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

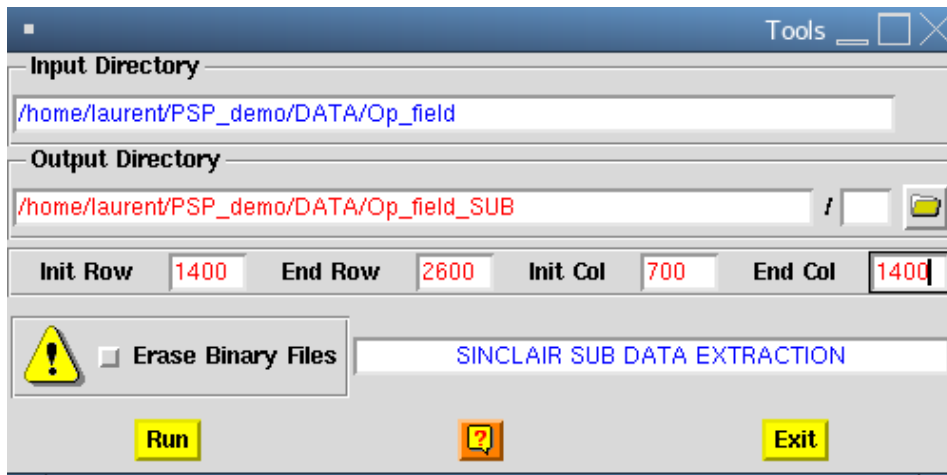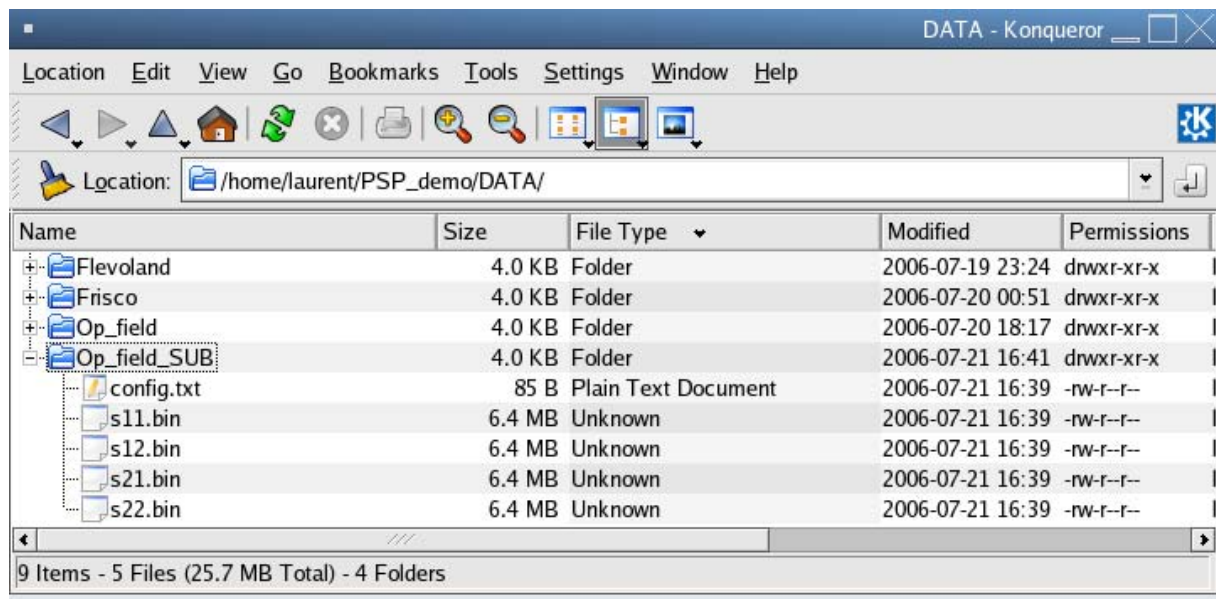- Select the sub-image dimensions and positions as shown in the following picture

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/.

Figure 2

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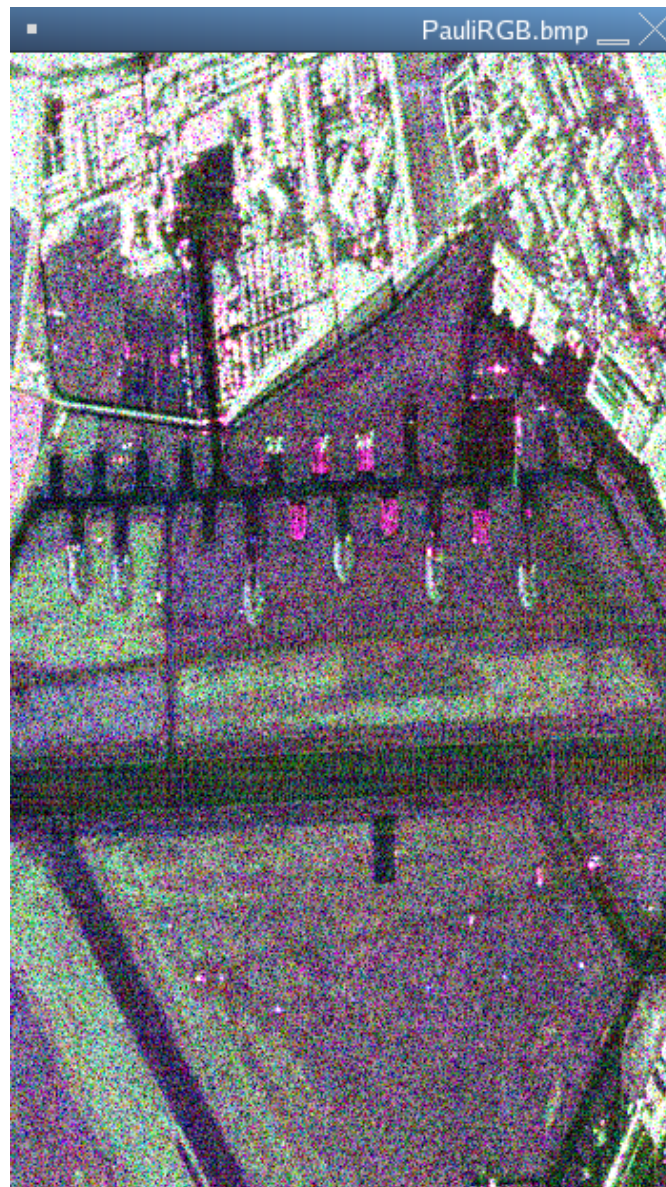- Create a Pauli color-coded image

Figure 3

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→[S2]→Single data set→Statistics.
- Following the software recommendation, open the Pauli image view the PolSARpro viewer.

- Click on the polygon, select a homogeneous area, save and run
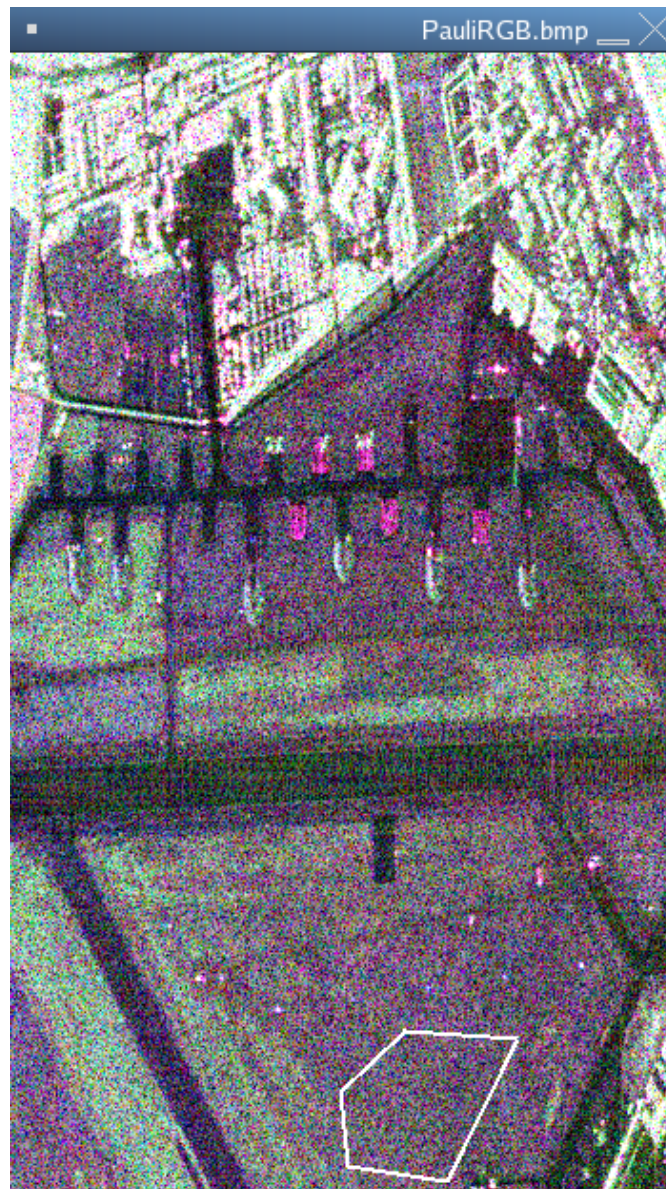
Figure 4

- 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

S11 Amplitude (Rayleigh model)
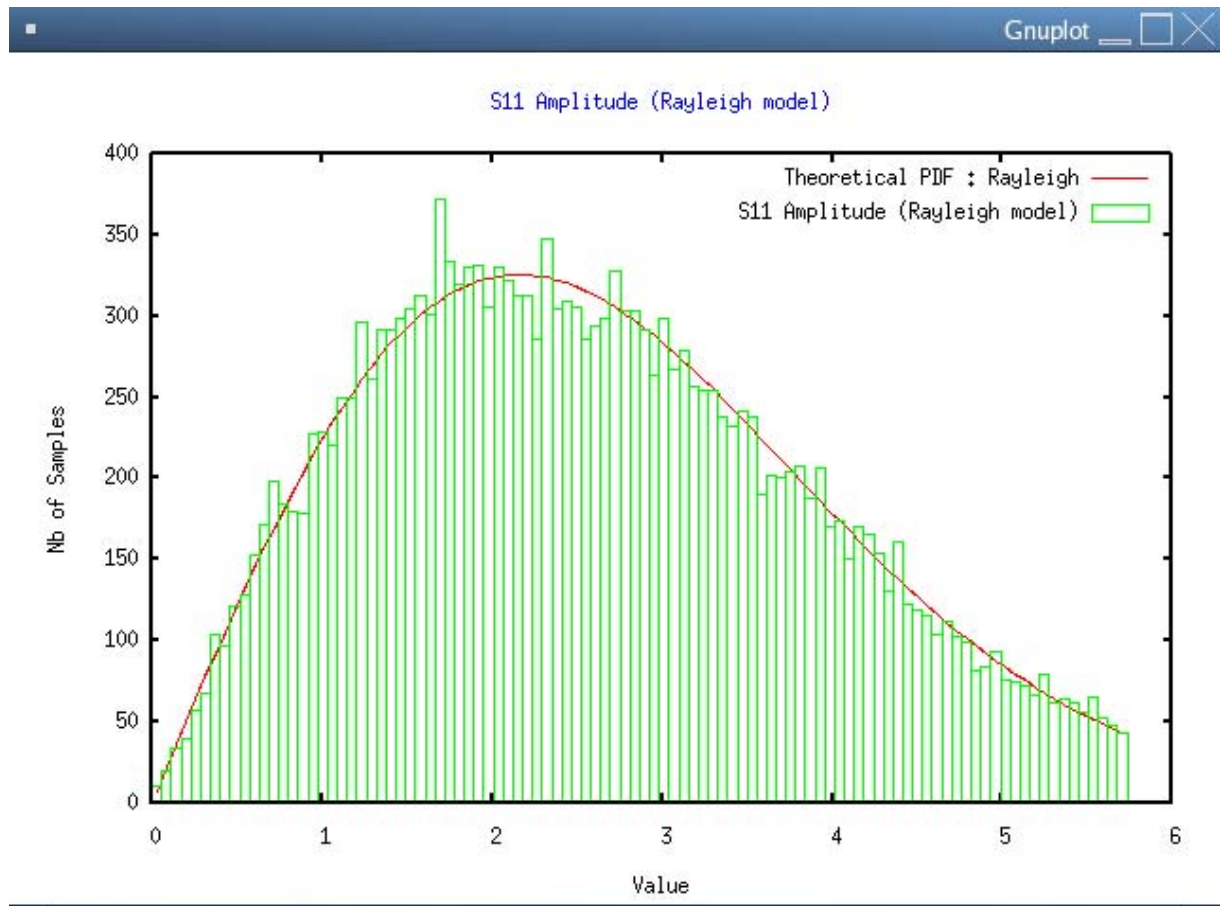
Figure 5

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

S11 Real Part (Gaussian model)
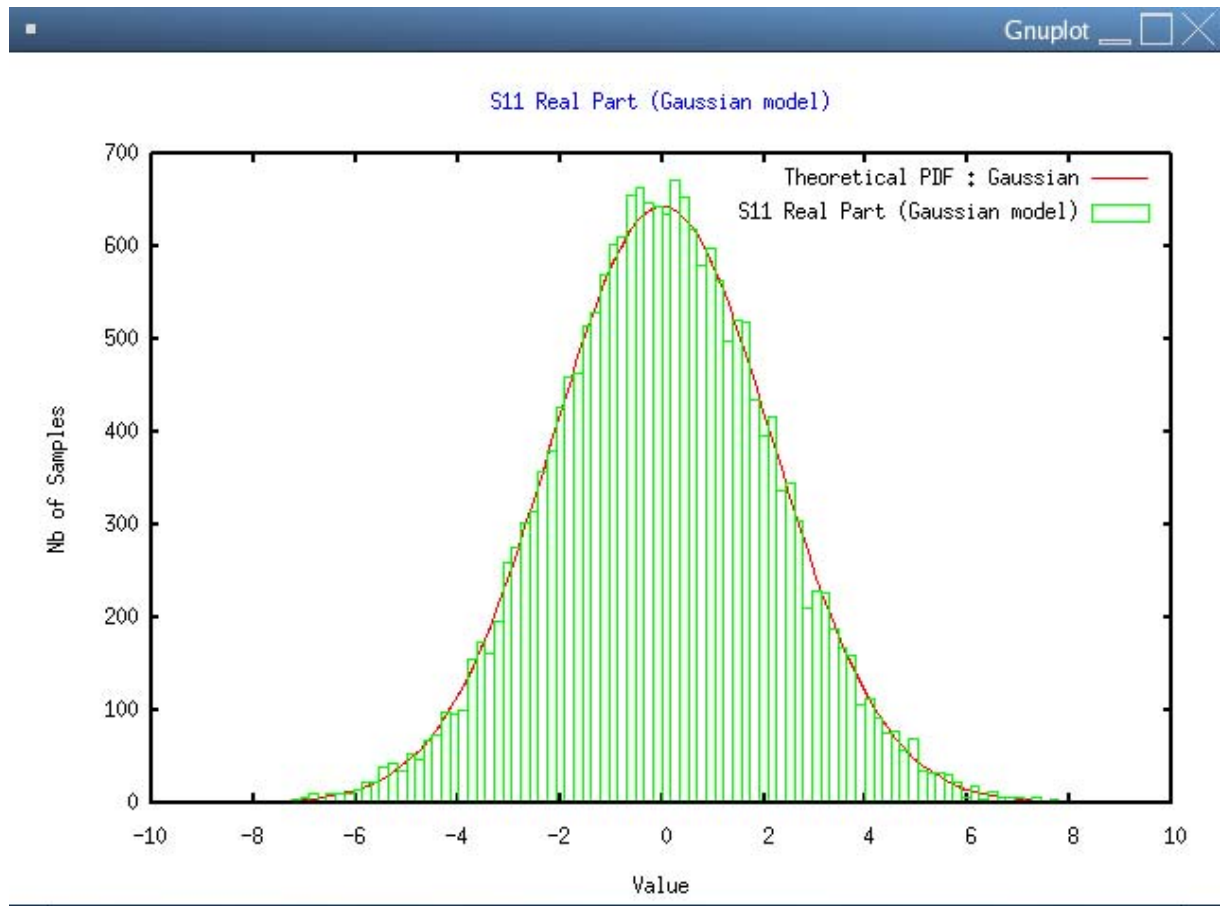
Figure 6

- The display of S11 phase argument together with the uniform theoretical distribution also validates commonly made assumptions.
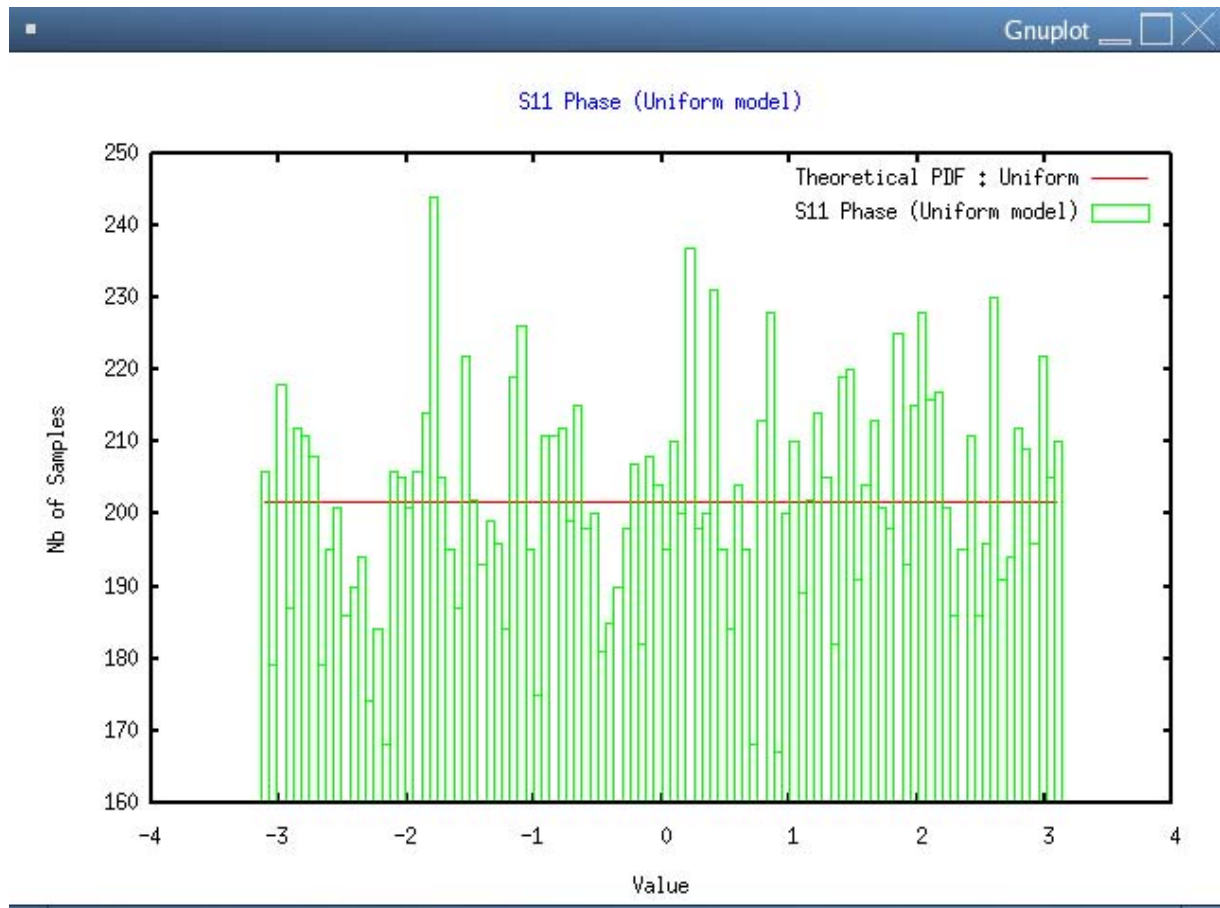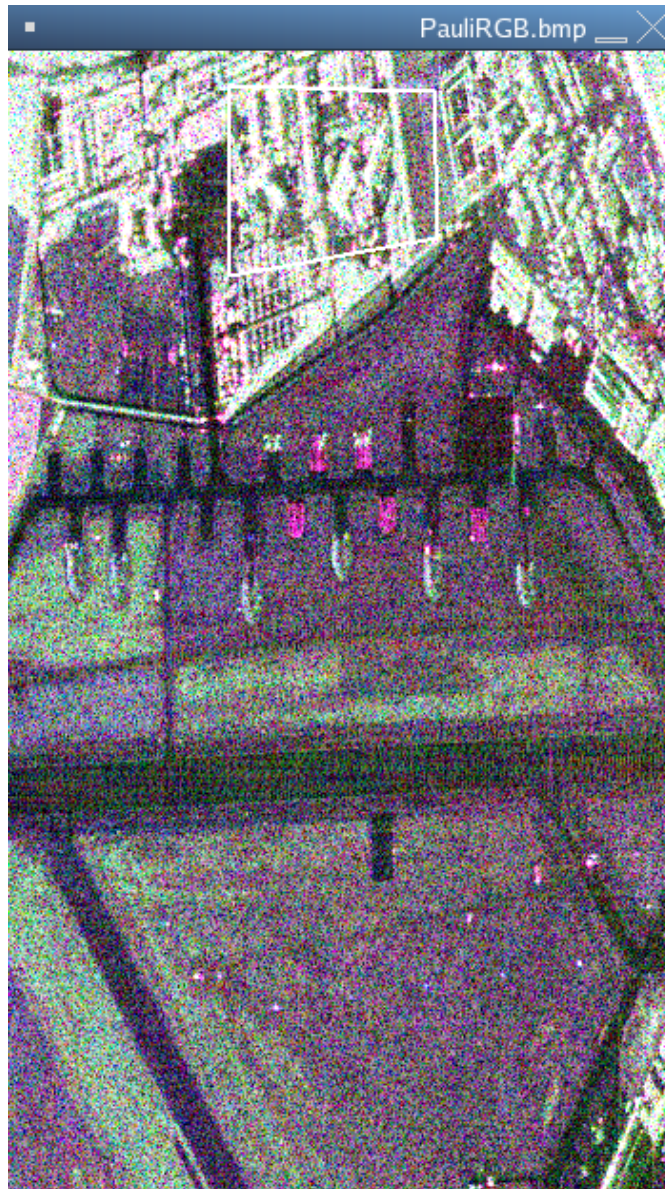
Figure 7

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.

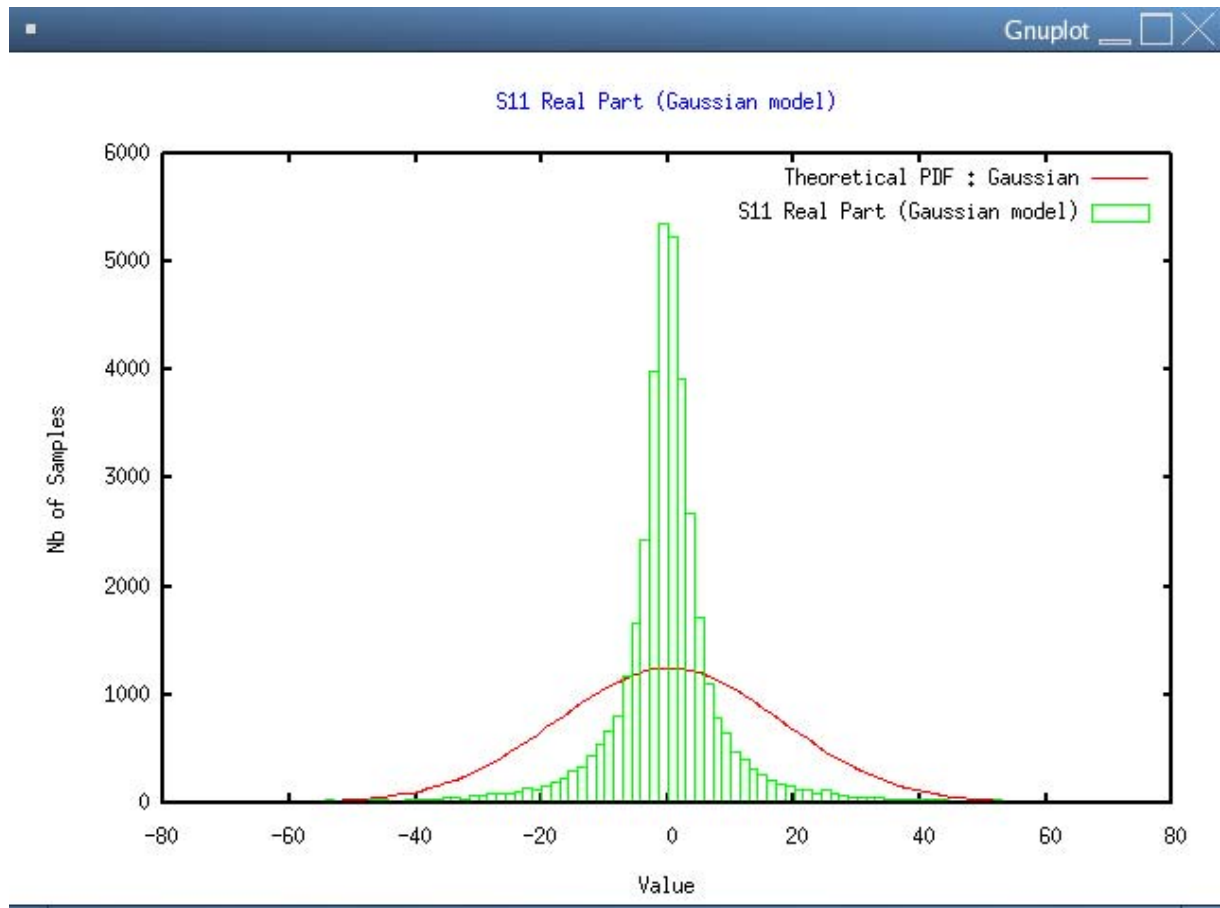The following experiments show this fact over heterogeneous built up areas.

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

Figure 8

- 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
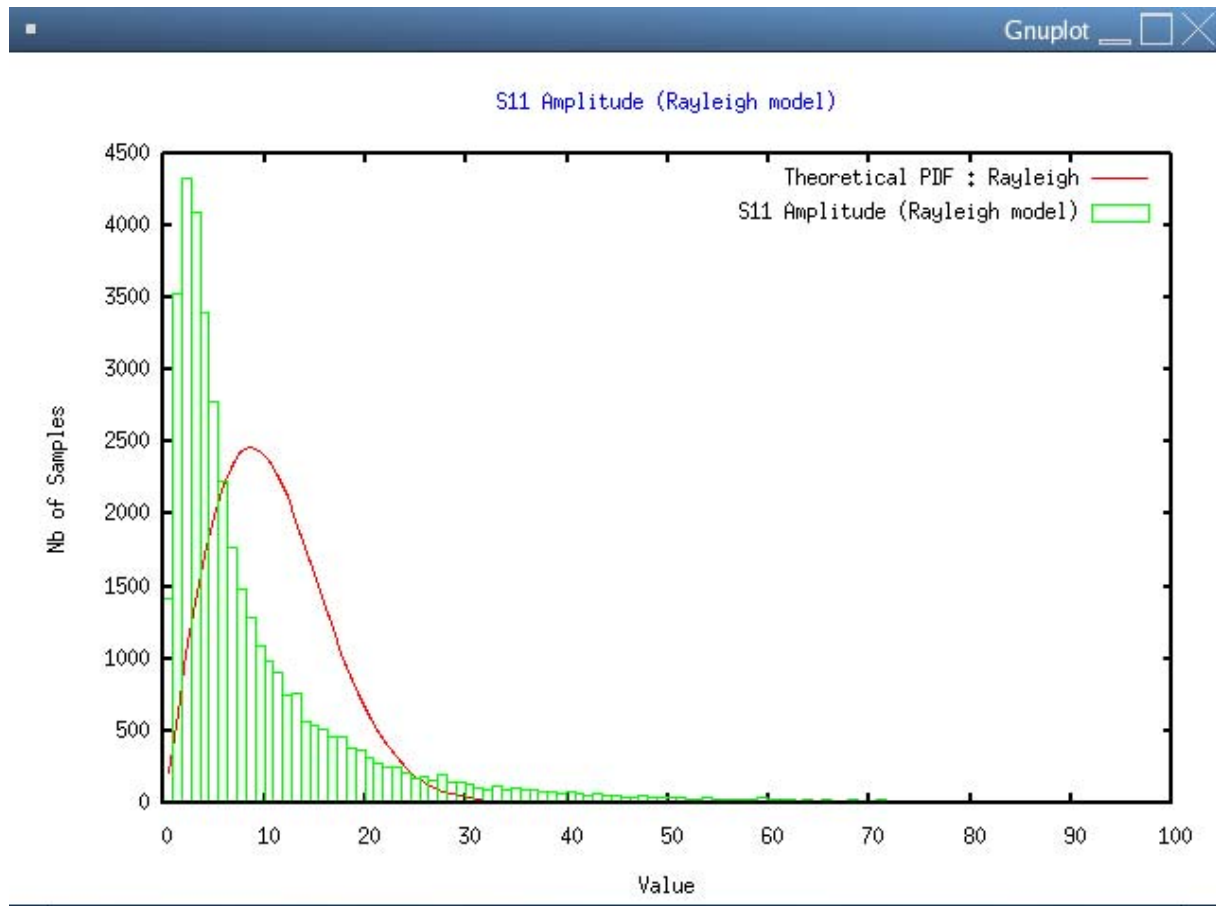
Figure 10

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

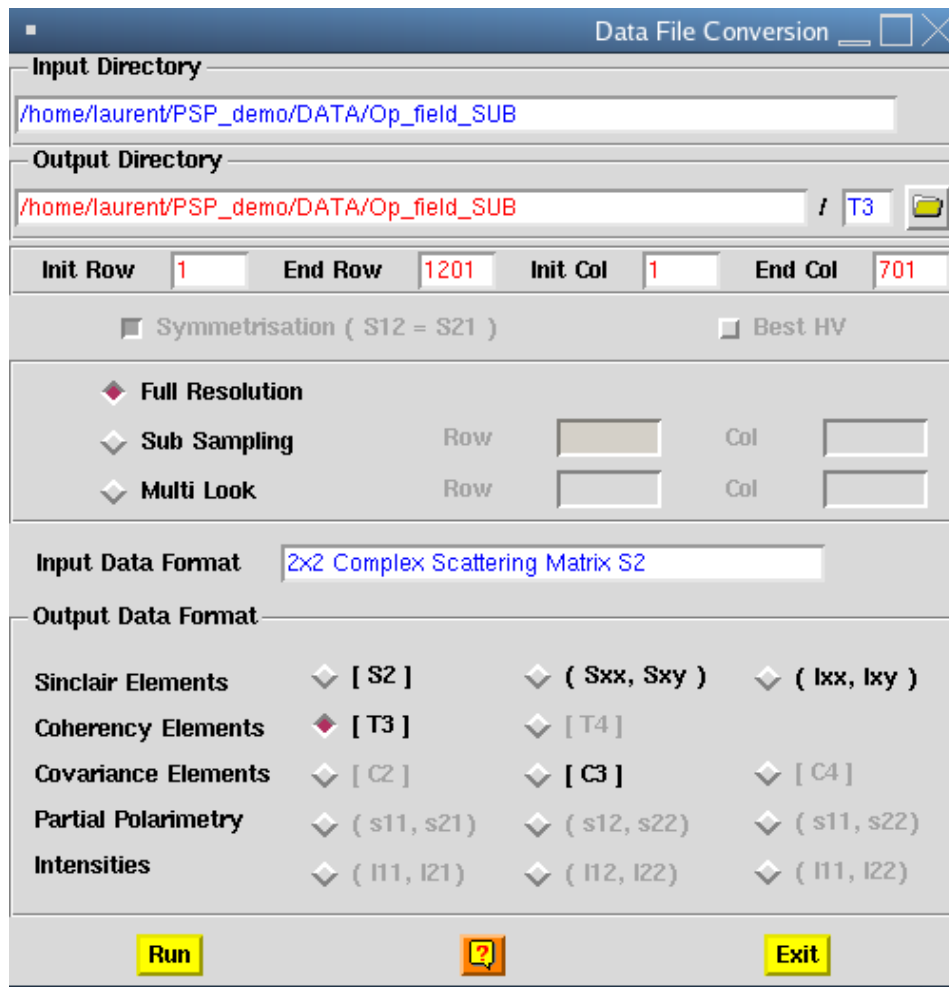**Figure 11**

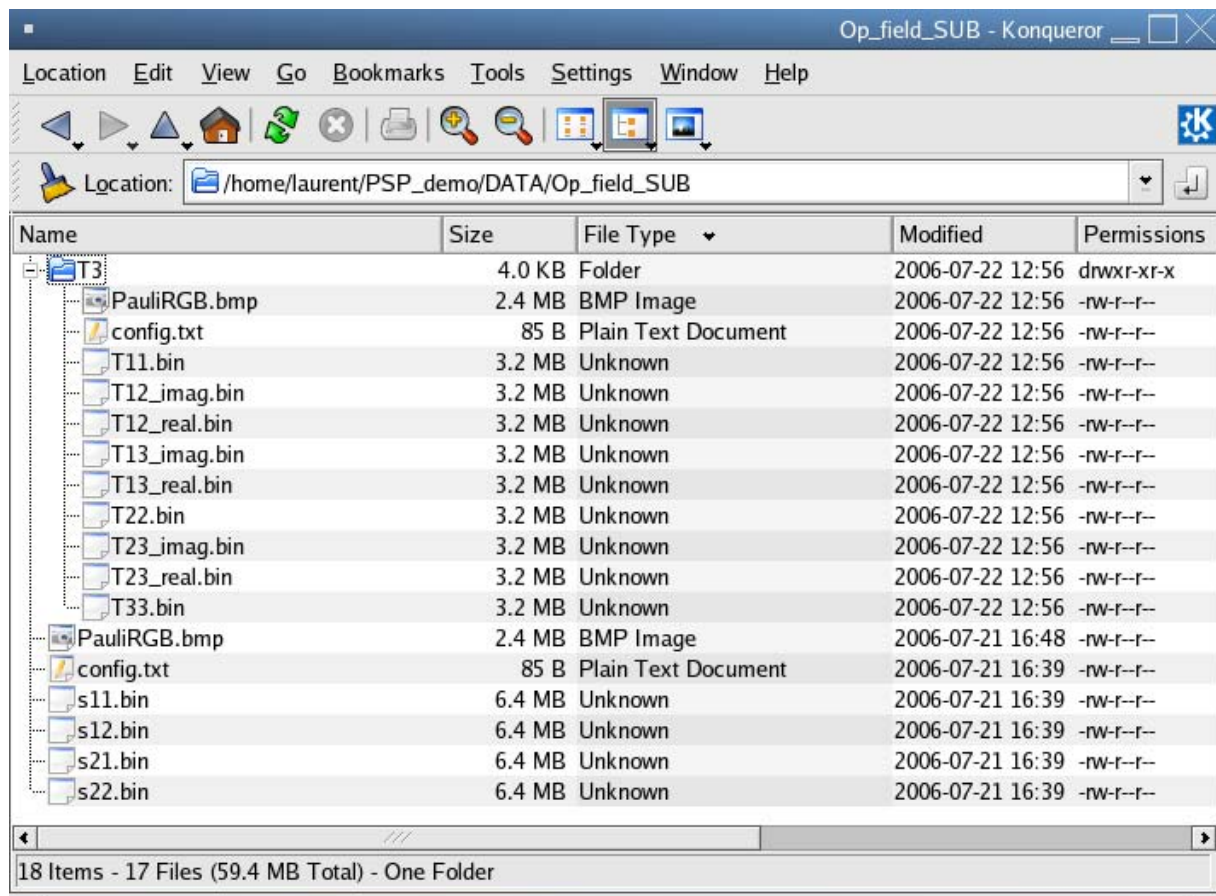A new directory, containing [T3] matrix elements has been created

Figure 12

2.1.2   Boxcar filtering

- In PolSARpro main window, select Process→[T3]→ Single data set→Speckle filter→Boxcar filter : The boxcar filter widget appears

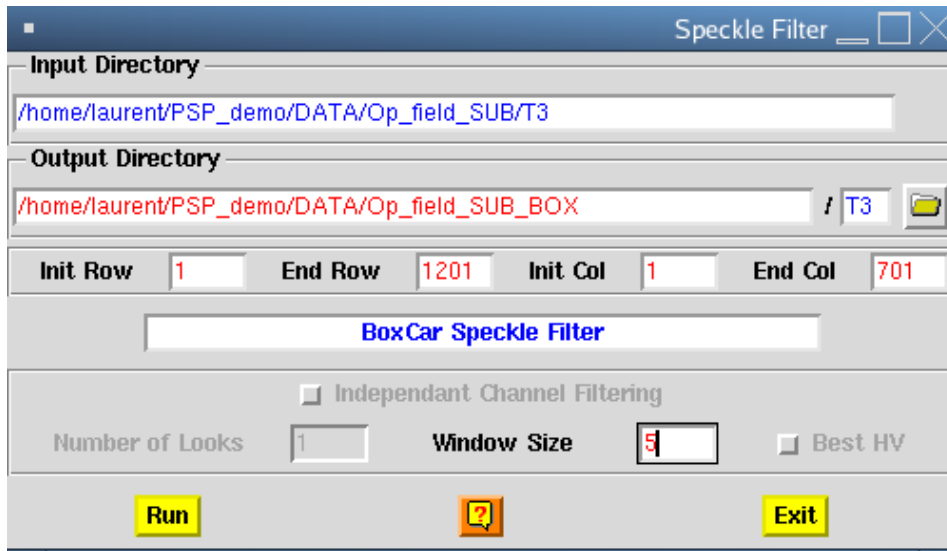- Set the window size to 5, i.e. data will be filtered using a square 5*5 sliding window, run

Figure 13

A new directory, containing [T3] matrix elements, has been created
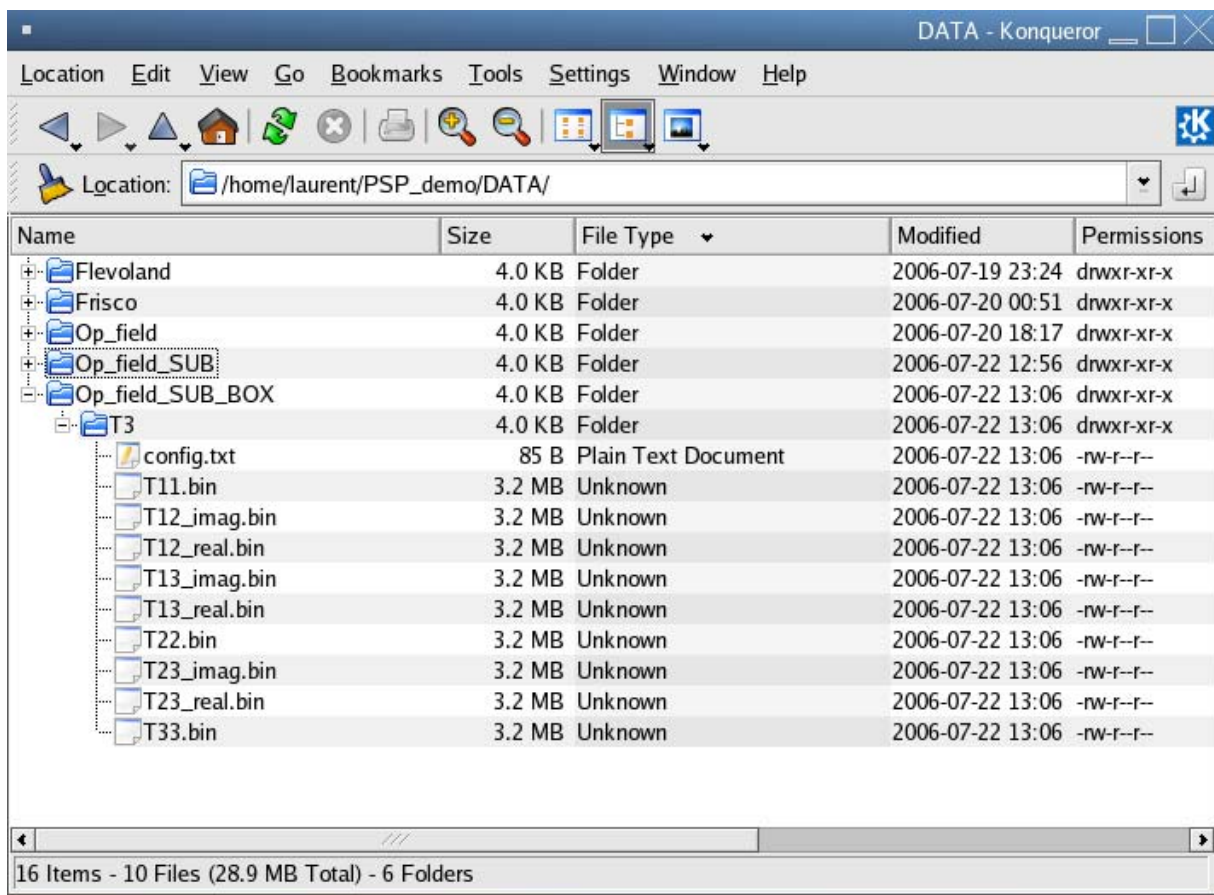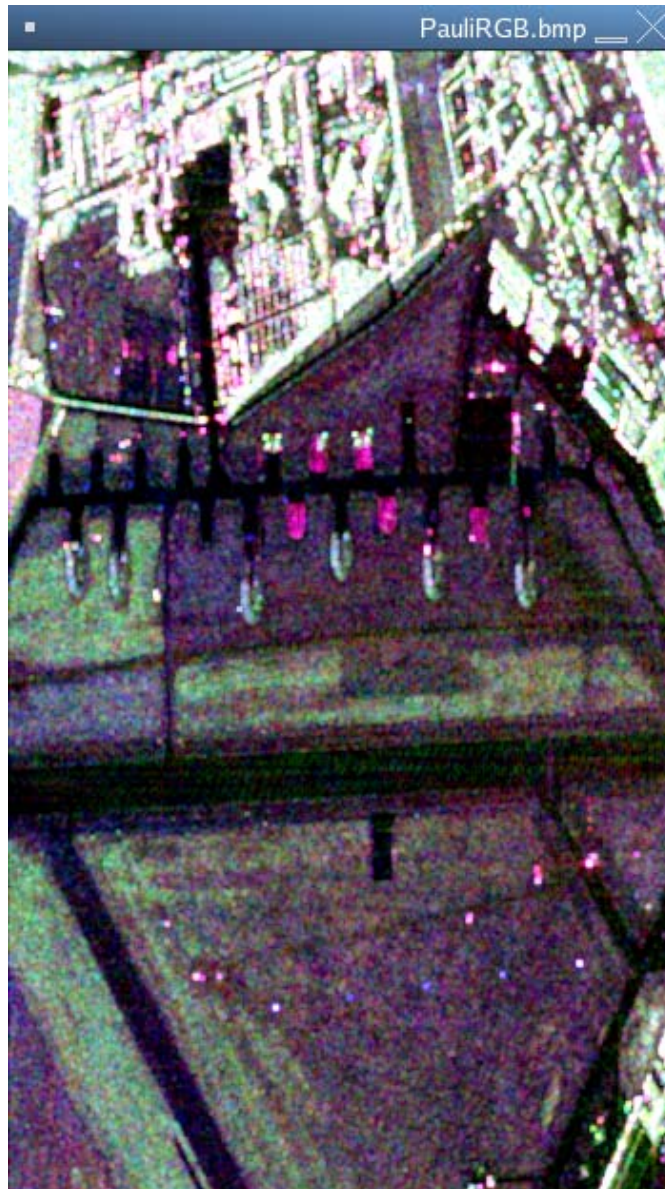

Figure 14

- Create a Pauli color coded image from the filtered data

Figure 15

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
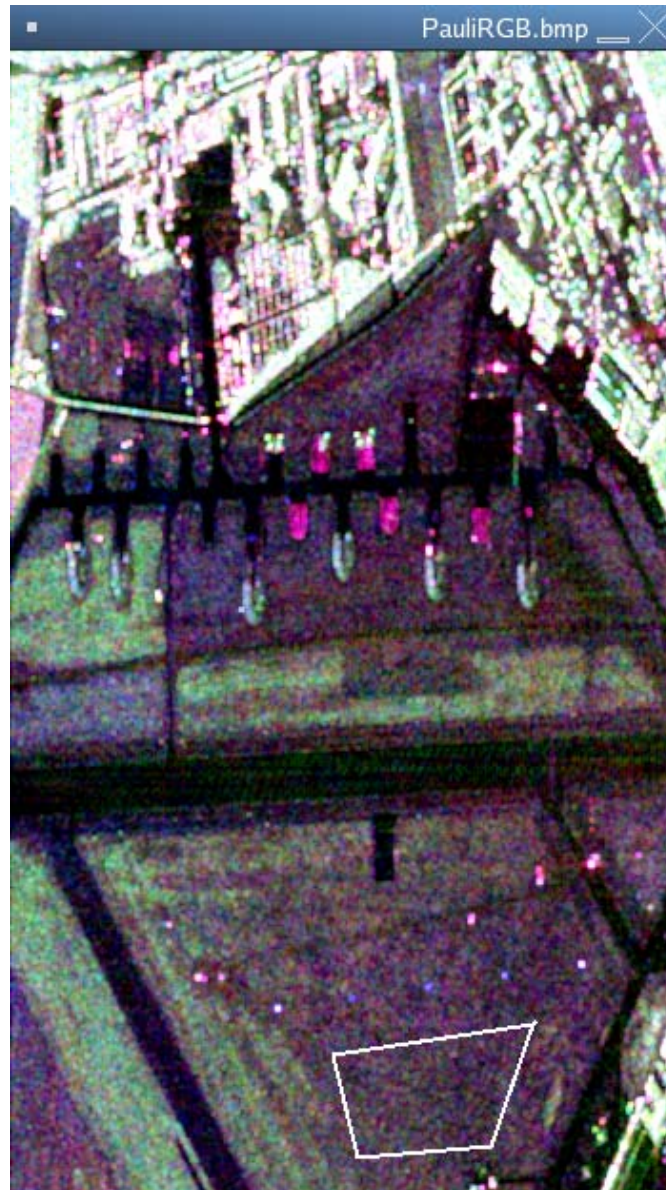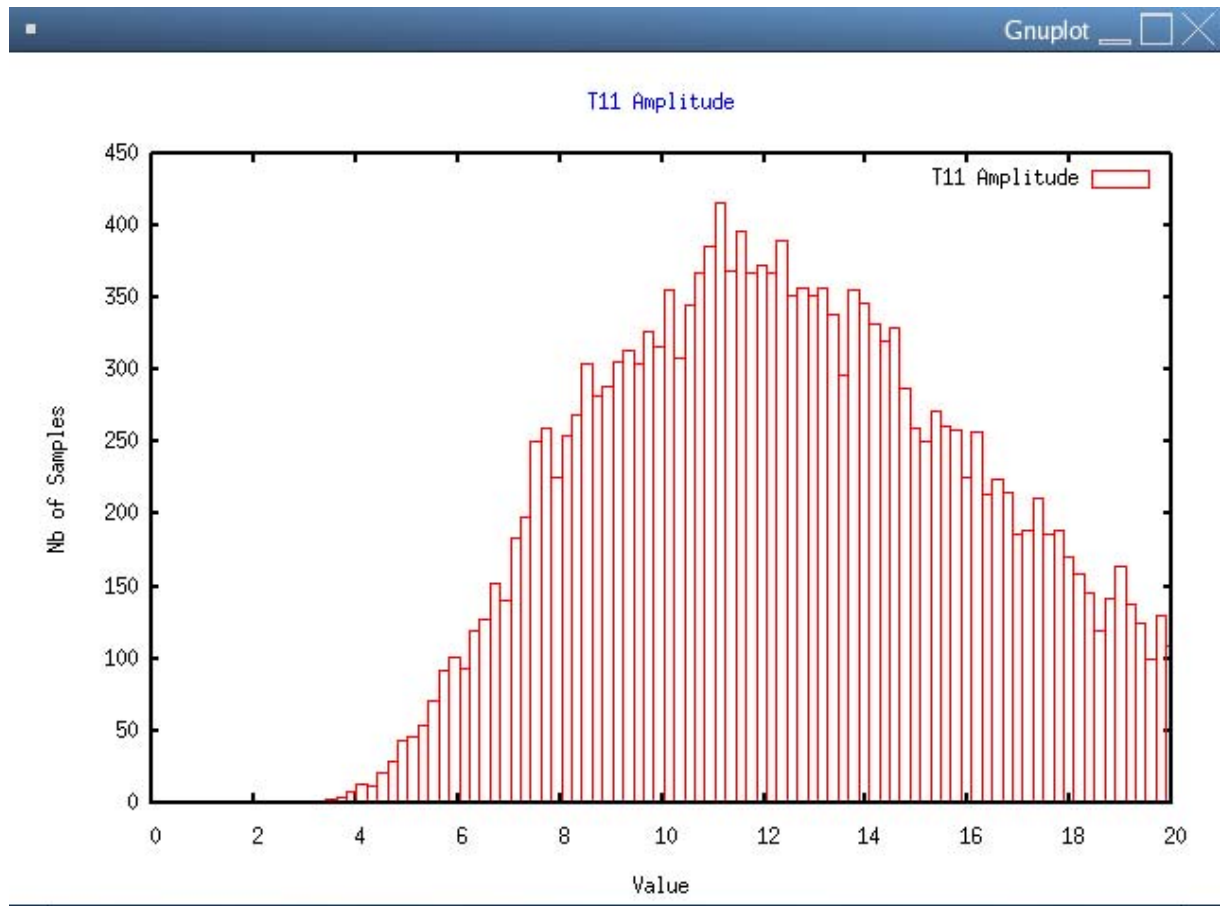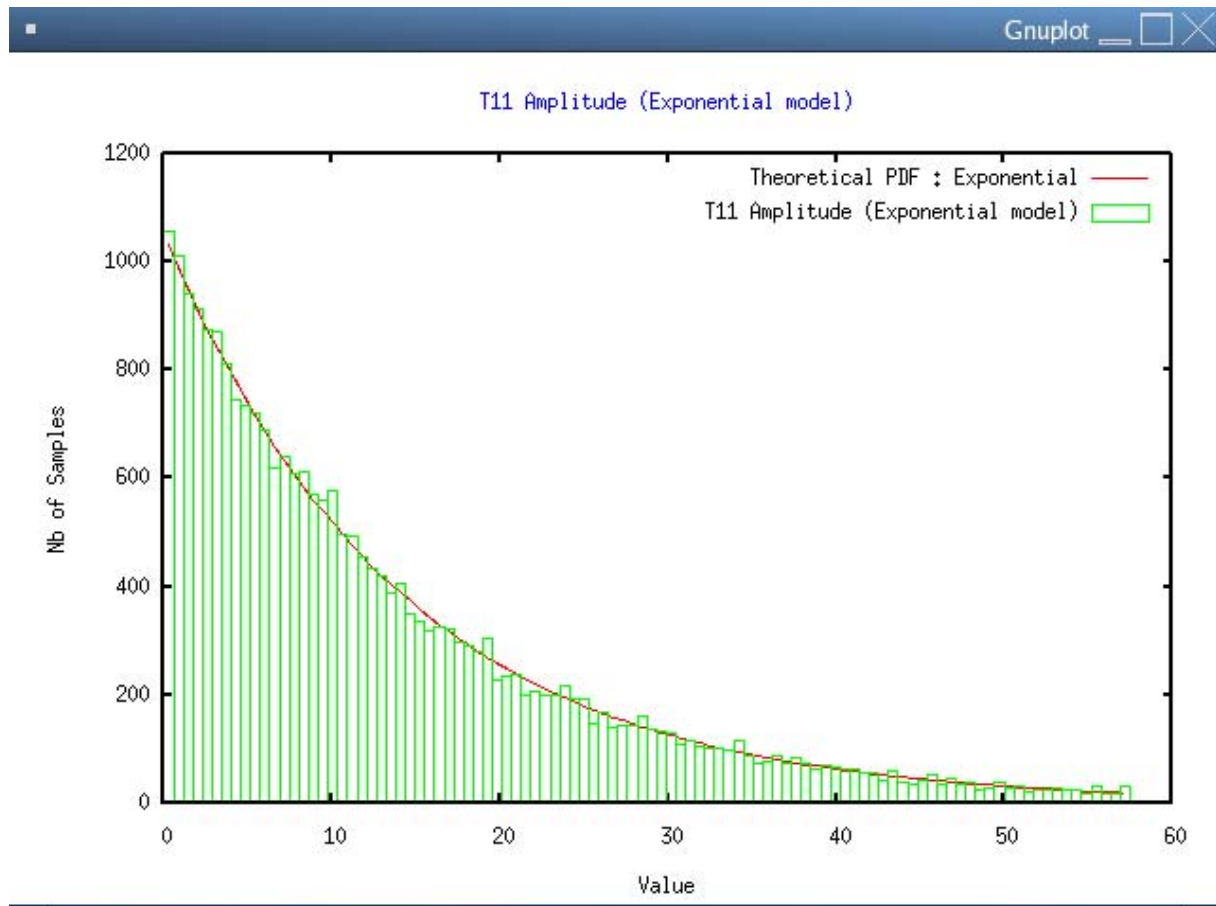

Figure 16

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

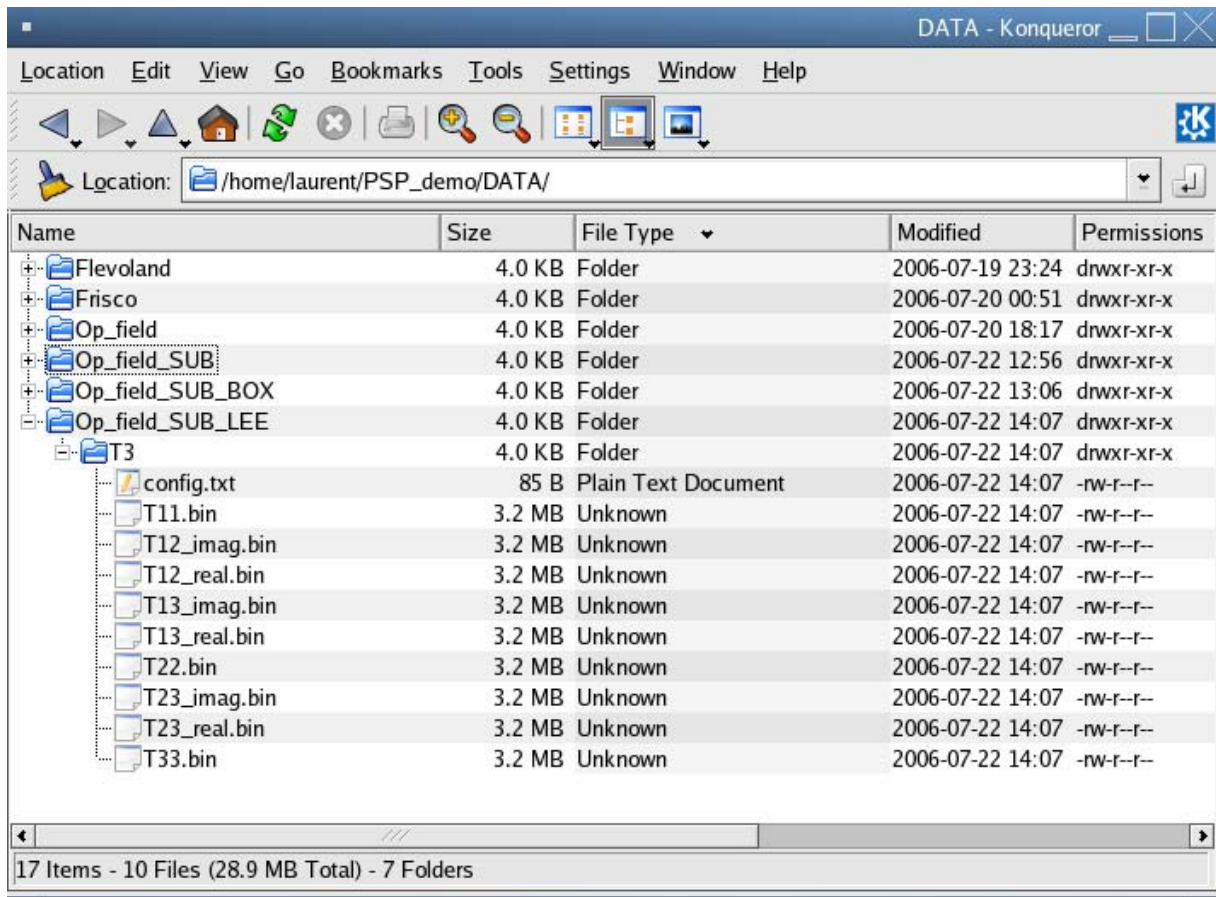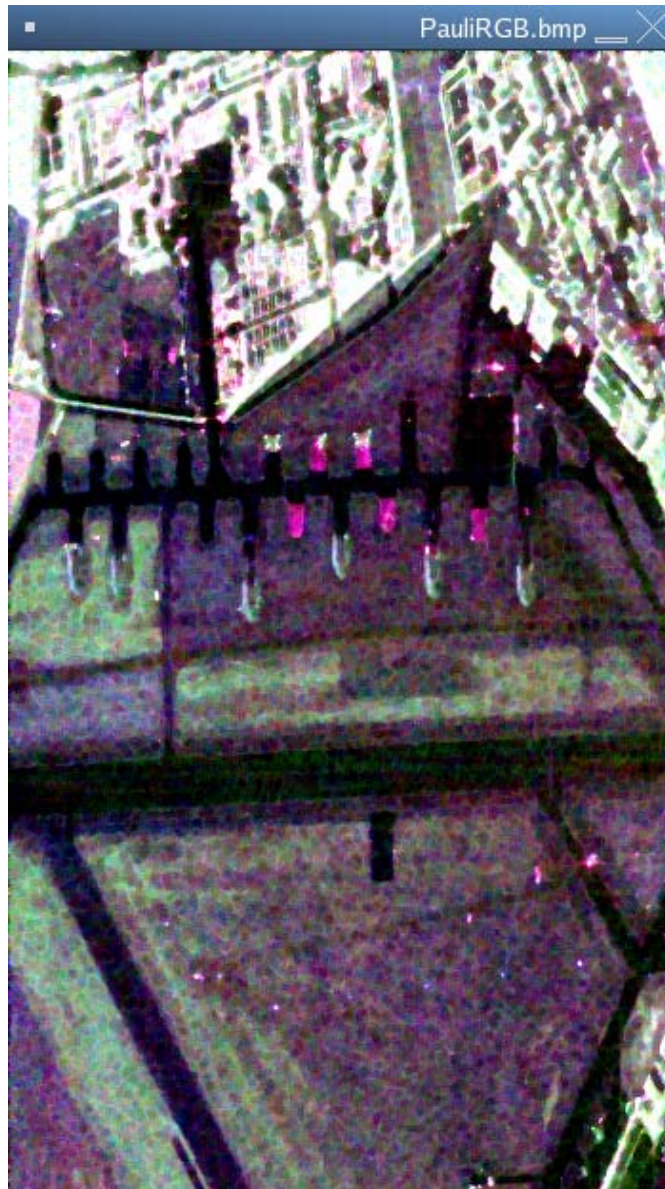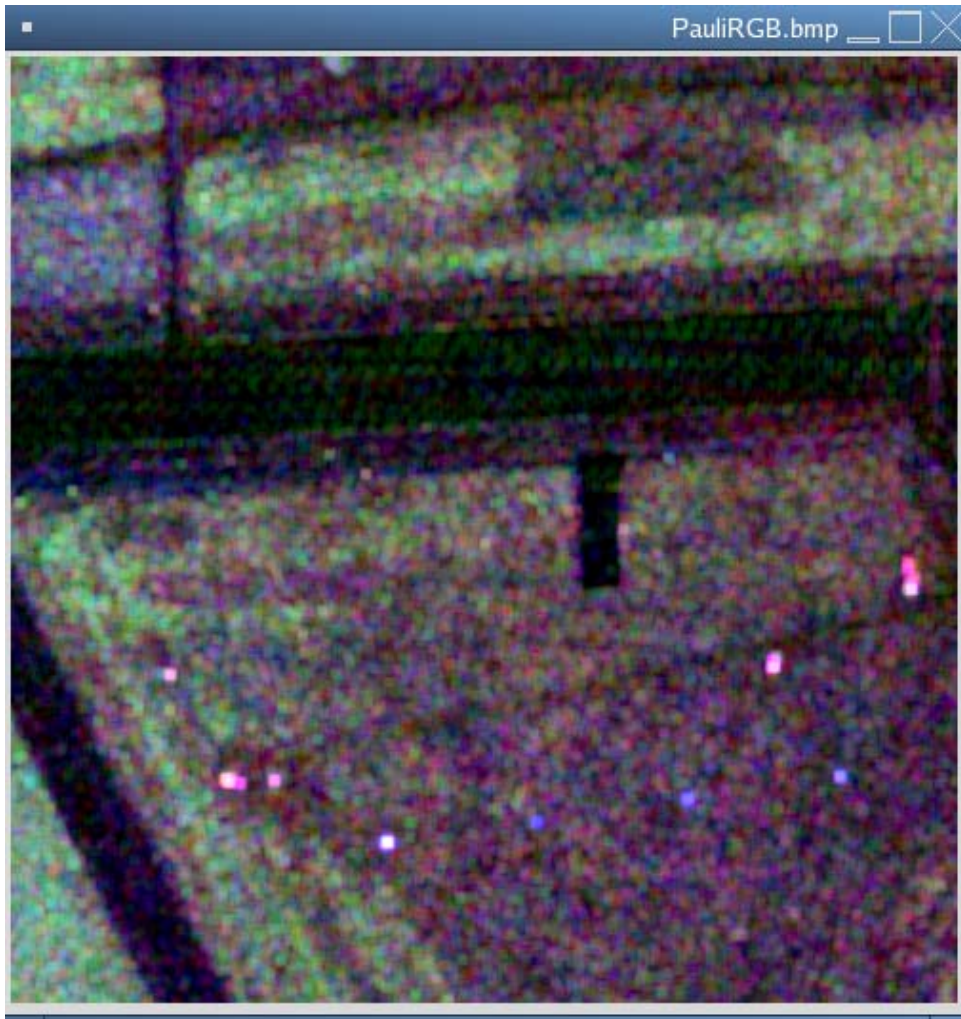- A new directory, containing [T3] matrix elements, has been created

Figure 19

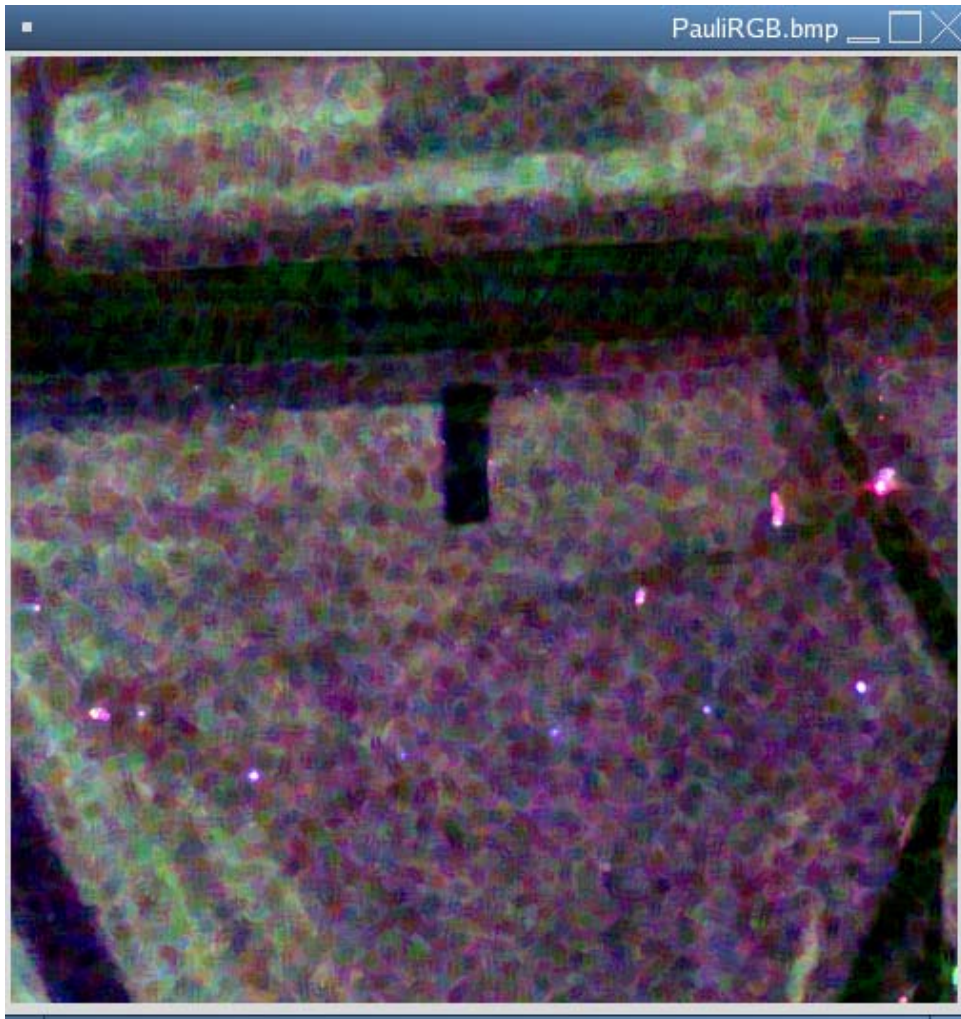- Create a Pauli image of the filtered data

Figure 20

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