Why does my SATURO give me a negative K_{fs}?

The automated dual head method of the SATURO to measure field saturated hydraulic conductivity (K_{fs}) improves sampling throughput and gives you the power to increase pressure heads to more effectively measure infiltration in compacted soils that would take forever to get an accurate reading using past methods. The dual head infiltrometer method uses 2 pressure heads to model the lateral flow from the sensor by calculating the water flux at each pressure head (SATURO user manual). The method requires the system to reach a steady state for the calculation to work correctly. This entails a soaking period before the reading begins, then 2-3 cycles of 2 pressure heads. Equation 4 in the user manual is the key to our discussion here:

$$K_{fs} = \frac{\Delta(i_1 - i_2)}{D_1 - D_2}$$

Let's focus on i_1 and i_2, since Δ, D_1 and D_2 are constants for any given measurement run. A negative K_{fs} results from the low pressure head infiltration (i_2) being larger than the high pressure head infiltration (i_1).

The most common cause of a SATURO giving a negative K_{fs} is the system not being in steady state when the calculation is made. In that case, the noise in the reading is too large to calculate a clear signal and i_2 can be larger than i_1. It is normal to see a high degree of variability in the water flux at both pressure heads until the system reaches steady state. If the measurement is completed and K_{fs} calculated before you reach steady state, the measurement will have a higher error and possibly be negative.

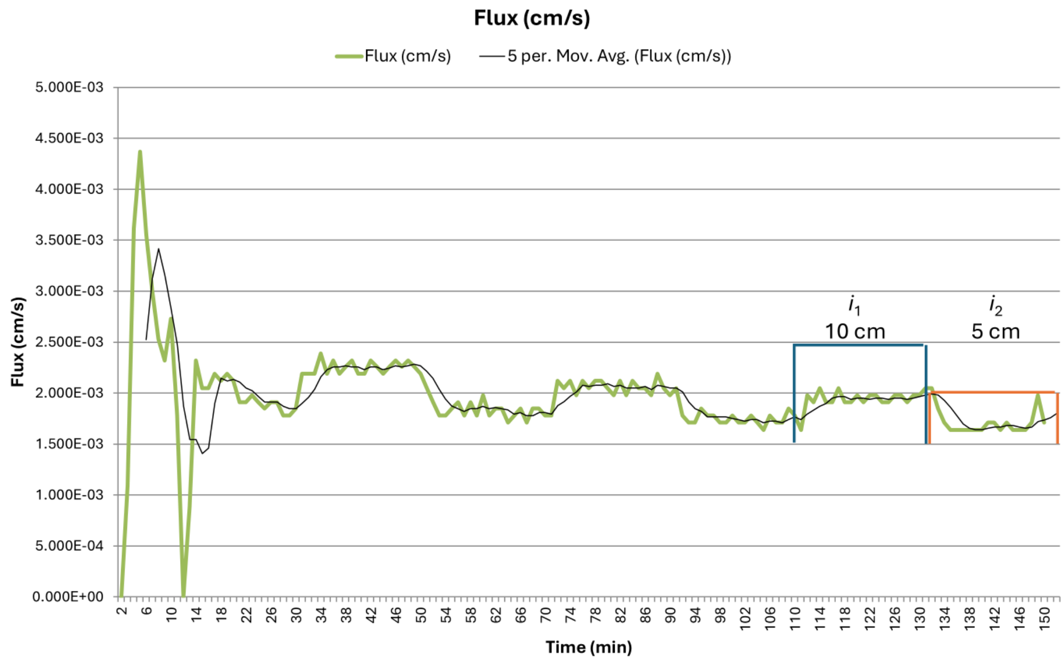

Fig 1. An example of a good SATURO run. Note how noisy the flux data are in the first 30 minutes, then it starts to stabilize and approach steady state. The 5 minute averages are very stable throughout the 2nd and 3rd cycles.

If the difference in pressure heads is too small, the difference in infiltration rates at those pressure heads may not be larger than the uncertainty of the measurement. This can also result in i_2 being larger than i_1, and you will get a negative K_{fs}. This scenario is common in compacted soils where the water flux into the soil at low pressure heads is very small.

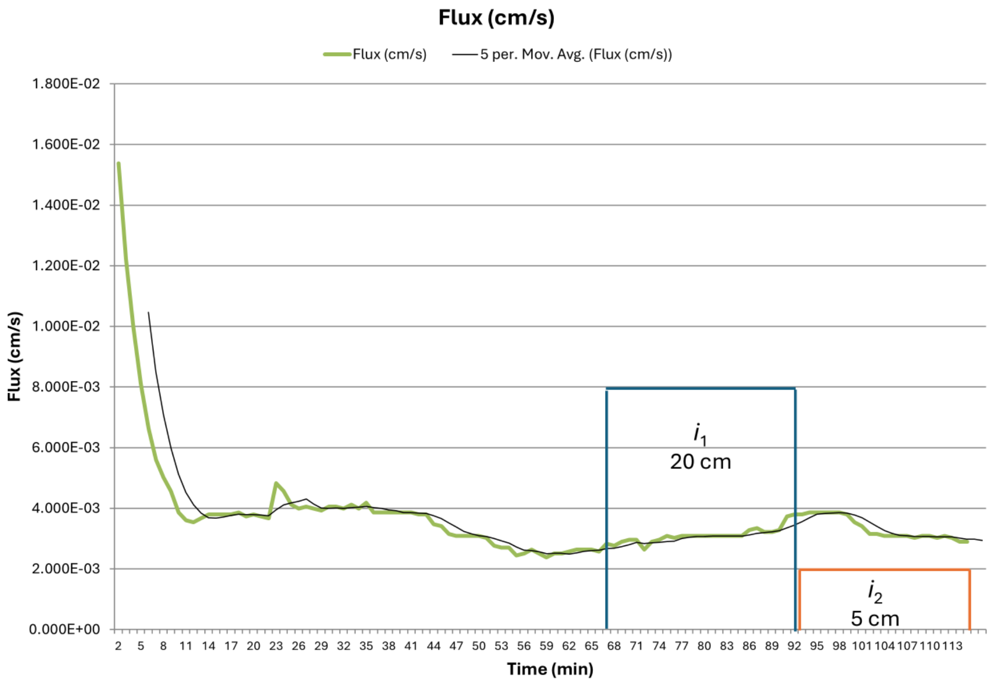

Fig 2. The plot above is indicative of both conditions that can lead to a negative K_{fs}. The device has not reached steady state as you can see that the high and low pressure peaks are not very clearly aligned in the flux data, and the difference between them is relatively small. The run above was done with 5 and 20 cm pressure heads and 2 cycles. The resulting K_{fs} is slightly negative.

How to adjust to a negative K_{fs} and improve your reading.

The first and most important thing that you can do is make sure that your run times are long enough to reach steady state. You may require a longer soak time or need to run a third pressure cycle. Keep an eye on your error value. That is the standard error. If it is close in magnitude to your K_{fs} reading, then you likely have not yet reached steady state.

Compacted soils can be very problematic to make K_{fs} measurements because the infiltration rate can be extremely low. The SATURO is particularly well equipped to take the best K_{fs} measurements in compacted soils. Raise the high pressure setting in your measurement run to increase the difference in pressure between i_1 and i_2 to achieve the best possible results in these difficult measurement conditions.