

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

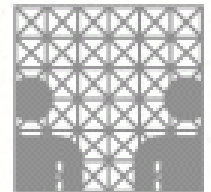
Requirements, Methods and Tools for the DTeddie Preprocessing Chain

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



Outline

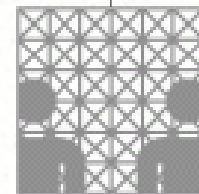
- Requirements of the DTeddie Project
- Data Acquisition
- Radiometric Calibration
- Geographic Calibration
- Discussion
- Outlook and Future Work

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Aim of the DTeddie Project

Detecting and Tracking Small Scale Eddies
in the Black Sea and the Baltic Sea
Using High-Resolution Radarsat-2 and
TerraSAR-X Imagery

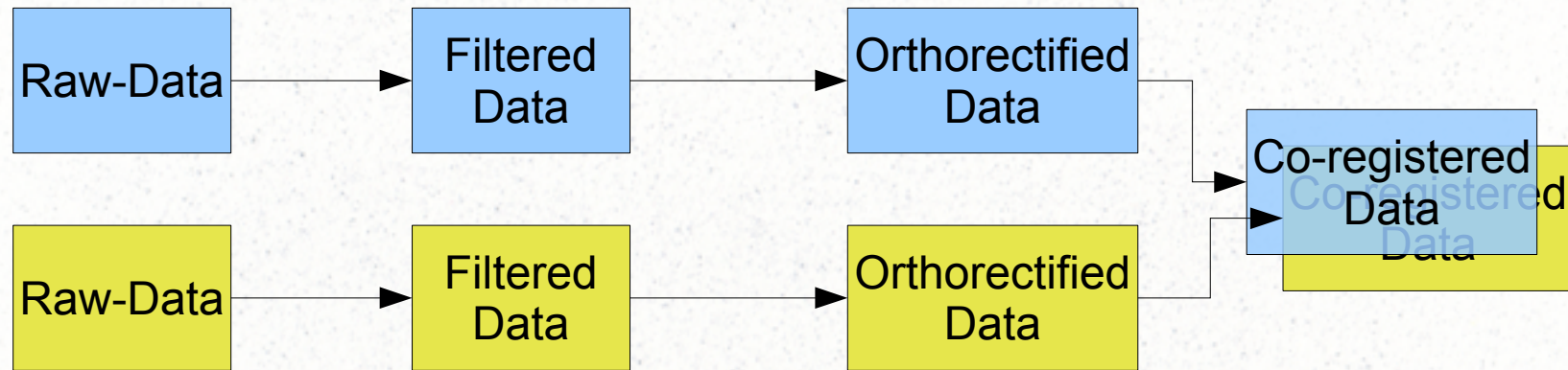


Requirements I

- 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



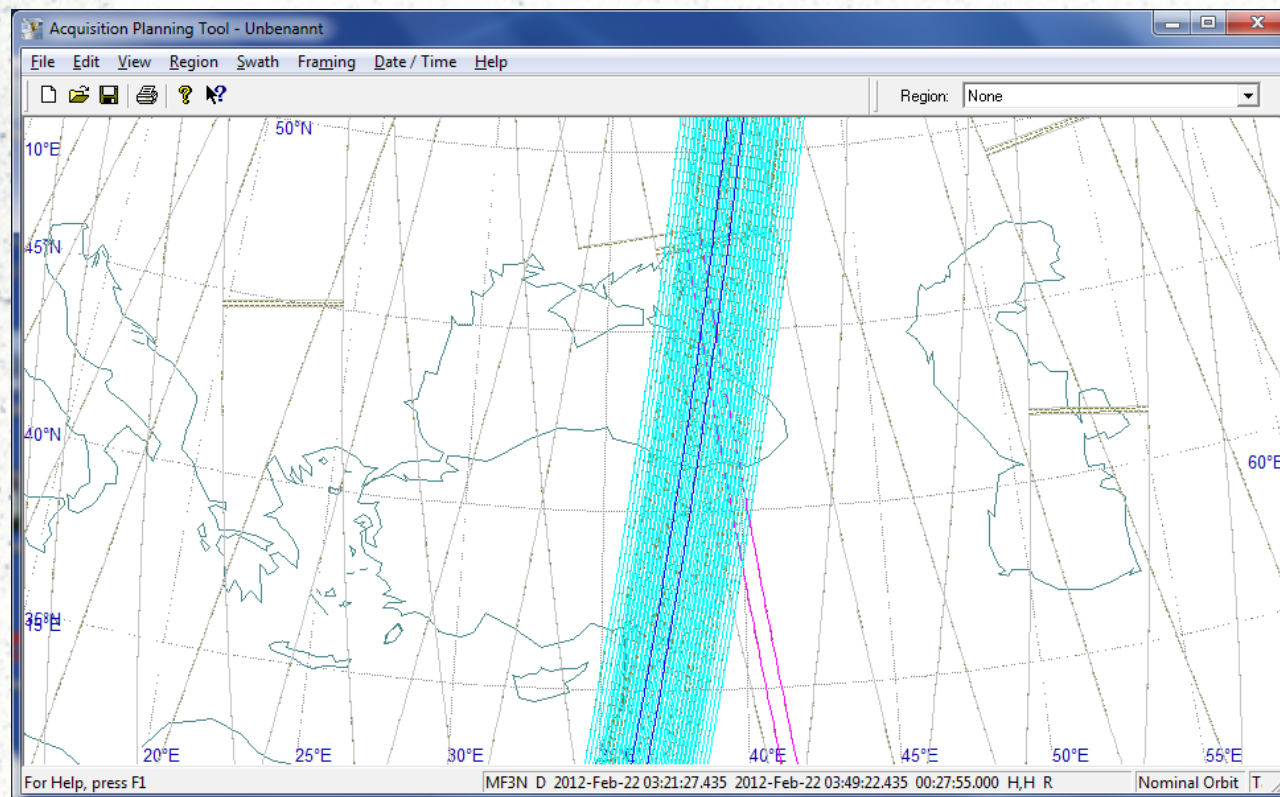
- Motion estimation
- Validation and explanation of results by means of other (e.g. in-situ) measurements

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Data Acquisition: Radarsat-2

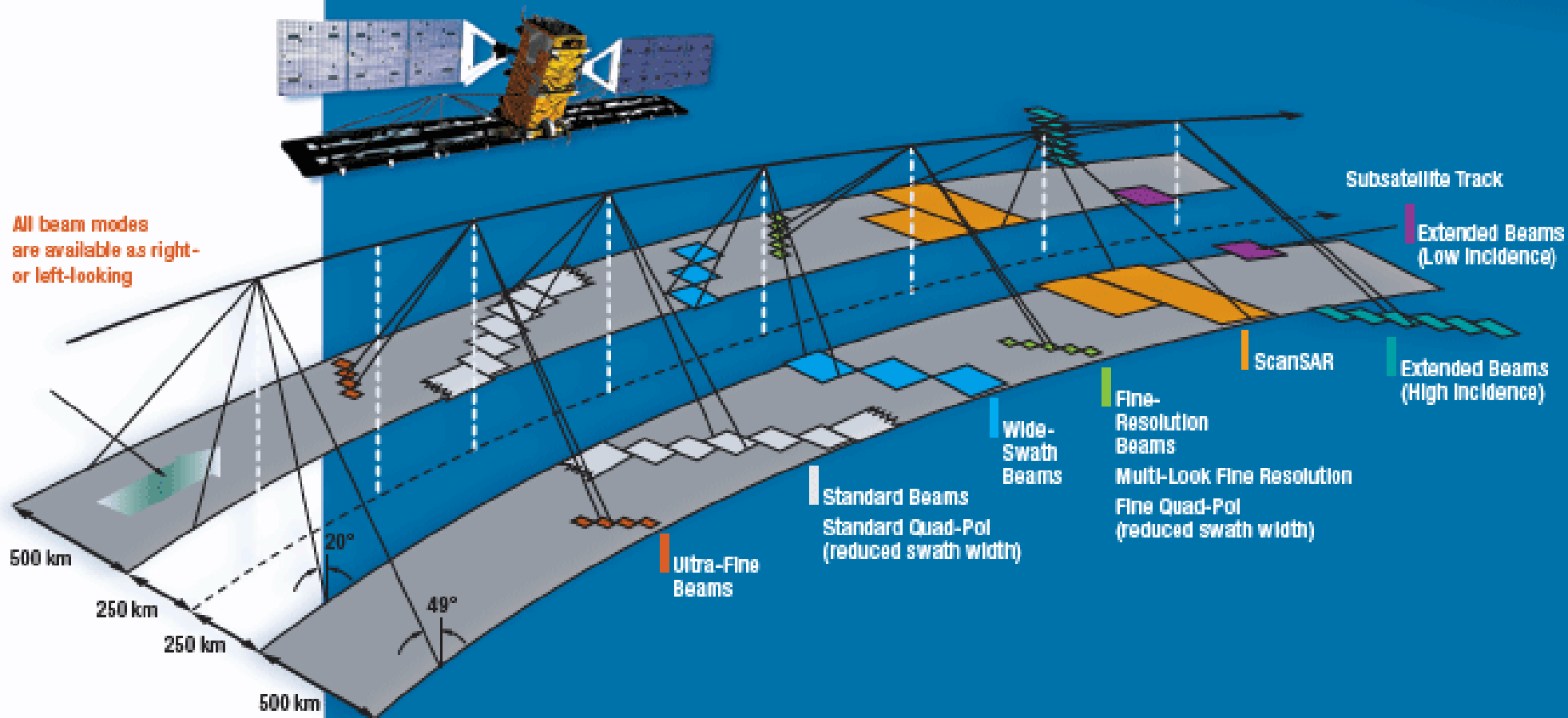
- MDA Acquisition Planning Tool (APT)
 - Windows only
 - Create and order via APT-files



The 'Generate Swath Footprints' dialog box contains the following settings:

- Start: 2012-FEB-21 10:33:24.863
- Stop: 2012-FEB-25 10:33:24.863
- Direction: ☒ Ascending and Descending, ☐ Ascending Only, ☐ Descending Only
- Mode: Multi-Look Fine
- Beam: MF23 to MF6F
- Tx Polarization: ☒ H, ☐ V, ☐ H+V
- Rx Polarization: ☒ H, ☐ V, ☐ H+V
- Orientation: ☐ Left, ☐ Right, ☒ Any
- Region: None
- ☐ Restrict Generation to Inner / Outer Incidence Angles (in degrees)
Inner: 30.30883 Outer: 49.78807 (Reset button)
- ☐ Restrict Swath to Downlink Durations within DRF Line of Sight
- Buttons: Generate, Cancel

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 taken from CSA-brochure, ©2012 CSA

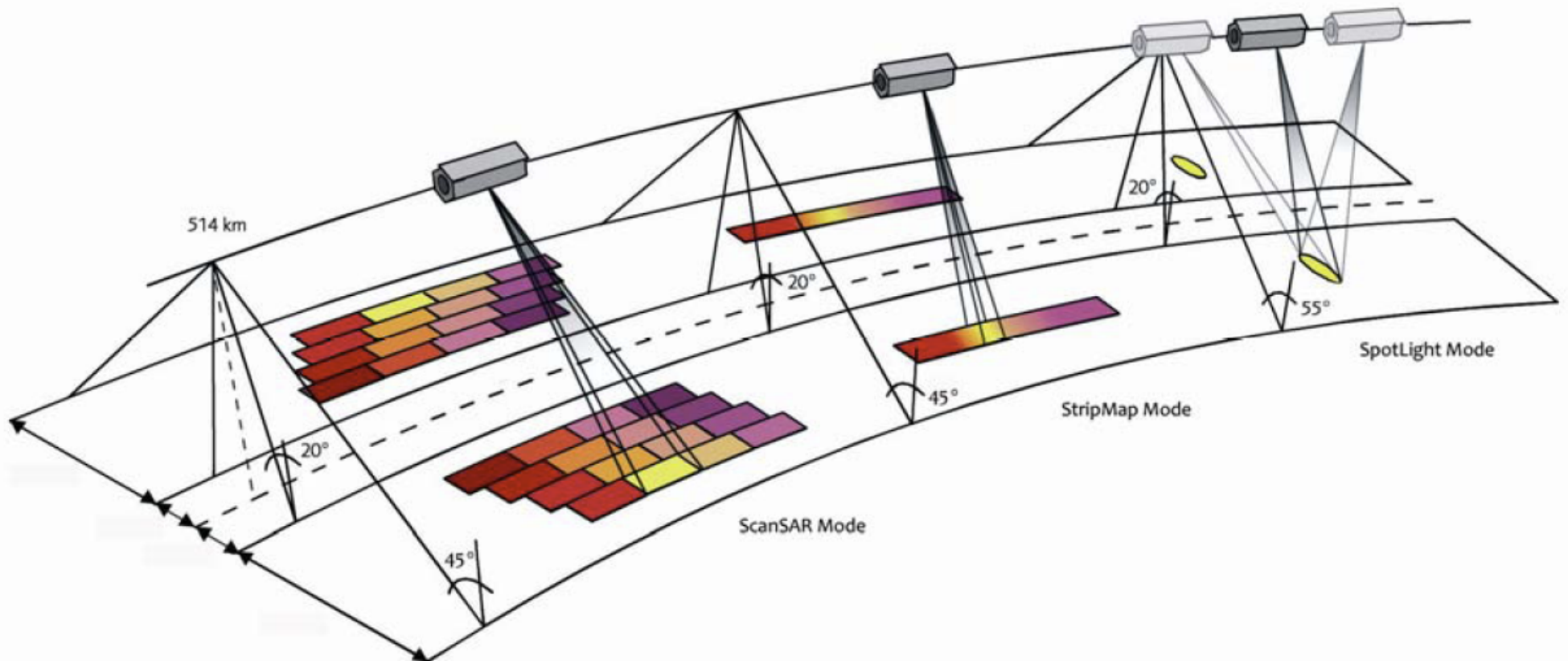
Data Acquisition: TerraSAR-X

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

The screenshot displays the EOWeb (Next Gen) web interface. The browser address bar shows the URL: <https://centaurus.caf.dlr.de/8443/eoweb-ng/template/default/welcome/entryPage.vm>. The page header includes the EOWeb logo and navigation links: Applied Remote Sensing Cluster, Home, Imprint, Contact. The user is logged in as CSA_dreschle_OCE0995. The interface features a search bar, a 'Search by ProductId' button, and a 'SRTM Data Download' button. The main content area is divided into two panels. The left panel, titled 'Collections', shows a tree view of product categories under 'TSX-1 Future Products'. The right panel displays a map of Eastern Europe with a red polygon over the Black Sea region. Below the map, a table lists data records with columns: Id, Avail., Abstract, Item Type, and Start Date. The table shows 18 records, with the first record selected.

Id	Avail.	Abstract	Item Type	Start Date
13	●	PID_TSX-1.SAR.Stripmap...	FutureScene	2012-02-26T03:34:52.7...
14	●	PID_TSX-1.SAR.Stripmap...	FutureScene	2012-02-26T03:34:53.7...
15	●	PID_TSX-1.SAR.Stripmap...	FutureScene	2012-02-26T03:34:53.7...
16	●	PID_TSX-1.SAR.Stripmap...	FutureScene	2012-02-26T03:34:54.7...
17	●	PID_TSX-1.SAR.Stripmap...	FutureScene	2012-02-26T03:34:55.7...
18	●	PID_TSX-1.SAR.Stripmap...	FutureScene	2012-02-26T03:34:56.7...

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	1.1	Single (VV or HH)	20° to 55°
			1.2	2.2	Dual (HH & VV)	
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	1.7	Single (VV or HH)	20° to 55°
			1.2	3.4	Dual (HH & VV)	
StripMap (SM)	30 x 50 single pol	1.650	1.2	3.3	Single (VV or HH)	20° to 45°
	15 x 50 dual pol		1.2	6.6	Dual (HH & VV, HH & HV, or VV and VH)	
ScanSAR (SC)	100 x 150	1.650	n/a	18.5	Single (VV or HH)	20° to 45°

Tool for Image-Series Acquisition

Create Wishlist

Import XML

All times

Import E Format

Title

Region

Enter a list of dates, each in a new line

0000-00-00 00:00:00.000

Timezone UTC-12

Save wishlist as...

Capturetime Calculator

Satellites:

Blue-Bight/radarsat2:multilookfine
Blue-Bight/terrasarx:stripmap

Add Remove

Start (UTC) 2012-03-01 00:00:00.000

End (UTC) 2012-05-01 23:59:59.999

Max. time difference 1:00:00

☐ Use Wishlist Configure Wishlist












Calculate Capturetimes

	RADARSAT-2/multilookfine	TerraSAR-X/stripmap
1	2012-03-03 03:36:17.450000	2012-03-03 03:26:36.733000
2	2012-04-27 03:32:07.726000	2012-04-27 03:26:36.733000
3	2012-04-12 15:29:24.813000	2012-04-12 15:15:22.733000

Export results

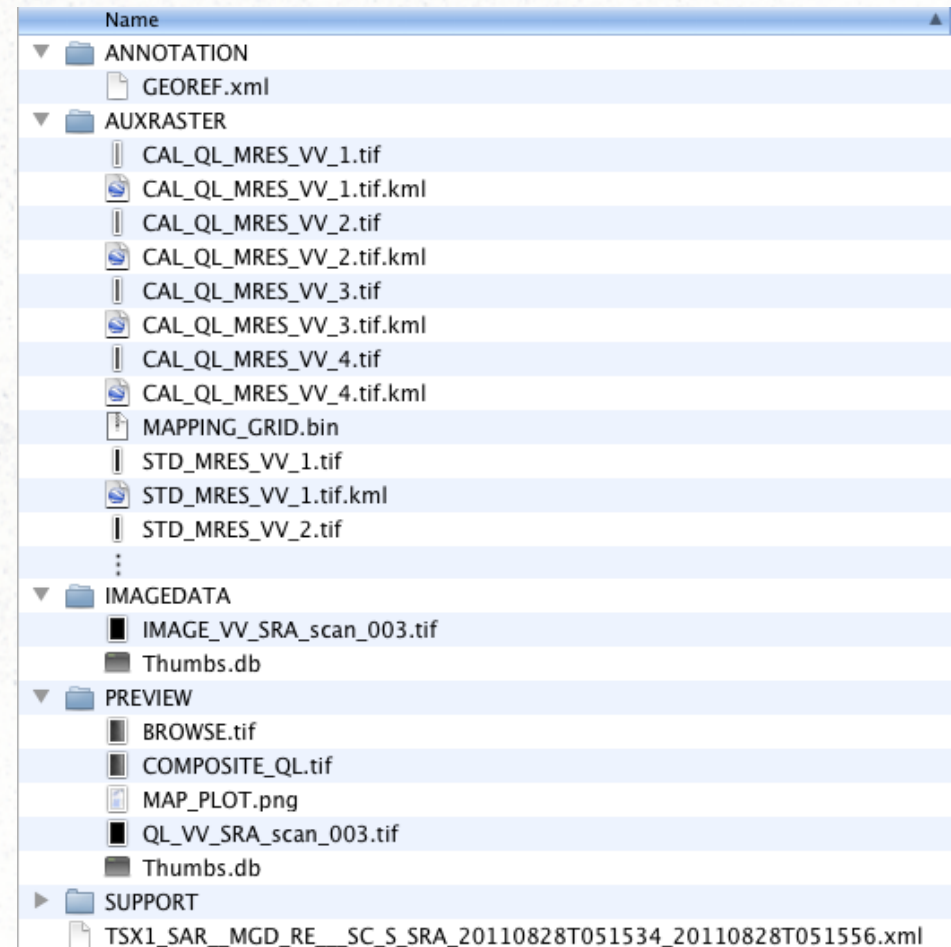
Delivered Data: Radarsat-2

- 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 Calibration: 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!

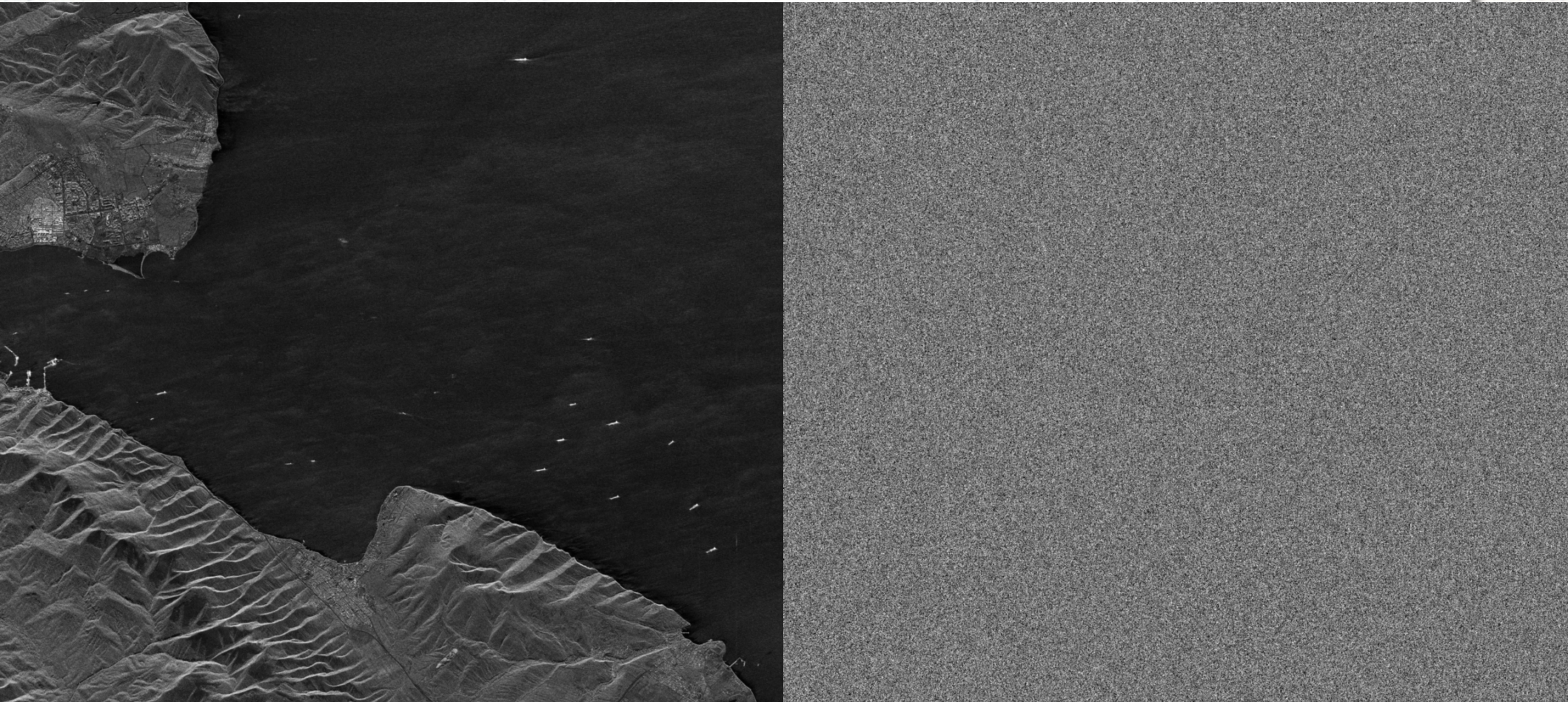
Radiometric Calibration: TerraSAR-X

- 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:

$$S_0 = R(x, \dots) \quad * \sin(x * (max_ang - min_ang) / w) \\ + CalibrationConstant$$

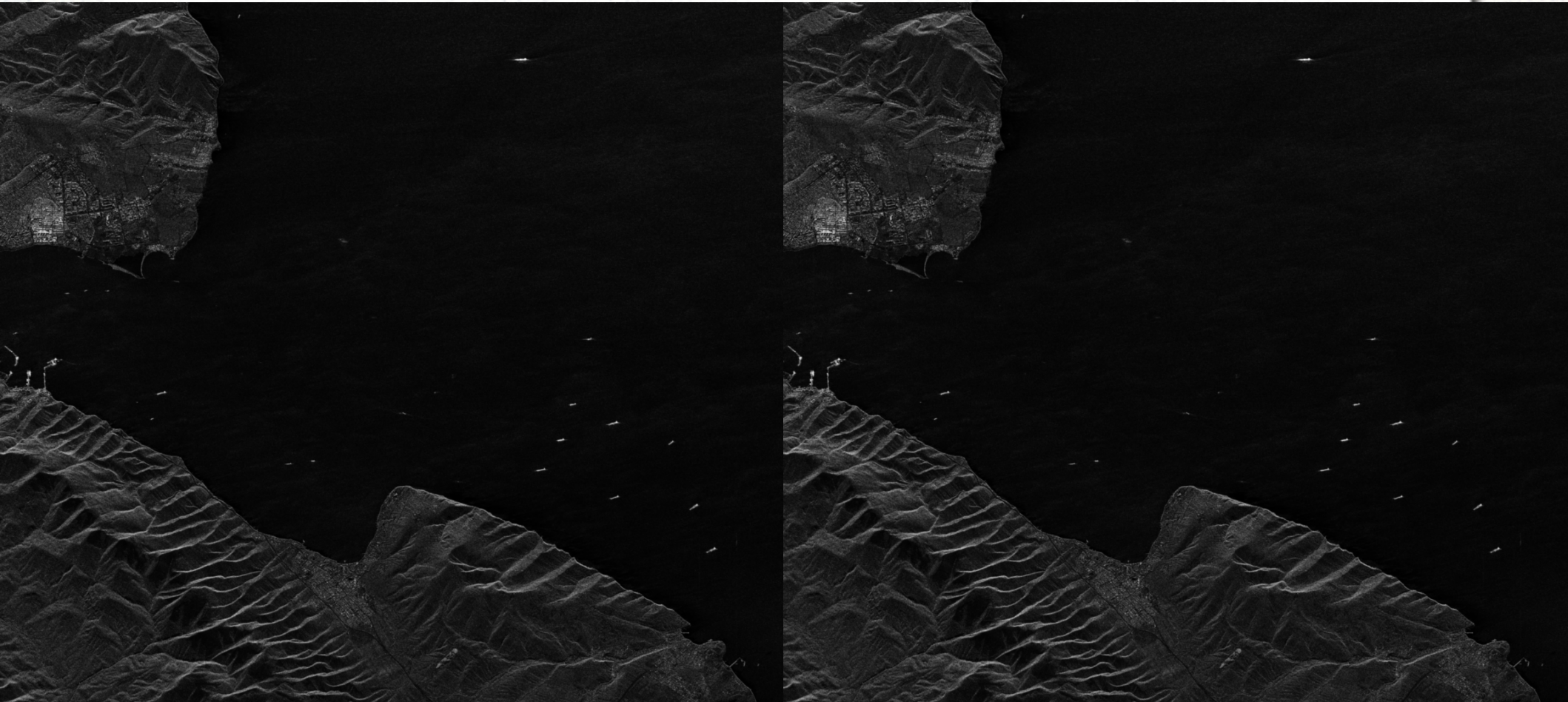
Examples for radiometric Calibration: Radarsat-2 UF_SLC

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

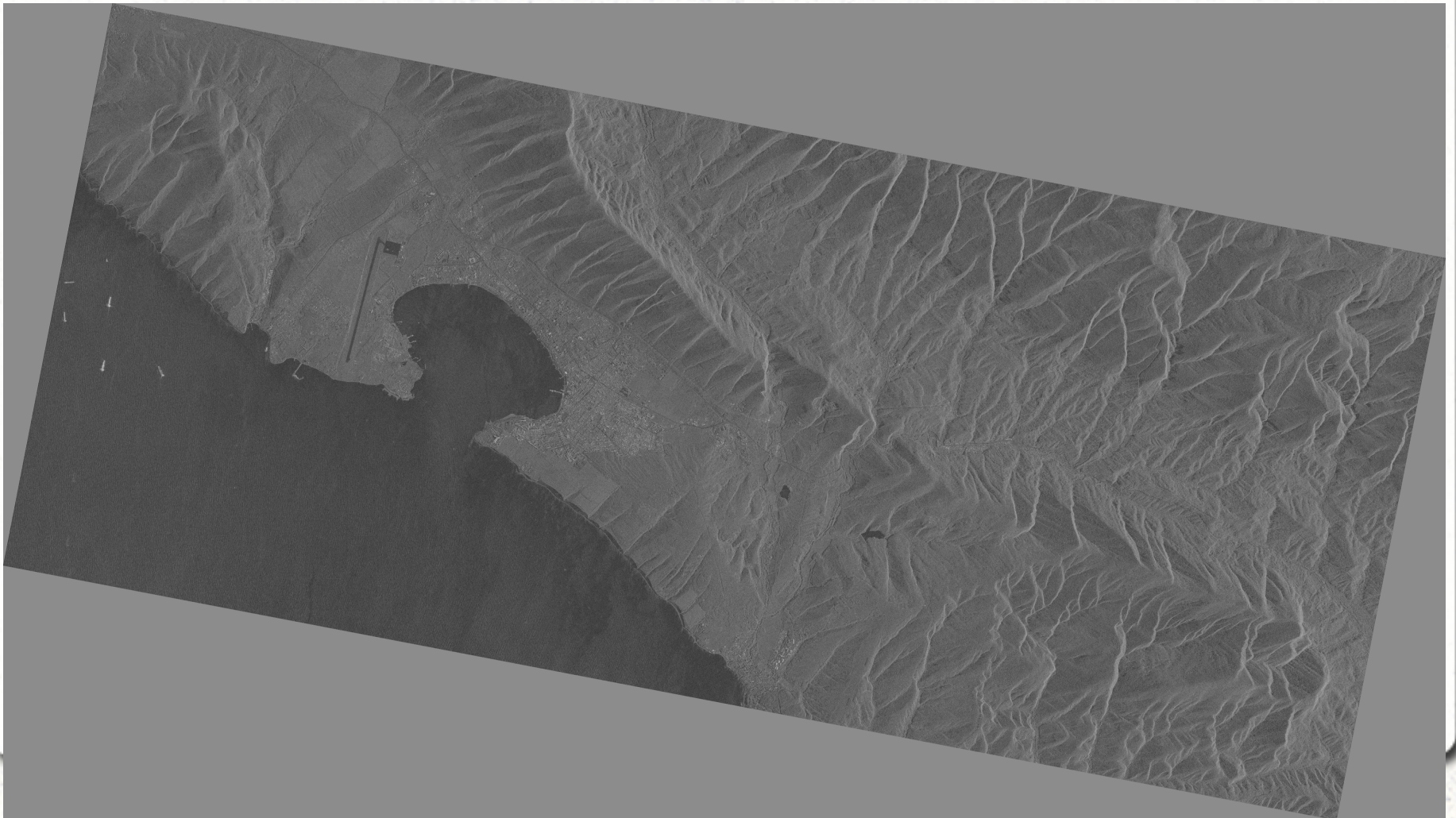
Examples for geographical calibration

- Sigma0-image of TerraSAR-X

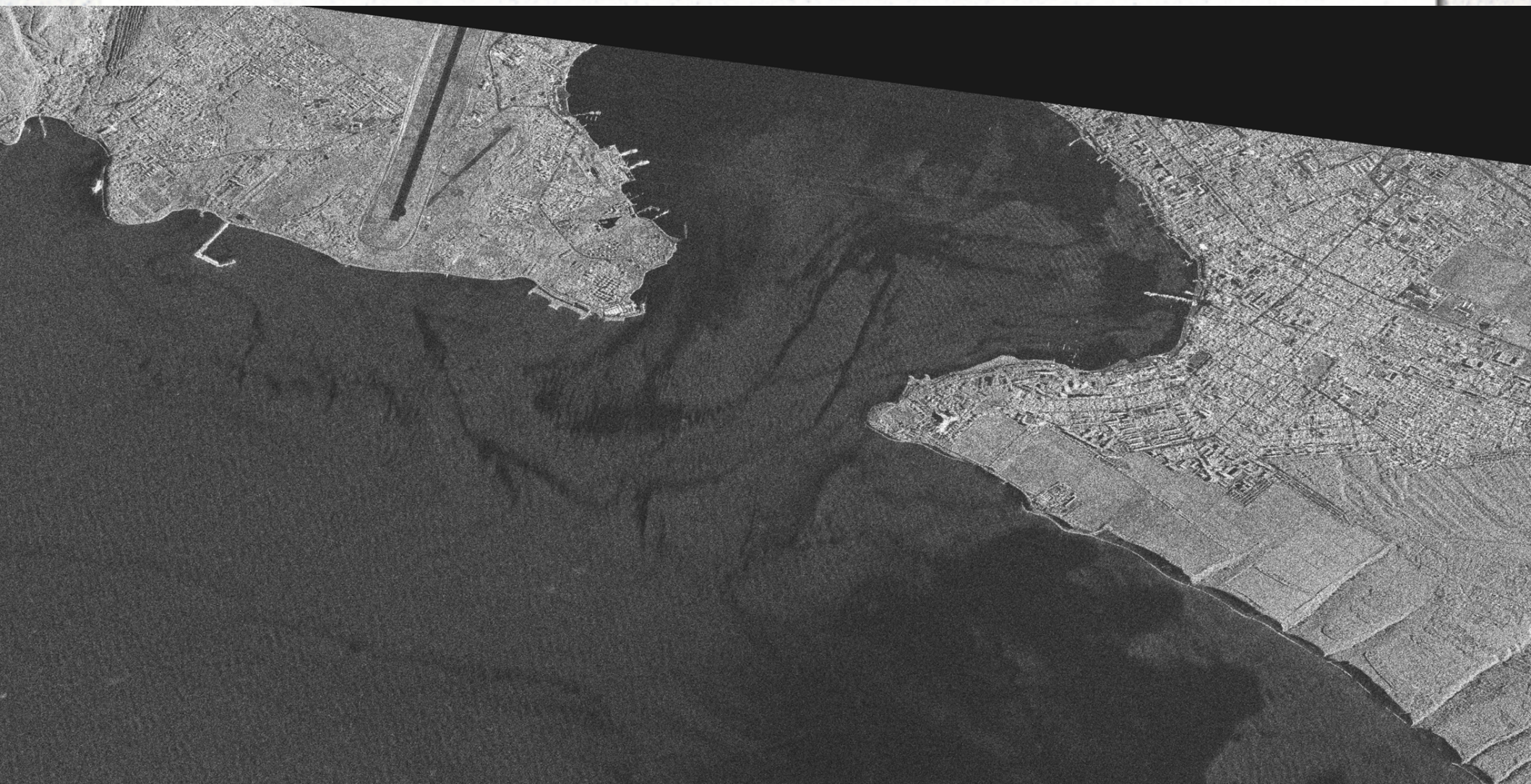


Examples for geographical calibration

- 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:
$$16,960 * 25,288 * 4 \text{ Byte} = 1.63\text{GB p. channel}$$
- 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 priori 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

- Acquisition 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!