Forest monitoring in Germany: User requirements and recent progress in the ForstEO project

Frank Thonfeld[1], Pawanjeet Datta[2], Javier Gonzalez[3], Stefanie Holzwarth[1], Adelheid Wallner[3], Marco Wegler[1], Jakob Wernicke[2]

[1] Deutsches Zentrum für Luft- und Raumfahrt (DLR), Deutsches Fernerkundungsdatenzentrum (DFD)
[2] Forstliches Forschungs- und Kompetenzzentrum (FFK), ThüringenForst AöR, Referat - Digitale Waldinformationssysteme
[3] Bayerische Landesanstalt für Wald und Forstwirtschaft (LWF), Abteilung 1 Informationstechnologie

Keywords: ForstEO, user requirements, monitoring, climate, disturbance

Forests cover about one third of Germany's land area. They are an important economic factor and fulfil several other ecosystem services at the same time. Furthermore, forests play a major role as carbon sink and are therefore essential for Germany to achieve national climate goals. According to the latest national forest inventory (NFI), conducted in 2021 and 2022, German forests turned into a net carbon source due to exceptional losses. These losses are mainly attributed to a severe drought situation between 2018 and 2020 and beyond. Compound and cascading effects of droughts, heatwaves and insect infestations led to large-scale disturbances, often resulting in salvage and sanitary logging. In essence, the decadal sampling of the NFI in Germany does not keep pace with the dynamics on the ground. In response to this new challenge, several policies such as the national forest strategy 2050 promote the development of digital technologies with the potential to monitor forests and to provide updates regularly and at higher temporal resolution in order to complement the in-situ measurements from the NFI. One key technology is remote sensing because of its capabilities to cover large areas synchronously on a regular basis. While Earth Observation (EO) is well-implemented in the monitoring of forests in the tropics, its potential is far from being deployed in operational monitoring in Germany. Nevertheless, several research projects have been funded over the past years to develop tools to monitor forest condition by means of remote sensing. The developed EO-based forest monitoring tools have some similarities, but there are also differences between the products. To date, none of these tools is able to address all requirements of the annual crown condition assessments used to assess forest condition in Germany based on field samples. The information the EO-based tools provide is often complementary to the field-based assessments as they reveal additional spatio-temporal details and characterize canopy condition from a top-view perspective rather than the ground-view perspective.

Within the ForstEO research project, we develop methods to monitor forests in Germany with a focus on climate-related disturbances. As a first step we conducted an anonymised online user survey across Germany from 19 January to 31 March 2024. It dealt with five main topics in the areas of "your person and your forest", "remote sensing-based forest disturbance detection", "forest disturbances", "temporal and spatial resolution" and "data delivery requirements". A total of 18 questions were asked on the main topics. A total of 183 people with different perspectives on the forest took part in the user survey, ranging from private forest owners, forest owner associations or forest owner organisations to members of state forest enterprises and ministries as well as the scientific community and the private sector. In order to obtain a

practical assessment of the needs, the forest ownership or forest in the area of responsibility was also surveyed.

The online user survey made it clear that more than half of the people who own or are responsible for forests describe their deciduous and/or coniferous forest as being in poor condition. The survey also revealed that 60 % of respondents rated the vitality status of mixed forests as more positive overall. Of the multiple responses, bark beetle infestation, drought damage and windthrow were the most frequently cited causes of damage, each at around 20 %, followed by snow breakage and fungal infestation. These responses support the assumption that extreme events, which can often be linked to climate change, favour abiotic and biotic disturbances and are therefore currently the most important causes of forest damage.

In this presentation, we will provide detailed results of the survey. Furthermore, we will demonstrate first results of the main methodological pillars of ForstEO. These are an update of the forest canopy cover loss (FCCL), forest die-back mapping in beech forests, and the automatic differentiation of disturbance agents.

Building on an earlier study, we provide an FCCL update until including September 2024 based on fully reprocessed and extended time series with a revised the approach. The FCCL time series covers September 2017 through September 2024 at monthly resolution and at 10 m pixel size. Further, we overlaid our FCCL results with a tree species map and computed statistics for the four major tree species in Germany, namely spruce, pine, oak and beech. In total, about 850,000 ha were affected by FCCL, corresponding to 8.4 % of the forest area. In some administrative districts of Germany about 45 % of the total forest area was cleared. Only a small share of FCCL can be attributed to land use changes for road construction, settlement expansion, or open-pit mining.

The FCCL information is of great importance for forest authorities and forest managers. It can be used to specify the need of seedlings and to plan replanting with species that are better adapted to future climate. With our contribution we demonstrate how spatially explicit information about forest disturbances can be provided in high temporal resolution to support the national forest monitoring.

Holzwarth, S., Thonfeld, F., Abdullahi, S., Asam, S., Da Ponte Canova, E., Gessner, U., Huth, J., Kraus, T., Leutner, B., Kuenzer, C., 2020. Earth Observation Based Monitoring of Forests in Germany: A Review. Remote Sensing 12, 3570. https://doi.org/10.3390/rs12213570

Holzwarth, S., Thonfeld, F., Kacic, P., Abdullahi, S., Asam, S., Coleman, K., Eisfelder, C., Gessner, U., Huth, J., Kraus, T., Shatto, C., Wessel, B., Kuenzer, C., 2023. Earth-Observation-Based Monitoring of Forests in Germany—Recent Progress and Research Frontiers: A Review. Remote Sensing 15, 4234. https://doi.org/10.3390/rs15174234

Kacic, P., Thonfeld, F., Gessner, U., Kuenzer, C., 2023. Forest Structure Characterization in Germany: Novel Products and Analysis Based on GEDI, Sentinel-1 and Sentinel-2 Data. Remote Sensing 15, 1969. https://doi.org/10.3390/rs15081969

König, S., Thonfeld, F., Förster, M., Dubovyk, O., Heurich, M., 2023. Assessing Combinations of Landsat, Sentinel-2 and Sentinel-1 Time series for Detecting Bark Beetle Infestations. GIScience & Remote Sensing 60, 2226515. https://doi.org/10.1080/15481603.2023.2226515

Thonfeld, F., Gessner, U., Holzwarth, S., Kriese, J., da Ponte, E., Huth, J., Kuenzer, C., 2022. A First Assessment of Canopy Cover Loss in Germany's Forests after the 2018–2020 Drought Years. Remote Sensing 14, 562. https://doi.org/10.3390/rs14030562