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How does canopy wetness shape evapotranspiration in a mountain cloud forest

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Interception plays an important role in the hydrological characteristics of cloud forest ecosystems due to frequent wetness of the canopy. The dynamics of this canopy interception processes are ecologically important for partitioning between interception evaporation and transpiration. Long term meteorological observations at the Chi-Lan Mountain site (24°35'N, 121°25'E) indicated that fog weather accounts for one third of the time on a year around and mainly prevails in the late afternoon and evening. However, it is still not clear how long the interception water could last on canopy surface under such diurnal foggy patterns and how this wetness further shapes the partition between interception evaporation and transpiration.

In order to explore the evapotranspiration patterns under wet canopy conditions, three-month intensive experiment was conducted at the CLM site from 2009/4/28 to 7/21. Eddy covariance method was applied to measure the net water vapor exchange between ecosystem and atmosphere. An open/closed-path eddy covariance system, including a sonic anemometer (Campbell CSAT3), an open path infrared gas analyzer (Licor LI7500) and a closed path infrared gas analyzer (Licor LI7000), was mounted at 1.8-fold of canopy height. The S-type sap flow sensors (Ecomatik SF-L) were mounted at 1.3 m height of trunk on five representative Chamaecyparis obtusa var. formosana trees as an index of transpiration rate. Three leaf wetness sensors (Campbell LW237) and two infrared surface thermometers (Apogee IRTS-P) were added to monitor the wetness and surface temperature of canopy.

The result showed that canopy wetness played a crucial role in partitioning the interception evaporation and transpiration at this forest stand. Evapotranspiration either under wet or dry canopy conditions was mainly driven by the evapotranspiration demand, as indicated by the potential evapotranspiration. However, evapotranspiration was lower for dry canopy condition. While total evapotranspiration rate increased with evapotranspiration demand, transpiration did not follow the increasing trend. Transpiration under dry canopy condition increased linearly with evapotranspiration demand and leveled off as evapotranspiration demand exceeded around 3 mmole m-2 s-1. This flatten trend reflected that water stress could develop at this forest under higher evapotranspiration demand even the soil was moist. On the other hand, transpiration under wet canopy condition was reduced while evapotranspiration increased, which reflected that canopy wetness possibly reduced the capability of transpiration. Complex of canopy wetness probably played an important role in partitioning the interception evaporation and transpiration under this wet canopy condition.

The diurnal courses of weather and water status during the experimental period showed fog typically formed in the afternoon and dissipated before midnight. Canopy surface was gradually wetted a few hours after the initiation of fog events. In the beginning hours of fog events during the late afternoon, canopy surface was only slightly wetted. Fog reduced solar irradiance but transpiration still was driven by the reduced evapotranspiration demand. As fog persisted in the following nighttime, canopy surface wetness increased and only trivial water vapor fluxes were observed due to lack of energy for evaporation and the cease of transpiration. As incident radiation rose after dawn, leaf temperature increased, intercepted water on the canopy surface was evaporated and canopy surface dry quickly in the morning. Both interception evaporation and transpiration contributed significantly to ecosystem water vapor fluxes during these drying periods till canopy surface was completely dry and transpiration dominated thereafter.