Developing the representation of standing water, inundation and river routing in JULES

Douglas Clark, UKCEH

with Toby Marthews, Dai Yamazaki, Simon Dadson and others

Hydro-JULES and WCSSP India CASPER projects

This talk describes work in progress in two areas:

River routing and inundation

- Introducing the CaMa-Flood model into JULES
  – an alternative to existing parameteristions

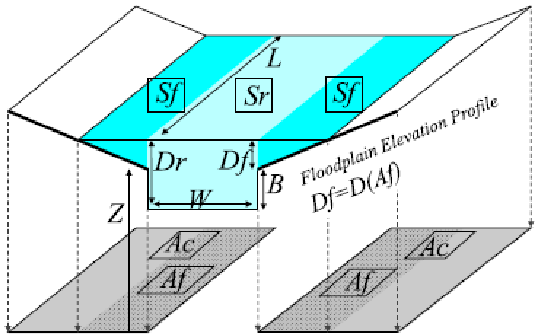
Effects of inundation

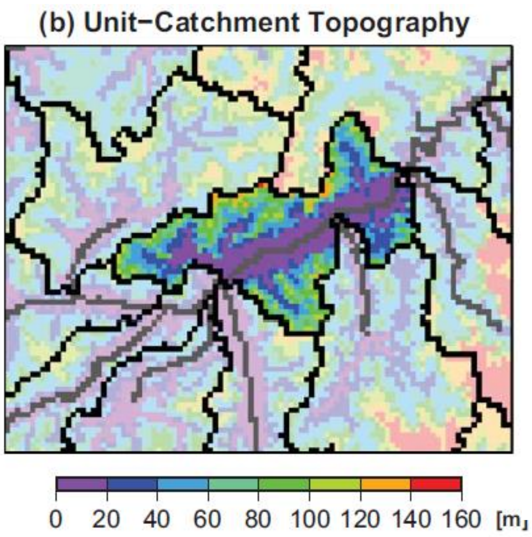
- Effects on evaporation, infiltration, etc.
  – not currently represented

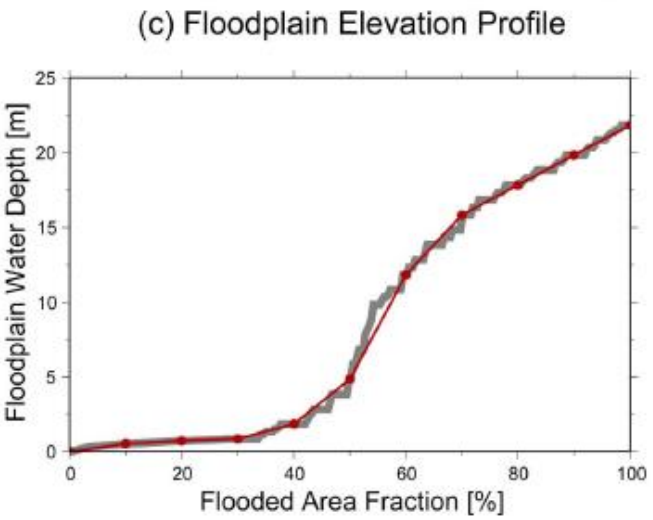
Catchment-based Macro-scale Floodplain model

Yamazaki et al., 2011, A physically-based description of floodplain inundation dynamics in a global river routing model, Water Res. Res.
Yamazaki et al., 2013, Improving computational efficiency in global river models by implementing the local inertial flow equation and a vector-based river network map, Water Res. Res.

A 1-D model of river routing and inundation
Uses the local inertial equation – improved physics over kinematic or diffusive wave models
Calculates water depth, then inundation estimated using sub-grid topography
Uses an adaptive timestep approach on a grid or unit catchment basis.



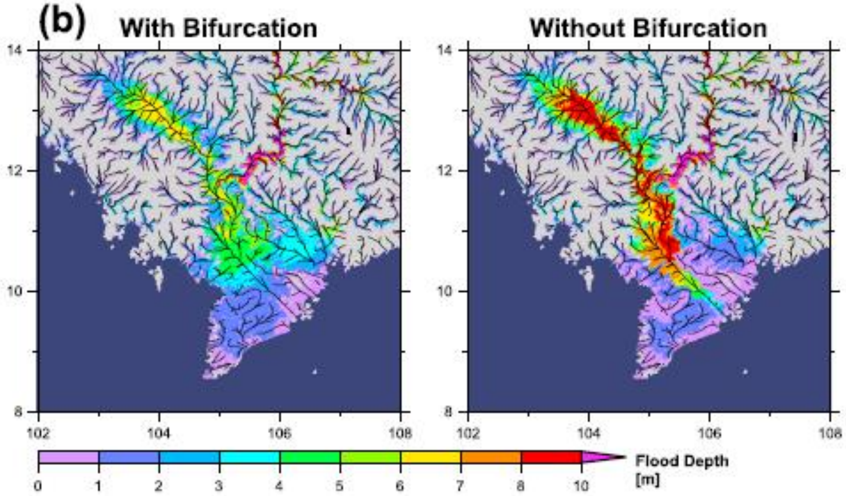




Figures from Yamazaki et al. (2011, 2013)

The local inertial equation allows backwater effects to be modelled.
A downstream water level (e.g. sea level) can be used as a boundary condition – can capture effects of marine storm surge on rivers.

Channel bifurcation has been parameterised – as the water level rises some of the flow can access different flow paths.

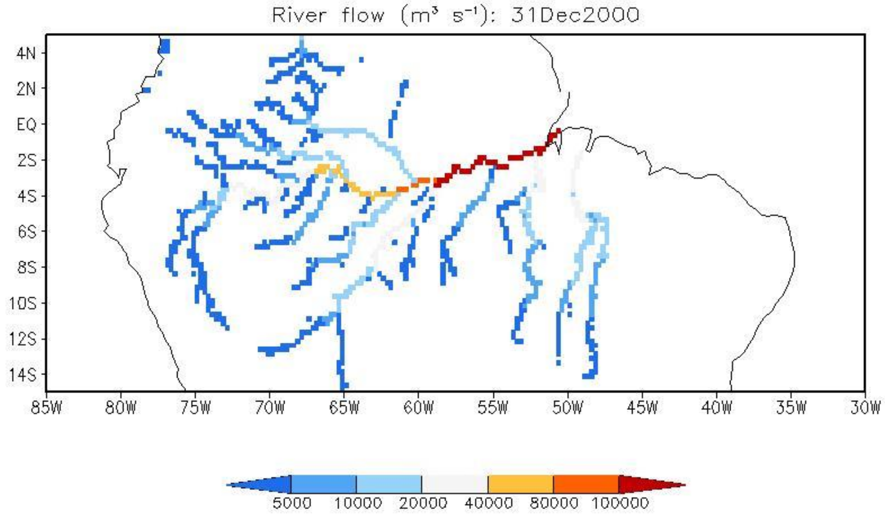


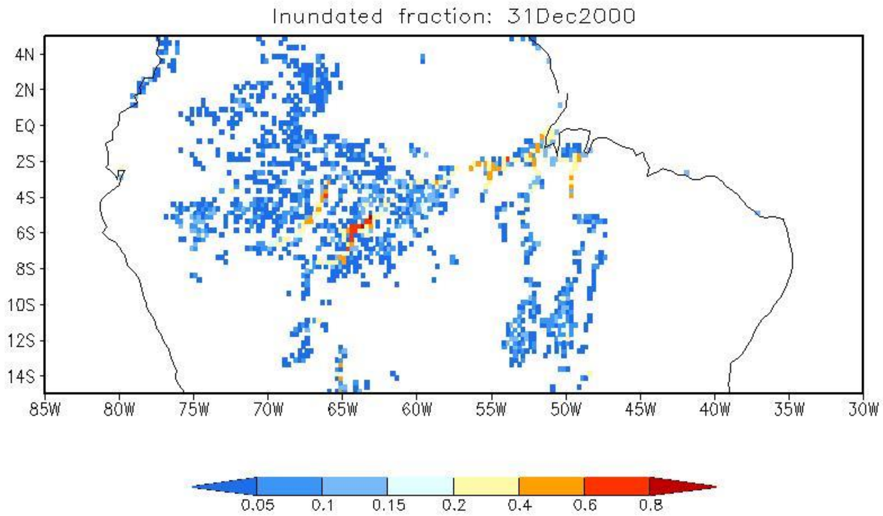
CaMa-Flood is being implemented as an option in JULES – alongside TRIP and RFM.

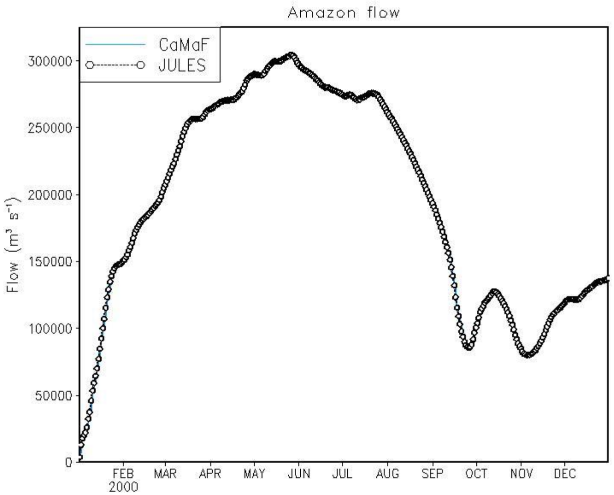
Test results: comparing JULES-CaMaFlood with CaMa-Flood v3.96a.

Both models are forced with runoff on a 0.25deg grid.

1 year run “from cold”.







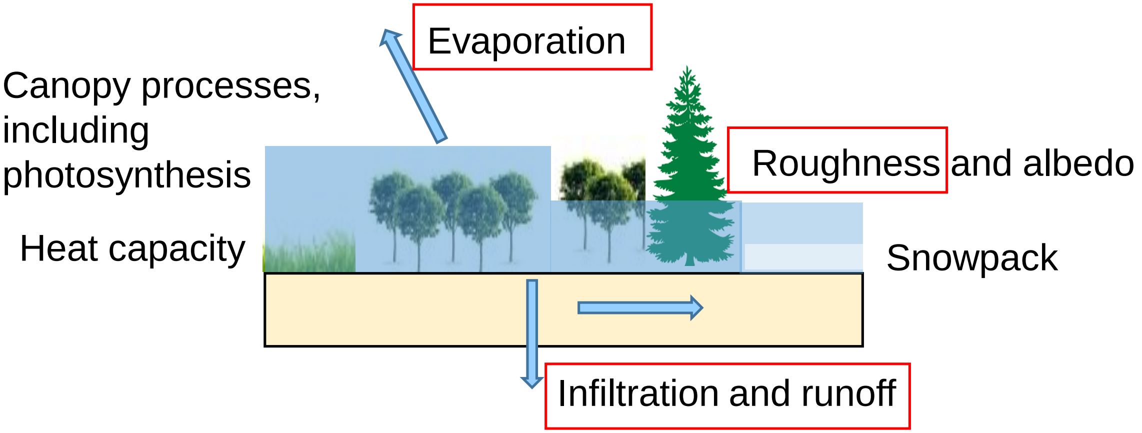
Next steps include:

- Further testing
- Downstream water level BC
- Bifurcation

Effects of standing water

At present overbank inundation is purely diagnostic in JULES – the flood water does not affect any other aspect of the model.

In reality, standing water affects many aspects of hydrology and surface-atmosphere fluxes.



Evaporation of standing water

This is similar to the existing "lake evaporation" except that it depletes a finite store.

$$E = E_{\mathrm{pond}} + E_{\mathrm{can}} + E_{\mathrm{soil}}$$

$$E = f_{\mathrm{p}} \frac{\rho\,\delta q}{r_{\mathrm{a}}} + (1 - f_{\mathrm{p}}) f_{\mathrm{c}} \frac{\rho\,\delta q}{r_{\mathrm{a}}} + (1 - f_{\mathrm{p}})(1 - f_{\mathrm{c}}) \frac{\rho\,\delta q}{r_{\mathrm{a}} + r_{\mathrm{c}}}$$

Fraction with E_{can} $f_{\mathrm{c}} = \frac{c}{c_{\mathrm{max}}}$

Fraction with E_{pond}

$$f_{\mathrm{p}} = \frac{z_{\mathrm{pond}}}{z_{\mathrm{veg}}}$$

= depth of standing water/ height of vegetation

$$f_{\mathrm{p}} = \frac{z_{\mathrm{pond}}}{10 z_{0,\mathrm{m}}}$$ for non-veg tiles = depth/10*roughness

We need a depth of standing water…

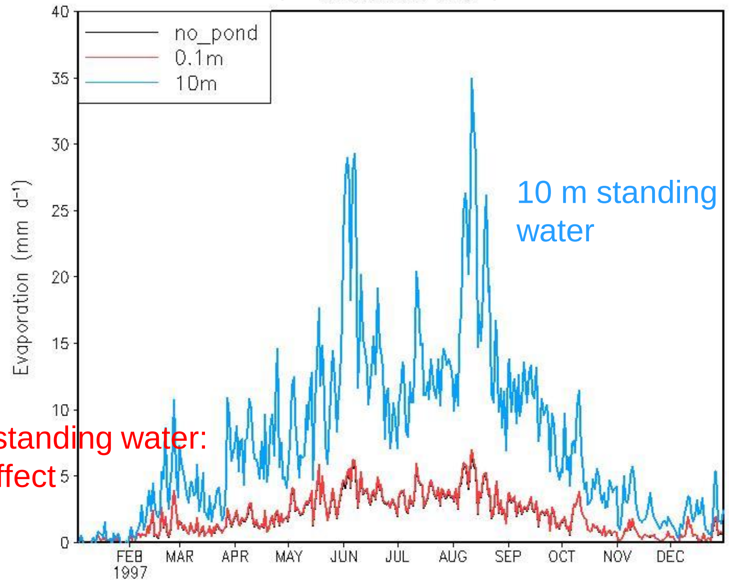
Evaporation of standing water

At present JULES cannot hold any water on the soil surface –
any input that cannot infiltrate immediately forms surface runoff.

> To allow testing I have simply diverted a constant fraction of throughfall into a new surface store.
> The surface store can evaporate or infiltrate (at a fixed rate up to Ksat).
> Or for testing…prescribe a constant depth of water.

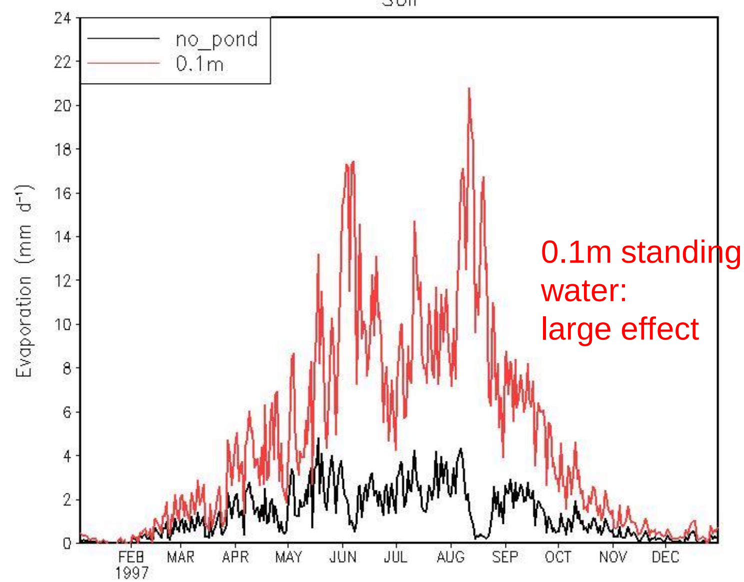
Total evaporation from:

19m tall tree



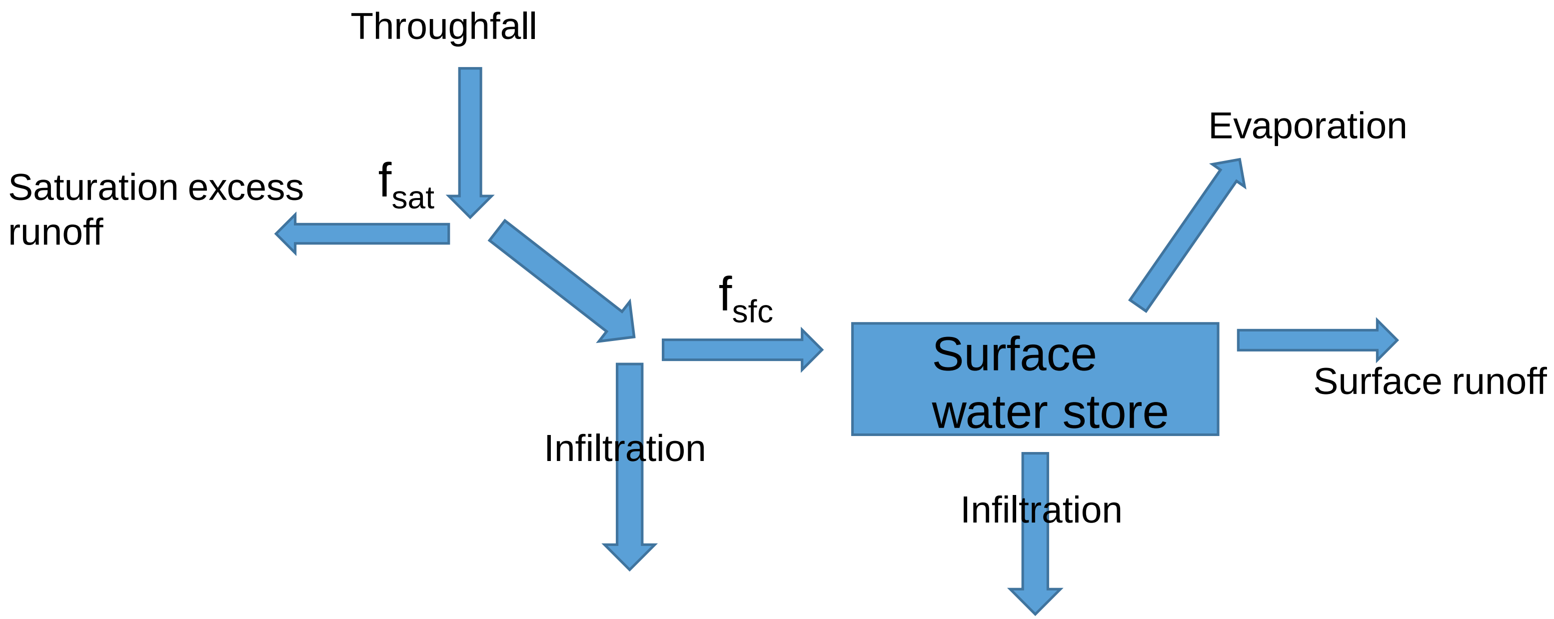
0.1m standing water:
little effect

bare soil



How to include standing water ?

An approach similar to that used in CLM5:



Microtopography is assumed to be distributed normally.
With assumptions about how patches are connected, we can calculate the extent of surface water and a threshold storage above which surface runoff occurs.

Needs to be made consistent with the rest of the model, including surface runoff (and rainfall distribution!), and groundwater and overbank inundation…

Summary

CaMa-Flood parameterisation of routing and overbank inundation

- Initial implementation working
- Needs tidying, testing, etc.

Representing the wider effects of inundation

- Standing water represented in surface fluxes
- Needs further work to introduce a store of standing water
  …which needs to fit with with existing parameterisations