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A comparison of three models used to determine water fluxes over the Albany Thicket, Eastern Cape, South Africa

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ABSTRACT

The Albany Thicket (AT) biome contains outstanding global biodiversity as well as the potential to achieve carbon credits associated with water-efficient Crassulacean acid metabolism (CAM). Understanding the water fluxes in the AT is crucial to determining carbon (C) sequestration rates and water-use efficiency. Despite large variation in water fluxes across the AT, only a few studies have been conducted in this region with their results validated against short periods of observed data. This study aims to evaluate three models of water fluxes over AT against data from an eddy covariance (EC) system active from October 2015 to May 2018. ET was modelled using the BioGeoChemistry Management (BGC-MAN) model, a biophysical model (Penman-Monteith-Leuning (PML)) and a remotely-sensed product (MOD16), and their results compared with that from the EC system. More than three decades of rainfall data from Climate Hazards Group Infrared Precipitation with Station Data (CHIRPS) was used to assess some rainfall characteristics of the region. The mean annual rainfall is 404 mm and mean monthly rainfall ranges from 6.0–66.7 mm, with minima likely to occur in winter period (between May and July) and monthly maxima in the summer period (between October and March). Among the three hydrological years in this study period, ET for 2016–2017 exceeded rainfall received by about 7% which shows that AT is likely to be supported by groundwater at some point but this requires further investigations. Generally, the three models applied in this study performed reasonably well when compared with the measured ET. The cumulative ET from BGC-MAN was slightly higher than that from EC by 16% and 8% in 2015–2016 and 2017–2018 hydrological years respectively while PML was slightly lower by 2% and 17% in 2016–2017 and 2017–2018; additionally, MOD16 was slightly lower by 14% and 7% in 2016–2017 and 2017–2018, respectively. However, the correlation between the ET from EC and simulated ET from the three models was significant at $p < 0.01$.

1. Introduction

Terrestrial biomes are strongly linked with climatic factors, soil types, land-form and disturbance regimes (Smart, 2016). The ecophysiological characteristics of the plant functional types, interaction with soil effects and climate parameters, give each biome a unique set of climate interactions with respect to the nature and strength of the interactions with the atmosphere. South Africa's Sub-tropical Thicket was recognised as a biome in mid-1990s, before then, it was seen as mixture of different biomes (Smart, 2016). The regional climate varies from subtropical to warm-temperate through frost-free or semi-arid to subhumid with a bimodal rainfall pattern (Cowling et al., 2005). The thicket can be distinguished by the presence or absence of succulent species and scrutinized by species evolutionary lineage (Smart, 2016). It comprises evergreen and weakly deciduous trees and shrubs of 2–5 m height (Cowling et al., 2005).

It is obvious that more attention has been given to carbon fluxes than water fluxes in historical studies in the AT. Even in semi-arid region of South Africa where water is scarce, little is known about the water flux across the Sub-tropical Thicket (Gwate et al., 2018). Some water related studies conducted on thicket in South Africa include the assessment of annual ET of some native thicket by Meijninger and Jarmain (2014). It was noted that annual ET for dune and spekboom thicket in the Western Cape ranges between 515 and 660 mm respectively while valley thicket in KwaZulu-Natal is 755 mm. Dye et al. (2001) noted that removal of riparian wattle, an invasive alien tree will lead to significant reductions in annual ET which in turn will enhance streamflow. So far, studies on ET over AT include: measurement of ET using an EC system (Gwate et al., 2016); development of ET predictive model to be applied at biome scale (Gwate et al., 2018); validation of

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