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Spatial pattern of terrestrial carbon dioxide and water vapor coupling

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The eddy covariance system installed at flux towers is capable to measuring simultaneously ecosystem-atmosphere exchanges of carbon dioxide (CO2) and water vapor (H2O). Therefore, such data has been utilized to study an important plant physiological characteristic, the amount of water being lost per unit carbon gain (water use efficiency, WUE) at ecosystem level. By using global fields of leaf area index and land cover based on data from the SPOT Vegetation and TERRA MODIS sensors in conjunction with soil maps we extrapolated flux tower information about inherent WUE from FLUXNET stations to the global land surface. The additional usage of climate fields led to global WUE maps then. Highest uncertainties occur in tropical forests with a coefficient of variability of 50 %. We compare these spatial details of median WUE and its uncertainty with estimates of four prominent land-surface schemes of climate models (CLM, JSBACH, ORCHIDEE, LPJ) which all model the combined flow of CO2 and H2O through the stomata of plants in different ways. Such model evaluation is important for a deeper understanding of the model's validity w. r. t. the carbon-water coupling. The data-driven WUE map shows a strong latitudinal pattern with peaks in the tropics and the boreal forest. The models mostly agree with this pattern, although WUE values are twice as high in the temperate and semi-arid regions, 25 % higher in the boreal zone, and two times higher in the tundra. Two of the models underestimate WUE in the tropics by 50 % when compared to the other two models and to the data-driven estimate. Disagreement between models and data does not depend on model structure which suggests that their parameterization does not adequately capture mean growing season WUE patterns - a result with implications for future climate simulations.