1. Introduction
We model the occurrence probability of severe weather – severe wind gusts (>25 m/s), tornadoes, large hail (>2 cm), and excessive rain (flash floods) – with predictors on the scale of global reanalyses and climate forecasts. The relationship between various predictors and severe weather probabilities is established with logistic regression models based on ERA-Interim reanalyses (Δx = 0.75°; available 1979-2013) and quality-controlled observations from the European Severe Weather Database (ESWD; reliably high coverage in central Europe since 2006). Afterwards it is applied to decadal climate predictions from the MPI-ESM system (Δx = 1.875°; 15 ensemble members per year initialized 1960-2011).

2. Methodology
We tested linear logistic regression and additive logistic regression models.
- Preliminarily two predictors: VCAPE and deep-layer shear (DLS)
- Maximum likelihood estimation of severe weather probability +/- standard error

3. Modeled severe weather probabilities [%]
Severe wind gusts
Tornadoes
Large hail
Excessive rain

Higher number of degrees of freedom can add „bulges“ and „dents“ to probability plane
- Extra degrees of freedom useful according to Likelihood Ratio Test!

• Modeled numbers of severe events do not fulfill χ² test (function too „stiff“)
• Linear logistic regression obviously not flexible enough, hence generalization to smooth additive predictors

→ relatively stronger dependence on DLS
relatively stronger dependence on CAPE →
4. ERA-Interim reanalyses vs. MPI-ESM climate hindcasts
Modelled annual number of severe weather events per 0.75° x 0.75° box, 1979-2013 average:

Performance of MPI-ESM:
- Overestimation of severe weather events due to simulation of too much CAPE (too cold mid-troposphere and too moist lower troposphere)
- Large-scale patterns well captured, but regional subtleties missed

Time series of modelled annual number of large hail events per 0.75° x 0.75° box averaged across 10 central European countries (mean and 95% confidence bands):

Decadal evolution:
- Weak decrease in SW Europe, no trends otherwise from 1980s to 1990s
- Pronounced increase from 1990s to 2000s
- Mostly tied to increase of CAPE, little change in DLS

5. Decadal trends in ERA-Interim reanalyses
Modelled annual number of severe weather events per 0.75° x 0.75° box, decadal averages:

6. Further plans
- Test alternative predictors for latent instability (e.g., maximum buoyancy and vertical wind shear (e.g., low-level shear)
- Introduce third predictor for likelihood of convective initiation
- Find objectively best set of predictors for each severe weather type
- Apply bias correction to MPI-ESM climate hindcasts

Acknowledgements: This study was funded by the German Federal Ministry of Education and Research (BMBF) as part of the MiKlip research programme under grant 01LP1117A.

References:

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