Vulnerability assessment to wind damage in a protective forest stand in the Alps

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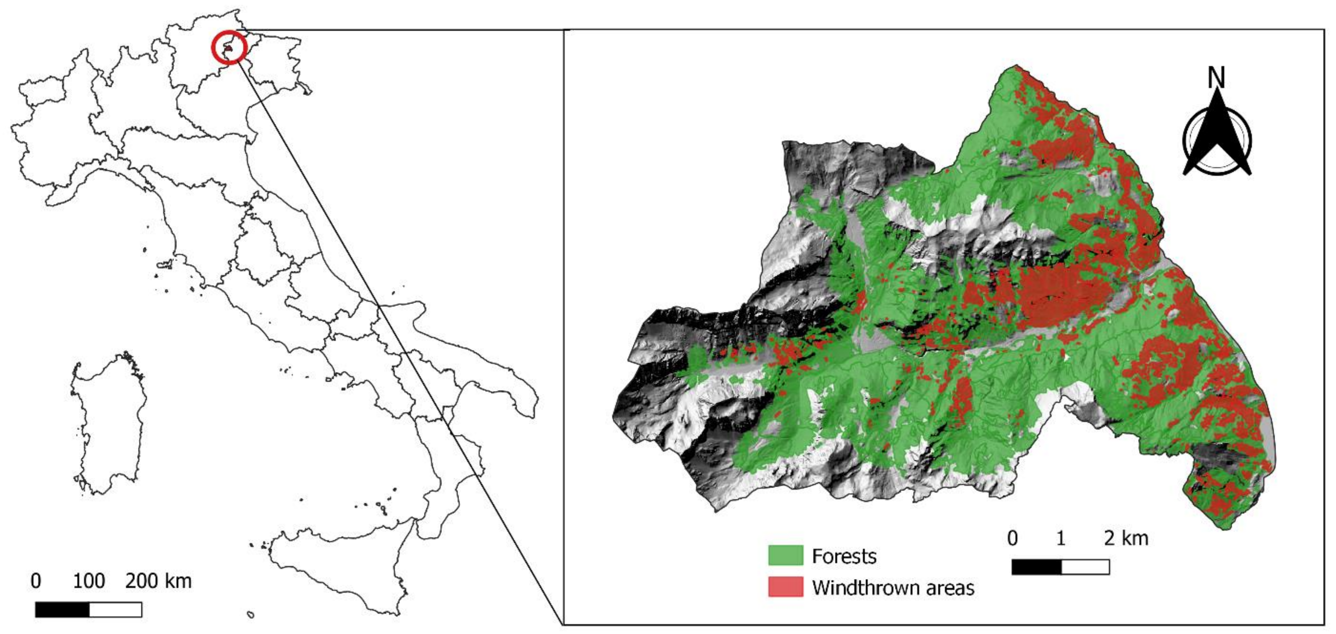
INTRODUCTION

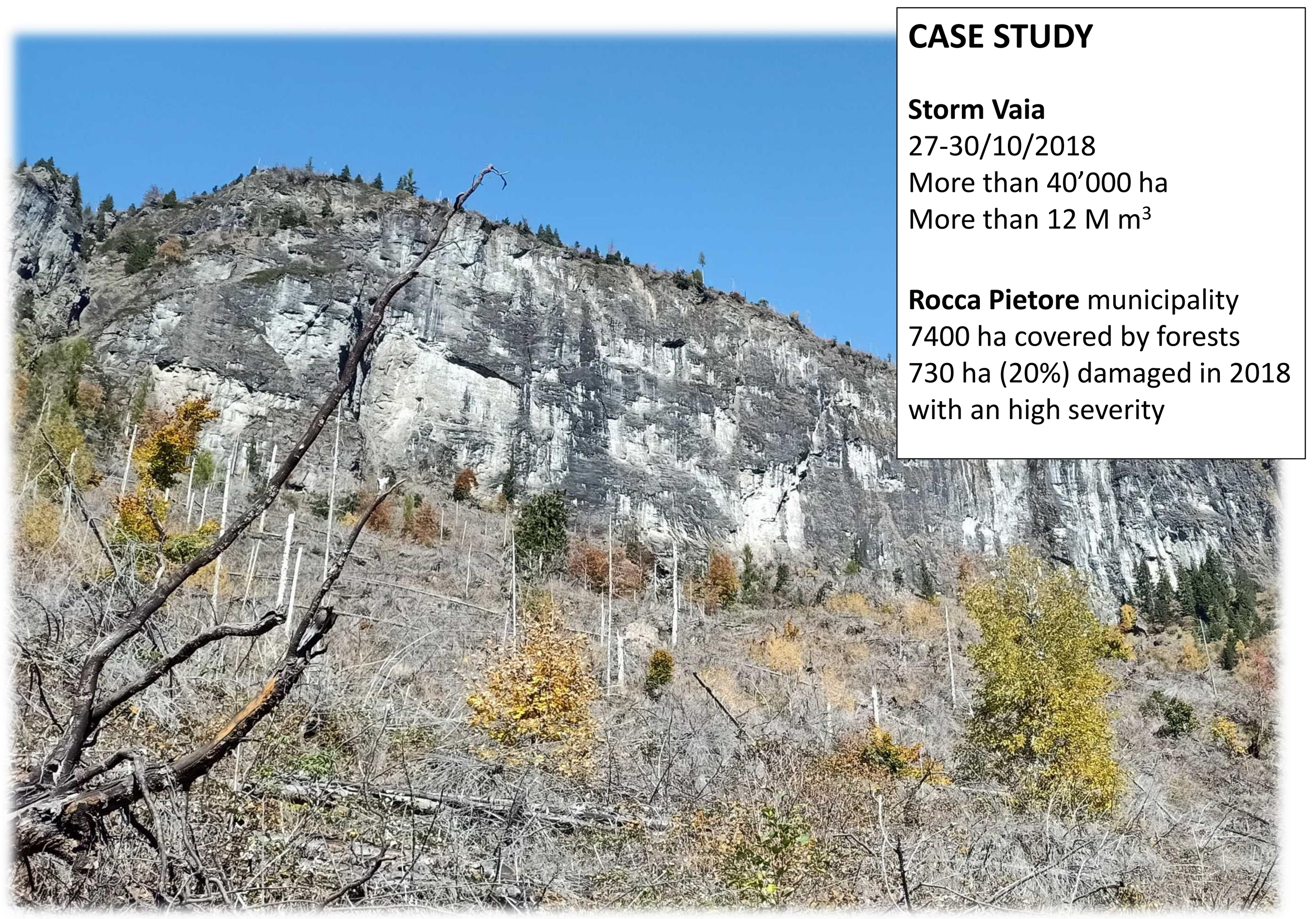
Wind is one of the main natural disturbances that threaten mountain forests in Europe, among them protective forests are at risk too.

Assessing wind damage ✓

Post disturbance management ✓

…but
how to assess vulnerability to prevent/mitigate wind damage in the Alps? ?





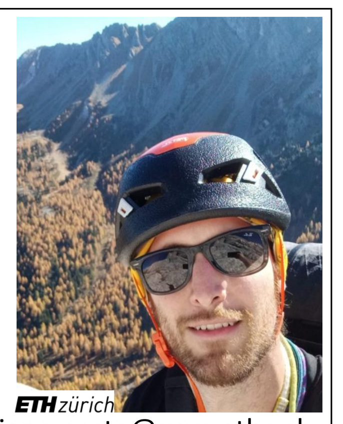
CASE STUDY

Storm Vaia
27-30/10/2018
More than 40'000 ha
More than 12 M m³

Rocca Pietore municipality
7400 ha covered by forests
730 ha (20%) damaged in 2018
with an high severity

OBJECTIVE

From LiDAR data to vulnerability maps, using a parametrisation adapted for the alpine scenario



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This work was carried out as part of the RESILIENCE project. Please visit the official website for more information: http://resilience.stat.unipd.it/

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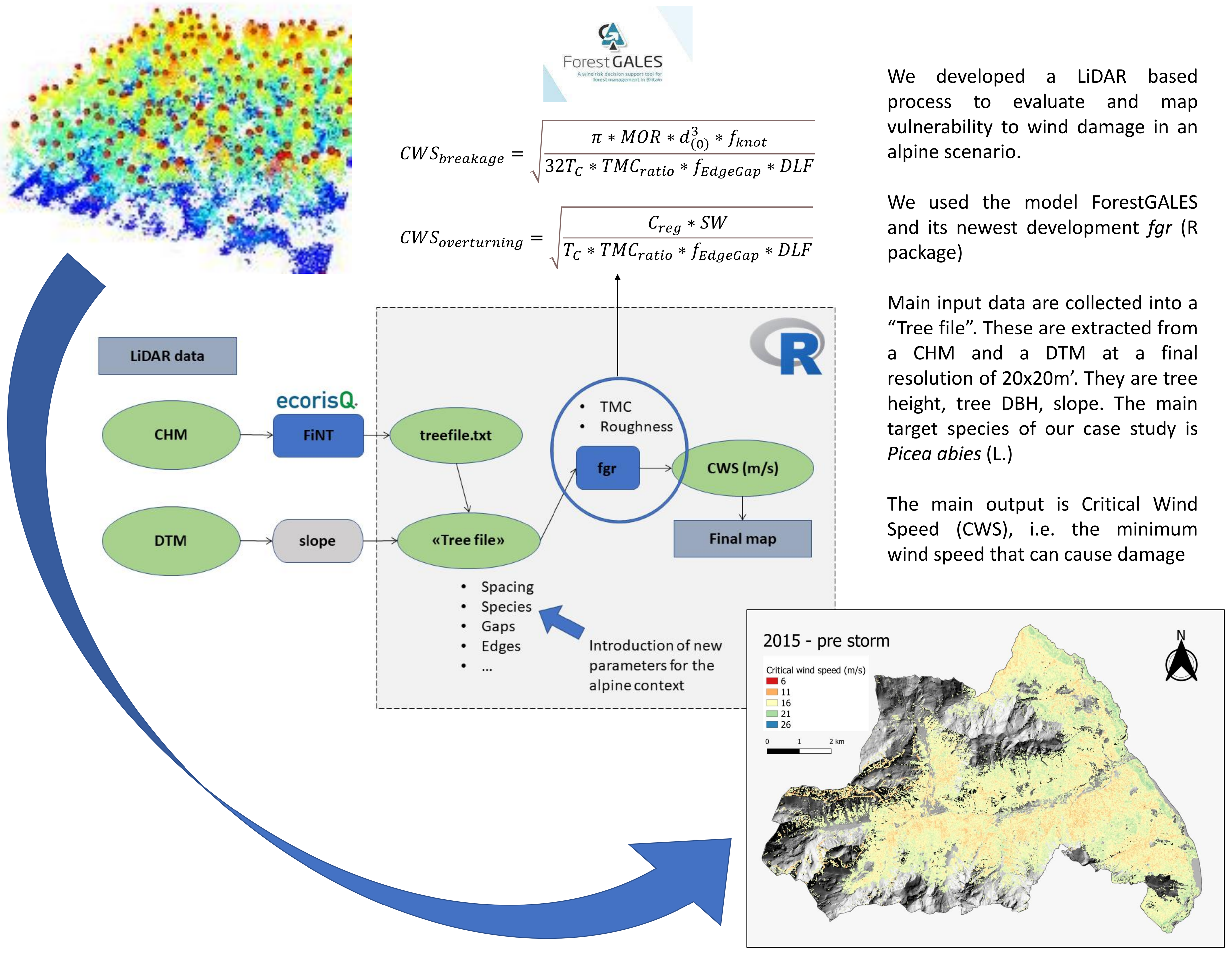
VULNERABILITY ASSESSMENT



$$CWS_{breakage} = \sqrt{\frac{\pi * MOR * d_{(0)}^{3} * f_{knot}}{32T_C * TMC_{ratio} * f_{EdgeGap} * DLF}}$$

$$CWS_{overturning} = \sqrt{\frac{C_{reg} * SW}{T_C * TMC_{ratio} * f_{EdgeGap} * DLF}}$$

We developed a LiDAR based process to evaluate and map vulnerability to wind damage in an alpine scenario.

We used the model ForestGALES and its newest development *fgr* (R package)

Main input data are collected into a "Tree file". These are extracted from a CHM and a DTM at a final resolution of 20x20m'. They are tree height, tree DBH, slope. The main target species of our case study is *Picea abies* (L.)

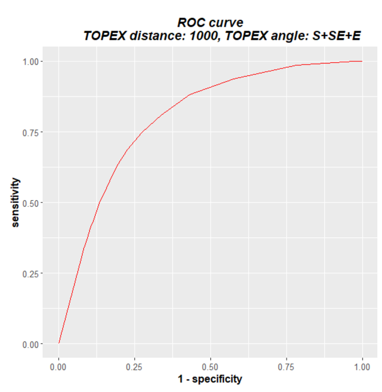
The main output is Critical Wind Speed (CWS), i.e. the minimum wind speed that can cause damage

MODEL VALIDATION

Modelled damage were evaluated combining vulnerability assessment model (fgr), topographic exposure to wind (TOPEX) and data from the storm Vaia. To validate our results modelled damage were compared to observed damage, creating a confusion matrix. The matrix was used to calculate the Success Index, the model was considerate validated when SI was higher than a threshold of 0.7, the same threshold was used for the Area Under the Curve (AUC)

	Modelled damage	Modelled no damage
Observed damage	Hits	Misses
Observed no damage	False alarms	Correct negatives

$$Success\ Index = \frac{1}{2}\left(\frac{hits}{hits + misses} + \frac{correct\ negatives}{observed\ no}\right)$$



When considering a distance from the horizon of 1000 m and winds coming from S+SE+E the SI was equal to 0.74 with an AUC) for the relative Receiver Operating Curve (ROC) of 0.79.

MAIN RESULTS

Since the model was validated, we could map vulnerability

Before the storm Vaia – LiDAR data from 2015
After the storm Vaia – LiDAR data from 2019

Using these maps, we computed the Difference of Vulnerability (DoV) raster

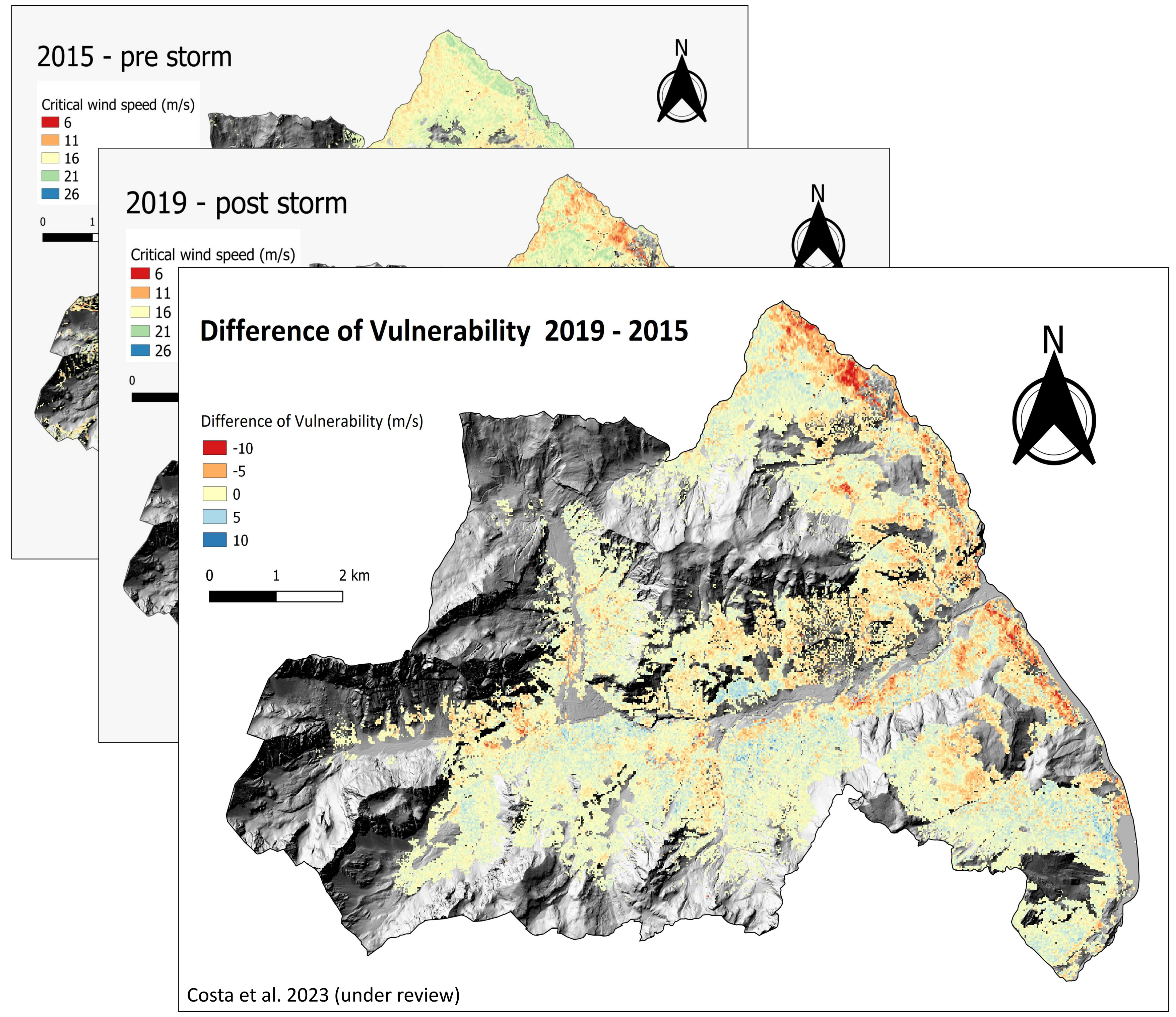
DISCUSSIONS

Thanks to a LiDAR-centered procedure it was possible to assess and map vulnerability to wind damage at the municipality level, the process can be upscaled.

The new parametrisation for the Alpine scenario was validated using data from storm Vaia

The creation of a DoV raster allowed us to observe the effect of the storm Vaia on vulnerability to wind damage, it appeared that:

High severity disturbance -> high vulnerability to future storms
Low severity disturbance -> "thinning" effect, lower vulnerability to future storms



Costa et al. 2023 (under review)

TAKE HOME MESSAGES

! More accurate airflow models are needed, multidisciplinary approach is the key (e.g., meteorologists)
! Models can be used to identify new areas at risk after a storm

NEXT STEPS

-> Coupling wind risk models (static) with dynamic vegetation models on a landscape scale
-> Models can be used for prevention of future disturbances, e.g. simulating different forest management strategies
-> Automatic extraction of tree parameters from LiDAR data (species differentiation, dominant height, crown width, distance to the edge)