

A Vision for the Joint UK Land Environment Simulation (JULES) System

Vision: The JULES system is a demonstrably world class land environment simulation system, underpinned by excellent science, to deliver measurable socio-economic benefits.

The JULES system is a unique tool that integrates a full suite of land-based processes, rigorously based on observations and theoretical science from a diverse community of scientists. The JULES system is a critical component of current UK-led coupled weather and climate prediction systems, and is also a powerful stand-alone tool, used to address science questions with societal impact. It is a process-based prediction system that can be used over a variety of spatio-temporal dimensions, with multiple configurations. The JULES system comprises a numerical modelling suite consisting of code, scientific configurations, documentation, driving and ancillary data, but also tools and data for evaluation and benchmarking. The operational background of JULES guarantees rigorous evaluation and ensures the robustness of scientific developments for future exploitation.

The JULES programme combines National Capability existing within NERC and Met Office to **provide** and **support** the JULES system for the UK and international academic and operational community, in order to **promote** and **capture** excellent science which is essential to maintaining world-leading status. The JULES programme enables our community to deliver world-class science, answering key scientific challenges, and underpins the delivery of socio-economic benefits

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The JULES system delivers world-class science that underpins the delivery of socio-economic benefits

The JULES system plays a significant cross-cutting role increasing the scientific understanding within the following themes; Hydrology (**H**), Ecosystem Services & Agriculture (**ES&A**), Urban (**U**) and Cryosphere (**C**). The science brings the following socio-economic benefits:

Hazards and Disaster Risk Reduction

The JULES system is the land surface component of the UK's operational weather and climate prediction system and central to forecasting of hazardous weather for the UK, and global forecasts across timescales. The JULES system is applied daily in an operational mode as part of the forecasting chain providing life-critical guidance to the public, government and business. Robust treatment of land-atmosphere feedbacks is also a vital element of longer-term prediction from seasonal to century scale climate projections, and underpins guidance to policy makers on issues such as the resilience of our energy networks, transport infrastructure and future urban planning.

High impact weather is likely to cause damage to urban environments and agriculture and exacerbate uneven distribution of water resources. The UN Sendai framework highlights the need to understand disaster risk reduction in order to build resilience, manage risks and enhance preparedness which in turn protects lives and livelihoods. Critical to this is accurate prediction and warning of environmental hazards, including high impact weather, flooding and droughts.

Example Science Questions:

1. Are changes in precipitation intensity and frequency affecting extreme hydrological events e.g. flooding and droughts? **H**
2. How does land-atmosphere coupling impact on the global water cycle? **H**
3. Can we quantify the key future risks and vulnerabilities for growing urban populations? **U, H**

Existing impact case study: JULES research informed Greater London Authority (GLA) guidance relating to identification and mitigation of the health risks associated with the Urban Heat Island.

Informing Climate Policy (ICP)

JULES is a central part of the UK's climate and earth system model that contributes to CMIP and IPCC Assessment Reports. Land surface hydrology is a crucial part of the global water cycle, and JULES also simulates natural carbon sinks and is used routinely to quantify the global carbon budget as well as how it may change in response to climate change. JULES also simulates managed lands which contribute to emissions of CO₂ and other trace gases but can also be utilised to achieve negative emissions (BECCS).

The UNFCCC Paris Agreement aims to prevent “dangerous” human interference with the climate system by stabilising greenhouse gas (GHG) concentrations and limiting global temperature increases to well below 2°C. Meeting these targets and reducing the impact of climate change on humans requires an understanding of many elements including impacts on ecosystems, agriculture and hydrology as well as the climate mitigation role of terrestrial carbon sinks and land based negative emission technology.

Example Science Questions:

1. What is the contribution of natural and managed ecosystems to GHG emissions and sinks? **ES&A**
2. What role could bio-fuels play in mitigating climate change, what are the possible side effects on food security? **ES&A**
3. What are the risks of large release of carbon from permafrost ecosystems? **ES&A, C**

Existing impact case study: JULES currently contributes to carbon estimates which scientifically underpin the Climate Change Committee's UK carbon

budgets and contribution to international negotiations such as the Paris Agreement.

Sustainable Resources Use (SRU)

The JULES simulation system integrates the land surface processes that enable us to make trustworthy predictions of water and food availability, natural ecosystem resilience and bio-energy production and can be used to explore the impacts of global drivers of change.

The Water-Energy-Food nexus describes the complex and inter-related nature of our global resources systems. The UN Sustainable Development goals recognise the importance of achieving water, energy and food security in the context of global challenges such as climate change, whilst promoting the sustainable use of our natural resources and promoting biodiversity.

Example Science Questions:

1. How do global environmental drivers impact on water supply and demand, and what infrastructure is required to mitigate potential risks? **H**
2. How resilient is agriculture to environmental hazards on weather and climate timescales? **ES&A**
3. What are the risks and impacts of changes in snow and ice for water storage and supply in a changing climate? **H, C**

Existing impact case study: JULES contributed to the underpinning science of the FCO 'Human Dynamics of Climate Change' tool, which demonstrated the multiple impacts of climate change on global vulnerability 'hotspots' and was used by UK Government in the run up to UN Climate Negotiations.

Building international reputation through rigorous evaluation

The world-leading JULES system has a comprehensive evaluation programme including:

Comparison against independent data: Rigorous comparison against Earth Observation data (global) and in-situ measurement networks (local) enables benchmarking for rapid evaluation of new system components.

Comparison against other models: Contribution to international MIPs to understand the performance and sensitivity the JULES system compared to other models of the same class.

Evaluation of process representation: Comparison of JULES diagnostics against Data Assimilation products to assess and improve JULES model parameters and alternate model structures.