Do It Yourself 3

Speckle filtering

The objectives of this third *Do It Yourself* concern the filtering of speckle in POLSAR images and its impact on data statistics.

1. SINGLE LOOK DATA STATISTICS

1.1 Data preparation

In order to reduce the computation time, a sub-part of the original [S] matrix image is selected:

- Set the main input directory to ~/PSP_demo/DATA/Op_field.
- In the main PolSARpro widget, click Tools→[S2]→Sub-data extraction
- Select the sub-image dimensions and positions as shown in the following picture

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- Input Directory			
/home/laurent/PSP_demo/DATA/O	p_field		
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Init Row 1400 End Row	2600 Init Col	700 End Col	1400
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Figure 1 Image sub-part selection.

- Run the application

A new image has been created and is located at ~/PSP_demo/DATA/Op_field_SUB/.

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- Set the input main directory to ~/PSP_demo/DATA/Op_field_SUB/.
- Create a Pauli color-coded image



1.2 [S] matrix element statistics

1.2.1 Homogeneous area statistics

PolSARpro permits to display and analyze some statistical properties of polarimetric quantities.

- In the PolSARpro main widget, click Process \rightarrow [S2] \rightarrow Single data set \rightarrow Statistics.
- Following the software recommendation, open the Pauli image view the PolSARpro viewer.

- Click on the polygon, select a homogeneous area, save and run



Figure 4

- Different statistical are then displayed in the text window and may be saved
- Select then S11 and amplitude, select the theoretical PDF option and set it to Rayleigh and click on histogram. The histogram as well as the theoretical distribution, computed from the pre-computed moments are then displayed



- Display the histogram of S11 real part with the Gaussian theoretical distribution. Over homogeneous areas, the Gaussian assumption is generally well verified.



- The display of S11 phase argument together with the uniform theoretical distribution also validates commonly made assumptions.



Figure 7

1.2.2 Heterogeneous data statistics

Over homogeneous areas, real and imaginary parts of the scattering matrix elements are generally assumed to follow independent Gaussian statistics. Over heterogeneous this hypothesis does not hold anymore.

The following experiments show this fact over heterogeneous built up areas.

- Select a heterogeneous region over a built up area as shown in the following figure.



- Plot S11 real part histogram and compare it to a Gaussian distribution



Figure 9

-

Plot S11 amplitude histogram and compare it to a Rayleigh distribution





2. BOXCAR SPECKLE FILTER

Over homogeneous areas, the boxcar filter presents the best filtering performance. A speckle filter cannot be directly applied onto scattering matrix elements. [S] matrices have to be converted to an incoherent second order representation, e.g. [T3] matrices.

2.1.1 [S] to [T3] conversion

- Set the main input directory to ~/PSP_demo/DATA/Op_field_SUB.
- In the main PolSARpro widget, click Convert→[S2] : The conversion widget appears.
- Click on Full resolution to convert the whole image and set the output format to [T3] and run

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—Output Data Format—						
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Coherency Elements	🔶 [ТЗ]	�[T4]				
Covariance Elements	💠 [C2]	💠 [C3]	💠 [C4]			
Partial Polarimetry	💠 (s11, s21)	💠 (s12, s22)	💠 (s11, s22)			
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A new directory, containing [T3] matrix elements has been created

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18 Items - 17 Files (59.4 MB Total) - One	Folder					

2.1.2 Boxcar filtering

- In PolSARpro main window, select Process→[T3]→ Single data set→Speckle filter→Boxcar filter : The boxcar filter widget appears
- Set the window size to 5, i.e. data will be filtered using a square 5*5 sliding window, run

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16 Items - 10 Files (28.9 MB Total) - 6	Folders				

Figure 14

- Create a Pauli color coded image from the filtered data



The filtered image aspect is less random, the contrast is significantly enhanced: the box filtered reduced speckle variance.

2.2 Filtered image statistics



- Select an homogeneous area over the filtered image and display T11 histogram

Figure 16



Figure 17 Filtered T11 histogram

- Select approximately the same area over the unfiltered image (~/PSP_demo/DATA/Op_field_SUB/T3) and display T11 histogram with a theoretical exponential distribution.



Figure 18 Unfiltered T11 histogram

On may then check that over homogeneous areas T11 follows an exponential distribution over which the mean amplitude cannot be visually determined.

After filtering, T11 is known to follow a chi-2 distribution. The histogram clearly shows a central value and depicts a less random behavior.

3. LEE SPECKLE FILTER

The Lee filter adapts the amount of filtering to the local statistics. Homogeneous areas are filtered with the maximum strength, whereas point scatterers are let unfiltered. Moreover an improved version of the filter uses directional windows to better preserve edges and heterogeneous features.

- Repeat the same manipulation than for the box filter, but select the Lee filter option instead.
- Choose a window size of 7 so that the number of pixels used to compute the filtered values is almost equal to 25, run
- A new directory, containing [T3] matrix elements, has been created

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+ Op_field_SUB	4.0 KB	Folder	2006-07-22 12:56	drwxr-xr-x	
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- Create a Pauli image of the filtered data



The comparison of Pauli images zoomed over point scatterers permits to appreciate the refinement of the LEE filter



Figure 21 Zoom of the box filtered Pauli image



Figure 22 Zoom of the Lee filtered Pauli images