Satellite Soil Moisture Data for Assessing Climatic Extremes

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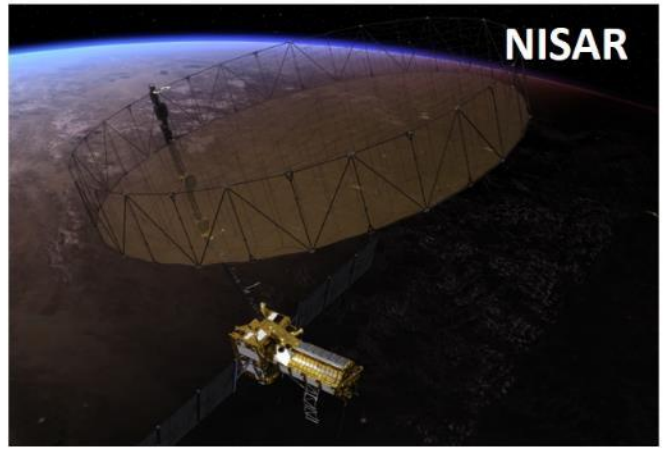
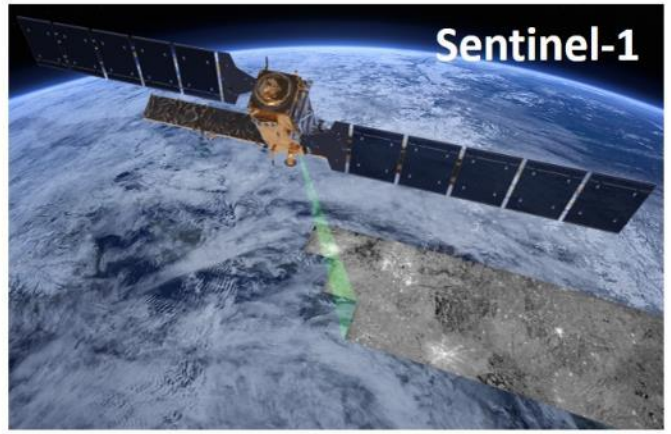
Microwave Satellites and Sensors for Soil Moisture Monitoring

	Radiometers	Active/Passive Microwave	Synthetic Aperture Radar
L-Band			
C-Band			

esa

EUMETSAT

NASA

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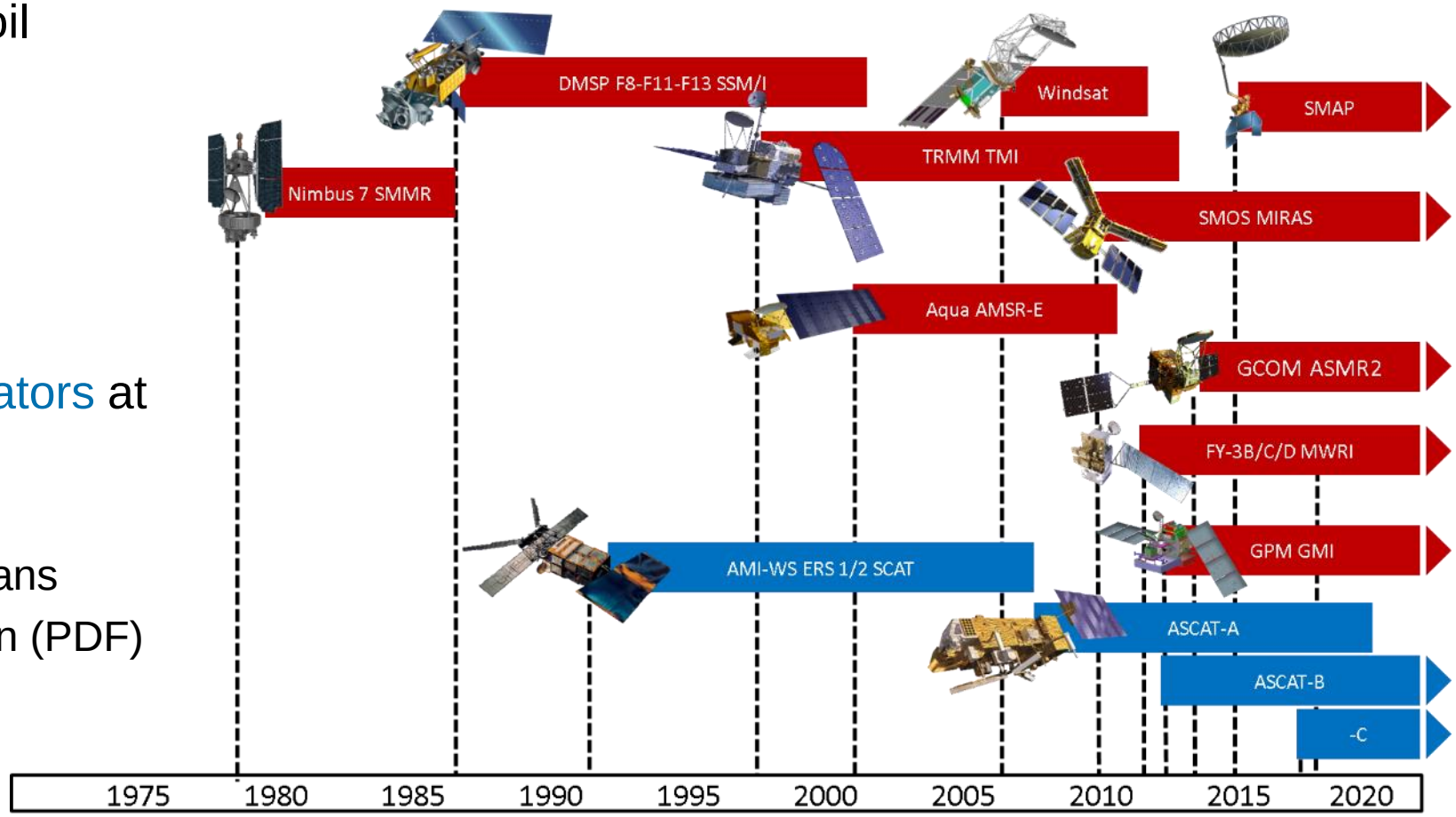
25km Soil Moisture Climate Data Records (1979 to present)

- Fusion of individual satellite soil moisture data sets
  - Uncertainty characterisation
  - Scaling
  - Merging
- Computation of anomaly indicators at coarse spatial scales possible
  - Percentiles
  - Deviations from seasonal means
  - Probability distribution function (PDF) based indices



https://esa-soilmoisture-cci.org/

Wagner et al. (2012) Fusion of active and passive microwave observations to create an Essential Climate Variable data record on soil moisture, ISPRS Annals, 10.5194/isprsannals-I-7-315-2012

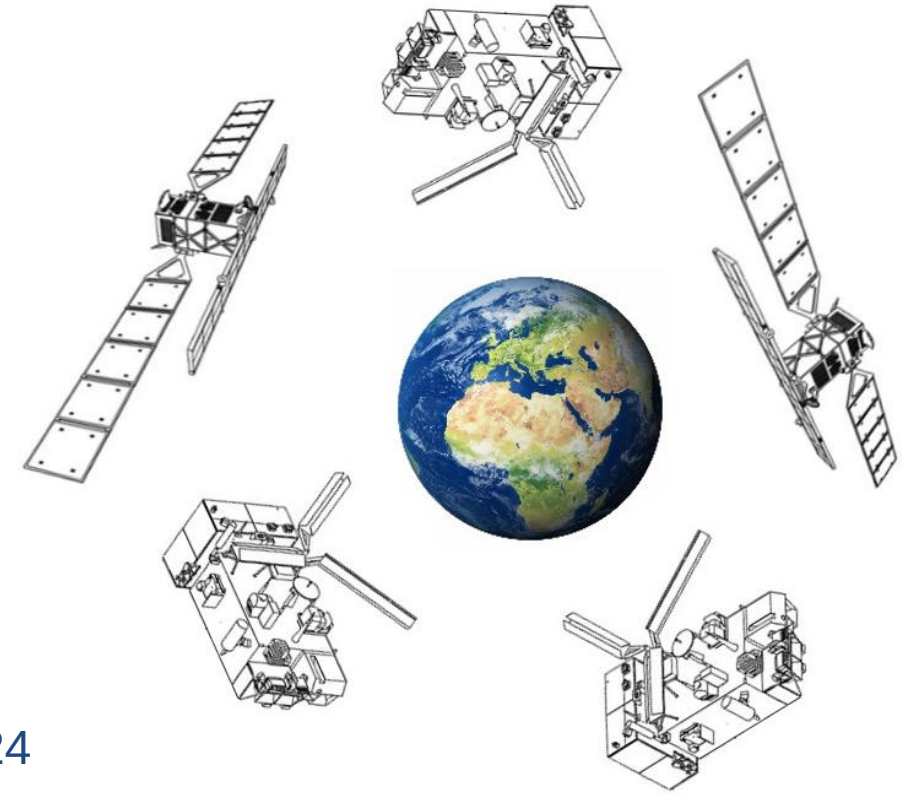
METOP ASCAT and Sentinel-1 SAR Constellations

METOP ASCAT

Frequency: 5.255 GHz
Polarisation: VV

Sampling: 6.25 km
Daily coverage: 82%

Satellites
METOP-A: 2006-2021
METOP-B: 2012 ongoing
METOP-C: 2018 ongoing
METOP-SG B1: foreseen 2024



Sentinel-1 SAR IW

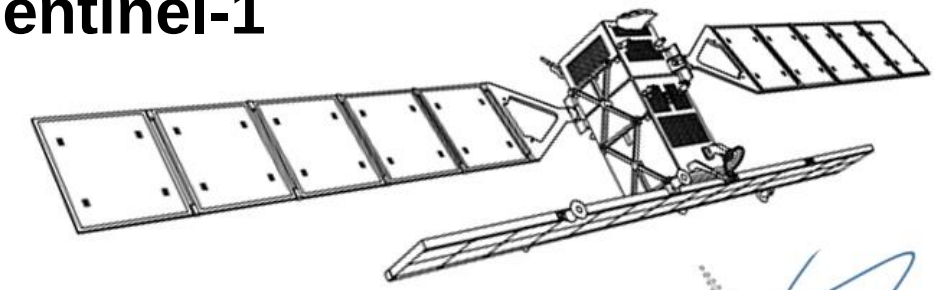
Frequency: 5.405 GHz
Polarisation: VV+VH

Sampling: 20 m
Repeat coverage: 3 – 12 days

Satellites
Sentinel-1A: 2014 ongoing
Sentinel-1B: 2016-2021
Sentinel-1C: foreseen 2023

Modelling Backscatter from Soil and Vegetation

Sentinel-1



Solar Panels

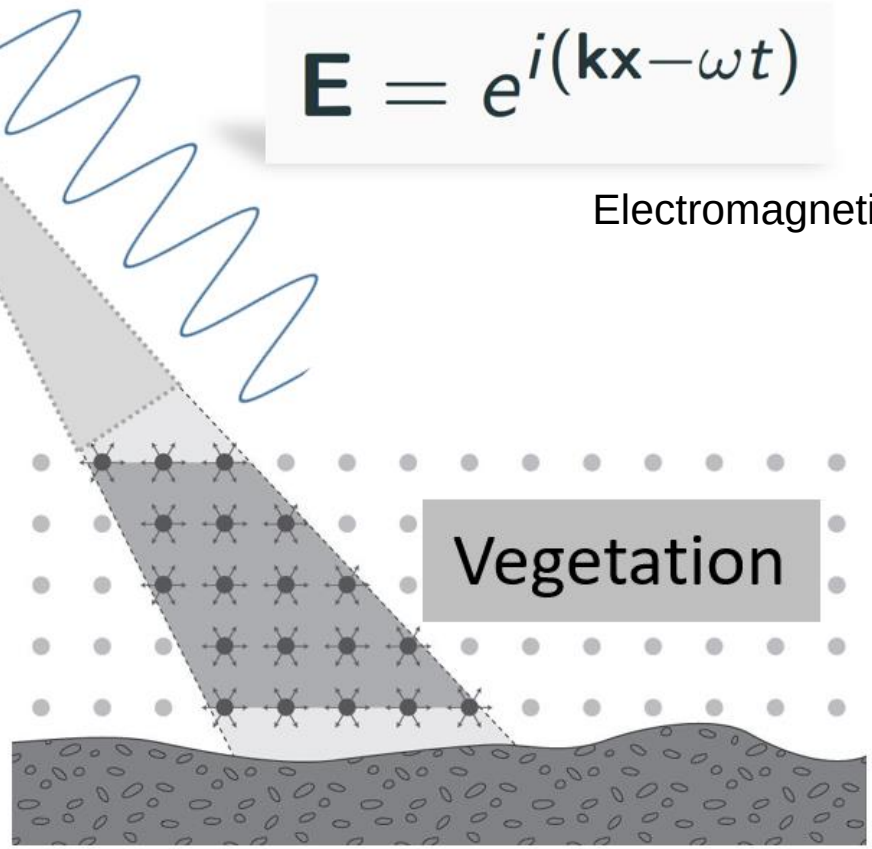
SAR Antenna

$$\mathbf{E} = e^{i(\mathbf{kx}-\omega t)}$$

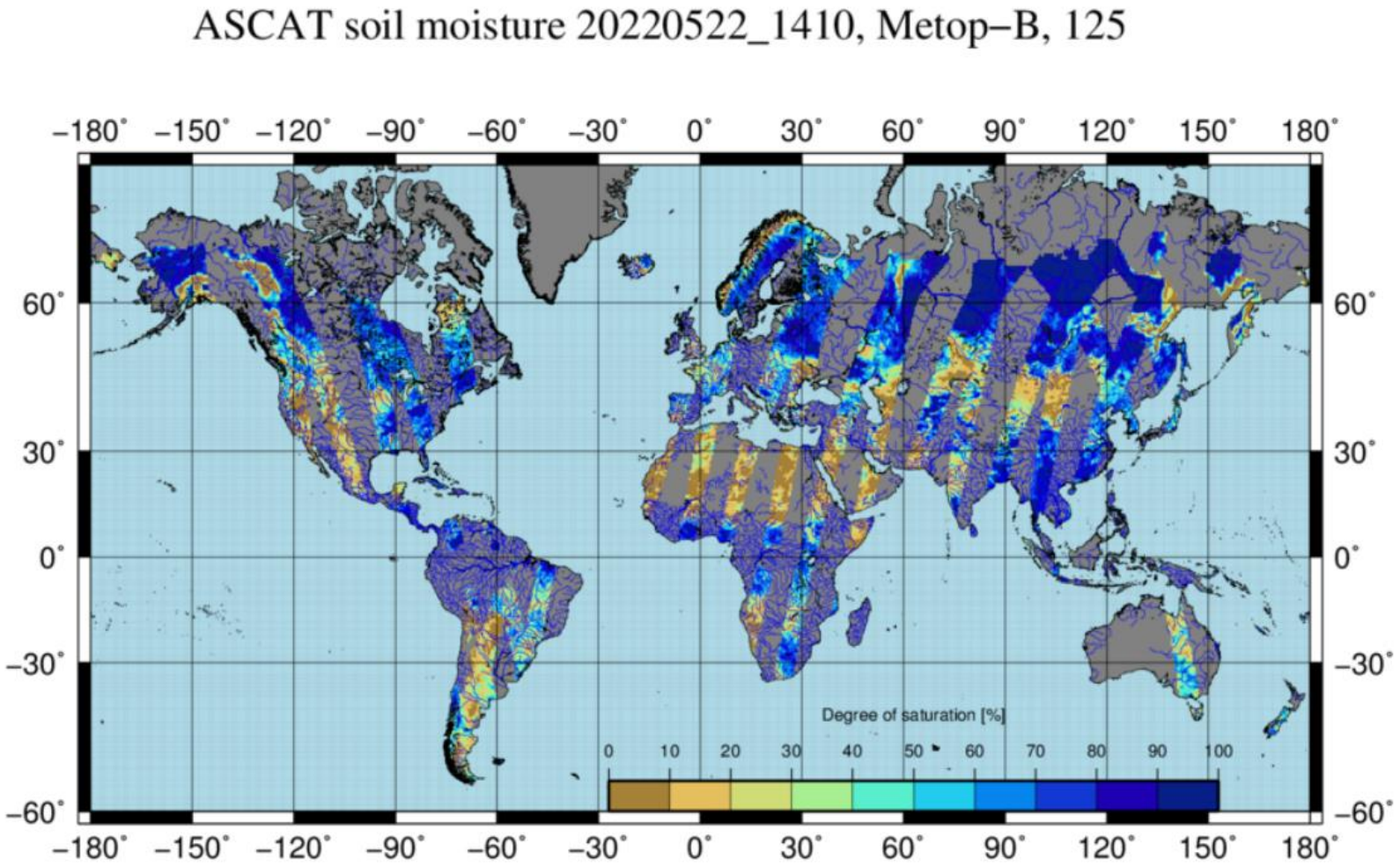
Electromagnetic Wave

Backscatter model for vegetated soil surface

$$\sigma^{\circ} = \sigma^{\circ}_{soil} e^{-2\tau} + \omega \left(1 - e^{-2\tau}\right)$$



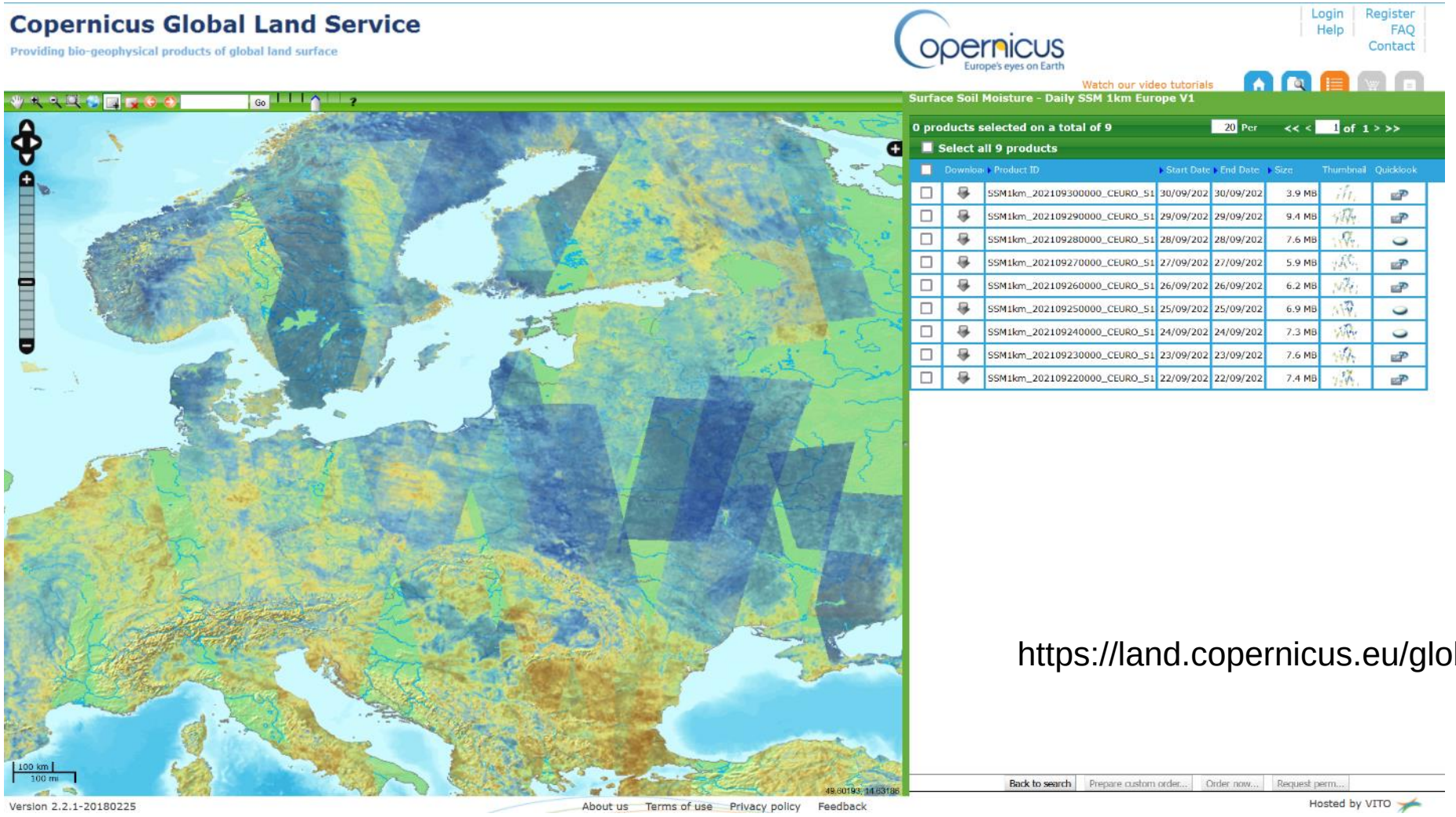
ASCAT Surface Soil Moisture



https://hsaf.meteoam.it/

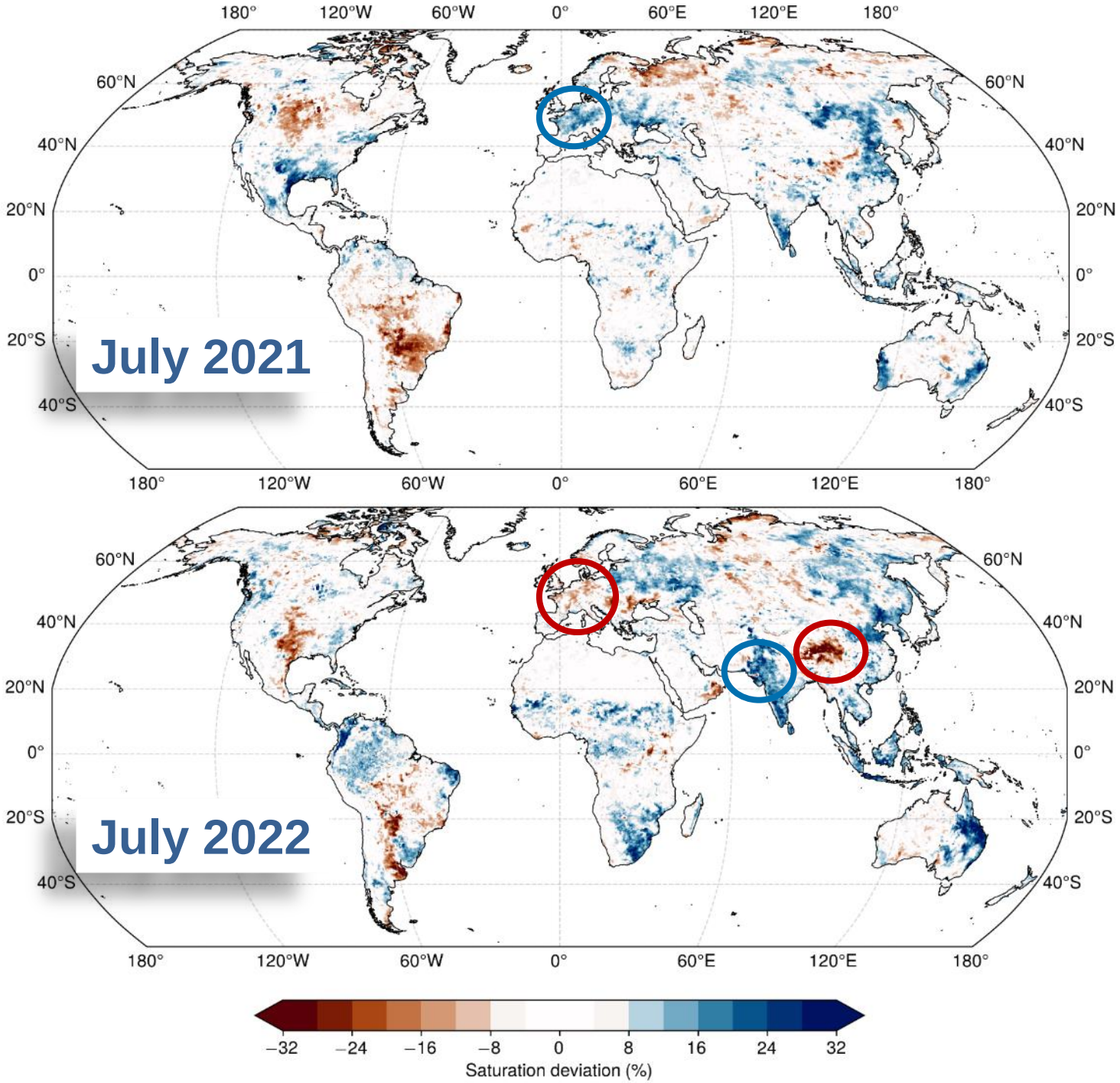
Wagner et al. (2013) The ASCAT soil moisture product: A review of its specifications, validation results, and emerging applications, Meteorologische Zeitschrift, 10.1127/0941-2948/2013/0399.

1 km Sentinel-1 Surface Soil Moisture



https://land.copernicus.eu/global/

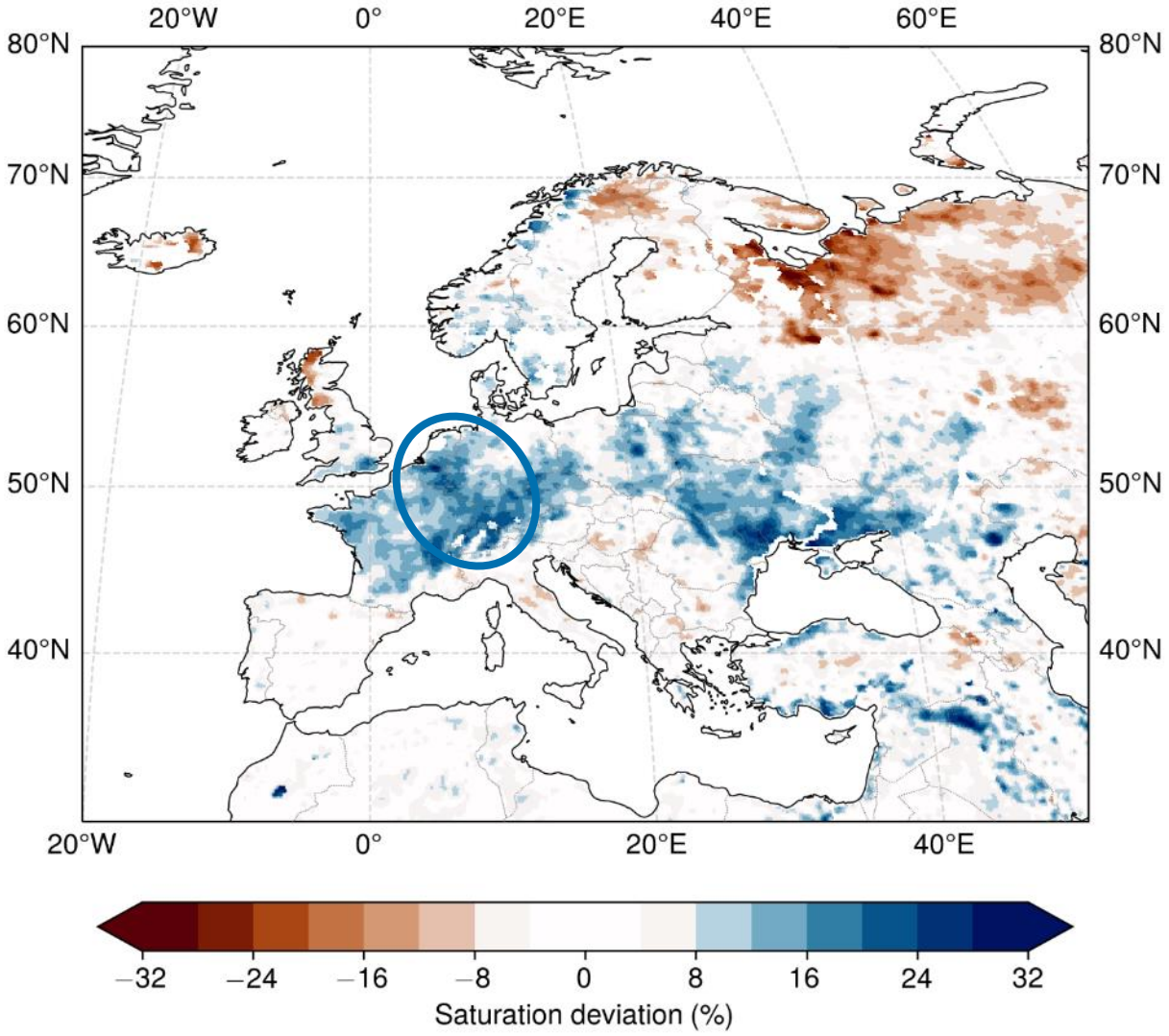
Bauer-Marschallinger et al. (2019) Towards global soil moisture monitoring with Sentinel-1: Harnessing assets and overcoming obstacles, IEEE Transactions on Geoscience and Remote Sensing, 10.1109/TGRS.2018.2858004



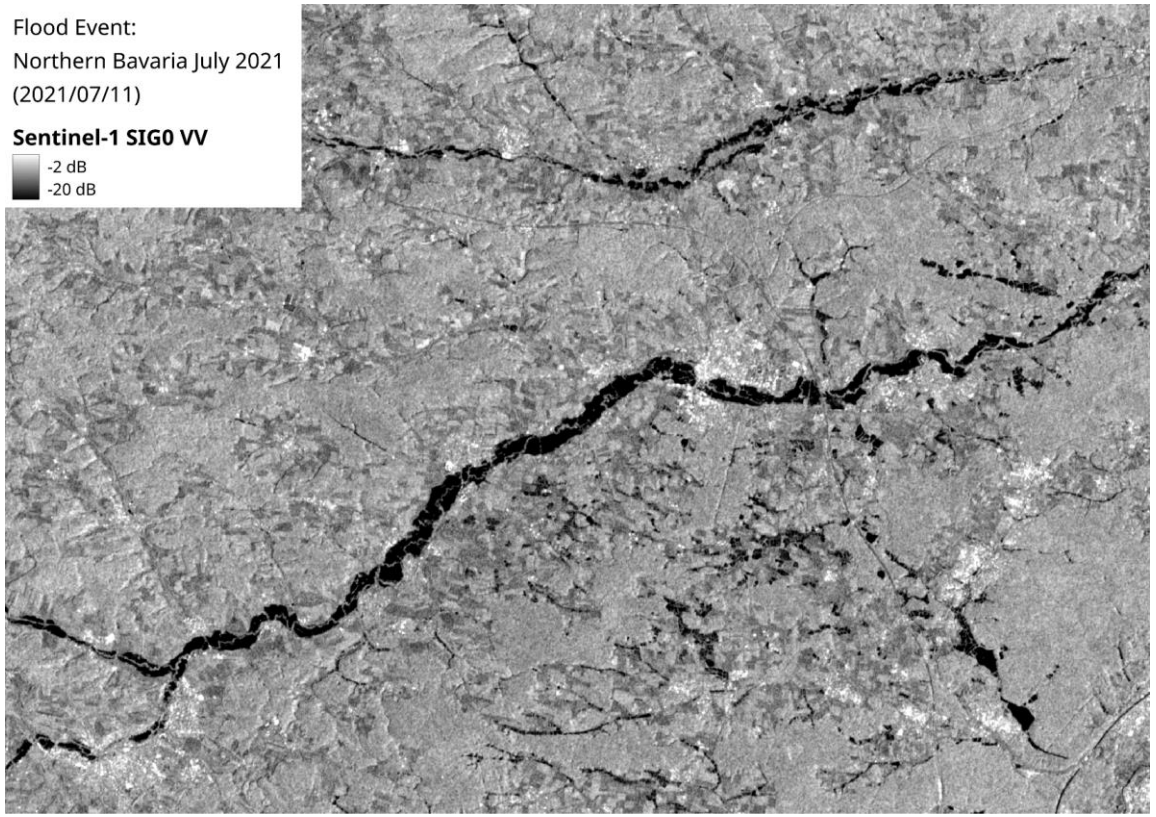
ASCAT Anomaly Maps

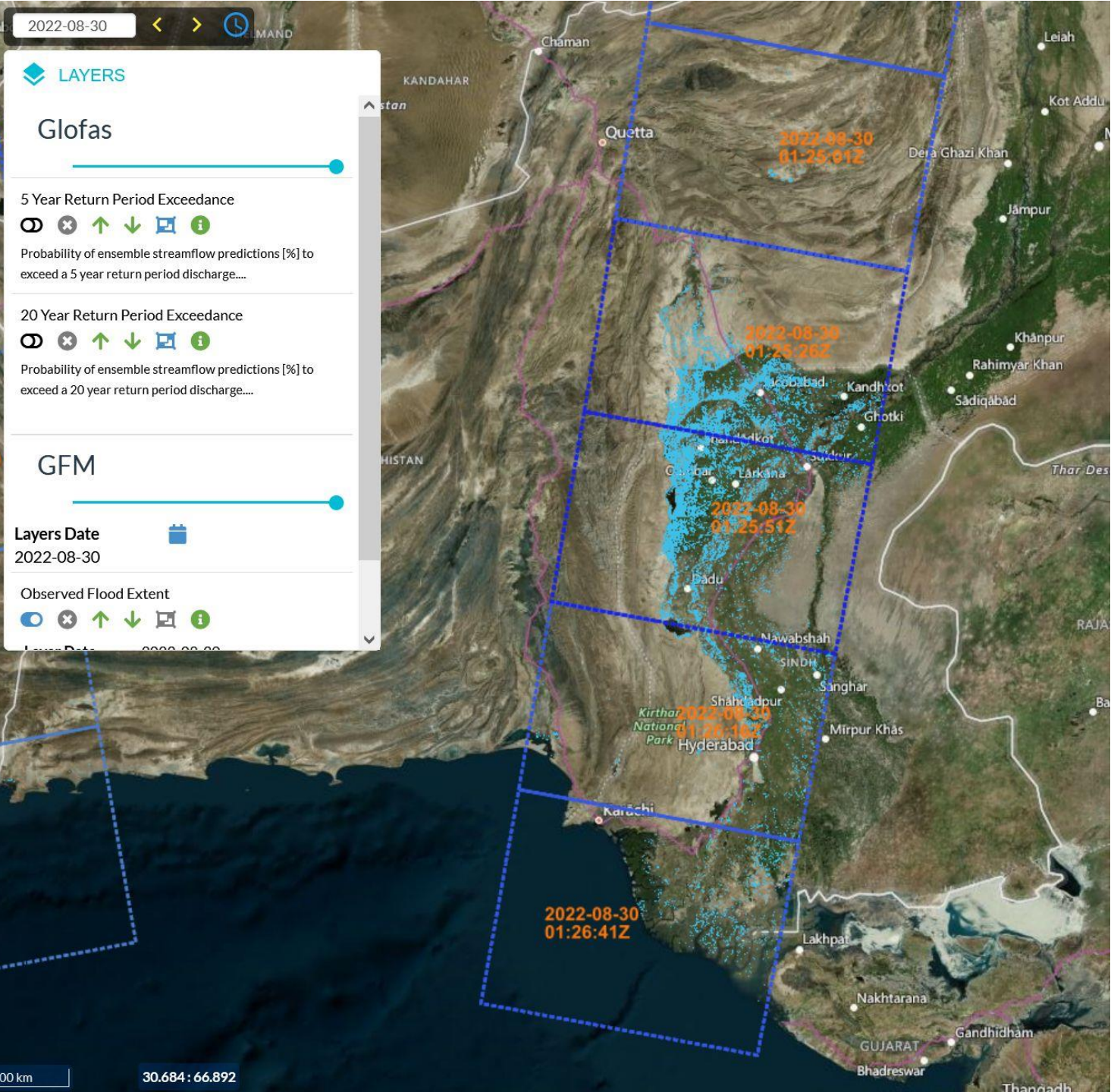
- H SAF ASCAT Surface Soil Moisture Data Record H119
  - Deviations in % from seasonal means calculated over the years 2007 to 2021
- **Blue colours** indicate **wetter** than usual
- **Red colours** indicate **drier** than usual
- Relating these anomalies to floods and droughts not straight forward

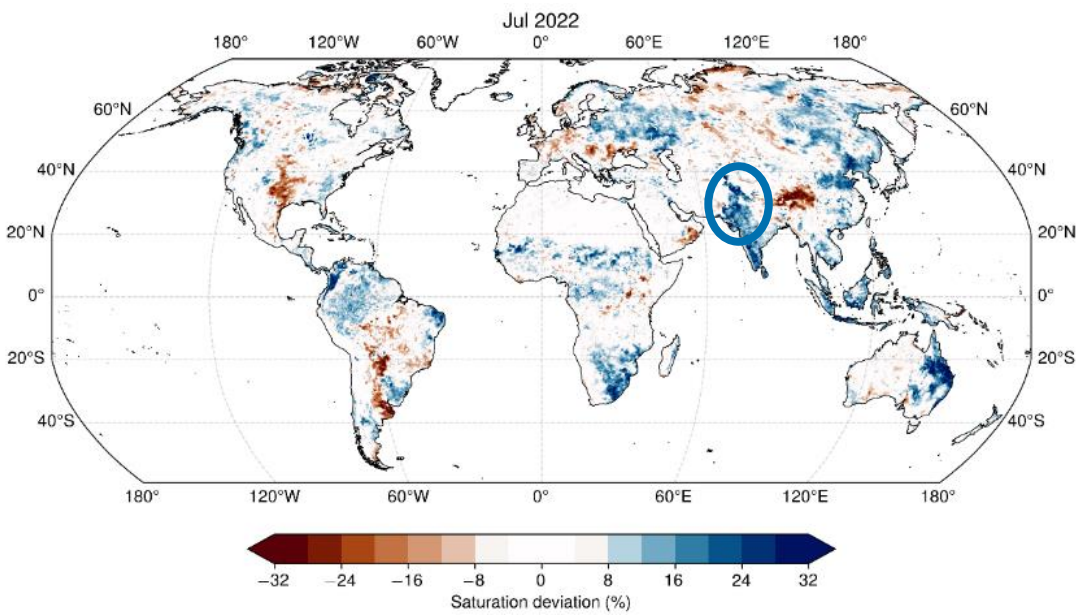
Floods in Germany and Belgium in July 2021



Flood seen in a Sentinel-1 backscatter image over the river Aisch in Bavaria, Germany

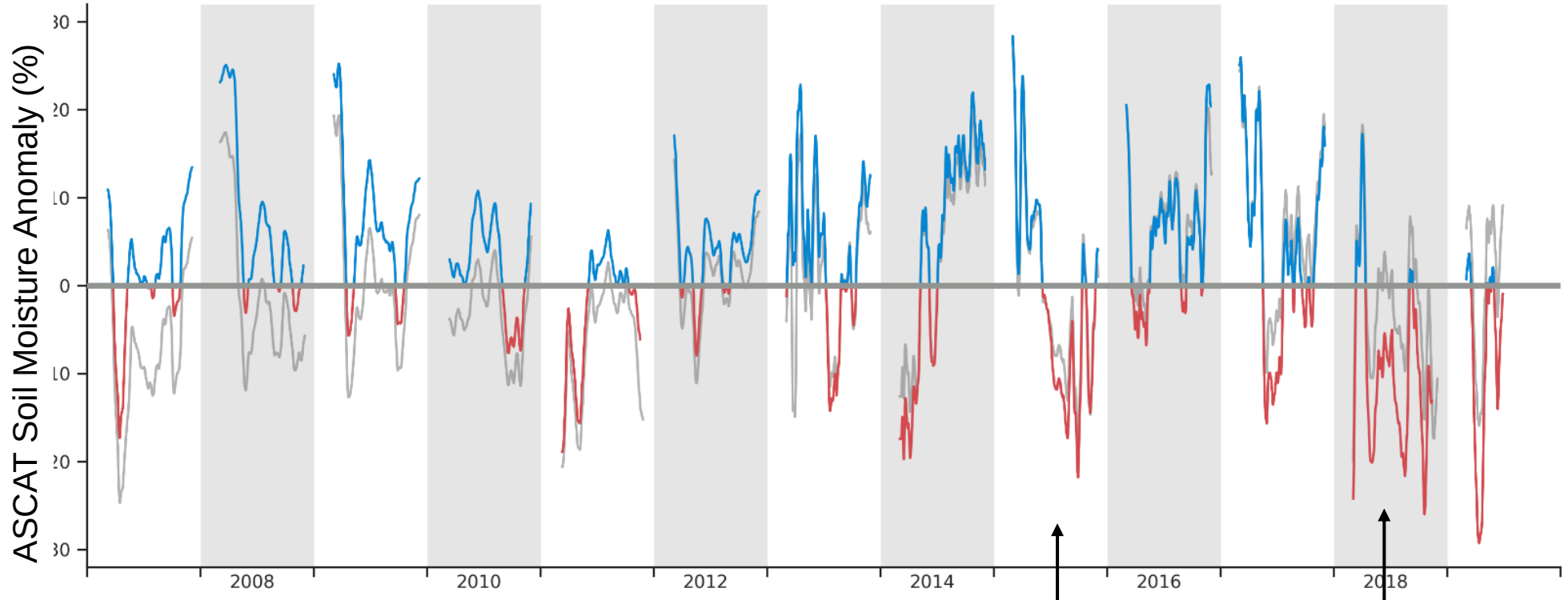






- Flood extent captured by Sentinel-1 overpass on 30 August 2022
- https://emergency.copernicus.eu/mapping/ems/information-bulletin-162-copernicus-emergency-management-service-monitors-flooding-event

ASCAT Soil Moisture Anomalies for Drought Monitoring



Drought-index derived from ASCAT soil moisture data over Offenhausen, Upper Austria. Grey line: without correcting for land cover changes.

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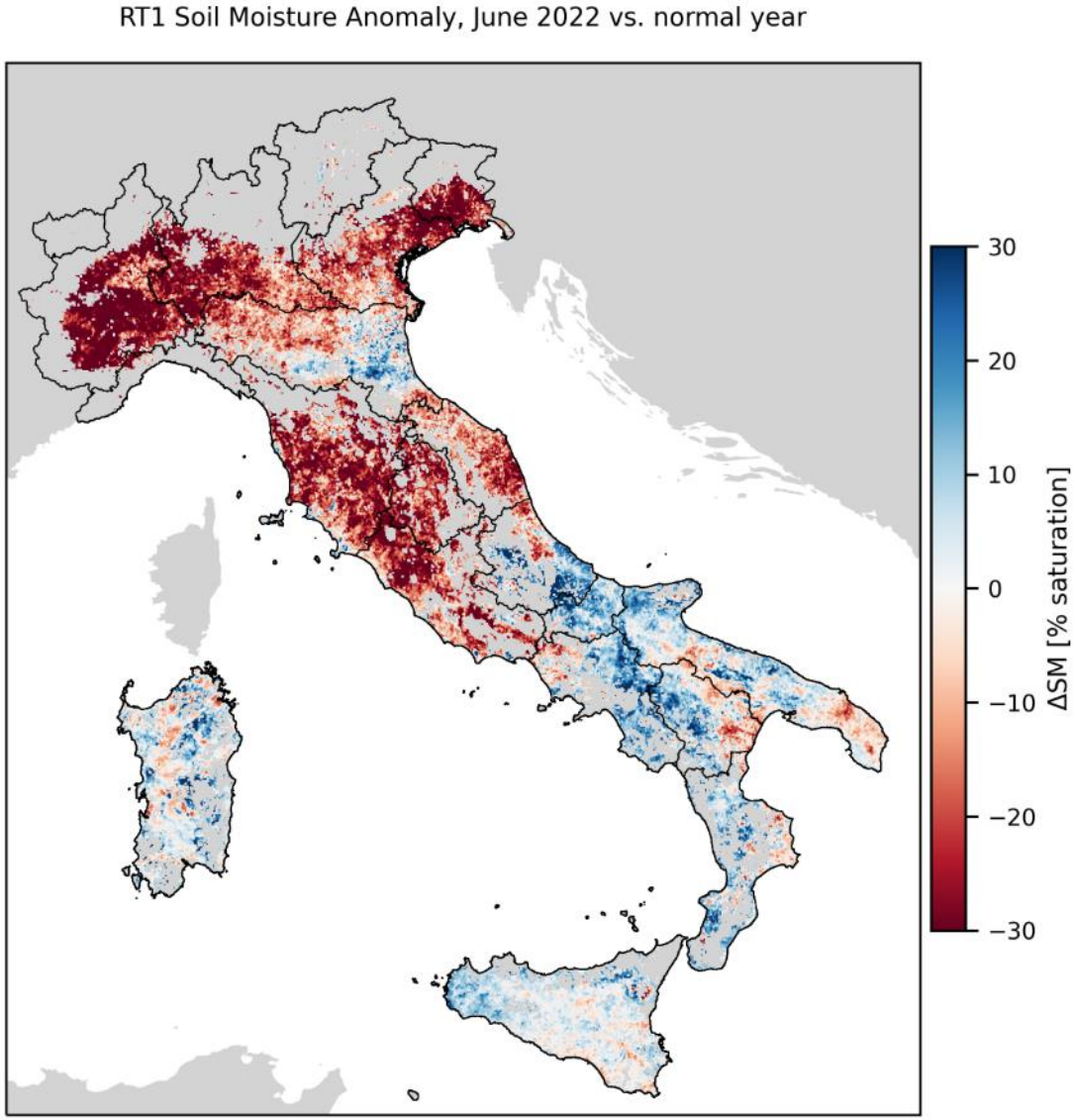
Sentinel-1 Soil Moisture Anomaly over Italy in June 2022



- Sentinel-1 allows to go to a much finer resolution (1 km)
- Data record is still rather short for drought assessments, but can support expert analysis

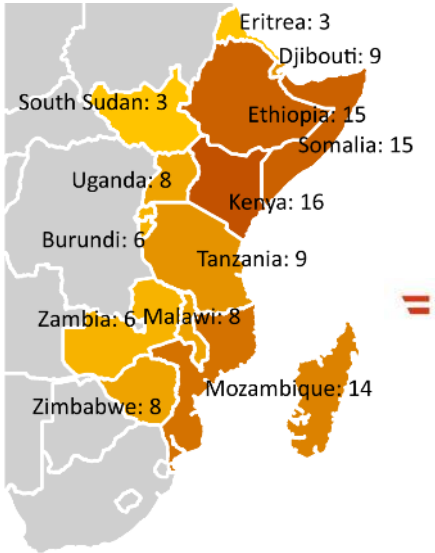
Comparing soil moisture conditions over Italy in June 2022 (drought year) to June 2020 (normal year)

Twitter tweet by Luca Brocca (IRPI) reached over 60 000 people within a day

Conclusions

- Satellite soil moisture data allow monitoring of extreme wet and dry conditions
  - Useful for early warning
- Translation of observed anomalies into impacts on the ground is not straight forward
  - Drought impact assessment typically requires looking at more variables (vegetation, temperature, etc.) and longer time intervals (multiple seasons).
  - Flood predictions need at least also rainfall (and snow melt) data

- If you are interested in working with us on how to link ASCAT soil moisture anomalies with drought impacts in Eastern Africa please contact me under wolfgang.wagner@geo.tuwien.ac.at
  - We will be able to send you demonstration data sets in 2023



ASAP Project
ROSSIHNI

FFG

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Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

Acknowledgements

ESA: DTE Hydrology, 4DMED, S1 GBM / EUMETSAT: H SAF / Copernicus: Land Monitoring Service, Emergency Management Service / FFG: Bmon, ROSSIHNI / CzechGlobe: SustES

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