Predicting ecosystem phenological metrics based on Sentinel-2 satellite data with new vegetation indices

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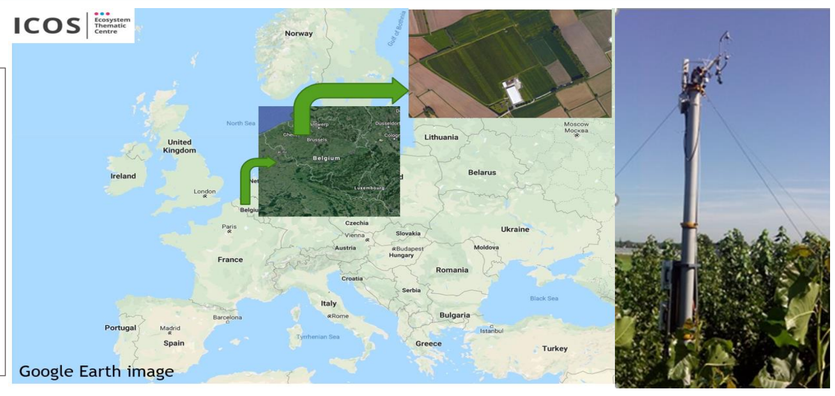
Aims

- 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

✓ Satellite Data: Sentinel-2

Vegetation Indices	Spectral band & Calculation
NDVI	(B08 - B04)/ (B08 + B04)
MTCI	(B06 - B05)/ (B05 - B04)
CHL-RED-EDGE	(B7/B5)^-1
EVI	2.5*(B08 - B04)/ (B08 + 6*B04 - 7.5*B02 + 1)
GNDVI	(B8-B3)/B8+B3)
MCAIR	((B5-B3))-0.2*(B5-B3))*(B5/B4)
PSSR	B8/B4

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

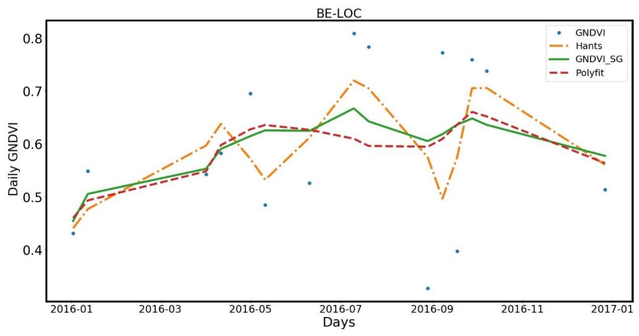
Estimating the Start and End of the Season by comparing the VIs derived by Satellite data with First derivative method

✓ Evaluate the result

Defining which VIs are ideal proxies for vegetation phenology

Vegetation Indices *Result3*

Greenness based VIs, such as NDVI, are often used to parameterize land surface models.



Each line of the graphs represents the three different smoothing method *(Savitzky Golay, Hants, and Polyfit method)*.
Each blue dots indicates the remote sensing indices from Sentinel-2.

SOS & EOS

	Smoothing algorithm function	Start of Season	End of Season	Length of Season
NDVI	Savitzky-Golay	01/05/16	08/10/16	160
	Hants	11/05/16	08/10/16	150
	Polyfit	11/04/16	08/10/16	180
EVI	Savitzky-Golay	01/05/16	08/10/16	160
	Hants	11/05/16	08/10/16	150
	Polyfit	11/04/16	08/10/16	180
MTCI	Savitzky-Golay	11/04/16	08/10/16	180
	Hants	11/05/16	08/10/16	150
	Polyfit	01/05/16	08/10/16	160
CHL-RED-EDGE	Savitzky-Golay	11/05/16	08/10/16	150
	Hants	11/05/16	08/10/16	150
	Polyfit	01/05/16	08/10/16	160
MCARI	Savitzky-Golay	11/05/16	08/10/16	150
	Hants	11/05/16	08/10/16	150
	Polyfit	11/04/16	08/10/16	180
PSSR	Savitzky-Golay	11/04/16	08/10/16	180
	Hants	01/04/16	08/10/16	190
	Polyfit	01/04/16	08/10/16	190
GNDVI	Savitzky-Golay	02/01/16	08/10/16	280
	Hants	12/01/16	08/10/16	270
	Polyfit	12/01/16	08/10/16	270

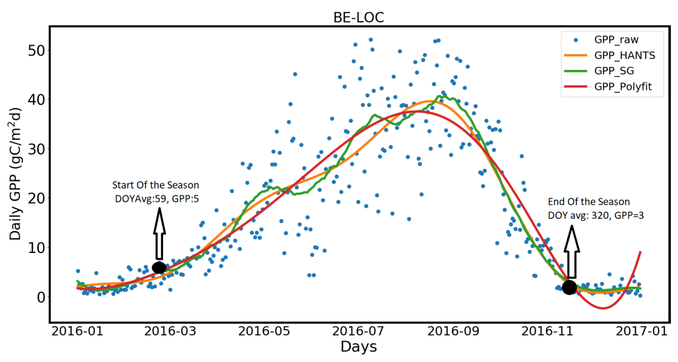
Even though, the Start of the Season from all remote sensing Indices is between April and May, the End of the Season is on October 8 for three smoothing methods and for all the indices.

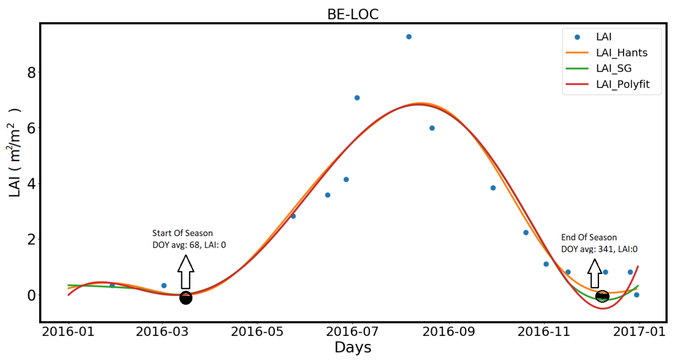
The only remote sensing index that has different days for Starting the Season is “GNDVI”. This index shows an earlier day, for all smoothing methods, is in February 2016.

NDVI & EVI have the same Start and End of the season among the other indices.

Table above shows the Start and End of the Season for each phenological extraction method. The last column indicates the Length of the season for each method.

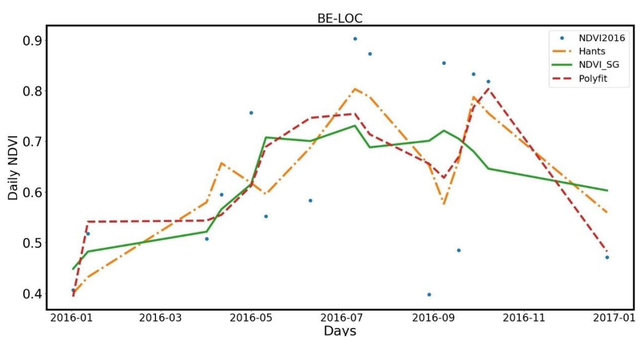
GPP & LAI * Result1*

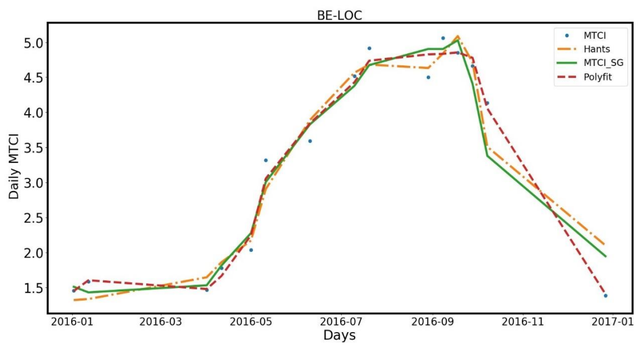


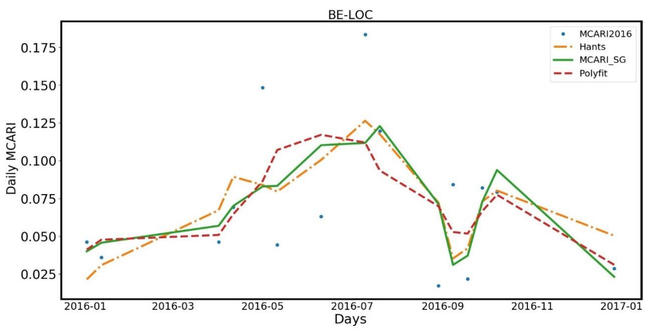


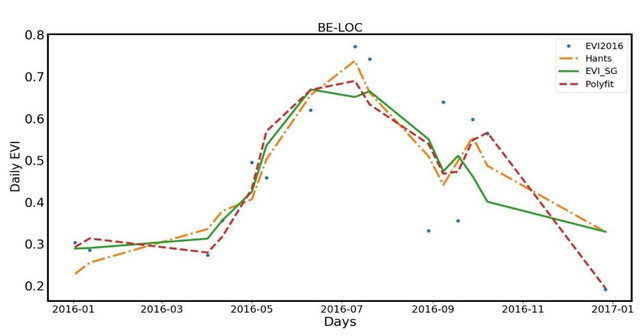
Each line represents smoothing method (Savitzky Golay, Hants, and Polyfit method).
The black circle dot indicates the Start & End “ with first derivative function” of three smoothed lines.

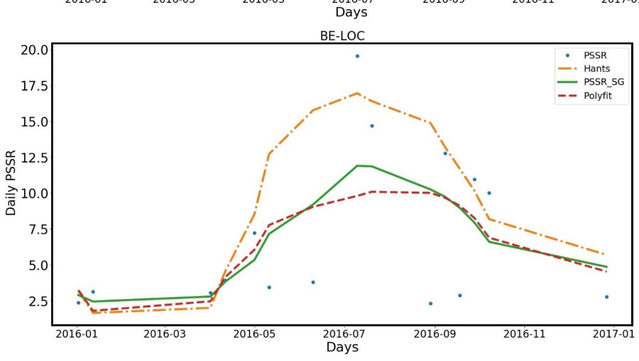
Vegetation Indices *Result2*

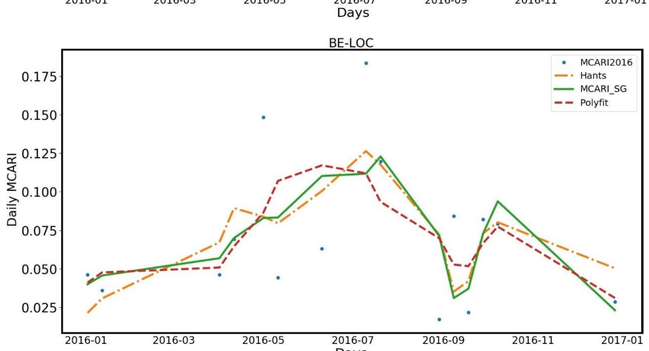












The spectral bands of Sentinel-2 offer the opportunity to calculate VI related to pigment content such as MTCI.

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

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