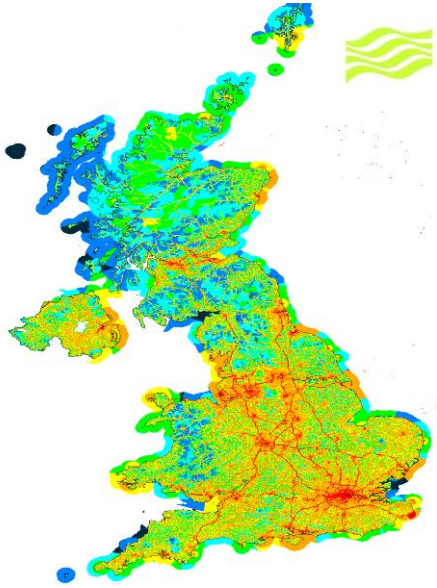
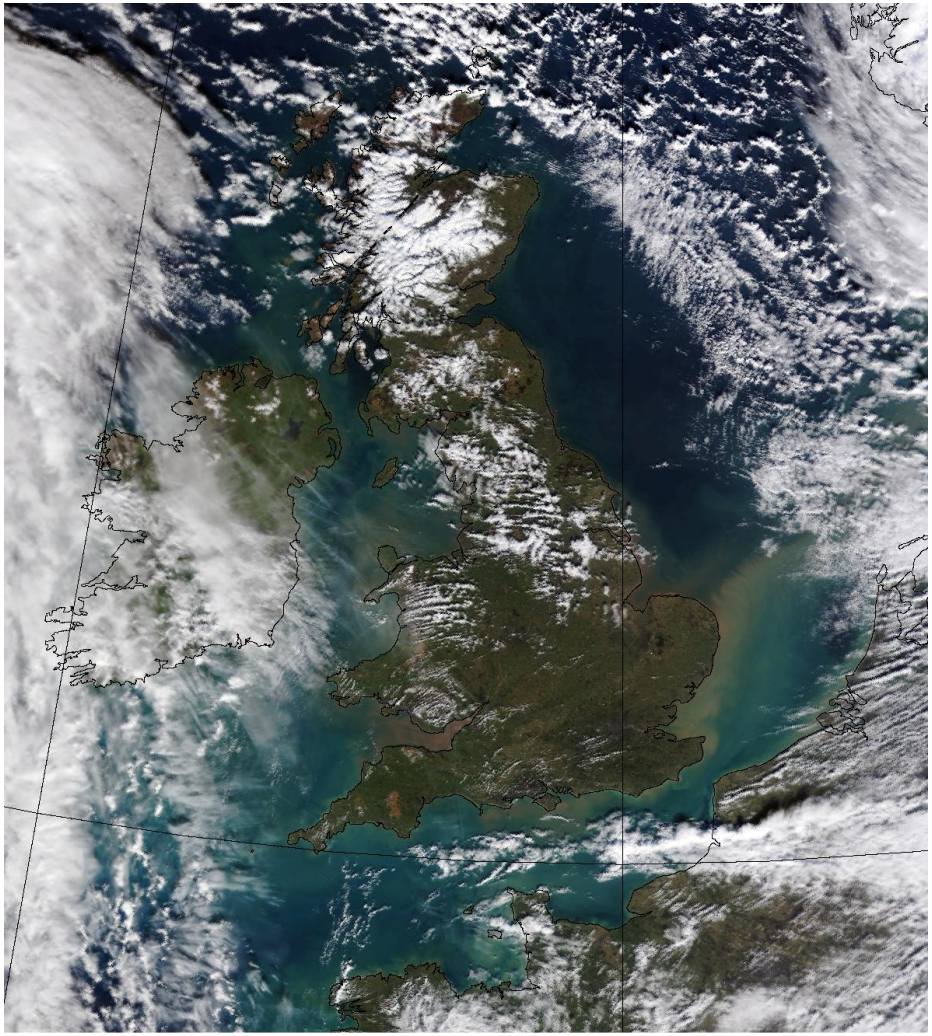
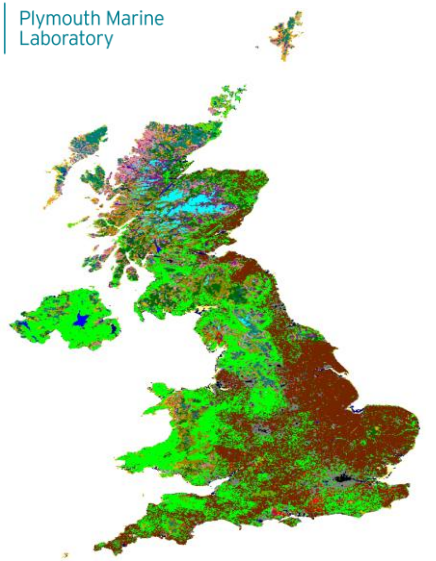
UK Environmental Prediction

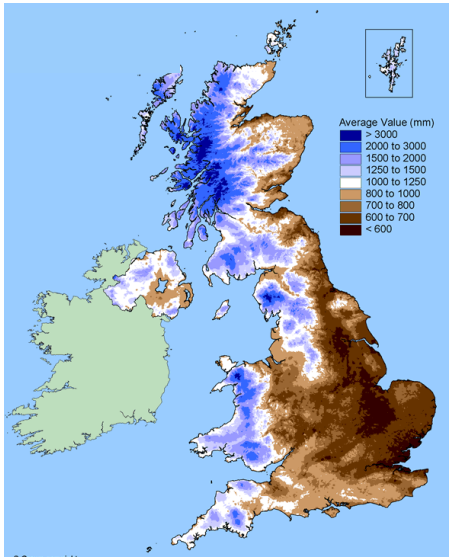
Met Office | Centre for Ecology & Hydrology, Natural Environment Research Council | National Oceanography Centre, Natural Environment Research Council | PML Plymouth Marine Laboratory

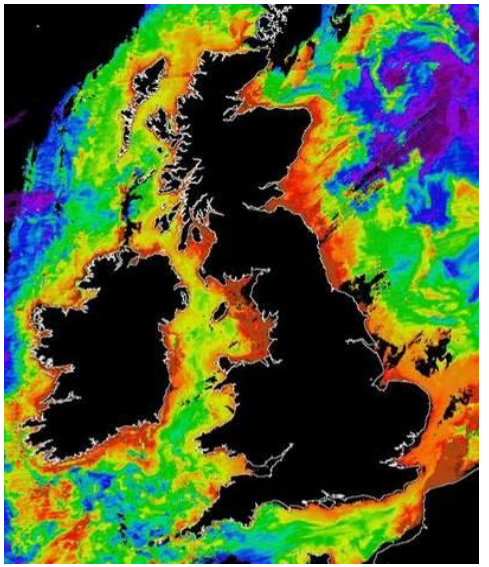
+ *others…*











Huw Lewis (Met Office)

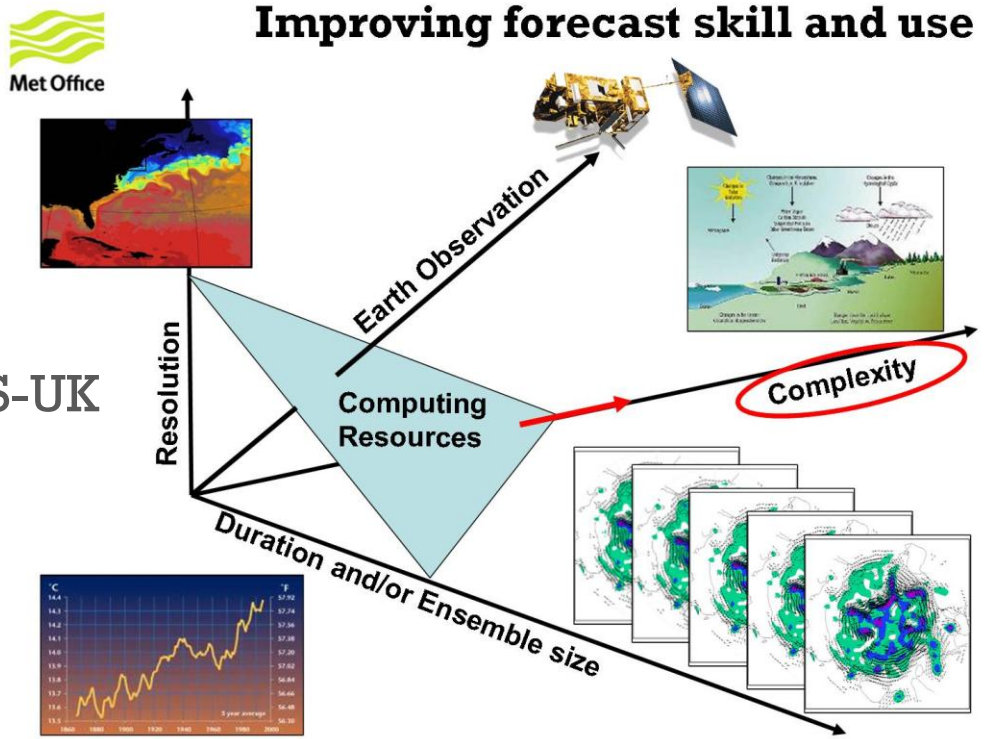
from .ppt to .F90

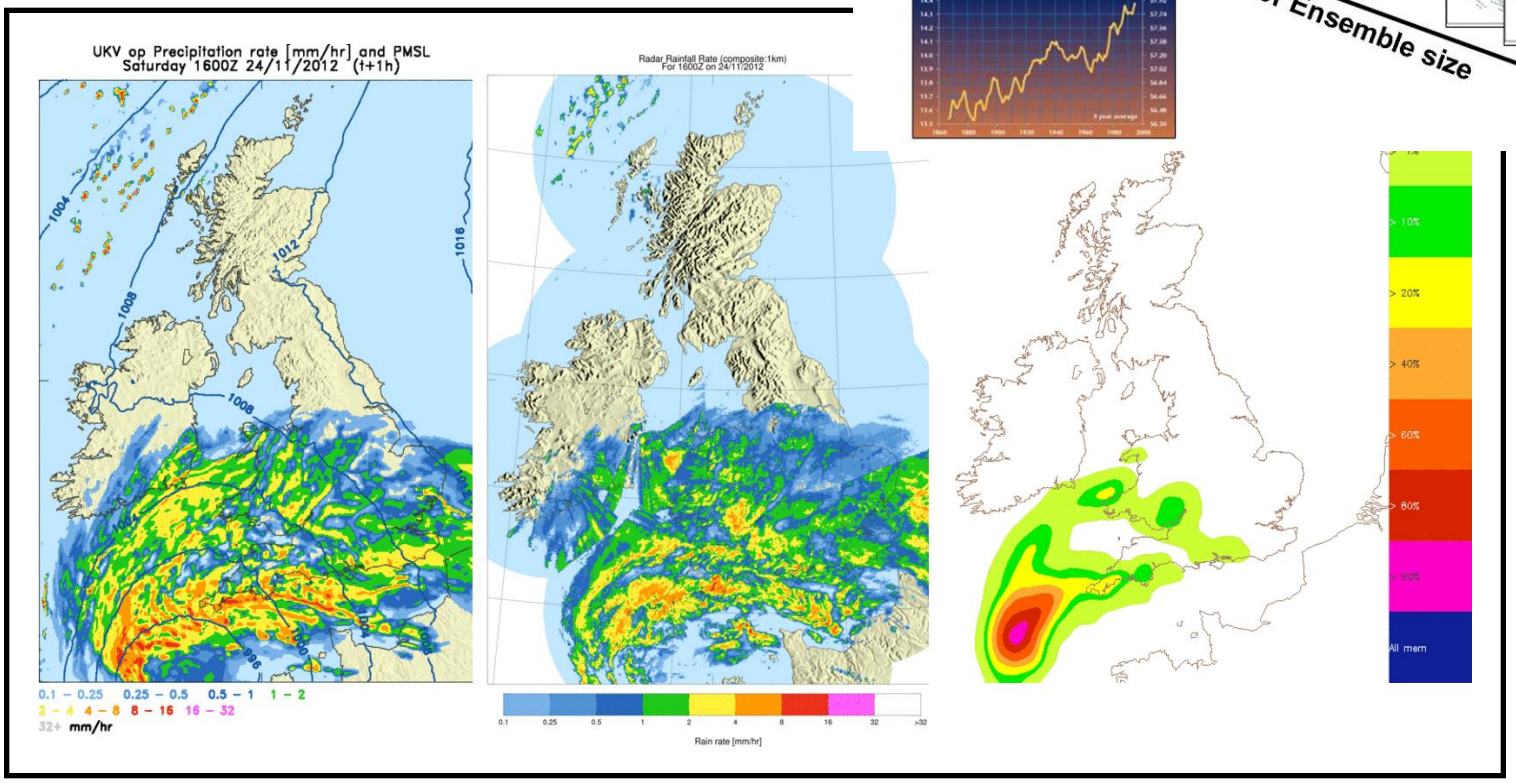
A UK weather forecasting view

Resolution → UKV

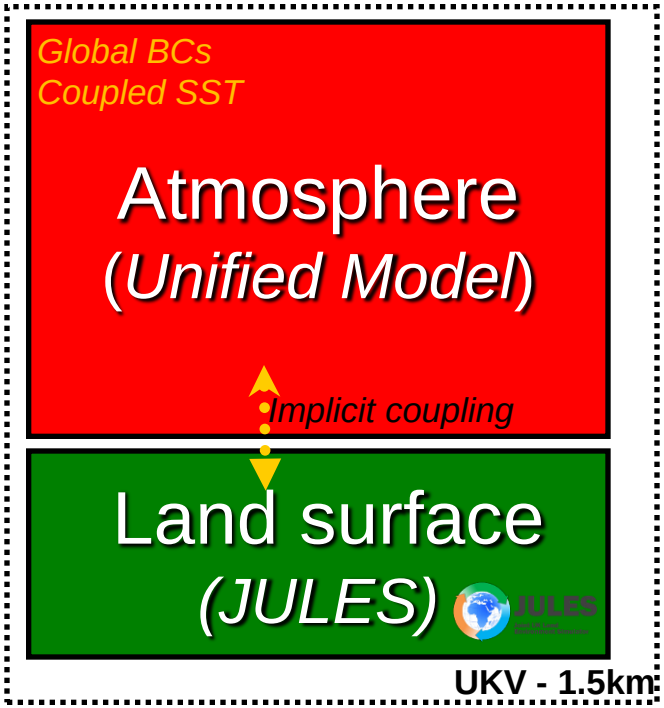
Uncertainty → MOGREPS-UK

Complexity → …



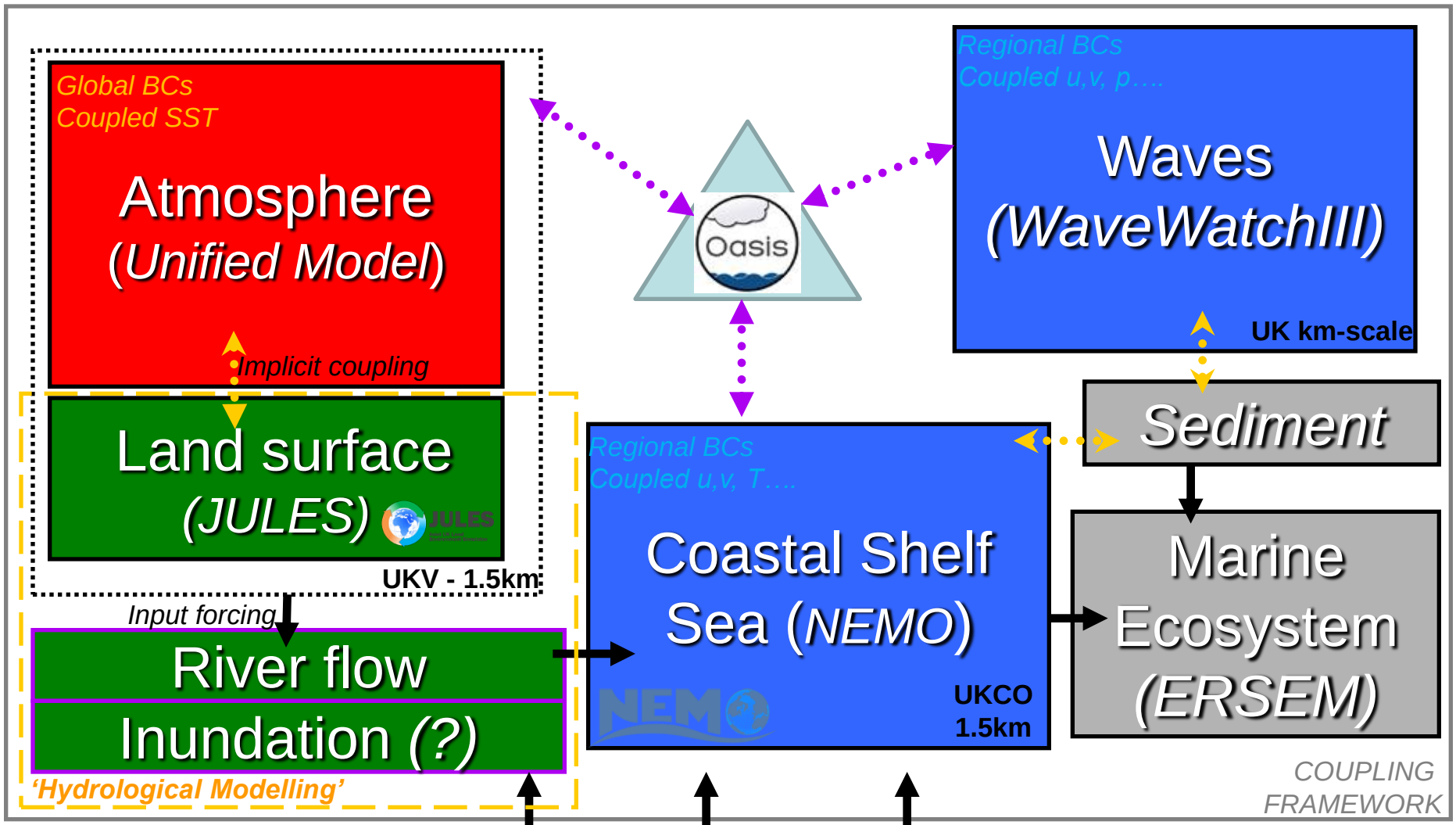


ATMOSPHERE + SURFACE



A *prototype* research system

ATMOSPHERE + SURFACE + MARINE + ECOSYSTEM



- DRAFT -
WORK IN PROGRESS

Global/regional scale boundary conditions (forecasts/analyses)

“Consider, [...], the possibility of modelling the subtle (and interdisciplinary) coupling between atmospheric forcing, catchment response, river runoff and coastal interaction with tidally-dominated sea levels; capturing these subtleties will require the dynamical coupling of many processes and components from different institutes and different computing systems.”

Beven (2007) Towards integrated environmental models of everywhere: uncertainty, data and modelling as a learning process *Hydrol. Earth Syst. Sci.* 11: 460-467

IMPROVING OUR PREDICTIONS

• e.g. Can coupled prediction improve atmospheric, marine, surface and/or hydrological predictability – increasing lead time and/or forecast skill?
• e.g. Can we improve guidance on storm surge and its impacts?

UNLOCKING NEW SCIENCE

• e.g. How do severe rainfall events affect the near-shore environment?
• e.g. What is the impact of severe weather on our domestic food security?

INCREASING EFFICIENCY AND USE OF COMMON TOOLS

• e.g. Where did all the water go?!
• e.g. What is the optimal coupling framework for integrated predictions?

PROVIDING NEW OPPORTUNITIES

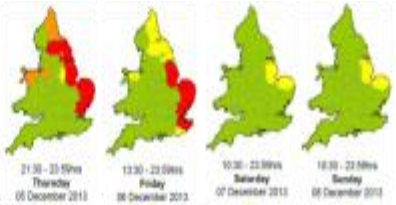
• e.g. Joining up hazard warning science and advice
• e.g. Driving catchment/city/bay-scale applications and assessments

Why ***– the key drivers and benefits***

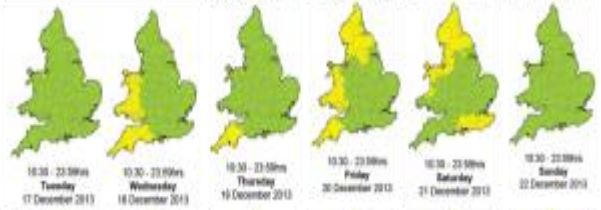
Flood Guidance Statement day by day

Week starting

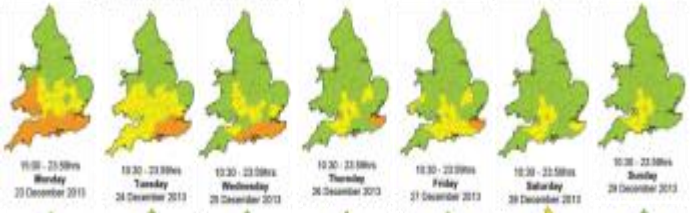
02/12/13



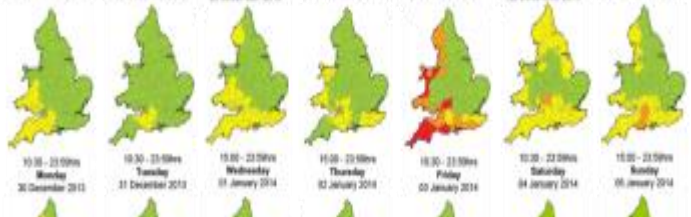
16/12/13



23/12/13



30/12/13



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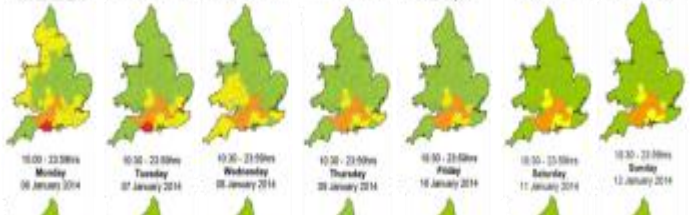

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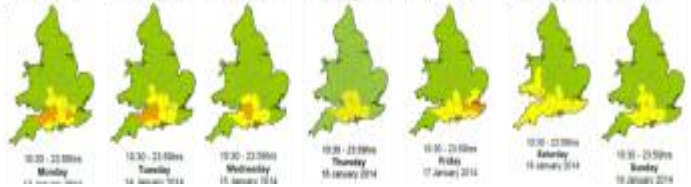

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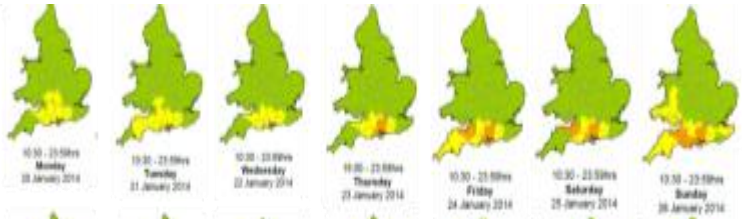

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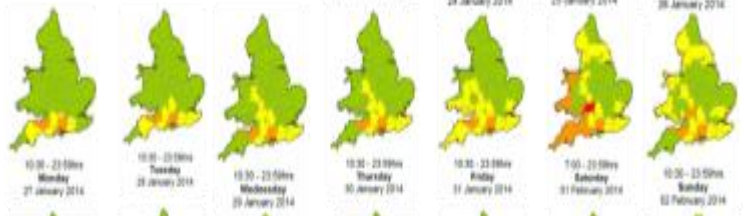

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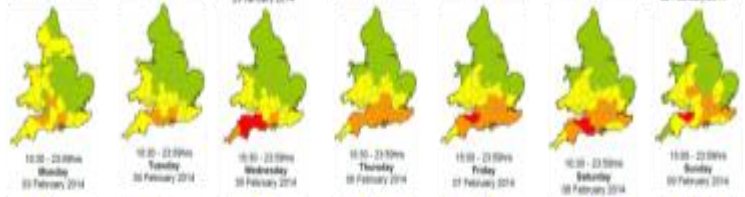

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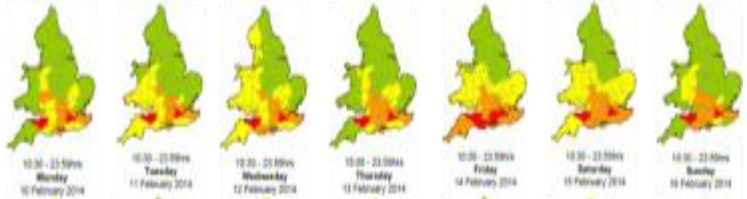

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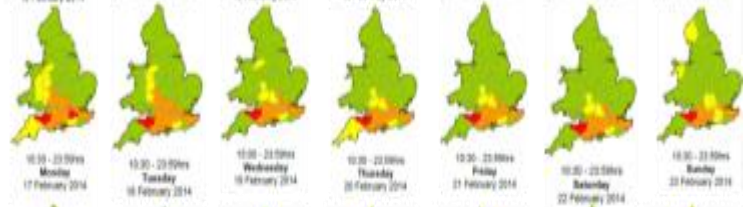

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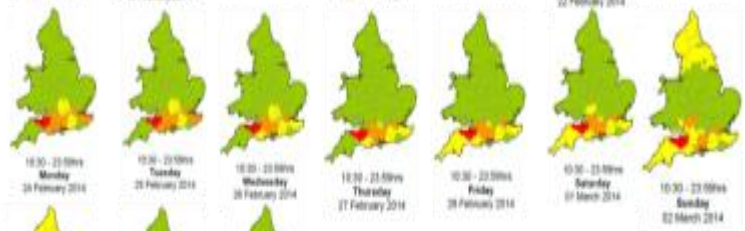

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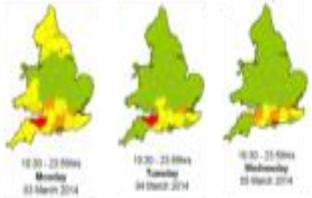
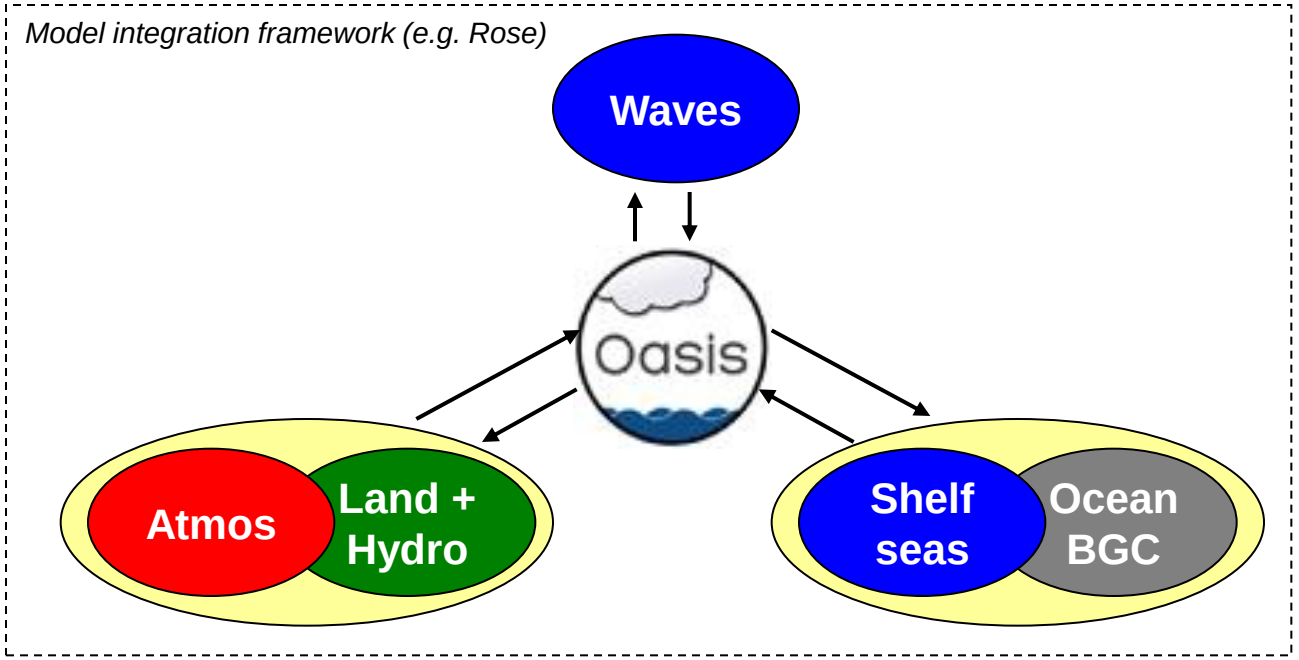


Somerset Moors & Levels

The *Prototype* project

Objectives:

1. To **build and evaluate** a 'first look' regional coupled prediction system for the UK at 1km scale.
2. To **identify key scientific and technical issues** to be addressed (within the timescale of the prototype project and for longer term R&D) to enable the UK Environmental Prediction vision to be achieved.
3. To **demonstrate** the UK coupled prediction concept.
4. If suitable, to identify and pick some 'low hanging fruit' for improved operational capability and/or societal application using the UK Environmental Prediction prototype system

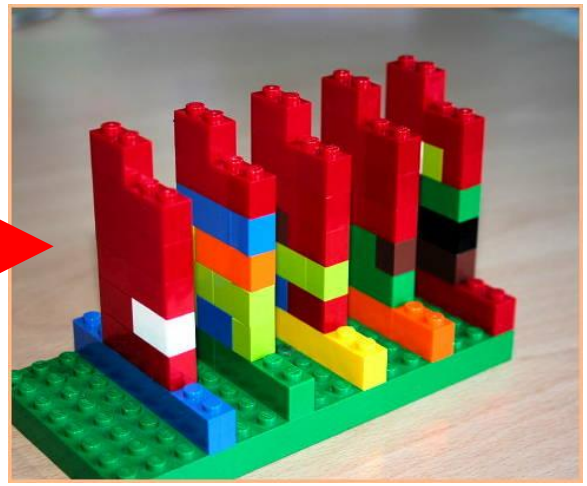


Challenges

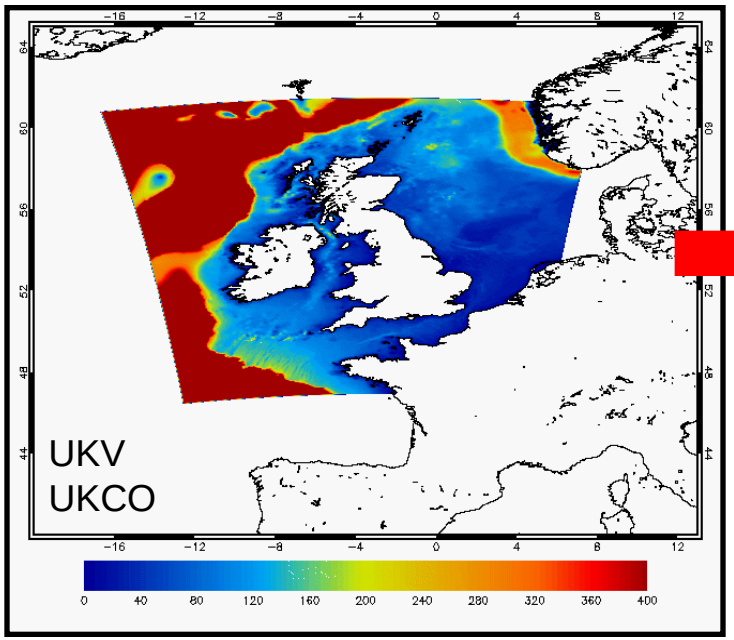
Technical integration and coupling science

- Diverse set of models
- Disparate communities and code design
- Pull through and collaboration hampered

??



- Modular
- Each ‘piece’ can be easily replaced with another
- Logical structure
- Extensible
- How?



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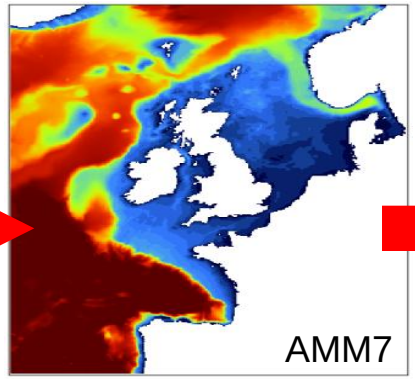

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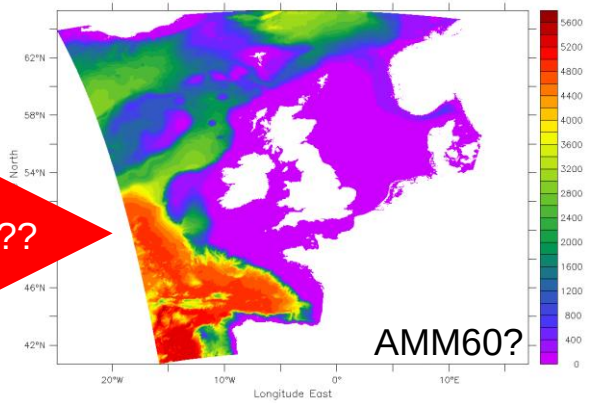
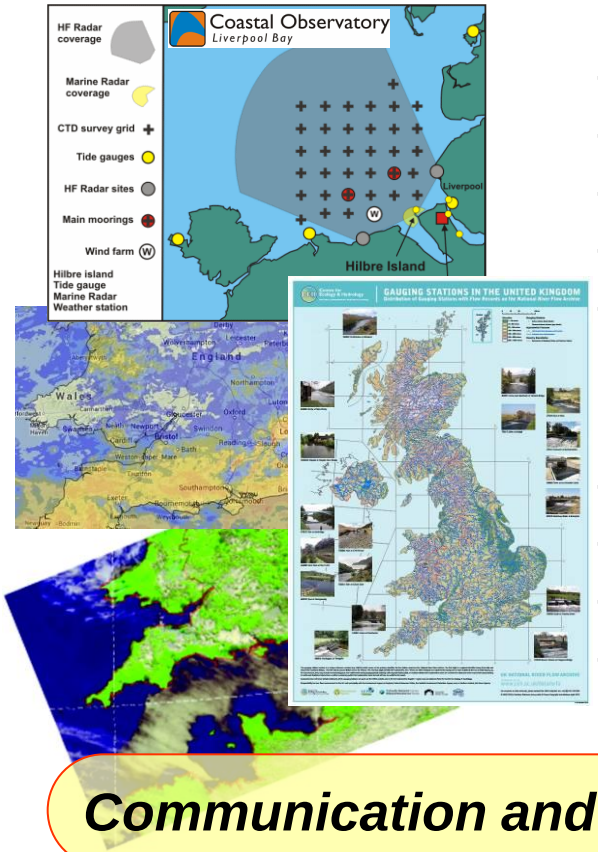


- Different models, grids, and preferred domains
- Capitalising on evolving operational configurations
- Future-proofing development

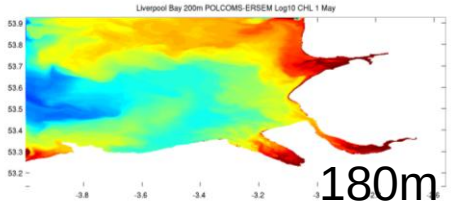
Challenges

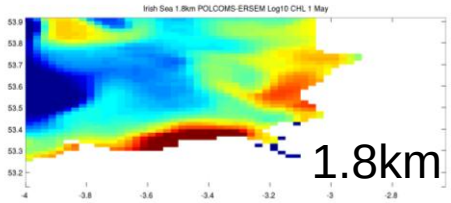
Evaluation and verification

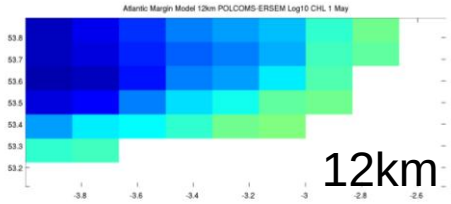
Data assimilation and observing systems



- Observation availability
- Data access
- Strategies for initialisation
- Research evaluation
- Routine verification







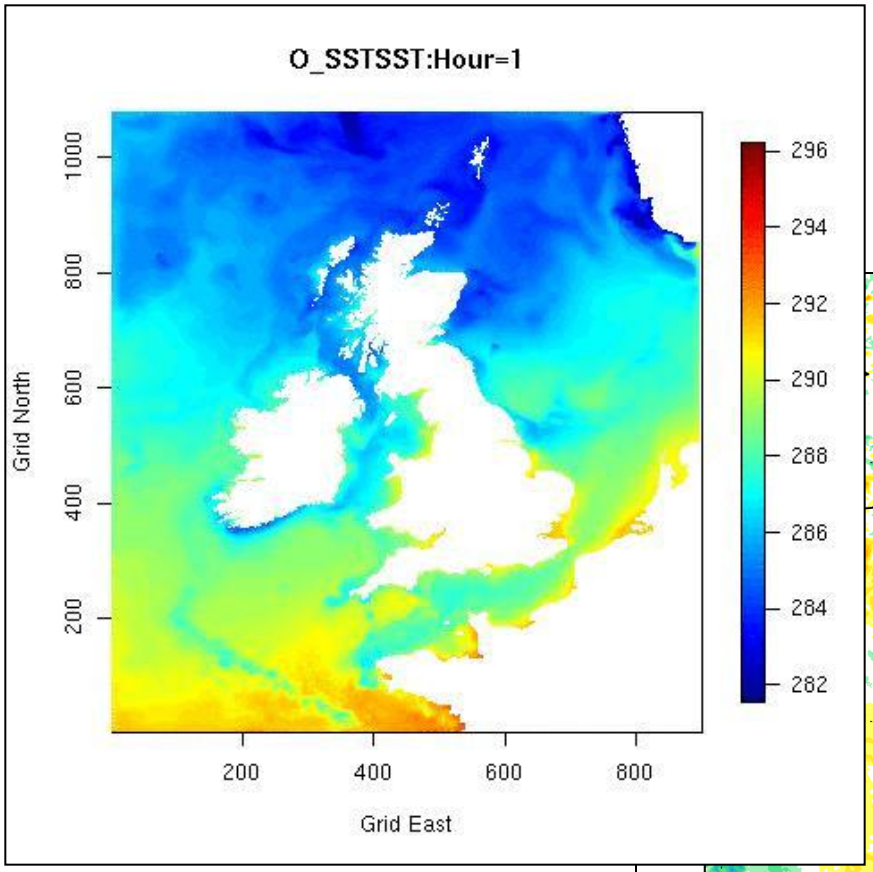
- ‘Forensic’ evaluation
- Assessing relevant scales
- Sufficiently detailed observations?
- Sufficiently detailed models?

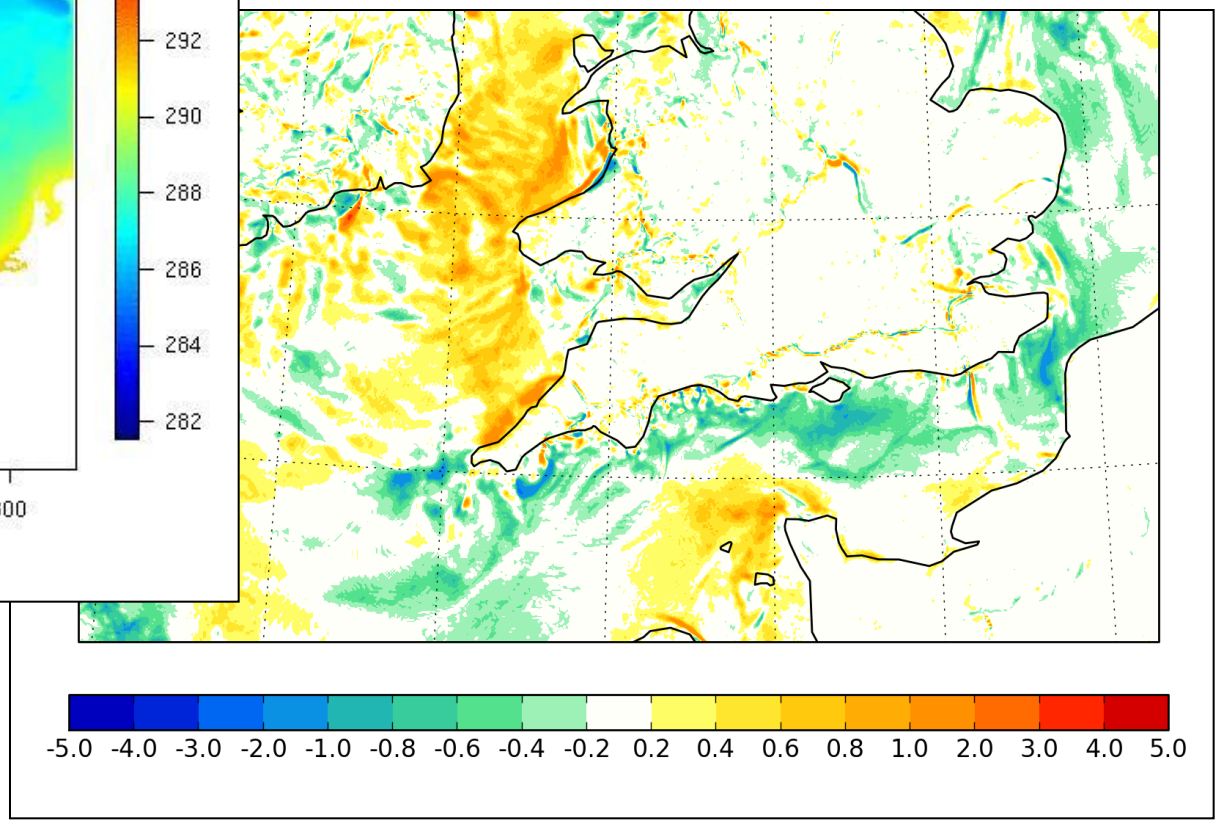
Communication and coordination

Met Office | Centre for Ecology & Hydrology, Natural Environment Research Council | National Oceanography Centre, Natural Environment Research Council | PML Plymouth Marine Laboratory

+ potentially many others….!

Initial progress - UKC0





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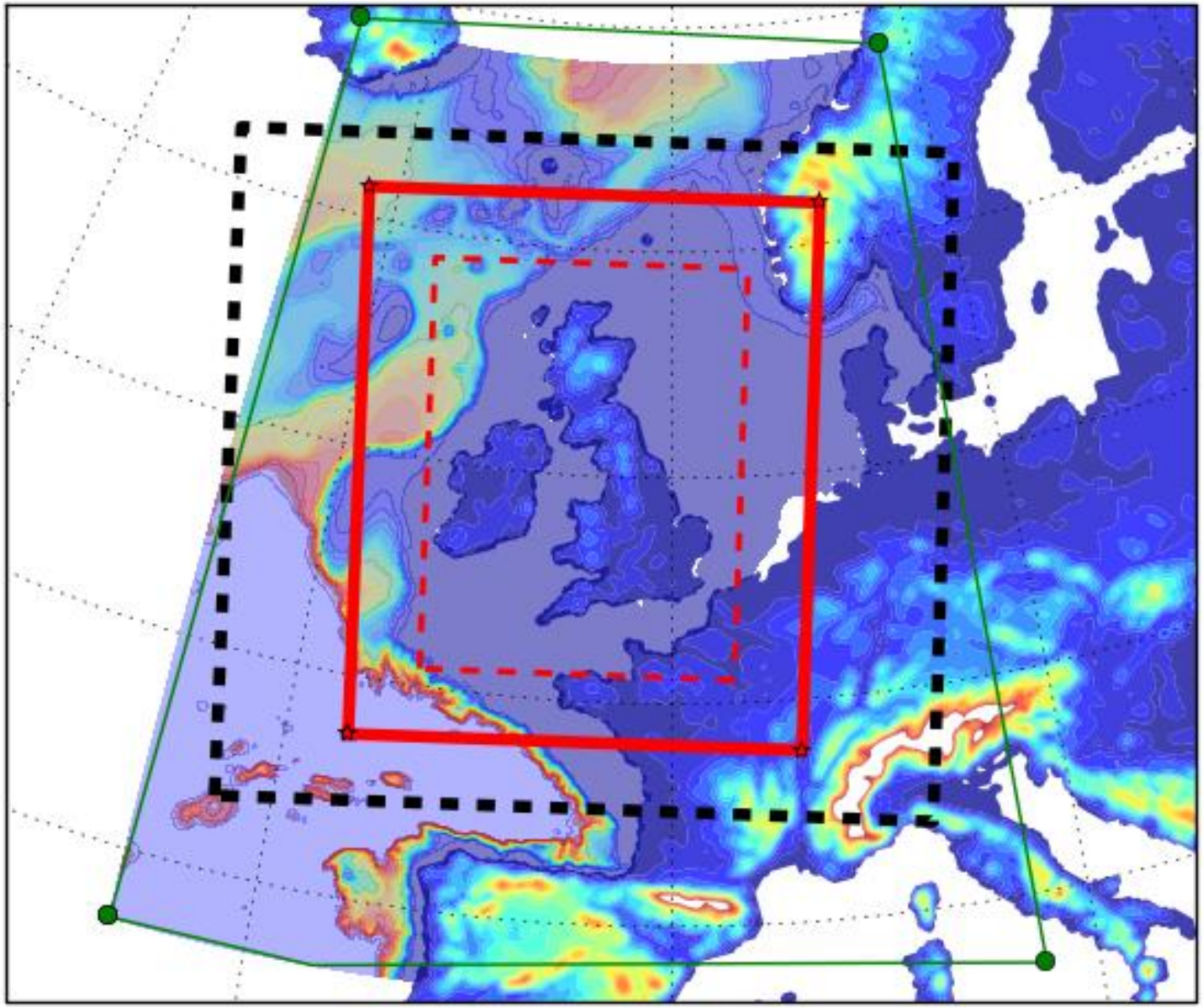
UKV 744x928=690432
Grid option 944x1018=270560 (39.2%)
AMM7 ocean

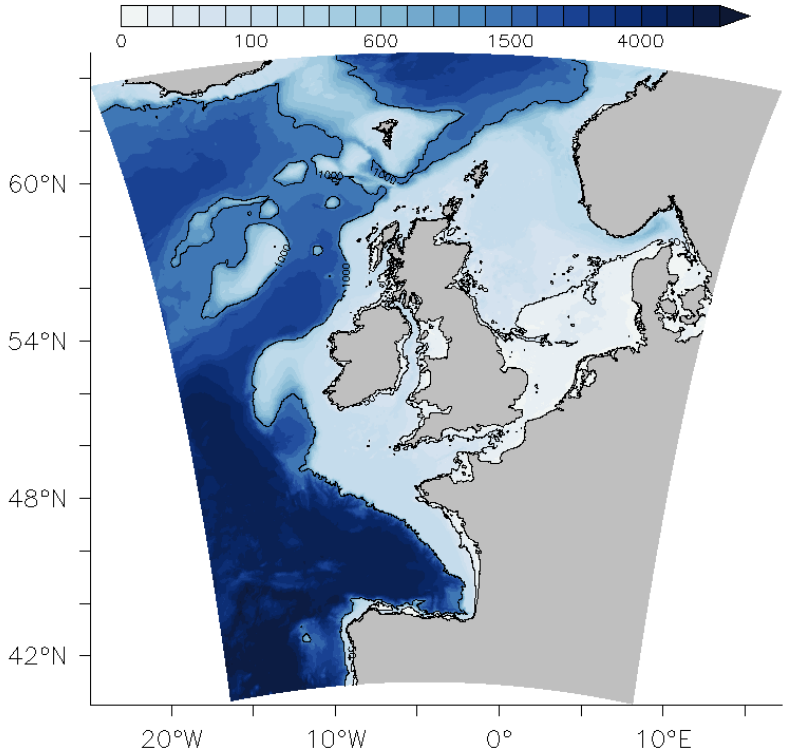


UKC1
UKC2

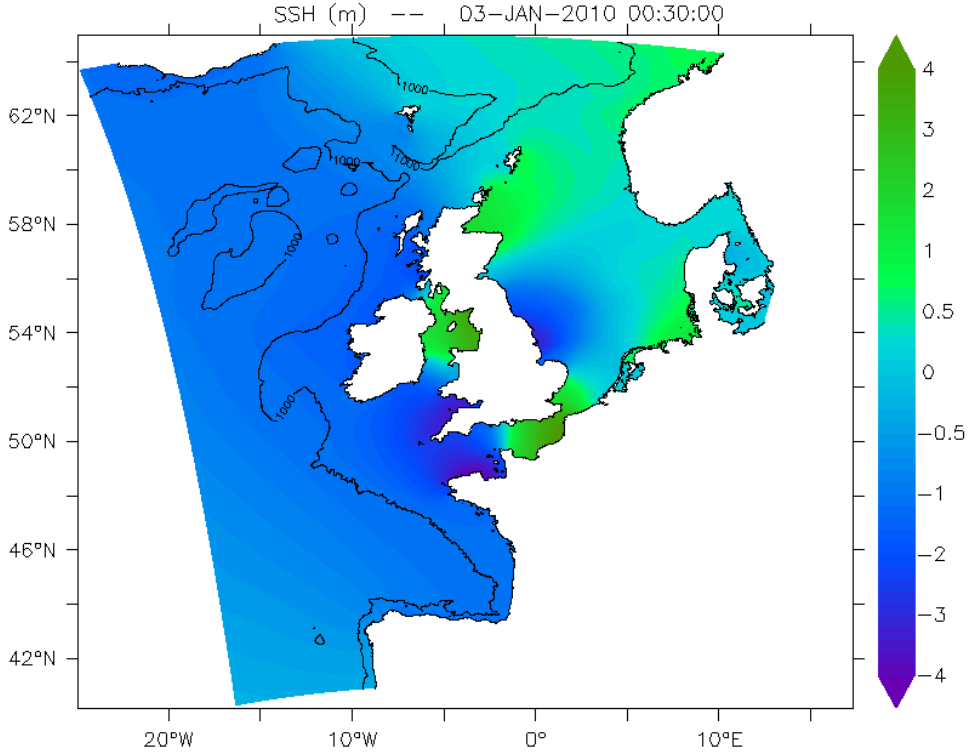
Initial progress – a new coastal ocean model (AMM60)

Met Office

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL



Bathymetry



Tidal simulation

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A land surface science opportunity

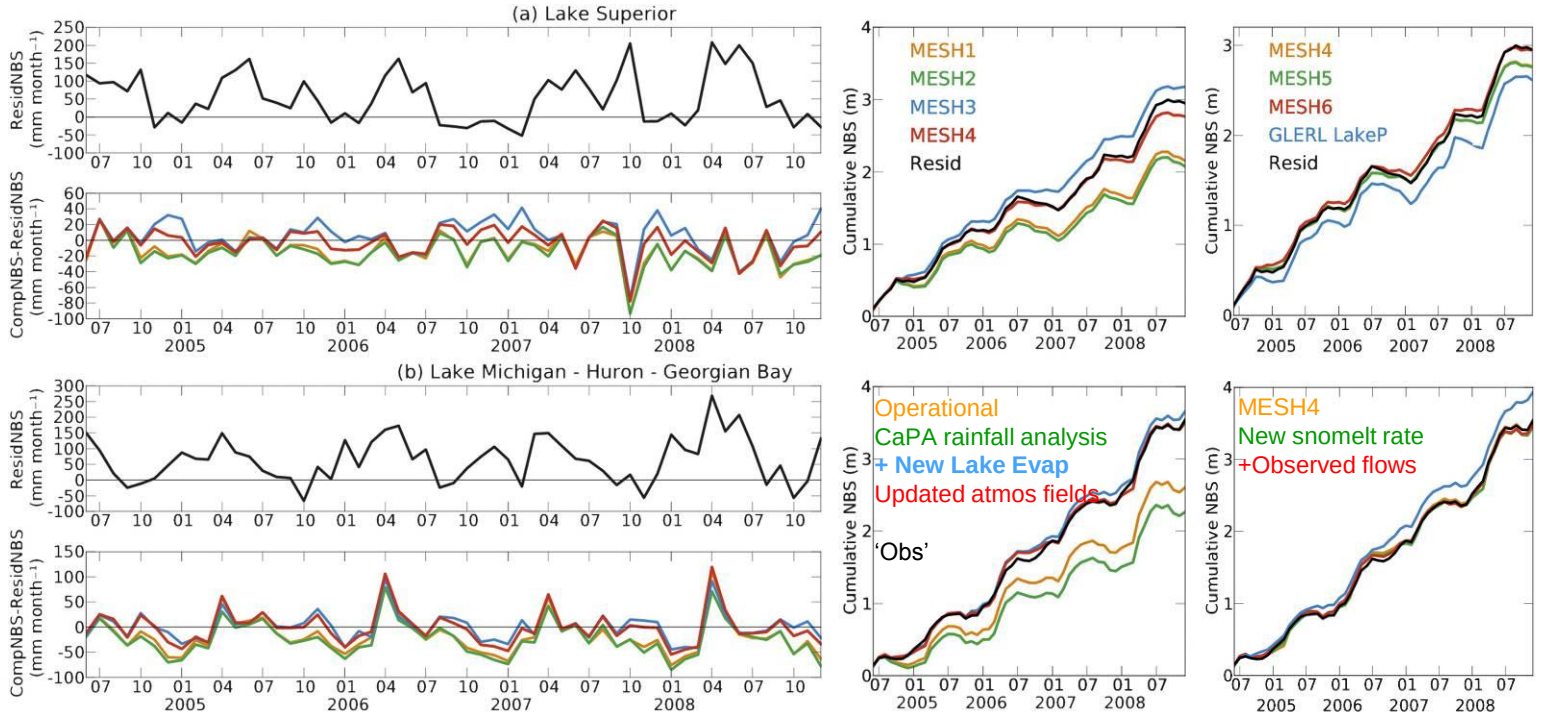
WP1: Hydrological Modelling

Design, build and evaluate the most appropriate integrated land surface and hydrology methodology for representing the UK terrestrial water cycle

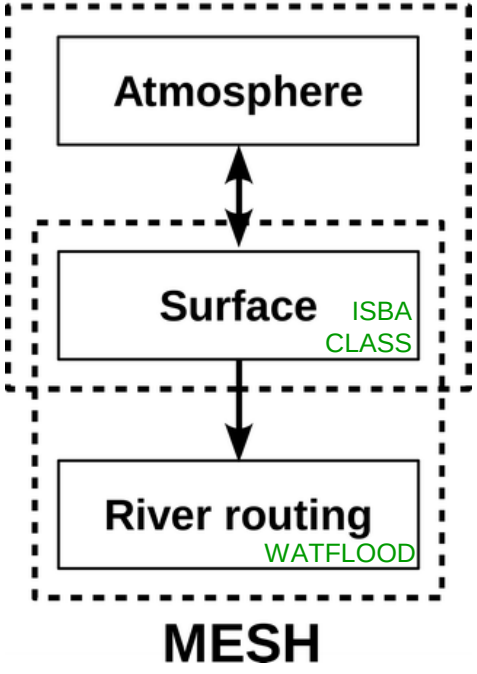
Deliver an integrated Soil – Vegetation – Hydrology – River flow capability for the UK at 1km scale

Year 1 - offline testing and evaluation
- JULES technical developments
- delivery of JULES-RFM for UKC1

Lead: Eleanor Blyth; CEH + Met Office input (+ others?)



GEM



"The MEC system allows different surface models to coexist within the same modelling framework so that they can be easily compared for the same experiment, using exactly the same forcings, interpolation procedures, grid, time period, time step and output specifications."

Net Basin Supply (NBS) = $Precip_{lake} - Evap_{lake} + Runoff$

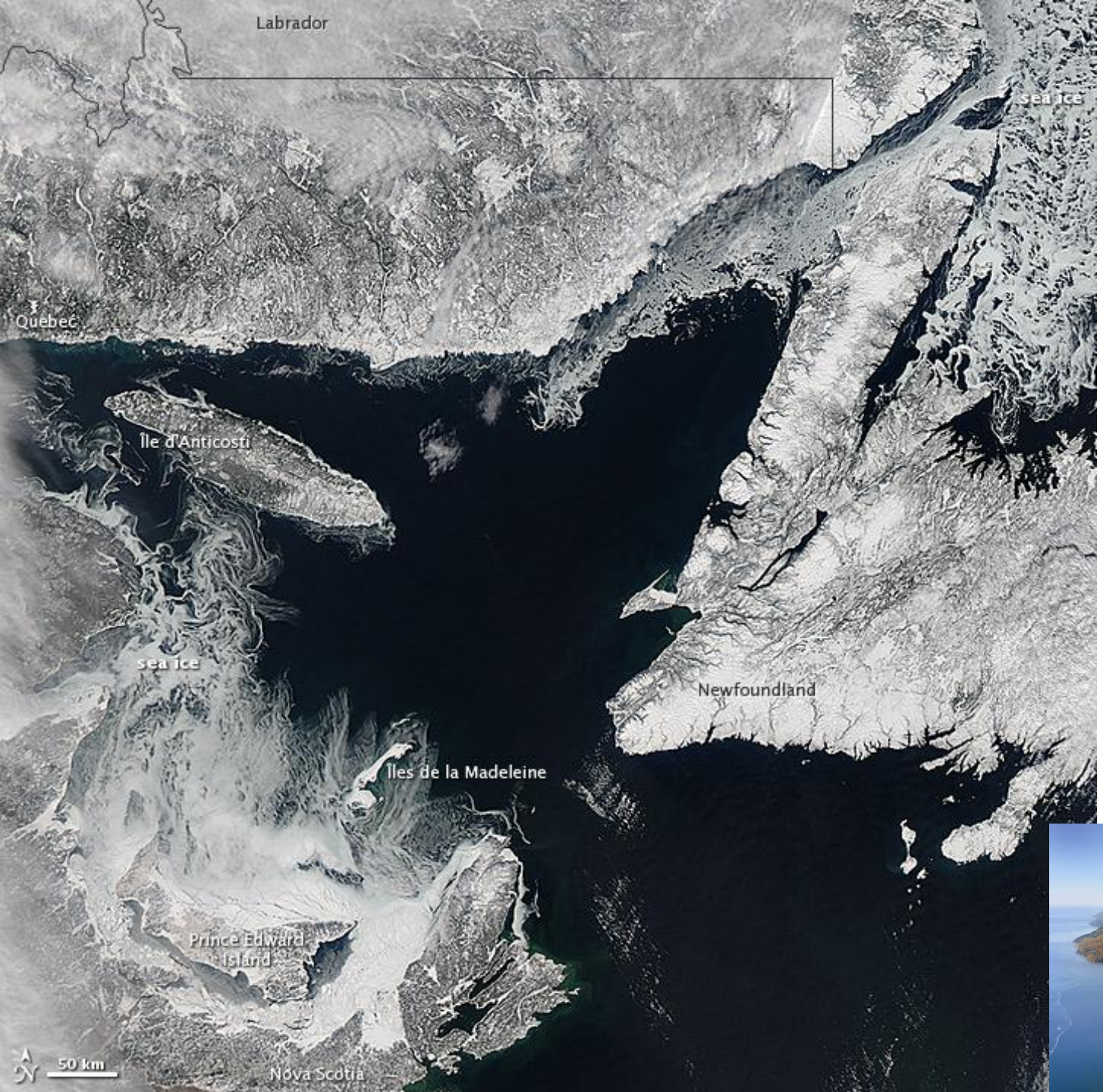
Soulis et al (2000) Towards closing the vertical water balance in Canadian Atmospheric Models *Atmosphere-Ocean*

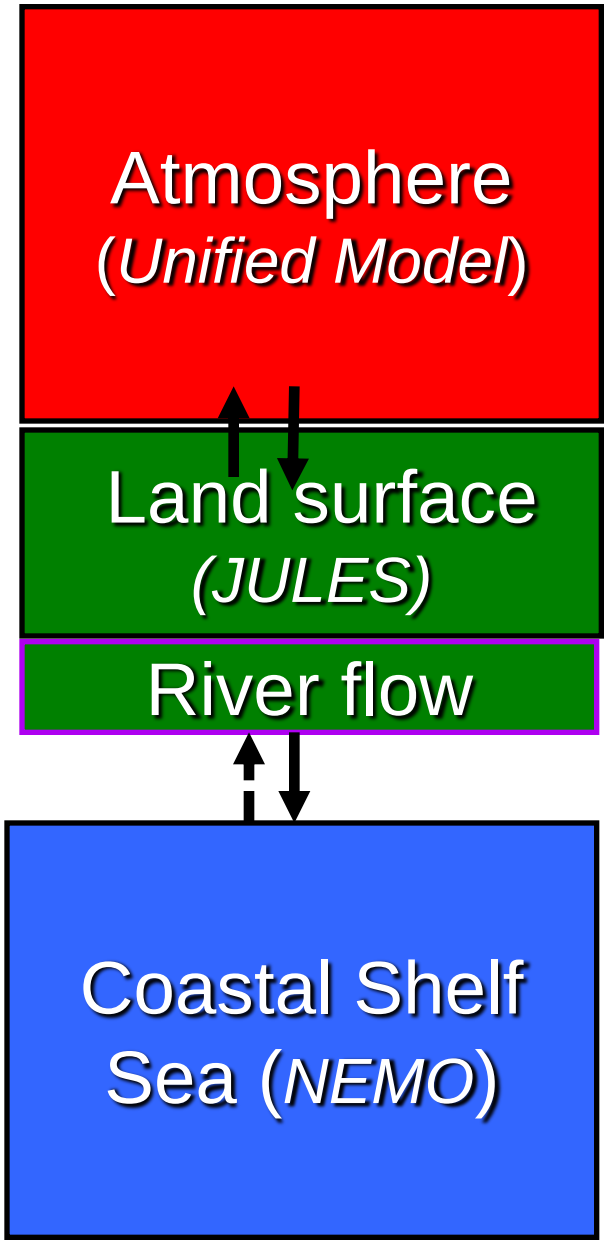
Benoit et al (2000) Toward the use of coupled atmospheric and hydrologic models at regional scale *Mon Wea Rev*

Pietroniro et al (2007) Development of the MESH modelling system for hydrological ensemble forecasting *HESS*

Deacu et al (2012) Predicting the Net Basin Supply to the Great Lakes with a Hydrometeorological Model *Journal of Hydrometeorology*

Environment Canada Environnement Canada


Labrador
sea ice
Quebec
Île d'Anticosti
sea ice
Newfoundland
Îles de la Madeleine
Prince Edward Island
50 km
Nova Scotia



- **How well is JULES performing at km-scale *(for the UK)*?**
- **Do we get the right results for the right reasons?**
- **How important are the land surface feedbacks in the coupled system? Are all key feedbacks well represented?**
- **How sensitive are ocean forecasts *(physics and biology)* to freshwater fluxes?**
- **Can we deliver more integrated hazard information *(e.g. surge inundation)*?**
- **...**

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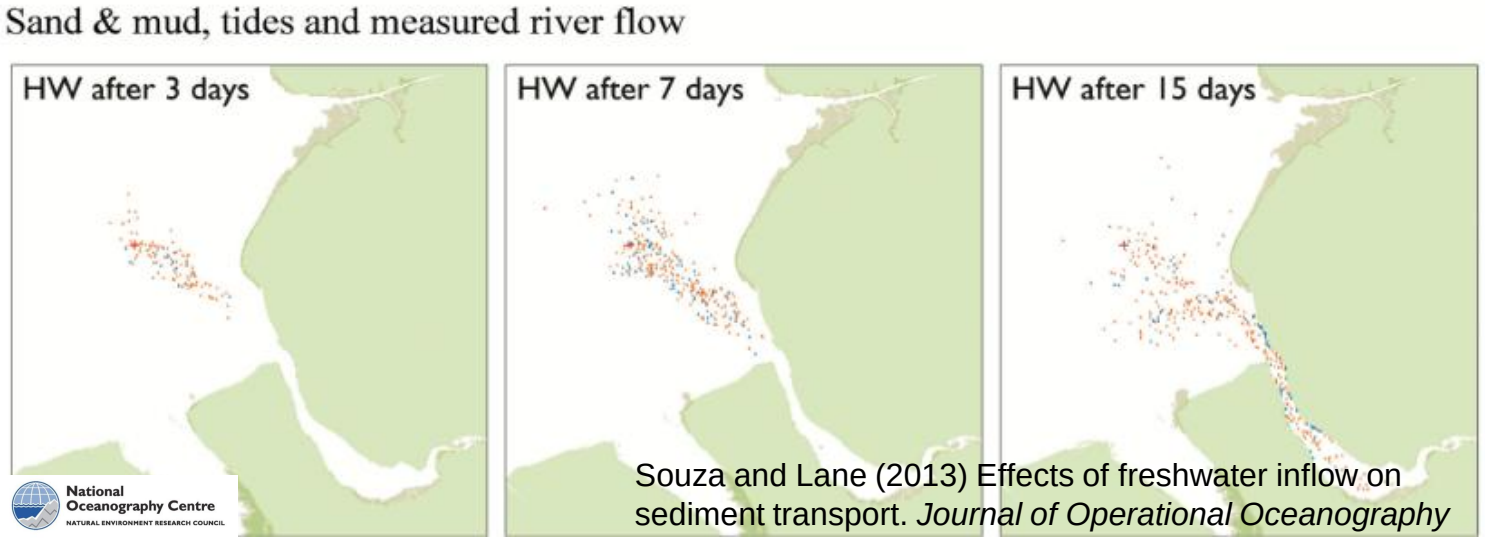
Future (phase 2) opportunities

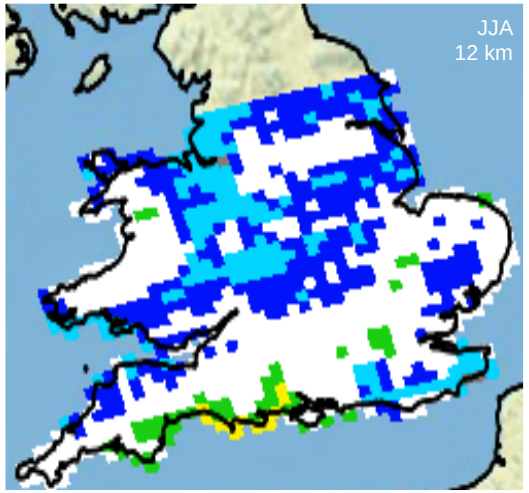


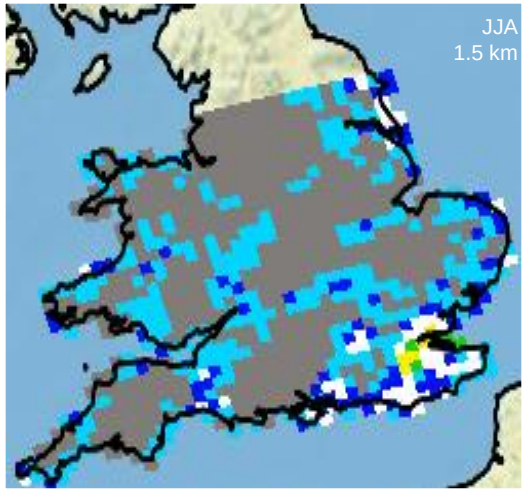
Souza and Lane (2013) Effects of freshwater inflow on sediment transport. *Journal of Operational Oceanography*

Where the land meets the sea!

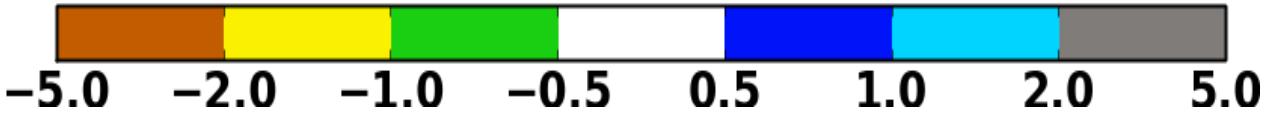
Integrated climate impacts scenarios

Kendon et al. (2014) Heavier summer downpours with climate change revealed by weather forecast resolution model. *Nature Climate Change*, 4, 570-576.





Met Office



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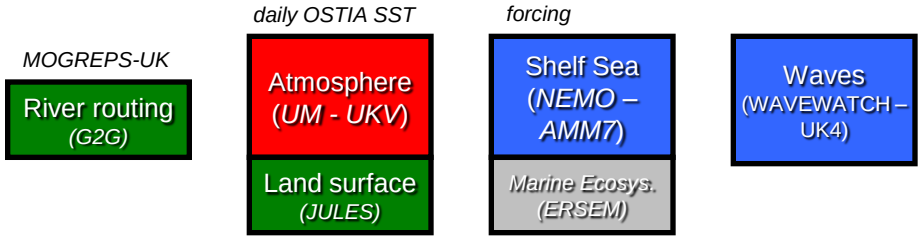
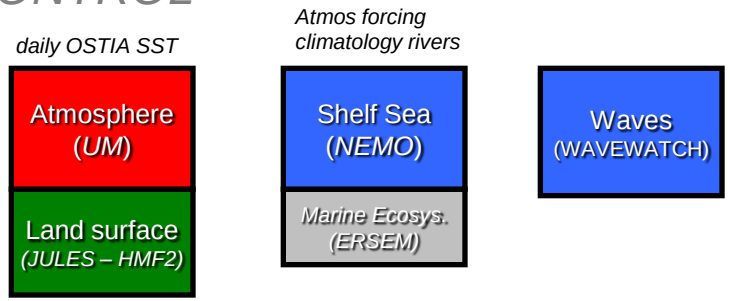
- **The UK community has an opportunity to develop and use world-leading Environmental Prediction capability**
- **We aim to improve model integration, and better understand the feedbacks to improve prediction**
- **We will accelerate progress in partnership**
- **JULES is a key component of the coupled system (across scales)**
- **Benefits of coupling will be evaluated in terms of the *details* – we are still in the early R&D stages**

- ***A significant opportunity for funding and impact***
- ***How do we best address the challenges together?***
- ***How do we best exploit synergies with other activities?***
- ***How do we ensure we deliver, alongside other priorities?***

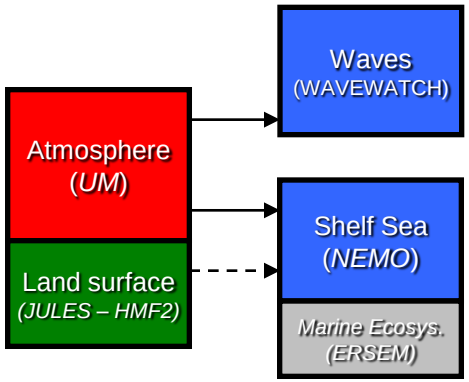
OPERATIONAL BASELINE



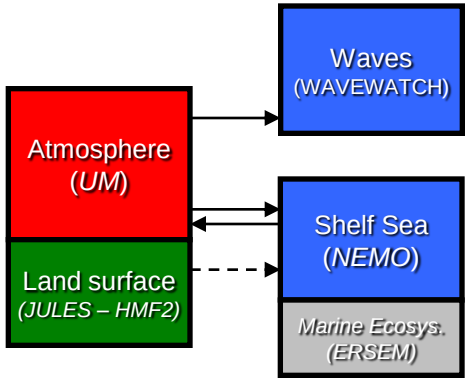
UKC2 CONTROL



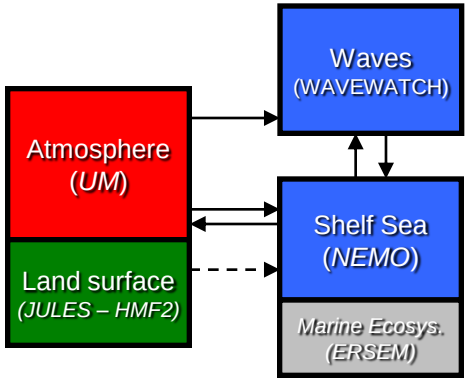
Expt. A – one-way coupling



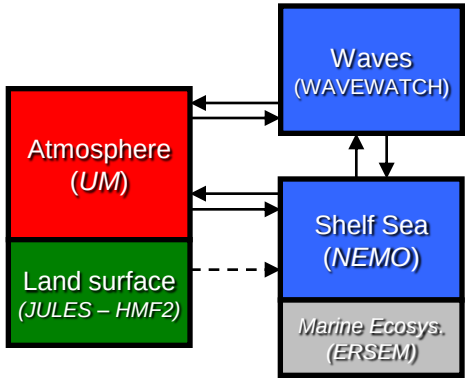
Expt. B – SST feedback



Expt. C – ocean-wave



Expt. D – fully coupled



WP5B