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Paving the road to FLEX and Biomass: A multi-frequency study to the vegetation in three regions in Europe

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Context

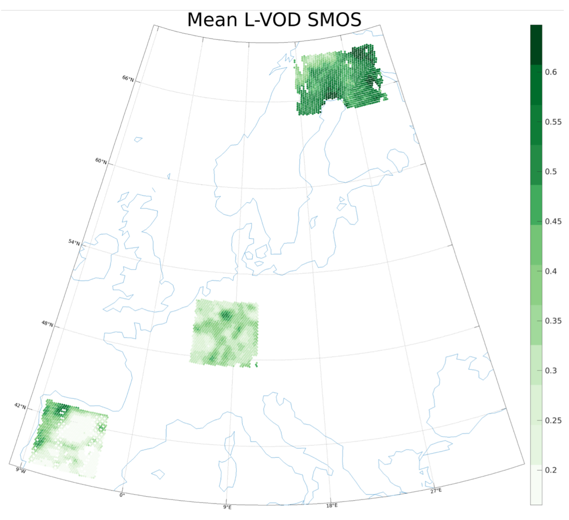
To understand the vegetation status and evolution, it is necessary to use a multi-frequency approach. Variables in the visible/near-infrared domains are sensitive to green components of the vegetation as they are related to the photosynthetically active parts of the vegetation. FAPAR quantifies the fraction of the solar radiation absorbed by living leaves for the photosynthetic activity while Solar Induced Fluorescence (SIF) represents an emission of energy emanating from chlorophyll molecules that is a function of the activity of competing pathways for de-excitation (photochemistry versus nonphotochemical quenching). These variables can be interpreted as a driver for the Gross Primary Production (GPP) but they saturate quickly even for moderate biomass values (<80 Mg/ha).

On the other hand, active microwave (MW) observations allow to map the Above Ground Biomass (AGB) distribution using the backscattered signal of Synthetic Aperture Radars (Bouvet et al. 2018). Active and passive MW observations also give access to the hydrological state of the vegetation via the optical depth created by the water molecules contained in the plants/trees (hereafter VOD, Vegetation Optical Depth). Depending on the frequency, MW radiation is sensitive to the water content in distinct parts of the vegetation, from the leaves, to the branches and the trunk (with small water-containing elements being transparent for long wavelength radiation).

We present an ongoing study of VOD at different frequencies and visible/infrared variables such as FAPAR and SIF over three regions in Europe. This study is part of the **ESA Land Carbon Constellation study** (LCC, Kaminski et al., this symposium), whose goal is to constrain Carbon-cycle models using the assimilation of a combination of data streams covering multiple spectral domains (Kaminski et al. this symposium). The LCC project helps to pave the road to studies that will be done in the future with dedicated SIF observations by the ESA FLEX mission (Moreno, 2021) and high resolution AGB maps from the ESA Biomass mission (Le Toan et al. 20211).

Data and regions of study

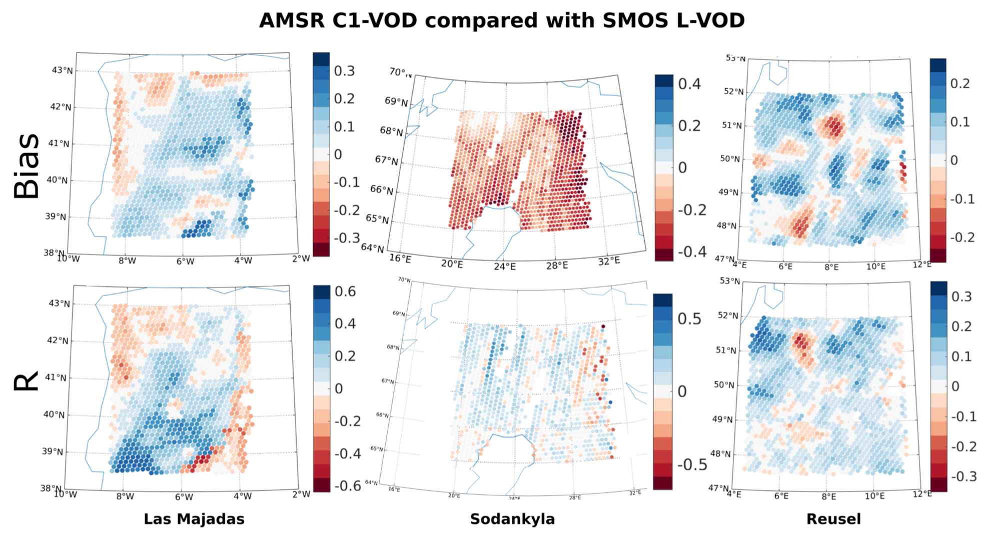
- Passive MW VOD at different frequency bands:
  - SMOS Soil Moisture and L-VOD (Kerr et al. 2012)
  - AMSR-2 C-VOD, X-VOD (van der Schalie et al. 2017)
- Active MW VOD at C-Band: ASCAT VOD (Vreugdenhil et al. 2016)
- Sentinel 3 FAPAR (Reyes Muñoz et al., this symposium)
- Sentinel 5P SIF (Guanter et al. 2021)
- ESA Climate Change Initiative AGB maps (Cartus et al., this symposium)



Three 500 x 500 km^2 regions in the Iberian Peninsula, Northern Finland and Central Europe were studied using time series in the period from 2010 to 2021. The regions include the instrumented sites of Las Majadas, Reusel and Sodankylä. These data are discussed by Lemmetyinen et al. (this symposium)

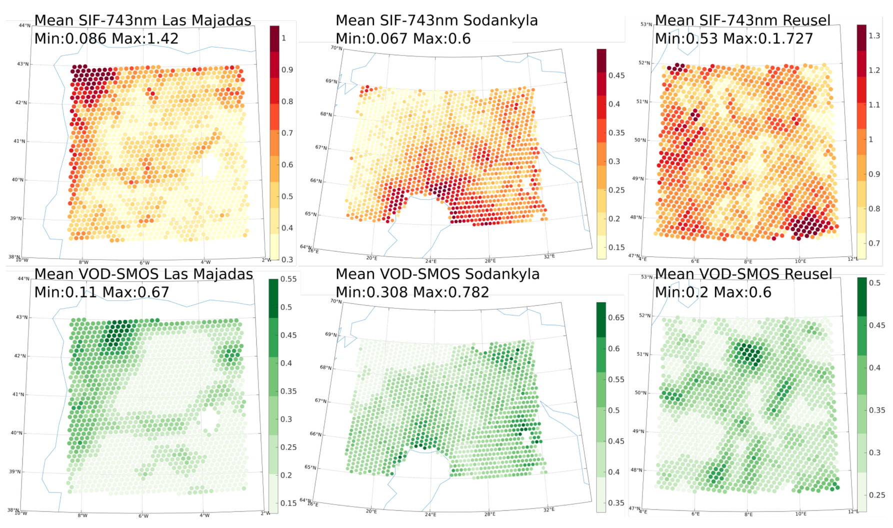
Microwave data

The VOD data from different sensors were compared showing a significant complementarity. Bias and temporal correlation maps of ASCAT and AMSR-2 VOD with respect to SMOS L-VOD shows regions with positive values and regions with negative values. The figure below show the Bias and the Pearson correlation of C-band AMSR-2 VOD and L-band SMOS VOD over the three regions. These maps were compared to land cover maps but no clear relationship was found. Further analysis is on-going.



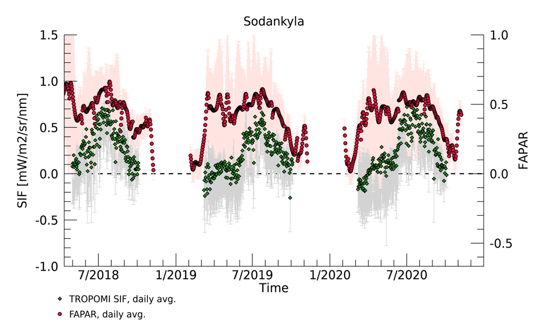
VOD vs SIF

The microwave data is also being compared to visible/infrared data. Many studies exist on VOD versus EVI or NDVI indices. Here we concentrate in the comparison of VOD versus the new TROPOMI SIF data. The maps below show the mean values of SIF and SMOS VOD for the three regions.

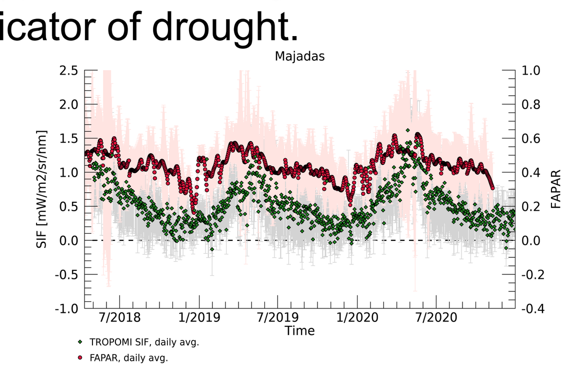


Visible/infrared data

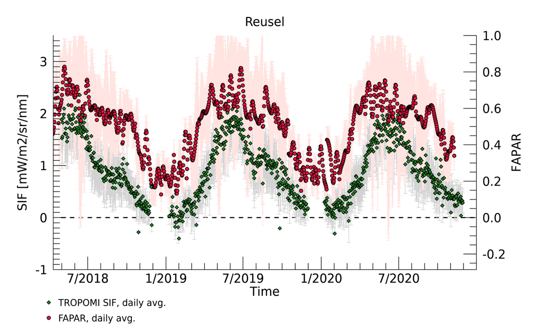
Sodankyla time series shows an interesting detail in spring: FAPAR values peak already in March while SIF values are still close to zero. According to SIF, the start of photosynthesis occurs in late May or June. Tentative explanation: in spring, the pine tree needles appear green although photosynthesis is not yet possible due to the frozen ground.



In Las Majadas, the time series shows coupled variability at most seasons, except during late summer, FAPAR remains high although SIF decreases. This may be caused by limited water availability for photosynthesis which is seen in the decrease of SIF but, for the dominant vegetation type in the region, FAPAR may be a less sensitive indicator of drought.



In Reusel, the time series show coupled variability at all seasons. An interesting detail is the double peak in SIF: the first and most significant maximum in June and another local maximum, although not as pronounced, in August-September. This appears also in FAPAR, although not as clearly. Possible reasons could be the land and crops management: e.g., harvest and irrigation



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