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KNMI Research

High resolution observations for climate change monitoring of extremes

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Introduction

A basic requirement for the monitoring of climate extremes is the availability of (and access to) high resolution observation data from meteorological stations. Availability of high resolution observation data is also required for delivering climate change information services in support of adaptation measures.

In Europe, the station network for near-surface climate observations is managed by a large number of predominantly National Meteorological and Hydrological Services (NMHS). Although each of these NMHS has its own data archive and its own data distribution policy, they are convinced that sharing their data is essential for assessing climate change in a European and worldwide context. KNMI has developed a framework which enables sharing and analyzing high resolution observation data. This highlight describes the approach, recent progress and future plans for this activity.

The activities under the umbrella of ECA&D provide vital ingredients for a successful monitoring of climate extremes in Europe

European Climate Assessment & Dataset (ECA&D)

The need for exchanging observation data with higher temporal and spatial resolution than available in existing international databases formed the motivation for the EUMETNET-European Climate Support Network (ECSN) to

start the project “European Climate Assessment & Dataset (ECA&D)” in 1998. The goal was to realize a sustainable operational system for gathering, archiving, quality control, analysis and dissemination of high resolution data.

The data gathering aspect refers to the collection of long-term daily resolution climatic time series from meteorological stations throughout Europe and the Mediterranean. Currently, over 50 countries participate. The archiving aspect refers to the transformation of time series to standardized formats and subsequent storage in a centralized database system at KNMI. Quality control refers to the use of standard procedures to check the data and attach quality and homogeneity flags. Analysis refers to the calculation of derived indices for climate extremes, such as the number of frost days or the number of high precipitation events, according to internationally agreed procedures. Finally, dissemination refers to making available to users both the daily data (including quality flags and homogeneity information) and the derived indices. Most of the daily series and all derived indices information (including time series plots, trend maps, anomaly maps and climatology maps) are publicly available at <http://eca.knmi.nl>. Among the users is the European Environment Agency (EEA)¹.

The ECA&D database has seen important updates over the past few years, significantly extending the number of stations and variables². To meet the changing requirements towards near real-time information, many of the scripts leading to the derived indices were made more computationally efficient in 2009. Data from synoptic messages distributed through the Global Telecommunication System (GTS) are now collected and merged as near real-time supplements to the climatic

time series. The amount of metadata in the database has been increased and made accessible via the ECA&D webpage. This information is required for the correct interpretation of the observational series. The metadata now includes not only station location, but also such things as pictures of the observing site, surface coverage information, station relocations, and (changes in) observing practices where available.

The analysis of changes in the frequency and strength of extremes using derived indices in ECA&D continues to be aligned with worldwide indices activities³. To illustrate the use of derived indices for analyzing observed changes in moderate extremes, Figure 1 shows the trends in the index “precipitation fraction due to very wet days (above the long term 95 percentile)”. This index can be used to investigate whether there has been a relatively larger change in extreme precipitation events than in the total amount. At stations where the total annual amount

increases, positive trends in this index indicate that extremes are disproportionately increasing more quickly than the total. At stations where the annual amount decreases, positive trends in this index indicate that very wet days are less affected by the trend in the total compared to the other wet days. Negative trends indicate a smaller than proportional contribution of very wet days to observed changes in total precipitation.

Figure 1a shows a positive trend in this index of 0.46 % per decade for De Bilt. The majority of the precipitation series in the Netherlands (Figure 1b) and Europe (Figure 1c) also show a positive trend in this index, indicating a disproportionately large change in the extremes relative to the total amounts. The Europe-average trend over the period 1946-2008 is 0.32% per decade (95% confidence interval: 0.14-0.51%). This supports the notion of a relatively larger change in extreme precipitation events compared to the annual

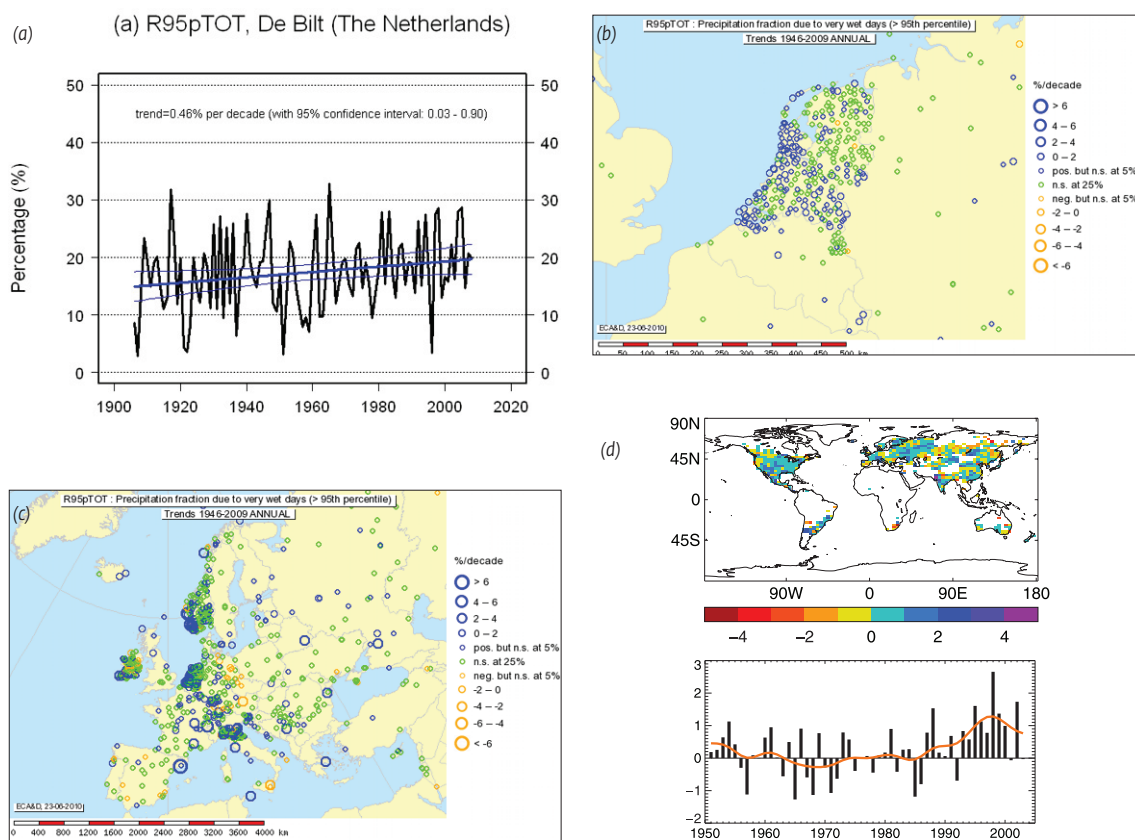


Figure 1. Observed trends in the extremes index “precipitation fraction due to very wet days” derived from daily ECA&D series: (a) the time evolution at station De Bilt (blue lines indicate the trend and its 95% confidence interval); (b) the trends over the period 1946 to 2009 at stations in the Netherlands; (c) the trends over the same period at stations in Europe; and (d) the worldwide trends between 1951 and 2003 and the anomalies averaged over grid cells with data. Source: <http://eca.knmi.nl> and 4). The analysis consists of the following steps: 1) identification of the very wet days in the daily precipitation series using a site specific threshold calculated as the 95th percentile of wet days in the 1961-90 period; 2) determination of the percentage of total precipitation in each year that is due to these very wet days; and 3) calculation of the trends in the time series of these yearly percentages. The maps show that positive trends dominate, but information is only available for roughly half of the global land area.

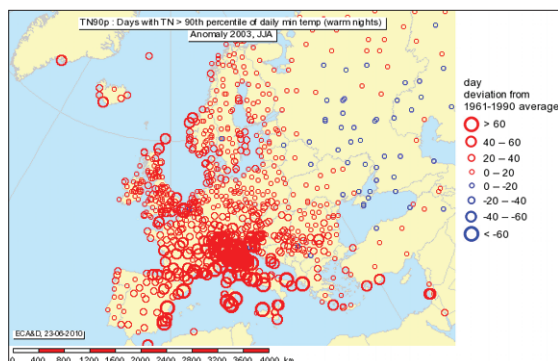


Figure 2. Use of ECA&D station series to describe the heat wave summer of 2003 in Central and Western Europe with the extremes index “warm nights”. For every station, the circle represents the number of nights with minimum temperature falling in the long-term 90th percentile range for the local climate. The size of the circle is proportional to the number of nights: blue indicates fewer “warm nights” than the climatological value and red indicates more “warm nights” than the climatological value. During summer 2003 in particular, the number of “warm nights” was much higher than usual in a large part of Central and Western Europe (red circles dominate the map). In areas with large red circles, there have been more than 40 additional “warm nights” compared to a normal summer season. This anomaly corresponded with mean summer temperatures that were more than 3°C higher than the long term average. (source: <http://eca.knmi.nl>).

totals. Together with similar results for other regions of the world (Figure 1d), this led IPCC⁴⁾ to conclude that heavy precipitation events increased over most areas during the second half of the 20th century, leading to a larger proportion of total yearly rainfall due to heavy falls.

Another example of the use of derived indices for analysing extremes is shown in Figure 2, in which the index “warm nights” is portrayed for the European heat wave summer of 2003. The results indicate that during this summer, the number of warm nights has been much higher than usual in a large part of Central and Western Europe. The anomalies in “warm nights” were generally larger than the anomalies in the number of “warm daytimes” (not shown).

Recent indices analysis has focussed on the influence of atmospheric circulation changes on the observed changes in the number of “warm days” and “cold days” in Europe⁵⁾. In this study, the temperature series were first adjusted for global warming before determining the indices for cold and warm extremes. The results show a warming effect for both winter and summer. For the “warm day” index, this change is not accounted for by the frequency change of circulation types, nor is it accounted for by the global warming trend

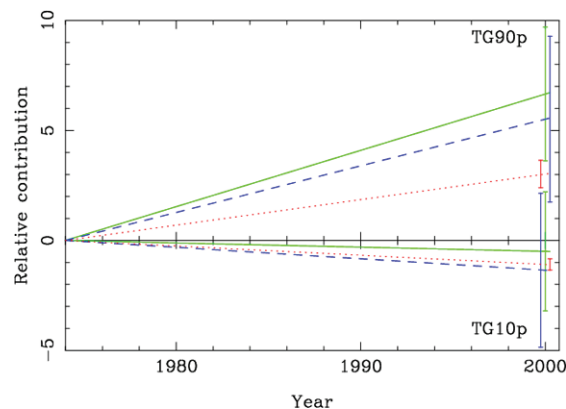


Figure 3. Relative contributions of several factors to the trend in the extremes indices “cold days” (below the zero line) and “warm days” (above the zero line) observed at ECA&D stations averaged over Europe. The green, solid lines show the trends as observed in the index for “cold days” (TG10p) and “warm days” (TG90p). The red, dotted lines show the trend contribution due to global warming. The blue, dashed lines show the accumulated contributions of global warming and changes in the frequency of circulation types. The error bars (uncertainties) are shown for the year 2000 (slightly shifted for clarity). (source⁵⁾)

(Figure 3). A simple snow model shows that variations in the European snow cover extent are likely influencing the cold and warm day indices in winter, i.e., the decreasing trend of snow cover extent is associated with the increasing (decreasing) trend of the number of warm (cold) days for stations throughout Europe.

E-OBS gridded version

In recent years, the ECA&D station data have been used in several activities and projects. Within the EU-FP6 project ENSEMBLES⁶⁾, a new daily gridded observation dataset (E-OBS) has been developed on the basis of the ECA&D station data⁷⁾. This new dataset enables, for the first time, evaluation of how well extremes are represented in Regional Climate Model simulations.

The E-OBS dataset is a European land-only, daily high-resolution dataset for precipitation and surface air temperature (minimum, mean and maximum) for the period 1950-now. This dataset improves on other products in its spatial resolution and extent, time period, number of contributing stations, and research into finding the most appropriate method for spatial interpolation of daily climate observations. Figure 4 shows the E-OBS dataset for the maximum temperature

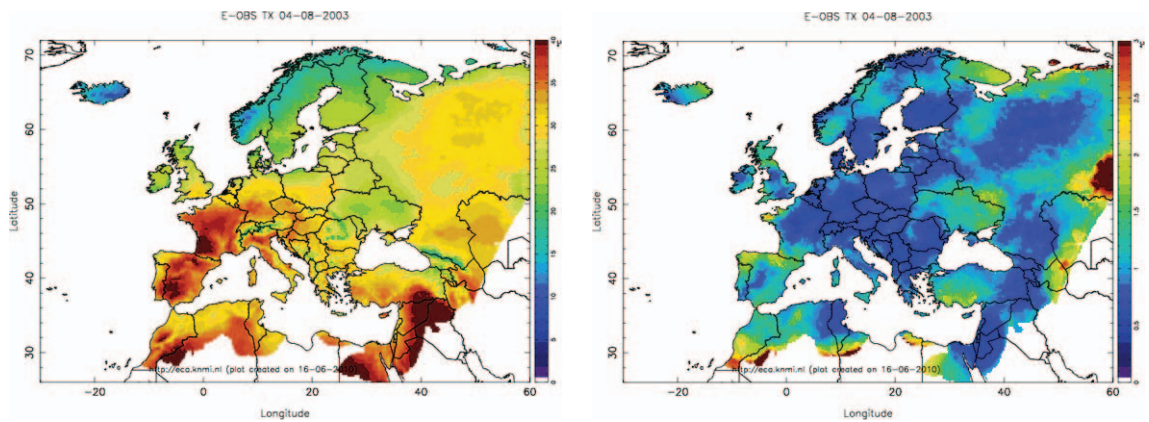


Figure 4. Illustration of the E-OBS dataset (0.25 degree regular grid) showing the maximum temperature (left) plus standard error (right) on the hottest day in Europe since 1950: 29 July 2002. The maximum temperature averaged over Europe on this day was 30.3°C, compared to the 1961-1990 summer mean of 22.4°C. The box defines the geographical extent of the dataset and white land areas indicate that there is not enough station data for interpolation. (source: <http://eca.knmi.nl/ensembles>).

on the hottest day in Europe since 1950, 29 July 2002. The E-OBS dataset is accessible by the public at <http://eca.knmi.nl/ensembles>. It will continue to be maintained and updated beyond the duration of the ENSEMBLES project, which ends in December 2009.

The new E-OBS daily gridded dataset for Europe enables, for the first time, evaluation of extremes in Regional Climate Model simulations

Statistical homogeneity tests performed routinely within ECA&D⁸⁾ and for ENSEMBLES⁹⁾ reveal that many of the underlying station series are subject to potential inhomogeneities due to, for instance, changes in observing practices. This affects, in particular, the understanding of extremes because changes in extremes are often more sensitive to inhomogeneous climate monitoring practices than changes in the mean. In addition, there are limitations in the ability of the interpolation method to estimate grid values from the underlying station network. In areas where relatively few stations have been used for the interpolation, both precipitation and temperature are 'over-smoothed'. This leads to reduced interpolated values relative to the 'true' area-averages, in particular for extremes¹⁰⁾. This implies that future work on the E-OBS gridded dataset is necessary and care must be taken when using it. But E-OBS is the only daily gridded dataset currently available and quality control procedures have successfully filtered out the most severe data problems.

Outlook

After more than 10 years, ECA&D has entered a mature phase. From 2009 onwards, the system will continue to be maintained by KNMI as an operational activity, rather than as a research activity. Recently, the status of Regional Climate Centre (RCC) for high resolution observation data in WMO Region VI (Europe and the Middle East) has been obtained. This means that the activity is recognized by WMO as an important contribution to regional and global climate monitoring and service delivery. RCCs are Centres of Excellence that assist WMO members in a given region to deliver better climate services and products, and to strengthen their capacity to meet national climate information needs. ECA&D provides such RCC-services for daily station data and derived extremes indices data.

Starting in 2010, KNMI will develop new ECA&D functionalities and conduct scientific research with the observation data within the EU-FP7 funded project European Reanalysis and Observations for Monitoring (EURO4M), for which KNMI is the coordinator. The aim of EURO4M is to describe the evolution of the Earth system components by seamlessly combining two different but complementary approaches: regional observation datasets of Essential Climate Variables (ECVs) such as provided by ECA&D on the one hand, and newly developed state-of-the-art (model based) regional reanalysis on the other.

EURO4M will extend, in a cost-effective manner, European capacity to systematically monitor climate variability and change (including extremes) on a range of space and time scales. The project will reach out with innovative and integrated data products and climate change services to policy-makers, researchers, planners and citizens at European, national and local levels. This will directly

address the needs of, for instance, the EEA for their environmental assessment reports, and even provide online reporting during emerging extreme events.

EURO4M is an important building block for Global Monitoring for Environment and Security (GMES). It has the potential to evolve into a future GMES service on climate change monitoring that is fully complementary and supportive to the existing operational services for land, marine, emergency, atmosphere, and security.

Conclusion

The activities under the umbrella of ECA&D provide vital ingredients for a successful monitoring of climate extremes in Europe. ECA&D also enables adequate climate change information services in support of adaptation measures on a European scale. The project is well on its way to become Europe's primary source of timely and reliable information about the state of the climate. This will help us better understand and predict climate change, extremes and weather related hazards, so that society can respond in the best possible way.

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