New Insights into How Key Biosphere-Atmosphere Processes Impact Tropospheric Composition in UKESM

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Abstract

The emission of biogenic volatile organic compounds (BVOCs) has implications for air quality and climate, as they can contribute to ozone and secondary organic aerosol (SOA) formation. Developments in satellite remote sensing have allowed for the direct retrieval of isoprene, the globally dominant BVOC, from space. Additionally, recent developments within the UK Earth System Model (UKESM) enable the evaluation of key processes related to BVOC emissions and oxidation, including SOA formation pathways. We compare our UKESM1.1 baseline nudged simulation (2005-2014) to satellite retrievals of isoprene, formaldehyde (HCHO, a product of BVOC oxidation) and aerosol optical depth (AOD). We then utilise a range of model sensitivity experiments, including new BVOC emission factors, variations in the complexity of the chemistry scheme, as well as a revised boundary layer nucleation scheme and updated hygroscopicity values, to perform a comprehensive model-satellite comparison and quantify the importance of these model processes for tropospheric composition and air quality. Further, we consider how the satellite-observed relationships between land cover and atmospheric composition are reproduced within UKESM, and their sensitivity to these driving processes. Initial model results highlight that simulated isoprene column amounts are overestimated in many tropical BVOC emission hotspots, while HCHO column amounts are underestimated in these regions. The sign of the AOD model bias varies regionally. In terms of process importance, the new BVOC emission factors and more complex chemistry scheme (CRI-Strat 2) most strongly affect simulated regional column isoprene (>100% difference), HCHO (>30%) and AOD (>30%), although the boundary layer nucleation scheme is of equal relevance for AOD (30%). The CRI-Strat 2 chemical scheme reduces satellite-model trace gas biases but its impact on AOD differs regionally. The new emission factors generally result in an improvement of regional land cover-isoprene relationships by strengthening the influence of broadleaf forest cover on isoprene column concentrations.

Early Career Scientist

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