Climate Extreme Indices for Climate Monitoring and Adaptation

The CLIVAR/CCl/JCOMM Joint Expert Team on Climate Change Detection and Indices (ETCCDI)

A brief overview of the ETCCDI achievements over the past decade as prepared for CLIVAR.

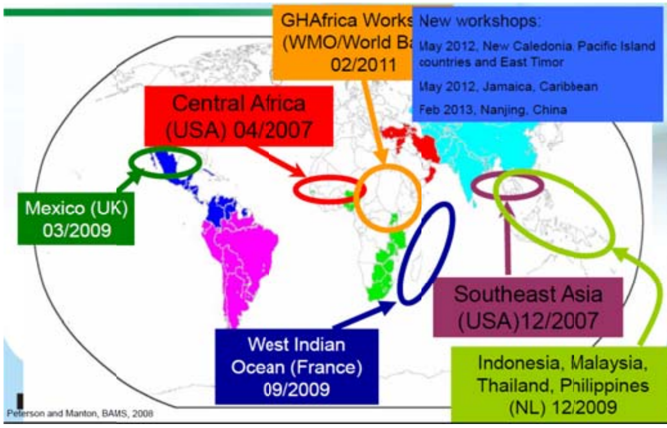
The ETCCDI has a mandate to facilitate the international coordination of the calculation of a suite of temperature and precipitation indices for the monitoring and assessment various aspects of changes in climate extremes. This team has focused on the following aspects including (1) the development of a set of indices and software that computes the indices, (2) capacity building through hands-on training of data analysis by organizing regional climate change workshops, (3) coordinating the calculation of indices for both observed and climate model simulated data, and (4) contributing to climate change science.

1) Indices and tools

The ETCCDI has taken two-pronged approach to promote and facilitate the monitoring and analysis of daily climate records to identify trends in extreme climate events. The approach includes the development of a suite of indices of climate extremes that can be computed from daily precipitation and temperature internationally using standard, easy to understand definitions, and to prompt the analysis of extreme indices by organizing regional climate-change workshops that provided training for the local experts and conducted data analysis. A set of 27 indices have been defined (Klein-Tank et al. 2009, Zhang et al. 2011, Zwiers et al. 2013). Software packages RClimDex and its variants (e.g., FclimDex and CLIMDEX.PCIC) for indices calculation and RHtest for data homogeneity testing have been developed and are widely used. A technical document (Klein-Tank et al. 2009) provides guidelines to the National Meteorological and Hydrological Services (NMHSs) for identifying and describing changes in extremes.

2) Capacity building

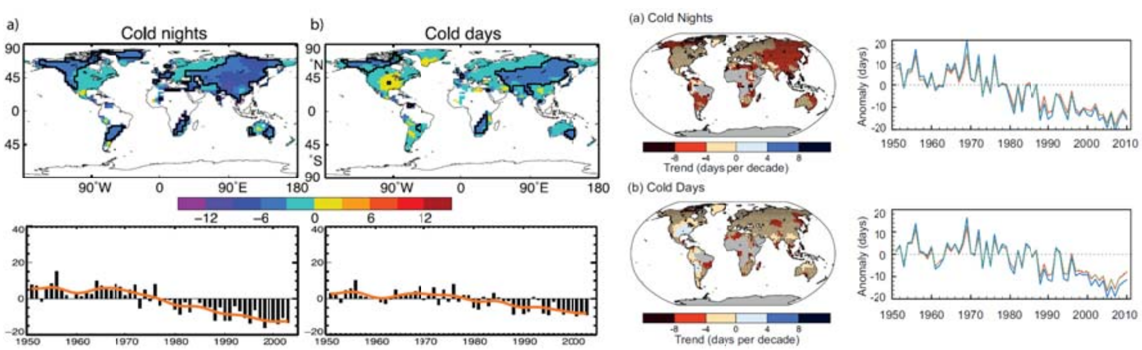
ETCCDI organizes regional and sub-regional workshops for the analysis of extreme indices based on daily temperature and precipitation. With the help of experts, participants conduct analysis at the workshops on their own data in multiple steps including data quality control, data homogeneity testing, indices calculation and analysis, gaining important hands-on experience. The ETCCDI workshop approach has been very successful in spreading the science knowledge and practical tools, methodology and software for analysing climate variability and climate change and has produced a slew of peer-reviewed publications written by participants, contributing significantly to analyses in data sparse regions of the globe (Alexander et al. 2006, Donate et al. 2013a). These efforts have also assisted in enhancing regional collaboration in the analysis of climate variability and change and WMO Members contribution to the IPCC assessments. Note that while members of ETCCDI play important role in the workshops planning and execution, much of the work are performed by many who are interested in the work and who are not members.



Participants improving their capacity to process climate change data and interpret the results at the Expert Team on Climate Change Detection and Indices Workshop for Central Africa (23-27 April 2007, Brazzaville, Congo)

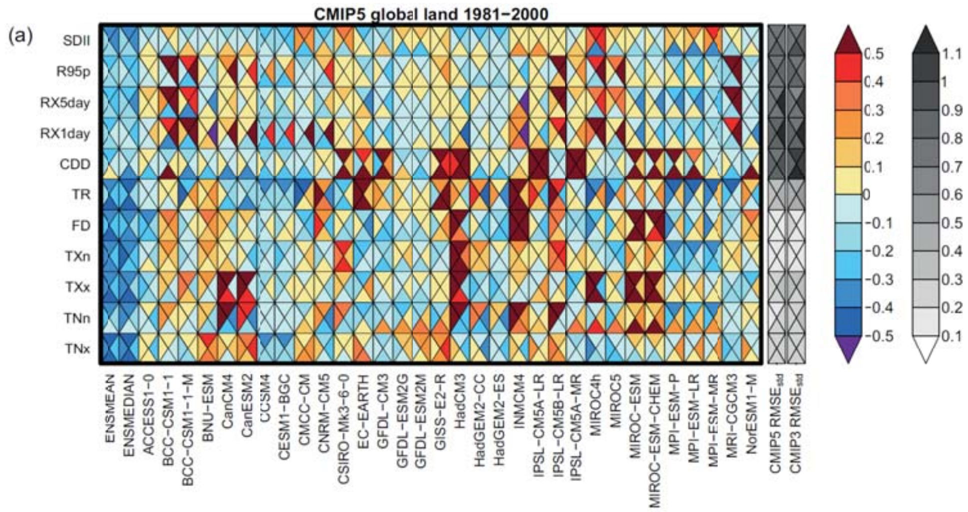
3) Indices data development

Internationally coordinated efforts for the calculation and analysis of the extreme indices have resulted in two versions of global data sets of climate extreme indices (HadEX, Alexander et al. 2006; HadEX2, Donat et al. 2013a,b). Both the station-based indiecs and gridded data are freely available and have been widely used by climate researchers. The underlying HadEX2 are primarily sourced from ECA&D (Klein Tank et al., 2002) and associated datasets in south-east Asia and Latin America, GHCN-Daily, ETCCDI regional workshops and individual researchers.



Trends in annual frequency of extreme temperatures for cold nights and cold days over the period 1951-2010 based on HadEX (left, FAQ 3.3 Fig. 1 of Trenberth et al. 2007, adapted from Alexander et al. 2006) and over the 1951-2010 based on HadEX2 (right, Fig 2.32 of Hartmann et al. 2013, updated from Donate et al. 2013).

The WCRP Coupled Model Inter-comparison Project Phases 3 and 5 (CMIP3 and CMIP5) have produced a large amount of data that are challenging to process for many people. To make the model simulated extremes information more accessible, the ETCCDI has organized the calculation of climate extreme indices. ETCCDI indices are now available for both the 20th and 21st century simulations for a large number of CMIP3 and CMIP5 models, as well as for a number of reanalysis products (Sillmann et al. 2013a, b). These indices are freely available and have been used to evaluate performance of climate models in simulating aspects of extreme temperature and precipitation (Flato et al. 2013), in the understanding the causes of changes in extreme precipitation and extreme temperature (Bindoff et al. 2013), and in the projection of changes in extreme temperature and precipitation (Collins et al. 2013).



An application of ETCCDI indices for climate model validation. Portrait plot of relative error metrics for the CMIP5 temperature and precipitation extreme indices based on Sillmann et al. (2013a). Reddish and bluish colours indicate, respectively, larger and smaller root-mean-square (RMS) errors for an individual model relative to the median model. The relative error is calculated for each observational data set separately. The grey-shaded columns on the right side indicate the RMS error for the multi-model median standardized by the spatial standard deviation of the index climatology in the reanalysis, representing absolute errors for CMIP3 and CMIP5 ensembles. Results for four different reference data sets, ERA-interim (top), ERA40 (left), NCEP/NCAR (right) and NCEP- Department of Energy (DOE) (bottom) reanalyses, are shown in each box. The analysis period is 1981–2000, and only land areas are considered. (Flato et al. 2013, Figure 9.37)

4) Contribution to climate change science

The ETCCDI's international coordination of calculation and analysis of temperature and precipitation indices have helped improve the understanding of how extremes are changing globally or regionally both in the past and for the future. Studies based on ETCCDI indices represent the main body of literature regarding changes in precipitation and temperature extremes that was assessed in the IPCC AR4 (Trenberth et al., 2007), SREX (Seneviratne et al. 2012), and AR5 reports (Hartmann et al. 2013; Flato et al., 2013; Bindoff et al., 2013; Collins et al. 2013). A large number of figures in these reports with regard to climate extremes are based on ETCCDI coordinated work. ETCCDI members have also played significant roles in these assessments as Convening Lead Authors, Lead Authors, and Review Editors.

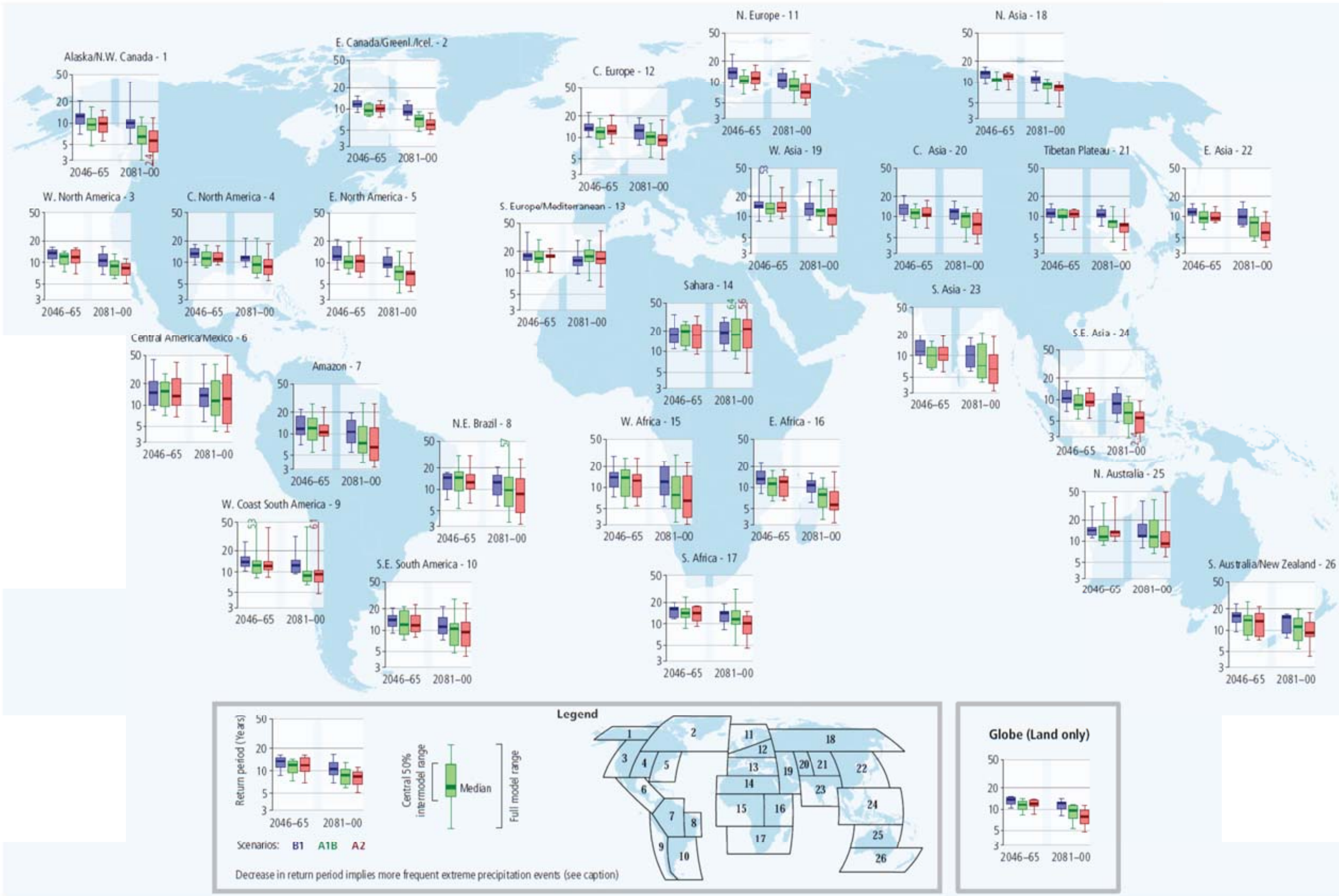


Figure SPM.4B | Projected return periods for a daily precipitation event that was exceeded in the late 20th century on average once during a 20-year period (1981–2000). A decrease in return period implies more frequent extreme precipitation events (i.e., less time between events on average). The box plots show results for regionally averaged projections for two time horizons, 2046 to 2065 and 2081 to 2100, as compared to the late 20th century, and for three different SRES emissions scenarios (B1, A1B, A2) (see legend). Results are based on 14 GCMs contributing to the CMIP3. The level of agreement among the models is indicated by the size of the colored boxes (in which 50% of the model projections are contained), and the length of the whiskers (indicating the maximum and minimum projections from all models). See legend for defined extent of regions. Values are computed for land points only. The 'Globe' inset box displays the values computed using all land grid points. [3.3.2, Figure 3-1, Figure 3-7]

5) Looking forward

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