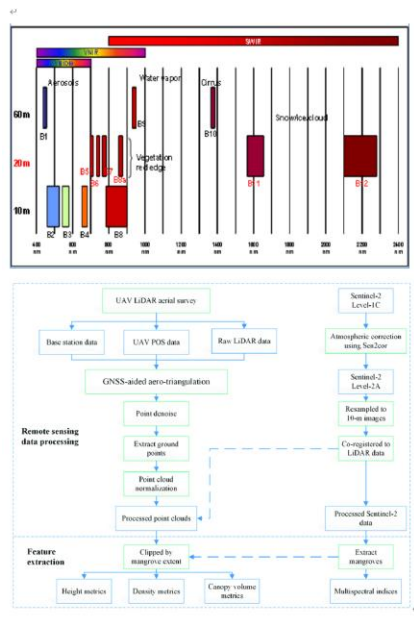


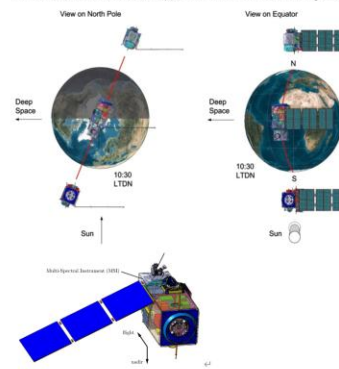
Vegetation Change Detection Using NDVI and Unsupervised Clustering on Sentinel-2 Imagery in part of Iceland

description of the problem to be tackled

This project tackles the challenge of monitoring vegetation health changes over time using satellite imagery. As climate change and human activities increasingly impact ecosystems, tracking these changes becomes crucial for environmental management. The solution analyzes Sentinel-2 satellite images from two different months (April and May) to identify areas where vegetation has improved, degraded, or remained stable. Unlike simple visual inspection, this automated approach provides quantitative measurements of change through advanced image processing and machine learning techniques, enabling more objective and comprehensive environmental monitoring.



AI algorithms in satellite imagery allow automated detection of features like vegetation health or land cover. The process involves acquiring Sentinel-2 images, preprocessing them (e.g., cloud masking, NDVI), then using the data for model training or analysis. The results are refined and visualized to support environmental monitoring and decisions.⁴¹



Sentinel-2 is a European high-resolution, wide-swath, multi-spectral imaging mission. Two satellites fly in the same orbit, phased 180° apart, providing a 5-day revisit at the Equator. Each carries the Multi-Spectral Instrument (MSI), which captures 13 spectral bands: 4 at 10 m, 6 at 20 m, and 3 at 60 m resolution, with a swath width of 290 km.⁴²

References⁴³
https://www.researchgate.net/figure/Sentinel-2-spectral-bands-Martimort-et-al-2007_fig1_267981491⁴⁴
https://www.researchgate.net/figure/Workflow-of-UAV-LiDAR-and-Sentinel-2-data-acquisition-and-processing-and-variable_fig1_335864637⁴⁵
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https://www.researchgate.net/figure/Sentinel-2-satellite-design_fig1_268554909⁴⁷

environmental cost of this research project is minimal due to its efficient design and use of existing resources. All analysis was performed using pre-collected Sentinel-2 satellite imagery from the Copernicus program, eliminating any additional emissions from new data acquisition. The computational work was conducted in Google Colab's cloud environment, which utilizes renewable energy sources, and focused exclusively on lightweight algorithms like K-means clustering and Gaussian Mixture Models that don't require energy-intensive GPU processing.

Several optimizations were implemented to further reduce the environmental impact. The code employed downsampling techniques to decrease image resolution for analysis, processed only cropped subsets of the full images, and used vectorized NumPy operations for maximum efficiency. These choices kept the total computational demand extremely low - estimated at less than five hours of standard CPU time. To put this in perspective, the project's total carbon footprint is comparable to that of a few hours of typical internet browsing or video streaming, likely under 0.1 kg of CO₂ emissions.

This approach demonstrates that meaningful environmental research can be conducted with negligible ecological impact. The project's design carefully balances analytical rigor

with sustainability, showing how remote sensing studies can maintain scientific value while minimizing energy consumption. Future improvements could explore additional optimizations like adaptive resolution processing or more efficient clustering convergence criteria, but even in its current form, this work sets a strong example of environmentally-conscious research practices.