Comparison of MODIS-Data With Selected Model Parameters and Measured Flux-Data for two Biome Types (Broadleaf-Deciduous and Needle-Leaf Forest).

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1. Objectives

- To examine how MODIS-derived leaf area index (LAI) and photosynthesis (PSN) compare to modeled and measured LAI and PSN at site level.
- To compare modeled LAI and net ecosystem exchange (NEE) with measured flux data for four different sites (Table 1).

2. Methods

Remotely sensed data:
- The extracted MODIS-data are 5x5 km² cutoffs with center at the Flux towers.
- Eight day LAI, Fpar and PSN are averaged over the best quality pixels of the cutoff areas to remove spatial uncertainties due to cloud cover.

Modelling:
- Biome-BGC used to model the LAI and NEE (Running & coworkers, 1988, 1991, 1994).
- General parameterization schemes according to White et al. (2000).
- Long term climatic records were generated by MT-CLIM (Thornton et al. 2000). For Hainich: User vegetation onset and offset because the model internal vegetation onset was ~14 days too early.

Direct measurements:
- Four sites with different phenology and climate (Table 1) were selected. On all sites direct measurements of climate and fluxes were available.

3. Results

- Measured and modeled NEE show high correlation and typical annual patterns (Figure 2, left panel).
- MODIS-LAI for 2001 shows higher LAI in summer than in winter for all sites (Figure 2, right panel).

Deciduous broadleaf forest (Hainich and Sorø, Figure 2, right panel):
- Winter MODIS LAI > modeled LAI, (caused by understory vegetation: moss, grass).
- Spring MODIS LAI > modeled LAI, (due to growth of understory vegetation prior to bud brake at the beech forest sites Hainich and Sorø).
- Summer and autumn MODIS LAI reach modeled max LAI before leaf senescence in late autumn (canopy not opaque).

Evergreen needle leaf forest (Tharandt and Hyytiälä Figure 2, right panel):
- Winter MODIS LAI (Tharandt) < measured and modeled LAI, (caused by snow cover and agricultural areas (ca. 30%) in cutoff area (Figure 1)).
- Spring and summer MODIS LAI (Tharandt) 25% < measured and modeled LAI (due to agricultural areas).
- Winter MODIS LAI (Hyytiälä) almost 0 (caused by the polar nights, visible light for only 1-2 hours).
- Summer MODIS LAI (Hyytiälä) > modeled and measured (green understory vegetation shining through the scarce canopy of the pine forest). Canopy opaque.

- MODIS PSN and modeled PSN show good correlation (Figure 3). Discrepancies between modeled and MODIS PSN are due to different meteorology used in the estimation of PSN. (MODIS PSN: DAO model, modeled PSN: flux tower).
- MODIS PSN always > measured NEE at the flux towers. Strongest correlation for Sorø, Hainich and Hyytiälä ($R^2_{RSO}=0.82, R^2_{RHA}=0.88, R^2_{RHY}=0.78$), lowest correlation for Tharandt ($R^2_{RTH}=0.58$).

4. Conclusion

- MODIS LAI describes measured and modeled LAI for deciduous broadleaf forest in autumn well. However, spring and summer MODIS LAI are too high due to green understory vegetation (canopy opaque).
- MODIS LAI will not be correct during winter for sites far north or south, (Hyytiälä) with long periods of darkness.
- MODIS PSN and modeled PSN show high correlation.
- 5x5 km² cutoff area is too large for fitting the modeled and measured LAI (other vegetation types start to play an important role) in the strong fragmented landscape of Central Europe (especially for the Tharandt site).
- The MODIS PSN product should also be evaluated with other models. Modeled PSN should be evaluated by other satellite data (not based on the same algorithm).

Figure 1: 5x5 km² cutoff for Hainich and Tharandt. Dots mark position of the flux towers (Winter & Beckel, 1997)

Figure 2: Comparison of modeled and measured NEE [gC m⁻² d⁻¹] (left panel), and comparison of modeled and measured LAI [m² m⁻²] as well as MODIS LAI (right panel) for four different sites.

- Hainich (Germany) Broadleaf deciduous temperate high 370 ppm (present)
- Tharandt (Germany) Evergreen needle leaf temperate middle 78 ppm (present)
- Sorø (Denmark) Broadleaf deciduous temperate high 370 ppm (present)
- Hyytiälä (Finland) Evergreen needle leaf boreal low 78 ppm (present)

Table 1: Site characterization

<table>
<thead>
<tr>
<th>Sites</th>
<th>Phenology</th>
<th>Climate</th>
<th>Nitrogen CO₂</th>
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<tbody>
<tr>
<td>Hainich</td>
<td>Broadleaf deciduous</td>
<td>temperate high</td>
<td>high</td>
</tr>
<tr>
<td>Tharandt</td>
<td>Evergreen needle leaf</td>
<td>temperate middle</td>
<td>low</td>
</tr>
<tr>
<td>Sorø</td>
<td>Broadleaf deciduous</td>
<td>temperate middle</td>
<td>high</td>
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<tr>
<td>Hyytiälä</td>
<td>Evergreen needle leaf</td>
<td>boreal low</td>
<td></td>
</tr>
</tbody>
</table>

5 km

51° 04' 45.137" N, 10° 27' 07832" E
50° 57' 49" N, 13° 34' 01" E

Figure 3: Comparison of MODIS PSN and modeled PSN for four sites as well as MODIS LAI and measured LAI.