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A Probabilistic View on Winter Storm Damages

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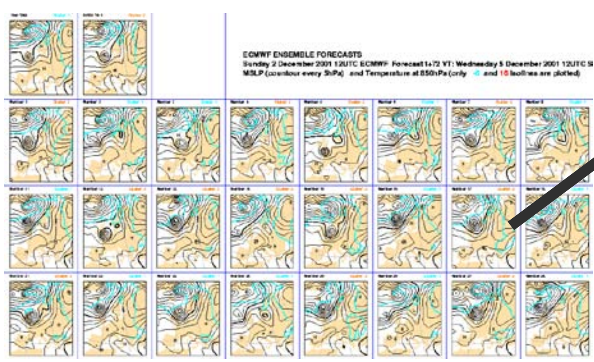
Introduction

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

- Potential developments of storms and estimation of likelihoods of severities

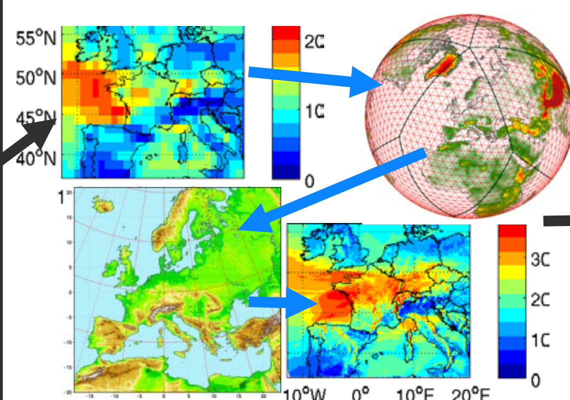
- Downscaling provides higher resolution for individual simulation results

EPS-storms
from ECMWF



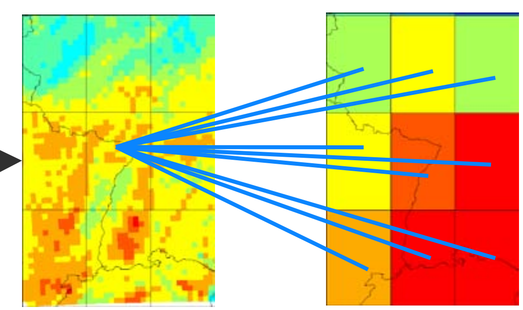
Years 2000-2010, T399

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



GME – COSMO-EU

Statistical transfer function
for gusts

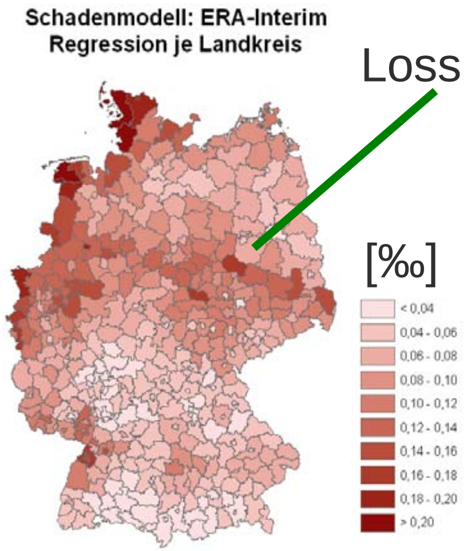


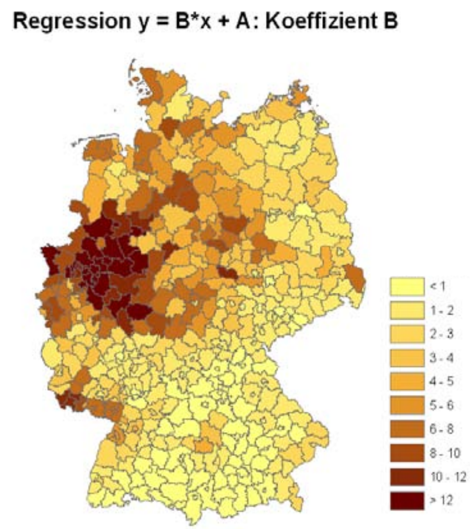
$$y = \sum_i a + b_i \cdot x_i + c_i \cdot x_i^2$$

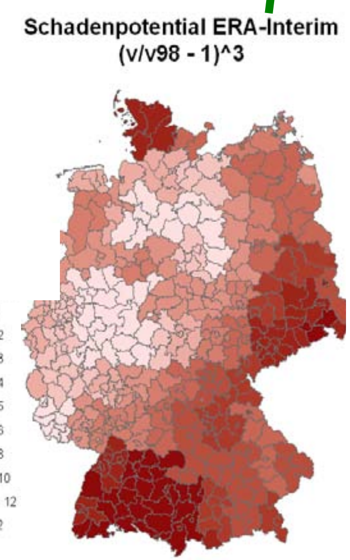
(T. Kruschke)

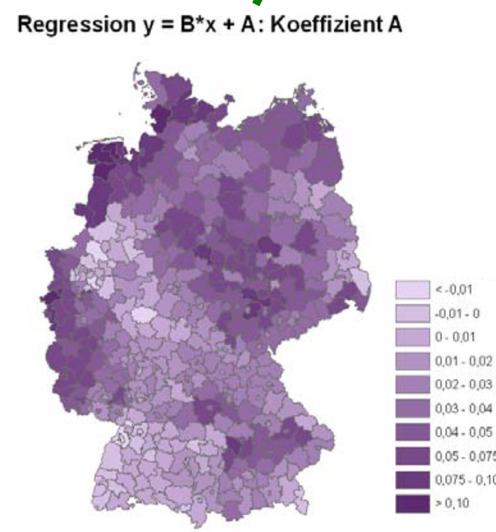
Deterministic loss model: Regionally trained wind-loss ratio relationship

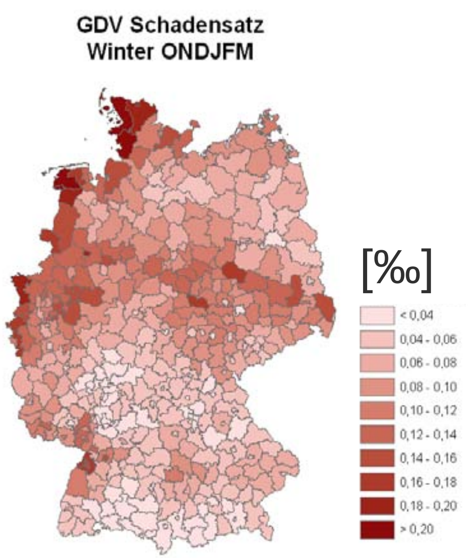
$$\text{Loss ratio (region)} = B(region) * \sum_{Tage}^{Jahr} \left(\frac{v_{max}(region, day)}{v_{98}(region)} - 1 \right)^3 + A(region)$$







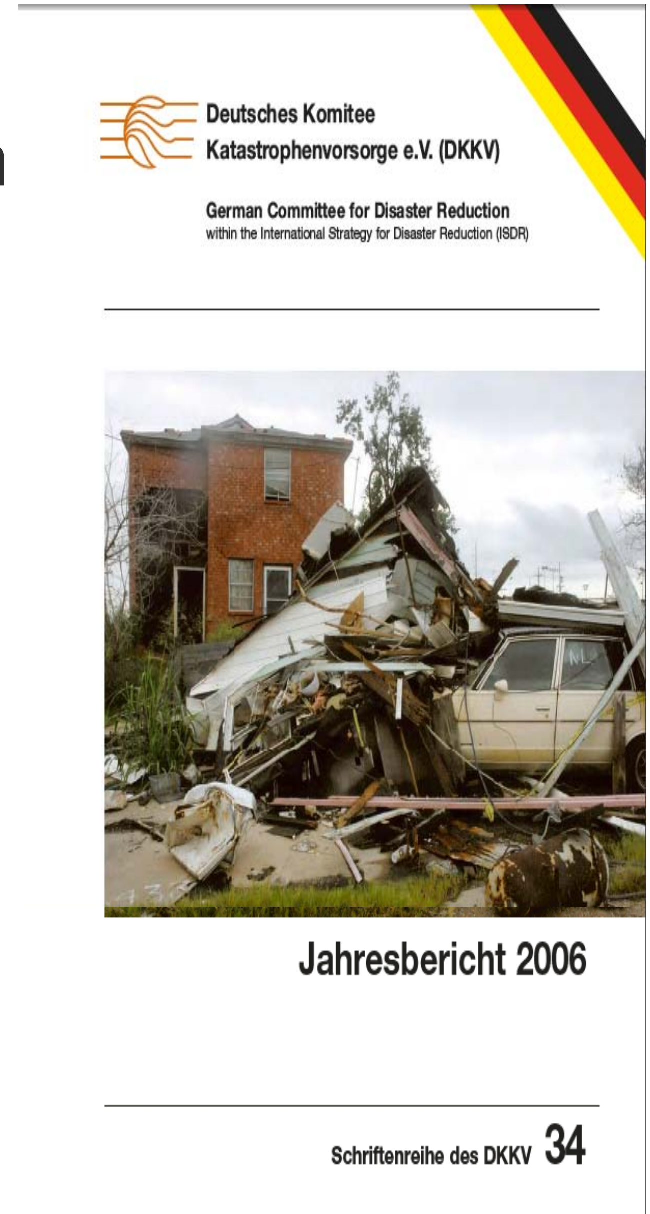




Observed loss ratios from GDV

However,
Grid-point wind – damage relation is **probabilistic !**

Source: GDV



A Probabilistic Model for Loss Occurrences

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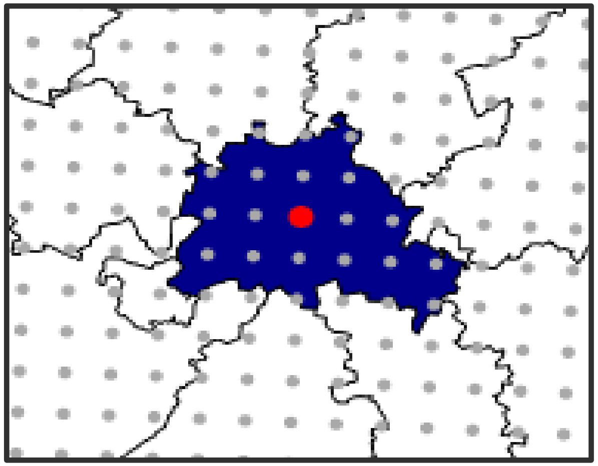
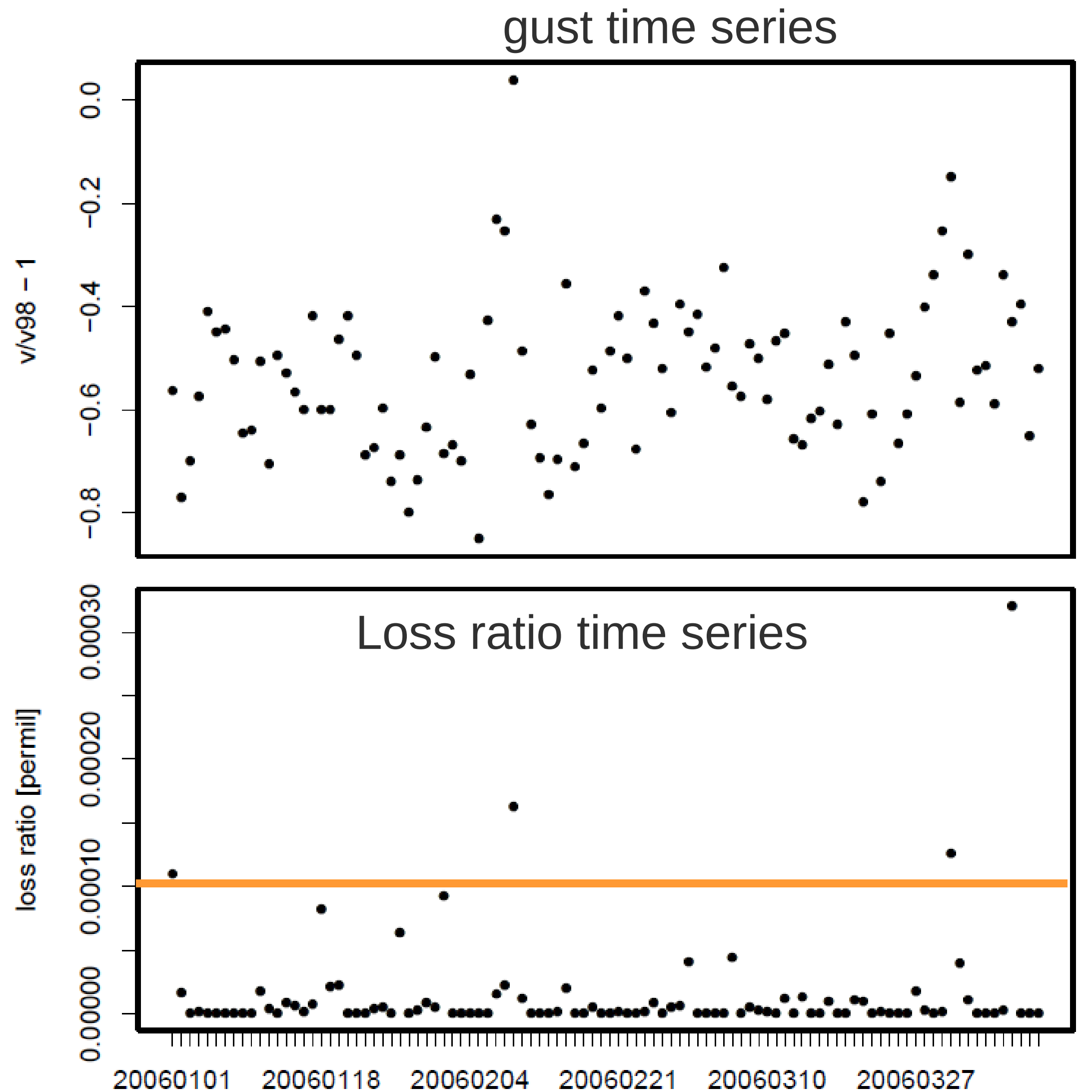
Relate normalized daily max. gusts at district center …





Define threshold according to user requirements,

Determine probability of exceedance dependent on wind speed

A Probabilistic Model for Loss Occurrences

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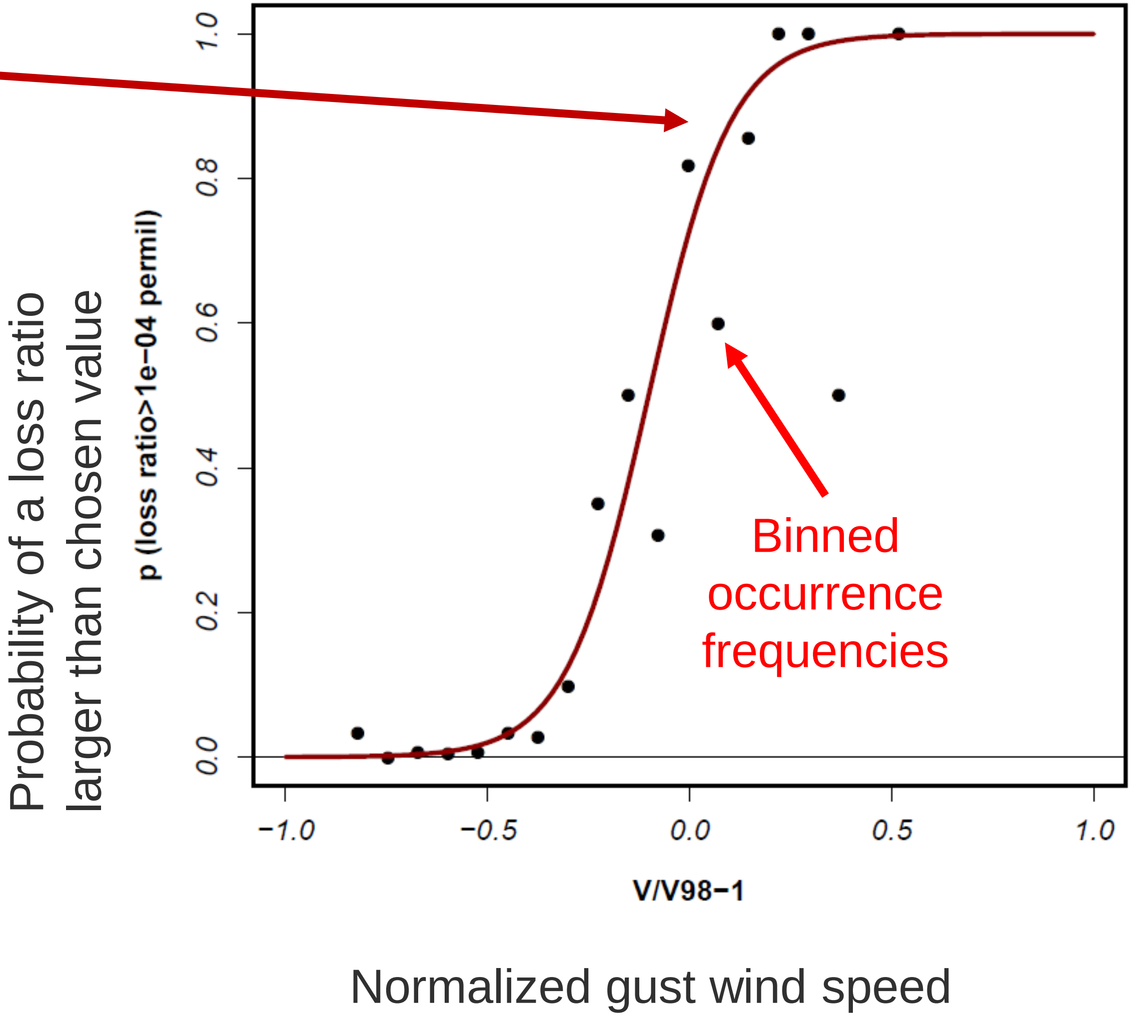
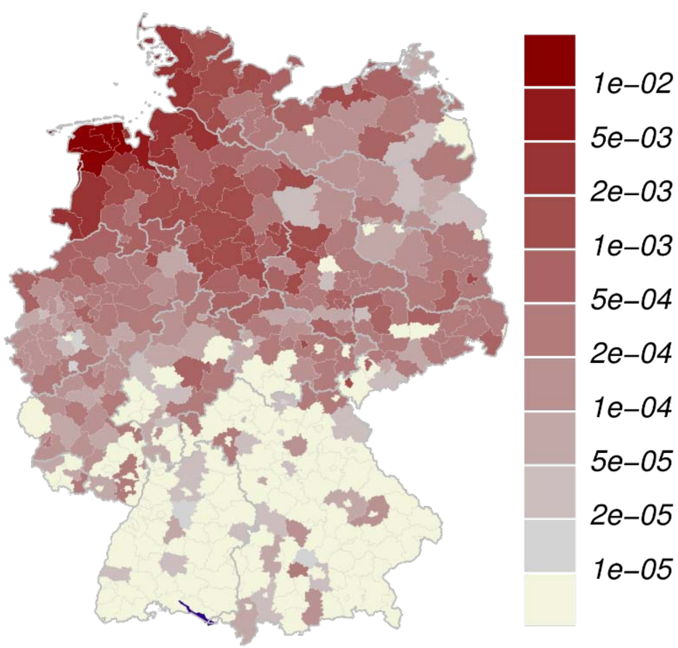
Logistic Regression

$$p(event) = \frac{\exp(a + bx)}{1 + \exp(a + bx)}$$

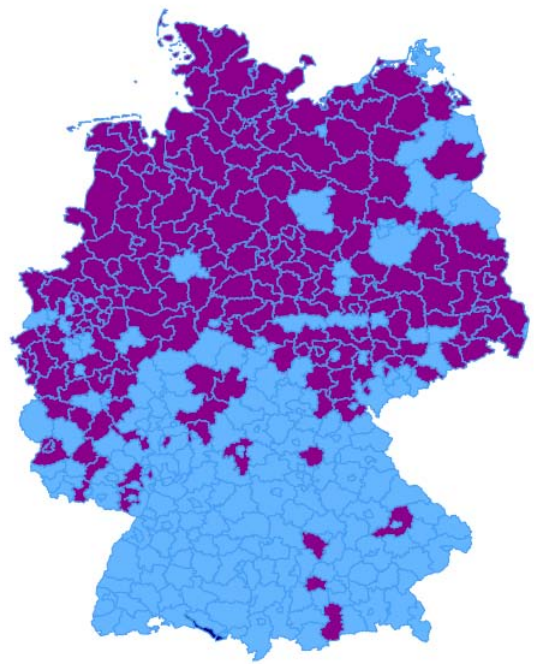


Example – Storm Britta (2006-10-31)

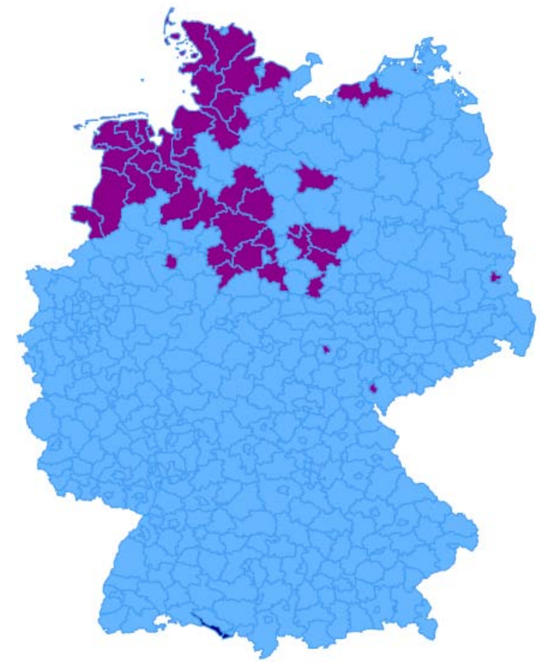
Loss ratio [‰]



Loss ratio > 0.0001



Loss ratio > 0.001



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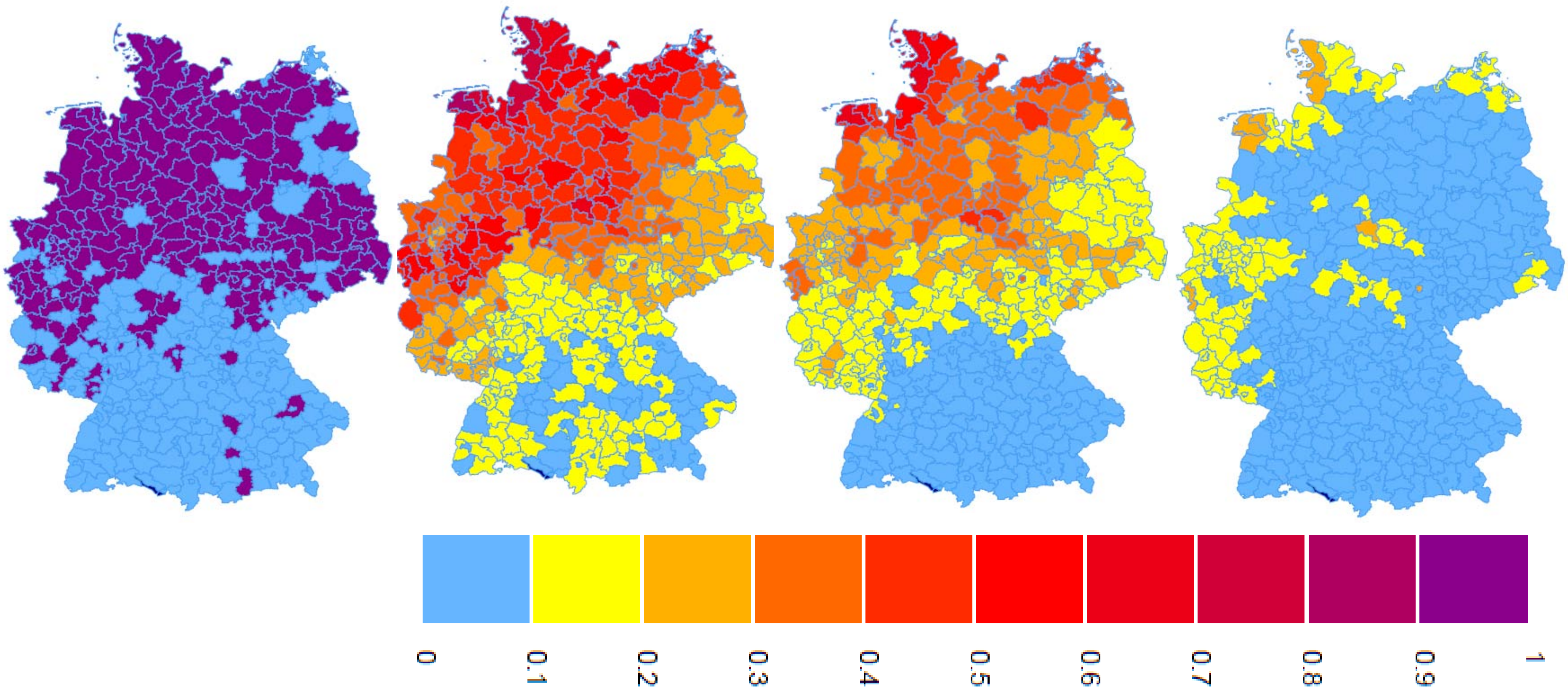
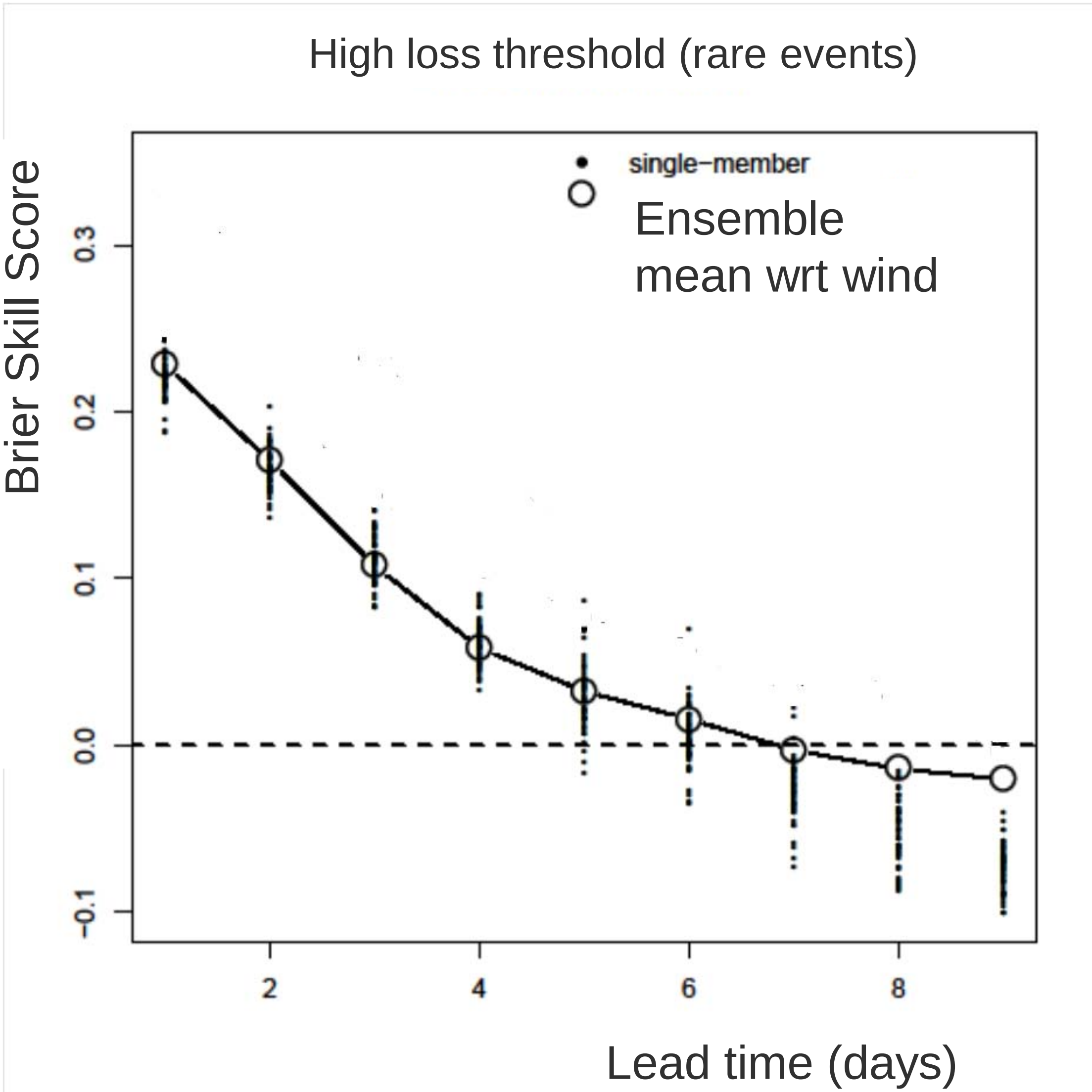
Example – Storm Britta (2006-10-31)

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?

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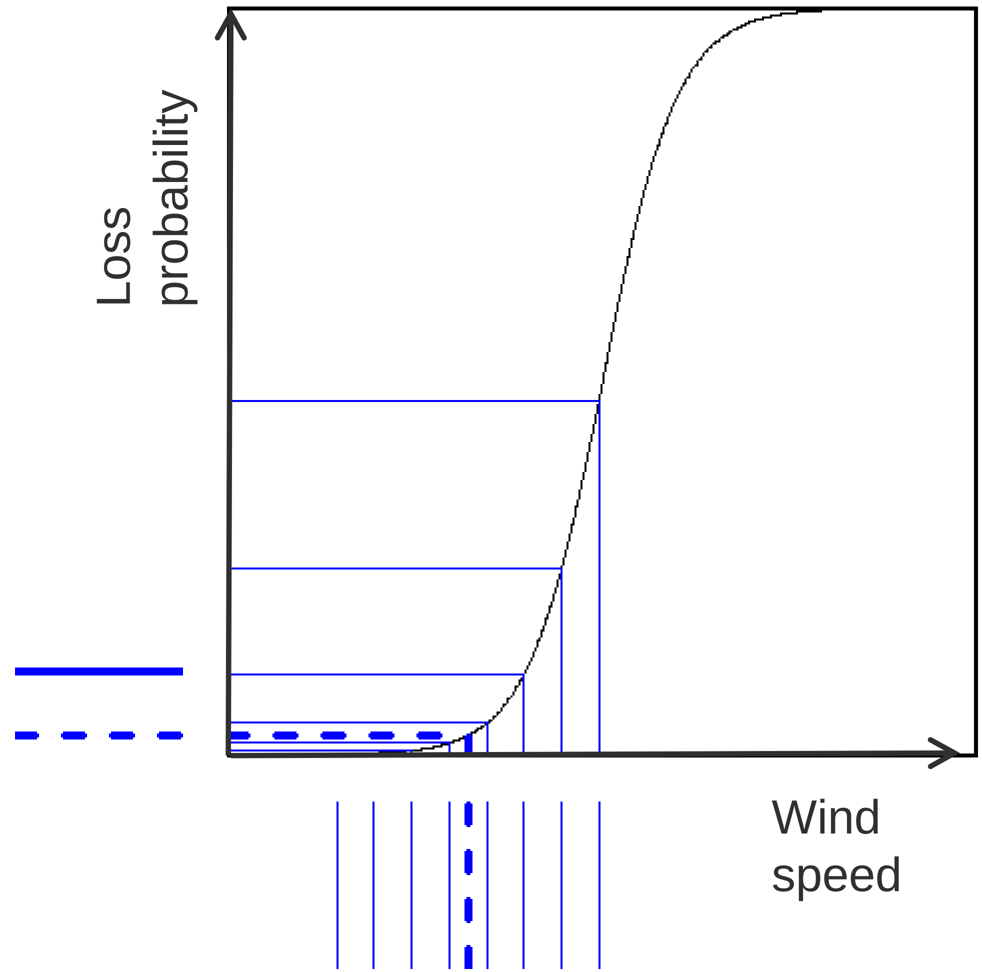
„Wind averaging“

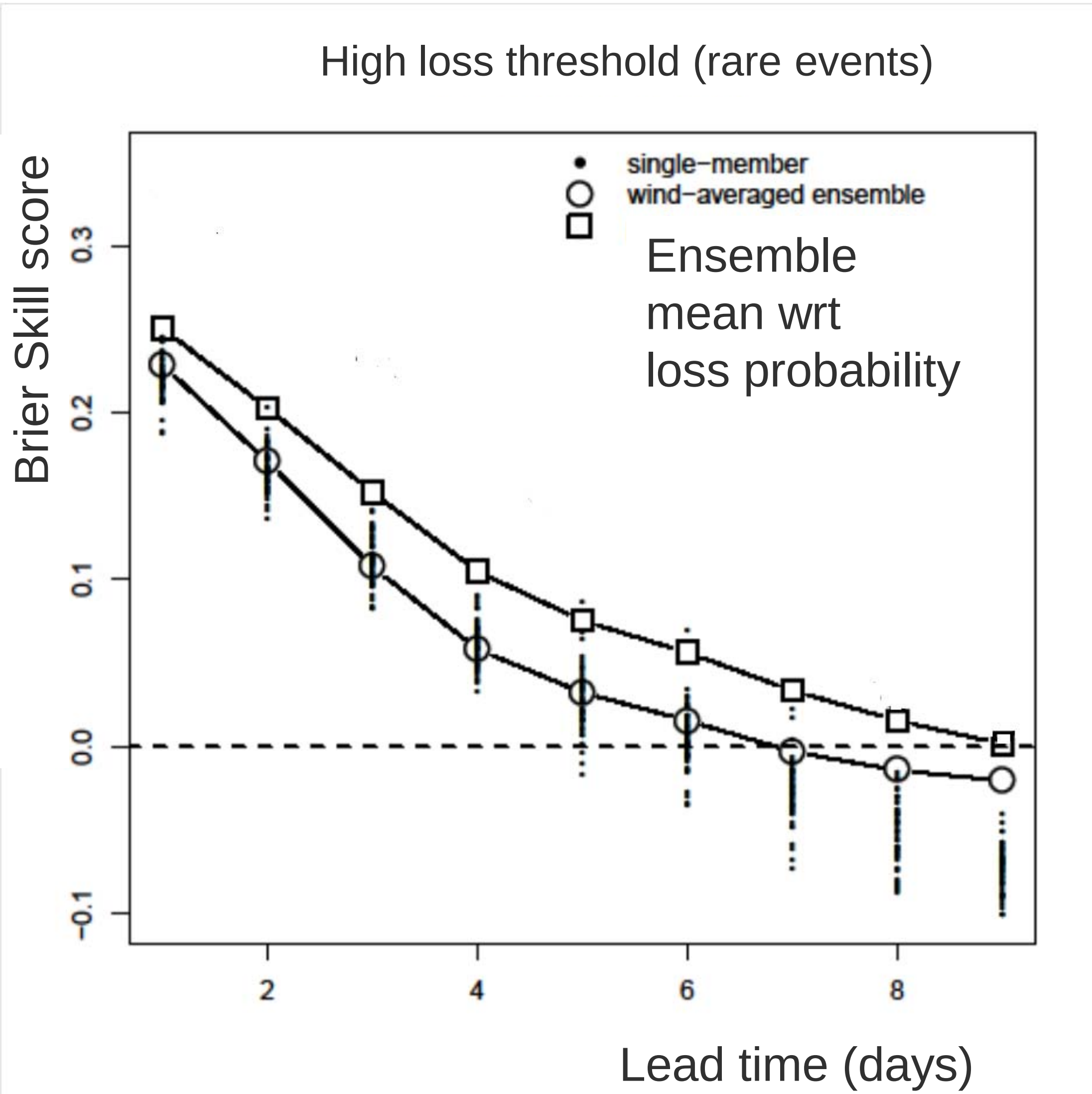
Apply transfer function to ensemble averaged wind speed

vs „Loss Probability averaging“

Applying transfer function, then calculating the ensemble average of resulting probabilities



Brier Skill Score
for different lead times

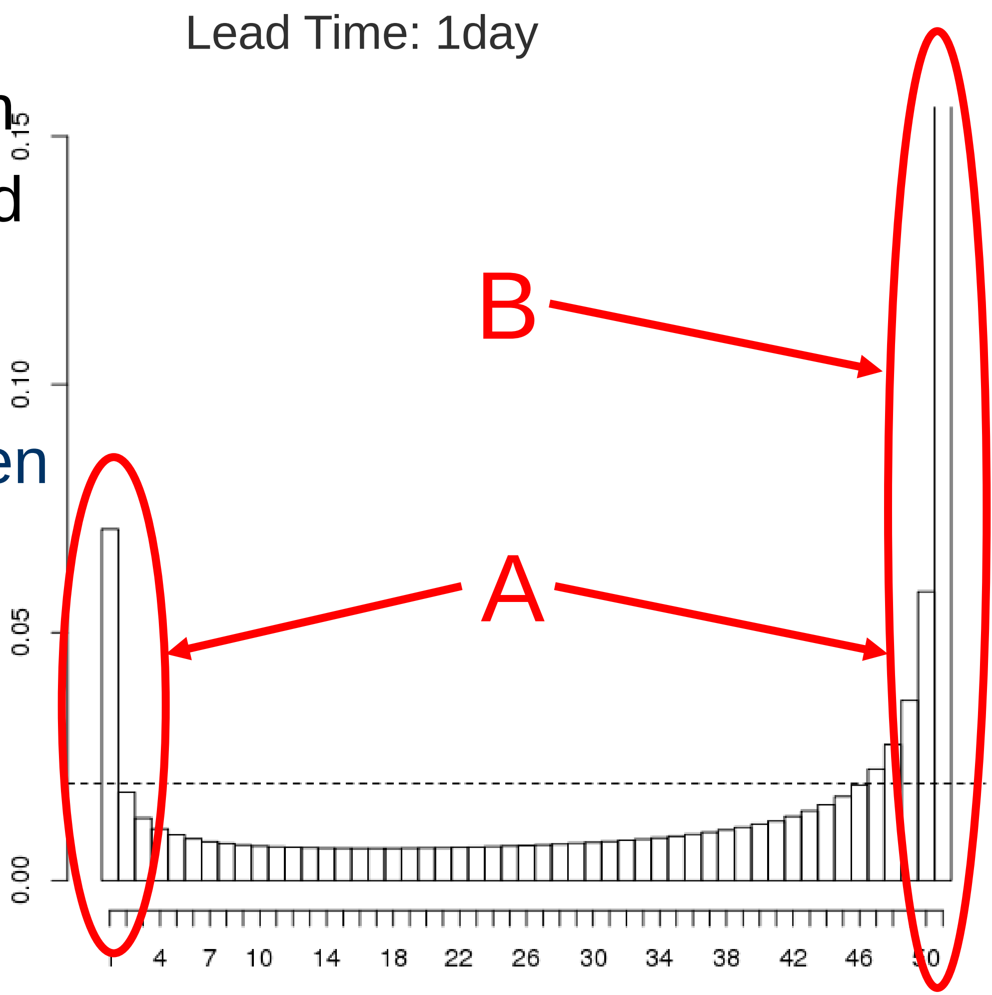


Improved score for ensemble mean using loss probability averaging!

Underdispersion of downscaled EPS

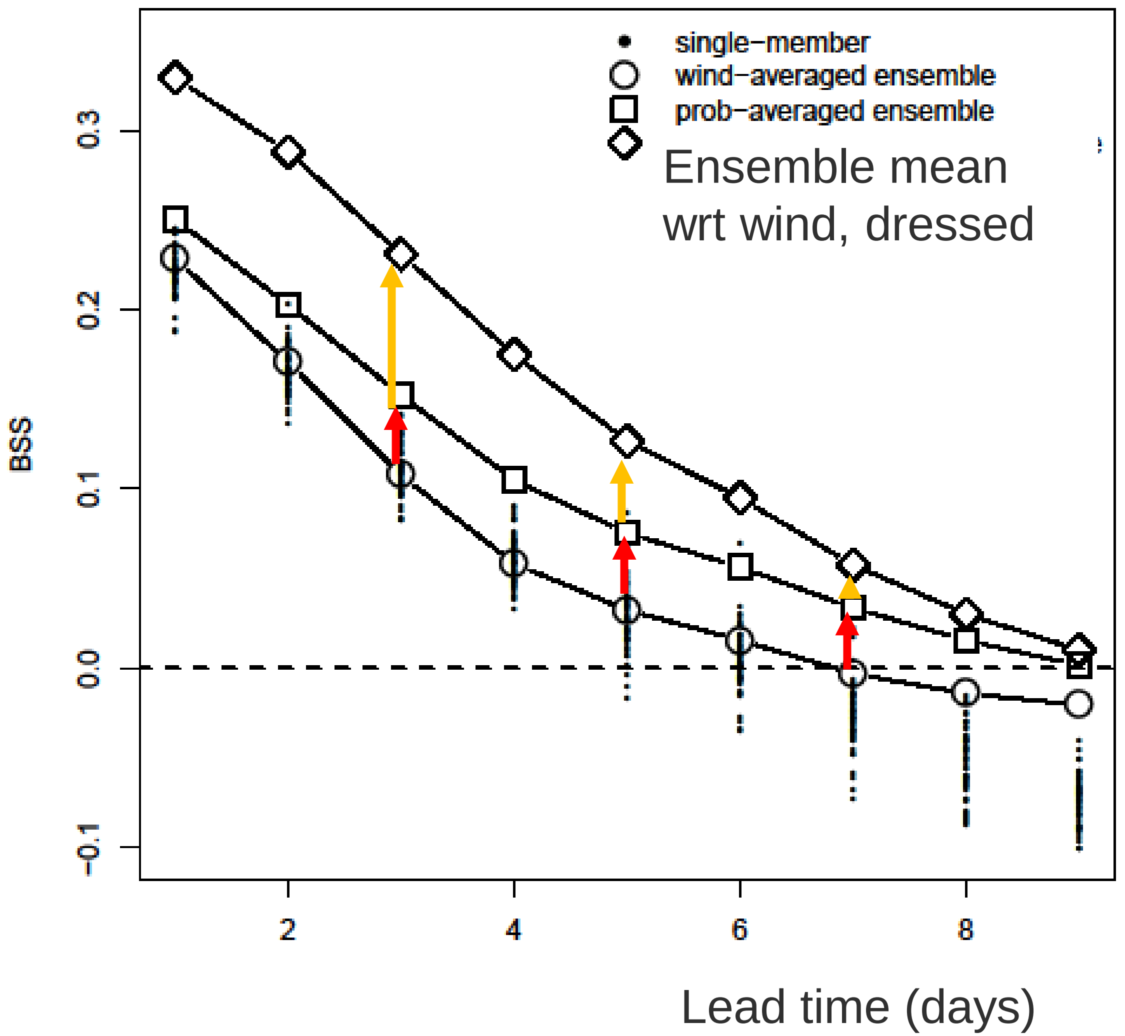
Rank histogram (Talagrand diagram): Where is observation (analysis) wrt the value-ordered ensemble ranks

- 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)



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