

# Flood Mapping – from semi-automatic tools to fully automatic Services

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# Rapid Mapping Workflow

**Crisis or Disaster**

## ① Mobilization

- triggering process
- situation briefing

- satellite tasking
- archive search
- auxiliary data

## ② Data acquisition

- geometric correction
- image enhancement

## ③ Pre-Processing

## ④ Analysis

- data fusion
- information generation

## ⑤ Map Production

- quality control
- maps (printed; online)
- GIS-ready geodata
- information dossiers

## ⑥ Dissemination

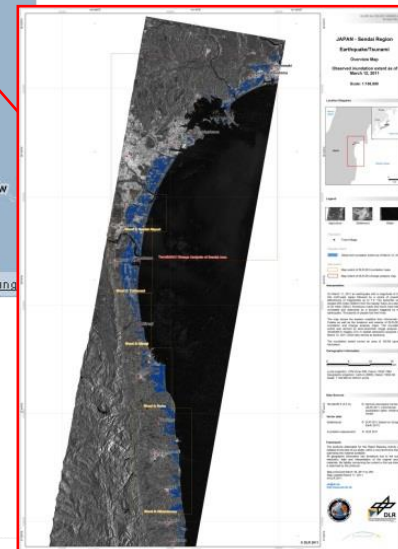
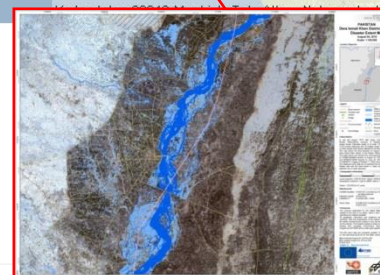
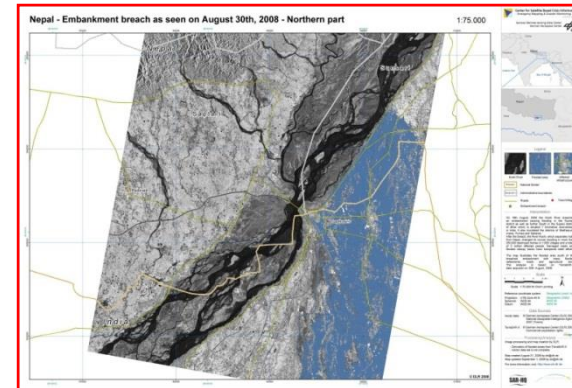
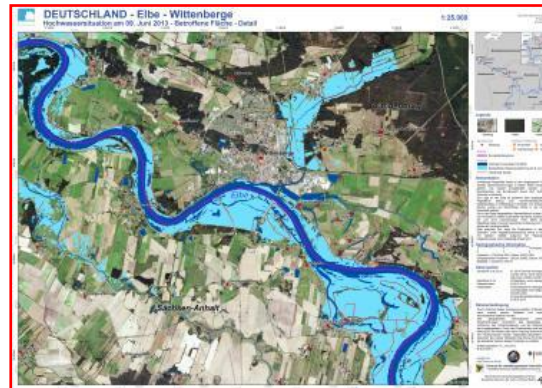
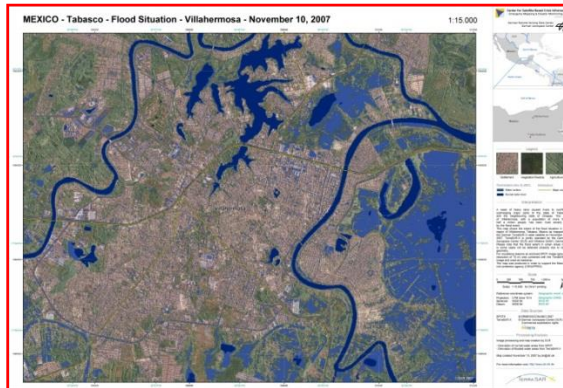
- Cooperation with national/local authorities
- Relief organisations, NGOs
- Public,...

Planning and Decision Support

Integration of auxiliary data

Integration in collaborative platform

# Flood mapping – from semi-automatic tools to fully automatic services



ZKI-activations (since 2003):  
regions and disaster types  
([www.zki.dlr.de](http://www.zki.dlr.de))



# Flood mapping – from semi-automatic tools to fully automatic services



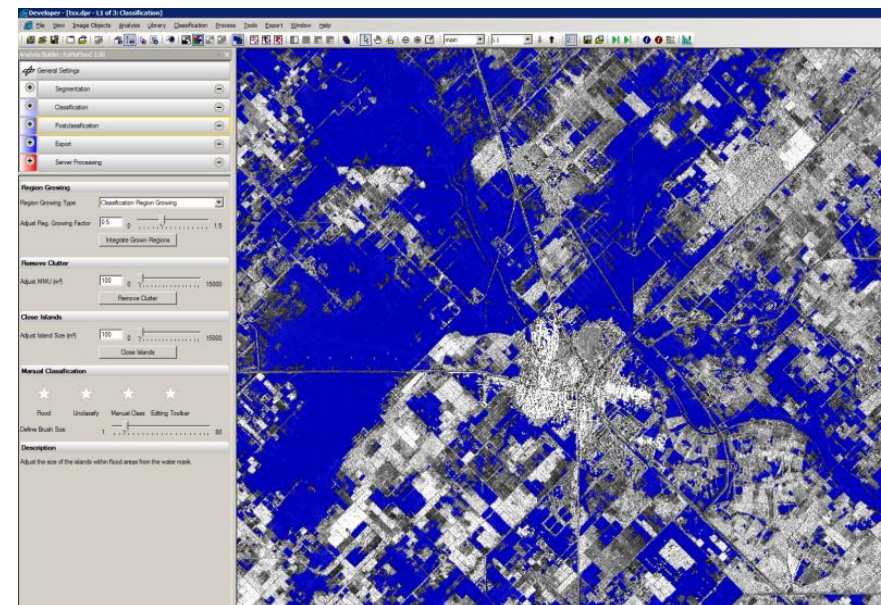
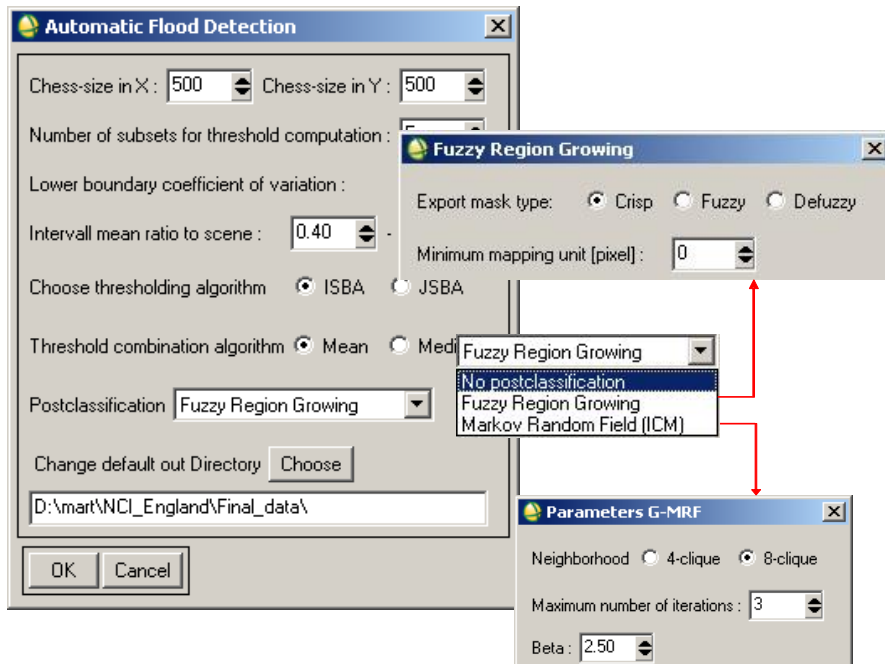
Center for Satellite Based Crisis Information  
– Emergency Mapping & Disaster Monitoring –  
*a service of DFD*

## ENVI/IDL:

- Automatic split-based thresholding
- Pixel-based

## eCognition Developer:

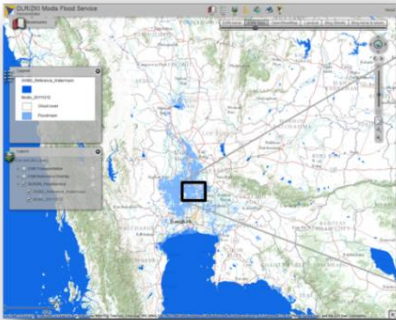
- Automatic and semi-automatic
- Segment-based (multi-scale)



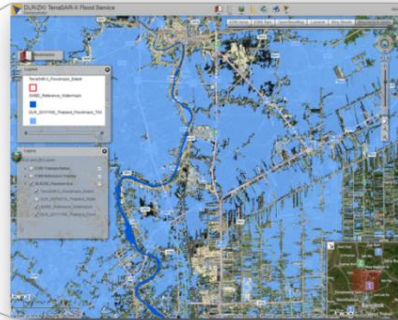
Martinis, S., Twele, A. & Voigt, S., 2011 - IEEE TGRS, 49 (1)  
Martinis, S. & Twele, A., 2010 - Remote Sensing, 2 (9)  
Martinis, S., Twele, A., Voigt, S., 2009 - NHESS, (9)

# DLR/ZKI flood monitoring services

Automated EO-based processing chains and services



MODIS Flood Service

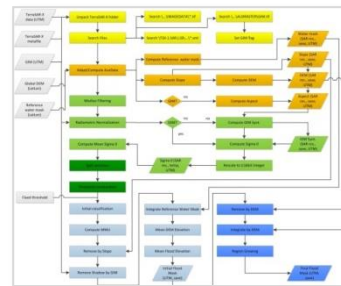
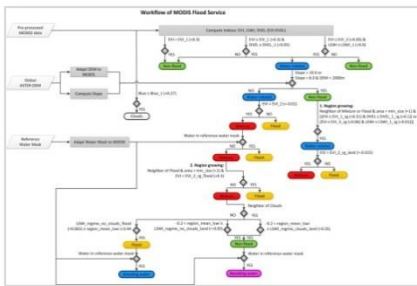


TerraSAR-X Flood Service

Current focus:

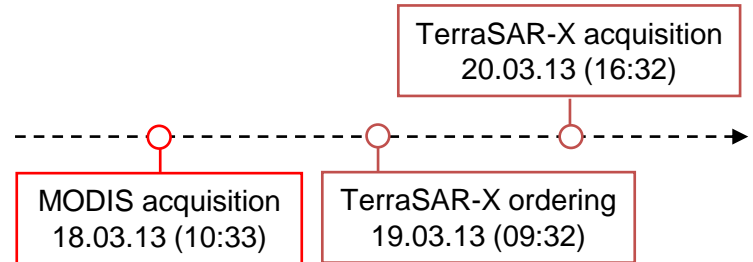
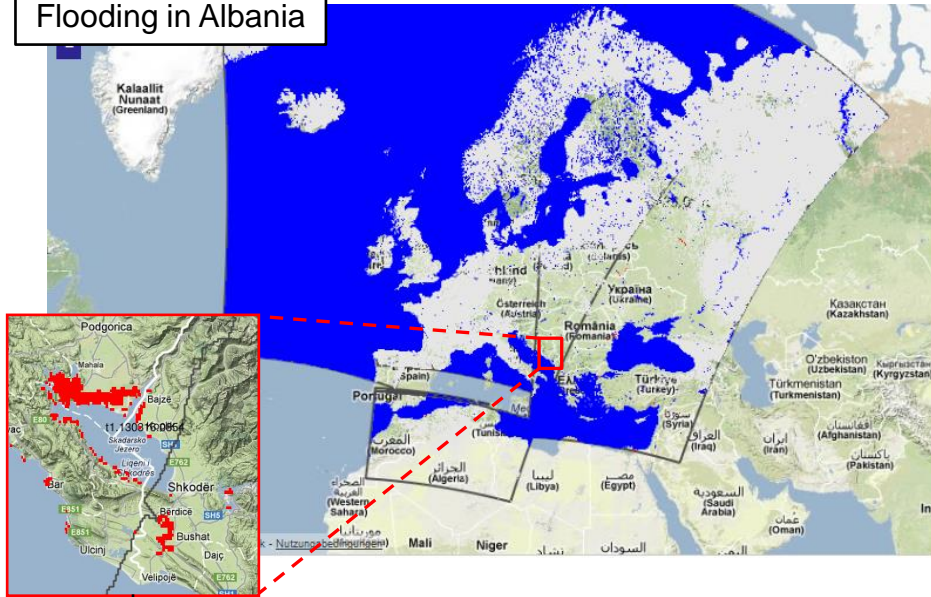


Sentinel-1

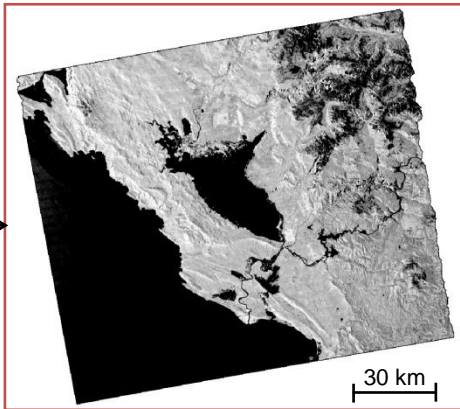


# Linking both scales

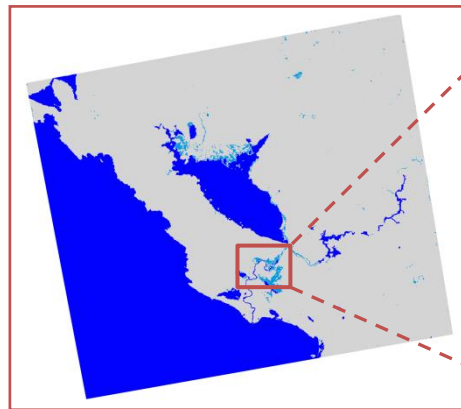
Flooding in Albania



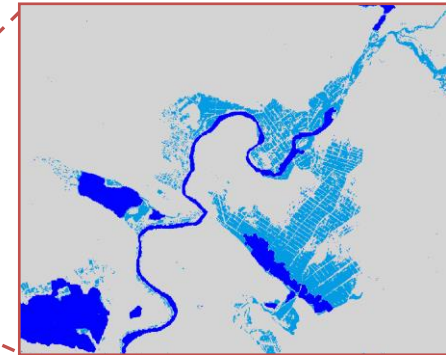
Alert



TerraSAR-X SC (20/03/2013)



TerraSAR-X flood mask



■ Flood  
■ Standing water  
■ No water



MODIS flood service

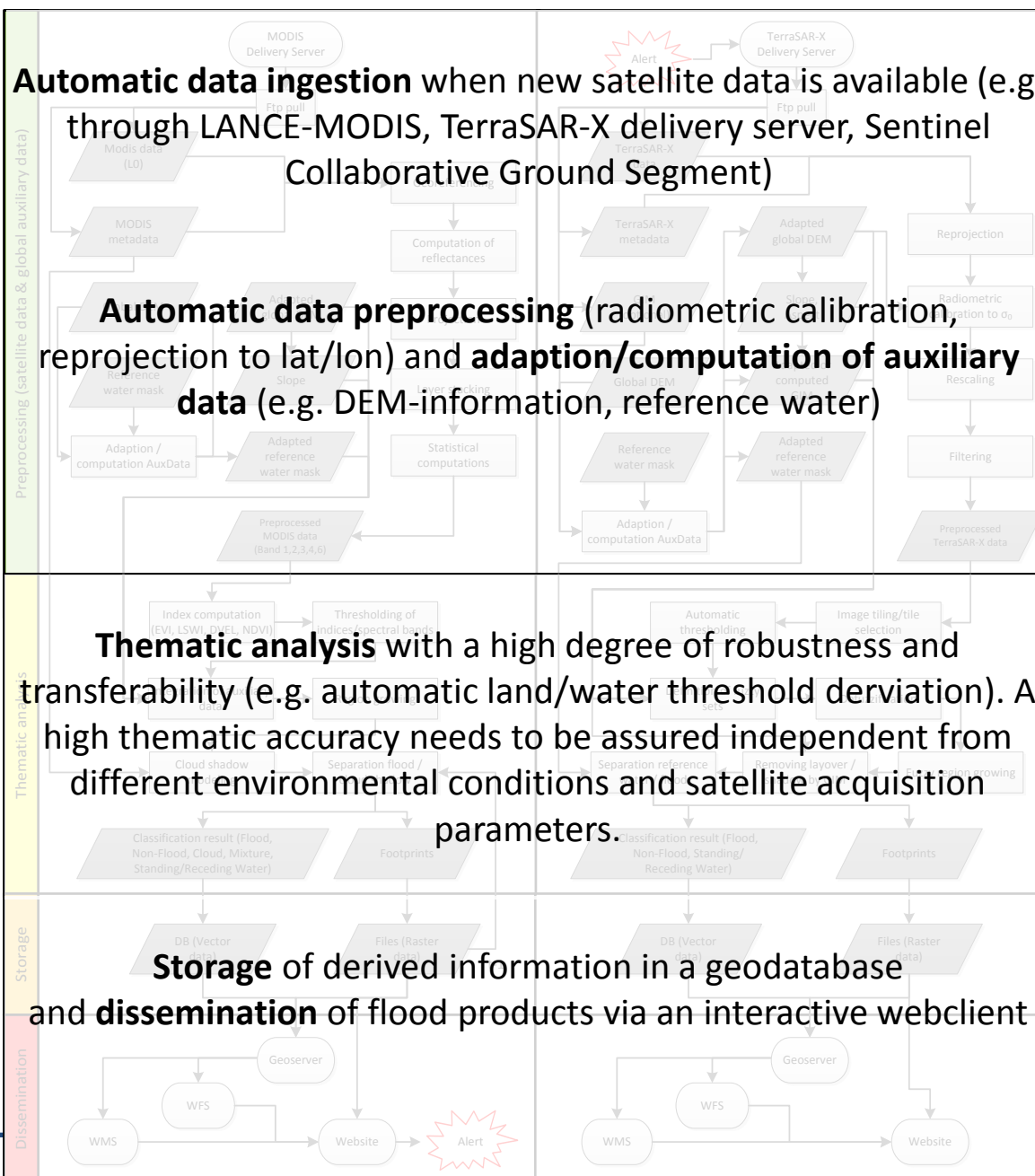
TerraSAR-X flood service

**Automatic data ingestion** when new satellite data is available (e.g. through LANCE-MODIS, TerraSAR-X delivery server, Sentinel Collaborative Ground Segment)

**Automatic data preprocessing** (radiometric calibration, reprojection to lat/lon) and **adaption/computation of auxiliary data** (e.g. DEM-information, reference water)

**Thematic analysis** with a high degree of robustness and transferability (e.g. automatic land/water threshold derivation). A high thematic accuracy needs to be assured independent from different environmental conditions and satellite acquisition parameters.

**Storage** of derived information in a geodatabase and **dissemination** of flood products via an interactive webclient

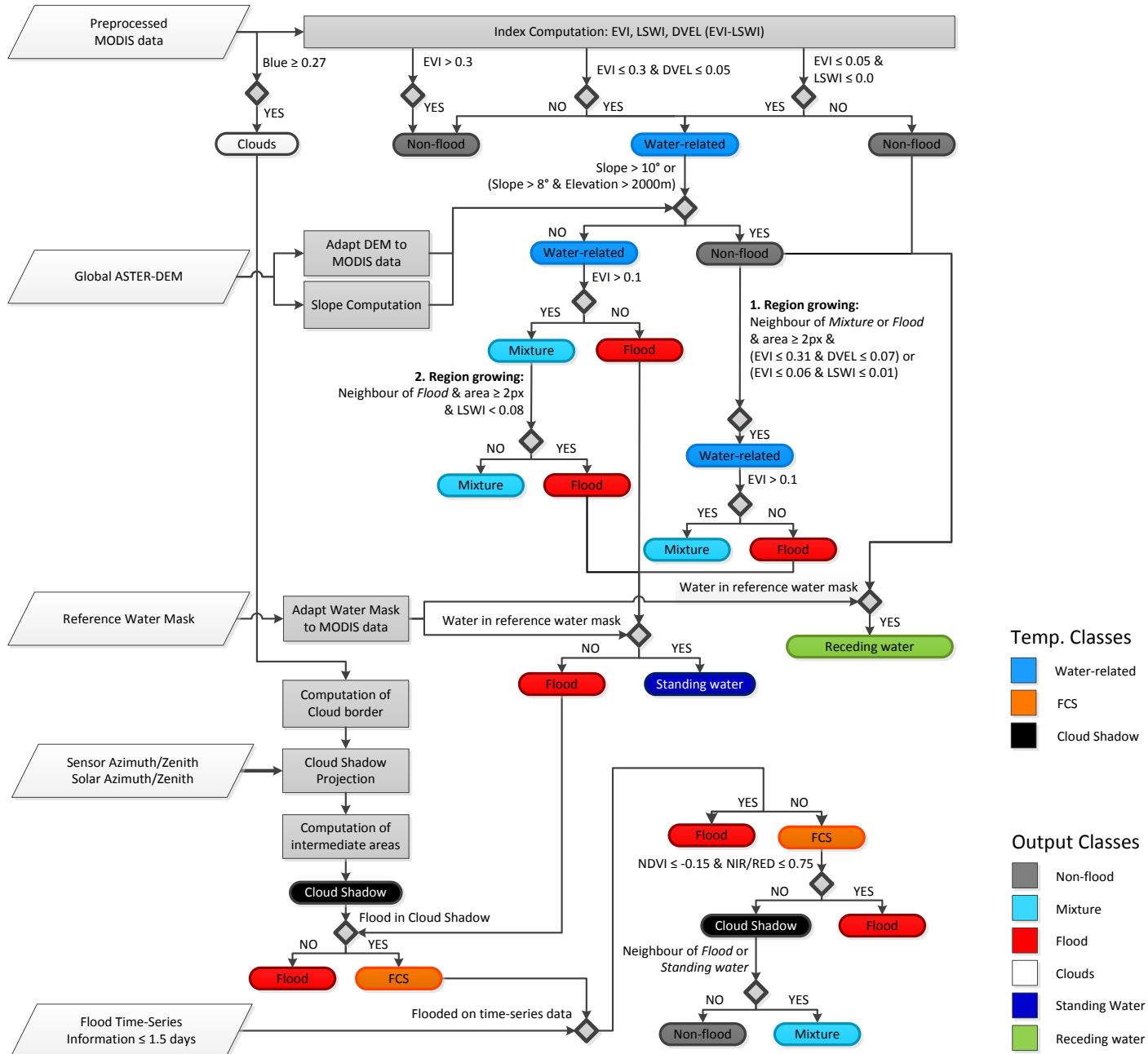


Martinis, S., A. Twele, C. Strobl, J. Kersten, and E. Stein. 2013. A multi-scale flood monitoring system based on fully automatic MODIS and TerraSAR-X processing chains. Remote Sensing



HORIZON 2020

# Workflow of MODIS flood service





# Flood monitoring: *MODIS flood service*

## Geometric calculation of synthetic cloud shadow position

Nadir projection of cloud:

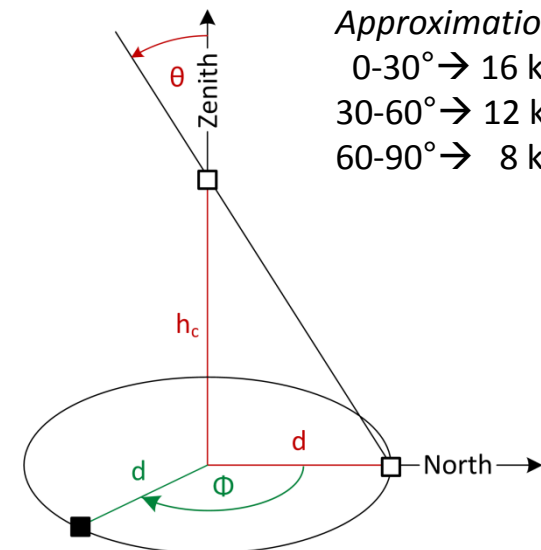
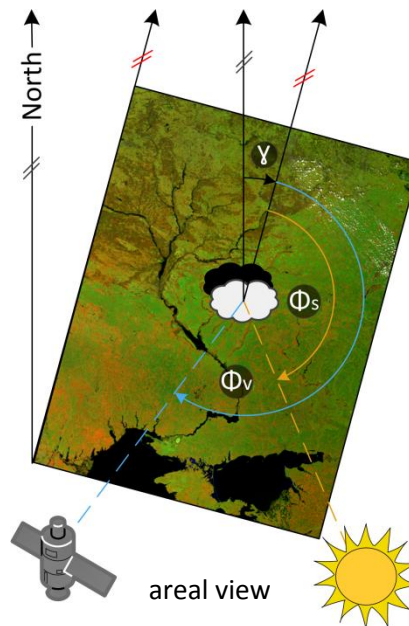
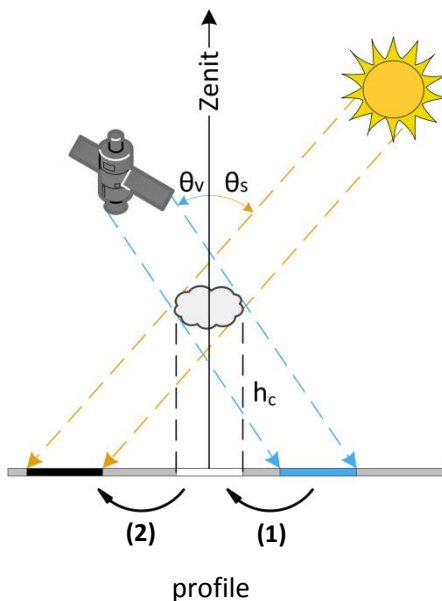
$$\begin{aligned} x_{\text{nadir}} &= x_{\text{img}} + h_c \tan \vartheta_v \sin(\Phi_v + \gamma) \\ y_{\text{nadir}} &= y_{\text{img}} + h_c \tan \vartheta_v \cos(\Phi_v + \gamma) \end{aligned} \quad (1)$$

Projection of cloud shadow:

$$\begin{aligned} x_{\text{shadow}} &= x_{\text{nadir}} - h_c \tan \vartheta_s \sin(\Phi_s + \gamma) \\ y_{\text{shadow}} &= y_{\text{nadir}} - h_c \tan \vartheta_s \cos(\Phi_s + \gamma) \end{aligned} \quad (2)$$

⇒ Effect of zenith/azimuth angles :

- zenith angles  $\vartheta$  and cloud height  $h_c$  affect the length of the distance  $d$
- azimuth angles  $\Phi$  are used for orientation of the distance  $d$

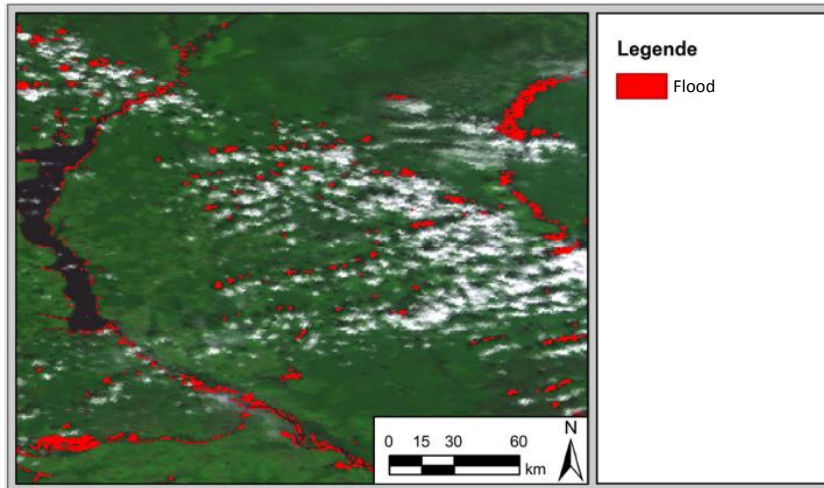


Approximation of  $h_c$ :

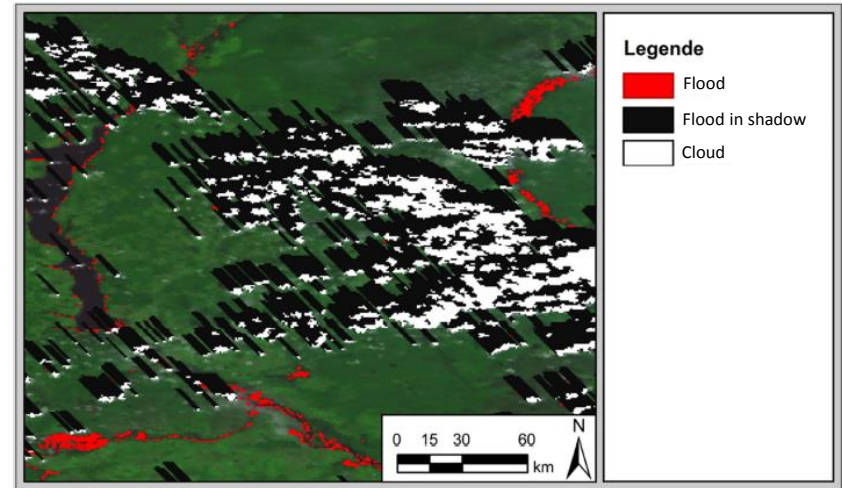
- 0-30° → 16 km
- 30-60° → 12 km
- 60-90° → 8 km

effect of zenith/azimuth angles (Luo et al. 2008)

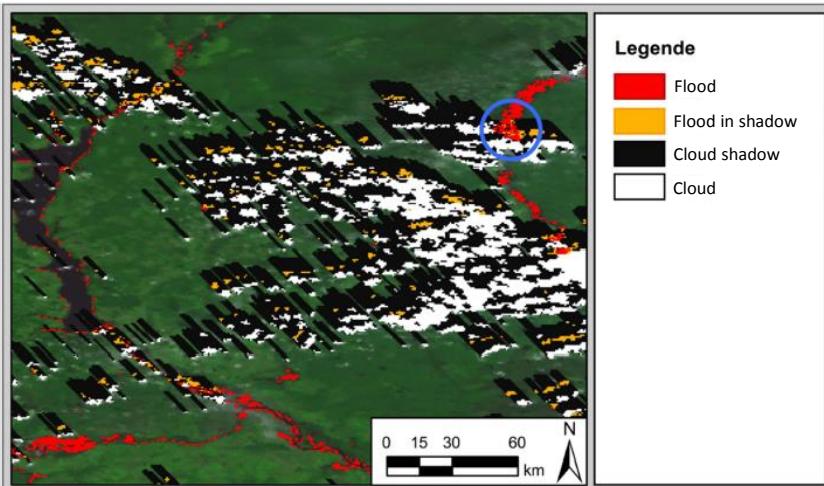
# Flood monitoring: *MODIS* flood service



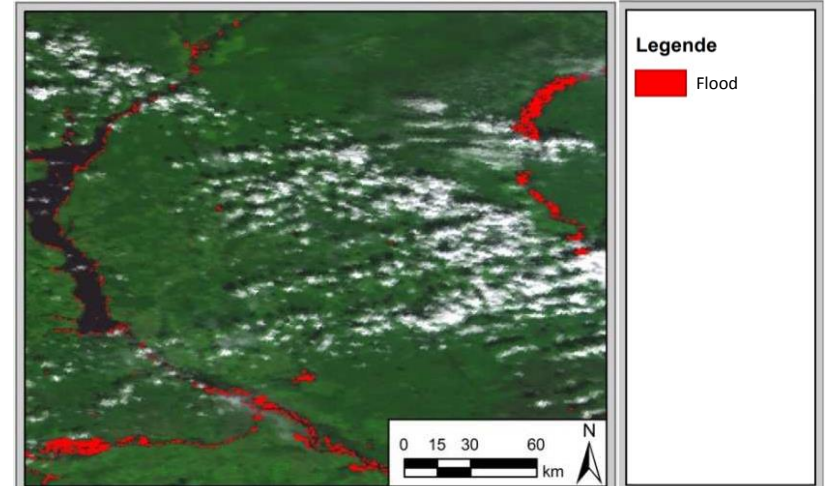
Initial classification



Modeling of cloud shadows



Detection of potential flood areas in modeled cloud shadows

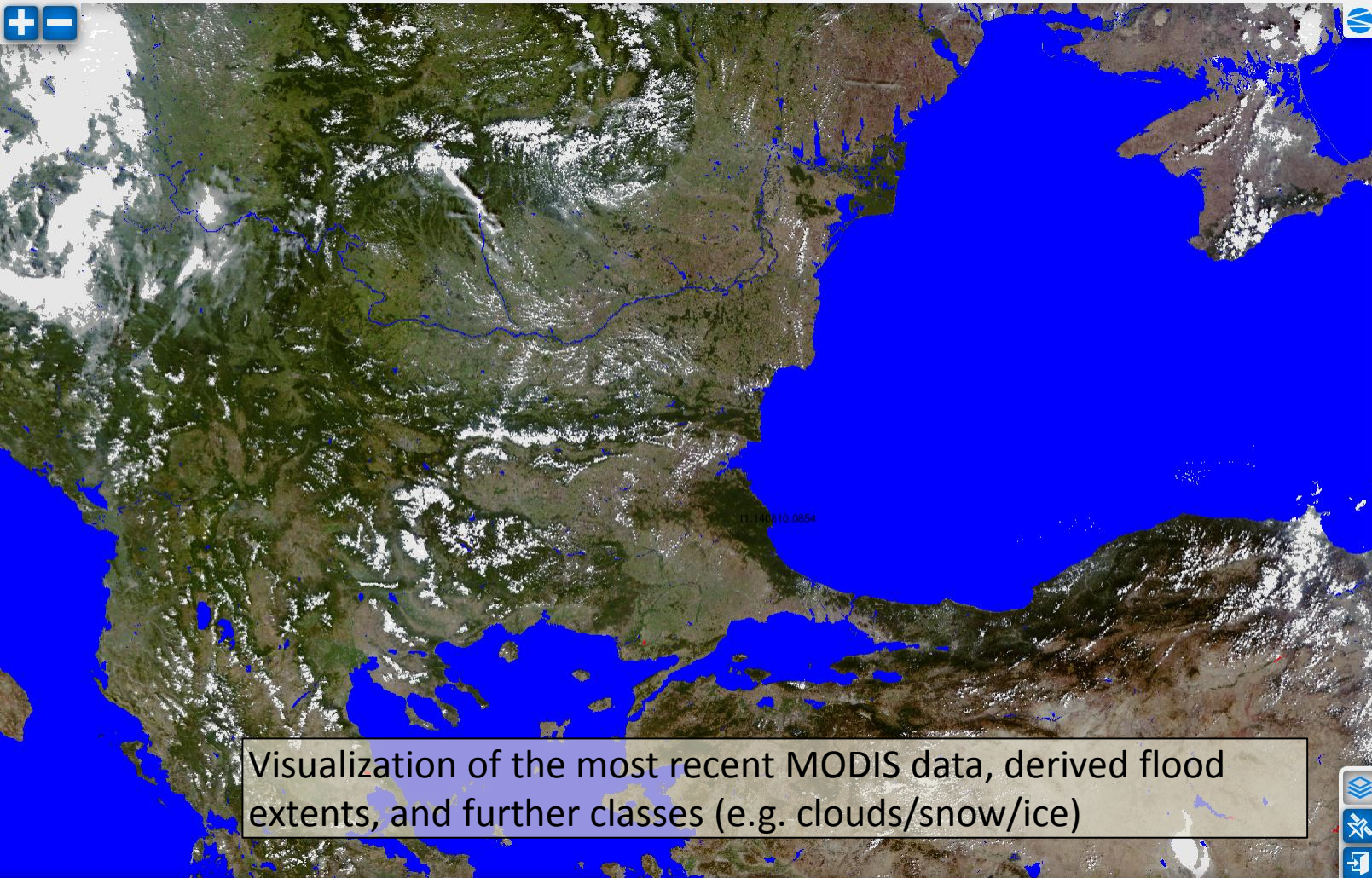


Improvement by integrating time-series & spectral information



# MODIS Flood Service

floodService | 0.83 beta



## Layers

### Baselayers

- Cloudmade Pale i
- OSM (DE) i

### Floodlayers

- Date: < 10.8.2014 >
- Satellite Image i
  - Water Reference i
  - Flood i
  - Standing Water i
  - Receding Water i
  - Mixture i
  - Non-Flood i
  - Clouds/Snow/Ice i
  - Footprint i

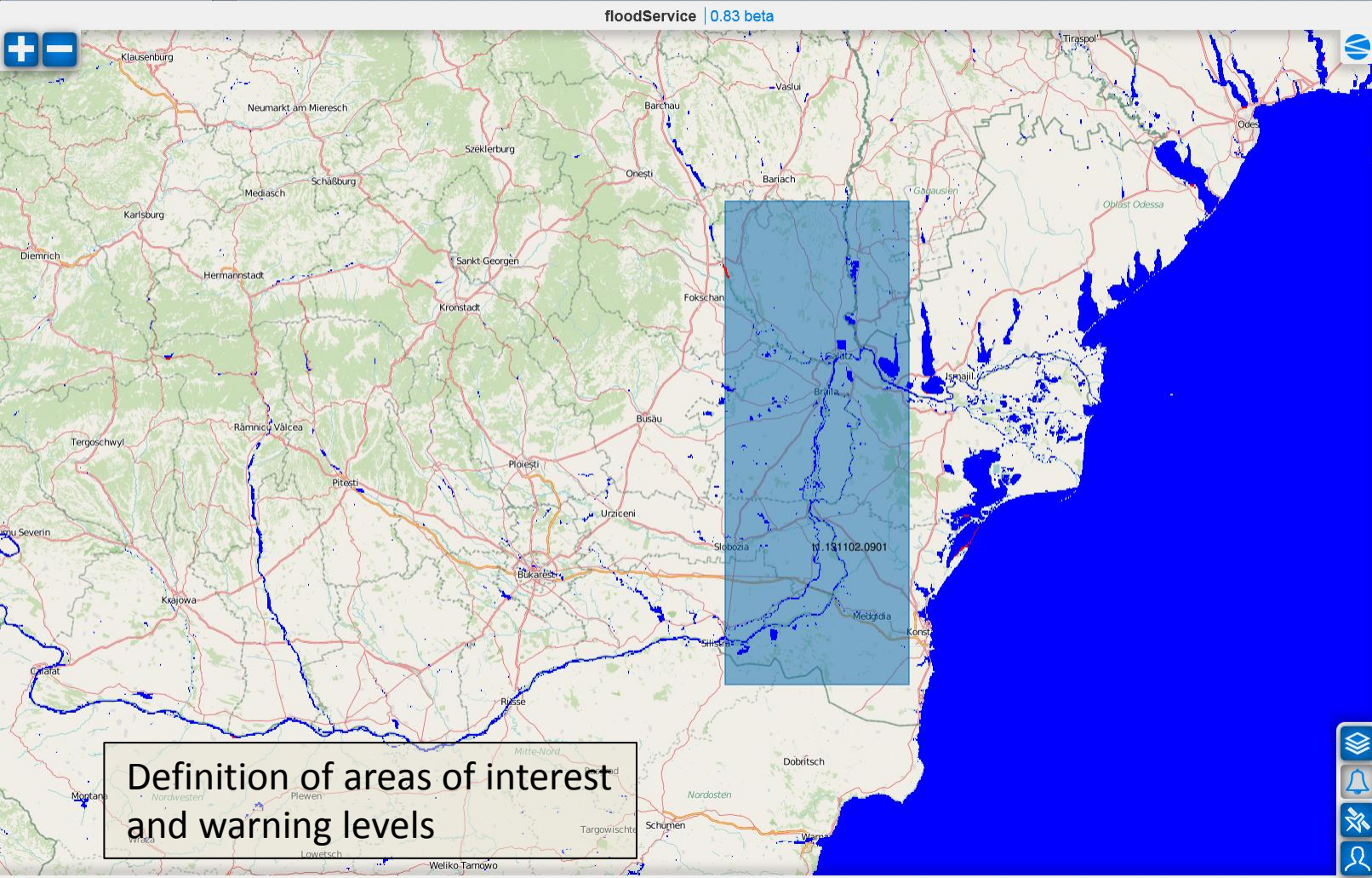
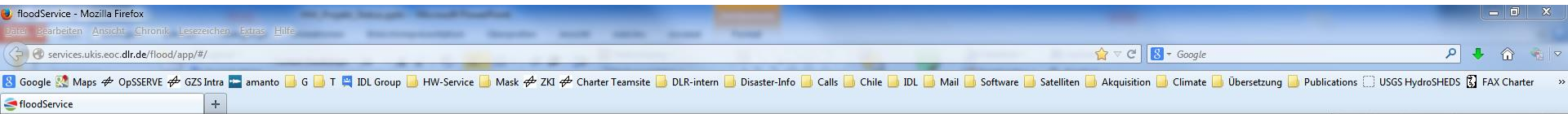
### Overlays

- Satellite i





# MODIS Flood Service



### Alert-Service

Subscription "sub\_234"

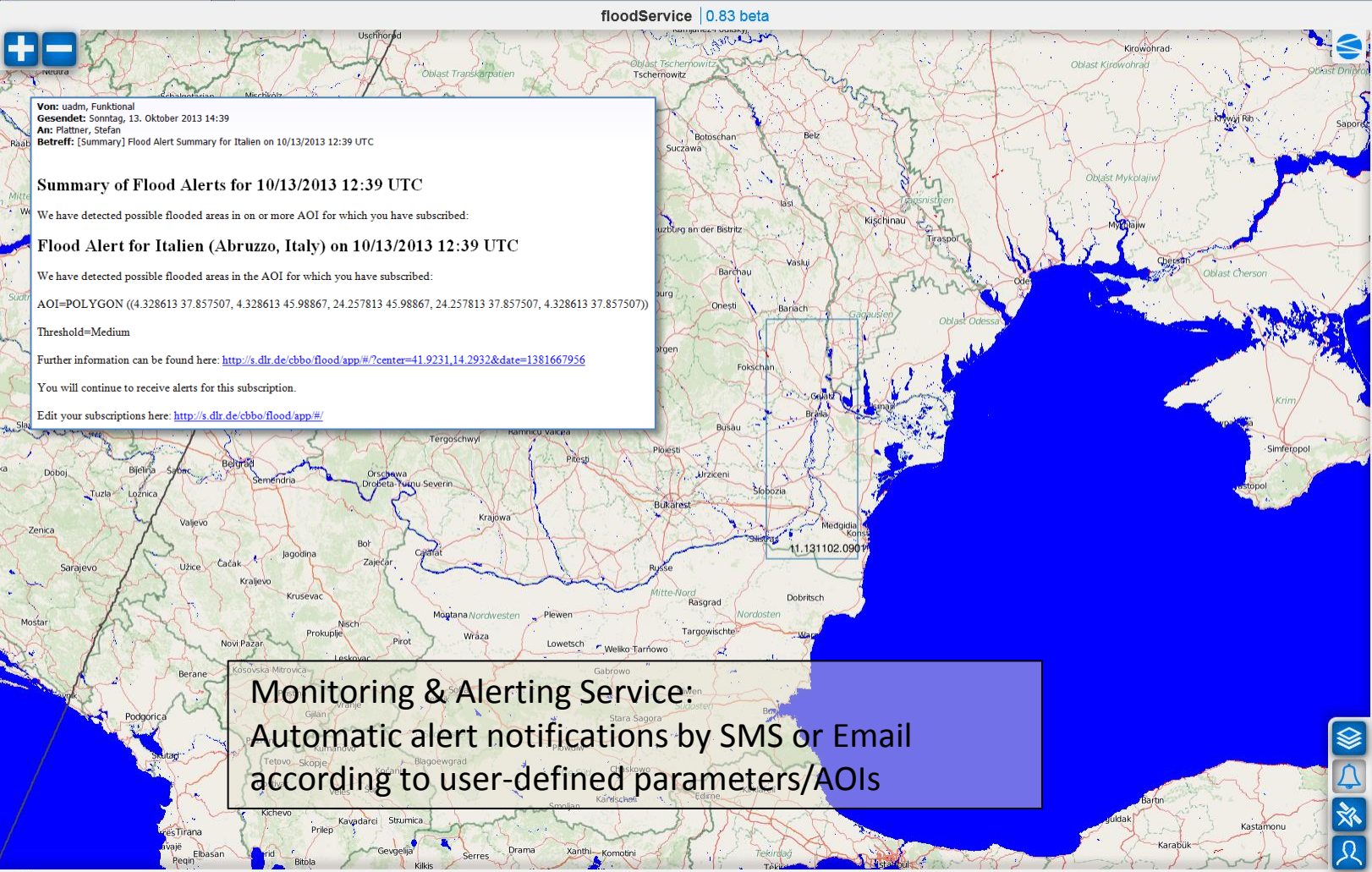
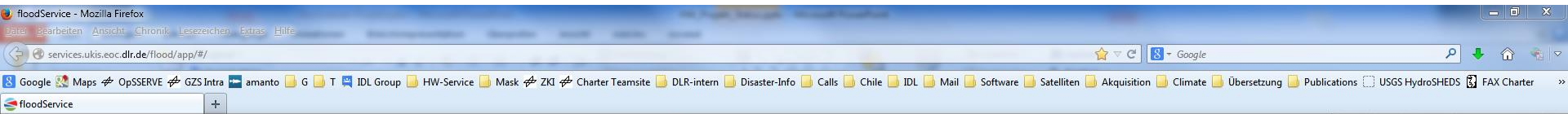
- rename
- resize
- delete
- threshold
  - low  
1 pixel
  - medium  
10 pixels
  - high  
100 pixels

[back to the list](#)

Definition of areas of interest and warning levels



# MODIS Flood Service



### Alert-Service

Subscriptions

- sub\_234
- + add a subscription

### Settings

- immediate (per subscription) ⓘ
- immediate (per overpass) ⓘ
- daily digest ⓘ
- Email notifications ⓘ
- SMS notifications ⓘ

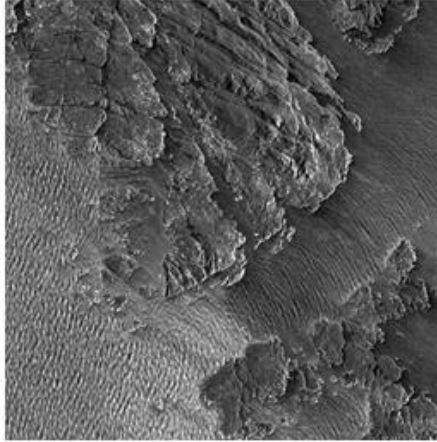


# Challenges in SAR-based flood detection

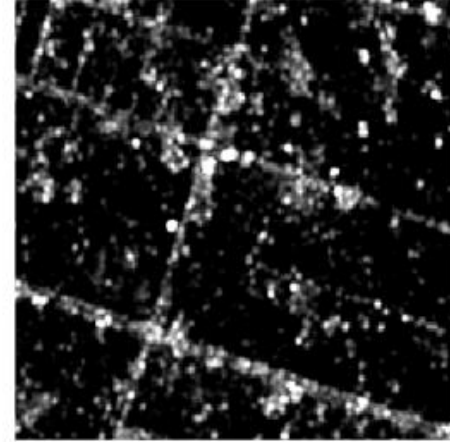
## Underestimations in flood monitoring



Flooded vegetation – Arkansas (USA)  
TerraSAR-X SM HH, © DLR 2008



Wind/Waves – Bergen (Norway)  
TerraSAR-X SM HH, © DLR 2008



Debris/Vegetation – Sendai (Japan)  
TerraSAR-X SM HH, © DLR 2011

## Overestimations in flood monitoring



Radar shadow – Sinabung (Indonesia)  
TerraSAR-X HS HH, © DLR 2014

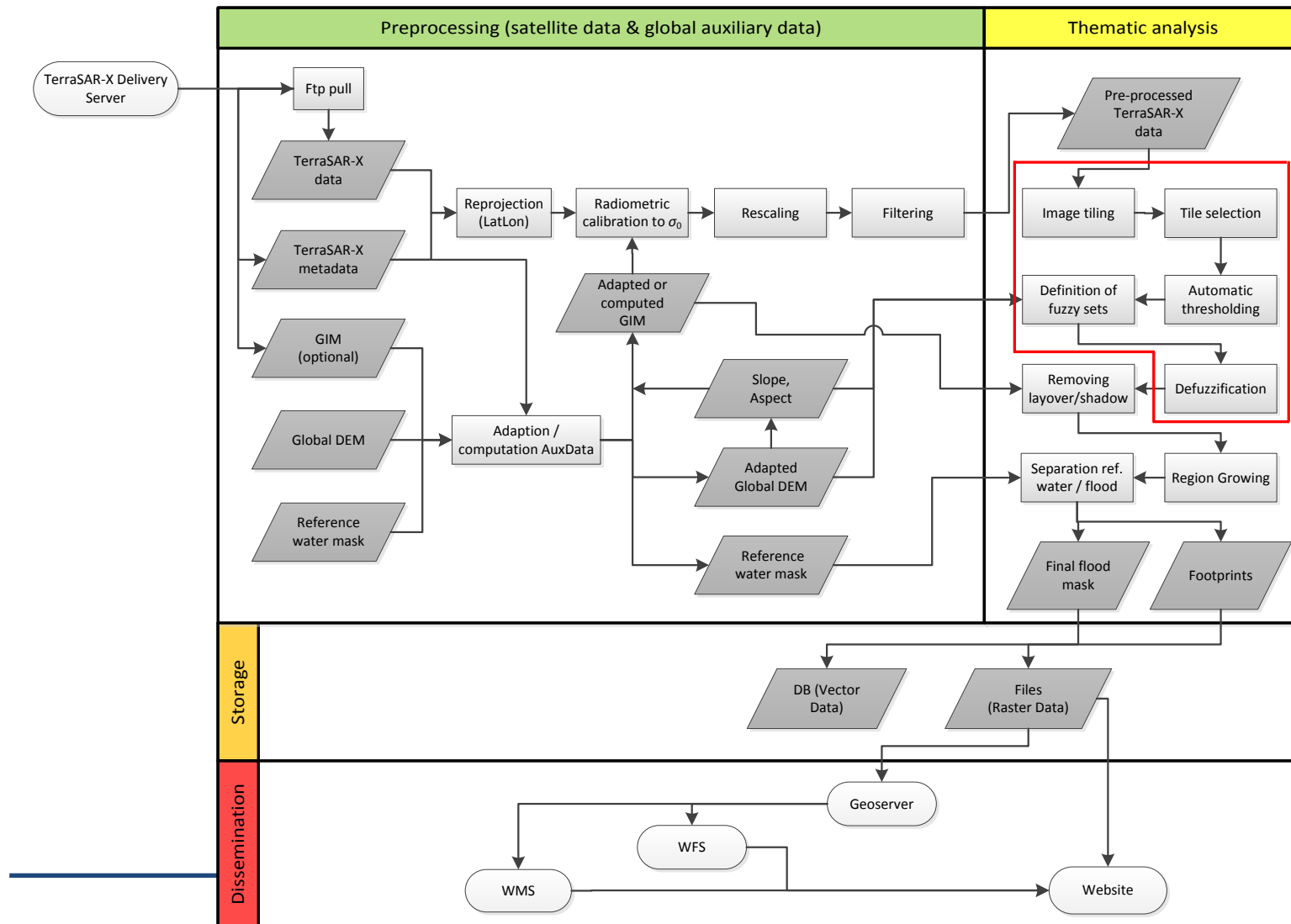


Sand dunes – Walvis Bay (Namibia)  
TerraSAR-X SM HH, © DLR 2008



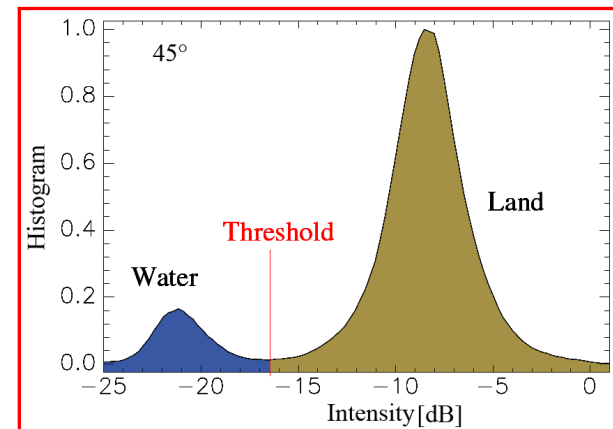
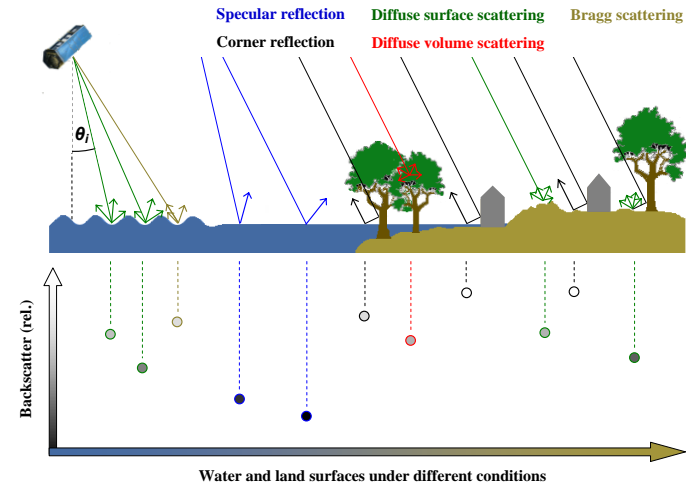
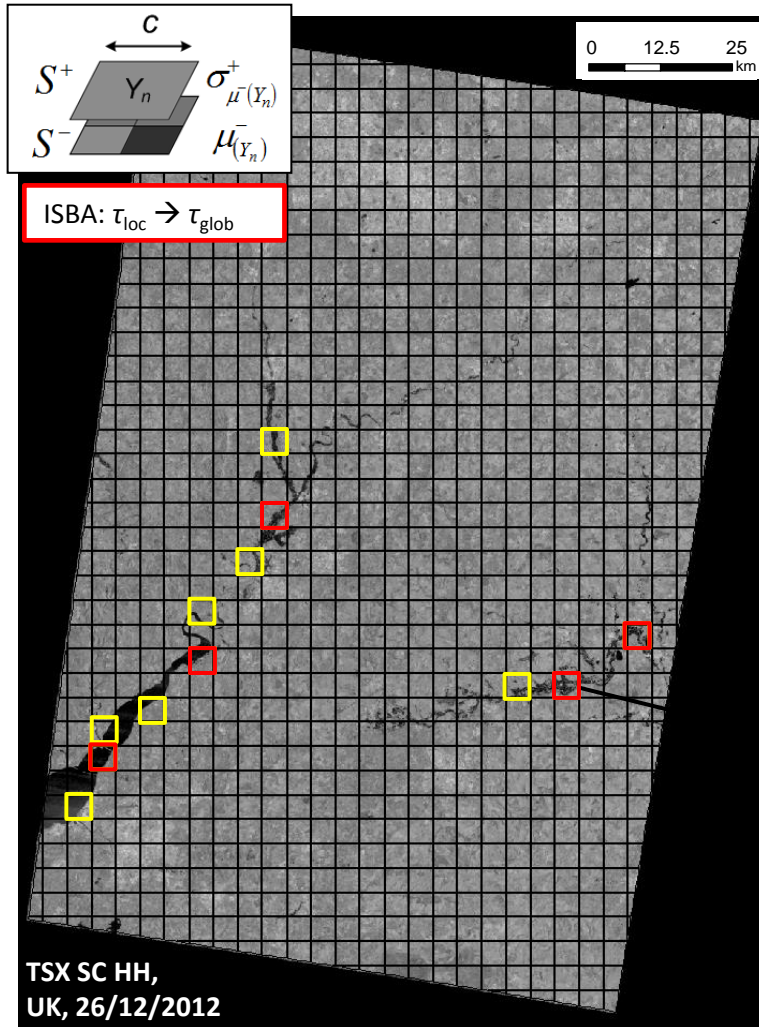
Streets/Airport – Leipzig (Germany)  
TerraSAR-X SM HH, © DLR 2011

# TerraSAR-X flood service: *Workflow*



Workflow of TerraSAR-X flood service

# TerraSAR-X flood service: *Thematic Analysis*



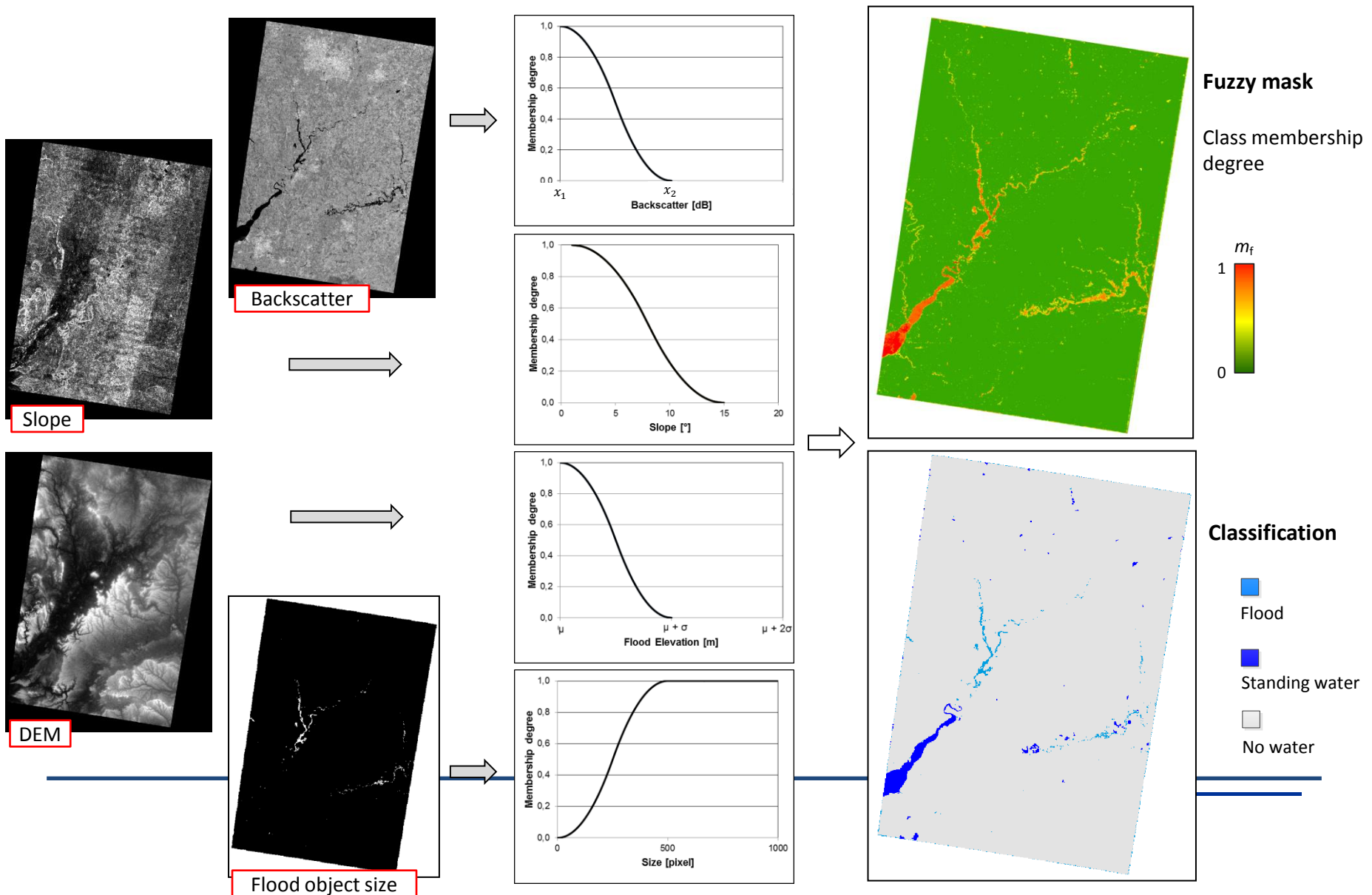
Separability land/water

Martinis, Twele, Voigt, 2011 - IEEE TGRS, 49 (1)

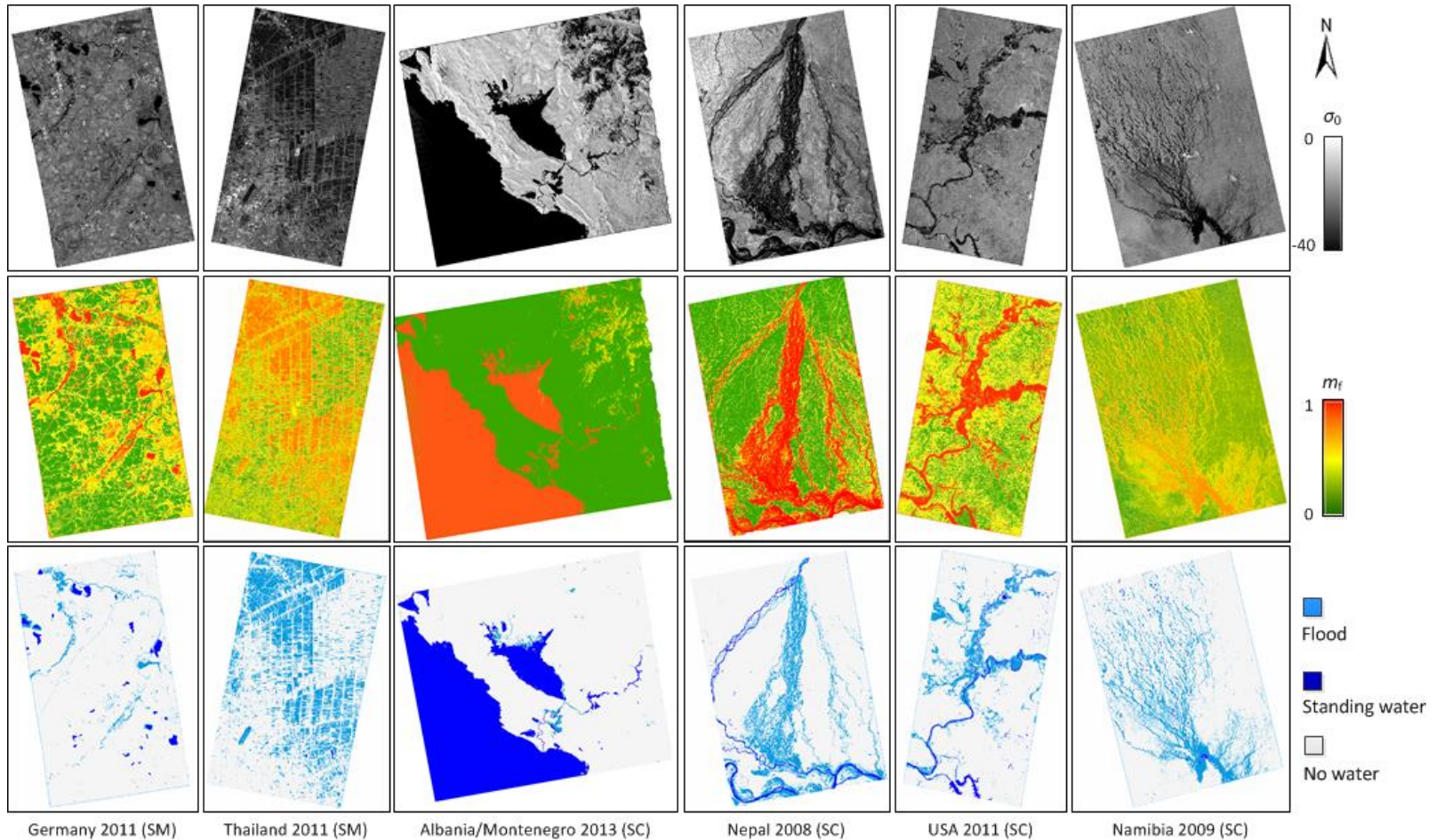
Martinis, Twele, Voigt, 2009 - NHESS, (9)



# TerraSAR-X flood service: *Thematic Analysis*



# TerraSAR-X flood service: *Thematic Analysis*



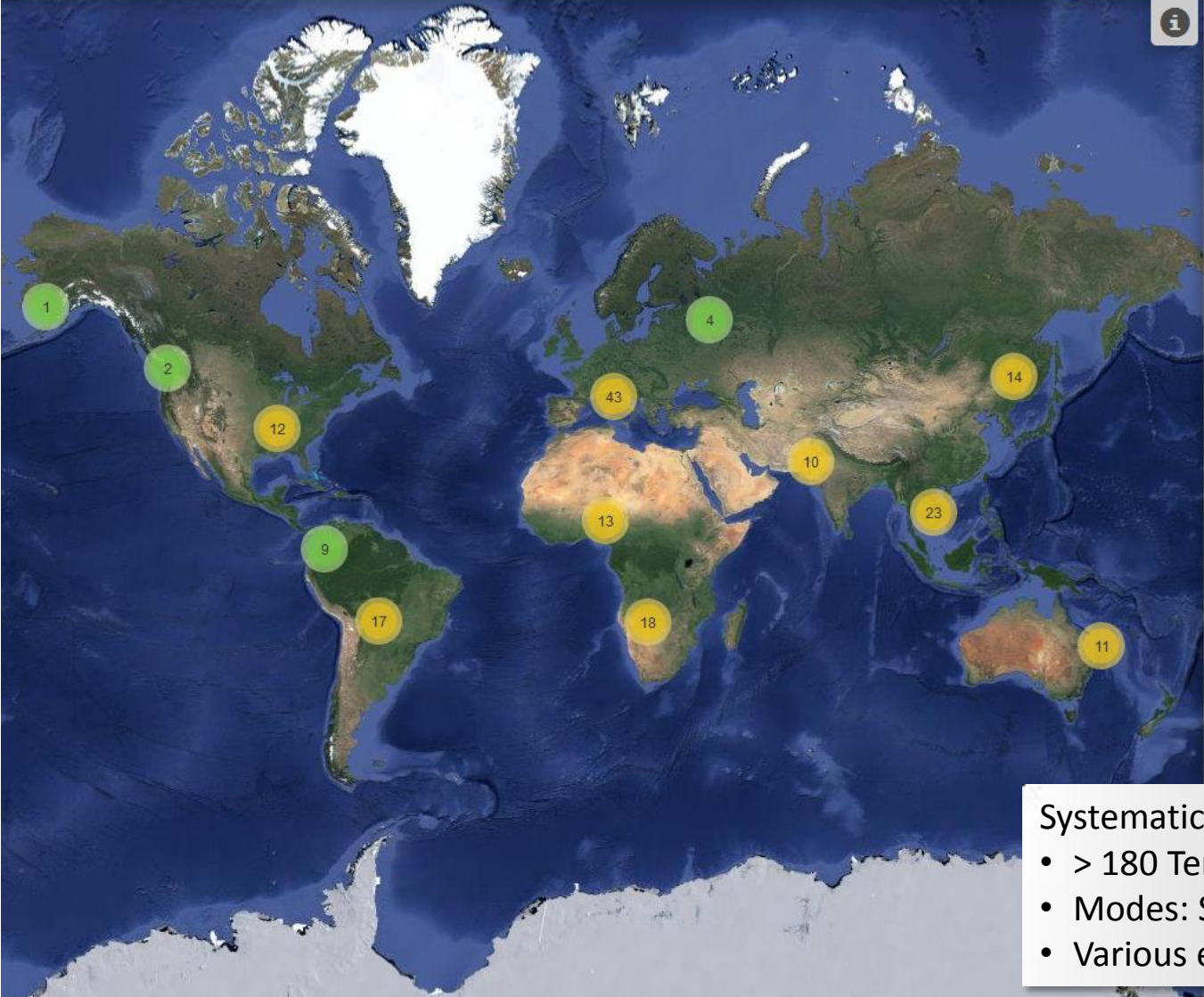
TerraSAR-X data (upper row), fuzzy maps (mid row), and final classification results (lower row) for different test areas



# TerraSAR-X flood service: *Dissemination*

TerraSAR-X Flood Client | 0.1

UKIS DLR



Layers

- Footprint  off
- TerraSAR-X Image  off
- Non-Floodmask  off
- Standing-Watermask  off
- Floodmask  on
- Markers  on

Baselayers

- ESRI grey
- Cloudmade Pale
- Google Satellite

Systematic testing

- > 180 TerraSAR-X scenes
- Modes: ST, HS, SL, SM, SC, WS
- Various environmental conditions



# TerraSAR-X flood service: *Dissemination*

TerraSAR-X Flood Client | 0.1

UKIS DLR

Layers

- Footprint  off
- TerraSAR-X Image  off
- Non-Floodmask  off
- Standing-Watermask  off
- Floodmask  on
- Markers  on

The image displays the TerraSAR-X Flood Client interface. The main map shows a global view with numbered markers (1-14) indicating flood events. A red dashed line highlights a region in Europe, which is further zoomed into a detailed view of the River Elbe in Germany. The detailed view shows the river and surrounding land, with numbered markers (1-5) indicating flood events. The interface includes a 'Layers' panel on the right with toggle switches for various data layers: Footprint, TerraSAR-X Image, Non-Floodmask, Standing-Watermask, Floodmask (checked), and Markers (checked). The title bar indicates the client version is 0.1 and the logos for UKIS and DLR are present.

Germany, River Elbe, 2013



# TerraSAR-X flood service: *Dissemination*

TerraSAR-X Flood Client | 1.0

The screenshot displays the TerraSAR-X Flood Client interface. The main map shows a region in Germany, including cities like Dessau-Roßlau, Lutherstadt Wittenberg, and Zerbst/Anhalt. The Elbe river is prominent, with blue overlays indicating flood areas. The interface includes a top navigation bar with zoom controls and logos for UKIS and DLR. A right-hand panel contains 'Layers' and 'Baselayers' sections. The 'Layers' section has five items: TerraSAR-X Image (off), Non-Floodmask (off), Standing-Watermask (on), Floodmask (on), Markers (off), and Footprint (on). The 'Baselayers' section has three items: ESRI grey, OpenStreetMap (selected), and Google Satellite. A scale bar at the bottom left shows 10 km and 5 mi. The bottom left corner contains attribution text: 'Leaflet | tsx-hydr; © DLR/EOC, © OpenStreetMap contributors'.

Layers

- TerraSAR-X Image
- Non-Floodmask
- Standing-Watermask
- Floodmask
- Markers
- Footprint

Baselayers

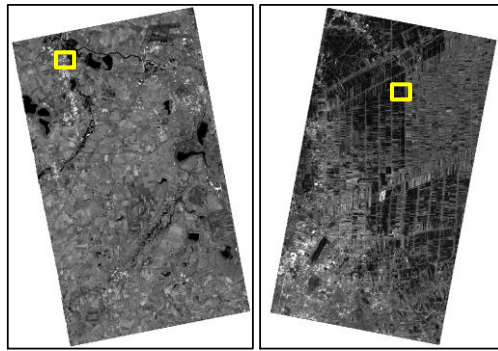
- ESRI grey
- OpenStreetMap
- Google Satellite

Leaflet | tsx-hydr; © DLR/EOC, © OpenStreetMap contributors

10 km  
5 mi



# TerraSAR-X flood service: Accuracy Assessment



TerraSAR-X SM  
Germany/Saale  
(17-01-2011)

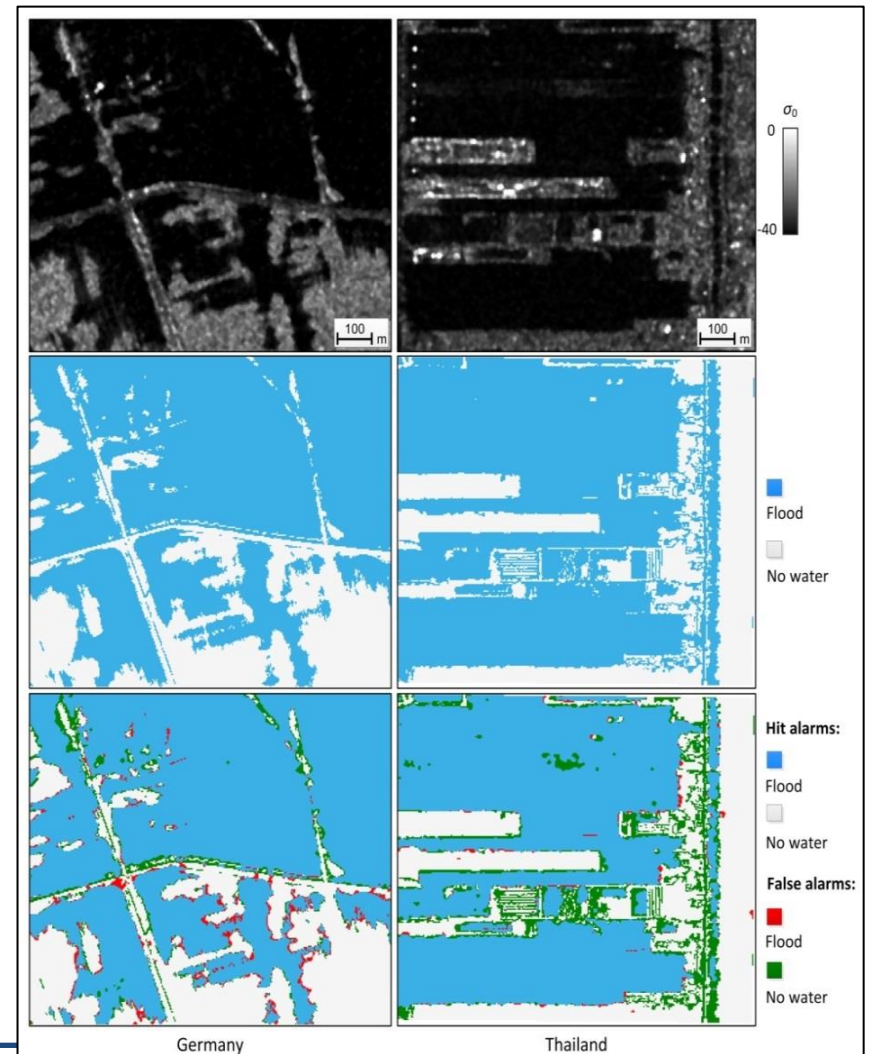
TerraSAR-X SM  
Thailand  
(06-11-2011)

Overestimations due to radar shadowing → **low backscatter**

Underestimations due to vegetation → **high backscatter**

	Classes	Flood	No flood	row total	UA [%]
Thailand	<b>Flood</b>	44731	656	45387	<b>98.55</b>
	<b>No flood</b>	9130	23468	32598	71.99
	column total	53861	24124	77985	
	<b>PA [%]</b>	<b>83.05</b>	97.27	<b>OA [%]</b>	<b>87.45</b>
			<b>Khat [%]</b>	73.22	

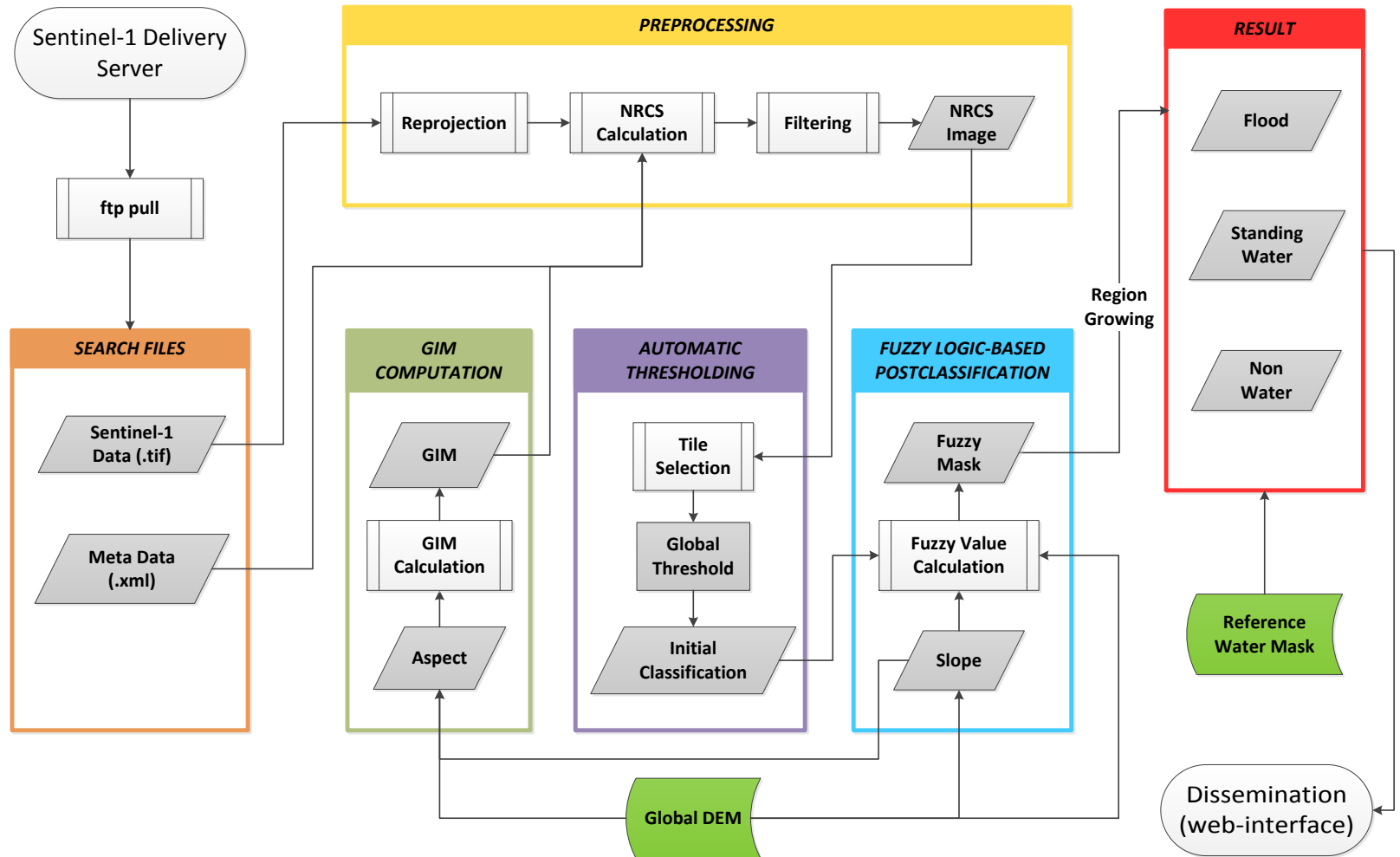
	Classes	Flood	No flood	row total	UA [%]
Germany	<b>Flood</b>	51608	4123	55731	<b>95.37</b>
	<b>No flood</b>	2505	20892	23397	83.52
	column total	54113	25015	79128	
	<b>PA [%]</b>	<b>92.60</b>	89.29	<b>OA [%]</b>	<b>91.62</b>
			<b>Khat [%]</b>	80.28	



TerraSAR-X data, validation masks and classification results for AOIs in Germany (left) and Thailand (right) (Martinis et al. 2014).

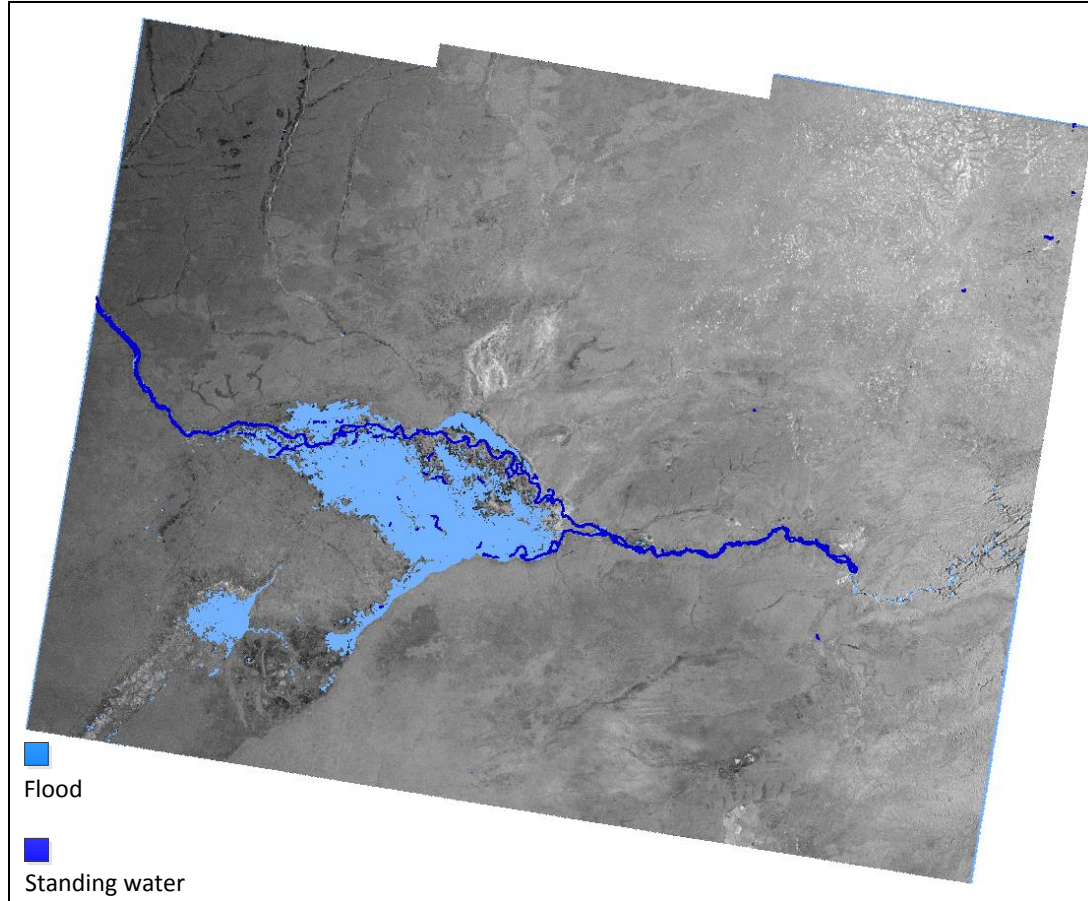


# Outlook: Sentinel-1 flood service

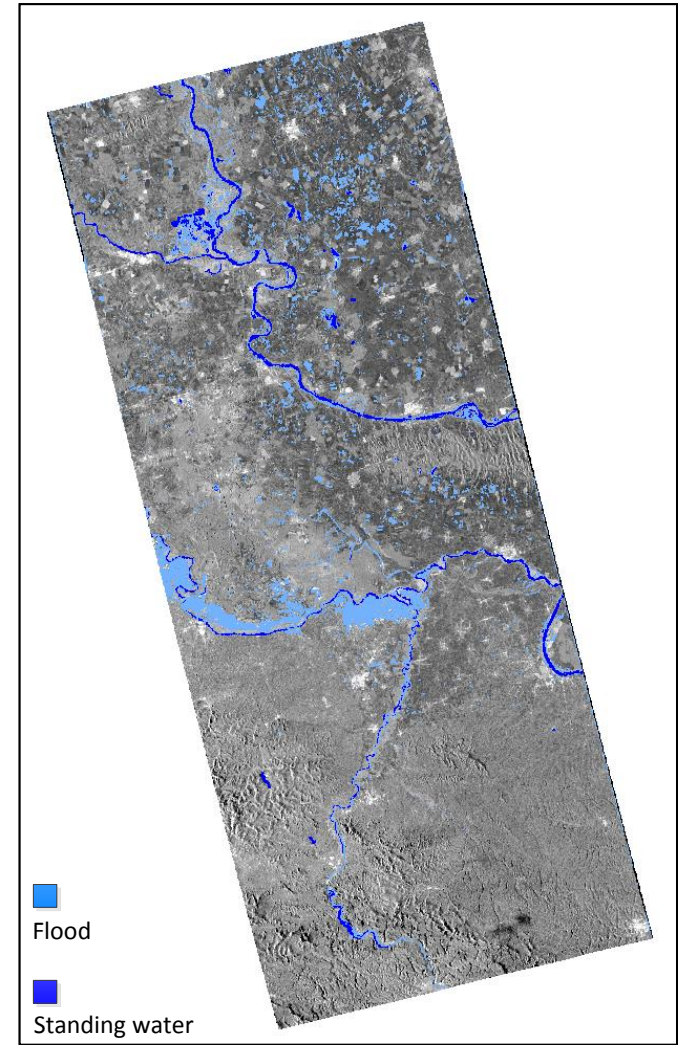


Prototypical workflow of the Sentinel-1 flood service

# Outlook: Sentinel-1 flood service



Sentinel-1, Caprivi/Namibia, 13-04-2014, © ESA



Sentinel-1, Balcan, 24-05-2014, © ESA



