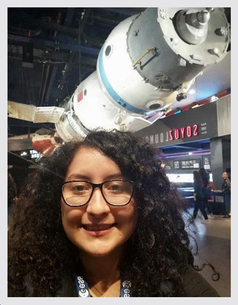


Using Sentinel-2 satellite data to predict the ecosystem phenological metrics with new vegetation indices

Maleki M. [1] , Balzarolo M. [2] , Janssens I.[1] , Arriga N. [1] ,
Barrios J. M. [3] , Liu Q. [4] , Wieneke S. [1]

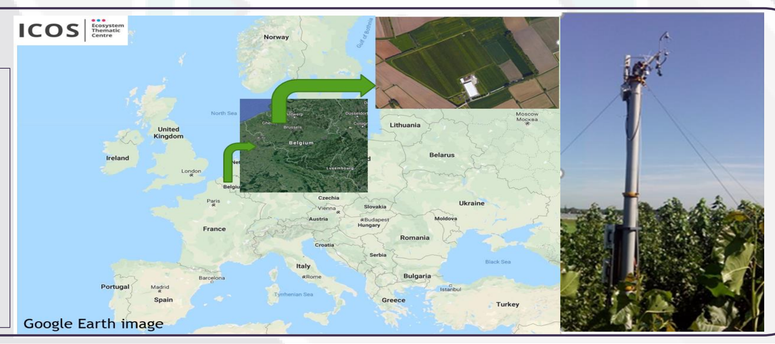
Universiteit Antwerpen

Aims

- To improve estimation of Start and End of Season (SOS/EOS) of a Poplar plantation in Belgium.
- To test several structural and chlorophyll sensitive Vegetation Indices (Vis) derived from Sentinel-2 (e.g. Modified Terrestrial Difference Vegetation Index (MTCI) & Normalized Difference Vegetation Index (NDVI)).
- To compare different Remote Sensing indices from Sentinel-2 (e.g. Pigment Specific Simple Ratio (PSSR) & Green Normalized Difference Vegetation Index (GNDVI).

Fluxnet site

Flux measurements in this study were performed at a bioenergy plantation established in Belgium in 2010.



Data & Methods

Vegetation Indices	Spectral bands & Calculation
NDVI	(B08-B04)/(B08+B04)
MTCI	(B06-B05)/(B05-B04)
CHL-RED-EDGE	(B07/B05)^-1
EVI	2.5*(B08 - B04)/((B08 + 6*B04 - 7.5*B02) + 1)
GNDVI	(B08-B03)/B08+B03)
MCAIR	((B05-B03)-0.2*(B05-B03))*(B05/B04)
PSSR	B08/B04

B2: 490nm, B3: 560nm, B4:665nm, B5:705nm, B6:740 nm, B8:842nm

- ✓ Experimental site data

Flux data:
Gross Primary Production (GPP), Leaf Area Index (LAI)

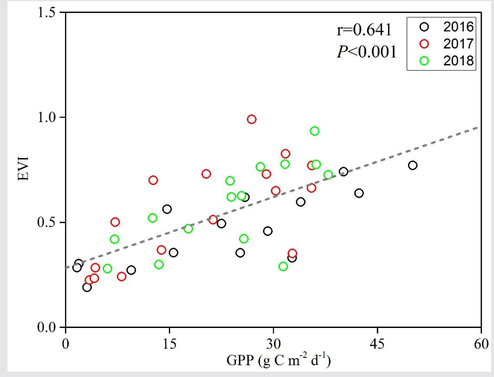
- ✓ Phenological extraction methods (Smoothing algorithm functions)
  - ❖ Savitzky-Golay filtering method (Savgol)
  - ❖ Harmonic Analysis of time series method (Hants)
  - ❖ Polynomial function (Polyfit method)
- ✓ Estimating the Start and End of the Season

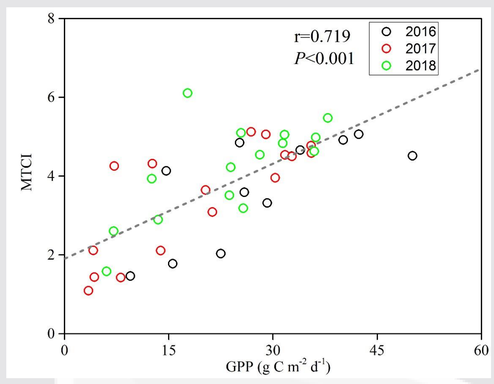
Estimating the Start and End of the Season by comparing the VIs derived by Satellite data with First derivative method

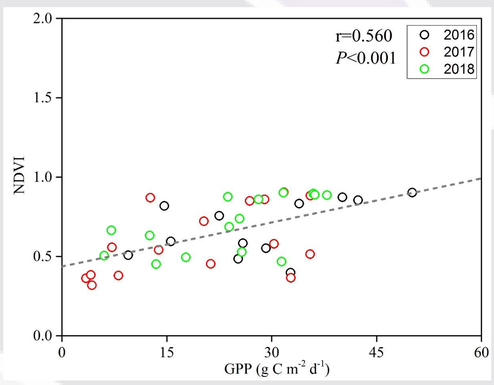
- ✓ Evaluate the result

Defining which VIs are ideal proxies for vegetation phenology

RS indices VS GPP in 2016 & 2017 & 2018 *Result3*

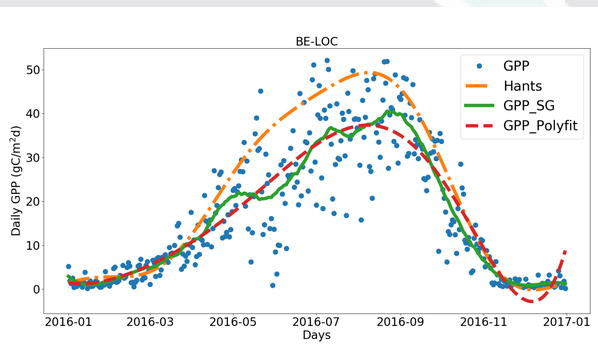


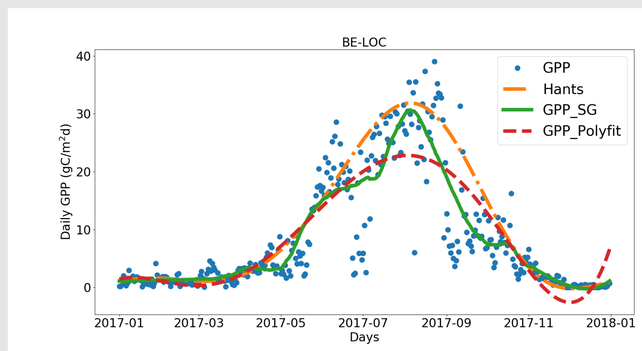


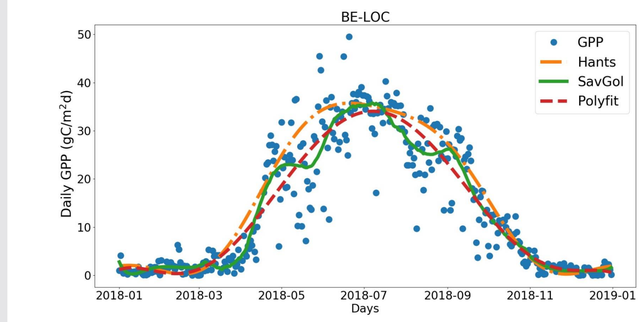


- ❖ Each graph shows three years of values of GPP and RS index.
- ❖ The values are chosen during a year without applying the data before first and after end of the season.
- ❖ MTCI with highest R and R^2 shows the better correlation with GPP.

GPP 2016 & 2017 & 2018 *Result1*



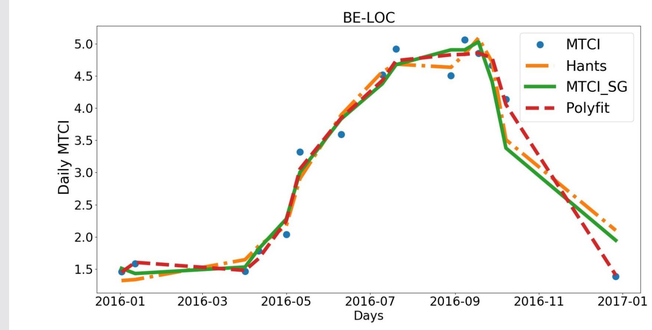


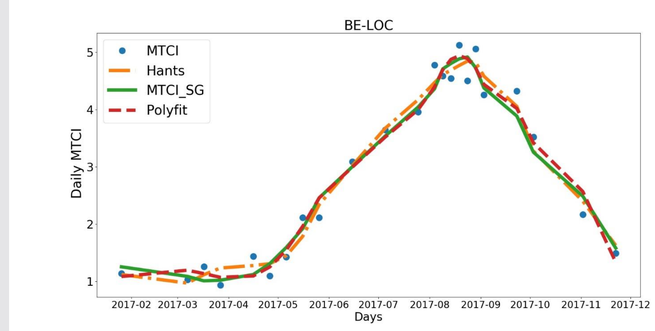


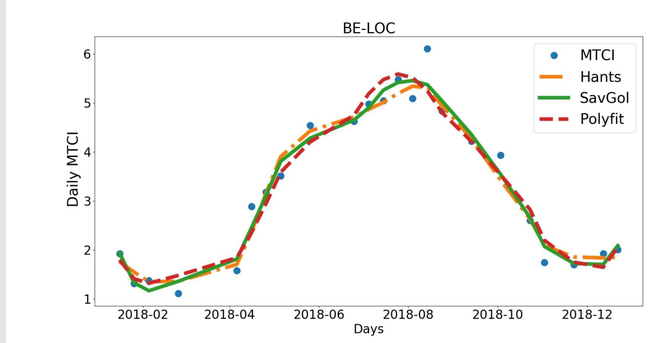
- ❖ In 2017 start of season has delayed in comparison with 2016, and it has increased sharper.
- ❖ In 2018 the peak of the curves has lowest GPP and 2016 has the highest.
- ❖ Savitzky-Golay follows the pattern of the data much more. However, Polyfit and Hants indicate the direction of the curve easier.

Each line represents smoothing method (Savitzky Golay, Hants, and Polyfit method).

Vegetation Index *Result4*

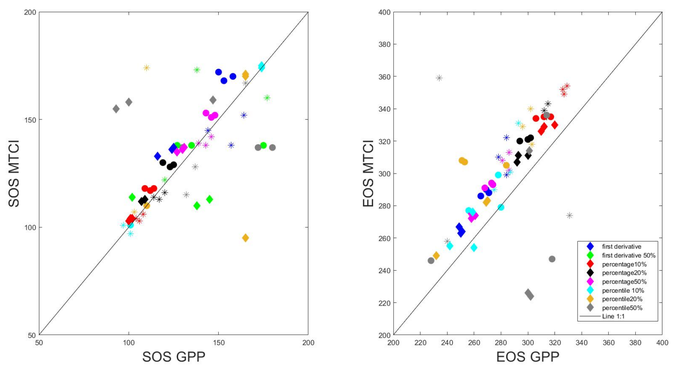


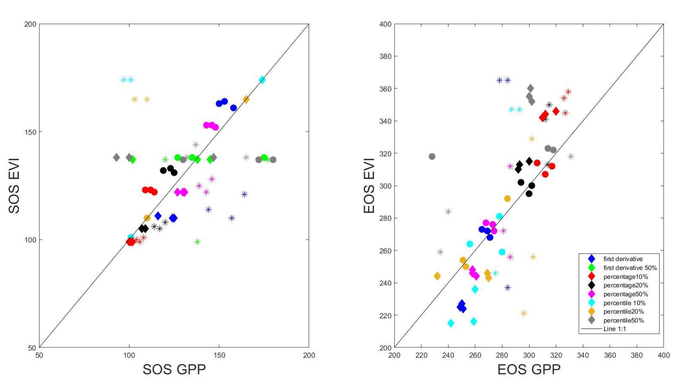


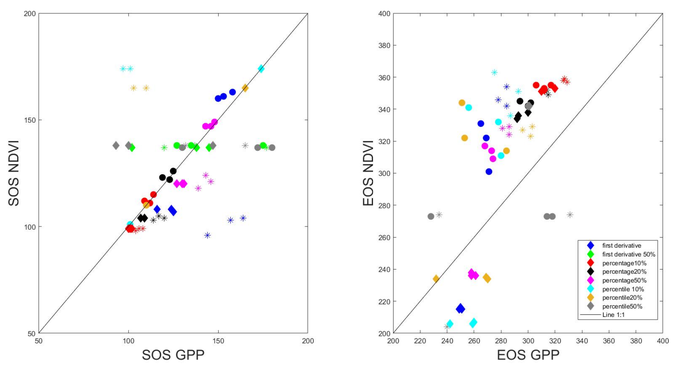


- ❖ These three graphs show the MTCI changes during 2016, 2017, and 2018 of Poplar plantation in Belgium.
- ❖ Three smoothing functions have been applied for each index.
- ❖ In 2017 SOS is later than 2016. Because, the plan has been cut at the end of 2016.
- ❖ MTCI in 2016 and 2018 have almost same SOS. However, in 2016 weather was cloudy and in 2018 was sunny with less rain.

SOS/EOS for RS indices *Result2*







- ❖ Each graph indicates the comparison between different ways for estimation of SOS/EOS for three remote sensing indicators (MTCI, EVI, and NDVI) with correspondence GPP of that year.
- ❖ Stars show 2016, circles show 2017 and diamonds present 2018.
- ❖ Each color in the legend represents different methods (e.g. first derivative, percentile, percentage) of estimation for SOS/EOS.
- ❖ Different percentages (e.g. 10%, 20%, 50%) for each method has been applied.
- ❖ The closet data to the 1:1 line, the most matched RS index, is with GPP.
- ❖ X and Y Axis represent the day of a year for start and end of the season.
- ❖ MTCI among the RS indices is the closed one to 1:1 line.

Conclusion

- ❖ Sentinel-2 data for Belgium in 2016 provided not enough cloud-free data to track phenological changes well. This year was exceptionally cloudy.
- ❖ Some smoothing algorithm functions fit better at the beginning of the season with the pattern of the data, some better at the end of the season.
- ❖ Finding the ideal proxy for GPP and improving the phenological changes is challenging.

Recommendation

- ❖ Along with Sentinel-2, having data from different satellite products may help to have a better estimation.
- ❖ The more data sites we have, the better the analysis will be.
- ❖ During cloudy periods, remote Sensing products like high resolution satellite is not reliable to track phenological changes.
- ❖ Each phenological extraction method represents a different pattern. With applying more methods a more accurate result will be estimated.

Acknowledgements

This study is supported by ECOPROPHET project funded by BELSPO (Belgian Science Policy Office) in the frame of the STEREO III programme (Contract number: SR/00/334)