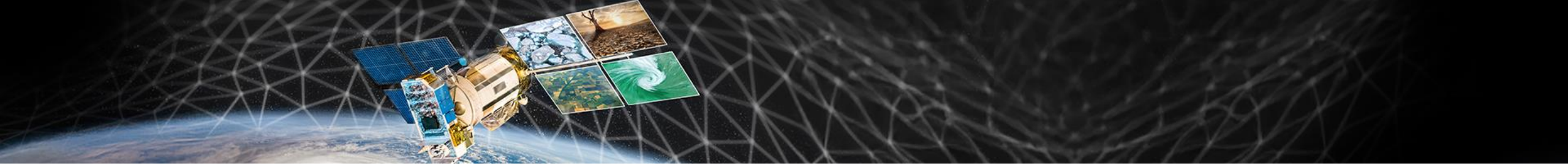
NASA
esa
International workshop on AI Foundation Model for EO
5-7 May 2025 | ESA ESRIN - Frascati, Italy



Addressing cloud- and shadow-induced data gaps in complex terrains for forest monitoring: Advancing EO foundation models with a multi-resolution approach

J. Lampert, P. Fanta-Jende, J. Salzinger, L. Beltrame, P. Thiele, D. Duarte , B. Schumacher, C. Briese

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Massive amount of EO data available.

Pretrained Foundation Models offer a great opportunity for scientists.

Fine-tuning for domain-specific applications challenging.

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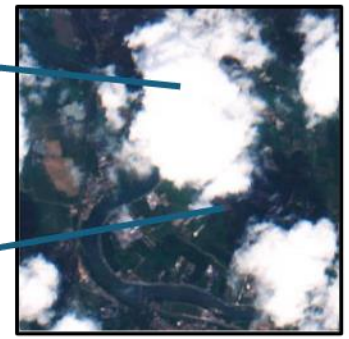
Raw Satellite Data



Data Exploitation

Direct prediction is **UNRELIABLE**

SAFIR

Image **ENHANCEMENT**

removing clouds and shadows

HIGH QUALITY intermediate data

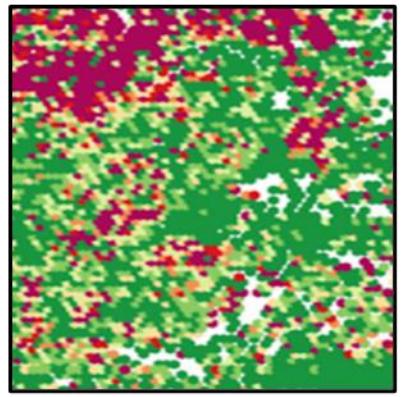
high-quality ground truth

Prediction from **HIGH QUALITY**

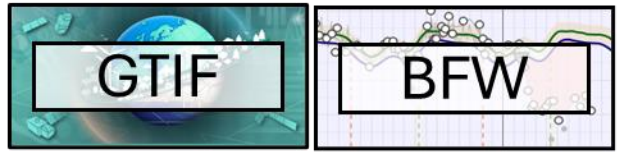
predicting from enhanced images

Actionable Insights

- windthrow
- anomaly
- …



integration



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SAFIR

Sentinel-Assisted Forestry Insight and Research - AI for Climate-Responsive Forest Monitoring in Mountainous Regions

- Call: Digital Twin Austria
- Project duration: 3 years
- Project start: 1.11.2024
- Coordinator: AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

Associated Partners

LSCE

Technische Universität Braunschweig

d.gTerritório Direção-Geral do Território

UNIVERSIDADE D COIMBRA

Stakeholders

ÖSTERREICHISCHE BUNDESFORSTE

BFW BUNDES FORSCHUNGS ZENTRUM FÜR WALD

Project Partners

eodc

INESCC

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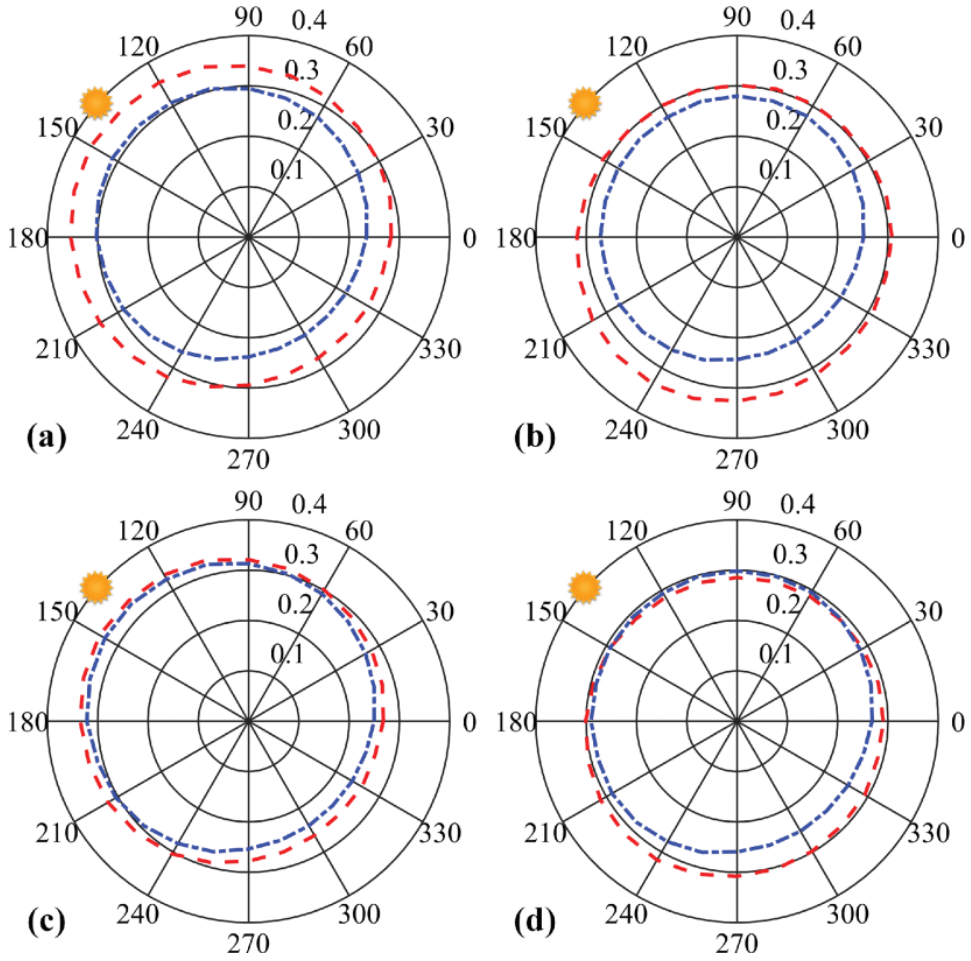
Key Challenges for Remote Sensing-Based Forest Monitoring:

- Increased monitoring frequency is necessary (due to natural hazards and climate change-related effects).
- Shadowing effects caused by mountainous terrain and cloud shadows in optical Earth observation data hinder monitoring:
  - Data is not directly usable
  - Delays detection and timely response
  - Leads to ecological and economic consequences (e.g., late detection of damage events)

Sentinel-2 and Geoland ortho mountain shadows, Source: gtif.esa.int

Topographic correction:

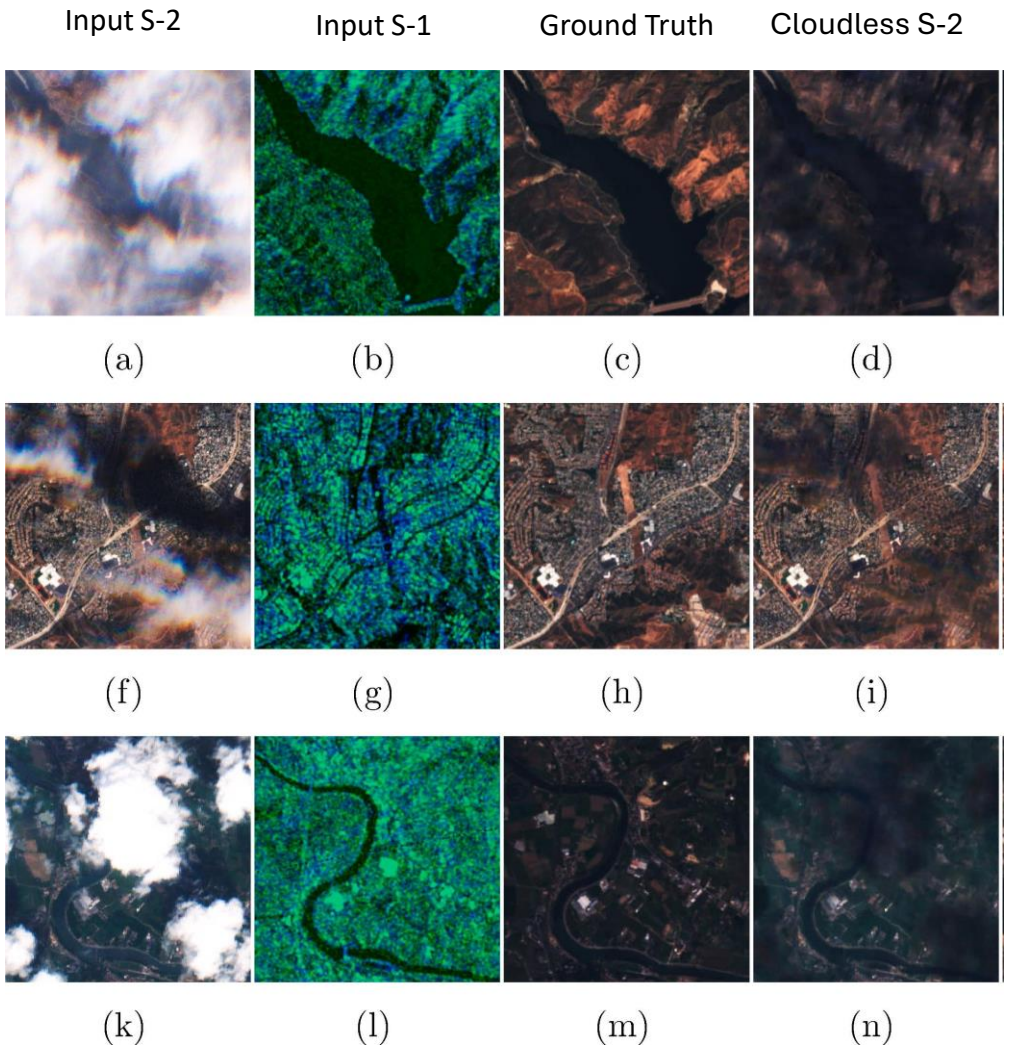
- Benefit: Accounts for differences in illumination due to terrain.
- Approach: Radiometric correction of data using a digital elevation model.



G. Yin *et al.*, "PLC-C: An Integrated Method for Sentinel-2 Topographic and Angular Normalization," in *IEEE Geoscience and Remote Sensing Letters*, vol. 18, no. 8, pp. 1446-1450, Aug. 2021, doi: 10.1109/LGRS.2020.3001905

Deshadowing and declouding of Sentinel-2 images:

- Benefit: Additional images for training of downstream tasks.
- Approach: Detection and correction of clouds and cloud shadows using neural networks and radar data.



Meraner, Andrea, et al. "Cloud removal in Sentinel-2 imagery using a deep residual neural network and SAR-optical data fusion." *ISPRS Journal of Photogrammetry and Remote Sensing* 166 (2020): 333-346.

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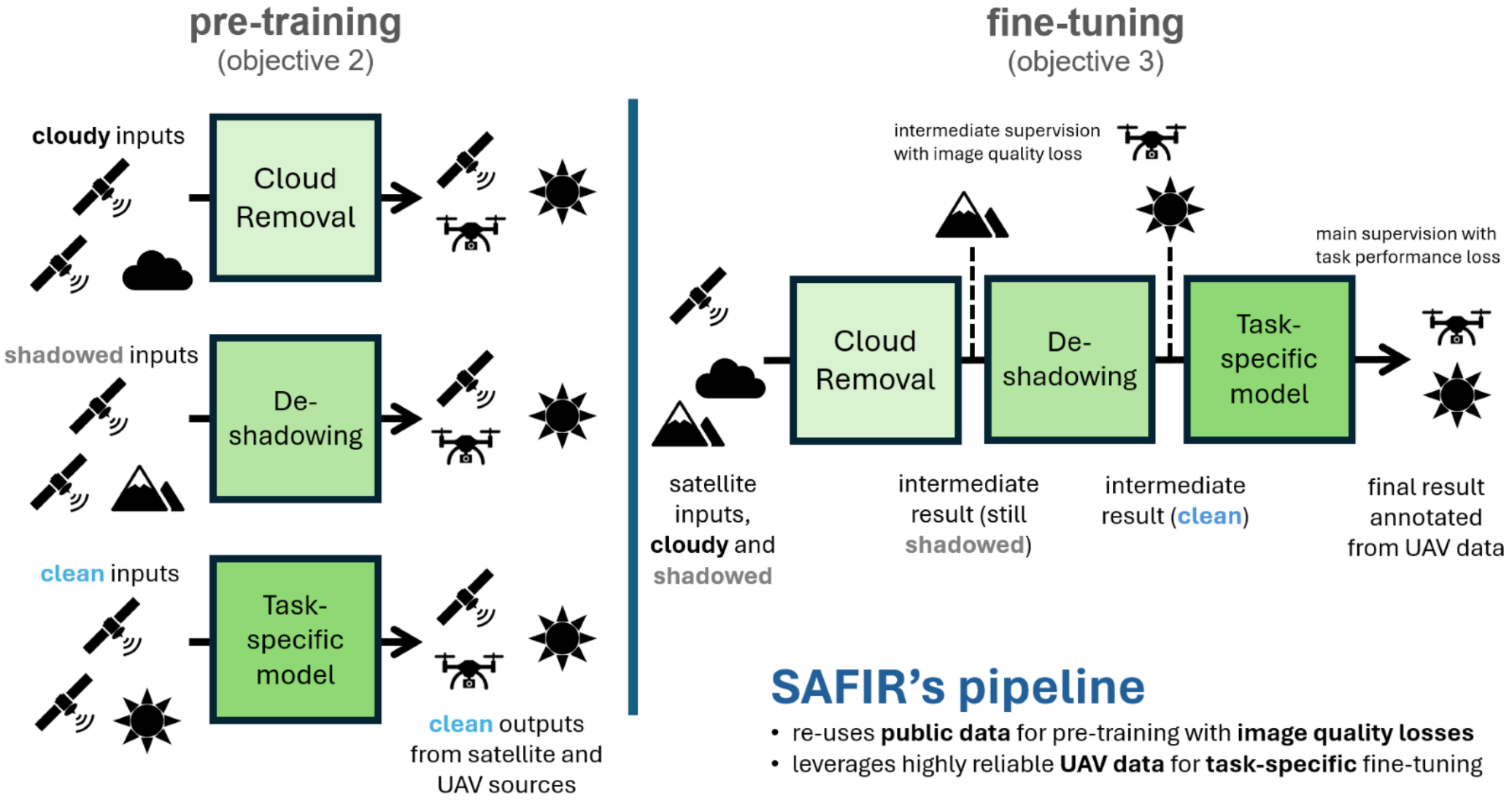

SAFIR's pipeline

- re-uses **public data** for pre-training with **image quality losses**
- leverages highly reliable **UAV data** for **task-specific** fine-tuning

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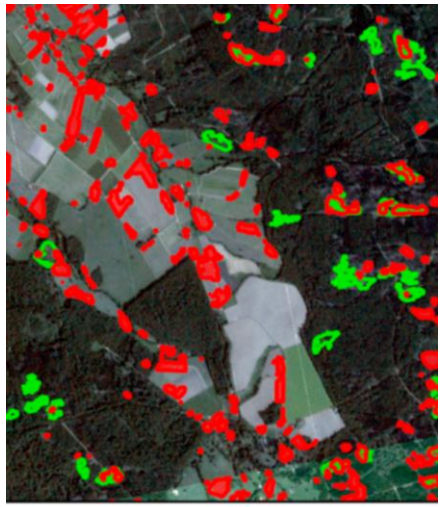
Task 1: Windthrow Detection

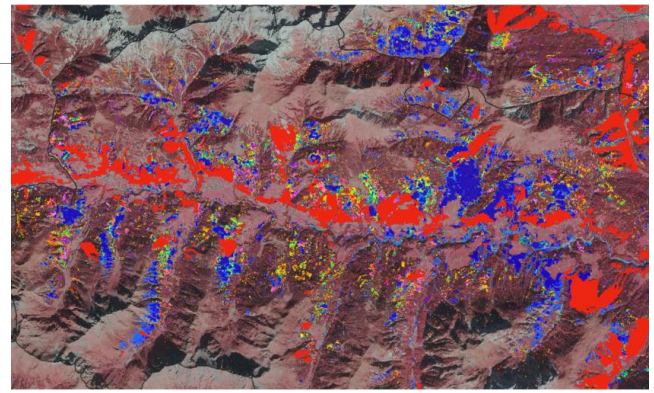
- Benefit: Rapid detection of windthrows
- Products: Binary raster layer
- API/WebUI: Data layer integrated as a mock-up for demonstration purposes in GTIF



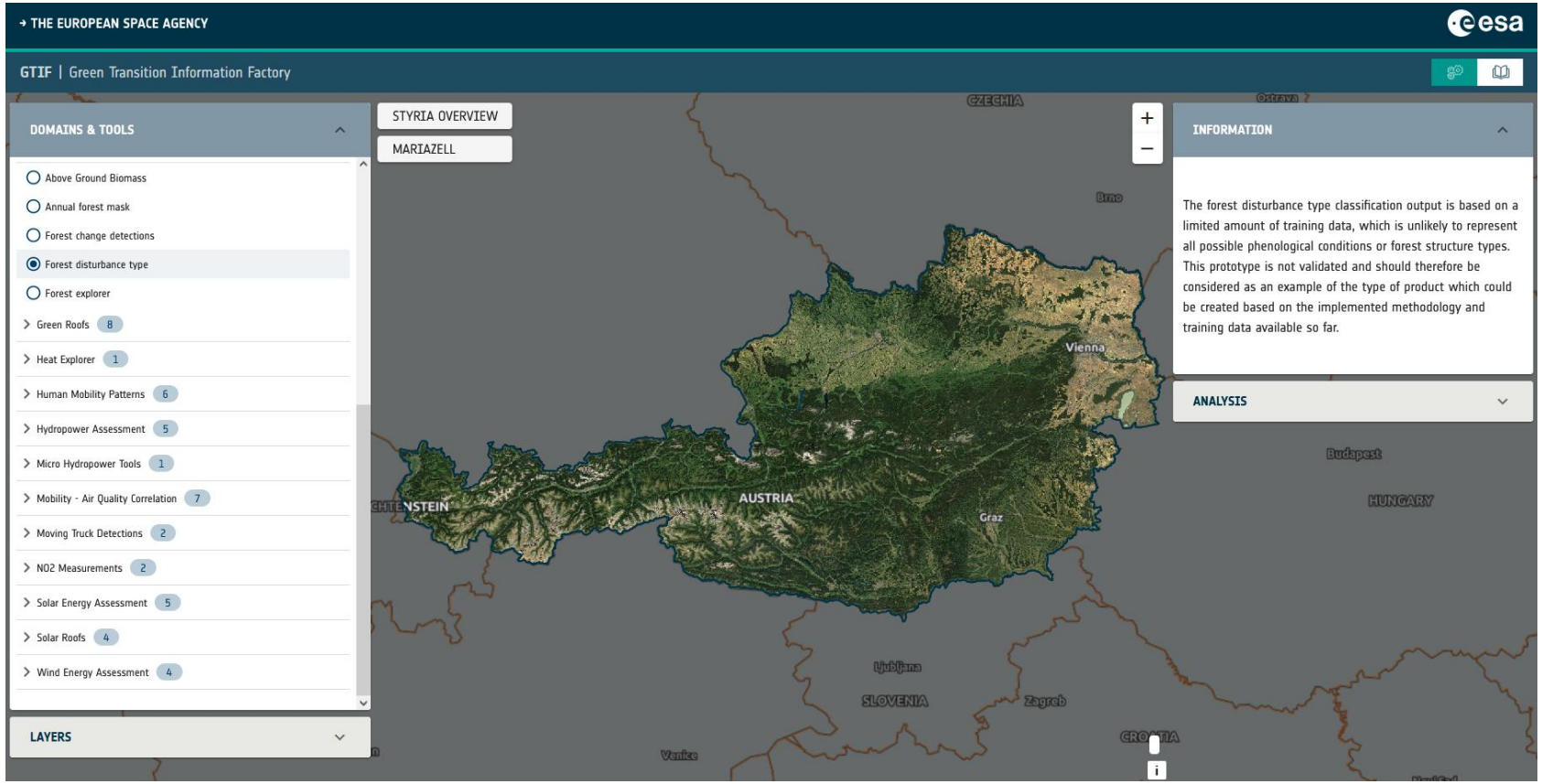
Deigele, W.; Brandmeier, M.; Straub, C. A Hierarchical Deep-Learning Approach for Rapid Windthrow Detection on PlanetScope and High-Resolution Aerial Image Data. *Remote Sens.* **2020**, *12*, 2121.

Task 2: Anomaly Detection

- Benefit: High-frequency forest anomaly detection
- Products: Raster layer time series
- API/WebUI: Data layer integrated as a mock-up for demonstration purposes in GTIF



ESA‘s Green Transition Information Factory (https://gtif.esa.int/)



European data and analytics infrastructure concept:

- First demonstrator in Austria.
- Combines Earth Observation, cloud-computing and cutting-edge analytics.
- SAFIR will provide results for GTIF.

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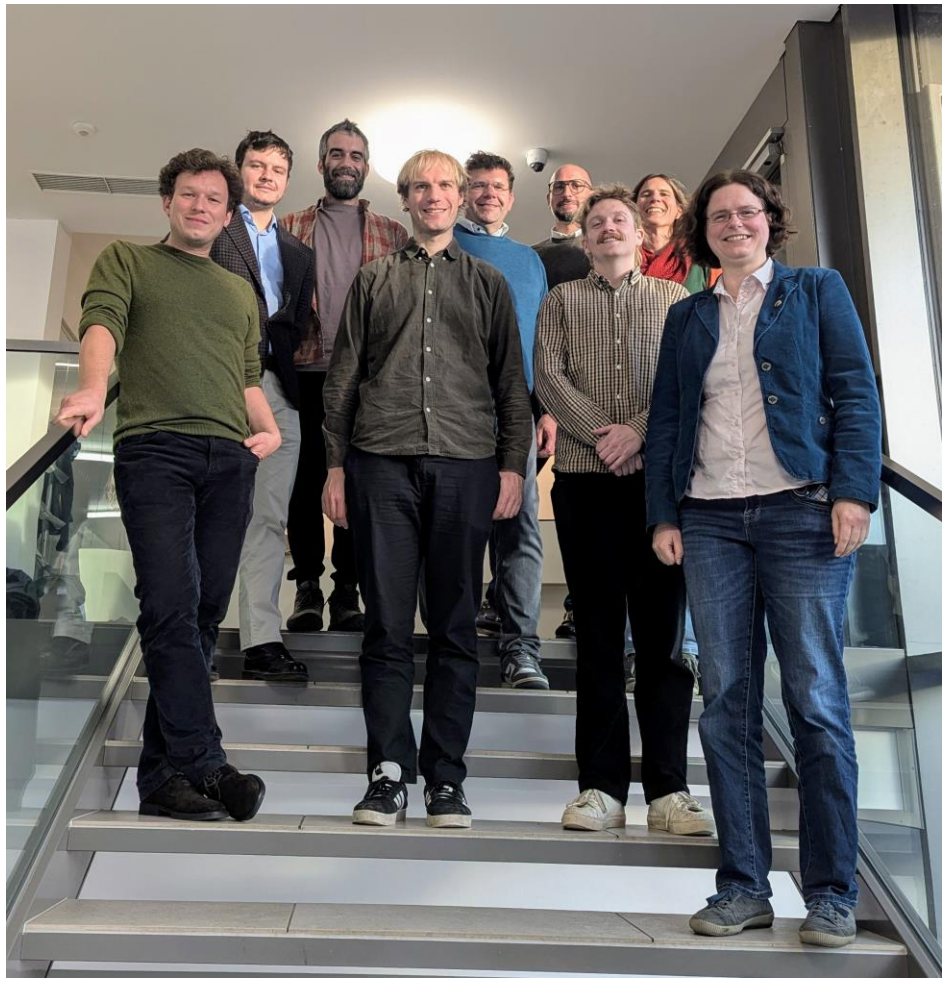
Tackling downstream tasks effectively requires domain knowledge.

More diverse, multi-modal datasets for fine-tuning foundation models are needed.

Development of new foundation models should be guided by needs of the EO community.

Thank you for your attention!



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The developments described are carried out within the SAFIR project funded by the Austrian Research Promotion Agency (FFG) in the frame of the Research, Technology & Innovation (RTI) initiative “Digitaler Zwilling Österreich”.