

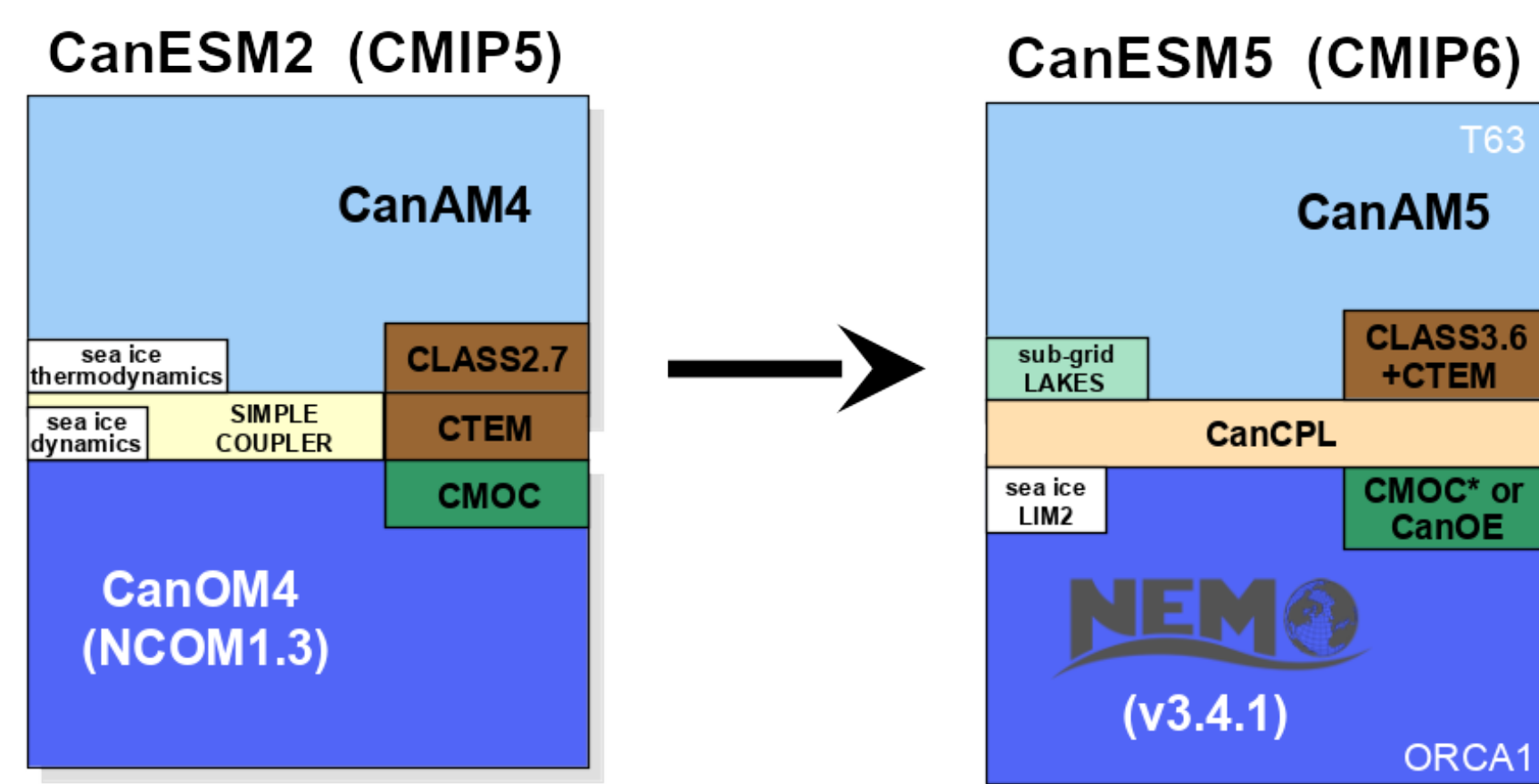
Ocean biogeochemistry in the Canadian Earth System Model 5 (CanESM5)

Neil Swart (neil.swart@canada.ca), Jim Christian, Andrew Shao, et al.

Canadian Centre for Climate Modelling and Analysis (CCCma), Environment and Climate Change Canada, Victoria, BC Canada.

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).

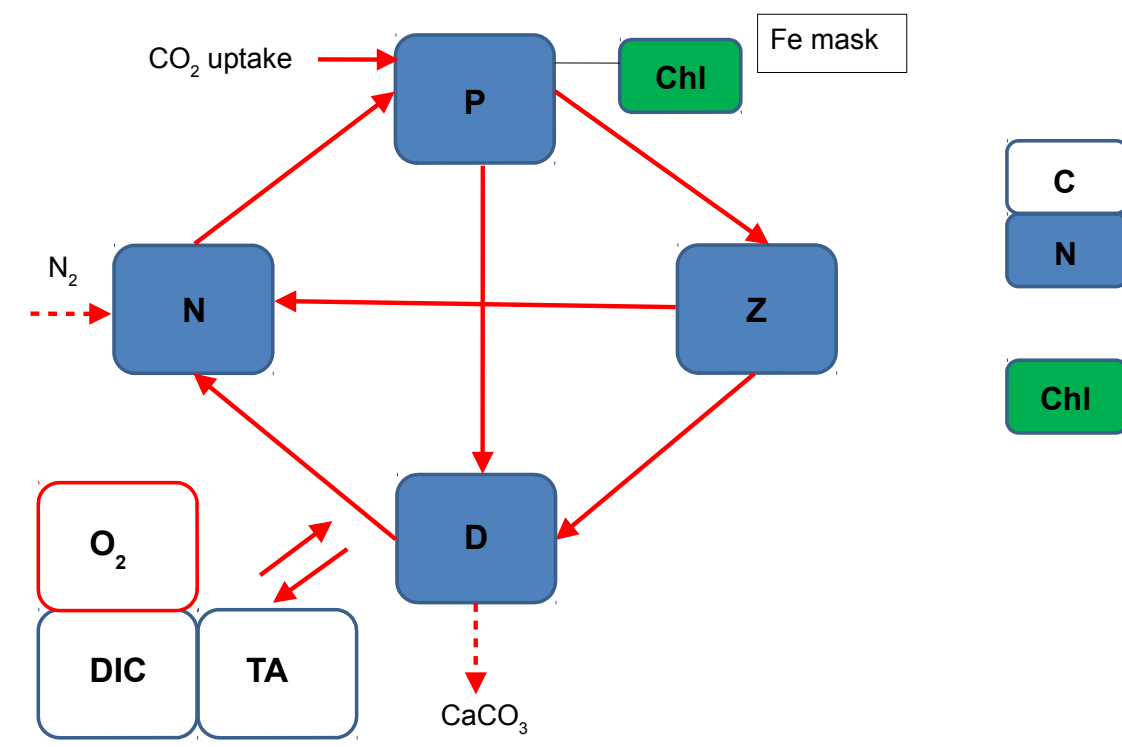


CanESM5 nominal ocean resolution is 1° on the ORCA1 tripolar grid, with refinement at the equator. Atmospheric resolution is T63 (2.5°).

Ocean biogeochemistry models

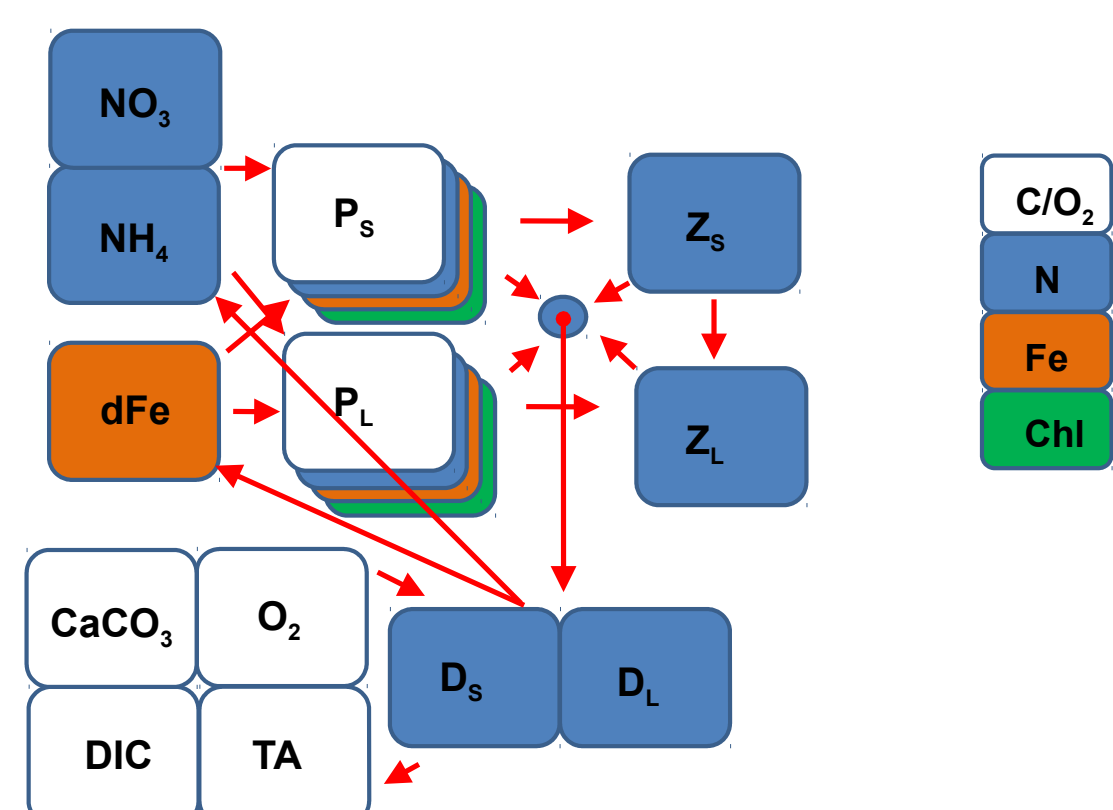
Canadian Model of Ocean Carbon (CMOC)

- OMIP6 carbon chemistry
- NPZD biology with fixed stoichiometry
- Parameterized iron limitation, calcium carbonate sinking and N_2 fixation.



- *CanESM5* with CMOC will contribute all CMIP6 experiments submitted by CCCma.

Canadian Ocean Ecosystem (CanOE)

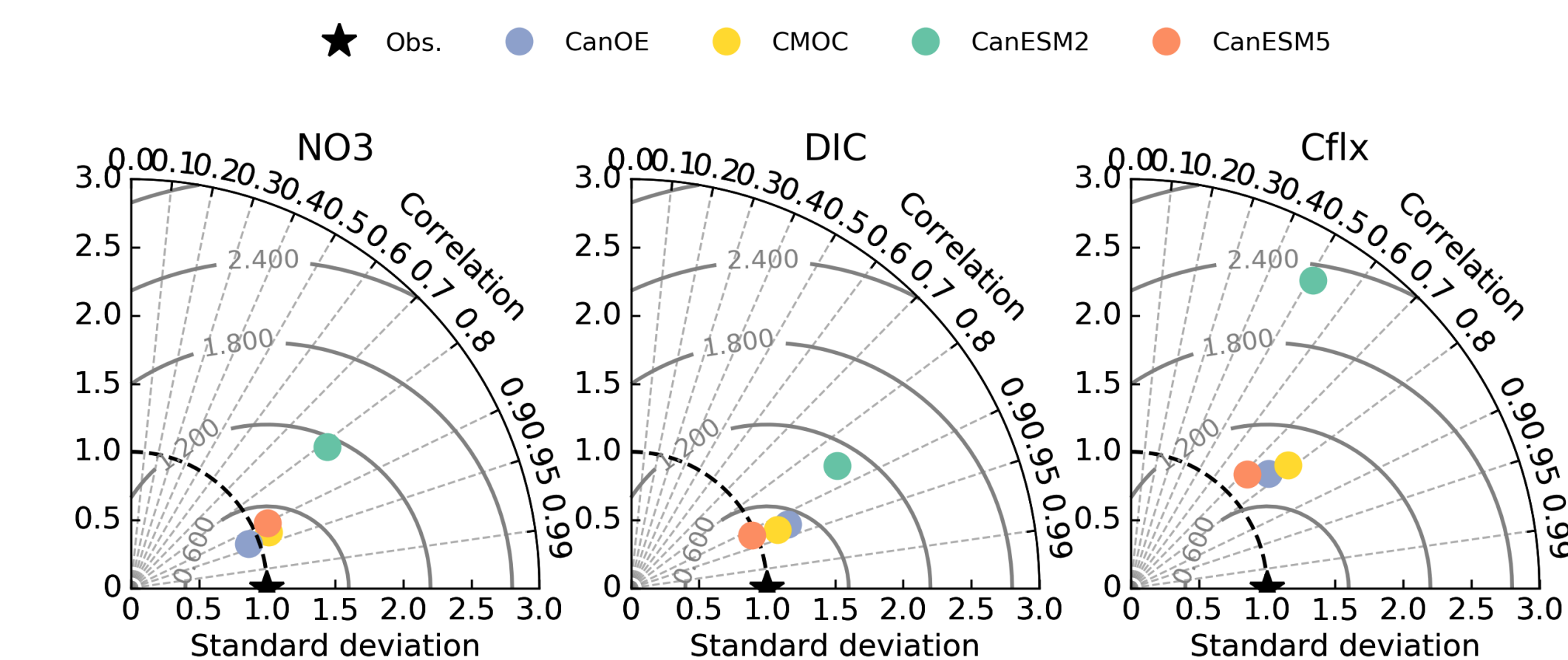


- OMIP6 carbon chemistry
- 2N2P2Z biology with variable phytoplankton stoichiometry
- Explicit iron and calcium carbonate cycles, and denitrification.

- *CanESM5-CanOE* will contribute DECK-hist-SSP and OMIP experiments to CMIP6.

Validation and model comparison

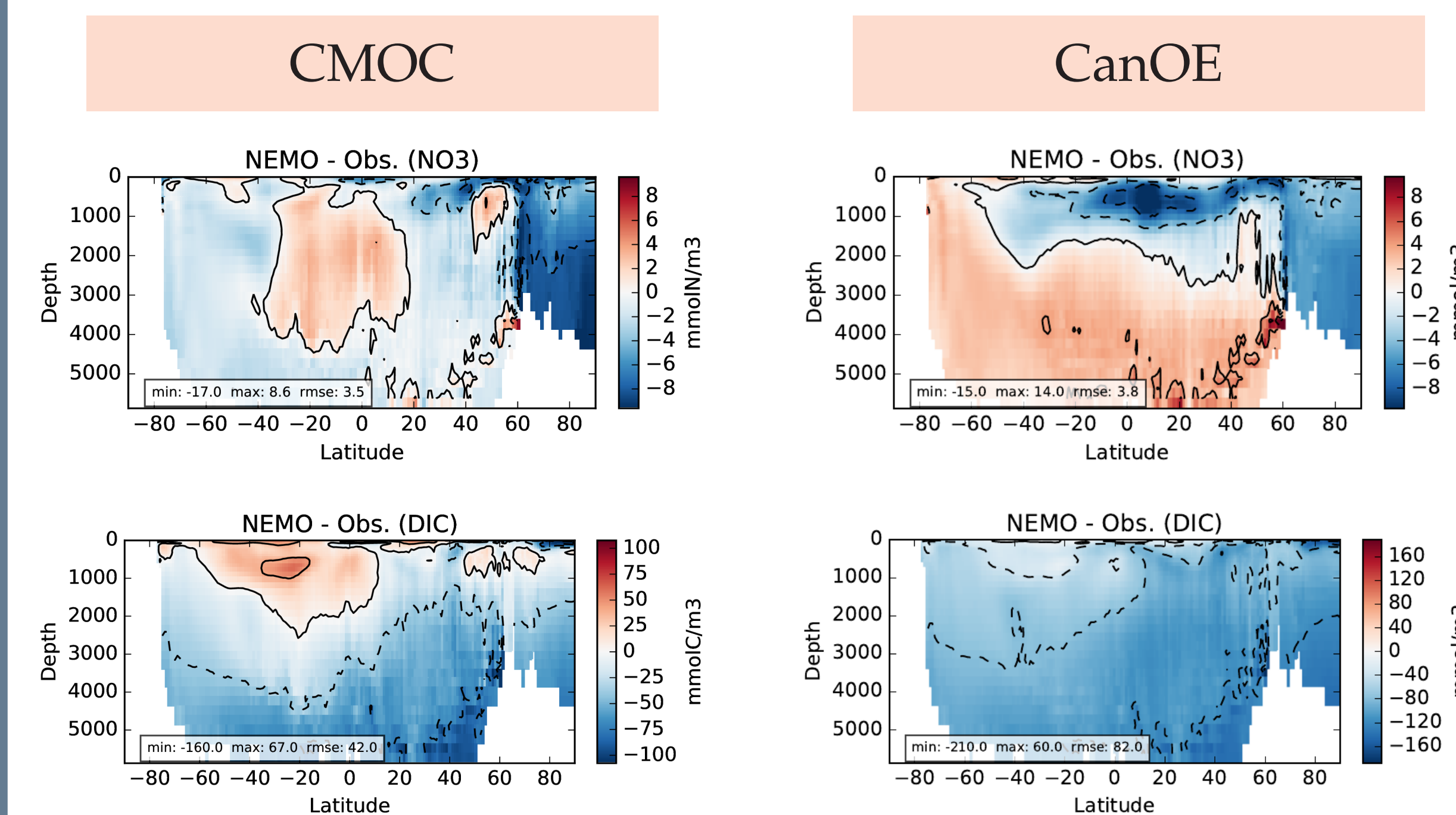
Ocean only and coupled runs skilfully reproduce the 3D climatological distributions of DIC and NO_3 , and the surface CO_2 flux.



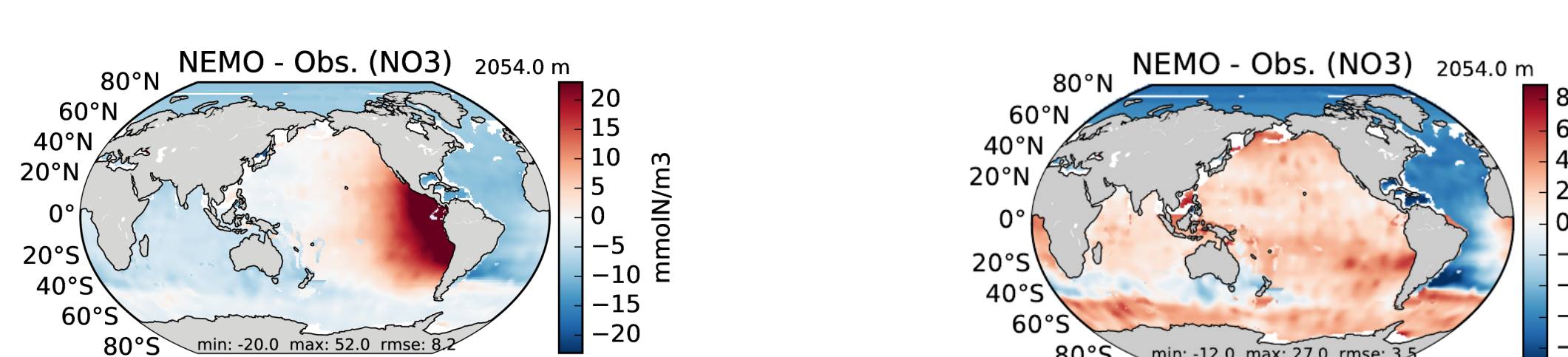
CMOC and CanOE points are from ocean-only OMIP runs. CanESM2 and CanESM5 are coupled model runs, both with CMOC.

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

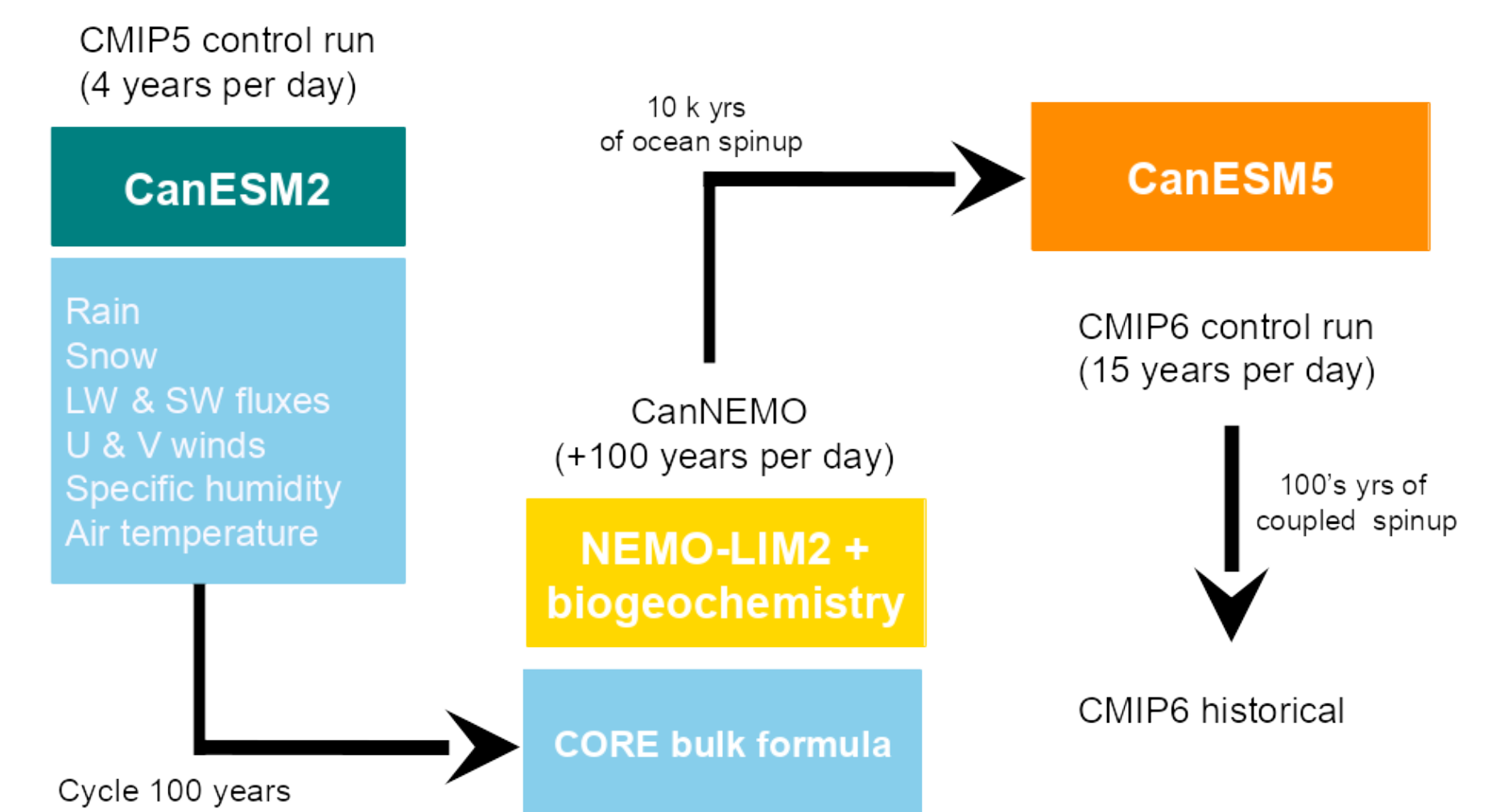
Regional biases differ in CMOC and CanOE under the same circulation. CMOC shows tropical nutrient trapping, while CanOE overestimates bottom water NO_3 , and underestimates NO_3 in NADW. Both models have DIC deficient bottom waters.



CMOC has excessive NO_3 accumulation in the eastern tropical Pacific, likely due to over-simplified denitrification. CanOE overestimates NO_3 in the Southern Ocean and Indo-Pacific (Circumpolar Deep Water, Antarctic Bottom Water), and underestimates NO_3 in North Atlantic Deep Water.



Carbon spinup

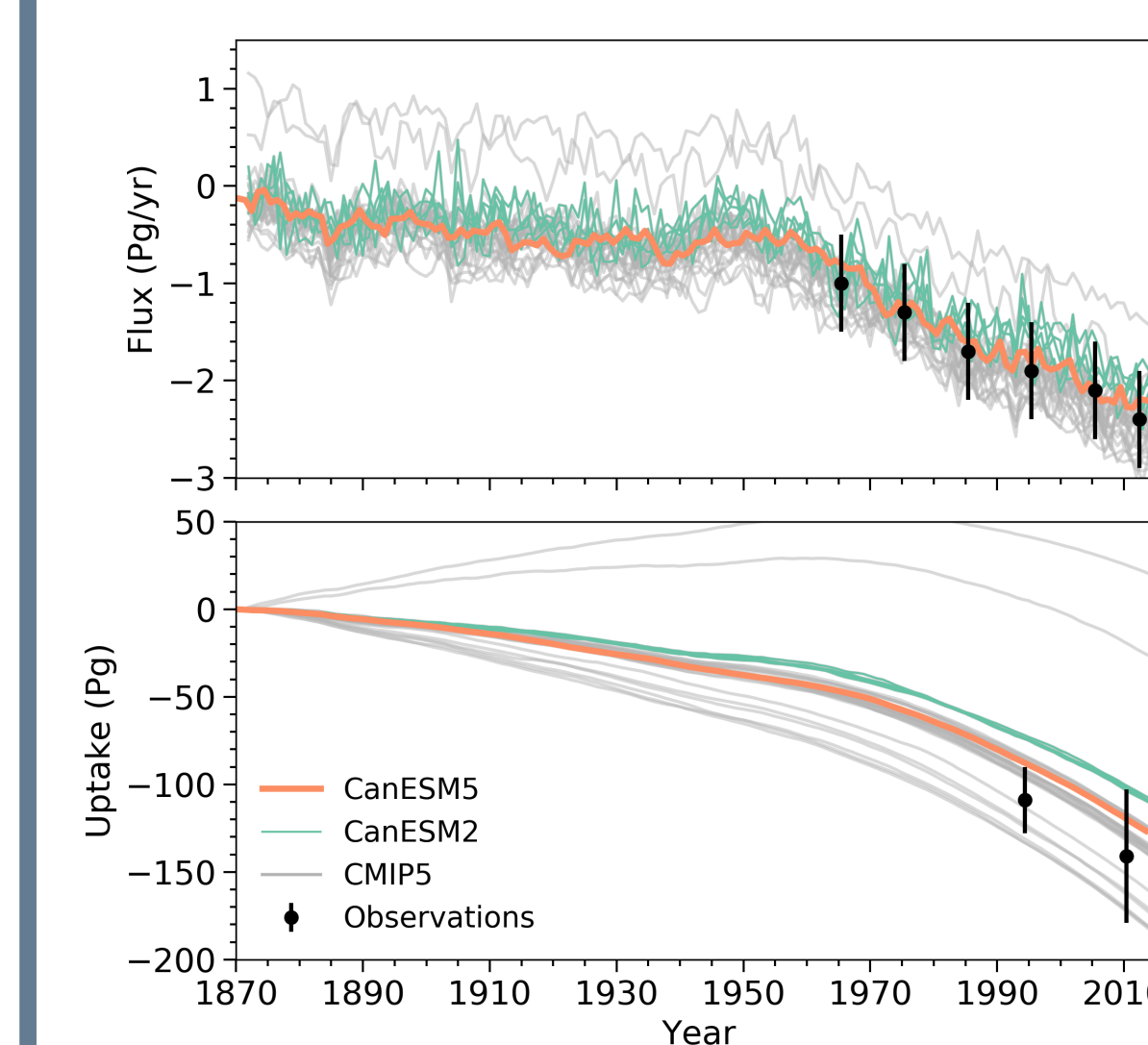
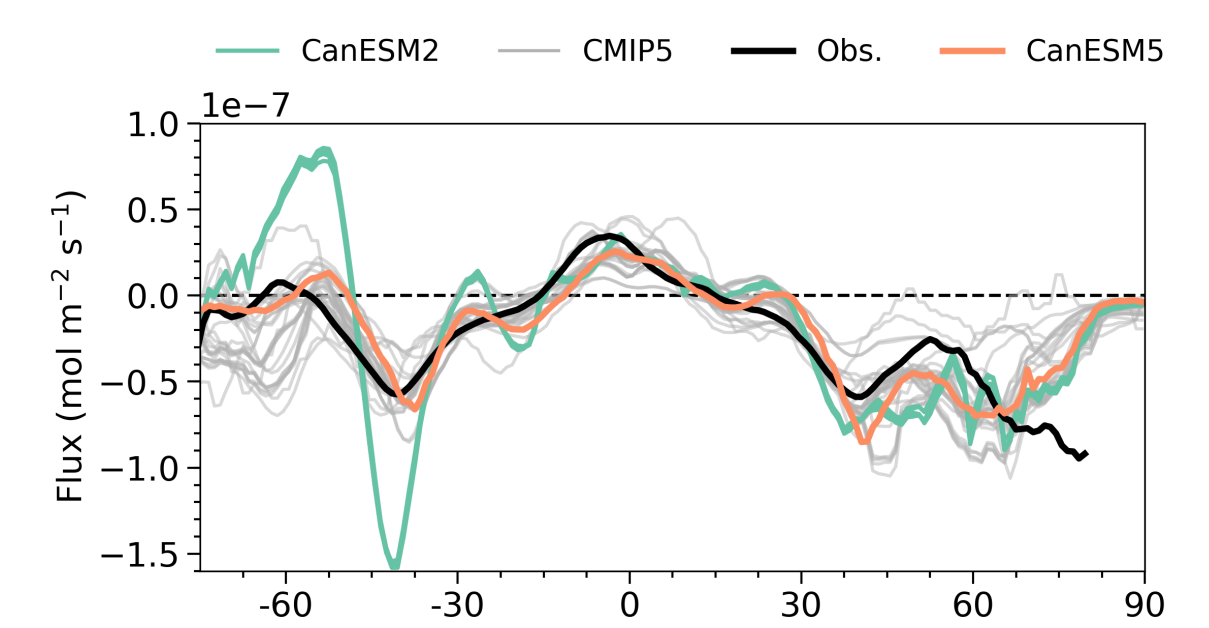


Output from CanESM2 is used to drive NEMO in an OMIP-style ocean only run. 10,000 years of spin-up was achieved, and the resulting restarts used to initialize the CanESM5 spinup run.

CanESM5 simulations (CMOC)

Zonal mean CO_2 fluxes

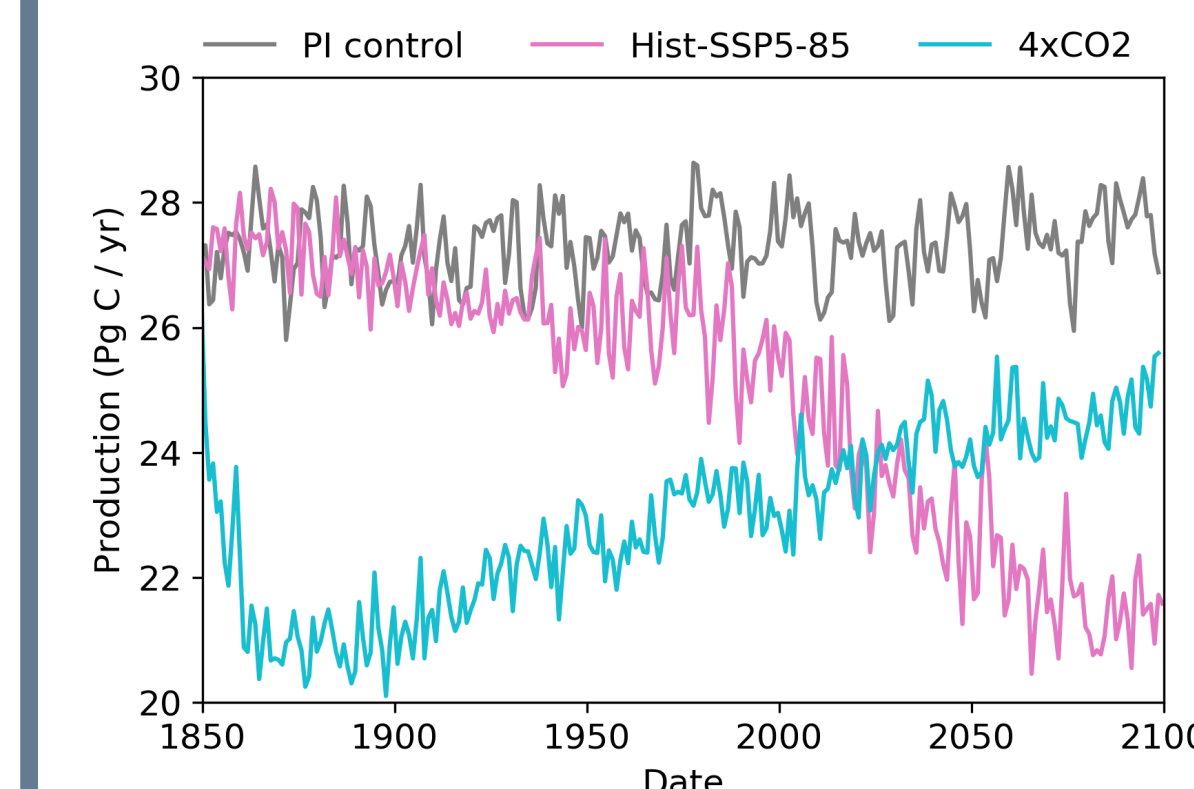
CanESM2 had an unrealistic Southern Ocean flux dipole, which is corrected in CanESM5.



Historical CO_2 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.