

## SAR for Agriculture - Practical

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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

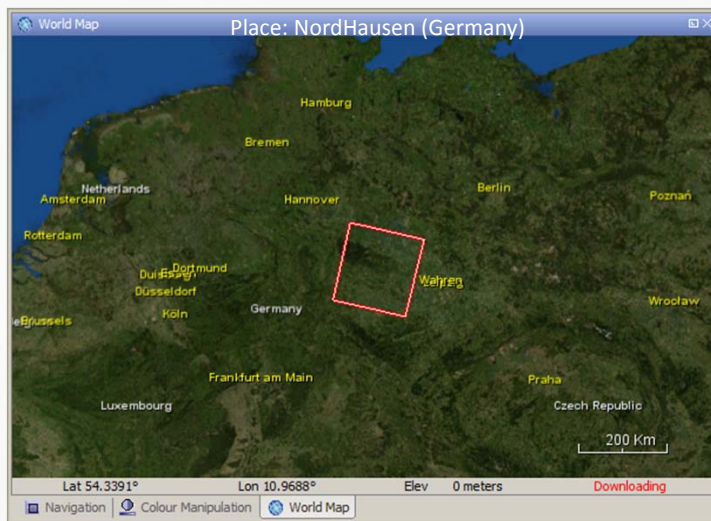
Product type: detected (APP/IMP) – 12.5 m pixel spacing – ground range geometry

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

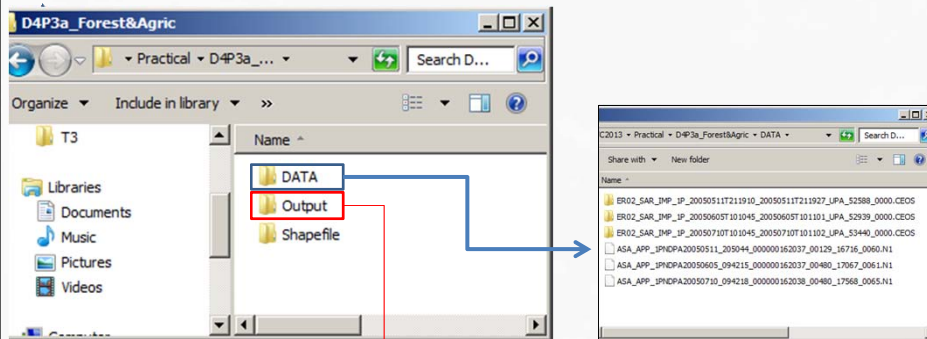
Username: nestuser

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

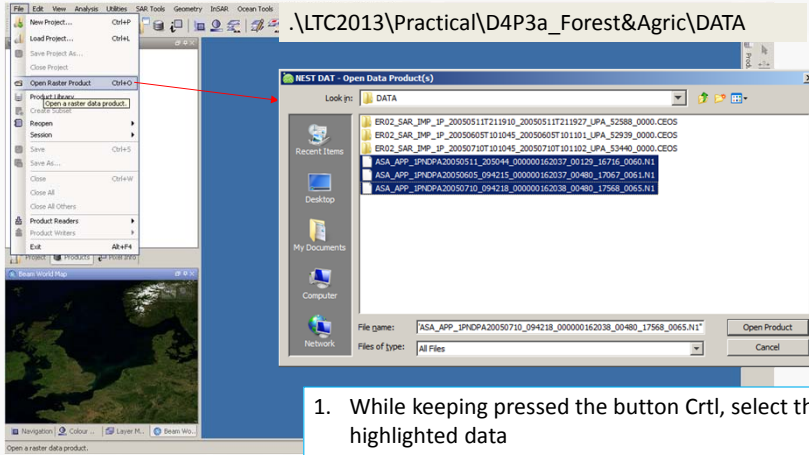


### Exercise steps

- 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



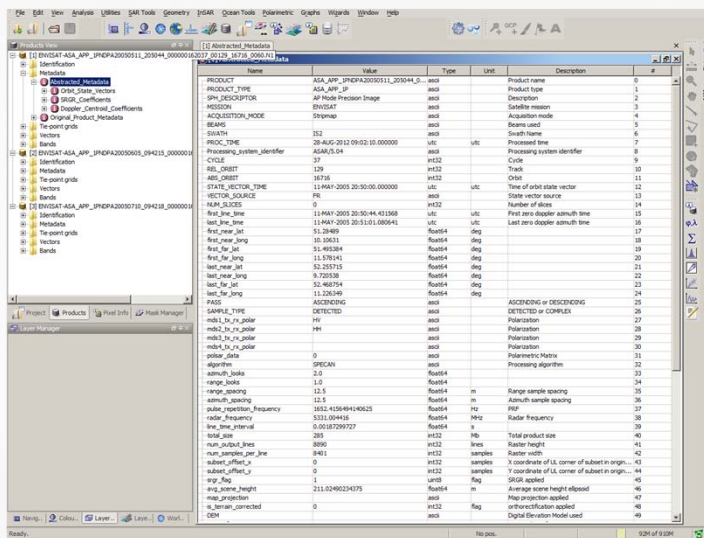
### 1. Open the ASAR data



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_CROSSPOLAR	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
SWATH		asc		Swath 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	10776	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_Swath	51.28469	float64	deg	Swath	17
First_Orbit_Swath	10.19631	float64	deg	Swath	18
Last_Orbit_Swath	51.46584	float64	deg	Swath	19
First_Orbit_Swath	11.578141	float64	deg	Swath	20
Last_Orbit_Swath	52.255715	float64	deg	Swath	21
First_Orbit_Swath	9.79203	float64	deg	Swath	22
Last_Orbit_Swath	52.468754	float64	deg	Swath	23
First_Orbit_Swath	11.226149	float64	deg	Swath	24
SAMPLE_TYPE	ADZKING	asc		ADZKING or DESCENDING	25
DEFECTED	DEFECTED	asc		DEFECTED or CORNER	26
mbd1_mn_polar	HV	asc		Polarization	27
mbd2_mn_polar	HV	asc		Polarization	28
mbd3_mn_polar	asc			Polarization	29
mbd4_mn_polar	asc			Polarization	30
mbd5_mn_polar	asc			Polarization	31
mbd6_mn_polar	asc			Polarization	32
algorithm	SPECAN	asc		Processing Algorithm	33
range_resolution	2.5	float64		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_subswath_lines	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_projection	211.0296224375	float64	m	Average scene height ellipsoid orthorectification applied	46
img_projection	asc			Map projection applied	47
img_projection	asc			Orthorectification applied	48
DDH	0	int32	flag	Digital Elevation Model used	49

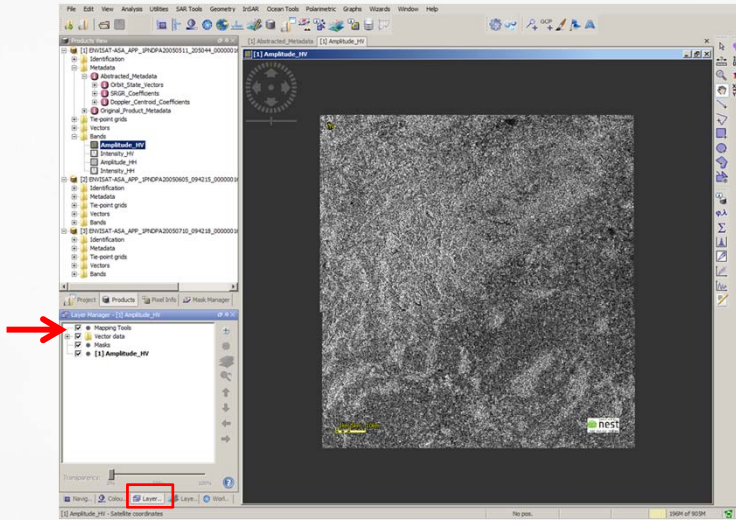
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### Display the Amplitude Image

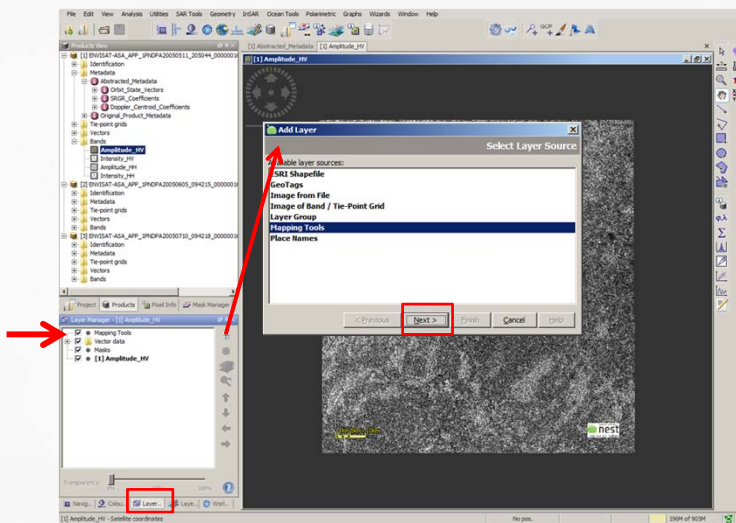
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## Mapping Tool (Activate/deactivate)



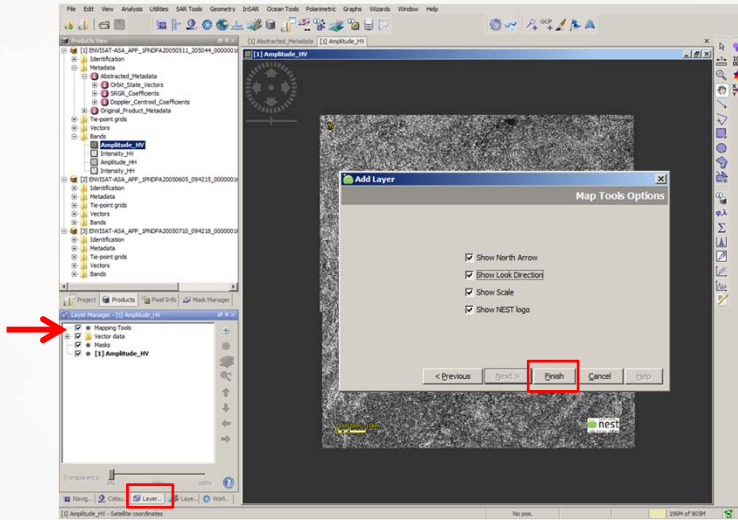
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## Mapping Tool (Activate/deactivate)



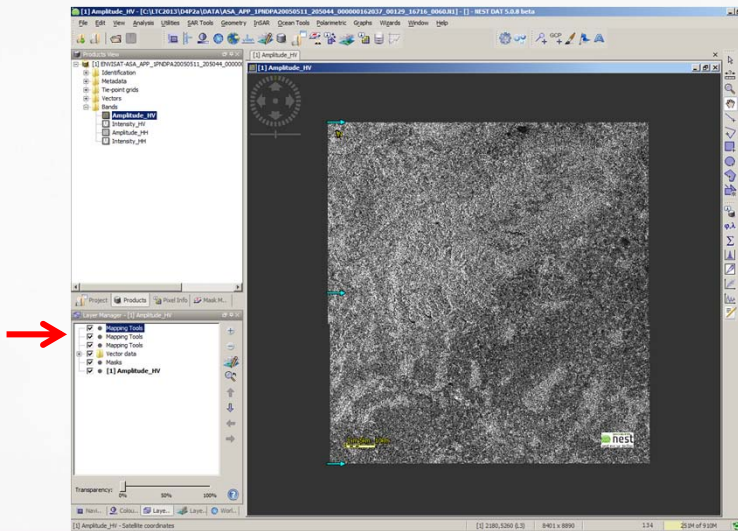
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### Mapping Tool (Activate/deactivate)



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### Mapping Tool (Activate/deactivate)



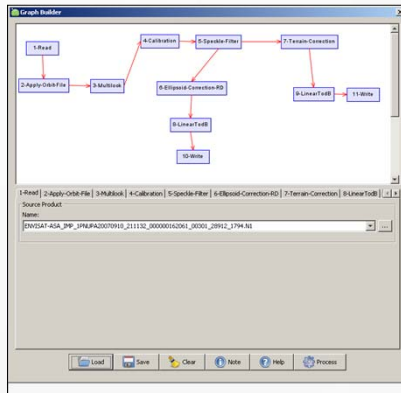
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## Create the processing chain for ASAR using the Graph Builder



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



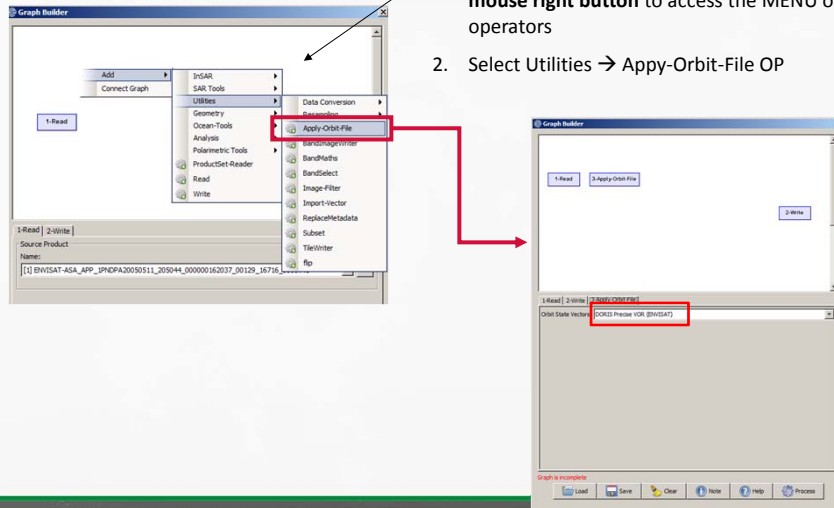
### GRAPH BUILDER

- 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

## Building the chain for the ASAR image: DORIS Precise Orbit

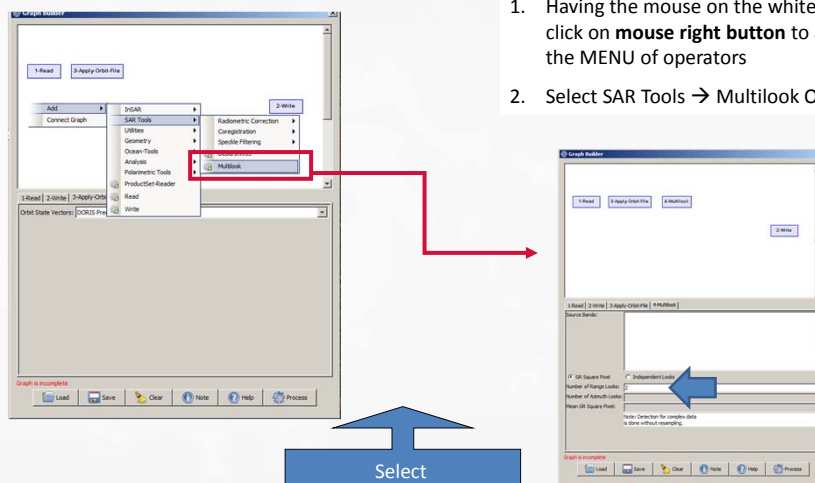
1. Having the mouse on the white space, click on **mouse right button** to access the MENU of operators
2. Select Utilities → Apply-Orbit-File OP



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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

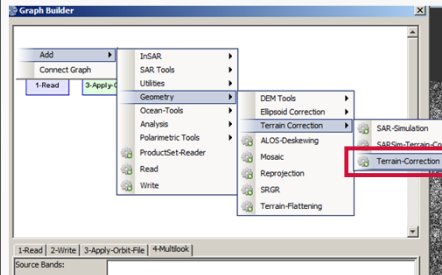


Select  
Product Auxiliary file

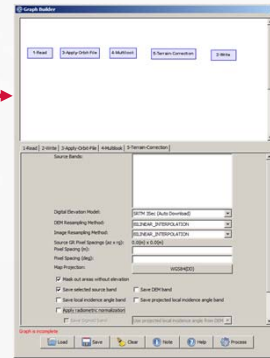
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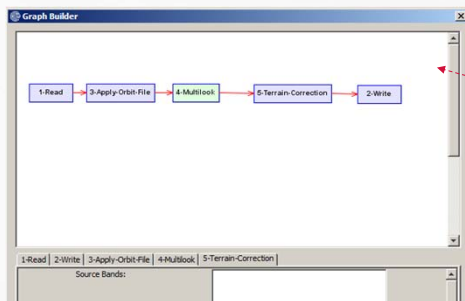
### Building the chain for the ASAR: Terrain Correction



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

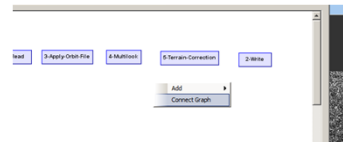


### Building the chain for the ASAR



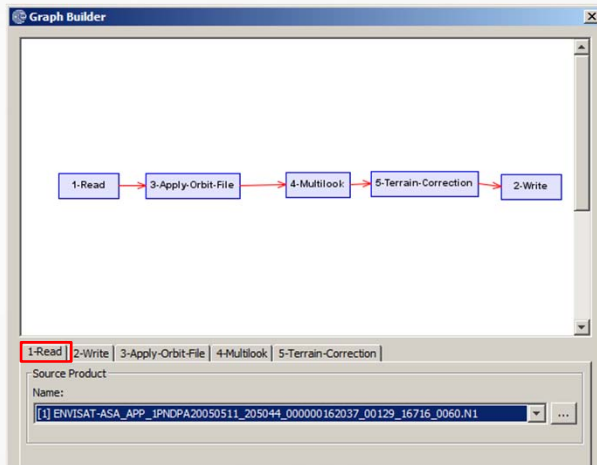
1. Link all the blocks with arrows. To draw the arrow press the left mouse button and link the blocks from right to left

*Or push over*





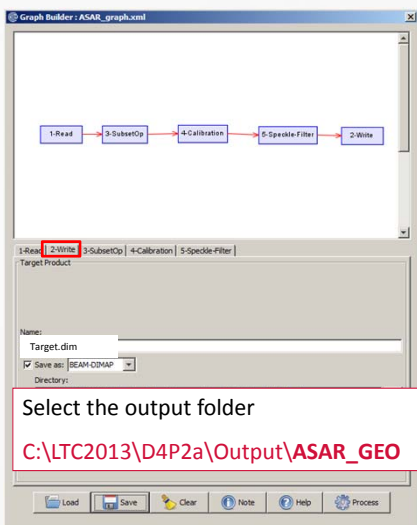
### Building the chain for ASAR



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/m<sup>2</sup>] 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

$\beta^0$	$\sigma_E^0$	$\gamma_E^0$
$A_\beta = \delta_r \cdot \delta_s$	$A_\sigma = \delta_r \cdot \delta_s$	$A_\gamma = \delta_r \cdot \delta_s$

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

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

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:

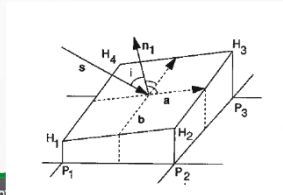
$$\sigma_{Norm}^0 = \sigma_{Ellipsoid}^0 * \frac{\sin \theta_{DEM}}{\sin \theta_{EUL}}$$

Kellndorfer et al., TGRS, Sept. 1998.

$\theta_{DEM}$

Local incidence angle projected into the range plane

Local incidence angle



### Building the chain for the ASAR

C:\LTC2013\Practical\D4P3a\_Forest&Agric\Output

The screenshot shows the Graph Builder interface with a workflow of five steps: 1. Read, 2. Write, 3. Apply Orbit File, 4. Multibook, and 5. Terrain Correction. The 'Save' button at the bottom is highlighted with a red box. A 'NEST DAT - Save Graph' dialog box is open, showing the save path as 'Output' and the file name as 'ASAR\_Graph.vml'. The dialog also shows 'Files of type: Graph (\*.vml)'.



### 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_IPNDPA20050511_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 VOR (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
[Empty Table]					

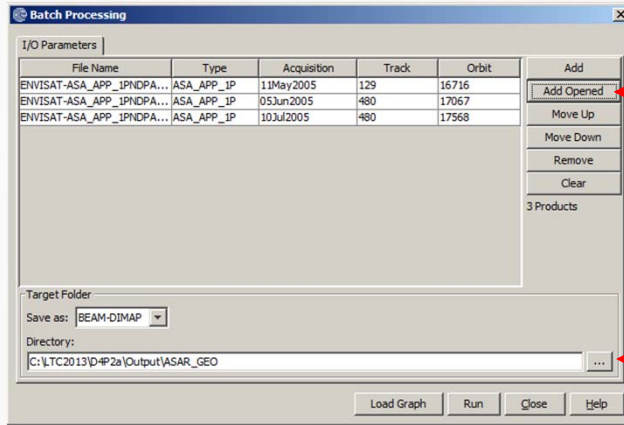
Target Folder:  
Save as: [HEAM-DIMAP]  
Directory: C:\LTC2013\D4P2a\Output\ASAR\_GEO

Buttons: Load Graph, Run, Close, Help

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### The Batch processing

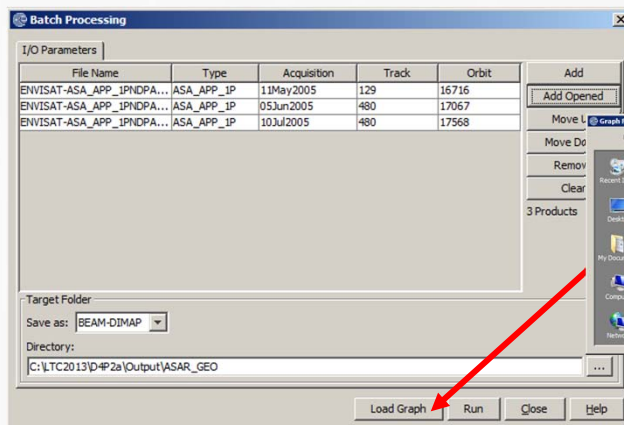


CLICK on  
Add Opened

Select Output directory



### The Batch processing



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



## The Batch processing

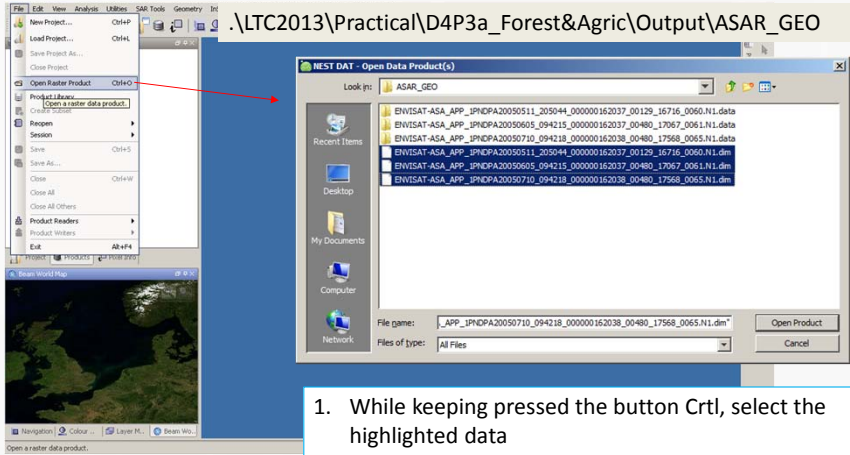
File Name	Type	Acquisition	Track	Orbit
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	11May2005	129	16716
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	05Jun2005	480	17067
ENVISAT-ASA_APP_IPNDPA...	ASA_APP_IP	10Jul2005	480	17568

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

## Open the GEOCODED ASAR dataset



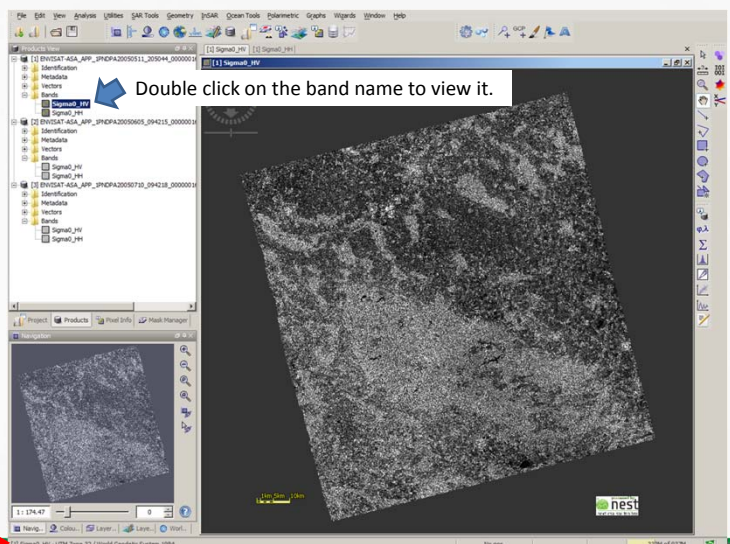
### Open the GEOCODED ASAR dataset



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



### 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

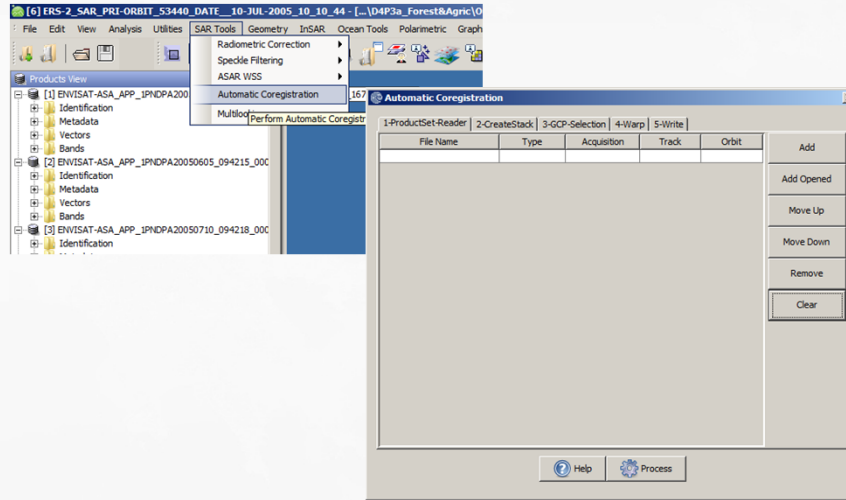


File Name	Type	Acquisition	Track	Orbit
ERS-2_SAR_PRI_ORBIT_535..._ERS2_SAR_PRI		11May2005	129	52588
ERS-2_SAR_PRI_ORBIT_529..._ERS2_SAR_PRI		05Jun2005	480	52939
ERS-2_SAR_PRI_ORBIT_534..._ERS2_SAR_PRI		10Jul2005	480	53440

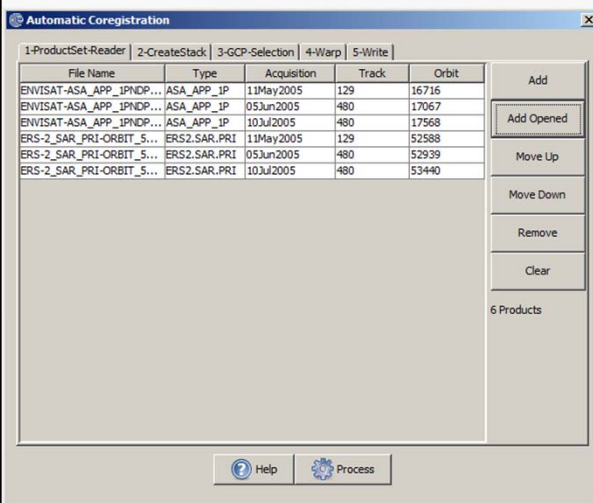
Target Folder: [BEAM-CDMAP]  
Directory: C:\LTC2013\Practical\D4P3a\Output\ERS\_GEO



### Coregistration of ASAR and ERS geocoded data



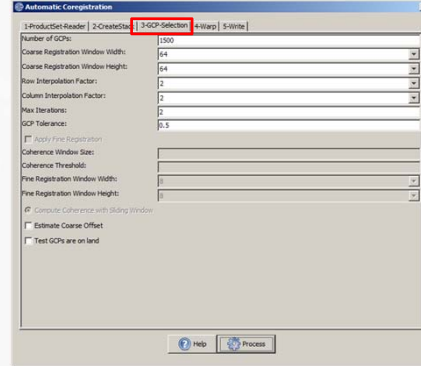
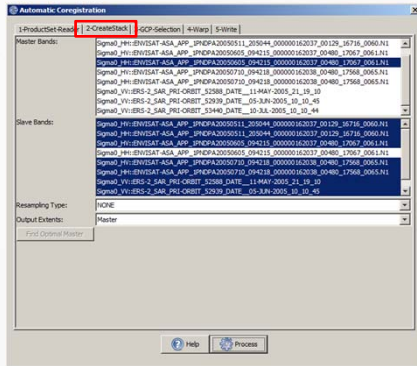
### Coregistration of ASAR and ERS geocoded data



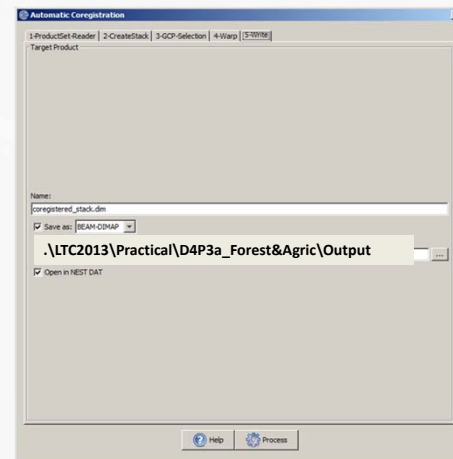
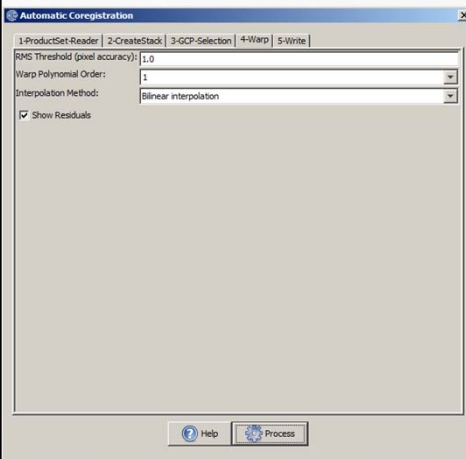
CLICK on  
Add Opened

## Coregistration of ASAR and ERS geocoded data

Select as a Master: HH - 05062005

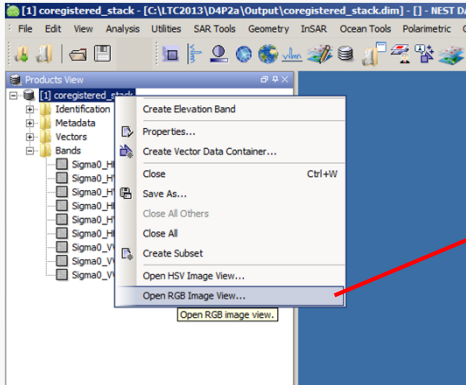


## Coregistration of ASAR and ERS geocoded data

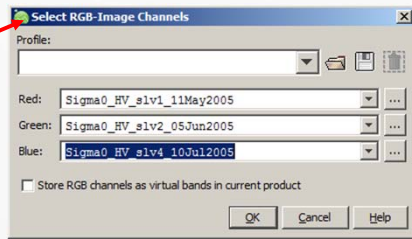




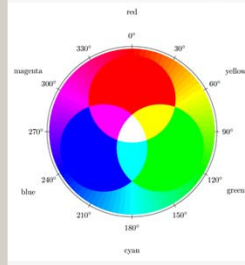
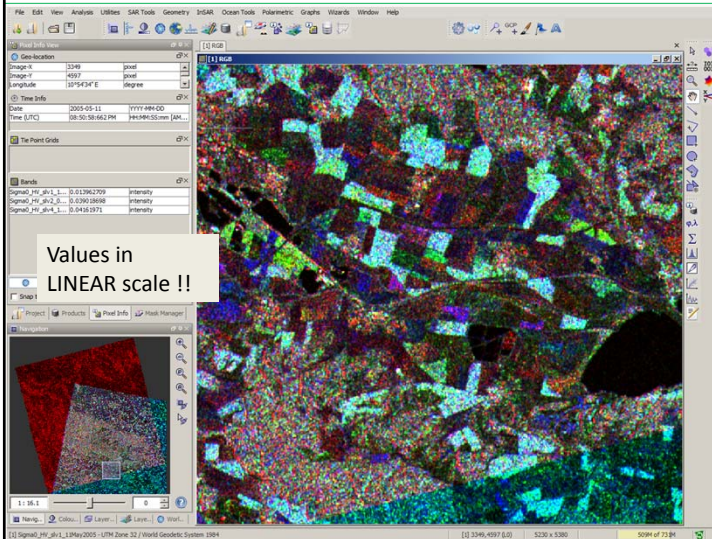
### RGB visualisation: HV polarisation (ASAR)



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

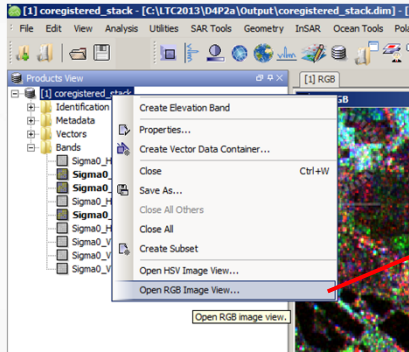


### RGB visualisation: HV polarisation (ASAR)

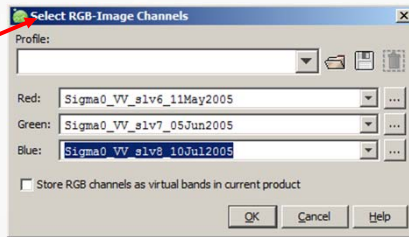




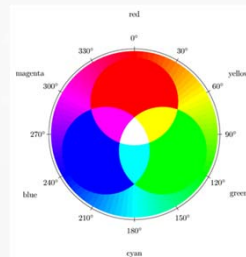
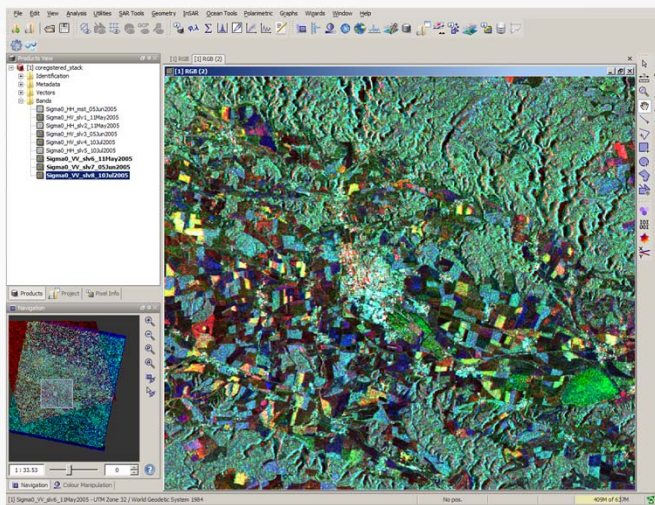
### RGB visualisation: VV polarisation (ERS)



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

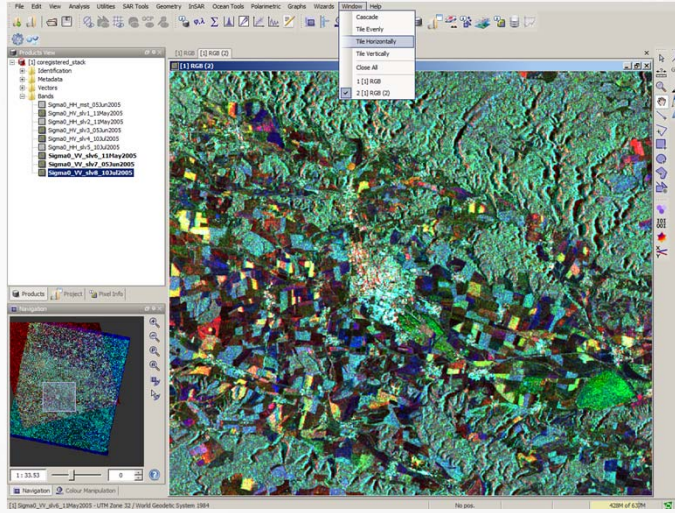


### RGB visualisation: VV polarisation (ERS)





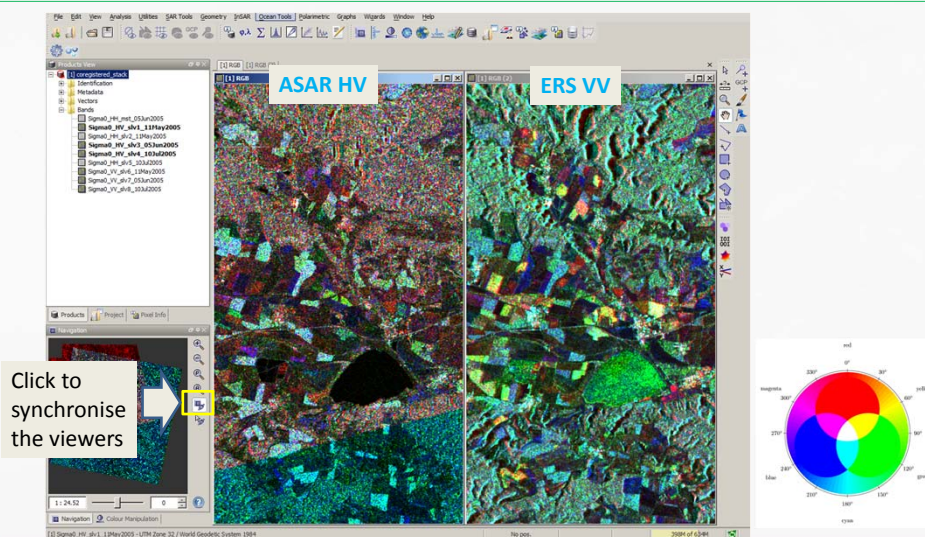
### RGB visualisation: ASAR HV vs ERS VV



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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

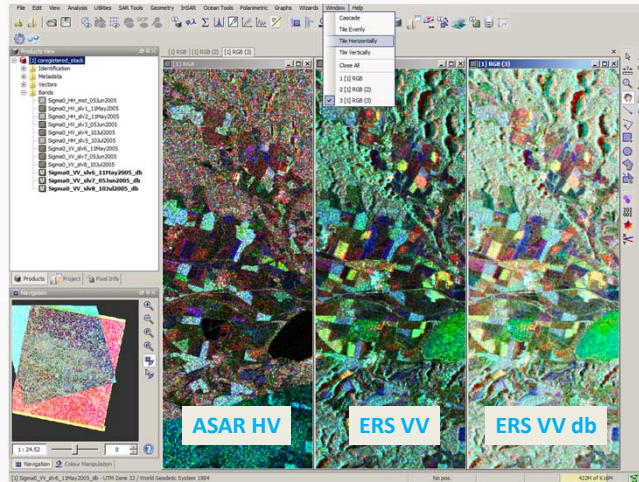
Store RGB channels as virtual bands in current product

OK Cancel Help

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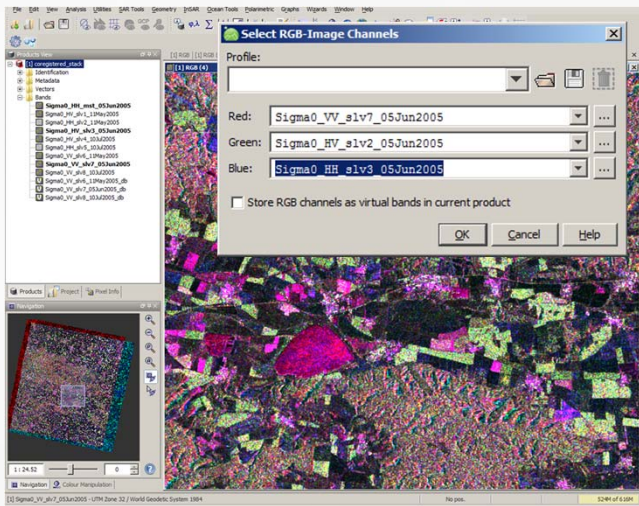
### RGB visualisation (db): ERS VV



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

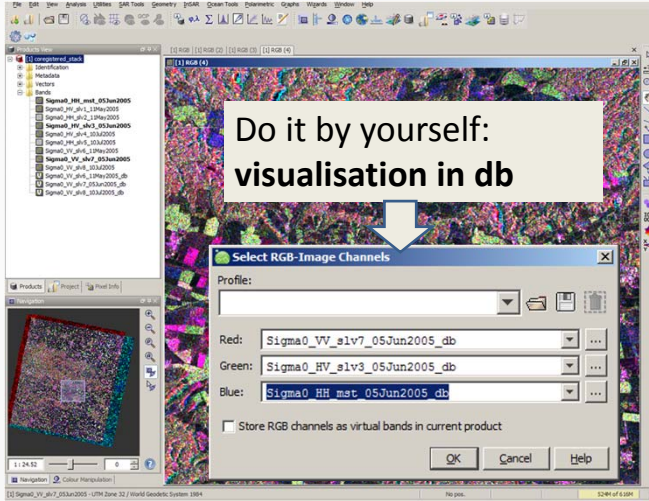


Red – ERS VV  
 Green – ASAR HV  
 Blue – ASAR HH

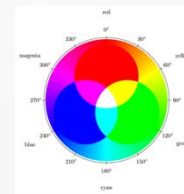
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### 05-06-2005 RGB visualisation: ERS VV – ASAR HV – ASAR HH



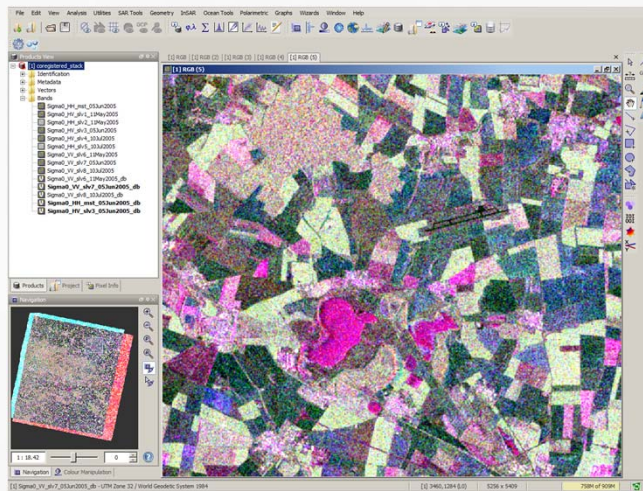
Red – ERS VV  
 Green – ASAR HV  
 Blue – ASAR HH



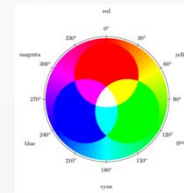
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### 05-06-2005 RGB visualisation (db): ERS VV – ASAR HV – ASAR HH



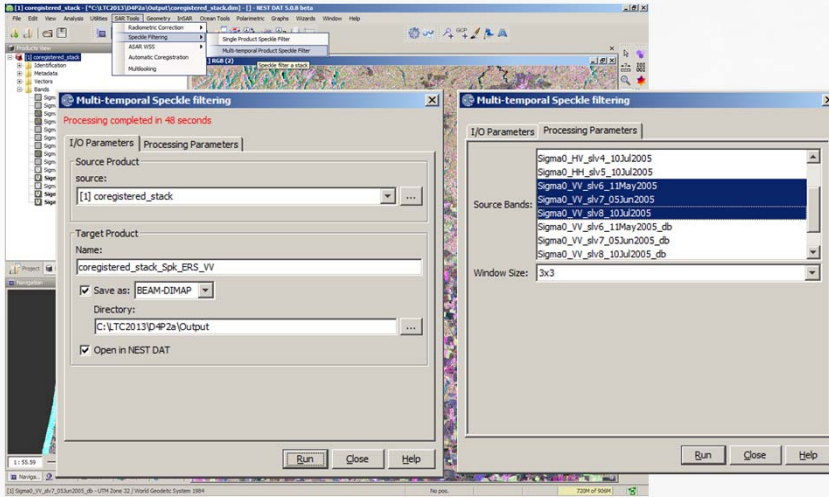
Red – ERS VV  
 Green – ASAR HV  
 Blue – ASAR HH



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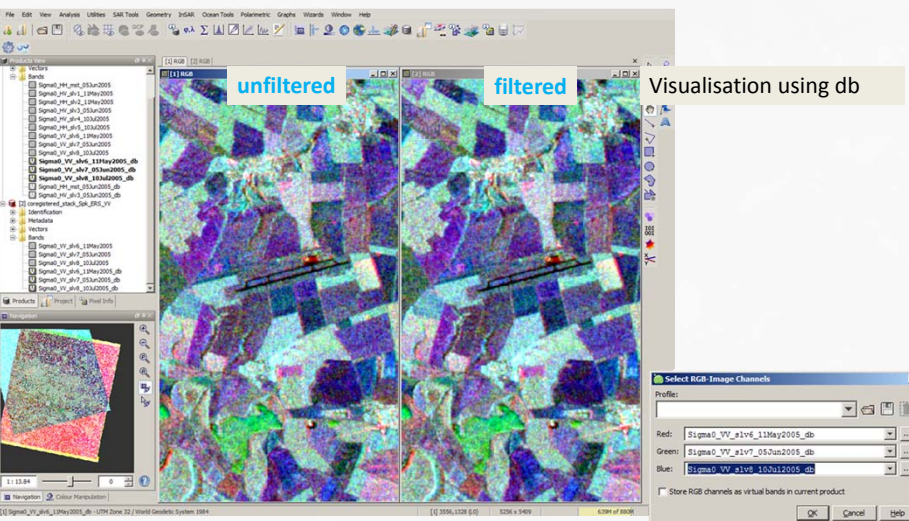
### Multitemporal Speckle filtering: ERS-VV



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### Multitemporal Speckle filtering: unfiltered vs filtered ERS-VV

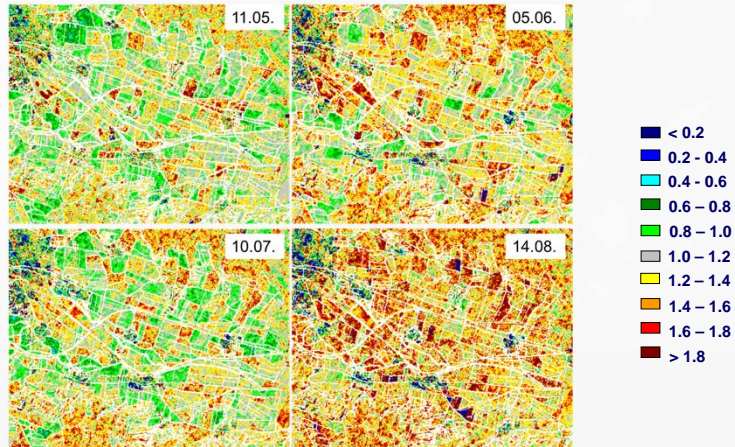


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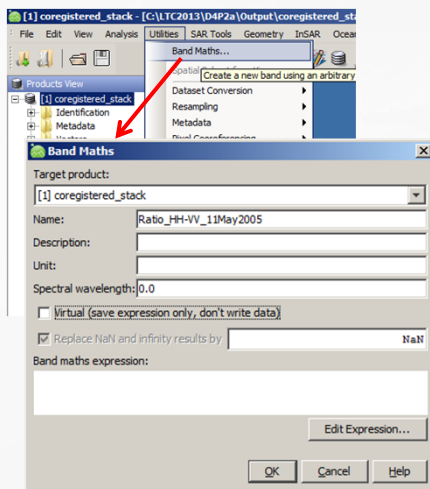
## SAR data interpretation – agriculture: Ratio HH / VV

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

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



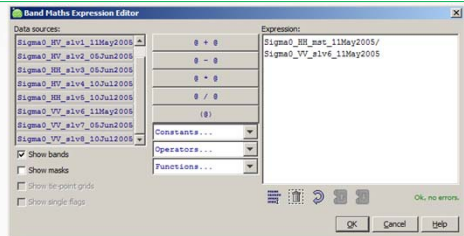
## Compute ratio HH / VV (11 May 2005)



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

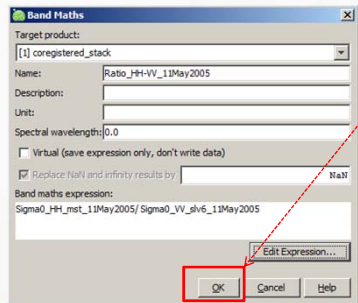


### Compute ratio HH / VV (11 May 2005)



6. Write the expression select the bands

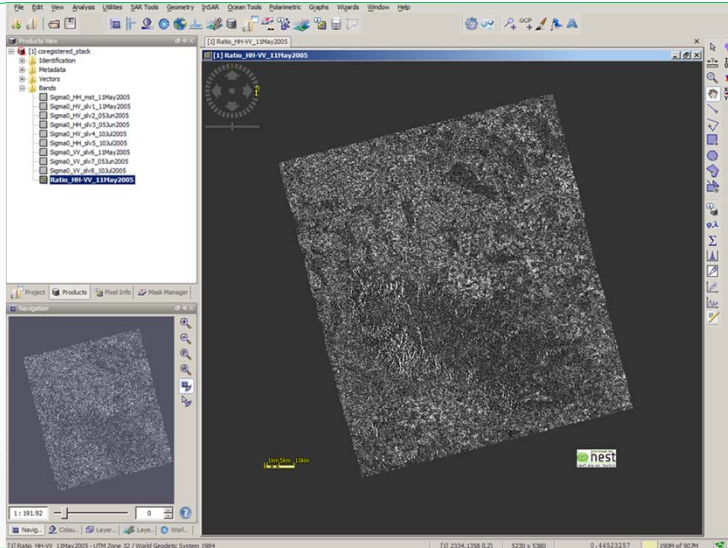
7. Click OK



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

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### Overlay shape file information

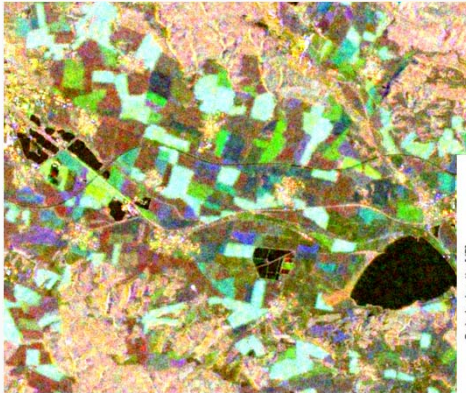
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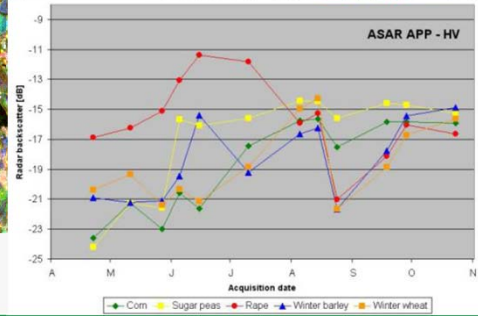
### SAR data interpretation– agriculture

#### 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!