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QWeCI

Quantifying Weather and Climate Impacts on Health in Developing Countries

D5.4f – Implemented forecast dissemination, decision support system with WP 5.1

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Lead contractor: ICTP, ECMWF
Coordinator of deliverable: ICTP
Evolution of deliverable

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Dissemination Level		
PU	Public	PU
PP	Restricted to other programme participants (including the Commission Services)	
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)	

INTRODUCTION

This report introduces the web-based decision support system in support of opertional seasonal forecasting. The late delivery of the report is due to complexities of setting up the integrated forecasting system and the unpredictable size of the task necessary to remove errors and uncertainties from the health data sets required to validate the system.

THE ECMWF IMPLEMENTATION

While both stand-alone tools and web-web tools that allow the two dynamical malaria models to be run by end users have been developed as set out in the DoW (see reports in WP5), these are not suitable for use in an operational environment forecasting. The scope of QWeCI was to investigate the *potential* for a malaria forecasting system, however, the success of the project had led partners ECMWF and ICTP to develop a prototype *operational* system. Such systems require model implementations that fit strictly within the operational software environment of the centre. Thus the decision support system for this prototype system is presently graphically based and not interactive. These products will be revised and honed interactively with end-users at the ministry of health Malawi with whom QweCI have established contacts during the course of the project. *It should be emphasized that this prototype operational implementation at ECMWF of the ICTP malaria model, and the development of the new malaria model itself, is research and technical work that has been conducted beyond the scope of the QWeCI DoW and represents a significant step towards fulfilling one of the present grand challenges as stated by the WMO to increase the use of seasonal forecast climate information for health applications in developing countries (ECMWF workshop, 2012)*.

The pilot system, fully implemented in ECMWF's systems management software (SMS) to allow 24hour supervision of the suite by ECMWF's round the clock operational staff, consists of the following components (illustrated in FIGURE 1).

a) the forecasting system

The seamless forecast is constructed by appending the monthly forecast with the seasonal forecast. The first 25 days are taken from the varEPS-Monthly forecast, then month 2 to 4 are taken from the system-4. Daily values are provided for the 120 days range forecast. Precipitation fields are accumulated over the 24 hours before while 2m temperature fields represent the daily average. All fields are bias corrected. The bias correction for the first 25 days is performed as documented in Di Giuseppe, Molteni and Tompkins (2012, QJRMS in press) and the correction for the seasonal forecast is performed in the standard way using the hindcast suite for training purposes over an 18 year period. To avoid any discontinuity in between the two forecast both fields are corrected for the mean GPCP observations. The explanation of the seamless forecast can be found in deliverable **Milestone 3.1a: Prototype seamless products from monthly to seasonal EPS systems** and deliverable **D3.1e. Report on the seamless calibrated products for disease-related variables integrating the output from medium-range, monthly and seasonal ensemble forecast systems using ECMWF products.**

This seamless ensemble system is then used to drive the ICTP VECTRI model documented in Tompkins and Ermert (2012, Malaria Journal, in review), for a Africa wide domain. At the moment this pilot implementation uses a relatively coarse resolution of 1 degree, but after testing, the second phase of implementation will add a second suite for targeted subdomains including the 3 pilot areas at a much high resolution of 10km to improve the resolution of the topography which will be implemented in December 2012.

b) End User Interface

A web site has been specifically designed for the QWECI project. Output data are displayed at

http://nwmstest.ecmwf.int/products/forecasts/d/inspect/catalog/research/qweci/

Presently, the page contains a range of meteorological products that are publically viewable for Africa, and a section that is currently under development containing prototype health information that is password protected and is only presently available to the involved QWeCI partners during development.

An example of the page is given in Figure 2, and shows that the page uses the standard interface developed at the centre over long period to view general meteorological products from the seasonal and other operational systems. This figure shows the full page as a en-user partner in associated health ministries equipped with the health access password would see. *It should be emphasized that this is an interim report describing work in progress and thus this diagram of the webpage, complete with its presently uncorrected Italian spelling, does not show the final format of the interface and available products.*

The menu of available products is placed clearly on the left hand side along with information concerning start dates and lead times of the forecasts – Users can also set the latter parameters through a series of dropdown menu options to facilitate this usage.
At the moment the available meteorological products include

1. 2m temperature (T2m)
2. calibrated and uncalibrated precipitation
3. anomalies in precipitation and temperature
4. other full fields such as geopotential height at several levels (Z).

Examples of the calibrated precipitation anomaly (fig 3), temperature and precipitation anomalies (fig 4) and full meteorological fields of T2m and Z (fig5) are given below, in addition to a plot of uncalibrated and calibrated precipitation anomalies.

Concerning the products, the first release of this web interface contains direct maps of LEVEL 1 (direct output) and LEVEL 2 (derived) processed health related products. The main product is based on the entomological inoculation rate, (EIR), which is the number of infective bites per person per unit time, and is therefore an indication of malaria transmission intensity. Figure 7 shows an example of EIR anomalies from the system for an example forecast. We recall that the anomaly is calculated with respect to the hindcast ensemble covering the previous 18 years starting on the same start date. Since the mean EIR changes dramatically from epidemic to endemic locations (depending on both climate and environmental factors such as population density and topography slope in this system) the anomaly is normalized to allow for comparison. Thus full field EIR maps are required to allow an end user to gauge these plots in light of the typical transmission intensity, In this particular example, using both the uncalibrated and calibrated forecasts produces a forecast of lower than usual transmission over the Gulf of Guinea coast and a positive anomaly over southern Sudan and the southern border of Ethiopia. It is recalled that the delay between the malaria season and rainfall indicates that one can not expect to see a direct correlation between the climate and malaria transmission charts at a set forecast lead time, and malaria transmission anomalies can be significant after the rainy season has already come to an end.

Since the normalized anomaly is shown, there is a danger of misinterpretation of apparently large anomalies in transmission outside the main transmission season. In order to prevent this, anomalies are masked out in regions where the mean transmission in the 18 year hindcast is lower than a small threshold. This requires improvement since it precludes the prediction of outbreaks in regions where malaria has not previously occurred. A simple improvement will be to apply a mask according to the mean hindcast transmission and the absolute magnitude of the anomaly.

While given some indication of changing risk, the transmission intensity has little direct relevance to decision makers, since it's relationship to actual clinical case numbers and likely intervention actions is highly nonlinear. An increase in intensity in a region that is holoendemic will likely have a smaller impact than a similar proportional increase in an hypoendemic region. Much work still needs to be done to translate the VECTRI model output into relevant level 2 derived products that are more useful, or easier to interpret and understand for end-users. Examples of level two products are given in figure 8, which converts EIR into the predicted length of the upcoming malaria transmission season (LTS) based on an EIR threshold. This is then further processed to give a simple binary map of malaria climate suitability (CS), which in this example indicates those regions where the upcoming transmission season is expected to exceed 3 months. We again stress that this is work in progress, and such level 2 products will be refined and developed over the final stages of QWeCI, and beyond, interactively in collaboration with end-users. Once this is established, LEVEL 3 products with the user interface derived in collaboration with the ministry of health Malawi can be developed as laid out in **Deliverable 5.4d Report from ICTP concerning potential forecast dissemination format.**

Another aspect that should be emphasized is that beyond the deterministic timescale of a few days, forecasts need to portrayed probabilistically using an ensemble system, as emphasized in the DoW. Nevertheless, communicating uncertainty to forecast users is not a straightforward task; even meteorological institutes in Europe rarely use ensemble products to their full potential. As a first step, the portrayal of the ensemble uncertainty is conveyed in the simplest, albeit least compact, way, by issuing stamp maps of EIR predictions for each member of the forecast ensemble (figure 9). We recall that the forecast ensemble spread (differences between the various members) is entirely driven by differences in climate; the malaria model is identical in each integration. This could be improved upon by implementing a grand ensemble, either by incorporating other statistical or dynamical maleria models into the system, or by running perturbed physics versions of the VECTRI model from each climate forecast. The relatively low numerical cost of the malaria model makes these feasible, and we aim to investigate this technical development further.

Conclusions and Future Development

This document shows that, despite some delay due to the complexity of the technical infrastructure necessary to translate an offline research system into an operational pilot system (beyond the plans of the project DoW), much progress has been made in developing the prototype operational malaria forecasting system. An end-user interface displays both meteorological and health related products. Nevertheless, further development is underway. This concerns the following issues:

a) Forecast validation

ICTP has used many of its project PM in a concerted effort to bring the clinical datasets provided by colleagues at the ministry of health in Malawi, Uganda and Rwanda up to a controlled standard such they can be used to evaluate the forecast quality (none of these are QweCI partners and this work is unfunded on the part of our Africa colleagues. ICTP has used and will continue to use its own financial resources to bring some of these partners to ICTP in April to the workshop to introduce the system and brainstorm further improvements in the products.) Work is underway to perform this forecast evaluation

b) Scales

The forecast system is presently integrated at a course 1 degree resolution and presented as Africa-wide maps. This information is at too coarse a scale to be of great help to district level planning, although it may be helpful to provide some broad-scale information to regional disaster agencies and national level policy actions, possibly through the regional consensus outlook forums that regularly take place in Africa. Using a topography based downscaling technique, the VECTRI malaria model can run easily on spatial scales 10 times finer, and thus the next step will be to establish fine resolution integrations on regional scales, aggregated to health district level in order to provide detailed planning aid to users.

c) level 3 products

Once the LEVEL 1 and 2, products are fully tested, work may continue to produce the final system for level 3 products google based geo-referenced products down to the clinic level, as laid out in the report for deliverable **5.4d Report from ICTP concerning potential forecast dissemination format.** The responsibility for this development now lies with QWeCI partner **IC3**, since the person at ICTP responsible for the level 3 plan and its associated software development has moved on from ICTP to partner IC3 after the first year of the project. As these level 3 products are beyond the strict formatting scope of the ECMWF operational website, it is likely that forecast output will have to be transferred offsite, and the level 3 system products hosted at ICTP.

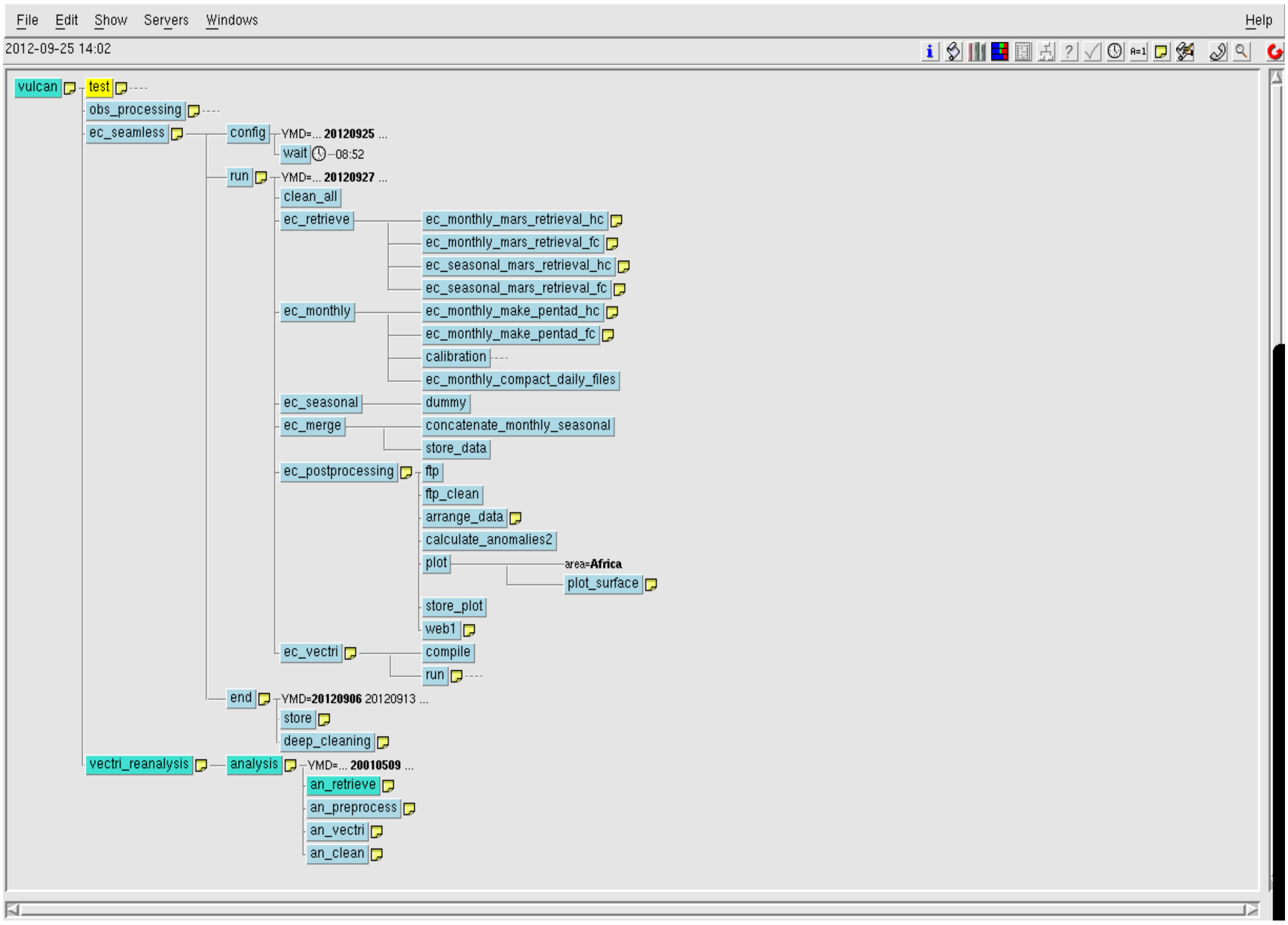
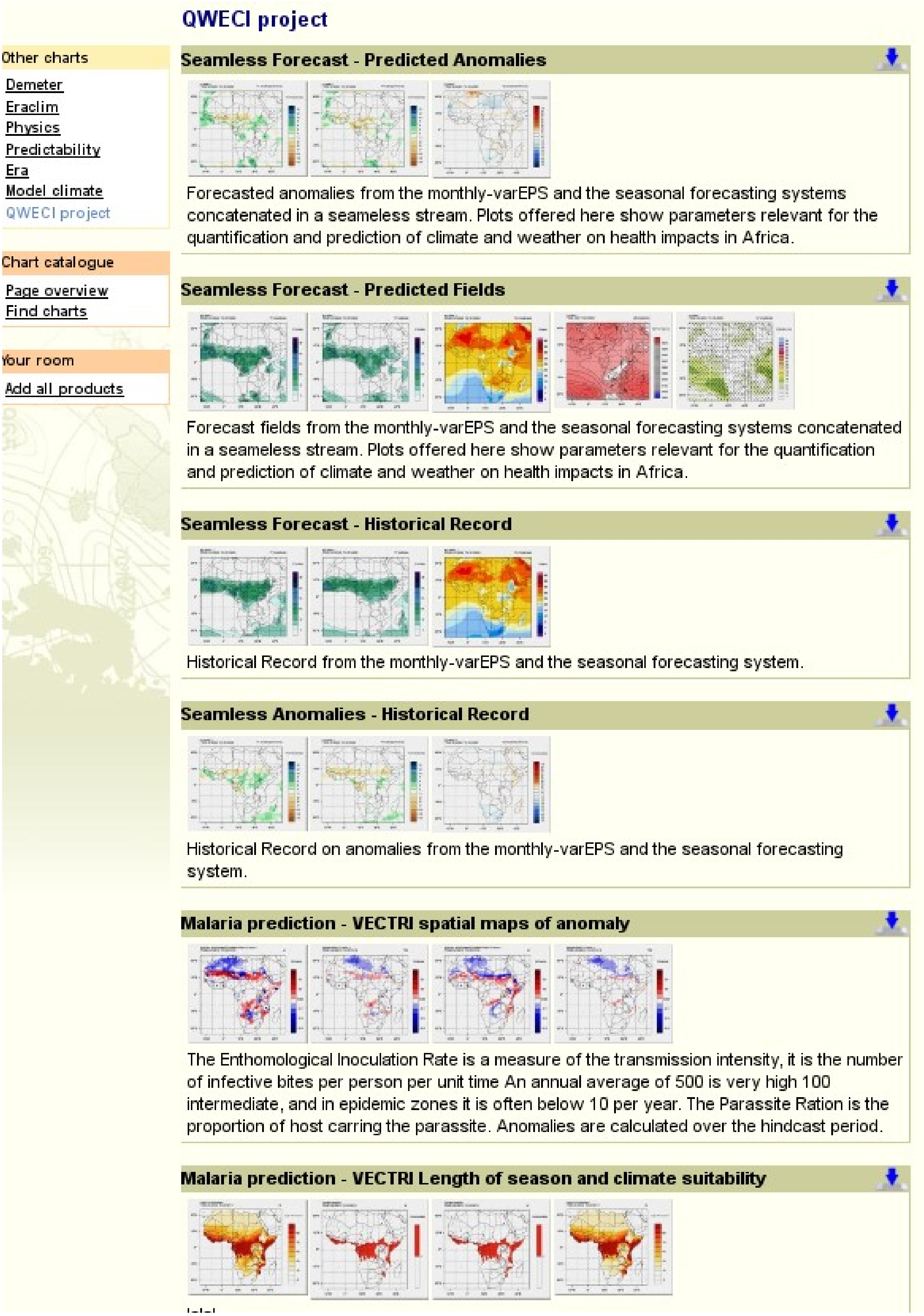


figure 1: Snapshot o fthe ECMWF operational implementation for the production of the seamless forecast for the QWECI project



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Seamless Forecast - Predicted Anomalies

Forecasted anomalies from the monthly-varEPS and the seasonal forecasting systems concatenated in a seamless stream. Plots offered here show parameters relevant for the quantification and prediction of climate and weather on health impacts in Africa.

Seamless Forecast - Predicted Fields

Forecast fields from the monthly-varEPS and the seasonal forecasting systems concatenated in a seamless stream. Plots offered here show parameters relevant for the quantification and prediction of climate and weather on health impacts in Africa.

Seamless Forecast - Historical Record

Historical Record from the monthly-varEPS and the seasonal forecasting system.

Seamless Anomalies - Historical Record

Historical Record on anomalies from the monthly-varEPS and the seasonal forecasting system.

Malaria prediction - VECTRI spatial maps of anomaly

The Enthomological Inoculation Rate is a measure of the transmission intensity, it is the number of infective bites per person per unit time An annual average of 500 is very high 100 intermediate, and in epidemic zones it is often below 10 per year. The Parassite Ration is the proportion of host carring the parassite. Anomalies are calculated over the hindcast period.

Malaria prediction - VECTRI Length of season and climate suitability

figure 2: Snapshot of the web page created for QWECI

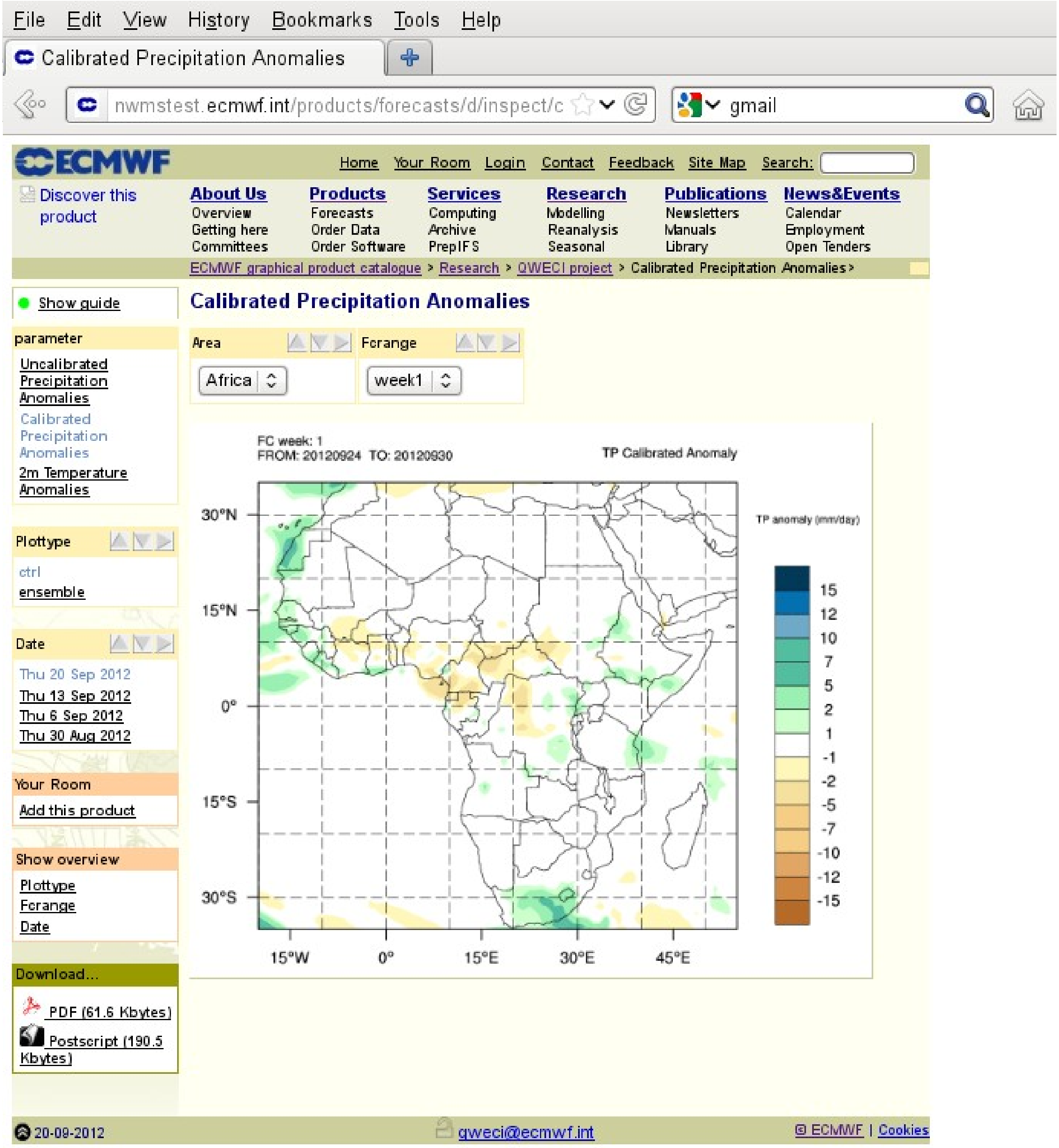

figure 3: example of calibrated seasonal forecast of precipitation anomaly in week 1

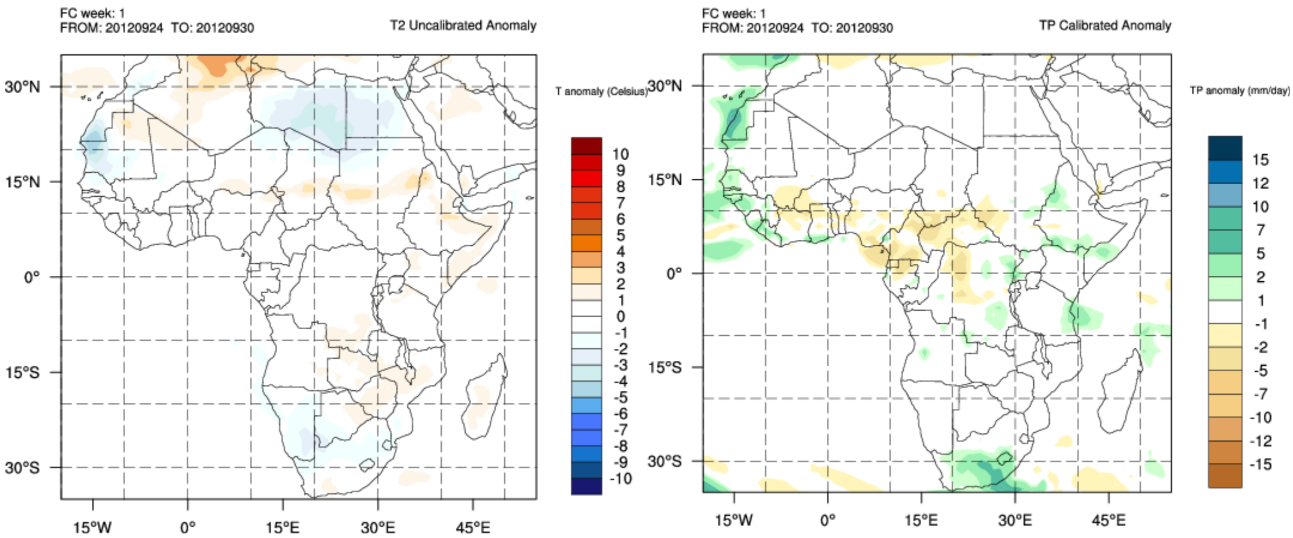

figure 4: anomalies example

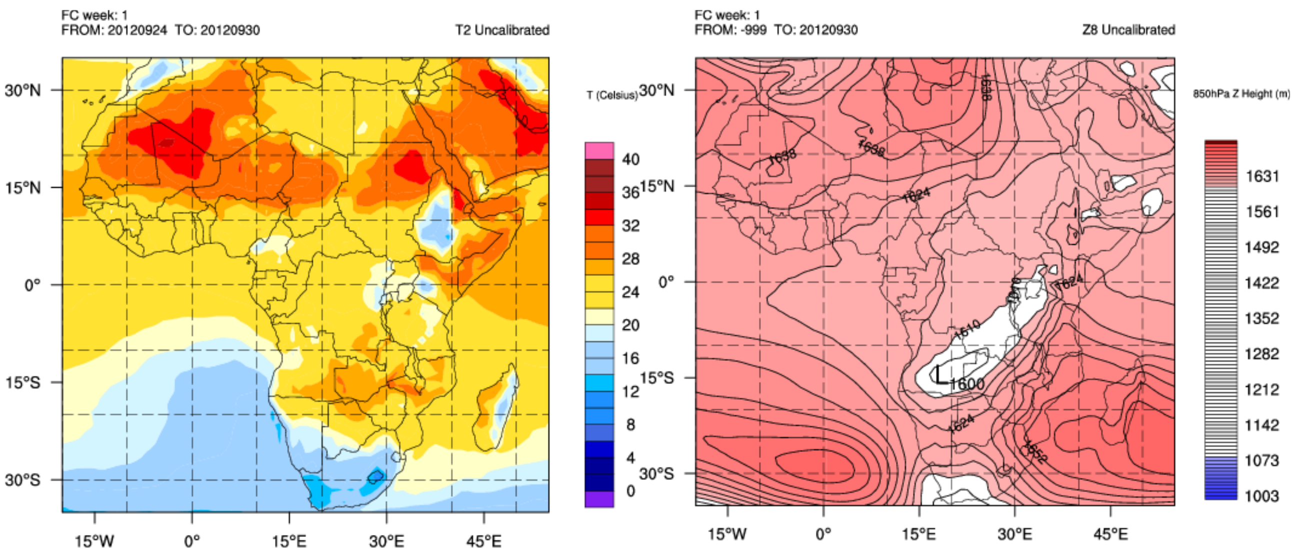

figure 5: example of meteorological fields lead time week 1 starting the 20-09-2012

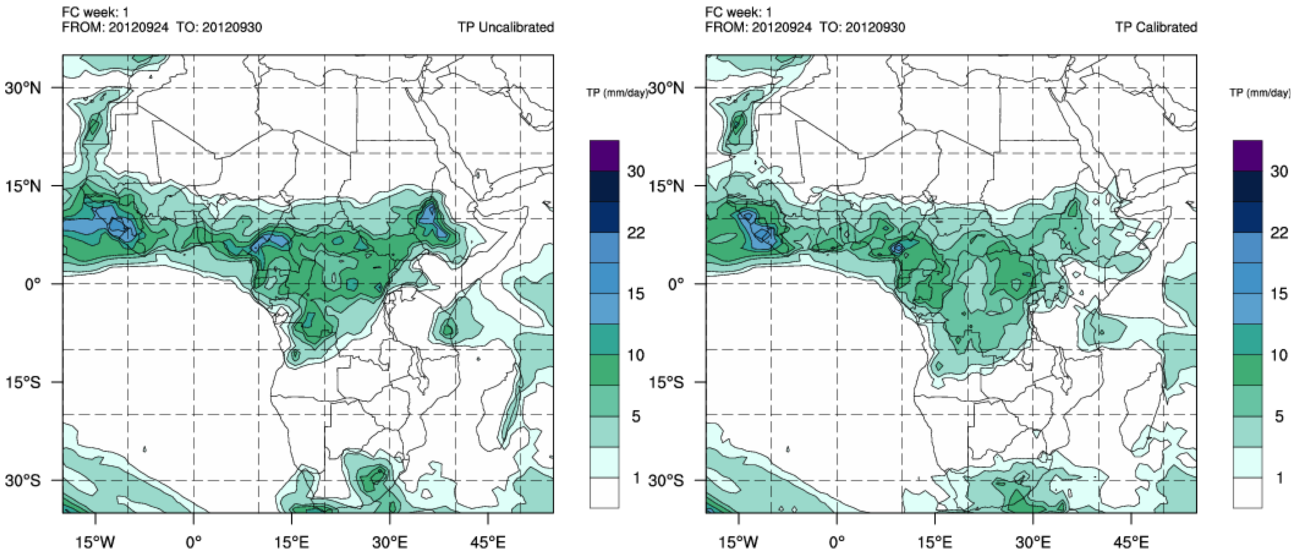

figure 6: example of clibrated and uncalibrated precipitation

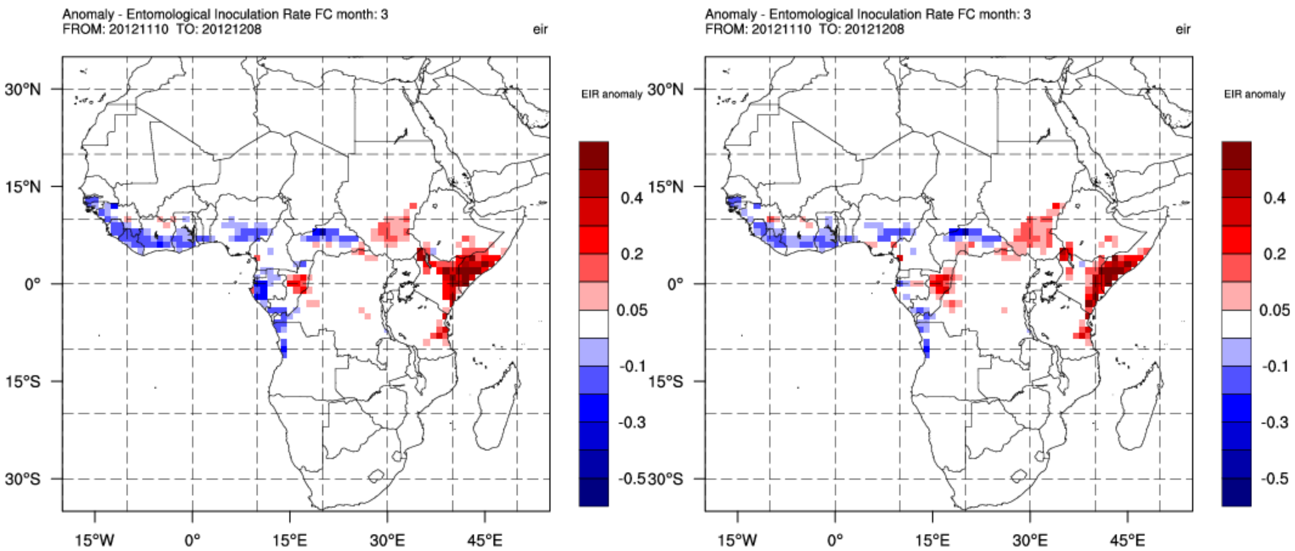

figure 7: eir example from uncalibrated and calibrated forecast

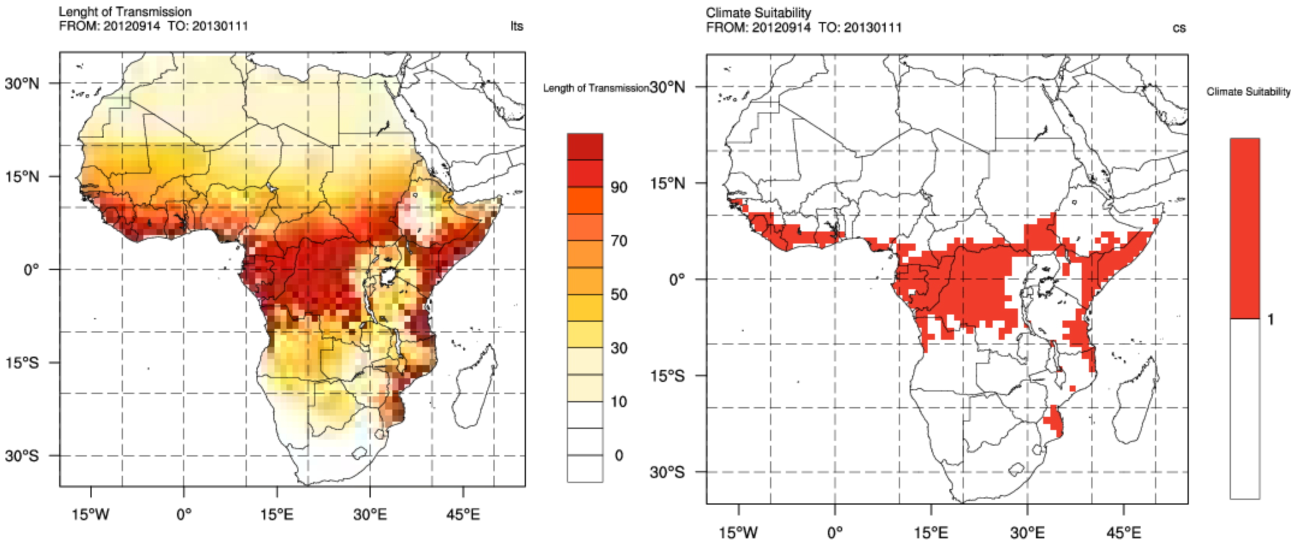

figure 8: example lenght of transmission and climate suitability

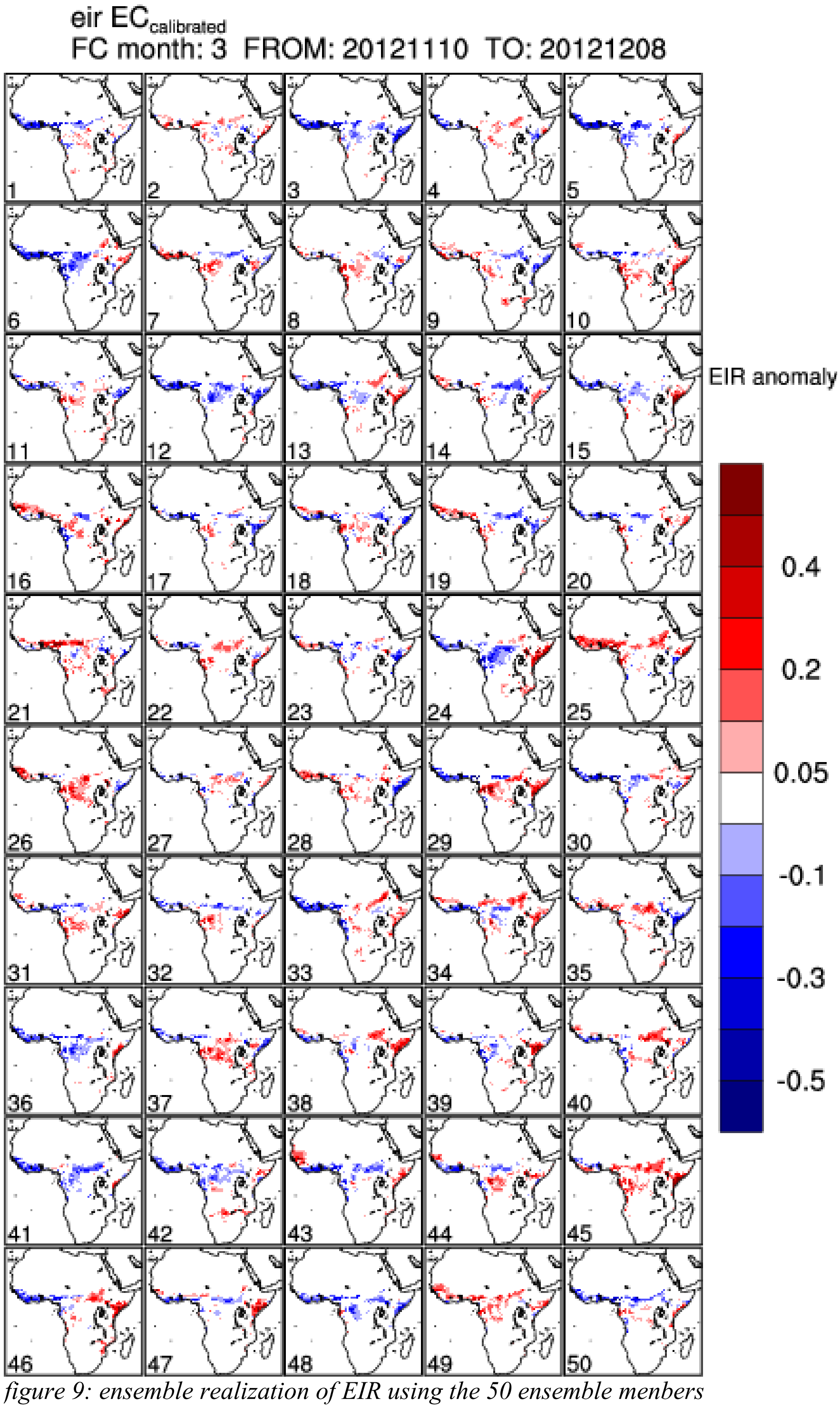

figure 9: ensemble realization of EIR using the 50 ensemble menbers