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Satellite Flood Monitoring

Radars on Sentinel-1 satellites for fully-automatic flood monitoring

Online Event | **Session 4** - Urban planning and disaster management
2020-09-02

Flood disasters

- Floods are the most frequent and costliest natural disasters worldwide.
- Losses & damages will increase
  - climate change will increase flood frequency
- Vulnaribility towards floods will increase
  - urbanisation & population growth
  - land cover change
  - inadequate infrastructure

United Nations Office for Disaster Risk Reduction (UNISDR)…

www.preventionweb.net/knowledgebase/disaster-statistics

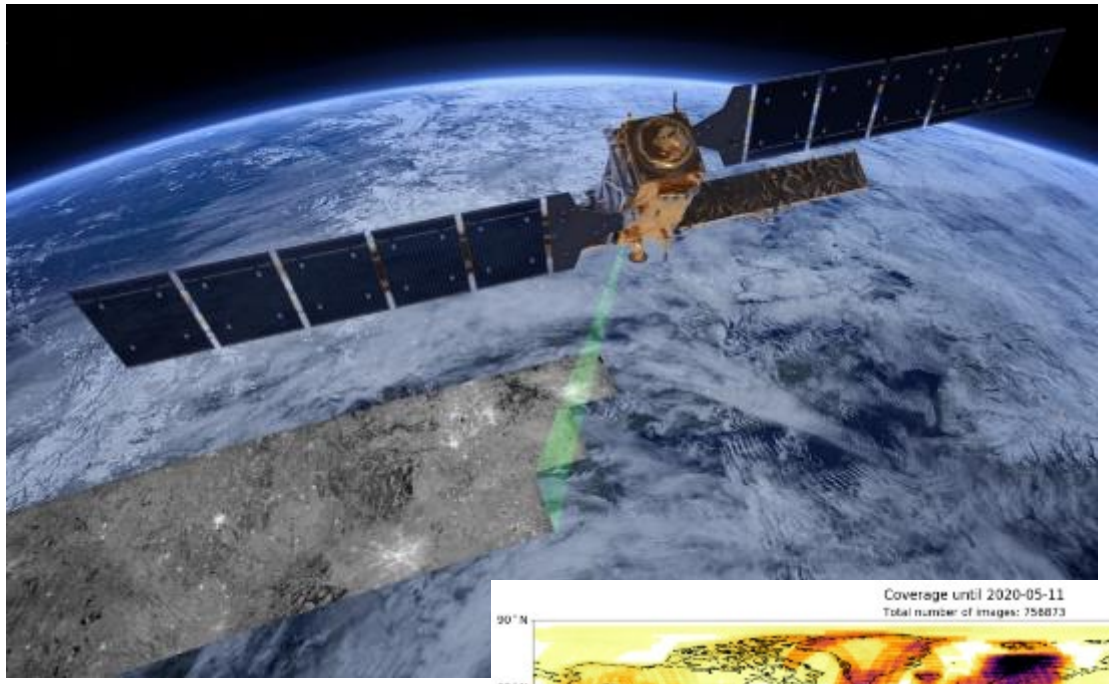
→ need for global, fast, and accurate mapping of flood extents!

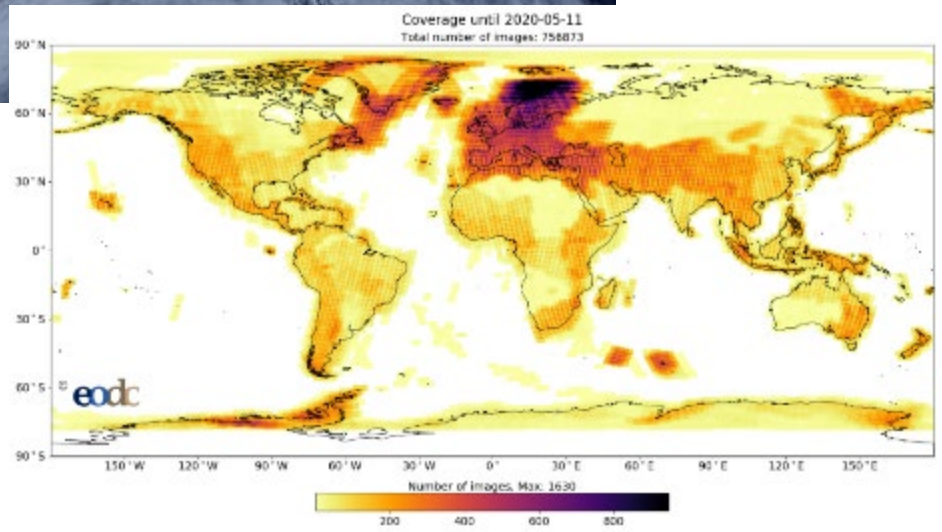
brings help for…

- affected people
- emergency units
- authorities
- prevention planers

Europe's Sentinel-1 radar satellite mission

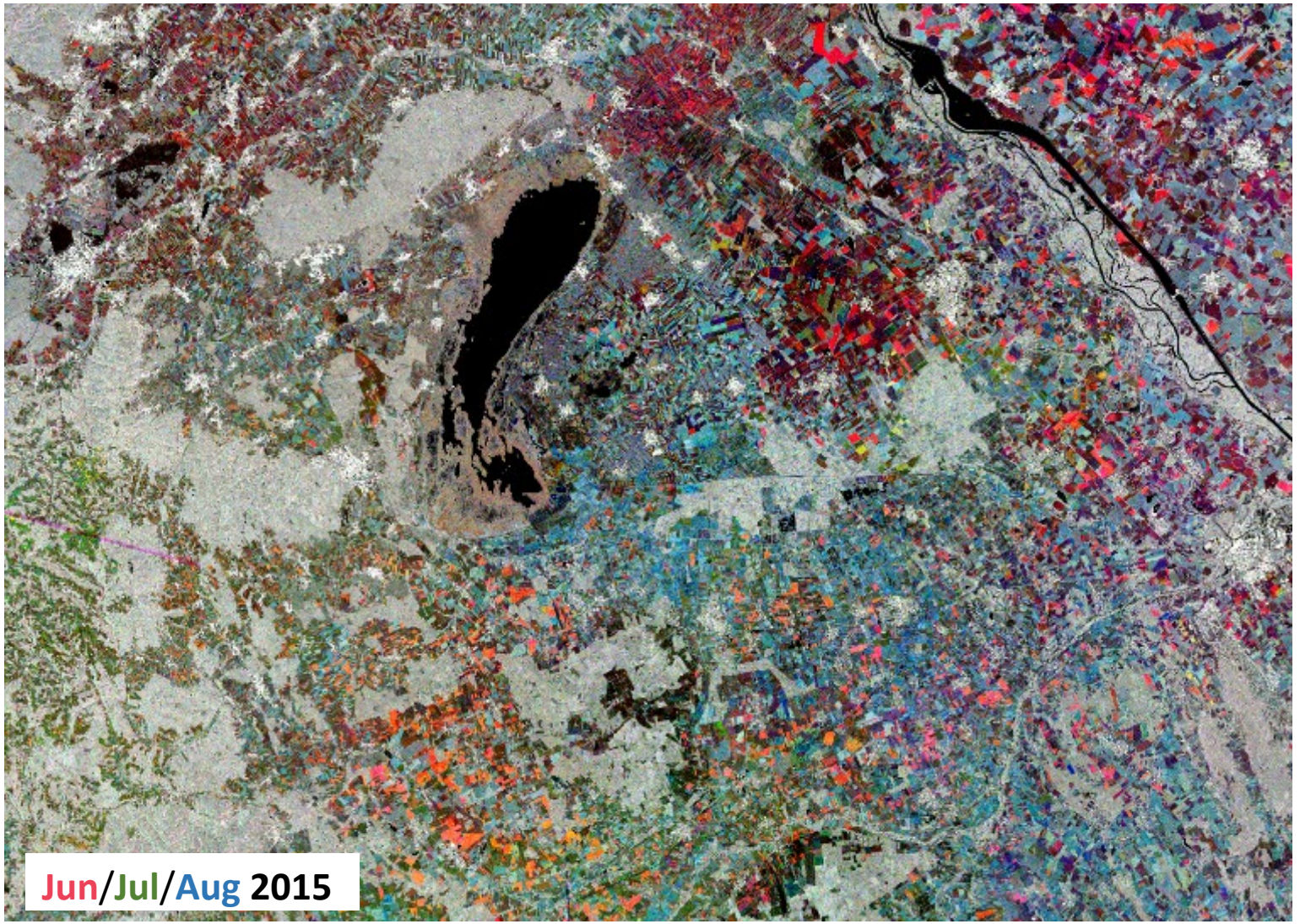
- Synthetic Aperture Radar (SAR)
  - 5.4 GHz microwaves
  - 2 Satellites in orbit
    - since 2014/16
- SAR is used for
  - topography, vegetation, soil moisture, water bodies
  - independend from weather, clouds, and daylight
- High-resolution radar imagery
  - 20m ground pixels
  - good „revisit time"
    - 1.5-4 days over Europe
    - 3-12 days global
  - → high data volume!
    - ~1TB per day
- Sentinel-1 is the first SAR mission capable of systematic & fully-automatic monitoring of floods



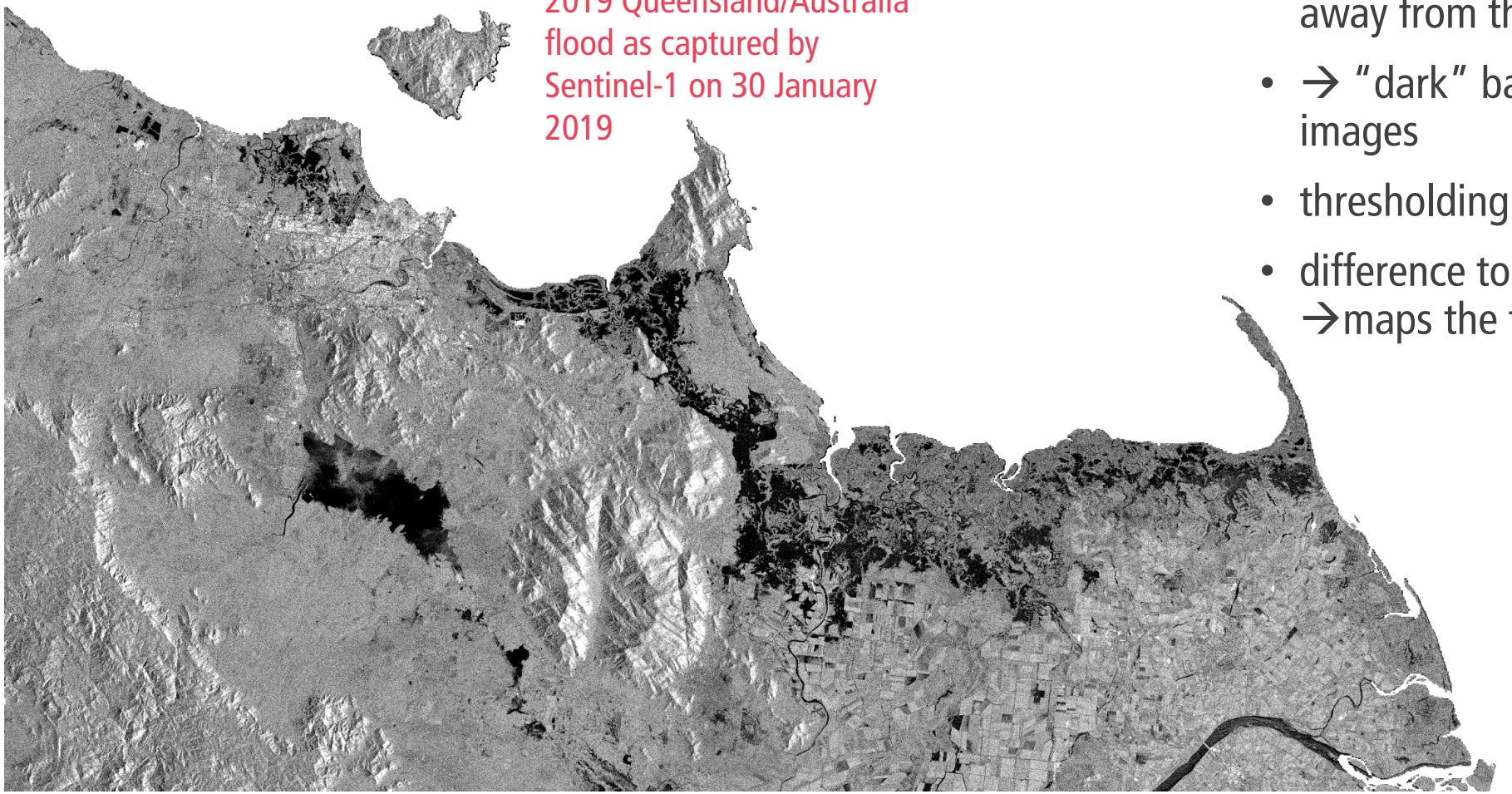


SAR data!?

- SAR imagery allow a different view on Earth's surface
- signal is built from the radar backscatter
  = the microwave echo received at the satellite sensor
- governed by the surface geometry and dielectric properties
  - local soil „roughness"
  - wetness
  - vegetation structure
  - …



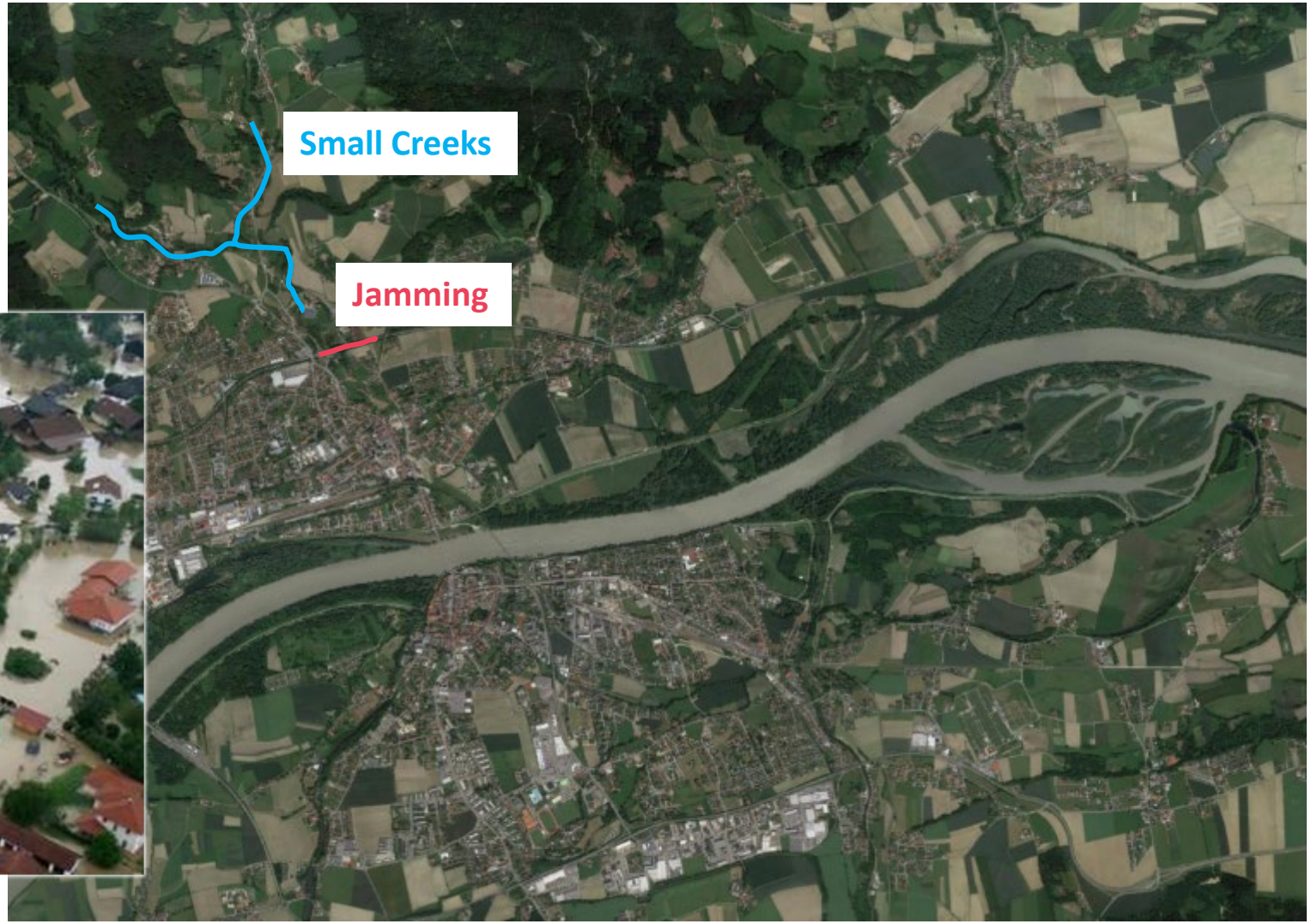
SAR flood mapping principle



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

- Calm, open water reflects radar pulses mostly in the forward direction, i.e. away from the satellite sensor
- → "dark" backscatter in the SAR images
- thresholding can map water surfaces
- difference to previous conditions →maps the flooded areas

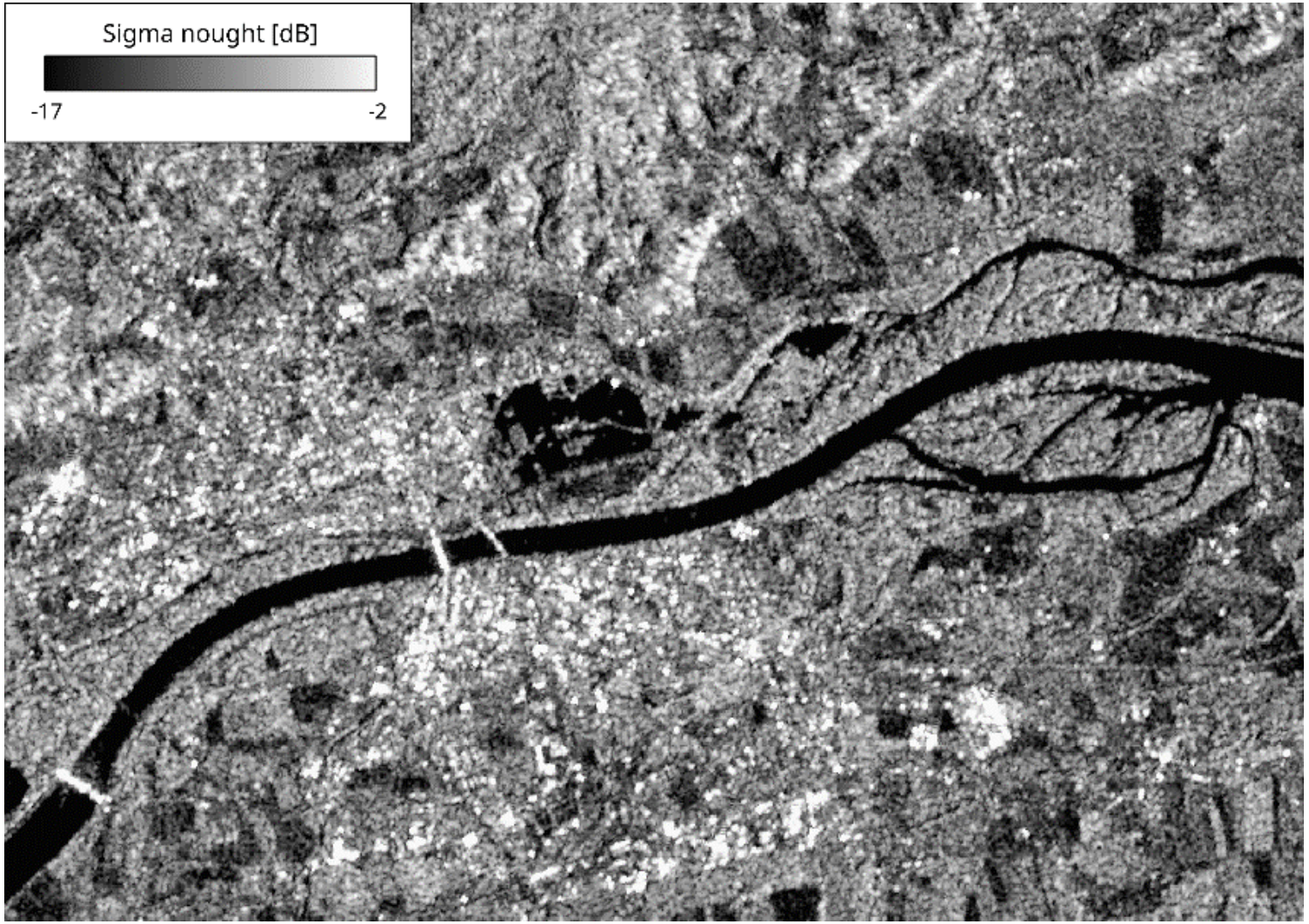
Flood in Simbach/GER | 2016 June 1



https://www.mittelbayerische.de/bayern/niederbayern-nachrichten/nach-der-flut-wenn-die-seele-ueberlaeuft-21764-art1458246.html

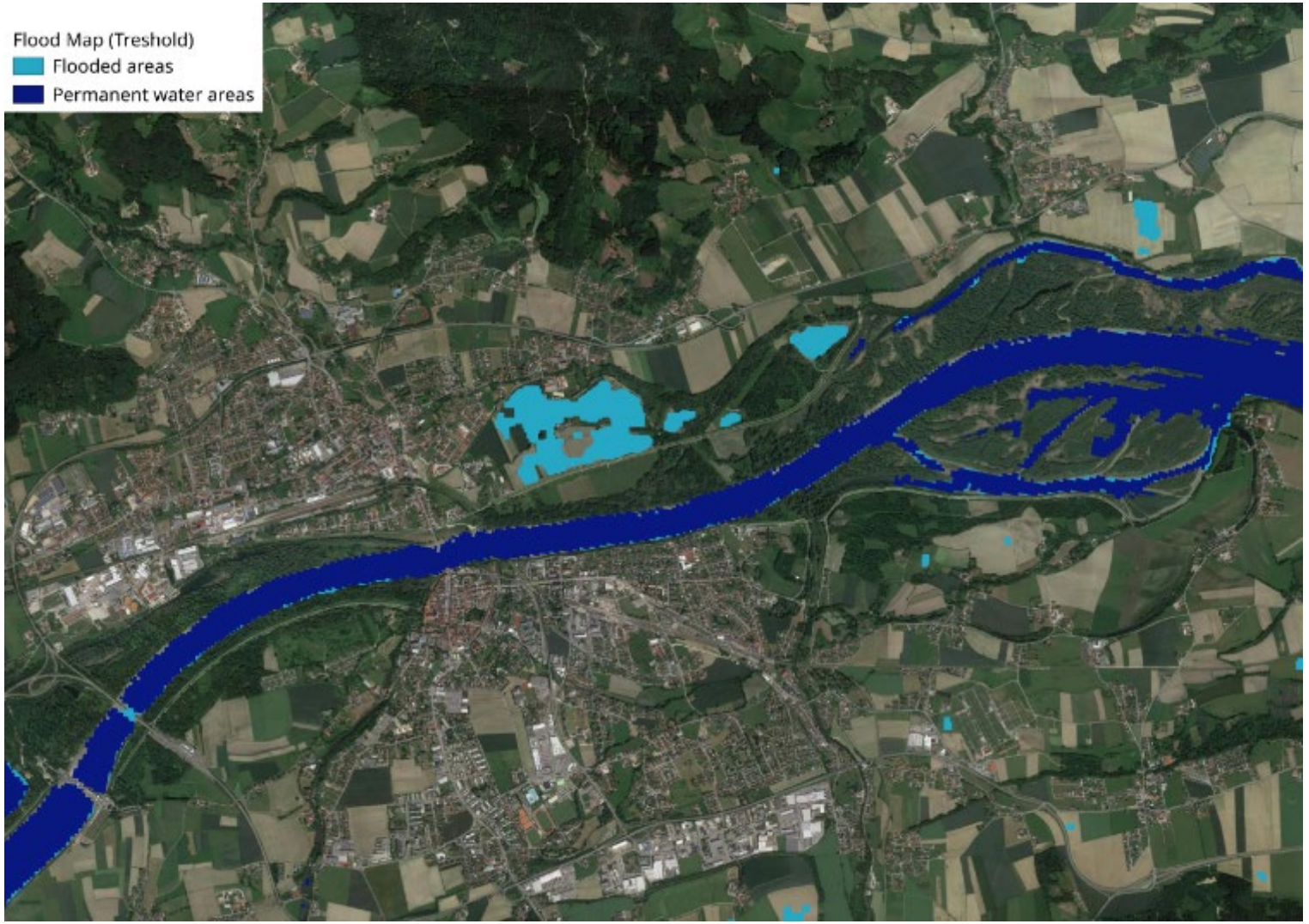
Flood in Simbach/GER | 2016 June 1

- Sentinel-1 image of Simbach (Germany) and Braunau (Austria)
  - at the banks of the river "Inn"
  - acquired on 3.6.2016



Flood in Simbach/GER | 2016 June 1

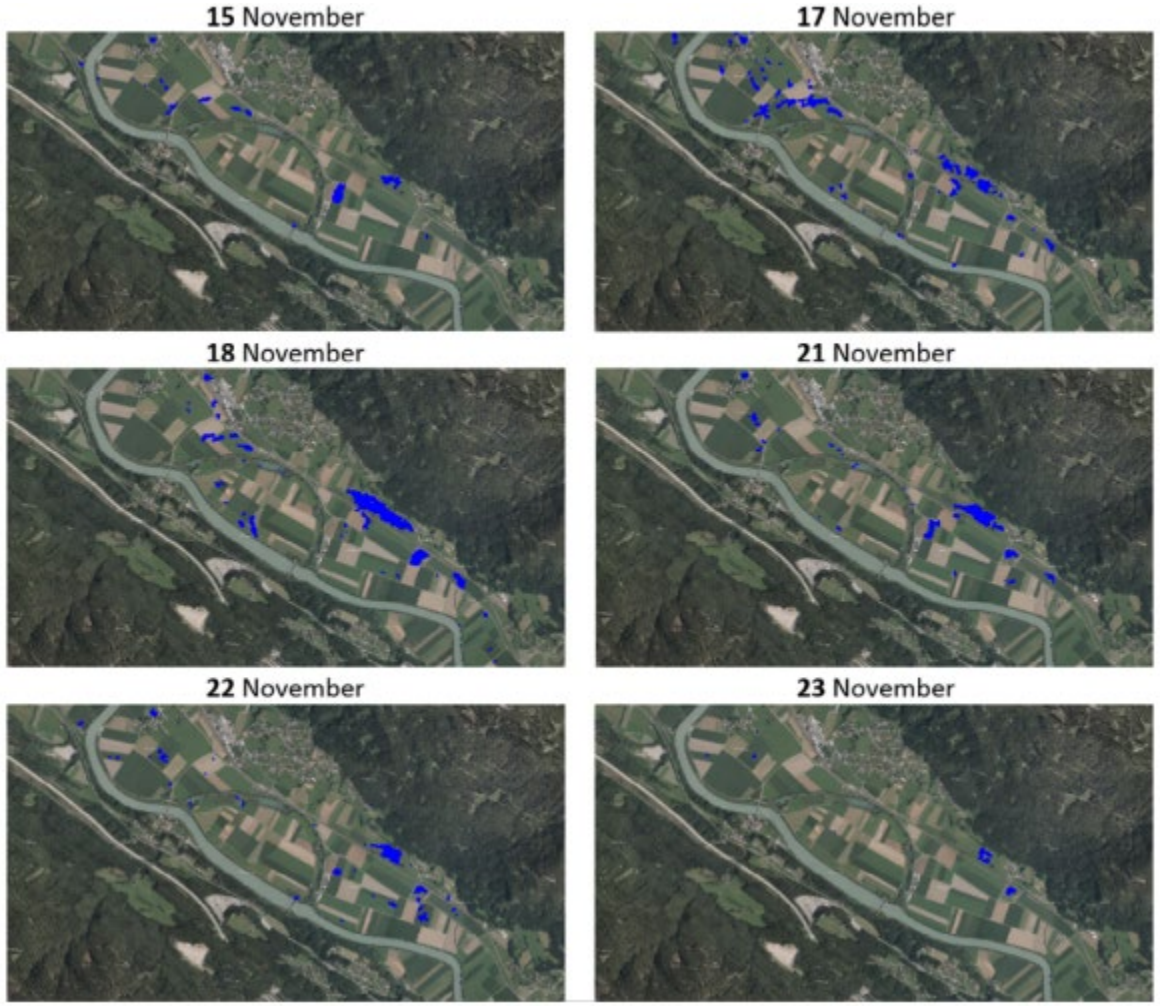
- Flooded areas left on 3.6.2016
  - through application of -17dB as threshold to the Sentinel-1 backscatter image
- BUT: caveats of simple thresholding…
  - False negatives due to high backscatter over inundated areas
    - rough water surface (wind!)
    - vegetation over water
  - False negatives over non-sensitive areas
    - dense vegetation
    - double bounces in urban areas
  - False positives over other low backscatter areas
    - dry grasslands
    - smooth fields
    - asphalt
    - radar shadow
- → mask and uncertainty layers required!



Satellite datacubes for flood monitoring

- a datacube comprises co-formated spatial data and provide also access via the time axis
- Advantages
  - Users get both real-time and historic data
    - "Permanent" water reference layers are available
  - Flood mapping algorithm can be calibrated
    - e.g. through advanced change detection & machine learning
  - Uncertainty can be specified
  - Exclusion areas can be derived
    - → known unknowns
- Disadvantages
  - Petabyte-scale storage needed
  - High performance computing needed for re-analysis
  - complex hard-/software

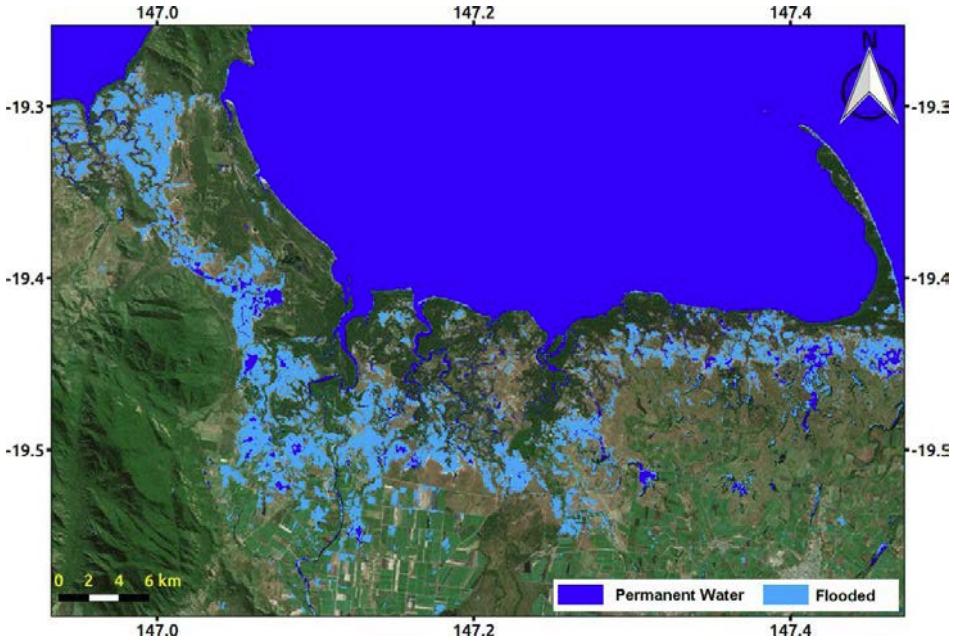
ACube4Floods

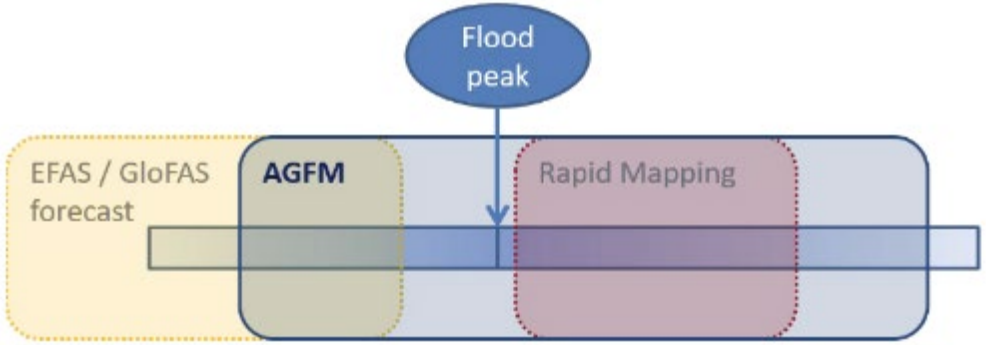


Progression of the November 2019 flooding along the river Drau near Weißenstein in Carinthia, Austria, for the period 15 to 23 November 2019, as captured by Sentinel-1

Copernicus: Automated Global Flood Monitoring (AGFM)

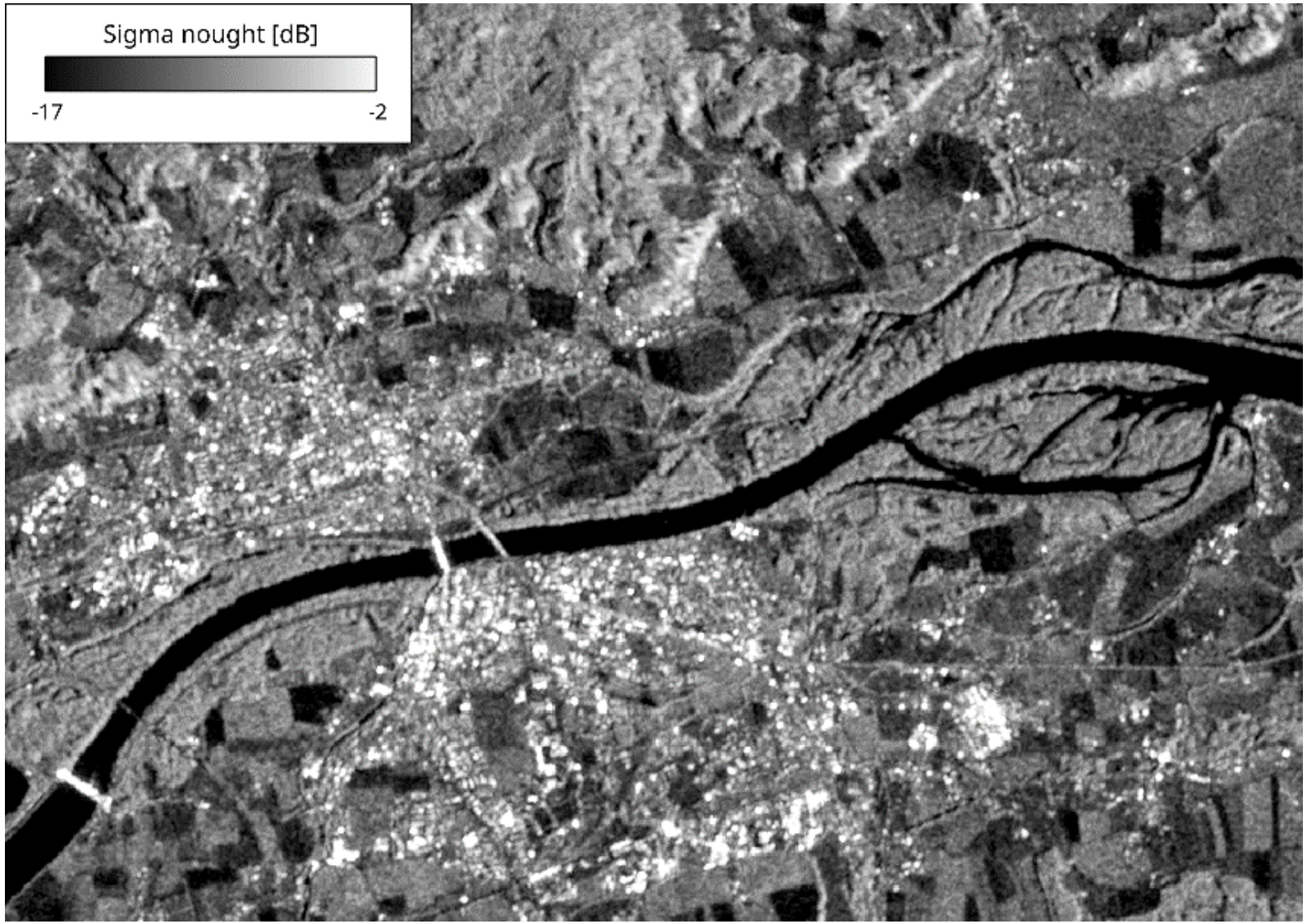
- EU Commission / JRC will setup a new flood monitoring component
  - within the Copernicus Emergency Management Service (CEMS)
- Expert Group in 2020: JRC Feasibility Study for SAR flood mapping
  - Matgen et al. (2020) Feasibility assessment of an automated, global, satellite-based flood monitoring product for the **Copernicus Emergency Management Service**, EUR 30073 EN, Publications Office of the European Union, Ispra, 2020, doi:10.2760/653891
  - identified scientific challenges
  - identified user requirements
  - proposed the monitoring service layout, using datacube architecture
    - 20m pflood mapping
    - global and systematic coverage
    - fast automatic production & good „timeliness"
      - 8-12h after sensing
    - exclusion layer
    - product uncertainty
    - advisory flags
- in 2021: phasing-in of the AGFM





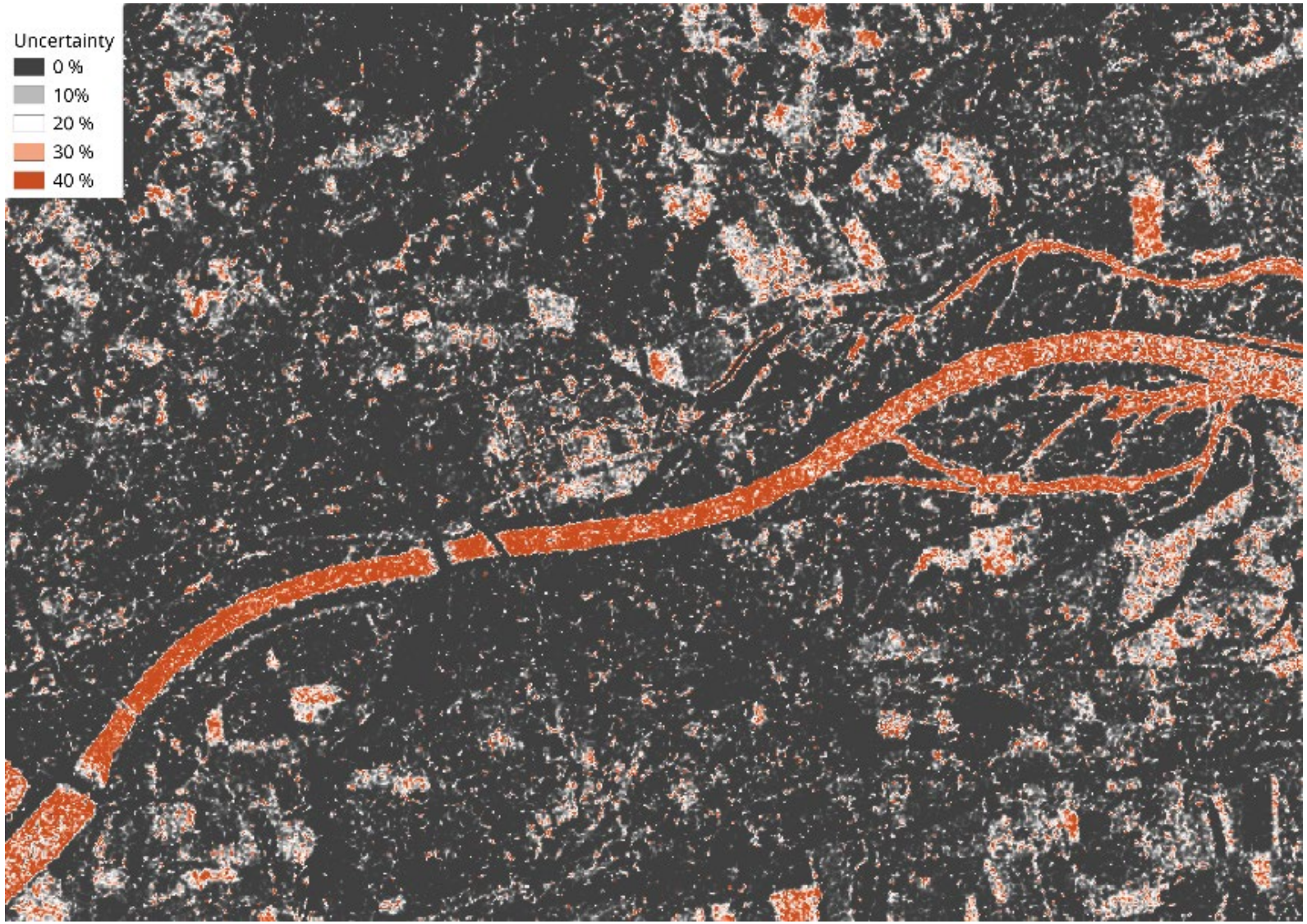
Simbach flood – as from datacube approach

- Synthetic reference image based on Sentinel-1 Data Cube analysis (mean backscatter for the year 2016)



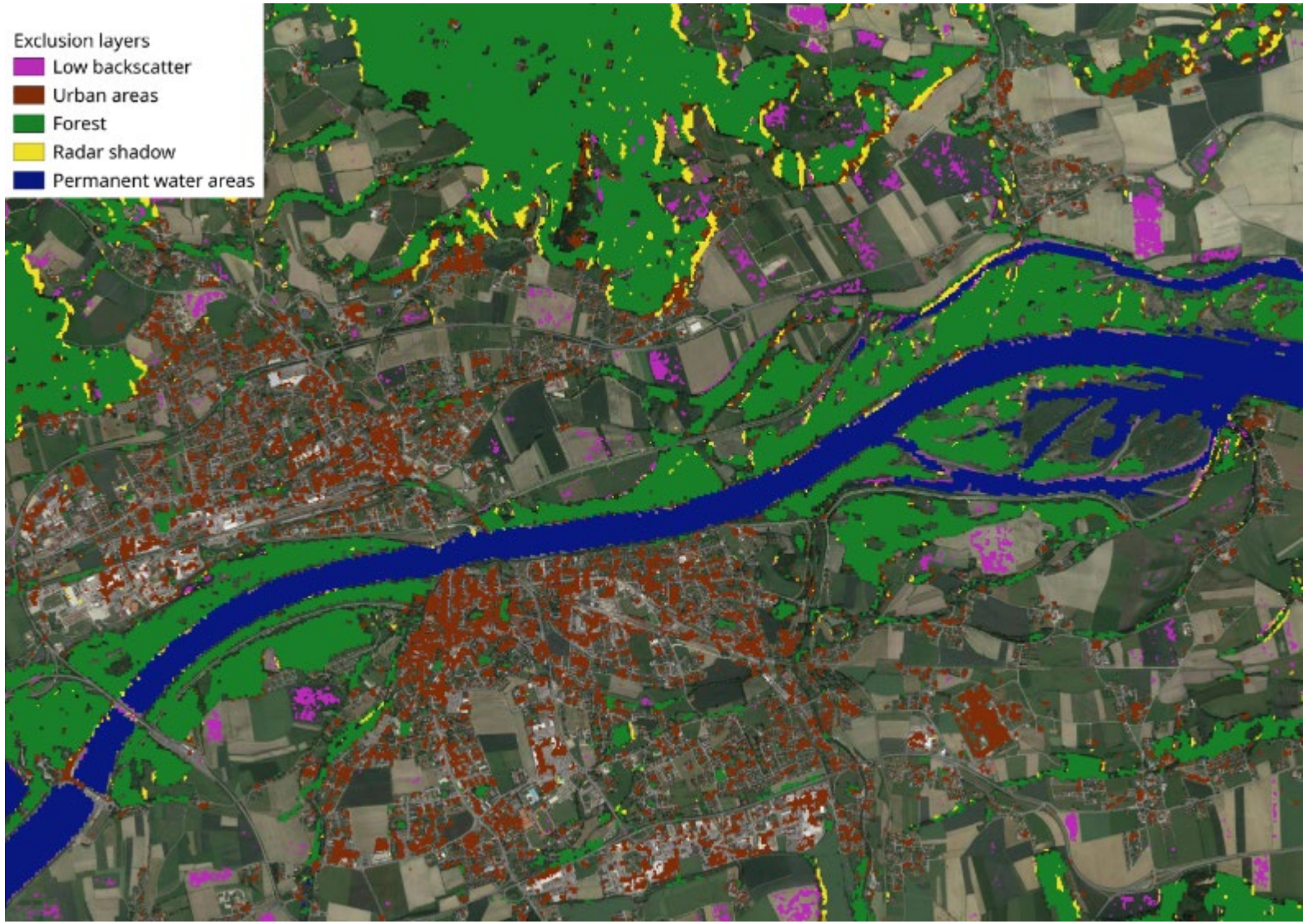
Simbach flood – as from datacube approach

- Uncertainly for water/no-water classes as derived from Sentinel-1 image acquired on 3.6.2016



Simbach flood – as from datacube approach

- Exclusion layers for Sentinel-1 flood product



Simbach flood – as from datacube approach

- Sentinel-1 flood map of Simbach on 3.6.2016 with exclusion layer

Conclusions

- Satellite observations provide „bird's eye" information on flood situations
- Optical sensors are often impeded by bad weather or clouds
- Radar sensors, and especially the operational Sentinel-1 SAR mission, allow monitoring of global water and flood surfaces
  - multiyear datacubes enable masking and uncertainty info through enhanced analysis
- EU Commission-JRC / Copernicus will setup an Automated Global Flood Monitoring (AGFM)
  - based on high performance computing applied on a Sentinel-1 datacube
    - 20m pflood mapping
    - global and systematic coverage
    - fast automatic production & good „timeliness"
      - 8-12h after sensing
    - exclusion layer
    - product uncertainty
    - advisory flags
  - Copernicus CEMS: https://emergency.copernicus.eu/

Acknowledgements

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