A Probabilistic View on Winter Storm Damages

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Introduction

• Operational forecasting using **Ensemble Prediction Systems (EPS)**

• Potential developments of storms and estimation of likelihoods of severities

• Downscaling provides higher resolution for individual simulation results

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**EPS-storms** from ECMWF

Years 2000-2010, T399

**Dynamical downscaling** using a subset of storm events (from EPS & reanalyses)

GME – COSMO-EU

**Statistical transfer function** for gusts

\[ y = \sum_{i} a + b_i \cdot x_i + c_i \cdot x_i^2 \]

(T. Kruschke)
Deterministic loss model: Regionally trained wind-loss ratio relationship

\[ \text{Loss ratio (region)} = B(\text{region}) \times \left( \frac{\sum_{\text{Tage}} \left( \frac{v_{\text{max}}(\text{region, day})}{v_{98}(\text{region})} - 1 \right)^3}{Jahr} \right) + A(\text{region}) \]

Regression $y = B \times x + A$: Koeffizient B

Schadenpotential ERA-Interim $(v/v_{98} - 1)^3$

Regression $y = B \times x + A$: Koeffizient A

GDV Schadensatz Winter ONDJFM

Observed loss ratios from GDV
However, Grid-point wind – damage relation is probabilistic!
A Probabilistic Model for Loss Occurrences

Relate normalized daily max. gusts at district center …

Define threshold according to user requirements,

Determine probability of exceedance dependent on wind speed

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gust time series

Loss ratio time series
A Probabilistic Model for Loss Occurrences

Logistic Regression

\[ p(\text{event}) = \frac{\exp(a + bx)}{1 + \exp(a + bx)} \]

Binned occurrence frequencies

Normalized gust wind speed
Example – Storm Britta (2006-10-31)

Loss ratio [%]

Loss ratio > 0.0001

Loss ratio > 0.001
Example – Storm Britta (2006-10-31)

Ensemble mean wind based

Lossratio > 0.0001  Lead time 1 day  Lead time 3 days  Lead time 9 days
Brier Skill Score for different lead times

Result for Germany:

„Skillfull“ forecasts for lead times up to 6 days i.e. better than forecasting the climatological probability for each day
Use ensemble mean wind speed, or ensemble mean loss probabilities?

„Wind averaging“
Apply transfer function to ensemble averaged wind speed

vs „Loss Probability averaging“
Applying transfer function, then calculating the ensemble average of resulting probabilities
Brier Skill Score for different lead times

Improved score for ensemble mean using loss probability averaging!
Underdispersion of downscaled EPS

Rank histogram (Talagrand diagram): Where is observation (analysis) wrt the value-ordered ensemble ranks

- Analyses („observations“) often outside of ensemble range
  → Underdispersion
- More frequently above all ensemble members
  → Bias
Brier Skill Score with ensemble dressing

High loss threshold (rare events)

Ensemble mean wrt wind, dressed

Lead time (days)
Summary

• Estimate relationship of (gridpoint) wind and likelihood of damage in excess of a threshold from observations

• Forecasts using the ensemble mean damage result in better skill wrt damage than forecasts using the wind damage

• Ensemble post processing (“dressing”) yields further gain, up to 2 days
Thank you for your attention