European Meteorological Society

Session OSA2.4: Atmospheric effects on humans
Copenhagen, Denmark (12 September, 2019)

# Analysis of environmental characteristics on urban road-surface and air temperatures in Seoul: A case study during heat wave days

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This study was published in the Journal of *Atmos. Oceanic Sci. Lett.* in 2019.
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# Contents

1. Introduction
2. Method
3. Results
4. Summary


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# Introduction



- Heat waves are one of the major meteorological disasters because they can affect many aspects of human life, such as through their impacts on health, socioeconomics, drought, and roads (Schwartz, 2005; Barnett, 2007; Schubert et al., 2014; Kim et al., 2017).

- Especially, in summer, high surface temperatures can cause tire blowouts and deformation induced by thermal stress on the rails or roads (Campbell, 2008).

- Despite progress made in road weather information systems (RWIS), the performance of road-surface temperature prediction models is still limited in areas with sparse observations (Chao and Zhang, 2018).

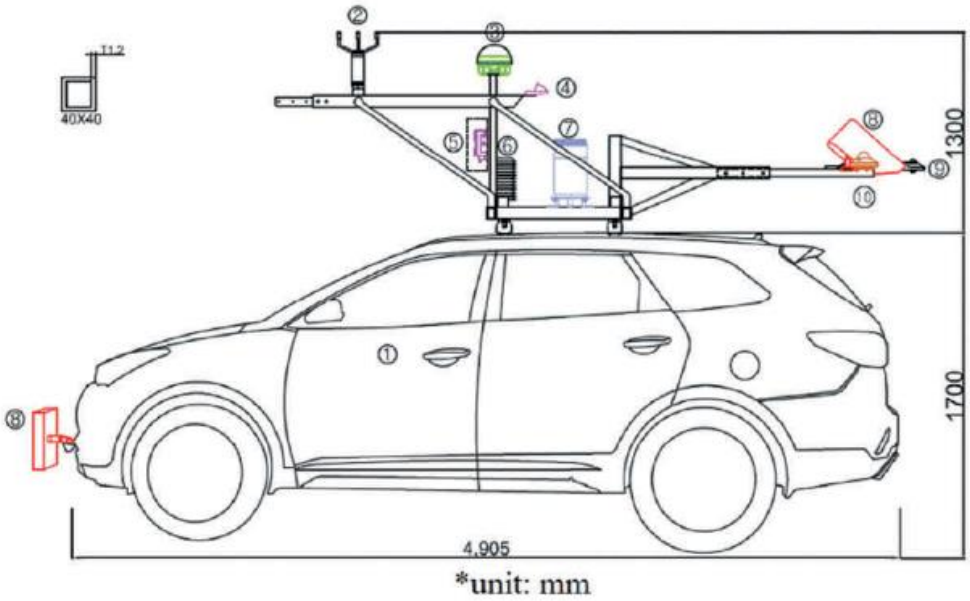
- Therefore, a well-designed observation framework based on mobile platforms with both road-surface and meteorological sensors is required to capture accurate road-weather information in vulnerable regions.

- The purpose of this study is to investigate the characteristics of road-surface and air temperatures for heat-wave episode that occurred on 16-17 August 2018 in Seoul, the capital city of Korea.

# Observation Vehicle



## ❖ MOVE (Mobile Observation Vehicle) Platform




NOTE

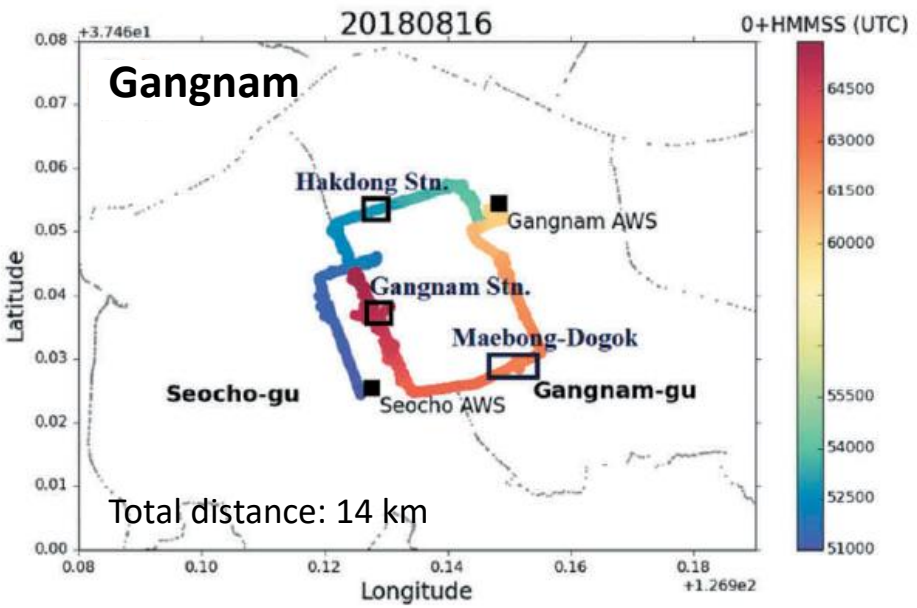
| | | | |
|---|---|---|---|
| ① | Sport Utility Vehicle (MAXCRUZ, Hyundai) | ⑥ | Humidity & Temp. Probe (HMP155, Vaisala) |
| ② | Ultrasonic Wind Sensor (WMT703, Vaisala) | ⑦ | Rain Gauge (RG13H, Vaisala) |
| ③ | GNSS Antenna (TRM59800, Trimble) | ⑧ | Road Weather Sensors (DSP101 & DSC111, Vaisala) |
| ④ | Rain Detector (DRD11A, Vaisala) | ⑨ | Net Radiometer (CNR4, Kipp & Zonen) |
| ⑤ | Barometer (PTB110, Vaisala) | ⑩ | Pyranometer (CMP11, Kipp & Zonen) |

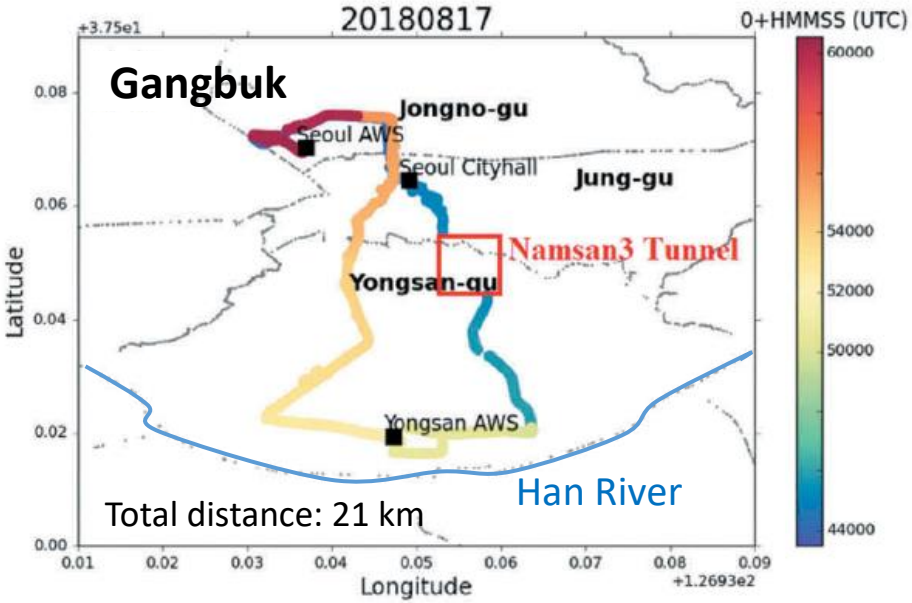
- The MOVE dataset was generated by equipment that included road weather sensors (DSP101) and an air temperature probe (HMP155) and radiation sensors (CMP11).
- All data were collected at a 1-s rate, and transmitted to a server within 5 min using M2M.
- The operating air temperature of the DSP101 sensor ranges from -40 to +71.1℃, and the response time of the HMP155 and CMP11 sensors are less than 20s and 0.7s, respectively.

# Observation Method



## ❖ Observation routes (Gangnam & Gangbuk area)

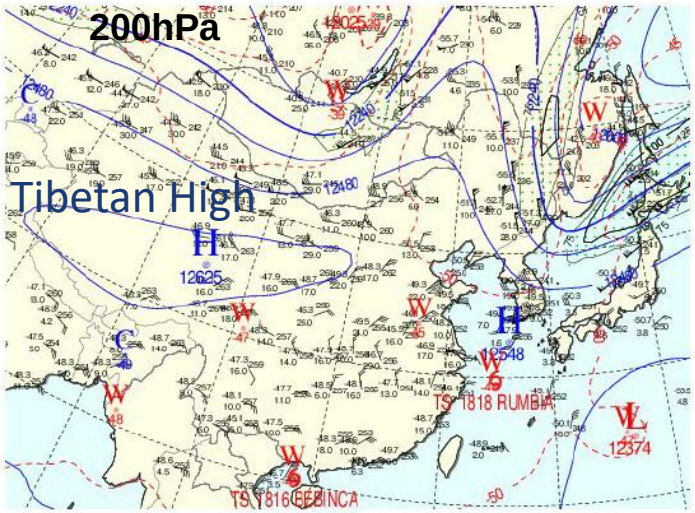


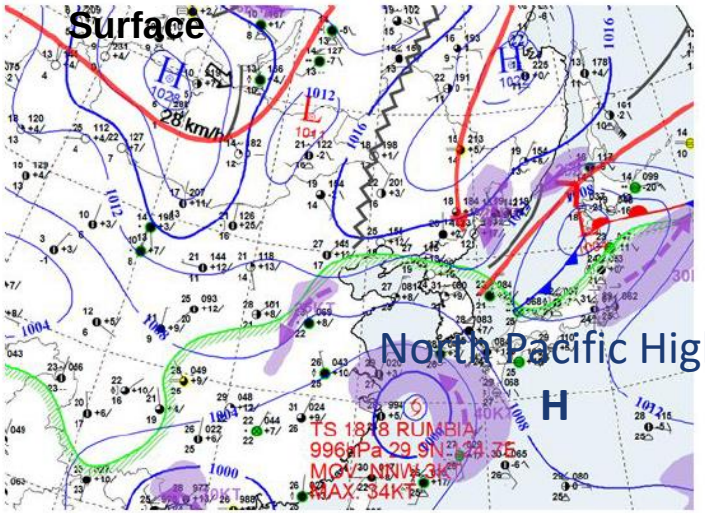



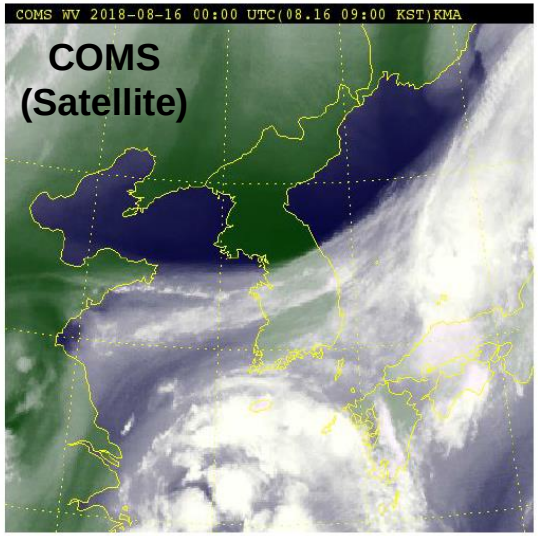

- To compare characteristics of road-surface and air temperatures in two sectors with different local features, we selected urban roads in southern (Gangnam) and northern (Gangbuk) areas of Han River.
- To minimize the impact of nearby vehicles, we kept enough distance, and the cruise control was set at 30-40 km $h^{-1}$, except in traffic jams.
- We designed optimal observation routes and the warmest times, for a relative comparison of characteristics of urban roads under a similar synoptic pattern and solar elevation.

# Synoptic Analysis (16 August, 2018)

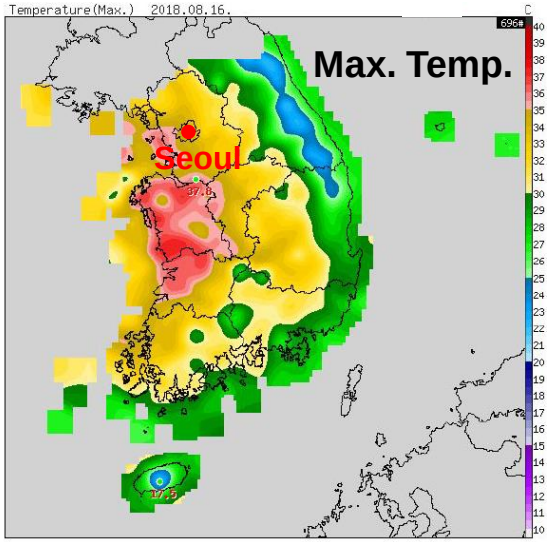





Southwesterly water vapor

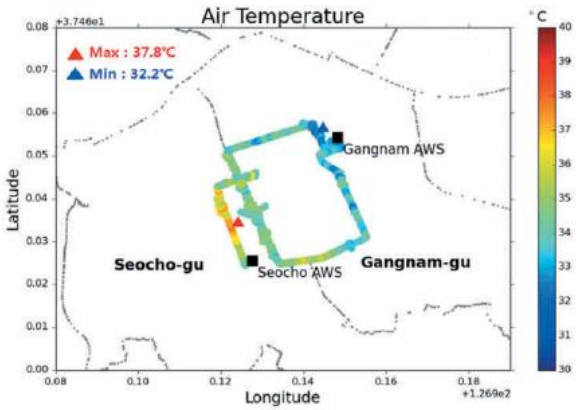


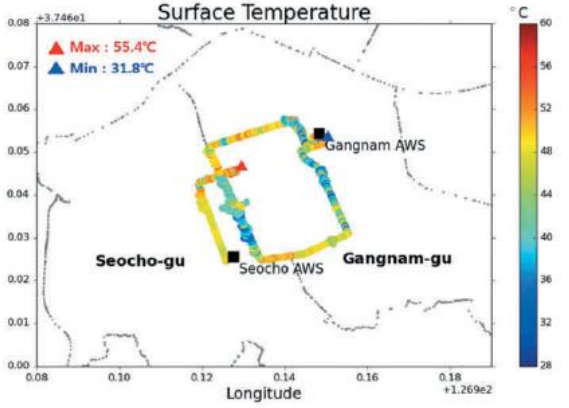
# Gangnam Road (16 August, 2018)

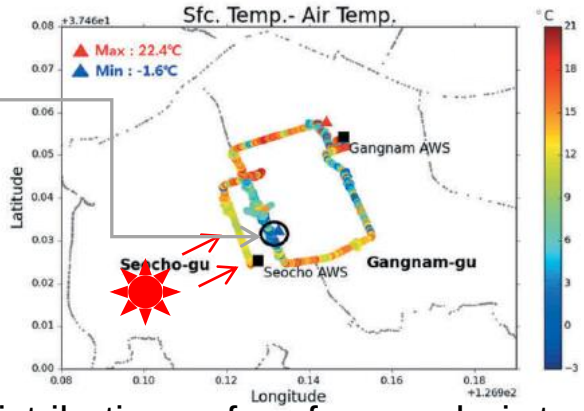


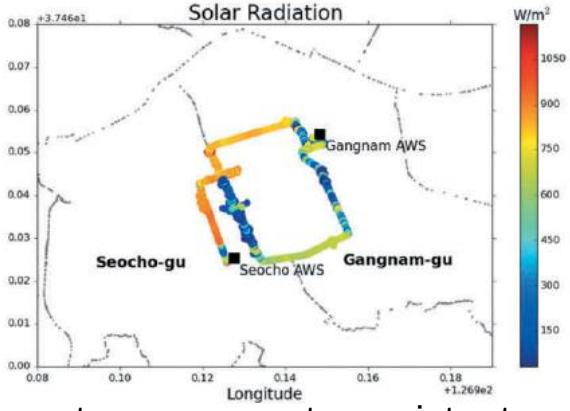
cf) At 0600 UTC in Seoul,
Solar altitude: 50°13’21.1”
Solar azimuth: 242°53’21.8”
(Korea Astronomy and Space science Institute)

**3D map view (Vworld Web Service)**

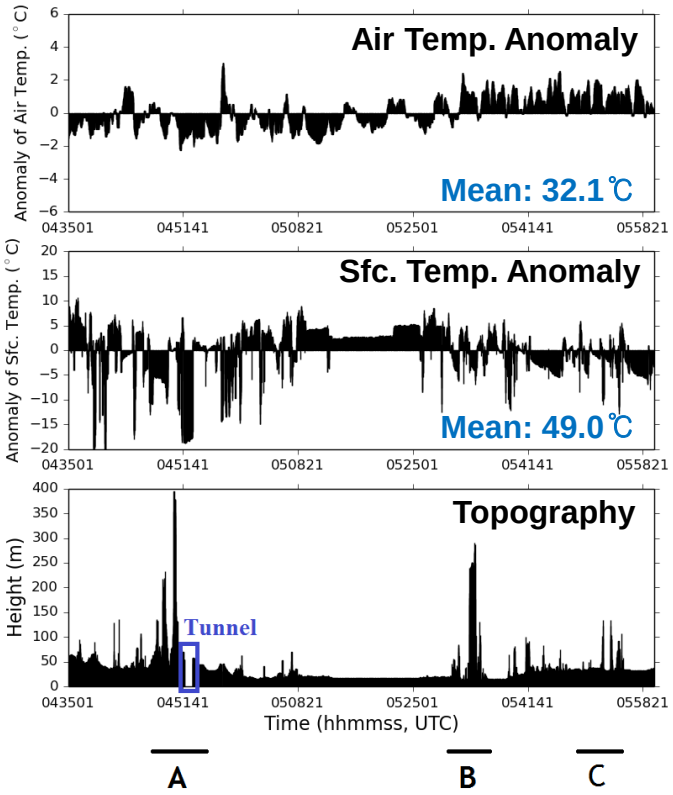



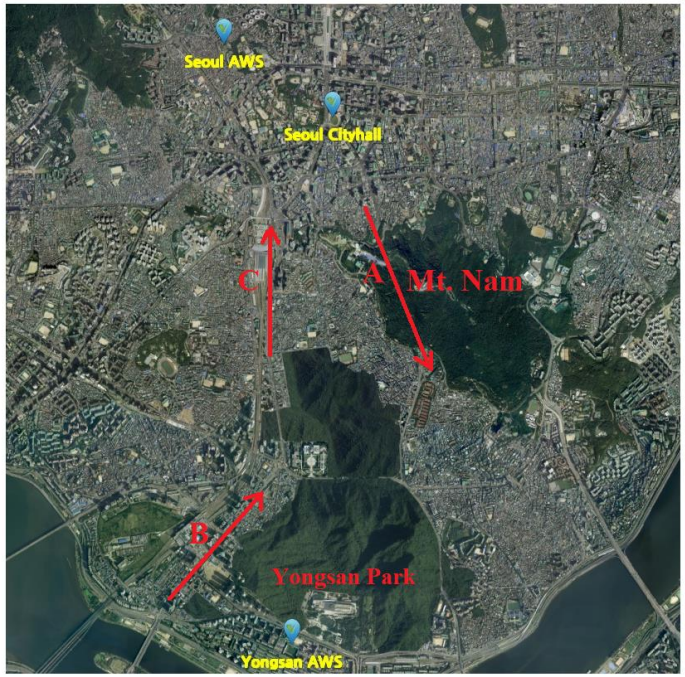

- It is interesting to note that the distributions of surface and air temperature were not consistent, despite the same observation time.
- The distribution of solar radiation to have comparatively similar patterns and good agreement with those of surface temperature and the difference in temperature.
- The magnitude of urban road-surface temperature is mainly caused by screening impacts such as the differences between sun-exposed and shading sections due to high-rise buildings.

# Gangbuk Road (17 August, 2018)






**Moving route & Topography map**

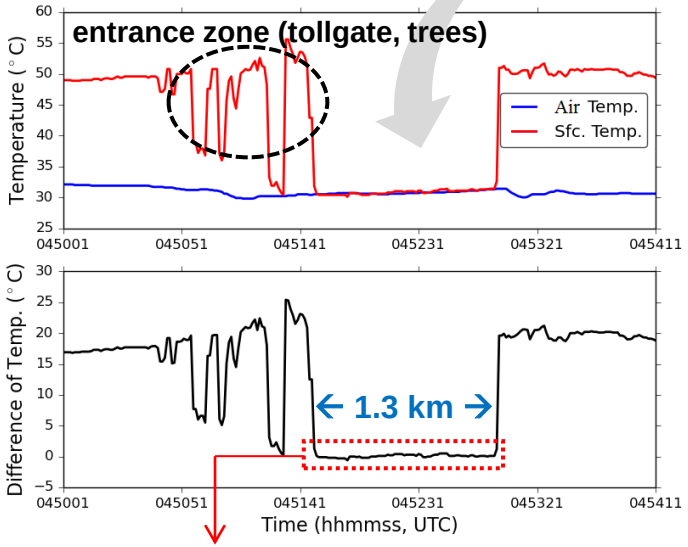



- The sfc. temp. in 3 sections showed a tendency of negative anomalies, which may be attributable to the influence of surrounding soil surfaces and a larger cooling rate at higher altitude.
- However, there were no significant characteristics of the relationship between air temperature above the road and topography from our examination.
- We found that air temperatures were more dependent on the diurnal variation (out of phase around 0500 UTC) than the topographic effect.

# Urban-Tunnel & Water-Sprinkling Effect

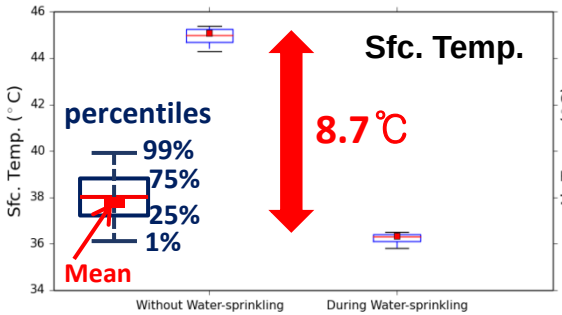


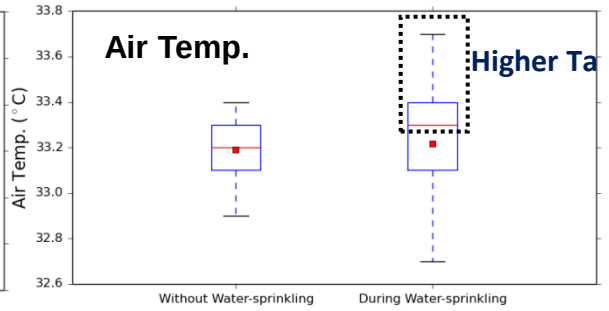
## Urban-Tunnel Effect






## Water-Sprinkling Effect




**As a result of additional thermal environments (due to high traffic volume, short tunnel length, and lack of ventilation facilities)**

- The sfc. temp. in the tunnel dropped with a maximum difference of 25.5℃, whereas air temp. indicated a steady value without any significant differences from before and after passage.
- Significant differences (about 8.7℃) in road-surface temp. were noted between those within and outside the water-sprinkling section.
- However, the ambient air temp. in the water-sprinkling section were higher values at median and high percentiles, since they have a higher heat release rate as incoming solar energy is balanced by evaporative cooling, rather than the ground radiating heat (Rasmijn et al., 2018).

# Summary



## Gangnam & Gangbuk Roads

*MOVE; Mobile Observation Vehicle

- ✓ We used a MOVE dataset to investigate the urban road-surface and air temperatures for a heat-wave episode that occurred on 16-17 August 2018 in Seoul, Korea.
- ✓ In Gangnam, the road-surface temperature is mainly caused by differences between sun-exposed and shading sections due to arrangement of high-rise buildings.
- ✓ In Gangbuk, the road-surface temperature is associated with topographical features, whereas air temperatures were more dependent on the diurnal variation than the topographic effect.

## Urban-Tunnel & Water Sprinkling Effect

- ✓ In the section of Namsan3 tunnel, the differences between road-surface and air temperatures were almost zero, which may be attributable to the additional thermal environments, such as high traffic volume and lack of ventilation facilities.
- ✓ During water-sprinkling period, the road-surface temperature was cooled by about 8.7℃, compared to that without water-sprinkling, but there was no significant change in mean ambient air temperature.

- ➢ Our findings will assist planners and decision makers determining policy priorities (e.g. planting urban trees and water-spraying) to mitigate heat waves with regard to road-surface temperature, and provide reliable local-scale information on urban road risks.



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