



# Surface iron budget change in a RCP8.5 simulation

- Analysis on the Equatorial Pacific -

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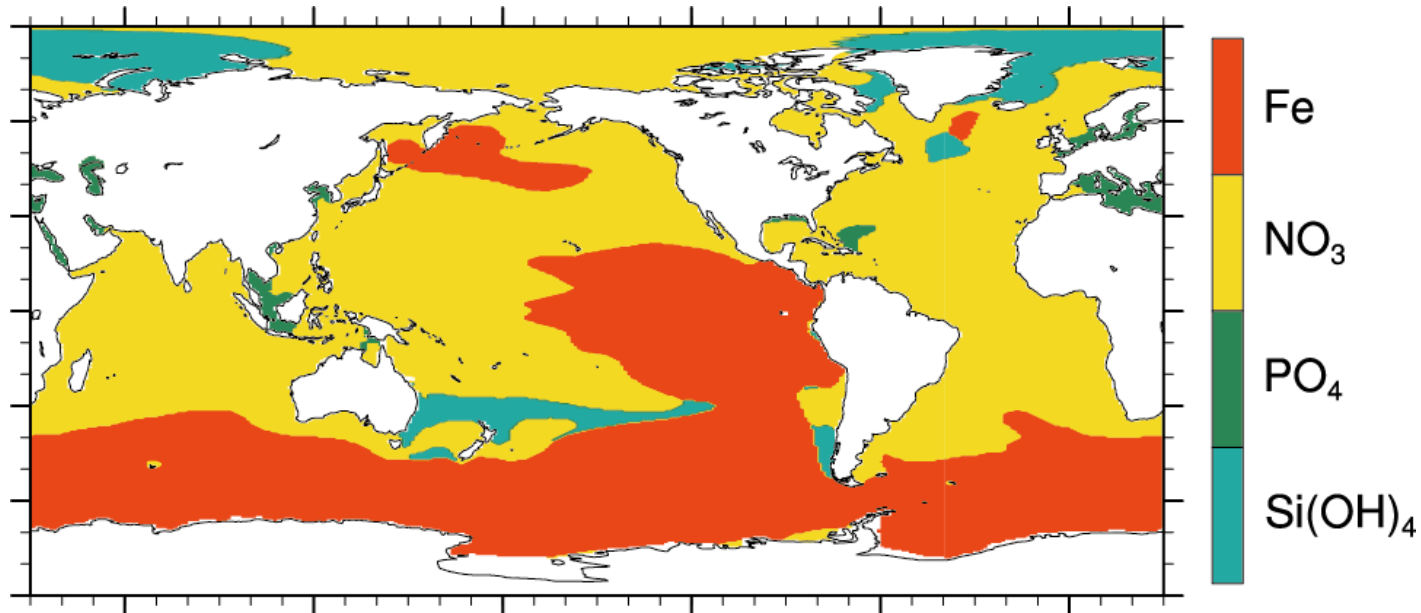
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J. K. Moore, S. C. Doney, D. Tsumune, Y. Yoshida

Ocean Modeling Working Group Meeting

Jan. 22, 2013

# Importance of iron

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

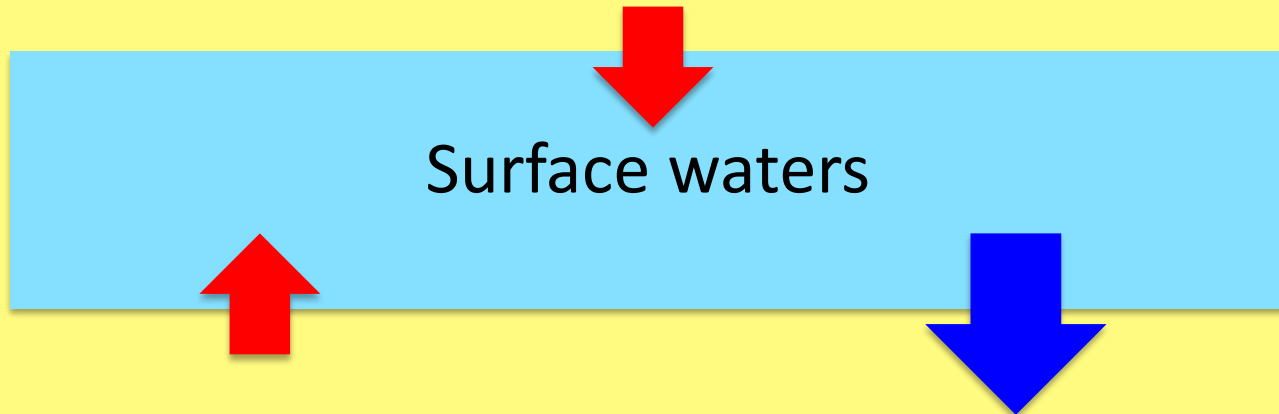


Iron limited areas (for diatoms) simulated by the CESM1.

# Iron budget in surface waters

## External forcings

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



Surface waters

## Ocean physical processes

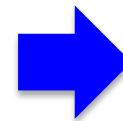
- Upwelling/mixing of recycled iron

## Biogeochemical processes

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



Iron supply



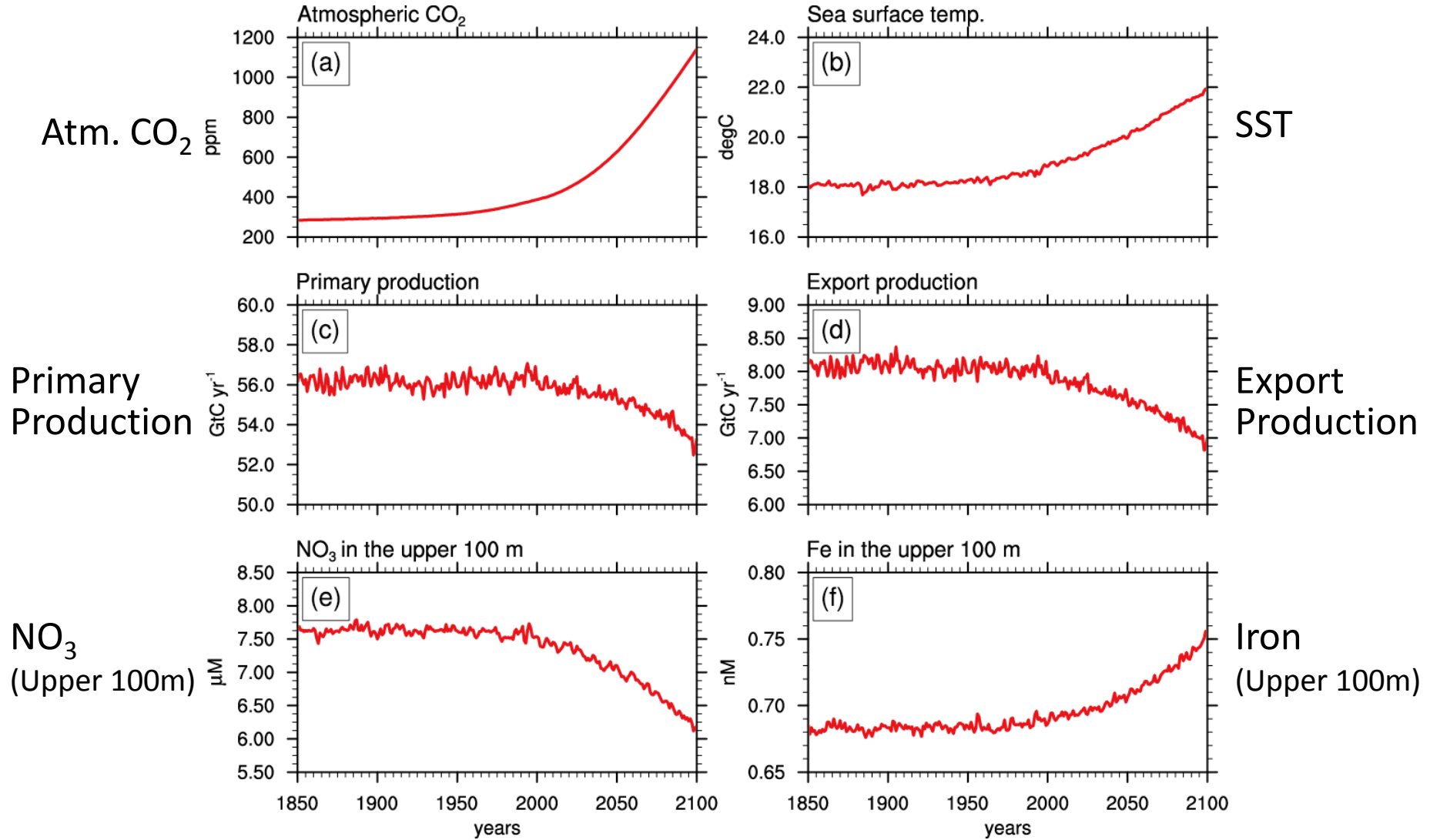
Iron removal

# Data & Model

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- 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.)



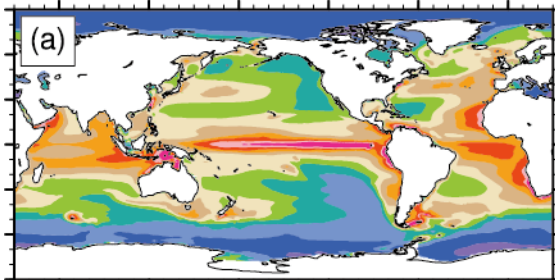
# Production and nutrients

1990s

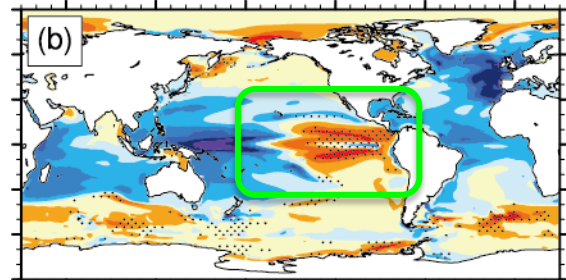
2090s – 1990s

(upper 100m)

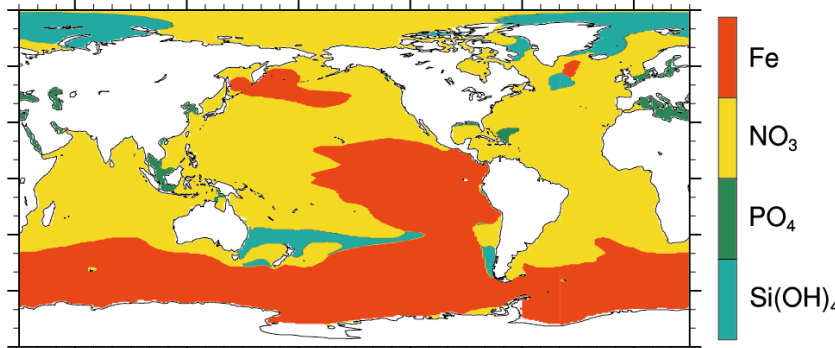
Primary prod. (1990s)  $\text{molC m}^{-2} \text{yr}^{-1}$



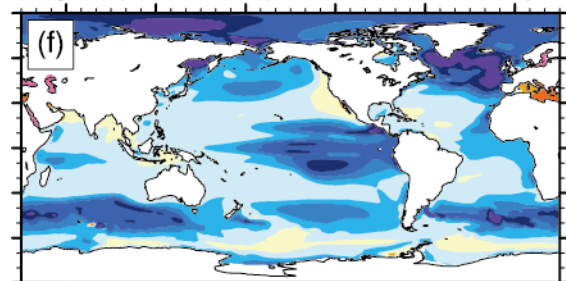
Primary prod. diff. (2090s-1990s)  $\text{molC m}^{-2} \text{yr}^{-1}$



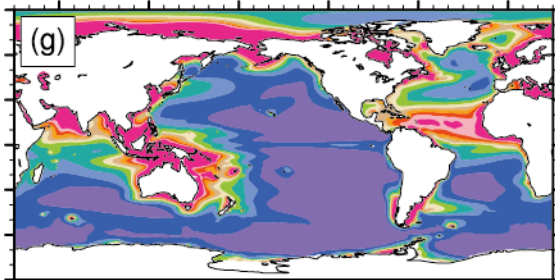
Primary  
Production



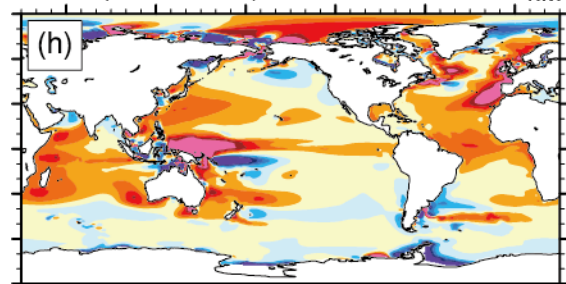
$\text{NO}_3$  diff. (2090s-1990s)  $\mu\text{M}$



$\text{NO}_3$



Fe diff. (2090s-1990s)  $\text{nM}$



Iron

# Iron budget in the BEC model

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$$\begin{aligned}
 TEND &= PHYS + BGC + FRC \\
 &= (ADV + MIX + MIX_n) + BGC + FRC
 \end{aligned}$$

*TEND* Net tendency

*PHYS* Ocean physical processes

*ADV* Advection

*MIX* Isopycnal and parameterized eddy mixing

*MIX<sub>n</sub>* Non-local convective mixing

*BGC* Biogeochemical processes (biological uptake / scavenging)

*FRC* External forcing (aeolian dust / sediments)

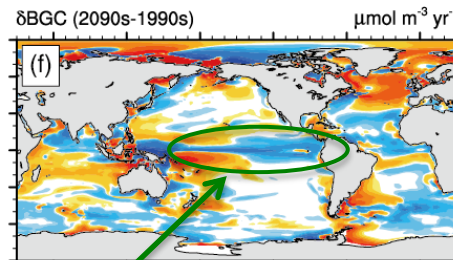
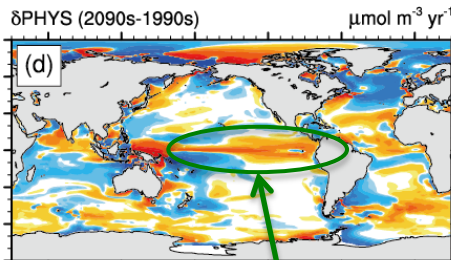
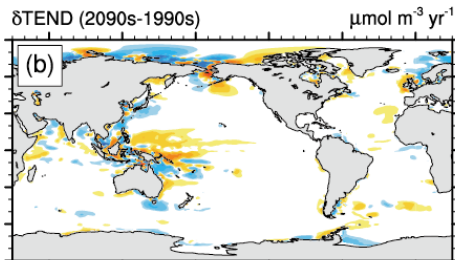
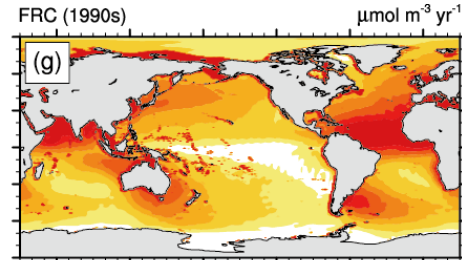
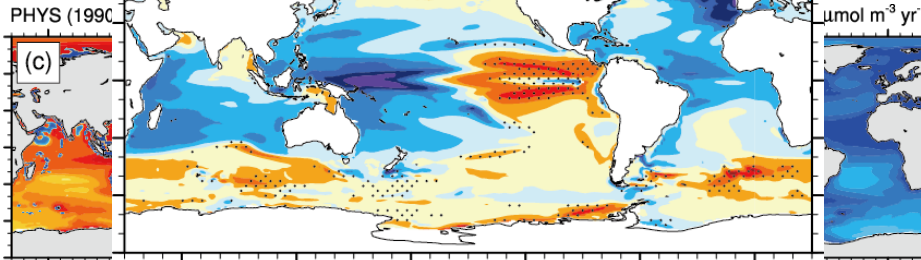
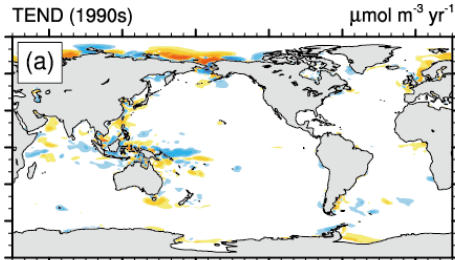
# Iron budget in the upper 100m

Positive tendencies (iron Primary prod. diff. (2090s-1990s) molC m<sup>-2</sup> yr<sup>-1</sup> removal) (in log-scale)

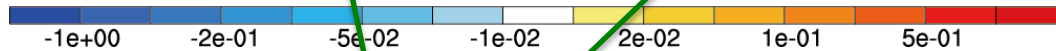
*TEND*<sub>1990s</sub>

*P*

*FRC*<sub>1990s</sub>



**Fixed!**  
(Yes! It's a big problem)



*ΔTEND*

*ΔPHYS*

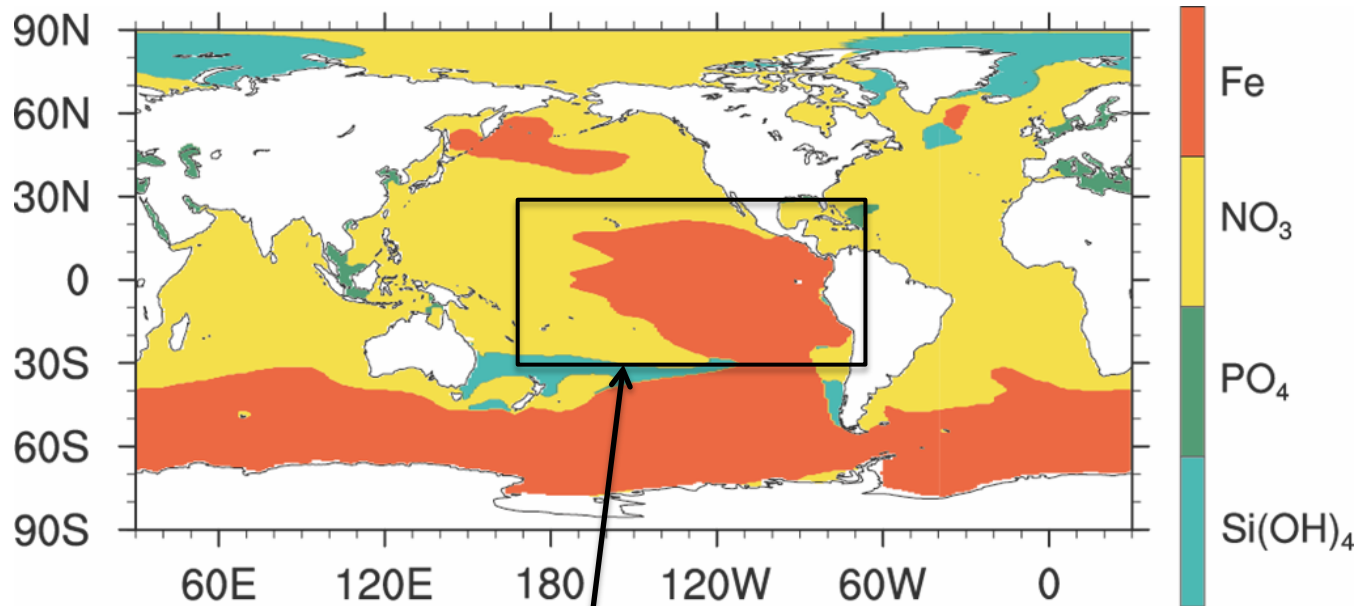
*ΔBGC*

2090s - 1990s

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

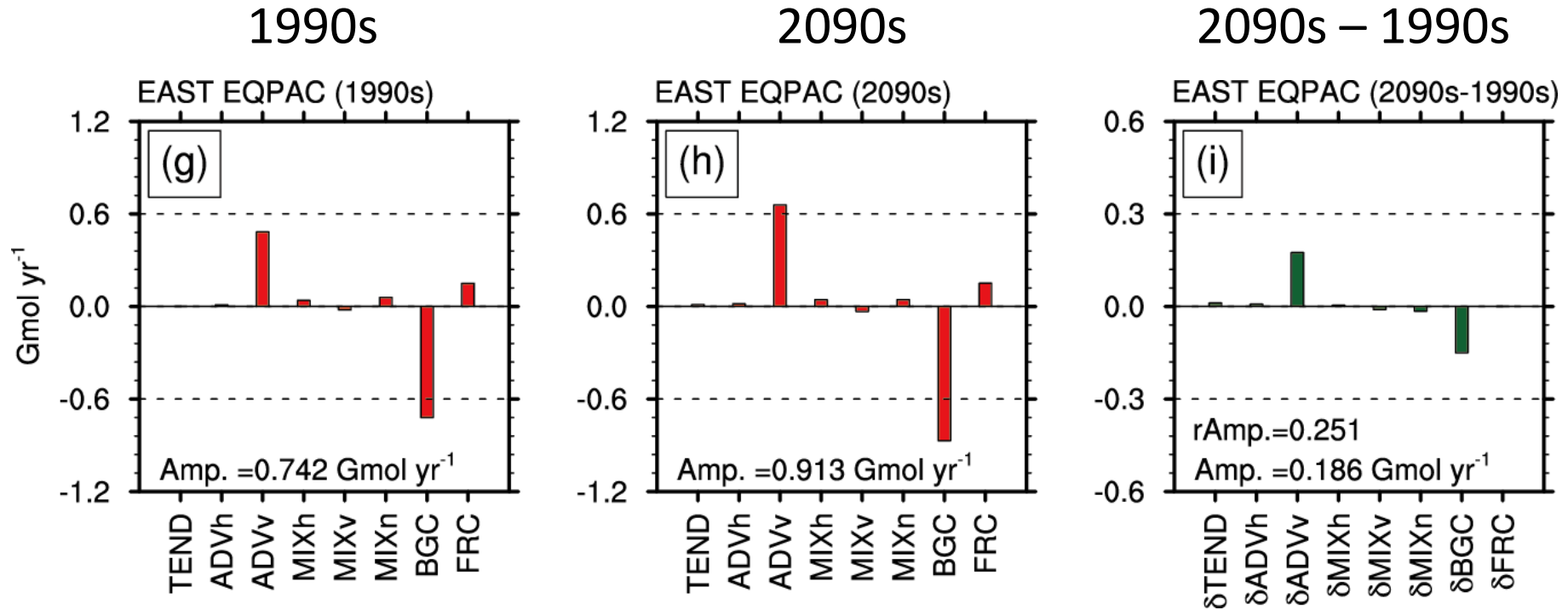


# Iron budget in the eastern EqPAC



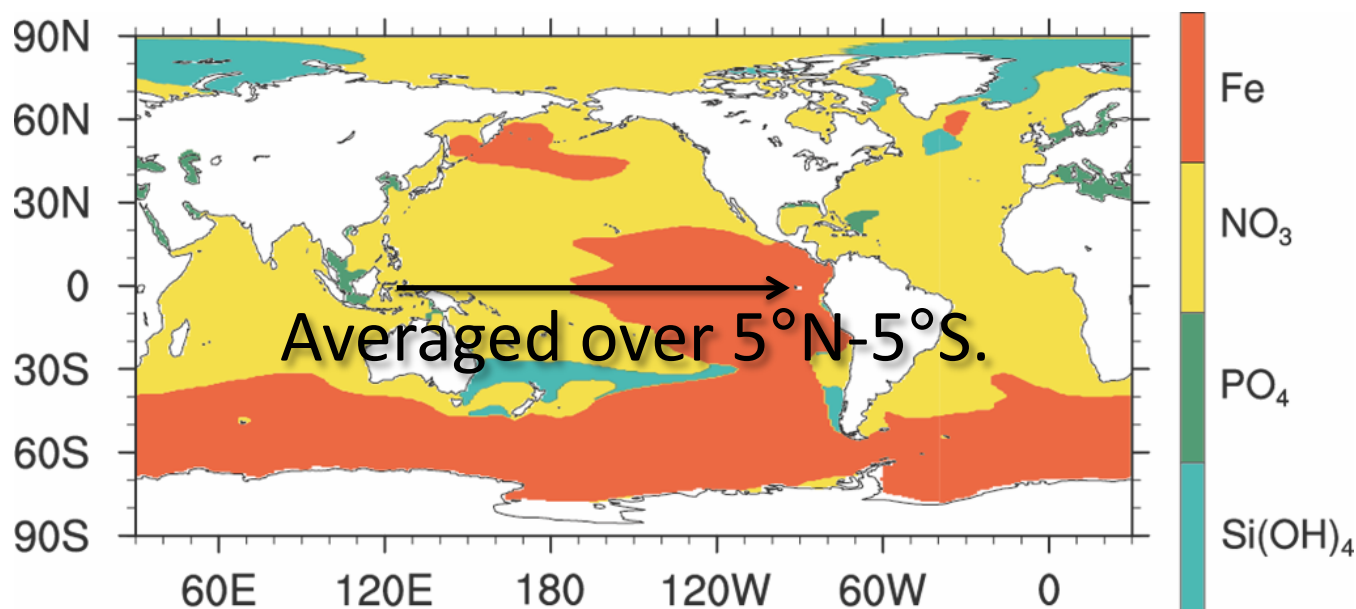
Integrate each budget term in the box only for the red-colored region.

# Iron budget in the eastern EqPAC

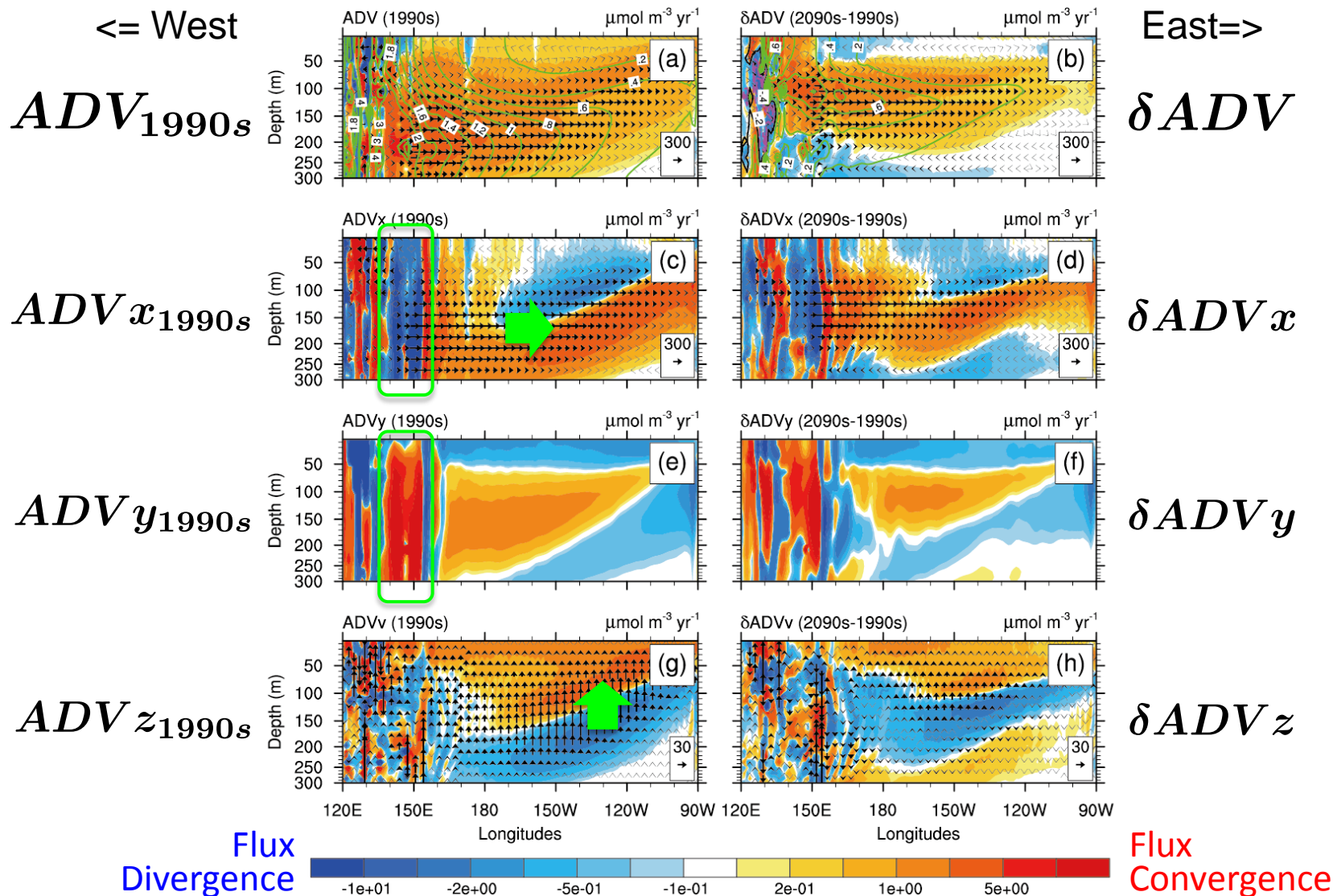


Most iron is supplied by the ADVv term; namely, by the equatorial upwelling.

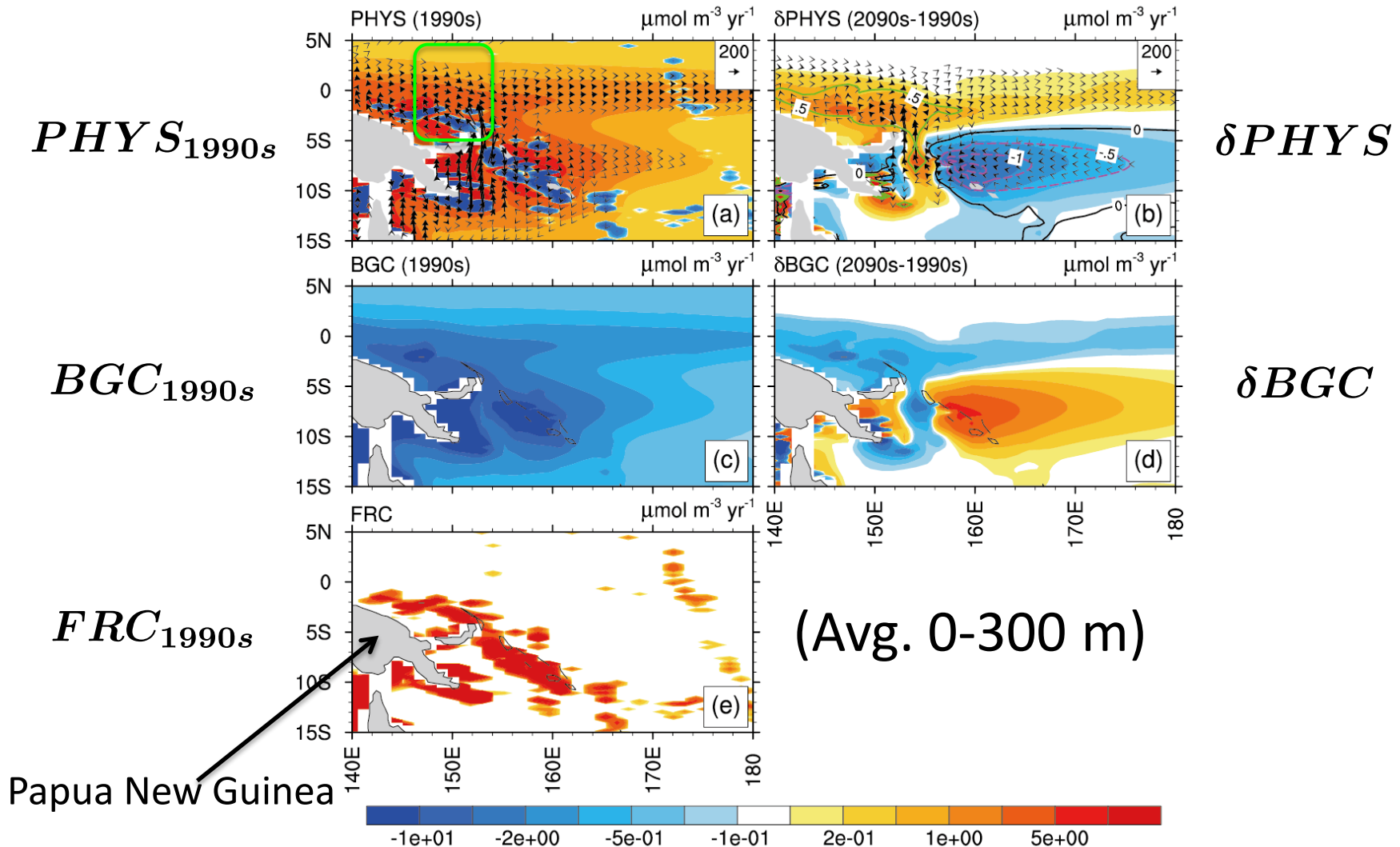
# Zonal cross section of the ADV term along the EqPAC



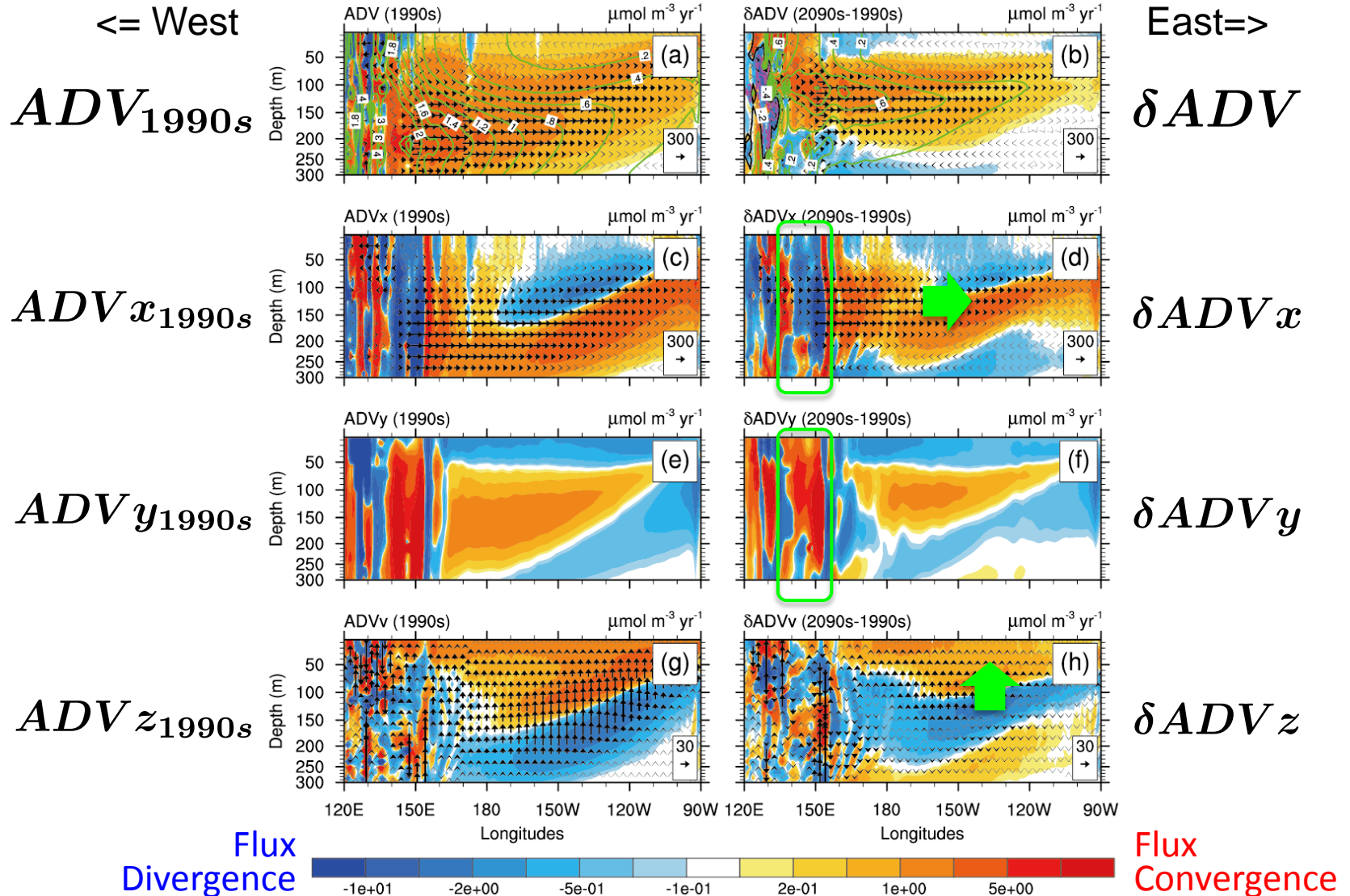
# Zonal cross section of the ADV term along the EqPAC



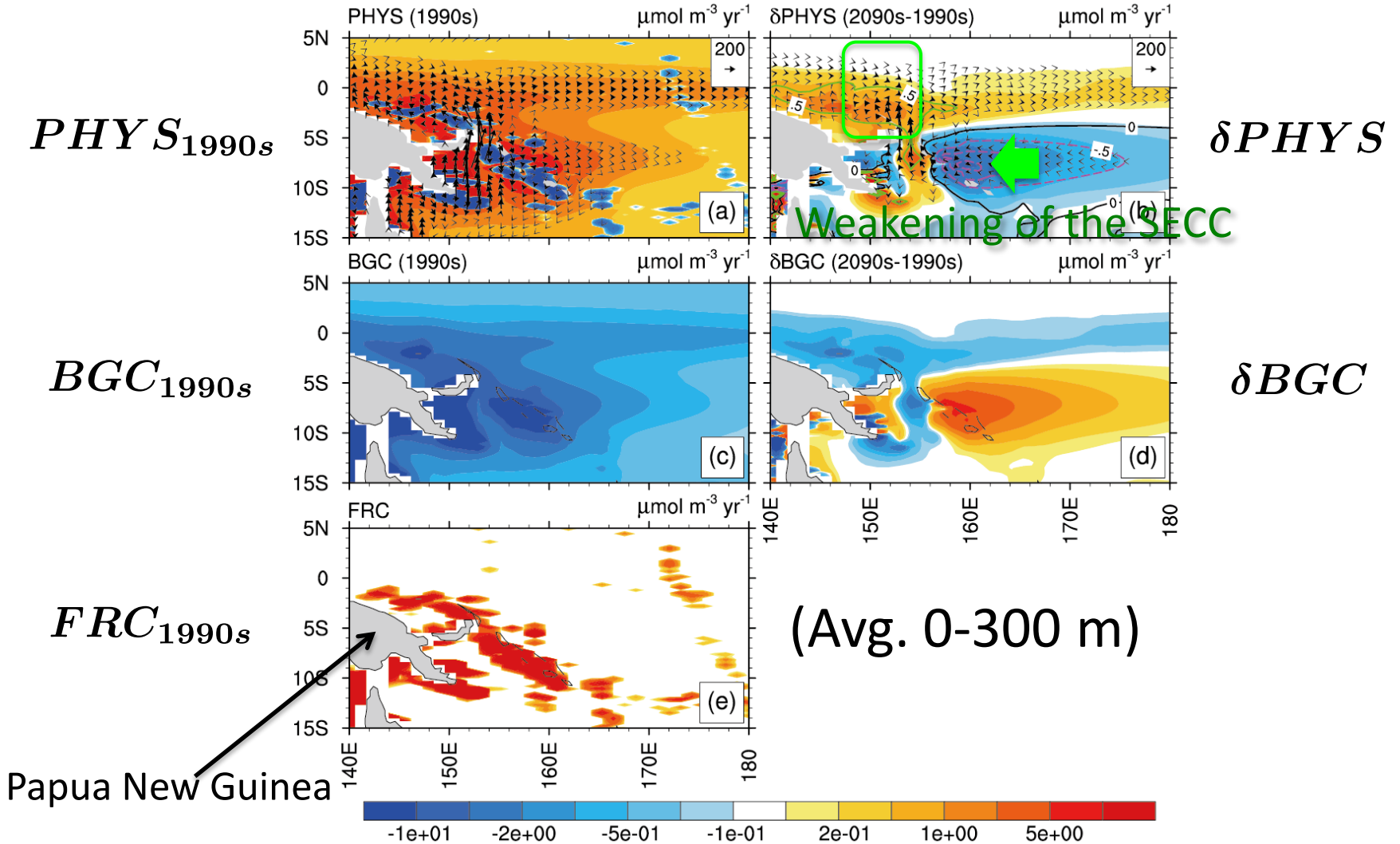
# Horizontal iron flux in the western EqPAC



# Zonal cross section of the ADV term along the EqPAC

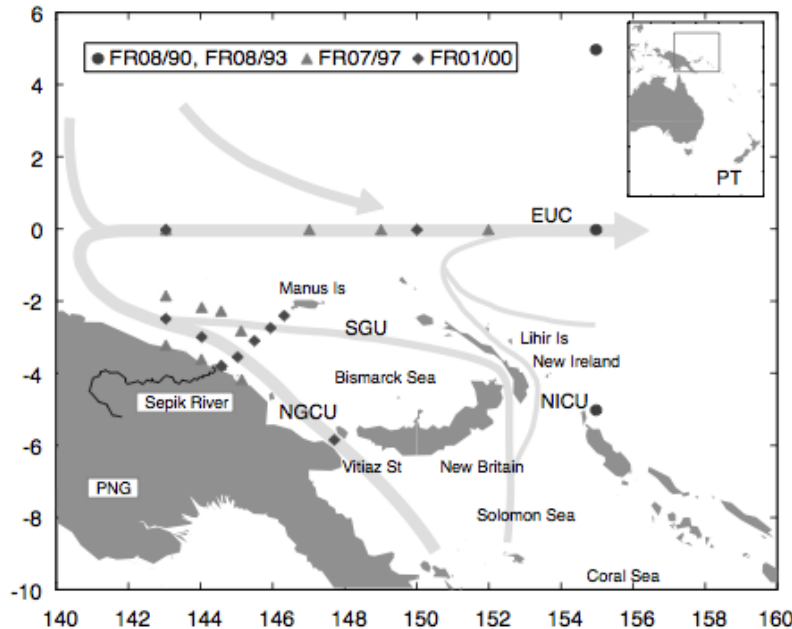


# Horizontal iron flux in the western EqPAC



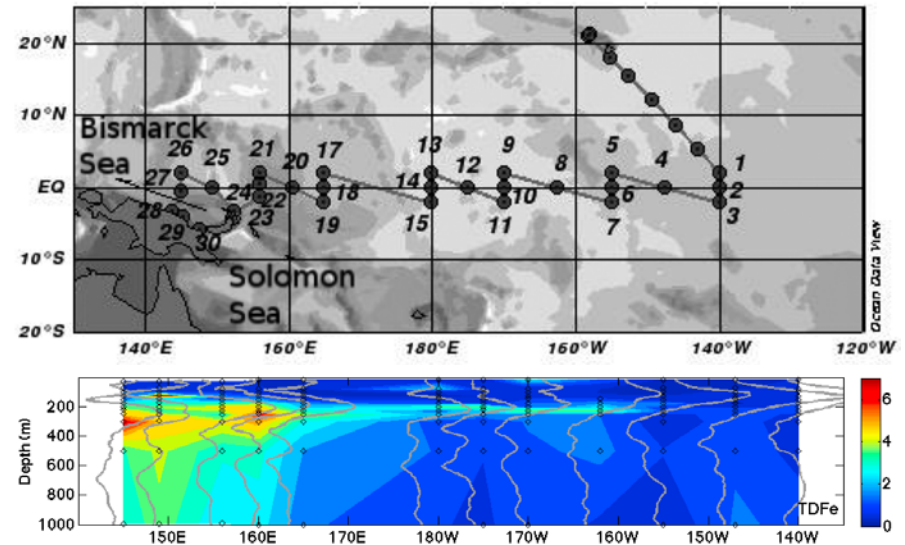
# Are the iron transport processes realistic?

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)

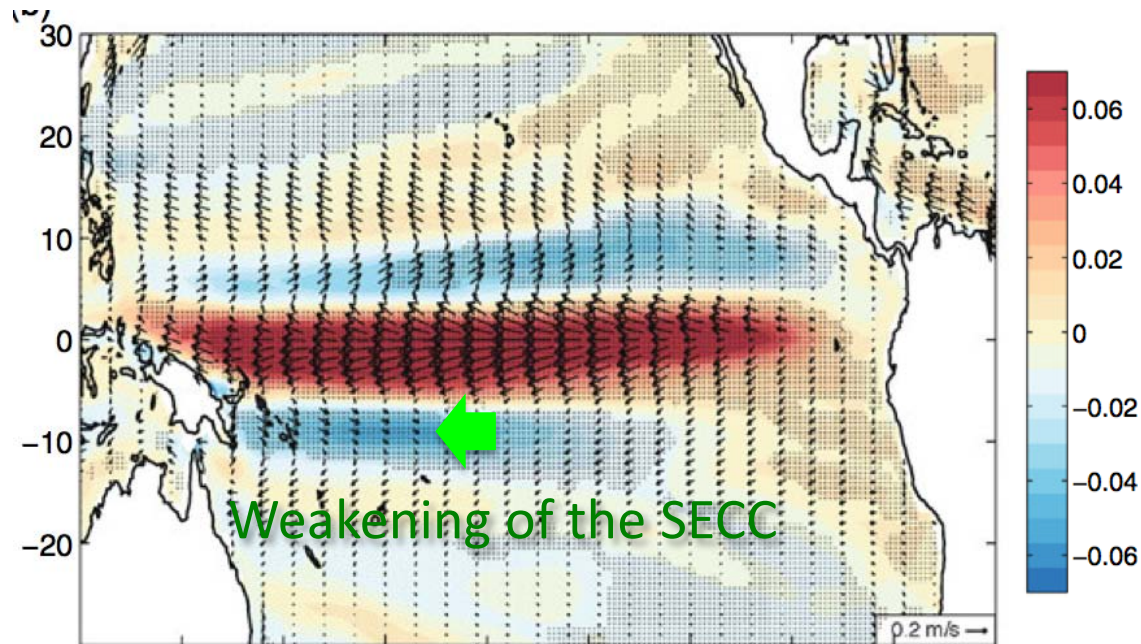


“The present study shows that the western equatorial Pacific is a primary source of the micronutrient iron to the lower waters of the Pacific EUC.”



# 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.



Ganachaud et al. (2012)

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

# Primary production and projected change (SRES A2)

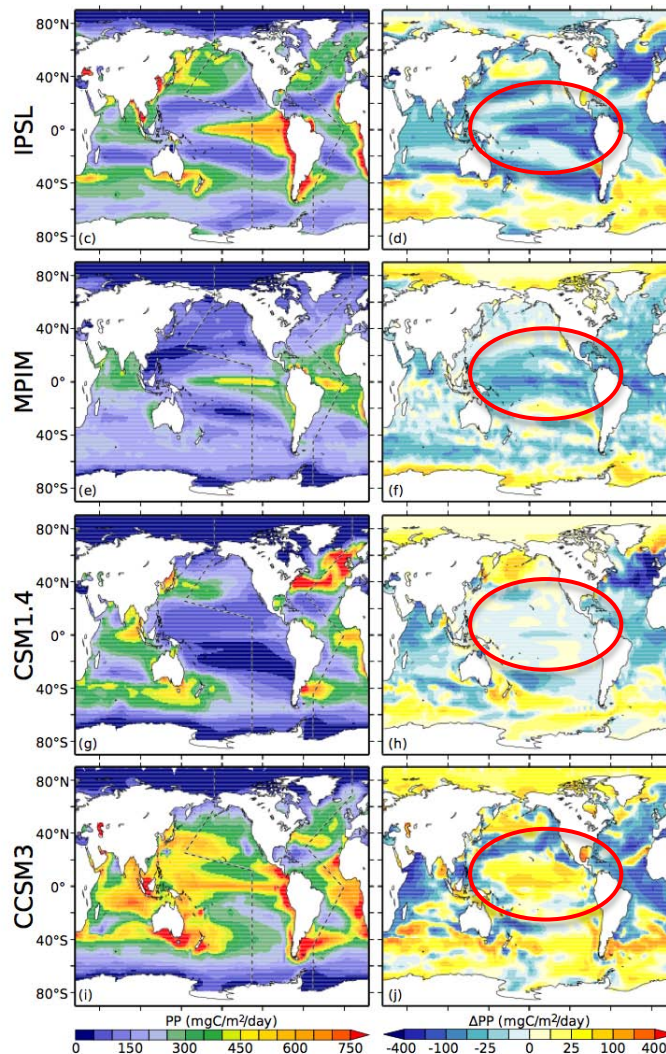
1990s 2090s – 1990s



Old (OCMIP')



New (BEC)



Steinacher et al. (2010)

# Conclusions

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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)

