CCl/CLIVAR Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI) First Team Meeting Report

24-26 November 2003
Zuckerman Institute / Climatic Research Unit, East Anglia University, Norwich, UK

Contents

Action list

1. Circulate to members and inform CLIVAR SSG of the ET interpretation of the terms of reference that resulted from discussion during the team meeting and is summarized in the meeting report. – *Zwiers/Yan*

2. Prepare a template letter to WMO Permanent Representatives in relevant countries, which states objectives and benefits of workshop and type of participant desired. - *Mokssit/Zwiers/Alexander/Haylock/Hewitson* (Llanso/Detemmerman to resurrect previously used letter by early January 2004)

3. Develop a template screening questionnaire for choosing workshop participants, based on previously used. – *Mokssit/Zwiers/Hewitson*

4. Check all aspects of the ClimDex software that will be used in workshops. - *Klein-Tank/Alexander*

5. Prepare a Resource CD containing ClimDex documentation and other supporting materials for workshops. - *Alexander/New/Stephenson*

6. Arrange for translation of the software document into other languages. - *Stephenson for Portuguese /Llanso for French and Spanish* (Carriers of Actions 4&5 to make sure that the document is ready by 1 March 2004*)*

7. Identify targeted regions not covered by pervious workshops. - *Mokssit/Alexander/Haylock*

8. Organize and deliver workshops in coordination with supporting organizations and funders (see Table 1). – *Local organizers / ET contacts*

9. Prepare a short document on preferred practices for index construction and analysis, including guidance for "reanalysis" of previously collected indices. Include a cross-referenced list of indices computed by the various pieces of software that are currently available so as to identify differences in index definitions. Also include advice on analysis methods appropriate to each index. Publish as a CCl/CLIVAR report and post on the web. - *Stephenson/Klein-Tank/Haylock/Zwiers/Zhang*

10. Make sure that workshop information (including outputs and follow-up activities) is available at the ET web and linked to the CLIVAR web site. - *Zhang/Zwiers/Yan*

11. Prepare a short document on suggested large-scale atmospheric, oceanic and marine climate indices for monitoring and detection that should be considered for the IPCC 4th Assessment Report (AR4). – *Bindoff/Folland/Swail/Karoly*

12. Write to JCOMM expressing need for marine climate change detection, monitoring and indices. - *Co-chairs/Swail*

13. Develop an ET website focused on local indices. If feasible, include with group email/seminar capability and data-visualizing tools. – *Zhang/Zwiers*

14. Prepare a timetable for ETCCDMI activities, taking the IPCC AR4 and CLIVAR and relevant WMO activities into account. – *Co-chairs/Yan*

Table 1. Summary of ET regional workshop planning

Region	S Africa	S America	C America	Tibet	Asia Minor /Caucasus
Area covered	Africa with priority for regions not covered by Casablanca Workshop	Most of S American	Central and northern S America	Asian plateau	W Asian and some SE European countries
Time	31 May – 4 June 2004	August 2004	November 2004	Late 2004	2 weeks in May 2005
Venue	University of Cape Town and South Africa Weather Service, Cape Town, South Africa	University Federal de Alagoas, Maceio-Alagoas, Brazil (offers also from CPTEC and IAI)	Netherlands Antilles	WMO Beijing Climate Center, Beijing, China	Meteorological Guest House Alanya, Antalya, Turkey
Organizer /ET contact	Hewitson /Zwiers	Molion /Karoly	Martis /Jones	Zhai /Yan	Sensoy /Mokssit
Lecturers /Instructors (more to be considered)	New Stephenson Collins	Alexander Haylock Sensoy	Alexander Zwiers	Stephenson Folland Sensoy	Jones Mokssit Klein-Tank
Associated meeting /conference	9th Int. Mtg. Stat. Climat. 24-28 May 2004	No	No	To be considered	To be considered

General requirements

Length: a week with/plus two days for lectures
Language: English desirable for participants
Technical needs: computer facilities with Windows95 up and better one person capable of Visual Basic
Data needs: GSN sites and reference stations with metadata (less than 10% missing records) from 1950 (or at least 1961) onwards, in format suitable for input into ClimDex software
Variables: including daily Tmean, Tmax, Tmin and precipitation

Expected outcomes

For organizers	For participants
• Inventory of daily data • Indices • Improved access to daily data	• Inventory of daily data • Quality-controlled daily data • Skills in climate data analysis

• Greater understanding of data-sparse regions' problems • Contribution of results to a central (ET) website within 2 months • Feedback on software and documentation • Feedback on indices • Peer reviewed publication • CD of outputs	• Appreciation of wider picture (global change issues in the region) and of value of sharing data • National report on climate change as indicated by indices (in regional context) • Increased capacity to institute regular climate change reporting • Ongoing regional network • Peer reviewed publication – for input to IPCC • CD of outputs

Background

The Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI) is jointly sponsored by the Commission of Climatology (CCl) of the World Meteorological Organization (WMO) and the Climate Variability and Predictability (CLIVAR) project of the World Climate Research Programme (WCRP). It plays a primary role in developing and implementing CLIVAR's research programme for climate change detection and attribution and in coordinating and providing guidance for CCl's global climate monitoring activities. The ETCCDMI is the successor of the CCl/CLIVAR Working Group on Climate Change Detection (with a history archived at http://www.clivar.org/publications/wg_reports/wgccd/wgccd_report_3.pdf). The terms of reference for the new team (http://www.clivar.org/organization/etccd/index.htm) had been discussed by the team by email and their interpretation of these is summarized later in this report (section 2.3).

The current team members are:

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

Dr. D. Stephenson, University of Reading, Reading, UK, is a Special Advisor to the team. The International CLIVAR Project Office contact for the team is Dr. Z. Yan.

The objectives of the first team meeting were

- to review progress in the field of CCDMI and identify priorities for the near future,
- to pave the way towards successful regional workshops in 2004-2005, and
- to develop marine / oceanic aspects of CCDMI.

1. Introductory remarks

The first CCl/CLIVAR ETCCDMI meeting was held at the new Zuckerman Institute, University of East Anglia, Norwich, UK. Dr. F. Zwiers (Co-chair) opened the 2.5-day meeting on the morning of 24 November 2003. He thanked Prof. P. Jones, Ms. J Burgess and Dr. Z. Yan for their efforts in organizing the meeting and CCl and CLIVAR for their sponsorship. Prof. Jones, the director of the host institute (Climatic Research Unit), welcomed the team and experts (Appendix 1) to Norwich and expressed appreciation of the team meeting at East Anglia as a first international venture in the new institute.

The Co-Chairs introduced the meeting agenda (Appendix 2) and objectives. They expected to make a 2-3-year work plan for the team, as annual team meetings are unlikely. Dr. Zwiers expected that the team would contribute to CLIVAR and IPCC by improving global coverage for climate change indices and analysis tools and providing global assessment to indices. The team could also contribute to CCl's implementation

programme by developing an official toolkit (software, documentation and supporting materials) to be promoted for application in national operational agencies, reviewing the Annual WMO Climate Assessment and by the capacity building in the detection and monitoring area through regional workshops.

Dr. Mokssit stressed that the team should work on both scientific (CLIVAR) and operational (CCl) aspects. It was desirable that the teamwork would lead to more national operational agencies being involved in the process of capacity building in the CCDMI area. For workshops, Dr. Mokssit asked the team to consider of possible follow-up activities in order to assure sustainability of the teamwork.

The participants discussed the meeting agenda and agreed with the deliverables and expectations introduced by the co-chairs. Mr. M. Haylock reminded the team of possible links to the START / Asian-Pacific Network (APN), which also would organize similar regional workshops. It was noted that CLIVAR SSG (12th session, Victoria, May 2003) encouraged the team to work with START and GCOS when planning regional workshops. The team agreed to keep up information and communication with relevant organizations through both the ICPO and the team members.

2. The ET role in CCl and CLIVAR

2.1. The CCl perspective

Mr. P. Llanso, Chief of the World Climate Data and Monitoring Programme (WCDMP) under the World Climate Programme (WCP), outlined relevant information of WCP, WCDMP and CCl. He pointed out some WCP areas of interest, including

- monitoring and understanding the global climate system,
- collection, rescue and management of climate data,
- detection and assessment of climate variability and changes, and
- capacity building, transfer of knowledge, techniques and guidance.

As Mr. Llanso outlined, the WCDMP was aimed at

- detection of climate change,
- analysis of interannual variability of the global climate system,
- implementation of methods to rescue, preserve and manage climate data, and
- preparation and distribution of global and regional data sets, including metadata.

These clearly overlap with the team's objectives.

With support from WCDMP, CCl have established 3 Open Programme Area Groups (OPAGs), each with an Implementation/Coordination Team (ICT), and an Expert Team (ET) and Rapporteurs. The 3 OPAGs are (1) Climate Data and Data Management, (2) Monitoring and Analysis of Climate Variability and Change, and (3) Climate Applications, Information and Prediction Services. As a part of the effort to fulfill the CCl's tasks, a CCl/CLIVAR Working Group for Climate Change Detection (WGCCD) was established in 1999, which organized two regional workshops, one in Kingston (January 2001) for the Caribbean area and another in Casablanca (February 2001) for Africa. To further progress, CCl established the ETCCDMI under OPAG2, in coordination with CLIVAR during late 2002.

Mr. Llanso summarized the CCl perspective for ETCCDMI with expectations for the team to

- develop indices of climate change and variability, with emphasis on daily to seasonal extremes, and standardized software packages,
- study further indices, application of indices as input data to models and homogeneity issues, and
- provide guidance for NMHS' needs, including guidelines on CCDMI, planning workshops, and inputting to the annual WMO Statement on the Status of the Global Climate, etc.

During discussion, Dr. N. Bindoff questioned the relationship between the Expert Team (ET) and the Implementation/Coordination Team (ICT). Logically, it was anticipated that the ET provide scientific guidance and develop CCI and standard software while the ICT carry out applications and capacity building in WMO member countries. Dr. V. Swail commented that CCl might need to pay more attention to marine and oceanic aspects of climate.

2.2. The CLIVAR perspective

Dr. Yan briefed the team on relevant information of WCRP and CLIVAR. He forwarded an apology from Dr. H Cattle, the director of the International CLIVAR Project Office, who co-authored the presentation but was unable to attend the meeting. As the presentation showed, the Joint Scientific Committee (JSC) reaffirmed during its recent annual meeting that, after discussions initiated by the WCRP Banner Project, the aims of WCRP remained as originally specified, i.e.,

- to determine to what extent climate can be predicted and the extent of human influence on climate, aiming at the goal of greatly improved understanding of the role of climate in the total earth system.

To help achieve this overall objective, CLIVAR has been set up with 4 specific objectives:

- to describe and understand the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial time-scales,
- to extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled instrumental and proxy data sets,
- to extend the range and accuracy of seasonal to interannual climate prediction through the development of global coupled predictive models, and
- 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.

Dr. Yan anticipated that the ETCCDMI's activities would directly contribute to the 2nd and 4th specific objectives and help in some aspects for achieving the other two. He suggested the team consider possible links and coordination with other CLIVAR activities, especially those of the CLIVAR Data and Information System, the CLIVAR/PAGES Working Group, and the Working Group for Coupled Modeling. Links to developing CLIVAR basin panels are encouraged, if the team is to promote development of marine and oceanic aspects of CCDMI.

The team was also briefed on some outcomes from the 12th CLIVAR SSG session (Victoria, May 2003). The SSG agreed to suggested changes in TOR resulting from discussions among team members early this year and encouraged the team to work with START and GCOS when planning regional workshops. It was noted that the SSG called all CLIVAR groups to provide a brief summary of what they have accomplished relative to what they set out to do and what they think they can achieve by a given sunset date of 2013.

The team was encouraged to use the CLIVAR Exchanges newsletter for publishing outcomes of the regional workshops as appropriate and to take part in the first International CLIVAR Science Conference, 21-25 June 2004, Baltimore, USA.

During discussion, it was stressed that the anthropogenic climate change (ACC) be a cross-cutting theme of the CLIVAR programme. However, as Prof. D. Karoly commented, CLIVAR might not have made sufficient effort in that direction. The ETCCDMI should be able to make substantial contributions in this area. Dr. Bindoff supported links between ETCCDMI and CLIVAR basin panels, in order to promote marine and oceanic aspects of CCDMI across the CLIVAR community.

2.3. The ET interpretation of the terms of reference

With respect to the CCl and CLIVAR perspectives, Drs. Zwiers and Mokssit guided the discussion on ET's terms of reference (TOR). A 10-item TOR was reported by Dr. Mokssit at CLIVAR SSG-11 (Xian, May 2002). The SSG recommended there could be fewer and simpler items, while keeping details in working plan. This led to discussions among team members and a shorter version resulted and presented to the CLIVAR SSG-12 earlier this year. The team reviewed each of the items. Table 2 summarizes the team's interpretation.

Table 2. The ET interpretation of the TOR

Item	*Interpretation (with item number in the shorter version)*

1. To further develop and publicize indices and indicators of climate change and variability, with particular emphasis on the creation of indices of daily to seasonal extremes covering the global land surface using standardized software packages	*Ok (1)*
2. To further develop other indices of value to the IPCC, related to changes in mean climate and its variability from the sub-surface of the oceans to the stratosphere	*Ok (2)*
3. To provide input on indices to WMO publications such as the Annual Statement on the Status of the Global Climate	*Ok (3)*
4. To compare modeled and observed indices, and report on the comparisons, with some emphasis on changing extremes	*Ok (4)*
5. To assist in the specification and implementation of observing system experiments with models used for global and regional climate change detection, with emphasis on the GUAN and GSN networks	*The team will work in this area as appropriate under item 8*
6. To arrange for or make assessments that identify and quantify the magnitude of biases introduced by automated means of measurements and their consequences for detection and attribution	*The homogeneity issues are recognized as being important and within the ET purview*
7. To consider other issues of homogeneity as deemed appropriate	*Within the ET purview*
8. To collaborate with and provide inputs to other groups, especially those set up under IPCC auspices, regarding the adequacy of the global observing system for the purposes of supplying advice to Conferences of the Parties to the Rio Greenhouse Gas Convention, and regarding the development of indices	*To collaborate with and provide inputs to other groups, especially those set up under IPCC auspices, regarding the adequacy of the global observing system and the development of indices (5)*
9. To maintain plans for capacity building in developing countries in the above activities, particularly through Workshops. In particular, to work closely with START on capacity building through its Monitoring Extreme Climate Events (START-MECE) group	*The team will support capacity building in the above activities, particularly through workshops and collaboration with START*
10. To submit reports in accordance with timetables established by the COPAG and/or Management Board, and agreed with CLIVAR participants	*Within the ET purview*

During discussion, Dr. C. Folland and L Molion noted that it could be worthwhile explicitly stating the homogeneity issues in the working plan for ETCCDMI activities, especially for the regional workshops, where homogeneity could be overlooked. The team agreed to circulate its interpretation of the TOR to relevant parties.

Action 1. Circulate to members and inform CLIVAR SSG of the ET interpretation of the terms of reference that resulted from discussion during the team meeting and is summarized in the meeting report. – *Zwiers/Yan*

3. The ET role in other programs

A number of international programmes/organizations are engaged in the field of CCDMI. The team was briefed on some of them, to which the team could make direct contribution.

GCOS – In his presentation of the Global Climate Observation System, Dr. Folland pointed out that indices could be a key issue for climate change detection and monitoring. He showed a few aspects to be considered in order to guide GCOS/ETCCDMI's work. The first is to identify questions indices should answer. Example questions are:

- How warm is the world now, including ocean and atmosphere and selected regions?
- What are the current/recent states of regional atmospheric circulation and how unusual are they?
- What are current/recent states of the ocean and how unusual are these states?
- What is the state of ENSO?

- Have recent extreme events broken records and if so where, and what types of extremes?
- For seasonal to interannual prediction, what is the expected state of key climatic indices in the near future and what is our confidence in the predictions?

Based on data availability, Dr. Folland took example indices related to these questions, including global temperature, annual surface temperature anomalies and percentiles, upper-300m ocean temperature anomalies, seasonal anomalies of global temperature for the lower troposphere, global tropopause level pressure, OLR, sea ice extent, land snow cover, monthly precipitation in typical regions such as the Asian monsoon region, and circulation indices for the North Atlantic Oscillation, Southern Oscillation and other modes of variability.

Dr. Folland called the team to consider who its audiences are, what space and time scales are important, who else has developed climate indices, and how the GCOS/ETCCD group choose from the vast range of possible indices. He wished for current index states to be put in historical context and include uncertainties where possible. He concluded with a recommendation to set up a dedicated web site hosting a new GCOS/ETCCD diagnostics/index monitoring system, which should complement and be linked to other sites. He noted this would need considerable expertise and time. He mentioned possible use of the ERA-40 reanalysis data set, which has recently been made available (free online).

JCOMM – Dr. V. Swail thanked Peter Dexter (JCOMM Secretariat, Geneva) for his input to his presentation. The WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology is an intergovernmental body of experts, which provides the international, intergovernmental coordination, regulation and management mechanism for an operational oceanographic and marine meteorological observing, data management and services system. As Dr. V. Swail showed, JCOMM makes effort to further develop the observing network, partly under the guidance of GCOS. Its data management activities are coordinated with other bodies including GOOS and WMO/CCl. JCOMM has archived various types of data for meteorology, surface oceanography, sea level and sea ice, including those from volunteer vessels, drifters, buoys, satellite and in-situ, which are useful for studying seasonal to interannual and longer-term climate variability.

As Dr. Swail discussed, a notable JCOMM activity is the MCSS - Marine Climatological Summaries Scheme. Established in 1964, the MCSS has as its primary objective the international exchange, quality control and archival of delayed mode marine climatological data, in support of global climate studies and the provision of a range of marine climatological services. Two Global Data Collecting Centres (GCC) were established in 1993 in Germany and the United Kingdom. All data are eventually archived in the appropriate World Data Centres, such as the National Climatic Data Center (NCDC). Another notable advance took place with the CLIMAR workshops. As Dr. Swail outlined, the 1st CLIMAR workshop (Vancouver, 1999) brought together COADS and JCOMM, and was followed by workshop in Boulder (2002) and CLIMAR II (Brussels, 2003), which further developed its scope. CLIMAR set 3 streams of work on:

- historical data – to identify, locate, digitize, quality control, homogenize and exchange, leading to data products,
- climate analysis - mean, variability, extremes, uncertainty, trend, indices, leading to information products, and
- observational systems – involving GCOS/GOOS, VOSClim, AVOS, ocean observatories and satellite

More JCOMM data activities can be traced through the JCOMM web site at: http://www.jcommops.org.

The team appreciated JCOMM's efforts in archiving marine and oceanic climate data. It was felt that JCOMM could make considerable contribution in the area of climate change detection and monitoring. The team agreed with Dr. Swail's suggestion of cooperation with JCOMM in order to promote developing marine and oceanic aspects of CCDMI.

START – The IGBP/IHDP/WCRP co-sponsored SysTem for Analysis Research and Training plays an important role in capacity building for global change studies. START was involved in earlier CCl/CLIVAR regional workshops and is continuing to provide support. In spite of the failure to arrange a START representative to attend the meeting, the team highly appreciated START's contribution in past activities and would keep close collaboration with START in the future.

IPCC – Working Group I of the Inter-governmental Panel for Climate Change is in charge of the scientific assessment of climate change and publishes IPCC Assessment Report (AR) regularly every 4 years. Dr. Zwiers outlined plans for IPCC AR4 (co-chaired by Dahe Qin and Susan Solomon), to which the team will make considerable contribution. Specifically, the outputs of the regional workshops (details in section 5) will fill geographical gaps of observed climate change assessment for AR4's Chapter 3 (Observations). The team will possibly contribute to Chapters 4 and 5 (Cryosphere and Ocean). Dr. Zwiers anticipated impact on other chapters, giving the role of indices in:

- global and regional model assessment (Chapters 8 and 11)
- climate change detection and attribution (Chapter 9) and
- assessment of global and regional projections (Chapters 10 and 11)

Dr. Zwiers showed the time line for AR4 and called the team planning activities accordingly. A key time point is December 2005, when all material referenced should be in press or published. This should be considered when planning regional workshops. Dr. Mokssit added that the previous Caribbean and African workshops could also contribute to help fill the gaps in the map of climate change assessment based on CCI.

The team agreed in principle to adjust the working plan to the IPCC time line. However, as Dr. Stephenson argued and suggested, the team should develop a wider scope than just working along with IPCC. Nonetheless, it was arguably recognized that in practical terms, the IPCC activities could serve as a driving force for the team activities.

4. Science review

There have been a number of European projects, which lead in the field of climate change, extremes and indices. The team was briefed on some of the scientific advances, in order to identify priorities for future works.

MICE – Modeling the Impact of Climate Extremes. Prof. J. Palutikof introduced this project, as a part of a cluster of 3 projects dealing with extremes within European Union Framework 5, running from February 2002 until July 2005. The project aims to

- identify and catalogue extremes in observed and modelled climate data,
- assess future changes in climate extremes using Extreme Value Theory,
- assess the impact of changes in extremes, and
- communicate the results to stakeholders.

As Prof. Palutikof explained, MICE does not carry out downscaling analysis, as many model-observation comparative studies do. It considers more weather types than single-station or –grid statistics. Prof. Palutikof showed some examples linking extremes and impacts, including energy consumption and crop production. For impact studies, the MICE experience suggests that down-scaling is not necessarily a better way. More details are online at http://www.cru.uea.ac.uk/cru/projects/mice/.

STARDEX – STatistical and Regional dynamical Downscaling of Extremes for European regions, one of the 3 EU projects. STARDEX is coordinated by the University of East Anglia and includes 12 European partners. As Mr. Haylock introduced, the objectives of STARDEX are to improve downscaling techniques of extremes and apply more robust techniques to providing projections of changes to climate extremes under climate change. STARDEX has developed a software tool that calculates 57 climate indices, mostly dealing with extremes. A core set of 10 indices is being used throughout the project to develop scenarios for Europe. There are differences in the definitions of some indices compared with the method of calculation in other European studies. The question of what constitutes a climate "extreme" has been an important point of discussion in STARDEX, but the need for statistical confidence in downscaling extremes means that only more moderate extremes (return periods of less than a year) can be currently considered. More details are available at http://www.cru.uea.ac.uk/cru/projects/stardex.

Questions were raised about the 57 indices and how to choose indices. Prof. Jones and Mr. Haylock explained that the project's top 10 indices were based on considerations of both practical and statistical significance and of modeler's interests. The team recognized the need for identifying different types of extreme indices for

different climate regimes. In later discussions on workshops, Mr. Haylock agreed to make a table comparing all indices available and commonly used in international research, in order to assess the various indices.

ECA – European Climate Assessment. Mr. A. Klein-Tank introduced the project and discussed recent results obtained from studying trends in indices for extremes in Europe, as well as future plans. Currently ECA joins 41 participants from 39 countries in Europe and the Mediterranean. Under a contract of the organization of meteorological services in Western Europe (EUMETNET), the ECA project will continue at least until 2008. The public website http://www.knmi.nl/samenw/eca gives access to all results (report, papers, presentations) and data (over 500 daily station series). Definitions for a core set of internationally agreed indices are also provided at the website. Among the indices described are those in the ClimDex software tool that has been developed by NCDC for the Caribbean and African workshops on extremes. Current ECA work includes improving data accessibility (netCDF, DODS, etc.), further developing techniques for homogeneity assessment of daily time series, providing monitoring of indices products (like the prototype shown for the 2003 summer heat wave in Europe) and investigating trends in extremes using more advanced statistical methods.

Mr. Klein-Tank noted that IPCC WGI (Beijing, 2003) recommended using more advanced methods than simple description of extremes. However, the question "which methods best supplement the 'simple' descriptive indices" remains open, although it is recognized that the indices that have been used so far describe only part of the characteristics of extremes (amplitude, rate, duration, persistence, etc.). Later discussions at the meeting made clear that the infrastructure developed at KNMI in the past 5 years and the coming years for ECA will be available for use in other regions and for the ETCCDMI.

Comparing observed with modeled changes – Dr. Folland introduced a recent study by Kiktev et al., who compared observed and modeled trends in extremes of surface temperature and precipitation during the second half of the 20th century. The study derived from station daily data a few annual climate indices (e.g., Frost Days and Consecutive Dry Days) and interpolated them to model grids. The maps show that data are available in North America, the Eurasian continent and Australia, leaving gaps elsewhere. The model outputs are from 3 ensembles of HadAM3 runs with observed SST and 3 sets of forcing: solar variability and volcanic forcing; plus greenhouse gases, direct aerosol effects and ozone factors; and plus indirect aerosol effects. Main conclusions are:

- Observed results mainly confirm earlier findings (Frich et al., IPCC TAR), but with more rigorous estimates of trend uncertainty to determine the significance of trend patterns.
- Gridding provides coherent observed trend patterns and allows comparison of observed trends with those simulated by models forced by observed SST, sea-ice and human-induced forcings.
- Comparisons with HadAM3 runs indicate that inclusion of anthropogenic effects in model integrations improves the simulation of changing extremes in temperatures over 1950-1995.
- HadAM3 shows little skill in simulating 1950-1995 precipitation extreme trend patterns.

There is obviously a need for comparison with coupled model data to determine if changes in extremes are unusual in the context of natural climate variability, and to estimate total anthropogenic effects on changing climate extremes. Dr. Folland supposed this could be done with HadCM3 and CCM3 first. He suggested that this should be a recommendation of ETCCDMI to the CLIVAR WGCM. One difficulty deals with the forcings. Dr. Zwiers noted that forcings for the 21st century had not been agreed yet. It remains unclear how to better coordinate between the more observation-based studies of ETCCDMI and the more model-based ones of WGCM.

Extremes simulated in models – Dr. Zwiers started his talk by showing a few daily precipitation series, which can hardly distinguish the observed from the modeled. Undoubtedly, model can produce variability similar to the observed. However, as he further showed, there are still big gaps and difficulties. The study he described involved daily temperature from 12 AMIP2 models and precipitation from 16 models, compared with observed data including NCEP and ERA-15 reanalysis and station data. Classical extreme value theory was applied to fit annual extremes and to estimate 20-year return values. For temperature, models tend to underestimate warm and overestimate cold extremes. For precipitation, there are large differences between different data sets. Several models exhibit insufficient variability in the tropics and the erroneous split ITCZ. Models substantially underestimate extremes (about 75% of ERA-15 and 50% of station-observed over part of world). Some scenarios for 2050 simulated by CGCM2 were also presented. Dr. Zwiers concluded that

- data for assessment of extremes is a serious problem, while models are different from “reality”;
- it is difficult to identify causes of model problems, though there are indications towards land surface parameterizations and parameterizations of convection;
- projections of the future are sensitive to model quirks, but there is confidence in some aspects.

Methodology in CCDMI – Dr. Stephenson focused his talk on statistical methods for estimating trends in climate change indices. He discussed indices used for monitoring and detecting climate change and how best to assess long-term trends in such indices. The basic definition of ETCCDMI "extremes" indices (as used in the CLIMDEX, ECA, STARDEX, and PRUDENCE projects) was first described and an interpretation in terms of "marked point process" of daily exceedences was presented. A brief discussion of what is meant by "extreme" followed together with a look at caudology (the study of tails). The question of what exactly is a "trend" was then raised and various definitions were given. Trend analysis was illustrated on a particularly difficult example of a Russian Heat Wave Duration Index (HWDI) provided by Lisa Alexander at the Met Office. The probability model approach to describing a trend in the mean was explained. Residuals from a linear fit to the HWDI were shown to have very strange non-normal (non-Gaussian) behavior caused by the non-normal distribution of the HWDI variable. The advantage of using non-local in time robust fits such as LOWESS was demonstrated along with the idea of assessing trends on only the non-zero values of the HWDI. A list of problems with the usual linear least-squares trend approach was discussed and some alternative methods such as Generalized Linear Models (GLM) suggested. There is no unique definition of trend and so care should be taken when doing trend analysis of extremes indices. This will form ongoing work for the ETCCDMI team.

It was argued, however, that linear trend remains a most straightforward expression for climate change in many cases (e.g., global warming). Nevertheless, non-linear ‘trends’ will be more useful in analyzing series of climate extreme-related indices. During discussion, Dr. Folland emphasized that statistical uncertainty should be estimated for any climate change analysis. It was noted that well-designed GLMs could serve a useful tool in estimating climate extremes and trends with statistical uncertainty assessment.

5. Regional workshop planning

Due to technical problems, the planned phone session with Dr. T Peterson was replaced by a later telephone-communication between Drs. Zwiers and Peterson. Dr. Yan briefed the team on a presentation by Dr. Peterson sent before the meeting, which provides some context for the workshop discussion. After a brief history review, the presentation listed the general goals of regional workshops:

- Analyze indices from daily data, especially measures of changes in extremes
- Fill in blank areas in “global” analyses
- Isolated analyses are questionable, but become trustworthy when neighboring stations/countries show similar changes
- Insights gained and shared improve the analyses for neighboring countries
- Foster greater appreciation for data and data archeology

Specific goals include producing peer-reviewed journal article on analysis of climate change for the region and providing the data and indices used in the analyses. Careful post-workshop data analysis is necessary to accomplish these goals.

Funding remains a critical factor for organizing workshops. The current information shows there could be limited funds for 3 regional workshops. Top 3 priorities were allocated for Southern Africa, Central America and Southern America. It was recommended that the Asian plateau and Southwest Asia be the next two targets. Possible actions for the ETCCDMI include

- Helping to identify potential participants for each workshop
- Lining up institutional support (CLIVAR and CCl)
- Providing recommendations/guidance
- Coming up with additional funding to cover recommendations beyond contributing to IPCC and minor capacity building

Having considered Dr. Peterson’s report and other relevant workshops (e.g., the SCAR READER project for Antarctic daily/sub-daily data in September 2004, the APN SE Asia workshop organized by Neville Nichols in

March 2004 and the APN Oceania Workshop by Jim Salinger in December 2003), the team agreed a prioritized list of 5 workshops for S Africa, S America, C America, the Asian plateau and SW Asia during 2004-2005.

Taking the Casablanca workshop (summarized by Easterling et al., Bulletin of American Meteorological Society October 2003) as an example, Dr. Mokssit guided the team to consider more details of the objectives, deliverables and contents of such workshops. It was suggested that the workshops include 2 days for seminars given by invited experts. It is ideal to have one lecture about general analysis of climate change using proxy data (e.g., for the period of the1950s backwards) with focus on the region, and one about modeling with IPCC-type background and scenarios with regional focus. The discussion also led to a number of action-related agreements, including:

- The ClimDex software, used for previous workshops, will be maintained and improved and be applied in future workshops. A thorough check and updated documentation will be made in accordance to the S Africa workshop planning.
- Document packages in French, Spanish and Portuguese, in addition to English, will help to promote activities for some regional workshops. An updated English document for ClimDex will be ready for translation to French, Spanish and Portuguese versions by the end of February 2004.
- The daily data series to be analyzed should be sufficiently long (at least since the 1960s), with a missing rate of less than 10%. The data should be prepared before the workshops in the format required by ClimDex.
- GSN (GCOS Surface Network) sites and neighboring reference sites are preferable. This point will be included in the letter and screening questionnaire to the WMO PRs in relevant countries, in order to choose data.
- For choosing participants, it would be better to consider potential trainers instead of trainees. This may be crucial for maintaining follow-up activities, which will be agreed and carried out by participants.

The team was briefed on the preparation for the first priority workshop – S Africa – by Dr. B. Hewitson over the telephone. The workshop will be hosted by the University of Cape Town and the South Africa Weather Service, Cape Town, during the 1st week of June 2004, immediately after the 9th International Meeting for Statistical Climatology. START has agreed to provide funds (which may cover 2/3 of those required, and WMO is considering adding support according to the latest information). The next steps will be to identify participants with required data, to start training on software, and to plan seminars with invited experts. At least 15 PCs plus technicians will be ready for participants. As the team suggested, targeted countries should include all those of Africa, with priority to those not covered by the Casablanca workshop. Some detailed requirements resulting from the team discussion will also be followed, as summarized in Table 1. The meeting and outputs will be reported over the coming weeks through a central ETCCDMI web. Dr. M. New agreed to draft a paper of the output of workshop as input to IPCC AR4.

The team recognized the necessity to prepare a Resource CD for the coming workshop. A list of contents of the CD-ROM were suggested, including:

- ClimDex Manual (in English, French, Spanish and Portuguese)
- Chapters of observations and regional scenarios of IPCC WGI Assessment Report
- Frich et al., 2002: Observed coherent changes in climatic extremes during the second half of the twentieth century. Climate Research 19, 193-212
- Klein-Tank and Konnen 1993: Trends in indices of daily temperature and precipitation extremes in Europe 1946-1999. J. Clim. 16: 3665-
- Kiktev et al., 2003: Comparison of modeled and observed trends in indices of daily climate extremes. J. Clim. 16: 3560-
- Caribbean & African workshop papers (e.g., Easterling et al. 2003)
- Table of categorized indices (Haylock/Klein-Tank)
- Document of methodology (Stephenson/Klein-Tank/Haylock/Zwiers/Zhang)
- Report of CCl/CLIVAR ETCCDMI-1
- Web links to useful sites and reference material
- ClimDex software
- GrADS software
- Test data

The CD will have 2 directories, one including software and documents, and another with reference papers and reports.

L. Molion and S. Sensoy briefed the team on their preliminary proposals for the S America and SW Asia workshops. As Mr. Molion described, the working environment for climate study in Brazil is getting better. He was optimistic for organizing the S America workshop in August 2004. The team appreciated Mr. Sensoy's proposal of a 2-week workshop in Turkey in May 2005. All possible aspects were discussed for each workshop, including dates, venue, targeted area, associated international meetings, experts and ET coordinators. The number of participants was estimated at 15-25 for each workshop, with 1-2 person(s) per country. It was recommended that SW Asia workshop include some SE European countries. Some members hoped the Asian plateau workshop would include India, while acknowledging the difficulty due to the distinct climate between India and the plateau area. Table 1 summarizes the workshop planning, general requirements and expected deliverables. Administratively, a letter to PRs of involved countries should be sent out as early as possible from WMO. A screening questionnaire for choosing candidates should be sent out through the PR from WMO or a committee in case of an associated conference.

Action 2. Prepare a template letter to WMO Permanent Representatives in relevant countries, which states objectives and benefits of workshop and type of participant desired. - *Mokssit/Zwiers/Alexander/Haylock/Hewitson* (Llanso/Detemmerman to resurrect previously used letter by early January 2004)

Action 3. Develop a template screening questionnaire for choosing workshop participants, based on that previously used. – *Mokssit/Zwiers/Hewitson*

Action 4. Check all aspects of the ClimDex software that will be used in workshops. - *Klein-Tank/Alexander*

Action 5. Prepare a Resource CD containing ClimDex documentation and other supporting materials for workshops. - *Alexander/New/Stephenson*

Action 6. Arrange for translation of the software document into other languages. - *Stephenson for Portuguese /Llanso for French and Spanish* (Carriers of Actions 4&5 to make sure that the document is ready by 1 March 2004*)*

Action 7. Identify targeted regions not covered by pervious workshops. - *Mokssit/Alexander/Haylock*

Action 8. Organize and deliver workshops in coordination with supporting organizations and funders (see Table 1). – *Local organizers / ET contacts*

Action 9. Prepare a short document on preferred practices for index construction and analysis, including guidance for "reanalysis" of previously collected indices. Include a cross-referenced list of indices computed by the various pieces of software that are currently available so as to identify differences in index definitions. Also include advice on analysis methods appropriate to each index. Publish as a CCl/CLIVAR report and post on the web. - *Stephenson/Klein-Tank/Haylock/Zwiers/Zhang*

Action 10. Make sure that workshop information (including outputs and follow-up activities) is available at the ET web and linked to the CLIVAR web site. - *Zhang/Zwiers/Yan*

6. Marine and oceanic aspects

There is great potential of developing marine and oceanic aspects in the area of CCDMI. A few talks were invited at ETCCDMI-1 to address relevant issues.

Status of marine data and monitoring – Dr. Folland briefed on recent advances in developing global marine and ocean surface data sets, including:

- I-COAD – SST time series are extended back to the 1810s and improved with new data since1850 (comparing COADS), e.g., Japanese whaling ship data (30k reports), historical sea ice data from

WMO Global digital Sea Ice Data Bank, Japan, Baltic, China and Russia. However, biases due to use of uninsulated buckets need re-assessing in new I-COADS data set.

- Ocean air temperatures – recent improvements to NMAT using new corrections for marine screen heights and increased data from I-COADS have been documented.
- HadISST - improved from HadSST (used in IPCC 2001), HadISST1 combines SST and sea ice in a "globally complete" data set and is optimally interpolated and uses AVHRR satellite SST data.
- High-resolution Satellite SST – advances may be foreseen from the GODAE High Resolution (6 hour and 10 km) SST Pilot Project, aimed at high resolution global time and space SST analyses using polar orbiting and geostationary infrared data, microwave satellite data, and quality controlled ship, buoy and Argo data.
- MSLP – development of HadSLP2m with improved coverage (global 5x5deg) due to inclusion of I-COADS and additions from the terrestrial data bank is underway. Daily gridded MSLP series 1850-2002 for the North Atlantic – European area is also being developed. The HadSLP2m data will be updated in near real time using GTS data.

Having illustrated some improvements and problems in data, Dr. Folland concluded:

- Historical SST and sea ice data can be considerably improved. Biases need more attention post 1945 and around 1939-1941.
- Recent developments may particularly improve knowledge of ENSO, the Interdecadal Pacific Oscillation, and longer time scale SST variations in North Atlantic.
- Gridded SST data should be optimally interpolated (OI) with caution.
- Error bars should be placed on SST NMAT and MSLP through optimum averaging.
- It has been possible to develop high spatial and diurnal resolution worldwide SST using microwave and infrared satellite data and in situ data, perhaps including Argo.
- Substantial improvements to marine SLP data have emerged, working towards an International historic SLP data sets (perhaps I-MSLPm and I-MSLPd).

Monitoring and assessing marine climate change – Focusing on winds and waves, Dr. Swail outlined current status, plans and targets for marine climate monitoring. A 42-year wind and wave hindcast developed at CRB showed that in the period 1958-1997, the 90-percentiles of significant wave height for winter increased in the northeast North Atlantic by 2-6 cm/year and decreased by 1-3 cm/year in the subtropical North Atlantic. Analysis showed possible links between the wave height increases in the northeast Atlantic and the NAO variability. Study of marine climatology has obviously benefited our understanding of climate system. Dr. Swail noted that a first Global Wave Climatology Atlas derived from 45-year ECMWF reanalysis data was recently published (http://www.knmi.nl/onderzk/oceano/waves/era40/index.html). Monthly and seasonal statistics and anomalies and other wave/wind data and information are also available online, e.g., the I-COADS web http://www.cdc.noaa.gov/coads-las/servlets/dataset.

Dr. Swail briefed on some recommendations from CLIMAR-II 2003, including

- Investigate how to apply proposed wind homogenization techniques to global data bases such as I-COADS where you do not always have ancillary data or metadata. Is the SST adjustment approach suitable for winds?
- Recommend to I-COADS that they investigate inclusion of wave information in climate summaries.
- Develop a list of recommended climate indices for winds and waves, and pressures. Indices should be appropriate to the data bases used to develop them.
- Recommend to JCOMM that they promote development of climate information, especially indices, as a logical update in technology to outdated MCSS analysis
- Recommend to JCOMM that they identify operational and experimental climate information products, and include these as part of the new JCOMM Products portal (may remain resident with developer, e.g. I-COADS)
- Participate in the JCOMM Products Workshop Toulouse May 10-12, 2004

The team discussed how to coordinate with JCOMM and agreed to write to JCOMM to address need for marine and oceanic climate monitoring, change detection and indices.

Status of deep ocean data and monitoring – Dr. Bindoff reported on sub-surface ocean temperature and salinity observations (deeper than 10m) that are part of the CLIVAR program. He briefed on the historical data that exist prior to the 1990's, during the WOCE experiment, and those that are planned for the CLIVAR repeat sections and for the carbon cycle work (e.g., USA) over the next 10-15 years. In addition, Dr. Bindoff reported on the Argo program, and showed new results from the November 2003 Argo Workshop in Japan. Although there are only ~1000 floats currently deployed in the oceans these data are already useful for estimating heat and freshwater changes on a zonal basis in the Northern and Southern subtropical gyres over the last decade. The importance of the Argo data set for climate change detection in the coming decades is going to increase. He appealed to the CLIVAR International Program for more effort in promoting and supporting Argo, and the CLIVAR repeat hydrography and carbon cycle sections.

Monitoring and assessing ocean climate change – Dr. Bindoff went on to report on ongoing efforts internationally to detect climate type signals in the major ocean basins. He showed examples from all ocean basins that support the notion that key oceanographic water masses in both the Southern and Northern Hemispheres are changing, in particular, the mode waters and intermediate waters in both hemispheres. The mode waters show warming, the intermediate waters show a freshening, suggesting that both the surface temperatures and surface salinities are changing. The changes are broadly consistent with results from climate changes simulations from the Hadley Centre and well established results from various simulations of climate change showing strengthening of the hydrological cycle with increased evaporation at mid-latitudes, and increased precipitation at high latitudes.

The team discussed indices for detection of marine and ocean climate change. As Dr. Bindoff pointed out, one of the key issues in detecting climate change is the types of variables that are most suitable for detecting change. Signal and noise are important considerations. It is clear from coupled model simulations of natural variations and climate change that variables such as the transport of heat (at 24N in the Atlantic) are not significantly different from the control in the climate change simulations. On the other hand, sea-surface temperature, and water mass properties are significantly different. Similarly it is important to look at the water masses that are most likely to change, i.e., those that are relatively close to their source regions, and in areas where the natural variations are likely to be smaller. Coupled models suggest that water masses in the southern Ocean are a more sensitive indicator of change, because the signal-to-noise ratio is higher there. Thus, for the detection and attribution of climate change, the best ocean variables to use for indices would emphasize storage terms (such as heat, salt, carbon) variations in the water-mass properties and volumes, sea-level and perhaps large scale changes in ocean stratification. It is also important that these indices have value for establishing relationships between the oceans and terrestrial variations. Together, these requirements suggest that there will be need for both global scale and regional scale indices that address global scale issues of climate change, and regional scale impacts.

The team recognized that for climate change detection and attribution, it is important to create proper indices. Example indices were proposed, including: global ocean heat content and sea level, zonal average salinity, temperature and heat and those averaged by water mass, thickness, etc., indices indicating current bifurcation such as Indian Ocean Dipole and Aleutian Dipole, indices for ocean-atmosphere interactions such as Asian-Australian monsoon and overturning modes. However, it was noted that the number of indices should remain small and should include those that have been commonly used, e.g., those about ENSO. The team charged Drs. Bindoff, Folland, Swail and Prof. Karoly to summarize and circulate a list of ET-recommended marine and oceanic indices for IPCC AR4, together with the comparative list of indices made by Mr. Haylock.

Action 11. Prepare a short document on suggested large-scale atmospheric, oceanic and marine climate indices for monitoring and detection that should be considered for the IPCC 4th Assessment Report (AR4). – *Bindoff/Folland/Swail/Karoly*

Action 12. Write to JCOMM expressing need for marine climate change detection, monitoring and indices. - *Co-chairs/Swail*

7. ET web sites, national activities and others

ETCCDMI indices website – As Dr. Zwiers proposed, the bi-lingual ET website will be hosted at CRB within the web domain of the University of Victoria. Focused on indices, the web site will contain information of software for calculating indices (or links, e.g., those of NCDC, ClimDex, APN and STARTDEX), all post-processed peer-reviewed indices (downloadable), workshop reports and follow-up activities, all available homogenized daily data (or links), post-workshop indices (submitted to web master – Dr. Xuebin Zhang) and an updated list of references. The site will establish a mechanism for recognizing users through password-controlled download. It was expected to have a clickable map for choosing data sets from at least 10 indices at thousands of sites. Dr. Mokssit suggested that some modeled scenarios vs observations (e.g., from the EU project PRUDENCE and Meteo France) could be included. Dr. Bindoff noted that the web should be viable for marine indices, which had not been available yet. Prof. Jones enquired whether frequencies of extremes could be included. It was also recommended that the web incorporate bulletin board service to facilitate discussion among the team members and users.

GCOS website – Dr. Folland introduced the planning of the possible website. Challenging questions the web site will face include:

- Who approves the content of a GCOS web site?
- Will we encourage on line debate on content and who monitors this?
- Can we obtain near real time updates of extremes behaviour?
- What about showing short-term climate predictions?
- Should animation be included?

It is possible that BMRC and Met Office will lead the initiative in 2004. One problem deals with some official limits for data release from Met Office/Hadley Center.

Additional available web resources – Existing web resources dealing with climate extremes and indices include those web pages in association with the relevant EU projects at the Climatic Research Unit (http://www.cru.uea.ac.uk) and that of ECA (http://www.knmi.nl/samenw/eca/index.html). As Mr. Klein-Tank reported, the ECA web will remain until 2008. It is updated every 6-months, Statistics show good visiting rates, about 10 questions and 30k page views per week. A list of FAQs is therefore very helpful. Dr. Yan assured the team that CLIVAR website will include all these links.

National activities – Almost all countries are involved in studies of climate change detection and monitoring, due to the widespread impact of climate change on many economical and social aspects. In Australia, as Dr. Bindoff briefed, relevant research activities are mainly organized through BMRC, CRC, CSIRO and several universities. A main driving force for Australia is associated with the role of land cover change. For regional cooperation, Australia plays a role in organizing APN workshops on climate extremes and indices. In Brazil, as Mr. Molion briefed, it is difficult to obtain daily data from met offices for research. However, it is easier to get daily hydrological data associated with hydropower applications in 27 states, including rainfall and river runoff. He suspected the current indices (e.g., the 57 indices of STARDEX) might not be suitable for tropical climate regimes and addressed need to develop new indices. He hoped the ET workshop would promote studies of climate in the country. A detailed report for Turkey by Mr. Sensoy, and one for the US special ad hoc Working Group on Climate Change Detection by Dr. Zwiers were also presented at the meeting. The reports are available at CLIVAR's web site (http://www.clivar.org/organization/etccd) through the ETCCDMI-1 meeting agenda. The team appreciated all the reported national activities, which are deemed valuable for the development and implementation of CCl/CLIVAR's science plan.

During the last half hour of the meeting, the co-chairs reviewed the action list and deliverables. It was suggested that a timetable for ETCCDMI activities be established, taking into account the IPCC AR4 time lines and WMO/CLIVAR's long-term working plans. The co-chairs highly appreciated contributions from all participants and the help from the host, Prof. Jones and his team, which led to a very fruitful meeting. The 1st ETCCDMI team meeting was closed at noon on 26 November 2003.

Action 13. Develop an ET website focused on local indices. If feasible, include with group email/seminar capability and data-visualizing tools. – *Zhang/Zwiers*

Action 14. Prepare a timetable for ETCCDMI activities, taking the IPCC AR4 and CLIVAR and relevant WMO activities into account. – *Co-chairs/Yan*

Appendix 1. Attendee list

Appendix 2. Meeting agenda