Understanding phenological changes of coniferous forests in Cyprus using time-series of SAR data from 2015 till 2020

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1. Introduction

Recent reports stressed the vulnerability of the forest ecosystem in the European Union (EU), especially to the south [1] [2]. Climate change alters our environment by shifting weather conditions, rising sea levels, increasing flood risks and threatening food production. Shoukri and Zachariadis, 2012, highlighted that Mediterranean Europe is expected to experience the most adverse climate change effects compared to other European regions [3]. Furthermore, Cleland et al., 2017 showed that climate change confers shifts to blooming time [4]. According to Wolkovich et al., 2012, the phenological responses (i.e., alternations in blooming timing) of plants to warmer conditions are unpredicted [5]. According to the US committee on phenology, phenology is "the study of the timing of recurring biological events, the causes of their timing with regard to biotic and abiotic forces and the interactions among phases of the same or different species"[6]. This includes structural changes – e.g., relating to how leaves of trees change seasonally – that can be identified by observing the backscattered coefficient of SAR data. The overarching aim of this study is to understand the phenological changes of a coniferous forest over time in Cyprus by analysing time series of SAR data.

2. Study Area

The study area is a coniferous state forest dominated by *Pinus Brutia*. It is located on the Troodos mountains range in Cyprus; it covers the Paphos forest and its surrounding forested areas. Cyprus is an island in the north-eastern end of the Mediterranean Sea [7]. While according to the literature, 18.7% was covered by forests in 2008 [8], ancient statements reveal that the entire inland including its plains used to be covered by forests [9]. In Cyprus, the summers start in mid-May and last till mid-September and they are dry and warm. Winters start in mid-November and end in mid-March and are mild [10].

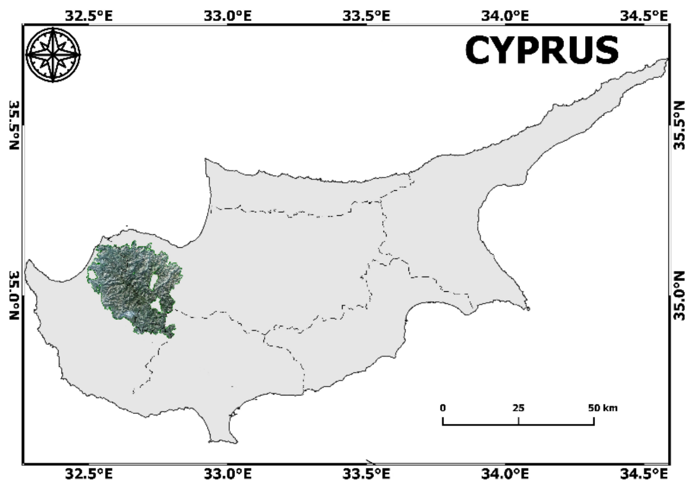

Figure 1. Study Area on the west-north end of Troodos Mountains range.

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3. Data

The study interprets Sentinel-1 data from the timeframe Oct 2014 till Dec 2020. A total number of 304 images were downloaded but after filtering images acquired during high rainfall, 252 images remained for interpretation. This corresponds to an average of 42 images per year.

4. Methods

Pre-processing was done in SNAP ESA tool, while the extraction of the phenological graphs was automated in Python with specialised implemented tools for extracting the average backscattered coefficient from a given mask defining the area of interest. The tools then gather the average backscattered coefficients, clean the data from noise and create the phenological graphs. There is work in progress for generating forecasting and predicting models that will be trained by extracting feature (e.g., peak backscattered coefficient amplitude that represents peak structural blooming timing). Evaluation will be done using four years (2015-2018) as the training dataset and the other 2-years (2019-2020) as the testing dataset.

5. Preliminary Results, Discussion and Conclusions

Figure 2 shows a time-series of the normalised Backscattered coefficient (σ_0) of the VH and VV polarizations of Sentinel-1. It shows that the phenological cycle of the coniferous forest starts in November each year and contains on average two peaks: one in January and one in July. The first one correlates with the rainy season, and it should, therefore, relate to increased Leaf Area Index. The 2nd peak comes a couple of months after the blossoming time of the Pines during the cone growing period. It seems that monitoring both peaks by SAR could contribute into identifying forest degradation and its ability to regenerate itself as its regeneration depends on seeds. This is extremely important considering that in recent survey research 65.65% of Cypriot participants stated that they observed moderate to very much forest degradation including difficulty of regeneration [11] .

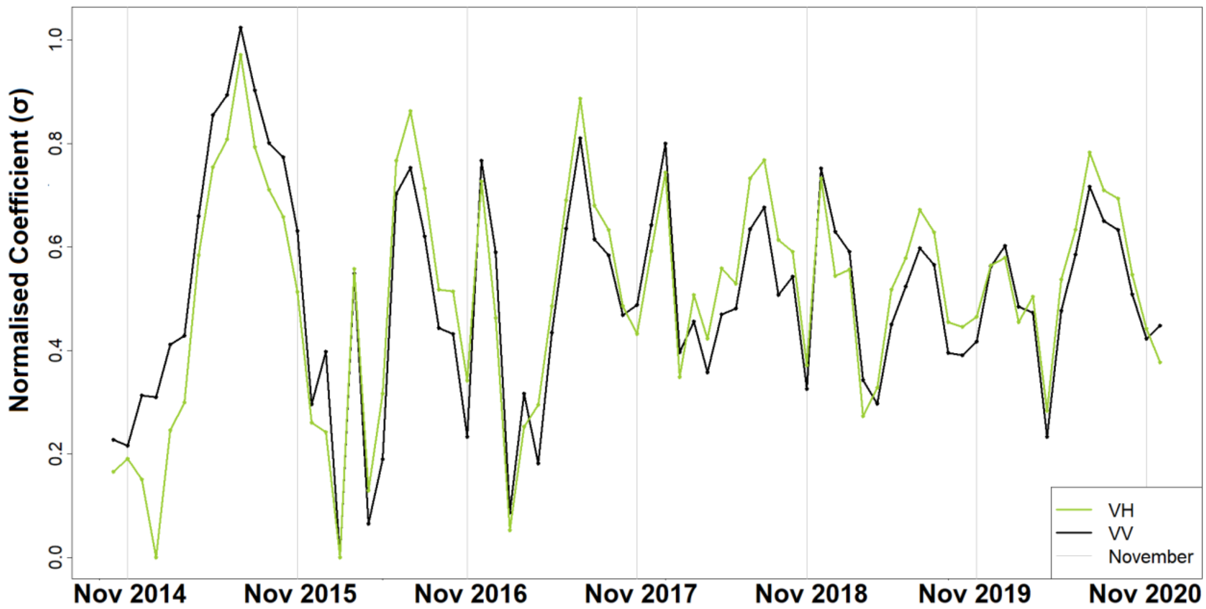

Figure 2. Normalised Backscattered Coefficients of VV and VH polarizations

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