

Interactive comment on “Why CO₂ cools the middle atmosphere – a consolidating model perspective” by H. F. Goessling and S. Bathiany

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COMMENT: A study of this sort is sorely needed. As the authors identify in their introduction, the literature is lacking a clear explanation of why CO₂ increases cool the middle atmosphere. Most explanations are either too simplistic to be accurate, or arise from complex model calculations so their physical interpretation is unclear. The manuscript is very clear and well-organised. I also appreciated the 'building' analogy for understanding the results. I have a few comments and suggestions.

REPLY: We are grateful for this comment which confirms us in our concern to clarify the reasons of CO₂-induced stratospheric cooling. We also thank A. Ferraro for the constructive comments that we will address below.

COMMENT: P2, L9-10: “ As ozone concentrations are expected to recover in future, it

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seems likely that CO₂ concentrations will be of growing importance also in the lower stratosphere.” I find Cordero and Forster (2006) an unusual reference here as they don't seem to present model results for the 21st Century, during which ozone concentrations are expected to recover. Model results for this period have been presented by, e.g. Stolarski et al (2008) and Ferraro et al (2015).

REPLY: We thank A. Ferraro for pointing out these very interesting studies of which we were not aware. They are indeed more suitable to be cited. We will do this in the revised manuscript.

COMMENT: P5, L8 and L10: You seem to switch notation for optical depth from delta to tau here.

REPLY: We will use only one letter in the revised manuscript.

COMMENT: P10, L3: I am a little confused by your reference to “skin temperature” here. Equation 31 is for TOA temperature. I interpret skin temperature to mean the temperature of the surface.

REPLY: We have adopted the usage of “skin temperature” as a synonym for “TOA temperature” in our model, as for example in Pierrehumbert (2010; e.g., chapter 3.6). However, to avoid ambiguity, we will use “TOA temperature” consistently in the revised manuscript.

COMMENT: Figure 9: I find the text on the legend and axes labels a bit small here. Perhaps you might consider increasing the font size?

REPLY: We will increase the font size in the revised manuscript.

REFERENCES:

Ferraro, A., Collins, M. and Lambert, F. (2015). A hiatus in the stratosphere?. *Nature Climate Change*, 5(6), pp.497-498, doi:10.1038/nclimate2624.

Stolarski, R., Douglass, A., Newman, P., Pawson, S. and Schoeberl, M. (2010). Rela-

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tive Contribution of Greenhouse Gases and Ozone-Depleting Substances to Temperature Trends in the Stratosphere: A Chemistry–Climate Model Study. *Journal of Climate*, 23(1), pp.28-42, doi:10.1175/2009JCLI2955.1.

Pierrehumbert, R. T.: *Principles of Planetary Climate*, Cambridge University Press, 2010.

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