

First results of climate change impacts on severe convective storms in Europe

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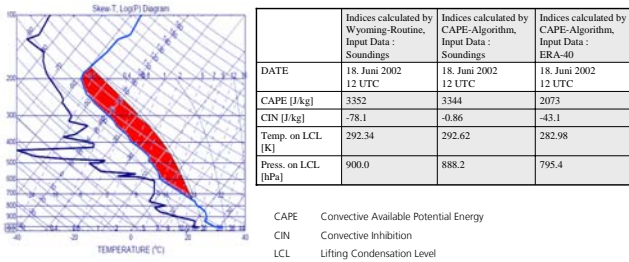
Motivation

Severe thunderstorms are a major meteorological hazard. To consider the impact of climate change on these storms, it is necessary to assess atmospheric conditions, e.g. via sounding-derived convection-indices. Therefore, an algorithm was developed for calculating reversible mixed-layer CAPE and deep-layer wind shear from 3-dimensional meteorological fields. This is in line with recent investigations by Brooks (2006, 2007) and Trapp et al. (2007) for the United States. Our present study **extends the analysis to Convective Inhibition (CIN)**. This study is focussed on Central Europe and will eventually provide an assessment of the thunderstorm probability for the current atmospheric situation and how this state is going to change due to climate change scenarios.

Data

- The current atmospheric state (1958-2001) is evaluated by analysing ERA-40 reanalysis data at full vertical model level resolution. (horizontal resolution 1.125°, 6h time resolution, atmospheric fields: wind, temperature, specific humidity, pressure).
- Verification of the ERA-40 parameters is attained by comparing the results with those from radiosondes (<http://weather.uwyo.edu/upperair/sounding.html>) and severe storm reports from the European Severe Weather Database (www.esrl.org/ESWD/, Dotzek et al. 2008).
- Future trends will be derived from simulations of the regional climate model CLM (www.clm-community.eu, Scenarios A2, A1B, B1).

Verification example: 18 June 2002 – 12 UTC, de Bilt (NL) – severe hailstorm day



Background: German research project RegioExAKT

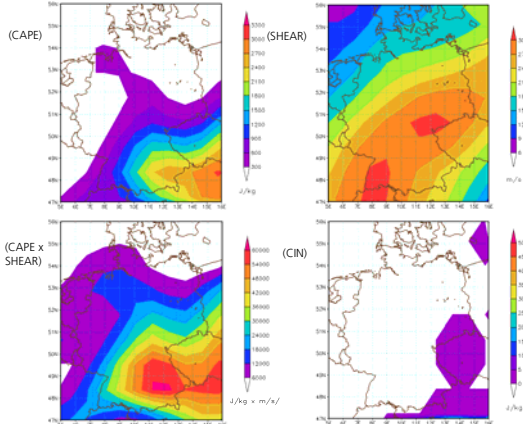
„Regional Risk of Convective Extreme Weather Events: User-oriented Concepts for Trend Assessment and Adaptation“

Main objective: Determination of the climatic trends in occurrence of, and threat by, severe convective storms in Germany until 2030, as well as the development of adaptation concepts for targeted main users (Munich Re Group, Munich international airport) on the spatial and temporal scales relevant for their business operations.

Internet portal : www.regioexakt.de

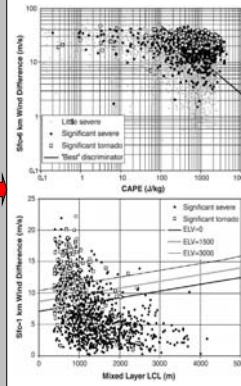


Case study: 12 July 1984 – 18 UTC Munich hailstorm

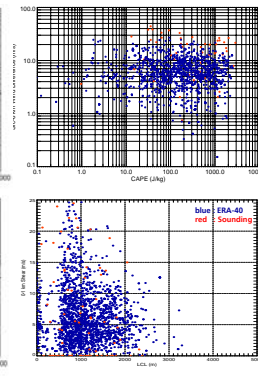


Brooks et al. (2003) and Trapp et al. (2007) advocated the **product of CAPE and deep-layer vertical wind shear** in order to estimate severe thunderstorm probability. Our analysis also confirmed that **CIN** was approaching zero at the time of convective initiation.

USA, Brooks et al. (2003)



Europe (present study)

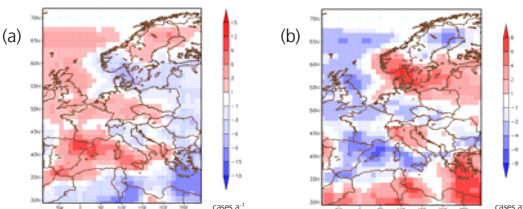


The figures show the distribution of calculated indices for severe convective events (damaging winds, large hail, tornadoes, floats, etc.) in Europe.

Johns, Davies and Leftwich (1993) derived a hyperbolic relation of CAPE and vertical wind shear in the environment of a tornado. Brooks et al. (2003) product of CAPE and vertical wind shear shows:

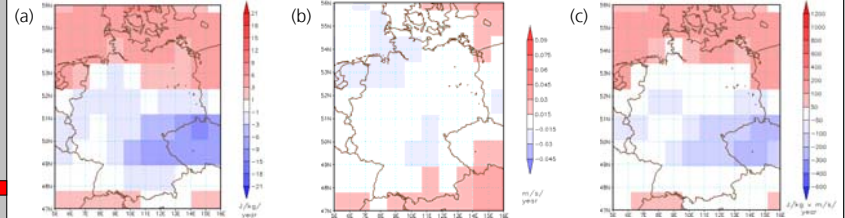
- broad distribution of non-severe thunderstorms in CAPE and shear values
- distribution becomes narrower for more severe thunderstorms
- tornadoes primarily in connection with high shear values.

Annual zero CAPE (a) and CAPE < 500 J/kg (b) trends (1979-2001)



Over Western Europe, there is an increase in zero CAPE cases. Northern Italy, Southern Norway and Greece show an increase in situations with CAPE between 0 and 500 J/kg.

90th percentile trend for CAPE (a), SHEAR (b), and CAPE x SHEAR (c) between 1979 and 2001



The change of a single convection-index alone does not necessarily imply a change in severe thunderstorm probability. Thunderstorms are complex mesoscale phenomena and need a synopsis of trends in all relevant parameters, including CIN (Colby, 1984).

Conclusions

- Convection indices can be evaluated from reanalysis data with resolution of more than 100 km.
- It is important to make a synopsis of all relevant parameters to get robust results. The change of a single convection-index alone does not necessarily imply a change in severe thunderstorm probability.
- There are weak trends in different CAPE-classes over Europe in recent decades. Given the inherent uncertainties of reanalysis data, the significance of these trends need further confirmation.

References

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- Trapp, R. J., Dillenbaugh, N. S., Brooks, H. E., Baldwin, M. E., Robinson, E. D. and J. S. Pal, 2007: Changes in severe thunderstorm environment frequency during the 21st century caused by anthropogenically enhanced global radiative forcing, Proc. Nat. Acad. Sci., 104(50), 19719-19723.