Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC3
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Comment on gmd-2021-439

Patrick Stegmann (Referee)

Referee comment on "Introduction of the DISAMAR radiative transfer model: determining instrument specifications and analysing methods for atmospheric retrieval (version 4.1.5)" by Johan F. de Haan et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-439-RC3, 2022

Journal: Geophysical Model Development
Year: 2022
Title: Introduction of the DISAMAR radiative transfer model: Determining Instrument Specifications and Analysing Methods for Atmospheric Retrieval (version 4.1.5)

Comments:
In the manuscript, the authors describe the so-called DISAMAR one-dimensional radiative transfer model.
The model is described by the authors as a polarized all-sky radiative transfer model, i.e. it is suitable for purely absorbing clear-sky atmospheres and atmospheres with scattering clouds.
The application focus of said model are satellite radiance retrievals, in particular for the TROPOMI instrument on board the european Sentinel-5p satellite.
Nevertheless, the authors list a suite of different available solvers and a range of additional model features that are not required for retrievals, such as irradiance computations.
It is emphasized by the authors that the primary advantage of their model is the seamless combination of all necessary features for satellite remote sensing in their model.

Comments on the Introduction:

- line 44: The assumption that the atmospheric input profile of the radiative transfer model is hydrostatic is of some importance. How does this approximation impact the DISAMAR retrieval results?

- line 47: Is a Lambertian reflectance the only surface reflectance type available? Does this limit the accuracy of the model over ocean surfaces where the Cox-Munk model is typically applied?

- It would be advantageous to provide a list of other relevant radiative transfer models with similar purpose and complexity in comparison to DISAMAR.
Examples include the CRTM [1-3] and RTTOV [4].

Comments on Section 2:

- line 65: Please provide a short explanation on the purpose of the wavelength grid.

- lines 71 and 72: Please provide references for the application of the derivatives for optimal estimation and the application to the error covariance matrix, gain vectors, and averaging kernel.

- line 73: The formal theory of evaluating the derivatives of a computer program is quite well developed [5].
Could you please elaborate whether your semi-analytical approach computes the forward-mode (tangent-linear) or reverse-mode (adjoint) derivative of your code output/ the radiance spectrum?

Comments on Section 3:

- line 92: Are there any restrictions when using a tabulated ISRF? It is stated in Section 2 that the radiance wavelength grid is given on a set of Gaussian quadrature points. Are the tabulated values automatically interpolated onto the grid?

- line 106: How does the line-by-line absorption model impact the calculation time of DISAMAR?
Does DISAMAR include faster absorption models when calculation time is a constraint?

- line 140: Please explain how the pressure levels are translated into altitude levels. Are you using the hypsometric equation?

- line 185: There are different adding-doubling initialization schemes [6] and this is known as the infinitesimal generator initialization.

- I have not checked equations (19) to (26) for correctness.

- line 335: If the Layer-Based Orders of Scattering method is fast for optically thin clouds, wouldn't it provide some advantages to initialize the Adding-Doubling solver with a LABOS solution, since it spends a lot of computation time doubling a small initial layer?

- Is the LABOS method related to the Successive Order of Scattering approximation? If so, what are the characteristic differences?

References:

[1] C. H. Lu, Q. Liu, S. Wei, B. T. Johnson, C. Dang et al. (2021): The Aerosol Module in the Community Radiative Transfer Model (v2.2 and v2.3): accounting for aerosol transmittance effects on the radiance observation operator. Geosci. Model Dev., 15, 1317–1329.

[2] B. M. Karpowicz, P. G. Stegmann, B. T. Johnson, H. W. Christopherson et al. (2022): pyCRTM: At python interface for the community radiative transfer model. J. Quant. Spec. Rad. Trans. 288.

[3] P. G. Stegmann, B. T. Johnson, I. Moradi, B. Karpowicz, W. McCarty (2022): A deep learning approach to fast radiative transfer. J. Quant. Spec. Rad. Trans. 280.

[4] R. Saunders, J. Hocking, E. Turner, P. Rayer, D. Rundle, P. Brunel, et al. (2018): An update on the RTTOV fast radiative transfer model (currently at version 12). Geosci. Model Dev., 11, 2717–2737

[5] A. Griewank, A. Walther: Evaluating Derivatives, Principles and Techniques of Algorithmic Differentiation. Society for Industrial and Applied Mathematics; 2nd edition (November 6, 2008)

[6] Wiscombe, W. J., 1976. On initialization, error and flux conservation in the doubling method. J. Quant. Spectrosc. Radiat. Transfer 16, 637-658.