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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Two adaptive radiative transfer schemes for numerical weather prediction models" *by* V. Venema et al.

V. Venema et al.

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Response to interactive comment by Anonymous Referee 2

GENERAL

Referee 2 wrote: "This manuscript presents new methods for improving the accuracy of simulated radiative fluxes at the surface in numerical weather prediction (NWP) models. ... important manuscript, well worth of publishing in ACP. However, the clarity and organization of the presentation leaves some room for improvement, mainly in sections 5 and 6, which appear to be somewhat cluttered by details."

We would like to thank referee 2 for his kind words and useful comments. We have improved the organisation of the Section 5 and 6, mainly by adding subsection titles (and some reordering), reducing the number of number that can be read in the Tables as well and removed the paragraph on memory vs. CPU time.

Referee 2 wrote: “My single major scientific comment concerns atmospheric radiative heating rates. A scheme that corrects the surface net flux but not the atmospheric heating rates seems slightly inconsistent in principle, and the short-time scale variations in heating rates could also be significant in practice. ...”

We agree that it is inconsistent to treat the atmospheric heating in the old way and to only implement the adaptive scheme for the net surface radiative flux. The final scheme should preferably contain both the surface net flux as well as the atmospheric heating rates. To simplify this first proof-of-principle paper on adaptive schemes, we have chosen to concentrate on feedback effects via the surface, expecting that this term is the dominant one.

However, the dynamical feedback over atmospheric absorption is certainly interesting and will be investigated. For the current paper this would be much work because we did not store the large 3D fields that would be needed for such a study. We hope that the scientific contribution of this manuscript is sufficient and that the referee is satisfied with our promise to implement a full 3D version of the spatial scheme in our upcoming paper where the scheme will be implemented in the LM itself.

Referee 2 wrote: “Finally, a logical extension of this work would be to test the impact of the new parameterization schemes on numerical weather forecasts: take a simulation with a very short radiative time step as the reference, and investigate how fast simulations applying (i) the persistence assumption and (ii) the adaptive schemes diverge from the reference. It might be wisest to leave this for future papers, though.“

For this we need to implement the schemes into an NWP model. Such a comparison is planned in our upcoming paper.

SPECIFIC COMMENTS

Referee 2 wrote: “1. ...Therefore I find the use of the term "heating rate" disturbing in this paper, ...”

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We changed “heating rate” to “surface net radiative flux “.

Referee 2 wrote:” 2. p. 7237, lines 21-23: Does this imply that adaptive schemes are, in general, best suited for high-resolution short-term NWP models, and less suited for coarse-resolution climate models?”

We wrote: “With the increase in the number of grid-boxes, the spatial correlations between adjacent grid boxes will become stronger, favouring a transition from traditional to adaptive parameterisation schemes.” We intentionally wrote about the number of grid boxes and not about the resolution of the model. If the atmosphere were self-similar, the number of grid boxes would fully determine the spatial correlations between adjacent grid boxes. In a fractal world, the scale does not matter, if you zoom in, the structure of the field stays the same. Thus in a fractal atmosphere high-resolution NWP models and coarse resolution climate models could benefit the same from adaptive schemes. See also the subsection with the new number 6.1.3.

Researcher such as Shaun Lovejoy and Daniel Schertzer typically find (ensembles of) measurements of the atmosphere to be fractal, other researchers (including ourselves) do find deviations from perfect scaling (but then often in single measurements). This debate is not closed yet. However, even if there are moderate deviations from fractal scaling, adaptive schemes are probably just as valuable on global scales as on local scales. If you look at the fields of a climate model, you see that adjacent grid boxes are also strongly correlated.

What is special about the radiative transfer scheme is that is computationally exceptionally costly. As a consequence in NWP modelling a large time step is utilised, leading to considerable persistence errors. These errors due to the time step were easily corrected in this paper, leading to a parameterisation scheme that is more realistic. In climate models the time step of the radiative transfer parameterisation is typically closer to the dynamics time step. Consequently the persistence error of climate models is probably smaller. Therefore, the main advantage for climate models and for other parameterisation in NWP models is likely that it would be possible to implement computationally more costly intrinsic parameterisations with a higher explained variance.

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Interactive Comment

Referee 2 wrote: "3. p. 7239, first paragraph: It would be relevant to mention (either here or on p. 7241 or p. 7255) the neural networks version of the ECMWF longwave scheme (Chevallier et al. 1998, J. Appl. Meteor, 37, 1385-1397; Chevallier et al. 2000, Quart. J. Roy. Meteor. Soc., 126, 761-776)."

We should have mentioned this work. We added another paragraph in the introduction on ANNs. Roger Pielke Sr. pointed us to his interesting work on parameterisation schemes utilising look-up-tables. This alternative nonlinear method fits well to the ANNs and was added to this new paragraph as well.

Referee 2 wrote: "4. p. 7243, Eq. (3): To be sure, please state explicitly that the "deltas" are absolute values of the differences. Or are they?"

Yes, of course, minimising the differences would not be a good idea without taking the absolute differences. Sorry for the mistake.

Referee 2 wrote: "5. p. 7243: More generally, it is not quite clear to me how the spatial local-search scheme works. The algorithm searches for similar nearby columns, but (if I understand it correctly) it does not copy their radiative flux values directly but uses them to determine the temporal change in the flux. How does it work? ..."

The algorithm searches for the most similar nearby column and uses its transmittance in the solar regime and directly uses its surface net flux in the infrared. We now wrote this explicitly in the paragraph below Eq (3). We do not consider changes in the LWP in the spatial scheme, only the temporal scheme does. A combined scheme may work like you suggested.

Referee 2 wrote: "6. I found sections 5 and 6 a bit laborious to read. I think there are more details than necessary to convey the ideas. It could also help to use more informative subsection titles (e.g., "Sensitivity tests for the temporal perturbation scheme", etc.). One specific comment concerns the paragraph starting on p. 7247, line 19. As it stands now, it disturbs the flow of the text. It would better be located in a separate subsection ("Modifications of the persistence scheme", or something like that)."

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We added subsections for the longer sections; see also our reaction to the general remarks. The mentioned paragraph has now become subsection 5.1.3.

Referee 2 wrote: “7. p. 7247, line 19-: This is not really a correct simulation of a "coarse-grained" radiation parameterization. I suppose that in reality, you would average the input data for the radiation calculations, not the output! Because of non-linearities, the difference could be significant. A further point (p. 7247, line 27): why an average delay of 7.5 min? It would also be worth pointing out explicitly that all model configurations you discuss in this paragraph have the same computational costs (equally many calls to the radiation scheme), so you are really looking for the optimal combination of spatial and temporal resolution for radiation calculations.”

This calculation was not thought to be a correct simulation, this can only be performed with a coarse grained parameterisation. We added explicitly: “This calculation can only illustrate the problem of the phase error. To confirm that 3x3 columns is the optimal spatial resolution, a more accurate calculation should be performed with a coarse-grained parameterisation in which the input fields are averaged and the coarse tendencies are disaggregated afterwards.”

The 1-hour persistence scheme utilises a cloud field that is on average half an hour old. The 2x2 column coarse-grained scheme is called every 15 minutes and thus on average utilises a cloud field that is 7.5 minutes old. We now explicitly wrote that the 2x2 scheme is called every 15 minutes to keep the computational costs the same.

Referee 2 wrote: “8. p. 7249, line 25: The size of the optimal search region is 5 x 5 columns here but 7 x 7 columns on p. 7243. What is the difference?”

The optimal size for the final algorithm was 7x7; this is corrected on page 7249. The difference between 5x5 (d=2) and 7x7 (d=3) is minimal as can be seen in Figure 10. This was probably why for a previous version of the algorithm we found 5x5, sorry that we did not notice the change in this section.

Referee 2 wrote: “9. p. 7250, line 14: the values of infrared RMS and bias error given here *differ from those in the first line of Table 3."*

The value in the table is right; the value in the text has been corrected.

Referee 2 wrote: "10. p. 7265, Table 3. Why does the regression algorithm produce such a large bias? Is it related to the fact the coefficients are based on numerous days of data for various times of the day, but they are applied here to a single near-noon situation?"

The coefficients are based on the analysis at 12 UTC, we thus do not expect that the time difference to 12:30 UTC is the reason. Over the 3-month validation dataset, the regression algorithm did not have a bias. The bias errors for this one day are still within the RMS error of the regression algorithm over the full 3 month training period. For a specific day and region, which will have a cloud and humidity profile that deviates from the average profiles, the RMS error of the regression algorithm is not gentile white noise as the cloud and humidity fields correlate. As a consequence, for a specific field, the errors of a regression algorithm (or an ANN for that matter) will be bias errors.

Referee 2 wrote: "11. p. 7275, Fig. 10: One of the interesting features that should be commented is that LWP appears to be by far the most important variable for the spatial local-search scheme. Use of LWP alone would yield an RMS error of 34 W m-2 only!"

This is written qualitatively in Section 3. We added to Section 5.4: "It is interesting to note that a spatial parameterisation scheme that would be based on the similarity in LWP would be able to achieve an accuracy of 33.9 W m-2 in the solar regime; see the green line in Fig 10a. Such a scheme would thus only be 2.9 W m-2 less accurate as the standard scheme."

TECHNICAL CORRECTIONS

The technical corrections have all been implemented. Except that we prefer the term "subgrid-scale clouds" over "cloud fraction", as it is typical to distinguish the clouds into grid scale clouds and subgrid scale clouds.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 7235, 2007.

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Interactive Comment