Review to Tulaczyk and Foley, 2020

Tulaczyk and Foley (2020) derive the reflection coefficient for the low loss region, the high loss region, and provide the general reflection coefficient that describes the regions of conductivity that are in between. The revised version of the manuscript highlights the impact that conductivity has on the reflection coefficient and notes that for highly conductive materials with low permittivity values, one could obtain reflection coefficients that are even greater than for a pure water subglacial lake. This is a key point for the glaciological community to understand, as one often quickly attributes a brightly reflecting subsurface as subglacial water; however, Tulaczyk and Foley raise the concern that instead of attributing a strong bed echo directly to subglacial water, we should look for additional constraints such as the phase of the returned signal before making such an assertion, because "subglacial sediments can be conductive enough to produce radar reflectivity that is the same, or higher, than reflectivity from an ice-lake interface", even if they have a lower relative permittivity.

In addition to reminding the community of the significance of conductivity in radar reflection, the reminder of the resistive nature of ice and the role that conductivity plays in radar signal attenuation and reflectivity is appreciated since it is an important aspect of the material property that often gets overlooked.

In the revised manuscript,

- The additions to section 2 (Background) including the physical meaning and interpretation of the control parameter was useful.
- The modified Figure 1 with four panels is much cleaner and easy to follow.
- The addition of Table 1, while similar to compilation tables in Peters et al. 2005 and Christianson et al. 2016, was useful for providing a quick reference/overview of different material permittivity values, conductivity values, and reflectivity values at 10 MHz and 100 MHz.
- The additions to Section 5 have made a stronger case to consider the impact of electrical conductivity on radar bed reflectivity. For example, Section 5 discussed approaches to using radar data to constrain both permittivity and electrical conductivity of subglacial materials, and how the inclusion of electrical conductivity in analysis of radar bed reflectivity could be used when mapping of sub-ice geology (e.g., clay content) and fluid salinity on Earth and icy bodies such as Europa.

Minor Comments

It would be useful for the radioglaciological community to see Figure 1C and Figure 2B go out to center frequencies greater than 100 MHz. For example, MCoRDS operates from 140 to 230 MHz and the ApRES operates between 200 to 400MHz. In general, it would be interesting to see the limits of lossless and high-loss conditions for linear radar frequencies up to around 400 MHz since these are frequencies widely used by the radioglaciology community.

The denoted line numbers below correspond to the "tc-2020-9-manuscript-version3.pdf" document.

Line 45 The authors note that "inferences about sub-ice conditions, e.g., the presence or absence of subglacial water, are drawn from the lateral variations in radar bed reflectivity." In addition to lateral variations, the authors should consider that these inferences of subglacial water could come from temporal variations in reflectivity; for example, a stationary ApRES system that is deployed for a year to monitor the reflectivity changes at a single location.

Line 53-55. Is the use of complex variables actually that significant of a barrier? I would consider removing this sentence as it feels more like a conjecture, and it does not add anything to the manuscript.

Line 59 insert "the" to read as "In general, the mathematical treatment"

Table 1 (Lines 229-250): I would double check the table entries; for example, in the second row of the far right column, the real amplitude reflection coefficient, r, should be a positive number as shown in Equation 8.

Line 288 insert "of" to read as "a system of two equations"

Line 289 insert "the" to read as "illustrate the limitations"

Line 289, Line 323, and Line 365: Consider using "regimes" or "regions" instead of "regimens"

Line 295 Equation 11. I would again note to the reader that you are assuming that both of the media have the magnetic permeability of free space, or at least make it clearer in line 265 that from this point going forward the following equations assume that both of the media have the magnetic permeability of free space.

Line 305 Equation 12. While I believe $\beta_2 = \alpha_2$ in this case, I would still change the term after $(\alpha_1 - \alpha_2)^2$ to be β_2^2, not α_2^2, in both the numerator and the denominator for consistency and clarity to the reader.

Line 399-401 The following lines sound a bit awkward and should be revised for brevity and sentence structure:
"*It would be, of course, best to be actually able to use radar observations to constrain both the permittivity and the electrical conductivity of subglacial materials. One piece of observational evidence, the phase shift of the reflected wave, can be used, at least under some circumstances, to independently check if electrical conductivity of the sub-ice material...*"

Line 403 While it is noted in the main text that Figure 1D is "plotted for the case of 100 MHz linear frequency", I would also highlight this point for Figure 2A.

Figure 1D and Figure 2A: I would again note "plotted for the case of 100 MHz linear frequency" in their captions for clarity.

Line 415: In addition to super wide bandwidth radars, I would also note that dual-frequency and multifrequency radar systems (such as a combined HF radar and VHF radar) could help with this.

Line 428-429 Consider "is a frequency dependent measurement." for brevity

Line 451 Would this technique allow one to better estimate the salinity of subglacial lakes on Earth and icy planetary bodies than current approaches? Also, what are the limitations? For example, scattering effects at different frequencies could also play a role in the change in received power.

Figure 2B Consider adding the electrical conductivity symbol for one of the conductivity values (i.e. $\sigma = 4$ S m^{-1}) next to the corresponding line, similar to what is done for Figures 2A and 2D where you showed their relative permittivity symbols for several lines (i.e. $\epsilon_r = 85$, etc.), for clarity.