Mapping the probability of wind disturbances in forests – an empirical modelling approach

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Alnarp, 6.2.2019
Thunder storms in 2010 in Eastern and Central Finland – damage: 8.1 million m$^3$
Project StromTree: Creating national high-resolution forest wind damage risk maps

1. Wind damage observations in national forest inventory

2. Statistical modelling of damage probability using forest properties and environmental variables

3. Computing damage risk maps with GIS data of forest properties, land use, soil & wind conditions
Statistical models

Model data
- NFI 11 field data

Spatial data
- MS-NFI forest resource maps
- Max wind 10 year return levels
- Soil data
- Forest management notifications

Test data
- NFI 12 field data

Wind damage models
- GLM, GAM and BRT

Cross-validation of models

Preparation of covariates for prediction

Spatial prediction of wind damage probability

Testing the map with external data
Wind damage observations in the Finnish National Forest Inventory (NFI)

Field data for the 11th National Forest Inventory (NFI) was collected from 2009 to 2013.

In this study we use 41,397 NFI plots on forest areas, where

- 1,070 plots had wind damage in the forest stand (within previous 5 years)
- ~2.6% of plots with wind damage
Statistical modelling & machine learning approaches

Generalized linear mixed models (GLM)
  – Fully parametric models (logistic regression model)

Generalized linear additive models (GAM)
  – Accounting for non-linearity with non-parametric smoothing splines

Boosted regression trees (BRT)
  – Ensembles of regression trees

Increasing
  • flexibility
  • ability to account for non-linearity
  • risk of overfitting
Responses of damage probability to model predictors

GLM
Responses – comparison of methods

**GLM**

- [Graph 1: Fitted vs. Tree height (dm), pine]
- [Graph 2: Fitted vs. Tree height (dm), spruce]
- [Graph 3: Fitted vs. Tree height (dm), other]

**GAM**

- [Graph 4: Fitted vs. Tree height (dm), pine]
- [Graph 5: Fitted vs. Tree height (dm), spruce]
- [Graph 6: Fitted vs. Tree height (dm), other]

**BRT**

- [Graph 7: Fitted vs. Tree height (dm), pine]
- [Graph 8: Fitted vs. Tree height (dm), spruce]
- [Graph 9: Fitted vs. Tree height (dm), other]
Cross-validation results

10-fold cross-validation

* AUC when full data used for both training and testing

→ GLM model chosen for the map
2 The Map

Wind damage models
GLM, GAM and BRT

Spatial data
- MS-NFI forest resource maps
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Testing the map with external data
GIS data for model predictors

- Properties of the forest stand: tree height, diameter, species
- Open stand borders
- Forest management history: time since last thinning
- Local wind conditions: max wind 10-year return rate (details here)
- Soil: peatland, fine/coarse mineral soil, soil depth
- Climate: Temperature sum (degree days)
Spatial predictions of damage probability

MODEL (GLM) + GIS layers = WIND DAMAGE PROBABILITY MAP
Testing the map = does it work?
Testing with new NFI data

Comparing the map predictions to NFI12 damage observations
– with wind damage
– without wind damage

True positive rate
True negative rate
AUC = 0.71
Wind damage probability map for Finland

• Shows the wind sensitivity of forests in fine spatial resolution

• Release as:
  1. Easy to use web-map application *(out now & developing)*
     https://metsainfo.luke.fi/en/tuulituhoriskikartta
  2. GIS data set *(out later)*

• Methods & results will also be published in a scientific paper
Thank you!

#MyrskyPuu
#StormTree