URBAN FOOTPRINT MAPPING WITH SENTINEL-1 DATA

Data: Sentinel-1A IW SLC 1SSV:

- S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D
- S1A_IW_SLC__1SSV_20160126T005142_20160126T005207_009658_00E14A_49C0

Calculation of geocoded terrain corrected backscatter intensity from an SLC dataset

1. Open file
   1.1. File / Open Product
   "S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D"
   "S1A_IW_SLC__1SSV_20160126T005142_20160126T005207_009658_00E14A_49C0"
2. View image single bands
   2.1. Select "Bands" folder in "Product Explorer" window and view each band by double clicking on band name.
   2.2. You will see SAR data in Single Look Complex (SLC)-format. The SLC data contain phase and amplitude information. From two phases you can calculate an interferogram and an interferometric coherence (Steps 11-16).
3. Data subset
   3.1. Radar / Sentinel-1 TOPS / S-1 TOPS Split
   3.2. In the "Processing Parameters" select
   Subswath "IW1" and Bursts "4 to 8"
   3.3. In the "I/O Parameters" select
   "S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D". The target product will be automatically renamed with the ending "_split".
   3.4. Select "Run"
4. Apply precise orbits *(why? The orbit file provides accurate satellite position and velocity information. Based on this information, the orbit state vectors in the abstract metadata of the product are updated)*
   4.1. Radar / Apply Orbit File
   4.2. In the "I/O Parameters" select
   "S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split". The target product will be automatically renamed with the ending "_Orb".
   4.3. In the "Processing Parameters" check "Do not fail if new orbit file is not found"
   4.4. Select "Run"
5. Radiometric Calibration
   5.1. Raster / Radiometric / Calibrate
   5.2. In the "I/O Parameters" select
   "S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split_Orb". The target product will be automatically renamed with the ending "_Cal".
   5.3. View the "Processing Parameters" tab (but leave all settings as default)
   5.4. Select "Run"
6. TOPS Deburst *(In order to remove gaps in the image we apply TOPS Deburst function)*
   6.1. Radar / Sentinel-1 TOPS / S-1 TOPS Deburst
   6.2. In the "I/O Parameters" select
   "S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split_Orb_Cal". The target product will be automatically renamed with the ending "_deb".
   6.3. View the "Processing Parameters" tab (but leave all settings as default)
   6.4. Select "Run"
7. Multi-Looking
   7.1. Radar / Multilooking

7.2. In the “I/O Parameters” select “S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split_Orb_Cal_deb”. The target product will be automatically renamed with the ending “_ML”.
7.3. In the “Processing Parameters” check “GR Square Pixel”. You should get automatically “Number of Range looks”. By clicking “Independent Look” you can define the “Number of Azimuth Looks”.
7.4. Select “Run”

8. Convert to dB
8.1. Expand the bands of the speckle filtered stack in the “Product Explorer” window
8.2. Right mouse click on each band and select “Linear to/from dB”
8.3. Save the newly created virtual band to actual band by right clicking on the band and selecting “Convert band”

9. Geocoding / Terrain Correction
9.1. Radar / Geometric / Terrain Correction / Range Doppler Terrain Correction
9.2. In the “Processing Parameters” leave all settings as default (you can set pixel spacing, map projection of the output product and select additional output bands (e.g. “DEM”, “Local incidence angle” etc.)
9.3. In the “I/O Parameters” select “S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split_Orb_Cal_deb_ML”. The target product will be automatically renamed with the ending “_TC”.
9.4. Select “Run”
9.5. Open the terrain corrected Sigma0_VV_db. Now the dataset is geocoded.

10. Repeat the steps 3-9 for “S1A_IW_SLC__1SSV_20160126T005142_20160126T005207_009658_00E14A_49C0”

11. Close all products

Calculation of geocoded interferometric coherence from two SLC datasets

12. Open file
12.1. File / Open Product “S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split_Orb” and “S1A_IW_SLC__1SSV_20160126T005142_20160126T005207_009658_00E14A_49C0_split_Orb”

13. Coregistration of SLC pairs
13.1. Radar / Coregistration / S1 TOPS Coregistration / S-1 Back Geocoding
13.2. In the “ProductSet-Reader” add “S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split_Orb” and “S1A_IW_SLC__1SSV_20160126T005142_20160126T005207_009658_00E14A_49C0_split_Orb”
13.3. View the “Back-Geocoding” tab (but leave all settings as default)
13.4. In the “Write” the target product will be automatically renamed with the ending “_Stack”.
13.5. You can reduce the product name by removing the acquisition date information. Your product will have the name for example “S1A_IW_SLC__1SSV_split_Orb_Stack”.
13.6. Select “Run”

14. Coherence estimation
14.1. Radar / Interferometric / Products / Coherence Estimation
14.2. In the “I/O Parameters” select “S1A_IW_SLC__1SSV_split_Orb_Stack”. The target product will be automatically renamed with the ending “_coh”.
14.3. View the “Processing Parameters” tab (but leave all settings as default). Here you can change the coherence window size in Range and Azimuth direction.
14.4. Select “Run”

15. TOPS Deburst *(In order to remove gaps in the image we apply TOPS Deburst function)*
15.1. Radar / Sentinel-1 TOPS / S-1 TOPS Deburst
15.2. In the “I/O Parameters” select “S1A_IW_SLC__1SSV_split_Orb_Stack_coh”. The target product will be automatically renamed with the ending “_deb”.
15.3. View the “Processing Parameters” tab (but leave all settings as default)
15.4. Select “Run”

16. Multi-Looking

16.1. Radar / Multilooking
16.2. In the "I/O Parameters" select "S1A_IW_SLC__1SSV_split_Orb_Stack_coh_deb". The target product will be automatically renamed with the ending "_ML".
16.3. In the "Processing Parameters" check "GR Square Pixel". You should get automatically "Number of Range looks". By clicking "Independent Look" you can define the "Number of Azimuth Looks".
16.4. Select "Run"

17. Geocoding / Terrain Correction
 17.1. Radar / Geometric / Terrain / Range Doppler Terrain Correction
 17.2. In the "Processing Parameters" leave all settings as default (you can set pixel spacing, map projection of the output product and select additional output bands (e.g. "DEM", "Local incidence angle" etc.)
 17.3. In the "I/O Parameters" select ""S1A_IW_SLC__1SSV_split_Orb_Stack_coh_deb_ML". The target product will be automatically renamed with the ending "_TC".
 17.4. Select "Run"
 17.5. Open the terrain corrected interferometric coherence. Now the dataset is geocoded.

18. Close all products

Creating an RGB composite from backscatter and coherence layers

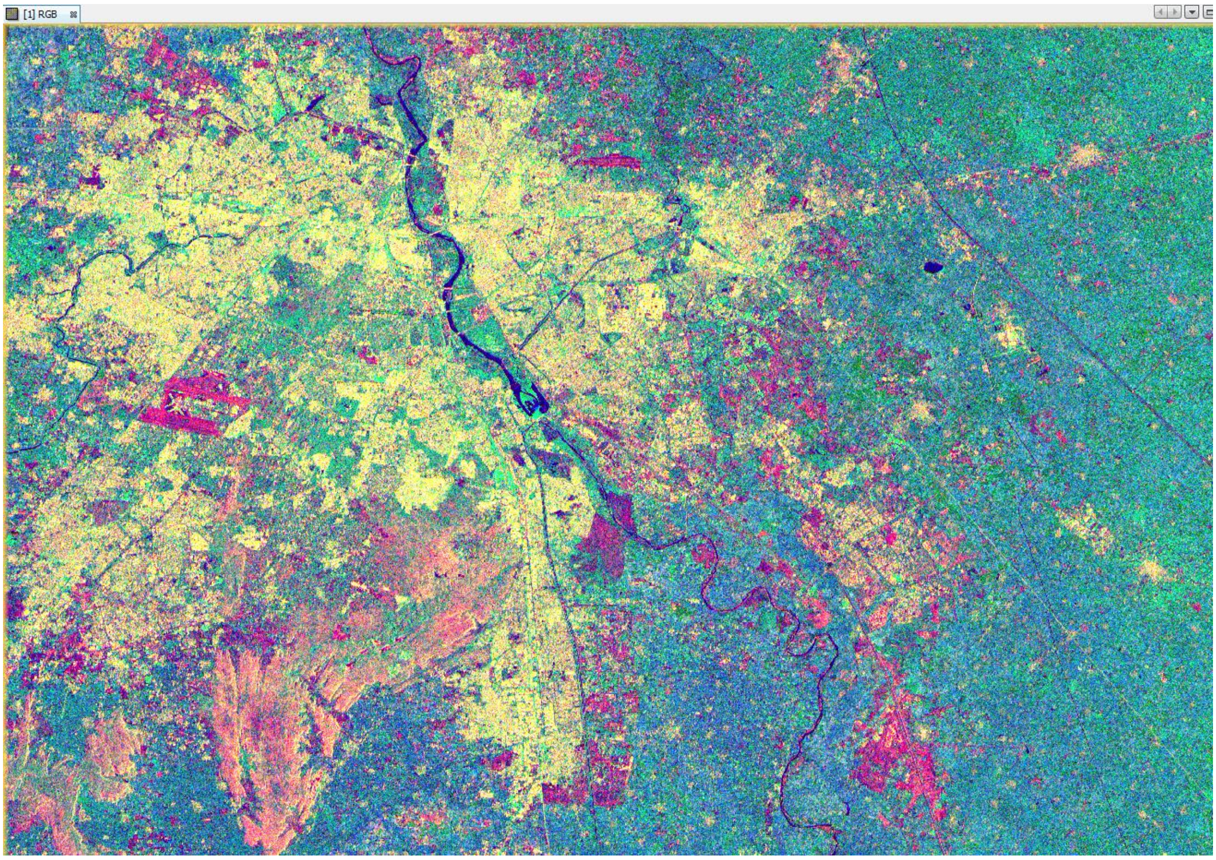
19. Open file
 19.1. File / Open Product "S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split_Orb_Cal_deb_ML_TC"; "S1A_IW_SLC__1SSV_20160126T005142_20160126T005207_009658_00E14A_49C0_split_Orb_Cal_deb_ML_TC" and "S1A_IW_SLC__1SSV_split_Orb_Stack_coh_deb_ML_TC"

20. Create layer stack
 20.1. Radar / Coregistration / Stack Tools / Create Stack
 In the "ProductSet-Reader" add three opened layers
 20.2. View the "CreateStack" tab (but leave all settings as default)
 20.3. In the "Write" the target product will be automatically renamed with the ending "_Stack".
 20.4. Select "Run"

21. Calculate average backscatter
 21.1. Raster / Band Maths
 21.2. Set the Name of new layer: "mean_dB"
 21.3. Deselect "Virtual" to write the new created band to the file
 21.4. In the "Edit Expression": select "(Sigma0_IW_1_VV_db_slv2_02Jan2016 + Sigma0_IW_1_VV_db_mst_26Jan2016) / 2".
 21.5. Select "Ok"

22. Calculate difference backscatter
 22.1. Raster / Band Maths
 22.2. Set the Name of new layer: "difference_dB"
 22.3. Deselect "Virtual" to write the new created band to the file
 22.4. In the "Edit Expression": select "Sigma0_IW_1_VV_db_slv2_02Jan2016 - Sigma0_IW_1_VV_db_mst_26Jan2016"
 22.5. Select "Ok"

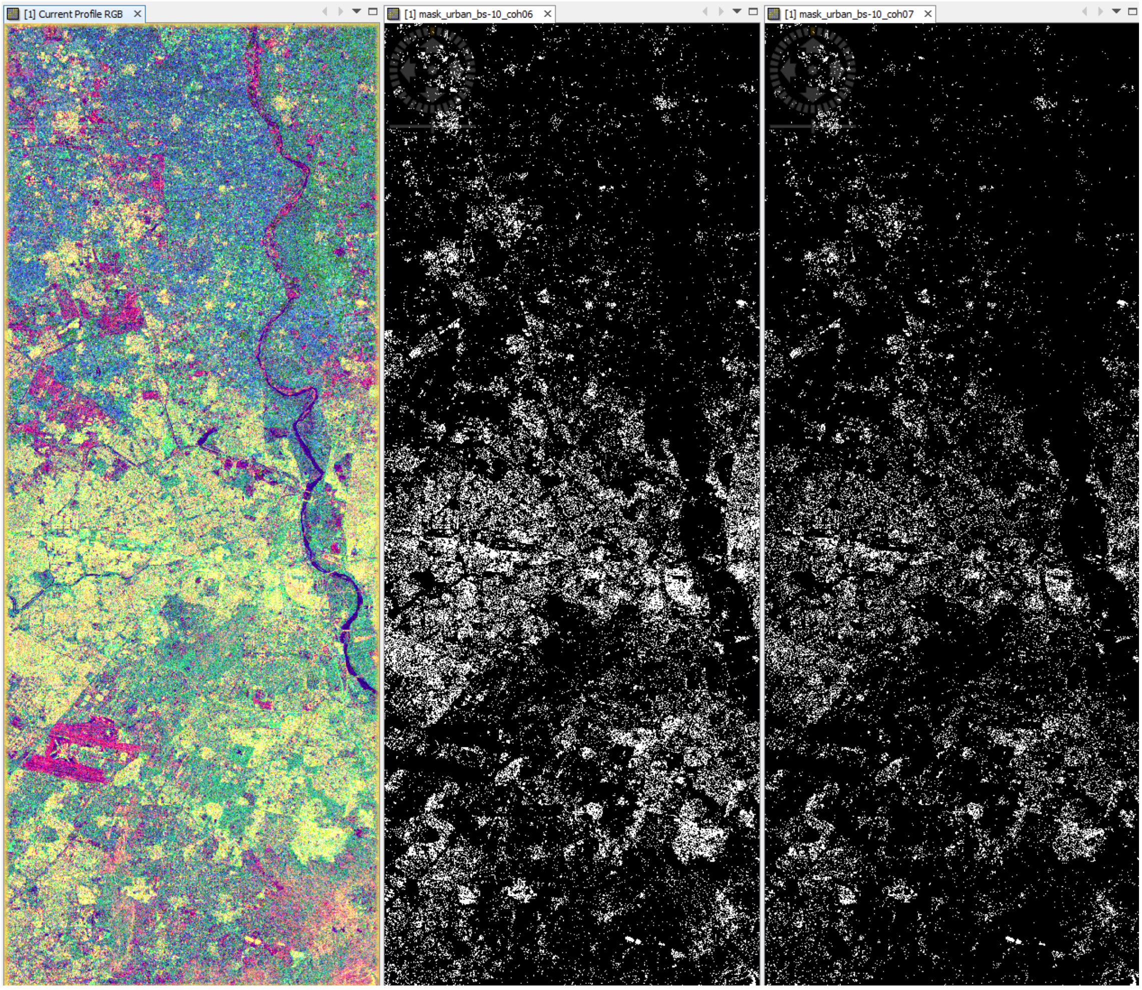
23. RGB image view
 23.1. Window / Open RGB Image Window
 23.2. Select the following bands: Red = "coh_IW1_VV_02Jan2016_26Jan2016", Green = "mean_dB", Blue = "difference_dB "
 23.3. Contrast stretch the images: Colour Manipulation tab, move triangular sliders to either side of the histogram for each R, G and B channel. Or you can stretch the RGB values to 95% distribution (ignore extreme min and max values) by clicking "95% butto" in the Color Manipulation tab



24. Some interpretation hits of RGB composite (Step 21)
    24.1. High coherence → areas that are stable between two acquisitions, e.g., urban areas, bare soil
    24.2. Low coherence → areas that has been changed between two acquisitions, e.g., volume decorrelation → forest areas
    24.3. High backscatter → double bounce, volume scattering, e.g., urban and forest areas
    24.4. Low backscatter → single bounce, e.g., agriculture, bare soil
    24.5. Red colored areas: low backscatter, high coherence values→ agriculture / bare soil
    Yellow colored areas: high backscatter, high coherence values → urban areas
    24.6. Using threshold values for backscatter/coherence we will obtain urban masks

Urban footprint mapping

25. Open file
    25.1. File / Open Product
    "S1A_IW_SLC__1SSV_20160102T005143_20160102T005208_009308_00D72A_849D_split_Orb_Cal_deb_ML_TC_Stack"
26. Mask of urban areas
    26.1. Raster / Band Maths
    26.2. Set the Name of new layer: "urban_footprint"
    26.3. In the "Expression" window, type "if mean_dB > -10 and coh_IW1_VV_02Jan2016_26Jan2016 > 0.6 then 1 else 0".
    26.4. Select "Ok"
    26.5. Save the newly created virtual band to actual band by right clicking on the band and selecting "Convert band"
    26.6. Obtain urban mask with another threshold for coherence (e.g., 0.7). Repeat steps 26.1-26.5.
27. Compare urban masks obtained with different coherence thresholds
    27.1. Open urban masks based on thresholds of coherence of 0.6 and 0.7
    27.2. Window / Tile Evenly, then link viewers in the "Navigation" tab


[1] Current Profile RGB
[1] mask_urban_bs-10_coh06
[1] mask_urban_bs-10_coh07