Aerosol Spatial Distribution Observed by a Mobile Vehicle Lidar with Optics for Near Range Detection

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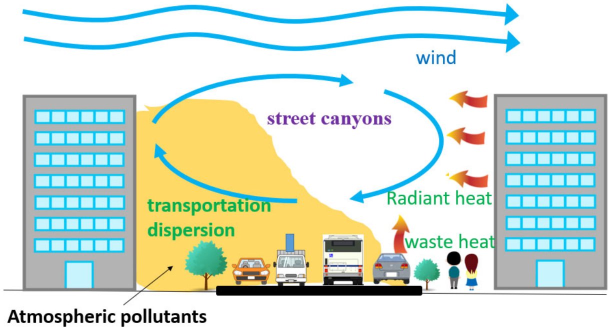
Knowledge of localized air quality within street canyons is important in urban areas with high-rise buildings that alter wind and pollutant transport. In addition, observing horizontal aerosol distributions with a high-range resolution is valuable for a sensor in smart agriculture.

We developed a mobile vehicle lidar system to achieve the continuous monitoring of atmospheric aerosols with high spatiotemporal resolutions.

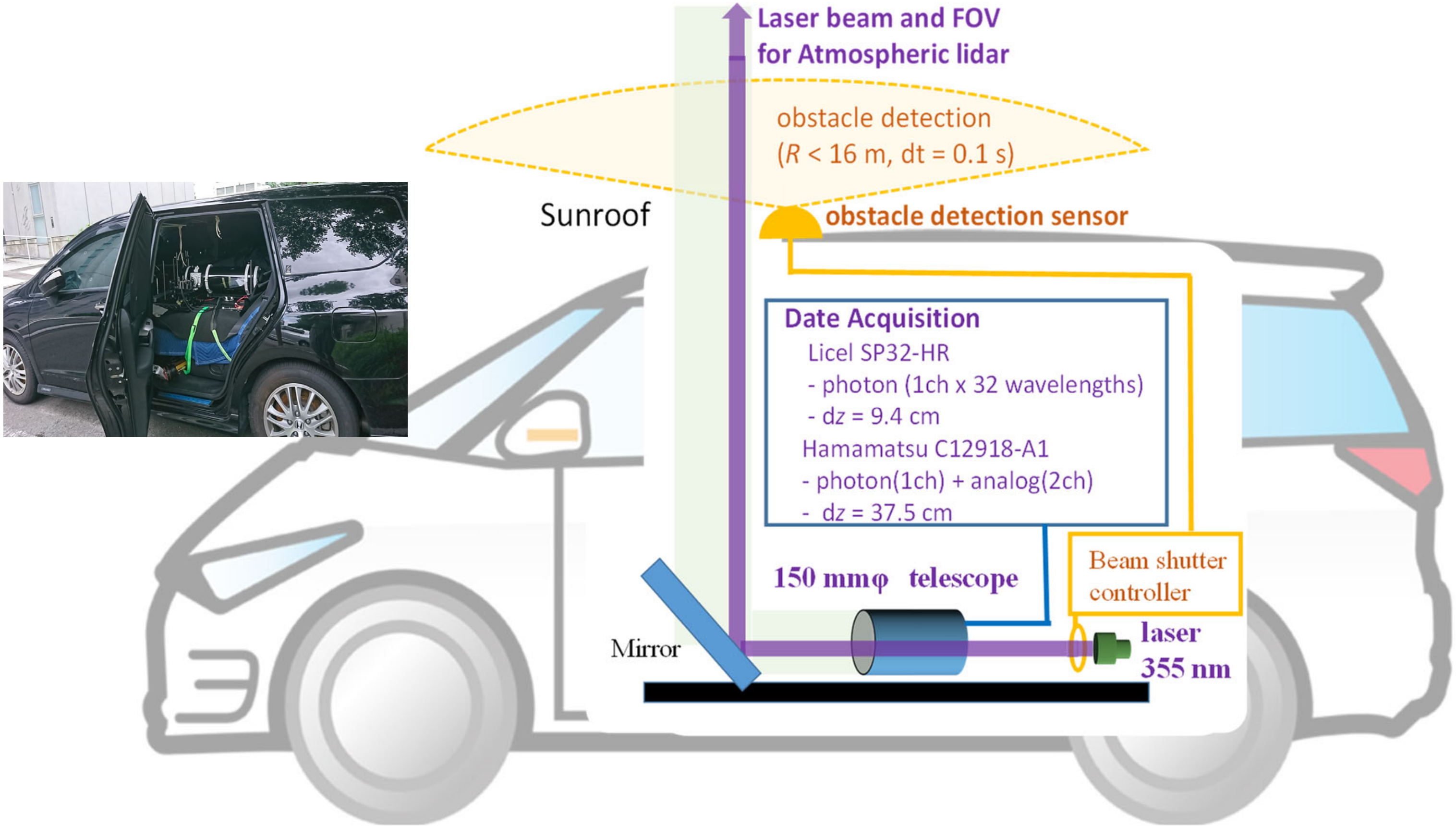


Street canyon (Urban canyon)

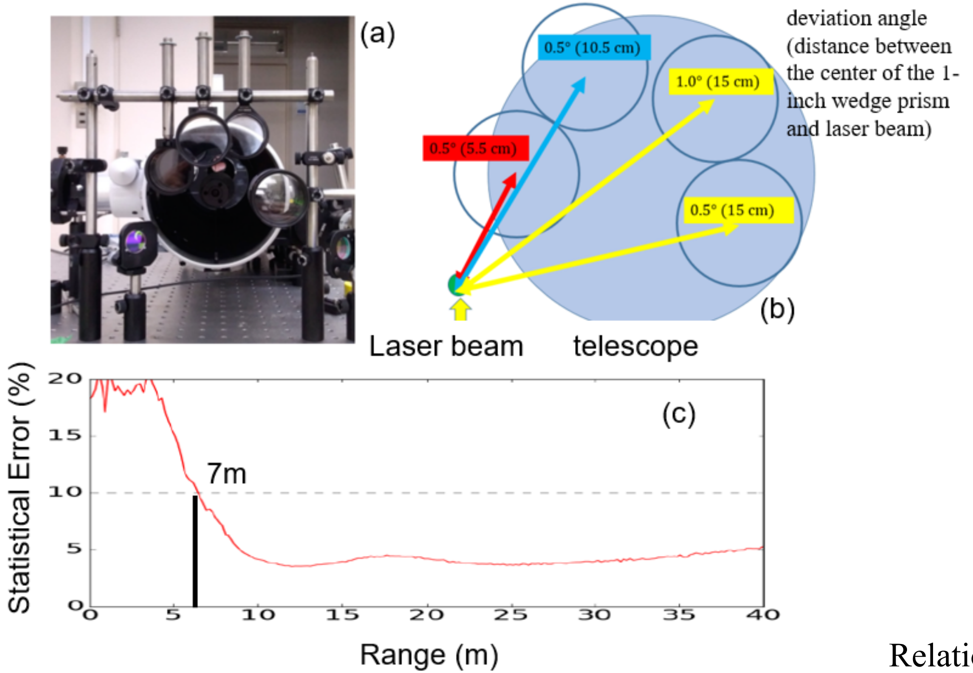
Features of a mobile vehicle lidar

- **Laser safety**
  eye-safe laser + beam shutter controlled by obstacle detection sensor
- **Near-range detection by wedge-prism optics**
  the near-measurable range after overlap correction was 7 m
- **High-spatiotemporal resolutions**
  time-resolution: 0.1–1.0 sec, range-resolution: 0.375 – 1.875 m

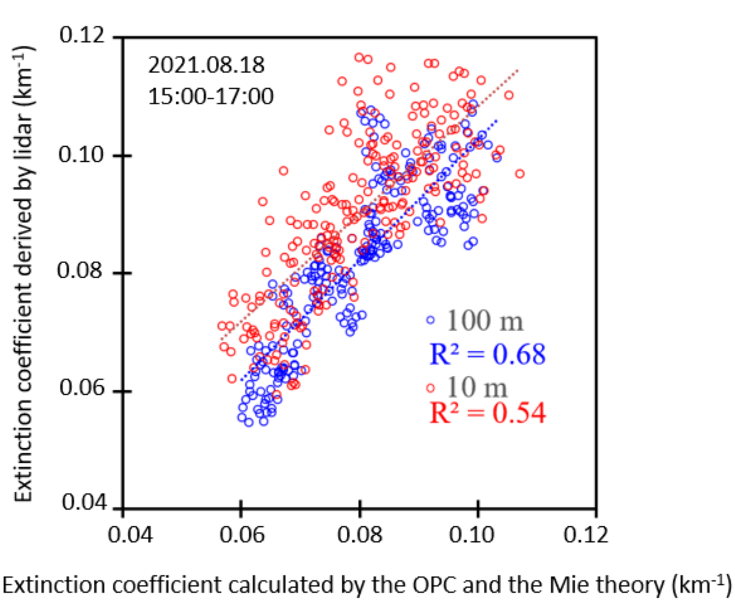
Schematic diagram of a mobile vehicle lidar in the car with a sunroof



Evaluation of the near-range detection

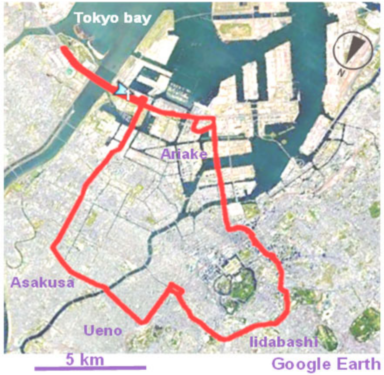


(a, b) Front views of the wedge prism optics of the mobile vehicle lidar. (c) Statistical error of the received signals for the analysis conditions of the extinction coefficients.



Relationship of the estimated extinction coefficients between the lidar signals and the in-situ observations at 10 and 100 m from lidar. The extinction coefficients of in-situ observations were calculated from the OPC (optical particle counter) number size distribution using the Mie scattering theory.

Vertical distributions in urban areas (July 3, 2020)



Track of the mobile vehicle lidar.

Before the onset of morning traffic, a low aerosol-loading layer was observed at altitudes lower than 30–40 m in the high-rise community.

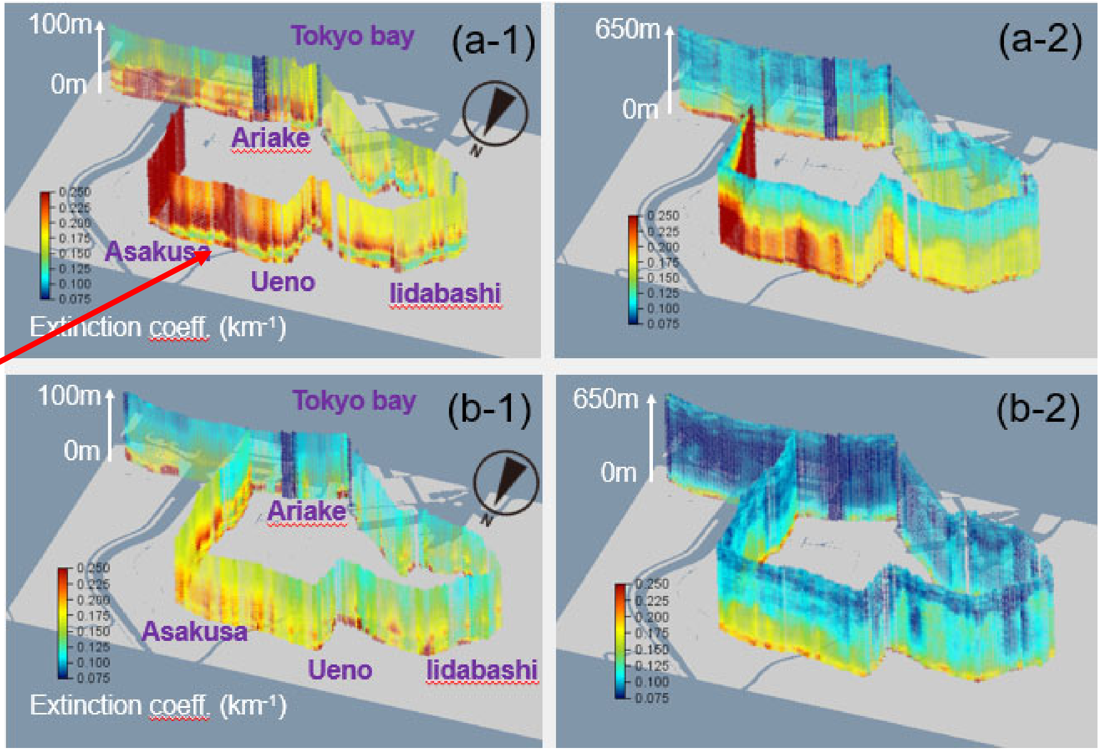
dt=1 sec
dz=0.375 m (7-100m)
1.875 m (100-650 m)

(1) 7 – 100 m

(2) 7 – 650 m

(a) 5:00 – 6:20 JST

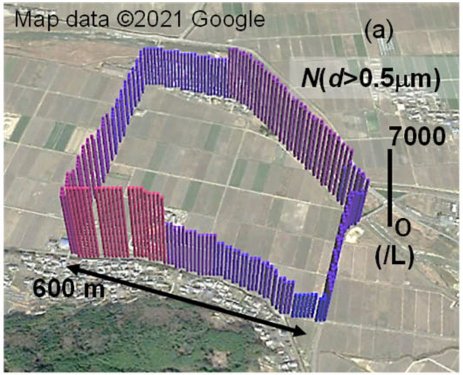
(b) 6:27–7:55 JST



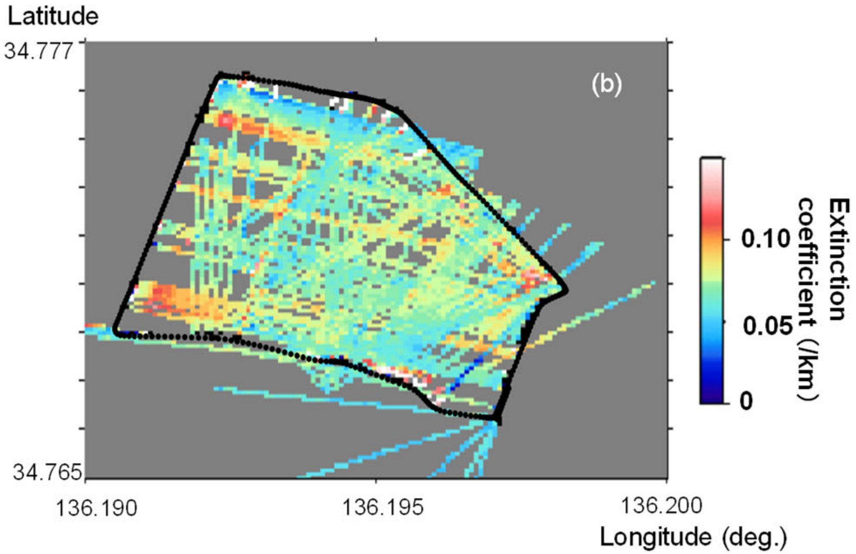
Aerosol extinction coefficient at λ = 355 nm along with a travel path around Tokyo Bay area

Horizontal observation over farmland: low aerosol-loading case (14:49–14:55 JST on August 22)

Rice field area (Iga, Japan)



Number concentration distributions of aerosols with diameters larger than 0.5 μm along the travel path

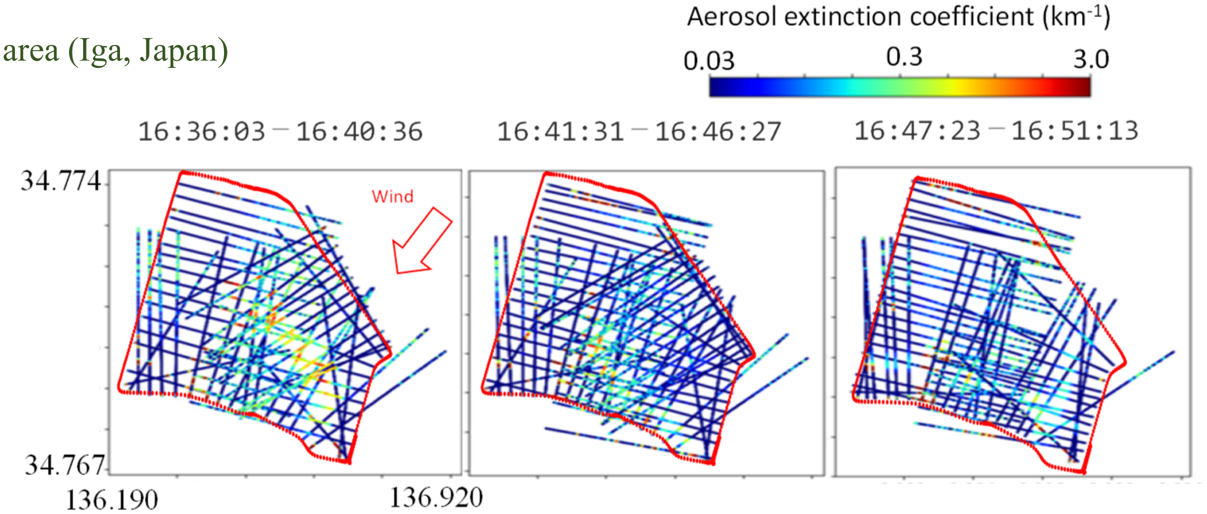


aerosol extinction coefficient at $\lambda = 355$ nm over a farmland area (dt=0.1 s, dr=1.875 m)

Local differences in aerosol concentrations were observed even under such a low aerosol-loading condition.

Horizontal observation over farmland: high aerosol-loading case (16:36–16:51 JST on December 20, 2021)

Rice field area (Iga, Japan)



Aerosol transport originating from biomass burning near the center of the farmland area. Three panels indicate the movement of aerosol distribution observed during 16:36–16:40, 16:41–16:46, and 16:47–16:51 JST on December 20, 2021.

The lidar observation successfully visualized the smoke transport along the prevailing wind direction.

Acknowledgements

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