Software Tools for Change Detection with Polarimetric SAR Imagery

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Summary

This contribution describes open source software tools for the application of multivariate statistical change detection with polarimetric SAR imagery. The tools encode the processing chain starting from single look complex (SLC) multi-temporal data through to change detection maps. They have been developed for the EU Project *Service Provision of Geospatial Intelligence in EU External Actions Support - G-SEXTANT, Work Package 550: Nuclear Activities Scenario.*

Many change detection techniques have been developed for application to synthetic aperture radar (SAR) remote sensing imagery. These methods are in general *univariate*, that is, applicable to scalar SAR data. Multivariate change detection algorithms applied to polarimetric synthetic aperture radar (polSAR) data are less common. This is because, up until recently, not many researchers or practitioners have had access to polarimetric data. On the other hand, the emission and detection of all combinations of horizontally and vertically polarized radar pulses may be expected to yield more information and to be more sensitive to physical changes on the Earth's surface. With the advent of several spaceborne polarimetric SAR instruments such as the Japanese ALOS, the Canadian Radarsat-2, the German TerraSAR-X, the Italian COSMO-SkyMed and the Sentinel-1 mission, the availability of high and intermediate resolution polarimetric data has increased dramatically.

The change detection procedure which is implemented in the software exploits the complex Wishart distribution of dual and quad polarimetric imagery in look-averaged covariance matrix format in order to define a per-pixel change/no-change hypothesis test (Conradsen et al., 2003). It includes approximations for the probability distribution of the test statistic, and so permits quantitative significance levels to be quoted for change pixels. In addition, an improved multivariate method (Anfinsen et al., 2009) is used to estimate the *equivalent number of looks* (ENL), which is a critical parameter of the hypothesis test.

The theory underlying the change detection technique is outlined and an open source implementation of the processing chain is described in detail. It consists of freely available preprocessing software from the European Space Agency and the Alaska Satellite Facility, as well as Python scripts for ENL estimation and complex Wishart change detection developed by the authors. For ease of use and portability, the Python scripts are served as an iPython notebook running in a Docker container.

Detailed examples (case studies) of the processing steps are given.

References

Anfinsen, S., Doulgeris, A., and Eltoft, T. (2009). Estimation of the equivalent number of looks in polarimetric synthetic aperture radar imagery. *IEEE Transactions on Geoscience and Remote Sensing*, 47(11):3795–3809.

Conradsen, K., Nielsen, A. A., Schou, J., and Skriver, H. (2003). A test statistic in the complex Wishart distribution and its application to change detection in polarimetric SAR data. *IEEE Transactions on Geoscience and Remote Sensing*, 41(1):3–19. Internet http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=1219.