Long-Term Seaport Activity Monitoring with Sentinel-1 Polarimetric SAR Imagery

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Abstract

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Keywords: remote sensing, synthetic aperture radar, statistical testing, sequential change detection, cloud computing

1. Introduction

Synthetic Aperture Radar (SAR) is being widely used for monitoring purposes over many areas of interest throughout the world. The Sentinel-1 SAR space mission operated by the European Space Agency offers free access to the sensor data, unlike some other radar imagery suppliers that charge fees for each dataset. A convenient and near-real-time source of time-sequential SAR data is provided by the Google Earth Engine (GEE) platform (Gorelick et al., 2017) which archives Sentinel-1 dual polarimetric SAR images as soon as they are made available by the European Space Agency. The GEE also offers a platform to design and execute algorithms on remote sensing datasets through cloud services, thus relinquishing user's local network from the burden of data storage and processing.

This paper describes the application of a sequential change detection algorithm to time series of Sentinel-1 images over the Port of Long Beach and Los Angeles, the object being to track the effect of erratically declared American tariffs since the beginning of the Trump administration on west coast shipping activity. Long Beach / Los Angeles is the busiest seaport in

the western hemisphere and one of the busiest in the world, approximately 15,000 longshore workers usually pull shifts around the clock, moving billions of dollars' worth of cargo in cars, agriculture, auto parts, toys, clothes and furniture. It thus offers itself as an ideal indicator of major shifts in international trade involving the USA.

The algorithm used in the study is based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices (Conradsen et al., 2016). It enables geospatial and temporal isolation of changes in a time series of multi-look SAR data in polarimetric matrix representation, with single polarization and diagonal-only intensity data included as a special cases. The ability of the sequential change detection method to detect and isolate regions of intense activity, together with easy access to Sentinel-1 SAR imagery on the GEE, suggest specific applications in the area of remote monitoring. The change detection method, including open source change detection software for interaction with the GEE is described in in Chapter 9 of Canty (2025). The software is available on GitHub and the client-side programs run in a local Docker container.

2. Port of Long Beach and Los Angeles

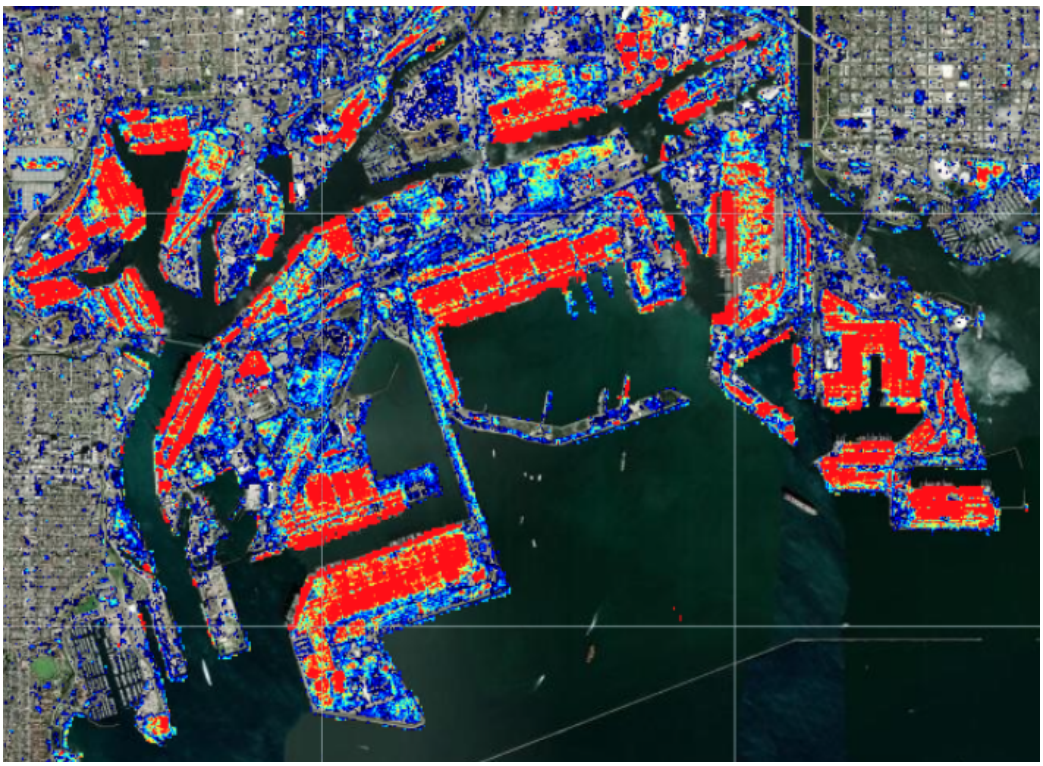

Figure 1: Fraction of changes per pixel from Jan. 2022 through May 2025 excluding water surface. Dark blue: few. Red: more than 20.

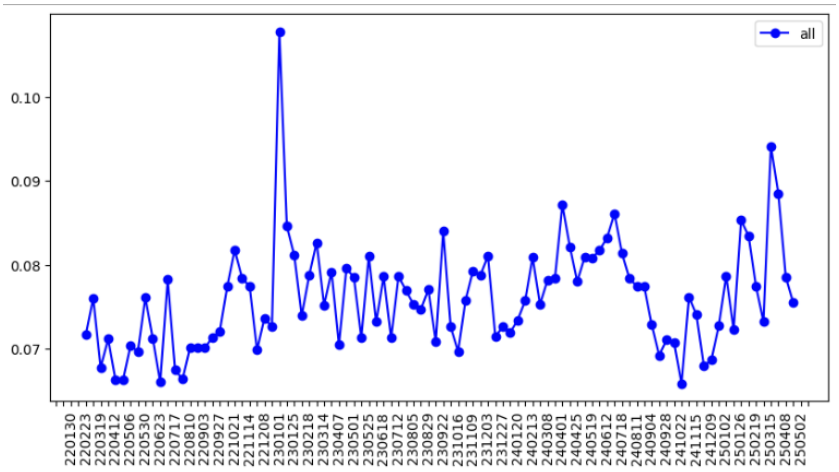

Figure 2: Number of changes per interval, Jan. 2022 to May 2025. "The US West Coast gateway ports of Los Angeles and Long Beach saw a surge in container volumes in January 2023 as retailers restocked inventory ahead the Lunar New Year shutdown in China." (Seatrade Maritime News, Feb. 15, 2024)

Figure 3: Middle Harbor Terminal (Pier T) operated by COSCO (China Ocean Shipping Company) and Long Beach Container Terminal (LBCT). The terminal is a Primary Chinese Connection.

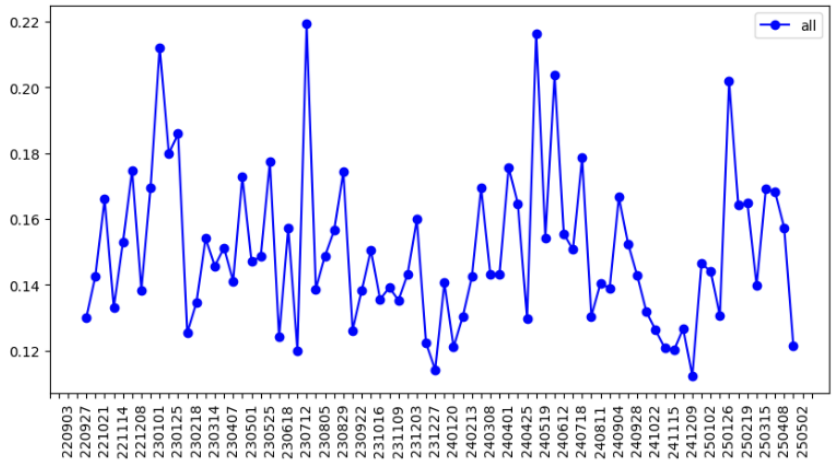

Figure 4: Middle Harbor Terminal (Pier T) change fractions per interval, Sept 2022 to May, 2025.

3. Conclusions

some nice conclusions

References

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