2021 EUROGEO Annual Meeting and Conference

Madrid, 22-23 April 2021

Seasonal Trend Analysis of MODIS-EVI time series over Europe (2000-2020)

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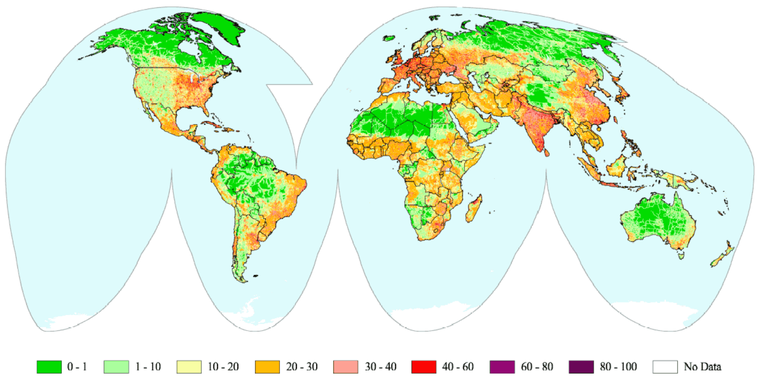
1. INTRODUCTION

- Global change(1) refers to planetary-scale changes in the Earth system, and more specifically, to interferences and disruptions as a whole produced by human activity on the processes that determine the balance of the planet. **Figure 1**

- Global warming(2) is part of global change and refers to the long-term heating of Earth's climate system observed since the pre-industrial period due to human activities, which increases heat-trapping greenhouse gas levels in Earth's atmosphere. **Figure 2**

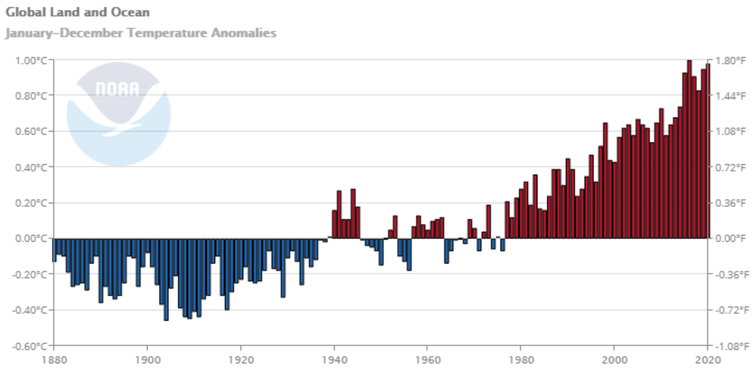
- Concerning that, there is increasing evidence associating vegetation and land-cover changes with warmer temperatures and land-use changes. From the mid-1980s onwards, satellite data has been used to study these processes. In this work, we deal with this research front.

Figure 1
The human footprint



The human footprint is measured using eight variables: population density, croplands, pasture lands, built-up environments, electric power infrastructure, roads, railways, and navigable waterways. Source: EarthData (NASA)

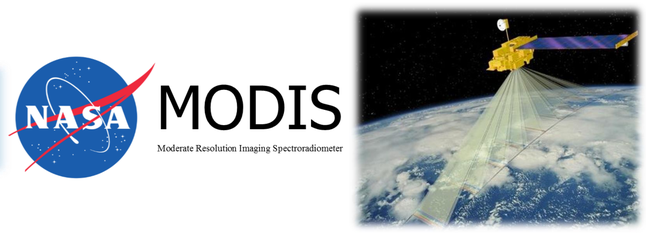
Figure 2
Global surface temperature since 1880



Regarding climate change, one of the most obvious signals of global warming is the rise in global average temperature over the past several decades. Source: NOAA Climate

2. RESEARCH OBJETIVES

- This research aims to detect the main trends in the seasonality of vegetation over Europe by using remote sensing gridded data and time series analysis.



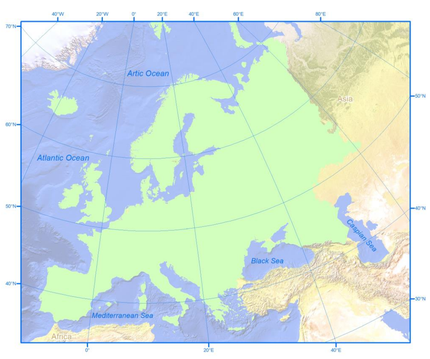
2. DATA & METHODS

- Europe(3) covers about 10.180.000 km^2. **Figure 3**

- Preprocessing (R environment): MOD13A2 MODIS products were used in this research using MODIStsp R package(4). The V6 product provides two Vegetation Indices(5): the Normalized Difference Vegetation Index (NDVI), and the Enhanced Vegetation Index (EVI), which we used in this research. EVI is similar to NDVI, but EVI corrects some atmospheric conditions and canopy background noise and is more sensitive in dense vegetation areas. **Figure 4.1**

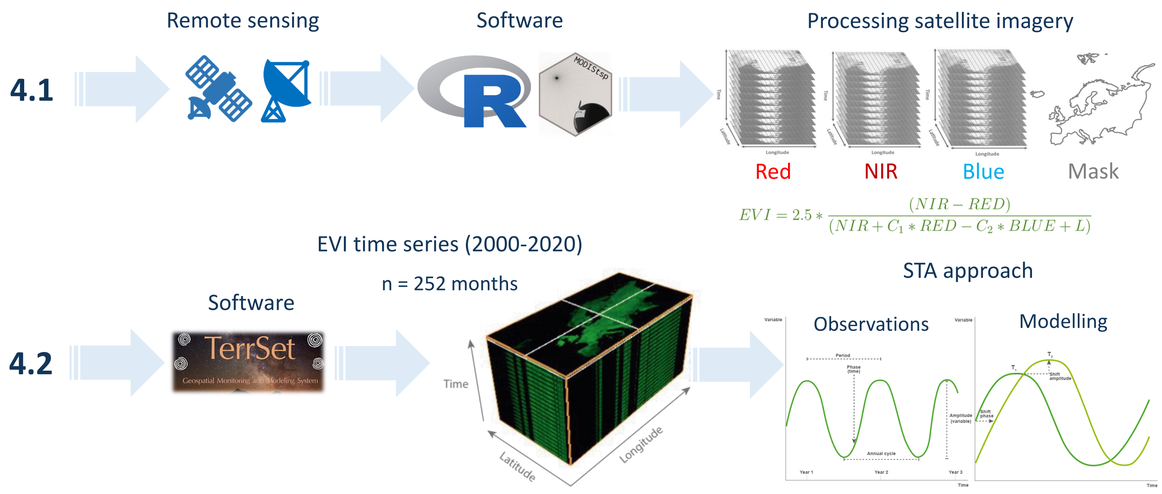
- Analysis (Terrset environment): From the gridded monthly time series (2000-2020) of the Enhanced Vegetation Index (EVI), we applied the Seasonal Trend Analysis(6) to detect significant trends (Mann-Kendall Significance(7): *p-value* ≤ 0.05) in the seasonal inter-annual curve: amplitude and phases parameters. **Figure 4.2**

Figure 3
Study area: Europe



Europe is a group of connected peninsulas and nearby islands in the west of the Eurasian supercontinent. The Arctic Ocean borders this territory to the north, the Atlantic Ocean to the west, the Mediterranean Sea to the south, and Asia to the east. Source: own elaboration.

Figure 4
Seasonal Trend Analysis (STA)



STA is based on: 1) Harmonic analysis of each year to extract the annual and semi-annual harmonics; 2) Trends in these harmonics' parameters over the years are then analysed using a median-slope procedure; 3) Images of these trends are used to create colour composites highlighting the amplitudes and phases of seasonality trends.

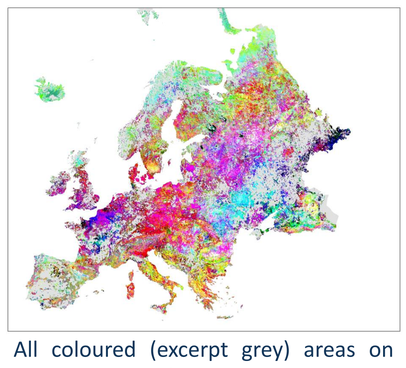
3. RESULTS

- From 2000 to 2020, most of the European territory (~70 %) has experienced significant trends ($p < 0.05$) in the seasonality of EVI. **Figure 5**

- From the European territory, which has shown significant trends in the same period, over the 80 % has experienced positive trends of an annual mean (called Amplitude 0 in STA procedure) of EVI. **Figure 6**

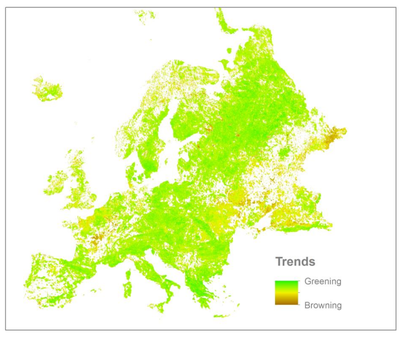
- The EVI fitted seasonal curves modelled for the whole of Europe show a change in the seasonality of vegetation with a greening trend every month of the year. **Figure 7**

Figure 5
Trends in seasonality



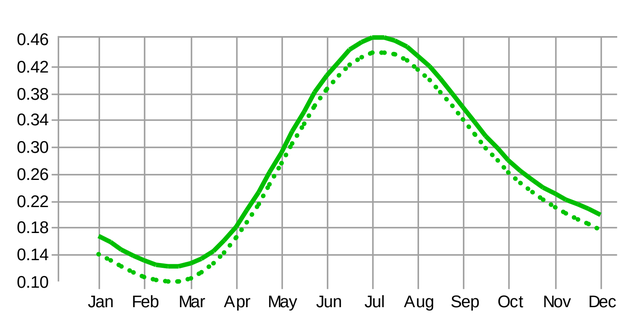
All coloured (excerpt grey) areas on land characterize trends that are significant at the $p < 0.05$ level for one or more shape parameters. Source: own elaboration.

Figure 6
Trends in annual mean EVI



This image expresses significant trends ($p < 0.05$) in Amplitude 0 (annual mean EVI), from the browning (negative trends) to the greening (positive trends). Source: own elaboration.

Figure 7
EVI fitted seasonal curves



These are the EVI fitted seasonal curves modelled for the whole of Europe. The continuous line shows the modelled trend for the start of the series (2000), and the dashed line shows it for the end of the series (2020). Source: own elaboration.

4. CONCLUSIONS

- Preliminary results evidence significant and generalised trends in seasonality of EVI during the last two decades over Europe, mainly with an increase in greenness.

- Future works should analyse trends at biomes and ecoregions scales and evaluate the statistical significance of the observed trends in gridded data.

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Acknowledgements. This research has been supported by the Ministerio de Economía y Competitividad del Gobierno de España through the PALEOPINSAPO Project (Ref. CSO2017-83576-P)