SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2014
Project Title:	Use and value of ECMWF short-range and seasonal forecast products for developing countries in terms of end-user impact variables
Computer Project Account:	SPITP4DC
Principal Investigator(s):	Adrian Tompkins ………………………………………………………
Affiliation:	Abdus Salam International Institute for Theoretical Physics (ICTP)
Name of ECMWF scientist(s) collaborating to the project (if applicable)	……………………………………………………… ………………………………………………………
Start date of the project:	1 January 2013
Expected end date:	31 December 2015

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	300	0	300	0
Data storage capacity	(Gbytes)	100Gb		100 Gb	

Summary of project objectives
(10 lines max)

The projects examines the scope for operational seasonal forecasting of health risks in developing countries, with the primary interest concerning the prediction of malaria transmission in Africa, with a focus on Malawi, Uganda and Rwanda. The project aims to couple the (bias corrected) monthly EPS and SYSTEM4 seasonal forecast system to the ICTP dynamical malaria model VECTRI. The precipitation and temperature forecasts then lead to forecasts of malaria transmission intensity, prevalence rates and eventually also actually hospital case data. The project will set up the pilot system, examine the skill in the target countries using hindcast datasets, analyze if improvements can be made including non-climatic factors, and finally, but most importantly, work directly with the ministry of health in the target countries to develop and hone end-user products that are directly useful to stakeholders and decision makers.

Summary of problems encountered (if any)
(20 lines max)

none to report

Summary of results of the current year (from July of previous year to June of current year)

In summary, the key activities of the year have focussed on the processing of the country level health data in order to start the validation of the ECMWF-ICTP pilot malaria forecasting system. The following tasks were highlighted on the previous progressive report 1 year plan:

- *Upgrade the VECTRI model version in the forecast system from 1.26 to 1.31*
  - The system has been upgraded to v1.3.2
  - VECTRI is now freely available through a GIT-hub repository to facilitate future upgrades at ECMWF
  - VECTRI is now used activity by 6 other institutes in Europe, Africa and the USA meaning that problems with the code and improvements in development speed are expected.
- Develop some specific country and district level plots for Uganda, Rwanda and Malawi
  - Ongoing, publication in preparation.
- Begin the process of country level validation of hindcasts against health databases
  - Ongoing, publication in preparation.
- Investigate methods for improving the representation of uncertainty, for example by introducing a VECTRI perturbed ensemble (stochastic physics) for the impacts component.
  - Although the structure of VECTRI facilitates such stochastic model runs, this has not been achieved at the moment due to the computational demands of running such super-ensembles on the cluster. The aim is to parallelize the VECTRI code over the next year as time allows such that the malaria model can be moved to the supercomputer facilities, permitting larger ensembles.

Potential prediction of malaria using ECMWF-ICTP pilot early warning system.

On completion of the pilot system, it has been used to demonstrate the potential predictability of malaria using the reanalysis-driven VECTRI model (terms a malaria analysis) as the truth due to the lack of a continent-wide health dataset for the disease in Africa. The paper has been submitted to the journal of applied meteorology and climatology" and is presently in review. On the following page, a figure is reproduced from that publication (labled figure 4) which highlights the prediction skill of malaria, temperature and rainfall (the latter two variables being the key *climate* drivers of malaria variability) at lead time of 1 to 4 months ahead.

Examining first the shorter range predictions one month in advance (Fig. 4 left column), encouragingly, there is model skill in malaria predictions in the target prediction zones throughout the calendar year. In some regions the predictability derives from correctly forecasting variations in temperature, but in southern Africa in a band stretching from Botswana through to Malawi and also across eastern Africa there are wide areas in which malaria predictive skill derives from both rainfall and temperature; for these the analysis does not show which variable contributes most to the skilful malaria prediction.

In some locations the malaria forecasts are not significantly skilful, marked by a limited number of black points where predictions of all variables fail, or by blue, purple or red points which indicate skill in climate but not malaria prediction. In the northern-most Sahel belt spanning Senegal, Mali and Niger in July and August, wide areas display skill in temperature only (red colours) while in some points rainfall is also correctly predicted (purple colours) but no potential malaria prediction skill ensues. In this northern-most zone of the Sahel, rainfall variability and the northern extent of the monsoon limit malaria transmission. Thus where rainfall predictions are inaccurate, a frequent short-coming in atmospheric models, malaria predictions will also fail. Where both rainfall and temperature are skilfully predicted, the failure to translate this into accurate malaria prediction could relate to the nonlinear relationship between transmission and rainfall, where intense rain events flush early stage larvae breeding sites and monsoon breaks lead to puddle desiccation. This nonlinearity is fully sampled by the high day-to-day variability of rainfall in the tropics, thus significant skill in predicting seasonal rainfall anomalies may not be sufficient if sub-seasonal rainfall variability is poorly represented.

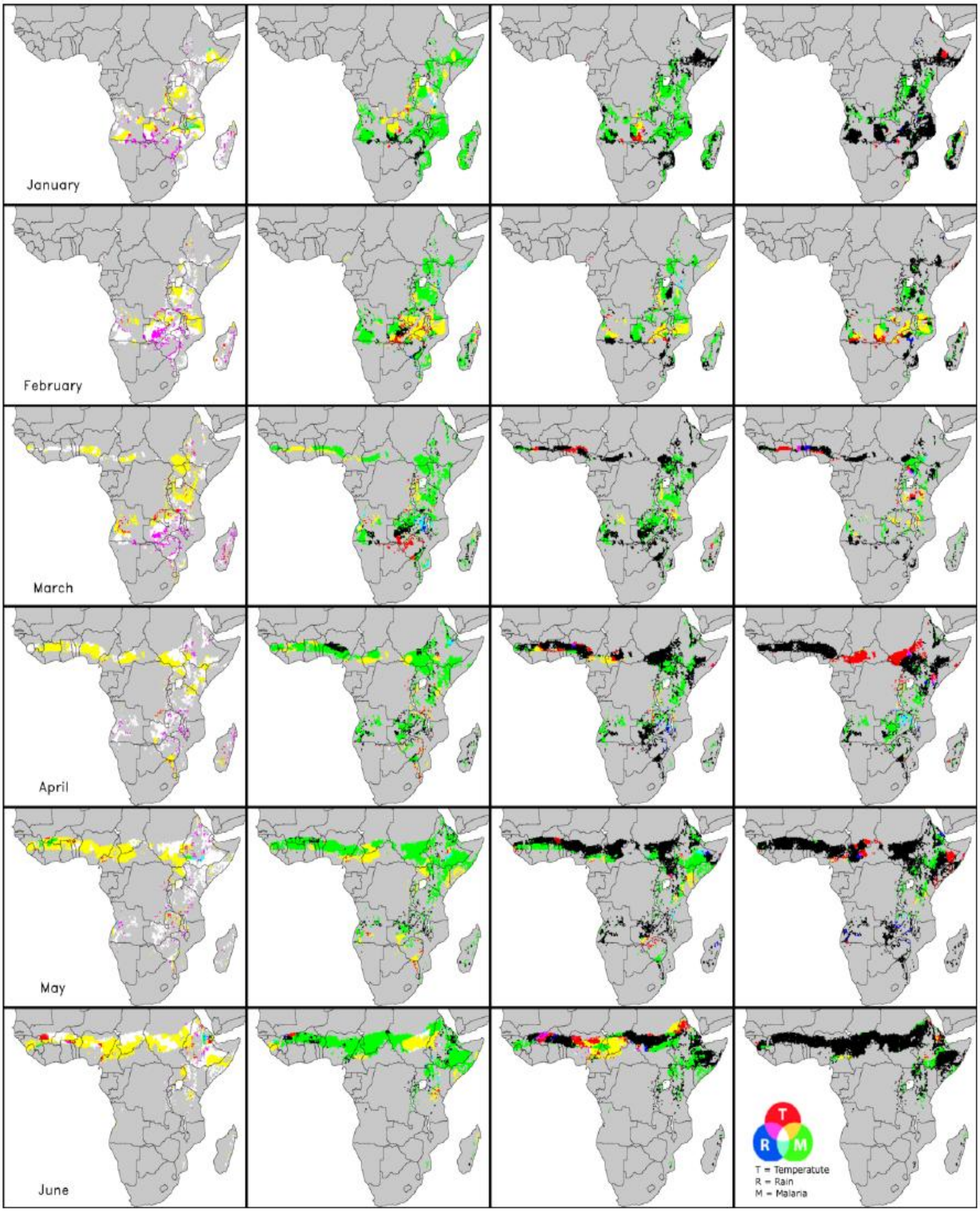

FIG. 4. Composite plot of temperature (red), precipitation (blue) and malaria (ln(EIR), green) forecast anomaly correlation coefficients that are statistically skillful at the 95% confidence level for issuing warnings for 1 through 4 months in advance (lead time) for each calendar month of the year. White points mark cells with skill in all three variables, black points mark cells without any skill. See legend for color definitions of intersecting categories. (CONTINUED)

Figure 1: reproduced figure from Tompkins and Di Giuseppe 2014 (in review) - see reproduced caption for details

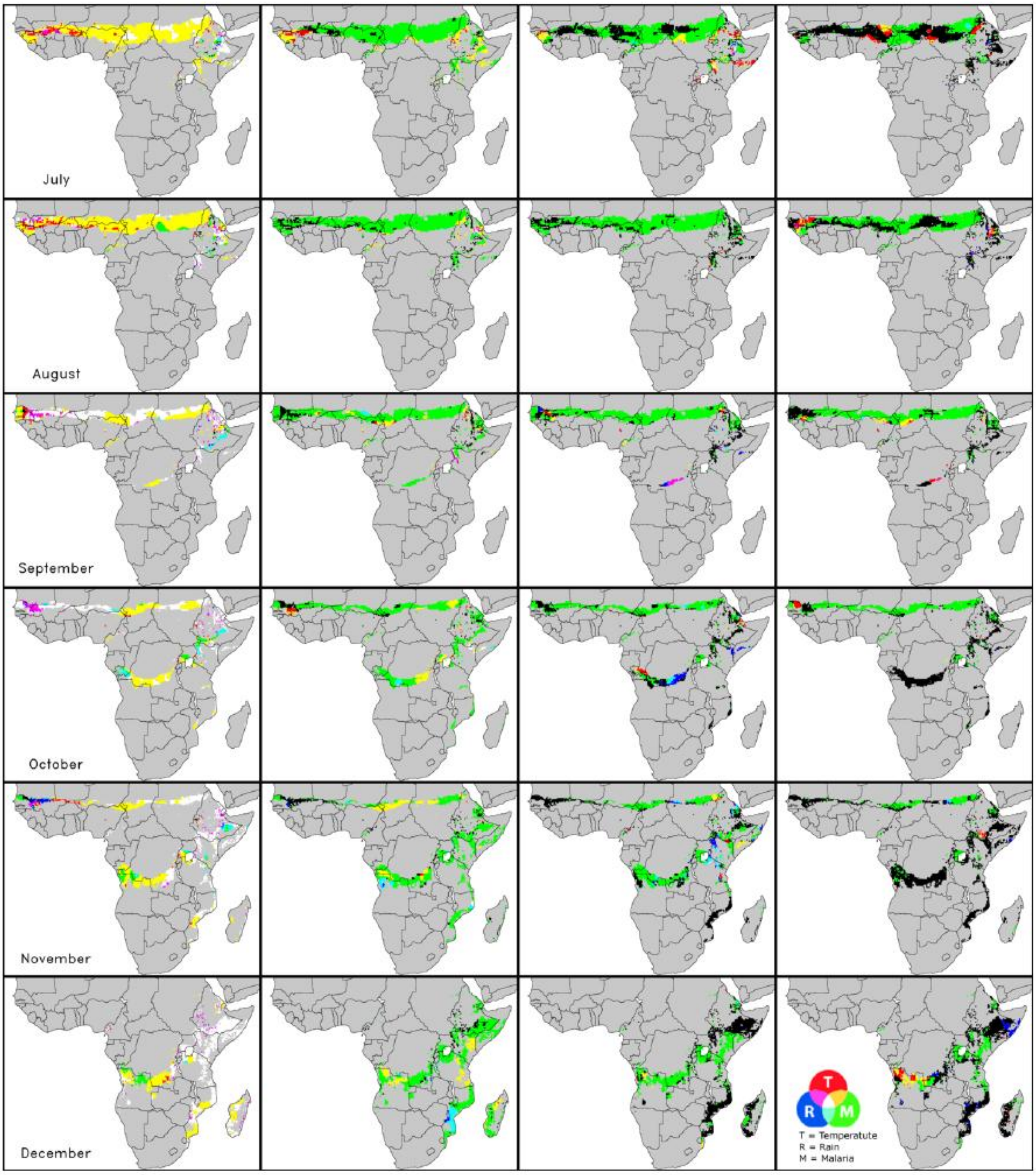

FIG. 4. cont.

The publication showed an example of a real alert level prediction for a highlands area in East africa where the forecast appears to have real skill when compared to documented outbreaks (Fig.2) , at least for selected the correct years of outbreaks, even if the timing of the events compared to uncertain district health statistics is not always accurate) and went on to discuss how the hazard assessments should be used in an operational environment in combination with social vulnerability assessments. Work is now focusing on the validation at district level validation, with analysis maps showing that the system has statistically significant skill 4 months in advance for over half of the districts in Uganda. An example is shown in Fig. 3. for Kanungu in SW Uganda using confirmed cases from a sentinel site. The anomalous conditions of 2010 are shown to be predicted, which resulted from the warmer than usual season associated with El Nino conditions. The model in general tends to do well for temperature associated anomalies that occur in El Nino years, but has lower skill at predicting outbreaks associated with rainfall variability.

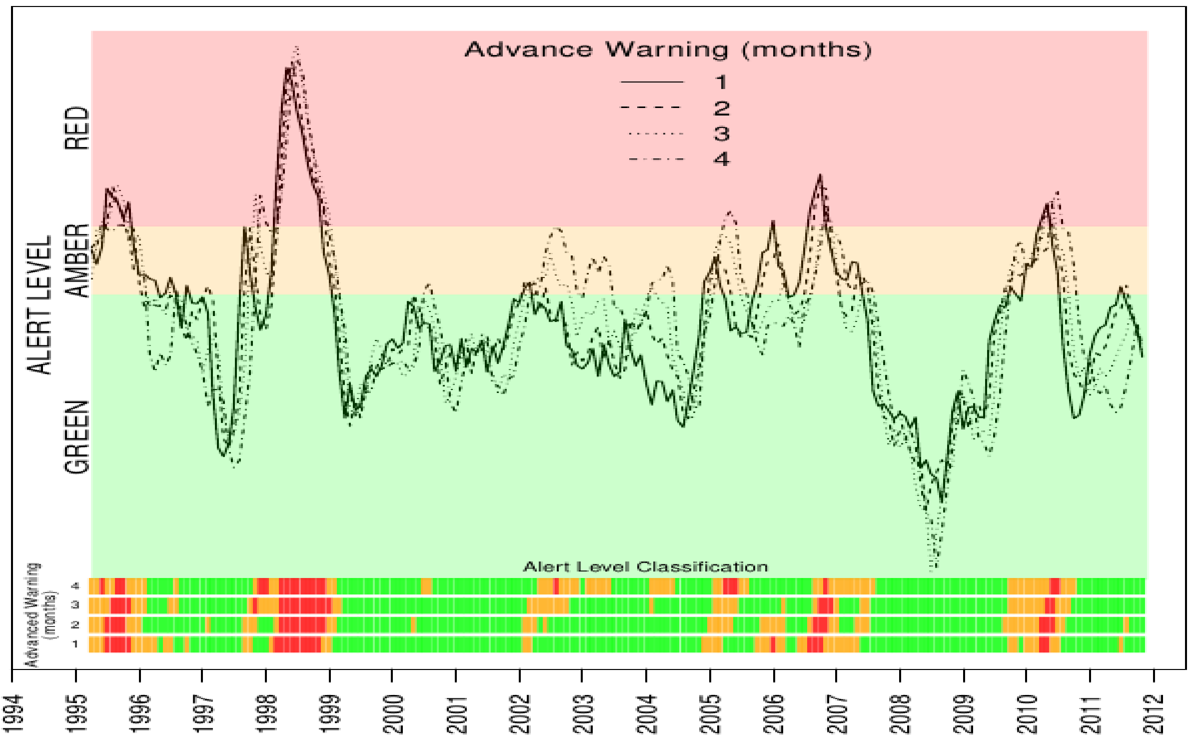

Figure 2: Green-amber-red alert levels 1-4 months ahead for the highlands of Uganda and Western Kenya. The red alerts in 1998, 2007 and 2010 all correspond to epidemic years documented in the peer-review literature, with the 1998 outbreak being particularly acute, but the exact timing of the predictions is not always accurate.

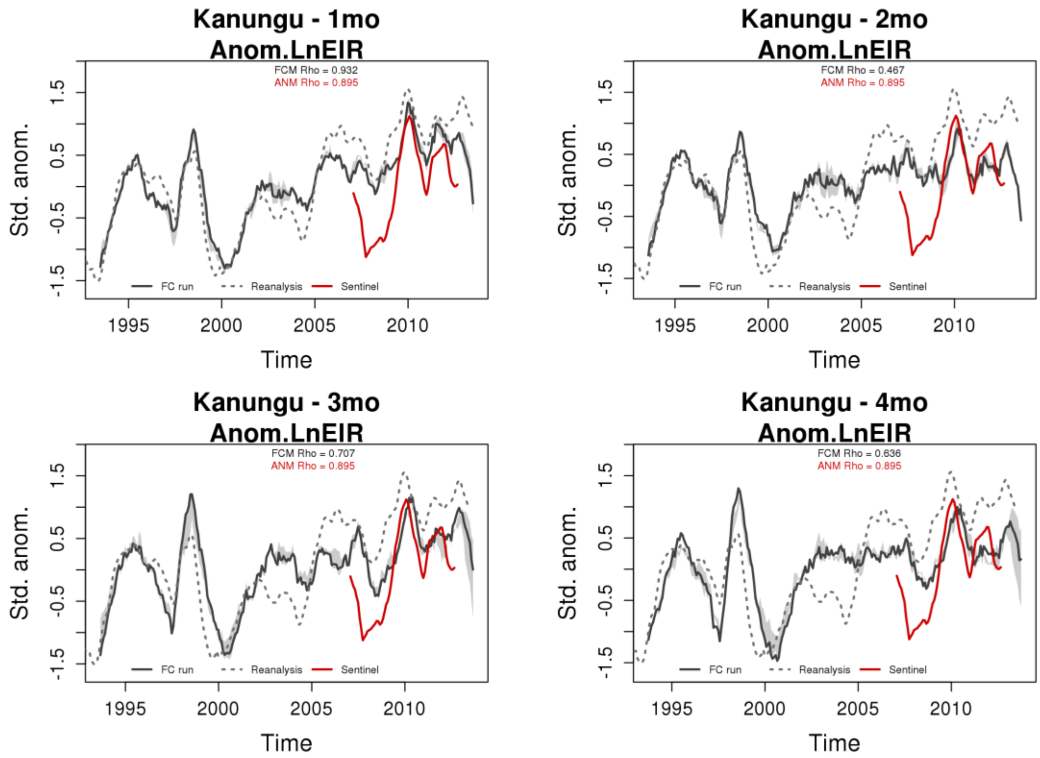

Figure 3: Reanalysis driven and malaria forecast prediction of expected case anomaly compared to sentinel confirmed cases in Kanungu SW Uganda. Paper in preparation.

Use of computer resources

As the system is run on the cluster to date and has been the key activity, we have not used our computing resources so far in 2014.

List of publications/reports from the project with complete references

Tompkins, Adrian M., and Volker Ermert. "A regional-scale, high resolution dynamical malaria model that accounts for population density, climate and surface hydrology." Malaria journal 12.1 (2013): 65.

Caminade C, Kovats RS, Rocklov J, Tompkins AM, Morse AP, Jesus Colon-Gonzalez F, Stenlund H, Martens P, Lloyd SJ, 2014: Modelling the impact of climate change on malaria: a comparison of global malaria models, PNAS, doi: 10.1073/pnas.1302089111

Piontek et al. (incl. Tompkins) 2013: Multisectoral climate impact hotspots in a warming world, PNAS, doi: 10.1073/pnas.1222471110

Tompkins A. M. and F. Di Giuseppe, 2014: The potential use of seasonal climate forecasts to plan malaria intervention strategies in Africa, submitted

Summary of plans for the continuation of the project

The next steps of the project for the following 12 months are

- Finish analysis of the system at the district level in Uganda, Rwanda and Malawi.
- Start analysis in Senegal, subject to health data being obtained.
- Investigate methods for improving the representation of uncertainty, for example by introducing a VECTRI perturbed ensemble (stochastic physics) for the impacts component.
- Examine potential to role out a pilot pre-operational uptake of the system in one of the above four African countries in a pilot project (NERC and EUAID proposals have been submitted that could facilitate this).