BGC Practical Lab Notes
Coupled & Ocean

Keith Lindsay, NCAR/CGD

NCAR is sponsored by the National Science Foundation
BGC in CESM

• Features available since CESM 1.0
• On by default in CESM 2

• CAM CO$_2$ features
  – CO$_2$ constituents that use LND & OCN CO$_2$ fluxes as surface boundary condition
  – Pass CO$_2$ to driver for LND & OCN flux computations
  – Couple CO$_2$ constituents to radiation computations

• POP Ecosystem model
  – uses MARBL library in CESM2

• CLM features covered elsewhere
Coupled BGC Compsets

• Terminology
  – BGC CO₂: what is used by surface components
  – RAD CO₂: what is used by ATM radiative code
  – Diagnostic CO₂: prescribed ATM concentrations
    • Ex: constant, read from file, 1% ramp
  – Prognostic CO₂: predicted ATM concentrations
    • atmospheric constituent computed from surface CO₂ fluxes

• B1850, BHIST
  – compset long name has BGC%BDRD
  – coupled model, BGC & RAD CO₂ are diagnostic

• B1850_BPRP, BHIST_BPRP
  – shortnames introduced in CESM 2.1.1
  – compset long name has BGC%BPRP
  – coupled model, BGC & RAD CO₂ are prognostic
Ocean Specific BGC Compsets

- **C1850ECO**
  - Ocean alone, 1850 aerosols, normal year forcing

- **G1850ECO**
  - Ocean-Ice, 1850 aerosols, normal year forcing

- **G1850ECOIAF**
  - Ocean-Ice, 1850 aerosols, interannually varying forcing

- **./query_config --compsets pop**
  - run from same directory as create_newcase
Initial Conditions (IC)

• Coupled BDRD compsets (BDRD is default)
  – default RUN_REFCASE set for f09_g17 and f19_g17 res
  – provided ICs were spun-up with f09_g17 res
    • carbon cycle not balanced with f19_g17 res as well as with f09_g17 res

• Coupled BPRP compsets
  – default RUN_REFCASE set for f09_g17

• Ocean Alone, Ocean-Ice
  – ICs are provided, but are not spun-up
BGC env*xml variables

- **CCSM_BGC**
  - Controls which CO$_2$ fields are exchanged between CESM components, see table at end

- **CCSM_CO2_PPMV**
  - Constant CO$_2$ ref value used in some configurations

- **OCN_CO2_TYPE, LND_CO2_TYPE**
  - Controls CO$_2$ used by ocean and land components
  - constant, prognostic, diagnostic

- **OCN_TRACER_MODULES**
  - Controls which ocean tracers are used
  - Ocean ecosystem model is called ecosys
Exercise

• Set up different experiments and compare resulting case directories. Do differences make sense?

• Experiment 1: B1850, f19_g17
• Experiment 2: B1850_BPRP, f19_g17
  – What happens when you run create_newcase?
    • follow instructions to get it working
    • don’t do this for real unless you know what you’re doing
• Run case.setup and preview_namelists for each case
• What changes occur when the carbon cycle is made prognostic?
POP BGC Specific Output

- ocn/hist/$CASE.pop.h.ecosys.nday1.????-??-??-??\.nc
  - Selected ocean ecosys variables at daily resolution
  - Surface flux related, productivity & functional group vertical integrals

- ocn/hist/$CASE.pop.h.ecosys.nyear1.?????.nc
  - Selected three dimensional ocean ecosys tracer budget terms
UNITS & SIGN CONVENTIONS

- CAM variables CO2, CO2_LND, CO2_OCN, CO2_FFF have units kgCO$_2$/kg dry air
- This is NOT a typical unit for carbon cycle modelers
- To convert ppmv, multiply by $1.0e6 \times \frac{28.966}{44.0}$
  - $28.966$ and $44.0$ are molecular weights of dry air and CO$_2$ respectively

- Same quantity in different component output has
  - Different names
  - Different units
  - Different sign conventions (for fluxes)
<table>
<thead>
<tr>
<th>Component</th>
<th>Variable Name</th>
<th>Units</th>
<th>Sign Convention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>SFCO2_LND</td>
<td>kgCO2/m²/s</td>
<td>Positive up</td>
</tr>
<tr>
<td>Land</td>
<td>NEE</td>
<td>gC/m²/s</td>
<td>Positive up</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>SFCO2_OCN</td>
<td>kgCO2/m²/s</td>
<td>Positive up</td>
</tr>
<tr>
<td>Ocean</td>
<td>FG_CO2</td>
<td>mmolC/m³·cm/s nmolC/cm²/s</td>
<td>Positive down</td>
</tr>
</tbody>
</table>
**CCSM_BGC settings**

<table>
<thead>
<tr>
<th></th>
<th>CO2A</th>
<th>CO2B</th>
<th>CO2C</th>
</tr>
</thead>
<tbody>
<tr>
<td>prog CO₂ -&gt; land</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>diag CO₂ -&gt; land</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>land CO₂ flux -&gt; atm</td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>prog CO₂ -&gt; ocean</td>
<td>Y</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>diag CO₂ -&gt; ocean</td>
<td>Y</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>ocean CO₂ flux -&gt; atm</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

- **CO2A**: land only or ocean only runs
- **CO2B**: atmosphere-land runs
  - Ocean & Fossil Fuel CO₂ fluxes read from file
- **CO2C**: fully coupled runs