EODC Forum 2021

2021-06-08

VIENNA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF GEODESY AND GEOINFORMATION
RESEARCH GROUPS PHOTOGRAMMETRY & REMOTE SENSING

Bernhard Bauer-Marschallinger &
many colleagues from **TU Wien** and **EODC**

Global Sentinel-1 data collections in EODC's datacube

the basis for the Copernicus Global Flood Monitoring (GFM) Service

Copernicus Europe's eyes on Earth

JRC EUROPEAN COMMISSION

CEMS

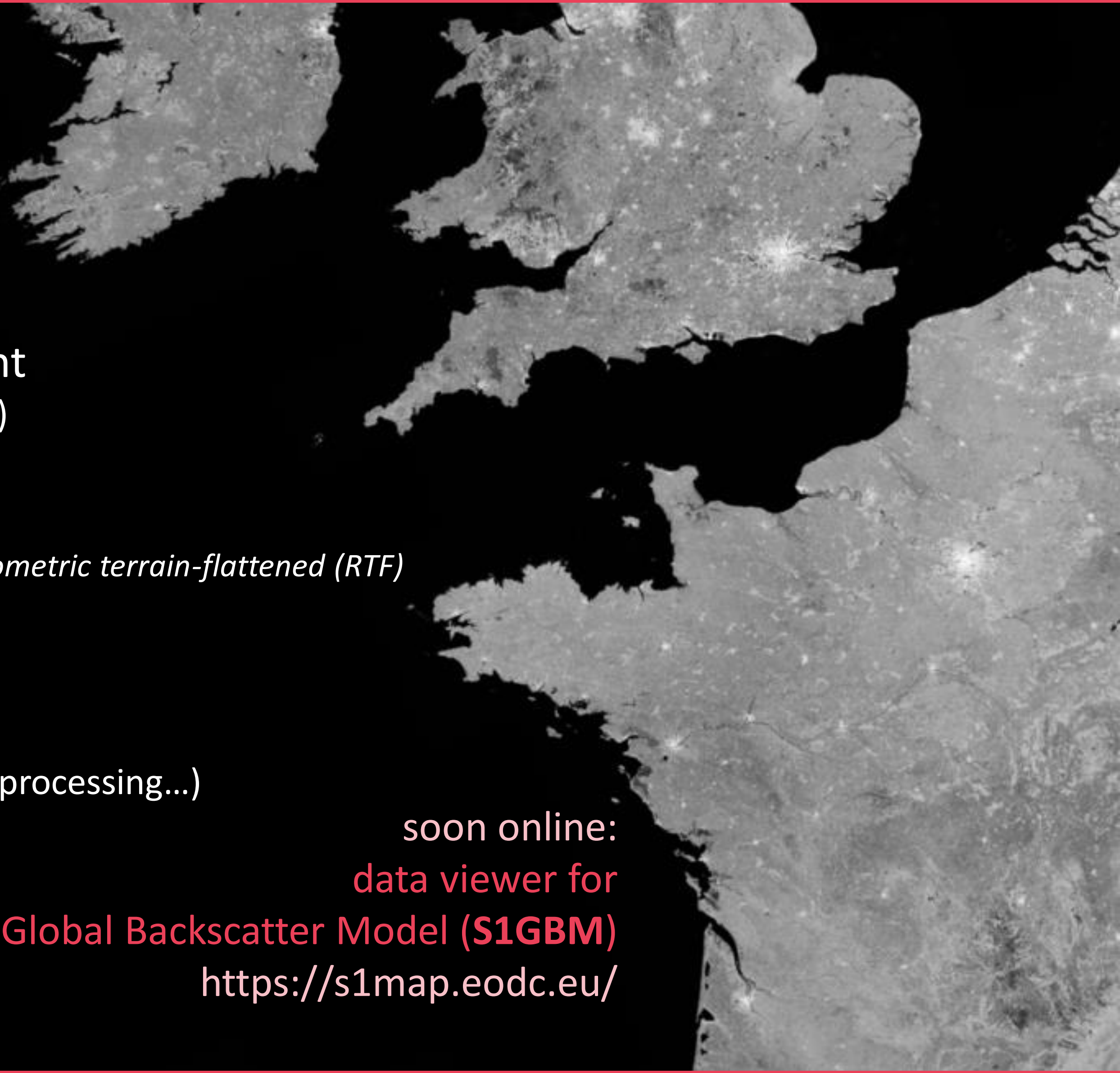
Sentinel-1 datacube activities at Vienna

- Overview on infrastructure at EODC/TU Wien, Sentinel-1 data cube, and it‘s applications
  - *Wagner et al. (2021) A Sentinel-1 Data Cube for Global Land Monitoring Applications, Big Data from Space 2021 (BIDS’21), 18-20 May 2021*

- Global mosaicking + details on the preprocessing, data management, and quality curation:
  - *Bauer-Marschallinger et al. (2021) The normalised Sentinel-1 Global Backscatter Model, mapping Earth’s land surface with C-band microwaves, Nature Scientific Data, in review.*

- Today: focus on preprocessing activities, data collection status, temporal parameter examples, uptake in Copernicus GFM operational service

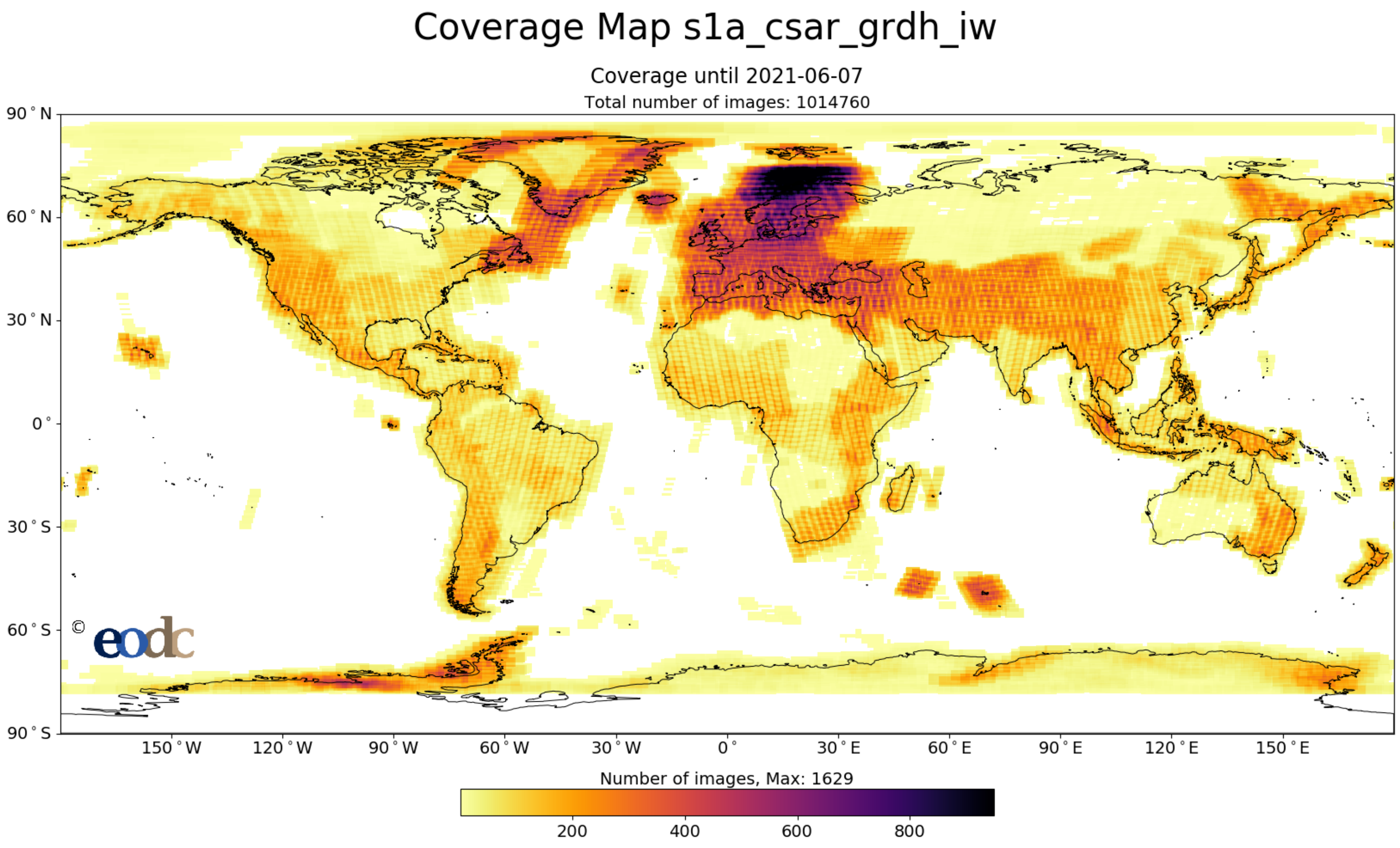
Sentinel-1 in EODC‘s data cube



- S-1 backscatter data for all continents (ex. Antarctica)
  - overal aim: serving land monitoring applications
  - covering the archive **starting 2015**
  - constantly being **updated in NRT**
  - + maintained + quality checked
- Sentinel-1 **SIG0** (sigma nought) backscatter coefficient
  - **Interferometric Wide** (IW) swath Ground Range Detected (GRD)
  - VV & VH polarisation
  - fully pre-processed → ARD-like
    - *but not compliant to CARD4L, as holding* ***sigma nought*** *instead of radiometric terrain-flattened (RTF) gamma nought*
  - **30m Copernicus DEM**-based terrain-correction
- **20m** pixel sampling
  - improved image quality (less speckle) + reduced costs (storage, processing…)
  - co-registrated and co-formatted
  - **tiled + stacked images** in Equi7Grid
  - three-dimensional data access
  - additional layers and by-products (mean, incidence angle, etc.)

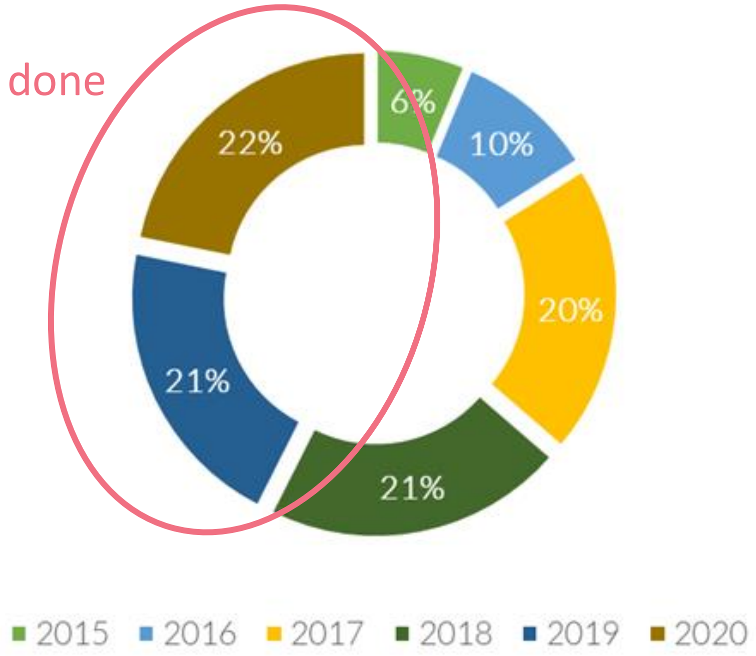
soon online:
data viewer for
Sentinel-1 Global Backscatter Model (**S1GBM**)
https://s1map.eodc.eu/

Sentinel-1 archive @ EODC

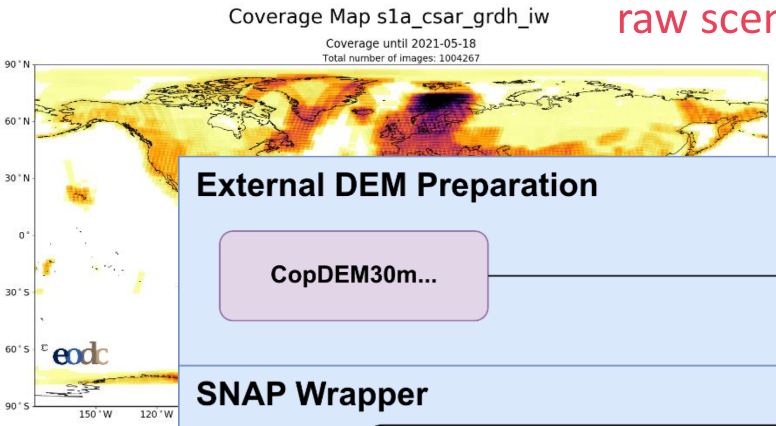


https://eomex.eodc.eu/cm

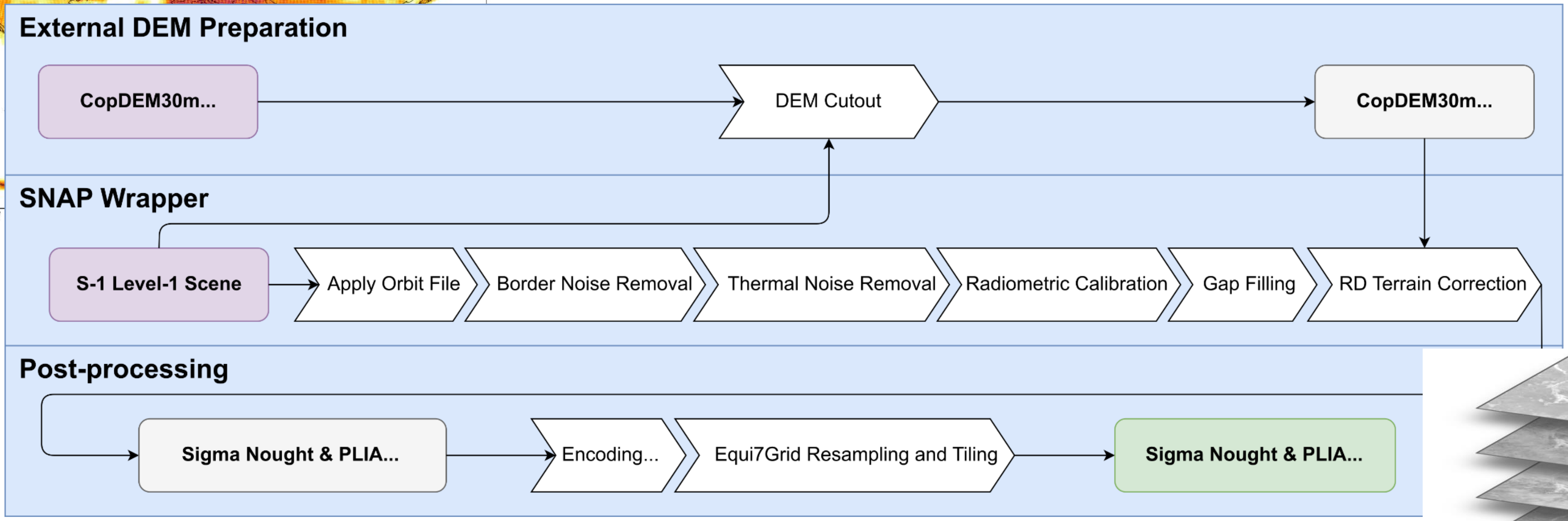
- Number of images since launch of satellites
  - S1A ~ 1 million
  - S1B ~ 0.6 million
  - each ~1 GB
- Sentinel-1 observations over land
  - ~1.6 PB for Level 1 IW GRDH

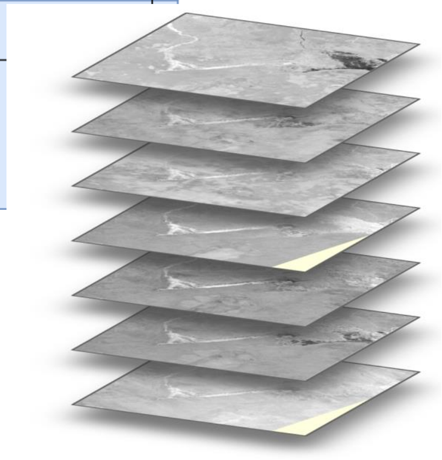


Sentinel-1 SAR pre-processing



raw scenes





preprocessing engine

for reprocessing: employed on VSC-3/4

heavy I/O activity on EODC Storage

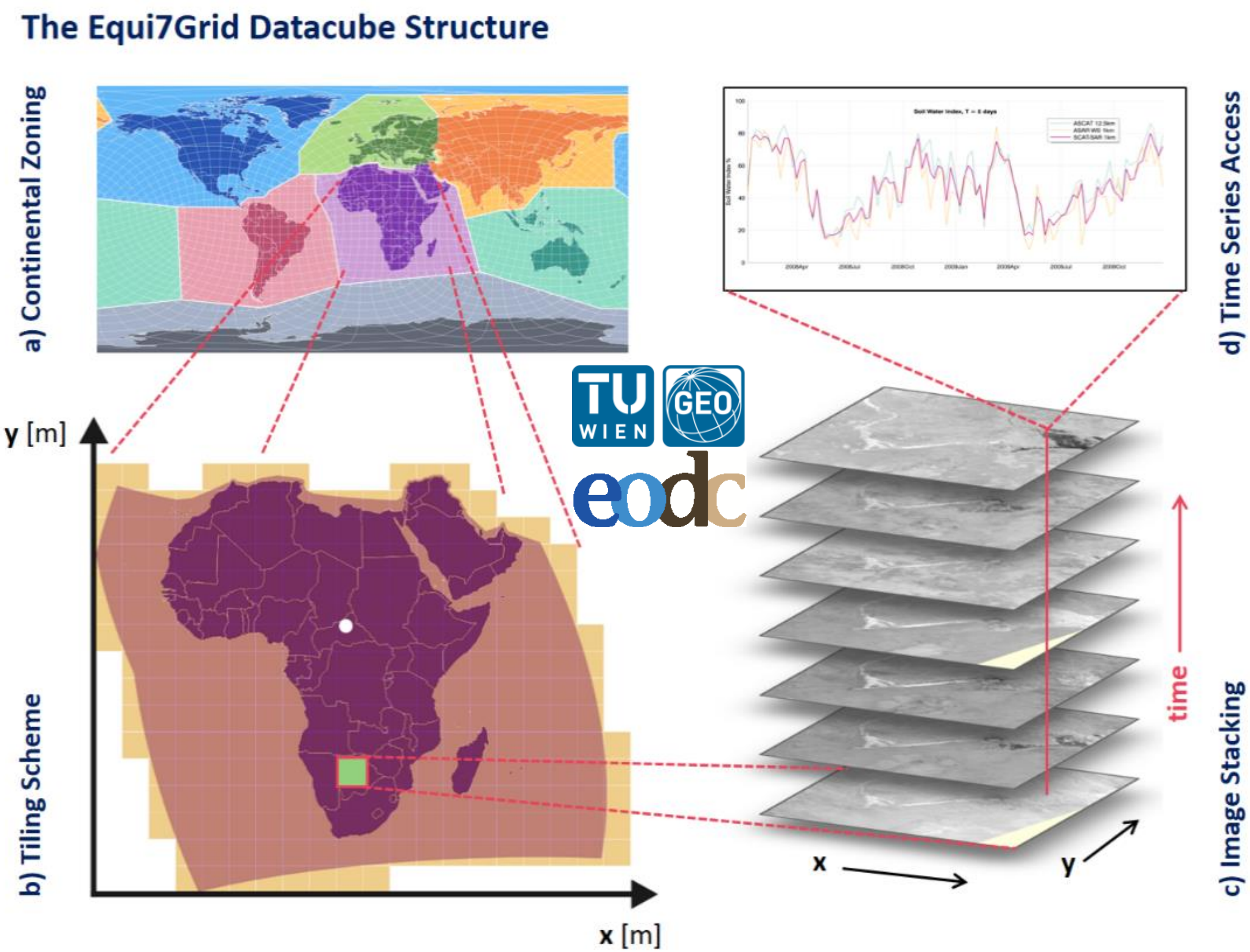
outlook: SNAP 8 potentially increases speed (for mid latitudes) by factor 2!

datacube

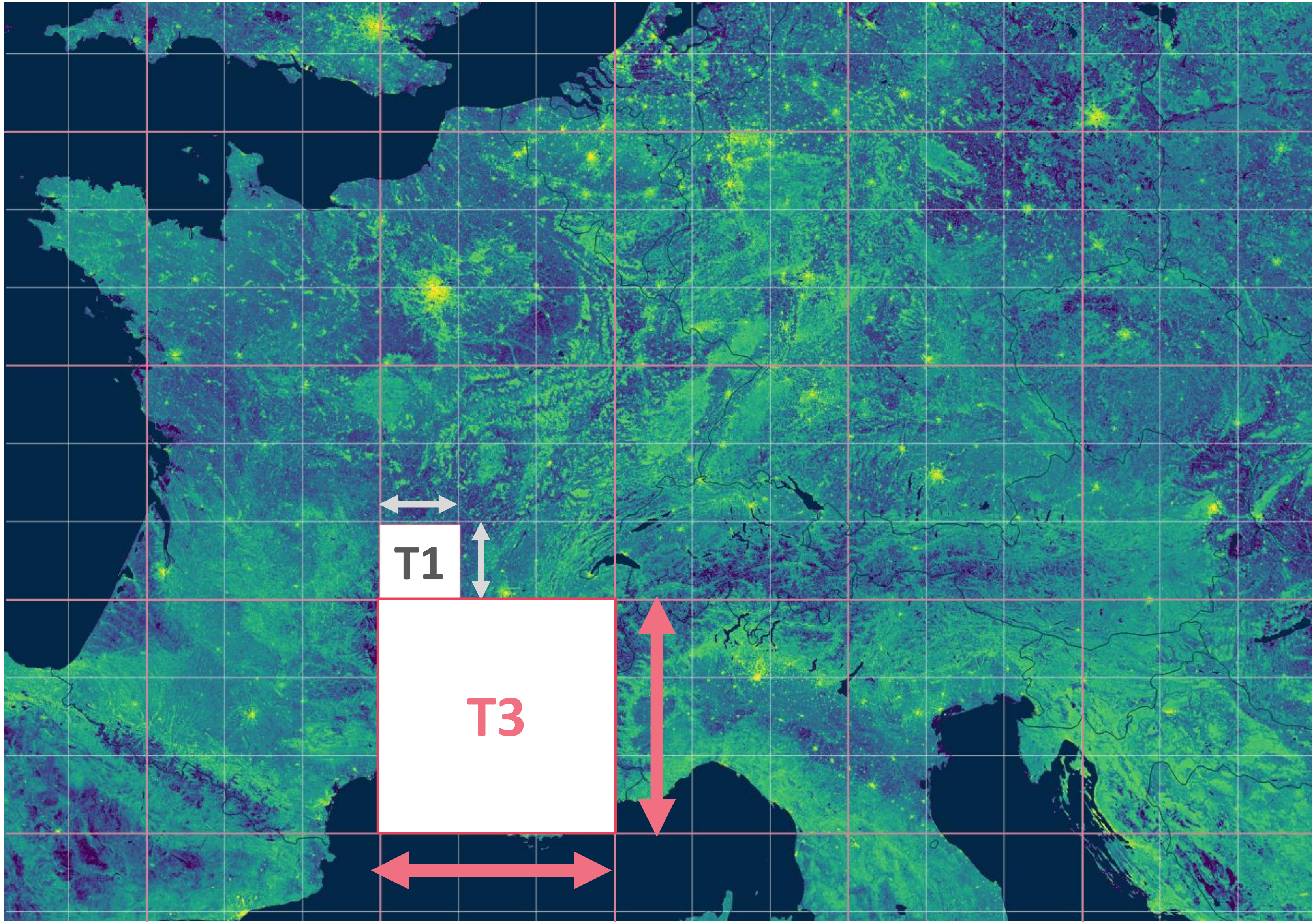
gridding & tiling

- storing, processing, analysis, and display is ideally in one single system
- data tiling allows direct parallelisation
- → with **Equi7Grid** little geometric distortions and ~2% geospatial overhead
  - with **Latlon** ~36% through oversampling
  - with **UTM/MGRS** ~30-50% through massive overlapping, when used as by S-2
  - only 7 zones (compare with UTM: 62 zones)
  - https://github.com/TUW-GEO/Equi7Grid

GitHub



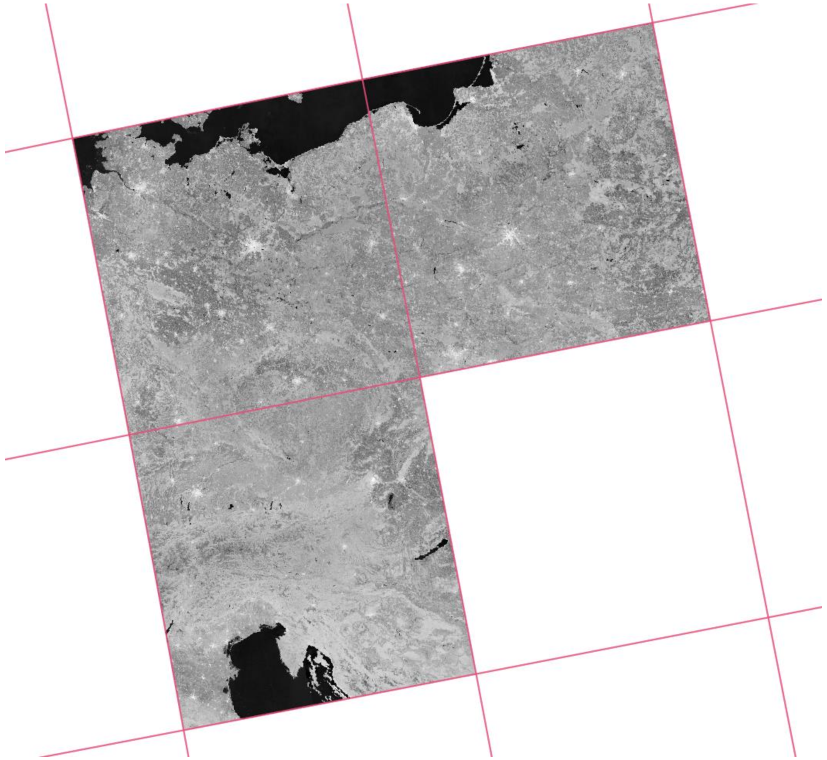
Sentinel-1 data collections – used tile structure



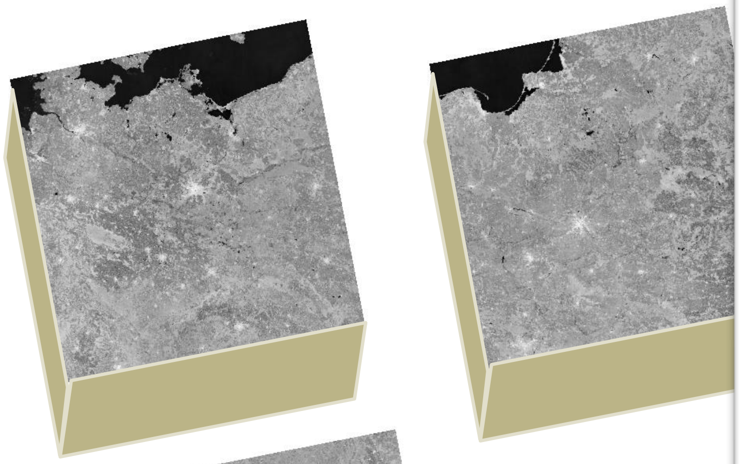
file organisation

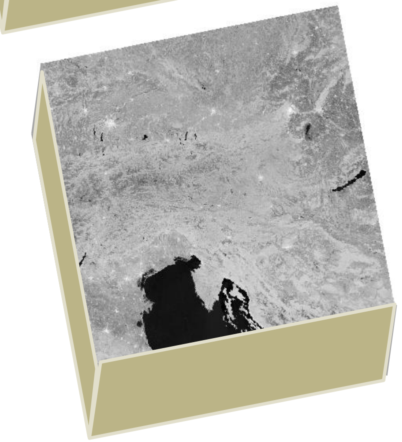
- one folder per tile
  - datacube is populated with tiled & formated files
  - mainly GeoTIFFs (or netCDF)
    - *with attached metadata*
- metadatabase keeps register on datasets
- python-based datacube-interface **yeoda**
  - https://github.com/TUW-GEO/yeoda
    - *search/query, sort/filter, display/plot, read/write, …*

geographic logic



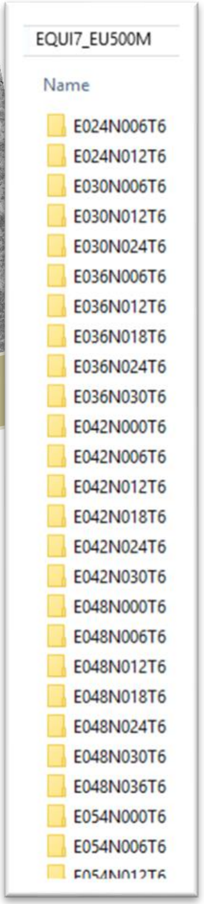
file-system logic





georeferenced image stacks per tile

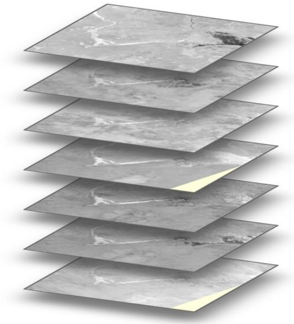
→ time via time-stamp in filename



some data volume figures

- Re-processing of Sentinel-1 archive triggered by new **Copernicus DEM**
  - **548 k** Sentinel-1 IW GRDH products for **2019 + 2020**
  - Processing took 1 ½ months using up to 450 computing nodes at VSC-3
    - *Input: 471 TB*
    - *~4 Million core hours*
    - *Output: 181 TB*
  - → basis for our **global temporal parameters**

- to be completed in July (2015-NRT)
  - *NRT: raw growth per month data*
    - ~ 28 k IW scenes
    - ~ 23 TB
  - *SIG0 single image data collection growth per month*
    - ~ 160 k tiled files
    - ~ 8 TB

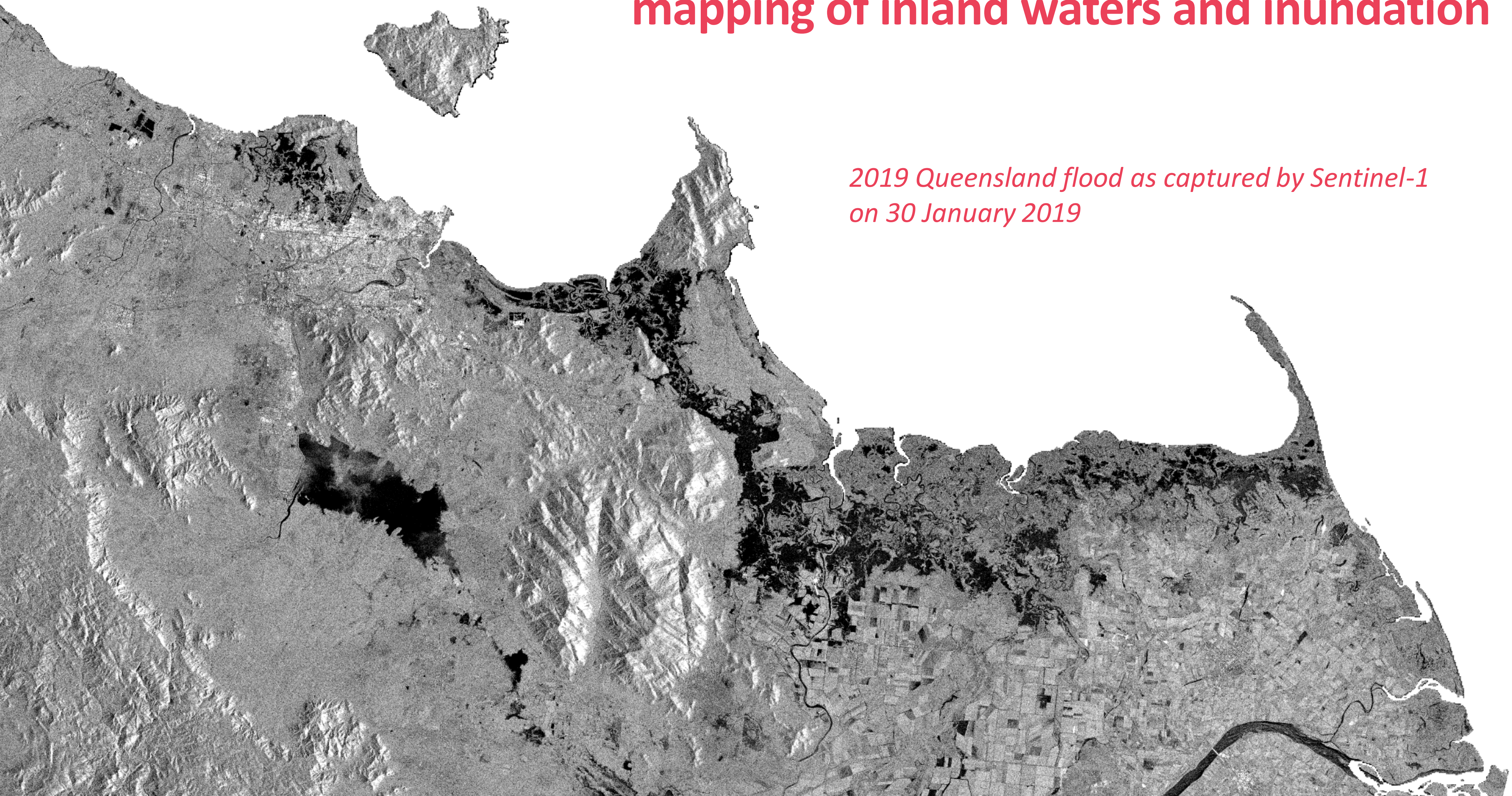


Sentinel-1 20m SIG0 data collection
(status June'21: comprising 2019-2020)

Continent	Tiled Files	Volume
global	3802 k	181 TB
Africa	685 k	34 TB
Antarctica	0.5 k	0.02 TB
Asia	821 k	39 TB
Europe	1030 k	48 TB
N-America	589 k	28 TB
Oceania	305 k	15 TB
S-America	372 k	18 TB

mapping of inland waters and inundation

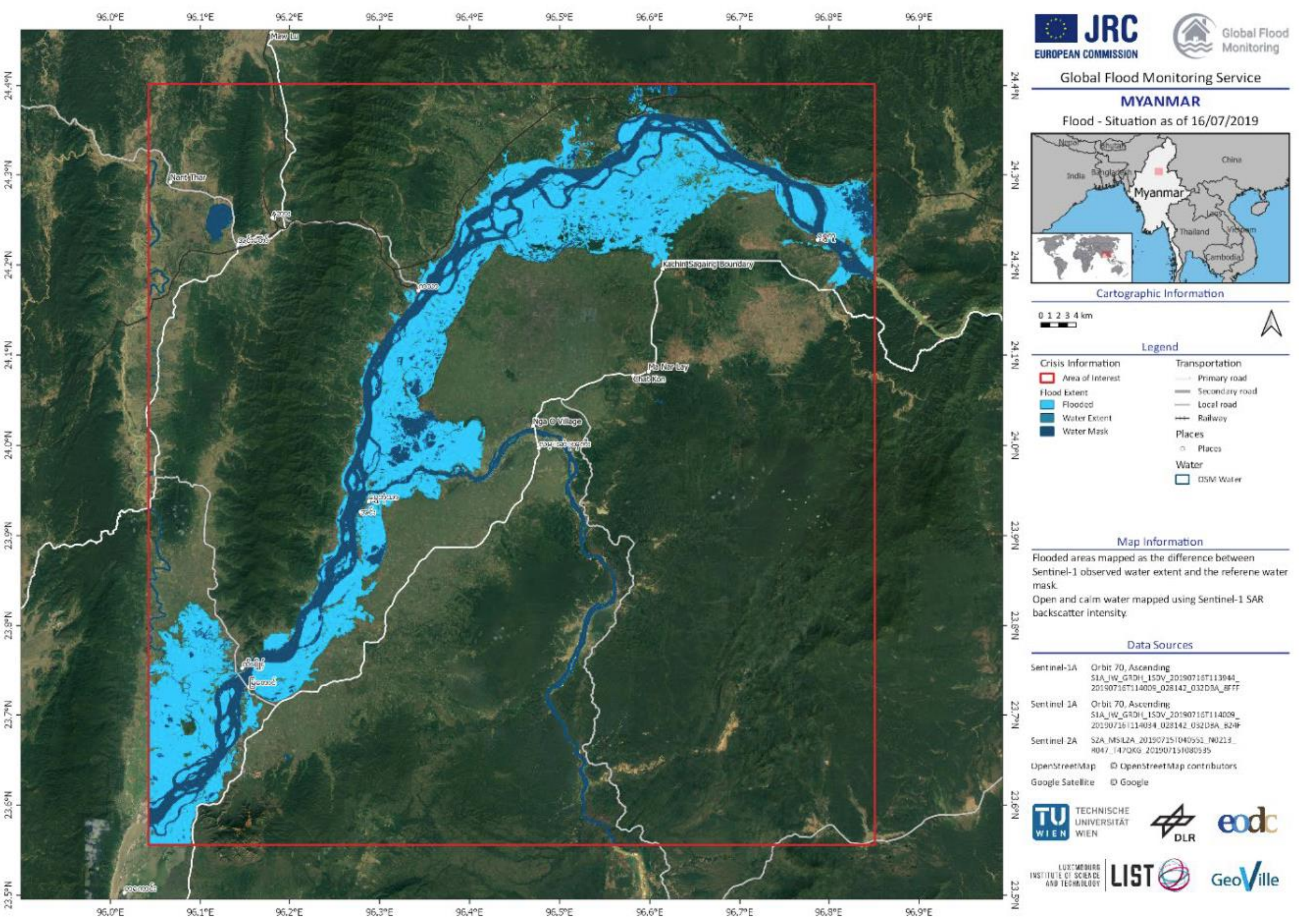
2019 Queensland flood as captured by Sentinel-1 on 30 January 2019



Global Flood Monitoring @ CEMS

- **JRC Copernicus EMS (CEMS) Global Flood Mapping (GFM) (new)**
  - NRT-operations on global flood mapping
  - using our Sentinel-1 datacube architecture

- *→ Talk of Peter Salamon, tomorrow in Session 3: „Copernicus Global Flood Monitoring“*



Copernicus Europe's eyes on Earth

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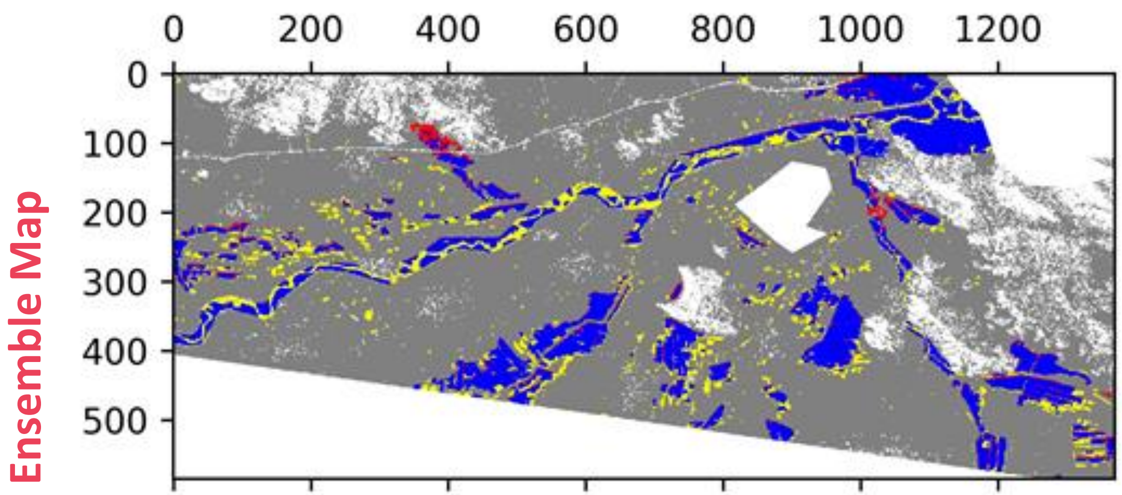
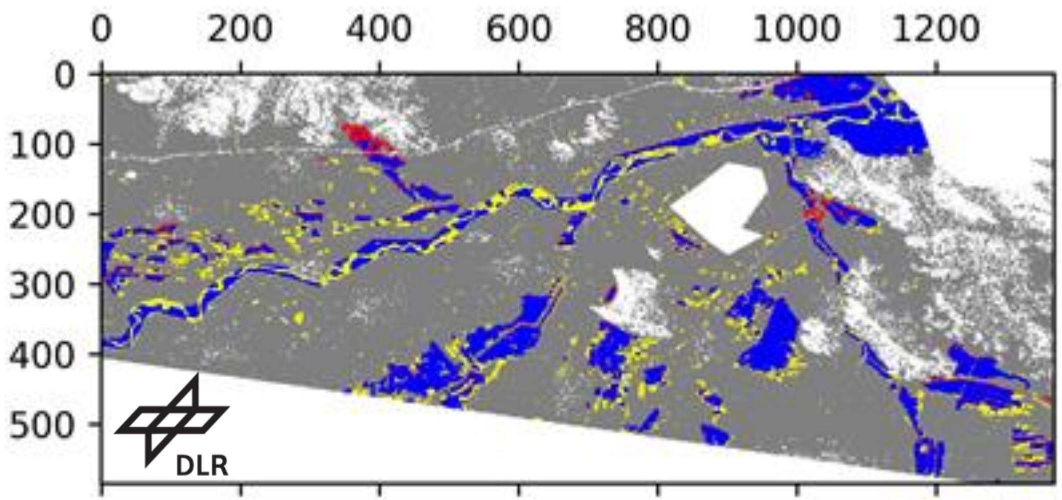
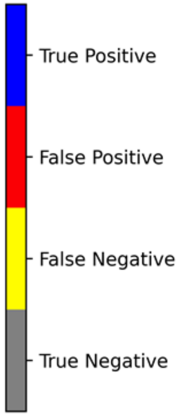
CEMS

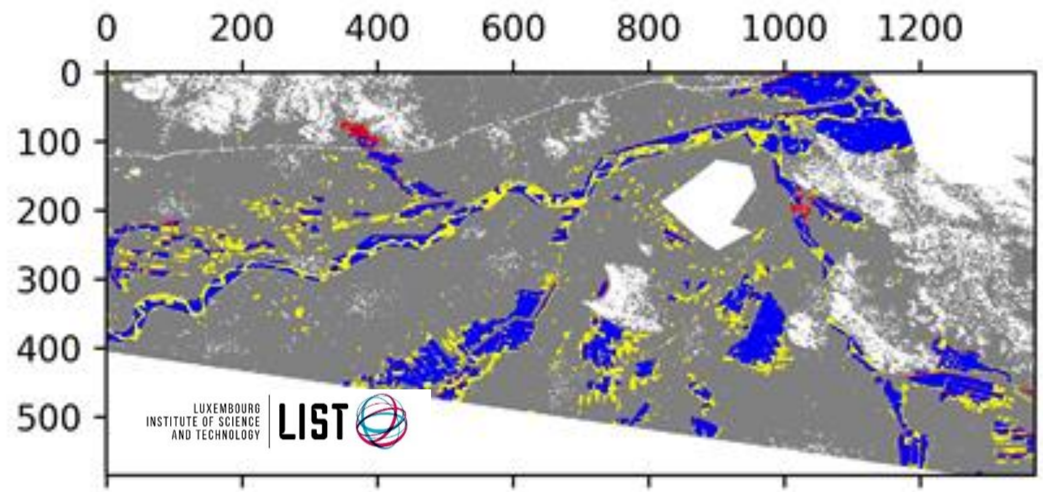
GFM: example floods images from DLR & LIST & TU WIEN



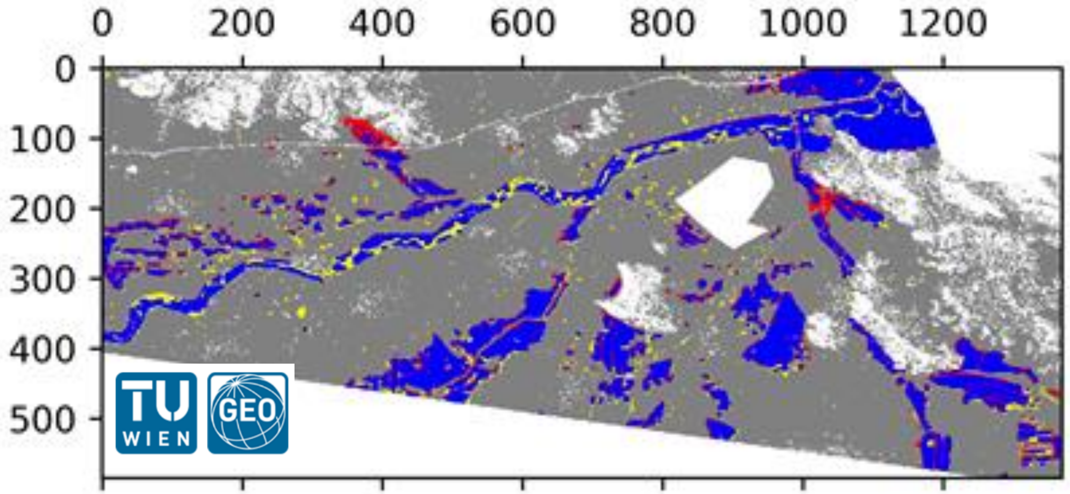


Martinis et al., 2015





Chini et al., 2017



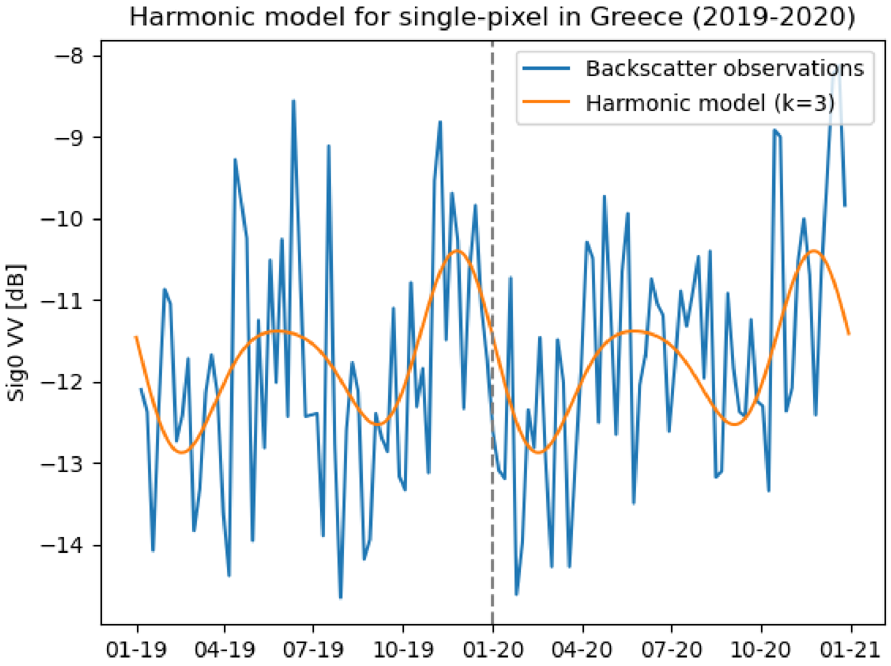
Bauer-Marschallinger et al., in prep.

TU Wien Harmonic Parameters

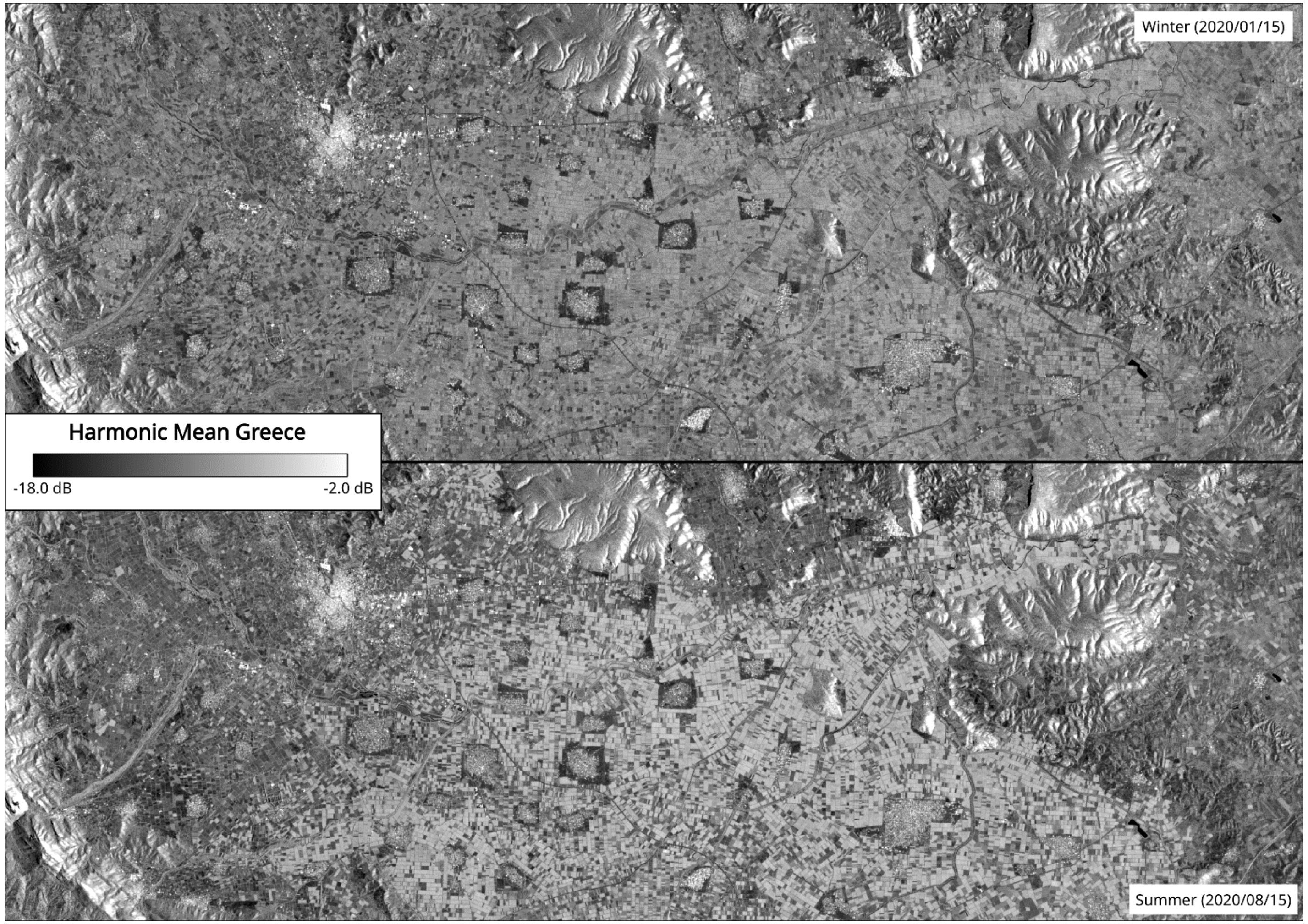
- Backscatter seasonality
  - Harmonic model

$$\widehat{\sigma^0} = \overline{\sigma^0} + \sum_{i=1}^{k} \left\{ C_i \cos\frac{2\pi i t}{n} + S_i \sin\frac{2\pi i t}{n} \right\}$$

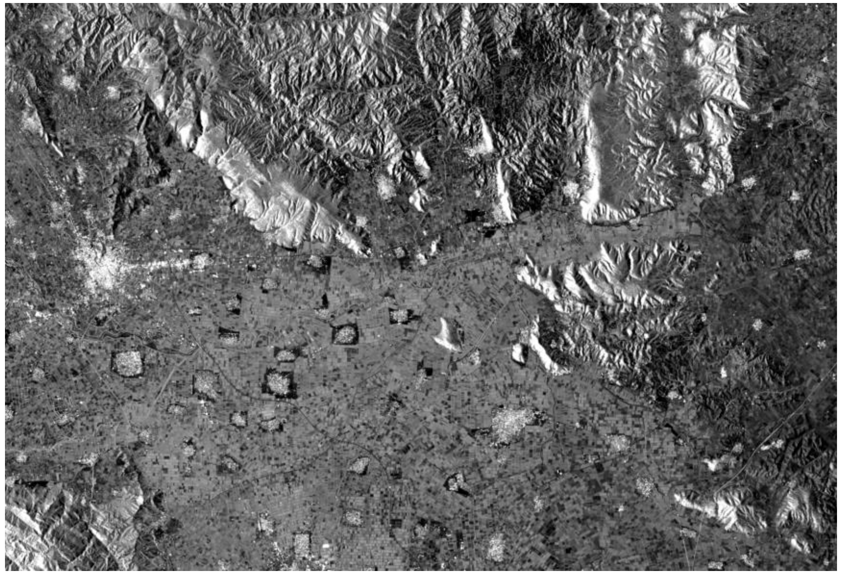
  - → Harmonic Parameters C_i and S_i



Synthesis → **Reference image** for specific time of year



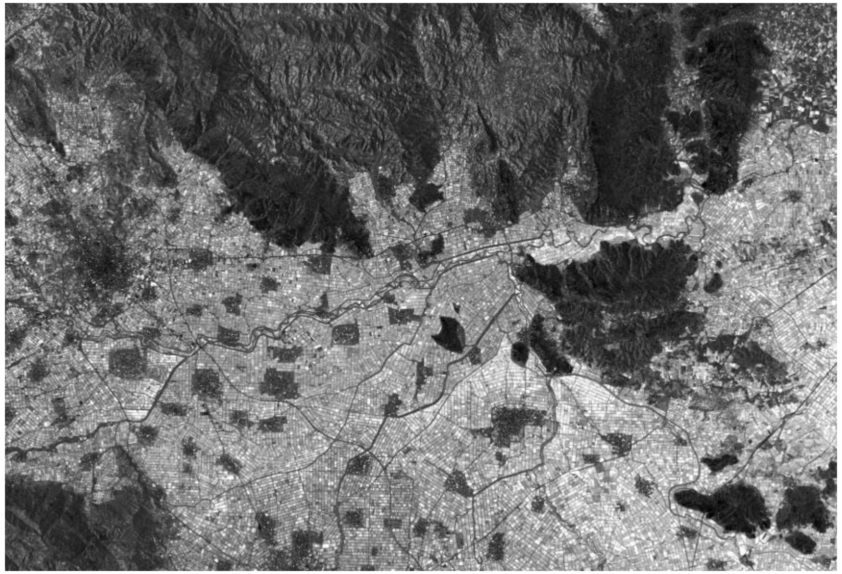
temporal parameters | examples over Thessaly | S-1 VV | orbit 175



Mean SIG0

-5 dB

-15 dB

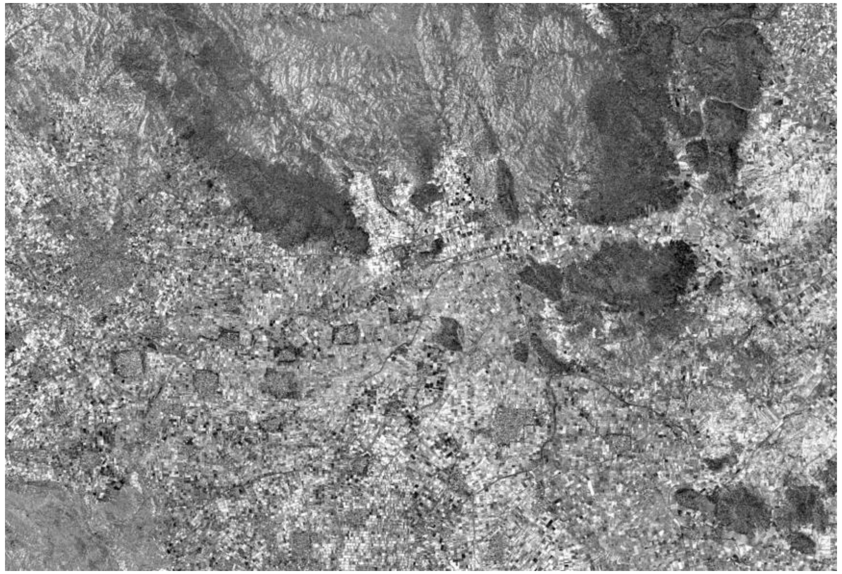


Standard Dev. SIG0

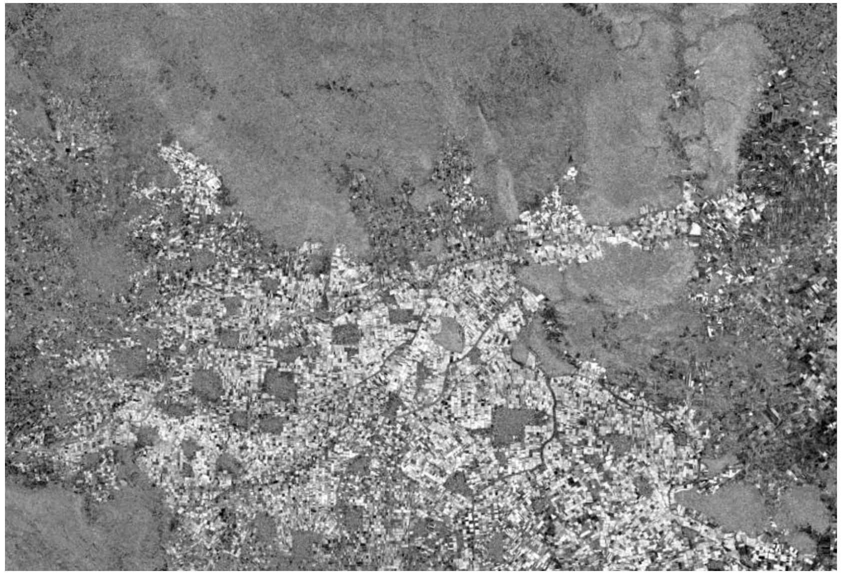
2.5 dB

0.5 dB

30 km



C1 Harmonic Parameter



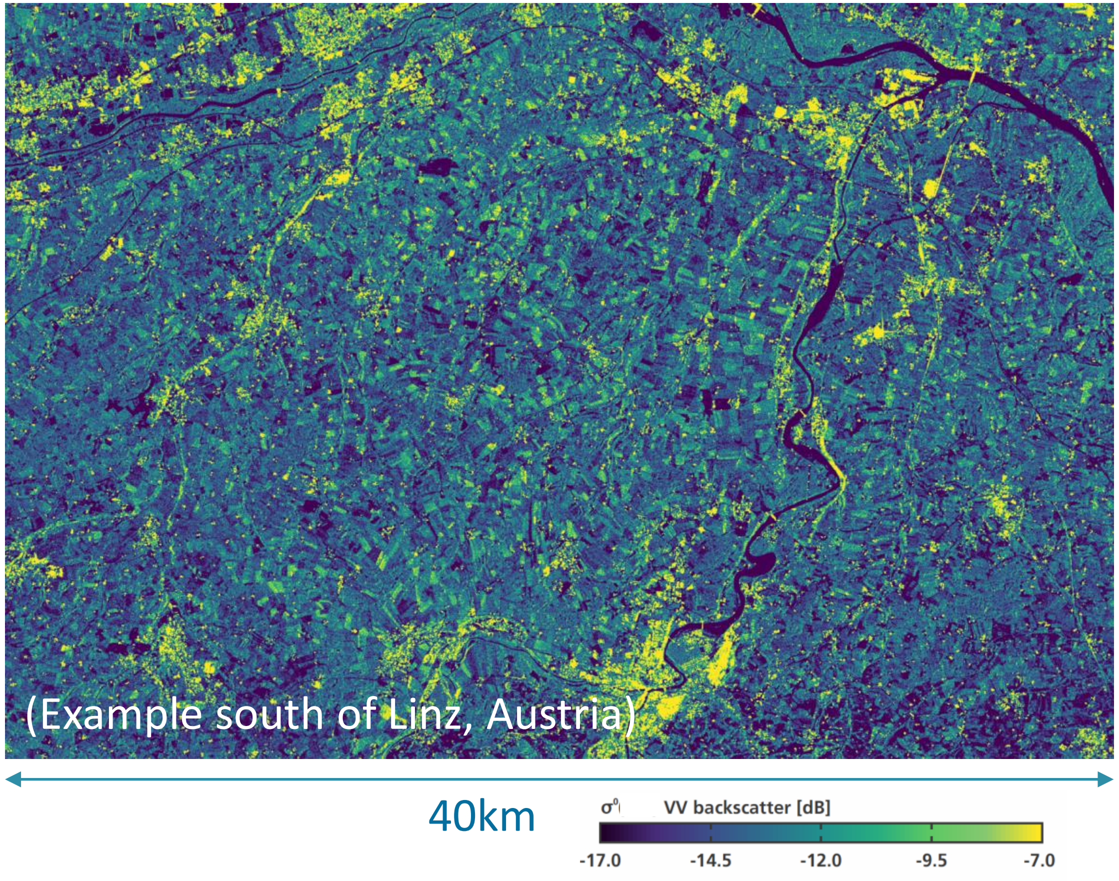
S2 Harmonic Parameter

+1.5 dB

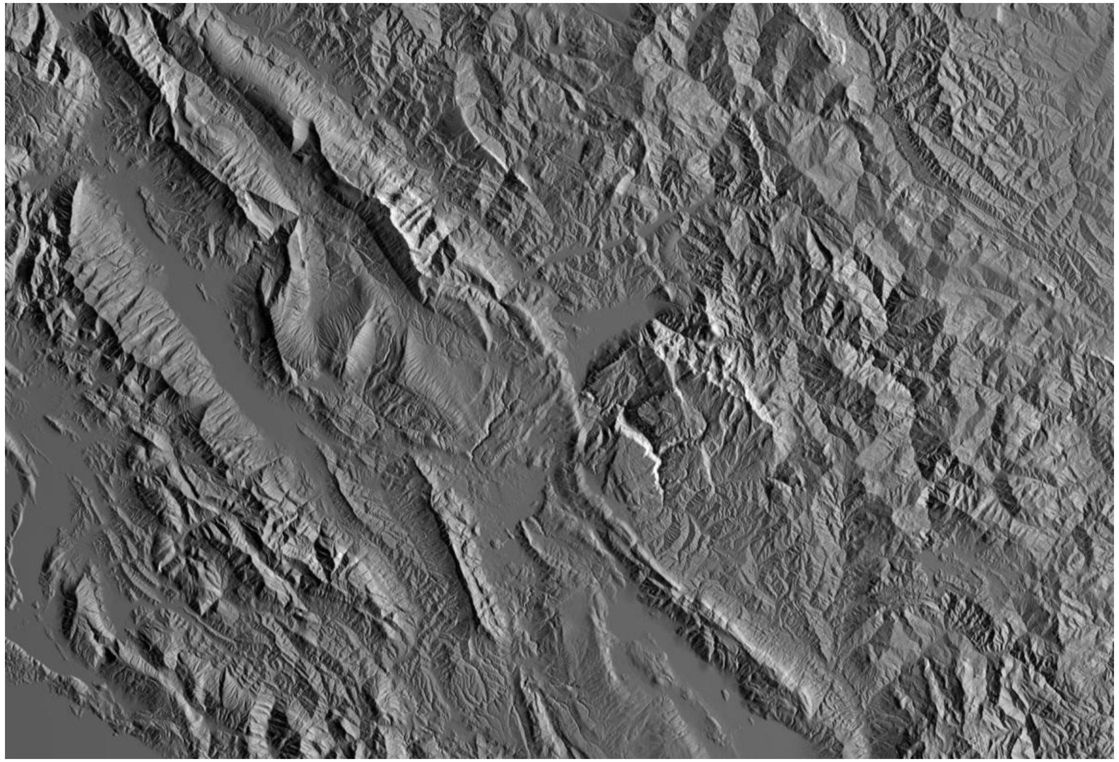
-1.5 dB

10m? monthly aggregated mean + PLIA!

- geocoding/preprocessing is performed on 10m pixel sampling (higher accuracy) → short-living 1-month rolling archive
- temporal aggregation reduces (native) SAR noise
  - → high-quality monthly aggregated images



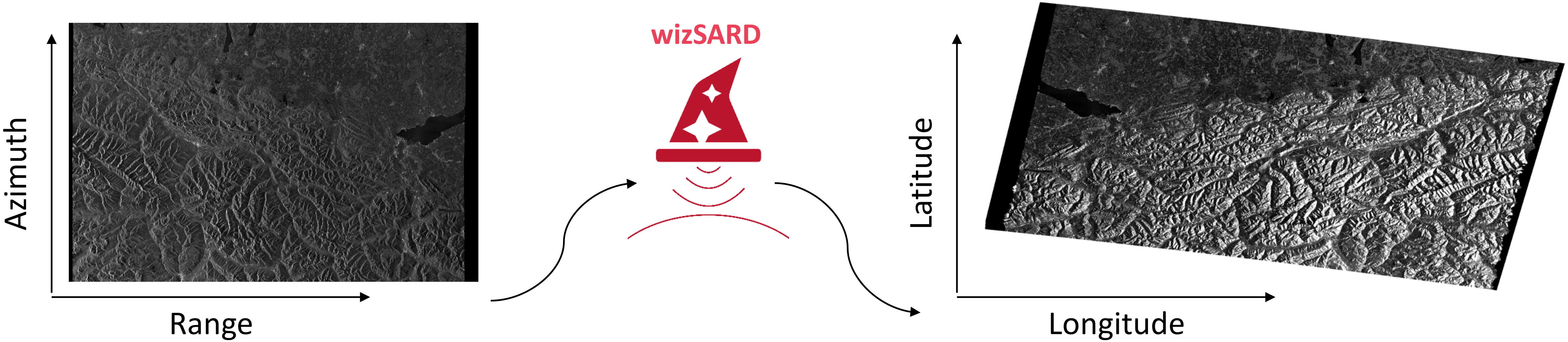
- averaged projected local incidence angle (PLIA)
  - per orbit



(Example over Thessaly, Greece)

outlook: enhanced Sentinel-1 pre-processing

- **SNAP 7/8** offers direct support from ESA and the community, but has some drawbacks:
  - non-optimal parallelisation
  - it is modular to reach a vast user community, but: not tailored for HPC processing activities on a global scale!
  - lacks in some functionality, e.g. a robust border noise removal
  - SAR experts at TU Wien and EODC cannot add new features, or easily or tune existing ones
- → TU Wien and EODC are currently developing **wizSARD**: a SAR geocoding toolbox tailored for large-scaled processing
  - written in Python (with support from Numba/Cython)
  - first performance tests (parallelisation on 4 cores) yielded that **wizSARD** is about **3-times faster than SNAP 8**



Contacts

Interested in the operational flood mapping in the GFM?

Peter Salamon‘s talk tomorrow in Session 3: The new Sentinel-1 based global flood monitoring system of the Copernicus Emergency Management Service

Interested in our Sentinel-1 data collections at EODC’s datacube?

info@eodc.eu

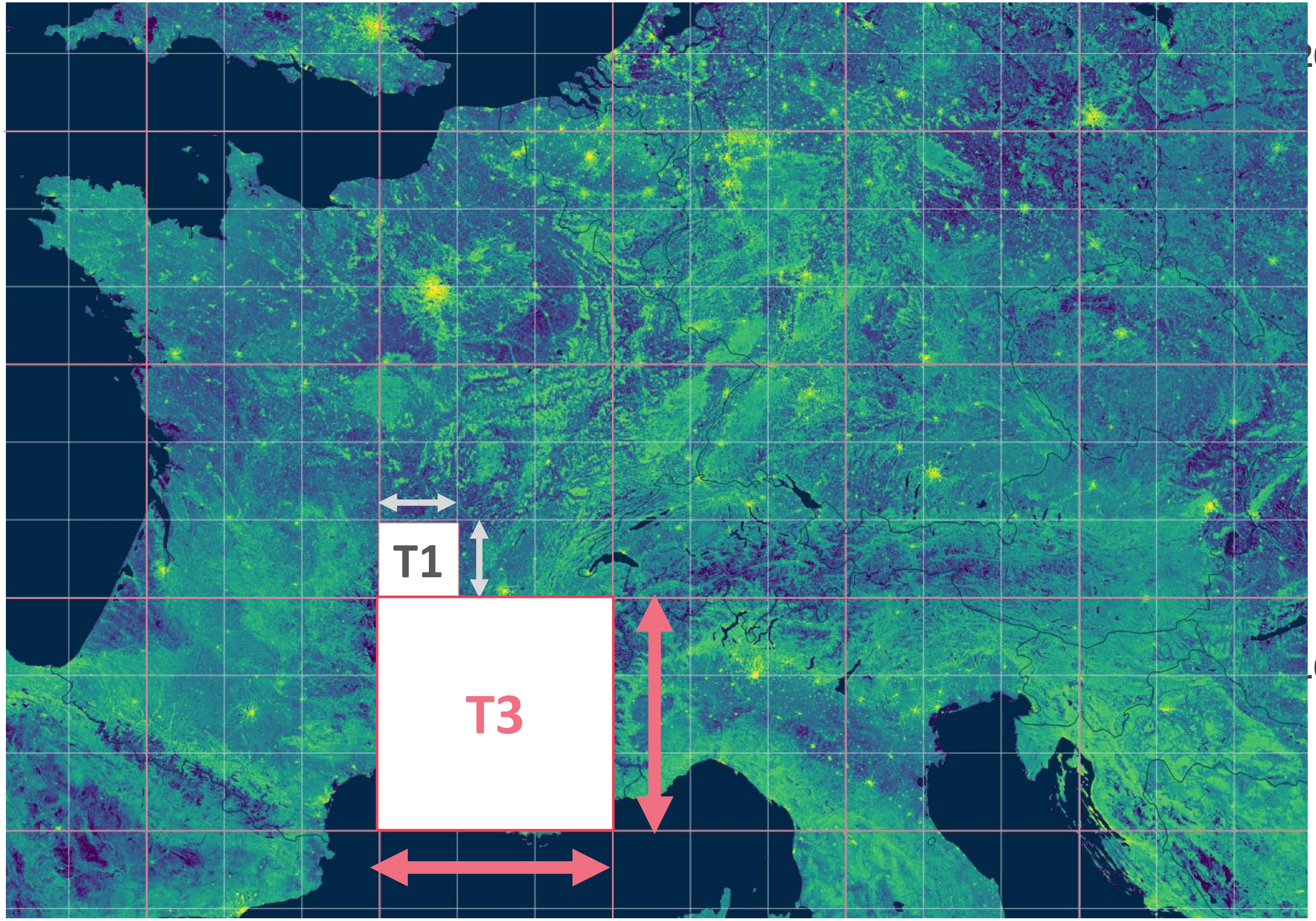
Thank you for your attention!

bbm@geo.tuwien.ac.at

Acknowledgements

ESA: Sentinel-1 Global Backscatter Model / Copernicus: Global Land Service & Emergency Management Service / ASAP: ACube & ACube4Floods

Sentinel-1 data collections & used tile structure



20m / T3

SIG0

single images

SIG0-TAG-*PAR*

total (time) aggregation…

percentiles

mean

lower-than-15dB count

number of observations

SIG0-HPAR

harmonic parameters

SIG0-GMAG-MED

median images per grouped month-of-year

PLIA-TAG-MEAN

total agg. mean of projected local incidence angle

10 m / T1

SIG0-MAG-MEAN

monthly aggregation: mean

PLIA-TAG-MEAN

total agg. mean of projected local incidence angle