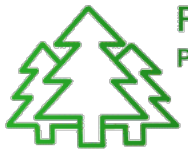




Towards a Digital Twin of the Earth's Forests

By the Forest DTEP consortium

Living Planet Symposium, 26 May 2022



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Part of ESA's Digital Twin Earth



funded by

Forest Digital Twin Earth Precursor

Land Use for a Carbon Neutral Europe

Matti Möttöus¹, Tuomas Häme¹, Eelis Halme¹, Lauri Seitsonen¹, Heikki Astola¹, Annikki Mäkelä², Francesco Minunno², Jussi Rasinmäki³, Juho Penttilä³, Matthias Dees⁴, Gero Pawlowski⁴, Monika Krzyżanowska⁵, Staszek Dątek⁵, Gheorghe Marin⁶ and others

¹VTT Technical Research Centre of Finland

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³Simosol OY (part of AFRY)

⁴Unique GmbH

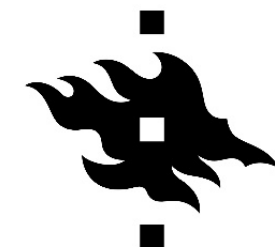
⁵Cloudferro Sp z o.o.

⁶Institutul Național de Cercetare-Dezvoltare
în Silvicultură Marin Drăcea (INCDS)

Under contract from



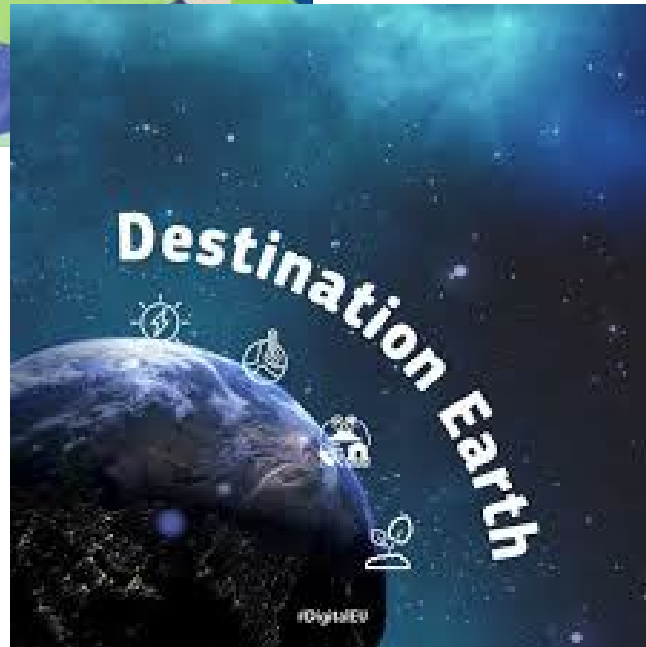
European Space Agency



HELSINGIN YLIOPISTO



Forest Digital Twin Earth Precursor



- EU Green Deal and EU Data Strategy call for bringing together European scientific and industrial excellence **to develop a very high precision digital model of the Earth.**
- DTE will provide a leading edge capability to “visualize, monitor and forecast natural and human activity on the planet in support of sustainable development thus supporting Europe’s efforts for a better environment as set out in the Green Deal”.
- Implemented in synergy with many parallel activities on monitoring the forests and carbon accounting.



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07/09/2022

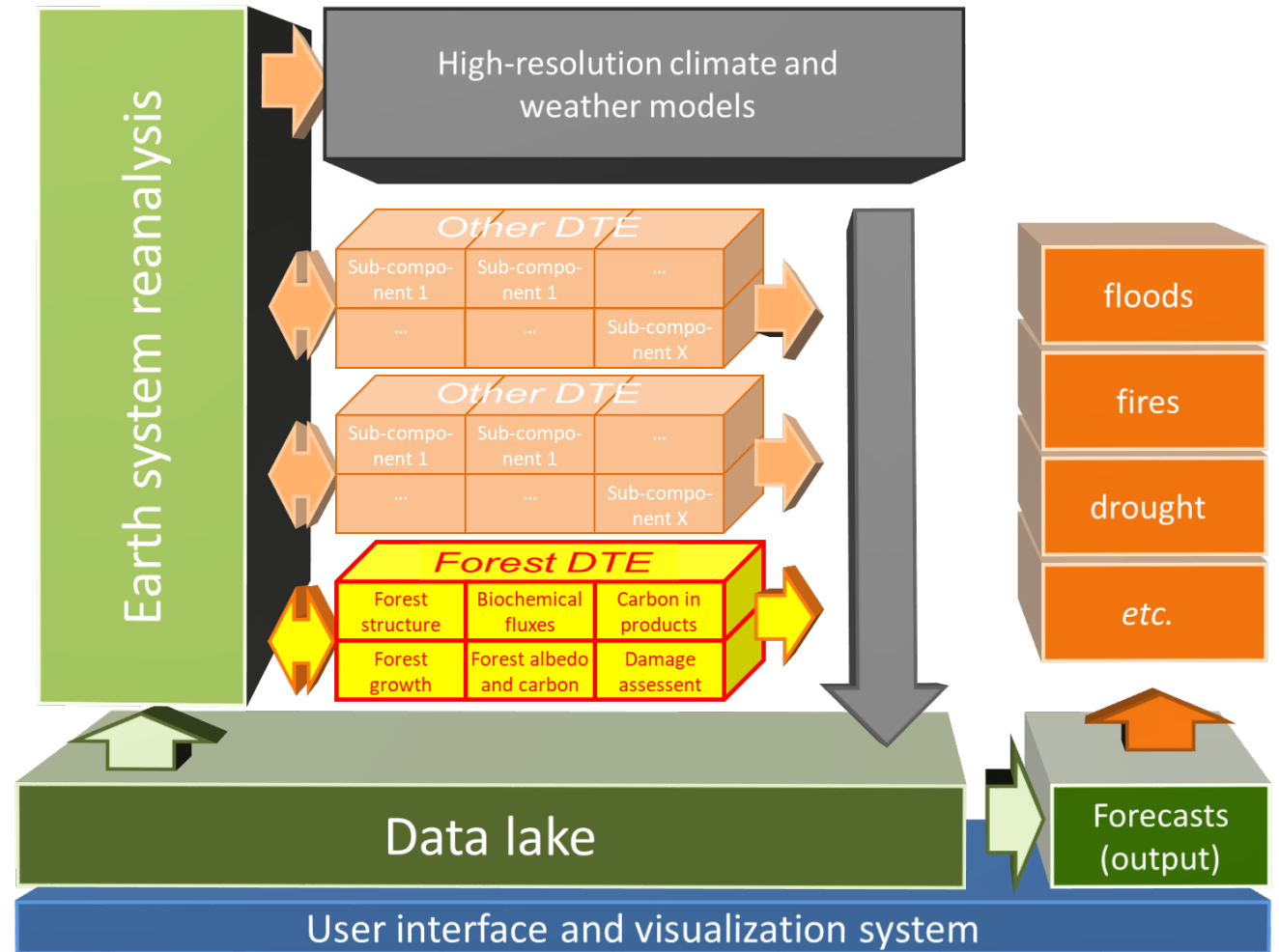


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Part of Digital Twin Earth

A specialized Digital Twin Earth can be used to simulate forest processes only:

- For simulations, requires data on the surrounding environment, e.g., climate data and ambient CO₂ concentration.
- Can provide more accurate information about chemical and physical exchanges (e.g., carbon, water or nutrients)
- Interacts with the data lake.



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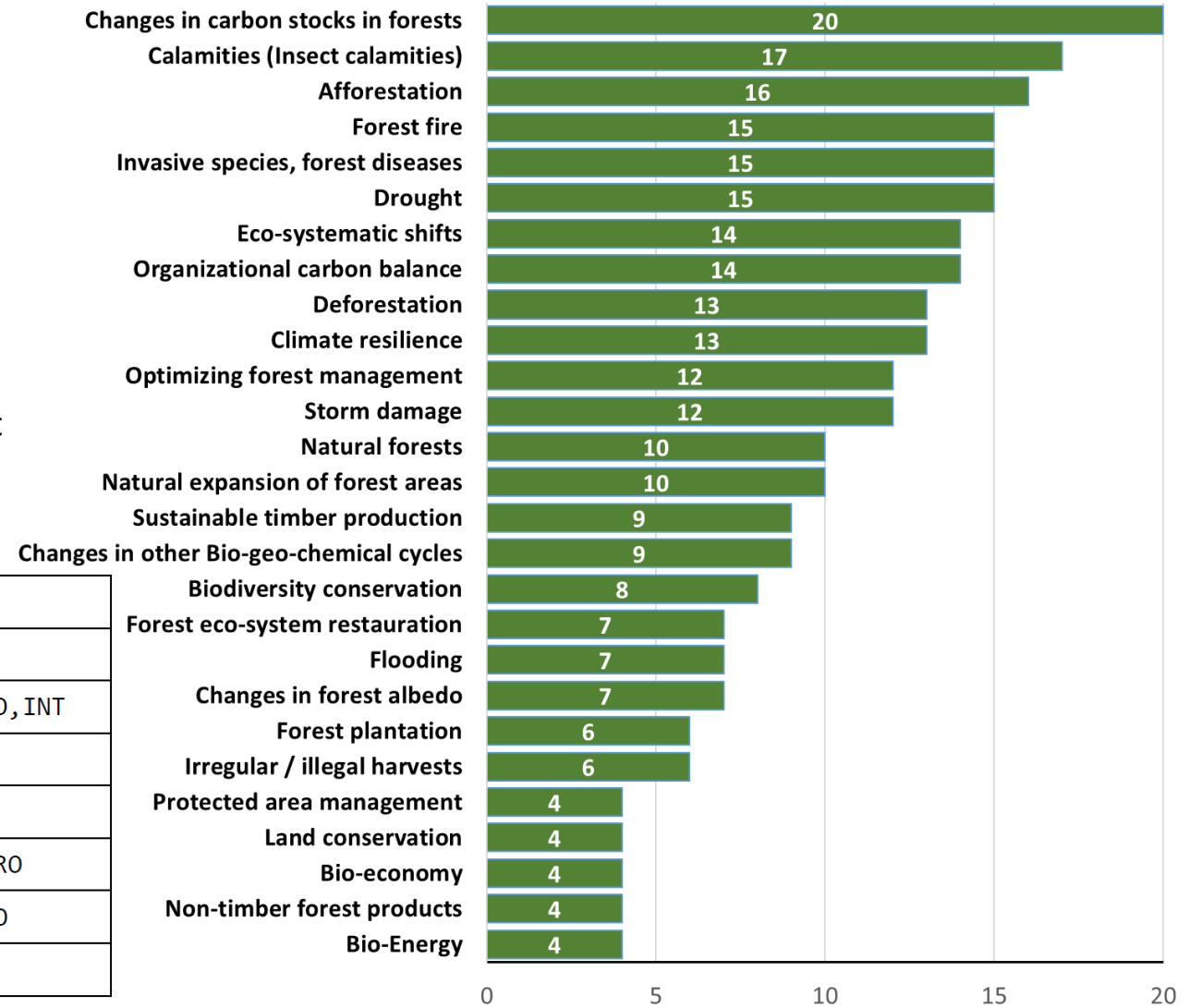
User requirements for DTE: most relevant topics

User requirements questionnaire in 2020

Möttus, M., Dees, M., Astola, H., Dałek, S., Halme, E., Häme, T., Krzyżanowska, M., Mäkelä, A., Marin, G., Minunno, F., Pawlowski, G., Penttilä, J. & Rasinmäki, J. (2021) A methodology for implementing a digital twin of the earth's forests to match the requirements of different user groups. *GI_Forum*, 9, 130–136

doi: 10.1553/GISCIENCE2021_01_S130.

User category	number	countries
Forest enterprises	5	DE, FI, RO
Governmental bodies & international organizations	9	DE, FI, PL, RO, INT
Forest and Wood Industry	3	FI, SE
Service Companies	1	DE
Scientific users	7	DE, FI, GB, RO
Public research institutes	5	DE, ES, FI, RO
total	30	



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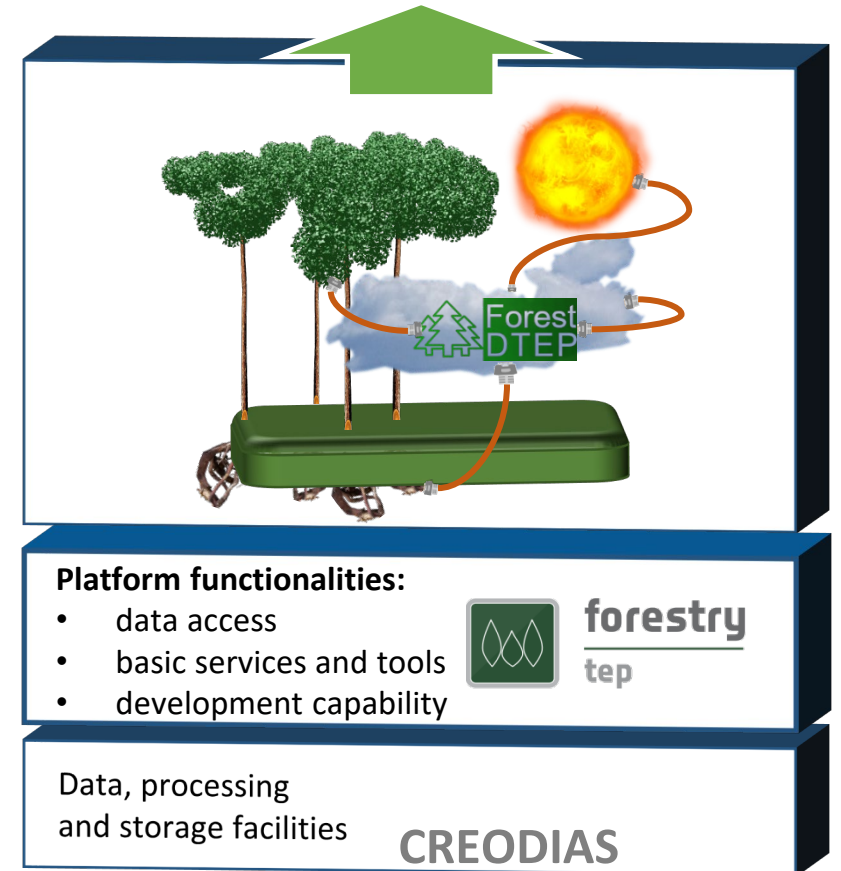
Forest Digital Twin Earth Precursor

A specialized Digital Twin Earth to provide Earth system reconstruction

- for variables not directly accessible by land surface models, e.g., detailed radiation balance;
- at resolutions not possible using only EO data and generic land surface models (e.g., forest structure);
- providing unique process-based understanding on the circulation of carbon and water among the different forest elements (soil, canopy components);
- Implemented on a cloud platform close to data with a web interface and API access.



End users

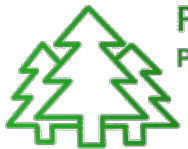
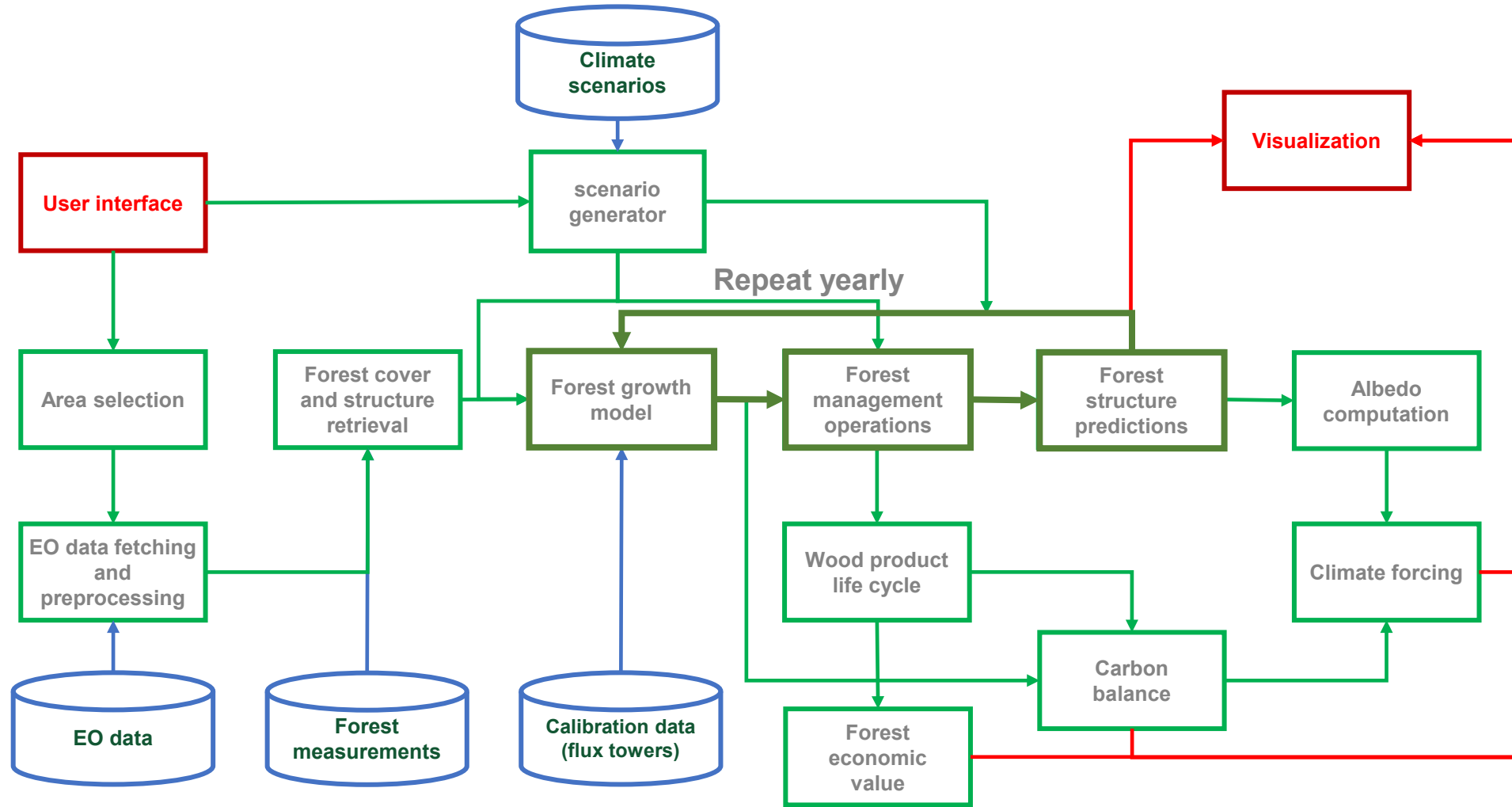


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Forest digital twin



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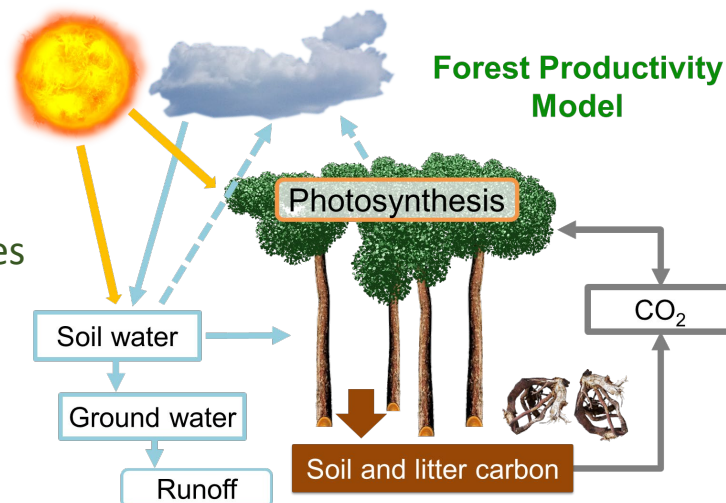
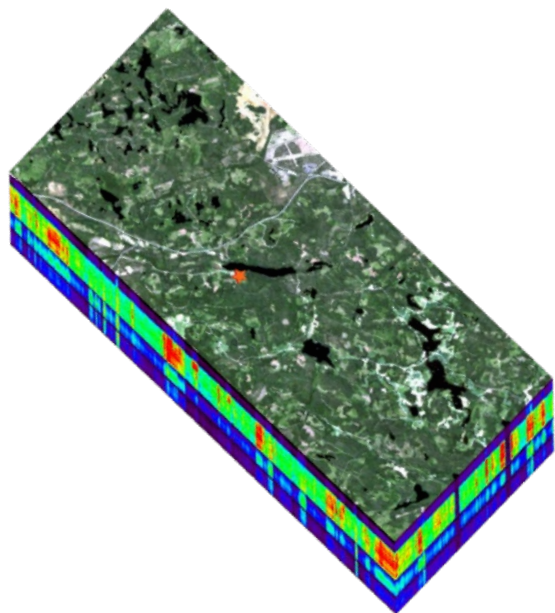


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Forest Digital Twin Earth Precursor

In:

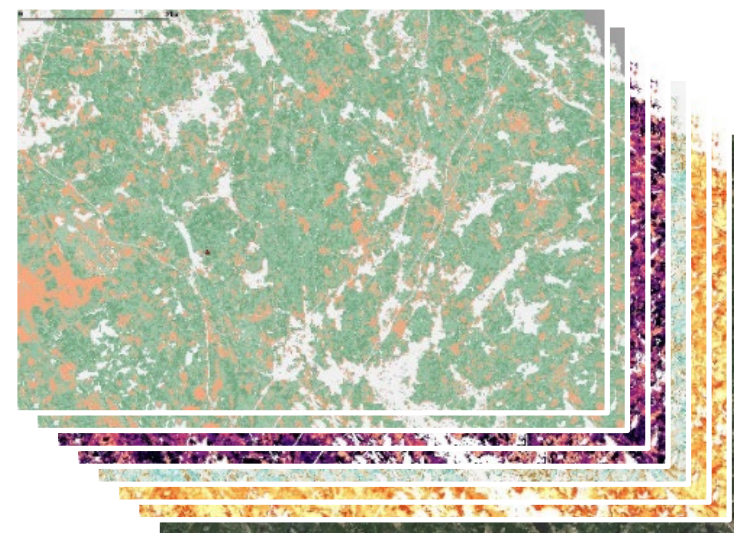
- Sentinel-2: optical multispectral data
- Forestry field data and national data bases
- weather data and climate scenarios



Out: Dynamic forest maps

- Above ground biomass (AGB)
- Below ground biomass
- Net Ecosystem Exchange
- Gross Primary Production
- Growing stock volume
- *etc.*

At very high resolution (Sentinel-2)



PRELES (light use efficiency model)

- ✓ inputs: Sol.rad., temp., VPD, Precip., LAI
- ✓ outputs: GPP, ET, SW

CROBAS (tree growth model)

- ✓ Inputs: stand variables (DBH, H, Hcb, BA)
- ✓ outputs: stand variables V, biomasses, litterfall

YASSO15 (Soil carbon model):

- ✓ inputs: litterfall, woody debris
- ✓ outputs: soil carbon, heterotrophic respiration

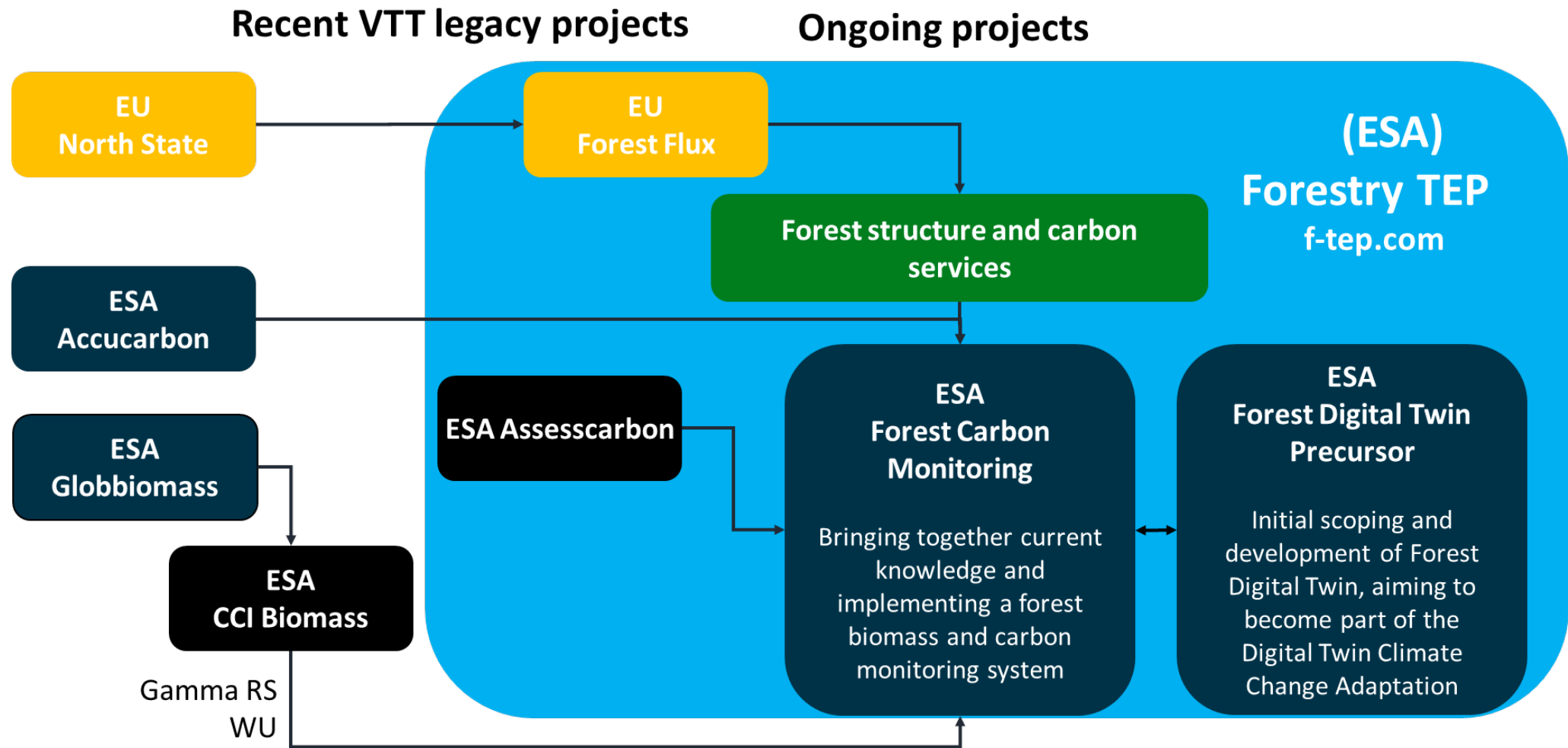


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Forest biomass and carbon monitoring project family



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Forestry TEP as a platform

<https://f-tep.com>



Led by VTT

- Coordination
- Domain expertise

Users' data →

Auxiliary data →

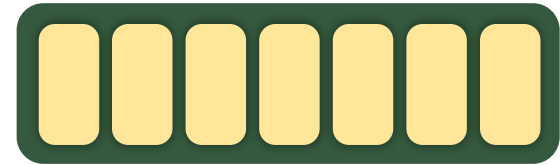


End users

Value-added information



3rd party services and applications



Platform functionalities - including data access; basic services and tools; development capability



forestry
tep

Data, processing and storage facilities

CREODIAS



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Data in Forest DTEP

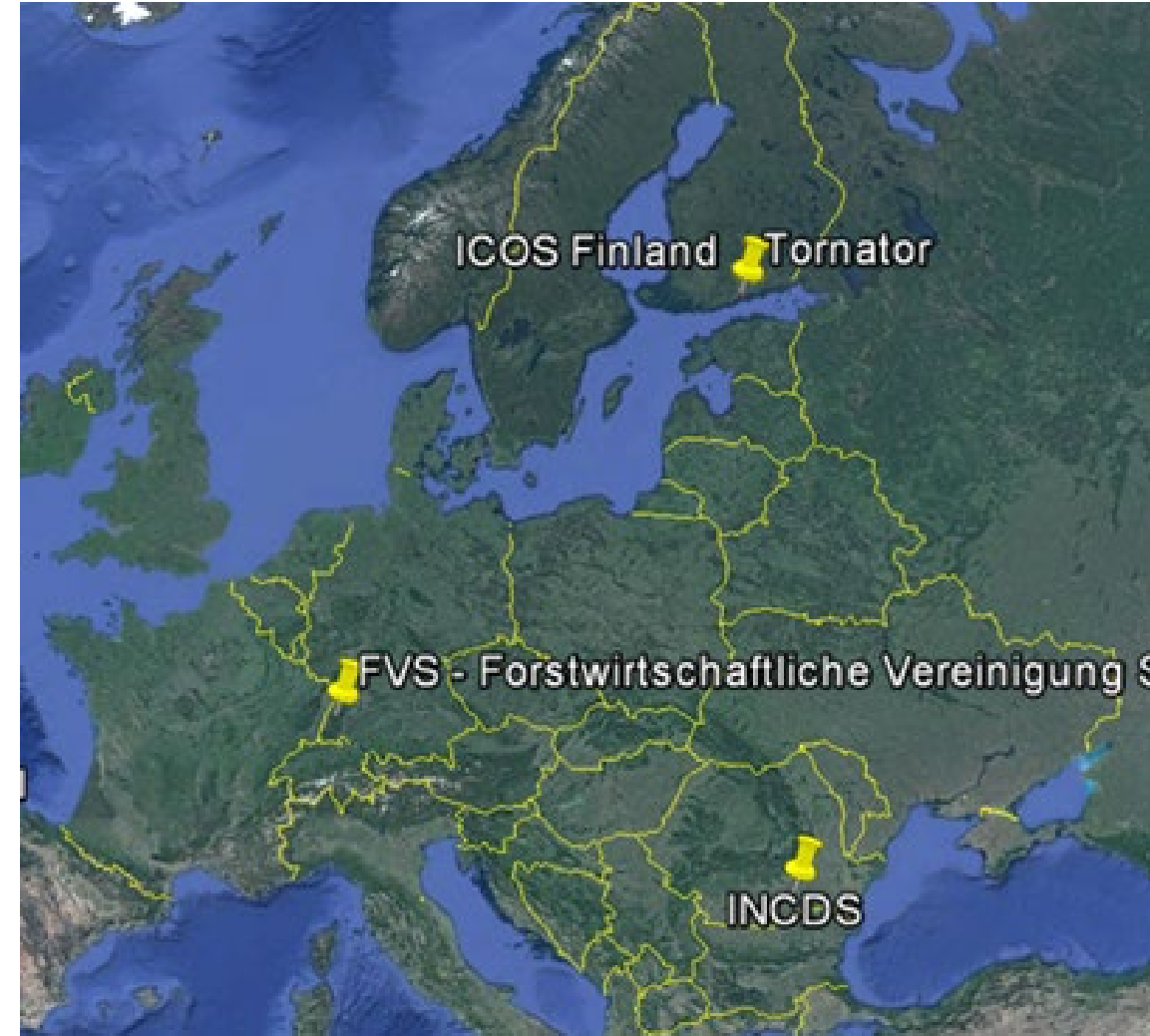
Data in precursor stage:

- Sentinel-2 optical multispectral data.
- Existing field data and national data bases on forest resources.
- Driven by weather data and climate scenarios (CMIP6).

Test areas in Finland, Germany and Romania

Data available on Forestry TEP platform

- accessible via links to the data
- Web-based visualization using CesiumJS



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Region Products Viewing

Demo sites

Finland Germany Romania

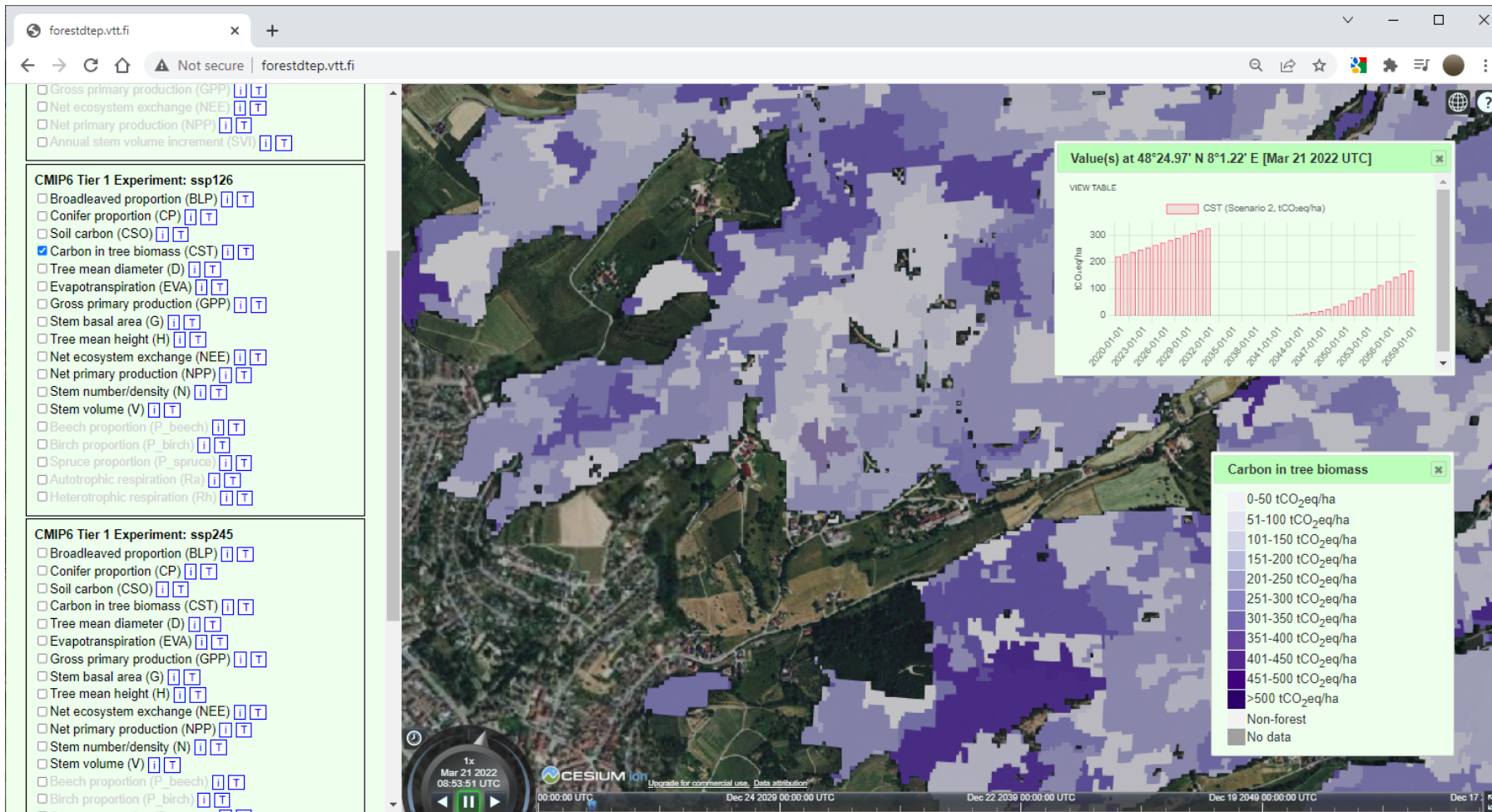


1x
 Oct 12 2021
 21:56:57 UTC

Navigation controls: play/pause, stop, and directional arrows.

Forest Digital Twin Earth Precursor - ESA

<https://www.foresttwin.org/>

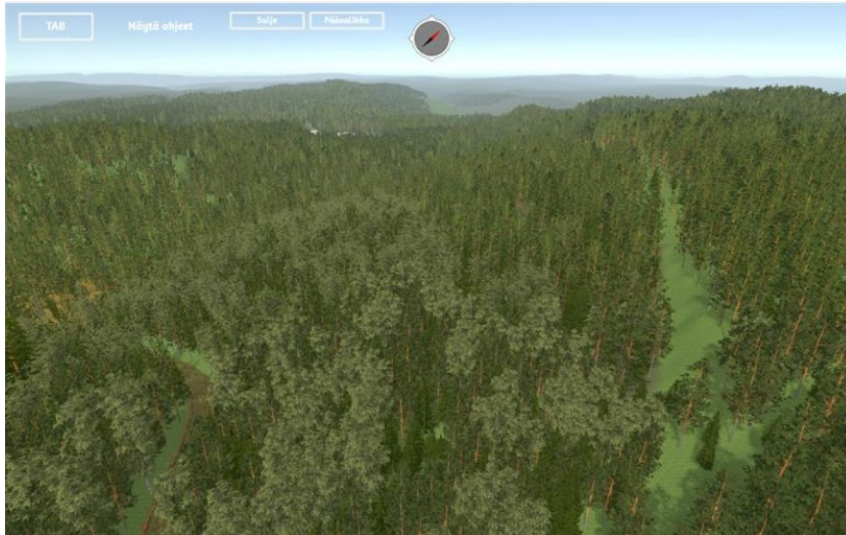


Web-based visualizations for a test area in Germany:



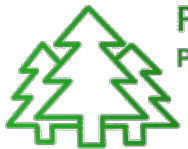
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Representations of future simulated forest from Digital Twin



Roadmap: the work ahead

Identified priority gaps	Path to solution
Availability of standardized and representative forestry field data of known quality.	Collection of a public dataset of geolocated forestry field data, both historical and current, and accompanied with EO data.
Validation capabilities at the spatial and temporal resolution of the Forest DTE outputs.	Creating a validation scheme for Forest DTE based on a data assimilation scheme of existing flux towers, forest productivity monitoring sites and EO data
Determination of overstory species and their proportions.	Use of hyperspectral and other new data sources
Use of AI to reduce the need of field data, make better use of VHR data and improve computational speed.	Developing AI tools to make use of the forestry field and EO data in automated prediction of forest variables
Integration with other specialized DTEs: technical tools and protocols	Specialized digital twins will need to be designed with compatibility and co-operation in mind
Ease of use: easy access to the simulation results for pre-specified scenarios.	Requirements on harmonized user interfaces for the specialized DTEs will need to be specified

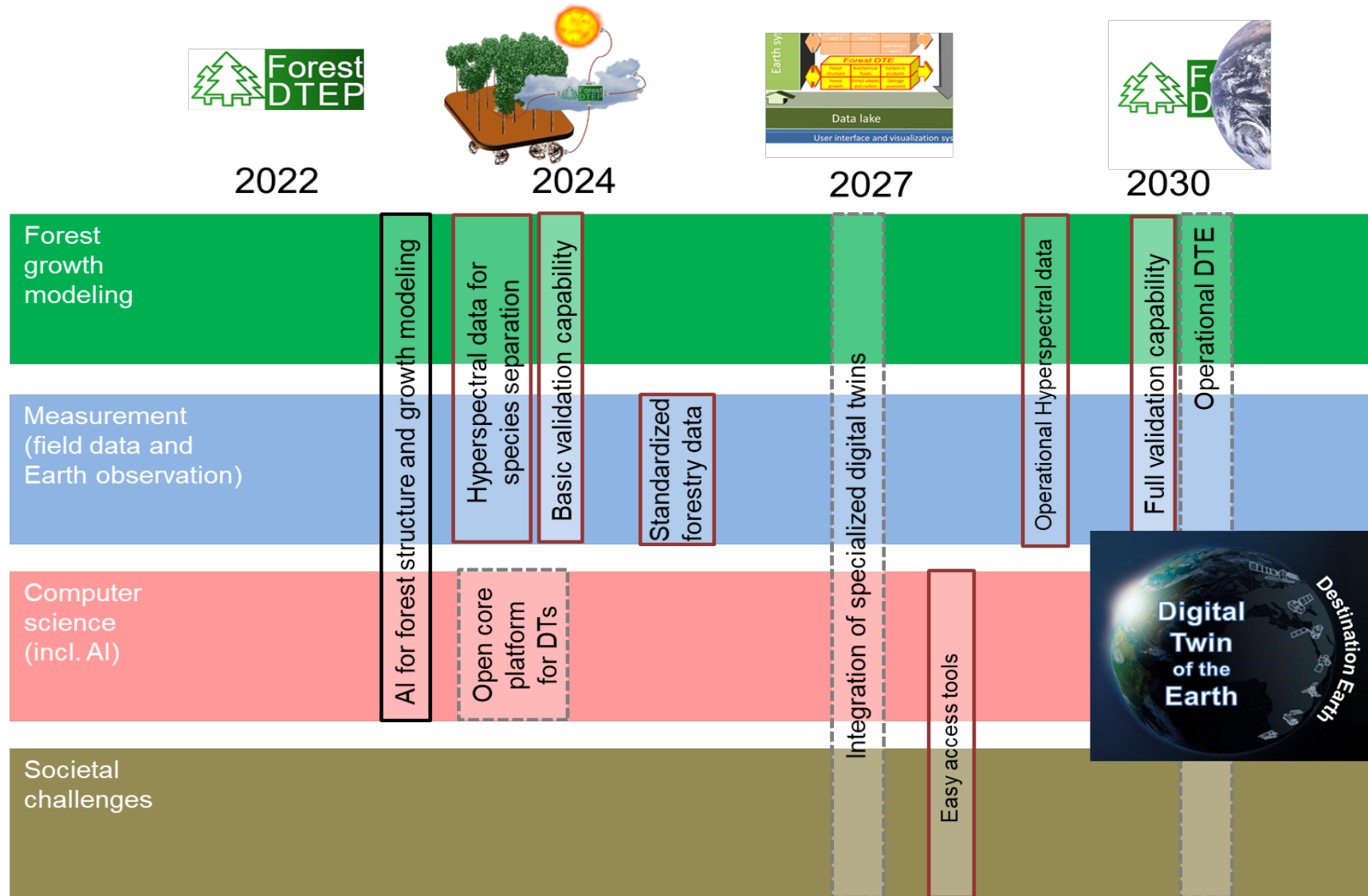


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Roadmap



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bey⁰nd

the obvious

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