Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2020-137-RC2, 2020

Geoscientific Model Development Discussions
Open Access
EGU

Interactive comment on "Methane chemistry in a nutshell – The new submodels CH4 (v1.0) and TRSYNC (v1.0) in MESSy (v2.54.0)" *by* Franziska Winterstein and Patrick Jöckel

Anonymous Referee #2

Received and published: 7 September 2020

General comments:

This paper describes a new and simple chemical mechanism that can be run as a sub-model called CH4 within the Modular Earth Submodel System (MESSy). It represents methane and four of its most prevalent isotopologues for carbon and hydrogen by using pre-defined fields of methane sinks. It can also simulate the stratospheric water vapour (and HDO) production from methane, which can be fed back to the model's water vapour tracers. In addition, the paper describes how the CH4 sub-model can include age and emission region classes, such that the modelled trace gas concentration at a particular location in time can be attributed to particular source sectors and/or regions.

Printer-friendly version

Discussion paper

It also provides some examples of the CH4 sub-model's capability.

I thought that the manuscript was well organised and very clearly written. The schematics included in the manuscript were very informative. However, I did have one main concern (See below) which relates to the lack of an in-depth assessment of the model performance. I also include a list of more specific and technical comments - see below. If the main concern and the more detailed comments can be adequately addressed in a revised version, then the manuscript would be wholly suitable for publication in Geoscientific Model Development.

Main concern:

The CH4 model is being promoted as a useful alternative for studying methane, its isotopes, and stratospheric water vapour to the more complete and computationally expensive full chemistry scheme. As a result, I thought that the manuscript could be improved by including some verification of the CH4 model compared with the (presumably) EMAC simulation from which the sink fields used in the CH4 set up originated. How do they compare in terms of global mean methane concentration, methane lifetime, methane budget etc..? How does the modelled lifetime compare with other (full complexity) models (e.g., Stevenson et al., https://acp.copernicus.org/preprints/acp-2019-1219/) and/or inversion studies? Benchmarking the CH4 model performance against EMAC and placing its performance in the context of other models/studies would be a valuable addition to the manuscript.

The inclusion of optional region and age classes is a valuable addition to the CH4 model and this information will be useful for estimating emission strengths. The authors cite the example of using a fixed-lag Kalman Filter, which performs an inverse optimization of the emission inventory by comparing simulated and observed mixing ratios of a trace gas. However, although the example provided of the time evolution of a single region class is a nice illustration, it is by no means evidence of the suitability of the CH4 model as a tool for doing emission inventory optimization. In line with

the comment above, providing a more in-depth assessment of the model performance against observations would greatly strengthen the manuscript and provide evidence of its suitability as a tool for estimating emissions.

The authors, in the context of isotopes, also state that the simulation results compare well to observations. Can you include these comparisons with observations, for example?

Specific comments:

1. Page 2, line 25 and Page 2, line 33: While methane as a source of stratospheric water vapour (SWV) is unequivocal, it is important to, at least, acknowledge the role of methane as an ozone precursor. From a climate forcing perspective, this indirect forcing is much larger than that from methane-driven changes in SWV but is neglected from the MESSy/CH4 configuration presented here.

2. Page 8, line 190: Can you be specific about what fraction of the age class is moved to the next class when this option is used?

3. Page 8, line 194: Can you comment on how significant or large is this lack of conservation?

4. Page 14, line 331: Here, you refer to the temperature bias in EMAC leading to a negative bias in water vapour. Is this temperature bias even evident in simulations with specific dynamics or when EMAC is free running?

5. A complete listing of the CH4 chemical mechanism, including isotopes, would make the description more complete rather than only showing the temperature dependent KIEs. This could be added to the Supplementary Material.

Technical comments:

1. Page 4, line 102: Please change “The here presented new submodel for simplified CH4 chemistry (CH4) and the auxiliary submodel TRacer SYNChronization (TRSYNC)

are implemented based on this framework." to "Presented here is a new . . .."

2. Page 7, line 160: Change "which can be specified by the user via namelist" to "which can be specified by the user via a namelist"

3. Page 7, line 162: Change "denotes thereby" to "thereby denotes"

4. Page 7, line 167: Change "identical" to "identically"

5. Figure 2: The onward arrow from "tracer e02 a02" should possibly be dotted to be consistent with the one from "tracer e01 a02"

6. Page 7, line 176: Change "fixed-lag" to "a fixed time lag"

7. Page 8, line 184: The sentence "The implementation of this option is not conform with a Leapfrog time stepping with Asselin-filter and might cause numerical oscillations with negative values" Is very awkwardly written – please rephrase.

8. Page 8, line 193: Again, awkward phrasing with the use of "to be conform" in the phrase "This option is specifically implemented to be conform with the Leapfrog time stepping (c.f. option (1))". Please re-phrase.

9. Page 9, line 220: Replace "the here presented CH4 submodel" with "the CH4 submodel presented here"

10. Page 10, line 232: Replace "H2OISO doubles the hydrological cycle for the water isotopologues" with "H2OISO models the hydrological cycle for the water isotopologues" or "H2OISO represents the hydrological cycle for the water isotopologues"

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-137, 2020.