APN CAPaBLE

Asia-Pacific Network for Global Change Research

- Making a Difference –

Scientific Capacity Building & Enhancement for Sustainable Development in Developing Countries

Final Report

Project Reference Number: CBA2014-08NSY-Koshy

"WCRP-ICTP Summer School on Climate Change"

The following collaborators worked on this project:

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UNIVERSITI SAINS MALAYSIA

CENTRE FOR GLOBAL SUSTAINABILITY STUDIES

WCRP World Climate Research Programme

WMO IOC ICSU International Council for Science

Project Reference Number: CBA2014-08NSY-Koshy

Title of the Project:

"WCRP-ICTP Summer School on Climate Change"
- Attribution and Prediction of Extreme Events -

Trieste, Italy, 21 July - 01 August 2014

Final Report submitted to APN by:

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

A Summer School on 'Attribution and Prediction of Extreme Events' was organized by the International Centre for Theoretical Physics (ICTP), in collaboration with the World Climate Research Programme (WCRP) and eight other international co-sponsors, from 21 July to 01 August 2014 in Trieste, Italy. There were 35 international students of which 10 were from Asia-Pacific countries, selected out of 54 applicants and sponsored by Asia Pacific Network for Global Change Research, APN. The Centre for Global Sustainability Studies (CGSS), Universiti Sains Malaysia facilitated the participation of the Asia-Pacific participants. The school focused on three topic areas: (i) statistical theory underpinning extreme values analysis, (ii) detection and attribution of observed changes in the frequency and/or intensity of extremes, and (iii) event attribution, and the physical mechanisms that are involved in amplifying and/or extending the duration of some specific extreme events such as flooding. The two-week school comprised lectures and hands on activities by the students. For the 35 international participants the school provided an exclusive learning opportunity, involving a variety of modalities such as self-study, computer based group activities, oral and written presentations. This also included skill enhancement to develop key data resources that are used to place current extremes into a historical context, thus providing insights into some near term prediction of the likelihood of flooding, drought, heat wave etc., enabling improved planning and response to climate disasters.

Keywords

Climate change; Extreme events; Attribution and prediction; Trend Analysis; Climate responses.

Objectives

The purpose of the school was to train students with outstanding research potential in emerging analytic techniques required to better understand observed and future changes in extremes, attribute observed variability to extremes, and develop skills to simulate scenarios addressing prominent and important societal and scientific questions about extreme events that are receiving increased attention from the public and policy makers.

The key objectives were:

1) Provide students with the tools required to better understand observed and future changes in extreme climate events
2) Familiarize with key data resources enabling the students to near term prediction of the likelihood of extreme events
3) Understand the physical mechanisms that produce many of the most impactful climatic extremes, and
4) Learn about "complex" hydrological extremes such as flooding and the role of coupled land-atmosphere feedback mechanisms in amplifying extreme temperature events.

Amount received and number years supported

This is a one-event one-year Project: 2014-2015
The Grant awarded to the project was USD 29,378 and the Amount received is USD 23502.

Activity undertaken

The summer school took place in Trieste, Italy, during 21 July-1 August 2014 at the premises of the Abdus Salam International Centre for Theoretical Physics (ICTP). Following a call for applications, 35 participants were selected from 236 international applicants based on their capacity to benefit from the training and prospects for making sustained contributions to climate science and its practice in their home countries. An international scientific steering committee (see Appendix) was responsible for the selection of the students, arranging financial support, coordinating the content of lectures and research problems for the students, providing resource persons and making all the logistical arrangements.

K. Koshy, the proponent of this project was among the 12 resource persons and attended the summer school for three days and lectured on “disaster risk management for sustainable development”, highlighting climatic extremes as a major development challenge for which practical and cost effective sustainable pathways were also suggested to progressively reduce risk and disaster. According to the co-chairs, Francis Zwiers, Canada and Sonia Seneviratne, Switzerland, this was a fitting conclusion to the school. The overall feedback from the students indicates the summer school as a very valuable capacity enhancement initiative, both for their professional work and for the organisations they came from.

Results

With WCRP’s reputation in climate science and ICTP’s experience in providing international training, the partnership proved to be very successful in attracting sponsors for supporting the participants. Thanks to APN and the Centre for Global Sustainability Studies, Universiti Sains Malaysia, about 10 students from the Asia-Pacific region participated in this highly competitive international training, networking and capacity building project.

The material covered in the lectures was consolidated through structured tutorials, and its practical application was accomplished through a suite of research problems that formed the core of the school and are an important part of the school's long-term legacy. The participants worked in teams led by the faculty and advisors throughout the two weeks, presenting their progress mid-way and at the end of the course. The teams have continued to work on their research projects since the summer school, with the support of their mentors. A special issue of the Elsevier journal 'Weather and Climate Extremes' is in preparation, with seven papers submitted, led by representatives of each research project group.

In addition, the school trained students in the development of some of the key data resources that are used to place current extremes into a historical context, and provided insights into some of the emerging thinking on the near term prediction of the likelihood of extreme events, where by “near term” we intend up to seasonal time scales. The school also taught the importance of understanding the physical mechanisms that produce many of the most impactful extreme events, with lectures on "complex" hydrologic extremes such as drought and the role of coupled land-atmosphere feedback mechanisms in amplifying extreme temperature events.

The course material is freely available on the website, also for the benefit of those who could not attend. The lectures were all professionally filmed and are served via the website. All data processed for the research projects is freely available and the analysis tools were purposely developed with open source software. Another key aspect was to foster lasting relationships with the faculty and other participants. The research component of the school created close, informal conditions to develop ideas and relationships, and various social events that were organized, including a closing dinner paired with a mentor-led discussion on career development.

All students have also been awarded certificates of participation and group photos.

Relevance to the APN Goals, Science Agenda and to Policy Processes

The summer school was closely aligned to the "scientific capacity development for sustainable development" and "science-policy interfacing" activities of the CAPaBLE Programme. As there are many examples for unusual climatic conditions causing major economic and human losses in Asia-Pacific countries, skills developed by the students to better understand observe and create scenarios of future changes in climate extremes is very timely and need based. This way the project addressed directly the APN Goal 2, 3 and 4.

There is clear evidence that climate has changed as a result of human-induced greenhouse gas emissions, and the awareness of changing climatic extremes is also increasing. But the same cannot be said about A-P countries' capacity to carry out outstanding research to predict future changes in extremes. The proposal was designed with this capacity concern in mind and we are pleased to mention that the summer school participants have been provided with tools, skills and world-class mentors to become champions to lead solution oriented research in climate extreme in their home countries.

Self-evaluation

One of major objectives of the Summer Schools was to train a cohort of young climate scientists and practitioners to foster their vocational training as well as their policy outreach and to be of real value to their native countries and organisations they work for. The summer school as the first of a series of capacity development activities focusing on WCRP Grand Science Challenges (http://www.wcrpclimate.org/index.php/grand-challenges) has really gone a long way towards achieving this objective.

Regarding details, the school was to train students in observing, understanding and predicting changes in extreme climate events. This has been achieved very effectively.

The work programme of the summer school was designed to include lectures in the mornings and practical application of the material covered in the lectures during the afternoons. This was supplemented by structured tutorials, and a set of research problems that formed the core of the school and served to produce an important part of its long-term legacy. Overall, the background of the selected students, the calibre of the lecturers, facilities at the training centre and the aura of the Adriatic summer added to the uniqueness of the summer school that it was.

Potential for further work

The scope is huge, in our assessment. Using the linkages established among the peer groups and mentors and the new knowledge, skills and tools at their disposal, it is only a matter of time and sustained interest that will bring forth the best out the participants. For example, the Malaysian participant in collaboration with a modeler and a climate researcher at the Centre for Global Sustainability Studies has already developed a research project to study climatic extremes in the country and the proposal is currently under review. It is also our recommendation that APN keep an eye on these A-P participants for any future work in this area requiring their support.

Publications

A special issue of the Elsevier journal *'Weather and Climate Extremes'* will soon be published, with seven papers submitted by representatives of each of the research project group set up during the summer school (in Press):

1. 'Systematic investigation of gridding-related scaling effects on annual statistics of daily mean temperature and precipitation maxima: A case study for south-east Australia' - F. Avila
2. 'Spatial clustering of summer temperature maxima from the CNRM-CM5 climate model ensembles and E-OBS over Europe' - M. Bador
3. 'Unusual past dry and wet rainy seasons over Southern Africa and South America from a climate perspective' - O. Bellprat
4. 'Combining large scale model ensembles with extreme value statistics to improve attribution statements of rare events' - S. Sippel
5. 'The ability of a multi-model seasonal forecasting ensemble to forecast the seasonal distribution of daily extremes' - A. Pepler
6. 'Potential increase in wheat and maize production due to human-induced changes in growing season length' - B. Mueller
7. 'Impact of soil moisture on extreme maximum temperatures in Europe' - K. Whan

There is also extensive data and information on climatic extremes in the summer school website: http://www.wcrp-climate.org/index.php/ictp2014-about

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The great dedication and hard work of the following people are acknowledged with thanks: Catherine Michaut (IPSL/France) for helping with the webpage, Petra Krizmancic (ITCP/Italy) for the secretarial support, and Anna Pirani & Adrian Tompkins (ITCP/Italy) for the organization. At USM, the Vice Chancellor, Prof. Dato' Omar Osman for institutional support, Director, Prof. Kamarulazizi Ibrahim of CGSS/USM for professional guidance, and the finance divisions of both CGSS and USM for handling monetary matters.

TECHNICAL REPORT

Preface

There is increasing evidence that the disasters caused by climatic extremes are both more frequent and more severe. This has created a pressing need to educate future researchers in the techniques required to understand observed and future changes in extremes. This Summer School was organised by WCRP and ICTP in collaboration with eight other international organisations, in Trieste, Italy between 21 July and 01 August 2014. A group of 35 highly motivated participants - Ph.D., postdoctoral researchers and early career scientists – were selected from 236 applicants, representing all regions of the world. Of these 10 were from Asia-Pacific countries sponsored by Asia Pacific Network for Global Change Research, APN. About a dozen world-class climate experts were involved in the two-week training, which involved a combination of learning approaches, and personal attention focusing on lectures, hands on activities using computer software, group work, individual presentations. Apart from the state-of-the-art training in Attribution and Prediction of Extreme Weather Events, all the participants were provided with tools to create future scenarios for planning and responding effectively to climatic extremes. The students were also able to develop peer reviewed research proposals and a paper for publication. This was an excellent example of international cooperation to address an emerging global threat and we would like to acknowledge the support of all who were involved in the success of the summer school.

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1.0 Introduction

Weather and climate extremes affect every aspect of our society, and there has been an increase in damage associated to weather and climate extreme events. Society is increasingly asking for information on the causes of extremes and an ability to predict these extremes on time scales from days to seasons to centuries.

The purpose of the summer school was therefore to train students with outstanding research potential in the techniques that are required to better understand observed and future changes in extremes. The School addressed the understanding, monitoring, modelling and predicting climate extremes and their changes; topics that are of critical importance in informing society on the design of sustainable development measures.

Since the focus was very much on emerging analytic techniques, the school organized around three broad areas:

- Statistical theory underpinning extreme value analysis,
- Detection and attribution of observed changes in the frequency and/or intensity of extremes, and
- Event attribution and the physical mechanisms that are involved in amplifying and/or extending the duration of some specific extreme events such as heat waves.

In addition, the school also educated students in the development of some of the key data resources that were used to place current extremes into a historical context, and provided insights into some of the emerging thinking on the near term prediction of the likelihood of extreme events, whereby "near term", was meant to imply, up to seasonal time scales. The school also covered the importance of understanding the physical mechanisms that produce many of the most impactful extreme events, and thus lectures on "complex" hydrologic extremes such as drought and the role of coupled land-atmosphere feedback mechanisms in amplifying extreme temperature events were also part of the package.

For each topic, there were lectures that covered the basics and they were well received by most participants. In addition, the school included a limited number of 'guests', lectures which provided in depth excursions to the current frontiers of some aspects of research on extremes and their impact on economy and society. Lectures were provided mostly in the morning of each day, with occasional lectures in the evenings. The afternoons and remaining evenings were devoted to the practical application of the material covered in the lectures. This was accomplished both through the use of structured tutorials, and a set of research problems that formed the core of the school and served to produce an important part of its long-term legacy.

Research problems were, therefore, a key aspect of the summer school. Teams, each with 4-6 students, worked to tackle 6 problems that were developed specifically for the school by its lecturers. Problems were carefully selected by the school's steering committee to ensure that they are tractable via team work with the resources that were available at the ITCP, that students working in teams with experienced lecturer-advisors and were able to advance the problems over the 2-week duration of the school, and that the results were developed into seven papers to be published in a special issue of the Elsevier journal *'Weather and Climate Extremes'*. The full set of problems were presented on the first day, and students were organized into teams on the first day as well, so that they were able to immediately begin to think about how they will tackle their problems.

The problem set included a data set development problem, two detection and attribution problems, an extreme events prediction problem, and two event attribution problems. Many, if not all of those, relied on both the use of the advanced analysis techniques that were taught at the school and an understanding of the relevant underpinning physical processes. The programme required that the students gave an update on their progress half way through the school, and that they will present preliminary results at the end the school together with a plan for how the student team will continue to collaborate. It was gratifying to report that some of these projects would lead to publications resulting from the extra work carried out by them after the end of the school in collaboration with some of the lecturers.

In full recognition of the support provided by sponsors for the school, we would like to acknowledge them all at the outset: the Abdus Salam International Centre for Theoretical Physics (ICTP), the World Climate Research Programme (WCRP), the International Union of Geodesy and Geophysics (IUGG), the International Council for Science (ICSU), the Asia-Pacific Network for Global Change Research (APN), the Australian Research Council's Centre of Excellence for Climate System Science (ARC), the US National Oceanic and Atmospheric Administration (NOAA), the US Department of Energy (DoE), the International and US Climate Variability, Predictability and Change Projects (CLIVAR, US CLIVAR) and the Institute Pierre Simon Laplace (IPSL) took place in Trieste, Italy between 21 July and 01 August 2014. The school website, with list of participants, agenda, reading and research project material, lecture videos and photos can be found at http://www.wcrp-climate.org/ictp2014-about

2.0 Methodology

2.1 Call for Summer School

Because of the technical nature of the training, selecting a group of students with the right academic and professional background and organising a team of resource persons to handle the rigour of the curricular aspects were key to the success of the summer school. The announcements calling for participation made it clear that scientists and students from all countries which are members of the United Nations, UNESCO or IAEA may attend the workshop. As it will be conducted in English, participants were expected to have an adequate working knowledge of the language. Although the main purpose of the school was to help research workers from developing countries through a programme of training activities within a framework of international cooperation, students and post-doctoral scientists from advanced institutes were also welcome to attend.

2.2 Student Selection and Resource persons

Following a rigours selection procedure, 35 participants - Ph.D., postdoctoral researchers and early career scientists – were selected from 236 applicants, representing all regions of the world. The selection process involved careful consideration of the applicant’s academic qualifications, professional experience, nationality, career background, relevance of research, quality of proposal, benefit to the applicant/institution and the overall suitability of the candidate to be a member of tight and high-quality participant groups for the research component of the course.

The groups were taught, monitored and mentored by 11 leaders of the international research community, as well as 7 teaching assistants who worked in support of their faculty colleagues. The proponent of this project was one of the 11 Lecturers.

2.3 The Curriculum and Management

The curriculum for the entire training was designed and implemented keeping in mind the need to train students with outstanding research potential in the analytic techniques required to study current and future changes in climatic extremes, and their impacts on economic development and society’s well-being. Given the current level of intense attention from the public and policy makers, the need to develop in-country capacity to understand, predict and manage disaster risk was particularly critical.

The detailed agenda for daily activities, persons in charge of the training and pattern of activities are provided in the 'Agenda' attached to the Appendix.

The school took place during the second half of July 2014, however, the research problems that the students addressed during the school under the guidance of the school steering committee, were further pursued remotely after the school. Each group nominated a leading author and the results of the research works will be published in a special issue of Weather and Climate Extremes (Elsevier).

In addition, the school trained students in the development of some of the key data resources that are used to place current extremes into a historical context, and provided insights into some of the emerging thinking on the near term prediction of the likelihood of extreme events, where by "near term" we intend up to seasonal time scales. The school also taught the importance of understanding the physical mechanisms that produce many of the most impactful extreme events, with lectures on "complex" hydrologic extremes such as drought and the role of coupled land-atmosphere feedback mechanisms in amplifying extreme temperature events.

The material covered in the lectures was consolidated through structured tutorials, and its practical application was accomplished through a suite of research problems that formed the core of the school and are an important part of the school's long-term legacy. The participants worked in teams led by the faculty and advisors throughout the two weeks, presenting their progress mid-way and at the end of the course.

2.4 The APN sponsored Participants

K. Koshy, the Proponent of this proposal to APN, was a member of the international Steering Committee, which in consultation with Roberta Boscolo (WCRP) and Anna Pirani (ICTP) selected the Asia-Pacific participants using a selection matrix that involved academic qualification, current position, research relevance to school, and an abstract. K. Koshy attended the summer school for three days and gave a presentation on "disaster risk management for sustainable development" on the last day, highlighting climatic extremes as a major development challenge, which according to the co-chairs was a fitting conclusion to the school. The overall feedback from the students is that the school was a very valuable capacity enhancement initiative, both for their professional work and future research.

3.0 Results & Discussion

3.1 Research questions and Supervisors

About 35 young scientists, selected from around the world, were able to address relevant research questions such as: (i) are human activities influencing the length of the agricultural growing season or the number of extreme weather events? and (ii) are temperature and precipitation swings in one region of the world related to those in another region?, thanks to the guidance of school's co-directors Francis Zwiers, Professor of the University of Victoria, Canada, and Sonia Seneviratne, Professor at ETH Zurich, Switzerland, together with an outstanding group of international scientists and tutors:

Francis Zwiers (Pacific Climate Impacts Consortium, Canada)
Sonia Seneviratne (ETH Zurich, Switzerland)

Francisco Doblas-Reyes (IC3, Spain)
Arun Kumar (NOAA/CPC, USA)
Lisa Alexander (UNSW, Australia)
Eric Gilleland (NCAR, USA)
David Karoly (Uni. Melburne, Australia)
Philippe Naveau (LSCE-IPSL, France)
Friederike Otto (Uni. Oxford, UK)
Peter Stott (Met Office, UK)
Han Quizi Wen (Environment Canada)
Rene Orth (ETHZ, Switzerland)
Daniel Mitchel (Uni. Oxford, UK)
Fraser Lott (Met Office, UK)
Andrew Ciavarella (Met Office, UK)
Markus Donat (ARC Centre of Excellence for Climate System Science, Australia)
Chloe Prodhomme (IC3, Spain)

3.2 The Participants and Weekly Programme

The work programme was an excellent blend of theory and hands-on research where students worked in groups of five using open source data and software tools on research problems that have been carefully prepared by the lecturers.

Week 1 Agenda

	Monday	Tuesday	Wednesday	Thursday	Friday
09h00-09h45	What is an extreme event? ***D. Karoly***	Extreme Value Theory (multi-variate) ***P. Naveau***	Detection and attribution (General introduction) ***F. Zwiers***	Physical mechanisms (Large-scale circulation) ***D. Karoly***	Prediction - seasonal prediction systems ***A. Kumar***
09h45-10h30	How do extremes changes in the context of climate change? ***S. Seneviratne***	Extreme Value Theory (non-startionarity) ***P. Naveau***	Detection and attribution (Optimized & non-optimized methods) ***F. Zwiers***	Physical mechanisms (Large-scale circulation) ***D. Karoly***	Prediction - Predictabiity, and extremes ***F. Doblas-Reyes***
Coffee break					
11h00-12h30	Statistical Theory (EVT1) ***E. Gilleland***	Introduction to R & NCAR extreme package ***E. Gilleland***	Practical exercise with R: Optimal fingerprinting ***F. Zwiers/Q.Wan***	Climate extremes: Data issues ***L. Alexander***	Practical exercise on prediction Sea Forecast practical ***A. Kumar, F. Doblas-Reyes, C. Prudhomme***
Lunch					
14h00-15h30	Statistical Theory (EVT2) ***E. Gilleland***	Introduction exercices NCAR extreme package ***E. Gilleland***	Group projects	Group projects	Group projects
Coffee break					
16h00-17h30	**Project 1** **Project 3**: Growing season length **Project 5:** 5a) Event attribution with CMIP5 data 5b) How does climate change alter the distribution of weather? **Project 6** : Land surface drivers of droughts: the role of soil moisture persistence	Group projects	Group projects	Group projects	Project progress reports (15 min each)
After dinner	Welcome reception	Statistical Theory - Advanced talk ***P. Naveau***		Dinner Outing	

Week 2 Agenda

	Monday	Tuesday	Wednesday	Thursday	Friday
09h00-09h45	Detection and attribution (Extreme values) ***F. Zwiers***	Physical mechanisms (Land-climate feedbacks) ***S. Seneviratne***	Event attribution: Theory ***P. Stott***	Event attribution: Theory ***F. Otto***	Disaster Risk Management for Sustainable Development ***K. Koshy***
09h45-10h30	Detection and attribution (Extreme values) ***F. Zwiers***	Physical mechanisms (Local vs large-scale drivers) ***S. Seneviratne***	Event attribution: Theory ***P. Stott***	Event attribution: Theory ***F. Otto***	Final Project wrap up and ongoing collaboration planning
Coffee break					
11h00-12h30	Practical exercise with R : D&A Extreme Values ***F. Zwiers/Q. Wan***	Practical exercise - land-climate interactions and soil moisture memory ***R. Orth / S. Seneviratne***	Practical exercise with climate prediction.net data Worksheet 1 ***F. Otto***	Practical exercise with climate prediction.net data Worksheet 2 Worksheet 3 ***F. Otto***	Project presentations (30- minutes each)
Lunch					
14h00-15h30	Group projects	Group projects	Group projects	Group projects	Project presentations (30-minutes each)
Coffee break					
16h00-17h30	Group projects	Group projects	Group projects	Group projects	Project presentations (30-minutes each)
18h00			Guest Lecture : Response of hydroclimatic regimes to global warming **F. Giorgi**		
After dinner				End of school Dinner	

The lectures were all professionally filmed and are served via the website (http://users.ictp.it/~video/Conferences/2595/password.htm).

3.3 Programme Management

The material covered in the lectures was consolidated through structured tutorials, and its practical application was accomplished through a suite of research problems (see appendix) that formed the core of the school and are an important part of the school's long term legacy. The participants worked in teams lead by the faculty and advisors throughout the two weeks, presenting their progress mid-way and at the end of the course. The teams have continued to work on their research projects since the summer school, with the support of their mentors. A special issue of the Elsevier journal 'Weather and Climate Extremes' is in preparation, with seven papers submitted, led by representatives of each research project group:

'Systematic investigation of gridding-related scaling effects on annual statistics of daily mean temperature and precipitation maxima: A case study for south-east Australia' - F. Avila

'Spatial clustering of summer temperature maxima from the CNRM-CM5 climate model ensembles and E-OBS over Europe' - M. Bador

'Unusual past dry and wet rainy seasons over Southern Africa and South America from a climate perspective' - O. Bellprat

'Combining large scale model ensembles with extreme value statistics to improve attribution statements of rare events' - S. Sippel

'The ability of a multi-model seasonal forecasting ensemble to forecast the seasonal distribution of daily extremes' - A. Pepler

'Potential increase in wheat and maize production due to human-induced changes in growing season length' - B. Mueller

'Impact of soil moisture on extreme maximum temperatures in Europe' - K. Whan

A core objective of the school was to enable the participants to continue to pursue new research avenues based on the training acquired through the school. The course material is freely available on the website, also for the benefit of those who could not attend (http://www.wcrp-climate.org/ictp2014-about). The lectures were all professionally filmed and are served via the website. All data processed for the research projects is freely available and the analysis tools were purposely developed with open source software. Another key aspect was to foster lasting relationships with the faculty and other participants. The research component of the school created close, informal conditions to develop ideas and relationships, and various social events that were organized, including a closing dinner paired with a mentor-led discussion on career development.

Above all, the two-week summer school was a success beyond expectations for the early-career scientists from around the world on the use of new computational tools for the study of climate extremes, and providing state-of-the-art research experience in understanding, predicting, and attributing extreme weather events.

4.0 Conclusions

It is very fair to say that the first WCRP-ICTP School which studied weather events and prediction has forged extreme collaboration. "Extremes are a hot topic," said Francis Zwiers of the University of Victoria in Canada, one of the school's co-directors. Sonia Seneviratne of ETH Zurich, Switzerland, was the other co-director of the school and co-chair of WCRP's GEWEX project on the global energy and water budget.

Weather and climate extremes affect every aspect of our society, and there has been an increase in damage associated to weather and climate extreme events. Society is increasingly asking for information on the causes of extremes and an ability to predict these extremes on time scales from days to seasons to centuries. This School addressed the understanding, monitoring, modelling and predicting climate extremes and their changes; topics that are of critical importance in informing society on the design of sustainable development measures.

This partnership between WCRP and ICTP aimed at training top students from both developed and developing countries in the WCRP Grand Challenges research topics. The School format was designed to enhance the knowledge exchange of, on the one hand, advanced academic techniques and on the other hand, expertise in regional processes, impacts and societal needs, both essential if the international research community is to deliver actionable climate information to society.

The School was based on training the students in the use of freely available multi-model archives and open source analysis software. The WCRP strives for scientific data and tools to be provided with an open access policy for the benefit of educational and research activities of scientists all over the world and in support of society's needs.

The summer School addressed emerging research topics applying frontier analysis techniques, the application of which have potentially significant benefits to society through its of adaption and development strategies. The attribution and prediction of climate extremes has been so far generally constrained to a few localized advanced Institutes in the Northern Hemisphere. The community is seeking to broaden the international participation, in particular from scientists in the developing world

The innovative approach placed emphasis on the practical aspect of the School and gave the students high level practical training that not only consolidated their understanding of the lecture topics. Unlike training courses that provide just lab exercises, the research problems gave the students confidence in using the open source software packages in a research context so they can continue to work independently when they go back to their own Institutions. It trained them in publishing their work and results in the peer-reviewed literature and created a collaborative relationship between the students and lecturers that continued to built upon and after the School, strengthening the international research network to include these top young scientists who are entering the field.

The topics covered in the school's lectures included both the basics and the most recent advances in climate science and statistics. They featured such issues as the simulation of climate extremes in long-term predictions and shorter term seasonal predictions and exposed students to the ways that climate modellers and statisticians approach the topics differently. "WCRP brings teaching and mentoring on state-of-the-art research topics," Anna Pirani, one of the co-organizers of the school said, highlighting how the school's instructors are leaders in the international research community.

In the afternoons, students worked in groups of five on research problems that have been carefully prepared by the lecturers in such a way that they led to interesting results that could be pursued further. The following research problems were presented:

1. Data set development

To assess how changing station networks or parameter settings within an interpolation method affect trends in temperature extremes.

2. Dimension Reduction for Extremes

Climate science resorts to spatial statistics for predicting future changes, detecting large time scales, or modeling unobserved zones and times (broadly termed climate reconstruction). One of the main objectives of statistical climatology is to extract relevant information from complex spatial-temporal climatological datasets.

3. Detecting human influence in extreme temperature indices

The objective of the project is to use formal detection and attribution methods to determine whether observed changes in these indices can be attributed to human influence on the climate system, understanding the criteria for the evaluation of the indices, the detection and attribution methodology and how to best apply it to different indices, and the interpretation of results.

4. Event Prediction

Multi-model global retrospective predictions will be used to investigate the ability of current operational systems to predict the 10th and 90th percentiles of the seasonal precipitation, temperature and wind, comparing the skill and reliability of the predictions for extreme events with the forecast quality of the seasonal averages, exploring the conditional skill by stratifying the events as a function of a subset of large-scale variability modes (NAO, ENSO) and investigating how the skill and the prediction uncertainty changes as more prediction systems are added. A discussion of the relevance of predicting seasonal extreme events for different sectors is expected.

5a. To what extent is it possible to reliably calculate any changed risk of unusually warm or cold or dry or wet seasons in regions of the world attributable to anthropogenic influence on climate? Assessment of CMIP5

An analysis will be made of the CMIP5 coupled climate model simulations, comparing simulations that include both anthropogenic and natural forcings on climate with those that include only natural forcings, estimating the changed probability of unusually warm/cold/dry/wet seasonal means. The reliability of these estimates will be evaluated, as will the uncertainty in these estimates due to modelling uncertainties.

5b. To what extent is it possible to reliably calculate any changed risk of unusually warm or cold or *dry or wet seasons in regions of the world attributable to anthropogenic influence on climate? Assessment of climatepredict.net simulations (F. Otto & M. Allen)*

See 5a.

6. Land surface drivers of droughts: The role of soil moisture persistence (S. Seneviratne)

Soil moisture persistence is an important component of drought development. In this project the students will investigate how soil moisture anomalies propagate in time and how drought predictions can be improved by using information on initial soil moisture conditions. They will learn how to use a simple water-balance model and a mathematical framework to assess the respective contributions of initial soil moisture anomalies vs atmospheric conditions (precipitation, temperature) to the intensity of a given drought event. They will also assess the propagation of drought anomalies from soil moisture conditions to stream flow availability.

5.0 Future Directions

Organizers of the school believe that it has the potential not only to further climate science, but also to help both WCRP and ICTP, as well as the participants expand their research reach. WCRP has lots of tentacles using which ICTP's visibility across the world could be improved as a quality capacity builder, according to a local organizer Adrian Tompkins. For the first time, because of the quality of cooperation among the donor agencies, the limitation on the number of participants was not because of funding, but because of the choice to form tight, high-quality participant groups for the research component of the course. This could be a model for future global change training and capacity building.

This type of global experience gives participants the right environment to develop new ideas for future work back home. The diversity of the participants and the teams they worked in will most likely lead to lasting relationships across students and faculty, for the connections students make at such a school can forge relationships for a scientific lifetime.

The presentation of their work to their peers in plenaries, halfway through and at the end of the school, led to lively discussions among participants and lecturers. Each team ended their 10-minute presentation with a long to-do list for future research. Clearly, there is still plenty for the young scientists to accomplish to meet the emerging climate changes, but armed with the school's lessons they are already well on their way.

References

A special issue of the Elsevier journal 'Weather and Climate Extremes' is in preparation, with seven papers submitted, led by representatives of each research project group (in Press):

'Systematic investigation of gridding-related scaling effects on annual statistics of daily mean temperature and precipitation maxima: A case study for south-east Australia' - F. Avila

'Spatial clustering of summer temperature maxima from the CNRM-CM5 climate model ensembles and E-OBS over Europe' - M. Bador

'Unusual past dry and wet rainy seasons over Southern Africa and South America from a climate perspective' - O. Bellprat

'Combining large scale model ensembles with extreme value statistics to improve attribution statements of rare events' - S. Sippel

'The ability of a multi-model seasonal forecasting ensemble to forecast the seasonal distribution of daily extremes' - A. Pepler

'Potential increase in wheat and maize production due to human-induced changes in growing season length' - B. Mueller

'Impact of soil moisture on extreme maximum temperatures in Europe' - K. Whan

Appendix

Summer School Agenda

Week 1

	Monday	Tuesday	Wednesday	Thursday	Friday
09h00-09h45	What is an extreme event? ***D. Karoly***	Extreme Value Theory (multi-variate) ***P. Naveau***	Detection and attribution (General introduction) ***F. Zwiers***	Physical mechanisms (Large-scale circulation) ***D. Karoly***	Prediction - seasonal prediction systems ***A. Kumar***
09h45-10h30	How do extremes changes in the context of climate change? ***S. Seneviratne***	Extreme Value Theory (non-startionarity) ***P. Naveau***	Detection and attribution (Optimized & non-optimized methods) ***F. Zwiers***	Physical mechanisms (Large-scale circulation) ***D. Karoly***	Prediction - Predictabiity, and extremes ***F. Doblas-Reyes***
			Coffee break		
11h00-12h30	Statistical Theory (EVT1) ***E. Gilleland***	Introduction to R & NCAR extreme package ***E. Gilleland***	Practical exercise with R: Optimal fingerprinting ***F. Zwiers/Q.Wan***	Climate extremes: Data issues ***L. Alexander***	Practical exercise on prediction Sea Forecast practical ***A. Kumar, F. Doblas-Reyes, C. Prudhomme***
			Lunch		
14h00-15h30	Statistical Theory (EVT2) ***E. Gilleland***	Introduction exercices NCAR extreme package ***E. Gilleland***	Group projects	Group projects	Group projects
			Coffee break		
16h00-17h30	**Project 1** **Project 3**: Growing season length	Group projects	Group projects	Group projects	Project progress reports (15 min each)

	Project 5: 5a) Event attribution with CMIP5 data 5b) How does climate change alter the distribution of weather? **Project 6** : Land surface drivers of droughts: the role of soil moisture persistence				
After dinner	Welcome reception	Statistical Theory - Advanced talk ***P. Naveau***		Dinner Outing	

References*:*

What is an extreme event?

- WMO (2014) Atlas of Mortality and Economic Losses
- Media release on 11 July 2014 when the WMO report was released
- Bureau of Meteorology Special Climate Statements (for Australia for 2009 to the present)

Climate Modes of Variability Outreach materia

- The Climatedogs: the four drivers that influence Victoria (Australia) climate
- The Pacific adventures of the climate crab

Statistical Theory

- Eric Gilleland's home page provides very useful references: http://www.ral.ucar.edu/~ericg/spatialextremes.php

Extreme Value Theory

- Bernard, E., Naveau, P., Vrac, M., and Mestre, O. (2013). Clustering of maxima: Spatial dependencies among heavy rainfall in France. Journal of Climate **26**, 7929–7937.doi: http://dx.doi.org/10.1175/JCLI-D-12-00836.1
- P. Naveau, A. Toreti, I. Smith and E. Xoplaki.. A fast non-parametric spatio-temporal regression scheme for Pareto distributed heavy precipitation. Water Resources Research. DOI: 10.1002/2014WR015431, 2014.
- Naveau, P., Guillou, A. and Rietsch, T. (2014), A non-parametric entropy-based approach to detect changes in climate extremes. Journal of the Royal Statistical Society: Series B (Statistical Methodology). doi: 10.1111/rssb.12058

T. Rietsch, P. Naveau, N. Gilardi and A. Guillou, Network design for heavy rainfall analysis, Journal of Geophysical Research: Atmospheres, DOI: 10.1002/2013JD020867

Week 2

	Monday	Tuesday	Wednesday	Thursday	Friday
09h00-09h45	Detection and attribution (Extreme values) ***F. Zwiers***	Physical mechanisms (Land-climate feedbacks) ***S. Seneviratne***	Event attribution: Theory ***P. Stott***	Event attribution: Theory ***F. Otto***	Disaster Risk Management for Sustainable Development ***K. Koshi***
09h45-10h30	Detection and attribution (Extreme values) ***F. Zwiers***	Physical mechanisms (Local vs large-scale drivers) ***S. Seneviratne***	Event attribution: Theory ***P. Stott***	Event attribution: Theory ***F. Otto***	Final Project wrap up and ongoing collaboration planning
Coffee break					
11h00-12h30	Practical exercise with R : D&A Extreme Values ***F. Zwiers/Q. Wan***	Practical exercise - land-climate interactions and soil moisture memory ***R. Orth / S. Seneviratne***	Practical exercise with climate prediction.net data Worksheet 1 ***F. Otto***	Practical exercise with climate prediction.net data Worksheet 2 Worksheet 3 ***F. Otto***	Project presentations (30- minutes each)
Lunch					
14h00-15h30	Group projects	Group projects	Group projects	Group projects	Project presentations (30-minutes each)
Coffee break					
16h00-17h30	Group projects	Group projects	Group projects	Group projects	Project presentations (30-minutes each)
18h00			Guest Lecture : Response of hydroclimatic regimes to global warming **F. Giorgi**		
After dinner				End of school Dinner	

References

Detection and attribution

- Good Practice Guidance Paper on Detection and Attribution Related to Anthropogenic Climate Change, 2010
- *Citation: Hegerl, G.C., O. Hoegh-Guldberg, G. Casassa, M.P. Hoerling, R.S. Kovats, C. Parmesan, D.W. Pierce, P.A. Stott, 2010: Good Practice Guidance Paper on Detection and Attribution Related to Anthropogenic Climate Change. In: Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Detection and Attribution of Anthropogenic Climate Change [Stocker, T.F., C.B. Field, D. Qin, V. Barros, G.-K. Plattner, M. Tignor, P.M. Midgley, and K.L. Ebi (eds.)]. IPCC Working Group I Technical Support Unit, University of Bern, Bern, Switzerland*.

- Climate Change Science 2013 Haiku, G. Johnson

Event attribution

- Allen, Liability for Climate Change, Nature, 2003
- Stott, Stone, Allen, Human contribution to the European heatwave of 2003, Nature, 2004.

The Recent Storms and Floods in the UK - briefing report released by the Met Office in February 2014

Research Problems and descriptions

1. Data set development

Faculty: L. Alexander, M. Donat

Participants: F.B. Avila, K.P. Menang, J.W. Rajczak, S. Dong, M. Renom Molina

Uncertainty in observed datasets has many forms, from the quality and/or consistency of the underlying data to the choices made within a chosen gridding/interpolation method (parametric uncertainty), to the network selection and analytical framework (structural uncertainty). Of these structural uncertainty generally has the largest influence on the resulting gridded product, particularly in the representation of extremes and their trend estimates. However rarely are datasets produced with uncertainty estimates and users are often unaware that the choice of observational product can substantially affect results. This project will assess how changing station networks or parameter settings within interpolation methods affect trends in temperature extremes and in turn whether this could affect detection and attribution analysis. The objective of this research problem is to test the sensitivity of gridded output to changing parameters and input station networks and to discuss in detail how and why the results vary when changing input parameters, what is important/less important when considering the climate of the region. Students will decide what parameters settings to test and how the station networks are set up. Data from the ETCCDI temperature indices e.g. annual maxima Tmax (TXx), annual minima Tmin (TNn) contained in the HadEX2 observational extremes indicators dataset (Donat et al., 2013) will be supplied for different regions. Ultimately the results from this project could feed into Research Problem 3.

2. Dimension reduction for extremes

Faculty: P. Naveau

Participants: R. Wills, V. Otieno, M. Castella Sanchez, T. Andry Arivelo, M. Bador

Climate science resorts to spatial statistics for predicting future changes, detecting large time scales, or modeling unobserved zones and times (broadly termed climate reconstruction, using a variety of, often ad-hoc, imputation techniques). The amount of data involved is so large that it becomes a statistical problem. Indeed, in the presence of very large datasets, the estimation of parametric models, the prediction at unobserved sites and the associated uncertainty estimation may not be computationally feasible. Consequently, one of the main objectives of statistical climatology is to extract relevant information hidden in complex spatial-temporal climatological datasets. To identify spatial patterns, most well-known statistical techniques in climate studies are based on the concept of variance, like the k-means clustering algorithm, or the Empirical Orthogonal Function (EOF) analysis that decomposes estimated variance-covariance matrices. This makes sense for applications that aim at identifying patterns with respect to mean behaviors. In particular, it is ideally suited when the variable of interest follows a mixture of normal distributions because Gaussian random vectors are fully characterized by their mean vectors and their covariances matrix. A possible avenue to bridge this methodological gap resides in taking advantage of multivariate EVT and to adapt it to the context of dimension reduction. The problem of dimension reduction is challenging here, since multivariate EVT is by nature non-parametric (unlike Gaussian modeling through correlation matrix), and most applications of non-parametric multivariate EVT have dealt with very low dimensions (less than 10).

3. Detecting human influence in ETCCDI temperature indices

Faculty: F. Zwiers and H.Q. Wen

Participants: H. C. Nnamchi, C. E. Iles, M. J. Hauser, R. H. Rimi, B. Mueller

Both cold and warm temperature extremes have warmed since the middle of the 20th century, and a number of detection and attribution studies have demonstrated that human influence on the climate system has very likely contributed to this warming (IPCC, 2013). It is also widely accepted that human influence has affected the characteristics of warm spells/heat waves and other indicators of temperature that are related to impacts, such as the number of frost days per year (days with minimum temperature below 0C), the number of tropical nights per year (days with minimum temperature above 20C, a key factor associated with the health impacts of heat waves), and the number of warm days per year (days with daily maximum temperature above 25C). While it is generally accepted that human influence has affected these indices, this has not yet been confirmed with formal detection and attribution studies. The objective of the project is, therefore, to use formal detection and attribution methods to determine whether this acceptance, which is reported in IPCC assessments, is in fact, reasonable. This will involve (i) the careful assessment of a range of observed and simulated temperature indices that are contained in the HadEX2 observational extremes indicators dataset (Donat et al., 2013) and that have been extracted from CMIP5 simulations (Sillmann et al., 2013) respectively, and where appropriate, (ii) the application of well established detection and attribution methods (e.g., Hegerl and Zwiers, 2011) to determine whether observed changes in these indices can be attributed to human influence on the climate system. The indicators need careful assessment prior to becoming a subject of a detection and attribution analysis because model biases, or index definitions that are inappropriate for the climate to which they are applied, may create situations in which the indices become ineffective as indicators of variability or change.

Event prediction

Faculty: F. Doblas-Reyes, A. Kumar and C. Prodhomme

Participants: S. Abelen, U. J. Diasso, L.B. Diaz K. Kashinath, A. S. Pepler

The assessment of the prediction skill of extreme climate events is the first step towards an efficient application of seasonal prediction in both society and the industry. Multi-model global retrospective predictions will be used by the students to investigate the ability of current operational systems to predict the 10th and 90th percentiles of the seasonal precipitation, temperature and wind. They will compare the skill and reliability of the predictions for extreme events with the forecast quality of the seasonal averages, explore the conditional skill by stratifying the events as a function of a subset of large-scale variability modes (NAO, ENSO) and investigate how the skill and the prediction uncertainty changes as more prediction systems are added. A discussion of the relevance of predicting seasonal extreme events for different sectors is expected. Our research unit at IC3 is developing a set of R functions to perform the analyses on climate predictions that will be released via the CRAN.

Introductory material on predicting seasonal or decadal extremes:

- Doblas-Reyes, F.J., J. García-Serrano, F. Lienert, A. Pintó Biescas, L. R. L. Rodrigues, 2013: Seasonal climate predictability and forecasting: status and prospects. WIREs Clim Change, 4: 245-268. doi: 10.1002/wcc.217
- Barnston, A., and S. J. Mason, 2011: Evaluation of IRI's Seasonal Climate Forecasts for the Extreme 15% Tails. Weather and Forecasting, 26, 545-554.
- Hamilton, E., R. Eade, R. J. Graham, A. Scaife, D. M. Smith, A. Maidens, and C. MacLachlan, 2012:Forecasting the number of extreme daily events on seasonal timescales. Journal of Geophysical Research, 117, D03114, doi: 10.1029/2011JD016541
- Short-Term Climate Extremes: Prediction Skill and Predictability - http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-12-00177.1
- Anatomy of Extreme Events - http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-12-00270.1
- Making of an Extreme Event - http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-12-00069.1

5a. To what extent is it possible to reliably calculate any changed risk of unusually warm or cold or dry or wet seasons in regions of the world attributable to anthropogenic influence on climate? Assessment of CMIP5

Faculty: P. Stott, F. Lott, A. Chiavarella

Participants: H. R. Parker, L. A. Pampuch, C. N. Gulizia, O. Bellprat, I.S. De Sousa Pinto

An analysis will be made of the CMIP5 ensembles of coupled model simulations, comparing simulations that include both anthropogenic and natural forcings on climate with those that include only natural forcings. Estimates will be made of the changed probability of unusually warm/cold/dry/wet seasonal means in these models runs between the two runs. Investigations will also be carried out into the relability of these estimates, by comparing with observational estimates of the variability of temperature and precipitation, and into the uncertainty in these estimates due to modelling uncertainties. If comparable estimates [from a companion project - Project 4] are available from atmosphere only runs forced with observed SSTs and sea ice conditions, it would be interesting to compare and contrast results of the change in probobaility (eg for a particularly cold winter or wet summer in Northern Europe) from coupled model runs (which provide the overall change of risk) with results from SST and sea ice forced runs (which provide the change of risk conditional on a particular marine state, eg with the ENSO and Arctic sea ice conditions seen in a particular year. In this way it would be possible to investigate to what extent it is possible to partition any changed risk (eg in a cold winter or a wet summer) into a component attributable to anthropogenic climate change and a component attributable to natural internal climate variability.

5b. To what extent is it possible to reliably calculate any changed risk of unusually warm or cold or dry or wet seasons in regions of the world attributable to anthropogenic influence on climate? Assessment of climatepredict.net simulations

Faculty: F. Otto and D. Mitchel

Participants: S. Sippel, L. J. Harrington, M. T. Black, N. H. Mohd Salleh, A. J. Dittus

A shift in the distribution of variables such as daily maximum winter temperatures and daily precipitation extremes (Coelho et al. 2008), towards higher values has been attributed to anthropogenic climate change for various mid-latitudal regions in the past (e.g. Pall et al. 2011, Otto et al. 2012). However, while there are many process based arguments suggesting also a change in the shape of these distributions, attribution studiesdemonstrating this have not currently been undertaken. With the very large ensemble of simulations of the European winter (DJF) 2013/2014 the students in this project will have the opportunity to explore, in the first instance, how the estimated parameters of the Generalized Extreme Value (GEV) distribution vary under a climate change scenario (Kharin and Zwiers 2005). While it is expected that the location parameter will change (i.e. the GEV distribution shifts to a warmer state), it is unknown how the scale and shape parameters might vary, as well as higher order extreme diagnostics such as the extremal index. The students will look at these measures over a range of different climate fields. Secondly there are 11 ensembles of this past winter as it might have been in a world without anthropogenic climate change with each of these ensembles being forced with observed SSTs but with 11 different plausible patterns of warming removed. The students will investigate whether and how the distribution of the analysed variables have changed.

- Kharin, Viatcheslav V., and Francis W. Zwiers. "Estimating extremes in transient climate change simulations." Journal of Climate 18.8 (2005): 1156-1173.
- Coelho, C. A. S., et al. "Methods for exploring spatial and temporal variability of extreme events in climate data." Journal of Climate 21.10 (2008): 2072-2092.
- Otto, F. E. L., N. Massey, G. J. van Oldenborgh, R. G. Jones, and M. R. Allen (2012) Reconciling two approaches to attribution of the 2010 Russian heat wave. Geophys. Res. Lett., 39, L04702.
- Pall, P., T. Aina, D.A. Stone et al. (2011), Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000, Nature, 470, 382-385.

6. Land surface drivers of droughts: The role of soil moisture persistence
Faculty: S. Seneviratne and R. Orth
Participants: E. Asare, M. Shongwe, K. Whan, M. Rahimi, J. Zscheischler

Soil moisture is an important quantity in the assessment and investigation of droughts. In this project the students will study the importance of initial soil moisture conditions versus subsequent meteorological forcing using an reverse-ESP (Ensemble Streamflow Prediction) approach proposed by Wood and Lettenmaier 2008. Furthermore they will investigate changes in drought occurrence probability caused by trends in the mean and variability of soil moisture, and related changes of the soil moisture-temperature coupling (Mueller and Seneviratne 2012). We will divide the students in two sub-groups to address these two topics. They will work with the R programming language and use a conceptual simple water balance model to infer soil moisture from meteorological information (Orth and Seneviratne 2014). We will focus on North America and compare the results with respective findings for Europe.

- Gilleland, E., B. G. Brown, and C. M. Ammann, 2013. Spatial extreme value analysis to project extremes of large-scale indicators for severe weather. Environmetrics, 24 (6), 418 - 432, DOI: 10.1002/env.2234. Available at:http://onlinelibrary.wiley.com/doi/10.1002/env.2234/abstract.
- Mueller, B., and S.I. Seneviratne, 2012: Hot days induced by precipitation deficits at the global scale.Proceedings of the National Academy of Sciences, 109 (31), 12398-12403
- Orth, R., and S.I. Seneviratne, 2014: Using soil moisture forecasts for sub-seasonal summer temperature predictions in Europe. Climate Dynamics, in press
- Wood, A.W. and D.P. Lettenmaier, 2008: An ensemble approach for attribution of hydrologic prediction uncertainty. Geophys. Res. Lett., 35, L14401

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2. World Climate Research Programme (WCRP),
3. International Union of Geodesy and Geophysics (IUGG), the International Council for Science (ICSU),
4. Australian Research Council's Centre of Excellence for Climate System Science (ARC),
5. US National Oceanic and Atmospheric Administration (NOAA),
6. US Department of Energy (DoE), the International and US Climate Variability, and
7. Predictability and Change Projects (CLIVAR, US CLIVAR) and the Institute Pierre Simon Laplace (IPSL)

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3. International Union of Geodesy and Geophysics (IUGG), the International Council for Science (ICSU),
4. Australian Research Council's Centre of Excellence for Climate System Science (ARC),
5. US National Oceanic and Atmospheric Administration (NOAA),
6. US Department of Energy (DoE), the International and US Climate Variability, and
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Letter from a Student - Siyan Dong (China)

I am an assistant researcher in National Climate Centre, China Meteorological Administration. I am pleased that I was selected to participate at the "WCRP-ICTP Summer School on Attribution and Prediction of Extreme Events". First of all thanking APN for giving me this opportunity by providing financial support. Many thanks to ICTP for kind hospitality and the honor you showed me during my recent visit to ICTP. It was nice of you to introduce to so many of famous professors and celebrated scholars at summer school.

For the two week duration of the school, we had lectures in the morning, with occasional lectures in the evening. The afternoons and remaining evenings were mainly on the practical application of the material covered in the lectures. The research topics included data set development, detection and attribution, extreme events prediction, and event attribution et al. I participated in the first group, and the research project is "scale of the extreme data gridding". In this group, we systematically compared how the order of operation (annual maxima calculated from daily grids versus gridded point-based estimates) affects the statistics of extremes. These applications include representation of long-term changes, inter-annual variability, spatial patterns, and extreme value analysis. At the end of the summer school, we had formed the preliminary results and clear research ideas, the group members would continue to keep in contact and do follow-up research work and the draft prepared for a journal article.

During two week duration of the school, I learned the techniques which pertain to the statistical analysis on extremes, extremes attribution and physical mechanisms. I also took this opportunity to share some ideas and research experience on the study of climate extremes with the others, which play an important role in improving the level of scientific research. China is frequently hit by disasters associated with climate extremes (e.g. floods and droughts), causing enormous economic loss and societal disruptions. Thus, to understand the cause of climate extremes and to project future change in climate extremes are of particular importance for China. In general, these advanced techniques and thoughts may help me and my colleagues to find a suitable method for analyzing observed and future changes of climate extremes in China. I am also aware that our department should be further strengthened international cooperation.

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Siyan Dong