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QWeCI

Quantifying Weather and Climate Impacts on Health in Developing Countries

D5.4.d – Report from ICTP concerning potential forecast dissemination format

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Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	PP
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

D5.4d) Report from ICTP concerning potential forecast dissemination format

1. *Introduction*

This report is closely linked to deliverable 5.4c, in that it discusses the potential forecast dissemination system for Malawi. For the reasons given in the introduction of deliverable 5.4c this report was delayed since the collaboration between the Malawi Ministry of Health and QWeCI partners took place over a three week visit from staff of the MoH to ICTP in September 2011.

2. *Identification of end users*

As stated in deliverable 5.4c, a considerable effort was made by UNIMA to identify and interact with stakeholders. Deliverable 5.4c stated:

"*During the preparation and execution of the first kick off meeting for the Malawi pilot in November 2010, local and national stakeholders were identified and meetings were arranged. These included*

- *The Ministry of Health (MoH) in Malawi,*
- *The national malaria control programme (within the MoH),*
- *The NGO BAOBAB Health Trust (see report 5.4e for details) active in data collection and storage in southern Malawi,*
- *Department of Climate Change and Meteorological Services, under the Ministry of Natural Resources, Energy and Environment,*
- *District health officers (DHO) responsible for health data collation, and*
- *Local (MoH, NGO and CHAM) clinic directors in the focus region of Mangochi.*

Representatives from all six of the above stakeholder categories were visited or meetings held by the UNIMA/UNILIV/ICTP QWeCI consortium during the November 2010 visit (…) Representatives from the MoH and NMA were invited to join the first QWeCI workshop at ICTP in 2011 under the budget of ICTP in order to develop the plan for a potential operational system further."

Deliverable 5.4c discussed general forecasting product needs in more detail that resulted from a three week long exchange with MoH elected contact Mr James Chirombo, which was instrumental in the development of the prototype graphical products along the lines laid out in D5.4c.

3. *Forecast tools*

At the project design stage, the forecasting system was envisaged to be based on the Liverpool Malaria Model (LMM, a dynamical modelling system, to be driven by bias corrected ECMWF forecasts. During the course of the project, it was realized that an improved measure of uncertainty could be obtained using a multimodel approach, especially using new modelling tools that could account for land surface type and socio-economic factors. Therefore the LMM was supplemented by two new tools under development, the dynamical model VECTRI (VECToR borne disease model of ICTP) and a generalized linear statistical modelling framework already successfully applied in other regions (e.g. Lowe *et al.,* 2011, Computers & Geosciences).

Thus the general framework for the operational system within QWeCI is presented in Fig. 1. There are 5 arrows leading to the end user to describe the 5 possible prediction pathways, either supplying the user forecast information directly from the VECTRI, LMM or statistical model framework, or additionally using the VECTRI and LMM dynamical model results as input to the statistical model (instead of direct climate information) to better resolve the nonlinear climate-disease relationships in a "hybrid" system. It is the aim of QWeCI to determine which of these formats is the most accurate/reliable or indeed if all of the combinations should be used in a "multi-model superensemble".

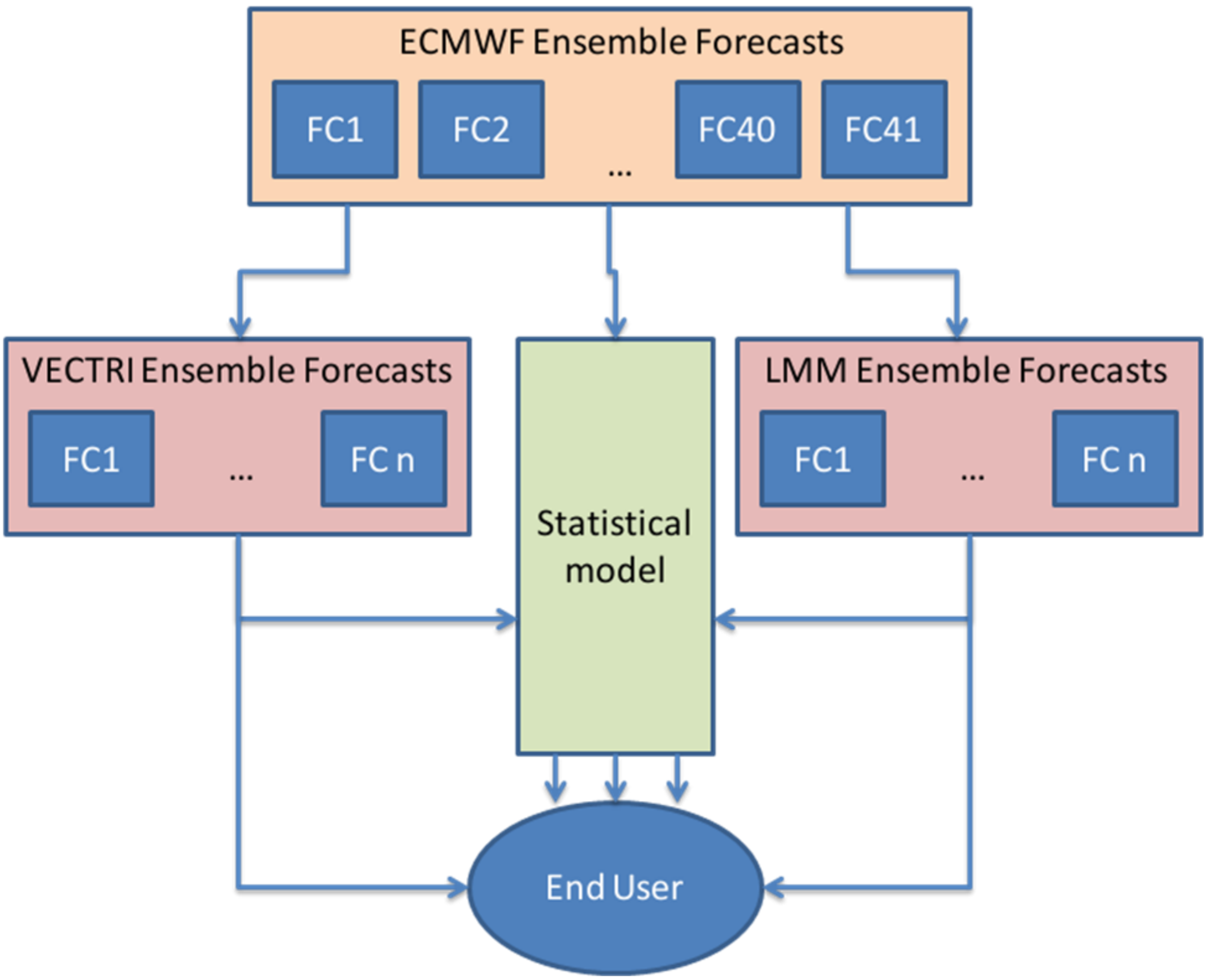

Figure 1: Modified modelling framework developed during the course of QWeCI

4. Format requirements

i. Maps

As stated in report 5.4c, dynamical model output for the atmosphere is most commonly displayed in a gridded format, much like the gridded malaria model integration result for parasite ratio (PR) displayed in Figure 1. Such plots have little value for planning since they do not correspond to the health districts on which present planning is conducted.

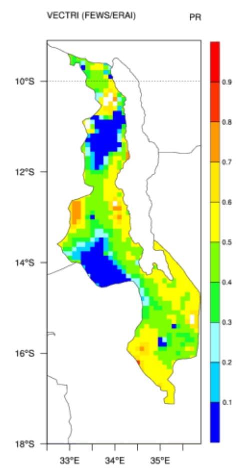

Figure 2: Example gridded output from a dynamical modelling system

Instead, aggregating PR (or other related diagnostics) up to the district level would be much more relevant to supplement planning needs. An example of such a potential model output is given in figure 3, which in this case is generated using observed cases as the interface to the gridded dynamical malaria models and the statistical malaria modelling system was still under construction at the time of writing. Figure 3 shows a seasonal mean anomaly of cases for a particular year, but month by month maps could also be generated. This kind of output leads to a product similar to that presently used for disease monitoring non-real time. The aim would be to introduce a system that could display past *actual* cases, past *hindcasts* and the *present forecast* using the same system and colour scales for easy comparison.

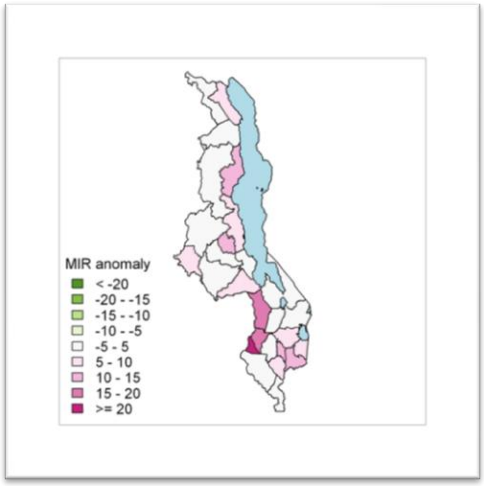

Figure 3: Anomaly of malaria infection rate for each health district in Malawi

ii. Uncertainty

One obvious drawback of the district level PR anomaly displayed in figure 3 is that the forecast is shown in a *deterministic* sense. In other words, the displayed anomaly could be from a single forecast, or alternatively it could display as a forecast *ensemble mean*. The obvious drawback of this approach is that no information concerning the ensemble spread and forecast uncertainty is communicated. In the atmospheric forecast world, there are a number of methods to display such information, such as maps of tercile probabilities for example, which are usually displayed as gridded output, but could easily be adapted to produce district mean maps as in Figure 3. For reasons of brevity, such maps are not reproduced here, but the reader is instead referred to the seasonal forecast map room of QWeCI partner ECMWF (European Centre for Medium Range Weather Forecasts).

http://www.ecmwf.int/products/forecasts/d/charts/seasonal/forecast/eurosip/

One disadvantage of the tercile based summaries (see examples in the above link) is that they are quite complicated to interpret for the uninitiated user. Even after two decades of operational ensemble forecasting in Europe for example, ECMWF finds that the ensemble tercile products are not widely used by member state organizations, and that even experienced operational forecasts can misinterpret the information.

In order to simplify the communication of uncertainty within the ensemble system framework, QWeCI will likely adopt the visualization methodology developed prior to the project by ICTP researcher R Lowe and colleagues at the University of Exeter (Jupp *et al*., 2011, Royal Phil. Trans. A). This technique is demonstrated in Figure 4. The plot (made in this case with fabricated ensemble data to demonstrate the concept for the target region) employed a simple-to-interpret RGB colour scale to incorporate information from the ensemble. Thus, if all ensemble members show the malaria incidence falling in the lower (medium/upper) tercile category, the RGB coordinate system results in a district adopting the deep blue (green/red) colour.

The advantage of this triangulation system is that if the modelling system results in even distribution between the three tercile categories (i.e. the outcome is uncertain) then the result RGB coordinate falls in the white area and the district is uncoloured. Thus the simple map format can also convey information concerning uncertainty. The right hand panel shows how the malaria risk may have fallen into tercile categories in reality.

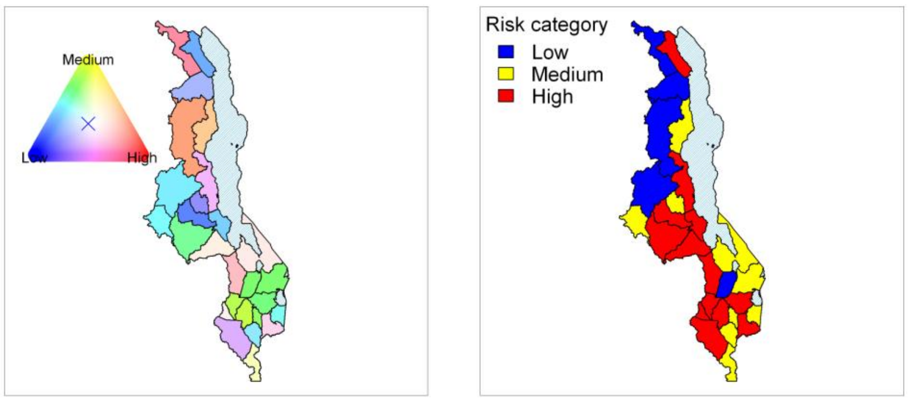

Figure 4: Left: Example method of using ensemble integrations to display uncertainty according to Jupp et al.(2011). Right: Risk category actually observed (NOTE : this plot is made with generated data).

iii. Timeseries

In addition to spatial maps, information concerning timeseries progression can be useful. One example of this is shown in Fig 5, taken from research conducted by Jones and Morse (2010, J Climate). The plot shows a forecast ensemble plume, and compares it to observations (in this case a separate malaria model integration driven by climate observations, but the availability of data in Malawi would allow actual observations to be used). The shaded areas given quintile information from the forecast system and thus again show an indication of inter-ensemble spread. In response it was remarked that the high temporal resolution of this plot would make it hard to compare to actual observations which are collated on a monthly timescale. Again, it emphasizes the fact that health planners are used to seeing data not only aggregated to district scale, but also on a month by month basis. Combining the plume information succinctly with information concerning the malaria long-term mean and inter-annual variability is also challenging.

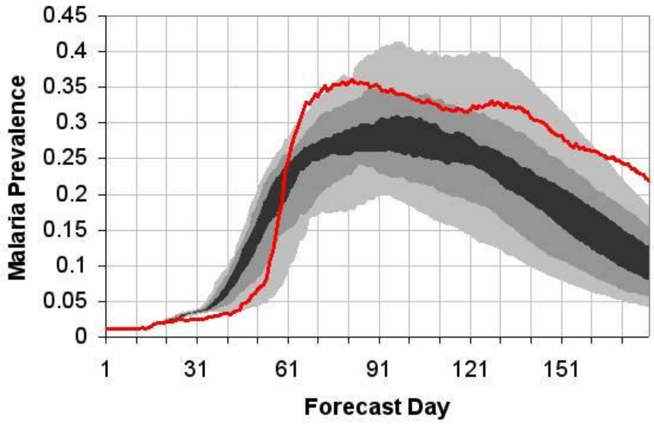

Figure 5: Displaying ensemble uncertainty using a forecast plume - the forecast PDF is given by the shaded areas, while the red line shows what actually happened (using reanalysis driven LMM if observations are not available)

Another example of timeseries information, this time averaged to a month by month scale is given in figure 6. In this example, the information concerning forecast variability can be displayed using a box whisker chart, with the boxes displaying the inner quartiles (50% of the forecasts) while the extremes give the maximum and minimum incidences. This chart was developed for a research product, and in addition to the helpful quantity of PR for planners, also contains other charts of direct model output for the advanced user, such as vector density. Such quantities are obviously near-impossible to validation from observations, but could be useful for inter-comparing seasons and especially to help assess the impact of various intervention strategies. They are likely to be excluded from the basic STAGE 1 web-based information system outlined below, but could be included as “optional layers” for the advanced user in the STAGE 2 system.

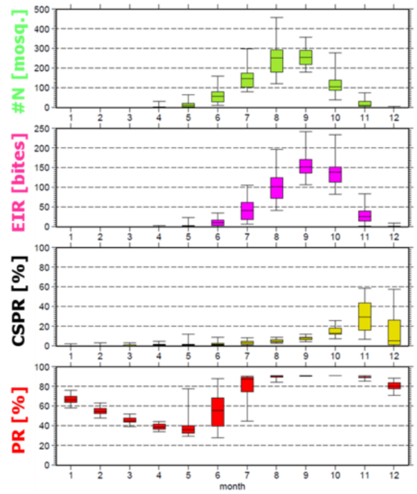

Figure 6: Another example of showing spread. In this case the data is displayed as monthly averages. This plot shows the malaria "climate" (long term mean and variability) with box whiskers. A deterministic forecast or ensemble plume could be overlaid

iv. Local/regional scales

A clear requirement was expressed to be able to examine forecast information at the facility level. Given a district mean anomaly for a season, experienced regional health planners may know from experience how this would be distributed on the sub-district scale due to local environmental factor concerning the clinic location, catchment size, rural or peri-urban environment. Another factor related to climate is coping with the vicissitudes of topography, as some districts cover a wide range of conditions ranging from low-land, lake-side environments to much cooler, low transmission high-land regions. A central planner may have less awareness of these small scale factors and the ability thus to disaggregate information to the clinic level was deemed important. This could be achieved either through a statistical post-processing of forecast system output, which would reply on access to past data at the sub-district level, and/or could involve a pre-processing downscaling of temperature information to a much finer resolution using available satellite retrievals of topography.

Once the health information is disaggregated to clinic level, a clear methodology is required to allow its interrogation and the Google Earth system offers an obvious platform to achieve this. Clinic coordinate data has been processed using standard GIS techniques to enable the array of clinics to be displayed as a layer in Google Earth using the standard clinic symbol as a marker (Fig. 7). The forecast information concerning the upcoming season will be colour coded in the symbol, and rolling the mouse over the symbol could bring up auxillary information about the clinic in addition to providing options to examine timeseries progression according to the above discussion.

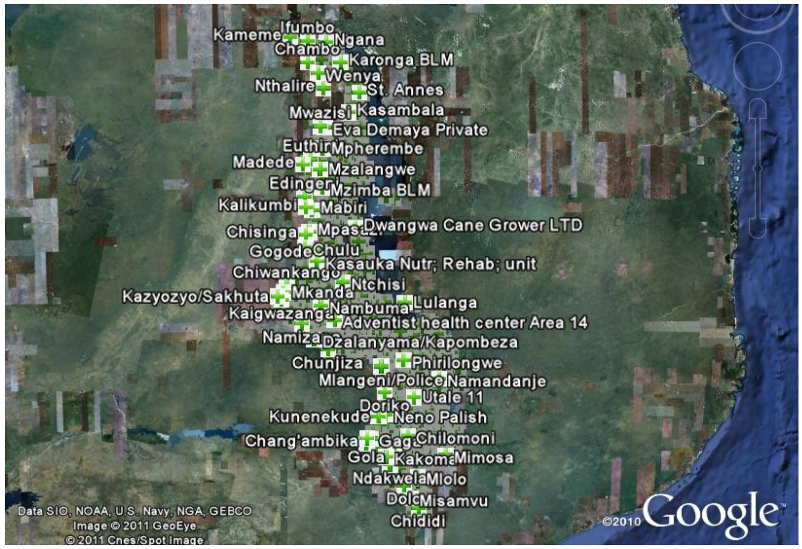

Figure 7: Example of Malawi health facilities in Google Earth. Forecast information for each facility could be related to each marker.

5. Summary

This report summarizes the first consultation process that took place between QWeCI partner ICTP and stakeholder MoH QWeCI contact Mr James Chirombo. This was an interactive process that occurred over a period of three weeks during a visit of Mr Chirombo to ICTP, including the ICTP summer school on climate impacts and the first QWeCI workshop in September ICTP, with this exchange itself a result of the extensive groundwork laid during the first kick off meetings in Lilongwe in 2010. As a result of this interactive process it was decided to implement a simple two stage process of prototype forecast product dissemination. It should be emphasized that the QWeCI project aims did **not** include the actual production of a fully operational forecasting system, merely an assessment of the potential for such a system using ECMWF **hindcast** information. Nevertheless, if this system proves to have significant skill for operational planning purposes, QWeCI partners are committed to attempt to implement such a system. The consultation process that is reported here is an important first step to ensure that the products that are derived are **fit for purpose** and communicate both forecast skill and uncertainty.

<u>SYSTEM 1: Web based basic dissemination</u>

The web based system would be hosted firstly by a QWeCI partner in Europe, likely ICTP/UoC and would consist of two simple components only:

1) Maps of district level anomalies using RGB triangulation alongside a summarized risk map (Fig 4)

2) A list of districts (or a "clickable" district map) that would bring up timeseries information (Fig 6)

3) There is the potential to include higher resolution district maps dividing the district along topographical (temperature) lines, this needs to be investigated further prior to use.

To retain simplicity of this system it is recommended that no clinic level information be included. Moreover the information will likely summarise the multimodel superensemble only.

SYSTEM 2: Google Earth display

In this system, the google earth software, freely available, will be used as the driver for information display. The maps described in SYSTEM 1 will be included as multiple “layers”. Separate layer could be available for each individual malaria model or for multi-model system combined.

In addition to the basic information, a grid of clinic level information will be available, with a symbol displayed for each clinic colour coded according to risk. These systems could be clickable to bring up clinic summary statistics concerning the size and historical records of the clinic, and also allow concise timeseries display of the information.

The development of this system will proceed in tandem with the information systems of WP5.1 for compatibility, so that the advanced user that either runs the code locally or through the remote web-based GUI systems developed in that WP may still take advantage of the Google Earth output facilities outlined here.