Estimation of Snow Depth in the Hindu Kush 2 Regions of Afghanistan During Peak Winter and 3 Early Melt Season 4

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Overall Recommendation: Major revision.

General Statement

This paper describes a polarimetric method for SWE retrieval by using C-band Sentinel 1 dataset in the high altitude mountain above 3000 meters a.s.l. This is a quite interesting and detailed study based on recent applications of the C-band SAR dataset toward SWE retrieval. However, It still shows a lack of reliability to use SAR dataset without a deep physical understanding of the microwave propagation of the media, here the snowpack at C-band, which is relatively low frequency with a deep penetration depth.

Any free-space solutions should be justified with supporting observations, and I have no doubt that the field opportunity for snow microphysics and ground-based remote sensing measurements are great assets for a future SWE retrieval mission from space. However, its description should be self-organized to support the findings of the paper to improve a microwave forward model of snowpack.

Major issue

1. ***Abstract***: One sentence is enough for the motivation of this study. Directly go to the proposed methods with scientific specifications of the remote sensing devices toward improvement of the SWE retrieval skills.

2. ***A lack of hydrological modeling modified by snow observations***: Snowmelt-runoff is different from a rainfall-runoff due to its timing of the released water and distribution of the SWE over the watershed. The improved SWE observations from the remote sensing would result in a better prediction of the streamflow in the outlet of the watershed. A recent research trend shows remote sensing is merged with hydrological modeling after updating winter precipitation based on the snow observations from space. Please include any preliminary application of the snow hydrological model in the Amu River Basin with the updated SWE information.

3. Line 112. Please change a title of section 2 to Methods and Materials Accordingly, the methods come first followed by the study site. Then, evaluations

can be logically located at the end by comparing retrieved snow properties with in-situ observations. I understand re-structuring is not trivial but, it would help readers to focus more on the methodologies and how they were applied to the study area.

4. Lower background scattering: C-band observations should have the background scattering component in case of 1.5-2 meter of snow depth prevalent in the mountains in Afghanistan. In Figure 5, how the snow-ground interface is accounted for? Please refer to the literature below at least to describe the limitation of this study regarding the background scattering component especially at the low frequency application to snowpack.

   https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8412144

5. How LWC is incorporated is not clearly described. In the manuscript,

   Thus, in this study, we utilize the effective permittivity for modeling the snow depth from the DInSAR displacements, instead of utilizing the snow density as in [17]. Thus, introducing the effect of the volume scattering in the snow on the line of sight displacement leads to the following relation which can be deduced from equations (7) and (9).

   LWC is related with the imaginary part of the snow permittivity. Can the authors clarify how the imaginary part of the snow permittivity is calculated from the equations cited, which is a function of the LWC of the snowpack? I believe the attenuation constant already includes the imaginary part of the absorption due to the wetness but please clarify it explicitly with equations.

6. Lastly English writing: The reviewer myself also spent a significant effort due to my own language issue. Please put more dedications to improve a scientific writing in English. It would result in more views and circulations of this valuable research within and beyond a snow community.

Minor issues

1. Too many figures: In the 90's and 2000's, numerous geoscience papers were generated. This is now 2020, and is a time for the cumbersome papers need to be succinct with direct findings. Please remove or reduce number of figures, which are unnecessary. The key findings are 1) a SWE retrieval by using 2) semi-polarimetric C-band radar and 3) a dielectric constant of an effective snowpack. In accordance with findings, please remove unnecessary figures.

2. Line 18: Put 'GHz' and 'active/passive' of the Sentinel 1. The frequency and sensing type are essential for the retrieval algorithm of the earth observables in the microwave remote sensing. Please be mindful when the authors use which channel and a sensing type for geophysical applications.

3. Line 62-63: Please be specific. Now potential readers can be from 'remote sensing' and 'hydrology' communities. For example,
   Key inputs to update weather forcing dataset to drive the land surface model to simulate the surface and sub-surface runoff to form the streamflow.

4. Line 90-91: Please be specific:
   c-band of SAR images ➔ c-band of SAR acquired from the Sentinel-1.

   A revisit cycle is independent from a microwave frequency for observations, but is subjective to the orbit altitude.

5. Figure 1: please include any streamflow gage stations in the lower watershed, which are mostly concerned by water resources managers in the snowmelt dominant watersheds.

6. Line 210: phase values ϕ_1 and ϕ_2 → phase values ϕ_1 and ϕ_2 with two timely different observations

7. Line 254: $\varepsilon s = n2$ ➔ $\varepsilon_s = \mathrm{n}^2$

8. Line 332: please describe in details how the phase unwrapping method is applied in Matlab™ environment.
9. Line 347: Figure 7 or 9?
10. Figure 13: please add descriptions of (a) to (d)
11. Figure 15, 'Spatial variation of means': Change Snow Property to Snow Physical Properties
12. Conclusion: How about point-by-point conclusions such as
    * Snow depth in the Khanabad watershed was extracted by using Sentinel-1 dual polarimetric and interferometric Observations with a comparison statistic of XX.

    - However, it shows a limitation when the snowmelt is prevalent such as not enough number of revisits and a relatively poor formulation of the imaginary part of the snow permittivity when the liquid water content is present in the snowpack.