Automatic flood extent mapping using long time series of SAR imagery and water levels or discharge data

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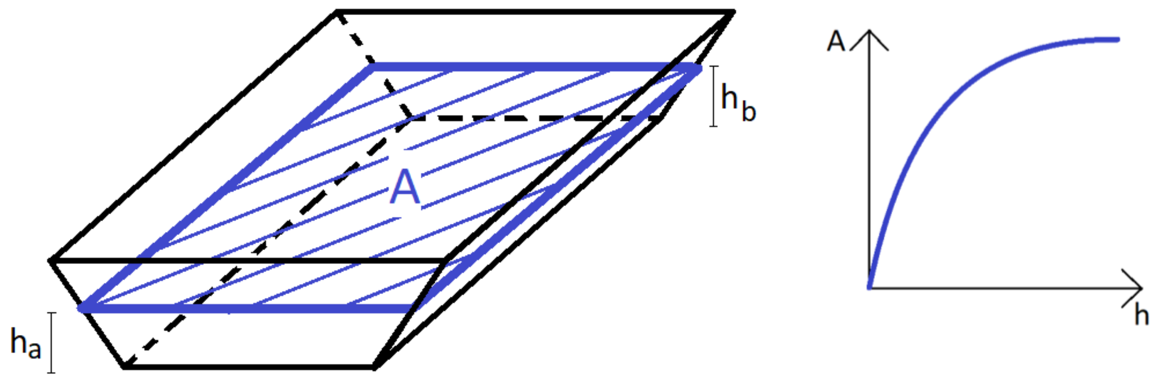
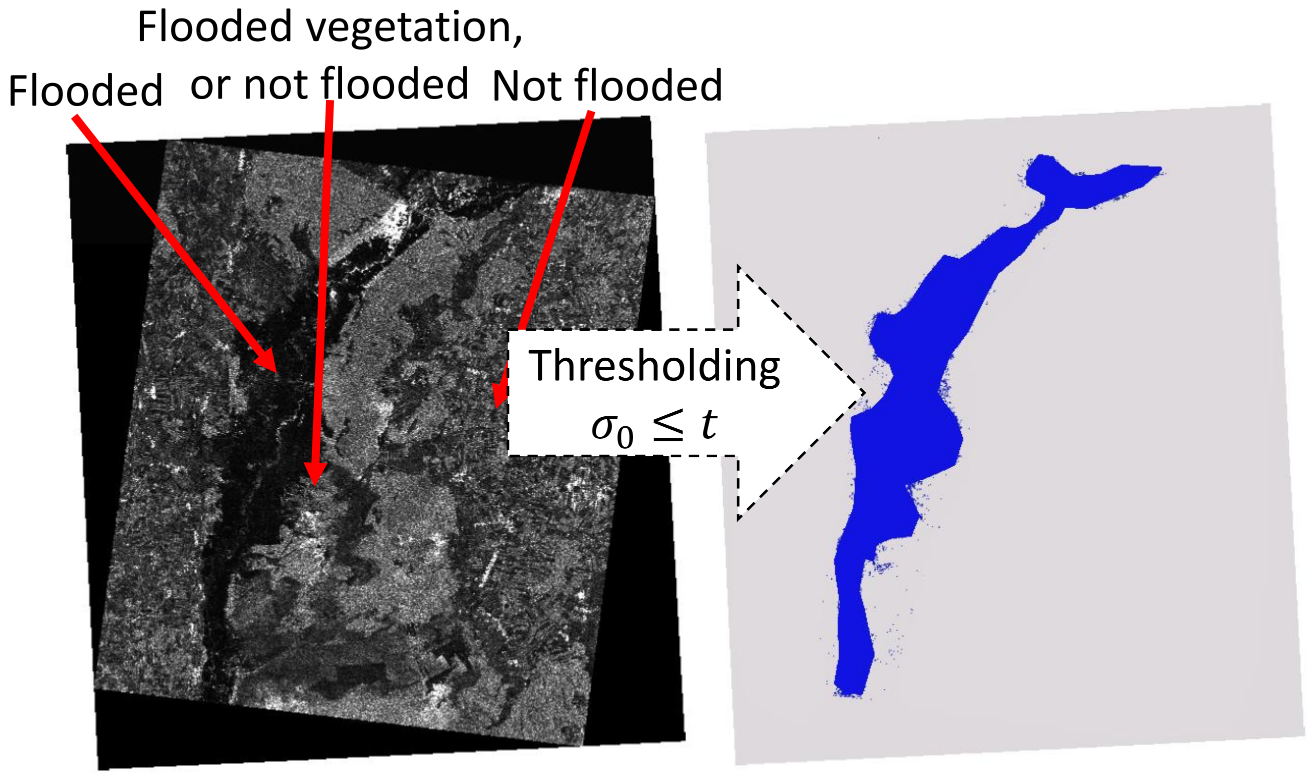
Assumption

- The key assumption of this algorithm is that the flooding extent is correlated to these two observed variables and the highest correlation is obtained when the flood/no flood threshold value of SAR backscatter coefficient is optimal.

Flooded area between the cross-sections a and b





Sentinel 1, C band, VV, study area

Linking scattering coefficient, flooding area and discharge

- Both discharge and scattering coefficient can be related to the flooding area
  - For water levels,

$$A = f(h)$$

  - For scattering coefficient

$$A = f(t) = \sum_{i=1}^{N} \begin{cases} c, & \sigma_0^i \le t \\ 0, & \sigma_0^i > t \end{cases}$$

  where *c* is a SAR image raster cell area, *N* is the total numer of cells and *t* is the σ_0 threshold value.

- The value of *t* is unknown, but can be estimated using optimization:
  - e.g by maximizing correlation between the water levels and the SAR flooding area:

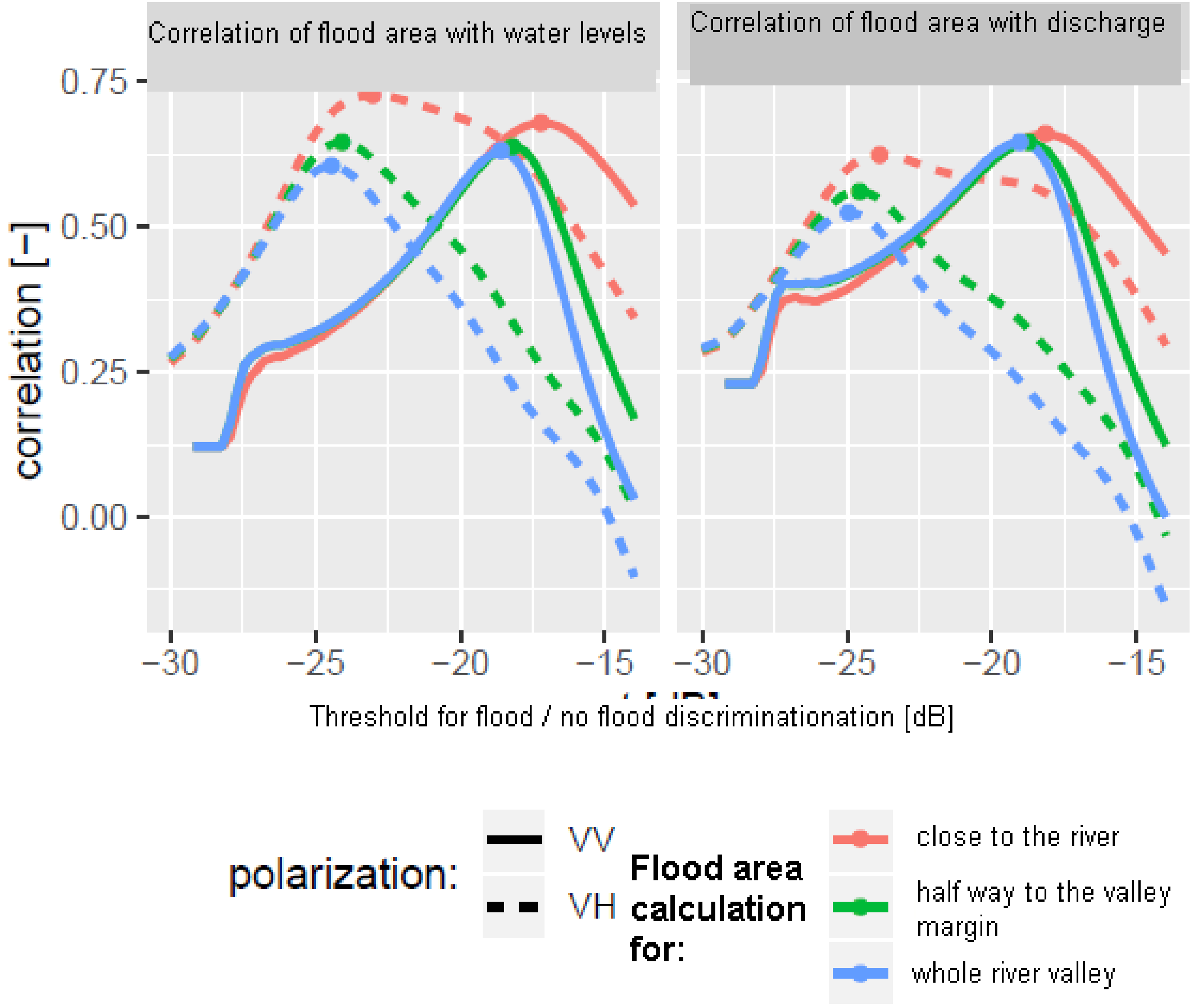
$$\arg\max\left(\mathrm{cor}\left(h, \boldsymbol{A}(t)\right)\right),\ t \in R$$

  - where ***h*** and ***A**(t)* are vectors of corresponding observations of water levels and SAR derived flooding area

Data and processing

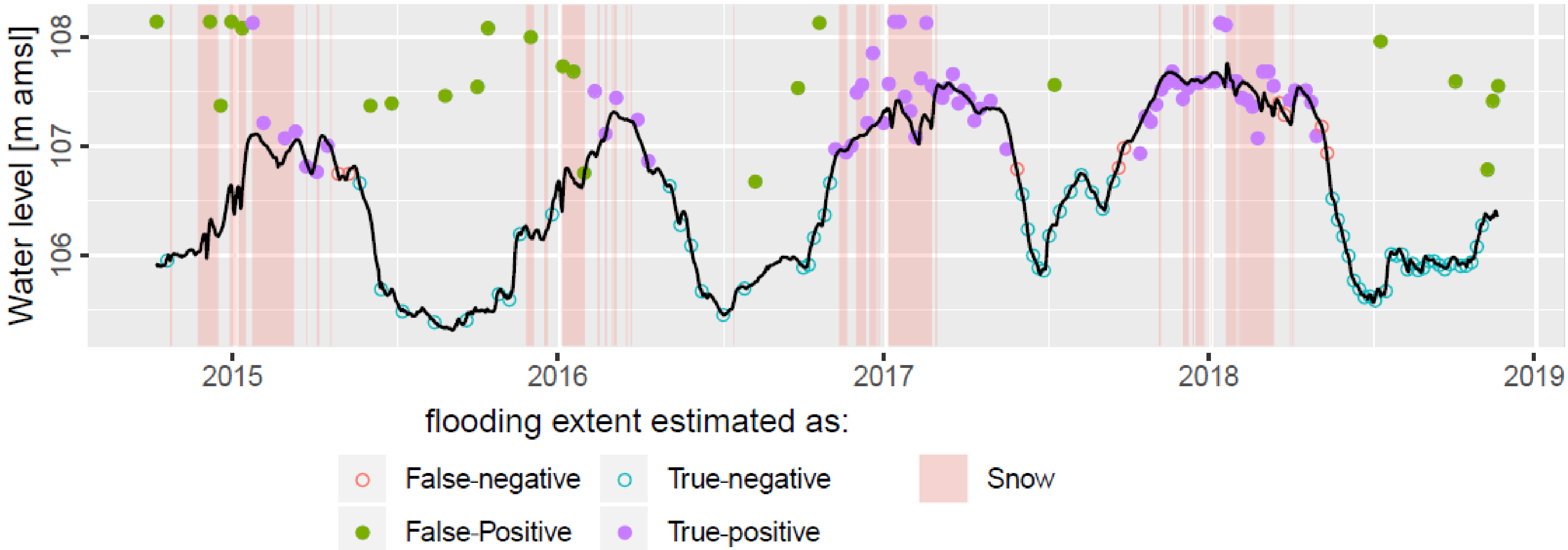
- We used 161 Sentinel 1A/B VV images since December 2014 to November 2018 (Sentinel Open HUB, Alaska Satellite Facility)
  - Radiometric calibration and terrain correction in SNAP software
- Hourly discharge and water level data from the three profiles near the outlet of the Biebrza River floodplain (Institute of Meteorology and Water Management, Poland)
  - Aggregation to daily time series
- Optimization was implemented in the R software
- The study area is Biebrza River valley located in NE Poland, approx. 220 km^2 wetland floodplain.

The t_0 threshold optimization results



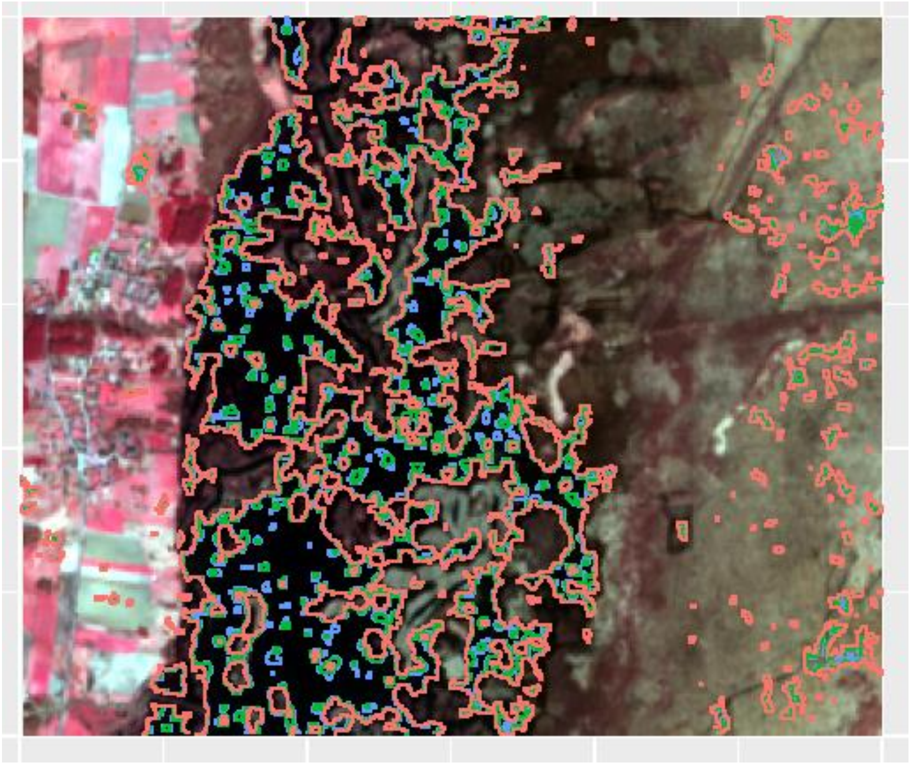
Validation

- Water lines of the estimated flooding extent for optimal t_0 were extracted and their elevation was compared to the water gauge observations. The water gauge used for validation was different than one used for finding t_0 (~40 km distance)
- RMSE for the best scenario was 0.16m, i.e, 19% of the water levels range

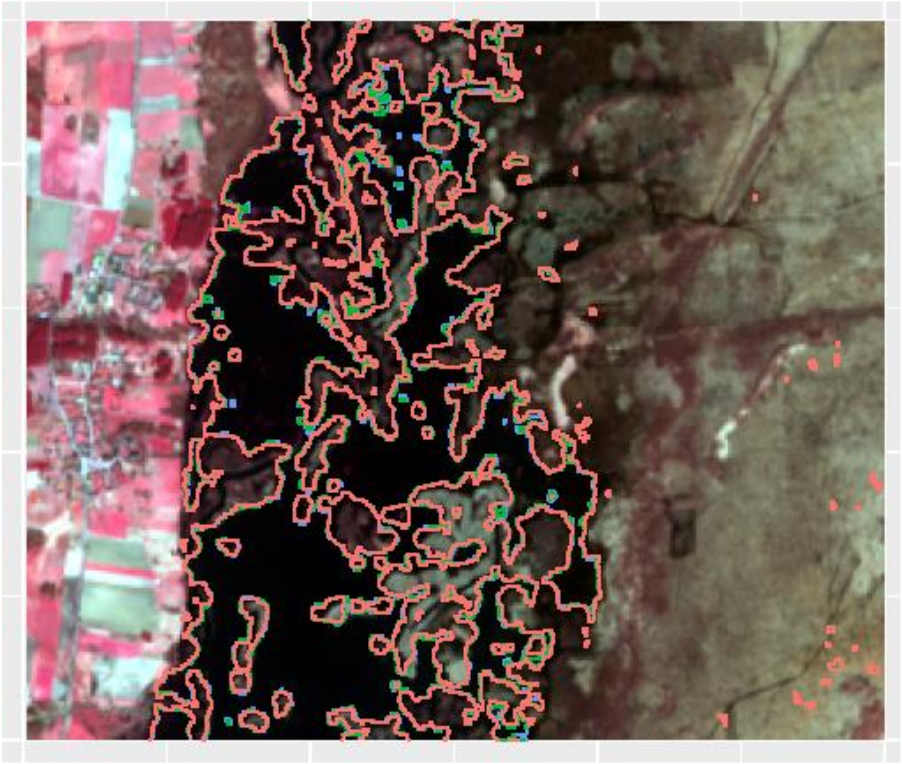


Comparison with VIS-NIR image

VH polarization

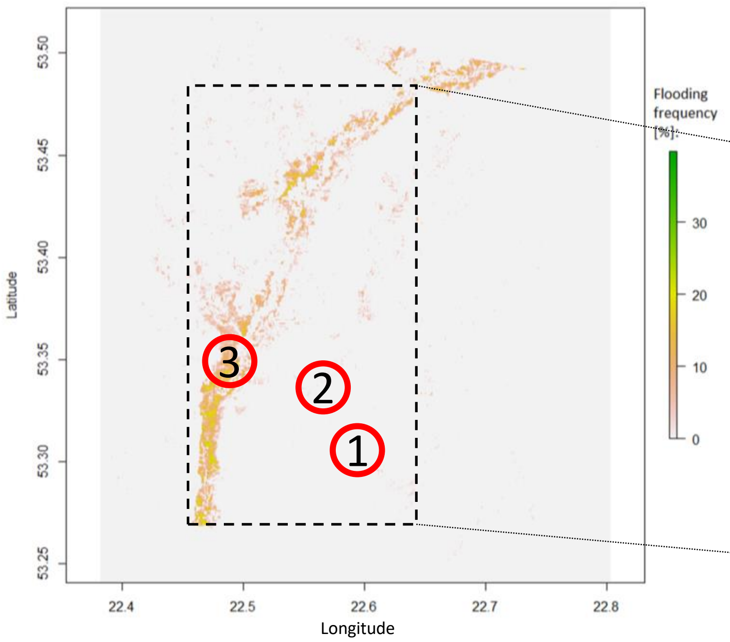


VV polarization



Flooding in remote parts of the floodplain

SAR derived flooding frequency



Daily extent of an average flood with respect to water sources.
A result of 3D hydrodynamic modeling with a mixing solver

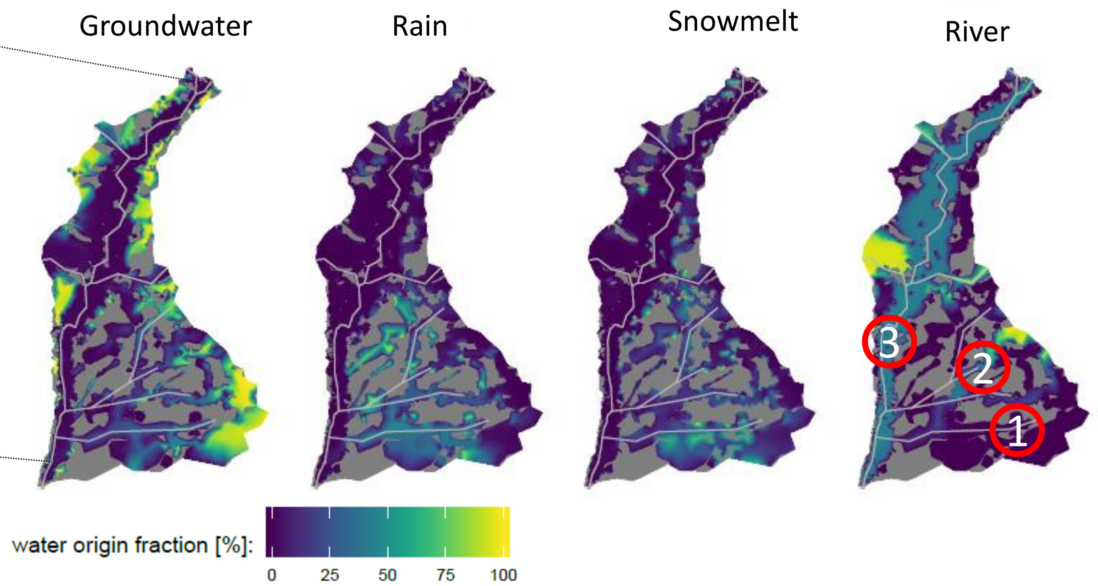


Figure adapter from: Berezowski, T., Partington, D., Chormański, J. and Batelaan, O., 2019. Spatiotemporal dynamics of the active perirheic zone in a natural wetland floodplain. *Water Resources Research*, *55*(11), pp.9544-9562.

Conclusions

Problems

- No vegetation filtering
- Small spots of flooding outside the floodplain (false positives) especially in VH
- Method generally failed to identify water from sources other than river (false negatives), this is not always bad
- Snow and ice causes problems

Advantages

- The method is straightforward and has a theoretical background
- Easy way to produce long time series of flood inundation
- Preliminary validation shows that it is relatively accurate (at least with respect to river water)
- VV data and water level observation provided more accurate flooding extent estimations than other scenarios