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**Interactive comment**

# *Interactive comment on* "Use of Sentinel-1 radar observations to evaluate snowmelt dynamics in alpine regions" *by* Carlo Marin et al.

## Anonymous Referee #2

Received and published: 18 November 2019

This is a well-written and clearly organized paper which utilizes the rich new time series of C-band SAR data from Sentinel-1 to explore the extent to which remote sensing can provide snow melt state information for Alpine snowpacks. Detailed analysis of simulations from the physical model SNOWPACK at sites with comprehensive snow state and meteorological measurements allows extension of the approach broader regions. This provides a realistic approach with respect to operational implementation. I have a number of comments which will hopefully constructively improve the final manuscript.

1. Line 143: to what extent are C-band measurements influenced by snow grain size/shape?

2. Line 289: "These phases have been identified from the SWE and LWC data according to section 2.1." Were quantitative threshold values of LWC or change in SWE used

to identify the three different phases? If so, these are not described in Section 2.1. Some additional detail on how the three melt phases were classified based on the in situ snow measurements would be helpful.

3. Section 4.1 provides a detailed description of the S-1 backscatter time series as they relate to snow observations and SNOWPACK simulations. In general, the text provides sufficient explanations for what is shown in Figure 4. This provides a clear observational basis for the synthesis in Section 4.2. My main concern is then the statement on line 385 that "Figure 5 shows the theoretical temporal evolution of backscatter for a complete hydrological year." While the conceptual framework of this figure is based on the measurements in Figure 4, the 'theoretical' component of this figure would be stronger if it contained actual backscatter simulations using a radiometric model (there are numerous options but SMRT comes to mind as a logical choice). I suggest the schematic approach to Figure 5 be augmented with radiometric simulations.

4. The Conclusion section is quite brief, and does not include a discussion in a number of relevant areas. A couple of suggestions to expand this section: >There is recent work which suggests SWE can be retrieved from cross-pol C-band SAR measurements, including in the Alps. I agree with your statement on line 150 that "During the accumulation period, dry snow is almost transparent for C-band..." C-band sensitivity to SWE defies a physical explanation. The time series of Sentinel-1 data in your study provide no evidence of sensitivity to SWE (e.g. Figure 4). Can you provide a comment on this in the Discussion, in the context of the work by Lievens et al? https://doi.org/10.1038/s41467-019-12566-y

>Are the accuracies produced from this study (expressed as the RMSE's on line 495) sufficient to improve current prediction systems used in the Alps? Are operational hydrological modeling systems ready to implement the ingestion of snow state estimates from C-band SAR data or are there any impediments? Since the technique relies on the timing of the backscatter minima to identify the change from ripening to runoff, what is the latency in which a Sentinel-1 derived runoff retrieval could be used given the re-

peat interval of 6 days (for example, do you need to wait 6 times x number of days to ensure the minima was reached?)?

Editorial: Line 30 – The meaning of the sentence starting with "Precise predictions of the timing. . ." is not clear. I suggest removing it - the following sentence is more impactful anyway.

Line 36: I don't think 'favored by' is the right word choice. . .'driven by'?

Line 46: sentence starting "An increase of LWC. . ." – this is a very long sentence with many commas. Split into two sentences for readability.

Line 49: change to "Continuous measurements of SWE. . ."

Line 502 – if this is in reference to the western United States network of sites, it should be noted as 'SnoTel'.

Looks like the panels of Figure 4 are separated by Table 1 and Table 2?

Figure 6b requires a legend to indicate the values of the colour scale.

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Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-175, 2019.