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# Multiscale Physical Modelling in Urban Environment: Case study for Ningbo & Xiamen

Jie Zheng

Fangxin Fang, Linfeng Li

# Multiscale physical simulations for Urban scales

PALM (Parallelized Large-Eddy Simulation Model)

**PALM** is a large-eddy simulation model for urban climate and environmental research.

## ➤ Integrated physical modules:

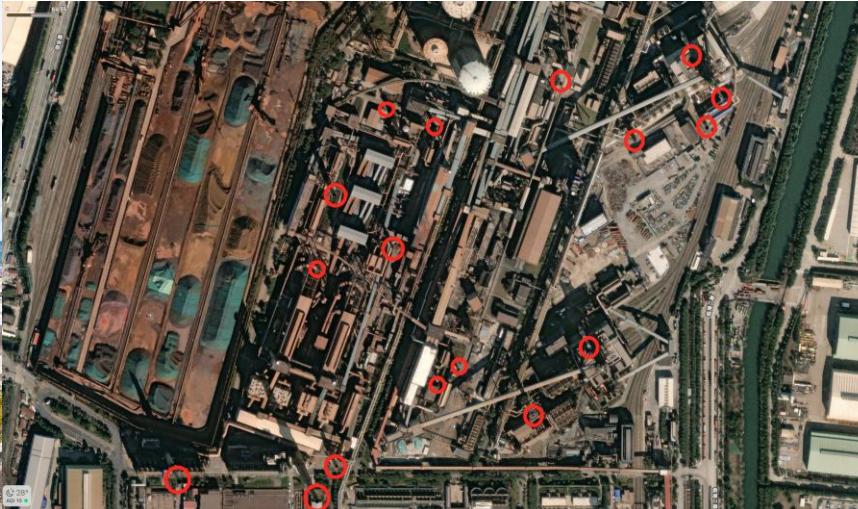
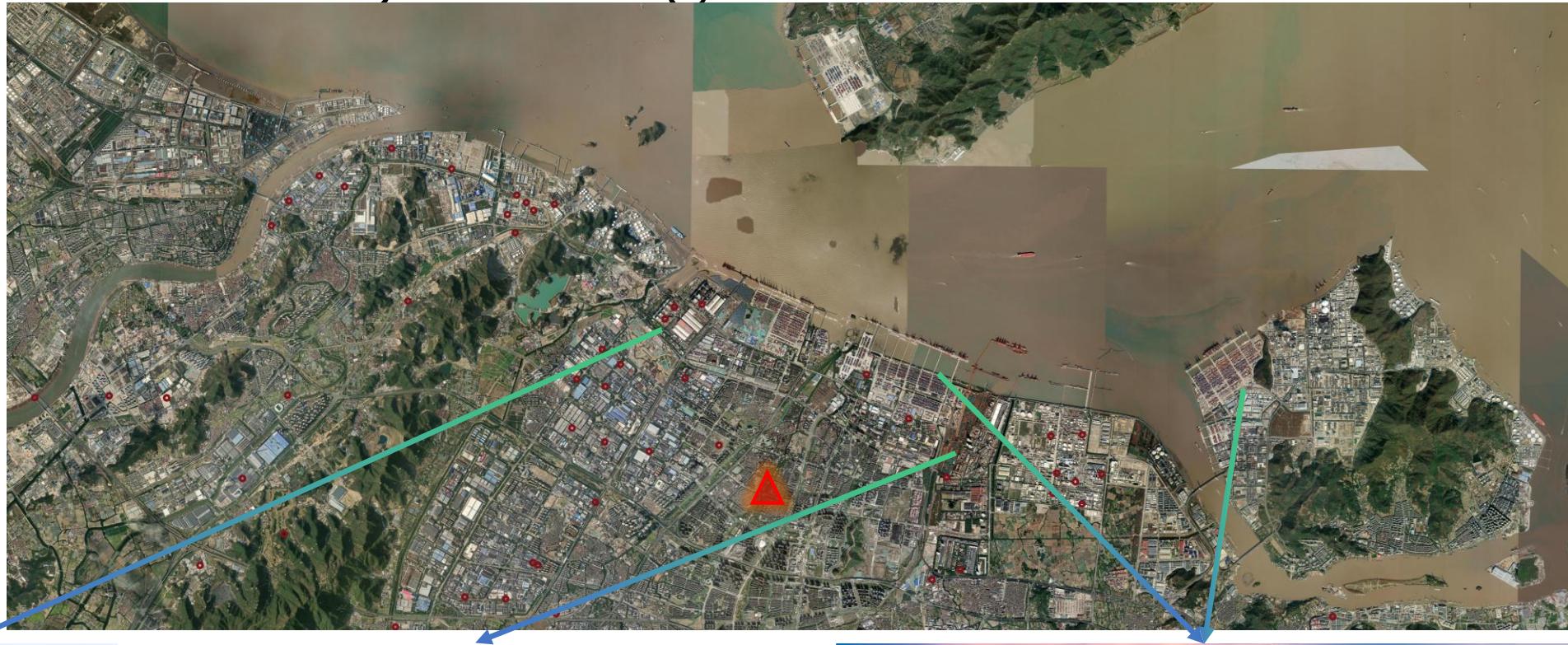
- **Radiative Transfer Module** – simulates shortwave and longwave radiation in complex urban/natural settings.
- **Land Surface Module** – represents soil–vegetation–atmosphere exchanges of heat and moisture.
- **Urban Surface Module** – captures building surfaces, walls, roofs, and their thermal dynamics.
- **Plant Canopy Module** – resolves vegetation impacts on momentum, heat, moisture, and pollutant transport
- **Indoor climate module** - Calculates temperature and other parameters inside buildings.
- **Atmospheric Chemistry Module** - Simulates the transport, chemical reactions (gas-phase chemistry), and dry deposition of air pollutants.
- **Aerosol Module** - Can be coupled to the chemistry module for a detailed description of aerosol size distribution and chemical composition.

## ➤ Coupling and extensions:

- Regional and mesoscale models (e.g., WRF, **ERA5**, **EAC4**) for boundary conditions.
- Time-varying emissions from traffic and other anthropogenic sources
- Energy system models, pollutant chemistry, and urban planning tools.
- High scalability for massively parallel computations on supercomputers.

# Why is Ningbo

1. Port–industry–urban integration
2. Complex terrain: mountains + sea
3. High-density steel / power plants
4. Intensive port, shipping and container traffic



# Case Study

- Ningbo Beilun
- Industrial Point Source
- 3 Nested Domains
  - Parent domain D01:
    - $70 \text{ km} \times 51.2 \text{ km}$
    - $\text{dx}=\text{dy}=100\text{m}$ ,  $\text{dz} = 40\text{m}$
  - Child domain D02 :
    - $32 \text{ km} \times 12.8 \text{ km}$
    - $\text{dx}=\text{dy}= 50\text{m}$ ,  $\text{dz} = 20\text{m}$
  - Child domain D03 :
    - $9 \text{ km} \times 6.4 \text{ km}$
    - $\text{dx}=\text{dy}= 10\text{m}$ ,  $\text{dz} = 10\text{m}$



# Static driver

D01 Great Ningbo: regional terrain & coastline



D02 Great Beilun: port–industry–city corridor



3D view of buildings



D03 Main Beilun:  
urban & industrial  
core

# Case settings

- Spatial discretisation:

	Grid size	# of grid
Parent domain D01	100m x 100m x 40m	700 x 512 x 60
Child domain D02	50m x 50m x 20m	640 x 256 x 50
Child domain D03	10m x 10m x 10m	900 x 640 x 40

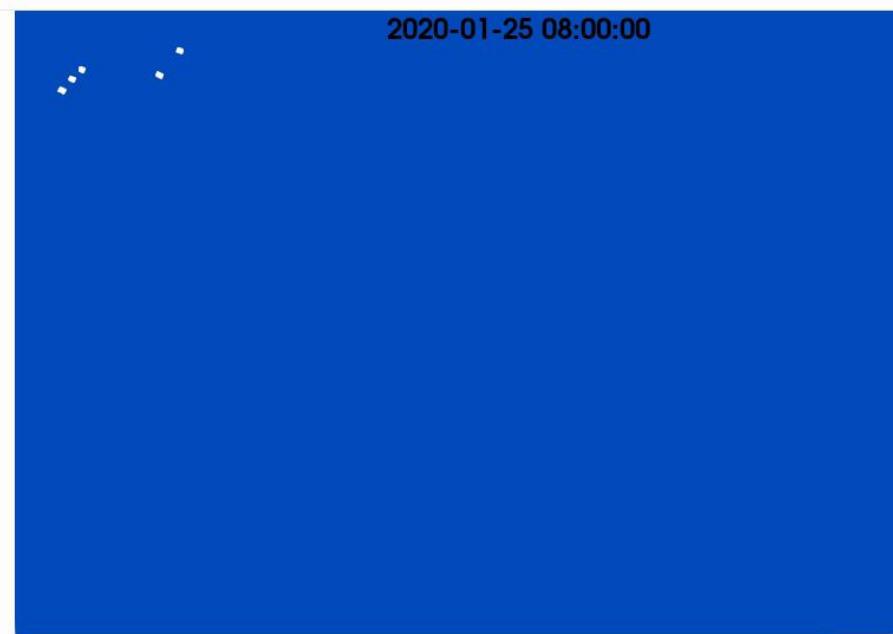
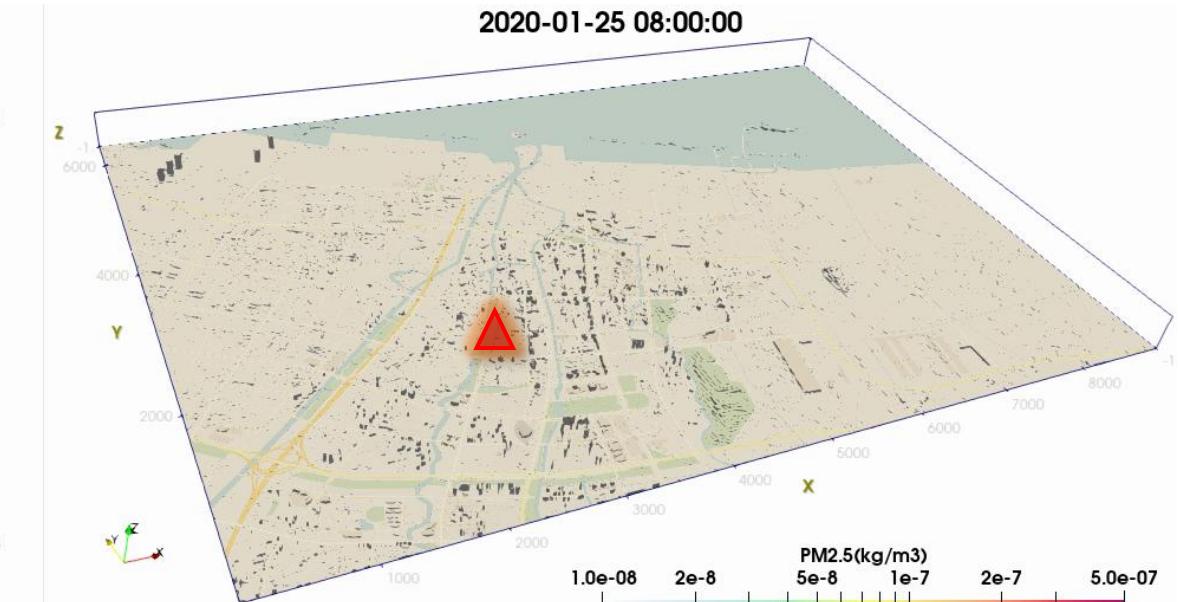
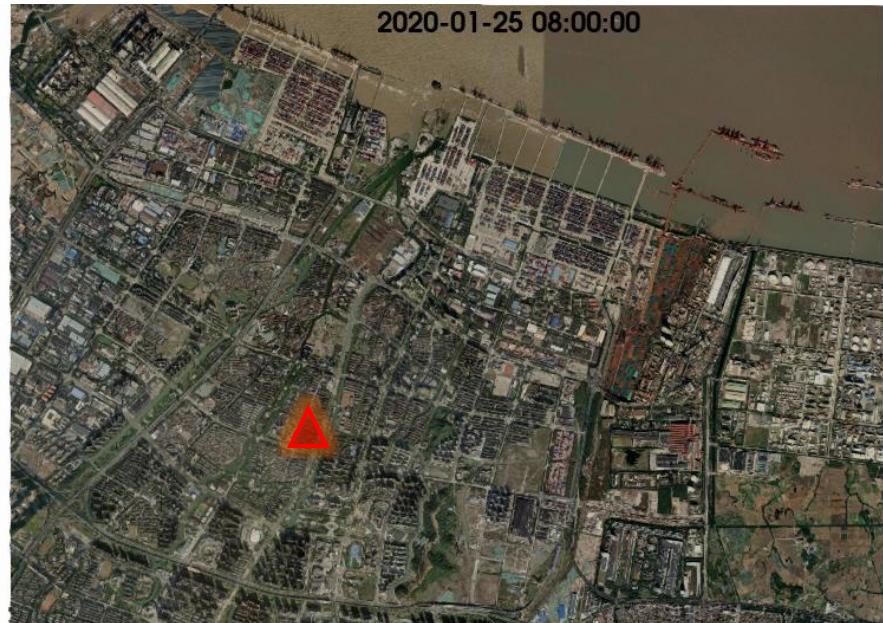
- Run on [ARCHER2](#) (UK Tier 1 HPC)
  - 8 nodes (1024 cores)
  - 13 hr CPU time for 1 day (**2020-01-25**) simulation
- Activated [physics model](#)
  - Urban surface (only in Child domain N03)
  - Radiation
  - Land surface
  - Dynamic driver( [ERA5](#) reanalysis data @ 0.25 deg )

# Results

# Overview (D01 Great Ningbo on 20200125 )

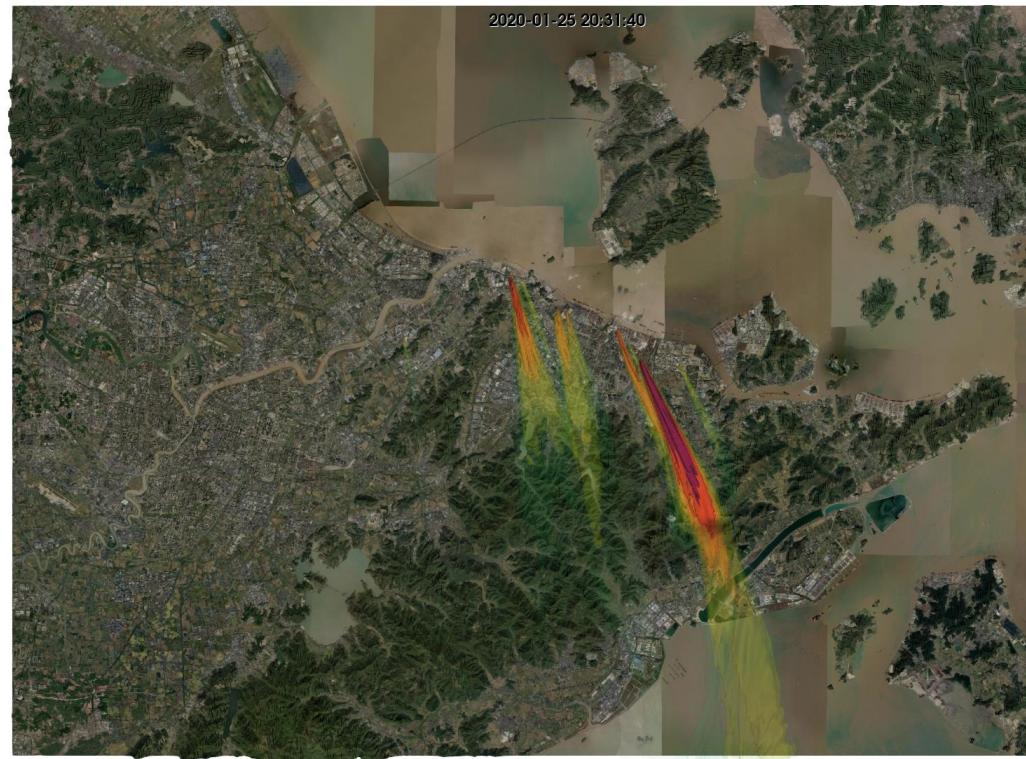


# Overview (D03 Main Beilun on 20200125 )

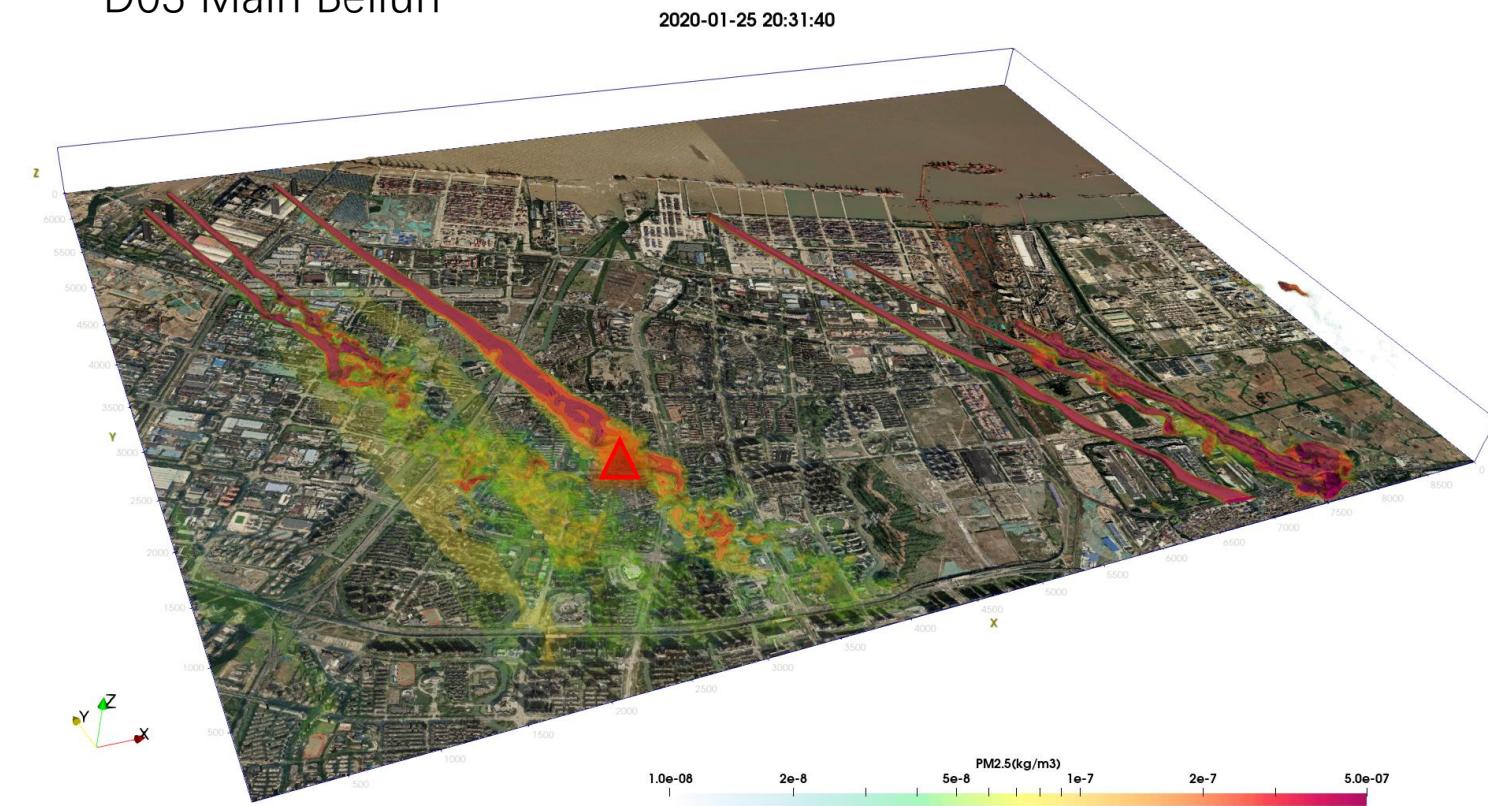


# Northwest Wind Simulations

D01 Great Ningbo

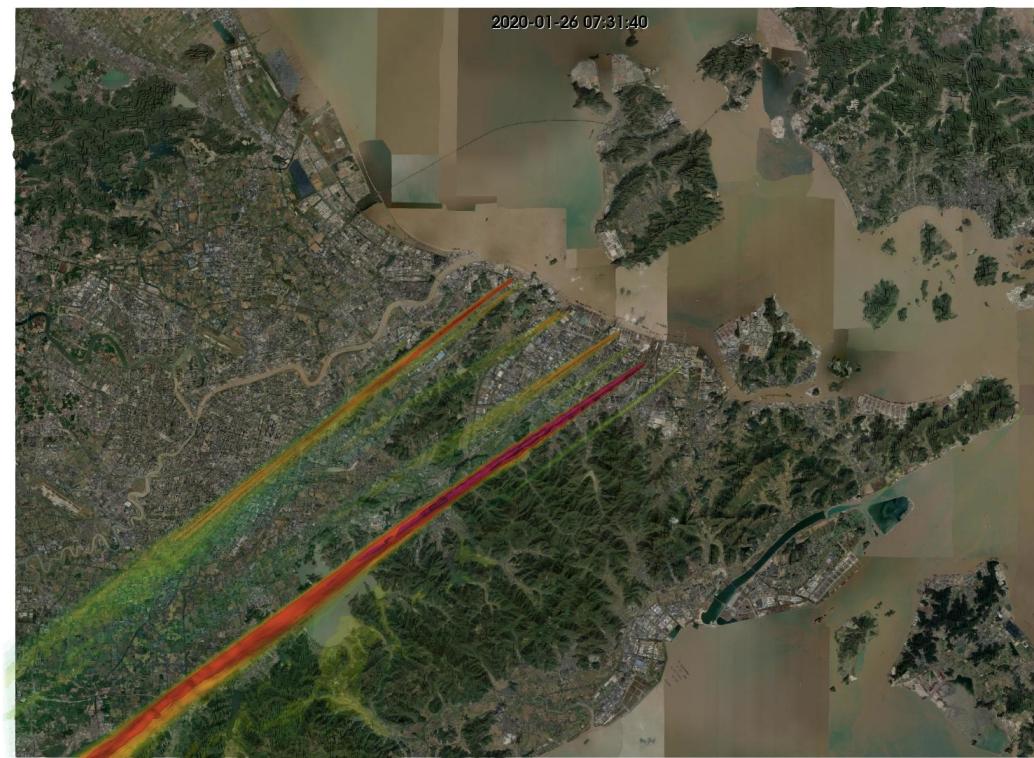


D03 Main Beilun

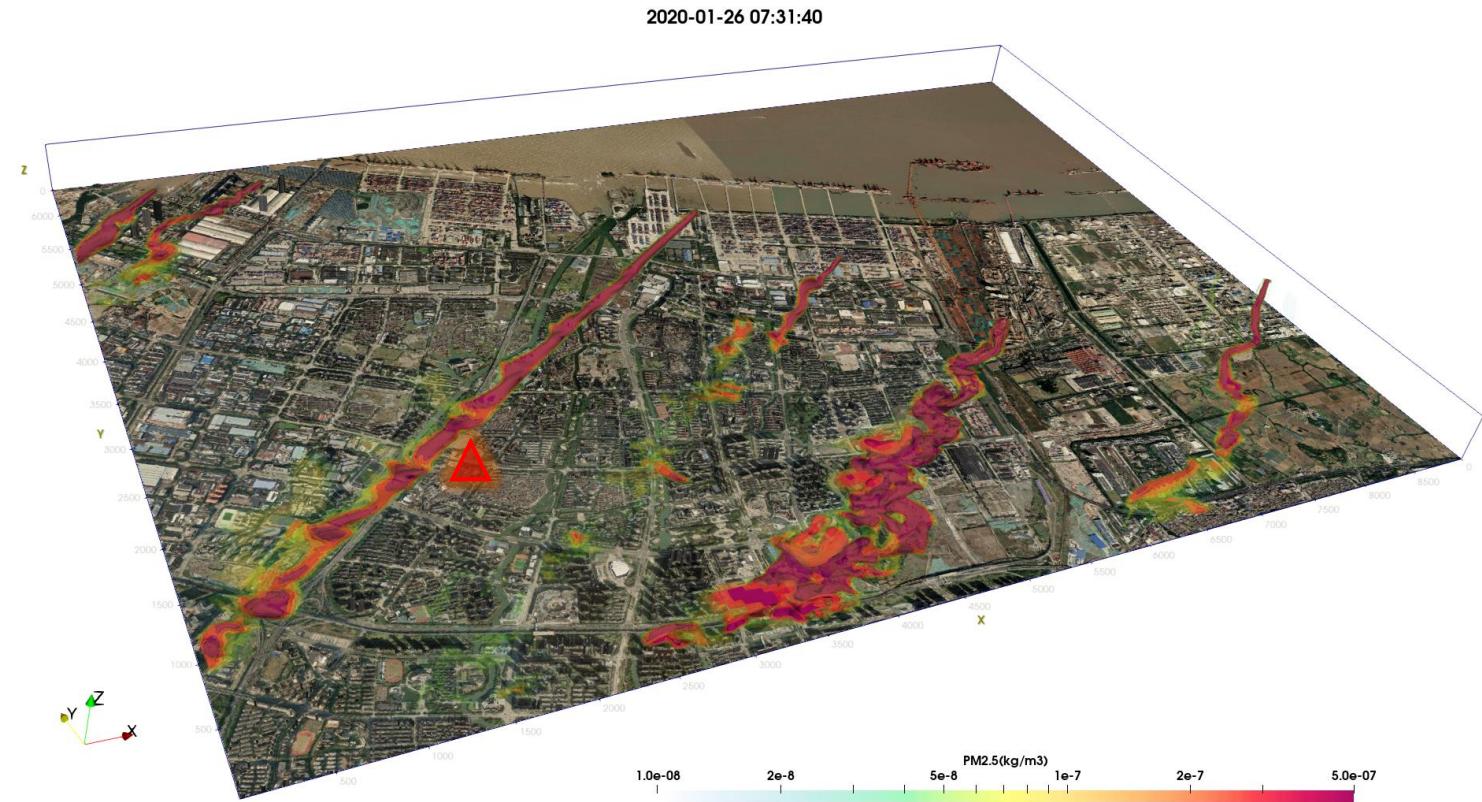


# Northeast Wind Simulations

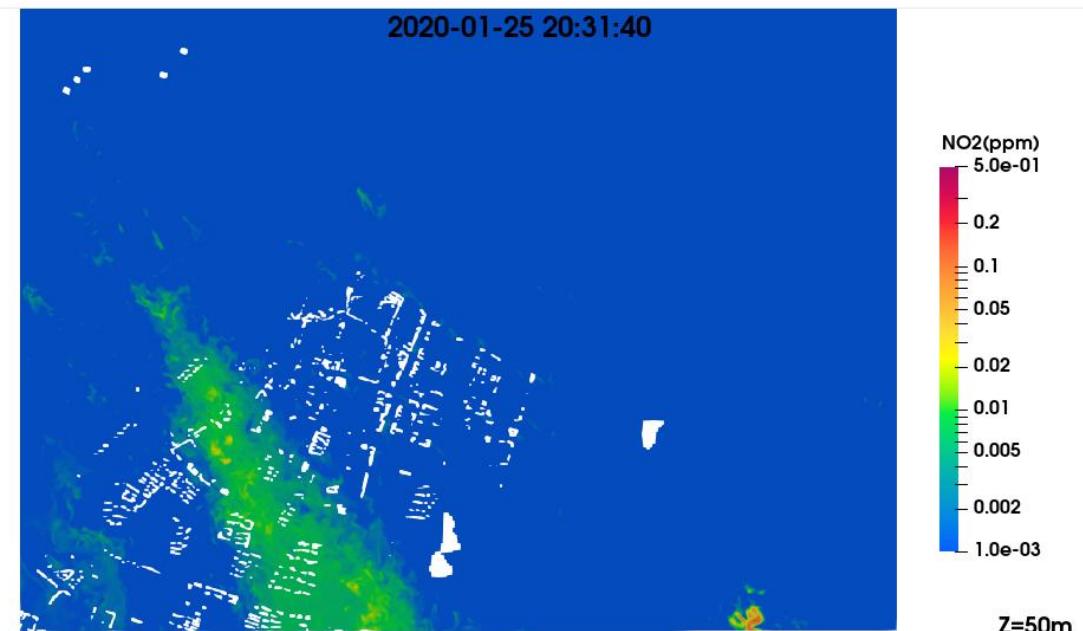
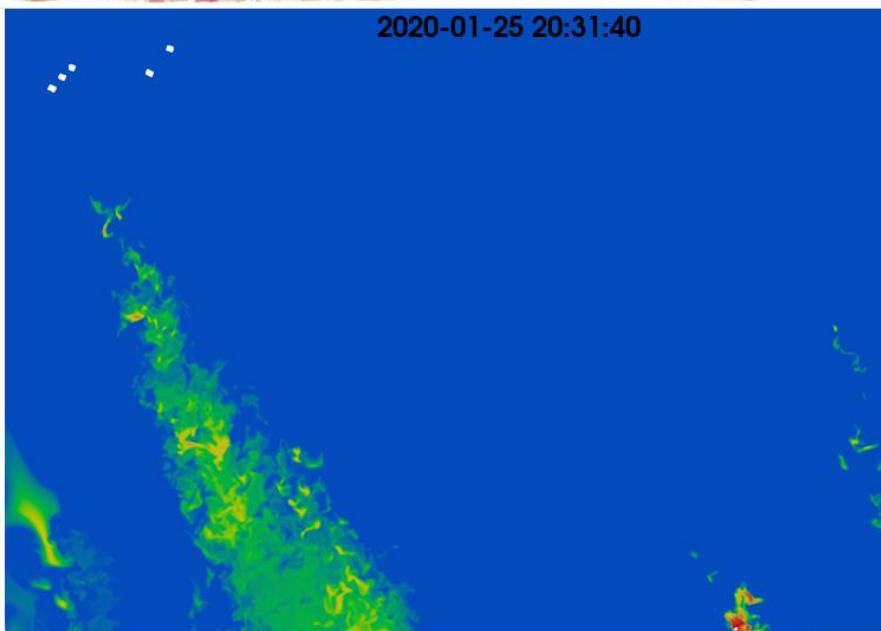
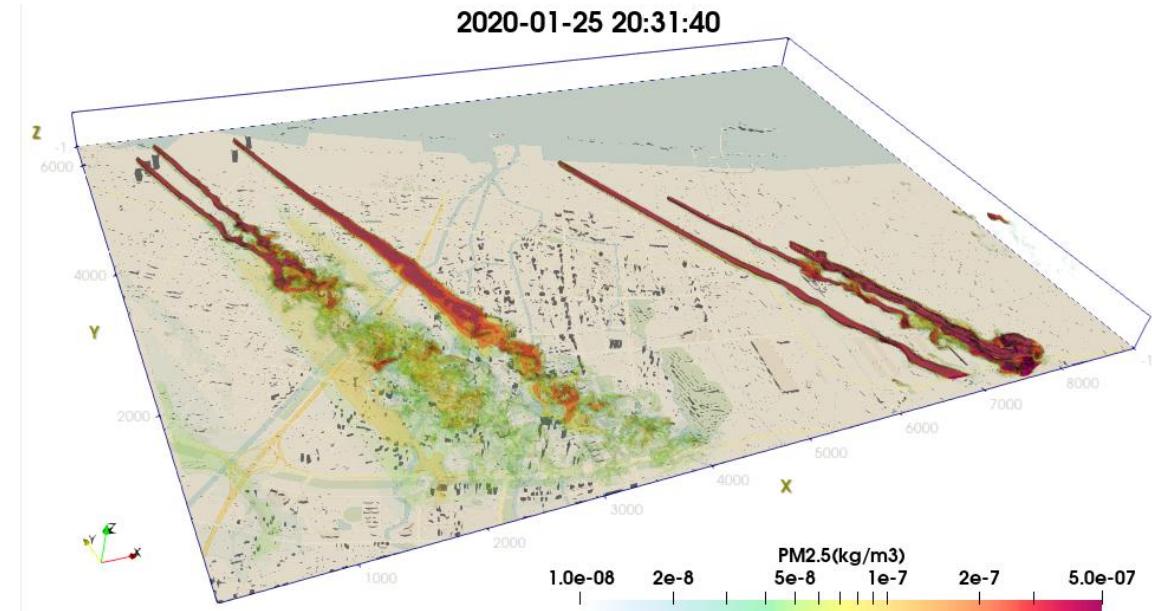
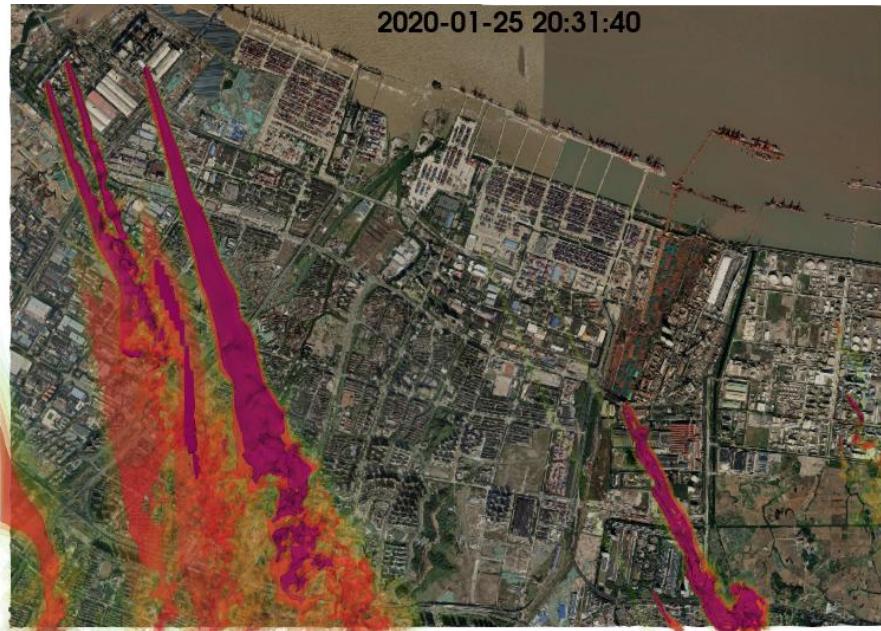
D01 Great Ningbo



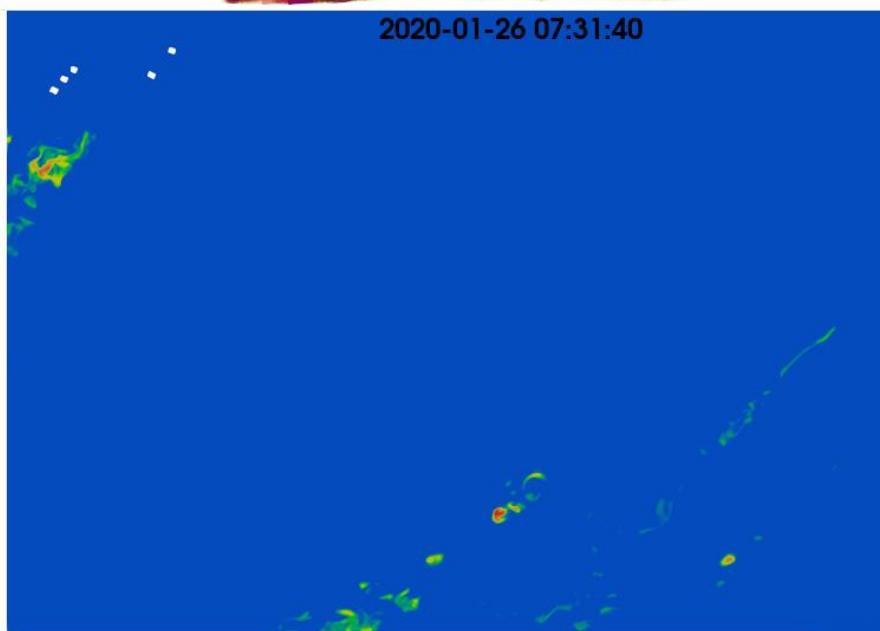
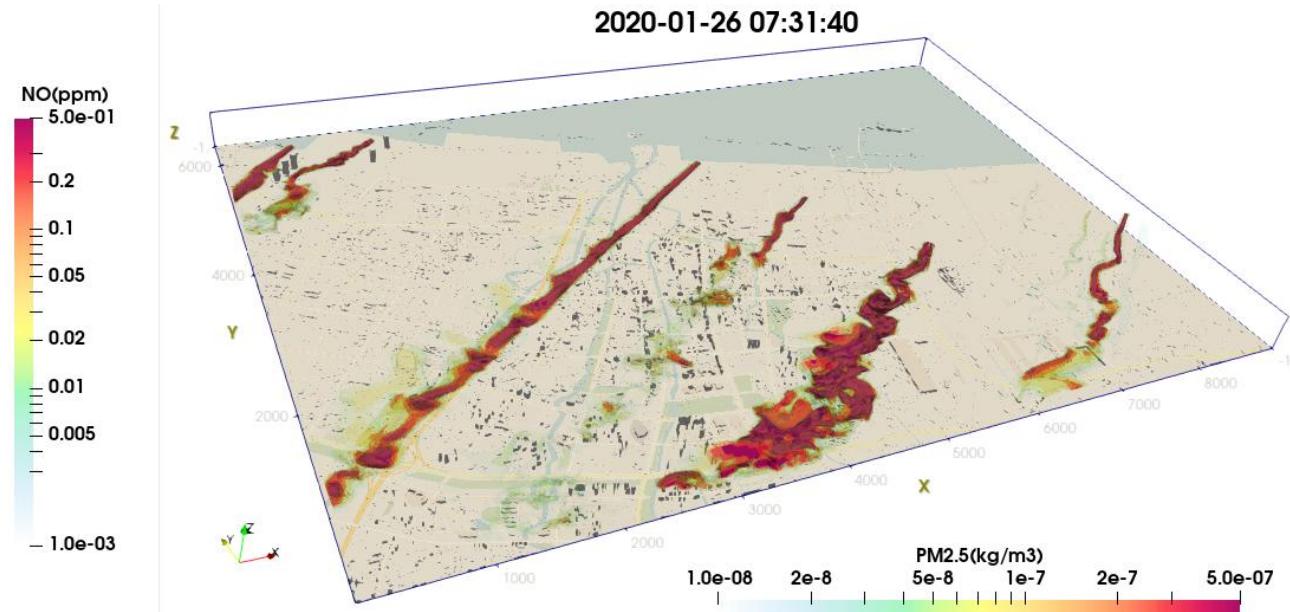
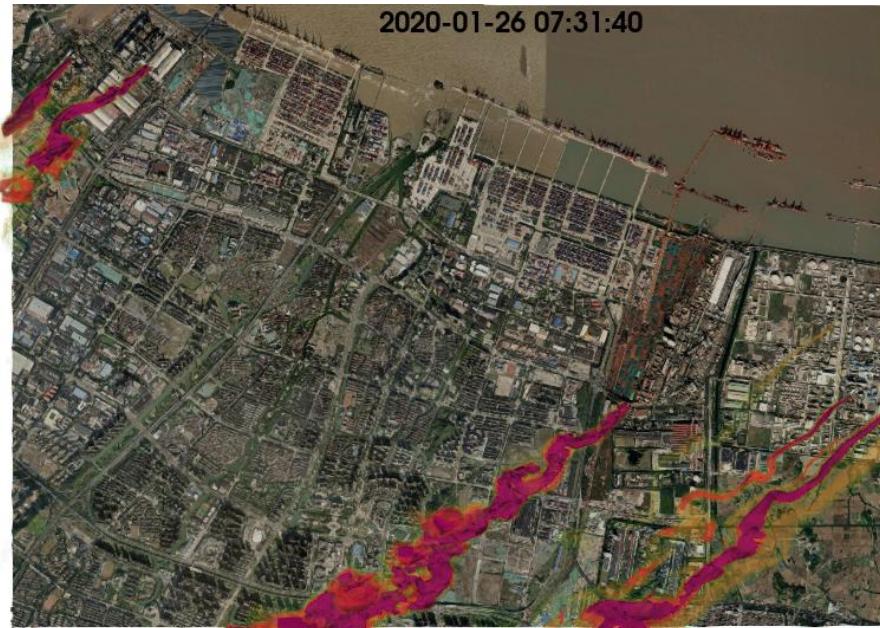
D03 Main Beilun



# Northwest Wind Simulations

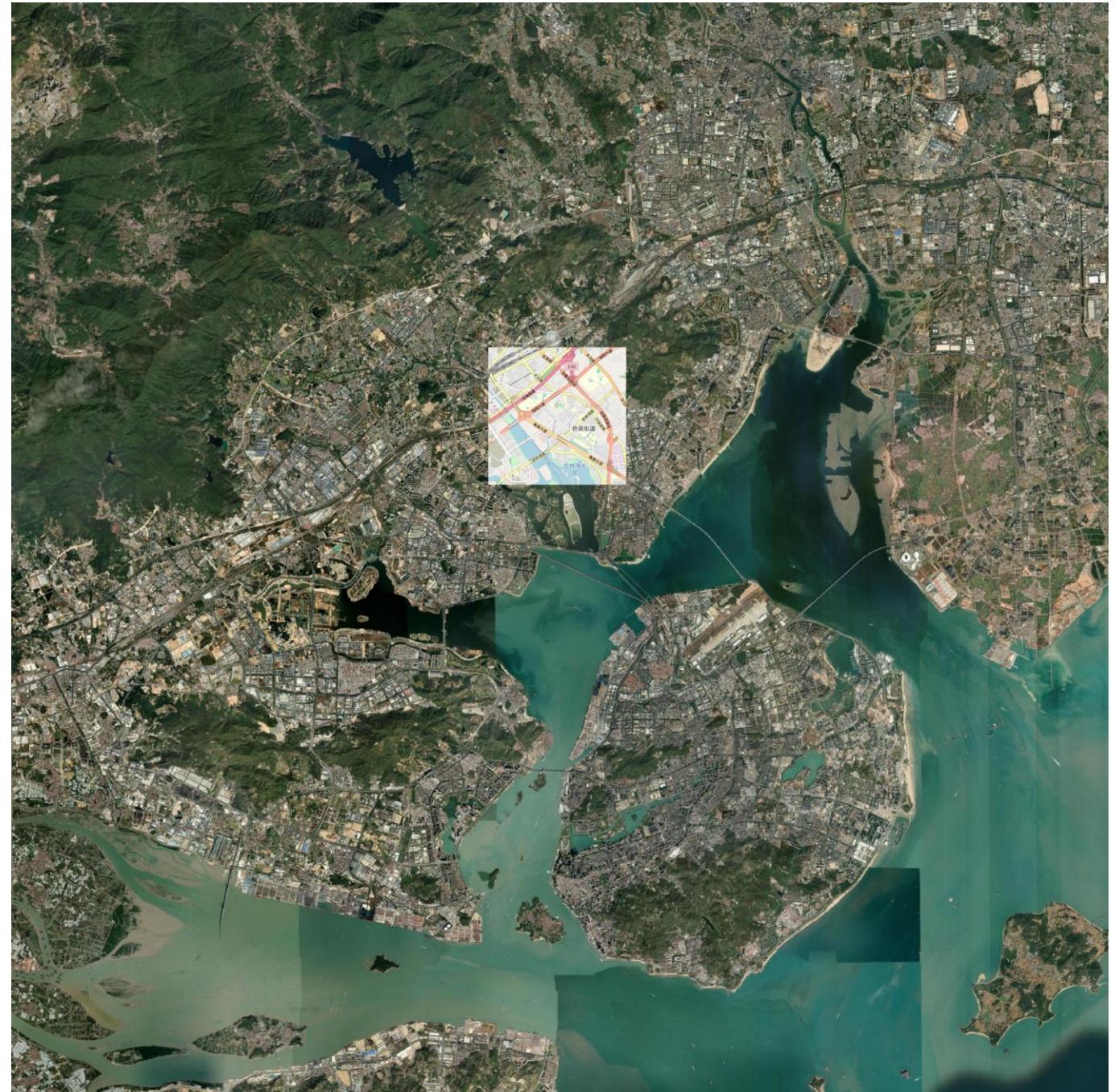


# Northeast Wind Simulations



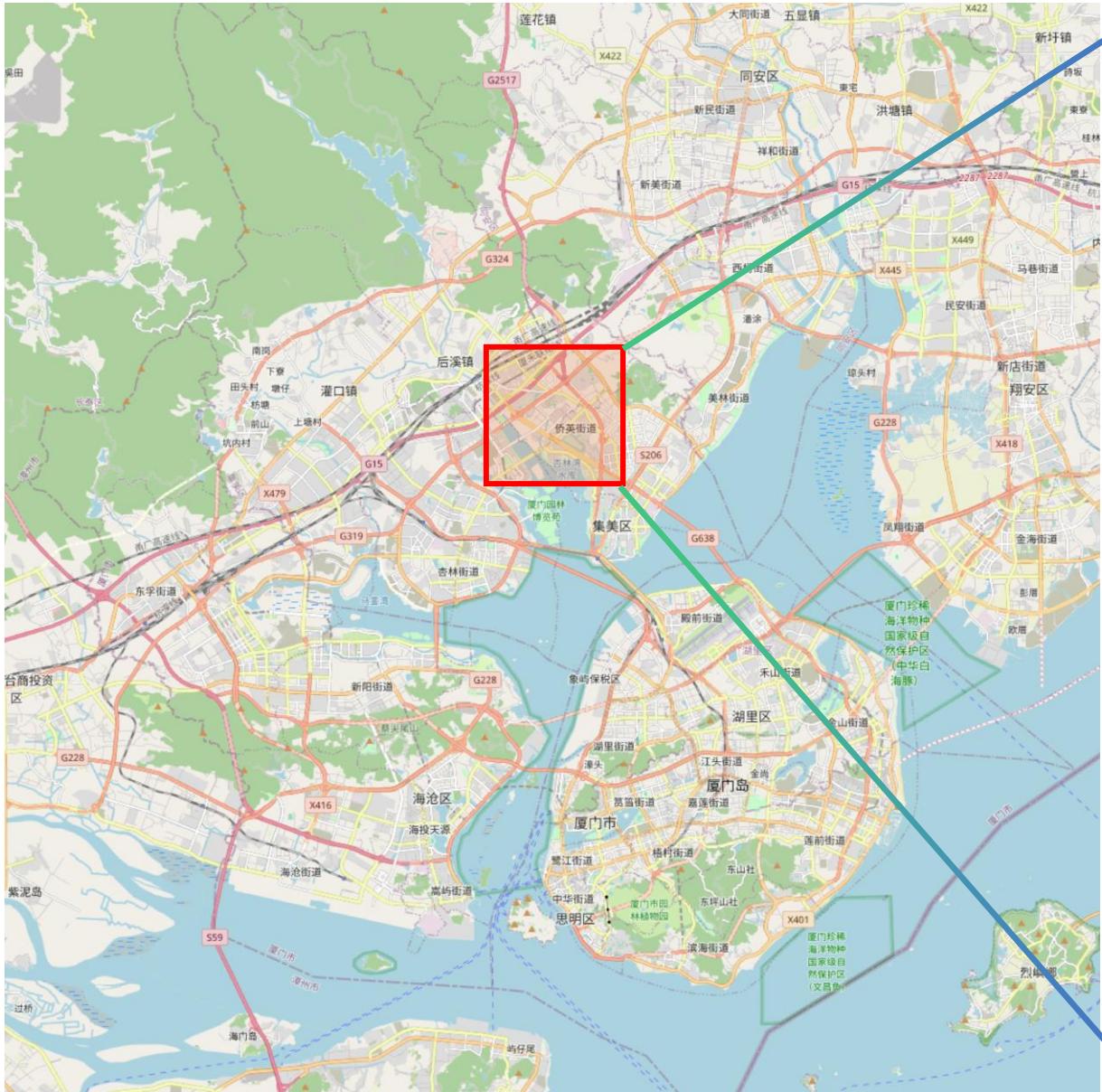
# Case Study

- Xiamen [Jimei](#)
- Traffic Sources
- 2 Nested Domain
  - Parent domain D01:
    - $40 \text{ km} \times 40 \text{ km}$
    - $\text{dx}=\text{dy}=100\text{m}$ ,  $\text{dz} = 50\text{m}$
  - Child domain D02 :
    - $5 \text{ km} \times 5 \text{ km}$
    - $\text{dx}=\text{dy}= 10\text{m}$ ,  $\text{dz} = 10\text{m}$

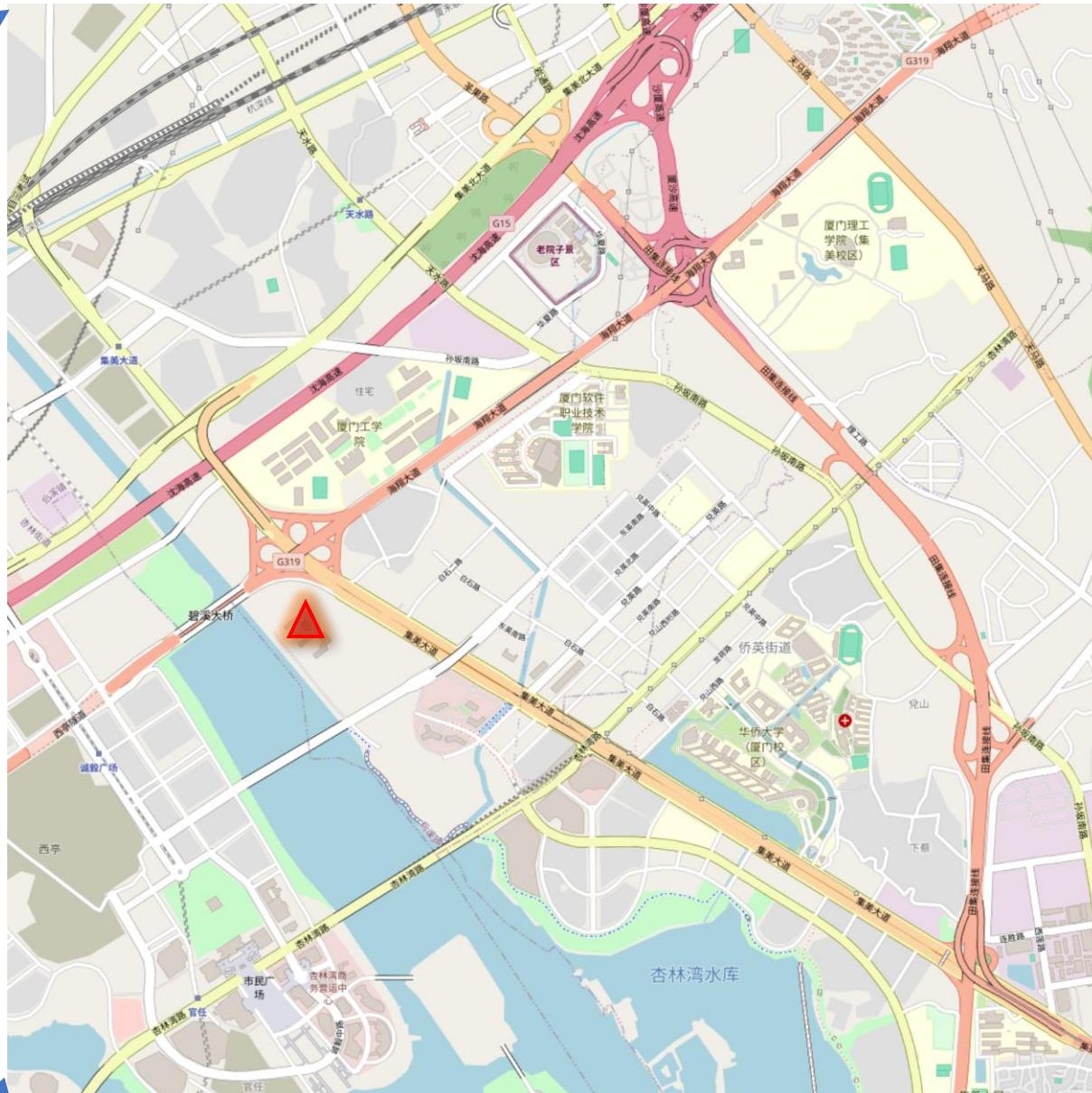


# Static driver

D01 Xiamen



D02 Jimei



# Case settings

- Spatial discretisation:

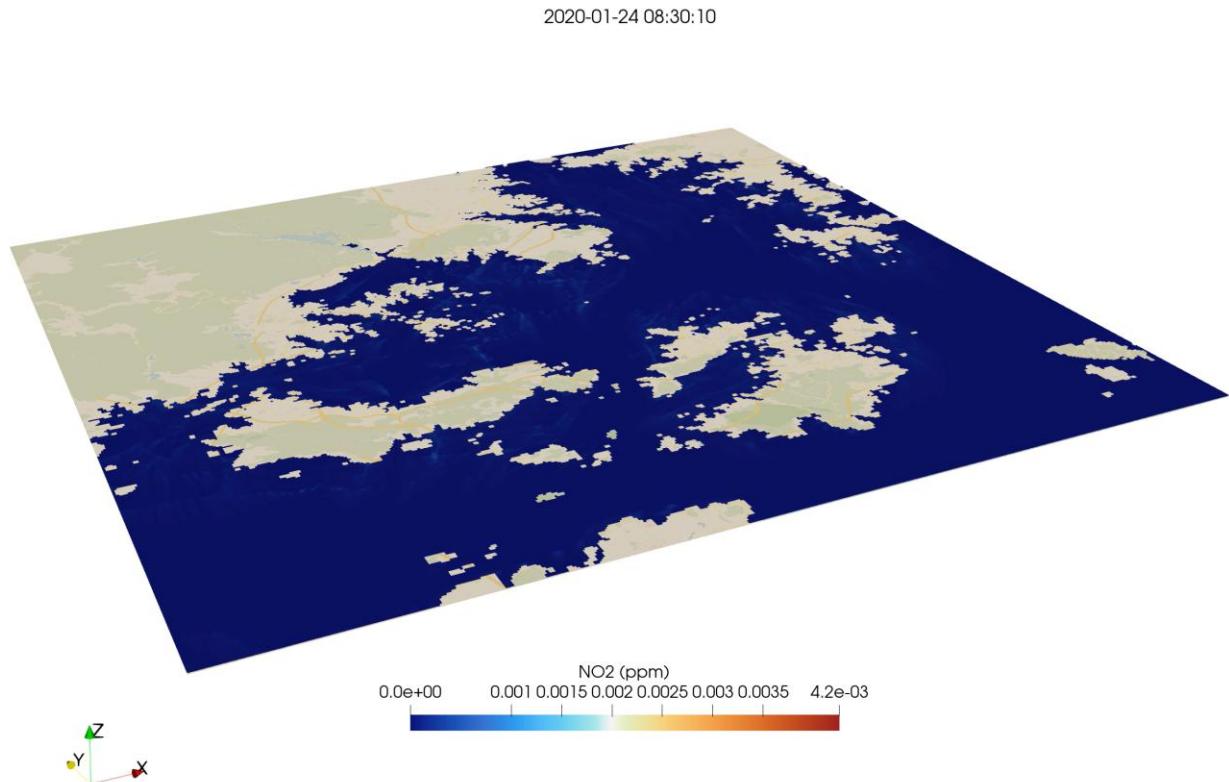
	Grid size	# of grid
Parent domain D01	100m x 100m x 50m	400 x 400 x 50
Child domain D02	10m x 10m x 10m	500 x 500 x 50

- Run on [ARCHER2](#) (UK Tier 1 HPC)
  - 8 nodes (1024 cores)
  - 5 hr CPU time for 1 day (**2020-01-25**) simulation
- Activated [physics model](#)
  - Urban surface (only in Child domain N02)
  - Radiation
  - Land surface
  - Dynamic driver( **ERA5** reanalysis data @ 0.25 deg)

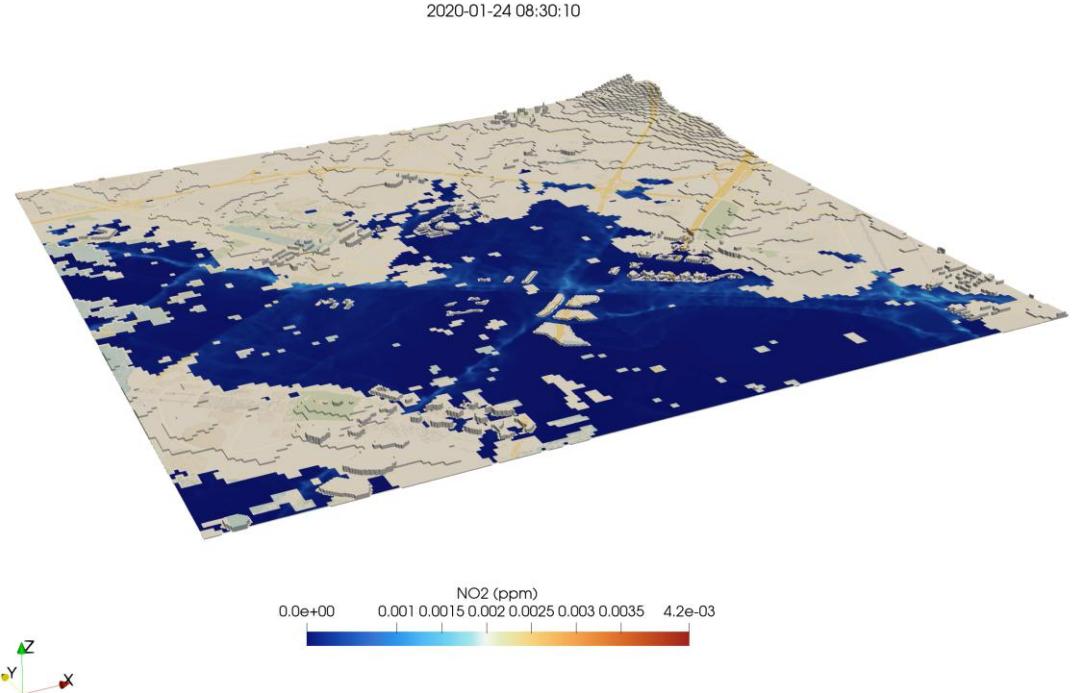
# Results

# Multiscale physical simulations

## Case study: Xiamen nested grid schemes



**Large area:** 40km x 40 km in horizontal and 2500m high  
**Mesh resolution:** 100m x 100m in horizontal and 50m in vertical

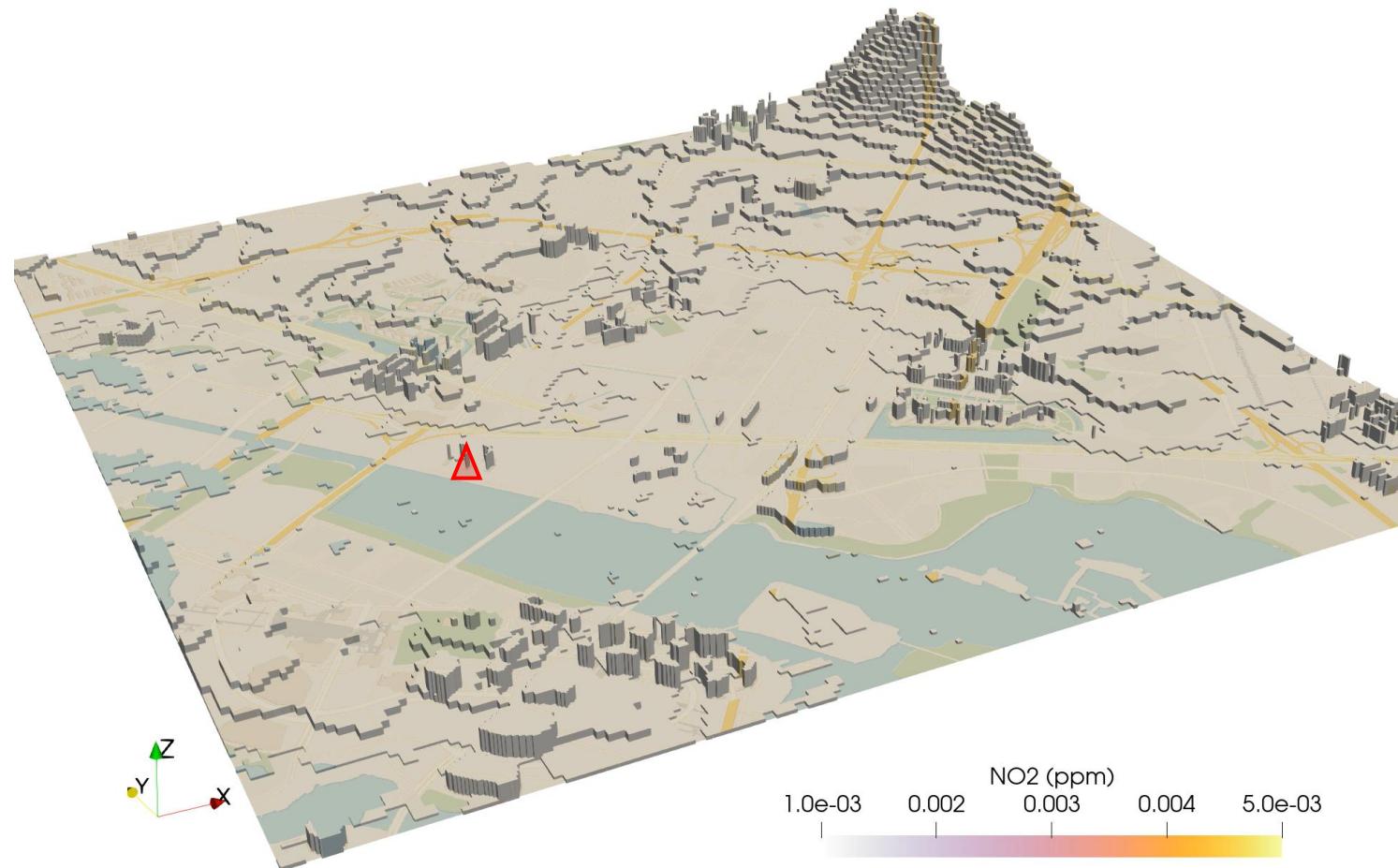


**Small area:** 5km x 5km in horizontal and 500m high  
**Mesh resolution:** 10m x 10m in horizontal and 10m in vertical

# Multiscale physical simulations

Case study: Xiamen nested grid schemes

2020-01-24 08:30:10





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# Thank you !

Jie Zheng

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