Geophysical Research Abstracts
Vol. 21, EGU2019-5239, 2019
EGU General Assembly 2019

Catchment-scale estimation of enhanced wet canopy evaporation by woodland for Natural Flood Management

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Wet canopy evaporation (Ewc: the difference between the gross rainfall [Pg] incident upon a vegetation canopy and the fraction that reaches the ground as net rainfall [Pn]) has historically been studied because of the negative effects on resources available for public water supply. Recently in the UK, there has been an interest in the role of increased Ewc from woodland planting as part of Natural Flood Management (NFM). It is, however, thought by some that planting trees as an NFM intervention has the potential for reducing peaks in flow, but not during large flood events. A review of global Ewc studies does, however, show that high Ewc losses do occur at high-rainfall temperate sites during rainfall events. The magnitude of the losses during larger rainfall events (≈>50 mm/d) tends to be between 2% and 35% of Pg. Although relatively few studies include observations during extreme rainfall events (≈>150 mm/d), where observations have been made similar magnitudes are reported. The significant variability of these losses is to be expected and is associated with canopy characteristics and meteorological conditions, the latter of which can vary significantly both during and immediately after rainfall events of different intensity, duration and frequency. These all-important concurrent meteorological conditions are, however, rarely reported in enough detail to be able to determine the magnitude of their control on Ewc for individual events.
We summarise the magnitude of wet canopy evaporation from studies undertaken in high-rainfall temperate sites globally and investigate the meteorological conditions required to drive these rates using Penman-Monteith theory (whilst acknowledging its constraints). We then focus on a number of upland UK sites where long-term high-frequency meteorological observations are available during large and extreme rainfall events. Analysis of these data allows us to demonstrate that these conditions occur frequently enough to be able to say that the conditions for high rates of Ewc are possible in some locations but that the extrapolation of these results across even meso-scale catchments (10-10,000 km2) is highly uncertain. Given these findings, we present a method that allows estimates of Ewc during rainfall events of various magnitudes to be made across meso-scale catchments. Because of the significant uncertainties associated with the Ewc observations, the driving meteorological observations and their interpolation and extrapolation in time and space, estimates of Ewc and subsequent simulations are made within an uncertainty framework. The method is demonstrated for three meso-scale catchments in mountainous Cumbria (UK) where hydrological simulations of the effects of various woodland planting scenarios are required. The way that the propagation of uncertainties affects simulation results and their meaning for decision making is discussed, as is the role of additional data collection in understanding Ewc during large and extreme events and their role in reducing uncertainties.