

Topic 6: Recent and future changes in the thunderstorm and hail potential

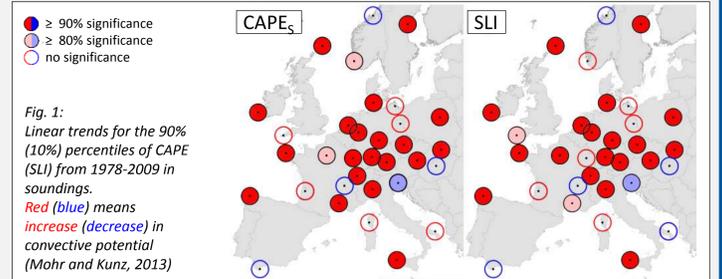
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motivation

Severe thunderstorms and associated extreme events such as hail represent a substantial hazard potential for buildings, crops, and critical infrastructure. Due to their local-scale extent and a lack of appropriate monitoring systems, hailstorms are not captured reliably and comprehensively for a long period of time, which hampers statistical analyses including estimation of trends.

Within the frame of the project **HARIS-CC** („HAIL RISK and Climate Change“) it is examined how and to what extent the convective potential represented by various proxy data has changed in the past and will change in the future.



Regional climate model (RCM) data from **IMK-TRO**, KIT (Berg et al., 2012):

- ✗ COSMO 4.8, resolution 0.0625° (~ 7 km)
- ✗ Driven with reanalysis data ERA40 (IMK40) and global climate simulations ECHAM5 Run1-3 (IMKR1, IMKR2, IMKR3), scenario A1B



CCLM consortium runs (CR) from CCLM-Community (Hollweg et al., 2008)

- ✗ COSMO 3.1, Datastream 2, resolution 0,165° (18 km)
- ✗ Driven with global climate simulations ECHAM5 Run1-2 (CRR1,CRR2), scenarios A1B & B1

Hindcast **CoastDatII** of HZG, Germany (Beate Geyer)

- ✗ COSMO 4.8 with spectral nudging, 0.22° (~ 24 km) resolution
- ✗ Driven by reanalysis data NCEP-NCAR 1



Building insurance data of **SV SparkassenVersicherung**

- ✗ period: 1992-2000, Baden-Wuerttemberg
- ✗ adjusted for inflation and corrected due to portfolio

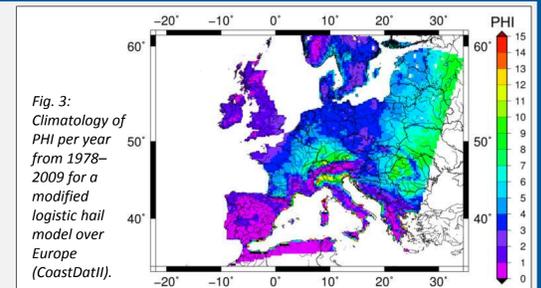


data base

PHI in Europe

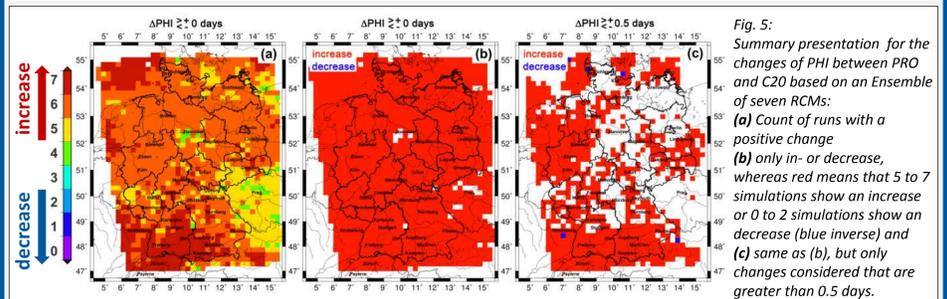
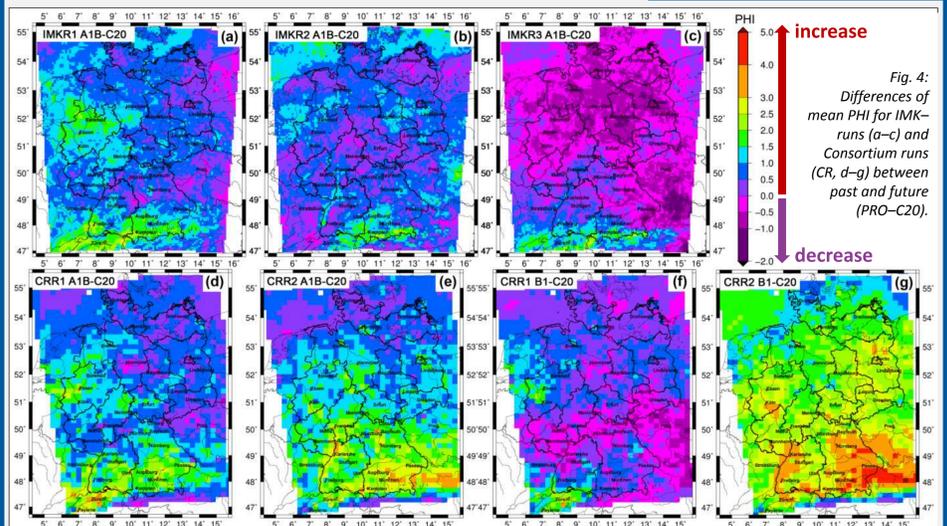
What is climatology of PHI in Europe?

- ✗ A **modified** logistic hail model shows high variability of PHI in Europe.
- ✗ High hail potential north and south of the Alps.



What changes of the hail potential can be expected?

PHI in the future



- ✗ Five of seven RCM runs show an increase in PHI with highest changes in South Germany.

logistic hail model

How can the diagnostic of hail events be improved?

method: Development / calibration of a logistic regression using reanalysis data (IMK40) and insurance data (SV) for Baden-Wuerttemberg

logistic hail model:

$$P_{\text{hail}} = \beta_0 + \beta_1 \cdot \text{SLI} + \beta_2 \cdot T_{\text{min}} + \beta_3 \cdot T_{2m} + \beta_4 \cdot \text{oWL} \quad \beta_1, \beta_2, \dots, \beta_6 : \text{regression coefficients}$$

$$P_{\text{hail}} = \begin{cases} 1 & \text{hail: YES} \\ 0 & \text{hail: NO} \end{cases} \quad \text{whereas } 0 < P_{\text{hail}} < 1$$

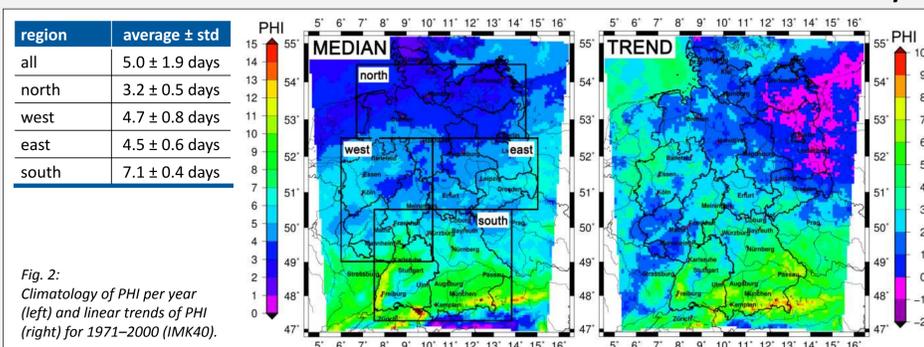
with:

- Surface Lifted Index at 12 UTC (SLI)
- Minimum temperature in the morning (T_{min})
- Surface temperature at 12 UTC (T_{2m})
- Hail-related and hail-unrelated objective weather types (oWL, see Mohr, 2013)

if $P_{\text{hail}} \geq 0.4 \rightarrow$ day with hail \rightarrow definition of **Potential Hail Index (PHI)**
[unit of PHI is the count of days with hail]

climatology & trends of PHI

What are mean and trends in PHI in Germany?



- ✗ Climatology of PHI shows a strong north-to-south gradient over Germany.
- ✗ Maxima located in the south, particularly in Rhine Valley and northeast of Munich.
- ✗ Positive trends of PHI with strongest changes in South Germany.

conclusions

- ✗ Improvement of analytical quality of hail events using a specified logistic hail model and development of a new index: **Potential Hail Index (PHI)**.
- ✗ Climatology of PHI shows a distinct north-to-south gradient over Germany and mainly a positive trend between 1971-2000. This agrees well with analyses of sounding data (Mohr and Kunz, 2013).
- ✗ A modified version of the logistic hail model confirms partly hail relevant regions known from literature.
- ✗ Ensemble of seven RCMs shows primarily positive changes (ca. 22 - 42%) of hail potential in the future in Germany (2021-2050 to 1971-2000).

Berg, P., Wagner, S., Kunstmann, H. & Schädler, G., 2012: High resolution RCM simulations for Germany: Part I - validation. *Clim. Dyn.*, 1-2, 1-14.
Hollweg, H. D., U. Böhm, I. Fast, B. Hennemuth, K. Keuler, E. Keup-Thiel, M. Lautenschlager, S. Legutke, K. Radtke, B. Rockel, M. Schubert, A. Will, M. Woldt, and C. Wunram, 2008: Ensemble simulations over Europe with the regional climate model CLM forced with IPCC AR4 global scenarios. Technical Report No. 3, Modelle & Daten (M & D), Hamburg, Deutschland, 152S.
Mohr, S. & M. Kunz, 2013: Recent trends and variabilities of convective parameters relevant for hail events in Germany and Europe. *Atmos. Res.*, 123, 211-228.
Mohr, S., 2013: Änderung des Gewitter- und Hagelpotentials im Klimawandel. Wissenschaftliche Berichte des Instituts für Meteorologie und Klimaforschung des Karlsruher Instituts für Technologie, Band 58, Karlsruhe, Deutschland (ISBN 978-3-86644-994-7).