Improved flood detection by using bistatic coherence data of the TanDEM-X mission

Gebhard Warth[1]
Sandro Martinis[2]

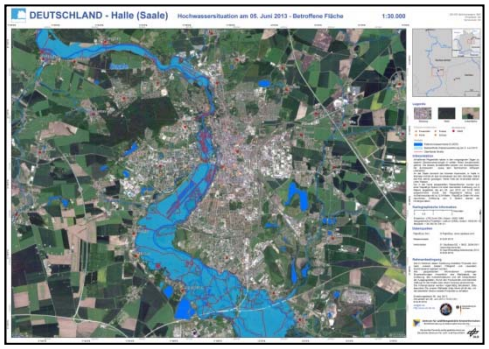
[1] University of Tuebingen
[2] German Aerospace Center (DLR)

Contents

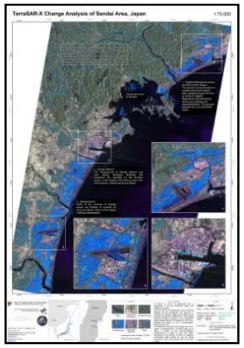
Center for Satellite Based Crisis Information
– Emergency Mapping & Disaster Monitoring –
a service of DFD

ZKI/DLR:

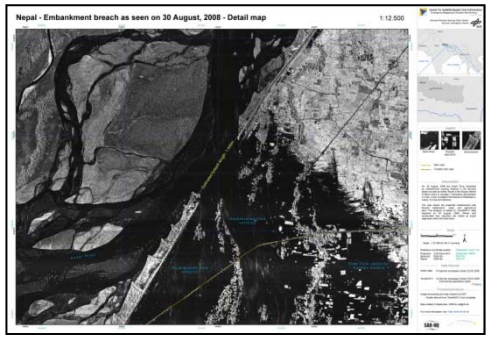
- 24/7 service for disaster information based on remote sensing:
  - Natural and environmental disasters
  - Humanitarian relief activities
  - Civil security issues
- In commission of the charter “Space and Major Disasters” and the Federal Ministry of the Interior



Flood extension map, Halle (Saale) (Ger) 2013



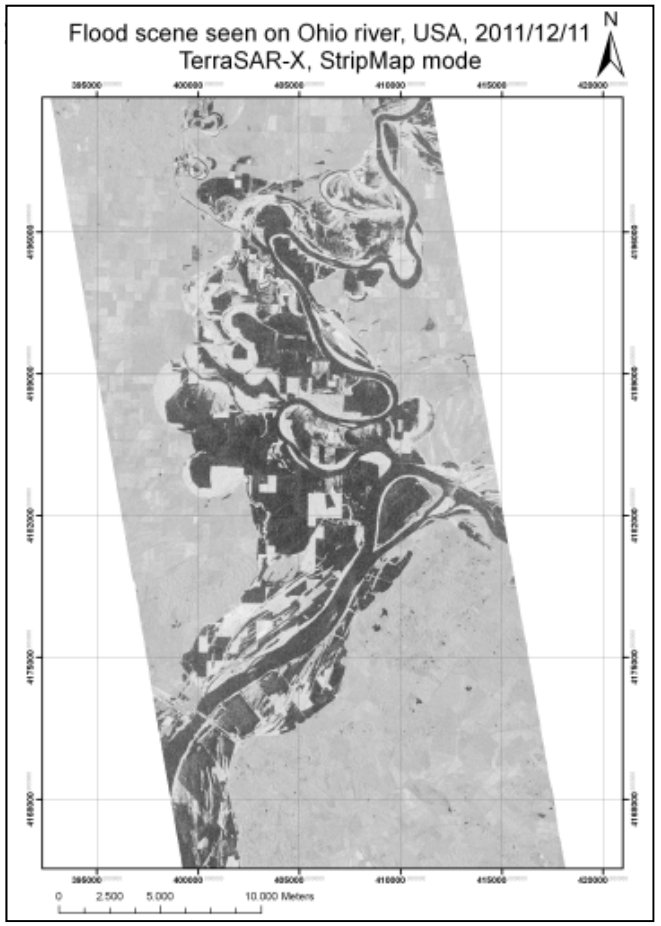
Flood extension after Tsunami, Japan 2011



Embankment breach, Nepal 2008

DLR

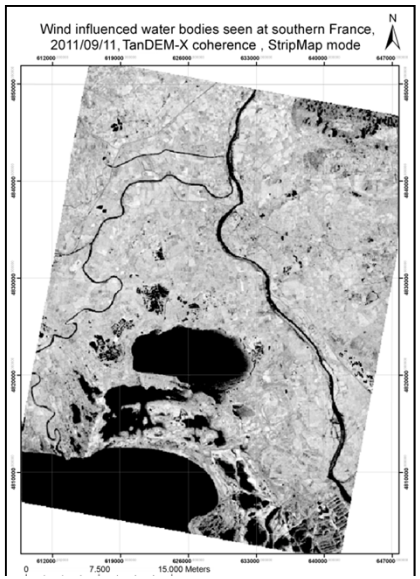
- X-band SAR amplitude very suitable for flood detection
  - Repetition rate, spatial resolution and characteristics of radar radiation
  - Low surface roughness of water bodies causes low amplitude backscatter
  - High contrasts between “water” and “no water”

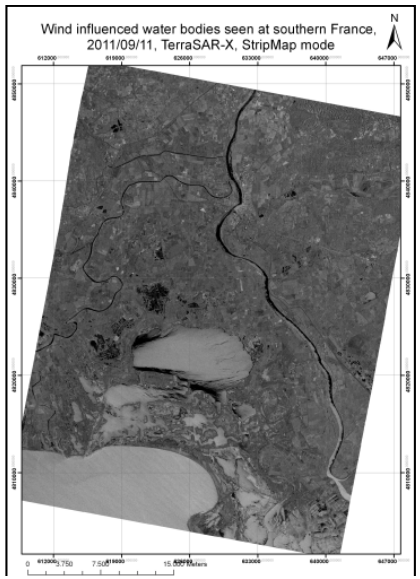


Flood scene, Ohio river, USA 2011/12/11, TerraSAR-X, StripMap

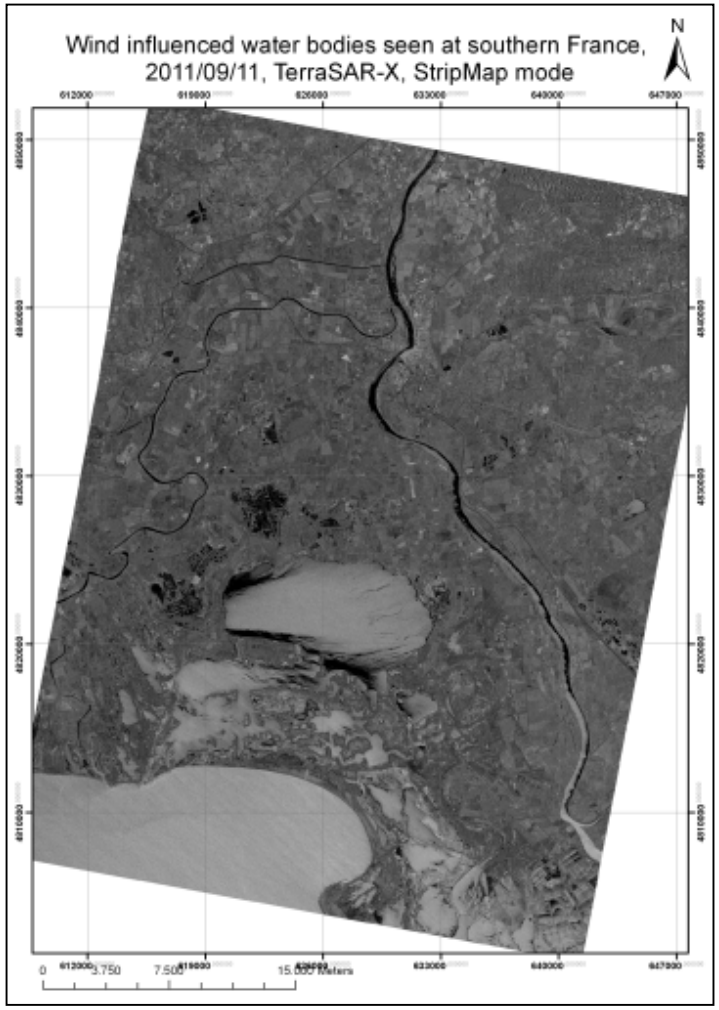
- Amplitude could contain look-alikes:
  - Roughening effects of wind on water: misclassified as land
  - Low roughness of land surface: misclassified as water
- Coherence on water bodies very low
- Land surface induces high coherence values
- SAR coherence as auxilliary data source to reduce amplitude limitations
- Topic: Improvement of flood detection approaches based on TerraSAR-X data by TanDEM-X coherence

Water bodies, south France 2011/09/11, TanDEM-X coherence, StripMap

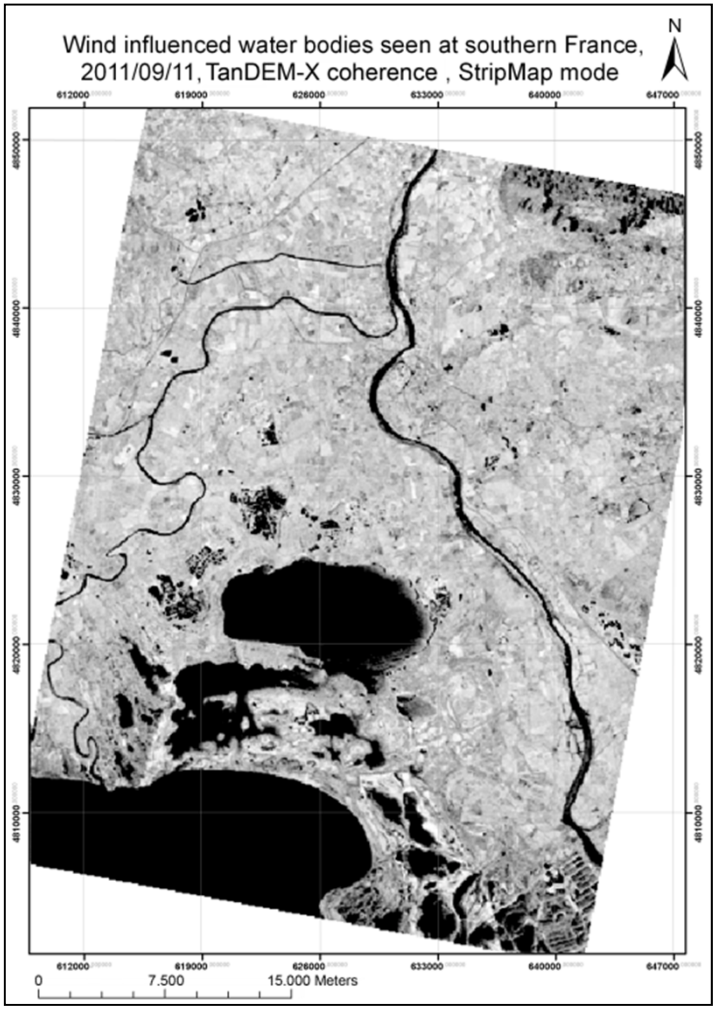




Water bodies, south France 2011/09/11, TerraSAR-X amplitude, StripMap



Water bodies, south France, 2011/09/11, TerraSAR-X amplitude, StripMap



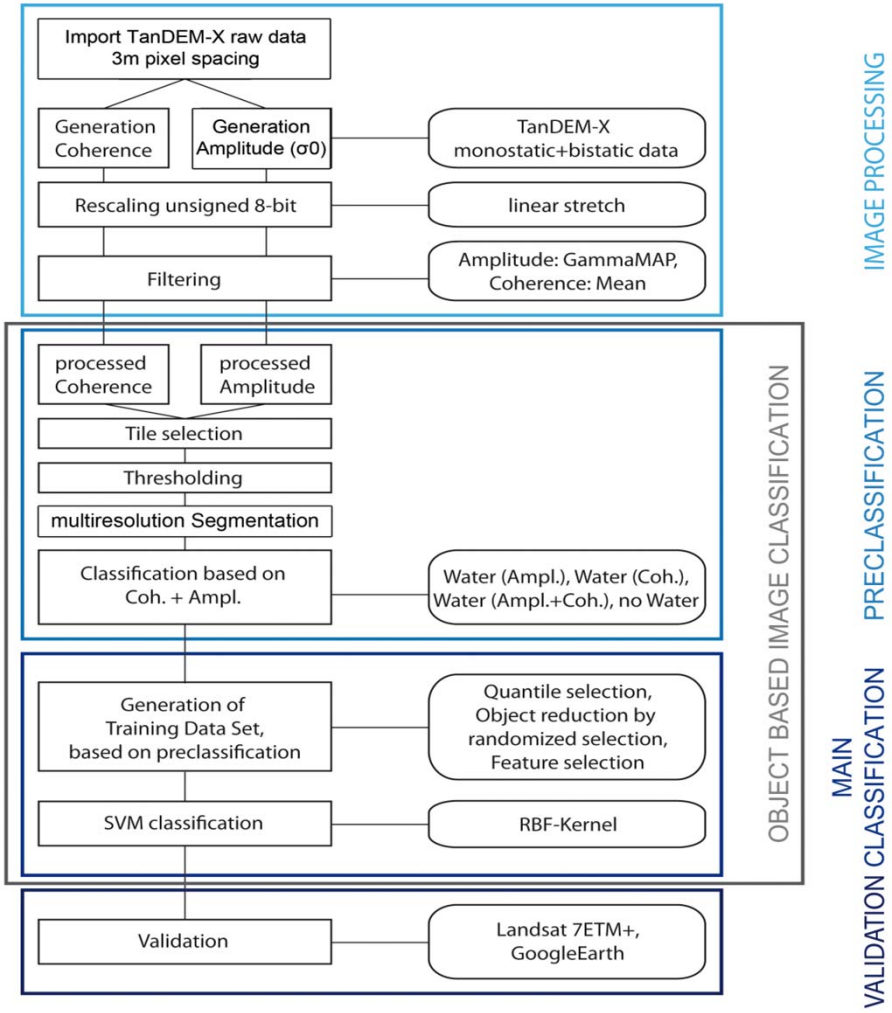
Water bodies, south France, 2011/09/11, TanDEM-X coherence, StripMap

Topic of this work:

- Development of an automatic classification approach to separate “flood” and “non-flood” areas
- Single-pass approach
  - worldwide reference data for rapid mapping are not available
  - No time decorrelation

Classification contains several steps:

- Object based preclassification:
  - Automatic thresholding
  - Threshold based classification
- Main classification by using support vector machine (SVM), object based approach



Workflow of the classification approach

Initialization: *Automatic tile-based thresholding*

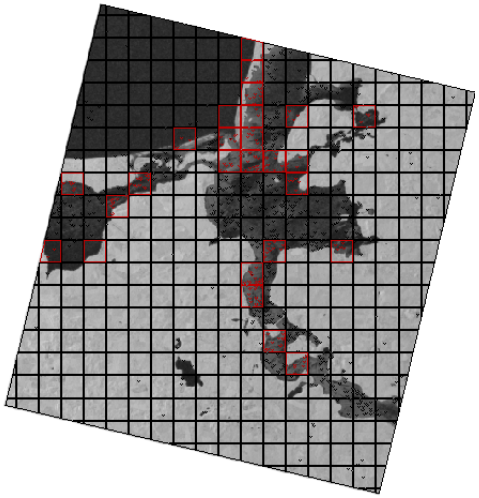
1. Tile selection

Histogram based thresholding algorithm:

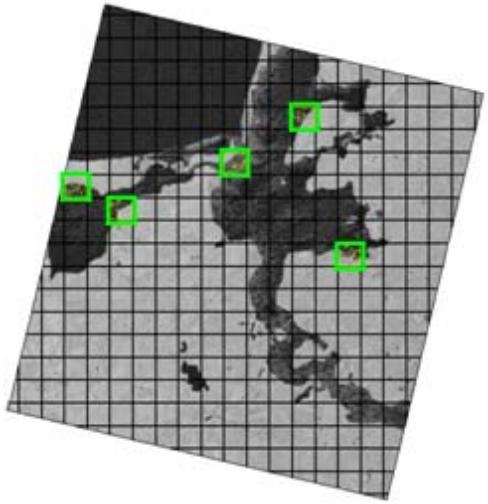
- Water causes low backscatter/ low coherence, land causes high backscatter/ high coherence → bimodal histogram characteristics

Hierarchical quadtree approach: image split into quadratic tiles Y_n

- Tiles are subdivided into 4 equal splits $Y_{n'}$
- Analysis and comparison of (sub-) tiles
  1. High standard deviation of $Y_{n'}$ mean values ($\mu Y_{n'}$) indicade >1 semantic classes
  2. $\mu Y_{n'} < \mu Y_n$ indicate tiles at boundaries of “water“ / “no water“



Selected tiles by criterion 1 (red)



Selected tiles by criterion 2 (green)

TDX coherence, Stralsund, 2011/09/29

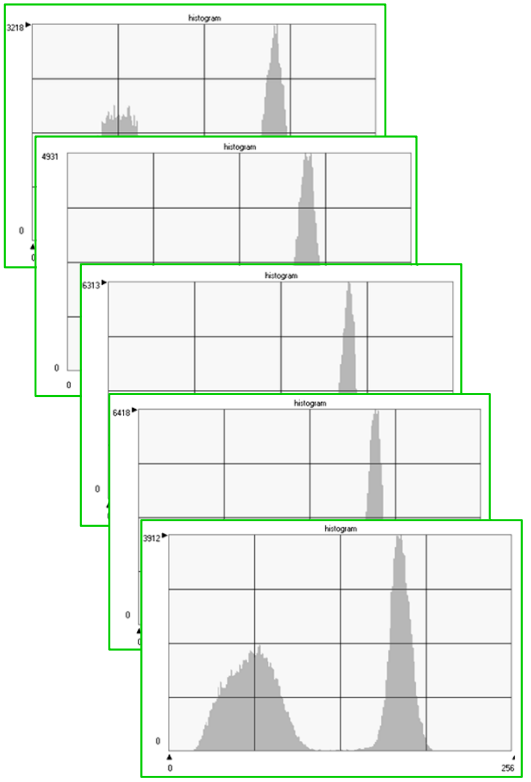
Martinis, S., Twele, A. & Voigt, S. (2009): Towards operational near real-time flood detection using a split-based automatic thresholding procedure on high resolution TerraSAR-X data. NHESS, 9: 303–314.

Martinis, S., Kersten, J., Twele, A. (2013): A fully automated TerraSAR-X based flood service, ISPRS, submitted.

Initialization: *Automatic tile-based thresholding*

2. Parametric thresholding algorithm

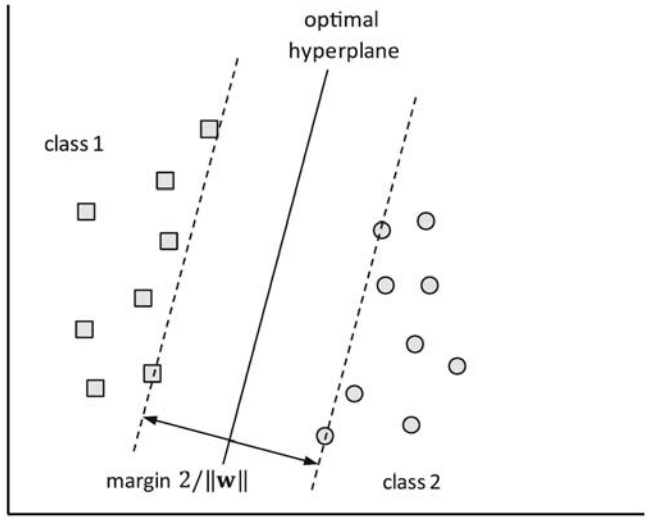
- 5 best fitting tiles are selected for histogram analysis
- Assumptions:
  - histogram of tile Y_n represents two 1-D normal distributions of the classes “flood” and “non flood”
  - Classification threshold is at the intersection point of both distributions
- Threshold is derived by means of a cost function
- Iterative algorithm



Histograms of selected tiles TDX coherence

Main classification: *Support Vector Machine (SVM) approach*

- Support vectors (training data) are transferred into a multi-dimensional feature space
- Threshold derivation to maximize the minimum margin between hyper plane and support vector
- If support vectors are not linearly separable, enhancement of dimension of feature space
- SVM are reported to work with small training data sets
- ~ 30 features (texture, etc.) are chosen to train SVM classifier



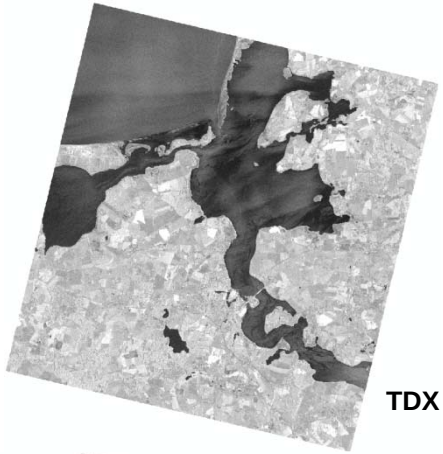
Schematic illustration of finding the ideal hyperplane (Richards 2013)

Stralsund (Germany), 2011/09/29, TanDEM-X StripMap:

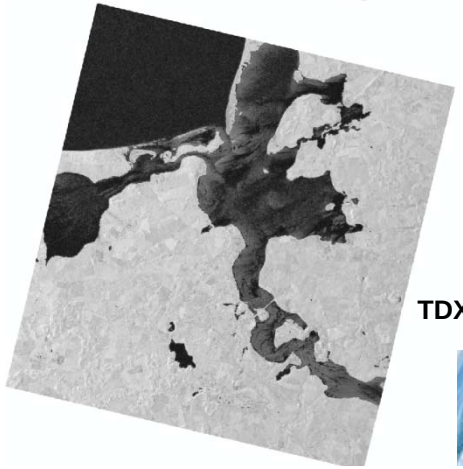
- High accurate classification results
- Coherence and amplitude complement weaknesses

	No Flood	Flood	Sum
No Flood	1,643,511	23,271	1,666,782
Flood	5,604	459,293	464,897
Sum	1,649,115	482,564	

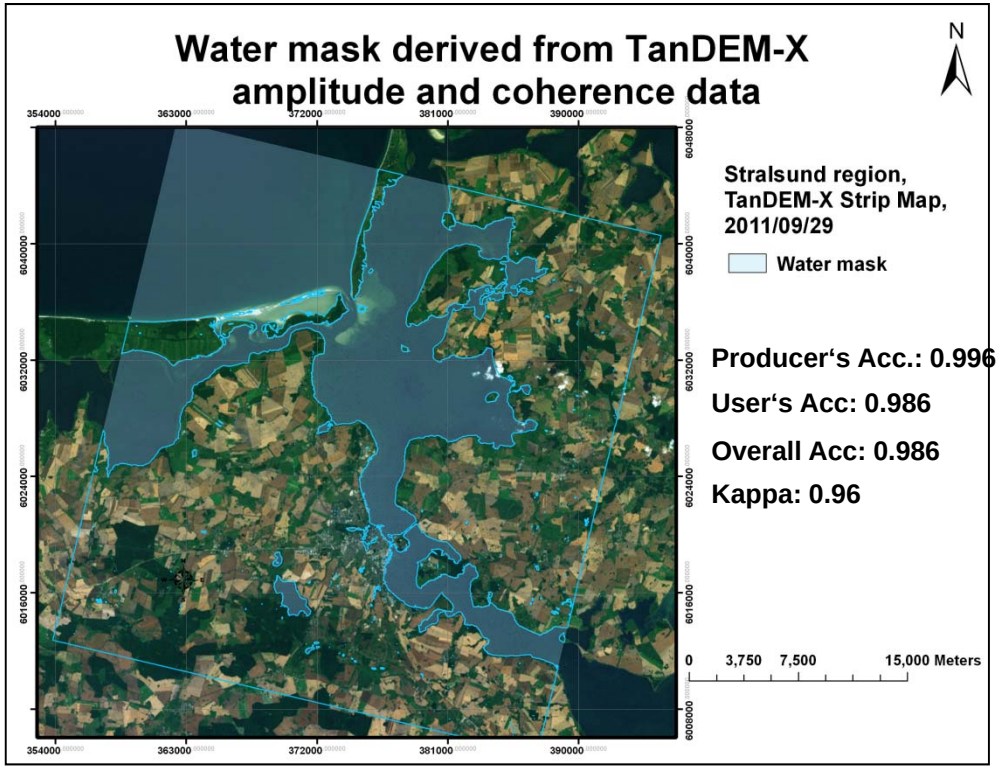
Classification confusion matrix



TDX amplitude



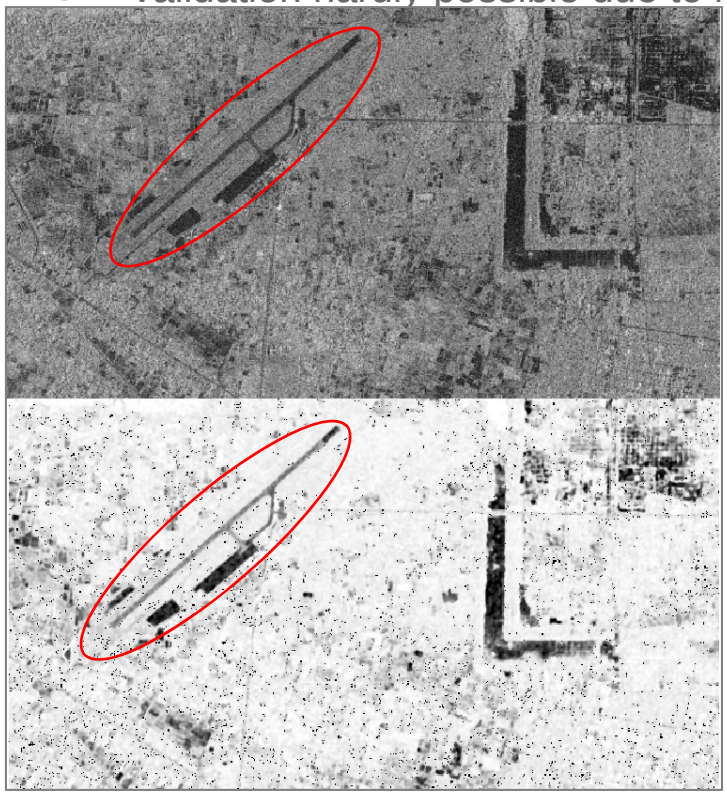
TDX coherence



Water mask derived from TDX amplitude and coherence data

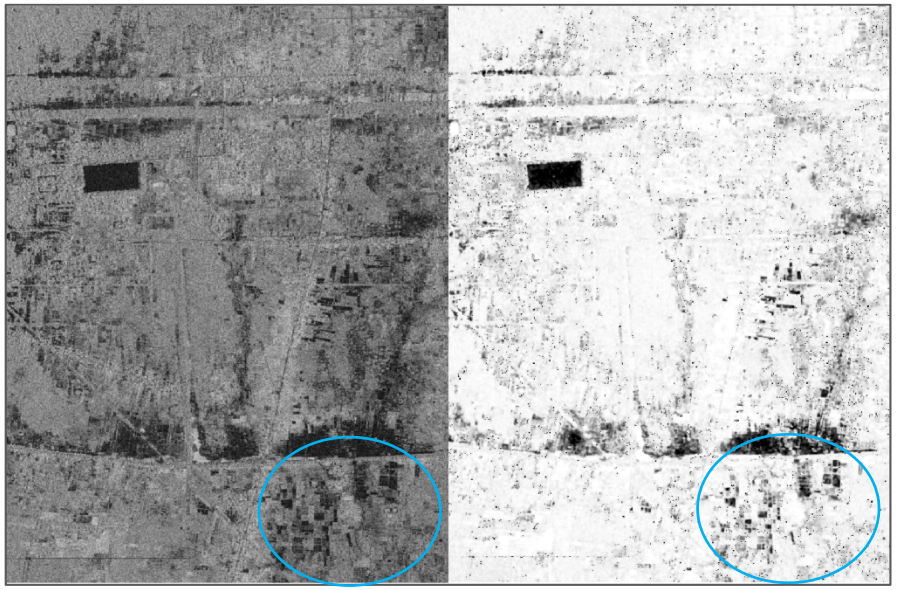
Angkor, Cambodia, 2011/09/13, TanDEM-X StripMap:

- Approach seems to work proper
- Validation hardly possible due to missing reference data



Airstrip **Coherence**

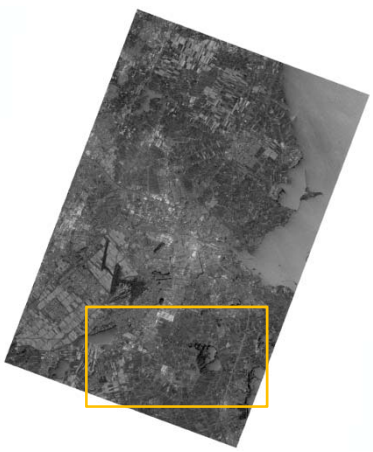
Amplitude



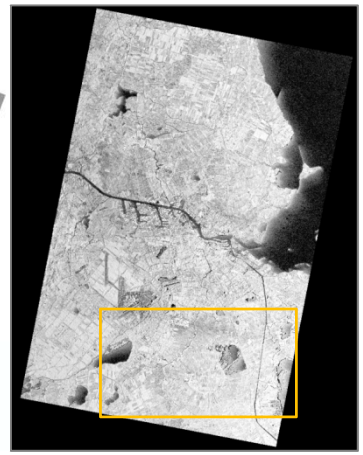
Irrigated fields **Coherence**

Problems with datasets:

- Coherence on water could contain values compared with land values
- Leads to inaccurate flood/water-masks



Amplitude



Coherence

Overview and detail view. High coherence values on water bodies.
TanDEM-X StripMap, Amsterdam region, 2011/10/08

- Misclassifications of look-alikes caused by rough water and smooth land surface could be reduced
- Use of bistatic coherence increases the quality of SAR based flood detection
- Radar coherence and amplitude complement one another with their benefits
- The presented approach has potential for flood detection applications
- Problems with missing validation data need to be solved

- Approach has to be applied and validated on flood events
- Validation data of flood events are rare, next step is to obtain TanDEM-X data and validation data of flood events

  → TanDEM-X data orderings besides the TanDEM-X science proposal and parallel orderings of validation data
- Causes of high coherence occurence in shore-near water are yet unclear

Thank you very much for your attention!