



# Copernicus Emergency Management Service

## The Global Flood Monitoring ensemble flood product

17<sup>th</sup> EFAS Annual meeting 2022

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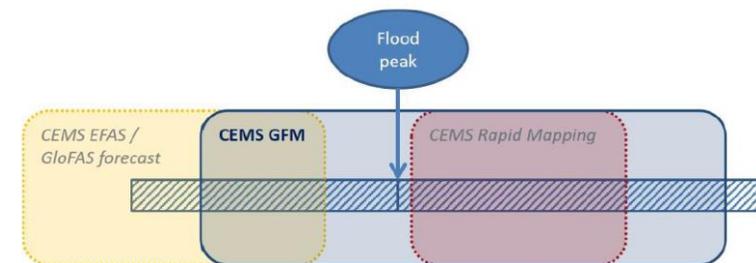
28 09 2022



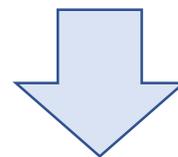
# Motivation for Global Floods Monitoring (GFM)

Due to:

- No constant automatic monitoring,
- Required user activation,
- Often late arrival of activation requests (missing flood onset/peak), and
- Limited resources made it impossible to map all floods



JRC initiated the expansion of the CEMS with the new GFM component.



**GFM: A global **near real time (NRT)** flood monitoring system based on the Copernicus Sentinel-1 SAR mission.**



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## Key specifications

**The GFM product is specifically designed to address three major user requirements for floods:**

- providing a continuous global & systematic monitoring,
- significantly enhancing the timeliness,
- improving the effectiveness of activation requests.

**GFM's key features are:**

- SAR enables all day & all weather conditions flood monitoring
- Near Real Time Flood map provision + regular quality control
  - **within 8 hours** after a Sentinel-1 data acquisition
- Integration into emergency systems & third party solutions
  - **APIs & UIs** and notifications services for all products
- High spatial resolution
  - **20 meter pixel sampling**
- Complete spatial coverage
  - **global** (except poles)
- Global flood archive
  - **2015 – ongoing**



# Approach

Flood mapping is carried out in two steps:

1. Three independent flood mapping algorithms (run in parallel) generate:
  - Three flood extents.
  - Three associated likelihood of flood detection.
2. An ensemble algorithm generates:
  - A combined flood extent based on majority voting.
  - A combined, average likelihood of flood detection.

## Caution: What might go wrong?

There are many “water-look-alike” surfaces

Static: Tarmac, sand deserts, grasslands, shadows, ...

Dynamic: Agricultural fields, wet snow, frozen soils, ...



may cause  
**false positives**

There are no-sensitivity-areas

Dense vegetation, urban areas, etc.

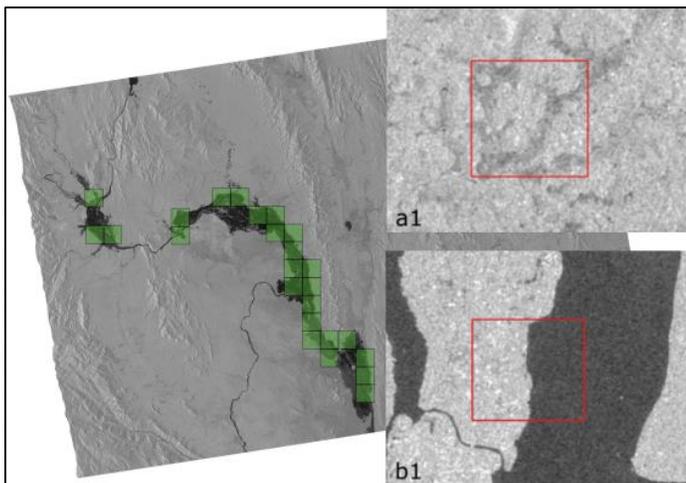


may cause  
**false negatives**

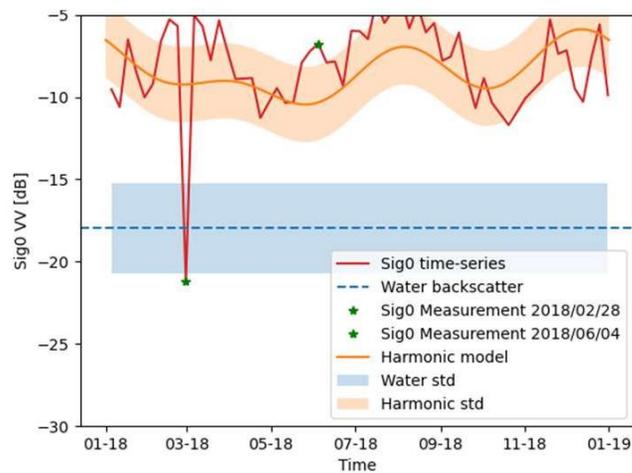


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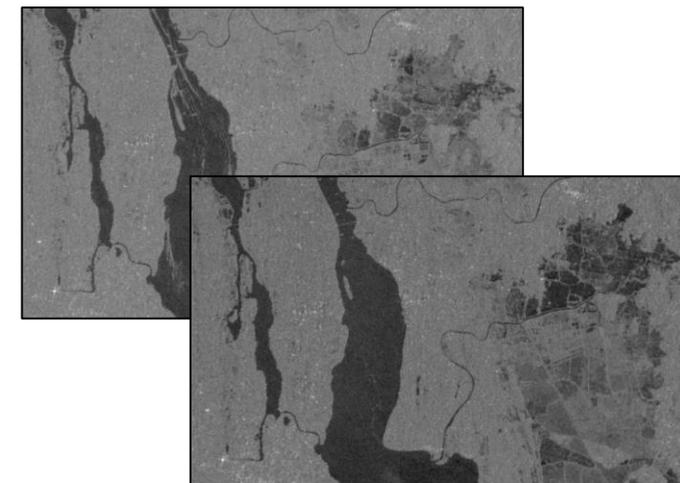
# Combining different strategies to increase robustness



- Hierarchical tile-based thresholding
- Post classification and likelihood estimation through fuzzy logic-based refinement



- Per-pixel time series analysis
- Flood as deviation from harmonic model
- Likelihood through probability of opposing class

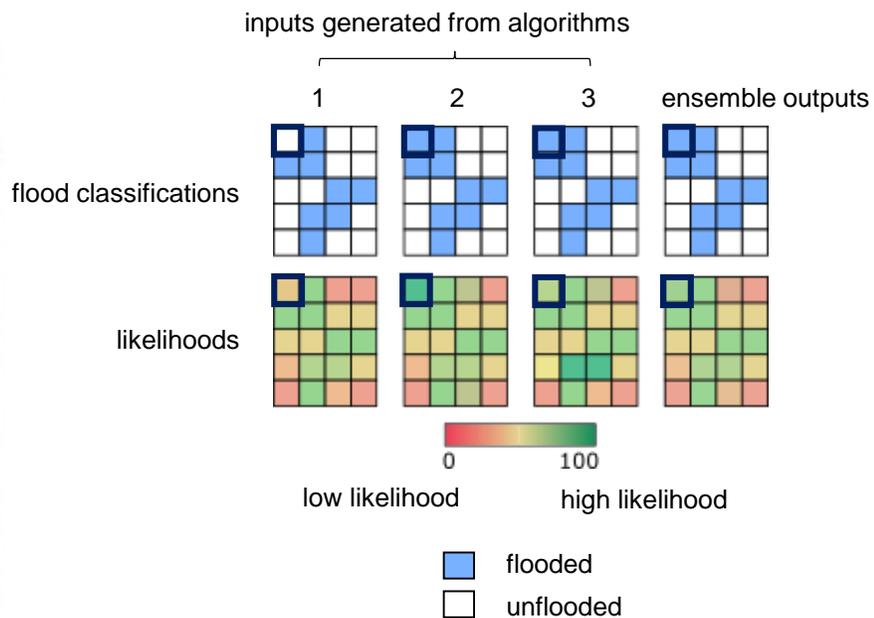
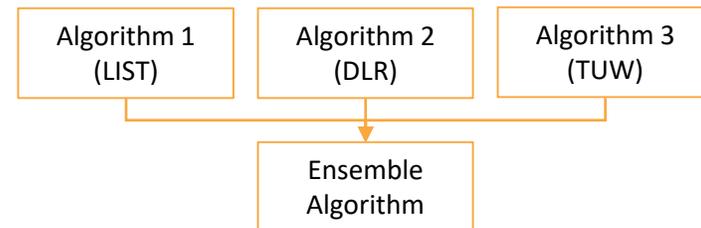


- Change detection
- Flood as deviating water surface
- Likelihood through probability

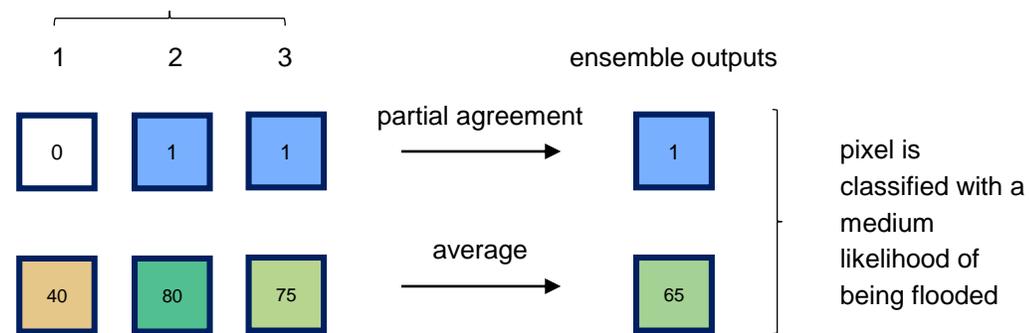


# Flood Ensemble

- 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



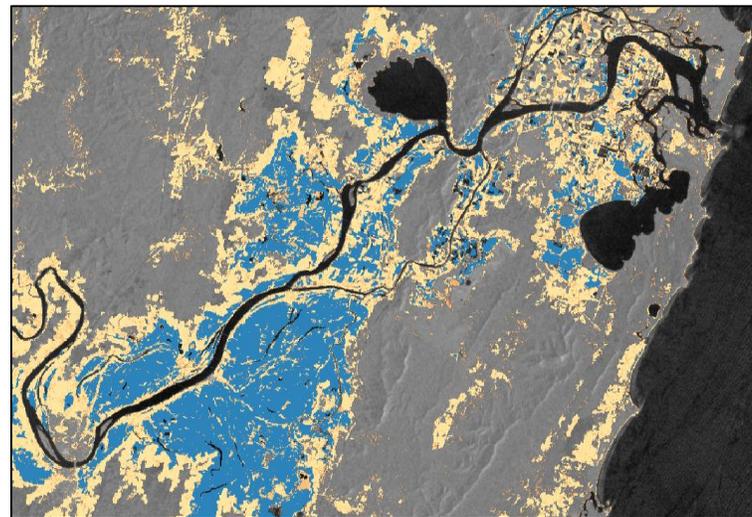
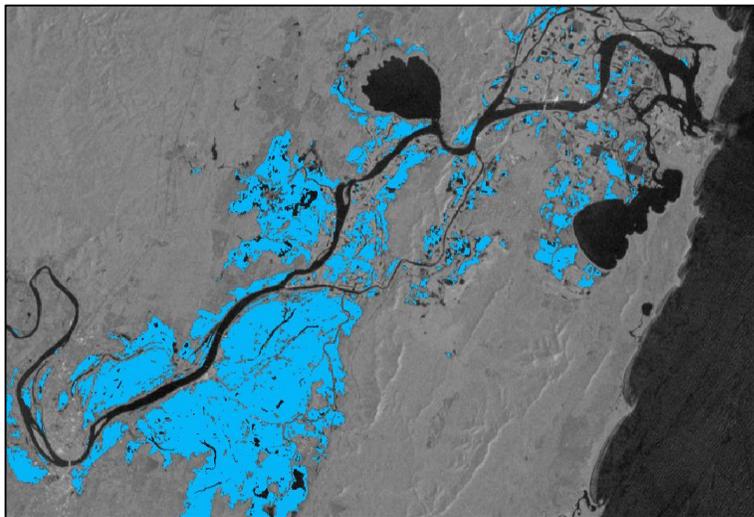
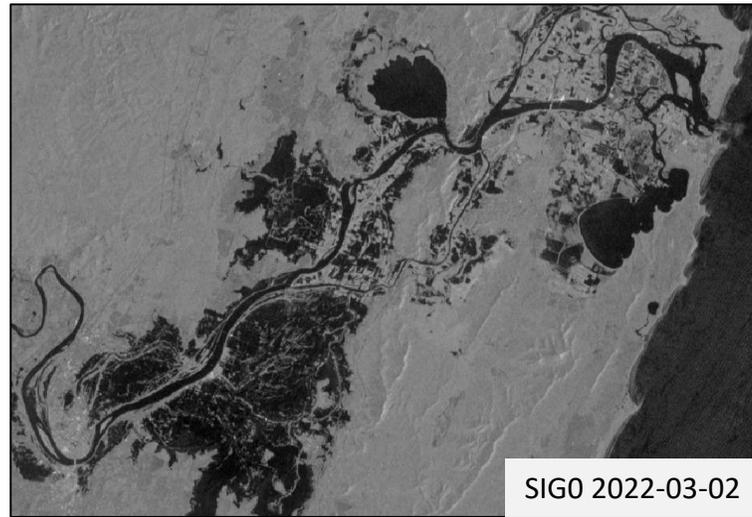
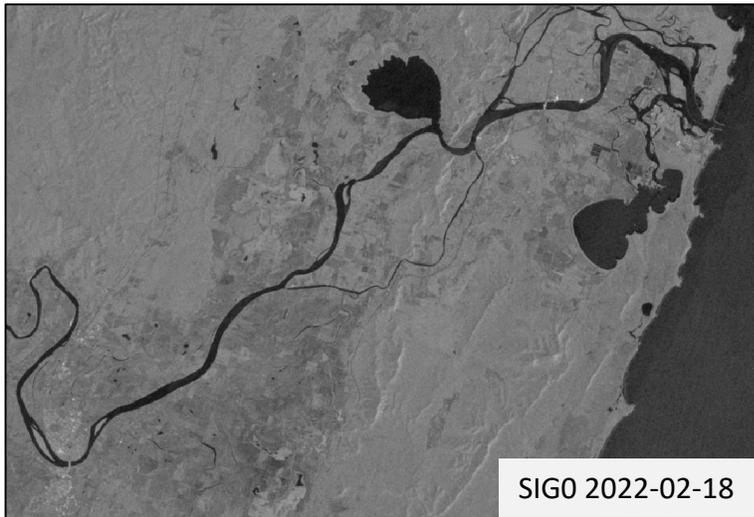
example of values from three algorithms over same pixel location in SAR scene





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# Ensemble Flood Results



**Ensemble flood**

 Flood

**Ensemble likelihood**

 Certainly flood

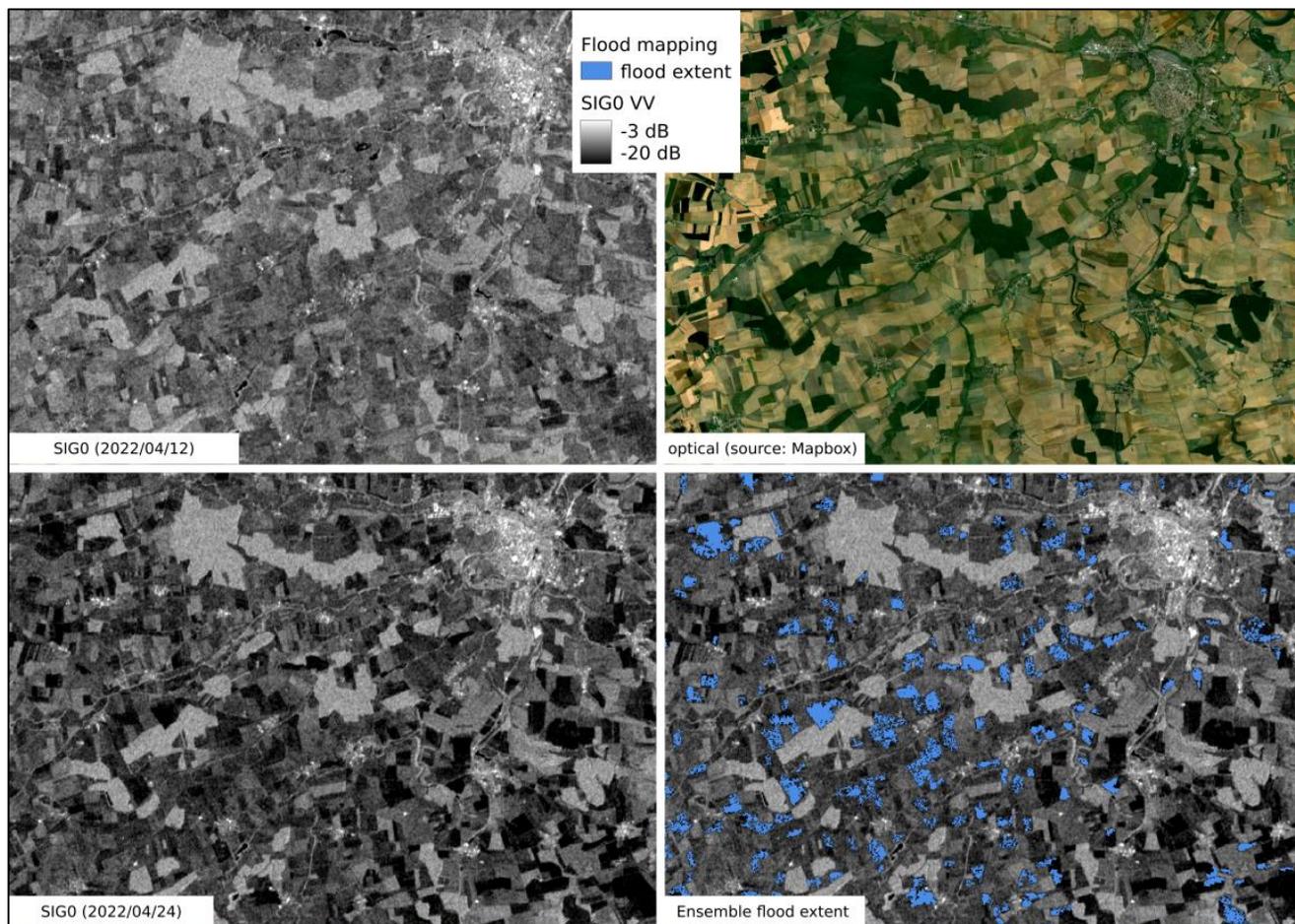
 Certainly non-flood

10 km



# Uncertainties & Limitations

- Ensemble flood output is a complex scientific data product supported by several novel data layers
- Not all detection errors can be captured
  - Wet snow
  - Frozen soils
  - Agriculture
- Interpret flood pixels using available information
  - Likelihood Layer
  - Exclusion Mask
  - Reference Water
  - Advisory Flags
  - Environmental factors
  - Use local knowledge





# Product Output Layers: Water observations

## S-1 observed flood extent

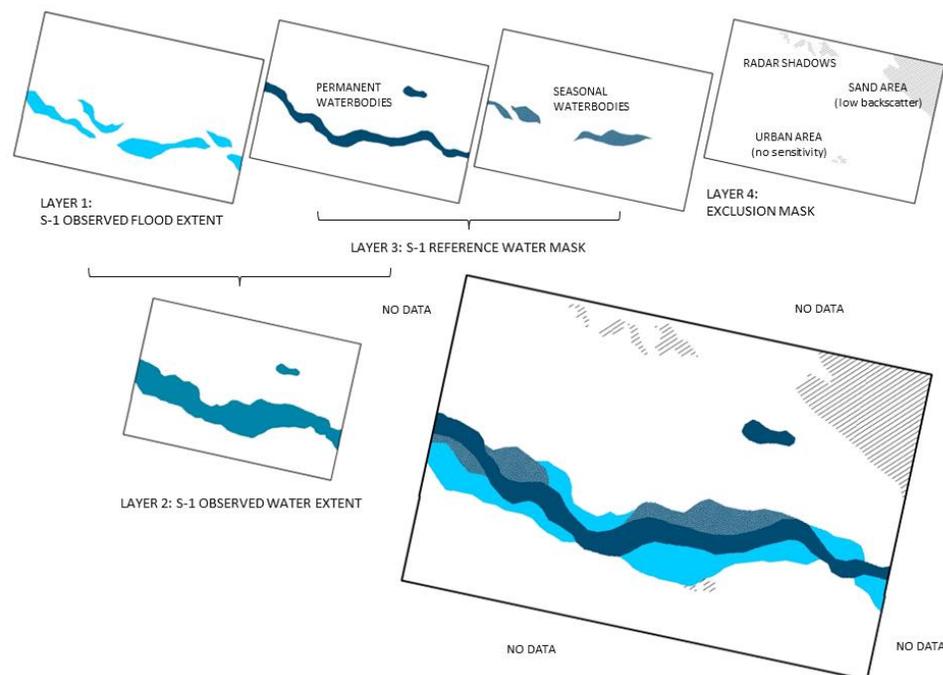
- Ensemble flood extent through flood algorithms by DLR, LIST & TUW

## S-1 reference water mask

- Based on water algorithms of DLR & LIST
- Permanent & seasonal water

## S-1 observed water extent

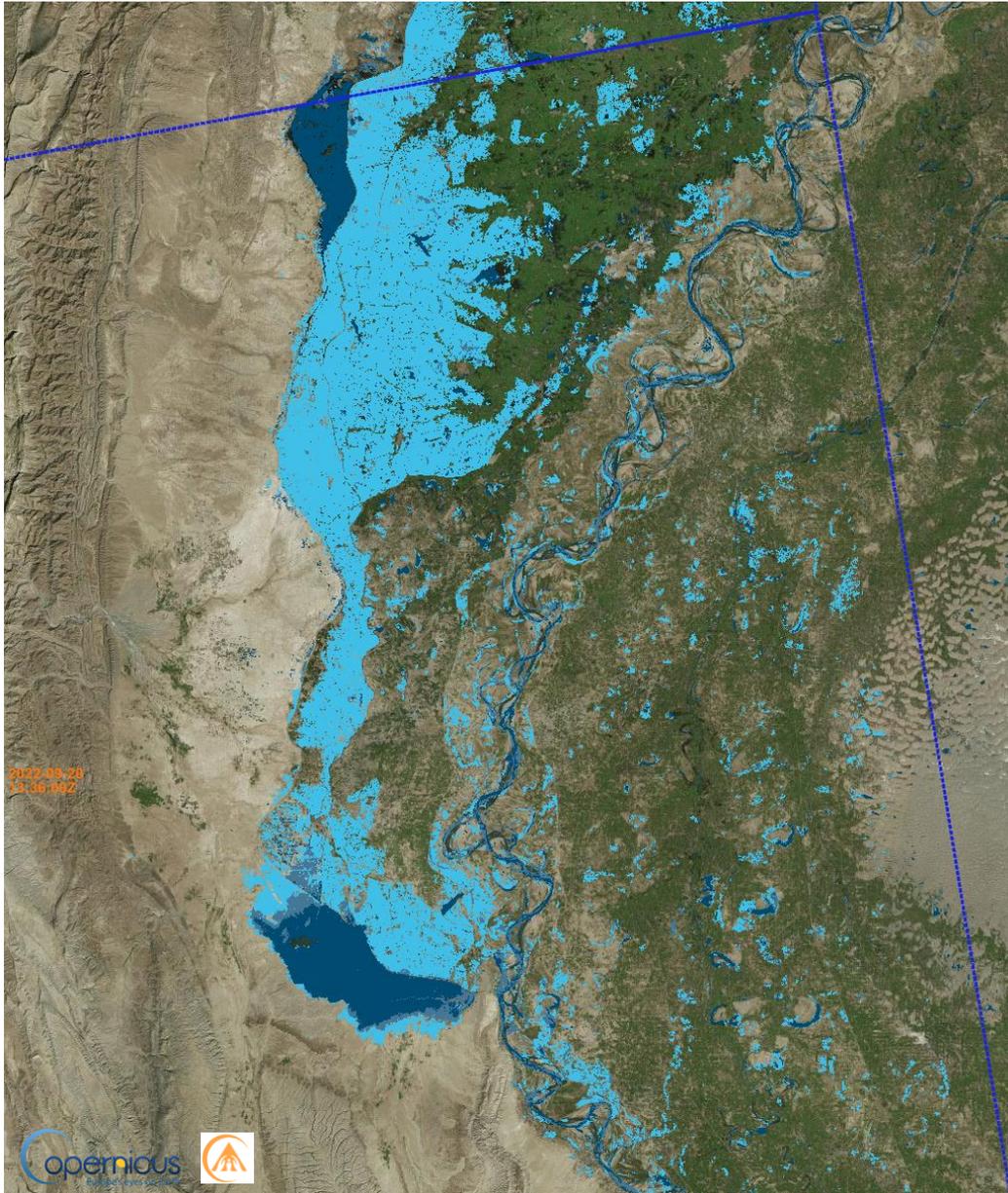
- Open water extent as combination of flood extent and reference water





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# Product Output Layers: Water observations



## S-1 observed flood extent

 Floodwater

## S-1 reference water mask

 Permanent Water Body  
 Seasonal Water Body (for the current month)

## S-1 observed water extent

 Water



# Product Output Layers: Contextual Information

## Exclusion mask

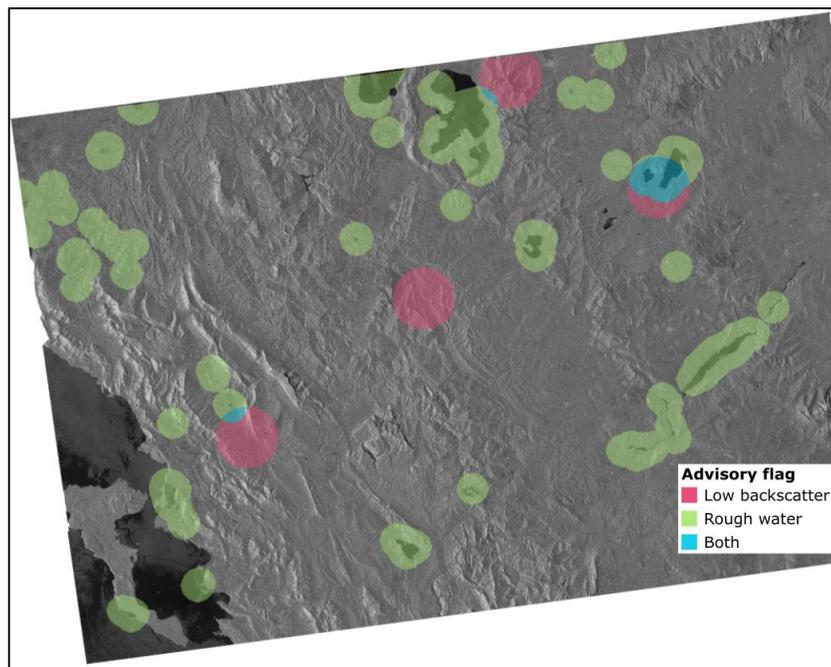
- Exclusion mask where S1 flood delineation is hampered
- 4 layers:
  - No sensitivity
  - Low backscatter
  - Topographic distortion
  - Radar shadows

## Likelihood values

- Likelihood values accounting for classification confidence

## Advisory flags

- Advisory flags indicating challenging classification circumstances
- Mask dynamic influences
  - Low regional backscatter (snow, ice dryness)
  - Rough water surface (wind)

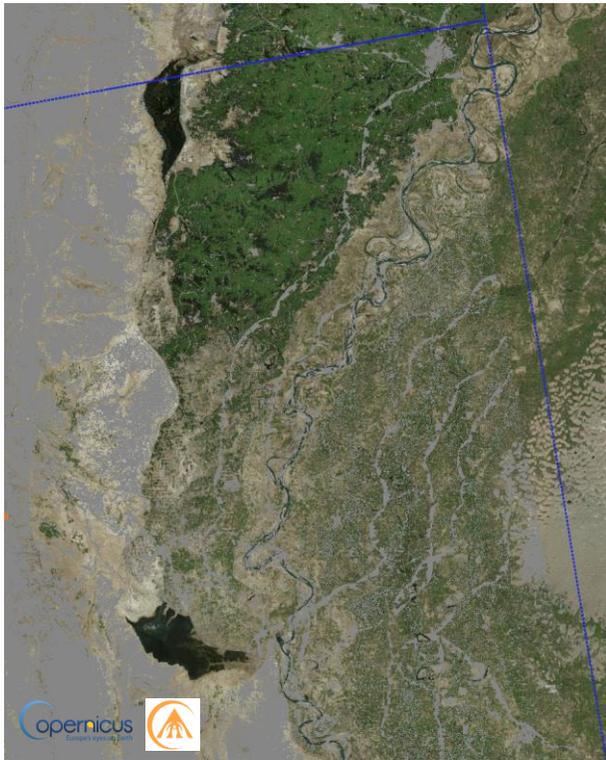




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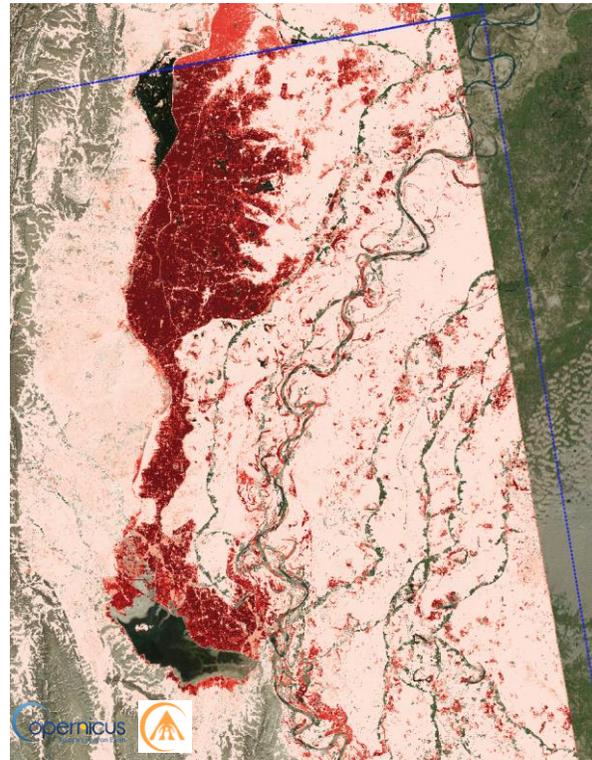
# Product Output Layers: Contextual Information

Flooding in Pakistan, 20.09.2022  
GloFAS



Exclusion mask

Exclusion Mask set



Likelihood values

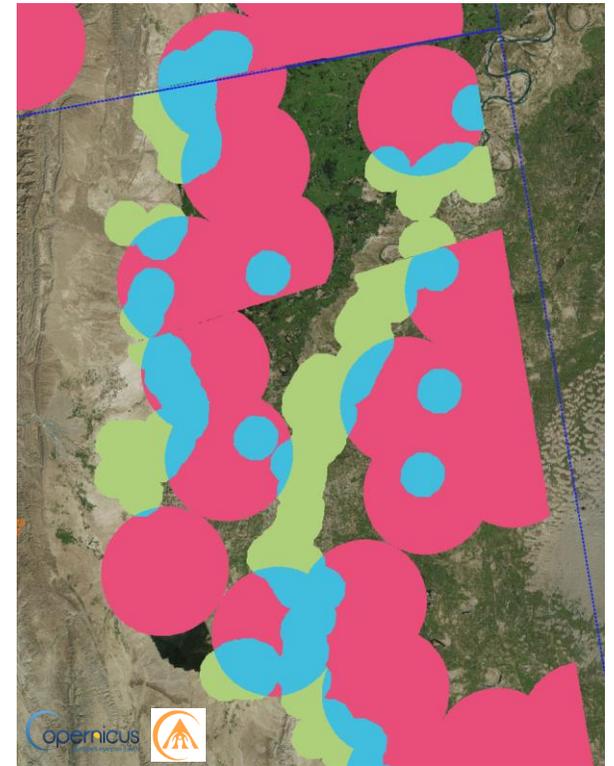
Low likelihood of flood classification

25%

50%

75%

High likelihood of flood classification



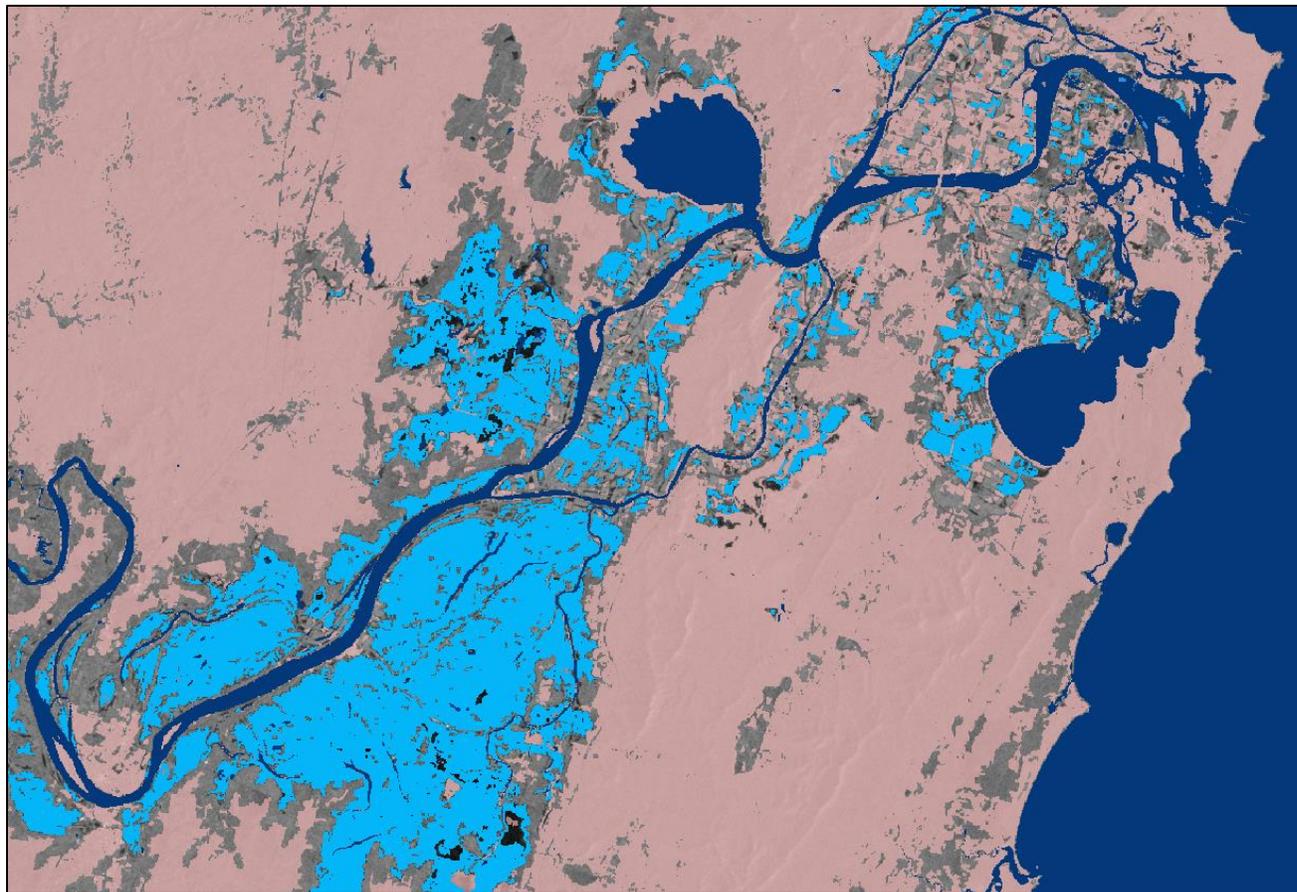
Advisory flags

- Low regional backscatter (snow, ice, dryness)
- Rough water surface (wind)
- Low regional backscatter and rough water surface



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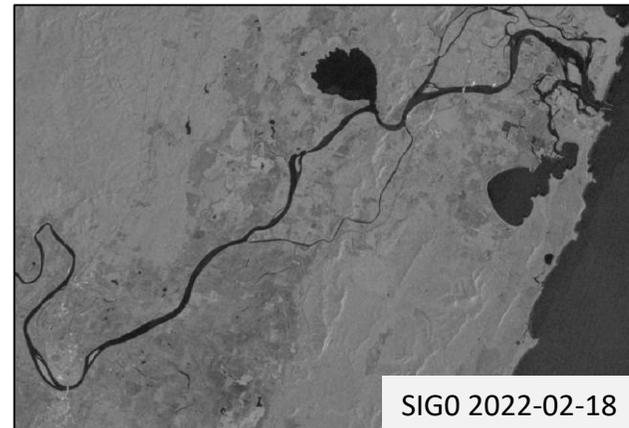
# Final Results



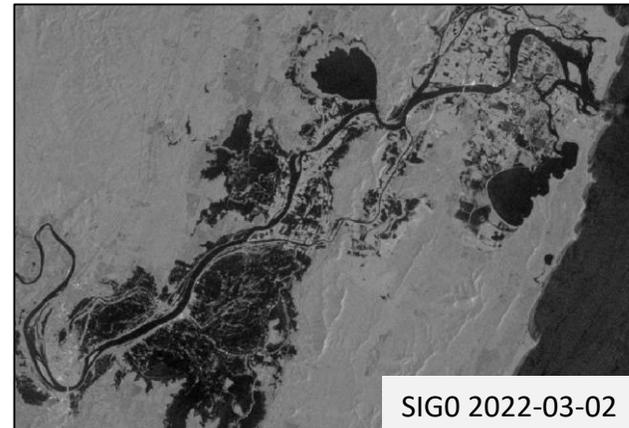
10 km

 Ensemble flood

 Exclusion mask



SIGO 2022-02-18



SIGO 2022-03-02



## Coming up

- Next EFAS release with GFM product integrated
- Improved visualisation & data access features
- Global Flood Archive
- Increased number of use cases and stratified sampling for QA
- Updated permanent/seasonal reference water mask
- Algorithm improvements to address overdetection
- And more to come...

For more insights, please visit the GFM Wiki  
<https://extwiki.eodc.eu/en/GFM>

Contact us via  
[gfm-support@eodc.eu](mailto:gfm-support@eodc.eu)

**Thank you for your attention!**

