

# ***Interactive comment on “An improved parameterisation of ozone dry deposition to the ocean and its impact in a global climate-chemistry model” by Ashok K. Luhar et al.***

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We thank Dr. Fairall for reviewing the manuscript and providing very useful comments. In the following, we provide a response to the comments made by him (the Referees' comments are given in inverted commas).

Comment: “This paper describes an improved parameterization for oceanic deposition of ozone. It is based on a 2-layer molecular/turbulence model where the reactive component on the Oceanside is restricted in depth. The concentration of the reactive component (iodide) is represented as a function of ocean temperature. The new parameterization is compared to a set of direct observations from shipboard measurements. It gives a much better fit to the data compared to the 1-layer approach. The

parameterization is incorporated into a global chemistry model and the results with different parameterizations are compared. The basic approach is sound and the new parameterization fits the data very well.”

Response: Thank you for your comment.

Comment: “In my view the paper is acceptable for publication in its present form. One essential point is the restriction of the reaction to within 2 microns of the surface. This seems artificial and, as discussed by the authors on page 13, may be a surrogate for the decrease of turbulence near the surface because of dissipation. Perhaps this issue could be solved with a better representation of turbulent mixing, near the interface, but for now their method is successful as a parameterization that seems to work. The authors may wish to reiterate this point in their conclusions.”

Response: The ozone-iodide reaction in seawater is fast such that the bulk of it takes place within the thin viscous sublayer near the water surface. In the current parameterisation, the waterside eddy diffusivity is assumed to vary linearly with depth. This assumption is valid for a fully turbulent flow and overestimates turbulent transfer in the viscous sublayer because it does not account for viscous dissipation of turbulence in this layer. This overestimation leads to a stronger chemistry-turbulence interaction, with the overall impact being an overestimation of ozone deposition velocity using the one-layer reactivity scheme.

As mentioned by the referee and discussed on pages 13 and 16, the two-layer reactivity scheme limits the iodide concentration to a specified depth from the water surface, thereby restricting the ozone-iodide reaction to that depth. Although this restriction is artificial, it works as surrogate to compensate for the overestimation of turbulent mixing in the viscous sublayer. A better parameterisation of turbulent mixing near the interface in the concentration conservation equation could overcome the issue. However, as commented by the referee, for now the two-layer method is successful and is adopted as a parameterization for deposition velocity. We will reiterate this point in the conclu-

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sions.

Comment: "Here are a few other comments: \*Figure 5b is confusing in that it appears that an increase in  $a$  can lead to a decrease in  $V_{dw}$ . I finally figured out that reactivity is not an independent variable but correlated with temperature. \*Figure 7. It would be amusing to see the 1-layer no turbulence solution on this graph."

Response: Yes, that is correct. The y-axis in Fig. 5b is ' $\alpha * V_{dw}$ '. Reactivity ( $\alpha$ ) is the product of the second-order rate coefficient and iodide concentration (Eq. 5), both of which increase with sea surface temperature (SST) and result in an increase of  $V_{dw}$  with SST. However, the ozone solubility in water ( $\alpha$ ) increases with decreasing SST. As mentioned in the first paragraph on Page 15, "there is a slight increase in ' $\alpha * V_{dw}$ ' with decreasing reactivity, which is mostly due to the larger influence of solubility which increases with decreasing temperature."

Regarding "Figure 7. It would be amusing to see the 1-layer no turbulence solution on this graph," we plot the one-layer no turbulence solution in the following figure (represented by small dots). The bottom figure is the same as the top one except that the points predicted by the two-layer model are not plotted for clarity. At SSTs greater than 17 deg C, the one-layer (no turbulence) and two-layer solutions are very similar as chemical reaction dominates over turbulence. For SSTs less than 17 deg C, the one-layer (no turbulence) solution predicts progressively lower deposition velocities than the two-layer solution because it neglects turbulence whose influence becomes important compared to weaker chemical reaction at such temperatures.

We will replace Figure 7 with the attached figure.

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Interactive comment on *Atmos. Chem. Phys. Discuss.*, doi:10.5194/acp-2016-844, 2016.



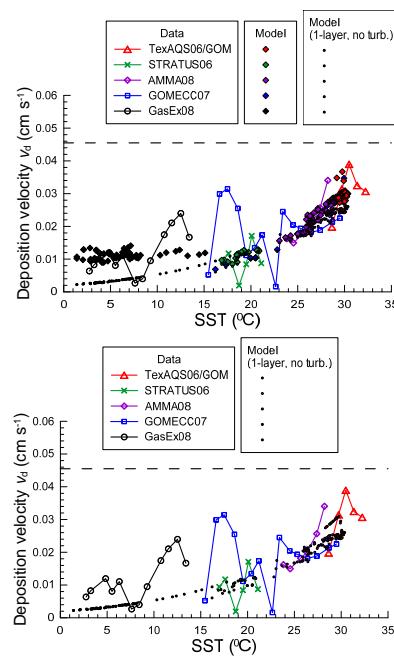


Figure: Ozone dry deposition velocity ( $v_d$ ) as a function of sea surface temperature (SST) from five field experiments (Helmig et al., 2012; Ludovic Bariteau, personal communication, 2016) and the corresponding values obtained from the ACCESS-UKCA model using the two-layer reactivity scheme for ozone deposition to the ocean. The small dots represent the values obtained using the one-layer reactivity scheme without oceanic turbulence solution.

**Fig. 1.** Figure 7 with no turbulence solution plotted