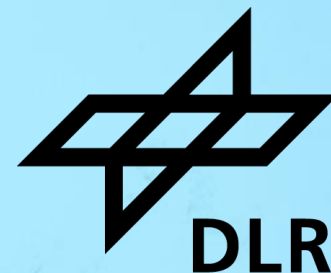


MONTHLY FOREST CANOPY COVER LOSS IN EUROPE, 2017–2024

Frank Thonfeld, Patrick Kacic, Marco Wegler, Kjirsten Coleman, Niklas Jaggy, Sarah Asam, Claudia Kuenzer



Background

- EO had no role in systematic forest (condition) monitoring @ national scale in Germany
- No national EO-based product available in 2020

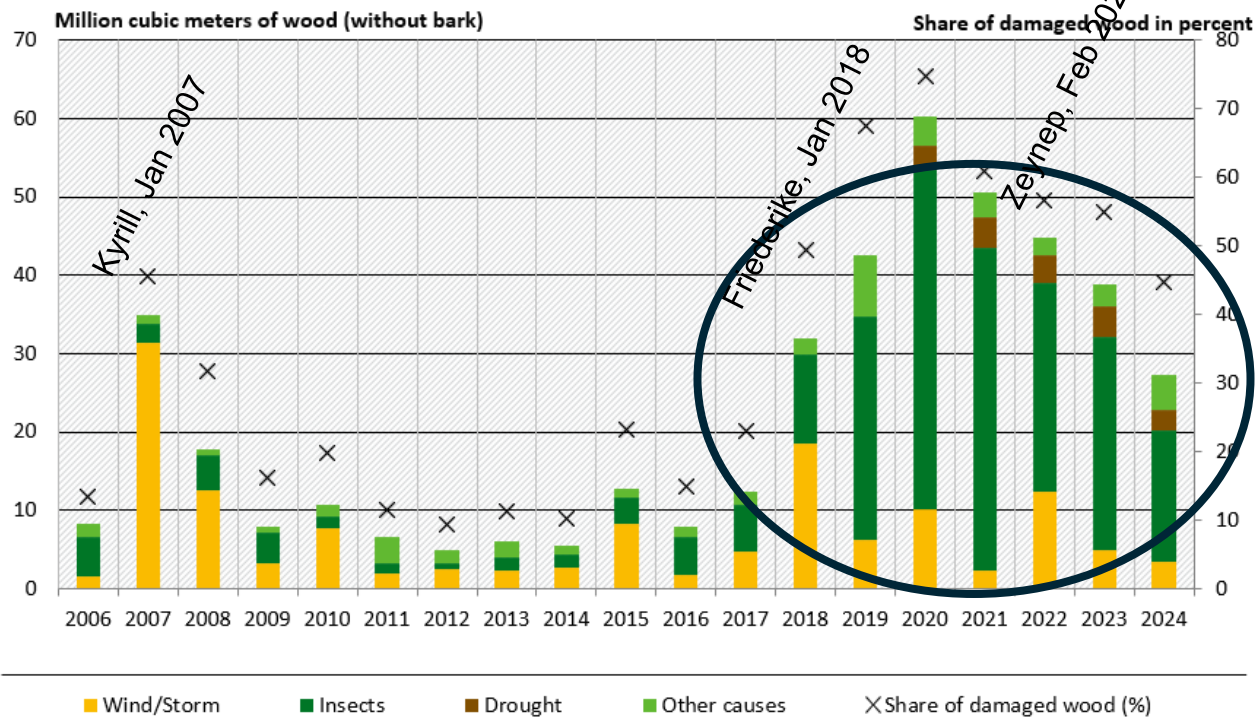


Review

Earth Observation Based Monitoring of Forests in Germany: A Review

Stefanie Holzwarth ^{1,*}, Frank Thonfeld ^{1,2}, Sahra Abdullahi ¹, Sarah Asam ¹, Emmanuel Da Ponte Canova ¹, Ursula Gessner ¹, Juliane Huth ¹, Tanja Kraus ¹, Benjamin Leutner ¹ and Claudia Kuenzer ^{1,2}

Timber harvesting in Germany due to damage



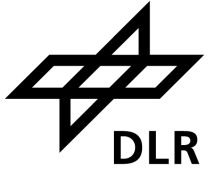
The cause of felling 'drought' has only been recorded separately in the statistics since the 2020 reporting year and is therefore included in the 'Other causes' category in the chart up to 2019.

Source: Federal Statistical Office 2025: Timber Harvesting Statistics

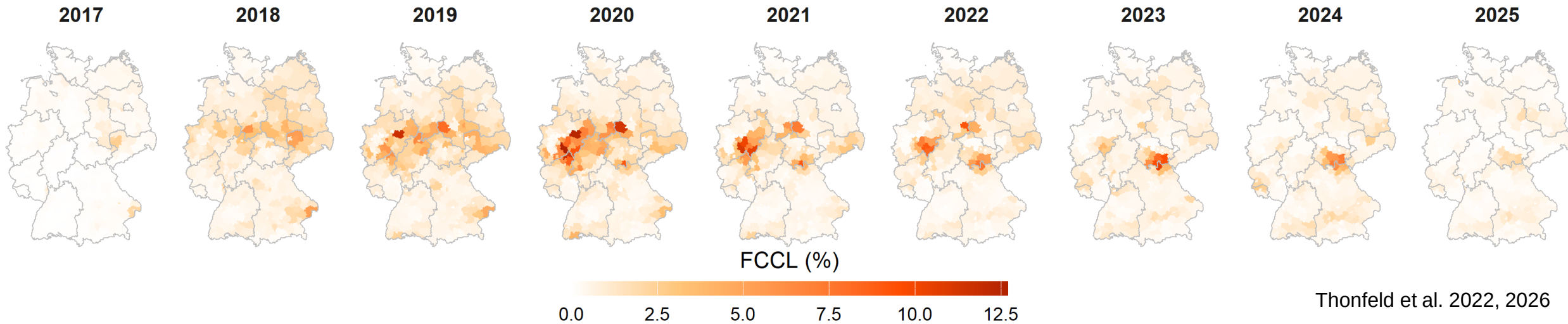
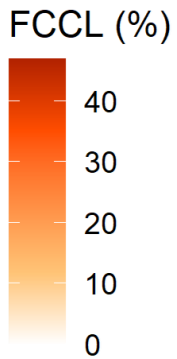
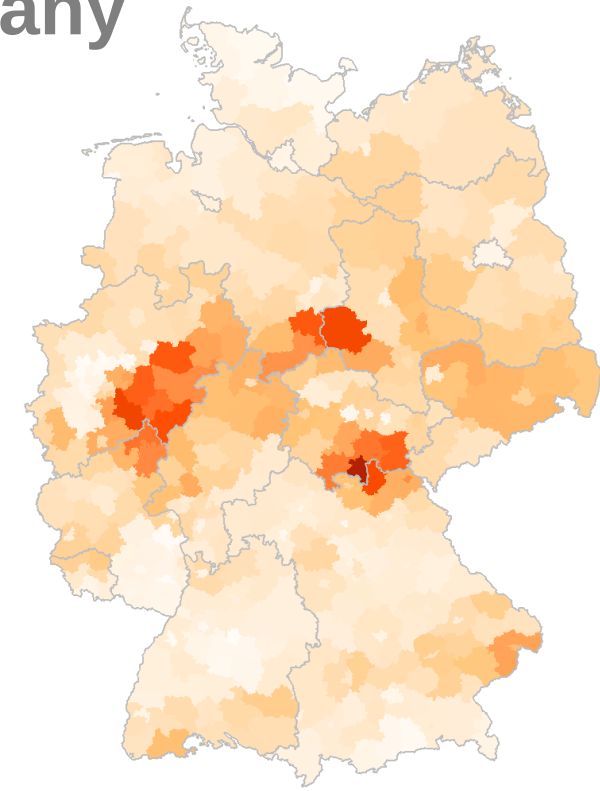


Forest Canopy Cover Loss (FCCL) in Germany

2017-2025

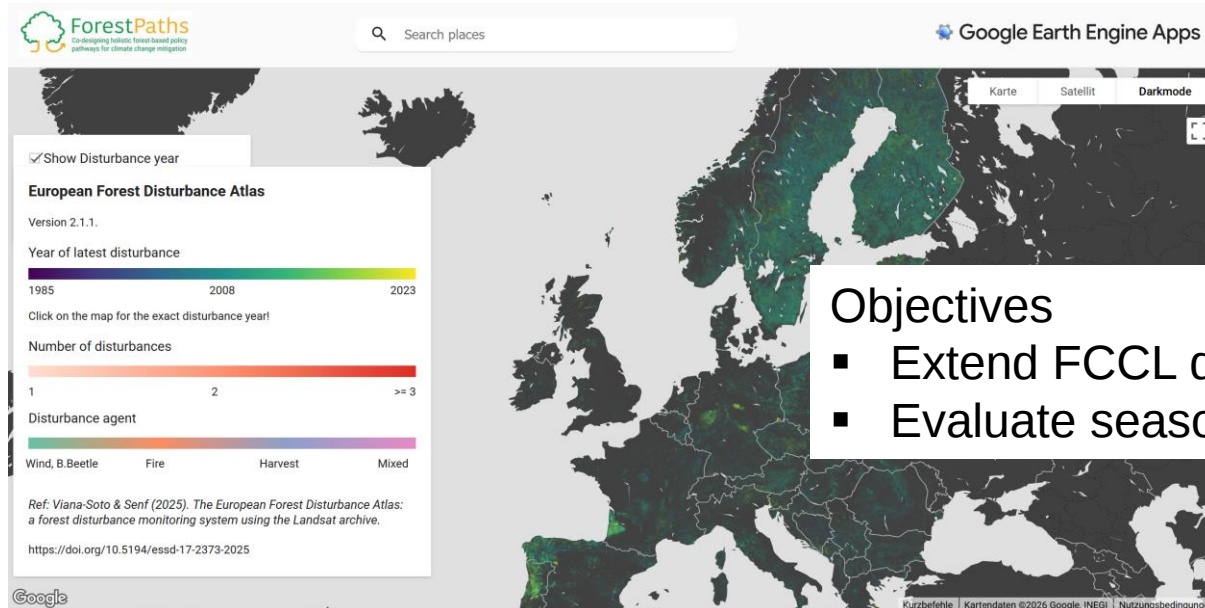


- 09/2017 – 10/2025 (ongoing)
- Sentinel-2A/B/C, Landsat-8/9
- 10 m
- Monthly (only few gaps)
- Disturbances (natural & management)



Thonfeld et al. 2022, 2026

Disturbances in Europe

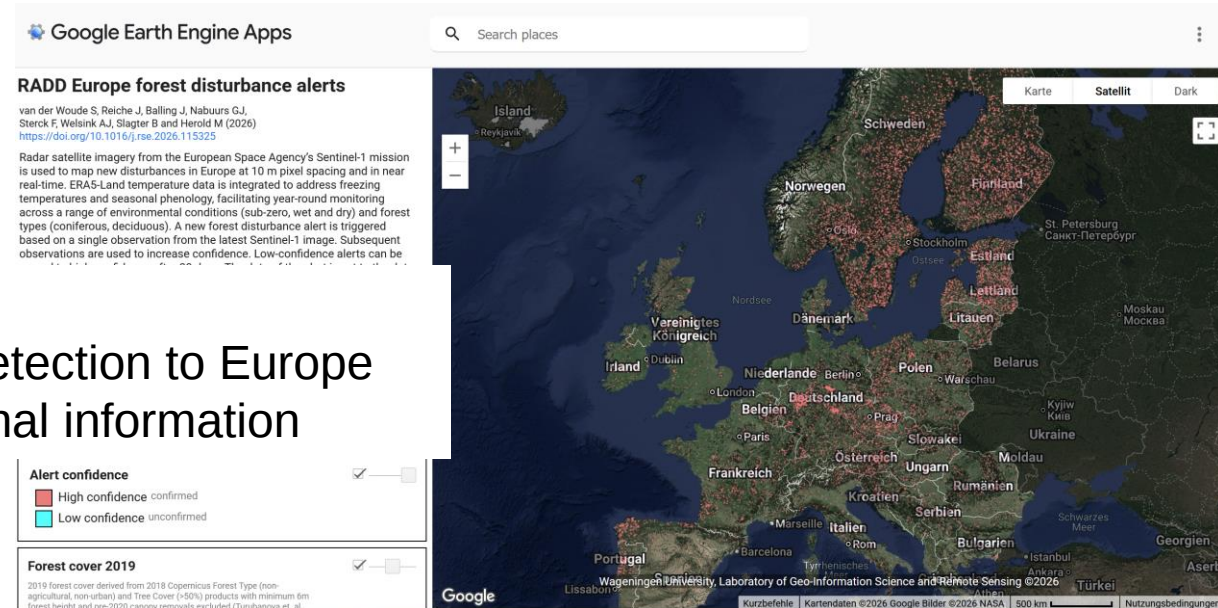


Objectives

- Extend FCCL detection to Europe
- Evaluate seasonal information

Viana-Soto & Senf 2025,
<https://albaviana.users.earthengine.app/view/european-forest-disturbance-map>

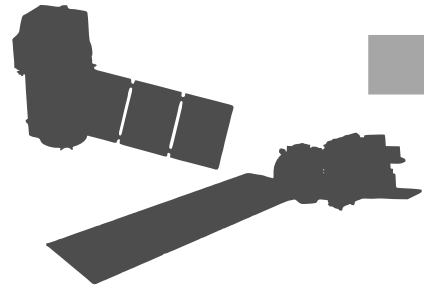
- Landsat (30 m)
- Annual
- > 40 years (from 1985)
- + Classification of agents (windthrow/bark beetle, fire, harvesting, mixed)



van der Woude et al. 2026,
<https://wurrt-radd-europe.projects.earthengine.app/view/radd-europe>

- Sentinel-1 (10 m)
- NRT (6/12-day temporal resolution)
- From 2020

Methods



Sentinel-2 A/B/C &
Landsat 8/9 OLI Surface
reflectance 2017 – 2025

Cloud cover threshold
($< 80\%$), cloud masking

Tasseled Cap
Components

Disturbance Index
Individually for coniferous
& broadleaved forests

Forest Type Map

Time Series Smoothing

Annual Median
Composite
Reference year

Monthly
Composites
Monitoring period

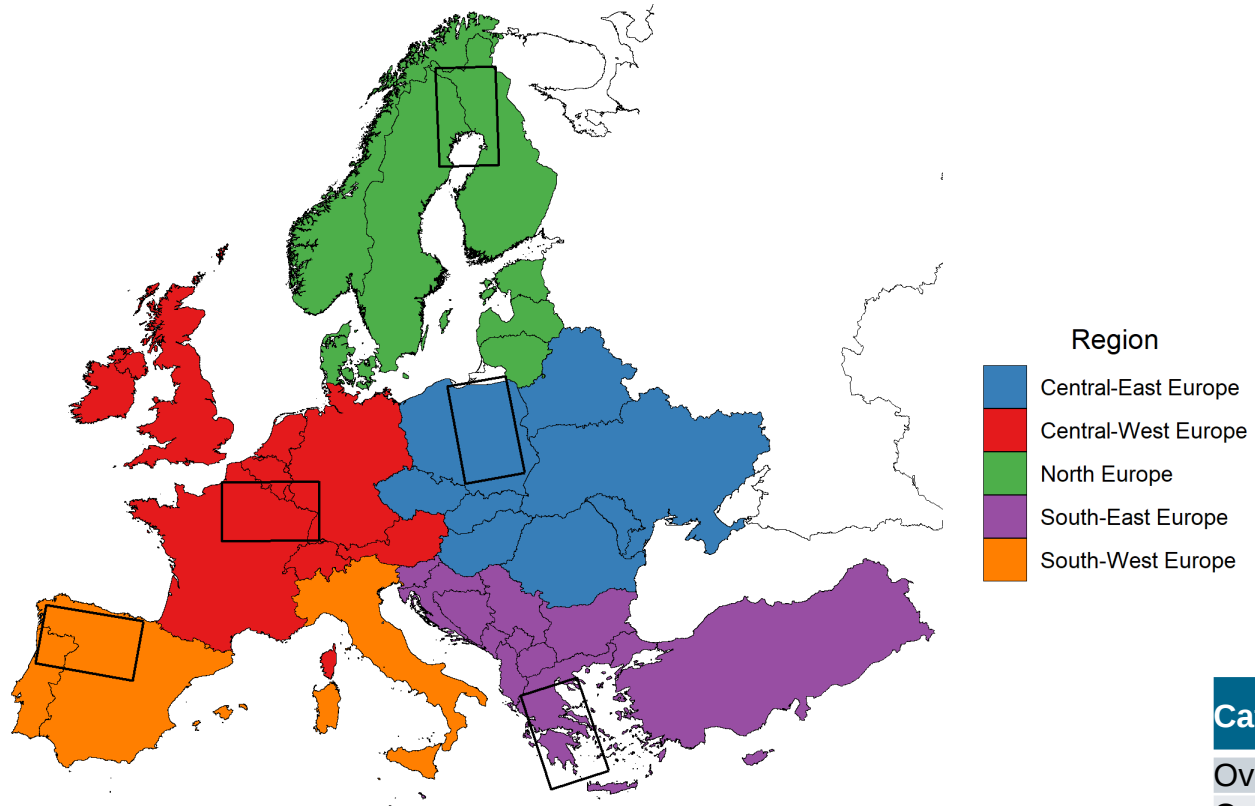
Monthly Composite
Difference to Reference

Thresholding

Consistency
Check



- Increased data availability by combining Landsat & Sentinel-2
- Phenology removed by normalisation
- Artefacts removed by filtering



- Sentinel-2A/B/C, Landsat-8/9
- 10 m, monthly (including winter)
- From Sep 2017 – Oct 2024
- Disturbances (natural & management)
- Includes Ukraine, Belarus, Moldavia, Atlantic Islands

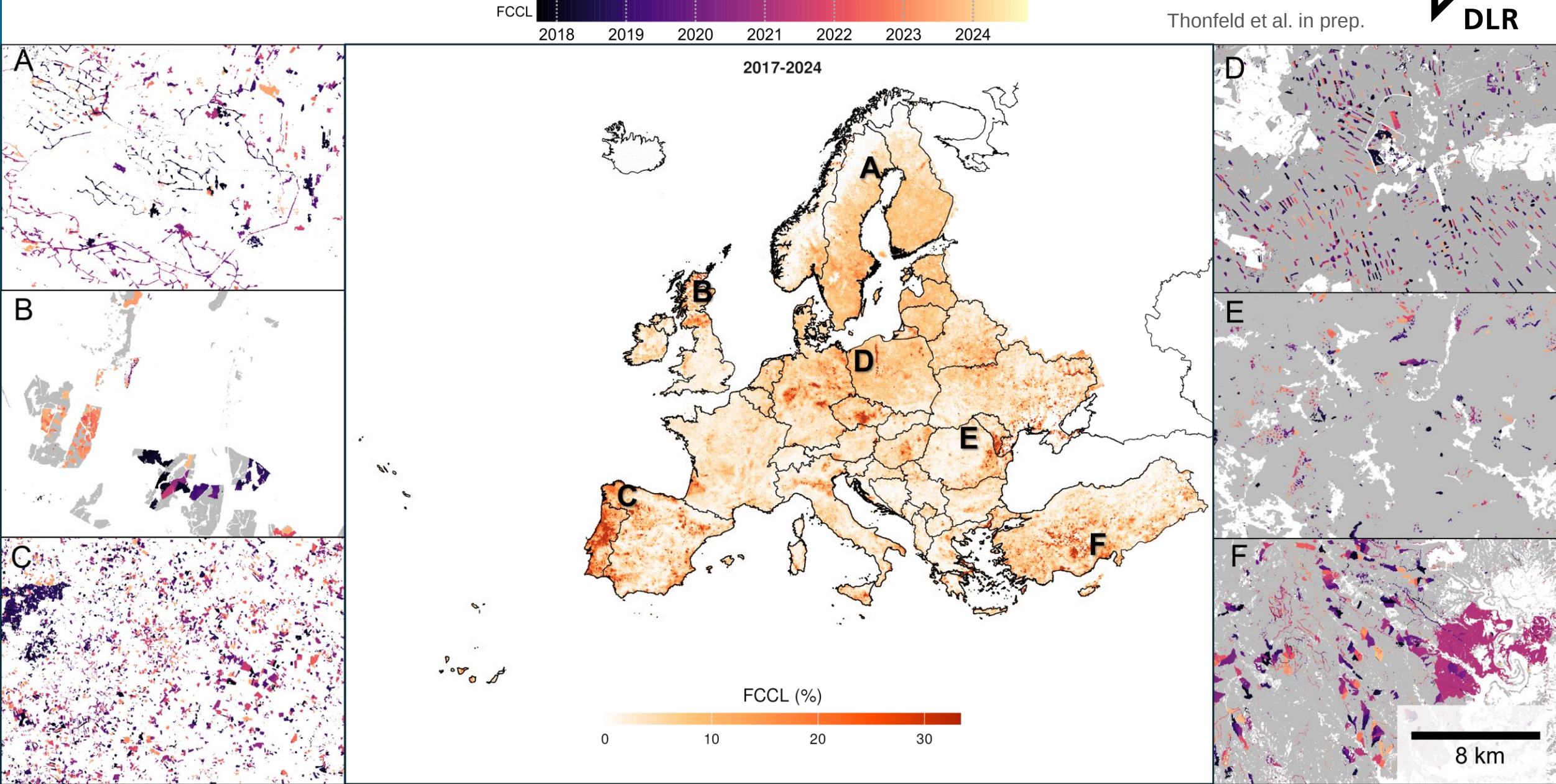
Validation North Europe

Category	Metric	Naive	Weighted (based on Olofson et al. 2014)
Overall	OA	0.9511	0.9716 ± 0.0095
Overall	F1 (macro)	0.9097	0.8846
Disturbed	UA	0.8660	0.8660
Disturbed	PA	0.8317	0.7169
Disturbed	F1	0.8485	0.7844
Undisturbed	UA	0.9671	0.9783
Undisturbed	PA	0.9746	0.9914
Undisturbed	F1	0.9708	0.9848

Stratum	N	Weight (Wi)	Accuracy
Undisturbed	442	0.8518	1.0000 ± 0.0000
Disturbed	97	0.0596	0.8660 ± 0.0681
Buffer	74	0.0887	0.7703 ± 0.0965

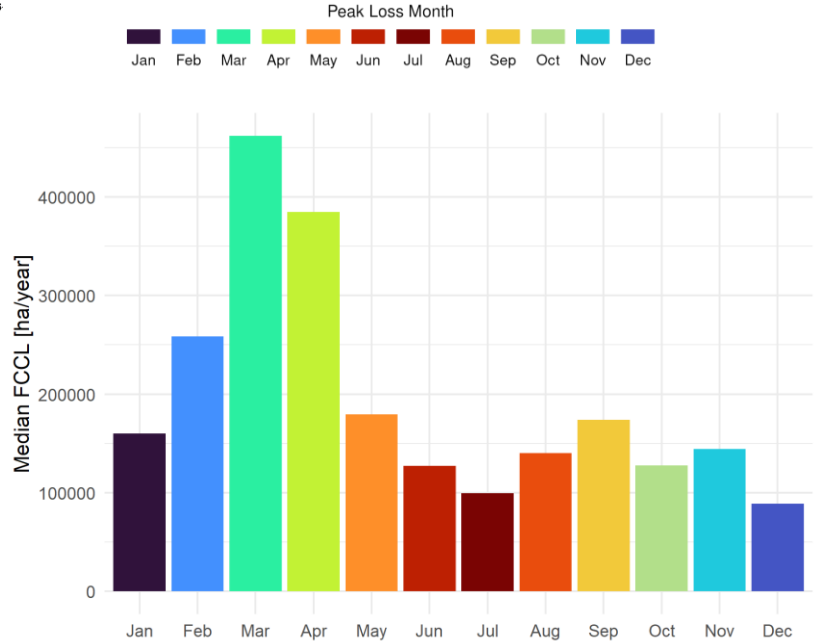
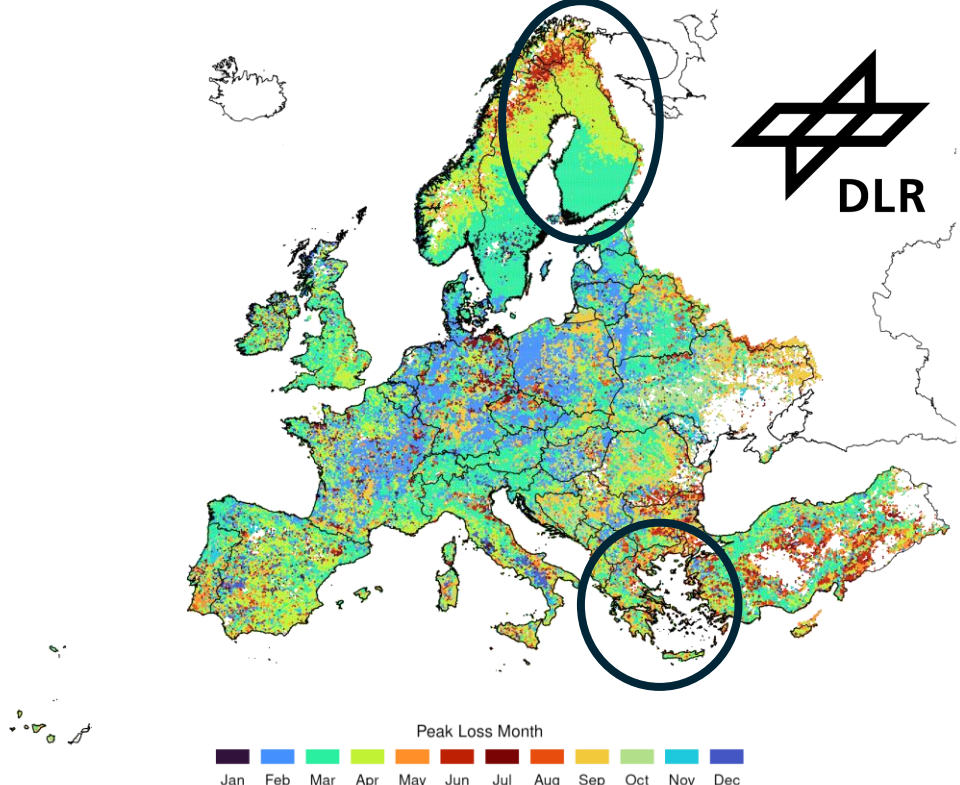
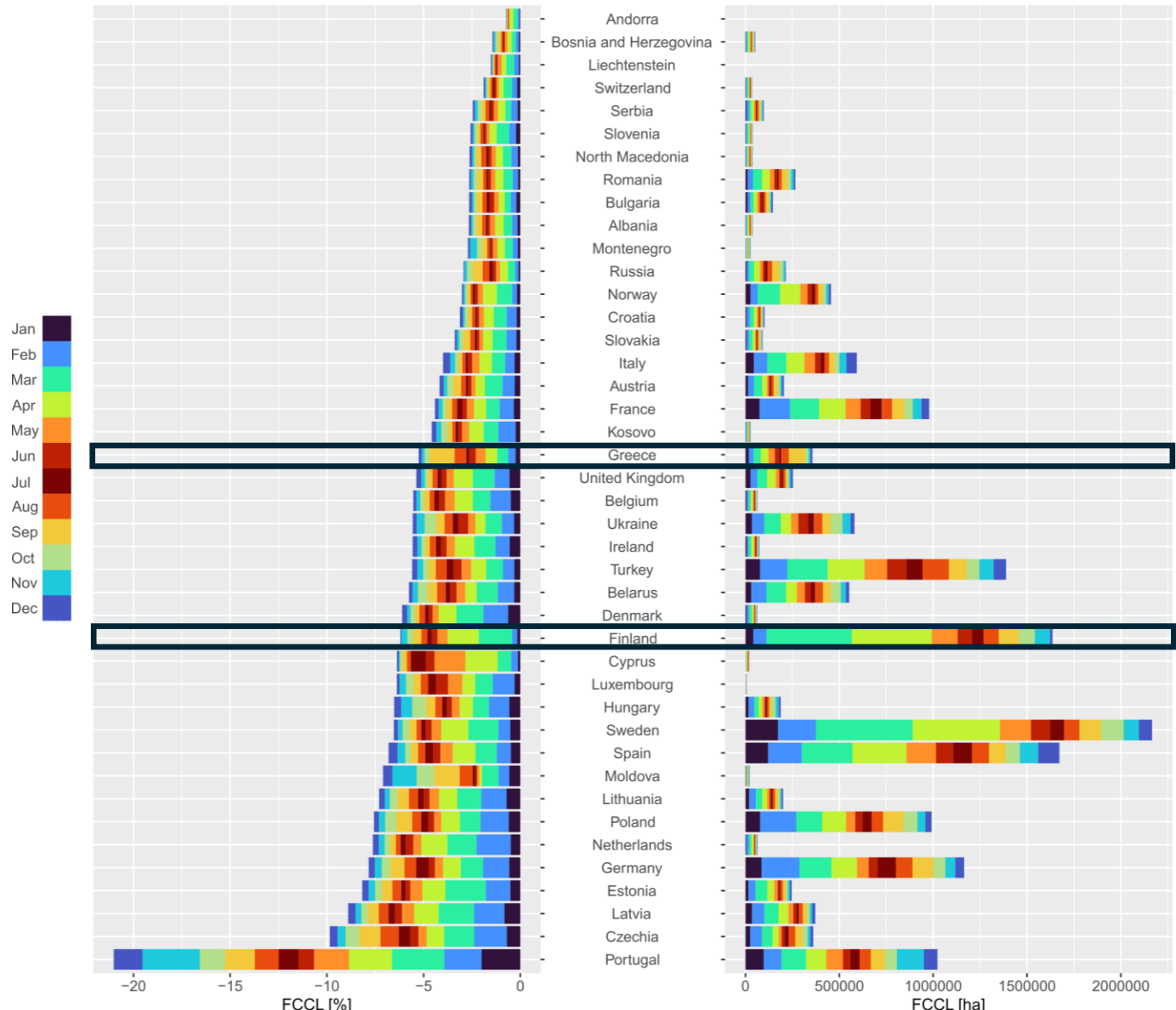
* Regions from FOREST EUROPE, 2026: State of Europe's Forests 2025.

FCCL in Europe



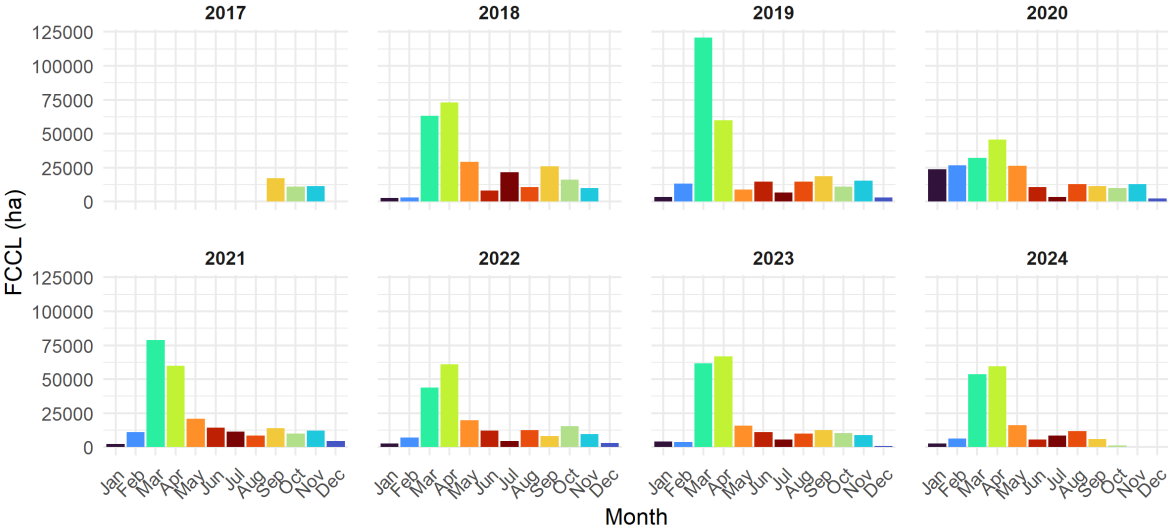
FCCL in Europe

Forest Canopy Cover Loss by Country (2017–2024)

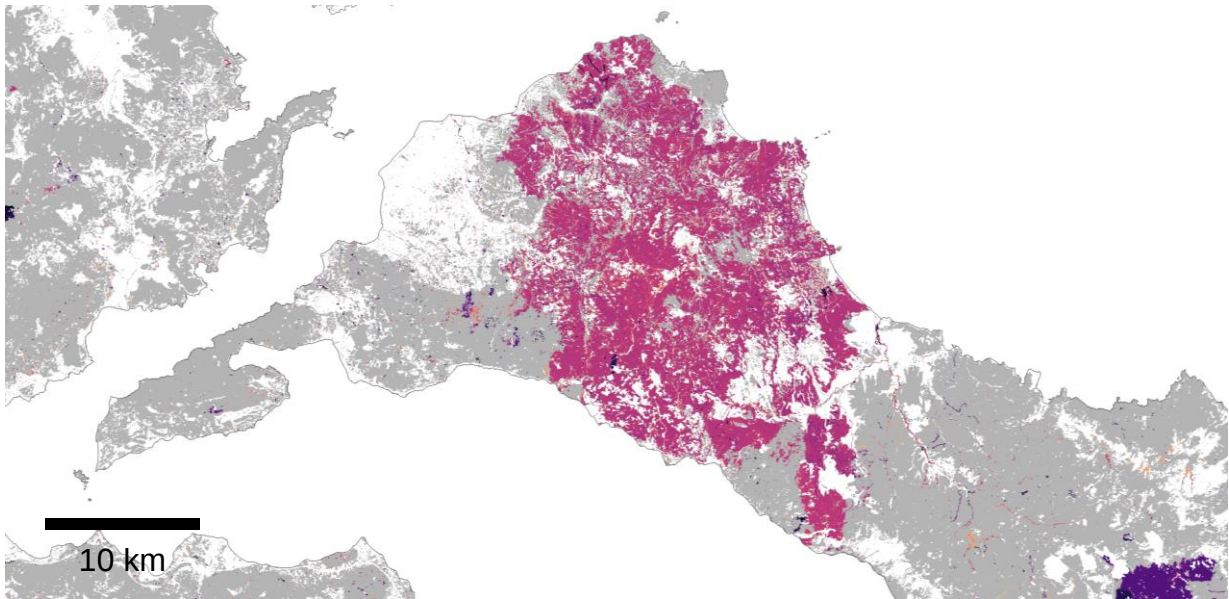
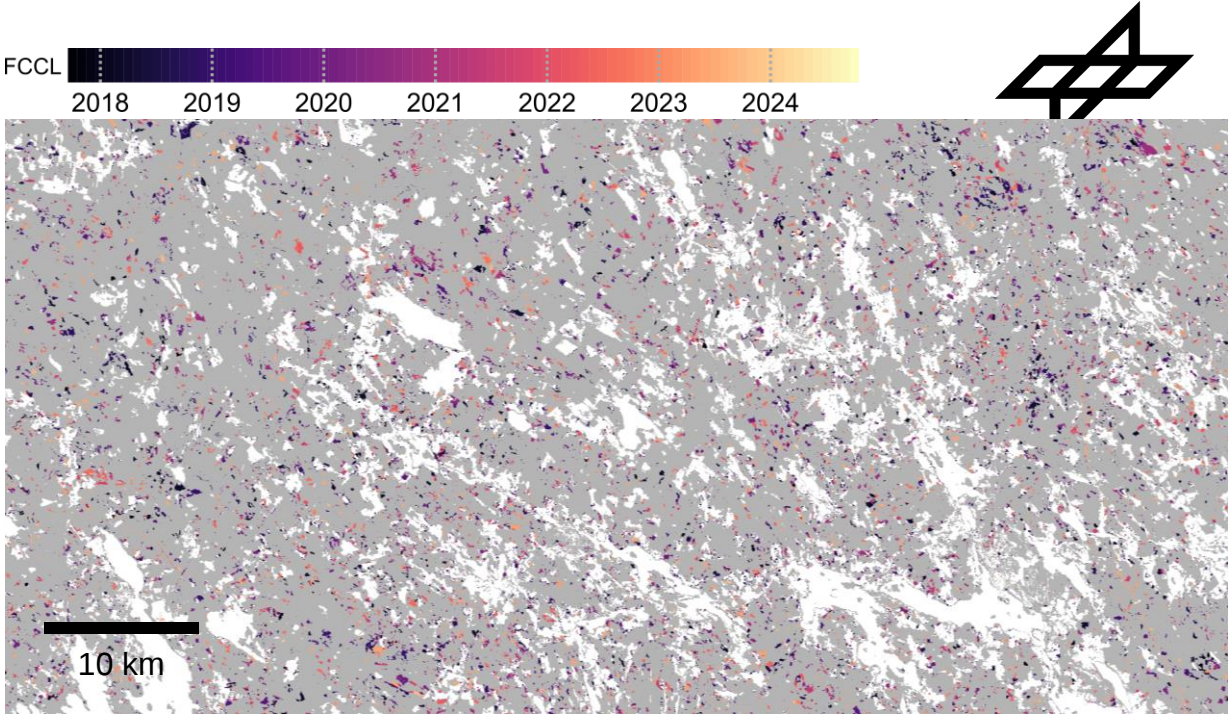
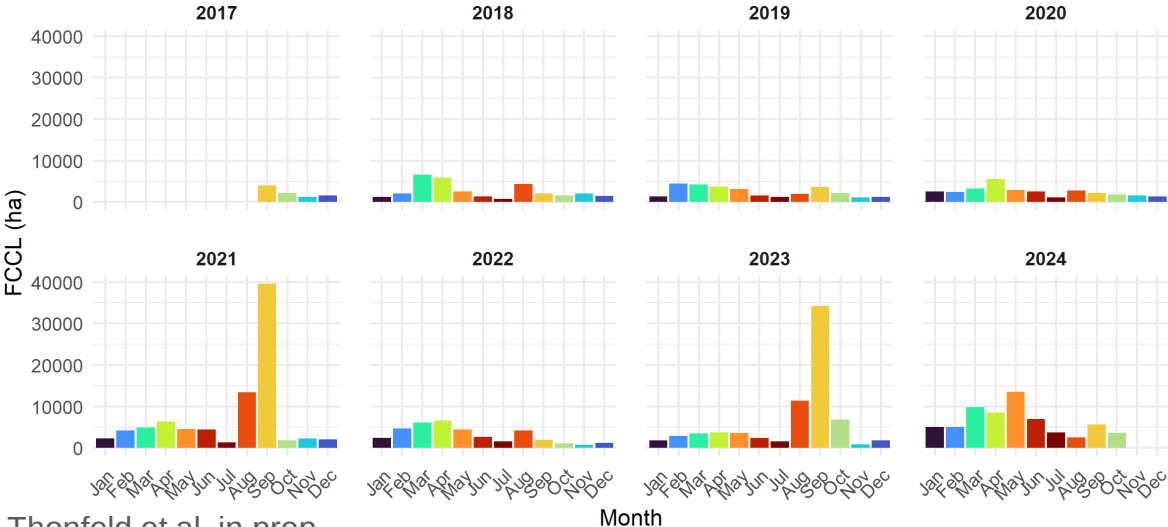


Finland vs. Greece

Monthly FCCL distribution per year (Finland)

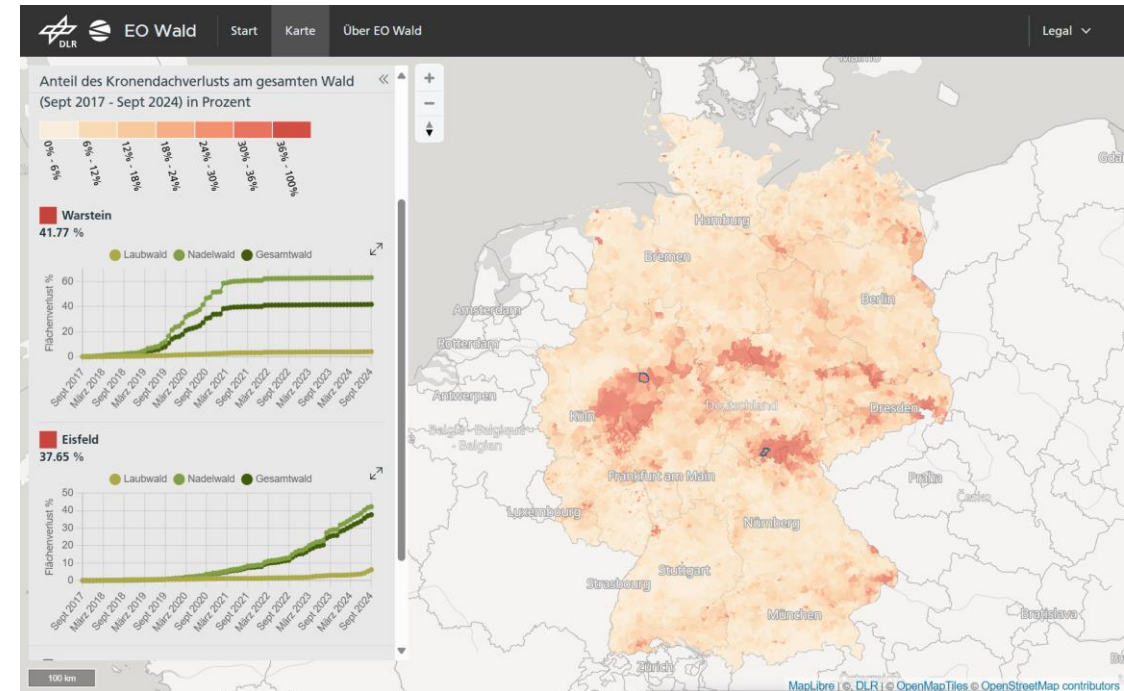


Monthly FCCL distribution per year (Greece)



Summary & Outlook

- Monthly FCCL monitoring at continental scale works
- Majority of FCCL detected in winter
- Seasonality seems to be related to different agents (→ can be helpful for better classification)



<https://geoservice.dlr.de/web/datasets/fccl>
https://geoservice.dlr.de/web/datasets/fccl_stats
<https://eowald.dlr.de/>

Thank you!

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frank.thonfeld@dlr.de

ForstEO

Gefördert durch:



Bundesministerium
für Ernährung
und Landwirtschaft

aufgrund eines Beschlusses
des Deutschen Bundestages

Gefördert durch:



Bundesministerium
für Umwelt, Naturschutz, nukleare Sicherheit
und Verbraucherschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

 **Waldklimafonds**

 **FNR**
Fachagentur Nachwachsende Rohstoffe e.V.