Response to review by anonymous referee #3

Opening remarks

We warmly thank the four anonymous referees and Tim Hewison for taking the time to review our manuscript and to provide valuable feedback. As there are commonalities between several of the reviews, we start with some general remarks.
To begin, we emphasise that our goal is not to encompass the entire AWS mission. First of all, this would be very challenging to cover within a standard manuscript length and would approximately double the number of co-authors. For example, the primary objective of AWS is numerical weather prediction (NWP), and addressing the aspects and applications of AWS within this area could be a manuscript in itself. The manuscript's aim is instead to provide the necessary information to understand the design of the AWS radiometer and to utilise the L1b data from this instrument. In the revision, we focus on improving the text around these aspects based on the provided feedback, as well as adding some new information.
A related question is how much in-orbit characterisation to include. Here, we hope to have an understanding of the difficulty of compiling the manuscript at the same time as the team is preoccupied with the satellite's commissioning phase. The initial aim was to submit the manuscript in 2024. In particular, the sudden deviating behaviour of the 174 GHz receiver (Sec. 6.3) caused significant concern and resulted in a substantial delay in the manuscript. Nevertheless, our approach is to include some initial basic results, primarily to indicate that the findings from the on-ground tests appear to be valid. We have added a sentence to exemplify this further and on the same time indicate the range of aspects that has to be considered. We avoid going further to leave room for one or several upcoming articles that are entirely focused on in-orbit testing. In addition, to fully cover the in-orbit testing would again require a considerable extension of the list of authors. This work is ongoing and far from complete. At least one update of the L1b processing algorithm is foreseen.
In summary, we find it reasonable to focus on the development of the instrument up to the launch. On this side, we think the manuscript is already more information-rich than usual. This brings us to an unstated objective. It is already difficult to find in the open literature the relevant background information about the satellite instruments we use for research. The trend towards new space and more substantial commercialisation risks making the situation worse; with this manuscript, we aim to demonstrate that this need not be the case.

The replies below refer to the revised version of the manuscript we have prepared.

Replies on referee's comments

- "There has been considerable recent interest and activity in the area of earth observing small satellites that typically require sacrifices in performance, capability, and/or reliability in order to reduce costs and facilitate their implementation in an effective and expeditious manner. This paper does not adequately mention or reference prior art or previous work in this area ..."
    - These are highly important considerations that have been discussed in the work leading up to AWS. For example a review of cubesat mission was made. However, it is difficult to discuss the matters in a rigorous manner as the details and the final performance of those small missions are not clearly described in the open literature. However, there is a fundamental difference between AWS and cubesat missions (as far as we understand). While sacrifices in performance seem to be accepted for those very small missions, AWS aims to be at least similar to the state-of-the-art missions in terms of core performance.
    - We tried to avoid this complicated question, but the referee is correct, the relationship to prior work shall be clear. The impressive technical feat behind cubesat missions has acted as inspiration for AWS, but the actual roots of the mission is rather find in some national (Swedish led) satellite mission. There is a new paragraph in the Introduction, indicating these links.
- "Regarding the technical content of the paper, many details are given in the paper, but I think there are a few basic pieces of information that are missing that would be of keen interest to the readership. For example, what is the mass, volume, power consumption, and data rate of the instrument (and even better, simple comparisons to what is flying now or is planned to fly)? There is some of this kind of information presented for the satellite bus, but instrument parameters would be more meaningful."
    - Thanks for pointing out this neglection. Numbers on the mass, power consumption and data rate have been added (end of Sec. 2.1).
- "The instrument does not include "traditional" channels near 24 and 31 GHz due to the size of the reflector that would be needed. This is a reasonable design trade, but those are very important channels for the retrieval of total precipitable water - it would be useful to simply discuss the impact of this omission and how it might be mitigated."
    - There is no mitigation on the AWS platform for the lack of channels at 24 and 31 GHz. However, a discussion of this omission is far from trivial, and we select to not include such a one. In short, it is clear that AWS would have provided more information on total precipitable water if also having those channels, given the budget and time needed to implement the channels without any negative effect on the other channels. If the issue

instead is looked upon with actual budget and time as constraints, AWS would have become a poorer instrument by including 24 and 31 GHz as it would have demanded significant compromises for the other channels, including a full removal of the 325 GHz receiver chain and possible also some other. Or more likely, if suggested with 21 and 31 GHz the budget and the technical risks would likely been seen as too large and AWS would not had been realized at all.

- "Another design choice appears to be to fly the satellite at a lower altitude than current operational sensors (600 km versus 817 km). This of course yields better spatial resolution for a given reflector size, but at the cost of substantial footprint broadening at larger instrument scan angles. The spatial resolution at the scan edges (55 degrees) could be much too coarse for effective operational use. Some discussion of this point would be helpful - what are the AWS scan-edge resolutions and how do these compare with present systems, for example? And how does this impact the planned approach of spatially combining/aligning the footprints for the various bands?"
    - This is a fair comment, but we again select to not extend the discussion due to the complexity of the question and limit the information to: An altitude of 600 km has been targeted as a good compromise between brightness size requirement, ground coverage, launch cost and end-of-life deorbiting considerations.
      As this comment indicate, there are multiple considerations when selecting the orbit altitude, including ones around launch and deorbiting that largely excluded orbits around 800 km. To this can be added that the many NWP centers, when assimilating data from microwave cross-track scanners, anyhow exclude data from the outer parts of the swath (as far as we understand).
- "Another compromise is the choice (reasonably) of a constant scan velocity versus and non-constant scan velocity (whereby the scan is slower over the earth and faster away from the earth, so that the integration time for earth-viewing footprints is longer, thus noise is lower). The penalty paid for this is approximately sqrt(2) in noise amplification (assuming scan accelerations consistent with current operational sounders). Again, some discussion of the regret of this would be useful, especially in light of the profound impact of the radiance noise in numerical weather prediction applications."
    - A short discussion has been added at the beginning of Sec 2.5.
- "The terms "inter-pixel error" and "orbital stability" are used without definition - what are these and how were they quantitatively assessed?"
    - The choice of these words likely indicated a standard assessment of these aspects, that is not correct. Sec 4.5 has been rewritten and hopefully better clarifies the approach and ambition of the tests.

- "I believe the L-band satellite communications transmitter frequency (1.7 GHz) falls within the IF bands of the high-frequency receivers - was any prelaunch testing done to ensure electromagnetic compatibility of the spacecraft hardware and the radiometer? Does the radiometer noise measured on-orbit increase when the communications transmitter is on?"
    - This possible interference has been considered and tested, both on ground and in orbit. Comments about this have been added to Secs. 2.2 and 6.3.