UNECE

Food and Agriculture Organization of the United Nations

Federal Ministry
Republic of Austria
Agriculture, Forestry, Regions and Water Management

# Innovative tools in line with methodological aspects for harmonized forest damage assessment in the ECE region

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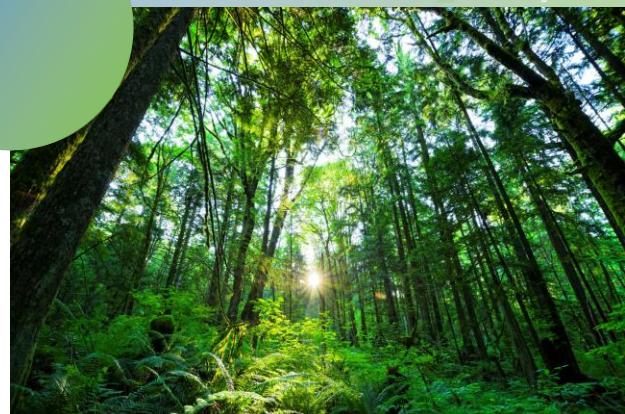
## Assessing Forest Damage and Disturbance

**Scientific-Technical Symposium jointly organized by UNECE, FAO and the Austrian Federal Ministry of Agriculture, Forestry, Regions and Water Management**

University of Natural Resources and Life Sciences Vienna, Austria
29-30 September 2022

BOKU



# Introducing “Innovative tools…”

- **Chapter 7** in forthcoming “Reporting and Assessment of Biotic and Abiotic Forest Damage and Disturbance in the ECE Region"
- **Theme:** Innovative methods to accomplish forest damage/disturbance assessment in a harmonized way
- **Objectives:** Build on existing methods and data with
  - Analytical approaches that everyone can implement similarly
  - Data sources that are available universally or that can be measured or recorded consistently

# What issues must be resolved?

- **Successful harmonization** requires shared understanding about several aspects
- **Revisited** throughout chapter

## Issues of scale

- Reference time period
- Reporting resolution
- Minimum area of damage/disturbance
- Minimum threshold of severity/intensity

## Issues of attribution

- Causal agent
- How agents are recorded
- Cases of multiple agents
- Forest context (diversity/geography)

## Issues of data

- Direct vs. indirect measurement
- Type of damage/disturbance (e.g., mortality)

# Existing harmonization approaches

**Largest common denominator approach**

(e.g., report total amount or extent of damage/disturbance in broad categories)

- Typical approach right now
  - Leaves potentially useful information "on the table" OR
  - Increases reporting burden for individual countries AND
  - Regardless, some countries don't report reliably

**Information needs approach**

- Ignore current data situation to focus on what is needed
- Innovative methods could close gaps between availability and needs

# Adopting a geospatial framework

- **Limitations** of “largest common denominator" approaches
  - Don't address issues like double-counting
  - Don't really capture trends. What happened before a disturbance? After?

- **Large-scope assessments** should look at departures from historical patterns: “beyond reference conditions"

- **Tracking damage/disturbance** geospatially, and preferably through time (e.g., annually), can enable this

# Remote sensing (RS) as analytical foundation

## Advantages for harmonization

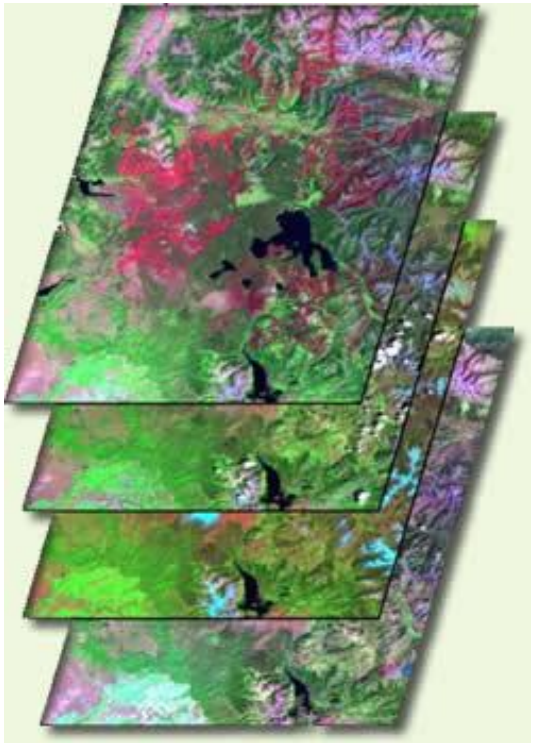
- Wall-to-wall geographic coverage, consistent spatial framework
- Enables time series
- Moderate resolution, multispectral RS data are readily available
- Growing body of research on techniques

## Disadvantages

- Indirect measure of forest disturbance/damage
- Not all disturbance/damage is easily detectable
- Identified disturbance/damage occurrences are not usually attributed to a causal agent

# RS-based mapping of damage/disturbance

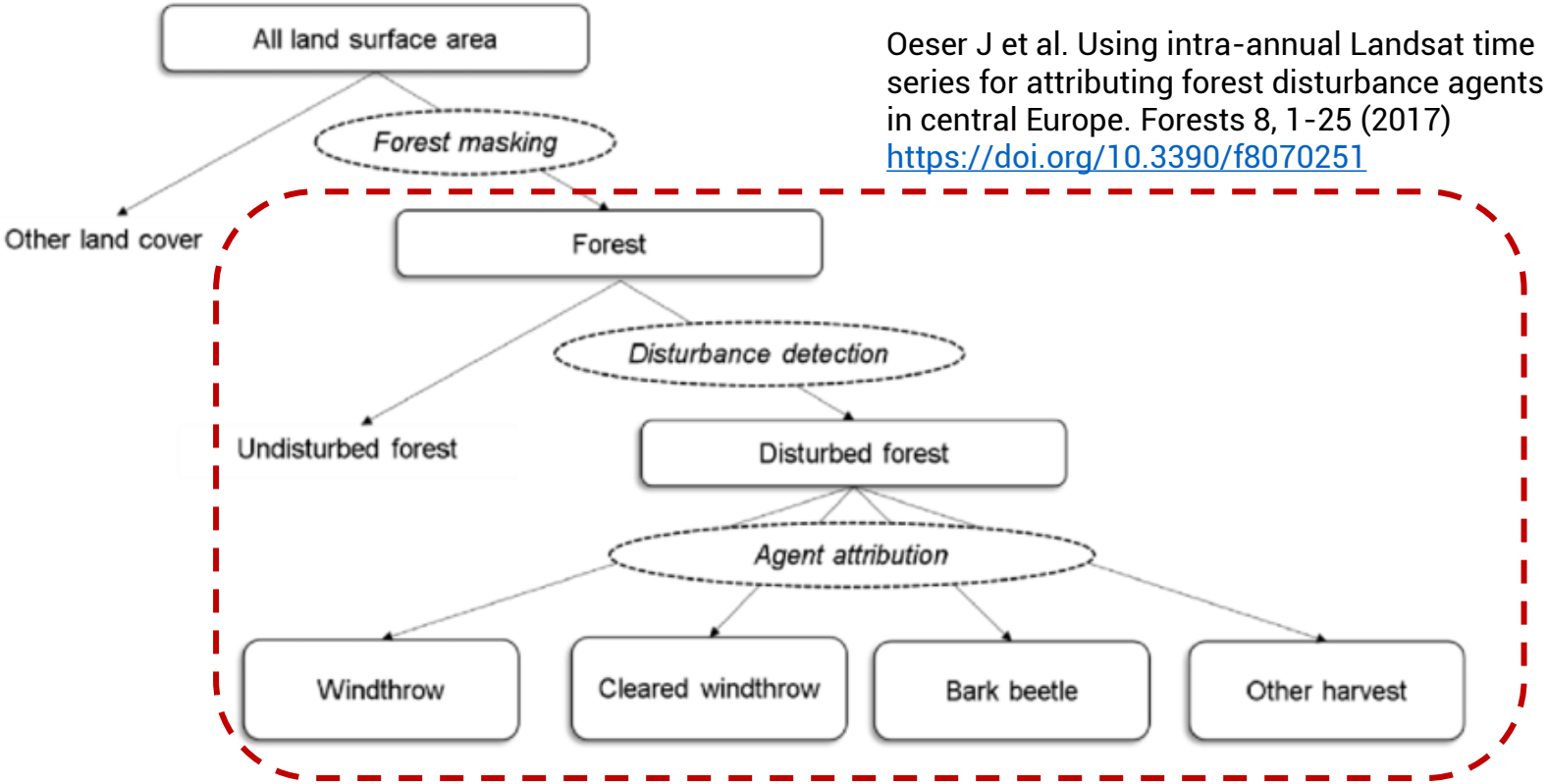
- **Data:** Moderate-resolution, multispectral satellite imagery (e.g., Landsat) as foundation
- **Goal:** Large-scope (continental, global) spatial databases of forest damage/disturbance through time
- **Enabled** by advances in
  - Satellite data availability
  - Analytical approaches and algorithms
  - Cloud computing platforms and workflows



https://landsat.gsfc.nasa.gov/article/unleashing-climate-data-and-innovation-for-more-resilient-ecosystems/

# RS-based mapping of damage/disturbance

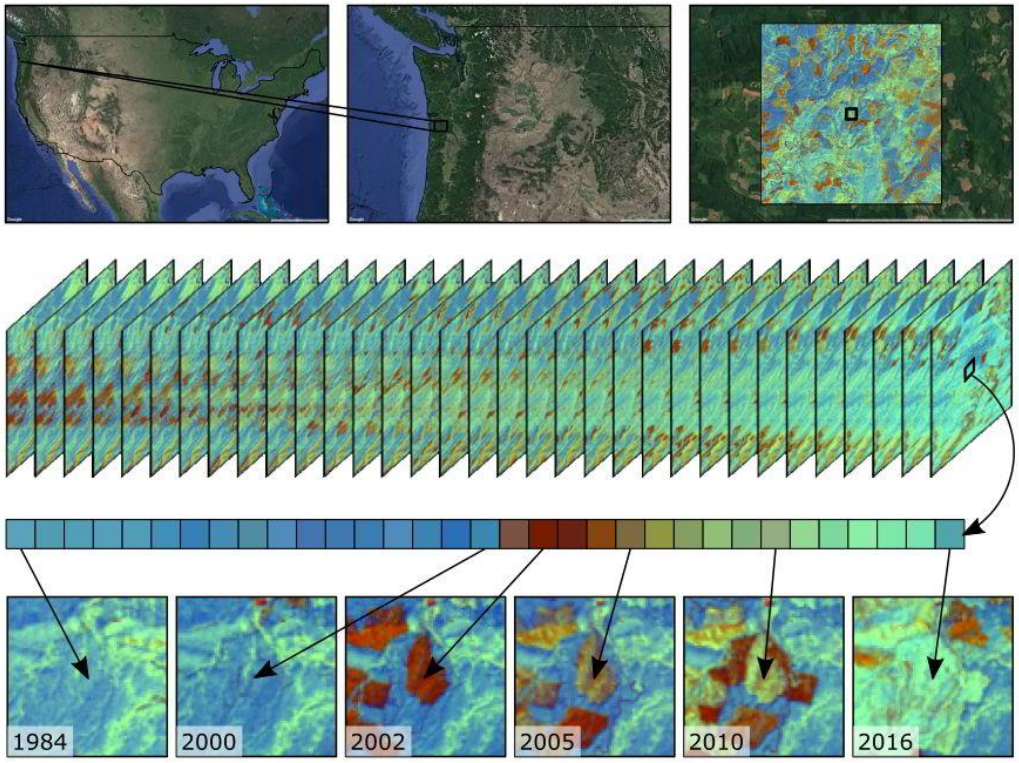
- **Phased strategy:** Map <u>all</u> forest damage/disturbance regardless of cause; <u>attribution</u> is a distinct process step




Oeser J et al. Using intra-annual Landsat time series for attributing forest disturbance agents in central Europe. Forests 8, 1-25 (2017) https://doi.org/10.3390/f8070251

# Increased satellite data availability

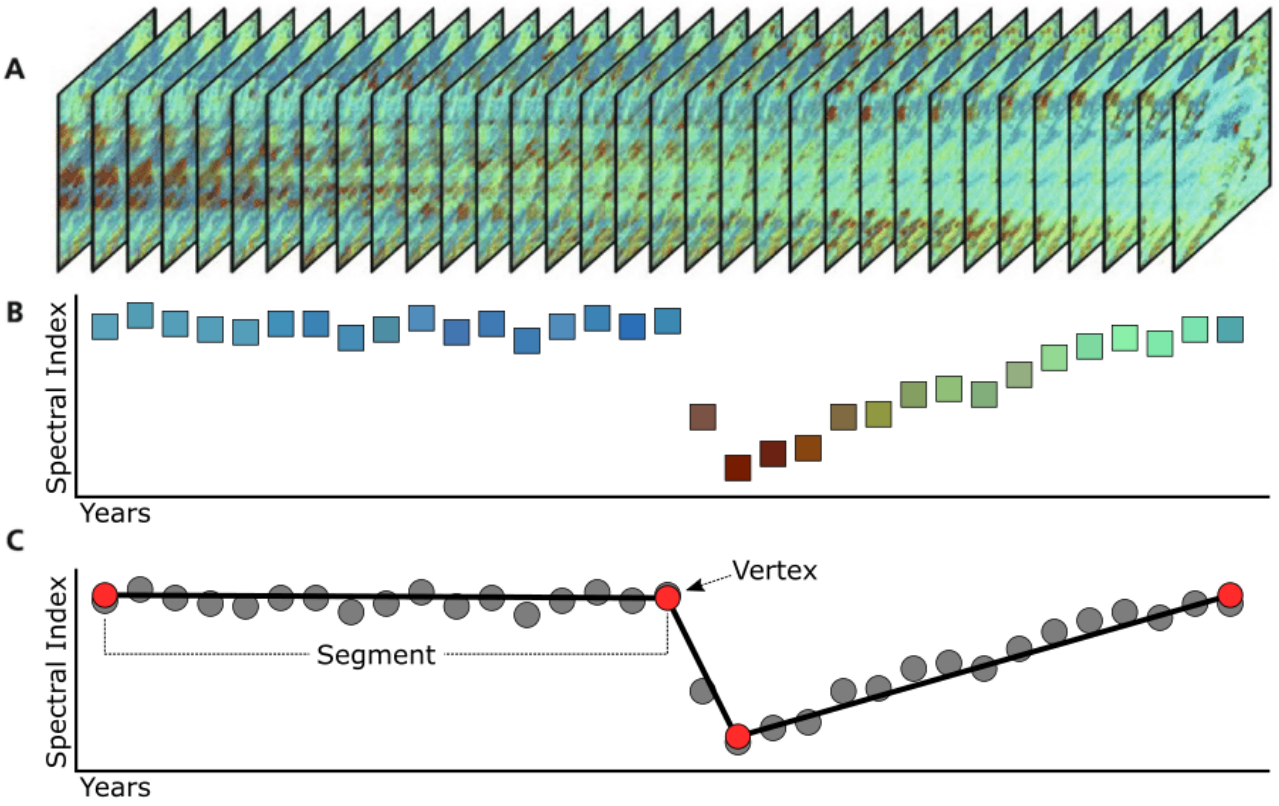
- **2008 = watershed moment:** entire Landsat image archive became freely available to any user
- **Enabled** analysis of Landsat time series (LTS) image stacks
- **Led to** algorithms for exploiting this decades-long data history
- **Evolving approaches** also being applied to newer sensors (e.g., Sentinel-2)




https://emapr.github.io/LT-GEE/landtrendr.html

# New analytical approaches & algorithms

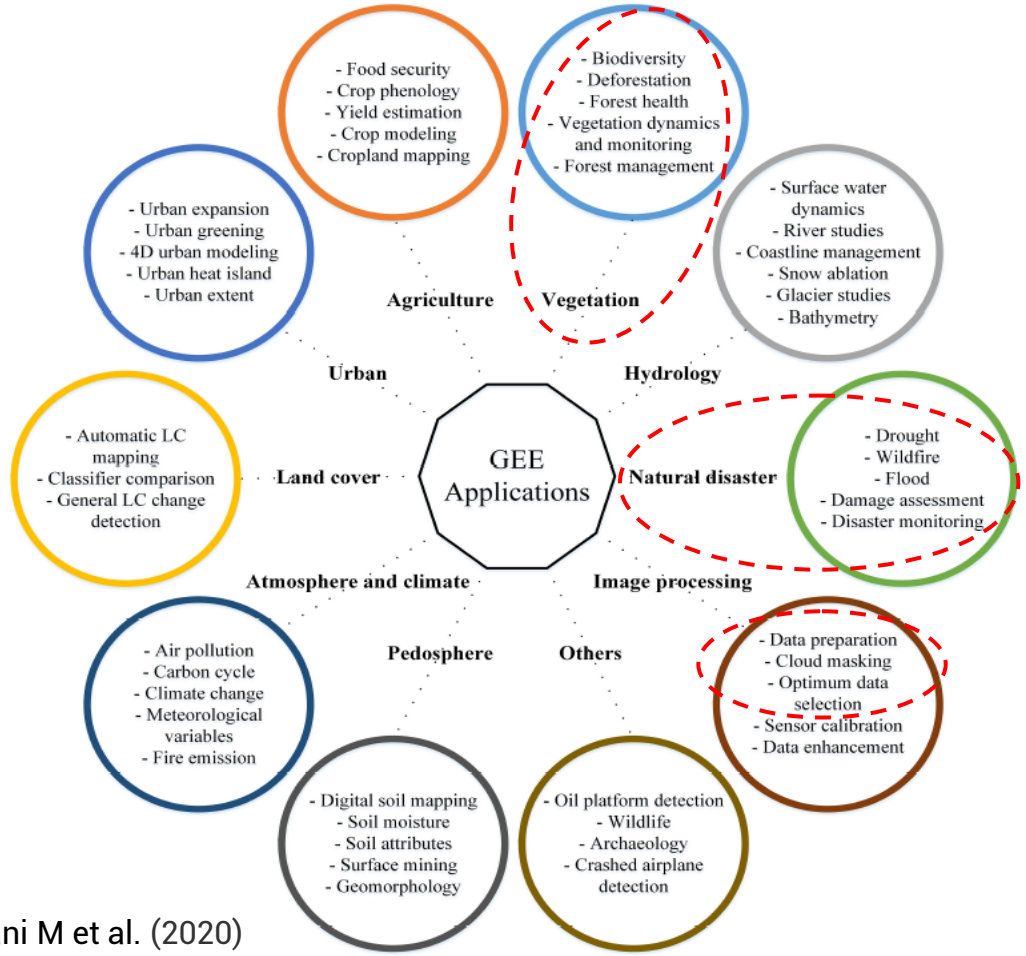
- **Trajectory analysis** of spectral data on a by-pixel basis
- **Prominent example:** LandTrendr (Landsat-based detection of Trends in Disturbance and Recovery)




https://emapr.github.io/LT-GEE/landtrendr.html

# Cloud computing platforms & workflows

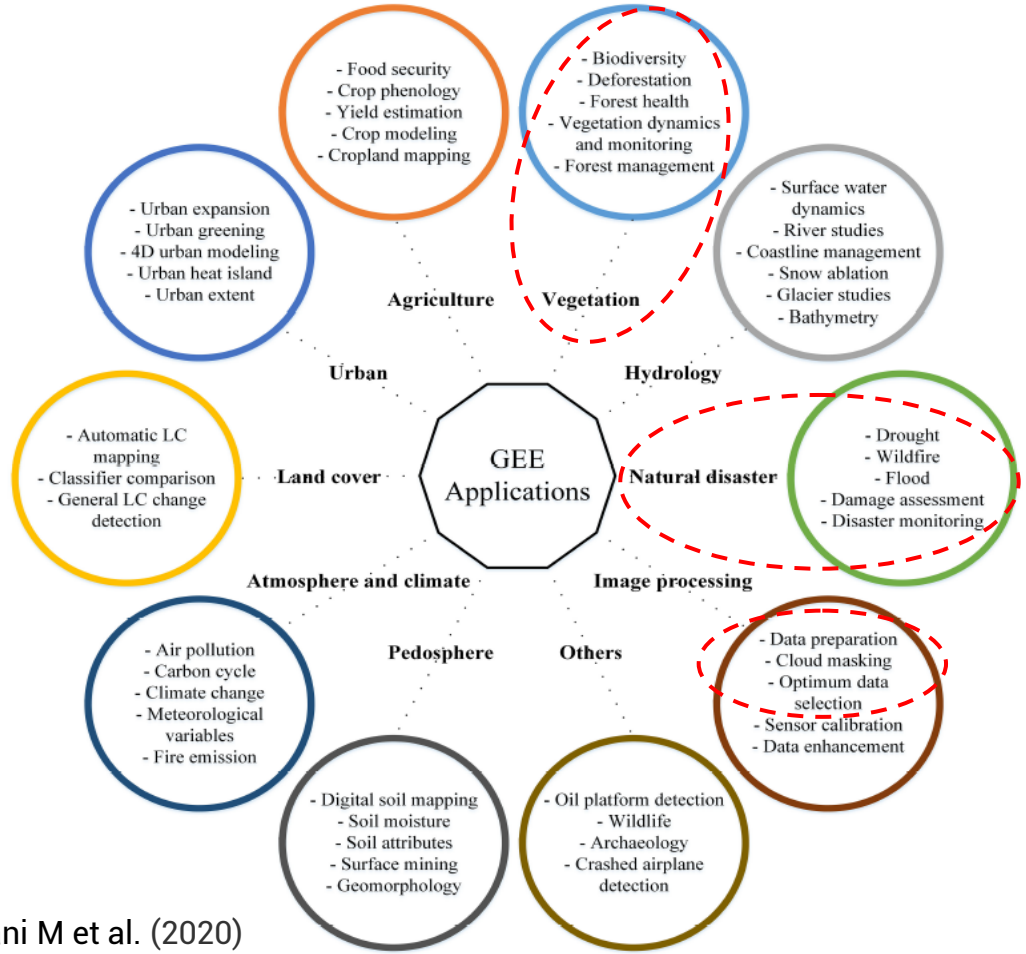
- **Distributed cloud computing** platforms enable global-scale geospatial analyses with massive data sets
- **Best-known example:** Google Earth Engine (GEE)
- **Vast data catalog** of GEE includes Landsat image archive; MODIS, Sentinel-2, other sensors; climate/ weather; topography; human demography; etc.
- **Parallel processing infrastructure** = efficient batch computation




Amani M et al. (2020)
https://doi.org/10.1109/JSTARS.2020.3021052

# Cloud computing platforms & workflows

- **Cloud computing platforms** can handle complex workflows with different inputs or algorithmic outputs
- **Machine learning techniques** are artificial intelligence methods increasingly applied to RS data
  - Examples: artificial neural networks, stochastic gradient boosting
  - Technique known as random forests is especially popular
  - Random forests implemented on GEE platform




Amani M et al. (2020)
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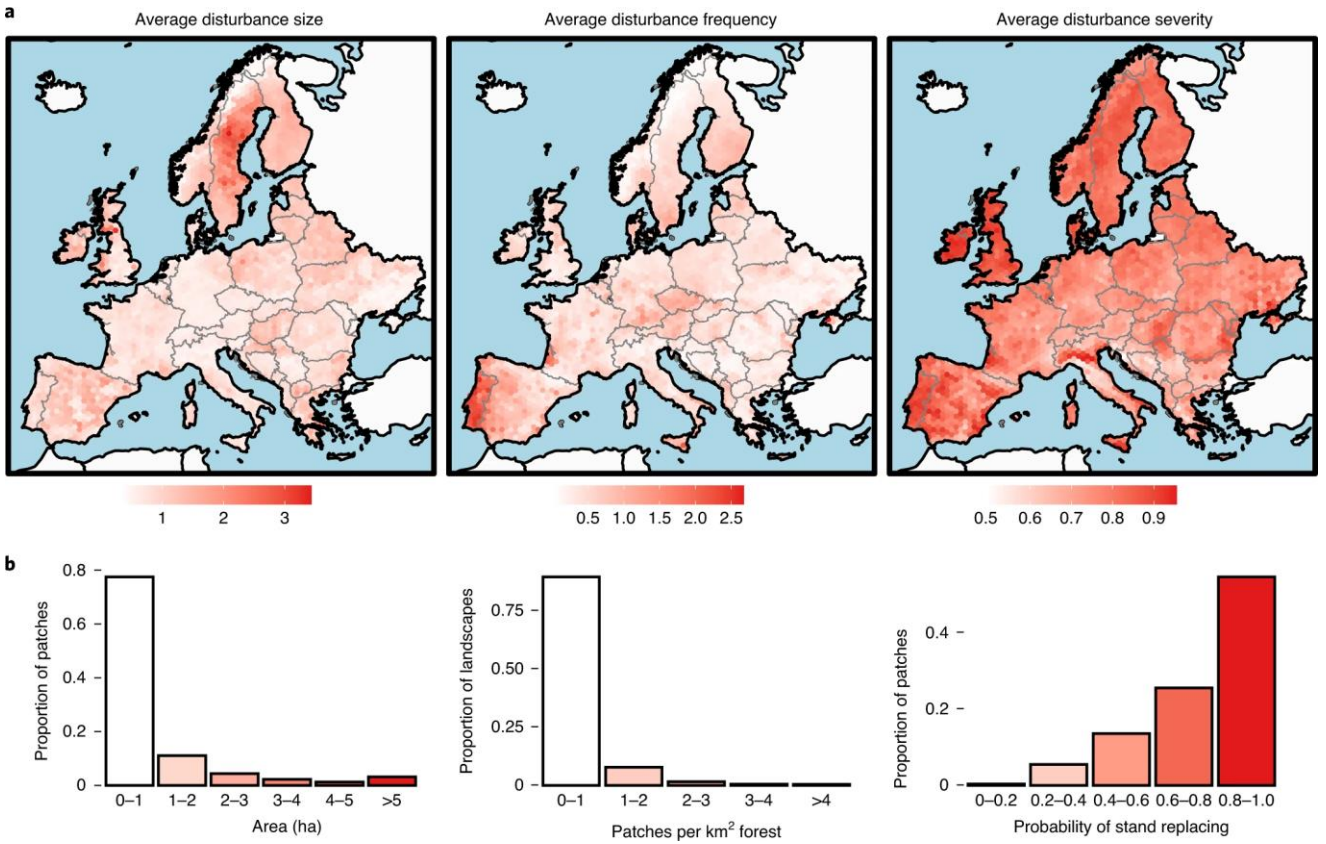
# What can pre-attribution results look like?

- **Illustrative example:** Senf C; Seidl R. Mapping the forest disturbance regimes of Europe. Nature Sustainability 4, 63-70 (2021) https://doi.org/10.1038/s41893-020-00609-y

Forest disturbance regimes (1986-2016) mapped across Europe

Can also examine temporal trends in these metrics



# Causal attribution: ancillary data sources

GlobFire database

Global Fire Atlas

**National forest inventories (NFIs)**

European Forest Fire Information System (EFFIS)

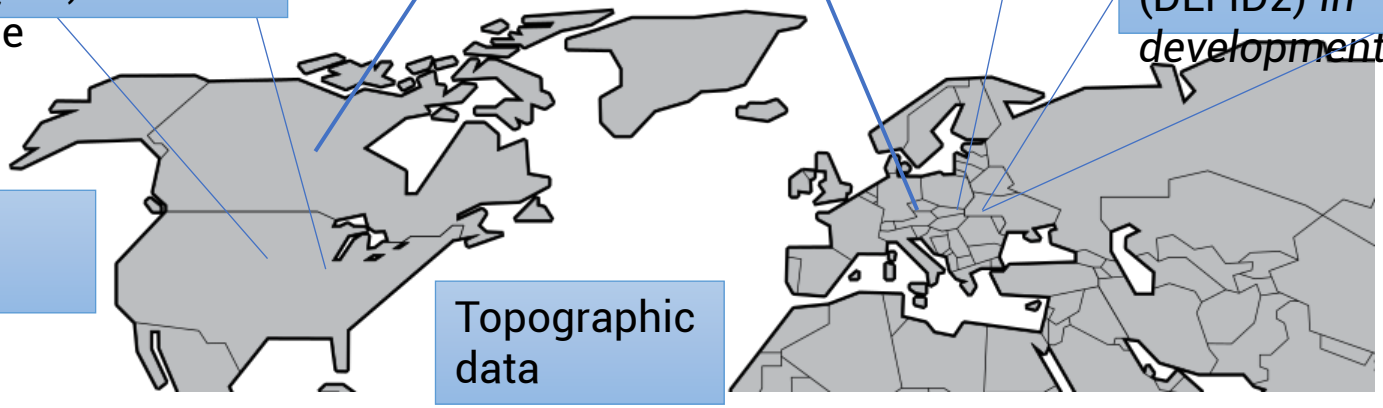
Monitoring Trends in Burn Severity (MTBS) data

FORWIND database of wind disturbances

USDA Forest Service Insect & Disease Survey (IDS) database

ERA5-Land climate variables

Database of European Forest Insect and Disease Disturbances (DEFID2) *In development*



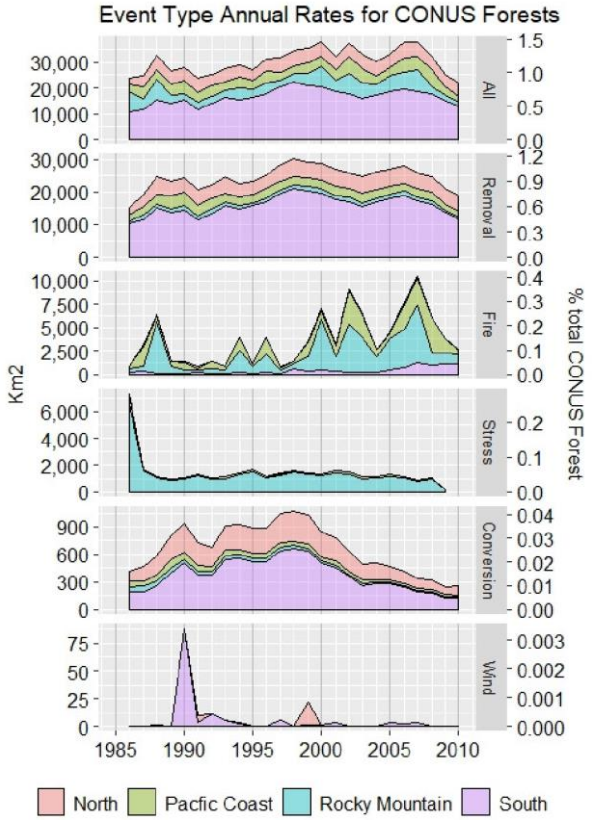
High-resolution imagery

Topographic data

And many more…

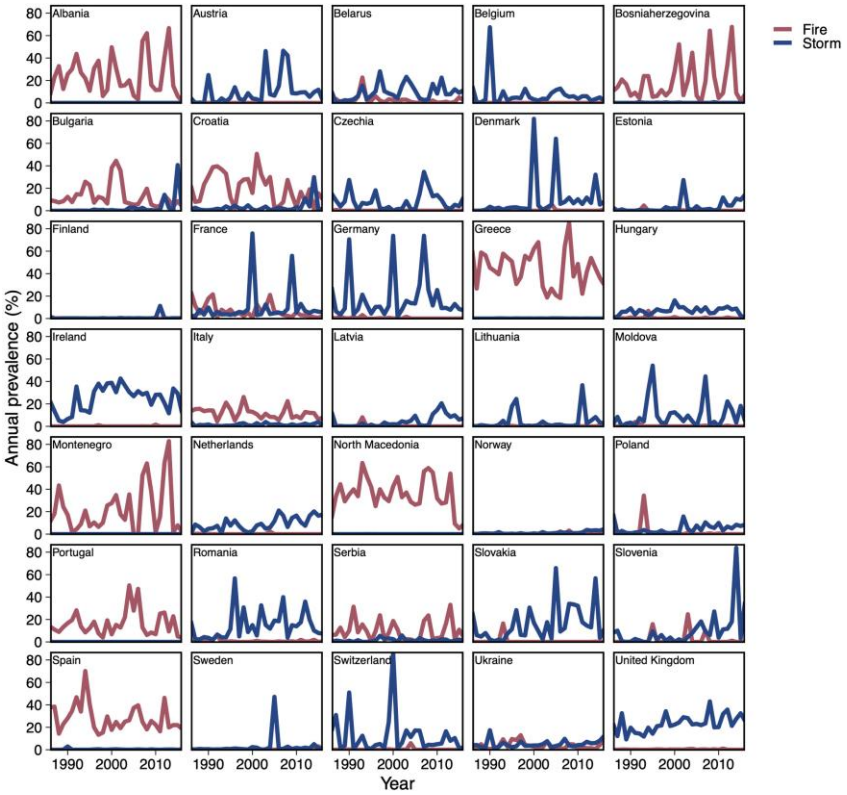
# Causal attribution: summary examples

Schleeweis KG et al. US national maps attributing forest change: 1986-2010. Forests 11, 653 (2020)




https://doi.org/10.3390/f11060653

Senf C; Seidl R. Storm and fire disturbances in Europe: distribution and trends. Global Change Biology 27, 3605-3619 (2021)




https://doi.org/10.1111/gcb.15679

# Challenges & opportunities

- **With new tools and techniques**, loss of potentially meaningful data that occurs with traditional harmonization approaches may be unnecessary

- **But a remote sensing foundation** comes with challenges
  - Computing resources and data needs are not trivial
  - Some causal agents difficult to capture, especially ones with subtle impacts
  - Cases of causal ambiguity
  - Regional differences in damage/disturbance spatio-temporal patterns
  - Still need to resolve issues of scale, thresholds in particular

# Challenges & opportunities

- **Remote sensing** is not a panacea
  - Fundamentally indirect measurement
  - Cannot detect every meaningful damage/disturbance event
- For this and many other reasons, existing data streams like NFIs have tremendous value
- Ultimately, must look toward **hybrid approaches** that utilize as much available data as possible
  - Advances in cloud computing, machine learning, etc., can also facilitate this
- **One final question:** How to get buy-in from policy makers on innovative tools when it comes to "official" reporting?

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# THANK YOU

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