CCl/CLIVAR WORKSHOP TO DEVELOP PRIORITY CLIMATE INDICES

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This WMO-sponsored workshop on climate variability and change in Africa resulted in some of the first analyses of climate extremes for many parts of that continent.

There is general agreement within the climate community that changes in the frequency or intensity of extreme climate events would have profound impacts on nature and society. It is critical that, where possible, all parts of the world are examined for evidence of changes in extremes. One area of the world that has suffered from a relative lack of analysis is the continent of Africa. Although African climate data for longer averaging periods (monthly and longer) have been available from a variety of sources (e.g., Vose et al. 1992), long-term data suitable for examining changes in short-term extremes have not been widely available to the scientific community. The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR; Folland et al. 2001) showed that large parts of Africa have warmed considerably over the twentieth century, with the strongest warming taking place since 1975. Analysis shows that annual precipitation in most of the analyzed area in Africa decreased greatly in 1901–2000; however, parts of western Africa have seen increases since 1975. At issue though, is that large parts of the continent remain unanalyzed even with respect to annual average quantities.

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A workshop to address some of the issues of data availability and data analysis in Africa was held by the Working Group on Climate Change Detection, part of the joint World Meteorological Organization Commission for Climatology/World Climate Research Programme (WCRP) project on Climate Variability and Predictability (CLIVAR). Held in Casablanca, Morocco, from 18 to 23 February 2001, the workshop aimed to fill in data "gaps" and develop climate indices for Africa. It brought together scientists (see Table 1) from 23 African countries, providing each one with assistance and guidance in analyzing changes in daily temperature and precipitation climate extremes with resulting analyses provided to the scientific community.

The workshop was composed of three parts: 1) a series of talks discussing data quality and homogeneity issues, 2) use of software specifically developed by

TABLE 1. Listing of participants and countries in the workshop.

Mr. M. Adjez	Algeria
Mr. J. Noukpozounkou	Benin
Ms. P. M. Lesolle	Botswana
Mr. E. Kabore	Burkina Faso
Mr. K. Zihindula	Democratic Republic of the Congo
Mr. I. Fesseha	Eritrea
Mrs. I. Gaye	Gambia
Mr. Z. Minia	Ghana
Mme. A. Diallo	Guinee
Mr. P. Amgenje	Kenya
Mr. J. K. Muhindi	Kenya
Mr. S. Isukulu	Lesotho
Mr. K. I. Elfadli	Libya
Mr. Z. Rabefitia	Madagascar
Mr. D. A. Maiga	Mali
Mr. S. Mohamed	Morocco
Mr. B. Mostafa	Morocco
Mr. I. L. Mouhamadou	Niger
Mr. S. Prosper	Seychelles
Dr. E. Aguilar	Spain
Prof. M. Brunet	Spain
Mr. A. Saad Mohmed	Sudan
Mr. M. A. Dlamini	Swaziland
Mr. H. K. Saleh	Tanzania
Mr. J. Elkamel	Tunisia
Mr. M. M. Waiswa	Uganda
Mr. B. S. Mutepfa	Zimbabwe

the National Climatic Data Center (NCDC) for this kind of workshop to assess the quality and homogeneity of daily climate data, and 3) use of these data to calculate long-term trends in a number of climate extremes indices and to produce a brief report for each country. This approach was modeled after the successful Australia–Pacific Network (APN) workshop held in Melbourne in 1999 (Manton et al. 2001). At the end of the workshop, the participants were provided with the software used in the workshop and have been encouraged to update the workshop analyses regularly and to perform a full analysis of all the daily records back at their home institutions.

The first day of the 5-day workshop was devoted to a series of introductory talks given to set the groundwork for the workshop. One talk, by L. Alexander of the Met Office, discussed a similar regional "hands on" workshop that had been held for the Caribbean region at the University of the West Indies in Jamaica about 1 month prior to this one. Alexander discussed common data problems found, such as lack of digitized records, insufficiently long coherent data records, and the need for thorough homogeneity testing and quality control. The main results were also shown that broadly agreed with those in IPCC TAR. The workshop encouraged a more consistent approach to data collection and analysis in the Caribbean region and has aided in future collaboration between each country (Peterson et al. 2002).

A general discussion led by D. Easterling (NCDC) on climate indices for examining climate extremes ensued, leading to identification of indices relevant to Africa from the list from Frich et al. (2002). Once the indices were identified, the next step was to introduce the participants to some of the issues of climate data quality and homogeneity. Easterling presented a talk on quality assessment of daily temperature and precipitation data, showing how outliers in the data can affect an analysis of extremes. The more subtle problem of time series homogeneity was then discussed showing how changes of station location, instrument changes, or even observing time changes can cause discontinuities (step changes) in climate time series that can affect trends, both in magnitude and direction (positive versus negative).

Country representatives at the workshop brought time series of daily maximum and minimum temperature and precipitation. The period of record varied by country and even station, although it generally covered 1961–90. The software used to assess the quality and homogeneity of the data was developed specifically for this workshop and the companion workshop for the Caribbean. Technical support in using the software was provided by R. Sebbari [Direction de la Meteorologie Nationale (DMN)] and L. Alexander. The software (ClimDex) is personal computer (PC) based and provides users with a method to detect temperature inhomogeneities that are manifested as discontinuities or shifts in the time series. These abrupt or sometimes gradual changes can be traced to both natural and artificial (human induced) changes.

ClimDex utilizes both visual inspection of a temperature time series and a statistical test (Student's *t* test) to test the difference between two adjacent period mean values. In the first step, ClimDex simply provides the user with a time series of annual mean (temperature) and accumulated (precipitation) values. These time series can then be examined in conjunction with any existing metadata to identify potential inhomogeneities. In the second step, using Student's *t* test, one defines a "window" size in years. This window size is then split into two adjacent periods and then the difference between the two mean values are tested for significant differences from 0 (e.g., two-sided Student's *t* test). The resultant probabilities from this statistical test are plotted as a time series that can be examined visually for evidence of data homogeneity problems.

ClimDex can currently calculate 18 different climate indicators, although the software is flexible enough that it can be easily rewritten to incorporate more indices. However, after discussion, the group chose to use only the six indices listed below, and each participant calculated the indices for their country's data.

- The percent of time *T*min = 10th percentile of daily minimum temperature (*T*n10). This indicates long-term changes in the coldest minimum temperatures of each month.
- The percent time *T*min = 90th percentile of daily minimum temperature (*T*n90). This would primarily sample changes in warm nighttime temperatures.
- The percent of time *T*max = 10th percentile of daily maximum temperature (*T* × 10) is calculated.
- The percent of time *T*max = 90th percentile of daily maximum temperature (*T* × 90) is also calculated.
- The change in the greatest annual 5-day total precipitation amount. This gives an indication of changes in the heaviest multiday precipitation events.
- The percent of annual precipitation, due to all 24-h rainfall totals exceeding the 95th percentile of daily amounts, is calculated.

The result was a time series of each quantity (see Fig. 1) that was then analyzed for trends. The four temperature indices are based on percentile thresholds that were calculated for each month. The annual value is the sum of the 12 monthly values.

Figure 2a shows the results for the trends in percentage of time (days) where the minimum is below the 10th percentile temperature threshold value on an annual basis. These are the trends for individual stations and are for the approximate period 1961–90. In general the results are consistent with the observed warming in annual temperature presented in the IPCC TAR for these parts of Africa. In this instance, the red dots indicate a decreasing trend, which would indicate that the number of days below the 10th percentile threshold is decreasing, which is consistent with warming at these stations.

Figure 2b shows the results for trends in the percentage of time where the minimum temperature exceeds the 90th percentile threshold value for each observing station. These results are also consistent with the annual temperature trends, with the exception of the coastal stations in Eritrea and Tanzania. The cooling shown at these stations for the minimum is not found in the results for maximum temperature and possibly indicates a data quality or homogeneity problem.

Results for the annual maximum temperature, shown in Figs. 3a and 3b, are broadly consistent with those for the minimum temperature, but do suggest somewhat less warming with somewhat smaller trends in both the percentage of days above the 90th percentile threshold and percentage of days below the 10th percentile thresholds. Furthermore, taken together, the trends in indicators for both maximum and minimum temperature appear to follow the general trends found in Easterling et al. (1997), where the minimum temperatures increased at a faster rate than maximums for the same general period.

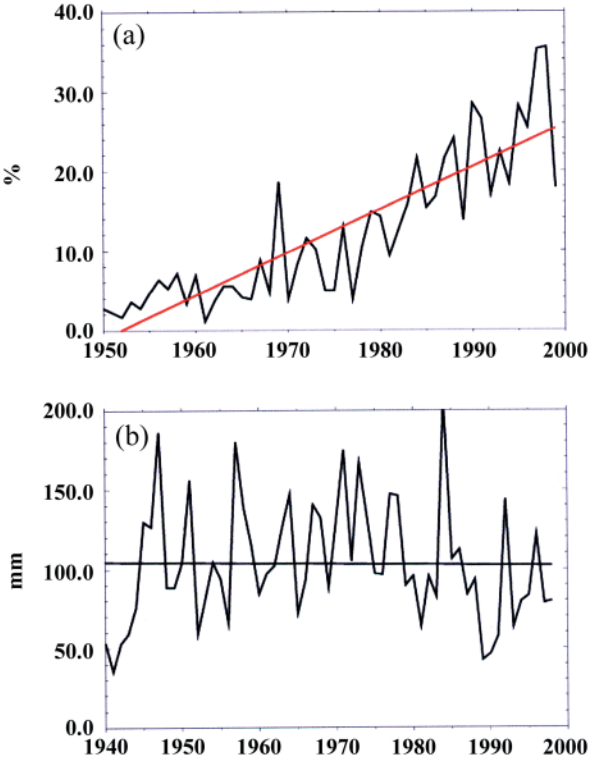

Fig. 1. Time series of (a) the percent of time the daily minimum temperature is ≥ 90th percentile threshold (*T*n90) for station Agadez, Niger, and (b) the annual maximum 5-day precipitation total (*R*5d) for station Dar El Beida, Algeria. Both time series are fitted with least squares trend lines. Red indicates that the trend is significant at the 5% level, using a Mann–Kendall test.

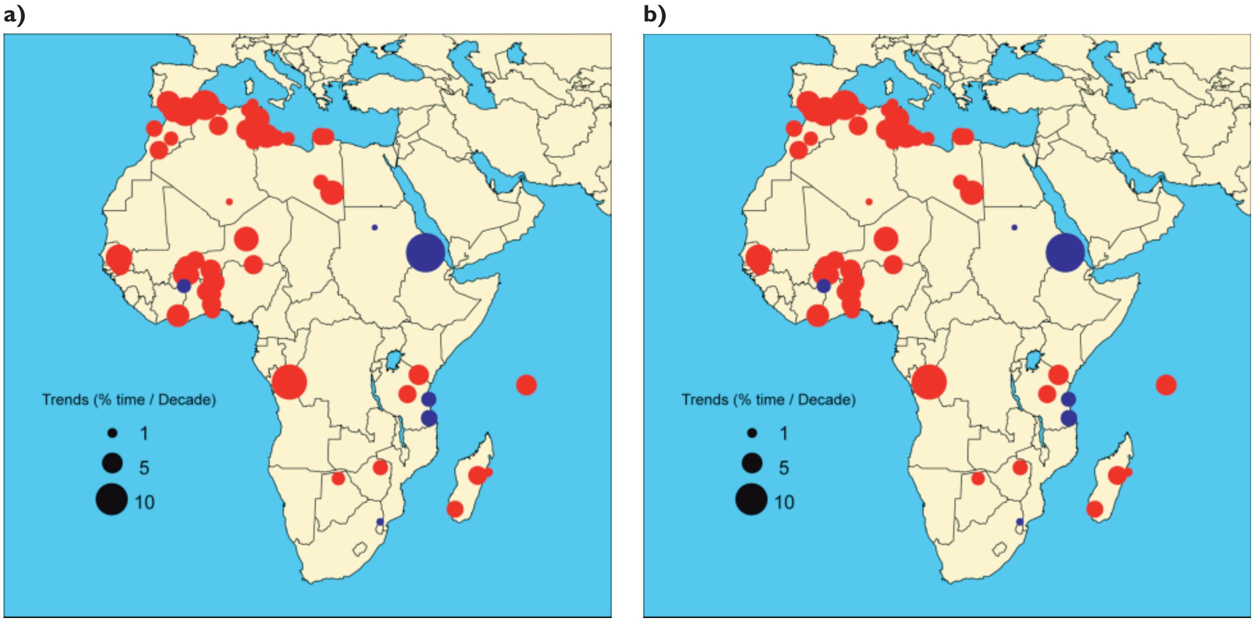

Fig. 2. Trends of the percentage of time (a) *T*min < 10th percentile and (b) *T*min > 90th percentile of the 1961–90 daily *T*min.

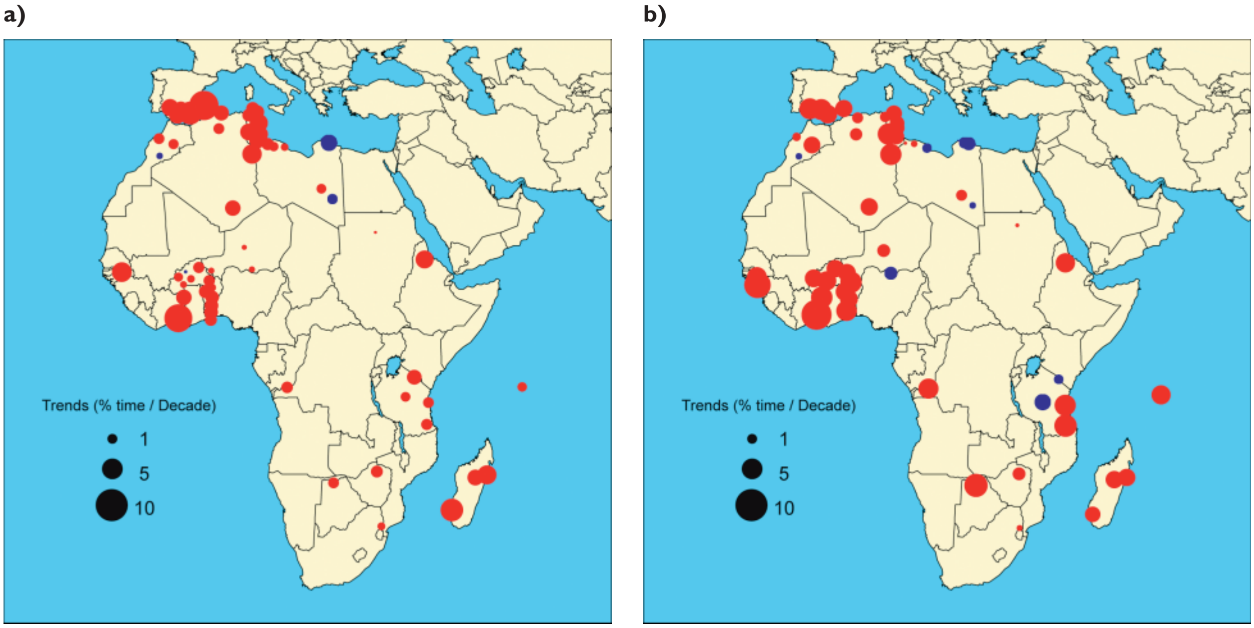

Fig. 3. Trends of the percentage of time (a) *T*max < 10th percentile and (b) *T*max > 90th percentile of the 1961–90 daily *T*max.

The last two figures (Figs. 4 and 5) show the two precipitation indices: the trends in the contribution of daily rainfall amounts above the 95th percentile threshold, and the contribution of the heaviest 5-day precipitation total to the annual total. Unlike with temperature, the trend in these cases are very different from one location to another, even within the same country, making it very difficult to get a consistent regional picture of the results. Extreme rainfall events seem to increase at some stations but decrease at others, often very close to one another. This mixed pattern of change is reflected in Frich et al. (2002) and IPCC TAR around the rest of the globe. These results point out the difficulties in analyzing precipitation trends at individual stations. Problems in accurately measuring precipitation have been well documented (e.g., Groisman and Easterling 1994), and spatial averaging of station data is necessary to

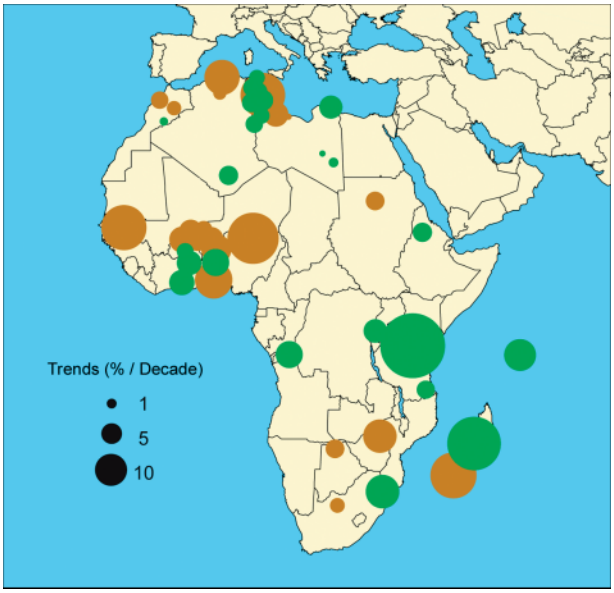

Fig. 4. Trends in greatest 5-day rainfall as a percentage of the annual total.

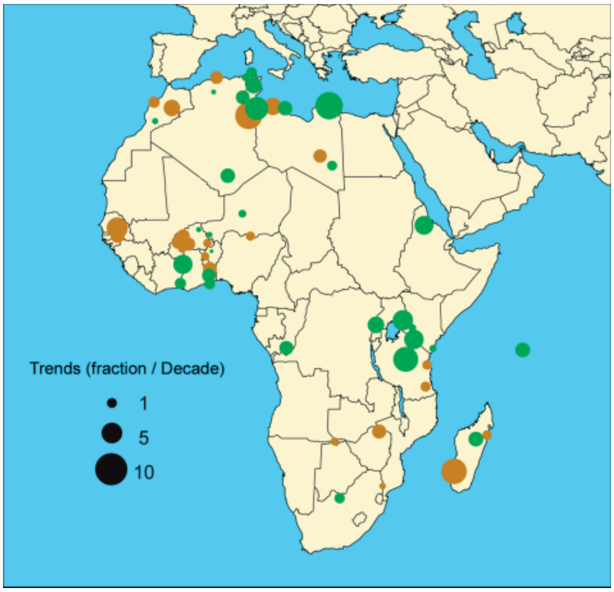

Fig. 5. Trends in the percentage of annual total, due to events equal to or greater than the 95th percentile threshold.

reduce noise and enhance the signal in precipitation time series.

This workshop was an opportunity to analyze weather extremes in Africa and provide the results to the scientific community via a workshop report. A secondary goal was to train the participants in data quality and homogeneity issues. Results included

- an inventory of daily data in 23 Africa countries,
- daily data that were homogenized and quality controlled for those 23 countries,
- a regional set of cumulative indices over Africa, and
- distribution of the ClimDex software to all participants and, potentially, to other remaining African countries.

The workshop also provided the opportunity to validate the concept of exchange of data or analysis results through value-added products, such as indices rather than actual data, and all participants enthusiastically provided their indices. Providing the raw data for distribution within the scientific community would have been much more desirable, because it would allow for more robust analyses. However, commercial and other issues have complicated this, making the exchange of indices easier. The workshop was a first step to gaining information from this data-sparse region. Further effort is required to encourage continued collaboration, data exchange, and analysis in the region.

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