**ScanSAR-FBD combination**

In order to efficiently combine ScanSAR results with FBD, the ScanSAR SD must be co-registered and re-sampled over the FBD footprint to the FBD resolution of 12.5 m. I found this to be the best method but it is very time consuming (a whole day, or more if I made a slip) and fiddly. Different machines ran Envi and matlab so I have indicated where data need to be transferred – this may not be the case for you.

In ENVI obtain FBD footprint using bandmath to get 1/intensity. Then mask everything that is Inf. Use raster to vector (with DN=1) to make an Envi vector file (.evf) (e.g. P443_F7170_C12.X.evf). Use this to select the FBD footprint region of the ScanSAR image. Make a mask of this footprint on the ScanSAR base image (e.g. S1_P443_F7170.fpt). Sftp to the machine running matlab (if necessary) and use enviread to import to a matlab array.

In matlab use sdmap.m to obtain temporal standard deviation (nwin=2) for the ScanSAR set normalised to the forest region covering the FBD image. So use e.g. sdmap(a, 2, FBD_X.*PF07) where FBD_X is the FBD mask and PF07 is the forest mask. Enviwrite to e.g. S1-P443_F7170_SD_PF07.env (in the end I shortened to F1, F2… to indicate the FBD name, i.e. it would become S1-F1_SD_PF07.env) and sftp to local machine. Edit header from the reference ScanSAR image to get geo-data. Check that the projection for the ScanSAR and FBD are the same.

The ScanSAR standard deviation results need to be co-registered with the FBD image but are insufficiently detailed to get ground control points. Therefore the strategy is to work with the reference ScanSAR image in tandem with the SD results using ground control points from the reference to co-register both.

From the FBD footprint, (overlaid as a vector on the reference file) use cursor location to get maximum and minimum x and y coordinates to extract a rectangular region enclosing the footprint (bounding box) – leave some leeway for warping to take place (~extra 50 pixels all round).

**Note** that saving as greyscale image or tiff will convert SD values to 1-255 so the best way to do all this use bandmath to multiply the reference scene by 1 (b1*1) and choose to save as the required spatial subset e.g. S1-ss.env (envi format where the ss stands for subset). Use the convenient “previous” option in the “Select Spatial Subset” menu to get the same subset for S1-SD_PF07.env. Check the result by overlaying the FBD vector footprint.

Use “resize” with cubic convolution from the basic tools menu to resample S1-ss.env and S1-SD_PF07-ss.env to 12.5 m. I used names S1-ss-8X.env and S1-SD_PF07-ss_8X.env.

**Co-registration**

Open and display FBD image and resized ScanSAR image in Envi.
Check/Change geographic data so that both have the same UTM (WGS-84) and projection.

Choose Map/Registration – select GCP's image to image.
In the Main FBD image window, find a suitable control point. Right click to get Geographic link and find the same point in the ScanSAR image. SWITCH OFF the geographic link. In the main window for FBD click on the control point e.g. sharp river bend, bridge, crossroads etc. Find the best estimated position on the ScanSAR image and click on that. It may be better in some cases to do it the other way around – i.e. find a recognisable point on the ScanSAR image first. Click "add point". Many features visible on FBD are not apparent in ScanSAR.

Switch the geographic link back on and repeat to find several points. Save GCP's to ascii (saves as .txt not .pts). See Envi Tutorials p 126-128. (Note I was unable to reload this file as saved; it needed editing to give just four columns.) In Ground Control Points Selection dialogue: Options>warp displayed band. Choose method: polynomial degree2, resampling MUST use cubic convolution – nearest neighbour caused degradation of signal. This gives a resampled ScanSAR image S1-ss-8X-warp.env co-registered with the FBD image.

Now open the standard deviation file (S1_SD_F1f). In Ground Control Points Selection dialogue: Options>warp File and choose it. Use the same ground control points as before, (Restore GCP's from ASCII) be sure to choose cubic convolution as the method. Save. ( e.g S1-SD_PF07-ss_8X-warp.env).

Now the warped images are co-registered with the FBD image but will still be slightly larger in extent if some leeway was allowed for the manipulations. The best way I have found to obtain the required subset image is again to use bandmath with expression b1*1 to get a spatial subset dialog. Obtain the the upper Left corner pixel coordinates of the warped file (e.g. S1-ss-8X-warp.env) from the header information e.g. xstart = -51, ystart = -102. The FBD file should have xstart = +1, ystart = +1 and unless the ScanSAR file has the same values and has the same number of lines & samples there will be overhang at the edges when the images are linked and ENVI will give an error. If the FBD total image size is X, Y then put –(xstart) + 2 in the box for starting values of samples and for the lines –(ystart)+2. Then put –(xstart) +2 +X -1 in the "To" box for samples and –(ystart) +2 +Y-1 in the "To" box for lines. Blank out the NS and NL boxes (when I tried to use these instead I got an error). So for the example I am working on X=6500, Y = 5800 and the boxes look like:

Samples 53 To 6552 NS blank

Lines 104 To 5903 NL blank

Then save with a new name, e.g. S1-ss-8X-reg.env, to indicate “registered” and avoid lengthy naming.

Import the result to matlab using Enviread.

In matlab use R1-compare.m to obtain the ratios R1, T1 and T2 from the FBD image. Assign SD to the ScanSAR temporal deviations and combine by the sum-rule using fuse_scores.m or by PCA (see FBD_analysis).

**Note** that for this application I did the co-registration manually using Envi, the reason being that ground control points are stored and can be used to apply the same warp to the standard deviation file. Maybe it would be possible (and more automatic) to use the Gamma procedures; I was not sure how to transfer the appropriate parameters to warp the SD file. In any case one would have to test the result against a manually co-registered SD file.