Air temperature retrieval from crowd-sourced smartphone battery temperatures for Dutch cities and its application in mesoscale model validation

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Context: OpenSignal App



- OpenSignal: application for smartphones
- Evaluates strength of wireless networks
- Free
- Also stores battery temperatures
- Sensor battery temperature: prevent damage



Data selection

Selected two groups of data (covers 60% of total dataset):

- Smartphone just plugged in the loader, and charges
- Smartphone is switched on or off and the battery discharges

Not selected: smartphone just unplugged and decharging

1.3 million records for 8 cities
At least 400 measurements available for 80% of the days, on average 844 (per city)
Two periods in 2012: 7 May - 31 August (summer) and 1
September - 22 November (autumn)
Reference: WMO-station at airport (5 - 27 km from centre)



Data selection – 8 cities



Overeem et al (2013)



Heat transport model



Overeem et al (2013)

- Assumption: smartphone is carried close to the user's body
- Heat of the smartphone in equilibrium with heat flows to and from the body and environment
- Conduction between the two systems proportional with temperature difference between the systems
- Convection, radiation and external heat sources neglected.



Heat transport model

Estimation of daily averaged air temperature from the daily mean battery temperature:

$$\overline{T}_{\mathbf{e},j,d}^{\mathbf{A},\mathrm{day}} = m_j(\overline{T}_{\mathbf{p},j,d}^{\mathbf{A},\mathrm{day}} - T_0) + T_0 + \epsilon_{j,d}$$

Value of m_j determined per season and per city Value of T_0 determined for all cities and all seasons Split dataset in two for calibration and validation







Daily mean temperatures – 8 cities



summer

autumn





of 573 km². Based on data from June 1, 2013 - August 31, 2013 (92 days). This selection has not been applied: "only those days have been selected with at least 100 observations and at least 20 hours with readings". The black circles represent the locations of the 30 most populated cities in the Netherlands.

Figure 1.11: Daily average number of selected battery temperature readings for area sizes Figure 1.12: Daily average number of selected battery temperature readings for area sizes of 92 km². Based on data from June 1, 2013 - August 31, 2013 (92 days). This selection has not been applied: "only those days have been selected with at least 100 observations and at least 20 hours with readings". The black circles represent the locations of the 30 most populated cities in the Netherlands.

of smartphone readings vs resolution?







Overeem et al (2014)

Netherlands – smaller scale: Amsterdam



City center scale

O: Health authority weather station

Wide Amsterdam Area



Overeem et al (2014)

Ref: Health Auth stations





Overeem et al (2014)

Adam city centre

area

"Wide" Adam

Even smaller, Utrecht (Netherlands)



Work in progress: towards hourly observations





WRF set-up

- Inner domain focused on Amsterdam, 600x600 m resolution
- August 1 & 2, 2013 (hot days) 3 days spin-up time
- Single-layer Urban Canopy Model
- Observations from GGD Amsterdam: mean of 5 stations

52°26'N -52°24'N -52°22'N -52°20'N -4°46'E 4°48'E 4°50'E Courtesy: Arjan Droste netherlands





OpenSignal

Science center

Dominant category (category)

WRF results Amsterdam



More information



http://opensignal.com

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End

Thanks for your attention

Junartphone

T_e





Discussion

- Method works often by averaging over many battery temperature records.
- Part of observations might be indoors
- Smartphones not always in pocket
- Constant value of m_j per city and per season (reality: each measurement has its own optimum value)
- The numerical value of m_j differs per city: clothing and how smartphone is carried
- Representativeness WMO-station and battery temperature
- Location smartphone: 40% within 300 m accuracy
- Limited number of battery temperatures at night
- Data OpenSignal: not realtime



Netherlands – smaller scale: Rotterdam











Figure 3: Comparison of model prediction of UHI (A) and air temperature (B) versus observations. In black is the WRF prediction; in solid red the average observed values; in dashed red the 95% confidence interval of the observations. Time runs from 00 UTC, August 1st to 23 UTC, August 2nd, though the cold front passes over at 18:00 UTC, August 2nd: the hours thereafter are not to be considered.