Geosci. Instrum. Method. Data Syst. Discuss.,
doi:10.5194/gi-2015-29-AC1, 2016

Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "Nordic Snow Radar Experiment" *by* J. Lemmetyinen et al.

J. Lemmetyinen et al.

juha.lemmetyinen@fmi.fi

Received and published: 3 June 2016

Referee#1: The manuscript presents continuous time series of active and passive microwave observations at the Finnish Meteorological Institute Arctic Research Centre (FMI-ARC) in Sodankylä, Finland, from 2009 to 2013. In complement to microwave observations, several manual in situ data collection were acquired. An overview of the weather and snow condition as well as microwave signature with some description is then given. The radiative transfer model MEMLS is then used to model the TB for active and passive measurements. The dataset is available through European Space Agency and the Finnish Meteorological Institute.

The study, present an impressive dataset of combined passive and active microwave observations. This kind of database, made available to the scientific community, could be of great use for radiative transfer model validation and cryosphere monitoring algorithm development. The manuscript is well written and concise. However, I do not see

the interest of Section 5 on model analysis considering the limited analysis/discussion

Authors' response: We thank the reviewer for the constructive comments provided. We also agree that section 5 was wanting in depth of analysis. Nevertheless, we feel it is an important contribution for potential data users, to demonstrate some of the basic behavior of the observations against snow parameters such as SWE and snow microstructure (represented here by the correlation length), compared to present expectations from electromagnetic models.

Consequently, we will provide additional discussion and analysis on the implications of the model results, including discussion on the potential of active/passive retrieval. Also, we will add model simulations and analysis from another season (season 3) for comparison.

Referee#1: 1. From the title, we expected that the database is only on radar measurements. I proposed to change it to include passive microwave observations (it is a proposition).

Authors' response: We thought about this, but would prefer to stick to the original title: The main reason is that the dataset is now widely known by this name (and acronym, NoSREx), and we would like the title to directly reflect this. We will modify the abstract and introduction slightly to reflect the supporting role of the passive microwave observations.

Referee#1: 2. In the abstract, I would include the name of the site.

Authors' response: We agree, the site name will be included in the manuscript

Referee#1: 3. Some dataset are mentioned, but not presented. It could be interesting to explain why some dataset are not presented and mentioned if the dataset are available to the scientific community.

Authors' response: We take it this means the SnowSAR dataset mentioned in the intro, as well as the ELBARA-II data. We suggest to remove the paragraph on SnowSAR

entirely, as these data are only recently available from ESA, and form a larger entity separate from NoSREx with acquisitions over other test sites as well.

A reference to the ELBARA-II observations will be added, which presents the data in detail (Lemmetyinen et al., 2016); we would prefer not to present the ELBARA-II measurements here in detail since they are mostly related to soil moisture/soil freeze thaw investigations; also the essential information is included in the new reference.

Referee#1: 4. p.3 - Line 12-13 : give reference

Authors' response: We will add references to several arcticles (Proksch et al., 2015; Tan et al., .2015; Chang et al., 2015; Pan et al., 2016).

Referee#1: 5. give lat/lon of the site

Authors' response: The coordinates of the site (67.3618N, 26.6338E) will be added in the text.

Referee#1: 6. Define in the text what is NosREx III and IV (year 3 and 4 ?)

Authors' response: The campaign seasons will be defined in the text of section 2.2.

Referee#1: 7. line 26 : (10 minutes) Does it mean that sky measurement is taken for 10 minutes? Maybe clarify it in the text.

Authors' response: This will be clarified: "measurement duration 10 minutes with 1 s integration time"

Referee#1: 8. p.6 – Line 3 : What TB sky are considered at these frequencies and how many measurements were considered?

Authors' response: The mean values and standard deviation of sky measurements, as well and number of measurements, will be added.

Referee#1: 9. p. 7 – Line 15-17 : maybe add a Table of these data or just mentioned the data observed at the station.

Authors' response: We agree, a table is useful; this will be added.

Referee#1: 10. p.7 – Line 7-8 : are these information come from automated stations or observations? In table 3, it could be very interesting to add air temperature information. It could significantly the temperature gradient in the snowpack and depth hoar formation.

Authors' response: (we assume the reviewer meant page 9, not page 7, of the original manuscript, and is thus referring to the discussion concerning Table 3.): The information in Table 3 is from a combination of automated measurements and manual observations, archived in the FMI weather database. This will be mentioned in the caption of Table 3.

We agree air temperature or temperature gradient information over the snowpack (delta_T = T_air – T_ground) will be a useful addition. The total effective temperature gradient (sum of delta_T*days) or a similar metric for each season will be calculated and added to Table 3. It will not be possible to calculate the effective gradient for the 30-year statistic, as ground temperatures are available only for a shorter period (as are manual grain size observations). Discussion on the effect of temperature gradients will be added. âĂČ

Referee#1: 11. p. 10 – Line 4-6 : Sentence is not clear.

Authors' response: We agree the sentence was confusing; this will be clarified by rewording and splitting the sentence

Referee#1: 12. Section 4.2 : The microwave signature could be explained more precisely and using literature. For example, "the sudden decrease in backscatter originating from snow melt" come from liquid water in snow (add reference for that). P.10 Line 28-29 (add reference).

Authors' response: We agree; suitable references will be added

Referee#1: 13. p.11 – Line 21-26 : is there an explanation for the low E values?. The

temperature gradient was low? (higher Tair). (see comment 10.)

Authors' response: The differing temperature gradients, together with prevailing snow conditions and in particular the timing of the first snowfall, are indeed the root cause for differences in E during the different seasons. This has been explained in section 4.1. also in the original manuscript. Discussion will be added to section 4.2 for clarity.

Referee#1: 14. I am not sure about the usefulness of section 5. Many hypotheses are made that reduce the analysis of the results (snow density constant [170 was considered low previously in the paper], constant temperature). I understand that the section is to ''demonstrate the use of the NoSREx data in evaluation of microwave emission and backscattering models". However, to do so, I think the analysis and the discussion on the results should be improved. Why active and passive give different results. Is it related to grain size? A discussion on how to improve both models (active and passive) should be given.

Authors' response: We agree the usefulness of section 5 in its present form is rather limited. However, as pointed out above, we feel the model analysis still gives some useful insight the reader as to how the observations compare to present electromagnetic models on backscattering and emission. Discussion will be added on potential reasons behind the model discrepancies. Discussion will also be added on potential improvements to the microwave models regarding existing knowledge gaps. Furthermore, we intend to expand the analysis by adding a second year of observations (season 3). NoSREx season 3 will represent an interesting comparison to Season 2 depicted in the original manuscript, due to the relatively low dynamics observed in both backscattering and emission, despite the overall high rate of snow accumulation over the season.

The rationale for using constant values in simulations will also be better explained; the rationale here is that e.g. density and temperature play a minor role in the forward simulation, while SWE and snow correlation length (proxy for snow microstructure) largely determine the outcome. Consequently, SWE and snow grain size (another

metric for microstructure) were also the only free variables in the envisaged CoReH2O retrieval algorithm. Similarly, the snow grain size is also used to tune the forward microwave emission model in the GlobSnow SWE retrieval approach (Takala et al., 2011) for passive microwave. Therefore, the capability of forward models to capture the detected signal dynamics with SWE and correlation length (or grain size) as the only free variables is of interest, as this replicates use of the model in the typical satellite-based retrieval. This will now be better emphasized in the text.

Referee#1: 15. In the discussion section, I think it could be interesting to discuss the usefulness of using combines active and passive observations for retrievals.

We agree, discussion on active/passive retrieval possibilities will be added, including references to past work exploring these capabilities.

Referee#1: Minor: p.9 - Line 2 : 2 "each" p.7 – Line 18 : cm3 Line 4 : define cal p.12 Line 10-11. Keep the same units for snow density? (kg m-3)

Authors' response: These will be corrected in the revised manuscript.

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