Ocean biogeochemistry in the Canadian Earth System Model 5 (CanESM5)

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Introduction to CanESM5

CanESM5 is CCCma’s latest fully coupled Earth System Model. It updates CanESM2, with new ocean and sea-ice models (NEMO-LIM2), a new coupler, and updates in the atmosphere and land models. CanESM5 will contribute to the Coupled Model Intercomparison Project Phase 6 (CMIP6).

CanESM5 nominal ocean resolution is 1° on the ORCA1 tripolar grid, with refinement at the equator. Atmospheric resolution is T63 (2.5°).

Ocean biogeochemistry models

Canadian Model of Ocean Carbon (CMOC)
- OMIP6 carbon chemistry
- NPZD biology with fixed stoichiometry
- Parameterized iron limitation, calcium carbonate sinking and N2 fixation.

Canadian Ocean Ecosystem (CanOE)
- OMIP6 carbon chemistry
- 2N2P2ZZ biology with variable phytoplankton stoichiometry
- Explicit iron and calcium carbonate cycles, and denitrification.

CanESM5 with CMOCT will contribute all CMIP6 experiments submitted by CCCma.

Validation and model comparison

Ocean only and coupled runs skilfully reproduce the 3D climatological distributions of DIC and NO3, and the surface CO2 flux.

- Skill improved in CanESM5 relative to CanESM2 due to better physical circulation.
- CMOCT and CanOE have similar global-scale skill.

Regional biases differ in CMOCT and CanOE under the same circulation. CMOCT shows tropical nutrient trapping, while CanOE overestimates bottom water NO3, and underestimates NO3 in NADW. Both models have DIC deficient bottom waters.

Carbon spinup

Outupt from CanESM2 is used to drive NEMO in an OMIP-style ocean only run. 10,000 years of spin-up was achieved, and the resulting restarts used to initialize the CanESM5 spinup run.

CanESM5 simulations (CMOC)

Zonal mean CO2 fluxes

CanESM2 had an unrealistic Southern Ocean flux dipole, which is corrected in CanESM5.

Historical CO2 uptake

- Ocean carbon uptake is within observation uncertainty in CanESM5.
- Cumulative carbon uptake is higher in CanESM5 than in CanESM2.

Ecosystem response to forcing

- Primary production declines over the historical / SSP5-85 experiment.
- In the 4xCO2 experiment declines begin recovery after about 50 years.