Working with RadarSat-2 and TerraSAR-X High-Resolution Data

Requirements, Methods and Tools for the DTeddie Preprocessing Chain

Joint Workshop in Tarusa 02/2012
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DER FORSCHUNG | DER LEHRE | DER BILDUNG

Outline

- Requirements of the DTeddie Project
- Data Acquisition
- Radiometric Calibration
- Geographic Calibration
- Discussion
- Outlook and Future Work

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Aim of the DTeddie Project

Detecting and **T**racking Small Scale **Eddie**s
in the Black Sea and the Baltic Sea
Using High-Resolution Radarsat-2 and
TerraSAR-X Imagery

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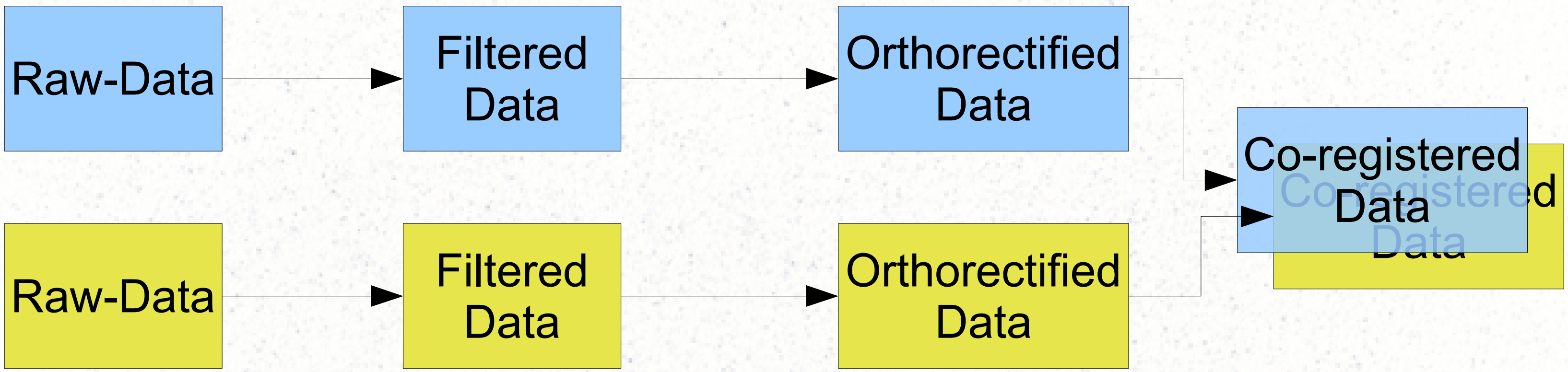
Requirements I

- High-resolution SAR data (1m – 50m p. pixel)
- Spatio-temporal *near* images
- Visibility of trackable objects and eddy-like structures
- Ground Truth w.r.t. real measurements
- Good radiometric quality
- Best geographic quality

Requirements II

- Generic and independent preprocessing chain



- Motion estimation
- Validation and explanation of results by means of other (e.g. in-situ) measurements

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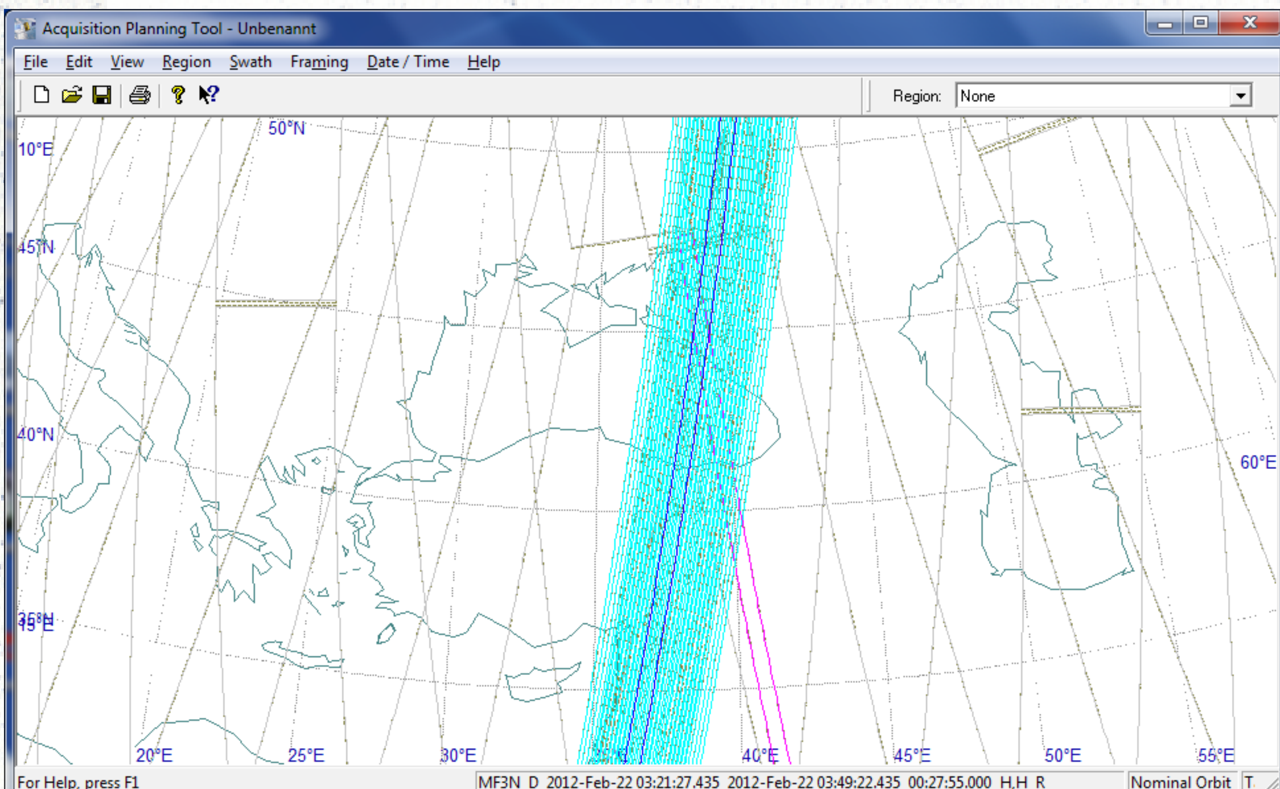
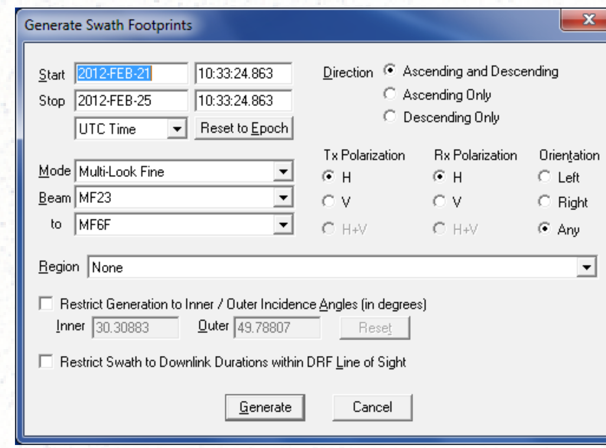
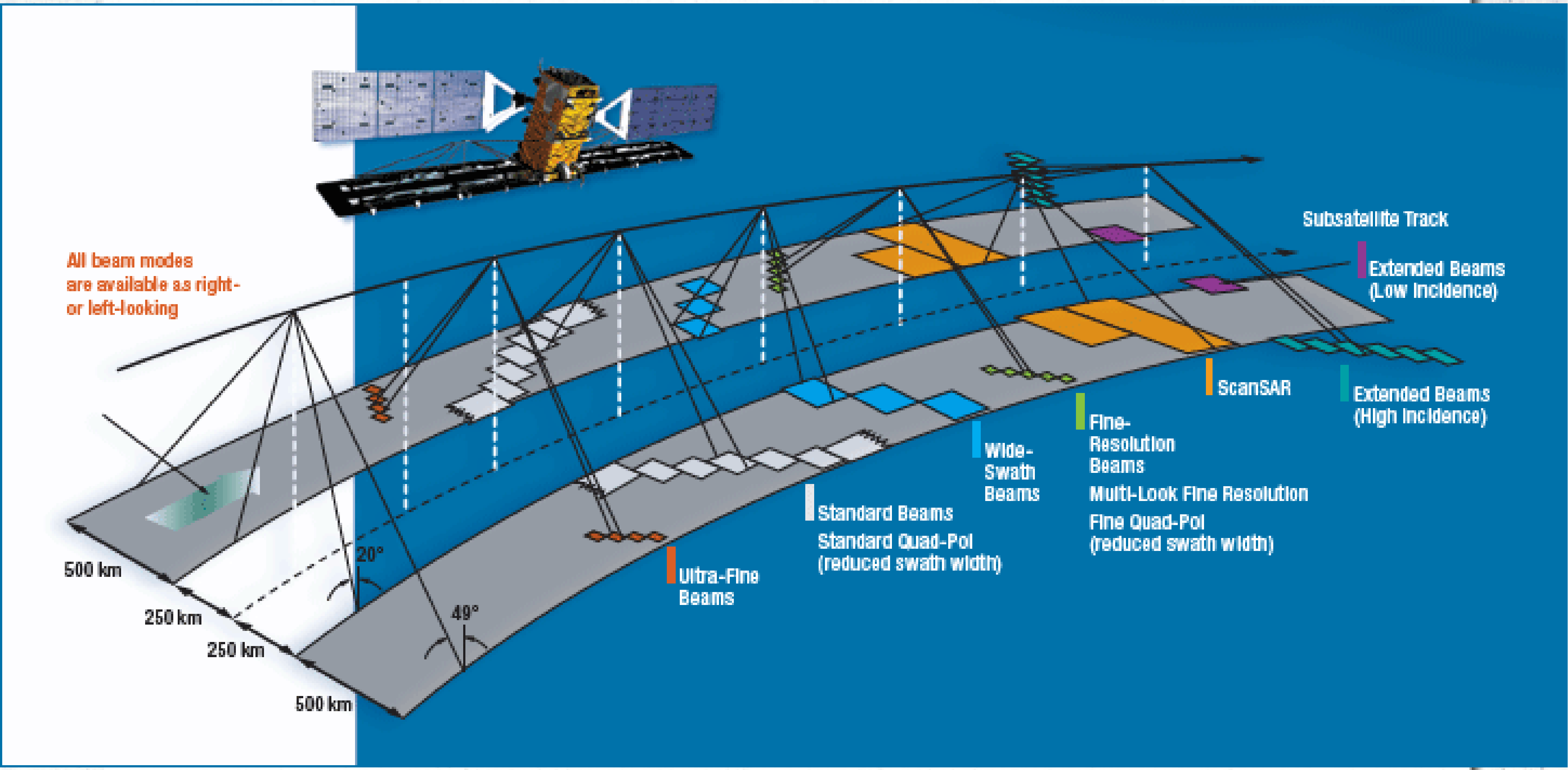
Data Acquisition: Radarsat-2

- MDA Acquisition Planning Tool (APT)
  - Windows only
  - Create and order via APT-files





Radarsat-2 Image Modes I



Data taken from CSA-brochure, ©2012 CSA

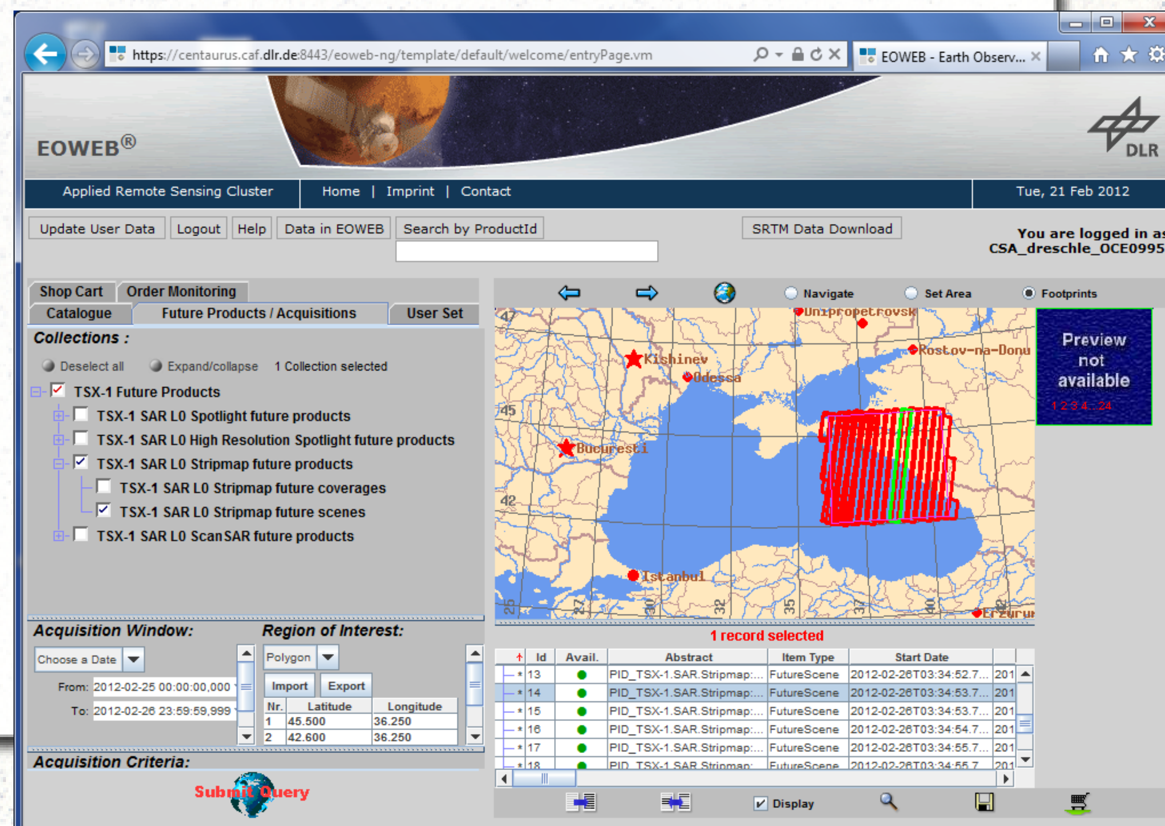
Radarsat-2 Image Modes II

BEAM MODE		APPROXIMATE INCIDENCE ANGLE	NOMINAL SWATH WIDTH	APPROXIMATE RESOLUTION [1]	NUMBER OF LOOKS
Selective Polarization transmission H or V receive H and/or V	Fine	37°- 49°	50 km	10 x 9 m	1 x 1
	Standard	20°- 49°	100 km	25 x 28 m	1 x 4
	Low Incidence	10°- 23°	170 km	40 x 28 m	1 x 4
	High Incidence	50°- 60°	70 km	25 x 28 m	1 x 4
	Wide	20°- 45°	150 km	25 x 28 m	1 x 4
	ScanSAR Narrow	20°- 46°	300 km	50 x 50 m	2 x 2
	ScanSAR Wide	20°- 49°	500 km	100 x 100 m	4 x 4
Polarimetric transmit H and V on alternate pulses receive H and V on any pulse	Fine Quad-Pol	20°- 41°	25 km	11 x 9 m	1 x 1
	Standard Quad-Pol	20°- 41°	25 km	25 x 28 m	1 x 4
Selective Single Polarization transmit H or V receive H or V	Ultra-Fine	30°- 40°	20 km	3 x 3 m	1 x 1
	Multi-Look FIne	30°- 50°	50 km	11 x 9 m	2 x 2

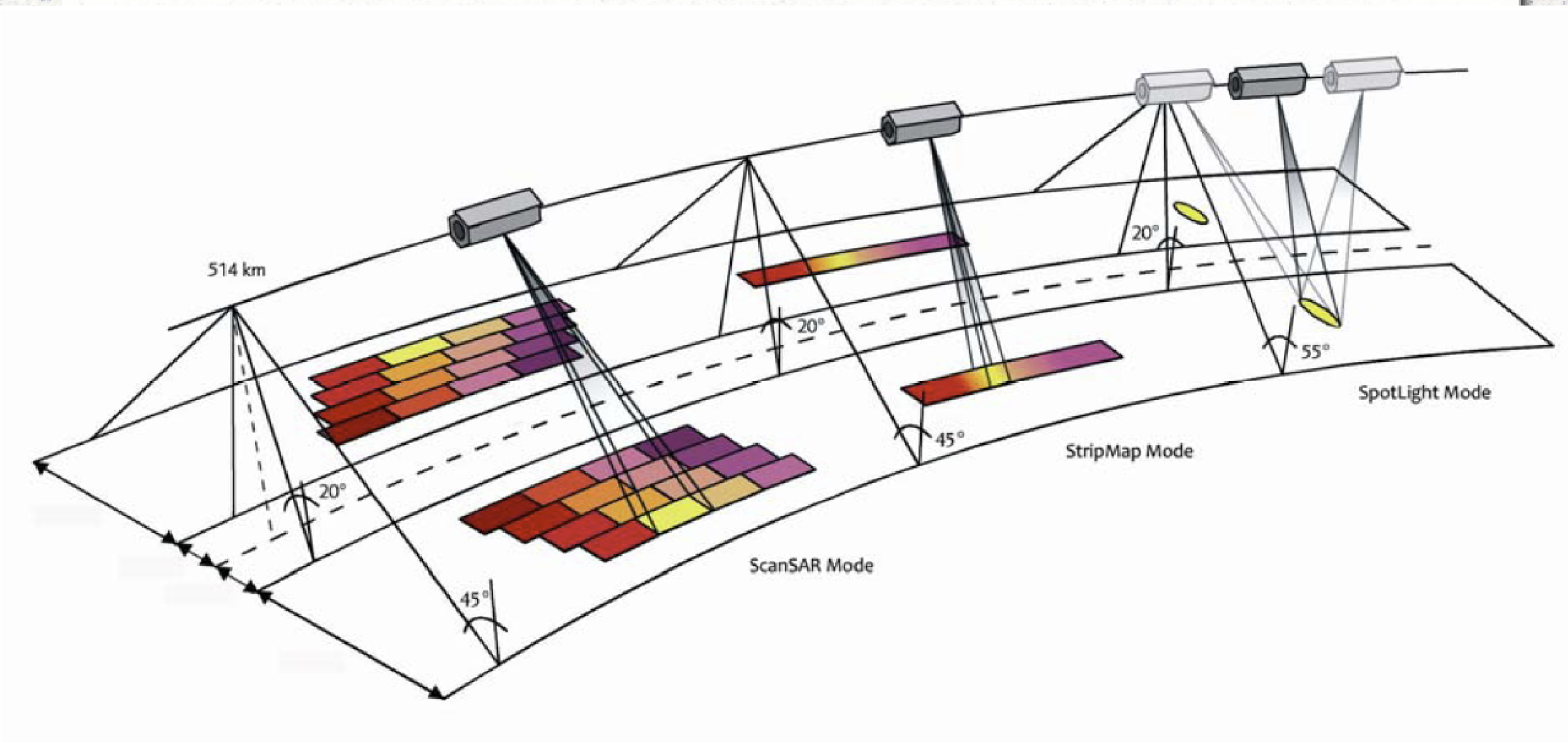
1. Ground range by azimuth

Data Acquisition: TerraSAR-X

- EOWeb (Next Gen)
  - Web-Interface (IE, Windows only)
  - Direct ordering



TerraSAR-X Image Modes I

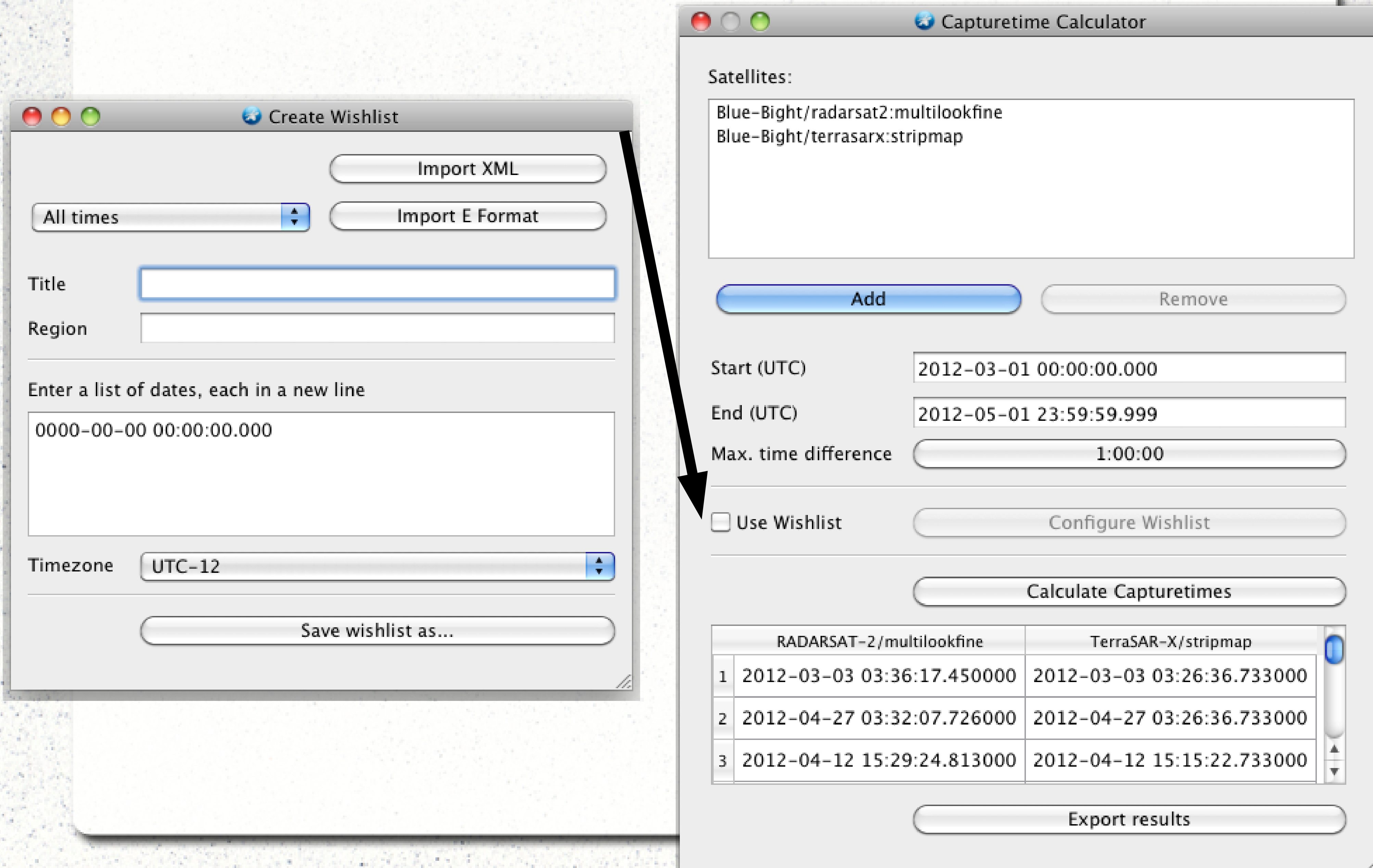


Data taken from infoterra-brochure, ©2012 infoterra

TerraSAR-X Image Modes II

Imaging Mode	Standard Scene Size* [km]	Maximum Acquisition Length [km]	Slant Range Res.[1] [m]	Azimuth Res.[1] [m]	Polarization	Full Performance Range [°]
HighRes SpotLight (HS)	10 x 5	5	1.2 1.2	1.1. 2.2	Single (VV or HH) Dual (HH & VV)	20° to 55°
HighRes SpotLight 300 MHz (HS300)	7-10 x 5	5	0.6	1.1	Single (VV or HH)	20° to 55°
SpotLight (SL)	10 x 10	10	1.2 1.2	1.7 3.4	Single (VV or HH) Dual (HH & VV)	20° to 55°
StripMap (SM)	30 x 50 single pol 15 x 50 dual pol	1.650	1.2 1.2	3.3 6.6	Single (VV or HH) Dual (HH & VV, HH & HV, or VV and VH)	20° to 45°
ScanSAR (SC)	100 x 150	1.650	n/a	18.5	Single (VV or HH)	20° to 45°

Tool for Image-Series Acquisition



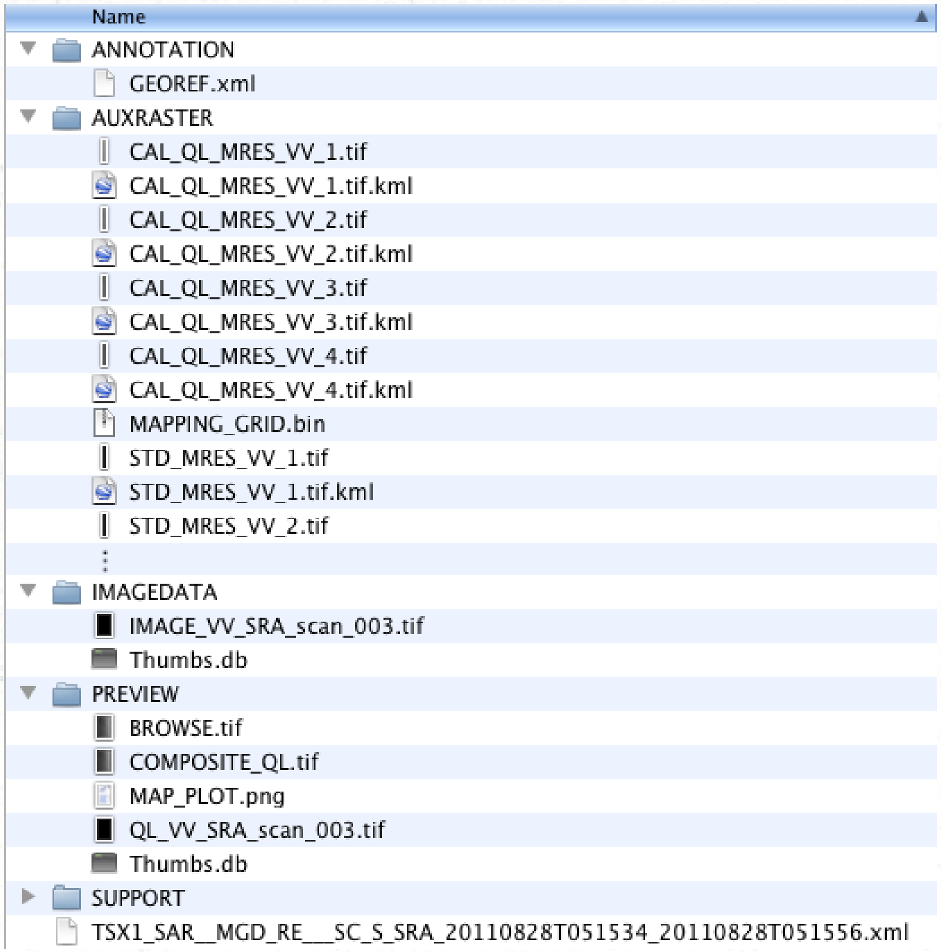
Delivered Data: Radarsat-2

- Compressed archive at CSA's FTP server
- Flat hierarchy (only one subfolder containing the XML-schemas)

Name
BrowseImage.tif
imagery_VV.tif
LI-11525-12 RS2 EULA_Single User_V1-9_15JUN2011_ENGLISH.pdf
LI-11525-12 RS2 EULA_Single User_V1-9_15JUN2011_ESPANOL.pdf
LI-11525-12 RS2 EULA_Single User_V1-9_15JUN2011_FRANCAIS.pdf
lutBeta.xml
lutGamma.xml
lutSigma.xml
product.xml
readme.txt
schemas

Delivered Data: TerraSAR-X

- Compressed archive at DLR's FTP server
- Hierarchy with subfolders for each type of metadata



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Radiometric Calbration: Radarsat-2

- Read from XML-Metadata (lutBeta.xml, lutGamma.xml, lutSigma.xml)
  - Column-length array gains `<gains> … </gains>`
  - Single offset `<offset> … </offset>`
- Apply gains and offset for Sigma-nought image

$$S_0 = R(x,..) * Gains(S_0,x) + Offset(S_0)$$

- Special computations needed for complex-valued images!

Radiometric Calibration: TerraSAR-X

- Read from XML-Metadata:
  - Incidence angles at Tie-Points

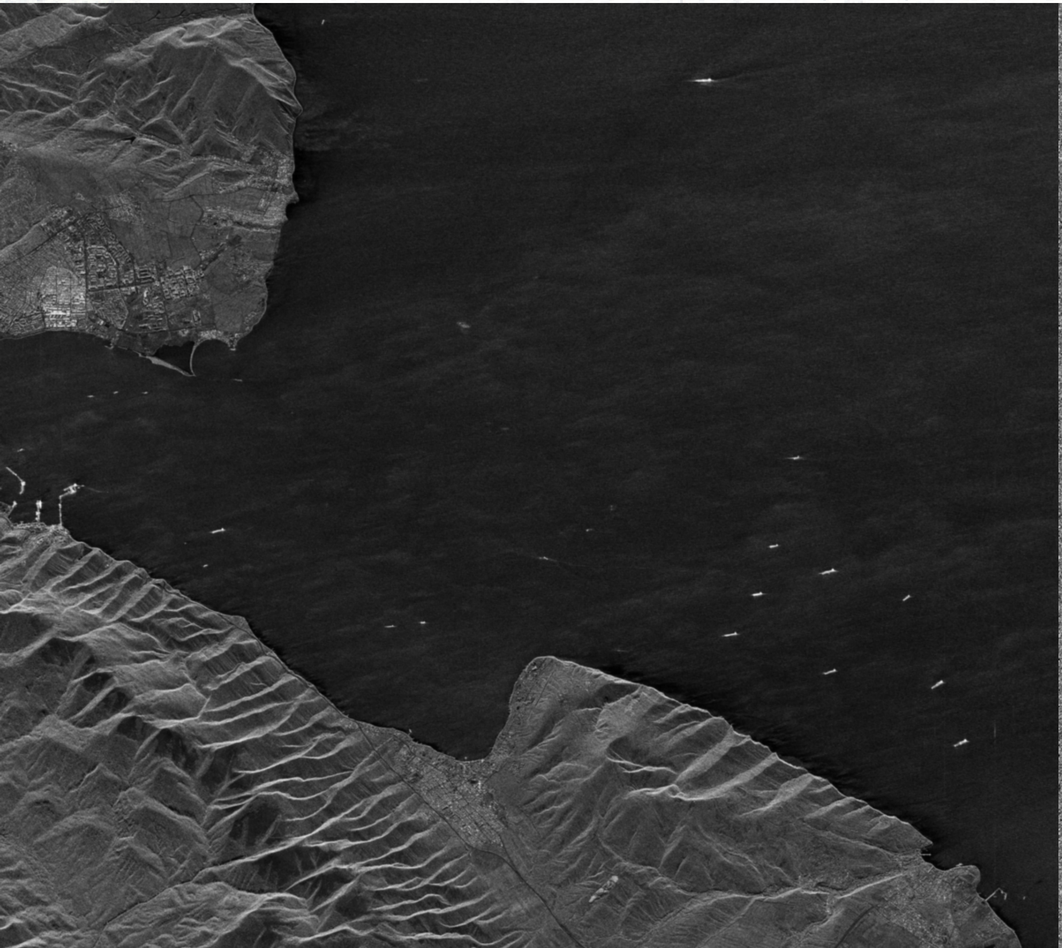
    `productInfo/sceneInfo/sceneCornerCoord/incidenceAngle`
  - Calibration Constant

    `calibration/calibrationConstant/calFactor`
- Get min. and max. incidence angle and assume linear distribution for correction:

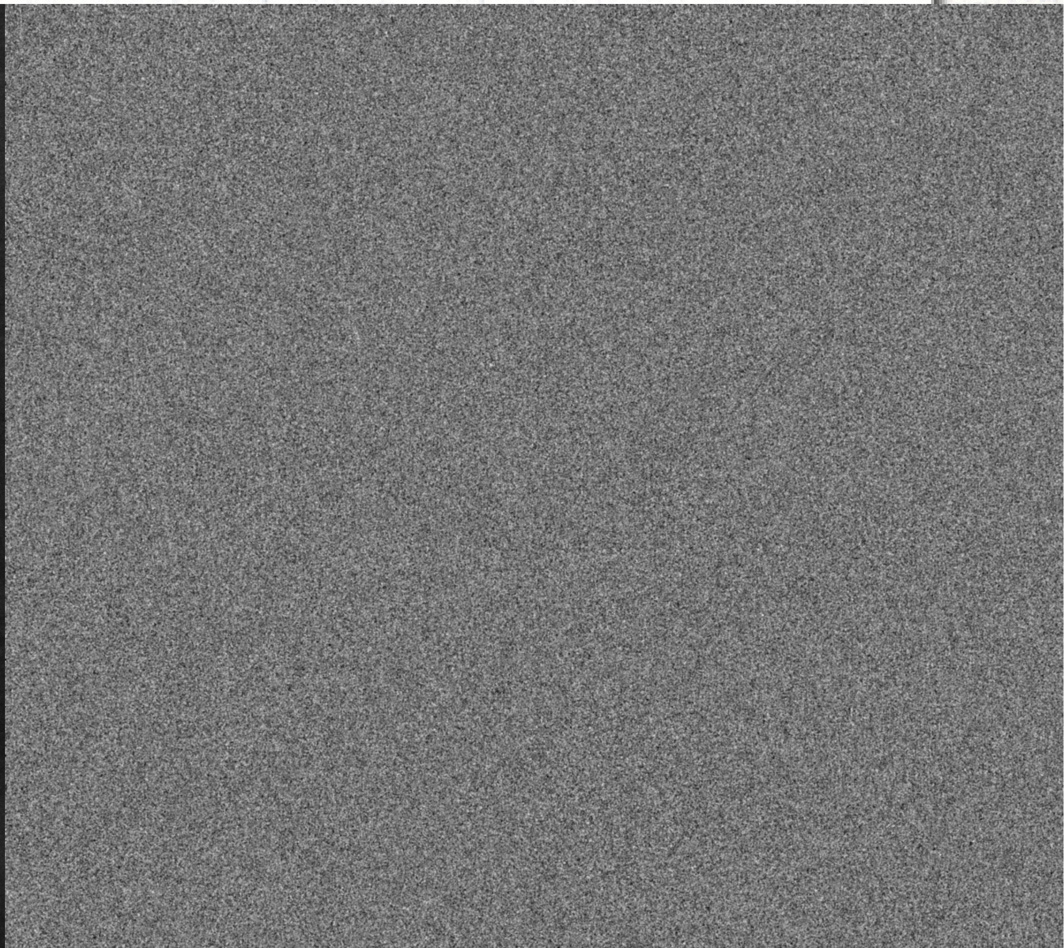
$$S_0 = R(x,\ldots) \quad * \sin(x*(max\_ang - min\_ang)/w) + CalibrationConstant$$

Examples for radiometric Calibration: Radarsat-2 UF_SLC

- Magnitude



- Phase



Examples for radiometric Calibration: Radarsat-2 UF_SLC

- Beta0

- Sigma0

Examples for radiometric Calibration: TerraSAR-X SM

- From Raw-Data to Beta0

Examples for radiometric Calibration: TerraSAR-X SM

- From Beta0 to Sigma0

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Geographic Calibration I

- Two-step approach:
  1. Orthorectify images (automatically)
  2. Co-register images (manually, pointwise)
- First step is executed by GDAL library:
  - ```
    gdalwarp „infile.tif“ „outfile.tif“
              -t_srs "+proj=longlat +ellps=WGS84“
    ```

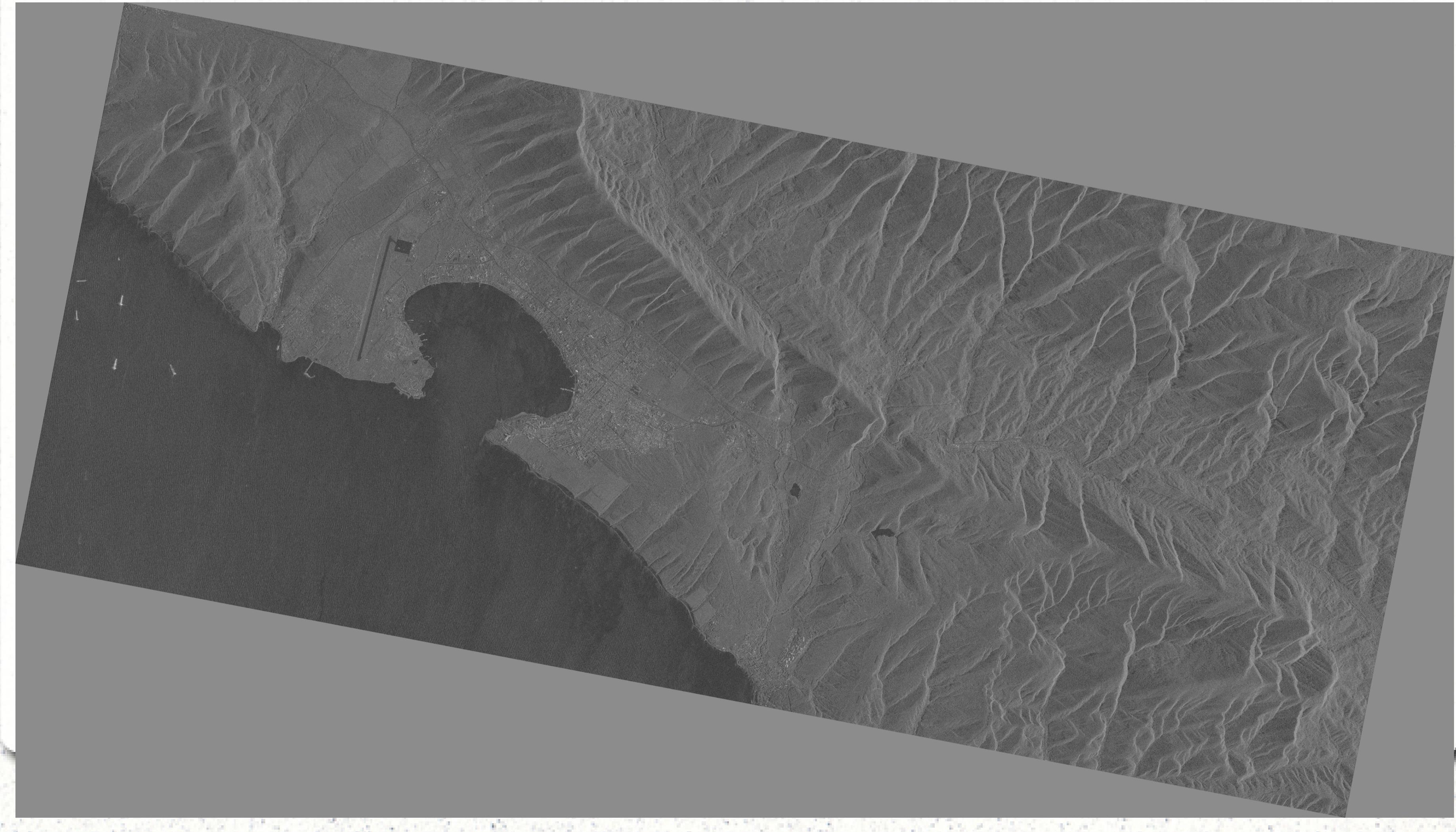
    transformes the Axis to lon,lat coordinates according to the WGS84 ellipsoid
- Co-registration of images using program of choice (e.g. ENVI)
    ```

Examples for geographical calibration

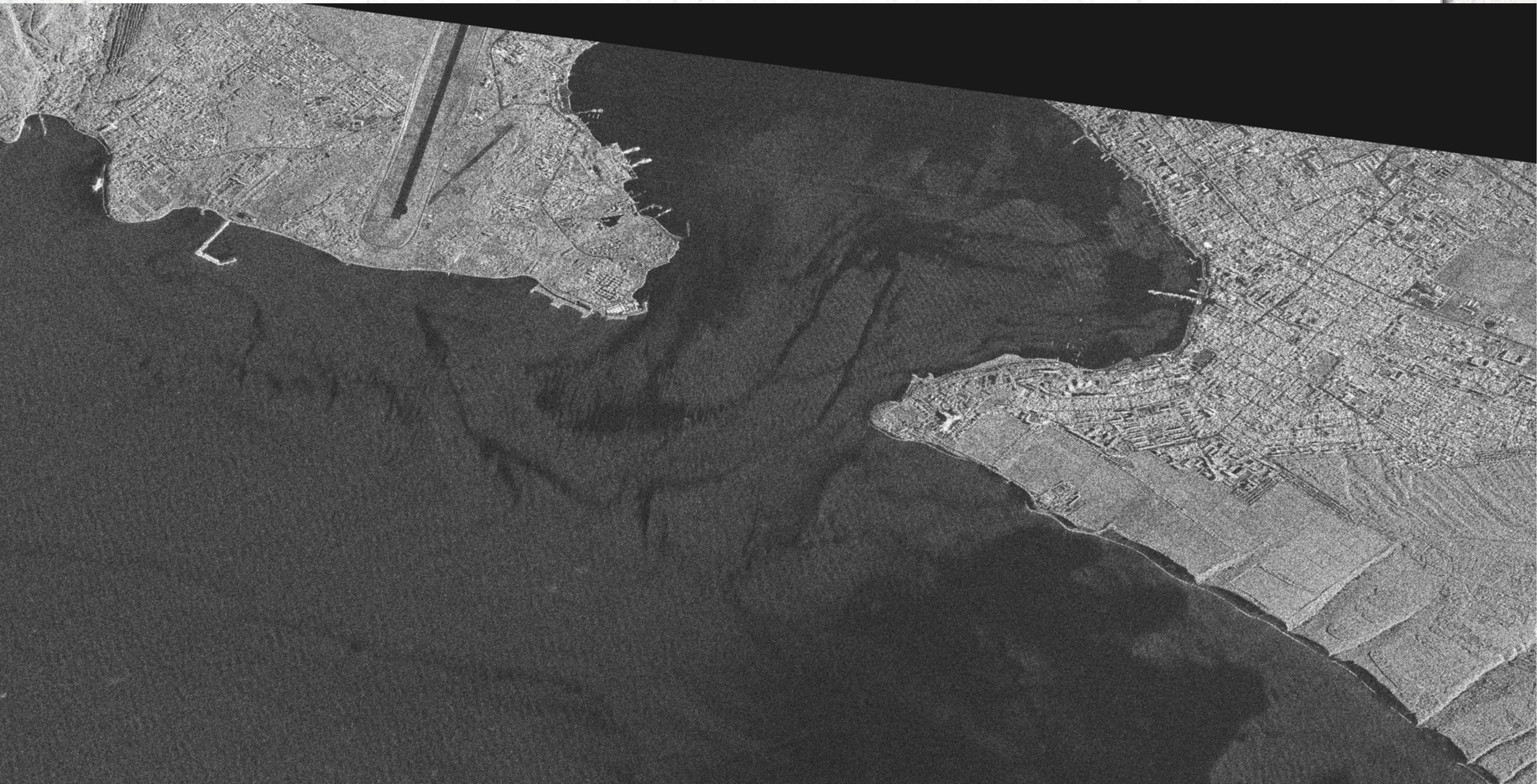
- Sigma0-image of TerraSAR-X

Examples for geographical calibration

- Orthorectified image



Co-registration Radarsat-2



Co-registration TerraSAR-X

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Discussion I

- We have implemented the whole processing chain in Python, using:
  - xml.etree for XML-related procedures
  - osgeo.gdal for RAW-Data handling
  - vigra for image processing
- Platform-independent
- Only ~500 lines of code
- But....

Discussion II

- … relatively large amount of memory needed.
- Images need to be stored as (unpacked) float arrays in RAM
- Example for a high-resolution TerraSAR-X image (16,960 * 25,288) px:

  16,960 * 25,288 * 4 Byte = 1.63GB p. channel
- Often, at least twice the memory of an image is needed, or more channels

Discussion III

- Memory problems solved by a workstation with 16 processors and 24GB of RAM
- Better implementation would yield a certain re-development:
  - Maybe without Python
  - Surely many more lines of code
  - Probably less reliable
- Costs above value!

Discussion IV

- Manual co-registration still necessary due to
  - Different flight directions
  - Different RADAR-bands
  - Different imaging modes
- A prori orthorectification has shown to be very helpful for this last manual step!
  - Orthorectification is done automatically
  - Coarse geometry is known afterwards

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Outlook

- Aqusition of more scenes for the DTeddie project by the help of the developed tool
- Running the Python Preprocessing tools on the acquired data
- Distribution of the data and the preprocessed data
- Adapt w.r.t. user needs?

Future work

- Test for Python-optimizations to further
  - increase speed and
  - decrease memory usage.
- Adapt for new data formats if necessary, currently supported:
  - Radarsat-2 Single Look Complex data
  - TerraSAR-X Stripmap Mode data
- Increase usability (currently commandline)

Thank you for your attention!