The authors would like to thank the editor and the referees for their comments on our manuscript. Following the comments, we make the following replies and corresponding revisions to the manuscript. Each item of the original comments from the referee is in *blue italic*, followed by our reply. Moreover, in the marked version of the revised manuscript, the revisions are highlighted with 'REV1'.

REVIEW 1

Review on "Quantifying the Influence of Snow over Sea Ice Morphology on L-Band Microwave Satellite Observations in the Southern Ocean" by

Zhou et al.

Utilizing the limited but widely collected data for the sea ice and snow in the south ocean by buoys, ship bases, and aviation satellites, based on the snowpack and radiation transfer models, the authors simulated and analyzed the impact of snow cover and its stratification on the passive microwave brightness temperature observation results. The latter is crucial for satellite remote sensing inversion of sea ice concentration and snow/sea ice thickness. Overall, the authors conducted a very detailed analysis based on the complex data. The comprehensiveness of the data is the greatest contribution of the paper, and the complexity of the data also brings many uncertainties to the results of the paper. Therefore, I recommend that the paper needs to undergo major revisions before it can be considered for publication. My main concern is still to focus on the analysis of complex data. Here are my general comments:

- *Does the snowpackmodel consider the effect of snowdrift? Is the thickness of snow simulated output or forced by observational data?*

Reply: we would like to clarify that: (1) SNOWPACK model does not include snow drift processes, and (2) we are aware of its limitations, we only use SNOWPACK in specific ways. For AWI buoys which do not directly report inundation, for the simulation of Tbs in RADIS-L v1.1, we use the percentage of this brine-wetted snow layer reported by SNOWPACK. For comparison, for cases which directly report negative freeboard (e.g., ZS-2010), the direct measurements are used instead.

Our second clarification is: the snow depth from direct observations (e.g., SIMBA buoys, OIB) are used to force the RADIS-L radiation model.

- *How are the differences in snow and sea ice characteristics in different regions, especially between the regions of drifting ice and landfast ice, considered?*

Reply: we agree with the referee that this is important, and are also fully aware of the fact that vast differences in snow and ice properties are present for the various observations used in this study. On the other hand, both the radiation model we develop (i.e., RADIS-L) and the SNOWPACK that we utilize are general-purpose tools that accommodate these large variability of key sea ice parameters such as snow and ice thickness, as well as snow-ice formation due to inundation. We acknowledge that certain limitations exist, such as the different levels of ridging between sea ice in Weddell Sea and other places. They may constitute sources of uncertainty when comparing data of different origins (e.g. F.g. 4-6). However, as shown in this study, in spite of the large variability of the data sources and conditions, the snow-ice formation and the effect on L-band Tbs is supported in in-situ measurements, and evidently, much better agreement with satellite Tbs. We fully agree that environmental and representation factors need to be considered fully, which we have planned for future work.

Special comments:

- *Line 18 "facilitating key biological processes"is not belong to the influences on the polar climate system"*

Reply: we revise the whole sentence as follows: "Snow on sea ice significantly influences the polar climate and ecosystems by mediating mass and energy exchanges during air-sea interactions, as well as key biological and biogeochemical processes".

- *Line 57: Why the evolving climate conditions in Antarctica would lead to snow melting and refreezing processes becoming more prevalent?*

Reply: we would like to clarify that: with warming of ocean on lower latitudes and frequent storm intrusion, the relatively warm surface conditions (even above 0 degC) are becoming more frequent over the sea ice. Hence the melt-refreeze cycles both over the top and bottom of the sea ice are more prevalent.

- *Line 76 "vis-à-vis"it is not a commonly used word.*

Reply: we have changed "vis-à-vis" to "with regard to", which is more commonly used.

- *Line 94 "We also use data collected from ice mass balance buoys (IMBs)": I wonder if this is also SIMBA buoys, as it is also not equipped with sonars. Please verify.*

Reply: we have verified that the buoys deployed are of SIMBA type (Wever et al., 2021). Therefore the manuscript is revised as: "*We also use data collected from ice mass balance buoys (IMBs) and snow buoys in the Weddell Sea from 2013-2014, and 2016. They are the SIMBA type buoys and equipped with a thermistor string to measure sea ice temperatures with a vertical spacing of 0.02 m*."

Since in Wever et al. (2021), the abbreviation of IMB (for Ice Mass Balance buoy) is used for SIMBA-type buoy as well, we choose to follow this practice in this article.

- *SIMBA-type buoy over Prydz Bay: the buoys deployed in the Prydz Bay included the SIMBA and CRREL-IMB.*

Reply: we thank the referee for pointing out this inaccurate statement. We have revised it to “Ice mass balance buoys over Prydz Bay”.

- *Line 127 “Vertical now salinity profiles”: It is snow profiles.*

Reply: corrected.

- *Line 153 “ et al. (2015)”: typing error.*

Reply: corrected.

- *ASPeCt snow and ice thickness data: This data actually has a significant error because it is visually judged by humans.*

Reply: we agree with the referee that ASPeCt thickness data contain relatively larger uncertainty than other in-situ data we use (e.g., buoys). Besides, similar representation error is also present for ASPeCt. However, it provides us with an important source of information, since observations are scarce for sea ice in Southern Oceans. Beyond this study, ASPeCt are also frequently used in many studies for the validation of satellite retrieval of sea ice thickness.

- *Method by Cox and Weeks (1983) and Leppäranta and Manninen (1988) is used to calculate the volume fraction of brine inside sea ice. Whether it is also suitable for the slush layer?*

Reply: we consider the brine volume fraction estimation in Cox & Weeks (1983) is sufficient for this study, which allows large and realistic brine volume under relatively warm conditions (i.e., near freezing). For example, the brine volume fraction at -2degC and 0.8m ice is 0.151.

- *Snow evolution off Zhongshan and Davis Stations in Prydz Bay: According to observations, negative ice freeboards and slush layers are rare in this regions because of strong katabatic downwind. See also:*
- *Li N, Lei R, Heil P, Cheng B, Ding M, Tian Z, and Li B. 2023.Seasonal and interannual variability of the landfast ice mass balance between 2009 and 2018 in Prydz Bay, East Antarctica, The Cryosphere, 17, 917–937, https://doi.org/10.5194/tc-17-917-2023.*
- *Lei R, Li Z, Cheng B, Zhang Z, Heil P. 2010. Annual cycle of landfast sea ice in Prydz Bay,east Antarctica. Journal of Geophysical Research: Oceans, 115(C2), C02006, 1–*

Thus, is the data of the ZS-2010 buoy representative？This buoy observed a negative ice freeboard because it was deployed near an iceberg. In addition, in the observation footprints of satellite remote sensing, the vicinity of this buoy should include signals from icebergs and land.

Reply: we consider the buoy ZS-2010 to be representative of the snow-ice formation and the change in Tbs. As pointed out by the referee, ZS-2010 resides on landfast sea ice for the period of study, and the surrounding conditions such as the iceberg remain the same.

According to the suggestion of the referee, we have revised the statements on line 360 that imply the causality of snow accumulation on snow-ice formation at ZS-2010 (i.e., the potential role of the nearby iceberg on the freeboard).

- *Line 405 "Essentially, this means that the conditions observed at the buoy location are representative of the entire grid cell, ensuring that the satellite Tb data is a valid proxy for the conditions across the whole floe"*

In fact, the surface brightness temperature at the floe scale depends not only on air temperature and lead distribution (or ice concentration), but also on the heterogeneity of snow and sea ice thickness, the latter of which undergoes significant changes at the floe scale of several tens of meters.

Reply: we agree with the referee that the buoys have potential representation issues. We would like to clarify that the word "means" here should be "implies". It is revised accordingly.

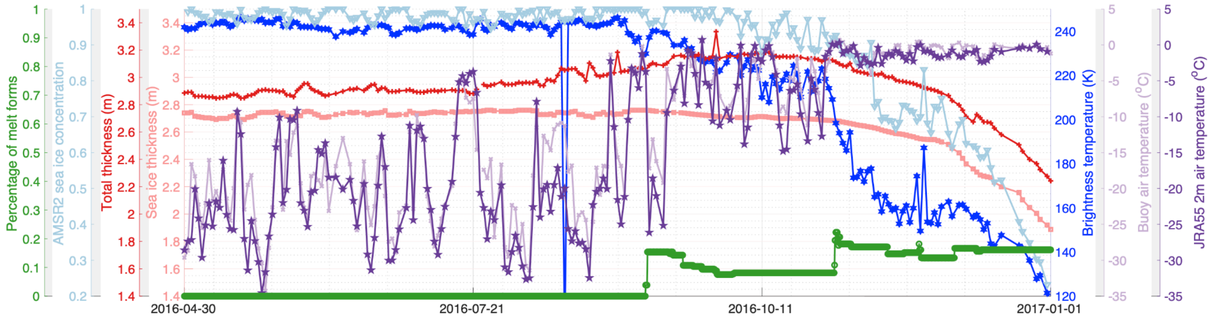
- *Line 458 "we conduct Tbs simulations following the trajectory of the ZS-2010 buoy"*

In fact, this buoy is deployed on landfast ice and would not drift, with the small distance from the shore.

Reply: we have revised it to "we conduct Tbs simulations at the location of the ZS-2010 buoy".

- *Figs. 4-6: Do you also consider using surface temperature observed by buoys to compare/verify brightness temperature?*

Reply: we confirm that the brightness temperatures are simulated using: (i) buoy measurements when temperature data is available. (ii) JRA55 2m temperature data when buoy temperature data is missing. These methods are used for buoy-based validations (see Tab. A1). In fact, we have conducted a validation comparing the temperatures between the buoy (represented in light purple) and JRA55 2m (represented in dark purple), as shown in the figure below. The correlation in air surface temperature between the buoy and JRA55 2m data is over 0.95, indicating a strong agreement with no significant bias.



Percentage of melt forms
AMSR2 sea ice concentration
Total thickness (m)
Sea ice thickness (m)
Brightness temperature (K)
Buoy air temperature (°C)
JRA55 2m air temperature (°C)
2016-04-30
2016-07-21
2016-10-11
2017-01-01