

General comment

The Earth Cloud and Radiation Explorer mission (EarthCARE) mission atmospheric L2 products will be based on the instrumental synergy of, for the first time, a HSR lidar (ATLID) and a Doppler radar (CPR) together with a multispectral imager and a three-view broadband radiometer.

The launch of the mission is planned for 2024. And it is important to test the inversion procedures on realistic synthetic L1 instrumental data.

This paper is devoted to the simulated L1 data of the four instruments for three main Halifax EarthCARE testing scenes generated with a high resolution atmospheric model (described in a companion paper). This paper presents a version of the EarthCARE simulator (ECSIM, Donovan et al.) used to create the synthetic L1 data. L1 data corresponded to each scene are also discussed.

The creation of these L1 data requires enormous work but will be absolutely necessary to validate the retrieval algorithms. It is therefore important to know how they were built, which radiative processes are considered or neglected, which is one of the interest of this paper which focuses on the radiative transfer algorithm used in ECSIM. And I have a few questions (see specific comment) about the radar data simulation under multiple scattering regime and about the 3D radiative transfer.

I recommend this article for publication but with the consideration of the opinion (possibly the corrections if necessary) of the authors on my specific comments, the correction of numerous small typo errors (see technical correction) and a rewrite of the conclusion.

Specific comments

1) On the radar simulation

- It is not clear how is considered the specific attenuation A (Eq. 21) of hydrometeors in the simulated CPR radar reflectivity. In other words, is (and how) attenuation considered in the simulations of L1 radar data (reflectivity and Doppler velocity) of this work? If not, authors should discuss a little bit about this assumption on L1 radar data.
- the formulas in this document describing how are simulated the CPR reflectivity and the (apparent) Doppler velocity do not take account of multiple scattering (contrary to the Monte Carlo lidar simulator described in detail in this paper). However, on Fig.13c (and Fig. 28) showing the (observed) CPR raw radar reflectivity factor, and as written by authors line 453, "the fainter CPR echoes that fill the surface echo gap around 4100 km are due to multiple scattering". I don't understand: do the L1 radar data simulated in this work take multiple scattering into account? If yes, how? It must be explained and described in the paper. If not, authors should discuss about this assumption on L1 radar data (reflectivity and Doppler velocity) of this work.

2) On the 3D radiative transfer and MSI and BBR simulation

- Line 394 : "The procedure was...while retaining a suitable degree of accuracy". This technique to speed up the calculation generates errors on the radiative fluxes, certainly

depending on the position (middle, cloud edge). What are the orders of magnitude of these errors?

- One of the objectives of this work is the production of “realistic” synthetic L1 data. I know that 3D radiative transfer (RT) is very expensive in computing time. The authors preferred to calculate TR in 1D for reasons of calculation time. What is the position of the authors on the "reality" of L1 data in that case? Can they give/discuss a little bit the order of magnitude of the error on the radiative fluxes because 3D RT effects are neglected?
- 3) The conclusion is a little hasty and does not include the important contents of the document. I think it is important to rewrite it.

Technical corrections

Please pay attention to space, lack of parentheses, style of units (not in italics) and capital letters (or not) of the titles of the sections throughout the document.

Line 2 : Since “high spectral resolution” is specified for lidar, therefore “Doppler” should be specified for the radar.

Line 21 : Please define Z_e and IWC .

Line 72 : typing error in Eq.1

Line 51 : the title of the section 2.1.1 is not adapted. Maybe “Hydrometeors microphysical properties” ?

Line 65 : the title of the section 2.1.2 is not adapted. Maybe “VIS-UV-IR optical properties of hydrometeors” ?

Line 90 : the title of the section 2.1.3 is not adapted. Maybe “Micro wave optical properties of hydrometeors ”

Line 99: the title of the section 2.1.4 is not adapted. Maybe “Aerosols microphysical and optical properties ” ?

Line 100 : please give the definition of HETEAC.

Line 104 : the title of the section 2.15 is not adapted. Maybe “ Gases transmission” ?

Line 109 : the title of the section 2.1.6 is not adapted. Maybe “Radiative properties of surface” ?

Line 110 : if possible, please change list level and the title “ SW” by something as “Short wavelength properties”

Line 113 : please give the definition of MOM.

Line 114 : please give the definition of “Iso-Vol-Geo-Kernel”

Line 119 : if possible, please change list level and the title “ LW” by something as “Long wavelength properties”

Line 123 : section 2.1.1 is empty. Maybe delete this section ?

Line 165 : Point is missing.

Line 181 : the title is not necessary. The section dealing with Rayleigh-Brillouin scattering can be included in the section “Spectral Broadening and Multiple scattering”.

Line 201 : give the unity of λ

Line 219 dans 220 : “co-polar” is used two times. Please correct.

Line 227 : the title of Table 3 is not valid. It is not the CRP, but ATLID ? Moreover, “End-of-life Co-polar-Mie transmission” appears 3 times in the parameter column. Please correct.

Line 227 : “as well as the effects of the background filter etc. Poisson shot...” These 2 last sentences are not clear. Moreover, please give the definition of ACCD.

Line 253 : ϕ or δ ?

Line 265 : “FOV” and not “fov”. Moreover, it is written that the “telescope fov is $5e-3$ mrad”. I don’t understand this value.

Line 273 : The problem of noise seems to be partially addressed already (line 227). Nevertheless, it is discussed again here without explaining how is calculated the effects of dark current and ACCD readout noise. Authors should regroup this topic here and should explain more.

Line 288 : “in Section 2”. Please correct.

Line 295 : typing error in Eq. 20. Please correct.

Line 295 : Eq. 20 , 21 , 22 : maybe give references for this equations ?

Line 301 :Eq. 23 : are there no typing errors with i, j, and h ?

Line 306 : nadir “one-way” ?

Line 306 : please define X-MET.

Line 322 : Table 4 : altitude is given 2 times, please define θ_{3dB} and IFOV

Line 323 “show in Fig 6a”

Line 331 “shown in Fig 6b”

Line 380 : define “tau” or replace it by τ

Line 386 : this sentence is not clear

Line 289 : typing errors in the formula (parenthesis problem)

Line 398 and 406 : Table 5 and 6: the wavelengths of the channels are not strictly the same as that indicated in Chang et al. 2019: Why?. Moreover, please define ν_1 and ν_2 .

Line 400 : MSI ?

Line 415 : Please give information of this formula (especially the definition of A), because Eisinger et al. (2022) and Velazquez-Blazquez et al. (2022) are not submitted yet.

Line 421 : please give the definition of « psf-weighting ».

Line503 : maybe add “as seen in Fig.13” or something like that.