TCD_2015_5: Malnes et al., "User requirements for the snow and land ice services- CryoLand"

Please find enclosed our answers to the referee comments to our paper, and the updated paper (marked version v3.0) .

Response to Anonymous referee #1

We thank referee #1 for the kind remarks on the paper.

Answers to specific comments:

Comment 1: p.794, line 21-23: do snow water equivalent, snow depth and wet snow have the same level of requirements?

Response: In the recommendations in IGOS Cryosphere report (page 26, R3.5) the panel desires a global multi-sensor observing system for 1) snow extent, 2) snow depth, 3) SWE and 4) snow wetness at high spatial resolution. While snow extent and snow wetness, at least partially is achievable with current sensors, observations of SWE and snow depth are still not possible to measure with current sensors. IGOS emphasise the need for research and new sensors for measuring SWE and snow depth.

We suggest to reformulate the sentence "Snow water equivalent, snow depth and wet snow are mentioned as highly desirable variables" on page 794, line 21-23 to "Wet snow should also be monitored consistently with current sensors, while snow depth and SWE are highly desirable, and require investments in sensors and research to become observable at a suitable scale/accuracy."

Comment 2: p.804, line 24: snow cover fraction is mentioned here, why is it not included in table 3? Is it included in snow extent?

Response: Snow cover fraction is included in snow extent in Table 3. We did not make the distinction between snow extent, snow cover fraction and snow covered area throughout the web-questionary (partly to reduce the number of questions). Since snow extent and snow covered area can be derived from snow cover fraction, we have implemented a Pan-European snow cover fraction product. This distinction was also discussed on page 795, line 6. In retrospect we should have asked explicitly about snow cover fraction instead of snow extent in the questionary, but this was not possible to do afterwards. We suggest to change "snow extent" to "snow cover fraction" in line 1 (regional) and 3 (pan-European) in Table 3.

As a consequence we also delete the words "snow cover and" in line 10, page 8.

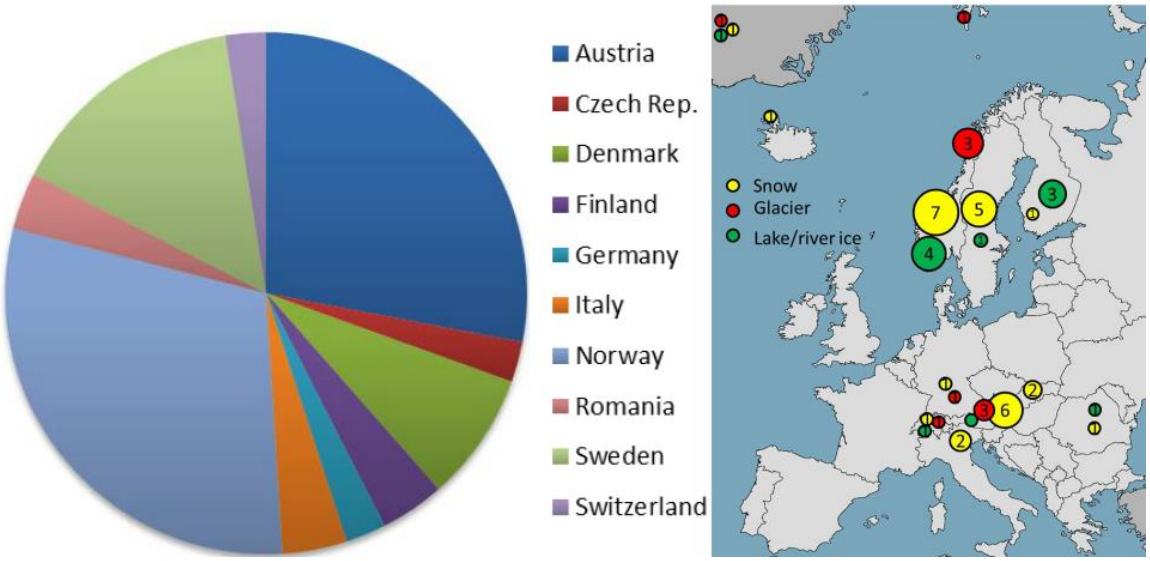
We also suggest changing the title of section 3.2 from "User requirements for snow cover services" to "User requirements for snow services" in order to reflect the fact that the services also measure e.g. snow water equivalent.

We also delete line 12, page 13 in acronyms "SCA Snow Cover Area" since it is not used.

Comment 3: Figure 2: it would be good to have a larger picture of the European location of the users and the dot dimension shall be proportioned to the number of users involved for that area/country.

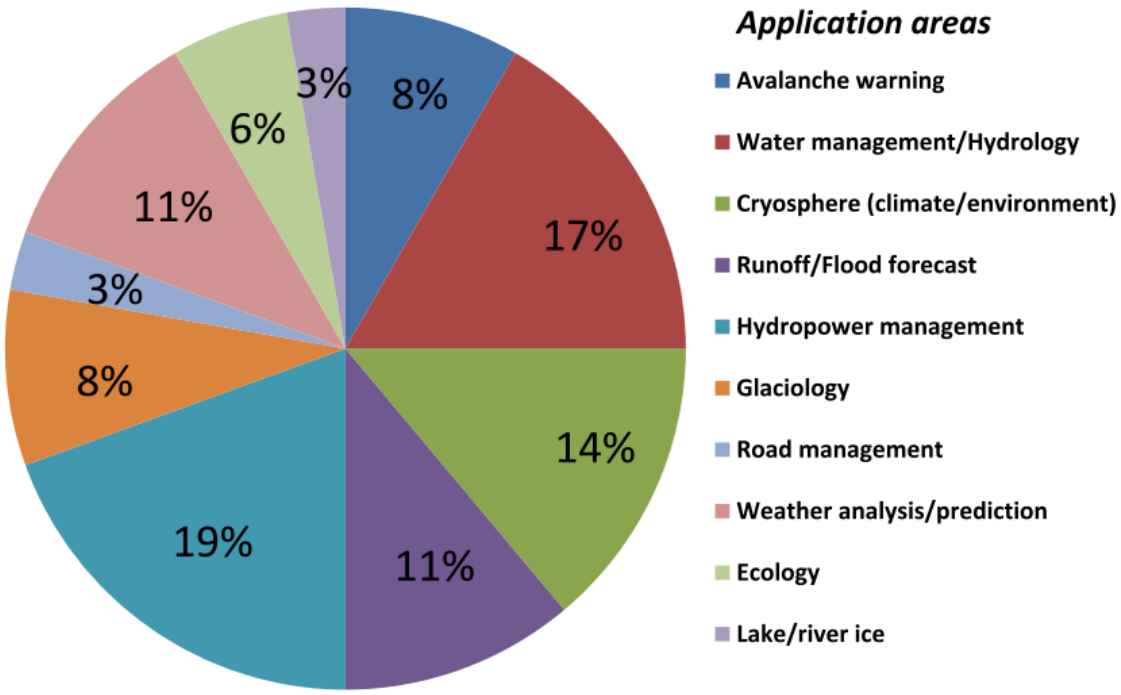
Response: The dots in the original figure represent answers from individual users and were also located in their region of interest, although some users has a much larger region of interest than others. We have made an attempt to update Figure 2 using dots that scale according to the number of users on a national scale (except for Greenland and Svalbard, which we think are important to address separately as they are not currently covered by the PanEuropean services). We include the number of responders in each dot since it is hard to see the differences in scaling sometimes. The new figure 2 replace the old Fig 2 (right) in the paper.

In Figure 2 caption we need to add: Dots are scaled according to the number of responders.



Comment 4: Figure 3: it would be helpful if the percentages were also reported on the pie diagram.

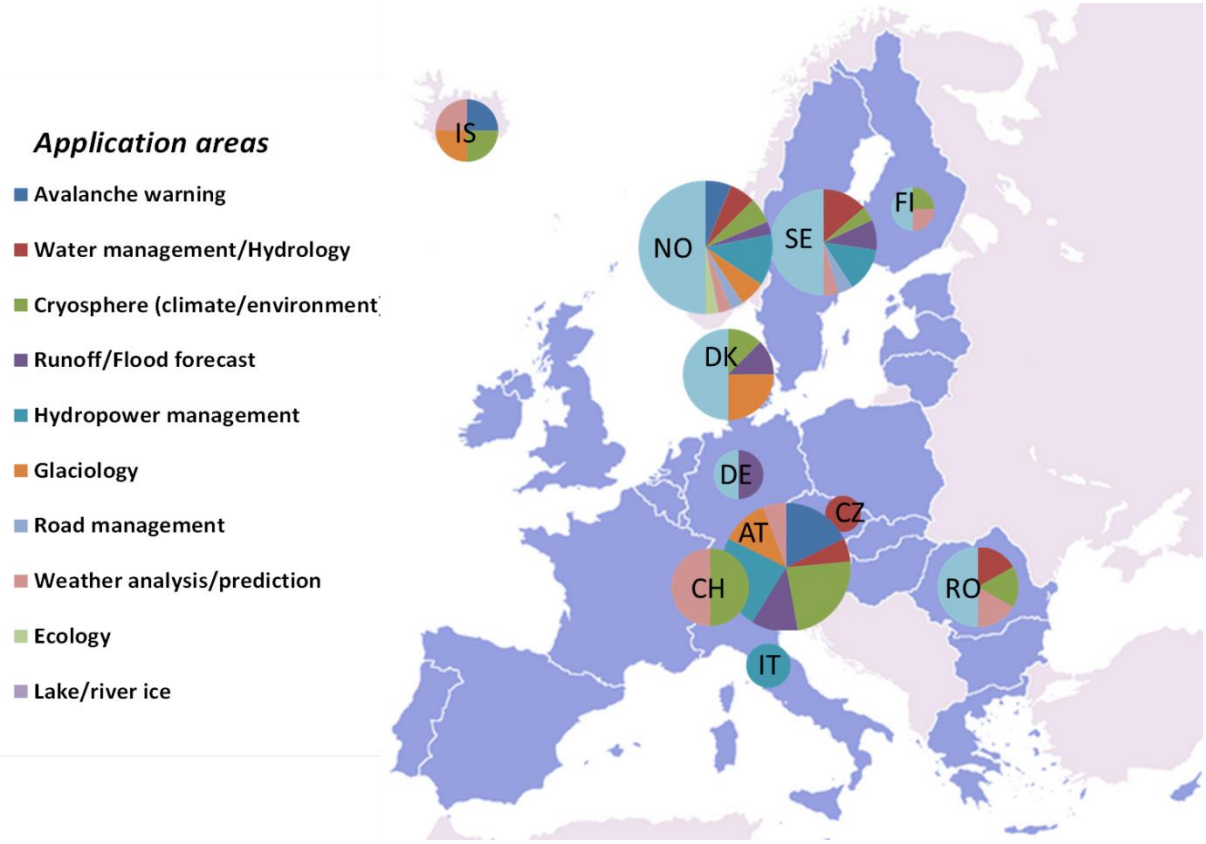
Response: Percentages have been included in updated Figure 3.



Comment 5: It would also be interesting to combine figure 2 and 3 to locate not only the users but also locate the applications areas geographically. Some more discussion on this point can be valuable.

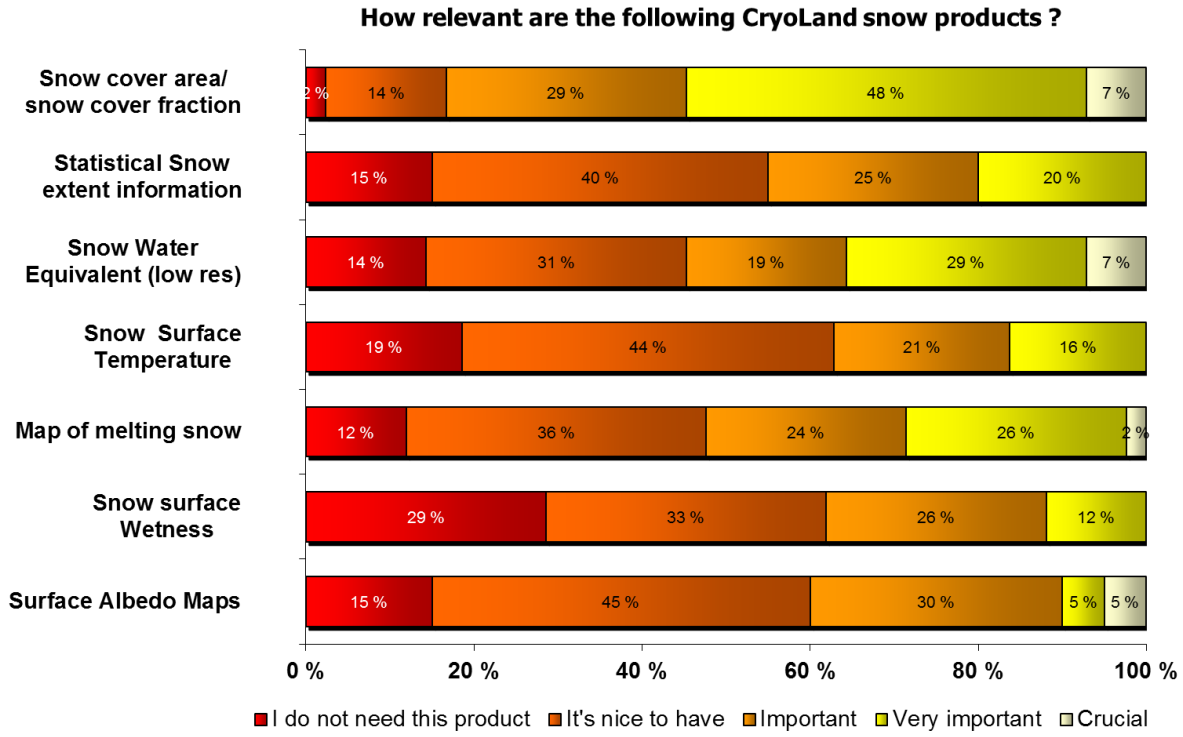
Response: (Combined Figure 2 and 3)

We have tried to make a combined figure 2 and 3 (see below) but we feel that the information that can be extracted is limited due to the low number of respondents that each pie-chart represents, and partly confusing due to the large number of colours/application areas. We thus suggest to not include the figure in the paper. A discussion on the subject is, however, very relevant, and we suggest adding a section (on Page 799, after line22): "There was a geographical bias in some of the application areas (e.g. glaciology and lake/river ice), but few responders in each country yields inconclusive findings with respect to the geographical distribution of the application areas".



Comment 6: Figure 4: also here snow cover fraction is not present. Is it included in statistical snow extent information?

Response: Snow cover fraction is included in the first row: "Snow cover area". It is also included in "statistical snow extent information", since the product "Snow cover fraction" is a pre-requisite in order to calculate "statistical snow extent information". The question in the questionnaire was posed actually on snow cover area, but the context indicates clearly that snow cover fraction is included here. We suggest changing the title of the first row in Figure 4 to: "Snow cover area /snow cover fraction ".



Answers to referee #2 (Aimee Devaris)

Thanks to A. Devaris for kind remarks.

Comment 1: Statement about relevant next steps to broaden the project:

Response: CryoLand is a project that ended on March 1, 2015. The CryoLand portal and most services will continue for at least 2015/2016. New initiatives are underway in response to Copernicus land monitoring core services. We suggest to add the following sentence in the conclusion after line 26, page 804 : " A continuation of the CryoLand -snow and land ice services has been suggested as a Copernicus land monitoring core service. This service will need to focus on broadening the number of countries/users involved."

Comment 2: New figures

Response: See answers to referee # 1. Figures 2 and 3 have been modified.

Answers to short comment by B. Raupb, Feb, 2015.

Comment 1: From the work of the Randolph Glacier Inventory (RGI, a data collection supplemental to, and to be incorporated into, GLIMS), the world's glaciers appear to number approximately 198 000, not 160 000.

Response: We will update the paper with the correct number of glaciers. In the paper page 795, line: 27 we change 160 000 glaciers to 198 000 glaciers.

Comment 2: A better URL for GLIMS is http://glims.org

Response: We modify the url to GLIMS (page 796, line 1) to http://glims.org

Comment 3: For the funding source for GLIMS in Table 1, "NASA" would be appropriate

Response: We modify Table 1 according to the comment: In the funding-collumn 2, we replace " <open space>" with "NASA".

Acknowledgements.

We suggest to add to the acknowledgements (page 805) : "We acknowledge B. Raupb, A.Devaris and an anonymous referee for valuable comments and suggestions for improvements. "

NEW TABLE 3 (see comment Referee # 1):

Table 3. Requirements for spatial and temporal resolution of products and product ranking

Product type	**Spatial resolution**	**EO sensors**	**Temporal resolution**	***Implementation Priority***	***User ranking [%]***
Snow cover fraction, regional in Nordic and Alps	250-500 m	MODIS, ASAR (archived), S1, S3	Daily, full year	1	83%
Snow extent (local)	25 – 50 m	Landsat, S2	monthly, full year	NA	NA
Snow cover fraction, pan-European	500-1000 m	MODIS, S1,S3	Daily, full year	1	83%
Snow Water Equivalent (Low res)	10-25 km	SSMI/S, AMSR2	Daily, dry snow season	2	55%
Melting snow area	25-100 m	ASAR (archived), Sentinel S1, S3	Daily	2	52%
Snow Surface Wetness	1000 m	MODIS, Sentinel S3	Daily	3	38%
Statistical snow Information	HRU/basin	NA	Daily	2	45%
Spectral Surface Albedo	250-500 m	MODIS, Sentinel S3	Daily	3	40%
Snow Surface Temperature	1000 m	MODIS, Sentinel S3	Daily	3	37%
Glacier outlines	10-25 m	SPOT, Landsat, Ikonos, Sentinel S2	Annually	1	88%
Snow/ice area on glaciers	< 25 m	ASAR (archived), TSX, Landsat TM, SPOT, Sentinel S2	Annually	2	71%
Glacier Ice velocity	10-25 m	TSX, Sentinel	Annually	2	57%
Glacier lakes	10-25 m	TSX, Sentinel	Annually, weekly (fast analysis), hours (emergency)	2	57%
Ice extent and ice concentration	100 m	MODIS, ASAR (archived), TSX, Sentinel	Daily, Oct-May	1	85%
Snow covered area on lake ice	250 m	MODIS, Sentinel S1	Daily	3	13%
Snow Surface Temperature	1000 m	MODIS, Sentinel S3	Daily	3	37%
First and last day of ice cover	100 m	MODIS, ASAR (archived), TSX, Sentinel	Annually	2	67%
River ice jam, flood inundation area	30 m	ASAR (archived), TSX	Daily (emergency)	3	NA

Lake surface temperature	500 m	MODIS, Sentinel S3	Daily	3	NA
Snow depth on lake ice	25 km	SSMI/S, AMSR2	Daily	3	NA