ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
Sensorscope
Make Sensing Easy

Design Project - SIE 2014

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Low power strategies for accurate outdoor temperature measurements

Motivations

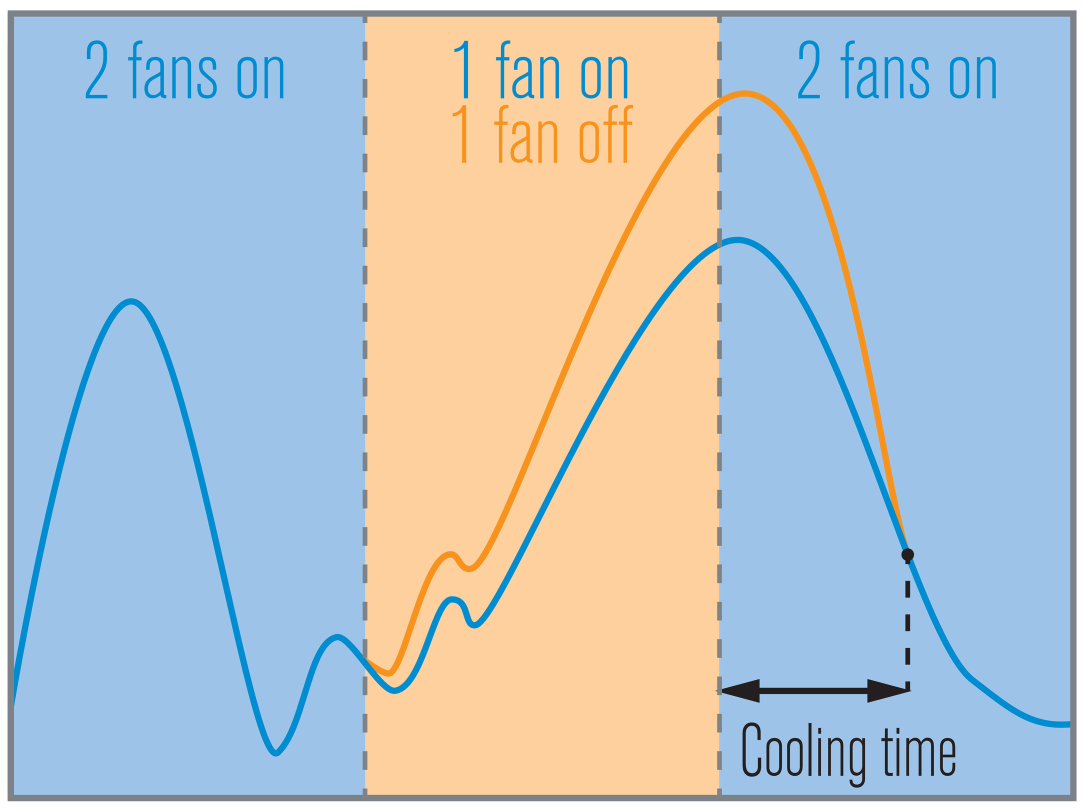
Actively ventilated temperature sensors **consume much more power** than passively ventilated ones, partly due to incident solar radiation. This issue may lead to unfeasible deployments of stations on a large scale given the sheer power cost, if the need for accurate temperature readings is important.

Objectives

From data gathered near Sion (VS) over 3 months, the goal of this project is to **calibrate** the passive sensor to the active one in order to obtain accurate temperature measurements using environmental variables, and to develop **power-aware strategies** using only active sensors.

Methodology

Power-aware strategy

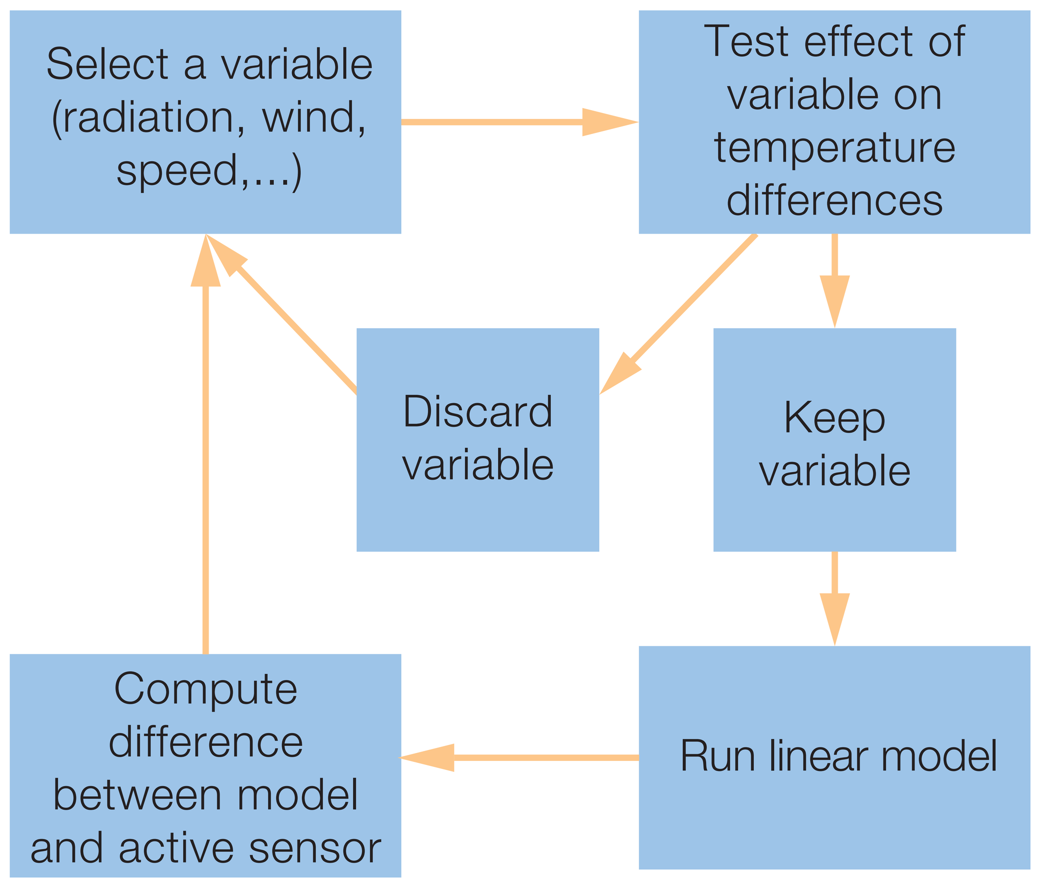


Temperature vs. Time

The power aware strategy seeks to determine the time it takes for the active sensor to cool down once the fan has been reactivated, as **the fan is the most power-demanding module**.

The passive calibration strategy tries to iteratively **explain the temperature difference using as many available parameters as possible**. The process stops once the difference becomes lower than a certain tolerance.

Calibration

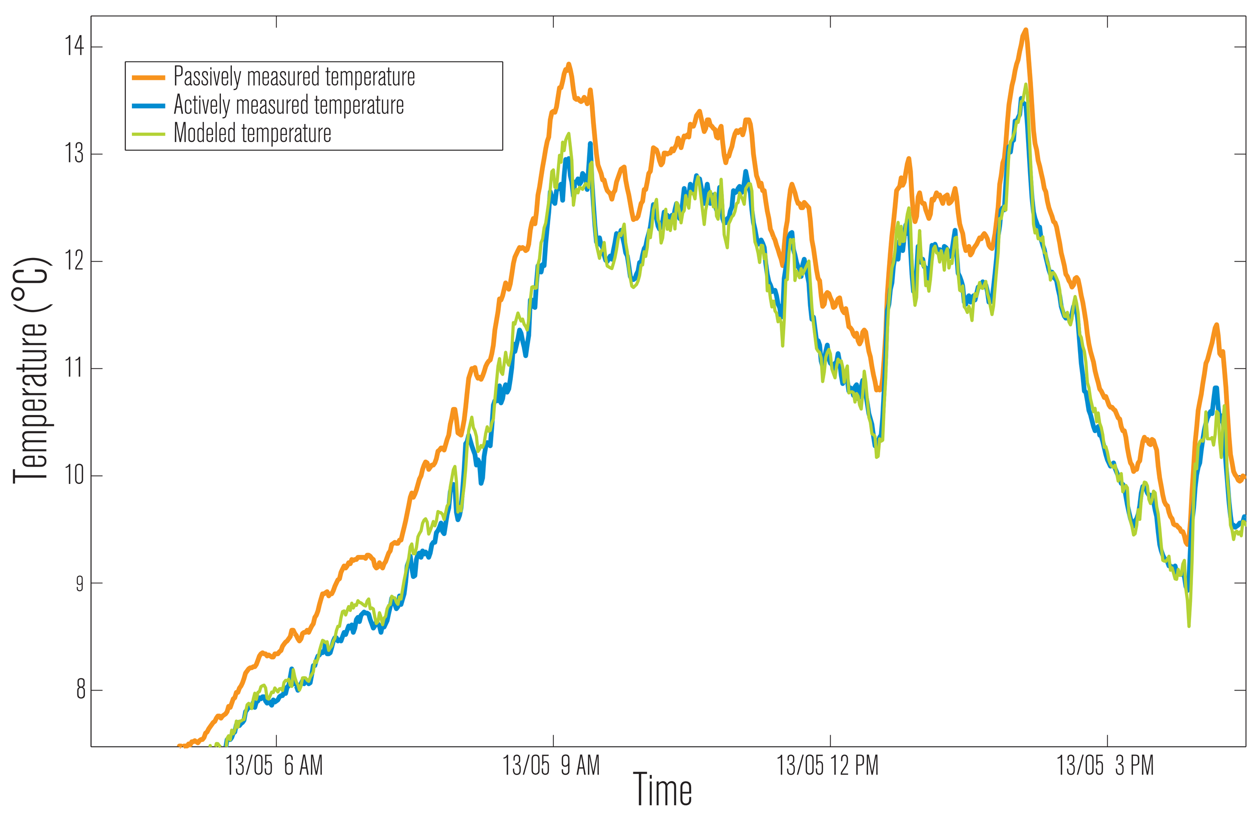


Results

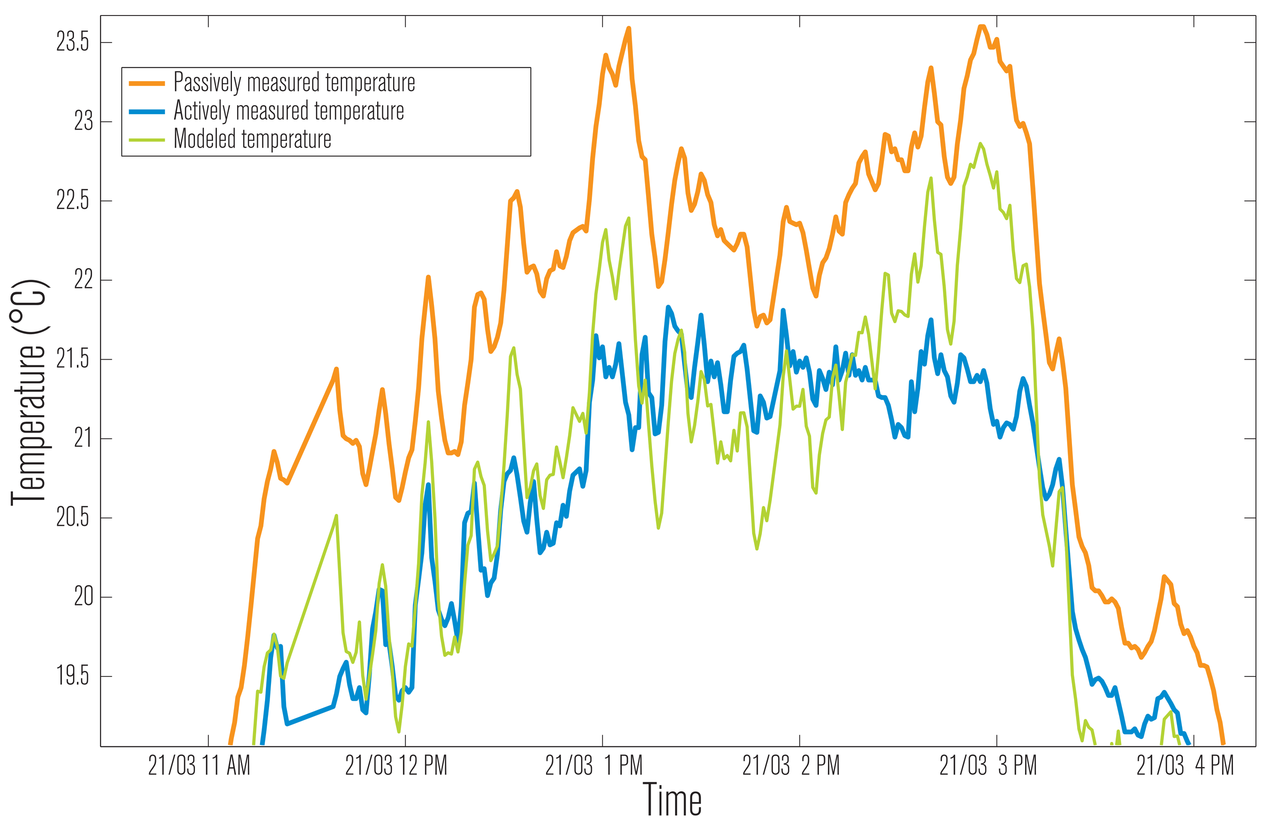
Calibration model

Linear model, where EMA is the moving average of the temperature over the previous five minutes.

$$T_{model} = \begin{bmatrix} b_1 & b_2 & b_3 & b_4 & b_5 \end{bmatrix} \cdot \begin{bmatrix} T_{passive} \\ \log(Radiation) \\ Windspeed \\ EMA \\ Cst \end{bmatrix}$$

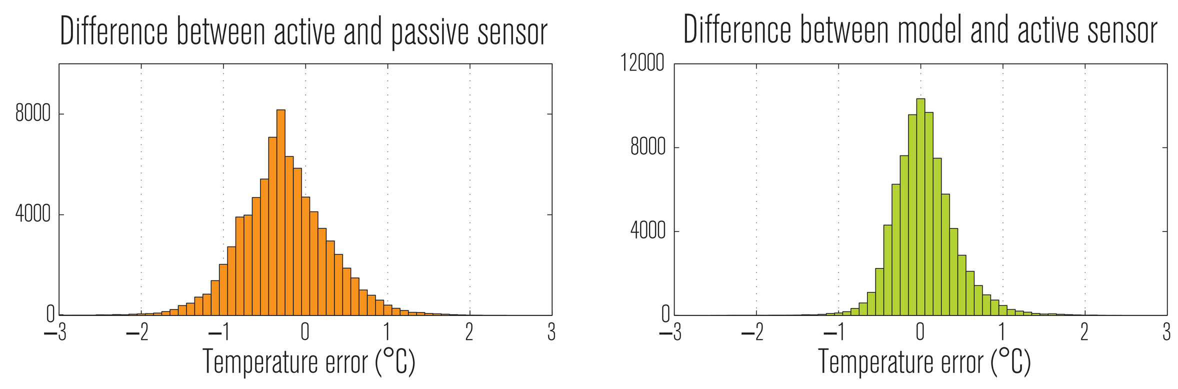


The model yields **an accurate estimate of the temperature**.
It does not correct temperatures during the night, as the accuracy of both sensors are close, and solar radiation is negligible.



However, **measured parameters are not able to account for the temperature difference** over the whole data set. Other parameters could be used, such as long wave radiation.

Validation of the model



Residuals are much smaller using the modeled temperature, with more than 50% of the differences being smaller than the precision of the sensor (0.2°C).

Statistics

R^2	0.996
Std. Dev.	0.37°C

These statistics indicate that the model is an overall good fit of the active sensor data.

Conclusion

The power aware strategy is **suited for situations where the sampling time is lower** than the sensor cooling time, and is preferred as the accuracy is likely higher.

For experiments requiring a high sampling frequency (~1 min), the calibration strategy provides very **low energetic consumption** and a **low trade-off in temperature accuracy**.