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

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# 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.

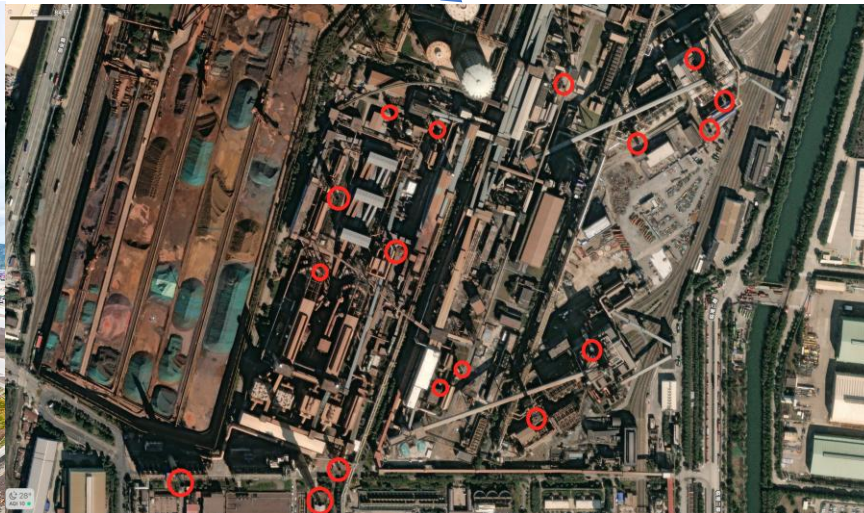
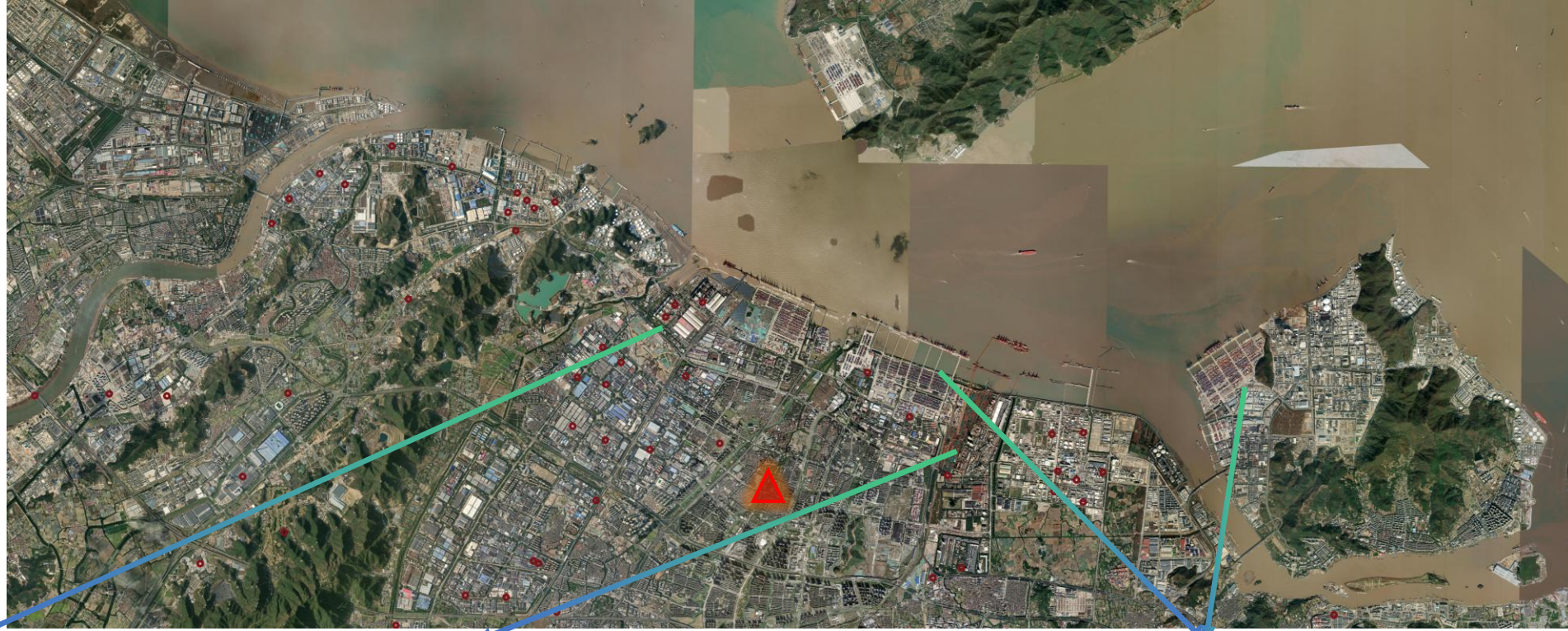
## ➤ Coupling and extensions:

- 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 km x 51.2 km
    - $dx=dy=100\text{m}$ ,  $dz = 40\text{m}$
  - Child domain D02 :
    - 32 km x 12.8 km
    - $dx=dy= 50\text{m}$ ,  $dz = 20\text{m}$
  - Child domain D03 :
    - 9 km x 6.4 km
    - $dx=dy= 10\text{m}$ ,  $dz = 10\text{m}$





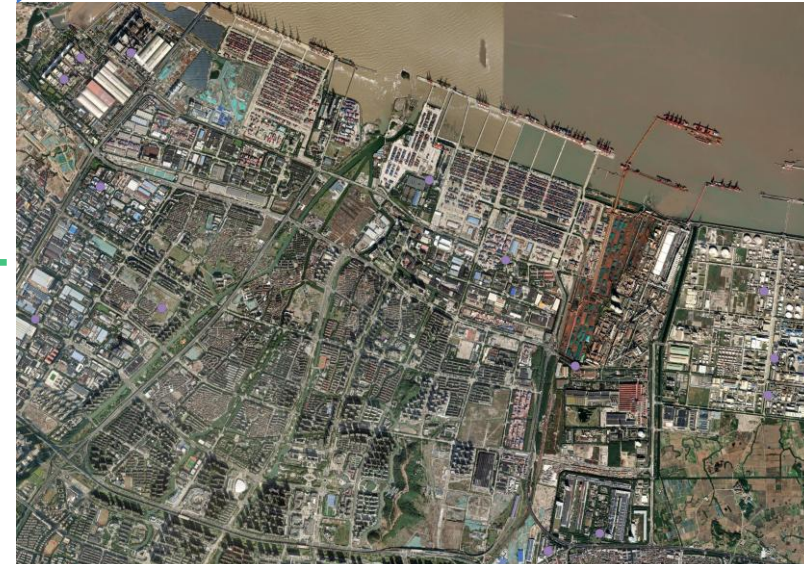
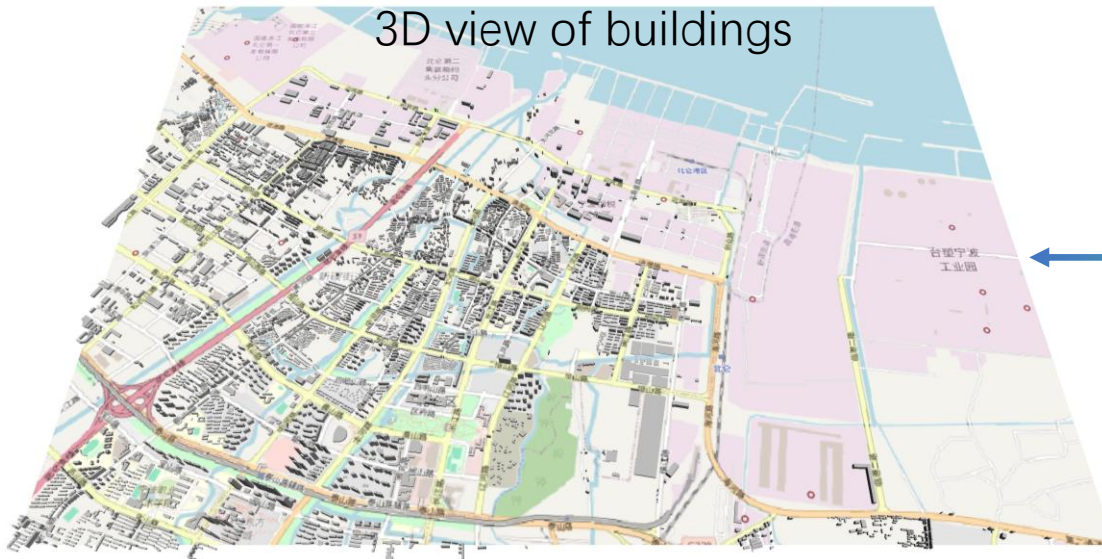
# Static driver

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 )

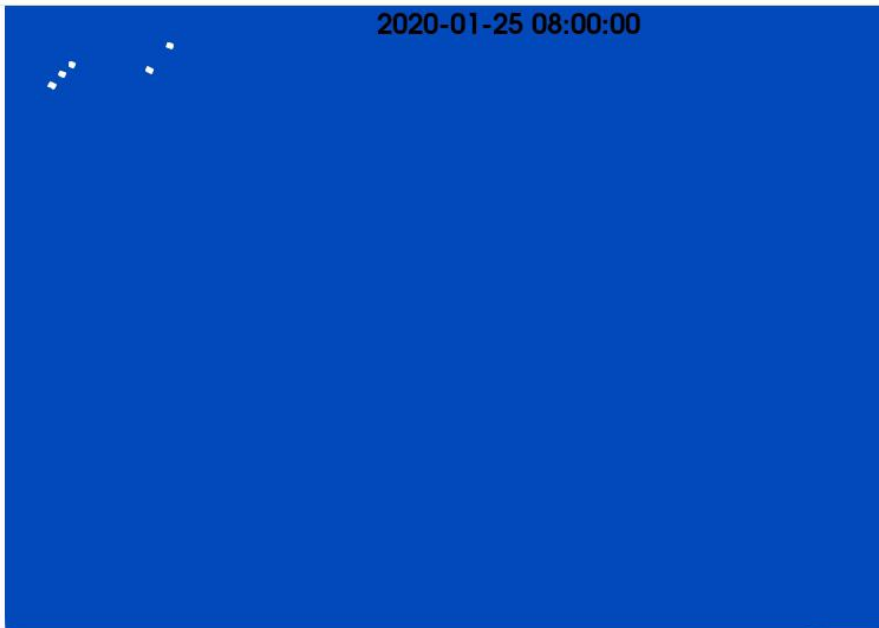
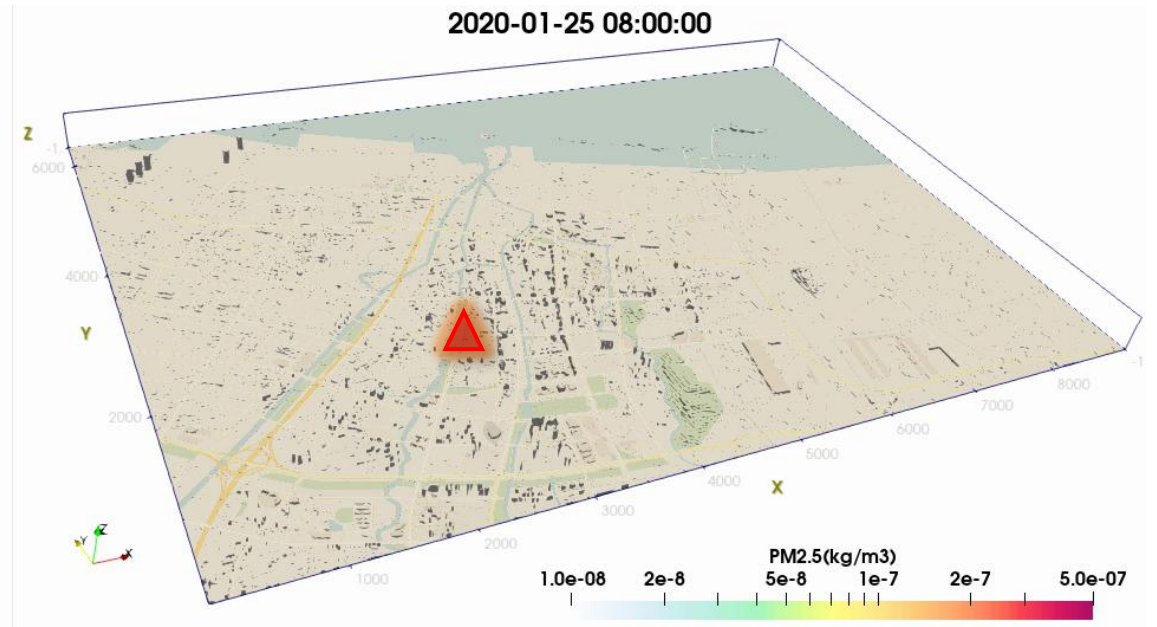
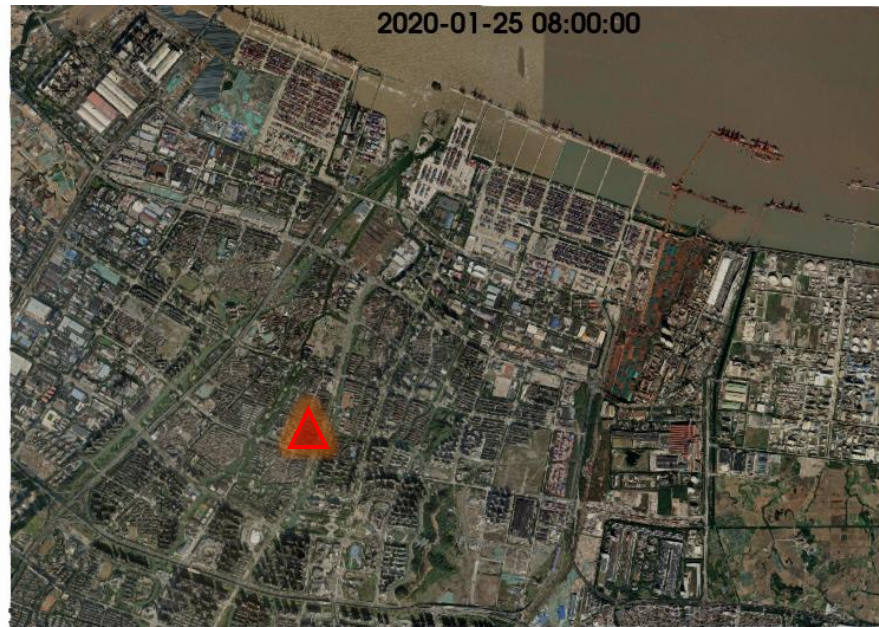
# Results

# Overview (D01 Great Ningbo on 20200125 )





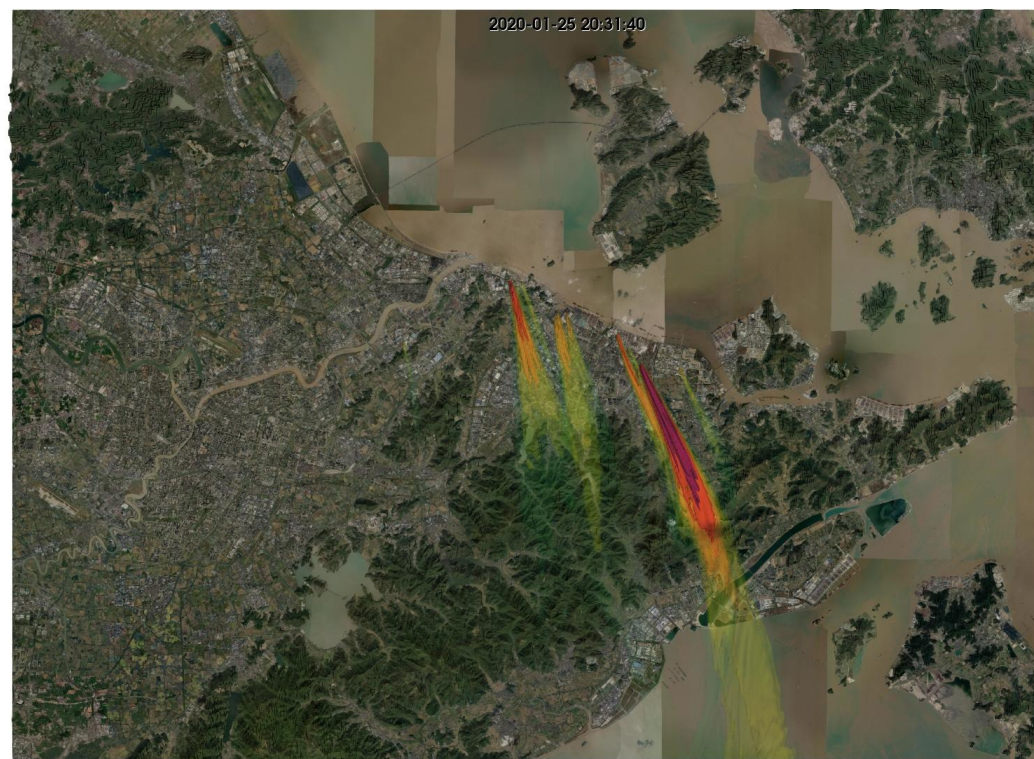
# Overview (D03 Main Beilun on 20200125 )



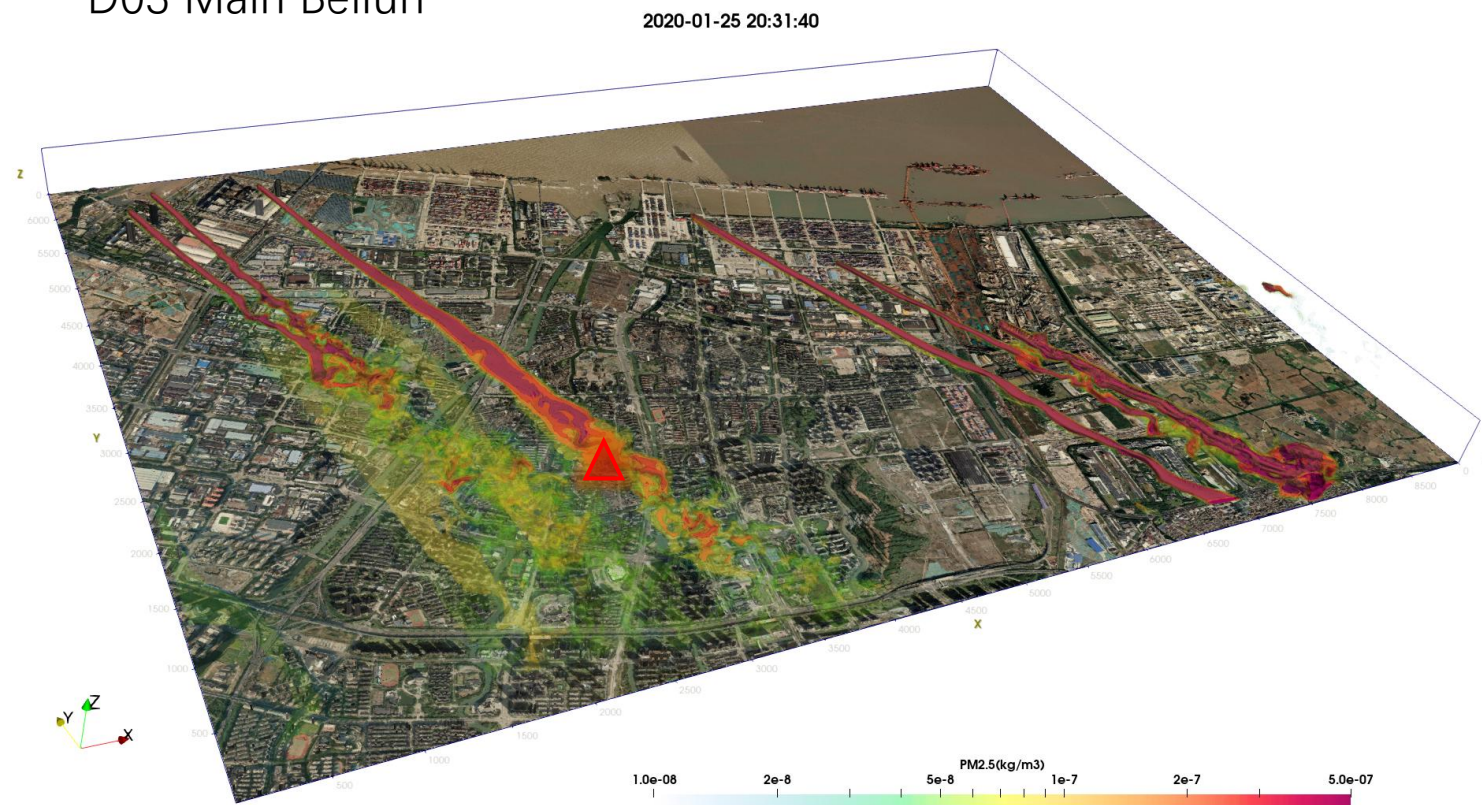


# Northwest Wind Simulations

D01 Great Ningbo



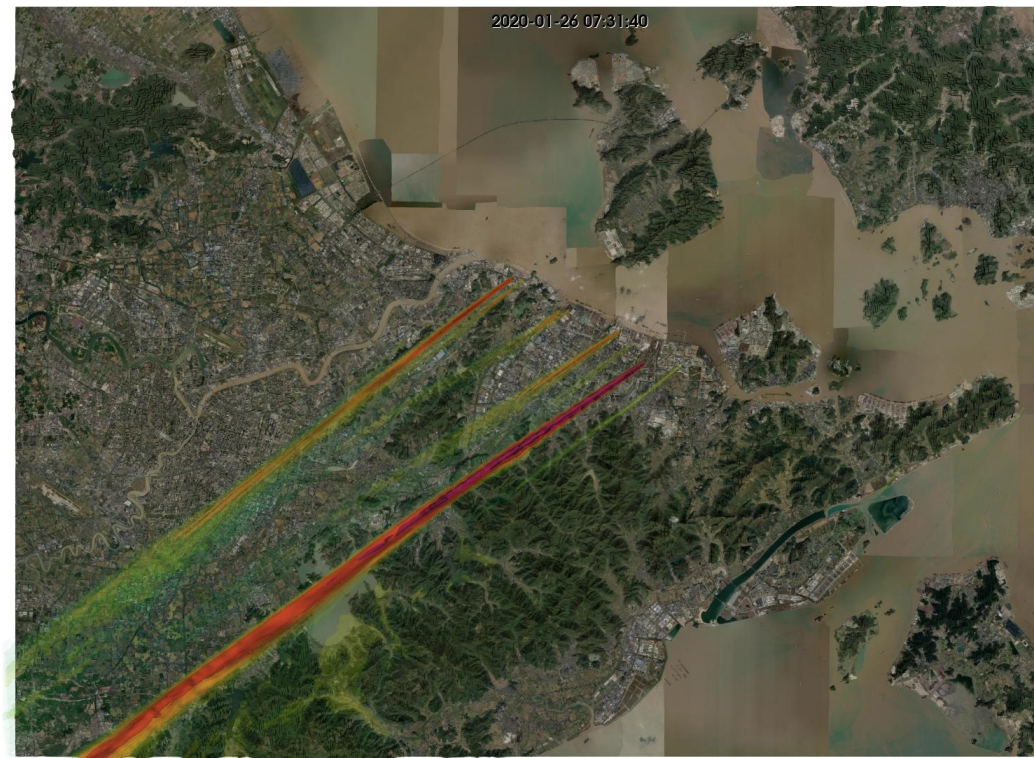
D03 Main Beilun



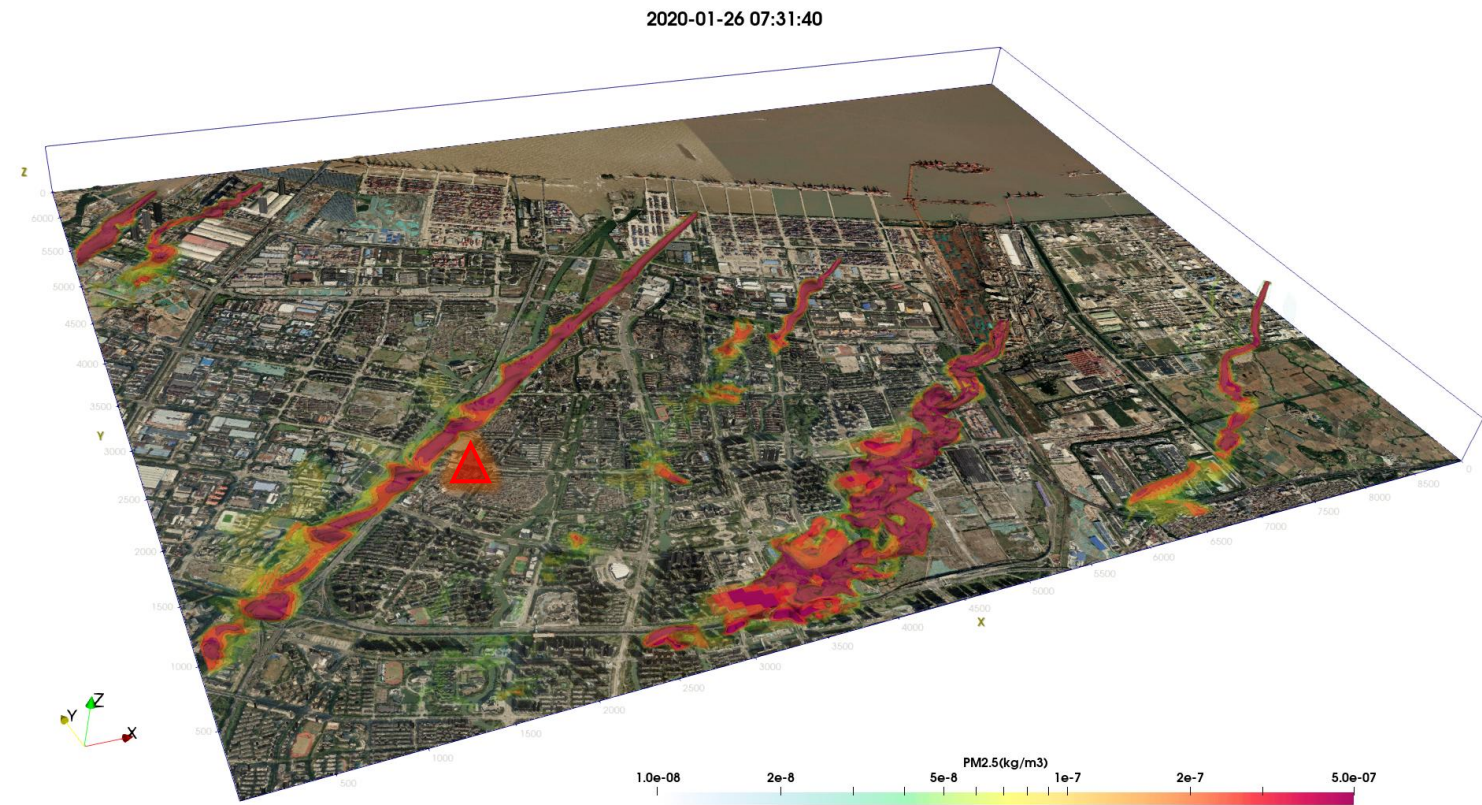


# Northeast Wind Simulations

D01 Great Ningbo

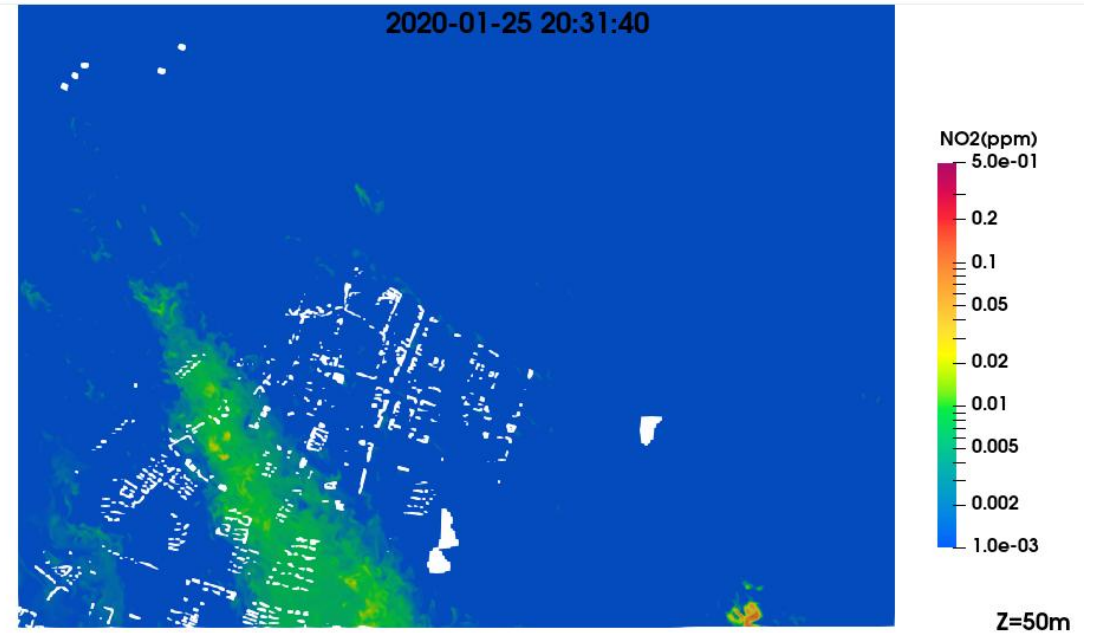
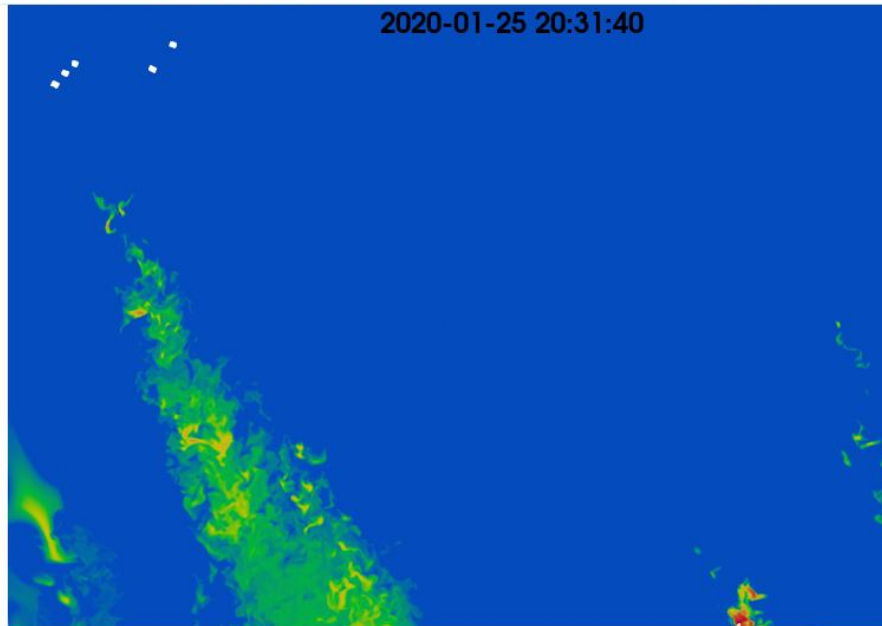
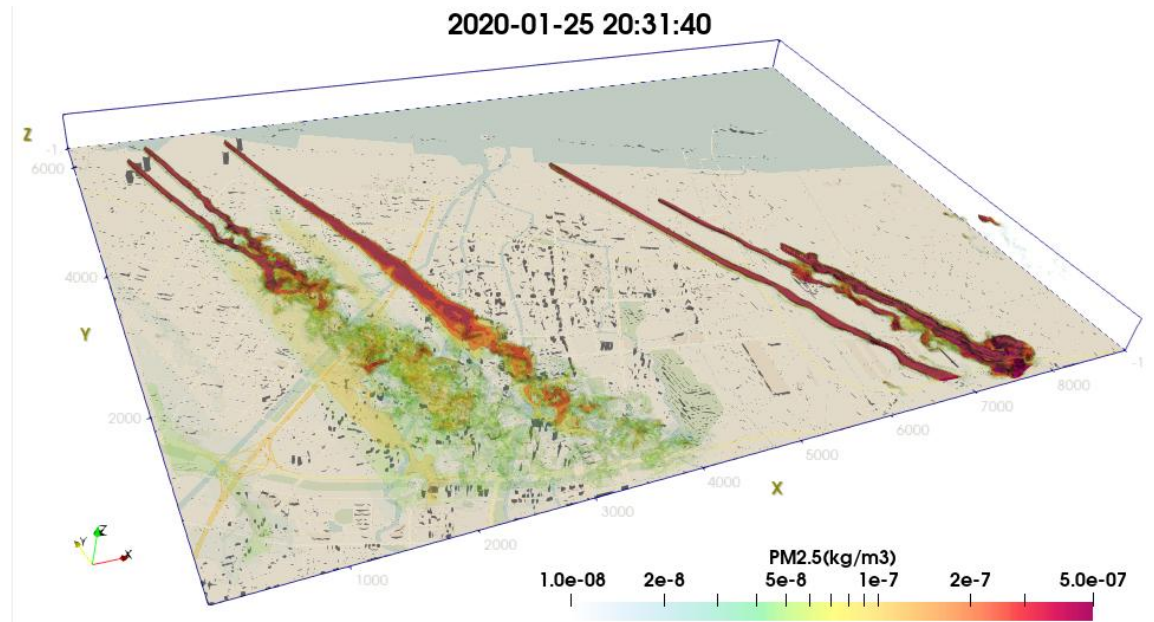
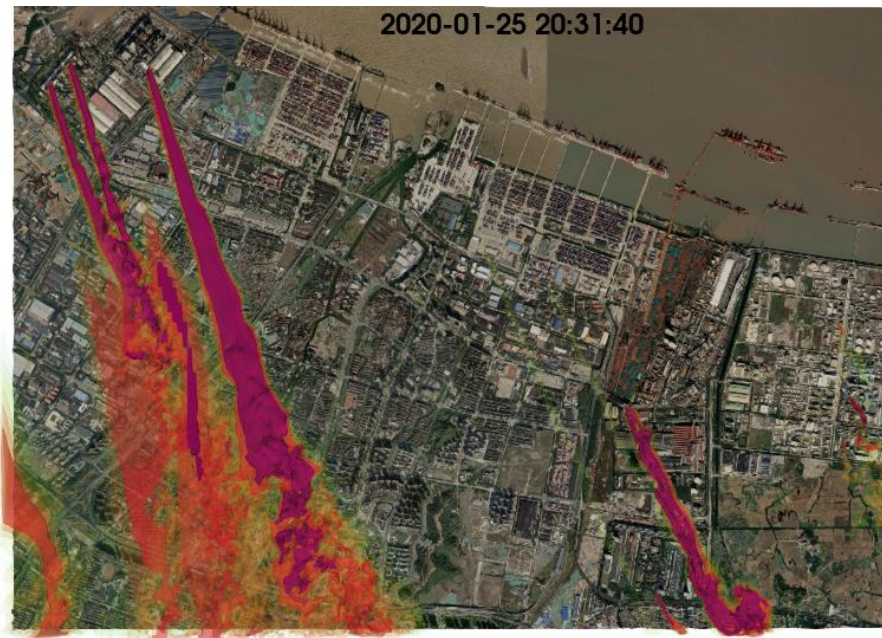


D03 Main Beilun



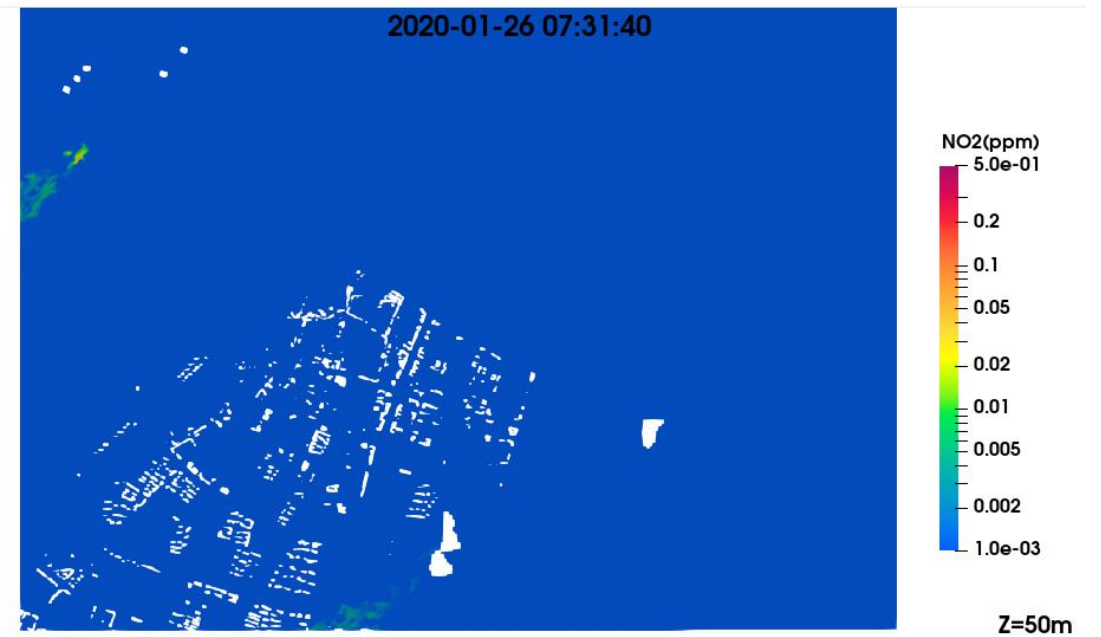
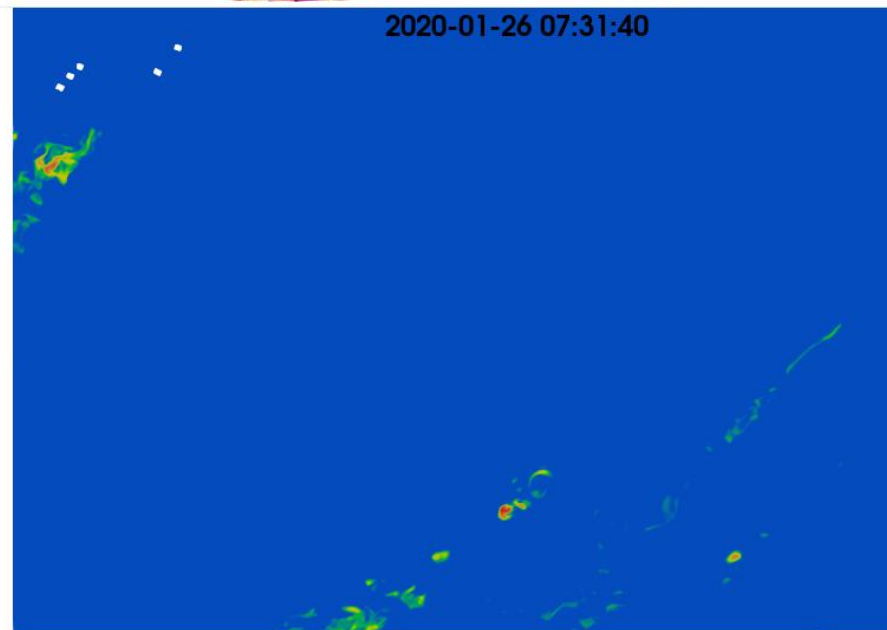
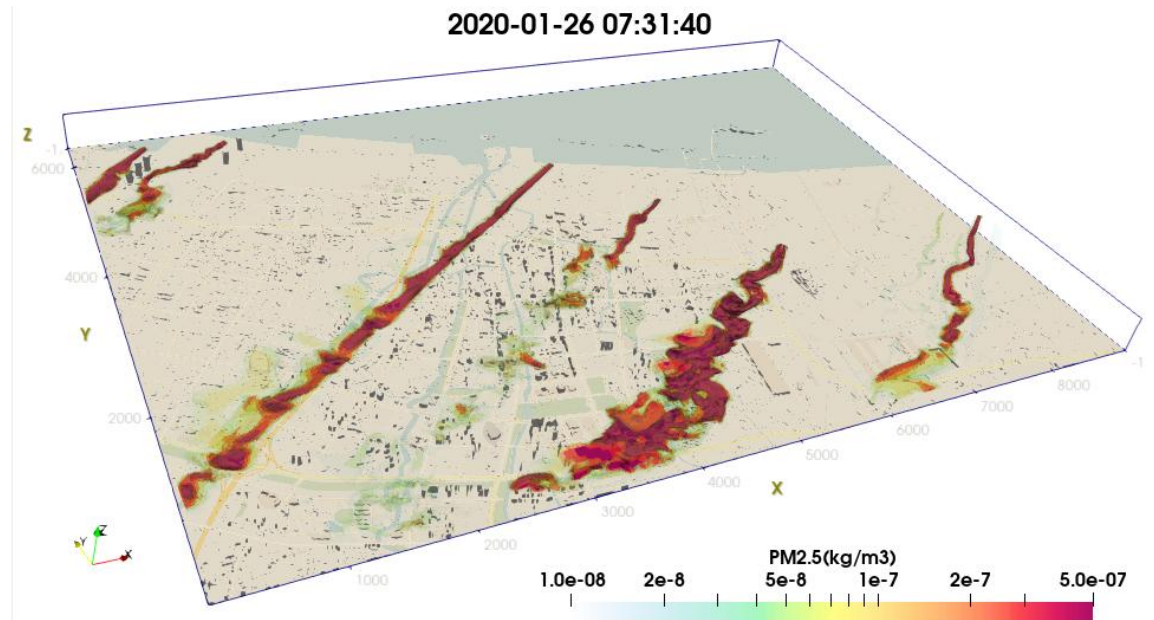
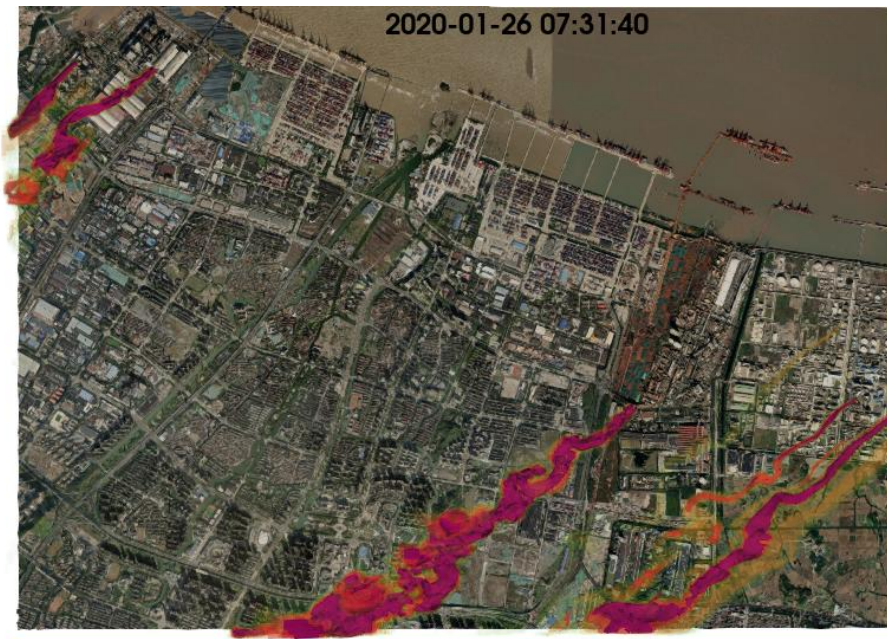


# Northwest Wind Simulations





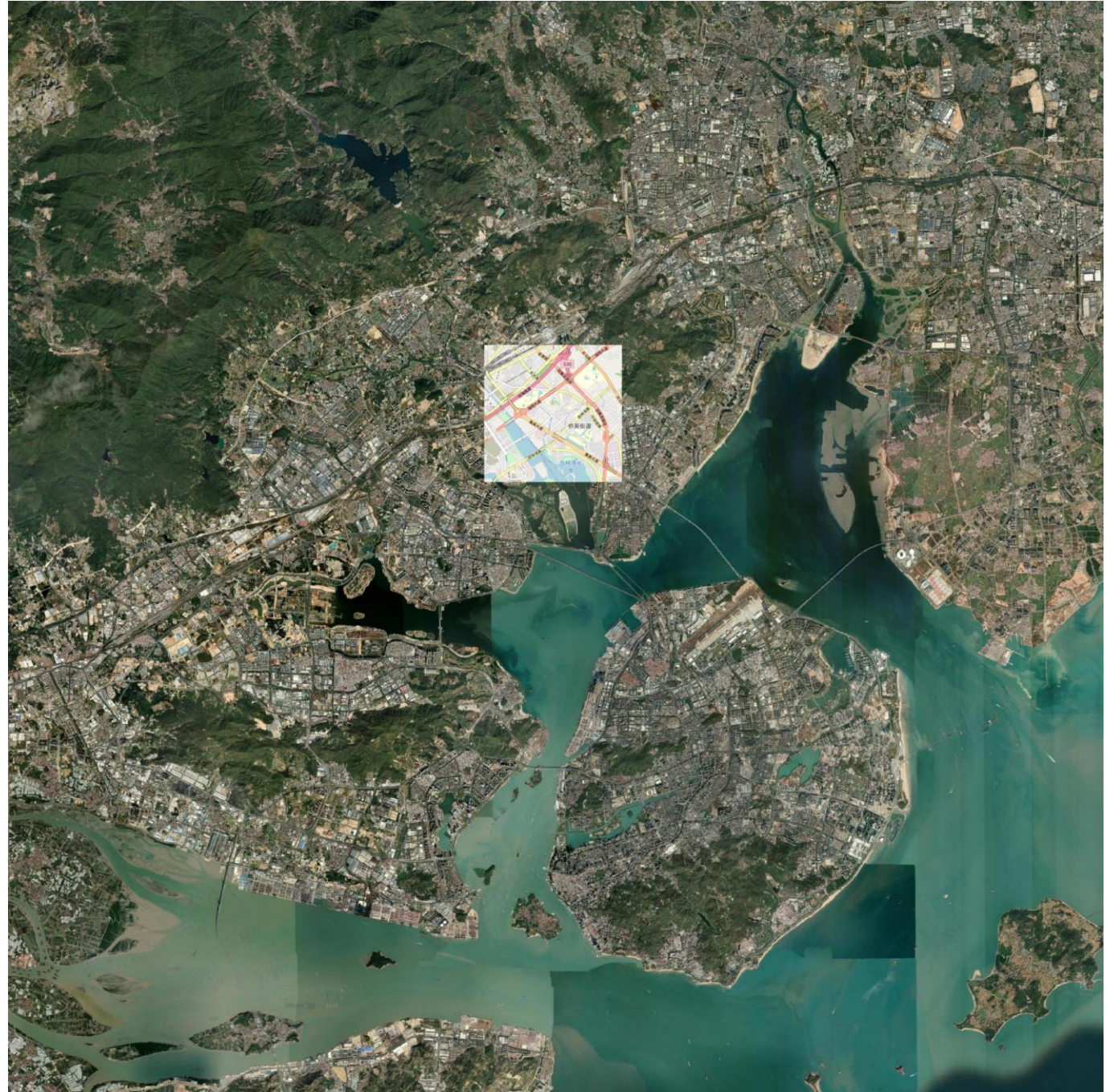
# Northeast Wind Simulations





# Case Study

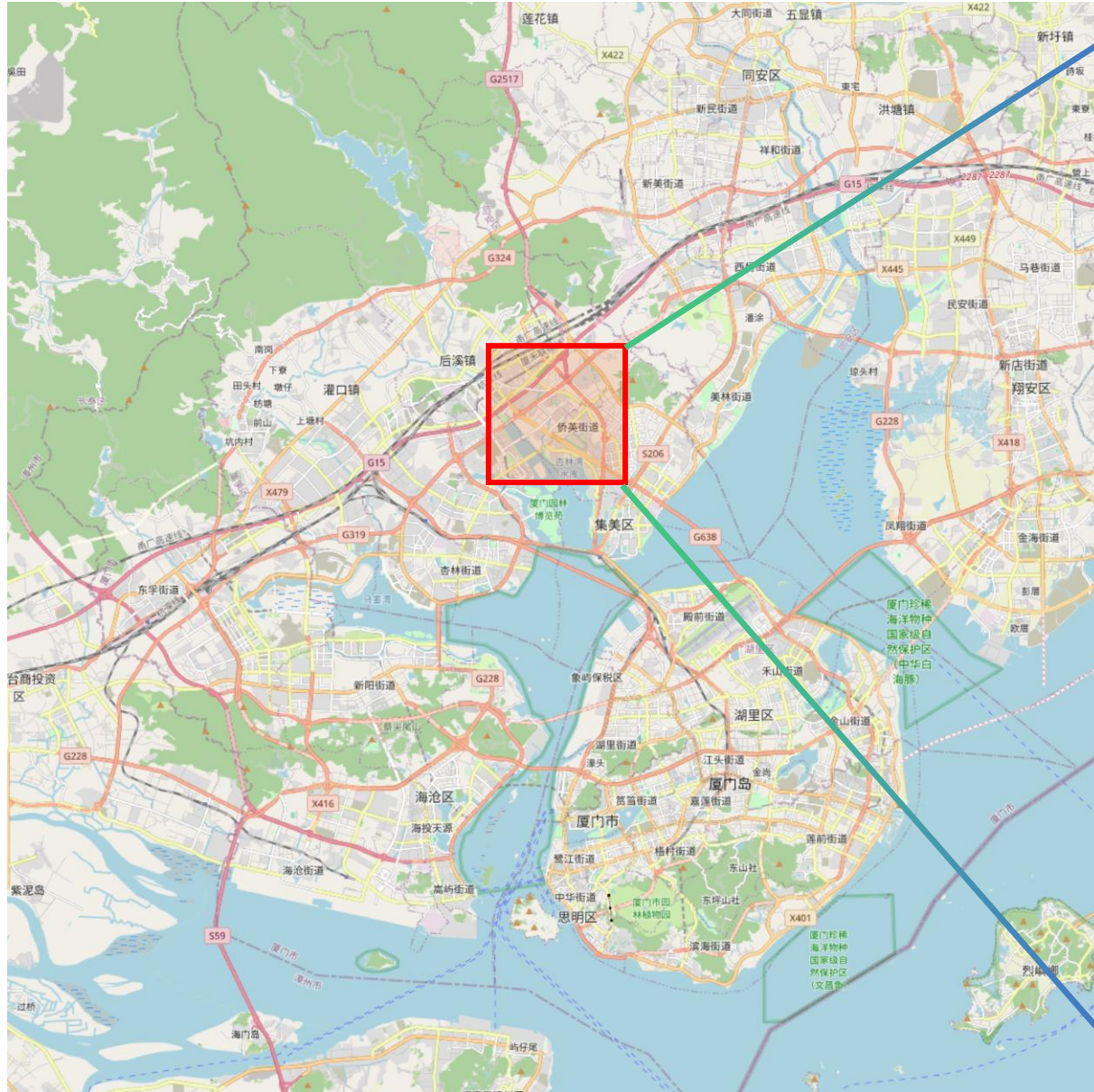
- Xiamen Jimei
- Traffic Sources
- 2 Nested Domain
  - Parent domain D01:
    - 40 km x 40 km
    - $dx=dy=100m$ ,  $dz = 50m$
  - Child domain D02 :
    - 5 km x 5 km
    - $dx=dy= 10m$ ,  $dz = 10m$



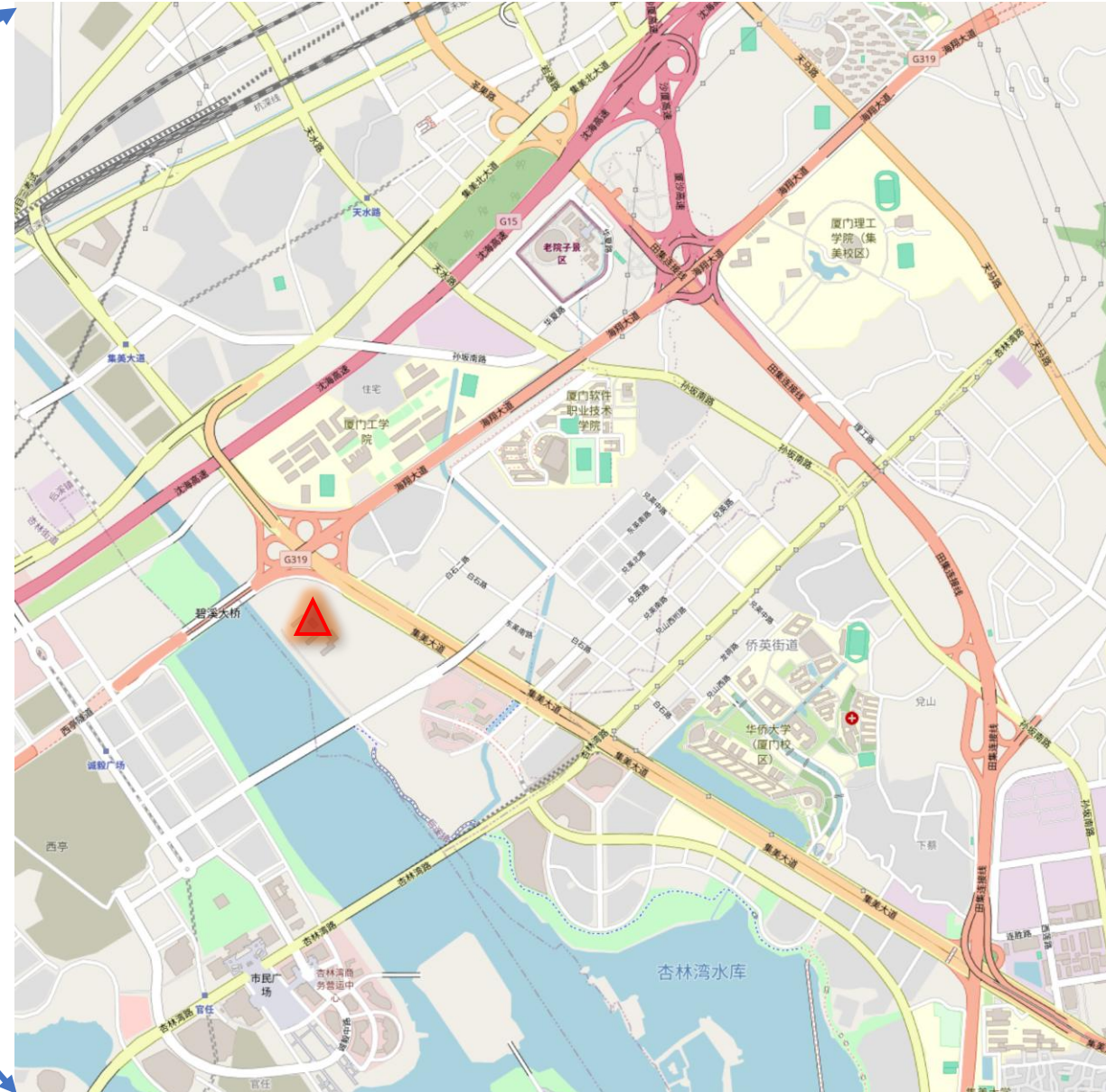


# Static driver

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)

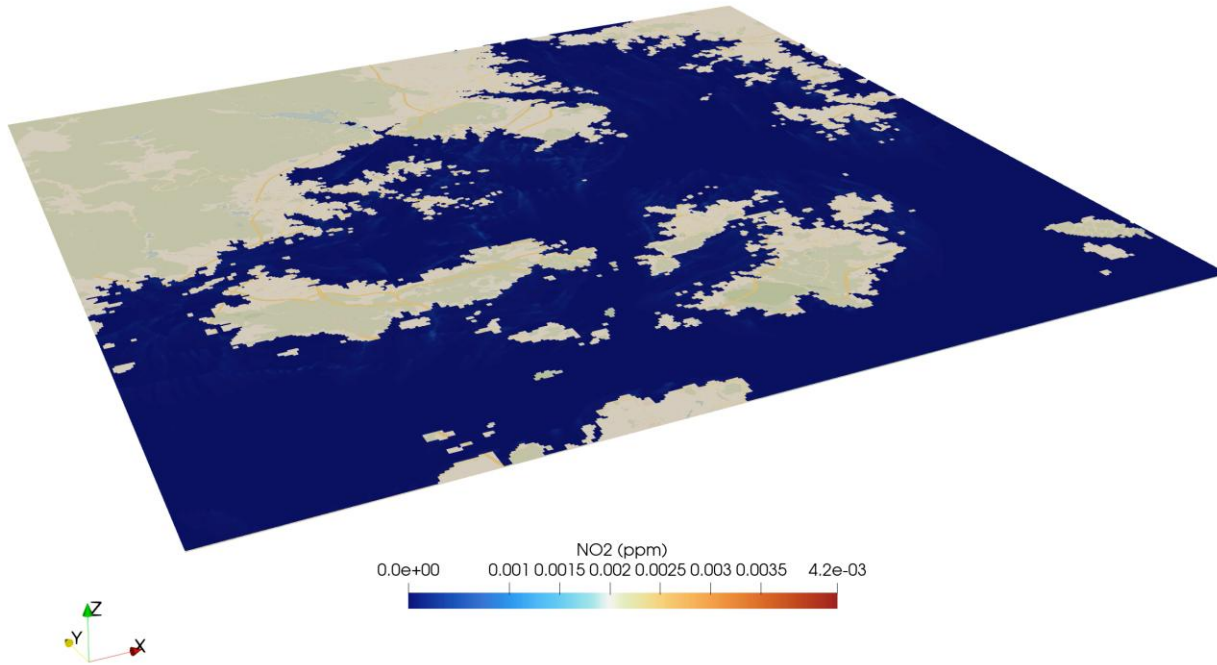


# Results

# Multiscale physical simulations

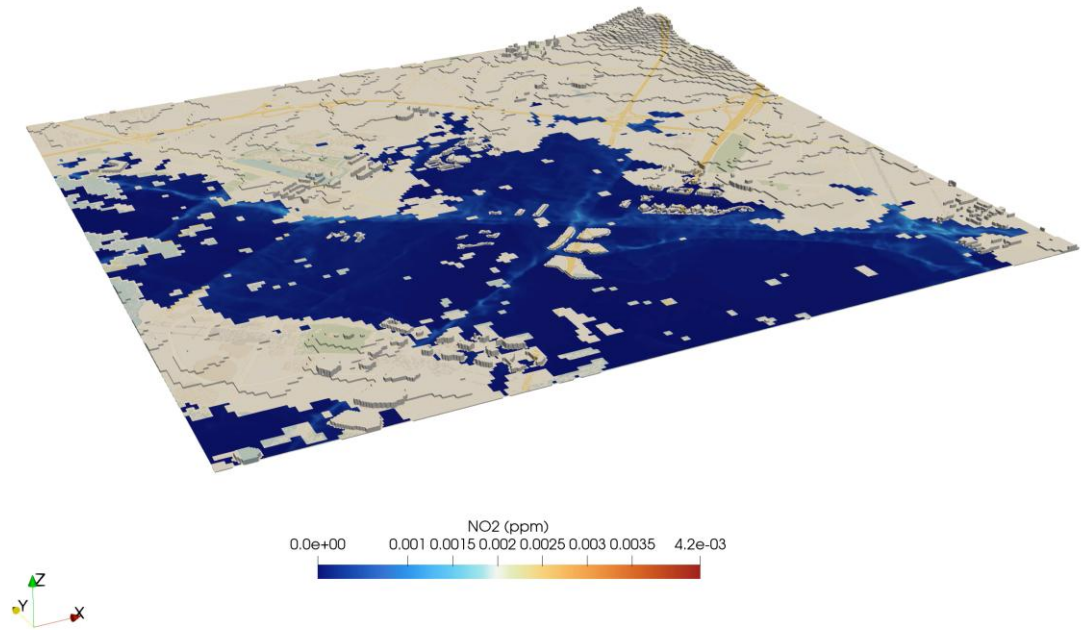
## Case study: Xiamen nested grid schemes

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

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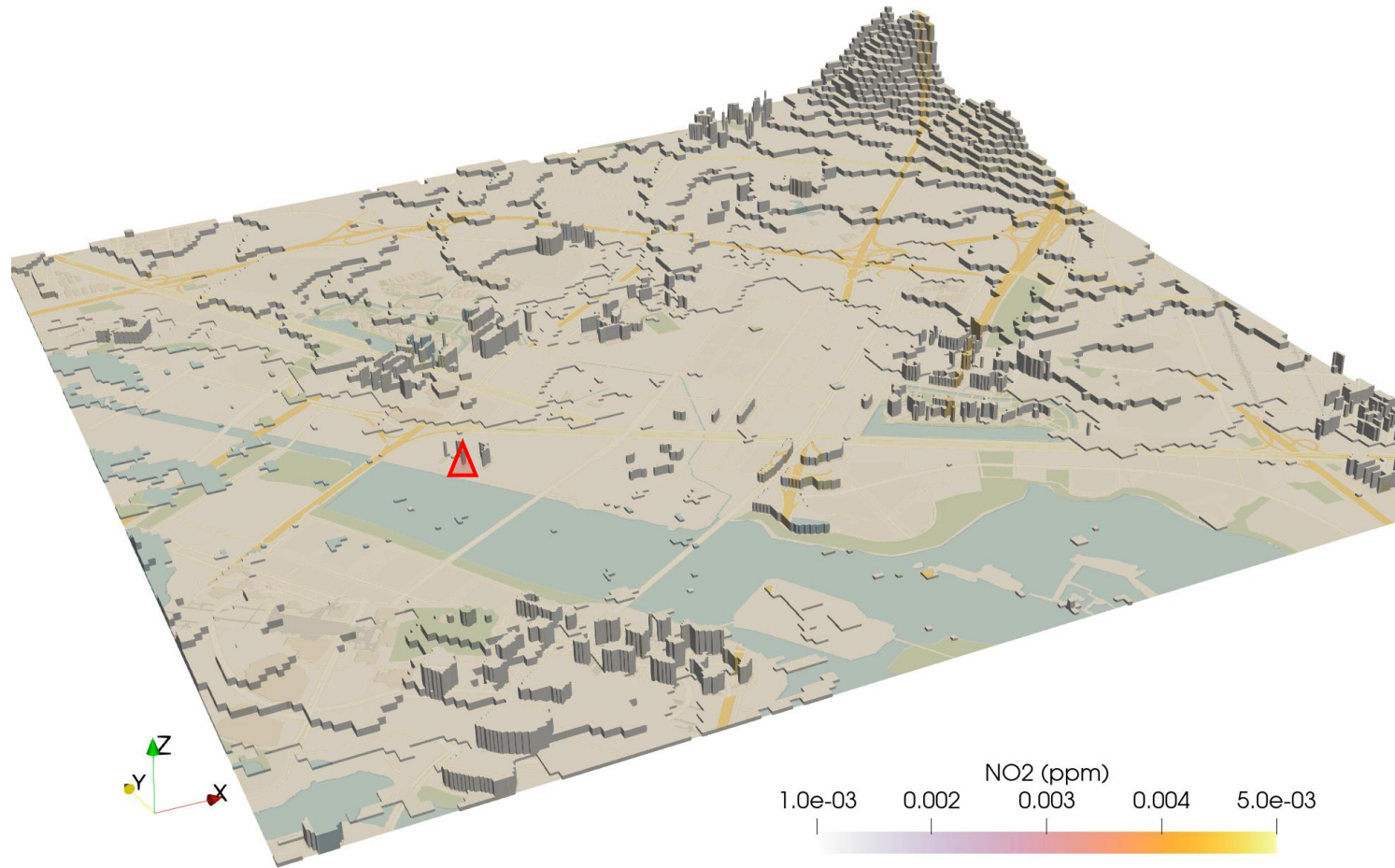
**Small area:** 5km x 5km in horizontal and 500m high  
Mesh resolution: 10m x 10m in horizontal and 10m in vertical



# Multiscale physical simulations

## Case study: Xiamen nested grid schemes

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# Thank you !

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