Geosci. Model Dev. Discuss., 2, C552–C559, 2010
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Geoscientific
Model Development
Discussions

Interactive comment on "Tracers and traceability: implementing the cirrus parameterisation from LACM in the TOMCAT/SLIMCAT chemistry transport model as an example of the application of quality assurance to legacy models" *by* A. M. Horseman et al.

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Firstly we would like to thank both reviewers for their positive and constructive comments and address their specific points below. As both reviewers have made comments regarding the validation section we try to answer both in a separate section at the end.

Reviewer No. 1

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Interactive Discussion

Discussion Paper

Specific Comments:

p.1300, l.27: Besides the number and shape also the size of the crystals is important for the radiative balance.

We have added size to the sentence.

p.1302, l11-17: This section is hard to understand when you read it the first or second time. You might split the first sentence into two parts. And the last sentence of this section should start in a new line. Both may make the text clearer.

The section has been amended as suggested.

p.1308, l.11: In section 2.2.2 you introduced different kinds of testing (unit, integration, acceptance). Do you use the term "tested" here in an unspecific way? If so, please mention it.

We have replaced 'tested' with 'proven' to avoid confusion.

p.1308, l14-19: Do you have two options to calculate the vertical wind? The first based on Prather, the second using on the divergence of the horizontal wind field. Which definition is used here? Add a few words to clarify this.

To simplify this section we have modified it to read:
"Instead, the transport functions of the model employ the advection scheme of Prather (1986) driven by a vertical flux determined from the adiabatic heating rate."

p.1313, verification section: In LES the time step is of order seconds if nucleation occurs. What internal time step do you use in the cirrus module? Do you have as small time steps? Do the number of nucleation events and nucleated ice crystals sensitively depend on the time step?

The parameterisation is sensitive to the size of the time-step. The figure used is 36 iterations per 1 hour SLIMCAT time step. This is a figure that was originally arrived at

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during the LACM work of Ren et al. and tested in the verification section. We have modified the last line of the paragraph to explain this.

p.1315, l. 7/8: Lynch, 2002 is a comprehensive book. Can you thus specify the chapter and its according author you refer to? Also give short hints why the comparison is not straightforward.

A separate reference to the relevant chapter has been included and the sentence amended to read
"Satellite data is a better match in resolution and coverage, but then comparison is not straightforward because the retrieval of cirrus quantification data is subject to variations in background, similarities to other cloud types, and requires the analysis of radiances scattered or emitted over a wide spectrum (Minnis, 2002)."

p.1315/6, Ice parameter comparison: Do you also assume sphericity like Meerkötter?

Yes. The text has been amended to show this.

Isn't subvisual cirrus unimportant for the comparison of your model results with ISCCP data? Do satellites see subvisual cirrus? The choice of the τ -threshold should be motivated by the detection limit of the satellite detectors, not by a visibility threshold based on humans' vision. I am not sure whether your agreement with ISCCP data will be still reasonable when you raise the threshold to 0.1 or even 0.2? Even for the low threshold of 0.01, Fig. 3 reveals that the patches of tropical cirrus are smaller in the model output than in the ISCCP plots.

This is correct and is one of the reasons why we did not pursue an exhaustive validation in the paper. By adjusting the threshold of τ within the model we can obtain slightly different frequencies of occurrence. However, none of the values tried gave results approaching the spatial extent given by any reference data we tried such as Sassen et al. JGR 2008, Greenhough et al. Adv. Space Res. 2005. See also the validation

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section below.

Generally, does your reasonable agreement validate mainly the CTM, the model input data or the cirrus parameterisation? This issues must be discussed in the paper.

It is used to describe the first stages of validation of the integrated model; the CTM and cirrus parameterisation upon which the model is based have already been through their own, separate, published tests. Also see the separate section below.

Technical Corrections

p.1305, l.19: This is rarely the context...

Amended.

p.1311, l.13: You might replace "parameterisation" by "cirrus parameterisation".

Line 13 of p1311 of our copy does not contain the word parameterisation. Perhaps the reviewer means line 26 in which case we have adopted the suggestion.

Reviewer no. 2

Specific comments:

Page 1301 lines 8 – 20: The text might suggest that so far only a few GCMs have implemented a nucleation scheme and that this is the first CTM to which such a tool is added. It might be worth to mention at least one example for a CTM, e.g. Spichtinger and Gierens, ACP, 2009.

We were not aware of the Spichtinger and Gierens paper at the time of writing. We have corrected this omission.

Figure 1: In order to reflect the discussion in the text, this figure could become more illustrative to group boxes according to 'Requirements', 'Testing' and 'De-

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sign'. Also the term 'Revision/configuration control' should appear. I'm wondering whether the 'design' task could be explained in the manuscript as well with an own section

The diagram has been amended accordingly (see attached). The difficulty in incorporating the terms revision/configuration control is that it encompasses all the stages shown so they are difficult to represent on the diagram. This reviewer comment does point out that we omitted the word 'documentation' from the list of items to be included in configuration control in section 2.2.3. We have now added this. The addition of a design section is more problematic when using legacy models. In our example case most of the design stage applied to the legacy models and nearly all the existing design information has been lost. It is difficult to prescribe a design process as this, of all the development stages, is the most dependent on what detail and documentation is available for the legacy code. It would therefore be the developer's decision what to do. We would anticipate that the most likely case is that we already describe.

Page 1309 'Model requirements': The authors do not pick up the term 'user requirements' from chapter 2 anymore. Do you consider the first four bullets as user or software requirements? If the later ones, what are user requirements in your specific case? Is it worth to add frequency of time steps (even if kept flexible) or spatial resolution as user requirements?

In section 2.2.1 we explain that the separate user and software requirements are amalgamated into a single list and hence development stage. However, the reviewer is right to point out that we have used the term software requirements in a confusing manner here. It would be clearer to say "specific implementation requirements" and have amended the text accordingly.
Spatial resolution and model time steps are already accounted for within the CTM and thus are not new requirements.

Section 4.3-5 Validation: The comparison with data remains rather vague and not

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quantitative. Are the authors satisfied here to provide evidence that 'the results can be considered reasonable' (p 1315, l 1) and to refer for a more detailed analysis to subsequent papers? They should at least give their rational why they have chosen the two examples in 4.4. and 4.5, and how this choice can be regarded as a strategic one. For a full validation, I expect a more quantitative comparison between simulations and observations, sensitivity tests and comparison with other model tools ('why is our model an improvement?').

The quantities of ice and water amounts were chosen as they represent the most significant way in which the addition of an ice formation mechanism will affect the chemistry within the CTM. Specifically the removal of water vapour and the production of ice surfaces for chemistry such as the destruction of ozone. Also see the validation section below.

Page 25, line 25: Since 2000, the tropics have been examined in a large number of balloon, aircraft and satellite experiments, so it can't be regarded as 'not well sampled' anymore. Nevertheless, the SCOUT-O3 data are suited to be used here.

The wording of the sentence has been adjusted to reflect this.

Validation

We understand the concerns of the reviewers that new models undergo substantial validation and already indicate in the text that this is necessary. At the same time, we do not want to put too much emphasis on the validation stage as we would like to raise the importance of the other development stages that we believe are often overlooked. We think that including sufficient discussion of the complexities of a full validation in this paper would require too much space and change the emphasis of the work too greatly. Consequently, as the validation of our model reached a natural breakpoint, we believe that a detailed examination is best reserved for a separate paper focussed upon just this subject. To help the reader we have added subsection (repeated below)

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to explain the philosophy of validation and its position in the development process, and to indicate that validation/regression should be considered a continuous process with many possible breakpoints (early in the process in our case).

4.5.1 Numerical validation

The next stage of validation within the development process would be to obtain statistical values for the comparisons between modelled and measured data. This could start in the form of correlation diagrams necessitating regridding of the data as preparation for the calculation of a number of metrics for example Pearson's product-moment correlation coefficient, Spearman rank correlation, coefficient of efficiency, root mean square error and mean absolute error etc. Willmott (1981), Legates and McCabe (1999) and Wilks (2006) amongst others discuss the techniques and metrics used in evaluating model data. A suite of test metrics is preferable because, as these authors point out, each has at least one limitation. More than one quantity and preferably more than one measurement dataset should be considered the goal to exercise different model components. The initial validation of our model, although simple, has already identified a significant model limitation, so we adjourn the rest of the validation of SLIMCAT-Cirrus until the issue of capturing more sub-grid scale effects has been addressed. In the complete software development scheme the results of the validation steps provide a basis for future regression testing; used to assess improvements, as well as to ensure that changes do not have a detrimental effect on existing performance.

Interactive comment on Geosci. Model Dev. Discuss., 2, 1299, 2009.

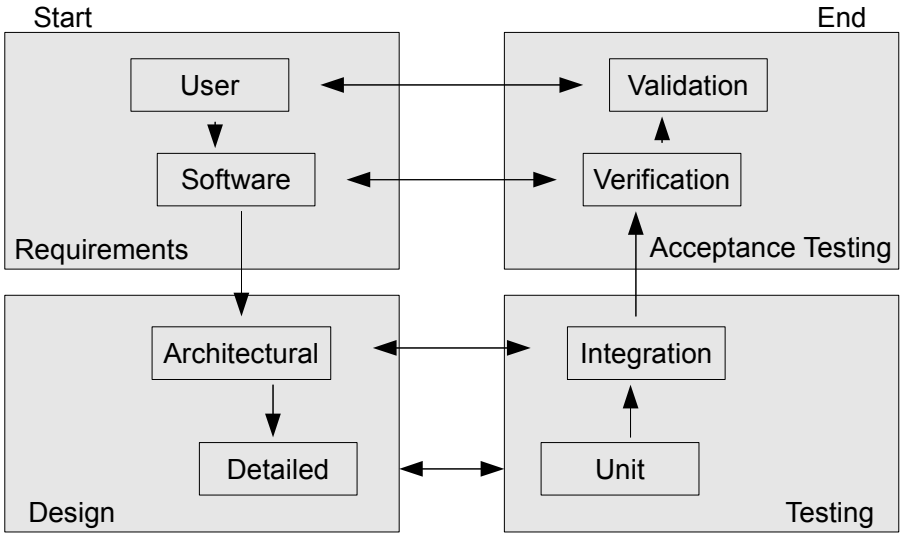

Fig. 1. Revised waterfall software lifecycle diagram.

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