Automatization of the totalizer network in Switzerland: results of the pilot phase

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1 Introduction & Motivation

A totalizer is a high-volume precipitation gauge used primarily in remote mountain areas. Totalizers are collecting precipitation over a longer period, in most cases during a hydrological year. **The measurement values are read manually.**

The first totalizer networks in Switzerland were established in 1914 mainly in context of planned hydropower dams (Félix and Konzelmann, 2016). **Today, the corresponding - partly centennial - time series** are considered as an **important climate archive**, as the type of instrument and the wind protection ring has not changed since the 1920ies.

In Switzerland, from a climatological perspective, eight of the totalizer gauges are to be retained with priority 1 and another 27 with priority 2 as a part of the **Global Climate Observing System GCOS Switzerland** (MeteoSwiss, 2025).

The **climatic conditions of high mountain ranges -** as the **European Alps** - are often **critically depending on long time series of totalizer measurements** (Efthymiadis et al., 2006; Schwarb, 2000).

However, the **value of manual reading is also limited** as frequent reading or on-line communication of the measurement data is often not possible.

Automated daily or monthly values would even enlarge the basis for deriving hourly climatologies. In this context it is important to mention that e.g., present radar-gauge derived **gridded hourly precipitation** over Switzerland ('CombiPrecip') **underestimates the end-of-season snow accumulation on Swiss glaciers by factors of 2.2 up to 3.7** (Gugerli et al., 2020). Near many **Swiss glaciers** there are **one or several totalizers**, an incorporation of their **daily** or **monthly values** may **massively improve the accumulation modelling**.

Moreover, this **underestimation** may have important consequences for **natural hazards** as **mudflows**, **floods** and **avalanches**.

A **higher temporal resolution** of the totalizer-measurements would also **improve the data base** of **climate change analysis** and **modelling** over the **Alps**,

To overcome the coarse temporal resolution of precipitation information in high alpine regions **a low-cost solution** which **preserves the legacy manual readings** is presented.

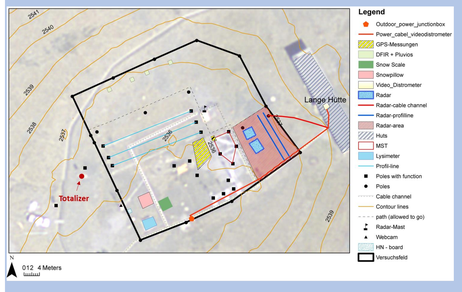

Fig. 1: Instrumentation of the Weissfluhjoch test site (near Davos, 2536 m asl.) of the WSL Institute for Snow and Avalanche Research SLF, Switzerland

2 Test Site

The **Weissfluhjoch test site** of the WSL Institute for Snow and Avalanche Research SLF (2536 m asl.) is offering **ideal conditions for evaluating the automized totalizer**. Beside the official MeteoSwiss precipitation gauge, there is a **double fence intercomparison reference** gauge **(DFIR)** and the daily measurement of the new **snow water equivalent (SWE)** as well as the fortnightly values of the SWE of the total snow cover which can serve as a comparison. Furthermore, there is a **webcam with hourly footage**.

3 Methodology and data

Since there is no power connection at the totalizer locations, a **low power consumption** of the sensors and an **appropriate transmission technology** was a crucial criterion in the evaluation of the measuring instruments.

To determine the fill level of the totalizer on the Weissfluhjoch, a **pressure sensor** (High-Precision Pressure / Liquid Level and Temperature Sensor from Keller, DL-PR46) and an **ultrasonic sensor** (Ultrasonic Distance / Level Sensor from Maxbotix, DL-MBX-006) were used (see Figure 2).

The measurement data is transmitted via the **highly energy-efficient communication** network **LoRaWAN** (Long Range Wide Area Network), which was specifically developed for the **Internet of Things** (IoT).

Even if the load sensor was specifically temperature compensated **a specific high pass filtering had to be applied**. However, temperature compensation of load sensors is also a problem in operational load sensor-based instruments (Knechtl&al, 2019)

Fig. 2: The boxes containing the electronics for the pressure (right above) and the ultrasonic sensor (right below) were attached to a support of the totalizer (left), pointing towards the LoRaWAN antenna.

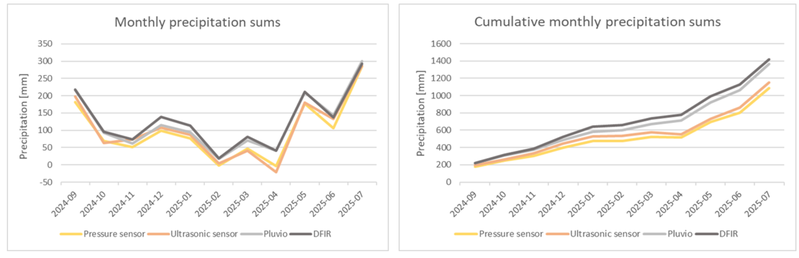

Fig. 3: Monthly precipitation and the cumulative monthly precipitation totals from Sep. 2024 to July 2025.

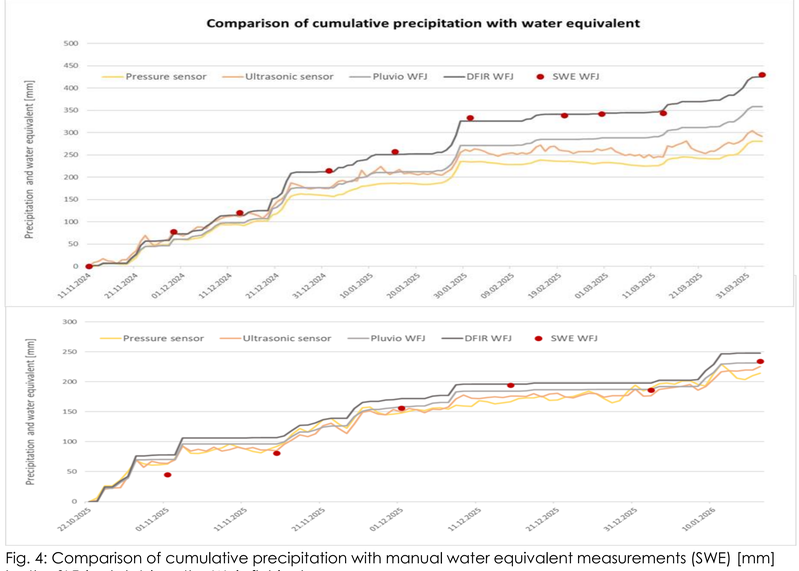

Fig. 4: Comparison of cumulative precipitation with manual water equivalent measurements (SWE) [mm] by the SLF (red dots) on the Weissfluhjoch

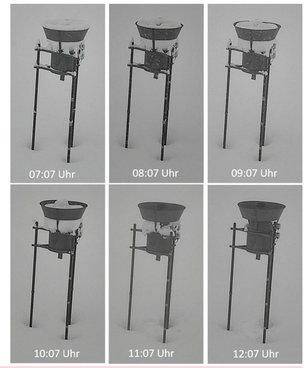

Fig. 5 Above: The snow deposits that formed around the collection orifice and on the inside of the windshield were mostly quite small. right: Development of a snow cap on May 5, 2025, btw. 7 & 12 a.m. From its maximum size at approximately 7 a.m. until its complete disappearance, it took only 5 hours

4 Results

- Somewhat surprisingly, **evaporation losses are not totally negligible in totalizer measurements**, this even during winter season and in the European Alps, despite the application of 0.5 l of Vaseline oil. However, **in comparison to heated tipping buckets, the evaporation losses are still modest** (Rohrer et al., 2013)
- Generally, the formation of **snow-caps**, which severely narrow or block the collection opening, was **a minor problem**.
- Admittedly, it is important to mention that for good results **sophisticated correction procedures must be applied**. **However**, **such corrections are also necessary for the current operational precipitation measuring instruments based on the weighing principle** (Knechtl et al., 2019).
- The results of the pilot project of winter 2024/2025 and the preliminary results of the winter 2025/2026 show that **manual totalizers in a high alpine environment can be automatized with reasonable efforts**.
- It is shown that - mainly with the pressure sensor **- monthly and relevant daily precipitation values can be well derived**, almost equivalent in quality of a reference measurement.

5 Conclusions and Outlook

- The **pilot project on the Weissfluhjoch/Davos** demonstrated that **even in high alpine regions**, where very **large temperature fluctuations** are common and **snowfalls** are frequent, **monthly totals & relevant daily precipitation values approximate the values of the reference measurements in a reasonable way**.
- The **data transmission functioned almost seamlessly at 10-minute intervals** with **minimal power consumption**, using only two small alkaline C-batteries that provided energy for over a year, without the need for a solar cell.
- It's planned to **implement the automatization of the totalizers** over the **next few years** step-by step

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