Improving the WMO Guide n.8. Results on the experimental evaluation of the effect of presence of obstacles in the vicinity of sites hosting near-surface meteorological measurement. The case of the road.

Graziano Coppa[1], A. Quarello[2,3], A. Merlone[1]

[1]*INRiM, Istituto Nazionale di Ricerca Metrologica, Torino, Italy*

[2]*UniTo, Università di Torino, Torino, Italy*

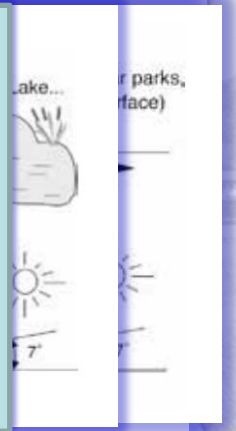
[3]*Université Paris Diderot, Paris, France*

Siting related uncertainty

WMO current classification of meteorological observation sites is a qualitative one based on operative procedures by Météo-France.
It establishes a 5-class hierarchy based on the distance of the sensors from a range of obstacles (roads, trees, buildings,

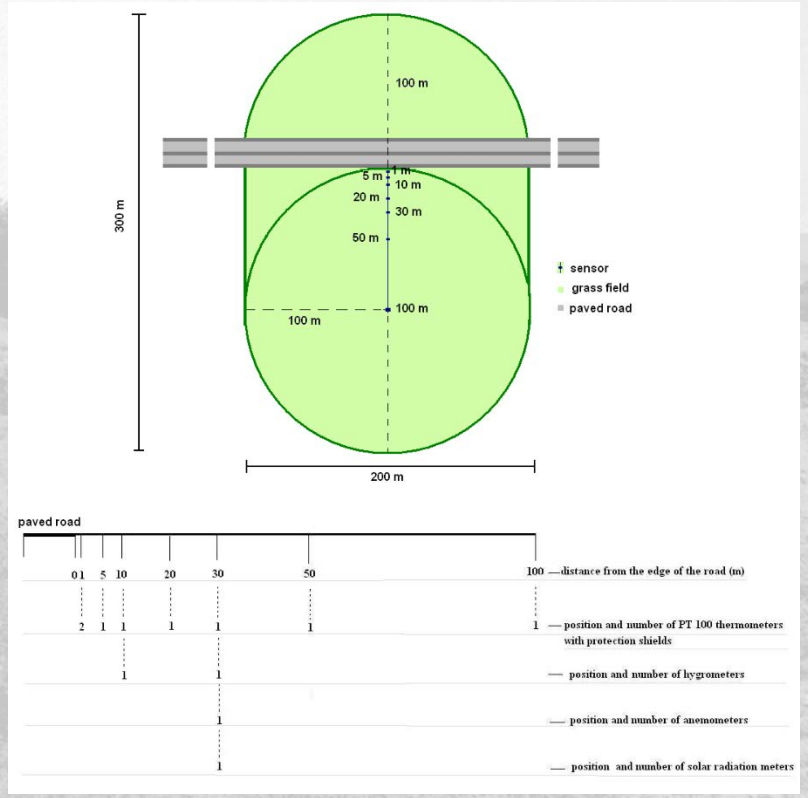
Class 5

None of the previous!



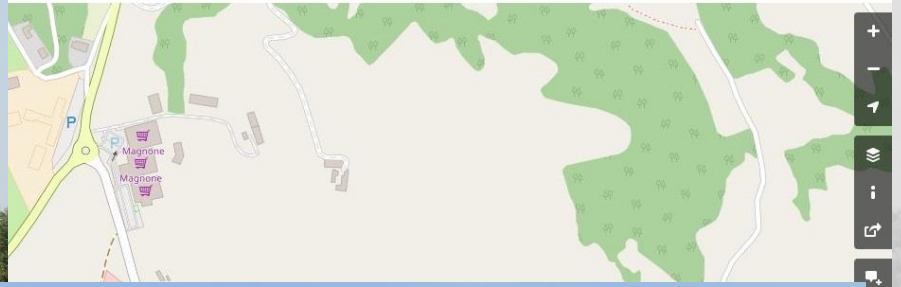
Within project MeteoMet2 a task is dedicated to the evaluation of the influence of obstacles **(«siting»)** on the uncertainty in surface air temperature measurements.
INRiM, CEM, CMI and IMBIH prepared a threefold experiment, in three different countries, each one dedicated to the evaluation of different siting effects on temperature.

Experimental layout



- 7 Pt100 thermometers + 1 redundancy
- 2 hygrometers (#3 - #5)
- 1 anemometer (#5)
- 1 radiometer (#5)

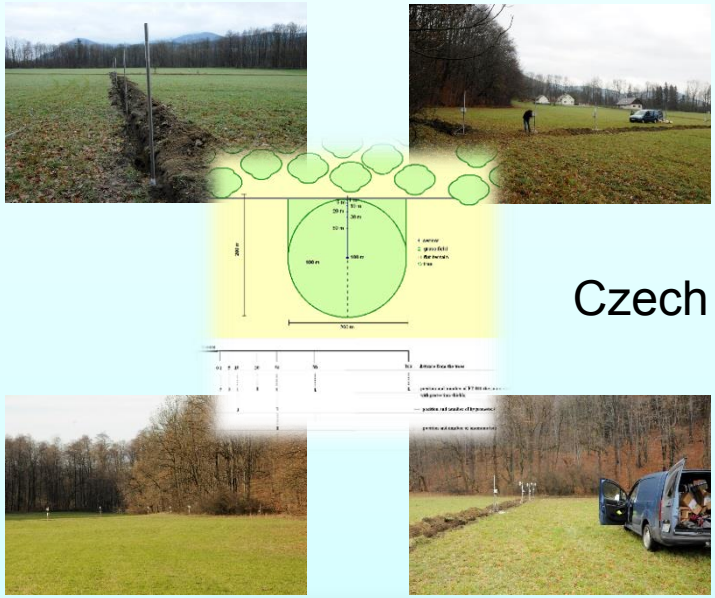
Castelnuovo Don Bosco airfield



Sister experiments

Trees

Morávka field (Czech Republic)



Czech Rep.

CZECH METROLOGY INSTITUTE

Buildings

Elgorriaga factory, Ávila (Spain)

Spain

P1_10

CEM CENTRO ESPAÑOL DE METROLOGÍA

Data and principle

- One full year of data
- Time interval: 30 s
- > 1,000,000 records (and 13,000,000 fields)

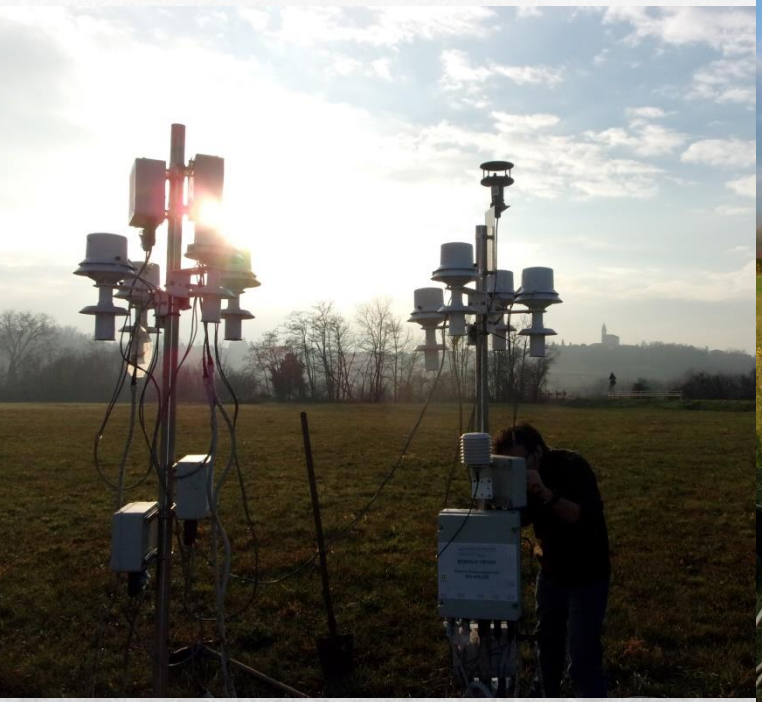
How to handle this very large amount of data?

No correction will be provided -> only the «worst case scenario»

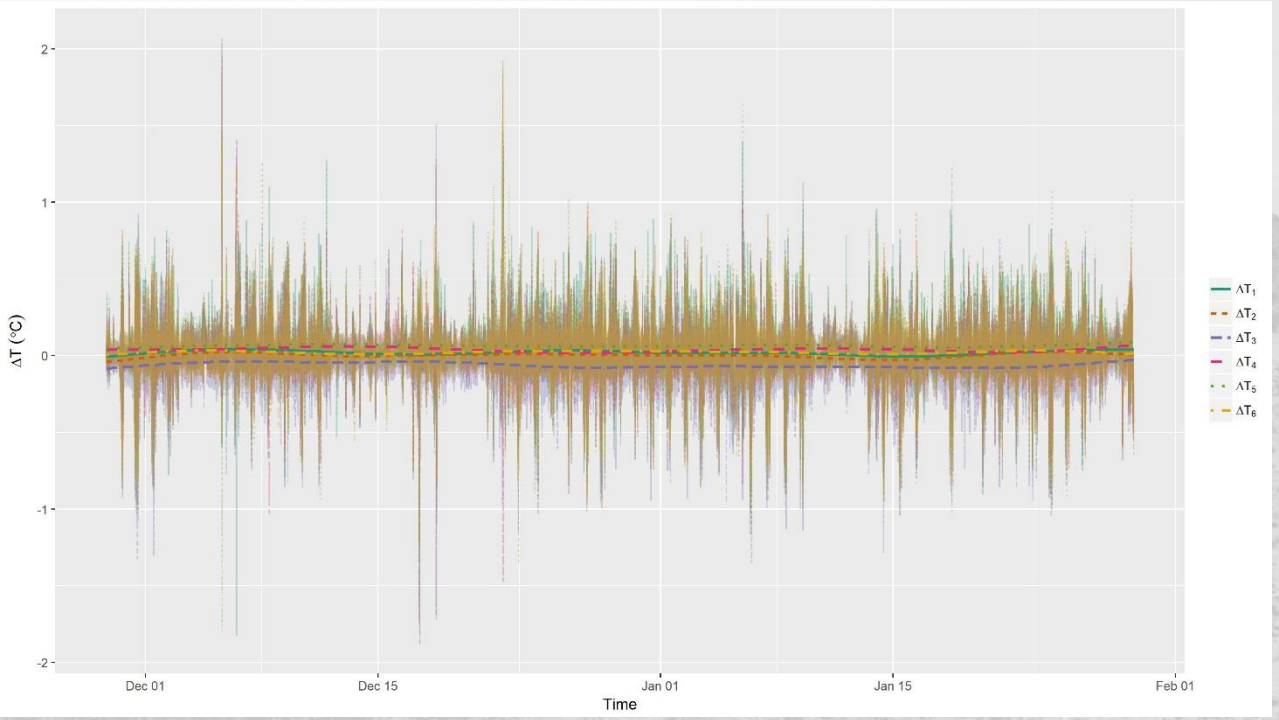
The idea: we are going to identify subsets of data where our «road siting effect» is most evident

Measurement uncertainties

Evaluation of in-field behaviour of thermometers in the same conditions



Measurement uncertainties



Evaluation of in-field behaviour of thermometers in the same conditions

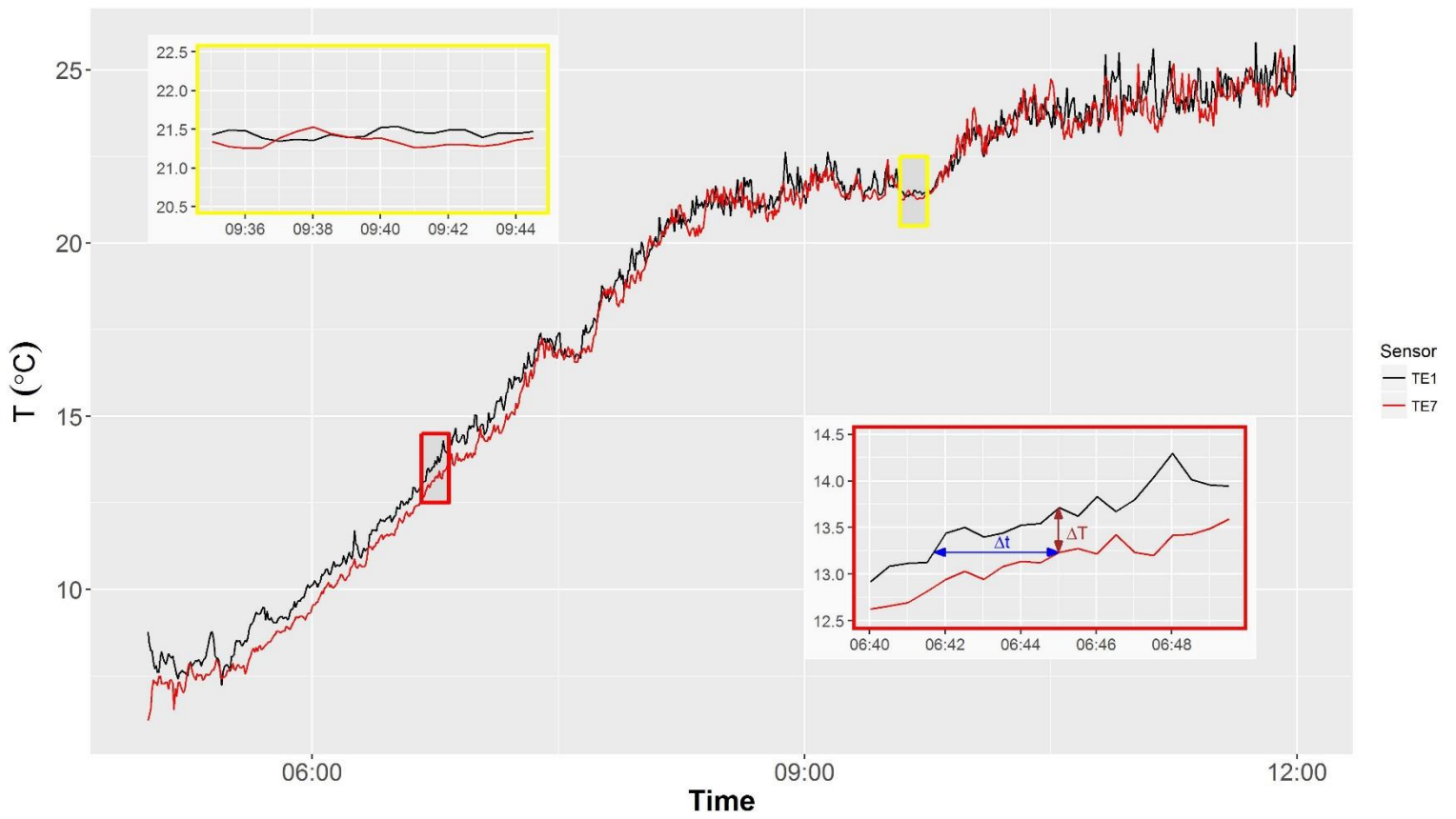
MAX(ΔT) = 2 °C (spikes)

ST.DEV(ΔT) = 0.1 °C

This is what we assume as measurement uncertainty

Also useful to assess systematics (#1)

The analysis…



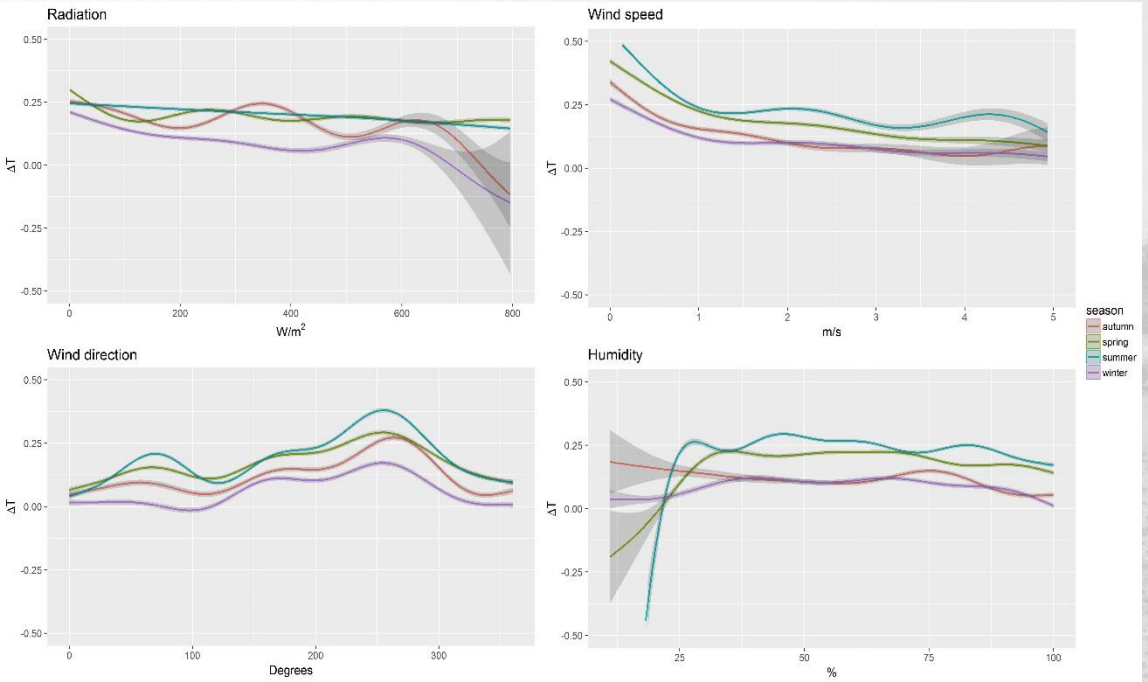
The analysis…

Semi-parametric GAM model for ΔT1:

$$E(\Delta T_1) = s + s_1(RAD, \lambda, s) + s_2(WS, \lambda, s) + s_3(WD, \lambda, s) + s_4(H, \lambda, s)$$

Where s_j are smooth non-linear functions, based on thin plate regression splines

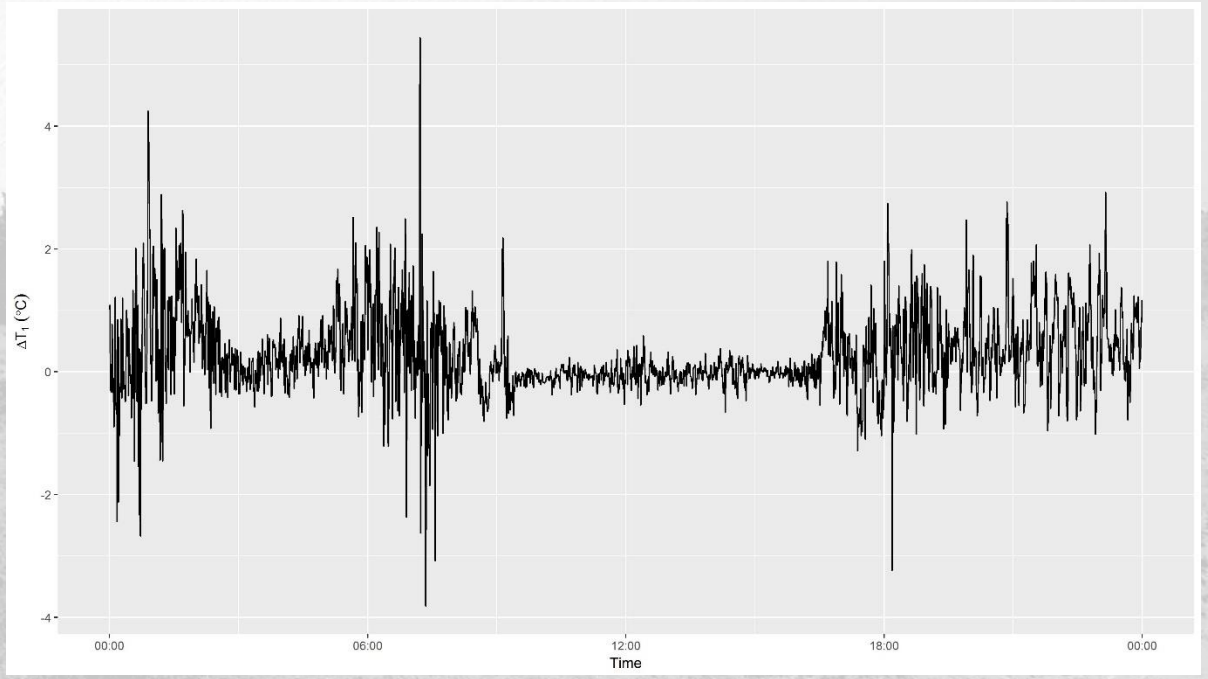
The analysis…



The statistical analysis has given important insights about the dependencies of the effect:

- larger at lower radiation values
- larger at lower wind speeds
- larger with lateral winds
- Independent of humidity

The analysis…

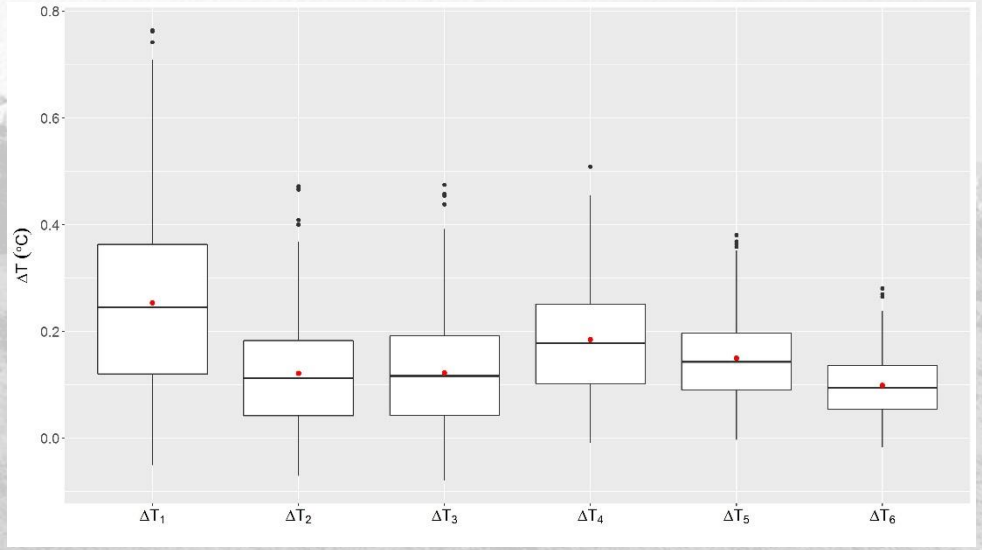


Typical day behavior

Differences lower during the day (as suggested by the GAM analysis

-> Only nights analysed

Underlying effect

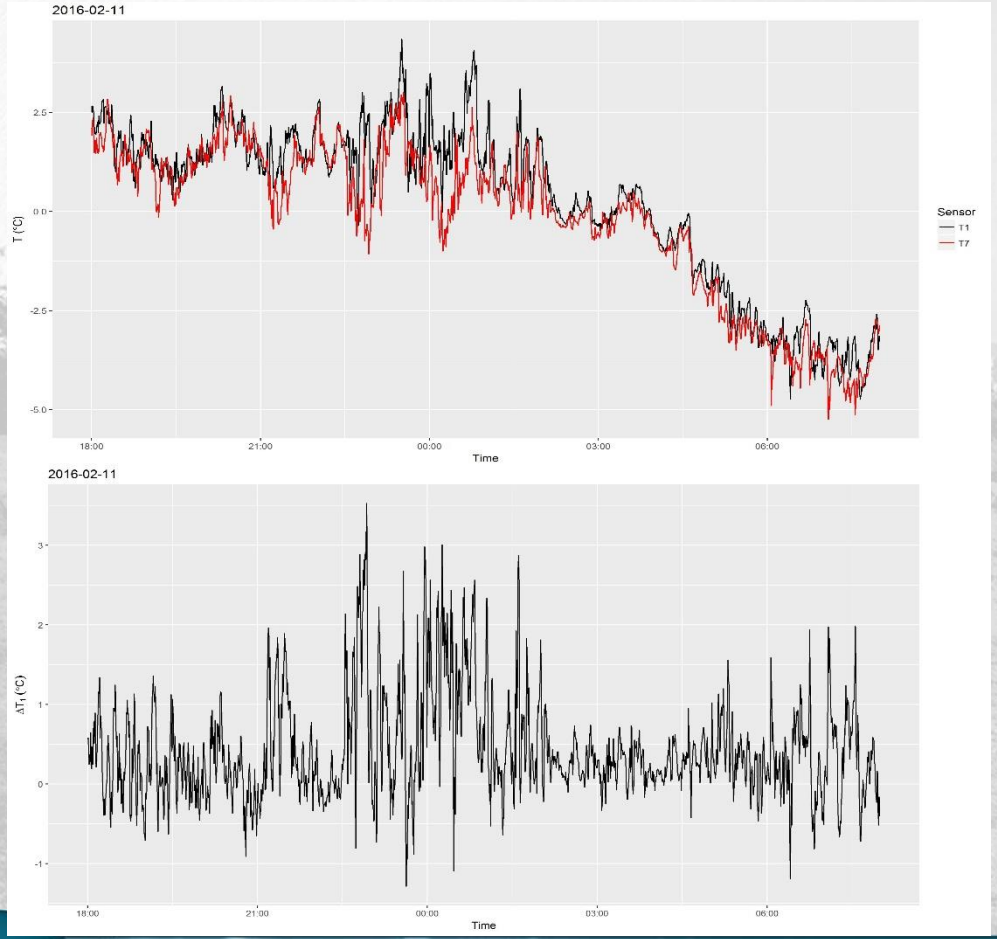


Distribution of ΔTi during nights

- only ΔT1 shows a clear road effect signal,
- all other ΔTi are positive, even though no definite trend can be detected (compatible with a flat distribution)

Effect only detectable very close to the road (~ 0.25 °C)

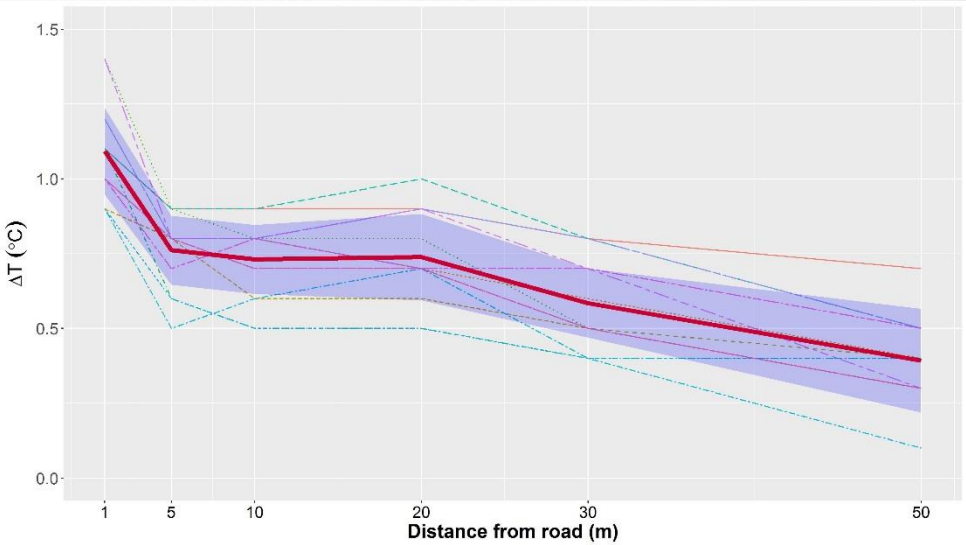
Principal effect



Shorter but sustained effects were found, especially right after sunset

By visual inspection at the nightly plots, we selected some clear examples of sustained differential heating between TE1 and TE7: for these events, also the temperatures measured by the other stations were checked.

Principal effect



Plot of the ΔTi from a number of sustained events converted into distances from the road considering TE7 as the reference measurement.

Sharp decrease in ΔT within 5 m from the road, a plateau up to 20 m, then a slow and steady decline until the 50 m station.

Uncertainty budget

	1 m	5 m	10 m	20 m	30 m	50 m	100 m
Type A							
Measurement	0.13	0.13	0.14	0.13	0.09	0.12	0.11
Underlying	0.16	0.10	0.10	0.10	0.07	0.06	0
Effect	0.14	0.12	0.12	0.14	0.12	0.17	0
Type B							
Calibration	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Datalogger	0.024	0.024	0.024	0.024	0.024	0.024	0.024
Total (*k=1*)	0.25	0.20	0.21	0.22	0.17	0.22	0.11
Extended (*k=2*)	0.50	0.40	0.42	0.44	0.34	0.44	0.22

Conclusions

- Instrumental contribution to uncertainty 0.1 °C
- Max ΔT up to 5 °C
- All ΔT larger than 2 °C are found in short spikes (0.08 % of all measurements) -> not attributable to road siting!
- Larger effect at nights and with weak or no wind. No dependence from humidity
- Underlying night effect of about 0.25 °C
- Sustained (1 hour) ΔT of about 1-2 °C

Summarizing

- Siting effect on uncertainties in temperature measurements
- 3 identical experiments (road, trees, building)
- Avoid rapid temperature changes!
- Semi-parametric statistical model built -> road experiment

Coming next

- Apply study to 10-20 minutes averages eliminating turbulent flows

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

METEOMET
Metrology for Meteorology

Thanks for your attention