Water and Global Change

evaluating the global water cycle's response to the drivers of climate change

SIXTH FRAMEWORK PROGRAMME

Newsletter No. 2 **May 2009**

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EDITORIAL

Dear Reader,

The WATCH project has completed its second year and some interesting results are starting to emerge. We have updated the look of our website and are now publishing our results in technical reports so go ahead and take a look at the site: www.eu-watch.org! Aditionally you can read a summary of our recent activities below.

Thanks to everyone working on or associated with WATCH.

The WATCH secretariat

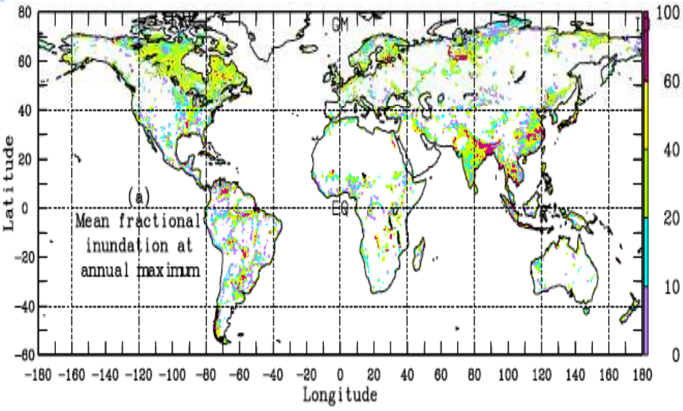
Two Years of Collaboration (01/02/2007 – 01/02/2009)

This interdependent project brings together different expert groups (hydrologists, climatologists, water use experts etc.) divided into different WorkBlocks. Overall progressed in the second year of the project has been excellent. The development of global data sets, both for driving models and their verification has been good. In particular the intercomparison project is generating considerable interest both within and outside WATCH and will provide a platform for the integrated modelling system and uncertainty analyses. Outputs have been substantial, as evidenced by the 18 WATCH technical reports and over 30 presentations of WATCH results, spanning both scientific and stakeholder forums.

The 20th Century

Work has continued on generating new data products in three main areas: Satellite-derived products; consolidated European Streamflow data; and a new half-degree forcing data set.

An innovative method was developed to estimate the global monthly distribution and area of land-surface open water from multi-satellite observations. This method used a group of complementary satellite observations. The use of satellite data with different sensitivities to the various parameters (e.g. vegetation, roughness, water presence) makes it possible to isolate the contribution of the surface-water in the signal.



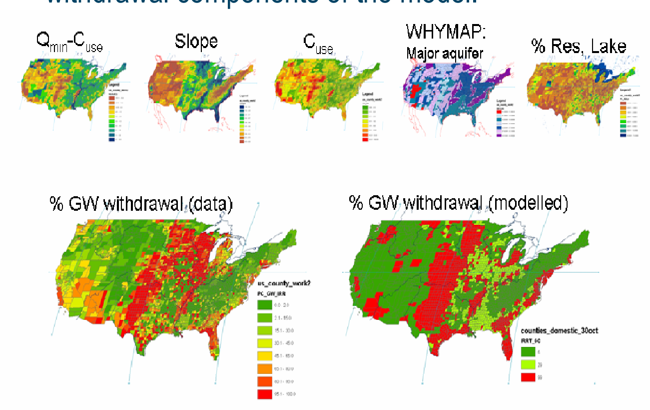
Global satellite-derived mean fractional inundation at annual maximum in % of the equal area 773 km² pixels (0.25°x0.25° at the equator) for the 1993-2000 period.

The "WATCH forcing data" for the twentieth century is being generated in two stages: a) 1958-2001 based on the three-hourly ECMWF ERA40 reanalysis data and b) 1901-1957 by downscaling CRU (Climate Research Unit) monthly gridded observations via a "weather generator" using the means and variability (i.e. spectral-) characteristics of the data obtained in the first stage.

The new data are based on one-degree ERA40 reanalysis data down-scaled to half-degree spatial resolution (i.e. 0.5º x 0.5º). All the data are provided in NetCDF format using the CRU half-degree land-sea mask, only at land points and exclude Antarctica. The initial forcing data has allowed the first land surface model and hydrological model intercomparison runs.

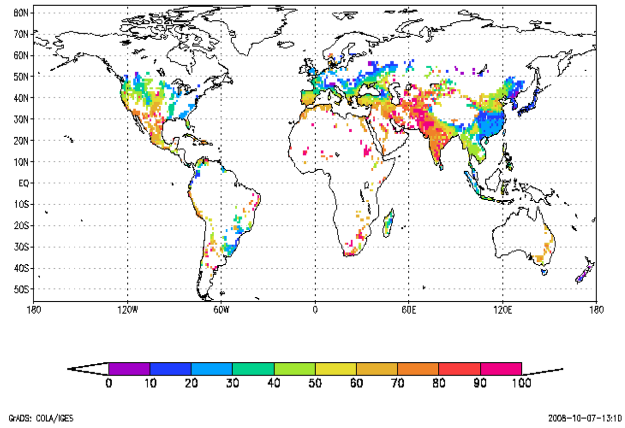
The UK Met Office land surface scheme (JULES) was extended to include a simple representation of groundwater, to incorporate this into the JULES land surface model, a TOPMODEL-type approach was applied. For instance, changing the topography has a large impact on both deep and surface runoff. As the mean water table rises, the region over which the water table reaches (or exceeds) the surface also increases, resulting in more surface runoff. Changes in deep runoff drive changes in surface saturation which, in turn, are responsible for smaller changes in surface runoff. Where by an increase in deep runoff will lead to an increase in total runoff (and vice-versa). Incorporating a groundwater model gives significantly different results in surface and sub-surface runoff components. The groundwater model is sensitive to landscape and the reduction of porosity with depth. Including the groundwater model produces long term mean runoff results that are closer to what is observed over many regions.

Known withdrawals and consumptive use of groundwater (GW) are important to realistically determine GW availability at a particular point in time, as well as the longer-term water balance, and the sustainability of the GW resource. A preliminary modelling scheme uses GW withdrawal statistics plus indicator driven GW use as drivers to allocate withdrawals. These values per grid square drive the withdrawal components of the model.



Groundwater withdrawal likelihood modelling for the irrigation water use sector for 3000+ US counties.

Partners in WATCH have also developed a new representation of crops and irrigation. The impact of irrigation on crop biomass has significant spatial variation. Irrigation causes an increase in net carbon uptake only in areas with high crop densities. On a global scale the interaction of an increased carbon sink with climate is small and depends on the fate of the crop. Irrigation is costly in terms of water consumption, but can be highly efficient (see figure below). Areas which have the potential to gain most from irrigation in terms of agricultural output require a significant input of water (>1800 kg m^{-2} yr^{-1}). However, in these areas nearly 100% of water added through irrigation is used by crops. Areas with low irrigation efficiency, have other factors that limit growth thus water added during irrigation is lost via runoff.



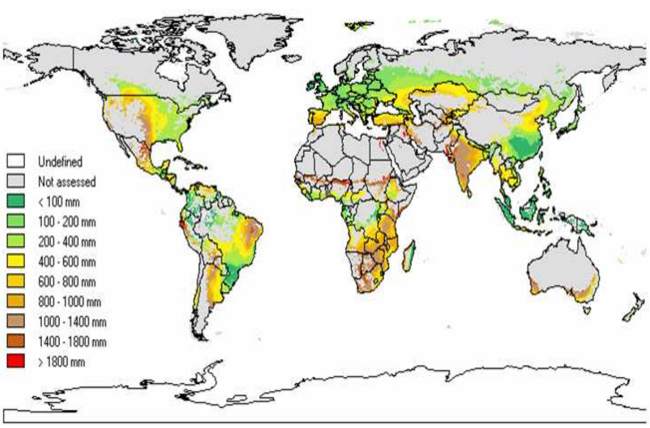
Irrigation efficiency (%): water lost via transpiration as a % of water added through irrigation

The results highlight the important links between food, water and climate change and shows how models can be used in the assessment of climate adaptation strategies. Climate interaction is potentially significant in areas with high irrigated crop coverage.

Capturing human impacts

This section aims to deliver datasets on population; land cover and use; and sectoral water demands. Data on spatially explicit estimates of present and past domestic water use has been compiled to validate the domestic water use model. For instance the basic approach of the domestic water use model is to first compute the domestic water intensity (m^3/cap-year) and then to multiply this by the population of water users. Changes in water use intensity can be expressed by structural changes and structural change is based on the observation that, as average income increases, water consumers tend at first towards a more water-intensive lifestyle. Finally a maximum level is reached after which per capita water use is either stable or declines.

Crop water deficits have been calculated globally by estimating the water a crop uses that is in excess of what is supplied by rainfall. In addition, the potential production increase for an area which could be fully irrigated has been calculated. The next step is to compare the water deficit with water availability.



Mean annual water deficit 1901-1995 in areas with cultivation

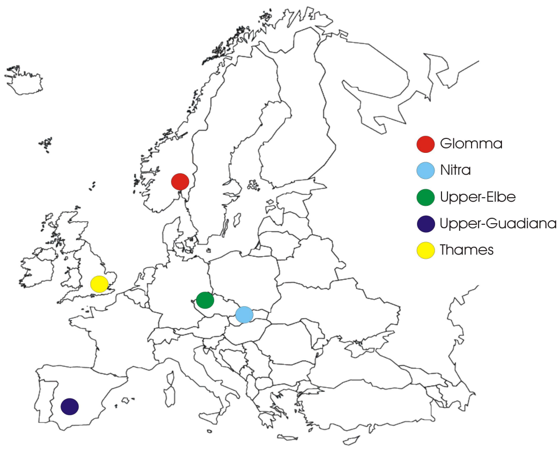
In order to produce a spatially explicit global database of water use in industry and energy production data was compiled and calculated on water use in the manufacturing sector. Here the manufacturing water use refers to the annual amount of water withdrawn (and consumed) in production processes. In addition water use for producing electricity for each year assesses the amount of water withdrawn (and consumed) for cooling purposes of thermal power plants in the electricity sector. Finally a variety of existing maps, data and information, notably the Global Lakes and Wetlands Database (GLWD) has been chosen to represent the best available information on global dams. This information on water use reconstructions and scenarios will be incorporated into the projects data framework.

The 21st Century

Future climate model scenarios depend crucially on their adequate representation of the hydrological cycle. Within WATCH special care is taken to couple state-of-the-art climate model output to a suite of hydrological models, this is expected to lead to a better assessment of changes in the water cycle. Methodologies were developed to adequately handle biases in climate model output and to quantify the resulting uncertainties in estimating future global water cycle components. Moreover comprehensive analyses of projected changes in the hydrological cycle over Europe have been conducted, because they are represented in existing global and regional climate model simulations. Further work includes discussions on defining scenarios for the 21st century so that regional and global changes in socio-economic conditions are reflected. This shall be used to prescribe temporal, and spatially distributed, boundary conditions for global and regional hydrological sensitivity simulations.

Analysis of 20th Century Floods and Droughts

Work on developing a river basin datasets, includes a comprehensive metadata catalogue, for the WATCH river basins (see below). These datasets are used to study processes generating drought, including the propagation from meteorological drought into hydrological drought as well as spatial and temporal patterns of drought at the river basin scale.



Location of the selected river basins for hydrological extremes study

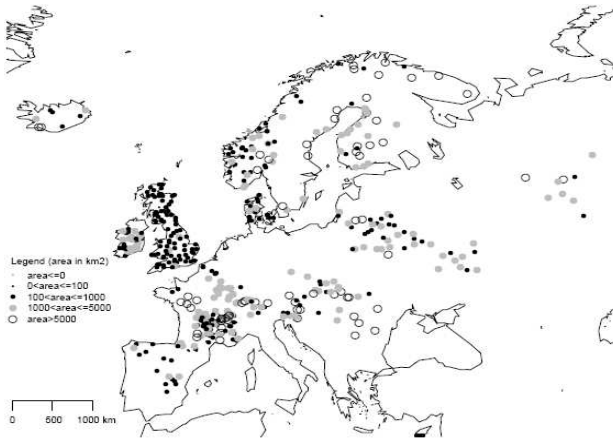
The time series were analysed to investigate droughts in precipitation, recharge and groundwater discharge. The study confirmed that climate (including snow accumulation and melt), soils and the responsiveness of the catchment (e.g. aquifer characteristics) have a major influence on drought generation, and show that natural variability in the climate system causes droughts to occur irregularly in time and space at the regional scale.

In a special study on the Pang catchment (Thames, UK) emphasis is on how a meteorological drought (deficit in rainfall) is propagated in the hydrological cycle to appear as a drought in groundwater recharge, hydraulic head and groundwater discharge. Rather large differences in the spatial and temporal characteristics of drought for the different variables were revealed. Meteorological droughts frequently cover the whole catchment and last for a short time, whereas droughts in recharge and hydraulic gradient typically cover a smaller area and last longer.

A methodology for understanding and assessing some of the main processes for generating major floods has been investigated, focusing on two main aspects: (i) the severity of rainfall preceding or during a major flood event; and (ii) the main atmospheric conditions prevailing before and during a major flood event. This is made up of three main steps: the first one aims to identify the flood events and to build a flood series. The second step establishes the preceding conditions of the flood events, either in terms of rainfall or in terms of atmospheric circulation type. The final stage consists of analysing the two series (flood and preceding conditions) in order to identify the main processes that could be the cause of large floods.

The methodologies that quantitatively describe the space-time development of drought and large-scale floods are applied at different scales, and focused on Europe. Information on the space and time scales as well as severity of major historical drought and floods also contributes to the drought and flood catalogues. Preliminary result shows some atmospheric conditions, as described by circulation and weather types, are more often associated to drought and flood events than others.

Comparative research on a regional scale is being undertaken to assess hydrological change in small basins at the sub-grid scale of climate models. The newly assembled and updated stream-flow data set for small basins across Europe now includes recent severe drought periods and covers the WATCH focus region "Europe".



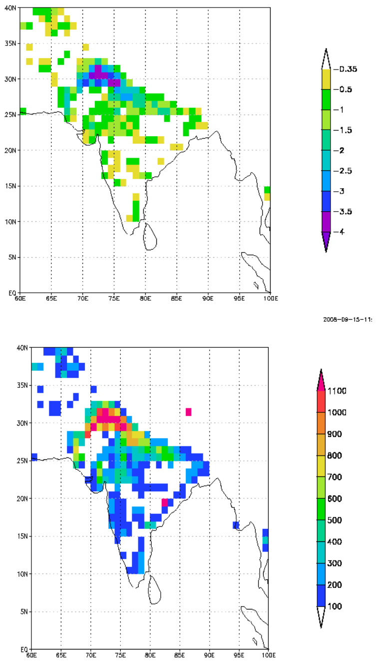
Map of the river basins considered for the flood study.

Methodologies to correct biases in climate model output, and to quantify and handle resulting uncertainties in the water cycle, have been described. A methodology was developed to predict the spread in hydrological model output resulting from the use of forcing data from an ensemble of climate models. These approaches address the propagation of uncertainties in the model chain: climate-hydrology-detection of extremes.

Quantifying Feedbacks in the system

Work has progressed on methods to assess feedbacks in the water cycle and its impact on global water resources. Feedbacks associated with changes in land use have expanded in scope to include global landcover-change feedbacks and the impact of wetlands on regional rainfall generation in West Africa. Additionally climate change is likely to impact on agricultural outputs and consequently food supplies. Agricultural practices such as irrigation, may help adapting to change in areas with a lot and unreliable rainfall. However, irrigation has implications on water resources and feedbacks to climate.

In terms of water consumption irrigation is costly, but can be highly efficient. In areas with low irrigation efficiency other factors limiting growth, and the water added during irrigation is lost via runoff. Adding moisture to the soil cools the land surface, decreasing the heat flux to the atmosphere and increasing evaporation. In North West India where the coverage of irrigated crops is greater than 75%, the surface cooling effect is considerable (4°C- see figure below). Such modifications may have important interactions with the climate by affecting the formation of cloud.



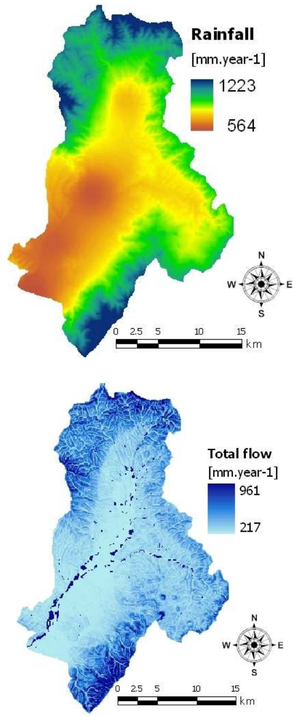
Effect of irrigation on a) surface temperature (°C) and b) evapotranspiration (kg H20 m-2 yr-1)

Irrigation is an important tool in improving crop yield, but increasing agricultural output comes at the price of increased water consumption, and potential climate interactions. The results highlight the important links between food, water and climate change and shows how models can be used in the assessment of climate adaptation strategies. Climate interaction is potentially significant in areas with high irrigated crop coverage

Water resources vulnerability

Assessing vulnerability of water resources in the future century is undertaken as models are improved for the climate change impact and vulnerability analyses. The model intercomparison exercise will guarantee that results from the different models within the modelling framework will be comparable, providing a better indication of the impact and uncertainties of future climate change on water resources. A key issue is to develop the first global model including surface water quality indicators. In the past year continued development of the WaterGAP water quality model and the further compilation of the data for running and testing the model took place.

A number of test basins across Europe are used to translate water resources applications from the global water cycle system to basins. With in the last year, at the test basins, model and tool development occurred to study the impact and uncertainty of future climate change on water resources. All test basins have collected local data and have, until now, focused mainly on using "local" climate change scenarios. A more overarching protocol is being developed on how to use these datasets within WATCH to see how the global and regional analyses of water can be translated to local basins. For instance the first areal pictures on precipitation, evapotranspiration, soil moisture and runoff distribution were obtained for the upper Nitra basin:

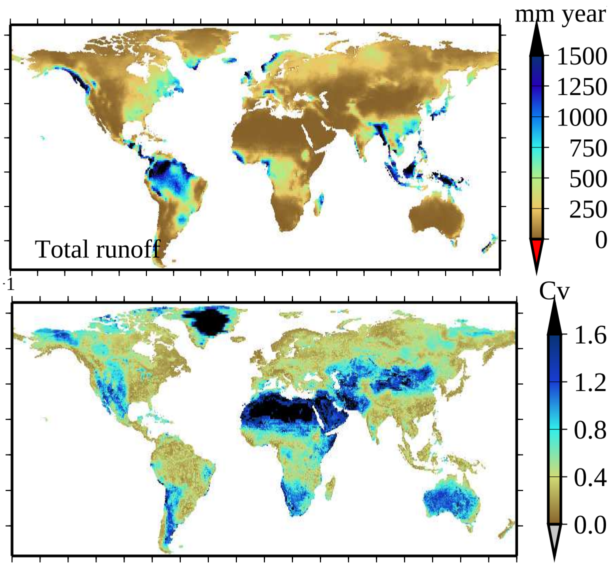


Spatial distribution of precipitation (top) and runoff (bottom)

Water MIP Progress

Water-MIP is the WATCH-GWSP Model Intercomparison Project. The land surface hydrology models and global hydrology models involved in WaterMIP all make use of the WATCH forcing data which is provided in a common format. The models deliver simulation results in the same common format. The initial phase has been completed and we are now moving into the testing phase. The last two WaterMIP workshops have helped consolidate this community and advance the work protocols. Meetings were held in November 2008 (Bratislava) and May 2009 (Wallingford, UK), both workshops were jointly organised and funded by WATCH and the GWSP. These workshops were important for the development of the protocol of the Model Intercomparison work (details available from the WATCH project website). Representatives from the 12 different models attended both workshops, making them international events. The model intercomparison work has taken full advantage of the opportunity to engage Project Associates from outside the WATCH community, thereby facilitating the exchange of WATCH generated forcing data.

Over the past year the focus of WaterMIP has been on the differences in model physics and testing the modelling framework as well as developing a standardised protocol. Data analyses focussed on global figures and a few large Basins. The figure below shows simulated mean annual runoff, and the coefficient of variation of the model simulation results for 10 different models. The highest values of the coefficient of variation are typically found in dry areas, and to some extent in areas experiencing some snowfall.



Top panel shows mean annual runoff, as an average of 10 model simulation results. Bottom panel shows the coefficient of variation of the model results.

More details on WaterMIP can be found at (www.eu-watch.org/modelintercomparison).

WATCH Summer Schools

Within WATCH we are dedicated to training and the project has a specific work package dealing with training activities alone. Two WATCH summer schools were held in June 2008 hosted by the ICTP in Trieste, Italy. The first summer school was directed at secondary school students and the second was a graduate level course.

The summer course for secondary school students was held at the United World College of the Adriatic on Climate Change and the Water Cycle from 2nd to the 7th of June 2008. Thirty-eight students from 11 different countries participated in a one week series of lectures and debates from WATCH scientists and guest speakers. Topics included: introduction to the climate system, the hydrological cycle, ethics of climate change and more.

At the end of the course students were asked to write up a short researched and referenced essay on one of a series of suggested topics. Students were also asked to compile an evaluation for the school. The overall opinion of the students was a positive one with many expressing an interest in learning more about climate change and water as well as being inspired to implement changes to their daily routines.

The International Summer School on Hydrology, Drought and Global Change was held in Trieste from 22 to 27 June 2008 and was organised by WUR, UiO and ICTP. The objectives, procedure for the selection of candidates and the programme of the International Summer School on Hydrological Drought and Global Change are summarised as a technical report (no. 8) which is available via the project website. The report has a comprehensive set of annexes (e.g. flyer, application form, list of lecturers, list of participants, title of contributions from participants, questionnaire) which might be useful for future courses. The evaluation of the summer school is based upon an extended questionnaire (86% response) and covers the major part of the report. The vast majority of the participants were very happy with the summer school. About 90% of the students classified it as good to excellent.

General Assembly Meeting

The second WATCH GA meeting took place 3-7 November in Bratislava, Slovakia. This event was well attended with 70 members from 23 of the 25 WATCH partners. We were also able to have three members of the External Scientific Advisory Group present, Dr Holzwarth and Dr. Arnell were able to attend the first days' of the meeting and we were fortunate that Dr. Bates remained for the full duration of the meeting. We also had two keynote address one from Dr. Bates and from Dr. Halenka the coordinator of the CECILIA project with comments on possible ties to the WATCH Project.

During the meeting there were progress reports from each workblock including an outlook for the future direction of each WB. In addition during the GA meeting members were briefed on the current funding and reporting requirements plus the new Project Associates were formally accepted. Six focus groups met on the topics of: Uncertainty, Evaporation, Data, West Africa, Test Basins and the India Second Test Region. The focus group meetings enabled in-depth discussions and resulted in decisions on how to move forward with these specific tasks in WATCH.

WATCH in China

From 24 to 26 November CEH organised a workshop on "Climate Change and Global water" in Beijing, China. Our hosts were from the MAIRS project located in the Institute of Atmospheric Physics (Chinese Academy of Science). This event brought together 45 representatives from the climatological, hydrological and water policy sectors. This workshop was largely supported by the Research Council UK-China office. The work of WATCH was presented and resulted in developing good ties to the MAIRS project. A key aim of this event was to bring together the climate / water communities of China, the UK and EU. Additionally we wished to highlight current and future projects operating in China and to identify funding organisations such as the EU, RCUK. These goals were, on the whole, fulfilled. An interesting outcome was the recognition by the Chinese participants that more dialogue between researchers in the field of climate and hydrology is needed. Indeed the discussions on the final day clearly identified, in China, the need to bring the water and climate communities together, since at present they work at different scales, use different models and techniques and have a limited mutual understanding. Additional recognition was given to integrate land use and agricultural processes and to link biophysical modelling with the socio-economic understanding.

The workshop was a very positive experience, and allowed a sizeable group of European scientist to attend and meet face-to-face with their Chinese colleagues. The discussions during the workshop made important contributions to building a network of contacts. Most participants had never met prior to the meeting, especially those travelling from outside Beijing; this is a significant benefit of the workshop which was to facilitate discussions and sharing of research ideas. The opportunity to benefit from personal contacts and focused scientific discussions should not be underestimated.

WATCH and HighNoon projects unite

WATCH has two test regions, the first one is Europe and the second selected test region is the Northern Indian subcontinent. With the aim of facilitating working partnerships with Indian colleagues a planning and open science workshop was held from13 – 15 May 2009 in New Delhi, India. The open session was held on 13 and 14 May 2009 titles “Future of Water Resources in India under a Changing Climate” and was hosted at TERI’s India Habitat Centre in New Delhi. This workshop aimed to discuss the state-of-the-art knowledge on glacier retreat and changing monsoon patterns affecting the water resources of the Ganges river basin.

The workshop included the kick-off meeting of the FP7 HighNoon project (www.eu-highnoon.org) plus the starting point for the collaborative work of WATCH with Indian and Nepalese partners. The HighNoon project will assess the impact of Himalayan glaciers retreat and explore possible changes of the Indian summer monsoon on the spatial and temporal distribution of water resources in Northern India. Both WATCH and HighNoon aim to provide a greater understanding of water resources in the Indian region as well as outlining strategies for strengthening the incentive for adaptation to water related extreme events.

The meeting was well attended by a strong delegation form the EU office in Brussels, as well as representatives from both the WATCH and HighNoon communities. This included EU and regional delegates plus delegates from the British embassy and research council, the Dutch and French embassies. WATCH looks forward to the upcoming work with ITT Delhi.

Links & Associates

WATCH is now endorsed by the GWSP and is benefiting from the increased exposure of being associated with this project.

Partners in WATCH are free to engage individuals or organisations from outside to consortium who wish to align their work with WATCH. A total of 5 new WATCH Associate partners have joined over the past year and we look forward to this new working partnership. These new associates are mainly active in the Model Intercomparison exercise.

Upcoming Events

12-15 May 2009: WATCH/HighNoon Workshop; New Delhi, India

27-29 May 2009: Model Intercomparison Workshop, Wallingford, UK.

15-17 June 2009: XEROCHORE workshop on Drought and the Natural System, Noordwijkerhout, the Netherlands.

13-15 July 2009: GEWEX International Symposium on Global Land-surface Evaporation and Climate, Wallingford, UK.

2-3 November: WaterMIP workshop, Potsdam, Germany

3-6 November 2009: WATCH General Assembly meeting; Potsdam, Germany.

12 November 2009: Uncertainty Workshop, London

Glossary

CEH: Centre for Ecology and Hydrology (UK)
FP7: the EU’s Seventh Framework Programme
GCM: Global Climate Model
GEWEX: Global Energy and Water Cycle Experiment
GHM: Global Hydrology Model
GLASS: Global Land-Atmosphere System Study
GW: Groundwater
GWSP: Global Water Systems Project
ITCP: International Centre for Theoretical Physics
LSHM: Land Surface Hydrological Model
RCM: Regional Climate Model
TERI: The Energy Resources Institute (New Delhi)
UiO: University of Oslo (Norway)
WUR: Wageningen University (Netherlands)

Contact

WATCH is funded under the sixth Framework Programme of the EU and is coordinated by Dr. Richard Harding at CEH. All inquires should be address to: info-watch@ceh.ac.uk. For further information on this project please visit our website: www.eu-watch.org .