Report

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The WATCH IP: Water and Global Change

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1) Scientific activities and achievements of the year (2010 'highlights')

WATCH is a integrated project bringing together the hydrological, water resources and climate communities to analyse, quantify and predict the components of the current (20th C) and future (21st C) global water cycle. The project aims to evaluate the uncertainties of, and clarify the overall vulnerability of, global water resources related to the main societal and economic sectors.

Over the past year the WATCH project has brought together cross cutting activities, underpinned by the production of common data sets accompanied by increasing understanding across the community. The major output of the 20th century analysis has been the delivery of the WATCH Forcing Data (WFD). An important aspect of this data set has been the extensive testing programme, for example against FLUXNET data series. This landmark dataset has been well received across the WATCH community and is generating considerable interest from the wider community. It is being used as a basis of analysis in most of the other parts of the project, in particular within the WaterMIP project as well as by regional river basin modellers.

The Water Model Intercomparison Project (WaterMIP[1]) is composed of a group of thirteen different land-surface and global hydrology models each being run with identical forcing data with the aim to improve our understanding of uncertainties as well as the global hydrological cycle. New parameterisations within the Land Surface Hydrology Models (LSHMs) and Global Hydrology Models (GHMs) have been developed. In particular new descriptions of irrigation, dams, reservoirs, groundwater and crops have been introduced and are being implemented and evaluated within WaterMIP. A key aim of this exercise is to improve model physics and the initial findings, show increasing convergence of model outputs. Further information on WaterMIP is available from the project website (www.eu-watch.org/modelintercomparison)

In parallel new and consolidated global spatial datasets, which are required by the hydrology and water resource models, have been developed and enhanced over the past year. Data on spatially explicit estimates of present and past domestic water use have been compiled to validate the domestic water use model. Analysis of domestic water use and consumption has been improved to better define human behaviour. Additionally compilation and calculation of a spatially explicit global dataset on water use in the manufacturing and energy sector has advanced and applied to the WaterGAP model. To assess future vulnerability of water resources scenarios of future water use in these sectors will be provided based on the IPCC-SRES scenarios A2 and B1.

Additionally WATCH has developed a 21st century forcing data set to complement the 20th century WATCH Forcing Data, this will enable the global hydrological models to be run off-line in a consistent way for the 20th and 21st centuries. The new data sets are based on climate model outputs; unfortunately these models have regional biases in rainfall and have an incorrect distribution of within month rainfall (with too many days of drizzle). Thus we have

[1] Work in WaterMIP is a joint undertaking between the WATCH project (www.eu-watch.org) and the Global Water System Project (GWSP, www.gwsp.org).

developed a bias correction methodology trained on 20th century simulations and the WFD. The bias corrections have been applied to three European climate models (ECHAM5/MPIOM from MPI-M, CNRM-CM3 from CNRM, and LMDZ-4 from IPSL) and two climate scenarios (B1 and A2). A protocol for the production of equivalent regional datasets has been developed in collaboration with user research groups across WATCH. Results from the application of the bias correction also led to improvements of the methodology.

Preliminary work on the effect of land use changes, which is a potentially crucial anthropogenic influence on the terrestrial water cycle, has been conducted with the LPJmL[2] hydrology and vegetation model. Figure 1 shows the absolute changes by the 2050s (in $km^3\ yr^{-1}$) in global transpiration, soil evaporation, interception loss, and river discharge compared to the present situation (1991-2000 average) (more details on this simulation in Rost et al. 2008, "Human alterations of the terrestrial water cycle through land management", *Adv. Geosci.*). Climate change affects all components of the water cycle, but it also becomes clear that the effect of land use change may exceed this climate effect. Impacts of irrigation are smaller but significant in specific regions, and they are likely to be stronger in the future because irrigated areas will probably be expanded. A strong influence of land use change on discharge was in previous analyses also shown for the 20th century; though the land use effect was found to be lower during that period (see Gerten et al. 2008, "Causes of change in 20th century global river discharge", *Geophys. Res. Lett.*).

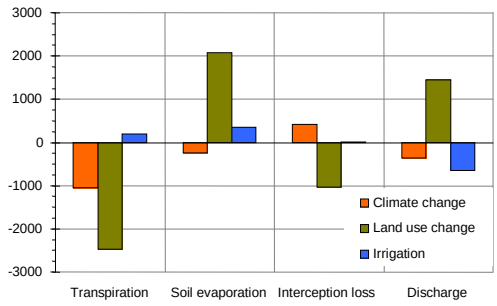

***Figure 1**: Projected changes by the 2050s (in $km^3\ yr^{-1}$) in global transpiration, soil evaporation, interception loss, and river discharge compared to the present situation (1991-2000 average).*

To advance understanding and to estimate the likely frequency severity and scale of hydrological extremes (floods and droughts) in the 20th century, a major output has been the development of a drought catalogue, as well as good progress on the floods catalogue. The drought and flood catalogues aim to provide a "baseline" of 20th century extremes. A new analysis of the Small Catchment Data set over Europe now includes an analysis of changes and trends in streamflow and low flows; see figure 2.

[2] LPJmL hydrology and vegetation model Vegetation and Water Balance Model

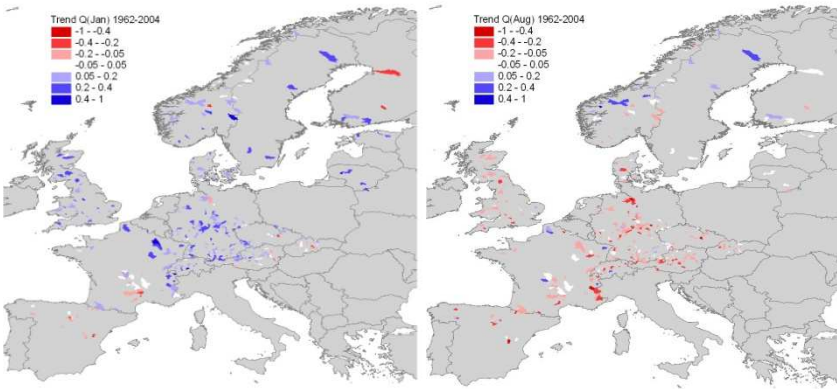

Figure 2 Streamflow trends in January (left panel) and August (right panel).

The WATCH Forcing Data has been successfully tested on regional catchments with good agreement on simulated flows compared with locally produced inputs. Additionally the impact of physical catchment structure (e.g. soils, aquifers, land use) and hydroclimatology on drought across the world is being studied using time series of weather data from the WFD with a synthetic model (combination of a soil water balance model and a conceptual saturated zone model). The resulting time series of simulated hydrometeorological variables were used to identify meteorological drought and hydrological drought (groundwater and streamflow).

A Multi-Model analysis of extremes was commenced to compare the coarser model grid with the observational scale. The aim of this exercise is to explore to what extent large-scale models (GHMs and LSMs) capture characteristics of different types of historic drought or floods (e.g. frequency, duration, scale, severity). The modeling and assessment framework aims to characterise regional river flow extremes in 20th Century using observational datasets, characterise regional runoff extremes from 20th Century hydrological simulations (driven by WFD) and to compare observed and simulated catalogues and analyse potential differences. The drought and flood indexes developed here are useful tools for analysing regional runoff extremes from large-scale models.

The development of a new global evaporation product including validation with flux data has been finalised. A simple methodology to derive daily 0.25 degree global evaporation based on satellite observation has been developed by GLEAM (Global Land-surface Evaporation: the Amsterdam Model). The GLEAM evaporation model is based on the Priestley and Taylor (PT) equation, which is formulated for four main land surface types with unique physical processes. The total evaporation is the aggregate of the evaporation values based on the cover fractions of each land surface type within the pixel. Fundamentally new and different from previous attempts, our evaporation methodology also deals with rainfall interception and soil water stress and is described in four interconnected modules. The model results are being incorporated into the GEWEX LandFlux project.

Assessment of water resources is primarily achieved through the WaterMIP efforts, among these are the uncertainty in the prediction of future water availability and water scarcity by taking into account the spread of the output resulting from the model ensemble. The models involved in WaterMIP will each be run with and without major human impacts (e.g. dams, irrigation). By analysing the difference between the two runs it will be possible to attribute changes in water resources to either human influences and/or changes in the climate system. Furthermore initial analyses on the impact of future climate change on water temperature have

been completed (see van Vliet and Zwolsman 2008[3]). Towards translating the global water cycle to river basins, a framework has been implemented to compare local data and models with the global datasets and models developed by project members.

2) Major activities and achievements

The WATCH project has made considerable progress over the past year and has made significant contributions to the field. One particular aspect is the WATCH Forcing Data (WFD) which has generated much interest. There have been requests by researchers from outside the project to have access to using this data set. It is anticipated this will be a strong legacy of the project. This data set is available to all partners and is part of the cross-cutting efforts of the project as at both the global and regional scale this data set is being applied. In conjunction with this the WATCH/GWSP model inter-comparison (WaterMIP) is providing an important contribution towards developing and assessing the models involved in this exercise.

The progress of WaterMIP has continued to attract attention with the number of participating models increasing to thirteen. Two international workshops were held the first in June 2010 in Wageningen (the Netherlands) and the second in November 2010 Amsterdam (the Netherlands) in conjunction with the WATCH General Assembly meeting. Preliminary results from the modelling groups for the 20th C naturalised runs as well as runs including human influences were presented. Both meetings advanced the working between groups and good discussion on model out puts were held. These events were well attended with over 30 participants at both meetings. This is a continuing exercise and future meetings are planned, especially as a growing sense of community is being established.

At the world water week in Stockholm (5-11 Sept 2010) WATCH hosted a side event titled: Impacts of Climate Change on water Quantity and Quality. This event attracted around 100 delegates with a large contingent from developing countries. The usefulness of the work by WATCH project was apparent from the discussions following the presentations. This event was successful in accessing an audience not generally reached by scientific/research events.

3) Publications and other products for the scientific community

The current number of publication produced by members of the WATCH community has grown considerably over the past year. A complete list of watch related publications are hosted on the project website. Some that are of particular interest are:

Special Collection of WATCH papers titled: “Water and Global Change” to appear in the Journal of Hydrometeorology: 12 papers expected in the course of 2011

Jung, M., Reichstein, M., et al.: *Recent decline in the global land evapotranspiration trend due to limited moisture supply*, Nature, 467, 951-954

Blyth, E.M, Gash, J.H.C., Lloyd, A., Pryor, M., Weedon, G.P. and Shuttleworth, J.W. 2010. Evaluating the JULES model with Fluxnet data. Journal of Hydrometeorology. In press

Dolman A. J. and de Jeu R. A. M 2010 Evaporation in focus *nature geoscience VOL 3 296*

[3] Van Vliet, M. T. H. and J. J. G. Zwolsman, 2008: Impact of summer droughts on the water quality of the Meuse river. J. Hydrol., 353, 1-17

Fader, M. Rost, S., Müller C., Bondeau, A., Gerten, D. 2010 Virtual water content of temperate cereals and maize: Present and potential future patterns *Journal of Hydrology* 384 218–231
Fleig AK, Tallaksen LM, Hisdal H, Stahl K, Hannah DM. (2010) Inter-comparison of weather and circulation type classifications for hydrological drought development. Physics and Chemistry of the Earth (in press). doi:10.1016/j.pce.2009.11.005
Hannaford, J., Lloyd-Hughes, B., Keef, C., Parry, S., Prudhomme, C. Examining the large-scale spatial coherence of European drought using regional indicators of rainfall and streamflow deficit. In press, *Hydrological Processes.*
Hoff H., Falkenmark M., Gerten D., Gordon L., Karlberg L., Rockström J. 2009 Greening the global water system *Journal of Hydrology* doi:10.1016/j.jhydrol.2009.06.026
J´odar, J., Carrera J., and Cruz A. 2010 Irrigation enhances precipitation at the mountains downwind *Hydrol. Earth Syst. Sci.,* 14, 2003–2010
Miralles, D. G.; J.H. Gash, T.R.H. Holmes, R.A.M. de Jeu, and A.J. Dolman (2010), On estimating global rainfall interception loss, J. Geophys. Res. In review
Tallaksen, L.M., Hisdal, H. & van Lanen, H.A.J. (2009) Space-time modeling of catchment scale drought characteristics. J. Hydrol., **375**, 363-372 (doi:10.1016/j.jhydrol.2009.06.032).
Taylor, C. M. 2010 Feedbacks on convection from an African wetland Geophysical Research Letters doi:10.1029/2009GL041652.

The project website[4] has a list of all forms of publications produced by WATCH. The technical reports of WATCH represent an important contribution and provide information on the development and progress of the project. All of the technical reports are available from the website. The newsletters, articles and presentation on WATCH are similarly available. The website is kept up-to-date and is well used by the members in WATCH.

The protocols for WaterMIP are available via the project website and is an important forum informing the modellers of the available data, delivery timeframes and planned meetings. In addition members interested in the WATCH Forcing Data can apply and are listed on the projects website; this has led to a diversification in the application of this data set outside the project.

4) Products and end-users

The work conducted by WATCH is of relevance to a number of end users, and with this in mind we have worked towards engaging this community. On our website we have a dedicated section for policy makers to quickly view the relevance our delivered results have to their work.

Over the past year we have developed stronger ties with other EU projects such as Scenes, HighNoon, Ensembles, Hyacints etc. Additionally, WATCH has close ties to the strategic steering group of the WFD-CIS[5] and has been represented at the meetings of this group over the last year. There are also plans to hold a stake-holder meeting in-order to ensure the WATCH products are in line with the requirements of the next IPCC assessment report.

5) Training and capacity building activities

[4] www.eu-watch.org/publications
[5] Water Framework Directive – Common Implementation Strategy

All partners in WATCH have actively promoted the project at a variety of workshops, conferences and meetings. At the EGU 2010 meeting WATCH had a strong presence. At least eighteen members attended who presented and/or co-convened sessions. The details of this were also publicised on the WATCH project website.

In addition we are developing an information web portal to communicate our findings to the informed public, it is anticipated this will be available in the coming months (www.waterandclimatechange.eu)

Model Intercomparison workshop: two were held, the first in June and the second after the WATCH General Assembly meeting in November. Both workshops were jointly organised and funded by WATCH and the GWSP[6]. The first of the 2010 workshops was held in Wageningen and included a meeting of the Multi-Model Analysis of Extremes. This event went a long way to fostering closer working ties between the LSM, GHM and RBHM[7] modelling communities. At the second workshop in November outcomes were discussed and the planned special issue to Journal of Hydrometeorology will publicise these initial findings. These were international events with representatives from the different models present at the workshops (details of this available from: www.eu-watch.org).

WATCH was represented at the Topical Conference Earth Observation for Land-Atmosphere Interaction Science organised by ESA, iLEAPS and EGU from 3-5 Nov. 2010. At this event discussions centred on the developing benchmarking for model evaluations, the metrics developed for floods and droughts were deemed useful tools to the wider research community.

Within WATCH we are dedicated to training and the project has a specific work package dealing with training activities alone. WATCH held a summer school in June 2010 hosted by the ICTP[8] in Trieste, Italy. The summer school titled "Water in the Anthropocene" was directed at secondary school students. This intensive five day program covered an introduction to the climate system and the mechanisms of anthropogenic forcing which define the Anthropocene This was a successful event and was well attended.

A summer school is planned for June 2011 and will be held in Oxford, this is directed at graduate level attendees.

6) Deliverables for the project:

Project deliverables are published as technical reports, and these are all available via the project website. There are currently 25 reports and in the coming year we will be adding to this considerably. The WATCH data sets will be made publically available at the end of the project. Interested researchers can request early access by contacting the WATCH office on info-watch@ceh.ac.uk.

7) Changes to the originally proposed activity

There are no changed to the original work activities of WATCH; however the end date of the project has been extended by 6 moths. The new project termination date is 31 July 2011.

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[6] Global Water System Project
[7] River Basin Hydrological Models
[8] International Centre for Theoretical Physics