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Effect of spatial heterogeneity on remotely sensed GPP

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Satellite based remote sensing provides an efficient way to estimate carbon balance components over large spatial domains with acceptable temporal and spatial resolution. However, for heterogeneous landscapes these remotely sensed data may be biased towards one dominant land-cover type. In the present study, remote-sensing based gross primary production estimates (GPP MOD17, 1 km x 1 km spatial resolution) were evaluated using data from a tall eddy-covariance flux tower located over a heterogeneous agricultural landscape in Hungary. We present a novel approach for GPP model validation, exploiting the advantage of footprint-size similarity between remote sensing and the hourly eddy covariance signal measured at the tall tower. Further, we present a new methodology for improved remote-sensing based GPP estimates. This methodology addresses land-use heterogeneity by incorporating a footprint climatology and by downscaling MOD17 GPP using the 250-m resolution MODIS-NDVI (Normalized Difference Vegetation Index) dataset.

The results show that GPP was underestimated by MOD17 especially in years with average precipitation during the growing season, while model performance was better during dry years. Our downscaling technique significantly improved agreement between the MOD17 model results and the eddy-covariance measurements (modelling efficiency (ME) increased from 0.783 to 0.884, root mean square error (RMSE) decreased from 1.095 g C m^{-2} day^{-1} to 0.815 g C m^{-2} day^{-1}), although GPP remained underestimated (bias decreased from -0.680 g C m^{-2} day^{-1} to -0.426 g C m^{-2} day^{-1}).

The presented methods are applicable to any eddy-covariance tower with limitations depending on the complexity of landscape around the flux tower. As incorporation of footprint information clearly impacts validation results, future model validation and/or calibration should also involve source area estimation which can be easily implemented following the presented approach.