Continuous Change Detection and Classification (CCDC) Using NASA's Harmonized Landsat and Sentinel-2 (HLS) Data in Google Earth Engine (GEE)

Demonstrating the benefits of HLS data for CCDC analysis on the GEE platform

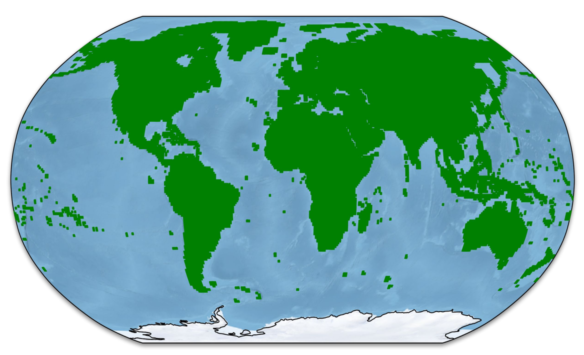
National Aeronautics and Space Administration

Overview of CCDC

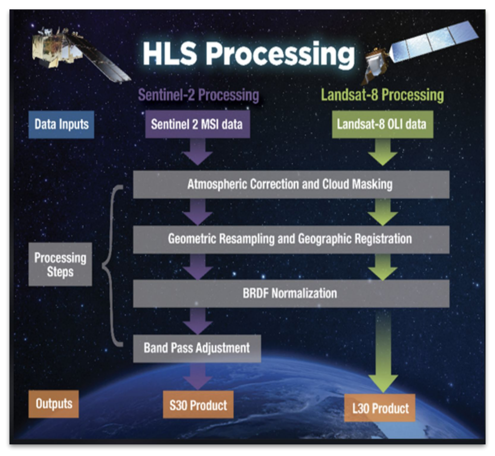
The CCDC algorithm has proven effective in monitoring land surface dynamics using a series of Landsat data (Zhu and Woodcock 2014). However, limitations in temporal resolution and cloud contamination in Landsat series can restrict the applications at certain locations and seasons. This study is an investigation of implementing CCDC algorithm on the GEE platform using HLS data, which is a combined surface reflectance data derived from five satellites and thus offers improved temporal frequency and spectral consistency.

Overview of HLS

- HLS is a solution from the NASA's Satellite Needs Working Group (SNWG).
- Products harmonize Sentinel-2 A/B/C and Landsat 8/9 surface reflectance data.
  - HLSL30: Apr. 2013 - present
  - HLSS30: Nov. 2015 - present
  - Archive size: ~5 PB, ~30 M granules
- Cloud-based processing generates near-global coverage of all land areas at 30m spatial resolution with 1.6 day latency.
- HLS data is being ingested to GEE platform and expected to complete in 2025.
- HLS data can be accessed through NASA's Earthdata Search and WorldView platforms.



HLS near-global coverage



Objectives

Modify gee-ccdc-tools package to enable change detection using CCDC algorithm for HLS dataset and demonstrate benefits of high temporal frequency, cloud-free surface reflectance at pixel and spatial scales.

Authors

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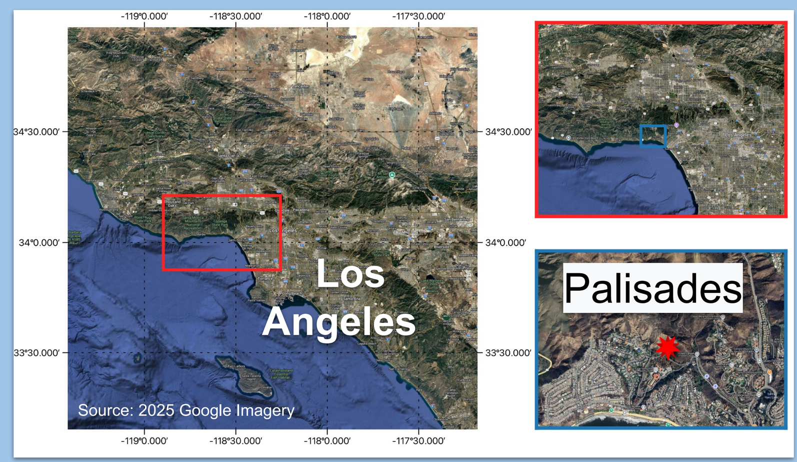
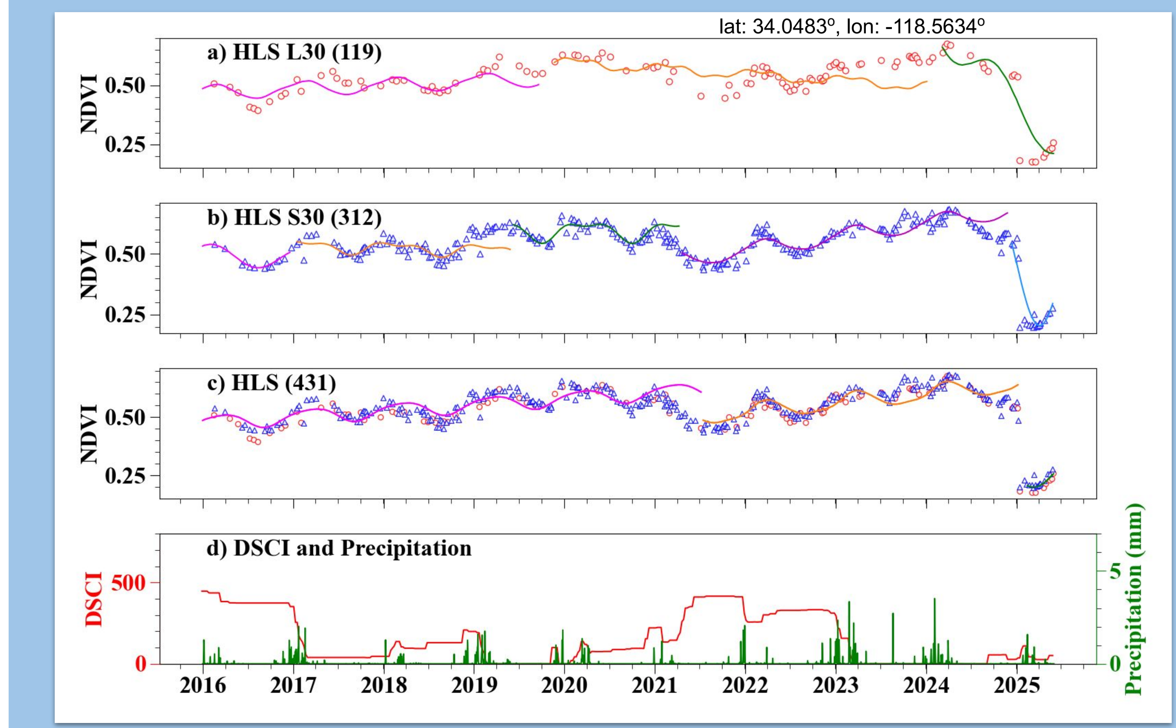
Results

1. Southern California (2015-2025)

The study area is located near Los Angeles, California. It includes the hills of Pacific Palisades—one of the locations of highly destructive wildfires of 2025.

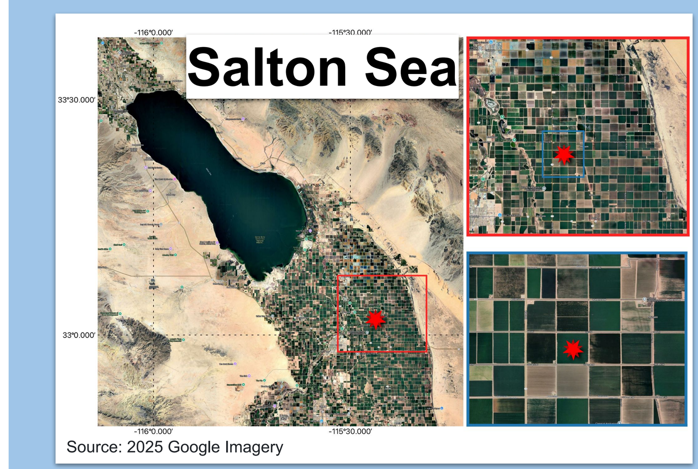


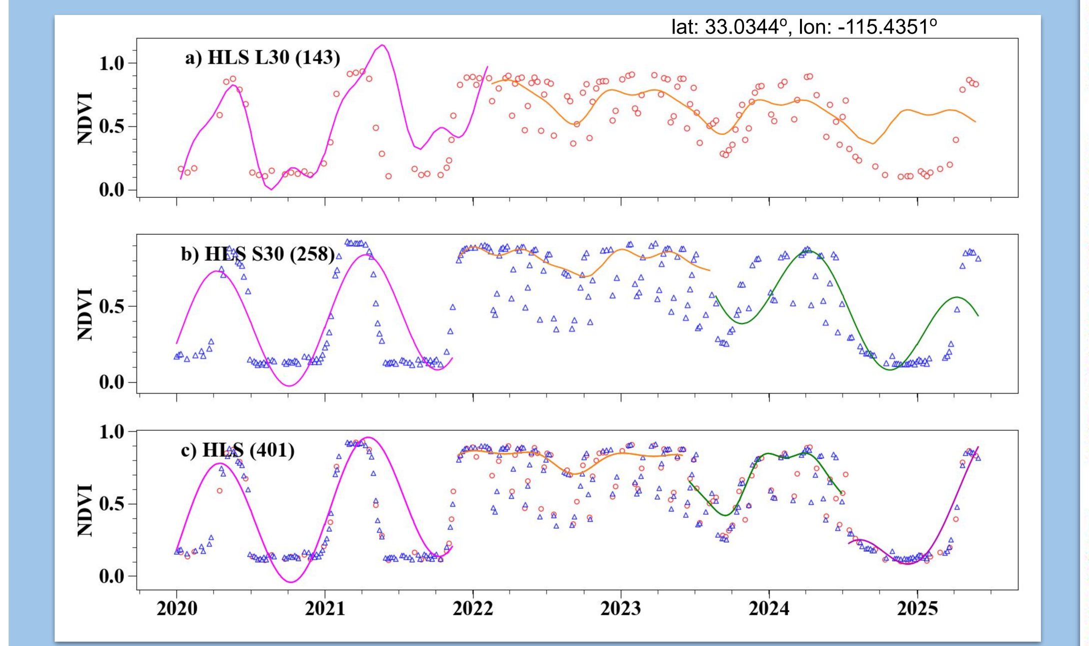


*DSCI: Drought Severity and Coverage Index

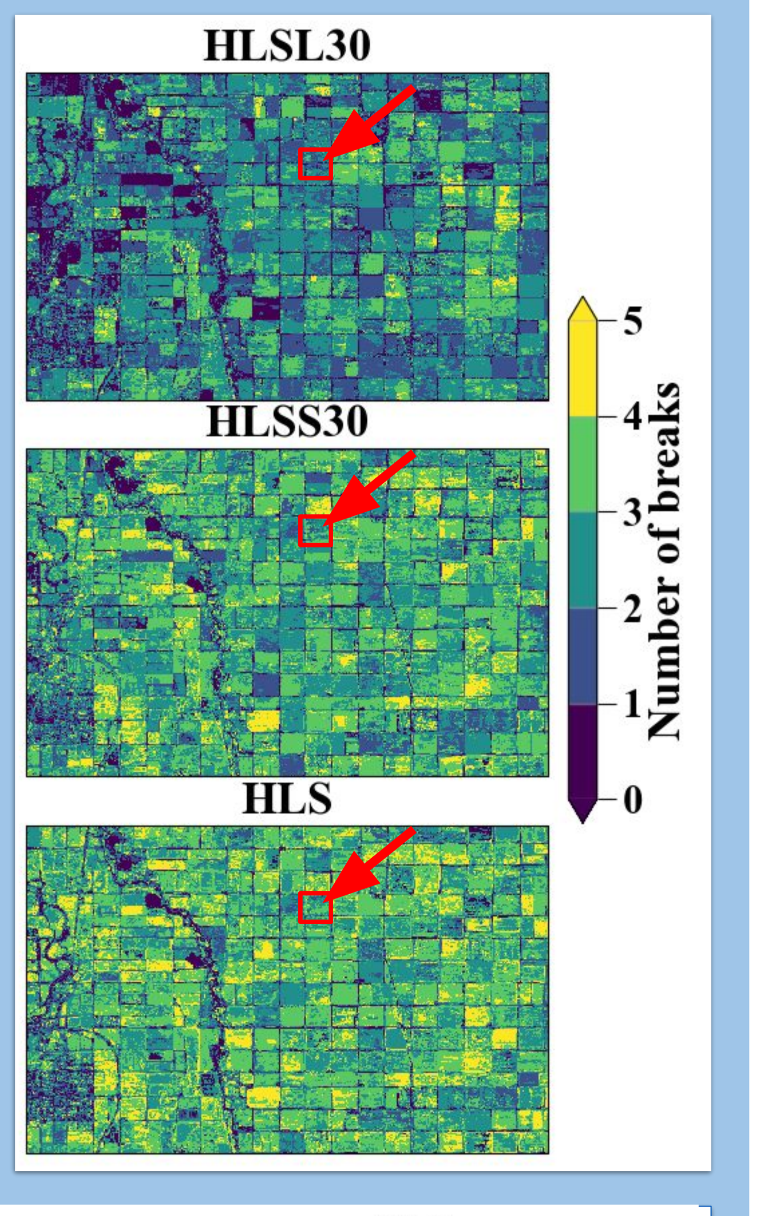
- HLSL30 does not detect the breakpoints of dry and wet years from 2020-2025.
- HLSS30 detects the breaks due to denser cloud-free obs., yet, the signal is interrupted around mid-2019 and 2023.
- Combined HLS captured trends well during the pre- and post- conditions leading to 2025 wildfires.

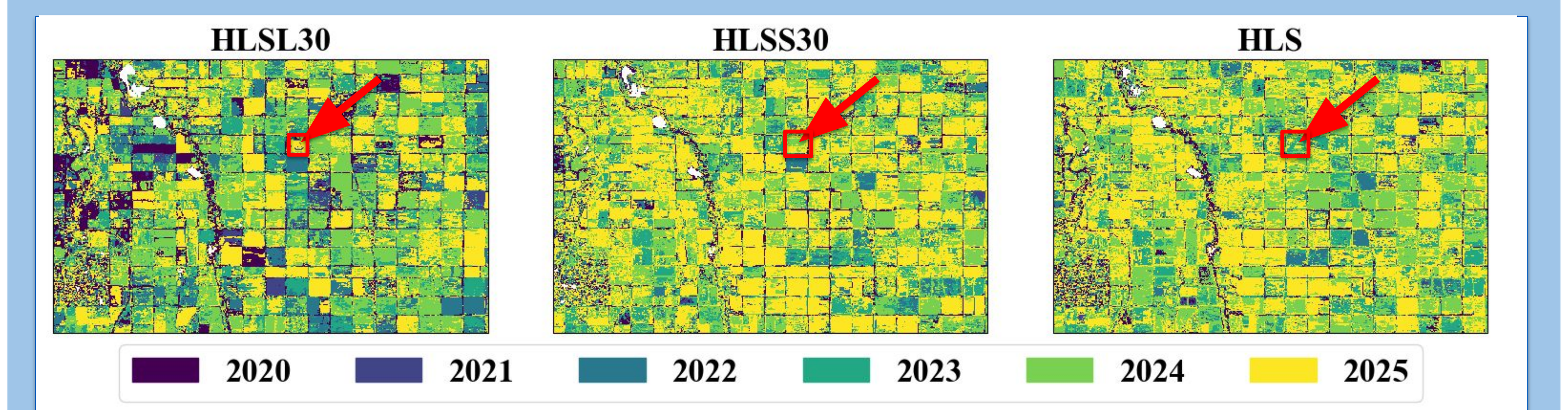
2. Salton Sea agricultural fields (2020-2025)





Combined HLSL30 & HLSS30 time series is able to capture the break in NDVI around mid-2024 when land cover land use change occurs.





Year with most recent break in NDVI time series

Methods

To implement change detection, we utilized the gee-ccdc-tools package (Arévalo et al. 2020)—a community-developed toolset designed to run the CCDC algorithm on the GEE. Instead of the traditional Landsat input, we updated the package to accept HLSL30 and HLSS30 datasets both individually and combined to highlight the differences and improvements using more frequent observations.

The workflow involves the following steps:

1. **Data Preparation**: HLS-derived input data was filtered out for selected domains and timespan, with cloud and cloud shadow masking applied using Fmask QA layer. NDVI and other indices were computed to demonstrate the change detection of vegetation and phenology.
2. **Pixel-scale change detection**: gee-ccdc-tools was used to fit harmonic models to the spectral time series for each pixel and breakpoints were identified.
3. **Local-scale change detection:** the pixel change detection was performed over a defined domain to derive the maps of change detection (e.g., time of maximum change).

Summary

- The availability of HLS data series on the GEE empowers scientists and decision-makers with timely, high-resolution insights for accurate environmental monitoring and informed land management decisions.
- Future investigations are anticipated to explore the potential of HLS dataset on land cover classifications using the CCDC algorithm.

Selected References

Zhu, Z., & Woodcock, C. E. (*2014*). Continuous change detection and classification of land cover using all available Landsat data. *Remote Sensing of Environment*, 144, 152-171.

Arévalo, P., Bullock, E.L., Woodcock, C.E., Olofsson, P. (*2020*). A suite of tools for Continuous Land Change Monitoring in Google Earth Engine. *Frontiers in Climate*.

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