Impact of sea smell overestimated by present climate models

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The formation of sulfur dioxide from the oxidation of dimethyl sulfide (DMS) and, thus, of cooling clouds over the oceans seems to be overvalued in current climate models. Credit: Tilo Arnhold, TROPOS

Leipzig. The formation of sulfur dioxide from the oxidation of dimethyl sulfide (DMS) and, thus, of cooling clouds over the oceans seems to be overvalued in current climate models. This concludes scientists from the Leibniz Institute for Tropospheric Research (TROPOS) from a model study on the effects of DMS on atmospheric chemistry. Until now, models considering only the oxidation in the gas phase describe merely the oxidation pathway and neglect important pathways in the aqueous phase of the atmosphere, writes the team in the journal *PNAS*. This publication contains until now the most comprehensive mechanistic study on the multiphase oxidation of this compound. The results have shown that in order to improve the understanding of the atmospheric chemistry and its climate effects over the oceans, a more detailed knowledge about the multiphase oxidation of DMS and its oxidation products is necessary. Furthermore, it is also needed to increase the accuracy of climate prediction.

Dimethyl sulfide (DMS) is formed by microorganisms and is, for example, also part of human breath odor. However, it is more pleasant to remember as the typical smell of the sea. DMS represents the most common natural sulfur compound emitted to the atmosphere. Major contributors are oceans, which make up around 70 % of Earth's surface. DMS is formed by phytoplankton and then released from the seawater. In the atmosphere, DMS oxidizes to sulfuric acid (H2SO4) via dimethyl sulfoxide (DMSO) and sulfur dioxide (SO2). Sulfuric acid can form new cloud nuclei, from which new cloud droplets can emerge. Hence, marine clouds will be visually brightened, which influences the radiative effect of clouds and thus Earth's climate. Therefore, the understanding and quantification of these chemical processes in the atmosphere is of high importance for the knowledge of the natural climate effect.

The oxidation process of DMS has already been investigated in various model studies - albeit without accurate considered aqueous-phase chemistry. In order to close these mechanistic gaps, scientists of TROPOS have developed a comprehensive multiphase chemical mechanism ("Chemical Aqueous Phase Radical Mechanism DMS Module 1.0"). This mechanism was coupled to a comprehensive gas-phase (MCMv3.2) and aqueous-phase mechanism (CAPRAM) and applied with the SPACCIM model. The SPACCIM model was developed at TROPOS and is, due to the detailed and combined description of microphysical and chemical processes in aerosols and clouds, particularly suitable for complex studies on atmospheric multiphase processes.

As most important outcome, the new model results showed that: "The processes in the aqueous phase significantly reduce the amount of sulfur dioxide and increase the amount of methanesulfonic acid (MSA). In earlier models, there was a gap between the projected values in the model and measurements. Now, the scientists have been able to clarify this contradiction and thus confirm the importance of the aqueous phase for the atmospheric oxidation of dimethyl sulfide and its products such as MSA", reports Dr. Andreas Tilgner of TROPOS.

The results show that the role of DMS in Earth's climate is still not sufficiently understood - despite many global model studies. "Our simulations indicate that the increased DMS emissions lead to higher aerosol particle mass loads but not necessarily to a higher number of particles or cloud droplets. The modeling results are important to understand the climate processes between ocean and atmosphere. In addition, geoengineering ideas are constantly being discussed, which are hoping for more cooling clouds by fertilizing the ocean", explains Prof. Hartmut Herrmann from TROPOS. However, this study suggests that the production of sulfur dioxide is less pronounced and the effects on the back-reflection effect of the clouds are lower than expected. Therefore, the corresponding geoengineering approaches could be less effective than assumed. Tilo Arnhold

More information: Erik Hans Hoffmann et al, An advanced modeling study on the impacts and atmospheric implications of multiphase dimethyl sulfide chemistry, *Proceedings of the National Academy of Sciences* (2016). DOI: 10.1073/pnas.1606320113