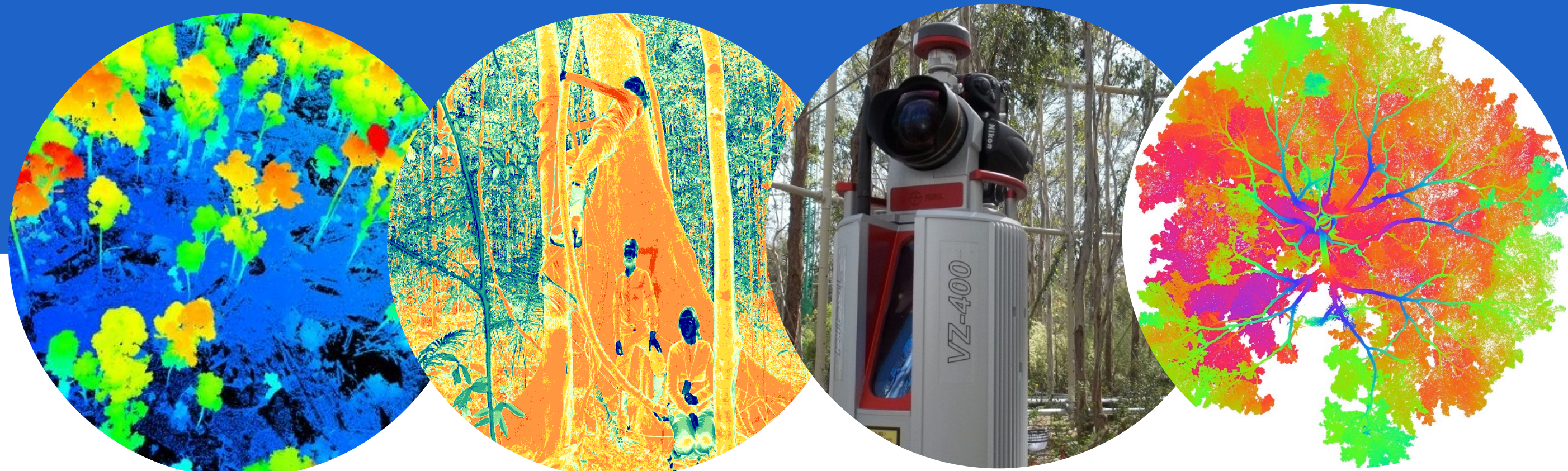


Digital twins for understanding forest disturbances and recovery from space

Kim Calders et al.

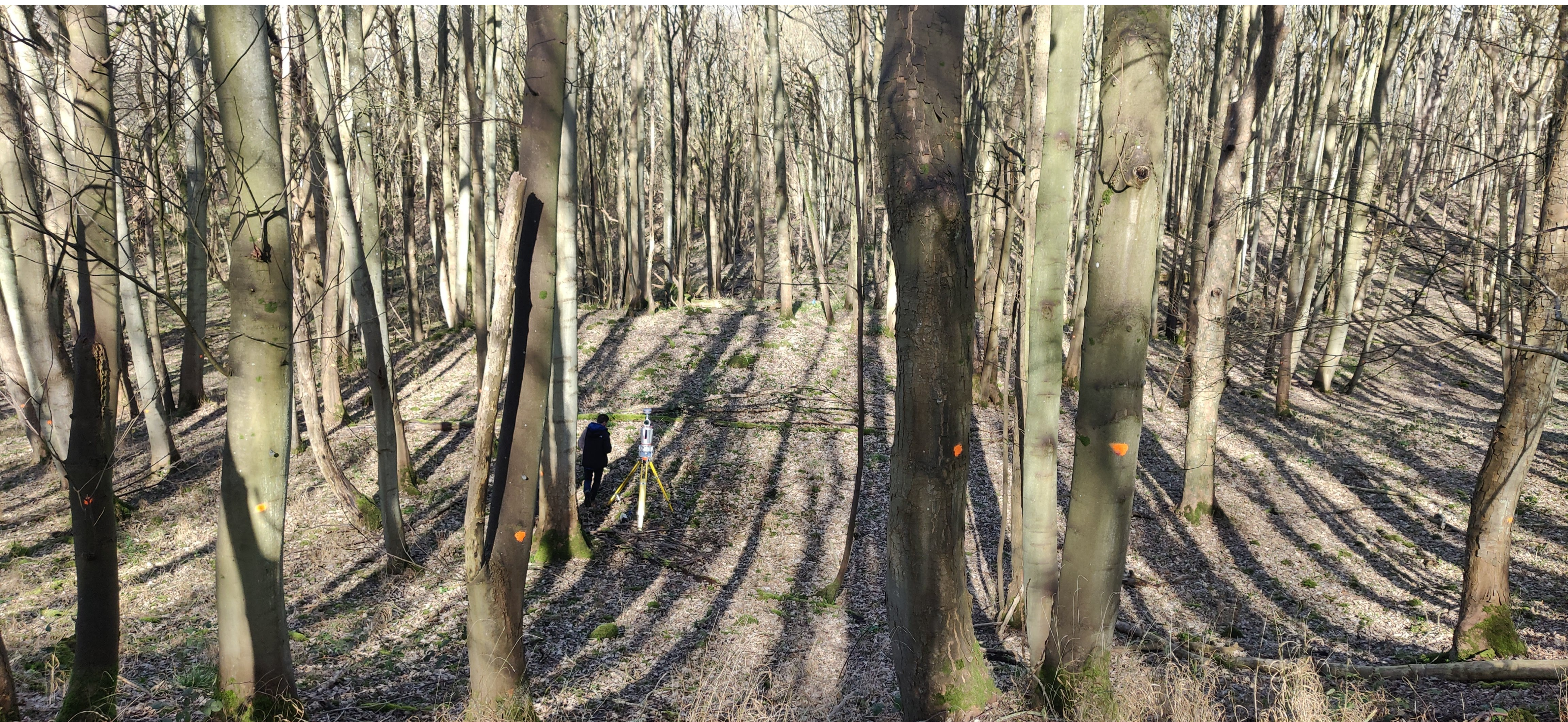
10/05/2023



Forests in the world



Forests in the world



Forests in the world

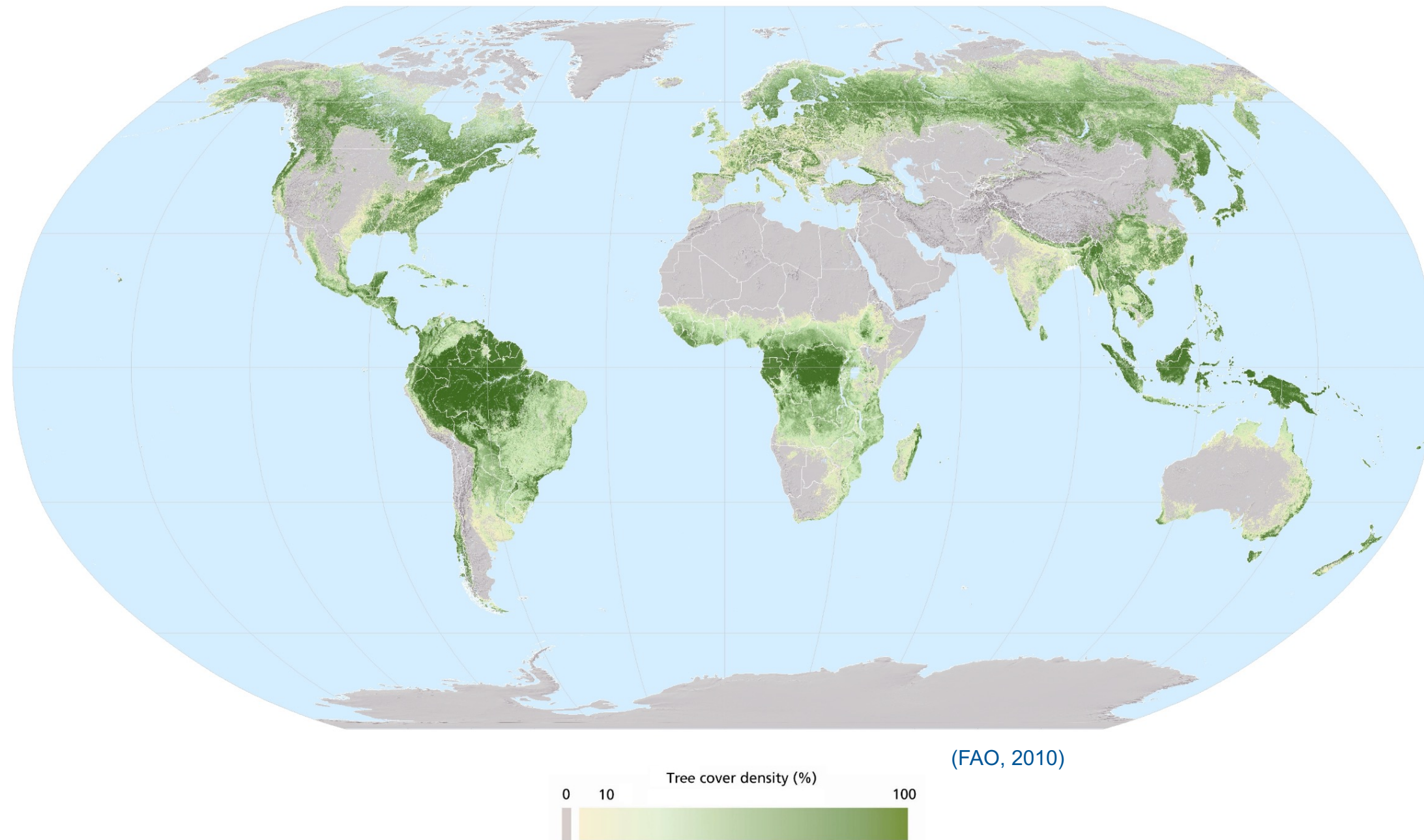




Forests in the world



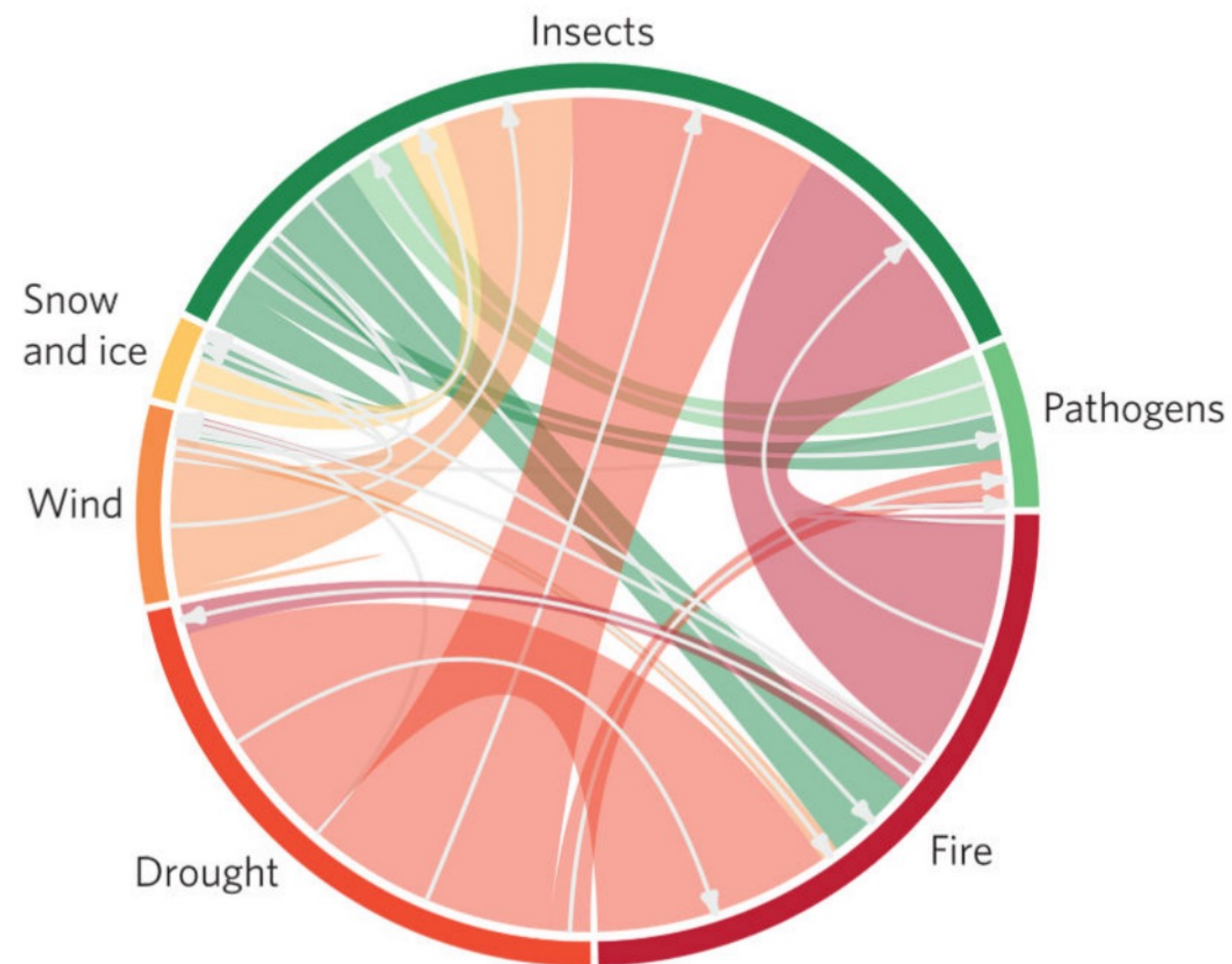
Forests in the world



Monitoring challenges: → Huge variety in forests (types, composition, structure)
→ Large-scale & unprecedented changes due to disturbances

Forest disturbances & recovery

“**Disturbances** disrupt the **structure**, composition and **function** of an ecosystem, community or population, and change resource availability or the physical environment.”



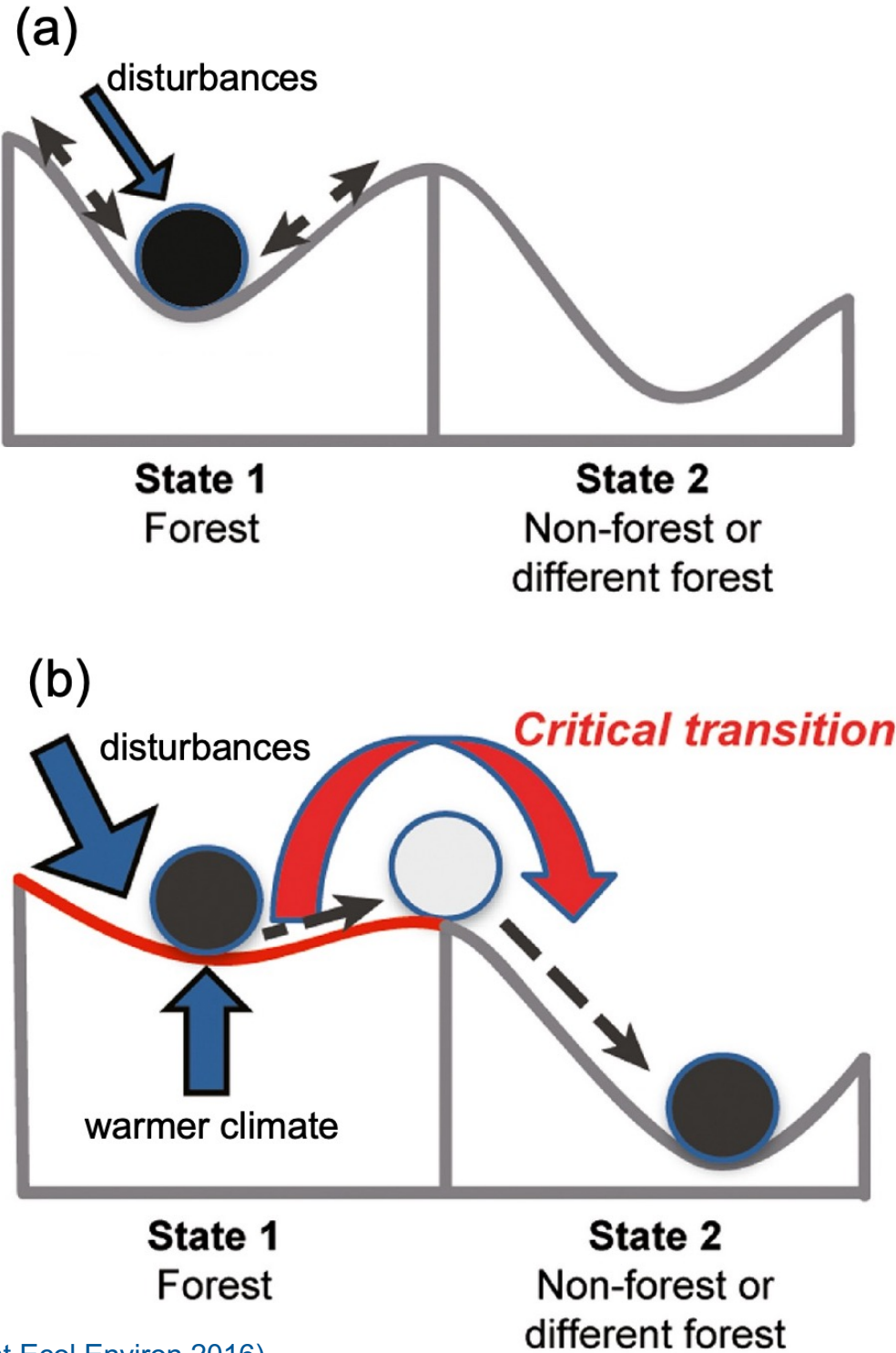
Forest disturbances & recovery

“**Disturbances** disrupt the **structure**, composition and **function** of a forest ecosystem”

Sep 2019



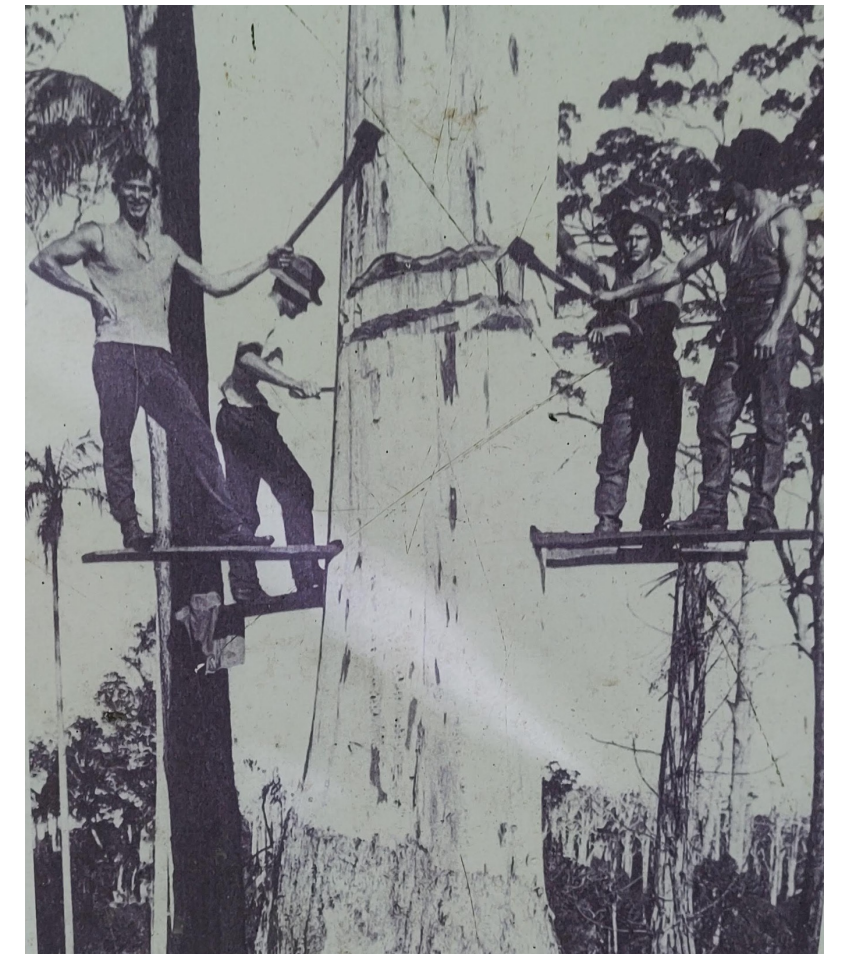
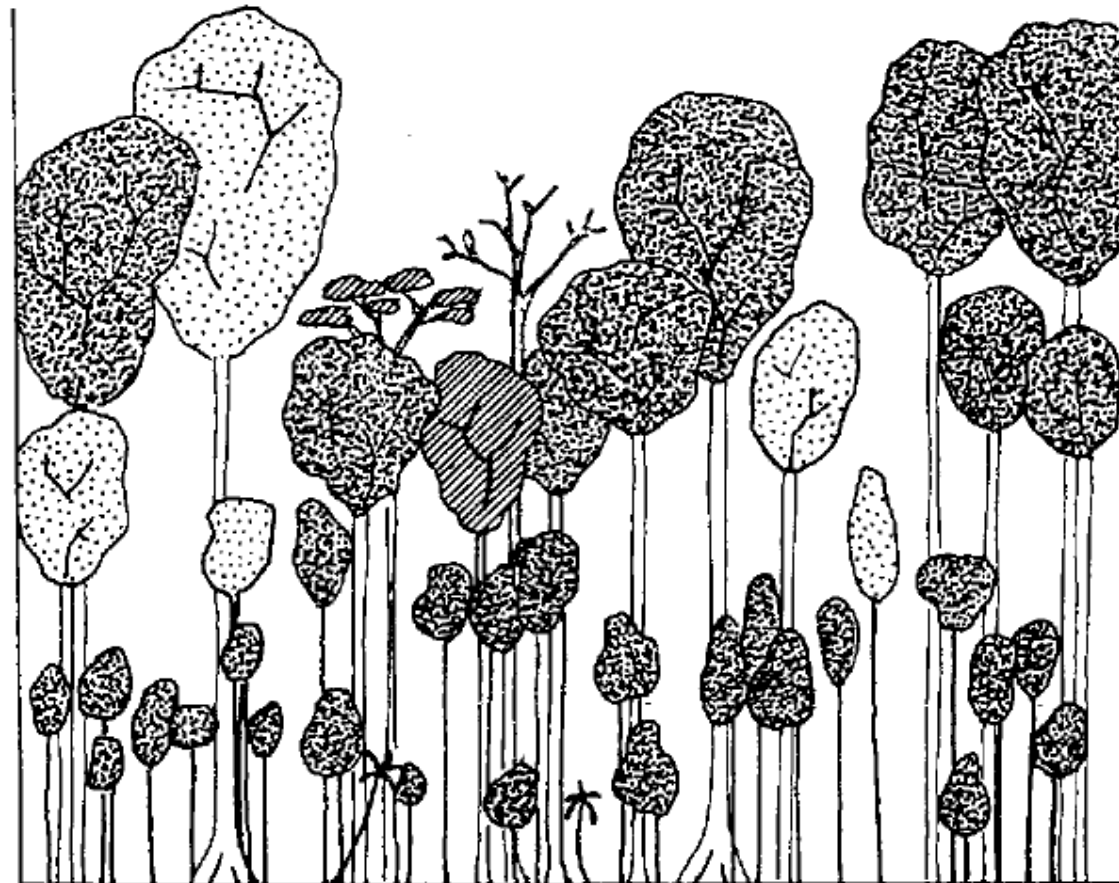
Nov 2019



Baseline forest structure

Monitoring forest structure, disturbances & recovery:

- Remote sensing: less detail (2D or low resolution), more (global) coverage
- In situ (fieldwork): lots of detail, not a lot of coverage



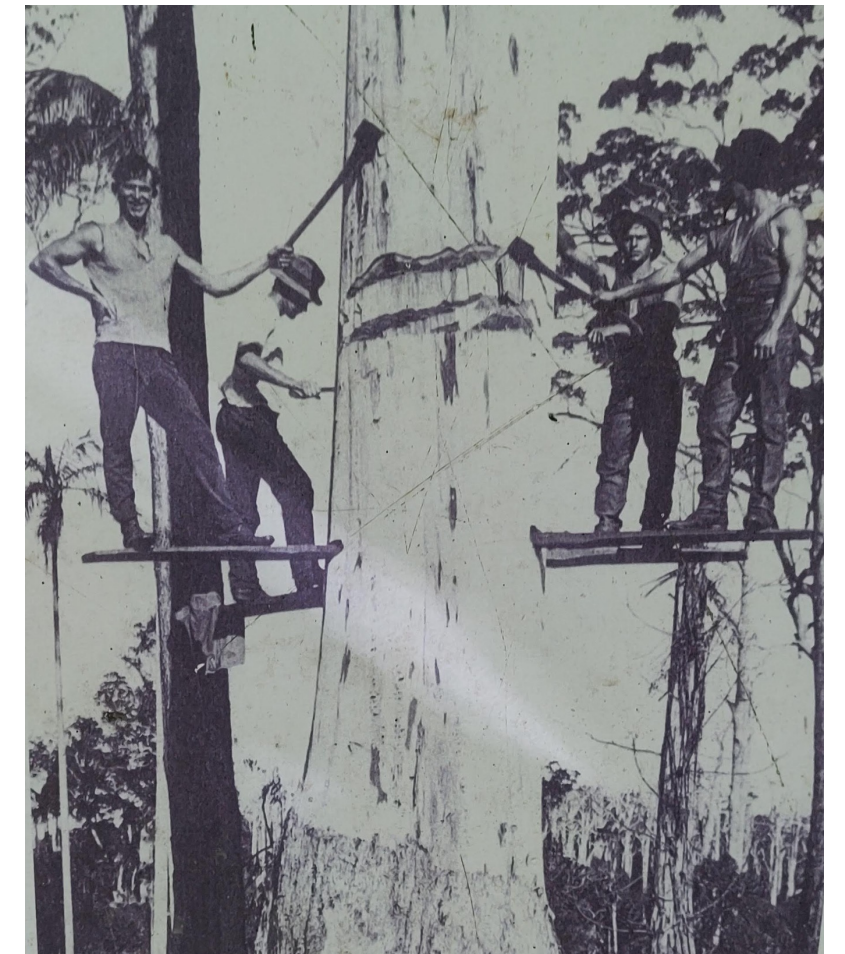
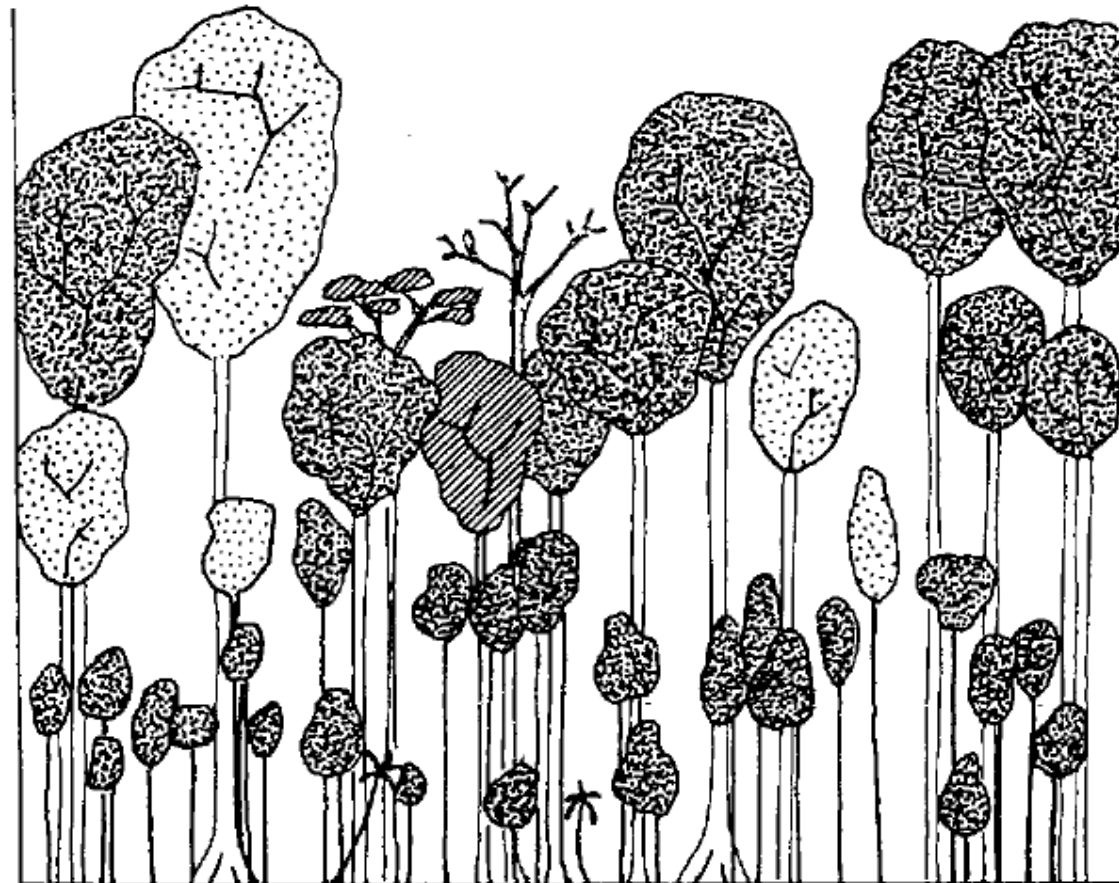
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baseline scenario of forest structure + repeat **measurements**



Baseline forest structure

The broken link between remote sensing and in situ data:

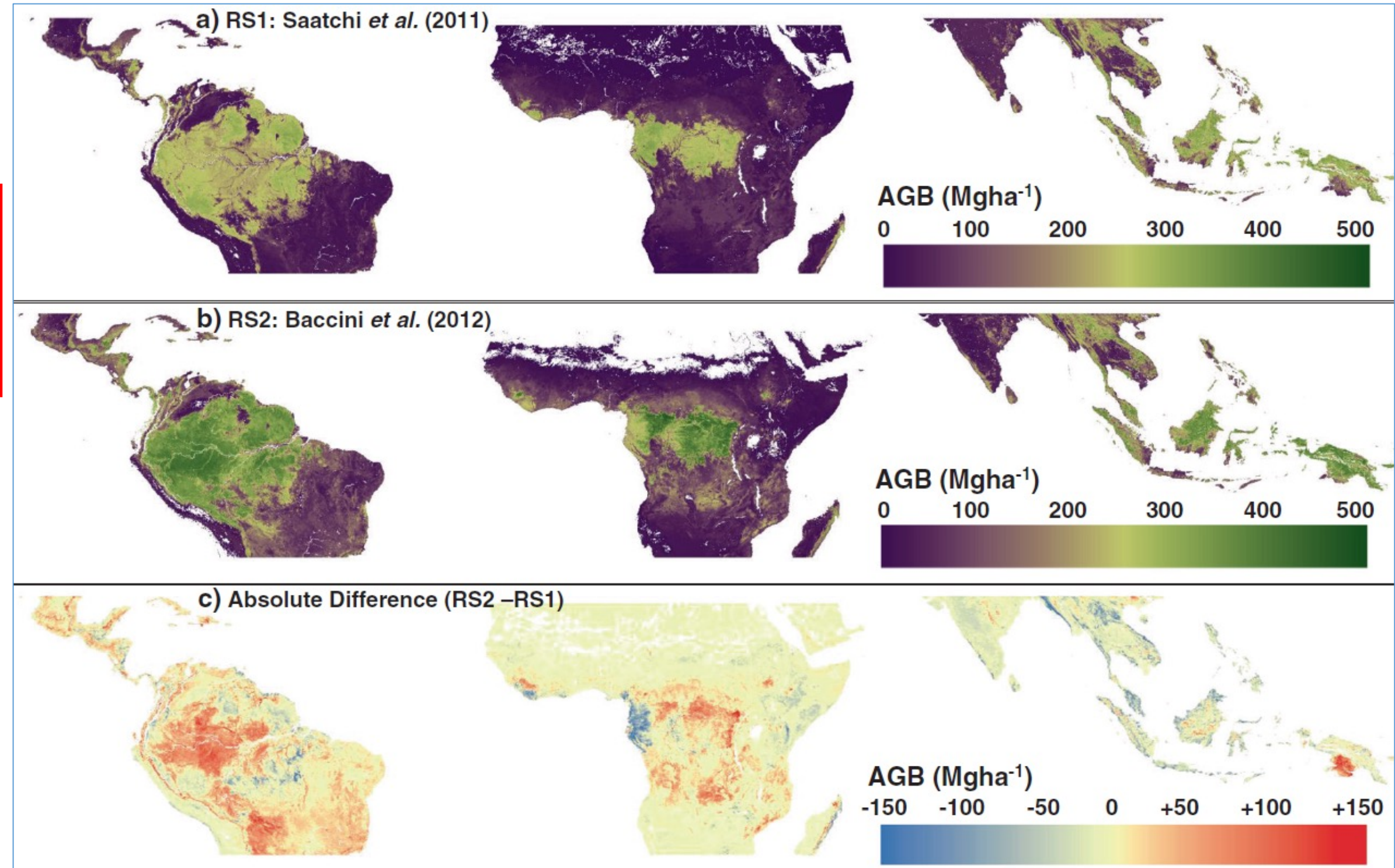


Baseline forest structure

The broken link between remote sensing and in situ data:

Maps do not always agree..

→ Measuring forest structure is complicated..

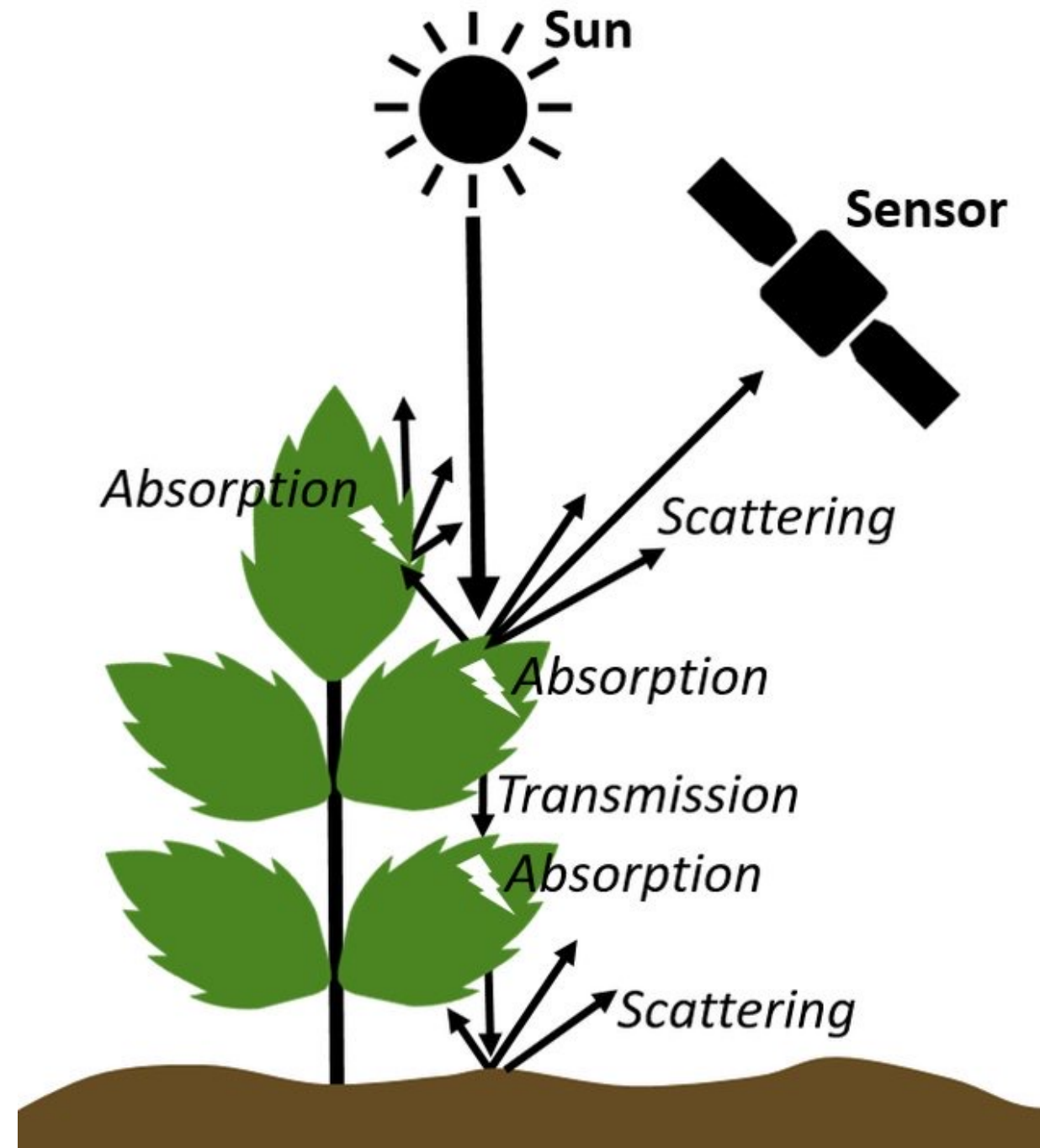


Virtual forests as model input

The ~~broken~~ link between remote sensing and in situ data:

Maps do not always agree..

- Measuring forest structure is complicated..
- Radiative transfer model: the link between in situ data and remote sensing



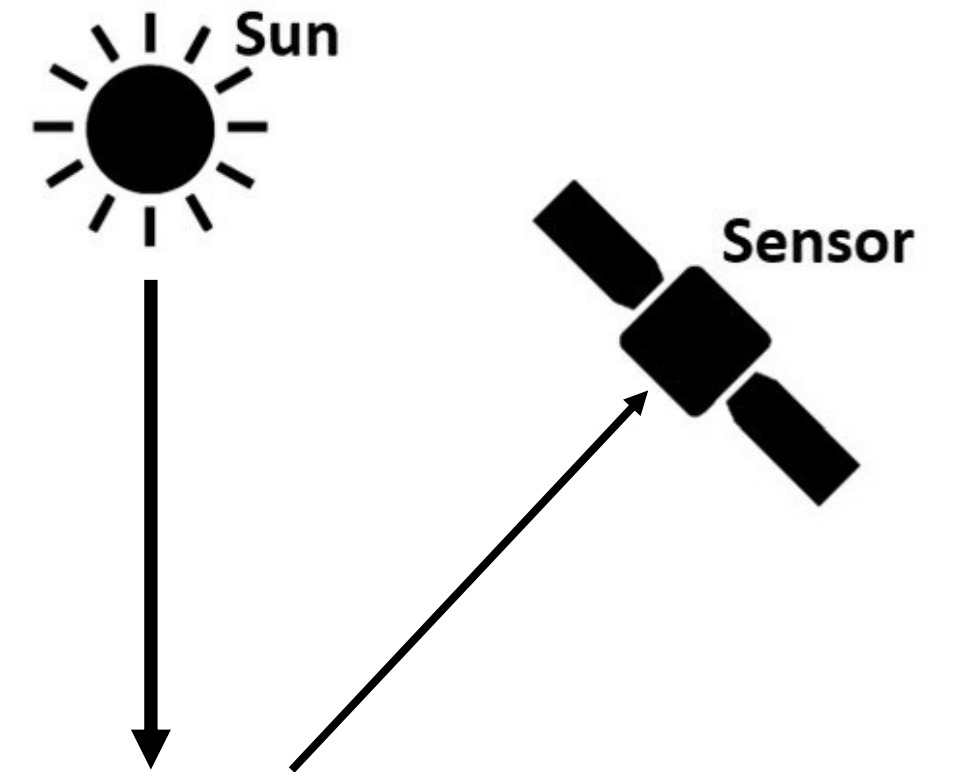
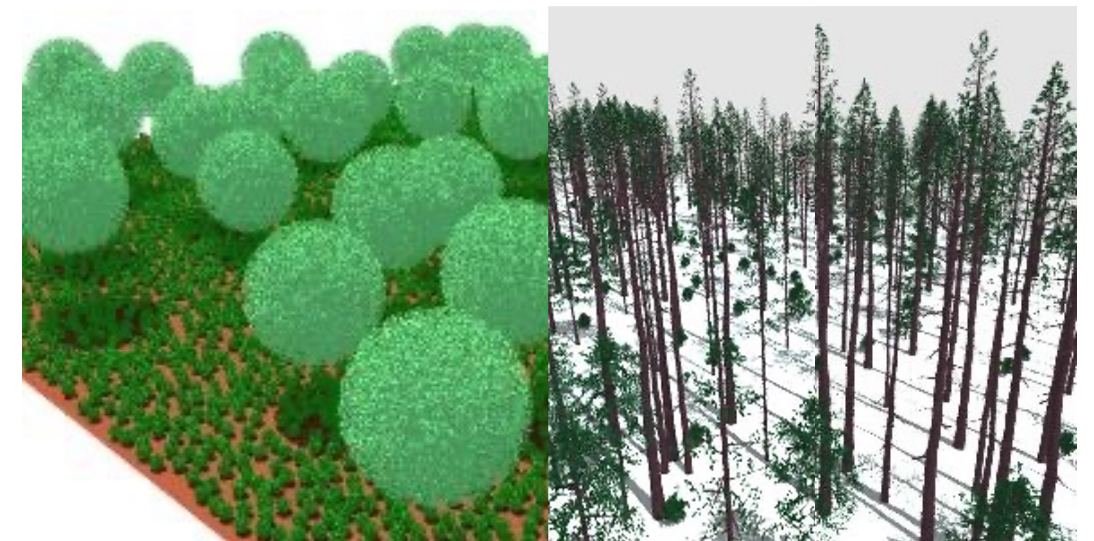
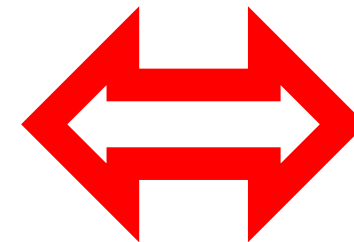
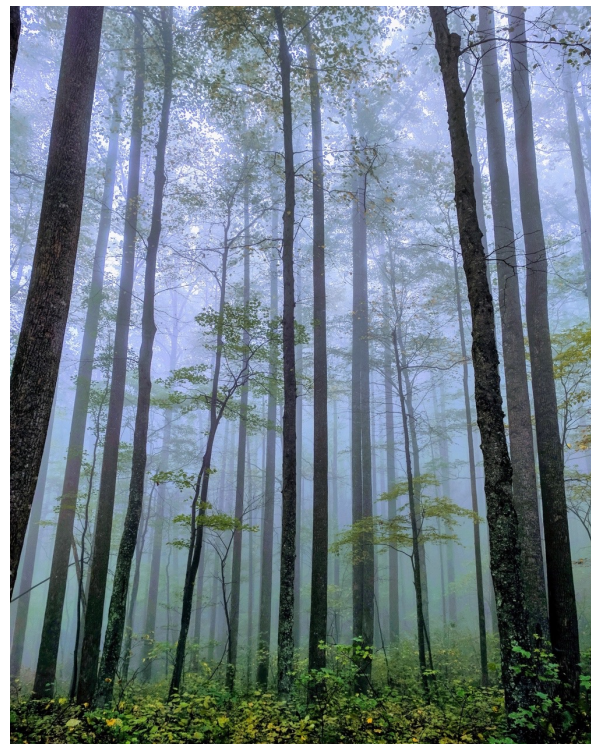
(Source: Teja Kattenborn)

Virtual forests as model input

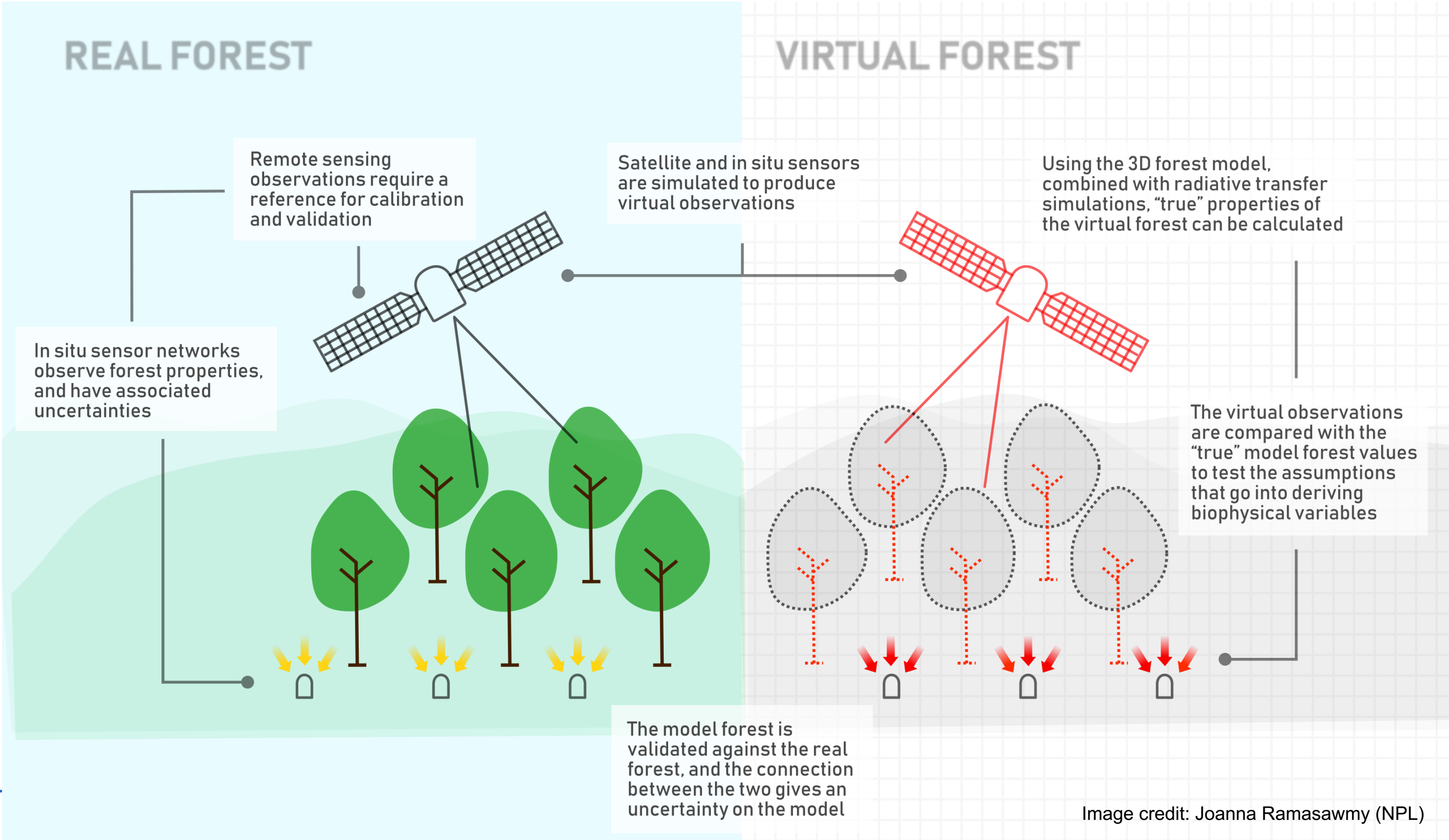
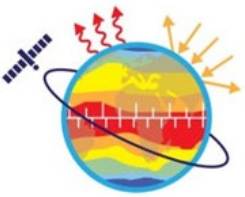
The ~~broken~~ link between remote sensing and in situ data:

Maps do not always agree..

- Measuring forest structure is complicated..
- Radiative transfer model: the link between in situ data and remote sensing



Virtual forests as model input: forest digital twins



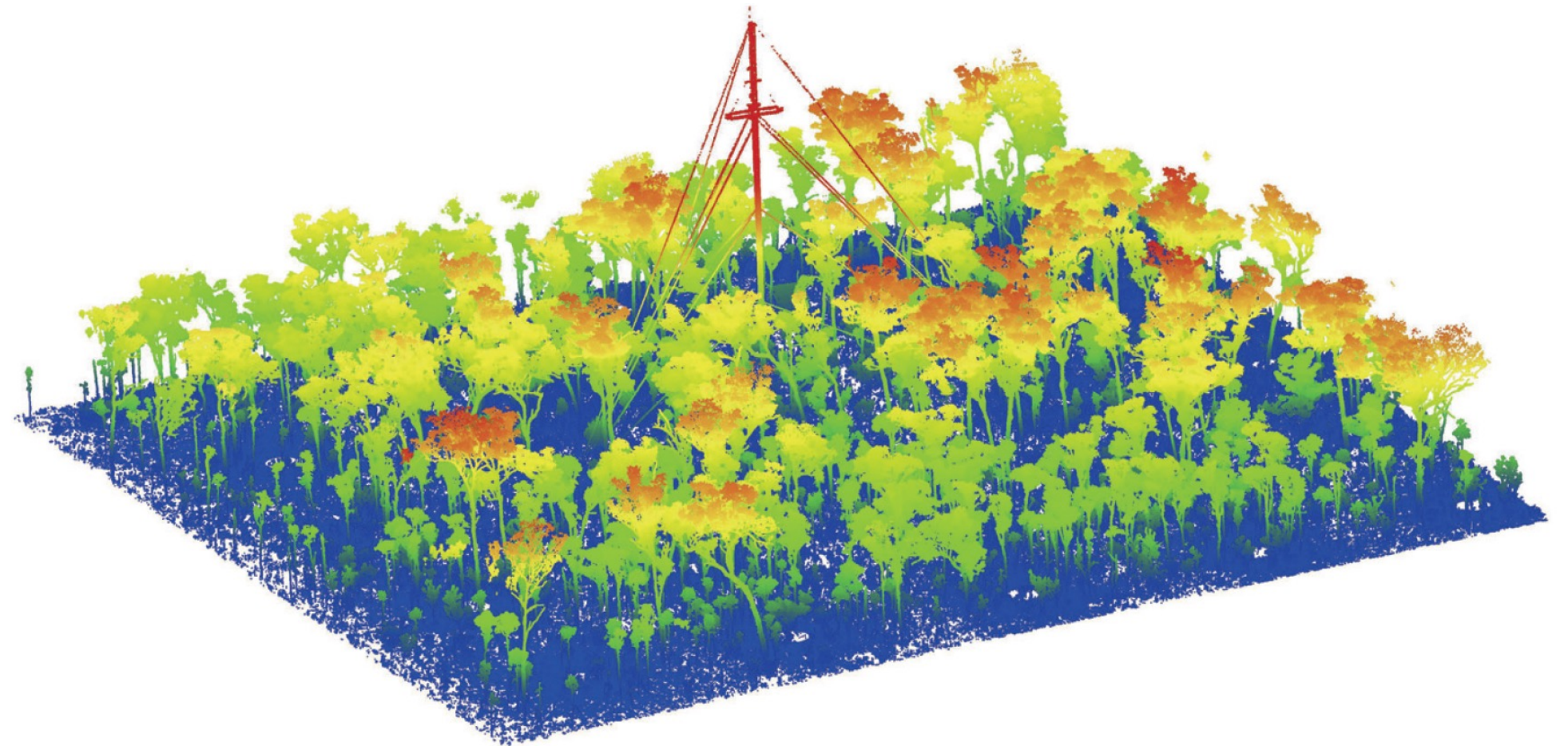
Virtual forests as model input

Monitoring forest structure, disturbances & recovery:

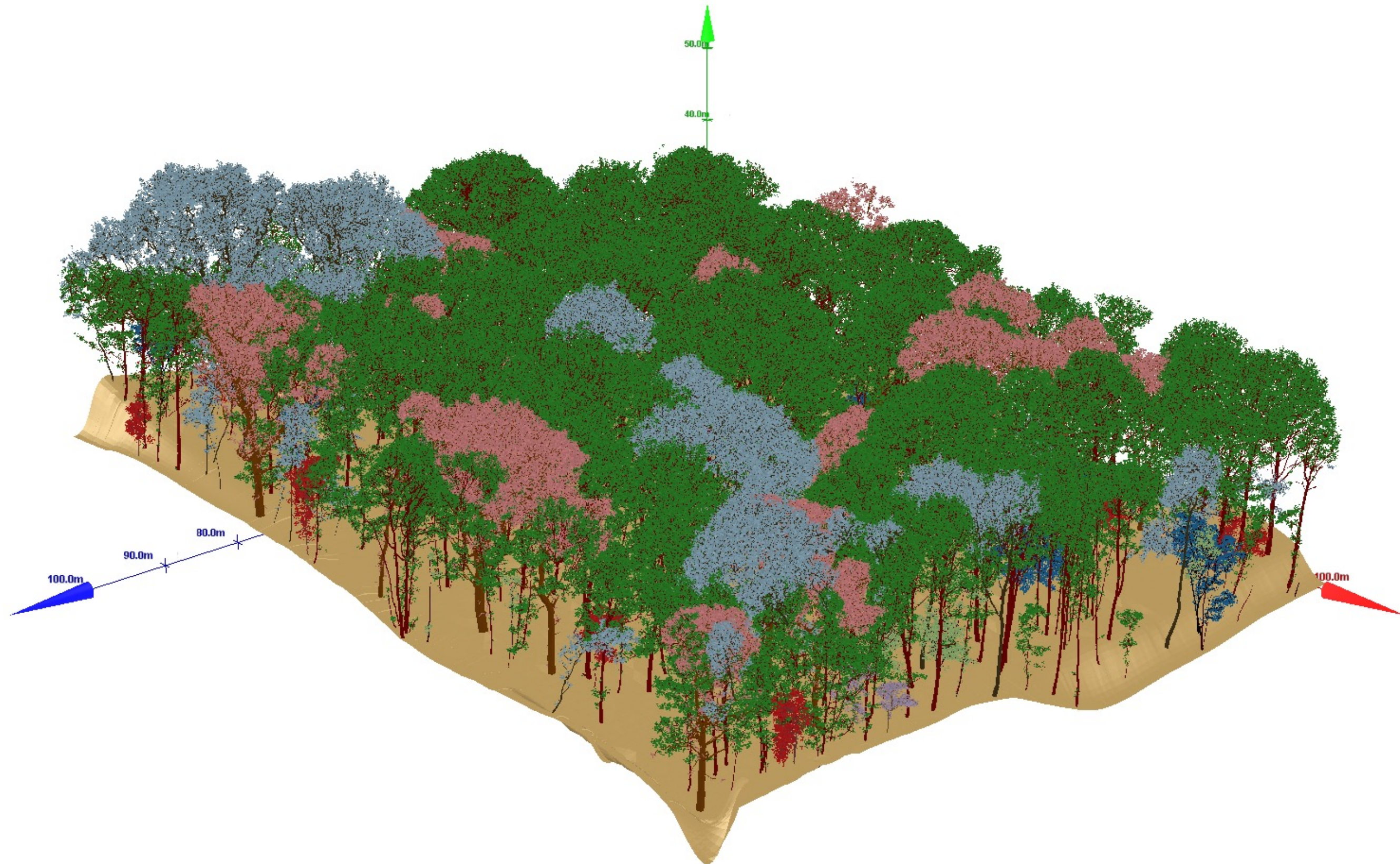
- Remote sensing: less detail (2D or low resolution), more (global) coverage
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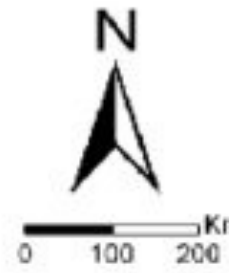
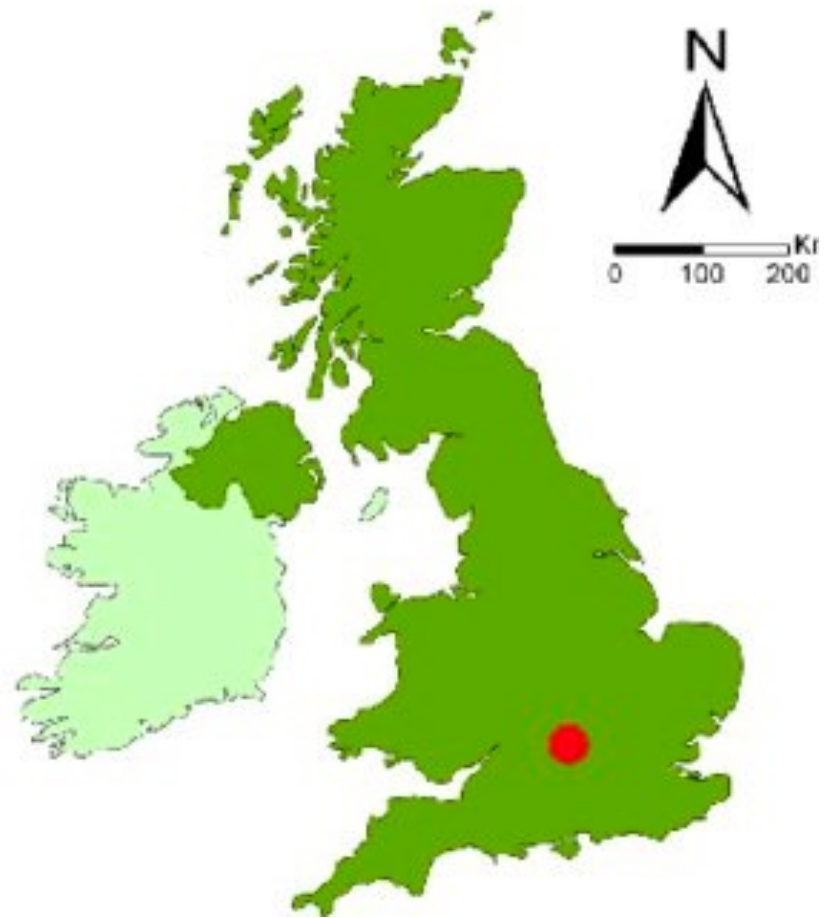
baseline scenario of forest structure + repeat **measurements**



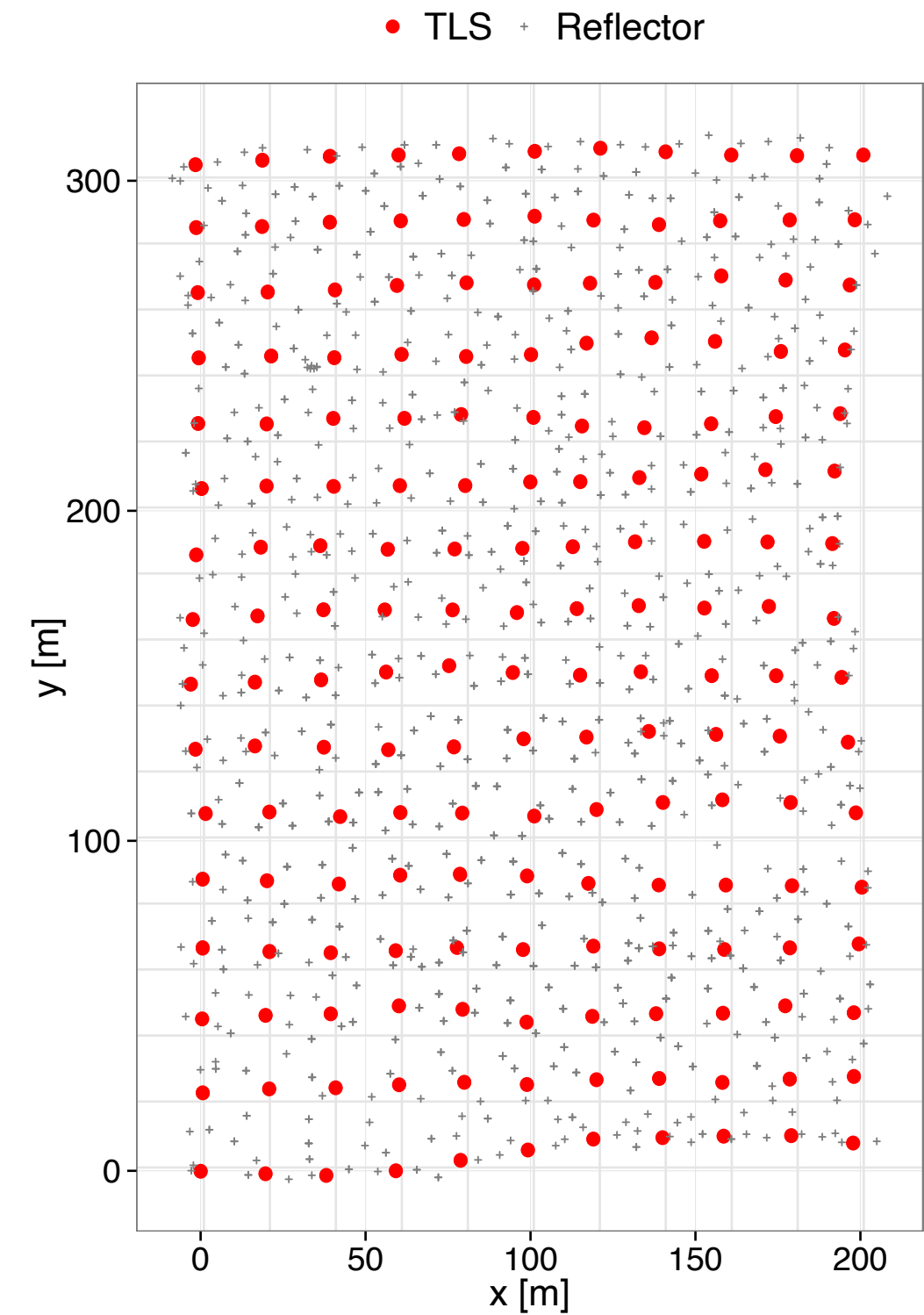
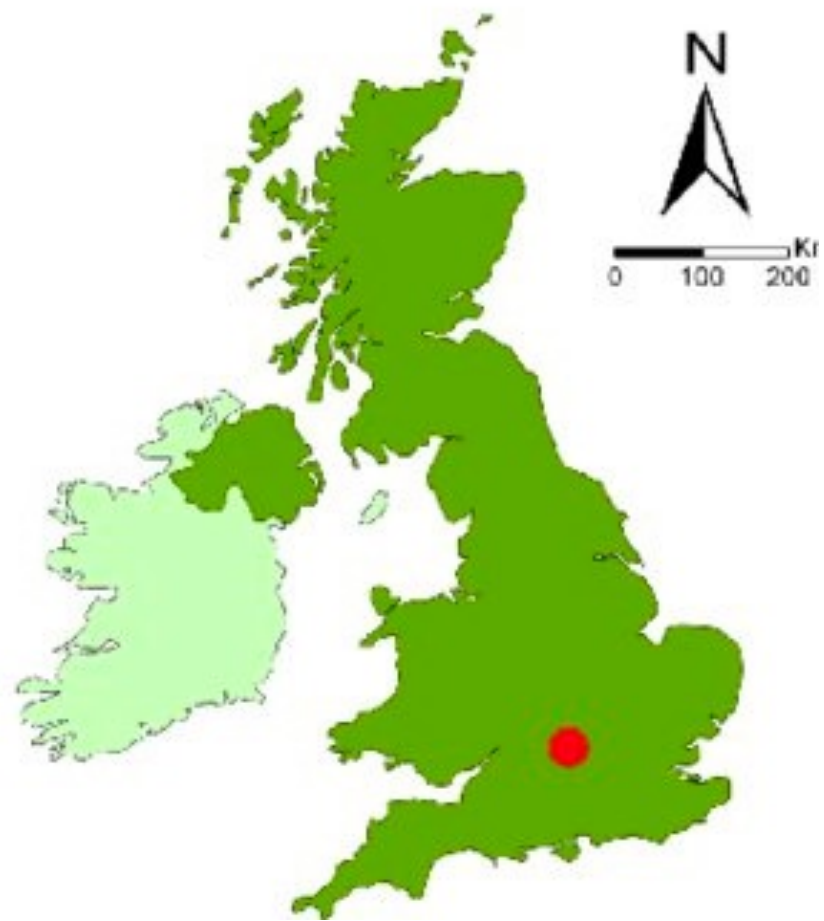
The Wytham Woods digital twin



The Wytham Woods digital twin

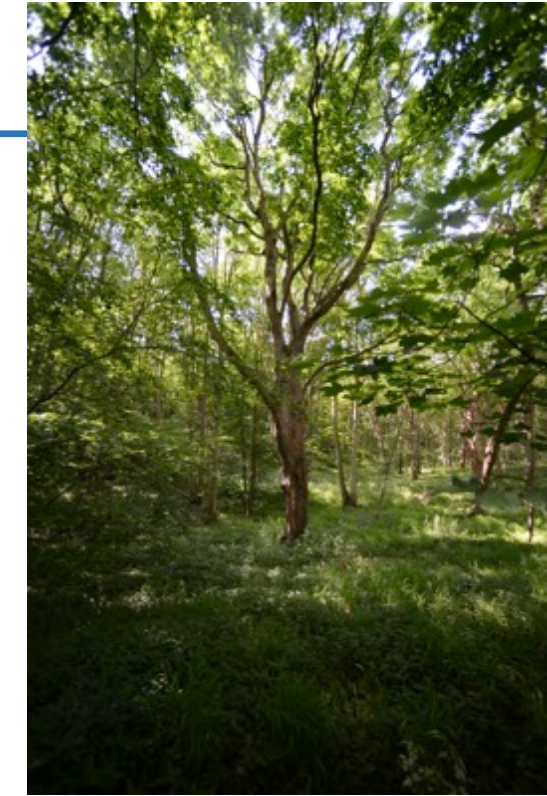
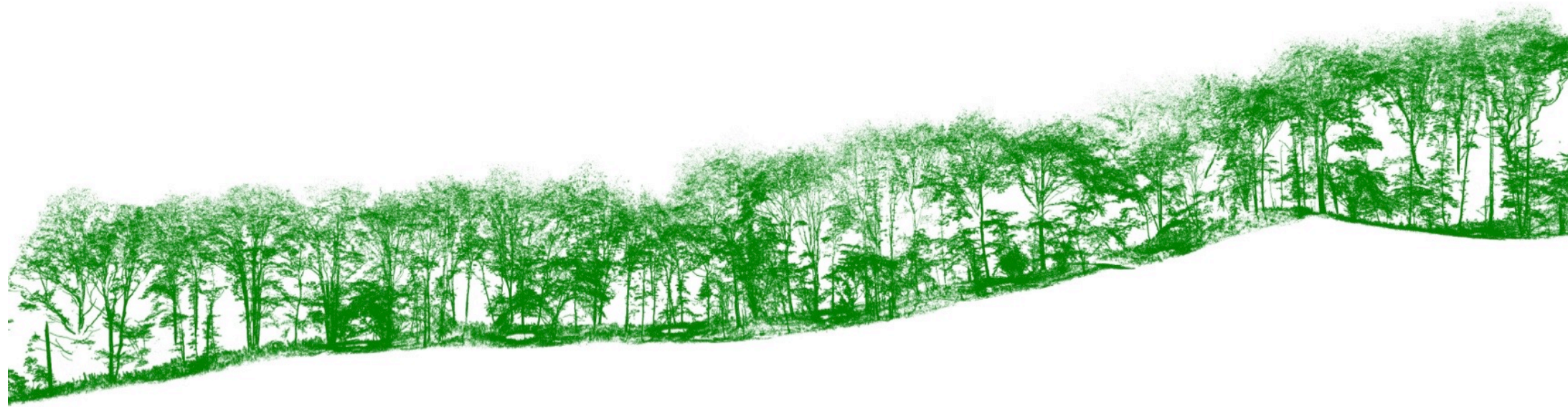


The Wytham Woods digital twin



The Wytham Woods digital twin

Leaf-on



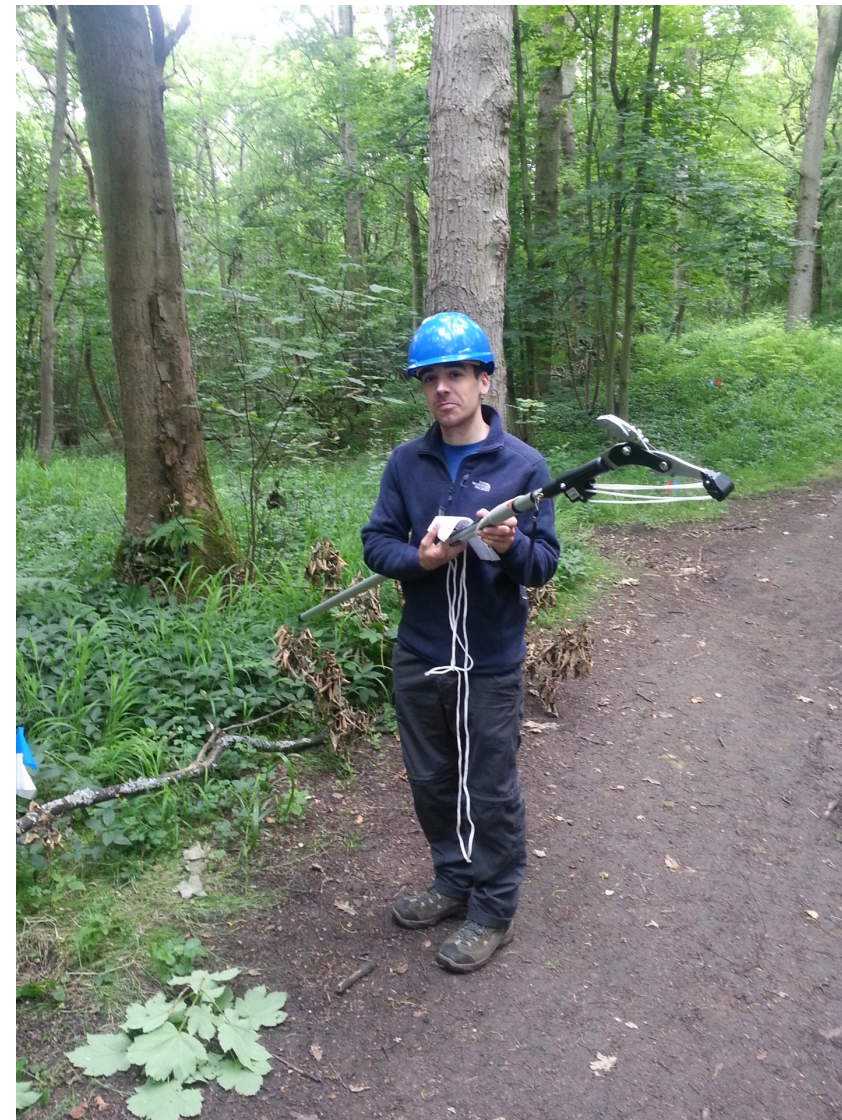
Leaf-off



The Wytham Woods digital twin



The Wytham Woods digital twin



The Wytham Woods digital twin

The Wytham Woods point cloud segmentation (still a bottleneck!)



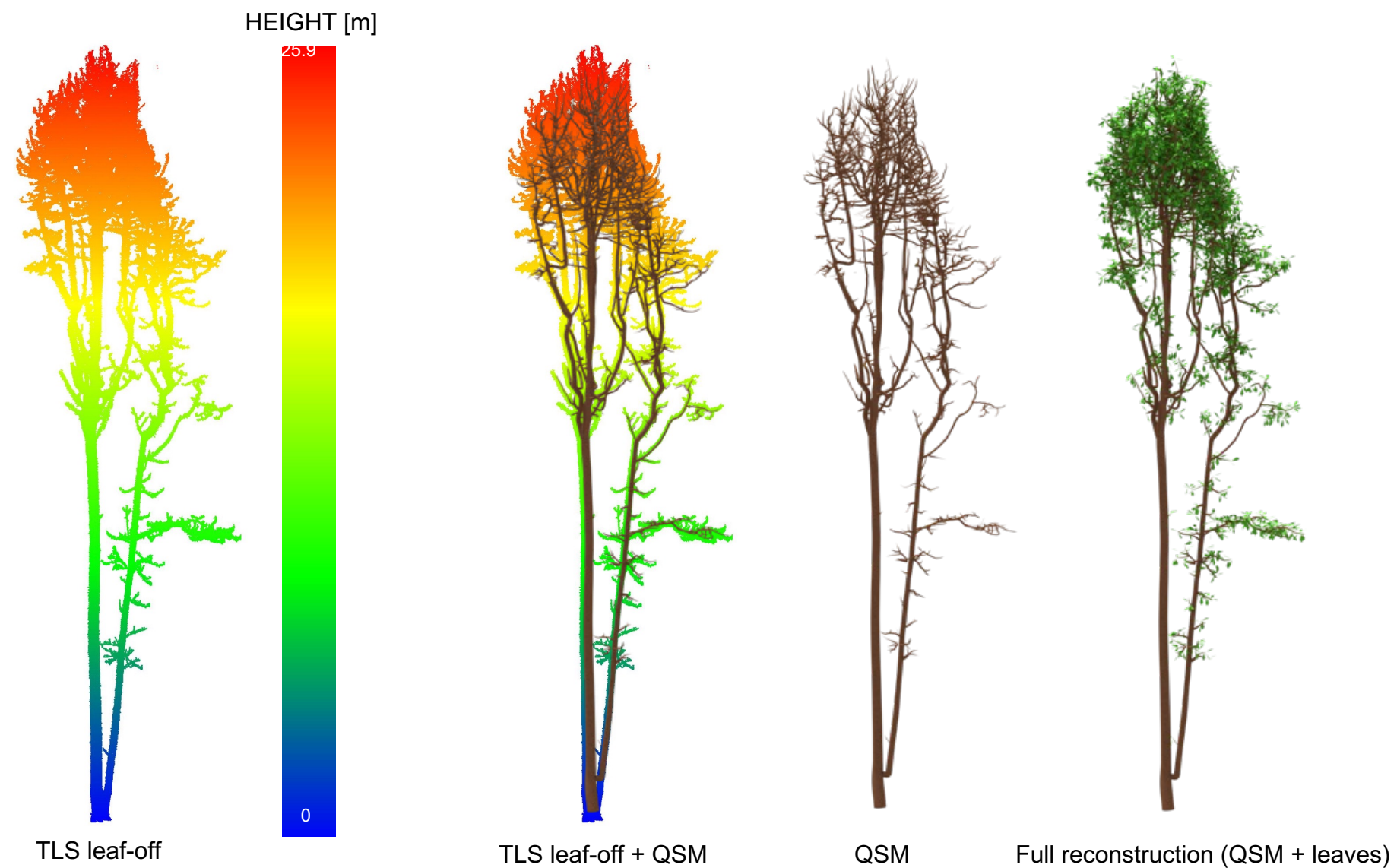
The Wytham Woods digital twin

The Wytham Woods virtual forest:

Adding foliage: How much leaf material?

→ Extrapolate to larger area using Leaf-on/off Pgap TLS measurements:

Redistribute the total leaf area based on branch length of each tree

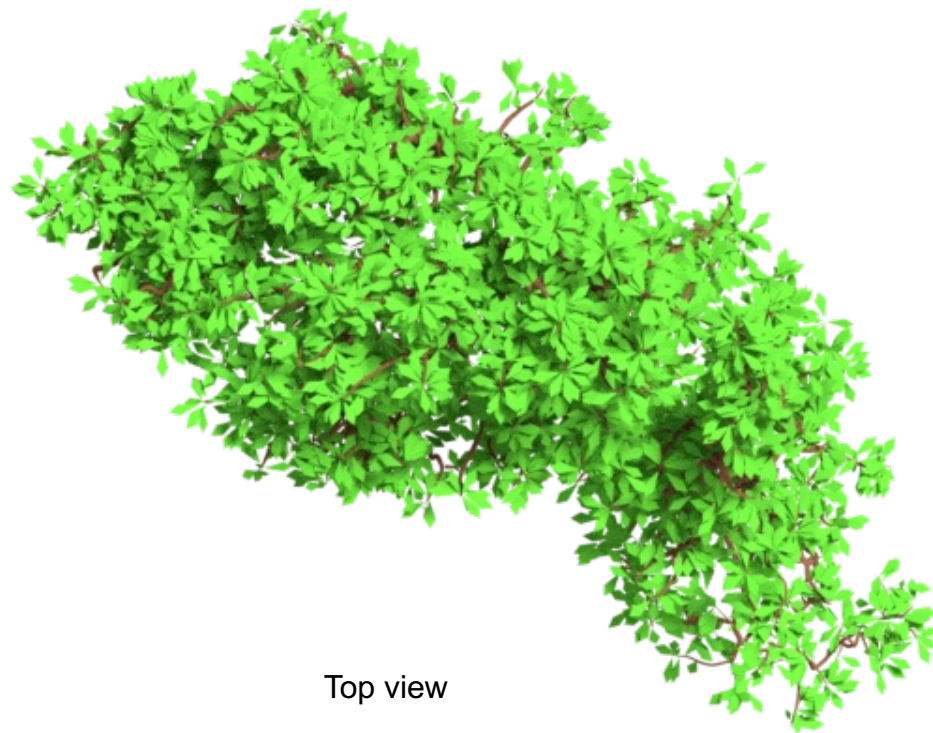


Adding foliage: → Input parameter framework:

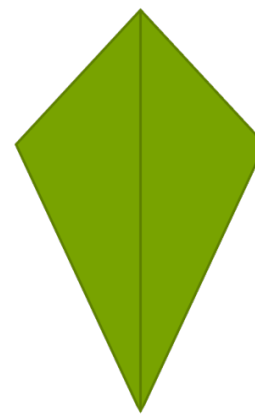
- Leaf location (leaf area density distribution, LADD): more leaves towards the top and tips
- Leaf size: a uniform distribution with length tetragon is sampled between 25 and 30 cm.
- Leaf Orientation: e.g., uniform distribution



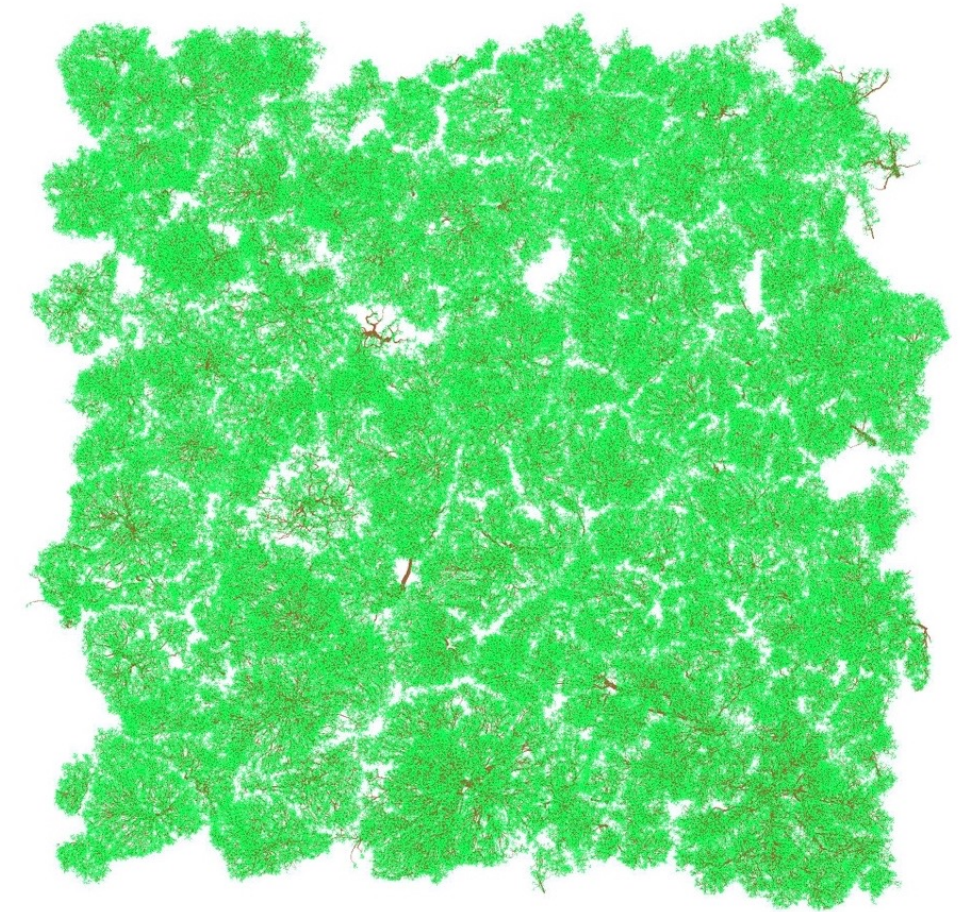
Side view



Top view



Leaf shape (tetragon)





Input for realistic radiative transfer simulations

librat

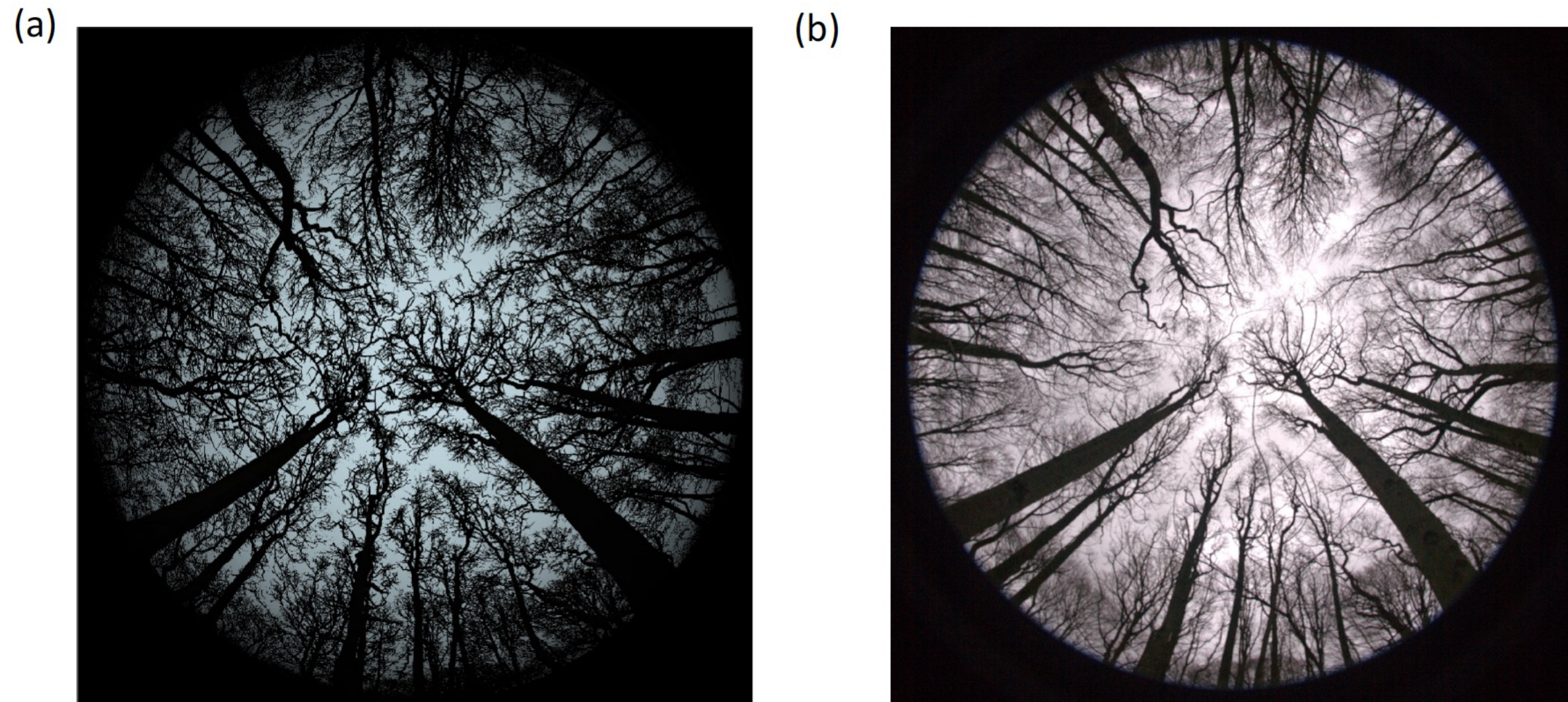


Figure 6. Simulated and real upward-looking in situ digital hemispherical photograph (DHP) in Wytham Woods at approximately the same location. (a) Simulated in-situ DHP using the Wytham Woods leaf-off scene model (b) Real in-situ DHP (see Calders et al. [2] for details of image acquisition).



Input for realistic radiative transfer simulations

librat

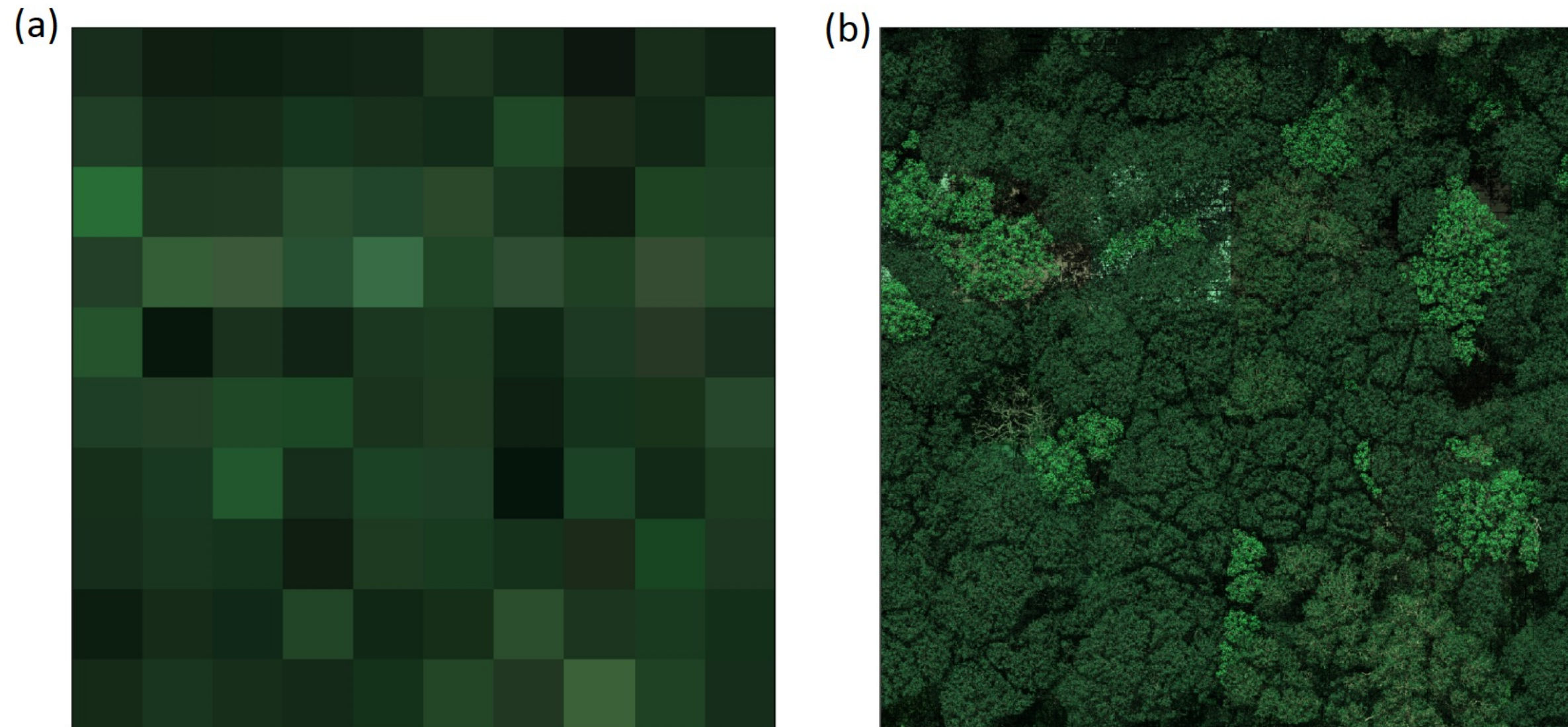


Figure 7. Simulated Sentinel-2 satellite image over the one hectare Wytham Woods model. (a) 10 m spatial resolution image (100 pixels); (b) 10 cm ground sampling distance (1 megapixel).

Wrap up - What's next?

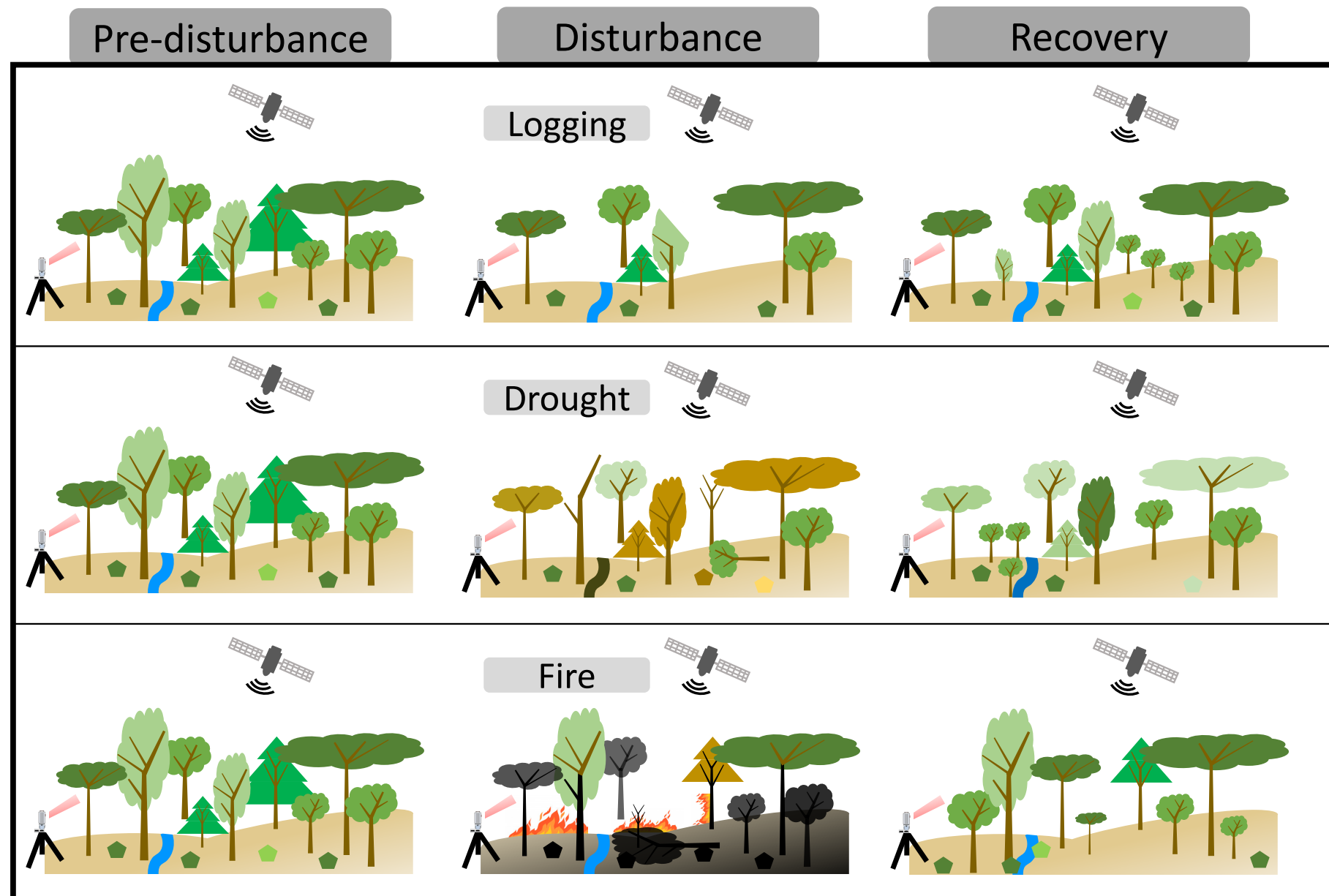


SPACETWIN

+50 different disturbed forests:

- ➔ converted to digital twins
- ➔ 4D twins across disturbances
- ➔ Spectral & microwave RTM

Wrap up - What's next?



SPACETWIN

+50 different disturbed forests:

- ➔ converted to digital twins
- ➔ 4D twins across disturbances
- ➔ Spectral & microwave RTM

Digital twins for understanding forest disturbances and recovery from space

Kim.calders@ugent.be; @kimcalders

10/05/2023

