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Climate controlled root zone parameters show potential to improve water flux simulations by land surface models

Fransje van Oorschot[1,2], Ruud van der Ent[1], Andrea Alessandri[2,3], and Markus Hrachowitz[1]
[1]Department of Water Management, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands (f.vanoorschot@tudelft.nl)
[2]Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands
[3]Institute of Atmospheric Sciences and Climate, National Research Council of Italy (CNR-ISAC), Bologna, Italy

The root zone storage capacity (S_r) is the maximum volume of water in the subsurface that can potentially be accessed by vegetation for transpiration. It influences the seasonality of transpiration as well as fast and slow runoff processes. Many studies have shown that S_r is heterogeneous as controlled by local climate conditions, which affect vegetation strategies in sizing their root system able to support plant growth and to prevent water shortages. Root zone parameterization in most land surface models does not account for this climate control on root development, being based on look-up tables that prescribe worldwide the same root zone parameters for each vegetation class. These look-up tables are obtained from measurements of rooting structure that are scarce and hardly representative of the ecosystem scale. The objective of this research was to quantify and evaluate the effects of a climate-controlled representation of S_r on the water fluxes modeled by the HTESSEL land surface model. Climate controlled S_r was here estimated with the "memory method" (hereinafter MM) in which S_r is derived from the vegetation's memory of past root zone water storage deficits. $S_{r,MM}$ was estimated for 15 river catchments over Australia across three contrasting climate regions: tropical, temperate and Mediterranean. Suitable representations of $S_{r,MM}$ were then implemented in HTESSEL (hereinafter MD) by accordingly modifying the soil depths to obtain a model $S_{r,MD}$ that matches $S_{r,MM}$ in the 15 catchments. In the control version of HTESSEL (hereinafter CTR), $S_{r,CTR}$ was larger than $S_{r,MM}$ in 14 out of 15 catchments. Furthermore, the variability among the individual catchments of $S_{r,MM}$ (117—722 mm) was considerably larger than of $S_{r,CTR}$ (491—725 mm). The HTESSEL MD version resulted in a significant and consistent improvement version of the modeled monthly seasonal climatology (1975--2010) and inter-annual anomalies of river discharge compared with observations. However, the effects on biases in long-term annual mean fluxes were small and mixed. The modeled monthly seasonal climatology of the catchment discharge improved in MD compared to CTR: the correlation with observations increased significantly from 0.84 to 0.90 in tropical catchments, from 0.74 to 0.86 in temperate catchments and from 0.86 to 0.96 in Mediterranean catchments. Correspondingly, the correlations of the inter-annual discharge anomalies improved significantly in MD from 0.74 to 0.78 in tropical catchments, from 0.80 to 0.85 in temperate catchments and from 0.71 to 0.79 in Mediterranean catchments. Based on these results, we believe that a global application of climate controlled root zone parameters has the

potential to improve the timing of modeled water fluxes by land surface models, but a significant reduction of biases is not expected.