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Significant Variation of Vegetation Characteristics and Dynamics from Ecohydrological Optimality of Net Carbon Profit

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Recent contributions to the ecohydrological literature have questioned the continued usefulness of the classical model calibration paradigm to estimating parameters in coupled models of soil moisture dynamics, ecophysiological gas exchange and photosynthesis. In their seminal papers, (Kleidon, 2004; Kleidon, 2007; Schymanski et al., 2007; Schymanski et al., 2008a) have demonstrated that the principle of vegetation optimality provides an attractive and parsimonious alternative to using site specific calibration measurements for estimating vegetation cover, rooting depth, transpiration fluxes, and CO2 assimilation. Optimality based approaches not only reduce the need for detailed field measurements, but also provide flexible frameworks to continuously adapt vegetation responses to changing environmental conditions. Yet, the main focus in optimality-based approaches has been on finding a single optimal combination of ecohydrological parameter values. This approach downplays the importance of variability, and implicitly ignores model and measurement uncertainty. Here we show that significant advances to optimality based modelling can be made if we embrace a novel concept of stochastic optimization that includes explicit recognition of parameter uncertainty. To illustrate our ideas, we develop a multi-layer soil and canopy Vegetation Optimality Model, hereafter referred to as VOM(mlsc), and apply this extended VOM model to a Douglas Fir stand in the Netherlands. We use the DiffeRential Evolution Adaptive Metropolis (DREAM) Markov Chain Monte Carlo algorithm for parameter exploration with NCP as optimality criteria. Our results show that significant dispersion exists in optimized vegetation structure and properties from optimality of NCP, and that modelled and measured H2O and CO2 fluxes compare rather poorly. These findings question the usefulness of NCP as single optimality criteria, and advocate the simultaneous use of multiple non-commensurable (optimality) criteria for ecohydrological parameter estimation and model evaluation.