Increasing atmospheric CO_2 leads to large impact of biology on Southern Ocean CO_2 uptake via changes of the Revelle factor

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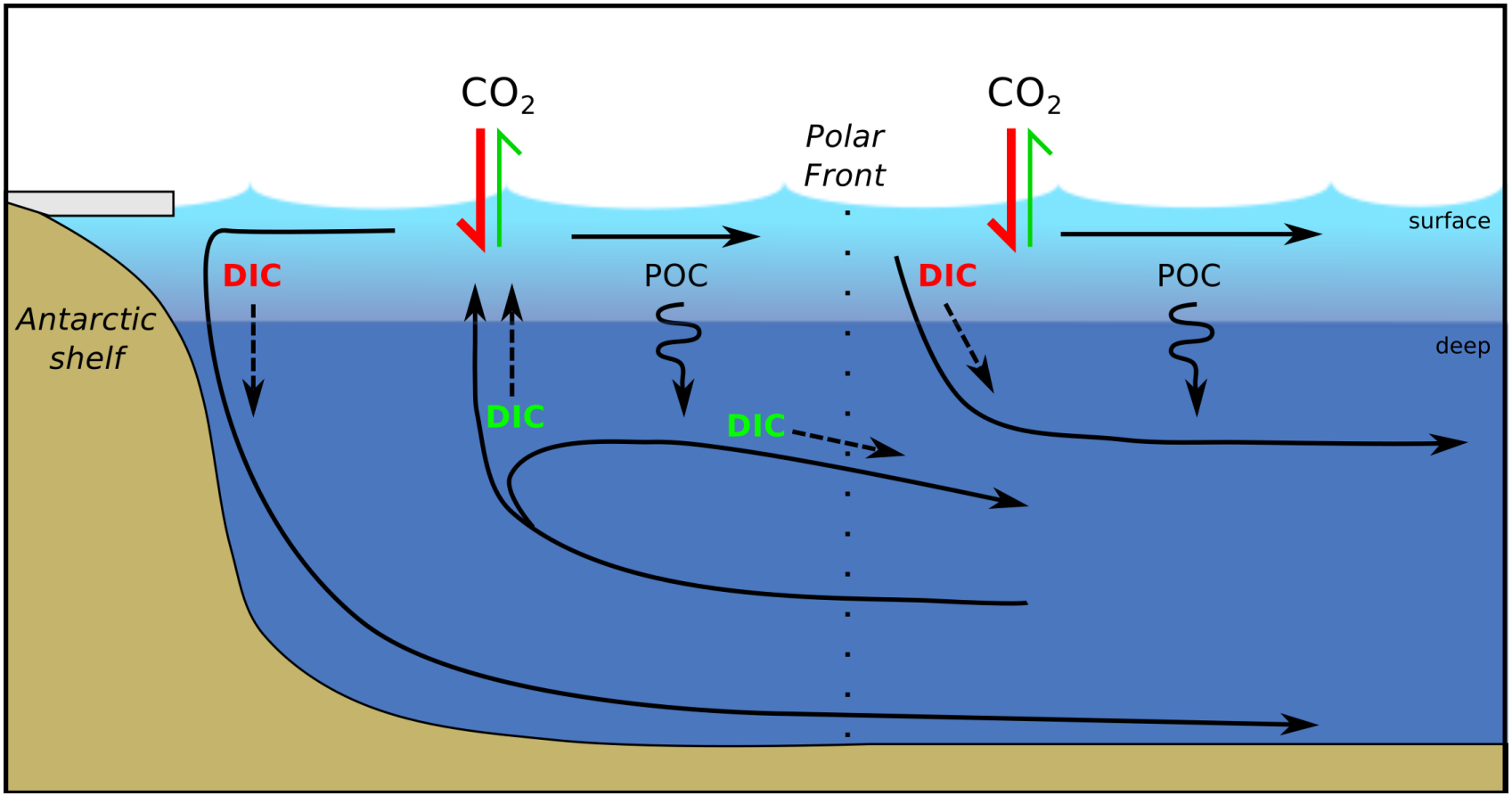
HELMHOLTZ ASSOCIATION

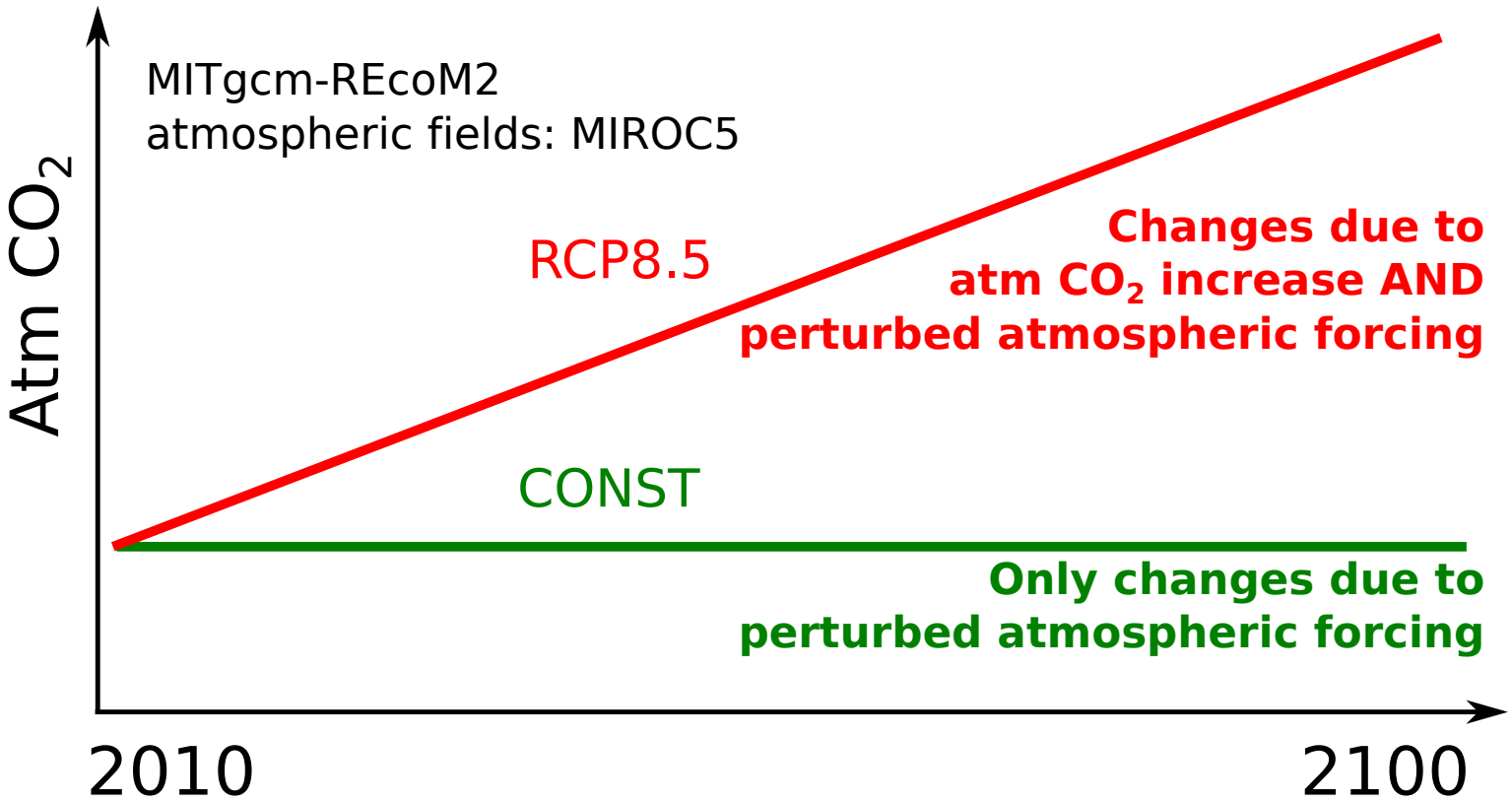
CarboChange meeting, Bergen
21 January 2015

CARBOCHANGE

THE SOUTHERN OCEAN

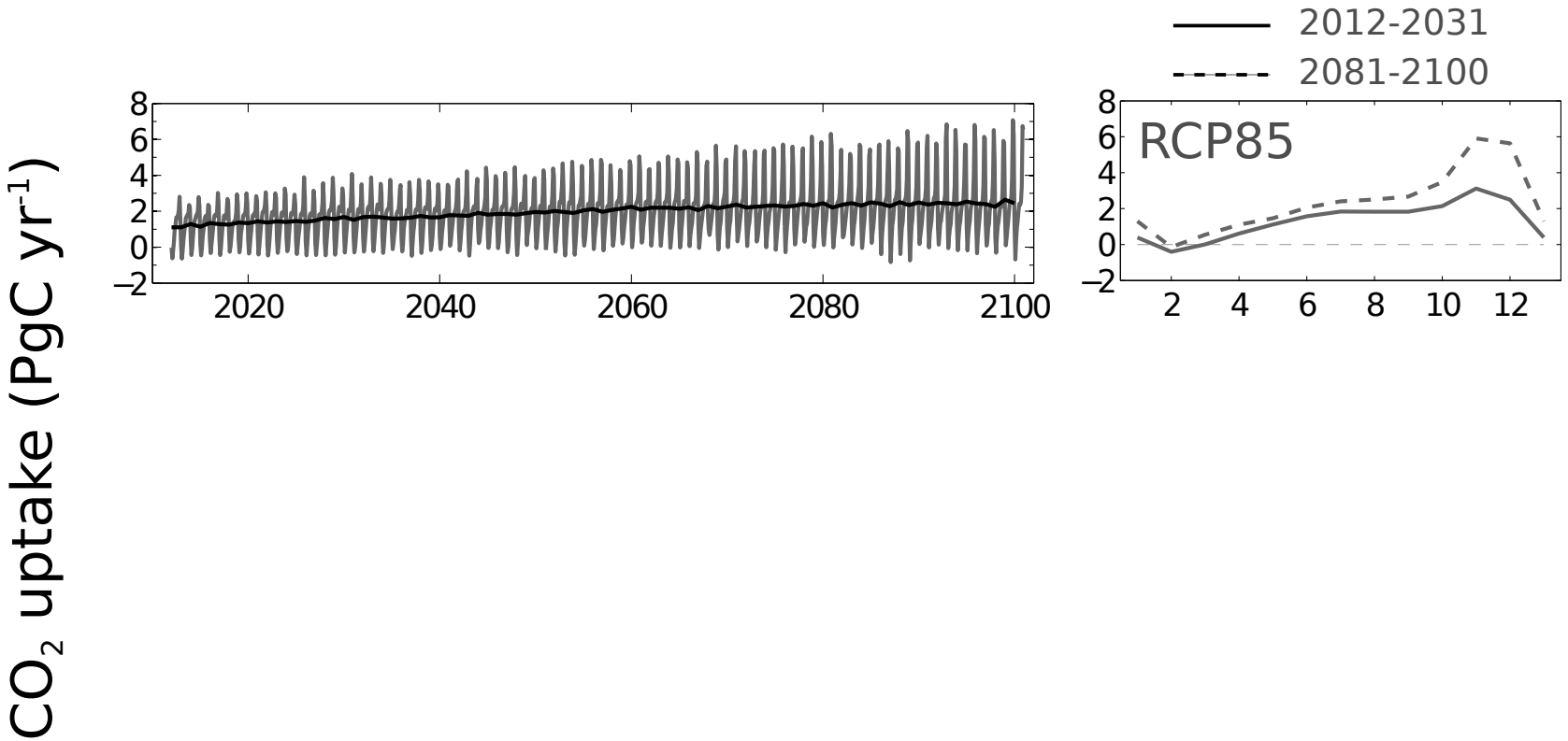


MODEL RUNS


MITgcm-REcoM2
atmospheric fields: MIROC5
Atm CO_2
RCP8.5
Changes due to
atm CO_2 increase AND
perturbed atmospheric forcing
CONST
Only changes due to
perturbed atmospheric forcing
2010
2100

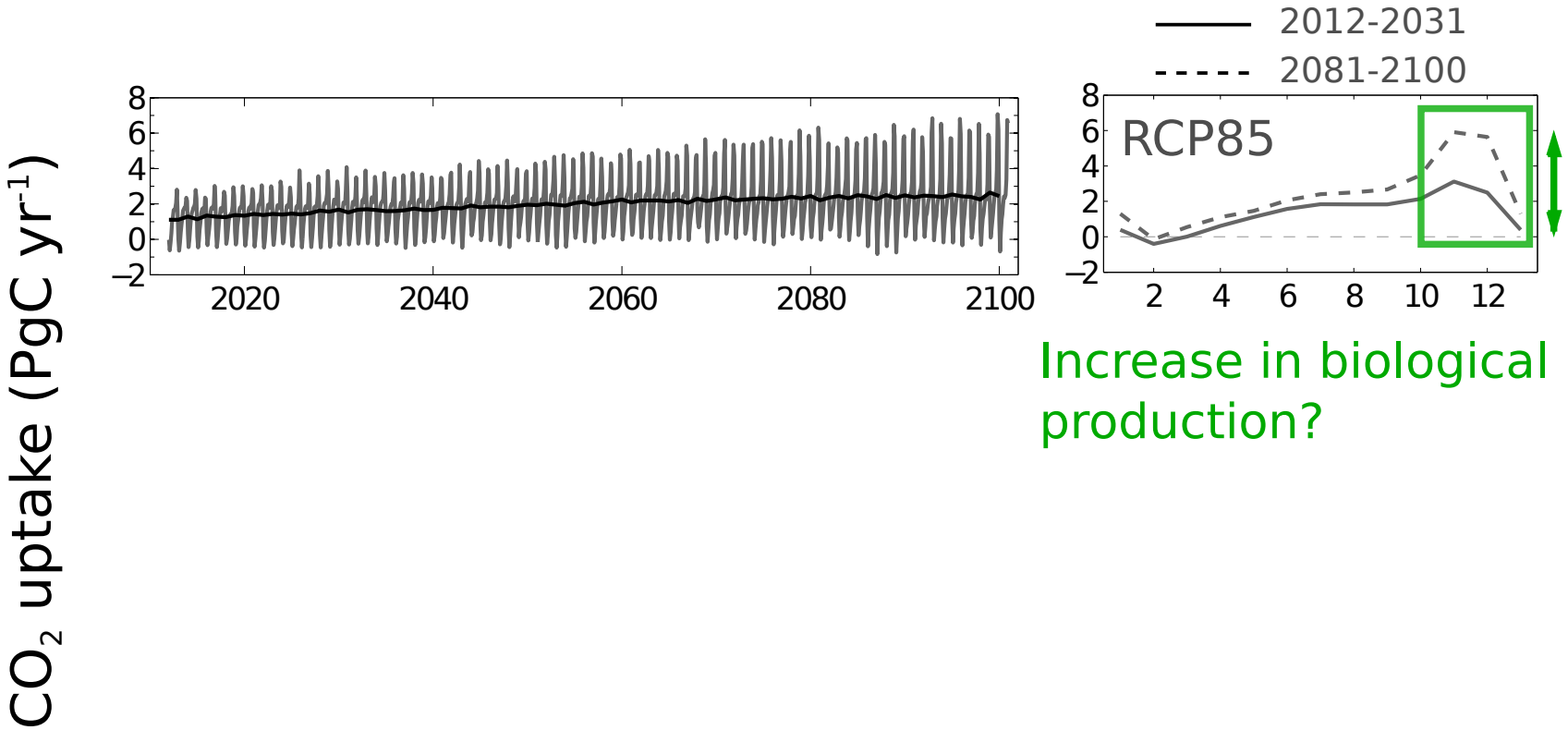
MITgcm-RECOM2 FUTURE SIMULATION

CO_2 UPTAKE, SOUTH OF 30°S



MITgcm-RECOM2 FUTURE SIMULATION

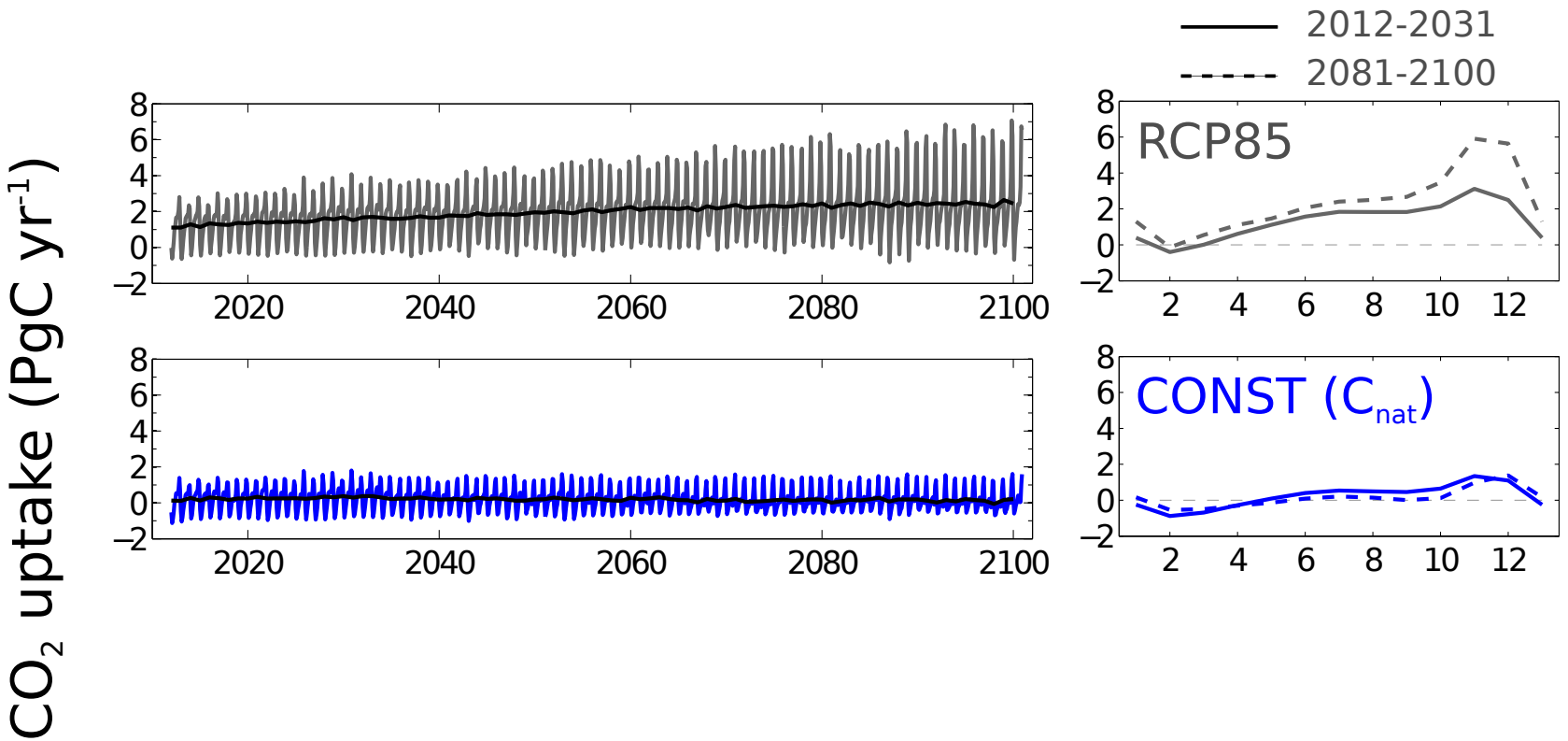
CO_2 UPTAKE, SOUTH OF 30°S



Increase in biological production?

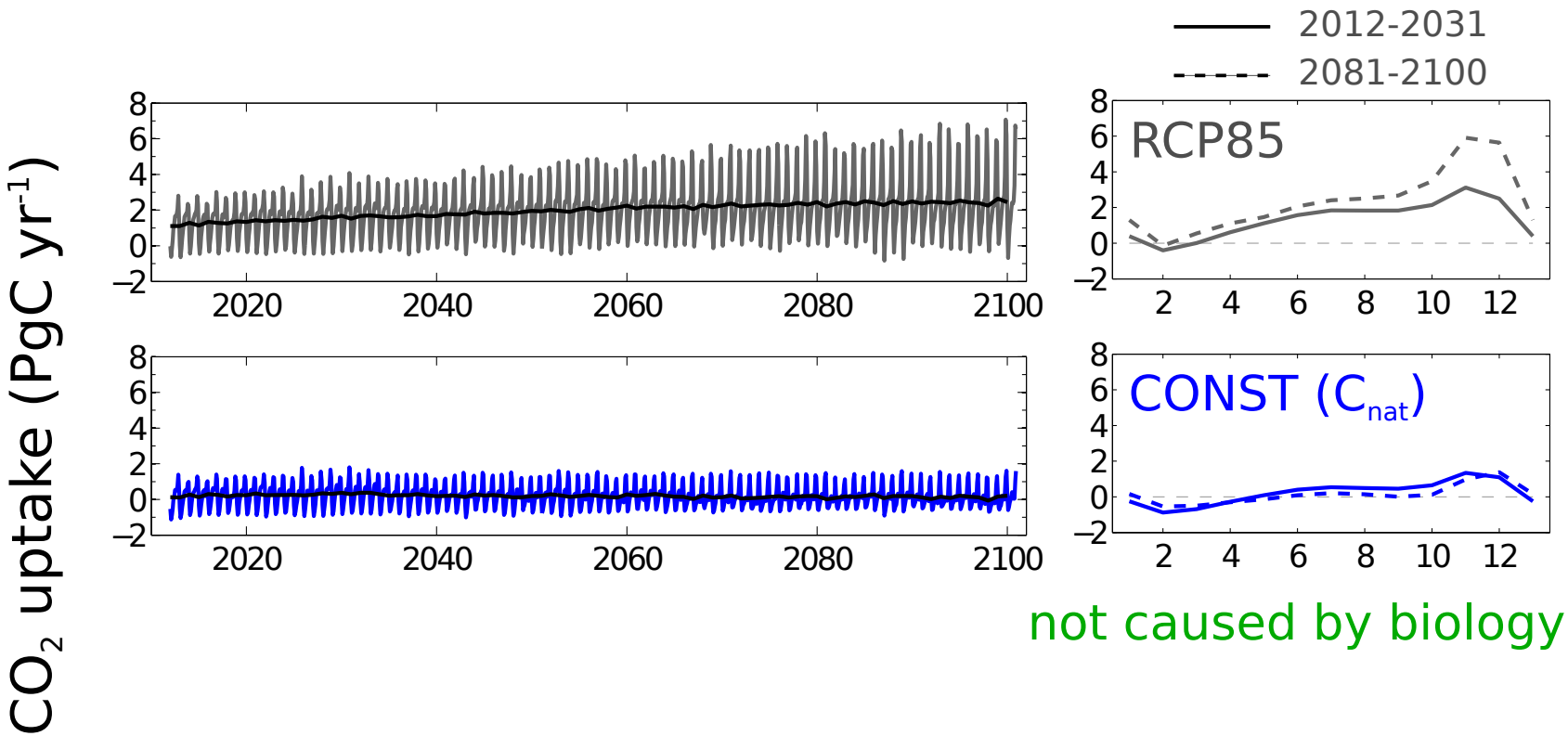
MITgcm-RECOM2 FUTURE SIMULATION

CO_2 UPTAKE, SOUTH OF 30°S



MITgcm-RECOM2 FUTURE SIMULATION

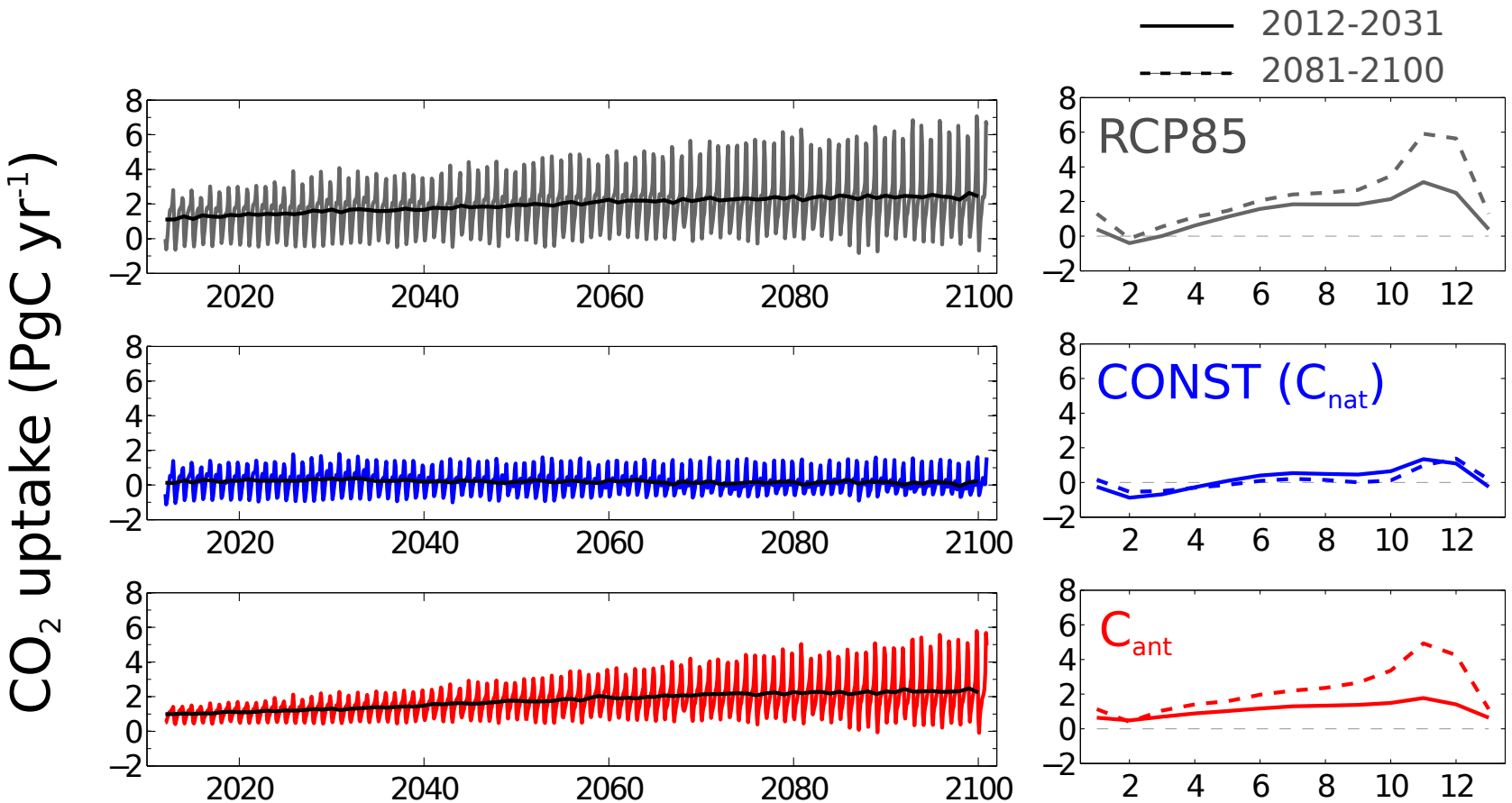
CO_2 UPTAKE, SOUTH OF 30°S



not caused by biology

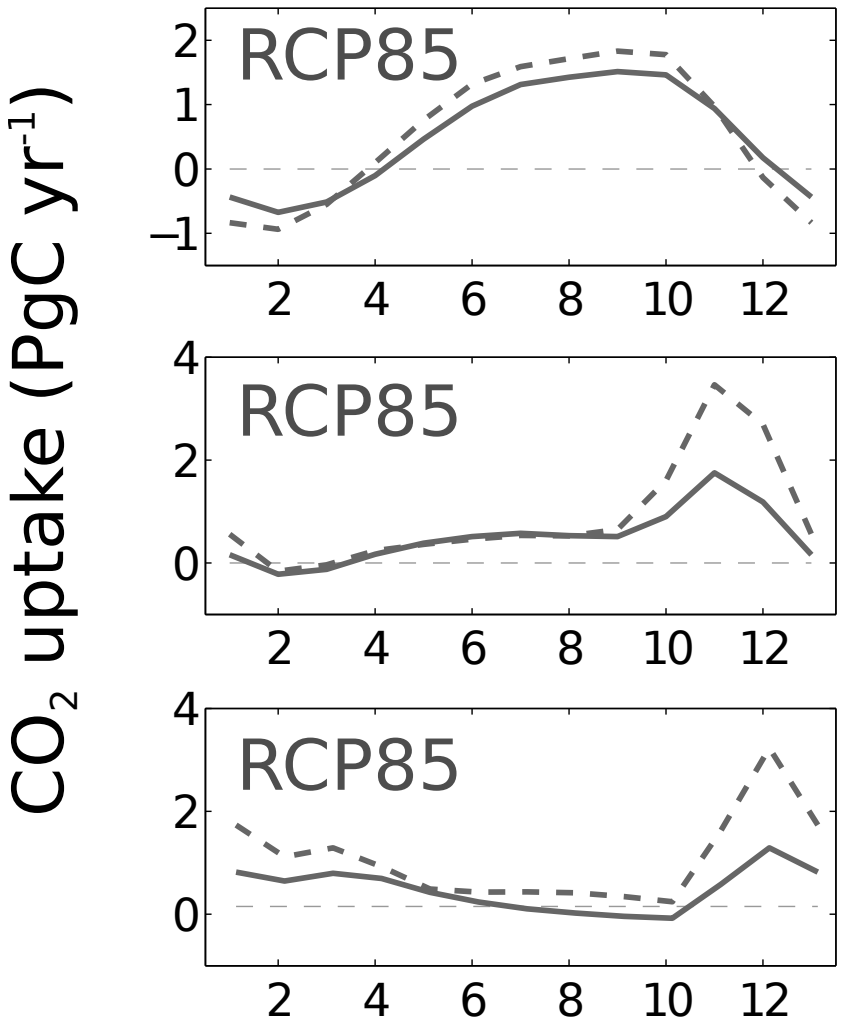
MITgcm-RECOM2 FUTURE SIMULATION

CO_2 UPTAKE, SOUTH OF 30°S



MITgcm-RECOM2 FUTURE SIMULATION

CO_2 UPTAKE, SUBREGIONS



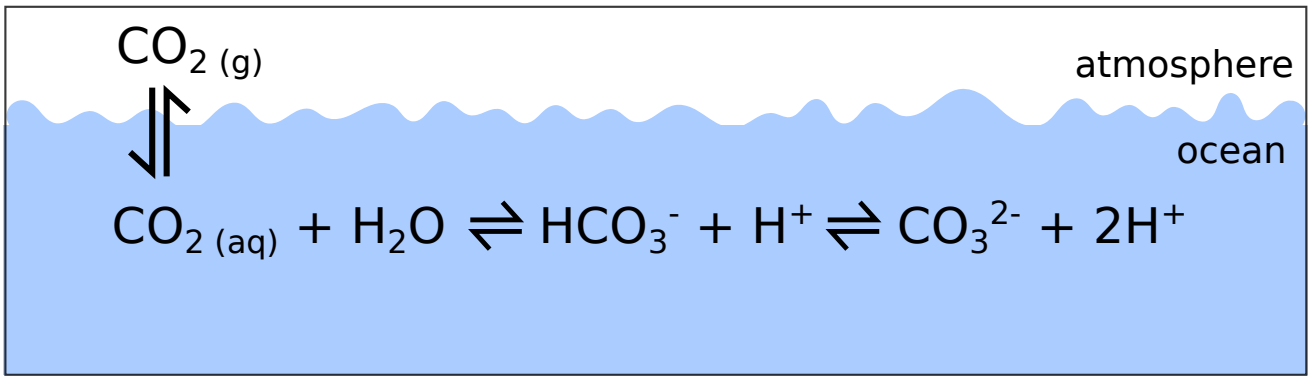
30 - 44°S

44 - 58°S

Large effect south of 44°S

< 58°S

Buffer factor



Revelle factor:
ratio of the relative change of $CO_{2\ (aq)}$ to the relative change of DIC

BUFFER FACTOR

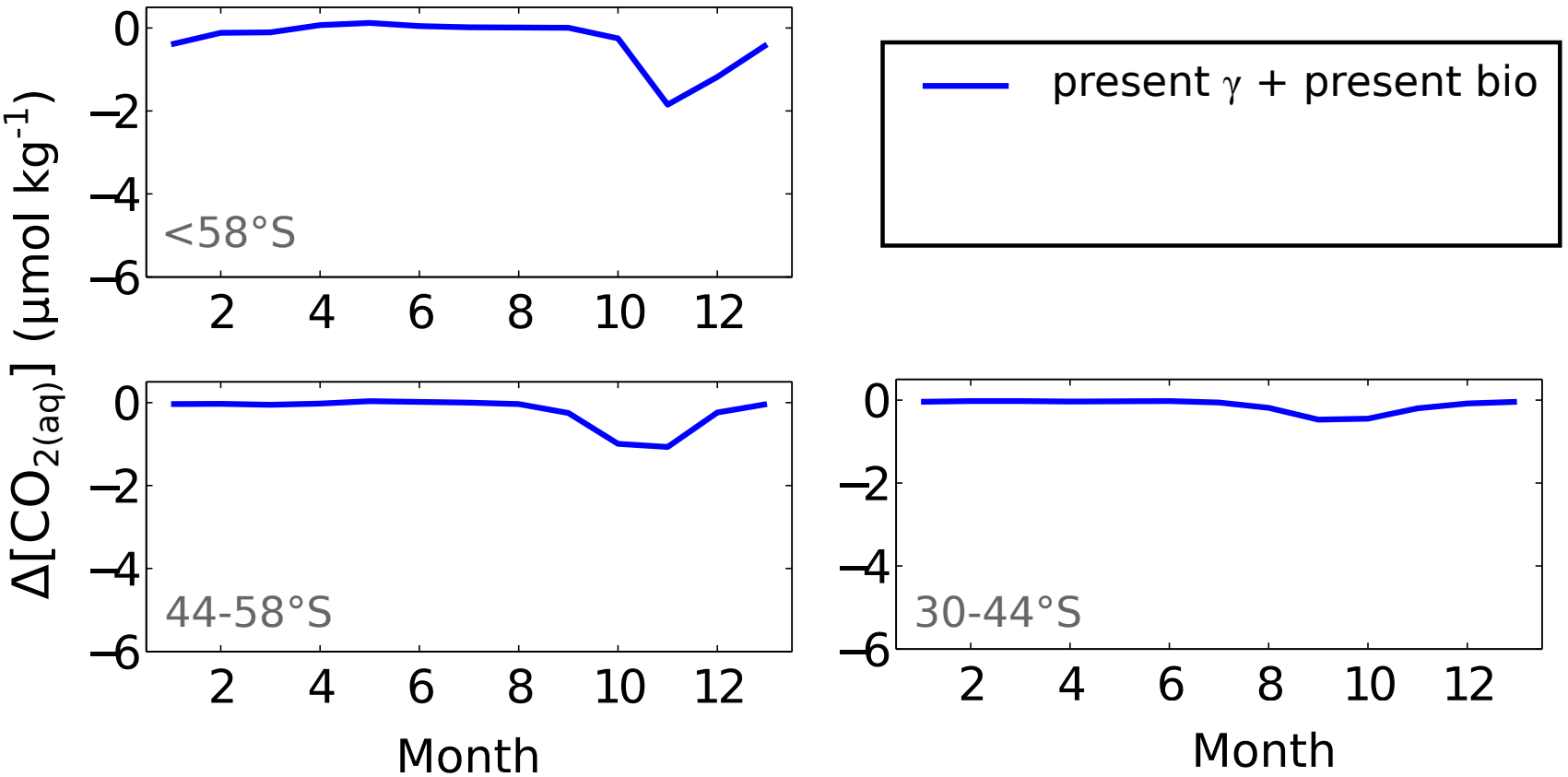
GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 24, GB1002, doi:10.1029/2008GB003407, 2010

Revelle revisited: Buffer factors that quantify the response of ocean chemistry to changes in DIC and alkalinity

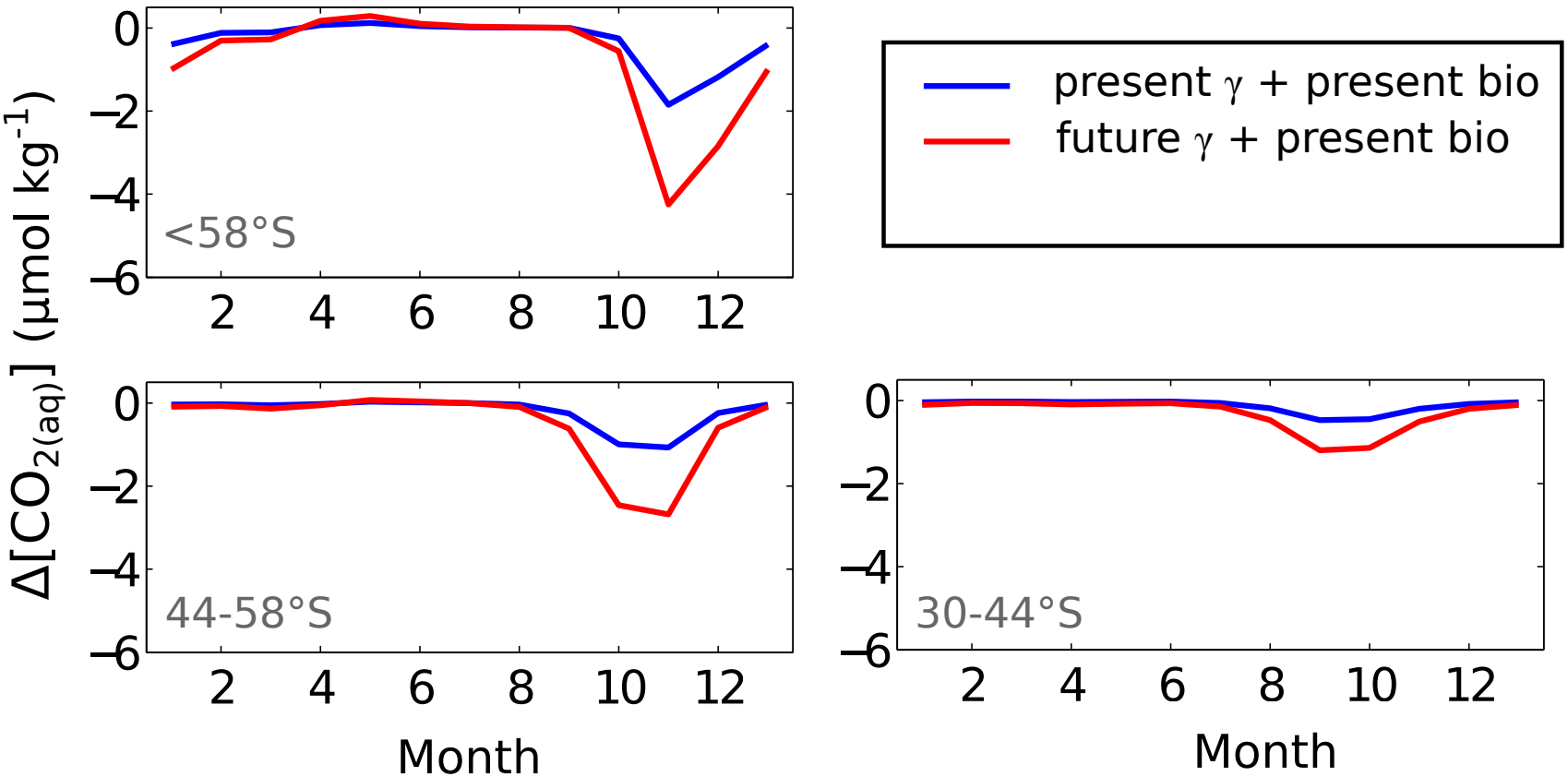
Eric S. Egleston,[1] Christopher L. Sabine,[2] and François M. M. Morel[1]

"So in such an ocean, the chemistry of surface seawater becomes much more sensitive to local variations in DIC and Alk. For example diurnal and seasonal variations in pH and Ω caused by photosynthesis and respiration would be increased by more than 40% and 60%, respectively, compared to present. For the same reason, export production would play an increasingly efficient role in controlling [CO_2] at the surface."

EFFECT OF BUFFER FACTOR ON $CO_{2(aq)}$



EFFECT OF BUFFER FACTOR ON $CO_{2(aq)}$



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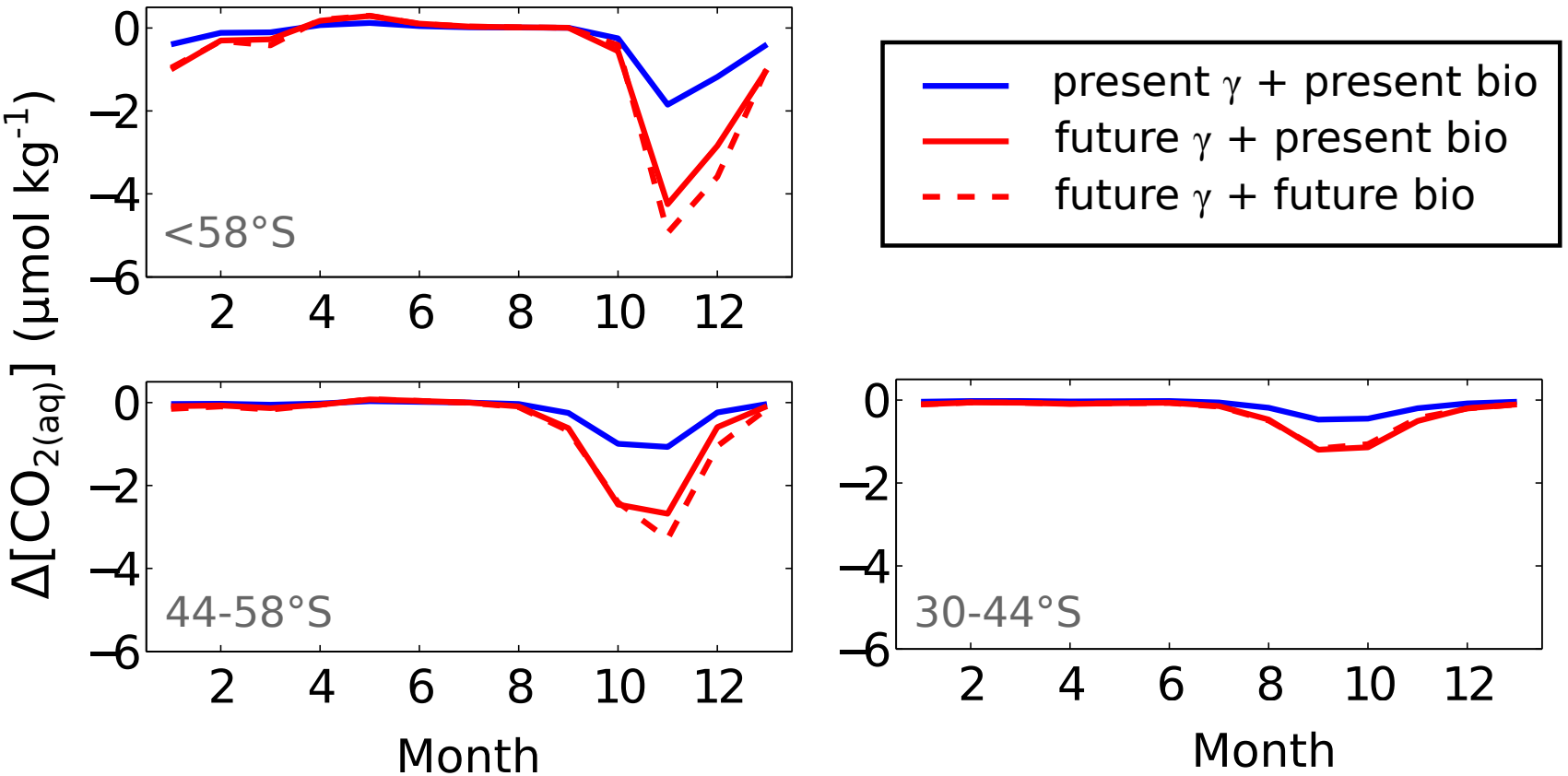
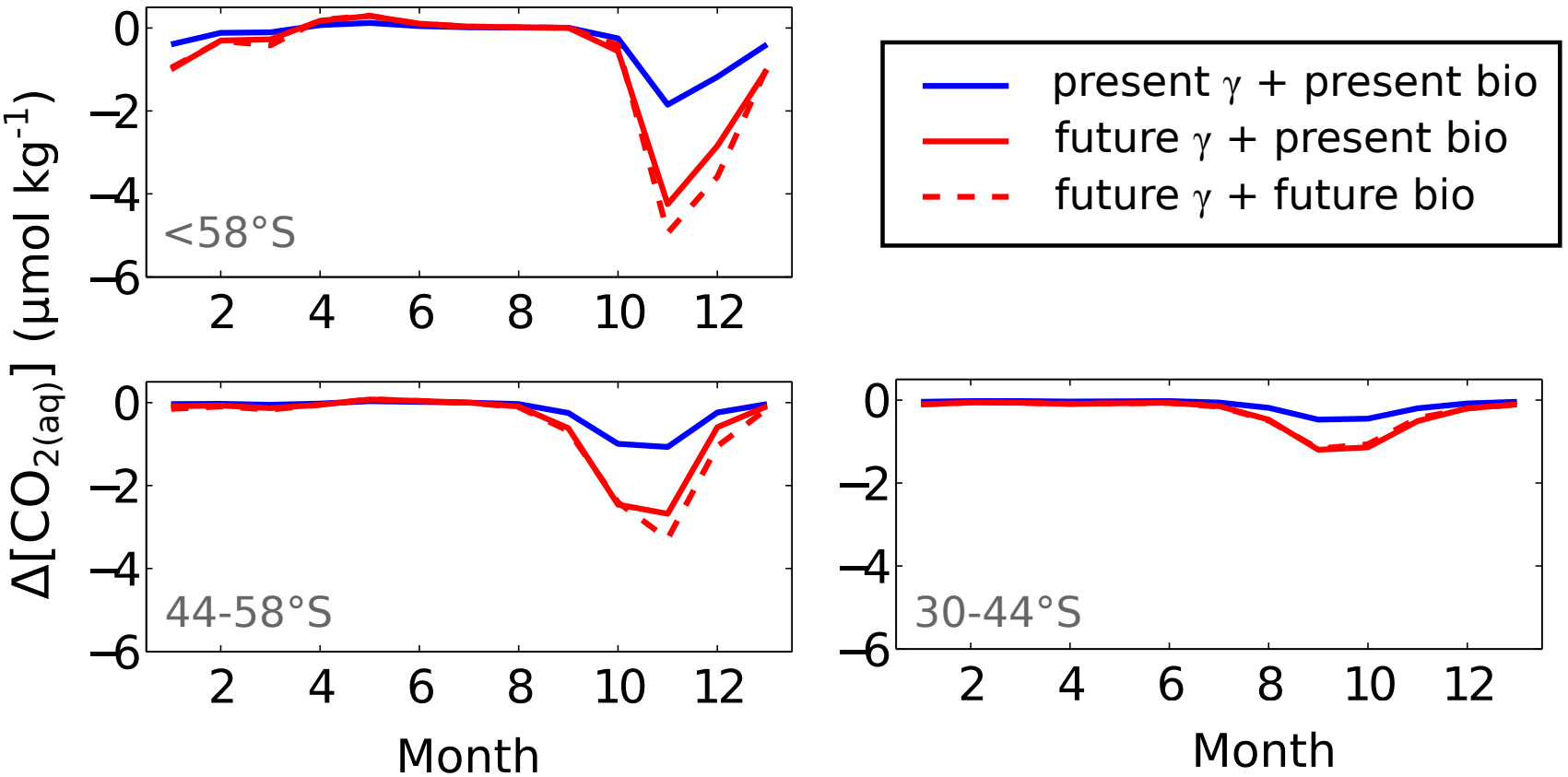


EFFECT OF BUFFER FACTOR ON $CO_{2(aq)}$



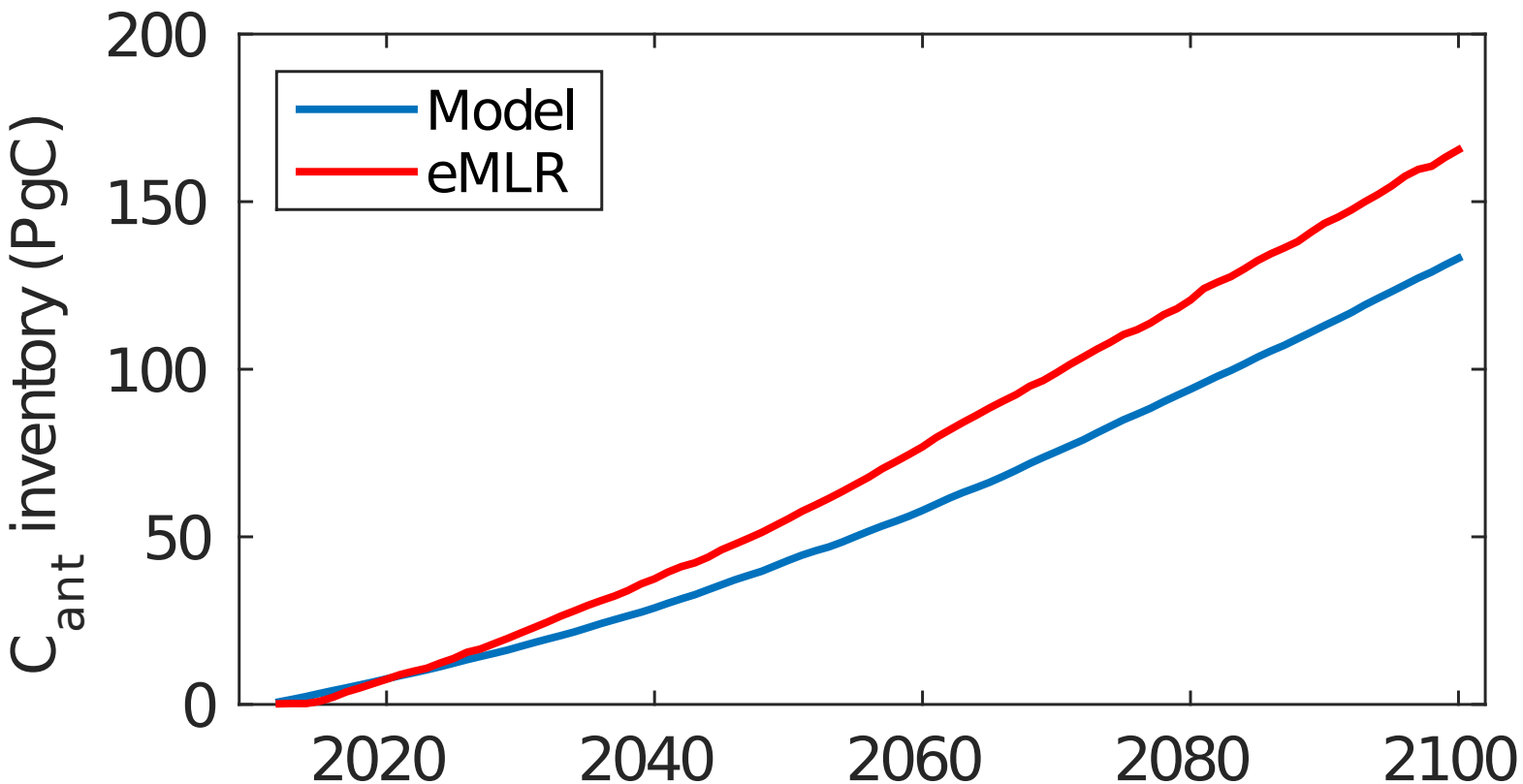
Increasing Revelle factor (decreasing buffer capacity) of the ocean interacts with biology and leads to more CO_2 uptake per DIC draw-down by biology

Implications

- Generally less C_{ant} uptake at higher Revelle factor - but larger C_{ant} uptake in regions with high seasonality
- Total $CO_{2(aq)}$ draw-down more than doubles only due to the change in the buffer factor.
- Larger contribution of southern Southern Ocean to total CO_2 uptake (also in MAREMIP/CMIP5 models, see poster!)
- This effect leads to a strong and increasing seasonality of C_{ant} uptake
- Back-calculation techniques that assume constant relationship between biological DIC draw-down and CO_2 uptake might become (more) biased in the future

IMPLICATIONS

- Back-calculation techniques that assume constant relationship between biological DIC draw-down and CO_2 uptake might become (more) biased in the future



IMPLICATIONS

GEOPHYSICAL RESEARCH LETTERS, VOL. ???, XXXX, DOI:10.1029/,

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Revelle factor