Wishart Wizard Documentation

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Overview

The Wishart Wizard is a graphical user interface (GUI) implemented in IDL as an extension for the remote sensing image analysis environment ENVI. It provides a simplified and user-friendly platform for performing multivariate change detection with bitemporal polarimetric SAR imagery. The change detection procedure implemented exploits the complex Wishart distribution of polarimetric SAR image observations 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., 2009a) is used to estimate the *equivalent number of looks* (ENL) of the look-averaged images, which is a critical parameter of the hypothesis test.

If SARscape is licensed in the ENVI environment, the Wizard accesses the SARscape API at the IDL scripting level to expose only that functionality necessary for the change detection analysis, thus guiding the user and simplifying the processing chain. If SARscape is not present, open source alternatives for the required preprocessing are available and are described in this documentation.

Processing chain

Figure 1 shows the processing sequence for generating a change map from two polarimetric SAR images provided at the single look complex (SLC) processing level. First of all, two multi-look images in covariance matrix format are generated from the SLC data (step 1). This format consists of separate files for each of the covariance matrix elements, one file for each of the real diagonal elements and two for each of the complex above-diagonal elements. These are then geo-referenced and terrain corrected with a DEM (step 2).

The first two processing steps can be performed with the SARscape polarimetric features and basic geo-coding modules if these are available in the ENVI environment. The Wizard exposes the necessary functions in its main menu. Otherwise they can be carried out externally and prior to further processing in the Wishart Wizard with the open source software packages PolSARpro (European Space agency), together with MapReady (Alaska Satellite Facility). PolSARpro is first used to create multi-look images in co-

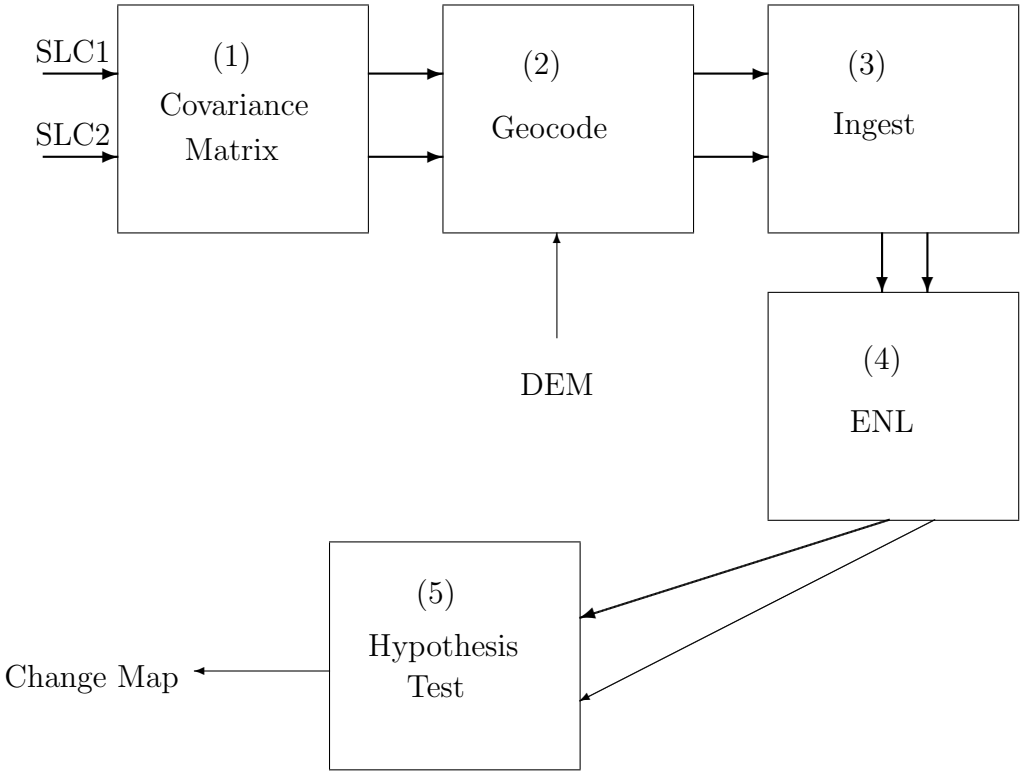

Figure 1: Processing chain.

variance matrix format (step 1), which are then exported to MapReady for geo-referencing and terrain correction with a DEM (step 2).

The resulting matrix element images are then ingested into the Wizard in ENVI standard format floating point images (step 3) consisting of 9 bands for quad polarimetric, four bands for dual polarimetric, and one band for single polarimetric images. In step 4, the ingested images are processed to determine a global value for the equivalent number of looks (ENL) before being passed to the change detection algorithm (step 5). The final product is a geo-referenced change map showing changes at the desired significance level. An example is shown in Figure 2.

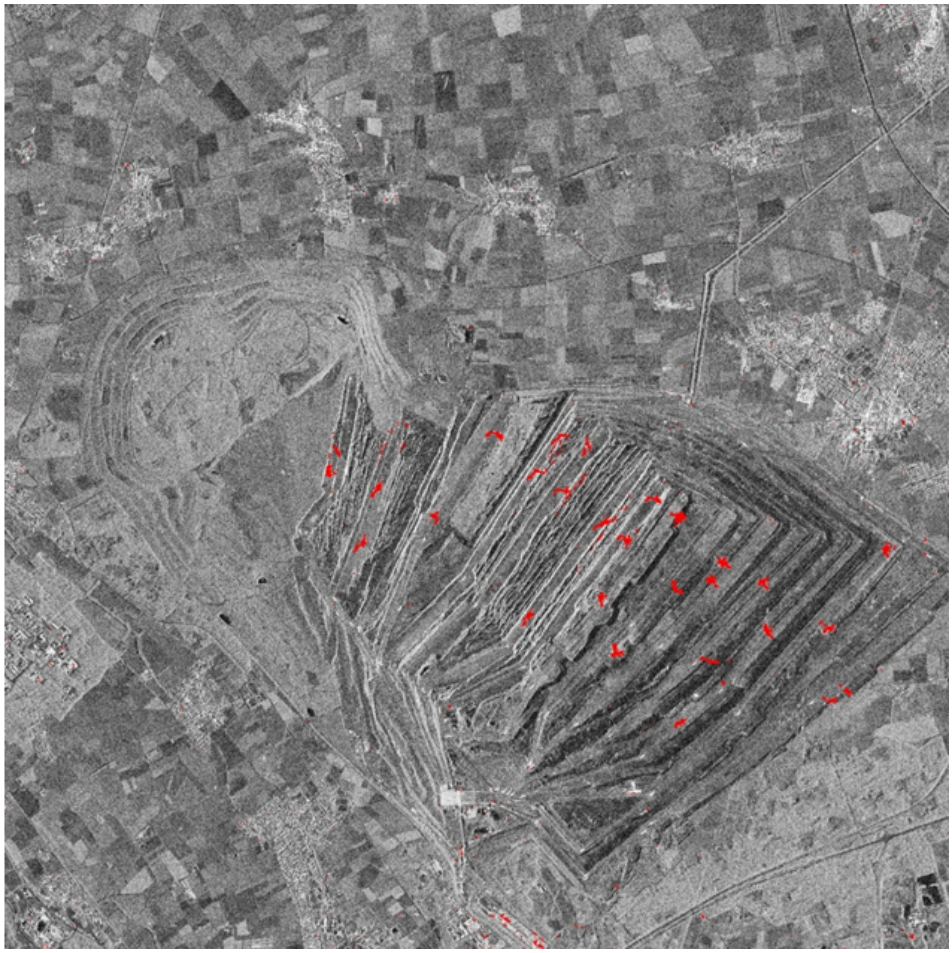

Figure 2: Changes at the 1% significance level for TerraSAR-X quad polarimetric images over an open cast mine in Germany.

Wishart Wizard Main Menu

The Wishart Wizard GUI is shown in Figure 3. The program checks on startup for the availability of SARscape, and the corresponding main menu item is grayed out if SARscape in not present. In the latter case, preprocessing can be effected with the open source PolSARpro and MapReady software as described by Gens et al. (2013).

SARscape Menu

The SARscape menu is intended to simplify the necessary preprocessing of SLC image data. The submenu items access the SARscape API directly.

SARscape/Working Directory/Set working directory

Set a working directory for the output and meta files generated by SARscape. Must be set prior to importing SLC data.

SARscape/Working Directory/Clear working directory

Erase the current working directory.

SARscape/Working Directory/Show working directory

Display the working directory in the status bar.

SARscape/Set range looks

Choose the number of range looks for multi-looking (default 3). The azimuth looks will be chosen automatically to correspond as closely as possible to a square pixel.

SARscape/Set DEM

Choose a digital elevation model (DEM). This is a prerequisite for geocoding and terrain correction.

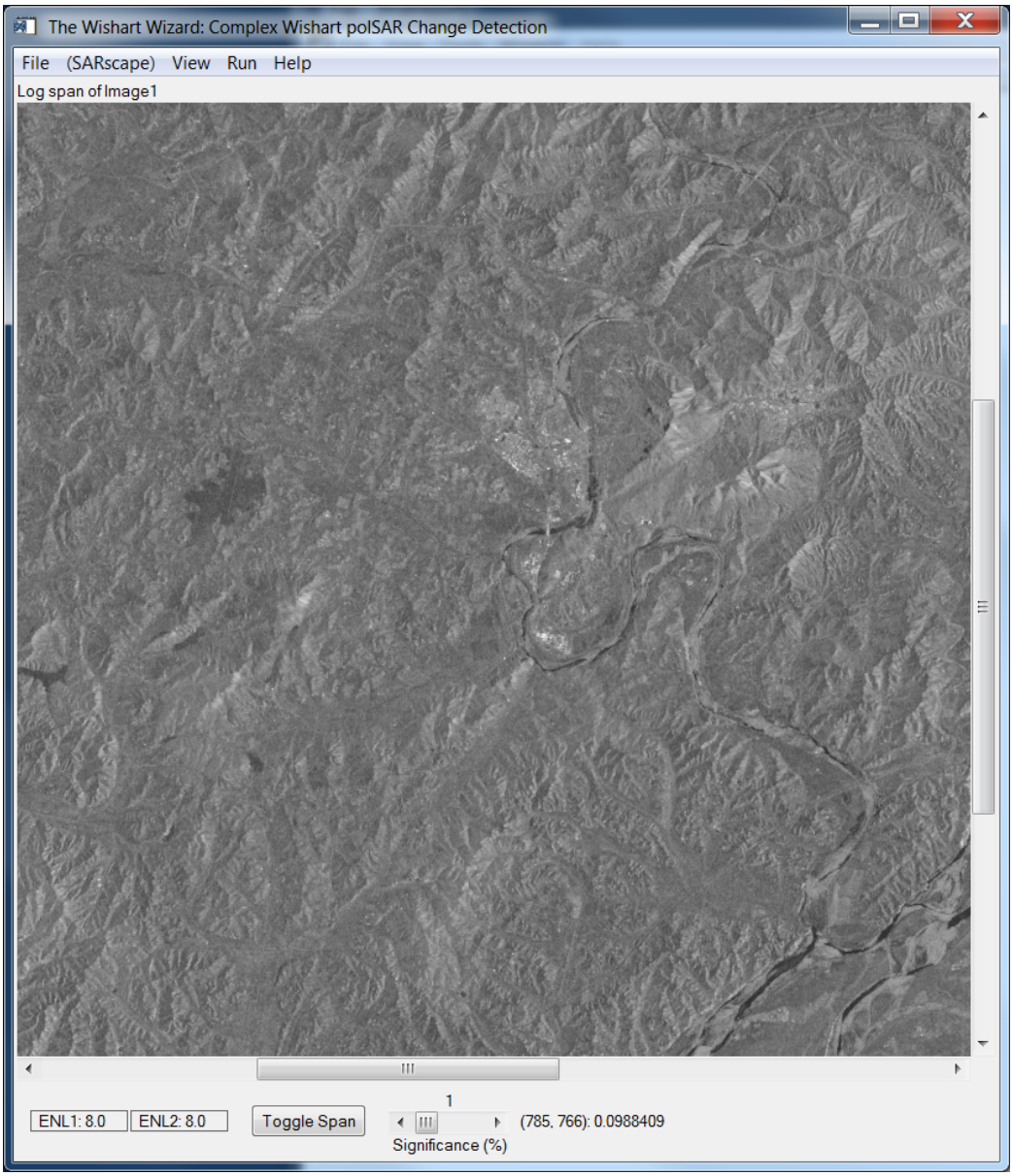

Figure 3: The Wishart Wizard GUI.

SARscape/Import SLC

Imort SLC data and generate multi-look covariance matrix element image bands. The currently supported sensors/formats are:

- RadarSAT-2 quadPol
- TerraSAR-X quadPol
- TerraSAR-X singlePol
- COSMO SkyMed singlePol

In each case it is necessary only to enter the main product file. Generation of the multi-look covariance matrix element bands proceeds automatically: first data import and then generation of polarimetric features (matrix elements). Each step must be terminated with OK. The bands are written in ENVI standard format.

SARscape/Geocode

Select all the matrix element bands for geocoding and terrain correction. They are presented automatically in a file selection window. Processing is again automatic and the resulting grid size (pixel dimension) is chosen to correspond as closely as possible to the multi-look geometry.

File Menu

When the multi-look, geocoded and terrain corrected covariance matrix bands have been generated (either via SARscape or using the PolSARpro/MapReady processors), they can be ingested into the Wizard for change detection.

File/Ingest/First covariance matrix elements

All of the files in the current working directory are presented in a file input dialog window. The user need only choose a (spatial subset) of any one of the preprocessed covariance matrix bands (with the filename ending _geo) corresponding to the first (time 1) polSAR image. The others will be found automatically and loaded into the Wizard. The main window will then display the span image in a logarithmic stretch.

File/Ingest/Second covariance matrix elements

This menu item only becomes available after ingestion of the first image. The working directory should first be set to that corresponding to the second (time 2) image. The file input dialog presents the preprocessed matrix element bands, any one of which may be chosen. The others are loaded automatically and co-registered to the first image.

File/Save

Save the ingested images to the file system. The covariance matrix images are stored as single multi-band files and can be reloaded into the Wizard at any time

File/Reload

Reload a previously saved covariance matrix element image.

File/Save view to ENVI

The currently displayed view in the main window is transferred to the ENVI memory where is can be displayed/saved/further processed. If the change map is in the view, then only the change pixels themselves, not the span image background, are passed to ENVI. They are given file type ENVI Classification, so they can be overlayed onto ENVI image windows. They can also be exported to Google Earth with the ENVI Image menu command Tools/SPEAR/Google Earth/Export Image.

File/Quit

Exit the Wishart Wizard,

View Menu

View/Span

Display the span (trace of the covariance matrix) of the first (time 1) or second (time 2) image. Use the Toggle Span button at the bottom of the

Wizard window to toggle between the the span images.

View/ENL

Display the ENL raster for the first (time 1) or second (time 2) image.

View/Change statistic

Display the change statistic image ($-2\rho \log Q$; see Conradsen et al. (2003)).

View/Change probability

Display the change probability image ($\Pr(-2\rho \log Q < z)$; see Conradsen et al. (2003)).

View/Change map

Display the change pixels at the chosen significance level in red superimposed onto the span image. The significance level can be set from 1% to 5% with the Significance slider at the bottom of the Wizard window.

Run Menu

Run/Co-register

In the event that, after ingestion, the two span images are not well registered, this menu item may be chosen to attempt to improve co-registration. The ENVI batch procedures for automatic location of ground control points and image warping are invoked to co-register the second image to the first image. It is advisable to first save the second image to disk before carrying out this step, as results may be unsatisfactory.

Run/Calculate ENL

Before carrying through the change detection procedure, it is necessary to estimate the equivalent number of looks (ENL) for each of the two images. The multivariate maximum likelihood estimation method described by Anfinsen et al. (2009a) is used; see also the discussion in Anfinsen et al. (2009b).

The ENL values are calculated in a running window (default 7×7 pixels) and then displayed in the Wizard view. The status bar above the Wizard view indicates calculation in progress. A histogram of the values is also displayed in an ENVI plot window , see Figure 4.

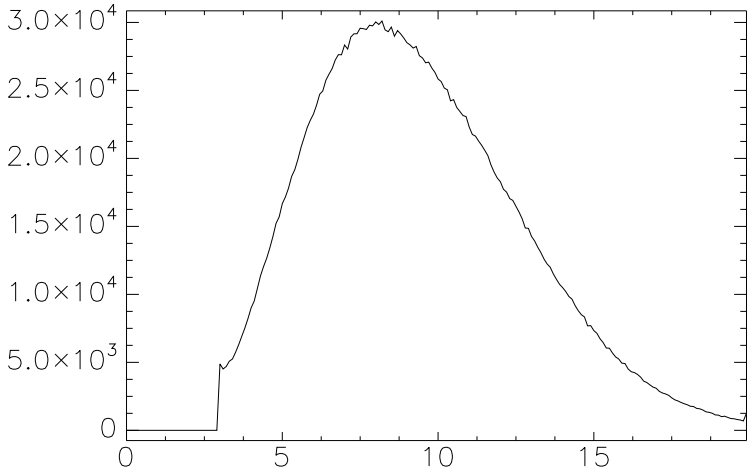

Figure 4: Histogram of ENL values.

Generally, it is sufficient to chose the mode of the histogram (position of the maximum) as global ENL value for the change detection calculation.

Run/Set ENL1

Set an ENL value for the first (time 1) image. The current value is shown in the status bar at the bottom of the Wizard window.

Run/Set ENL2

Set an ENL value for the second (time 2) image. The current value is shown in the status bar at the bottom of the Wizard window.

Run/Change detection

Carry out the pixel-wise change-no-change hypothesis tests. The status bar above the Wizard view indicates calculation in progress.

Help Menu

Help/Open help file

Display this help file in PDF format.

Help/About

Display version information.

References

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

Anfinsen, S., Eltoft, T., and Doulgeris, A. (2009b). A relaxed Wishart model for polarimetric SAR data. In *Proc. PolinSAR, 4th International workshop on science and applications of SAR polarimetry and polarimetric interferometry, Frascati, Italy*.

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.

Gens, R., Atwood, D. K., and Pottier, E. (2013). Geocoding of polarimetric processing results: Alternative processing strategies. *Remote Sensing Letters*, 4(1):38–44.