

Response to Anonymous Referee #1, received and published: 10 March 2020

13 March 2020

Please see our responses in [blue color](#) in the reviewers text.

[Thank you for this careful review and the constructive comments below, which have been used to revise the paper.](#)

Anonymous Referee #1

Received and published: 10 March 2020

————— Summary —————

This paper introduces the Copernicus polar Ice and Snow Topography Altimeter (CRISTAL), which is a Polar orbiting satellite that has been identified as a high-priority candidate mission by the European Commission (EC) in collaboration with the European Space Agency (ESA). CRISTAL will build on the heritage of previous Ku- and Ka-band satellite radar altimeters by operating at both frequencies, as well as flying a high-resolution passive microwave radiometer. Such a mission is crucial for the continuation and improvement of large-scale observations of the polar and terrestrial ice and snow cover, as well as ocean dynamics. Therefore, this paper will be of interest to a large and varied readership, and I am pleased to see an update on CRISTAL's progress being submitted. However, I do have some concerns and comments that should be addressed before publication.

[Thank you for this careful review and the constructive comments.](#)

My main concern is that this should be “the” paper highlighting the importance of CRISTAL, above and beyond other candidate satellite missions. Therefore, it needs to be clear, convincing, and accessible to a wide audience. The current manuscript reads too much like a copy and paste from an ESA report.

[The paper is intended to inform the scientific and user community of this candidate mission in preparation. It is not the intention of the authors to rank or prioritise this candidate mission above and beyond other candidate satellite missions in preparation. To address the comment from the reviewer, it is proposed to change the title, the abstract and to restructure/reorganise the paper has been considerably so that it reads better. We have tried to rework the paper so that it reads less like a white paper.](#)

- The paper would benefit from being more concise, with improved coherence between sections, less repetition, and an early focus on the scientific benefits of CRISTAL instead of having them spread throughout

[The mission is addressing operational user requirements and needs identified by the European Commission. A general background and context of the mission is considered important as it cannot be found anywhere else.](#)

[However, the authors acknowledge the concern of the reviewer and propose a considerable change in the paper \(new title, now “The Copernicus Polar Ice and Snow Topography Altimeter \(CRISTAL\) High-Priority Candidate Mission”, a better tailored abstract and to rework the paper \(e.g. interchange sections 4 and 5\).](#)

- A number of acronyms are not introduced in the main text (e.g. GMES, EUMETSAT, OSTST), which assumes too much prior knowledge considering the wide readership Potential

Ok. We have checked again the acronym list and tried to introduce them all at the first instance in the text. Also, a large number of acronyms are removed for clarity.

- It is very hard to digest such long sentences. I appreciate this is a style preference but it was an issue for me. This includes P2L43-46, P4 L120-122, P6170-186 (secondary objectives summary), P89L238-242, and many others.

Ok. We have re-arranged all sentences mentioned by the reviewer. We have also reworked the paper so that it becomes better readable.

————— Specific comments —————

P1L36: This makes it sound like the paper might be more technical than it is. Make it clear that the paper is primarily mission contributions, and does not include in-depth technical information (which can't be available at this time).

Ok. Modified.

P3L89: What is meant by “next generation of the current Sentinels 1 to 6 series”? Could do with a little more information, or relevant references.

Ok, reference added.

P4L105-106: What is “an integrated end-to-end system approach”? These more technical/agency terms should be explained in a science journal.

Ok. A sentence is added.

P4L13: Remove “inhospitable”. The Arctic human population is mentioned in the same sentence.

OK. done

P5L150: Who recorded this recommendation? Please provide a reference.

The OSTST in their closing session. Reference added.

Section 3: The beginning of Section 3 (up to P5L155) is very sea ice heavy. I encourage the authors to provide more on the importance (climatic and observationally) of glaciers, ice caps and ice sheets prior to introducing them as a primary mission objective.

Agreed. Floating ice are listed as the top priority in the PEG report. Therefore, this is more emphasised here. The importance of glaciers and ice caps is now further emphasised.

P6L179-180: Please provide some references for the evidence of frozen rivers and lakes being influenced by climate change

ok, new reference added as well as sentence slightly modified.

P7L202: The authors state that “Compared to heritage missions, the Ka-band channel (35.75 GHz) is added for snow: :” but later in the paragraph, they describe SARAL (AltiKa) as a heritage mission, which could be confusing to readers who are not familiar with the history of Ka-band altimeters.

Ok, sentenced changed.

P7L208: Which radar system does the 500 MHz bandwidth apply to? As I read it, they mean just Ka. However, AltiKa also has a bandwidth of 500 MHz so I'm not sure how this would lead to an improved range resolution in comparison.

500 MHz applies to entire system and both frequencies, Ka-band and Ku-band. This is now better formulated.

P7L209: The reference to Egido and Smith (2017) should also be included here

Ok. Added.

P8L239: Add reference to Armitage and Davidson (2013) – DOI: 10.1109/TGRS.2013.2242082

Ok, added, Armitage and Davidson (2014).

P8L244-245: The authors state that “Retrievals are likely improved by a factor 2: : :” but it’s not clear what retrieval parameter they are referring to. The number of retrievals? Accuracy of individual retrievals?

Ok, updated.

P10L270-271: I understand that it is only Arctic sea ice that is a driving force of the global thermohaline circulation

ok, changed.

P10L278: The Perovich (2017) reference is over two years out of date. NSIDC, for example, can provide the most up-to-date statistics on sea ice extent decline.

Ok, added.

P11L311-313: Include some discussion/reference to Mallett et al. (2020) – DOI: 10.5194/tc-14-251-2020, which finds that assumptions concerning the time evolution of overlying snow density can lead to underestimates of sea ice thickness from radar altimetry. This will have the opposite impact of the salinity consideration of Nandan et al. (2017).

OK. Text added and Reference added. Please note that the Mallett et al reference was not available at the time of submission of this paper.

Section 5.1: Include a comment on the importance of sea ice in Antarctica. There are many examples relating to ecosystems/surface momentum exchange/ice shelf-ocean interactions etc.

Ok, one sentence is added.

Section 5.2: Currently this paragraph applies only to Arctic sea ice. The authors could address the difficulties of applying a dual-frequency snow depth retrieval method in Antarctica (much more complex penetration). Also, the first sentence needs tidying up.

First sentence corrected. Complex situation over Antarctica mentioned.

P13L372: Add reference to Foresta et al. (2016) – DOI: 10.1002/2016GL071485

Sections 5.1 and 5.3 are lacking in references. This needs to be addressed before publication in a scientific journal.

Foresta reference is added. It is noted that Section 5.1 now contains almost 25 references, Section 5.3 8 references. Please understand that the paper cannot provide a complete overview of all aspects studied in literature wrt sea ice and ice sheets; it is also not the intention of this paper but to introduce CRISTAL.

P14L407: The designed operational lifetime of CRISTAL (7.5 years) is key and interesting information, so I suggest mentioning this earlier in the manuscript, such as in the introduction and even the abstract

It is now added earlier in chapter 4.

P16L478-479: What is the timeframe of prototype and potential satellite development?

A couple of tables would be useful in the paper: One that summarizes the current mission milestones and timeframe, and another with instrument information (not limited to altimeters)

This information cannot be provided at this point in time, as it is now yet known and/or depends on the consortiums and instrumentation selected for Phase B2, C/D, E1. More details on the instrument algorithms and performance could be subject for future publications.

————— Technical comments —————

P2L41: “: : :see Chen et al (2013)” -> “: : :(Chen et al., 2013)”

Ok, corrected.

P5L138: “: : :from SAR: : :” -> “: : :from SAR **altimetry** : : :”

Ok, corrected.

P5L149: Remove “at large”

Ok, corrected.

P6L180: “: : :context of global warming: : :” -> ““: : :context of climate change: : :”

Ok, corrected.

P6L189: "requisite" -> "required"

Ok, corrected.

P8L216: This opening bracket has no end

Ok, corrected.

P9L250: Define SLA here, not P14L388

OK, introduced earlier.

P9L252: RMC is already defined on P7L211

OK, corrected.

P9L261: ": : :delivery as **a** Level 1B: : :"

OK, corrected.

P11L286: "ice-infested" -> "ice-covered"

OK, corrected.

P13L370: "..horizontal resolution of less or equal than 100 m: : :" -> "horizontal resolution of less than or equal to 100 m: : :"

OK

P13L378: ": : :helping us understanding and monitoring: : :" -> ": : :helping us to understand and monitor: : :"

Ok, corrected.

P14L391: ": : :supporting **sea** ice thickness retrieval: : :"

Ok, corrected.

P14L393: "associated to" -> "associated with"

Ok, corrected.

General: Please be consistent between "sea-ice" and "sea ice" and the same for land ice

OK, corrected.