

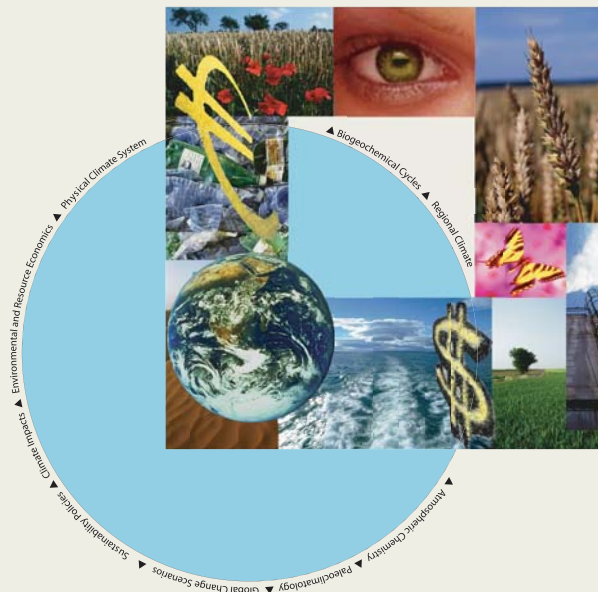


International Max Planck Research School on EARTH SYSTEM MODELLING

"DMS cycle in the ocean-atmosphere
system and its response to
anthropogenic perturbations"

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Abstract

Dimethylsulfide (DMS) is the main biogenic sulfur compound in the atmosphere. DMS is mainly produced by the marine biosphere and plays an important role in the atmospheric sulfur cycle. It has been proposed that DMS is linked to the global climate through a negative biogeochemical feedback cycle stabilizing the Earth against global warming. This so-called CLAW hypothesis initiated extensive research and improved the understanding of many aspects of the biogeochemical sulfur cycle. However, the overall magnitude and even the sign of this feedback cycle are still open questions in present-day research.

The objectives of this work are to study the DMS cycle in the ocean and atmosphere and to investigate its response to anthropogenic perturbations. The novelty of this study is the coupling of the relevant components. A global coupled ocean-atmosphere circulation model was established with a fully coupled prognostic treatment of DMS in the ocean, its flux into the atmosphere, and the resulting sulfur concentrations in the atmosphere. The DMS cycle in the ocean is linked to plankton dynamics simulated in the marine biogeochemistry model HAMOCC5, which is embedded in an ocean general circulation model (MPI-OM). The atmospheric model ECHAM5 is extended by the microphysical aerosol model HAM, treating the sulfur chemistry in the atmosphere and the evolution of the microphysically internally- and externally mixed aerosol population.

In order to evaluate the established modeling system, a climatological mean simulation was performed and compared to available measurements. Thereby, aerosol and aerosol-precursor emissions were set to conditions representative for the year 2000. The simulated global annual mean DMS sea surface concentration is 1.8 nmol l^{-1} . The DMS emission amounts to 28 Tg(S) yr^{-1} , resulting in a DMS burden of the atmosphere of 0.077 Tg(S) , and a DMS lifetime of 1.0 days. DMS contributes 25% to the global annually averaged SO_2 column burden and 27% to the SO_4^{2-} column burden. The global distribution of DMS sea surface concentrations compares reasonably well with measurements. In the marine biological active season SO_4^{2-} surface concentrations are overestimated in regions where DMS is the main SO_4^{2-} precursor. As the DMS sea surface concentrations are in agreement with the observations, the most likely explanation is a missing chemical reaction mechanism in the atmosphere preventing the formation of SO_4^{2-} from DMS oxidation.

The response of the DMS cycle to global warming was investigated in a transient climate simulation from 1860 to 2100. The results were analyzed in terms of simulated changes between the periods 1861–1890 and 2061–2090. The global annual mean DMS sea surface concentration and DMS flux decrease by 10% in a warmer climate. Thereby, the response to global warming is largely driven by changes in the ocean dynamics, such as an enhanced ocean stratification causing a reduction in marine net primary production and a decrease in the DMS production in the ocean. The DMS burden in the atmosphere is reduced by 3%, owing to a 7% longer lifetime of DMS in the atmosphere in a warmer climate. The simulated decrease in the DMS emission and atmospheric DMS concentrations in a warmer climate is in contrast to the proposed negative feedback in the CLAW hypothesis, in which increasing DMS emissions in a warmer climate constitute a key mechanism.