

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

Kana Kamimura*, Kazuki Nanko, Asako Matsumoto, Saneyoshi Ueno,
James Gardiner, Barry Gardiner

*Corresponding author. Email: kamimura@shinshu-u.ac.jp

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Legend for data S1

Other Supplementary Material for this manuscript includes the following:

Movies S1 to S3
Data S1

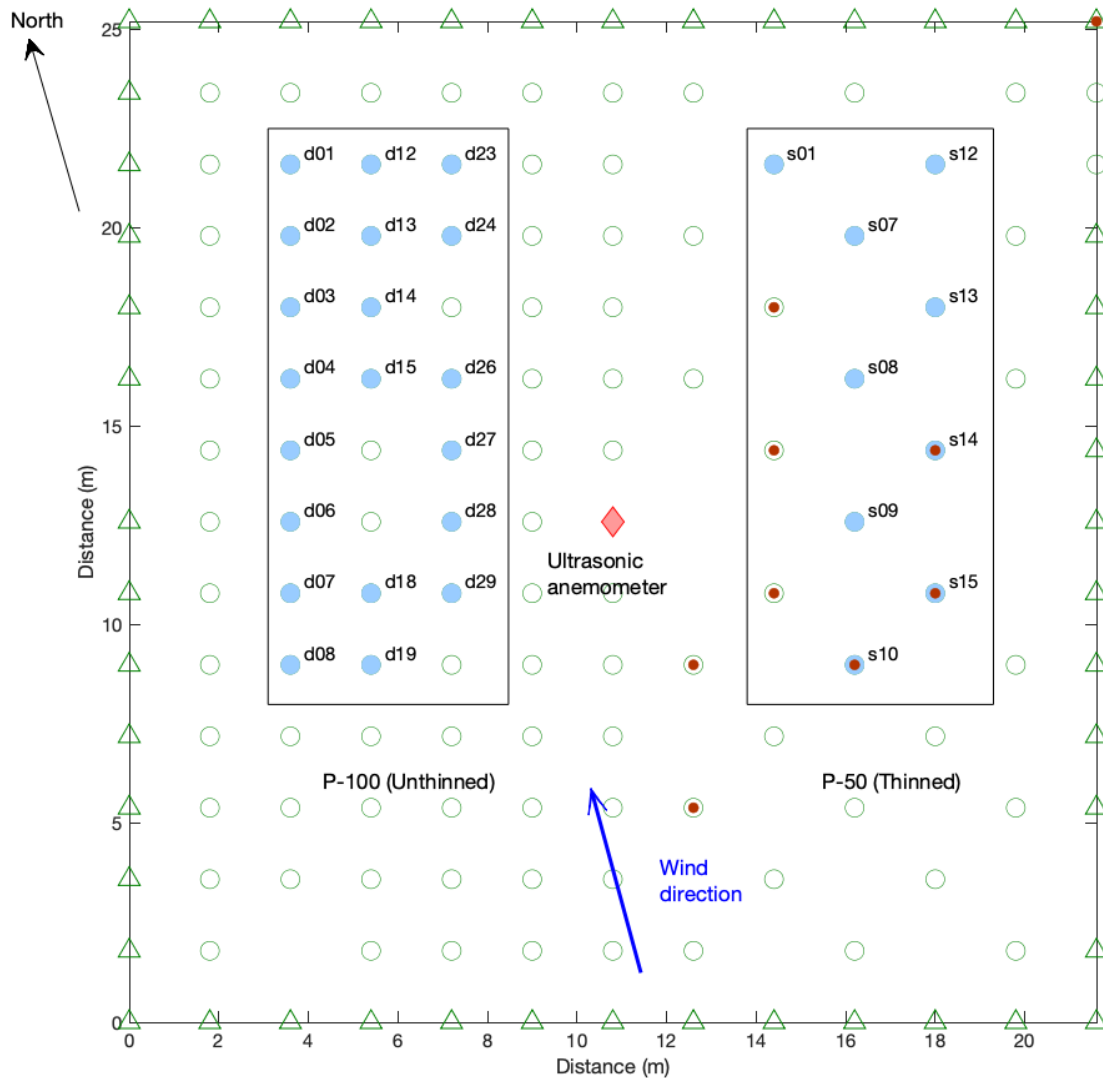


Fig. S1. Research compartment including positions of the plots and an anemometer with data availability

Research compartment with unthinned (1.8 m mean between tree spacing; P-100) and thinned treatments in 2017 (3.6 m mean between tree spacing, P-50). Green circles and triangles indicate trees; red filled circles were the damaged trees; light blue filled circles were the instrumented trees (either with strain gauges or IMU) with identification labels (shown to the right side of the symbols). There were no trees outside the compartment (roads and open fields). All trees with the circle symbols were genetically related (full siblings). Wind direction (blue arrow) was observed at a propeller vane anemometer located outside the plots and operated by FFPRI (see Fig. S6).

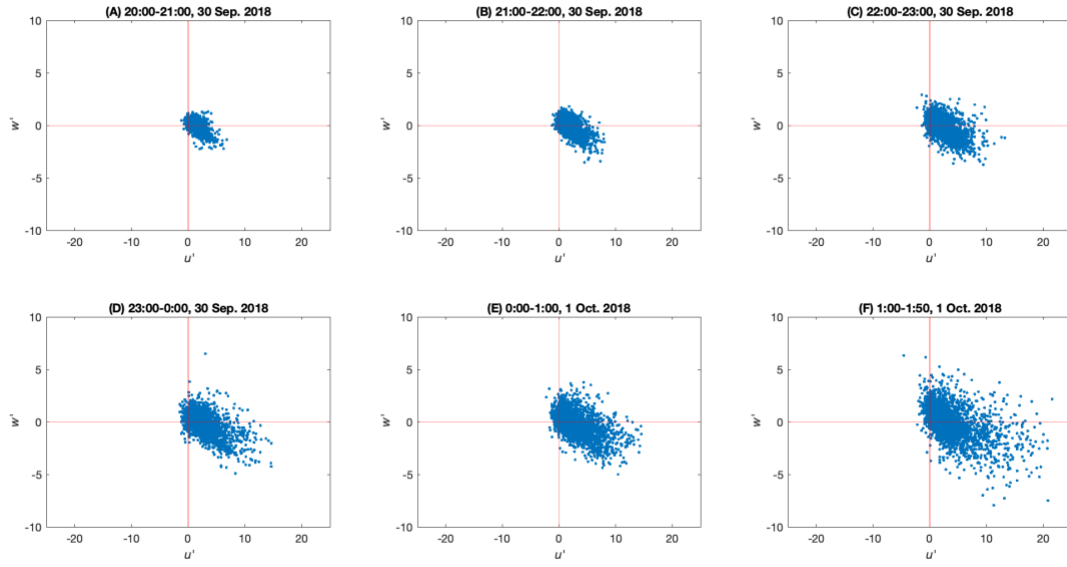


Fig. S2. Wind momentum sweeps and ejections

Wind momentum sweeps (right-lower part of each plot) and ejections (left-upper part of each plots) from the beginning of the typhoon wind period (20:00, 30 September 2018) to the end of observations (1:50, 1 October 2018) with the ultrasonic anemometer located between the P-50 (thinned) and P-100 (unthinned) plots at 12.5 m height, about 1.3 m below the mean tree height (see Fig. S1).

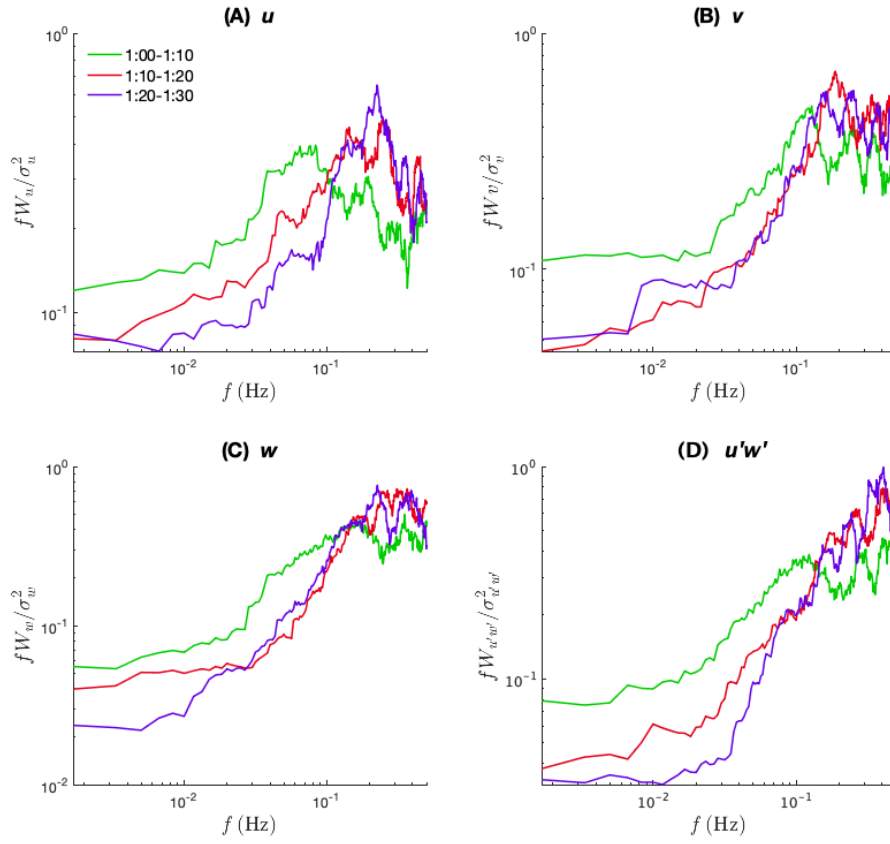


Fig. S3. Normalized power spectrum of wind from 1:00 to 1:30, 1 October 2018

Normalized power spectrum densities (NPS) of wind components (u , v , w) and $u'w'$ plotted against frequency every 10 minutes from 1:00 to 1:30, 1 October 2018 (moving average over 0.05 Hz).

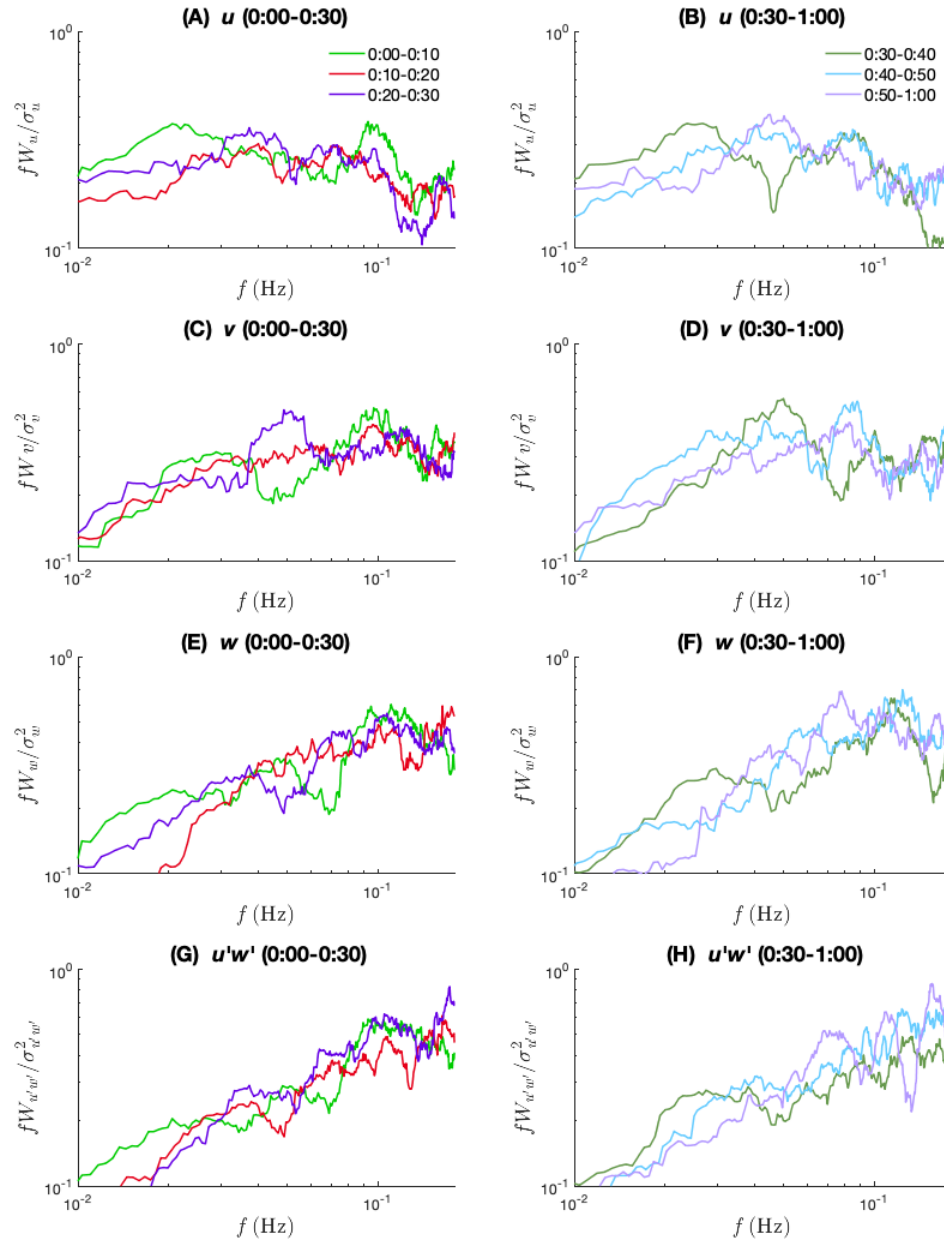


Fig. S4. Normalized power spectrum of wind components from 0:00 to 1:00, 1 October 2018

Normalized power spectrum densities (*NPS*) of wind components (u , v , w) and $u'w'$ plotted against frequency every 10 minutes from 0:00 to 1:00, 1 October 2018 (moving average over 0.05 Hz).

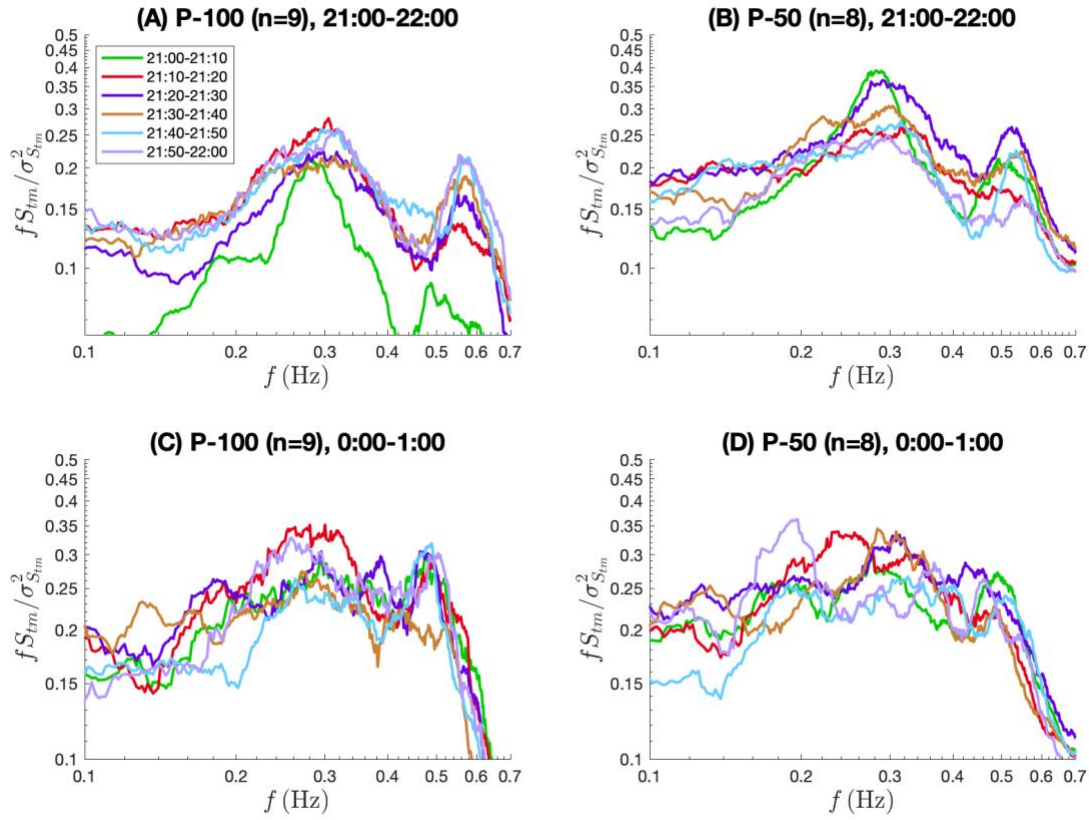


Fig. S5. 10 minute mean normalized power spectrum of turning moment from 21:00 to 22:00, 30 September, and 0:00 to 1:00, 1 October 2018

10 minute mean normalized power spectrum densities (*NPS*) of *TMs* in P-100 and P-50 plotted against frequency (moving average over 0.05 Hz). The plots are focused on the frequency range consisting of the *NPS* peaks with a maximum limitation of 0.7 Hz.



Fig. S6. Map of anemometer positions

Locations of three anemometers: ultrasonic anemometer (Sonic) in the research compartment, 3-cup anemometer (Cup) attached to an electronic pylon tower, and a propeller anemometer (operated by FFPRI) outside the compartment.

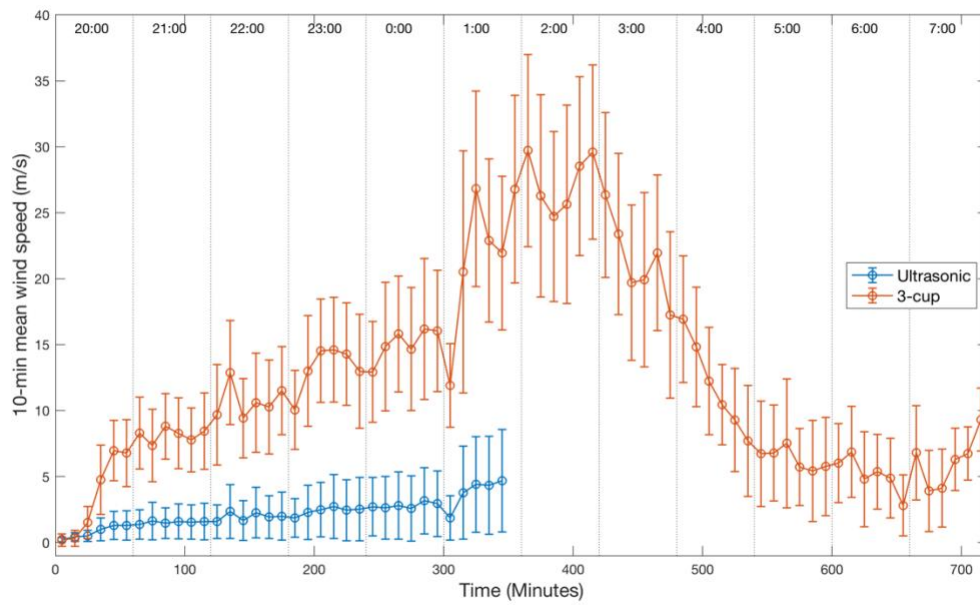


Fig. S7. Wind speed at the ultrasonic and 3-cup anemometers

10 minute mean wind speed and standard deviation from the ultrasonic anemometer (inside the compartment) and from the 3-cup anemometer (outside the compartment). The two datasets were significantly cross-correlated with a zero time-lag ($r > 0.95$).

Table S1. Information on tree sizes in the compartment and within the plots in 2018

Mean and standard deviation (*s.d.*) of stem diameter at a breast height of 1.3 m (*dbh*) and height of the trees in the research compartment and the analyzed trees in the two research plots: P-100 and P-50, along with the undamaged and damaged tree groups

		<i>Dbh</i> (cm)		Tree height (m)	
		n	Mean (<i>s.d.</i>)	n	Mean (<i>s.d.</i>)
Trees in the compartment (including the trees in the plots)					
Inside	All	105	17.0 (3.3)	43	13.8 (1.1)
	Undamaged	97	17.0 (3.4)	35	13.7 (1.2)
	Damaged	8	17.9 (2.6)	8	14.0 (0.7)
Edge	All	48	21.0 (5.3)	41	12.5 (1.2)
Trees in the plots					
P-100	All	14	15.0 (3.1)		13.3*
P-50	All	8	15.2 (3.6)	8	13.1 (1.8)
	Undamaged	5	14.2 (4.4)	5	12.8 (2.2)
	Damage	3	16.8 (1.3)	3	13.7 (0.7)

* Tree height of 3 visible trees measured using a Vertex (HAGLÖF SWEDEN Co., Långsele, Sweden) from outside the plot.

Movie S1. Video of the research plots recorded after damage from super typhoon Trami

This video was taken by the corresponding author on 24 October 2018, who entered the research plots from the north side of the compartment. First it shows the P-50 plot (damaged) on the left side and then the P-100 plot (undamaged) on the right side.

Movie S2. Animation of IMU derived tree displacements for damaged tree S14 during typhoon Trami

Large scale displacements of the tree can be seen, particularly from 0:18 on the 1 October 2018 onwards, when the tree was estimated to be damaged. A progressive lean of the tree towards the north east can be observed to develop as damage is accumulated during of the storm. The black marker and line represent the current time point and progressively fade to light orange and then disappear as time passes, leaving a ghost trail. Playback speed of video is x10 the actual speed during the storm. Left animation gives a 3D view of the whole tree stem with the circle marking the location of the IMU. Right animation provides a bird's eye plan view of the displacement at the center of the tree stem (~6m above ground) where the IMU was located on the tree with the large open circle representing the base of the tree. Bending of the tree during wind loading has not been accounted for in the animations.

Movie S3. Crown movements in the unthinned area of the research compartment

The target area in this vertical looking movie includes the P-100 trees. It was recorded by the corresponding author on 30 May 2019, when the hourly maximum wind speed was approximately 4.95 m/s at the 3-cup anemometer (outside the plot).

Data S1. (separate file) Tree heights and recorded stem angles at the point of maximum applied force in the tree-pulling experiments, 2019

The data file gives the tree heights and stem angles of the uprooted trees when the maximum applied force was measured in tree-pulling experiments. The pulling experiments were conducted in the unthinned (undamaged) area of the research compartment from 11 to 14 November 2019. The averaged angles were used to help determine which trees were damaged trees by the typhoon in 2018. The tree ID with their positions can be found in the schematic below and also in Fig. S1.

[North]		
394	407	420
d01	d12	
d02	d13	d24
d03	d14	d25
d04	d15	d26
d05	d16	d27
d06		d28
d07		
d08	d19	d30
d09	d20	d31
d10		d32
d11	d22	d33
	419	
[South]		