



*Supplement of*

## **MESMO 3: Flexible phytoplankton stoichiometry and refractory dissolved organic matter**

**Katsumi Matsumoto et al.**

*Correspondence to:* Katsumi Matsumoto (katsumi@umn.edu)

The copyright of individual parts of the supplement might differ from the article licence.

1 These supplemental figures compare MESMO 3, newly described in this submission, with  
2 its predecessor, MESMO 2, as well as with the World Ocean Atlas. The aim of the  
3 comparison is to demonstrate that the new model simulates the ocean biogeochemistry  
4 just as well as MESMO 2 for those properties that have previously been simulated.

5  
6 Figure S1. Model-data comparison of surface ocean  $\text{PO}_4$  and  $\text{NO}_3$  concentrations. (a, b)  
7 Observations are from the World Ocean Atlas 2018 (Garcia et al., 2018, 2019). (c, d)  
8 MESMO 2 results are from Matsumoto et al. (2013). (e, f) MESMO 3 results are from this  
9 study. Unit =  $\mu\text{mol kg}^{-1}$ .

10

11 Figure S2. POC export production at 100 m in MESMO 2 (left, Matsumoto et al., 2013) and  
12 MESMO 3 (right, this study). Unit =  $\text{mol C m}^{-2} \text{ year}^{-1}$ .

13

14 Figure S3. Model-data comparison of dissolved  $\text{O}_2$  concentrations. (a) Global mean vertical  
15 profiles. Distribution of  $\text{O}_2$  at 1000 m from: (b) World Ocean Atlas 2018 (Garcia et al.,  
16 2019), (c) MESMO 2 (Matsumoto et al., 2013), and (d) MESMO 3 (this study). Unit =  $\mu\text{mol}$   
17  $\text{O}_2 \text{ kg}^{-1}$ . The colored lines in (a) indicate: black = WOA2018, red = MESMO 2, green =  
18 MESMO 3, and blue = MESMO 3+ $\text{DOM}_r$  (run ID=201027c, see main text).

19

20 Figure S4. Model-data comparison of  $\text{Si}(\text{OH})_4$  concentrations. Surface concentrations from:  
21 (a) World Ocean Atlas 2018 (Garcia et al., 2018) and (b) MESMO 3. Zonally averaged  $\text{Si}^*$   
22 from (c) MESMO 2 (Matsumoto et al., 2013), and (d) MESMO 3 (this study).  $\text{Si}^* = [\text{Si}(\text{OH})_4]$ -  
23  $[\text{NO}_3]$ . Unit =  $\mu\text{mol Si kg}^{-1}$ .

24

25 Figure S5. Surface ocean FeT in MESMO 2 (left, Matsumoto et al., 2013) and MESMO 3  
26 (right, this study). Unit =  $\text{nmol Fe kg}^{-1}$ .

27

28 Figure S6. Annual mean depth-integrated  $\text{N}_2$  fixation (a) and denitrification (b) in MESMO  
29 3. Unit =  $\text{mol-N m}^{-2} \text{ year}^{-1}$ .

30

31 **References**

32

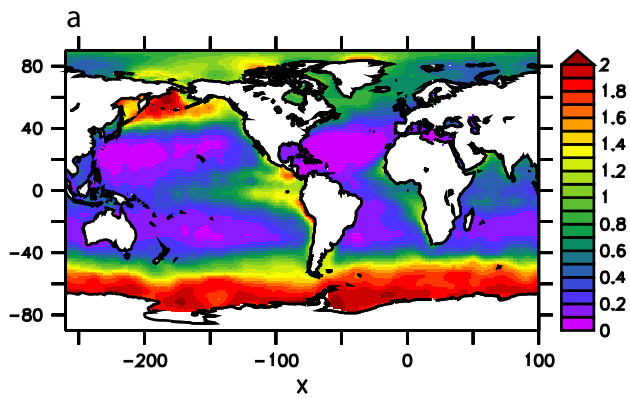
33 Garcia, H., Weathers, K. W., Paver, C. R., Smolyar, I., Boyer, T. P., Locarnini, R. A., Zweng, M.  
34 M., Mishonov, A. V., Baranova, O. K., Seidov, D. and Reagan, J. R.: World Ocean Atlas 2018.  
35 Volume 4: Dissolved Inorganic Nutrients (phosphate, nitrate and nitrate+nitrite, silicate),  
36 NOAA Atlas NESDIS 84, 84(July), 35, 2018.

37 Garcia, H. E., Weathers, K., Paver, C. R., Smolyar, I., Boyer, T. P., Locarnini, R. A., Zweng, M.  
38 M., Mishonov, A. V., Baranova, O. K., Seidov, D. and Reagan, J. R.: World Ocean Atlas 2018,  
39 Volume 3: Dissolved Oxygen, Apparent Oxygen Utilization, and Oxygen Saturation, NOAA  
40 Atlas NESDIS, 3(83), 38 pp., 2019.

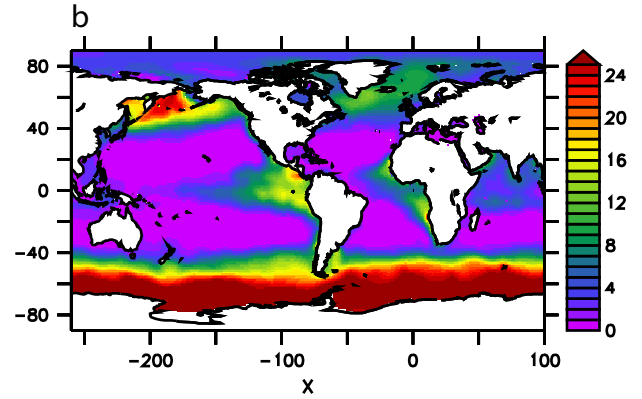
41 Matsumoto, K., Tokos, K., Huston, A. and Joy-Warren, H.: MESMO 2: a mechanistic marine  
42 silica cycle and coupling to a simple terrestrial scheme, *Geosci. Model Dev.*, 6(2), 477–494,  
43 doi:10.5194/gmd-6-477-2013, 2013.

44

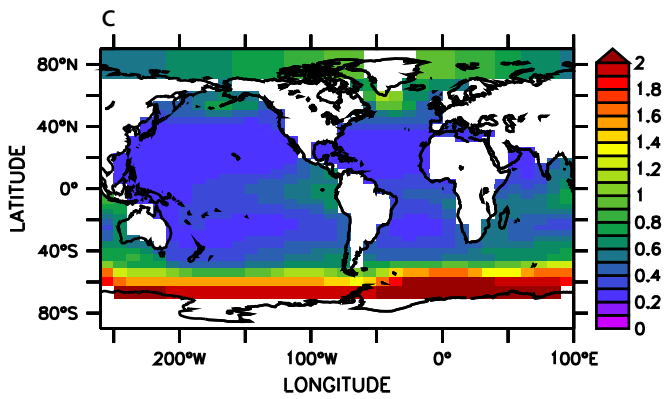
45



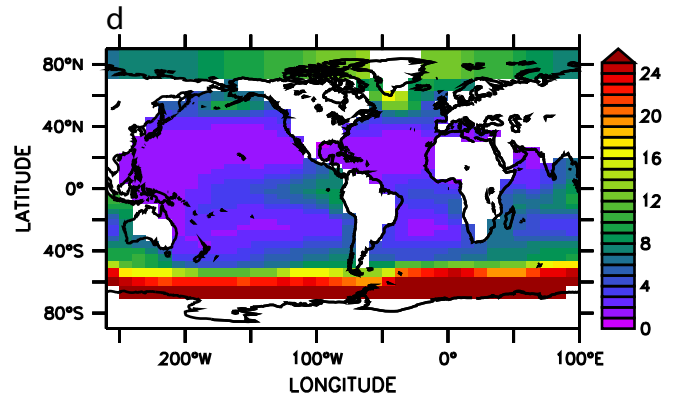
WOA18 P04



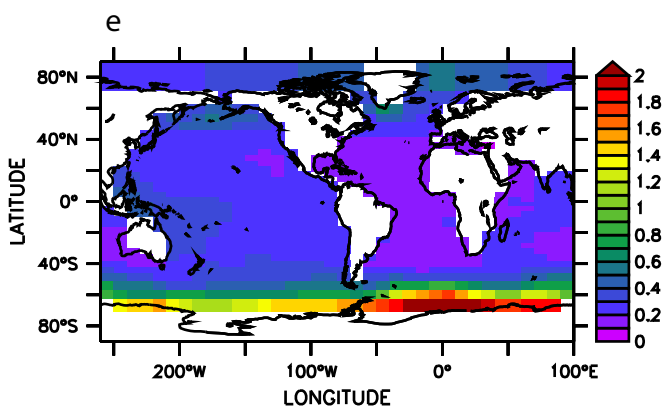
WOA18 N03



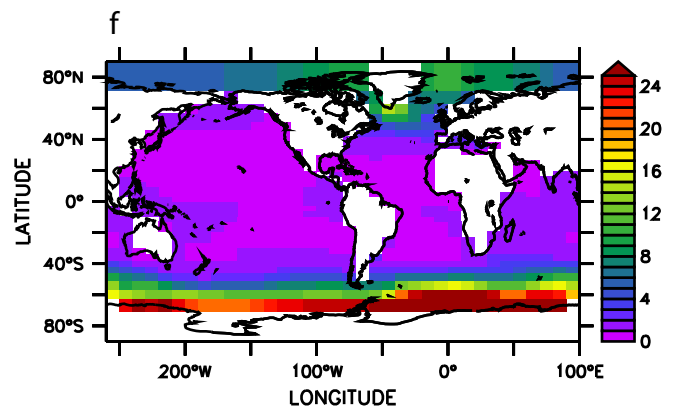
MESM02: P04



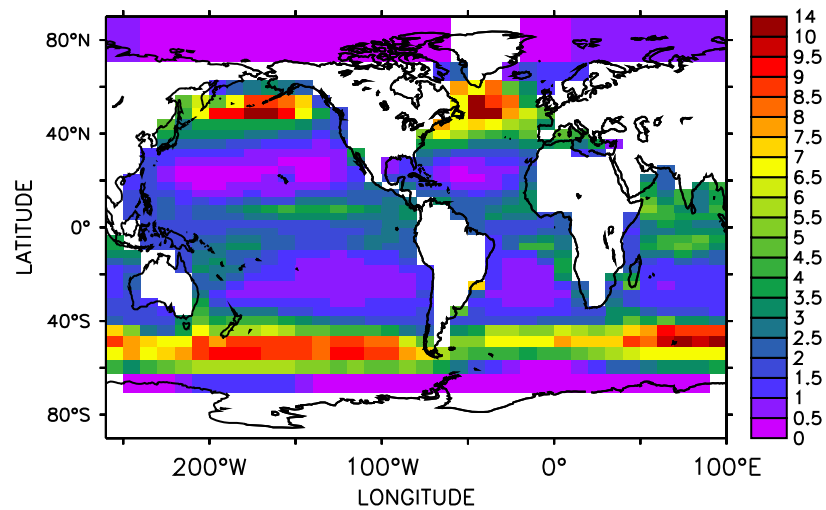
MESM02: N03



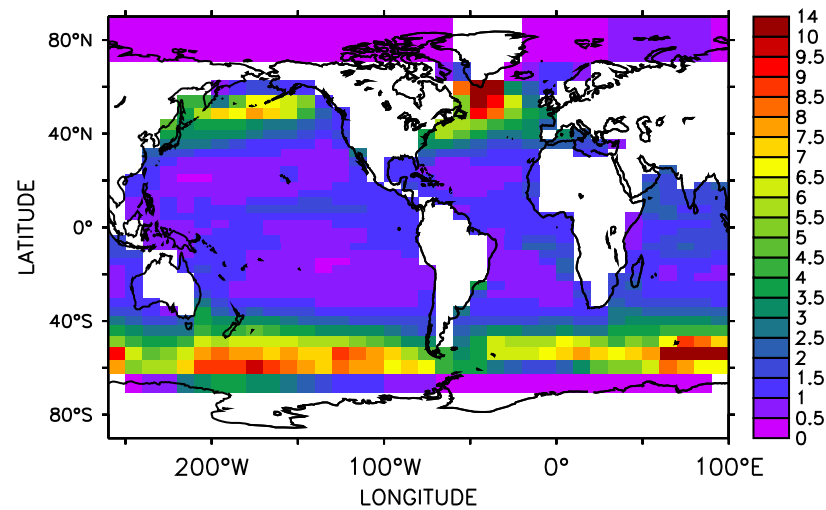
MESM03 P04



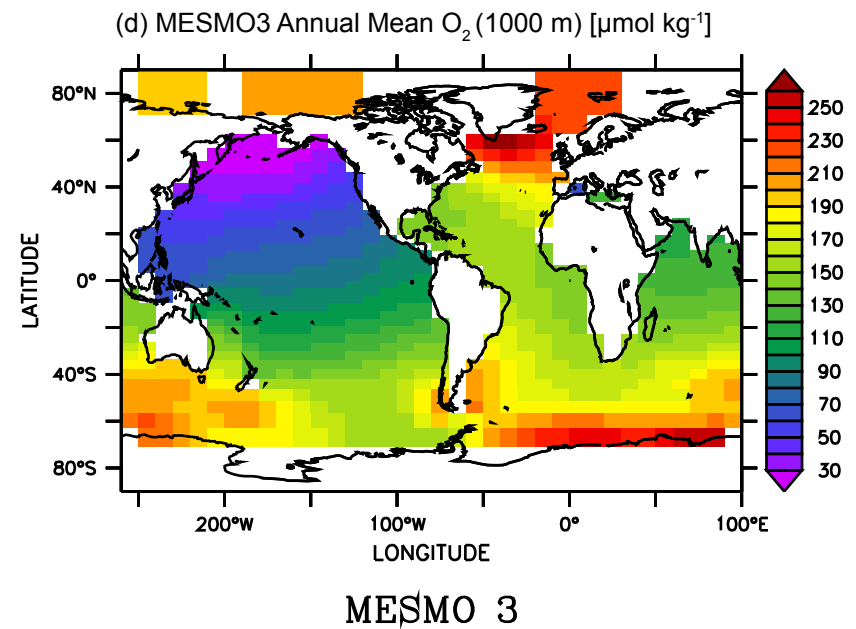
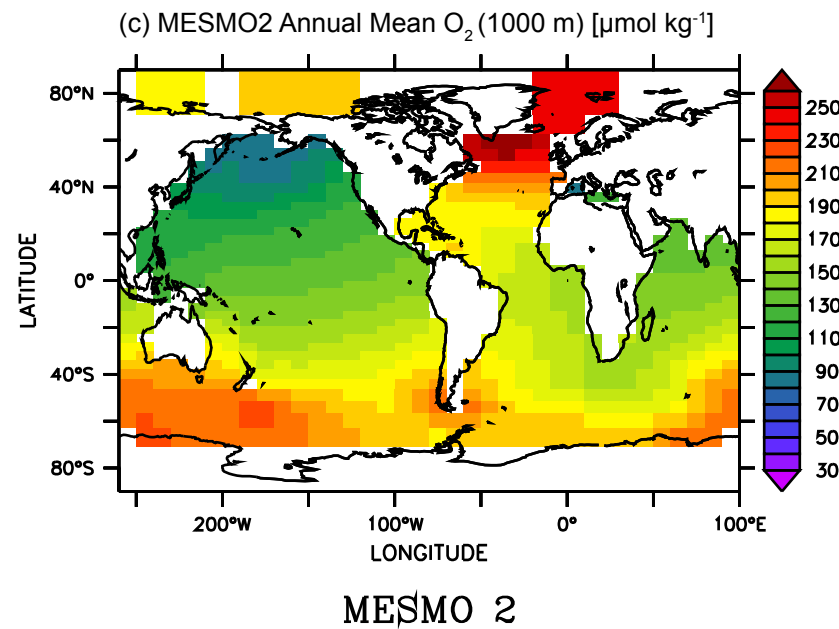
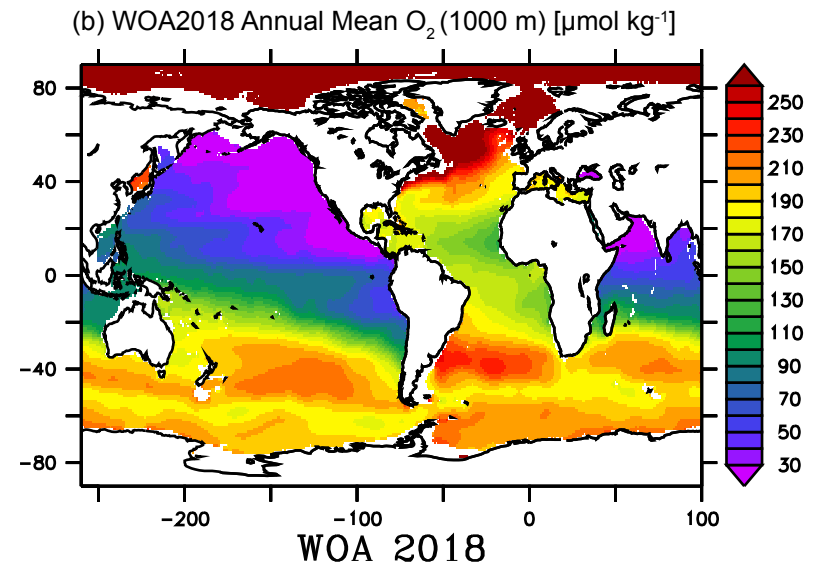
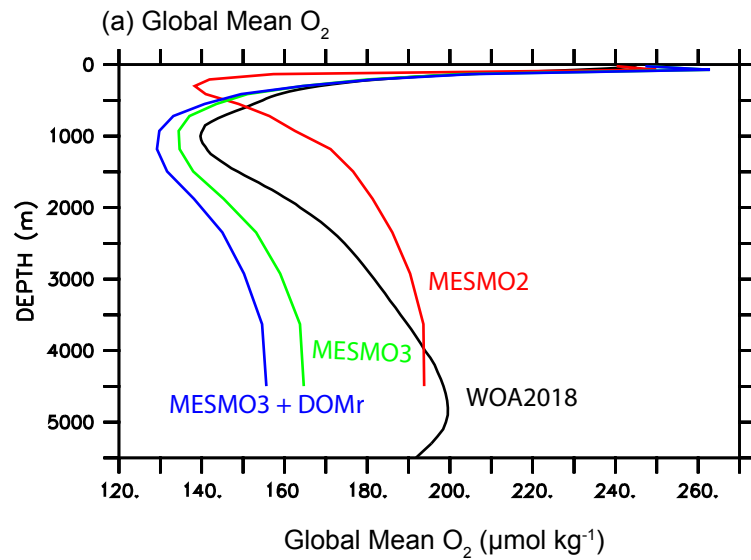
MESM03 N03



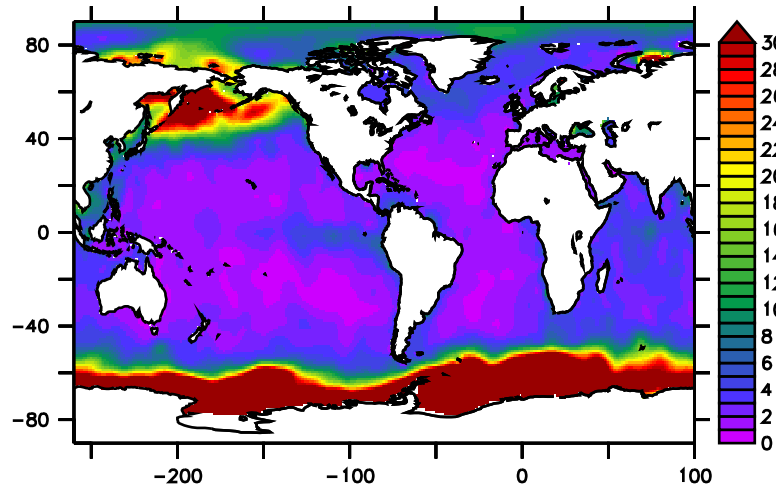
MESM02: POC export



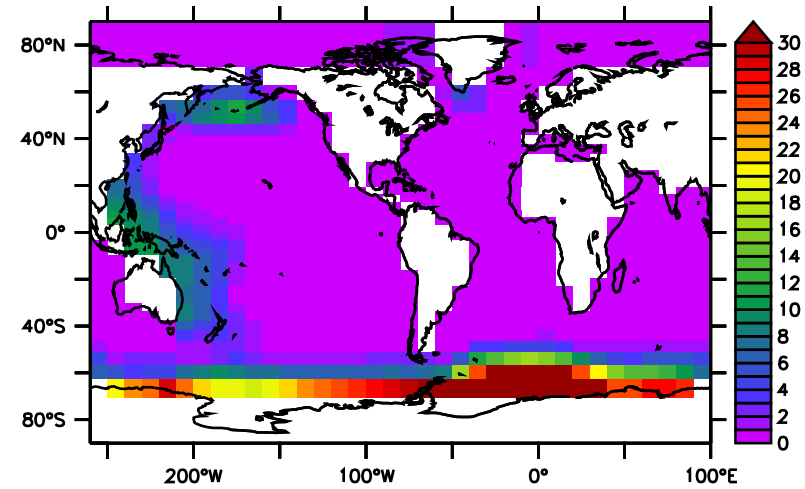
MESM03 POC export



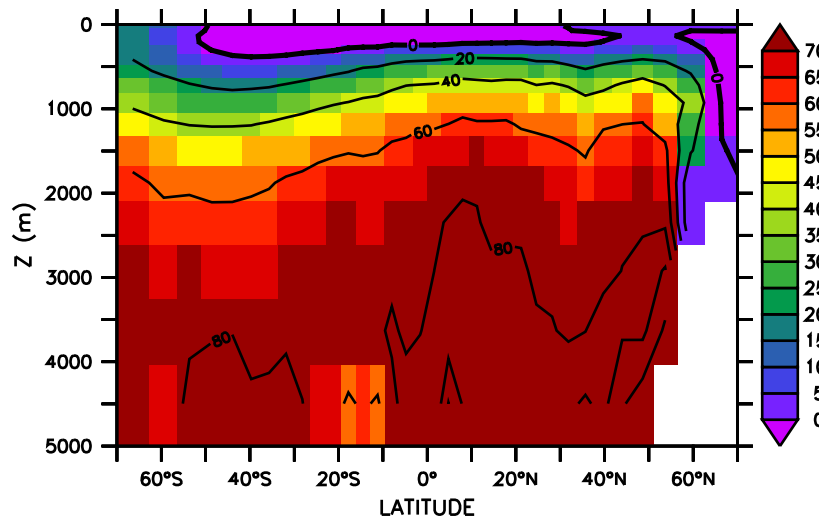
a) WOA2018  $\text{Si}(\text{OH})_4$  (Surface) [ $\mu\text{mol kg}^{-1}$ ]



b) MESMO3  $\text{Si}(\text{OH})_4$  (Surface) [ $\mu\text{mol kg}^{-1}$ ]

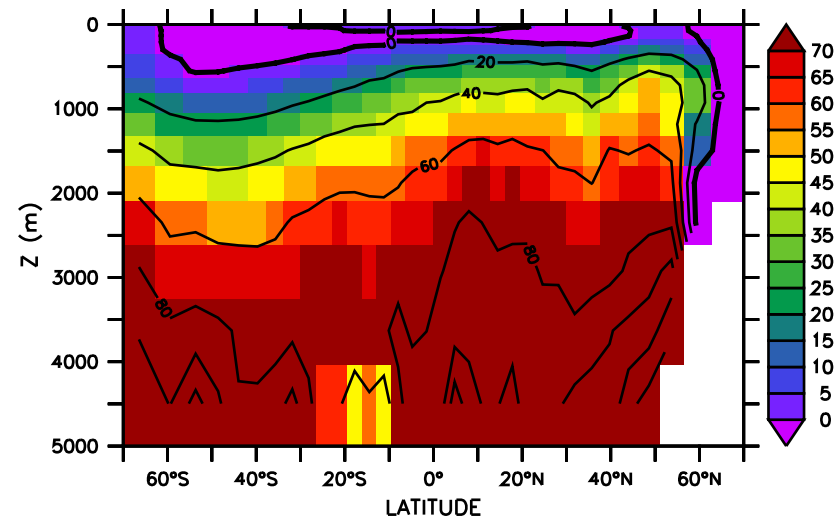


c) MESMO2  $\text{Si}^*$  [ $\mu\text{mol kg}^{-1}$ ]

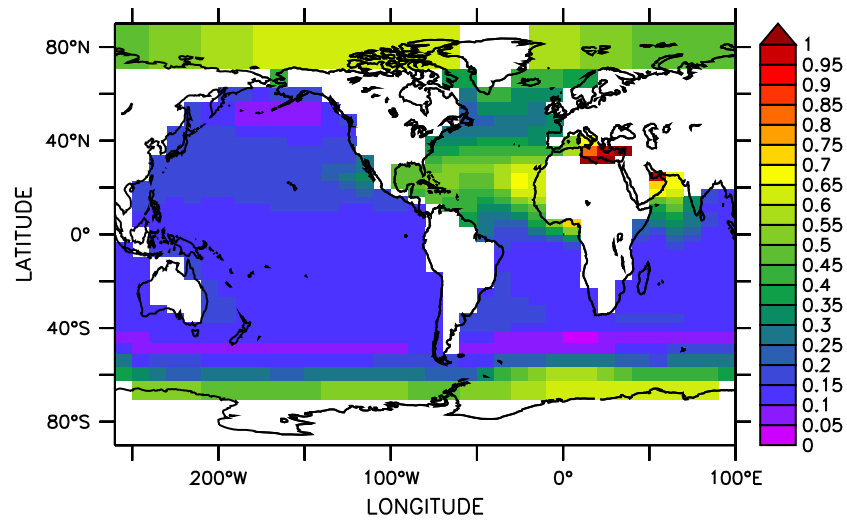


$\text{Si}^*$  ( $\mu\text{mol/kg}$ )

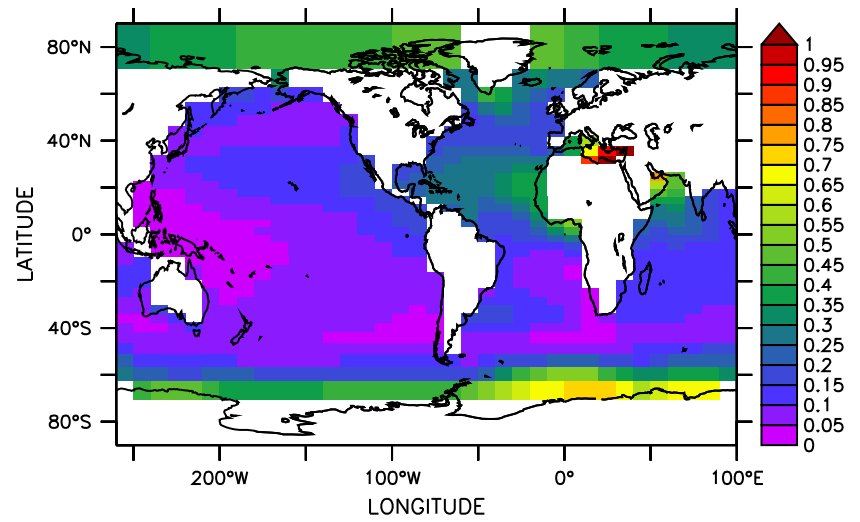
d) MESMO3  $\text{Si}^*$  [ $\mu\text{mol kg}^{-1}$ ]



$\text{Si}^*$  ( $\mu\text{mol/kg}$ )

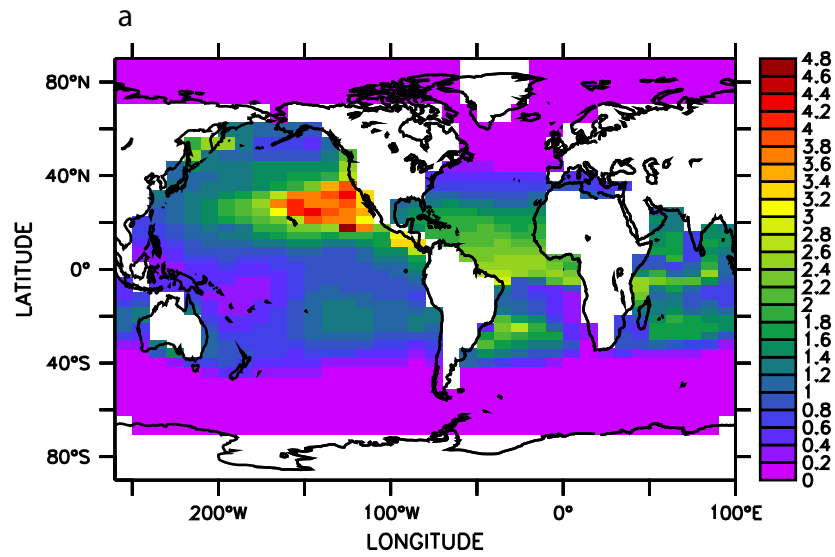


MESMO2:FeT

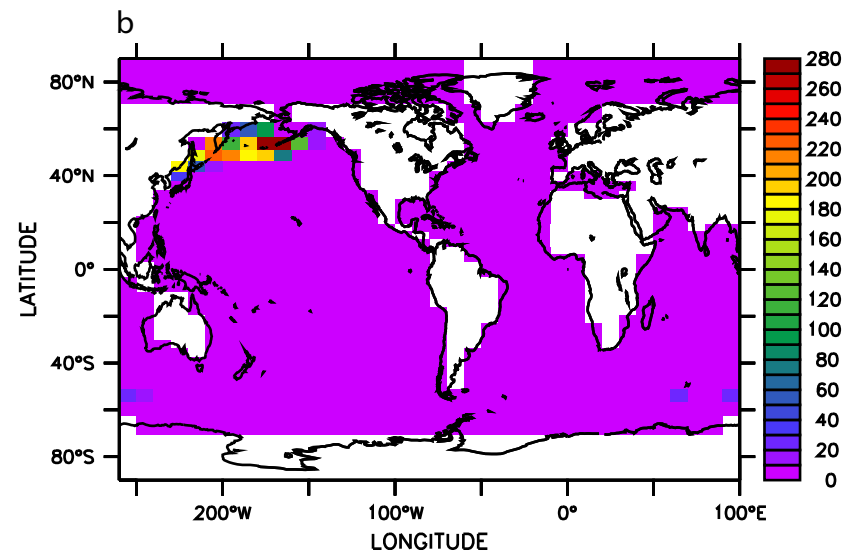


MESMO3 FeT





N-fixation (flux) ( $\text{molN m}^{-2} \text{yr}^{-1}$ )



oceanic denitrification (flux) ( $\text{molN m}^{-2} \text{yr}^{-1}$ )