Review of article TChem-atm (v2.0.0): Scalable Performance-Portable Multiphase Atmospheric Chemistry

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This publication describes the implementation of TChem-atm (v2.0.0), a software designed to permit efficient resolution of of stiff ODEs of atmospheric chemistry, including interaction between gas-phase and aerosol-phase compounds, using Kokkos to avoid being dependant to specific hardware-dependant optimizations in the code. This publication is timely, and relevant to the scope of GMD. I believe that there are a few shortcomings in the study, in particular the two points I list as general comments : **clarify the relationship between TChem-atm, and earlier components TChem and CAMP**. In this respect, I suggest a**dding a figure showing how things are organised within TChem-atm**, and possible inclusions from other models. I also suggest that the authors **explain how they see the road towards the use of TChem in real-world geophysical applications** (if possible, based on previous work with TChem and CAMP in this field).

Even though I do not think that these shortcomings question the relevance of the article or the quality of the results, I think the lack of clarity regarding these aspects requires **major revisions** to make sure before publication that the paper contains all the useful information for the geophysical modelling community.

General comments

Need for clarification between TChem-atm / TChem / CAMP

"*Since TChem is primarily used for gas-phase chemistry, particularly in combustion applications, we decided to name the specialized version of TChem for atmospheric chemistry TChem-atm. It is important to note that TChem-atm is a standalone code, distinct from TChem, and has its own dedicated GitHub repository*".

More clarification would be useful for the reader. I think I understand from the paper that Tchem-Atm is an evolution from Tchem, in order to adapt it to the necessities of atmospheric chemistry, and in particular the need to take into account the existence of a condensed phase. I think the following questions would deserve clarifications, either in the introduction or in section 2.1 :

1. **What exactly in Tchem-atm is new, and what comes from Tchem ?** Which version of Tchem ? Is is feasible on Fig. 1 (or another figure) to delimit, in TChem-atm, what comes directly from TChem, and what has bee added ?
2. If some or all the code from Tchem has been included in Tchem-atm, why has it been decided to make include the code from TChem directly in Tchem-atm rather than using TChem-atm as an external library ?

Similarly, in section 2.5 and 2.6, some features described seem to come directly from CAMP. Again, the article would benefit from clarification in **what parts of CAMP are directly included**

in TChem-Atm, and the relationship between both models. Is TChem-Atm a kind of merge between key-features of CAMP and Tchem, as suggested in the Abstract but not developed very much in the rest of the paper.

Figure 1 gives a convincing visualisation of how thing work around TChem-Atm, but I think some readers like myself might be lacking **a visualisation of the structure of things inside Tchem-Atm : Which functions are covered within TChem-Atm ? Do they come from TChem, from CAMP, or are they implemented in new code developed on purpose for TChem-atm ?**

Need more details on applications

It is clear that a tool of the kind of TChem-atm could be useful for chemistry-transport modelling (and possibly also, climate modelling, etc.). However, the example applications presented by the authors are just idealized test cases. It would be highly beneficial if the authors give some precision on the possible application to real-world cases, including the following questions :

1. Have TChem and / or CAMP already been implemented in research / operational chemistry-transport models ? Which models if any ? Has this implementation ever been used in real-world applications (forecast, case studies...)
2. Is an implementation of TChem-atm in an operational / research chemistry-transport model considered in the near future ? Which model(s) ?

Minor comments / technical issues

l. 13 : replace Understanding by “modelling” or “simulating”

l. 15 : “often across large spatial and temporal scales” : unclear if the authors mean large domains, or mean multiscale interactions across different scales.

l. 19 : “ across fine spatial and temporal scales”. This is unclear, as above. Here the authors probbly mean “at fine resolutions”.

L. 24 : capitalize earth

l. 64 : “this work lays the foundation for next-generation weather, climate, and air quality models,”. This looks like an overstatement to me. The part of the sentence that comes just after seems more adepted to me.

l. 66 : remove (or replace) “individually”.

l. 403 : “By integrating the chemical mechanism infrastructure of CAMP with the Kokkos-based backend of **TChem-atm**, TChem-atm (...)” to be replaced by TChem I guess