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Coupling interactive fire with atmospheric composition and climate in the UK Earth System Model (UKESM)

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Fires constitutes a key process in the Earth system (ES), being driven by climate as well as affecting the climate by changing atmospheric composition and its impact on the terrestrial carbon cycle. However, global modelling studies on the effects of fires on atmospheric composition, radiative forcing and climate have been very limited to date. The aim of this work is the development and application of a fully coupled vegetation-fire-chemistry-climate ES model in order to quantify the impacts of fire variability on atmospheric composition-climate interactions in the present day. For this, the INFERNO fire model is coupled to the atmosphere-only configuration of the UK's Earth System Model (UKESM). This fire-atmosphere interaction through atmospheric chemistry and aerosols allows for fire emissions to feedback on radiation and clouds changing weather which can consequently feedback on the atmospheric drivers of fire. Additionally, INFERNO was updated based on recent developments in the literature to improve the representation of human/economic factors in the anthropogenic ignition and suppression of fire. This work presents an assessment of the effects of interactive fire coupling on atmospheric composition and climate compared to the standard UKESM1 configuration which has prescribed fire emissions. Results show a satisfactory performance when using the fire-atmosphere coupling (the "online" version of the model) when compared to the offline UKESM that uses prescribed fire. The model can reproduce observed present day global fire emissions of carbon monoxide (CO) and aerosols, despite underestimating the global average burnt area. However, at a regional scale there is an overestimation of fire emissions over Africa due to the miss-representation of the underlying vegetation types and an underestimation over Equatorial Asia due to a lack of representation of peat fires.