Harnessing Open Science through Digital Innovation

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EO Science Strategy Workshop, 07-08 May 2024, Frascati

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Accelerate Scientific Discovery for Earth Action

Unprecedented Challenges

Ambitious Science Strategy & CSQs

Need for Accelerated Discovery

Key Enablers: Open Science and Digital Innovation

Utilising Advanced Technologies

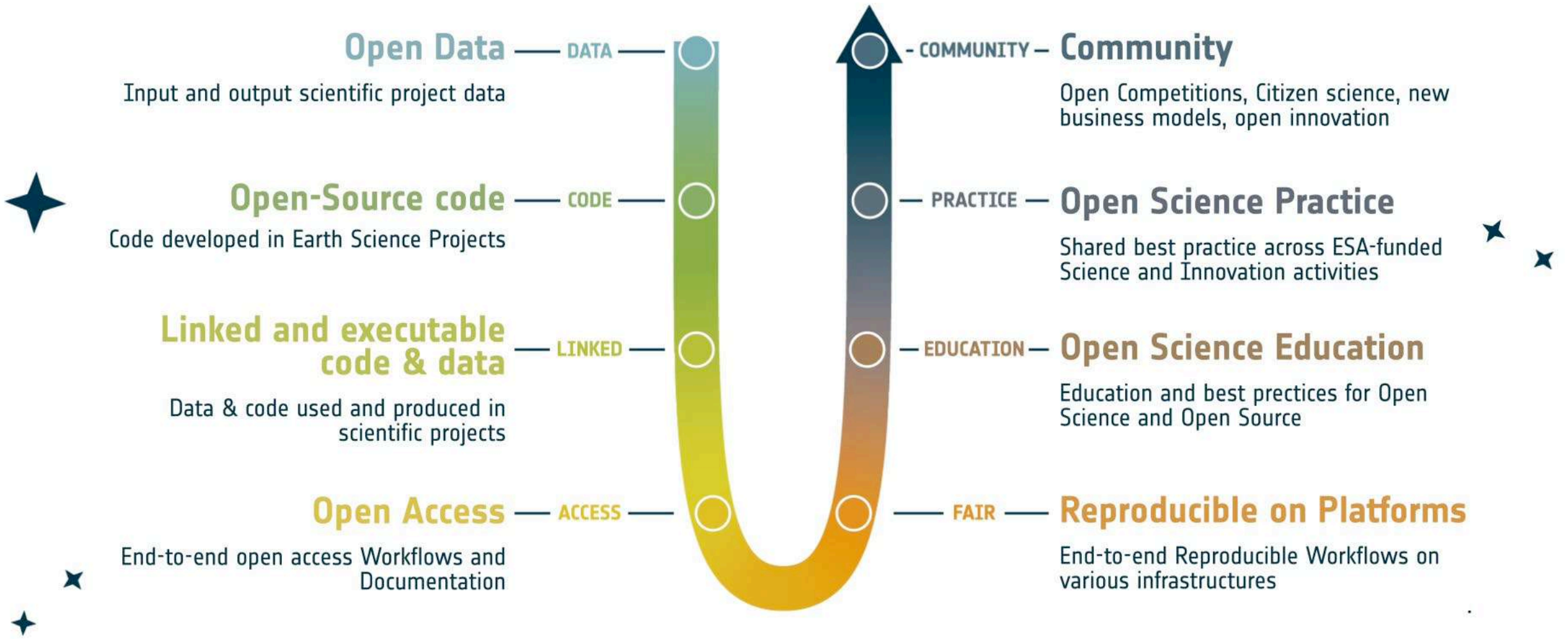
Promoting Sustainability

Enhancing Collaboration & Interdisciplinarity

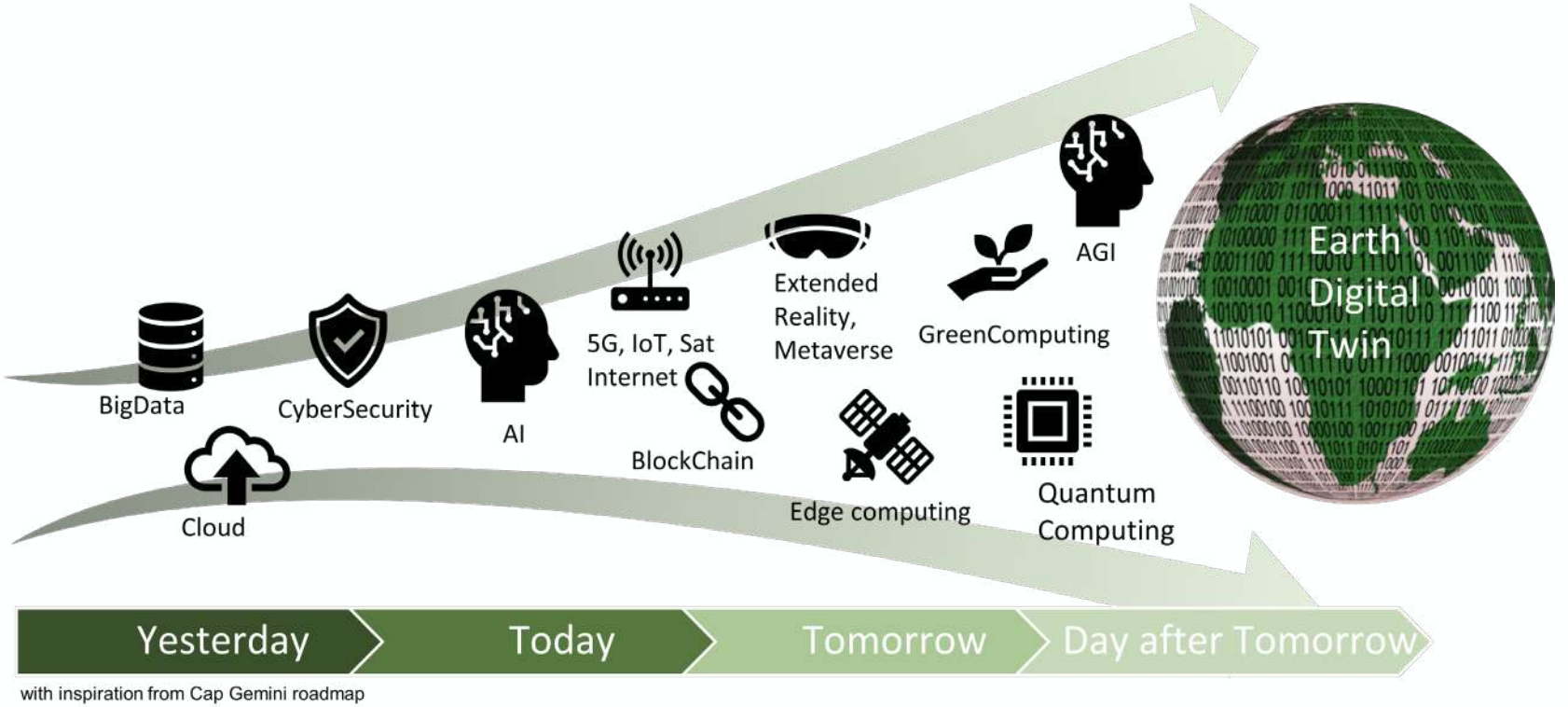
Ethical and Inclusive Science Practices

Deliver trusted, validated and actionable information

Culture of Openness



Digital Innovation - Trends and Opportunities



with inspiration from Cap Gemini roadmap

- Maximise data exploitation and the socio-economic benefits of AI integration within European data pipeline
- Revolutionise Resources and Hazards management with AI action-based applications
- Lower the adoption barrier for EO driven solutions with operational value-adding on-demand cloud services
- Empower end-users EO data exploitation by providing transparency and trust (DLT, web3, and explainable AI)

Areas of Action

Frontier Science and Discovery

From Science to Benefits

Reducing critical knowledge gaps

Filling critical observation gaps

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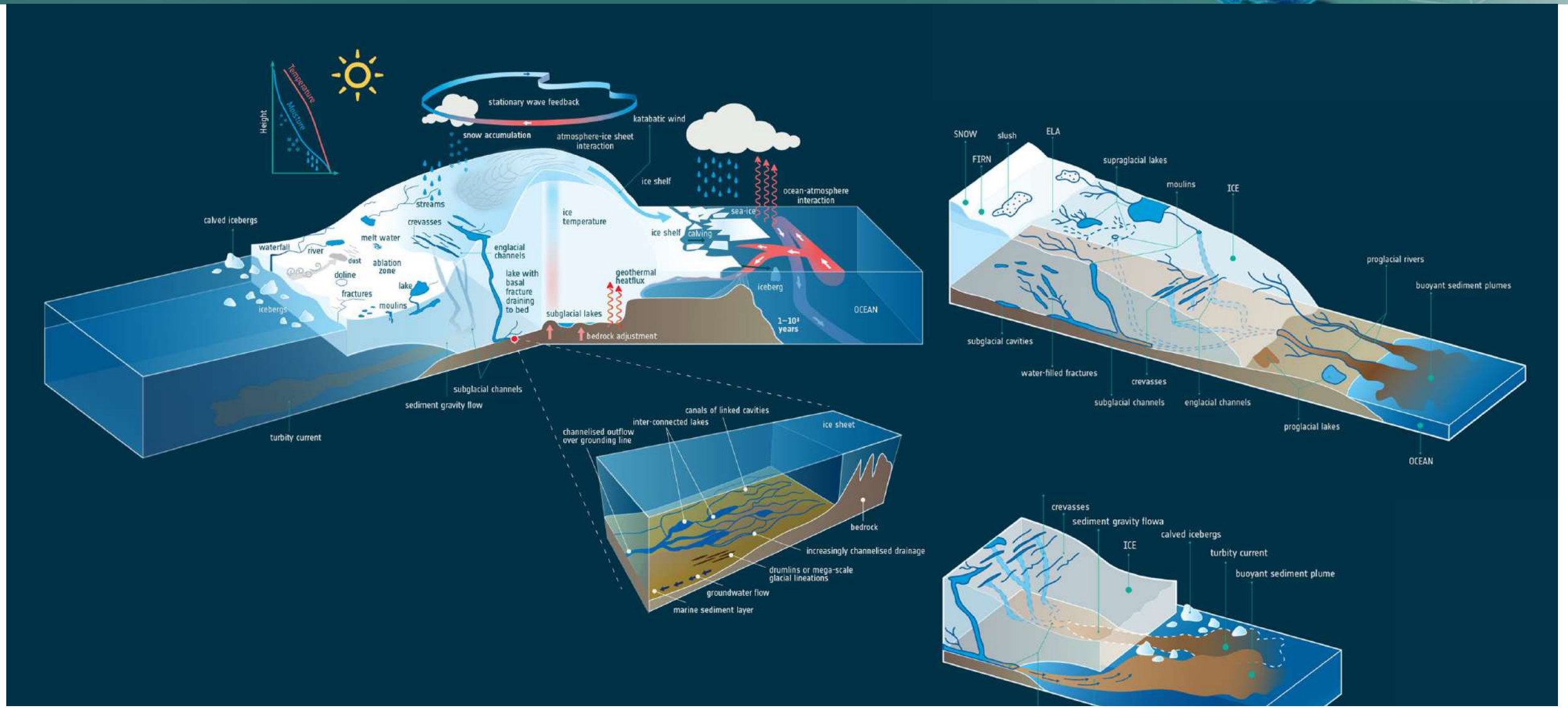
Understanding the Antarctic System



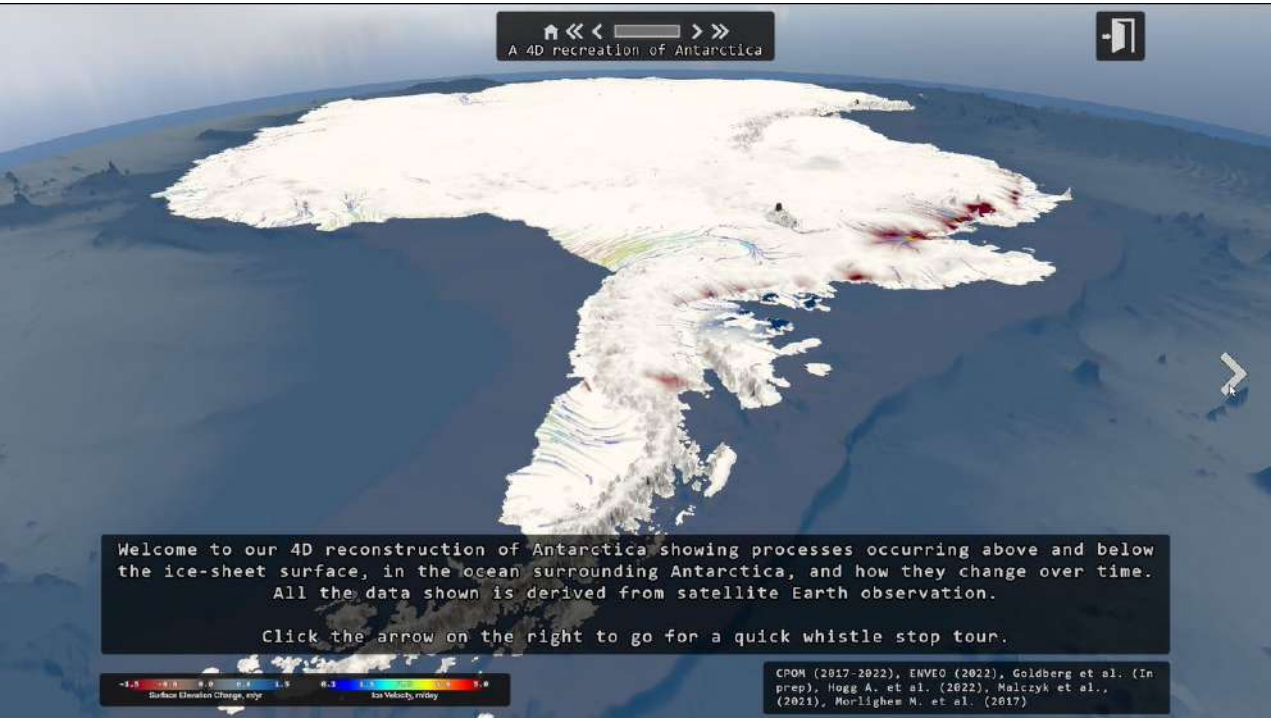
Reconstructions of the Earth's sub-systems: 4D Antarctica

Multivariate data exploration and analytics in a web platform

DeepESDL 4D viewer
- Works with datacubes
- Metadata includes info on visualization properties

earthwave

EARTH SYSTEM DATA LAB



4D-Antarctica

Federating Space and Ground Measurements with IoT

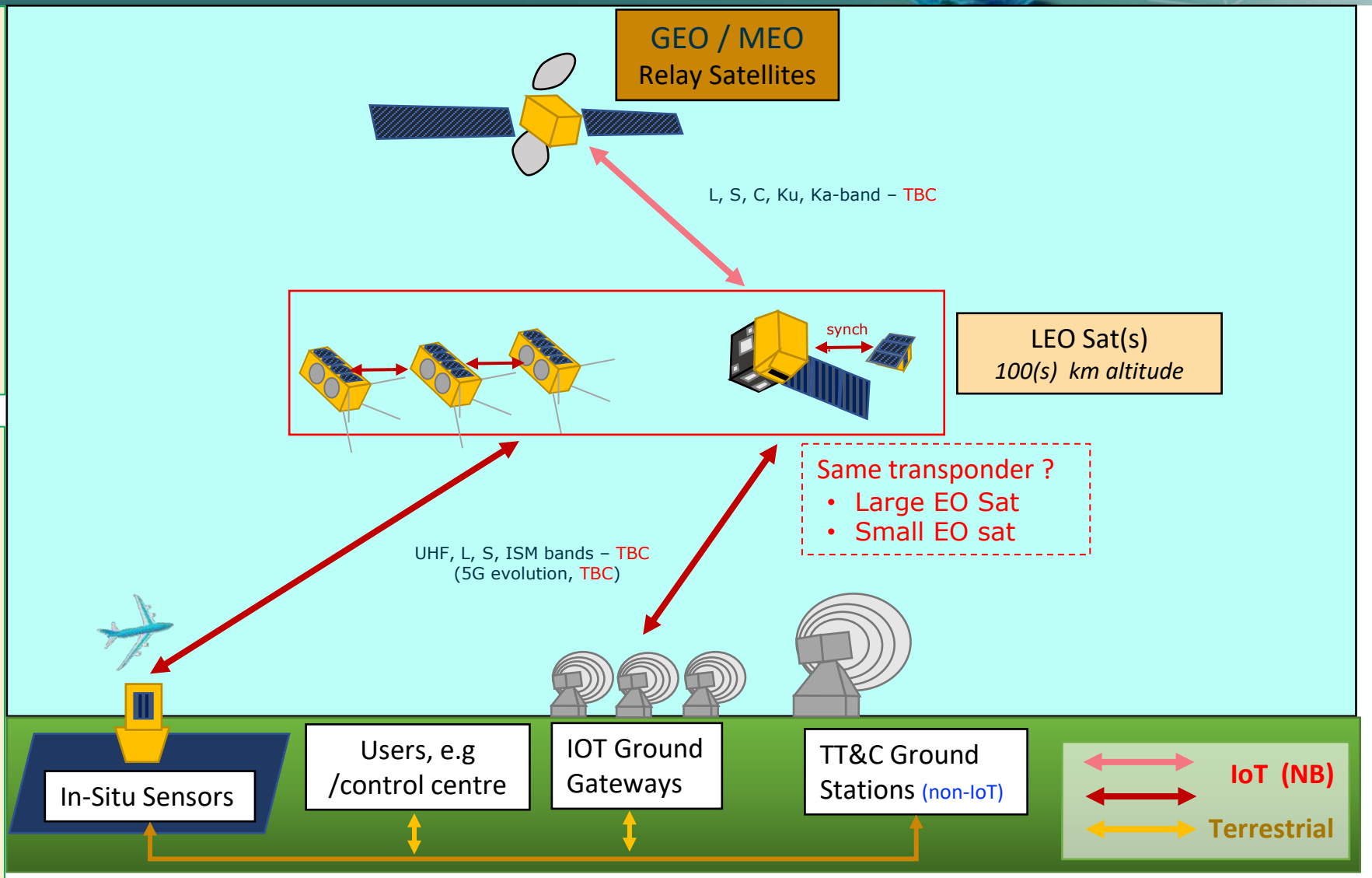
Seamless network

LEO EO sat (Sentinels) with

1) **GEO/MEO** relay
2) **LEO** (Harmony, small sats)
3) **On-ground**
   - Gateways
   - in-situ sensors (also via Terrestrial)
     → federating & automating & efficiently (e.g. for data fusion, CAL/VAL)
     → trigger Near RT acquisitions

Benefits of IoT Federation

- **Timeliness**
  Near permanent connectivity + Near Real Time
- **Simple:** no pointing, low power → **low rate [kb/s]**
- **Enabler for New Use Cases:**
  - Multi mission measurements synchronicity
    - Signal separation
    - Signal coverage
    - Signal combination
  - Tasking the sats in NRT
  - Actionable information to Earth in NRT
  - High-interaction with Mission Control Centre
    → gain Autonomy



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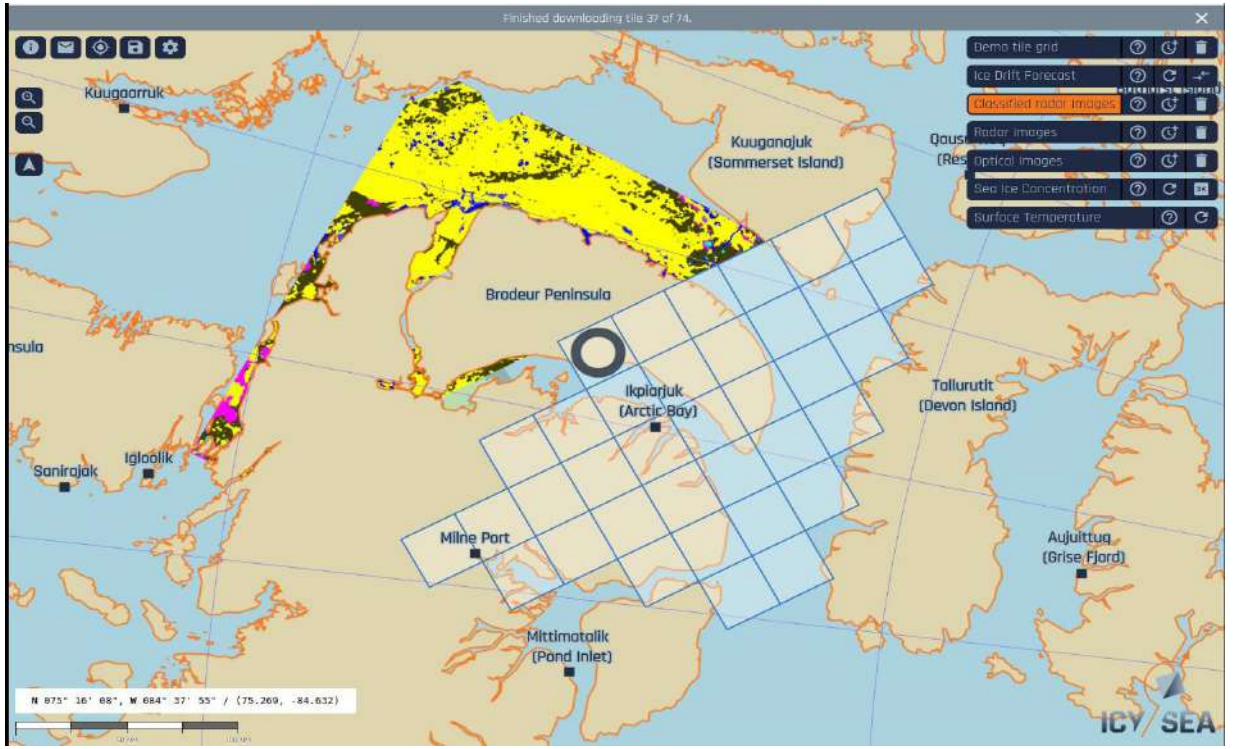
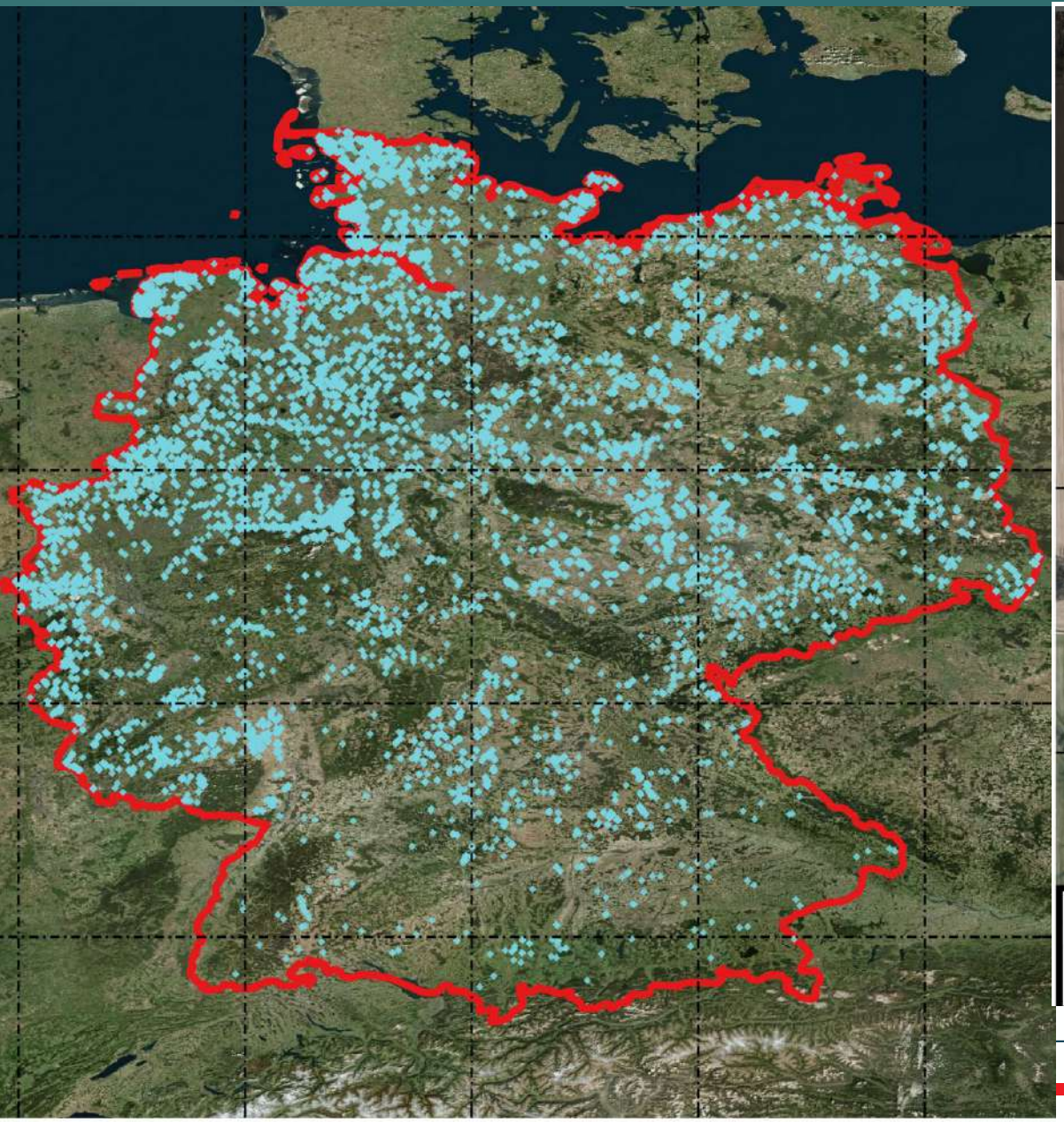
Operational Sea-Ice Charting Service

Sea-ice charts are currently created by national ice services through human analysis of SAR satellite images. Using ML and scalable cloud platforms, sea ice chart production can be automated so that ships can have access to timely and accurate information.

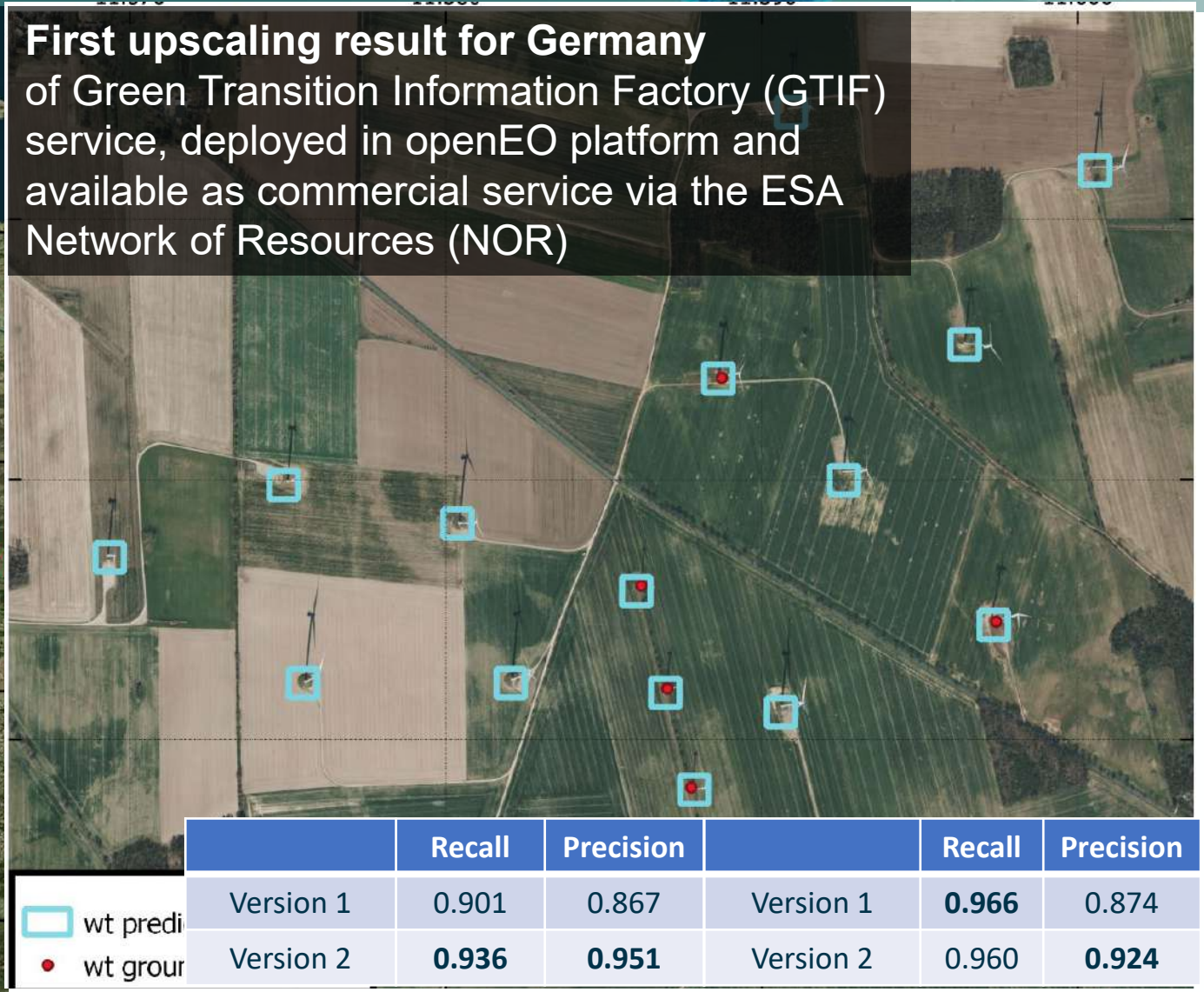
Polar TEP cloud platform is using a Convolutional Neural Network (CNN) to derive sea ice information from Sentinel-1 images that is then operationally delivered directly to ships in near-real-time through the IcySea app



GTIF Services: wind turbine detection on-demand



First upscaling result for Germany
of Green Transition Information Factory (GTIF) service, deployed in openEO platform and available as commercial service via the ESA Network of Resources (NOR)

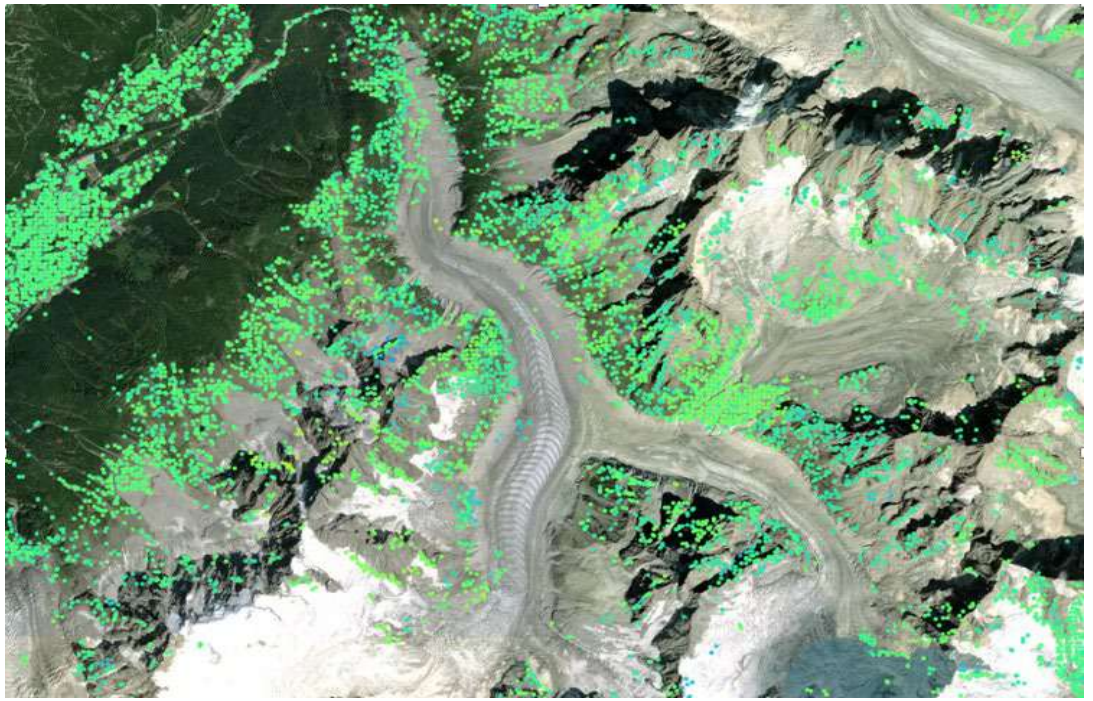


	Recall	Precision		Recall	Precision
Version 1	0.901	0.867	Version 1	**0.966**	0.874
Version 2	**0.936**	**0.951**	Version 2	0.960	**0.924**
	vs Open Street Map			vs independent test set	

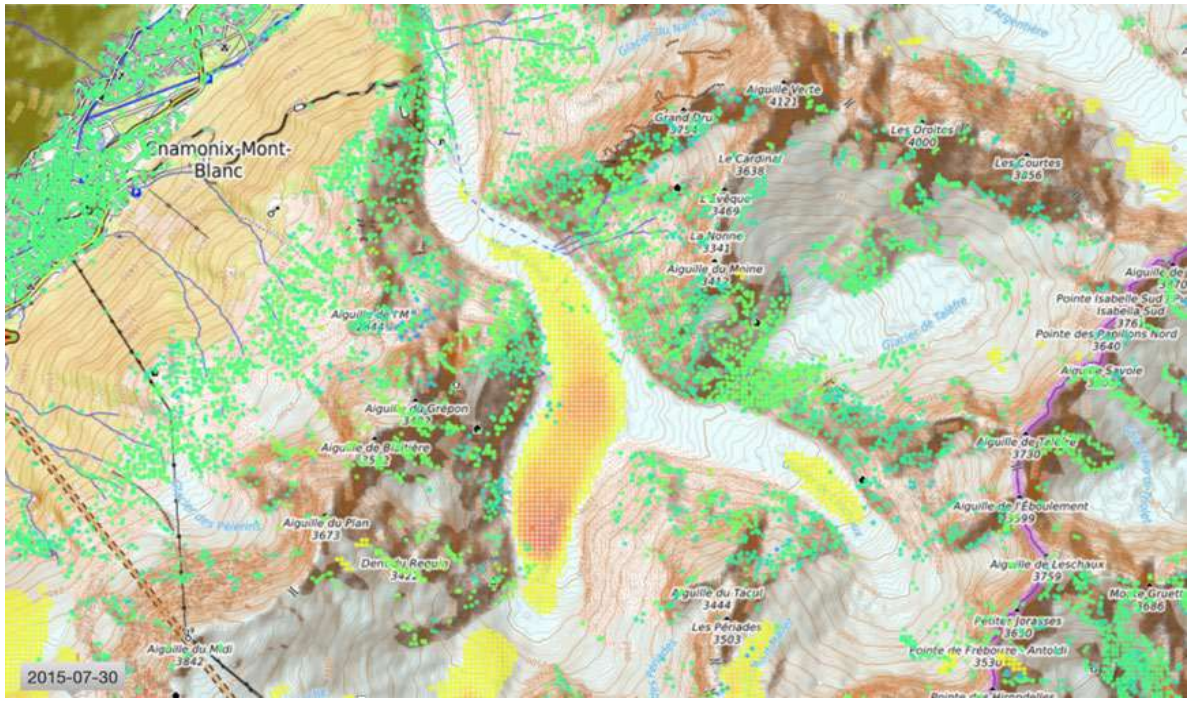
Operational Terrain Motion Map service

The Cloud platform Geohazards Exploitation Platform (GEP) provides advanced terrain motion mapping combining both mass production of Sentinel-1 interferometric data and correlograms using large Sentinel-2 data collections. The capability is operational, scalable and available on the Network of Resources originated by ESA

Surface displacements based on 4 years of Sentinel-1



Glacier displacements



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Multivariate Data Exploration and Analytics

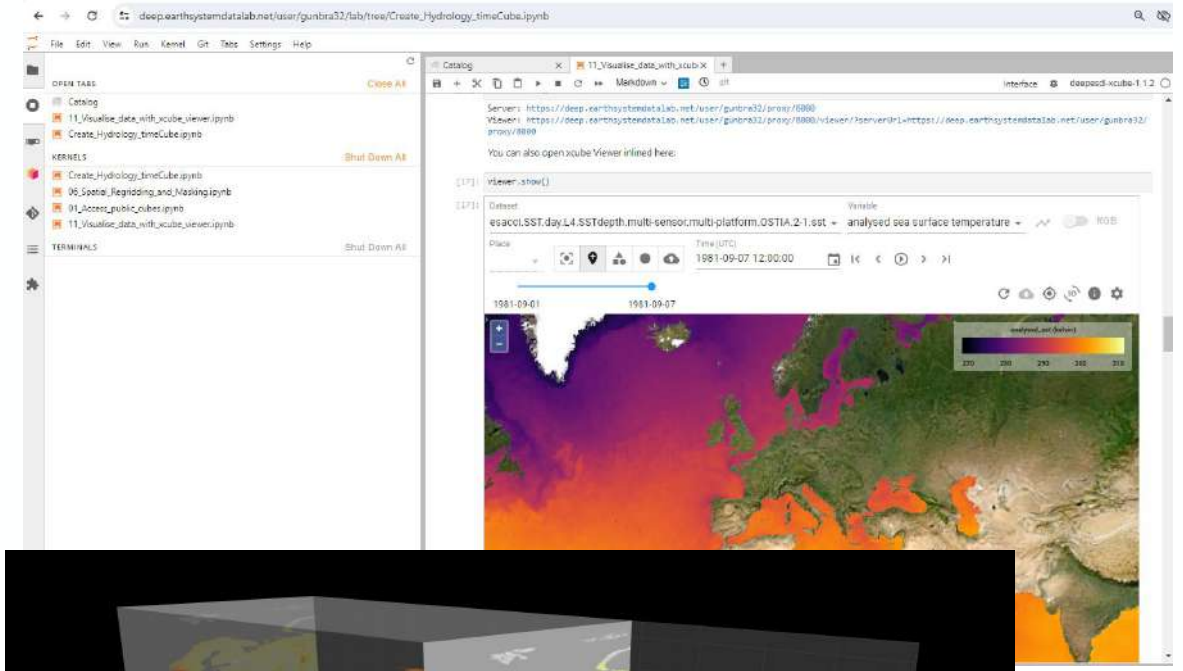
EARTH SYSTEM DATA LAB

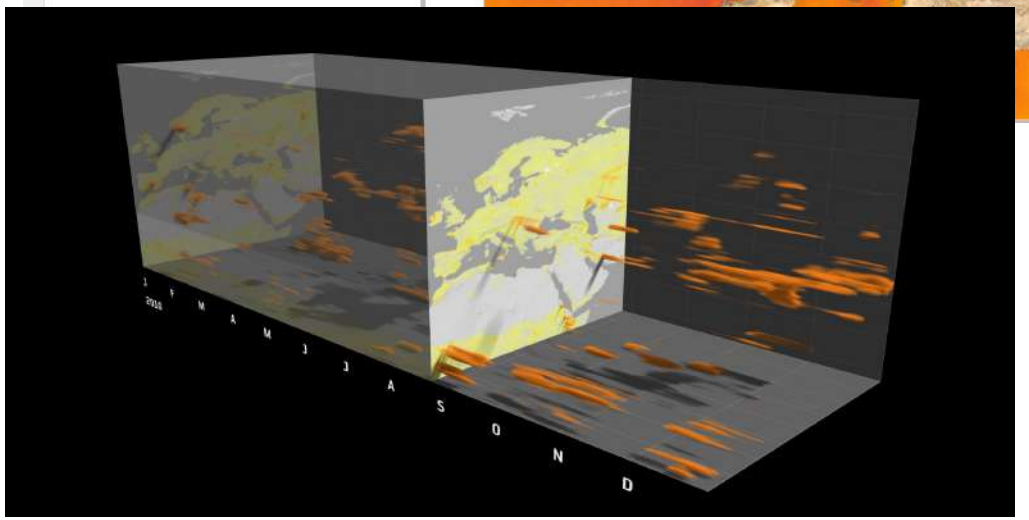
esa

BROCKMANN CONSULT

UNIVERSITÄT LEIPZIG

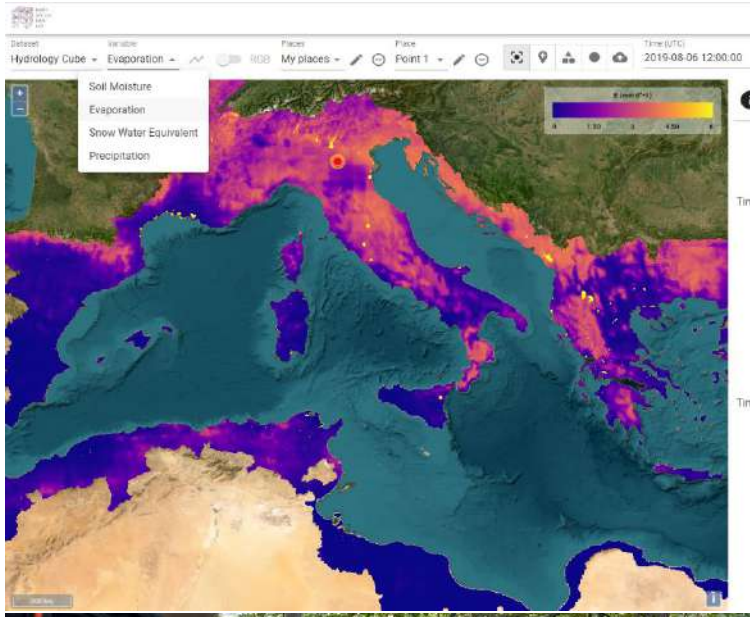
Integrated in Jupyter





Advanced spatio-temporal data exploration "look inside the cube"

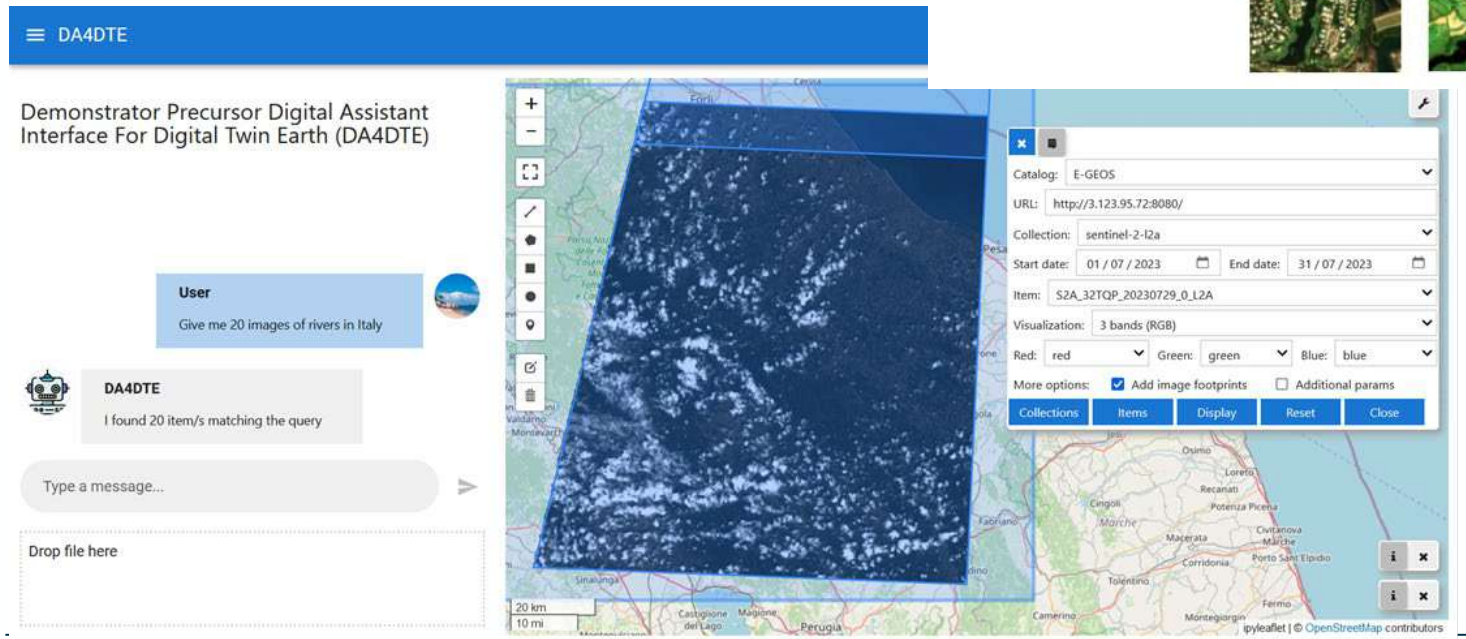
Web based exploratory tools



Coupled with location data for site-specific understanding

Precursor Digital Assistant for EO and Digital Twins

Search by Example query, searching for Sentinel-2 semantically similar image

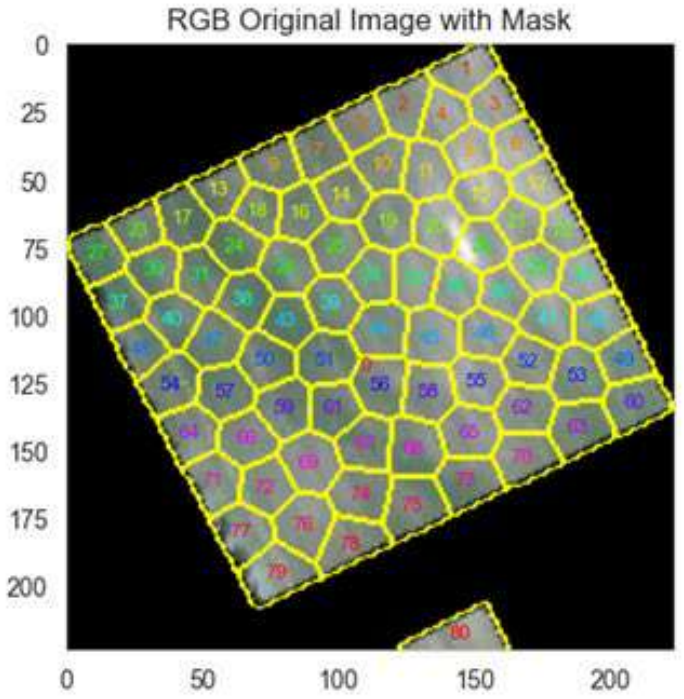


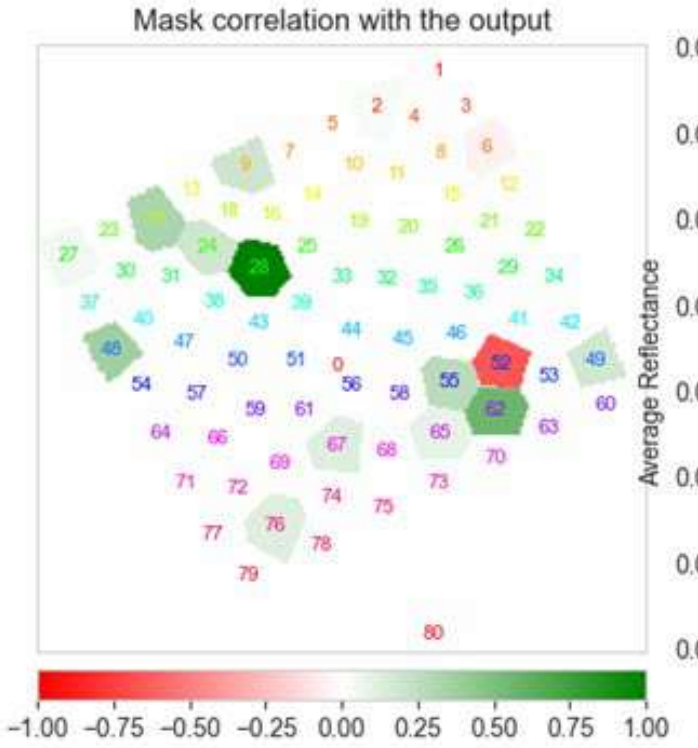
Digital Assistant powered by Natural Language Processing (NLP)

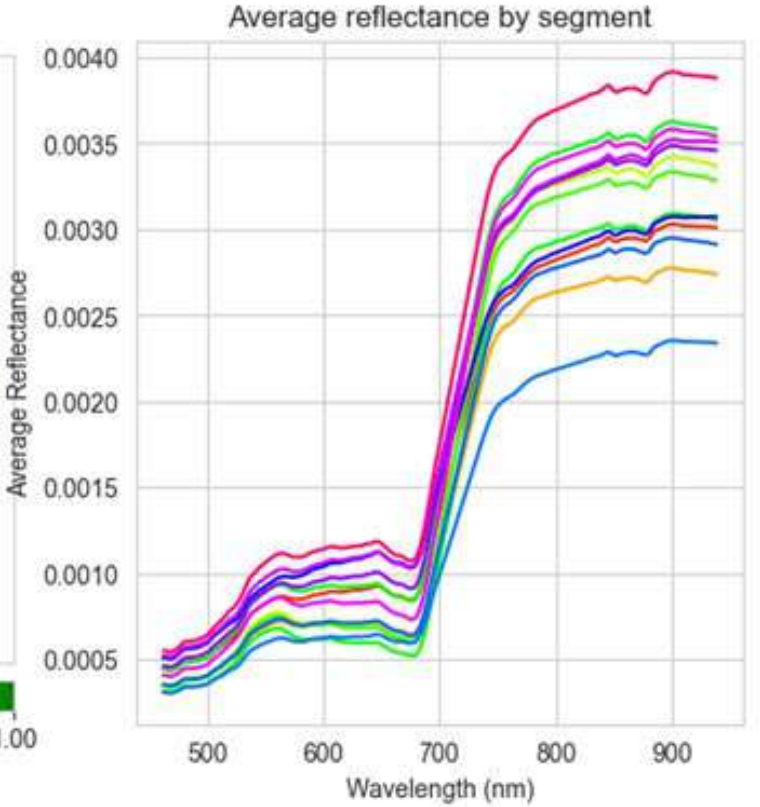
DA4DTE project by E-GEOS, TU Berlin and Univ Athens

Explainable AI for EO and Earth Science

Using ExplainableAI(xAI) techniques to explain the spatial-spectral correlation between high-dimensional Hyperspectral data and soil chemical components – KPLabs/Univ. Warsaw







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Flooded Areas Reconstruction under Partial Cloud Cover

Illustration from Incubed ESA-funded FloodSENS project
(credit RSS-Hydro - LU)

An AI algorithm efficiently reconstructs flooded areas under partial cloud cover in optical EO-based satellite images, using auxiliary derivative layers from Copernicus DEM, and water flow algorithms.

On the use of physics-informed Machine Learning algorithms to better monitor (and predict) flood hazards

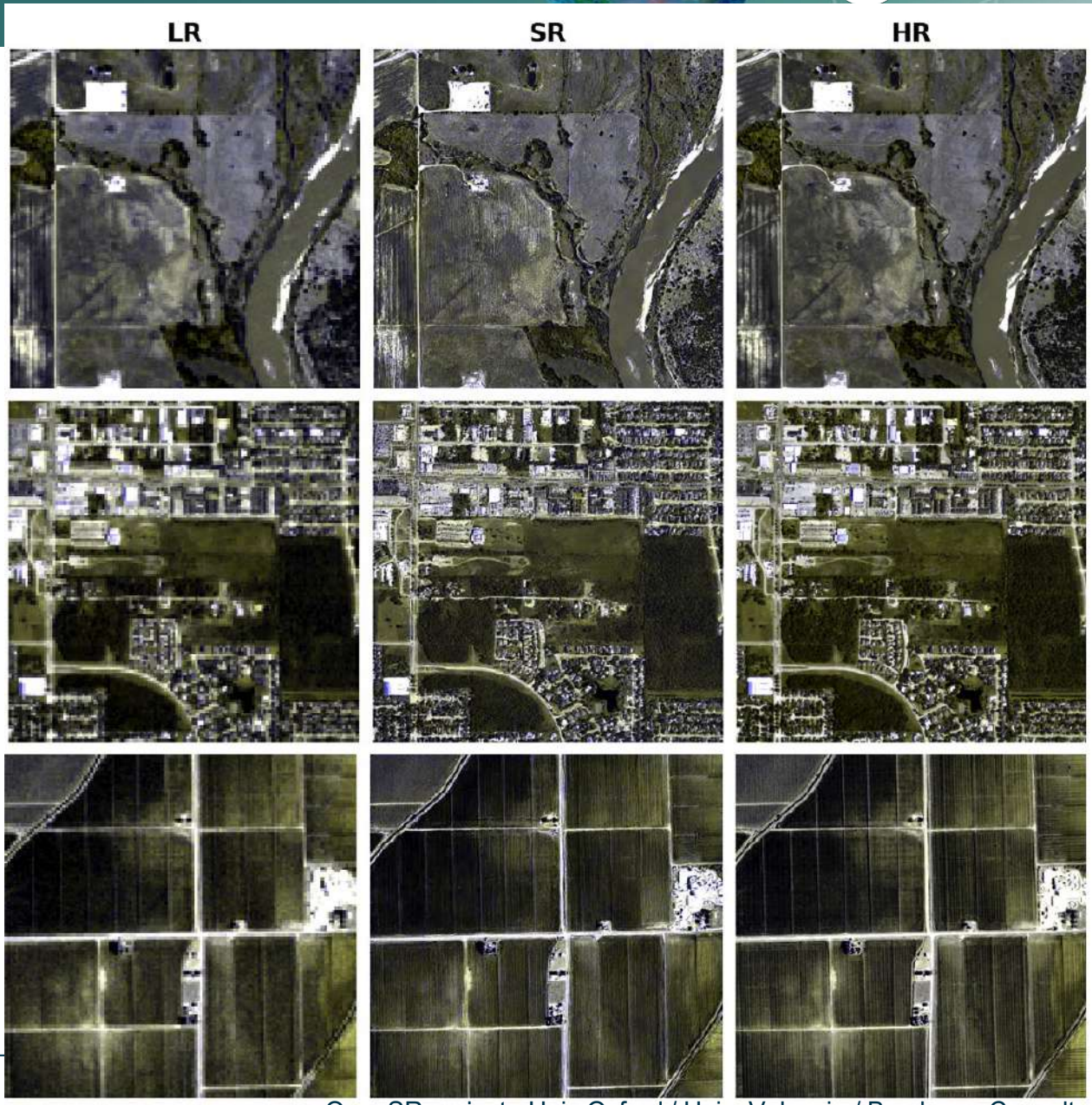
Extended reality using NVIDIA Omniverse to help humanitarian and disaster relief organizations

VHR with Super Resolution

Super Resolution (SR) algorithm based on "Diffusion" model trained on a massive dataset with Sentinel-2 collocated to VHR imagery.

- LR – Low Resolution from Sentinel-2
- SR – Super Resolved images at 2.5 m
- HR – High resolution reference images at 2.5 m

Limited error expressed as artefacts due to "hallucinations"



OpenSR project - Univ Oxford / Univ. Valancia / Brockman Consult

Strategic Objectives – for discussion at Splinter #4

To foster the development of a culture of openness in EO science, applications and industry, and of a sustainable open innovation ecosystem.

To develop and enhance European capabilities for harnessing digital innovation, particularly AI, to maximise the exploitation of EO data for scientific and socio-economic benefits.

Splinter #4 Accelerating discovery in Earth science with open science and digital innovation

→ Review strategy to harness Open Science through Digital Innovation
→ Aiming to maximise impact and look towards the future
→ Gather feedback from community
→ Propose updates to the text

Splinter #4 Open Science & Digital Innovation

Raporteurs:

Anca Anghelea, Zaynab Guerraou, Julia Kubanek, Claudio Iacopino

Discussion:

- **ESA's strategic approach to:**
  - Open Science and Open Innovation
  - Open-source
  - Data-intensive & High-performance computing
  - Interoperability, open architectures
  - New technologies for Earth Action (AI/ML, data fusion, edge computing, prescriptive analytics, IoT, VR, etc..)
  - Transparent but Trusted and Secure
  - International collaboration, partnerships
  - Ethics, inclusivity, participatory science