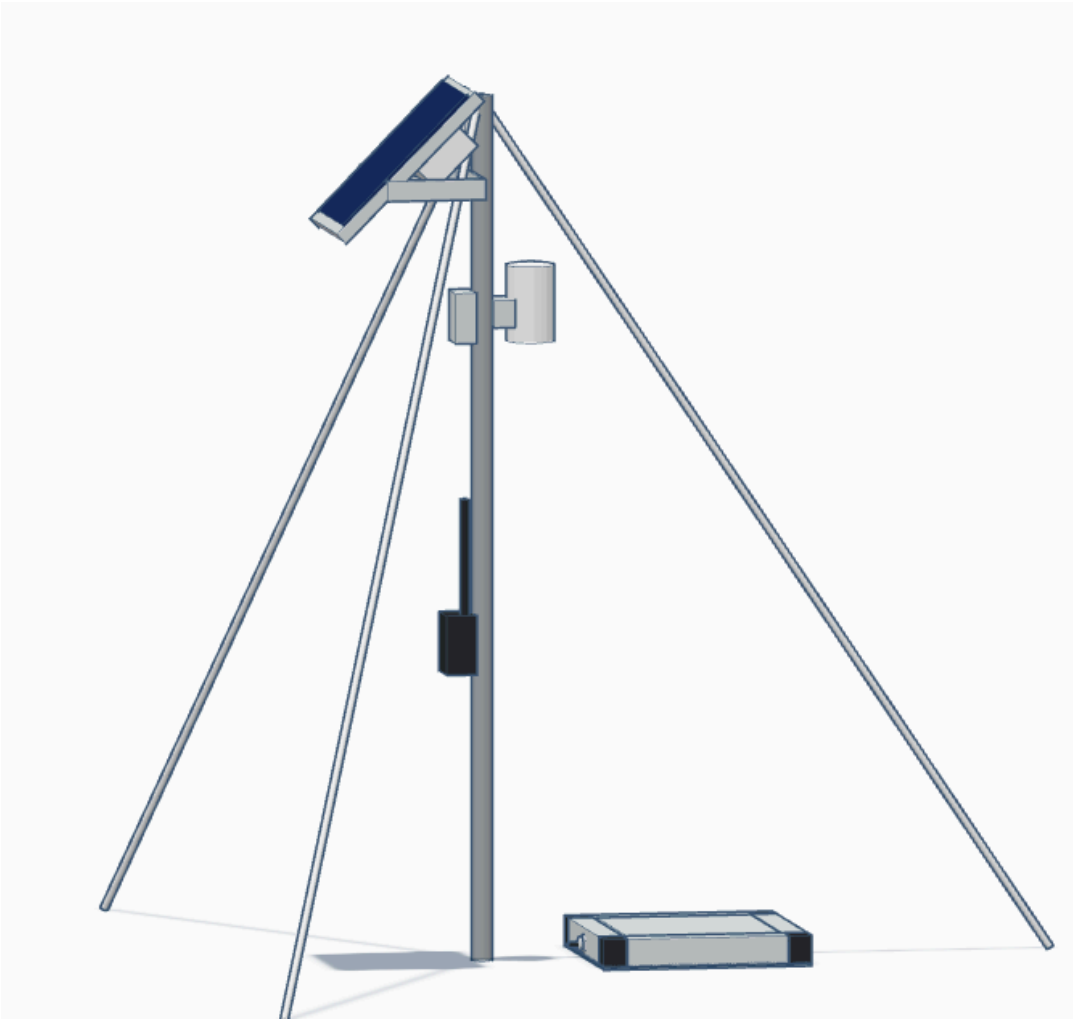
Mini Nival Weather Station - CEAZA-Node v1.2

Center for Advanced Studies in Arid Zones (CEAZA), 2024
Cristian Orrego, Adrián Gallardo, CEAZA, 2024

Introduction

The development area of CEAZA has spent the last 6 years developing telemetry devices to monitor nival parameters for the High Andes in the Coquimbo region, Chile. Starting from very rough prototypes until the version that currently has. The aim of the device (node) is to solve some very limiting problems with operational telemetry in harsh environments like cost, weight and operations. For this the CEAZA is using low cost sensors and also making some from the ground, the same has been done with the logger, in which the whole electronics and operative system has been made from scratch. The current node has been set up to measure: Air temperature, snow depth and snow weight (this is a very early prototype sensor) and has the capabilities of logging at 10m intervals, long range radio communications, GNSS receiver and a high efficiency energy management. This development has been funded by several ANID project (R19F10002, ID22I10074) and will continue for the next years.



Measurements and sensors

Datalogger (self developed)

- Model: CEAZA Telemetry Logger 1.2 CTL1200
- Sensor Interface: Serial RS485
- Radio: LoRa 915Mhz
- Memory: 1Gb
- GPS
- Capabilities: Wifi/Bluetooth
- Energy consumption @12V: <1mA deep sleep, ~50mA measuring
- Firmware: Customized by applications

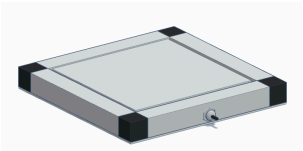
Air Temperature (3m):

- Model: Waterproof Dallas DS18B20,
- Measurement range: -55 to 85°C
- Accuracy +-0.5°C

Snow height (3m):

- Model: Garmin Lidar Lite V3
- Range: 0 to 40m (70% refletive target)
- Accuracy +-5cm
- Operating temperature: -20 to 60°C

Snow weight (Self developed) (0m):



- Model: CEAZA MSS-01 (CEAZA self developed mini snow scale)
- Communications: Serial RS485
- Measurement range: 0 to 80kg (29x29cm area)
- Accuracy: in evaluation

Specifications

Energy

- 10W solar panel with 12v/2.4A battery
- Consumption: <1mA at rest, 50mA average when measuring
- Mast: 32x3mm aluminum, height: 3m
- Weight: ~20kg

Tests *(currently running, updated 2024-08-28)*

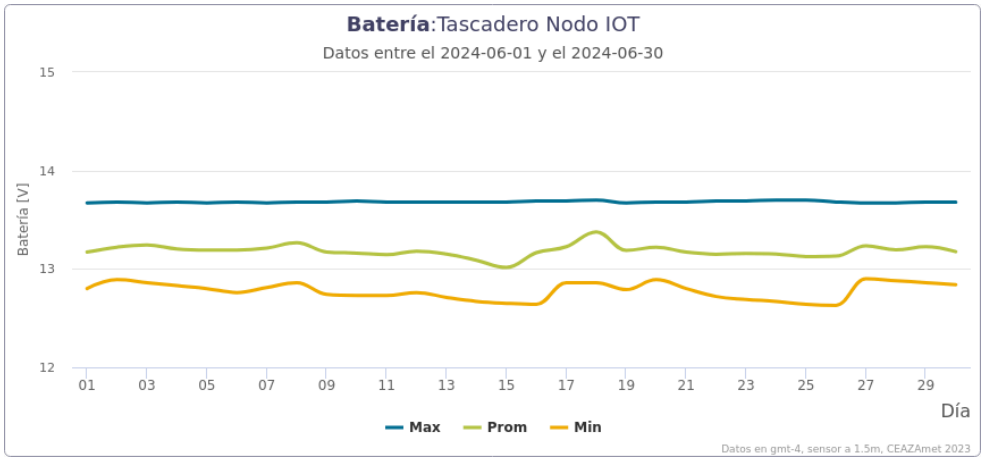
The current node system is currently under development and testing, so far the tests have been conducted in CEAZA's facilities, in the High Andes of Coquimbo region, Chile and Broken River basin, New Zealand. From 0 to 4500m a.s.l in places like "El Tapado Glacier" [Elqui basin, Chile] and "Tascadero" [Limarí basin, Chile]

Tascadero 2024 tests

In 2024 a node was prepared and installed beside a CEAZA scientific weather station in Tascadero (-31.262951° , -70.539993° ,3427m a.s.l). In system wise terms the node has been functional the whole time.

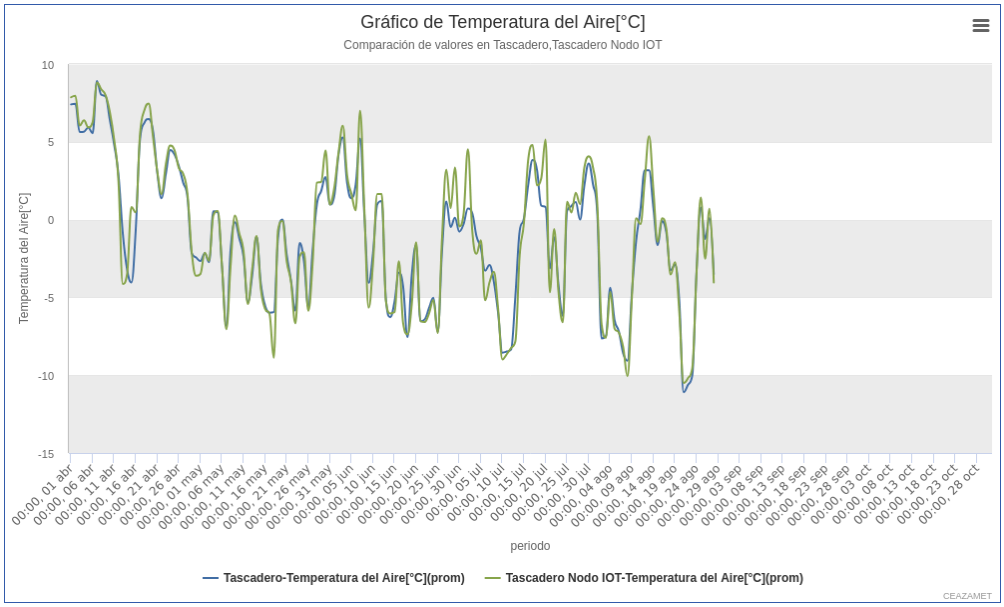
Energy (10W solar panel, 2.4A/12V battery version)

The energy system has worked as expected and the battery never dropped below 12.5V being capable of holding the system working without any significant drop in periods with low solar radiation (see for example Jun, 21 to 26).



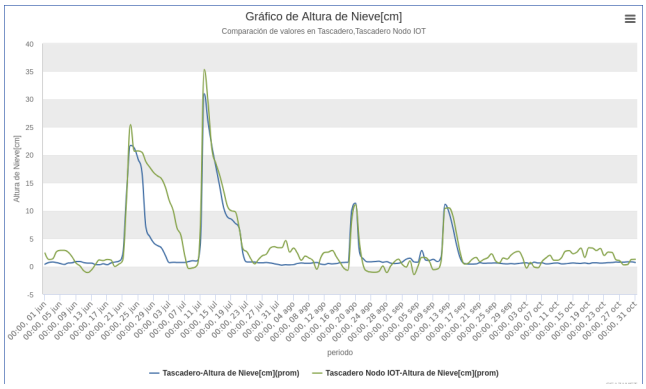
Since the start of the year, air temperature, snow height and snow weight has been collected from the Tascadero weather station and the node. So far the average daily temperature has been correct overall but the node installed in that place has a outdated version of the temperature sunshield that causes it to gain a little more temperature on sunny days (see problems and solution section).

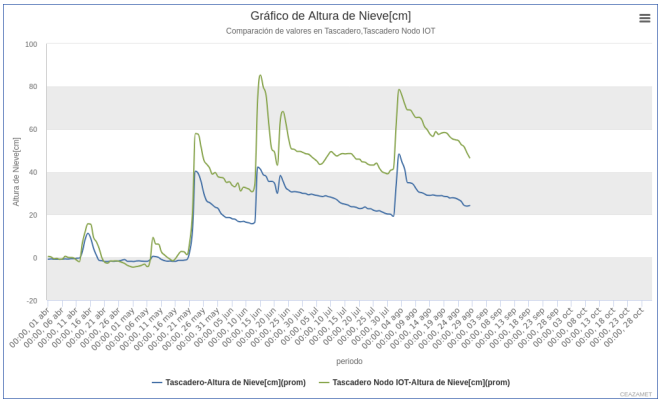
Air Temperature in Tascadero



Snow depth in Tascadero

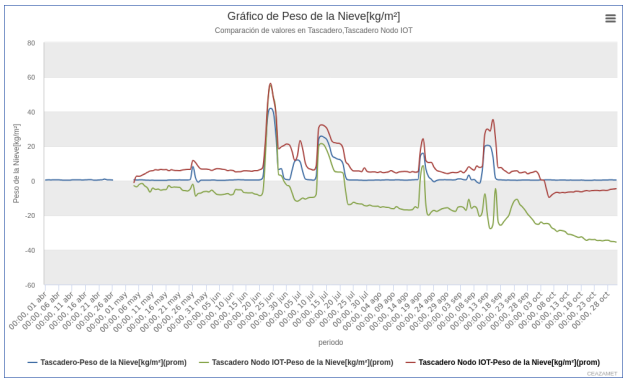
The comparison between the Campbell SR50 snow depth sensor and the Garmin Lidar Lite v3 HP is shown in the graphics for the year 2023 and 2024. In general for the year 2023 data, the amount of snow was low (max 35cm of depth) but can be seen that the values are within the +-5cm difference. In 2024 after the first event there's a almost constant offset of 20cm, this could be that in the node location there's more accumulation or the mast is tilted so next summer visit to the place should clear what happened.

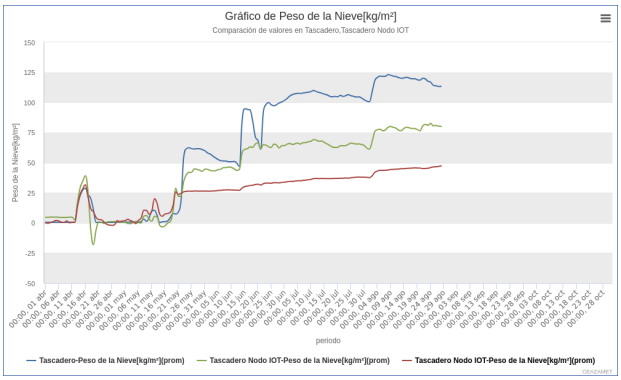




Snow weight in Tascadero

Current version of the snow scale (v2024/29x29cm) has been working in general good in the sense that the scale has relation with the snow events as goes up and down with the Summer SSG-2 Snow Scale installed in Tascadero, however there's issues to be addressed still in terms of the proportion (magnitude) of the weight and some creep effect that affected the 2023 setup.





Future developments

Still the mini weather station has many components to further develop to be in production stages. In terms of the energy for example, the holder for the battery and the solar regulator need some electronic and structural improvements. The datalogger needs a more complex and configurable firmware, the same with the user interface.

SWE sensors need to be further tested and redesigned, and is planned to make larger versions of the sensor (from 29x29cm [10% m2] to 50x50cm [25% 1m2]) and change the plastic support for the load cells to the weighing platform. Also the load cells that have been used so far are generic cheap ones (less than 4 USD each), so new prototypes will still be cheap but with a known brand model and specs.

Links

CEAZAs RedNival [Telemetry for snow development area]
http://rednival.ceazamet.cl/index.php?pag=intro

Lidar Lite V3 HP
https://static.garmin.com/pumac/LIDAR-Lite_v3HP_Instructions_EN.pdf

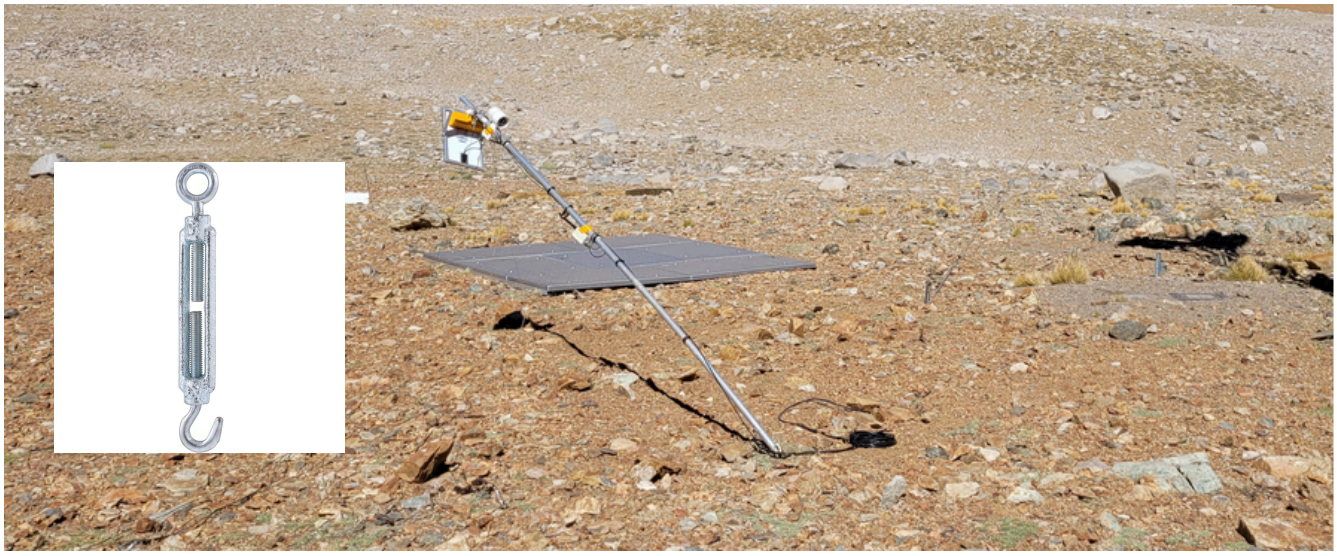
Datasheet Dallas DS18b20
http://pdf2.datasheet.su/dallas%20semiconductor/ds18b20+.pdf

Problems and solutions

Since this development is made almost from scratch, i.e. all the systems (electronics, firmware, structures, parts, electrical, communications) where customized for the requirements (low cost, low energy consumption, transportability, low weight, etc) and the field test are done in a yearly basis (once the winter start one cannot access the installation sites) this is a slow development process and since the environments where the equipments are used is a harsh one (low temperature, high wind, low atmospheric pressure, snow/rain) problems are very common, and many times, difficult to diagnose. Next, it presents a list of some of the problems that we have encountered and solved so far (as in 2024).

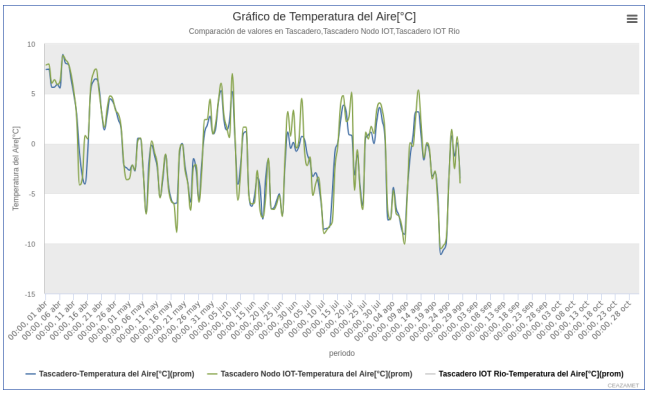
The tensor type

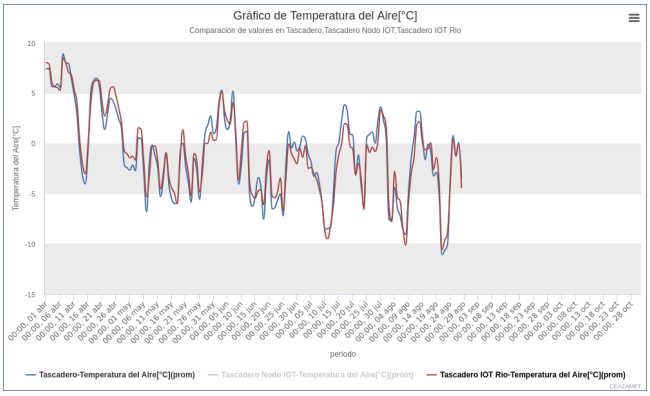
Some of the nodes where installed with a eye-hook fixing mechanism, wind and the natural forces made the fixing cables to get loose, then the hook detached from the stake and then the whole node collapses into the ground, since this also causes to lose the solar panel orientation little time after that all the measures were lost. This problem was structural and was presented in a number of installations this causes revisiting many places before winter season started,but also, in some cases that was not possible so data was lost.



The temperature shield

Since the beginning of the prototype generation of the nodes the air temperature chip was the same, but the sunshield was not. This part has been specially problematic to diagnose at first. The early position for the sensor was in direct air contact and just covered from the light coming from the sky; this failed because in certain parts of the day light reflected, heated the sensor. Then next versions of the shield covered the sensor completely, but still in sunny days the T° was more than the reference, then we realized that PLA plastic used to print the shield was a little translucent and this would cause it to absorb energy. Current temperature shield is painted, and also a “hat” was added to the upper part of the shield. Now the temperatures are even between nodes and reference stations, in the next graphics the difference in warm days with previous/current shield can be seen.

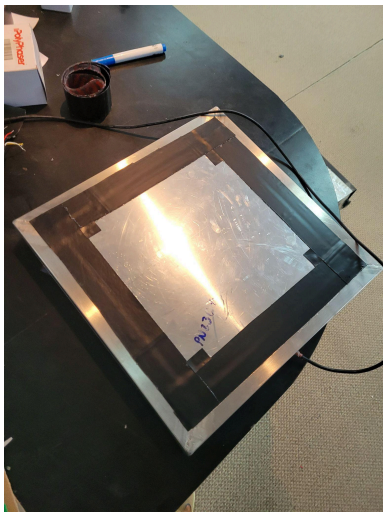


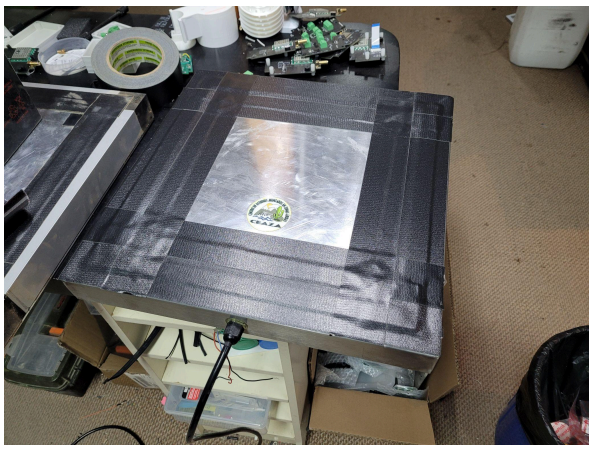


Left: non painted sunshield (2023 version) and daily temperature spikes (green line) over weather station caused by translucent material. Right: New sunshield design (2024 version), graphics shows that now the node temperature (red line) does not spike above the scientific sensor (blue line). Note: This second graphic corresponds to a node located at 20m lower location 100m further from the weather station.

The waterproof seal in the Snow Scale

Since the CEAZA Snow Scale design is dependent on being waterproof but with flexibility to allow the scale square to move freely from the frame, finding a seal has been challenging, when the seal is lost water has entered into the scale and the load cells and electronic boards have gotten rust and board failures. Multiple tapes have been tested and the sealing is still a work in progress.





CEAZA Mini Snow Scale

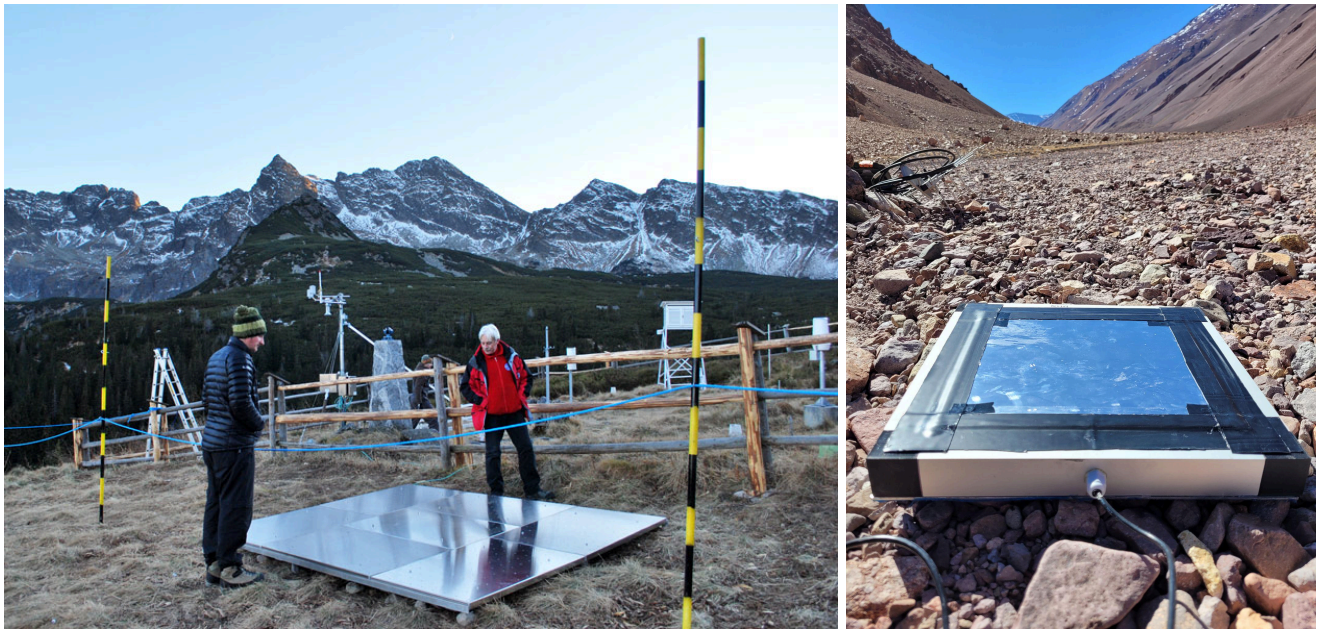
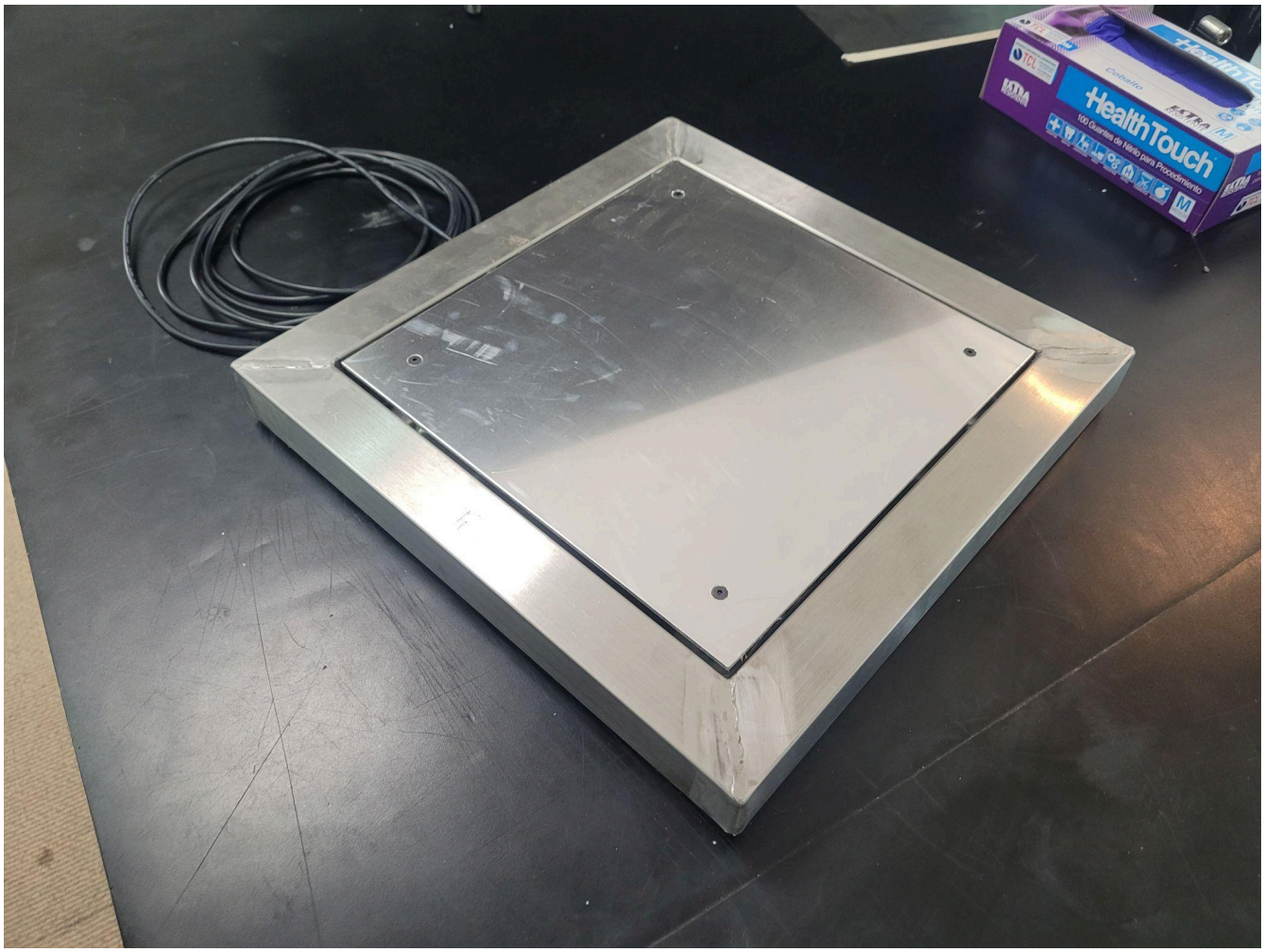
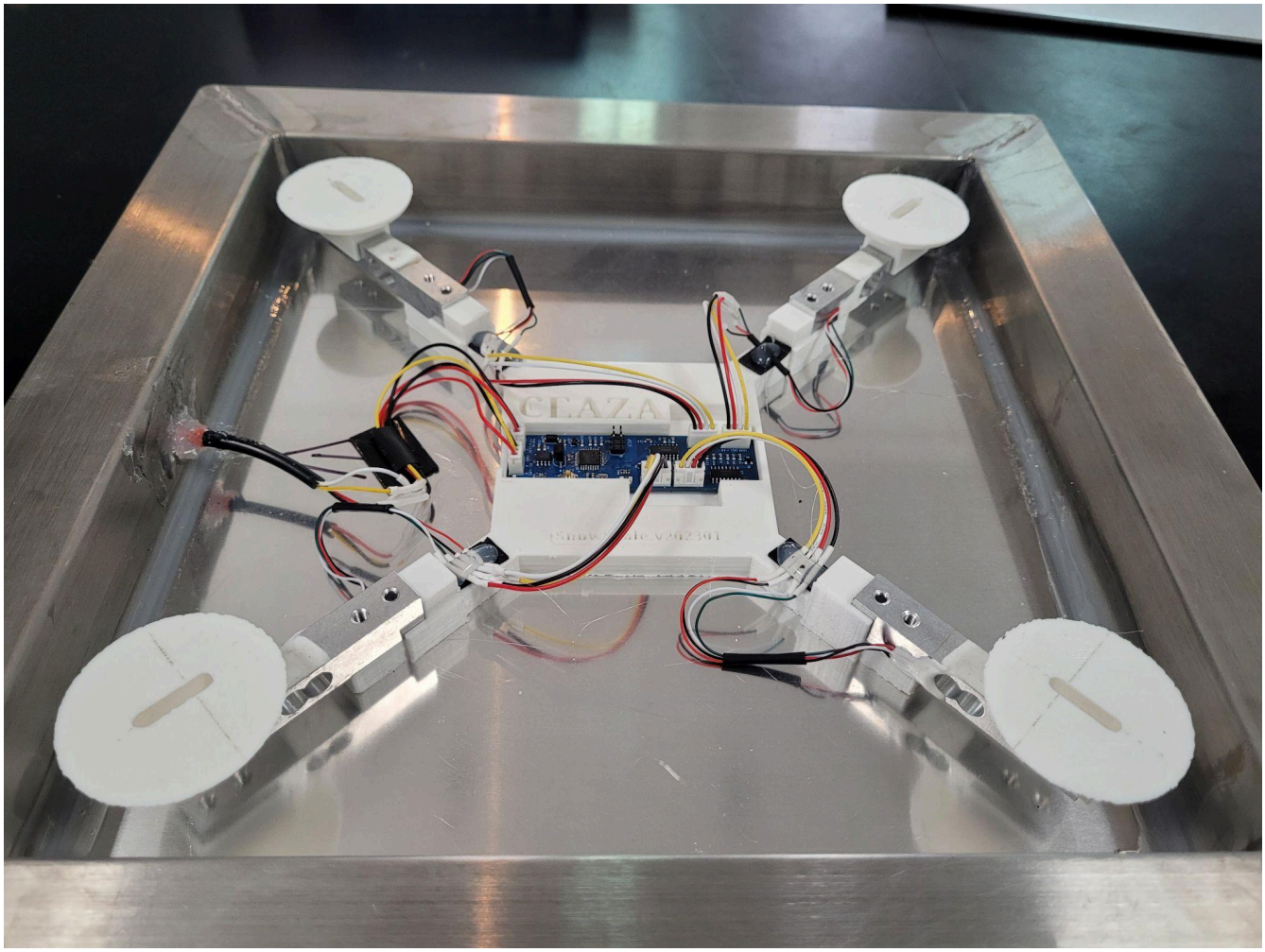


Figure SW1: Sommer SSG-2 Snow scale and





CEAZA Mini Snow Scale.