Climate Consulting s.r.l.

OMD
Osservatorio Meteorologico
di Milano Duomo

Urban Climate Monitoring: the "Climate Network®" in Milano

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STRUCTURE OF PRESENTATION

- **Climate Network:** description and importance of monitoring weather data in urban city centres
- **Study case in Milano area:** Heat waves and Urban Heat Island phenomena
- **Climate Network Future Goals and Potentials**
- **Conclusions and Further Developments**

The Climate Network CN®

CLIMATE NETWORK® : Private and professional network of urban meteorological stations in ITALY. Managed by **CLIMATE CONSULTING Srl**, company founded in 2010 on the tradition of **Osservatorio Meteorologico Milano Duomo** (OMD) (ex Brera), existing from 1763.

Why monitoring URBAN weather?

Cities are continuosly evolving (due to the rise in city population):

- Development of built-up areas and metropolitan areas to the detriment of green areas

Evolution of cities' needs in terms of:

- Energy demand (more heating and cooling electrical consume)
- Urban planning
- Building construction technologies and building materials

Weather data can support the future urban planning and the management of the energetic resources.

That's why CN exists: to provide high quality weather data measured in urban areas!!!

The Climate Network CN® Description

- National coverage: Stations located in the main Italian cities in URBAN areas, such as MILANO, TORINO, FIRENZE, ROMA..

- Nowadays (Sep 2013): **32** fixed meteorological stations located on the national territory

- Within 2016: **80** fixed meteorological stations and some mobile stations

- **Variables measured** (resolution 10 min):
  - **Temperature** (average, min, and max)
  - **Relative Humidity** (average, min, and max)
  - **Atmospheric pressure** (average, min, and max)
  - **Rain** (amount, intensity and duration)
  - **Hail** (amout, intensity and duration)
  - **Wind speed and direction** (ultrasonic bi-axial sensor)
  - **Solar radiation** (global and diffuse) (not in all stations)

Climate network

The Climate Network CN® KEY STRENGHTS

HIGH QUALITY and **CONSISTENCY** of WEATHER DATA, with HIGH **METROLOGICAL STANDARDS**.

HOMOGENEITY OF THE STATIONS:

- Same criteria to place all stations: terraces or top roofs in city centres (fulfilling WMO/TD-No. 1250 2006 requirements: correct representation of URBAN CANOPY LAYER)
- Same type of weather stations (VAISALA WXT520)
- Same calibration method for all Temperature sensors.

INTERNAL CALIBRATION LABORATORY:

Using referential instruments certified by the National Institute of Metrological Research of Torino, we calibrate temperature sensors:
CALIBRATION UNCERTAINTIES are:

✓ U_T = 0.14 °C (at 20°C)

(Poster EMS2013-296-GF61 (ASI6))

First line reference standard:
Secondary Reference Platinum Resistance Thermomether calibrated at INRIM, National Istitute of Metrology in TORINO

Second Line reference standard:
3 Resistance Thermometers (PT100 OHM)

Our sensor:
Weather trasmitter Vaisala WXT520

The Climate Network CN® AIM

Climate Network (high quality) weather data can support all **urban activities/sectors** influenced by weather conditions:

- **Energy companies:** to manage energy connected to heating and cooling demand

- **Insurance companies** for extreme meteorological events (ex. Hail or cloud-burst…)

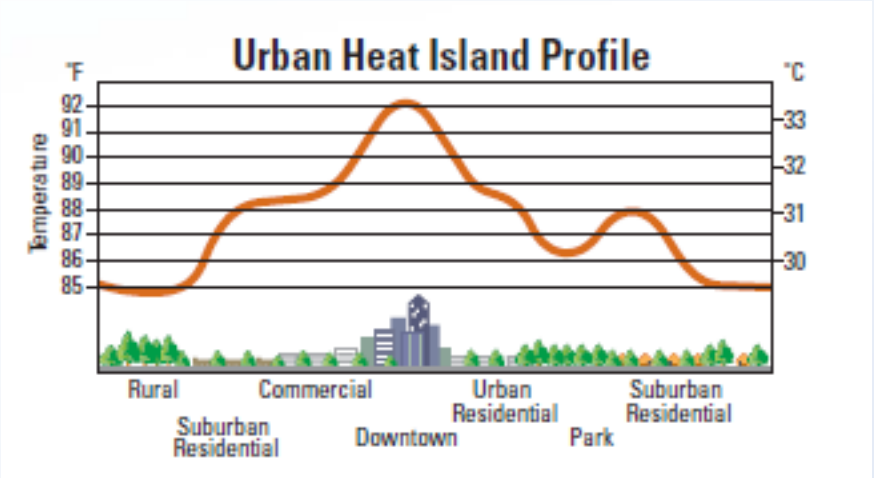
- **Building** and **trasport** sectors

Urban area's development leads to:

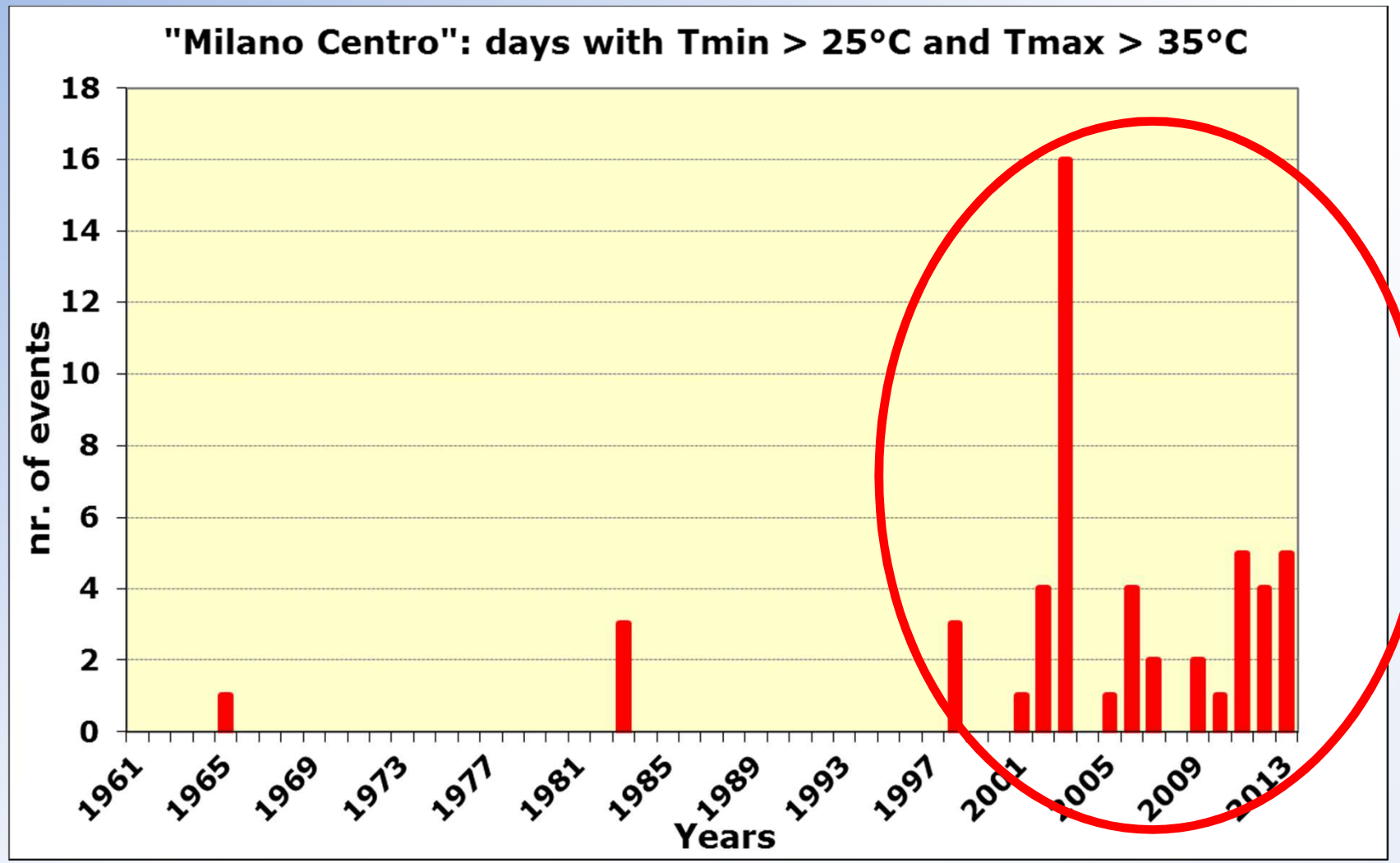
- UHI **Urban Heat Islands**: urban regions experience warmer temperature than their rural surroundings;
- **Heat waves** (hot and wet days with Tmax > 35°C e Tmin >25°)

(EPA estimated that every increase in summertime temperature of 0.6°C implies an electric demand increase of 1.5 -2%!!!!).

Important economic implications!!!



Ex. Heat waves in Milano City Centre from 1961 up to 2013:

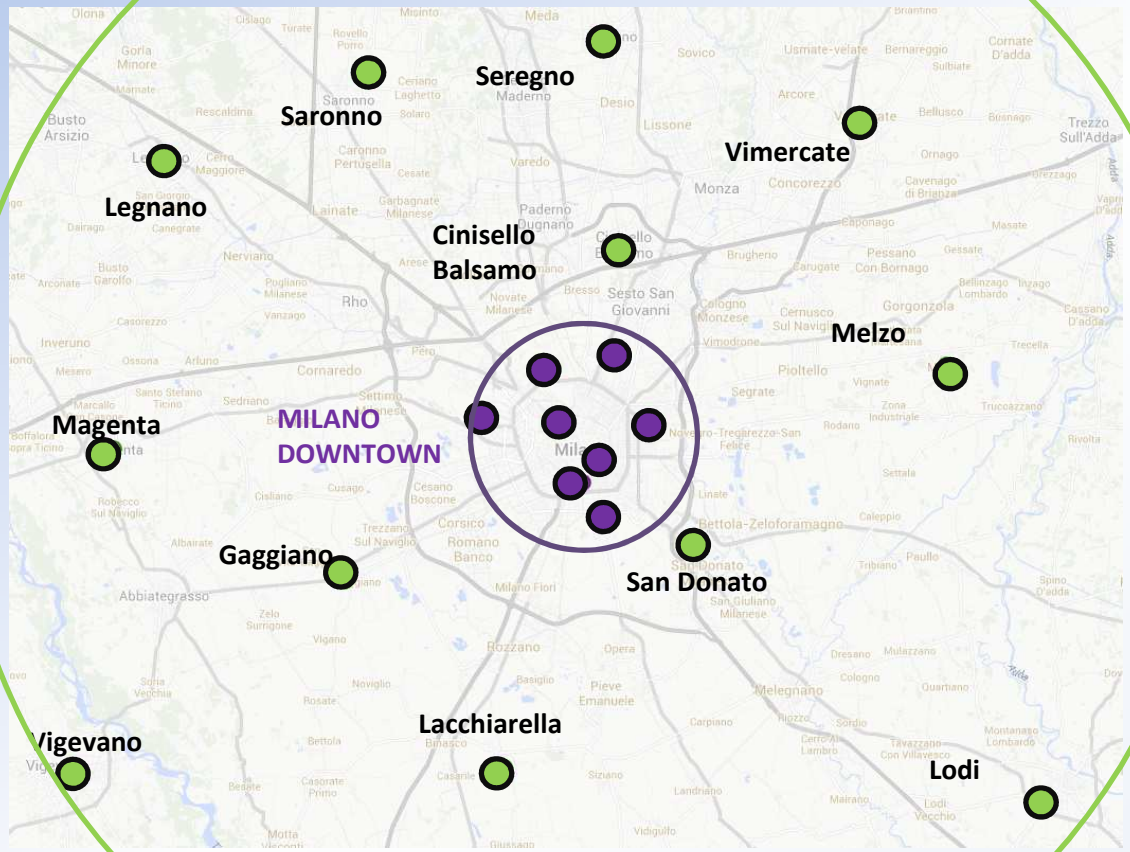


In the last years, the number of heat waves is definitely rising, up to 16 days of the summer of 2003.

Weather Urban Network: Milano case

To study the Urban Heat Island phenomenon in Milano area we are implementing a «weather urban network»:

- + MILANO AREA (central + surroundings): **20 stations** in a maximum radius of 35 km from the centre:
- MILANO DOWNTOWN: **8 stations** in a radius of 7 km from the «Milano Centro» station



We placed 20 stations because:

- Milano is hightly populated (5 million inhabitants in the entire Milano Area)
- Milano is in the centre of Po valley that, due to the orography, generates the atmospheric stability (70% of days/ year)

UHI are frequent and last a lot days!!!

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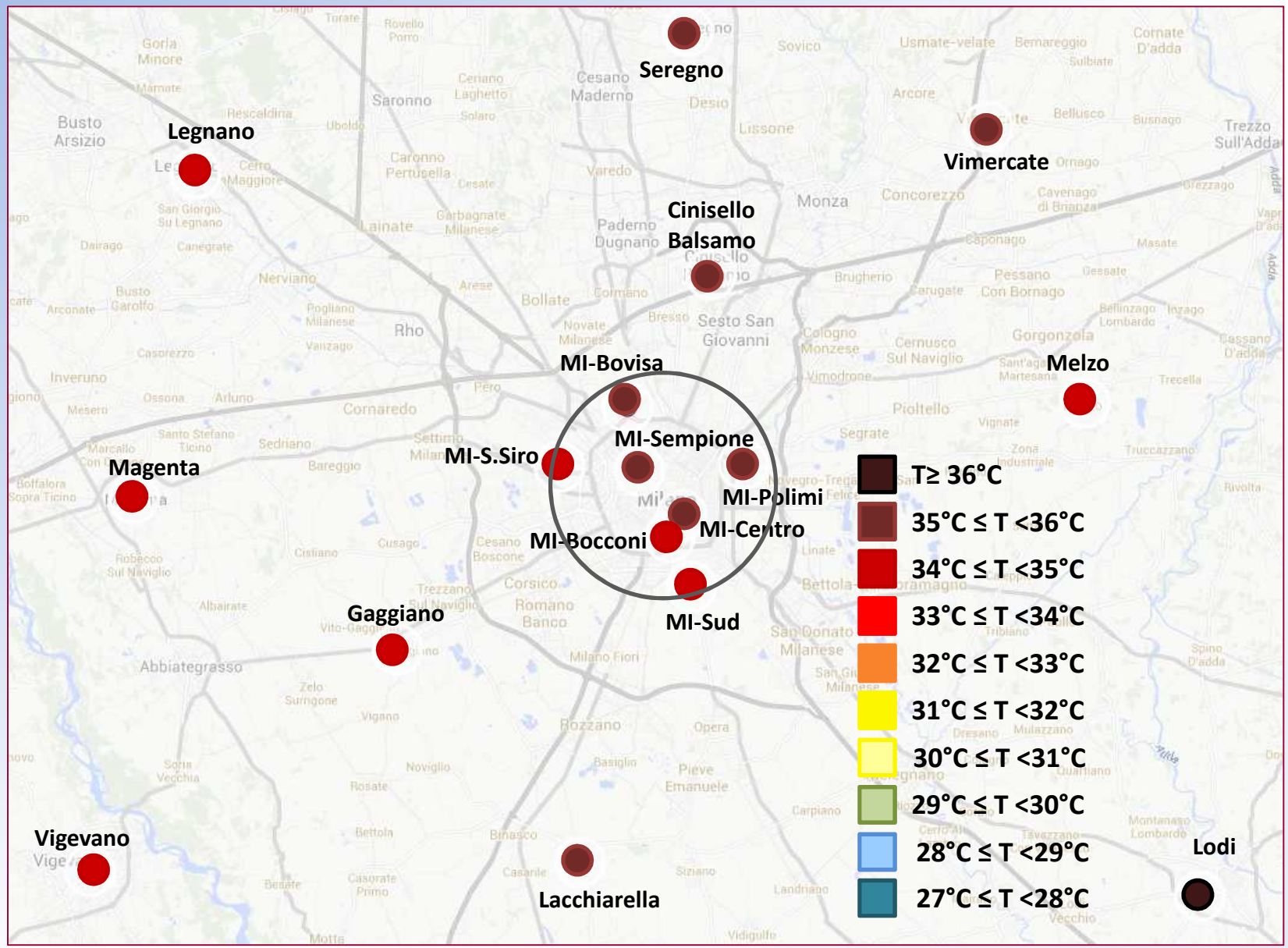
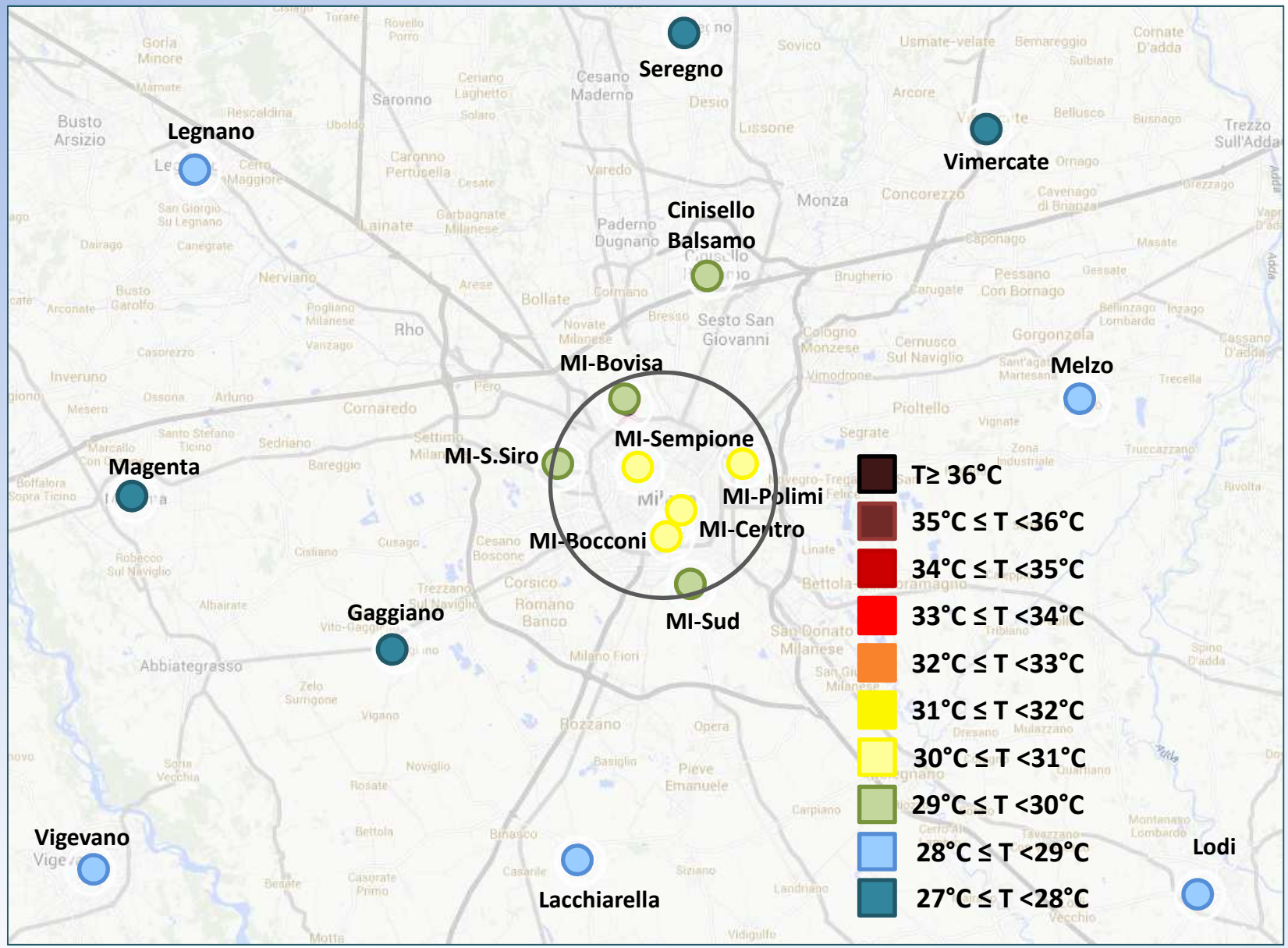
Metropolitan Milano Area: AVERAGE HOURLY TEMPERATURE (°C) - 21.08.2012 h. 3:00 – 4.00 pm



Metropolitan Milano Area: AVERAGE HOURLY TEMPERATURE (°C) - 22.08.2012 h. 0:00 – 1.00 am



CLIMATE NETWORK FUTURE GOALS AND POTENTIALS

Supply our customers with weather data (T, RH) for each site within Milano area, not only where we actually placed the stations.
HOW: By interpolation method, that can be applied due to the high density of stations in Milano area and good placement criteria

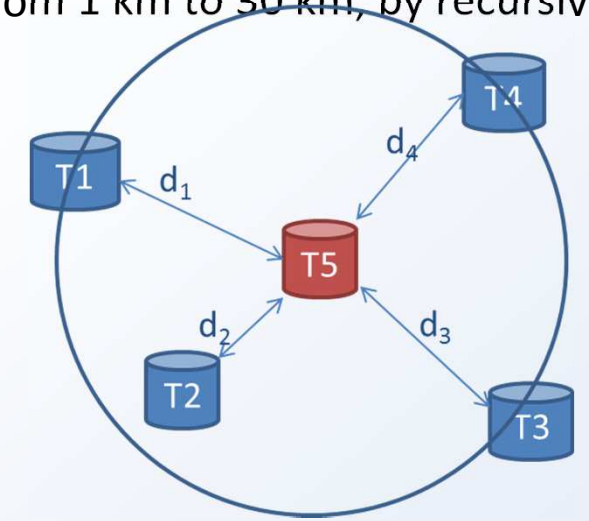
First Approach: **Interpolation method weighted on the squared distance of the stations from the maximum radius**

Estimation of the temperature corresponding to a given station by taking the weighted average of the temperatures observed by the surrounding stations.

Constrains: the minimum number of the considered surrounding stations needs to be at least **3** in a radius maximum than spans from 1 km to 30 km, by recursive range increments of 3 km each.

$$T5 = \sum_{i=1}^{4} \left(\frac{(R - d_i)^2}{\sum_{i=1}^{4} (R - d_i)^2} \right) * T_i$$

Weight



R = maximum radius
d_i = distance

Application of the this method to CLIMATE NETWORK DATA:

- DATA: CN ® mean daily values from June 2012 to May 2013 for all stations in Milano area
- Variables considered: Temperature, Relative Humidity

Comparison between interpolated and measured data

Name station	ΔT (Interpolated - Measured) averaged on 1 year data	σ of ΔT	R(km)	Nr. Stations
Milano Politecnico	0.14	0.23	5	5
Milano Bovisa	0.01	0.21	6	7
Milano Sempione	-0.16	0.19	5	5
Milano Centro	-0.24	0.24	6	7
Milano San Siro	0.61	0.30	7	7
Milano Sud	0.42	0.31	6	5
Milano Bocconi	-0.20	0.18	6	5
Milano Bicocca	0.05	0.15	6	6

For each station we evaluated: difference between measured and interpolated temperature values, averaged on a period of 1 year and their standard deviation.

In areas surrounding those stations where the annual mean difference and σ in Temperature are COMPATIBLE to MEASUREMENT UNCERTAINTY (0.25°C)

it will be possible to estimate the temperature, within those areas, without direct measurements!!!

Talk EMS2013-180 (ASI10)

CONCLUSIONS

CLIMATE NETWORK supplies weather data to all activities influenced by weather conditions, in particular to support energy companies and insurance companies in Italy.

In the future a multi-year database will allow to:

- Determine the urban area climatology
- Study of analysis models applied to energetic consumes
- Implement models for urban planning
- Check the efficiency of the plans of adaptation and mitigation adopted

FURTHER DEVELOPMENTS

ON STATIONS' PLACEMENT

- Fulfillment of the project of installing a total number of 80 weather stations in the entire national territory.

- Duplication the «urban weather network», firstly created in Milano, in other big cities, such as Roma or Firenze.

ON DATA ANALYSIS

- Development of the interpolation method taking into account also the ALTITUDE of stations' placement, and not only their LONGITUDE AND LATITUDE.
- Use of other interpolation methods
- Application of interpolation method on variables, like rain or wind, hightly depending on time and space.

THANK YOU VERY MUCH FOR YOUR ATTENTION!!!

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Climate network