ABSTRACT

In June and August 2003 Europe suffered an extreme heat wave and dry spell which caused about 50,000 fatalities and economic losses totaling 18 billion €. In Southeast Germany the dry spell and high air temperatures of up to 40 °C caused low flow conditions in many rivers and extremely high water temperatures of up to 28 °C. In France and Germany several nuclear power plants had to reduce their production due to a lack of cooling water and temperatures exceeding the legal limit of 30 °C. A similar heat wave occurred in July 2006 in Southeast Germany. The heat waves and dry periods in summer have mostly been linked to the atmospheric circulation type (CP) “Ridge of high pressure over Central Europe” (BM) combined with a few additional types which can therefore be called “critical” CPs. The results of the time series analysis of the “critical” CPs will be demonstrated for the period 1881-2006. Frequencies and maximum persistence of the “critical” CPs show highly significant increasing trends and step changes in 1972 for summer (June - Aug.) and the vegetation period (May – Sept.) during the meant three decades. In particular, the increasing maximum persistence of the “critical” CPs since 1972 indicates an increased risk of getting more severe heat waves and dry spells in large parts of Western and Central Europe. The heat waves of June and August 2003 and July 2006 have been responses of the climate system to an already changed summer climate for large parts of Europe.

Questions:
1. What circulation types (CP) have caused the dry spell and heat wave in Southwestern Germany in the summer of 2003 and 2006?
2. Do these “critical” CPs show significant changes in frequency and maximum persistence within the observation period 1881-2006?
3. Are the recent dry spells and heat waves of 2003 and 2006 already signals of a changed climate in Southwestern Germany?

Data used

European atmospheric circulation types (Grossweatherlagen Europas) of the German Weather Service (DWD) Time series: 1881 until Sept. 2006.

Daily mean temperatures for 35 stations of southern Germany

RESULTS

Fig. 1: Daily mean temperature anomalies [°C] in summer 2003 (JJA) and July 2006 compared to 1961-1990 for 35 stations of southeast Germany. German Weather Service (DWD), 2003 & 2006.

Fig. 2: Map of perceived temperatures in Europe on August 5, 2003 at 13:00 UTC (left) with number of victims of the heat wave for different countries. German Weather Service (DWD), 2006.

Fig. 3: Sun level pressure (SLP) anomaly of circulation type “Ridge of high pressure over Central Europe” (BM).

Fig. 4: Sun level pressure (SLP) anomalies for “critical” circulation types “High across Norwegian Sea [northern anticyclone]” (BM) and “Southwest, anticyclone” (Sia) in summer (JJA) 2003.

Fig. 5: Circulation type “Ridge of high pressure over Central Europe” (BM) for summer (JJA) of the observation period 1881-2006: a) Frequencies [%], b) min. persistence of BM-periods (days), c) Tmax (°C) (running average 11 years), d) maximum persistence of BM-periods (days), e) Tmax (°C) (running average 11 years), f) occurrence in 1972.

Fig. 6: CP “Ridge of high pressure over Central Europe” (BM) for vegetation periods (July-Aug.) of the observation period 1881-2006: a) Frequencies [%] b) Right max. persistence of BM-periods (days), c) Change in persistence and breakpoint in 1972 on the 95% level of significance for both parameters frequency and max. persistence.

Fig. 7: Mor. persistence Tmax [°C] as a function of frequency [%] for circulation type BM in summer (JJA) of the observation period 1881-2006 compared to the breakpoint at 1972 for BM in the “critical” sectors before and after the breakpoint (1972).

Conclusions

The heat waves and dry spells of June and August 2003 and July 2006 were mostly linked to the atmospheric circulation type (CP) “Ridge of high pressure over Central Europe” (BM) combined with a few additional types. “High pressure over Norwegian Sea – Iceland, anticyclone” (BM) and “Southwest, anticyclone” (Sia) which can therefore be called “critical” CPs.

CP “Ridge of high pressure over Central Europe” (BM) shows a highly significant (99% level) increasing trend for frequency in summer and max. persistence of BM-periods for summer (JJA) and also for the vegetation period (July-Aug.) of the period 1881-2006.

Non-parametric tests of the time series of the “critical” CP BM indicate that non-stationarity of the summer (JJA) frequencies and maximum persistence show a highly significant step-change in 1972.

The risk of getting an extreme summer within the “critical sector” (≥ 28 °C) has increased dramatically after the breakpoint for the period 1973-2006 compared to the period 1881-1972 by a factor of 15!!

Statistical analysis of frequencies and maximum persistence of the combined CPs BM-Sia shows highly significant (95%-level) increasing trends for summer (JJA) of the period 1881-2006.

The observed increase in frequency and maximum persistence of CPs producing heat waves and dry spells in summer is consistent with regional studies for southern Germany obtained in the KLIWA project (www.kliwa.de) as well as international studies with IM Klima (EU-research project “PRUDENCE” http://prudence.demi.dk/).

It also coincides with the results and prefarations of the FPC IPCC-WGII (2007) projects for Central and Eastern Europe a decade of extreme precipitation, causing higher water stress. Health risks due to heat waves are pre- sented to increase.

The heat waves of June and August 2003 and July 2006 combined with the high economic losses and large number of victims have been responses of the climate system to an already changed summer climate for large parts of Western and Central Europe.

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