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HONG KONG OBSERVATORY

APPLICATION OF MINIATURE SENSORS IN THE DEVELOPMENT OF MICRO-CLIMATE STATIONS FOR URBAN CLIMATE STUDIES IN HONG KONG

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Micro-climate in Hong Kong:

- Weather conditions can change rapidly in both temporal and spatial scales

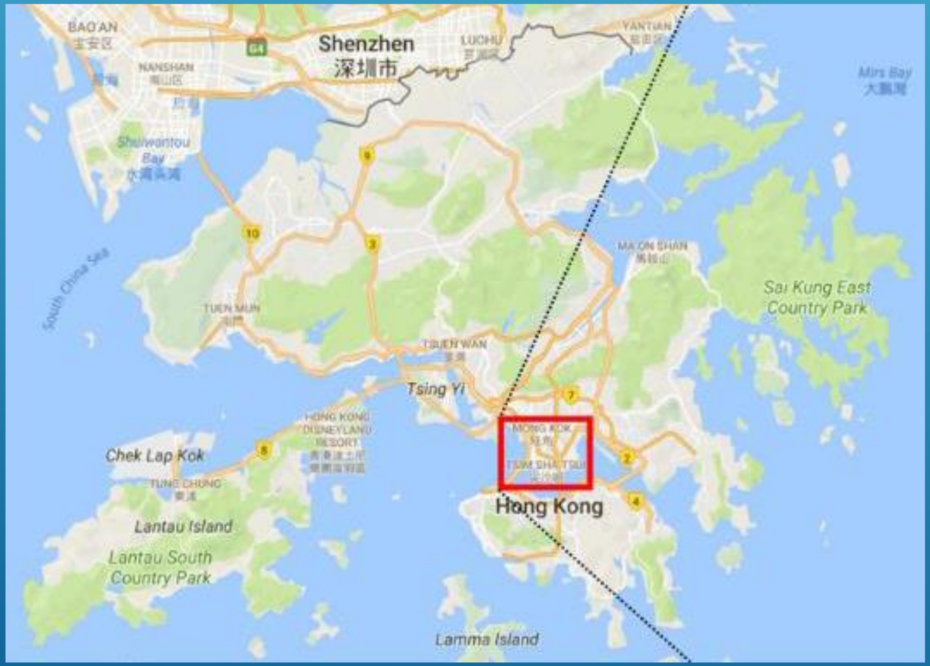

Photograph courtesy of Asia Fininancial Forum

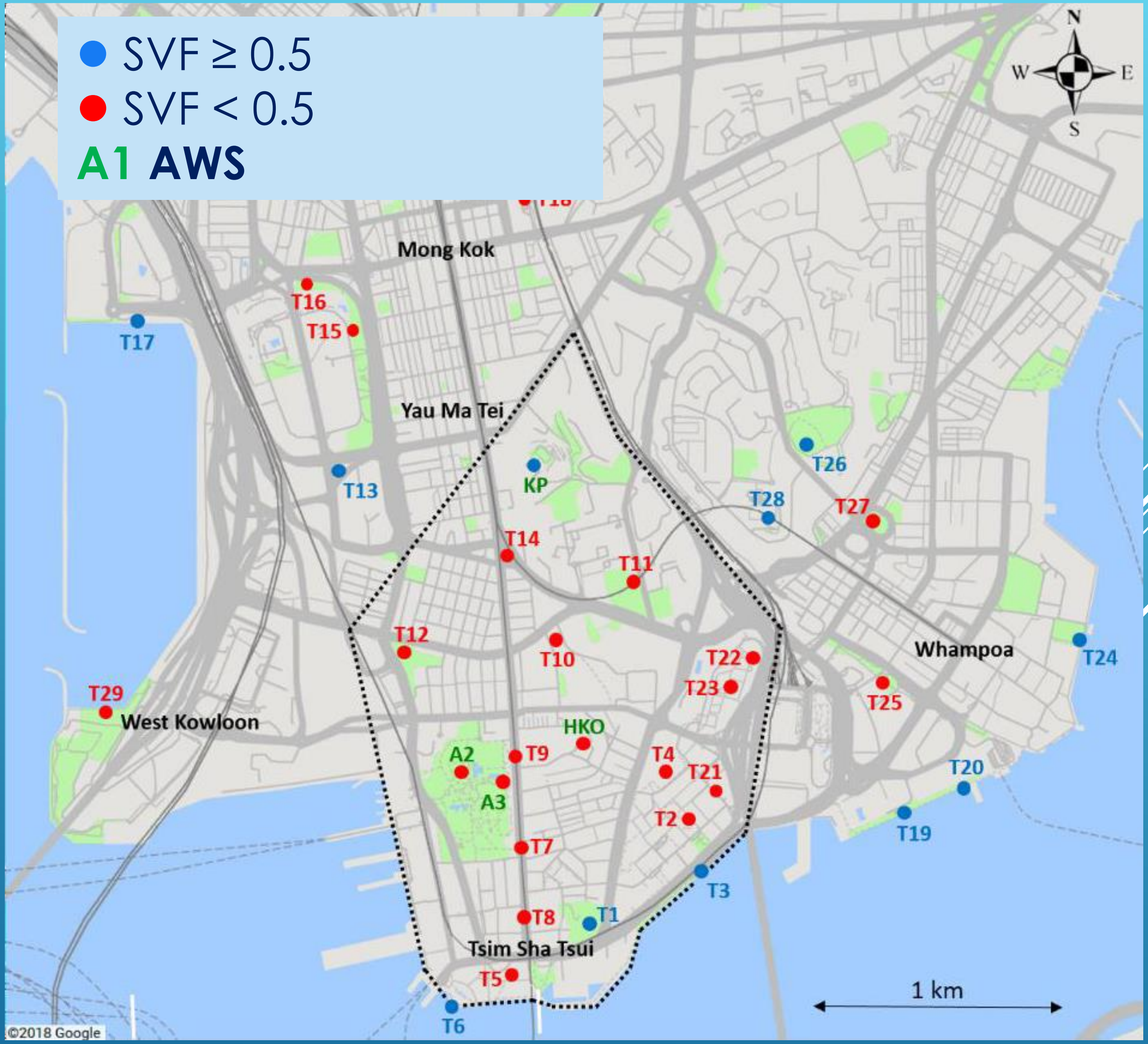
Pilot Project (2017):

- To study the temperature variations on a microscale level under various meteorological scenarios with a view to better understanding the urban climate of Hong Kong

- Implementation of 30-odd miniature passive (so called i-button) temperature sensors over the Kowloon peninsula at the city centre of Hong Kong.

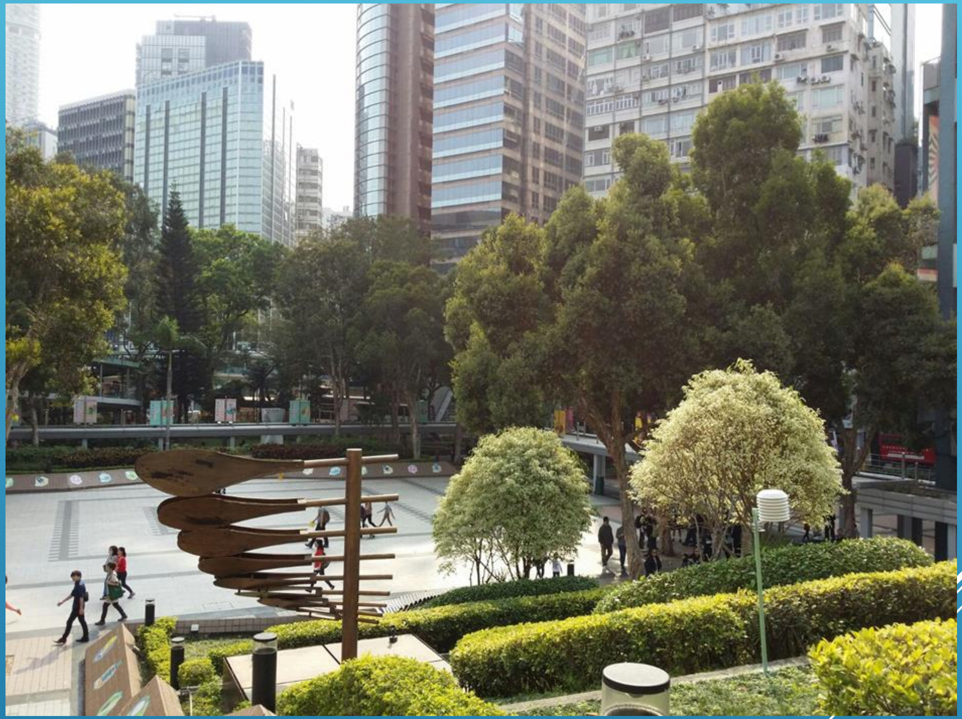
Pilot Project:
~30 i-button temperature observation network over the Kowloon peninsula





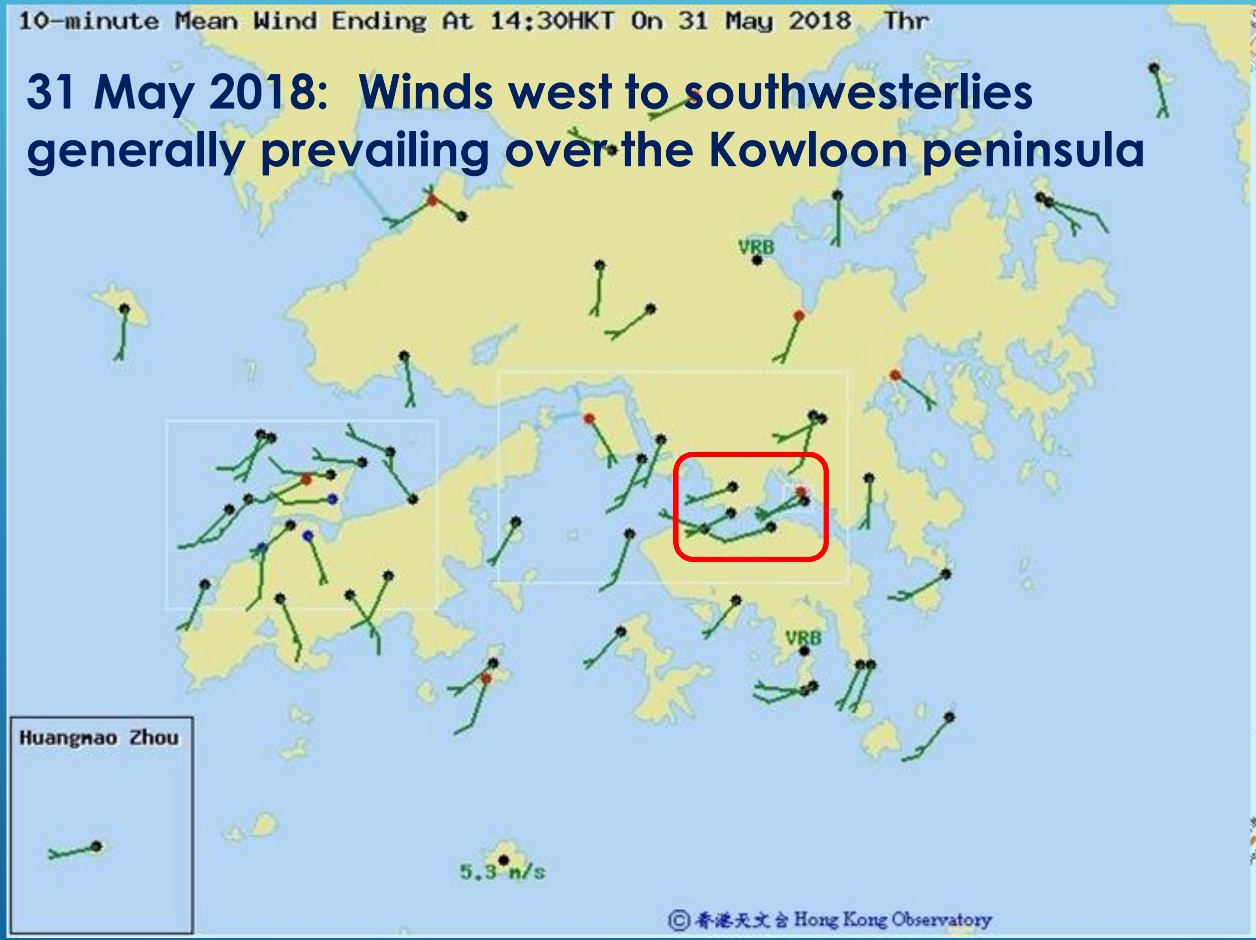
Stated uncertainty ±0.5°C

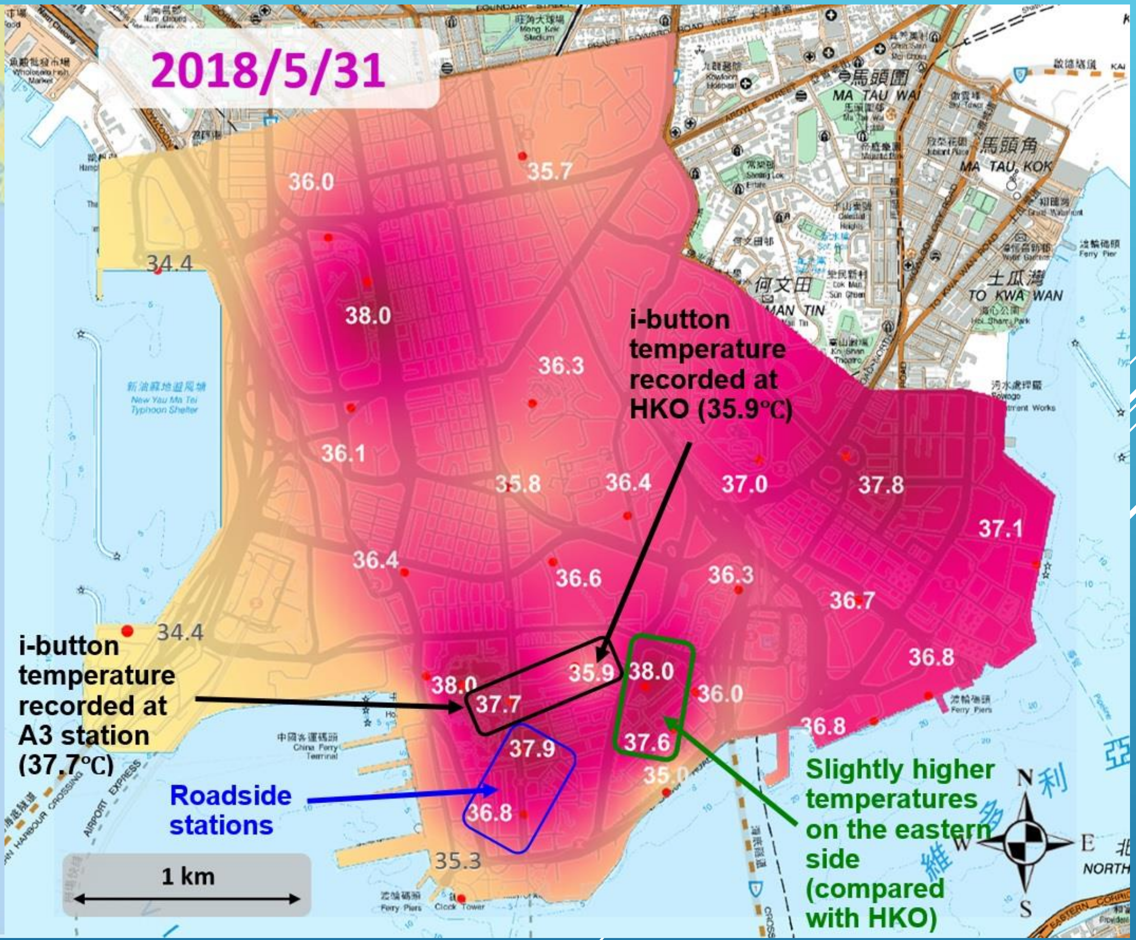
East Tsim Sha Tsui Promenade (T3)
Seaside, East of HKO



Science Museum (T4)
Green Park, East of HKO

Temperature distribution over the Kowloon peninsula at 2:30 p.m. on 31 May 2018





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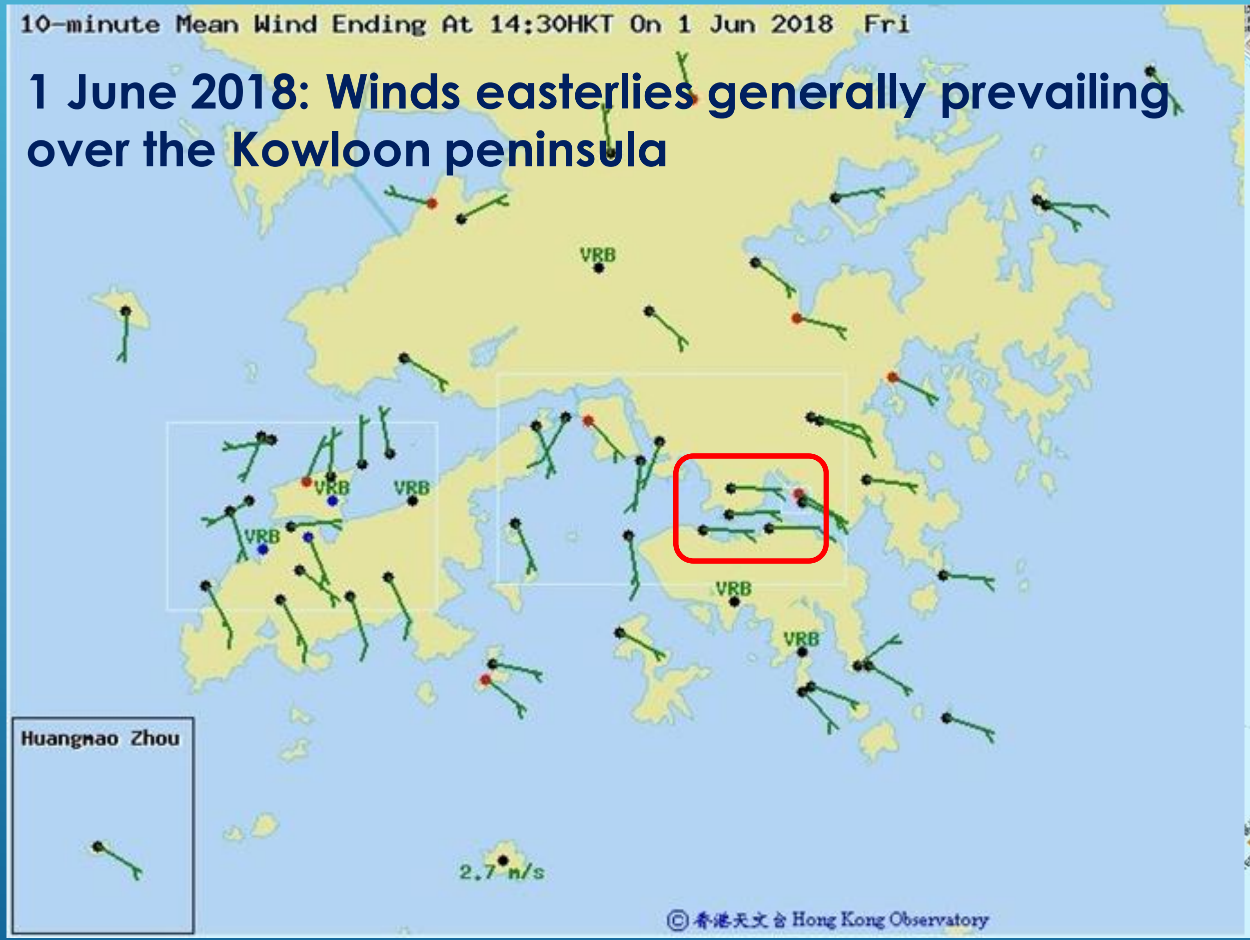
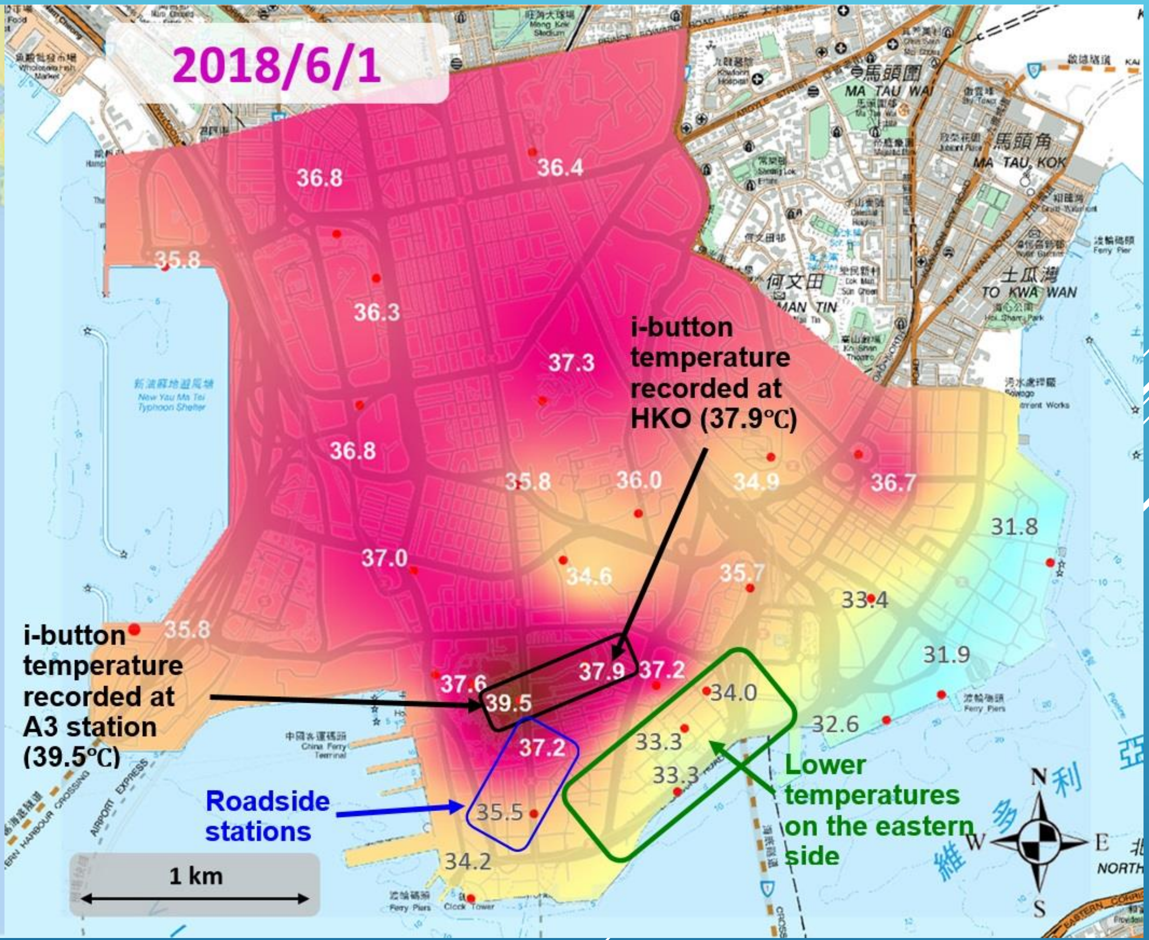
Temperature distribution over the Kowloon peninsula at 2:30 p.m. on 1 June 2018





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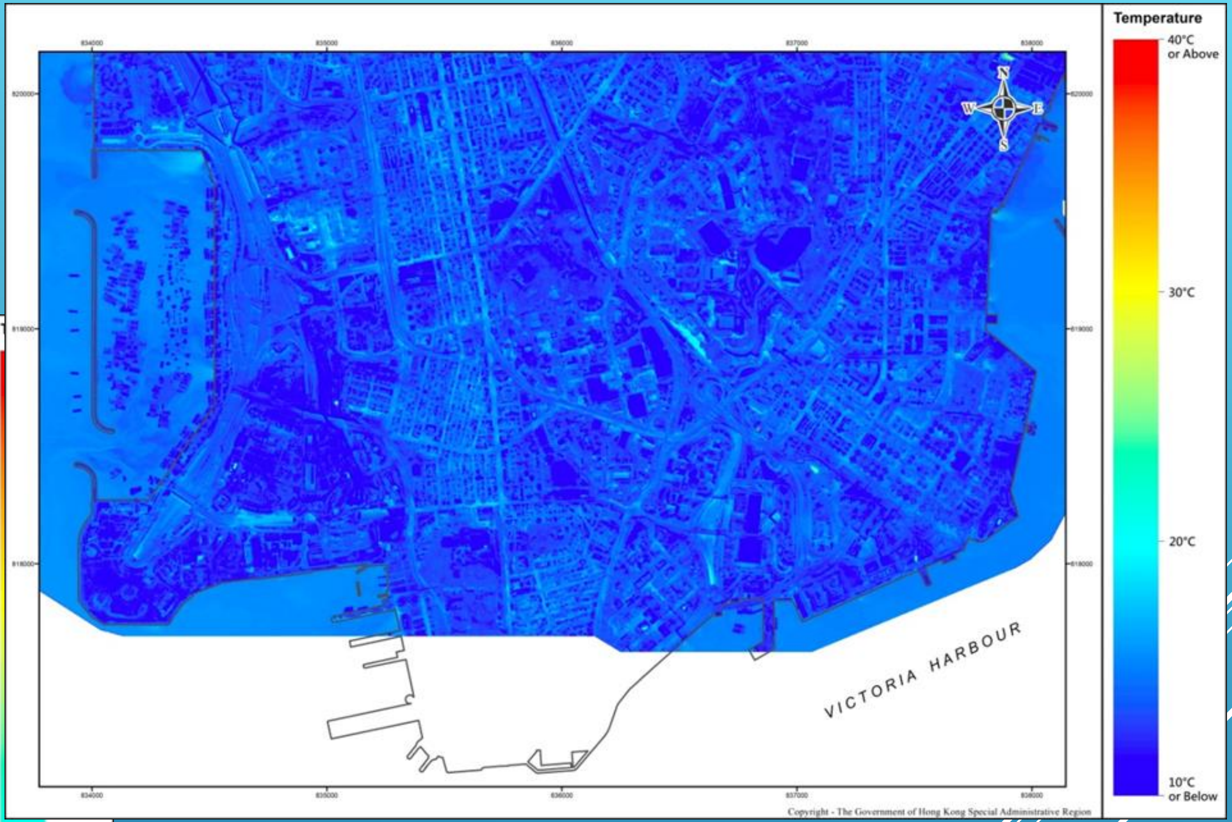
Ortho-rectificed thermal maps
on 14 January 2018 (Daytime)



Ortho-rectificed thermal maps
on 14 January 2018 (Nighttime)

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Comparison of surface temperatures derived from ortho-rectified thermal maps (taken during daytime flight (top) and nighttime flight (bottom) on 14 January 2018) and temperature measurements of i-button sensors placed on the surfaces

Daytime flight from 13:32 to 14:43 on 14 January 2018

Station	*Surface*	**(A)** *Surface Temperature derived from Thermal Map (°C)*	**(B)** *Surface Temperature measured by i-button sensor during flight time (°C)*	**(A)** lies within range of **(B)** ?	If No, smallest difference between **(A) and (B)** *(°C)*
HKO	Grass	16.9	16.1 - 17.4	Yes	-
	Concrete	30.7	30.5 - 32.2		-
A2	Grass	28.2	27.7 - 32.1		-
A3	Grass	28.0	26.3 - 28.9		-
KP	Grass	31.5	32.0 - 34.9		-0.5
	Concrete	33.1	30.6 - 33.4	Yes	-
T13	Grass	33.1	33.8 - 35.7	No	-0.7
T26	Grass	23.2	21.2 - 23.6	Yes	-

Nighttime flight from 20:30 to 21:35 on 14 January 2018

Station	*Surface*	**(A)** *Surface Temperature derived from Thermal Map (°C)*	**(B)** *Surface Temperature measured by i-button sensor during flight time (°C)*	**(A)** lies within range of **(B)** ?	If No, smallest difference between **(A) and (B)** *(°C)*
HKO	Grass	10.2	13.1 - 13.2	No	-2.9
	Concrete	13.0	14.5 - 14.9		-1.5
A2	Grass	11.5	13.9 - 14.3		-2.4
A3	Grass	9.6	12.4 - 12.7		-2.8
KP	Grass	8.3	12.0 - 12.5		-3.7
	Concrete	13.1	16.2 - 16.9		-3.1
T13	Grass	9.6	12.0 - 12.6		-2.4
T26	Grass	9.0	12.3 - 12.5		-3.3

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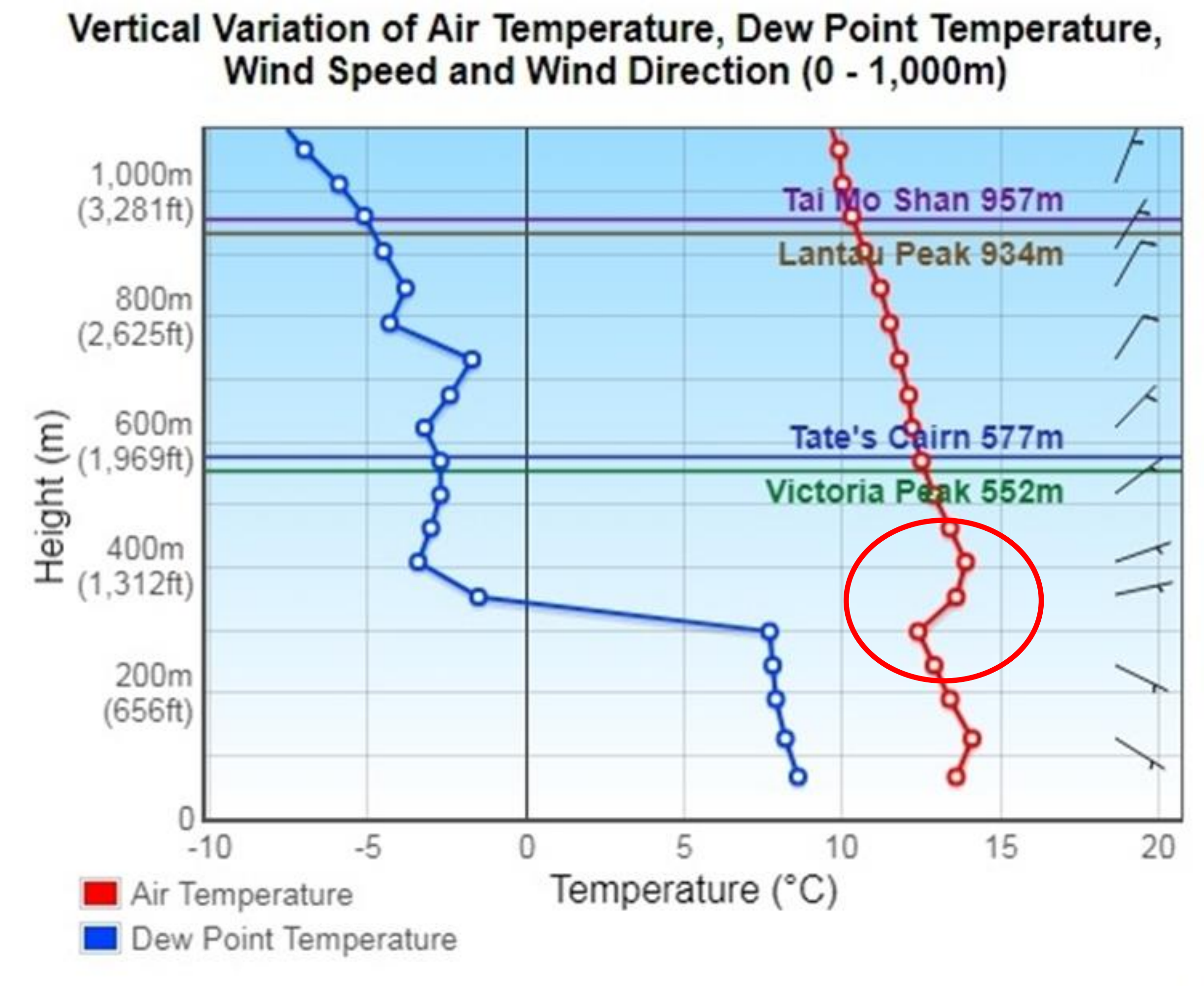
For the systematic negative bias of the emissivity-derived surface temperatures, it was thought that the presence of a weak inversion near the height of 300m - 400m might have affected the derivation as it was assumed that the vertical distribution of both temperature and relative humidity would be uniform between the ground and the helicopter flight level



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Pilot Project (2017):

The network can produce good and consistent temperature measurements to identify microscale structures in the temperature distribution over a relatively small area

Drawbacks

- Manual data retrieval (passive sensor – no real time data)
- Sampling frequency low (~5 min/reading) to preserve battery life


Photograph courtesy of Asia Fininancial Forum

Automatic multi-sensor micro-climate station

Challenges:

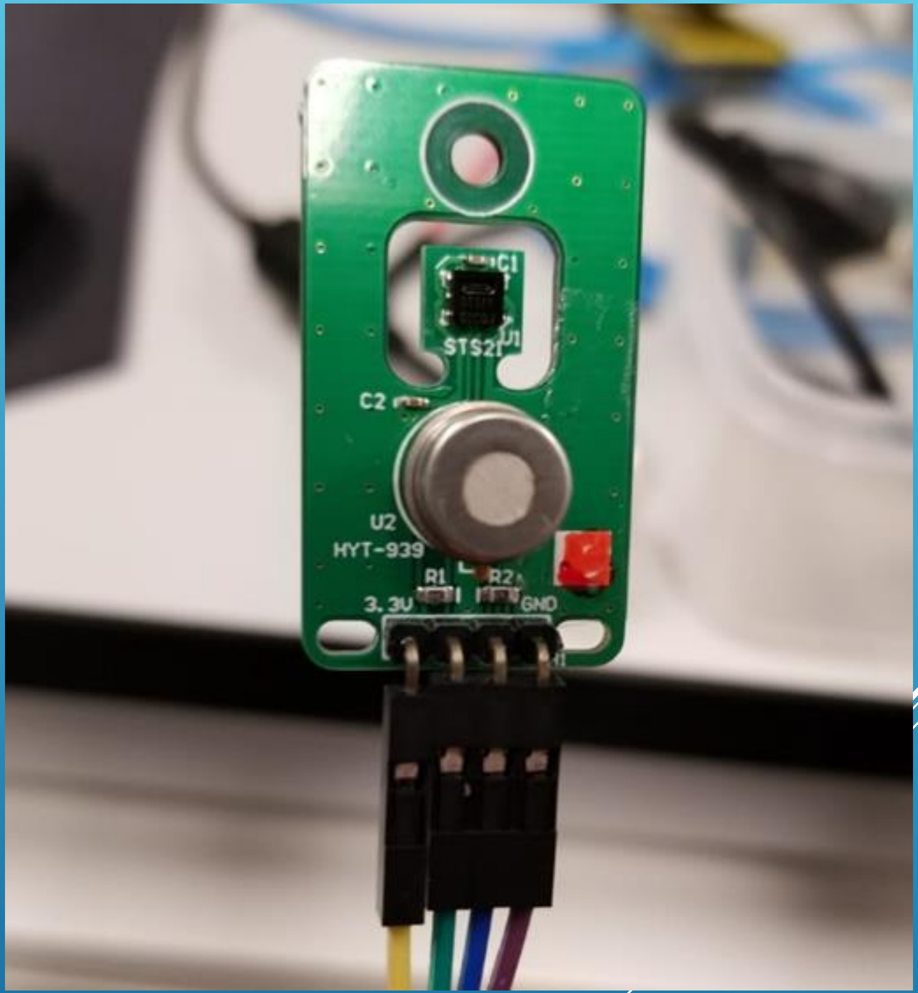
- Sensor type and their uncertainty
- Control interface and system integration
- Size and appearance of the micro-climate station
- Power consumption and source
- Method of data transmission

East Tsim Sha Tsui Promenade (T3)
Seaside, East of HKO

Microclimate Station Sensors

Prototype of an external, exchangeable module with small footprint digital sensors to measure temperature and humidity

I2C control interface with microcontrollers/microprocessors



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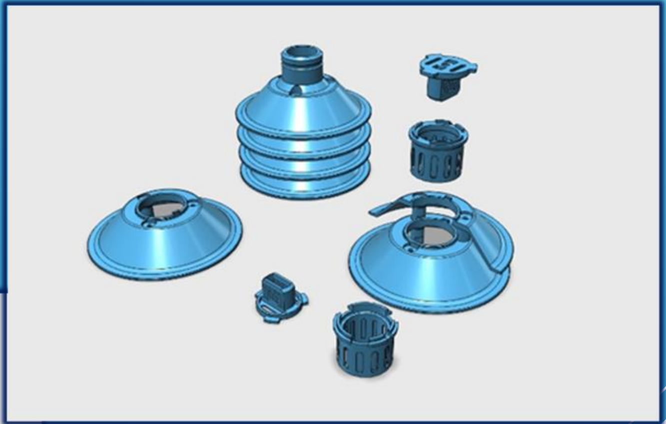
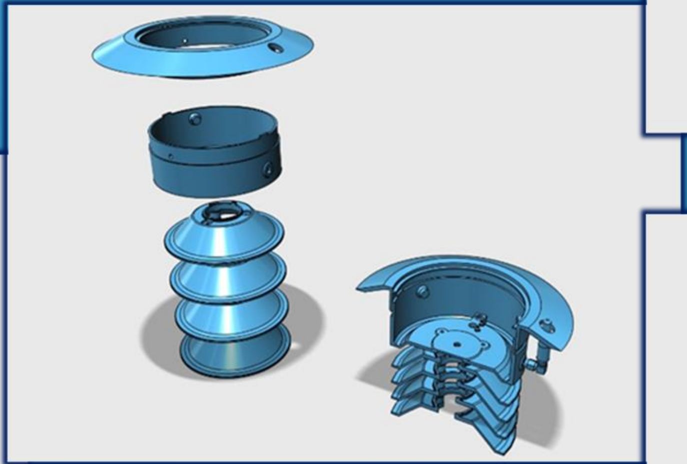
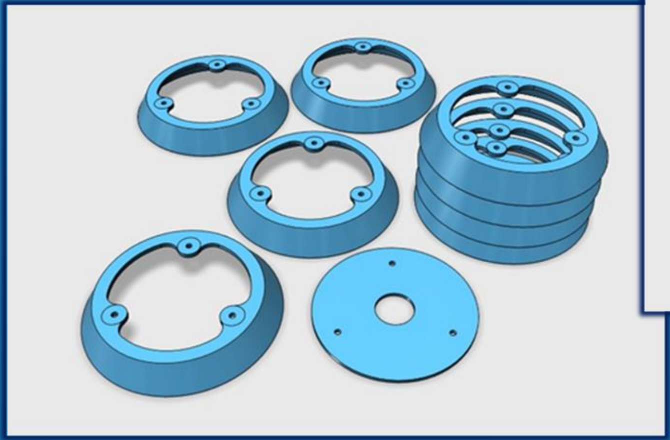
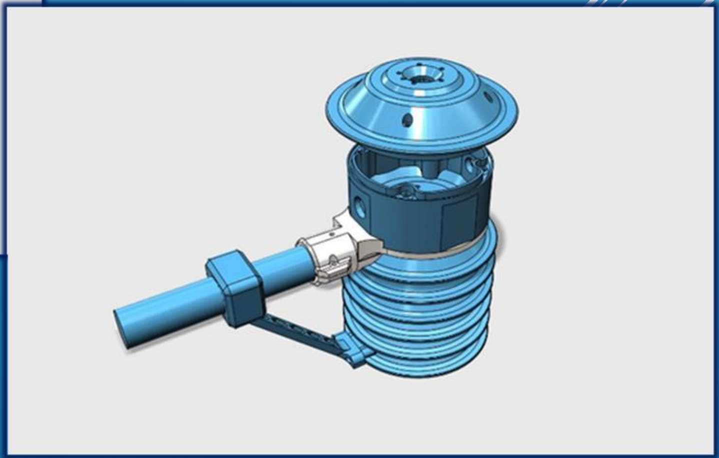
Application of 3-D printing technology

Illustration of the various designs of the radiation shields and housings for the electronics of the micro-climate stations using 3-D printing technology









Locations of the measurement nodes and their respective measured weather elements at the micro-climate station at HKO Headquarters

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Locations of the measurement nodes and their respective measured weather elements at the micro-climate station at Zero Carbon Building in East Kowloon

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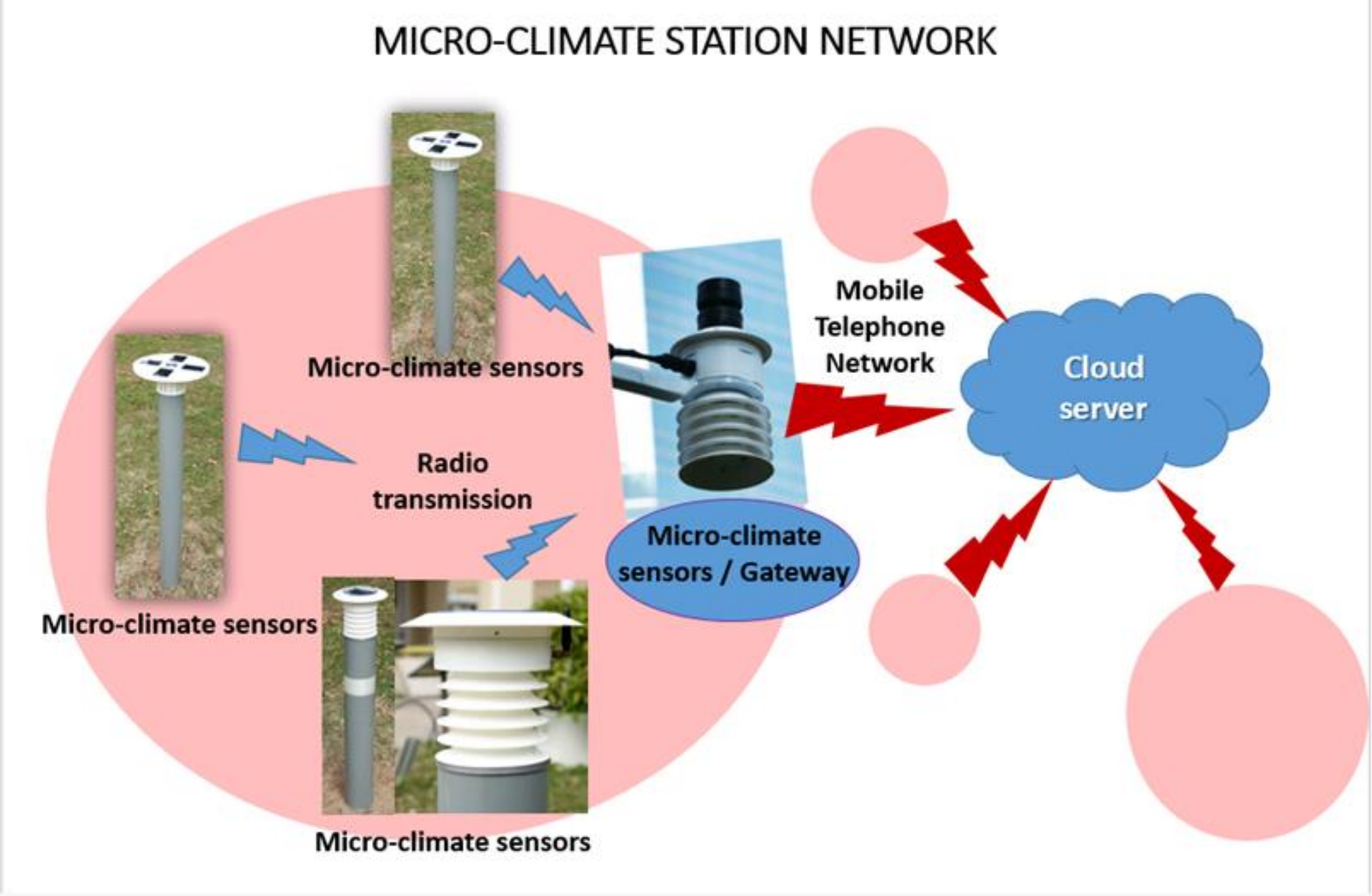
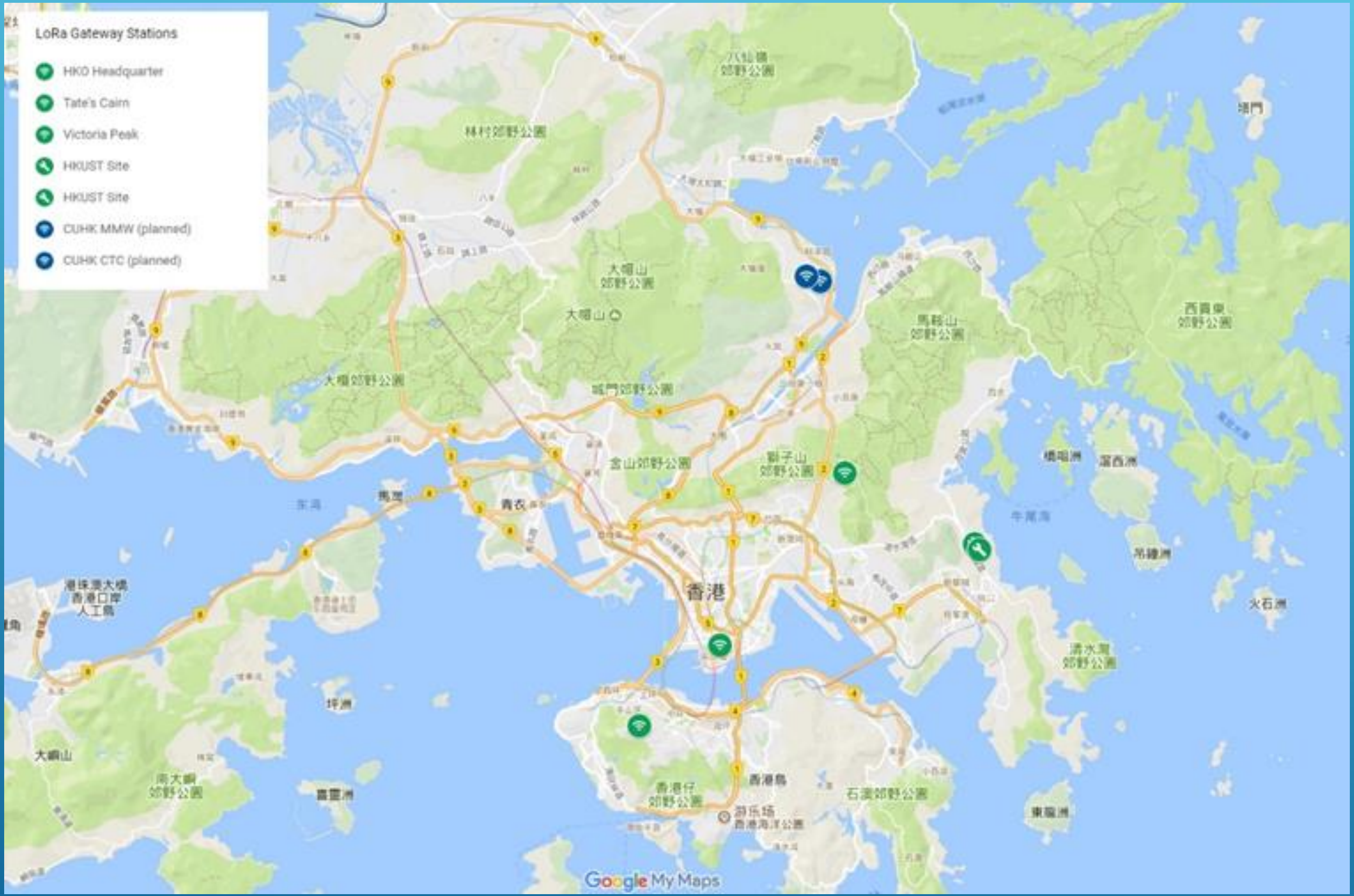
Data transmission pathway

FM radio between sensor node to a gateway

Gateway to a cloud server through mobile telephone network such as GPRS/3G/4G…

Drawback: relative high power requirement for the network modems





The LoRaWAN being set up by the Observatory.
Labels in green show the LoRa gateways that have already been built while those in blue are planned ones

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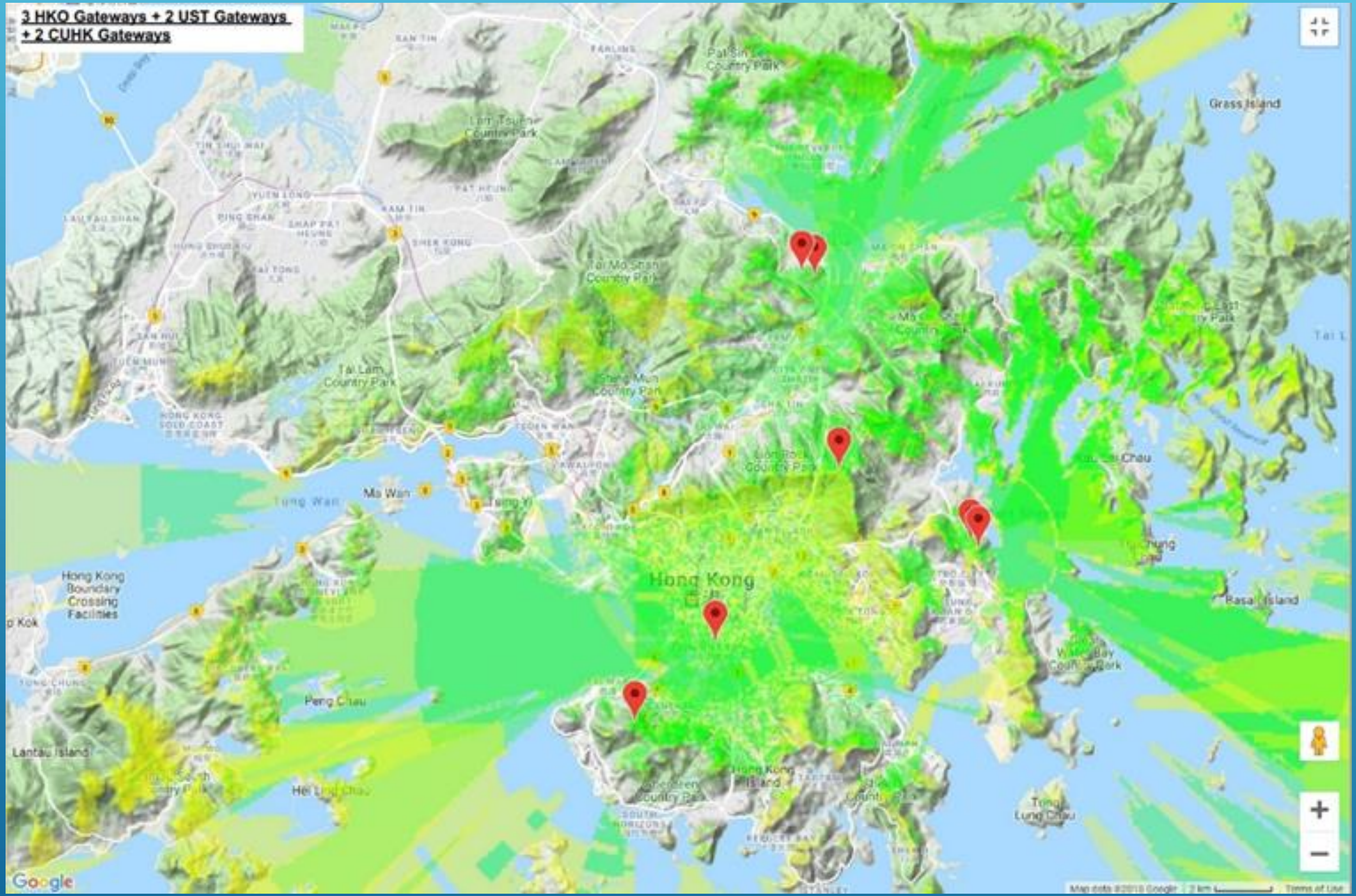

Simulated coverage of the LoRaWAN based on gateways

Future work

- Development of a network of micro-climate stations to provide real-time weather data for use in urban climate studies
- Implement of LoRaWAN to provide a lower power option for real-time data transmission
- Application with smart city planning

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THANK YOU