JULES-crop

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Why?

Not *another* crop model. What’s new?

– Coupled to atmosphere
  • Improve simulation of land surface for climate model
  • Fully coupled impact assessment

– Global application

– Biophysical consistency with other land-surface processes
Land surface can affect climate.
Crops now a significant component of land surface

Atlas of the Biosphere
Center for Sustainability and the Global Environment
University of Wisconsin - Madison

Ramankutty and Foley (1999)
Especially so in particular regions

Ramankutty and Foley (1999)
Crops differ to “natural” vegetation …

McPherson et al. (2004)
… leading to differences in near-surface climate (e.g. max daily air temperature)
Including explicit crop parameterisation improves simulation of land-surface fluxes.
Growing crops in a climate model can feedback on to simulated climate variability.

NW India

- **Wet**
- **Dry**
- **CI (5,95)**

Osborne et al (2009)
Response of vegetation to environment can affect climate.

FACE: Free Air CO₂ enrichment
Fraction of total surface warming (warming caused by the combined CO2-radiative and physiological effects) associated with the physiological forcing of CO2.

Cao L et al. PNAS 2010;107:9513-9518
Development of JULES-crop

Aims:
1) Improved representation of land surface in cropped regions.
2) Physically consistent prediction of crop yields under variable environmental conditions.
Development of JULES-crop

Aims:
1) Improved representation of land surface in cropped regions.
2) Physically consistent prediction of crop yields under variable environmental conditions.

Challenges:
1) Representing the wide variety (175, Monfreda et al) of crops
   – Crop Functional Types.
2) Generic parameterisation suitable for all crop types.
3) Parameterisation of management (non-climatic influences)
# Crop Functional Types

<table>
<thead>
<tr>
<th>PHOTO SYNTHESIS</th>
<th>PHOTOSENSTIVITY</th>
<th>C / L / O</th>
<th>OTHER</th>
<th>CFT</th>
<th>EXAMPLE</th>
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<tbody>
<tr>
<td>C3</td>
<td>LONG DAY SENSITIVE</td>
<td>CEREAL</td>
<td>-----------------</td>
<td>1</td>
<td>WHEAT, BARLEY, RYE, OAT</td>
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<td>OILSEED</td>
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<td>3</td>
<td>LENTIL, CHICKPEA, DRYBEAN</td>
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<td>OTHER</td>
<td>ROOT / TUBER</td>
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<td>POTATO, SUGARBEET</td>
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<td>NOT</td>
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<td>5</td>
<td>RAPE</td>
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<td>SHORT DAY SENSITIVE</td>
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<td>-----------------</td>
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<td>RICE</td>
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<td>LEGUME</td>
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<td>SOYBEAN</td>
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<td>CASSAVA, SWEET POTATO</td>
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<td>NOT</td>
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<td>9</td>
<td>COTTON</td>
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<tr>
<td>C4</td>
<td>------------------------</td>
<td>CEREAL</td>
<td>SMALL GRAIN</td>
<td>10</td>
<td>SORGHUM, MILLET</td>
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<td>MAIZE</td>
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<td>OTHER</td>
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<td>SUGARCANE</td>
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</table>
Generic parameterisation

CLIMATE

JULES

DEVELOPMENT INDEX

C$_3$ or C$_4$

NPP

LEAVES

STEM

ROOTS

HARVEST

JULES_crop

informs

carbon

partition coefficients
Development Index (DVI)

<table>
<thead>
<tr>
<th>Stage</th>
<th>DVI</th>
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<tbody>
<tr>
<td>Sowing to emergence</td>
<td>-1 - 0</td>
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<tr>
<td>Emergence to flowering</td>
<td>0 - 1</td>
</tr>
<tr>
<td>Flowering to maturity</td>
<td>1 - 2</td>
</tr>
</tbody>
</table>

But, complicated by daylength, vernalisation, high temperatures.
Partitioning of NPP
Site evaluation: Mead, NE
Emerge
Sow
Flower
Harvest
Obs ~ 2000

- Different time periods
- Maize varieties
- Yield Gap
- It’s a model
Evaluation of planting date

200 grid cells with largest fractional coverage in Monfreda et al dataset.
Earlier planting of crops in US: part climate, part technology

Sacks and Kucharik (2011)
- JULES-crop technically works. But:

- Does it meet its dual aims?
  - Too many CFTs for weather and climate models
  - Not crop-specific for impacts

- Still a need to properly calibrate and validate.
  - Sufficient data to do both properly and independently
  - Depends on intended use (local v global, NWP v impacts)