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Assessing the application of land surface models for flood forecasting in the UK

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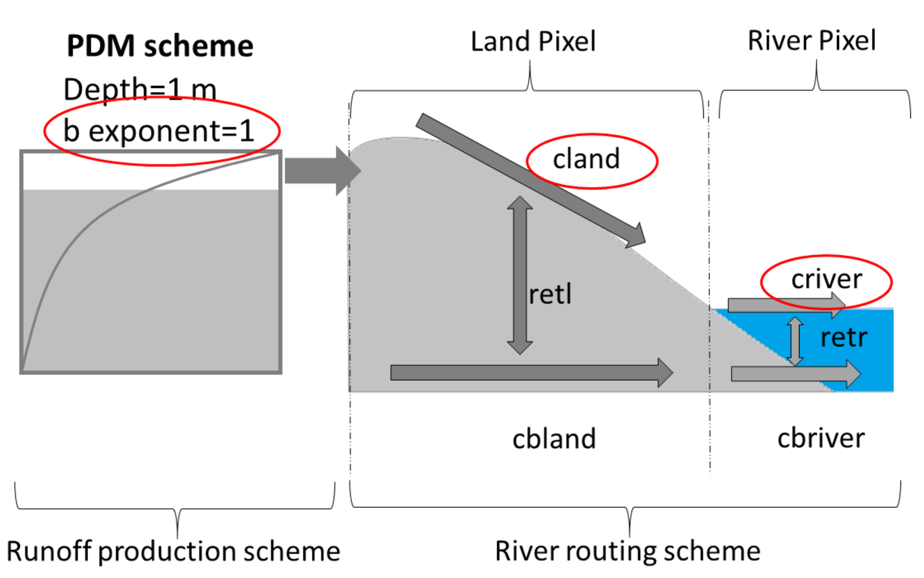
Motivation and Objectives

Floods are a major problem in UK which can cost lives and money. Physics based Land Surface Models (LSM) simulate the exchanges of energy, water and biogeochemical cycles between the land surface and the lower atmosphere. However, their performance has not been extensively assessed for flood forecasting. The Joint UK Land Environment Simulator (JULES) is the UK LSM used operationally. Our objective is to evaluate the ability of JULES to simulate floods while identifying possible model limitations. To do that:

- We test the default performance of JULES for a ten-year period in hourly time step.
- We propose a new parameterization for river routing directly accounting for the effect of topography.
- We analyse flood events based on the monthly maxima focusing on the flood peaks, flood volume and time to peak error for the different configurations.

Model

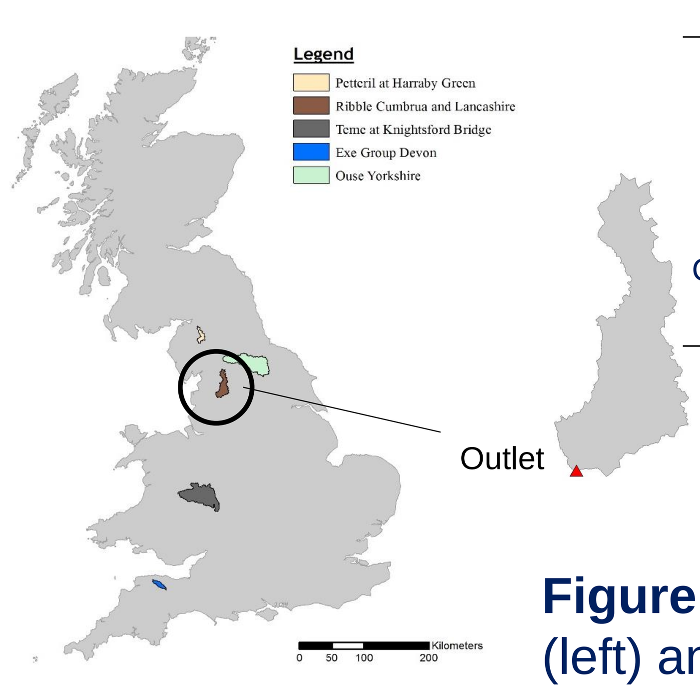
JULES-River Flow Model (RFM)



	Parameter Name	Default Value
Flow routing	cland	0.4 m/s
	criver	0.5 m/s
	cbland	0.05 m/s
	cbriver	0.05 m/s
	retl	0
	retr	0.005
	a_thresh	10
JULES-PDM	b_pdm	1
	dz_pdm	1 m

Figure 1. JULES River Flow Model comprises of runoff production scheme based on the Probability Distribution Model (PDM), and flow routing parameterization where wave speeds are specified as universal constants. Red circles depict the most sensitive parameters according to the Morris Sensitivity Analysis method.

Study area



Name	Area (km^2)	BFI	Runoff ratio	Mean Annual Rainfall (mm/year)	Mean Annual Flow (m^3/s)
Ribble Cumbria and Lancashire	456	0.31	0.7	1348	13.6

Figure 2. Map of the selected catchments (left) and the Ribble catchment (right).

Different parameterization of river routing

What affects the surface velocities?

- Slope
- Discharge
- Land use

Manning equation: $V=1/n*S_o^{0.5}R^{2/3}$

Where $R=A/P$ and for *base* ≈ 1km then R ≈ y (depth)

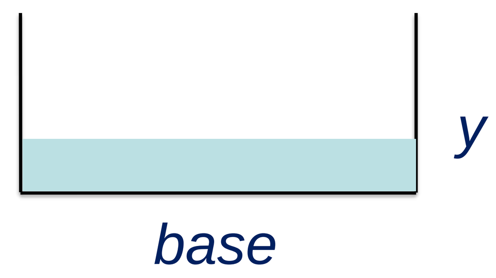


Figure 3. Cross section of a pixel.

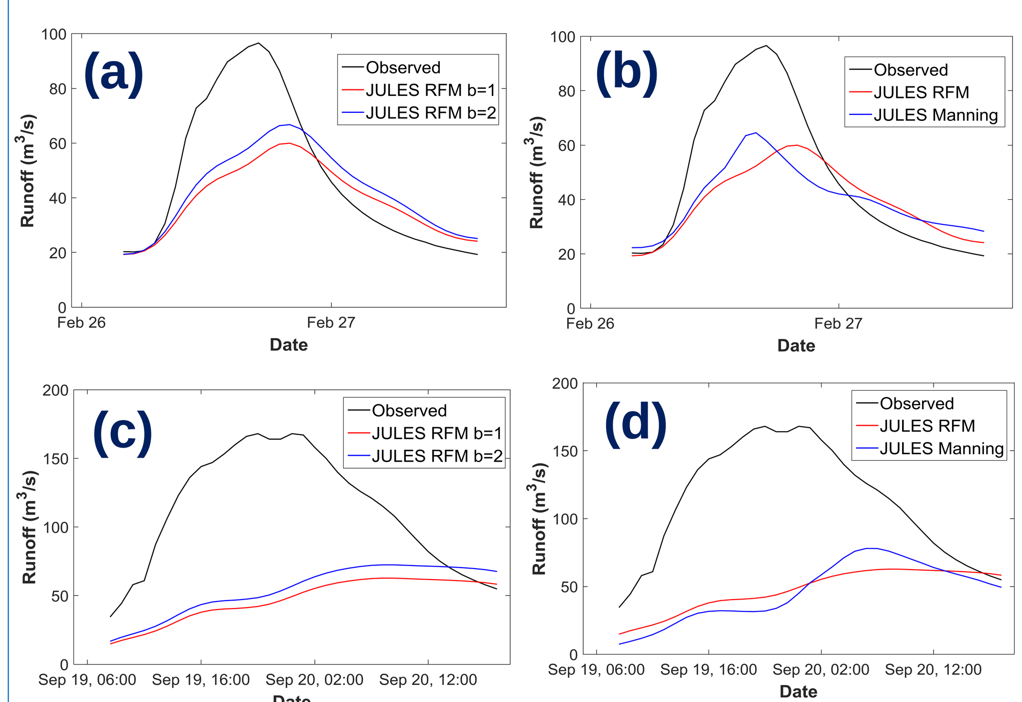
Results of different configurations

Overall KGE JULES RFM b=1 [2006-2015]	0.616
Overall KGE JULES Manning [2006-2015]	0.617
Overall KGE JULES RFM b=2 [2006-2015]	**0.688**

***** According to Martinez-de la Torre et al. (2013) and our sensitivity analysis, the optimum value for b exponent is equal to 2.

Flood event analysis

- The monthly maxima were selected in order to define the flood events (120 events totally in 10-year period study).



	Mean time to peak error		Mean volume error for each event (hm^3)
JULES RFM b=1	**6.1**	JULES RFM b=1	1.0
JULES Manning	7.3	JULES Manning	0.94
JULES RFM b=2	6.12	**JULES RFM b=2**	**0.72**

	Mean flood peak error		Runoff ratio error
JULES RFM b=1	52.3	**JULES RFM b=1**	**0.006**
JULES Manning	49.1	**JULES Manning**	**0.006**
JULES RFM b=2	**45.8**	JULES RFM b=2	-0.01

Figure 4. Comparison of the three different configurations for a winter flood event (a, b) and for an autumn flood event (c, d).

Conclusions-Further analysis

- The new river routing parameterization has weaker dependence on the parameters that need to be calibrated and shows small improvements compared to default RFM parameterization.
- The value of *b* equal to 2 improves performance in JULES (high value of *b* can extract more water from the soil moisture and increase runoff)
- Our further analysis will investigate the role of groundwater interactions (not currently included in JULES).

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