

Global fields of sea-surface DMS – Review & Data

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The principal precursor of DMS in oceanic surface waters is dimethylsulphoniopropionate (DMSP), which is primarily synthesized by phytoplankton. The transformation of DMSP to DMS and the accumulation of DMS in surface waters are intricately linked to food-web dynamics and physico-chemical processes, including photochemical degradation, vertical mixing, and sea to air flux (Simó 2001, Archer et al. 2002, and references therein).

To our knowledge, the study of Archer et al. (2002) is the first attempt to test our understanding of the cycling of DMS in the sea with such a detailed model following the pioneering work done by Gabric. No attempts have been made yet to couple comprehensive ecosystem models of this type to oceanic and atmospheric general circulation models to predict global DMS flux. Given the magnitude of computing resources and the time that would be required to complete a one-year simulation, trying to couple such detailed models is currently impractical. Our inability to constrain parameters associated with DMS cycling at the global scale is also an important limitation. For the time being, global scale distributions of oceanic DMS concentration have to be approached by statistical analyses of field observation datasets, and prediction has to rely on empirical parameterisations, such as those described below. We compare here four different global fields of sea-surface DMS.

The first one is the updated climatology of Kettle and Andreae (2000), which is derived from a compilation of measurements of DMS in surface sea water and an interpolation procedure in regions or seasons where no data are available (Kettle et al., 1999). DMS records from the Kettle et al. database can now be retrieved from a particular region or time, using the new interactive tools developed by T.S. Bates (Pacific Marine Environmental Laboratory), at the following address:
<http://saga.pmel.noaa.gov/dmserver/index.php>.

The work of Anderson et al. (2001) forms the basis for the second dataset. In this study, the Kettle et al. database, which contains chlorophyll a as a recorded variable, was extended by merging nutrients and light from globally gridded fields to generate the CJQ index where C is the chlorophyll concentration, J is the irradiance and Q is a nutrient uptake term. The CJQ index is a proxy of the algal growth rate. Log(CJQ) was shown to be significantly linearly correlated to DMS in the range 2.3-22 nM.

The work of Simó and Dachs (2002) forms the basis of the third dataset. Again, the Kettle et al. database of DMS and chlorophyll a (Chl) was extended by adding the climatological mixed layer depths (MLD). A double-equation algorithm with Chl and MLD was found to explain a large fraction of the variance for surface DMS concentration. The global distribution of oceanic DMS is estimated from the 1997–2000 SeaWiFS (satellite based) measurements of the sea-surface Chl concentration and from a

global MLD climatology (Levitus). In more than 80% of cases the DMS concentration appears to be solely a non-linear function of the MLD.

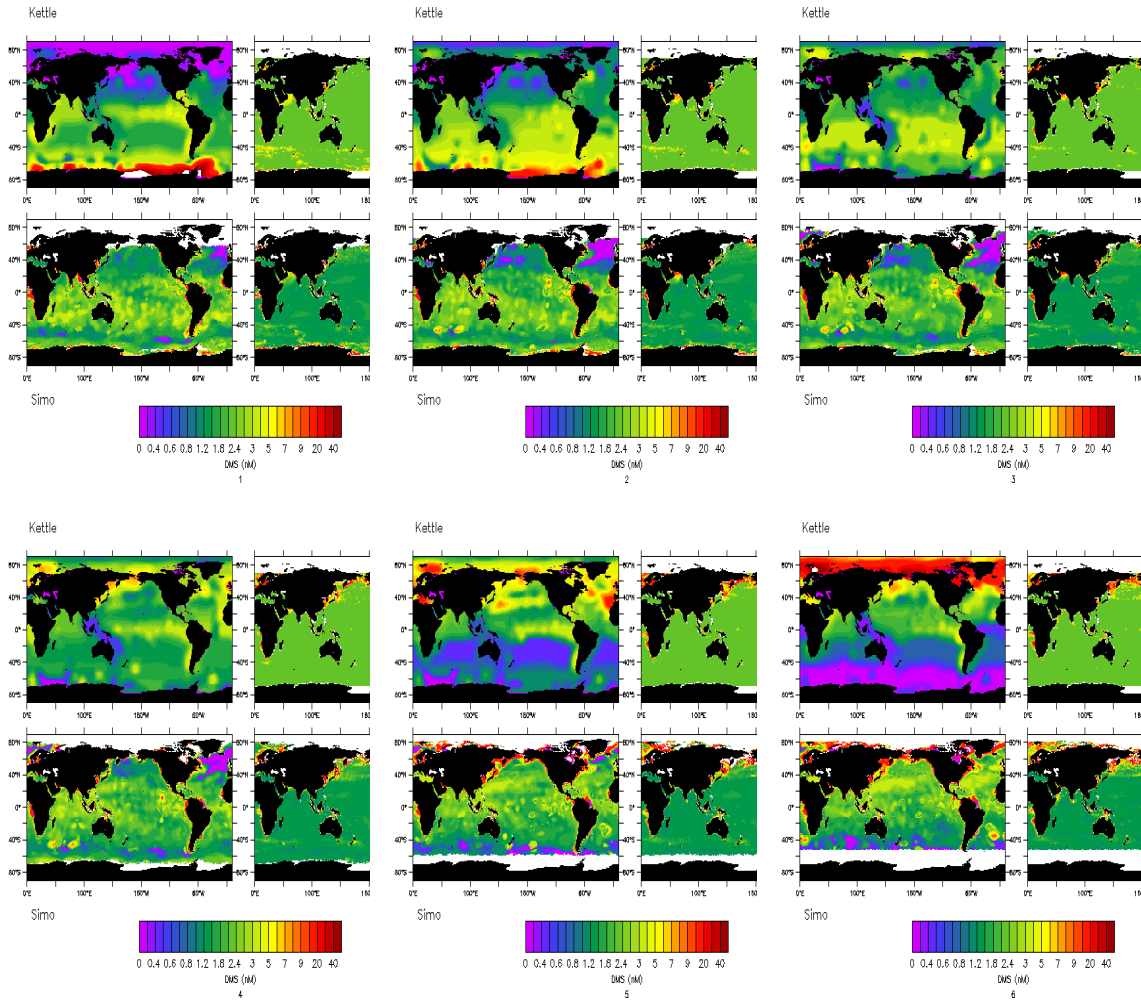
The fourth DMS climatology originates in the work of Belviso et al. (submitted), which has already been coupled to an atmosphere model by Boucher et al. (2003). The global distribution of oceanic DMS concentration is estimated from the 1998–2001 SeaWiFS measurements of the sea-surface Chl a content and from a phytoplanktonic community structure index which are then empirically linked to the DMS concentration as in Aumont et al. (2002) and Bopp et al. (2003). However, here the phytoplanktonic community structure index is a non-linear function of Chl a, so that sea surface DMS concentration is computed solely from SeaWiFS ocean color measurements. A maximum value of 50 nmol l⁻¹ was introduced to overcome the few unrealistic values obtained at very large Chl a content in coastal waters.

Before comparing all four parameterisations with each other, it has to be stressed that both Anderson and Simó, unlike Belviso, used the Kettle's database of field observations to develop their algorithms. Therefore, any comparison of Anderson and Simó with Kettle is somewhat redundant with the results of the correlations used to set the parameterisations, particularly in the regions and months where the Kettle database is well fed with hard data. In regions and months to where Kettle et al. extended the database by means of extrapolations, interpolations and smoothings, such comparison is useful to confront prediction capabilities.

In the area 60°N–60°S, where SeaWiFS data are available all year round, the average oceanic DMS concentration of Kettle is in general markedly lower than that of others (Table 1). Contoured data for each month can be viewed in Plates 1 through 12. DMS fields of Anderson, and to some extent of Belviso, do not capture any variability for most of the low-DMS areas. Baseline DMS concentration in Belviso is roughly half that in Anderson. Anderson's and Belviso's approaches do the same job at getting "hot-spots" of DMS in subtropical and polar frontal systems between 40° and 50°S in spring and summer. Only Simó, and to some extent Kettle, suggest that the Southern Ocean between 40° and 60° S is a region of almost-permanent low concentrations (according to Simó this is because winds are strong and mixed layers are deep).

It is important to clarify if this is true or not, because this is a very windy region that, if exhibited moderate-to-high concentrations, would give high DMS emissions. This is also important because this is a region for which significant changes are expected under global warming. Neither the geographical extent nor the homogeneity of the summer high DMS spot within Kettle's Antarctic biogeochemical province are reflected in Simó, Anderson and Belviso. It is not clear whether the Equatorial Pacific (and the adjacent ITCZ) is or is not a region of enhanced DMS during most of the year. This is well defined in Kettle, and is somehow reflected in Simó, but it is hardly seen in Belviso. Finally, Simó predicts lower concentrations than Kettle, Belviso and Anderson in the North Atlantic, north of 40°N, in late winter and early spring. This is probably because the region exhibits deep mixed layers in spring, according to Levitus.

The 8 observational transects shown in Figure 1 can be used as a way to compare or validate the parameterisations. However, caution has to be applied to their interpretation. Firstly because the field data correspond to particular situations that might not be representative of the region and the whole “climatological” month. Secondly, it has to be noticed that Kettle's good match with all transects is because those field data were used to feed Kettle's database.



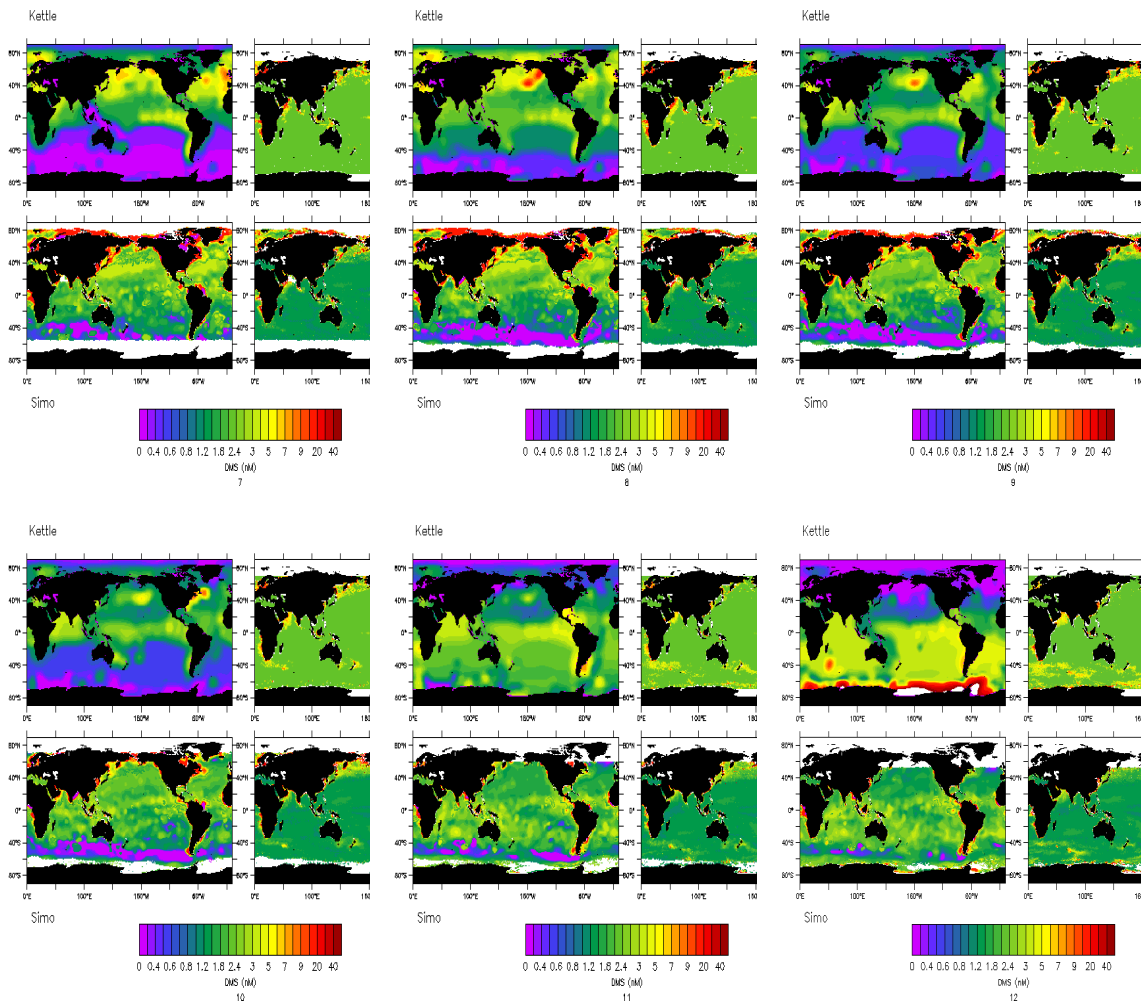


Table 1: Monthly mean of oceanic DMS concentration in the latitudinal band 60°N-60°S as given by each of the four parameterisations. Unit is nmol l⁻¹.

	Kettle	Anderson	Simó	Belviso
January	1.44	2.53	2.33	1.97
February	1.74	2.50	2.26	1.97
March	1.65	2.51	2.26	1.98
April	1.40	2.57	2.27	2.14
May	1.36	2.60	2.36	2.37
June	1.16	2.59	2.45	2.24
July	1.15	2.56	2.34	2.07
August	1.38	2.61	2.22	2.08
September	1.08	2.55	2.16	2.05
October	1.05	2.55	2.16	2.03
November	1.62	2.57	2.24	2.10
December	1.98	2.65	2.26	2.00
Annual	1.42	2.57	2.27	2.23

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