

The Copernicus Global Flood Monitoring Service: How it serves Society and Science

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Technische Universität Wien



Earth Observation Data Centre for
Water Resources Monitoring

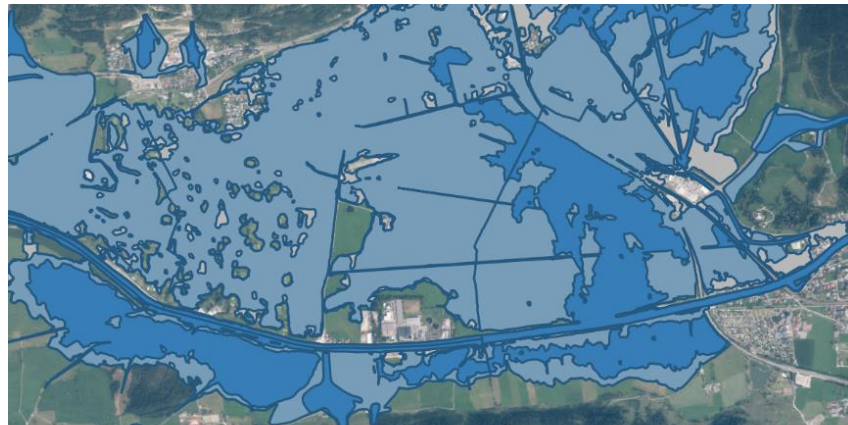
When a Disaster Strikes ...



<https://www.welt.de/politik/deutschland/article232596141/Hochwasser-Monumentales-Versagen-Expertin-macht-Behoerden-schwere-Vorwuerfe.html>
<https://www.tagesschau.de/inland/unwetter-katastrophenschutz-kritik-101.html>
<https://www.versicherungsbote.de/id/4906841/Hochwasser-2021-Hatten-viele-Schaden-vermieden-werden-konnen/>

Flooding Salzach July 2021

Sentinel-1 flood map of Salzach on 19 July 2021



Scenario-based simulations of flood inundation areas for 30, 100 and 300 years return periods (HQ = „Hoch“ und Abfluss-Kennzahl Q)

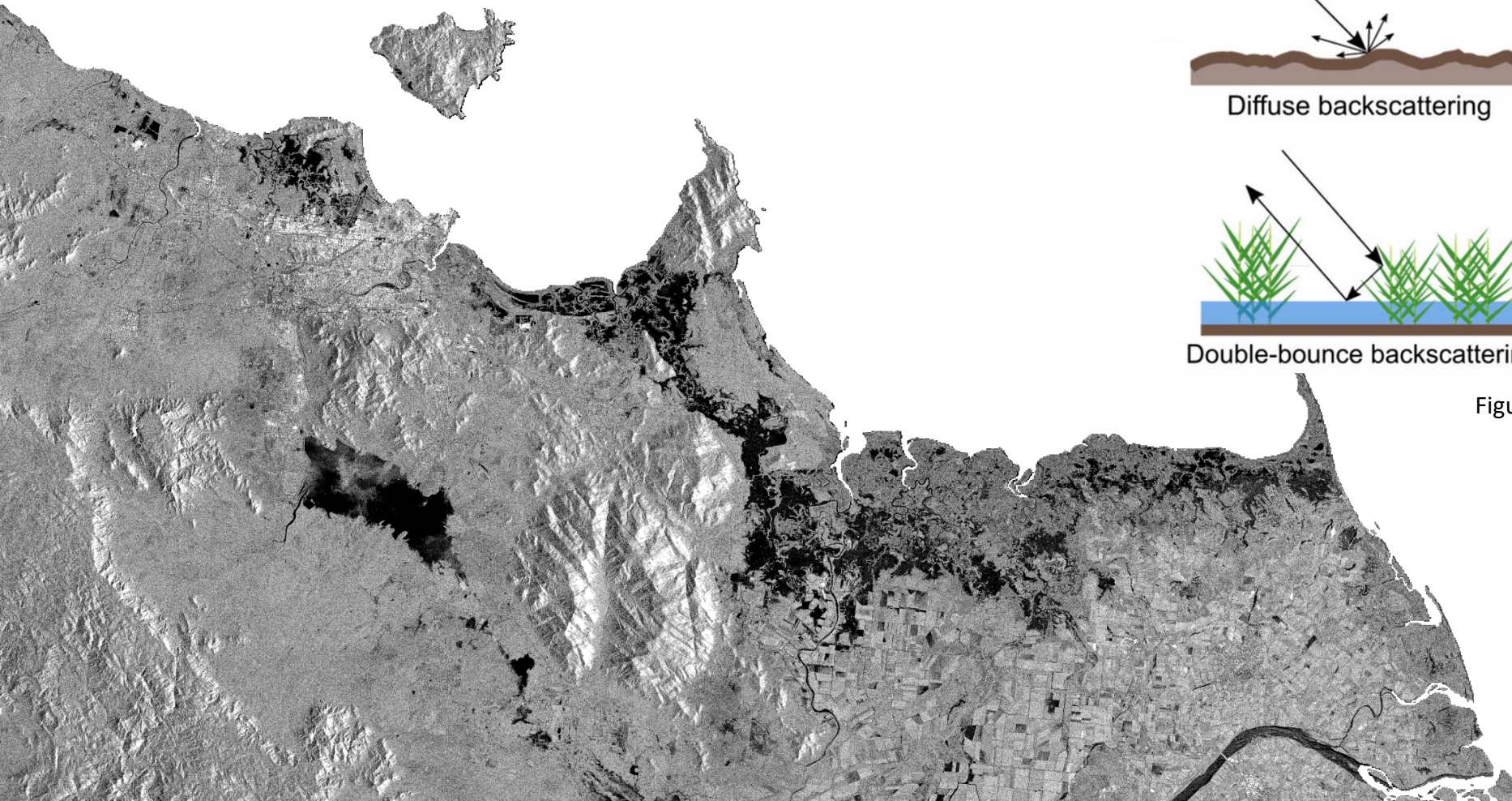


 Federal Ministry
Republic of Austria
Agriculture, Regions
and Tourism

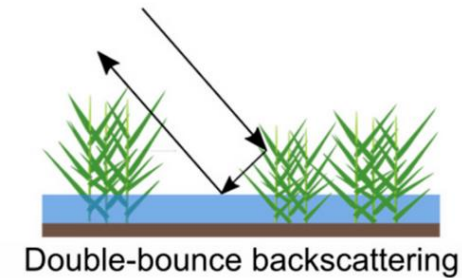
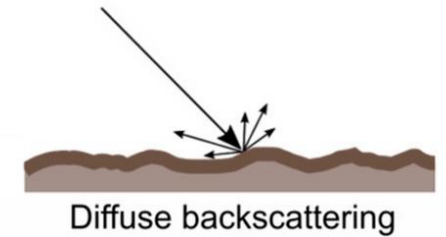


Sentinel-1 SAR for Flood Mapping

2019 Queensland flood as captured by
Sentinel-1 on 30 January 2019



High Backscatter



Low Backscatter

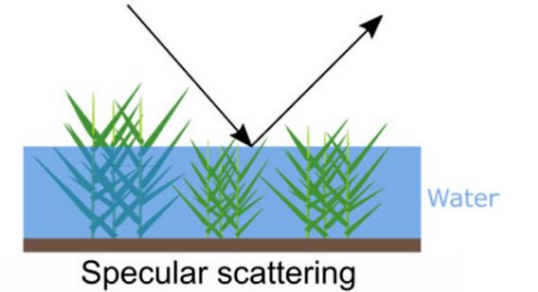
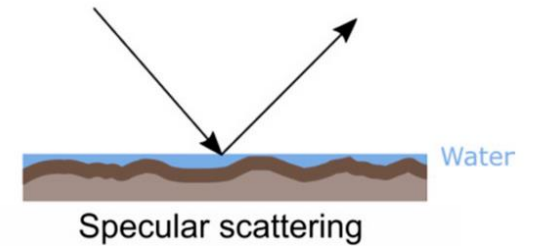
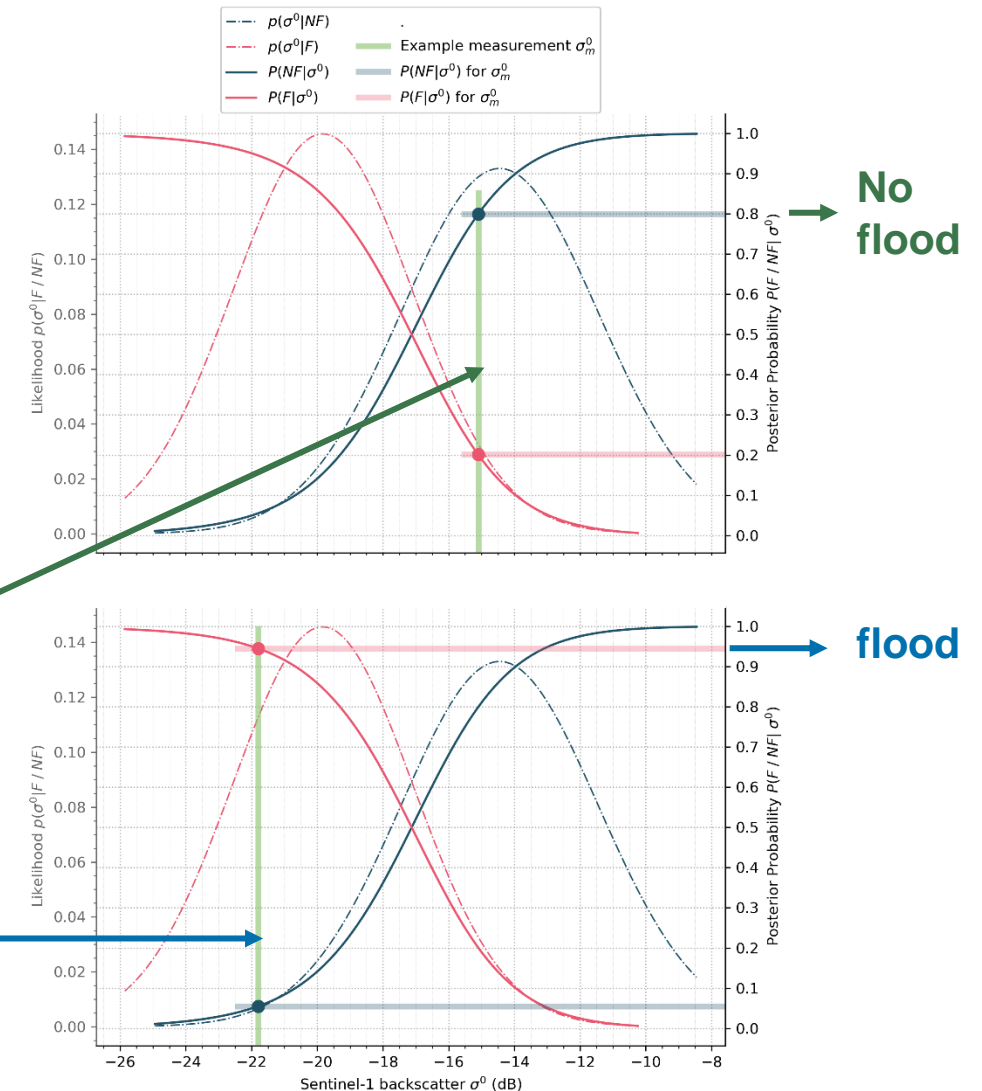
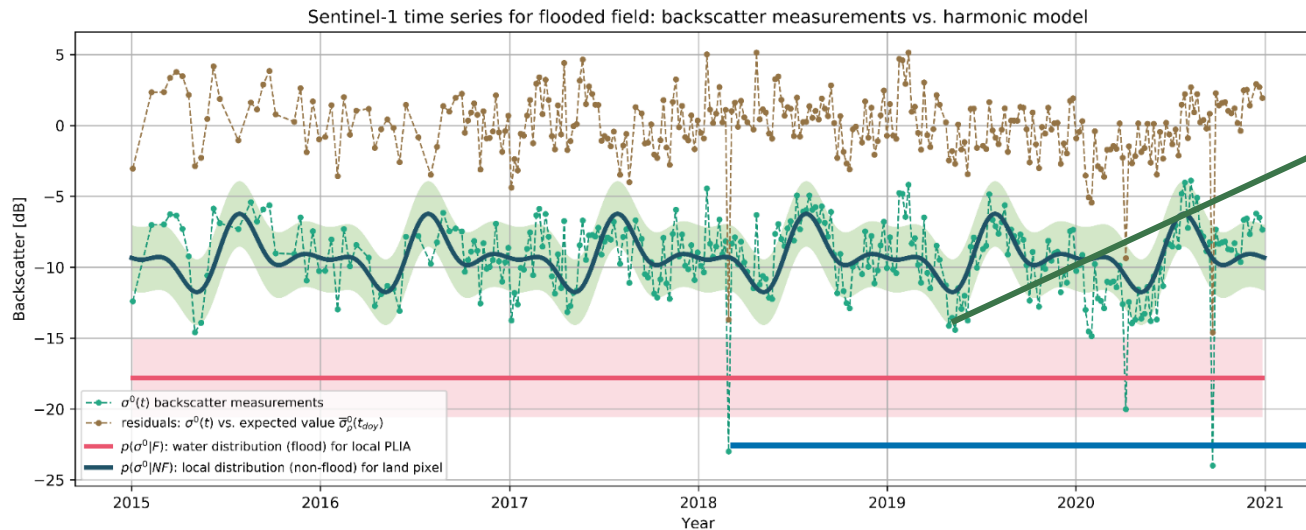


Figure modified from Ottinger and Kuenzer (2020)
Remote Sensing, 12(14).

Sentinel-1 Flood Mapping: TU Wien Algorithm

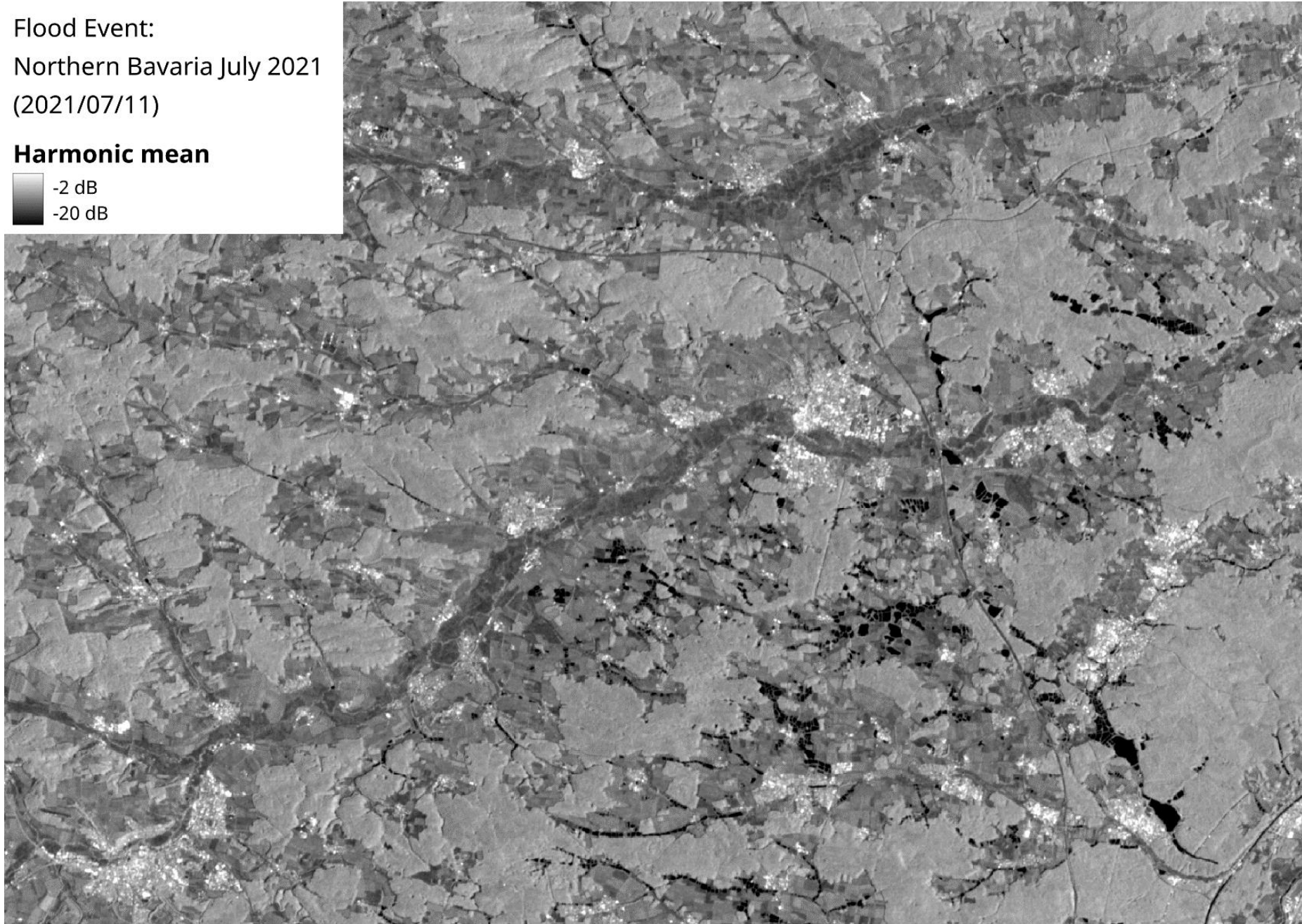
Pixel-wise Bayes decision

- non-flood distribution described by a harmonic model for each 20m pixel
- flood distribution valid worldwide



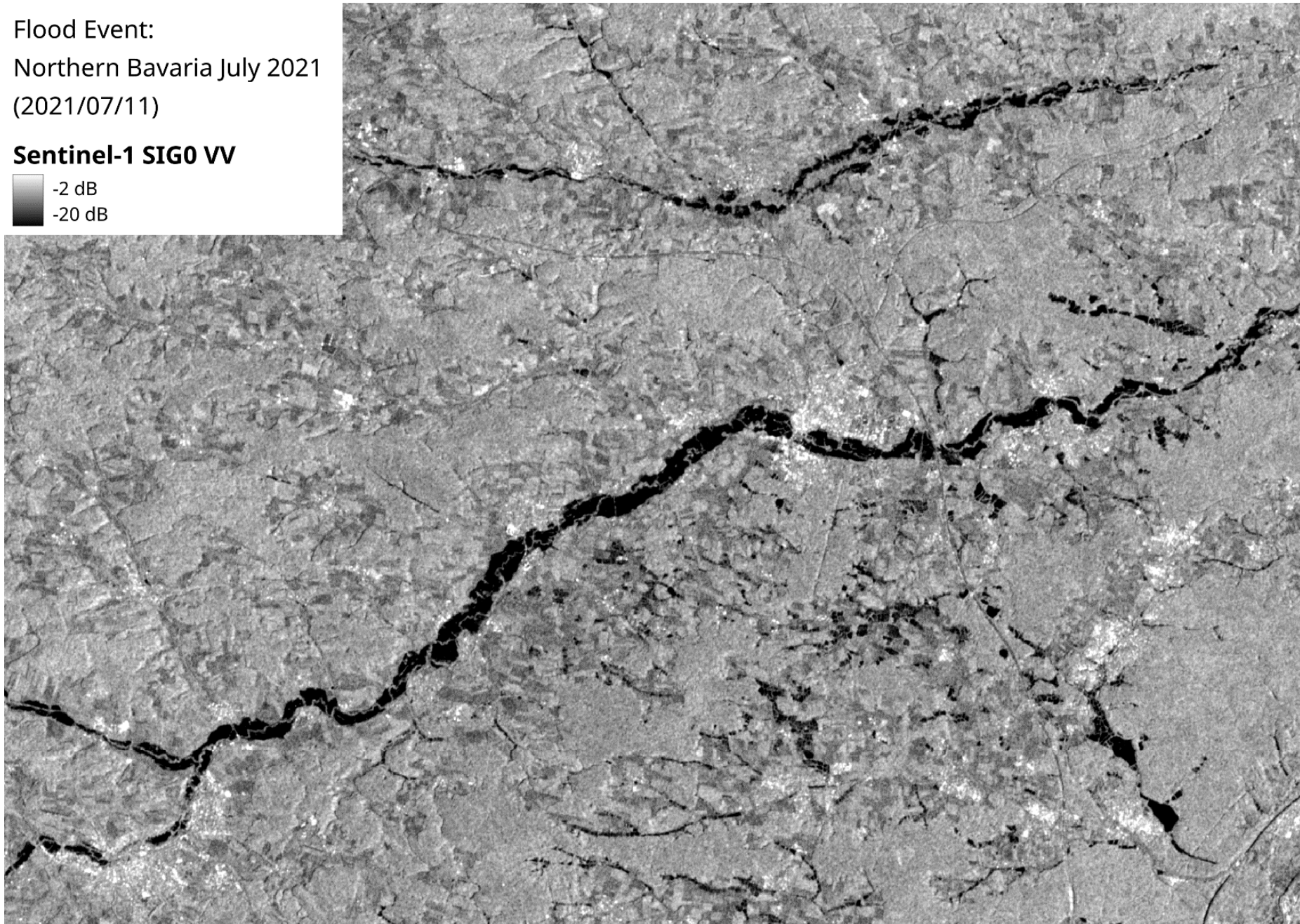
Flood Event:
Northern Bavaria July 2021
(2021/07/11)

Harmonic mean




Flood Event:
Northern Bavaria July 2021
(2021/07/11)

Sentinel-1 SIG0 VV



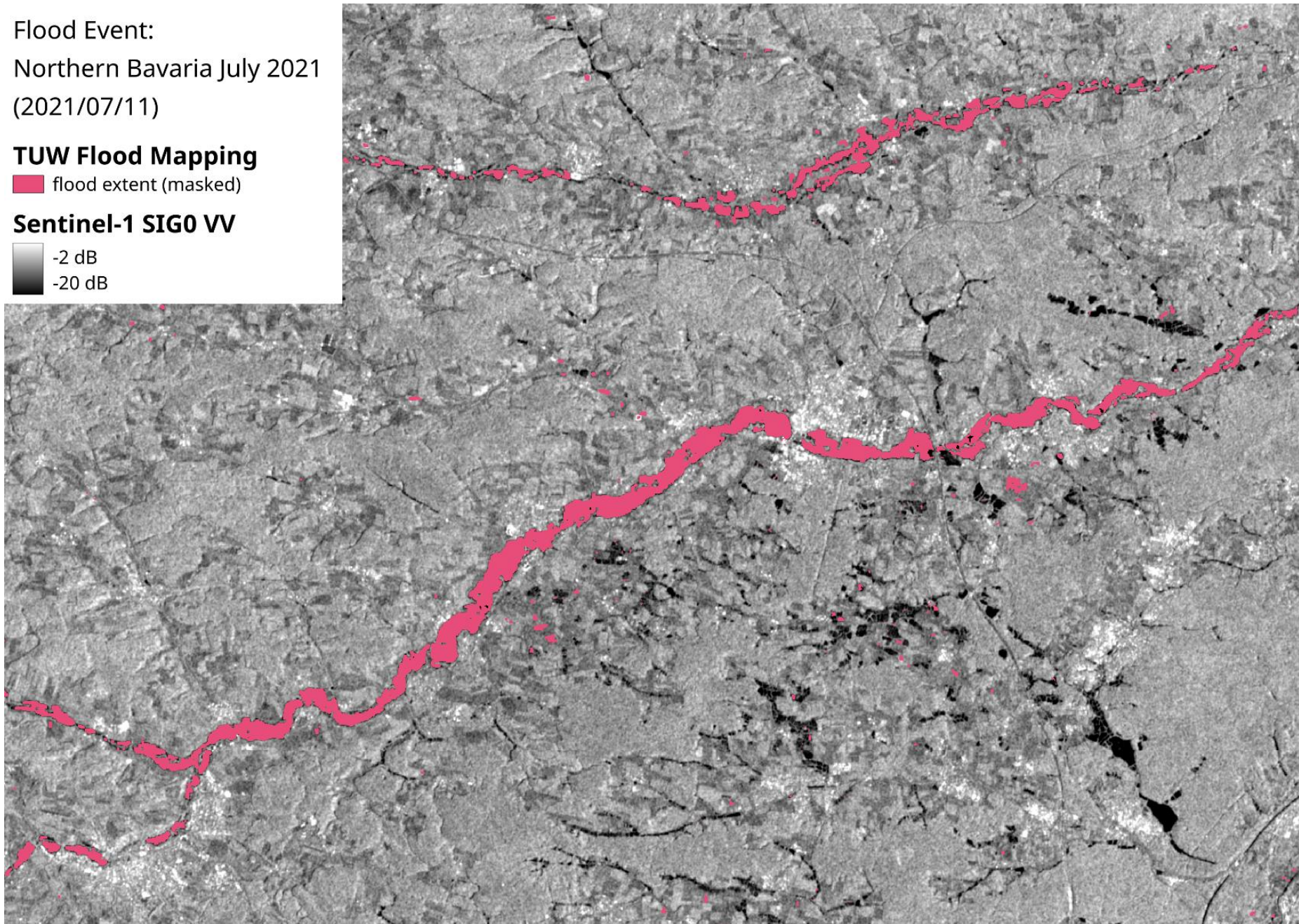
Flood Event:
Northern Bavaria July 2021
(2021/07/11)

TUW Flood Mapping

 flood extent (masked)

Sentinel-1 SIG0 VV

 -2 dB
-20 dB



Flood Event:
Northern Bavaria July 2021

Exclusion layers

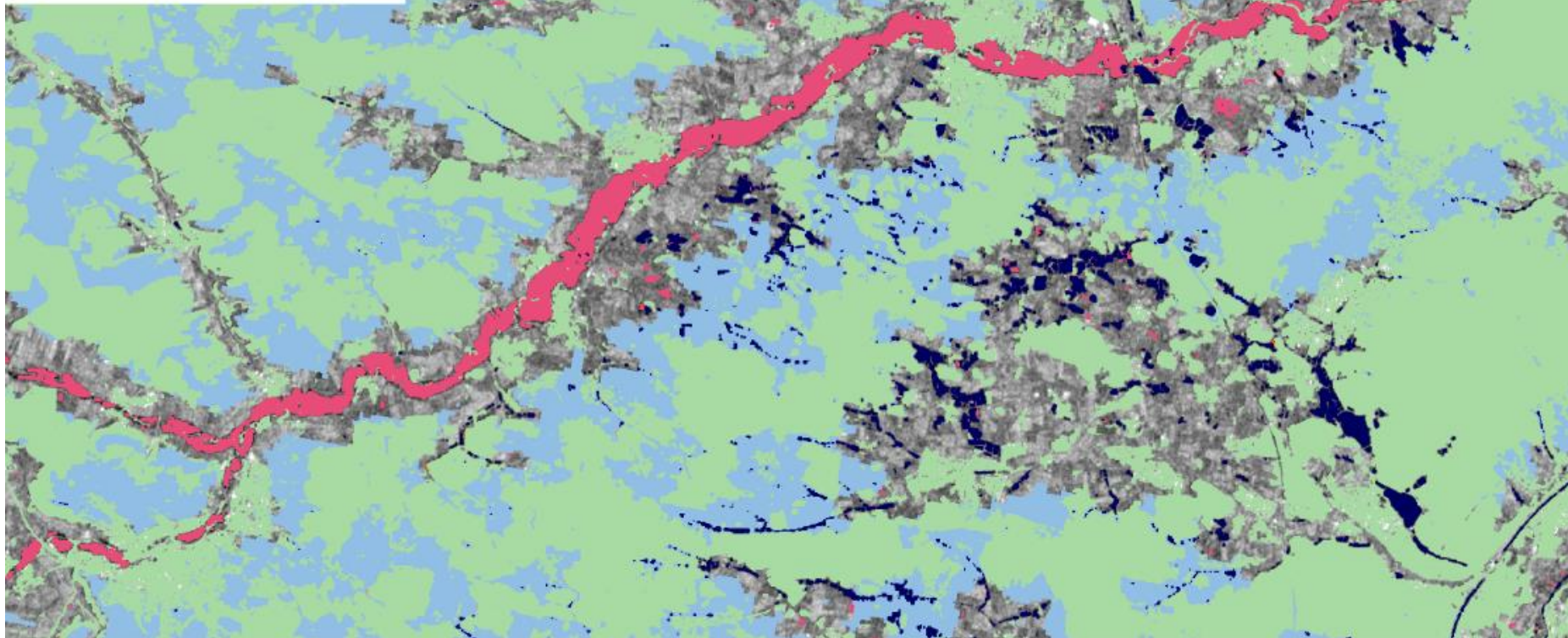
- no sensitivity
- low backscatter
- topographic distortion
- radar shadow

Flood Mapping (2021/07/11)

- flood extent

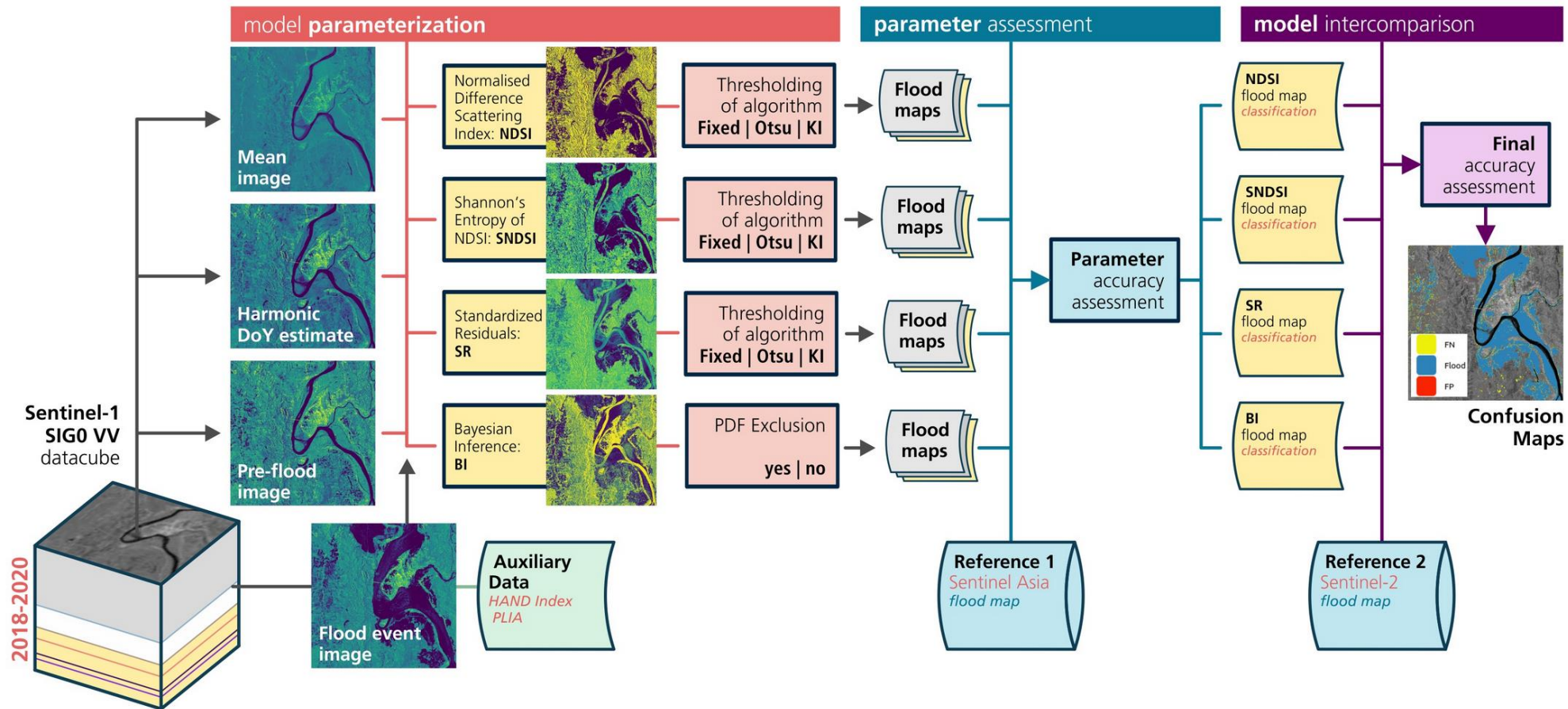
Sentinel-1 SIG0 VV (2021/07/11)

- 2 dB
- 20 dB



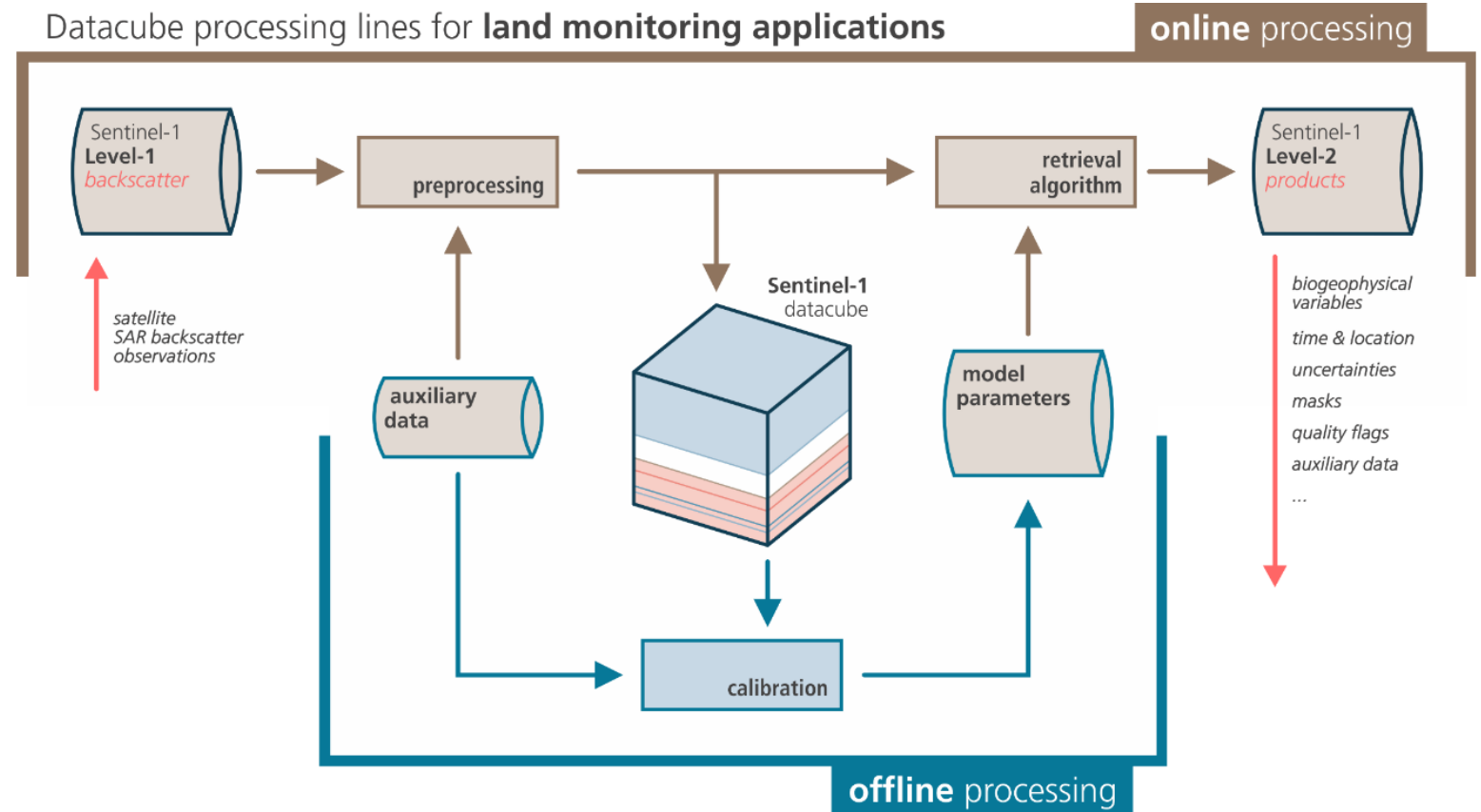
Robust Parameterisation of TU Wien Flood Mapping Algorithm

- Compared to other popular change detection algorithms the TU Wien flood algorithm is quite robust against changes in the model parameterisation



The Robustness comes with Costs and additional Benefits

- One requires a **datacube processing architecture**
- Costs
 - Large data volumes (100s TBs per year)
 - Scalable computing capabilities
- Benefits
 - Historic data archive
 - Allows training of AI models



Wagner et al. (2020) Data processing architectures for monitoring floods using Sentinel-1, ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., V-3-2020, 641–648.

Wagner et al. (2021) A Sentinel-1 Backscatter Datacube for Global Land Monitoring Applications, Remote Sensing, 13, 4622.



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Emergency Management

Copernicus Emergency Management Service - Global Flood Monitoring





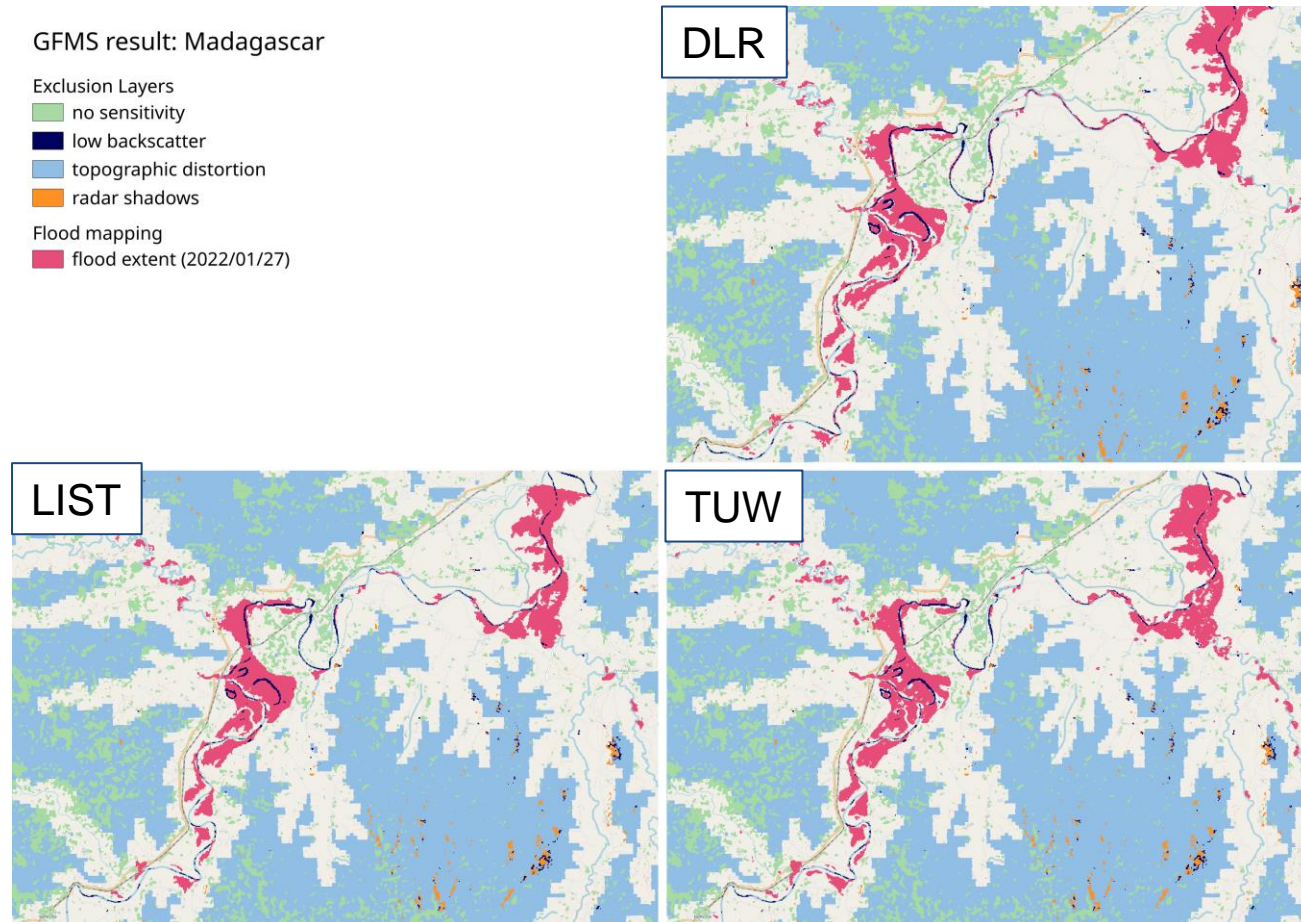
Copernicus Emergency Management Service (CEMS) Global Flood Monitoring (GFM) Service:

- **Sentinel-1** Synthetic Aperture Radar (SAR)
- **Fully automatic global processing** of all incoming Sentinel-1 scenes within 8 hours
- **Ensemble** of 3 flood mapping algorithms (DLR, LIST, TU Wien)
- **11 output layers** incl.
 - Flood extent
 - Uncertainties
 - Exclusion mask
 - Advisory flags

GFMS result: Madagascar

Exclusion Layers
■ no sensitivity
■ low backscatter
■ topographic distortion
■ radar shadows

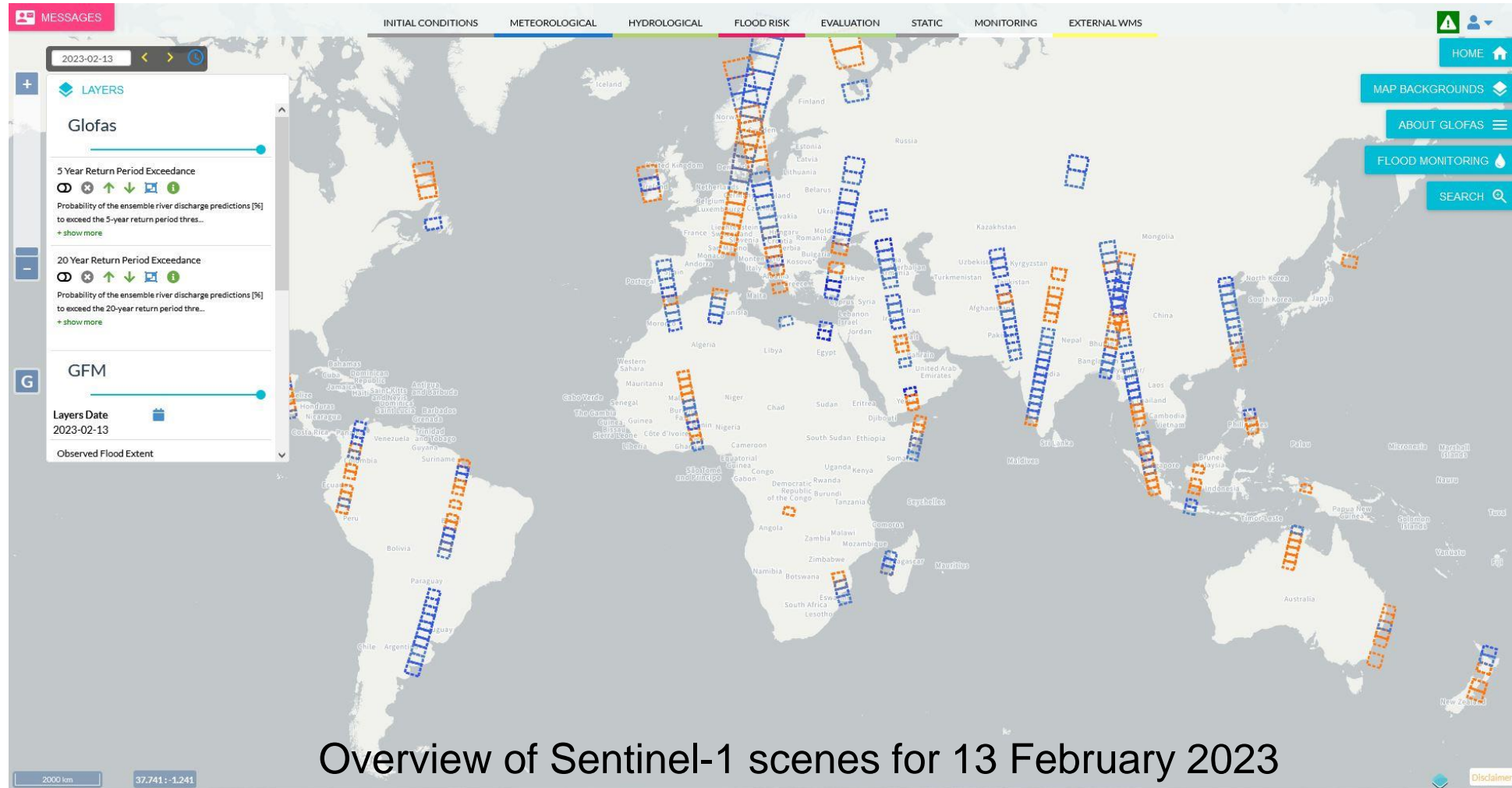
Flood mapping
■ flood extent (2022/01/27)





Emergency
Management

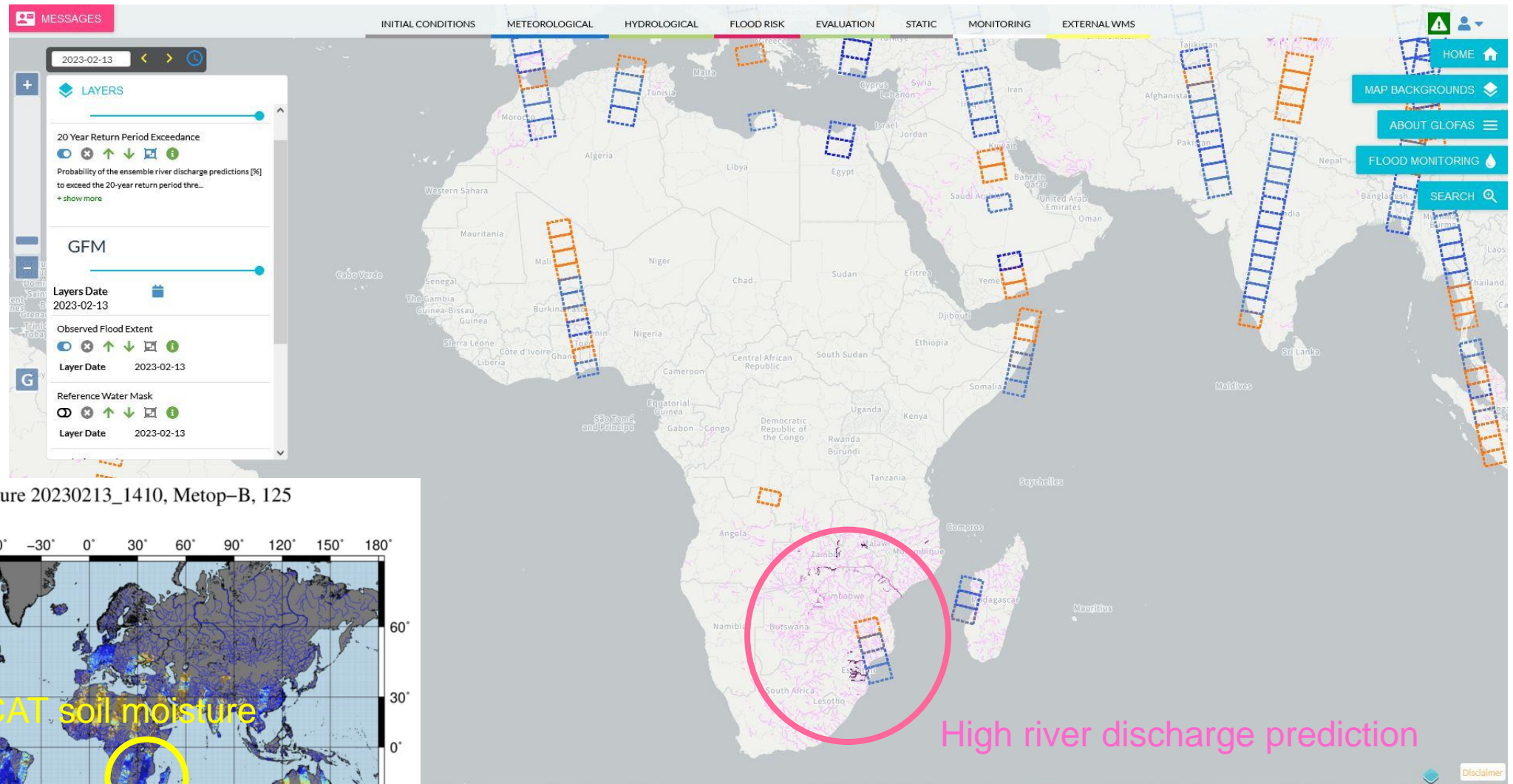
GLOFAS User Interface



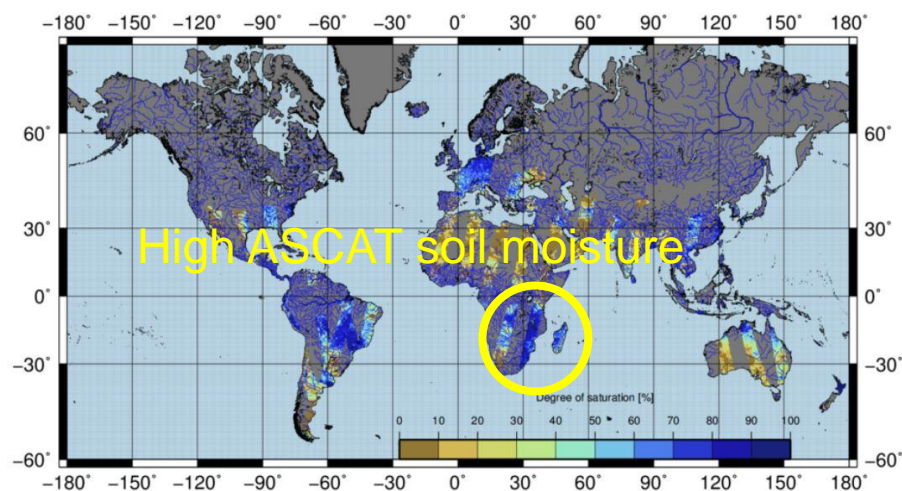
Overview of Sentinel-1 scenes for 13 February 2023

<https://www.globalfloods.eu/glofas-forecasting/>

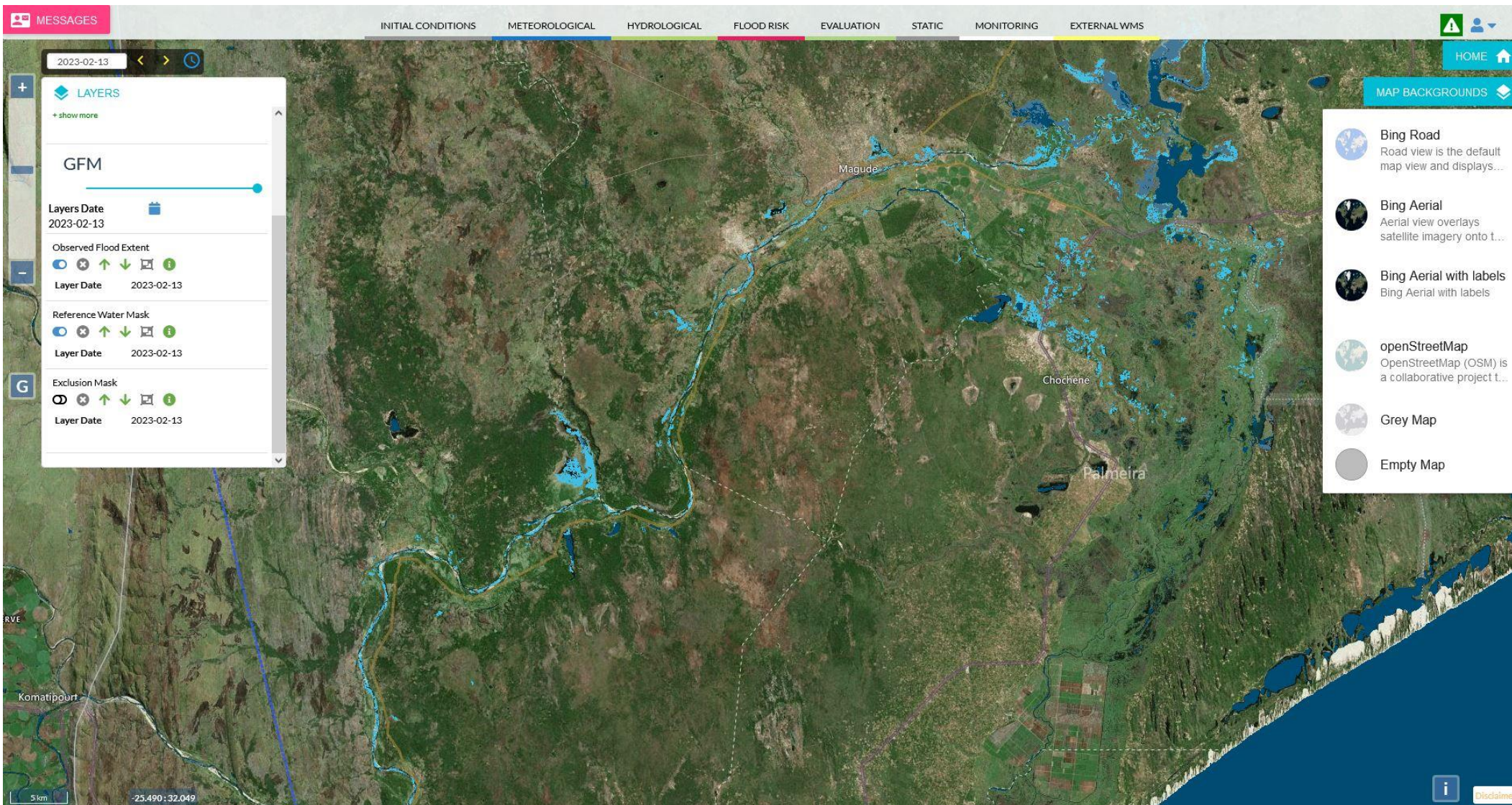
Soil Moisture and River Discharge over Africa on 13.2.2023



ASCAT soil moisture 20230213_1410, Metop-B, 125



Further Zooming into Flooded Areas 13.2.2023




← Different map background selected

Dark blue areas show permanent water bodies

Google FloodHub

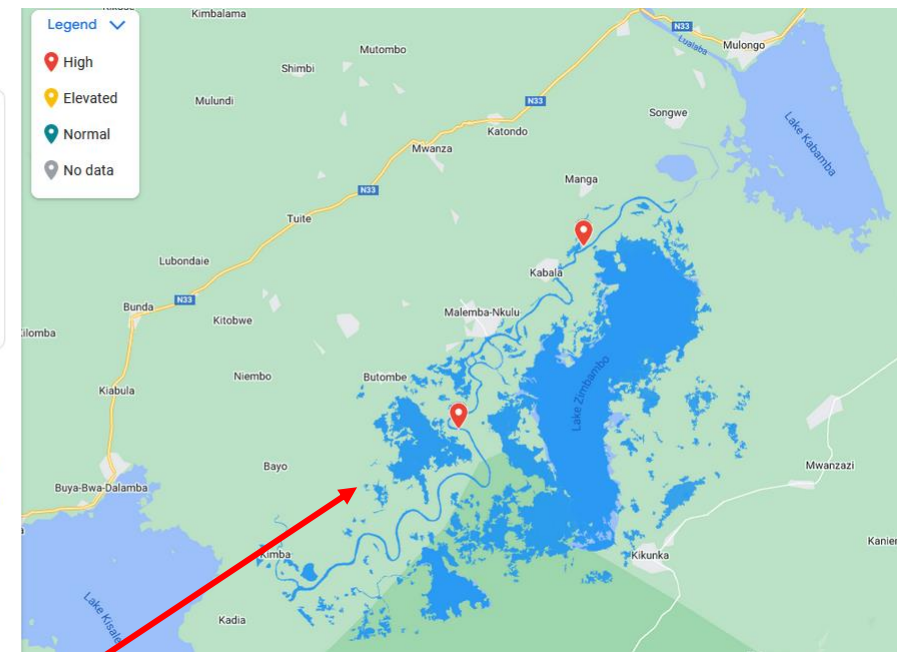
- River forecasts using public data and machine learning
- Satellite data for flood extent maps
 - Permanent water is also shown in deep blue in case of flooding

River forecast  expected to drop

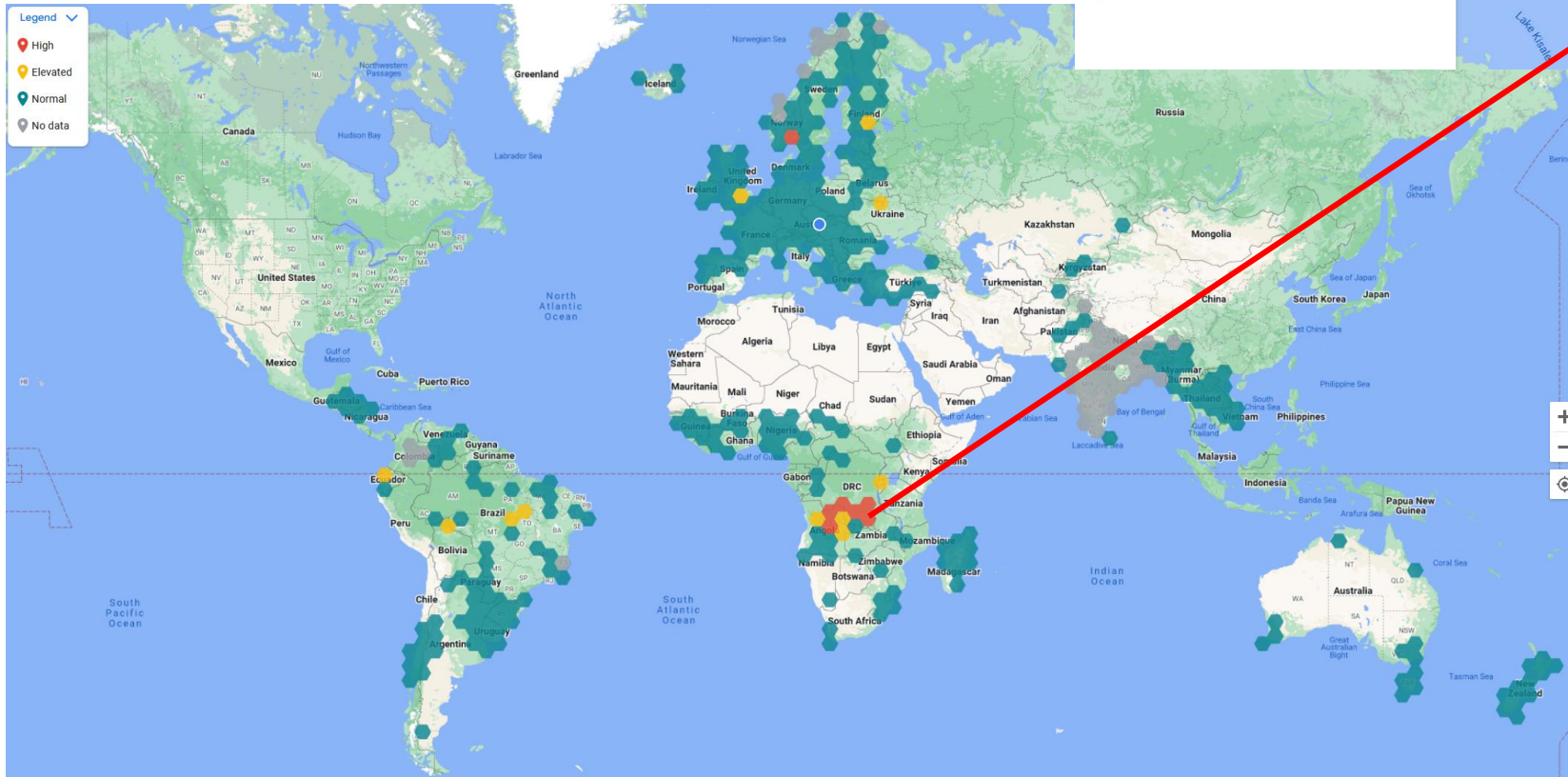


 Give us feedback

This map displays the approximate flood area based on Google Flood Forecasting models that use data from public sources such as ECMWF, NASA, and NOAA. You should not use the information presented on the website as a sole source of data as actual flood conditions may vary. Unless otherwise stated, the models do not use data provided by governmental entities, nor is Google Flood Forecasting project affiliated with, sponsored by, or endorsed by any governmental entity.

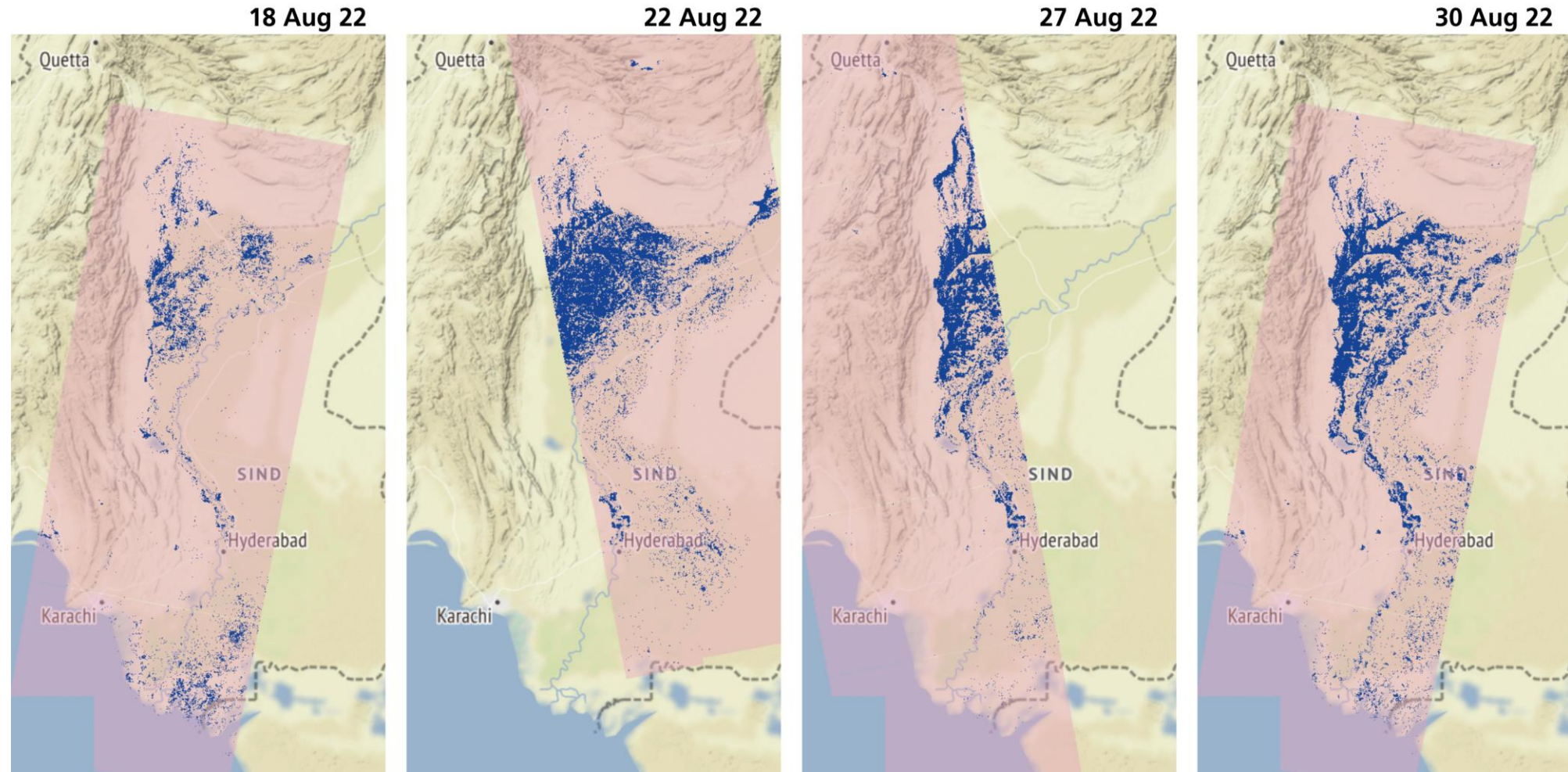


<https://sites.research.google/floods/>
Accessed on 26 April 2023



Pakistan Flood 2022

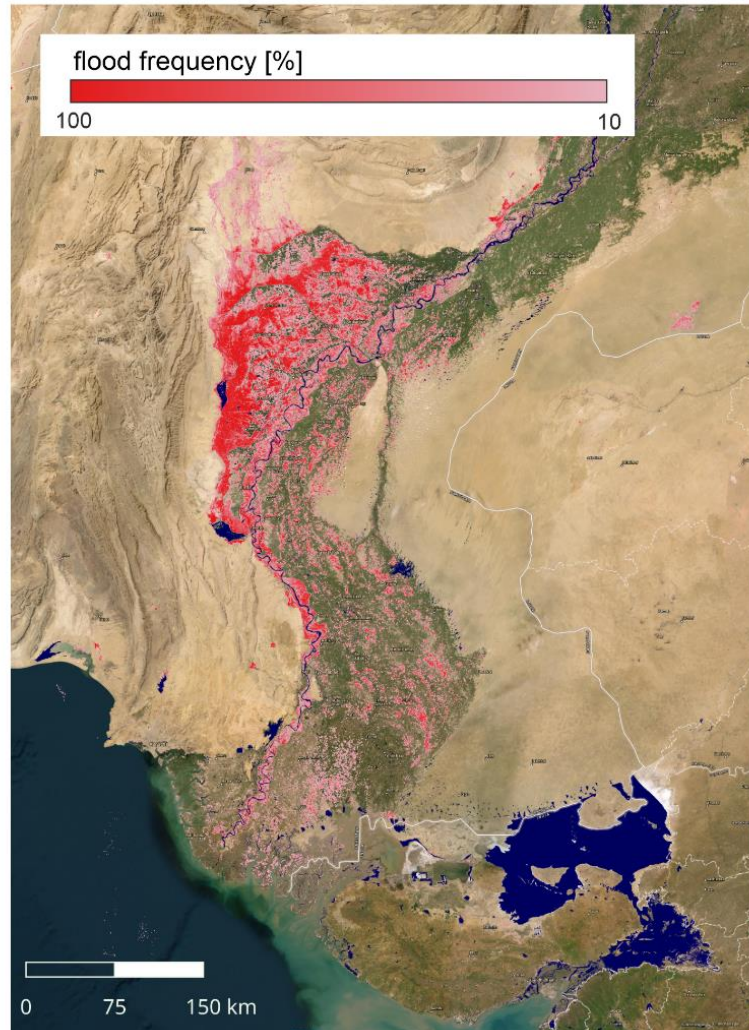
Flood progression covered by Sentinel-1 overpasses



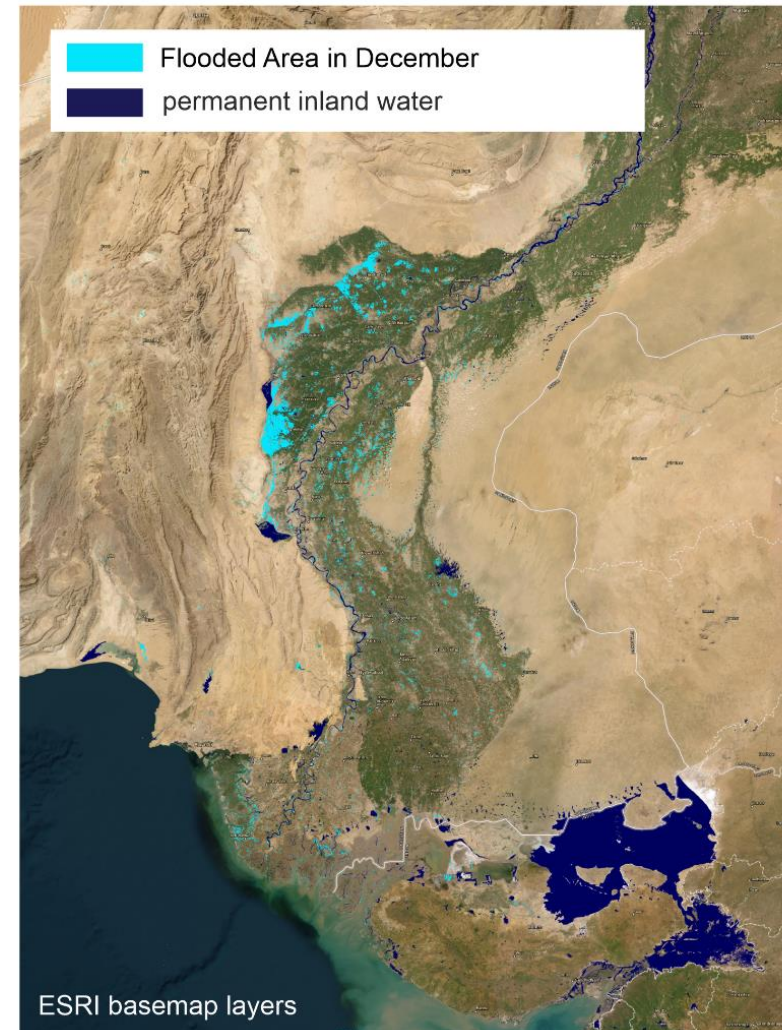
Roth et al. (2022) Sentinel-1 based analysis of the Pakistan Flood in 2022, EGU sphere [preprint], <https://doi.org/10.5194/egusphere-2022-1061>.

Pakistan Floods 2022 - Persistence into December

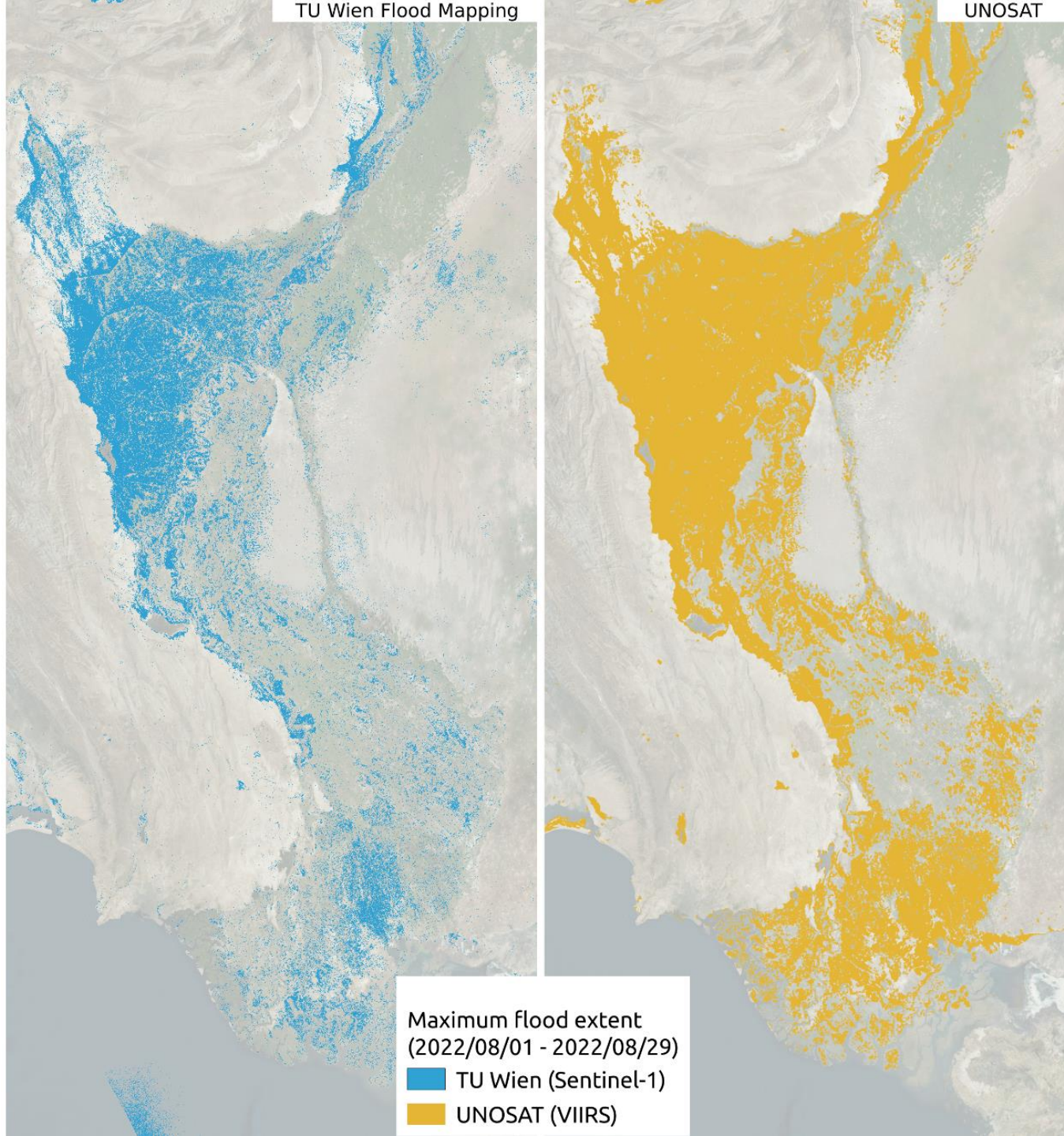
Flood maps based on TU Wien algorithm as part of the **CEMS Global Flood Monitoring (GFM)** ensemble product which automatically analyses images acquired by the **Copernicus Sentinel-1** radar satellite



flood frequency | Pakistan / Indus Valley
frequency of flood detection in period 18 Aug - 23 Sep 2022



remaining flood area
flood area remaining in period 1 Dec - 15 Dec 2022

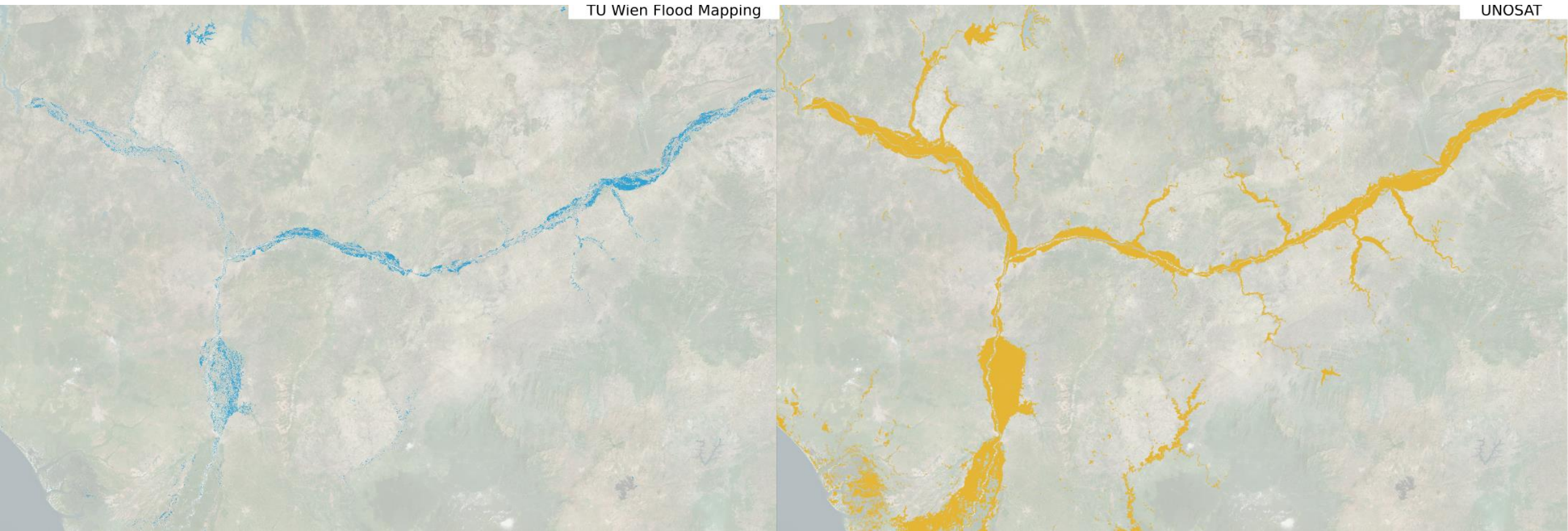


Comparison to UNOSAT

- UNOSAT result (FloodAI)
 - Visible Infrared Imaging Radiometer Suite (VIIRS)
 - Twice-daily global coverage at 400m
- Sentinel-1 maps only based in TU Wien algorithm

<https://unosat.org/products>

Nigeria Flood 2022



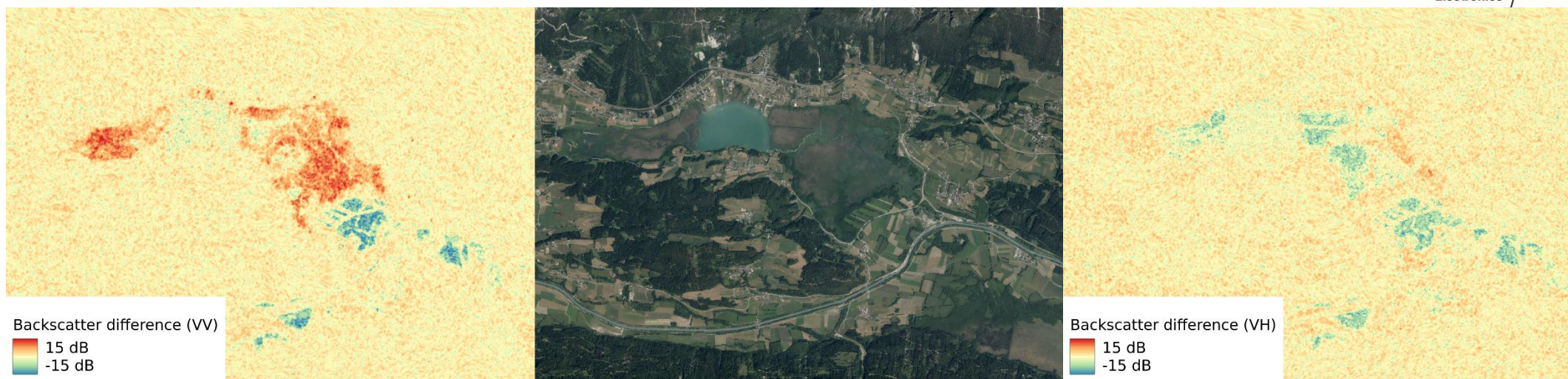
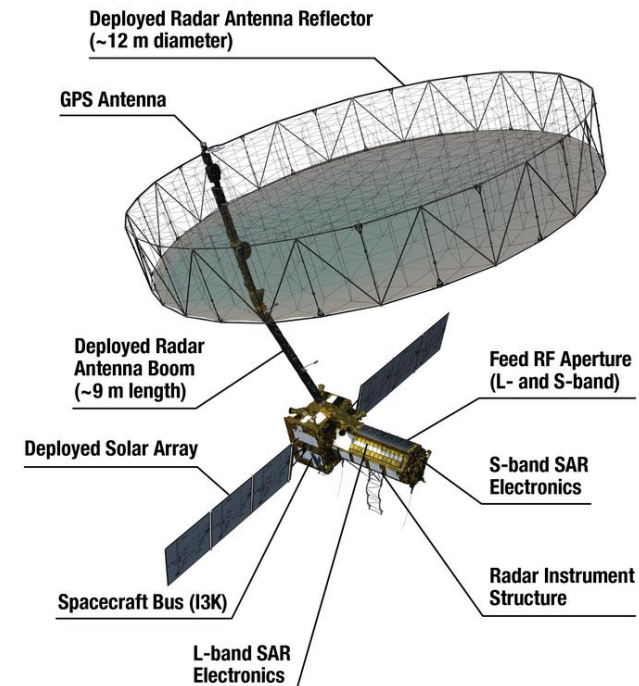
Flood maps based upon Sentinel-1 (left) and VIIRS (right) data from the period 1 to 25 October 2022.

Next Steps

**Federal Ministry
Republic of Austria**
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

**Federal Ministry
Republic of Austria**
Agriculture, Regions
and Tourism

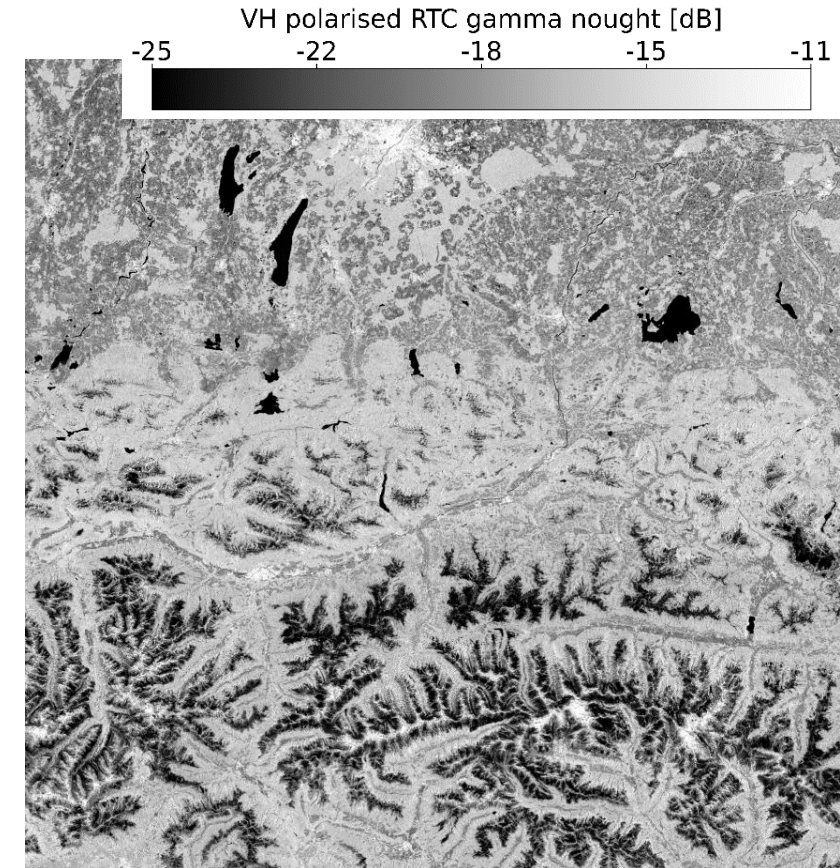
- **ScaleFloods** Project
 - Prepare for ROSE-L using data from NISAR
- **S1Floods.AT** Project
 - Improved flood mapping component for Austria



Inundated vegetation may be detected from increased VV backscatter (left) and decreased VH backscatter (right).
Sentinel-1 image from 2018/11/02 for a small-scale flooding of the river Gail in southern Austria.

Improvements of Pre-Processing Workflows

- Move towards new Analysis Ready Data (ARD) standard
 - Terrain flattened γ_T^0 backscatter
 - Using wizard we can now process γ_T^0 images in 3 min instead of >60 min with SNAP
- Even if ESA will adopt the Sentinel-2 grid for Sentinel-1 we will stay at the Equi7Grid
 - Equi7Grid minimizes data volume, geometric distortions, and processing complexity
 - Sentinel-2's UTM grid overhead is about +33%
- Cooperation with DLR under discussion
 - Reprocessing starting from Level 0
 - Interferometric processing



Summary

- Benefits for society
 - In a crisis situation it is invaluable to have fast access to standard flood maps (without having to order the satellite data first)
 - Post-crisis the Sentinel-1 archive allows assessing flood severity, impacts, etc.
 - Satellite maps help in public communication (even if the harsh reality of the Pakistan flooding went unnoticed by many ...)
- Benefits for science
 - Focuses attention on the need to develop robust algorithms that work everywhere anytime
 - Masks where floods cannot be mapped due to physical reasons
 - Flood archive will be useful to check and improve high-resolution Earth system models as will e.g. be deployed within Destination Earth

Acknowledgements

*Copernicus: Emergency Management Service (CEMS) / FFG: ACube4Floods, S1Floods.AT, ScaleFloods /
ESA: S1GBM, EO Africa / BMBWF: Cloud4GEO*

