



Fisheries and Oceans
Canada

Pêches et Océans
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Canadian Centre for Climate Modelling and Analysis
Centre canadien de la modélisation et de l'analyse climatique



New developments in ocean biogeochemistry at the Canadian Centre for Climate Modelling and Analysis

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University
of Victoria

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History of CanESM

CanESM1

- T47, 192x96, L29 (Christian et al., 2010)
- NCOM-based (regular grid)
- first CCMa model with interactive C cycle

CanESM2

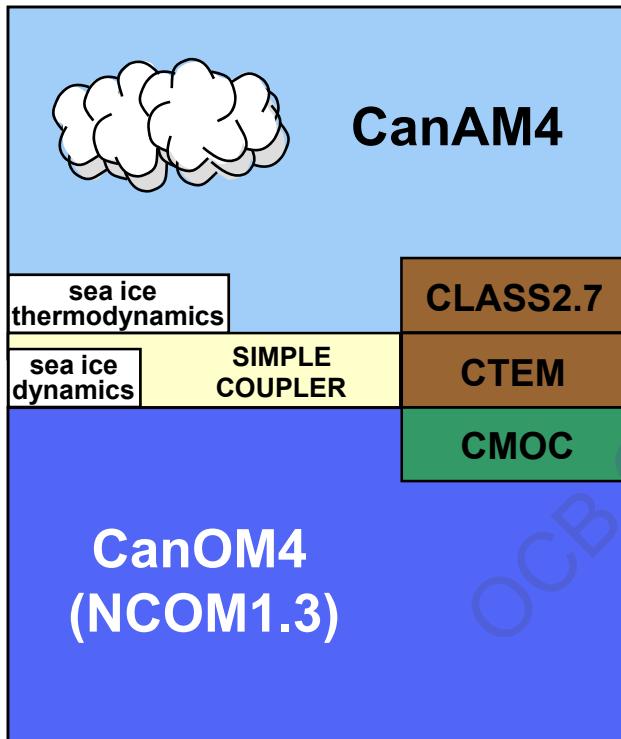
- T63, 256x192, L40 (Arora et al., 2011)
- used for CMIP5

CanESM5

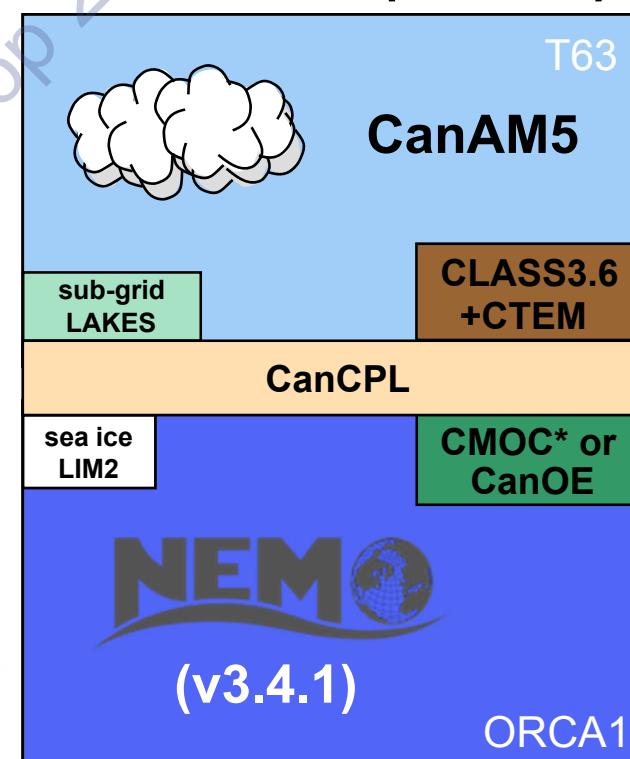
- T63, 362x292, L46
- NEMO-based
- two ocean biogeochemistry modules

From CanESM2 to CanESM5

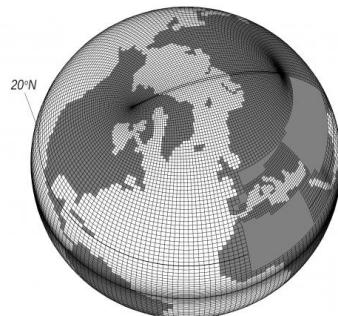
CanESM2 (CMIP5)



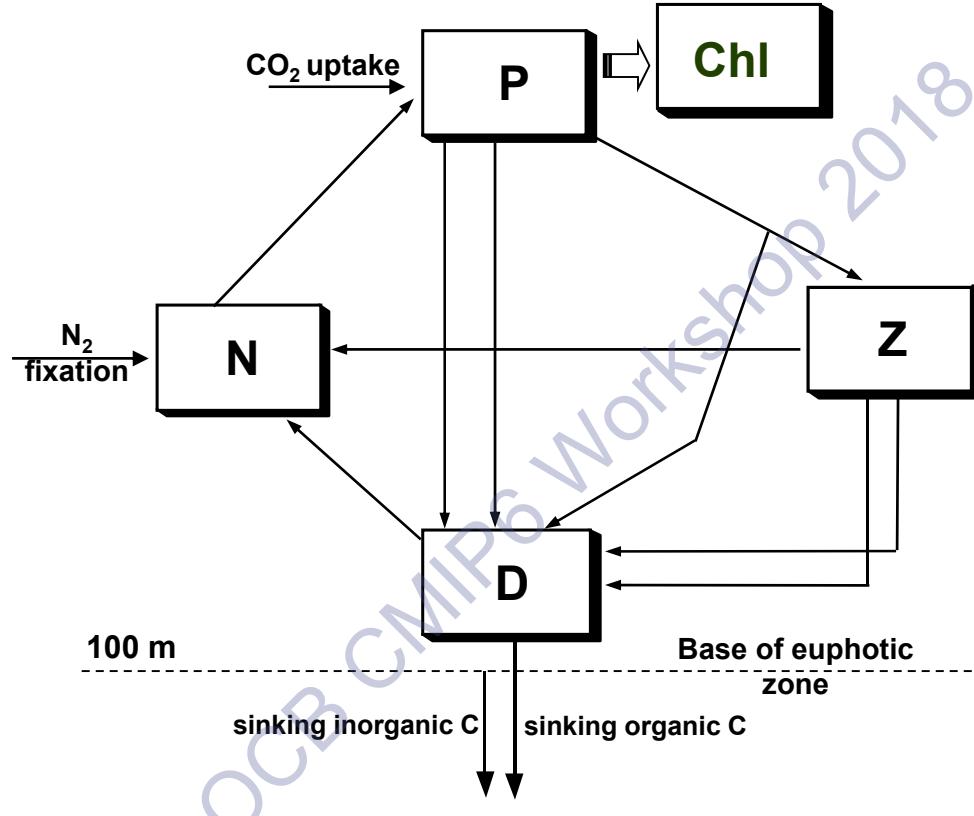
CanESM5 (CMIP6)



OCB CMIP6 Workshop 2018



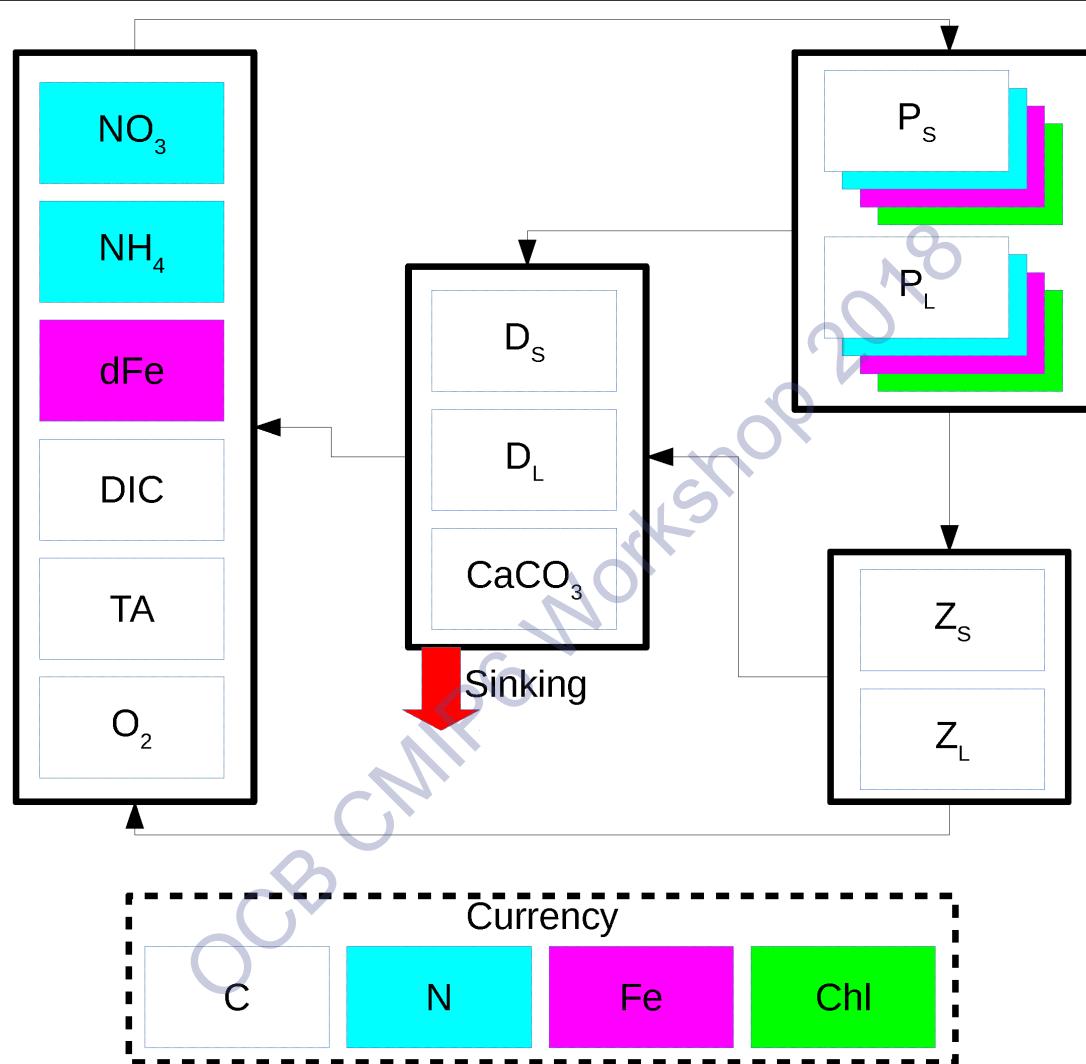
CanESM1/2 ocean ecosystem model (CMOC)



NPZD with simple parameterizations of N₂ fixation, denitrification, calcification, and iron limitation

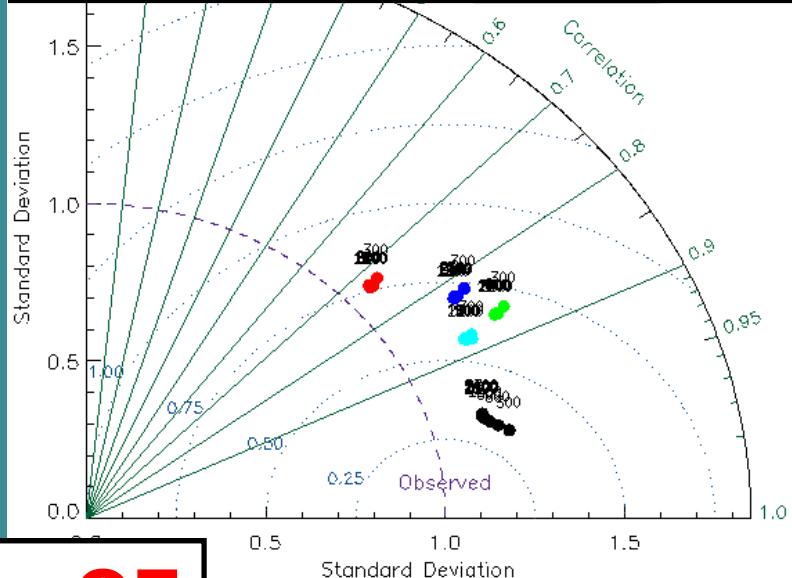
Single detrital sinking rate (10 m/d)

New ocean ecosystem model (CanOE)



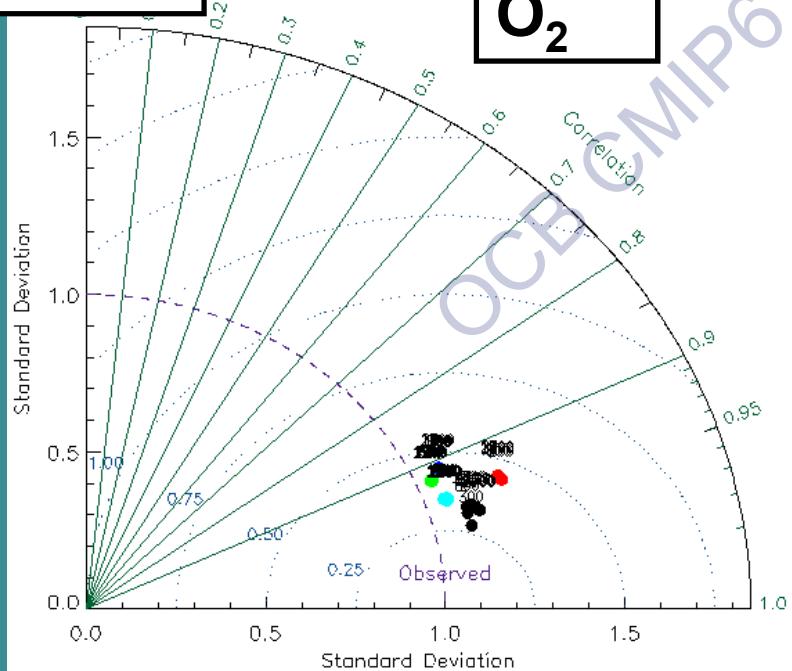
- multiple species, flexible C/N/Fe ratios
- prognostic iron cycle
- distinct sinking rates for D_s , D_L , CaCO_3

Taylor diagrams by depth level (~100-2000 m)

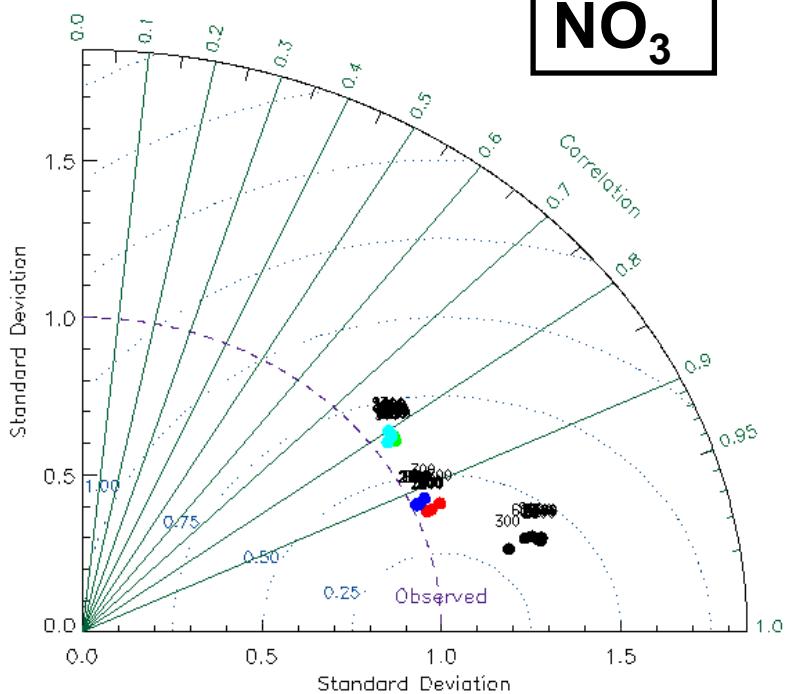
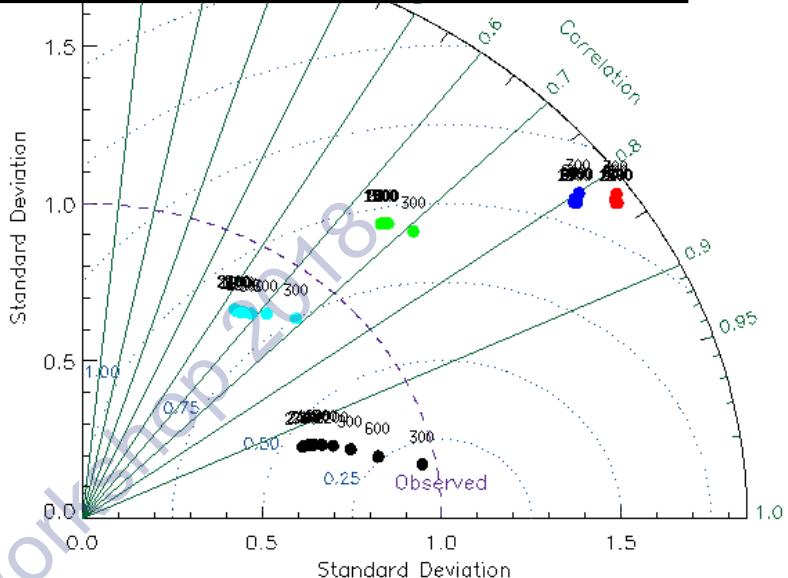


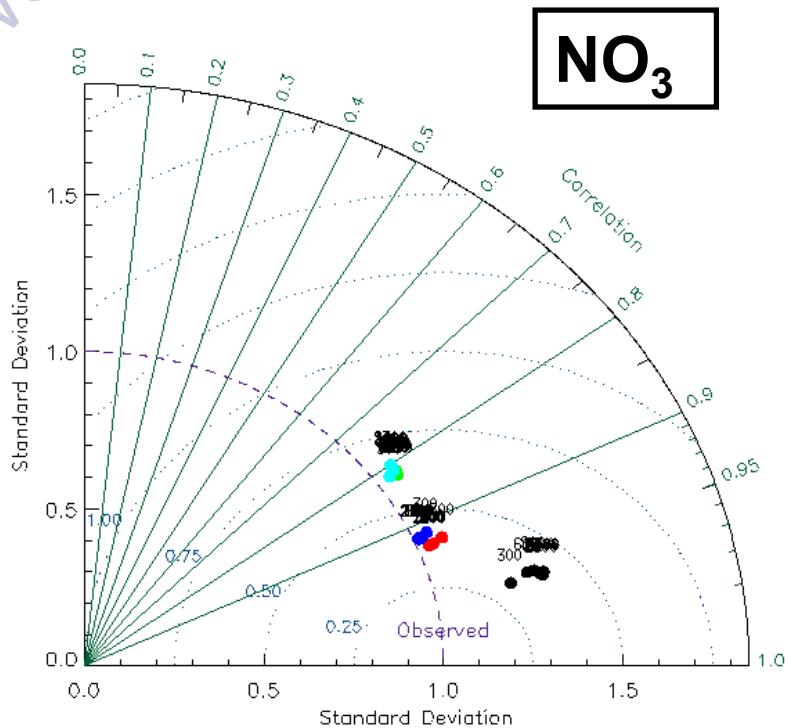
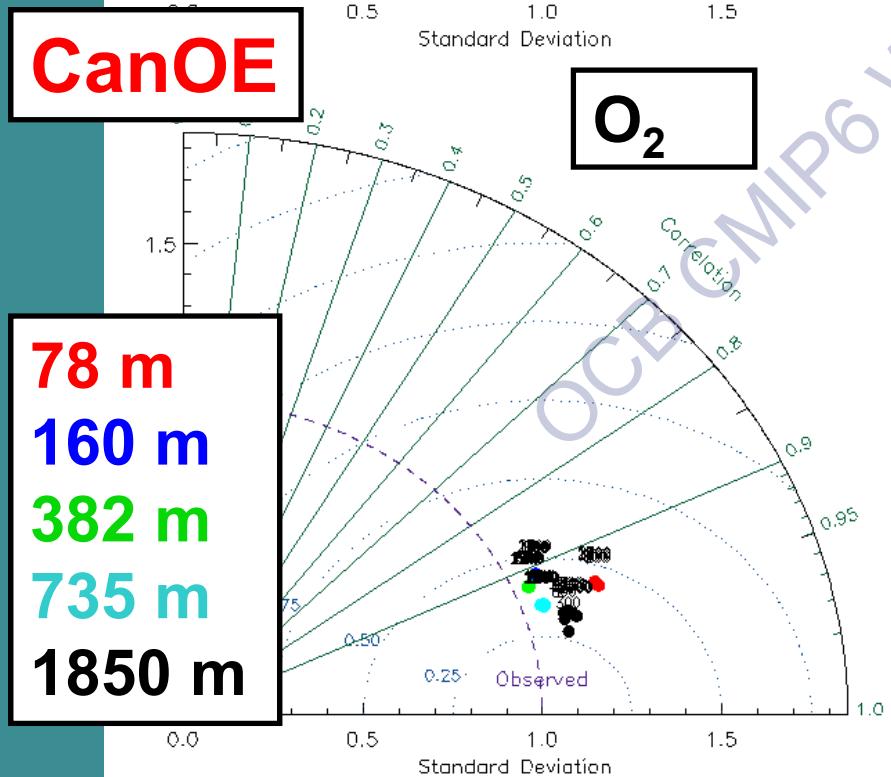
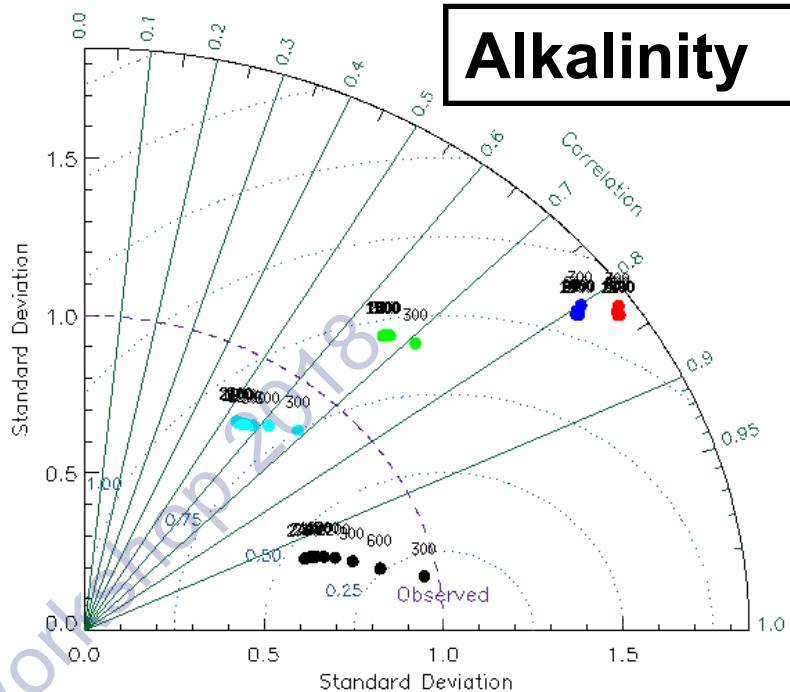
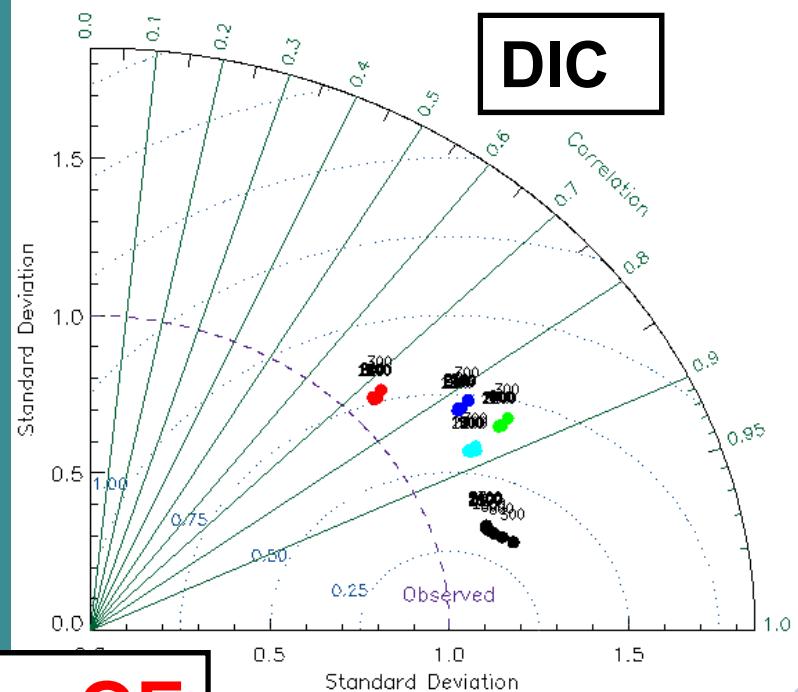
CanOE

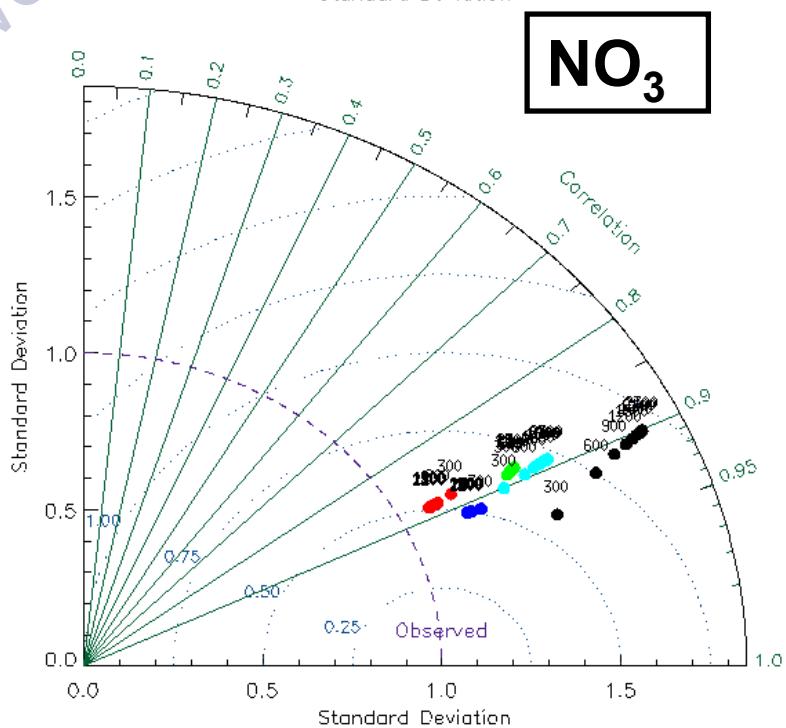
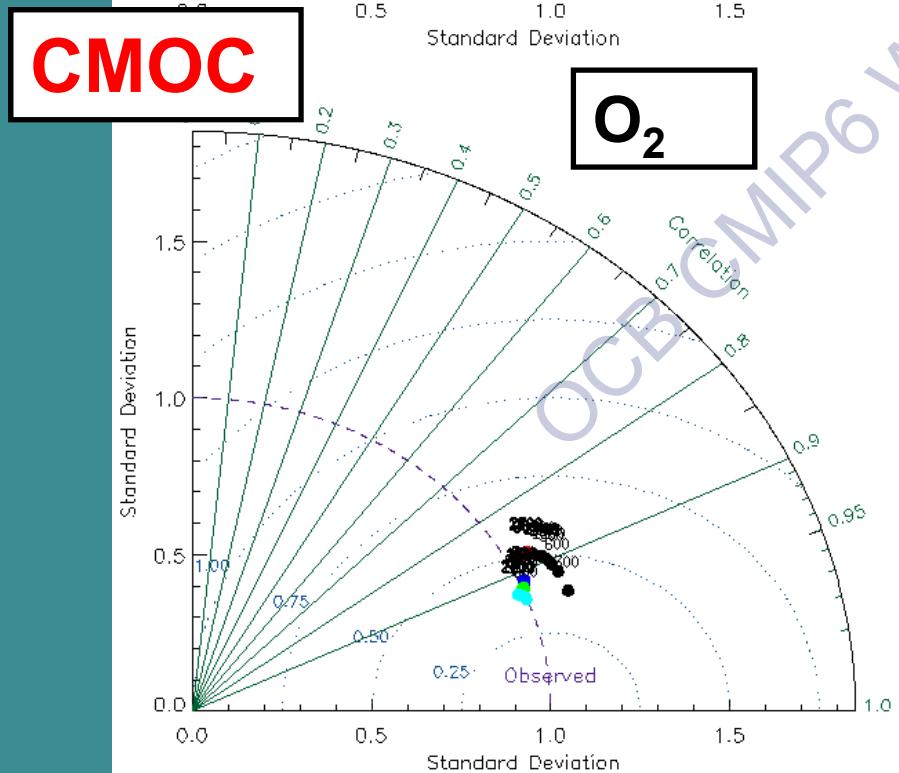
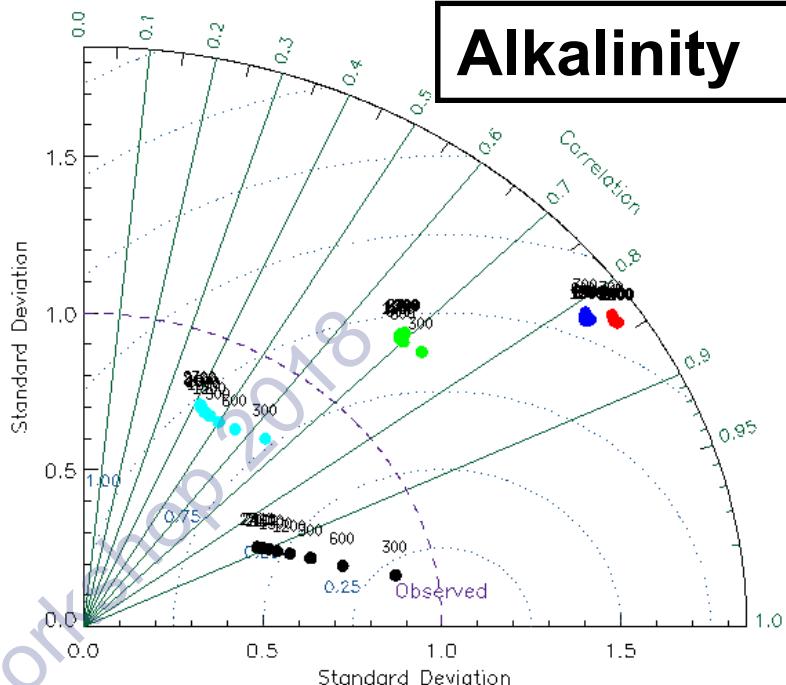
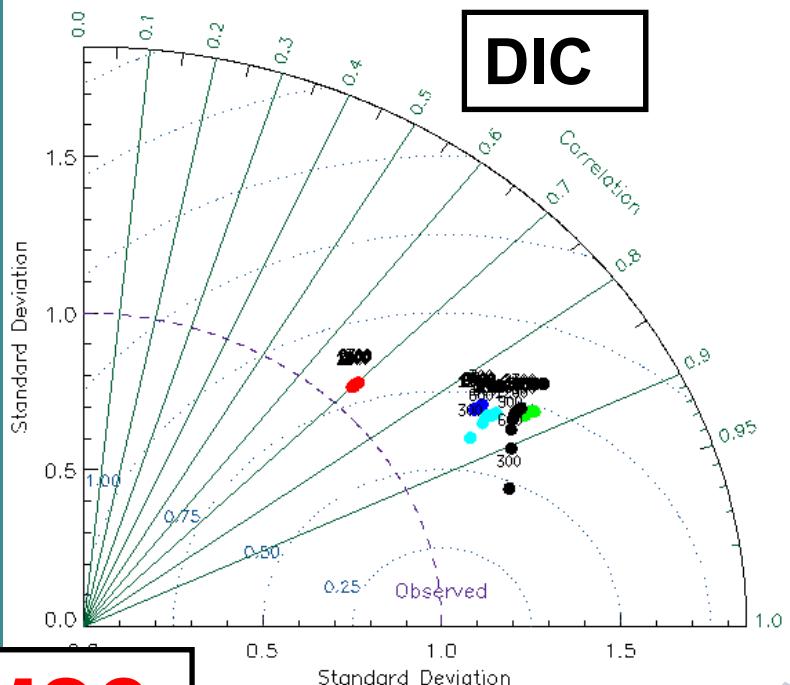
O_2



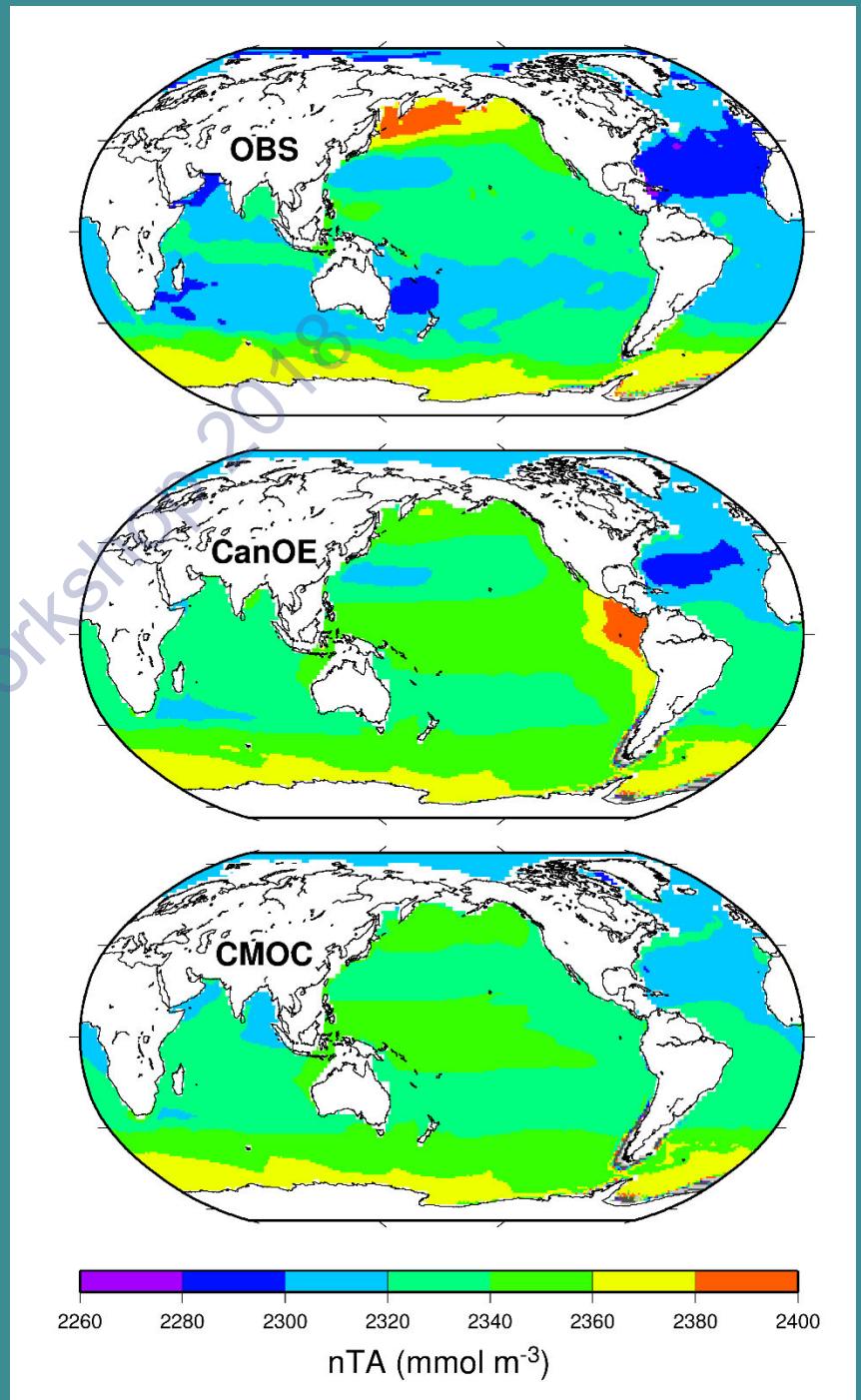
NO_3







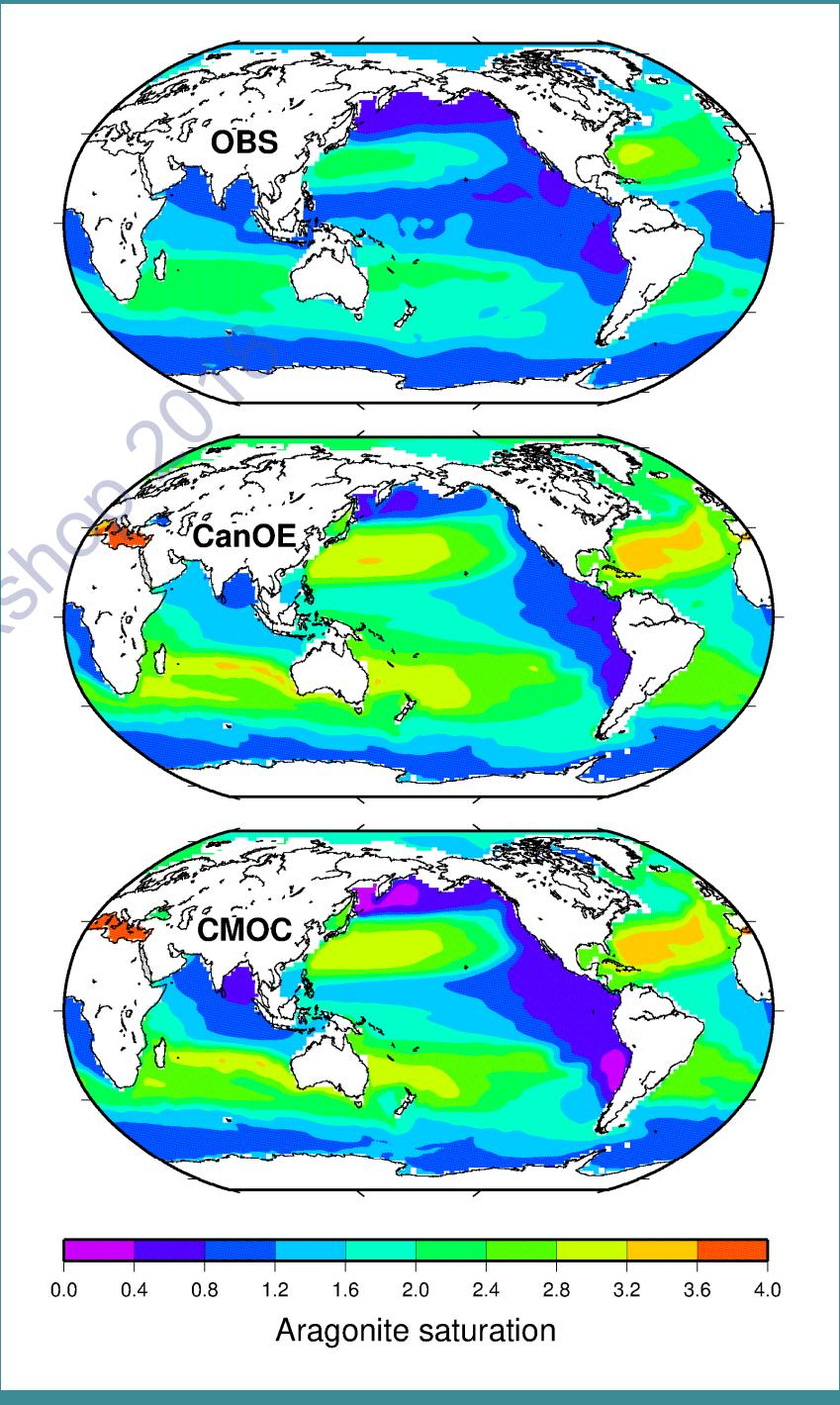
Normalized (S=35) alkalinity at 382 m

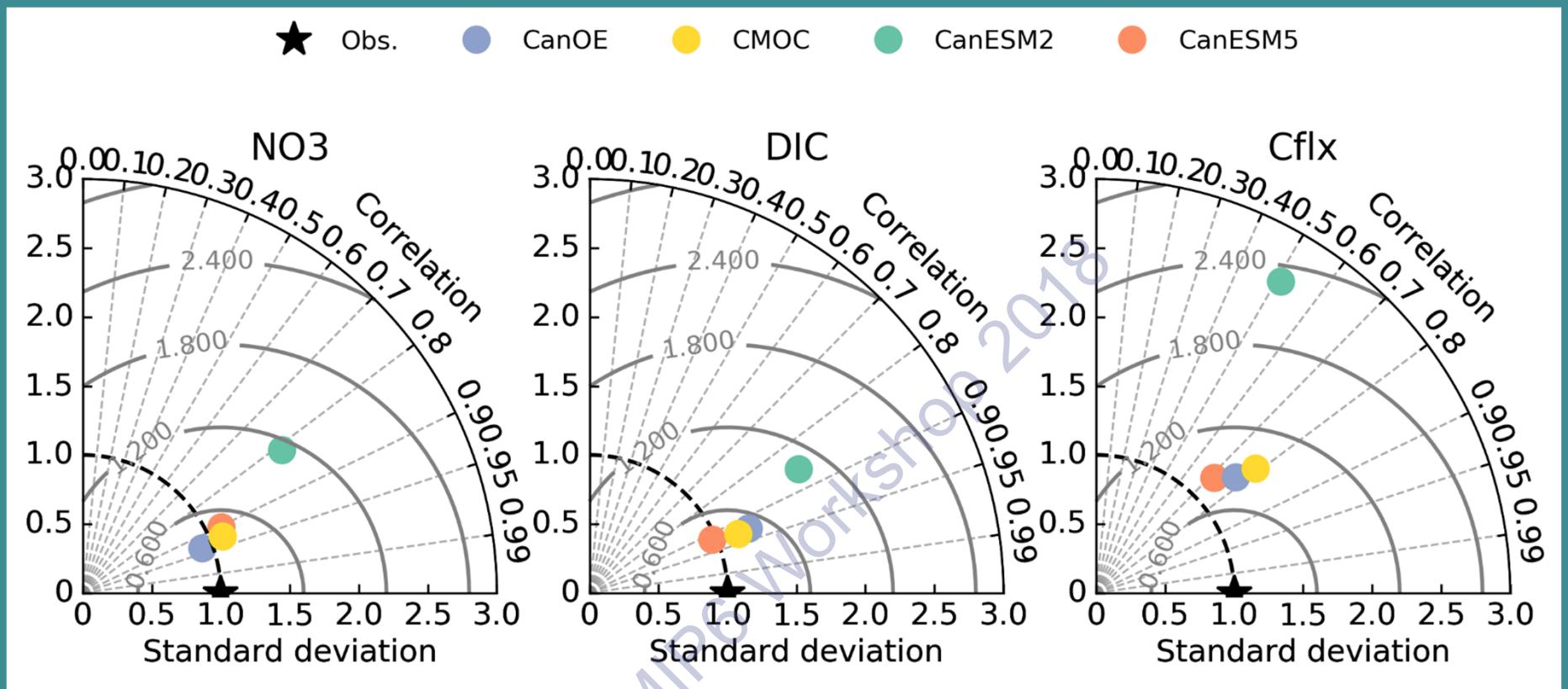


Ω_A at 382 m

In Northeast Pacific and
eastern Tropical Pacific
CMOC is biased low while
CanOE is biased high.

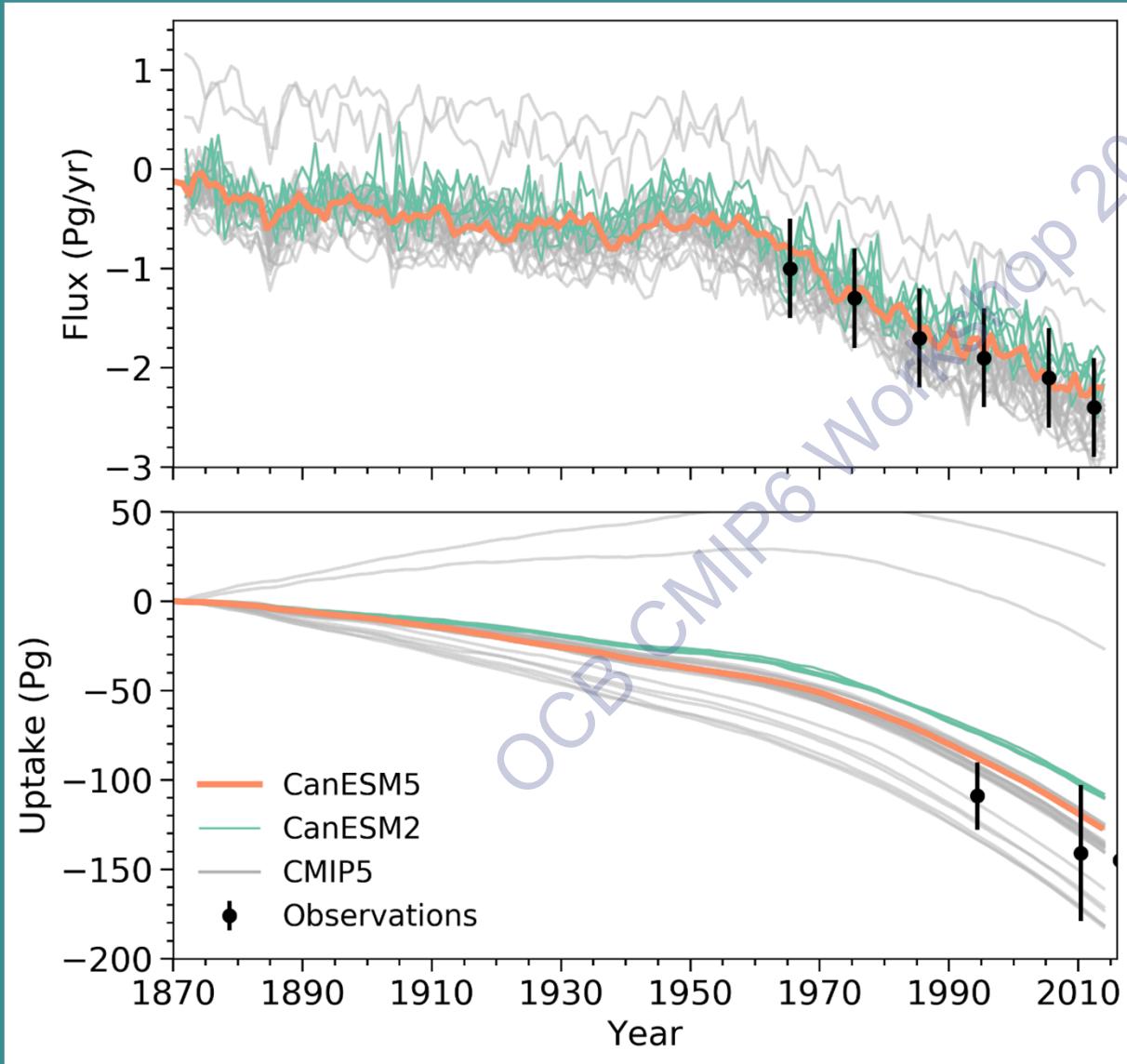
Errors in DIC and alkalinity
offset somewhat.





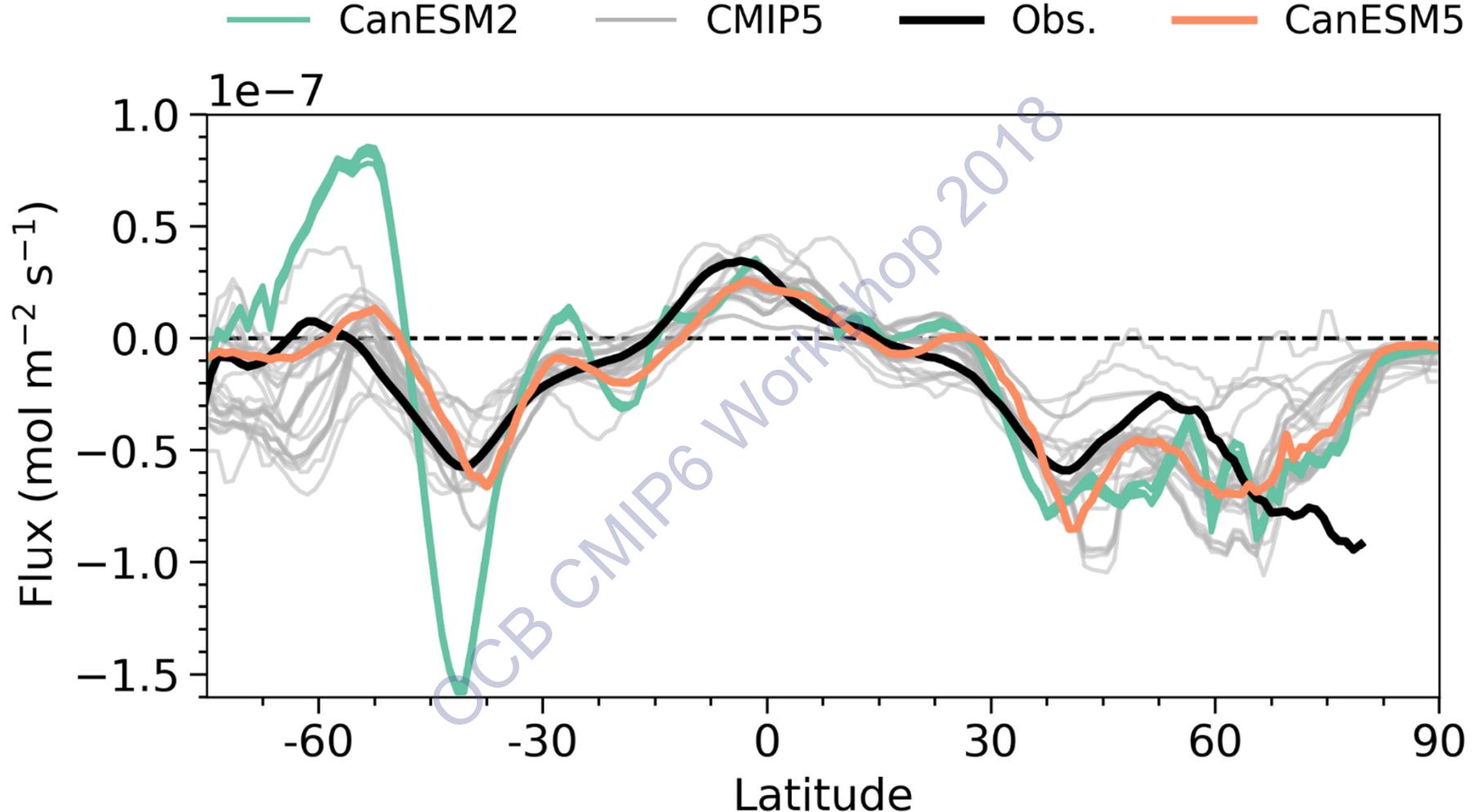
- CanESM5 significantly improves skill over CanESM2 – purely due to physical circulation**
- Similar large-scale skill between CMOC and CanOE (in OMIP-type runs)**

Historical ocean carbon uptake



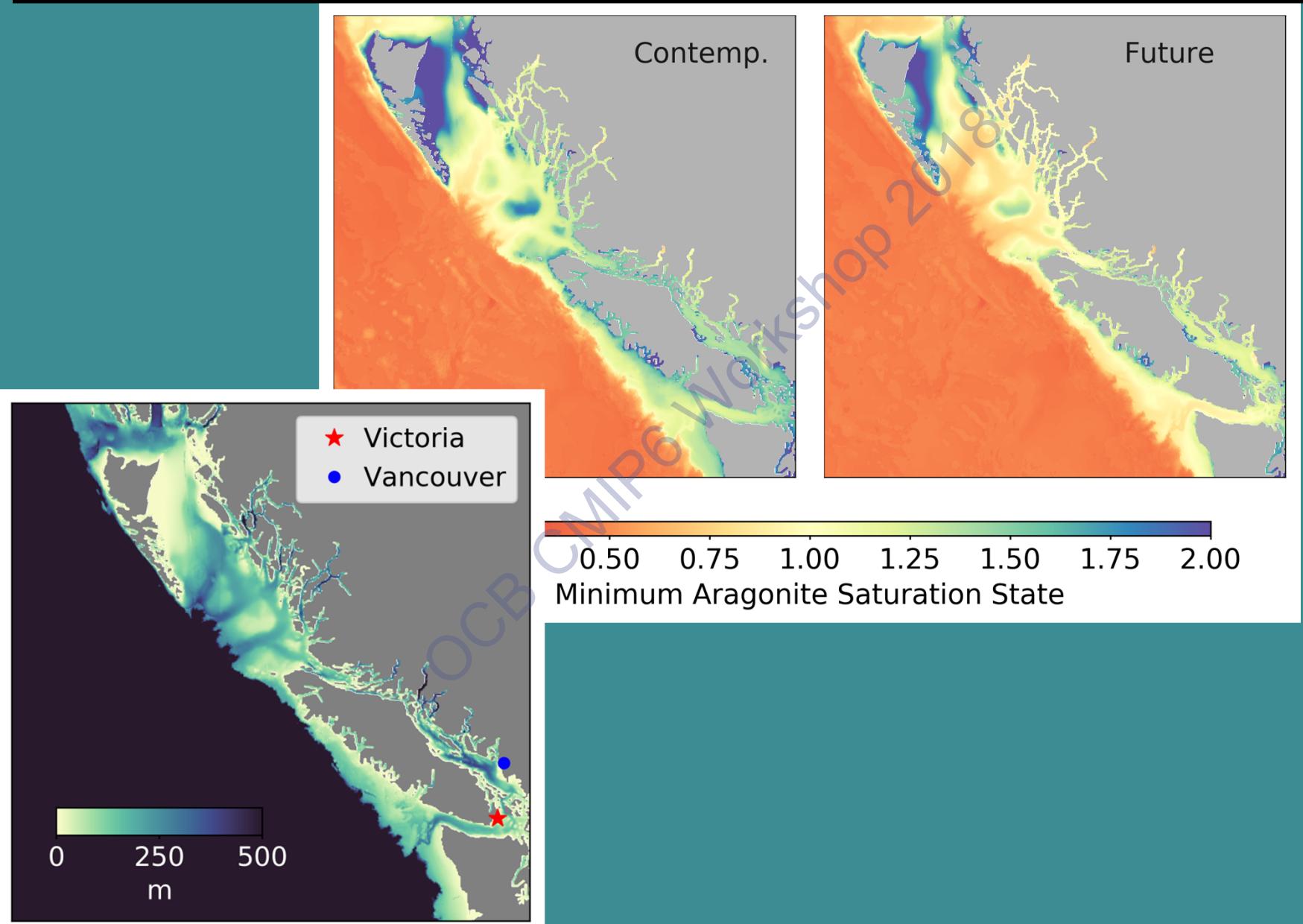
Increased
carbon uptake in
CanESM5 vs
CanESM2

Zonal mean CO₂ fluxes



Strong Southern Ocean flux dipole much reduced in CanESM5

NEP36/CanOE – Minimum Ω_A in August for contemporary (1985-2005) and future (2045-2065, RCP4.5) climate





Summary

- CanESM2 biogeochemistry module (CMOC) has been implemented in NEMO coupled to CCCMa atmosphere model, along with additional CMIP6 tracers
- new biogeochemistry module CanOE offers greater realism and complexity and will be used for a limited suite of CMIP6 experiments
- greater biological complexity in CanOE improves skill with respect to DIC etc, but not dramatically
- multiple BGC models and expanded suite of tracers will help to elucidate roles of circulation and biology in determining distribution of O_2 and Ω

