Study on Urban Microclimate Based on Local Objective Analysis Data and Meteorological Observation

Background

- Urban wind environment is affected by the wind profile in the atmospheric boundary layer.
- Statistical analysis based on long-term observation data are vital for assessing the urban natural ventilation efficiency, pedestrian wind environment and wind load for structures.
- Observation data provided by observatories is the main source of long-term observation data such as AMeDAS data.
- Low-resolution observation is not sufficient for urban-scale wind environment assessment.
- High-resolution meteorological data are not available for long periods of the past. It is difficult to make statistical analysis.

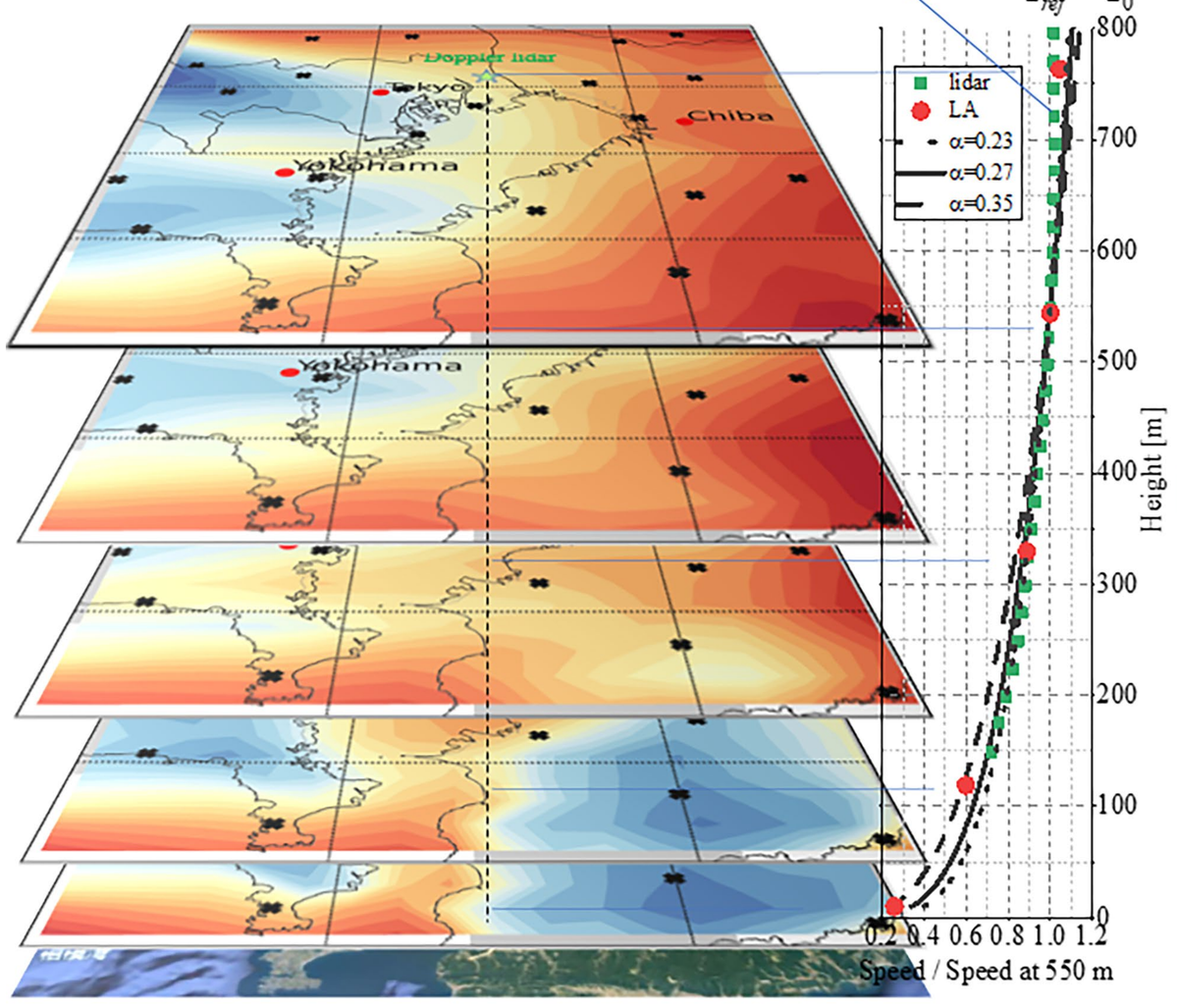
Purposes

- Develop a method or database that can provide site-specific wind profiles to supplement the urban wind data when field observational data are insufficient or absent
- Construct a long-term and high-resolution database by fusing observation and local objective analysis data

a. Wind profile index α under different atmospheric stability

Local objective analysis

$$U_{PL}(z) = U_{ref}\left(\frac{z - z_0}{z_{ref} - z_0}\right)^{\alpha}$$



Distribution of wind profile Index in Tokyo Bay under different atmospheric conditions

Virtual Potential Temperature (VPT):

$$\theta_v = \theta(1 + 0.61q) \quad (1)$$

$$\theta = T + g/C_p \cdot \Delta z \quad (2)$$

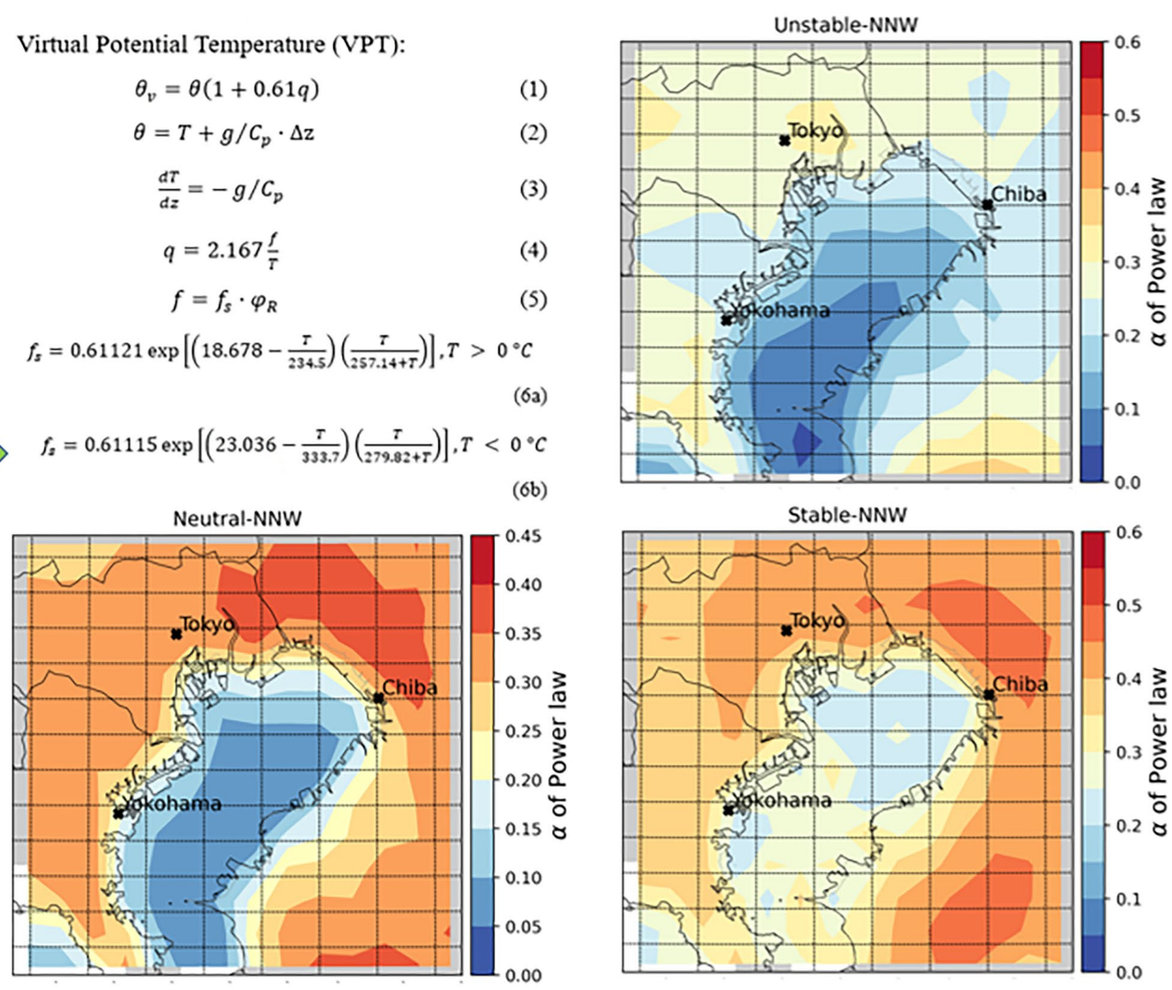
$$\frac{dT}{dz} = -g/C_p \quad (3)$$

$$q = 2.167\frac{f}{T} \quad (4)$$

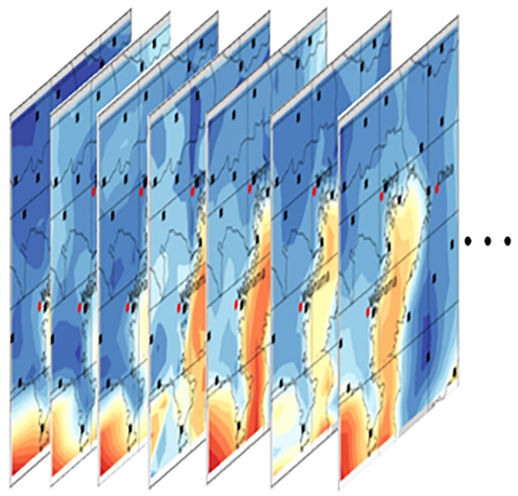
$$f = f_s \cdot \varphi_R \quad (5)$$

$$f_s = 0.61121 \exp\left[\left(18.678 - \frac{T}{234.5}\right)\left(\frac{T}{257.14+T}\right)\right], T > 0\,°C \quad (6a)$$

$$f_s = 0.61115 \exp\left[\left(23.036 - \frac{T}{333.7}\right)\left(\frac{T}{279.82+T}\right)\right], T < 0\,°C \quad (6b)$$

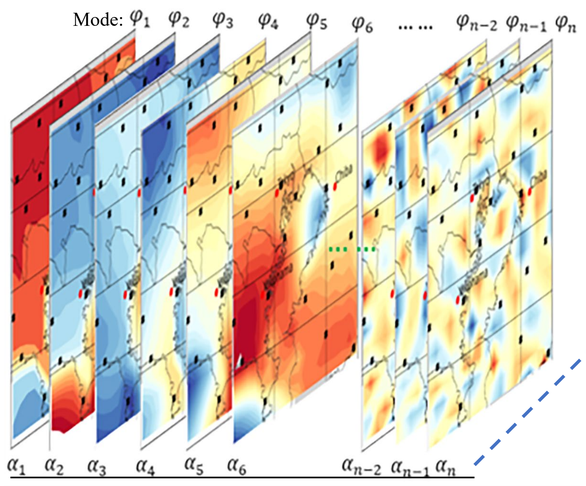


b. Basic wind speed u_0 based on probability density distribution



Snapshots of wind speed at 10 m in the Tokyo Bay area of LA data

POD



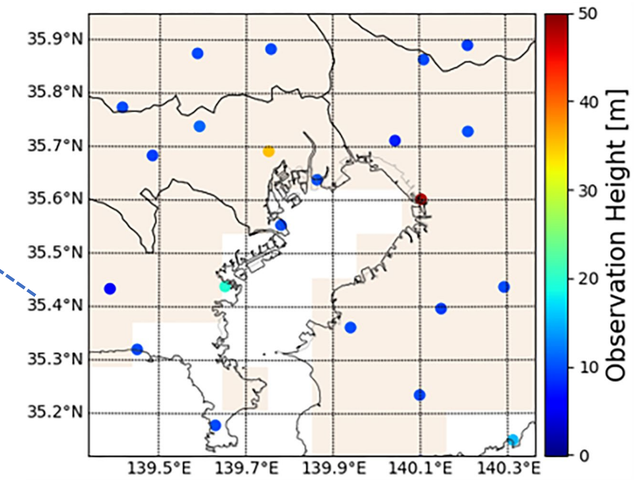
Temporal coefficients (α_i) and mode (φ_1) of LA data by POD method

Linear Stochastic Estimation (LSE)

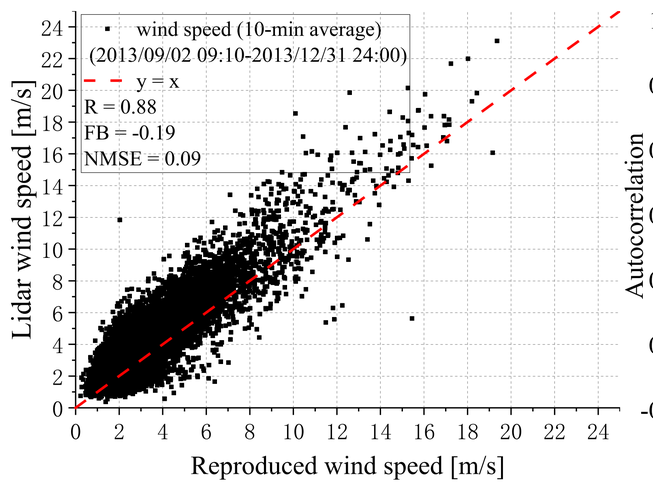
$$\alpha' = \langle \alpha \mid \boldsymbol{E} \rangle$$

α' is the estimated temporal coefficient
α is the temporal coefficient of LA
$\boldsymbol{E}$ is the AMeDAS data;

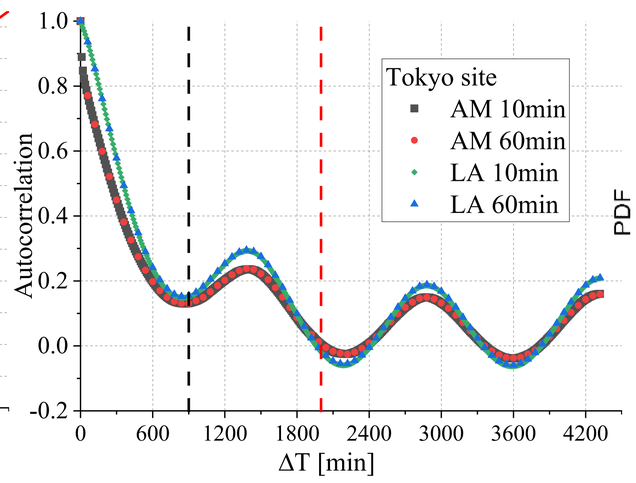
Training dataset:
LA and AMeDAS data during 2018,01,01,00-2021,12,31,23 UTC
Input dataset:
AMeDAS data during 2009,01,01,00 – 2018,12,31,00 JST



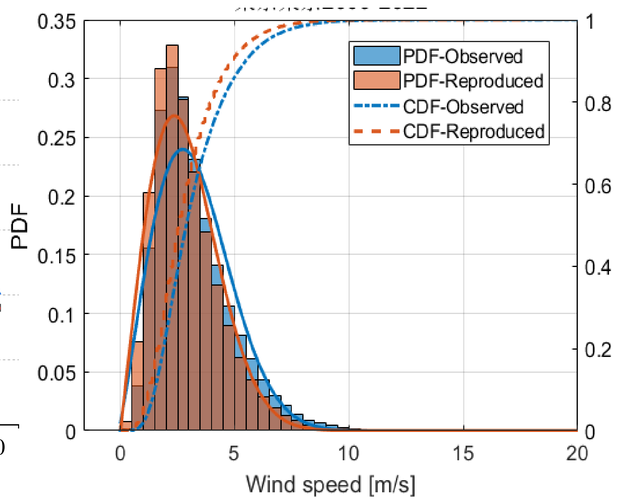
Distribution and height of observatory in the Tokyo Bay region (AMeDAS)



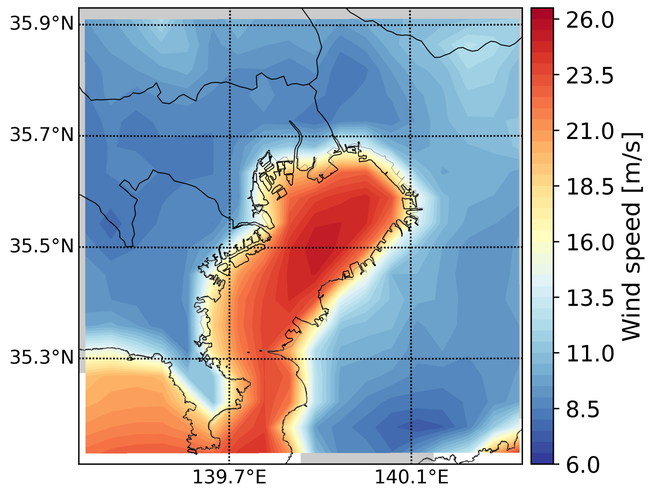
Comparison between reproduced and LA wind speed



Autocorrelation between observed and reproduced data, different interval.



Distribution between observed and reproduced data at Tokyo



Map of basic wind speed with annual return period at Tokyo Bay Region

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