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# BVOC emissions and SOA yield impact on the direct and indirect aerosol effects in three ESMs

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Biogenic volatile compounds (BVOCs) have been found to be an important source of aerosol mass. As the knowledge on the importance of BVOCs has increased, parametrizations of secondary organic aerosol (SOA) formation from BVOCs are being implemented in many Earth System Models (ESMs). In this study, sensitivity tests connected to SOA formation from BVOCs have been run with three different ESMs to test how sensitive the direct and indirect aerosol effects are to changes in SOA yields and BVOC emissions.
The three models are the Norwegian Earth System Model (NorESM), EC-Earth and ECHAM-HAM. A control simulation and 5 sensitivity simulations were performed with all three models. Each run was nudged to ERA-interim data for 6 years where the first year is considered spin-up and not used in the analysis. The 5 sensitivity tests are:

- Yields higher - increase the yields in the BVOC to SOA reactions by 50 %
- Yields lower - decrease the same yields by 50 %
- No LVSOA (low-volatile SOA) - only semi-volatile SOA is allowed to form, SOA cannot contribute to new particle formation
- No isoprene - turn off isoprene emissions
- No monoterpene - turn off monoterpene emissions

The three models show quite different responses to the sensitivity tests. For the direct radiative effects (DRE) the models respond with the same sign for the same sensitivity test. In the Yields higher simulation the DRF become stronger in response to increased SOA production in all three models. Similarly, for the the simulations where the SOA production decreases (Yield lower, No isoprene, No monoterpene) the DRF is weaker in all three models. However, the magnitudes in the change in DRF vary between the models. EC-Earth displays the largest changes in DRF (min: -0.14 $Wm^{-2}$, max: +0.15 $Wm^{-2}$) while ECHAM has the smallest changes (min: -0.03 $Wm^{-2}$, max: +0.04 $Wm^{-2}$).
For the indirect aerosol effect the differences between the models is considerably larger. Again, ECHAM is the least sensitive model (maximum change in the short wave cloud forcing (SWCF) of 0.04 $Wm^{-2}$). NorESM shows the largest sensitivity in the simulations with changed yields, but in the No isoprene simulation, which results in the largest changes in the SWCF, EC-Earth is the most sensitive. Moreover, the model changes have opposite signs with +0.55 $Wm^{-2}$ for NorESM and -1.0 $Wm^{-2}$ EC-Earth in the No isoprene simulation. In NorESM, the removal of isoprene results in fewer particles that grow to CCN size while in EC-Earth, the removal of isoprene results in more SOA production from monoterpenes which increases aerosol particle concentrations.
The results of this study indicate that the changes in forcing from BVOC emissions is highly model dependent and that even changes to the same parameter give very different responses in different models. Further investigation of the impact of how biogenic SOA is implemented in models is needed.