The JULES Integrated Impacts Configuration

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Who?

- Andy Wiltshire, Rich Betts, Chris Jones
- Crops – Jemma Gornall, Tom Osborne (Reading), Josh Hooker
- Urban – Mark McCarthy, Maggie Hendry, Arora Porson, Ian Harmon (Reading), Sylvia Bohnenstengel, Peter Clark, Stephen Belcher, …
- Rivers – Doug Clark (CEH)
- Shallow Groundwater – Nic Gedney
- Irrigation – Nic Gedney, Rutger Dankers
- LUC – John Hughes (Leeds)
- Ancillaries – Ron Kahana
- Others – Stephen Sitch (Exeter), Lina Mecardo, Pete Falloon, Camilla Mathison, …
Why do we need a Configuration?
Why do we need a configuration?

• JULES has many data requirements
  • Parameters, Ancillaries
  • Model Switches
  • Meteorological Forcing

• Standard will make life easier

• Complete experiments in a consistent way to help understand improvements due to model development

• Understand how new physics and experiments complement on our existing climate HadGEM2-ES model simulations
What is in the ‘Configuration’

- Model Code – based on JULES 3.0
- Model Configuration Files
- Parameter Files (HadGEM2-ES tuning)
- Ancillary Files (from the Central Ancillary Program)
- Meteorological Forcing Data (including future climate projections from MOHC)
Why do we need an Impacts Configuration?
2030’s perfect storm

‘Demand for food and energy will jump 50 per cent by 2030 and for fresh water by 30 per cent, as the global population tops 8.3 billion’ John Beddington, 2009
Integration is Important

• Water and Food is closely connected, cannot interpret impacts of food and water independently

• Crops, land-use change exert a significant effect of regional climate and through carbon cycle feedbacks.

• Earth-System processes are critically related to the impacts
Ozone

- Ozone exerts a direct influence on plant stomatal control
- Potential Impact of Crop Yield

Sitch, 2007
Diffuse Radiation

Light quality influences C sequestration

Mecardo, 2009
Runoff

• Water Resources Influenced by
  • Land-Use Change
  • $\text{CO}_2$ physiological forcing

Gedney, 2006
Earth System Processes are Important

- Land-Use Change is in HadGEM2-ES but not JULES
- Ozone is in JULES but not HadGEM2-ES
- Diffuse Radiation is in JULES but not HadGEM2-ES

- Useful to see how these processes complement the HadGEM2-ES AR5 simulations
What is in JULES-Impacts?
Impacts Components
Built on JULES version 3

- Urban
- Climate
- CO₂
- Land-Use Change
- Ozone
- Eco-systems
- Water
- Agriculture

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Base Configuration
Configuration 1

• Built on JULES 3.0

• Model parameters, switches, ancillaries configured to match HadGEM2-ES

• Using HadGEM2-ES forcing should be able to closely replicate HadGEM2-ES evolution of land-surface

• Available Forcing:
  • 150 years pre-industrial control (pool spin-up)
  • 1860 - 2005 Historical
  • 2005 – 2100 RCP2.6, 4.5, 6.0, 8.5 Climate Scenarios
  • Atmospheric CO$_2$, O$_3$, IAM Land-Use Scenarios
New Crop Model (Reading)

- Crop Model – Crop Types
  - Wheat, GroundNut, Lentil, Potato, Rape, Soya, Cassava, Cotton, Millet, Maize, Sugar

- Simulates
  - Crop Phenology, Crop yield, Carbon Cycle, Pasture (Natural Grasses)

- Biogeophysical interaction
  - Albedo, roughness, surface conductance
New Irrigation Module

- Nic Gedney, Rutger Dankers

- ‘partial soil tiling’ – soil moisture in irrigated fraction is kept at critical point during growing season
  - Separate surface fluxes and soil hydrology
  - Soil temperature homogeneous for entire grid box
River Flow
(Doug Clark)

TRIP river routing model
Irrigation: Crop – Water Interaction

Scenario Update

Irrigate?
Crop in the ground?
Irrigation Equipped?

Crop Phenology
Crop Module

Shallow Ground-Water
LSH

Irrigation Module
Update Soil Moisture

Extraction

River Storage
TRIP
Land-Use Change

Scenario Update

Land Use Change

Crop
- Update Crop Fractions

Pasture
- Update C3, C4, Bare Soil Fractions

Urban
- Update Urban Roof & Canyon Structure

TRIFFID

Land Cover

Diagnose LULCC C Fluxes
Ecosystems

- TRIFFID Dynamic Vegetation Model
  - Broadleaf Trees, NeedleLeaf trees, C3 Grass, C4 Grass, Shrubs and Bare Soil

- Interacting with Climate

- Interacting with Land-Use

- Interacting with non-climatic forcing – \( \text{CO}_2, \text{O}_3 \), Direct/Diffuse Radiation

- Ability to ‘managed’ vegetation distribution as opposed to ‘potential’
Time-Varying Ancillaries

- Updating Atmospheric CO$_2$, O$_3$ fields
- Updating Pasture, Crop, Urban Fraction Fields
<table>
<thead>
<tr>
<th>Category</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation dynamics</td>
<td>TRIFFID, TRIFFID+LUC</td>
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<tr>
<td>Soil carbon</td>
<td>Single-pool, RothC, ...</td>
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<tr>
<td>River routing</td>
<td>TRIP, Grid2Grid</td>
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<td>Canopy Rad</td>
<td>HG2, 1, 2, 3, 4, 5</td>
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<td>Groundwater</td>
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<td>Irrigation</td>
<td>No Tile, Partial Tile</td>
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<tr>
<td>Canopy Model</td>
<td>1, 2, 3, 4</td>
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<tr>
<td>Crops</td>
<td>JULES-CROP, JULES-SUCROS</td>
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<tr>
<td>Snow</td>
<td>Single layer, Multi-layer</td>
</tr>
<tr>
<td>Urban</td>
<td>1-Tile, 2-Tile, MORUSES</td>
</tr>
<tr>
<td>Additional Forcing</td>
<td>Diffuse Radiation, Ozone</td>
</tr>
</tbody>
</table>
Testing and Evaluation

- Configuration will pass relevant JULES benchmarks
- Configuration performance will be independently evaluated
- Not an ‘official’ JULES release
- Relevant components (Crops, Irrigation, Rivers) will be submitted for official release
- Future JULES releases will eventually supersede the Impacts Configuration
What questions can JULES-Impacts help answer?

- Impacts of CC and Socio-economic change on food, water and urban and natural environments?
- How do we mitigate climate change, but provide ecosystem resilience, food, water and poverty alleviation for a growing population whilst adapting to CC?
- Deforestation and food production?
- Food production and water resources?
- Adapting Urban environments to CC?
Conclusions

- A community configuration of JULES
- A setup of JULES easy to run, as all data requirements are available
- Actually two configurations
  - One to help understand HadGEM2-ES AR5 simulations
  - One to help understand the impacts of and adaptation to climate change
- Not all about Impacts
- Not subverting the JULES process
Getting hold of the JULES Impacts Configuration

• Still working on it…

• Hopefully, finished, benchmarked, documented and evaluated by Summer 2012

• Configuration will then be made available through BADC (hopefully).
Questions and answers