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BVOC-cloud-climate feedbacks investigated using NorESM

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Emissions of biogenic volatile compounds (BVOC) from vegetation contribute to aerosol formation in the atmosphere and can therefore affect clouds and climate. The rising levels of CO_2 and temperature in the atmosphere result in higher BVOC emissions which lead to increased aerosol formation. Higher aerosol loading can result in brighter clouds that cool the climate. This has been recognised as a negative climate feedback but its magnitude and importance is highly uncertain.

We have investigated the BVOC feedback using the Norwegian Earth System Model (NorESM). The Community Atmospheric Model, with the OsloAero aerosol scheme (CAM5.3-Oslo) was run interactively together with the Community Land Model (CLM4.5). CLM4.5 includes the Model of Emissions of Gases and Aerosols from Nature (MEGAN) version 2.1 which provide emissions of monoterpene and isoprene. These BVOC can condense onto existing aerosols or participate in new particle formation in CAM5.3-Oslo. To investigate the BVOC feedback, we have run simulations where we both double CO_2 w.r.t. year 2000 levels and raise the fixed sea surface temperatures to the year 2080 levels (RCP8.5). This setup was run with both the feedback turned on (interactive emissions) and with the feedback turned off (emissions are kept constant at the year 2000 conditions) to estimate the importance of the feedback.

The global yearly BVOC emissions are almost twice as high in the simulation with the BVOC feedback turned on compared to the simulation with the feedback turned off. The largest difference in BVOC emissions between the simulations is seen in the tropics and over the NH boreal regions. The higher levels of BVOC emissions lead to more Secondary Organic Aerosols (SOA) formation (126 vs 77.7 Tg yr $^{-1}$) as well as somewhat higher aerosol number concentration for the simulation with the feedback turned on. This results in higher cloud droplet number concentration (CDNC) in the Arctic and the tropics, but over highly polluted regions, the CDNC is instead lower. The decrease in CDNC is caused by lower hygroscopicity of the aerosol due to more organics present in the particles. The net cloud forcing (NCF) is -0.3 W m^{-2} globally when the feedback is on compared to when it is off, but the difference in the NCF varies a lot spatially. In the Arctic, during summer, the NCF is down to -10 W m^{-2} when the feedback is turned on. During winter on the other hand, the higher BVOC emissions lead to warming over the continental sub-Arctic due to more low-cloud cover. The NCF also indicates a warming over the polluted regions where CDNC is lower when the feedback is on. The impact of the BVOC feedback can thus be of importance both globally and especially, regionally.

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