REGIOEXAKT – REGIONAL RISK OF CONVECTIVE EXTREME WEATHER EVENTS: USER-ORIENTED CONCEPTS FOR TREND ASSESSMENT AND ADAPTATION

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www.pa.op.dlr.de/RegioExAKT/info/index_en.html

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I. INTRODUCTION

Extreme weather events from severe thunderstorms (damaging winds, hail, heavy precipitation and tornadoes) pose a threat to life and safety of European citizens and lead to significant property damage. For Germany, the Munich Reinsurance Group estimates a total damage of € 1 to 2 billion per year. For Europe as a whole, thunderstorms are likely to cause € 5 to 8 billion annual total damage. A field of particular concern, and also at the cutting edge of science, is the estimation of regionalised severe convective storm risk in a changing climate with time horizon 2030 and beyond.

There is a strong demand for regionalised hazard assessments and adaptation strategies by weather-sensitive economic sectors like the insurance industry, airports, water management, and also national weather services like the DWD in Germany in its efforts for optimisation of forecasts and warnings of such events. The adaptation of existing building codes with respect to wind loads and precipitation maxima to climatic trends in extreme weather events is also economically relevant. From these target groups, Munich international airport (Fig. 1) and the Munich Re Group were chosen as exemplary users and project partners.

FIG. 1: Munich international airport, one of the targeted users.

The BMBF-funded klimazwei-project links the users with an interdisciplinary research group (see project website). The three-year project which started in January 2007 develops hydro-meteorological and insurance-related scenarios of extreme weather events following from regionalised climate and vulnerability projections compared to an assessment of the present state. Together with new wind zone maps for Germany, this helps to enable timely adaptation of insurance business strategies or building codes. For Munich airport, an optimised thunderstorms nowcasting (using polarimetric radar and total lightning data) and drainage is developed based on the current situation and climate change scenarios. On behalf of the whole RegioExAKT consortium, this paper highlights selected results after two thirds of the project time.

II. RESULTS

Meteorological reanalysis and model data (ERA-40, regional and global climate, weather forecasting), wind- and water engineering, socio-economic approaches, advanced remote-sensing and in-situ observational tools are available to address and satisfy user demands for adaptation guidance. The assessment of the economic and climatologic hazard of severe thunderstorms is strengthened by the recent availability of a pan-European severe weather database, ESWD (Fig. 2, www.essl.org/ESWD/, Dotzek et al., 2009).

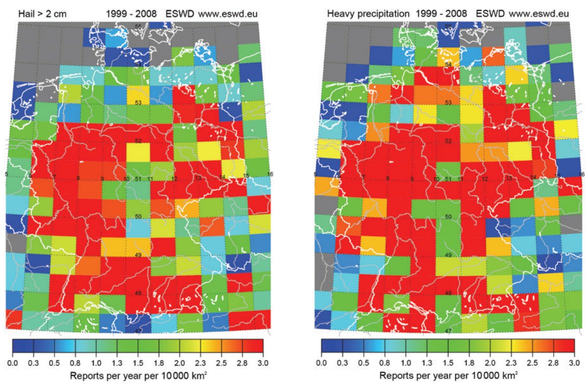

FIG. 2: Incidence (reports per year and per 10,000 km2) of large hail (left) and heavy precipitation (right) in Germany between 1999 and 2008 on a 0.5° x 1° latitude-longitude grid based on the ESWD.

Hazard assessment for various severe thunderstorms phenomena based on ESWD reports is enhanced by evaluation of thunderstorm parameters in ERA-40 reanalysis data. The physical parameters evaluated are surface-based and mixed-layer convective available potential energy (CAPE), convective inhibition energy (CIN), deep-layer (0-6 km AGL) wind shear and the product of $(2\ \mathrm{CAPE})^{1/2}$ x deep-layer shear. The latter is the main metric for severe thunderstorm potential. Note that CAPE alone is not a useful metric of thunderstorm potential. The ERA-40 analysis does not show significant trends in severe thunderstorm potential over Germany in the period 1979-2001.

ERA-40 data are also being applied to evaluate precipitation extremes against rain gauge observations in the recent decades and to identify the main weather patterns responsible for high precipitation events in (southern)

Germany. In addition, a long-term ECHAM5 climate model run pointed to no significant changes in annual maxima of daily precipitation until about 2030, but an increased variability of these extremes afterwards.

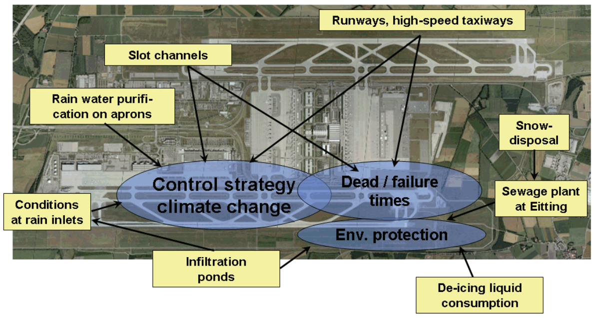

FIG. 3: Adaptation options of the Munich airport drainage and water management system.

The analysis of the water management and drainage facilities at Munich airport helped to identify quite a number of options to adapt to potentially higher precipitation extremes in the future and to optimise the current procedures. These measures are summarised in Fig. 3 and encompass both the climate change control strategy and environmental protection or the reduction of periods in which the runways and taxiways are not fully serviceable due to heavy rain or post-rain water layers.

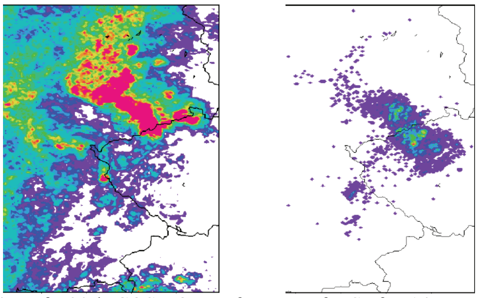

FIG. 4: Left: 20-h COSMO-DE forecast of DSI for 14 May 2007, 2000 UTC, right: verification by LINET-measured number of flashes between 2045 and 2115 UTC.

The development of short-term forecasting and nowcasting algorithms is illustrated in Fig. 4 which shows a 20-hour forecast field of the dynamic state index (DSI, Névir, 2004), verified by total lightning observations (ground and cloud flashes).

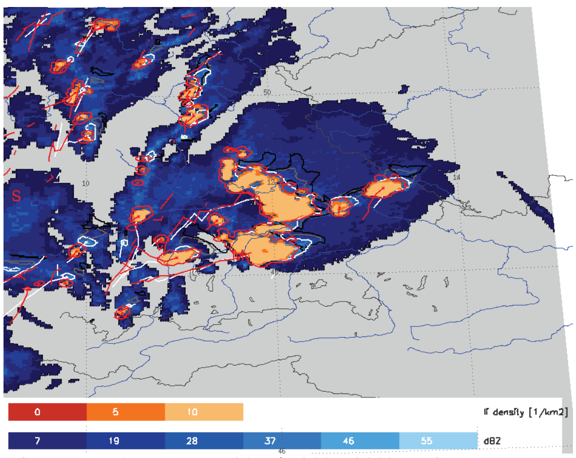

FIG. 5: ec-TRAM nowcast 21 July 2007, 2000 UTC.

The same total lightning data sampled by the LINET system is also used in the nowcasting algorithm ec-TRAM which combines radar data (cell identification and tracking) and LINET (also grouped in "cells" and tracked). Fig. 5 gives an example of a major thunderstorm day in southern Germany. This algorithm can also exploit polarimetric radar data as available with DLR's POLDIRAD radar and the next generation of DWD's operational radar network. This will improve the identification of the thunderstorms life cycles. Aside from the early detection and warning of hazardous cells approaching Munich airport, it is also possible to nowcast the time when the hazardous situation at the airport will be over – an important, cost-saving point in air traffic management (ATM) and air traffic control (ATC).

III. CONCLUSIONS

After about three quarters of the project, we can identify this set of conclusions and recommendations:

- Severe thunderstorm parameters can be evaluated from large-scale fields, like those produced in the ERA-40 reanalysis or CLM regional climate model simulations;
- For recent decades and the present state, there is apparently no significant trend in severe thunderstorm environments;
- Initial results for the future climate rather point to an enhanced variability of extremes after about 2030, than to a trend in the average level of severe convective storm activity;
- The popular quantity CAPE should not be used on a stand-alone basis to draw conclusions on future severe thunderstorm occurrence. This holds in particular for surface-based CAPE being dominated by the predicted surface values of temperature and water vapour. Instead, mixed-layer CAPE should be used in concert with parameters like CIN and deep-layer wind shear;
- For drainage and water management in urban infrastructures, effective adaptation measures can be developed. Similar arguments hold for current and future wind loads, for which RegioExAKT provides new wind zone maps and novel high-resolution measurements of gustiness for various wind events (winter storms, squall lines, downbursts);
- The application of DSI in short-term thunderstorm forecasting and of radar and total lightning data in nowcasting algorithms shows promising results and a large potential for user-friendly display interfaces.

The remaining project time will focus on the climate change impact analysis and refinement and synthesis of results.

IV. ACKNOWLEDGMENTS

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V. REFERENCES

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