The ACCESS CM2 and ESM 1.5 climate models and CMIP6

Martin Dix: CSIRO Climate Science Centre
Australian Community Climate and Earth System Simulator

**National effort since 2005**
- All timescales, weather to climate
- Local and imported components
- CSIRO, BoM, Universities
- NCI

**Support from**
- NESP Earth System and Climate Change Hub

**ACCESS**
- Atmospheric chemistry (UKCA)
- Atmosphere (UK Met Office UM)
- Ocean (NOAA GFDL MOM)
- Sea-ice (DOE LANL CICE)
- Ocean carbon (WOMBAT)
- Land (CABLE)
- Land carbon (CASA-CNP)
- OASIS3-MCT coupler
Two ACCESS configurations for CMIP6

• ESM 1.5
  • Older atmosphere from CMIP5 (ACCESS 1.3)
  • Includes carbon cycle
  • Less expensive to run

• CM2
  • New atmospheric model with more sophisticated chemistry/aerosol/cloud interactions
  • Physical model only – no carbon cycle
  • Same as UK HadGEM3-GC3.1 atmosphere but with CABLE replacing JULES
ACCESS-CM2 grid

- Atmosphere: 1.875° x 1.25° resolution, 85 levels
- Ocean: 1° resolution, 50 levels
- 20 minute time step, hourly coupling between atmosphere and ocean/ice
  - Land is directly coupled within the atmospheric model
Computational aspects

- UM and CICE are hybrid MPI-openMP, MOM is pure MPI
  - No advantage from multi-threading at climate resolution though it is used for NWP

- CM2 typically uses ~ 1000 cores on raijin
  - ~ 4 hours per simulated year
  - 4-5 years/day throughput for a single experiment
  - Atmosphere limits scaling and dominates cost

- 1300 simulated years for minimal CMIP6 submission
  - Several thousand in development and spinup
Historical simulations in CMIP6

~30 models available at the moment
Historical simulations

Anomalies relative to 1961-1990 mean
Pre-Industrial control drift removed
GHG emissions and concentrations

Global CO₂ emissions

CO₂ concentration

Shared socioeconomic pathways
Future projections

Temperature change relative to 1961-1990 mean
CM2 solid
ESM 1.5 dashed
ESM carbon cycle simulations

Cumulative land and ocean carbon flux since 1850

<table>
<thead>
<tr>
<th></th>
<th>Fossil</th>
<th>Ocean</th>
<th>Land</th>
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Historical: 1850-2014, SSPs: 2015-2100
Idealised experiments and climate sensitivity

All presently available CMIP6 models
Equilibrium climate sensitivity from 4xCO2

<table>
<thead>
<tr>
<th>Model</th>
<th>2xCO2 ECS</th>
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<tbody>
<tr>
<td>ACCESS ESM 1.5</td>
<td>3.8</td>
</tr>
<tr>
<td>ACCESS CM2</td>
<td>4.7</td>
</tr>
<tr>
<td>HadGEM3 GC3.1</td>
<td>5.2</td>
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Gregory method 4xCO2 regression

Change in surface air temperature (K) vs. Change in radiative flux (W/m²)

Science, 19 April 2019
Summary

• Highest priority simulations are complete
  • Looking forward to doing some analysis of the results
  • Extra ensemble members and some lower priority simulations will be done on gadi

• Grateful to NCI for ongoing support with computation and particularly now with data publication and the Earth System grid
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