

Short resume

This paper investigates the typical variability of atmospheric trace gas species using model simulations, with the aim to provide a user-friendly tool to be used in validation studies. The motivations and the theoretical framework are well introduced and the critical discussion of the results is well argued.

This paper fits the scope of AMT, and it is logically written. From my side, I have some comments on specific aspects and a few technical corrections. A whole revision of the paper for typos is needed.

Specific comments

1. The theoretical framework in Sect. 3.1 is well introduced and justified. However, the statement about the stationary increments at lines 58-59 is taken as granted; wouldn't it be better to say that the authors assume that the distribution of the differences does not depend on t , based on literature?
2. Symbols and used variable names.
I find the mathematical symbols used in the paper sometimes confusing and inconsistent. I would suggest to introduce a symbol/name also for the quantities introduced in Eqs. 4,5,8 and for the atmospheric variability, which can then be referred to in the text and in the figures. The amount of trace gas is referred to as X in Sect. 3.1 and as VMR in other equations. In addition, I find the usage of 'x' for the mismatch in Sect.5 not optimal, especially because τ was already introduced in Sect.3.1, where t was also assumed to indicate time or space.
3. Regarding the variability values shown, for example, in Fig.1, the authors explained that they increase at northern latitudes due to the presence of the polar vortex: wouldn't it be possible to consider points which have a compatible PV values, as usually done in validation studies? In this respect, the assumed parameterization at line 135 doesn't not apply for high latitude case at large distances, right? You could point this out in the description of Fig.2.
4. Was the period chosen for the simulations with the BASCOE model arbitrary?
5. It is not so clear to me until line 173 that you used only BASCOE simulations for Figs.1-4, is it right?
6. Regarding Figs. 6-8, I was wondering if the discrepancies that can be seen for example for H_2O in spring w.r.t. the other seasons, or for O_3 in autumn w.r.t. the other plots are just random or reflect variability in the data set or are related to the restricted chosen time period. I would also reduce the span of both x and y axis of Fig. 8 to better see the dots.
7. Have you seen similar linear dependencies as in Figs. 6-8 when changing the 400 km separation? Possibly, a sentence could be added in this respect.

Technical corrections

Two frequent incorrent spelling I found are the word 'stationnary' \rightarrow 'stationary', and the construct 'as a function of': can you please check its usage in the text? In addition, in Sect. 3.1 please replace 'gase' with 'gas'.

P1, 14: 'look-up tables on the natural varaibility' → 'look-up tables of the natural variability'

P1, 15: I would say 'distance and time separation'. Also variability values instead of variabilities.

P1, 16: I would write '...and the season-independence of the linear...'

P1, 114: What does this sentence mean? 'Also different impact of prior information on the result has to be considered'. Do you refer to systematic errors due to the a priori value?

P1, 117: state variable measured → measured state variable

P1, 120: of which → in case

P2, 127: developped → developed

P2, 128: vairability → variability

P2, 130: recepee → recipe

P2, 133: frop → from

P2, 136 usually → generally

P2, 137: delete 'of' after study

P2, 147: what does 'they' refer to? Maybe write 'The model simulations contain...'

P2, 149: geopotential heights → geopotential height

P3, 156: not stationary → non-stationary

P3, Last paragraph of Sect. 3.1: please check typos like 'stydyng' or 'conlusions'. '...basing on the shape of the statistics obtained...' → '...based on the shape of obtained statistics...'

I would mention also in the introduction that MIPAS has been chosen as example.

P4, 196: it provides → , which provides

P4, 1100: present → presents

P4, 1106: I would add at the end of the sentence 'for each latitude band and height'

P5, 1117: variation → variations

I would put the sentence at lines 118-119 after Eq. 6, right before 'We are not considering...'

and add a reference to Sect. 6 where the software is described.

Maybe move the sentence at 139-141 to Sect.3.3.

P6, 1159: encounter → tackle.

P7, 1166: I would delete 'of the squares', just leave variance of the differences.

P9, 1172: delete the repetition of 'were available' and also the spelling of WACCM6 as it was already introduced.

P9, 1173 and 1175: delete 'The' before Figure.

P9, 1173: what do you mean with 'after this manipulation of the data'?

P9, 1179: expectalbe → expected.

P9, 1186: 'collocation criteria choosen' → 'chosen collocation criteria'

P11, 1191: I would say 'at given altitude, latitude band and mismatch'.

P11, 1192: check 'corresponding'.

I would move the last sentence at line 208-209 to the conclusions as an outlook.

P12, 1211: exercice → exercise.