# Fitting the seasonal cycle with ADJULES

## JULES Science Meeting

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and Peter Cox

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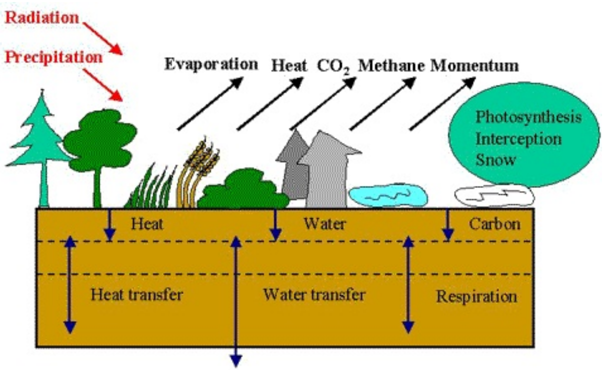
National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

# Outline

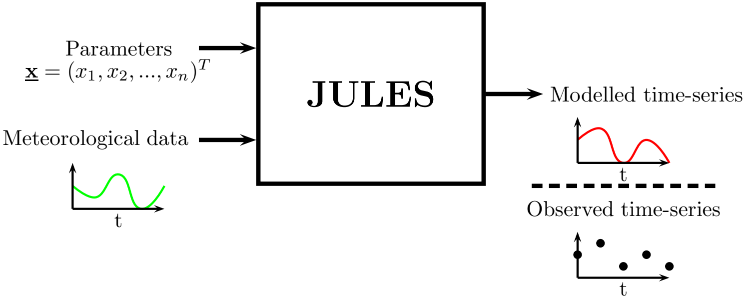
# JULES - Joint UK Land Environment Simulator

Models the land surface.




10,000 lines of Fortran.

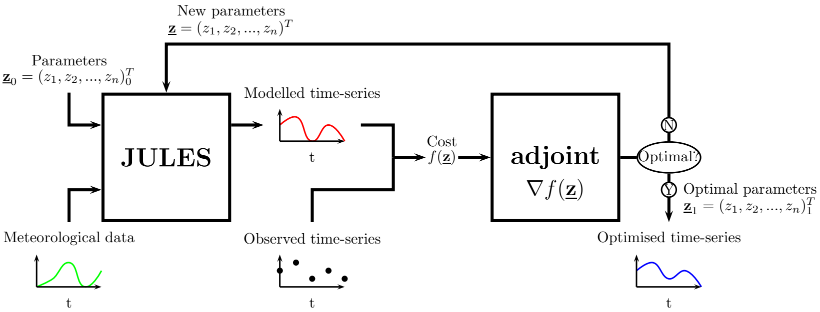
# JULES - a land surface model



# Get a better fit - adjust the parameters!

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

# ADJULES - the adjoint of JULES



# Example optimisation

- One year run (1999) at Harvard.
- Prescribed monthly LAI and fixed broadleaf tree vegetation (as in Blyth et al., 2010).
- 12 parameters allowed to vary: `nl0`, `alpha`, `f0`, `tupp`, `rootd`, `dcatch_dlai`, `dqcrit` (pft-specific), `smvccl` (4 values, one for each soil layer), `cs`.
- Optimised 15 day averaged latent heat and net ecosystem exchange against flux tower observations.

# Changes to modelled time series

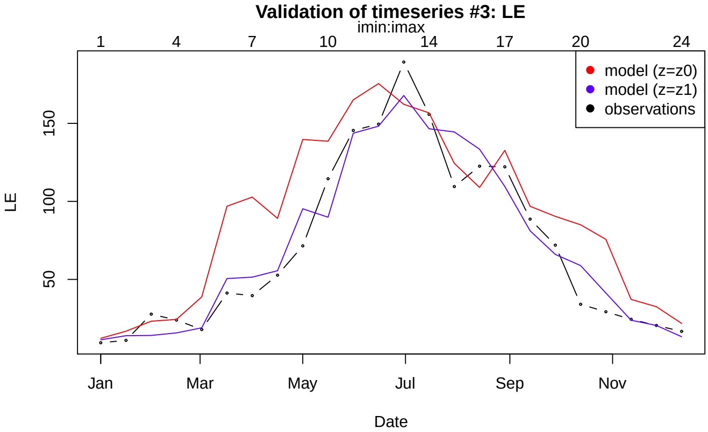



Figure: Time series of latent heat flux at Harvard Forest.

# Changes to modelled time series error

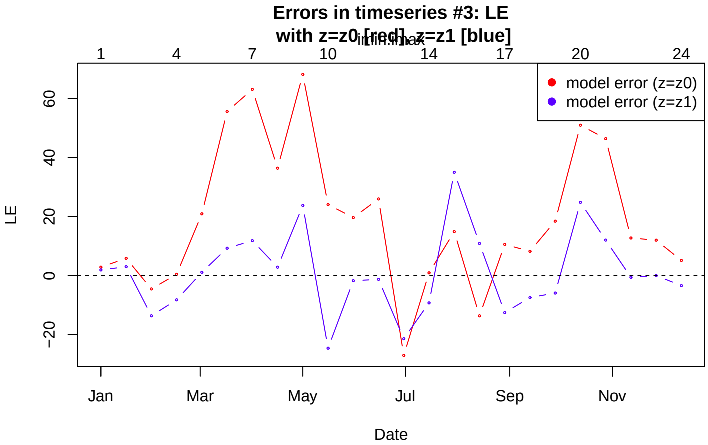



Figure: Errors in time series of latent heat flux at Harvard Forest

# Changes to modelled time series

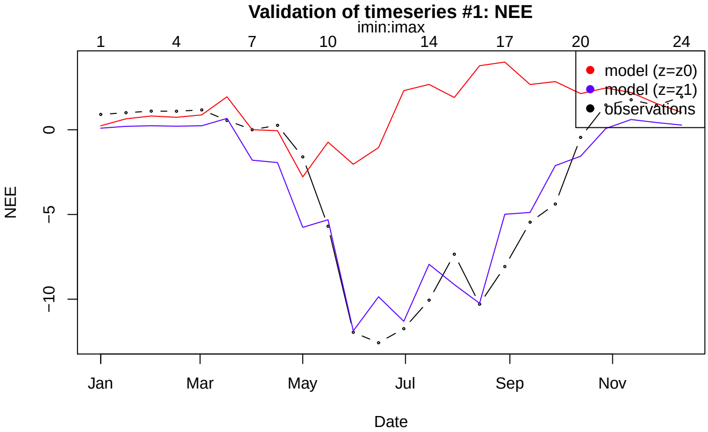



Figure: Time series of carbon flux at Harvard Forest.

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# Changes to modelled time series error

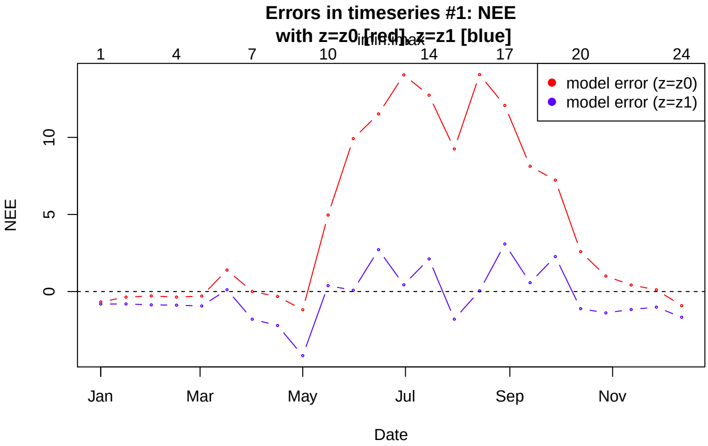


Figure: Errors in time series of carbon flux at Harvard Forest.

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# Slice through cost function

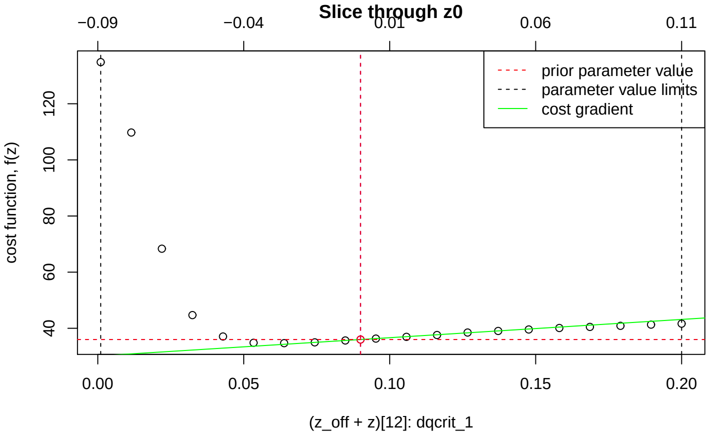


Figure: Initial cost function value against *dqcrit*.

# Slice through cost function

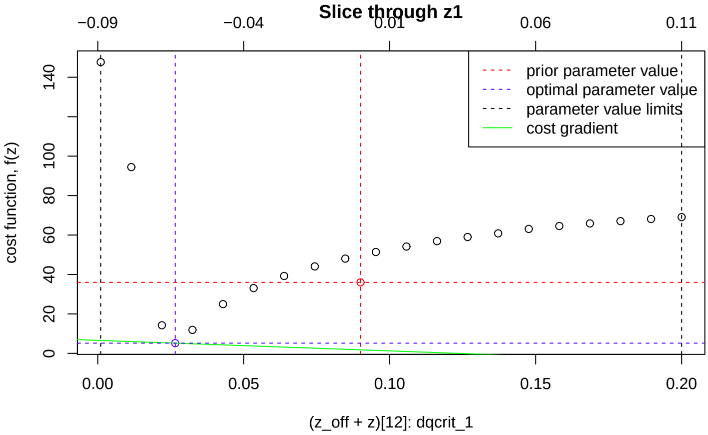


Figure: Optimised cost function value against *dqcrit*.

# Use of 2nd derivative

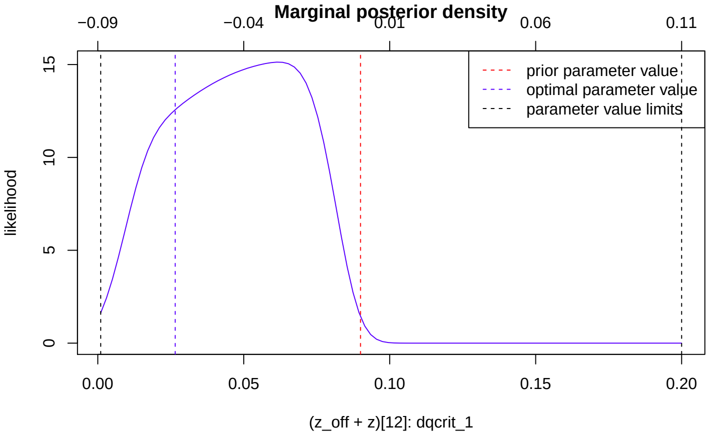


Figure: Posterior marginal density.

# Covariance between parameters

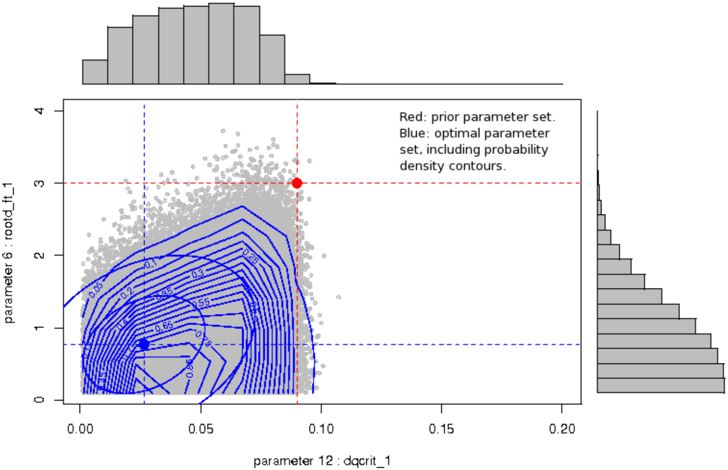


Figure: Posterior bivariate density.

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# Future plans

**Short term**

- Optimise parameters for the JULES benchmarking sites.
- Investigate assimilation of satellite albedo product (in conjunction with Tristan Quaife and others).

**Medium term**

- Develop JULES 3.2 adjoint.
- Gridded ADJULES.

**Long term**

- Develop mechanism to assimilate top of atmosphere observations.
- Incorporate atmospheric transport to allow for $CO_2$ assimilation.

# 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 observational data in conjunction with ADJULES could improve many parameter estimates.

# Questions and comments

## Thank you

**Contacts**

If you would like more information, or to use the ADJULES system please contact:


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