

SAR for Agriculture - Practical

Andrea Minchella (RSAC c/o ESA-ESRIN)

Michael Foumelis (ESA)

Prof. Chris Schmullius (Dept. for Earth Observation University Jena, Germany)

1–5 July 2013 | Harokopio University | Athens, Greece

Hands-on exercise: Objectives

- How creating a **geocoded and radiometrically normalised time series** employing ENVISAT ASAR APP (HH/HV) and ERS-2 IMP (VV) ascending and descending products;
- Derive an Index (ratio HH/VV) for monitoring the temporal behaviour of agriculture fields;
- The exercise will be done using the **DAT** (interface), the **Graphic builder** and the **Batch processing Tool**.

Dataset

Acquisition times:

ASAR APP - HH / HV polarisation (IS2)

1. **2005-05-11 – Ascending**
2. **2005-06-05 – Descending**
3. **2005-07-10 – Descending**

ERS-2 VV polarisation

1. **2005-05-11**
2. **2005-06-05**
3. **2005-07-10**

Both ascending and descending orbits

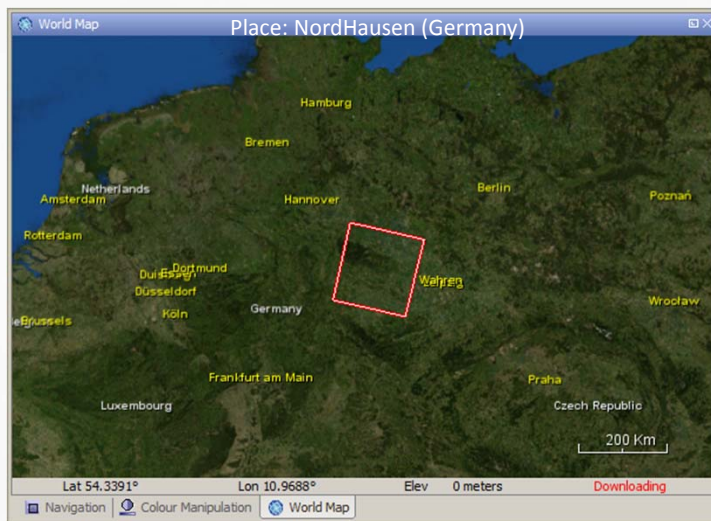
Product type: detected (APP/IMP) – 12.5 m pixel spacing – ground range geometry

Look angle mid swath = 23 degrees

28 minutes of difference in the acquisition's time between ERS and Envisat

Place: NordHausen (Germany)

Dataset



Dataset and Results

The products are freely available at:

SFTP (port 22): nestbox.esrin.esa.int

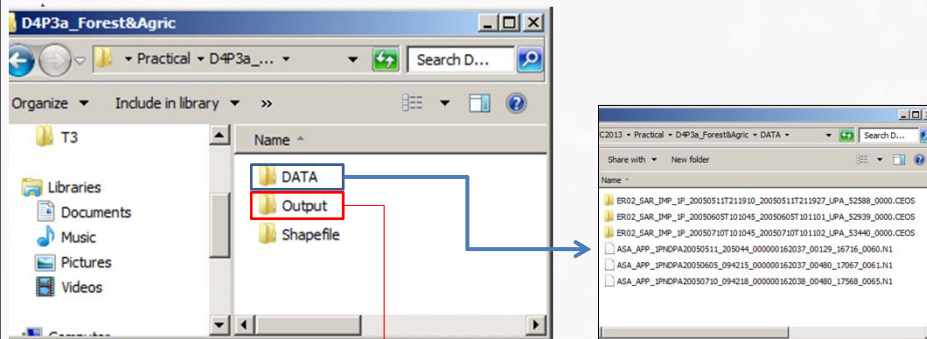
Username: nestuser

Password: password

Folder: DATA/NordHausenASAR_ERS

Exercise folder framework

C:\LTC2013\Practical\D4P3a_Forest&Agric\DATA



The outputs of the exercise will be stored here



Exercise steps

- 1 Open and Inspect ASAR products
 - 2 Create the processing chain for ASAR using the **Graph Builder**
 - 3 Apply the processing chain to all ASAR products via the **BATCH Processing Interface**.
 - 4 Open the ERS geocoded data (already processed)
 - 5 Coregistration of ASAR and ERS geocoded images **Using the DAT**
- Apply Precise Orbit
- Multilook
- Terrain Correction and Radiometric normalisation

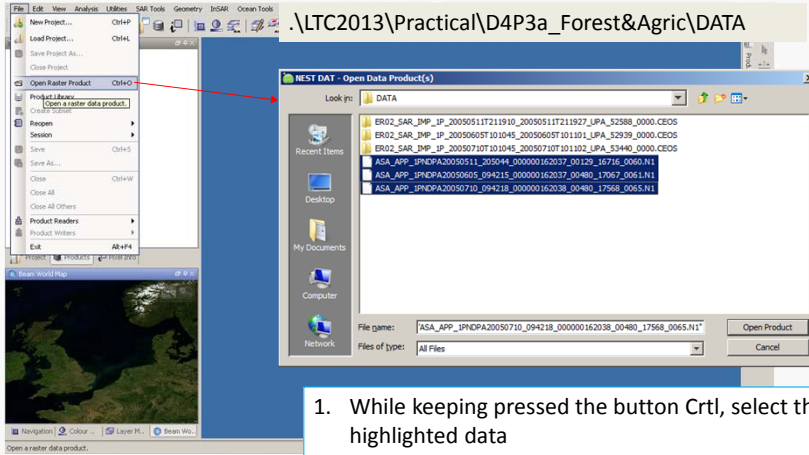


Exercise steps

- 6 RGB visualisation: HV polarisation (ASAR)
- 7 RGB visualisation (linear and db): VV polarisation (ERS)
- 8 RGB visualisation: ERS VV – ASAR HV – ASAR HH (05-06-2005)
- 9 Multitemporal Speckle filtering: ERS-VV
- 10 Computation of Ratio HH / VV
- 11 Overlay shape file information
- 12 Question Time



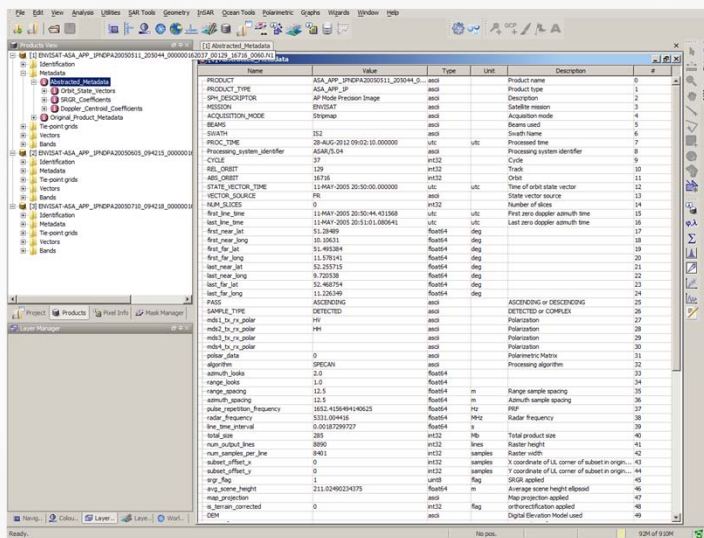
1. Open the ASAR data



1. While keeping pressed the button Ctrl, select the highlighted data
2. then click to **Open Product**



Metadata inspection





World MAP

Name	Value	Type	Unit	Description	#
PRODUCT	ASA_APP_IPCPA20090511_20044_0...	asc		Product name	0
PRODUCT_TIME	ASA_APP_IP...	asc		Product type	1
SW_RESOLUTION	AP Mode Precision Image	asc		Description	2
MISSION	BHVISAT	asc		Satellite mission	3
ACQUISITION_MODE	STRANS	asc		Acquisition mode	4
BEAMS		asc		Beams used	5
SQUATCH	152	asc		Squatch name	6
PROG_TIME	28-AUG-2012 09:02:10.000000	utc	UTC	Processed time	7
Processing_System_Identifier	ASAS05.04	asc		Processing system identifier	8
CYCLE	37	int32		Cycle	9
MSI_ORBIT	109	int32		Orbit	10
ABS_ORBIT	10775	int32		Orbit	11
START_VECTOR_TIME	11-MAY-2005 20:50:00.000000	utc	UTC	Time of orbit state vector	12
VECTOR_ORIGINE	PS	asc		State vector source	13
NAMP_SLICES	0	int32		Number of slices	14
First_Orbit_Time	11-MAY-2005 20:50:44.431568	utc	UTC	First zero doppler azimuth time	15
Last_Orbit_Time	11-MAY-2005 20:51:01.080941	utc	UTC	Last zero doppler azimuth time	16
First_Orbit_Azimuth	51.28469	float64	deg		17
First_Orbit_Azimuth	10.19631	float64	deg		18
Last_Orbit_Azimuth	51.46584	float64	deg		19
First_Orbit_Azimuth	11.578141	float64	deg		20
Last_Orbit_Azimuth	52.255715	float64	deg		21
First_Orbit_Azimuth	9.79203	float64	deg		22
Last_Orbit_Azimuth	52.468754	float64	deg		23
First_Orbit_Azimuth	11.226149	float64	deg		24
SAMPLE_TYPE	ADZKING	asc		ADZKING or DESCENDING	25
DEFECTED	DEFECTED	asc		DEFECTED or CORRECT	26
mbd1_mn_polar	HY	asc		Polarization	27
mbd2_mn_polar	HY	asc		Polarization	28
mbd3_mn_polar	HY	asc		Polarization	29
mbd4_mn_polar	HY	asc		Polarization	30
mbd5_mn_polar	HY	asc		Polarization	31
mbd6_mn_polar	HY	asc		Polarization	32
algorithm	SPECAN	asc		Processing Algorithm	33
range_resolution	2.5	float64	m	Range resolution	34
range_spacing	1.0	float64	m	Range sample spacing	35
azimuth_spacing	12.5	float64	m	Azimuth sample spacing	36
azimuth_resolution	1452.634941496215	float64	Hz	PRF	37
radar_frequency	5311.024416	float64	MHz	Radler Frequency	38
img_intp_resolution	0.01029299237	float64	m	Resolution	39
total_area	285	int32	MB	Total product size	40
num_subswaths	8890	int32	lines	Subswath height	41
num_samples_per_line	8401	int32	samples	Subswath width	42
subset_start_x	0	int32	samples	X coordinate of UL corner of subset in origin	43
subset_start_y	0	int32	samples	Y coordinate of UL corner of subset in origin	44
img_flag	1	uint8	flag	Shift applied	45
img_sensor_height	211.0296224375	float64	m	Average sensor height ellipsoid	46
img_projection		asc		Map projection applied	47
img_theta_resolution	0	int32	flag	Theta resolution applied	48
DDH		asc		Digital Elevation Model used	49

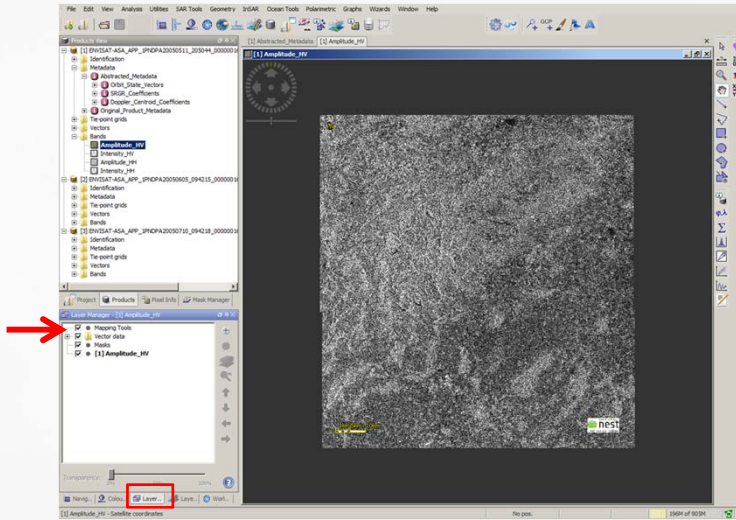
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Display the Amplitude Image

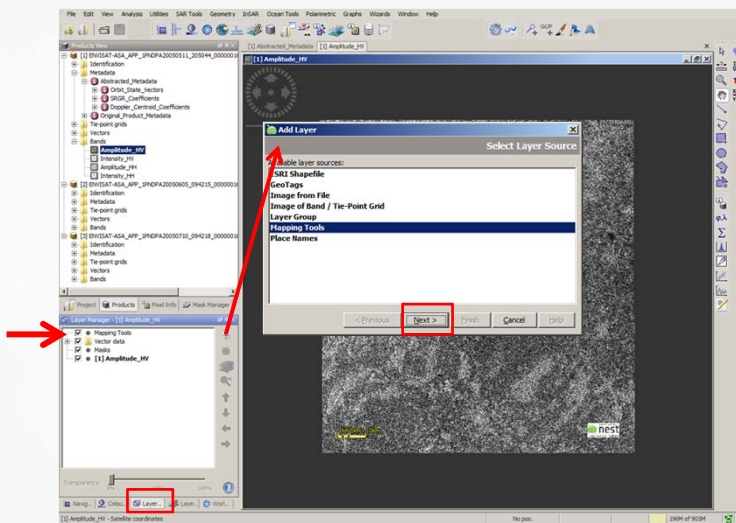
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Mapping Tool (Activate/deactivate)



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Mapping Tool (Activate/deactivate)



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Mapping Tool (Activate/deactivate)

The screenshot shows the ENVI software interface. On the left, the 'Layer Manager' is visible with a red arrow pointing to it. The 'Add Layer' dialog box is open, showing 'Map Tools Options' with several checked items: 'Show North Arrow', 'Show Lock Direction', 'Show Scale', and 'Show NEST logo'. The 'Refresh' button in the dialog is highlighted with a red box. The main window displays a satellite image with a 'nest' logo in the bottom right corner.

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Mapping Tool (Activate/deactivate)

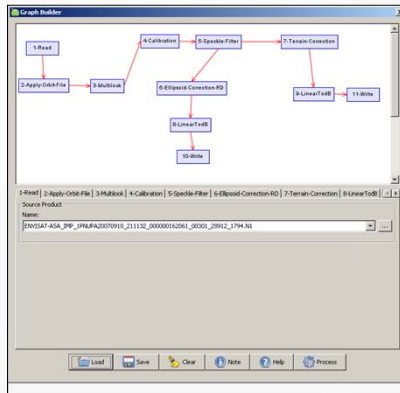
The screenshot shows the ENVI software interface. The 'Layer Manager' is visible with a red arrow pointing to the 'Mapping Tools' layer, which is checked. The main window displays a satellite image with a 'nest' logo in the bottom right corner.

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Create the processing chain for ASAR using the Graph Builder



- Apply Precise Orbit
- Multilook
- Terrain Correction and Radiometric normalisation



GRAPH BUILDER

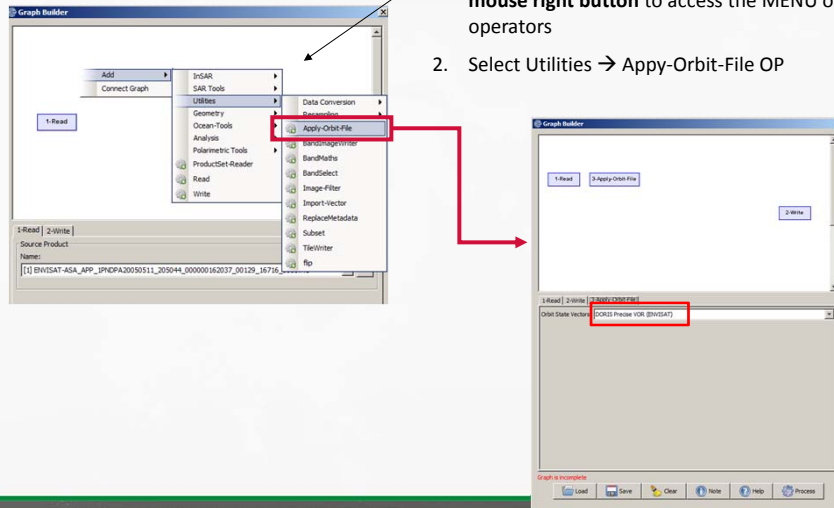
- Visual Graph Processing Framework interface
- Create your own processing chains
- Executed from command line or from GUI
- Allows for batch processing on stack of images

Launch the Graph Builder

CLICK on the **Graph Builder icon**

Building the chain for the ASAR image: DORIS Precise Orbit

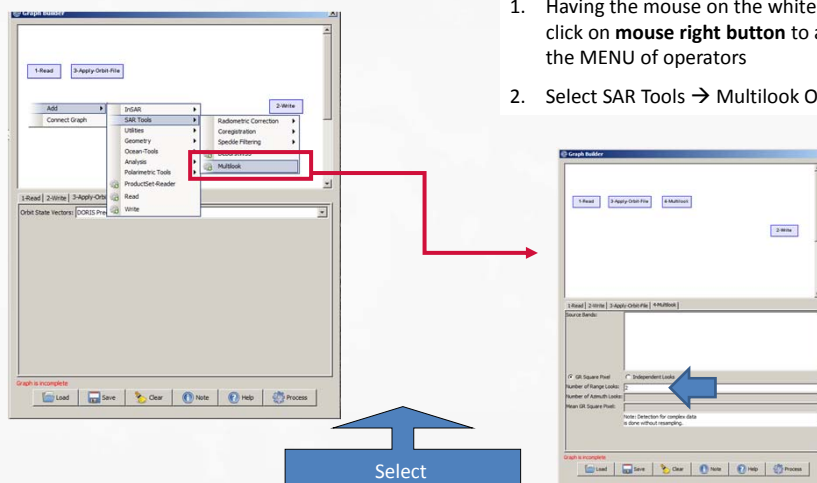
1. Having the mouse on the white space, click on **mouse right button** to access the MENU of operators
2. Select Utilities → Apply-Orbit-File OP



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Building the chain for the ASAR: Multilook

1. Having the mouse on the white space, click on **mouse right button** to access the MENU of operators
2. Select SAR Tools → Multilook OP

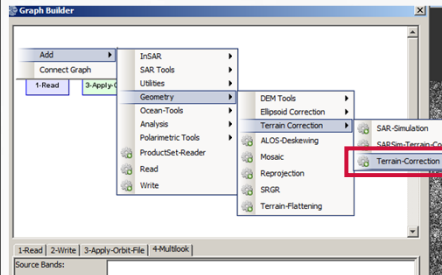


Select
Product Auxiliary file

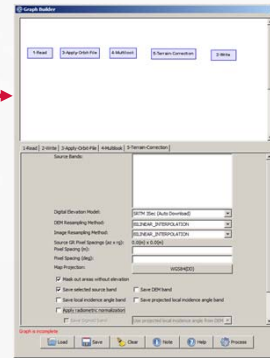
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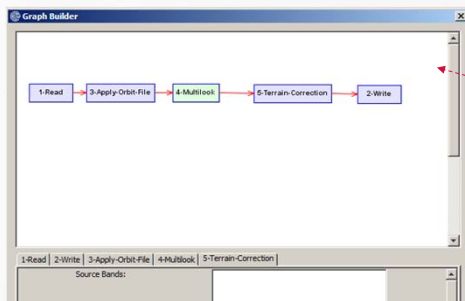
Building the chain for the ASAR: Terrain Correction



1. Having the mouse on the white space, click on **mouse right button** to access the MENU of operators
2. Select Geometry → Terrain correction → Terrain-Correction OP

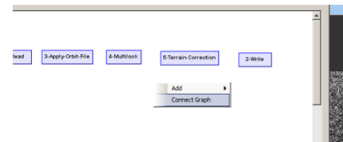


Building the chain for the ASAR



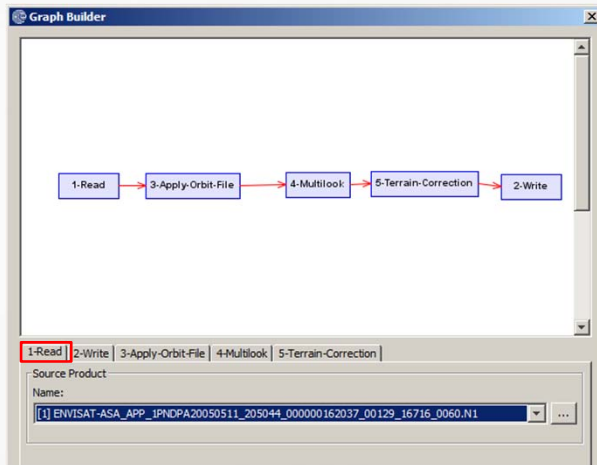
1. Link all the blocks with arrows. To draw the arrow press the left mouse button and link the blocks from right to left

Or push over





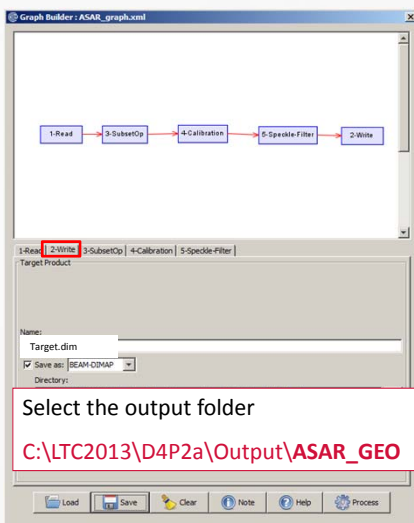
Building the chain for ASAR



Select the first ASAR Product



Building the chain for ASAR



Select the output folder
C:\LTC2013\D4P2a\Output\ASAR_GEO

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Building the chain for the ASAR : TC

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Radar backscatter: Ellipsoid-normalisation

Conventional Radar Backscatter

- Backscatter coefficients [dB/m²] are ratio of scattered to incident power per unit area:

$$\beta = k \cdot \frac{P_s}{P_i} \quad \beta^0 = \frac{\beta}{A_\beta} \quad \sigma_E^0 = \frac{\beta}{A_\sigma} \quad \gamma_E^0 = \frac{\beta}{A_\gamma}$$

- Known: transmitted & received power P_t & P_r
- Derive: incident & scattered power P_i & P_s from P_t & P_r

$$\beta^0 = k \cdot \frac{f_s(P_r)}{f_i(P_t)} \cdot \frac{1}{A_\beta} \quad \sigma_E^0 = k \cdot \frac{f_s(P_r)}{f_i(P_t)} \cdot \frac{1}{A_\sigma} \quad \gamma_E^0 = k \cdot \frac{f_s(P_r)}{f_i(P_t)} \cdot \frac{1}{A_\gamma}$$

David Small (RSL, UZH) - QIWO ESSRN 2009.10.27-28

Ground Illuminated Area

$$\gamma_E^0 = \beta^0 \cdot A_\beta / A_\gamma = \beta^0 \cdot \tan \theta$$

$$\sigma_E^0 = \beta^0 \cdot A_\beta / A_\sigma = \beta^0 \cdot \sin \theta$$

David Small (RSL, UZH) - QIWO ESSRN 2009.10.27-28

Ellipsoid-normalisation

ASAR: Calibrated sigma nought for detected products can be derived as:

$$\sigma_{i,j}^0 = \frac{DN_{i,j}^2}{K} \sin(\alpha_{i,j})$$

$$\downarrow$$

$$\beta^0$$

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Radar backscatter: slope-normalisation

Normalisation for local variation of scattering area:

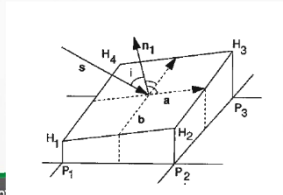
$$\sigma_{Norm}^0 = \sigma_{Ellipsoid}^0 * \frac{\sin \theta_{DEM}}{\sin \theta_{EUL}}$$

Kellndorfer et al., TGRS, Sept. 1998.

θ_{DEM}

Local incidence angle projected into the range plane

Local incidence angle



Building the chain for the ASAR

Graph Builder workflow: 1-Read → 3-Apply-Orbit-File → 4-Multibook → 5-Terrain-Correction → 5-Write

Path: C:\LTC2013\Practical\D4P3a_Forest&Agric\Output

NEST DAT - Save Graph

Save in: Output

File name: ASAR_Graph.vml

Files of type: Graph (*.vml)

Graph Builder settings:

- Source Bands: Amplitude_HV, Amplitude_HH
- Digital Elevation Model: SRTM 3Sec (Auto Download)
- DEM Resampling Method: BILINEAR_INTERPOLATION
- Image Resampling Method: BILINEAR_INTERPOLATION
- Source GR Pixel Spacing (lat x lng): 12.5(m) x 12.5(m)
- Pixel Spacing (m): 25.0
- Pixel Spacing (deg): 2.2457882102968038E-4
- Map Projection: UTM Zone 32 / World Geodetic System 1984
- Mask out areas without elevation
- Save selected source band
- Save local incidence angle band
- Save projected local incidence angle band
- Apply radiometric normalization
- Save Signal0 band (Use projected local incidence angle from DEM)
- Save Gamma0 band (Use projected local incidence angle from DEM)
- Save Beta0 band
- Auxiliary File (ASAR only): Latest Auxiliary File



Building the chain for the ASAR

```

<graph id="Graph">
  <version>3.0</version>
  <node id="1-Read">
    <operator>Read</operator>
    <sources>
      <sourceProduct refid="5-Terrain-Correction"/>
    </sources>
    <parameters class="com.bc.ceres.binding.dom.XppDomElement">
      <file>C:\LTC2013\D4P2a\DATA\ASA_APP_IPNDFA20050511_205044_000000162037_00129_16716_0060.N1</file>
    </parameters>
  </node>
  <node id="2-Write">
    <operator>Write</operator>
    <sources>
      <sourceProduct refid="1-Read"/>
    </sources>
    <parameters class="com.bc.ceres.binding.dom.XppDomElement">
      <formatName>HEAM-DIMAP</formatName>
      <file>C:\LTC2013\D4P2a\Output\ASAR_GEO\target.dim</file>
    </parameters>
  </node>
  <node id="3-Apply-Orbit-File">
    <operator>Apply-Orbit-File</operator>
    <sources>
      <sourceProduct refid="1-Read"/>
    </sources>
    <parameters class="com.bc.ceres.binding.dom.XppDomElement">
      <orbitType>DORIS Precise YOR (ENVISAT)</orbitType>
    </parameters>
  </node>
  <node id="4-Multilook">
    <operator>Multilook</operator>
    <sources>
      <sourceProduct refid="3-Apply-Orbit-File"/>
    </sources>
    <parameters class="com.bc.ceres.binding.dom.XppDomElement">
      <sourceBands>
        <multilook>2</multilook>
        <multilook>2</multilook>
        <multilook>2</multilook>
      </sourceBands>
      <outputIntensity>true</outputIntensity>
      <note>Currently, detection for complex data is performed without any resampling</note>
    </parameters>
  </node>
</graph>

```

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The Batch processing

CLICK on the Batch *processing* icon

File Name	Type	Acquisition	Track	Orbit	Add
Add Opened					
Move Up					
Move Down					
Remove					
Clear					

Target Folder:
Save as: [HEAM-DIMAP]
Directory: C:\LTC2013\D4P2a\Output\ASAR_GEO

Buttons: Load Graph, Run, Close, Help

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The Batch processing

File Name	Type	Acquisition	Track	Orbit
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	11May2005	129	16716
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	05Jun2005	480	17067
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	10Jul2005	480	17568

Target Folder
Save as: BEAM-DIMAP
Directory: C:\TTC2013\D#P2a\Output\ASAR_GEO

Buttons: Load Graph, Run, Close, Help

Annotations:
- CLICK on Add Opened (points to 'Add Opened' button)
- Select Output directory (points to 'Directory' text box)

The Batch processing

1. Load the created ASAR GRAPH
2. Start the batch processing
→ Click RUN

The Batch processing

File Name	Type	Acquisition	Track	Orbit
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	11May2005	129	16716
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	05Jun2005	480	17067
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	10Jul2005	480	17568

Target Folder: Save as: BEAM-DIMAP
Directory: C:\I.TC2013\ID#P2a\Output\ASAR_GEO

Processing completed in 7,28 minutes
Image Resampling Method: BILINEAR_INTERPOLATION

1. Load the created ASAR GRAPH
2. Start the batch processing
→ Click RUN

Open the GEOCODED ASAR dataset



Open the ERS geocoded data (pre-computed)

C:\LTC2013\Practical\D4P3a_Forest&Agric\Output\ERS_GEO

1. While keeping pressed the button Ctrl, select the highlighted data

2. then click to **Open Product**



Open the ERS geocoded data (pre-computed)

- The ASAR and ERS images are:
- geocoded into the same CRS (UTM 32N)
 - Pixel size = 25 meters
 - Radiometrically normalised

We can coregister the data to create the time series

C:\LTC2013\Practical\D4P3a_Forest&Agric\Output
→ ERS_Graph.xml

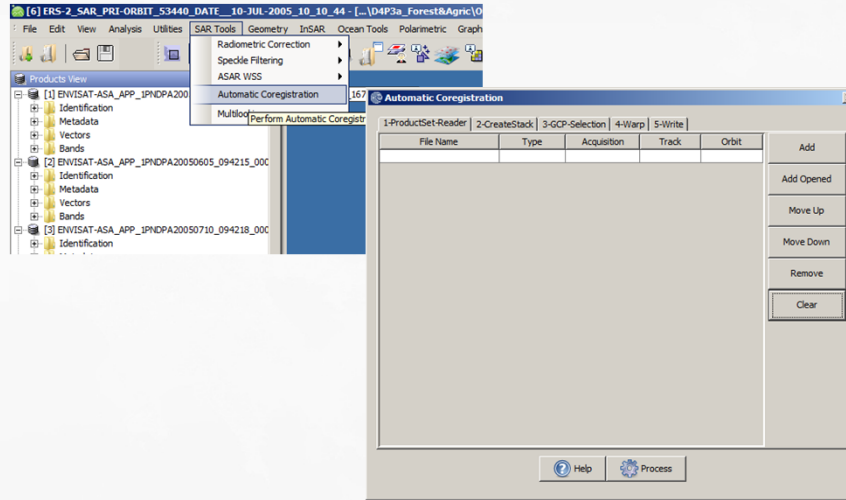


File Name	Type	Acquisition	Track	Orbit
ERS-2_SAR_PRI_ORBIT_535..._ERS2_SAR_PRI		11May2005	129	52588
ERS-2_SAR_PRI_ORBIT_529..._ERS2_SAR_PRI		05Jun2005	480	52939
ERS-2_SAR_PRI_ORBIT_534..._ERS2_SAR_PRI		10Jul2005	480	53440

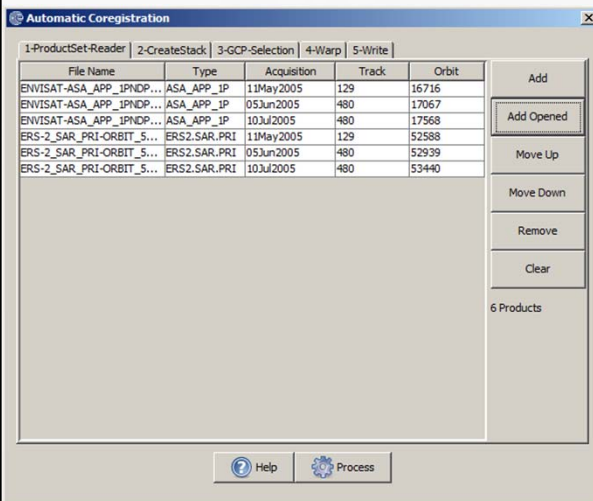
Target Folder: [BEAM-CDMAP]
Directory: C:\LTC2013\Practical\D4P3a\Output\ERS_GEO



Coregistration of ASAR and ERS geocoded data



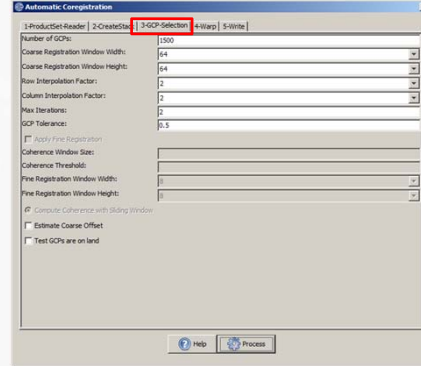
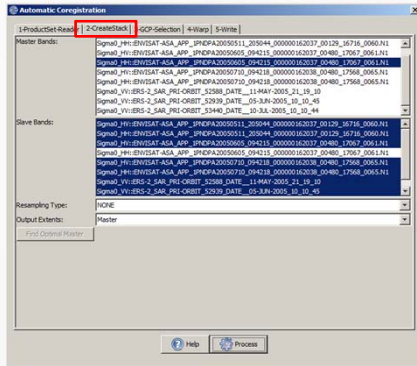
Coregistration of ASAR and ERS geocoded data



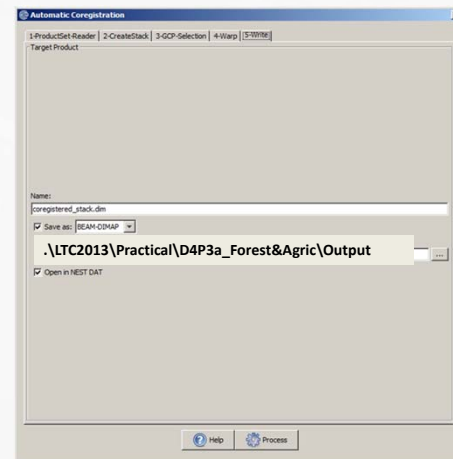
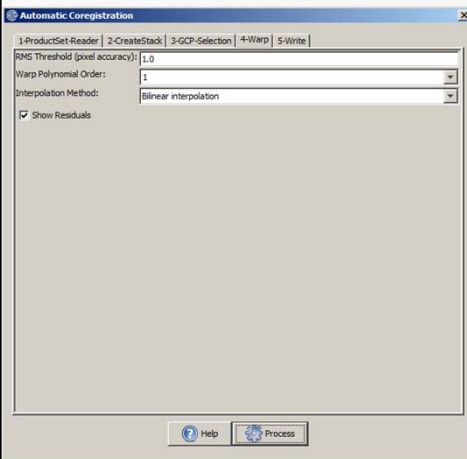
CLICK on
Add Opened

Coregistration of ASAR and ERS geocoded data

Select as a Master: HH - 05062005

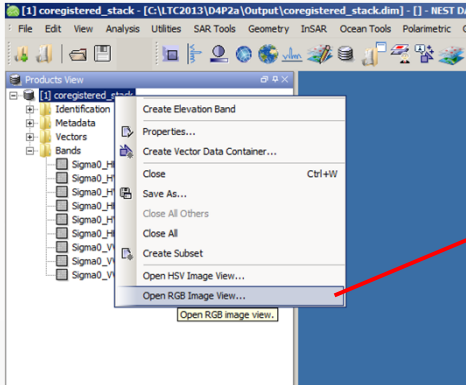


Coregistration of ASAR and ERS geocoded data

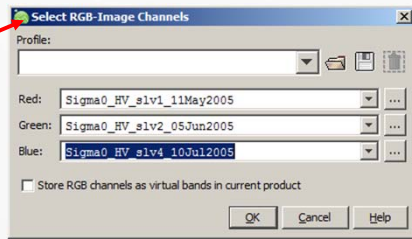




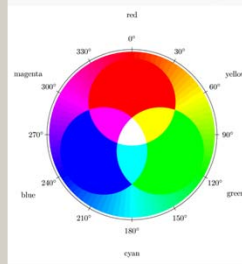
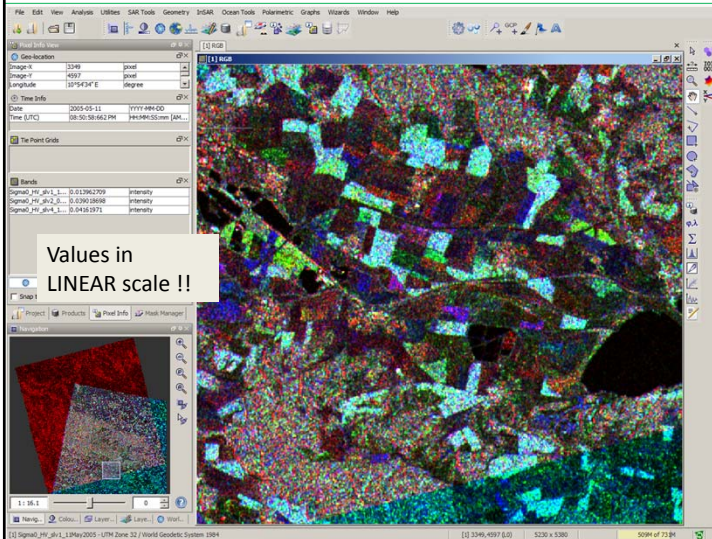
RGB visualisation: HV polarisation (ASAR)



1. Mouse right click over the name of the product
2. Click *Open RGB Image View*
3. Select the dates/bands
4. Click OK

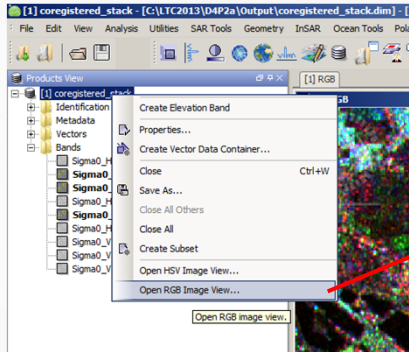


RGB visualisation: HV polarisation (ASAR)

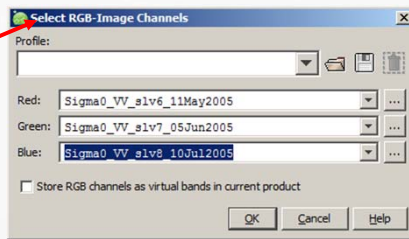




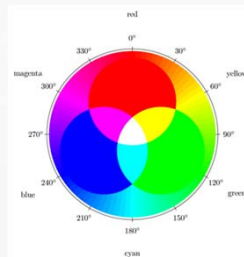
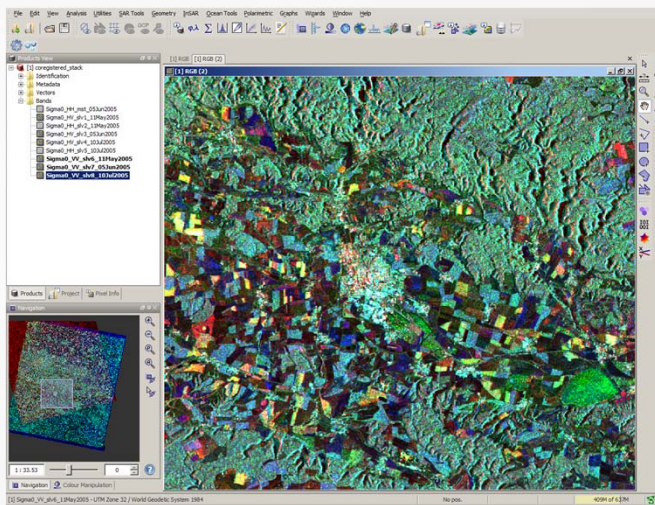
RGB visualisation: VV polarisation (ERS)



1. Mouse right click over the name of the product
2. Click *Open RGB Image View*
3. Select the dates/bands
4. Click OK

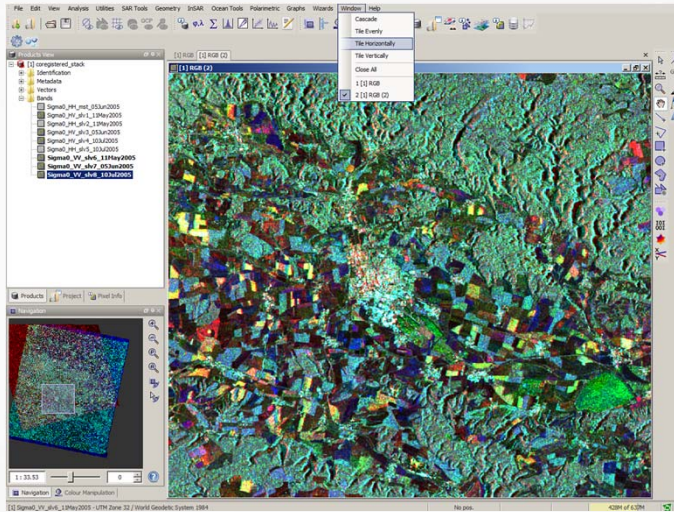


RGB visualisation: VV polarisation (ERS)





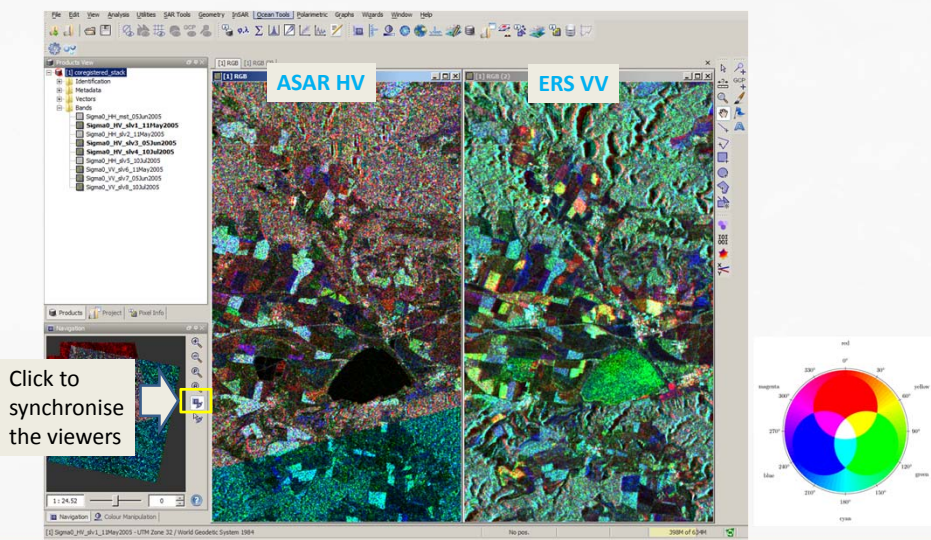
RGB visualisation: ASAR HV vs ERS VV



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RGB visualisation: ASAR HV vs ERS VV



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RGB visualisation (db): ERS VV

Mouse Right click → linear to db

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RGB visualisation (db): ERS VV

Select RGB Image Channels

Profile: [dropdown]

Red: Sigma0_VV_slvr6_11May2005_db

Green: Sigma0_VV_slvr7_05Jul2005_db

Blue: Sigma0_VV_slvr8_10Jul2005_db

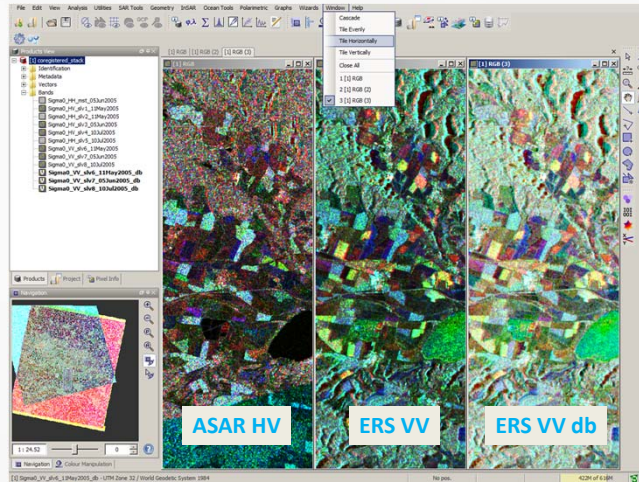
Store RGB channels as virtual bands in current product

OK Cancel Help

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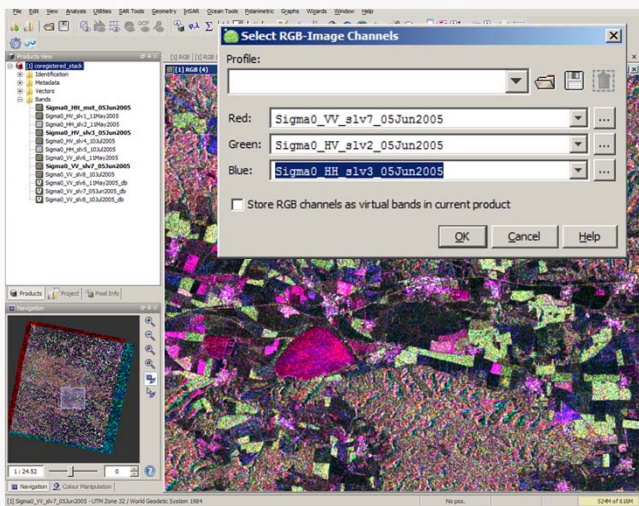
RGB visualisation (db): ERS VV



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05-06-2005 RGB visualisation: ERS VV – ASAR HV – ASAR HH

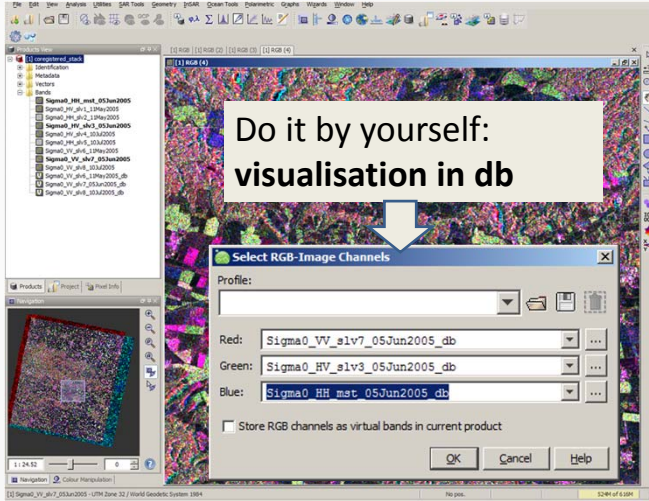


Red – ERS VV
Green – ASAR HV
Blue – ASAR HH

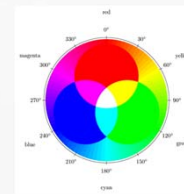
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05-06-2005 RGB visualisation: ERS VV – ASAR HV – ASAR HH



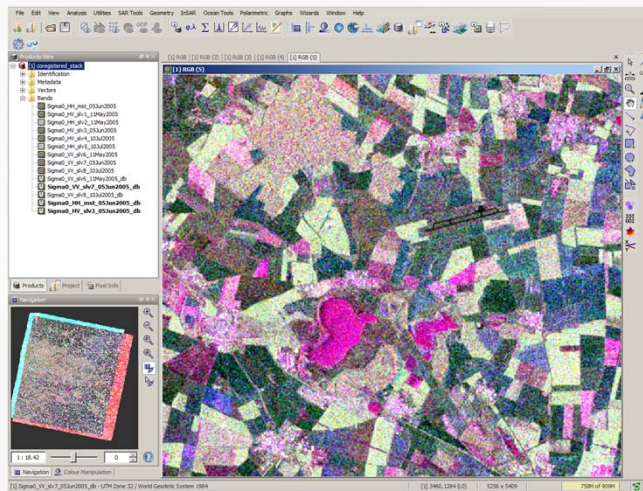
Red – ERS VV
 Green – ASAR HV
 Blue – ASAR HH



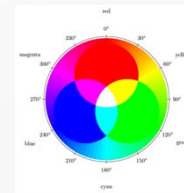
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05-06-2005 RGB visualisation (db): ERS VV – ASAR HV – ASAR HH



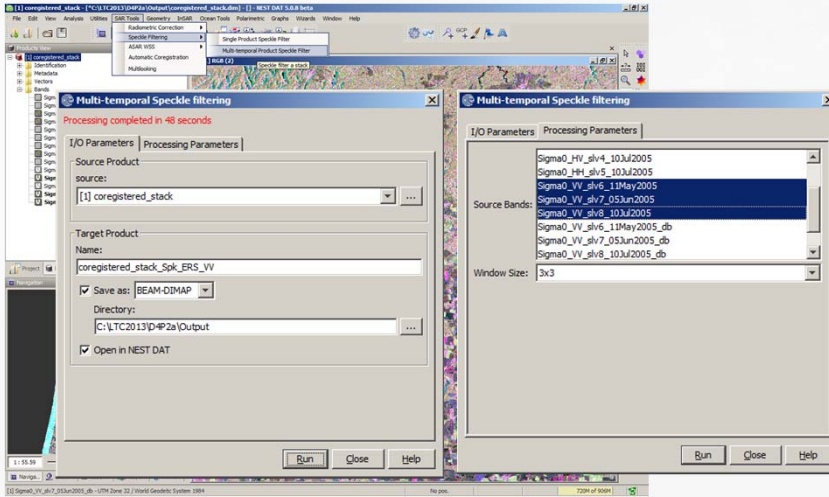
Red – ERS VV
 Green – ASAR HV
 Blue – ASAR HH



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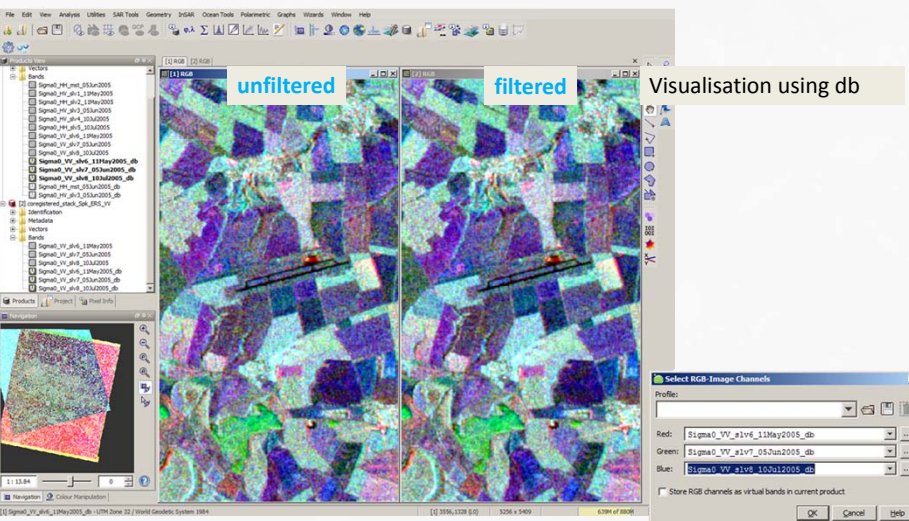
Multitemporal Speckle filtering: ERS-VV



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Multitemporal Speckle filtering: unfiltered vs filtered ERS-VV

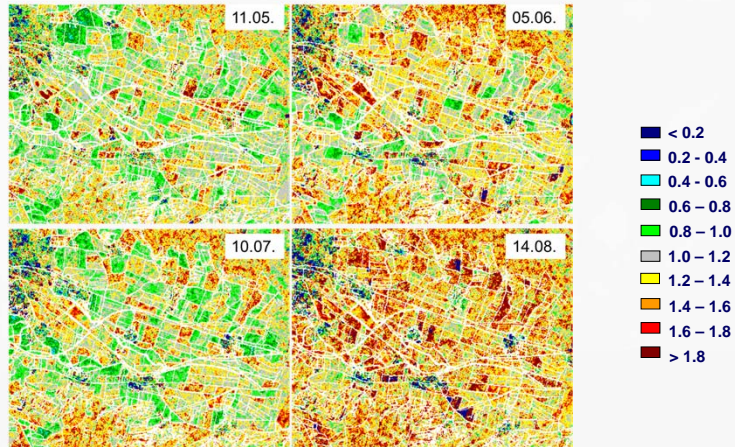


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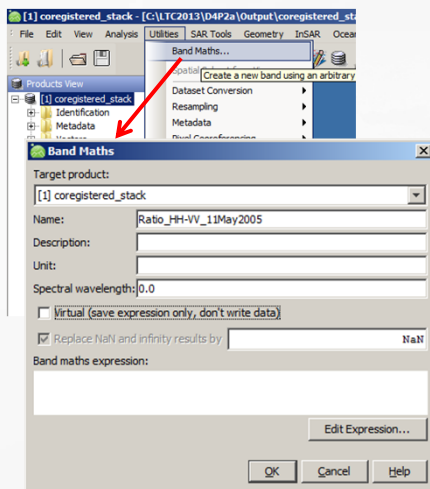
SAR data interpretation – agriculture: Ratio HH / VV

Ratio HH / VV to monitor the Temporal behaviour of the culture

Example winter wheat field - red (other fields similar):



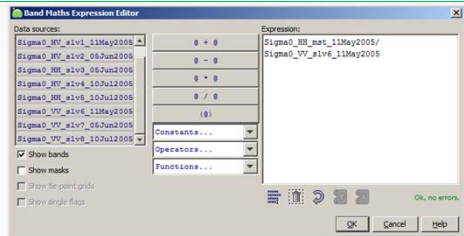
Compute ratio HH / VV (11 May 2005)



1. Utility → Band Maths Op
2. Select Target product: ERS VV
3. Name: write **Ratio_HH-VV_11May2005**
4. Uncheck Virtual option
5. Click to Edit Expression



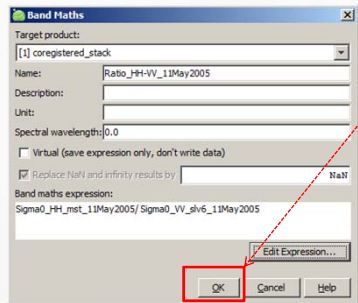
Compute ratio HH / VV (11 May 2005)



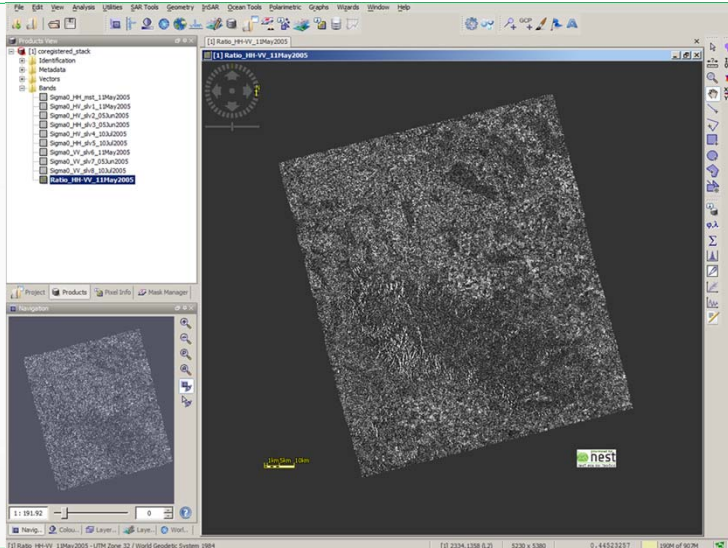
6. Write the expression select the bands

7. Click OK

8. Click OK



Compute ratio HH / VV (11 May 2005)





Overlay shape file information

1. Select Layer Manager
2. Click on + button
3. Select ESRI shapefile
4. Click Next

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Overlay shape file information

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Overlay shape file information

No CRS found for ESRI Shapefile. Please specify.

Coordinate Reference System (CRS)

Use target CRS WGS 84 / UTM zone 32N

Custom CRS

Geodetic datum: World Geodetic System 1984

Projection: Geographic Lat/Lon (WGS 84)

Predefined CRS

< Previous **Next >** Finish Cancel Help

Layer Preview

nordhausen_crop_types_2005_fina.shp Style: Default Styler

Model bounds [624305.330 ; 5698142.514, 637766.387 ; 5709390.105]

< Previous **Next >** **Finish** Cancel Help

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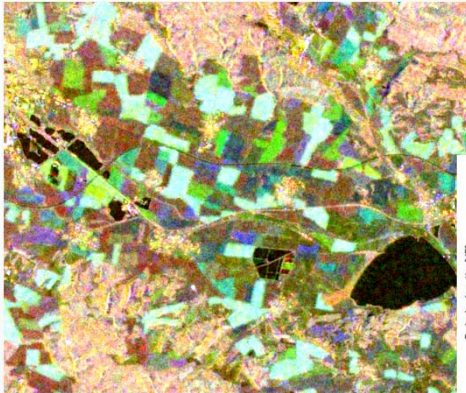
Overlay shape file information

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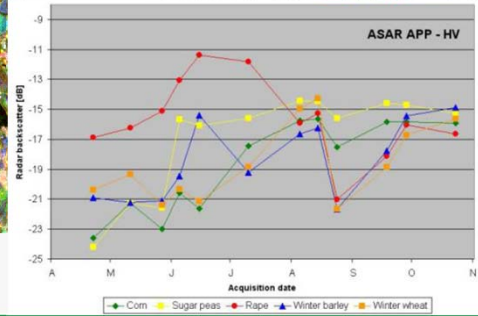
SAR data interpretation– agriculture

Temporal behaviour of Radar backscatter



HV – 04-22 / 06-15 / 07-10

$$\text{Mean}_{\text{db}} = 10 * \text{LOG}_{10} (\text{Mean}_{\text{linear}})$$



THANK YOU for your attention!