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Temporal source apportionment of $PM_{2.5}$ over the Pearl River Delta region

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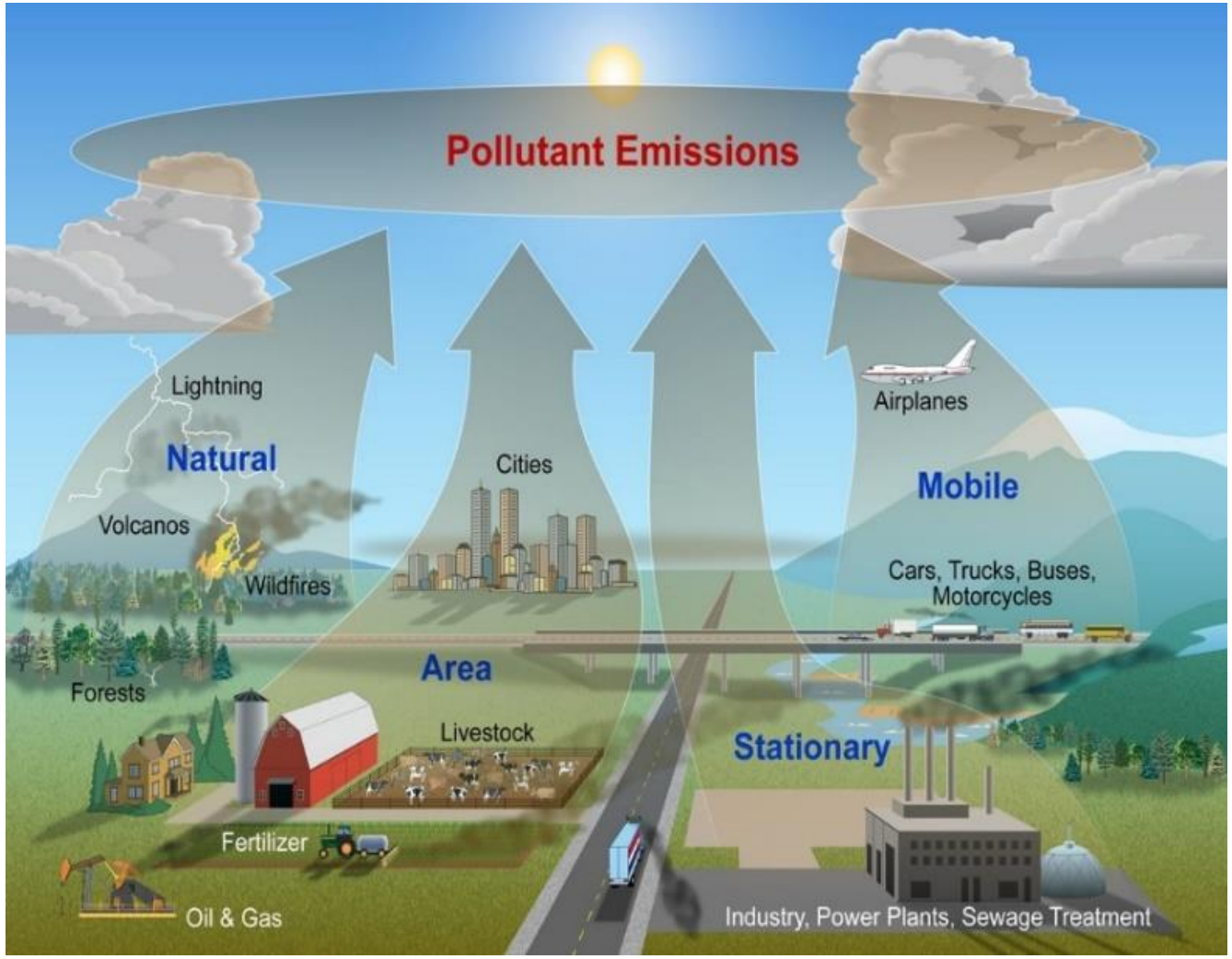
Introduction

$PM_{2.5}$, one of the major ambient pollutants, can decrease atmospheric visibility and exert adverse health effects.

As one of the earliest and most prosperous urban agglomerations in China, the Pearl River Delta (PRD) region has suffered from heavy $PM_{2.5}$ pollution.

Introduction



The $PM_{2.5}$ and its precursors come from various of anthropogenic and natural emissions.

We need to know the contribution of different emissions and the better control policy can be implemented.

Introduction

Model	Method
Observation-based Receptor Model	Chemical mass balance(CMB), Positive matrix factorization(PMF), Multilinear Engine 2(ME-2)…
Emission-based Air quality Model	Brute force method (BFM), Particulate Source Apportionment Technology(PSAT), Integrated Source Apportionment Method (ISAM)…

Previous source apportionment studies over the PRD region focused on source area and source category, no studies focused on the source time.

If the influence of pollutants emitting at different time can be found, more effective and efficient emission control measurement can be taken in advance.

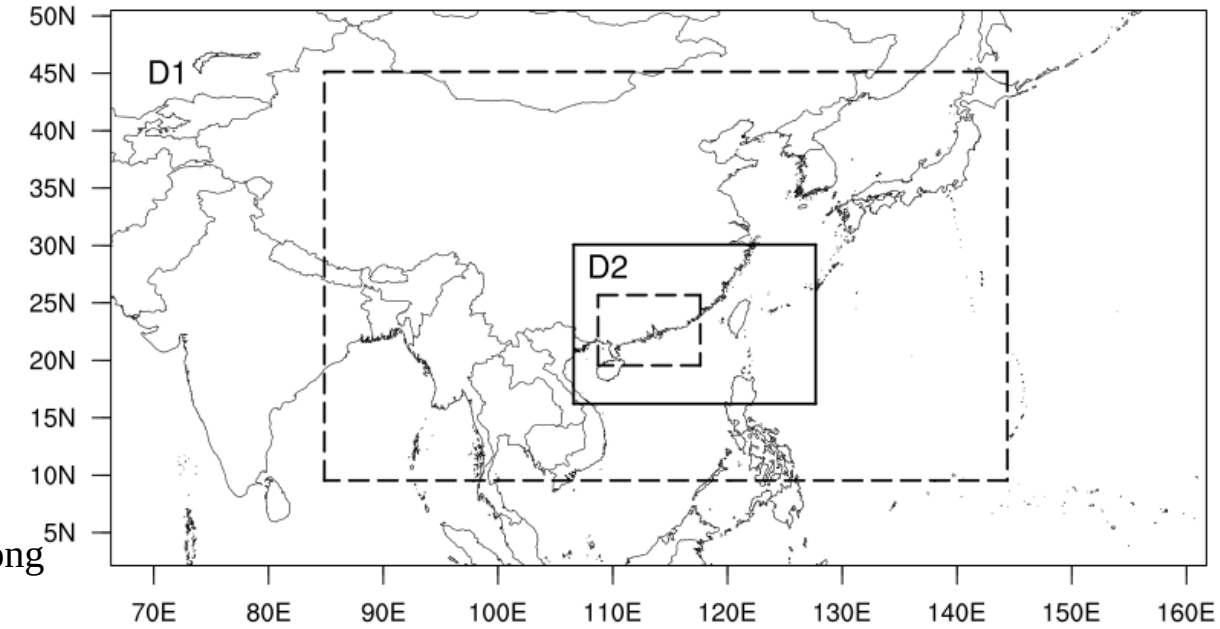
Model Setting

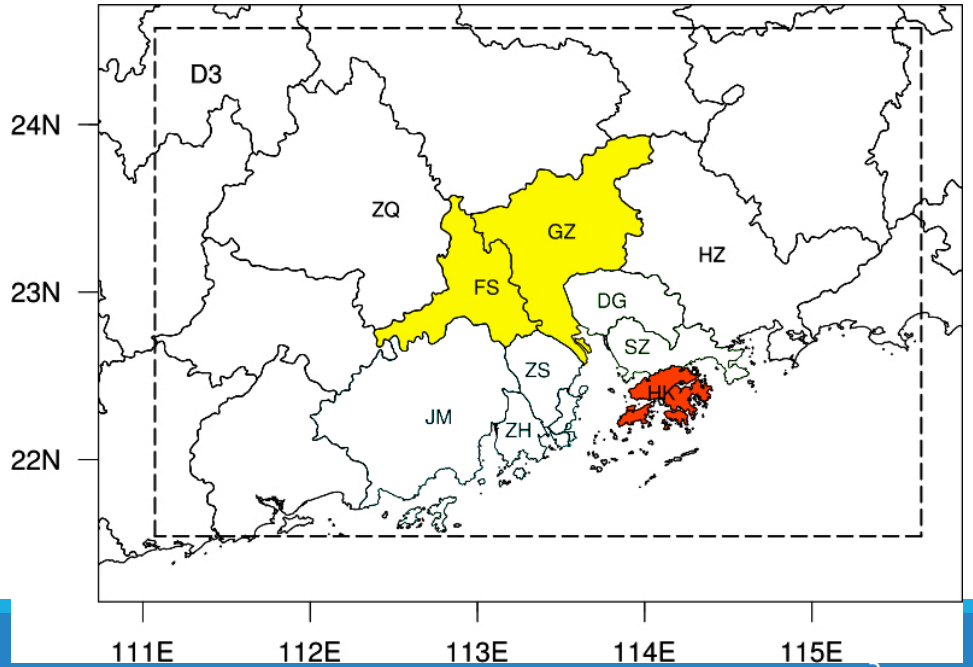
- WRF-SMOKE-CAMx/PSAT
- Emission
- Anthropogenic emission

  The PRD region: a highly resolved emission inventory provided by the Hong Kong Environmental Protection Department

  Region outside PRD : the MIX emission inventory developed by Tsinghua University

- Biogenic emission: MEGAN model
- Domain
- D1: 27km, D2: 9km, D3: 3km
- The source apportionment was conducted in D3.
- Time period
- January and July in 2015



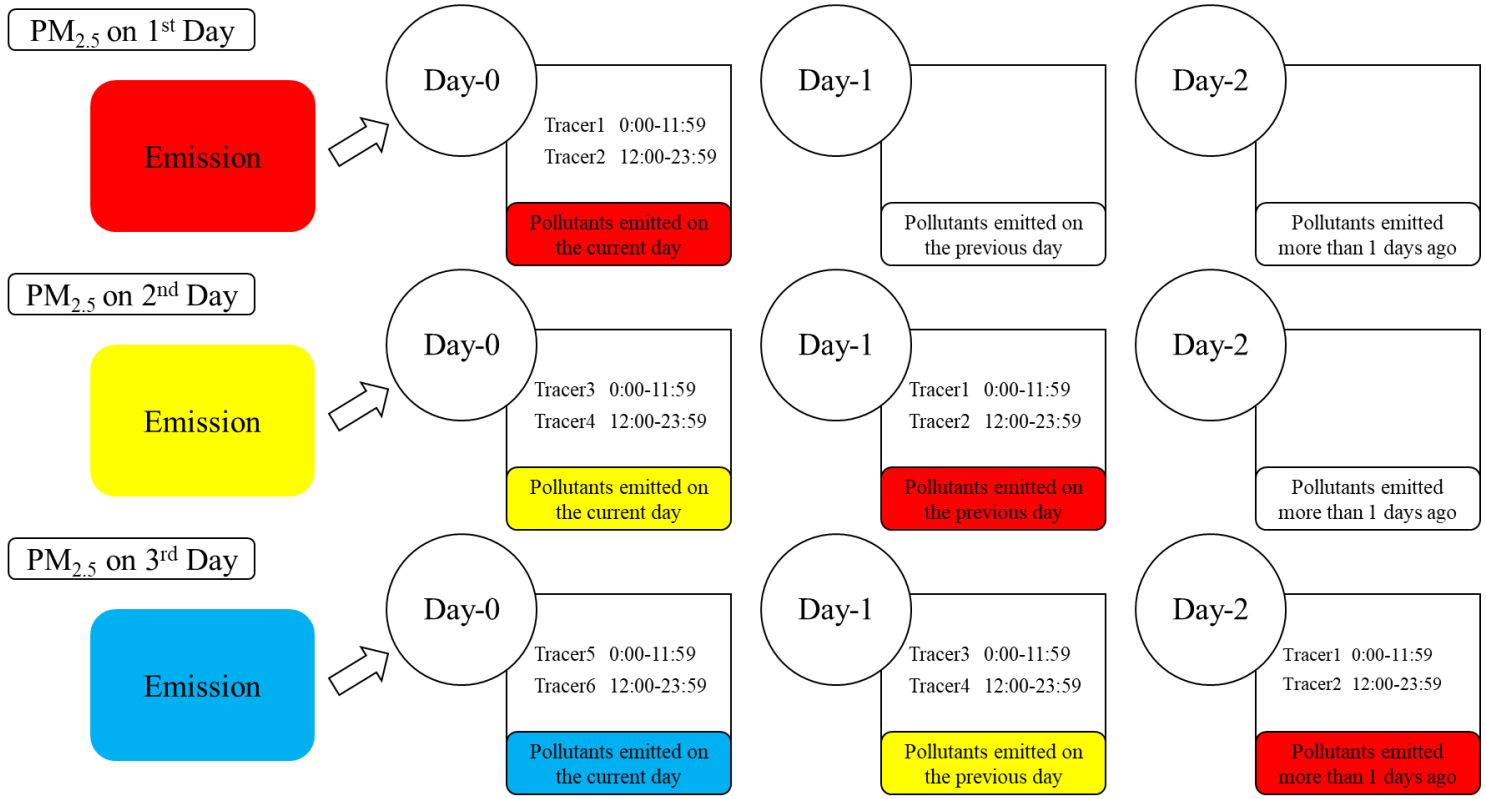


Method

The original PSAT model can track the contribution of different source areas and source categories.

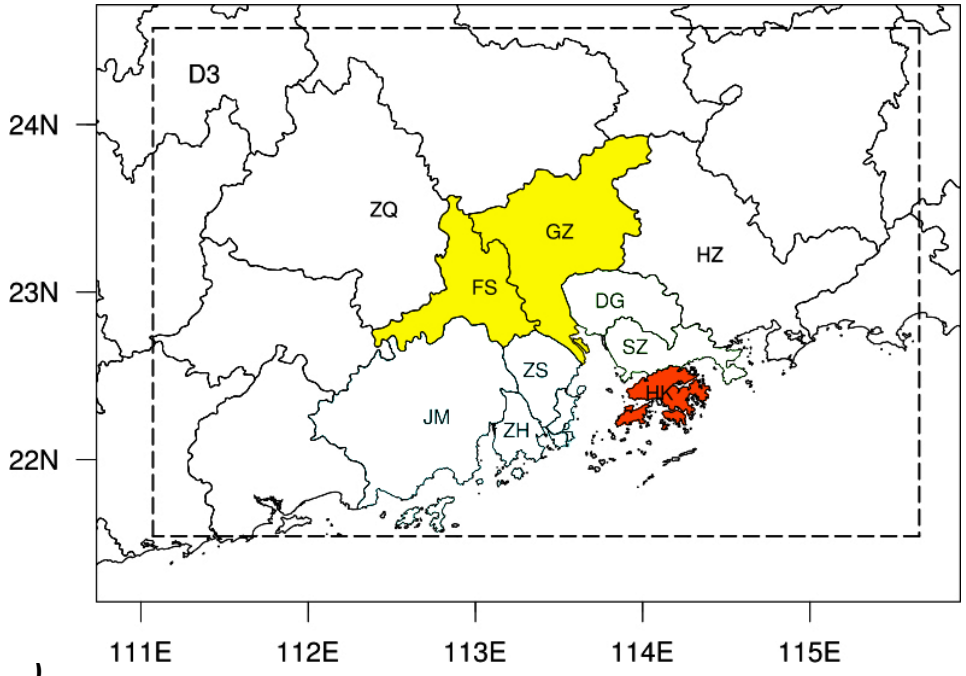
The extended PSAT used a fixed number of tracers to track the contribution of emission from different emitting time periods.

For instance, the tracking time period is the **3** days:Day-0(current day), Day-1(previous day), Day-2(=Day2+Day3+Day4+…). Each day is divided into **2** sub-time periods(0:00-11:59, 12:00-23:59). The total number of tracers is **6**(2x3).



Source Setting

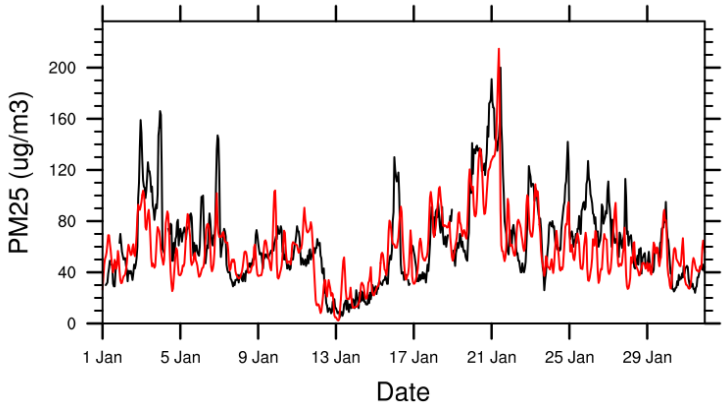
- Source Area
  - Guangzhou and Foshan (GF, yellow)
  - Hong Kong (HK, red)
  - Other regions in Domain 3 (Areas in white colors)
  - Region outside Domain 3 (Cross-Boundary)
- Source Time
  - Track days: 4days: **Day-0**, **Day-1**, **Day-2**, **Day-3**(=Day3+Day4+Day5….)
  - Each day: 0:00-5:59, 6:00-11:59, 12:00-17:59, 18:00-23:59



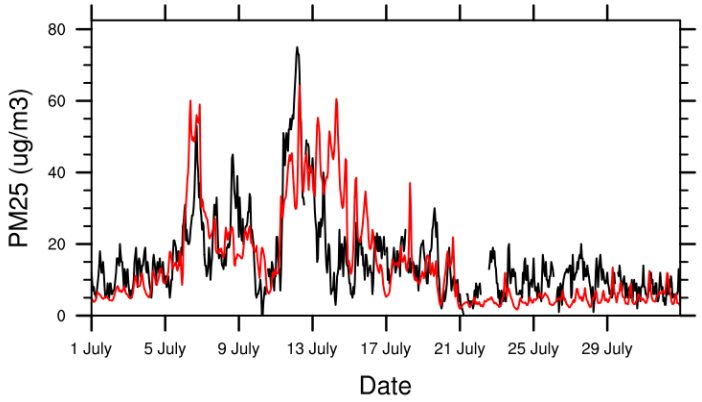
Model evaluation

	Period	MB	ME	NMB	NME	IOA	RMSE	Mean Obs	Mean Mod
$PM_{2.5}$	201501	-4.44	19.05	-0.09	0.36	0.72	25.43	53.47	49.03
	201507	-1.68	11.51	-0.08	0.53	0.65	15.89	21.62	19.94

Guangzhou



Hong Kong



- Overall, the CAMx model well reproduces the variation trend and magnitude of $PM_{2.5.}$ The simulation results are capable for further analysis.

Total Emission

- Guangzhou and Foshan (GF)
- Hong Kong (HK)
- Other regions in Domain 3

} **D3**

- Region outside Domain 3 (**Cross-Boundary**)

- The daily average $PM_{2.5}$ concentration over the PRD region was dominated by the emissions from the current day (**Day-0**) and previous day (**Day-1**)
- Jan: **Day-0** ≈55% **Day-1** 40% July: **Day-0** ≈60% **Day-1** 35%
- The **Day-0** sources mainly originated from **D3** emissions, whereas the **Day-1** sources mainly originated from **cross-boundary** transport

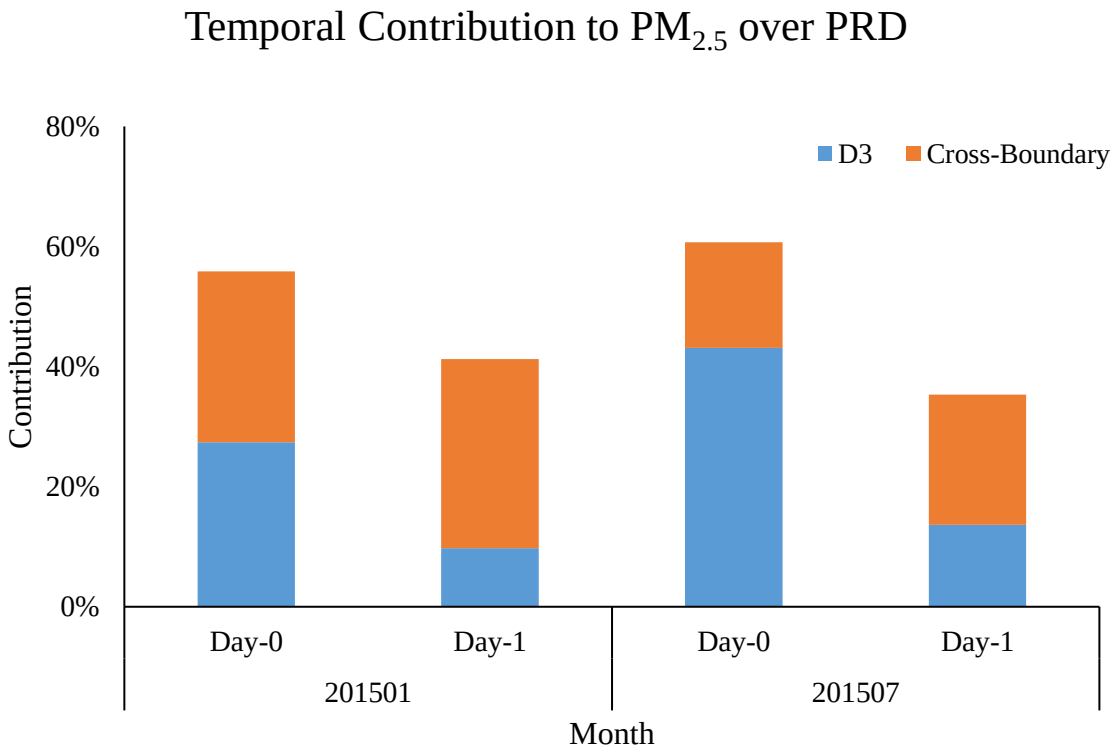


Figure 1. Monthly temporal contributions of emissions to the daily average $PM_{2.5}$ concentrations in the PRD region

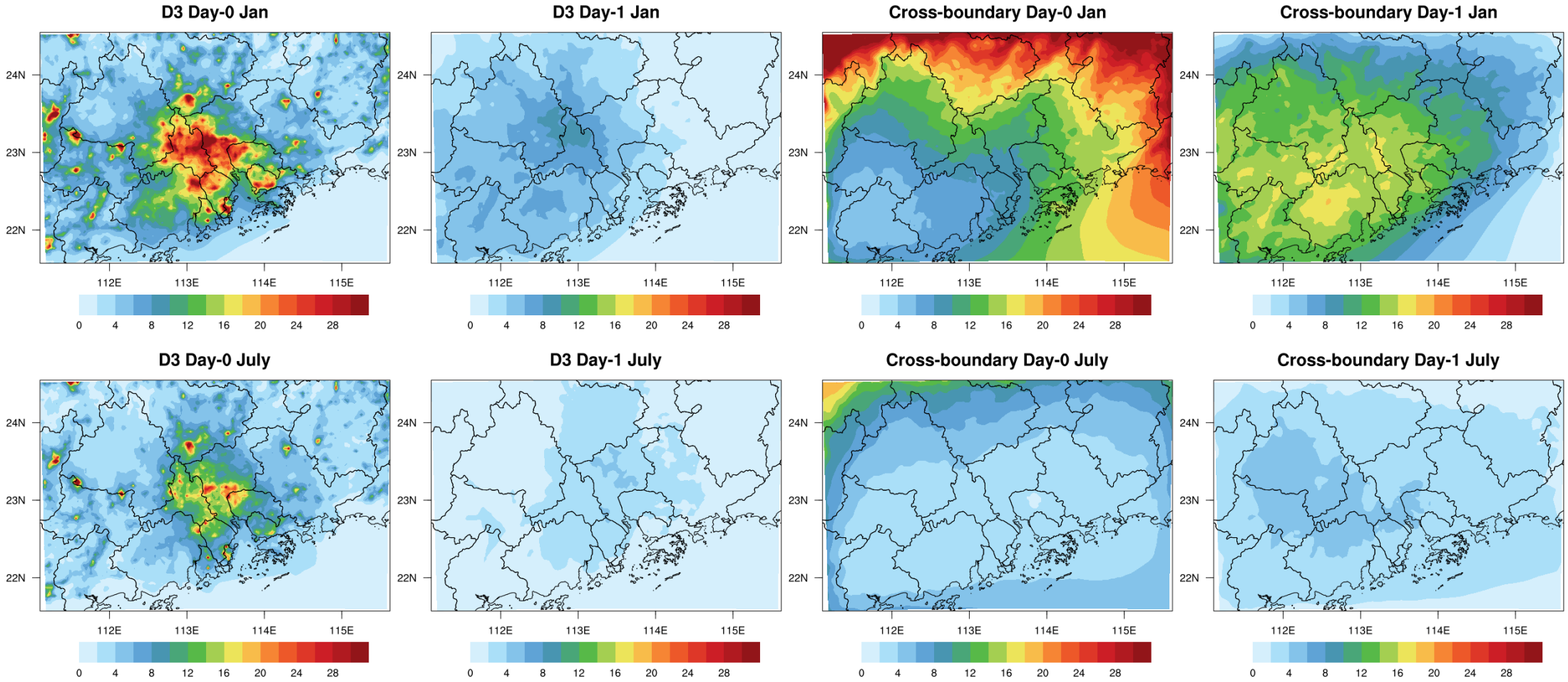


Figure2. Spatial distribution of daily average $PM_{2.5}$ concentration contributed by emissions within D3 and cross-boundary transportation from different time periods over the PRD region (unit: $\mu g/m^3$).

- The influence of D3 emissions from Day-0 was larger and mainly concentrated in the GF region
- The cross-boundary transport from Day-1 had a larger effect.

D3 Emission

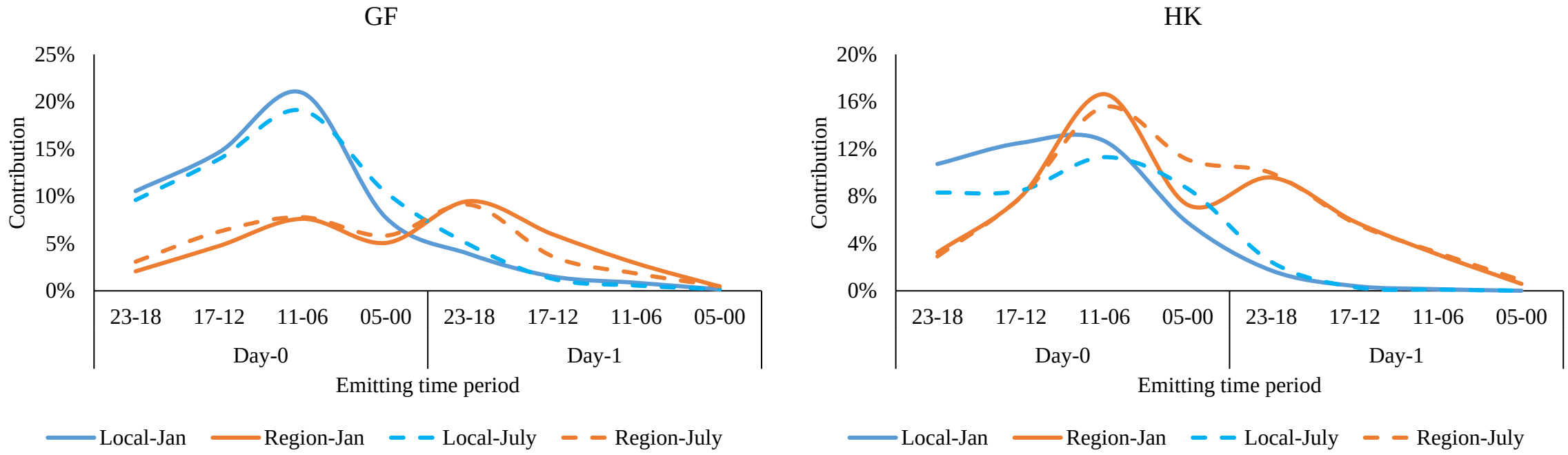


Figure 3. Average temporal contributions of local and regional emissions to the $PM_{2.5}$ concentrations in GF and HK.

D3 emission

Local: emissions within the local area (e.g., GF or HK)

Regional: emissions from other areas but within the D3 region

- The contributions of local emissions in different areas showed a similar unimodal distribution.
- The contributions of regional emission displayed a bimodal curve with two peaks at 6:00-11:59 on Day-0 and 18:00-23:59 on Day-1.

Diurnal Variation

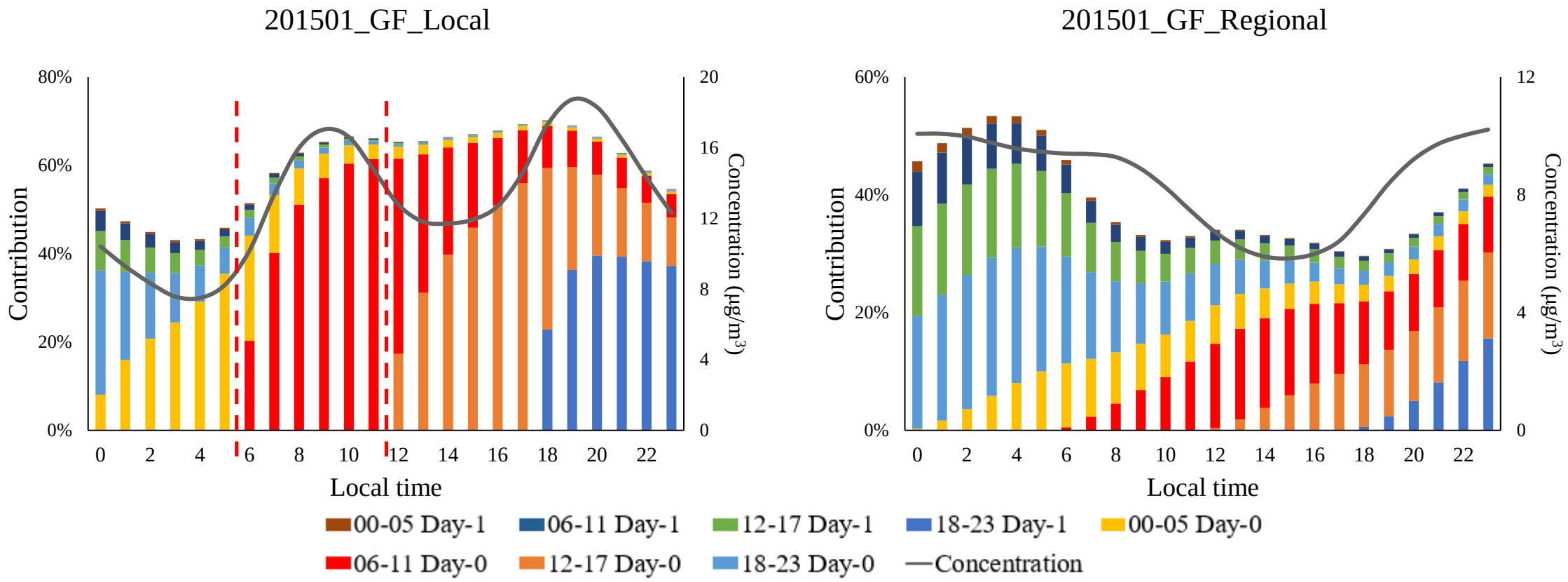


Figure 4. Monthly mean diurnal cycle of temporal contributions from local and regional emissions to the $PM_{2.5}$ concentrations in GF region in January [color bar represents the emission contribution (unit: %); curves represent the contributed concentration ($\mu g/m^3$)]

- The hourly $PM_{2.5}$ concentration was mainly influenced by the **local emissions** in each period, and the influence gradually decreased over the next 6 hours owing to pollutant transport and dilution.
- The **regional influence** was the joint effect of regional emissions from various periods.

Diurnal Variation

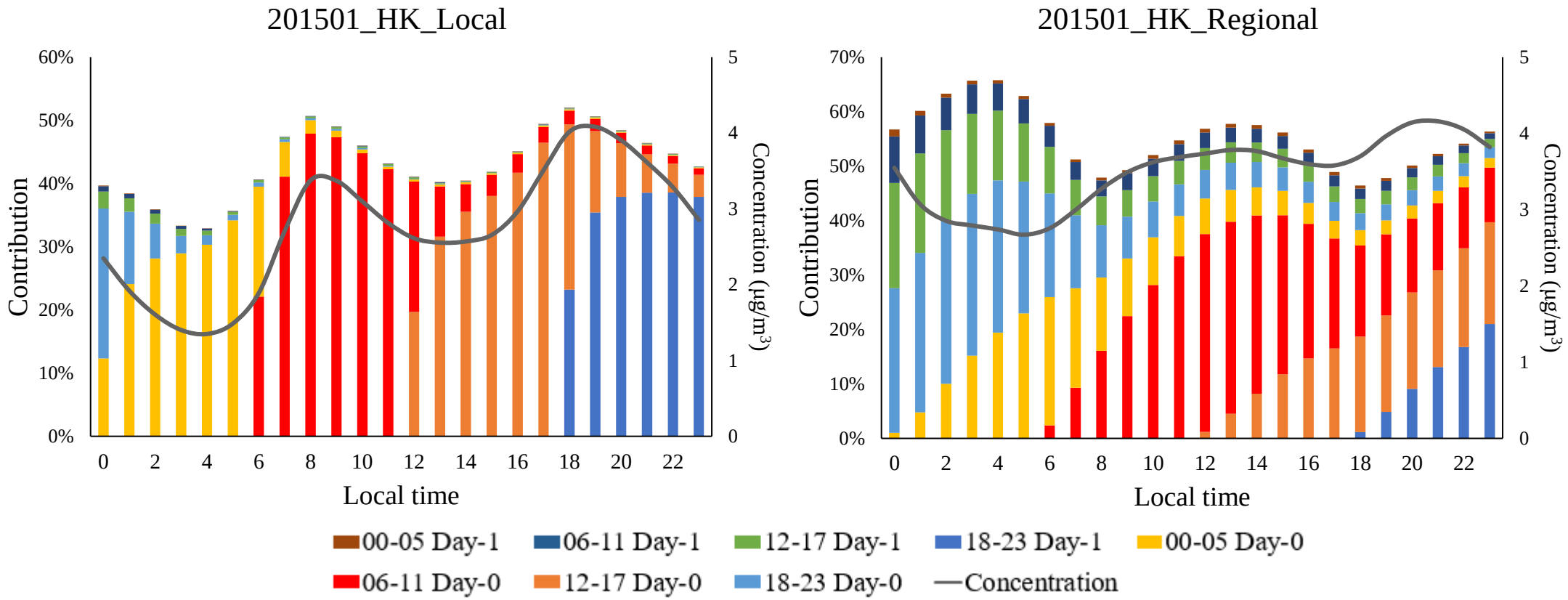


Fig. 5. Monthly mean diurnal cycle of temporal contributions from local and regional emissions to the $PM_{2.5}$ concentrations in HK regions in January [color bar represents the emission contribution (unit: %); curves represent the contributed concentration ($\mu g/m^3$)]

Pollution Episode

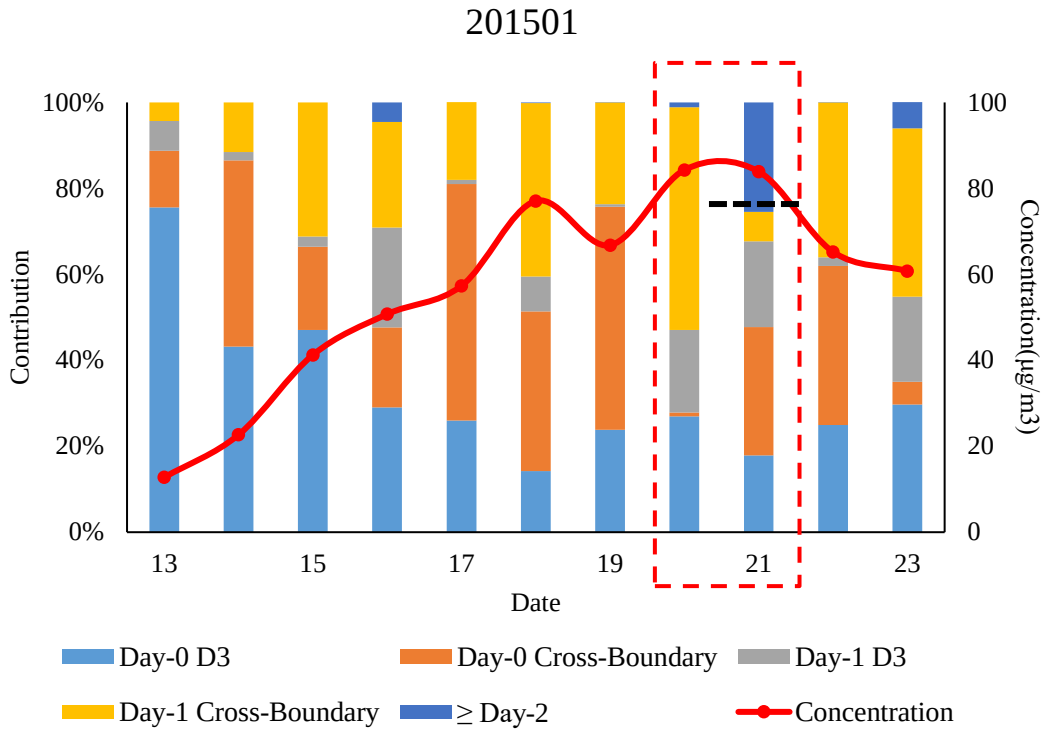


Fig. 6. Time series of the average temporal contributions to $PM_{2.5}$ in the GF region.

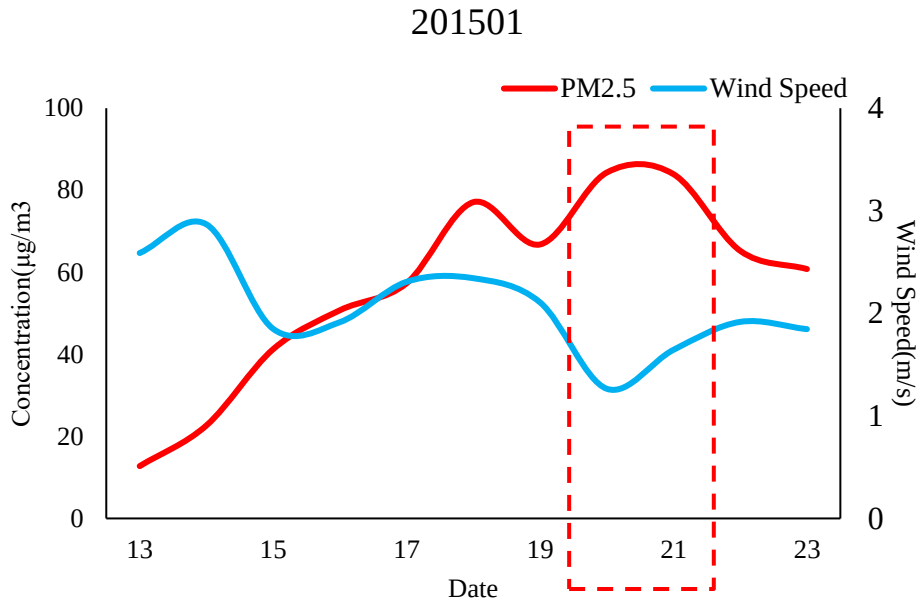


Fig.7. The time series of daily $PM_{2.5}$ concentration and average wind speed in the GF region.

- Pollutants outside the PRD region were generally transported to the GF region before the episode (18-19th Jan).
- During the episodes(20-21th Jan.), fewer cross-boundary pollutants were transported to the GF region in the current day because of the slower wind speed.
- The pollutants from **2 days earlier** could still account for more than **20%** of the $PM_{2.5}$ in current day.

Summary

- The $PM_{2.5}$ over the PRD region in 201501 and 201507 was mostly affected by the emission from **the current day and the previous day**.
- The major contribution of **local emission** is in **6:00-17:59** in the current day(30%),while the **regional emission** from **previous day** could still have influence on the $PM_{2.5}$ in the current day.
- The emission **from 2 days ago** can still have influence during pollution periods because of the weaker wind speed.
- Further clarifying the contribution of cross-boundary pollutants released in different source areas and periods is needed for better cross-province collaboration.

Thank you!

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