

Interactive comment on “Sensitivity of stratospheric Br_y to uncertainties in very short lived substance emissions and atmospheric transport” by R. Schofield et al.

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We thank the reviewer for their careful review and suggestions for improving the style and readability of our manuscript through simplifying figures and language.

Overall: this is an intelligent paper with an interesting model approach. I don't have any serious criticisms of the technical aspects of the model. I would recommend publication. However, I think the main conclusions get obscured by the complexity of the figures, and at times, an awkwardness in the writing. The paper would have much more impact if it had a much stronger focus on the main conclusions, and the supporting evidence was presented in a simpler manner.

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Thank you for your suggestions for improvement, we have simplified all multiplot figures – and in the case of the detrainment figures introduced only the zonal mean profiles in place of the spatial information that was previously shown.

The paper uses a trajectory model, with episodic convective detrainment, to calculate a distribution of Br_y at 400 K. It explores the Br_y sensitivity to (1) boundary layer concentrations, (2) an "efficiency" parameter (or fraction of detrained air that is of boundary layer origin), (3) a washout parameter in the TTL for the soluble species (γ), and (4) Br species chemical lifetime.

Figures 3, 6, and 7 have an incredible amount of detail that makes the information from these figure hard to digest, and see. Most of this complexity is not directly relevant to the paper. I would suggest replacing some of the geographic variability with seasonal/zonal mean vertical profiles, perhaps of the detrainment rate, perhaps with a breakdown of ocean/continental/coastal.

Thank you for this suggestion – we have followed this through to improve figure 3 and agree that this is more pertinent information to include in the paper. In particular, breaking down the detrainment information into source regions demonstrated the strength of coastal and land convection, however zonal averaging from 20°N–20°S obscures this somewhat, as this latitude zone is made up of 71% ocean.

Figure 6 we have left unchanged as the spatial information concerning the seasons and resident times displays the seasonality absent in the predecessor ERA-40 runs and is useful for future studies that link trajectory studies with source regions.

Figure 7 we reduce to show just DJF and JJA, as the seasonal shift of the ITCZ is an important point that we conclude and this figure shows this shift in the source regions.

Figure 8 also has too much information to absorb; there are actually 60 different curves in this figure.

We now display just one of the plots (DJF for 30% BL air being detrained) – to illustrate

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how Br_y changes in transiting the TTL due to convection and washout.

I realize that the paper is not in a position to definitively answer how the observed 400 K Br_y values are achieved. But there should be a more condensed way of showing the results of these sensitivity studies. E.g. maybe the annual mean 400 K Br_y mixing ratio could be shown as a contour plot with the "efficiency" parameter on one axis and the "washout" parameter on another axis, with the observed range shaded (for specific choices of the other two sensitivities). I am not sure if such a contour plot is realistic given the required computer time; just a suggestion.

We were able to produce this plot (though it is not complete enough (or brings new insight) to warrant including it in the paper – containing just 6 data points) – we attach it here. It does show that if no washout occurs then the BL air component of detrained air should not exceed 30

Just after Equation 1: detrainment and divergence should not be used interchangeably. We now define the detrainment as given in ECMWF explicitly to avoid the confusion that arose here.

Figure 10 : I don't seem much interannual variability here. There is not very much – which is a point we make - we have reworded this caption to better describe this.

some examples of awkward writing: "exemplary trajectories" (example trajectories?), "When the emissions convected ..", "complexer emission pattern". We have attempted to remove these instances of awkward writing, making sentences simpler and increasing readability.

I have also a general comment about entrained air. It may be true, as the Romps study suggests, that only 10 - 30 % of air in detraining clouds originates from the boundary layer. However, deep convection typically occurs only when the column moisture is very high (papers by Neelin and others) - presumably after

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having been moistened by mid-level convection. If deep convection occurs under conditions of anomalously high RH, then presumably a background trace species value may not be realistic.

– firstly if the trace gases are hydrophilic then there may be some removal with high RH, though we assume that for the organic source species of bromine this is not the case (that in the space of hours that soluble PGs do not form).

- secondly, when deep convection is setting up in a previous convective cell – i.e. free tropospheric concentrations are mirroring underlying BL concentrations (i.e. geographical patterns), is something we mention that needs closer attention in both modelling and observational studies. We expect that our assumption that FT concentrations are adequately described by UT values is a poor assumption but until we have a better estimate unfortunately we can't improve upon this. We reiterate that we need a measurement based climatology of Br_y organic source gas measurements in the free troposphere.

One perhaps may want to look at the correlation between RH and a bromine species in the mid-troposphere, and use an effective entrainment Br mixing ratio which corresponds to the higher RH at which deep convection actually occurs.

It would be interesting to include RH in setting up such a free tropospheric climatology of stratospheric Br_y source gases, as this should provide some indication perhaps of BL or geographical source 'memory'. RH data is much more accessible (than bromine source gas data) and if this link could be made it would greatly improve future modelling studies. We find this a very interesting idea, though clearly beyond the scope of this paper.

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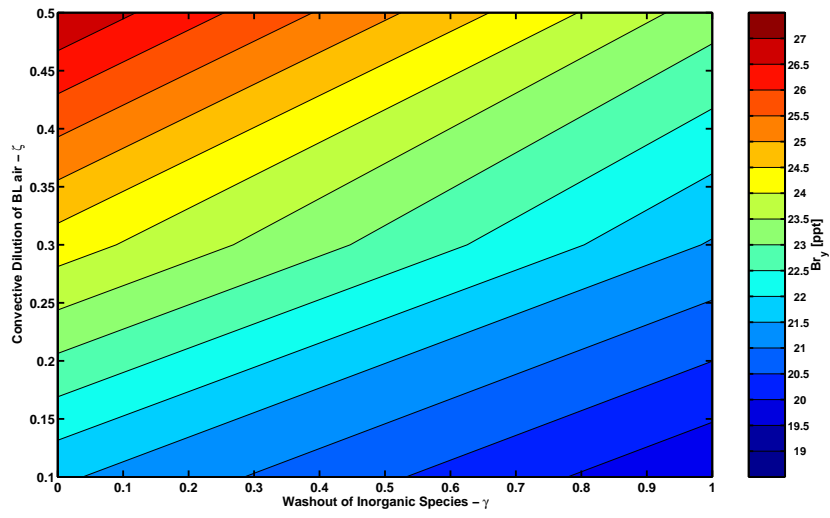


Fig. 1. Bry for different BL Convective Dilutions and Washout.

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