IMPACTS OF CLOUD IMMERSION ON MICROCLIMATE, PHOTOSYNTHESIS AND WATER RELATIONS OF FRASER FIR IN A TEMPERATE MOUNTAIN CLOUD FOREST

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The red spruce-Fraser fir ecosystem (*Picea rubens* Sarg.-*Abies fraseri* [Pursh] Poir.) of the southern Appalachian mountains is a temperate zone cloud forest immersed in clouds for 30 to 40 percent of a typical summer day, and experiencing immersion on about 65 percent of all days annually. We compared the microclimate, photosynthetic gas exchange, and water relations of Fraser fir trees in open areas during cloud-immersed, low-cloud, or sunny periods. In contrast to sunny periods, cloud immersion reduced instantaneous sunlight irradiance by 10 to 50 percent, and midday atmospheric vapor pressure deficit (VPD) was 85 percent lower. Leaf surfaces were wet for up to 16 h per day during cloud-immersed days compared to <1 h for clear days. Shoot-level light-saturated photosynthesis (A_{sat}) on both cloud-immersed (16.0 µmol m^{-2} s^{-1}) and low-cloud (17.9 µmol m^{-2} s^{-1}) days was greater than A_{sat} on sunny days (14.4 µmol m^{-2} s^{-1}). Daily mean A_{sat} was lowest on cloud-immersed days due to reduced sunlight levels, while leaf conductance (g) was significantly higher, with a mean value of 0.30 mol m^{-2} s^{-1}. These g values were greater than commonly reported for conifer tree species with needle-like leaves, and declined exponentially with increasing leaf-to-air VPD. Daily mean transpiration (E) on immersed days was 43 and 20 percent lower compared to sunny and low-cloud days, respectively. As a result, daily mean water use efficiency (A_{sat}/E) was lowest on cloud-immersed days due to light limitation of A_{sat}, and high humidity resulted in greater uncoupling of A_{sat} from g. Thus, substantial differences in photosynthetic CO_2 uptake, and corresponding water relations, were strongly associated with cloudy sky conditions.

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