Landscape heterogeneity around ICOS Belgian eddy covariance sites investigated through satellite imagery

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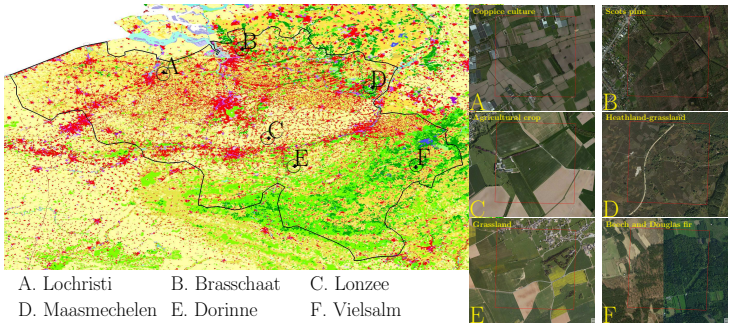
1 Background

- Measurements by flux towers are of paramount importance in understanding and quantifying carbon fluxes.
- The measured fluxes are strongly determined by the characteristics and dynamics of the vegetated areas surrounding the flux towers (footprint). In this respect, an important aspect to be investigated is the **heterogeneity** of the area contained in the footprint of eddy covariance towers.
- The high spatial resolution of Sentinel-2 imagery can be a great support in the assessment of spatial heterogeneity of the areas in the vicinity of flux towers at different timepoints in the growing season.
- This poster presents preliminary implementations of spatial heterogeneity assessment over 6 ICOS sites in Belgium on the basis of Sentinel-2 NDVI.
- This study was conducted in the frame of the recently launched ECOPROPHET project (funded by BELSPO) which aims at the improvement of current schemes of ecosystem productivity simulations for a diversity of biomes in the world.

2 Methods and study sites

1. The study was conducted at 6 belgian ICOS sites. Figure 1 shows the location of ICOS sites selected for this study.



A. Lochristi B. Brasschaat C. Lonzee
D. Maasmechelen E. Dorinne F. Vielsalm

Figure 1: Location of the study sites. Panels show and areal view of the surroundings of the EC towers(located in the middle of the 1000 ha polygon indicated in red)

2. At each site Sentinel2 NDVI images were retrieved for dates good quality images were available (no clouds, no shadows).
3. Square shaped areas around the stations were delimited to constraint the extent of the analysis. Three sizes were considered: 4, 25 and 100 hectares. Although no accurate estimation of the footprint is performed, it was assumed that such extents are likely to impact the measured fluxes. The area delimitation is illustrated in the scheme of Figure 2.

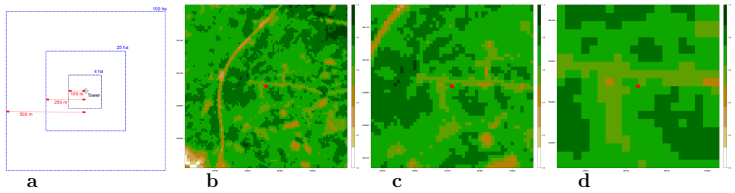


Figure 2: Scheme on area delimitation around stations (panel a) and examples of cropped Sentinel2 NDVI images covering 4, 25 and 100 hectares (b, c and d, respectively) around the station - Site in images: Maasmechelen (July, 7 2015)

4. The analysis of heterogeneity at each site was conducted by:

(a) examining the histogram

(b) calculating the 'spatial heterogeneity index' (SHI) as:

$$SHI_{ij} = \sum_{a=-1}^{1} \sum_{b=-1}^{1} |f(i,j) - f(i+a, j+b)| \quad (1)$$

where f is the NDVI value in the i^{th} row and j^{th} column of a particular image. At each date, the SHI values were aggregated across the image.

(c) drawing and fitting the variogram (sill as indicator of heterogeneity (sill is related to spatial variability))

3 Results

The histograms allowed a first appraisal of the spread of NDVI values in the vicinity of the flux towers. Figure 3 shows histograms for winter and summer NDVI for Brasschaat (Scots pine) and Lonzee (agriculture crop) within the three areal extents considered. From the visual inspection of this Figure, it can be learned that:

- Kurtosis in Brasschaat's histograms does not change much neither in time nor between examined area extents
- More contrasting conditions appear in a cropped environment as in Lonzee

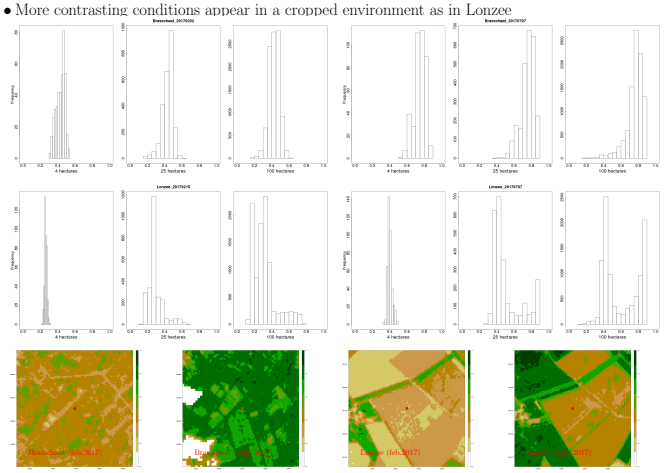


Figure 3: Histograms for winter and summer NDVI images at Brasschaat and Lonzee

A complementary view on this can be gained from the aggregated SHI values. Figure 4 shows a summary of the SHI values (extent=100 hectares) for clear-sky conditions at the six study sites in the form of box-plots.

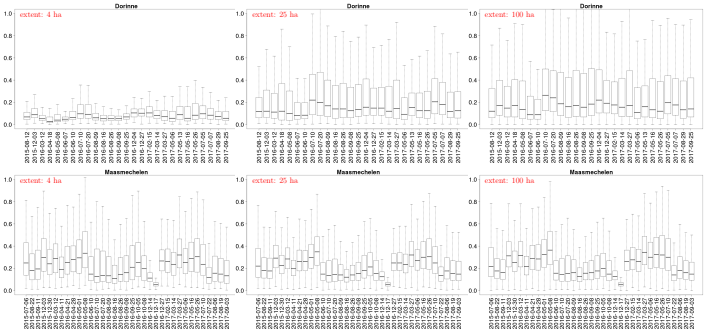


Figure 4: Aggregated value of SHI for different dates in Mechelen and Dorinne

From these plots tt can be learned that:

- Heterogeneity follows a seasonal pattern (in some sites more pronounced than in others)
- Need of propertly assessing the extent for conducting heterogeneity analysis (footprint)

Additional insight on the spatial heterogeneity can be obtained from analyzing empirical variograms as those shown in Figure 5.
The variation of the sill is of particular importance as it represents the spatial variability in the data. The sill and the range changed throughout the season in all sites.

In Vielsalm and Brasschaat, for instance, the sill was reached at about the same range in the different dates. This patterns constrasts with Lonzee and Dorinne semi-variograms which depict a trend instead of a flat sill.

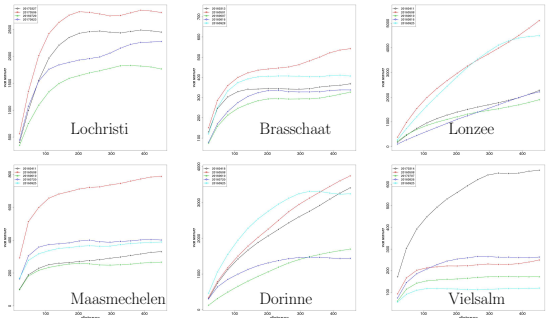


Figure 5: Empirical variograms for different sites over the NDVI images of the study sites

4 Preliminary conclusions and Outlook

The contents of this poster are part of the initial phase of the Ecoprophet project. Nevertheless, a few considerations can be drawn:

- The temporal and spatial resolution of Sentinel-2 NDVI enables the implementation of different approaches to investigate the spatial heterogeneity in the vicinity of flux measurement stations.
- The extent over which the landscape heterogeneity is analyzed is crucial. Thus, the exercises presented here should be complemented with estimates of the footprint at each location.
- The histograms are a basic tool for data analysis but do not reveal the spatial structure of the data.
- The range of SHI values for particular dates and its change in time give a more local view on the spatial heterogeneity. It is compare adjacent neighbours only. A complementary view can be attained with empirical variograms which allow analyzing different lag-distances.
- The use of variograms can be refined by considering directional variograms if flux path is known to follow certain gradients (e.g. dominant wind direction). The shape of variograms can vary in different directions, as exemplified in Figure 6.

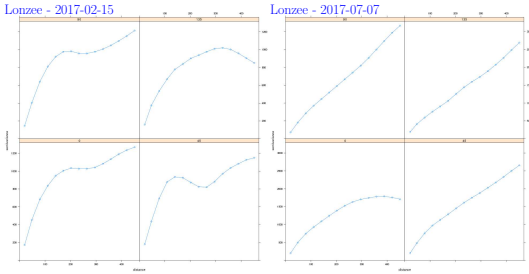


Figure 6: Directional empirical variograms winter and summer in Lonzee

Acknowledgement

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