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	2017
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 2016
Expected end date:	31 December 2018

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)	400,000	0	400 000	0
Data storage capacity	(Gbytes)	200Gb		200 Gb	

This template is available at:
http://www.ecmwf.int/about/computer_access_registratio
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Summary of project objectives

(10 lines max)

S2S and seasonal forecast products are used to evaluate their potential for developing sub-seasonal to seasonal prediction products for health, with a focus on developing countries. While phase 1 and 2 of the project focussed on malaria in Africa, stage 3 of this project has the aim is to widen the scope to additional health outcomes and regions. The first part of stage 3 therefore involves the generalization of the modelling tools and the development of an effective calibration framework, followed by a range of predictability studies for malaria, heat waves, and dengue in both Africa, South/Central America and Asia. A particular development unique to this project is the incorporation of mobility information into the prediction system.

Summary of problems encountered (if any)

(20 lines max)

cdcdcd

none to report

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

The key activities undertaking over the previous 12 months :

a) *Development of a new calibration technique for both the ECMWF EPS and the health impacts model.*

The new calibration technique is based on a modified "constrained" genetic algorithm. Tested using the Lorenz system, the technique allows one to calibrate a complex nonlinear model constraining the parameters within the range of a pre-determined prior of uncertainty (see Fig 1) . The technique has been tested with the idealized Lorenz system of equations (presented at the EMS meeting in 2016, see e.g. fig 2.) and would be suitable for use to automatically calibrate the ECMWF ensemble system. It is planned to set up experiments to this end using the special project account and openIFS during 2018.

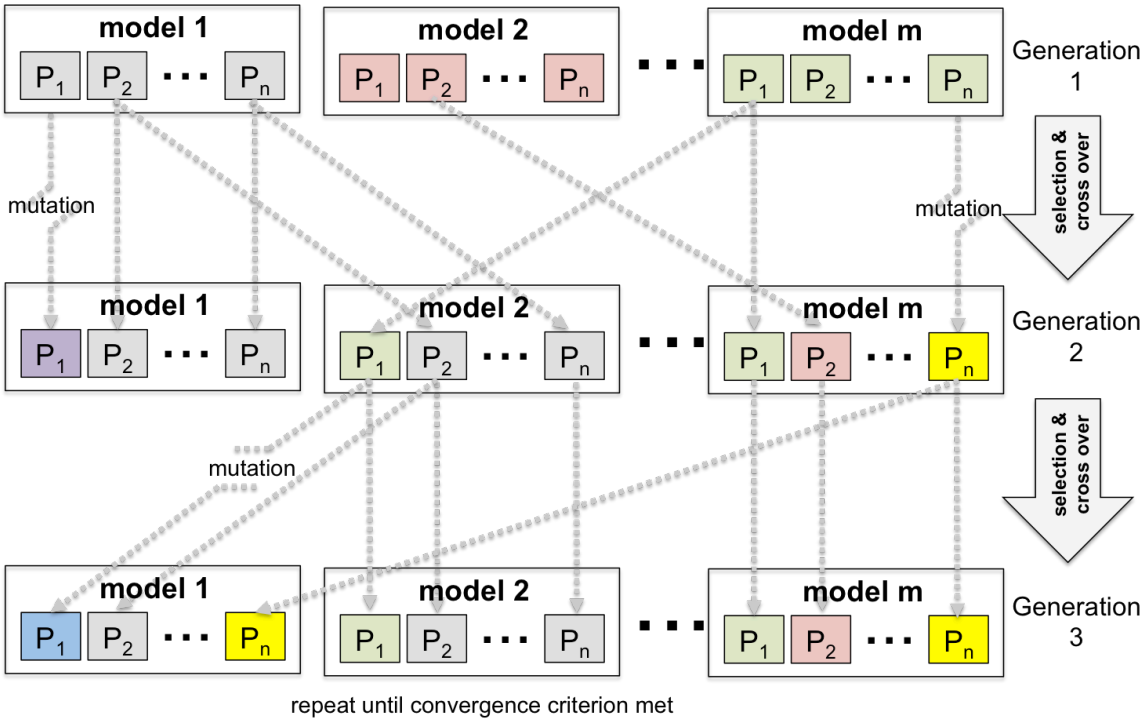

Figure 1: Schematic of calibration technique. M models have n parameter settings and are progressively bred over a number of generations to generate a calibrated ensemble. The parameter perturbations enter the cost function along the lines of 4DVAR to prevent unphysical model selection.

The system has also been applied to the malaria modeling system (with 20 degrees of freedom) and was found to be able to successfully calibrate the malaria model for a highlands location in Africa. The method was applied to calibrate both the malaria model itself as well as the driving climate data (either from observations or from the ECMWF system) and it was demonstrated that in highland areas the uncertainty in temperature was more important than errors in the modeling system itself (assuming the prior was correct). A manuscript has been submitted to PLOS Comp Bio. For full details of the method, please refer to the manuscript.

In the next steps of the project, the calibration system will be implemented to the ECMWF driven, pilot early warning system for evaluation in Kenya and Uganda.

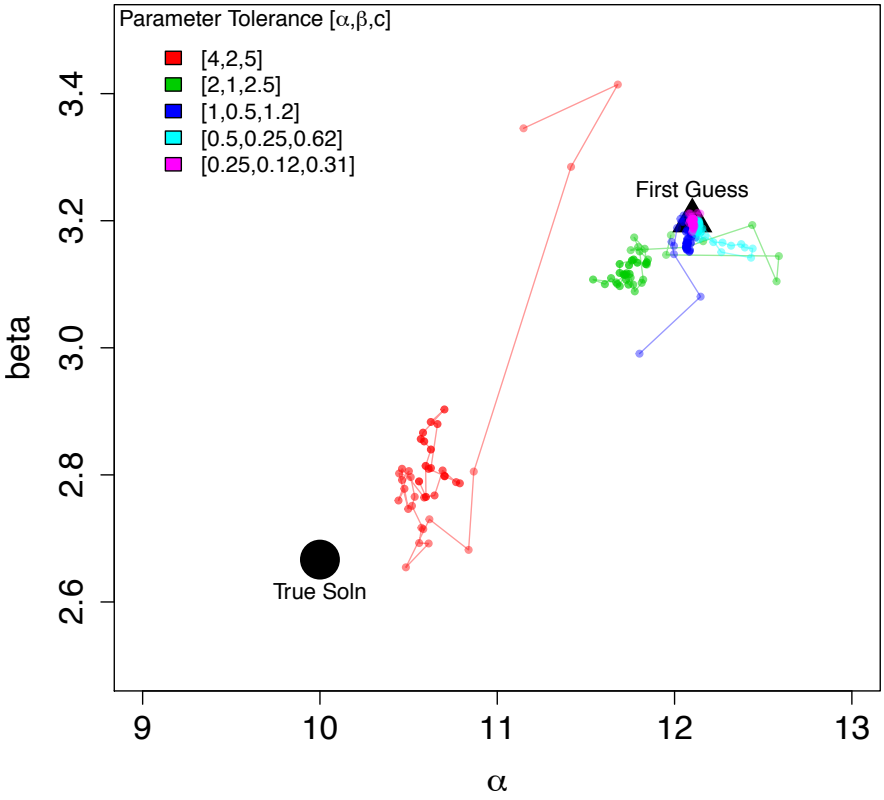

Figure 2: Illustration of over confidence in parameter uncertainty estimation, alpha and beta are two of the three Lorenz system parameters. High parameter confidence prevents calibration (cyan and blue cases), while medium (green) and low (red) confidence in the prior allows calibration towards the "true solution" (which is known in this case since the experiment uses a "perfect model" scenario, manuscript in preparation). However, the prior cost function prevents unphysical model selection in cases where parameters are well known from observations or theory.

b) Book chapter on S2S health predictions

A book chapter has been written focussing on the use of the S2S database hosted at ECMWF in health applications. The chapter is due to publication in early 2018 by Elsevier and is edited by Frederic Vitart of ECMWF.

c) Extension of analysis to other health impacts.

In collaboration with IRI, further analysis is underway to generalize the use of ECMWF (and other S2S) products for health applications. In particular, an preliminary analysis is underway for heatwave forecasting at S2S timescales, and the groundwork has been conducted to generalize the system to model dengue. Further results will be presented in the 3rd year report.

d) Collaborations of opportunity.

While not strictly related to the original aims of the project, phase 1 and 2 of the project often took advantage of "windows of opportunity" for collaboration between ICTP and ECMWF. To this end, in this phase of a project the opportunity was taken to contribute directly to ECMWF's

contribution to the fire monitoring and prediction component of the Copernicus programme. Tompkins has developed a new double-nested regression code in order to compile compression statistics of fire sizes and burn times, in addition to trigger locations and merge frequency of fires from around the globe from 2003 to 2017.

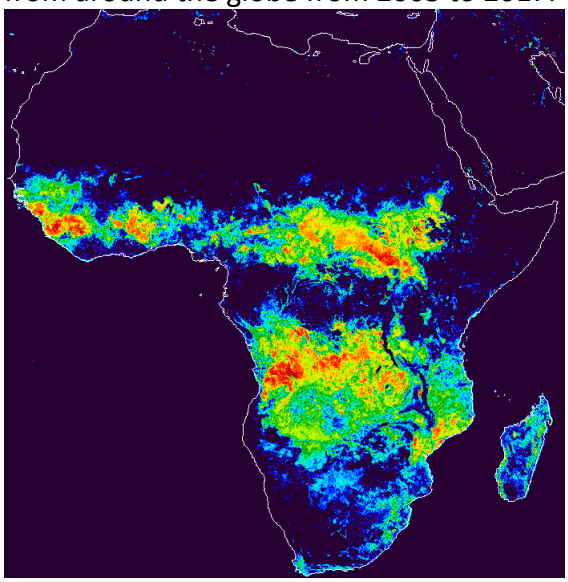

Figure 3: Fire burn frequency derived from Satellite observations (2003-2014) of radiative fire power. A threshold of 0.5 W/m2 is used to identify fire points. The dynamical range of the plot is such that the maximum shown is 10% burn frequency with red colors > 3% burn frequency.

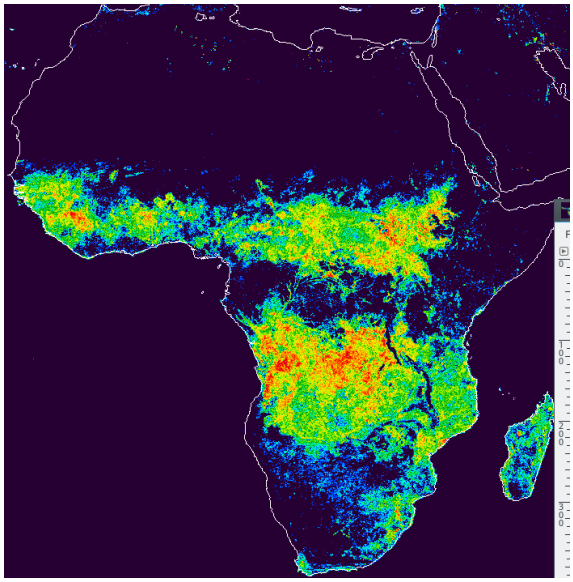

Figure 4: Analysis of trigger frequency. The Special project PI has developed a new double-nested recursion algorithm to identify all trigger points of fires, and document fire burn time, burn area, burn volume and number of trigger points per fire to document fire merging. Here the trigger frequency is shown with a dynamical range of 0-3% and red colors indicating a trigger frequency exceeding 1%. A full analysis is underway as a side project of the main spitp4dc project and represents an additional unfunded contribution of the special project to ECMWF's climate service Copernicus programme.

Preliminary results of this new algorithm are shown here, but a full analysis will be conducted in collaboration with ECMWF during 2017. The two plots show the fire burn frequency (fig. 3) and the trigger location frequency (fig.4) for the analysis conducted in Africa. Comparing the two panels with the algorithm allows the identification of triggering "hotspots" and further analysis on

percentage triggering caused by e.g. lightning strikes, in contrast to agricultural burning and other causes.

Use of computer resources

Use of ECMWF resources in mainly envisaged in late 2017/2018

List of publications/reports from the project with complete references

Tompkins and multiple co-authors: “S2S applications in health”, book chapter submitted for publication by Elsevier in 2018, eds: Frederic Vitart (ECMWF) and Andy Robertson (IR).

Tompkins and Thomson: Relative contribution of model parameter and climate uncertainty to malaria simulations assessed using a constrained genetic algorithm, manuscript submitted to PLOS comp. bio. 2017

Summary of plans for continuation of project.

In the third year, the plan is to:
1) complete implementation of calibration in the malaria health early warning system pilot
2) test the impact of using the system to automatically calibrate the EPS/openIFS
3) finish analysis of forecasting heatwaves on S2S timescales.

The computer resources allocated will mainly be used in year 3 for item 2, the computer units for 2017 can be allocated to other special projects.