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Extreme weather events in southern Germany – Climatological risk and development of a nowcasting procedure

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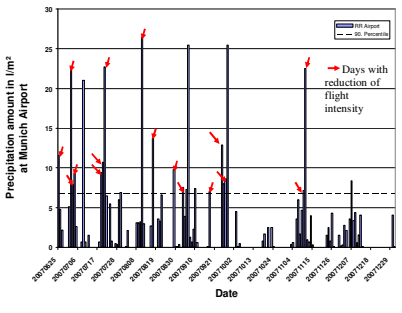
Introduction

Extreme weather events such as thunderstorms, hail and heavy rain or snowfall can pose a threat to human life and to considerable tangible assets. Yet there is a lack of knowledge about present day climatological risk and its economical 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, early warning and prediction systems to cope with such events. Such an attempt is made for southern Germany, in close cooperation with stakeholders. The study will also develop an optimized nowcasting procedure, wich will initially be tested at Munich Airport. This study is part of RegioExAKT, a collaborative BMBF klimazwei-project.

Climatological risk

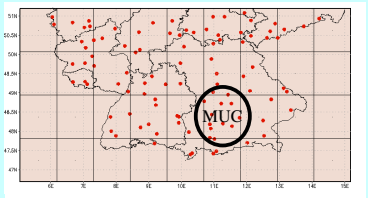
Analysis of observations with impact records of Munich Airport



Days with precipitation above the 90th percentile at Munich Airport have been analysed with a list of days with flight reduction due to weather events.

An examination of hourly precipitation data of the 7 strongest events did not reveal strong coherence between flight reduction and precipitation rates. This might indicate that precipitation has to be combined with other parameters such as wind and a human factor has to be considered in the impact lists.

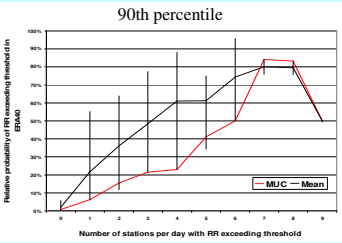
Analysis of ERA40 with observations

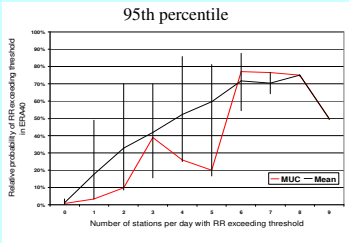


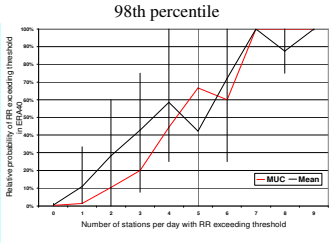
ERA40-grid of southern Germany with synoptic stations of the DWD; highlighted: gridbox containing Munich

The three figures below show the relative probability of precipitation above the 90th, 95th and 98th percentile in ERA40 gridboxes depending on the number of stations contained in these boxes exceeding this percentile.

Displayed are the graphs for the gridbox MUC containing Munich, the mean over all gridboxes and the range lines embracing the probabilities for all gridboxes.







New nowcasting and forecasting procedure

$$\mathrm{DSI} = \frac{1}{\rho}\,\frac{\partial(\Pi,\theta,B)}{\partial(x,y,z)}.$$

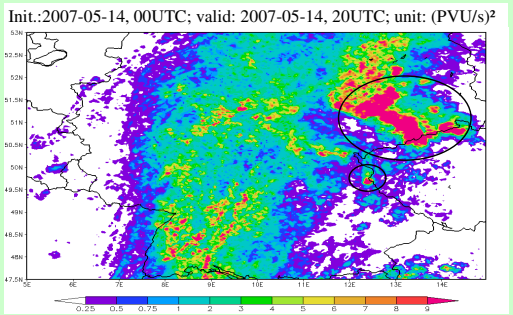
ρ: Density Π: Potential vorticity

Θ: Potential temperature

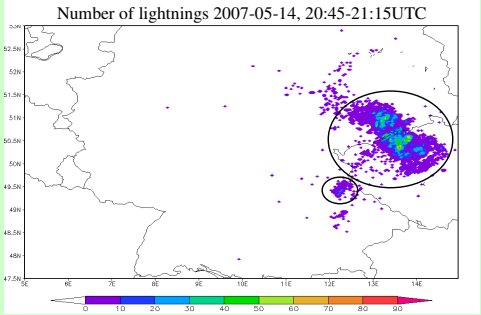
B: Bernoulli-Streamfunction

The Dynamic State Index (DSI) describes the deviation from a statationary, inviscid, dry solution of the adiabatic primitive equations (Weber and Névir, 2008). Therefore the index denotes the sum of non-stationary, diabatic and moist processes and friction in the atmosphere.

Calculating the DSI with the non-hydrostatic COSMO-DE (DWD, 2006) convective cells and thunderstorms can be detected as deviations from this solution. Here, the convective instability as well as the release of latent heat can be diagnosed and predicted.



20-hour DSI-forecast with COSMO-DE for 2007-05-14



Lightning data of that day by project partner NowCast GmbH

Overall goal of this part of the project is to establish a forecast procedure of lightning and extreme thunderstorm events, using the newly designed Dynamic State Index as an application of the Energy-Vorticity Theory of fluid mechanics.

Summary/outlook

The 90th percentile was chosen as threshold for extreme precipitation events because the fit between station data and ERA40 reanalyses is best for this percentile. Also this seems to identify amounts of precipitation that lead to reduction in flight intensity at the airport. Ongoing work deals with the identification of large-scale pre-conditions of extreme events in ERA40 and present day model simulations of ECHAM5-OM1 and CLM and the detection of a potential climate change signal in szenario simulations of these climate models. The DSI will also be examined concerning a possible anthropogenic climate change signal in lightning activity. Furthermore the early warning potential of the DSI for the indentification of extreme weather events will be tested in a consistent time series from May to September 2007 simulated with COSMO-DE.