CLIVAR/GCOS/WMO WORKSHOP ON INDICES AND INDICATORS FOR CLIMATE EXTREMES

WORKSHOP SUMMARY

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There is general agreement that changes in the frequency or intensity of extreme weather and climate events are likely to have profound impacts on society and the environment (Karl et al., 1997). A Workshop on Indices and Indicators for Climate Extremes was held in Asheville, North Carolina, 3-6 June 1997, to encourage the development of data sets, and analysis techniques, to determine whether such extreme events are becoming more extreme or variable. Over 100 participants, from 23 countries, including representatives from 15 insurance and re-insurance countries (which have a clear interest in extreme weather and climate), examined the following questions:

- What needs to be done to improve data sets and analyses for extreme weather monitoring?
- Can we establish priorities for specific data set development and improvement?
- Can we establish indices and indicators of extreme weather and climate?
- What are the impediments to improving the monitoring of climate extremes?

The incentive for holding this workshop came largely from the difficulties the Intergovernmental Panel on Climate Change (IPCC) has had in answering the question: *Has the climate become more variable or extreme?* The Second Assessment Report (SAR) of the IPCC was completed in 1995 and determined that (Nicholls et al., 1996):

> Overall, there is no evidence that extreme weather events, or climate variability, has increased, in a global sense, through the 20th century, *although data and analyses are poor and not comprehensive*. On regional scales there is clear evidence of changes in some extremes and climate variability indicators. Some of these changes have been toward greater variability; some have been toward lower variability.

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The SAR further noted:

- *The data on climate extremes and variability are inadequate to say anything about global changes*, but in some regions, where data are available, there have been decreases or increases in extreme weather events and variability.
- Other than the few areas with longer term trends to lower rainfall (eg., the Sahel), little evidence is available of changes in drought frequency or intensity.
- There have been few studies of variations in extreme rainfall events and flood frequency. In some areas with available data there is evidence of increase in the intensity of extreme rainfall events, but no clear large-scale pattern has emerged.
- There is some evidence of recent (since 1988) increases in extreme extra-tropical cyclones over the North Atlantic. Intense tropical cyclone activity in the Atlantic has decreased over the past few decades although the 1995 season was more active than recent years. Elsewhere, changes in observing systems and analysis methods confound the detection of trends in the intensity or frequency of extreme synoptic systems.
- There has been a clear trend to fewer extremely low minimum temperatures in several widely separated areas in recent decades. Widespread significant changes in extreme high temperature events have not been observed.
- There have been decreases in daily temperature variability in recent decades, in the Northern Hemisphere mid-latitudes.

Despite the difficulties in assessing whether there had been recent trends in climate extremes and variability, the SAR examined model projections, to assess the likelihood of future changes in extremes and variability (Kattenberg et al., 1996) and concluded that:

- A general warming would tend to lead to an increase in extremely high temperature events and a decrease in winter days with extremely low temperatures (eg., frost days in some areas).
- With increasing greenhouse gas concentration, many models suggest an increase in the probability of intense precipitation. A number of simulations also show an increase in the probability of dry days and the length of dry spells (consecutive days without precipitation).
- New results reinforce the view that variability associated with the enhanced hydrological cycle translates into prospects for more severe droughts and/or floods in some places and less severe droughts and/or floods in other places.
- In the few analyses available, there is little agreement between models on changes in storminess that might occur in a warmer world. Conclusions regarding extreme storm events are obviously even more uncertain. The formation of tropical cyclones depend not only on sea surface temperature

(SST) but also on a number of atmospheric factors. Although some models now represent tropical storms with some realism for present day climate, the state of the science does not allow assessment of future changes.

The lack of certainty with regard to past and future extremes evident in the SAR indicates that further work is necessary to develop data bases capable of monitoring changes in climate extremes and variability, and to develop systems for such monitoring. This will require daily weather data to be made available over long periods, and for problems arising from changes in instrumentation, exposure, siting, and even analysis and meteorological interpretation, to be overcome. The Third Assessment Report (TAR) of the IPCC will be completed at the end of this century. Considerable efforts are needed before then, to ensure that the data and analyses are available to allow the TAR to provide a more complete answer to the question: *Has the climate become more variable or extreme?* CLIVAR provides a mechanism to coordinate studies aimed at answering questions raised by IPCC assessments. The WCRP CLIVAR program (CLIVAR, 1995) includes amongst its objectives:

- To extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled paleoclimatic and instrumental data sets.
- To understand and predict the response of the climate system to increases of radiatively active gases and aerosols and to compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal.

These objectives will be pursued through one of the 12 Principal Research Areas of CLIVAR: *Climate Change Detection and Attribution*. Detection of climate change is the process of demonstrating that an observed variation in climate is highly unusual in a statistical sense. Detection of climate change requires demonstrating that the observed change is larger than would be expected to occur by natural internal fluctuations. Attribution of change to human activity requires showing that the observed change cannot be explained by natural causes, forced or unforced. It is the process of establishing cause and effect relations, including the testing of competing hypotheses. CLIVAR will aim to improve the current state of studies of climate change detection and attribution through, *inter alia*, encouraging the development of historical time series of relevant climate data, with the Global Climate Observing System (GCOS).

The first step in the detection/attribution of climate change is the assembly of high-quality time-series of key variables. We need to ensure that credible historical time-series are available, through the correction for time-varying biases caused by changes in observing practices, instrumentation, and location.

As well, continuation of high-quality climate observations into the future are a prime requirement. The Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS) have a leading role in ensuring the continuation of such observations, as does WMO with its Reference Climate Station program.

The preparation of high-quality, historical climate data sets for climate change detection will be pursued through the CLIVAR/CCL Working Group on Climate Change Detection (WGCCD). This group has the expertise and access to data and station documentation necessary for the detection and removal of inhomogeneities in the historical data. The GCOS Data and Information Management Panel (GCOS-DIMP) too has a role in this area. Close coordination between the WGCCD and the GCOS-DIMP will ensure that duplication of effort is avoided, and that the best quality data sets are produced for climate change detection studies.

The Workshop on Indices and Indicators for Climate Extremes, it was hoped, could address many of the questions IPCC and CLIVAR need to answer. The production of time series of global and regional indicators and indices of climate extremes by exploiting daily weather data, and the development of a mechanism to update these indicators and indices on a regular basis, can go far to ensuring that the IPCC TAR will be able to determine whether the climate is becoming more extreme or variable. The Workshop was intended as a first step towards the production of such time-series, with their necessary mechanisms for updating.

The Workshop commenced with views from IPCC, CLIVAR, GCOS, agriculture, and the insurance and re-insurance industry with regard to extreme climate and weather. Scientific papers then examined the available data sets, and methods for analysing climate extremes. Regional papers examined the quality of data and analyses for different parts of the world.

After the scientific papers, three breakout groups (Storms; Precipitation; Temperature) met to consider the requirements for the three areas of extremes. On the final day of the Workshop, a plenary session discussed the results of the deliberations of the breakout groups and reached the following conclusions:

- It was agreed that a small group of climate extremes indices should be selected, to simplify the analysis and presentation of climate extreme trends. These indices would be selected by the Chairs of the breakout groups.
- Regional rapporteurs were selected to encourage improved access to data and coordination of analyses, and the development of time-series of the selected climate extremes indices.
- A small task group should be established to facilitate inter-regional consistency of analyses and to improve data access and liaison with the insurance industry.

- The regional rapporteurs and the task group would decide on improved methods for archiving global climate extremes data.
- Global and regional bodies would be approached to encourage regional projects to develop data sets and analyses of climate extremes.
- A further Workshop would be held in approximately two years to determine progress and any impediments to determining whether the global climate was becoming more extreme or variable.

It was also agreed that the presentations at the Workshop, and summaries of the breakout group discussions, should be published as a special edition of *Climatic Change*. Some of the presentations were combined, to reduce the number of papers, to provide a more comprehensive regional coverage, and to promote "cross-fertilisation" between authors approaching the subject from different perspectives. The papers and discussions are included in this volume, and provide the most comprehensive description of what we can ascertain regarding changes in climate and weather extremes, the data we need to improve the monitoring of these extremes, and the analyses that still need to be undertaken.

References

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