TECHNICAL CHARACTERISTICS OF A HOMOGENEOUS URBAN METEOROLOGICAL NETWORK

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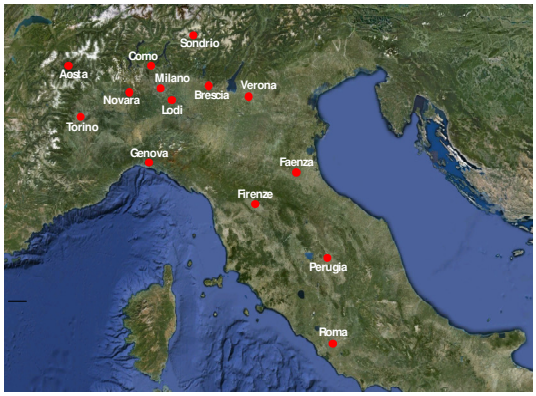
Climate Consulting s.r.l.

CLIMATE NETWORK® is a private and professional network of urban meteorological stations in Italy. Its aim is providing high quality weather data to industries and service sectors. Climate Network is particularly interesting for subjects operating in urban contexts and for whom the weather and climate data are sensitive variables in decision-making and management.
CLIMATE NETWORK® is designed, built and organized expressly to ensure high quality and consistency of data with high metrological and managerial standards.
The aim of maintaining and improving the quality of Climate Network data is supported by a constant attention to scientific research and development. Therefore our staff participate in important international projects of meteorological metrology and modelling.
Once completed, within the next 3 years, the network will consist of approximately 80 stations and it will cover the main national urban centres (fig. 1).
In cities with vast metropolitan areas We are realizing "weather urban networks". The weather urban network of Milano metropolitan area currently consists of 19 stations, 8 of which in Milano, and it has been working for two years (fig. 2).

We are able to supply daily the max, min and average measurements with a maximum time resolution of ten minutes, for the following meteorological parameters:
O TEMPERATURE (2 sensors, one of them redundant)
O RELATIVE HUMIDITY
O ATMOSPHERIC PRESSURE
O RAIN – amount, intensity and duration
O HAIL – amount, intensity and duration
O WIND SPEED AND DIRECTION, gust included (ultrasonic bi-axial sensor)
Some stations are also specialized to measure:
O SOLAR RADIATION - GLOBAL, NET, UV

APPLICATIONS IN THE ENERGY INDUSTRY:
Our measurements can be applied to:
CURRENT WEATHER DATA:
• fuel supply for thermal plants
• operation and maintenance of heating/cooling plants
• budgeting (heating and cooling degree days)
• contracts and tender offers
• use of weather derivatives

TIME SERIES:
• determination of the urban climate
• reliable meteorological inputs for energy demand modelling
• energy planning
• urban designing and planning
• design and verification of the effectiveness of urban climate mitigation and adaptation plans
• time-series modelling and probabilistic forecasts of daily temperatures
• weather derivatives modelling and pricing

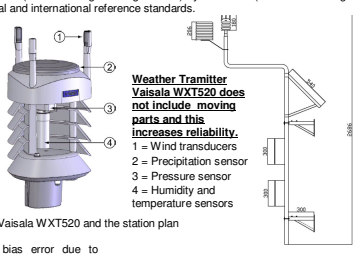


Main towns monitored by Climate Network®

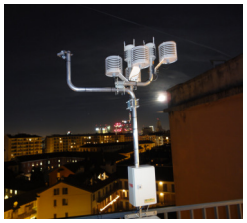
Milan weather urban network

COMPARABILITY AND HOMOGENEITY

Comparability is the level of confidence we get when different data series are compared. It results, for example, when we compare temperatures in city centers to temperatures in peripheral areas in order to determine the presence of a heat island effect.
We have to compare data not only from different sites but also in different moments, for example evaluating the evolution of temperatures in decades, as we do in climatological studies.
One of the main target of Climate Network is building decadal database of meteorological measures with the highest level of comparability.
We can obtain this standardizing hardware and software of our stations, using identical and documented criteria in weather station positioning and first of all with the metrological traceability.
Metrological traceability became a mandatory requirement after the signing of the CIPM-MRA (Mutual Recognition Agreement) by the WMO (World Meteorological Organisation) and since then every meteorological measure had to be related to the national and international reference standards.



Some Climate Network meteorological stations with their Weather Trasmitter Vaisala WXT520 and the station plan

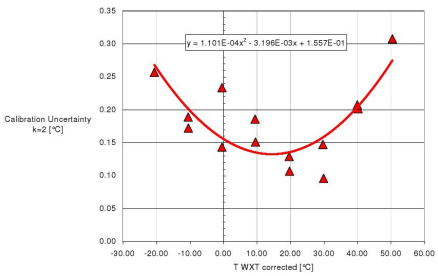

Sensors testing "tree"

The standardization can result in a bias error due to replication of measure's errors in the same quantity in all identical stations.
This is the reason why we take special care to stability of our reference standards, through periodic calibration of thermometric probes, comparative tests and interlaboratory tests with the National Metrological Institute.
Every modification of hardware and software of our stations is tested on field in our test site on the headquarter terrace. Our test site replicates the Climate Network base station and includes other sensors such as, radiometer and PT100 sensors with and without ventilation. For example the particular curved shape of the pole turns away the temperature sensor from the column of hot air generated by the heating of the solar panel especially during cold and clear winter days.


Climate Network testing station

CALIBRATION UNCERTAINTY ESTIMATION

The uncertainty estimation is a fundamental part of calibration process.
Every calibration increases uncertainty and we get, at the end of the traceability chain, the final calibration uncertainty.
Normally we can find uncertainty as a list of values. But we need uncertainty to be valued for every single value measured.
This is the reason why we express uncertainty as a function, in this way we can associate for every single value measured its own uncertainty.
This is a good starting point but we are doing comparative tests on field in order to estimate the variability due to influence parameters such as: wind, humidity, solar radiation, shelters ageing and so on .
With these additional data we are going to give our clients an uncertainty of measure in real conditions.
We know that a few decimal points of temperature's measurements move million euros, it is important, therefore, to know the uncertainty level of data and their confidence interval.



WXT Corrected	WXT Correction	WXT regression deviation	WXT Uncertainty U k=2
29.93	0.09	0.02	0.10
40.21	0.15	0.02	0.20
50.46	0.26	0.05	0.31
39.99	0.07	-0.06	0.21
29.73	0.00	-0.06	0.15
19.66	0.04	0.01	0.13
9.50	-0.06	-0.06	0.19
-0.40	0.10	0.10	0.23
-10.47	0.03	0.01	0.19
-20.55	-0.03	-0.08	0.26
-10.41	0.06	0.04	0.17
-0.40	0.05	0.05	0.14
9.60	-0.05	-0.05	0.15
19.78	0.04	0.01	0.11

Calibration uncertainty function graph and calibration data table

REPRESENTATIVENESS

Urban areas represent, from the climatic point of view, a sort of "hot spot" due to the heat island effect. Thus we need a solid study base to position meteorological stations in cities. Thanks to the large number of stations in Milan we can make a sort of validation of Climate Network positioning criteria and general approach to the urban climate.

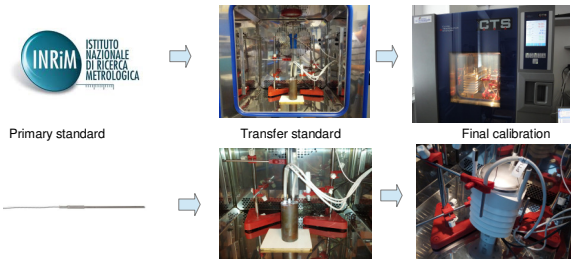
CN measuring target and task:
– Urban canopy layer (UCL) for (urban) energy applications, to more exactly measure the urban roughness sublayer (at building top height) characteristics.
CN siting criteria:
– Urban sites, building roofs, free of very local effects, fulfilling WMO/TD-No. 1250 2006 requirements, but in some cases logistics conditioned!
Verification:
– Through interpolation of nearby stations and comparison with measured data results for winter 2012-13

Conclusions: With few exceptions (likely in the real UCL because of atypical sites more isolated, and at higher elevation over ground) the CN is able to reproduce measured data with errors of less than about 0,2°C downtown Milano.

Station Nr and Name	Interpol. Radius [km]	Interpol. stations	Mean difference Interp.-Meas. [°]	Variance [°C]	Remarks
01-Univ. Stat.	6	7	-0,10	**0,12**	Urban, residential
02-Bicocca	6	6	+0,01	**0,02**	"
03-Sempione	5	5	-0,24	**0,05**	"
04-Bovisa	6	7	+0,05	**0,06**	"
06-Politecnico	5	5	+0,13	**0,10**	"
07-Bocconi	6	5	-0,26	**0,04**	"
08-Milano Sud	6	5	+0,72	**0,11**	atypical site! Industrial outskirts
10-S. Siro	7	7	+0,68	**0,21**	atypical site! 62 m over flat ground

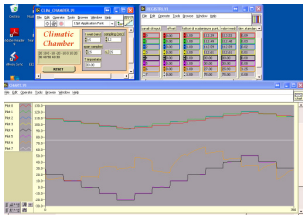
METROLOGICAL TRACEABILITY

Traceability is the property of a measurement result, where the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.
Our traceability chain starts from a Secondary Reference Platinum Resistance Thermometer (Fluke 5616) and has been calibrated, along with his multimeter (Fluke Hydra 2620A), at the National Institute of Metrology (INRIM) in Turin, Italy. The first line standard and the multimeter are combined in a single equipment: they have been calibrated together in order to maintain a single measurement chain.

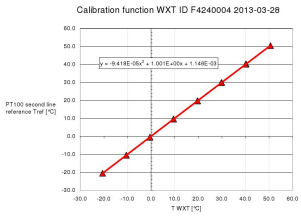


Primary standard — Transfer standard — Final calibration
First line reference standard U@ 20 °C 0,03 °C — Second line reference standard U@ 20 °C 0,04 °C — Weather trasmitter Vaisala WXT520 U@ 20 °C 0,14 °C

In our climatic chamber the first line reference standard is used to calibrate three Resistance Thermometers (PT 100 ohm in Class A according to IEC 751) and they are also connected to the multimeter Hydra 2620. The process consists of a sequence of temperature points. The calibration starts at 30°C then, by steps of 10 °C each, climbs up to 50°, drops down to -20°C, climbs again to 20°C.
By doing so, the process involves the sensor hysteresis and provides data used to estimate uncertainties.
The first line and second line standards are included in a comparison copper block in order to ensure temperature homogeneity. Finally we calibrate all our Vaisala WXT520 weather stations in the same climatic chamber, comparing them to the secondary reference standard thermometer.



Calibration program panel



Calibration function graph

ON FIELD TESTING

A good laboratory pratice isn't enough to guarantee good measures. While we can control many of the influence parameters in laboratory, we can't do the same on field.
We have many ways to study sensor's behaviour:
• simulating field condition in laboratory (system choosed by the national institute for metrology in the Meteomet project);
• comparing different sensors, with different principles of measure in order to evaluate biases;
• comparing identical sensors, in the same site with the same reference for calibration, in order to evaluate the minimum variability and get a real measure uncertainty along with the calibration uncertainty.
We have designed some sites specialized on a specific measurand (Milano Bicocca - Rain, Milano Politecnico – Solar Radiation, Torino – Wind).
In these sites we can test different instruments with different principles of measure, to get field data and to improve our knowledge of measure.

Climate Consulting is a partner

METEOMET
Metrology for Meteorology

Metrology for pressure, temperature, humidity and airspeed in the atmosphere