UK Environmental Prediction

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from .ppt to .F90

JULES meeting, Leicester July 2014
A UK weather forecasting view

Resolution → UKV

Uncertainty → MOGREPS-UK

Complexity → ...

Improving forecast skill and use

Resolution → Computing Resources → Duration and/or Ensemble size

Earth Observation

Complexity
ATMOSPHERE + SURFACE

Global BCs
Coupled SST

Atmosphere
(Unified Model)

Implicit coupling

Land surface
(JULES)

UKV - 1.5km
A prototype research system

ATMOSPHERE + SURFACE + MARINE + ECOSYSTEM

Global BCs
Coupled SST

Atmosphere
(Unified Model)

Implicit coupling

Land surface
(JULES)

Regional BCs
Coupled u,v, p....

Coastal Shelf
Sea (NEMO)

Regional BCs
Coupled u,v, T....

Waves
(WaveWatchIII)

Sediment

Global/regional scale boundary conditions (forecasts/analyses)

River flow
Inundation (?)

'Hydrological Modelling'

Input forcing

UKV - 1.5km

UK km-scale

- DRAFT -
WORK IN PROGRESS

Marine
Ecosystem (ERSEM)
“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.”

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

06/01/14

13/01/14

20/01/14

27/01/14

03/02/14

10/02/14

17/02/14

24/02/14

03/03/14
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?

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

Challenges

Communication and coordination

+ potentially many others…!
Initial progress - UKC0
UKV 744x928=690432
Grid option 944x1018=270560 (39.2%)
AMM7 ocean
Initial progress – a new coastal ocean model (AMM60)

Bathymetry

Tidal simulation
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?)
“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) = $\text{Precip}_{\text{lake}} - \text{Evap}_{\text{lake}} + \text{Runoff}$

- **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*
• 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)*?

• ...
**Future (phase 2) opportunities**

**Sand & mud, tides and measured river flow**


Where the land meets the sea!

**Integrated climate impacts scenarios**


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The data and graphics are used to illustrate the impact of climate change on sediment transport and future opportunities in the context of integrated climate impacts scenarios.
• 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**

MOGREPS-UK
- River routing (G2G)

**UKC2 CONTROL**
- daily OSTIA SST
- Atmosphere (UM - UKV)
- Land surface (JULES)
- Shelf Sea (NEMO – AMM7)
- Waves (WAVEWATCH – UK4)
- Marine Ecosys. (ERSEM)

**Expt. A – one-way coupling**
- Atmosphere (UM)
- Shelf Sea (NEMO)
- Waves (WAVEWATCH)
- Marine Ecosys. (ERSEM)

**Expt. B – SST feedback**
- Atmosphere (UM)
- Shelf Sea (NEMO)
- Waves (WAVEWATCH)
- Marine Ecosys. (ERSEM)

**Expt. C – ocean-wave**
- Atmosphere (UM)
- Shelf Sea (NEMO)
- Waves (WAVEWATCH)
- Marine Ecosys. (ERSEM)

**Expt. D – fully coupled**
- Atmosphere (UM)
- Shelf Sea (NEMO)
- Waves (WAVEWATCH)
- Marine Ecosys. (ERSEM)