Tree dynamic behavior with forestry activities and a category-5 tropical cyclone

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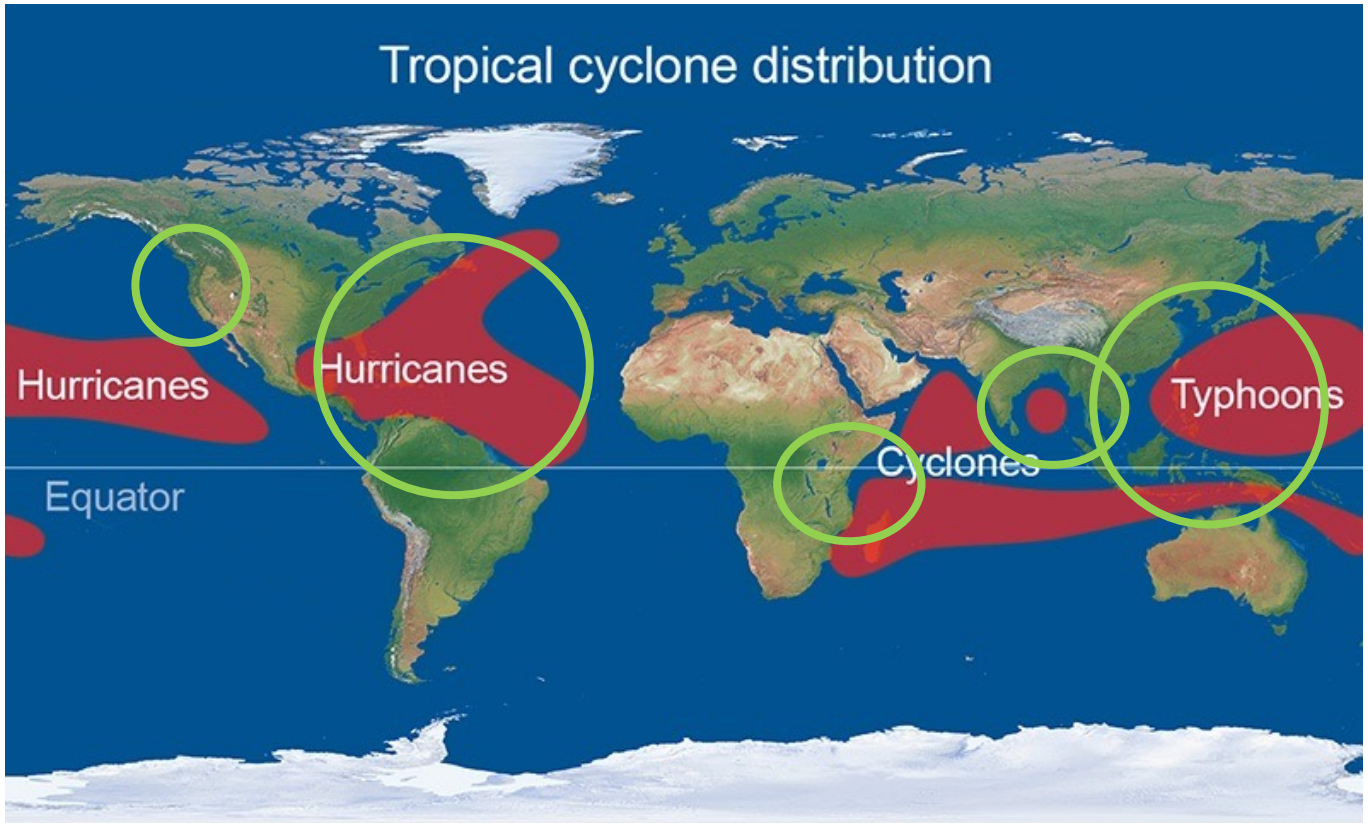
EGU22 session BG3.11 – 'Forest under pressure: the need to understand causes and mechanisms related to forest vulnerability and dieback phenomena'

Background

- Tropical cyclones and storms trigger catastrophic wind damage in forests.



https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/hurricanes/location

Research Question & Aim

SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES

Tree dynamic response and survival in a category-5 tropical cyclone: The case of super typhoon Trami

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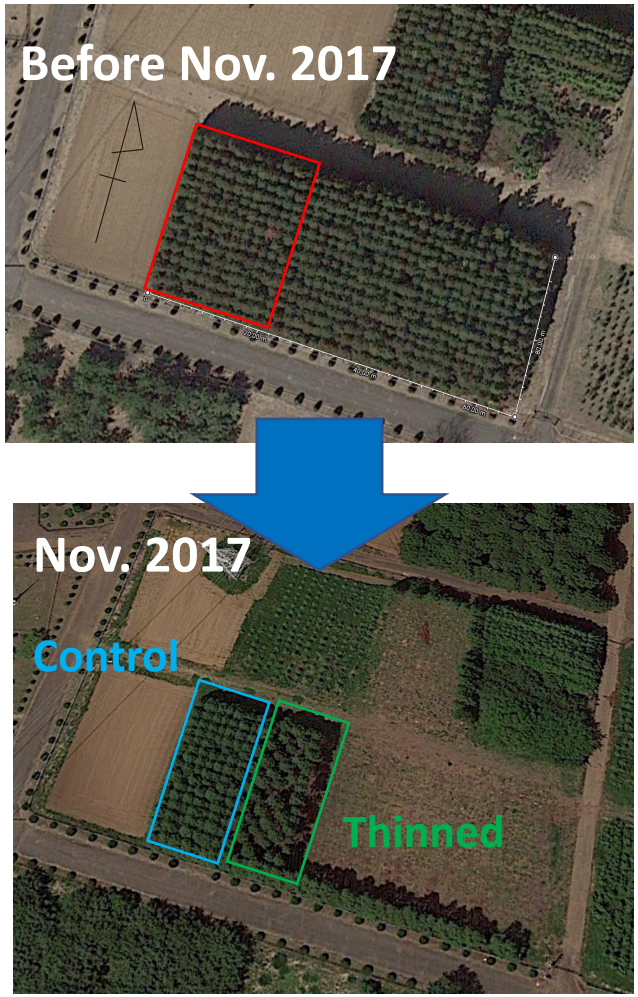
In the future with climate change, we expect more forest and tree damage due to the increasing strength and changing trajectories of tropical cyclones (TCs). However, to date, we have limited information to estimate likely damage levels, and nobody has ever measured exactly how forest trees behave mechanically during a TC. In 2018, a category-5 TC destroyed trees in our ongoing research plots, in which we were measuring tree movement and wind speed in two different tree spacing plots. We found damaged trees in only the wider spaced plot. Here, we present how trees dynamically respond to strong winds during a TC. Sustained strong winds obviously trigger the damage to trees and forests but inter-tree spacing is also a key factor because the level of support from neighboring trees modifies the effective "stiffness" against the wind both at the single tree and whole forest stand level.

Kamimura *et al.*, Sci. Adv. 8 eabm 7891 (2022) 11 March 2022

To address how the trees failed/survived during a category-5 tropical cyclone

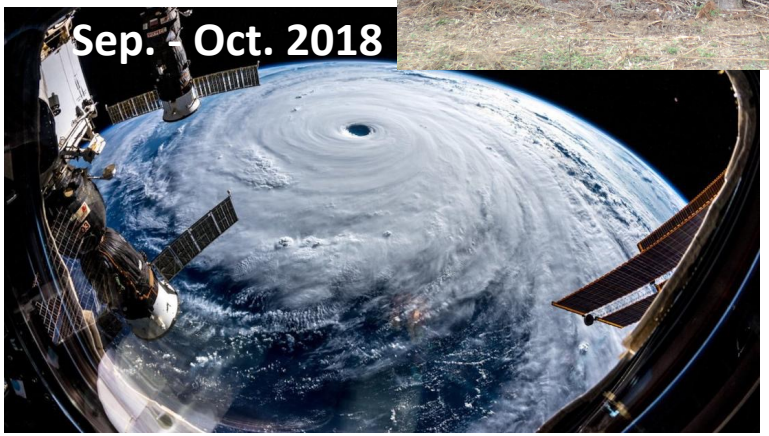
Methods: research plots & damage



$36.184°N, 140.216°E$

- We set up two plots in Nov. 2017.
- Tree species: *cryptomeria japonica* (full siblings, 14-year old)
- Control (3000 stem/ha)
- Thinned (1500 stem/ha)
- Typhoon Trami damaged some trees only in the **thinned** plot.

Thinned plot



https://edition.cnn.com/2018/09/26/asia/super-typhoon-trami-wxc-intl/index.html

Methods: sensors

- We were measuring tree oscilations and wind speeds.

IMU (*accelerometer, gyroscope, and magnetometer)* at 6m height

3-cup anemometer (outside the plots)

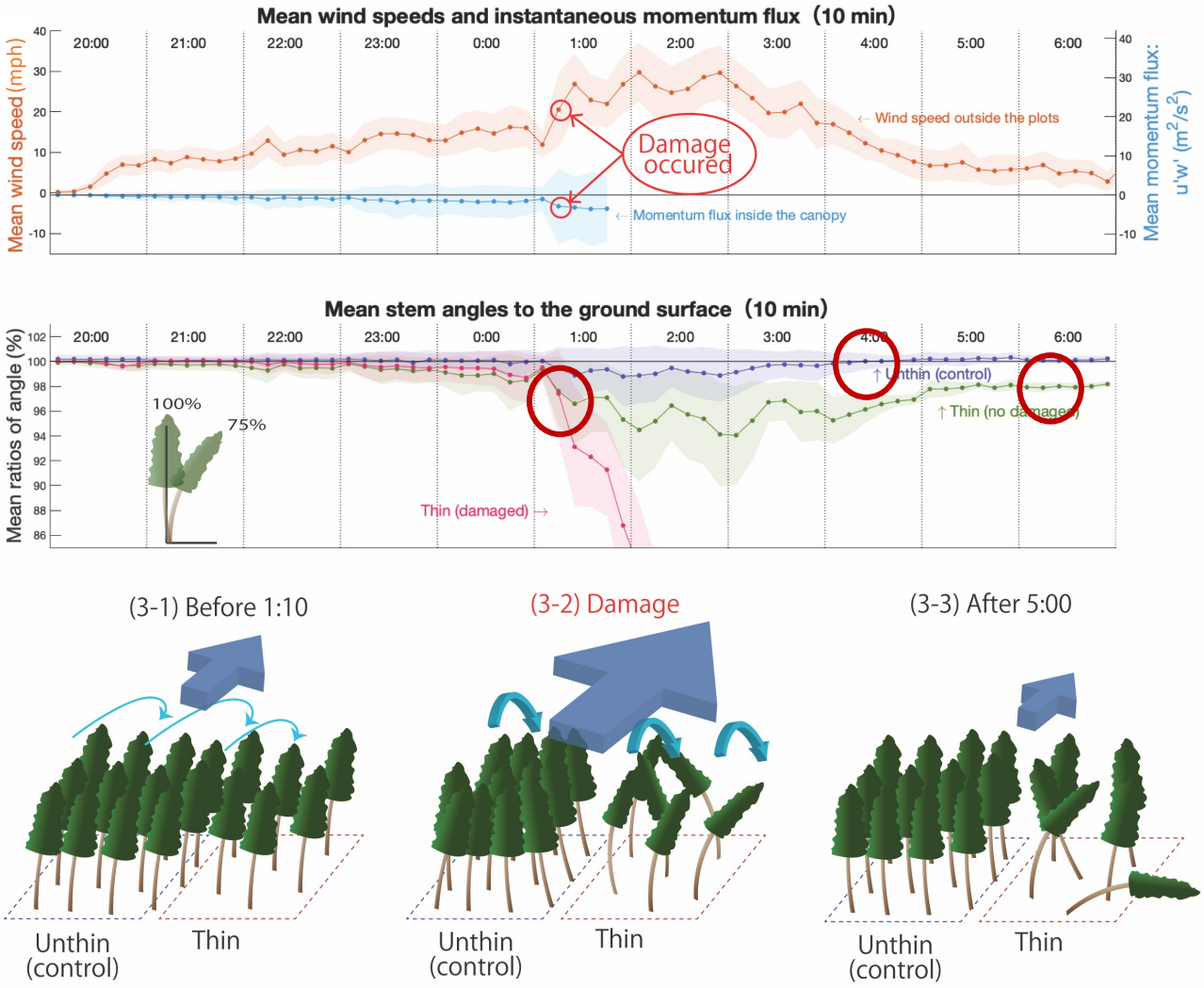
Ultrasonic anemometer (between the plots)

Strain gauge transducer at 0.25m height in north and east

To estimate the turning moment (***TM***)

Results

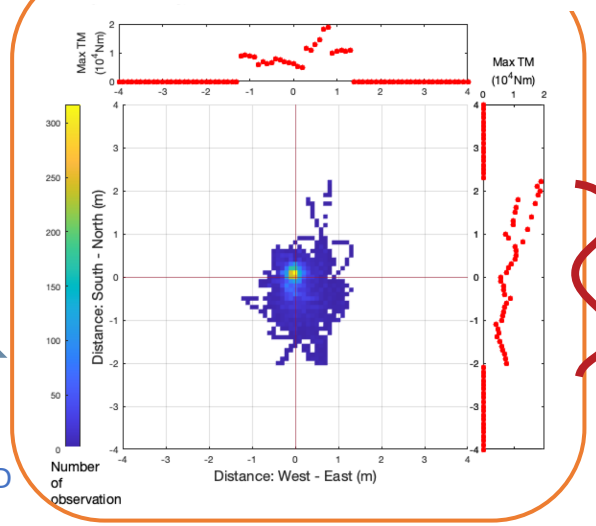
- The damaged trees started leaning at the same timing (**1:10-20**, 1 Oct. 2018).
- Trees in the control plot returned to the original position when wind speeds became lower,
- whereas trees in the thinned plot never returned to the original position.



Results: crown movements with *TM* (1:10-20)

Undamaged

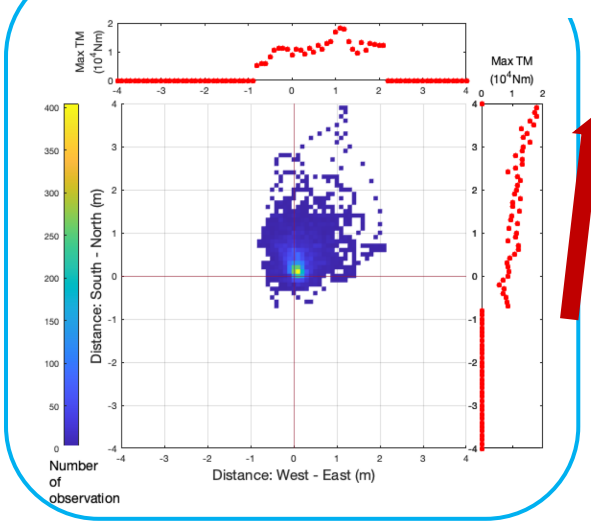
Tree 1 — Control



WIND

Nonlinear

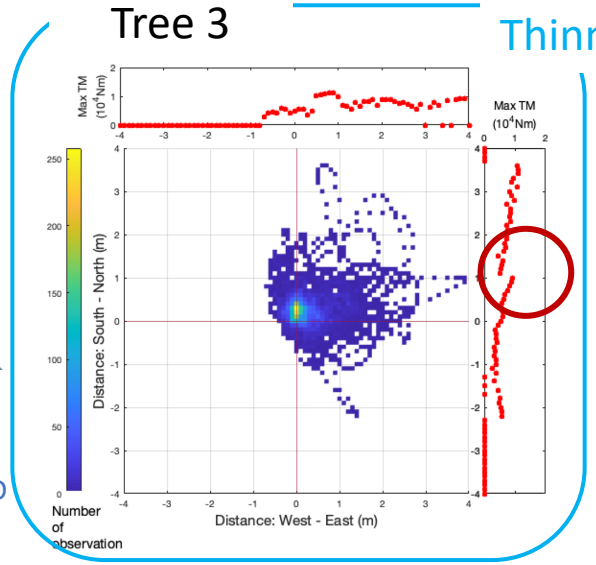
Tree 2 — Thinned



Linearly increased

Damaged

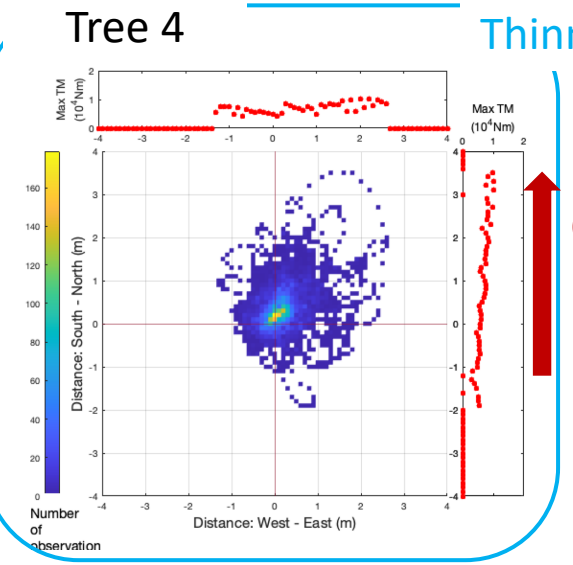
Tree 3 — Thinned



WIND

Main root was broken.

Tree 4 — Thinned



Constant

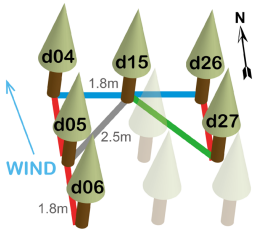
↓

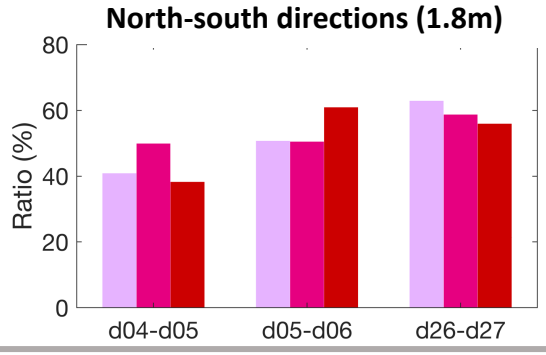
Roots were gradually broken.

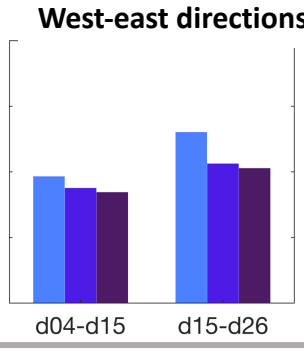
Results: crown collisions (0:00-3:00)

Many chances to collide with the neighbouring trees

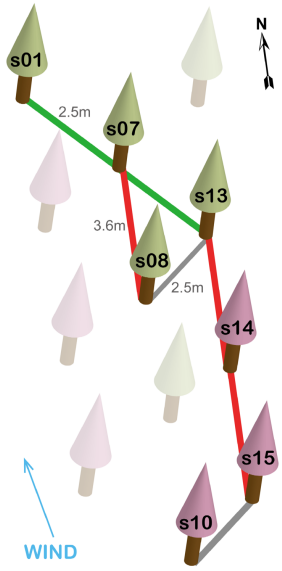
Control

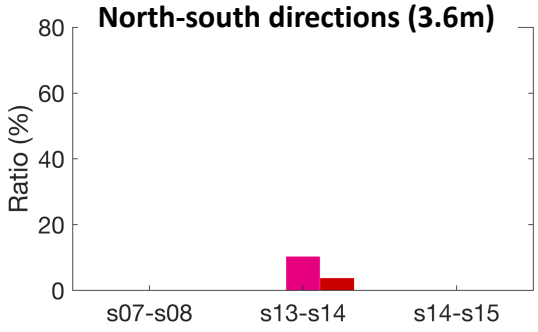






Thinned





Few chances to collide with the neighbouring trees due to longer distance

Conclusion

- **Support from neighboring trees** determined which trees failed and which trees survived.
- Sufficient **crown interaction** can increase the **effective stiffness** of individual trees and a whole forest stand.
- Tree failure in strong winds results from not only the wind turbulent structure but also the level of support that trees receive through crown collisions with neighbors,
- which can be controlled by **forestry activities** (e.g. thinning).