P1.21 CLIMATE EXTREME INDICES VIA REGIONAL CLIMATE CHANGE WORKSHOPS

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1. INTRODUCTION

For decades, most analyses of long-term global climate change using observational data have focused on changes in mean values. Several well respected data sets of monthly station temperature and precipitation data provide quite good coverage across the globe. However, analyzing changes in extremes (e.g., the number of days exceeding the 90th percentile of minimum temperature observations), requires long-term digital daily data. Unfortunately, long-term digital daily data are not readily available internationally for large portions of the world. In the 2002 "global" analysis by Frich et al. (2002), almost no analysis of extremes was possible for most of Central and South America, Africa, and southern Asia (see Figure 1). However, a concerted series of efforts to remedy that situation and create analyses of changes in extremes in the blank regions shown in Figure 1 are underway.

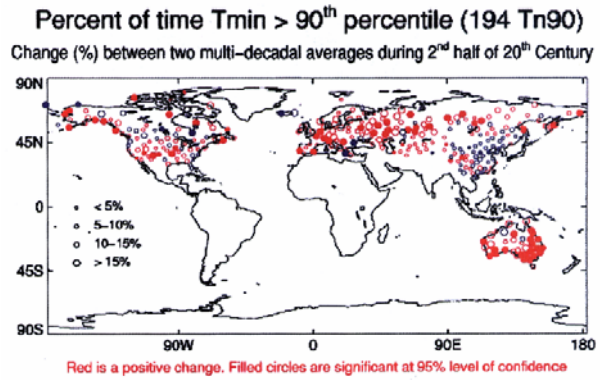

Figure 1. A temperature extreme index analysis from Frich et al. (2002). Note the large blank regions in this "global" analysis.

2. ROLE OF AN INTERNATIONAL EXPERT TEAM (ET)

Two complimentary efforts to enable global analysis of extremes are being coordinated by the joint World Meteorological Organization Commission for Climatology (CCl) / World Climate Research Programme (WCRP) project on Climate Variability and Predictability (CLIVAR) Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI). Detailed information on the ET is available at http://www.clivar.org/organization/etccd. Members of the expert team come from all the inhabited continents and encompass a wide range of expertise in the climate change field (see Table 1 for ET membership). The author is not a member of the ET but works closely with it as chair of the CCl Open Programme Area Group (OPAG) on the Monitoring and Analysis of Climate Variability and Change to which the ET belongs. As all ET members are volunteers with full time jobs (or jobs they wish were only full time), to accomplish very much, the focus of an ET's work must be on things they can coordinate, recommend or inspire rather than do themselves.

A. Mokssit (co-chair)	Meteo Moroc, Casablanca, Morocco
F. Zwiers (co-chair)	Canadian Centre for Climate Modelling and Analysis, Victoria, Canada
N. Bindoff	University of Tasmania, Hobart, Australia
C. Folland	Met. Office, Exeter, UK
P. Jones	Univ. East Anglia, Norwich, UK
D. Karoly	School of Meteorology, Univ. of Oklahoma, Norman, USA
L. Molion	CCEN, Universidade Federal de Alagoas, Alagoas, Brazil
S. Sensoy	Turkish State Met. Service, Kalaba / Ankara, Turkey

Table 1. Membership of the CCl/CLIVAR Expert Team on Climate Change Detection, Monitoring and Indices.

One of the ET's activities is international coordination of a suite of climate change indices derived from daily data which primarily focus on extremes. The development of the indices involved not only ET

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members but numerous other scientists working with daily climate data most notably including Albert Klein-Tank (The Netherlands), Lisa Alexander (U.K.), Byron Gleason (U.S.), Xuebin Zhang (Canada) and Gabi Hegerl (U.S.). By setting an exact formula for each index, analyses done in different countries or different regions can fit together seamlessly. The complete list of the 27 indices is available from http://cccma.seos.uvic.ca/ETCCDMI. This web site also provides FORTRAN code for calculating the indices from daily data and, thanks primarily to the efforts of Xuebin Zhang of Environment Canada, a very user friendly software package to calculate the indices. This software package, called RClimDex, uses the free software R (see http://www.r-project.org for more information), which is a language and environment for statistical computing and graphics.

Analysis software, however, does not do any good without data. In many parts of the world enough daily data have been digitized to contribute to an analysis but institutions are reluctant to part with data so someone outside their country can analyze how their extremes are changing. This is a far more difficult problem to address. The solution proposed by the ETCCDMI's predecessor was to hold regional climate change workshops modeled after the Asia Pacific Network workshops (Manton et al., 2000; Peterson et al., 2001). Two regional climate change workshops were held in 2001. Recognizing the successes and problems of these workshops, the ETCCDMI has embraced holding a series of additional regional climate change workshops to cover all areas of the globe.

3. REGIONAL WORKSHOP CONCEPT

These workshops bring together participants from every country or at least many countries across a region for a combination of seminars and hands-on analyses of the daily data they bring with them. Through the process of holding several workshops, a workshop "recipe" has been created. The workshops start with overview seminars describing the reasons for the workshops and how the climate of the region is projected to change. Then the participants describe the climate of their countries and the station data they brought with them. This introductory process helps everyone understand what lies ahead as well as helping participants get to know each other.

The hands-on analysis starts with quality control (QC). RClimDex has several QC checks. Some identify specific data points as outliers. For these tests, each data point that is potentially a problem is examined and based on data before and after as well as the understanding of the climate of the region, the data are edited if the problem is obvious (e.g., 182 degrees changed to 18.2), set to missing if it is clearly a problem with unknown solution, or kept if deemed probably valid. With each change or acceptance of an outlier, a record of the decision and the reasons behind it is made in the QC log file. The second stage of QC involves evaluating numerous detailed graphs of daily data to detect evidence of possible quality issues with the data. An example of this would be an impossibly long period of time with zero precipitation. This problem can arise because many countries do not record zero precipitation so missing values must initially be assumed to be zero.

The next stage of analysis is conducting homogeneity assessments. Homogeneity adjustments of daily data are very complex and difficult to make well (Aguilar, 2003). Therefore, the workshop focus on homogeneity is to identify significant problems. When the homogeneity testing software identifies a likely problem, the participant consults station history metadata, if available, to understand why. Non-climatic jumps in the time series have resulted in some stations not being used in the indices analyses or used only for the period after the discontinuity.

Once QC and homogeneity testing have been accomplished, the calculation of the indices is quite simple. One of the benefits of doing this at a regional workshop is the synergy of immediately being able to see how results compare across borders. The participants create a short presentation of what the analysis is indicating about changes in extremes for each country. When these presentations are made, the cross-border similarities become very clear. Similar results that span country borders verify the robustness of the analysis. Participants have found this workshop product quite useful when they return home.

The last part of the workshop is discussing the future. This includes user feedback and giving advice for future workshop organizers. Discussing how to improve the available of GCOS Surface Network data now that the participants clearly understand the value of being able to compare analyses across country borders is also relevant to the future. And lastly how to make the results of the analyses started at the workshop useful for climate change assessments. This includes deciding on who will lead the writing of multi-authored (the author list includes all participants who brought data contributing to the analysis) peer-reviewed journal articles (often one for temperature indices and one for precipitation indices), making the time series of the indices available to other researchers, and making the data themselves available to other researchers.

So far none of these workshops have been able to release time series of daily data. However, we've had great success in reaching agreement to release the indices and some success in encouraging the release of data from GCOS Surface Network (GSN) stations to the GSN Archive Center. For each of these series of workshops that have been held so far, peer-reviewed journal articles on changes in extremes in the regions are in preparation and the indices are being prepared to contribute to the global indices paper.

4. THE WORKSHOPS

The previous incarnation of the ETCCDMI, a CCl/CLIVAR Working Group, also addressed indices and regional climate change workshops. This Working Group held two workshops in 2001. The first was in the Caribbean where 18 of the 21 meteorological services participated. This workshop resulted in the release of daily data, indices, a meeting report, and a 17 author peer-reviewed journal article on how the climate in the region is changing (Peterson et al., 2002). The second workshop was held in Casablanca for various African countries and resulted in a meeting report (Easterling, 2003).

The ETCCDMI sought to improve and extend those workshops to cover more of the world. The prime limiting factor, however, was financial support. Thanks to funding from the U.S. State Department, with the author as Principal Investigator (P.I.), and SysTem for Analysis, Research and Training (START) and the World Climate Research Program (WCRP), with Bruce Hewitson (South Africa) as P.I., adequate resources have become available to hold five workshops.

Figure 2. World map showing the countries participating or expected to participate in the five regional workshops.

4.1 *Southern Africa*

Date: May 31 - June 4, 2004

Location: Cape Town, South Africa

Host institution: University of Cape Town

Funding agencies: SysTem for Analysis, Research and Training (START) and the World Climate Research Program (WCRP)

Team: Bruce Hewitson (South Africa)
Mark New (U.K.)
David Stephenson (U.K.)
Andries Kruger (South Africa)

Countries participating:
Botswana
Gambia
Lesotho
Malawi
Nigeria
Seychelles
South Africa
Tanzania
Uganda
Zambia
Zimbabwe

Journal article lead author: Mark New (U.K.)

4.2 *Southern South America*

Date: August 9-14, 2004

Location: Maceio, Brazil

Host institution: Universidade Federal de Alagoa

Funding agencies: U.S. State Department and the Inter American Institute for Global Change Research (IAI)

Team: Luiz Molion (Brazil)
Thomas Peterson (U.S.)
David Karoly (U.S.)
Malcolm Haylock (U.K.)
Lucie Vincent (Canada)

Countries participating:
Argentina
Bolivia
Brazil
Chile
Ecuador
Paraguay
Peru
Uruguay

Journal article lead authors:
Temperature indices: Lucie Vincent (Canada)
Precipitation indices: Malcolm Haylock (U.K.)

4.3 *South-west Asia*

Date: October 4-9, 2004

Location: Alanya, Turkey

Host institution: Turkish State Meteorological Service

Funding agency: U.S. State Department

Team: Serhat Sensoy (Turkey)
Thomas Peterson (U.S.)
Lisa Alexander (U.K.)
Xuebin Zhang (Canada)
Enric Aguilar (Spain)
Trevor Wallis (U.S.)

Ramazan Sagir (Turkey)
Valery Detemmerman (WMO

Countries participating:
Armenia
Azerbaijan
Bahrain
Georgia
Iran
Jordan
Kuwait
Oman
Qatar
Turkey
Syria

Journal article lead authors:
Temperature indices: Xuebin Zhang (Canada)
Precipitation indices: Enric Aguilar (Spain)

4.4 *Central America and northern South America*

Date: November 8-12, 2004

Location: Guatemala City, Guatemala

Host institutions: Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología (INSIVUMEH; Guatemala) in collaboration with the Comite Regional de Recursos Hidraulicos del Istmo Centroamericano (Costa Rica).

Funding agency: U.S. State Department

Team: Enric Aguilar (Spain)
Patricia Rameriz (Costa Rica)
Eddy Sanches (Guatemala)
Manola Brunet (Spain)
Malcolm Haylock (U.K.)
Javier Soley (Costa Rica)

Countries expected to participate:
Belize
Columbia
Costa Rica
Cuba
El Salvador
Guatemala
Honduras
Mexico
Nicaragua
Panama
Suriname
Venezula

Journal article lead authors:
To be determined at the workshop

4.5 *South-Central Asia*

Date: February 14-19, 2005

Location: Pune, India

Host institution: Indian Institute of Tropical Meteorology

Funding agency: U.S. State Department

Team: Rupa Kumar Kolli (India)
Thomas Peterson (U.S.)
Phil Jones (U.K.)
Albert Klein-Tank (The Netherlands)
Zhai, Panmao (China)

Countries to be invited to participate:
Afghanistan
Bangladesh
Bhutan
China
India
Kazakhstan
Kyrgyzstan
Mongolia
Nepal
Pakistan
Sri Lanka
Tajikistan
Turkmenistan
Uzbekistan

Journal article lead authors:
To be determined at the workshop

5. SUMMARY

This series of regional climate change workshops is achieving several important objectives. In regions with great reluctance to release data, it has been able to produce and release a suite of climate change indices that primarily focus on extremes. With release of daily data, the analyses would gain increased credibility by being reproducible. But the strong focus on quality control and homogeneity testing (the results of which are being released) make it possible to evaluate the data and to support the conclusions even without having access to the digital data.

Training scientists in these countries may not have been the driving goal, but the workshops have definitely had a major capacity building aspect as outside experts work closely with regional participants on data analyses, provide them with user-friendly software, and introduce them to a free statistical package. The capacity building, in turn, has helped foster a greater appreciation of the importance of long-term in situ data which has resulted in renewed efforts at digitizing historical records as well as fulfilling GCOS Surface Network data exchange goals.

Lastly, these workshops are in the process of making a clear contribution to our understanding of how climate extremes are changing around the world with the preparation of peer-reviewed articles timed to be

able to contribute to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

6. REFERENCES

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