living planet symposium 2016

A flood index based on EO big data for an improved flood mapping, depth estimation and impact assessment in a changing climate

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9–13 May | Congress Centre | Prague | Czech Republic

European Space Agency

FC4
FC5

Floods happen!

sses

omic

Slide 2

FC4 Inserire immagine inondazione
Fabio Cian, 2/5/2016

FC5 grafico munich re su incremento di flood damage
Fabio Cian, 2/5/2016

FC4
FC5

Floods happen!

Floods (riverine, flash and coastal floods) are the **greatest sources of losses** in the globe

Impacts are **constantly increasing** with climate change and **socio-economic change** as main drivers

Flood risk is not sufficiently understood

Data from satellites show potential for supporting decision making processes in order to reduce losses and increase adapting an coping capacity

Knowledge gap between stakeholders and RS

Sources:

Mysiak, J. (2013). Towards a potential European flood impact database. *EEA – JRC – ETC/CCA Joint Technical Paper*.

MunichRE, N. (2014). Loss events worldwide 2014 Percentage distribution

UNISDR (2011). Global Assessment Report on Disaster Risk Reduction. 2011 Global Assessment Report on Disaster Risk Reduction (pp. i–x). Geneva

Slide 3

FC4 Inserire immagine inondazione
Fabio Cian, 2/5/2016

FC5 grafico munich re su incremento di flood damage
Fabio Cian, 2/5/2016

Need of a better flood risk assessment?

Institutions demand better understanding of flood risk:

- support climate change **adaptation policies**
- develop robust public **disaster relief funds**
- develop risk profile for **financial institutes**
- risk portfolio for **re-insurance** companies
- risk in supply chain for **multinational companies**

Increasing need of **global** flood risk assessment

Sources:
De Moel, H., Jongman, B., Kreibich, H., Merz, B., Penning-Rowsell, E., Ward, P.J., 2015. Flood risk assessments at different spatial scales. Mitig. Adapt. Strateg. Glob. Chang.
UNIDSR, 2015. Making Development Sustainable: The Future of Disaster Risk Management. Global Assessment Report on Disaster Risk Reduction.

New Sentinels, new opportunities

Exploitation of **EO Big Data**: Sentinel-1

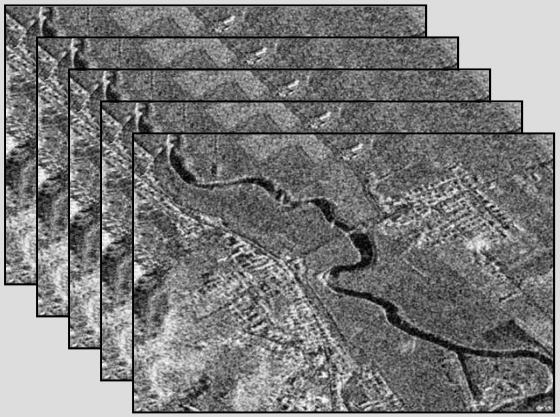
More precise flood mapping for emergency response and economic impact assessment

Evolution of flood events

Derivation of **Flood Depth**

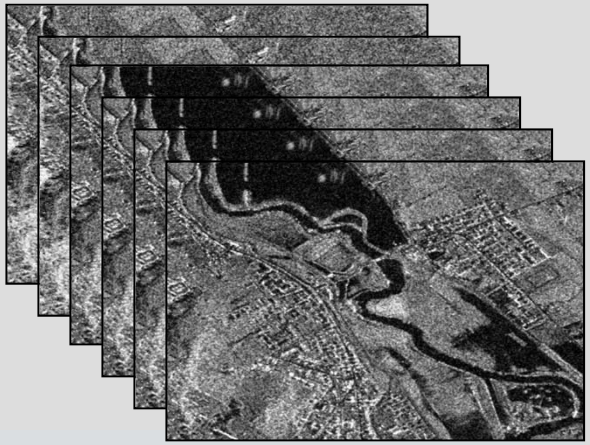
Assess the **extent** of a **flood event**

Compute the Normalized Difference Flood Index



Stack of **reference** images

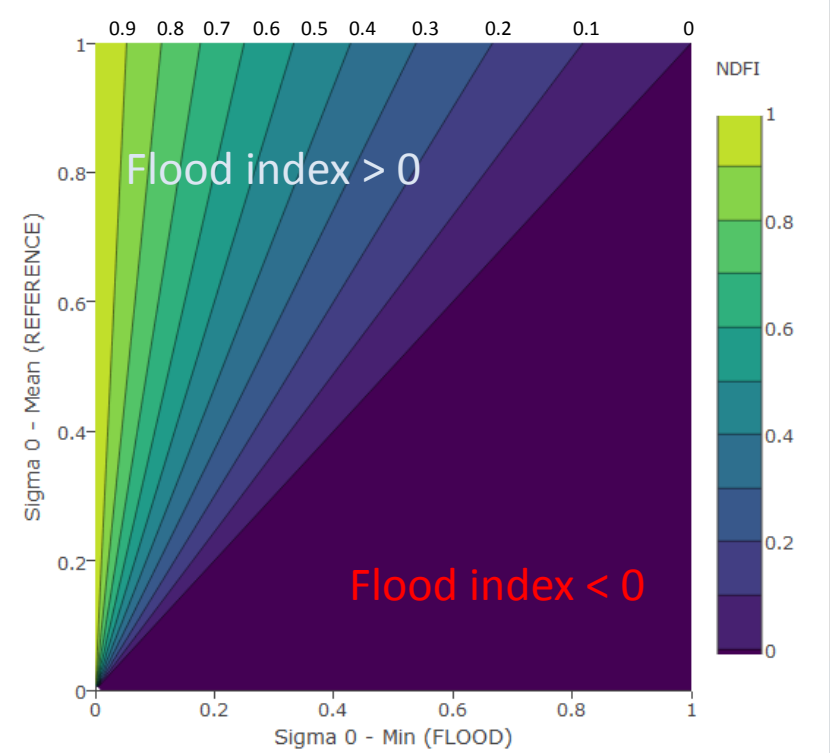
(selection of images in the same weather season)



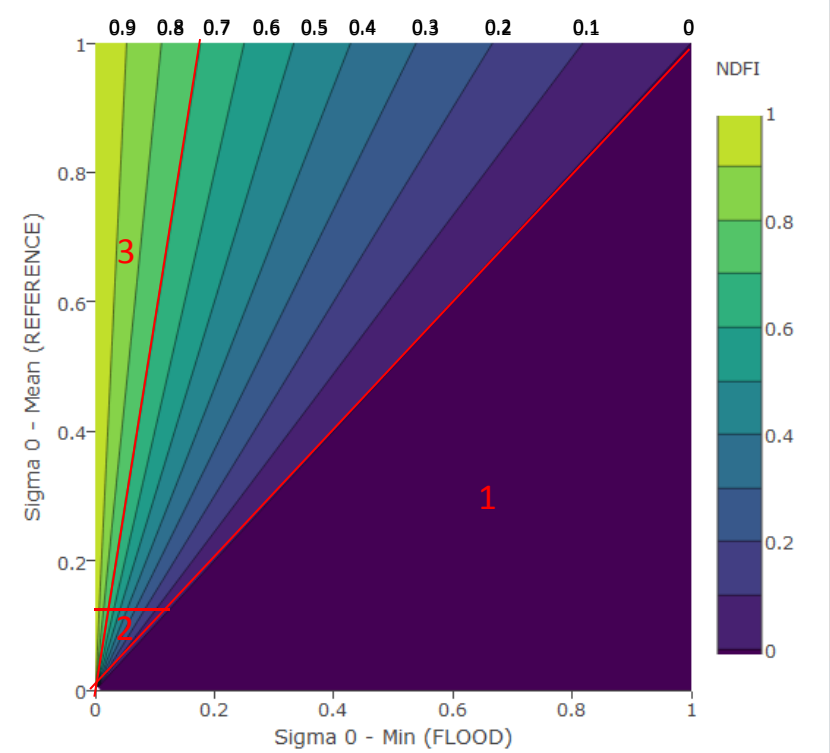
Stack with **flood** images

$$NDFI = \frac{(\textbf{mean}\, pixel\ intensity\ (reference) - \textbf{min}\, pixel\ intensity\ (flood))}{(\text{mean}\, pixel\ intensity\ (reference) + \text{min}\, pixel\ intensity\ (flood))}$$

Normalized Difference Flood Index



Normalized Difference Flood Index

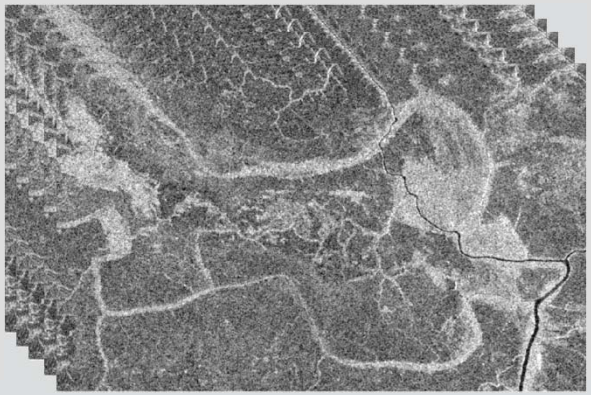


1 – unlikely values
2 – permanent water bodies
3 – flooded areas

Shallow Water in Short Vegetation

Compute the Normalized Difference Flood in Vegetated Areas Index

Stack with **flood** images

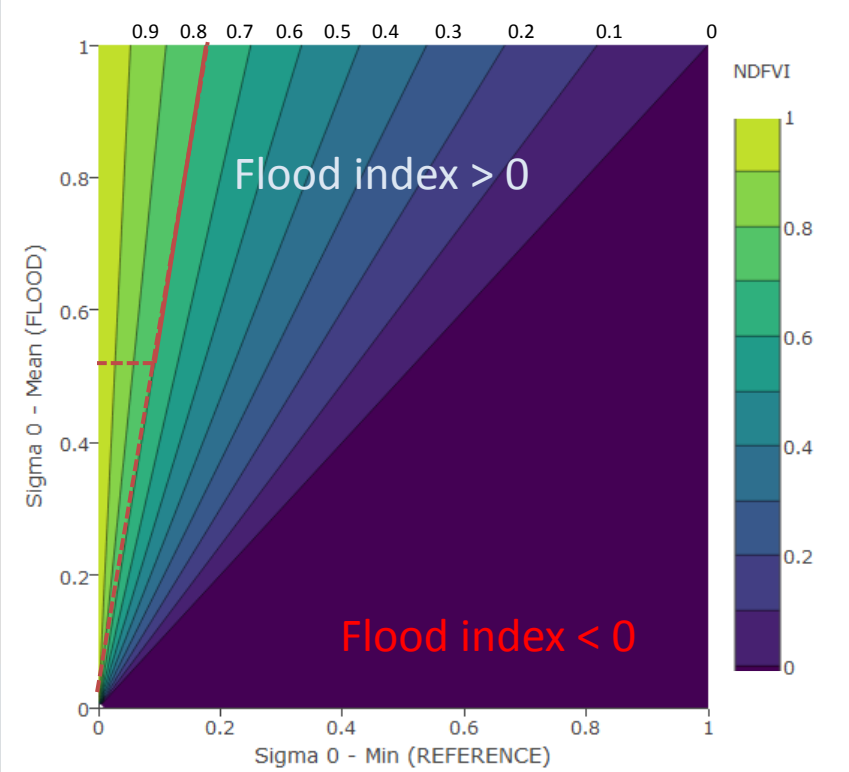


Stack of **reference** images

(selection of images in the same weather season)

$$NDFVI = \frac{(\mathbf{max}\ pixel\ intensity\ (flood) - \mathbf{mean}\ pixel\ intensity\ (reference))}{(\mathbf{max}\ pixel\ intensity\ (flood) + \mathbf{mean}\ pixel\ intensity\ (reference))}$$

Shallow Water in Short Vegetation

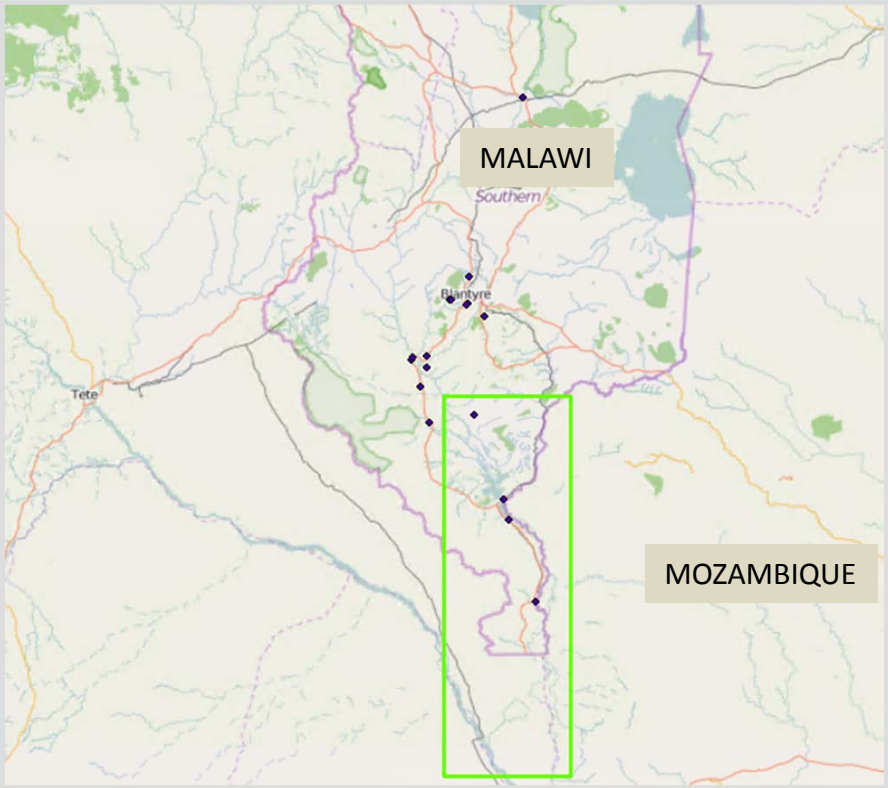


Flood in Malawi 2015 – Sentinel 1 Data

From beginning of **January** 2015 **heavy rain** caused a big flood in south Malawi, which lasted until the end of March

276 deaths
174000 displaced
1 million affected

Overcrowded displacement sites
Concern for rape, cholera, diarrhea, malaria



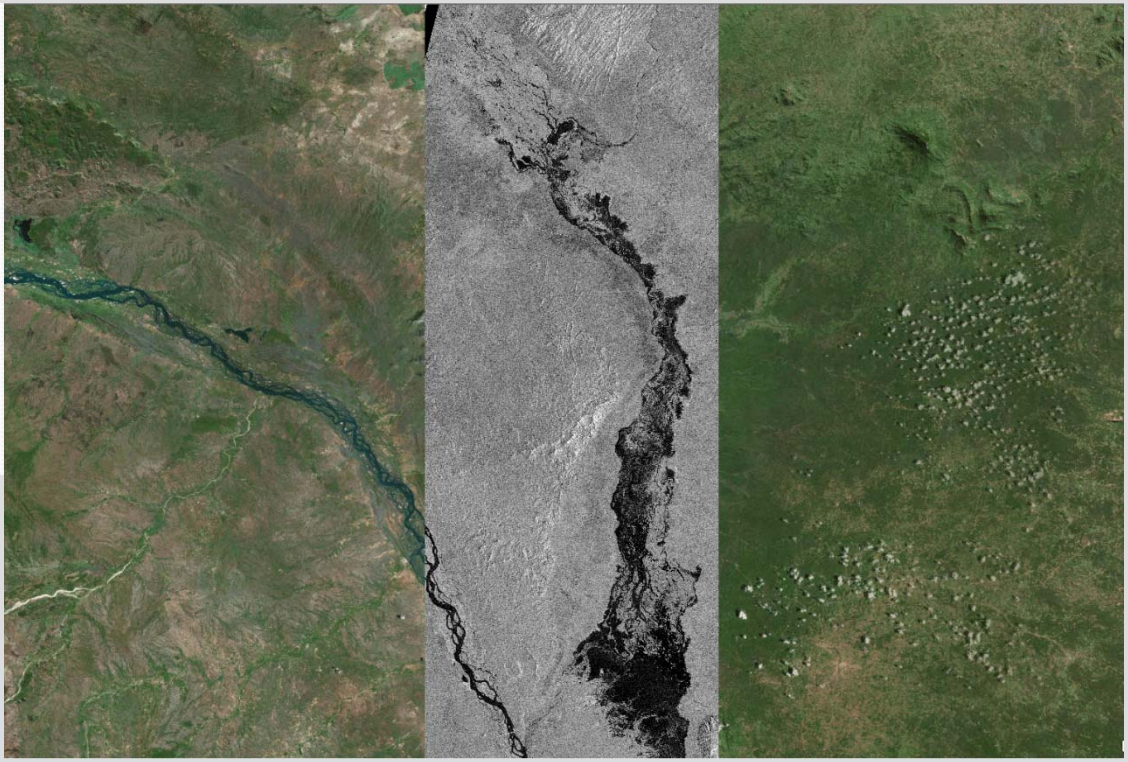
Flood in Malawi 2015 – Sentinel 1 Data

January 22nd, 2015

Sentinel 1 Data

Descending Orbit
VV Polarization

Reference Images
11 November 2014
05 December 2014
29 December 2014



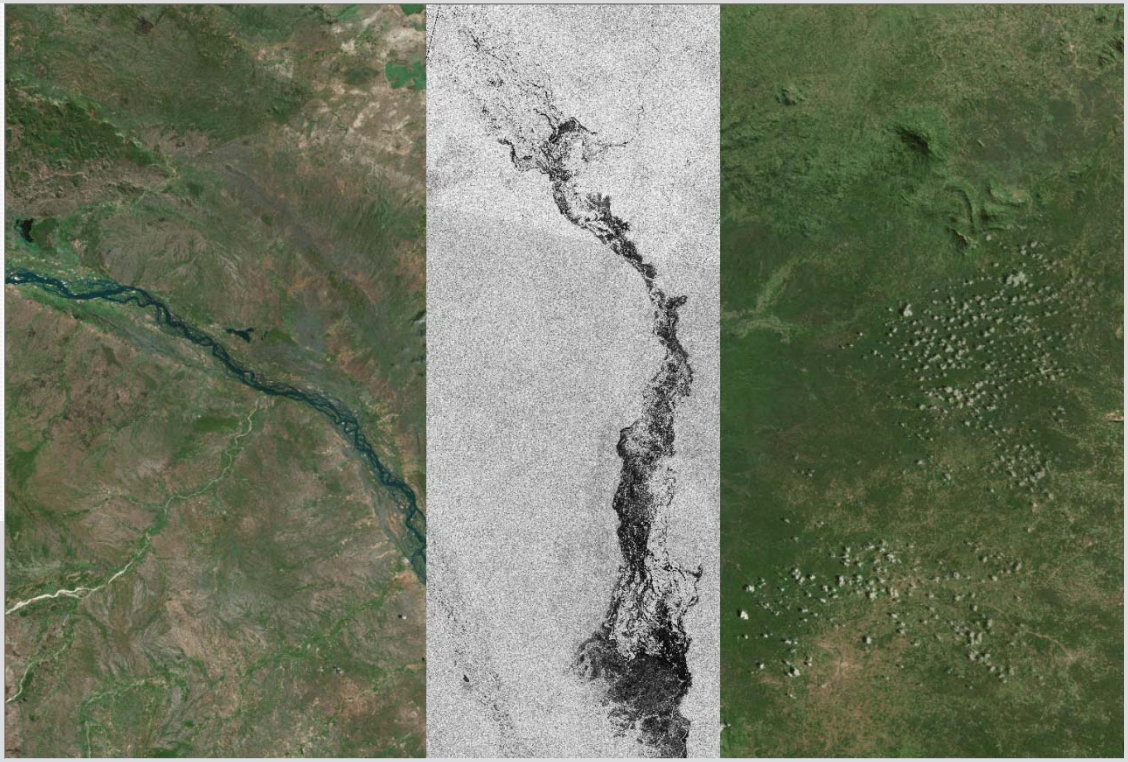
Flood in Malawi 2015 – Sentinel 1 Data

January 22nd, 2015

NDFI
(inverted grayscale)

Descending Orbit
VV Polarization

Reference Images
11 November 2014
05 December 2014
29 December 2014



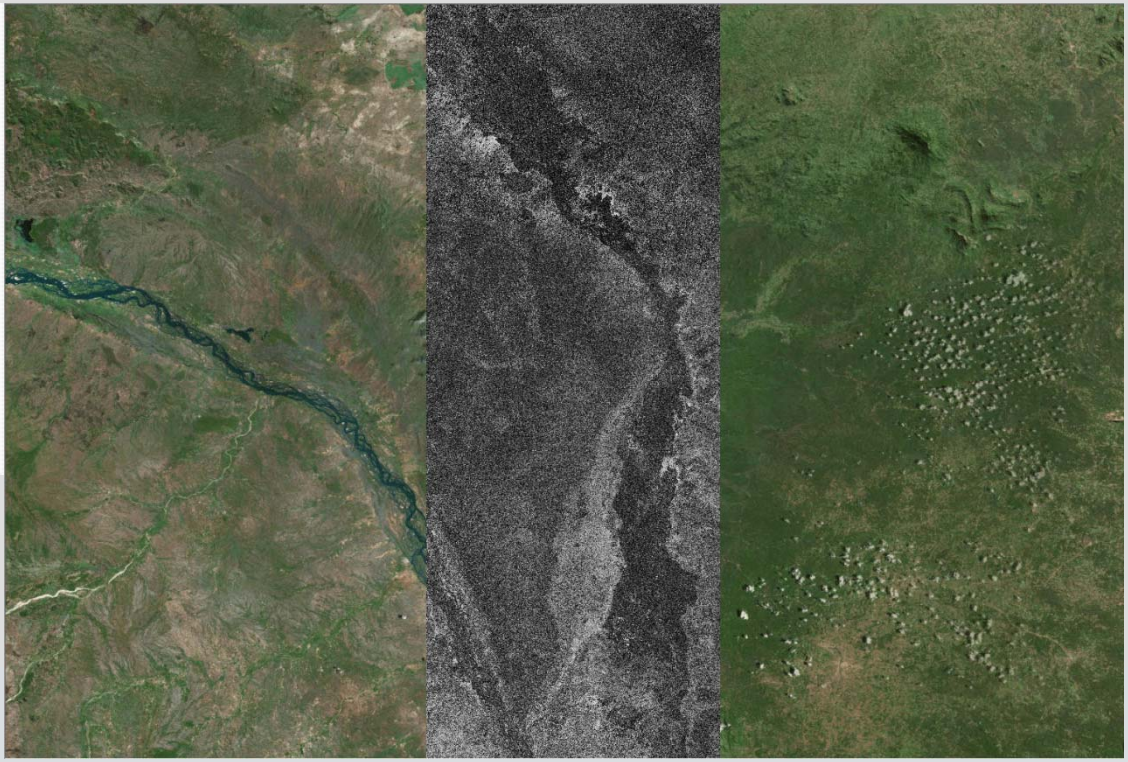
Flood in Malawi 2015 – Sentinel 1 Data

January 22nd, 2015

NDFVI

Descending Orbit
VV Polarization

Reference Images
11 November 2014
05 December 2014
29 December 2014



Flood in Malawi 2015 – Sentinel 1 Data

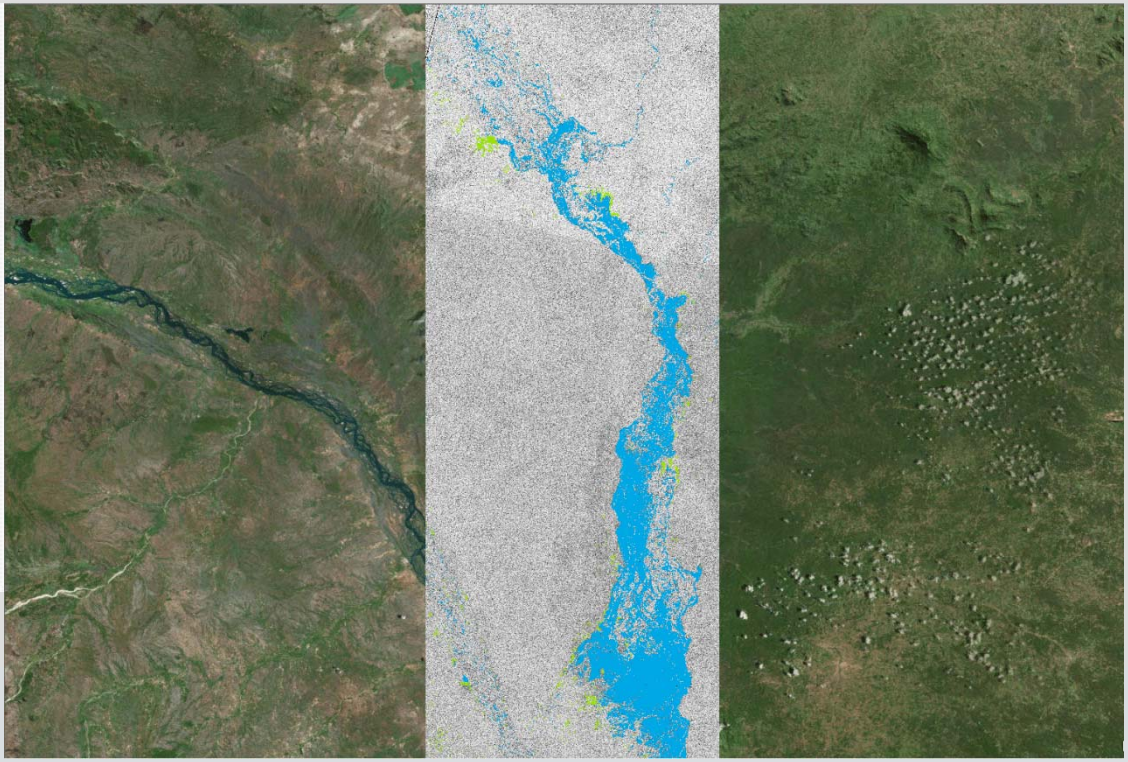
January 22nd, 2015

Flood Map

NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

Flood
Shallow Water in Short Vegetation



Flood in Malawi 2015 – Sentinel 1 Data

January 22nd, 2015

Flood Map

NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

Flood
Shallow Water in Short Vegetation

Flood in Malawi 2015 – Sentinel 1 Data

February 3rd, 2015

Flood Map

NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

Flood
Shallow Water in Short Vegetation

Flood in Malawi 2015 – Sentinel 1 Data

February 15th, 2015

Flood Map

NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

Flood
Shallow Water in Short Vegetation

Flood in Malawi 2015 – Sentinel 1 Data

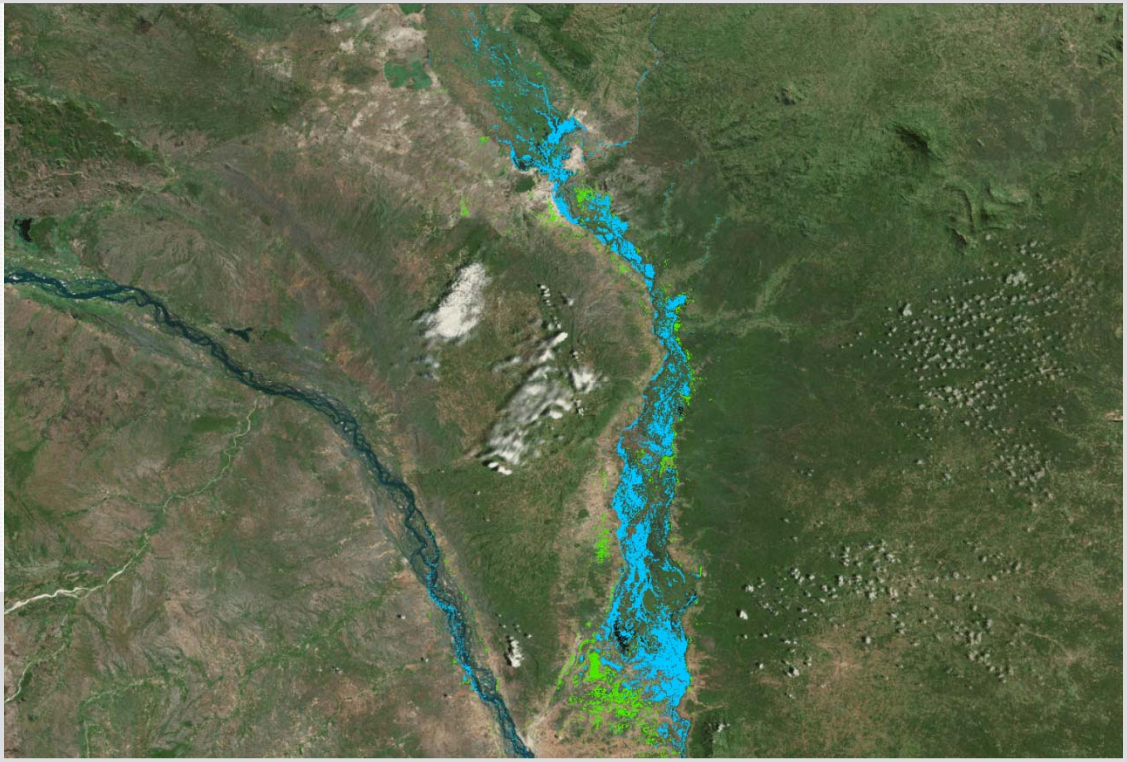
February 21st, 2015
(Ascending Orbit)

Flood Map

NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

Flood
Shallow Water
in Short Vegetation



Flood in Malawi 2015 – Sentinel 1 Data

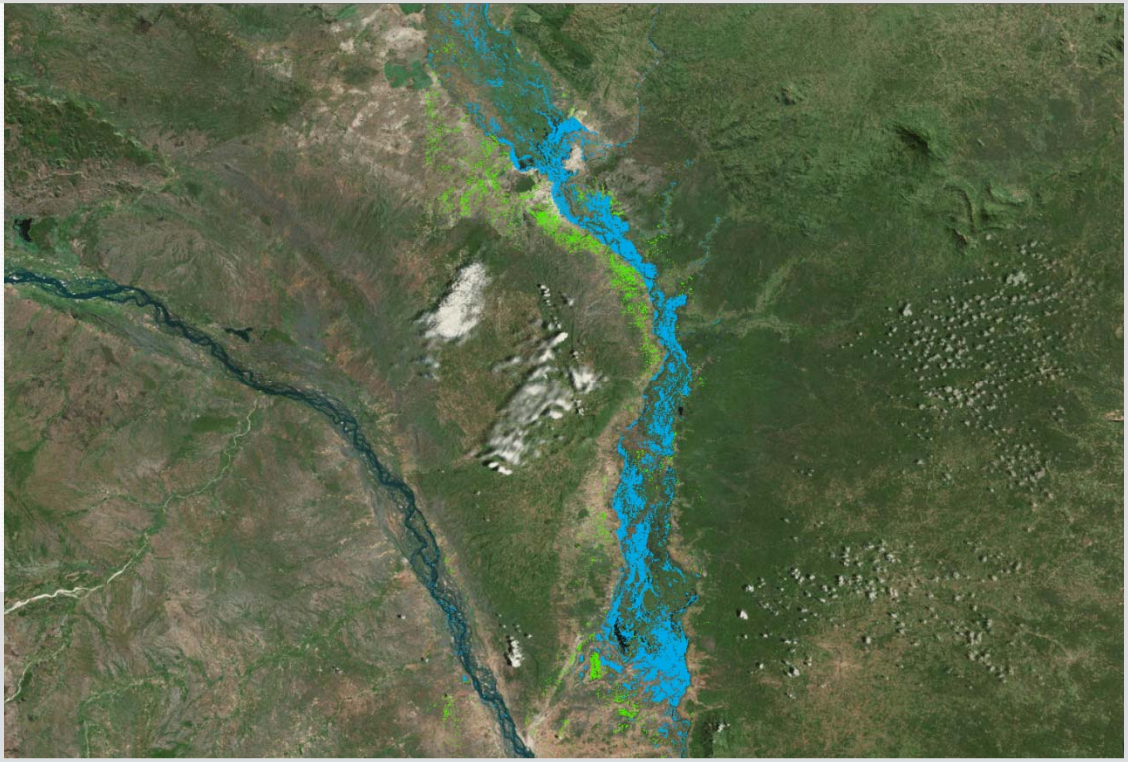
February 27th, 2015

Flood Map

NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

Flood
Shallow Water in Short Vegetation



Flood in Malawi 2015 – Sentinel 1 Data

March 23rd, 2015

Flood Map

NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

Flood
Shallow Water in Short Vegetation

Flood in Malawi 2015 – Sentinel 1 Data

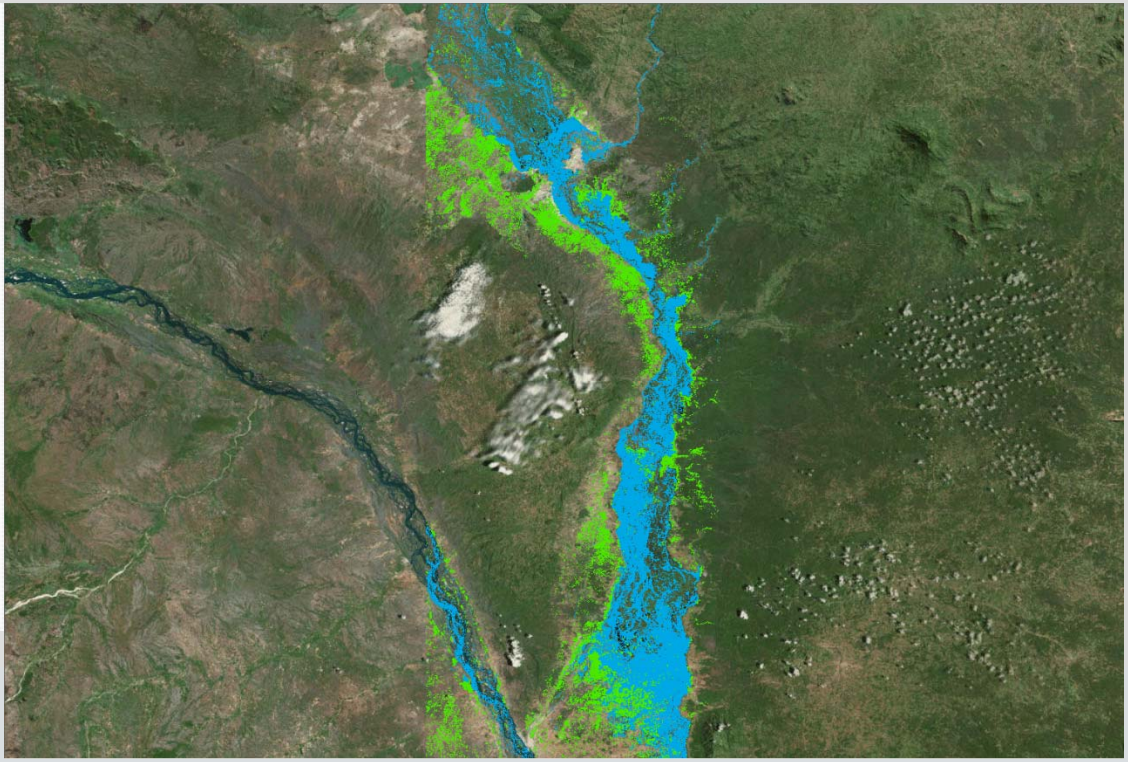
Overall Flood from January until March

Flood Map

NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

Flood
Shallow Water in Short Vegetation



Flood in Malawi 2015 – Sentinel 1 Data

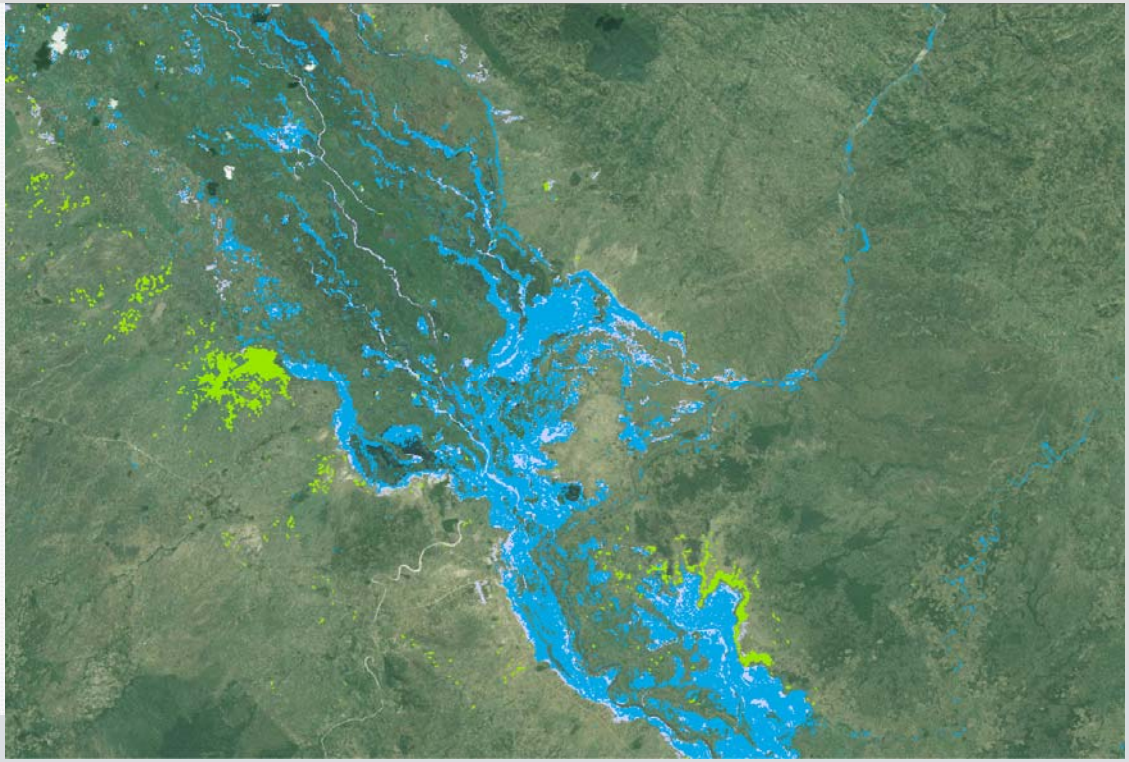
22 January – Comparison with Copernicus Products

Flood Map
(Detail, Bangula)

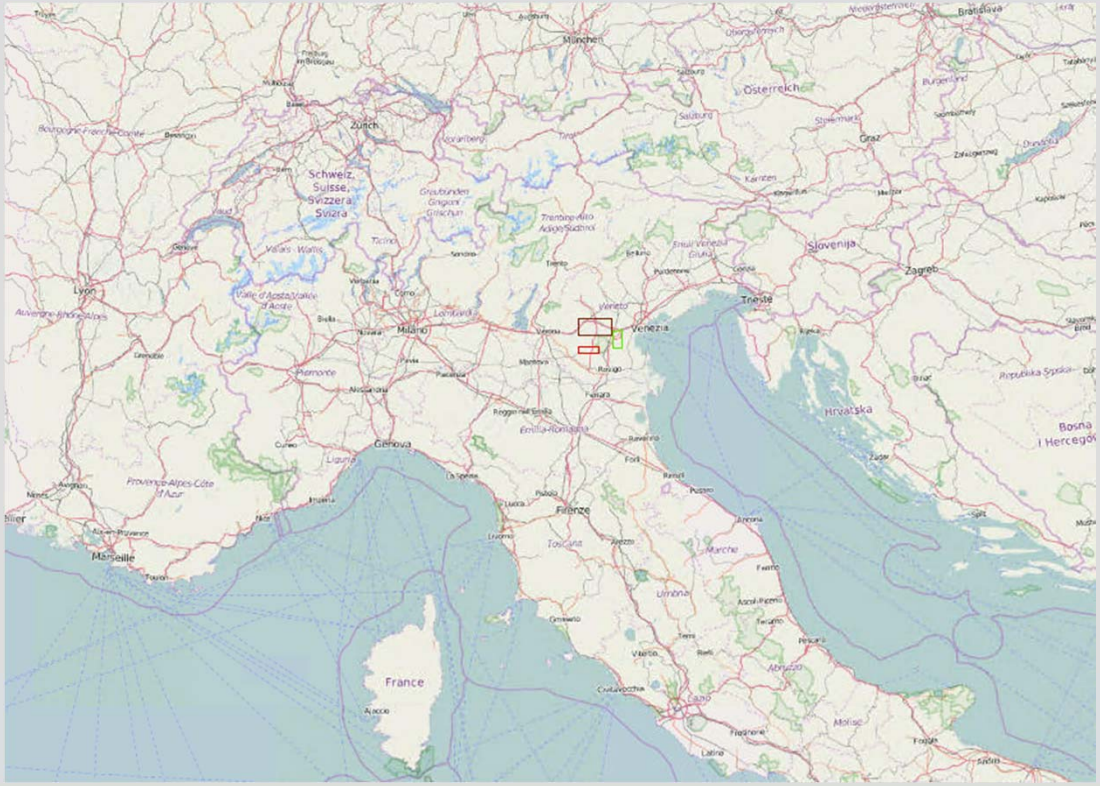
NDFI > 0.7
NDFVI > 0.75

Filtered:
Area < 1000 m²
Elevation --> Slope > 5°

- Flood
- Shallow Water in Short Vegetation
- Flood - Copernicus



Flood in Venice 2010

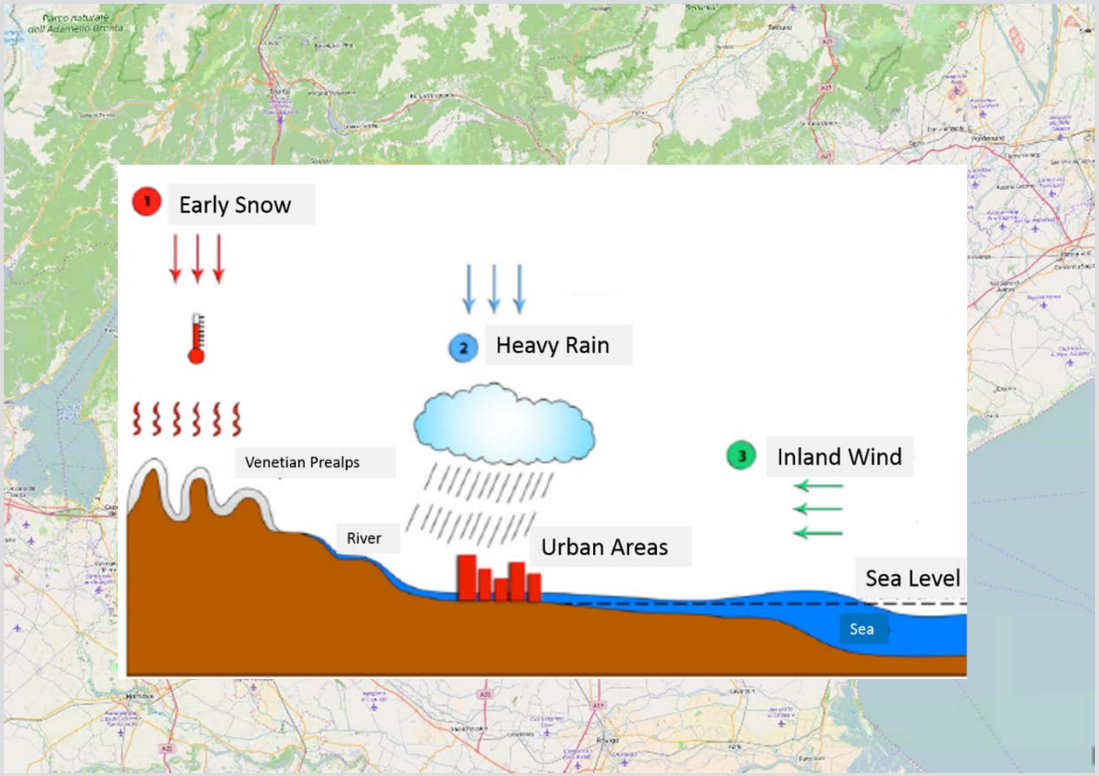


Flood in Venice 2010

Early snow in late October led to excessive runoff from the pre-alpine region

Heavy rain over urban areas

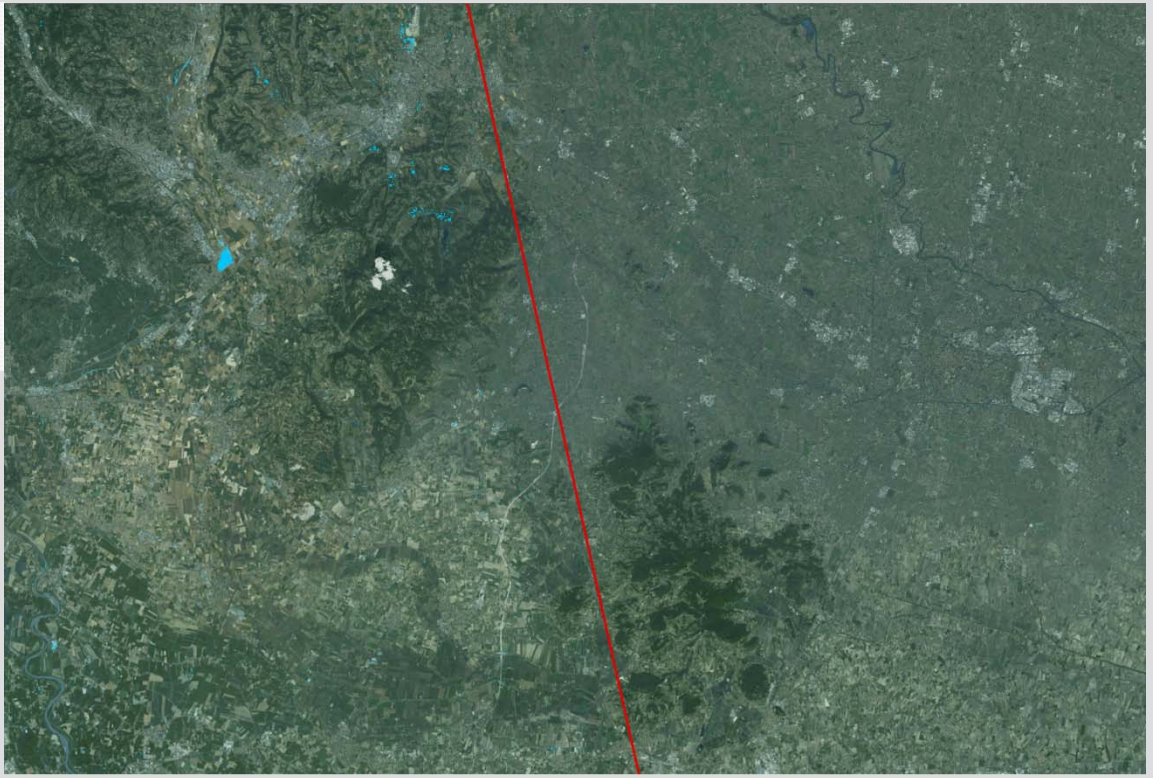
Wind to the south prevent rivers to discharge properly in the Venetian lagoon



Flood in Venice 2010

November 1st 2010
CSK
3 meters

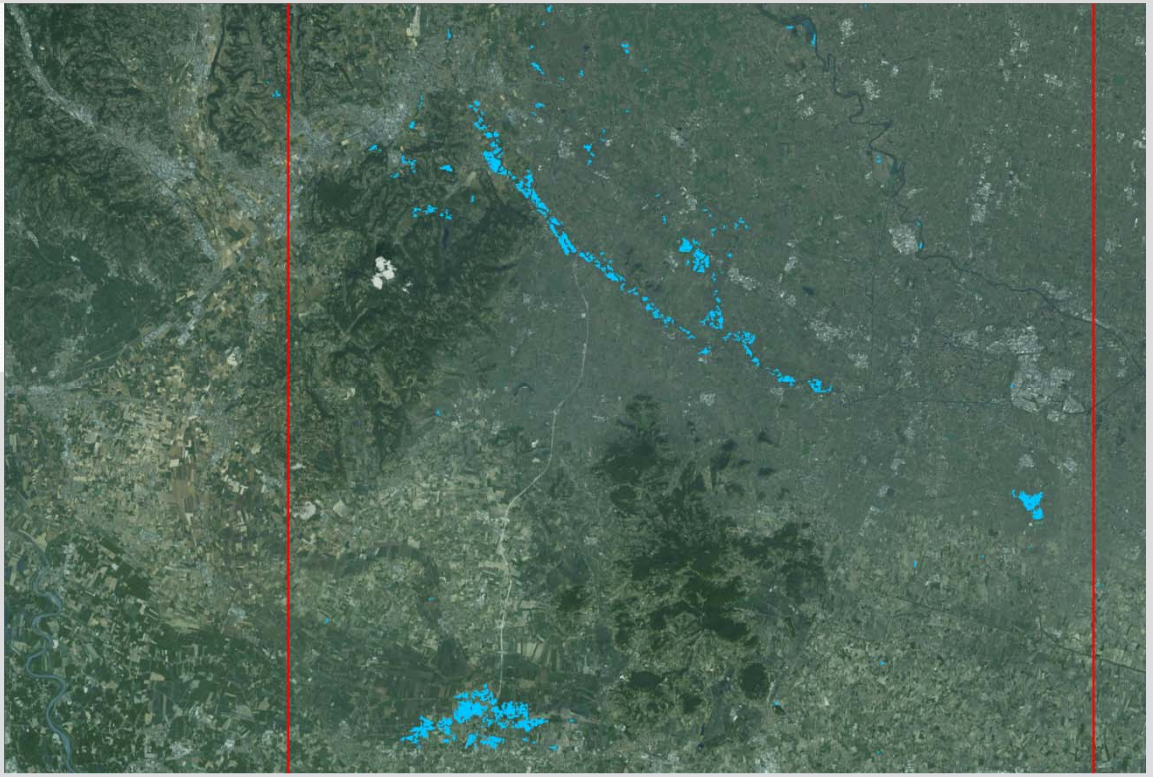
Few hours before the event



Flood in Venice 2010

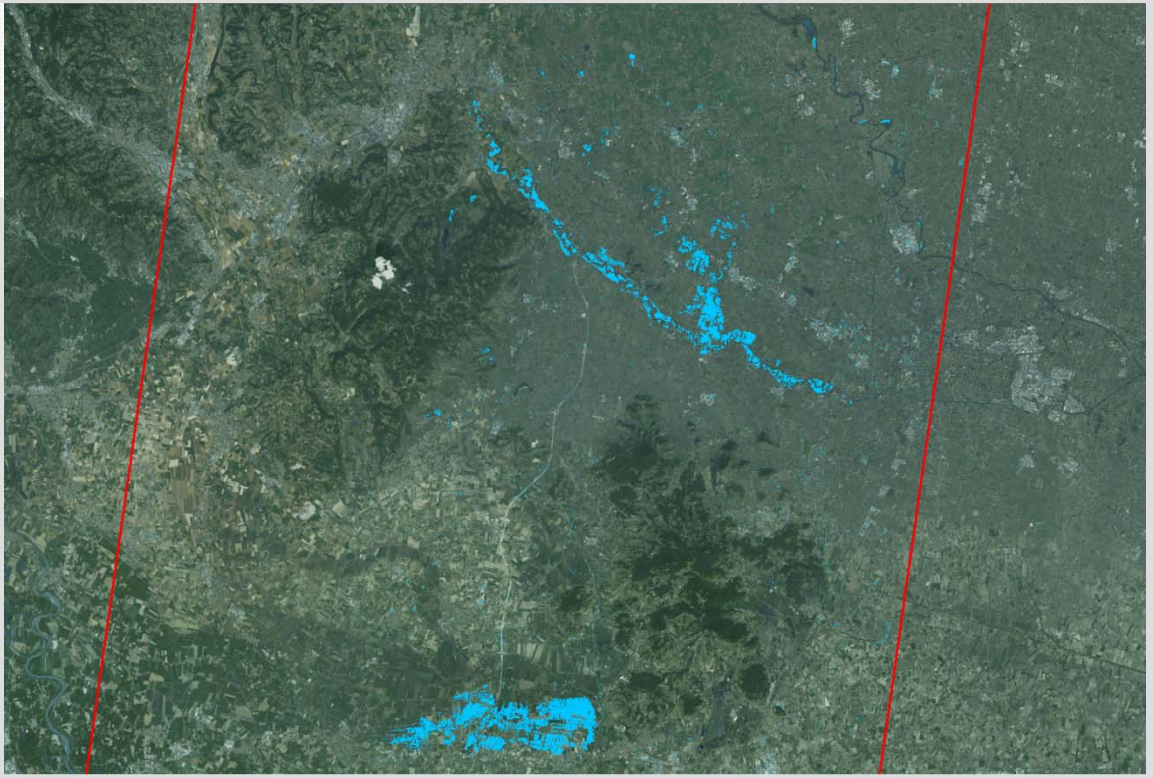
November 2nd 2010, RADARSAT 2 25 meters

First Image after the flood peek



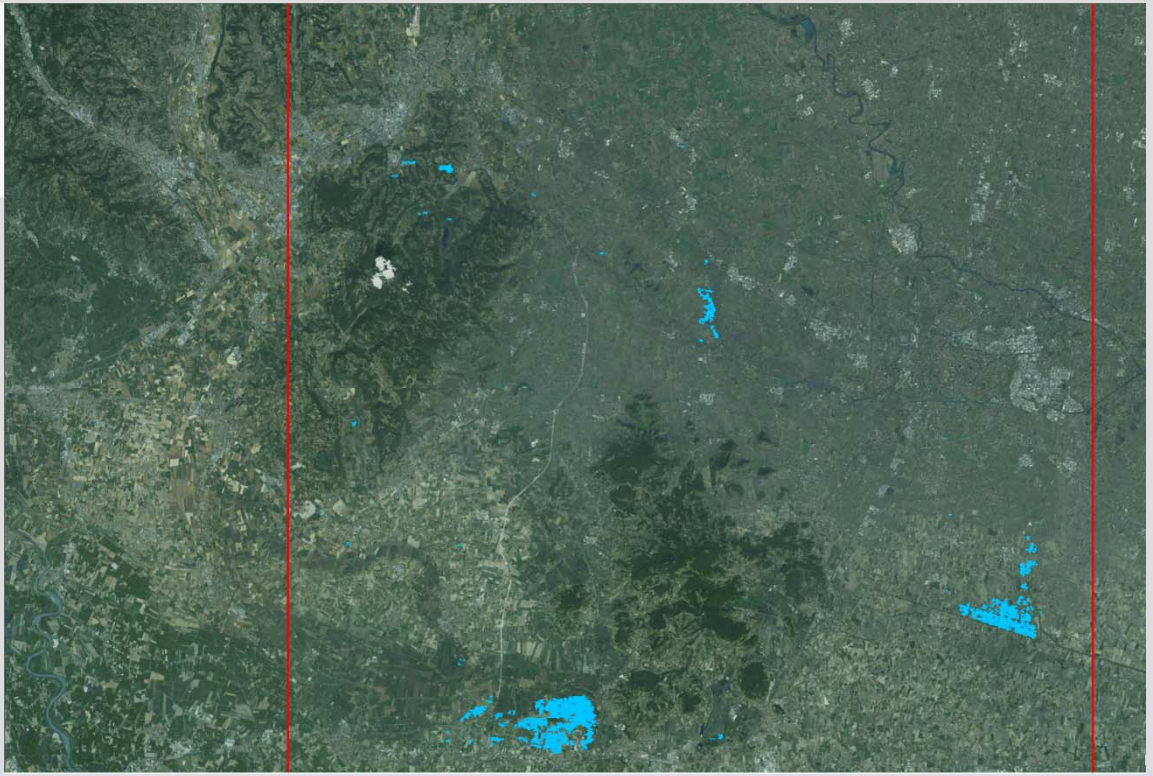
Flood in Venice 2010

November 3rd 2010, CSK 3 meters



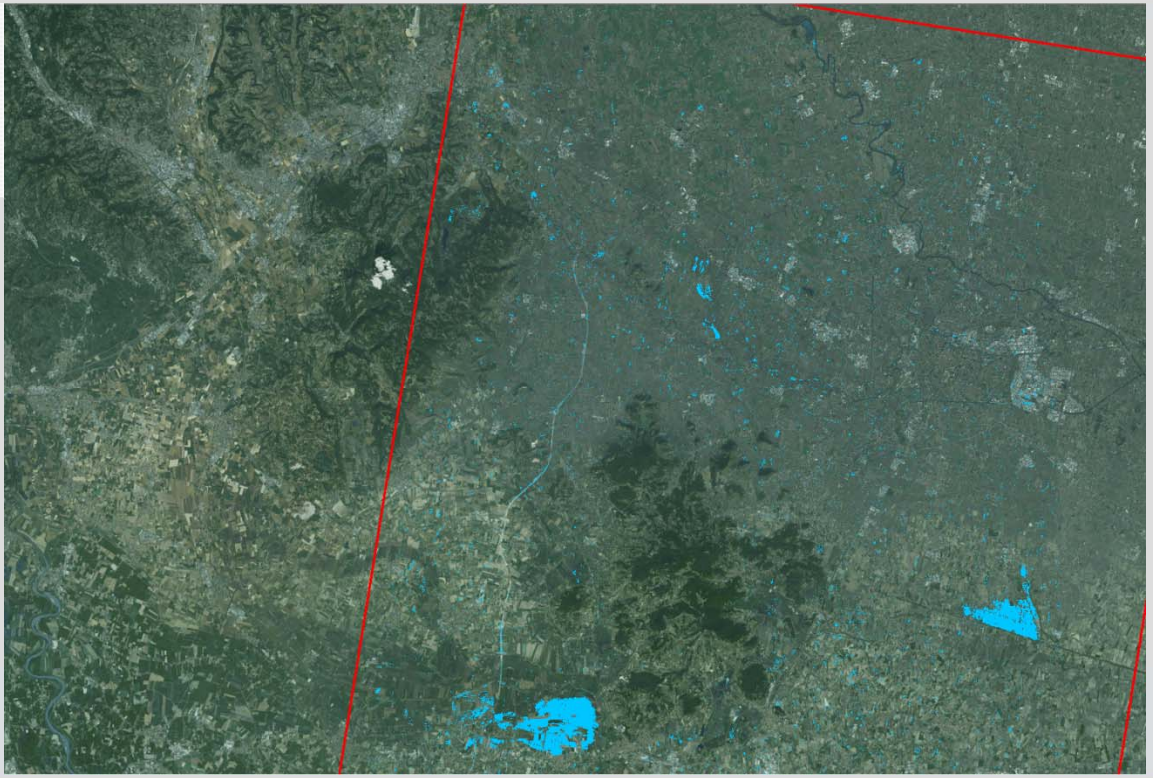
Flood in Venice 2010

November 5th 2010, RADARSAT 2 25 meters



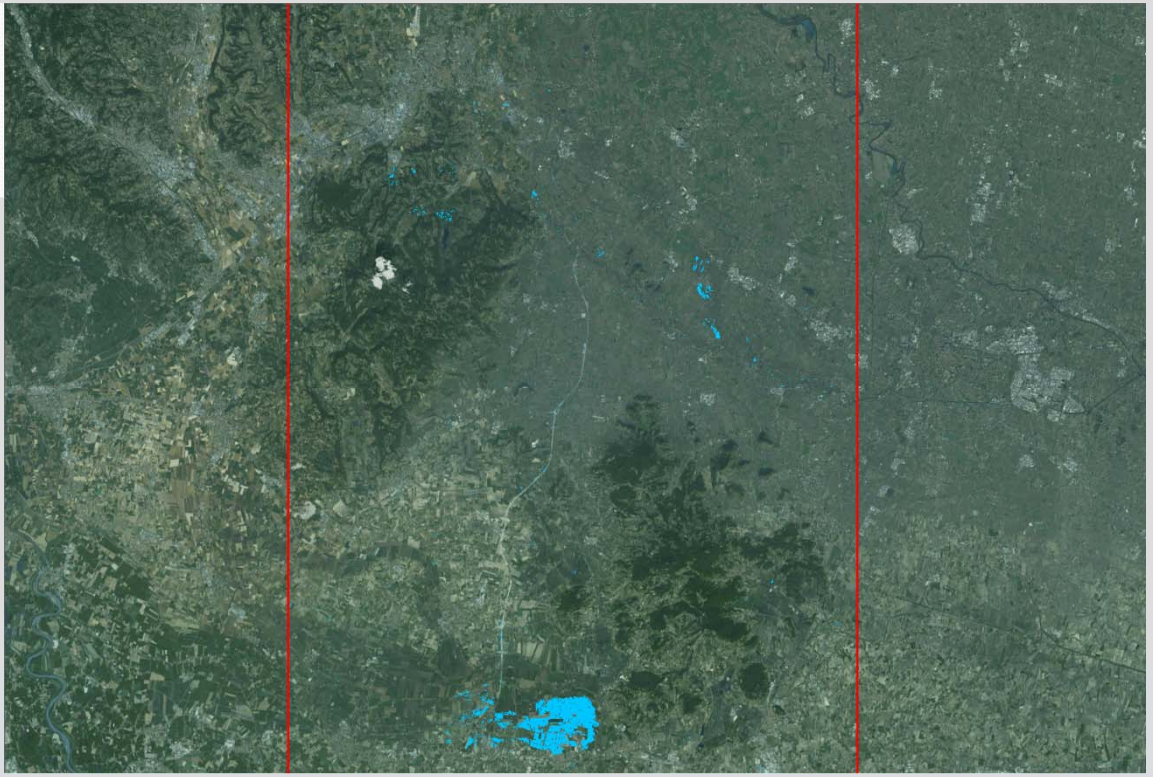
Flood in Venice 2010

November 6th 2010, CSK 3 meters



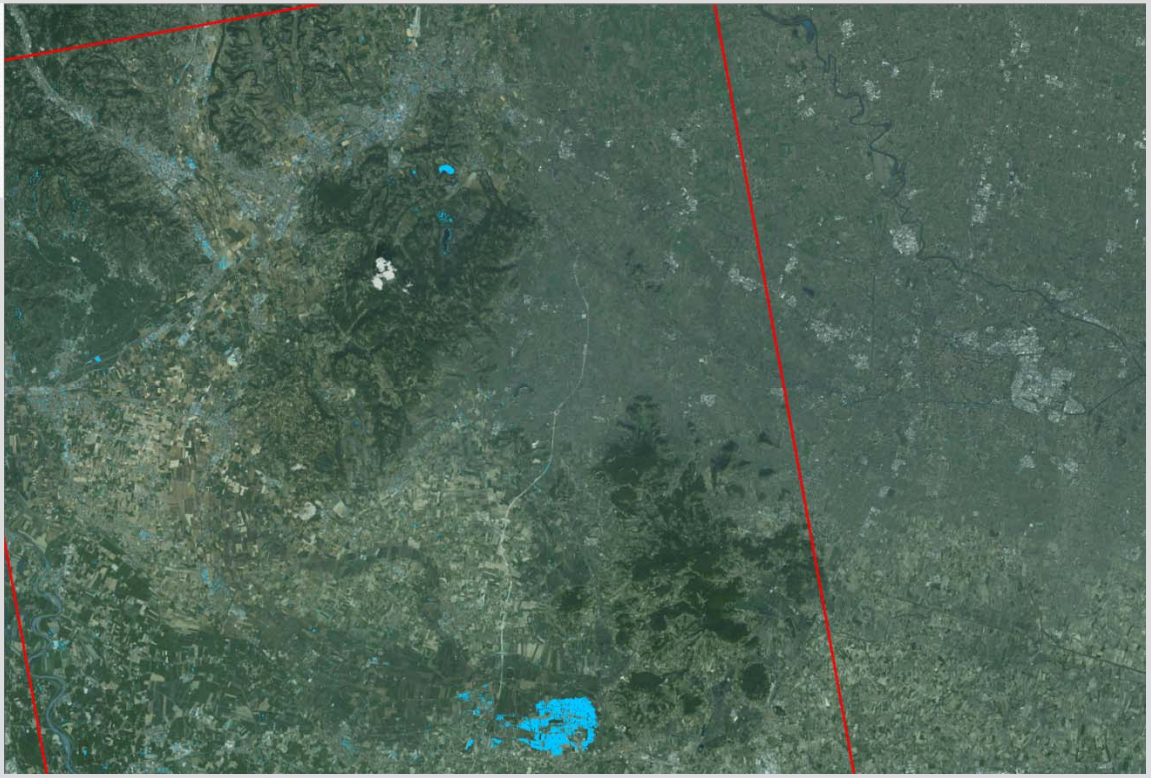
Flood in Venice 2010

November 6th 2010, TSX 3 meters



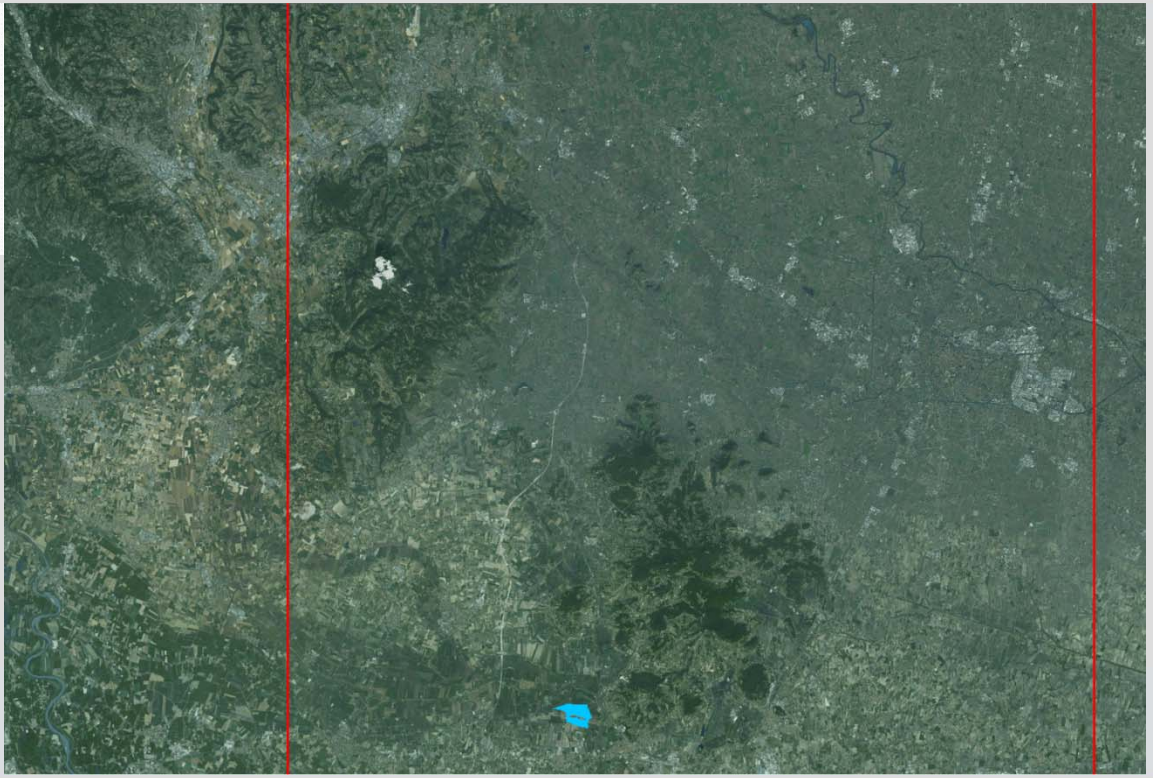
Flood in Venice 2010

November 7th 2010, CSK 3 meters



Flood in Venice 2010

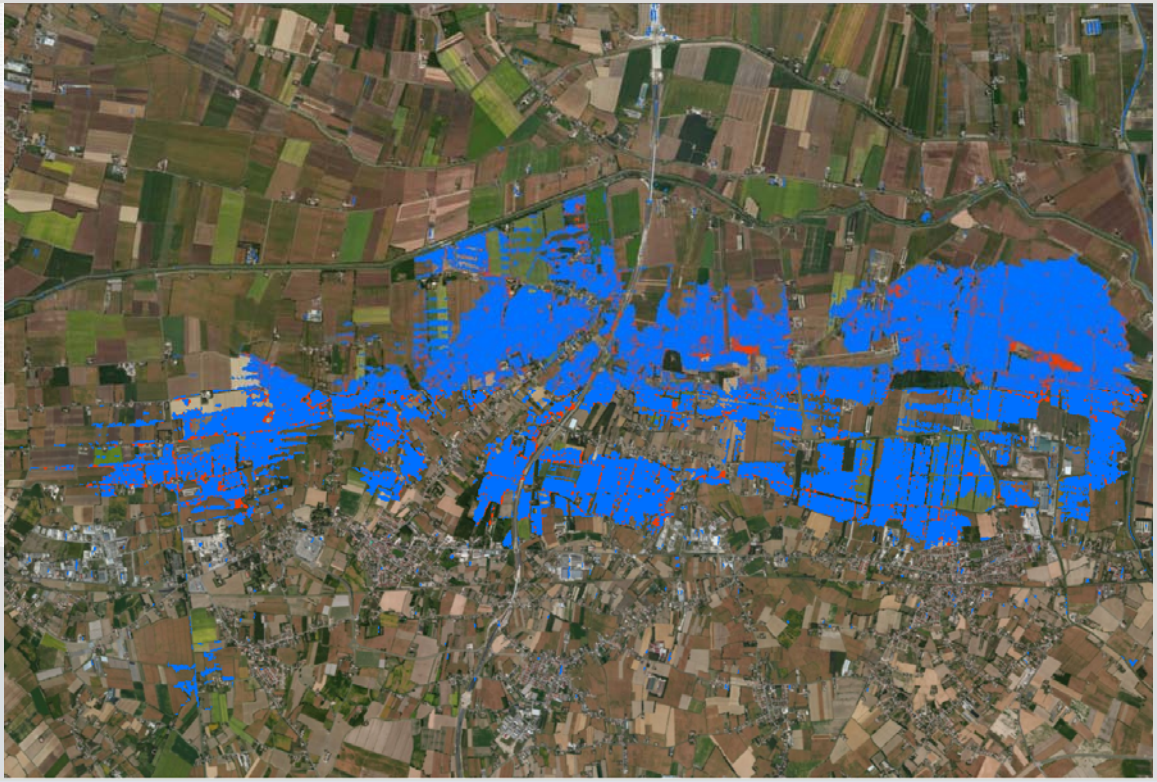
November 12th 2010, ENVISAT ASAR 150 meters



Flood in Venice 2010

November 3rd 2010
CSK 3 meters
(Detail, Saletto)

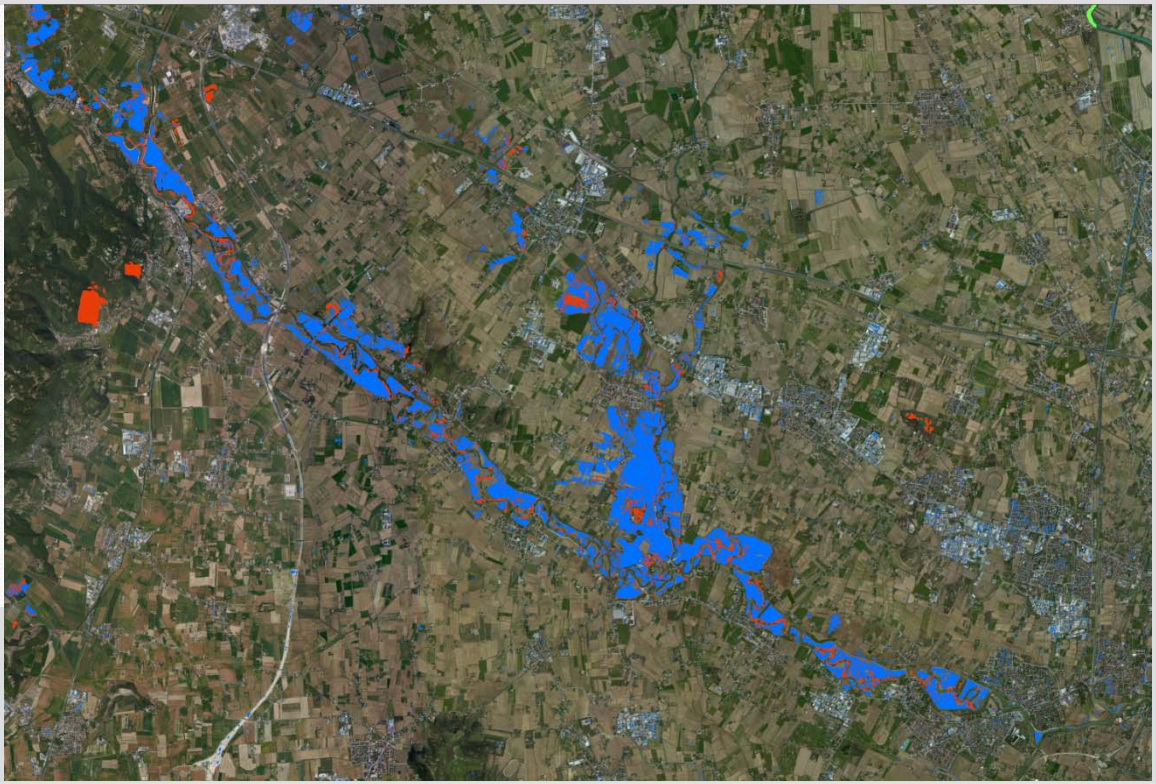
Comparison with maps produced by CIMA Foundation for the Italian civic protection (red)



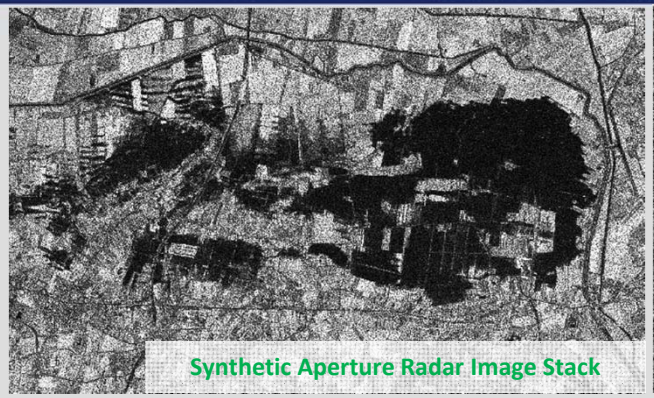
Flood in Venice 2010

November 3rd 2010 CSK 3 meters (Detail, South of Vicenza)

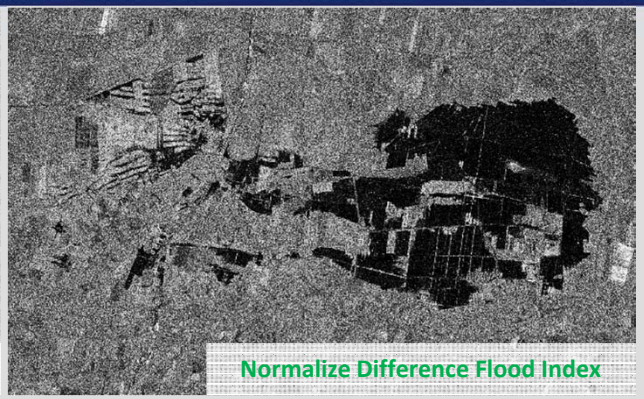
Comparison with maps produced by CIMA Foundation for the Italian civic protection (red)



Flood in Venice 2010 – Flood Depth Estimation

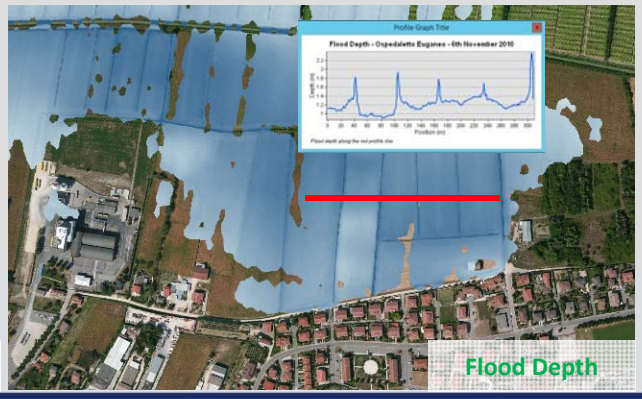


Synthetic Aperture Radar Image Stack



Normalize Difference Flood Index

Flood Depth



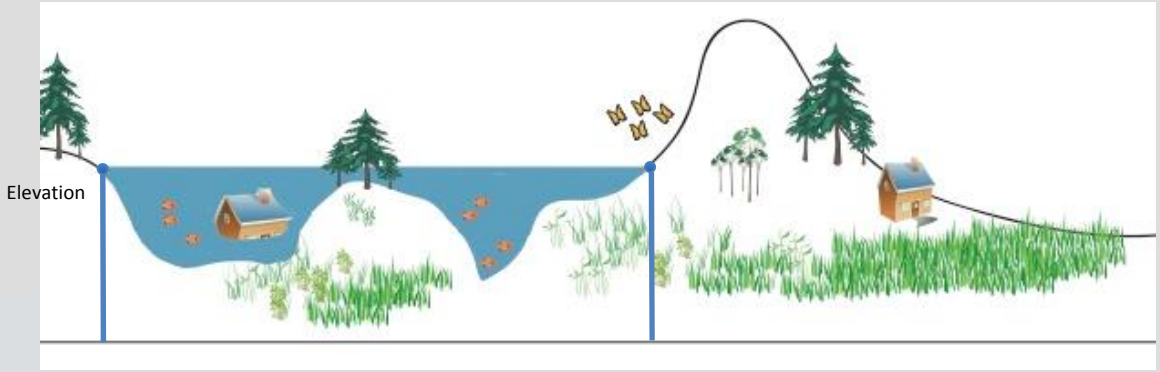
Flood Depth

Flood in Venice 2010 – Flood Depth Estimation

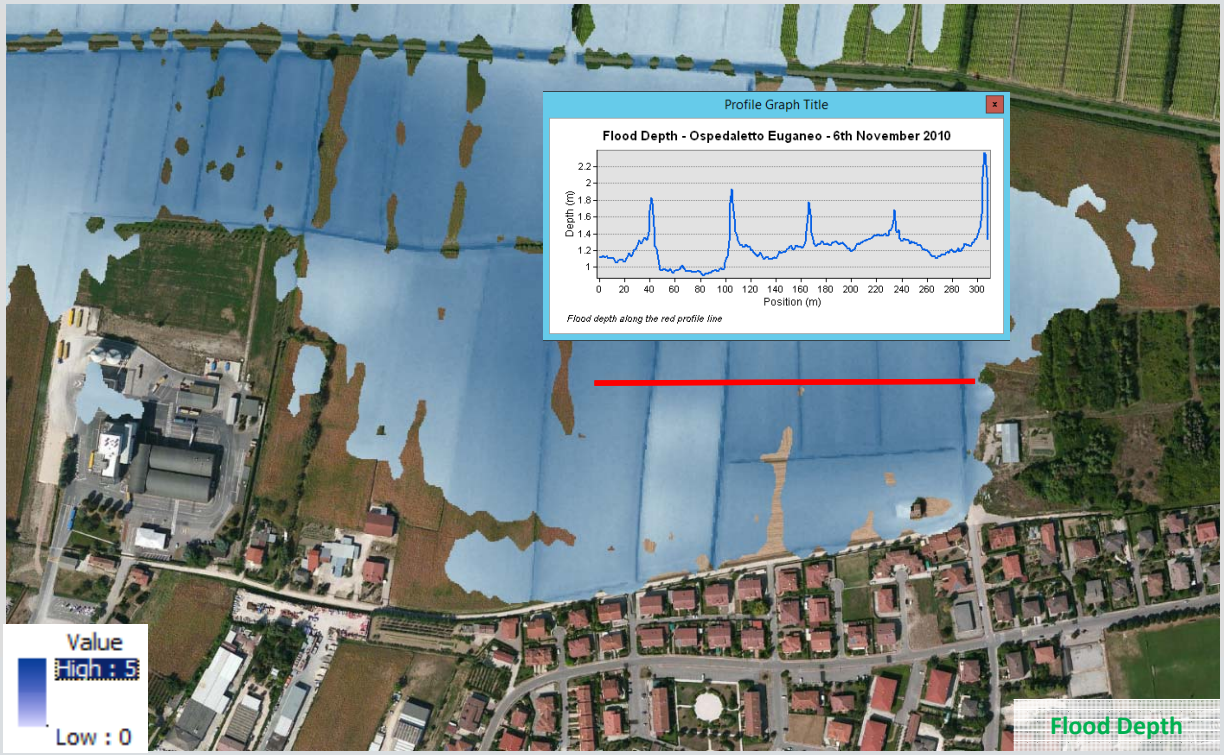
Hypothesis: water surface is a **plane** (true almost always)

If flood map is accurate, the elevation along the contour of each flooded area should be the same (there are exceptions)

Detect the **maximum elevation (95th percentile)** along the contour to compute flood depth



Flood in Venice 2010 – Flood Depth Estimation



Conclusions

Easy and precise flood mapping

- Thanks to EO Big Data: Sentinels

Fast mapping good for **emergency response** thanks to the methodology developed

Precise **Flood Depth estimation** possible when a high resolution DEM is available

Flood dynamics/evolution thank to frequent acquisition

Improvement for economic impact assessment