Geosci. Model Dev., 10, 2567–2590, 2017
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Geoscientific Model Development
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EGU

The carbon cycle in the Australian Community Climate and Earth System Simulator (ACCESS-ESM1) – Part 1: Model description and pre-industrial simulation

Rachel M. Law[1], Tilo Ziehn[1], Richard J. Matear[2], Andrew Lenton[2], Matthew A. Chamberlain[2], Lauren E. Stevens[1], Ying-Ping Wang[1], Jhan Srbinovsky[1], Daohua Bi[1], Hailin Yan[1,a], and Peter F. Vohralik[3]

Geosci. Model Dev., 11, 1133–1160, 2018
https://doi.org/10.5194/gmd-11-1133-2018

The Carbon Dioxide Removal Model Intercomparison Project (CDRMIP): rationale and experimental protocol for CMIP6

David P. Keller[1], Andrew Lenton[2,3], Vivian Scott[4], Naomi E. Vaughan[5], Nico Bauer[6], Duoying Ji[7], Chris D. Jones[8], Ben Kravitz[9], Helene Muri[10], and Kirsten Zickfeld[11]

OCEANS AND ATMOSPHERE
www.csiro.au

Ocean Reversibility: Results from ACCESS –ESM1

Andrew Lenton, Tilo Ziehn, CSIRO O&A, ACE CRC, CSHOR

CSIRO

What is CDR-MIP?

An initiative that brings together a suite of Earth System Models (ESMs) and Earth System Models of Intermediate Complexity (EMICs) in a common framework to investigate Carbon Dioxide Removal (CDR)

Exploring:

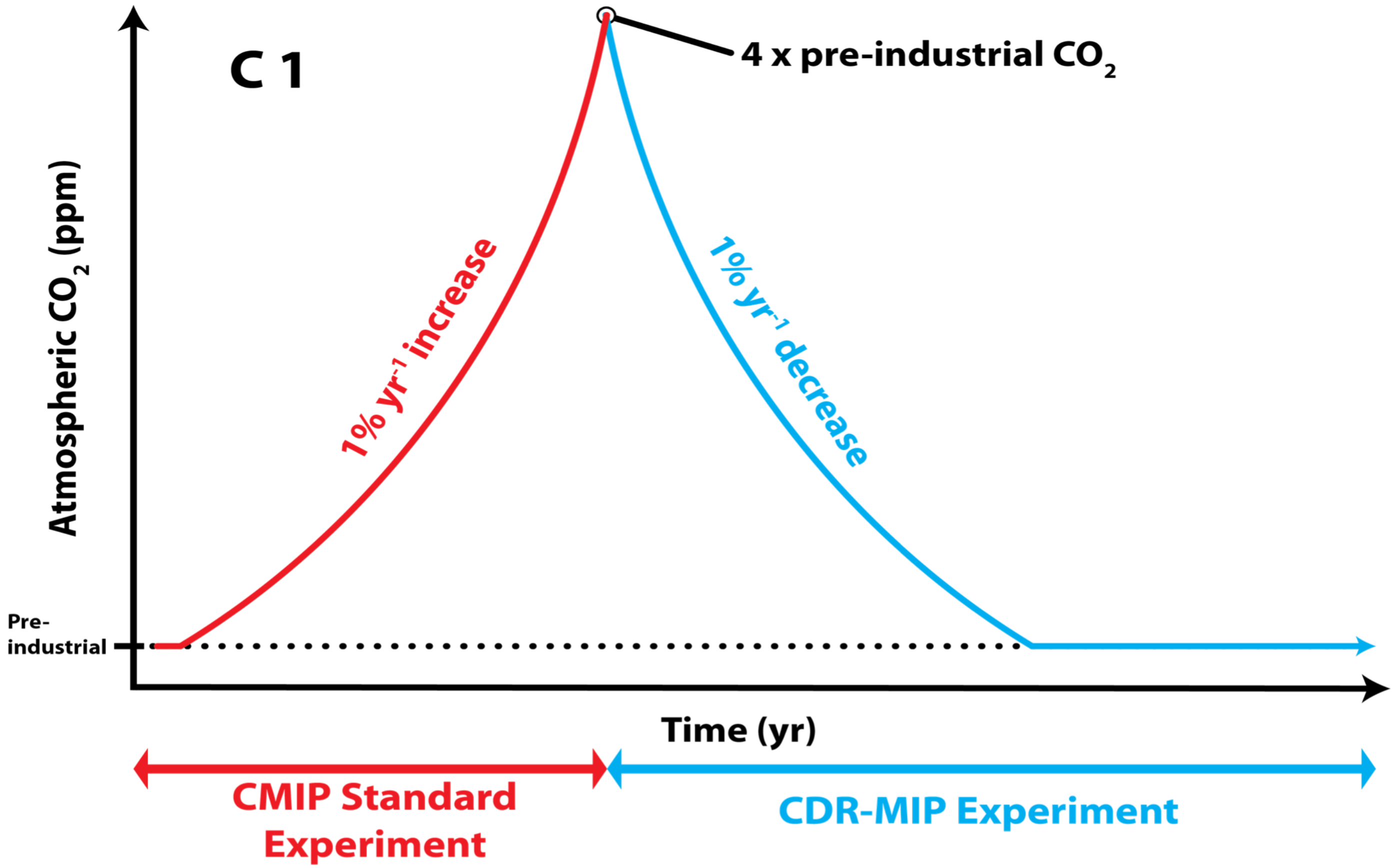
•The degree to which CDR could mitigate or even reverse climate change

•The potential risk/benefits of different proposed CDR

•To inform how climate and carbon cycle responses to CDR could be included when calculated and accounting for the contribution of CDR in mitigation scenarios

Endorsed CMIP6 - MIP

CDR-MIP Experiment *CDR-Reversibility*



Framework to consider overshoot

CDR-MIP Experiment *CDR-Reversibility*

IOP PUBLISHING ENVIRONMENTAL RESEARCH LETTERS
Environ. Res. Lett. **7** (2012) 024013 (9pp) doi:10.1088/1748-9326/7/2/024013

Reversibility in an Earth System model in response to CO_2 concentration changes

O Boucher[1], P R Halloran, E J Burke, M Doutriaux-Boucher[2], C D Jones, J Lowe, M A Ringer, E Robertson and P Wu

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24 March 2016
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LETTER

Simulating the Earth system response to negative emissions

C D Jones[1], P Ciais[2], S J Davis[3], P Friedlingstein[4], T Gasser[2,5], G P Peters[6], J Rogelj[7,8], D P van Vuuren[9,10], J G Canadell[11], A Cowie[12], R B Jackson[13], M Jonas[14], E Kriegler[15], E Littleton[16], J A Lowe[1], J Milne[17], G Shrestha[18], P Smith[19], A Torvanger[6] and A Wiltshire[1]

AGU PUBLICATIONS
Geophysical Research Letters
RESEARCH LETTER
10.1002/2015GL066160

A more productive, but different, ocean after mitigation

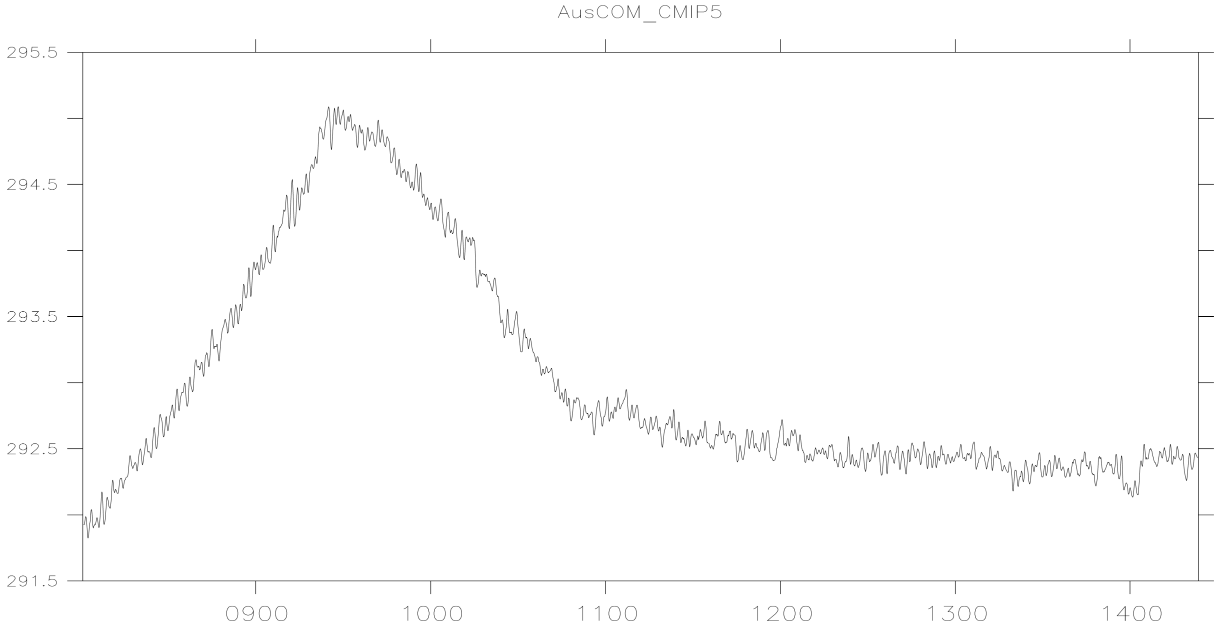
Jasmin G. John[1], Charles A. Stock[1], and John P. Dunne[1]
[1]Geophysical Fluid Dynamics Laboratory/NOAA, Princeton, New Jersey, USA

Key Points:
- Marine primary productivity exceeds

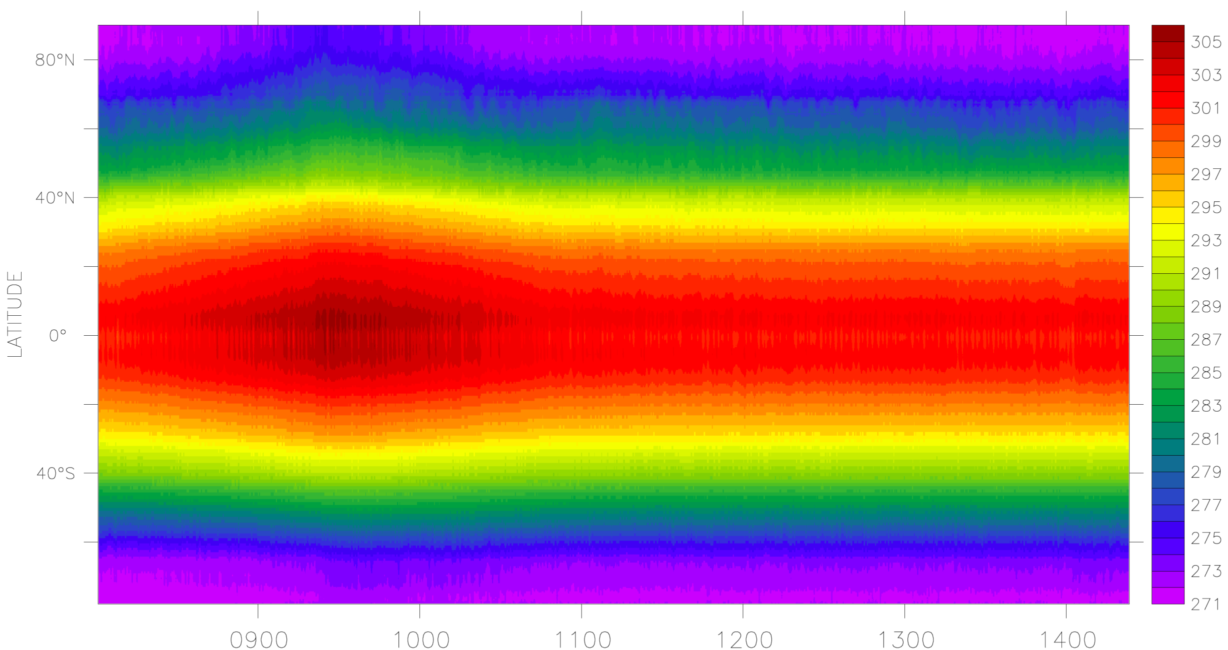
Consensus

CSIRO

CDR-Reversibility: SST

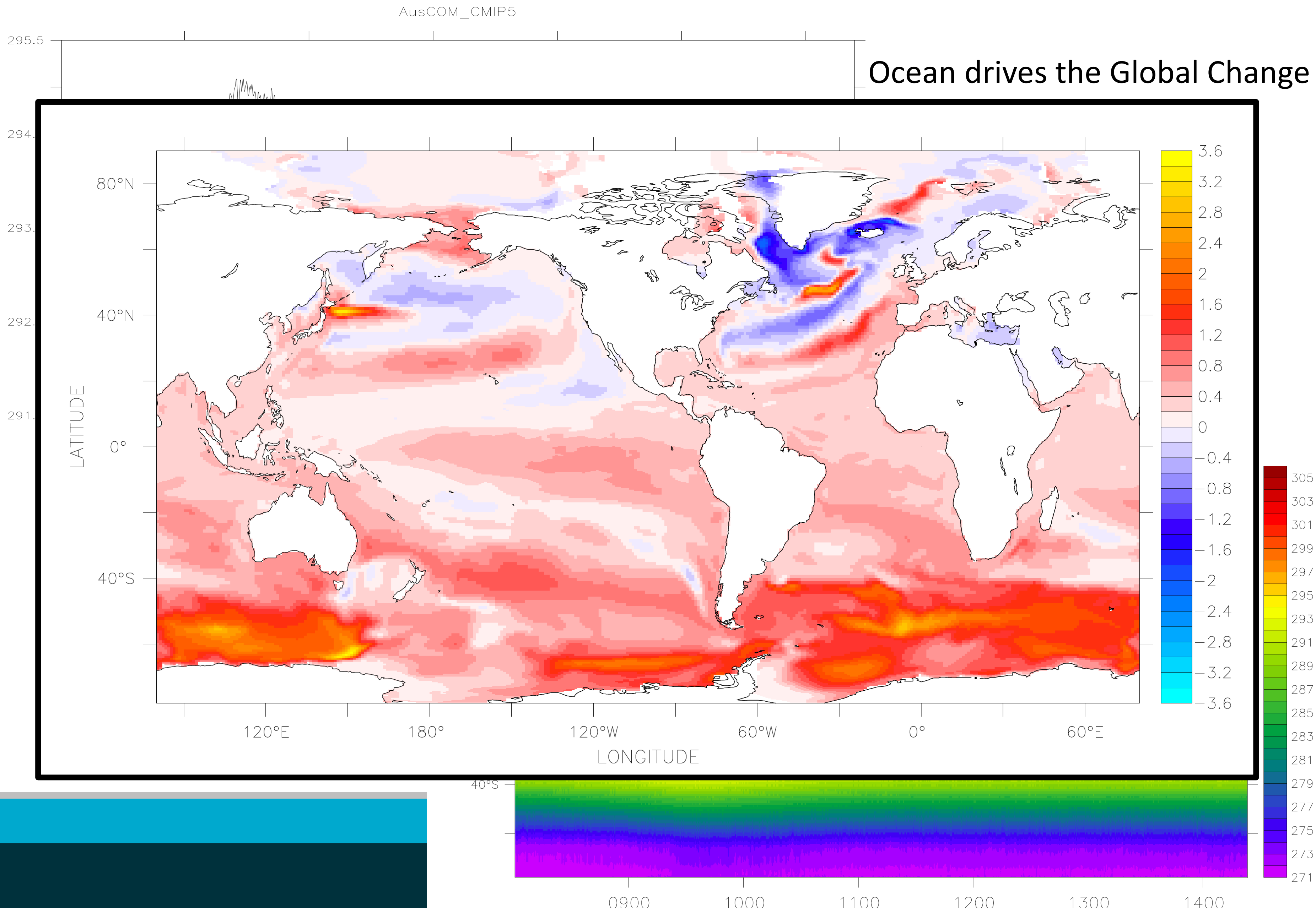


Ocean drives the Global Change

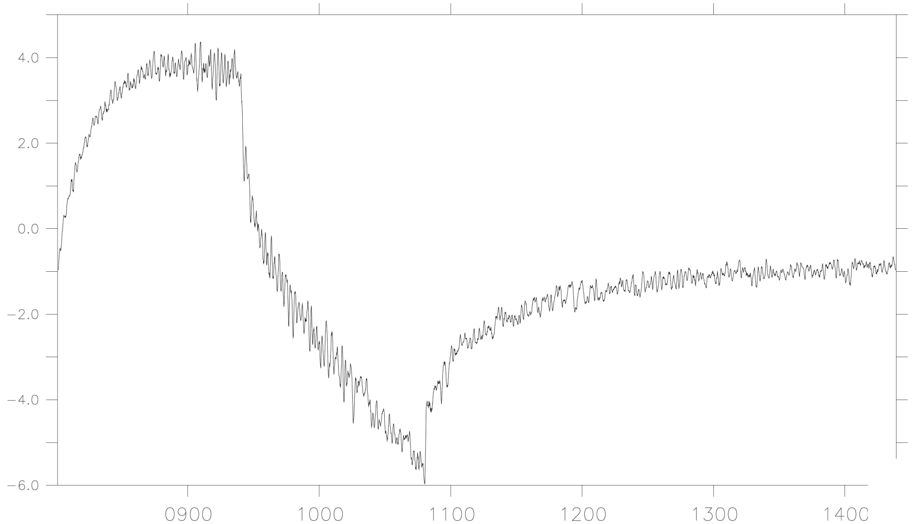


CDR-Reversibility: SST

Ocean drives the Global Change



CDR-Reversibility: CO_2 fluxes



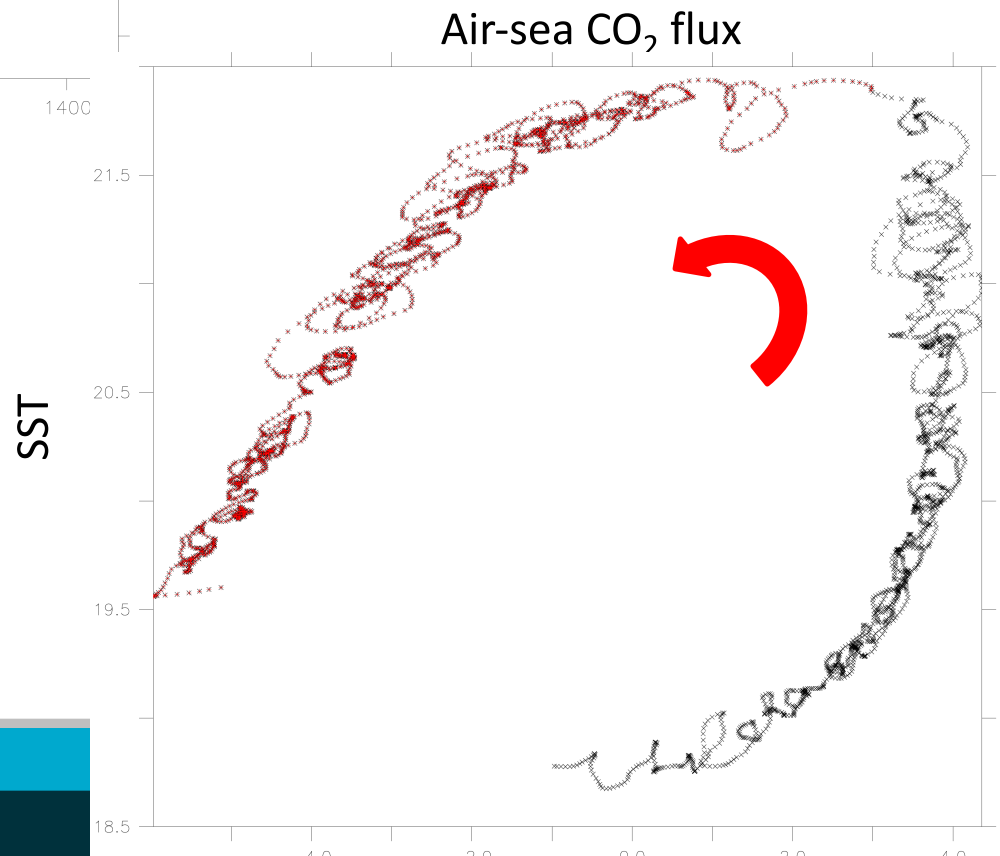
Air-sea CO_2 fluxes (PgC/yr)

Not in equilibrium

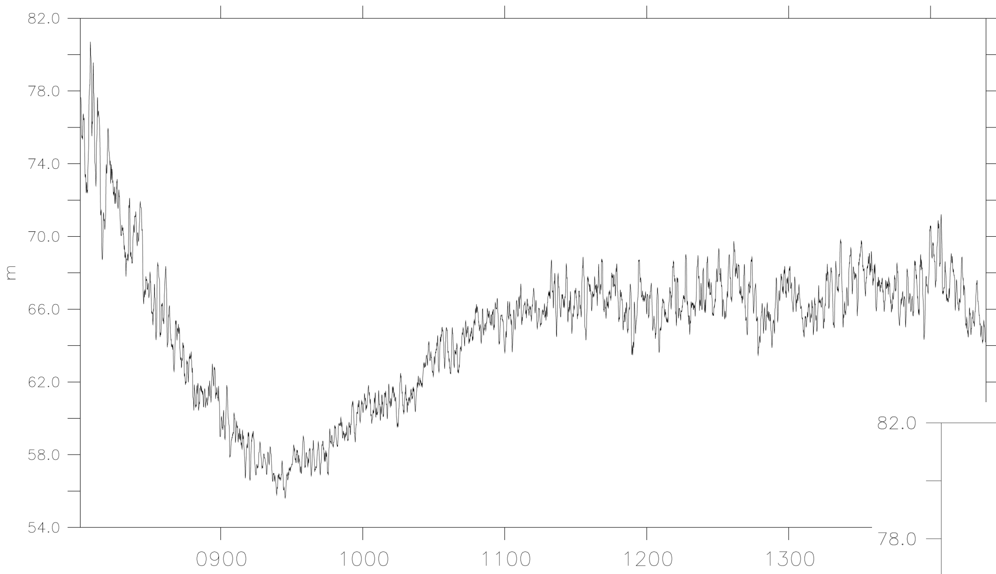
Outgassing the Tropics - pH

SST vs Air-sea CO_2 fluxes

Large hysteresis



CDR-Reversibility: MLD (0.03)



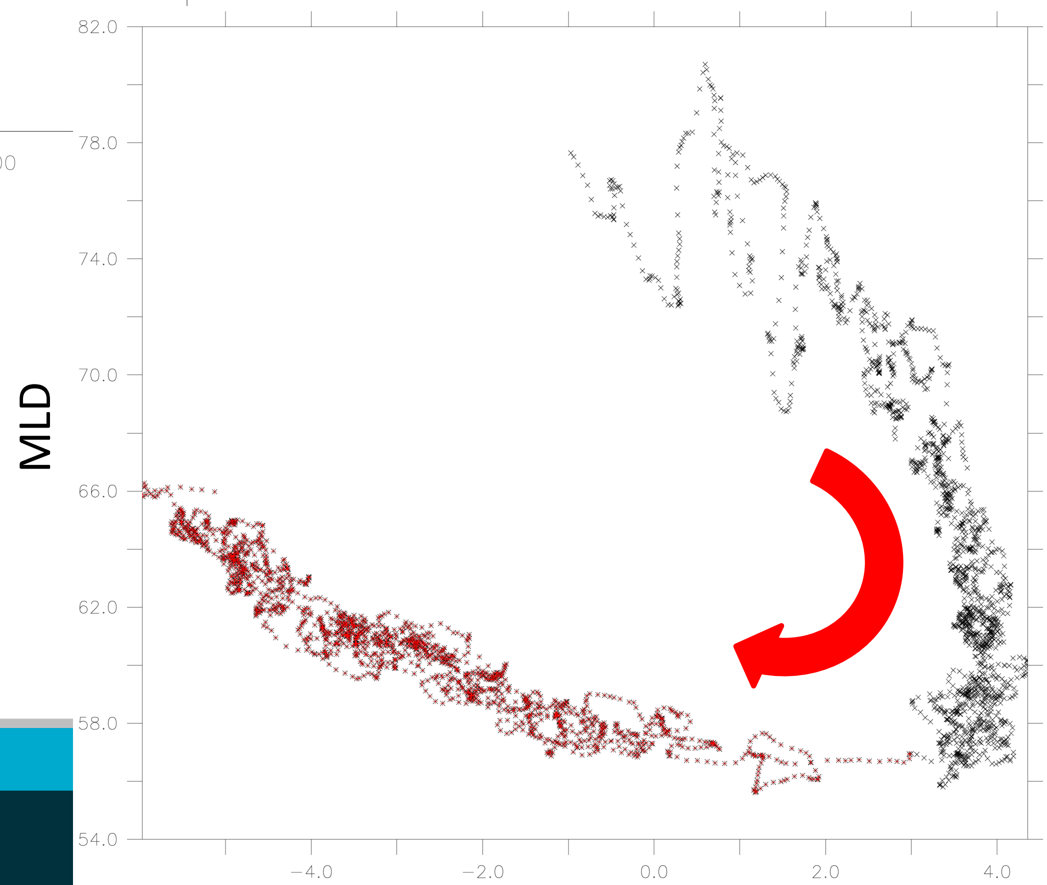
Decrease in MLD: Annually ~10m

Largest changes at higher lats

MLD vs Air-sea CO_2 fluxes

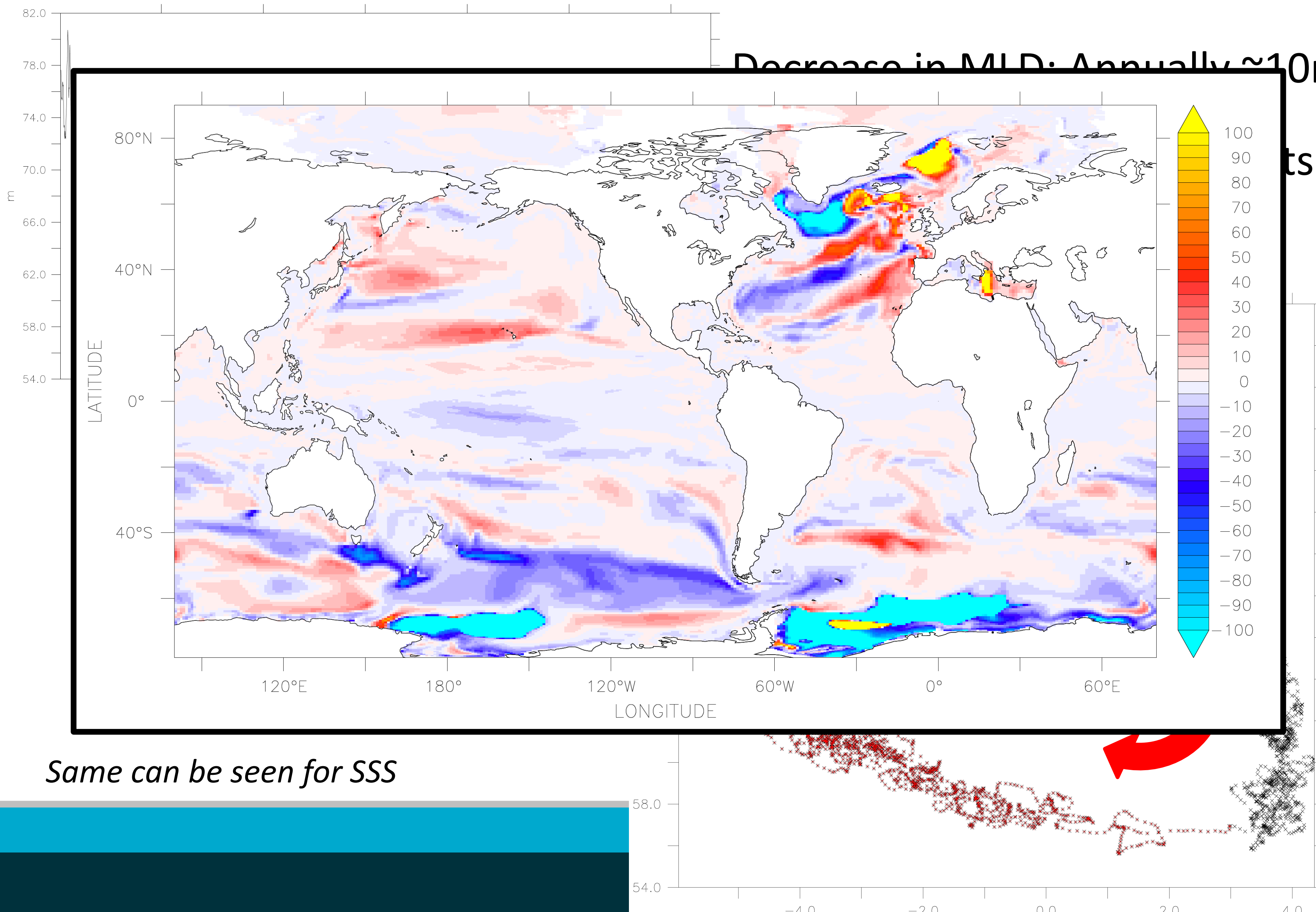
Large hysteresis

Same can be seen for SSS



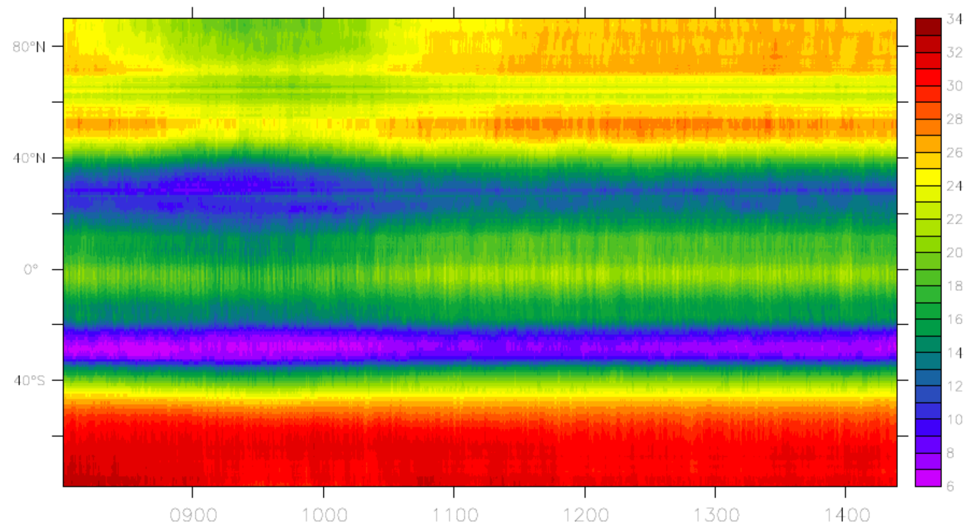
CDR-Reversibility: MLD (0.03)

Decrease in MLD: Annually ~10m



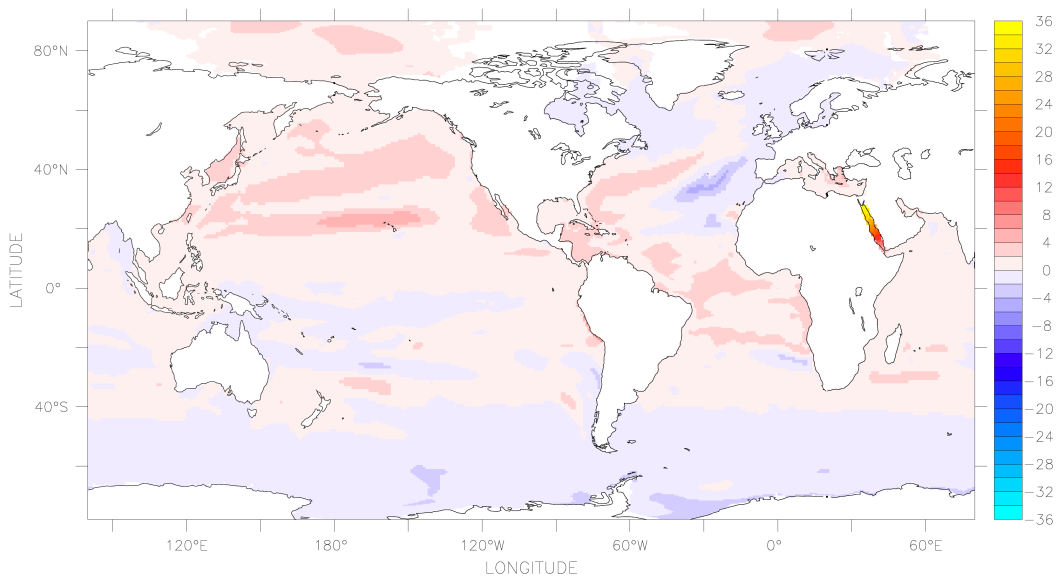
Same can be seen for SSS

CDR-Reversibility: Surface Nitrate

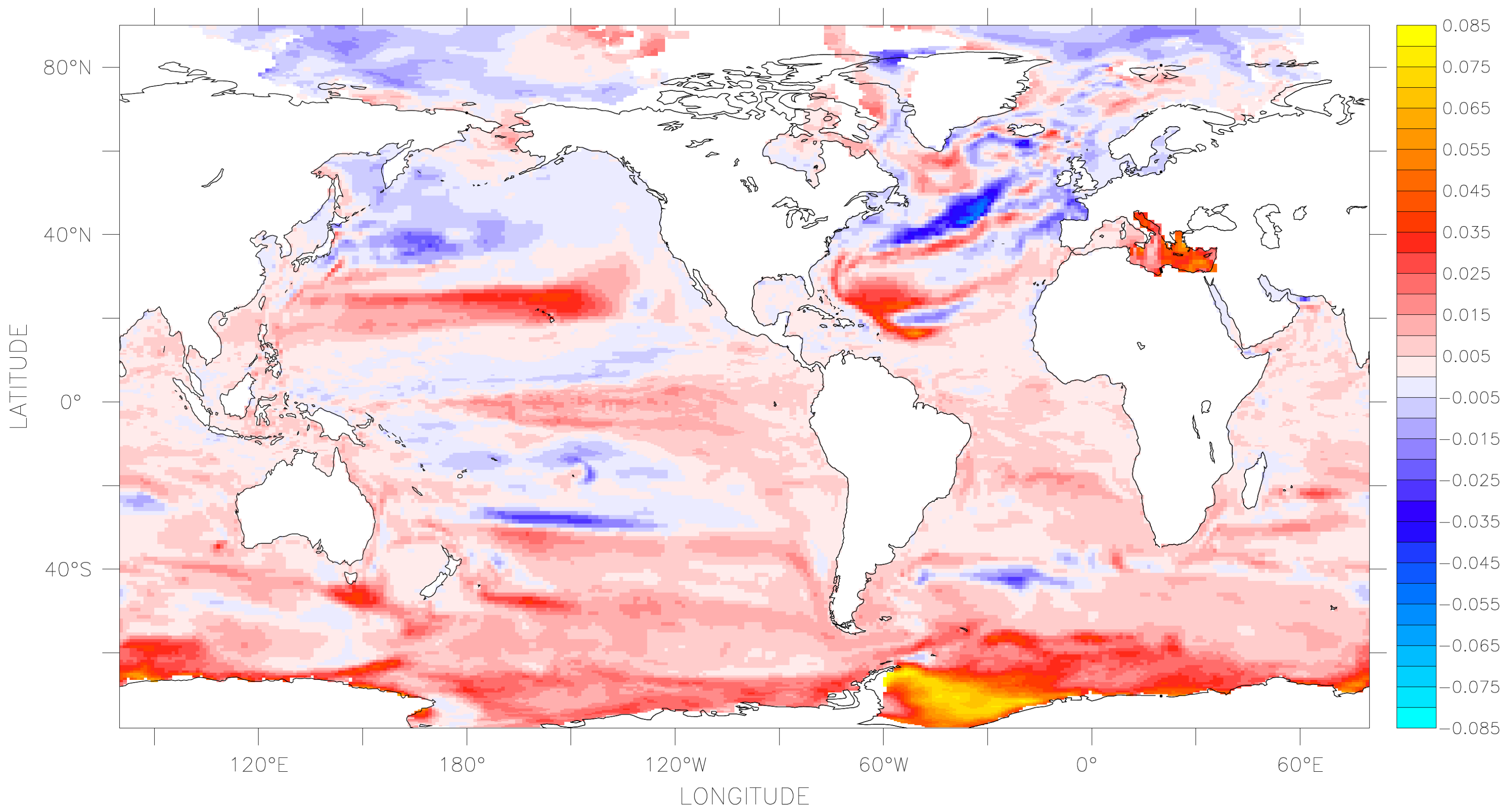


Imbalance between cooling subsurface and warming ocean -> slow return

300+ years after returning to PI



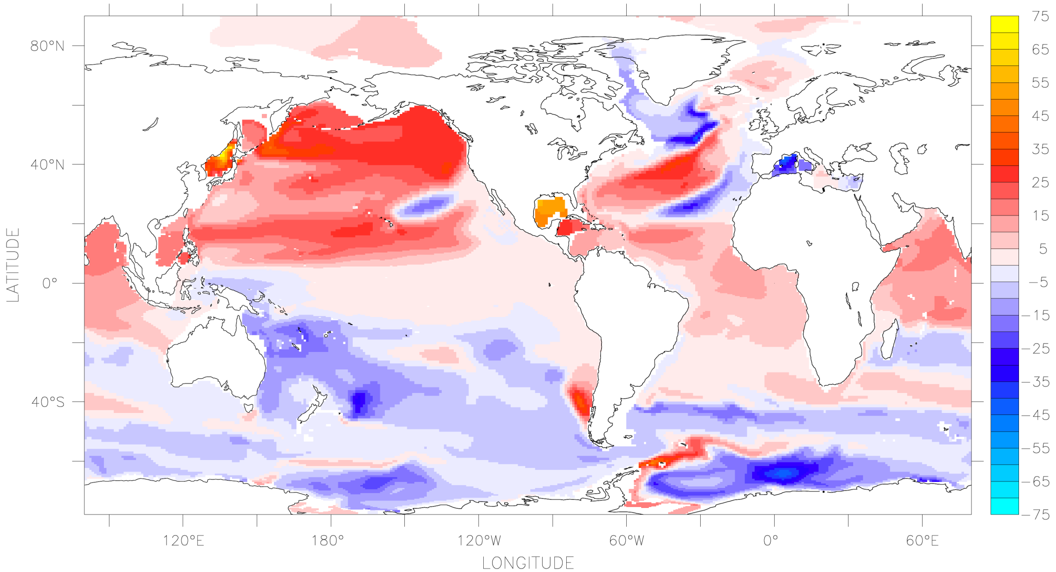
CDR-Reversibility: Surface Productivity



300+ years after returning to PI

?? Shifts in Structure
Marine Resources

CDR-Reversibility: Oxygen at 500m

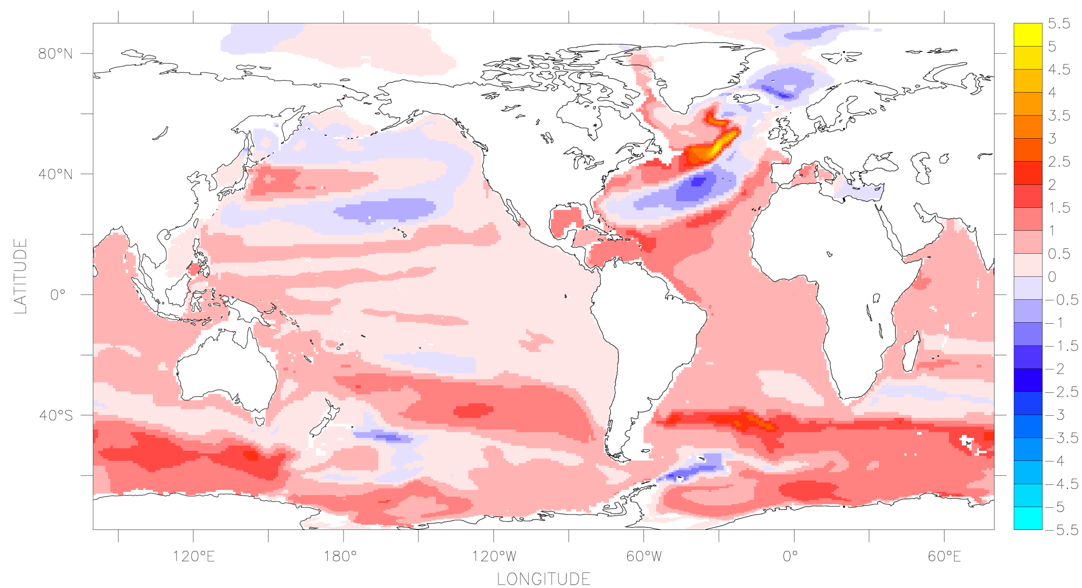


Oxygen

Oxygen at 500m

300+ years after returning to PI

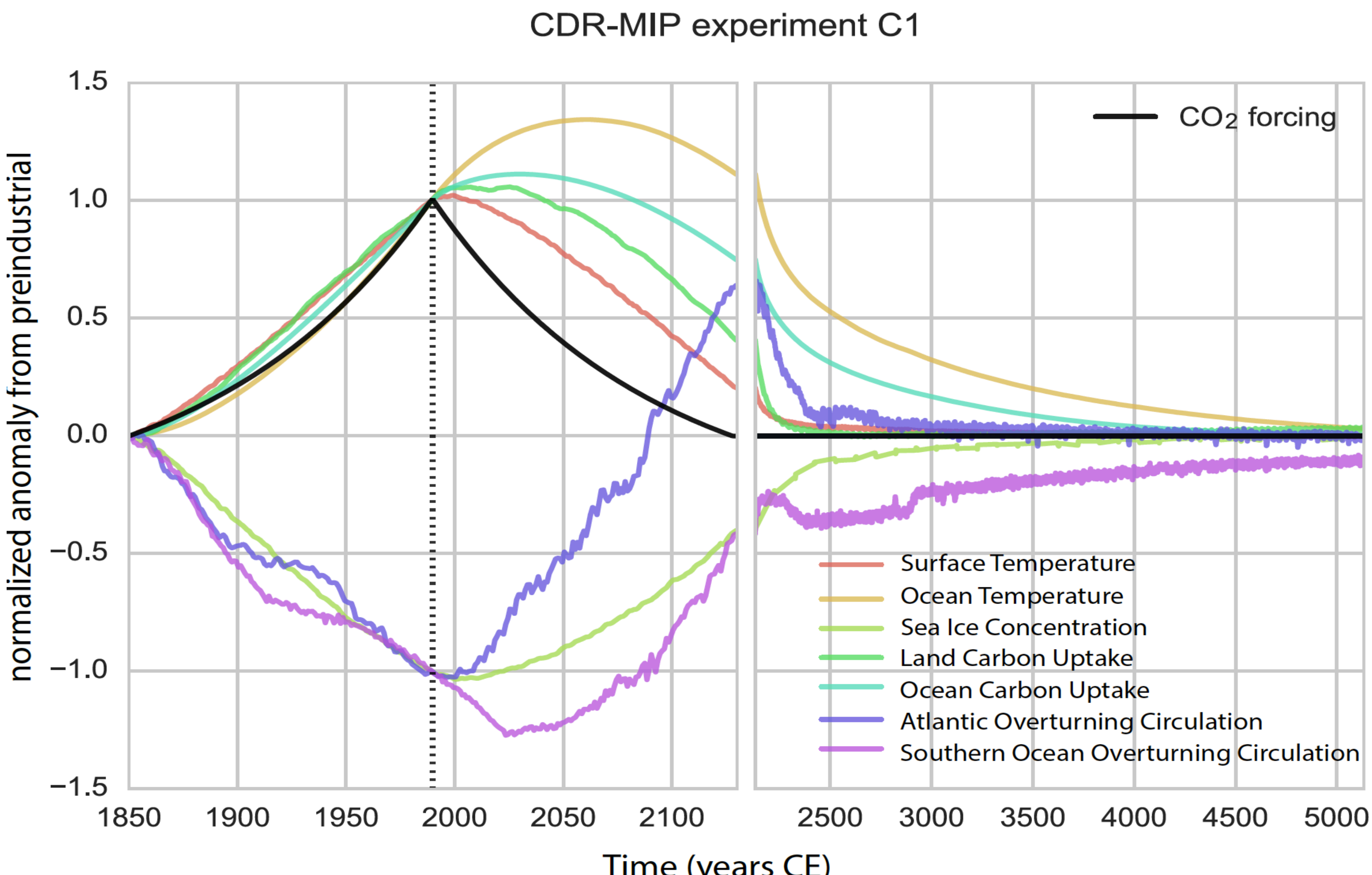
Temperature



Temperature at 500m

300+ years after returning to PI

CDR-MIP Experiment – *Time Scales*



Lenton et al (2017)

Thank you

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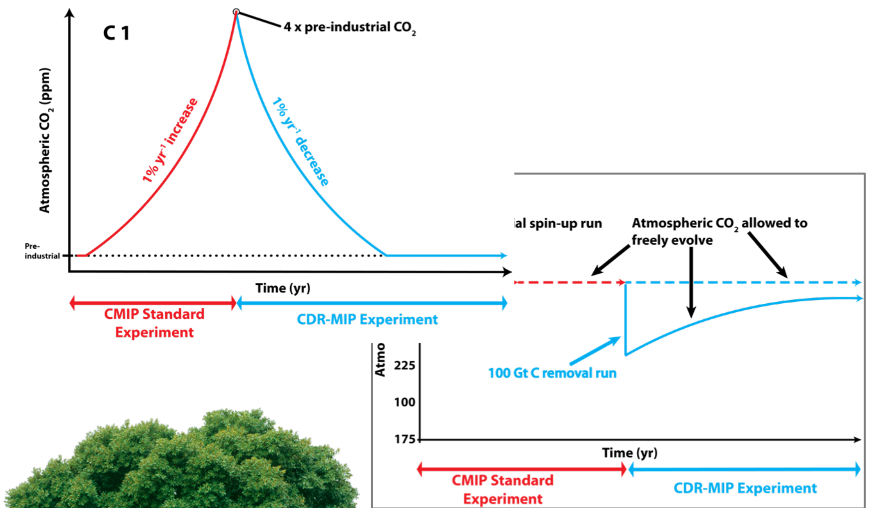
CDR-MIP Experiments

1. Reversibility
2. Direct air-capture

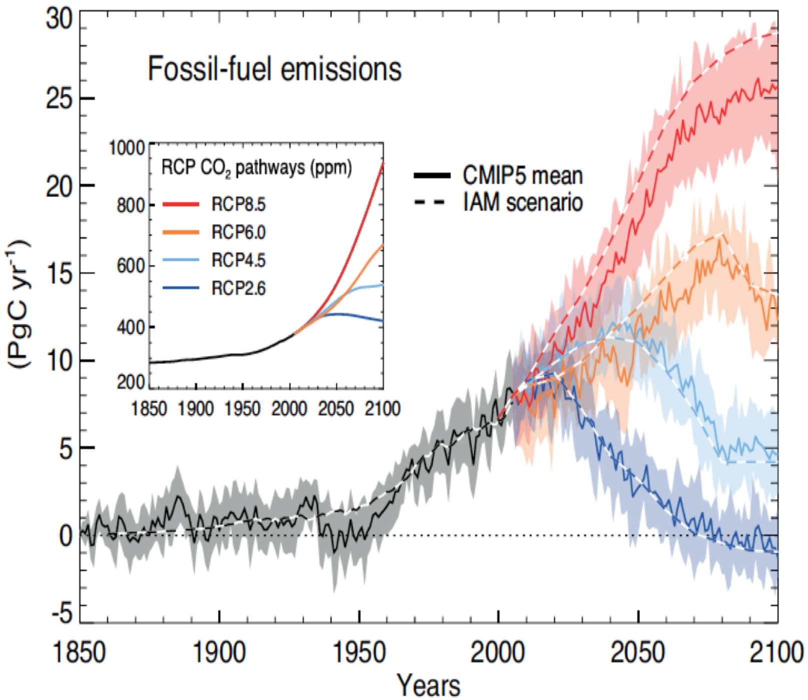
TIER 1

3. Afforestation / land use
4. Ocean alkalinization



CDR-MIP will be useful for other fields of climate science

- CDR-MIP output will be used to better constrain CDR in integrated assessment modelling (IAMs)
- Currently carbon cycle feedbacks are not accounted for when IAMs include CDR in scenarios like the RCP
- Adaptation Science



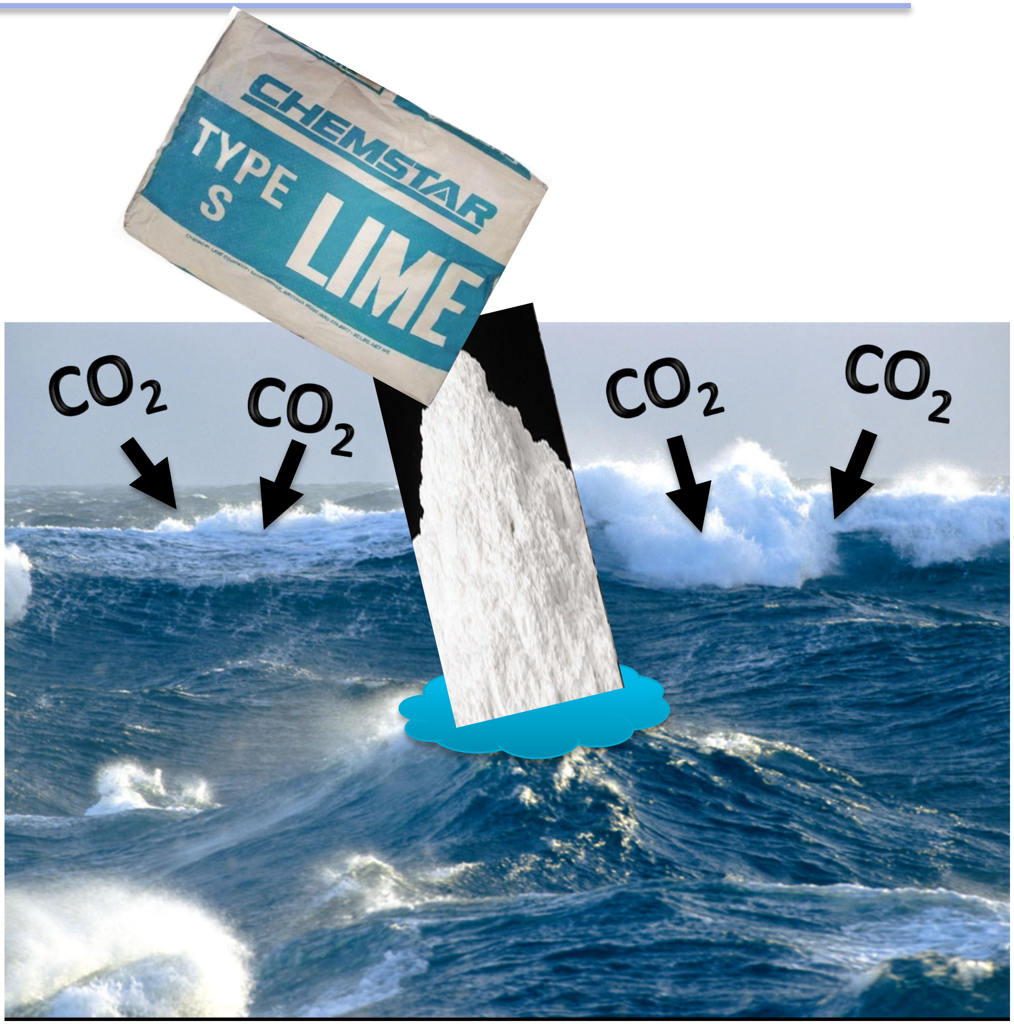
IPCC AR5, 2013

C4 – Alkalinity Ocean Addition (AOA)

During a high CO_2 emission scenario (SSP5-8.5) add 0.14 Pmol Total Alkalinity yr^{-1} to ice free waters from the year 2020-2100

50% of world's ships

Consider Alkalinity only not Iron or Silicic Acid associated with some forms of ALK e.g. Olivine



C4 – Alkalinity Ocean Addition (AOA)