

Supplement of Biogeosciences, 12, 6017–6031, 2015
<http://www.biogeosciences.net/12/6017/2015/>
doi:10.5194/bg-12-6017-2015-supplement
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Supplement of

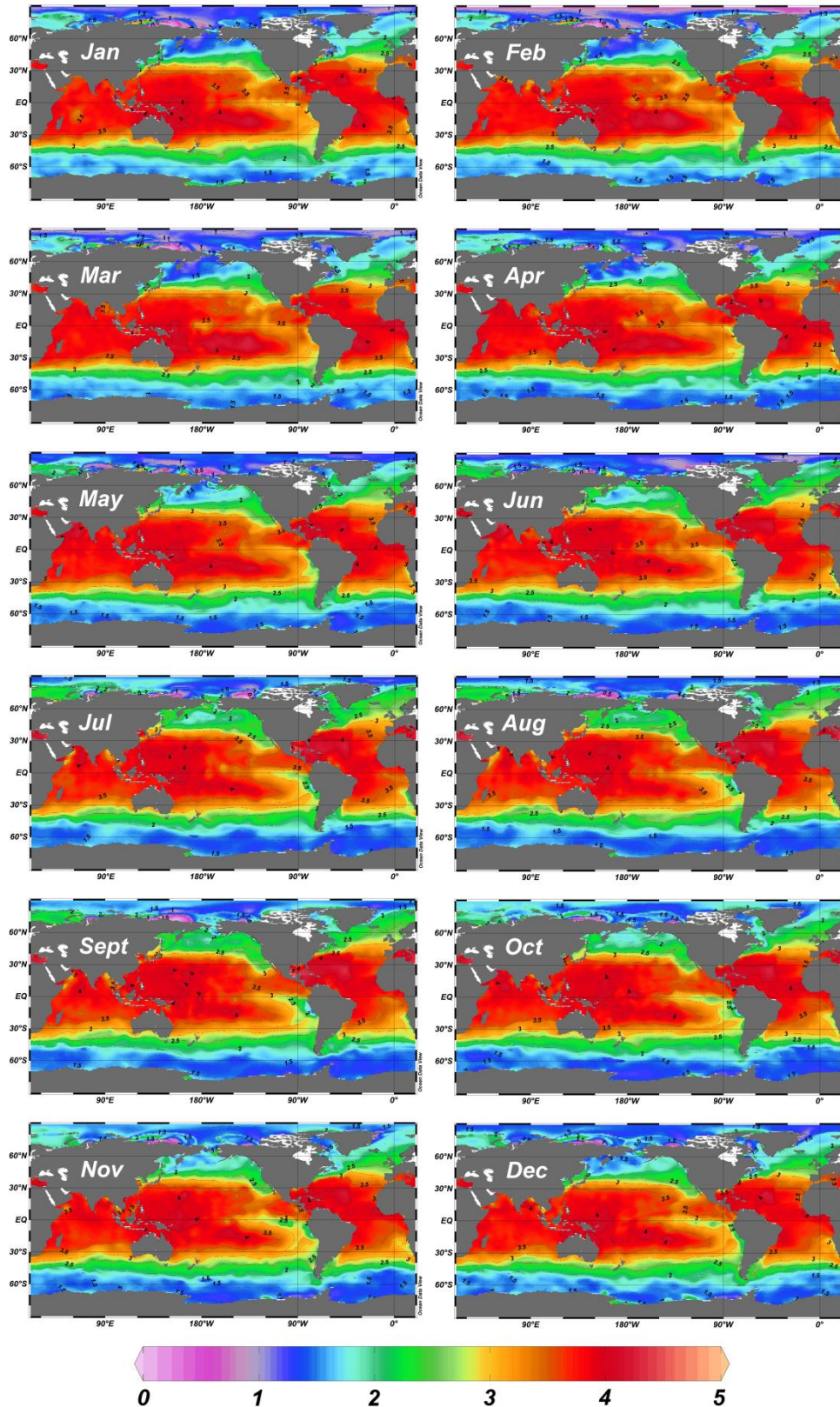
Quantifying the influence of CO₂ seasonality on future aragonite undersaturation onset

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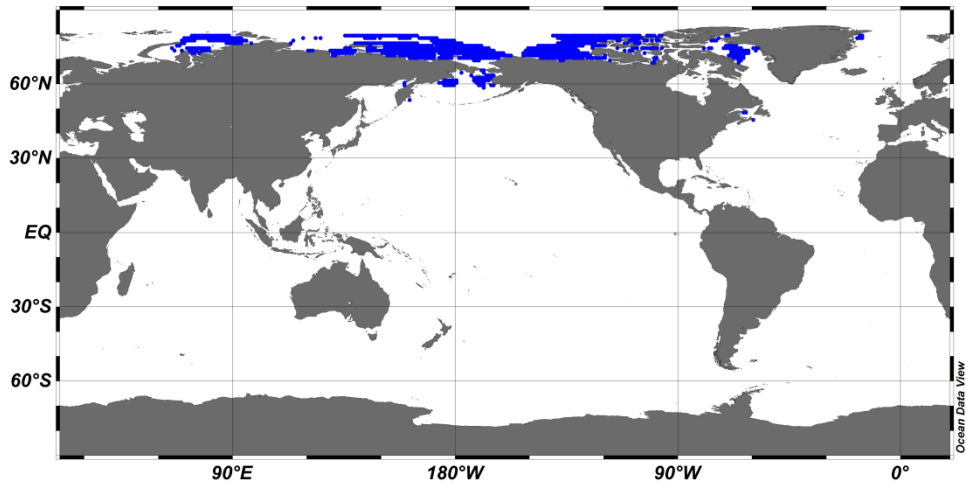
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- 1 **Supplement S1:** Monthly ocean surface Ω_{Ar} predictions.
- 2 **Supplement S2:** Locations where our results suggest at least month-long aragonite under-
3 saturation ($\Omega_{Ar} < 1$) occurs in the year 2000.
- 4 **Supplement S3:** Geographical separation of independently predicted measurements into 14
5 regions.
- 6 **Supplement S4:** Comparison between our data-based and model-based seasonal amplitudes.
- 7 **Supplement S5:** Onset year of permanent under-saturation and time difference between
8 annual-mean and permanent onset.



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2 **Figure S1:** Monthly Ω_{Ar} climatologies for the nominal year of 2000 calculated using the
 3 dissolved inorganic carbon and total alkalinity climatologies of Sasse et al (2013), in
 4 combination with the World Ocean Atlas 2013 Temperature, salinity and nutrient surface
 5 decadal averages.



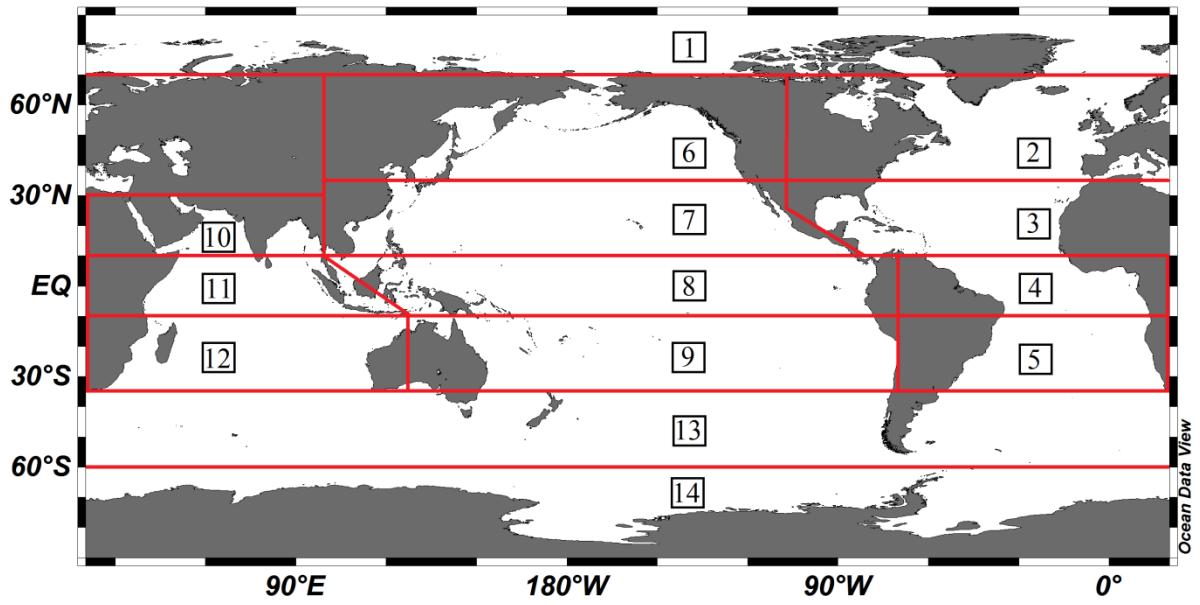
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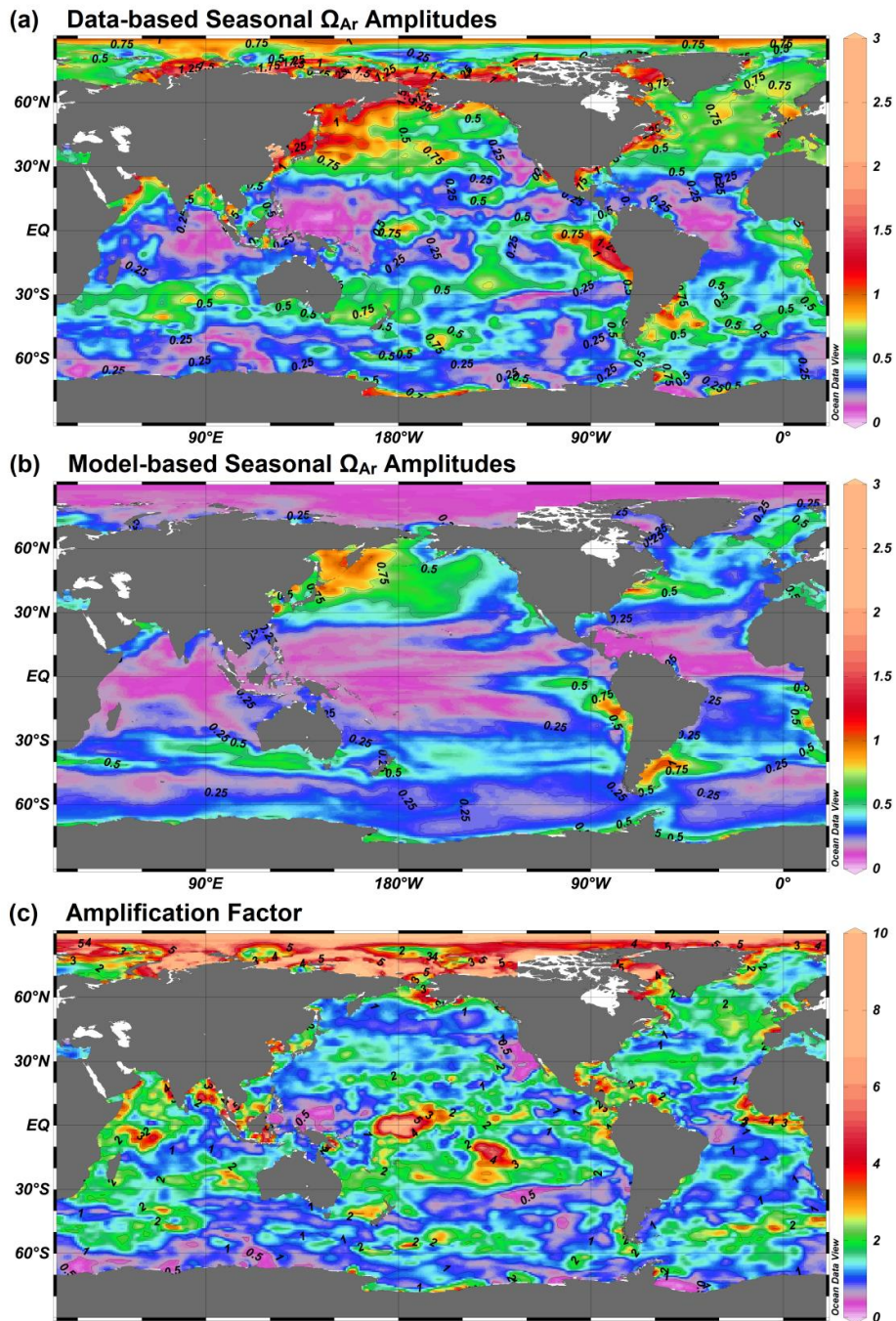
Figure S2: Locations where our Ω_{Ar} predictions suggest at least month-long aragonite under-saturation occurs in the year 2000.

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2 **Figure S3:** Geographical separation of independently predicted measurements into 14
3 regions.



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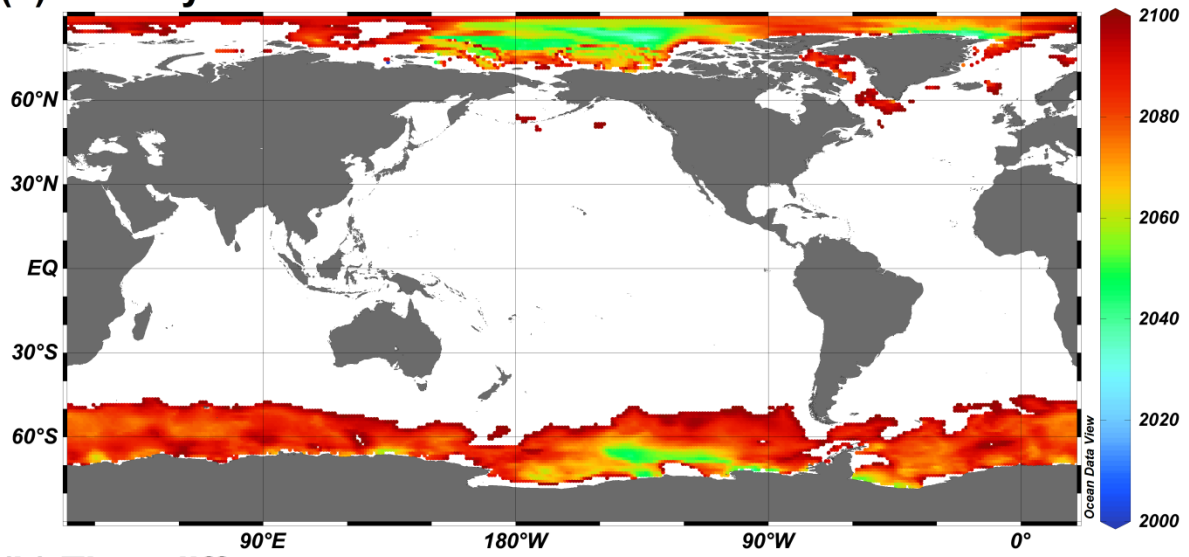
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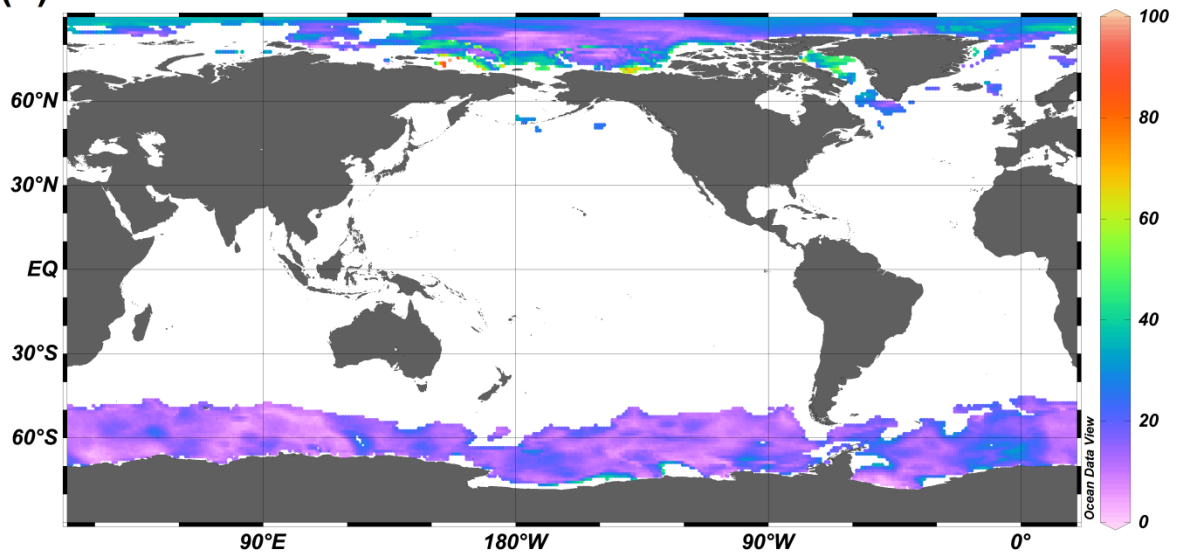
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Figure S4: Comparison between seasonal Ω_{Ar} amplitudes derived using our data-based climatologies for the nominal year of 2000 and the Earth System Model (ESM) ensemble median. (a) Our data-based Ω_{Ar} seasonal amplitudes (monthly max - min) for the nominal year of 2000. (b) The model based 2006-2016 mean seasonal Ω_{Ar} amplitudes (monthly max-min). (c) Amplification factor of our data-based seasonal amplitudes compared to the model-based estimates (i.e. data-based / model-based seasonal Ω_{Ar} amplitudes). An amplification factor of 1 indicates that our data-based amplitude equals the model-based estimate, whereas an amplitude factor of 2 indicates that our data-based amplitude was twice as large as the model-based estimate.

(a) Onset year



(b) Time difference



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2 **Figure S5:** (a) Estimated onset year for permanent aragonite under-saturation under RCP8.5.

3 (b) Time difference (years) between annual-mean and permanent onset.

1 **References:**

2 Sasse, T. P., McNeil, B. I., and Abramowitz, G. (2013), A novel method for diagnosing
3 seasonal to inter-annual surface ocean carbon dynamics from bottle data using neural
4 networks, *Biogeosciences*, 10, 4319-4340, DOI: 10.5194/bg-10-4319-2013

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