Estimation of the carbon balance components of heterogeneous agricultural landscape using tall tower based and remotely sensed data

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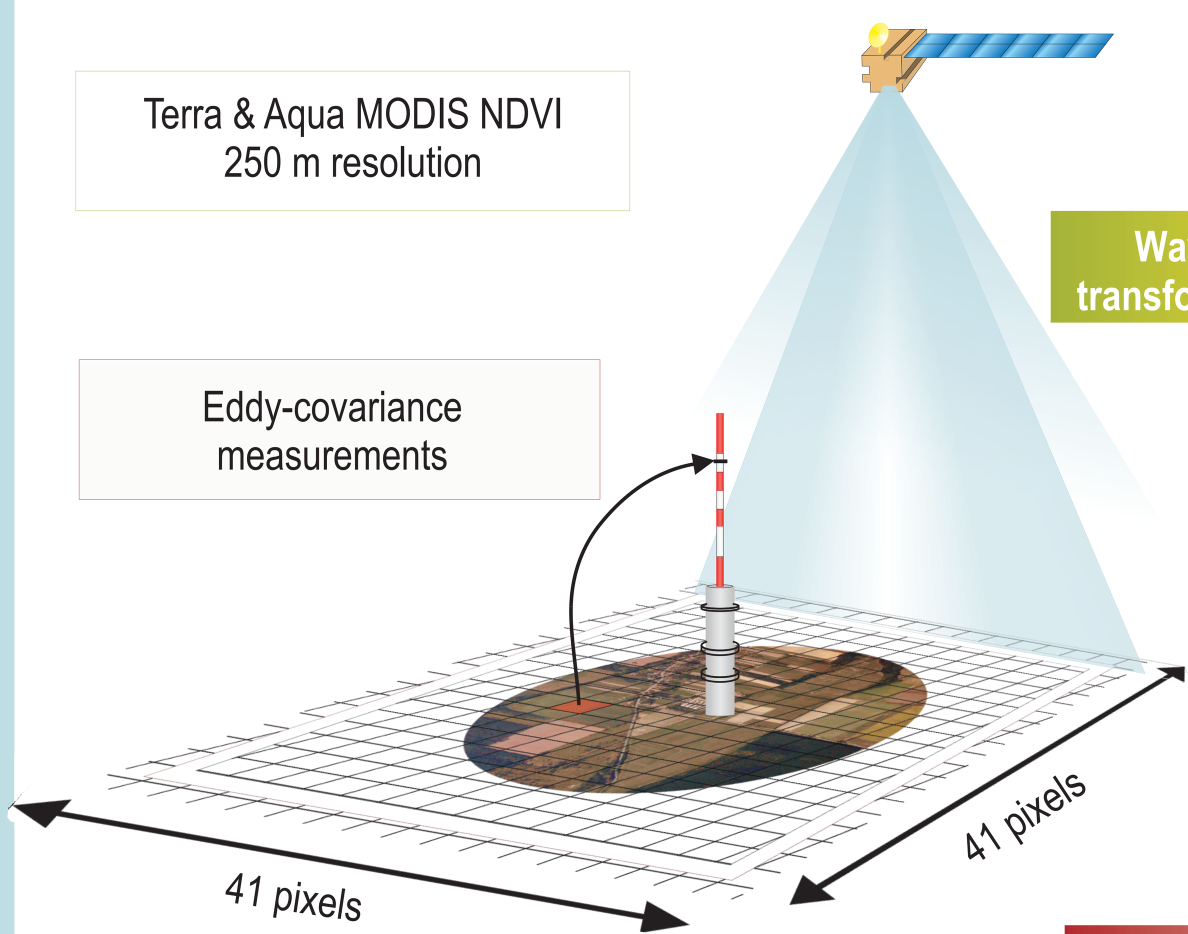
Using the combination of remotely sensed data, flux tower measurements and state-of-the-art footprint model, we estimate ecosystem productivity of heterogeneous agricultural landscape in Hungary. Gross Primary Production (GPP) estimation using remotely sensed data is based on the MOD17 GPP model. The results are compared to flux tower measurements. In order to utilize footprint information obtained with 250 m spatial resolution, the relatively coarse 1 km resolution MOD17 model is scaled down using NDVI data (MOD13).

Measurements

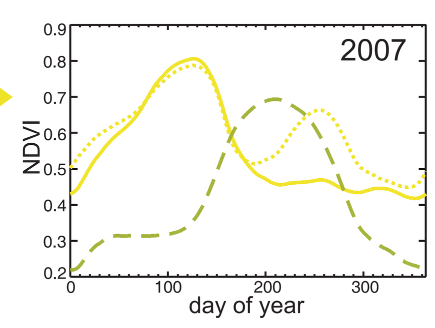
Terra & Aqua MODIS NDVI 250 m resolution

Eddy-covariance measurements



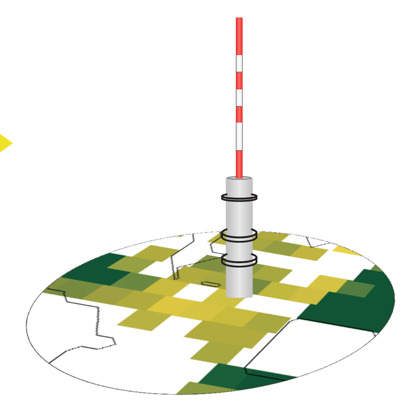
Wavelet transformation

Typical annual NDVI time series for winter and summer crops

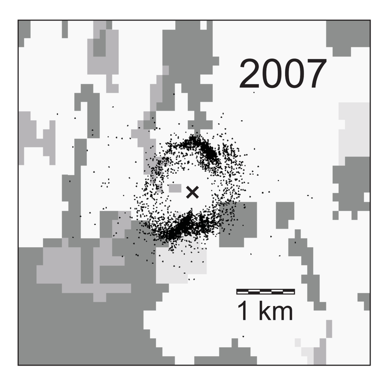


Crop classification

Crop fraction maps on 250 m NDVI grid (below: summer crop fraction in 2007)

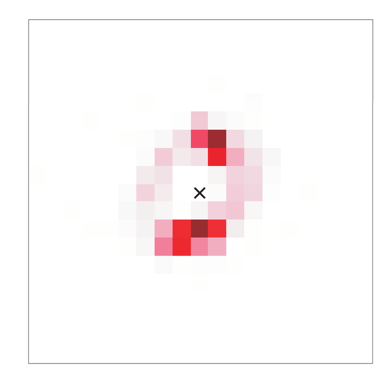


Hourly source area detection



Footprint climatology + CORINE2000 land cover (~100m resolution) Grey:non-agricultural area

Rasterization



Rasterized footprint climatology
250 m NDVI grid
Rasterized CORINE2000

Retrieved information on common grid

MOD17 model

250 m resolution FPAR

250 m resolution crop map

Dynamic simulation of tall tower EC measurements

250 m resolution footprint

250 m resolution land cover

Crop specific fluxes

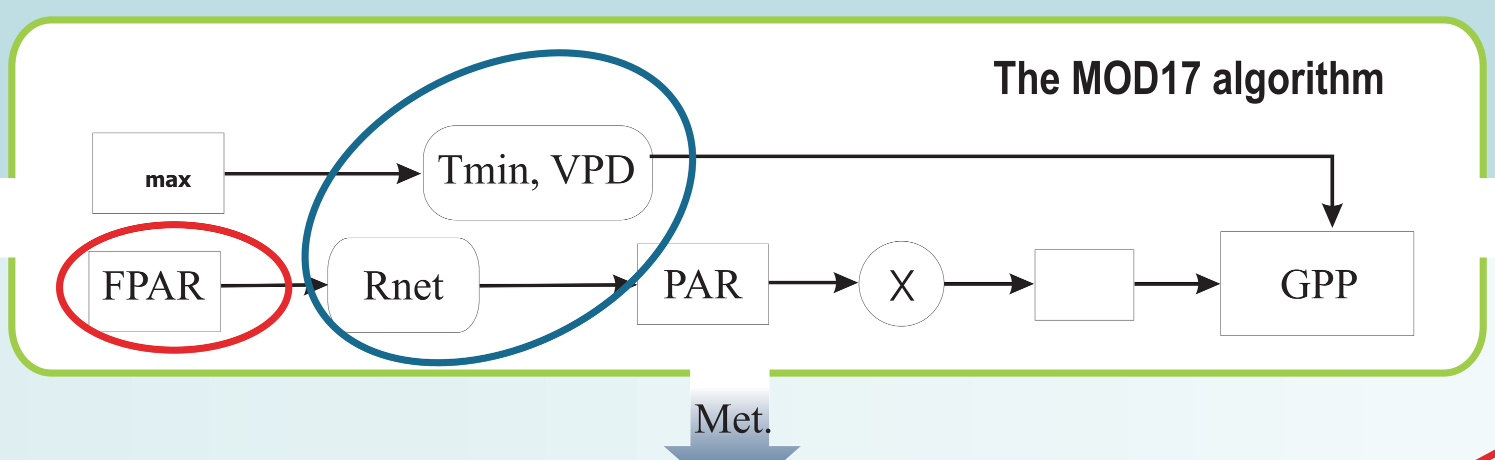
Synthesizing ground based and remotely sensed data over heterogeneous agricultural land. The 250 m resolution is comparable with individual field size. The cutout represents 41x41 pixels that covers the sampled area.

NDVI signal processing for crop classification. Determining representativeness of ground based measurements.

Retrieve land cover, crop type and footprint information on the same common (NDVI 250m) grid for modeling.

Kljun et al., 2004
Barcza et al., 2009

The MOD17 algorithm

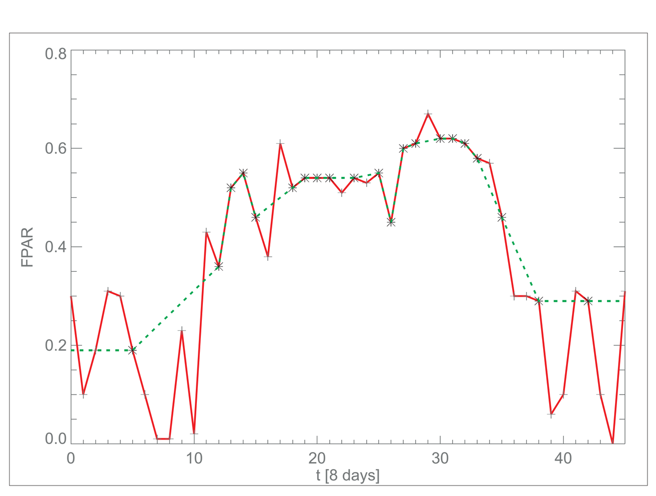


Official

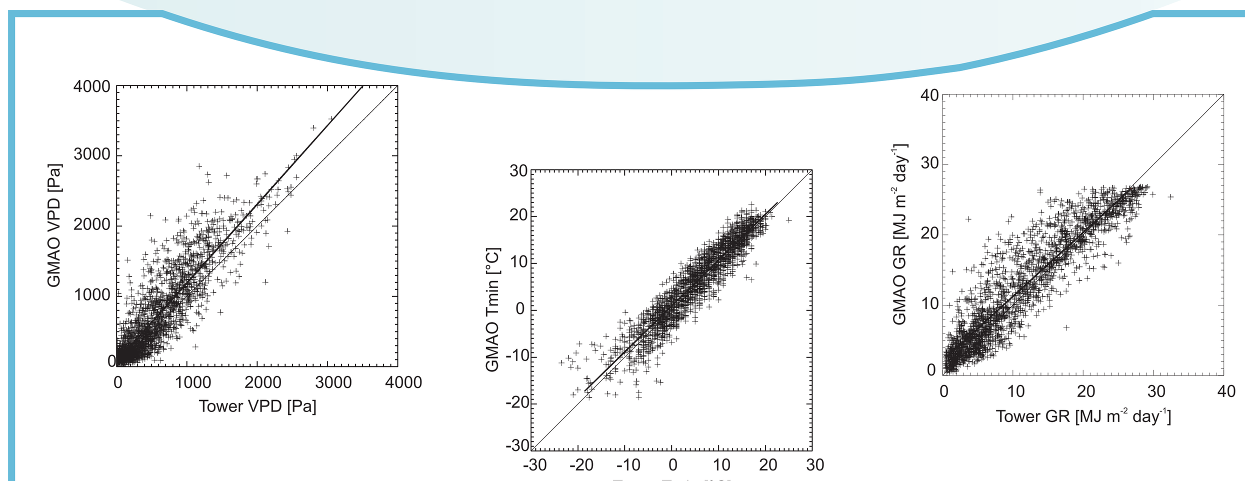
FPAR

MOD17 1km resolution

FPAR quality control and interpolation. Figure shows FRAP time series before and after the procedure



MOD17 tower meteorology



Six-years-long relationship between local measurements and the GMAO data. Note that GMAO accuracy varies between years, as well.

NDVI based downscaling of MOD17

Dynamically changing footprint location on the NDVI grid

Wavelet transformed NDVI signal from the corresponding pixel

Land cover type of the corresponding pixel

250 m resolution FPAR

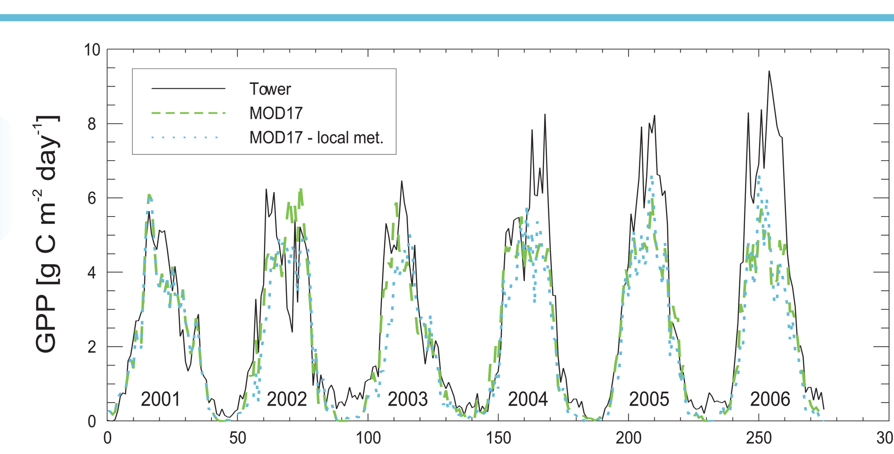
GPP algorithm

Flowchart of the downscaling algorithm

Official MOD17 product:
Light use efficiency (ε) based model

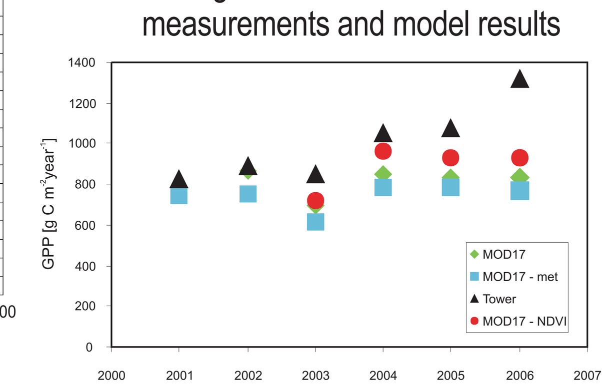
- Satellite data input: Land cover (MOD12), FPAR (MOD15)
- Meteorological input: GMAO reanalysis NTSG version 5.1
- Adapted algorithm: FPAR quality control, GPP calculations

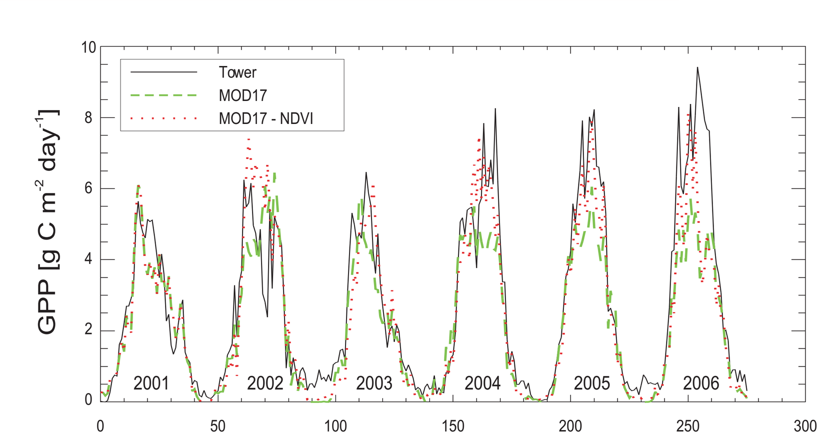
Results



GPP time series: tower measurements, model results (official and local meteorology)

Average annual GPP sums: tower measurements and model results





GPP time series: tower measurements, model results (official and downscaled)

Results from the three model setups show that errors in meteorology are not exclusively responsible for occasionally poor model performance. Improvements in model spatial resolution (primarily determined by FPAR resolution) can significantly improve accuracy. After eliminating possible sources of errors in input meteorology and spatial resolution, it is clear that the calibration of the model, even creating new PFTs is the next step toward more accurate results.

References:
Barcza, Z., Kern, A., Haszpra, L., Kljun, N. (2009). Spatial representativeness of tall tower eddy covariance measurements using remote sensing and footprint analysis. *Agric. Forest Meteorol.*, *149*, 795-807.
Kljun, N., Calanca, P., Rotach, M. W., Schmid, H. P. (2004). A simple parameterisation for flux footprint predictions. *Bound.-Lay. Meteorol.*, *112*, 503-523.

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