Silicon isotopes in an EMIC's ocean: sensitivity to runoff, iron supply and climate

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Abstract

The isotopic composition of Si in biogenic silica (BSi), such as opal buried in the oceans' sediments, has changed over time. Paleo records suggest that the isotopic composition, described in terms of δ^{30} Si, was generally much lower during glacial times than today. There is consensus that this variability is attributable to differing environmental conditions at the respective time of BSi production and sedimentation. The detailed links between environmental conditions and the isotopic composition of BSi in the sediments are, however, controversially discussed in the literature. In this study, we explore the effects of a suite of offset boundary conditions during the LGM on the isotopic composition of BSi archived in sediments in an Earth System Model of intermediate complexity. Our model results suggest that a change in the isotopic composition of Si supply to the glacial ocean is sufficient to explain the observed overall low(er) glacial δ^{30} Si in BSi. All other processes explored triggered model responses of either wrong sign or magnitude, or are inconsistent with a recent estimate of bottom water oxygenation in the Atlantic Sector of the Southern Ocean. Caveats, mainly associated with generic uncertainties in today's pelagic biogeochemical modules, remain.

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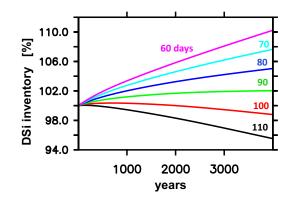
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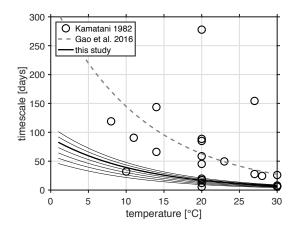
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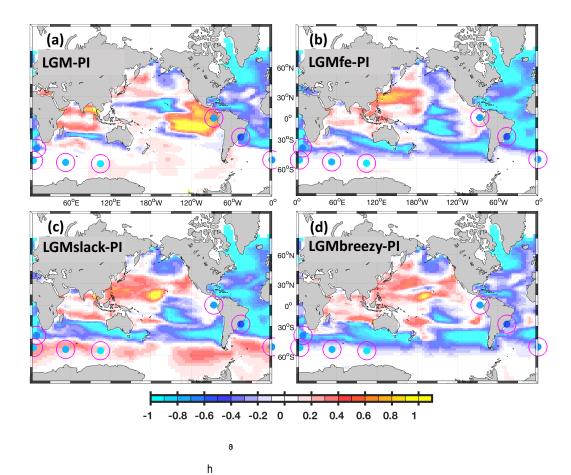
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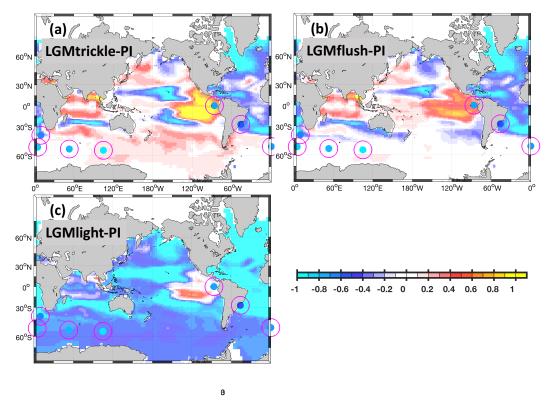


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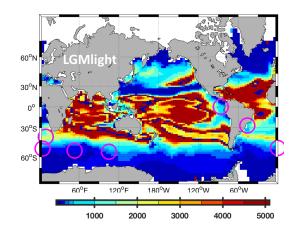
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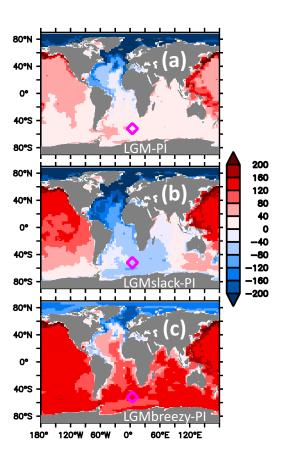
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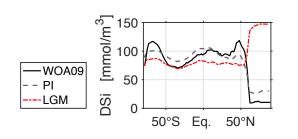
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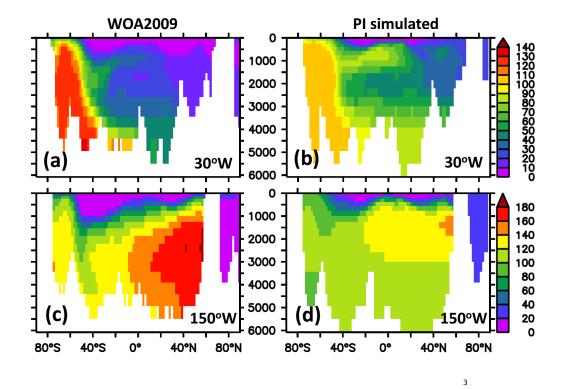
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Figure A.5. Meridional sections over depth (in m) of PO $_4$ in units mmol Sim 3 . Panel (a) and (c) refer to observations (Garcia et al., 2010) and panel (b) and (d) to the preindustrial simulation.

nutrient biased low it seems unlikely that a de cient circulation is the cause for these 651 biases (although this can not be ruled out). This suggests that the SO nutrient trapping 652 relates strongly to the biogeochemical model parameters. One conclusion from this may 653 be that the biogeochemical model is better tuned with respect to phosphate than to DSi. 654 This is to be expected because of the wider use of the phosphate-based biogeochemical 655 model and the much shorter equilibration time scales for phosphate which facilitate the 656 respective tuning to observations. In the Paci c, however, the situation di ers, and sub-657 surface maxima in the northern hemisphere (except the Arctic) are too low for both phos-658 phate and DSi. Following our reasoning above this may be indicative for aws in the ocean 659 circulation module. Please note, however, that the attribution of aws in model behav-660 ior to respective processes is challenging and may even be impossible given the current 661 set of observations (e.g. Loptien and Dietze, 2019). 662

Table A.1 provides a quantitative estimate of how our DSi/BSi module compares 663 against the underlying biogeochemical and ocean circulation module of Brennan et al. 664 (2012). The simulated temperature variance is overestimated by 3% and the temperature bias is 0.6 K, corresponding to 9% relative to the standard deviation in the obser-666 vations. The respective bias to standard deviation of salinity is with 0.03 even smaller 667 (5% relative to the standard deviation in the observations). Simulated phosphate con-669 centrations are, surprisingly, even closer to observations than simulated salinities: the 669 bias to standard deviation ratio is smaller (4%) and the simulated variance covers 86% 670 of observed levels (versus 70% for salinity). Given that the salinity distribution directly 671 a ects ocean circulation via density driven pressure gradients, it is remarkable that the 672 mist in this active physical property can be much larger than the mist of the rather 673 passive (in terms of their e ect on circulation) phosphate whose distribution is directly 674 shaped by oceanic circulation. This may be an indication that the biogeochemical mod-675

References 705 AISBIDBAG 706 ., **BANNHA** R2010)H 707 708 6**666**6618 p 709 BC200 (Shipi Hafa Awa 710 http://www.astrongenergies.com/astrongenergies 711 BEALESP 01 SELECEN 712 **11113**,5574 551010 114 6 713 714 6665i LebiRGA 715 **tial**, 06 07 ,**d**0101**g**00**0**4 021. 716 **BIBAH** 12011) 717 HILL HILL 718 719 **DECEMBER** 720 , **6) 50 h** (2012) **h** fit 721 **141100**,4 174 24, 722 d010 🕅 6 723 BADADK2012) 724 etittettett 725 PHONED , 726 4,44**7**660100000002012061. 727 BARCh MANHL 728 MSXCHEK2002)Av 729 £€) ťØ **HHHH** 730 H2,12,16, d01022001C14 4. 731 ATAL & SHIGH 732 200 Juliptiluis 733 **title**, **2**007 734 dd010222004 BC02 6. 735 736 Al Station Bold B 737 **66)** 738 **d**0**5**4 **b θ**4 2016 739 **ETEMPESE**K 740 . HAK HAR BAR 741 742 **HARE MEE**A 743 **50000** 14 222,1110,**S** 744 till Rola 745 effectives/addition/1 & 746 747 **656**,2 ,**656**,6010101**6**016 748 Ø Ø0 001. 749 e877783/4731/6641 8 750 **Gistisharitteide** 751 AN 566 , dd 0 10 \$174. 752 753 disisticitation of the second se 754 **60000000**8 25 755 d0101 g0110028756 e CHECKER COBIE 757 2012) **Hilling** 758 dddddd 4 14 21 ,dd 0 5 4 b 759

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