Incorporation and evaluation of the CRI v2.2 chemical mechanism in UKESM1: An alternative mechanism with updated isoprene chemistry for investigating the influence of BVOCs on atmospheric composition and climate.

James Weber1, Scott Archer-Nicholls1, N. Luke Abraham1,2, Youngsub M. Shin1, Thomas Bannan3, Rebecca Schwantes4, Michael Jenkin5, Anwar Khan6, and Alexander T. Archibald1,2
1Centre for Atmospheric Science, Department of Chemistry, University of Cambridge, Cambridge, CB2 1EW, UK (jmw240@cam.ac.uk)
2National Centre for Atmospheric Science, Department of Chemistry, University of Cambridge, CB2 1EW, UK
3School of Earth and Environmental Sciences, University of Manchester, Manchester, M13 9PL, UK
4Atmospheric Chemistry Observations and Modeling Laboratory, National Center for Atmospheric Research, Boulder, CO 80301, USA
5Atmospheric Chemistry Services, Okehampton, Devon, EX20 4BQ, UK
6Biogeochemistry Research Centre, School of Chemistry, University of Bristol, Cantock’s Close, Bristol, BS8 1TS, UK

We present the first incorporation and evaluation of the Common Representative Intermediates version 2.2 chemistry mechanism, CRI v2.2, for use in the United Kingdom Earth System Model (UKESM1). Tuned against the MCM v3.3.1, the CRI v2.2 mechanism builds on the previous CRI version, CRI v2.1, in UKESM1 (Archer-Nicholls et al., 2020) by updating isoprene chemistry and offers a more comprehensive description of tropospheric chemistry than the standard chemistry mechanism STRAT-TROP (ST).

CRI v2.2 adds state-of-the-art isoprene chemistry with the introduction of HO₂-recycling via the isoprene peroxy radical isomerisation pathway, making UKESM1 one of the first CMIP6 models to include this important chemistry. HO₂-recycling has noticeable effects on oxidants in regions with large emissions of biogenic volatile organic compounds (BVOCs). Low altitude OH in tropical forested regions increases by 75-150% relative to ST, reducing the existing model low bias compared to observations. Consequently, isoprene surface mixing ratios decrease considerably (25-40%), significantly improving the model high bias relative to ST. Methane lifetime decreases by 2% and tropospheric ozone burden increases by 4%.

Aerosol processes also differ between CRI v2.2 and ST, resulting in changes to the size and number distributions. Relative to ST, CRI v2.2 simulates an 8% decrease in the sulphate aerosol burden with 20% decreases in the nucleation and Aitken modes. By contrast, the secondary organic aerosol (SOA) nucleation mode burden increases by 11%. Globally, the average nucleation and Aitken mode aerosol number concentrations decrease by 20%.
The differences in aerosol and gas phase chemistry between CRI v2.2 and ST are likely to have impacts on the radiation budget. We plan to use CRI v2.2 and ST to investigate the influence that the chemical mechanism has on the simulated chemistry-climate feedbacks from BVOCs. In addition, CRI v2.2 will serve as the basis for the addition of a scheme describing the formation of highly oxygenated organic molecules (HOMs) from BVOCs, facilitating a semi-explicit mechanism for new particle formation from organic species.