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Water-use efficiency at different scales and its between-site variability

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The eddy covariance technique is widely applied for estimating the carbon and water exchanges between terrestrial ecosystems and the atmosphere, and also gross primary productivity can be reliably derived from such measurements. With such data we study intrinsic water-use efficiency (WUEi) at ecosystem scale that is the ratio between GPP and stomatal conductance which can be approximated as the ratio between GPP times VPD and evapotranspiration. Maximum LAI has an effect on WUEi which is highest in evergreen needle-leaved forests and grasslands. This effect is explained by combined impacts of light absorption on photosynthesis and bare soil evaporation. Increasing WUEi under drought conditions found at leaf level is partly confirmed at ecosystem scale at daily resolution, but the effect is small. At longer time scales, however, other ecosystem processes are suggested to override the impact of stomatal conductance on WUEi. This hypothesis is based on the pronounced between-site variability of WUEi (replacement of time by space), which shows increasing mean annual WUEi with both soil moisture at field capacity and mean annual soil moisture. This effect is strongest in deciduous broad-leaved forests. A potential explanation of this effect is nitrogen availability. Mean annual WUEi of herbaceous ecosystems is lower than that of forests, and deciduous broad-leaved forests mostly show higher mean annual WUEi values than evergreen needle-leaved forests. Presented relationships of WUEi at ecosystem scale to different ecosystem properties can be further used to extrapolate WUEi in space for deriving global maps as the basis for further diagnosis

and evaluation of ecosystem models.