The Copernicus Global Flood Monitoring – GFM

Introduction

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3rd CEMS GloFAS Annual Meeting – 05-March-2024

GFM in CEMS

THE COPERNICUS EMERGENCY MANAGEMENT SERVICE
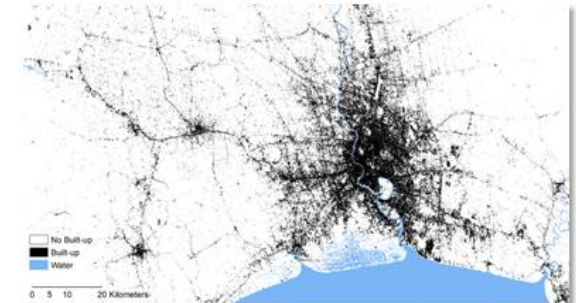
On-demand mapping — Rapid Mapping — Risk & Recovery Mapping

Early warning and monitoring — Floods — Fires — Droughts

Exposure Mapping — Population — Built-up areas
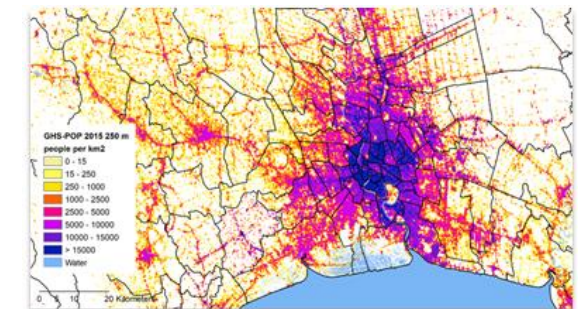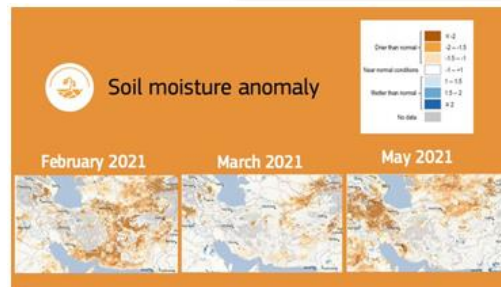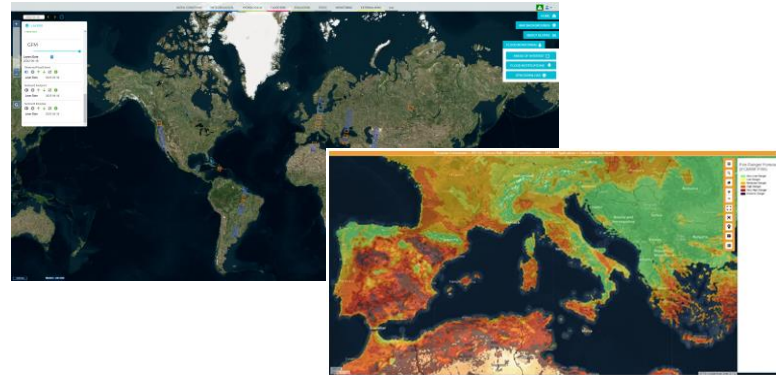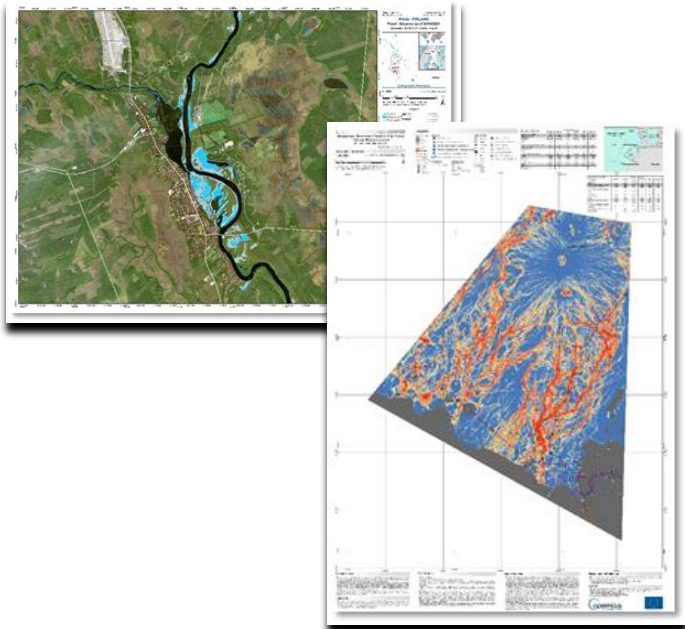
Global Flood Monitoring

Three major user requirements for floods

1. Global & systematic monitoring
2. Enhanced timeliness
3. Support activation requests

GFM's key features

- Near Real Time Flood map provision
  - **within 8 hours** after a Sentinel-1 data acquisition
- Integration into emergency systems & third-party solutions
  - **APIs & UIs**
- High spatial resolution
  - **20-metre pixel sampling**
- Complete spatial coverage
  - **global** (except poles)
- Full flood archive
  - **2015 – ongoing**

➔ **Advantages**
- No time is lost due to human intervention
- Discover unreported events

➔ **Disadvantages**
- False alarms
- Processing overhead

➔ **Challenges**
- Accuracy
- Timeliness

Copernicus Sentinel-1 SAR for flood mapping 1/2

- Sentinel-1 Synthetic Aperture Radar (SAR) global coverage
  - 2 satellites with systematic coverage: Sentinel-1 A + B/C
  - since Dec 2021: Sentinel-1B suffered anomaly and became non-operational
  - Sentinel-1C launch planned in Q4-2024

Coverage Map s1a_csar_grdh_iw
Coverage until 2024-02-29
Total number of images: 1596321

Number of images, Max: 1629
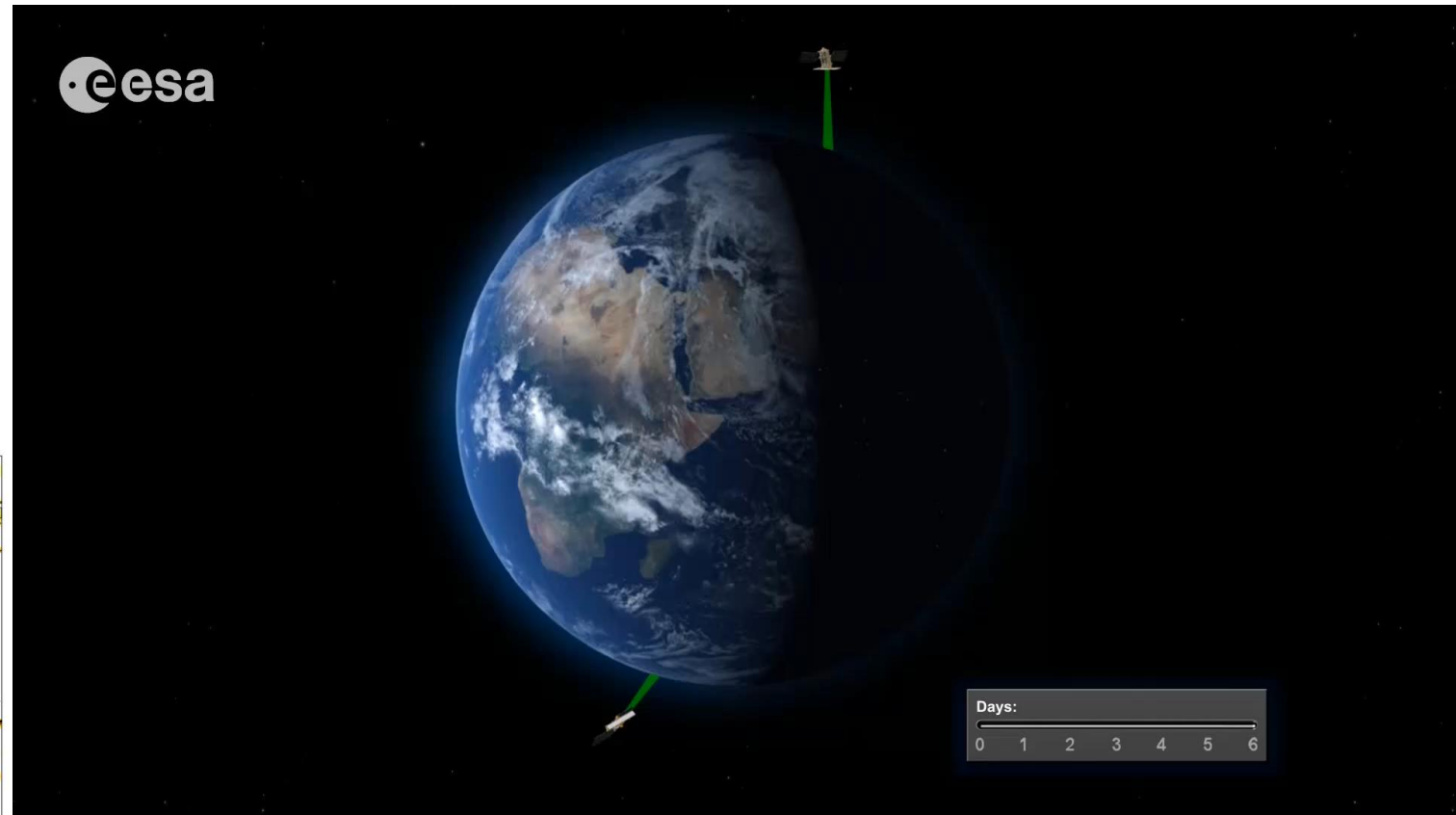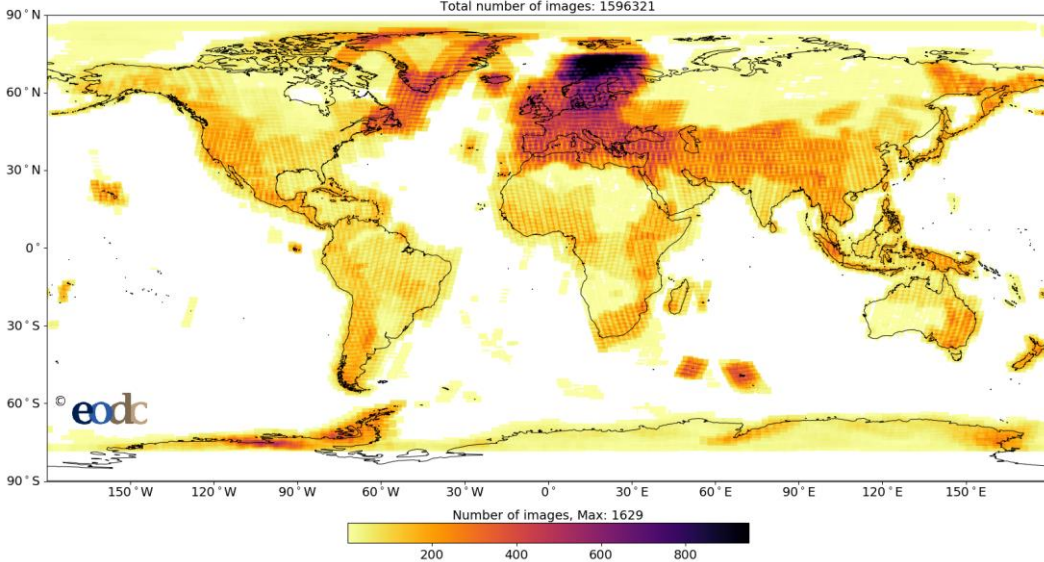
Copernicus Sentinel-1 SAR for flood mapping 2/2

- Sentinel-1 is **active** microwave sensor at C-band with 20m spatial resolution
  - Day and night
  - All weather conditions
  - Effective to discriminate water on ground

High Backscatter

Low Backscatter

Water

Diffuse backscattering
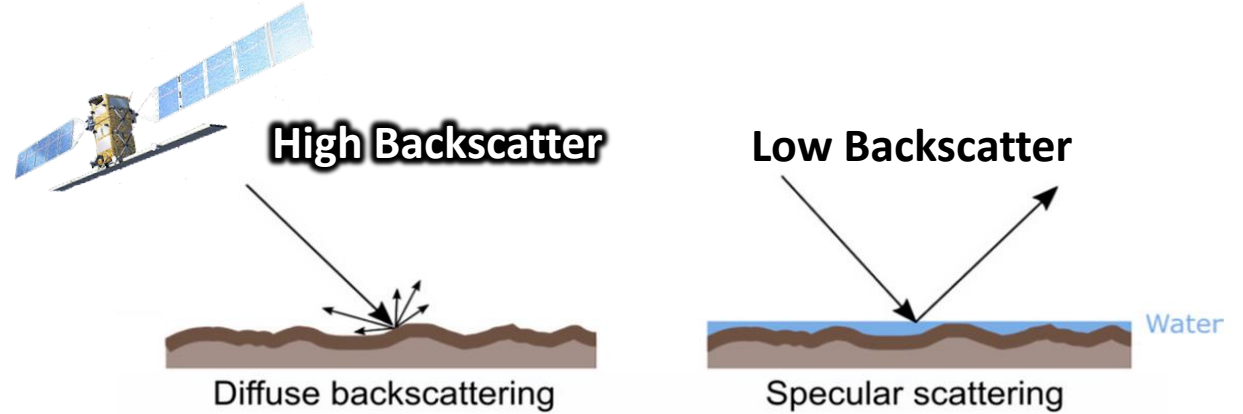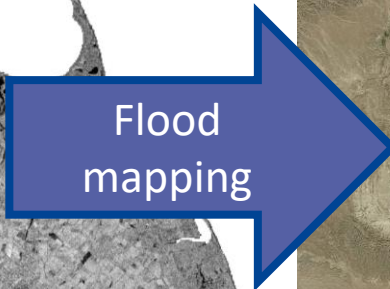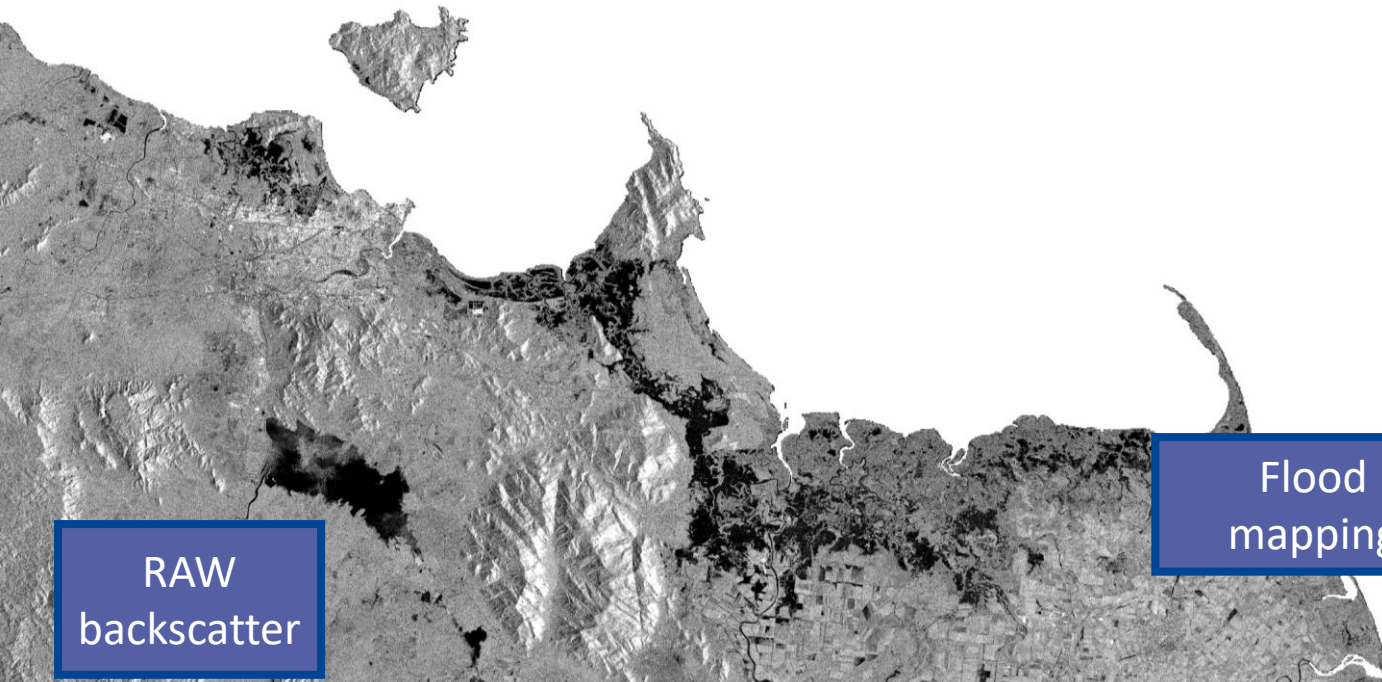
Specular scattering

Figure modified from Ottinger and Kuenzer (2020) Spaceborne L-Band Synthetic Aperture Radar Data for Geoscientific Analyses in Coastal Land Applications: A Review, Remote Sensing, 12(14).

RAW backscatter

Flood mapping

ENSEMBLE Flood

GFM ensemble flood algorithm 1/2

3 algorithms for Sentinel-1 flood mapping

- **DLR**: Image classification using fuzzy logic with post classification and region growing
- **LIST**: Change-detection using hierarchical split-based approach
- **TUW**: Bayesian classifier informed by full per-pixel Sentinel-1 signal history (harmonic model)

robustness through ENSEMBLE approach
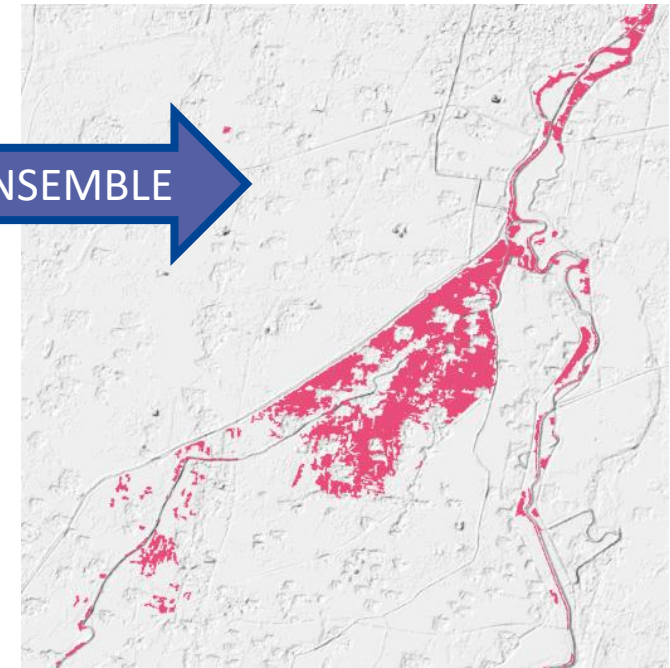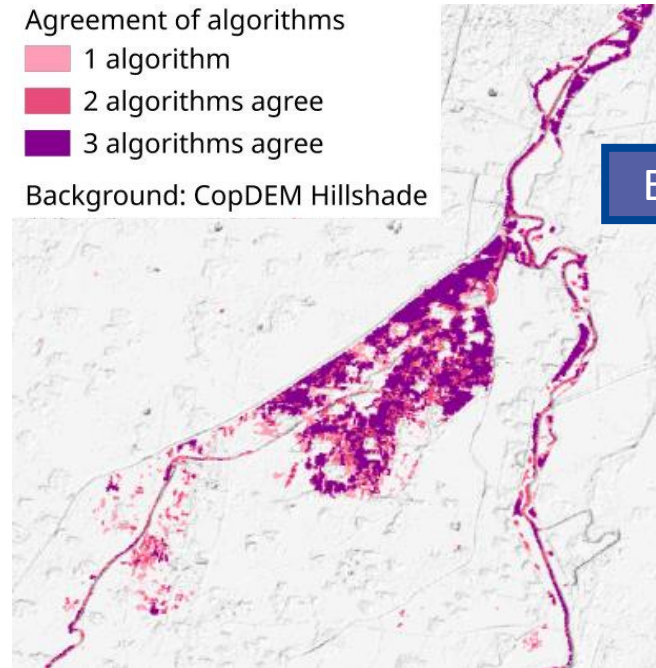
- At least two algorithms must agree

! water-look-alike surfaces (false positives)

- tarmacs, dry soil, wet snow, crop harvests

! no-sensitivity areas (false negatives)
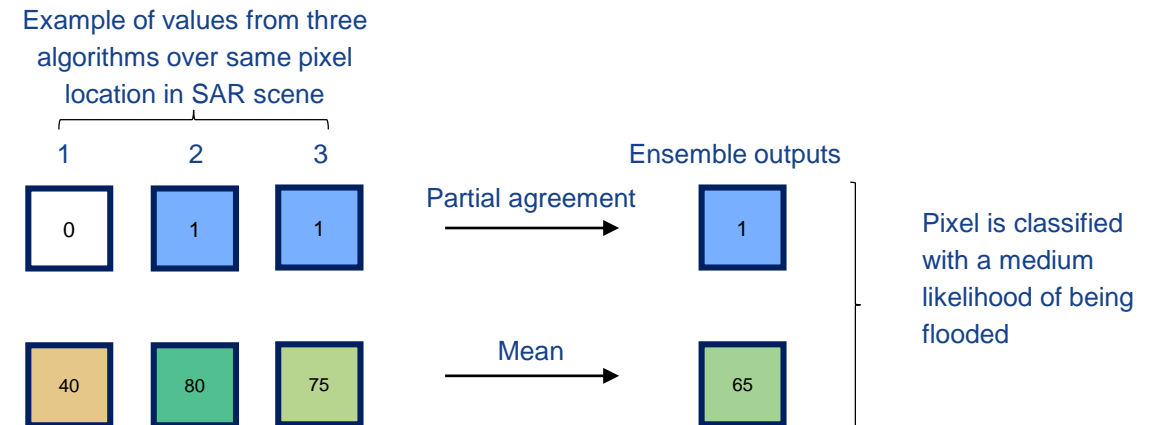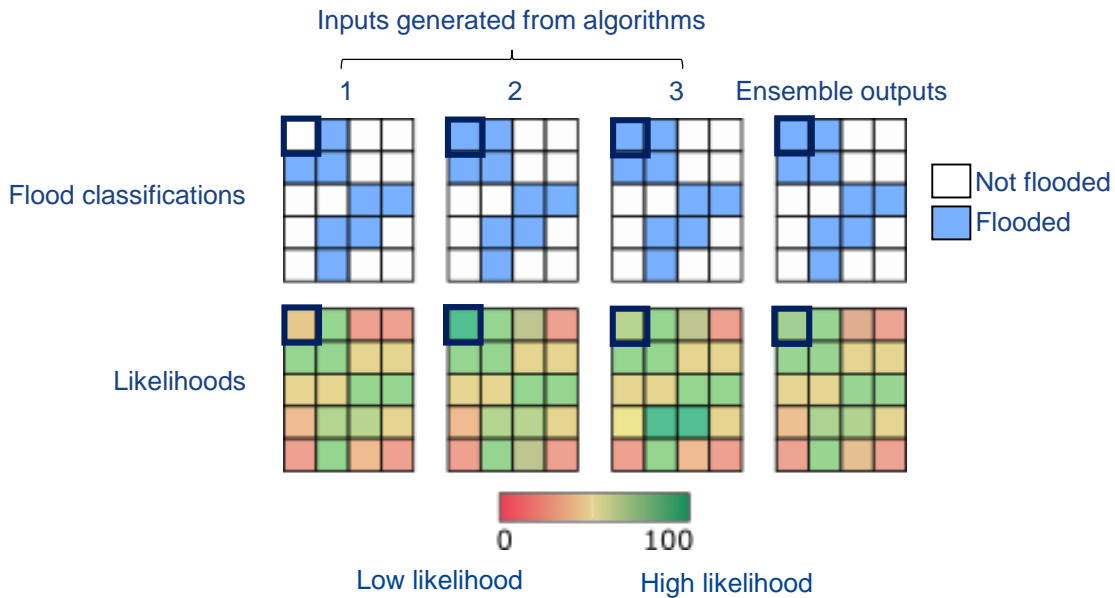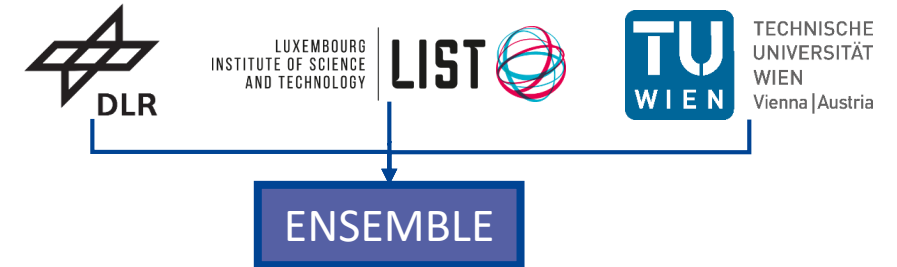
- dense vegetation, urban areas, etc.

Agreement of algorithms
- 1 algorithm
- 2 algorithms agree
- 3 algorithms agree

Background: CopDEM Hillshade

ENSEMBLE

GFM ensemble flood algorithm 2/2

- **Combining** flood and likelihood results of all three flood algorithms
- **Majority vote** decides if a pixel is marked as flood or non-flood
- Final likelihood layer is **the arithmetic mean** of all likelihoods

ENSEMBLE

Inputs generated from algorithms

1 2 3 Ensemble outputs

Flood classifications

☐ Not flooded
▨ Flooded

Likelihoods

0 — 100
Low likelihood   High likelihood

Example of values from three algorithms over same pixel location in SAR scene

1 2 3   Ensemble outputs

Partial agreement

0 1 1 → 1

Mean

40 80 75 → 65

Pixel is classified with a medium likelihood of being flooded

Product output layers – Water observations

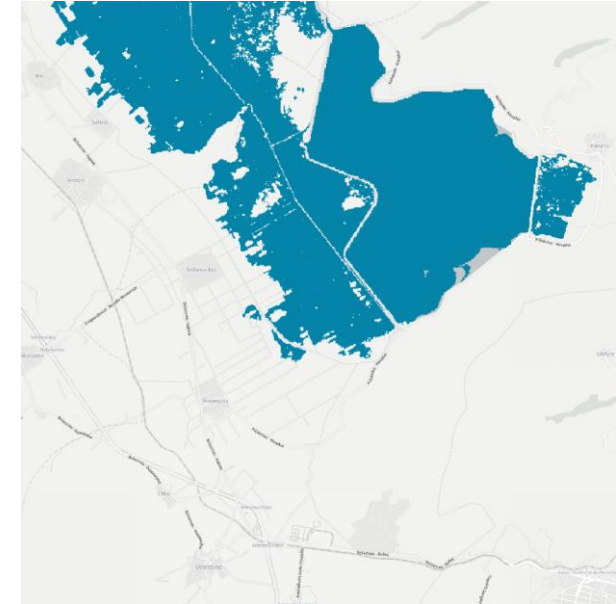**S-1 observed flood extent**

Ensemble flood extent
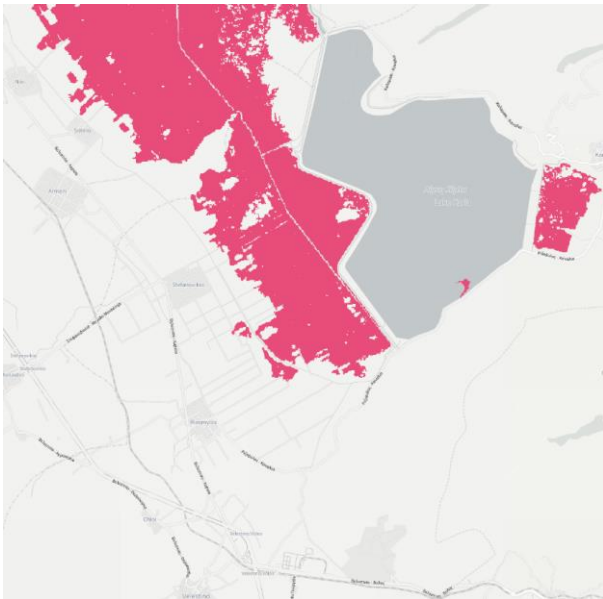
S-1 reference water mask

Permanent & seasonal water extent

S-1 observed water extent

Open water extent, as combined from flood and reference waters
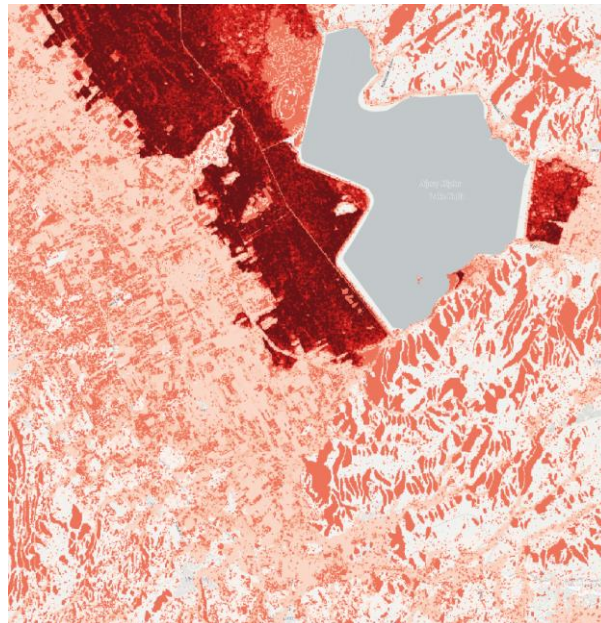
Product output layers – Contextual information

Exclusion mask

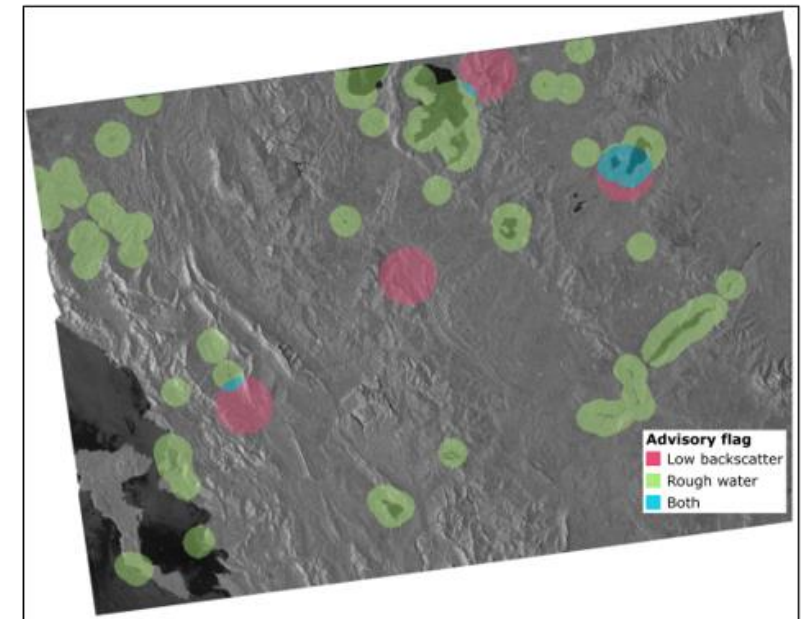Exclusion mask where S1 flood delineation is hampered

Likelihood values

Likelihood values accounting for classification confidence

Advisory flags

Advisory flags indicating challenging classification circumstances

Advisory flag
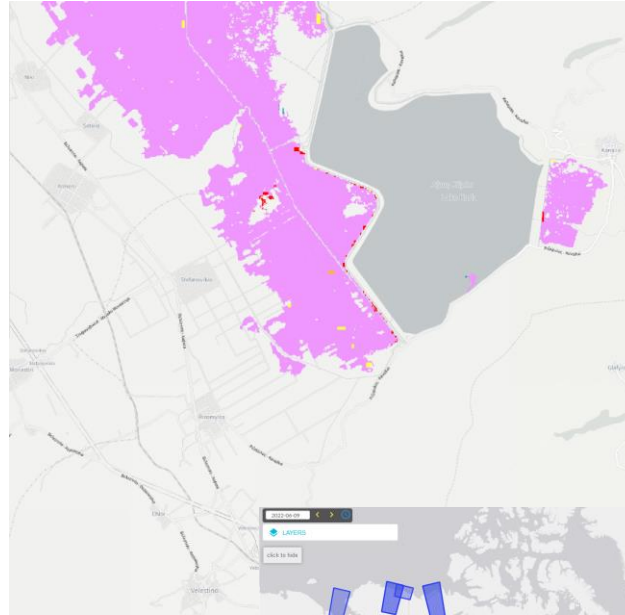- Low backscatter
- Rough water
- Both
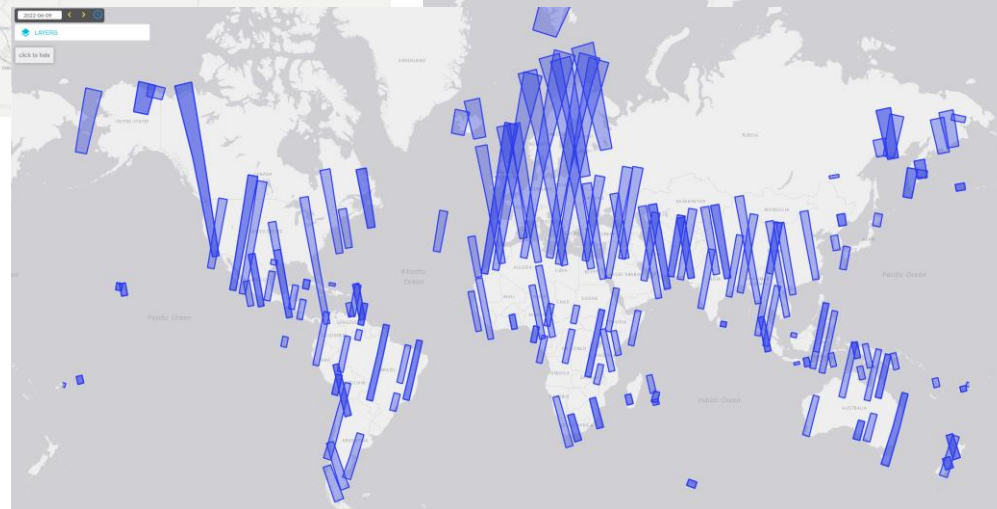
Product output layers – Metadata & Context

Affected Landcover/Population

GlobCover/CORINE Land Cover
GHSL (Global Human Settlement Layer)

S-1 Footprint + Metadata
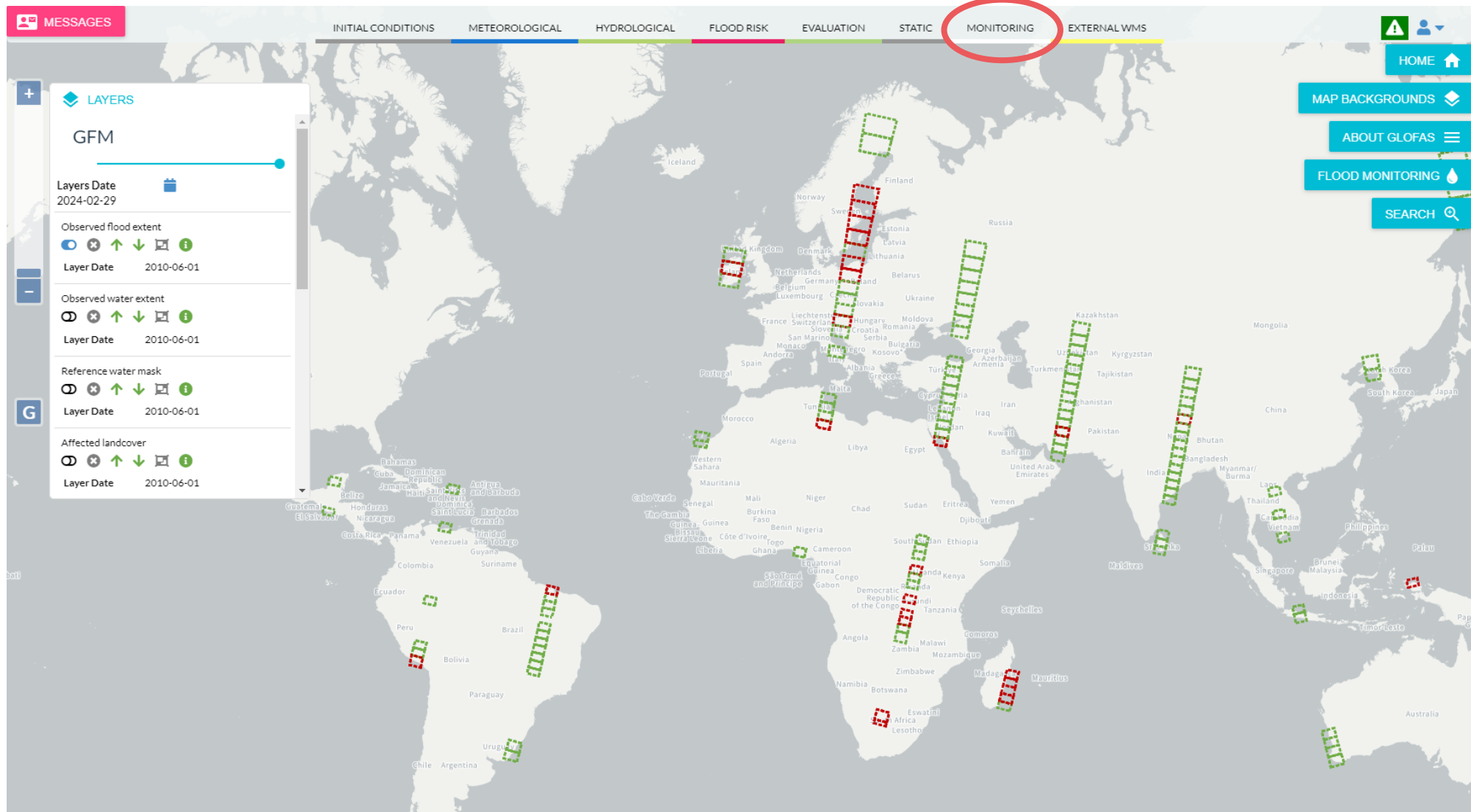
S-1 orbit footprint boundary for a specific day

S-1 Schedule

S-1 orbit overflight boundaries for the next 3 days

GFM Data Access – GloFAS Map Viewer

#EUSpace

Emergency Management

Thank you