EXTREME WEATHER EVENTS IN SOUTHERN GERMANY – CLIMATOLOGICAL RISK AND DEVELOPMENT OF A LARGE-SCALE IDENTIFICATION PROCEDURE

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I. INTRODUCTION

Extreme weather events like thunderstorms, hail and heavy rain or snowfall can pose a threat to human life and to considerable tangible assets. For example on July 12th 1984 an intensive hot spell ended by advection of cool westerly air masses entailing extreme weather phenomena around the frontal zone. One of these events, known as the “Munich Hailstorm”, caused overall losses of about 950 mill. US-$ including damages on more than 200.000 cars, 70.000 buildings and 180 aircrafts. Several greenhouses have been devastated by hailstones of up to 5 cm in diameter (testified maximum 9.5 cm) accumulating to vast layers of more than 10 cm. About 400 people have been injured by hail and consequences of heavy rain and wind gusts. Yet there is a lack of knowledge about present day climatological risk, its economic effects and its changes due to rising greenhouse gas concentrations. Therefore, parts of economy particularly sensitive to extreme weather events such as insurance companies and airports, require regional risk-analyses from warning time scale to longer term estimations.

II. METHODOLOGY

In this study an attempt to evaluate climatological risk of extreme weather events for southern Germany in close cooperation with stakeholders is made in a three-step-strategy. At first the extreme weather periods in summer and winter are identified via the connection of meteorological station data and impact data of project partners Munich Re and Munich Airport. The representation of extreme precipitation events in model data of recent climate is validated for ERA40 reanalyses. Diagnosis of large-scale processes causing these events is accomplished by classifying characteristics, intensity and frequency of relevant situations. In order to estimate the risk under anthropogenic climate change, findings will be transferred to simulations of AOGCM ECHAM5-OM1 and RCM CLM (driven by ECHAM5-OM1) by assessing changes in relevant circulation structures compared to recent climate.

III. RESULTS

Before starting to identify extreme weather events thresholds have to be defined to distinguish extreme from non-extreme events with respect to stakeholder’s requirements. Comparing ERA40 and station data with impact records of Munich Re and Munich Airport, the 90th percentile of precipitation was found to be a suitable threshold for extreme impact relevant precipitation events (Matthies et al., 2008).

At step two of this study, parameters are identified capable to assess large-scale conditions leading to extreme events. For correct classification of the large-scale flow conditions in southern Germany an objective scheme for the classification of Lamb's circulation weather types (CWT's) according to Jones et al. (1992) has proved to be most suitable. Certain CWT's have been turned out to be prone to heavy (e.g. northern, western, cyclonic and anticyclonic) and extreme precipitation (e.g. western and cyclonic, in winter also anticyclonic) or on the other side to have a very low risk of such events (e.g. southern CWT’s). Analysing the probability of precipitation exceeding the 90th percentile spatial patterns show systematic underestimation in ERA40 compared to observations. Characteristics of horizontal distribution of extreme precipitation probability are reproduced well and further analyses of processes causing extreme events are thus reasonable. Other large-scale parameters are tested additionally and in connection with CWT's to analyse the most suitable combination revealing the highest skill to identify extreme precipitation events in climate model data. The newly developed Dynamic State Index (DSI) already showed good skills tagging hurricanes (Weber and Névir, 2008) and frontal precipitation (Claussnitzer et al., 2008). For this study the DSI was used in two ways. At first to identify severe convective situations a Thunderstorm Index (TI) was created combining DSI at the 600 hPa level and CAPE (1).

$$TI = \left|DSI\right|^{0.5} * CAPE^{0.5} \qquad (1)$$

This index was tested in a case study of the “Munich Hailstorm” in ERA40 (Fig.1). The value reached in the grid-box containing Munich is the highest in 40 summer half years (1961-2000). Further results indicate that in combination with the anomaly of the amount of precipitable water in the atmosphere, the TI is capable to identify extreme convective events in summer. Systematic tests are in progress. Concerning extreme large-scale events such as frontal precipitation the DSI in this study was secondly combined with differential advection of temperature as a measure of instability. First results for both summer and winter are not as good as for the combination identifying convective summer events. Testing vertical profiles of DSI instead of single pressure levels is part of ongoing work.

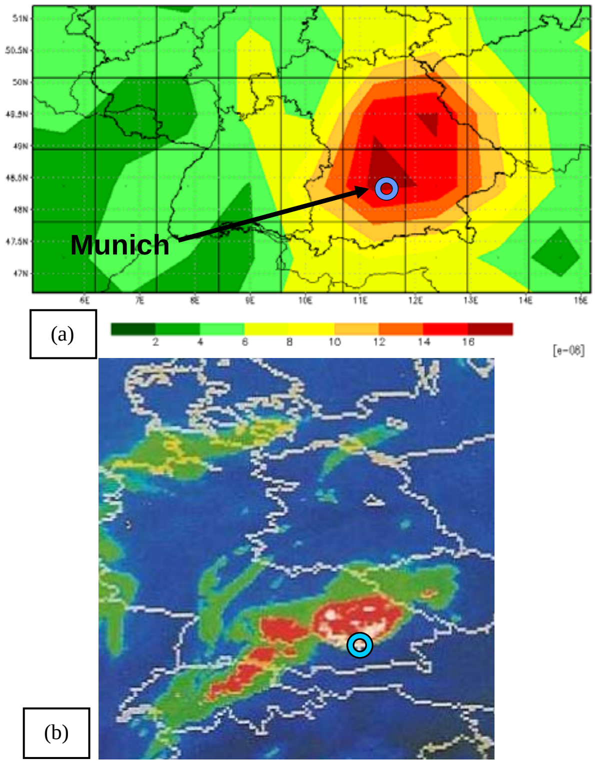

FIG. 1: (a) TI on July 12th 1984, 18UTC and (b) satellite image of same date and time (German Weather Service)

IV. CONCLUSIONS

Parameterisation of precipitation in global climate models suffers from large uncertainties. In this study large-scale parameters are tested in connection with CWT's to find a combination that has the highest skill to identify extreme precipitation events in gridded data. For convective summer events a combination of CWT's, the new Thunderstorm Index and precipitable water seems to work well. Large-scale events so far are identified best by a combination of CWT's, DSI and differential temperature advection, but testing of additional parameters is in progress. In the third step of this study the findings will be transferred from reanalyses to simulations of global and regional climate models. The aim will be to detect if the frequency of exceeding the thresholds of these extreme event combinations changes or if there is a change in intensity of exceedance that can be credited to anthropogenic climate change according to IPCC scenario A1B.

V. REFERENCES

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