Surface iron budget change in a RCP8.5 simulation

- Analysis on the Equatorial Pacific -

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Importance of iron

• Iron (Fe) is an essential nutrient for marine phytoplankton growth.

Iron limited areas (for diatoms) simulated by the CESM1.
Iron budget in surface waters

External forcings
- Deposition of iron-bearing dust
- Resuspension/reduction of sedimentary iron

Surface waters

Ocean physical processes
- Upwelling/mixing of recycled iron

Biogeochemical processes
- Sinking as Particulate Org. Matters
- Adsorption onto sinking particles

Iron supply
Iron removal
Data & Model

- We analyzed results for a 20C + RCP8.5 simulation.
- The model configuration is CESM1 (BGC): CAM4, CICE4, CLM4, POP2 and carbon cycle.
- The model includes a marine ecosystem module (the BEC model; Moore et al., 2004).
- We focus on the decadal averages for the 1990s and 2090s, and their differences (2090s - 1990s).
Temporal changes (Global int./avg.)

- Atmospheric CO₂
- Sea surface temp.
- Primary production
- Export production
- NO₃ (Upper 100m)
- Fe in the upper 100 m
- Iron (Upper 100m)
Production and nutrients

1990s

2090s – 1990s

Primary Production

NO₃

Iron

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Iron budget in the BEC model

\[ TEND = PHYS + BGC + FRC \]

\[ = (ADV + MIX + MIXn) + BGC + FRC \]

**TEND** Net tendency

**PHYS** Ocean physical processes

  **ADV** Advection

  **MIX** Isopycnal and parameterized eddy mixing

  **MIXn** Non-local convective mixing

**BGC** Biogeochemical processes (biological uptake / scavenging)

**FRC** External forcing (aeolian dust / sediments)
Iron budget in the upper 100m

Positive tendencies (iron supply) / Negative tendencies (iron removal) (in log-scale)

Larger iron supply (removal) by the PHYS (BGC) term

Fixed!
(Yes! It’s a big problem)
Iron budget in the eastern EqPAC

Integrate each budget term in the box only for the red-colored region.
Iron budget in the eastern EqPAC

1990s

Most iron is supplied by the ADVv term; namely, by the equatorial upwelling.
Zonal cross section of the ADV term along the EqPAC

Averaged over 5°N-5°S.
Zonal cross section of the ADV term along the EqPAC

<= West

$\text{ADV}_{1990s}$

$\text{ADV}_{x1990s}$

$\text{ADV}_{y1990s}$

$\text{ADV}_{z1990s}$

East=>

$\delta \text{ADV}$

$\delta \text{ADV}_x$

$\delta \text{ADV}_y$

$\delta \text{ADV}_z$
Horizontal iron flux in the western EqPAC

$PHYS_{1990s}$

$BGC_{1990s}$

$FRC_{1990s}$

Papua New Guinea

(Avg. 0-300 m)
Zonal cross section of the ADV term along the EqPAC

$ADV_{1990s}$

$ADVx_{1990s}$

$ADVy_{1990s}$

$ADVz_{1990s}$

$\delta ADV$

$\delta ADVx$

$\delta ADVy$

$\delta ADVz$
Horizontal iron flux in the western EqPAC

$PHYS_{1990s}$

$BGC_{1990s}$

$FRC_{1990s}$

Papua New Guinea

Weakening of the SECC

(Avg. 0-300 m)
Are the iron transport processes realistic?

Mackey et al. (2002)

“The concentration of Fe_{TD} in the NGCU does increase as it flows along the north coast of PNG.”

Slemons et al. (2010)

“The present study shows that the western equatorial Pacific is a primary source of the micronutrient iron to the lower waters of the Pacific EUC.”
How about projection of the SECC?

Our model projected weakening of the SECC, which is appeared to be intensifying the eastward iron transport by the EUC.

CMIP3 multi model mean. Vectors represent mean surface velocities, colors are projected changes of the zonal velocity component (eastward positive) in SRES A2.

Ganachaud et al. (2012)
Primary production and projected change (SRES A2)

1990s  2090s – 1990s

Old (OCMIP')

NCAR

New (BEC)

Steinacher et al. (2010)
Conclusions

Given that

- our model did a good job simulating iron transport processes in the equatorial Pacific,
- the simulated weakening of the SECC is seen in most CMIP3 models and
- I’m a user of the CESM1,

I believe the simulated response in the CESM1!
Are the iron transport processes realistic?

Comparison of dissolved Fe averaged in 200-500 m.

CESM1

Tagliabue et al. (2012)