REPLY TO RC1
MANUSCRIPT ESSD-2021-265

The manuscript describes the set-up, attitude control, and exemplary measurements of two vertical pointing radars onboard RV MS Merian during Eurec4a. Main focus of this data paper is the compensation of the ship motion in situations where the active stabilization platform was properly working and different treatment of data in situations where the platform got stuck in arbitrary orientations.

The manuscript is consistent and well written and certainly deserves publication as data paper. There are only minor modifications required. I like the lessons learned section, I hope that this will be considered in future campaigns.

We thank the reviewer for the attentive and constructive review of the publication.

Some general comments:

Obviously, the authors did develop the methods behind the ship motion correction by themselves, without borrowing from the airborne radar community (e.g. Bange, J. et al., 2013: Measurement of aircraft state and thermodynamic and yynamic variable, in: Airborne Measurements for Environmental Research: Methods and Instruments, edited by: Wendisch, M. and Brenguier, J-L., https://doi.org/10.1002/9783527653218.ch2). The methods are the same and there is an agreement between the two worlds (air – sea).

Based on the reviewer's suggestions, we expanded the literature review on the topic, exploring the Bange et al 2013 text suggested (https://onlinelibrary.wiley.com/doi/10.1002/9783527653218.ch2) which is also part of the book "Airborne Measurements for Environmental Research: Methods and Instruments" by M. Wendish and J-L. Brenguier (https://onlinelibrary.wiley.com/doi/book/10.1002/9783527653218) with particular interest in the chapter 9 on LIDAR and RADAR observations. However, we did not find specific mentions on corrections for mispointing on a moving platform. Therefore, we decided to add a general sentence as follows: "Similar methods have been derived for airplane based measurements with Doppler measurements see e.g. Bange et al, 2013".

For the W-band radar you do not mention anything about attenuation (gaseous, liquid) which certainly has to be considered, you call it just reflectivity (factor). Whereas for the MRR you talk about attenuated equivalent reflectivity (factor). This should be consistent. Otherwise one might assume that data from W-band radar are corrected for gaseous and liquid attenuation as well as for Mie effects. Reflectivity factor z implies Rayleigh approximation. However, since both systems are mm-wave systems you better write about effective reflectivity factor. This implies that Mie scattering effects have to be considered in the interpretation of reflectivity factor.

Thank you for this comment. The reflectivity provided by the postprocessing of the Wband radar(94 GHz, so λ is 3.19 mm) data is the equivalent reflectivity factor, i.e. the reflectivity calculated from the measured returned power assuming that the target is composed of liquid water droplets whose diameter is less then one tenth of the radar wavelength (droplets are treated as Rayleigh scatterers). When drops are larger than 3 mm, which is often the case in the data we collected, this approximation is not true and the equivalent reflectivity factor differs from the reflectivity factor. On top of that, while the RPG manual In (https://www.radiometer-physics.de/downloadftp/pub/PDF/Cloud%20Radar/RPG-FMCW-Instrument_Manual.pdf) details the gas loss correction, liquid attenuation affects the estimation of the equivalent reflectivity factor provided. All Wband radars as the one deployed on the ship (from RPG) provide in their data the equivalent reflectivity factor without corrections for liquid attenuation and Mie scattering because always Rayleigh approach is applied and we published the data following this line of conduct. Subsequent scientific publication planned on precipitation will focus on this aspect and provide the correction for Mie and liquid absorption for Wband radar data and compare them properly (on same resolution in time and space) with MRR data.

For the MRR data, the postprocessing algorithm calculates the equivalent radar reflectivity taking into account the attenuation due to liquid water contained in raindrops as well as the equivalent reflectivity non attenuated. For the MRR case, it is more difficult to get out of the Rayleigh approximation for the data collected, due to the different wavelength, but by definition, the equivalent reflectivity factor is assuming Rayleigh approach.

The plots show the equivalent reflectivity without any correction applied, so they are coherent with respect to the displayed quantity. We clarified better the differences between the datasets regarding the Rayleigh hypothesis.

I think the labels/numbers in the figures are too small, but I leave this to the technical editor.

We also wait for the technical editor's opinion on this. Thank you for noticing this aspect.

Reply to minor comments:

Line 14: I think DOI's have to be given in the abstract, but this is a task for the technical editor

We also do not know what is the best practice here. We wait for technical editor comments.

Line 22: What does OA stand for?

OA stands for ocean-atmosphere and is an acronym that represents the ocean-atmosphere research component that was part of the EUREC4A campaign (https://eurec4a.eu/overview/eurec4a-oa/). We included it because the RV Maria S. Merian was deeply involved in the operations regarding the investigation of sea-air interactions and the mesoscale eddies impact on the boundary layer. We included in the text a description of the OA and the link.

Line 69: Section instead of Session

Thank you for the comment, corrected.

Line 78: can you give here some numbers about the temporal drift

We added a estimation of the drift time. However, the drift is variable in time. We modified the sentence as follows: " Despite this effort, the time stamp synchronization suffered from a drift of the clocks with respect to the Global Positioning System (GPS) time of the ships inertial system variable between 1 and 4 s that we had to consider in the correction of the data for ship motions. "

Line 127: Why longitude and latitude with the same temporal resolution as the radar data are not copied to the radar dataset?
The latitude and longitude data come from the ship because they haven't been recorded by the radar. The lat and lon data have been resampled on the radar time resolution in the daily file version which is published online. Daily files are supposed to be used from the largest amount of users because they are ncdf files in a standardized format, easy to read and contain all the meteorological variables of interest.
Lat and lon are not included in the hourly radar files because such files contain only the radar-specific information, on top of the radar variables, and are of interest for specific radar applications only.

Lines 170 - 175: can you also give the temporal resolution of the MRU?
We added that the temporal resolution of the MRU is 1 s, thank you for the comment. The sentence reads now as follows: "All rotation angles are measured by the Motion Reference Unit (MRU) unit on the ship with a time resolution of 1 s."

Lines 179 - 184: this should go to section 2.3
Thank you for the comment: the sentence was somehow doubled, so we added some parts in section 2.3 and we left here only the sentence related to the figure 4. Please check the resulting text in the diff_versions.pdf file attached.

Figure 5 is hardly readable, the sketch of MS Merian is 2D, whereas the vectors are 3D; this figure should be improved considerable
We thank the reviewer for these comments. The readability has been improved by enlarging the fonts. We modified the image by splitting it in two parts. On one side one image of the RV, on the other we added the 3D reference system.

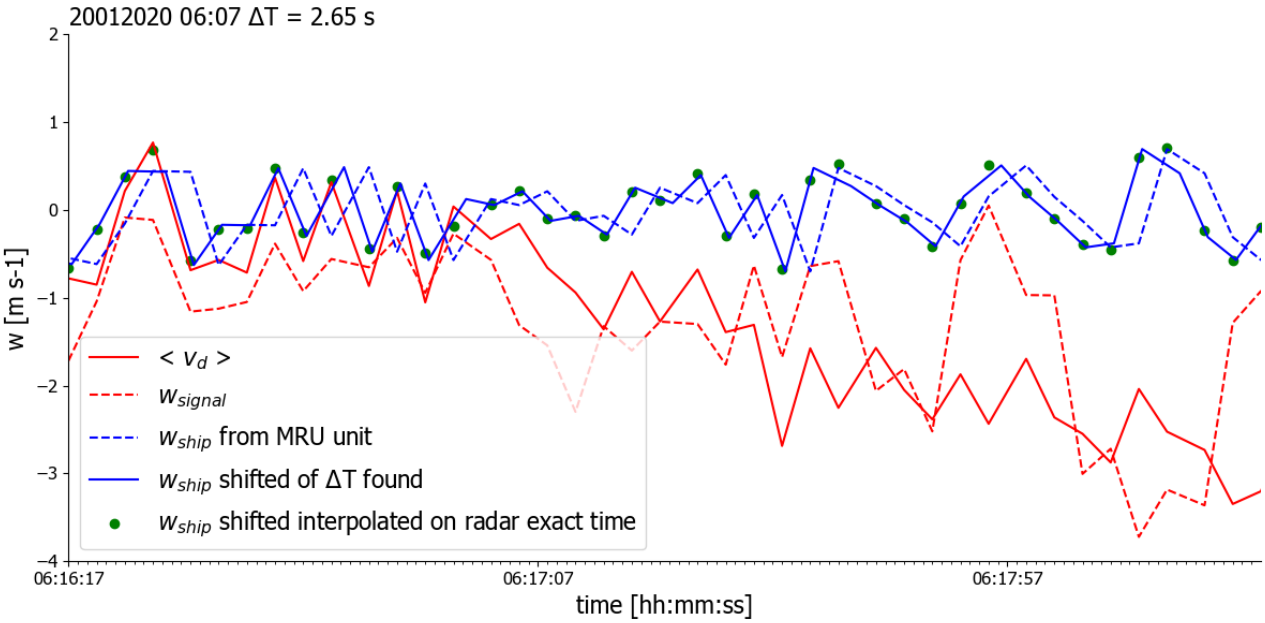
Lines 206 + 207: "whereas w_heave … gates" is repeated from above
Thank you for the comment. We stated it again because we wanted to clarify why by averaging over height the w_heave does not change. However, we removed the second sentence since your suggestion indicates that it is redundant.

Lines 224 - 230: confusing, ex,ey,ez is first ship relative and later horizon relative, maybe you could use different notations for the two reference systems
We thank the reviewer for the comment. Since the ship reference system and the horizontal reference system differ only because of the z direction, we preferred to keep the same notation, and just specify the direction. We went through the text and found an inaccuracy in the reference to the reference system. We corrected that and we hope that now the text can be less confusing.

Line 226: appendix C or equation C4

Corrected, thank you!

Figure 6: faint lines are hard to read, you could also use dashed lines instead
Please find here the new version of the plot:



This image has been substituted to the old Figure 6

Line 239: horizontal or ship relative coordination system? These are different reference systems
Horizontal reference system here. Ep is expressed with respect to the horizontal coordinate system

Line 262: v_trans would be more memorable for the translation velocity than v_trasl
We changed the naming

Line 264? - rotation vector: what is about bending and twisting of the ship body (I remember a video you showed once at a workshop)
Unfortunately there is no way to our knowledge to measure bending and twisting of the ship body itself. Also, We assumed that such deformations could be neglected because we did not experience rough sea conditions.

Figure 7: maybe panels a), b), c), e), f), g) could be larger, and d) and h) could be smaller (or omitted)
The figure was modified, thanks for the comment. We also extended the color bar range, to avoid the saturation for high Vdoppler values (see comment below)

Line 296: Figure 7 e)-g)
corrected thank you

Line 298: the high fall velocities in the second half of the plot and persistent through all heights seem unrealistic, can you comment on this?

In this plot, we chose to represent a precipitating shallow cumulus cloud not extending above the inversion and a deeper cumulus with top above 3000 m, to represent the variability in precipitation that we observed during the campaign. The high fall velocities observed are generated by the deeper cloud core, and the unrealistic effect mostly come from the fact that we used the same color bar for Doppler velocities even if the observed velocities span different ranges. A modified version of the plot has been prepared to avoid the saturation in the vd more negative values.

Line 311: signal to noise "ratio"
corrected

Line 313: Table 2 gives 7.5 to 34 m resolution. For the horizontal resolution also beamwidth has to be considered
Values presented in the table are provided by the manufacturer and refer to range vertical resolution.
We included in the table that is vertical resolution.

Line 321: numbering Fig. A1 is confusing. The figure does not belong to Appendix A
Thanks for the comment. However, the numbering of the images is ruled by the copernicus latex template and is assigned automatically, to my knowledge. The ordering of the images is independent from the ordering of the appendixes. We hope that the technical editor can help in this respect.

Figure 9 caption: interpretation "and made a hook rain structure … wind mixing" should not go to caption
thank you for the comment, we moved the sentence in the main text and riformulated the sentence at line 350 as follows: "Figure 9 d) shows a hook rain structure visible, possibly caused by downdraft wind mixing. The vortex structure was not visible in the original data (Figure 9 c)) and emerged from the noise after applying the correction on the mean Doppler velocity field. "

Figure 12: I think, images from both radars should have the identical height axis range and identical color bar range and color map. This makes comparisons between W- and K-band much easier, even though it is not the objective of the paper.
We thank the reviewer for this comment. The goal of this paper is not to compare between the W and K band radars, but instead to display the measurements collected and show their potential. The high resolution adopted with the Wband radar can be incredibly beneficial for process studies and model evaluations, therefore we opted for showing it visibly. More detailed studies on precipitation that are planned by the main author will exploit the diverse information on precipitation coming from the usage of the W and K band frequencies. There the approach suggested by the reviewer will be exploited for the future analysis.

Line 399: It might be worth to discuss shortly the observed differences between both radars and how the complement each another. Different attenuation due to different wavelengths, different sensitivity, …

In line with the previous reply, we think that an extensive discussion on this point would perfectly fit in a scientific publication focusing on precipitation more than in a data paper whose goal is to present a dataset, that can be used in various different ways, not necessarily exploiting the multifrequency approach. We actually will include such discussion in the planned publication on precipitation.

Line 434: just a comment: some airborne systems (unfortunately not HALO/HAMP) have an IRS/IMU as close as possible to the radar antenna
interesting thank you :)

Line 507: … by alpha clockwise from North
corrected thank you

Line 507: for non-meteorologists you could add "(the direction where the wind is coming from)" this makes it easier to understand the minus signs in Eq. B1
The sentence has been modified as follows: " In the Earth reference system, the horizontal wind vector in absolute coordinates is given with the zonal component towards East, and the meridional component towards North and it represents the direction where the wind is coming from."

Line 514: If "yaw" psi is indeed …
added, thanks

Line 523: heave is not discussed here
We removed the information on heave collected as last, because as suggested, is not relevant here.

Line 531 till end of page: check order of description of r_rot and v_rot, looks like repeating of definitions
We thank the reviewer for this comment, we rearranged the paragraph in a more linear way, we hope. Thank you for noticing.

Line 544, Eq. D1: should be e_p0 = … (?)
we added the definition of E_po

Line 547, Eq. D2: why not t_final for theta_tbl,S
Thanks for the comment. The distinction between t_final and to, the time when the table got stuck, follows from the fact that the time to is measured by the stable table, and not by the ship time. The t_final time stamp is the closest time to at which the ship sensor collected observations of roll, pitch, yaw. There might be a small difference between these two times because they are measured by two different sensors. This is why we maintain the separation.