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AI-Enhanced Multisensor Flood Detection: Integrating Sentinel-1 & Sentinel-2 for Disaster Management

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Motivation and context

- Remote sensing offers powerful tools for environmental monitoring, yet traditional flood detection techniques face limitations in cloud obstructed scenarios or other scenarios that could give false positive results[2]:
    - Wet soils, sandbanks, reflective coastal areas, recently irrigated fields, etc.

- According with IPCC[1] , it is increasing frequency and intensity of floods with high confidence of robust evidence, due to apoptogenic climate change

Aim and research question

- To design, implement, and evaluate an AI-enhanced flood detection system that integrates Coperenico’s Sentinel-1 and Sentinel-2 imagery for accurate and scalable flood mapping in disaster areas

- How can the integration of SAR and optical imagery improve flood detection performance compared to single-source approaches?
- How can model interpretability and generalization across regions be ensured?

First step - AOI definition

- **Log-Gaussian Cox Process for proxy model for hotspots detection**
- P(X | Z(x)) ~ no homogenous Poisson with intensity exp(Z(x)
- Variables:
  - Accumulated precipitation, e.g. $\frac{>30mm}{h} = \frac{\frac{30l}{m2}}{h}$ (real-time monitoring), relative heigh
  - Digital Elevation Models: Slopes and curvature (concave spaces and slope measure)
  - Heigh Above Nearest Derange (HAND)
  - NDVI (less vegetation, less filtration), land coverage from official data, NDWI
  - SAR Interferometry of coherence and intensity

- $Z(x) = \beta_0 + \beta_1 \cdot HAND(x) + \beta_2 \cdot NDVI(x) + \omega(X) + \ ...$

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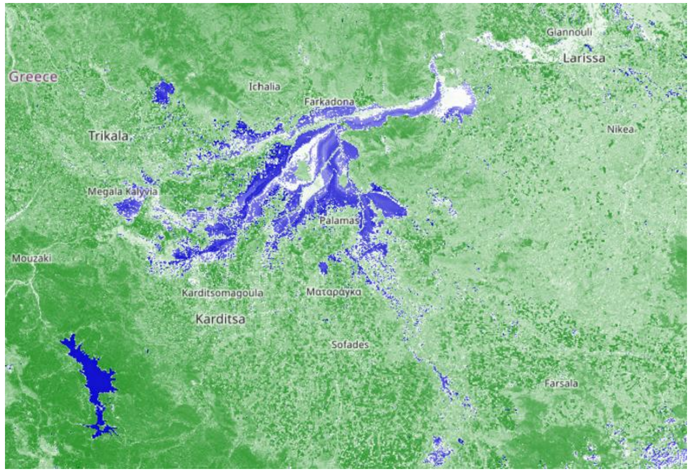
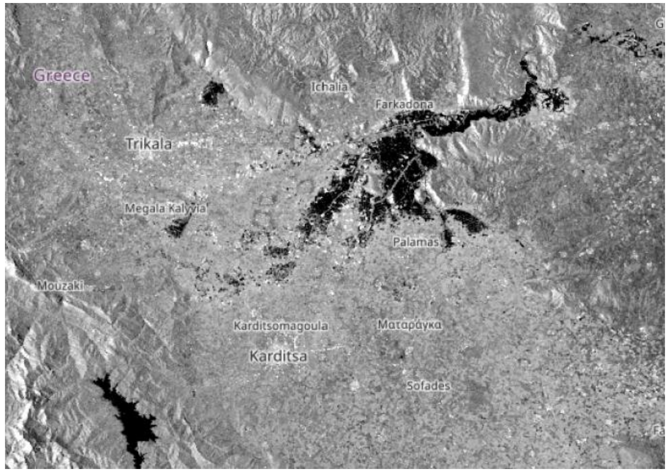
If high probability, then…

Flood in Central Greece, September 10, 2023

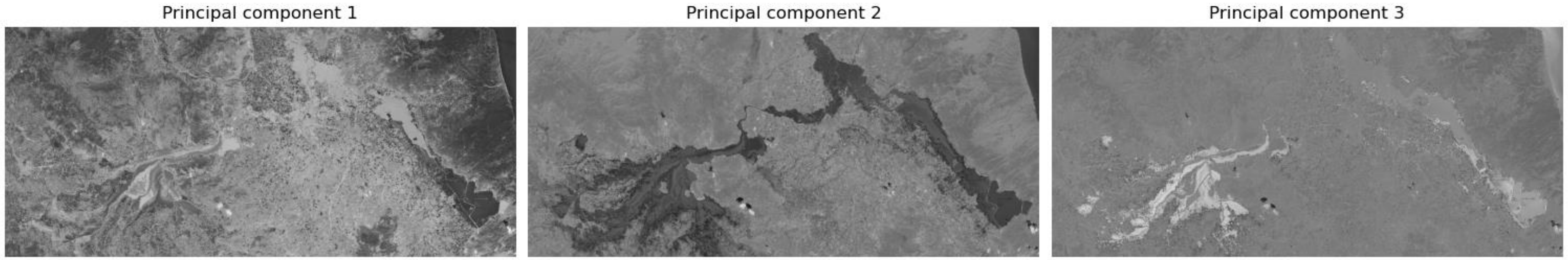
- Soruce. Copernicus Sentinel 1 and Sentinel 2

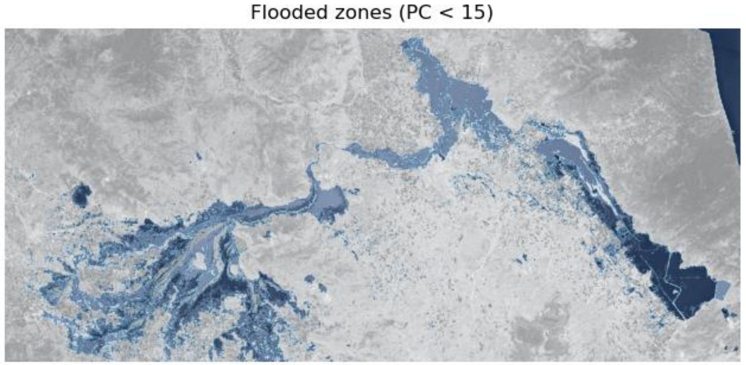




Left to right. S2 True color, S2 NDWI, S1 VV decibel Gamma0

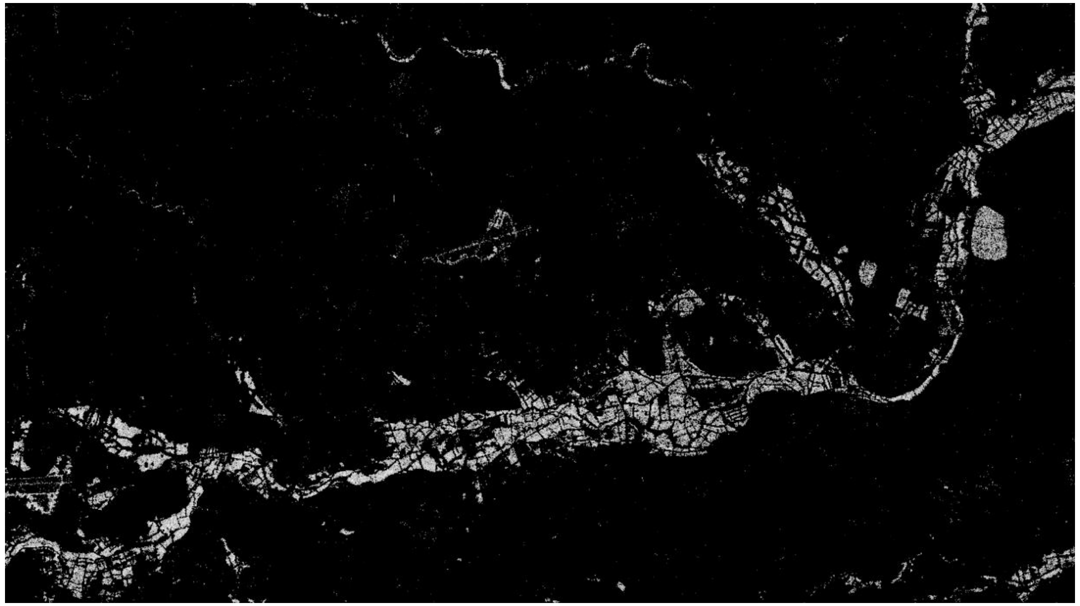
PCA Analysis – Sentinel 2 bands





Sentinel 1 - SAR

- // Water Surface Roughness Visualization
- function setup() {
- return {
- input: ["VV", "dataMask"],
- output: { bands: 4 }
- }
- }
- function evaluatePixel(sample) {
- var val = Math.log(0.05/(0.018 + sample.VV*1.5));
- return [val, val, val, sample.dataMask];
- }



Machine Learning Stage

- Desired output: c = {*flooded, not-flooded*}
- $f: a \rightarrow \mathrm{P}$
- $a \in \mathbb{R}^{m \times n \times b}$, $P \in [0,1]^{m \times n \times c}$
  - $a \in \mathbb{R}^{m \times n \times b}$, denotes a multi-band satellite image of spatial dimension $m \times n$ and b spectral bands.
  - $\mathrm{P} \in [0,1]^{m \times n \times c}$ represent per-pixel probability distribution}

- PCA Analysis
- Clustering

References

[1] Intergovernmental Panel on Climate Change (IPCC) (Ed.). (2023). Water. In Climate Change, 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 551–712). Cambridge University Press;

[2] Rambour, C., Audebert, N., Koeniguer, E., Le Saux, B., Crucianu, M., & Datcu, M. (2020). FLOOD DETECTION in TIME SERIES of OPTICAL and SAR IMAGES. In International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences—ISPRS Archives (Vol. 43, Issue B2, pp. 1343–1346). https://doi.org/10.5194/isprs-archives-XLIII-B2-20201343-2020