A few more GEOS/ECCO updates

Hong Zhang, Dimitris Menemenlis, and Joe Skitka

2024 ECCO Annual Meeting, March 20-22, 2024, University of Texas at Austin

1. pkg/shelfice: adopting ice-shelf as in ECCO v4r5 configuration

2. pkg/bling or pkg/dic: adding biogeochemical component for carbon cycle

3. pkg/rbcs: modified to allow Incremental Analysis Updates (IAU)
for Subseasonal-to-Seasonal (S2S) forecast initialization

4. background vertical mixing in high-resolution ECCO simulations

5. modify Leith so that it acts only on horizontally rotational part of flow

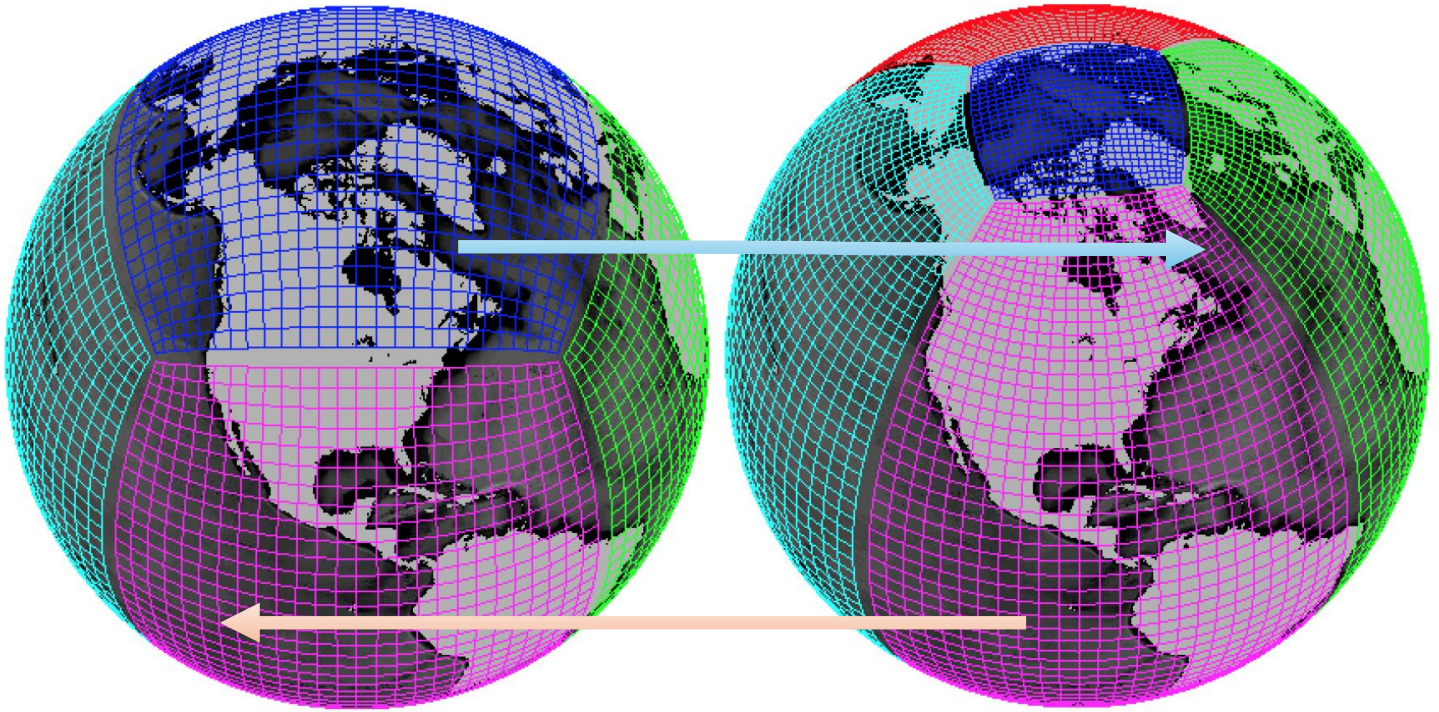
GEOS/ECCO Updates

1. Moving to ECCO v4r5 configuration

Differences from **v4r4** (current version for cs90-llc90):

1. Ice shelf package enabled;
2. Mask change induced by above;
3. Ice-shelf topography modified (to adapt to current “connection topology” w/ 360 cores)

Next need recovery of v4r5 ice-shelf topography (363+ cores) …
proposed “connection topology” w/ 384 cores in progress …



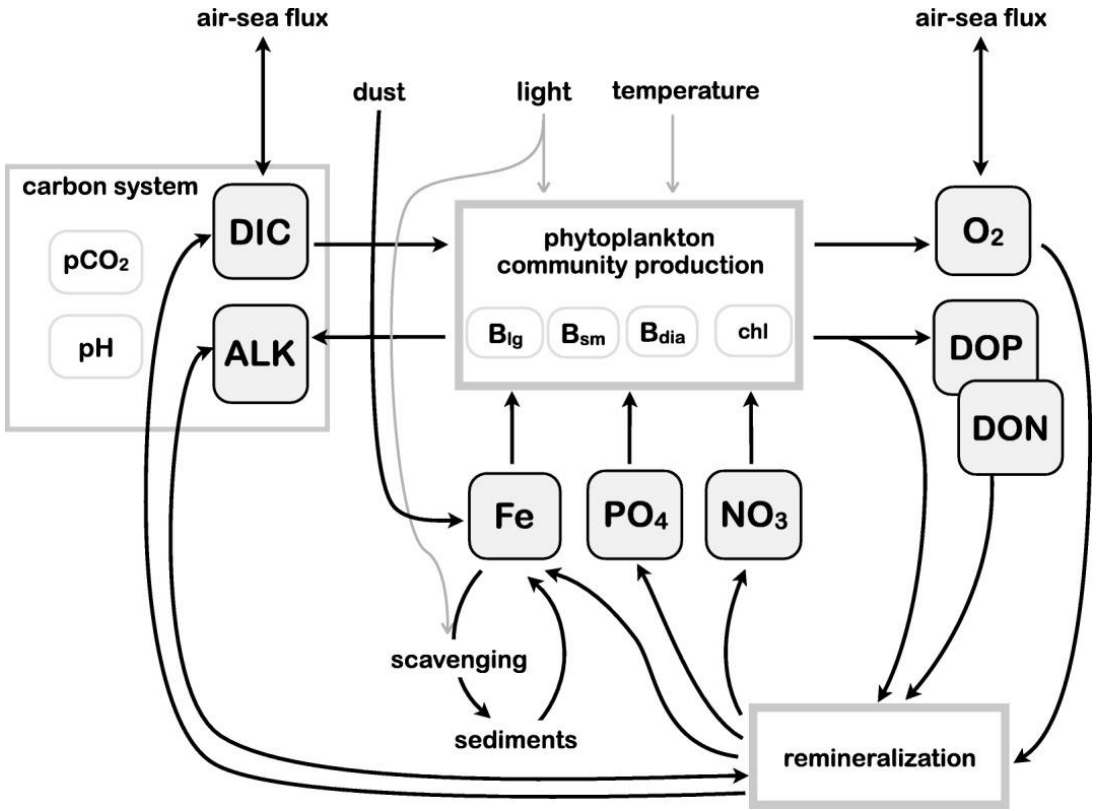
GEOS/ECCO Updates

2. Testing BGC component

ECCO-Darwin is expensive (31 prognostics), but considering simpler one:
pkg/dic (6 prognostics) or pkg/bling (8 prognostics)

For pkg/bling (Biogeochemistry w/ Light, Iron, Nutrients, and Gases)

A data assimilating model for estimating Southern Ocean biogeochemistry, Verdy 2017, *doi.org/10.1002/2016JC012650*

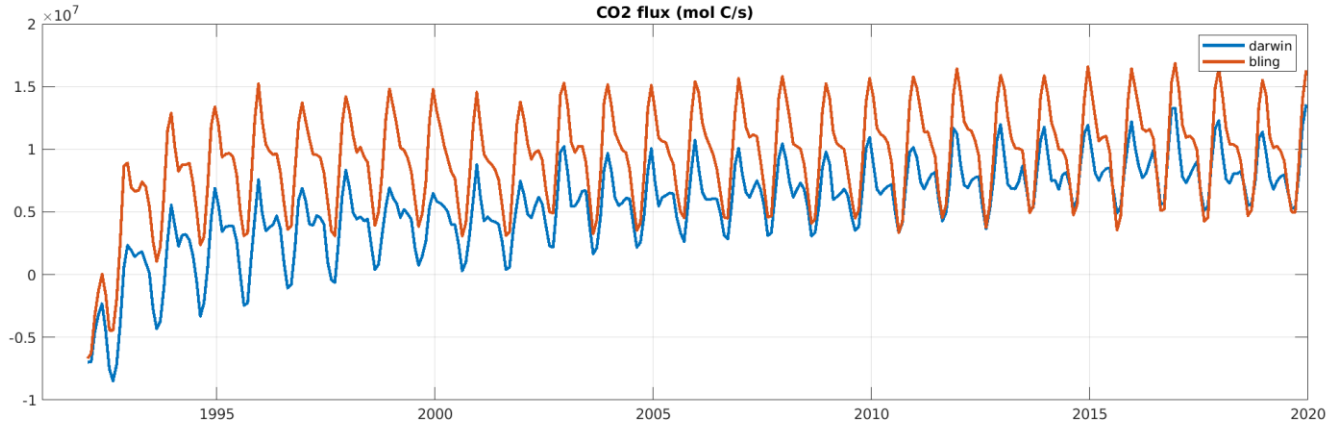


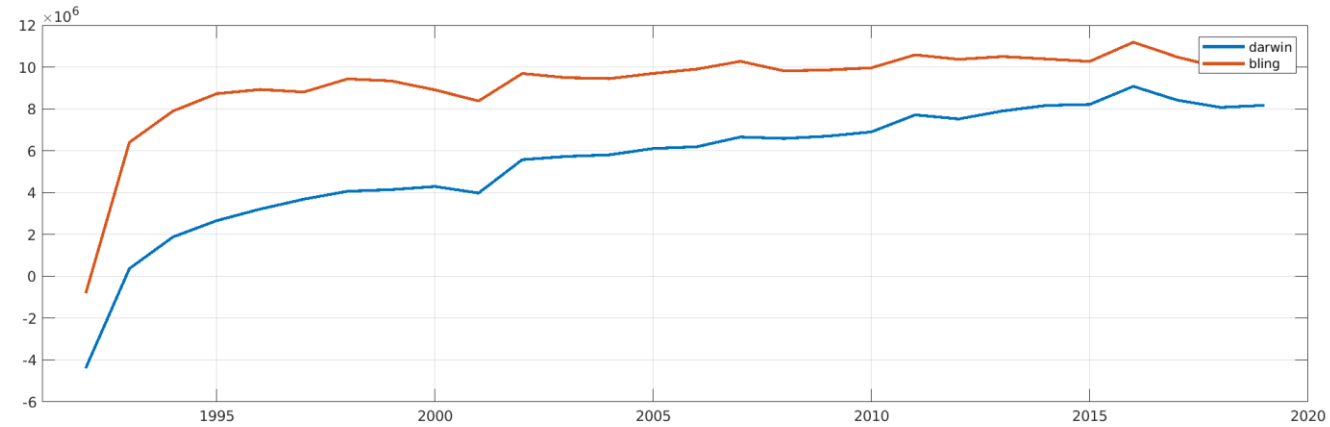
Eight prognostic variables (gray shaded boxes): dissolved inorganic carbon (DIC), alkalinity (ALK), oxygen (O2), nitrate (NO3), phosphate (PO4), iron (Fe), and dissolved organic matter (DON, DOP). Phytoplankton biomass, chlorophyll (chl), pH, and pCO2 are diagnosed from the prognostic variables. The phytoplankton community includes three types of organisms: large diatom-like cells, small calcifying cells, and diazotrophs. Community production is limited by the availability of light and nutrients and modulated by temperature. Uptake and remineralization of nutrients, as well as changes in oxygen and alkalinity, are calculated from the uptake and remineralization of nitrate via stoichiometric ratios. Black arrows represent fluxes and gray arrows indicate external forcing.

GEOS/ECCO Updates

2. Testing BGC component

For pkg/bling
Try to mimic ECCO-Darwin on ECCO-v4r5



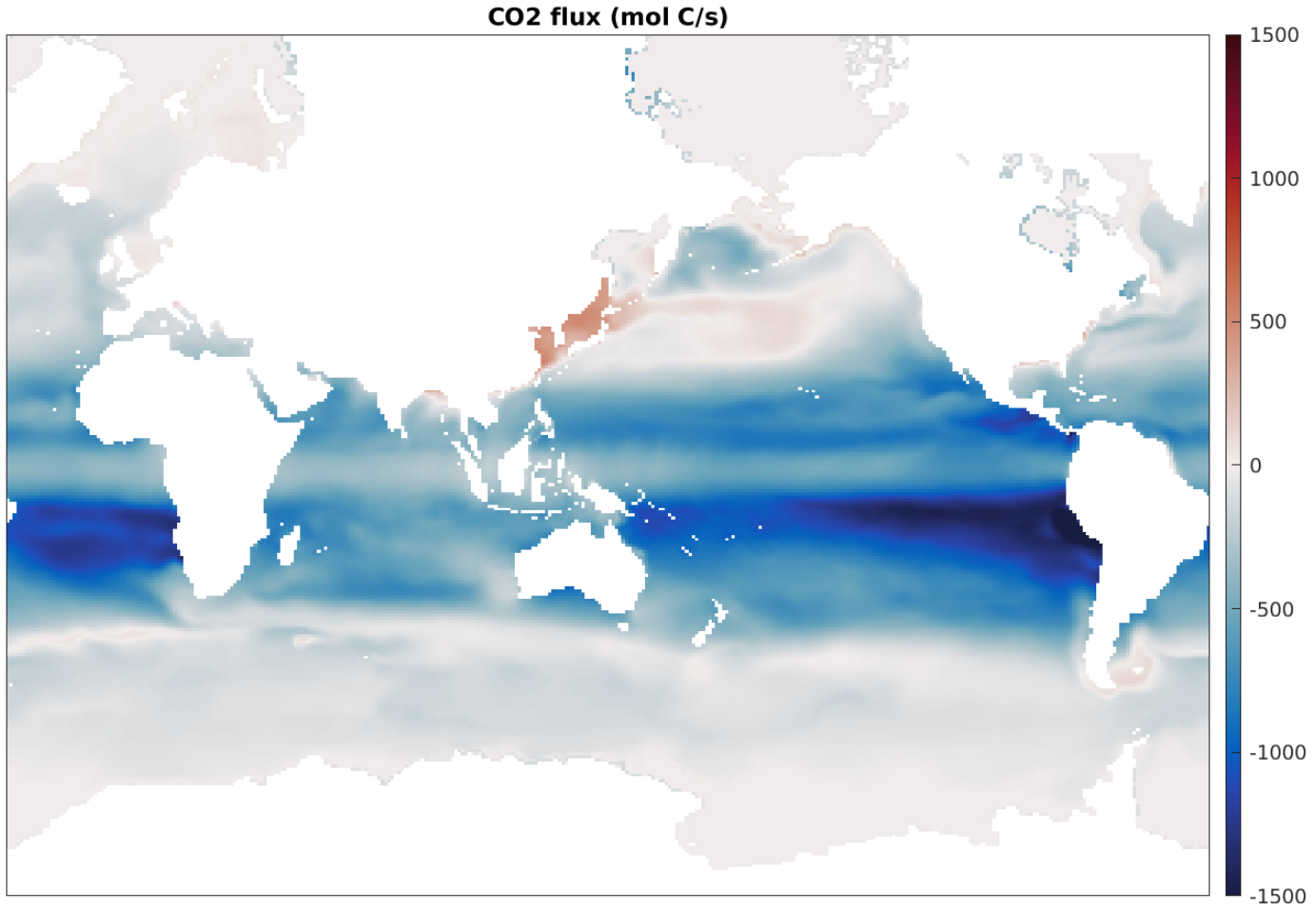


GEOS/ECCO Updates

2. Testing BGC component

For pkg/bling
on cs90-llc90 but very simplified case

1. uniform surface pressure (1 atm)
2. uniform CO2 (300 ppm)
3. uniform wind (5 m/s)



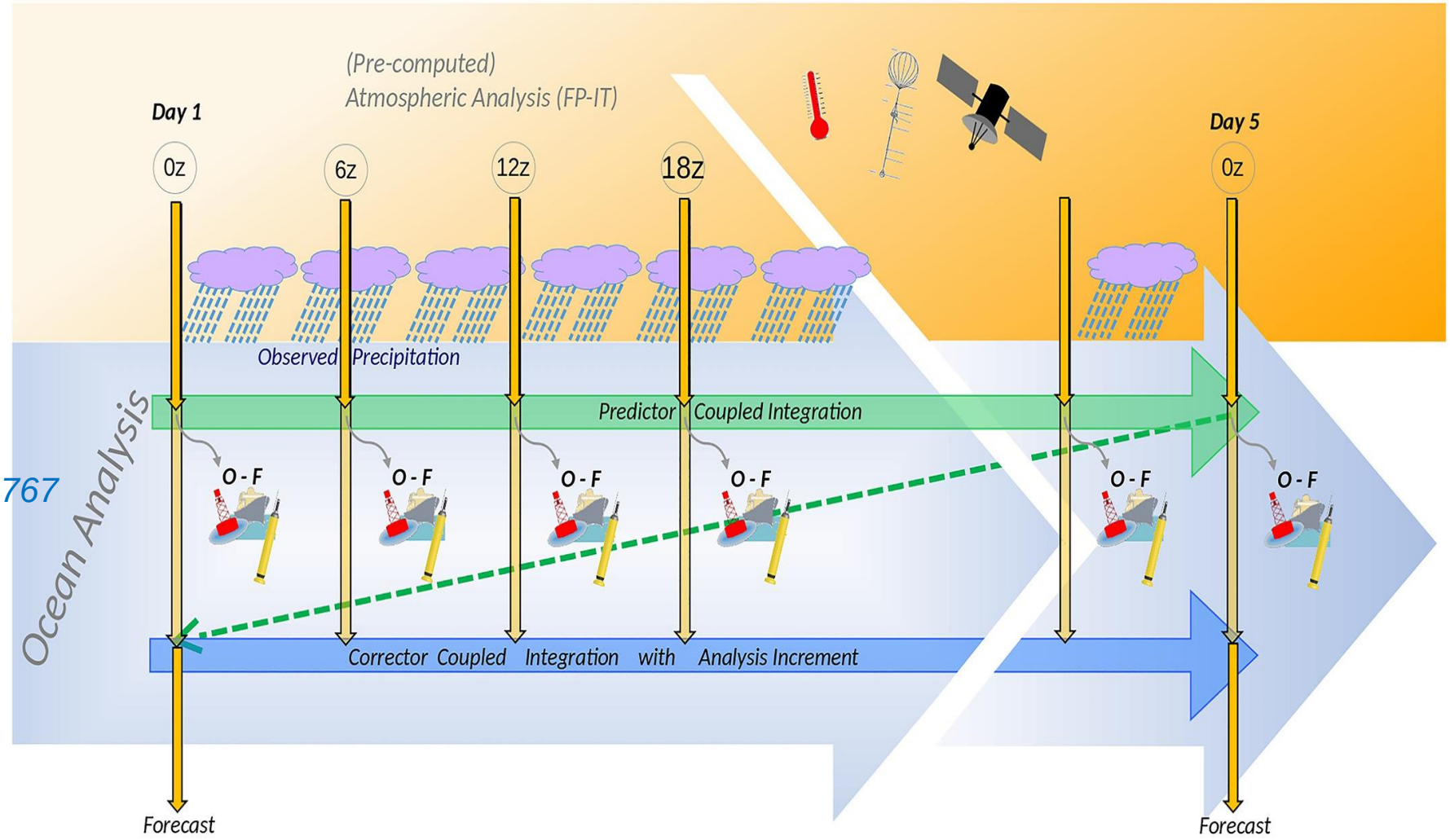
Next
need input from GEOS
surface pressure;
atmos CO2 concentration
surface wind

Next next
For pkg/dic

GEOS/ECCO Updates

3. IAU for S2S hindcast

Reference:
GEOS-S2S Version 2:
The GMAO High-Resolution Coupled Model and Assimilation System for Seasonal Prediction
Molod et al., JGR Atmos (2020)
https://doi.org/10.1029/2019JD031767



Schematic of DA system: An ocean predictor segment (the green line across the top of the figure) and a corrector segment (blue arrow across the bottom). During both segments the atmosphere is “replayed” to a MERRA2 state every 6 hr (downward yellow arrows). After the 5-day predictor segment, the ocean analysis increments wrt ECCO are computed, and returns to the beginning of the 5-day segment to perform the corrector segment.

GEOS/ECCO Updates

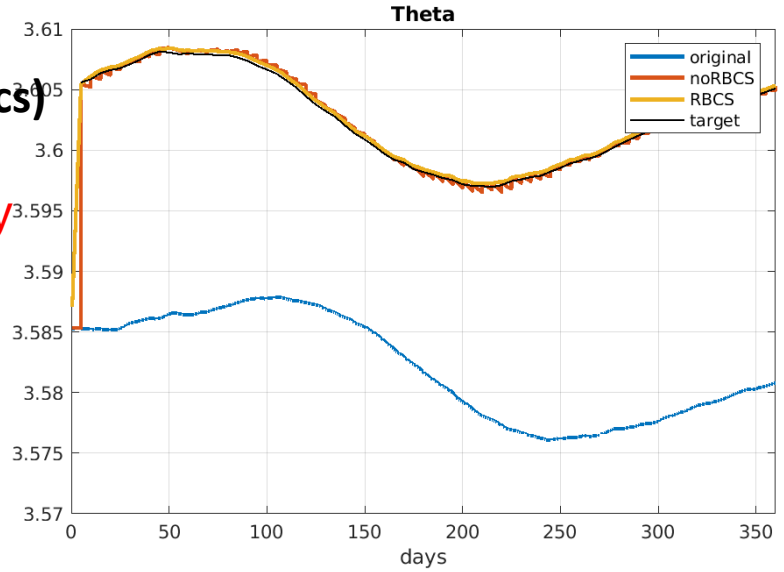
3. IAU for MITgcm (via pkg/rbcs)

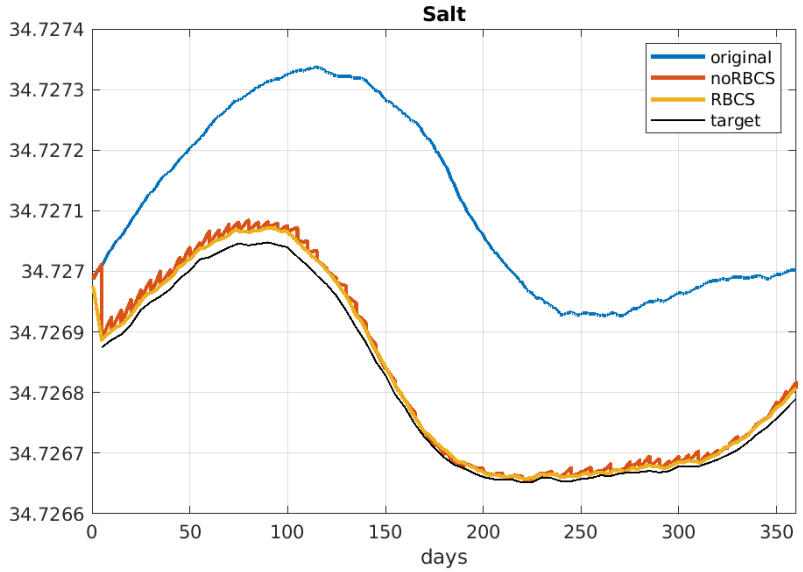
12 months run of ocean-only

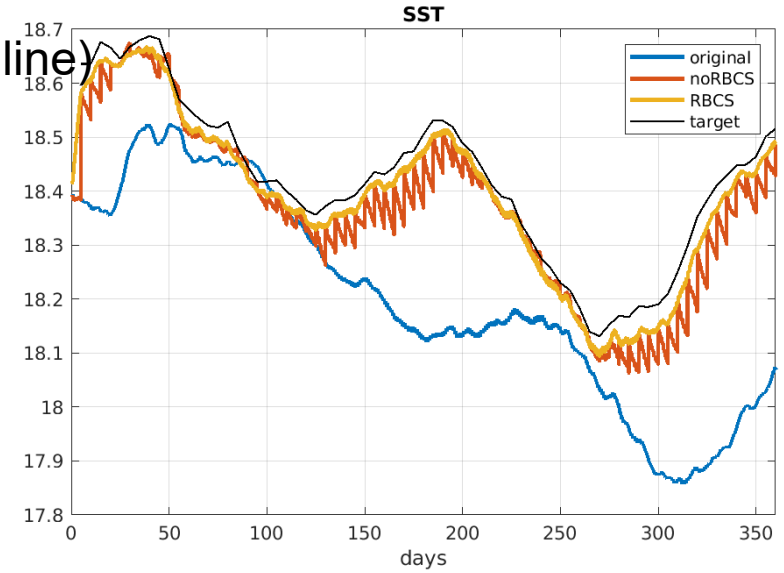
Top row for global mean THETA/SALT
Bottom row for global mean SST/SSS

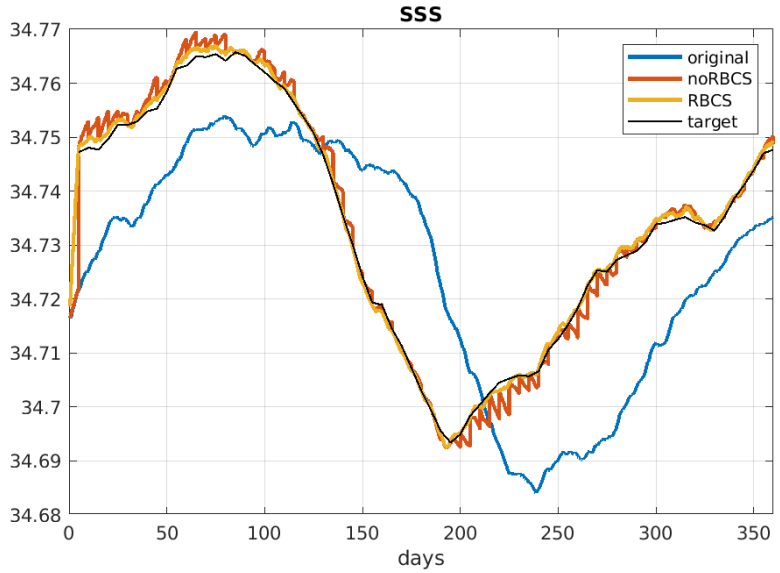
The result (“RBCS”, orange line) is close to target (black line)
“noRBCS” is discontinuous while “RBCS” is continuous

IAU timewindow is 5 days
IAU timescale is 5 days









GEOS/ECCO Updates

3. IAU for MITgcm (via pkg/rbcs)

4 months run of coupled-run

Top row for global mean THETA/SALT
Bottom row for global mean SST/SSS

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IAU timewindow is 5 days
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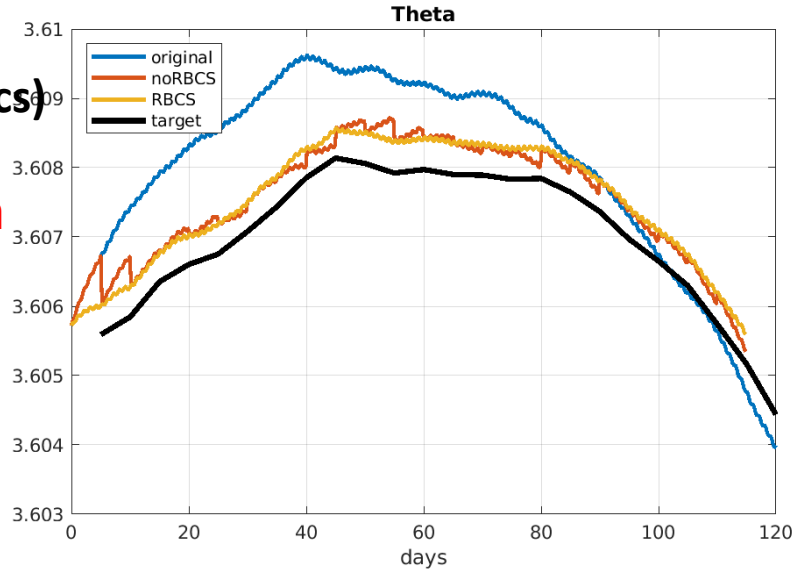
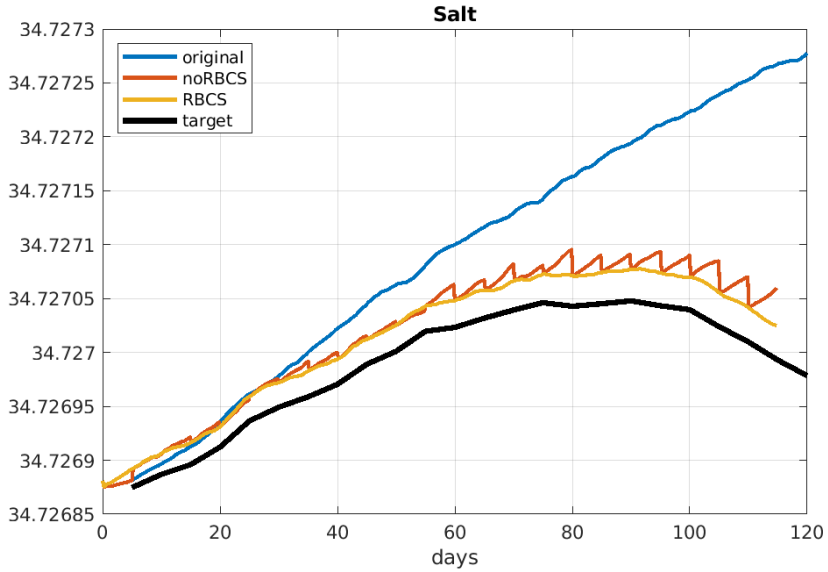
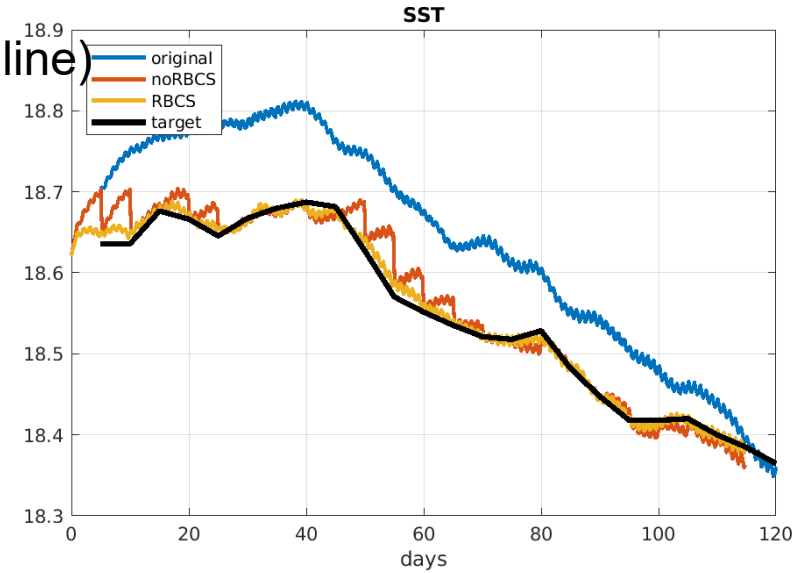
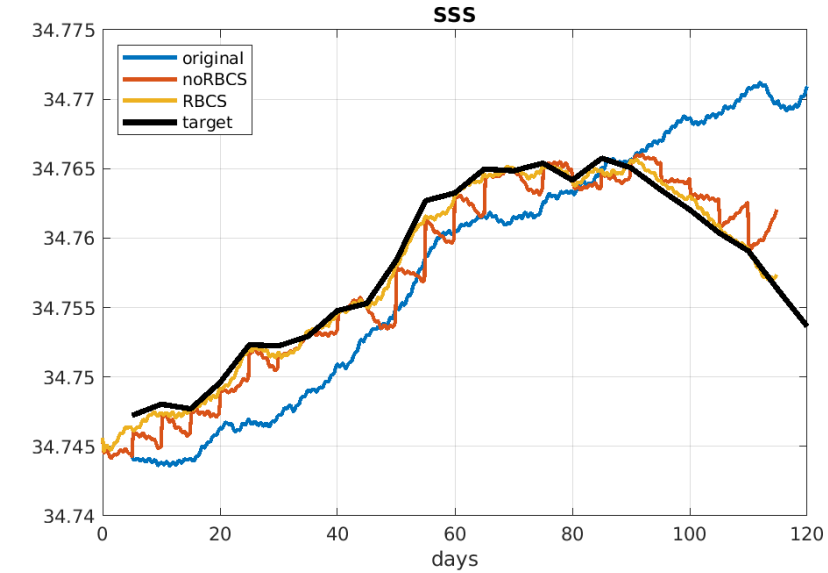
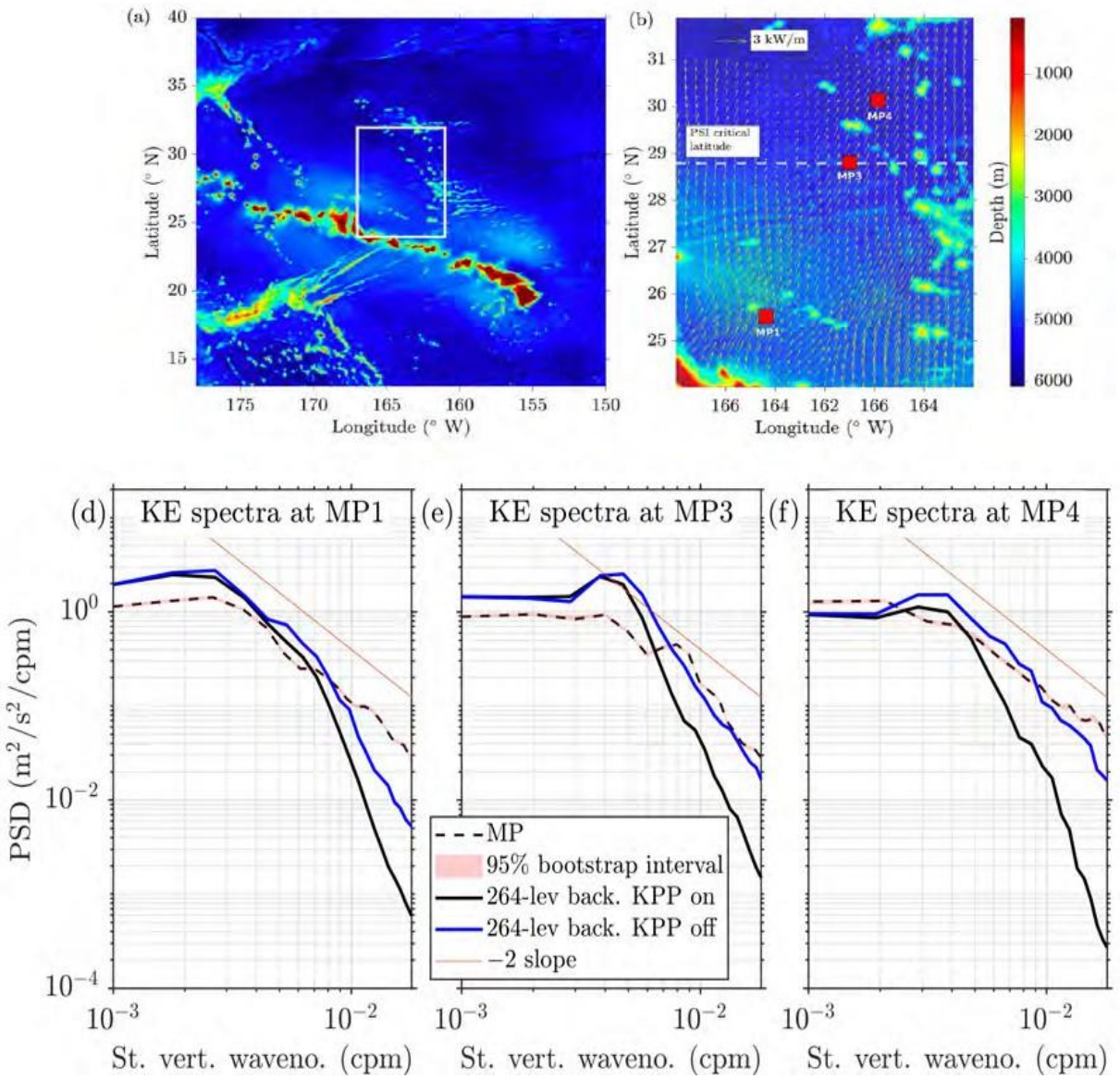








4. background vertical mixing in high-resolution ECCO simulations



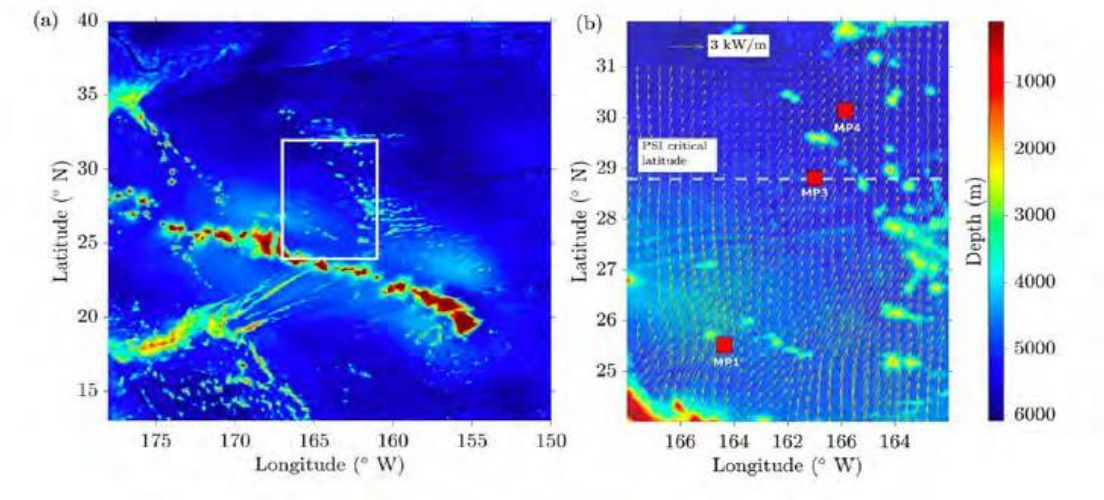
Thakur et al. 2022

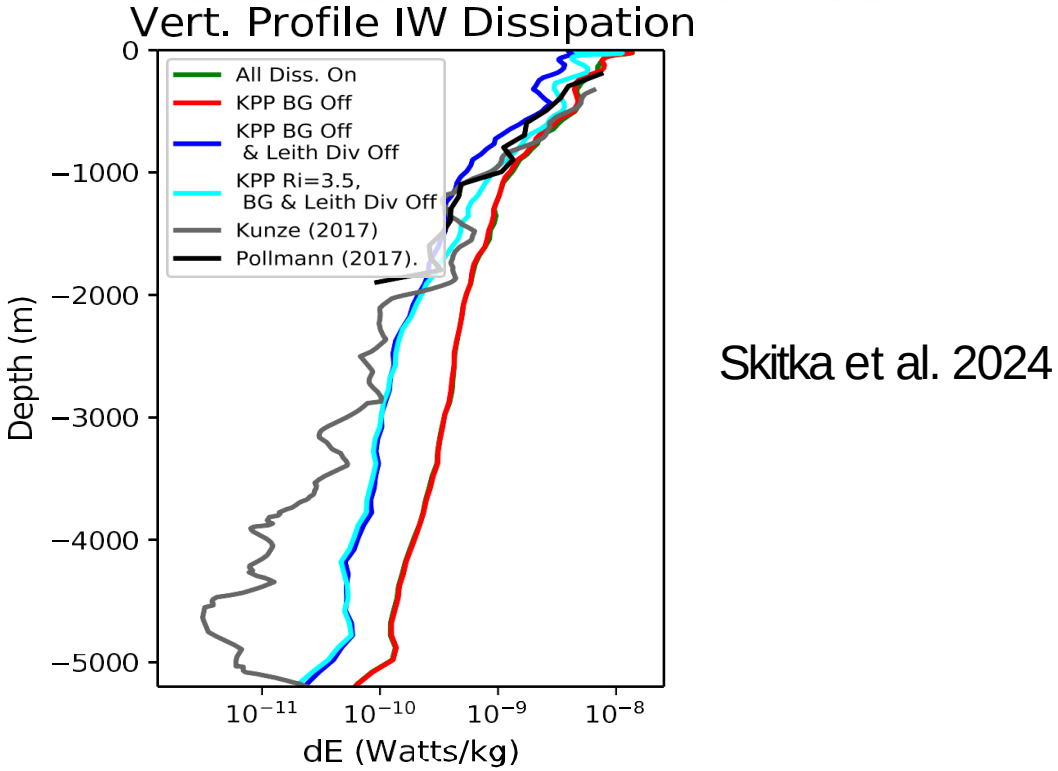
- Model simulations in a regional domain North of Hawaii, with boundary conditions from the LLC4320 (1/48°) global simulation indicate more realistic (closer to k^{-2} and McLane moored profiler observations) vertical wavenumber spectra without K-Profile Parameterization (KPP) background mixing.

- Without KPP background mixing, stronger vertical gradients in velocity are sustained in the simulation, which trigger the KPP Richardson number-dependent mixing terms.

- A 3-month (March 1 to May 31, 2012) global LLC4320 test simulation with KPP background terms off has been completed and is being evaluated.

5. modify Leith so that it acts only on horizontally rotational part of flow





Skitka et al. 2024

- Model simulations in a regional domain North of Hawaii, with boundary conditions from the LLC4320 (1/48°) global simulation indicate more realistic (closer to observations) vertical dissipation profiles when Leith viscosity does not act on divergent part of flow.
- However, initial tests in the global LLC4320 configuration show that the divergent Leith terms are needed to maintain stability, e.g., in shallow or in steep-bathymetry regions.
- Joe Skitka has added flags that will allow finer control of the divergent Leith terms. I plan to test these flags in LLC4320, e.g., by keeping divergent Leith term on in shallow regions only.

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