The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-108

Anonymous Referee #2

Referee comment on "Effect of snowfall on changes in relative seismic velocity measured by ambient noise correlation" by Antoine Guillemot et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-108-RC2, 2021

This study presents an interesting topic on the potential of using ambient noise seismology to monitor changes in the snow layer through precipitation/melting through quantification of velocity changes. It presents findings from a well-designed study of noise recordings over a period of a few months along with meteorological measurements and cameras for visual snow thickness estimation. The findings show that the noise recordings can appropriately pick up velocity changes linked to the snow fall/melt. A simulation of the snowpack is used to assess ; a simulation of the snowpack is used to assess the snow elevation. Finally, a simplified profile is used to forward model the velocity change as a function of frequency of Rayleigh waves, this profile assumes the soil layer is unchanged and assumes a temperature relation for density and P-wave velocity with unchanged poisson ratio, which assumes dry snow (no liquid water). The authors show their model to explain the decrease in velocity during the snowfall period, but cannot explain the snowmelt events.

In my opinion the paper deserves publication after major review. I suggest several edits:

-introduction: you mention previous delta V/V measurements in snow that are ambiguous or contradicting. It would be worthwhile to comment yourselves on the previous studies, as this is exactly what you are trying to solve.

-introduction: again the readers would benefit from a short intro on what the snow cover consists of (definitions of dry vs. fresh snow, phenomena of compaction, where does melting take place), how it interacts with the subsurface, and consequently how any snow changes affect velocity (is it all temperature related, phase changes, and if at all geomechanical changes due to loading/unloading?

-field site and instrumentation: Somewhere in this section or the next, you could include a schematic cross-section that defines the main layers at your field site would be beneficial. Also perhaps a time-lapse cross-section to show which layer from the snow changes (do both bottom and top snow layer change velocity, or do we define the bottom layer of snow as the one without changes in velocity, merely changes in thickness).

-field site: are sensors installed 30 cm to 50cm into the soil? Is there no snow at the time of burial?

-field site: sensors installed at a depth with snow falling on them. Does this imply that when you model Rayleigh waves, you should extract Rayleigh wave solution not at the free surface but at a certain depth. Is this effect negligible?

-CC and delta/V estimation in Figures 3-7. Why do you use a different CC cut-off? I understand that a smaller CC would decreases your confidence in estimated delta V/V. Is there a remedy to increase the CC by choosing a moving average for the reference? And then accumulate the delta v/v from this moving reference to a zero reference of your choice?

-snowpack simulation: please give more details in the physics of snowpack (ie FEM, what problem it solves mechanical, thermal, fluid flow?) State here your outputs snow elevation, density, temperature as a function of depth etc.

-I do not understand since you are getting a temperature profile from the snowpack simulation why you then choose to have a two layer model with average temperatures to use in the numerical model for Young's modulus E? The Young's modulus model appears to have an exponential relation with temperature, averaging temperature prior to estimating the Young's modulus will not give you the average Young's modulus. I see no merit in predicting a two-layer model for the snow's elastic constants in the forward model, as you never quite interpret (invert) your dispersion curve for two layers. It would make some sense to at least plot the continuous depth temperature and consequently continuous modelled velocity profiles to understand where the velocity changes are occurring. Then you may have an argument on modelling two-layer snow model in your Rayleigh velocity modeller, even though Geopsy I am sure accepts a velocity profile (if this is not possible could input many small layers). I believe that simplifying without reason your model may be one of the reasons for some discrepancies noted in your figures 9-12.

-It seems really low-hanging fruit to properly invert for your velocity curve from your experimental data. This would then properly give an understanding of where deltav/v varies more/less and why. We do not have this information readily available in the delta V vs. Freq. domain. This would also give you an opportunity to check constraints – having constant soil layers, or allowing the velocity in the first soil layer to change etc. Based on your Vp/Vs/density/temperature relationships, you could have even inverted for the temperature and seen if it agrees with the snowpack model.

-State early on when you present your model in 4.2 that it is for dry snow. It should be made clear that it cannot address the melting of the snow.

-While you state that a 3-phase modelling is outside of your scope, at least what is the qualitative understanding on the effect of having water on your delta v/v. How does this qualitative understanding translate to figure 12.