

Forest Digital Twin supports sustainable forestry and forest carbon management

Matti Möttöus, Tuomas Häme et al.
Carbon from Space Oct 24-27, 2022

Forest Digital Twin Earth Precursor Land Use for a Carbon Neutral Europe

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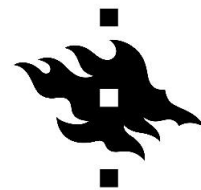
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⁶Institutul Național de Cercetare-Dezvoltare
în Silvicultură Marin Drăcea (INCDS)

Under contract from



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HELSINGIN YLIOPISTO



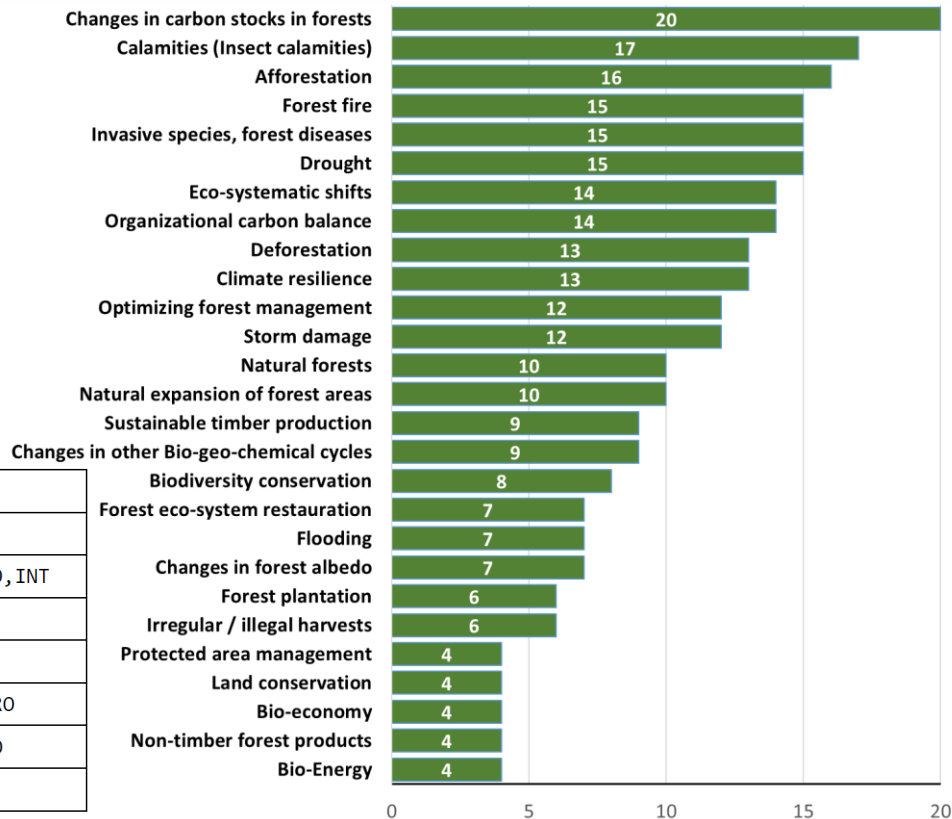
User requirements for DTE: most relevant topics

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	



Forest DTEP
Part of ESA's Digital Twin Earth

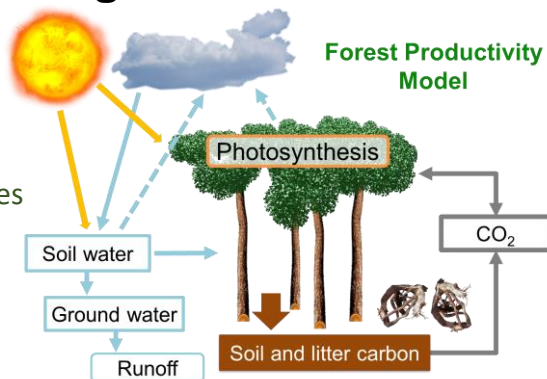
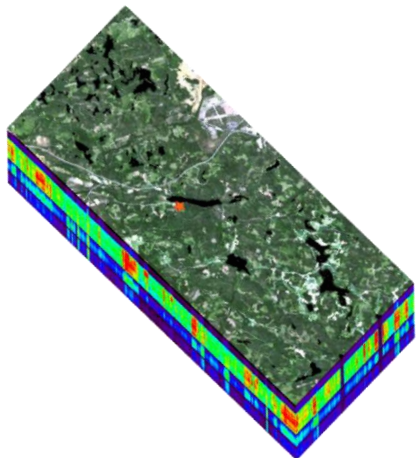


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Forest Digital Twin Earth Precursor

In:

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



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

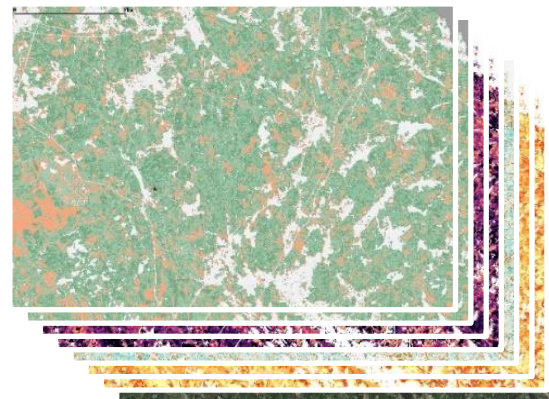
YASSO15 (Soil carbon model):

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

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)

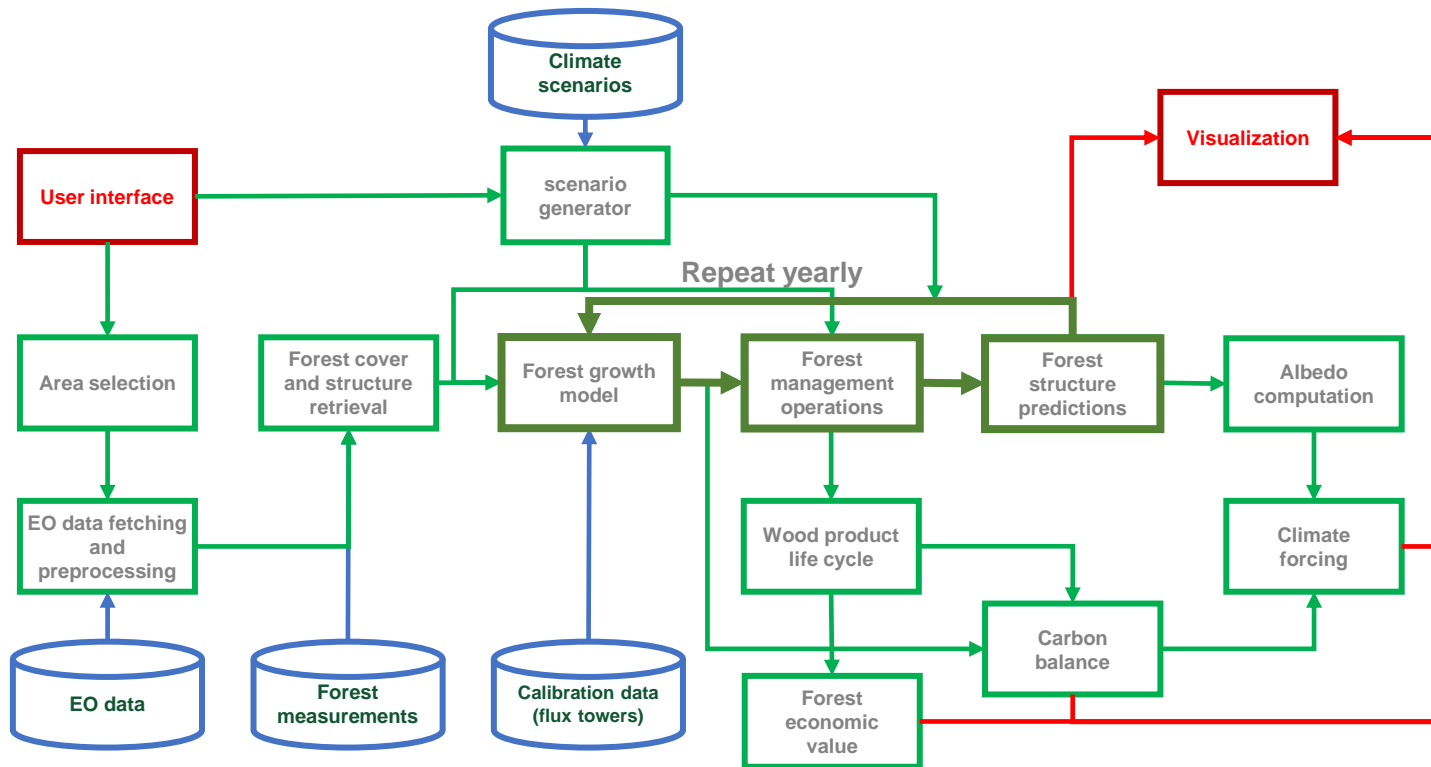


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Forest digital twin

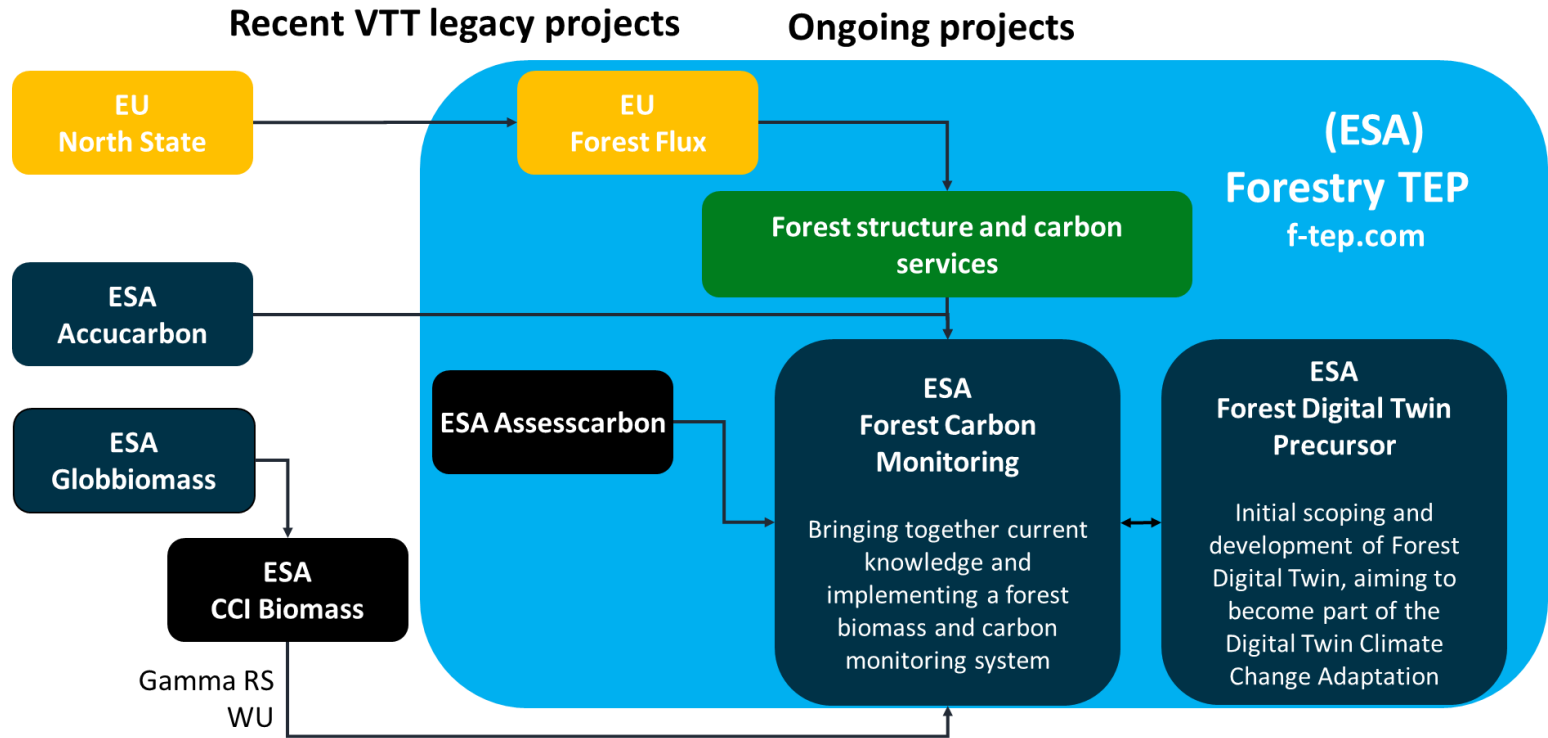


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Forest biomass and carbon monitoring project family

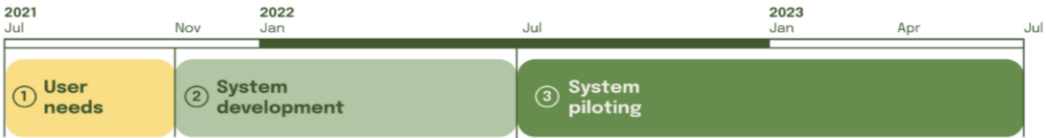


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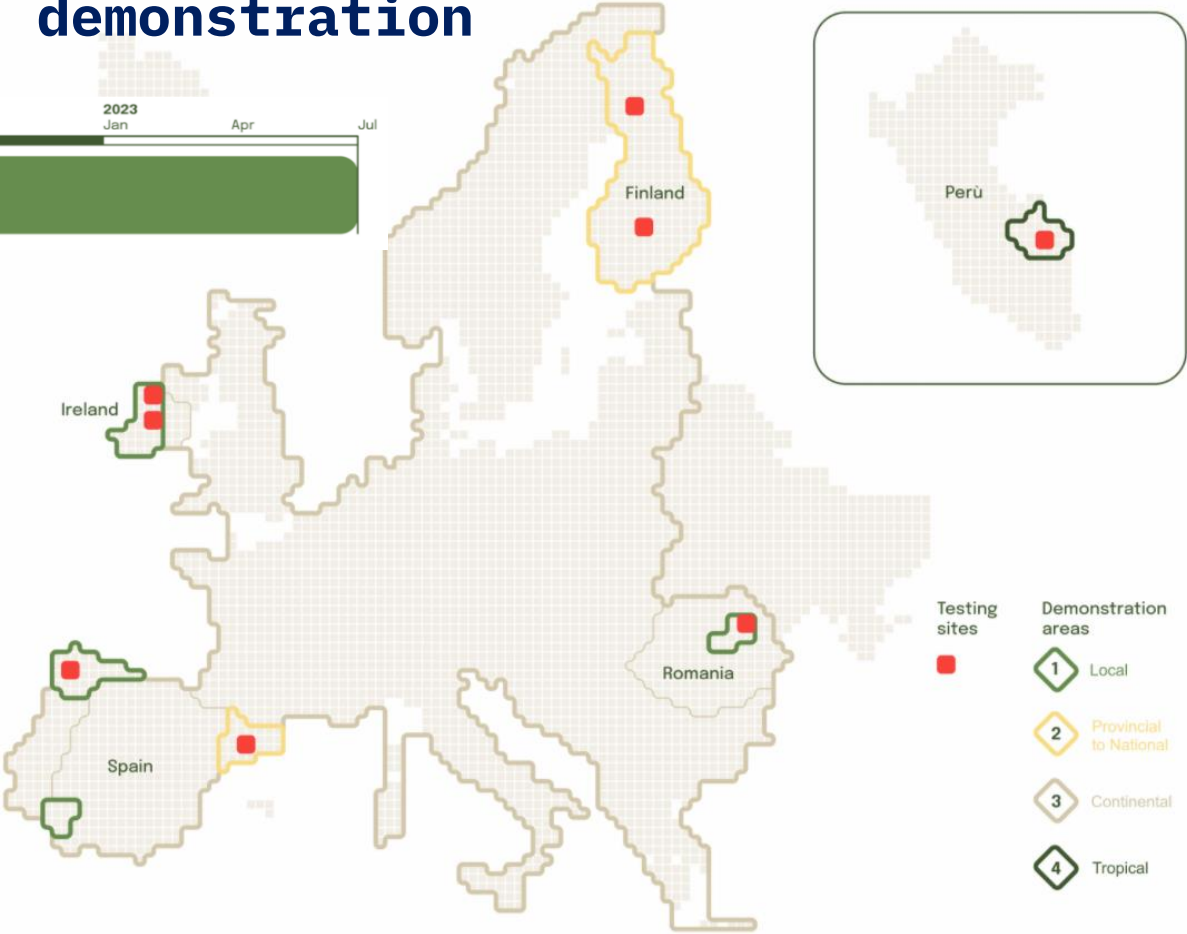


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Platform testing and demonstration



- 1** Local level demonstrations (1) designed to meet private company needs
- 2** Provincial to national level demonstrations (2 and 4) aimed primarily at administrative agencies
- 3** Continental level demonstration (3) in Europe



Forestry TEP as a platform

<https://f-tep.com>

VTT Led by VTT

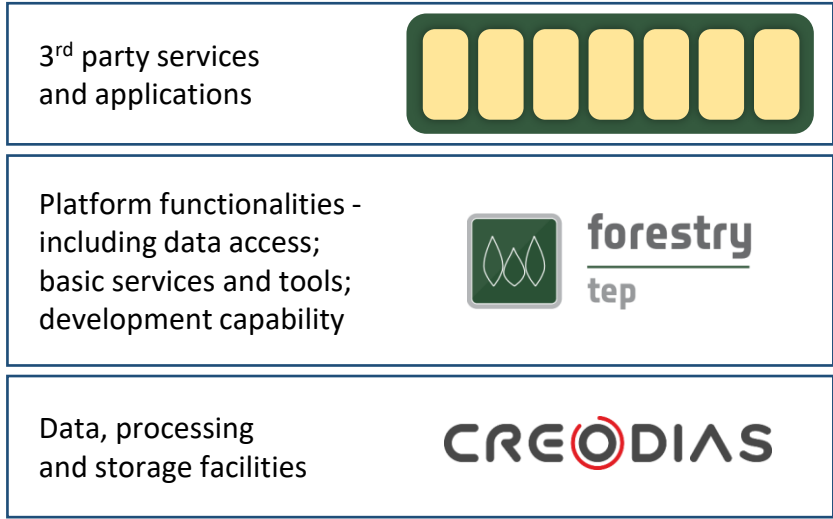
- Coordination
- Domain expertise



Users' data →

Auxiliary data →

esa →



Value-added information



End users



Forest DTEP
Part of ESA's Digital Twin Earth

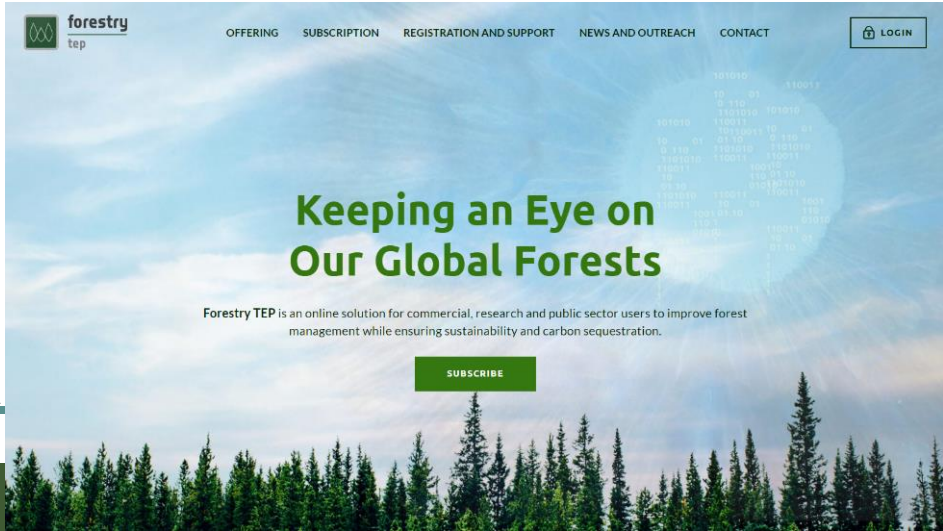
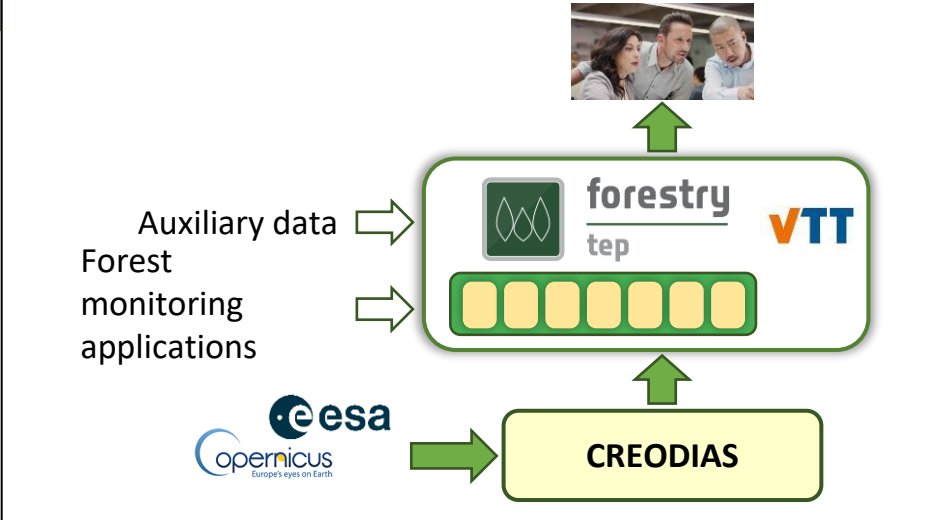


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Overall technical Framework: Forestry TEP

- **Online platform for forest monitoring to maximize the benefits of EO data**
- **Ways to use the platform**
 - Use available applications that combine EO data and your own input datasets
 - Develop your own processing scripts
 - Share or license applications
 - Access or share output products
- **Two modes of usage**
 - Online web user interface
 - REST API for interconnecting between systems

▪ **More about Forestry TEP:** <https://f-tep.com>

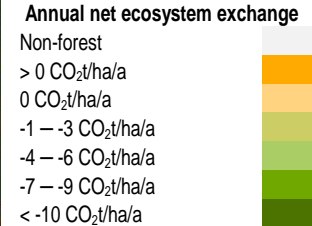
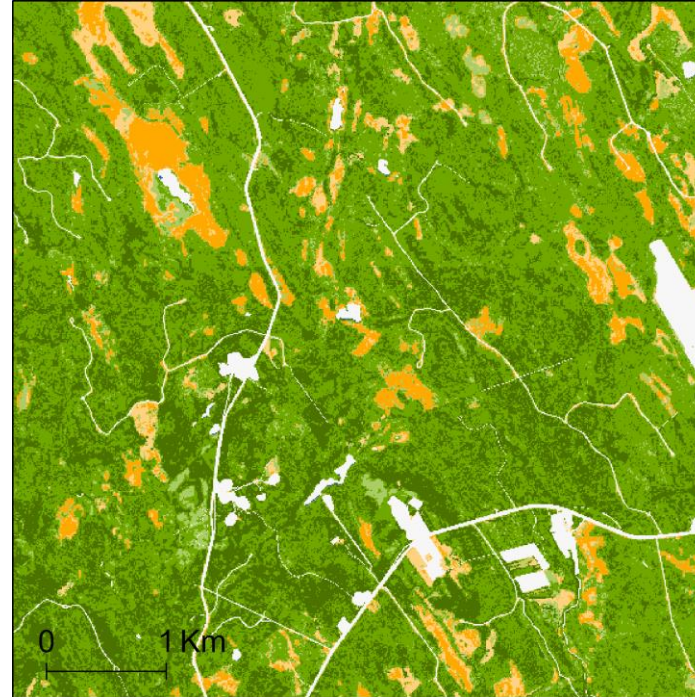
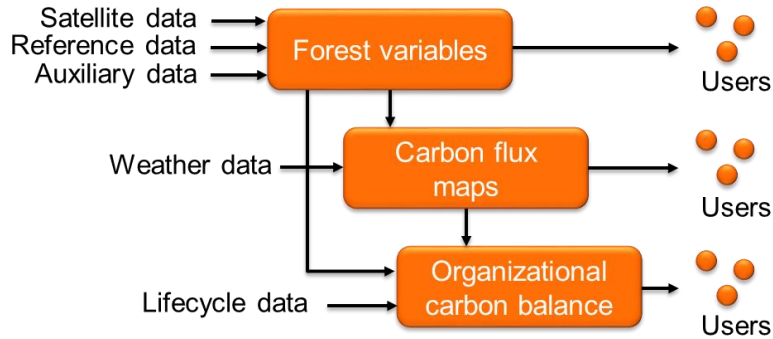


Forest Carbon Monitoring

Part of ESA's Digital Twin Earth

Forest Flux project – H2020 Innovation Action

Green color indicates carbon assimilation and orange slight carbon release



Imagery: Sentinel-2

Häme, T., et al. 2022 Forest Flux Final Report [VTT Technical Research Centre of Finland](#). 48 p. VTT Technology; No. 403. DOI: [10.32040/2242-122X.2022.T403](https://doi.org/10.32040/2242-122X.2022.T403)



Forest DTEP
Part of ESA's Digital Twin Earth



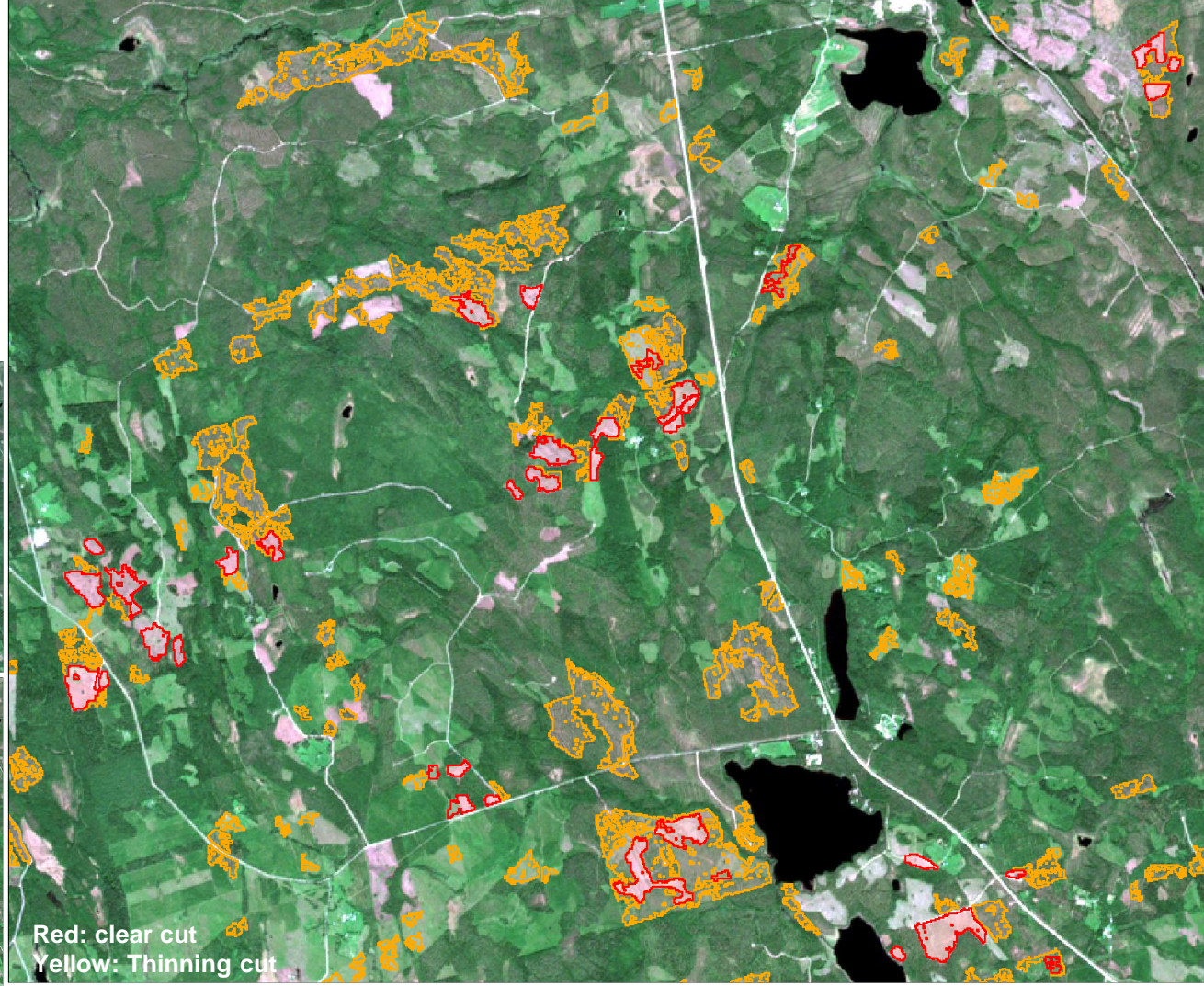
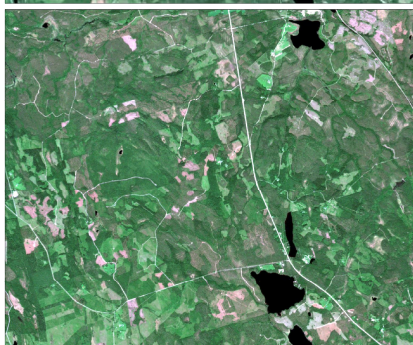
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Harvests using **AutoChange** in Finland from Sentinel-2 imagery

S2 19.7.2018



S2
14.6.2019



Forest Digital Twin Earth Precursor

Region Products Viewing

Demo sites

Finland Germany Romania

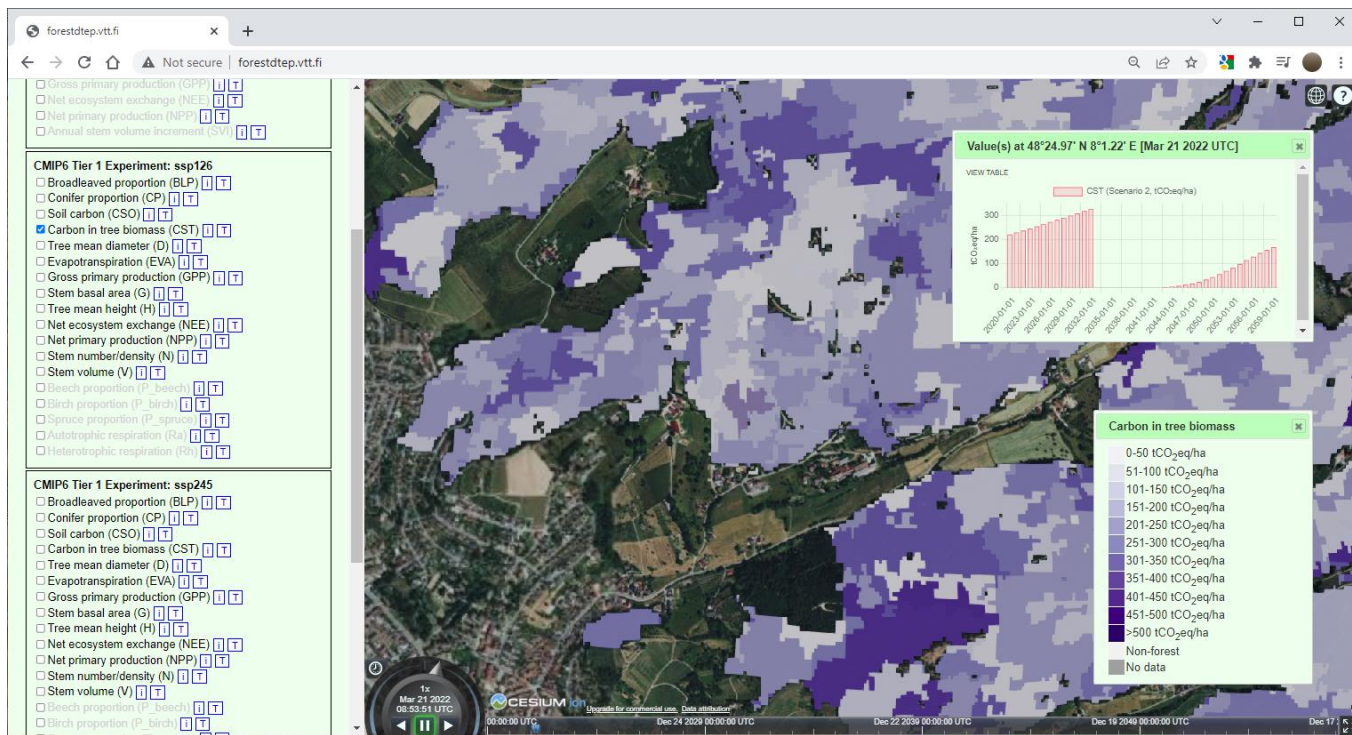


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21:56:57 UTC

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Forest Digital Twin Earth Precursor - ESA

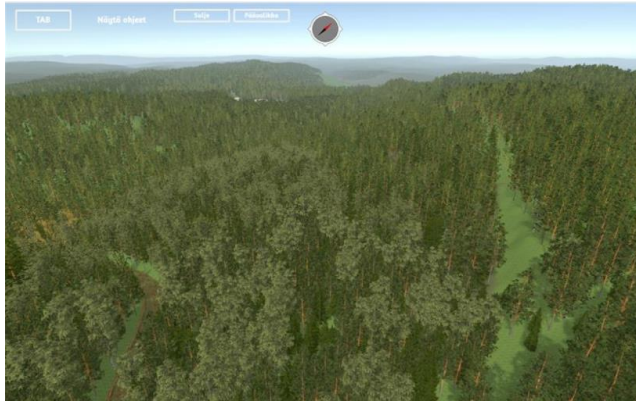
<https://www.foresttwin.org/>



Web-based visualizations for a test area in Germany:

Carbon stored in trees 2020–2060 from satellite data and climate models

Representations of future simulated forest from Digital Twin



Way forward

- Standardized and representative forestry field data of known quality.
- Standardized uncertainty assessment procedures.
- Species using VHR, super and hyperspectral imagery
- AI for automation, data and model assimilation (see presentation by F. Minunno)
- Digital Twin Earth network
- Ease of use

Relevant ongoing and recent projects

- Forest Digital Twin Precursor <https://www.foresttwin.org/news/>
- Forest Flux, H2020, VTT coordinated <https://www.forestflux.eu/>
- Forest Carbon Platform, ESA, VTT coordinates <https://www.forestcarbonplatform.org/>
- Pathfinder – Towards an integrated consistent European LULUCF monitoring and policy pathway assessment framework (EU HEurope). Coordinator Nibio (NO), VTT partner
- Earth observation for sustainable forest management via SDG targets and indicators (ESA). Coordinator IABG (DE), VTT partner
- Ecosystem restoration (ESA). Coordinator Hatfield Consulting (CA), VTT partner
- Artificial intelligence for twinning the diversity, productivity, and spectral signature of forests (Academy of Finland). VTT project

- Forestry TEP platform further development (ESA)
 - EOEPKA EO Exploitation Platform Common Architecture
 - Platform interoperability

bey⁰nd

the obvious

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