REPLY to REVIEWER 2

We thank the reviewer for the insightful and detailed comments.

Here after you will find the reviewer comments in bold and our replies in italic.

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.

We will try to be more specific and detailed in the revised version. The main difference from the Battaglia et al paper is that in that case the simulation used a very simple 1D scene (reconstructed from CloudSat). In the current implementation the full 3D scanning geometry of the WIVERN satellite is implemented. This allows to account and assess how the quality of the Doppler signal will depend on the azimuth viewing angle. Also the simulator is now coupled with a full 3D cloud output which allows to evaluate the importance of non uniform beam filling errors. Finally, there is an orbit model coupled to the radar instrument model. This for instance allow to link the instrument model to errors like the mispointing errors which are orbit related.

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 valueable 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.

Comment received. It is true that we are focusing more at the observation error analysis. We will change the title (to something like "Observation error analysis for the WIVERN W-band Doppler conically scanning spaceborne radar via end to end simulations") and the abstract accordingly.

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.

We will introduce a paragraph where we explain the key differences with other simulators currently available. The Earth CARE simulator in particular is for a pulse-pair (not for a polarization diversity pulse pair system) Doppler radar, and it is not for a conically scanning. In its current version it has no mispointing error characterization, and a very crude surface modelling.

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.

These are the different modules implemented in the E2E simulator. Some of them are based on previous work and described in the literature. We will make that clearer in the new text.

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?

SAM is what is used at the moment. We are currently working at interfacing the code with WRF. In principle any geolocated model output can be ingested. The model output needed are temperature, pressure and relative humidity plus the different hydrometeor contents (and particle size distribution assumption).

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?

Yes the orbit parameters can be changed. The simulator implements an orbital model deriving from the two-body problem theory, with the addition of orbital perturbations due to the J_2 effect to simulate Sun-Synchronous orbits. The user can indeed modify the initial date and duration of orbital propagation and the orbital parameters. Knowing the satellite position vector over time and the scanning method, a vector-based approach is followed to localize the antenna boresight direction and the illuminated region of the atmosphere and the surface.

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?

We have bulk extinction, backscattering and scattering coefficients tabulated per unit mass as a function of characteristic size (mean mass-weighted diameter) and mu (Gamma functions are used). The model also use exponential functions for PSDs with specific assumptions on N_0. We will include all the requested details.

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?

AT the moment the LDR is not consistent with reflectivities but it is simply based on climatological observations. The LDRs are relevant when considering the ghost effect; at this stage we only want to see what is the climatological impact of the ghosts, thus we believe this is enough at this stage. We do not have any polarimetric observation from space-borne radars (even at lower frequencies) but there is no reason (apart from the increased footprint size and increased levels of multipole scattering) why sat-borne measurements should be different from ground-based ones.

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

Yes Table 4 will be deleted.

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).

No, the model is full 3D, so the antenna pattern is currently modelled as a Gaussian main lobe. The simple plane parallel atmosphere was implemented in the 2018 version.

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

The Doppler velocity in radar systems is derived by measuring phase shifts between successive pulses (pairs). We will introduce some explanation and reference where relevant.

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?

Yes gas absorption is included. The Rosenkraz model is used. We will include appropriate references to it.

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?

You can see the strong wind shear in Fig.12 top right panel in the bottom right section of the 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.

We will do that.

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).

Ok we will try that and when needed introduce a double x-axis to help interpretation

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 th current state of the E2E in Sec2, it would be interestiung to know, which problems require additional simulator development/implementations and which are rather setup changes.

Thanks for the list of specific comments that will be implemented in the revised version.