A comparative study on evapotranspiration methods using SWAT model in a forest-dominated watershed, western Japan

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Soil and Water Assessment Tool is one of the most popular hydrological models in recent years. It has been used world widely to simulate water budget as well as sediment, and nutrient fluxes from headwater to coastal area in a watershed scale. From our preliminary studies revealed that the model tends to underestimate actual evapotranspiration (AET) in Japanese watersheds compared with previous studies including observation-based reports. From a point of view of hydrological cycle, evapotranspiration is a key factor on hydrological processes in surface and subsurface including surface runoff, lateral flow, and groundwater flow. Miscalculation of AET could disturb all the processes because most of the modeling studies rely on river flow rate for calibrating hydrological parameters as previous studies have done. Hence, this study aimed to evaluate capability of the model on estimation of evapotranspiration in Japan characterized as forest-dominated with steep slope topography. The study area was Asahi River watershed, located in the middle part of the Okayama prefecture in Japan, has a catchment area of 1,810 km^2 and a total stream length of 142 km. Annual mean precipitation to this watershed is 1,576mm. The watershed is mainly covered by forest (79%), and paddy field (11%). The soil types were categorized into Humic Cambisols (72.4%), Haplic Andosols (14.6%), Fluvic Gleysols (7.3%), and others (5.7%). The model was calibrated for the period from 2000 to 2003 using the SUFI2 method and validated for the period from 2004 to 2007. In the model, four methods are available to select; Penman-Monteith, Priestley-Taylor, Hargreaves, and manually calculated PET by user. As a result, estimated AET by Penman-Monteith was 612 mm which was accounted 39% for annual mean precipitation. AET increased if Priestley-Taylor or Hargreaves is chosen instead of Penman-Monteith in the model. Reported AET for this watershed in previous studies have varied from 549 to 800 mm estimated by Brutsaert-Stricker, Morton's Complementary Relationship Areal Evapotranspiration, and Thornthwaite. The AET estimated by Penman-Monteith in the model was 90 mm smaller than 702 mm as the median of previous studies. The reason of underestimation of AET could be caused by following three possibilities; First, tree parameters which control evapotranspiration have been still unknown because of lack of information though crops have been well investigated in agricultural field. More specifically, parameters of maximum root depth, maximum leaf area index, maximum canopy storage, and stomatal conductance were considered as possible sensitive parameters to improve AET. Secondly, mountainous soil parameters are difficult to determine due to lack of information as same as the above-mentioned plant parameters. Available soil water calculated by the difference between amount of soil water at field capacity and at permanent wilting point, is a critical parameter to AET. The parameter could be determined by calibration and be verified through ordinary process. However, there is few information to be able to judge the calibrated value is reasonable so far. Lastly, Current approach embedded in the model could not represent heterogeneity of regional climate. Although the model could consider elevation dependent vertical changing of temperature and rainfall using compensation parameters, it could not compensate for horizontal distribution. Especially, wind speed, and relative humidity are more difficult to be assumed as homogeneity distributed than air temperature or precipitation. This is possibly to contribute AET underestimation. Based on these results, we concluded that AET could be improved by current model functions. However, expanding and enhancing on forest parameter database including plant and soil are

necessary.

Keywords: Soil and Water Assessment Tool, evapotranspiration, Penman–Monteith method