Ocean Acidification in the Peru – Chile Current system

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Background

Rise in atmospheric CO_2 due to anthropogenic emissions has caused a decrease in ocean pH. This phenomenon is known as ocean acidification.

The Peru – Chile Current System (PCCS) is a natural acidic region. Due to the low pH, the calcium carbonate saturation state (Ω $CaCO_3$) is low and dissolution of $CaCO_3$ shells and particles is favored at shallow depths. This resembles conditions that are expected in a high CO_2 world.

Objective

With the help of a regional oceanic circulation model, we want to investigate:

- What is the response of the $CaCO_3$ saturation state and pH in the PCCS to past and future ocean acidification?

Main conclusion

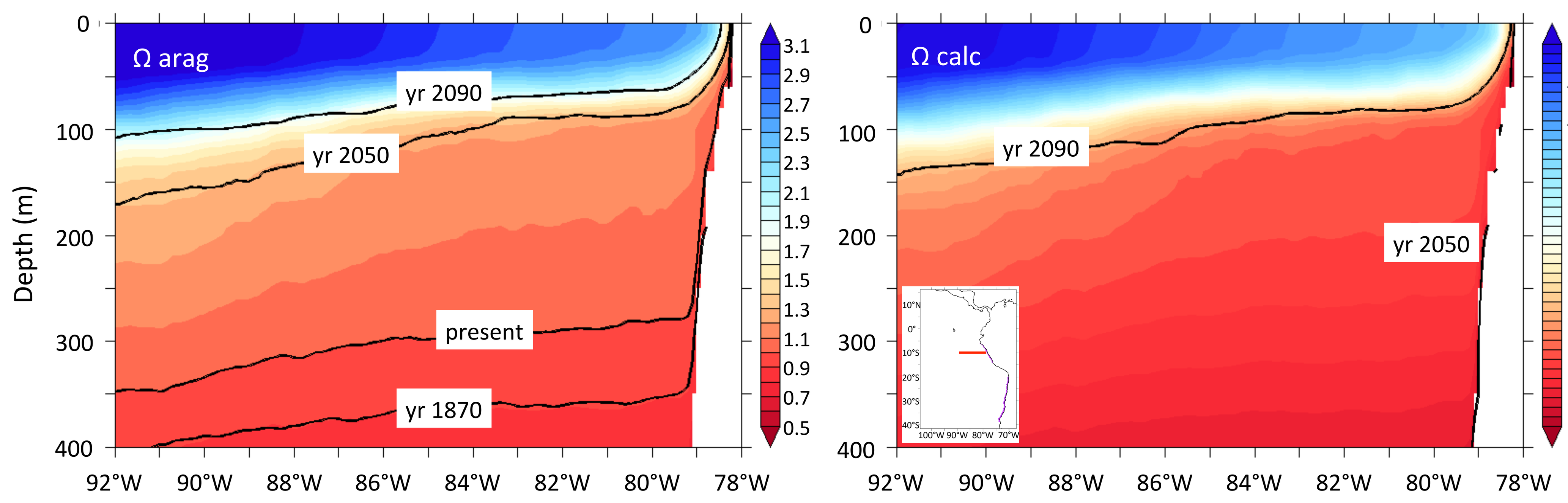


Figure 1. The threshold depth at which dissolution of $CaCO_3$ particles (aragonite or calcite) is favored is called **saturation depth**. A) aragonite saturation depth for the years simulated. B) calcite saturation depths. Colors: aragonite and calcite saturation state for present time.

Due to the sole effect of ocean acidification, the PCCS is projected to become a not only aragonite, but also a **calcite undersaturated ecosystem** by year 2090.

Change in habitat volume: calcite undersaturated water.

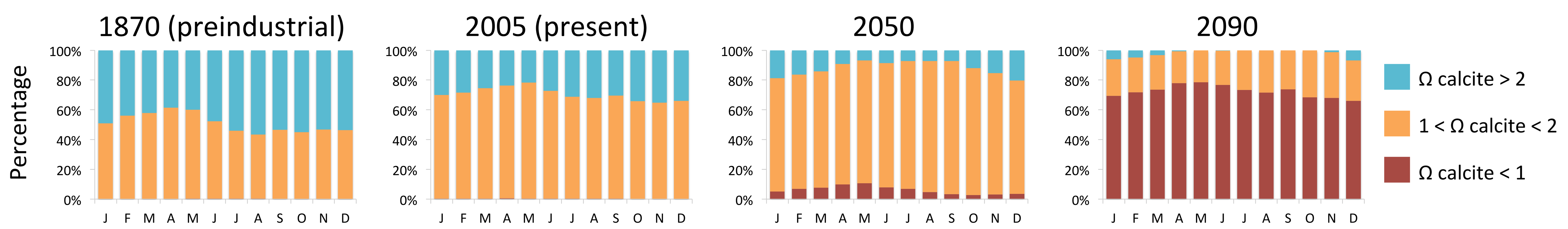


Figure 2. Percentage of volume of water with different Calcite saturation states. Analysis done for the first 50 km off the Peru coast, from the surface to 200 m depth, annual mean.

It is projected that by year 2090, more than 50 % of the water in the first 200 m will favor dissolution of calcite particles year round. In the Peru – Chile Current System, calcite calcifying organisms are an important component of the primary production and also export of organic carbon.

Decrease in surface pH

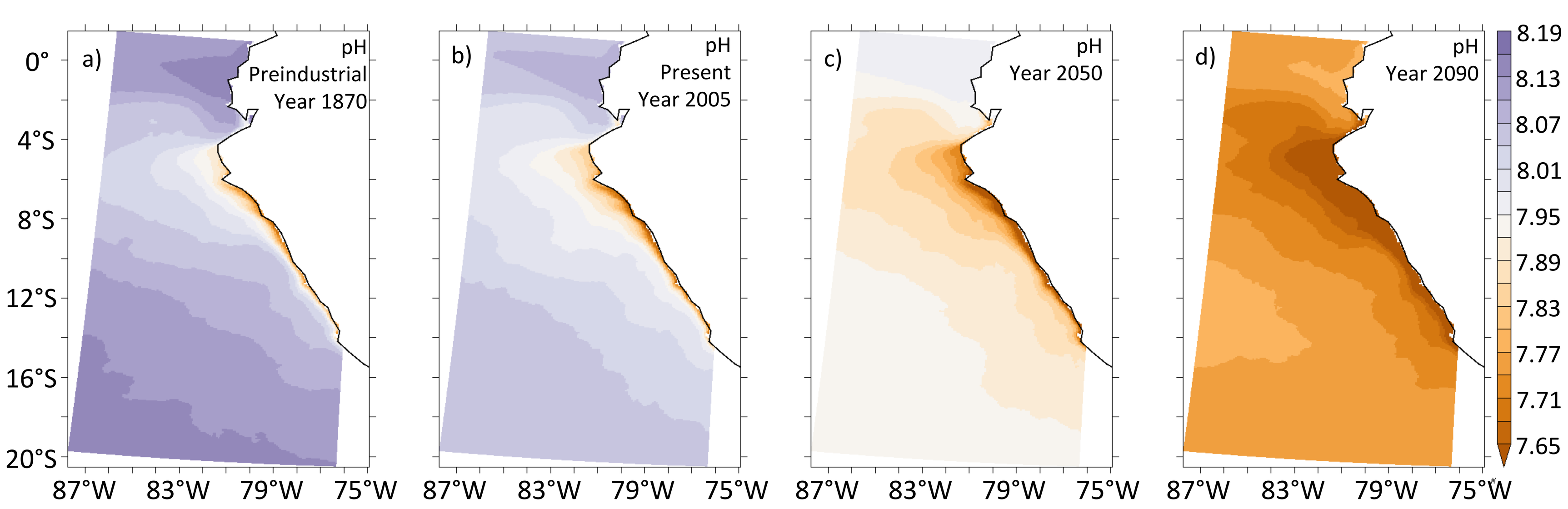


Figure 3. Simulated surface pH in the region off Peru for the years a) 1870, b) present day, c) 2050 and d) 2100. The correspondent atmospheric CO_2 values for each time – slice simulation are: 286 µatm for year 1870, 370 µatm for present time (year 2005), 538 µatm for year 2050 and 840 µatm for year 2090.

A decrease of up to 0.4 units of pH is projected to occur due to Ocean acidification. The region off Peru is particularly vulverable since the pH before anthropogenic influence was already low. The decrease of pH may affect not only calcifying organisms, but many other pH dependent processes.

Table I. Averaged surface pH and standard deviation for the first 50 km off Peru and Chile. Also shown is the spatial standard deviation (See inset figure 1).

Region	1870	Present (2005)	2050	2090
Peru	7.84 ± 0.02	7.78 ± 0.02	7.66 ± 0.02	7.44 ± 0.03
Chile	8.11 ± 0.01	8.03 ± 0.01	7.89 ± 0.01	7.67 ± 0.01

Tool: regional ocean model system (ROMS)

Physical model:

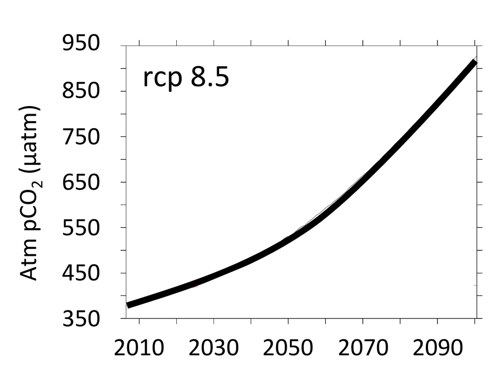
- Regional Ocean Modeling System (ROMS)
- Resolution: 7.5 km, 32 vertical layers
- Climatological boundary forcing (control simulation)
- 10 year spin-up, 5 year averages of the summer season.

Biogeochemical model:

- Nitrogen-based Nutrient-Phytoplankton-Zooplankton-Detritus (NPZD) model.
- Forced with modern CO_2 atmospheric conditions

Atmospheric CO_2

For the simulations of future years we used values from the representative Concentration Pathway (rcp) 8.5. For the Past we used historical values.



pCO_2 for simulations:
Year 1870: 286 µatm
Year 2005: 370 µatm
Year 2050: 538 µatm
Year 2090: 841 µatm

Overview

Here we consider the effects of increased atmospheric CO_2 on the $CaCO_3$ saturation State and seawater pH. However, these results should be taken with caution since other aspects of climate change like ocean warming, change in upwelling strength and deoxygenation are not considered.

Further work on the synergistic effect of different stressors and their implications for marine organisms is needed.

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