Estimation of LAI (Leaf Area Index) with Sentinel-1 SAR data

Introduction: LAI is well known as a biophysical parameter that can be suitable for the yield estimation of field crops. LAI indicates the coverage of the cropland area with the surface of leaves in percent. A value of LAI 1 indicates a coverage of the land surface of 100 %.

For this study we measured LAI in-situ with a smart-phone and the LAI-app 'Pocket LAI' from the Italian enterprise Cassandra Tech in different field crops in Hungary. The app estimates the total LAI, which means that all parts of the crop, no matter if green or brown, add to the value.

Method: A series of photos was taken from the ground towards the sky and estimated the surface coverage of leaves. The mean value was calculated from 5 photos for each sample.

The following examples show a single image from a series of five photos from one sample point. In the table below you see the mean value and the range of values from those 5 photos.

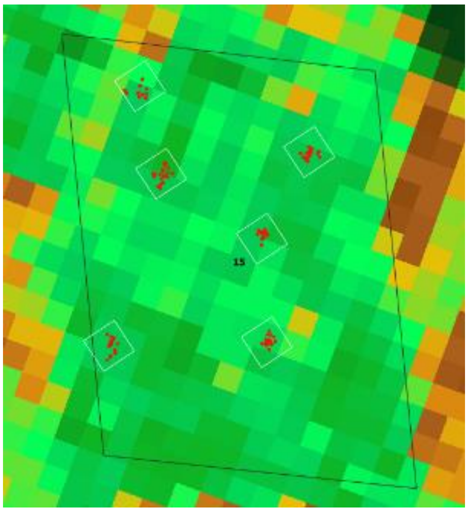
Plot 10	Wheat	Date	March 17
LAI Mean	0.24	LAI Range	0.18 - 0.53

Plot 10	Wheat	Date	Apr 15
LAI Mean	2.11	LAI Range	1.15 - 3.54

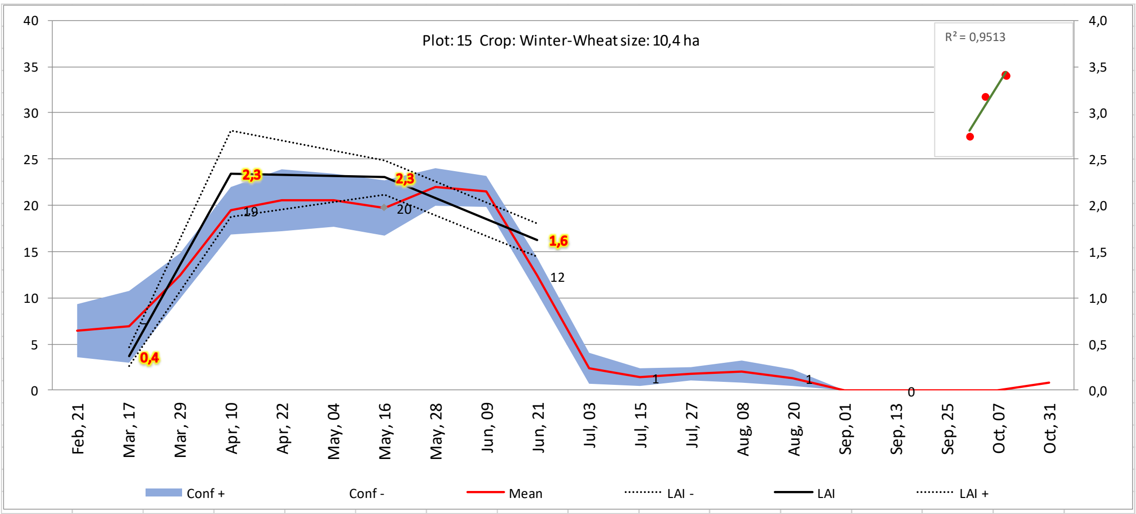
Plot 10	Wheat	Date	May 19
LAI Mean	1.5	LAI Range	1.4 - 1.7

The range of values indicates, that the single measurements differ significantly. Beside that the GPS signal shows some inaccuracies and shifts within a certain range. We used a frame around all measure points and projected all values on the center point of this frame. For this point we compared the values with Sentinel-1 SAR data.

From Sentinel-1 we used both polarizations to transform the signal into an index, which indicates LAI values. Sentinel-1 has a spatial resolution of 20 x 20 m. The in-situ measurement with the LAI app represents an area of < 1 m². Due to the different spatial representation, the values at single measure points can differ from the result of the model.

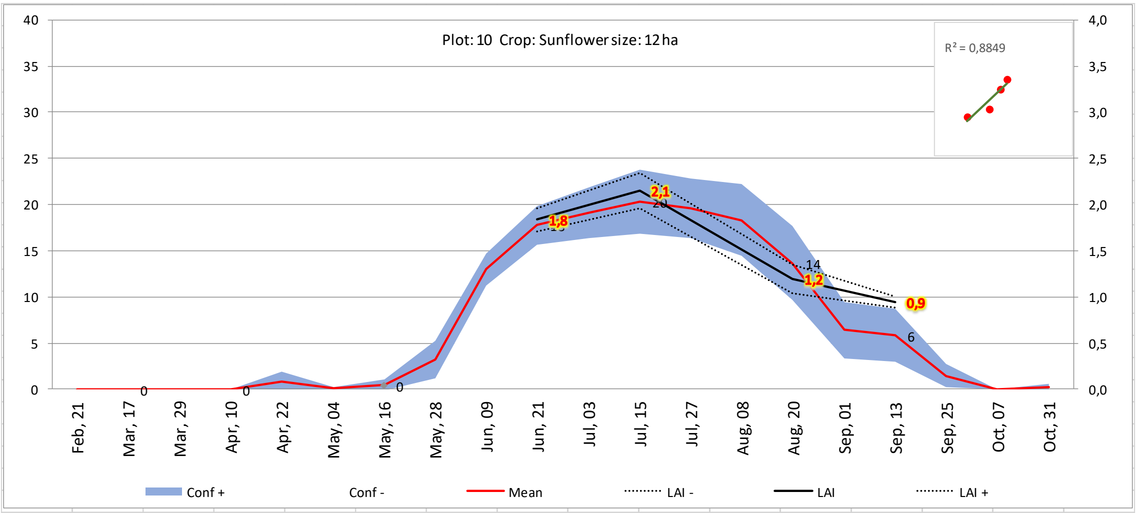


Here we compare the average values from between 6 and 9 measure points of 1 plot with the central pixel of the zone around the LAI measurements for each field visit. The correlation is calculated over the time-series.

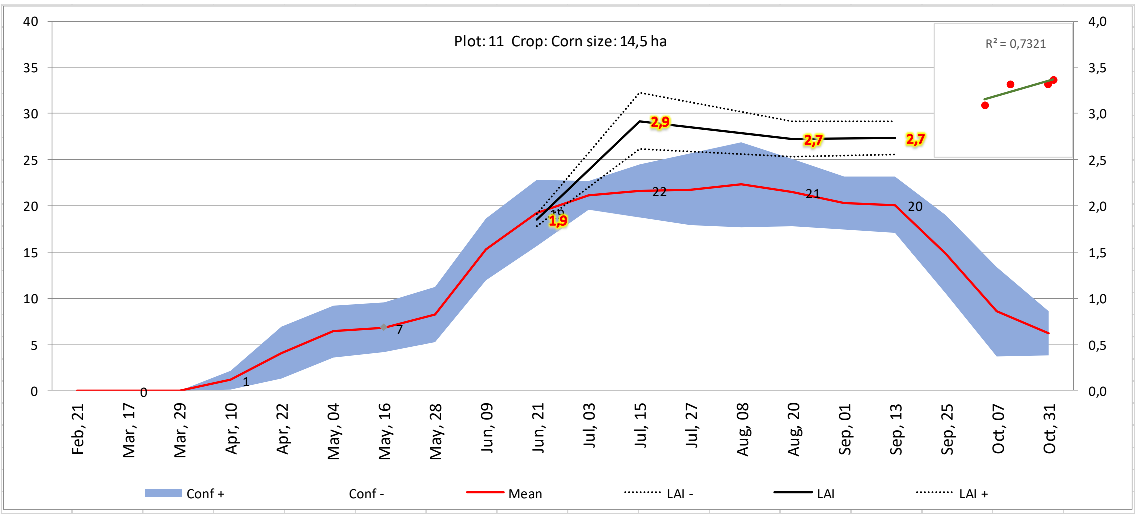


Results: The red curve (left axis) represents the modelled LAI values from Sentinel-1 SAR data. The values are multiplied by 10 to have integer values. The black curve (right axis) represents the average values of the in-situ measurements over 6-9 sample points per plot.

An example of a sunflower crop.

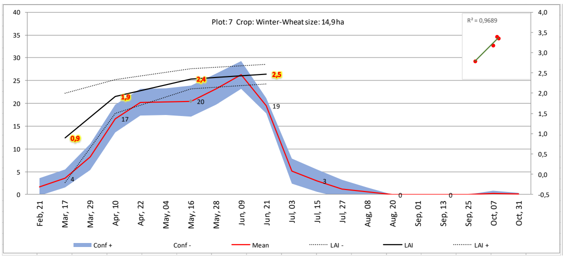


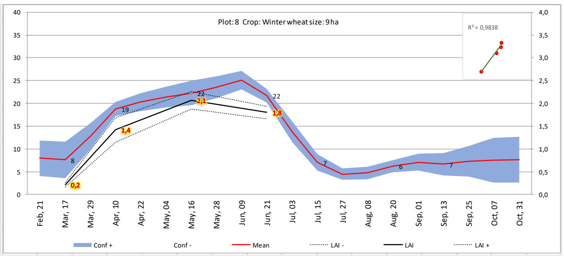
Another example of a corn crop with a slight under estimation of the in-situ measurement.



Comments: We find a good correlation over the time-series between in-situ LAI measurements and modelled LAI from Sentinel-1 SAR data. For some plots the model under or over estimates the values compared to the in-situ measurements. This depends not only on the crop-type but also on the different varieties and their phenotypes as the example below demonstrates.

The two different wheat crops show both a high temporal correlation. In the left plot the in-situ measurement is slightly under estimated. In the example on the right side the value is slightly over estimated.





For an approach to generate an LAI map over huge areas, without knowing the crop-type or the different varieties, Sentinel-1 data can deliver a suitable approximation of LAI values over cropland. We are currently testing the same approach in Santa Fé province in Argentina. The first results seem to be very promising and can be seen on our iMap platform.