

## ***Interactive comment on “The Copernicus Polar Ice and Snow Topography Altimeter (CRISTAL): Expected Mission Contributions” by Michael Kern et al.***

**Anonymous Referee #1**

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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

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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.

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 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
- 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
- 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.

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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).

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.

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

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

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sentence.

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

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

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

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.

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.

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

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

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?

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

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.

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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).

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.

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.

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.

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

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)

\_\_\_\_\_ Technical comments \_\_\_\_\_

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

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

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P5L149: Remove “at large”

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

P6L189: “requisite” -> “required”

P8L216: This opening bracket has no end

P9L250: Define SLA here, not P14L388

P9L252: RMC is already defined on P7L211

P9L261: “...delivery as \*\*a\*\* Level 1B...”

P11L286: “ice-infested” -> “ice-covered”

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

P13L378: “...helping us understanding and monitoring...” -> “...helping us to understand and monitor...”

P14L391: “...supporting \*\*sea\*\* ice thickness retrieval...”

P14L393: “associated to” -> “associated with”

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

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-3>, 2020.