Vegetation Index Changes in Climate Change Using Google Earth Engine in the Palgonsan Mountain Natural Park

Daham Hyeon[1], Yongwon Mo[1], Giyeong Jeong[1], Minseon Kim[1]
1) Department of Landscape Architecture, Yeungnam University, Republic of Korea, 2) Endangered Species Recovery Center, National Institute of Ecology, Republic of Korea
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National Institute for Environmental Studies,Japan

Contact: qwe02021@yu.ac.kr

Background

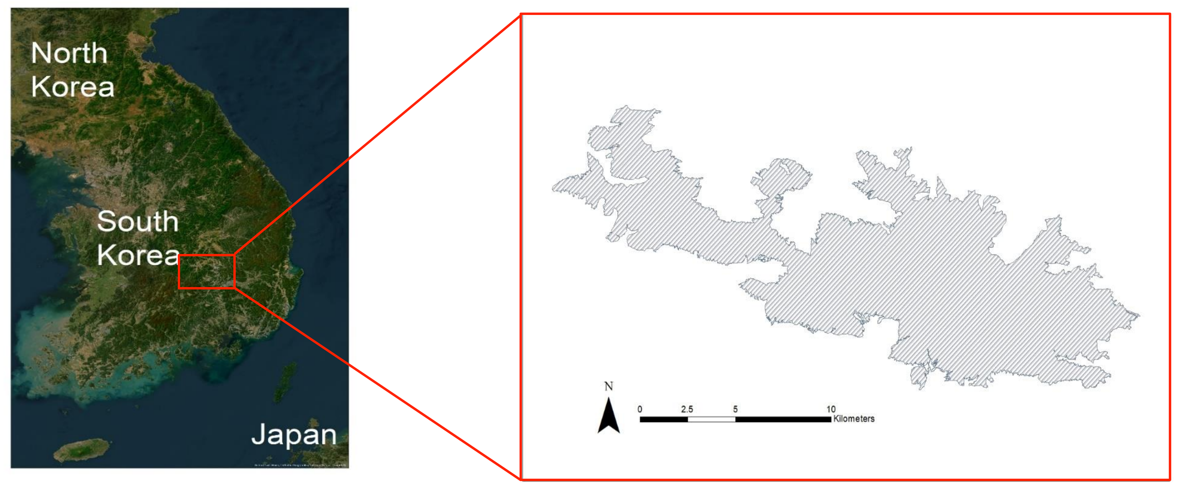
- Global temperatures are rising due to climate change, causing notable shifts in plant growth cycles. Many studies have reported phenological changes, especially in leaf-out timing, in response to warming.
- Such phenological shifts directly affect ecosystem structure and function, underscoring the importance of long-term time-series monitoring for understanding and managing ecosystem dynamics.
- In newly designated protected areas, past ecological data are often lacking. Remote sensing-based vegetation analyses using satellite imagery provide essential baseline information for ecological assessments and conservation planning.

Objectives

- This study aims to build long-term satellite-based time-series datasets for newly designated protected areas using Google Earth Engine, and to track leaf-out and leaf-fall timing as key phenological indicators through vegetation indices.
- In addition, the study analyzes correlations with temperature data to examine how rising temperatures relate to shifts in leaf-out and leaf-fall timing.

Study Site

- The study focuses on Palgongsan, an area of 126.852 km² with an elevation of 1,192.3 meters. The site was designated as a provincial park in 1980 and was upgraded to a national park in 2023.



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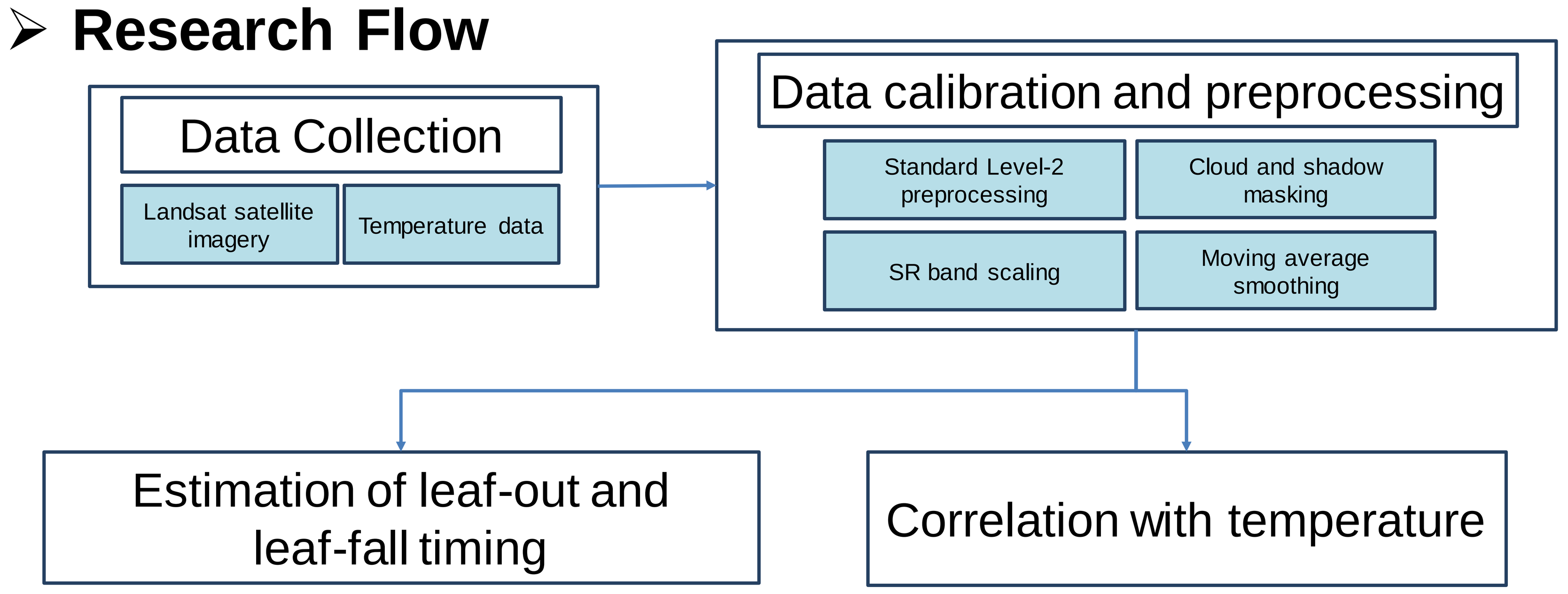
Methods

➢ Research Flow



➢ Using Google Earth Engine

- Google Earth Engine is a cloud-based platform for analyzing and processing large-scale satellite imagery and geospatial data.
- Using the Google Earth Engine Code Editor, Landsat data and temperature data from 1985 to 2025 were collected, and image correction and preprocessing were performed.
- The built-in correction provided by Google Earth Engine was applied, while preprocessing included cloud masking and time-series moving average smoothing.

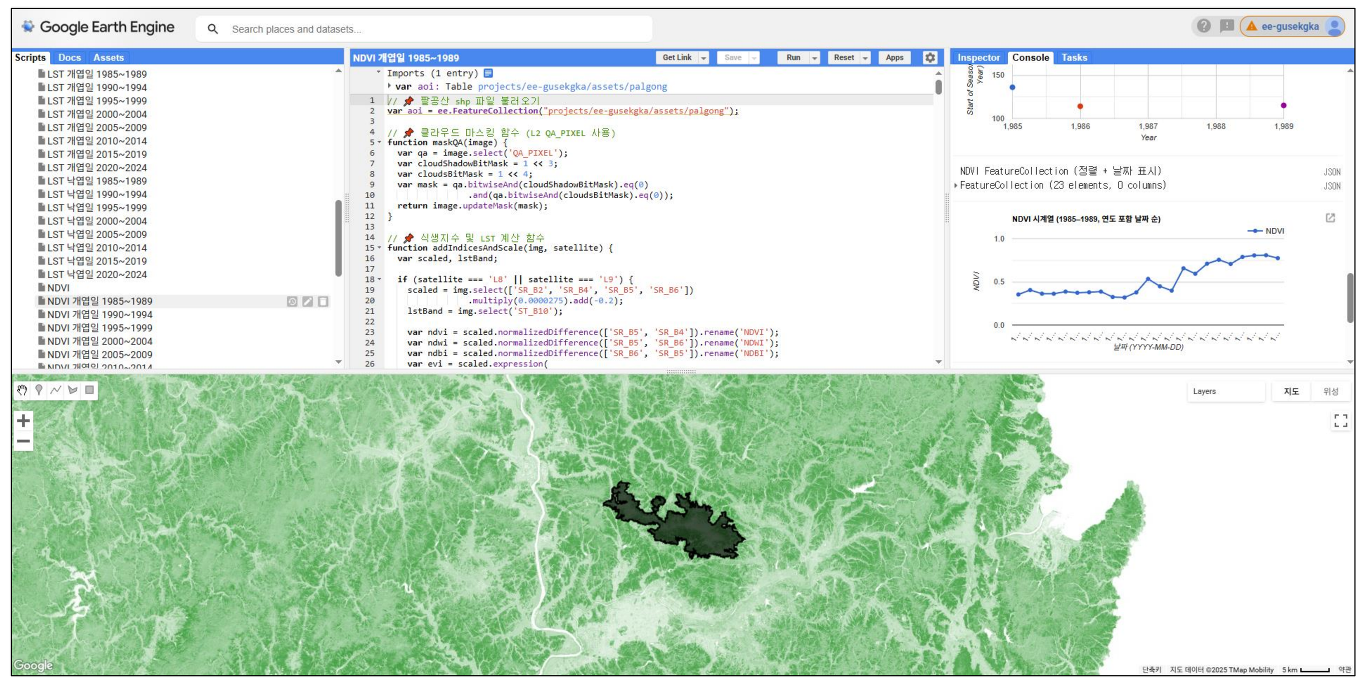


Figure 1. Preprocessing and correction of Landsat satellite imagery using Google Earth Engine

➢ Estimation of leaf-out and leaf-fall timing

- The Normalized Difference Vegetation Index (NDVI): quantifies vegetation by the difference between near-infrared light reflected and red light absorbed by vegetation.
- Leaf-out (start of season, SOS; March–June) and leaf-fall (end of season, EOS; September–December) were identified through NDVI threshold analysis, and changes in the length of season (LOS) were examined.
- An NDVI threshold of 0.5 was set for Palgongsan's mixed forest of coniferous and broadleaf trees; values above this marked leaf-out, and values below marked leaf-fall.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

NIR (Near Infrared) : Strongly reflected by healthy vegetation
RED : Red wavelengths absorbed by vegetation and used for photosynthesis

➢ Correlation with temperature

- Spearman's rank correlation was used to assess how rising temperatures affect NDVI-based phenological changes, including earlier leaf-out and delayed leaf-fall.

Results

➢ Estimation of leaf-out and leaf-fall timing

- A clear trend of progressively earlier leaf-out timing and delayed leaf-fall onset has been observed.
- Leaf-out and senescence timing was irregular until the mid-1990s, but since 2010 earlier leaf-out and delayed leaf-fall have been clear trends.
- LOS has gradually increased, with 2020–2024 showing about 30 more growing days than 2010–2014.

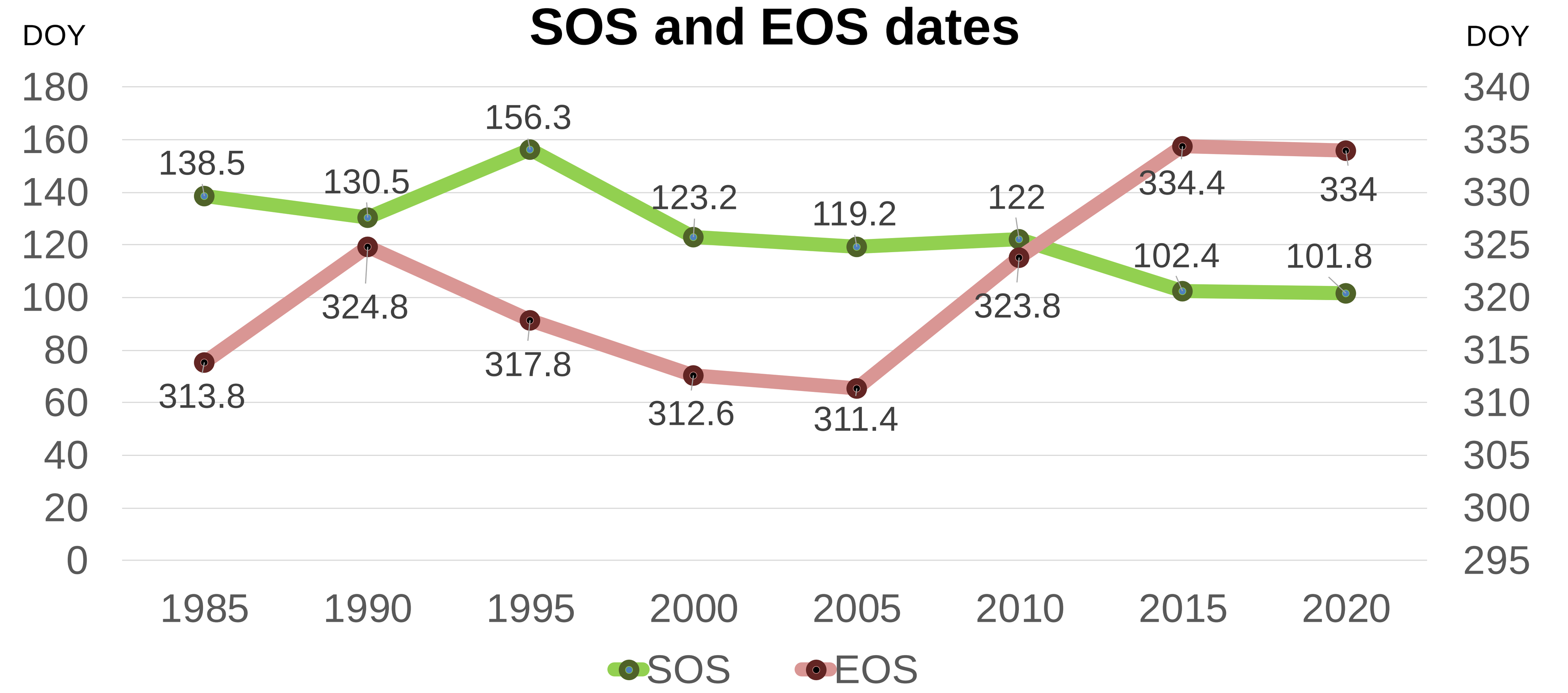
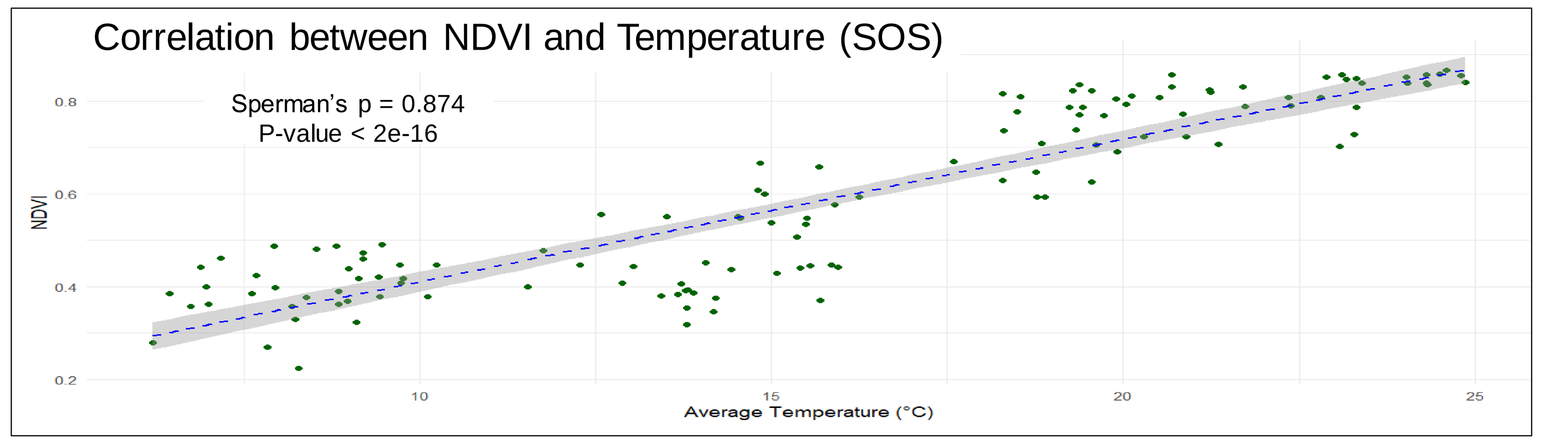


Table 1. Table of changes in leaf-out date, senescence date, and growing season length

➢ Correlation with temperature

- The correlation between leaf-out timing and NDVI showed a strong positive correlation of 0.874, indicating that higher spring temperatures are linked to higher NDVI values, suggesting earlier leaf-out.
- The correlation between leaf-fall timing and NDVI showed a strong positive correlation of 0.839, indicating that higher autumn and early winter temperatures are linked to sustained higher NDVI values, suggesting delayed leaf-fall.



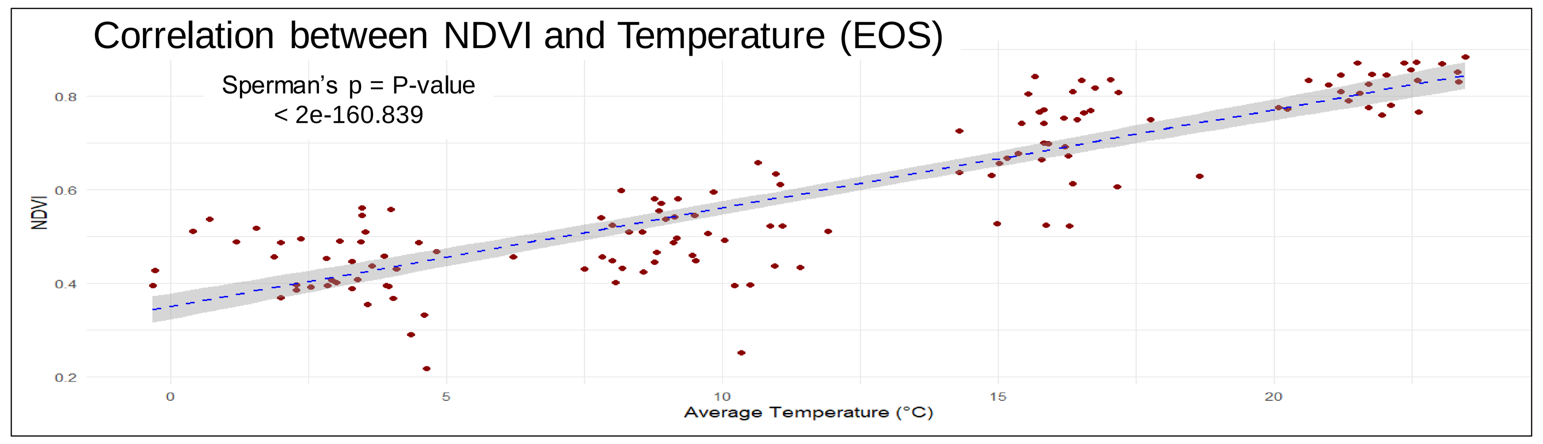


Table 2. Table of correlation analysis between temperature, leaf-out timing, and leaf-fall timing

Conclusion

- This study is crucial as it uses satellite remote sensing to analyze phenological changes in protected areas with limited field data, enhancing vegetation monitoring and providing essential baseline information for climate adaptation and conservation.
- Landsat data before the 2000s have long acquisition intervals, limiting usable images even over five years. More precise results are expected through complementary analyses with EVI or high-frequency data such as MODIS.