



Technical Report No. 50

**INTERNATIONAL SUMMER SCHOOL ON:
WATER RESOURCES AND THE WATER CYCLE IN A
CHANGING WORLD
OXFORD, UK 4-8 JULY 2011**



Author names: Tanya Warnaars
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WATCH is an Integrated Project Funded by the European Commission under the Sixth Framework Programme, Global Change and Ecosystems Thematic Priority Area (contract number: 036946). The WACH project started 01/02/2007 and will continue for 4 years.

Title:	International Summer School: on Water Resources and the Water Cycle in a Changing World
Authors:	Tanya Warnaars
Organisations:	Centre for Ecology and Hydrology
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Front cover pictures: Day 1 group photo of summer school, Graham Weedon lecturing on time series analysis, Final day group photo.

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1. Introduction

The WATCH project has the ambitious aim of assessing, for the first time, the impact of climate change on the water cycle at a global level and regional level. Included in this project are assessments of the extremes (flood and drought events), feedback between the climate and land surface as well as water resources. At this final stage of the project a large amount of data and results are available and as a means to transfer this knowledge to the future researchers a summer school for postgraduates and early career scientists was organised. A particular effort was made to include participants from developing countries who may not normally have access to such events.

The summer school was designed to be a combination of presentations on the results from the different work blocks of WATCH, as well as including more collaborative training modules where participants would learn the novel approaches undertaken by WATCH researchers. Furthermore attendees were asked to engage by presenting posters on their area of work. In addition the participants were set a task to discuss and present what they considered to be the major constraints to water in the future. As this was a very international group the presentations reflected the different regions where participants came from.

In essence this summer school was a summary of the key areas of WATCH work and its major results were presented. General information on the summer school can be found in the announcement (appendix 1) that was sent out to the water and climate community and published on the project website (eg WATCH, EDC, FRIEND, CEH).

The organising committee consisted of:

Tanya Warnaars, Centre for Ecology and Hydrology, UK
Richard Harding, Centre for Ecology and Hydrology, UK
Bridie-Ann Hawker, Centre for Ecology and Hydrology, UK
Graham Weedon, UK Met Office

The summer school would not have been possible without the support of the lecturers and presenters who are listed in the summer school programme (see appendix 2 and 3).

This event was held on the premises of St Catherine's college, University of Oxford (Oxford, UK). This made for an efficient and convenient organisation of the summer school as accommodation, meals and lectures were all held in easy walking distance of each other. In addition all facilities of the college were available to the participants and help to foster a sense of community for those at the summer school.

2. Objectives

The aim of the summer school on "Water resources and the Water Cycle in a Changing World" was to communicate the results of the WATCH project and in particular raise awareness of the data generated by the project. The audience we were aiming to attract were PhD, postdoctoral and early career scientists working in the area of water and climate change. In particular we were aiming to attract participants from the developing world. One outcome we wanted to achieve was to develop a network of early career scientists and to engage with participants from a variety of countries.

The achievement of these aims would only be possible with sound organisation and communication with the participants. Recognised experts in the field were invited as lecturers; in particular leaders of the different work blocks and work packages in WATCH were invited. Student attendees were invited to present their own research (oral or poster presentation) by means of an introduction to their backgrounds. Ample time was allowed for discussions including a closing session. Sufficient time for breaks (tea, coffee, lunch and dinner) was scheduled to allow lecturers and students to mix informally. A mid week excursion was organised to assist in developing contacts and to build networks. An end of course evaluation was prepared to get feedback from participants on their overall experience of the summer school.

3. Participants

3.1 The students

The course announcement was sent out to all WATCH members (over 100), including WATCH PhD students. Priority was given to applicants from the developing world and particularly those interested in increasing their knowledge of modern tools for analysing the global hydrological cycle. The applicants were asked to complete a simple application form and to attach their curriculum vitae (CV). The announcement resulted in over 85 applications; from this 32 were selected to attend the course which was a high number for the meeting venue. Unfortunately owing to difficulties in processing entry visas to the United Kingdom (and one instance of personal injury) the final number of participants was 24, which was more suited to the meeting venue facilities and computer exercise.

Of the selected participants 54% were female (46% male), and most were PhD students. Of the participants only 37% were from Europe; the others either travelled from their home country or were already working in Europe and travelled from their host university to the summer school. In total 15 nationalities were represented and these different nationalities are plotted below:

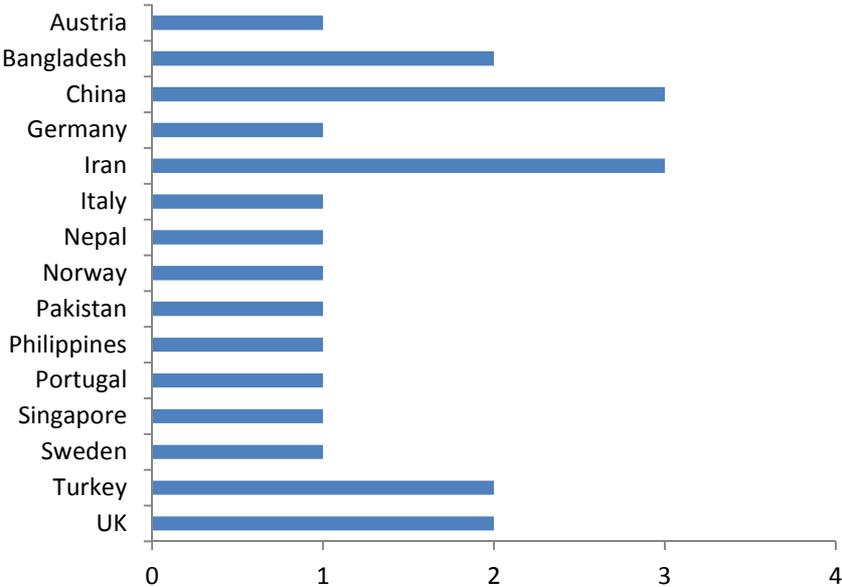


Fig. 1 Number of participants per country of origin (i.e. nationality).

3.2 The Presenters

Those chosen to speak at the summer school were generally leaders of workblocks or work packages who had intermit knowledge of the project from its beginnings. At the start of the summer school attendees were given backgrounds for each of the presenters, so that they could familiarise themselves with the speakers (appendix 2) In addition a data handling session was prepared to introduce attendees to the large data sets of WATCH and was aimed to familiarise participants with using NetCDF files. This is the adopted data format for all outcomes from WATCH. This exercise was designed by the modellers themselves and several were on hand to assist in this afternoon long excercise.

WATCH is assessing the water cycle at a global scale, however it does focus on two test regions, notably Europe and Indian subcontinent. Through its work in area of the Indian subcontinent there is a partnership with the FP7 HighNoon project. Experts from the HighNoon project were also invited to present their findings in an effort to highlight this ongoing working partnership.

4. Summer School Programme

The summer school was laid out to cover the main areas of WATCH work and a copy of the agenda is located in Appendix 3. The summer school progressed from global climate modelling to regional work. This was followed by the investigation of extremes (floods and droughts) followed finally by work on water resources and the Water Model Intercomparison project. One theme running through the summer school was data:

- the WATCH Forcing Data for the 20th C
- the generation of 21st C Driving Data
- the bias correction of the data
- multi-model analysis of extremes
- time series analysis of data
- model intercomparison work

The summer school started on Monday 4 July 2011 with an introduction to issues of climate change and the water cycle and presented the rational for proposing the WATCH project. This was followed by a data handling session where students were given a hands-on introductory training session to using large data sets in netCDF format. This was followed by dinner at the high table in the dining hall of the college.



Pictured: students at the data handling exercise

At the end of day three of the week long summer school an excursion was organised to give a guided walking tour of Oxford and participants learned more about the scientific achievements made at the University of Oxford as well as the town's history.

The final afternoon the participants were divided into 4 groups and set an exercise to discuss what they perceived to be the major constraints to water in the future. This exercise was aimed to at them using the additional knowledge gained over the course and to build on their existing expertise. This information would help them to formulate what options exist to solve a possible global water crisis. Each group had two experts in the room who were prepared to answer questions and to guide the debate. Each group was asked to prepare a short presentation for the following morning to the whole group outlining:

- a. What is the problem? (highlight scientific and/or societal implications)
- b. What is the scientific evidence to support the problem as you see it
- c. What is the knowledge gap? Suggest areas where more research is needed (this could include modelling needs, data needs, regional understanding etc.)
- d. Propose how to tackle this gap in the knowledge
- e. Who are the users of this research? (eg stakeholders, managers, policy makers, other scientists etc.)
- f. What are the wider impacts/outcomes of this research project? (adaptation measures, benefits of this new knowledge, link from science to policy, behavioural changes etc.....)



Pictured: students presenting outline of their proposals, four groups of six persons were assigned similar research questions

This was a very interesting conclusion to the summer school and the international aspect of the participants was reflected in the presentations given. Each presentation was in the form of a proposal for the need of future work. Regional examples were provided and these highlighted the issues faced at the local level in some developing nations. One theme that appeared in 3 of the 4 presentations was groundwater and our continued lack of knowledge in this area. What was particularly interesting was these groups arrived at identifying the issue of ground water independently as groups were in separate rooms to debate and prepare their presentations.

All presentations were collected at the end of the summer school and these were given to the participants of the summer school. This included the presentations prepared by the students as part of the exercise set them.

5. Evaluation of the summer school

To conclude all students were presented with a certificate of attendance. This was personally distributed by Dr. Richard Harding and each certificate awarded 2ETC to each attendee. In general there was a high degree of satisfaction on the part of the attendees with over 65% strongly agreeing that they would recommend this course to others.

On the final day of the summer school students were given a comprehensive evaluation form and asked to include comments on their experience. Also they were asked to feed back any areas where it could have been improved. The evaluation form was completed by 23 of the 24 participants (but it should be noted that on the final day one student was missing because of illness).

The evaluation form is included in appendix 4, and participants were asked a number of statements which required a numbered response that corresponded to: 5=strongly agree; 4=agree; 3= neutral; 2= disagree; 1= strongly disagree.

The overall satisfaction with the summer school was high with no neutral or disagreeing replies:

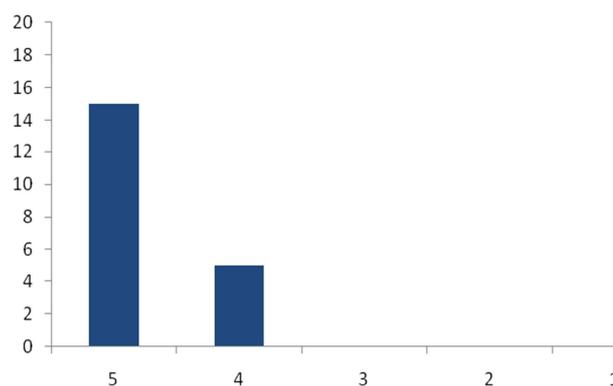


Fig 2. Overall satisfaction asked: You are overall satisfied with your experience at the summer school

The evaluation form was designed to cover question about the summer school as a whole, the ability of lecturers to communicate their science, the suitability of organising staff, materials provided, projects set,

activities undertaken, accommodation and knowledge gained at the summer school. The collated responses to each of these are described in turn below.

The general feedback from the attendees was very positive and all have been enthusiastic to receive a copy of the presentations. Some have commented specifically on the data produced by WATCH and are eager to get access to this.

Content suitability of the summer school as a whole to teach and build confidence in area of water and climate change is shown in fig3. This Figure is a summary of 12 individual questions and Annex 1 shows plots of some of these questions individually.

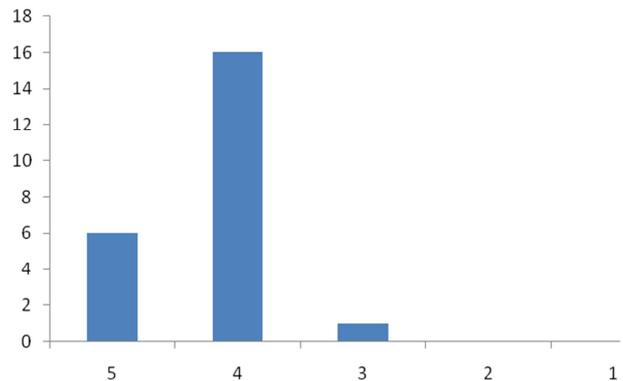


Fig3. Vertical axis records number of replies and horizontal axis refers to the agreement statements 5-1 listed above

In general satisfaction was high with the presentations given by the lecturers and the organising staff:

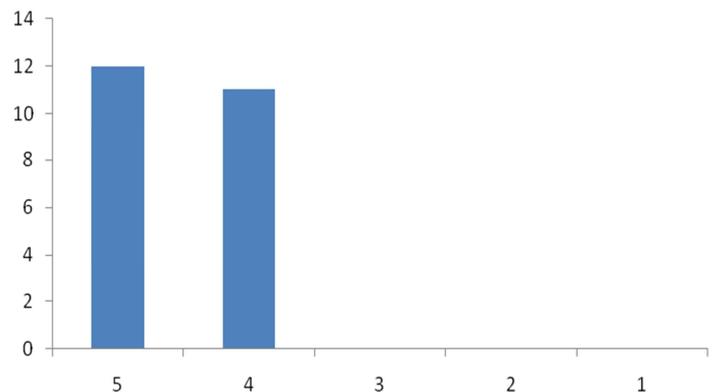


Fig. 4 Satisfaction in the presentation abilities of the lecturers and effectiveness of delivering scientific knowledge

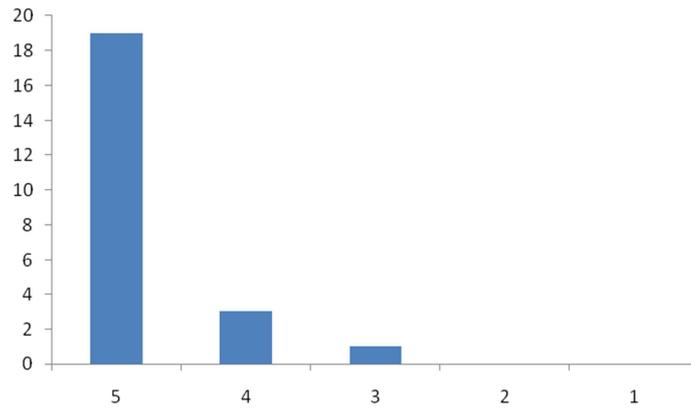


Fig. 5 Overall satisfaction in the staff organising and supporting the summer school

Materials, there were relatively few materials as much of the material was in electronic format. However computers were hired specifically for the data handling session and for the group exercises each room had a computer on which to prepare the presentations and these rooms were kept open after hours at the request of the participating groups. In addition to wifi facilities, the attendees of the summer school had access to the computer terminals of the college of St Catherines, the premises where the summer school was held.

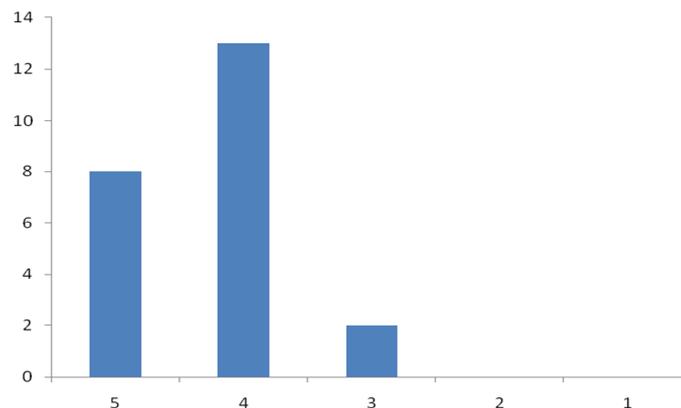


Fig. 6 Satisfaction with materials used in the summer school, it should be noted that after the event the presentations were forwarded to all participants.

During the week long course two exercises were held one was to introduce attendees to using and manipulating large data sets necessary for running climate or land surface models. This had the direct benefit of also introducing attendees to the data available through WATCH. Secondly group interactions were encouraged through the setting of a research question that was to be presented to the group on the final day.

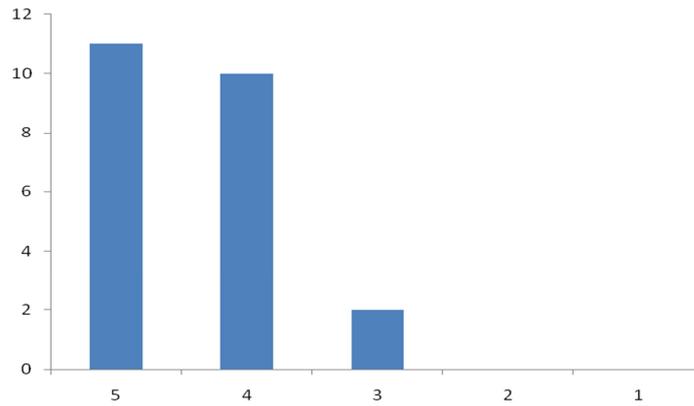


Fig. 7. Overall satisfaction with the projects assigned for completion during the course, there were two specific exercises one on data handling and a second to prepare a presentation using the knowledge gained

The aim of the summer school was also to enable networking and to foster ties with participants from different nationalities. Adequate breaks were included and all meals were taken together (lecturers and students) in a common dining hall, this encouraged informal discussions to continue. A tour of Oxford was organised to allow participants to learn of the town in which this summer school was held.

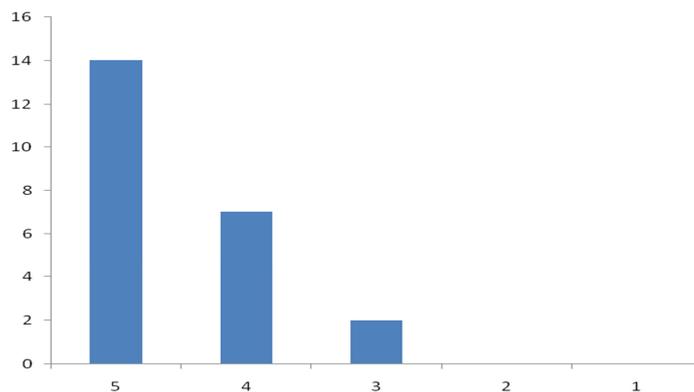


Fig 8. Overall satisfaction with the activities organised to engage in social mixing

Finally all attendees were asked the likelihood of using the knowledge gained from this summer school in the future:

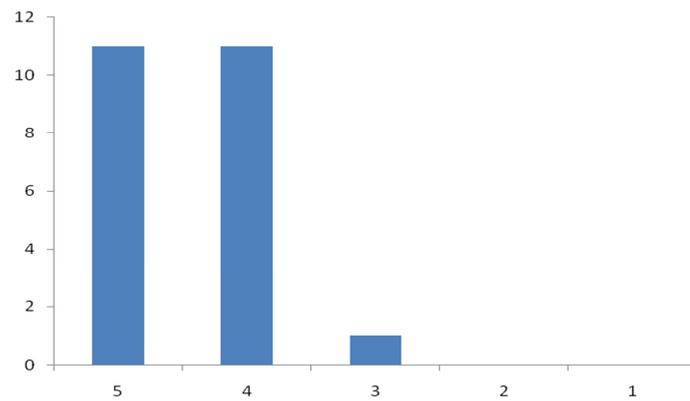


Fig 9. Overall expectation of using the knowledge gained during this summer school in the future

The individual comments written by the attendees were in general very positive and enthusiastic, it reflected the positive atmosphere that developed over the week. It was rewarding to see the results of WATCH received with such interest. Eleven participants provided written comments and below is a summary of some of these:

- Very useful and engaging
- Can't wait to get my hands on the data
- It was spot on for my research
- Nice to discuss with speakers in an informal setting
- A few lecturers talked too fast, otherwise really good!
- Good opportunity to see how the models are being used
- Interesting and well organised summer school, Thanks
- A bit more of an introduction would have been helpful
- Discussion groups were extremely helpful

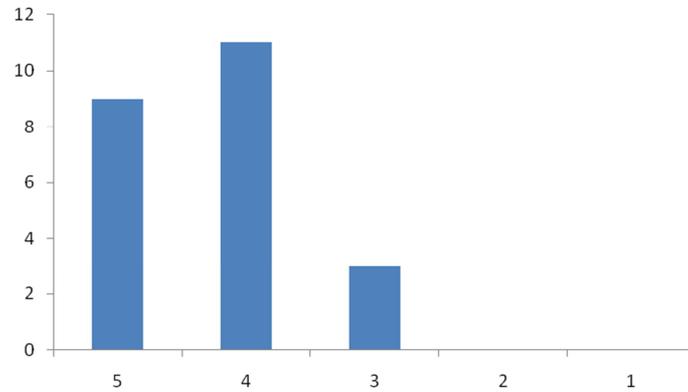
6. Conclusions

As a whole the summer school was a successful event that was positively received by all those who attended the course. This is reflected in the positive comments written in the evaluation forms. Overall this summer school as a good showcase for the achievements of the WATCH project. The highly international group that was brought together functioned well and it is hoped that these attendees will bring the message of WATCH to their host institutions. An important legacy of WATCH is the data it has generated and this was clearly presented at this summer school. In addition the WATCH project approach to uniting climate, hydrological and water resource modellers is an example that the participants engaged with positively and hopefully will carry back to their home organisations.

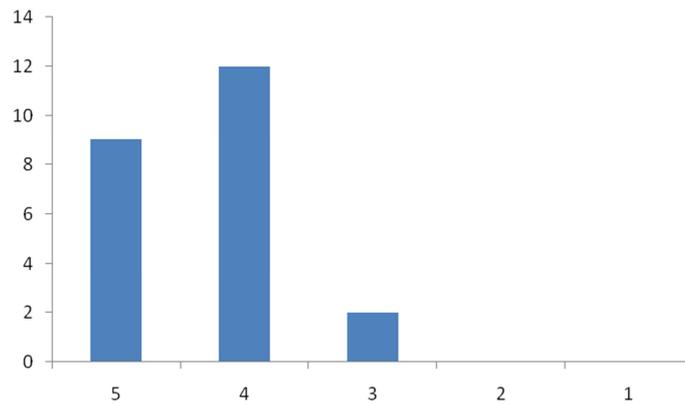
Appendix 1: Presentation of some of the individual questions in the evaluation form:

Summer school as a whole:

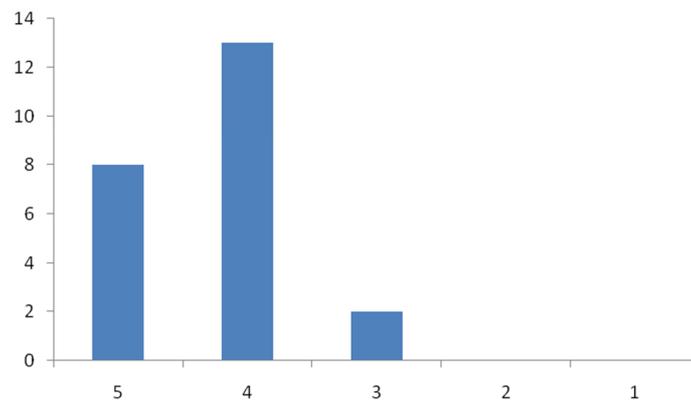
Question 1: ...had content that was appropriate for my background:



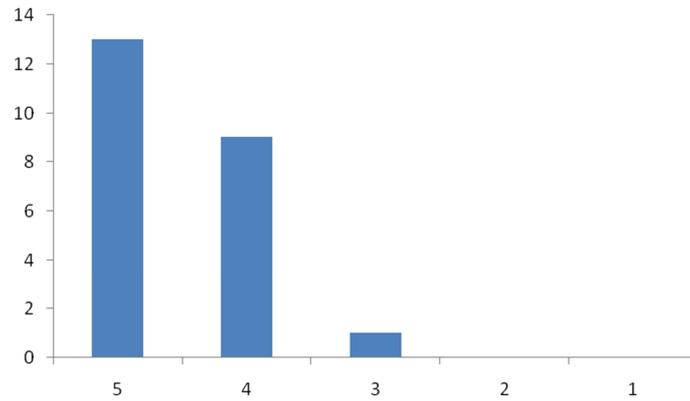
Question 2: ...had content that balanced (general and specific):



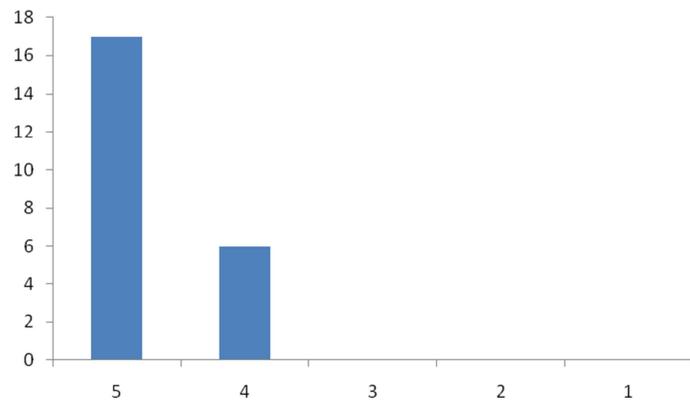
Question 3: ...met my needs and covered the topics I needed to know:



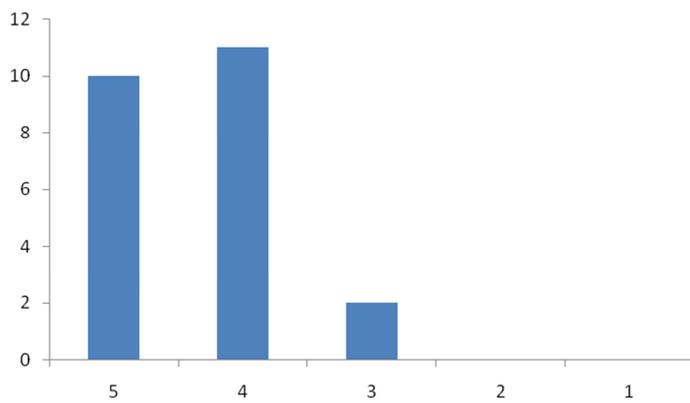
Question 5: ...managed time efficiently. Lectures began promptly and disruptions were minimal:



Question 9: ...increased my confidence in my understanding of the climate system and water cycle:

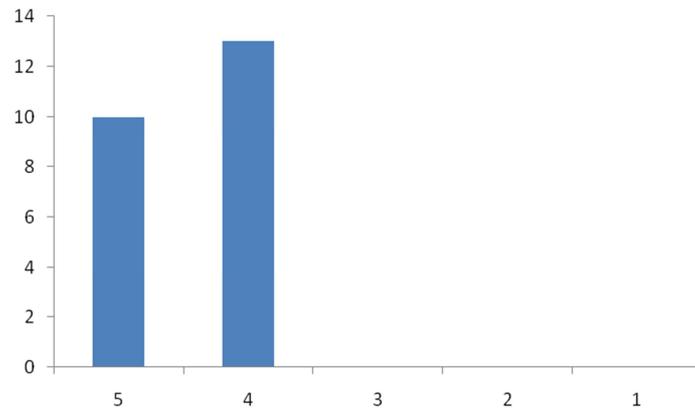


Question 11: ...increased my confidence in my ability to debate on climate change:

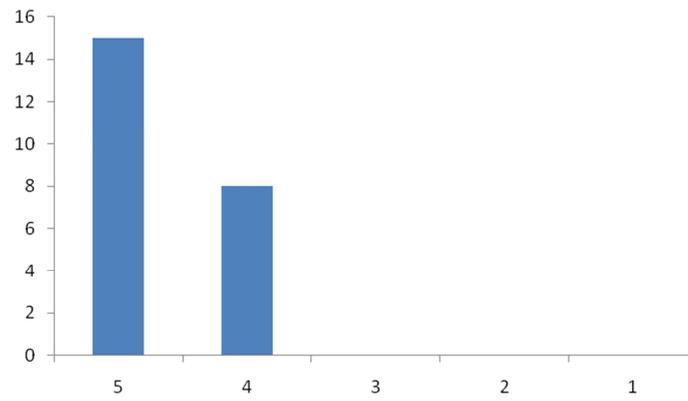


Lecturers:

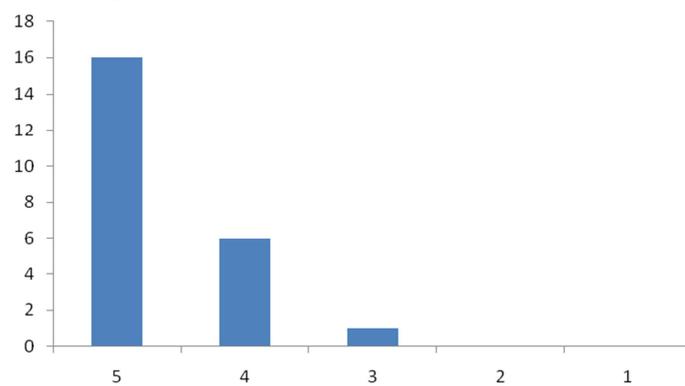
Question 1:.....clearly presented their subject matter



Question 5:.....were accessible and helpful:

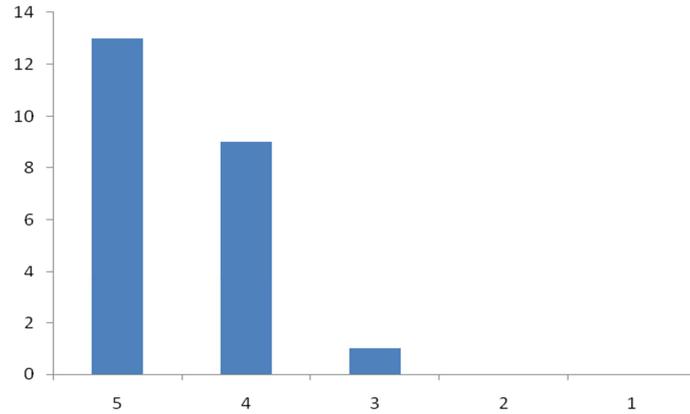


Question 7:.....were knowledgeable in their field:

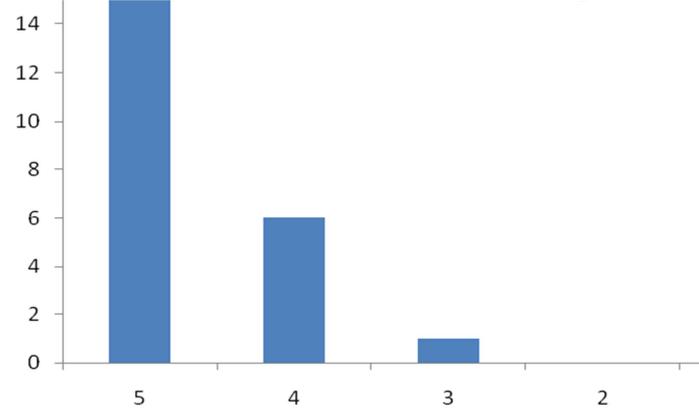


Using knowledge acquired at the summer school:

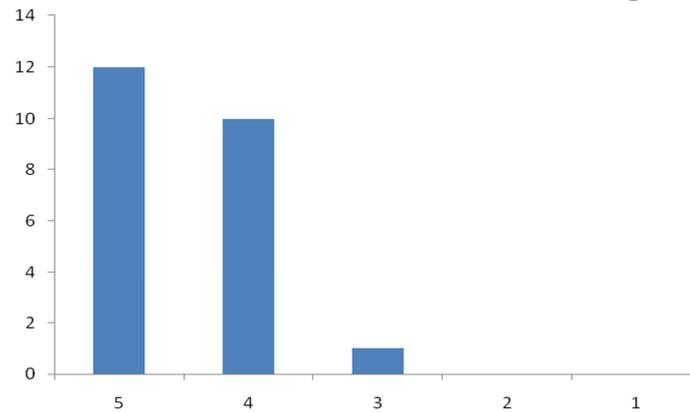
Question 1:.....do you better understand the certainties and uncertainties in climate change?



Question 2:.....The summer school has made me more aware of the global water issues?



Question 4:..... After this summer school I shall be more active in advocating our changing water cycle?



Appendix 1: course announcement



International Summer School on

Water resources and the Water Cycle in a Changing World

4th -8th July, 2011 St. Catherine's College, Oxford, UK

Sponsored by the WATCH "WATER and Global CHange" Project¹

A key component of the climate system is the global water cycle. As global temperatures increase and the climate changes a more intense but variable water cycle is resulting in globally increased precipitation with regionally more intense rainfall events leading to floods or failure in rainfall producing droughts. At the same time man's demands on water are increasing with engineering works (dams and reservoirs) and abstractions (for agriculture, industry and cities) strongly modulating the natural flows of many large river systems, greatly influencing available water resources, and increasingly causing conflicts between different water users.

This intensive 4 and a half day course will cover an introduction to the major issues in climate change, the water cycle and water resources. This will include consideration of newly-developed global and regional data sets to assess the past and future water cycle, the use of climate model outputs in hydrological analysis, large-scale hydrological models, evaporation, trend analysis and the detection and attribution of extreme events.

The course will mainly consist of morning lectures given by international experts combined with afternoon discussion sessions and some time for hands-on training. Participants will be asked to give a short presentation on their own research interests, preferably showing a link with global change, and to share knowledge among themselves and with the experts in the field.

The course will address in detail:

1. Global water cycle and past and future water resources
2. Regional case studies, continental to regional scale
3. Extremes (floods and droughts)
4. Human impacts on the water cycle

In addition discussion groups and exercises will explore

- How to access and make use of global and regional data sets and data from climate models.
- How to analyse time series
- Regional and global issues in water resources.

Who should attend?

The course is suitable for masters and PhD students as well as early career scientists, primarily studying or conducting research within the area of water and global change. Priority will be given to applicants from the developing world and particularly those who are interested in increasing their knowledge and learning more about modern tools for analysing the global hydrological cycle. The activity will be conducted in English.

A restricted number of places are available. There will be no registration fee and no accommodation fees. Some funds are available for travel for participants from the developing world. Participants will receive a certificate that specifies a workload of 2 ects (European Credit Transfer System).

The **Application Form** is available at: www.eu-watch.org

Applications should be sent via e-mail, no later than 1 April 2011, to info-watch@ceh.ac.uk.

Applicants will be notified of acceptance or otherwise by 20 April 2011

Centre for Ecology and Hydrology

Wallingford; United Kingdom (www.ceh.ac.uk)

¹ WATCH is a framework 6 European Union funded project linking the communities of hydrology, climate and water resources in the study of the global water cycle and how it is influenced by climate (and environmental) change. www.eu-watch.org

Appendix 2: Backgrounds for each presenter



4 - 8 July 2011

International Summer School on:

Water resources and the Water Cycle in a Changing World

Brief introduction to speakers:

Myles Allen is a University Lecturer and currently leads the Climate Dynamics Group in the Department of Physics. His research focuses on how human and natural influences on climate contribute to observed climate change and extreme weather risk. He served on successive Assessments of the Intergovernmental Panel on Climate Change. He has been working on quantifying the uncertainty in forecasts of anthropogenic climate change, and is the Principal Investigator of the climateprediction.net project, which is using a massive ensemble of models runs using PCs around the world to produce a probability-based forecast of 21st century climate. His latest research addresses the question of how scientific evidence can best be used to inform climate policy. .

Eleanor Blyth works at the Centre for Ecology and Hydrology and has over 20 years experience in research on representing the land surface in meteorological and hydrological models. Originally, she worked on evaporation, but increasingly, she has widened her interests to include soil processes, the generation of runoff and also photosynthesis. Currently she is using data from different biomes of the world to test and calibrate the JULES (Joint UK Land Environment Simulator) land surface model. In addition, her research interests include assessing methods to represent heterogeneous terrain (snow, vegetation, soil moisture, topography) and improving the representation of key hydrological processes. She is researching the effects of uncertainty in model structure, data and parameters.

Helen Bonsor works at the British Geological Society as a Hydrogeologist. Her main area of interest is international groundwater resources looking at issues of demand, vulnerability and access. She also works in using remote sensing data in ground water science and the impact of climate change on groundwater. She believes providing science and data to underpin groundwater management.

Douglas Clark works at the Centre for Ecology and Hydrology and is a land surface modeller, principally interested in hydrology and land-atmosphere interactions. In recent years he has been involved with developing the JULES land surface model, both adding new descriptions of physical and biogeochemical processes, and developing the overall model structure. During the WATCH project he has added a parameterisation of dam and reservoir operation to JULES, as well as helping to develop a multi-layer representation of snow processes.

Simon Dadson works at the centre for Ecology and Hydrology, and his research focuses on the processes that link climate, hydrology, and geomorphology. These links range from the potential impacts of future climate change on river flows, to the study of how continental-scale weather patterns have influenced the development of mountain topography over the past few million years. As part of the WATCH project he worked on Wetland Inundation Dynamics in the JULES land-surface Model. At present he is working on Changing Land-Atmosphere Feedbacks in Tropical African Wetlands.

Rich Ellis works at the centre for Ecology and Hydrology, and his research focuses on the interaction between the land-surface and the atmosphere. Within the WATCH project he was exploring pathways to use Earth Observation data to constrain and validate land-surface models as well as examining the sensitivity of land-surface models to driving data and parameters.

Dieter Gerten, group leader at the Potsdam Institute for Climate Impact Research, is a physical geographer and hydrologist with 15 years of expertise in ecological and hydrological modelling at scales from single river basins to global. Currently he is scientist in charge for the LPJmL global vegetation and water model with a focus on the hydrological cycle and its interactions with the terrestrial biosphere, and the human interference on the bio-/hydrosphere. He is (co-)author of about 50 reviewed papers and book chapters on hydrology, ecology, and also cultural issues. D. Gerten is currently actively involved in the EU WATCH project.

Stefan Hagemann has worked on hydrology within the framework of global and regional climate modelling since more than 17 years. He is familiar with modelling of hydrology and land surface processes as well as with the validation of the hydrological cycle of GCMs, RCMs and re-analysis data. He has lead the group Atmosphere Surface Exchanges at MPI-M for 1.5 years until it was dissolved due to re-structuring in December 2005. Since May 2006 he is leading the group Terrestrial Hydrology. He has actively contributed to the EU projects ERA40, MERCURE, PRUDENCE and the BMBF project BIOTA-South (phase 2 and 3), and is currently work block leader in the EU project WATCH

Richard Harding is the director of the **Biogeochemistry Programme** at the centre for Ecology and Hydrology. Dr Harding has over 20 years' experience in evaporation measurement and modelling techniques. He has made soil moisture, meteorological and evaporation measurements in India, Africa, North America and over Europe. In recent years he has concentrated on studies measuring and modelling fluxes from arctic land surfaces, particularly snow. Dr Harding is currently a PI on a number of EU and NERC funded projects making measurements and modelling studies in Europe, the arctic and Europe. He also leads the EU-funded WATCH Integrated programme - designed to better describe the 20th and 21st Century Global Water Cycle.

Phil Harris Phil Harris works at the Centre for Ecology and Hydrology as a climate and land surface modeller. To date his research interests have concentrated on modelling the water and carbon cycles in the tropics, particularly in West Africa under the AMMA programme and in the Amazon under the LBA programme. In recent years he has investigated the use of satellite Earth observation data in constraining land surface simulations using the JULES model. He works currently on these data assimilation problems under the NERC Changing Water Cycle (CWC) and National Centre for Earth Observation (NCEO) programmes.

Ronald Hutjes at Wageningen University conducts research on measuring, scaling and modelling of land cover-atmosphere exchange processes at the regional scale; hydrology, carbon and nutrient cycling. In this he uses aircraft observations of turbulent fluxes in the PBL and coupled high resolution land atmosphere models. His work is relevant for policy development in climate mitigation and adaptation in relation to land use. He is member of the advisory board of the Dutch national climate programme: Climate Changes Spatial Planning. For the WATCH project he has focused on mesoscale modelling (RAMS) of land cover climate interactions in areas of large scale irrigation.

Pavel Kabat is Professor of Earth System Science and Climate at Wageningen University and Chair of the Board of the Climate Change and Biosphere Centre, and Science Director of the National Climate Programme of the Netherlands. His research focuses on land use–hydrology interactions; climate impacts on water resources and global environmental change processes. He is chair of several

national and international research programmes such as IGBP-iLEAPS, and WCRP-GEWEX-ISLSCP, and the International Cooperative Programme on Water and Climate (CPWC). Prof. Kabat participated as PI and research co-ordinator in over 20 EU supported projects between 1990 and 2002 (in seven as overall co-ordinator).

Fulco Ludwig is a Research Scientist at Wageningen University. His main research interests are all linked to climate change, impacts, vulnerability and adaptation. His multidisciplinary work brings together skills in hydrological, ecological, agricultural and climate sciences. His first research line focuses on the impact of climate change on global water resources. He is one of the co-ordinators of WaterMIP, an intercomparison project including 13 global hydrological models and Land Surface Hydrological Models focussing on both the historical and future global water cycle. The second research line, looks at climate change vulnerability and adaptation in developing countries. Answering questions such as what kind of adaptation is necessary, which actions should have the highest priorities and how to improve the adaptive capacity of developing countries.

Henny van Lanen is an Associate Professor of Hydrogeology at Wageningen University. He has been involved in several EC projects. He was supporting co-ordinator of the EUFPV ASTHyDA project (Analysis, Synthesis and Transfer of Knowledge and Tools on Hydrological Droughts Assessment through a European Network, 2002-2004). He is coordinating the upcoming EU FPVII project Fostering European Drought Research and Science-Policy Interfacing (DROUGHT-R&SPI). He was co-ordinator and contributed to various UNESCO-IHP projects on drought, low flow and groundwater issues. He is editor of the recent textbook "Hydrological Drought – Processes and Estimation Methods for Streamflow and Groundwater", Developments in Water Science, Elsevier. He is one of the founders of the recently established European Drought Centre (EDC).

Camilla Mathison Camilla Mathison is a climate scientist working within climate impacts in both areas of adaptation and the impacts modelling development. Her work within the adaptation area involves working with business and government departments to help them understand their sensitivity to climate change and inform their adaptation strategy. Her work in the impacts modelling development area involves working on European projects such as ENSEMBLES and HighNoon. Currently Camilla is analysing recently completed regional model simulations over India as part of the HighNoon project. Camilla is also running regional simulations over Africa as part of a collaborative project considering the impact of climate on water resources in this region.

Claudio Piani is a Visiting Scientist at the Abdus Salam International Centre for Theoretical Physics. He has been investigating the attribution of climate change down to spatial and temporal scales that are relevant to individual. He is interested in the probabilistic global and regional climate forecasts, the uncertainty in climate projections and transfer to impact models. As part of the WATCH project effort, he contributed to the development of a bias correction methodology for hydrological simulations.

Christel Prudhomme works at the Centre for Ecology and Hydrology and has specialised in two main research areas: improving the methodology for assessing the impact of climate change on river flows (both for flood flows and low flows), and developing new techniques for the seasonal forecasting of river flows. Recently, she has set up a project aiming to facilitate access by CEH staff to climate change scenarios, so they can easily gain access to the latest projections.

Tanya Warnaars is an ecohydrologist at the Centre for Ecology and Hydrology. She is currently the manager of the FP6 project WATCH (WATER and global Change), liaising between the 25 project partners across Europe. Part of this role includes communicating project outputs to the wider public. Additionally she holds a Knowledge Exchange fellowship with NERC on the topic of climate change and water scarcity. Previously she was a research associate at the University of Minnesota (USA), and

worked at the National Center for Earth Surface Dynamics; funded by the National Science Foundation (NSF-USA).

Graham Weedon at the Met Office in the UK, works on the datasets needed for running land surface models such as JULES as well as analysing climate model output. His current activities include creating sub-daily global land, half-degree resolution meteorological data for 1901-2001 based on ECMWF ERA-40 re-analysis data. This activity is part of the EU FP6 programme WATCH. The resulting dataset is known as the WATCH Forcing Data. He is analysing the impact of uncertainties in the WATCH Forcing Data on the hydrological performance of the JULES. Originally a geologist his background is in time-series analysis of palaeoclimate records.

Andy Wiltshire is a Climate Impacts Scientist at the UK Meteorological Office. His main interest is understanding the integrated nature of climate change, climate variability and the impacts on food and water security. Andy is currently involved in the EU-HighNoon program looking at the impact of climate on the Indian Monsoon and Himalayan glaciers.

David Wiberg is at the International Institute for Applied Systems Analysis as a research scholar in the Land Use Change Program, where he has been developing methodologies to assess the impact of land use and climate changes on water resource availability, demand, required storage capacity, development costs and management options. He is involved in international research projects at IIASA and has consulted for the Dialogue for Water and Climate and UNESCO's World Water Assessment Program. His primary fields of interest are water modelling, climate change impact assessments, and efficient and sustainable water management strategies.

Appendix 3: Course Schedule

2011 International Summer School on: **Water resources and the Water Cycle in a Changing World**

Monday 4 July	Tuesday 5 July	Wednesday 6 July	Thursday 7 July	Friday 8 July
Introduction to climate modelling & Data	Regional Analysis	Hydrological Extremes	Water Resources	Future concerns and opportunities
08:30-09:00 REGISTRATION 09:00-09:30 General introduction (P. Kabat)	09:00 – 10:00 HighNoon: results from Indian test case (A. Wiltshire, S. Hagemann, C. Mathison)	09:00 – 09:45 Hydrological extremes and historic droughts (H.van Lanen, L. Tallaksen & K. Stahl)	09:00 -10:00 Water Scarcity & Modelling of water resources (F. Ludwig)	09:00 -10:30 presentations by breakout groups A, B, C
09:30 – 10:30 Climate Outputs and how models work(S. Hagemann)	10:00-10:30 : Land-atmosphere feedbacks in African wetlands (S. Dadson)	09:45 – 10:30 Historic and future droughts (H.van Lanen, L. Tallaksen & K. Stahl)	10:00 – 10:30 Global hydrological Model comparison (F. Ludwig)	
10:30 Tea/coffee break	10:30 Tea/coffee break	10:30 Tea/coffee break	10:30 Tea/coffee break	10:30 Tea/coffee break
11:00 – 12:00 20 th C data and WATCH forcing data (G. Weedon)	11:00 – 12:00 African Ground water Atlas (H. Bonsor)	11:00 – 12:00 Historic large-scale floods (C. Prudhomme)	11:00 – 12:00 Blue/Green water initiative (D. Gerten)	11:00-11:30 Presentation group D
12:00-13:00 Demographic data sets: land use, water use data (D. Wiberg)	12:00 – 13:00 Irrigation and feedbacks (R. Hutjes)	12:00 – 13:00 Historic and future large-scale floods (C. Prudhomme)	12:00 – 13:00 Detection & Attribution (M. Allen)	Concluding remarks (R. Harding)
13:00- 14:00 Lunch	13:00- 14:00 Lunch	13:00- 14:00 Lunch	13:00- 14:00 Lunch	13:00- 14:00 Lunch
14:00- 15:30 Data Session: Hands on use of data (D. Clark plus P. Harris & R. Ellis)	14:00-14:25 Bias correction: remaining challenges & suggested solutions. (C. Piani)	14:00 – 15:00 Time Series Analysis (G. Weedon)	14:00- 15:30 Students in groups to formulate presentation on key questions*	
	14:25-15:30 Presentations by 15 attendees	15:00 Tea/coffee break		
	15:30 Tea/coffee break	15:30 Tea/coffee break	15:30-16:30 Time Series cont.	
16:00-17:30 Continuation of Data Session	16:00-17:00 final presentation from 15 attendees (2min each)	<i>16:30 private walking tour Science at Oxford</i>	16:00 – 17:30 Continued discussion	
19:00 Dinner @ college	17:30 Poster session & Reception 19:00 Dinner@ college	Open: evening in Oxford (no dinner at college)	19:00 Dinner@ college	

Appendix 4: Course evaluation form:



International Summer School on

Water resources and the Water Cycle in a Changing World

4th -8th July, 2011 St. Catherine's College, Oxford, UK

Sponsored by the WATCH "WATER and Global CHange" Project

**Please give a number to each statement below:
5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree**

Overall satisfaction

1. You are overall satisfied with your experience at the Summer School _____
2. You would recommend this workshop to your colleagues _____

Summer School as a whole

1. ..had content that was appropriate for my background. _____
2. .. had content that balanced (general and specific). _____
3. ..met my needs and covered the topics I needed to know _____
4. ..gave me enough time to research. _____
5. ..managed time effectively. Lectures began promptly and disruptions were minimal. _____
6. .. fostered team building. _____
7. ..was flexible enough to allow me to pursue my interests and express my opinions. _____
8. ..had a good blend of instruction versus personal research time. _____
9. ..increased my confidence in my understanding of the climate system and water cycle _____
10. ..increased my confidence in my ability to work towards a sustainable future. _____
11. ..increased my confidence in my ability to debate on climate change. _____
12. ..had the right mix of ethical, social and dynamical aspects of climate change _____

Lecturers

1. ..clearly presented their subject matter. _____
2. ..were responsive to participants. _____
3. ..were engaging and dynamic _____
4. ..paced the workshop well. _____
5. ..were accessible and helpful. _____
6. ..were able to clarify difficult concepts. _____
7. ..were knowledgeable in their field. _____
8. ..were effective overall. _____

Staff

1. ..came quickly to my aid _____
2. ..knew how to address my difficulties _____
3. ..were supportive and kind _____

Materials: Paper, electronic documents and facilities

1. ..were clearly written _____
2. ..were useful as reference documents. _____
3. Computing resources were adequate to the workshop requirements. _____
4. The main lecture hall was adequate to requirements _____
5. Audio and video equipment were adequate to requirements _____

Projects

1. Assistance for individual projects was sufficient and clear. _____
2. ..were at a level of difficulty appropriate for my background. _____
3. Lectures gave me enough material to work on my own. _____
4. Lectures encouraged me to create my own opinion on climate change. _____

Activities

1. There were an appropriate mixture of activities. _____
2. Adequate time was devoted to social activities. _____
3. Allowed me to create bonds with students from other colleges _____
4. I enjoyed the Oxford tour and open evening _____

Logistics and accommodation

1. Meals were adequate _____
2. My special dietary needs were catered for. _____
3. Accommodation was clean and comfortable _____

Using knowledge acquired at the Summer School

1. Do you better understand certainties and uncertainties in climate change? _____
2. The Summer School has made me more aware of global water issues _____
3. After this Summer School I shall be more active in raising awareness of water resources _____
4. After this Summer School I shall be more active in advocating our changing water cycle _____

Please feel free to comment on any other aspect of the Summer School. (all non personal comments)