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Characterizing spatiotemporal patterns in time series of the remotely sensed Fraction of Absorbed Photosynthetically Active Radiation

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The CO_2 uptake of the terrestrial biosphere (Gross Primary Productivity, GPP) plays a key role in the global carbon balance. This carbon flux cannot be determined directly on a global scale. Yet, the remotely sensed Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) is a valuable proxy for GPP. This study aims at characterizing global FAPAR dynamics on different temporal scales and extracting corresponding spatial structures. The time series were analyzed to uncover the presence and extent of trends, and to identify quasi-oscillatory patterns from intra- to interannual time scales.

Eight years of FAPAR data derived from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) from 1998 to 2005 at a $0.5^\circ \times 0.5^\circ$ latitude/longitude grid and 10 days temporal resolution were investigated globally. In addition, the analysis was applied consistently to the bi-monthly Normalized Difference Vegetation Index (NDVI) sampled by the Advanced Very High Resolution Radiometer (AVHRR) available since 1981, as well as to ancillary climate variables; for the latter, we used the CRU-PIK climate data, originating from the global climate grid of the Climatic Research Unit (CRU). The overarching dominance of the annual cycle was removed by deseasonalizing the time series using Singular System Analysis. Spectral analysis was based on the Lomb-Scargle periodogram to extract the spectral power at each scale. Trend detection was performed by means of the nonparametric Mann-Kendall test. An advantage of all methods is their ability to handle short, noisy, and fragmented time series, which typically applies to remote sensing data.

The retrieved patterns of relative spectral power from monthly to interannual time scales in FAPAR data are spatially coherent and largely consistent with that of NDVI. By using temperature and precipitation data we identify regions where the scale-wise FAPAR behavior is closely related to climate dynamics. The coincidence of significant trends in FAPAR and NDVI suggest a recent 'browning' tendency in several areas. This can be attributed to a continuous rise in temperature and alterations of the hydrological cycle.

Overall, the study suggests that the FAPAR dynamics exhibits characteristic spatial patterns on different temporal scales that emerge from a complex interplay of corresponding fluctuations in temperature and precipitation. However, we can also find examples where FAPAR dynamics cannot be traced back to climate and is apparently shaped by other geo-ecological drivers.