Hydro-JULES
WP5: Hydrological Applications: the State of the Art

Jamie Hannaford
Leader, Hydrological Status and Outlooks Group, CEH

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Derwent Valley Reservoirs, 28th July 2018. (Katie Muchan)

Hydrological Applications and Evaluation

5.1: Enabling science for hydrological applications

5.2: Exploit data assimilation techniques for multiple observational sources

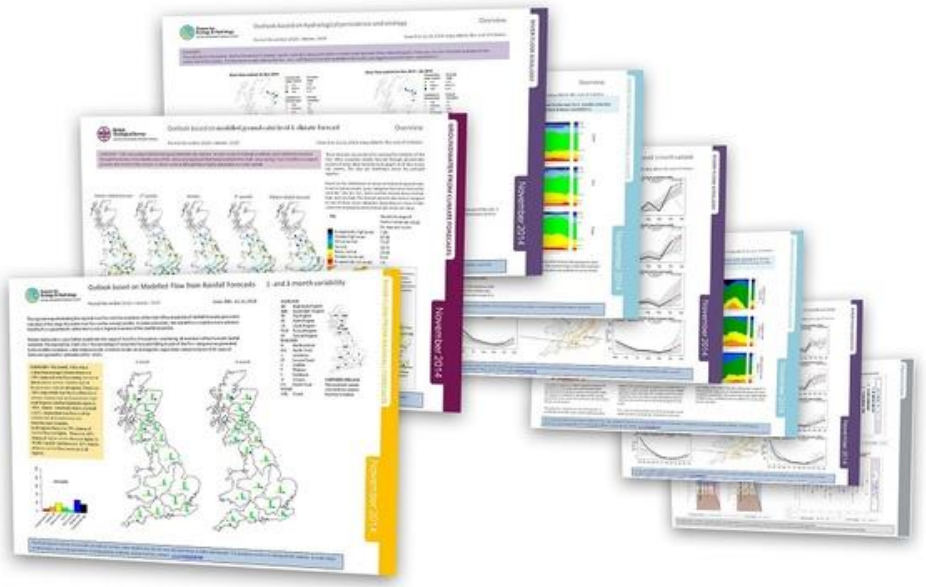
5.3: Participate in international benchmarking and intercomparisons

5.1: Enabling Science for Hydrological Applications

- **Objective:** advance hydrological forecasting for the UK at seasonal scales to support the development and application of HydroJULES outputs
- **Team:** Vicky Bell, Katie Smith, Cecilia Svensson

Focus: Hydrological Outlook UK

- Launched Oct 2013
- Produced monthly as an operational product
- Provides forecasts of river flow and groundwater levels for the next 1 – 3 months and beyond
- Freely available: http://www.hydoutuk.net/



Prudhomme, et al. (2018). Hydrological Outlook UK: an operational streamflow and groundwater level forecasting system at monthly to seasonal time scales (Hydrological Sciences Journal)

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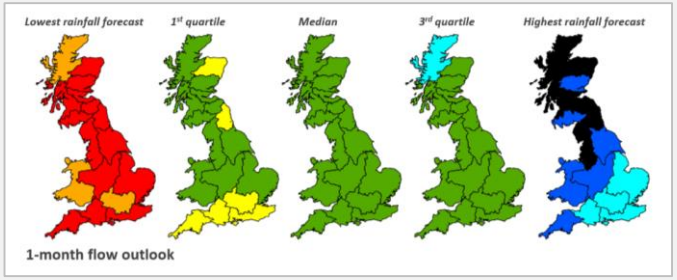
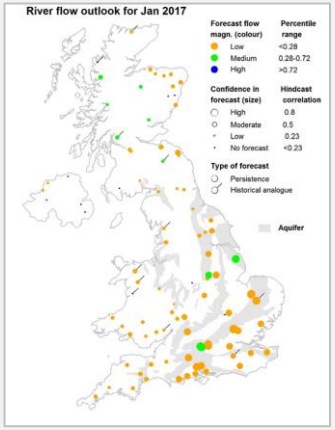
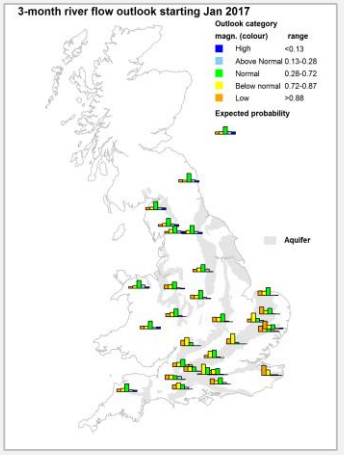
Hydrological Outlook UK

Method	Description	Scale	Forecast horizon	Example forecast
1) Flows modelled using dynamic rainfall ensemble	*Probabilistic forecasts using GloSea5 rainfall ensemble*	National across Great Britain (1km grid)	1 and 3 months	
2) Persistence and analogy	*Statistical based on persistence and historical analogues*	Catchments over UK	1 and 3 months	
3) Ensemble Streamflow Prediction (ESP)	*Probabilistic forecasts using historical rainfall ensemble*	Catchments over England & Wales	Up to 12 months	

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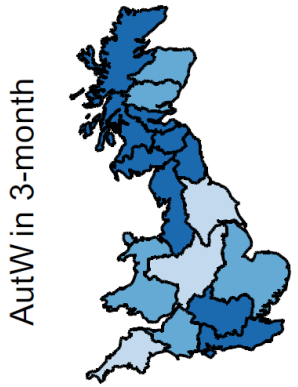
Similar outputs are available for groundwater levels (provided by BGS)

Summary of forecast skill

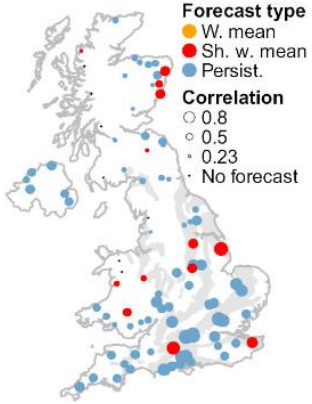
Method	When?	Where?	Who?
1.) Flows modelled using dynamic rainfall ensemble	At 1 to 3mn lead time, most skilful for **Aut/Wint**	North and West	Bell et al. (2018)
2.) Persistence and analogy	At 1 to 3mn lead time, most skilful for **Summer**	South and East	Svensson (2016)
3.) Ensemble Streamflow Prediction (ESP)	At 3 to 12mn lead time, most skilful for **Aut/Wint** At 1mn lead time, most skilful for **Summer**	South and East	Harrigan et al. (2018)

Example skill maps

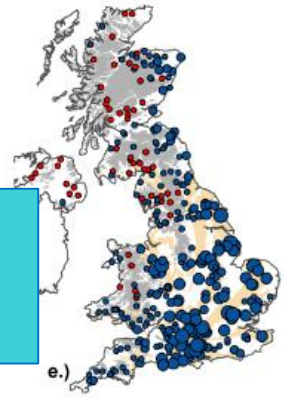
3-mn: Aut/Wint



1-mn: July

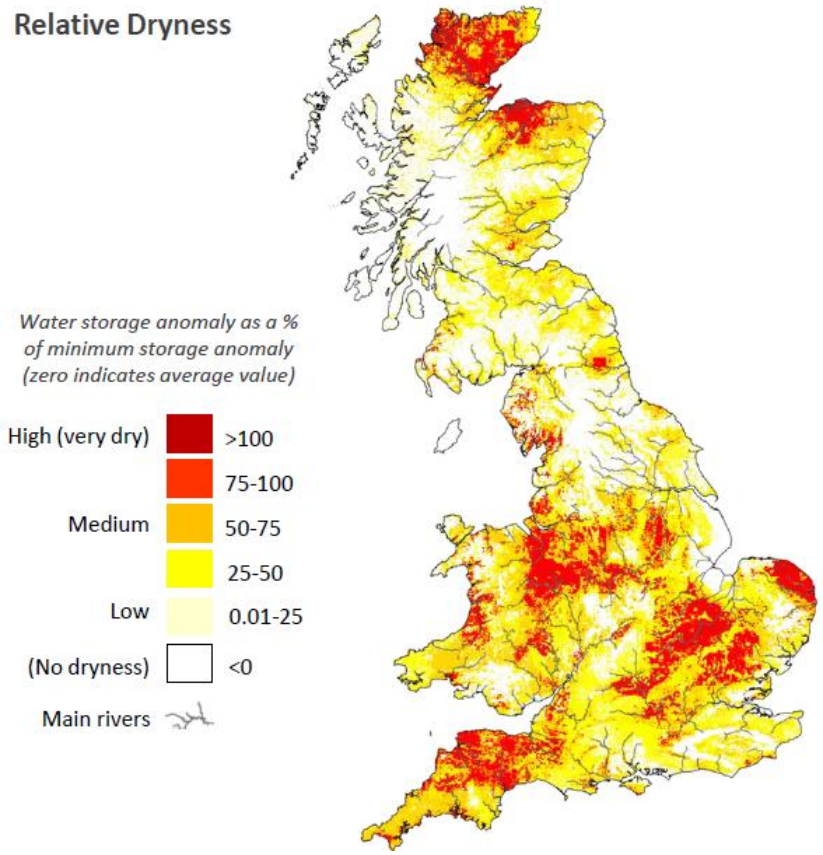


6-mn: January

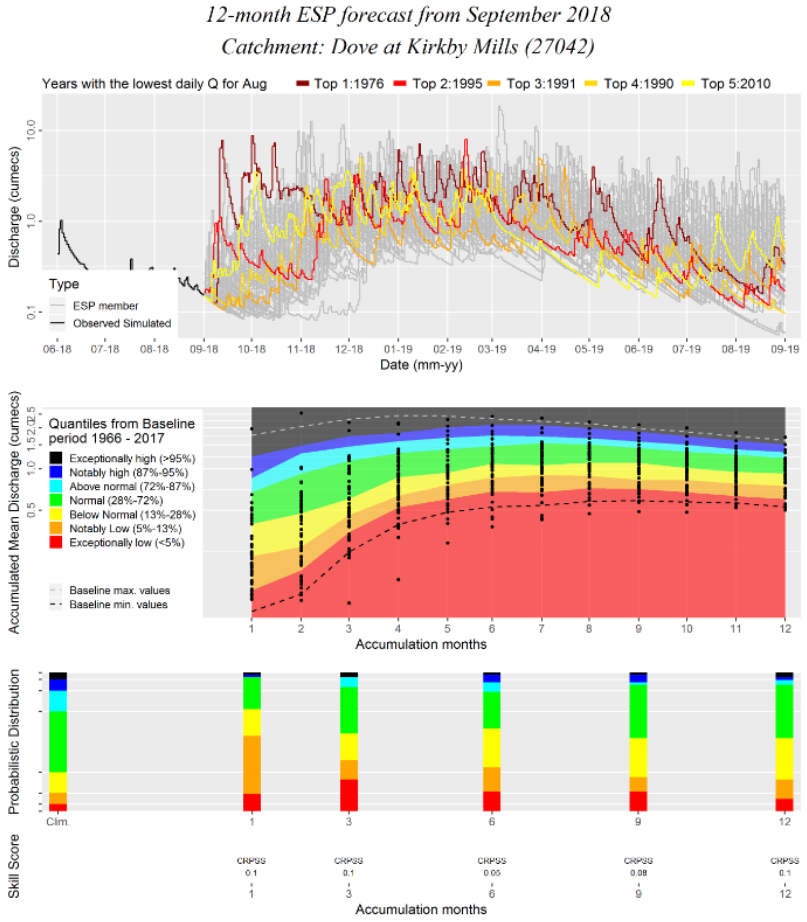


Note: different metrics and hindcast periods, but darker/ larger symbols = more skilful

Unlocking the potential of forecasts



Potential of gridded approach:
Relative dryness maps
(Ali Rudd, Vicky Bell)



Exploring the ESP ensemble
(Maliko Tanguy, Nikos Mastrantonas)

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About Drought
Maximising the impact of UK research on drought & water scarcity

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Planned new developments

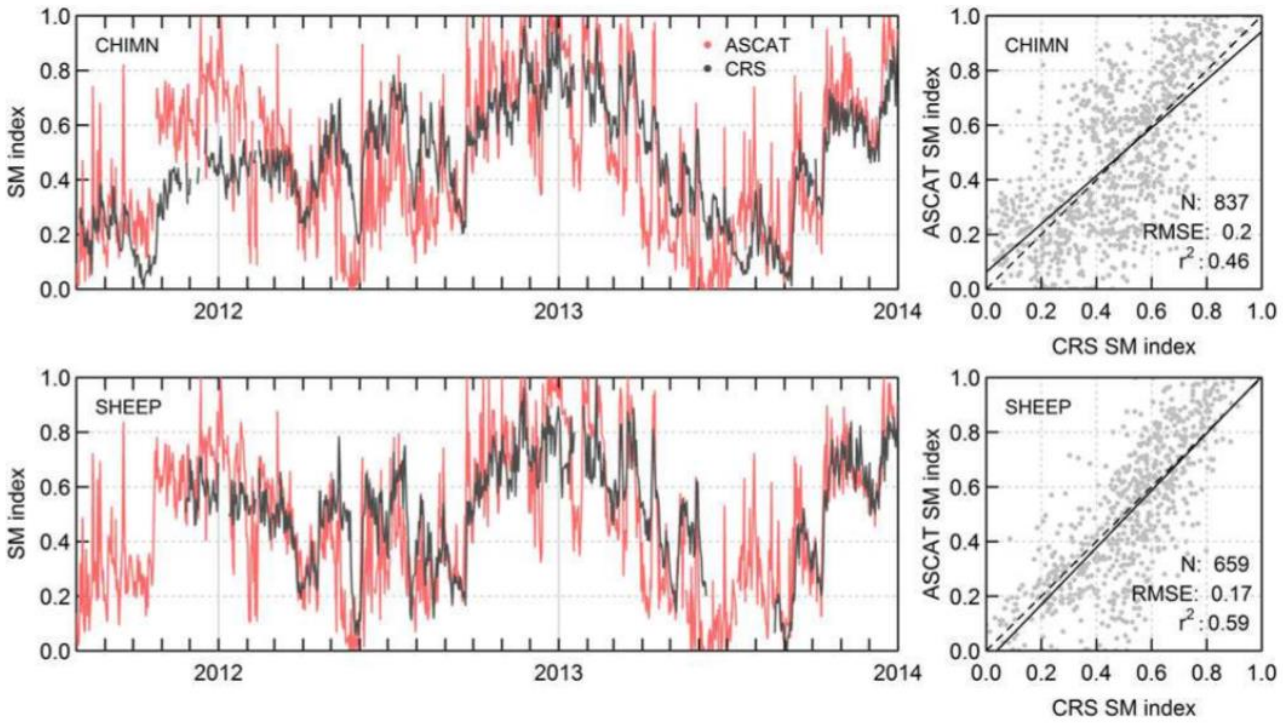
- Develop new forecast products (flow, soil moisture) using new higher spatial and temporal seasonal weather predictions (from UK Met Office).
- Evaluate skill and influence of higher resolution on uncertainties; feedback into HydroJULES development
- Improved integration of Outlook approaches (Met forecasts, ESP, statistical analogues)
- Long-term: evaluation (and incorporation?) of Outlooks based on HydroJULES modelling
- Long-term: International applications (with SUNRISE, HydroSOS)

5.2: Data Assimilation

- Objective: exploit the potential for wider use of data assimilation techniques for state-updating and parameter estimation
- Team: Simon Dadson, Jon Evans, Maliko Tanguy, Phil Harris

Exploiting new datasets

Real-time, wide area soil moisture
https://cosmos.ceh.ac.uk/



Earth Observation soil moisture vs COSMOS-UK soil moisture (Evans et al. 2016, *Hyd Proc*)

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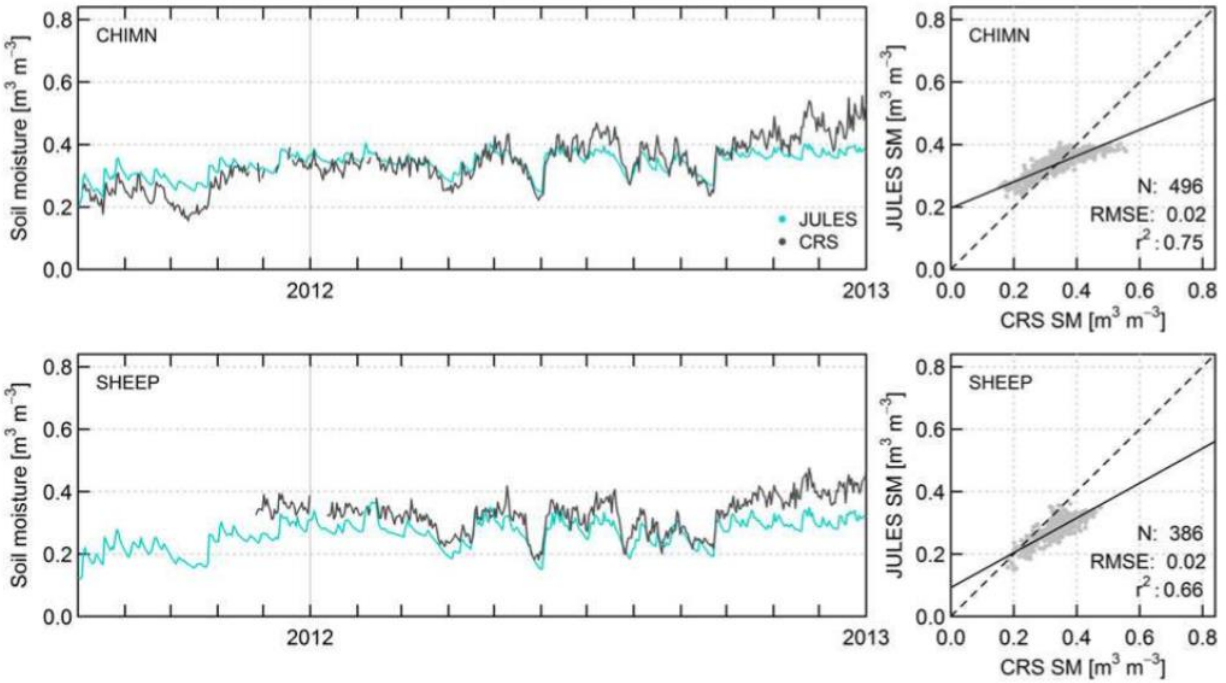

JULES soil moisture vs COSMOS-UK soil moisture (Evans et al. 2016, *Hyd Proc*)

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Planned new developments

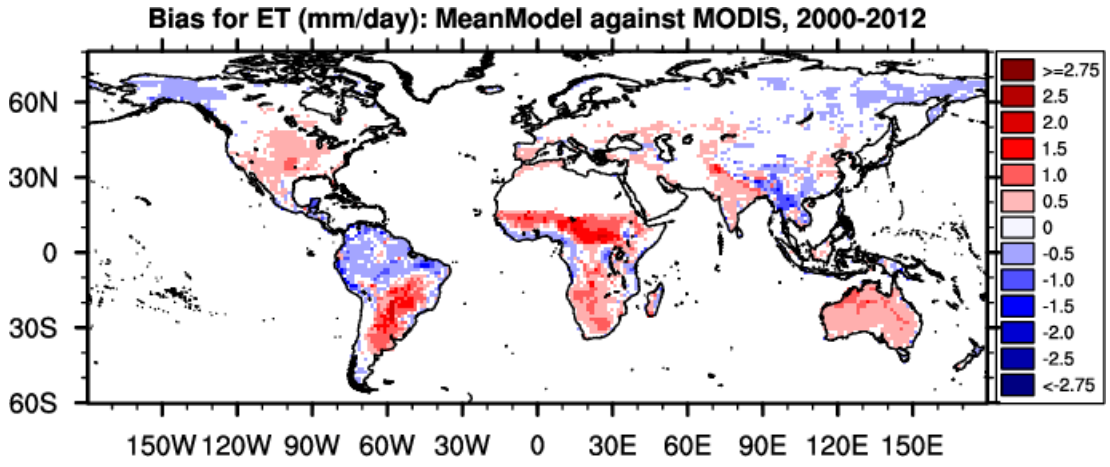
- Development of **1km^2 near-real-time gridded soil moisture product** combining Earth Observation and COSMOS UK
- Explore soil moisture dry-down processes and land-atmosphere coupling, to improve model process descriptions and enhance skill in hydrological simulation
- Prototype data assimilation using range of techniques (ensemble Kalman filters and 4-D variational methods for hydrological state updating)

5.3: Evaluation and Benchmarking

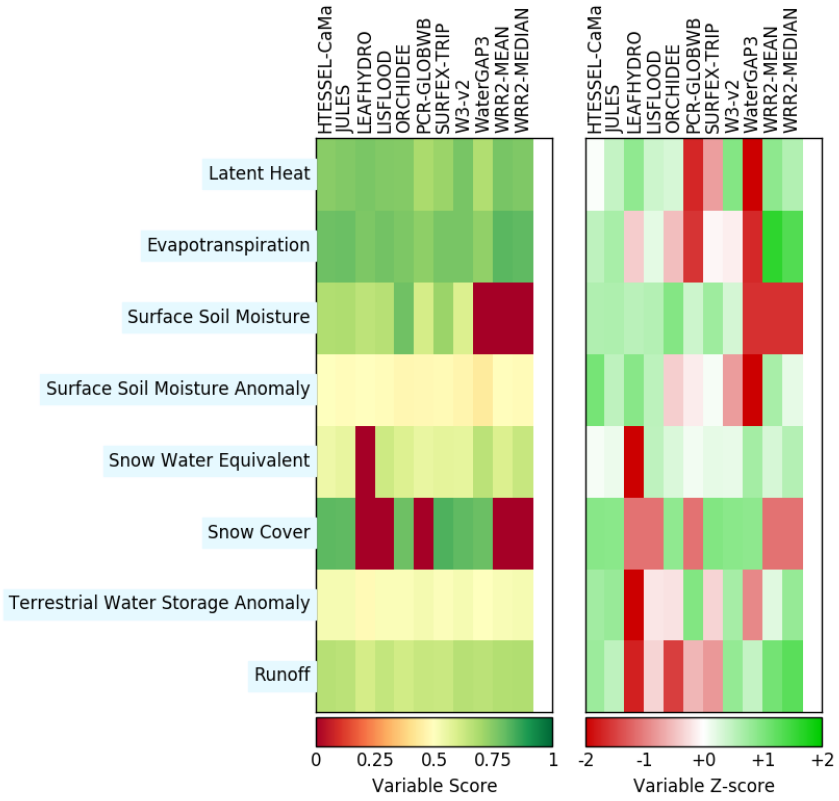
- Objective: develop evaluation framework/protocol and benchmarking configurations to support and quantify the project advances during its lifetime. Participate in world-leading model inter-comparison programmes.
- Team: Alberto Martinez, Emma Robinson, Toby Marthews

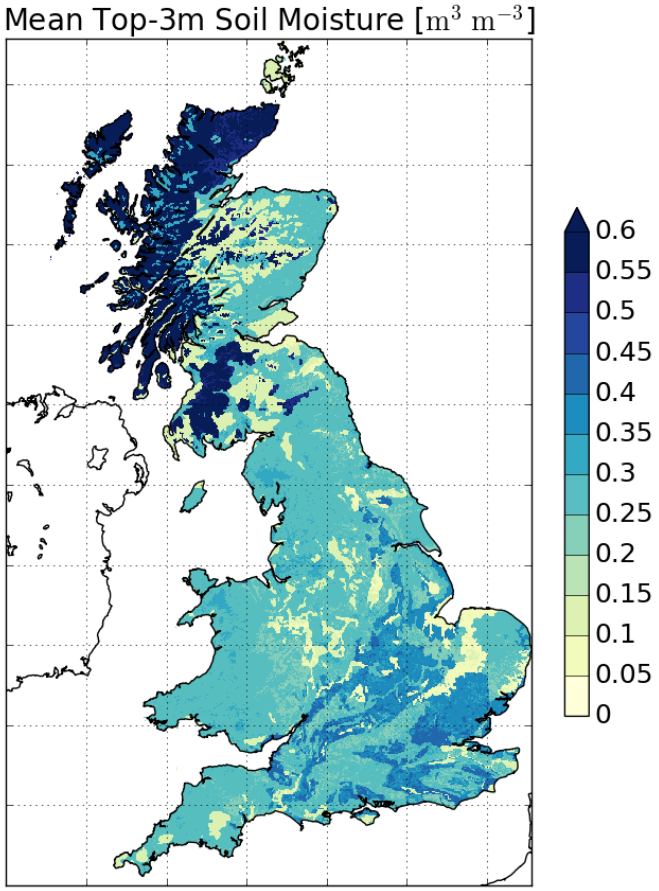
Evaluation system

- International LAnd Model Benchmarking project (www.ilamb.org)
- Compare gridded model outputs to observation/reference datasets
- Calculates a series of standard metrics pixel by pixel.
- We will customise ILAMB (new metrics relevant to time/space scales and new datasets, e.g. COSMOS))



Evaluation





Example output for Earth2Observe (Alberto Martinez)

Example benchmark: JULES soil moisture outputs from CHESS at 1km^2 (CHESS-Land)

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Planned new developments

- Development of HydroJULES evaluation framework at the national scale using ILAMB as a baseline and incorporating relevant metrics/datasets
- Routine testing of new HydroJULES development with the evaluation framework. Easy access and use for HydroJULES collaborators.
- Coupled/uncoupled routine testing of HydroJULES developments adapted by JULES using the existing UK ocean-land-atmosphere coupled model system UKCx (Lewis et al, 2018).
- Extension of the evaluation framework to the global scale and participation in international model intercomparison programmes.

Summary

- The demand for timely and robust hydrological predictions grows ever greater in a changing world
- WP5 will provide a framework (testbeds, tools, case studies…) to demonstrate, test and evaluate HydroJULES modelling outputs in real-world applications
- But it's not just the 'end of the pipe': application requirements will drive model design and development in an iterative process