Climatology of the Milano Canopy Urban Heat Island

by means of an operational urban meteorological network.

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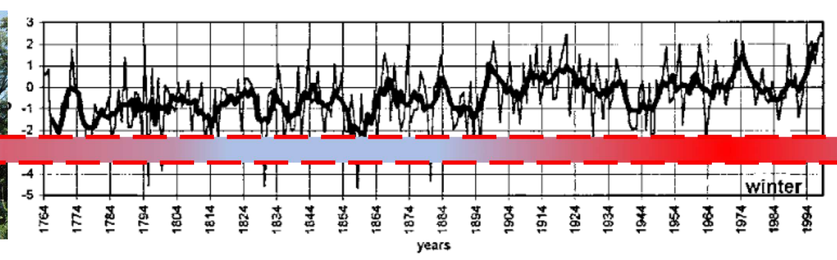
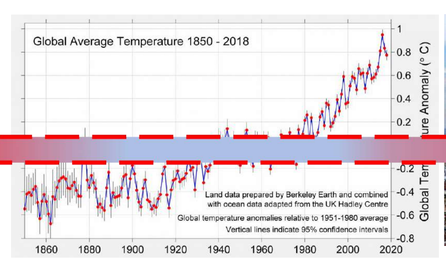
FONDAZIONE OMD

Motivation:

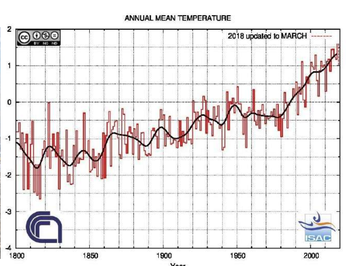
From past observations at Palazzo Brera in Milano ….



… considering urban evolution and global and local climate change….



…towards present and future needs :



Objectives

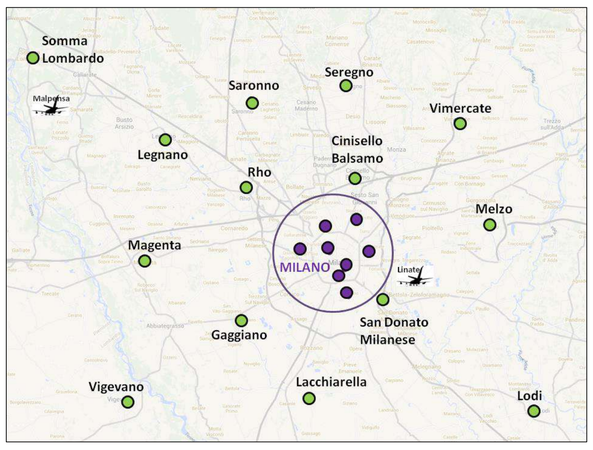
Updated and detailed urban climatology and UHI for general applications (as in ClimaMi project)

Tools

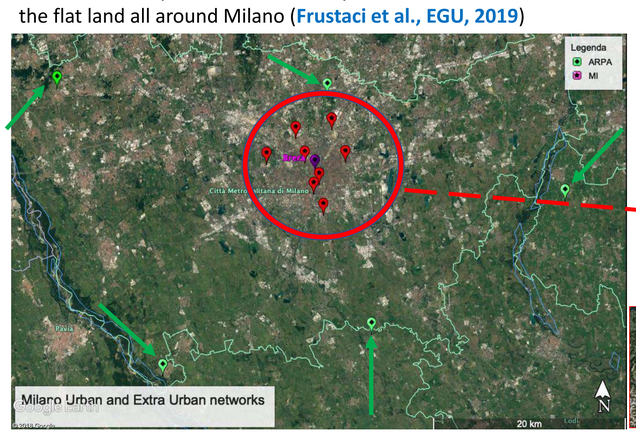
Fond. OMD Urban Climate Network, Milano subnet:

(Curci et al., MST, 2017)

Urban temperatures and other ECV at top of Urban Canopy Layer since 2011:



Extra urban temperatures: accurately selected rural stations in the flat land all around Milano (**Frustaci et al., EGU, 2019**)



Methods

UHI Index: difference "urban" minus "rural" temperature:

$$I_{UHI} \equiv T_u - T_r$$

Definition of **Urban Temperatures** T_u for this work:

- Measured at top of Urban Canopy Layer
- Siting and exposure as in: **Oke, IOM Report Nr. 81, 2004**
- Managed with «metrological» criteria as in MeteoMet , **Merlone et al., MST, 2017**
- Periodical calibration/maintenance and reference to national standards
- Extended and detailed metadata (Sensor exposure, Albedo, LCZ, etc.) as in **Curci et al., MST, 2017**
- Considering specially: A systematic review and scientific critique of methodology in modern urban heat island literature, **Stewart I.D, Int. J. Climatol. 31: 200–217 (2011)**

Definition of **Rural Temperatures** T_r :

- Data vailability , continuity and quality
- Effective rural siting, WMO class 1 sensor exposure

Separation of meso-synoptic phenomena from **real Urban Heath Island effect:**

- Meteorological filtering
- Frequency distribution analysis

UHI meteorological filters:

- Selection of cases with weather conditions a priori considered well suited for the development of a significative UHI phenomenon

or, better:

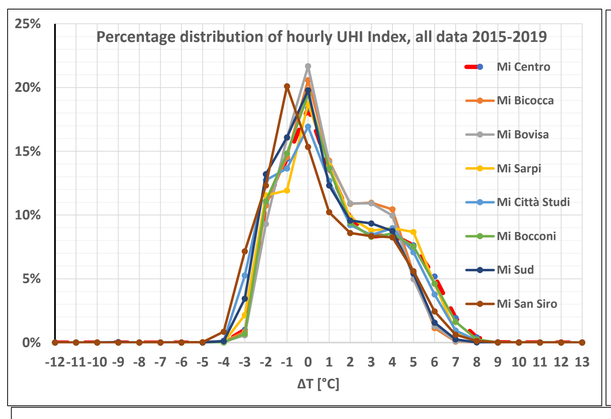
Synoptic / UHI distribution:

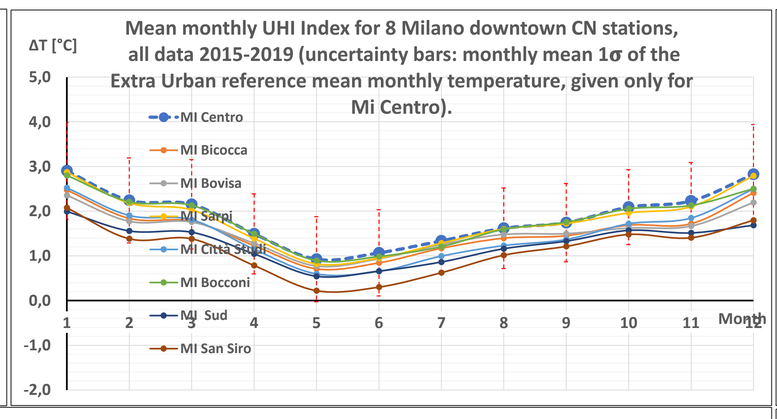
- Frequency distribution of UHI Index
- Lower limit of significant UHI Index
- Correlations with weather variables

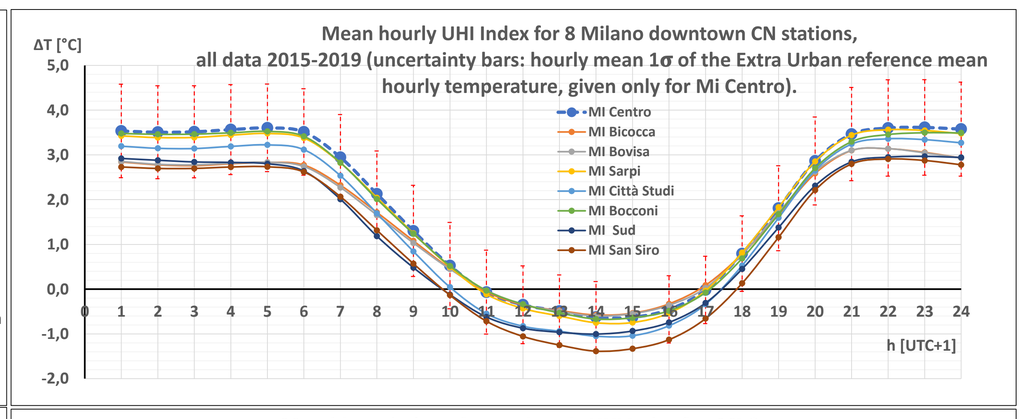
Results

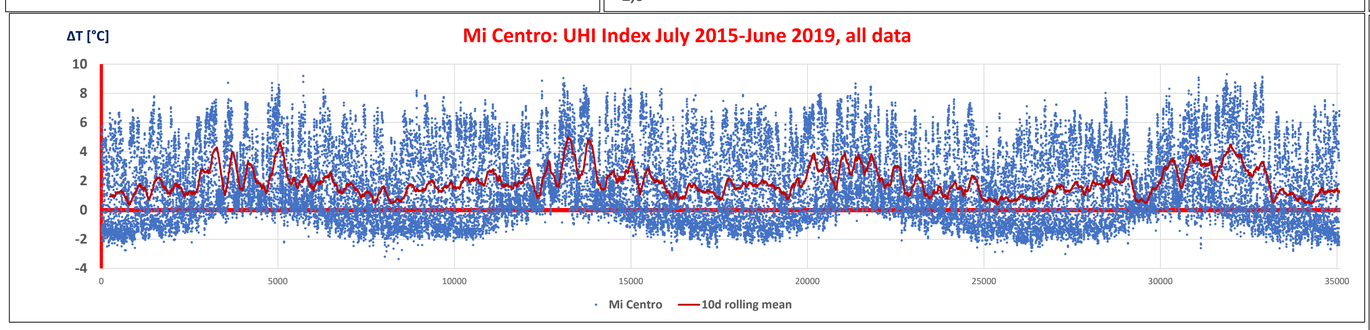
Milano UHI Index statistics

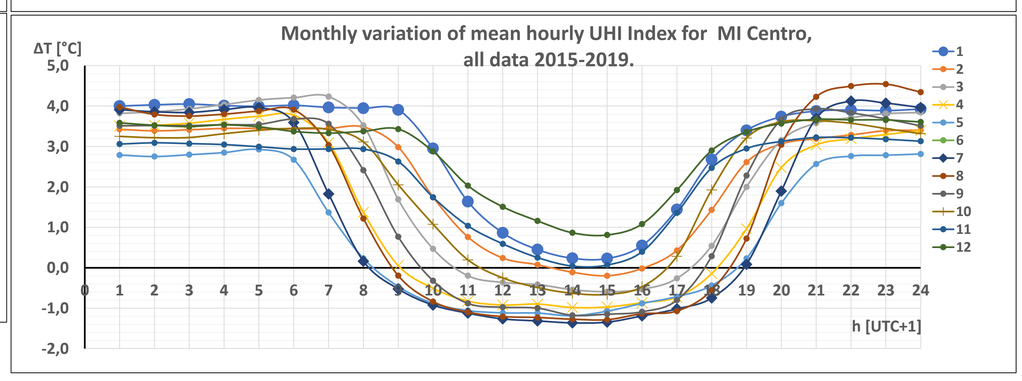
4 full years dataset. Computed UHI index: **99,98%** of nominal total of **35064** hourly observations



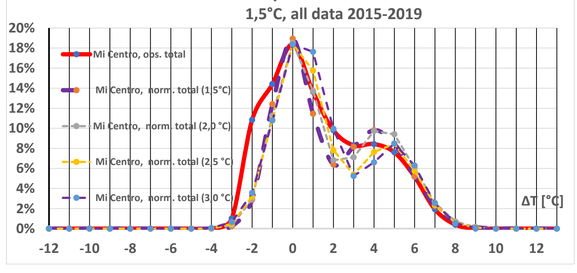








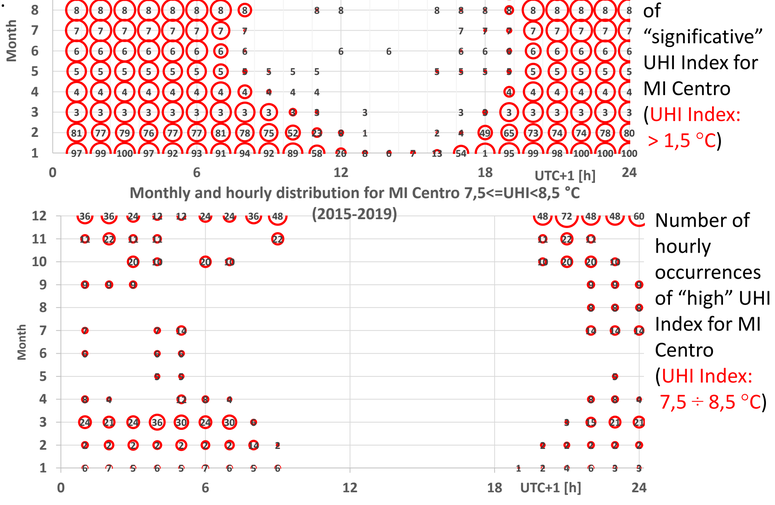
Filtering the (meso-)synoptic component



Gaussians from mean and std. dev. of observations for the synoptic (UHI Index ≤ 1,5°C) and the UHI (UHI Index > 1,5°C) components of the bimodal distribution.

The choice of the separating UHI Index value at 1,5°C is based on the minimum obtained fitting RMSE.

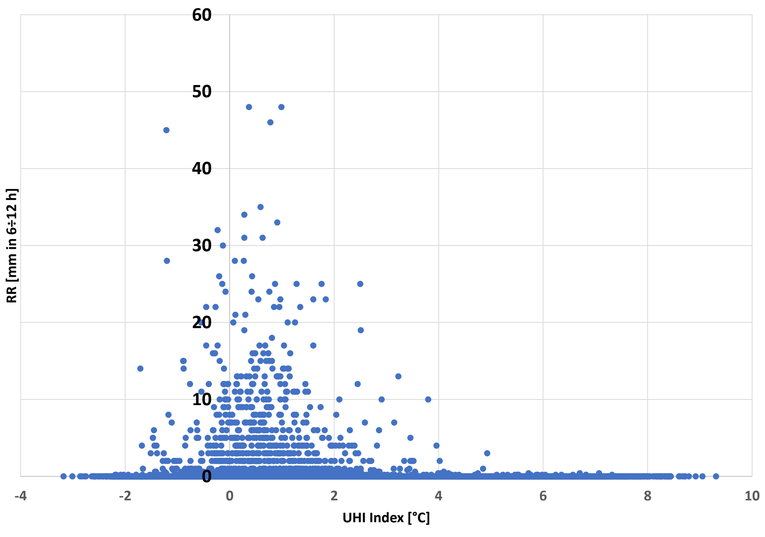
Filtered UHI Index statistics



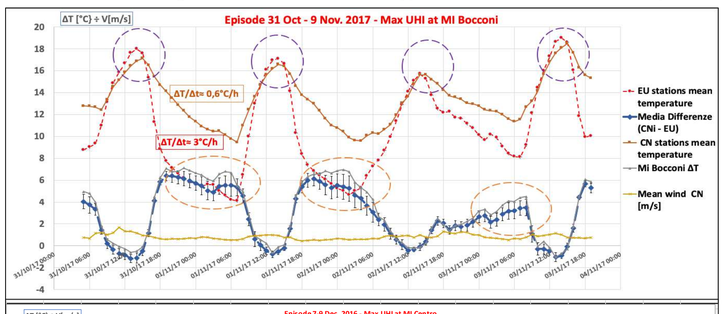
Number of hourly occurrences of "significative" UHI Index for MI Centro (UHI Index: > 1,5 °C)

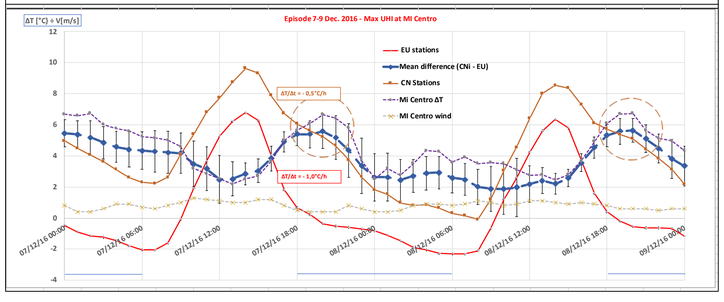
Number of hourly occurrences of "high" UHI Index for MI Centro (UHI Index: 7,5 ÷ 8,5 °C)

UHI Index classes and synoptic weather



Differential cooling estimation for Milano typical nocturnal UHI's development





Conclusions:

- Suitable and efficient observational network and methodology
- Marked Milano UHI effect of about 3,5 °C in the yearly mean
- UHI mainly nocturnal and winterly and up to 10 °C
- Strong seasonal variation with evident diurnal negative UHI
- Synoptic noise overlapping and prevalent for $I_{UHI} < 1,5$ °C
- Differential cooling in late evening of about 0,5÷2,5 °C/h

Further work:

UHI and Heath Waves
UHI and Meso-synoptic weather
Comparison with high resolution:

- remote sensing data
- urban modelling output