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	2015
Project Title:	Incorporating land-surface model uncertainty into the IFS
Computer Project Account:	spgbweis
Principal Investigator(s):	Antje Weisheimer[1,2] , Dave MacLeod[1] , Tim Palmer[1]
Affiliation:	[1]University of Oxford, [2]ECMWF
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…………………………………………………………… ……………………………………………………………
Start date of the project:	1st Jan 2014
Expected end date:	31st Dec 2016

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)	8,000,000		12,000,000	3,579,586
Data storage capacity	(Gbytes)	10,000		15,000	

Summary of project objectives
(10 lines max)

The land surface is a key source of seasonal predictability and it has been shown that land-atmosphere coupling contributes to the development of seasonal heatwaves. It is highly heterogeneous in space and time, which introduces uncertainty when the climate system is simulated on the typical grid resolution used in seasonal forecasting. Uncertain model parameter values are also a source of uncertainty in simulations. The aim of this project is to improve the representation of uncertainty in the land surface component of the IFS (HTESSEL). This has been first explored using perturbed parameter experiments, and following this, methods of stochastic perturbations are being designed and tested.

Summary of problems encountered (if any)
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As a consequence of the end of the availability of the previous HPC from IBM in September last year, no release of the IFS/NEMO model version for long-range (seasonal) experiments on the new HPC from Cray had been available until mid-May when CY41R1 was officially released. This delayed release of CY41R1 meant that we were unable to progress with experiments for some time. Unfortunately no research version of CY36R4 (which is what System 4 uses) is supported on the new HPC.

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

Continuing analysis of existing CY36 runs
We have continued analysis of the existing CY36R4 runs, with results written up into a paper (*MacLeod et al., 2015*). Figure 1 is taken from the paper, and demonstrates the improvement in extreme 2003 summertime temperature with our perturbed parameter experiment (described in previous progress report).

This shows the shifting of the forecast PDF for JJA 2m air temperature over the Mediterranean for 2003, with movement of ensemble members toward higher temperatures in the PP experiment.

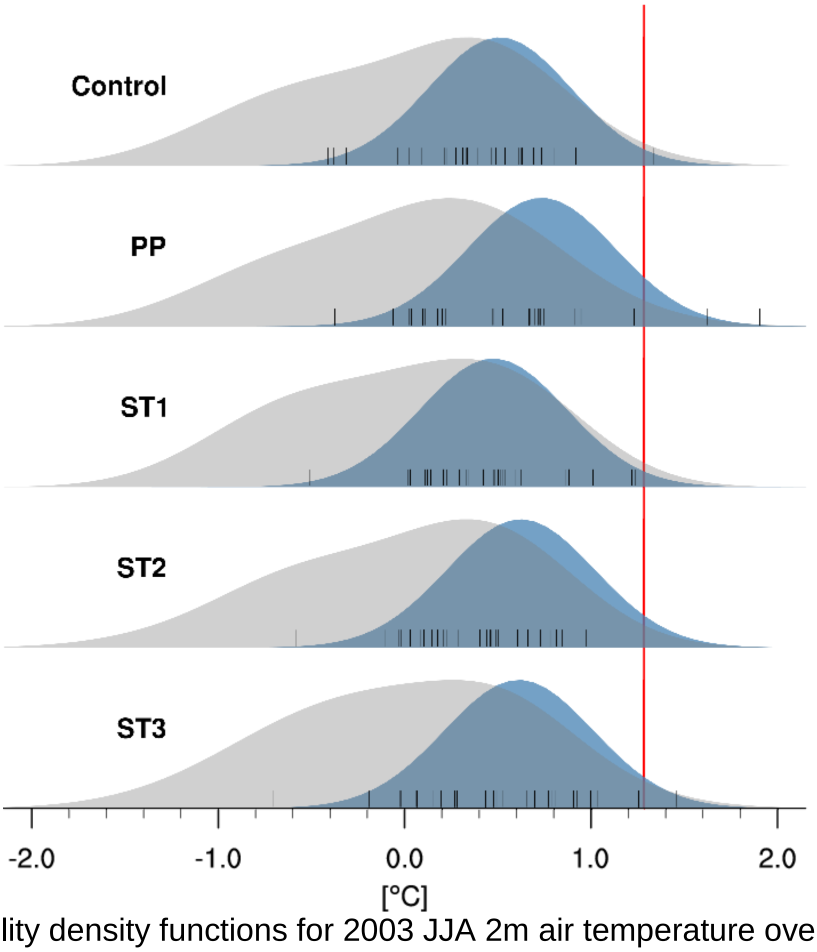

Fig 1. Probability density functions for 2003 JJA 2m air temperature over Europe (10W-40E, 30-48N), represented by the blue curve (small black lines indicate individual ensemble members). The grey curve indicates the climatological distribution, and the red line indicates the observed temperature from ERA-Interim. See progress report 2014 for description of experiments.

New experiments with CY41

Beyond this analysis, we decided to investigate the impact of these land surface perturbation experiments when applied to the new cycle CY41R1. Due to the delayed release of CY41R1, we had been working with versions of CY41R1 that were available in the meantime. However, we are re-running our analysis for the official release version of CY41R1 now to make sure that all changes have been incorporated appropriately.

The experiments we carried out were based on experiments described previously, with some modifications:

- Control: 1981-2013, May starts, 4 month lead, 25 members
- PP: perturbed parameter, as control with static parameterisation of van genuchten alpha and saturated hydraulic conductivity, perturbations taken from the range {-80, -40, 0,+40,+80%} for each.
- ST: stochastic tendencies, stochastic perturbation to soil moisture tendencies, with perturbations taken from the spectral pattern generator used in SPPT, with scale weighting set equally (max perturbation +/- 80%)
- SP: stochastic parameters, 2 parameters from PP experiment perturbed stochastically with the equal-scale spectral pattern generator.

Results from the new SP experiment showed relative little impact on the hindcasts. We think that this may be modified by experimenting with different pattern generator scales. The ST experiment has not shown much impact either (though this was somewhat expected, having little impact in the previous cycle).

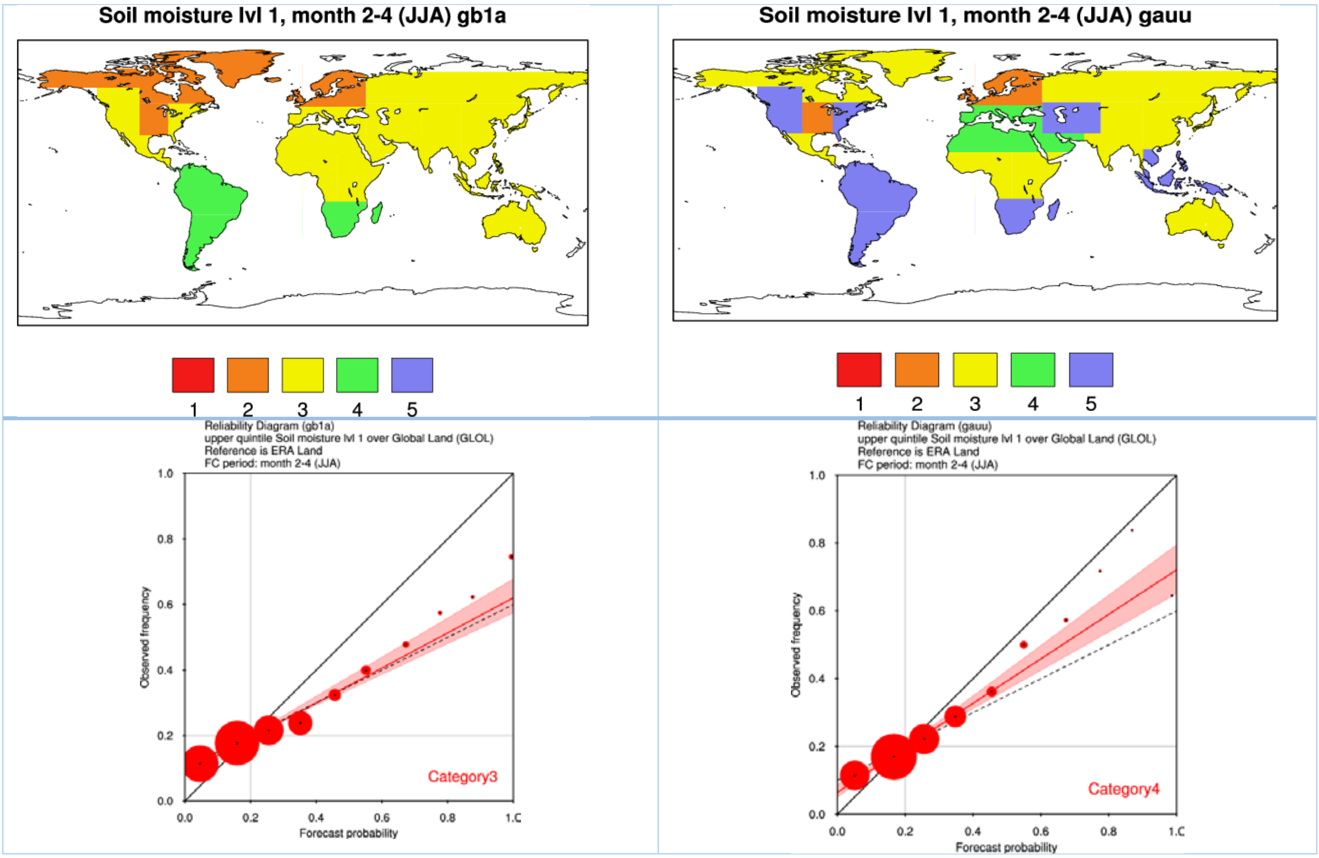

Fig 2. Top row: reliability category map for upper quintile soil moisture, CY41 control (left) and CY41 PP (right) experiment (categories based on Weisheimer & Palmer, 2013). Bottom row, reliability diagrams for upper quintile soil moisture for all land points.

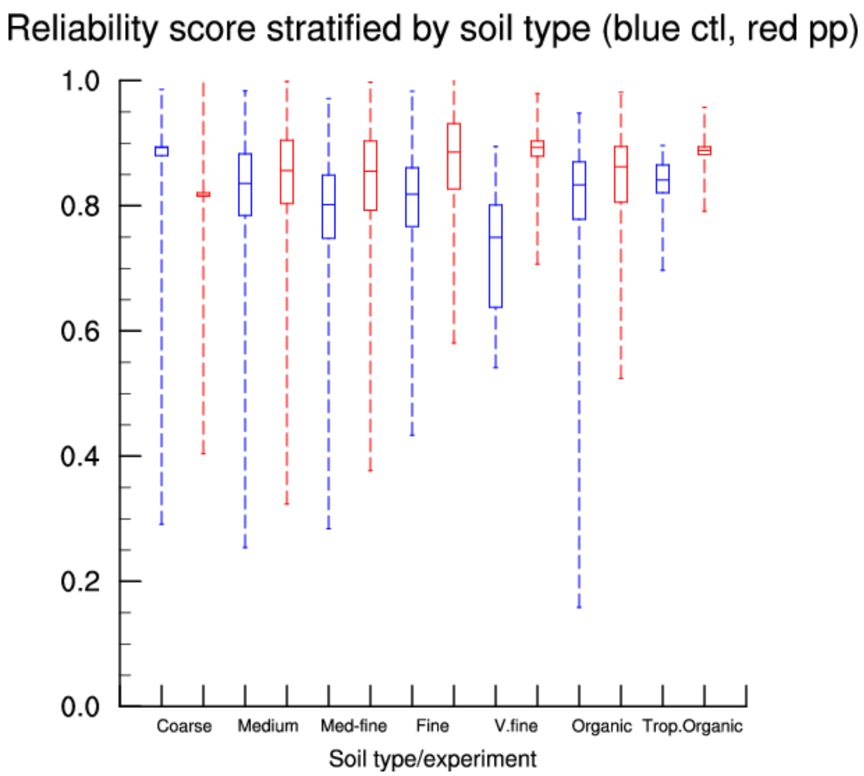

Figure 3. Reliability score (component of the brier score), comparing the control experiment and the perturbed parameter experiment, stratified by soil type.

Experiments with offline HTESSEL

Parallel to the runs with the full IFS, we have carried out some analysis of runs using the offline single column model version of HTESSEL.

We are following an experimental design inspired by *Wood & Lettenmaier 2008*. In this paper they use all combination of initial condition and forcing years to run a hydrological model for a single point, and use the variance of sub-ensembles to characterise the contribution to uncertainty from the initial conditions or the forcing.

We extend this by including an ensemble of model variations, to analyse model uncertainty also.

This results in a large number of simulations: with 25 initial conditions and 25 forcings (1981-2005), plus 25 model versions (each using a different parameter combination, described by the PP experiment above). We run a simulation for each combination in all three dimensions (giving a total of 25^3 =15,625 simulations). By looking at the ensemble variance for each initial start date calculated across runs with all forcing and model versions (with the variance averaged across all initial conditions), this gives an idea of the reduction of uncertainty gained by knowledge of initial conditions. In a similar way, contribution toward uncertainty can be assessed for the forcing and for parameters.

So far we have only run for a single gridpoint for France, with some preliminary results shown in figure 4. Near the start of the simulation the initial condition has the most importance, but over time the forcing takes over. This crossover point is closer to the start date for the top soil level, with initial conditions retaining importance for longer the deeper down the soil level is. Furthermore, the model uncertainty is relatively unimportant at the surface, but takes more importance for deeper levels.

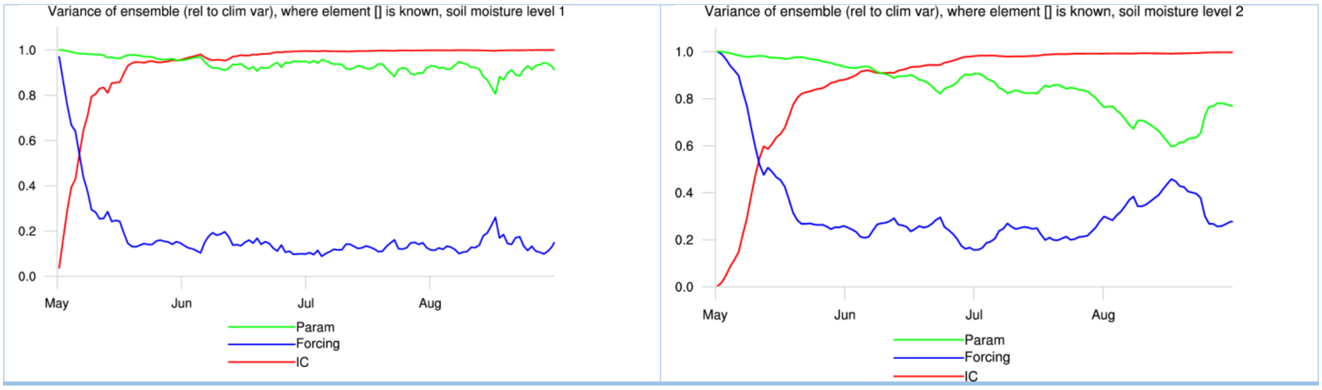

Figure 4. Results from experiments with the single column model, showing the reduction in total variance provided by each component of uncertainty. Left column: results for top level, right; level 2.

These experiments and analysis are only now beginning to be explored, but we are planning to extend the work, with extra gridpoints, start dates. We are in talks with Paul Dando from ECMWF User Support about the possibility of running a global-scope experiment on the supercomputer, though the time constraint is large; for one gridpoint the experiment takes 10 days.

We are hoping to produce the kind of analysis shown in figure 4 for many gridpoints across a global domain. The length of time to simulate this in the current setup is unfeasible; we hope to overcome this constraint with a combination of a reduction in ensemble size (if possible), parallelisation and gridpoint sub-sampling.

References:

Weisheimer, T. N. Palmer, 2014, On the Reliability of Seasonal Climate Forecasts, J. R. Soc. Interface 2014 11 20131162; DOI: 10.1098/rsif.2013.1162.

Wood, A.W., Lettenmaier, D.P., 2006. A test bed for new seasonal hydrologic forecasting approaches in the western United States. Bull. Am. Meteorol. Soc. 87 (12), 1699–1712

List of publications/reports from the project with complete references

MacLeod DA, Cloke HL, Pappenberger F and Weisheimer A, 2015 Improved seasonal prediction of the hot summer of 2003 over Europe through better representation of uncertainty in the land surface, QJRMS (under revision).

Summary of plans for the continuation of the project

(10 lines max)

We plan to continue experiments with CY41R1. These will include more variations of the stochastic parameter experiment, experimenting with different scales to get some impact.

We will also continue work with the single column model, to extend the analysis across a global domain.