



UNIVERSITY
of SOPRON

FACULTY OF
FORESTRY



Development of a Satellite based Forest Monitoring System

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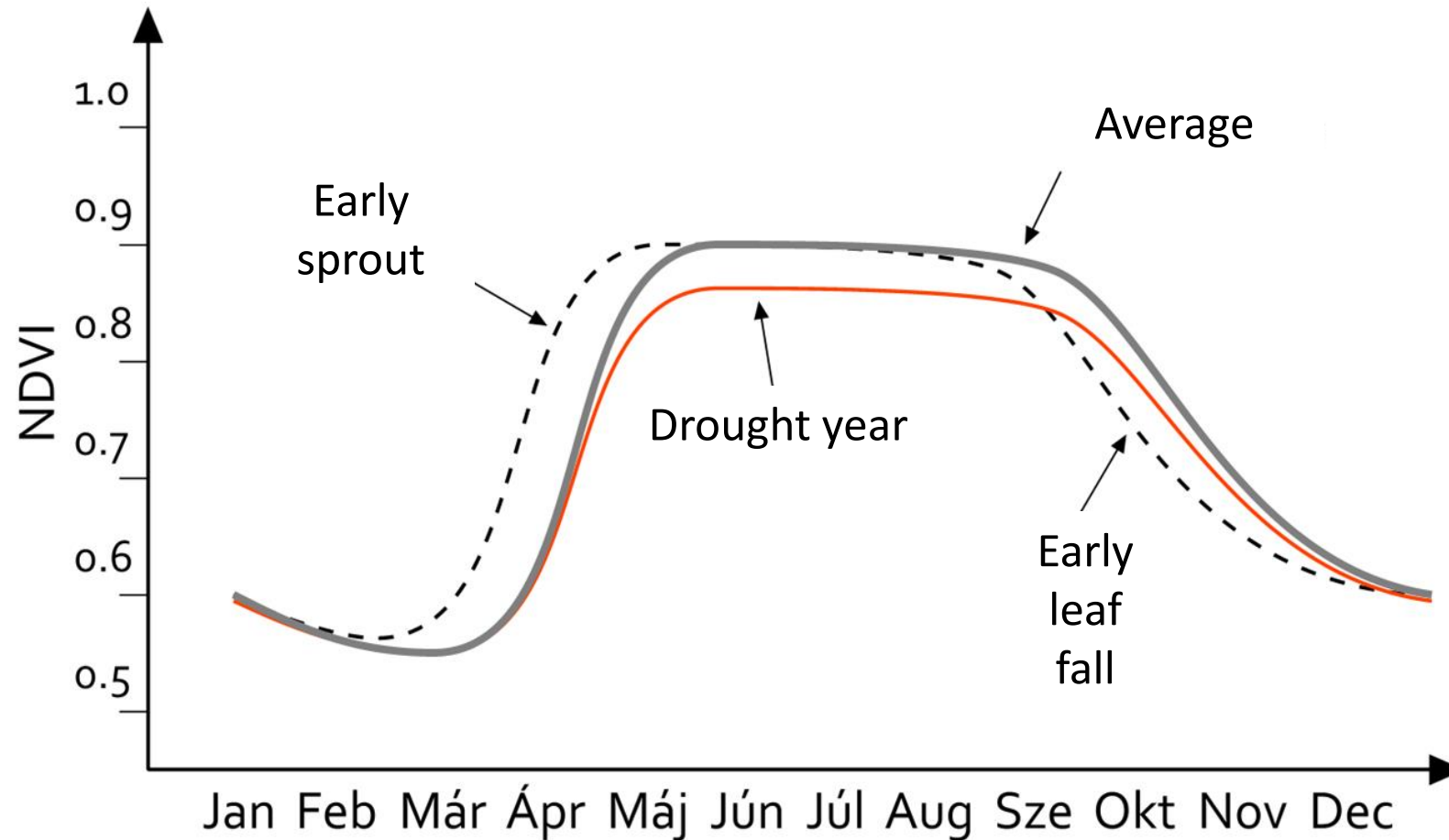


Forest Damage Monitoring

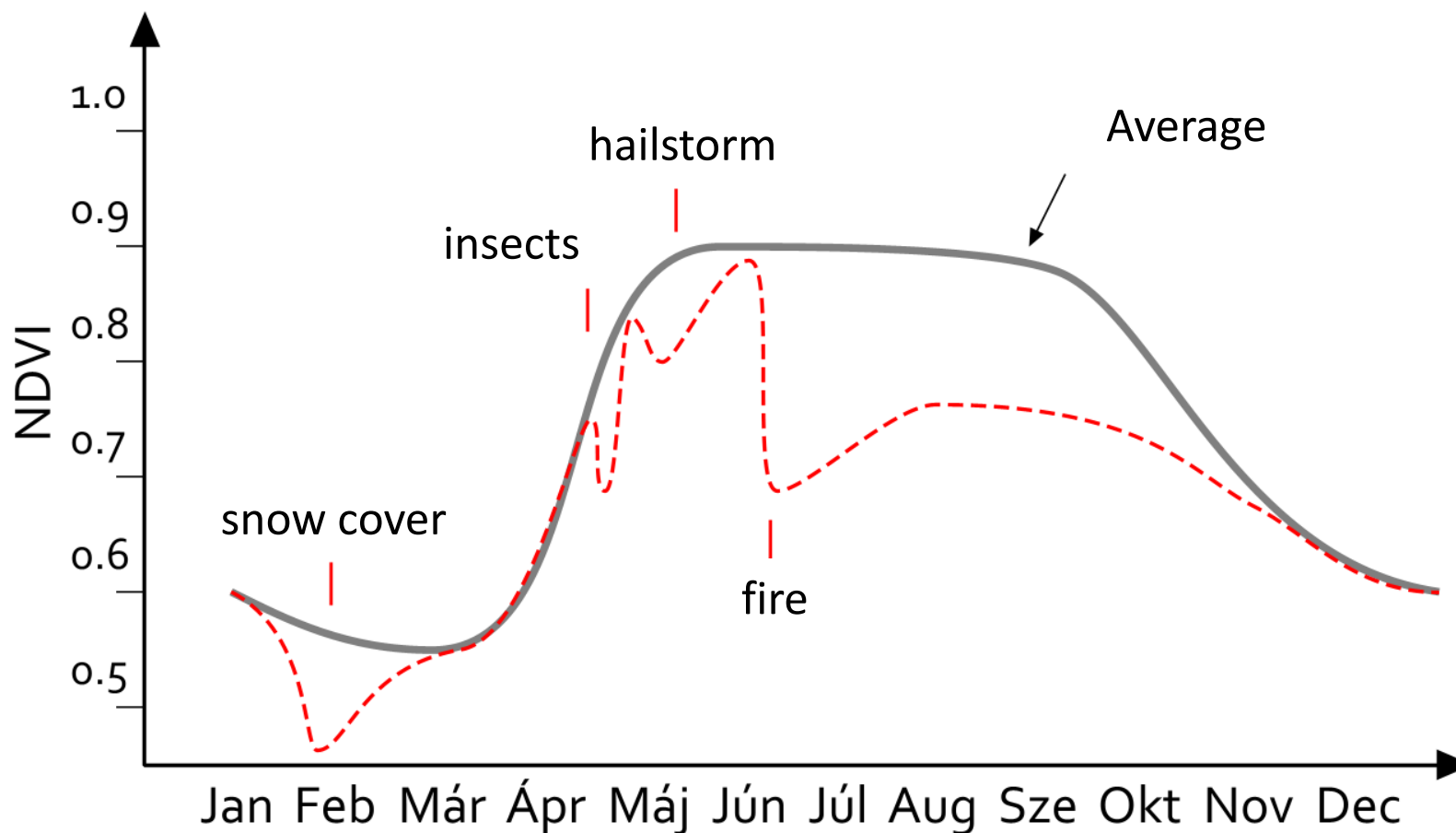
- Satellite remote sensing is excellent + terrestrial reference
- Multiple systems in operation (ForWarn, GlobalForestWatch)
 - Even in Hungary (TEMRE, FIR)
- Various sensors (MODIS, Landsat, Sentinel-2)
- Proven method: Vegetation index changes
- Various implementations
 - Simple difference
 - Standardization



Vegetation index - temporality

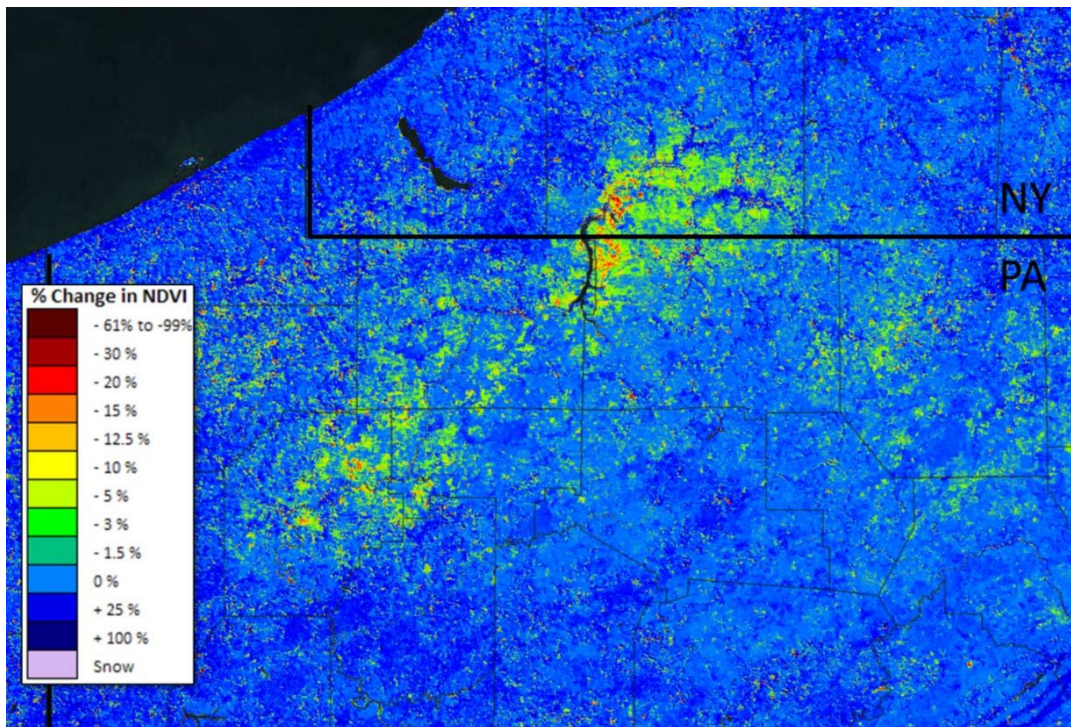


Vegetation index - temporality

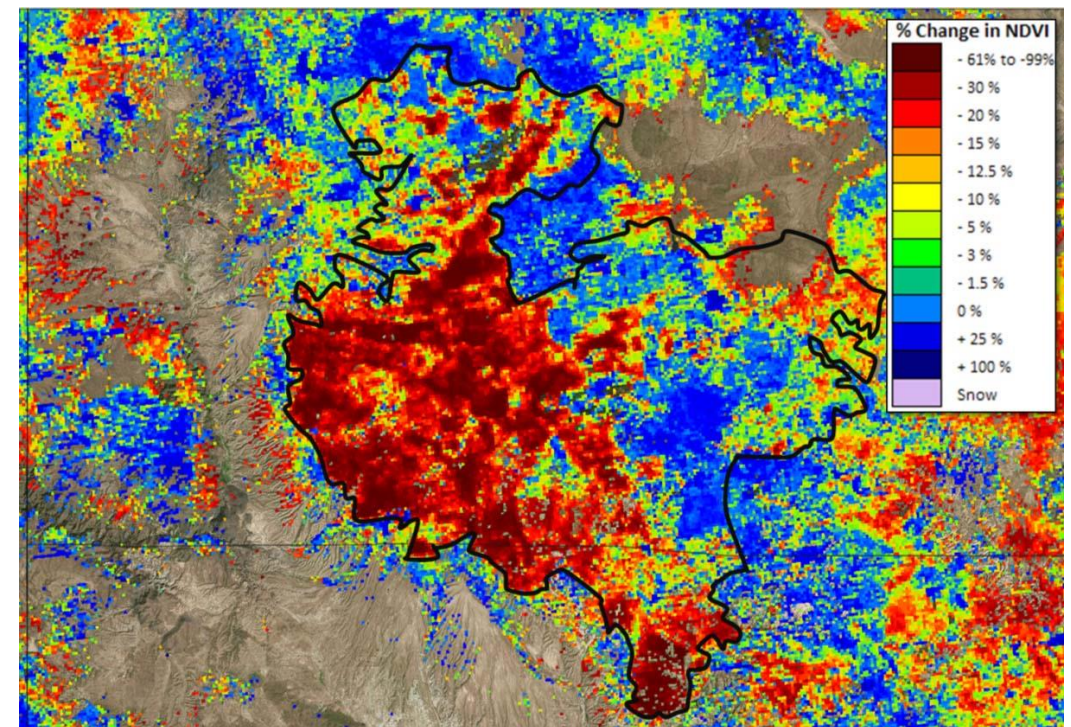


Vegetation index - spatiality (ForWarn)

Biotic damage



Forest fire



Problem

- Severe drought in 2022, NDVI drop of nearly 0.5
- Differential-based methods do not work
 - Current – previous month/year average, large difference
 - **Two or more drought years shift the average**
- Normalization-based procedures do not work
 - $(\text{Current} - \text{average of previous years}) / \text{Standard deviation of previous years}$
 - **Alternating drought-normal years take away the deviation**
- Is there a solution?

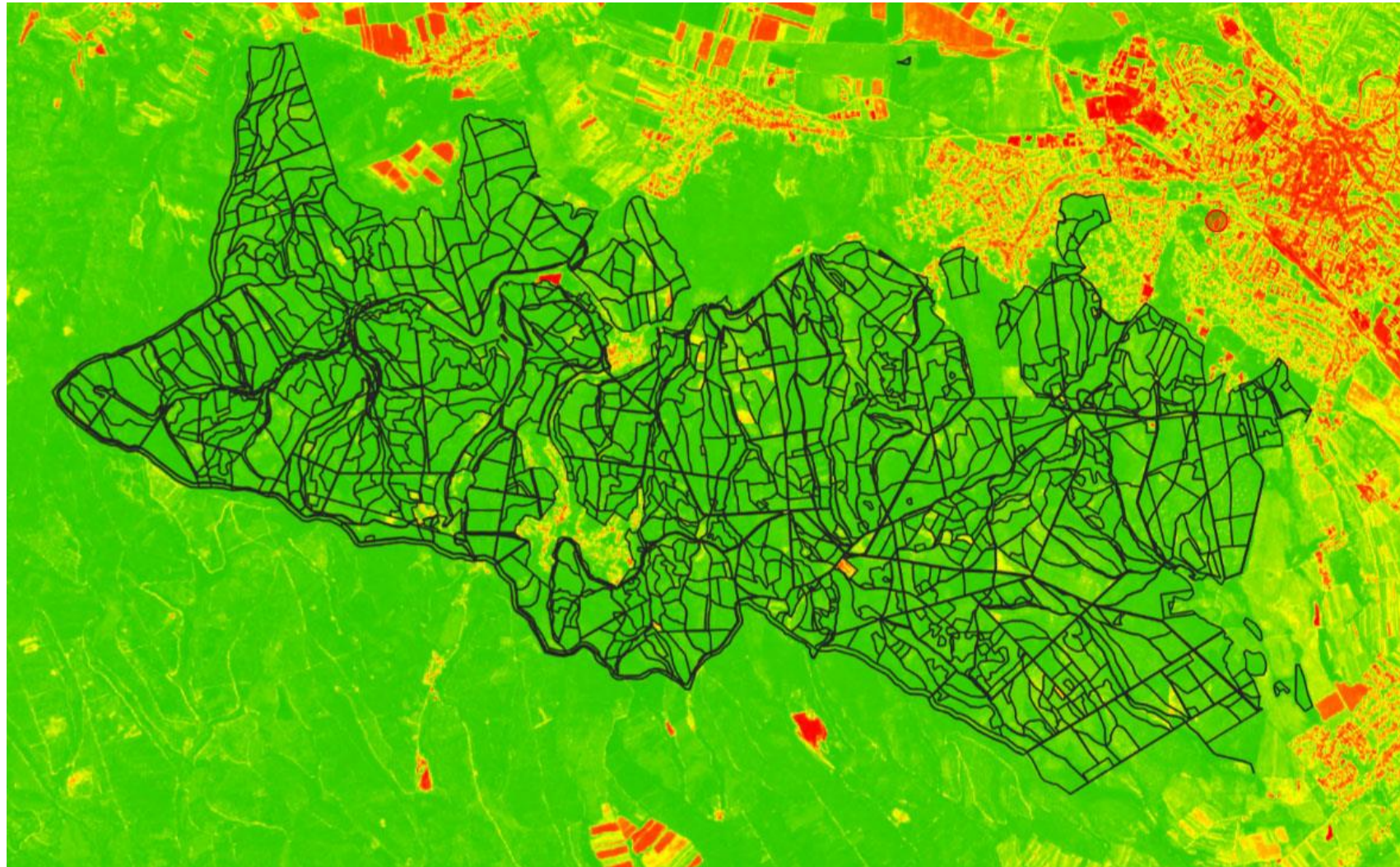


Development Objectives

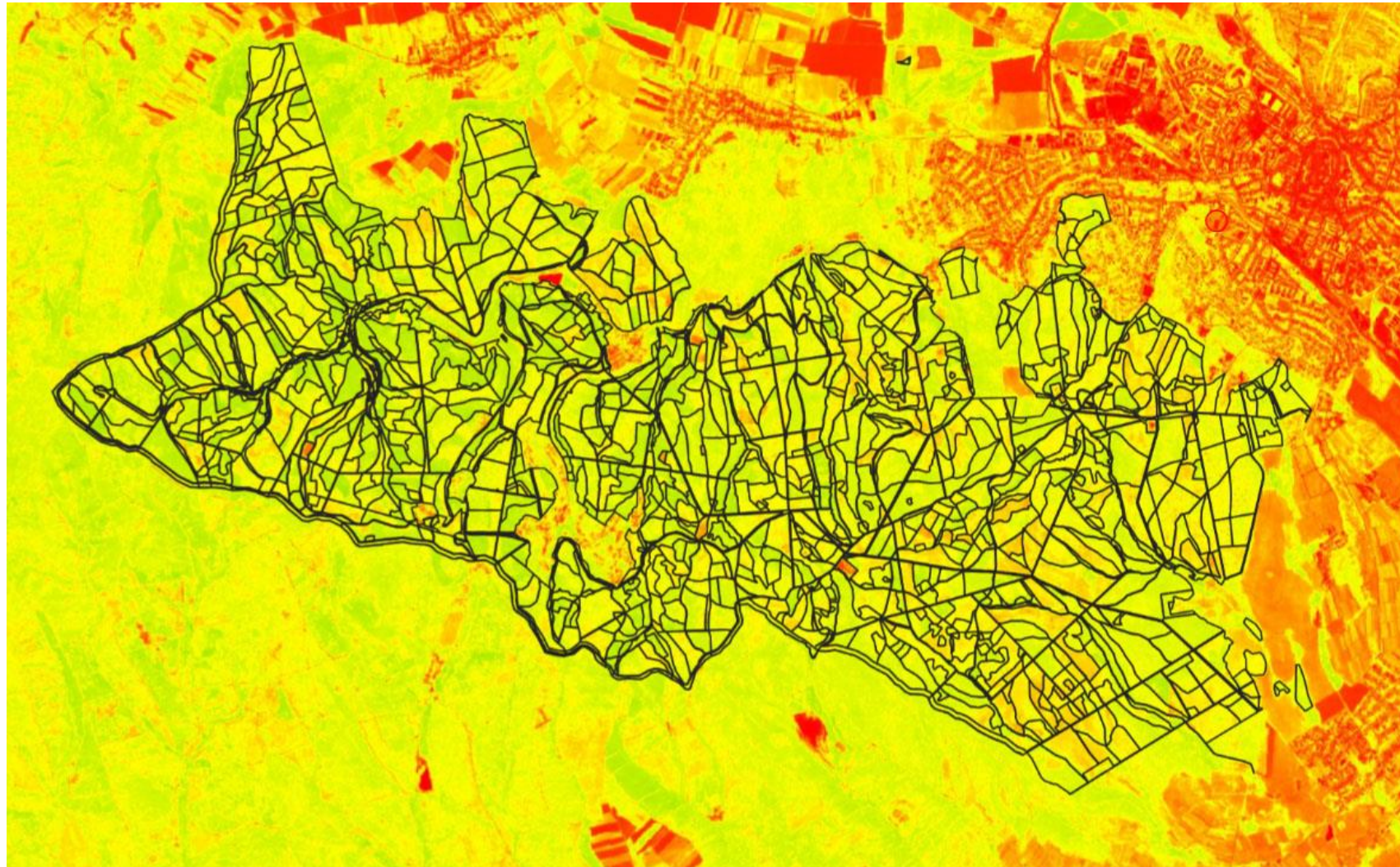
- Be a web system, serve multiple users
- Be manageable by forestry professionals
 - They don't like complicated systems
 - They don't like infrared images
- Can handle normal and drought years
- Introduce a single metric for forest damage
- Detect patches and patterns
- Recognize problems that begin



NDVI of August 2021.



NDVI of August 2022.



0.5 NDVI drop
for Forests



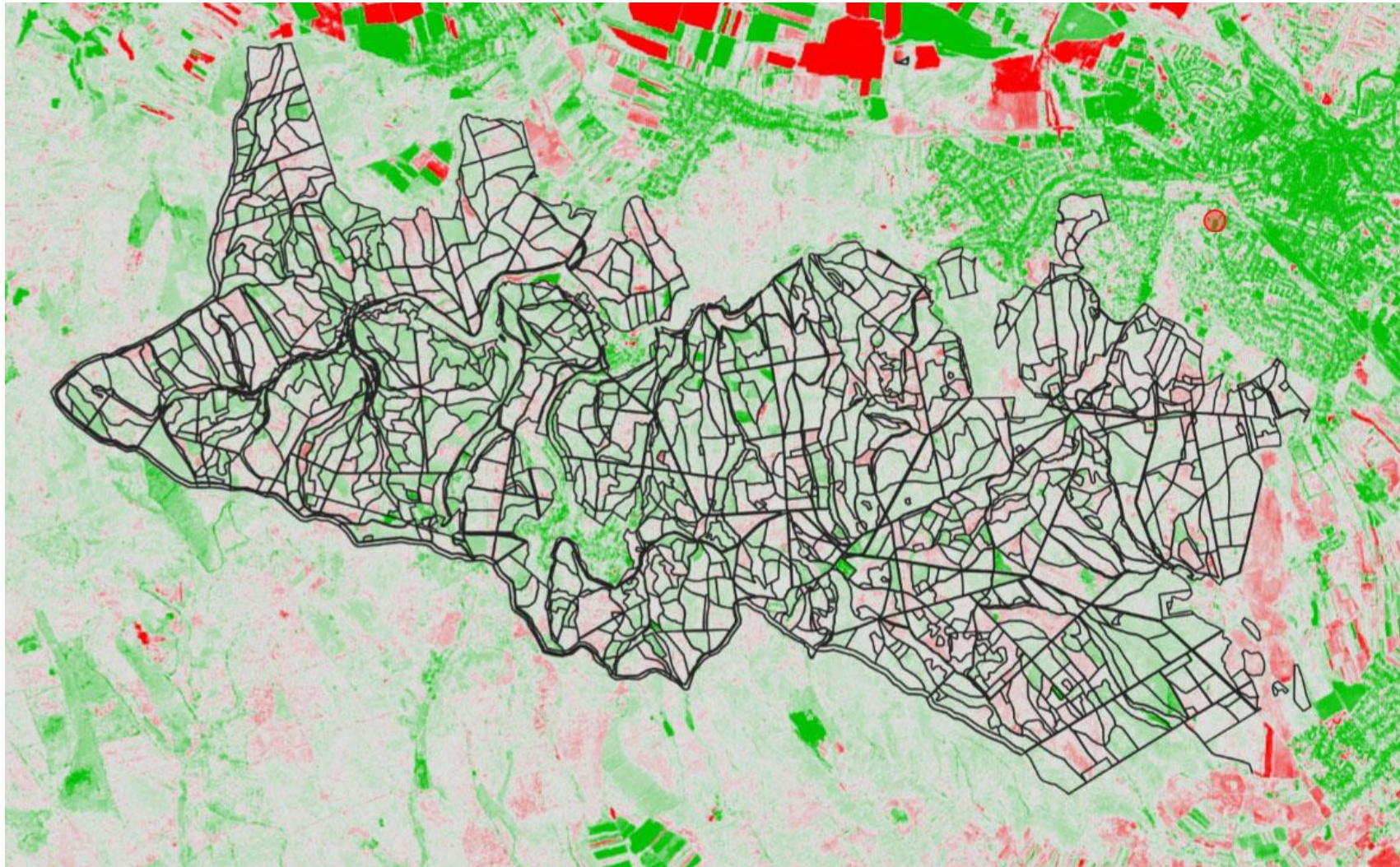
Introducing Double Difference

- Need a robust statistical estimator (median, percentile)
- Relate to the 75 percentile of forests in each period
- Compose a new index, a double difference:

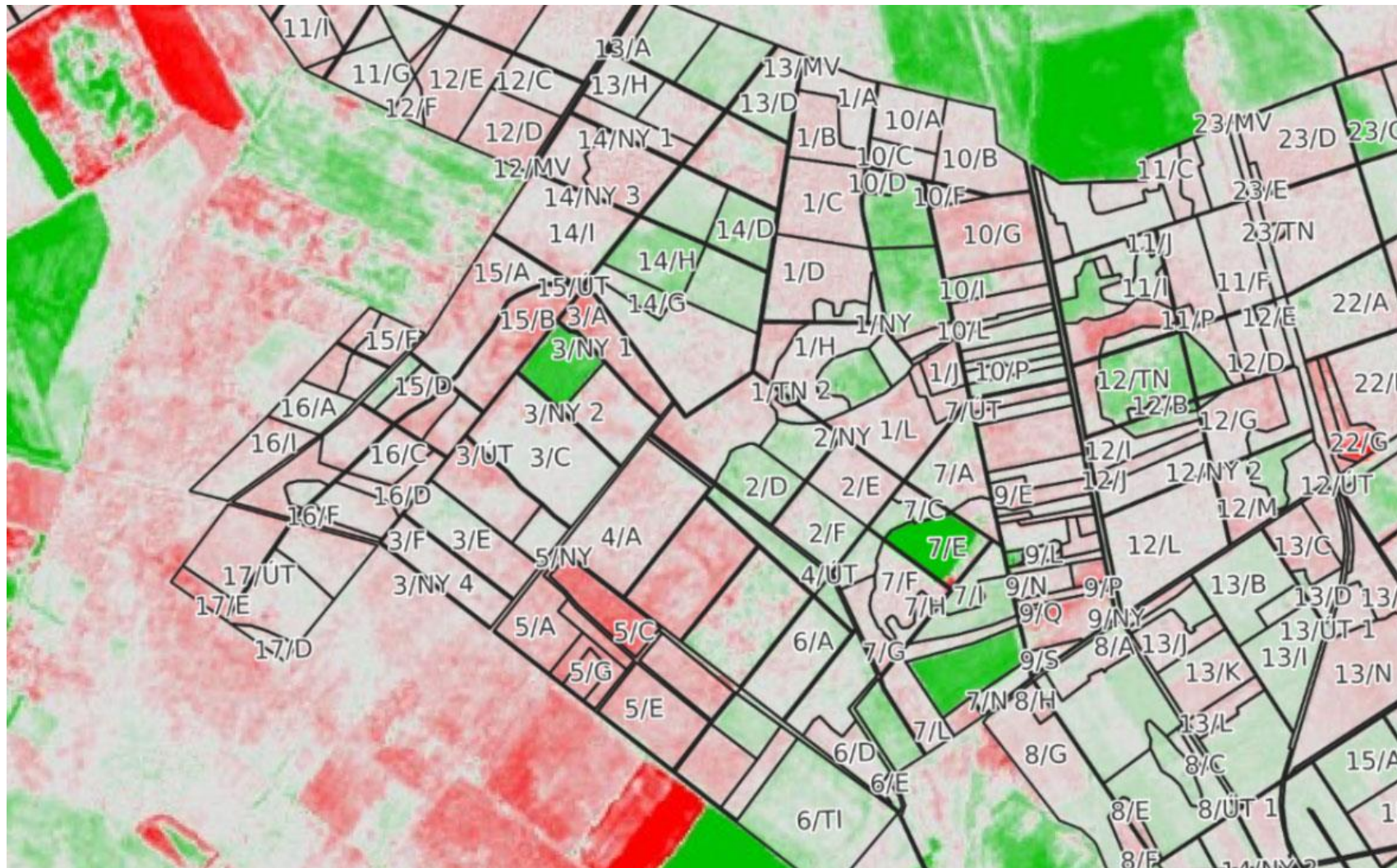
$$\text{Diff} = (\text{NDVI}_{\text{act}} - \text{NDVI}_{\text{act, perc75}}) - (\text{NDVI}_{\text{prev}} - \text{NDVI}_{\text{prev, perc75}})$$



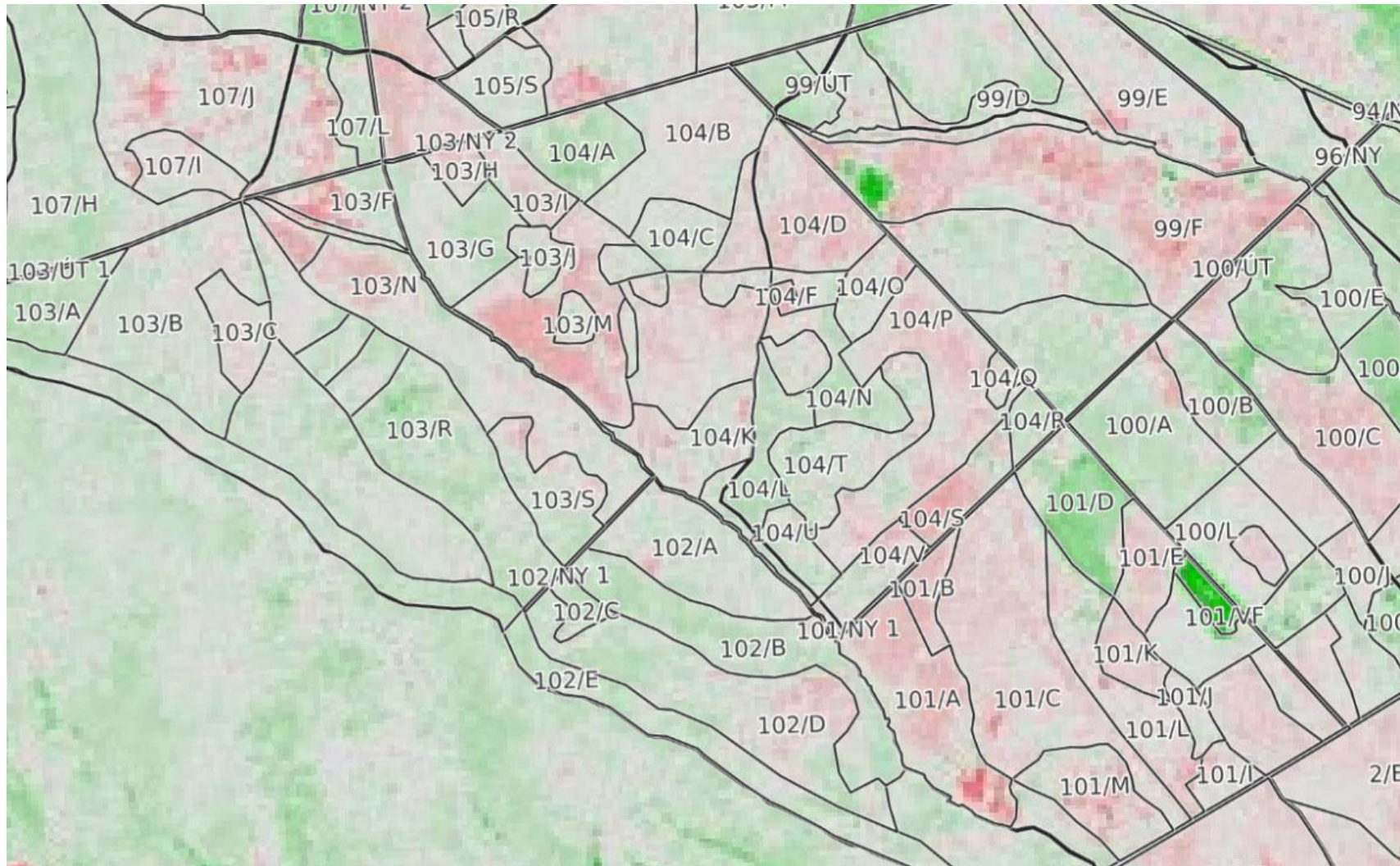
Double Difference



Double Difference (closer look, Lowlands)

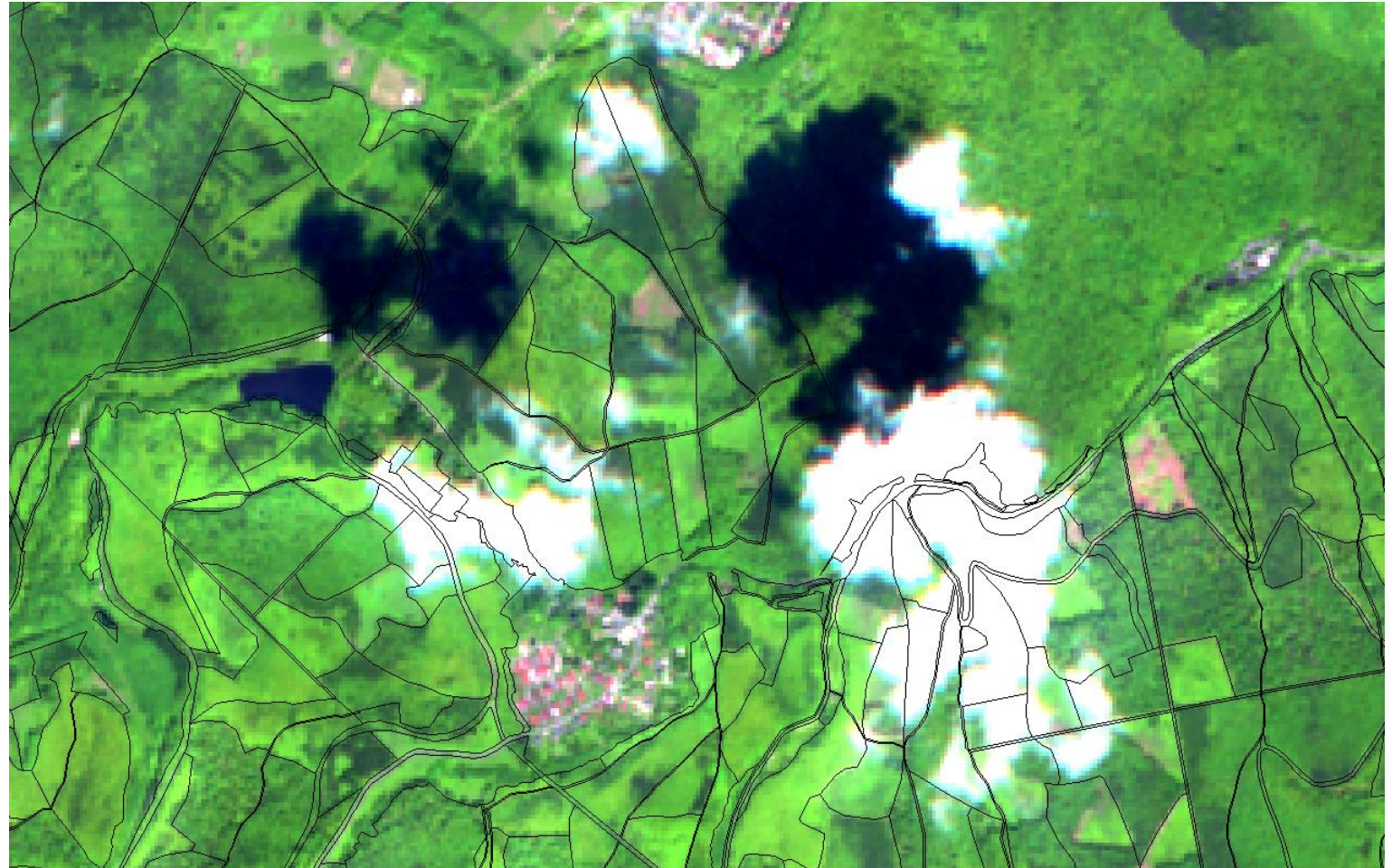


Double Difference (closer look, Highlands)



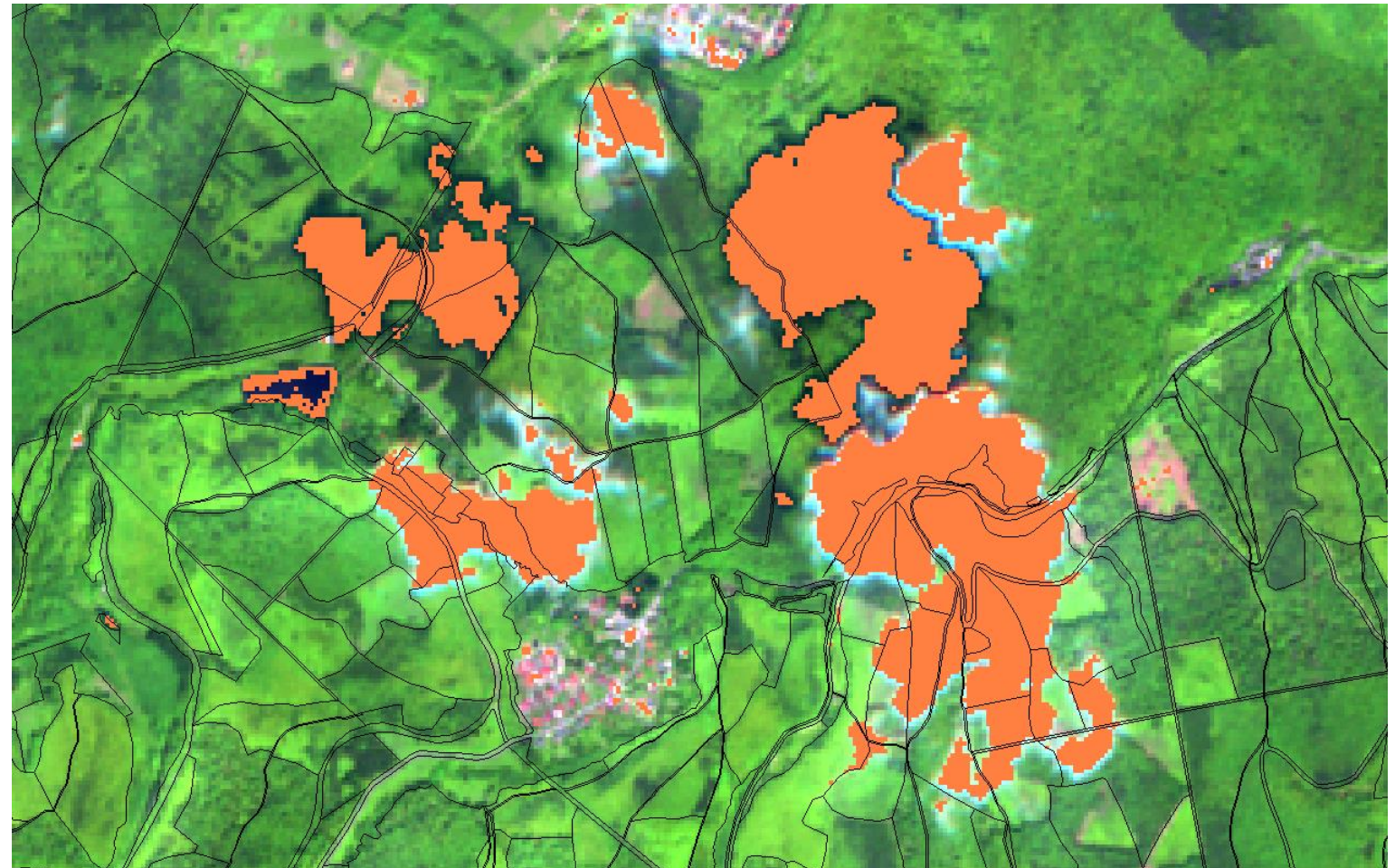
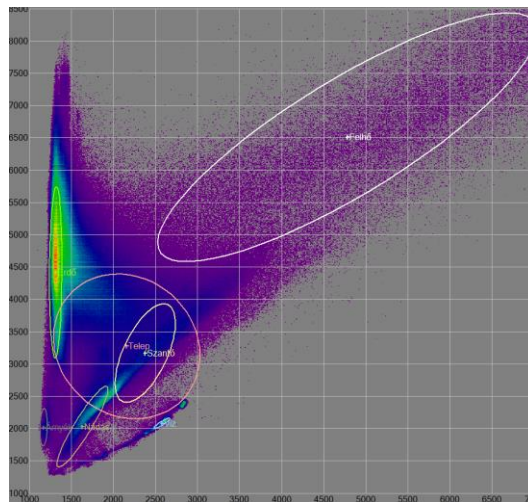
Clouds

- Clouds and their shadows are problematic, it generates false detections



Clouds

- Maximum likelihood based cloud and shadow detection for masking



Detection

- One or two metrics are required for forest sub-compartments
 - Pixels ratio, where $-0.1 \dots -0.2$ is the double difference
 - Pixels with a double difference of less than -0.2
 - Values can be transferred to the professional forestry system
- It is necessary to recognize plots (vector point layer for GIS)
 - Plot appearance of forest damage
 - Definition of plot size: 3, 5, 7
 - Adaptive 5x5 filter, minimum threshold and sum threshold introduced



Implementation and workflow

- Download Sentinel-2 image tiles
- Process JPEG2000 images directly
- Algorithmic image processing (topoXmap)
- Output image results, tiling
- Plot Detection, metrics for forest compartments

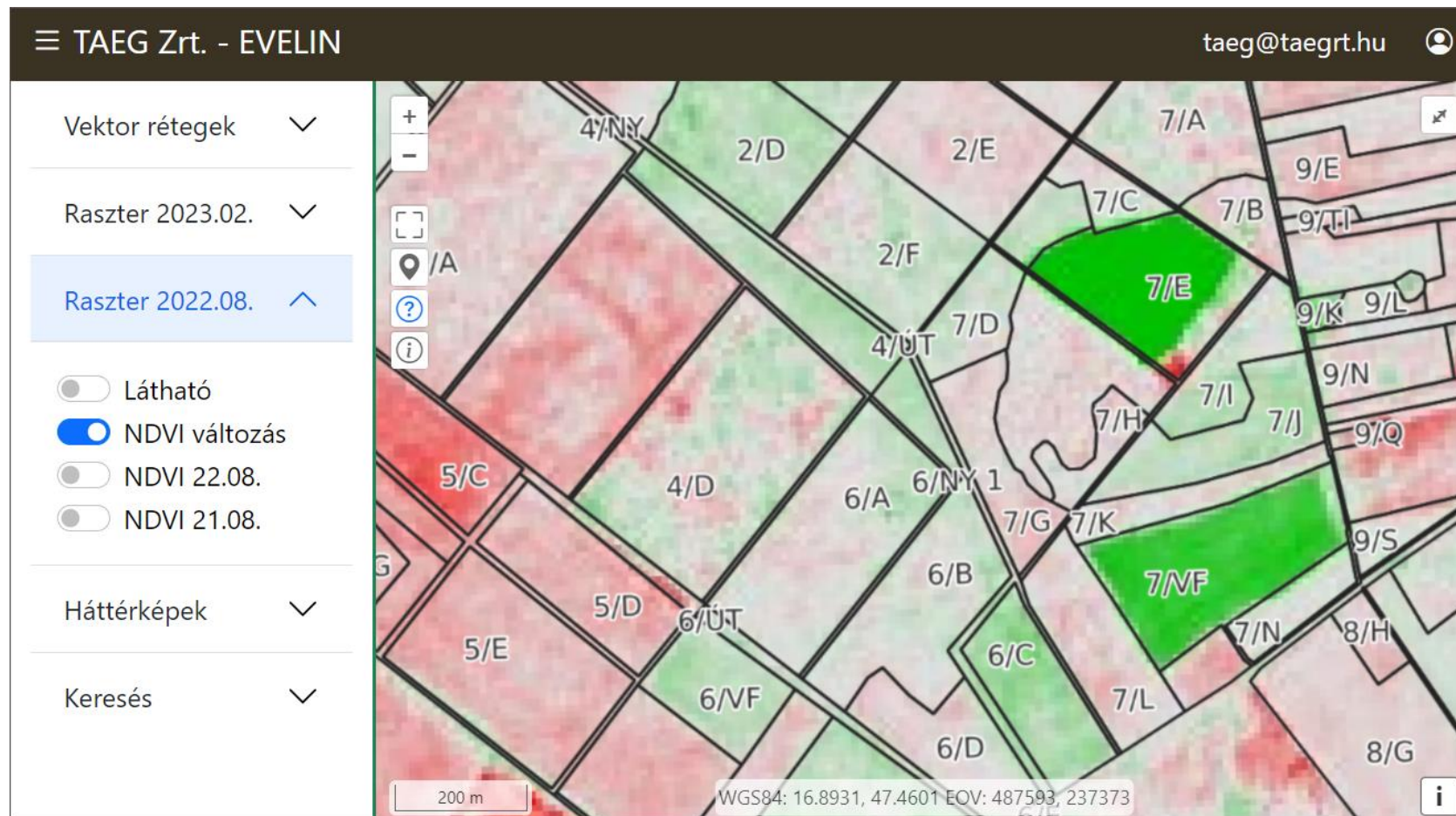


Web Application Development

- Periods, on average 1 good (cloudless) image per month
- Display of Current and previous years NDVI
- Display of Double difference
- Display of False Color image
- Fast system, lots of imagery, should run on mobile
- Geoserver independent solution development



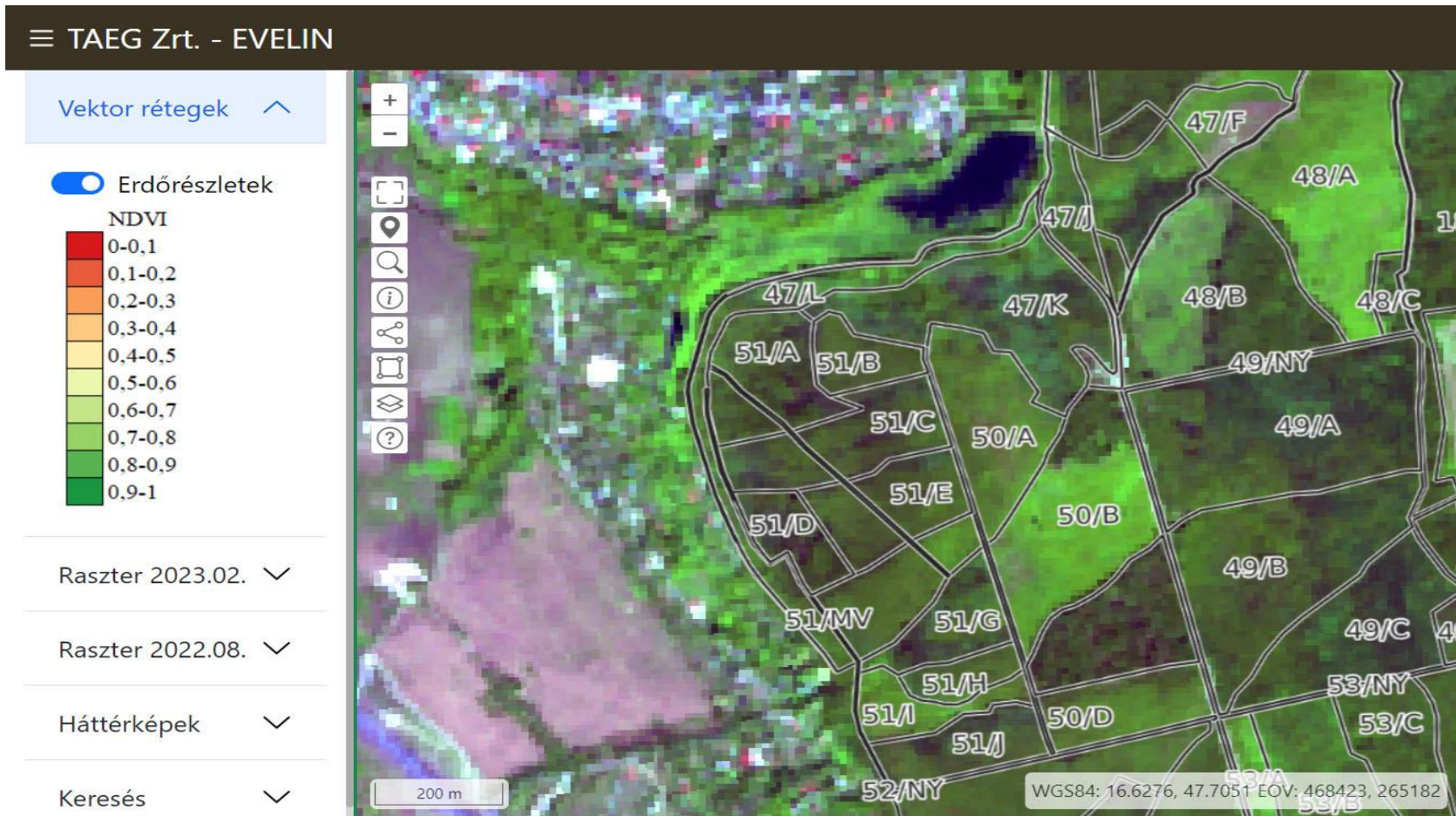
Web application



- Login
- Forest maps
- Images
- Background maps
- Search
- Measurement
- GNSS position



False color image, greens are forests



Linear Color Space
Transformation



Results

- Development of novel method, algorithms and processing
- Web application development, publication of results via Internet
- Field feedback (from TAEGL Zrt.), system use
 - Many detected damage plots validated
 - One important example: August footage showed a damaged plot: that plot of scotch pine dried up in spring
 - Not all stocks marked in red showed forest damage, but it shows the stress



Sequel

- Processing several periods including winter months
- Comparison with logging data (false alarm)
- Recognition of types of damage, based on measure and spatial pattern
 - Theft of wood
 - Drought damage
 - Storm damage
 - Insect damage
 - Complex damage (predisposing, provoking)





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Thank You for the Attention

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