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Comment on amt-2021-342

Anonymous Referee #2

Referee comment on "Observation error analysis for the WInd VELOCITY Radar Nephoscope W-band Doppler conically scanning spaceborne radar via end-to-end simulations" by Alessandro Battaglia et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-342-RC2>, 2022

According to title and abstract, the paper aims to present an end-to-end simulator for the scanning Doppler radar WIVERN proposed to the ESA Earth Explorer program. Particularly with this aim, I find the paper too unspecific and lacking details, ie failing the traceability criteria. Also, the differences and novelty compared to Battaglia et al. (2018) do not become sufficiently clear to me.

On the other hand, I find the paper to focus a lot on the WIVERN instrument and its observation error analysis. While this is very valuable and fits the scope of AMT (while a simulator-focused paper would better fit into GMD according to my understanding), it should be reflected more clearly in title and abstract.

In summary, I think this paper needs more "meat" and a somewhat different framing, ie major revisions, before it can be published in AMT.

Major comments:

The introduction elaborates on aims and novelties of the WIVERN mission (far too much in my opinion, since this is supposed to be a simulator-paper, not a WIVERN mission paper), however I miss putting it in context with the past and current sat-borne radar missions CloudSat and, due to its Doppler capabilities in particular, EarthCare. Also, it lacks a definition of what is meant by "end-to-end simulator", incl. what it distinguishes from satellite, observation, or forward simulators or operators (at least in the understanding and usage of the authors) and a review of the state of the art in such simulators or operators. In that context, a definition or explanation what the authors mean by "polarization diversity" could be helpful, too.

From the intro of Sec2, it is unclear to me whether the referenced literature describes approaches in general, or a specific algorithm or implementation of a module, and the following subsections do not make it clearer. Also, please distinguish between options available in the E2E simulator and specific setups used here.

It remains unclear, what the exact requirements are on the model input incl. which parameters are needed (which hydrometeor parameters specifically? temperature? etc.). Are the SAM data described in subsec 2.1 the only data the E2E simulator is/can be used as model input, or is this "just" what is used in the application examples later on? Subsec 2.2.1 details the planned WIVERN orbit and observation geometry. However, how is this implemented in the E2E simulator? Are, e.g., the orbits hardcoded or can orbit parameters be changed, ie different orbital setups be explored? If so, what can the user specify?

Subsec 2.2.2 lacks almost all useful details about the scattering lookup tables like: which parameters are tabulated, bulk or single scattering properties? Over which tabulation parameters? where does the size distribution information come from and how is it taken into account? what dielectric property assumptions are made? how can lookup tables be generated, e.g. to switch to other scattering approximations like the mentioned Rayleigh-Gans? How are the empirically derived LDR linked to Mie reflectivities, is there anything to ensure a certain level of consistency? As LDR are derived based on ground-based observations - are they comparable to sat-borne measured ones?

Table 4 is never discussed nor mentioned in text. It's completely unclear what it is presenting and why it is there.

Figure 6 seem to indicate that a plane parallel atmosphere model is used - is that so? Also, is the beam lobe modelled with a constant solid angle or a geometric distance opening (given values in meters, the figure seems to indicate the latter).

For subsec 2.4, please give a short explanation what pulse pair processing is (or, what you mean by that).

Does the E2E simulator for the radiometric mode shortly mentioned as subsec 2.6 consider gas absorption/emission, too, or just hydrometeors scattering and emission/absorption contributions? If the first, what absorption model is used?

For the case study (subsec 3.1), please be more specific: what date and time is that? what is the general weather situation? Where is the reader supposed to see "some strong wind shear" in the modelled scene?

For the figures in general, please consider the use of color schemes that are suitable for people with color vision deficiencies, preferably such that provide perceptual uniformity. For the case study figures, to allow easier comparison, please be so kind to use the same x-axis (incl. same axis parameters and units) for all of them (if using azimuth, axis ticks & labels at 90° spacing would be nicer and support interpretation better). Moreover, when discussing specific patterns in a figure, refer to the axis parameter used in that figure (in text, surface reflectivity is referred to in along track coordinates, while the plot is in azimuth coordinates).

For the list of problems to investigate in the future in Sec4, that by the way is quite specific compared to the rather indistinct description of the current state of the E2E in Sec2, it would be interesting to know, which problems require additional simulator development/implementations and which are rather setup changes.

Specific comments:

P01L15: reference missing.

P01L18: "wind lidar have" -> has

P02L07: "at 12 Revolution Per Minute (RPM)" - later on "rpm" is used, which I think, is indeed the proper unit symbol. At least be consistent throughout the paper.

P02L11: "other wind observations ([...], close to the ocean surface via scatterometers, via radio soundings) - unclear what the radio sounding "via" refers to. Reformulate.

P02L23: What is the start of the bullets in the numbered list? They do not form proper sentences nor have a common intro phrase.

P03L15: "should observe between one and two million winds per day" - lab slang.

Reformulate, e.g. "provides 1-2 million wind observation per day"

P04L09: "effect of "ghosts"" - please explain what "ghosts" means here.

P10L02ff: Please reformulate for better readability; the long parentheses in the middle of the phrase is hard to get.

P11L02: σ_0 has not been introduced so far.

Eqs (2),(3): For easier understanding, please formulate the equation consistently - either in terms of solid angle or in terms of polar & azimuthal angles.

P12L15: Please be so kind, and remind the reader about the relation of P and Z.

P12L19: what quadrature is used?

P13L05; "applied to a smaller dr " - smaller than what?

P15L05: where are the fall speeds from? are these bulk or size-resolved fall speeds?

P15L07f: "NUBF effects [...]" - something seems to be missing here; I cannot make sense of this sentence.

Eq (14): Please use a different symbol for the random number, since r has before been introduced before as the range distance.

P16L09: does the pointing uncertainty refer to mispointing in elevation or azimuth or either?

P16L09: "[...] uncertainty produces to a 1.0m/s LOS wind uncertainty" - maybe: "corresponds to"?

P16L12: "Previous industrial studies" - multiple studies? if so, I'd expect multiple references.

Fig11 caption: There is no (named) panel B in Fig2.

P19L16: "The surface Doppler shows" - word missing or lab slang. Please correct.

Fig12 caption: "clearly shows region of high attenuation below the freezing level" - below in terms of altitude or in terms of temperature? could you indicate more explicitly where - they do not show up clear enough to me to see them and understand what you are referring to.

Fig12 caption: "higher over land [...]" - could you indicate, either in words or even better graphically in the figure, where land and sea surfaces are.

Fig13 caption: "When no clouds are present the cross talk signal the SGR becomes $-\infty$ " - something missing? or too much? does not make sense to me.

P21L04: "Ghosts tend also to appear at cloud top" - why (in general)? and why aren't they occurring here?

Fig14: what are the red dashed lines?

P22L04: "vertical and horizontal TBs" - lab slang.

P22L06: "surface reference technique-based PIA estimates" - what's that? not introduced nor referenced. I don't get the point here.

P22L09: That's an interesting point. Could you elaborate a little more, what/how the coincident reflectivities and TBs provide over what microwave sounders and imagers provide?

P22L13: "The E2E simulator represents a perfect tool" - perfect? Dial it back a notch, please.

P23L02f: "to multiple scattering (Battaglia and Tanelli, 2011). The contribution of each of these errors can be quantified unambiguously by running two simulations where the effect is turned on and off." - how is multiple scattering modelled by the E2E? Not mentioned in Sec2 as far as I see.

Fig17 caption: "The color modulates" - rather: indicates, represents, or corresponds to.

P26L20: What is Thv?