Modeling timeseries of microwave brightness temperature at Dome-C, Antarctica.

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Introduction

Studies investigating the Antarctic climate change using observations from meteorological stations are limited by the sparsity of the stations (~120 met station to cover 14.10[6] km²). Space-born microwave radiometers are attractive tools as they offer the opportunity to map spatial variations of surface temperature from 1979 to nowadays. However, the microwave observations are not simply related to the surface temperature, **emissivity which depends on snowpack characteristics is an important factor**.

In previous studies, grain size and shape were estimated in the field by visual inspection with an optical lens, *Macelloni 2007*. Contrary to density and temperature, grain size is difficult to measure, especially because grains are delicate to separate without breaking them. Furthermore, accurate grain size is crucial to model accurate emissivities.

This poster aims at modeling brightness temperature (Tb) 1) with a grain size estimation by a Bayesian approach and 2) with a new snow micro-structure measurement, NIR photography.

Observations

✔ Snow temperatures were measured every hour down to 21 m.

✔ Snow density was measured in a snowpit and on a ice core.

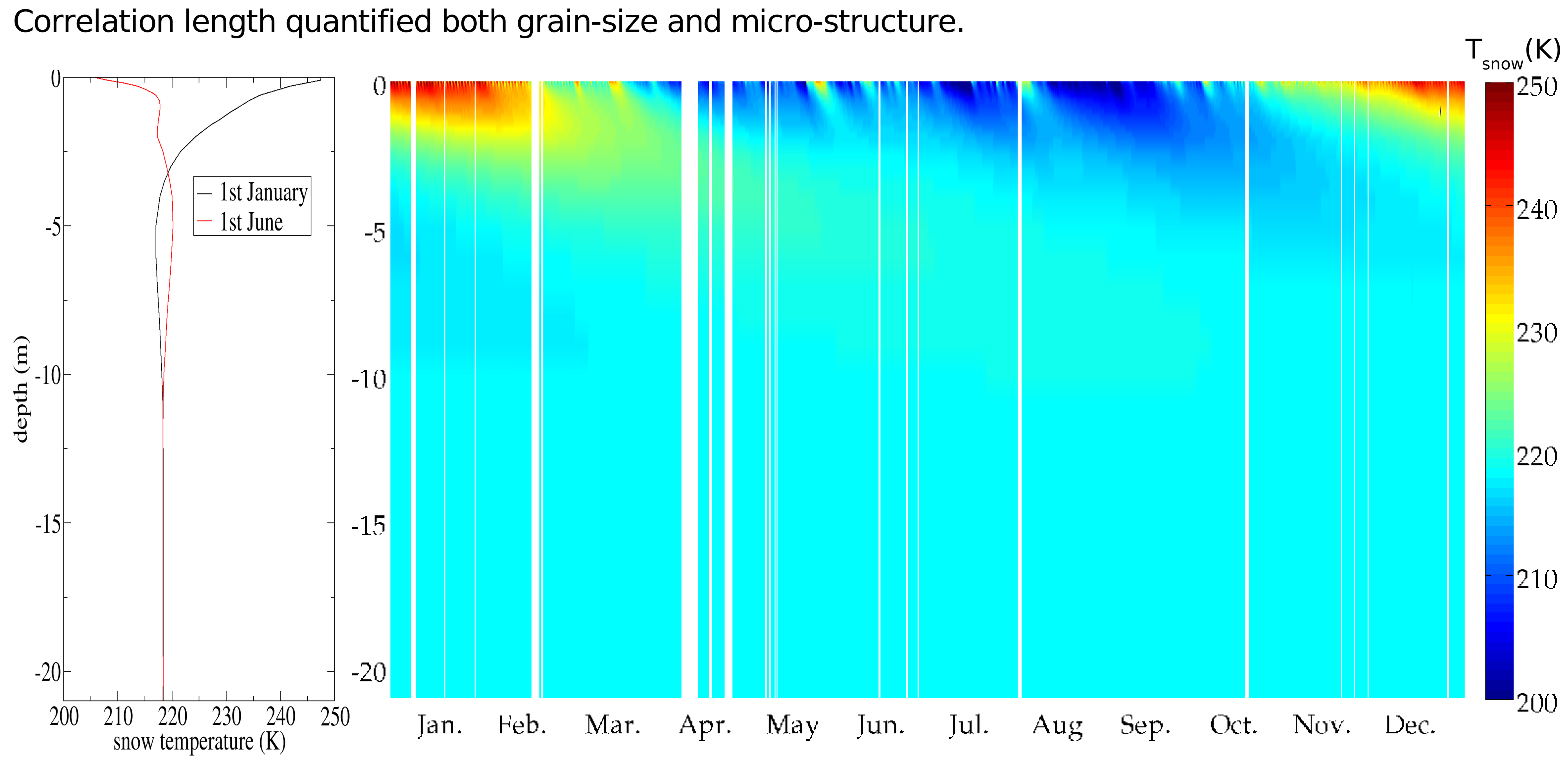
✔ Passive microwave observations were acquired daily by **AMSR-E** (**A**dvanced **M**icrowave **S**canning **R**adiometer - **E**arth Observing System). Two channels are used: 19 and 37 Ghz at Vertical polarization.

Microwave Emission Model of Layered Snowpacks (MEMLS)

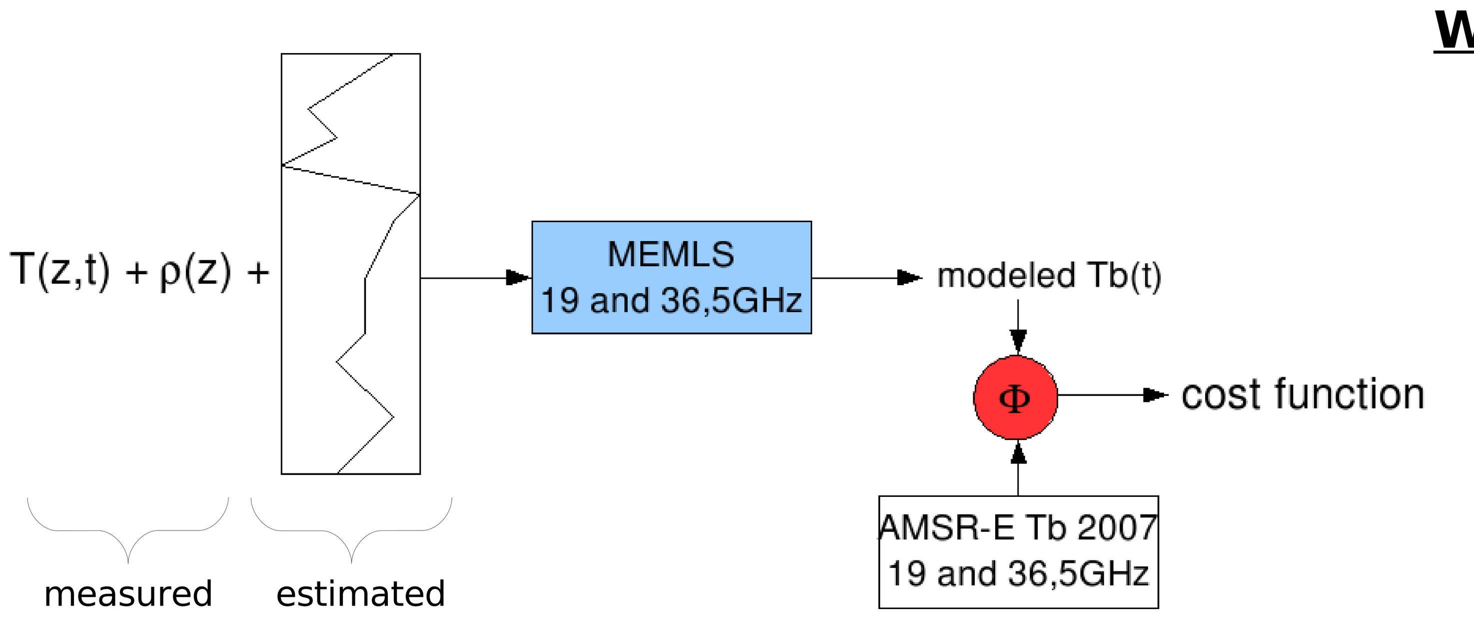
MEMLS is a thermal microwave emission model based on a multilayer radiative transfer scheme. MEMLS includes scattering by stratification because the snowpack could be consisting of several snow layers.

Primary parameters required for each layer are: **snow temperature T,**
snow density ρ,
correlation length l_c.

Correlation length quantified both grain-size and micro-structure.



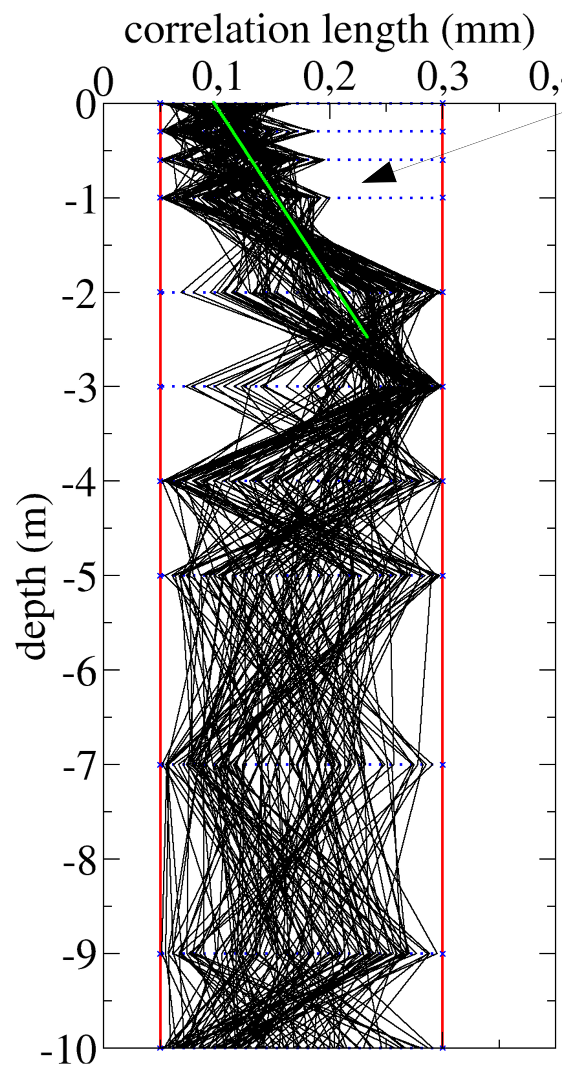
With a grain size estimation



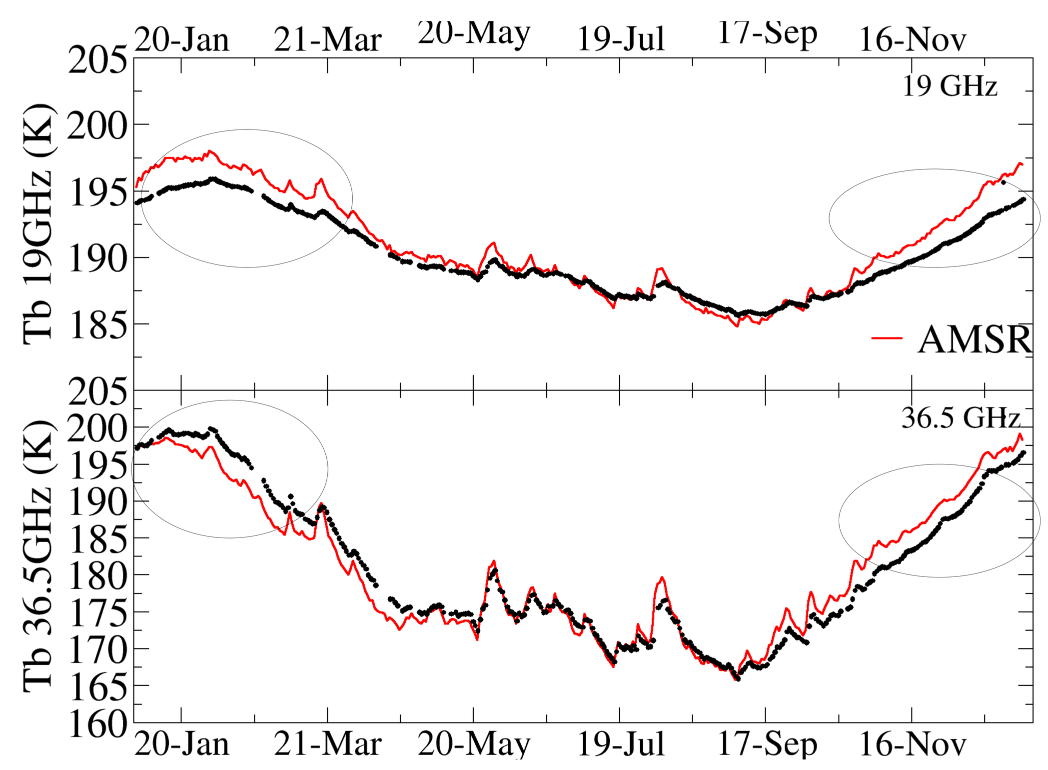
The correlation length profile consists of 11 levels of depths and each level has a random correlation length in the range 0.05 - 0.3 millimeters.

1 600 000 profiles were generated and their qualities were estimated with the RMSE:

$$RMSE=\sqrt{(2N)^{-1}\sum_{f=[19,37]}\sum_{t=2007}^{N}(T_{b,f}^{AMSR}-T_{b,f}^{mod})^2}$$

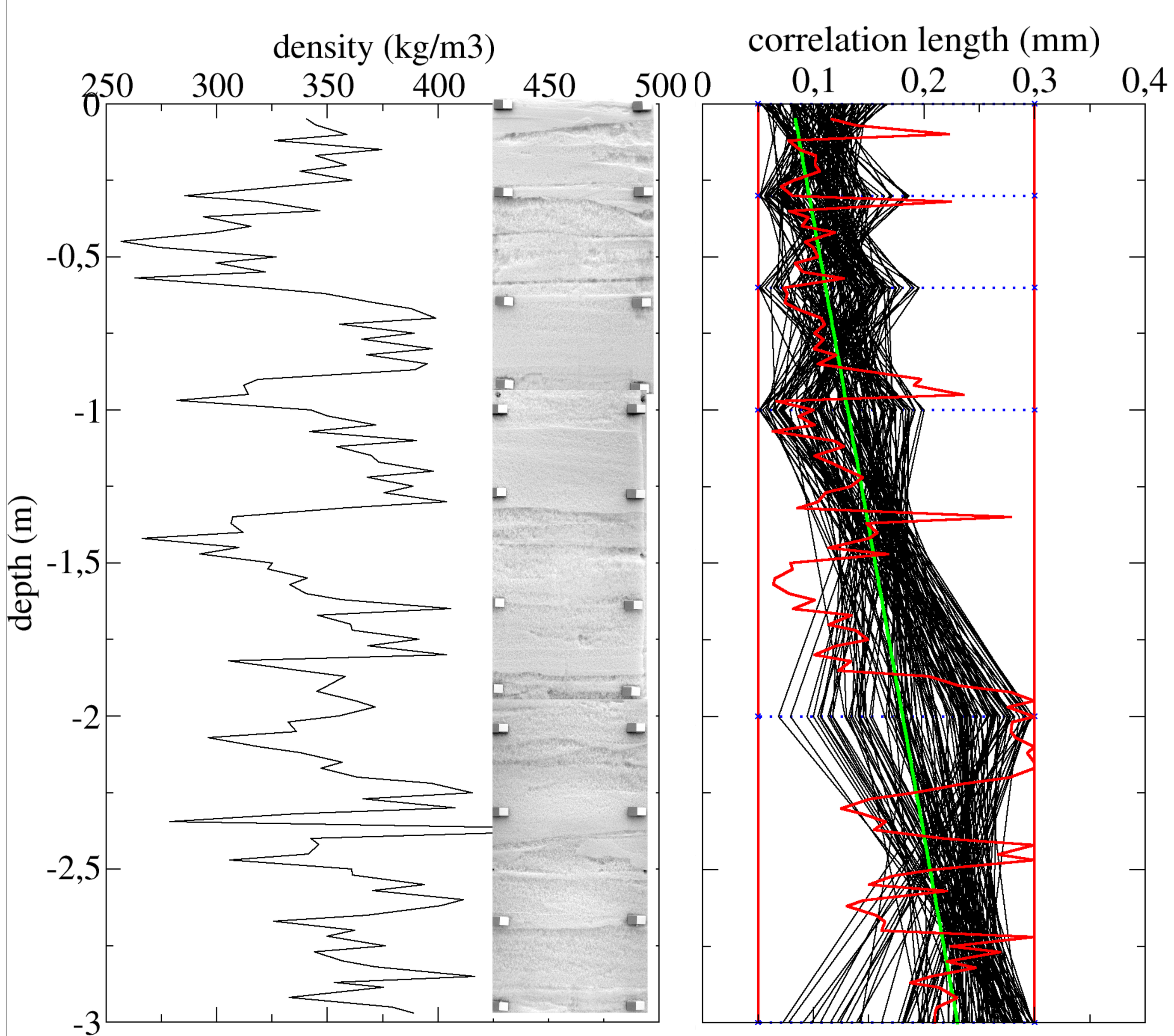


All profiles with RMSE < 3 K show, at the top of the snowpack, an increase of the grain size with depth.



Timeseries are well predicted with a low RMSE (**2,44 K**). Nevertheless modeled Tb are delayed when the snow temperatures are cooling and warming. We suppose that these effects are due to larger penetration depth than observed.

With Near Infra-Red Photography



Specific Surface Area (SSA) is the ratio between surface area of snow grain and its volume. It is considered an essential micro-structural parameter for the characterization of snow. Photography in the NIR spectrum is sensitive to the SSA, *Matzl 2006*.

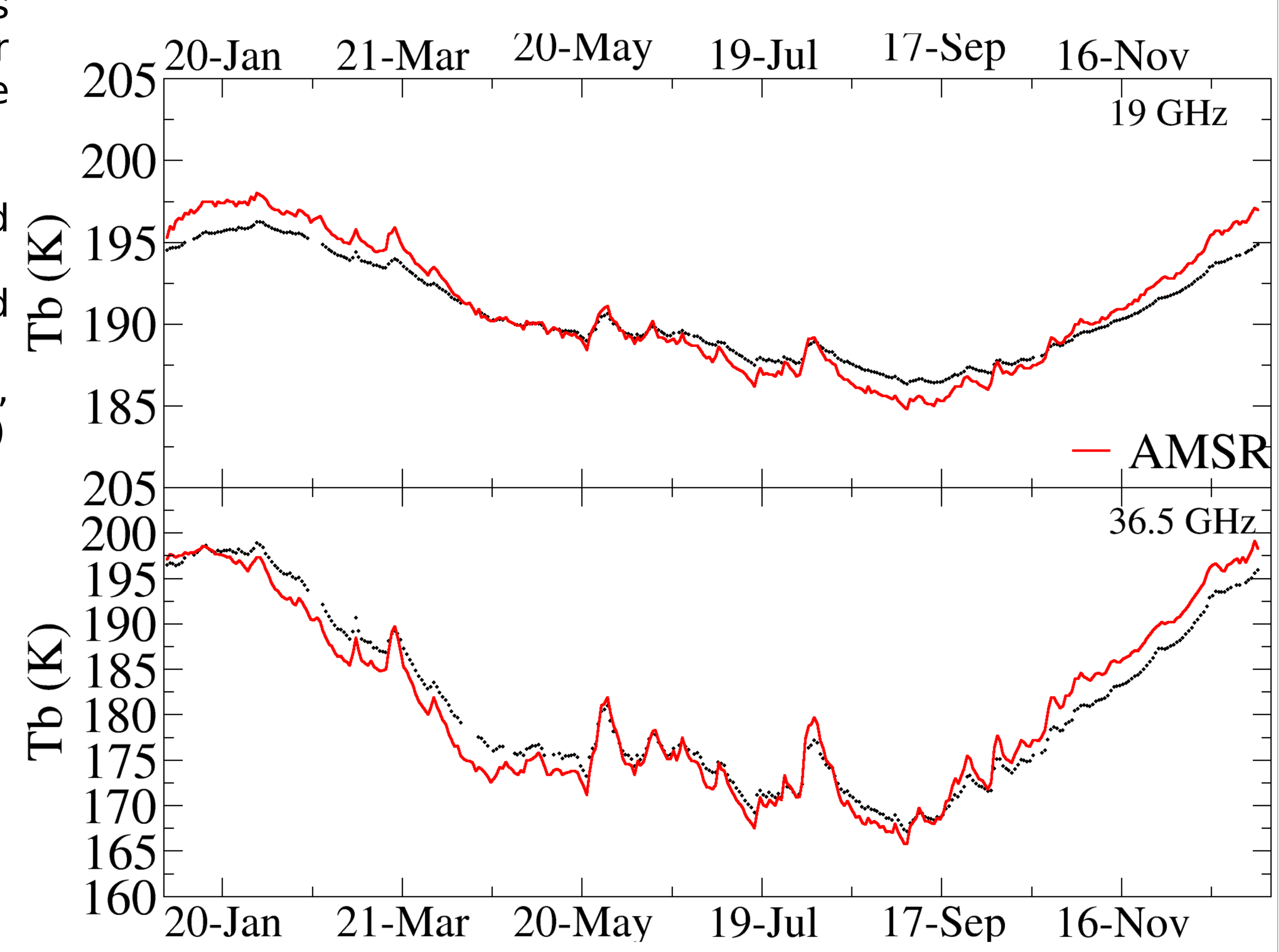
1) Snow reflectance is calculated from calibrated NIR photographies of snow-pit wall.
2) A calibration curve reflectance - SSA is defined with stereological measurements.
3) Reflectance profile is convert to SSA profile, and finally in correlation length profile (⇦ red curve)

$$l_c=\frac{\alpha\cdot(1-\frac{\rho}{\rho_{ice}})}{SSA}$$

Results

1) In the same way as estimated correlation length (previous section), the measured SSA profile yields a similar increase of the correlation length in the top 3 m (⇦ green line).

2) With correlation length computed from NIR photography, the lowest RMSE (**2,38 K**) is predicted with α = 2,08. In theory, for a random scatterer α =3, *Debye, 1957*.



Future work

- Investigate the penetration depth estimation.
- Validate the snow grain-size profile predicted by CROCUS over Antarctica.
- Adopt an approach based on physical modeling, which consists in a coupled snow evolution / emission model, like CROCUS-MEMLS.

References

Macelloni et al. 2007, Multifrequency microwave emission from the Dome-C aera on the East Antarctic Plateau: temporal and spatial variability. *IEEE TGRS. Vol. 45, N°7.*
· *Matzl et al. 2006*, Measuring Specific Surface Aera of snow by near-infrared photography. *Journal of Glaciology, Vol. 52 N°179.*
· *Debye et al. 1957, Scattering by an inhomogeneous solid. II. The correlation function and its application. Journal of applied physics, Vol. 28 N°6*