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Geoscientific Model Development
Discussions

Interactive comment on "ARTS, the atmospheric radiative transfer simulator – version 2.2, the planetary toolbox edition" *by* Stefan A. Buehler et al.

Anonymous Referee #2

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The Atmospheric Radiative Transfer Simulator (ARTS) is a versatile radiative transfer tool (apparently) mainly oriented towards various remote sensing applications. The paper by Buehler *et al.* describes version 2.2 of ARTS, with emphasis on new features not present in previous versions. A documentation of ARTS in an open-access journal like GMD would be very welcome, especially as the two peer-reviewed publications describing earlier versions of ARTS as a whole (Buehler et al. (2005a), Eriksson et al. (2011a); papers cited in the manuscript) have been published in JQSRT — which is a respectable journal but not accessible to everyone (including me, as an employee of a national weather service with a very large research department).

While I think it would be important to publish this work, I also think that this paper is clearly in need of improvement. Suggestions for improvement are given below.

Major comments

1. The focus on new features of ARTS is certainly a deliberate choice by the authors, but in my opinion it does not work entirely satisfactorily, at least for readers who are not familiar with ARTS beforehand. Much of the discussion is focused on how to compute gaseous line absorption parameters for planets with differing gaseous composition, and on exotic effects like Faraday rotation and Zeeman effect. However, the basic features of ARTS are not described properly (if at all), so the most basic question remains unanswered: *What is ARTS and what can it be used for?*

Therefore, I strongly recommend adding a section that summarizes the basic features of ARTS, not only the new features. The list of issues that should be reported includes at least the following:

- How is the radiative transfer equation solved: (i) scalar or vector radiative transfer; (ii) methods of treating multiple scattering; (iii) solution geometry?
- What is the wavelength region (that can be) considered?
- Treatment of gaseous absorption: (i) basic method (line-by-line?), (ii) absorbing species (you could possibly refer to Table 2); (iii) sources of line data?
- Treatment of emission (Planck function, local thermodynamic equilibrium)
- Treatment of scattering and absorption by particles (e.g., those in clouds)? E.g., what are the choices available for particle single-scattering properties?
- Treatment of the surface?

I recognize that some of this information is provided in the Introduction and in other sections, but it should be provided in a more coherent and systematic manner. It is not necessary to discuss all these features in-depth (most of the information could probably be put in a table), but the basic information should be provided, to put the new features in the context.

2. An unusual feature of this article is that it contains no results and almost no figures. While this is, of course, related to the nature of the article as a model description paper, it makes the paper rather boring to read. Some practical examples would be helpful. A couple of possibilities (you are welcome to invent more examples yourselves):

- In Sect. 2.1, show some examples of how different gas composition for different planets influences, through line broadening, the absorption spectrum of selected gases (e.g., CO_2 absorption on Earth vs. Mars).
- In Sect. 3.3.3, show an example of how the Zeeman effect splits a spectral line into several lines. I would be curious to see if this effect is relevant, for example, for Earth's middle/upper atmosphere.

3. The paper provides no information on if and how users of ARTS can verify whether they are using the model correctly. An ideal solution would be to provide a selection of test cases against which the users can compare their results. If this is impractical in the context of this paper (e.g. considering the length of the paper), it would at least be worth mentioning whether such test cases are provided at *www.radiativetransfer.org*, where ARTS is available.

Minor comments

1. p. 5, l. 10: How large are the pressure-dependent frequency shifts typically, e.g. at the surface level on Earth?

2. p. 5, Eq. (2): In the exponent, should n_{air} be n_a? Also, how did you choose the constants 0.25 and 1.5 (you state below Eq. (2) that this equation comes without any claim of general validity, but probably these are not totally arbitrary either)?

3. p. 7, l. 15: What is the wavelength range supported by ARTS? It is said here "up to 3 Thz", which corresponds to 100 μm, but ARTS has also been used for computing radiative fluxes integrated over the thermal infrared region (which starts at about 4 μm) (Pincus et al. 2015, paper cited in the manuscript). Is it so that the ARTS spectroscopic database starts at 100 μm and other databases (=HITRAN?) have to be used at shorter wavelengths? Please clarify.

4. p. 7, l. 29: "...Explicit values have been put where available". It is not obvious what this means. "Directly measured values"?

5. p. 9, Table 2: This lacks some gases (most notably CFCs) relevant for climate change. Is it because of the wavelength range considered?

6. p. 21, l. 11–12: Mention that CO_2 line mixing is already available in ARTS2.3? Pincus et al. (2015) (paper cited in the manuscipt) discuss this explicitly.

Technical corrections

1. p. 2, l. 1: replace “inside” with “among”

2. p. 3, l. 29: replace “triggered” with “motivated”?

3. p. 9, l. 12–13: this should be “dependence ... on”

4. p. 11, l. 10: this should be “Earth’s”

5. p. 11, l. 17: replace “sumbillimeter” with “submillimeter”

6. p. 15, l. 2: replace “underestimation” with “underestimate”

7. p. 18, l. 27: this should be “frequency-dependent”

8. p. 19, l. 27: this should be “variety”

9. p. 20, l. 2: this should be “seamlessly”

10. p. 26, l. 2: The length of Larson (2014) is probably less than 1009 pages.

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