MARBL in MOM6:
Status Update

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What is MARBL?

- MARine Biogeochemistry Library
- Ocean Biogeochemistry component of CESM (since CESM2)
- Designed as a OGCM-independent scientific core, coupled to OGCM via an OGCM-specific driver/interface layer
- MARBL is column oriented
  - computes source-sink terms for a single column at a time (currently)
- Developed in anticipation of CESM migrating away from POP2
- Initial development funded by a DOE SciDAC grant

June 2023 Status

- MARBL source-sink and surface flux computations applied to MARBL tracers in MOM6
- MARBL diagnostics controlled via MOM6 diag_table
- MARBL parameters set via user_nl_marbl
- Initial conditions provided on WOA x1 grid, interpolated to model grid by MOM6/FMS
- MARBL forcing determined from CESM mediator or file

- Implementation vetted by comparing 20-year MOM6-MARBL simulations to companion POP2-MARBL simulations, comparing global and regional timeseries of various fields

Feb 2024 Update

- Support for MKS units added to MARBL
- Support for tracer restoring added to driver
  - particularly useful for single column configuration
- Abiotic radiocarbon added to MARBL
  - useful for evaluating ocean ventilation, assuming spin up capability

- Initial MOM6-MARBL simulations for full JRA cycle performed
  - z* and hybrid vertical coordinates

MARBL Science Change to Accommodate MOM6

- When sinking particles reach sea floor, a fraction is buried and the complement is remineralized into the water column.
- Pre-MOM6 MARBL remineralized in the bottom model layer.
- This approach didn't play friendly with vanishingly thin layers at sea floor in MOM6.
- OGCM now provides MARBL with bottom flux to column tendency array.
- MOM6 bot_flux_to_tend corresponds to distributing flux across fixed thickness layer (default of 1 m)

Benefit of Improved Numerics in MOM6

- O_2 consumption in MARBL is ramped down when O_2 is low, i.e., in oxygen minimum zones (OMZs)
- This leads to high curvature in O_2 values where O_2 nears O_2 consumption threshold
- Vertical advection in POP generates artificial extrema from such tracer profiles, e.g. significantly negative O_2 concentrations
- Such artifacts are absent in MOM6-MARBL simulations

Potential Issues with Hybrid Vertical Coordinate

- Presence of thick (10s of meters) layers in euphotic zone

- Iron scavenging dependence on sinking particle flux has first order approximation with respect to layer thickness.

- Photosynthesis computation uses light averaged over model layer (not photosynthesis averaged over model layer). The accuracy of this approximation degrades with thick layers.
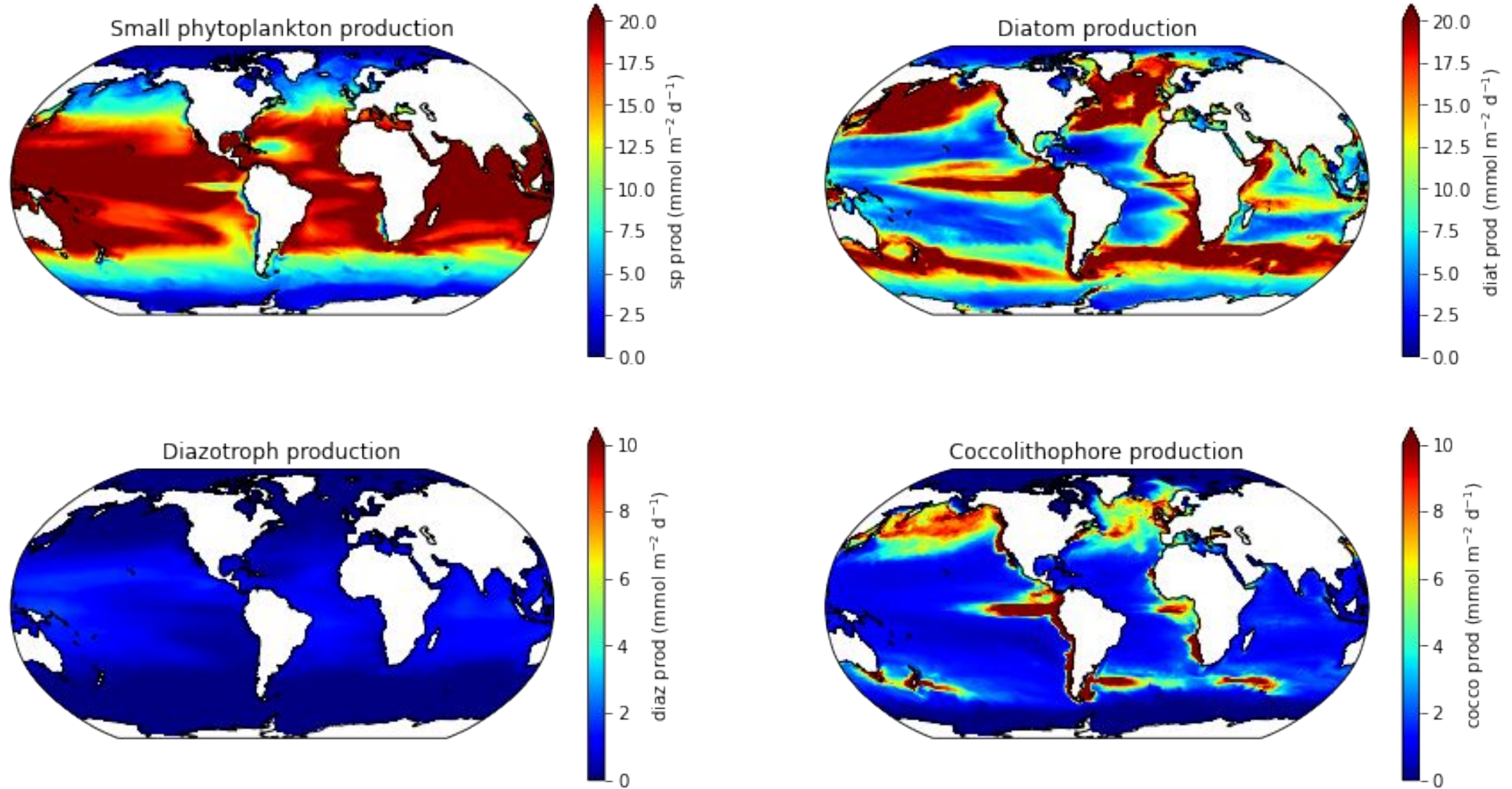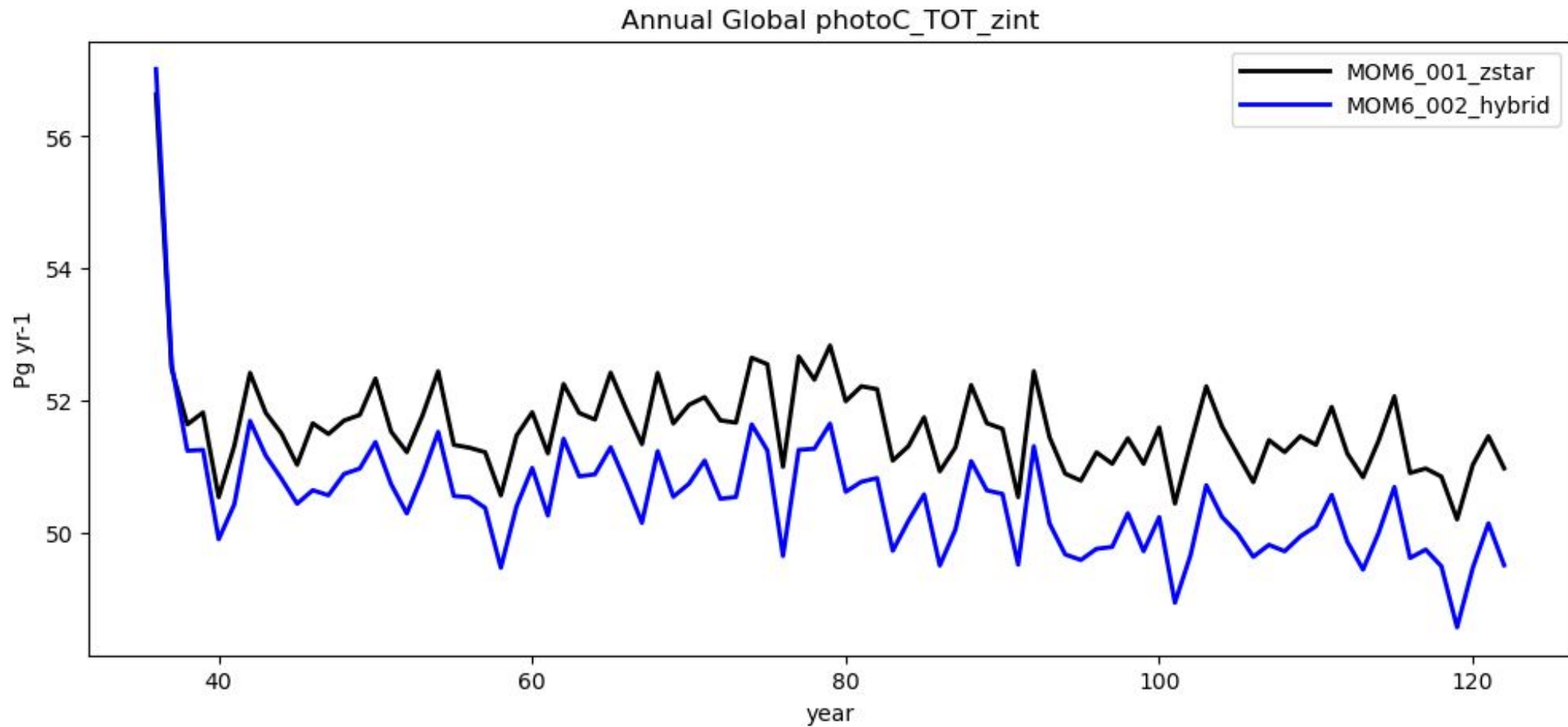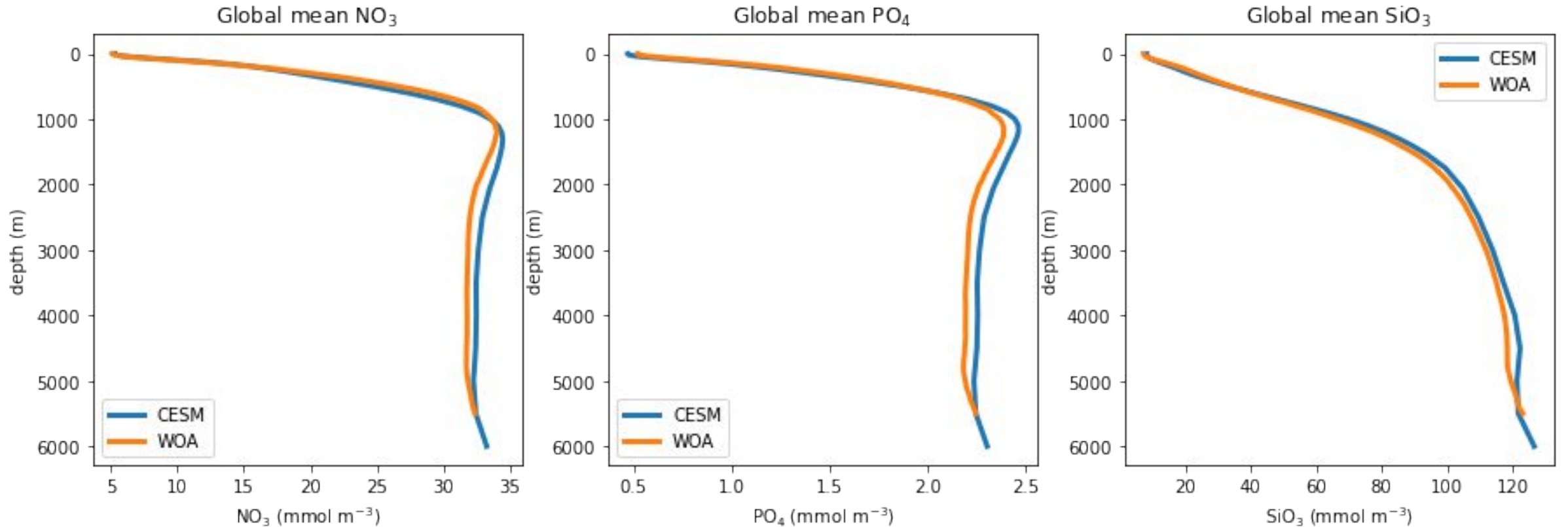
Global Primary Productivity with z* Vertical Coord
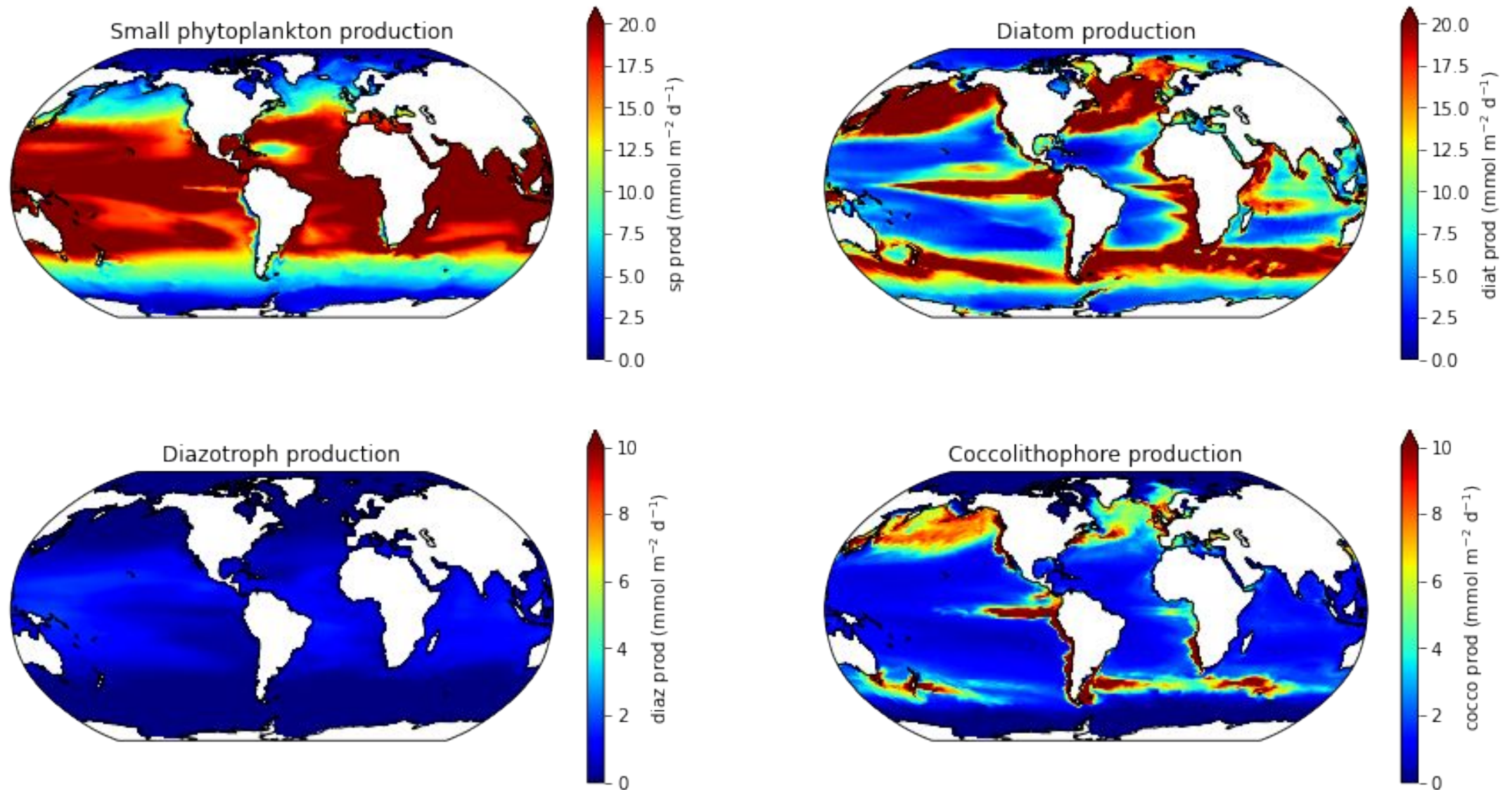
Global Primary Productivity with Hybrid Vertical Coord
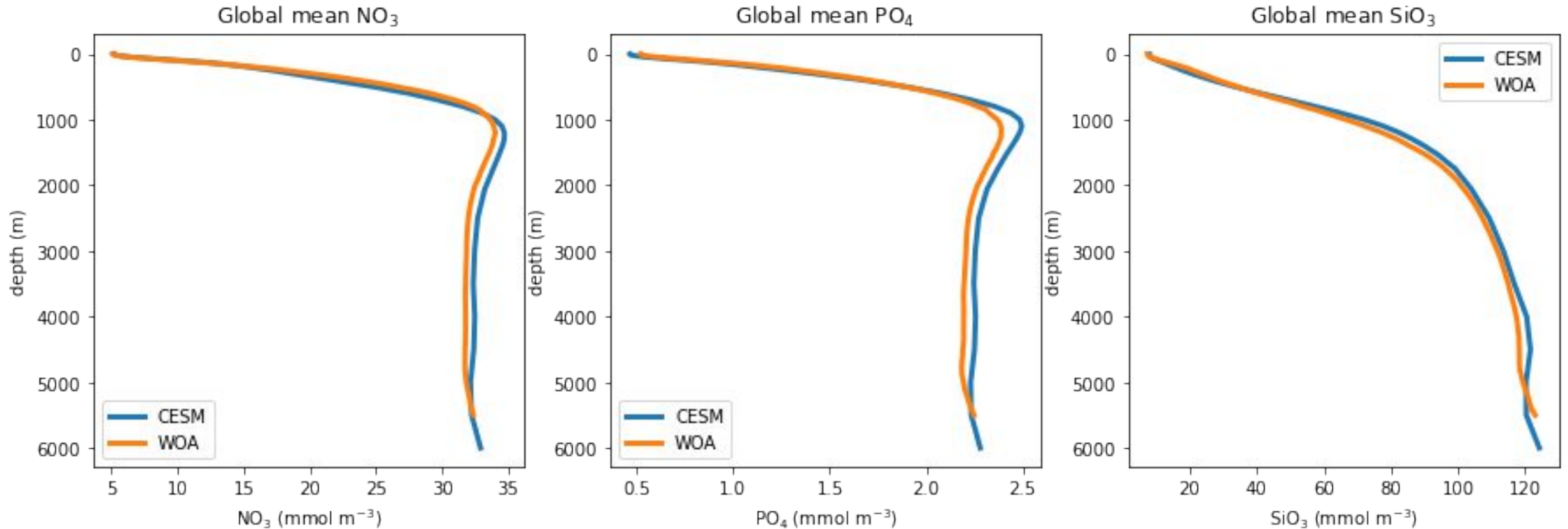
Global Primary Productivity in MOM6-MARBL

Annual Global photoC_TOT_zint
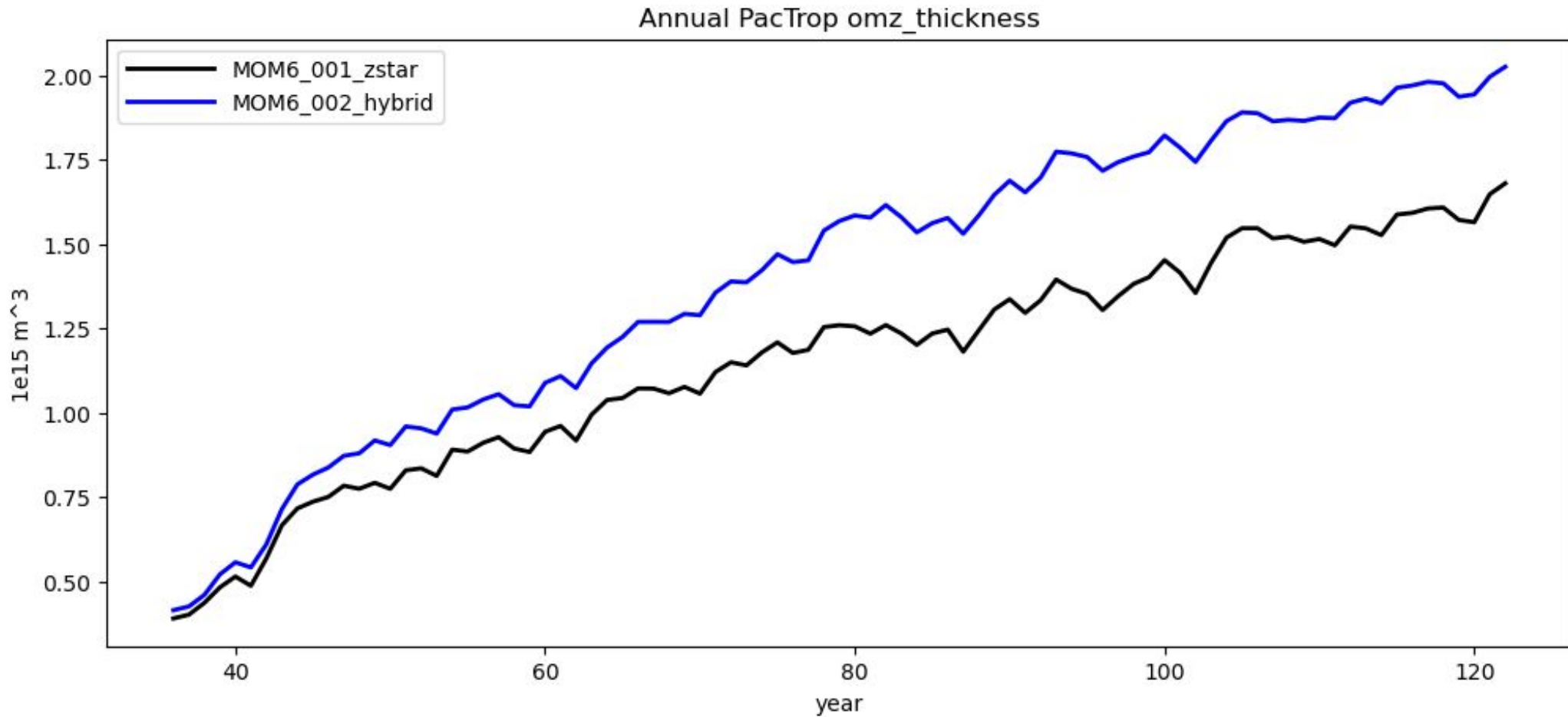
Global Macronutrient Profiles with z* Vertical Coord

Global Macronutrient Profiles with Hybrid Vertical Coord

Tropical Pacific OMZ Volume
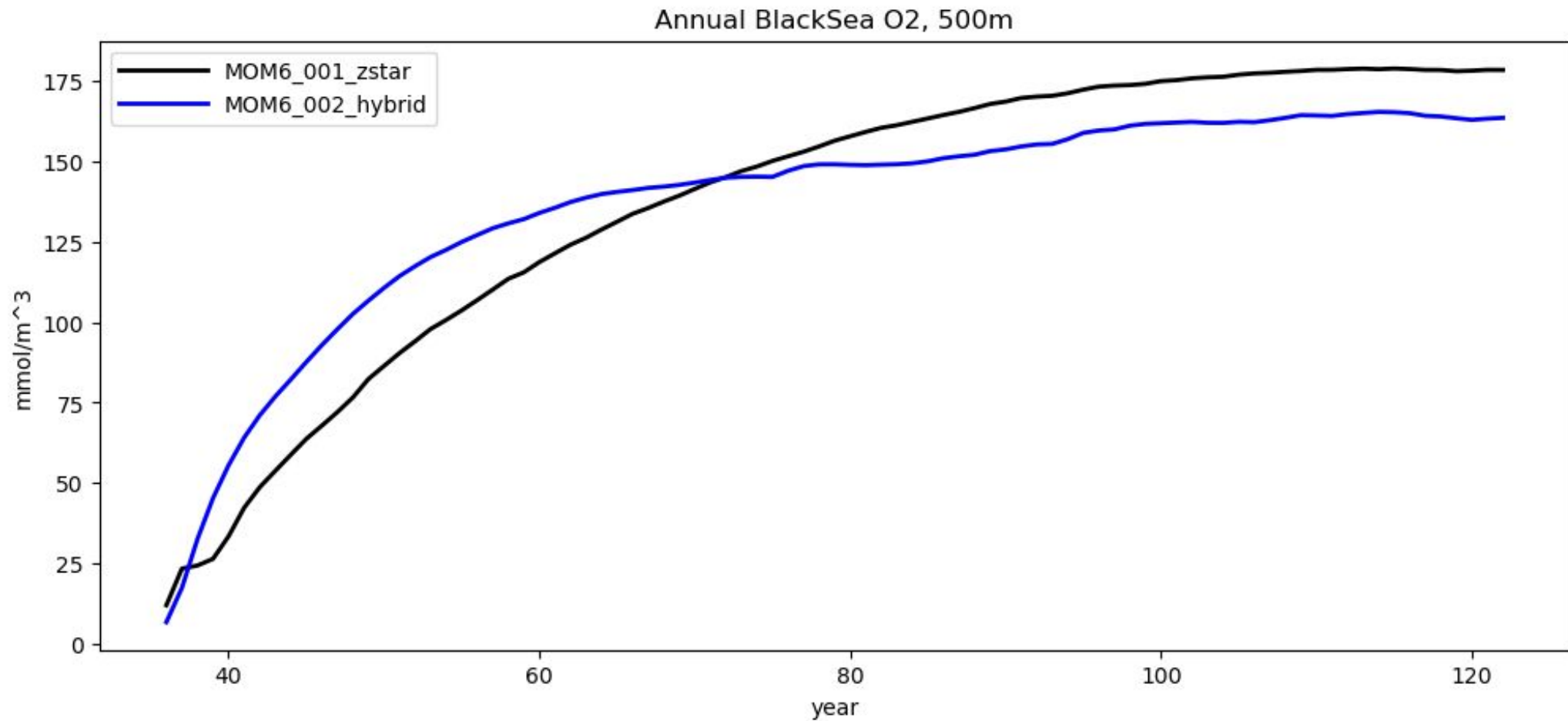## Why is bias worse with hybrid vertical coordinate?

Annual PacTrop omz_thickness

Black Sea Dissolved Oxygen at 500 m

Annual BlackSea O2, 500m

MARBL in MOM6

Near-term Tasks

- More thorough examination of z* vs hybrid vertical coordinate
- Investigate Black Sea drift
- Retune MARBL parameters
- Run MOM6-MARBL in coupled CESM
  - any gotchas
- Driver code cleanup
- Bring MARBL related mods to MOM6 dev/ncar branch

- Integrate MARBL diagnostics into CUPiD diagnostics framework

- Incorporate science updates from external collaborators