.92 W m^{-2}, 22.31 W m^{-2}, 139.40 W m^{-2} for wet canopy, snow-loaded canopy and the first 6 hours after wetness ended; the annual average daytime net ecosystem exchange was -1.9 μmol $m^{-2}s^{-1}$, -0.42 μmol $m^{-2}s^{-1}$, -7.43 μmol $m^{-2}s^{-1}$ for wet canopy, snow-loaded canopy and the first 6 hours after wetness ended. Correspondingly, the annual average daytime soil CO_2 flux was 2.53 μmol $m^{-2}s^{-1}$, 0.26 μmol $m^{-2}s^{-1}$, 2.93 μmol $m^{-2}s^{-1}$ when the canopy was wet, snow-loaded and during the first 6 hours after wetness ended. The gas exchange at the first 6 hours after wet is more active than that of wet canopy and snow-loaded canopy despite rainfall increased the CO_2 emission from the soil. Both measured data and simulation show the wet canopy can process gas exchange. The simulation showed that both interception situations are possible to happen but Model 1 is more suitable for this temperate forest. Meanwhile, the difference between the two models' performance is smaller during the rainfall than in the wet period after the rainfall, which means interception distribution had a larger impact on wet canopy gas exchange at the later wet period. Future studies should also concern about the mechanism and effect of gas exchange dynamics relating to different precipitation

patterns and water sources for latent heat flux.