

## Review of “Decomposing pre-industrial to present-day land use change forcing in the UK Earth System Model”

by Sands et al.

### General assessment

This study quantifies the effective radiative forcing (ERF) associated with land-use change between pre-industrial (1850) and present-day (2014) conditions using the UK Earth System Model (UKESM1.1). The new version includes several process updates, including organically mediated boundary-layer nucleation, updated aerosol hygroscopicity, and revised biogenic volatile organic compound (BVOC) emission factors. The resulting forcing is decomposed into contributions from surface albedo, ozone, methane lifetime adjustments, and aerosol–radiation and aerosol–cloud interactions.

I enjoyed reading this manuscript and consider it a valuable contribution to the UKESM community and, more broadly, to the Earth system modelling community. The topic is timely, the analysis is thorough, and the forcing decomposition is particularly useful. I only have minor comments and recommend publication after the concerns outlined below have been addressed.

### Minor comments

- The manuscript defines “land use” primarily through biophysical changes, while keeping anthropogenic emissions fixed at 1850 levels. While this isolates the impact of vegetation replacement, it excludes emissions associated with agricultural expansion (e.g., NO<sub>x</sub> and NH<sub>3</sub> from fertiliser application). The authors should emphasise this limitation and clarify how the results relate to studies that include these chemical fluxes.
- It is not fully clear which feedbacks are active in the model configuration used here. Please clarify what is prescribed versus prognostic in the radiation scheme (e.g., aerosols, ozone, methane, cloud properties).

- Figures: Consider removing country borders for clarity, particularly in panels where spatial gradients are subtle.
- Consider including a figure showing changes in LAI. While PFT fraction changes provide a useful overview of land-cover transitions, LAI is a particularly informative metric for the magnitude of vegetation change.
- CDNC at 1000 m: What is the rationale for diagnosing CDNC at 1000 m? Would it be more consistent to use a pressure level (e.g., 900 hPa), similar to Scott et al. (2014)?
- Fig. 2b: I was surprised not to see monoterpene emissions at higher latitudes (e.g., boreal forests). Consider revisiting the plotting choices (e.g., a different colour scale) to ensure that weaker but relevant emissions are visible.
- Section 3.3: Does the reported net ERF include the contribution from surface albedo changes? Please clarify explicitly.
- Fig. 4: Should total column OM and sulfate be expressed per unit area? The current units are unclear.
- Lines 293–296: Can the authors confirm this interpretation using chemical production and loss diagnostics (or relevant budget terms)?
- Line 328: “The tropospheric O<sub>3</sub> decrease may be driven by the loss of BVOCs, which are O<sub>3</sub> precursors”. Same here.
- Fig. 9: The resolution is too low to interpret the figure clearly. Please provide a higher-resolution version.
- Fig. 9: Why does RF<sub>alb</sub> differ between the chemical mechanisms?
- Lines 30–32: The authors may wish to cite an additional relevant reference: <https://www.nature.com/articles/nature06870>
- Line 101: Please define N96L85 and provide the approximate horizontal grid spacing (e.g., in degrees or km).
- Line 152: Please confirm consistency with Ghan (2013), which uses only shortwave fluxes.