Implementing a near-real time remote sensing monitoring system of forest disturbances in Bavaria, Germany

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In recent years, Bavarian forests suffered a constant decline in vitality due to various pressure factors. These impacts on the forest ecosystem lead to an increase in occurrence and severity of disturbances in recent years, driven by repeated drought years between 2018 and 2021. The need to assess forest dynamics on a regular basis for consistent and coherent forest monitoring is therefore fueled by the past developments. With forest inventories conducted only on annual or lesser basis, near-real time information on forest health is lacking. Since current inventories are mostly done through manual labor, acquiring information in denser intervals requires new methods.

Satellite remote sensing technologies are widely recognized as method to efficiently provide continuous data across large areas and is therefore broadly applied for forest application such as monitoring forest disturbances and disturbance drivers across different spatial and temporal scales.
Current efforts to assess forest condition have led to several nation-wide information products. These maps differ in which aspect of forest dynamics is captured, how regularly data updates occur as well as spatial and temporal resolution. So far, no

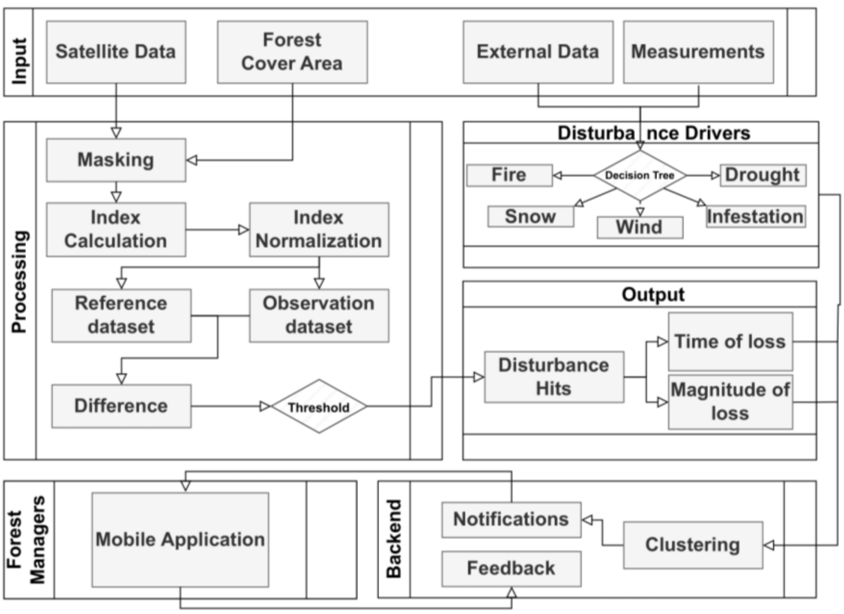

Figure 1: End-to-end workflow of the entire processing chain.

monitoring system exists that captures forest disturbances in Bavaria with high spatial resolution and provides information updates in near-real time.

In our work we aim to close this gap by developing a **near-real time forest monitoring system** that consistently detects disturbances on **biweekly** basis at 10m resolution and presents results to users through a **mobile app** (Figure 1). We included satellite data from the Sentinel-2 and Landsat-8/9 systems starting from September 2017 until present day in our analysis. All input data is passed in a thorough preprocessing to reduce contamination with clouds or other artifacts and filtered for snow. We relied on the disturbance index (DI)[1], which is based on the Tasselled Cap components, as robust measure to detect forest disturbances. The pre-processed satellite image time series are then aggregated to biweekly composites. Based on reference data from the year 2017 disturbances are detected if six consecutive detections are confirmed. The combined process chain is deployed on the HPDA platform terrabyte[2] and tailored to provide efficient mass data processing on high performance computing environments.

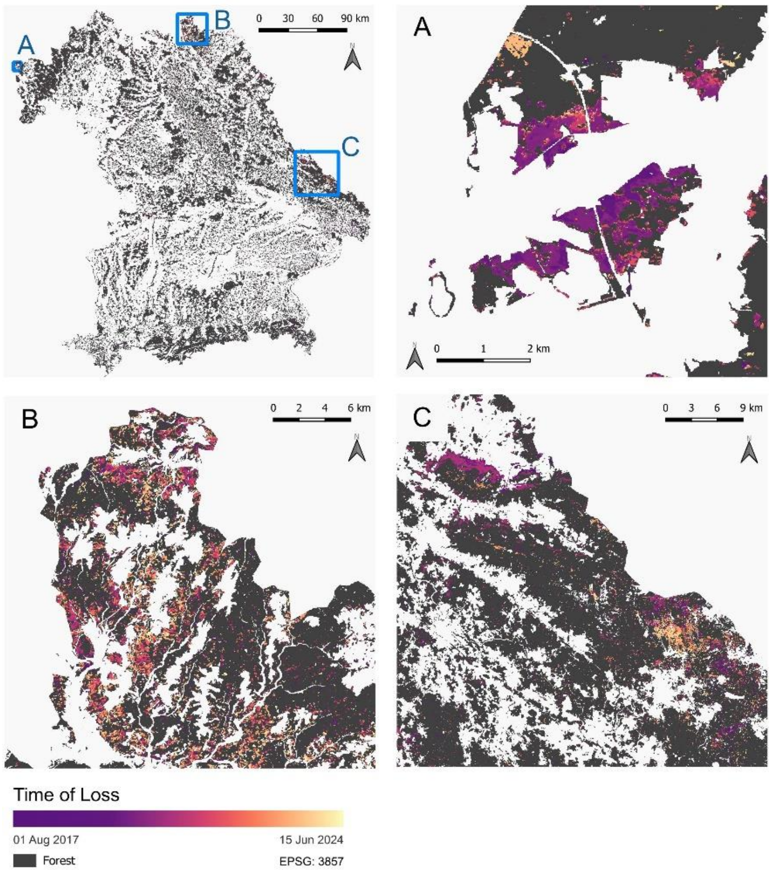

Figure 2: Map of biweekly canopy cover loss in Bavaria.

Subsequently, disturbances are attributed to one or several of the common **disturbance drivers** (drought, windthrow, insect infestation, fire) through the means of a decision tree that considers several external data sources with respect to each

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[1] Healey, S. P., Cohen, W. B., Zhiqiang, Y., & Krankina, O. N. (2005). Comparison of Tasseled Cap-based Landsat data structures for use in forest disturbance detection. *Remote sensing of environment*, *97*(3), 301-310.

[2] DLR. terrabyte High Performance Data Analytics (HPDA) platform. https://www.dlr.de/eoc/terrabyte.

cause of disturbance. Afterwards the single pixels are clustered and thus transformed into meaningful disturbance patches. All generated results are then integrated in a mobile app in which **end users**, e.g. forest managers, can subscribe to areas for which they receive notifications if new disturbances are detected. Furthermore, for each disturbance patch, we derive and display an explanation on observed local stress factors (wind, fire, snow, drought, insect, fungal) based on external data sources like German Weather Service data or digital bark beetle traps.

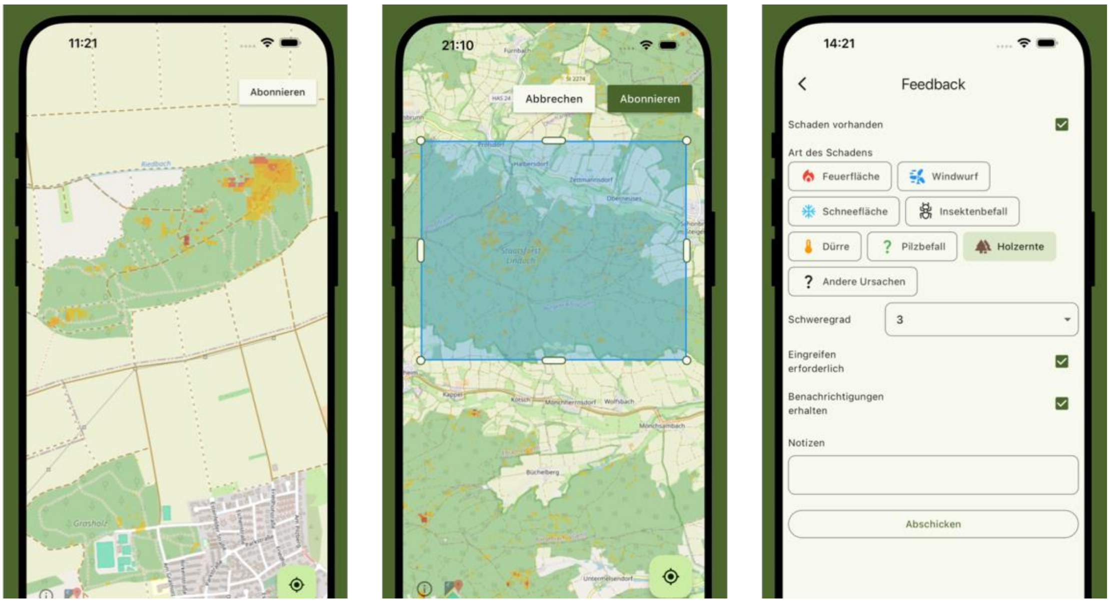

Figure 3: Mobile app for displaying and interacting with forest disturbance maps.

In its entirety, our ongoing ROOT project[3] presents an implementation of a near-real time forest monitoring system that is currently not available for Bavaria. Particularly the development of an end-to-end system that connects satellite image time series analysis results directly to practitioners is a novelty in the overall trend of transferring scientific results to public users. Evaluation and feedback of our approach and the mobile app will be gathered through workshops with forest managers and exchanges on conferernces.

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[3] Project pages: https://se.informatik.uni-wuerzburg.de/root & https://en.bidt.digital/?research-project=real-time-earth-observation-of-forest-dynamics-and-biodiversity-root