Quantifying Weather & Climate Impacts
QWeCI
on health in developing countries

QWeCI
Quantifying Weather and Climate Impacts on Health in Developing Countries

Newsletter September 2013, No. 7

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EDITORIAL

Dear Reader,

A very warm welcome to the seventh and final edition of the QWeCI Project newsletter!

Commendations must be noted to partners in IC3 after a wonderful final project meeting. A true demonstration of the collaborative foundation of QWeCI!

As this is our final message to you, we wish to offer our thanks to all those who've contributed to the project over the last 42 months and special thanks must go to our Principal Investigator, Professor Andy Morse. Without Andy's leadership, QWeCI could not have conducted the ground-breaking research it has.

Thank you and good luck to you all!

– The QWeCI Management Board

Coordinator's report

As I write to you for the last time, I must start by congratulating all our colleagues in IC3 who hosted an excellent Final Project Meeting in May. Thank you to all those who came and contributed to the debate and collaboration that went on in Barcelona.

This project has developed a major meteorological database and information system as well as adding to an existing pathogens database. QWeCI has seen development by project partners of a rich variety of new malaria and Rift Valley fever models, incorporating dynamic, semi-dynamic and statistical approaches. The models have been tested against observations and different modelling approaches have also been compared. The contribution of the field programmes has been important in improving and calibrating these modelling systems. The heart of the QWeCI modelling effort has been the integration of climate and disease models on monthly to seasonal timescales.

QWeCI has addressed new and emerging areas of research in investigating the African climate from seasonal to interannual and decadal time scales and has contributed to improve the state-of-the-art forecast quality for the climate and infectious diseases especially malaria. QWeCI has brought together scientists from a range of disciplines and has contributed to a better understanding of linkages and mechanisms between disease and the variability of the climate and environment. Of this, I am sure we are all particularly proud.

The focus on three countries in Africa with different field projects in each has helped to further develop and integrate the emerging African environmental science base working on and leading investigations with European partners within the QweCI project. There were a large number of inter-consortium extended visits that occurred. A large proportion of these scientific exchanges involved direct interactions between African and European partners.

The success of this project is evidenced by the individual successes of the pilot projects and their integration and use of products developed in other sections of the project.

Thank you all very much for this opportunity to work with you; for your hardwork, your stamina and your tolerance. QWeCI had produced remarkable benefits and of that we are all to be congratulated!

Well done & thank you!

With best wishes, Andy

Final Project Meeting

The final project meeting, jointly organised by UNILIV and IC3, took place from 16th to 18th May 2013 in Barcelona, Spain. The meeting was well attended with most project partners represented, and an invited international external panel. Those who were unfortunately not able to join in person contributed via teleconference.

On day one a presenter for each Work Package shared progress on specific areas and a number of science talks were given throughout the day covering a wide and varied array of topics. The agenda for day two was similar, but also included a discussion session between the external panel and meeting delegates.

The third and final day of the meeting was divided into a series of Breakout Sessions which ran simultaneously and were designed to facilitate discussions on the different Work Packages, with input from each work package leader and relevant partners.

The project was glad to welcome a distinguished team of external reviewers including: Dr Jan Polcher from the Catalan Institute of Climate Sciences; Dr Laragh Larsen from Trinity College, Dublin; the University of Burgundy's Dr Nadège Martiny; and Dr Nick Ogden of the Public Health Agency of Canada.

Dr Larsen said, "I really enjoyed hearing more about QWeCI project" and Dr Ogden said, it is clear the "project has been well–managed" and the "highly qualified personnel will be a legacy of the QweCI Project".

The meeting was a great success and an excellent opportunity to showcase the world leading science QWeCI has produced.

Science presentations can be found here and the conference programme can be downloaded here.

Professor Andy Morse wishes to extend his thanks to all those who contributed to the presentations, to the external panel members (Laragh Larsen, Trinity College Dublin; Nadège Martiny, Université de Bourgogne France; Nick Ogden, Public Health Agency of Canade; and Jan Polcher, IC3) for their valuable insights, helpful critiques and challenging questions.


June 30th – Partners
July 31st – Final edits
finalised


QWeCI is funded by the European Commission's Seventh Framework Research Programme under the grant agreement 243964
13 partners from 9 countries
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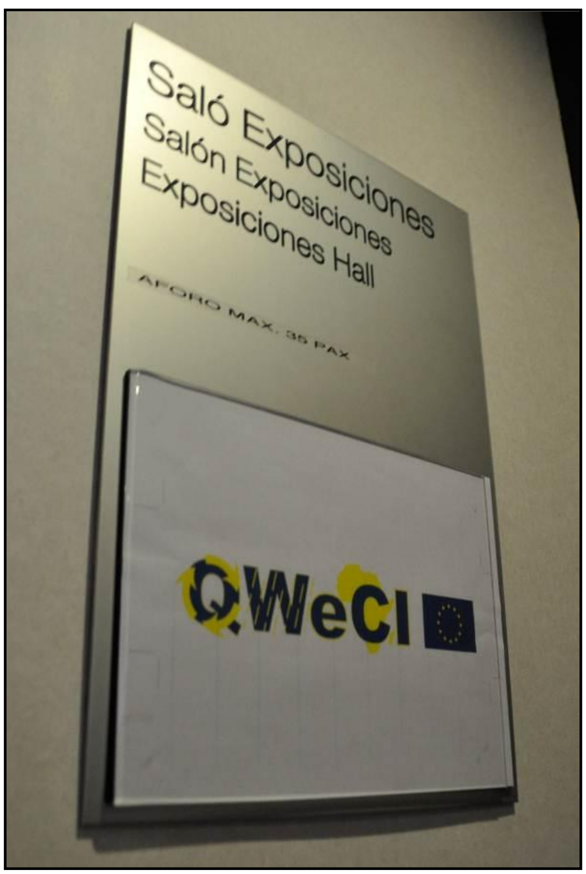
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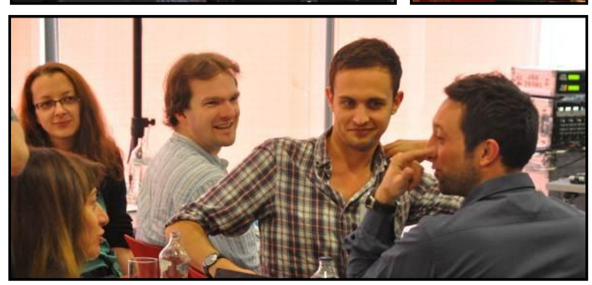


Participant Profiles

Dr Rachel Lowe

Catalan Institute of Climate Sciences, Spain

Dr Rachel Lowe is a Postdoctoral Scientist at IC3. Her research involves modelling climate-sensitive disease risk and finding novel ways to communicate probabilistic forecasts to public health decision makers. Rachel coordinates the IC3 Climate Service Strategy for Health.

Rachel graduated from the University of East Anglia in 2004 with a First Class Honours BSc in Meteorology and Oceanography with a year in Europe. She spent one year at the University of Granada in Spain reading Environmental Science. In 2007 she completed an MSc with distinction in Geophysical Hazards at University College London where she received a Graduate Masters Award. Rachel then went on to obtain her PhD in Mathematics at the College of Engineering, Mathematics and Physical Sciences, University of Exeter (PhD Thesis: Spatio-temporal modelling of climate-sensitive disease risk: towards an early warning system for dengue in Brazil).

Alongside her PhD, Dr Lowe was Network Facilitator for the Leverhulme Trust funded project EUROBRISA. As part of the project she collaborated with climate scientists and public health experts at CPTEC/INPE and the Oswaldo Cruz Foundation during long-term visits to Brazil, which resulted in her ongoing participation in the innovative Brazilian Observatory for Climate and Health.

Rachel was also a Visiting Scientist at the International Centre for Theoretical Physics (ICTP), Italy, as part of the QWeCI project, where she worked closely with James Chirombo (also as co-supervisor to his MSc in Biostatistics) at the Ministry of Health in Malawi towards the development of predictive models for malaria and a platform to integrate climate information and rural telemedicine.

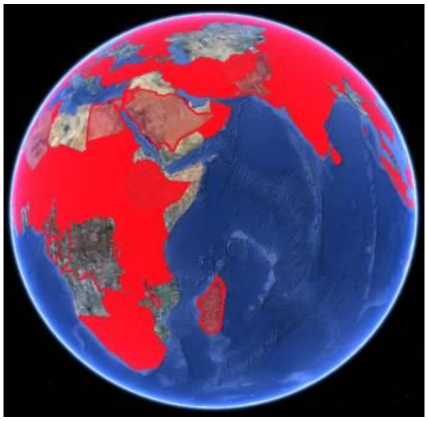
Rachel training participants in using the Climate Explorer tool

During the QWeCI project, Rachel has collaborated with Latin American scientists to assess the role of climate and non-climate drivers of dengue epidemics in Ecuador (Stewart-Ibarra & Lowe, AJTMH, 2013) and Brazil (Brazilian Observatory for Climate and Health workshop, 2013). Rachel has also been actively involved in outreach activities such as the ICTP Spring School on Modelling Tools and Capacity Building in Climate and Public Health, Trieste, Italy, 15 April-26 April 2013, the IAI Training Institute on Climate and Health, Piriápolis, Uruguay, 7^{th} – 18^{th} November 2011 and the Summer Institute on Climate Information for Public Health, International Research Institute for Climate and Society (IRI), New York, USA, 16^{th} – 27^{th} May 2011, providing lectures and practical session about spatio-temporal modelling of disease risk, using the statistical software R.

Rachel with participants at the close of the ICTP spring school 2013

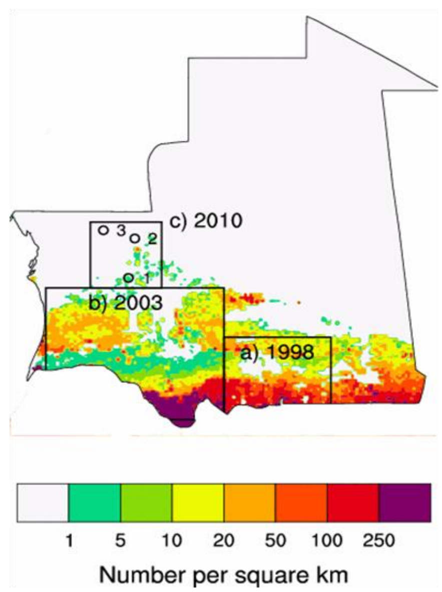
QWeCI Project Overview & Summary

1. *Climate-health relations*. The initial approach was to modify an existing climate database at Liverpool, but this idea was soon deemed inadequate for the requirements of QWeCI, so in conjunction with colleagues working on the sister project Healthy Futures (www.healthyfutures.eu), QWeCI partners designed and validated a new database, the ENHanCEd Infections Diseases database (EID2) to carry world-wide information on pathogens and hosts (insect vectors), including spatial distribution information and improving the understanding of their dependence on climate drivers. This was built on a model that includes an algorithm designed to optimise the predictive ability of pathogen presence automatically. We added spatial distributions of climate, disease and pathogen data at the same resolution to enable mapping according to values for temperature and rainfall. The EID2 database was later expanded with further climate sensitivities of environmental and vector variables, a researcher interface and a visualisation tool (figure to the left).



Example output from the EID2 database. The red colour indicates recorded sequences of rabies virus in the NCBI nucleotide database from appropriate countries. A red border indicates countries where 1-9 sequences were recorded; filled red indicates countries where 10 or more sequences were recorded. *Source:* National Center for Biotechnology Information (NCBI) nucelotide database (www.ncbi.nlm.nih.gov/nuccore).

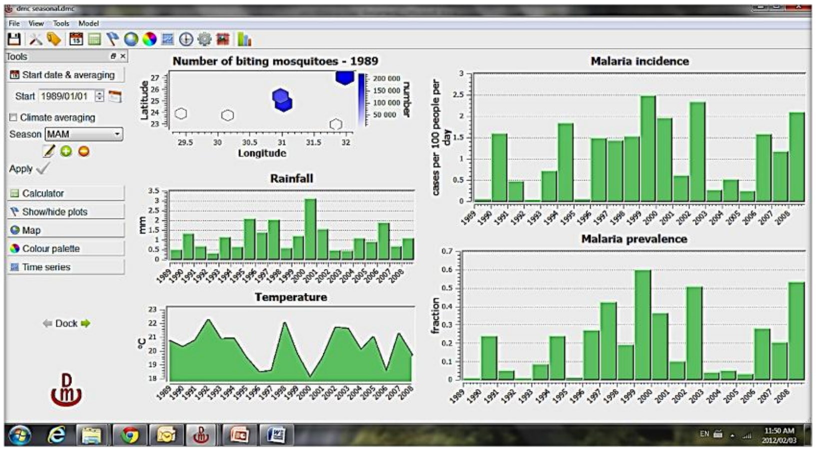
We then created a mapping tool for current and future distributions of disease risk areas (WP1.1). Meteorological datasets, time series data, and satellite-derived weather information and predictions, including daily and monthly precipitation estimates were assembled into a meta-database for atmospheric data (www.qweci.uni-koeln.de) that produces user-friendly outputs for public use (WP1.2). A key part of the database work was the quantification of the variability of climate drivers, and a review of the interactions between climate, particularly El Nino Southern Oscillation (ENSO), and localised sea surface temperature (SST) drivers, and human and animal disease pathogens and vectors, mainly malaria and RVF. This was necessary to clarify disease dependence on climate variables. Development of a climate-RVF model focussed on Senegal and trade routes into Mauritania, where RVF outbreaks had occurred (figure to the right), and a statistical model for Malawi were important in contributing to validation of the outputs (WP1.3).



Animal density (including sheep cattle and buffaloes) The four zones depict where the RVF outbreaks took place in Mauritania in1998, 2003 and 2010 *Source:* Food & Agriculture Organisation.

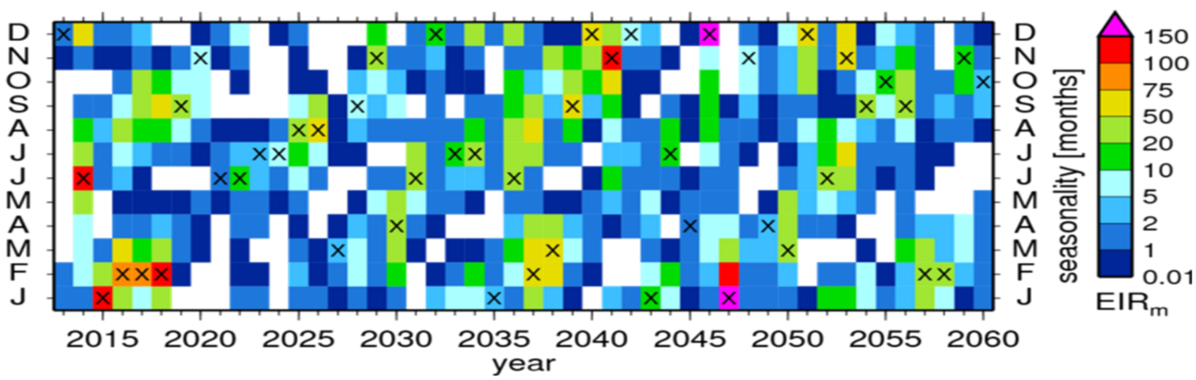
2. *Dynamic health models*. In preparation for development of a more modular based single host- single vector, a single host-two vector and a multiple host model for malaria and RVF, we compared and validated the Liverpool Malaria Model (LMM) and other dynamic disease models for malaria and RVF. The LMM, developed in EU FP5 DEMETER and refined in EU

FP6 ENSEMBLES, uses knowledge from local experts and the literature to predict malaria occurrence. It is driven by temperature and rainfall data from observational, gridded and forecast sources.



Malaria incidence and prevalence in South Africa during March, April and May. From the LMM, using the disease model cradle

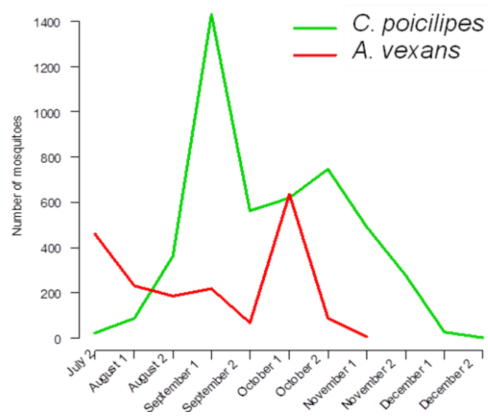
Following feedback and consultation with stakeholders and users, we delayed the generic model development until the end of the project and created a new interface fir users to be able to run the Liverpool Malaria Model on their own computers. Using the LMM, we used observational malaria datasets for Senegal and South Africa to validate seasonal patterns with local expert feedback, developed a new technique for calibration of rainfall forecasts, and a new interface, the Disease Model Cradle (figure to the left), which enables project partners and stakeholders to run disease simulations based on climate and non-climate



An example of downscaling. From an LLM forecast of mosquito biting rates for Kumasi. Red squares = high risk; blue squares = low risk

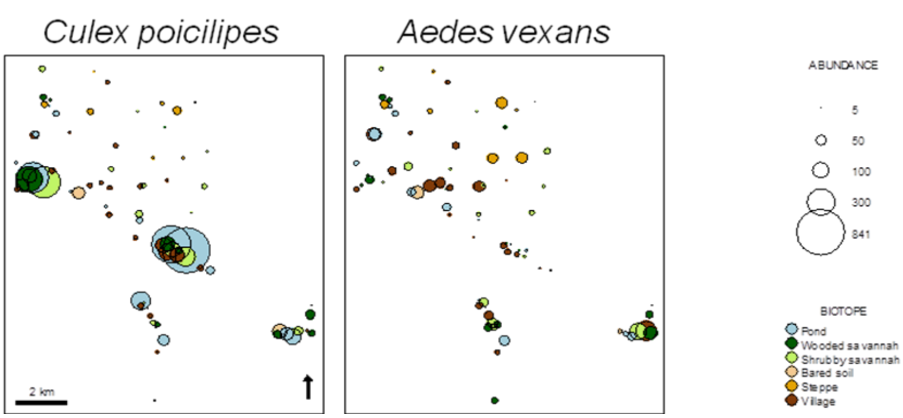
(WP2.1). In addition, a second dynamical malaria modelling system referred to as VECTRI was developed, which while similar in many respects to the LMM, included a physical representation of the surface hydrology of ponding and also the direct interaction between vector and population, allowing the model to represent the differences in rural and urban transmission settings. The model has been coupled to the atmospheric monthly and seasonal forecasts produced operationally by project partner ECMWF, using new bias correction techniques developed within the project, to produce the first pan-continental pilot operational forecasting system for malaria. Further evaluation of this system on a country-level is ongoing beyond the project end, and the LMM has been added to make the disease component truly multi-model to improve the way uncertainties can be accounted.

3. *Seamless atmospheric integrations*. Initially, as a science development stage it provided appropriate weather data at the required resolution to facilitate developments elsewhere within QWeCI. We applied calibration and downscaling methods to multiple state-of-the-art climate prediction models, and developed a prototype statistical downscaling portal. This enabled development of a seamless, unified prediction system as well as an ability to estimate uncertainty based on statistical and dynamic downscaling (WP3.1). In order to provide an assessment of forecast quality, we investigated the characteristics of African temperature and precipitation patterns on seasonal and interannual scales, and extended the capability to assess decadal scale prediction. We incorporated feedback from potential users into an assessment of forecast outputs. We also tested current state-of-the-art forecast quality with models based on dynamic and statistical analyses (WP3.2).



The temporal distribution of the same two Rift Valley fever vector species

4. *Coupled climate-health projections*. The integration of outputs from climate models with models of disease emergence and dynamics was achieved by the development of steady-state and dynamic versions of the LMM. These included the ability to incorporate monthly outputs and to automatically correct for bias. We incorporated hindcasts from GloSea (UK MetOffice) to create and validate the seamless prediction system for seasonal to decadal forecasts and for long-term projections of climate change. We also developed a GIS based, multi-agent decision-support system for RVF in Senegal, which is driven by rainfall data (WP4.1).



The spatial distribution of two major Rift Valley fever mosquito vectors. Graph from statistical modelling by QWeCI partners IPD/CSE, of vector abundance in the Sahelian area of Barkedji, Senegal. Bubble size indicates insect abundance

5. *Integrated decision-support systems in three pilot projects*. The need for area-specific decision support systems for health officials and workers in the pilot areas in Senegal, Ghana, and Malawi was met by establishment of a web-based Java framework to facilitate end-user input to help tailor model outputs to needs on the ground. This feedback, combined with new data on disease emergence and site-specific environmental data (figures above and on the left), was used to inform development of a multi-agency system (MAS), based on monthly, seasonal and decadal forecasts of climate-disease interactions. The MAS is an automated system that incorporates Spatial Decision Support Systems, Information Systems and Monitoring Tools, and is designed to help users assess vulnerability to disease by linking environmental variables with patterns of disease emergence.

A pilot system and the first versions of the MAS used the LMM and a statistical model for RVF. These were combined with remote sensing of standing water in Senegal, which provided data for the Monitoring Tool. The MAS also forms a key component of a Disease Early Warning System for vector-borne diseases (WP5.1). Communications were established between a range of stakeholders including scientists working in human and animal health at six sites in rural, peri-urban and urban areas of the pilot region of Ghana. Laboratory and environmental data were collected from health facilities and from the field, including on linkages and mechanisms of disease emergence, transmission and spread, and on climate variability and changes in different local environments (figure on the right). The collection of data on weather, physical and chemical variables and mapping of water bodies, the occurrence of *Anopheles* populations, characterisation of insect feeding success rate, and surveys of householder experiences were important for quantification of the effects of rainfall on malaria incidence (WP5.2).


Insect vectors were analysed for feed status and infective potential

Table 1. Some of the entomological data collected in the pilot study areas of Senegal

Parameters	Barkedji	Kangaledji	Keur Bandji	Niakha	W.S.Kibel	W. Sileymani
Land cover/land use	Wooded savanna	Bared soil	Steppe	Wooded savanna	Shrubby savanna	Shrubby savanna
Human biting rate (ma)	2.816	2.780	0.227	3.712	0.689	0.629
Parity rate (A)	0.393	0.393	0.579	0.459	0.320	0.650
Duration of the gonotrophic cycle (x)	2	2	2	2	2	2
Human blood index (HBI)	0.283	0.652	0.435	0.467	0.333	0.375
Human daily biting frequency (a)	0.141	0.326	0.217	0.233	0.166	0.187
Duration of sporogonic cycle (n in days)	9.5	10.4	9.6	9.6	9.5	9.5
Daily survival rate (p)	0.627	0.627	0.761	0.677	0.566	0.806
Survival rate after n days (p^n)	0.012	0.008	0.073	0.024	0.004	0.129
Mosquito life expectancy ($1/-\log_e p$)	2.142	2.142	3.661	2.563	1.757	4.637
Mosquito infective life expectancy ($p^n/-\log_e p$)	0.025	0.017	0.267	0.061	0.007	0.598
Stability index ($a/-\log_e p$)	0.066	0.152	0.059	0.091	0.094	0.040
Vectorial capacity ($ma^2 . p^n/-\log_e p$)	0.010	0.015	0.013	0.053	0.001	0.070

Disease simulations are based on climate and non-climate environmental drivers and their effects on vectors, pathogens and transmission rates. This makes good knowledge of the disease dynamics of malaria and RVF in the target areas critical for building useful climate-disease models. For three rainy seasons (2010-2012), we studied the roles of meteorological and environmental variables through collection of field data on climate, hydrology, vegetation, animals, life cycles of vectors of malaria and RVF, and disease transmission factors (Table 1). These included pond dynamics (hydrology, composition and ecology of anopheline fauna) and area of ponds, which were obtained from remote sensing of water bodies and land cover change. Data were also collected on social pastoral practices, biting rates and human or animal attractiveness.

WiFi connection installed in Mangochi, Malawi

A first validation of the LMM was made for Senegal and partners were able to assess existing hazard, vulnerability and risk maps produced in the EU FP6 AMMA (African Monsoon Multidisciplinary Analyses project database www.amma-international.org/about/index). We also increased understanding of an RVF event in Mauritania (WP5.3). The effective use of QWeCI integrated climate-disease outputs depends not just on the quality of the information supplied but on making sure that appropriate information is made available to professionals and decision-makers in the target areas as soon as possible. Hence the early warning systems would benefit from both the rapid communication of model outputs and provision of health data from field centres to central scientific and medical facilities. After consultations with governmental and NGO bodies in Malawi, successful WiFi connection was made to St. Martin's Hospital and the Ministry of Health DSIH health database. Strategies have been developed to connect the system with other rural clinics. A first integrated forecasting system was established and an automated SDSS made operational, enabling the dissemination of malaria forecasts. We surveyed health centres as potential sources of data and potential sites for WiFi links and provided installation and support for the considerable technical problems experienced. The WiFi network is used to collect disease incidence data from the two hospitals (Mangochi Hospital with St. Martin's Hospital in the district of Mangochi) for storage in a national database. Training was provided to local professionals on how to best use the forecasts (WP5.4).

6. *Dissemination, training and assessment.* The integrated climate-disease model outputs must be meaningful to health professionals and policy-makers in the target areas and countries, and their interpretation relies on appropriately trained people to make good use of the forecasts disseminated and to provide data to central databases. Thus training of QWeCI partners and stakeholders at national institutions and local health centres and scientific establishments is a priority. Successful knowledge exchange depends on effective two way communication, and this was built up through capacity building and promotion of a culture of holistic engagement with stakeholders. The use of focus groups and teleconferencing used in this process were also important tools for informing and enabling stakeholders not engaged in the scientific aspects of the project. QWeCI partners were involved in the European Geosciences Union meeting in 2012, where a session on climate and health was held and several fringe meeting discussed operational and theoretical aspects of QWeCI (Fig. 18). A programme of short and long term exchange visits was successful (WP6.1). We directed knowledge exchange through a web site and produced

Demonstration of field equipment maintenance newsletters, reports and a brochure to facilitate dissemination of QWeCI results to stakeholders and the general public as well as project partners. We also held workshops and symposia, which included presentations that provided context and detail about the project outputs (WP6.2). We established and maintained communications between the three pilot projects and the European partners to monitor progress against the project schedule (WP6.3).

Feedback from partners from the pilot study sites was crucial to the refinement of disease model outputs

7. Management. Active engagement with partners and close monitoring ensured smooth operation of the project as a whole. We created a project website (www.liv.ac.uk/qweci), held two planning and progress meetings and a teleconference, a project kick-off meeting in 2010 (Liverpool, UK) and held annual project meetings in 2011 (Senegal), 2012 (Nairobi, Kenya), and 2013 (Barcelona). These initiatives maintained the active engagement of partners and stakeholders in project objectives, enabled planning and scheduling of project events, and confirmed strategies and proposals for future work package stages. Minor changes were made to the scheduled programme of works because of occurrences external to and beyond the control of the project; such as, political instability in one of the pilot countries, the impacts of which were minimised wherever feasible.

Congratulations to Sammy!

In Octber 2013, the QWeCI Project was pleased to hear that Dr Sammy Tay of KNUST (Ghana) was promoted to the position of Associate Professor in the Department of Clinical Microbiology.

Professor Tay wishes to thank all those who've been involved in the AMMA and QWeCI Projects as well as the summer schools.

Many congratulations to Professor Tay!

Farewell from the Project Office!

Peris, Bev, Andrew and Tara would like to extend our collective thanks to all those who've been involved in QWeCI over the past three years and especially those we've had the pleasure of working with.

From the start of this project, the scientists have been greatly tolerant of us and have been very helpful.

Further Information

Coordination

The Coordinator and Principal Investigator of QWeCI is Professor Andy Morse of the University of Liverpool (A.P.Morse@liv.ac.uk) with Dr Adrian Tompkins acting as Deputy Coordinator at the International Centre for Theoretical Physics, Trieste (tompkins@ictp.it).

Publications

The Project Office would be grateful if partners and researchers could send details of any publications as part of the QWeCI Project.

Please use the following wording when acknowledging QWeCI funding in your publications:

> *This study was funded by the EU project QWeCI (Quantifying Weather and Climate Impacts on health in developing countries; funded by the European Commission's Seventh Framework Research Programme under the grant agreement 243964)*

Our Friends

Please see below the pages of related projects:

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www.liv.ac.uk/ENHanCE

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DMC now downloadable

The Disease Cradle Model, including the Liverpool Malaria Model, can now be downloaded here.

Photo Acknowledgements

Andy Heath	Andrew McCaldon
Rachel Lowe	Assorted QWeCI Contributors