Trends in ocean CaCO$_3$ undersaturation in the CMIP5 suite of Earth System Models

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What are the likely future changes in ocean calcite and aragonite saturation states?

How well do climate models reproduce the observed distribution of calcite and aragonite saturation states?

How do models differ in their regional responses?
\( \Omega \) is the saturation state of seawater with respect to CaCO\(_3\) minerals (calcite or aragonite)

\[
\Omega = \frac{[\text{Ca}^{2+}][\text{CO}_3^{2-}]}{(\text{saturation concentration})}
\]

\([\text{CO}_3^{2-}] = f(T, S, \text{DIC}, \text{alkalinity})\)
Aragonite saturation at 200 m depth gives an index of regions most vulnerable in terms of biological impacts.
Aragonite saturation horizon depth ($\Omega=1$)
Calcite saturation horizon depth ($\Omega=1$)
Global pattern correlation coefficients: models vs observations
Global total area of shallow undersaturation
Global total area of shallow undersaturation

Responds to mitigation

Order of magnitude increase
North Pacific fraction of total $A_{200}$
$A_{200}$ as function of cumulative anth CO$_2$ uptake
A_{200} as function of cumulative anth CO_{2} uptake
Take home messages

• no model performs best on all skill metrics

• growth of area with shallow undersaturation ($A_{200}$)
  • consistent across models
  • depends on rate of atm CO$_2$ growth
  • up to an order of magnitude under RCP8.5
  • responds to mitigation

• all models underestimate North Pacific fraction of $A_{200}$

• no simple relationship between $A_{200}$ and cumulative uptake