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Progress at Imperial

HyDEF meeting: Reading University, 18 Jan 2012

Application of JULES at the catchment scale

PhD students, focussing on Isle of Wight project (Mike Simpson)

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JULES application at a catchment scale

Nataliya Bulygina, Adrian Butler, and Neil McIntyre

Main project objectives

- To understand the limitations of the current generation of models for land surface-atmosphere feedback simulation, and . . .

- To develop the scientific basis and prototypes for the next generation of models

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Outline

- JULES performance at the catchment scale
  - Standard setup
  - Deep soil column
  - JULES-PDM
  - JULES-TOPMODEL

- Issues with the data / model

- Conclusions and ways forward

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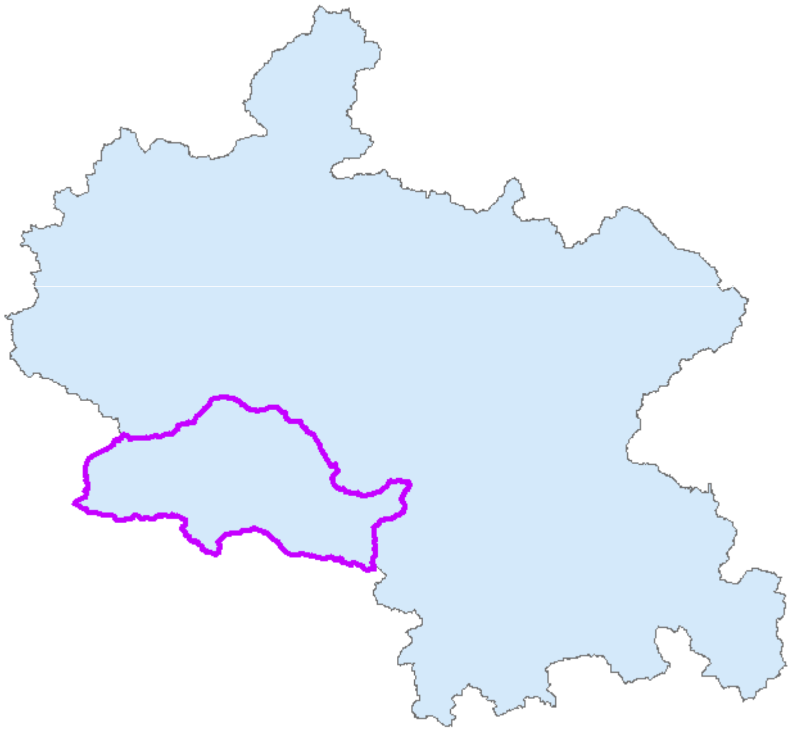
JULES performance: Kennet at Theale



AREA: 1037.36 km^2

SAAR: 758 mm

BFIHOST: 0.766

PROPWET: 0.31

URBEXT: 0.0137

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JULES performance: Data

JULES input type	Source data description	Source
1 km catchment grid	50 m resolution raster file	http://edina.ac.uk/digimap
Vegetation cover	50 m IGBP 2007 land cover map	http://webmap.ornl.gov/wcsdown
Soil parameters	0.5 degree IGBP maps of soil parameters based on Cosby et al (1984) relationships	http://cms.ncas.ac.uk/cap_interface
Meteorological inputs	3 hr, 0.5^0 WATCH 1997-2001 reanalysis data	http://www.eu-watch.org/data_availability
Flow observations	Daily flow data	http://www.ceh.ac.uk/data/nrfa/data

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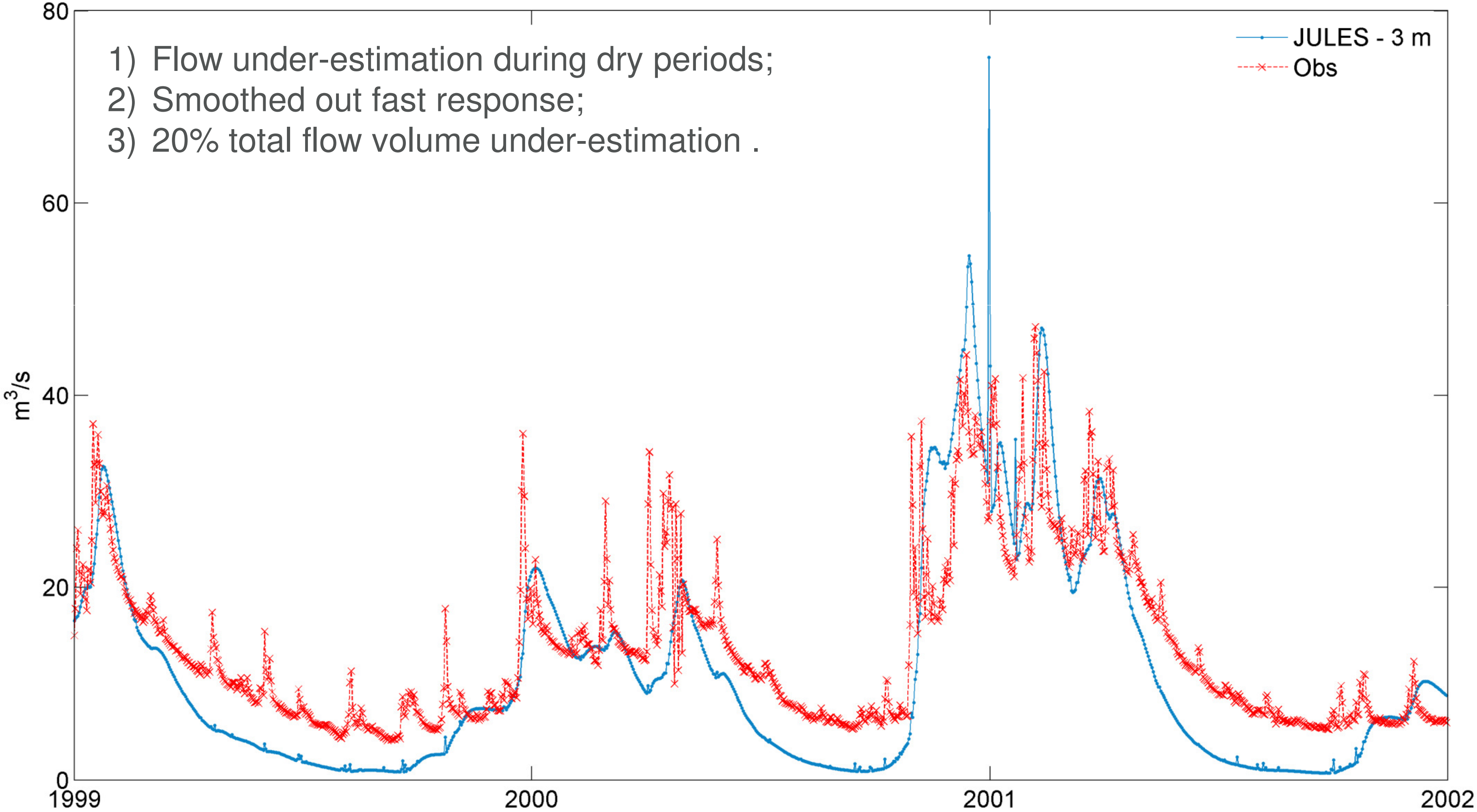
JULES performance: Standard JUULES setup

1) Flow under-estimation during dry periods;
2) Smoothed out fast response;
3) 20% total flow volume under-estimation .



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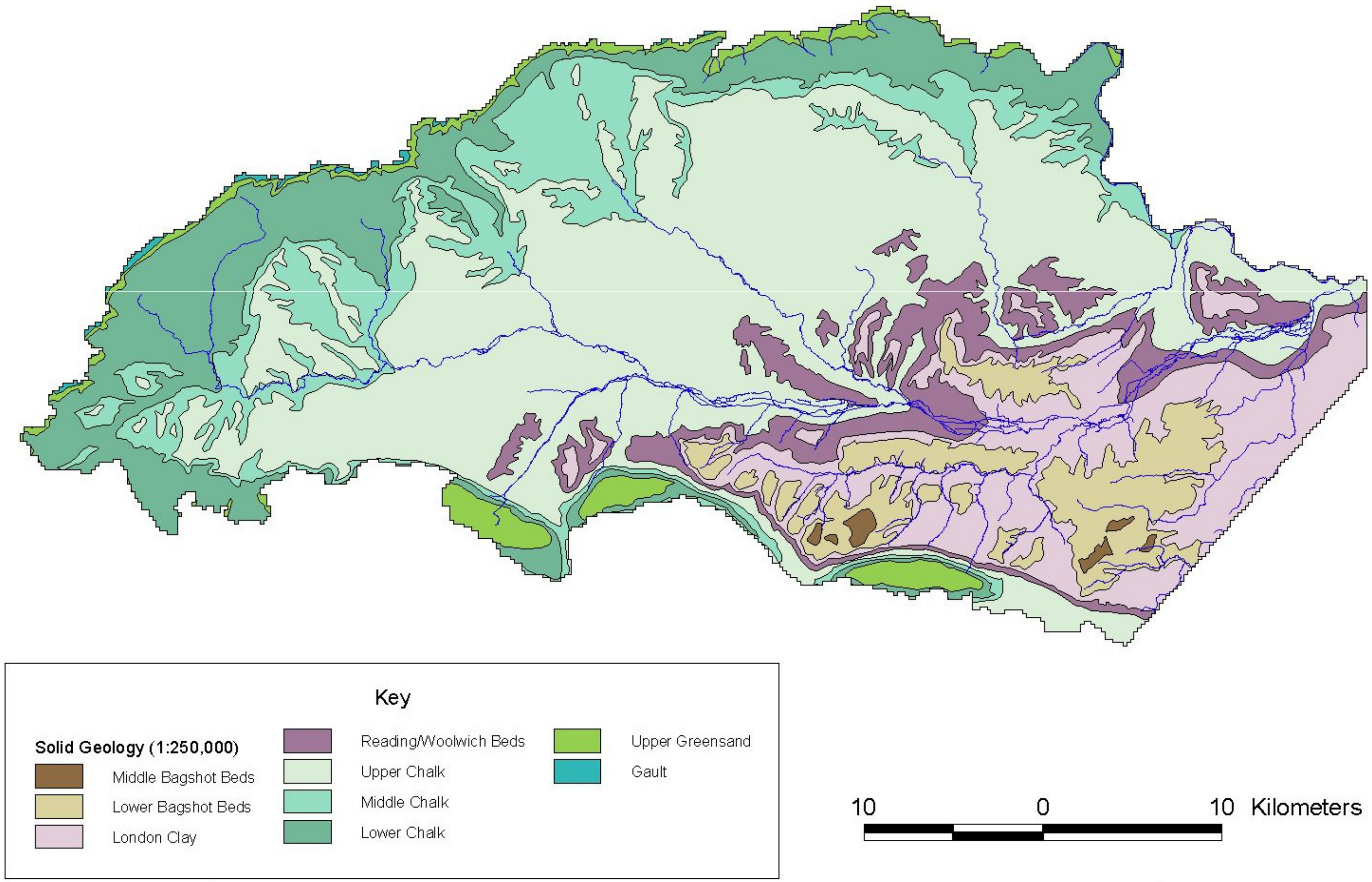
Solid Geology



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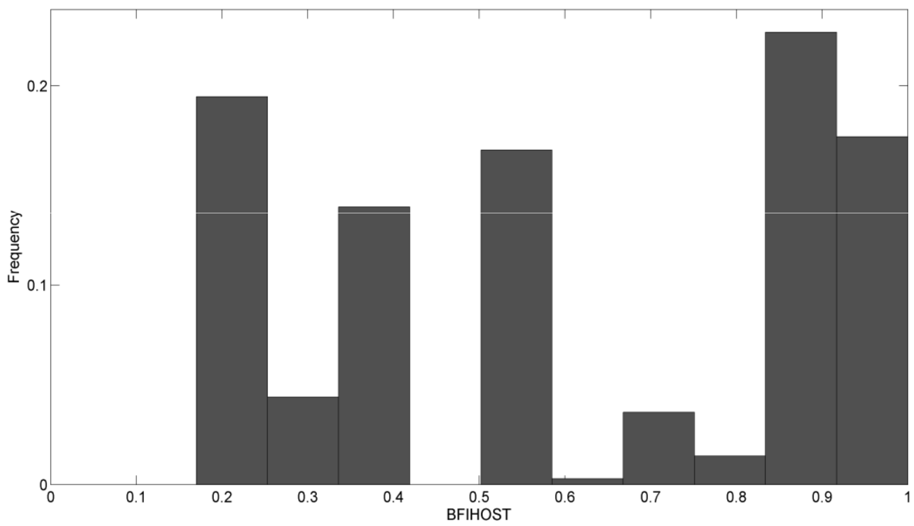
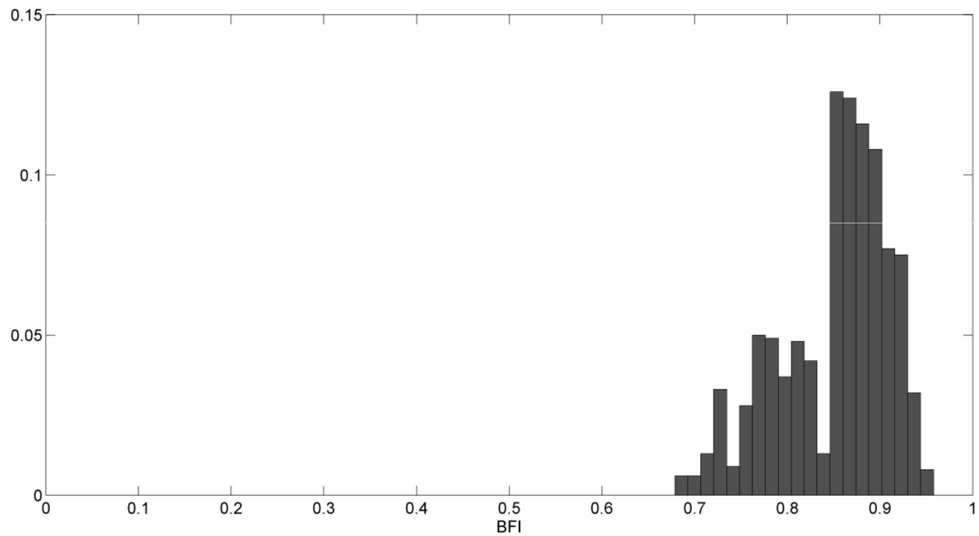
JULES performance: Standard JUULES setup

BFIHOST frequency for the Kennet



BFI range simulated by standard JULES setup for the Kennet met conditions



Standard JULES setup is incapable of representing flashy responses (low BFI)

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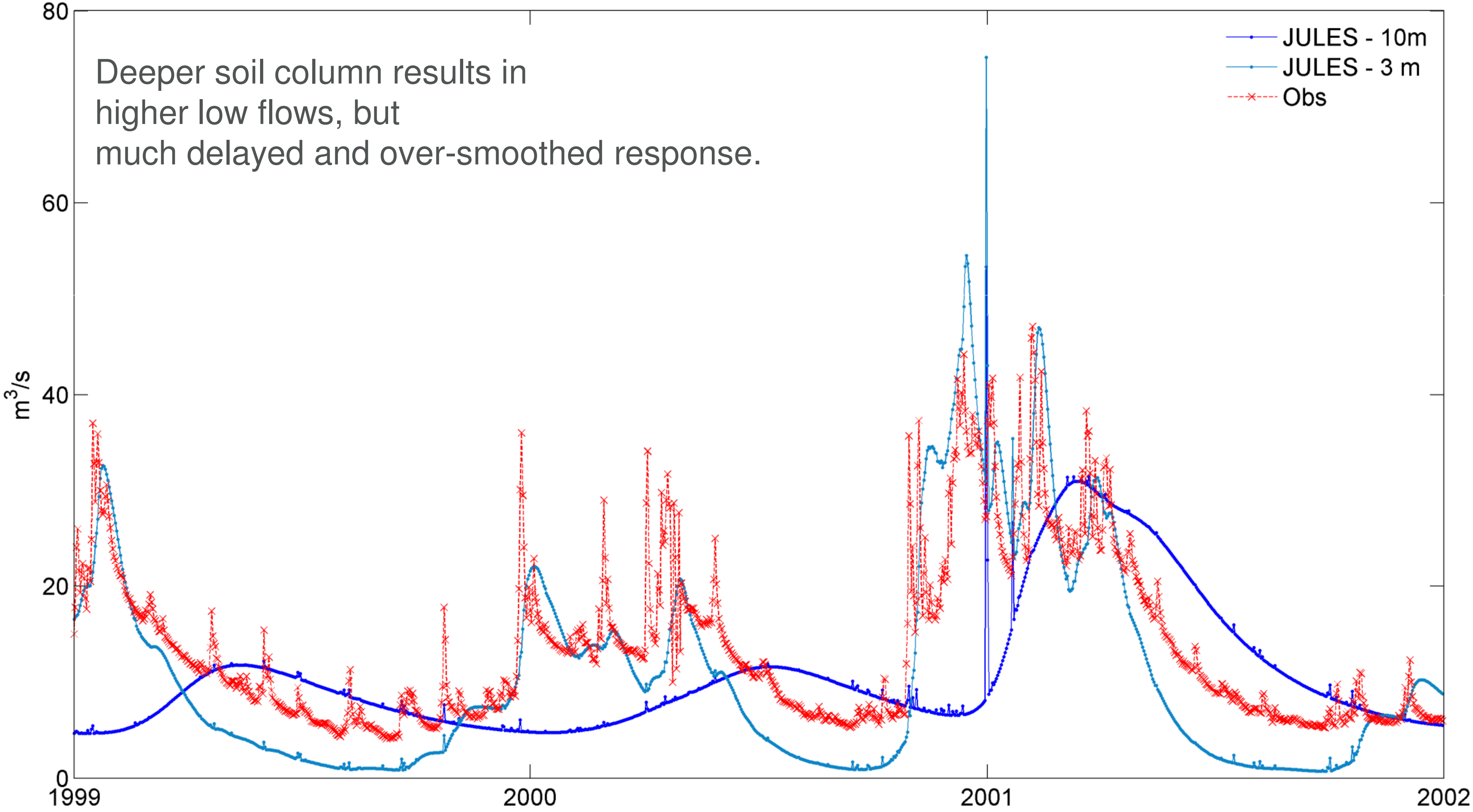
JULES performance: Deep soil column



JULES performance: JULES-PDM

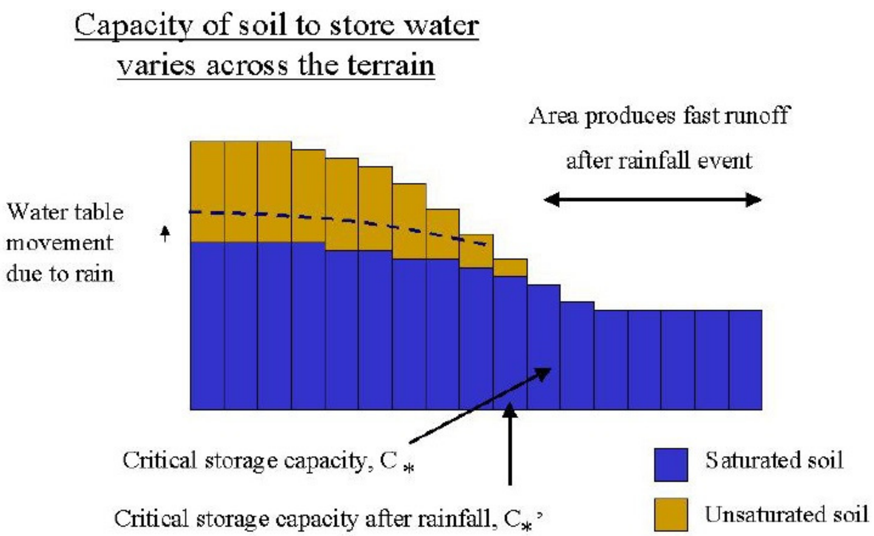


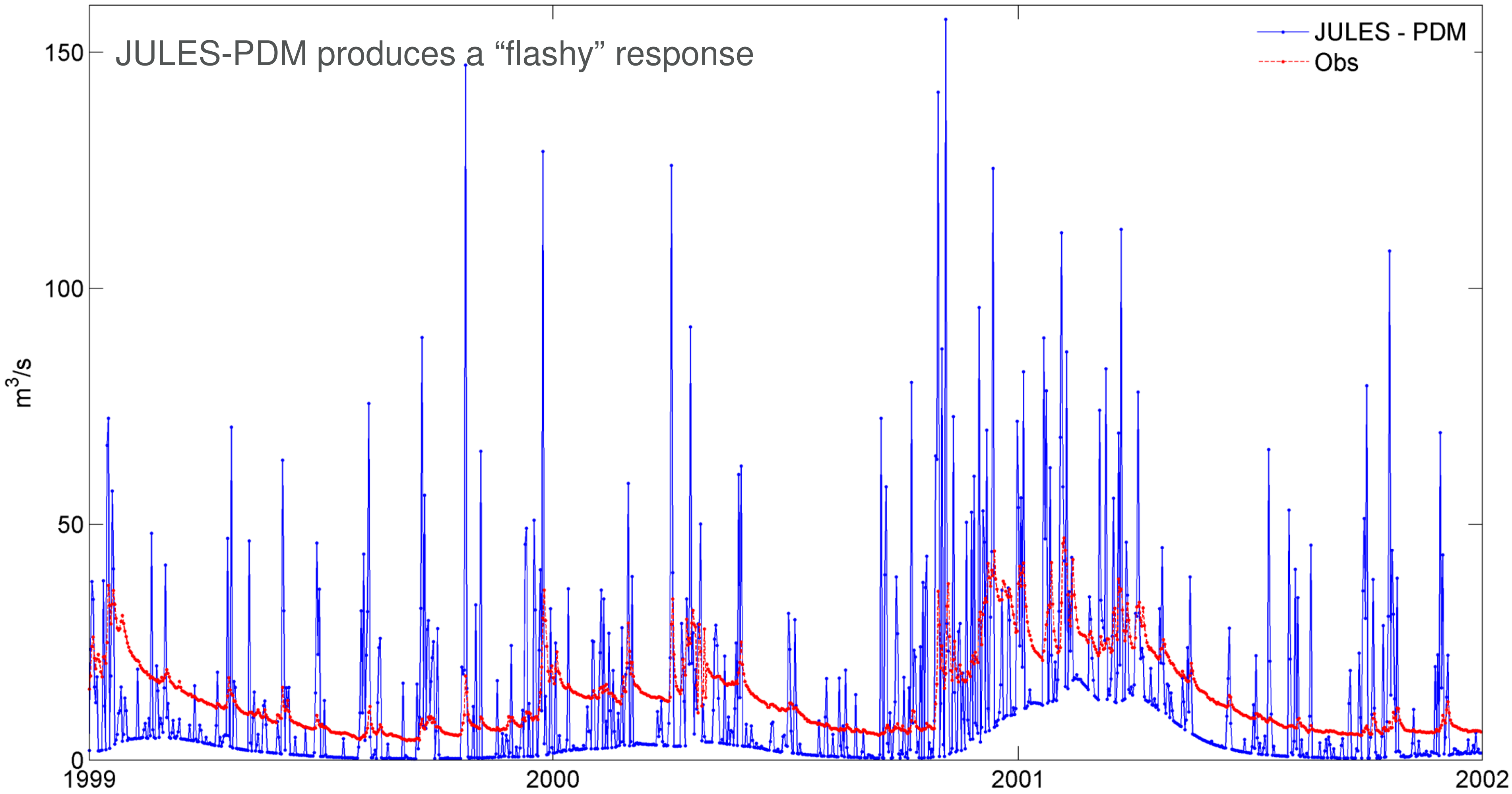
Fig. 1. *Schematic of the PDM rainfall-runoff model put into the top layer of MOSES*

Figure is taken from Blyth, 2002

PDM in JULES

- Variable soil moisture in the top soil layer – described by a pdf;
- Allows producing saturation excess runoff when a grid is not fully saturated;
- Does not affect infiltration excess, or subsurface runoff;
- Parameters are conceptual in nature, and require calibration (which is problematic!).

JULES performance: JULES-PDM



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JULES performance: JULES-TOPMODEL

TOPMODEL in JULES

- Introduces water table in the soil column;
- Saturated grid fraction is related to a grid topographic index* (TI) pdf;
- Parameters can be seen as conceptual (calibration), or topographically meaningful (a significant parameter dependence on the DEM resolution).

* $TI = \ln\left(\frac{Ac}{\tan(S)}\right)$ where Ac is a contributing area, S is a local slope

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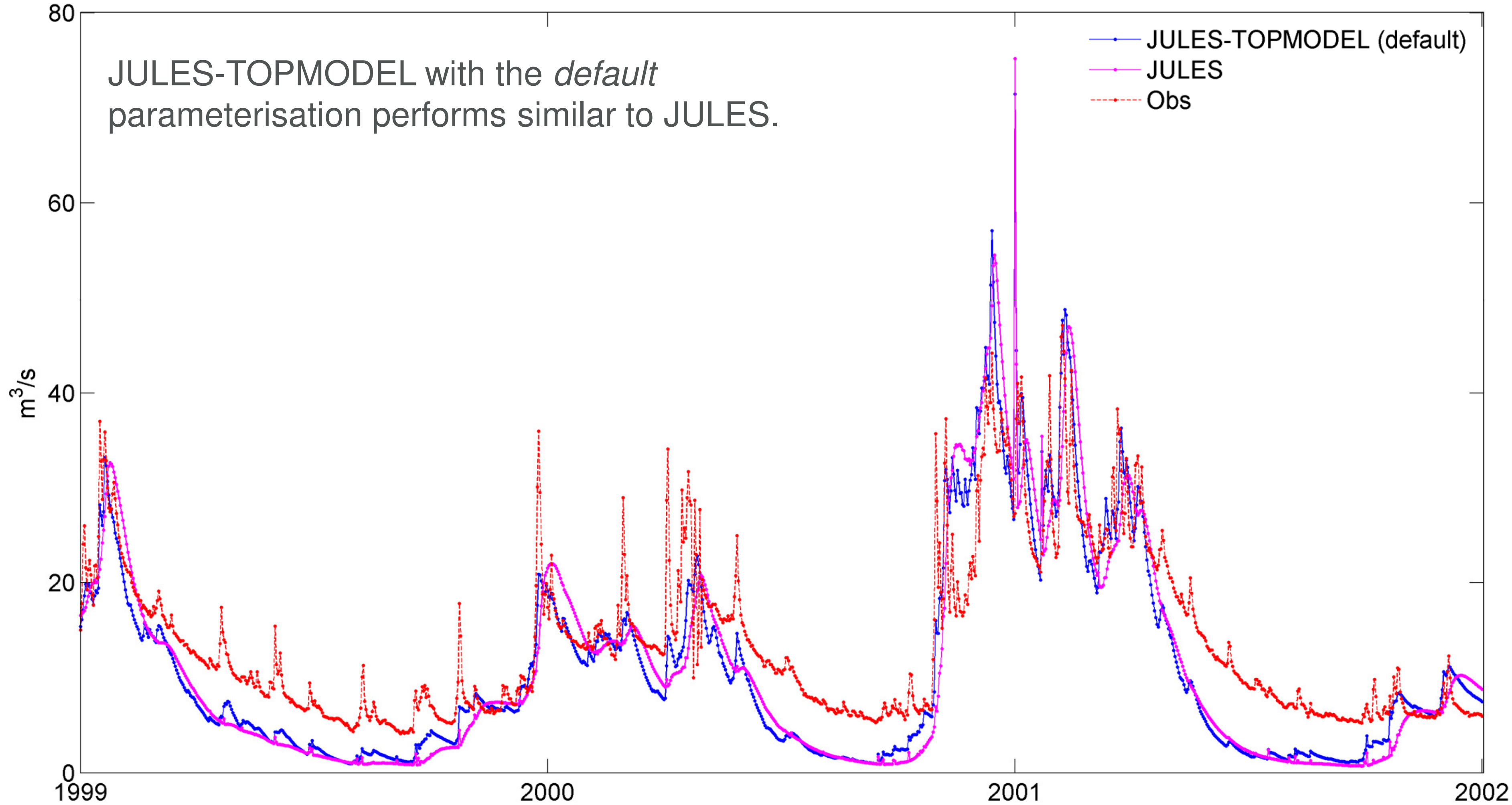
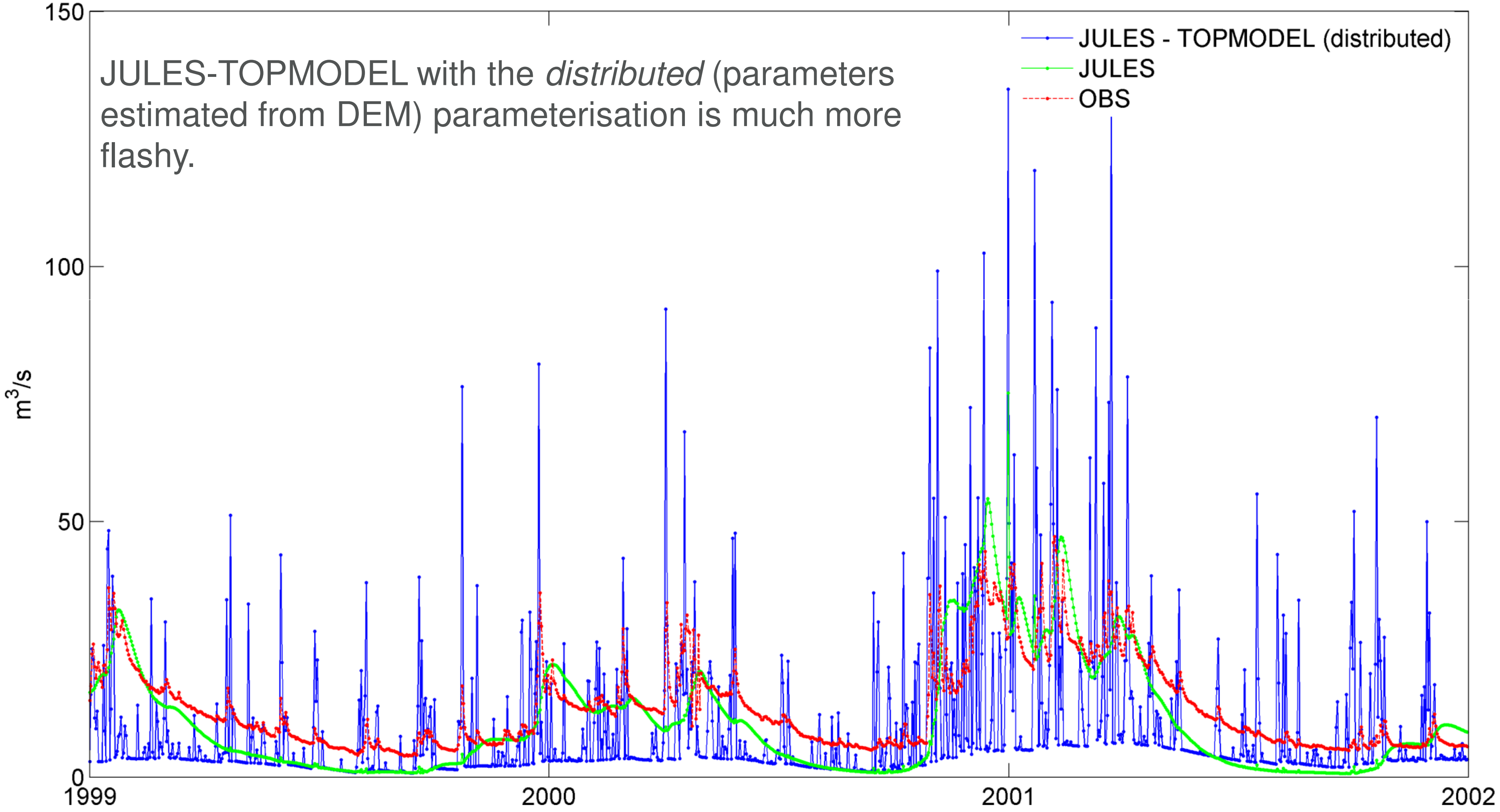
JULES performance: JULES-TOPMODEL



JULES performance: JULES-TOPMODEL



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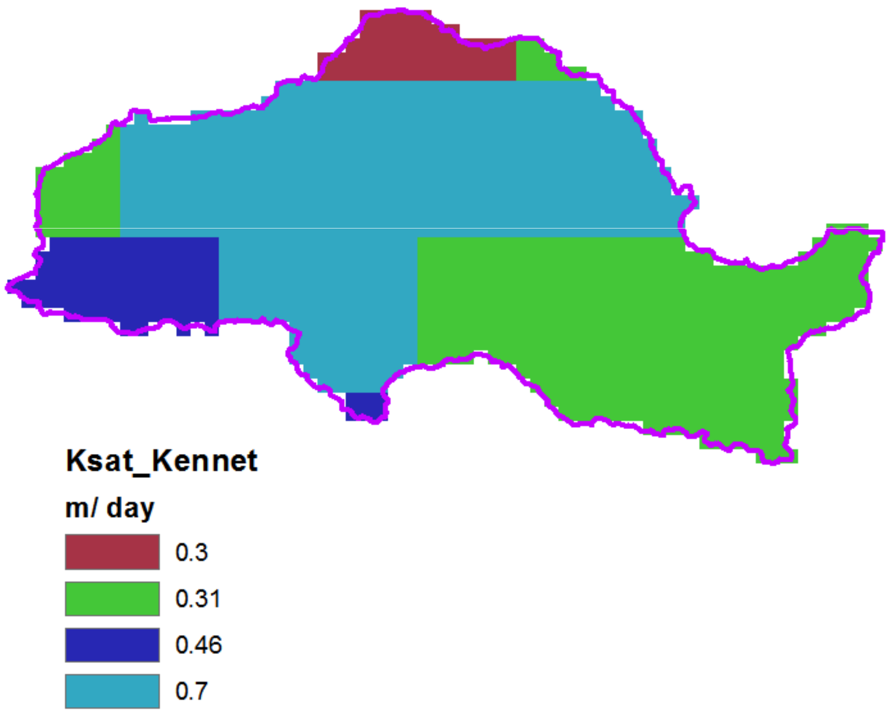
JULES performance: Soil evaporation

Soil evaporation for 1999-2001

Configuration	Evaporation, mm
JULES (standard)	936
JULES (deep soil column)	848
JULES – PDM	849
JULES – TOPMODEL (default)	935
JULES – TOPMODEL (distributed)	1010

Issues with the data/ model



1) 0.5^0 resolution of the soils and met drivers data results in loss of spatial variability;

2) soil hydraulic properties are derived using pedo-transfer functions (Cosby et al, 1984);

3) met data 3-hr resolution might not be appropriate for surface runoff generation.

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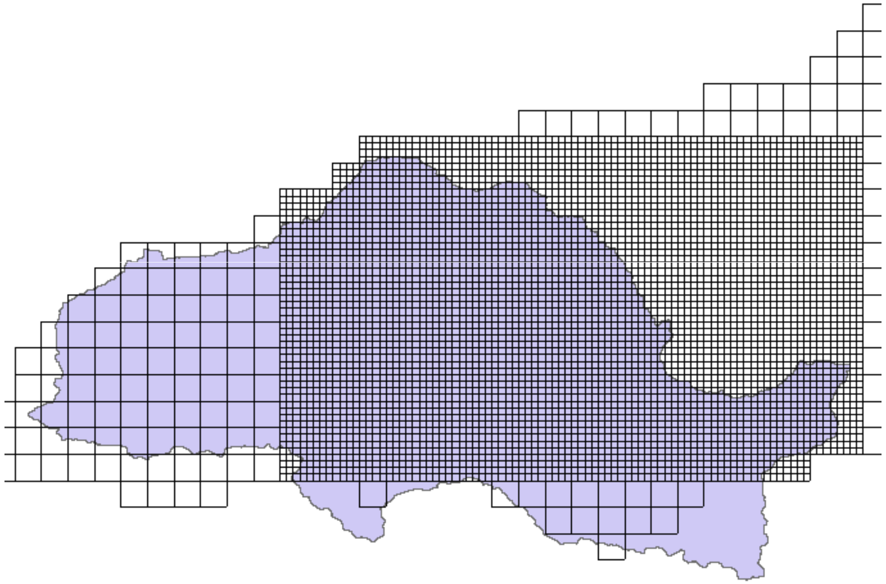
Issues with the data/ model



ZOOM domain for the Kennet does not seem to cover the whole catchment area.

Expansion of ZOOM's grid domain needed?

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Conclusions

1) JULES (standard setup) is incapable of simulating BFI range necessary for the Kennet;

2) JULES (standard setup) over-estimates low flows and smoothes out fast response;

3) Soil layer deepening significantly delays and smoothes the response;

4) JULES-PDM and JULES-TOPMODEL require conceptual parameter specification (do we want to calibrate?);

5) Currently available structural modifications to the standard JULES setup (i.e. deep soil column, TOPMODEL, PDM) do not seem to improve flow prediction for the Kennet;

6) Soil evaporation rate is sensitive to a JULES configuration (± 10%).

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Future work programme

1) Model performance evaluation using other (than river flow) measurement types, i.e. evaporation fluxes ;

2) Model parameter up-scaling using hydrological indices, remotely sensed data;

3) Comparison of JULES output with ZOOMDRM;

4) A 1- way coupling with GW model ZOOM (JULES only provides recharge);

5) A 2- way coupling with GW model ZOOM (JULES and ZOOM interact via changing JULES lower boundary condition);

6) Coupling with a simple GW model.

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CWC related PhD projects at Imperial

Katie Duan (Grantham, 3rd year)

Developing improved statistical downscaling models for precipitation through incorporation of new knowledge of large-scale climate processes, and treatment of non-stationarity in statistical relationships.

Tanya Jones (NERC DTG, 3rd year)

Developed GLM models of daily precipitation for the Kennet catchment. Now assessing deterministic and stochastic models of PE for the Kennet. Plan is to infill the daily records back to 1900 to support drought risk assessment.

Kirsty Upton (EPSRC DTG, 2nd year)

Evaluating long term risk to surface and groundwater resources in the Chalk. Developing detailed borehole models for inclusion in regional groundwater models for integrated resource assessment.

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CWC related PhD projects at Imperial

Christina Bakopoulou (External, 2rd year)

Critical assessment of the structure and parameterisation of the JULES land surface model at different spatial scales in Chalk catchments. Currently working on assessing the performance of JULES at the point scale.

Mike Simpson (CWC, 1st year)

Water resource impact and adaptation under climate change for the Isle of Wight. (Presentation to follow)

Tim Foster (Grantham, 1st year)

Hydro-economic modelling of agricultural resilience and adaptation to climatic and socio-economic changes on the Isle of Wight.