AN ECOHYDROLOGICAL MODELLING STUDY OF AN AUSTRALIAN EUCALYPTUS FOREST

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Statement of Original Authorship

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision.

The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to the final version of my thesis being made available worldwide when deposited in the University’s Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo

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Date: March 2018
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Abstract

In this study, a multilayer canopy-root-soil model (MLCan) was implemented to simulate the ecohydrological fluxes of a eucalyptus forest located in Tumbarumba, Australia. This model has not been previously tested in this type of ecosystem. This study particularly focused on estimating the forest land-atmosphere exchange fluxes of latent heat ($LE$), sensible heat ($H$) and CO$_2$ ($F_c$), as well as the soil moisture at the first layer ($SWS$), comparing model results to observations and examining the sensitivity of the estimates to selected model parameters. The parameter sensitivity analysis and model calibrations were performed using the Monte-Carlo based GLUE method.

The effects of multiple canopy layers on the model’s estimations were first examined, and the optimum number of canopy layers were determined. Sensitivity analysis on the values of root conductivities indicated the importance of axial root conductivity on the estimations of the latent heat flux, root water uptake, soil moisture and hydraulic redistribution.

As a result of the parameter sensitivity analysis using GLUE, it was found that the slope ($m$) and intercept ($b$) of the Ball-Berry stomatal conductance model were the most sensitive parameters for estimating the $LE$, $H$ and $SWS$. The $R_o$ parameter, soil respiration rate at 10 C°, was found to be the only sensitive parameter for estimating $F_c$. Model calibrations to observations were carried out using GLUE, both on individual variables (single-response) and on all variables (multi-response). The results of the single-response calibrations produced slightly better results but were biased towards the calibrated variable. The results of the model validations on the independent data during 2001-2008 showed that the model performed reasonably well in estimating the $LE$, $H$ and $SWS$. However, the model could not estimate the $F_c$ very well. The estimations of the $LE$ and $SWS$ using the MLCan model had a similar level of agreement with observations than previous results at the site using the CABLE model.

Comparing the effects of depth-constant and depth-varying initial soil moisture on model calibrations showed that the depth-constant initial soil moisture degraded the model’s performance in multi-response calibration, mainly due to the degradation in
the soil moisture estimation. However, it did not significantly affect the results in the single-response calibration. An analysis on the effects of parameters and initial soil moisture conditions on the soil moisture estimation showed that the deep layer soil moisture influenced the surface layer soil moisture estimations. This result suggested that vegetation has an effect on the soil moisture estimation through hydraulic redistribution. Results from the MLCan simulations at Tumbarumba also suggested that the soil moisture memory is in the order of 12 months. The results presented in this thesis demonstrate that the MLCan model can be used to adequately capture ecohydrologic fluxes in eucalyptus ecosystems in Australia.