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Assessing the spatial and temporal variability of fAPAR 2-flux estimates in a temperate mixed coniferous forest

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The fraction of absorbed photosynthetically active radiation (fAPAR) is recognized as one of the essential climate variables as it characterizes activity and dynamics of the Earth's terrestrial biosphere (GCOS, 2010). By linking photosynthetic active radiation (PAR) to the absorption of plants, fAPAR represents a crucial variable for describing land surface and atmosphere interactions considered in global circulation models as well as in production efficiency models for estimating terrestrial carbon balances.
Recent studies report discrepancies between global fAPAR satellite products regarding both absolute values and uncertainty representation, thereby stressing the need for independent ground measurements (D'Odrico et al., 2014; Picket-Heaps et al., 2014; Tao et al., 2015). However, there is a lack of basic information to better understand the spatial and temporal bias of PAR field observations, particularly in forest ecosystems. In theory, it is known that fAPAR estimates are affected by e.g. illumination conditions, leaf area index, leaf color, background brightness, which in turn may lead to considerable bias of field measurements. However, theoretical findings lack validation in the field as well as practical recommendations for field protocols. In this study, the variability of two-flux fAPAR estimates with regards to different illumination conditions (solar zenith angles, diffuse radiation conditions) are investigated.
Measurements of PAR are carried out at Graswang environmental monitoring site in Southern Germany within a temperate mixed coniferous forest. A relatively new environmental monitoring technology based on Wireless Sensor Networks (WSN) is applied, allowing for permanent synchronized measurements of transmitted PAR, thereby reducing temporal sampling bias. Transmitted PAR is obtained from 16 photon flux sensors, 1.3 m above the surface. With a reference sensor outside the forest measuring incoming PAR, a two-flux estimate based on the ratio of transmitted PAR and incoming PAR can be calculated for each 10-min timestep during daytime hours.
The fAPAR time series exhibit seasonal variability (mean=0.7, sd=0.4 for the average of all PAR sensors calculated for each 10-min timestep) according to phenological development, but also considerable inter-sensor variability between single days. Standard deviations for fAPAR in mid-summer vary between 0.26 for days with overcast sky and 0.19 for clear sky conditions. Diurnal cycles of fAPAR under clear sky conditions show a sharp increase of fAPAR with increasing solar zenith angles, suggesting for an underestimation of fAPAR with low solar zenith angles as it has also been found in studies based on radiative transfer modeling (Widlowski et al., 2010). The experiences gained from the field observations contribute to a bias assessment for ground measurements as demanded by authors of recent studies on comparing global fAPAR satellite products.