

Interactive comment on “Quantifying climate feedbacks in the middle atmosphere using WACCM” by Maartje Sanne Kuilman et al.

Anonymous Referee #2

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1 General Comments

The paper presents another application of CFRAM, a one-dimensional (mostly) radiative climate model for offline feedback analysis, in a more than a decade long series, now using output of the high top chemical climate model WACCM. In other studies it was used for example for a low top GCM (Taylor et al., 2013) or a CCM up to thermosphere (Zhu et al., 2016). When it was applied to global radiative models more than a decade ago, data transfer was straight forward but for use with complex 3D models it is essential to provide information on averaging of model output. I suppose CFRAM was applied for zonal averages at every meridional grid point and for every month of the 40 year time slices, am I right from hints only in the references? There are also a

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lot of other options. This has to be documented since this can contribute significantly to errors (see for example TEM-analysis mentioned by authors, line 652; Zhu et al., 2016).

The shown results are not new, they almost resemble what was found with chemical radiative convective models more than 30 years ago (e.g. Brühl and Crutzen, 1988). Concerning upper stratospheric ozone chemistry, the authors should for example read Cariolle (1983), what is written in the manuscript is a mess.

In general, the paper needs much more clear definitions what has been done.

2 Specific comments

The presented averages of temperature change from 12 to 80km altitude in the abstract and also key points are confusing and not physically meaningful because several different regimes are involved. Here it would be more useful to focus on the upper stratosphere. Is the averaging mass weighted or not?

More than a decade ago is not recently (paragraph beginning with line 136). What is the spatially limited domain, please define. Provide references earlier. Merge with next paragraph and rearrange.

The paragraph beginning with line 157 is confusing concerning the statements on ozone here, skip that or define clearly what are the ozone changes due to, including the altitude dependence.

In section 2.2 the assumptions for the other radiatively and chemically active gases should be provided. Is the double CO₂ scenario with preindustrial conditions for N₂O, CFCs, CH₄ and NO_x in the troposphere? This is also critical for the SST.

Section 2.3 should include how WACCM output is implemented into CFRAM, i.e. the

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averaging methods for space and time.

Split Fig. 2 and Fig. 4 into more vertical sections (e.g. lower stratosphere, upper stratosphere, mesosphere). What kind of averaging?

The paragraph beginning with line 564 is confusing. I suppose you mean ozone changes induced by CO₂ cooling. Ozone matters also in the infrared window.

Shorten the paragraph beginning with line 628.

You may improve the paragraph beginning with line 645 by the use of the textbook by Holton.

Don't forget to mention convection around line 688.

Does Fig. 6 show the average of the 40yr time slice?

Section 3.4 has to be rearranged and improved, the key processes are missing. The reaction O+O₃, the sink reaction in the Chapman chemistry, is strongly temperature dependent (see Brühl und Crutzen, 1988; Cariolle, 1983; or JPL). NO and Cl catalytic cycles matter mostly in the upper and mid stratosphere, in the mesosphere hydrogen species (e.g. OH) are most important. Check if in all calculations only CH₃Cl acts as chlorine source (pre-industrial!).

The statement in line 820 is quite controversial, a lot of models lead to different results here; please check.

Split the averaging region in line 903ff consistent with the new figures and the revised abstract.

3 Technical corrections

Please define all formula letters in line 298.

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In line 546 something is missing or twice.

Add 'high latitude' in line 616.

Typo in line 688.

Captions of Fig. 7 to 11 can be shortened (tropopause as in Fig. 6).

4 References

Brühl, C. and P.J. Crutzen: Scenarios of possible changes in atmospheric temperatures and ozone concentrations due to man's activities, estimated with a one-dimensional coupled photochemical climate model. *Climate Dynamics*, 2: 173-203, 1988.

Cariolle, D.: The ozone budget in the stratosphere: results of a one-dimensional photochemical model. *Planet. Space Sci.*, 31: 1033-1052, 1983.

Others see discussion paper.

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