Fitting the seasonal cycle with adJULES

JULES meeting, Leicester

Tim Jupp, Nina Raoult
Catherine Luke and Peter Cox

July 1, 2014

UNIVERSITY OF EXETER

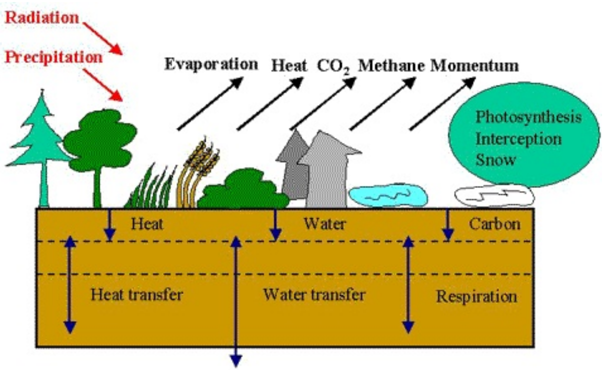
National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Outline

1. Introduction
2. Theory
3. Example
4. Summary

JULES - Joint UK Land Environment Simulator

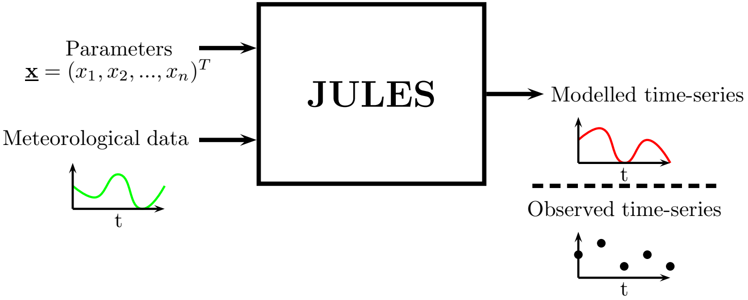
Models the land surface.



10,000 lines of Fortran.

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

JULES - a land surface model

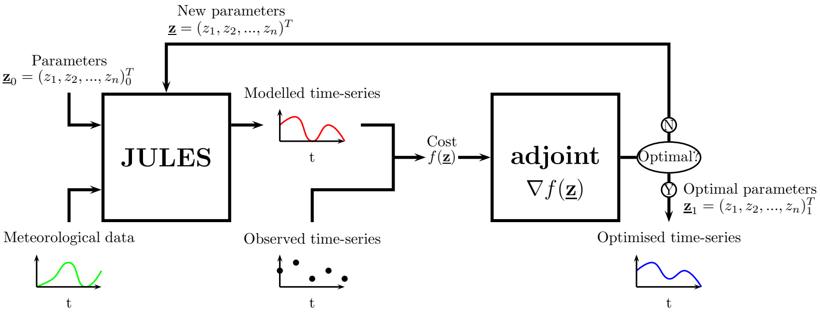


Get a better fit - adjust the parameters!

Figure : JULES has $O(100)$ parameters.

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

adJULES - the adjoint of JULES



Changes to modelled time series

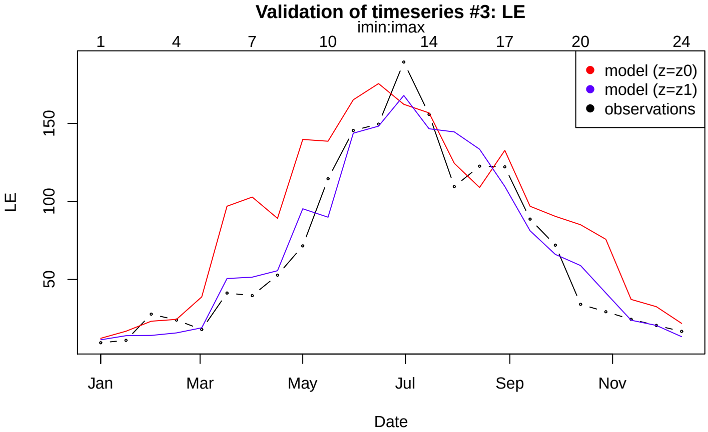


Figure : Time series of latent heat flux at Harvard Forest.

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Changes to modelled time series error

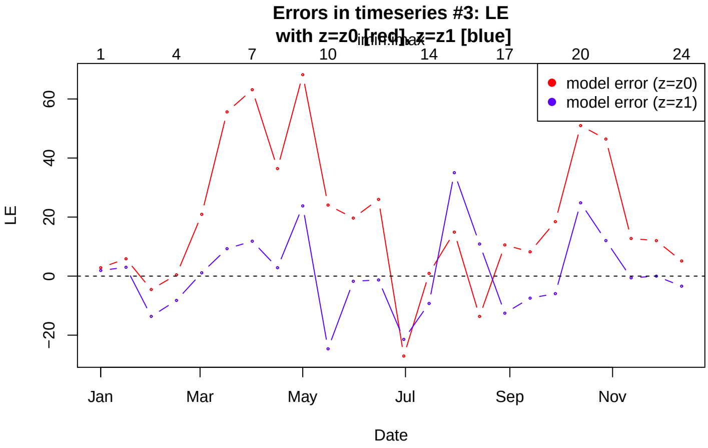


Figure : Errors in time series of latent heat flux at Harvard Forest

Changes to modelled time series

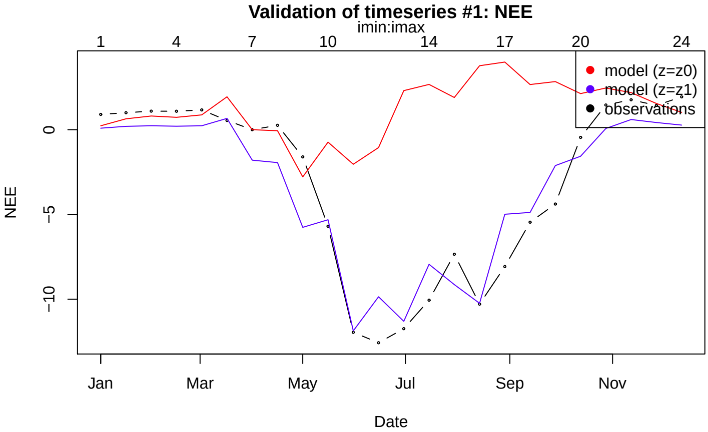


Figure : Time series of carbon flux at Harvard Forest.

Changes to modelled time series error

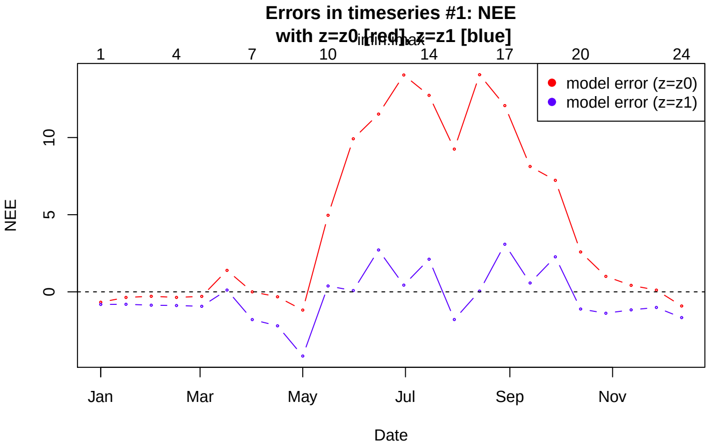


Figure : Errors in time series of carbon flux at Harvard Forest.

Slice through cost function

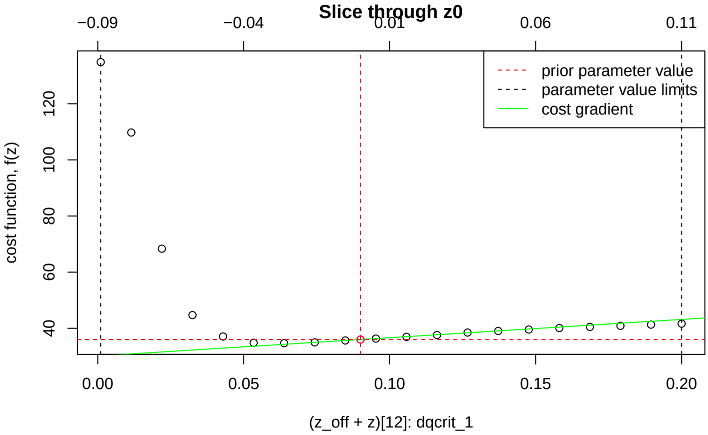


Figure : Initial cost function value against *dqcrit*.

Slice through cost function

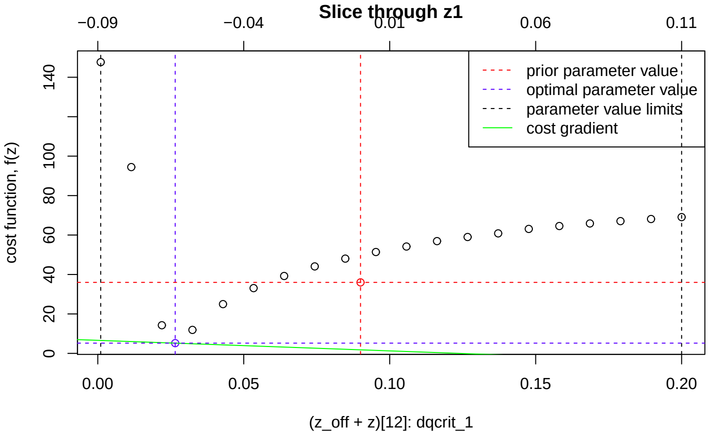


Figure : Optimised cost function value against *dqcrit*.

Use of 2nd derivative

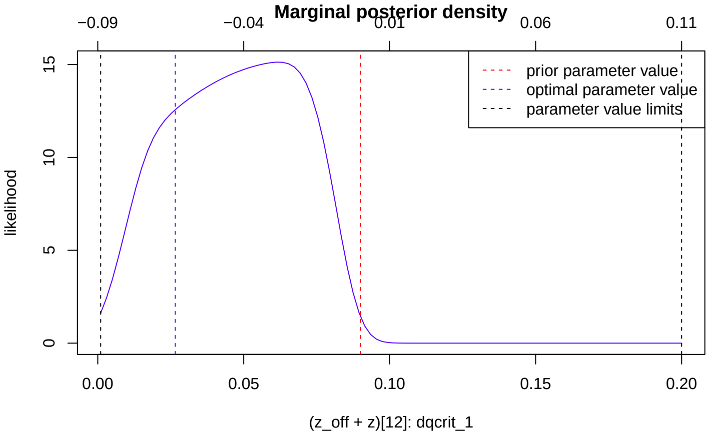


Figure : Posterior marginal density.

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Covariance between parameters

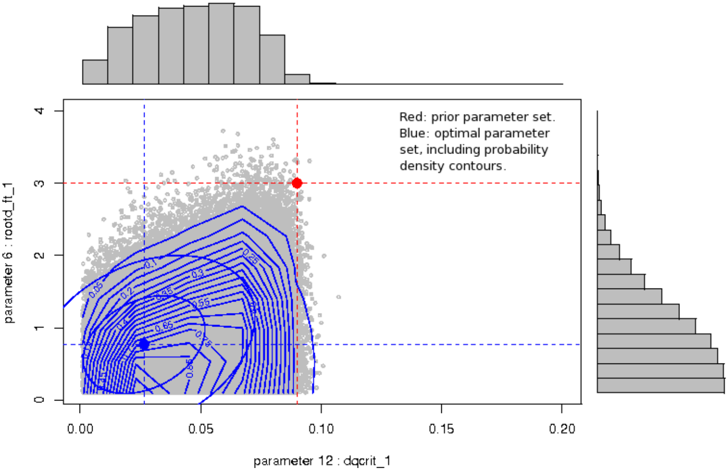


Figure : Posterior bivariate density.

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Review

JULES has been differentiated line by line using commercial software from FastOpt. For a given parameter vector $\mathbf{x}$, adJULES can:

- Find the cost function $f(\mathbf{x})$ (mean–square misfit to data).
- Find the analytical derivative of the cost function $\nabla f(\mathbf{x})$.
- Use R optimisation routines to search parameter space using derivative information from $\nabla f(\mathbf{x})$ to minimise $f(\mathbf{x})$.
- Return a (locally) optimum parameter set that minimises $f(\mathbf{x})$.
- The 2nd derivative of $f(\mathbf{x})$ can be used to produced (multivariate) posterior densities for parameters.
- The use of satellite data in conjunction with adJULES could improve many parameter estimates.

Latest results: Multisite Optimisation

Site name	Parameter						
	$n_l(0)$	α	F_0	T_{low}	T_{upp}	rootd_ft	DQ_{crit}
Harvard Forest	0.119	0.622	0.591	16.8	45.0	1.76	0.023
Morgan Monroe	0.0604	0.465	0.5	14.3	38.2	3.37	0.039
Multi (HF&MM)	0.13	0.372	0.739	21.4	29.1	2.54	0.0344

Table 1: Optimal parameter values for each site, to three significant figures. Parameters that reach their upper bound are denoted $^+$; parameters that reach their lower bound are denoted $^-$.

Figure : Multisite optimisation. Coloured in red are all the parameters with the 80% interval fraction strictly less than 0.3, in orange are the parameters between 0.3 and 0.7 and the ones in black are above 0.7.

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Latest results: Multisite Optimisation

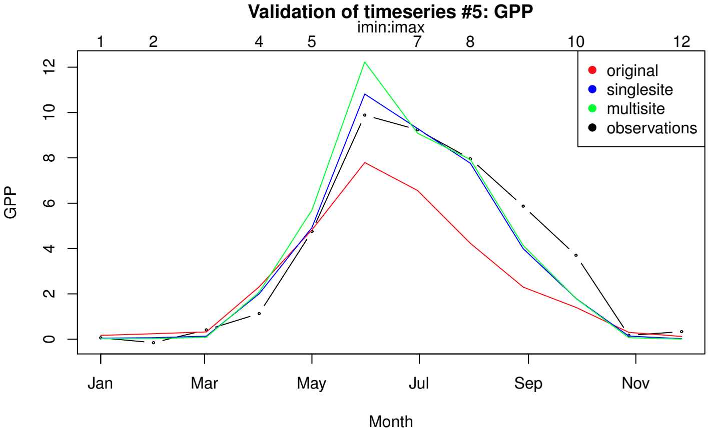


Figure : Results at Morgan Monroe (multisite fit included Harvard Forest).

Latest results: Multisite Optimisation

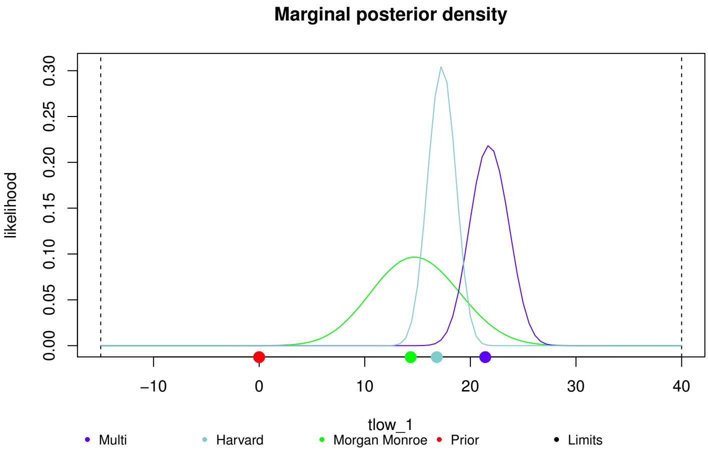


Figure : Multisite parameter fit.

Questions and comments

Thank you

Contacts

If you would like more information, on the adJULES system please contact:

- Tim Jupp, T.E.Jupp@ex.ac.uk

The code can be downloaded from

- www.adjules.ex.ac.uk

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL