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Biogeosciences
Discussions

Interactive comment on "Diagnosing sea-surface dimethylsulfide (DMS) concentration from satellite data at global and regional scales" *by* Martí Galí et al.

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Response to MAIN COMMENTS only

Reviewer: 1. One major contribution of this algorithm is providing DMS estimate with interannual and seasonal variability. Authors chose some regions to show the variability, but the results are part of the validation and not representative as mentioned in the manuscript (being the region where the algorithm works the best). It would be better if authors can discuss more about the variability on a global scale.

Author: I thank the reviewer for appreciating our contribution. As he/she indicates, a

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global-scale analysis of interannual variability would be an interesting exercise, and one that we plan to do soon. However, we declined this possibility in the present paper for the following reasons: (i) we thought of this paper as a proof-of-concept, and it is already quite long; (ii) running the algorithm for >10 years of satellite observations with the appropriate temporal resolution is doable but not trivial in terms of data storage and processing capacity; (iii) as described in the paper, we already implemented the algorithm for the MODIS-Aqua 2003-2016 record for latitudes >45N (at daily 4.6 km resolution), but the major results of this analysis will be analyzed elsewhere; (iv) an analysis of interannual variability of the seasonal cycle is most informative in coherent ecoregions where sufficient real DMS data are available for validation. In my opinion, there are two possible rigorous approaches to that: analyzing variability in regions/stations where in situ time series exist (which we did: BATS and OSP stations in Fig. 10); and analyzing variability in regions where the algorithm shows very good skill, evaluated both in a "scatterplot view" and in a "seasonal view", lending more credit to the satellite-diagnosed patterns (which we also did: Fig. 9 and Fig. S3).

I would also like to stress that the algorithm works well in regions other than the temperate and subpolar North Atlantic. I attached two figures (Fig. R1.1 and R1.2) showing that the algorithm works even better in the Bering Sea, which is well documented regarding in situ DMS data (see map in https://saga.pmel.noaa.gov/dms/). The figures correspond to areas of size similar to those shown in Fig. 9 of the paper and have the same legend. Both were derived from MODIS-Aqua data.

Reviewer: 2. Authors discussed regional tuning and biases as the strength of the algorithm. However, it raises the question about predictive power. In other words, the algorithm is largely built based on statistical regression, lacking fundamental scientific support. Authors should further clarify the optimized formula, differences caused by regional tuning, and regional tuning is required in some cases.

Author: We completely disagree with R#1 about the algorithm "lacking fundamental scientific support", ad we will make this clearer in the revised version of the paper. The effects of sunlight on DMS production-consumption budgets have been experimentally demonstrated by several studies (Archer et al., 2010; Galí et al., 2013a, 2013b, 2013c; Royer et al., 2016; Toole et al., 2006). Although UVB and UVA elicit the strongest responses, PAR can also stimulate plankton DMS production(Archer et al., 2010; Galí et al., 2013c). More importantly, since incident PAR and UVR are strongly correlated on a global scale, satellite-retrieved PAR is an excellent first-order approximation for UVR effects.

The reasons why solar PAR+UVR irradiance drive the DMS seasonal cycle were extensively discussed by Galí and Simó (2015). Basically, at high irradiance, there is (i) a higher proportion of high-DMSP phytoplankton species, (ii) a higher community DMSP-to-DMS conversion yield, (iii) an increase in DMS photolysis rate constants, and (iv) a decrease in bacterial consumption rate constants. Factors (i) and (ii) synergistically combine to increase gross DMS production rates, whereas factors (iii) and (iv) compensate each other so that total DMS removal rate constants do not change as much as gross DMS production. As a result, DMS budgets imply a higher "equilibrium" DMS concentration during high irradiance seasons (DMS is at quasi steady state on daily-to-weekly time scales most of the time, see also Royer et al. 2016). These are the robust theoretical underpinnings of our algorithm.

As a corollary, community DMSPt-to-DMS yields are significantly correlated to the DMS/DMSPt ratio. We attached a further figure to illustrate this (Fig. R1.3). The figure is based on the same global-ocean DMS(P) cycling process database analyzed by Galí and Simó (2015).

This also (partially) responds the specific comment "P4".

Reviewer: 3. The algorithm discussed here largely depends on the sub-algorithm. Though it is described in a previous publication, basic introduction and discussion about the sub- algorithm are needed for readers to understand the strength and limitation. For example, chlorophyll data contains no information about speciation, which plays an important role in the total DMS concentration.

Author: We will include a brief description of the DMSPt sub-algorithm in the revised version of the paper, perhaps in annex (we assume R#1 refers to the DMSPt sub-algorithm). Although this algorithm, thoroughly described and validate by Galí et al. 2015, does not include explicit phytoplankton speciation, it implicitly discriminates different types of phytoplankton communities.

Briefly, the DMSPt sub-algorithm is based on 2 equations that predict DMSPt from Chl and other secondary variables. The algorithm switches between these 2 equations depending on a classical bio-optical criterion, the ratio Zeu/MLD (Zeu is euphotic layer depth defined by 1% surface PAR penetration; MLD is mixed layer depth) (Uitz et al., 2006). * Zeu/MLD >1 indicates "stratified waters" where the mixed layer is entirely well illuminated. In these conditions, phytoplankton communities have higher proportions of DMSP-rich taxa, mainly haptophytes but also dinoflagellates, and other picoeukaryotes with generally lower abundance (chrystophytes, pelagopphytes, prasinophytes). * Zeu/MLD < 1 indicates more deeply "mixed waters" where part of the mixed layer is below the 1% irradiance level. In these conditions, DMSP-poor phytoplankton (mostly diatoms) dominates.

In accordance, at a given Chl concentration, the "stratified-waters " DMSPt equation produces a tenfold higher sea-surface DMSPt concentration (approximately) than the "mixed-waters" equation. Detailed information on the DMSPt sub-algorithm can be found in Galí et al. (2015), which is freely and legally available (after the 2 year embargo) on ResearchGate: https://www.researchgate.net/profile/Marti_Gali_Tapias/contributions.

This also responds the specific comment "P3".

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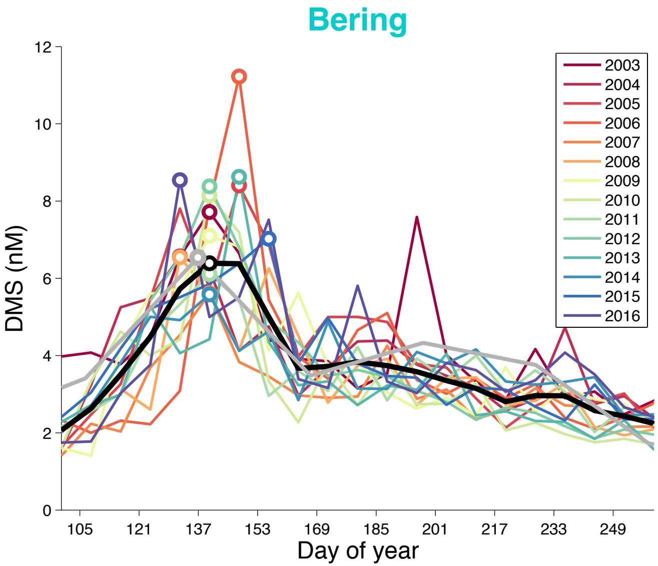

Fig. 1. DMS mean seasonal cycle and interannual variability in the Bering Sea (central shelf). Latitude 59-62N, longitude 169-174W (see text for details). Colors: years; black: mean; gray: L11 climatology

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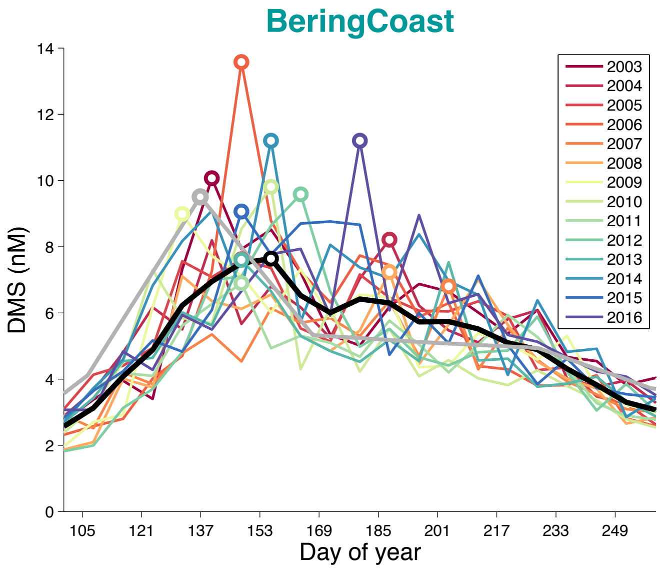

Fig. 2. As Fig. 1 for the coastal Bering Sea shelf. Latitude 54-57N, longitude 164-168W (see text for details). Colors: years; black: mean; gray: L11 climatology

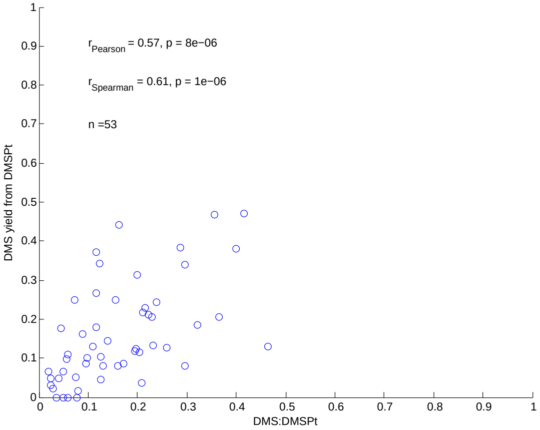

Fig. 3. Relationship between process-based DMS production yield from total DMSP and the DMS/DMSPt concentration ratio (see text for further details)

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