UNIVERSITÀ
DEGLI STUDI DI TRIESTE

dipartimento di matematica e geoscienze

Rapporti OM **N. 161**

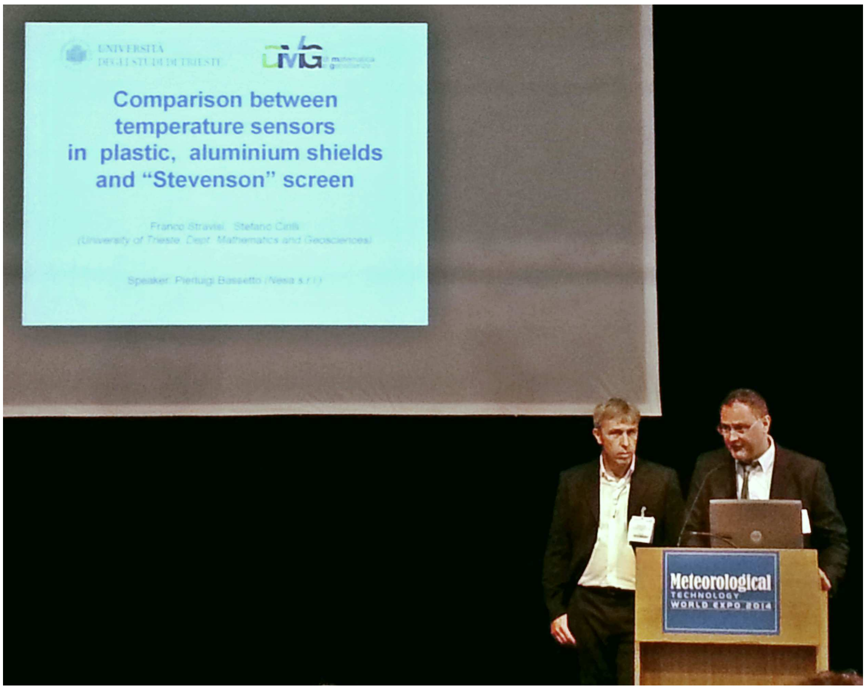
Franco Stravisi
Stefano Cirilli

Comparison between air temperature measured inside a conventional large wood shelter and by means of present day screens

Trieste 2014

Contents

Paper presented at the ***Meteorological Technology World Expo 2014***,
21-23 October 2014, Brussels, Belgium



Stefano Cirilli e Pierluigi Bassetto

Comparison between air temperature measured inside a conventional large wood shelter and by means of present day screens

Franco Stravisi,
Stefano Cirilli *(University of Trieste, Department of Mathematics and Geosciences)*

Abstract. A conventional large wood thermometer shelter is compared in field with a set of present day PVC and aluminium screens, in order to test the continuity of climatic air temperature series and the performance of current sensors.

Introduction

In 1992 new generation commercial instruments were introduced at Trieste in order to replace gradually the conventional mechanical equipment in use, almost unchanged, for more than one century. Air temperature and humidity are probably the most critical parameters to be measured, since strongly depend on solar screen (mainly temperature) and sensor (mainly humidity) type. Here we are concerned with air temperature only, with two objectives in mind: *(a)* to assure continuity of the time series by using new instruments in such a way they could render temperature data equivalent to those obtained in the past; *(b)* to test different present day passive solar screens in order to adopt the “best” one.

The meteorological station of Trieste

Instruments are located on the roof of the Nautical Institute, close to the sea (45° 38 ’50.66” N, 13° 45’ 52.42” E). Air temperature records at Trieste start at the end of XVIII century (3 measurements/day); since 1884 hourly data have been obtained with mechanical thermographs corrected by means of daily readings from minimum and maximum thermometers (Stravisi, 2006). The large wood shelter (LWS; fig. 1), based on a standard local design, was made in 1978; it has louvered walls, double along the three southern sides. In 1992 a Micros datalogger with related meteorological sensors began to work (fig. 2). Considering the time response of the different type of instruments and the speed and memory capability of the logger, we decided to sample data every 30 seconds and to compute and store the corresponding averages every 10 minutes Stravisi, 1988). This method was very appropriate for temperature, because the extremes of 144 daily data proved to be equivalent to the readings of the MIN/MAX thermometers.

Fig. 1.- *Trieste: large wood shelter* (LWS) *and conventional instruments.*

Conventional shelter and small screen

The new (1992) temperature sensor was a class B Pt100 connected to the data logger by means of a 4-wire cable mounted inside a PVC passive screen consisting of five 21 cm diameter cones and a flat 24 cm top cover (fig. 2). A second Pt100 was installed inside the LWS close to the reference thermometers. Both Pt100 have been calibrated

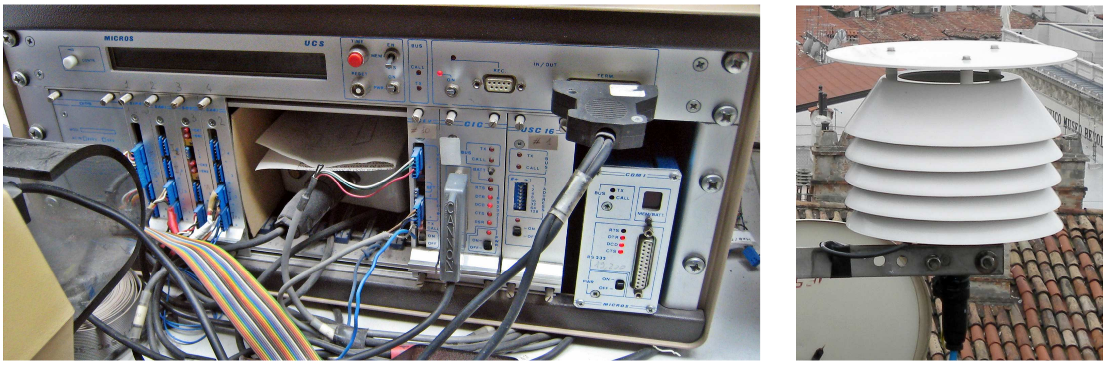


Fig. 2.- *Micros datalogger and PVC screen* SR.

in situ, with their final cable, by immersion in water at two temperatures; the resulting small linear corrections were introduced in the acquisition program of the datalogger.

For a few years daily readings from the reference MIN/MAX thermometers inside the LSW were continued: a comparison with the daily Pt100 (10 min averaged) extremes showed that their equivalence was quite acceptable, within a 0.3 °C standard deviation.

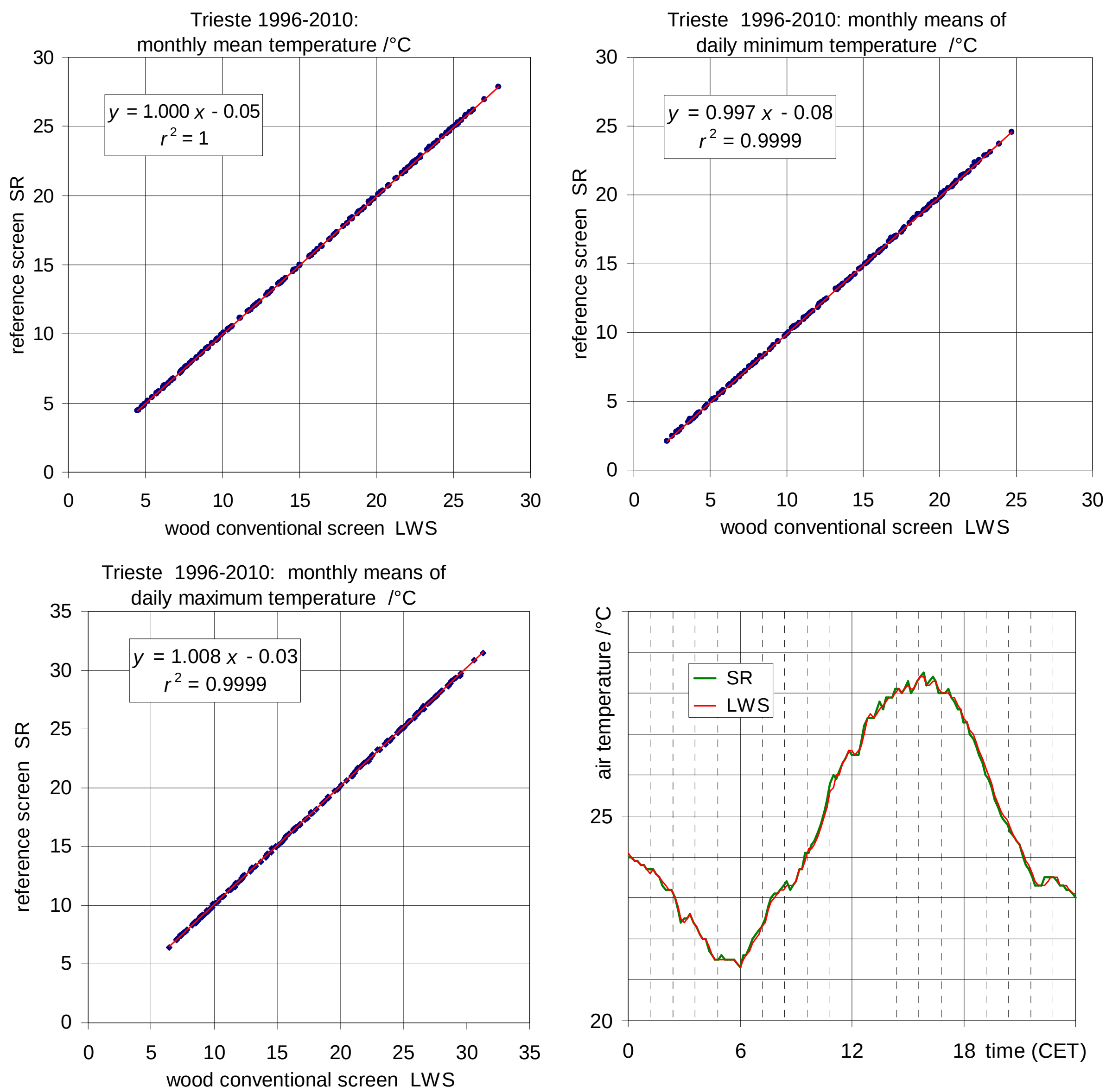


Fig. 3.- *Comparison between* Pt100 *air temperature measured in* LSW *and* SR.

The behaviour of the “old” LSW and the “new” SR has been observed for many years; fig. 3 shows the correlations between monthly values, years 1996-2010, of the mean temperature and the means of daily extremes. The conclusion is that the small PVC screen SR works, at all practical climatic effects, like the conventional wood shelter. The only difference, looking at the time response (10 min data, fig. 3), is that SR is a bit faster. After this 15-year test we could consider current methods reliable and homogeneous with the past methods and define, under this point of view, screen SR as our reference screen. Pt100 sensors, after a good calibration, are accurate and stable, and the routine use of reference thermometers is no more necessary.

Comparison of different passive screens

After twenty years it was time to update the electronic equipment in use at the meteorological station of Trieste. The use of current generation dataloggers is welcome: they are faster, have more local memory, and let us replace the old modem with an internet connection. As far as we are concerned here, problems can arise with new types of commercial screens. Therefore, without dismissing the well proved SR, we decided to test something new. This could be done thank to Nesa s.r.l., which provided us with different screen models; all these were realized in aluminium, with white powder coated 16 cm diameter conical lamellas and anodized aluminium stem. These characteristics should assure better reflectivity, resistance and duration than PVC screens.

Fig. 4.- *Test site at the meteorological station of Trieste.*

Tests were performed in natural operational conditions, assembling all screens close to each other and to the reference screen SR (fig. 4), over a deep shady courtyard to avoid warm air uplift from the roof. Data were recorded some months for each model; the same Pt100 type, 1/3 DIN, adopted by Nesa, was used in all screens.

SR **S1, S1’** **S2, S3** **S4**

Fig. 5.- *Reference and test screens.*

The following screens have been considered:

SR (reference), 5 PVC cones, 21 cm diameter, 24 cm diameter top, teflon stem;
S1 4 aluminium cones, 16 cm diameter, top cone, anodized aluminium stem;
S1' same as S1, with 5 cones, bottom open;
S2 4 aluminium cones, flat 16 cm diameter PVC top;
S3 same as S2, with 7 cones;
S4 6 aluminium 16 cm cones, 24 cm PVC top, teflon ring between stem and sensor.

In general, all Sn screens yield temperatures higher than SR: overheating is reduced from S1 to S4 (fig. 6). In the following only these two screens will be considered, since the behaviour of S1', S2 and S3 lays between S1 and S4. Overheating will be studied as a function of mean wind velocity and solar irradiance; all data are 10 min averages. Results are showed in fig. 7; S4 strongly improves the air flow around the temperature sensor reducing the still air overheating, and improves the sun protection as well. The use of a white Pt100 cap and the insertion of a teflon ring for thermal insulation in the support stem also help.

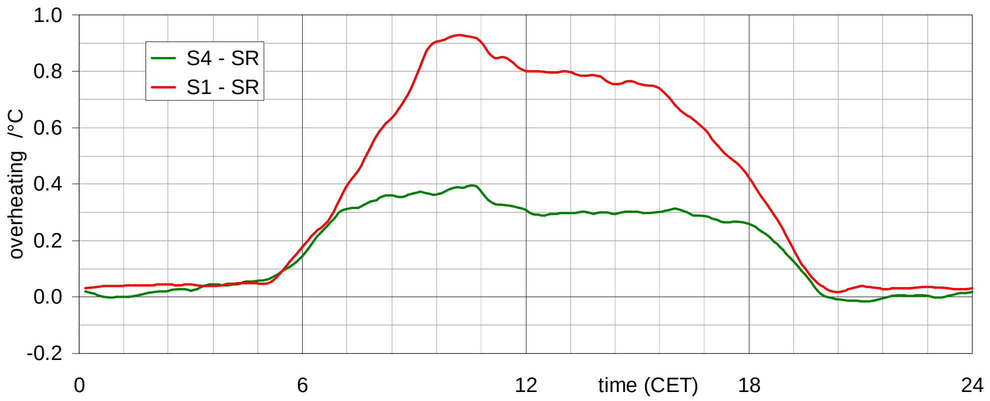


Fig. 6.- *Mean daily cycle of the air temperature difference (overheating) between* S1, S4 *and* SR.

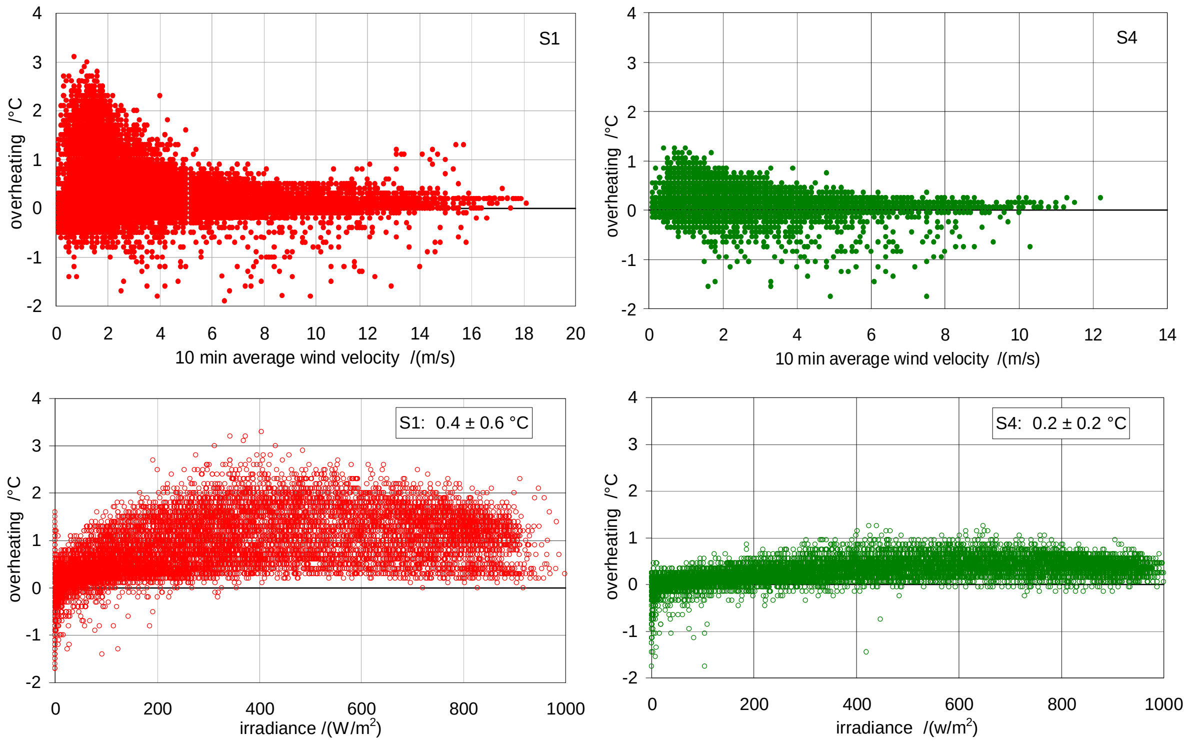


Fig. 7.- *Screen* S1 *(left) and* S4 *(right): temperature difference from* SR *as a function of mean wind velocity (top) and solar irradiance (bottom).*

Conclusions

The result of this test is that, for aluminium screens of these kind, the mean overheating can be reduced from 0.39 ± 0.59 °C (S1) to 0.15 ± 0.24 °C (S4); these figures are in line with those found by de Haij et al. (2013) for other screens. One should probably deduce that larger PVC screens are better than smaller aluminium ones, a convenient diameter being about 20 cm but, in order to attribute better quality to material or size, we should reproduce, for a future test, exactly identical screens.

Dimensions could also affect sensor protection by heavy rainfalls. An example is shown in fig. 8, an event (16 July 2014) with a maximum precipitation rate about 1 mm/min and wind gusts up to 15 m/s: the smaller screen S4 shows a temperature drop almost 4 °C higher, suggesting the psychrometric effect of a wet sensor. Note that the other Sn behave the same as S4, and that all screens use the same Pt100 type and therefore have the same time response.

A passive solar screen working in all kinds of weather conditions around the world is probably out of reach; however it should be strongly recommended to define, by means of international studies and agreements, a good standard model to be used in all scientific meteorological stations.

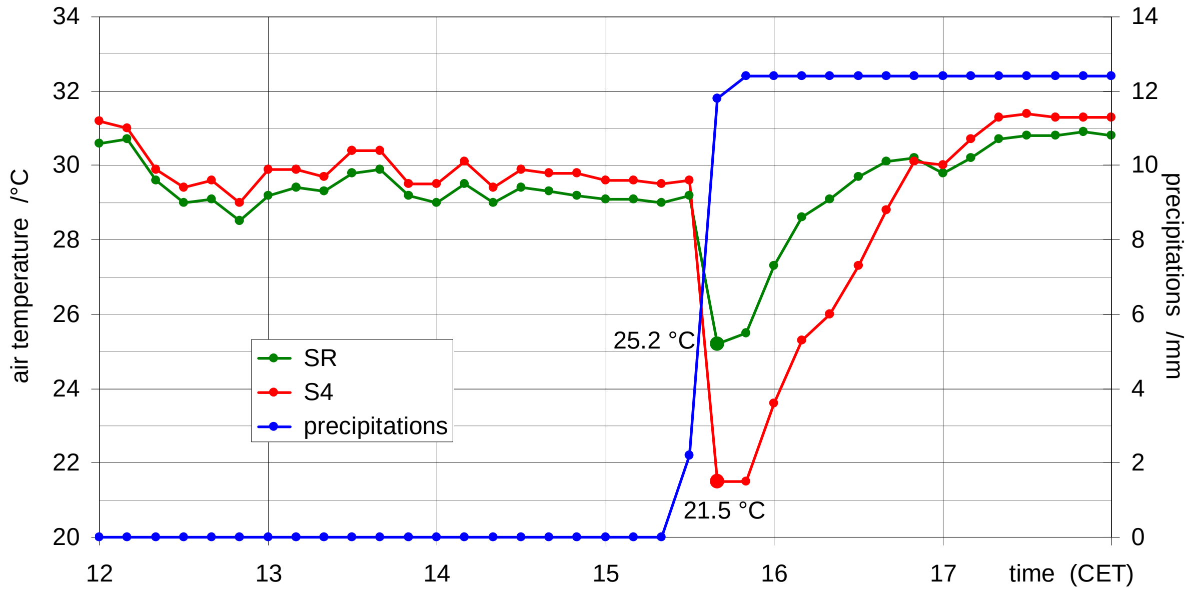


Fig. 8.- *Rain sensitivity of screens* SR *and* S4 *(16 July 2014 event).*

REFERENCES

DE HAIJ M., BIJMA J. AND PROKSCH N. (2013): *“(Too) hot or not? Field experiment with the KNMI thermometer screen*”, Royal Netherlands Meteorological Institute (KNMI).

LACOMBE M., BOUSRI D., LEROY M., MEZRED M., (2011) *“WMO field intercomparison of thermometer screens/shields and humidity measuring instruments”*, in: WMO Instruments And Observing Methods Rep. 106, WMO/TD No. 1579.

STRAVISI F. (1988): *"METEHO": a Fortran program for filing hourly meteorological data*, Trieste Univ., DMG, Rep. 9, 14 pag.

STRAVISI F. (2006): *La meteorologia a Trieste*, in: G.C. Cortemiglia, “La variabilità del clima locale relazionata ai fenomeni di cambiamento globale”, Pàtron ed. Bologna, 245-288.