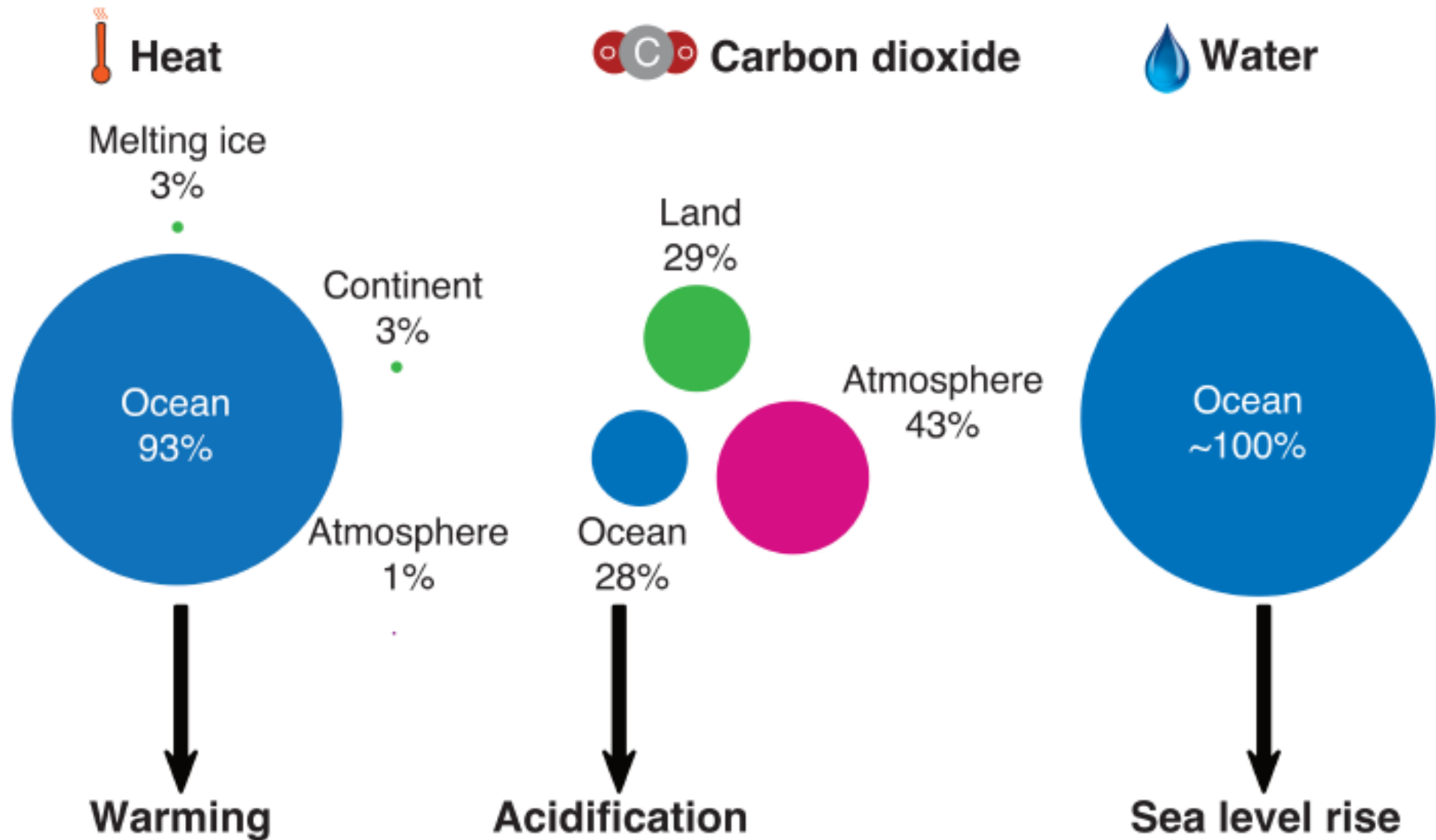


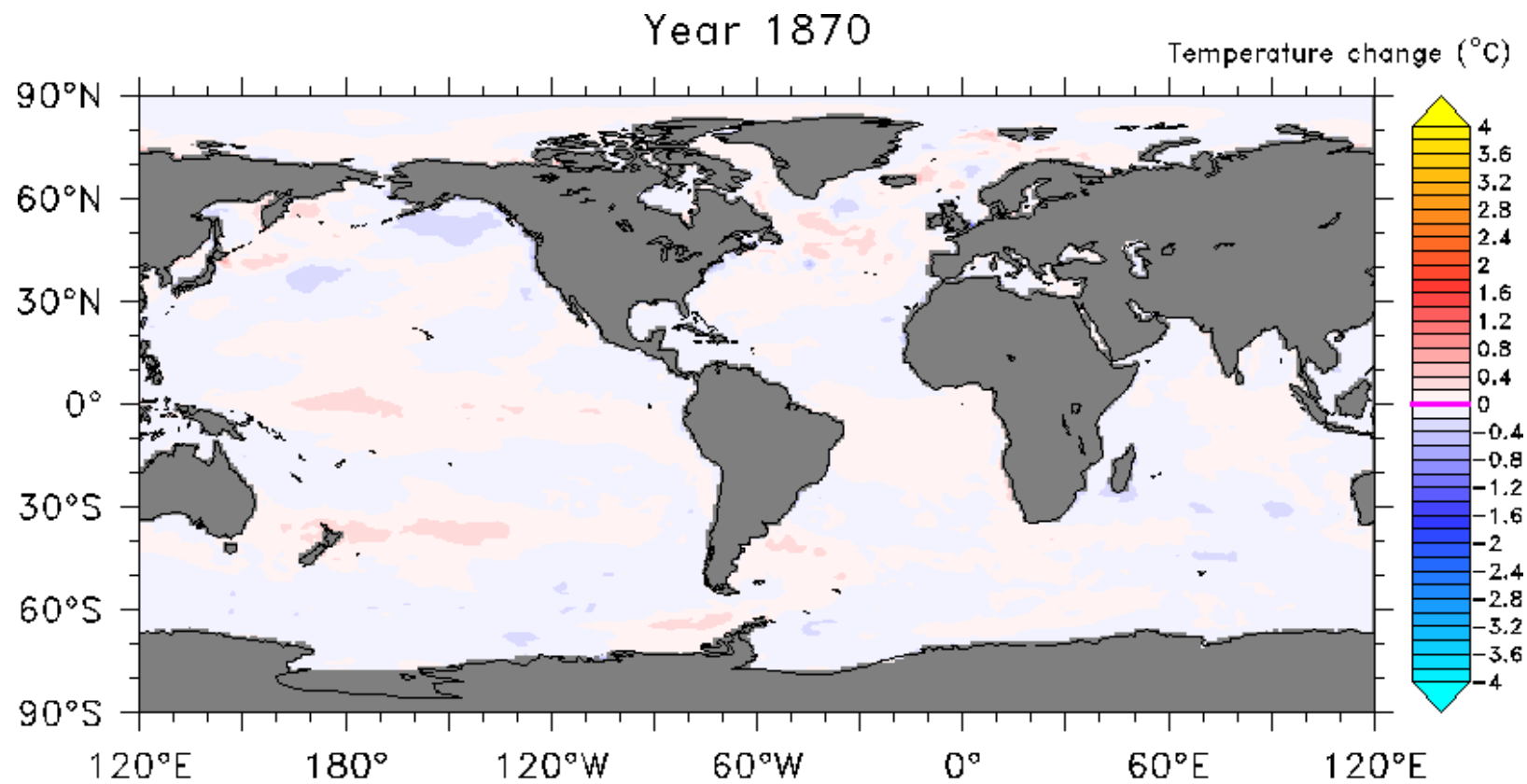
The ocean absorbs most of our *extra* heat & CO₂



Changes from our emissions of greenhouse gases

Gattuso et al. 2015

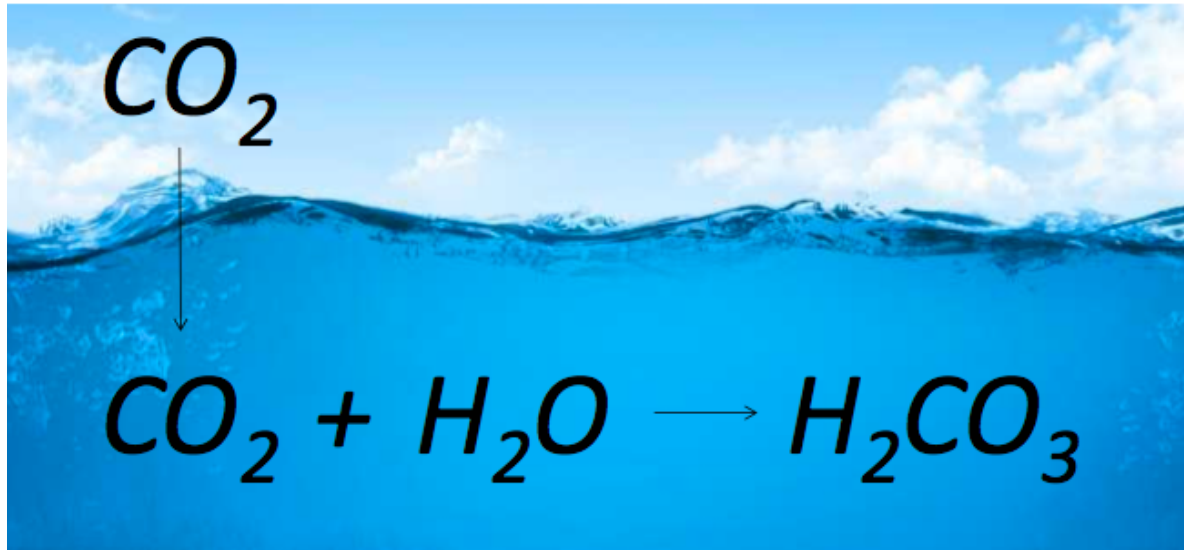
Surface ocean warms



Animation
Copyright: James C. Orr

Projection: mean of CMIP5 models
(IPCC AR5 WG1, 2013)
RCP8.5 scenario

More atmospheric CO₂ means increased ocean acidity



Schematic: Sam Dupont, University of Gothenburg

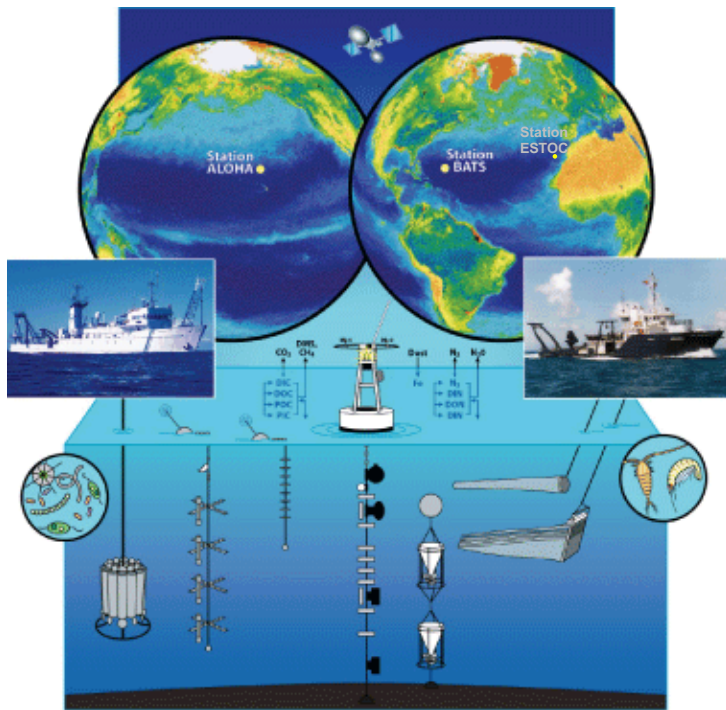
Some numbers:

4 kg CO₂ per day **per person** added to the ocean

+30% acidity in surface ocean since start of industrial era

+100 to 200% by 2100

Change in pH from ocean acidification is already measurable



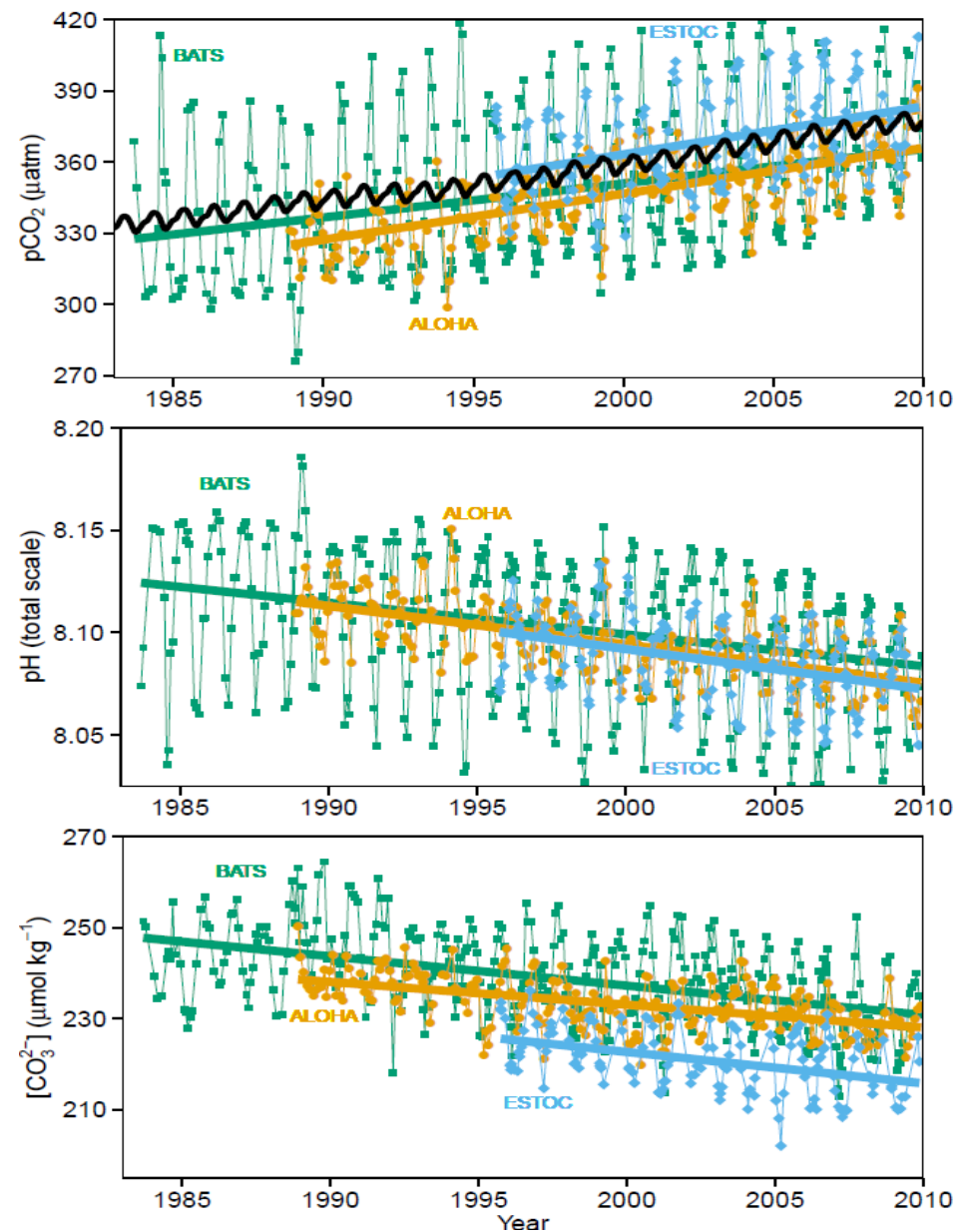
Data:

Bates (2007)

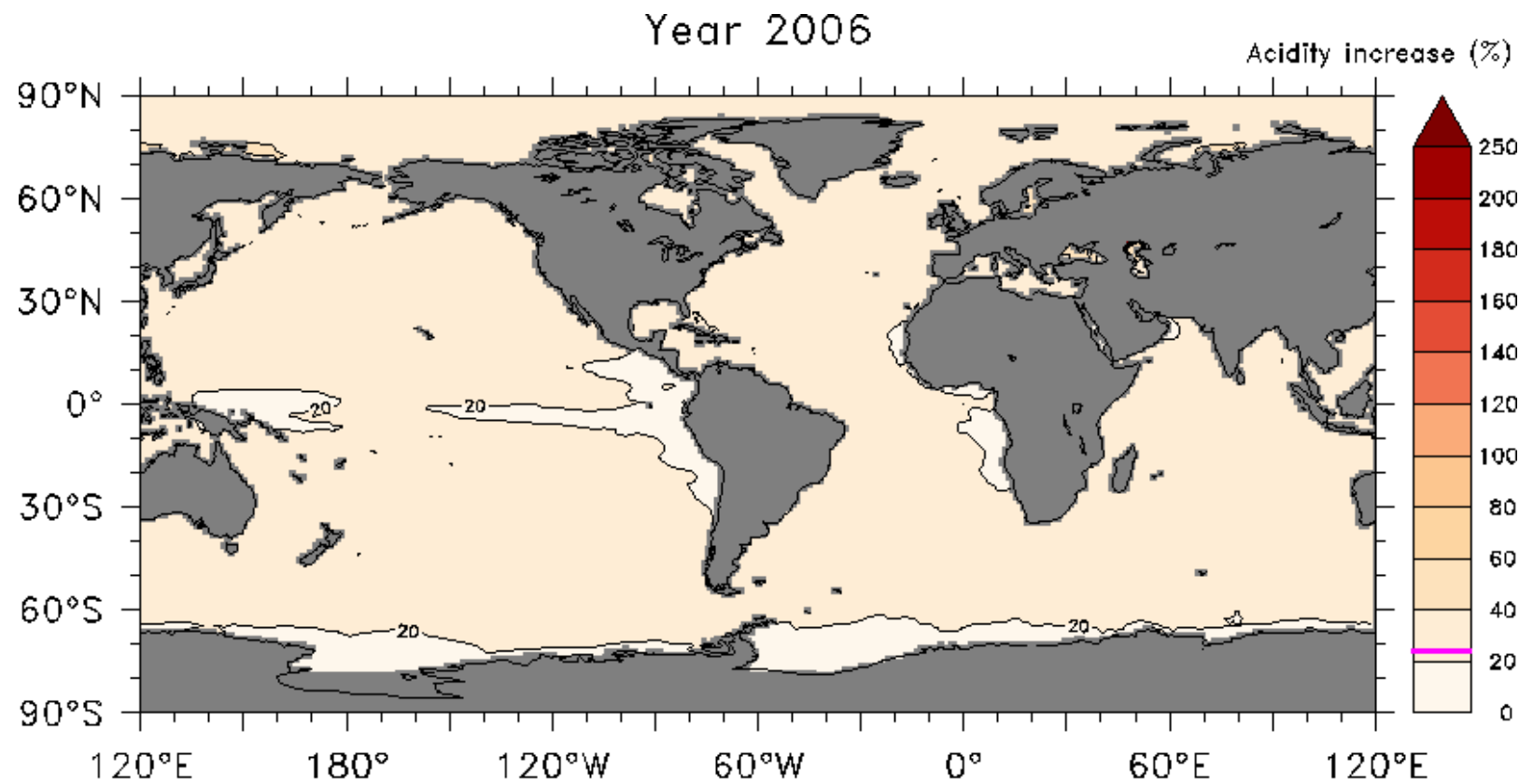
Dore et al. (2009)

Santana-Casiano et al. (2007)

Gonzàles-Dàvila et al. (2010)



Surface ocean acidity increases everywhere

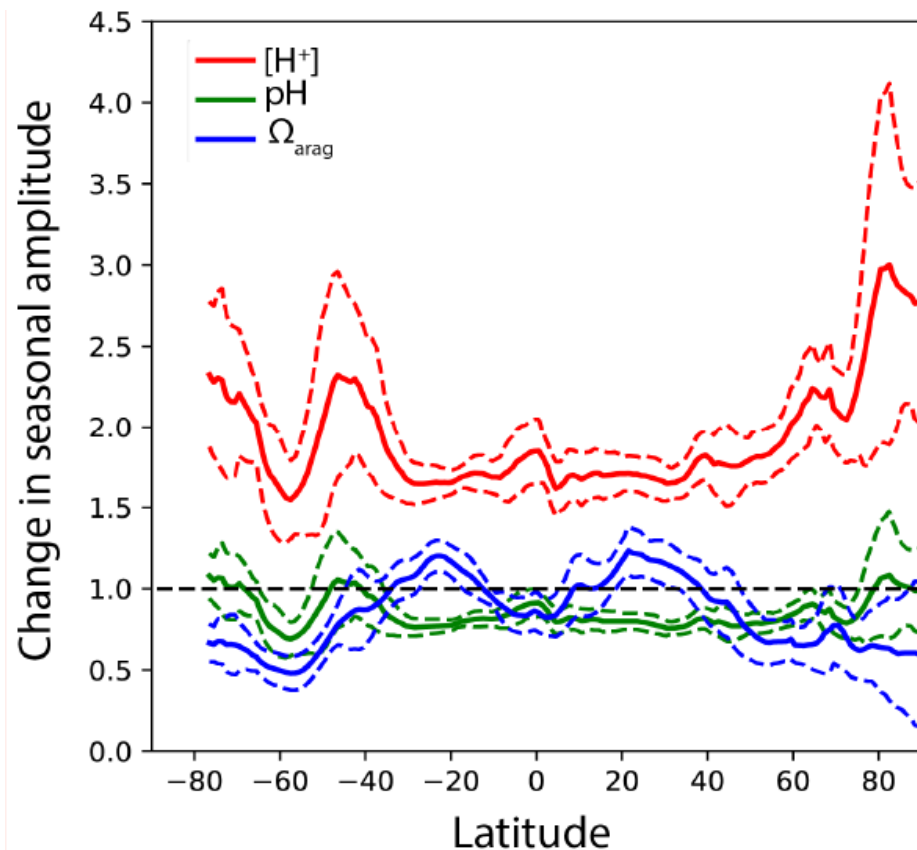


Animation
Copyright: James C. Orr

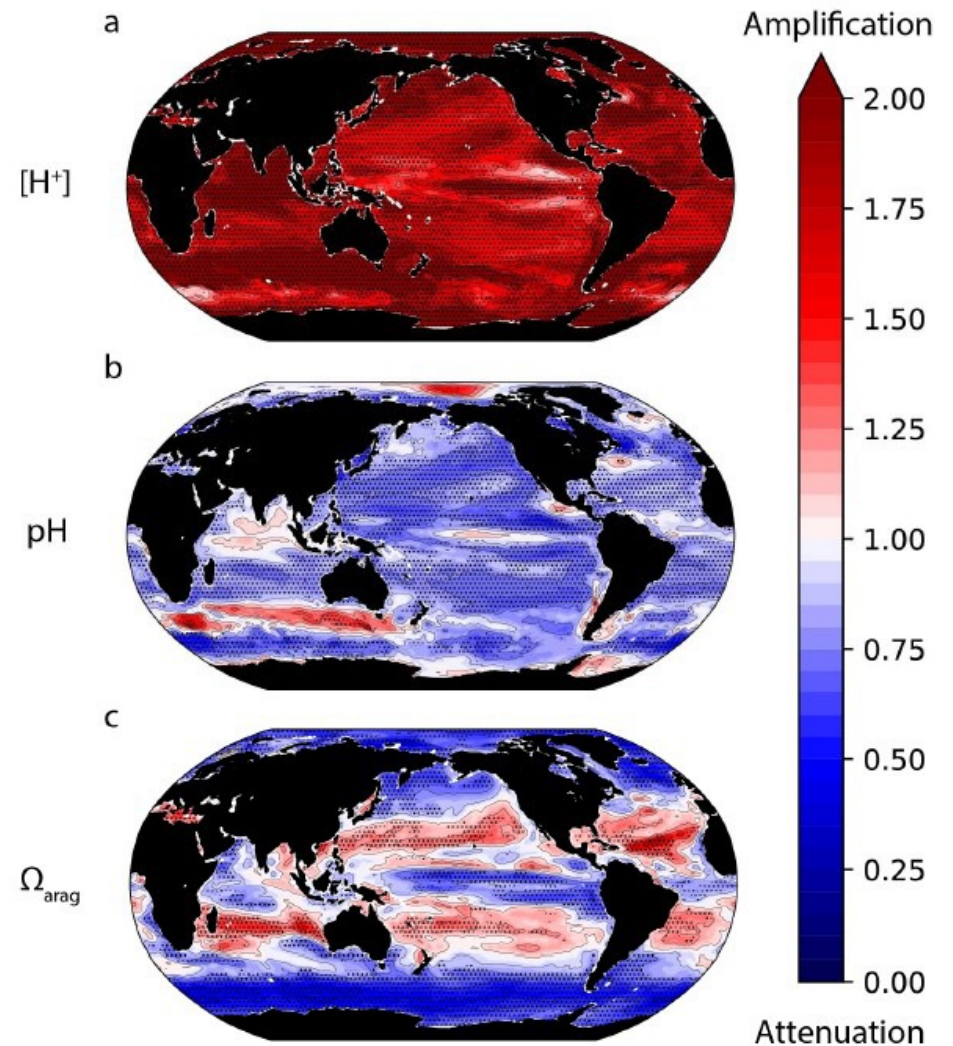
Projection: mean of CMIP5 models
(IPCC AR5 WG1, 2013)
RCP8.5 scenario

see also Bopp et al. (2013, Biogeosciences)

Ocean acidification **extreme events** will be **amplified** from diverging trends between seasons, night & day, ...



Seasonal extremes diverge for $[H^+]$



Kwiatkowski & Orr (2018, Nature Clim. Change)

Regions that are naturally rich in CO₂ confirm expected trends

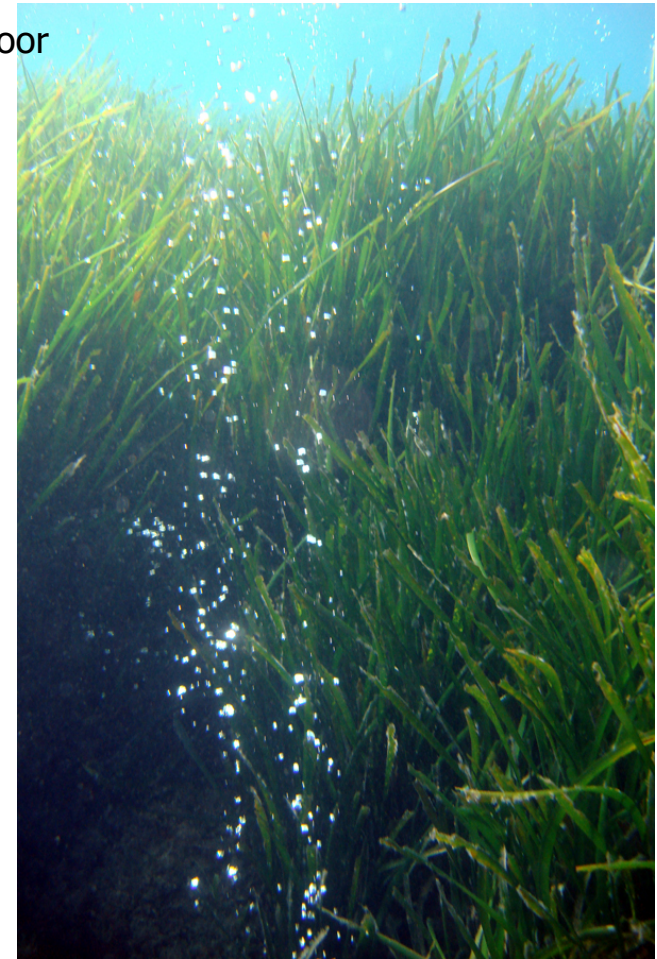
- less biodiversity
- fewer shells & corals
- more fragile shells
- invasive species
- more seaweed, coral degradation

CO₂ bubbles rise from seafloor at Ischia, Bay of Naples, a natural lab to study acidification

Hall-Spencer et al. (2008)

Rodolfo-Metalpa et al. (2008)

Photo: Steve Ringman, Seattle Times

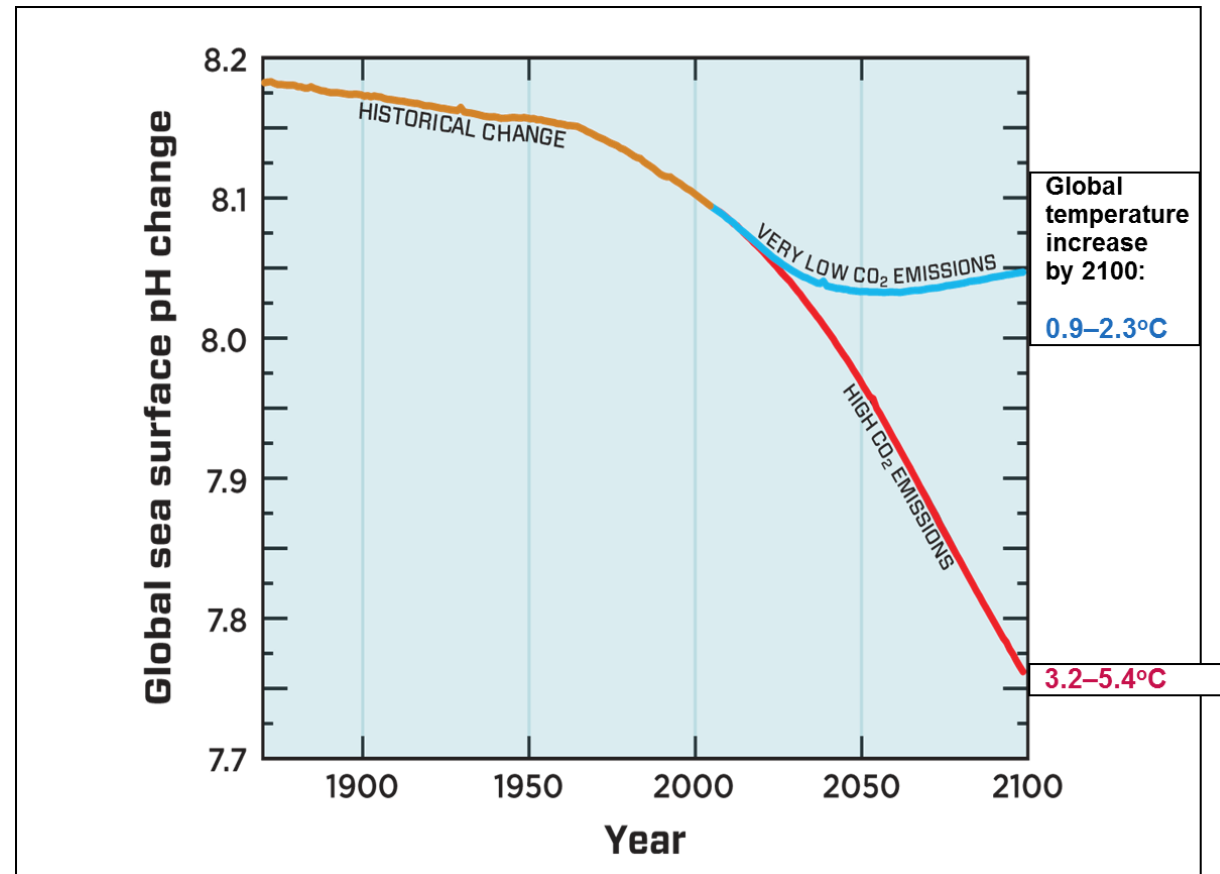


*Photo: Jason Hall-Spencer,
Plymouth University*

Another natural CO₂ vent site in Papua, New Guinea, used to study effects of acidification on corals

Ocean acidification is

- Already measurable
- Fast
- Caused by CO₂ emissions
- Detrimental to ocean ecosystems



Bopp et al. 2013

IGBP, IOC, SCOR (2013) Ocean Acidification Summary for Policy makers

What can be done?

- Severely limit atmospheric CO₂, the only way to limit ocean acidification
- Do we consider CO₂ as part of our daily equation?
- Support & take advantage of the international effort on ocean acidification e.g. through the IAEA's OA-ICC (Monaco)
 - Science
 - Capacity Building
 - Outreach