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POLDER aerosol retrievals can be used to attribute biases in modelled AAOD to specific processes

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Exploring aerosol model biases often involves numerous dedicated model runs (at different parameter settings). Examples of such studies use e.g. Perturbed Parameter Ensembles or an Ensemble Kalman Filter. Identifying structural biases in such studies is challenging (although possible). More-over, these studies, by their design, focus on a single model (version).

Here we present a new methodology that makes use of existing ensembles of diverse models (e.g. AEROCOM, CMIP). The heart of the methodology consists of substituting a much simpler model for the AGCM or CTM with aerosol module. Here we showcase the methodology with the simple model AAOD = Emission * Lifetime * Mass Absorption Coefficient (MAC) and apply it to fire aerosol from the Amazon and the African Savannah.

We show that relations exist between lifetime and precipitation or MAC and Single Scattering Albedo in AEROCOM models. Such relations are expected from a physical point-of-view, and also supported by in-situ observations. We use observations of precipitation and SSA in combination with these modelled relations to estimate real lifetime and MAC. This immediately provides an assessment of the biases in individual aerosol models in terms of lifetime and MAC. But it also provides a suggestion of what dominating faults really exist in these aerosol models: incorrect wet deposition and per particle absorption. Furthermore, the method allows a simple estimate of emissions. This emission estimate leads us to conclude there is substantial SOA formation over the Amazon but not the Savannah and we provide supporting evidence of this in the form of IASI formaldehyde measurements.

We show that two aerosol models (ECHAM-HAM & SPRINTARS, with very different biases) perform better when modified according to our findings.

Further analysis suggests that the major source of uncertainty in our method are the satellite retrieval uncertainties in AAOD and SSA. Also, we provide optimal retrieval uncertainty requirements for a study such as ours.

This study explored biomass burning regions across the globe but the method should also be applicable to other locations. The method is also flexible with regards to sort of observations used (here AOD, AAOD, precipitation and Angstrom Exponent). Limitations of the method will be discussed.

Keywords: aerosol, atmospheric modelling, POLDER, bias attribution

References

Zhong, Q., Schutgens, N., van der Werf, G.R. *et al.* Using modelled relationships and satellite observations to attribute modelled aerosol biases over biomass burning regions. *Nat Commun* **13**, 5914 (2022). https://doi.org/10.1038/s41467-022-33680-4