PicoR-Ice GPR System – Snow on Ice Workaround

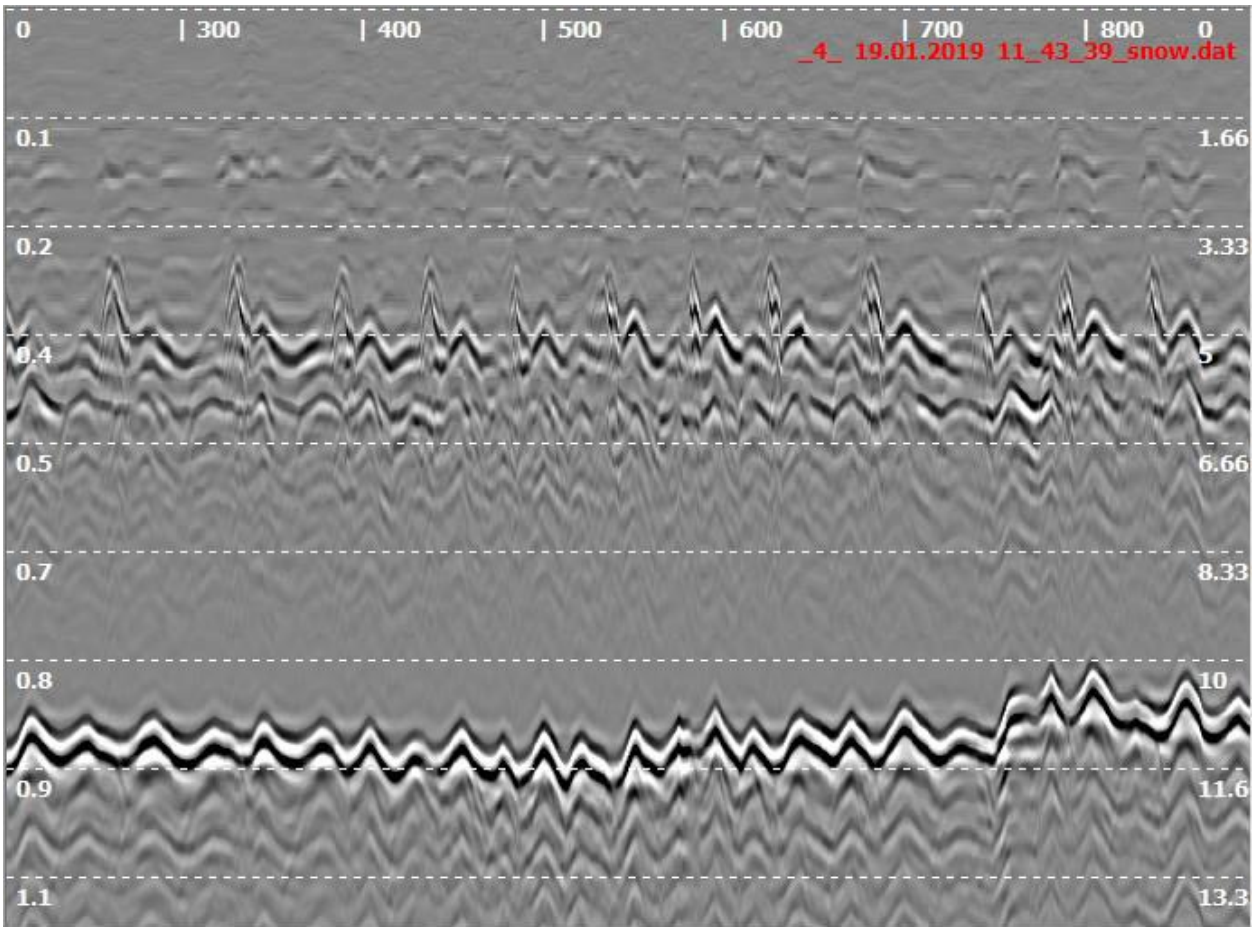
Concern:

Can PicoR-Ice detect and measure both an ice sheet and an overlying snow layer?

Yes, sort of.

The Field Experience:

Below is part of a PicoR-Ice radargram sample acquired on a partially snow-covered mountain lake.

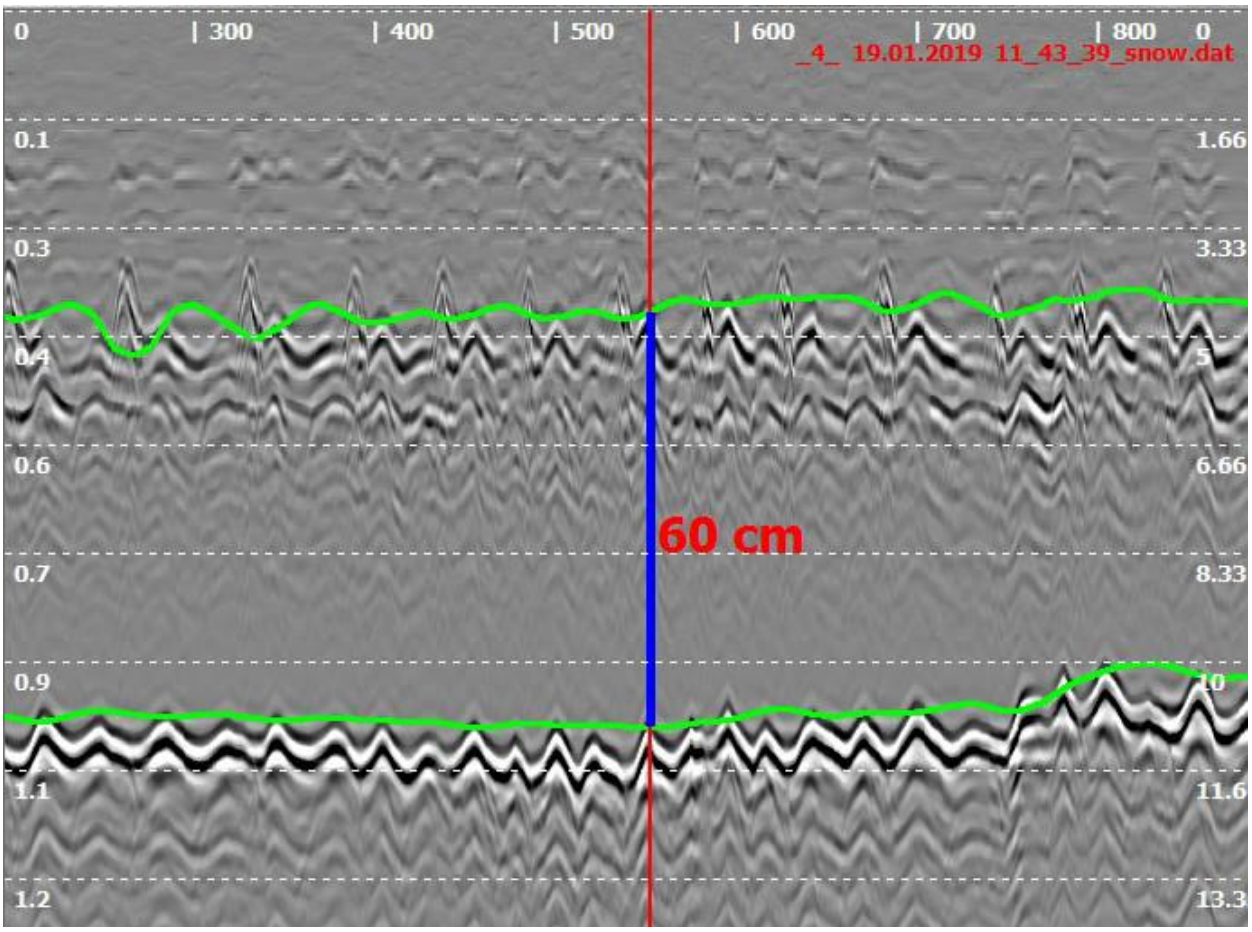


On the above sample, PicoR-Ice was clearly detecting two upper surfaces – the snow and the underlying lake ice. The operator, of course, knows that he/she is proceeding over snow-covered ice.

The PicoR-Ice software has separate real-time measurement algorithms for ice and snow. The selected algorithm is first calibrated to the actual snow or ice thickness. The operator drills a hole in the ice (or puts a measuring stake in the snow), measures the thickness, runs the PicoR-ice antenna over the same spot, and adjusts the ε value such that the PicoR thickness reading will equal the measured thickness.

Below (page following) is the same GPR segment with the ice thickness algorithm applied but showing only two detected interfaces (default setting). An adjustment was made to the ε value as well.

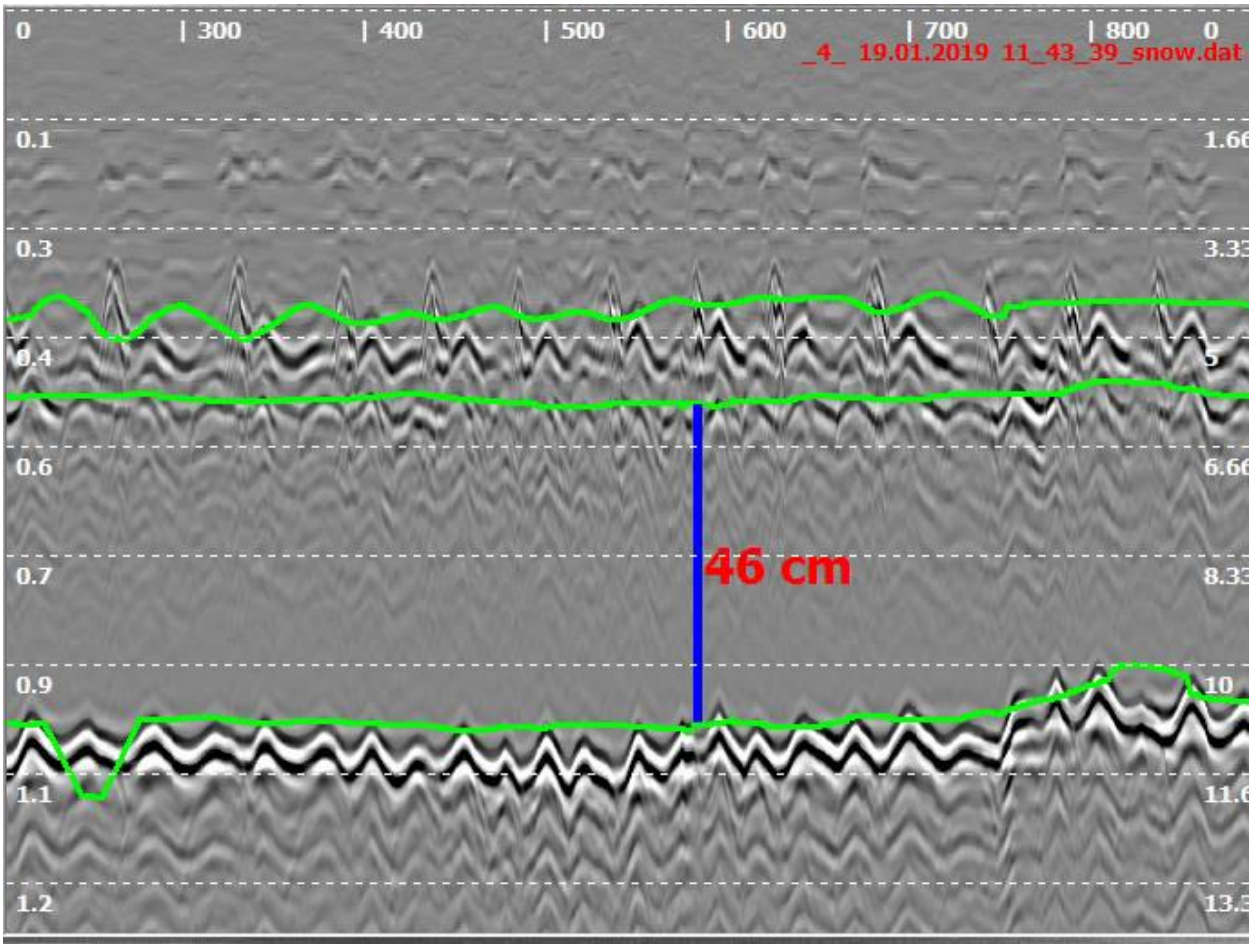
The top and bottom interfaces (green lines) have been smoothed to take out some of the distracting line anomalies.



The concern with this output is that the algorithm is interpreting the upper (snow) interface as the top of the ice and we are delivered an ice thickness value that is too high. Not good for on-ice safety. Of course, we can cheat this by re-jigging ε so that the combined snow and ice thickness is calibrated to the drilled and measured ice thickness. Then we would get a conservative (safer) thickness value.

Better, however, to have snow and ice layers distinguished on the screen display. PicoR-Ice lets us set a third interface, as shown below.

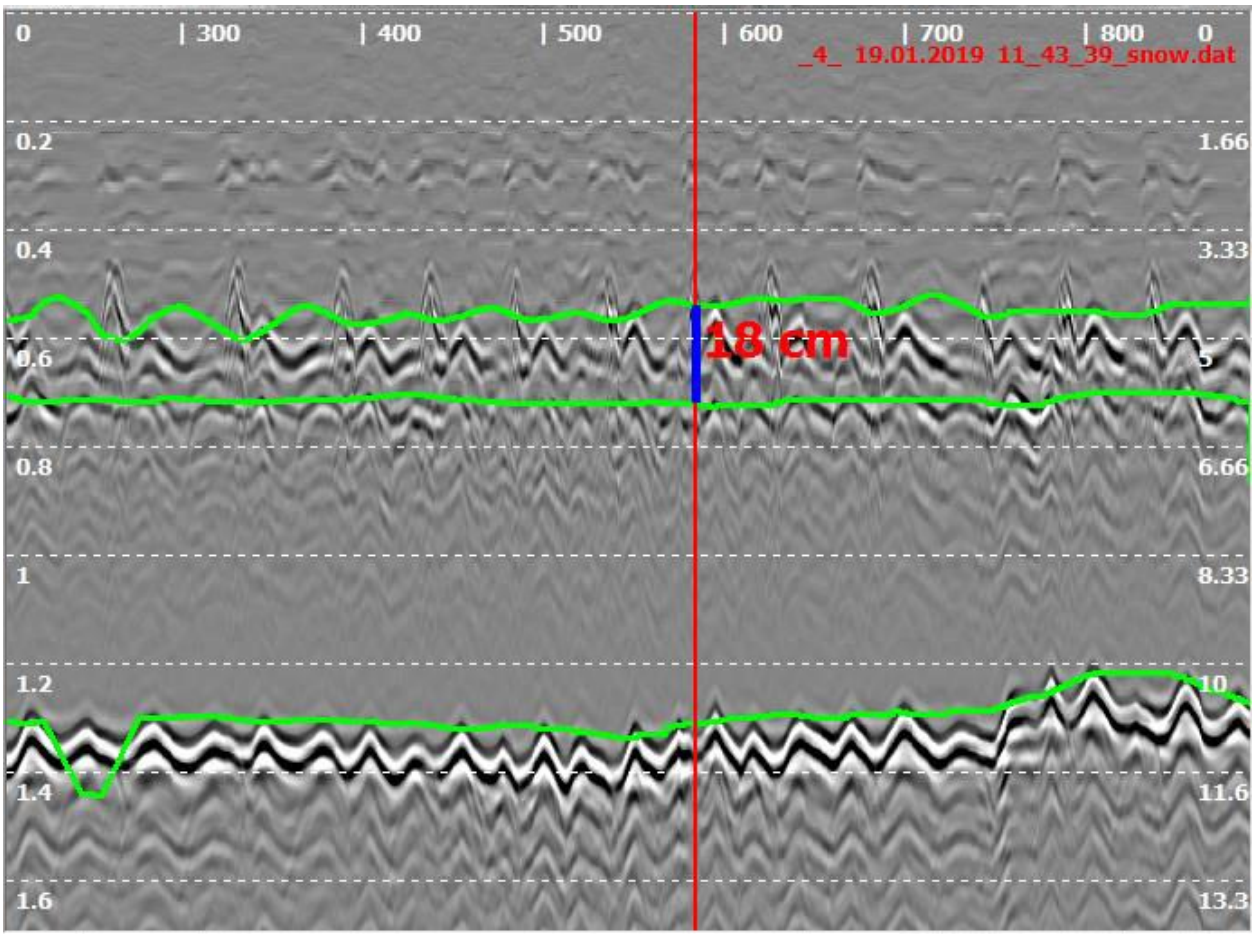
But using of 3 interfaces for an automatic algorithm will not always be correct due to the large number of failures (hopping of the maximum of the reflected signal between the interfaces). Automatic algorithms were originally developed for use with 2 interfaces. When using of 3 interfaces, it is necessary to make manual correction of algorithm errors.



Algorithm is calibrated. Only the real ice gets measured in real time. Can we eyeball the snow thickness from this? Would it be about 12 cm? Not exactly.

The ε for snow is not the ε for ice. We would expect an eyeball snow thickness based on the ε for ice to *underestimate* snow thickness.

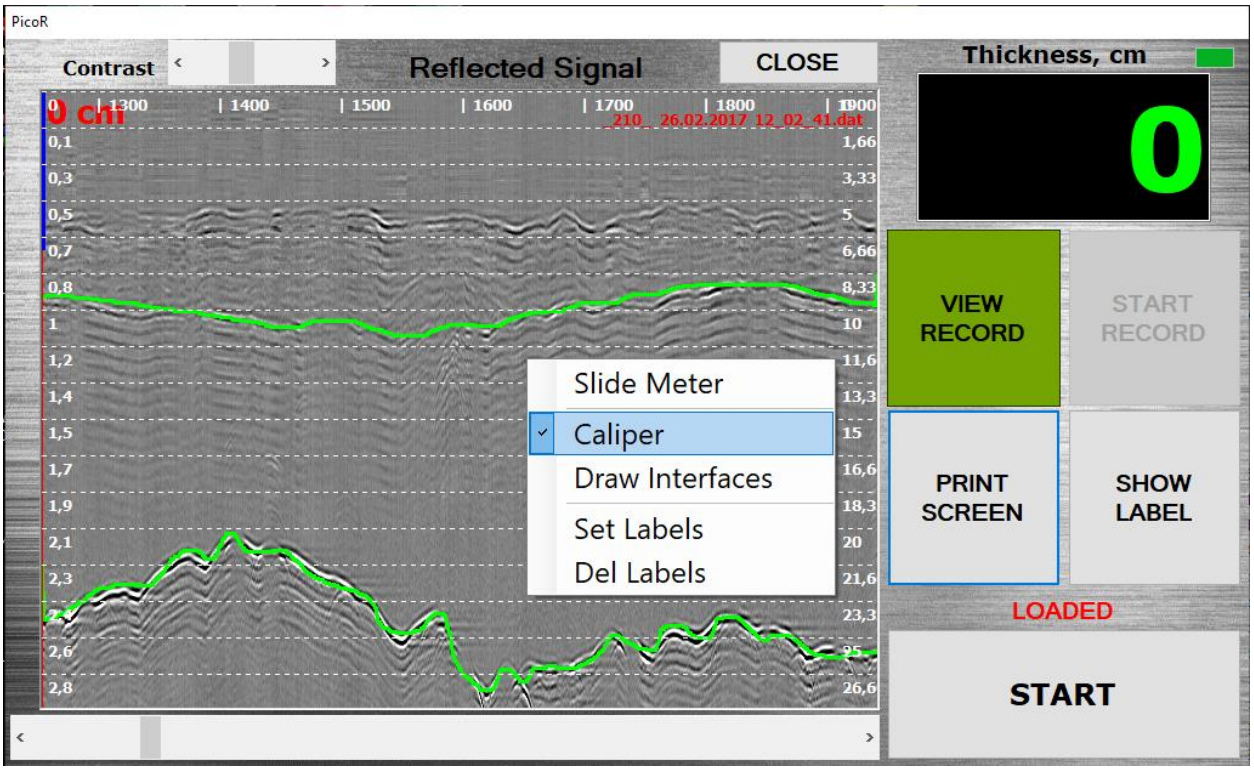
The following figure was produced after readjusting ε to the measured snow thickness and running the algorithm for snow.

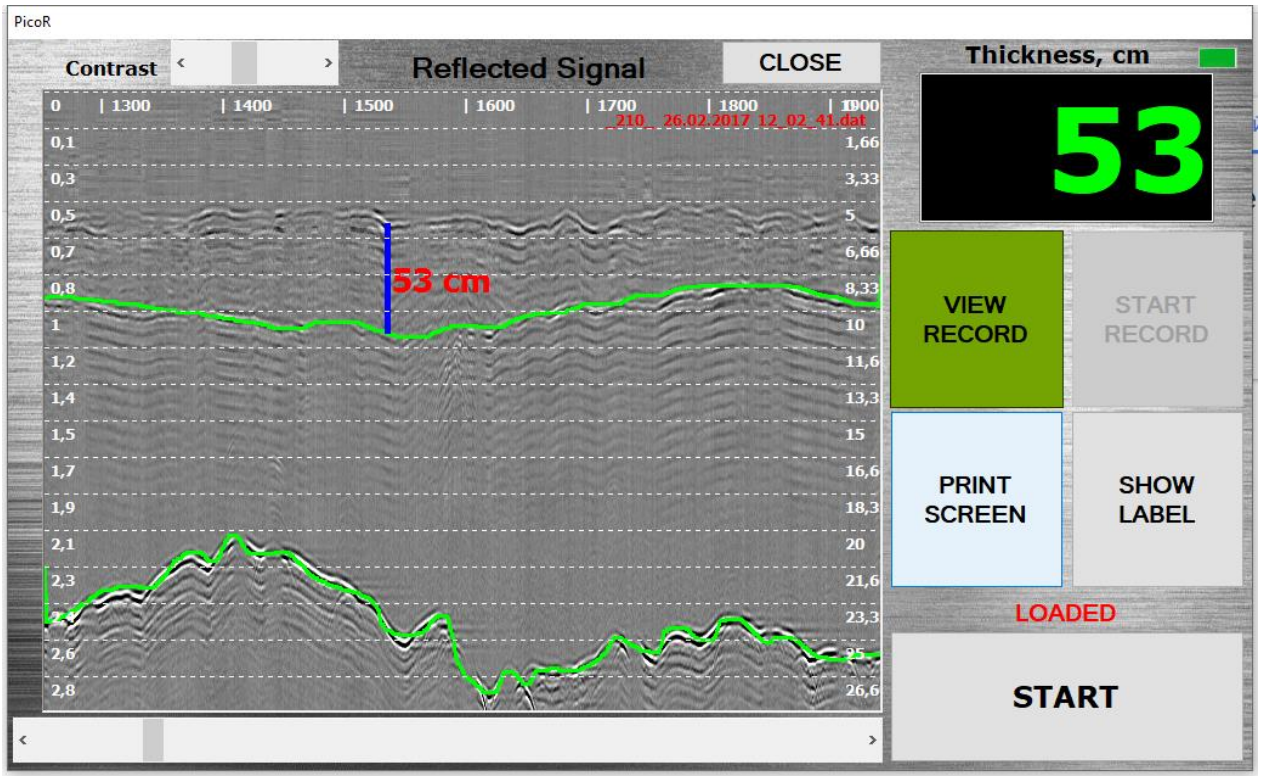


In fact, the snow layer is closer to 18 cm thick and not 12 cm.

In this situation, it would appear that the *eyeballed snow thickness* based on measured ice thickness should be increased by 40 percent.

Another convenient way would be to use the tool Caliper. In mode $\varepsilon = 2$ for snow, you need to put 2 points on the upper and lower interfaces of the snow layer and immediately see its thickness.


PicoR
Contrast
Reflected Signal
CLOSE
Thickness, cm
0
0 cm
Slide Meter
Caliper
Draw Interfaces
Set Labels
Del Labels
VIEW RECORD
START RECORD
PRINT SCREEN
SHOW LABEL
LOADED
START


PicoR
Contrast
Reflected Signal
CLOSE
Thickness, cm
53
53 cm
VIEW RECORD
START RECORD
PRINT SCREEN
SHOW LABEL
LOADED
START

The Workaround:

In summary, the proposed workaround consists of the following:

1. Run the ice thickness measuring algorithm. Ice thickness will be the more critical element in regard to personal safety.
2. Set PicoR-Ice to display three interfaces (green lines) – one for snow surface, one for ice surface, and one for ice bottom.
3. Estimate the snow thickness as a proportion of the displayed ice thickness and add one-third of the value to estimate thickness of snow layer. Measuring snow with the ice thickness algorithm will understate the snow thickness.

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