New Perspectives on Predicting Ecosystem Phenological Metrics based on Sentinel-2 satellite data

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

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)

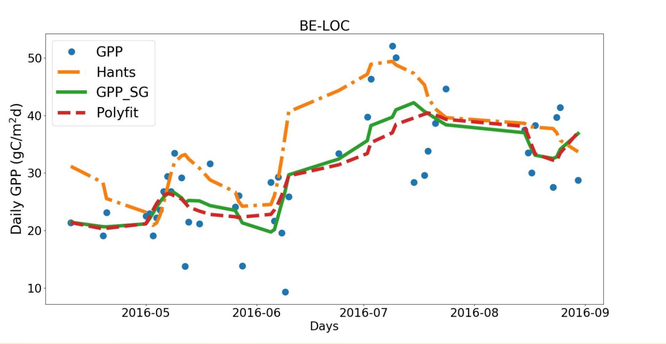
✓ Estimating the Start and End of the Season

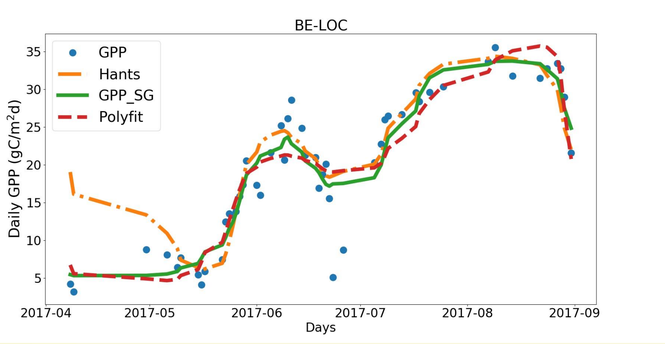
Estimating the Start and End of the Season by comparing the VIs derived by Satellite data with First derivative method

✓ Evaluate the result

Defining which VIs are ideal proxies for vegetation phenology

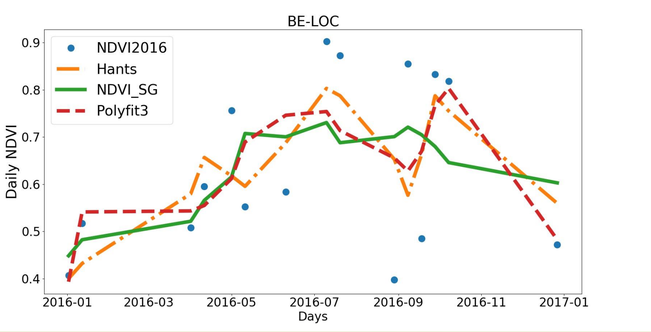
GPP 2016 & 2017 *Result1*

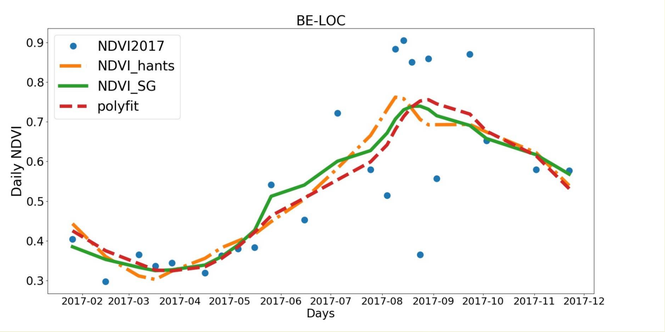


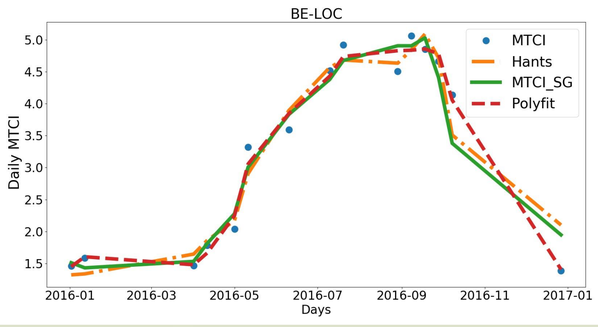


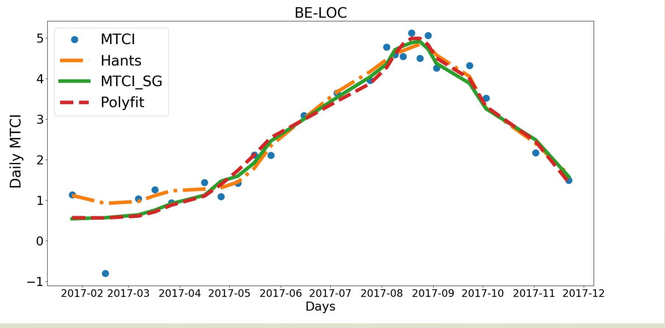
Each line represents smoothing method (Savitzky Golay, Hants, and Polyfit method).

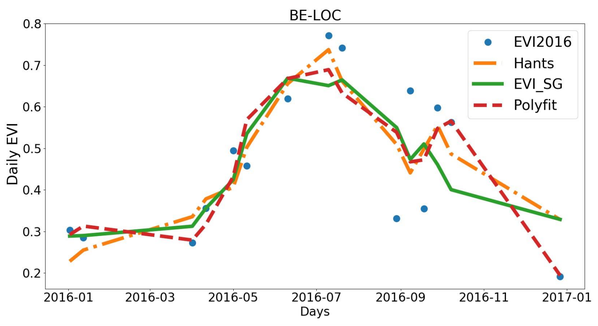
Vegetation Indices *Result2*

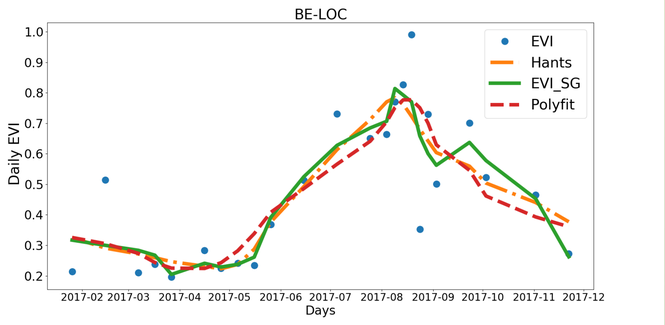


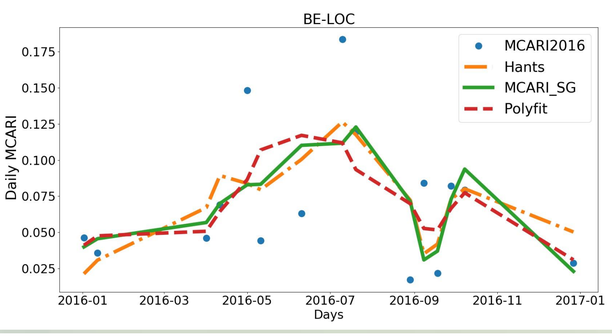


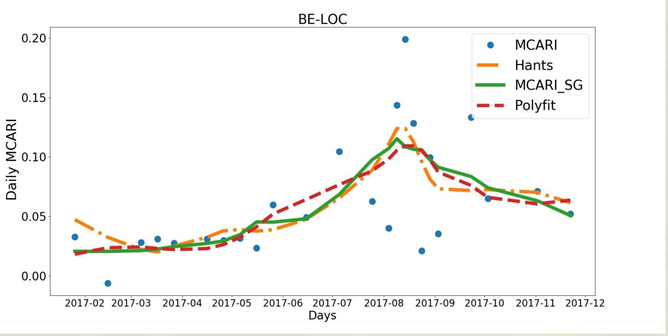


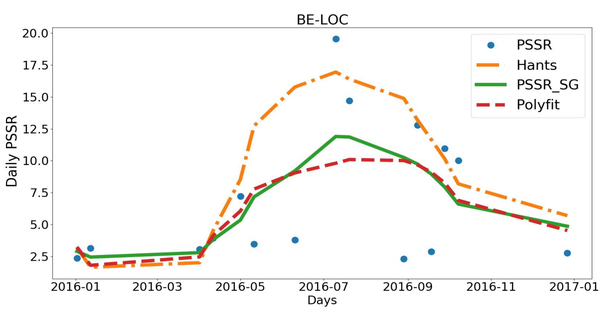


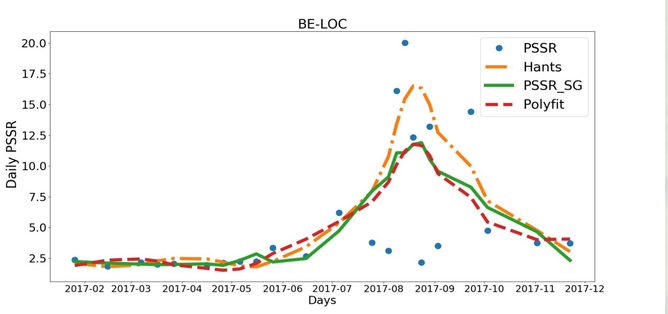






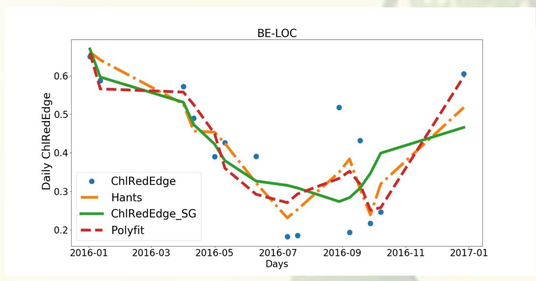


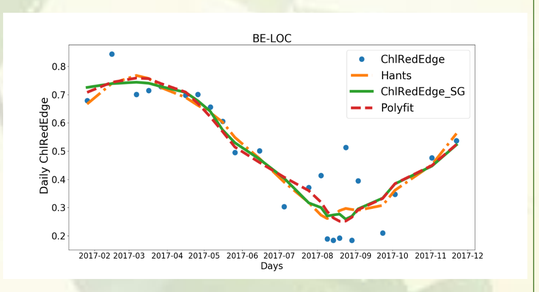




Vegetation Indices* Result3*

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





GPP 2016	Start of Season	End of Season	Length of Season
SvGI	02/05/16	15/08/16	105
Hants	06/05/16	25/08/16	111
Polyfit	02/05/16	16/08/16	106

GPP 2017	Start of Season	End of Season	Length of Season
SvGI	26/05/17	29/08/17	95
Hants	23/05/17	29/08/17	98
Polyfit	16/05/17	29/08/17	105

The length of the season for GPP 2016 &2017 are the same. But. The season starts earlier and finishes later than 2017.

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 in 2016.
The only remote sensing indices that have different days for Starting the Season are “GNDVI”&”Chl-Red_Edge”. These indices show an earlier day, for all smoothing methods.

Vegetation Indices 2016	Start of Season 2016	End of Season 2016	Length of Season 2016
NDVI	119	223	104
MTCI	119	223	104
EVI	119	223	104
MCARI	122	223	101
PSSR	95	223	128
Chl-Red-Edge	129	223	94
GNDVI	9	223	214

Vegetation Indices 2017	Start of Season 2017	End of Season 2017	Length of Season 2017
NDVI	139	306	167
MTCI	116	306	190
EVI	136	293	157
MCARI	79	269	190
PSSR	139	293	153
Chl-Red-Edge	26	186	160
GNDVI	126	306	180

Table above shows the Start and End of the Season for the average of all phenological extractions methods. The last column indicates the average of the Length of the season for all three methods in 2016 and 2017.

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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