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Name of the scientific representative of the project's co-ordinator,

Title and Organisation: Professor Andrew Morse, University of Liverpool.

Tel: + 44 151 794 2879

Fax: + 44 151 794 2866

E-mail: A.P.Morse@liverpool.ac.uk

Project website address: www.liv.ac.uk/qweci

Executive summary

The purpose of the project was to produce vector-borne disease models driven by climate variability and climate change trends from climate models and observations; ultimately leading to predictive tools designed for the needs of end-user health professionals and decision makers. These predictions were designed for important diseases affecting human populations and livestock in Africa especially malaria and Rift Valley fever. The QWeCI consortium consists of 13 partners from nine countries with six based in the EU and seven from mostly low-income African countries. The project had two sub-contacted stakeholders (the national programmes for malaria and livestock) from Senegal. The Malawi Ministry of Health become another effective stakeholder during the project and participated in the workshops and training structures. The project had three pilot field studies in Senegal, Ghana and Malawi. State-of-the-art European seasonal forecasting systems were coupled with malaria disease transmission models and the results disseminated to African partners and their stakeholders. The project ran from February 2010 to July 2013.

Outputs from the project include 52 deliverable reports, 29 milestone reports, most of which are available from the project website (www.liv.ac.uk/qweci), and to date over 29 peer reviewed journal publications hitting major top rated journals. A number of these publications are cited in the IPCC Fifth Assessment Reports. The contributions of the outputs so far have been significant and include the following: The evaluation of existing climate model outputs for their suitability to quantify health impacts in-region through the tailoring of model products; The use of these model outputs by scientific partners and in discussion with decision makers in region in Africa; The evaluation of climate-disease prediction models producing disease risk maps that have been disseminated; The establishment of long-range WiFi which has been shown to be viable to allow the central monitoring of local disease outbreaks and the communication of disease risk. Further, the QWECI project has made significant improvements to the vector-pathogen-host database at the Liverpool based National Consortium for Zoonosis Research which is available to registered users; QWeCI has set up an atmospheric database and Multi-Agency System portal based in Cologne and a climate model downscaling portal in Santander.

Stakeholder communication was an important feature of the project with regular six monthly newsletters produced and widely circulated, stakeholders participated in a number of project workshops and many had regular interactions with project partners. Dissemination of the project products is a key success of QWeCI, the LMM and VECTRI models have been interfaced into a pre-operational malaria early warning system. Feedback from African partners has assisted tailoring of the products of the early warning system to the needs of end-users in the target areas in a long-term process still underway. This system is driven by the ECMWF seamless monthly-to-seasonal model outputs to create a seamless forecasting system. At the moment these plots are being field trialled with users in Africa. Results have been disseminated at conferences, in workshops and by project and peer reviewed publications, and QWeCI will feature in a project commissioned forthcoming short film that will be made available through the project website. QWeCI was an ambitious and complex project driven by a team with the required skills and balancing European and African scientific and operational know how. QWeCI achieved all of its key objectives with little deviation from the original plan. The assessment of the project performance was undertaken and key findings and recommendations for future projects are made in the final report.

In summary, the achievements of QWeCI are multi-faceted and extensive, and in particularly the development of a pre-operational demonstration forecasting decision support system that went far beyond the original research plans and remit of QWeCI and represents a major advance in applied early warning systems. The progress would not have been possible without processing of existing data, building new model developments, gaining new field data to parameterise and evaluate the models and most importantly involving in-region scientists and users to evaluate the forecasting systems. The project has continued and extended collaborations between African and European institutions, and most importantly has connected, supported and inspired the next generation of African and European scientists who made key inputs to the project.

Summary description of context and objectives

Background and need for project

This project brings together and refines the best available knowledge of climate variability, disease dependence on climate, factors governing infection rates in humans and animals, and the needs of end-user health professionals. The result is a set of valuable predictive tools that anticipates disease outbreaks and optimises the ability of health professionals and decision-makers to manage some of the most important disease affecting human populations and livestock.

Vector-borne diseases (VBD) are the cause of major loss of life, hardship and economic stress in many African countries. Seasonal and interannual climate variability is a primary control of vector and pathogen survival and vector breeding success, leading to disease emergence and spread. A perfect storm of environmental drivers, as well as extreme events that cause floods and droughts are key factors in the dynamics of epidemics. Infection rates depend on vector and pathogen abundance, their proximity to human or animal hosts, and on environmental variables including temperature, vegetation and the availability of standing water, which supports aquatic stages of insect vector life cycles. Climate variability alters temperature and precipitation which, by increasing the area, depth, number and duration of breeding ponds, directly influences vector survival rates and abundance.

Climate variability and continuing global-scale climate change are predicted to alter weather patterns across the globe, leading to changed distributions of mean and extreme temperature and precipitation. These are the key drivers for many vector-borne diseases. By predicting spatial changes to climate, existing models infer changed distributions for many VBDs on regional and global scales. Knowledge of how current and future climate is likely to influence infection patterns will have profound implications for planning and disease prevention and control, and be a valuable tool for health professionals and government bodies in countries susceptible to VBD impacts.

Objectives

The overall objective of QWeCI was to combine state-of-the-art climate models, weather-dependent transmission parameters for key African diseases, and local knowledge about population behaviour, disease, vectors and transmission patterns. The modelled outputs can be added to local knowledge of population behaviour and known local transmission patterns could thus generate knowledge of infection risk appropriate to the decision-making of health professionals on the ground and the policy-making of governments of susceptible countries. The work involved integration of the most reliable climate-based prediction models with models of climate controls on disease risk variables for VBDs on short, medium and long timescales, and their translation into meaningful information, rapidly conveyed to end-users. The active participation of target populations was ensured by integrating stakeholder communities in decision-making from the start of the project. The three main aspects of the project were model development and refinement, development of decision support systems, and training and dissemination for participants, stakeholders and communities.

Three target areas in Africa were identified based on previous work carried out by the Centre de Suivi Ecologique, the Institut Pasteur de Dakar and the University Cheikh Anta Diop de Dakar (Senegal) on remote sensing and mapping of Rift Valley fever and malaria for the Ferlo Region of Senegal around their long established observing site at Barkedji; the particular situation in Kumasi (Ghana) where malaria is continuously prevalent despite seasonality in the form of a distinct dry season; and the high prevalence of malaria alongside the development of long-range, low-cost WiFi in Malawi, which is building the potential to connect several hospitals and clinics in a rapid communication network.

The project objectives were nested in seven themes and 15 work packages (WPs) designed to fulfil the requirements of the project in two divisions. Scientific development (7 WPs) involved creating and linking databases combining climate, disease and climate-disease associations; development of dynamic disease models; down-scaling and refining existing climate models into an integrated and seamless forecasting system capable of making localised forecasts as well as short term and decadal predictions; and development of seamless, refined climate-disease models that can make reliable predictions and projections of disease infection risk patterns on long and short timescales that are spatially focussed. The second division, concerned with implementation of the climate-disease model findings (7 WPs), focussed on development of site-specific decision support for health workers facing repeated outbreaks of malaria and Rift Valley fever, and exploring the potential for two-way communication of information using long-range WiFi facilities installed in health facilities in Malawi. An essential central feature was the inclusion of local professionals and communities in training and dissemination programmes in order to provide experiential feedback and recommendations on the effectiveness of the model and decision-support systems. Lastly, a project management WP ensured the smooth running of the project and the early recognition of unanticipated occurrences.

Fulfilling the obligations involved evaluating existing climate models for their suitability to quantify health impacts in target areas, developing ways of tailoring model outputs to the prediction of climate-dependent health impacts in forms appropriate to the needs of local end-users, evaluating and refining climate-disease prediction models for each selected disease type, producing disease risk maps, evaluation of site-specific environmental factors influencing disease occurrence, and assessing the ability of long-range WiFi to allow central monitoring of local disease outbreaks. In addition, the project sought to improve the vector-pathogen-host database at the Liverpool based National Consortium for Zoonosis Research, and to develop ways of quantifying the usefulness of climate driven disease model predictions.

The QWeCI project delivered all of it deliverables (52 in total) and all of its Milestones (29 in total) as well as over 29 per reviewed journal publications (8 in Open Access), the published papers are in top ranked journals and the leading journals in their field. All the deliverables and milestones that are public (PU) are available on the project website. The deliverables that are currently restricted are those with key data and figures currently in review for journal publications. Once the papers are in press these deliverables will be made public.

Project public website

www.liv.ac.uk/qweci

Description of the main scientific and technological results/foregrounds

As a lead into the main results section the details of the objectives and the principle activities towards these objectives of the grouped work packages of the project are listed.

Specific objectives were to:

1. Assemble a database of state-of-the-art knowledge of infectious diseases, especially malaria and Rift Valley fever, including models that successfully describe pathogen and vector life cycles;
2. Integrate a suite of the most useful seasonal, decadal climate variability prediction and longer term climate projection models to enable improved prediction capabilities;
3. Combine these into an integrated and seamless forecasting tool to allow mapping of disease risk, based on post-processed weather and climate predictions and projections, with outputs tailored to the needs of regional and local scientists, health professionals and decision-makers;
4. Develop decision-support systems in pilot projects in African countries to disseminate model outputs to decision-makers and end users according to their needs in understanding specific climate and weather impacts on health, leading to better targeting of spending and planning on different time-scales;
5. Assist development of improved WiFi links between health professionals and scientists in Malawi;
6. Programme of training, exchange visits, seminars and conference outputs.

Summary of the key Work Package activities towards the objectives

1. *Climate-health relations*. The initial approach was to enhance an existing pathogen database at Liverpool, but this idea was soon deemed inadequate for the requirements of QWeCI, so we designed and validated a new database, (in conjunction with the ERA-NET NERC funded ENHanCE project) the ENHanCEd Infections Diseases database (EID2) to carry world-wide information on disease pathogens and their hosts (including insect vectors) and where they occur. This was built on a model that includes an algorithm that automatically optimises the predictive ability of pathogen presence only data. We added spatial distributions of climate and disease 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. We then created a mapping tool for current and distributions of disease risk areas (WP1.1). Meteorological datasets, station time series data, and satellite-derived weather information and predictions from 12 sources, plus daily and monthly precipitation estimates were assembled into a database for atmospheric data (http://qweci.uni-koeln.de) that produces user-friendly outputs for public use (WP1.2). This database is a major community resource that will last beyond the end of QWeCI and key sharable data sets have been made available to the AMMA database to ensure there is a further system for users to access these datasets. A key part of the climate data work was the quantification of the variability of climate drivers, and a review of the interactions between climate 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, and a statistical malaria model for Malawi were important in contributing to validation of the outputs (WP1.3).

2. *Dynamic health models*. The development and validation of disease models for the regions of interest has been a major focus in QWeCI. The work package 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. In preparation for development of a single host- single vector, and 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 (VECTRI developed

within QWeCI at ICTP) for malaria. 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. In the interests of efficiency, we replaced the intended early delivery of a generic model with specific disease models and a generic model was developed towards the end of the project. Using the LMM, we used observational malaria datasets for Senegal and South Africa to validate seasonal patterns with local expert feedback, and developed a new technique for calibration of rainfall forecasts. A user-friendly interface to the Liverpool Malaria Model was developed through the Disease Model Cradle (DMC) and is available from the project website (http://www.liv.ac.uk/qweci/project_outputs/), it was shared amongst the project partners via two training workshops held in 2011 and the software has allowed users to test the LMM and explore parameter settings for their region. This has enabled project partners and stakeholders to run disease simulations based on climate and non-climate drivers and which were used also by PhD students in Senegal (WP2.1).

3. *Seamless atmospheric integrations*. 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).

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. A major achievement of QWeCI has been the development of a prototype integrated operational malaria forecasting system that has been set up at ECMWF, with further development and support this will become one of the major legacies of the project. The VECTRI and LMM models have been installed and run at ECMWF. If made public this system could provide dynamic, state-of-the-art ensemble malaria forecasts across Africa. The skill of predicting malaria using the ECMWF System-4 seasonal forecasts has been assessed for Senegal, Ghana, South Africa, Sahel, the Gulf of Guinea, Malawi and Botswana, where the System 4 forecast shows significant improvement against those from earlier forecasting systems utilised in FP5 DEMETER and FP6 ENSEMBLES. We incorporated decadal 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. After limited skill was found in the ENSEMBLES decadal hindcasts, the decision was made to focus on decadal to centennial timescales and use a multi-scenario multi-model ensemble of global climate model projections from the CMIP5 archive and regional climate model projections for Africa from CORDEX (linking to our sister project FP7 HEALTHY FUTURES). The super-ensemble of climate forecasts/scenarios were integrated with five different malaria models, including two from QWeCI, with high level publications submitted. This work will have a high impact and will be disseminated through the IPCC WGI further QWeCI papers will be in the WGII report. We also developed a GIS based, multi-agent decision-support system for RVF in Senegal, which is driven by rainfall data (WP4.1).

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 to tailor model outputs to needs on the ground. This feedback, combined with new data on disease emergence and site-specific environmental data, was used to inform development of a multi-agency system (MAS),

based on monthly, seasonal and decadal forecasts of climate-disease interactions. The MAS was built with Spatial Decision Support Systems (SDSS), Information Systems (IS) and Monitoring Tools (MT) designed to link 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 MT. The MAS also forms a key component of a Disease Early Warning System for vector-borne diseases. The UoC web portal has provided a further user-friendly interface to LMM and VECTRI, where users are able to run online two malaria models (WP5.1). In Ghana communications were established between a range of stakeholders including scientists working in human health and animal health at six sites in rural, peri-urban and urban areas of the pilot region. 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. The collection of data on weather, physico-chemical variables and mapping of water bodies, occurrence of *Anopheles* populations, characterisation of insect feeding success rate, measurement of water temperatures, and surveys of householder experiences were important for quantification of the effects of rainfall and water temperatures on malaria incidence (WP5.2). In Senegal the climate and non-climate environmental drivers were studied for 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 (2010-1012), 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. These included pond dynamics (hydrology, composition and ecology of anopheline vector 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 by the mosquitoes. The validation of the LMM for Senegal was made by using hazard, vulnerability and risk maps produced in the EU FP6 AMMA project. 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 getting that appropriate information 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 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 was 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 was 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 meetings discussed operational and theoretical aspects of QWeCI. A programme of short and long-term exchange visits was established

which will continue after the project end through the associate exchange programmes of project partner ICTP (WP6.1). We directed knowledge exchange through a web site and produced 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). As part of the project a workshop/school was organised at partner ICTP in 2011, including training classes demonstrating the LMM DMC and the VECTRI model to participants from developing countries. The success of this event led to a follow up school in 2013 focussing on climate and health, supported by QWeCI and sister project HEALTHYFUTURES, which also provided extensive training in QWeCI tools. We established and maintained communications between the three pilot projects and the European partners to monitor progress against the project schedule (WP6.3). We carried out a self-reflective assessment of the role of the field programmes and their interaction in the project.

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, and held annual project meetings in 2011 (Senegal), 2012 (Nairobi), and 2013 (Barcelona) as well as kick off meetings in 2010 in Liverpool. 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 delays and occurrences external to the project. Technological advances rendered some aspects obsolete, and personnel changes led to revisions of realisable objectives. These were minimised wherever feasible.

The overall structure of the project is illustrated in Figure 1

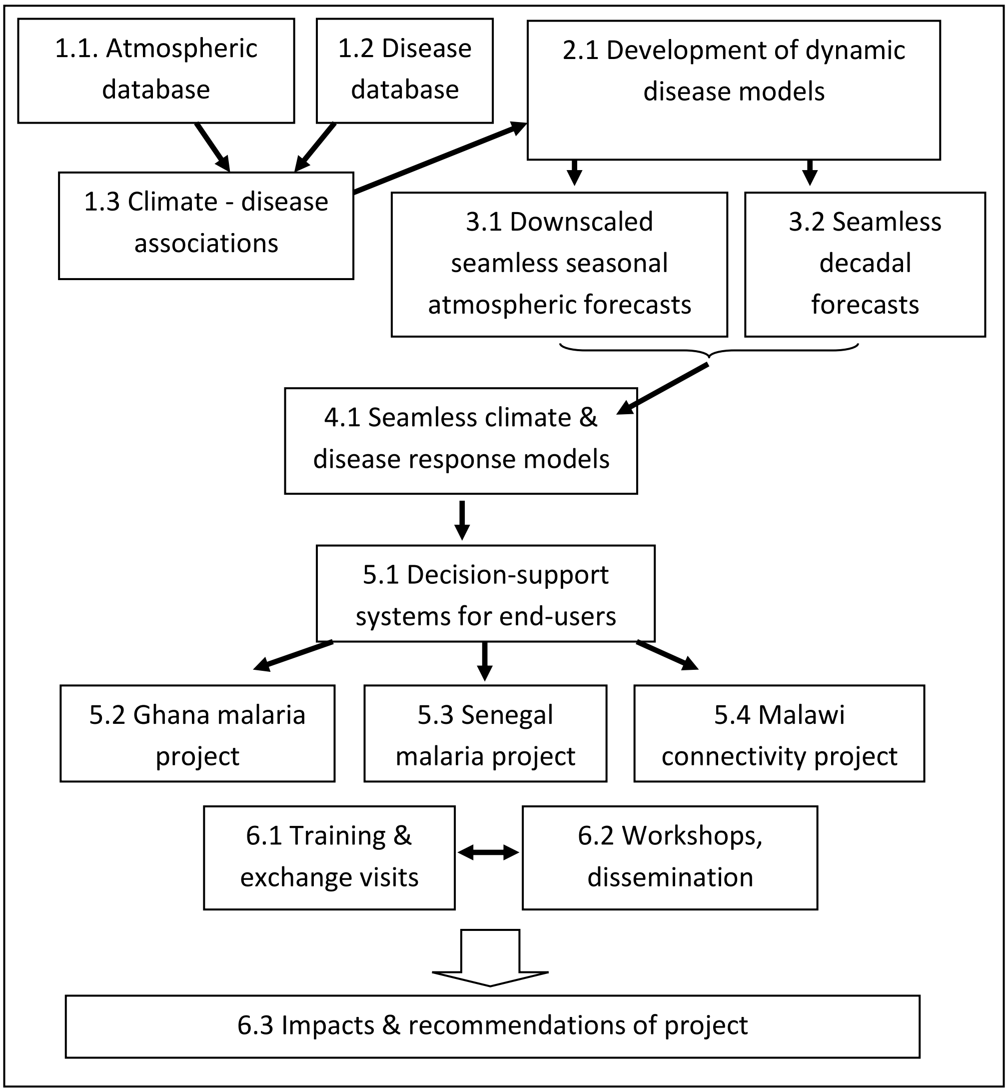

Figure 1 Schematic of the QWeCI project work packages.

Key Results from the Work Packages

Details of the results can be found in the Deliverables, Milestones and the externally peer reviewed journal papers published from the QWeCI project. The evolution of the project can be seen in the three Periodic Reports D7a,b,c and the more day to day aspects of working on QWeCI in the six newsletters D6.2e. In the sections below there are some example results from across the work packages.

All of the QWeCI work packages (WPs) had objectives that are useful in themselves but also contribute to the greater project goals of gaining a greater understanding of the major vector-borne diseases encountered by human societies and the potential to anticipate and control them. The project largely concerned the integration of existing but disparate knowledge and skills to increase their usefulness and applicability to addressing vector-borne disease impacts globally. This involved meticulous scientific testing and validation of model output performance against observations over time. This, in combination with good quality data collected during the project, led to the refinement of existing models and the development of new models, including integrated models that can achieve much more than the component models alone. The end result is the ability to produce high quality outputs at local, regional and global scales in forms relevant to the needs of end users and decision-makers in the African pilot study areas. The project achieved this in mathematical, graphical and communicative stages that involved active co-development to ensure that final user needs were matched by the products.

The project was structured so that the outputs of some WPs were inputs to others. The climate models give seasonal and longer range forecasts over large and country sized geographical areas. For an exploratory approach using pathogens considered in the project and a wider range the disease database enables disease risk to be estimated in response to climate and weather variables at different scales. The practical application of all of the models required detailed understanding of climate-disease relationships, whether these are simple one-to-one connections, e.g. directly dependent on rainfall, or the result of many changes and subtleties that operate to bring together conditions suitable for the emergence or spread or a particular disease. In gaining this level of understanding and incorporating it into model algorithms, the paths to disease outbreak in a particular area, be it a single event or a seasonal or interannual trend, might be predicted. The outbreak of weather-responsive diseases depends not just on rainfall and temperature but on land form and use, proximity of human or animal hosts and the behaviour patterns of local people. Indeed, anything that influences the ecology, i.e. the breeding or biting success of vector organisms, is a controlling factor in disease emergence. This means that models developed to describe endemic or epidemic disease occurrence based on climate are enormously useful.

1. Climate-health relations

1.1 Disease Database

The first stage was to bring together into an integrated system what is known about climate and weather variables, their interactions, and the known controlling variables of vector-borne disease transmission. This will enable the linkage of climate forecasts to conditions governing presence of disease vectors as well as their potential to infect people or livestock. Building a database containing accumulated knowledge of vector-borne disease pathogens was the starting point. The original plan was for partners to upload data on pathogens and climate drivers directly into the ENHanCEd Infections Diseases database (EID) by use of remote links, but innovative work at Liverpool enabled automatic entry of a greater amount of relevant information in a way that increased efficiency and accuracy. We achieved this by use of a critical review tool algorithm, which is able to detect pertinent information directly from the published literature in on-line databases and apply it to a new EID2 database in a spatially useful format. We also built this pathogen information into the EID2 at the spatial resolution appropriate for climate data. In discussions between partners and stakeholders, we agreed the exact scope of hosts and pathogens to be covered by the project. We then reviewed the literature of the disease database for climate-relevant relationships. In this way we were able to identify evidence of the impacts of climate drivers on disease dynamics. For each disease, QWeCI partners wrote a literature review on the effects of climate on disease dynamics, including vector population dynamics, factors affecting transmission, host organisms at risk, and pertinent local environmental variables that can be affected by weather (D1.1a). To facilitate public access to this information, we built a web interface that allows participants to search information from nucleotide sequences reported to the NCBI Nucleotide database as well as the peer-reviewed literature on pathogens, and their distribution.

We gave the EID2 the ability to map disease pathogen data at the same spatial scale as the climate data by including information on the geographical distribution of pathogens. This makes climate-disease associations directly comparable, and allows the generation of spatially explicit frequency histograms showing mapped grid blocks based on the temperature and rainfall patterns entered into the database. The spread of pathogens could also be depicted using pathogen and disease data from the pilot projects. The EID2 can export data on the climate of regions where pathogen presence has been reported and where there is no evidence for presence; this information can be used in ecological niche modelling, which can, for example, generate predictions of regions suitable for the pathogen under both current and future climate conditions. Sophisticated error control methods reduce the likelihood of an incorrect prediction, but some errors are persistent and require supplementary information about pathogen distribution. The database is functional with *Plasmodium falciparum* malaria, Rift Valley fever and the tick-borne infection bovine babesiosis caused by the pathogen *Babesia bigemina*.

Country-level statistical modelling used generalized linear modelling (GLM), and multivariate adaptive regression spline (MARS) techniques. Models were evaluated using a k-fold cross-validation procedure (k=5) in terms of their predictive skill as given by the ROC skill area metric (RSA). The independent contribution of the different variables was also assessed in the context of GLM modelling using a technique involving hierarchical partitioning in order to gain an insight into the importance of the climatic/human/animal factors in explaining disease occurrence. Our results indicate that no added skill was attained with the use of the more sophisticated MARS technique. Model skill was poor in the case of *B. bigemina* infection. Models for *P. falciparum* and particularly Rift Valley Fever attained moderate/good skill, indicating the potential usefulness of the models developed. Regarding variable importance, the results indicate that at the country-level, diseases can be modelled using bioclimatic variables as predictors, with little or no added benefit from the inclusion of host density predictors (Fig. 2). The exploitation of the data stored in EID2 has enabled a straightforward development of the models presented, leaving the door opened to further advances in disease distribution modelling using this database.

The presence or absence of pathogens was also modelled at a 0.25 degree square resolution using an expectation-maximisation (EM-) algorithm which was applied to generalised additive modelling (GAM) with a binomial logistic error distribution. Within the modelling exercise, the effects of (1) using different numbers of iterations within the EM-GAM modelling, and (2) the use of different Pi values (examining the effect of changing the prior probability of a detected absence actually being a presence within the data) were explored. A further Pi value (3) which estimated (using a combined assessment from data from EID2) the surveillance effort for a pathogen in different countries and of the general surveillance of all pathogens in one country relative to other countries was also examined. Model outputs suggested that (1) models converged after 20 iterations; (2) the Pi value to use within modelling cannot be estimated using the data; and (3) a model which incorporates surveillance adjusted Pi values should be utilised as the best Pi estimate for EM-GAM modelling. The modelling exercises that have been undertaken within this work have demonstrated the utility of the EID2 as a source of presence information for pathogens around the world. The use of the EM-GAM technique could provide national and global modelled outputs which could be used as a comparator for disease model outputs, developed using other methodologies. As such, the technique and modelled outputs for specific disease pathogens from EID2 could prove to be of great use within the disease modelling community in the future. Future work using this technique will need to include testing the accuracy of the outputs of EM-GAM modelling exercises, by comparing outputs with test data for disease pathogens; either from previous modelling exercise outputs describing the presence of pathogens, or real-world data.

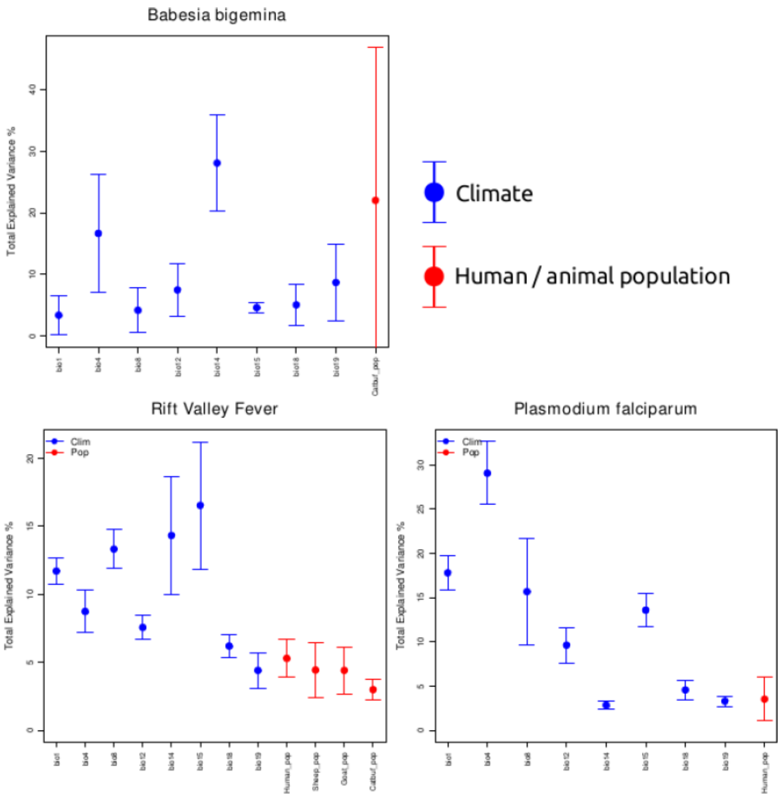

Figure 2. The relative importance of each explanatory variable for each of the disease models. See D1.1b for further details.

The web interface of the EID2 (http://www.zoonosis.ac.uk/EID2) has been completed, and the database is publically available (after user registration) on the world-wide web. The database allows interrogators to look at information in the context of the evidence available within the literature about disease pathogen spatial distribution. It is also possible to visualise the predicted current environmental niche of pathogens, modelled using the EM-GAM algorithm and specific climate variables, thus completing the objectives of the work package.

1.2 Atmospheric Database

In parallel with the disease database, we assembled an atmospheric database to hold meteorological datasets, time-series data and satellite-derived weather information. These climate data were produced on scales ranging from daily to monthly, and accompanied climate and weather predictions from selected sources. A key function of the database (http://qweci.uni-koeln.de) was its accessibility for all QWeCI partners. This was done by defining a metadata catalogue template on Java. For ease of dissemination and use by others, we provided the data in user-friendly and standard formats, including Comma-Separated Values (CSV), the Network Common Data Format (NetCDF) and the geographic information metadata XML format (eXtensible Markup Language; ISO 19139).

The database comprises:
Data from the (QWeCI partner) ECMWF 40 year Re-Analysis (ERA-40); The ECMWF Interim Re-Analysis (ERA-Interim); The Global Historical Climatology Network version 2 (GHCN) dataset;
Historical meteorological time series from Ghana (GMet); The Global Precipitation Climatology Project 1° daily dataset (GPCP v1.1 1dd); The Global Precipitation Climatology Project 2.5° monthly dataset (version

2.1) (GPCP v2.1); The Federal Climate Complex Global Surface Summary of Day version 7 (GSOD) dataset; Kumasi Precipitation Time Series (KuPTiS); Weather reports from the Met Office Integrated Data Archive System (MIDAS); The NCEP/NCAR Reanalysis 1 (NCEP-1); Owabi Automatic Weather Station data (OwabiAWS); SYNOPtic reports from the DWD archive (SYNOP); The Tropical Rainfall Measuring Mission, and (TRMM 3B42 V6); The Tropical Rainfall Measuring Mission and other daily and monthly precipitation estimates (TRMM 3B43 V6). In order to increase availability, we transferred the QWeCI-developed KuPTiS and OwabiAWS datasets to the AMMA database (http//:amma-international.org/about/index). Our aim was to pick the best available climate models and validate them for errors and forecast skill. This meant testing the potential of models for errors in spatial and temporal predictions of temperature and rainfall on daily, monthly, seasonal and interannual scales, including phenomena such as the West African monsoon (WAM). Included in these assessments were the seasonal forecasting systems of QWeCI partner ECMWF (System3 and System4) see work package 3.1, which we assessed for potential systemic bias, which was then addressed through technical refinements. This detailed assessment and validation work led to several improvements in existing models, and developments and further applications of others.

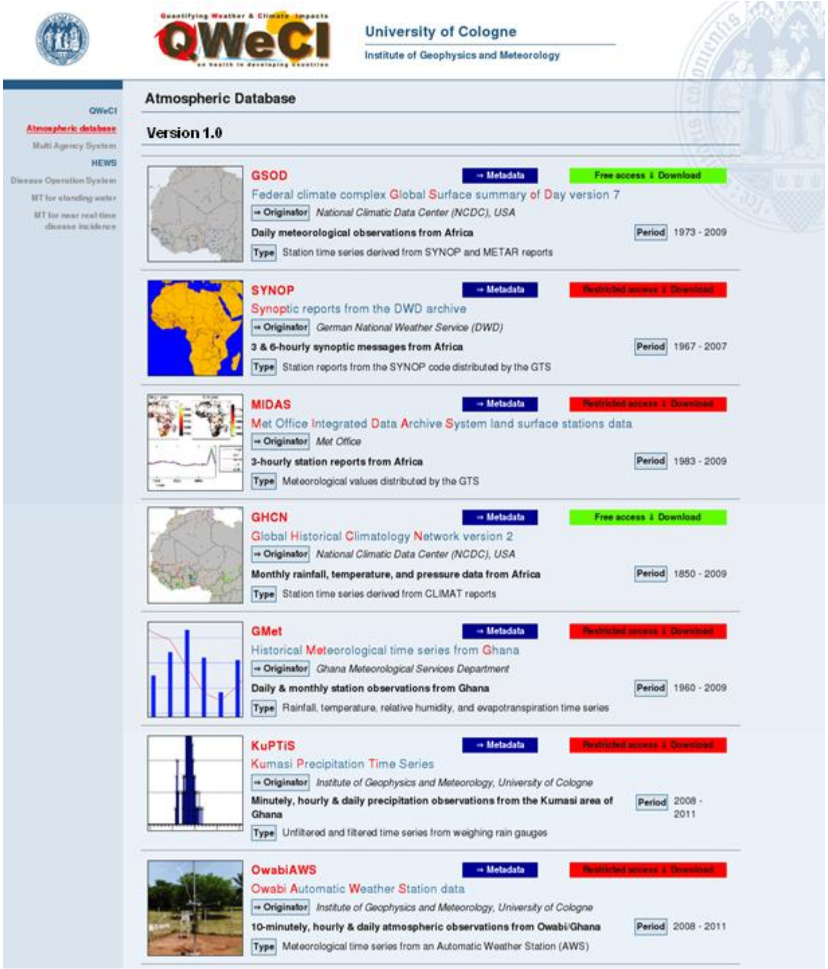

Figure 3. Screen shot of part of the database showing short profiles of the data held. Taken from D1.2c..

QWeCI partners in Ghana collected daily rainfall data from 191 weather stations covering the whole of Ghana but mostly in the denser populated parts. These data, representing about 47% of potentially available rainfall data over the period 1990 – 2010, contributed to the metadata of the QWeCI atmospheric database. Quality checks found the data to be reliable in most cases. Historical time-series rainfall and temperature data from 1994-2011 were augmented by new data collection where existing data were insufficient to optimise predictive skill. For example, data for pond water temperature, depth, breadth and position (using GPS) as well as presence of mosquito larvae were collected from ponds in the area of Kumasi three times daily over ten weeks.

Much of the work at this stage focussed on identification of the relationships between atmospheric variables and the control variables of vector-borne disease transmission, and assessment and reanalysis of meteorological data and outputs of existing models. The work underpins studies of the feasibility of predicting disease incidence from meteorological inputs.

Biases were investigated in the ERA-Interim reanalysis data and the operational forecasting system at ECMWF and reported in D1.2b where the figure 4 below is taken from.

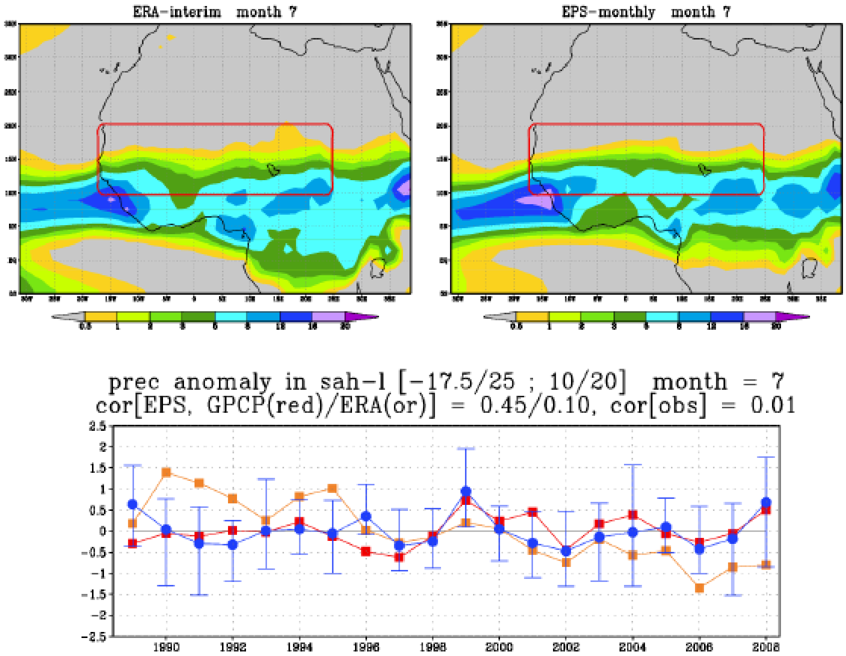

Figure 4. Comparison between ERA-I (left top) and the Ensemble Forecasting System (right top) and the GPCP precipitation data set for July. The lower panel shows the correlation between these data sets.

It can be seen that similar biases are found in the reanalysis and forecasting system. Care need to be taken when using data from models and bias corrections especially for rainfall and bias correction before the data can be used in an impacts model are normally required.

1.3 Climate-disease Associations

Working alongside the two major databases, the tasks was to put them together by development of techniques that could apply information from both to plot the likelihood of disease outbreaks associated with particular climate and weather conditions on useful geographical scales. A review document for planners has been compiled with inputs from a number of partners D1.3a. We planned a summary exercise looking at the most recent literature on priority climate-related disease in Africa but it became obvious that a focussed and selective review of the published literature was necessary. It was important to test published climate-disease associations with new datasets produced from the QWeCI pilot areas. Much of the literature data mining work was in fact carried out in Work Package 1.1 in building up the relevant sources for the EID2.

A statistical model were also developed Task 1.3d in Malawi incorporating socio-economic conditions such as the degree of urbanisation, education and poverty that are important factors in vector-borne disease transmission, but within these, demographic information such as age group, population density, housing conditions (e.g. number of rooms, presence of toilet), the use of insecticide-treated nets, and the presence of local health facilities were significant considerations in the vulnerability of human populations to infection. Important environmental considerations were geographical region, characteristic environment (i.e. lowland, lake shore, highland, mixed), annual cycle, temperature, rainfall, temperature-rainfall interactions, and geographical position (i.e. altitude, longitude, latitude). All of these factors were used to improve the fit between model outputs and observed conditions, and integration of the data into models for calibration, refinement and testing continued throughout the project. We simulated malaria risk as a function of various climate drivers by building increasingly complex models that combine social and environmental factors with climate information. Malaria transmission is influenced by weather conditions including temperature and rainfall patterns that affect both the ecology of mosquitoes and the availability of suitable breeding sites. Climate and weather predictions were produced on a grid system for Malawi. We interpolated the simulations in order to apply them at smaller scales, and laid the local socio-economic and environmental data on top, fitting them to the gridded data on climate and topographical variations. The relationship between malaria morbidity and climate variables is shown in linear and polynomial plots in the figure below. The model captures the observed annual cycle of malaria well, and has measured success in representing interannual variations

Working with EID2 in Work Package 1.1 we tested the reliability of statistical modelling tools for presence-only data and for predictive skill, and we modelled the occurrence world-wide of Rift Valley Fever and infections from *Babesia bigemina* and *Plasmodium falciparum* malaria infections at the country level. We used a hierarchical partitioning technique to assess the role of variables independently in explaining disease occurrence, i.e. climate, humans and animals.

In Senegal Rift Valley fever is becoming a major concern of the relevant government livestock and health ministries. Climate-modelling of late rainfall events emerged as an important study area. Recent outbreaks of Rift Valley fever in Senegal and trade routes into Mauritania were instrumental in revealing the importance of isolated rain events after the apparent retreat of the rains. The rainfall events in question were captured by the Global Forecasting System at NCAR model three days beforehand, it is not possible to evaluate such rainfall events from a seasonal forecasting system. Cattle had by then been brought in from their wet season pastures to drink at the ponds. It is known that when large rain events refill the ponds, it causes hatching of *Aedes* mosquitoes that are already infected with the virus. The meteorology of these events is a key new area studied by QWeCI. Satellite imagery, especially cold cloud plots, can be used to track large rainfall events that lead to the recirculation of the virus. The result is that we have been able to estimate RVF risk over the entire region of West Africa. Spatio-temporal data were also collected for RVF in Kenya. Based on earlier work the RVF climatic risk has been mapped over West Africa by Caminade et al., 2011. The method is based on the detection of dry spells (lasting for 6 days minimum) which are followed by a large rainfall event (above 20mm) during the late rainy season (Sept-Oct). This climatic feature has been observed during the four major RVF outbreaks that occurred over northern Senegal and has also been recently tested for Mauritania for four major outbreaks (1998, 2003, 2010 and 2012). We used TRMM satellite data (version 7) from WP1.2 to carry out this analysis. The link between climate variables and risks of RVF, malaria and babesiosis in Africa has been investigated in conjunction with WP1.1 (see Deliverable D1.1.b for further details). For example, the importance of bioclimatic variables was confirmed by the relative importance of some bioclimatic variables compared to population-related ones. In the case of *B. bigemina*, the most important variables were the precipitation of driest month and temperature seasonality.

2.1 Development of Dynamic Disease Models

A central tenet of the project is that outputs must be tailored to the needs of end users, and that this is best achieved through feedback and input from professionals in the three target regions of Ghana, Senegal and Malawi. We wanted to develop a unified climate-disease model capable of describing multiple hosts and vectors and flexible enough to be applicable to any district, but it became evident that there was a need for a locally-installable model with a simple-to-use front end and the ability for users to load various datasets and basic visualisation tools. This was met through development of a multi-platform system designed to allow users with limited computational experience to run and process data in models. The new, user-friendly Disease Model Cradle (DMC) (DMC-LMM is available here http://www.liv.ac.uk/qweci/project_outputs/ in the Software section) encapsulates different disease models as dynamic libraries and can display the results of model runs graphically. On-line availability allows partners to run models locally using their own meteorological datasets and to validate the results with epidemiological field data.

The DMC is built to hold the Liverpool Malaria Model (LMM) and other models such as the new QWeCI-developed RVF model. We used the LMM to simulate malaria infection patterns over Senegal, Ghana, Malawi and South Africa, and have made refinements and extensions so the model can accommodate more than one host species. The LMM library has been installed and tested with a seamless forecast/hindcast dataset at ECMWF, and is available online within the DMS. Local data from Senegal has been used to test the DMC, using the LMM. Testing of the LMM using spatially-calibrated and reanalysed datasets found the outputs to be realistic in matching reports from local experts for the regions, but they underestimated the northern extension of the malaria epidemic belt in the Sahel area and overestimated malaria incidence in south-west South Africa.

In Barkedji, Senegal, we collected field data for three entire rainy seasons 2010 to 2012 deriving parameter settings to use in the dynamic models. A workshop with stakeholders was organised by CSE in Dakar in November 2011. Morse and Heath (UNILIV) contributed to the workshop. This was well attended by national, regional and local representatives from Senegal. Almost 40 delegates attended from local, regional and national groups. In the workshop we explained the importance of the research and how climate impacted on vector-borne diseases as well as running a hands on session with the Liverpool Malaria Model. The village leader from the Barkedji also attended and said how important the research was for his village.

It was clear at the start of the project that we would gain more impact by running more than one dynamical malaria model with the ability to run pan-Africa. Therefore, it was decided that a model should be developed and coded independently of the UNILIV team by ICTP. Although the central core and the approach in VECTRI is very close to that of LMM it does have a significant number of differences. The VECTRI malaria model, developed by QWeCI partner ICTP, is a dynamical grid-based model that visualises the occurrence and distribution of the *Anopheles gambiae* complex infected with *Plasmodium falciparum*. We refined the model by writing generalised interfaces to allow both observational and model data to be used to drive VECTRI (Tompkins and Ermert 2012). We added a new hydrological component for ponds that includes water losses through evaporation and gains from runoff and infiltration and also accounts specifically for the local population density. In this way, the VECTRI model can be run at high spatial resolution and is the first regional-continental scale model to successfully simulate the observed differences in transmission intensity between rural and peri-urban environments in Africa. We adapted a QWeCI-developed RVF model for specific disease characteristics by making its functionality generic. This enables any disease model to use the generic core, giving sufficient flexibility to allow disease, vector or host specific sub-models to be built for specific tasks. The QWeCI Vector-Borne Disease Library (VBDLib) enables multiple host and multiple vector disease models to be created using the generic code. We have made the VBDLib available on-line via the DMC. The core library has undergone testing and a RVF two-host two-vector model has been configured and implemented.

As mentioned in section 1.3 above a number of other models including statistical models were produced by QWeCI partners. IC3 constructed a dynamical stochastic differential equation (SDE) model that can reproduce malaria dynamics in Senegal, and tested it for other regions of Africa where conditions are similar to the semi-arid areas of Senegal. We managed to acquire a very good and reliable dataset for Malawi and Ghana. Using this, we divided human populations into five sub-sets, viz. susceptible to infection, exposed (i.e. a non-infectious carrier), infectious, asymptomatic weakly infectious, and recovered but carrying parasites and infectious. The model reasonably well captures the seasonal endemic region as well as the shifts in mean malaria state after interventions by medical professionals. We have worked to investigate an underestimation in the model of observed disease of maxima and minima. Fig 5 shows the model compared with observations, showing the close agreement but underestimation of observed disease dynamics.

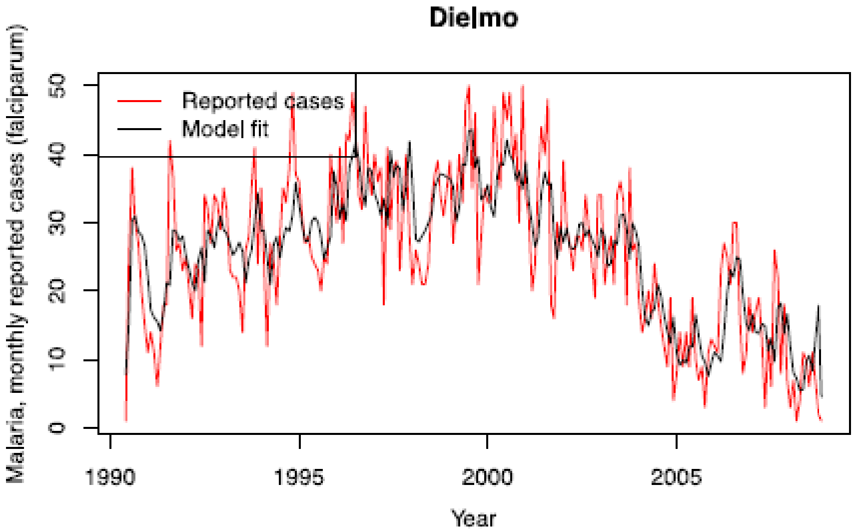

Figure 5. The time series of monthly malaria cases in Dielmo, Senegal with the corresponding IC3 SDE model output.

Partners at IPD developed a statistical Bayesian model to assess climate impacts on the spatial and temporal abundance of RVF vectors in Barkedji, Senegal. To study the importance of weather and local environmental factors in influencing mosquito abundance, we used data from fortnightly collections at 79 sites including villages, temporary ponds, shrubby and wooded savannah, steppes, and barren lands at different distances from the permanent ponds at Barkedji. Cumulative rainfall up to 20 days prior to mosquito collection was measured as an environmental variable. Relative humidity, maximum temperature and rainfall were associated with high vector abundance, with maximum densities in and around pools. Results showed a good fit between the model and observed seasonal distributions for *Aedes vexans* in all landscape types and for spatial variability in *Culex poicilipes* for all landscape types except for barren lands and steppe. The results confirmed that climate affects vector abundance in both species, and provided useful knowledge for surveillance and control of RVF vectors in the region. We modelled *Culex* spp. mosquitoes with the same structure as the LMM dynamic mosquito model, while the *Aedes* mosquito complex was modelled for larval development using a rainfall-driven trigger. This is because *Aedes* spp. eggs require a dry period followed by wetting in order to develop. Fig. 6 illustrates these features of the host component of dynamic RVF model.

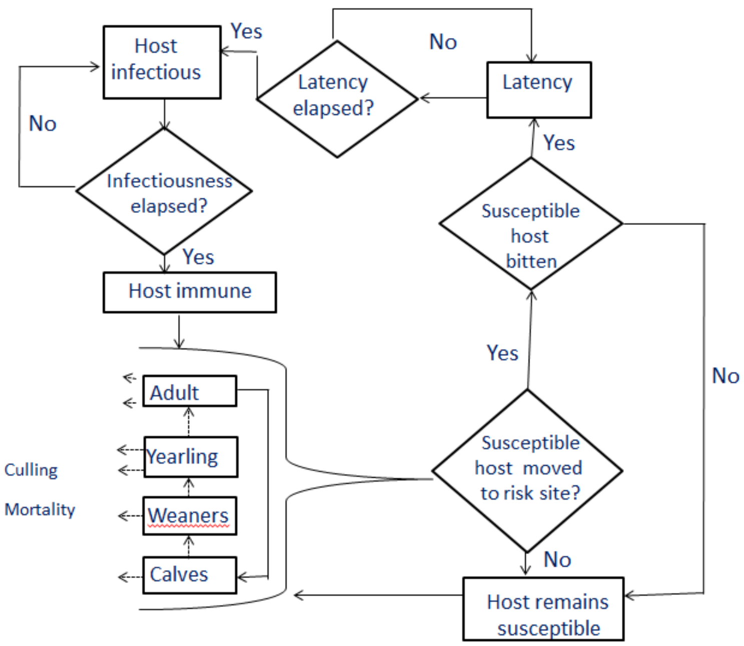

Figure 6. The host component of the RVF dynamic model.

CSE liaised with UNILIV for the development of the disease models. A report on the effectiveness of the dynamic and semi-dynamic modelling approaches for malaria and RVF was part of a successful PhD project (Ahmed Tidjane Cisse at UCAD)

We modelled projections of climate change by comparing five different malaria models (MARA, MIASMA, LMM_Ro, VECTRI and UMEA) with other observed malaria endemicity estimates over Africa for both climate data and climate change projections (Deliverable D4.1.b). This work is now submitted and in review (Caminade et al.) the paper summarised estimated impacts of climate change on malaria globally with different emissions and population scenarios and an ensemble of five different malaria models.

Overall, as a result of the activities performed within this WP, the following significant results can be highlighted:

- The Liverpool Malaria Model has undergone further parameter calibration, development/extensions and has been tested against observations collected in the project and against other models/mapped products.
- Development of the new malaria model VECTRI has continued and the model has been published and validated against various sources of observations.
- Developed, modified and made comparisons of LMM and VECTRI dynamic malaria models leading to a monthly to seasonal seamless operational forecasting system which is weekly updated, with a corresponding 18-years hindcast set see section 4.1.
- LMM and VECTRI contributed to the ISI-MIP impact model intercomparison project with bias corrected CMPI5 GCM data sets, with the results published in two peer reviewed papers and presented at an international conference in Potsdam in 2013.
- The Epidemiological modelling toolkit for climate sensitive disease (EpiCS) generic disease modelling library has been developed, tested and used to create and new dynamic Rift Valley fever model (LRVF). The use of EpiCS allows the expert user to build multi-vector and multi-host diseases transmission models. The new system has been run as LMM and compared with the original model output. A RVF model is written and is undergoing further development.

3.1 Downscaled and calibrated seamless seasonal atmospheric forecasts

The ability of health professionals and decision-makers in the target countries to monitor the health of populations and to anticipate approaching health concerns relies on the reliability of seasonal predictions on a regional scale. In order to address this we used a multi-model downscaled and unified approach. This method provides knowledge of climate and weather variables and estimates of uncertainty in the predictions on spatial and temporal scales and in a form useful to other WPs.

The challenge of calibrating and integrating daily, monthly, annual and decadal models and forecasts into seamless climate and weather outputs at small, medium and large spatial scales was centred on the development of a gridded observational dataset and a prototype downscaling portal. The statistical downscaling portal was adapted for the use and validation of new downscaling techniques. For different African regions, acceptable temperature forecasts emerged from different statistical downscaling techniques. Rainfall forecasts were less good. Testing of the predictive skill and reliability of models in various contexts is a critical main plank of output verification. Using the best available observations for the Ghana, Senegal and Malawi pilot areas, assessments were made using 40-years worth of hindcast data to analyse different combinations of potential predictors over different geographical zones within the pilot areas. These assessments considered periods in excess of 20 years in nearly all cases. Results are included in the downscaling portal to allow access for testing of new configurations and datasets. Reanalysis and forecast-driven simulations for seasonal predictions have been run and tested with success for southern areas of Africa. Extensive validation of different statistical downscaling techniques in different African regions considering both "perfect" forcing conditions (ERA-Interim) and a multi-model hindcast. Results are acceptable for temperature (with inter-seasonal correlations in the range 0.6-0.8 for different seasons/stations in Ghana and Malawi), but are poor in general for precipitation. Dynamical downscaling (with regional climate models) has been tested with promising results over the western and southern Africa domain. The regional model is not only able to reduce the wet bias of the driving GCM over most part of the domain but also enhances the temporal correlation between the forecast and observation over most part of the domain.

A user portal is available at https://www.meteo.unican.es/downscaling/qweci

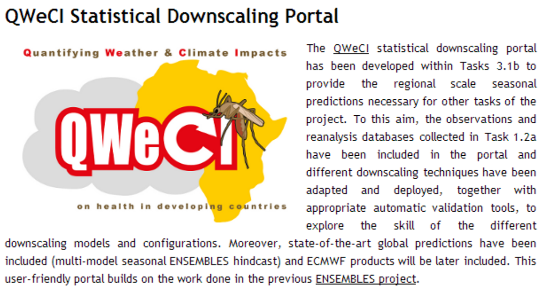

Figure 7. The QWeCI Statistical Downscaling Portal – Home Page

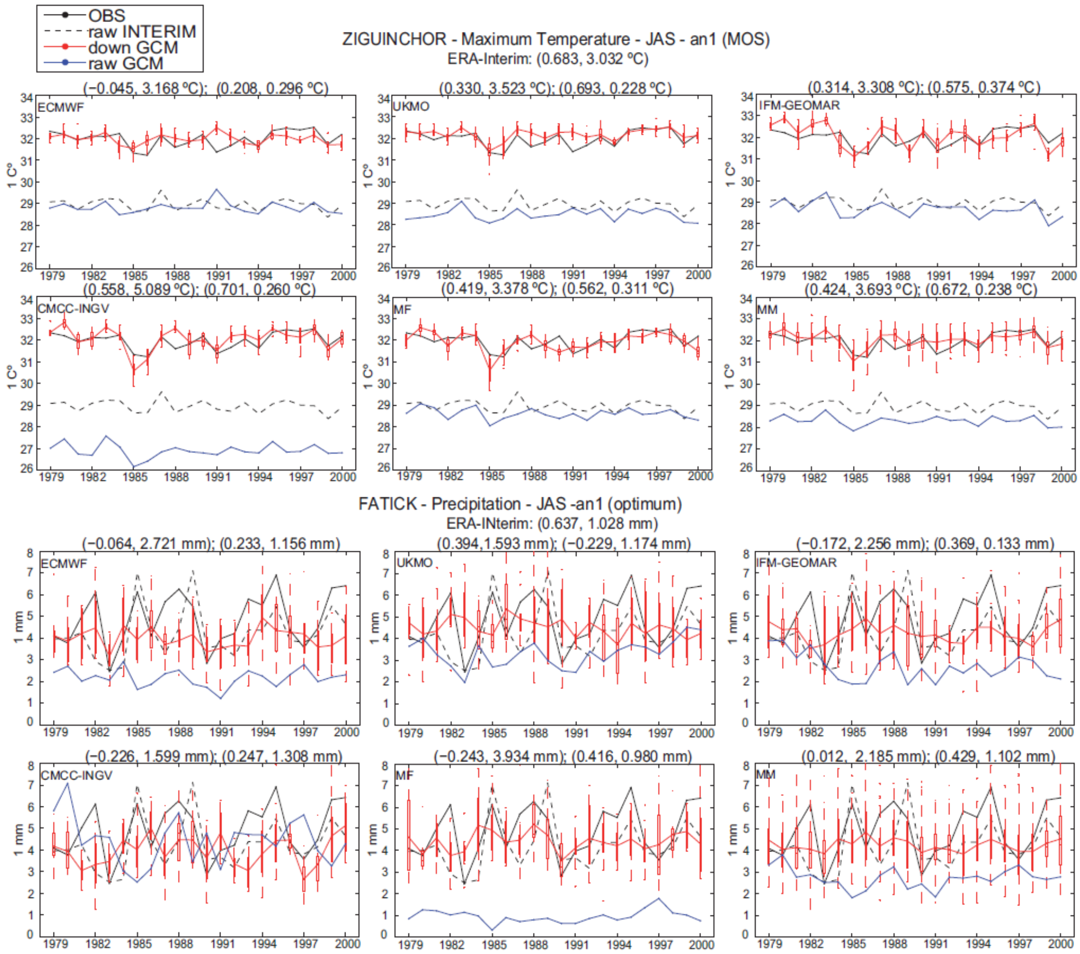

Figure 8. Data sets of maximum temperature and precipitation downscaled for selected stations in Senegal (Fatick and Ziguinchor).

As well as the statistical downscaling we used dynamical methods to downscale combined seasonal forecasts for southern and western African regions using the regional climate model RegCM4 and tested the effectiveness of the technique using quantified comparisons of ‘perfect’ and forecast datasets. An improved match between rainfall simulations and observations was achieved by a reduced wet bias and better temporal correlation.

We designed a calibrated seamless forecast system that produces 30-day rainfall forecasts, averaged over five day periods, and optimised for Africa. We also formulated a new calibration technique that can correct for errors in 5-day rainfall predictions in monthly and seasonal forecasts. In addition, by joining daily with monthly forecast systems, we developed a seamless weekly-updated operational forecasting system. A weekly updated monthly to seasonal seamless forecasting system using 18-year hindcasts is also operational. As the full site is not available to the public this is the public address for the project at ECMWF http://www.ecmwf.int/research/EU_projects/QWECI/ This system went operational during the project and was made available to partners in the project – who continue to have access to the site.

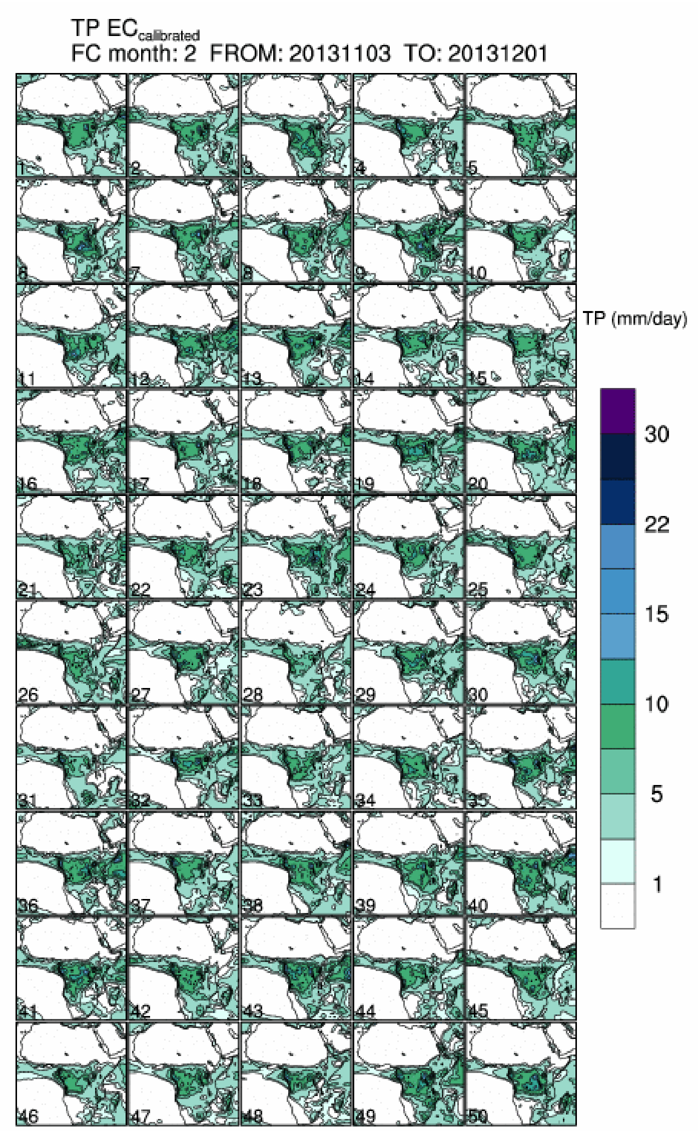

Figure 9. Stamps made of each calibrated ECMWF System 4 operation season forecast for Month 2 Precipitation for November 2013.

Both dynamical, i.e. responsive to changing variables, and statistical techniques were used to optimise potential forecasting ability. Dynamical downscaling has proven potentially useful over southern Africa, following a reduction in the 'wet bias' in the precipitation forecasts and has also improved the temporal correlation between the forecast and observations over most of the area.

3.2 Seamless decadal predictions and projections

Making projections of climate a decade or more in to the future is a considerable challenge. The importance of the Atlantic Ocean for rainfall in western Africa became evident from studies involving sea surface temperature (SST), the Atlantic Niño and the Atlantic Multi-Decadal Oscillation (AMO). Statistical analyses revealed that the main drivers of SST patterns are the Atlantic Niño and the AMO. We investigated the roles of coupled land-atmosphere processes in climate variation on decadal scales, concentrating especially on the rainfall over West Africa as a function of SST. We used mean weather averages for two contrasting decades on interannual to decadal scales. We did this by characterising rainfall and temperature variations of the comparatively wet decade of 1955-1965 and the dry decade of 1975-1985.

When we ran simulations using rainfall records for Guinea and Sahelian region, which are the two main modes of rainfall variability in western Africa, we found that the Atlantic Niño controls Guinean precipitation while the AMDO was found to be the main influence for the long-term (multi-year) ability to predict rainfall in Guinea and the Sahel. Subtleties in SST are influenced by rainfall in the Sahel and feed back into long-term Atlantic variability (García-Serrano et al., 2012). When we compared observations in the form of rainfall records for Guinea and Sahelian regions with multiple model outputs, we identified systemic errors on a decadal scale in the forecasts of several models, particularly over the West African coastline. By comparing these rainfall indices with simulations, we could assess the predictive skill of the models by re-running retrospective forecasts using historical data as the starting conditions for the model.

When observational data rather than simulations are used to restart multiple model runs, the models gain an increase in predictive skill up to six years ahead for impacts on Sahelian rainfall pattern predictions from the AMO. This advance constitutes significant progress made on the problem of prediction of the rainfall on within-season and at interannual timescales over west and southern Africa, and this is a particularly valuable tool for improving the predictive skill of climate models.

We also estimated the predictive skill of the ECMWF seasonal forecast models for within-season variability over Africa as a whole by assessing the seasonal to annual predictions for each grid square. This enabled assessment of the model's ability to predict the timing of the deep tropical convection as it migrates latitudinally across the continent. We assessed the relative advantages of combining information from dynamical and statistical interannual forecast systems, using the Guinean and Sahelian rainfall regimes. The statistical model did not improve forecast quality, but forecast reliability was high at lower resolutions.

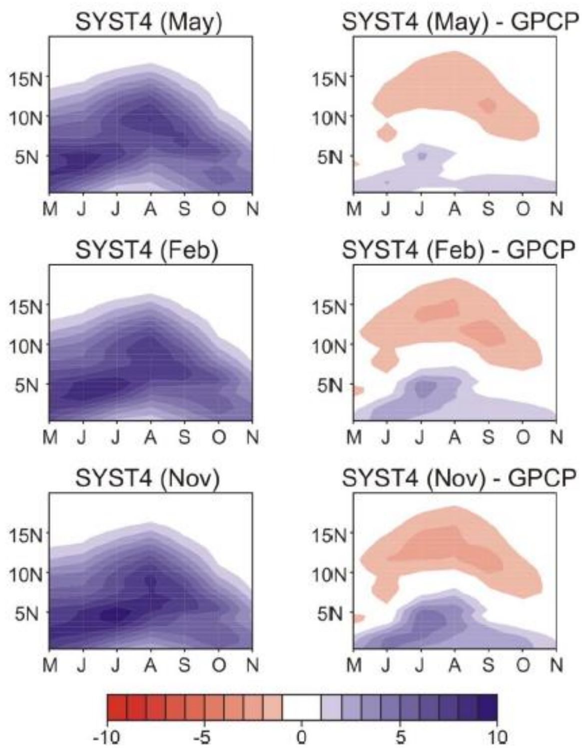

Figure 10. By using Hovmöller latitude-time diagrams for different start times of the ECMWF System4 (with 13 month integrations) the differences in the forecast June, July, August rainfall for West Africa with increasing lead time is compared to the GPCP rainfall estimates. May (zero lead time), February (3 month lead time) and November (6 month lead time).

Much more work remains to be done to determine the usefulness of such a novel tool as climate prediction beyond the seasonal time scale, but it is extremely important to note that the African continent has been one of the first land areas for which the skill of the new decadal predictions has been assessed. Feedback from the potential users of this information has been sought to modify the approach to address more specific requirements.

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4. Seamless climate-health integrations

Our next priority was to optimise the efficiency and applicability of the validated climate-disease model outputs by joining them together. The end-user will thus receive unified, or seamless, forecasts on continuous scales from monthly to seasonal and from region to broad scale forecasts. A major scientific achievement of the project was the development of an integrated multi-model that can predict the likelihood of disease outbreaks in the short and medium term for specific geographical areas. A lot of time was spent in identifying and correcting bias and errors present in models. Thus we were able to enhance the predictive skill and reliability of forecasts. Refinements, especially to precipitation forecasts, improved the predictive skill of the model outputs over different applications to the extent that we were able to establish towards a proof of principle for a potential operational malaria early warning systems for epidemic areas of Africa. This is of great value because low malaria immunity in such areas increases the risk, making outbreaks less predictable. With better predictive ability of malaria outbreaks, health facilities will be able to plan and prepare for significant outbreaks, as well as save costs at times of low risk.

The LMM and VECTRI models have been interfaced into a malaria early warning system, and feedback from African partners has assisted tailoring of the product to the needs of end-users in the target areas. Two malaria models (LMM and VECTRI) were driven by the ECMWF seamless monthly-to-seasonal model outputs to create a seamless forecasting system. For the first month weekly forecasts are made using the monthly system and forecasts with longer lead time are made with the System 4 seasonal system. Bias-correction of the combined forecast models produced the seamless output to drive the malaria forecasts. The project partners towards the end of the project had access to weekly updated malaria model runs – as this site is restricted to the consortium and public general site is listed here
http://www.ecmwf.int/research/EU_projects/QWECI/. The forecasts are updated weekly see Fig. 11 the outputs currently produced are for the Effective Inoculation Rate (EIR). Here a mask has been applied to highlight the forecasts for regions that have the most variability for this start date based on the hindcasts.
The unmasked plots (not shown) have malaria forecast in the Congo, but the application of the mask highlights that there is little interannual malaria transmission variability in that region (holoendemic). Further hindcast information showing the malaria climate and malaria variability for each start date are available on the web site. At the moment these plots are being field trialled with users in Africa and adjustment to the products and masking may be made in future. If the site is able to gain continued funding and support to go operational then a further selection of bespoke tailored products can be designed follow consultation with uses. At the moment this is a demonstration site to show operational capabilities. It is the first in the world with real time operational malaria forecasts with the ability to have user chosen lead times and options. Any previous seasonal malaria forecasts were one-offs once per year, and available for single countries as national averages using simple statistical disease models. Here using this system the users can see the evolution of the malaria season and eventually will be able to look at past performance of the models. It should be emphasized that the accomplishments with this pilot, pre-operational demonstration forecasting decision support system went far beyond the research plans and original remit of QWeCI and represent one of the major advances of the project. Further evaluation and operational rollout of forecasts must be left to a future project as further work is required for its implementation. In summary, QWeCI moved well beyond proof of concept of an operational malaria forecasting system, through a proof of technology towards a proof of principle where we can start to show the efficacy of such system.

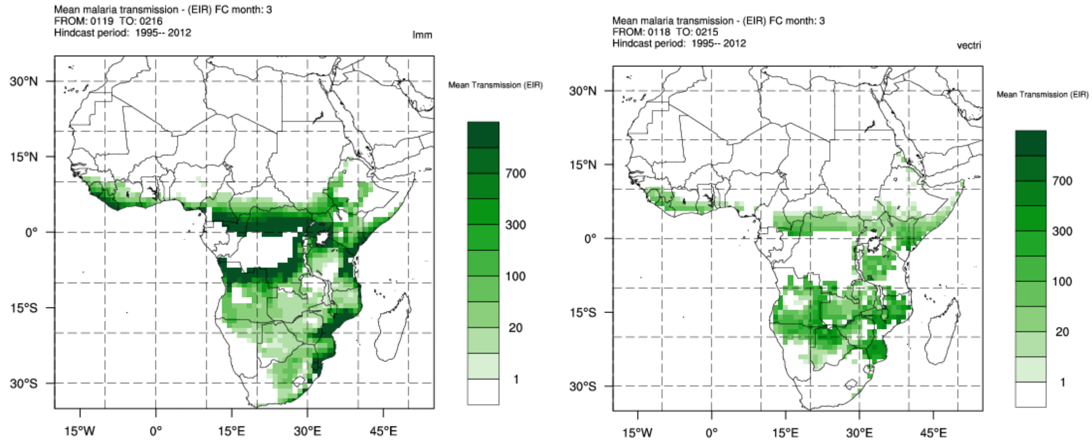

Figure 11. Shows a real time malaria forecasts with a two month lead time for LMM and VECTRI driven by ECMWF ensemble prediction systems. These plots are masked to eliminate grid points with low interannual variability e.g. the Congo basin.

The skill of integrated model malaria runs with ECMWF System 4 in West Africa was mixed. Although skill was found on the epidemic fringes and this may be of great use to decision makers. We wrote reports on the predictive skill of the malaria models for southern Africa and on the seamless calibrated products for disease-related variables. We validated System 4 for predictive ability for rainfall and temperature simulations against observations from west and southern Africa. This is important for producing malaria forecasts for target countries. We ran malaria seasonal forecasts for predicting high (upper tercile category) malaria years using System4 October forecasts for the March-April-May malaria season in Malawi for high malaria years. These forecasts when run against an ERA-Interim control showed accurate prediction with eight years (malaria seasons) of significant malaria outbreaks and also correctly predicted fifteen year where no significant risk was forecast. The model system also made five 'false alarm' predictions and missed one outbreak, the ROC area is about 0.9 showing that System 4 is skilfully capturing UT malaria events with respect to the control simulation (driven by ERA-Interim) (see D4.1.a for details).

One of the steps in forming the operational system was to see what skill was available from an operational system compared with the early R&D systems developed within the FP5 DEMETER and FP6 ENSEMBLES projects. We choose to test this in Botswana where there is a published observed clinical malaria index available.

Results in Table 1 show that System-4-driven forecasts for high events are nearly as high as that for the ERA-Interim ('perfect forecasts') reanalysis-driven runs.

Table 1. Tier-3 skill ROC Skill Scores (ROCSS) for LMM prediction of low (LT) and high (UT) malaria events in Botswana relative to Botswana Malaria Index (Thomson et al, 2005).

Model	LT	UT
DEMETER multimodel	**0.84**	0.67
ENSEMBLES multimodel	**0.85**	0.69
DEMETER-ECMWF	0.67	0.44
ENSEMBLES-ECMWF	**0.81**	0.59
SYSTEM-4	**0.77**	**0.89**
ERA-Interim	0.72	**0.91**

In Senegal we used the DMC-LMM to investigate endemic and epidemic malaria states in Senegal. Using local information on human mortality and the effects of drug interventions in the study villages for which long-term malaria incidence data were available the model could be refined for local usage. Further work led to the development of a final model that incorporated a range of additional local predictor variables including age group, annual cycle and the number of health facilities per inhabitant. In Senegal a signal-fitting technique to develop a method to simulate time-series data for an integrated multi-agency Rift Valley fever decision-support system, which uses rainfall data to simulate vector dynamics. Fig. 12 below shows a schematic of the interaction between the environmental conditions, the vectors and Rift Valley fever as simulated by the model.

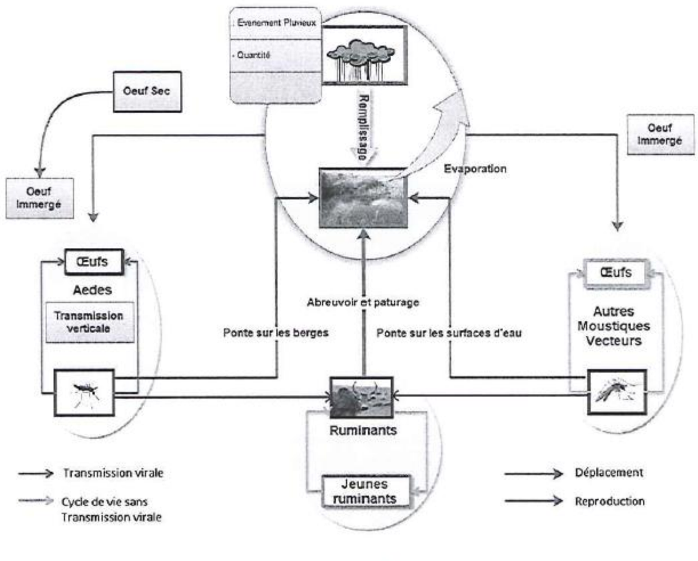

Figure 12. Vector dynamics for the Senegal partners Rift Valley fever model.

Given the limited skill of the decadal ensemble hindcasts in reproducing climate trends, and climate interannual variability for different regions over the globe (MacLeod et al., 2012), we did not consider driving the dynamical Liverpool Malaria Model using simulated rainfall and temperature from the decadal hindcasts at the daily time step (see QWeCI Milestones M4.1.b "Pilot Integration of the existing dynamic malaria model with a decadal ensemble prediction system" for further details). Instead, we decided to develop and use a simplified version of the LMM which uses monthly rainfall and temperature as inputs to the transmission model of the standard LMM. This LMM version is tested and validated against four other malaria models (MARA, VECTRI, MIASMA and the WHO-Umea statistical model) within the current study. We now focus on decadal/centennial projections using an ensemble of Global Climate Models (GCMs) and Regional Climate Model (RCM) projections driven by the latest RCP emission scenarios; using these, we estimated and discussed the different sources of uncertainty (related to the malaria model / climate model / emissions scenario). The details can be seen in D4.1b which is restricted as it has been recently submitted for publication.

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5. Integrated decision-support systems for the three pilot projects

5.1 Development of integrated information and decision support systems

Two critically important aspects of the work done by and in conjunction with African partners were the provision of knowledge and feedback on the applicability of the climate-disease model outputs to health professionals and decision-makers on the ground, and the supply of location-specific data to enable the models to reflect conditions in the target regions in effective ways. Effective methods of stakeholder dialogue designed to learn more about the needs of African decision-makers were important in construction of an effective spatial decision-support system (SDSS). This, along with information systems (IS) and monitoring tools (MT) comprise the multi-agency system (MAS) that is a core achievement of QWeCI. The MAS processes information from climate and disease model outputs and combines these with environmental information specific to the target locality. It can then enable environmental and climate predictors to be expressed in terms of disease outbreak risk for defined periods and areas. The decision support systems pull together much of the effort made in the other work packages and allow it to be used by project partners and other interested users http://qweci.uni-koeln.de/. This system represents a major legacy of the project, along with the atmospheric database, as it allows users to upload their own data and run all of the major models from the project including LMM and VECTRI. In addition, exemplary model runs are available from the statistical RVF model for Senegal can be accessed. The operational forecasts although are much more computationally intensive and are supported elsewhere as described in 4.1. The ability for researchers and decision makers in region to run the system is important as the outputs of climate-disease models predict the conditions in which vector-borne diseases can be expected to become prominent. For example an outbreak might be anticipated if optimum temperature and rainfall occur in a specific area. Data on local environmental and socio-economic conditions are thus a key part of a predictive tool, and clear, user-oriented information is fundamental to the facilitation of decision-making by health professionals.

Monitoring tools contain the tools necessary for maintaining observations of particular variables, e.g. a IS for standing water was constructed for Barkedji. Information systems are essentially data banks that are specific to a particular function. An IS developed by the Malawi Ministry of Health is also linked to this website. It provides disease reports and data, an archive of disease incidence data, graphics of disease time-series data, the ability to map disease incidence using GIS calculations of disease outbreak indicators. It can support early warning of disease outbreaks, evaluation of the impact of controls and interventions for disease outbreaks. As well as the assessment of the health value of training and outreach programmes, and reports and analyses on disease incidence.

From the beginning, QWeCI objectives for ease of use and flexibility necessitated the use of Java, Linux, Apache Tomcat, and the Google Web Toolkit to ensure open-access knowledge distribution and flexibility in setting up different interrogation systems. Our key priorities were functionality of monitoring and early detection. We used the LMM as a demonstration pilot system for the early MAS, and used remotely sensed satellite imagery to support an IS for standing water in Senegal. Meteorological and health statistics data were built into the MT for near-real time disease incidence in Malawi. Constructive dialogue with stakeholders helped the project make the SDSS, IS and MT systems of the MAS meaningful to end users in the three pilot areas in Ghana, Senegal and Malawi. We developed a statistical RVF model to identify environmental variables in relation to disease outbreaks.

We built a system that used local parameter settings for pilot regions, e.g. a rural area of Kumasi. This enables users to access the system to predict past epidemics for specific locations using hindcast data. In future regional parameter settings could feed into the LMM and VECTRI operational systems for the construction of regional forecasts. A web-based RVF model responding to bi-weekly temperature, humidity, vegetation and rainfall data was developed for the disease operation system. By default, the model is tailored to Barkedji data to give examples of inputs and outputs. Outputs are for temporal predictions for specific areas and landscape types.

We validated the seamless malaria forecast system by incorporation and testing of a suite of data and models from Kumasi, Ghana. We used observational and simulated data converted by downscaling (work package 3.1) to be locally applicable using ECMWF System4, running LMM and VECTRI to make seamless forecasts and malaria control runs. We set up a Multi Agency System (D5.1.b) comprising LMM, VECTRI, the pond IS for Barkedji, the statistical RVF for Senegal and a Health Early Warning system for Kumasi to include meteorological, entomological and human biting rate data alongside other malaria variables. This system is an IS on the web-based Java framework. With the support of the French Space Agency, we made updates with regard to the monitoring of ponds for standing water by improving the algorithm that controls water body detection from radar satellite data. We also made clarifications to the understanding and functionality of the IS for standing water, and provided data and equations for relationships such as depth to volume, depth to area and volume to area for compatibility with the LMM within the MT

5.2. Ghana pilot project: peri-urban malaria

In the three countries chosen to contain the target areas for field pilot studies, a main priority was to collect data where none or insufficient existed, and to relate these to both the requirements of the climate-disease models and decision-support systems and the environmental realities of disease and vector dynamics in the target areas.

In Kumasi, Ghana we built on some capacity developed during FP6 AMMA. The effectiveness of climate-disease models depends on good understanding of the cumulative effects of weather conditions on each stage of mosquito life cycles. We made detailed measurements of pond dynamics and vector life-cycles, which provided important data for the multi-agent models. Temperatures of water and air were measured at different times of day in peri-urban areas of Kumasi. Correlations revealed the close predictive connection between maximum daily air temperatures to midday pond water temperatures, which is an important predictor of larval development.

Field studies of entomological and environmental variables included the identification of *Plasmodium* species, collection of health laboratory data, and identification of high-risk homes and areas. The data were used to equip studies with definitive knowledge about disease risk in the specific target areas. Interpretation of the impacts of climate variability, e.g. rainfall patterns, temperature and relative humidity, when human and environmental factors such as land use, land use change, vegetation cover, topography, buildings and road construction projects are accounted for, revealed that malaria prevalence correlated well with climatic conditions. In particular there is a general increase in malaria with rainfall and a decrease when the rains cease. We analysed climate, malaria and entomological data from hospitals and all study sites and weather stations. Malaria data from the different health facilities in Ghana has culminated in a good database for the pilot area. Analysis has shown a correlation during the study period between increased rainfall and malaria incidence. Monthly data (1980 – present) from four meteorological stations in Kumasi has been plotted and correlated with malaria data.

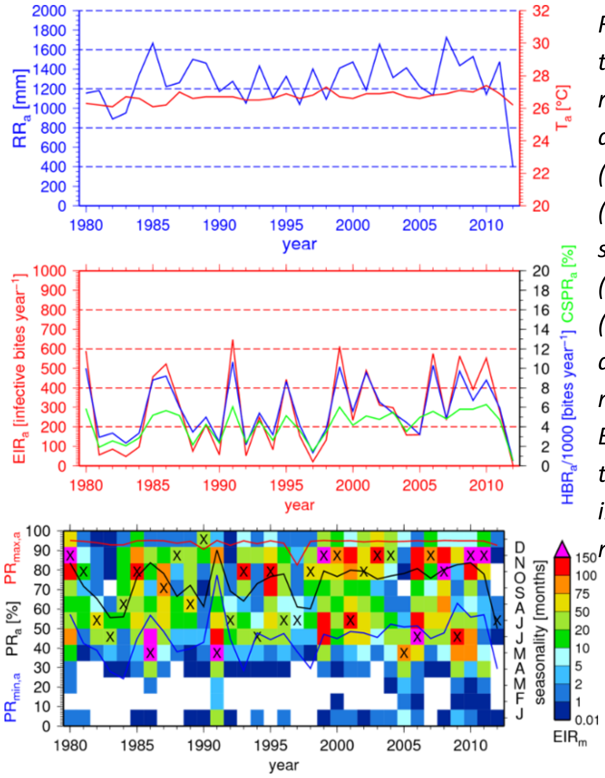


Figure 13: The inter-annual variability of rainfall, temperature with the simulated inter-annual malaria transmission and asexual parasite ratio between 1980 and 2012 for Kumasi using LMM. The top panel annual rainfall (RRa; in mm; blue line) and annual mean temperature (Ta; in °C; red line). Middle: Annual Entomological Inoculation Rate (EIRa; red line), annual Human Biting Rate (HBRa; blue line; right scale divided by 1000), and annual CircumSporozoite Protein Rate (CSPRa; in %; green line). Bottom panel: Annual mean parasite ratio (PRa; in %; black line), the annual minimum (PRmin,a; in %; blue line) and annual maximum (PRmax,a; in %; red line) of the parasite. The malaria seasonality (right scale; in month). The monthly Entomological Inoculation Rate (coloured squares) of month when the monthly Entomological Inoculation Rate reaches at least 0.01 infectious mosquito bites per human per month. The month with the maximum transmission is marked via an "X".

5.3 Senegal pilot project: RVF and malaria

After agreement with stakeholders on the data collection strategy, we made detailed characterisations of pond dynamics in relation to rainfall, ecology of the vectors of malaria and RVF, and pathogens for three rainy seasons, 2010-2012. We also made studies of biting rates and vector population dynamics in Barkedji. We used remotely sensed data for estimations of water body and land cover variables, and we installed and maintained automated weather stations. The 2011 rainy season in Senegal provided valuable data on the presence of ponds in relation to rainfall, the composition of anopheline species supported by them, the population dynamics, life-cycles and biting rates of malaria and RVF vectors, other vector survival factors, and host attractiveness. Analyses of the 2010 RVF outbreak in Mauritania were useful in verifying assumptions and understanding the evolution of the outbreak. We estimated the entomological parameters used in the LMM for six Senegalese villages having four different land-cover classes. This included inspecting female mosquitoes landing on people and those collected using pyrethrum spray in dwellings. We inspected the insects for blood meal, source of blood, presence of *Plasmodium*, and estimation of inoculation rate. We also carried out transmission experiments on field-collected RVF vectors to determine their role in the infection cycle. Further data on rainfall, pond size, position and longevity, and comparison with vector life-cycles has revealed important pathogen survival indicators, and studies at daily frequencies on interactions between mosquitoes and human communities has provided valuable data for the malaria database. We have correlated these with climate variables. Data on species assemblages, biting rates and the proportion of infected bites per person per year have shown that there is frequently twice the infection rate during the wet season than during the dry season, but this is dependent on the local environment.

We recorded four species of anopheline mosquito, mostly *A. gambiae*, and determined their biting rates. It was found that they increased and became more likely to bite as the rainy season progressed, though there was significant variation between villages. Blood meals were taken from human, bovine, ovine, chicken and equine hosts, with sheep and goats being the most favoured host. Statistical analyses were undertaken for population dynamics, the attraction of vectors to the main hosts, frequency of different vector (*Anopheles* mosquito species complexes) around temporary pools. Infection experiments, (within the national malaria programme's studies) showed that vectors differ in their ability to infect in the weeks following the meal. By integrating different datasets we facilitated more detailed and meaningful interpretation of the data based on the needs of decision-makers, stakeholders and end-users. We established the seasonal patterns of vector population dynamics and estimated the likelihood of infection according to land use, e.g. villages in shrubby savannah suffer less compared with villages in wooded savannah.

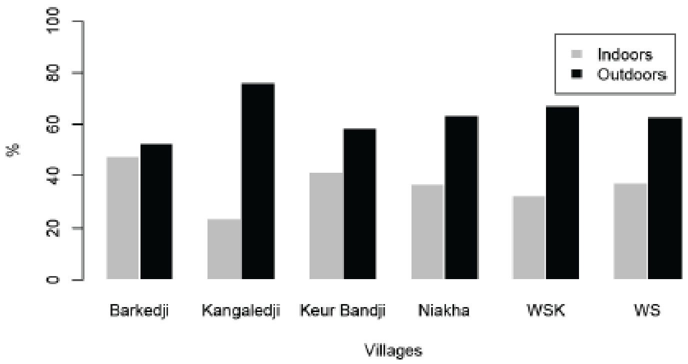


Figure 14. The proportion of mosquitoes found to feed indoors and outdoors at six villages in the Barkedji district.

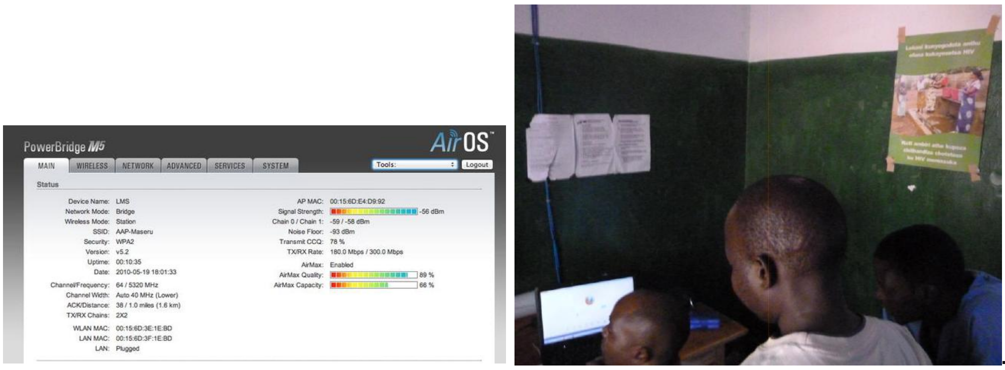
We completed the GIS Health Early Warning System. We also validated the LMM for Senegal, and developed a refined version of the MAS for RVF. We have also used CMIP-5 climate model data for climate change projections to predict RVF emergence in Senegal river basins.

We have achieved a greater level of understanding of the emergence of RVF in West Africa because the dynamics of malaria and vector populations are now much better understood.

5.4 Malawi pilot project: disease risk dissemination by long-range WiFi technology

Problems with the WiFi network dominated the early part of work in the Malawi pilot project. Civil unrest and hardware problems both posed considerable difficulties for the pilot project in Malawi. Monitoring of the link performance involved developing a program to monitor throughput and 'latency', confirm the quality of received information at specific times, and save the results in a log file. This was installed at Malawi Polytechnic, with receiving servers at Zomba Peak and Mangochi tower. Throughput was acceptable or good, and information losses were compatible with the length of the link (160 km), and at around 1 Mb per second was sufficient for data transfer, e-mail and web browsing with only intermittent episodes of quality loss, but the quality (RTT) was not sufficient for a video call but often sufficient for audio. Installation of a photovoltaic source would solve issues of power failures that affect the country.

Identification of suitable health facilities in the field, and developing collaborations with the Malawi Ministry of Health, the Malawi Meteorological Service and NGOs, e.g. Baobab, were crucial early steps in order to secure access to data and better understand the needs of stakeholders. Consultations with government offices and NGOs determined the forecasting system needed for the pilot areas of Malawi. Eventually, working and stable links were made between the St. Martin's Clinic on the eastern shore of Lake Malawi in an isolated rural location and Mangochi district hospital and a central database in Blantyre in a demonstration project. This showed how point to point wireless technology could enable isolated clinics to access the new DHIS2 web-based health database of the ministry of health, enabling near real-time uploading of disease incidence data. In addition the link is of sufficient band-width to allow interrogation of the web-based pilot forecast system. A complementary outcome of the system is that health workers in the rural clinic can now consult with medical specialists based in district hospitals using e.g. SKYPE via the system. Once the operational criteria were established and confirmed, health and science personnel were able to upload disease incidence data to the national database. Integrated climate-disease forecasting using VECTRI is under evaluation for Malawi with the aim of an operational uptake of the system during 2014.



a) b)

Figure 15. a) Diagnostics from the long-range WiFi system b) Health technicians at St Martin's Hospital with the new installed WiFi link. Although they had laptops previously they had to drive an hour to the nearest Cybercafé to send an email.

6. Dissemination, training and assessment

Regular and constructive communications between partners and stakeholders were vital to the successful completion of the project, but it was also important to publish QWeCI results in the peer-reviewed literature and to present them at international scientific meetings and conferences. A full programme of visits in both directions between African and European partner institutions was complemented by staff and student placements and tele-conferences. Disseminating the findings and outputs of the project in clearly understood ways involved workshops and training seminars for local stakeholders, NGOs and governmental agencies.

6.1 Targeted training and exchange visits

Many partner to partner visits were made through the project, often supplemented by frequent and extensive teleconferencing, using Skype, which tended to replace focus groups where it was found to be more efficient. These Skype meetings have become an essential monitoring and networking tool for the Senegalese, Ghanaian and Malawian project teams.

Scheduled project meetings were augmented by attendance of QWeCI partners at scientific conferences including the European Geosciences Union meeting (Vienna), where a QWeCI-organised plenary session on climate and health was held, as well as several fringe meetings to discuss progress on project objectives.

Exchange visits between core European partners and the main Africa partner proceeded successfully, and African partners spent time at European institutions. Two colleagues from KNUST spent 3 and 6 months at ICTP, and colleagues from UNIMA attended workshops and spent longer periods at European institutions. Two students from UP and staff from CSE, UCAD and ILRI visited UNILIV. The resulting scientific relationships are expected to be supported for much longer than the QWeCI project itself, and these are important achievements in the development of the science and collaborations between institutions.

6.2 Workshops and dissemination

QWeCI websites at UNILIV, ICTP, UoC and ECMWF were linked to provide updated information to partners and stakeholders. The main website is at the coordinator's institute the University of Liverpool.

A workshop was held at the Malawi Meteorological Service in Blantyre and at the Ministry of Health in Lilongwe , Malawi, and a second workshop at Dakar, Senegal involved international partners and major Senegalese stakeholders including policy-makers and NGOs. A bi-lingual brochure was produced and distributed in paper and electronic versions to all partners, and at international climate meetings attended by QWeCI partners.

A symposium was held at ICTP in September 2011 which included a workshop for young scientists from around the world with many attending from Africa and a number of these from QWeCI partners. The workshop had a strong climate and health theme and included hands on session with the Liverpool Malaria Model (LMM) within newly developed interface the Disease Modelling Cradle (DMC). This was used by as a training session and a feedback development session on the model and its interface. A workshop was held in Dakar in November 2011 running LMM-DMC with a range of stakeholders and decision makers, again valuable feedback was gained and a number of delegates installed a copy on their laptops. Some continued to work with the model in the subsequent months. During the October 2012 QWeCI annual meeting in Nairobi, we made LMM-DMC available for download. A further unscheduled training event was held at ICTP in April 2013 which provided further opportunities for training in the use of climate-health tools developed within QWeCI.

Newsletters and reports were published according to the project schedule, and additional relevant information, e.g. on the Healthy Futures project, were disseminated to stakeholders as they arose.

A joint QWeCI-Healthy Futures symposium was held during the 4th Annual East African Health & Scientific Conference, Kigali, Rwanda, fulfilling the scheduled D6.2f symposium, originally scheduled for Pretoria. The side meeting was well attended and had some prestigious keynote speakers from outside the two projects. Further it was the first meeting of the two projects and knowledge of QWeCI was taken up by the East African delegates. We organised a School on Modelling Tools and Capacity Building in Climate and Public Health in 2013 at ICTP, Trieste, with around 40 attendees from developing countries and staff and students from QWeCI partners. A web site for the workshop is available (http://cdsagenda5.ictp.trieste.it/full_display.php?smr=0&ida=a12175).

Partners have attended and given talks and posters at many conferences including the Open Science Meeting of the WMO World Climate Research Programme, 2011, EGU including our own QWeCI-HealthyFutures session in 2012. QWeCI was represented at the 4th International AMMA conference in July 2012. More recently we gave four papers at the 2013 African Climate Conference (http://www.climdev-africa.org/acc2013) Arusha, Tanzania and two papers and ran two sessions for the Africa 2013 Ecohealth in Côte d'Ivoire (1st African Regional Conference of the International Association on Ecology and Health and Second African meeting of researchers in ecosystem and human health approach, http://www.csrs.ch/Africa2013/eng/index.php). QWeCI researchers also attended the international climate impacts conference in Potsdam in June 2013.

We have produced the twice annual newsletters that include information about the project and its partners and the non-technical summary for end-users.

6.3 Quantification and assessment of pilot projects

Discussions in Senegal with the National Malaria Control Program and Directorate of Veterinary Services revealed that stakeholders expected QWeCI to produce a functional dynamic modelling system with the ability to monitor and predict malaria outbreaks, identify the key factors behind transmission, and develop methods of predicting emergence of the RVF virus several weeks before an outbreak. The project has produced an operational system for malaria prediction that works for regions where the seasonal forecasts are reliable (good) enough to drive the malaria models. For RVF much progress has been made but we have found that in West Africa the outbreaks are related to late intense rainfall events that are difficult to predict more than a few days in advance.

The scientific progress made during QWeCI has indeed contributed towards a functioning easy to use, predictive system. Data for vector-relevant environmental criteria collected in the field can be mapped and supplied to scientists and decision-makers with access to modelling tools, and disseminated to health professional through meetings and publications alongside the materials needed to intervene in disease evolution. In summary D6.3a reflected after compiling information about the three pilot studies with the following suggestions. Regarding (a) continuing and/or extending existing pilot projects and (b) identifying potential regions and countries in which products and project technology could be beneficial, the results of the pilots in Ghana, Senegal and Malawi suggest the following factors should be considered when considering the feasibility of further projects: *Technical*: is the project technically possible? Will the model work well enough to deliver expected health impacts? What initial analysis can be done to identify candidate regions? How will the results be disseminated and what actions will be taken? Is it advisable to focus on one region in depth, or to attempt to diversify the project across multiple regions? *Economic*: what are the costs and can the impacts on health be quantified? Who will fund the feasibility study? Who will fund ongoing operational use? How will the impacts be quantified and monitored? What hardware is needed (weather stations, networks, etc.), costs, ongoing maintenance, etc. Technology support for example sources of data and costs: meteorological, entomological, other. *Legal*: what are the legal, ethical, IP issues, etc. Consider limitations if human net landing catch method for mosquitoes is not allowed for ethical reasons, i.e. additional costs/resources for other methods, limitation of data accuracy via other methods. *Organisational*: which organisations are involved and will they provide the resources and accept the changes needed? Identify the stakeholders in the region (local, regional and national government, healthcare, etc.). Early engagement of the stakeholders is recommended, e.g. running workshops illustrating possible products. Who is authorising the project? Who will run the models, validate and disseminate the results on an ongoing basis? - are there junior staff members who can respond to day-to-day project needs? Skills/capabilities/resources gap analysis. Who will take action when the results are disseminated? *Scheduling:* can the project be completed in an acceptable timescale? Is the country susceptible to political instability? Do the project goals overly rely on one academic or is expertise spread across a large team? *Longer term legacy*: Does the project have longevity post-funding? Does the project provide sufficient capacity building to ensure maintenance of hardware and software systems and databases post-project? Do the goals of the project lead to operational systems that will require additional funding for their maintenance? What are the general prospects to gain funding from alternative sources post-project?

The QWeCI project involved a wide ranging set of research goals in a possibly unprecedented project in terms of its complexity, since some of the research goals were specifically written with operational forecasting products in mind for the post-project legacy. In addition, the platform of research involved three specific and disparate and geographically distinct pilot projects in three regions of Africa, each with very different goals and challenges. While problems and delays were experienced in all three pilot projects, it is notably that all deliverable targets in terms of research were met within the project. This report has attempted to summarize the causes for the delays, the contingency actions that were taken to address them and the general experience from each pilot in order to guide future project developments that involve similarly ambitious targets.

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7. Management

The overall management of QWeCI has gone smoothly, and the internal and external reporting, the meetings and visits programme, internal and external communications, budgetary control, and delivery of milestones and deliverables have mostly proceeded as foreseen in the planning stages of the project. Where deviations have occurred, these have been due to improved efficiencies, e.g. automation of data gathering for the initial database compilation, or to circumstances beyond the control of the project. Examples of the latter include political unrest in Malawi.

Project meetings:
QWeCI kick-off meeting – UNILIV, Liverpool June 2010;
Annual QWeCI meeting – Dakar, January 2011;
Annual QWeCI meeting – ICTP, Trieste September 2011;
International Workshop for End Users – CSE, Dakar November 2011;
Annual QWeCI meeting – ILRI, Nairobi, October 2012;
Final QWeCI Meeting – IC3 and UNILIV, Barcelona, May 2013
Numerous local workshops;

Other project management tasks included:
Regular weekly email updates to all partners; sending out partner report, dissemination and publication templates for all of reporting rounds.

QWeCI did have ethical review and approval from the University of Liverpool Ethics Committee RETH000378. This review was part of the project contracting process with the EC. The review permitted for the use of data from other in-region national surveillance and monitoring programmes that had their own national ethical and ministerial approval. Anonymous patient records from hospitals in Ghana, which were covered by project and local ethical approval and for which patients had provided informed consent, were made available. All other original data used by QWeCI was from mosquitoes caught and any indoor spraying programmes had informed consent from residents. Ethics was a standing item reported at project management meetings.

The potential impact, the main dissemination activities, and exploitation of results

Reference is made to the key points of the original impacts and dissemination statements from the original Description of Work. As the QWeCI project was about impacts and dissemination much of the details and highlights has already been reported above, here we try and reflect more broadly on the aspects of impacts and dissemination within the project.

Contribution of the projected to the expected impacts listed in the work programme

The impacts of climate on diseases has a profound influence on societies in Africa through the deaths of millions of people, often children, each year and through the associated effects on development and economies through the debilitation of adults who thus become economically under-active and through drains on already under-resourced public health systems. Therefore, QWeCI helped to provide the best possible climate information integrated with disease models across a range of time scales to allow better planning and to assist in the operational provision to help fight a range of infectious diseases in Africa.

QWeCI developed an effective knowledge exchange programme which was coupled with the development of decision support systems to maximize the impacts of the research outcomes on societies in Africa. QWeCI is a research project but the legacy of QWeCI will be the continued use of the integrated systems produced within the project in the countries where they are developed and the uptake of the systems, that will be flexible for modification, for use elsewhere in other regions and countries in Africa and beyond for regions that have a high burden of climate-driven infectious diseases.

- **Develop methods for the quantification of the direct and indirect impacts of climate and weather of various health outcomes in low income regions:**

The EID2 database is an output of major importance to research involving diseases of humans and livestock. We built the EID2 using quality-checked automated searches from on-line databases to contain information of the pathogens, vectors, hosts and diseases of most importance to human societies, including thousands of pathogens and 50 host species, as well as details of spatial and temporal distributions from 20 million publications. The database matches these distributions against known climate patterns globally. We developed a new algorithm for simulating the distribution of any pathogen or disease based on climate and other environmental drivers. This method is applicable to current or projected future distributions of pathogens and diseases. The modelling tool, including the R-code, is available for research by others, enabling research groups in related fields, such as climate-disease modellers, to obtain best-fit models and automatic generation of model outputs. This will have further useful application as a comparator in testing other modelling techniques.

- **Prioritisation of the health impacts from the viewpoint of their magnitude and graveness:**

We elaborated the non-climate drivers of importance to the occurrence of vector-borne diseases, e.g. socio-economic drivers such as demography, infection control measures, drug and vector resistance to insecticides, and we wrote a report (D1.3.a) that reviews the relationships between climate and disease for the use of governments and other professionals (e.g. NGOs) in planning of responses to disease outbreaks associated with environmental conditions. We wrote a literature review on climate-influenced infectious diseases specifically aimed at the QWeCI target countries Senegal, Ghana and Malawi plus South Africa. We documented the climate drivers for Rift Valley fever (RVF) and developed a demonstration of a 'early warning' system for the disease in Senegal.

The development of the Disease Model Cradle represents a significant step forward in making disease prediction accessible, and particularly flexible enough to be useful for research and health professionals who work remotely. The availability on-line of climate-disease models developed as part of QWeCI constitutes an important advance for health research and planning. These include the open-source VECTRI malaria model (http://users.ictp.it/~tompkins/vectri/), the QWeCI multi agent system (http://qweci.uni-koeln.de/), the Liverpool Malaria Model, and RVF models. These are available on the QWeCI website (http://www.liv.ac.uk/qweci/project_outputs).

Four new QWeCI malaria models, including two dynamic models (UOC-ICTP, IC3), a statistical model (IC3-ICTP), and a rules-based model (UP) are important contributions to the science and management of malaria. We also developed a new dynamic RVF model (UNILIV) and a new statistical RVF model (CSE-IPD-UCAD), which break new ground for research into RVF prediction and management.

We achieved the first-ever analysis of forecast quality for Africa on a decadal time-frame. We established and quantified the advantages of combining dynamical and statistical models for climate variability on interannual and decadal projections for Africa. We provided several peer-reviewed articles in the scientific literature, some of which have been scheduled for inclusion in the forthcoming IPCC report. There has been additional interest on economic grounds from the renewable-energy sector.

The IGBP/DIVERSITAS/IHDP/WCRP and the ESSP Planet Under Pressure 2012 meeting, the largest gathering of global change scientists leading up to the United Nations Conference on Sustainable Development (Rio+20) with a total of 3,018 delegates at the conference venue and over 3,500 that attended virtually via live web streaming. This provided scientific leadership to the 2012 UN Conference on Sustainable Development – Rio 20+ in London July 2012, where Morse co-convened a session and co-authored a briefing paper 'Global health for a planet under pressure' http://www.icsu.org/rio20/policy-briefs/Health_LR.pdf.

- **Test on case studies in at least three different countries:**

QWeCI enabled three pilot projects in Africa based in Ghana, Senegal and Malawi. QWeCI invoked a "bottom-up" approach whereby each pilot projects takes advantage of local expertise and scientific knowledge and stakeholder connections to focus on a new scientific frontier or dissemination technology. Therefore, while all projects involve the analysis, monitoring and predictions of climate impacts on malaria, a major health concern, the Senegal project uses a well-established field-site research programme to extend the dynamic disease models to other vector diseases such as RVF, the Ghana project tackles the scientific shortfall in our knowledge required to tackle climate-disease impacts in a peri-urban environment, and the Malawi project couples health and information technology scientific expertise to monitor disease and evaluate health forecast dissemination procedures to remote end-users for the first time in an African setting. A significant impact was made in terms of knowledge exchange in Ghana by the use of workshops in several hospitals. Quantification of the factors of transmission in the study area was an important achievement. In Senegal the project supported six Master's theses and potentially six PhD theses. The project has made a significant impact on reducing the vulnerability of people to both malaria and RVF in Senegal. This has been achieved by active networking and engagement with health professionals and government agencies. The successful electronic communication of malaria and other medical data is a significant advance on the former system, which used paper and the mail service to link distributed medical facilities to the central hospital data centres. Data can now flow to the central college of medicine in Blantyre, and telemedicine applications be distributed to health professionals at two health centres in the Mangochi district.

- **Effective transfer and use of the research results to be ensured by users and stakeholders in the project:**

The project created the first operational malaria seasonal forecast for Africa, and estimated the combined impacts of climate change and population change on the transmission of malaria in Africa and globally. This was achieved by completion of a large inter-comparison exercise of multiple malaria models. The models revealed an increase in malaria risk, largely as a result of population growth, an increase in malaria transmission over high areas of Africa such as the east African highlands, central Angola and the plateaux of Madagascar, a projected southward shift of the malaria epidemic belt over the Sahel, and a corresponding decrease in malaria transmission over the northern Sahel.

We made great inroads into improving the dialogue between academics, health and governmental stakeholders, and also accumulating data on the conditions in which vectors become infective. We expect a strong socio-economic impact for the malaria seasonal forecasts provided stakeholder confidence in the predictive skill of the model outputs can be maintained.

- **Steps taken to bring about the impacts**

Stakeholder interaction with the project was crucial to achieving the roll out of the systems produced in the project and for them to have any impacts in reducing the incidence of infectious diseases by using forward planning and early warnings based in skilful predictions. The project utilised contacts with key stakeholders in Senegal as sub-contracted participants within the project such as PNLP (the Senegal national programme for malaria control who are part of the Ministry of Health) and DIREL (the National Livestock Service, for RVF), in Ghana – KNUST have established working contacts with the Ghana Ministry of Health, the Ghana Health Service (at regional and district levels), and the National Malaria Control Programme in Ghana, further there are strong links to the Ghana National Meteorological Service. In Malawi UNIMA have long established connections with the Malawi Ministry of Health and have been involved in the development of a Health Management Information Systems.

Partners in the project are engaged in policy and research agenda activities that will allow the impact of the project to be communicated to a wider and influential audience e.g. Professor Andy Morse sits on the Earth System Science Partnership's Global Environmental Change and Human Health (GEC&HH) joint project and through the project on the WMO World Climate Research Programme's (WCRP) CLIVAR committees the Working Group on Seasonal to Interannual Prediction (WGSIP) and the panel on Variability of the African Climate System. Professor Morse has now rotated off the WCRP and CLIVAR panels and has been replaced on the WCRP WGSIP panel by Dr Tompkins which will ensure the high level connections of the legacy of the QWeCI project. This project has become an ESSP GEC&HH collaborative project and has the endorsement of that joint project. Professor Morse maintained links with ESSP and its associate programmes especially the WMO WCRP. He will also maintain contact through WMO's World Weather Research Programme (WWRP) especially THORPEX and THORPEX-Africa. Professor Morse is currently seeking connection to the new formed WMO/WHO ClimHealth initiative.

- **The need for a European and International approach**

The research was too complex for one country to undertake alone and thus brought together the best groups in Europe with experience in climate and impacts especially health and with a strong African involvement which was crucial to the success of the project. The project brought back together a core group of partners in both EU and Africa who had worked on previous programmes such as the EU FP6 projects AMMA and ENSEMBLES.

The societal implications of the work undertaken in QWeCI are extremely important and wide ranging. The diseases found in Africa have a habit of emerging in Europe, and this threat may become more important in future warmer climate. The most recent example being blue tongue, that has economic impacts on European livestock. This has raised important concerns that other vector-borne diseases could appear in Europe. These diseases could emerge being transmitted by currently widely spread, related but 'unforeseen' vectors or with climate change, the more established warmer climate vectors of these diseases.

- **Interaction of QWeCI with other research initiatives and programmes in Africa**

Africa is an important region for studying climate impacts on human health and animal health, for at least two reasons: (i) while inhabitants are poor in general, rural conditions render them extremely sensitive to environmental changes and associated risks including exposure to diseases and epidemics; (ii) Africa is also a delicate balance between climate and environmental variability, water resources, mosquito density, agricultural and pastoral outputs and the quality of life. QWeCI contributed to an emergence of expertise on Environment-Health issues at national and regional levels; as can be seen in its input to various major research meetings and conferences within Africa. QWeCI has benefited from AMMA, ENSEMBLES, EDEN, IMPETUS and other former EU projects.

During the QWeCI project UCAD and CSE also belonged to AMMA Africa and AMMANet. Professor Amadou Th. GAYE was the co-chair of AMMANet and Dr Jacques André NDIONE was the co-coordinator of AMMA Africa Health impacts WP. ILRI were partners in AVID RVF a project funded by a google.org Predict and Prevent Programme and this complements the activity in QWeCI and it is the programme that is funding the RVF activity at ILRI. ILRI were partners in AVID RVF a project funded by a google.org Predict and Prevent Programme and this complements the activity in QWeCI and it is the programme that is funding the RVF activity at ILRI. ILRI were also involved in the Global Environment Fund (GEF) funded project entitled 'Sustainable management of globally significant endemic ruminant livestock of West Africa'.

- **Interaction of QWeCI with other research initiatives and programmers within EU and Internationally**

As mentioned elsewhere QWeCI came out of the successful intersection between EU FP6 ENSEMBLES and AMMA project and the German funded IMPETUS project that was allied to AMMA.

The QWeCI project brought in connections with IPCC AR4 Health Impacts and the extension of the impacts work into decadal scales was particularly important to the forthcoming Fifth Assessment Report.

QWeCI became the sister project to FP7 HEALTHYFUTURES. The projects share three partners (UNILIV, ICTP and ILRI) and this has allowed a flow of ideas between the two projects. HEALTHYFUTURES is based in East Africa and initially focussed on climate change time scales and infectious disease. It made it an ideal partner project for QWeCI based in West and southern Africa with a focus on seasonal to decadal time scales. What has occurred is that ideas and climate data sets have been used to broaden the scope of both projects without compromising the original research plans.

The project grew strong ties with the ENHanCE project "Risk assessment of the impact of climate change on human health and well-being" (funded from a call under the ERA-ENVHEALTH project). It was coordinated by UNILIV Baylis/Morse and was relating infectious diseases to climate change in Western Europe through the use of the host-pathogen-vector database at Liverpool. There was a continuous exchange of ideas between the two projects. The project started in April 2009 so it was established ahead of QWeCI which allowed knowledge developed in the ERA-NET project to be shared with QWeCI.

IRLI were partners within the Environment Ontology (EnvO) Consortium. They supported the ILRI RVF and other projects providing help with data descriptors for complex databases. QWeCI was able to interact with these groups as the need arose.

Dissemination

Following some of the major heading in the Description of Work the following section describe some of the dissemination activities of the project

- **Data Management**

External data providers did impose restrictions on access to their data but it did not restrict the delivery of aspects of the project which depend on use of these data. The development of the databases generated in the project, the EID2 disease database in Liverpool and the Atmospheric Database in Cologne are hosted on publically facing websites. Both are open to bone fide researchers and much of the atmospheric database is freely open to the public. The main project website www.liv.ac.uk/qweci has copies of all the public Deliverables and Milestones and will be maintained. As additional Deliverables that are currently restricted become public, they will be added to the website. The main reason for their current restricted status is that the results are being or have been submitted for publication and once the papers are accepted the reports can be made public.

UoC's QWeCI web portal is used to disseminate the data sets. Data sets generated by the QWeCI project were transferred to the AMMA database.

- **Model output management**

Significant infrastructure and software and know-how to access data from the climate and weather model databases reside in the project. A number of the relevant scripts and know-how have been be passed on to partners especially to those from ICPCs so that they can become full users of the databases The partners running the disease models also have databases to store model output. These model runs are available on request but server capacity does not allow them to be fully available to the public. The ISI-MIP multiple malaria model runs with the CMIP5 selected GCMs with a range of RCPs are going to be made available for the global runs through the ISI-MIP data archive (http://www.pik-potsdam.de/research/climate-impacts-and-vulnerabilities/research/rd2-cross-cutting-activities/isi-mip).

- **Dissemination Activity**

The project has produced 29 peer reviewed papers (8 in Open Access) so far, and a number of the papers have been used in the forthcoming IPCC Fourth Assessment Report. The journals the papers are published are top ranked and leaders in their field e.g. Nature Climate Change, Nature Communications, Environmental Health Perspectives, Journal of Climate, Climate Dynamics, Malaria Journal, Journal of Geophysical Research, Geophysical Research Letters, Quarterly Journal of the Royal Meteorological Society, Environmental Research Letters. QWeCI produced all of its 52 Deliverables (actually 59 documents with multiple newsletters and monitoring reports) and all 29 Milestones over the course of 42 months.

The atmospheric database was provided on hard disk to all African partners. The QWeCI atmospheric database was advertised by the QWeCI newsletter. The project has two dedicated dissemination work packages 6.1 *Training and exchange visits* and 6.2 *Workshops and dissemination.* As mentioned in detail in 6.2 QWeCI ran and had papers delivered at a number of workshops and conferences. Workshops were held at the Malawi Meteorological Service in Blantyre and at the Ministry of Health in Lilongwe, Malawi, and a second workshop at Dakar involved international partners and major Senegalese stakeholders including policy-makers and NGOs. A symposium was held at ICTP in September 2011 Summer School on Climate Impacts Modelling for Developing Countries: Water, Agriculture and Health which included a workshop for young scientists. A further workshop was held in Dakar in November 2011 running a PC-based installation of the Liverpool Malaria Model with a range of stakeholders and decision makers. A joint QWeCI-Healthy Futures symposium was held during the 4th Annual East African Health & Scientific Conference, Kigali, Rwanda, We organised a School on Modelling Tools and Capacity Building in Climate and Public Health in 2013, with around 40 attendees from developing countries and staff and students from QWeCI partners.

Project partners have attended and given talks and posters at many conferences including the Third International Space Applications conference, June, 2010, France; the conference "Modélisation Mathématique et informatique des Systèmes Complexes", CoMMISCO, October, 2010, France; Climate and Health in Africa 10 years on, Addis Ababa, April,2011; UNFCCC meeting EU side event Durban, South Africa, November 2011; Open Science Meeting of the WMO World Climate Research Programme, Denver, USA, 2011; EGU including our own QWeCI-HealthyFutures session in 2012. QWeCI was also represented at the 4th International AMMA conference in July 2012, France and the International Society for Neglected Tropical Diseases, October 2012, London. In Ghana, a Climate impact modelling course was organized for students, researcher and health practitioners where LMM was demonstrated. COPED Conference, Dakar, Nov 2012, a paper was given at IMPACTS World conference, Potsdam, September, 2013. More recently at the 2013 African Climate Conference , Arusha, Tanzania and the Africa 2013 Ecohealth Conference in Côte d'Ivoire.

A bi-lingual (English and French) brochure was produced and distributed in paper and electronic versions to all partners, and at international climate meetings attended by QWeCI partners.

Web versions of the malaria models can be used world-wide and are advertised via presentations. The operational malaria seasonal forecasts could be made publicly available or could become a standard product of the ECMWF. The last aspect would require work beyond QWeCI especially on forecast validation in different regions of Africa.

We are involved in the making of a film with the Africa Turns Green Partnership but this is not due for completion until Spring 2014.

- **Management of the Intellectual Property Rights**

Participants of QWeCI are governed by the Consortium Agreement and which is in line with standard protocols of ownership of knowledge and publication of scientific papers. QWeCI as anticipated did not develop any patents.

- **Contribution to Policy Developments**

QWeCI did not contain a direct policy makers training section. The QWeCI project did however interact with decision makers as well as the wider scientific community in its chosen regions in Africa and beyond. QWeCI developed strong connections with the Humanitarian Futures Project (http://www.humanitarianfutures.org/) and interacted with a number of major international NGOs.

Section A (public)

This section includes two templates

- Template A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.
- Template A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

These tables are cumulative, which means that they should always show all publications and activities from the beginning until after the end of the project. Updates are possible at any time.

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES

NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[1] (if available)	Is/Will open access[2] provided to this publication?
1	Decadal prediction skill in a multi-model ensemble	van Oldenborgh, G.J. Doblas-Reyes F.J. Wouters, B.	Climate Dynamics	Vol.38, Issue 7-8	Springer Verlag		01/04/2012	1263-1280		No

[1] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).
[2] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

		Hazeleger, W.								
2	Development of a new version of the Liverpool Malaria Model. I. Refining the parameter settings and mathematical formulation of basic processes based on a literature review	Ermert, V. Fink, A.H. Jones, A.E. Morse, A.P.	Malaria Journal	11/02/2011	BioMed Central	Great Britain	11/02/2011	35		Yes
3	Decadal climate prediction with the ECMWF coupled forecast system: Impact of ocean observations	Doblas-Reyes, F.J. Balmaseda, M.A., Weisheimer, A. Palmer, T.N.	Journal of Geophysical Research	Vol. 116, Issue D19, 16/10/2011	American Geophysical Union		16/10/2011	13		No
4	The Impact of Regional Climate Change on Malaria Risk due to Greenhouse Forcing and Land-Use Changes in Tropical Africa	Ermert, V. Fink, A.H. Morse, A.P. Paeth, H.	Environmental Health Perspectives	January 2012, Vol. 120, Issue 1	Public Health Services, US Dept of Health and Human Services	USA	07/09/2011	77-84		Yes
5	Retrospective prediction of the global warming slowdown in the past decade	Guemas, V. Doblas-Reyes, F.J. Andreu-Burillo, I. Asif, M.	Nature Climate Change	Apr-13	Nature Publishing Group		07/04/2013	5		No
6	On the assessment of near-surface global temperature and North Atlantic multi-decadal variability in the ENSEMBLES	García-Serrano, J. Doblas-Reyes, F.J.	Climate Dynamics	Vol. 39, Issue 7-8	Springer Verlag		01/10/2012	2025-2040		No

	decadal hindcast									
7	Development of a new version of the Liverpool Malaria Model. II. Calibration and validation for West Africa	Ermert, V. Fink, A.H. Jones, A.E. Morse, A.P.	Malaria Journal	16/03/2011	BioMed Central	Great Britain	16/03/2011	62		Yes
8	Sensitivity of decadal predictions to the initial atmospheric and oceanic perturbations	Du, H. Doblas-Reyes, F.J. García-Serrano, J. Guemas, V. Soufflet, Y. Wouters, B.	Climate Dynamics	Vol. 39, Issue 7-8	Springer Verlag		01/10/2012	2013-2023		No
9	Real-time multi-model decadal climate predictions	Smith D.M. Scaife, A.A. Boer, G.J. Caian, M. Doblas-Reyes, F.J. Guémas, V. Hawkins, E. Hazeleger, W. Hermanson, L. Ho, C.K. Ishii, M. Kharin, V. Kimoto, M. Kirtman, B. Lean, J. Matei, D. Merryfield,	Climate Dynamics	Dec-12	Springer Verlag		01/12/2012	14		No

		W.J. Müller, W.A. Pohlmann, H. Rosati, A. Wouters, B. Wyser, K.									
10	Malaria epidemics and the influence of the tropical South Atlantic on the Indian monsoon	Cash, B.A. Rodó, X. Ballester , J. Bouma, M.J. Dhiman, R. Pascual, M.	Nature Climate Change	Vol 3	Nature Publishing Group		03/03/2013	502-507		No	
11	Understanding Atlantic multi-decadal variability predictions skill	García-Serrano, J. Doblas-Reyes, F.J. Coelho, C.A.S.	Geophysical Research Letters	Vol. 39, Issue 18, September 2012	American Geophysical Union		26/09/2012	6		No	
12	Ultra-low clouds over the southern West African monsoon region	Knippertz, P. Fink, A.H. Schuster, R. Trentmann, J. Schrage, J.M. Yorke, C.	Geophysical Research Letters	November 2011, vol. 38, Issue 21	American Geophysical Union	USA	09/11/2011	L21808		No	
13	Identifying the causes of the poor decadal climate prediction skill over the North Pacific	Guemas, V. Doblas-Reyes, F.J. Lienert, F. Soufflet, Y.	Journal of Geophysical Research	Vol. 117, Issue D20, October 2012	American Geophysical Union		27/10/2012	17		No	

		Du, H.								
14	Multiyear climate predictions using two initialization strategies	Hazeleger, W. Guémas, V. Wouters, B. Corti, S. Andreu-Burillo, I. Doblas-Reyes, F.J. Wyser, K. Caian, M.	Geophysical Research Letters	Vol. 40, Issue 9, May 2013	American Geophysical Union		16/05/2013	1794-1798		No
15	A rainfall calibration methodology for impacts modelling based on spatial mapping	Di Giuseppe, F. Molteni, F. Tompkins, A.M.	Quarterly Journal of the Royal Meteorological Society	15/10/2012	John Wiley and Sons Ltd		15/10/2012	13		Yes
16	Useful decadal climate prediction at regional scales? A look at the ENSEMBLES stream 2 decadal hindcasts	Macleod, D.A. Caminade, C. Morse, A.P.	Environmental Research Letters	7 044012 (7pp)	Institute of Physics Publishing		18/10/2012	8		No
17	Dynamical downscaling of ECMWF Ensemble seasonal forecasts over East Africa with RegCM3	Diro, G.T. Tompkins, A.M. Bi, X.	Journal of Geophysical Research	in press	American Geophysical Union		02/07/2012	5		No
18	A regional-scale, high resolution dynamical malaria model that accounts for population density, climate and surface hydrology	Tompkins, A.M. Ermert, V.	Malaria Journal	Vol. 12,	BioMed Central		18/02/2013	24		Yes

19	Development of dynamical weather-disease models to project and forecast malaria in Africa	Ermert, V. Fink, A.H. Morse, A.P. Jones, A.E. Paeth, H. Di Giuseppe, F. Tompkins, A.M.	Malaria Journal	11/11/2012	BioMed Central	Great Britain	11/11/2012	133		Yes
20	The real time correction of ERA-Interim rainfall	Di Giuseppe, F. Dutra, E. Molteni, F.	Geophysical Research Letters	2013	American Geophysical Union		01/01/2013	20		No
21	Climate Change and Infectious diseases: Can we meet the needs for better prediction?	Rodó, X. Pascual, M. Doblas-Reyes, F.J. Gershunov, A. Stone, D.A. Giorgi, F. Hudson, P.J. Kinter, J. Rodríguez-Arias, M.-À. Stenseth, N.Ch. Alonso, D. Garcia, J. Dobson, A.P.	Climatic Change	Vol 118, Issue 3-4, June 2013	Springer Netherlands		01/06/2013	625-640		No
22	Dependence of the climate prediction skill on spatio-temporal scales: internal versus	Volpi, D. Doblas-Reyes, F.J.	Geophysical Research	Vol 40, issue 12, 28th June 2013	American Geophysical		12/06/2013	22		No

	radiatively-forced contributions	García-Serrano, J. Guemas V.	Letters		Union						
23	Decadal prediction of the West African monsoon	García-Serrano, J. Doblas-Reyes, F.J. Haarsma, R.J. Polo, I.	Journal of Geophysical Research	Jun-13	American Geophysical Union		10/06/2013	20		No	
24	Climate and health: Observation and modeling of malaria in the Ferlo (Senegal)	Diouf, I. Deme, A. Ndione, J-A. Gaye, A.T. Rodríguez-Fonseca, B. Cissé, M.	Comptes Rendus - Biologies	13/06/2013	Elsevier Masson SAS		13/06/2013	8		No	
25	The Indian Ocean: the region of highest skill worldwide in decadal climate prediction	Guemas, V. Corti, S. García-Serrano, J. Doblas-Reyes, F.J. Balmaseda, M.	Journal of Climate	Vol. 26, Issue 3	American Meteorological Society		01/02/2013	726-739		No	
26	Initialized near-term regional climate change prediction	Doblas-Reyes, F.J. Andreu-Burillo, I. Chikamoto, Y. García-Serrano, J.	Nature Communications	1.357638889	Nature Publishing Group		16/04/2013	9		Yes	

		Guemas, V. Kimoto, M. Mochizuki, T. Rodrigues, L.R. van Oldenborgh, G.J.								
27	Seasonal Predictability of Wintertime Precipitation in Europe Using the Snow Advance Index	Brands, S.Manzanas, R.Gutiérrez, J. M.	Journal of Climate	Volume 25, Issue 12, June 2012	American Meteorological Society		01/06/2012	4023-4028		No
28	Precipitation variability and trends in Ghana: An intercomparison of observational and reanalysis products	Manzanas, R. Amekudzi, L..K. Preko, K. Gutierrez, J.M.	Climatic Change	Feb-13	Springer Netherlands		01/02/2013	16		No
29	The correction of ERA-I rainfall and its benefit for ts modelling base	Di Giuseppe, F. Dutra, E.	Quarterly Journal of the Royal Meteorological Society	2013	John Wiley and Sons Ltd		01/01/2013	13		Yes

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
No.1	Type of activitiesOrganisation of Conference	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleModelling vector-borne diseases: approach and multi-view perspective	Date23/10/2012	PlaceDakar	Type of audienceScientific community (higher education, Research)	Size of audience30	Countries addressedSenegal
No.2	Type of activitiesOrganisation of Conference	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleObservation and modelisation of malaria in Ferlo (Senegal): prelimary results	Date31/10/2012	PlaceDakar	Type of audienceScientific community (higher education, Research) - Civil society - Policy makers - Medias	Size of audience100	Countries addressedSenegal
No.3	Type of activitiesOrganisation of Workshops	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleMonitoring the hydrological dynamics of ponds to control the environmental-depending disease: the ca	Date02/07/2012	PlaceDakar	Type of audienceScientific community (higher education, Research)	Size of audience150	Countries addressedSenegal
No.4	Type of activitiesOrganisation of Workshops	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleClimate variability and malaria incidence over Sahelian regions, case of Ferlo, Senegal	Date15/10/2012	PlaceSpain	Type of audienceScientific community (higher education, Research) - Civil society	Size of audience70	Countries addressedSpain
No.5	Type of activitiesExhibitions	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleClimate variability and malaria incidence over Sahelian regions, case of Ferlo, Senegal	Date05/06/2012	PlaceDakar	Type of audienceScientific community (higher education, Research) - Policy makers -	Size of audience100	Countries addressedSenegal

						Medias		
No.6	Type of activitiesOrganisation of Workshops	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleHEWS: perspectives from Local Early Warning System on agriculture in Kaffrine (Senegal)	Date09/06/2012	PlaceDakar	Type of audienceScientific community (higher education, Research) - Civil society - Policy makers - Medias	Size of audience100	Countries addressedSenegal
No.7	Type of activitiesOrganisation of Workshops	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleBridging health and climate knowledge in West Africa: case of Senegal	Date28/06/2012	PlaceBurkino Faso	Type of audienceScientific community (higher education, Research) - Civil society - Policy makers - Medias	Size of audience80	Countries addressedBurkino Faso
No.8	Type of activitiesOrganisation of Workshops	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleLa complu en la calle, Sciencias UCM	Date09/03/2013	PlacePlaza de Espana	Type of audienceScientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias	Size of audience100	Countries addressedSpain
No.9	Type of activitiesPresentations	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleThe QWECI Project	Date20/03/2013	PlaceSaint Louis	Type of audienceScientific community (higher education, Research)	Size of audience30	Countries addressedSenegal
No.10	Type of activitiesPresentations	Main leaderEUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	Title Using ECMWF long range forecasts for health applications: The prototype Malaria Early Warning Sys	Date11/10/2012	PlaceECMWF, Reading, UK	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience50	Countries addressedEurope, Africa

No.1 1	Type of activitiesOrganisation of Conference	Main leaderEUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	TitleThe skill of ECMWF long range Forecasting System to drive impact models for health and hydrology in	Date22/04/2012	PlaceVienna, Austria	Type of audienceScientific community (higher education, Research)	Size of audience40	Countries addressedEurope
No.1 2	Type of activitiesOrganisation of Conference	Main leaderEUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	TitleSystematic Errors in the ECMWF long range Forecasting System over Africa	Date23/04/2012	PlaceVienna, Austria	Type of audienceScientific community (higher education, Research)	Size of audience40	Countries addressedEurope
No.1 3	Type of activitiesOrganisation of Conference	Main leaderEUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	TitleA rainfall calibration methodology for impact modelling based on spatial mapping	Date23/04/2012	PlaceVienna Austria	Type of audienceScientific community (higher education, Research)	Size of audience40	Countries addressedEurope
No.1 4	Type of activitiesPresentations	Main leaderEUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	TitleECMWF forecast systems, spatial bias correction and the ERA reanalyses	Date05/09/2011	PlaceICTP, Trieste, Italy	Type of audienceScientific community (higher education, Research)	Size of audience40	Countries addressedAfrica
No.1 5	Type of activitiesPresentations	Main leaderEUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	TitleA Bias correction method for seamless precipitation forecast	Date14/09/2012	PlaceICTP, Trieste, Italy	Type of audienceScientific community (higher education, Research)	Size of audience40	Countries addressedEurope, Africa
No.1 6	Type of activitiesPresentations	Main leaderEUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	TitleA prototype Malaria Early Warning System (MEWS)	Date30/04/2013	PlaceKigali, Rwanda	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience40	Countries addressedAfrica
No.1 7	Type of activitiesOrganisation	Main leaderUNIVERSITAE	TitleRisikoabschätzung des Auftretens der	Date01/10/2010	PlaceAachen	Type of audienceScientifi	Size of audience20	Countries addressedGermany

	of Conference	T ZU KOELN	Malaria in Afrika unter dem Einfluss des beobachteten und proji			c community (higher education, Research)		
No.18	Type of activitiesOrganisation of Conference	Main leaderUNIVERSITAET ZU KOELN	TitleThe potential effects of climate change on malaria in tropical Africa using regionallised climate pr	Date24/04/2012	PlaceVienna, Austria	Type of audienceScientific community (higher education, Research)	Size of audience50	Countries addressedEurope
No.19	Type of activitiesPresentations	Main leaderUNIVERSITAET ZU KOELN	TitleAbschätzung des Einflusses des Klimawandels auf die Verbreitung der Malaria im tropischen Afrika	Date08/11/2011	PlaceKolloquiumsvortrag im Rahmen der Essener Klimagespräche (EKG)	Type of audienceScientific community (higher education, Research)	Size of audience20	Countries addressedGermany
No.20	Type of activitiesOrganisation of Conference	Main leaderUNIVERSITAET ZU KOELN	TitleThe potential effects of climate change on malaria in tropical Africa using regionallised climate pr	Date30/08/2012	PlaceCologne	Type of audienceScientific community (higher education, Research)	Size of audience20	Countries addressedWorld
No.21	Type of activitiesPresentations	Main leaderUNIVERSITAET ZU KOELN	TitleEnhancement to the LMM and ist application to determine malaria risk change due to changing climate	Date13/09/2011	PlaceTrieste, Italy	Type of audienceScientific community (higher education, Research)	Size of audience100	Countries addressedWorld
No.22	Type of activitiesPresentations	Main leaderUNIVERSITAET ZU KOELN	TitleThe potential effects of climate change on malaria in tropical Africa using regionallised climate pr	Date19/05/2012	PlaceCologne	Type of audienceScientific community (higher education, Research)	Size of audience100	Countries addressedEurope
No.23	Type of activitiesPresentations	Main leaderUNIVERSITAET ZU KOELN	TitleAbschätzung des Einflusses des Klimawandels auf das Malariarisiko im tropischen Afrika	Date11/07/2011	PlaceCologne	Type of audienceScientific community (higher education,	Size of audience10	Countries addressedGermany

						Research)		
No.24	Type of activitiesPresentations	Main leaderUNIVERSITAET ZU KOELN	TitleThe QWeCI decision support system (DSS)	Date15/11/2011	PlaceDakar	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience20	Countries addressedEurope, Africa
No.25	Type of activitiesPosters	Main leaderUNIVERSITAET ZU KOELN	TitleDevelopment of dynamical weather-disease models to project and forecast malaria in Africa	Date10/10/2012	PlaceBasel, Switzerland	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience200	Countries addressedWorld
No.26	Type of activitiesPress releases	Main leaderUNIVERSITAET ZU KOELN	TitleMalariagebiete verändern sich schneller als gedacht	Date23/02/2012	PlaceCologne	Type of audienceCivil society	Size of audience	Countries addressedGermany
No.27	Type of activitiesInterviews	Main leaderUNIVERSITAET ZU KOELN	TitleMalariaforschung an der Universität zu Köln	Date28/02/2012	PlaceCologne	Type of audienceCivil society	Size of audience	Countries addressedGermany
No.28	Type of activitiesArticles published in the popular press	Main leaderUNIVERSITAET ZU KOELN	TitleMalariaepidemien auf dem Vormarsch	Date01/04/2012	PlaceCologne	Type of audienceCivil society	Size of audience	Countries addressedGermany
No.29	Type of activitiesPresentations	Main leaderUNIVERSITAET ZU KOELN	TitleRelevant research and other activities of the University of Cologne (UoC) in terms of the proposed I	Date28/06/2011	PlaceBamako	Type of audienceScientific community (higher education, Research)	Size of audience30	Countries addressedEurope, Africa
No.30	Type of activitiesPresentations	Main leaderUNIVERSITAET ZU KOELN	TitleRisk assessment with regard to the occurrence of malari in Africa under the influence of observed an	Date16/06/2011	PlaceTriest, Italy	Type of audienceScientific community (higher education, Research)	Size of audience20	Countries addressedEurope
No.31	Type of activitiesPresentations	Main leaderUNIVERSITAE	TitleDynamic climate-disease models:	Date14/11/2012	PlaceBirmingham, UK	Type of audienceScientifi	Size of audience25	Countries addressedUnited

		T ZU KOELN	emerging tools to assess changes in climate and vector-borne disease			c community (higher education, Research)		Kingdom
No.32	Type of activitiesOrganisation of Conference	Main leaderUNIVERSITAET ZU KOELN	TitleDer Einfluss des regionalen Klimawandels durch Treibhausgase und Landnutzungsänderungen auf das Mala	Date30/10/2010	PlaceWurzburg	Type of audienceScientific community (higher education, Research)	Size of audience40	Countries addressedGermany
No.33	Type of activitiesPresentations	Main leaderUNIVERSITAET ZU KOELN	TitleDevelopment of dynamical weather-disease models to project and forecast malaria in Africa	Date07/02/2013	PlaceBasel	Type of audienceScientific community (higher education, Research)	Size of audience20	Countries addressedSwitzerland, Europe
No.34	Type of activitiesOrganisation of Workshops	Main leaderInternational Livestock Research Institute	TitleRVF descision support tools	Date25/09/2012	PlaceNaivasha, Kenya	Type of audiencePolicy makers	Size of audience20	Countries addressedKenya
No.35	Type of activitiesOrganisation of Workshops	Main leaderInternational Livestock Research Institute	TitleRVF descision support tools	Date11/10/2012	PlaceDaresalaam,Tanzania	Type of audiencePolicy makers	Size of audience15	Countries addressedTanzania
No.36	Type of activitiesOrganisation of Conference	Main leaderInternational Livestock Research Institute	TitleSpatial-temporal analysis of the risk of Rift Valley Fever in Kenya.	Date23/08/2012	PlaceMaastricht, Netherlands	Type of audienceScientific community (higher education, Research)	Size of audience40	Countries addressedNetherlands
No.37	Type of activitiesOrganisation of Conference	Main leaderInternational Livestock Research Institute	TitlePersistence of Rift Valley fever virus in East Africa.	Date23/08/2012	PlaceMaastricht, Netherlands	Type of audienceScientific community (higher education, Research)	Size of audience40	Countries addressedNetherlands
No.38	Type of activitiesOrganisation of Conference	Main leaderInternational Livestock Research	TitleMapping the distribution of potential Rift Valley Fever hotspots	Date29/03/2013	PlaceKigali, Rwanda	Type of audienceScientific community	Size of audience	Countries addressedRwanda

		Institute	in East Africa			(higher education, Research)		
No.39	Type of activitiesOrganisation of Conference	Main leaderInternational Livestock Research Institute	TitleSpatial-temporal analysis of the of the risk of Rift Valley Fever in Kenya	Date22/04/2012	PlaceVienna, Austria	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedAustria
No.40	Type of activitiesOrganisation of Conference	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	Title4th International AMMA conference “Seasonal-to-decadal prediction of the West African Monsoon”	Date02/07/2012	PlaceToulouse, France	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience150	Countries addressedEurope, Africa
No.41	Type of activitiesOrganisation of Conference	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	Title4th International AMMA conference “A combined statistical-dynamical approach to modeling spatio-temp	Date02/07/2012	PlaceToulouse, France	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience50	Countries addressedEurope, Africa
No.42	Type of activitiesOrganisation of Workshops	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	TitleICTP Summer School on Climate Impacts Modelling for Developing Countries: Water, Agriculture and Hea	Date05/09/2011	PlaceTrieste, Italy	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedGlobal
No.43	Type of activitiesOrganisation of Conference	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	Title EGU 2012 CL2.5 climate and infectious disease interactions session	Date24/04/2012	PlaceVienna, Autria	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedGlobal
No.44	Type of activitiesMedia briefings	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL	TitleEGU 2012 Press Conference: Geosciences and Health	Date24/04/2012	PlaceVienna, Austria	Type of audienceMedias	Size of audience15	Countries addressedGlobal

		CLIMA						
No.45	Type of activitiesPresentations	Main leaderAGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	TitleCase studies in decadal prediction from the ENSEMBLES decadal re-forecasts	Date04/04/2012	PlaceAORI, JApan	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedGlobal
No.46	Type of activitiesOrganisation of Workshops	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	Title5th workshop for the Brazilian Observatory for Climate and Health “Challenges for modelling climate	Date09/12/2012	PlaceRio de Janeiro, Brazil	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience40	Countries addressedLatin America
No.47	Type of activitiesOrganisation of Conference	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	TitleA Dialogue for Climate Services Users and Providers: Towards Implementation of the GFCS “Climate Se	Date26/10/2012	PlaceGeneva, Switzerland	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience10	Countries addressedGlobal
No.48	Type of activitiesOrganisation of Workshops	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	TitleICTP School on Modelling Tools and Capacity Building in Climate and Public Health	Date15/04/2013	PlaceTrieste, Italy	Type of audienceScientific community (higher education, Research)	Size of audience80	Countries addressedGlobal
No.49	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleClimate, environment and health: recent achievements in Senegal	Date04/04/2011	PlaceUNECA conference centre, Addis Ababa	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience	Countries addressedAfrica
No.50	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleDesign of a multidimensional model on vector-borne diseases: case study on Rift Valley Fever (RVF) i	Date29/07/2011	PlaceNoordwijkerhout, Netherlands	Type of audienceScientific community (higher education,	Size of audience	Countries addressedWorld

						Research)		
No.51	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleAn Agent-Based model on vector-borne disease: the Rift Valley Fever case in Ferlo (Senegal)	Date31/05/2010	PlaceBordeaux, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedEurope
No.52	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleImplémentation sous GAMA d'un modèle à base d'agents sur la transmission et la diffusion de la Fièvr	Date11/10/2010	PlaceCoMMISCO' 2010, Bondy, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedEurope
No.53	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleConception d'un modèle multidimensionnel sur les maladies à vecteurs: Cas de la fièvre de la vallée	Date16/01/2011	PlaceRochebrune, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedEurope
No.54	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleAn Agent-based model on vector-borne disease: The case of the Rift Valley Fever in Ferlo (Sénégal)	Date06/02/2011	PlaceSalvador, Brazil	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedLatin America
No.55	Type of activitiesOrganisation of Workshops	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleDakar QWeCI Workshop	Date14/11/2011	PlaceDaka, Senegal	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience	Countries addressedWorld
No.56	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleThe QWeCI project: forecasting disease outbreaks. Rift Valley Fever example	Date28/11/2011	PlaceCoP17, Durban, South Africa	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedAfrica, Europe
No.5	Type of activitiesOral	Main leaderCENTRE	TitleInteractions society,	Date02/07/2012	Place4th International	Type of	Size of	Countries

7	presentation to a scientific event	DE SUIVI ECOLOGIQUE	environment and climate: Lessons learned from AMMA project and prospects for t		AMMA conference, Toulouse, France	audienceScientific community (higher education, Research)	audience	addressedWorld
No.58	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleUsing climate to forecast disease risk: case study of the 2010 Rift Valley Fever outbreak over Mauri	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.59	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleMonitoring the hydrological dynamic of the ponds to control the environmental-depending diseases: th	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.60	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleObservation and modelling of malaria Ferlo (Senegal): preliminary results	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.61	Type of activitiesPosters	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleClimate impacts on population health, determination of seasonal incidence of malaria by using a biol	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.62	Type of activitiesPosters	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleEnhancing raingauge network in the Barkedji Health and Environment Observatory with regards Rift val	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.63	Type of activitiesPosters	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleMonitor, predict and prevent epidemics: the contribution in Rift valley fever studies Barkedji	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher	Size of audience	Countries addressedWorld

			(Ferl			education, Research)		
No.64	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleHealth and disaster risk reduction: an emerging and challenging issue for developping countries in A	Date22/03/2012	Place9ème Forum International de la Météo et du Climat, Genova, Switzerland	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.65	Type of activitiesOral presentation to a scientific event	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	TitleA combined statistical-dynamical approach to modeling spatio-temporal variations of malaria risk	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.66	Type of activitiesOral presentation to a scientific event	Main leaderFUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	TitleSeasonal-to-decadal prediction of the West African Monsoon	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.67	Type of activitiesOral presentation to a scientific event	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleClimate and health observation modelling malaria in Ferlo (Senegal)	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.68	Type of activitiesPosters	Main leaderUNIVERSITE CHEIKH ANTA DIOP DE DAKAR	TitleClimate and health observation modelling malaria in Ferlo (Senegal)	Date02/07/2012	Place4th International AMMA conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.69	Type of activitiesArticles published in the popular press	Main leaderUNIVERSITAET ZU KOELN	TitleClimate and land use change to affect malaria spread in tropical Africa	Date02/01/2012	PlaceScience for Environment Policy, the European Commission's environmental news service for policy make	Type of audienceScientific community (higher education, Research) - Industry - Civil	Size of audience13000	Countries addressedWorld

						society - Policy makers - Medias		
No.7 0	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleClimate change and RVF emergence in Senegal: the contribution of tele-epidemiology, lessons learned	Date15/04/2013	PlaceQuinzaine Internationale des Sciences et des Technologies, Abidjan, Côte d'Ivoire	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedAfrica
No.7 1	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleRainfall and RVF emergence in Senegal: beyond twenty years of investigations, lessons learned and pe	Date27/03/2013	Place4th Annual East Africa Health and Scientific Conference & International Health Exhibition, Kigali	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedAfrica, Europe
No.7 2	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	Title. Surveiller, prévoir et prévenir les épidémies dans un contexte de changement climatique : apport d	Date12/12/2012	PlaceSymposium international, Population, développement et changement climatique, Dakar, Senegal	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedAfrica, Europe
No.7 3	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleMalaria risk and climate change over West Africa: lessons learned from AMMA project	Date12/12/2012	Place. Symposium international, Population, développement et changement climatique, Dakar, Senegal	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedAfrica, Europe
No.7 4	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleMapping Rift Valley Fever and Malaria risk over West Africa using climatic and remote sensing indica	Date30/10/2012	PlaceColloque international Science, Enseignement et Technologie pour le développement de l'Afrique, Daka	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedAfrica, Europe
No.7 5	Type of activitiesOral presentation to a scientific event	Main leaderCENTRE DE SUIVI ECOLOGIQUE	TitleWater and health: an emerging and challenging issue for developing countries in Africa.	Date01/10/2012	PlaceDAAD-UNESCO Conference on sustainable water management in Africa Countries, Kisumu, Kenya	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.7	Type of activitiesOral	Main leaderCENTRE	TitleThe QWeCI project:	Date26/06/2012	PlaceOuagadougou,	Type of	Size of	Countries

6	presentation to a scientific event	DE SUIVI ECOLOGIQUE	forecasting disease outbreaks. Rift Valley Fever example		Burkina Faso	audienceScientific community (higher education, Research)	audience	addressedAfrica, Europe
No.77	Type of activitiesOral presentation to a scientific event	Main leaderUNIVERSITAET ZU KOELN	TitleDynamische wetterbasierte Krankheitsmodelle zur Vorhersage und Projektion von Malaria in Afrika	Date18/06/2013	PlaceCologne, Germany	Type of audienceScientific community (higher education, Research) - Civil society	Size of audience20	Countries addressedGermany
No.78	Type of activitiesOral presentation to a scientific event	Main leaderUNIVERSITAET ZU KOELN	TitleQuantifying Weather and Climate Impacts on health in developing countries	Date18/06/2013	PlaceBrüssel, Germany	Type of audienceScientific community (higher education, Research) - Civil society - Policy makers	Size of audience30	Countries addressedGermany
No.79	Type of activitiesOral presentation to a scientific event	Main leaderUNIVERSITAET ZU KOELN	TitleEntwicklung wetterbasierter dynamischer Malariamodelle für die Vorhersage und Projektion der Malaria	Date08/07/2013	PlaceBonn, Germany	Type of audienceScientific community (higher education, Research) - Civil society - Policy makers	Size of audience20	Countries addressedGermany
No.80	Type of activitiesOrganisation of Workshops	Main leaderUNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION - UNESCO	TitleThe Dakar Workshop	Date14/11/2011	PlaceDakar, Senegal	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience	Countries addressedWorld
No.81	Type of activitiesOrganisation of Workshops	Main leaderUNITED NATIONS EDUCATIONAL, SCIENTIFIC AND	TitleClimate and Malaria modelling school	Date01/11/2011	PlaceAddis Abada, Ethiopia	Type of audienceScientific community (higher	Size of audience	Countries addressedAfrica

		CULTURAL ORGANIZATION - UNESCO				education, Research) - Policy makers		
No.8 2	Type of activitiesOrganisation of Workshops	Main leaderUNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION - UNESCO	TitleClimate and malaria modelling school	Date10/01/2012	PlaceArusha, Tanzania	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience	Countries addressedAfrica
No.8 3	Type of activitiesPosters	Main leaderTHE UNIVERSITY OF LIVERPOOL	TitleHealth Impact Models Intercomparison: The example of Malaria over West Africa	Date02/07/2012	Place4th AMMA international conference, Toulouse, France	Type of audienceScientific community (higher education, Research) - Policy makers	Size of audience	Countries addressedWorld
No.8 4	Type of activitiesOral presentation to a scientific event	Main leaderTHE UNIVERSITY OF LIVERPOOL	TitleClimate change scenarios over West Africa: from CMIP3 to CMIP5	Date02/07/2012	Place4th AMMA international conference, Toulouse, France	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.8 5	Type of activitiesArticles published in the popular press	Main leaderKwame Nkrumah University of Science and Technology	TitleEntomological Survey of Malaria Vectors within the Kumasi Metropolitan Area – A study of three commu	Date01/06/2012	PlaceJournal of Environmental Science and Engineering 1(2)	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld
No.8 6	Type of activitiesArticles published in the popular press	Main leaderKwame Nkrumah University of Science and Technology	TitleClimate variability and malaria incidence in peri-urban, urban and rural communities around Kumasi,	Date01/06/2012	PlaceInternational Journal of Parasitology Research, 4(2): 83-89	Type of audienceScientific community (higher education, Research)	Size of audience	Countries addressedWorld

Section B (Confidential[3] or public: confidential information to be marked clearly)
Part B1

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[4]:	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)

The QWeCI project produced no patents, trademarks, registered designs etc.

[3] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[4] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

Part B2

Please complete the table hereafter:

Type of Exploitable Foreground[5]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[6]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
	Ex: New supercond uctive Nb-Ti alloy			*MRI equipment*	*1. Medical* *2. Industrial inspection*	*2008* *2010*	*A materials patent is planned for 2006*	*Beneficiary X (owner)* *Beneficiary Y, Beneficiary Z, Poss. licensing to equipment manuf. ABC*

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[6] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

3.1 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	243964
Title of Project:	Quantifying Weather and Climate Impacts on Health in Developing Countries
Name and Title of Coordinator:	Andrew P. Morse, Professor

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***Yes***
2. Please indicate whether your project involved any of the following issues (tick box) :	***YES***
RESEARCH ON HUMANS	
• Did the project involve children?	No
• Did the project involve patients?	No
• Did the project involve persons not able to give consent?	No
• Did the project involve adult healthy volunteers?	No
• Did the project involve Human genetic material?	No
• Did the project involve Human biological samples?	No
• Did the project involve Human data collection?	Yes, secondary anonymous data
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	No
• Did the project involve Human Foetal Tissue / Cells?	No
• Did the project involve Human Embryonic Stem Cells (hESCs)?	No
• Did the project on human Embryonic Stem Cells involve cells in culture?	No
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	No
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	Secondary anonymous disease data
• Did the project involve tracking the location or observation of people?	No

RESEARCH ON ANIMALS	
• Did the project involve research on animals?	No (only secondary data from existing nationally run surveillance programmes
• Were those animals transgenic small laboratory animals?	No
• Were those animals transgenic farm animals?	No
• Were those animals cloned farm animals?	No
• Were those animals non-human primates?	No
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	Only secondary data
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	Some education
DUAL USE	
• Research having direct military use	No
• Research having the potential for terrorist abuse	No

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis). Not Full Time on Project

Type of Position	Number of Women	Number of Men
Scientific Coordinator	0	1
Work package leaders	2	11
Experienced researchers (i.e. PhD holders)	7	42
PhD Students	16	6
Other	22	5

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**33**
Of which, indicate the number of men:	22

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?

x Yes
○ No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
❑	Design and implement an equal opportunity policy	○	○	○	○	○
❑	Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑	Organise conferences and workshops on gender	○	○	○	○	○
❑	Actions to improve work-life balance	○	○	○	○	○

x Other: Followed institutions own equal opportunity and gender policy at recruitment and Ran some informal side events for early career researchers

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

x Yes- please specify Only as much as gender was recorded in some secondary data sets and thus the analysis could be looked at by gender.

○ No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

X No But the project was highlighted at general for public talks and events when invited.

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

X Yes- please specify A project commission short film is in projection and this is aimed at a general audience with a view that it may be seen as part of science curriculum broadening

○ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[7]: 1.4
○ Associated discipline[7]: 1.5 ○ Associated discipline[7]: 1.1

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*

X Yes
○ No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

[7] Insert number from list below (Frascati Manual).

	○ No ○ Yes- in determining what research should be performed ○ Yes - in implementing the research X Yes, in communicating /disseminating / using the results of the project

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ X	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

○ No
○ Yes- in framing the research agenda
○ Yes - in implementing the research agenda
X Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

X Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
○ No

13b If Yes, in which fields?

Agriculture X Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise Environment X External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid X		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health X Regional Policy Research and Innovation Space Taxation Transport	

13c If Yes, at which level? X Local / regional levels X National level X European level X International level	

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**29**
To how many of these is open access[8] provided?	**8**
How many of these are published in open access journals?	**8**
How many of these are published in open repositories?	**0**
To how many of these is open access not provided?	**21**
Please check all applicable reasons for not providing open access:	
X publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available X no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[9]: ……………	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**0**
	Registered design	**0**
	Other	**0**
17. How many spin-off companies were created / are planned as a direct result of the project?		**0**
Indicate the approximate number of additional jobs in these companies:		**N/A**

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	❑	In small & medium-sized enterprises
❑	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	X	None of the above / not relevant to the project
X	Difficult to estimate / not possible to quantify		

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:* Estimate 21

[8] Open Access is defined as free of charge access for anyone via Internet.
[9] For instance: classification for security project.

Difficult to estimate / not possible to quantify	❑

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes X No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

X	Press Release	X	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
X	DVD /Film /Multimedia	❑	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

X	Language of the coordinator	X	English
X	Other language(s) French		

***Question F-10*:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]

8. FINAL REPORT ON THE DISTRIBUTION OF THE EUROPEAN UNION FINANCIAL CONTRIBUTION

Not applicable at this moment in time as the final payment is not made until after the acceptance of the Final Report. The report will be returned once the final payment is received and distributed by the coordinating Institute i.e. The University of Liverpool.

This report shall be submitted to the Commission within 30 days after receipt of the final payment of the European Union financial contribution.

Report on the distribution of the European Union financial contribution between beneficiaries

Name of beneficiary	Final amount of EU contribution per beneficiary in Euros
1.	
2.	
n	
Total	