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Shenzhen Transport Emission Model based on Big Data

——Real-time Emission Monitoring Platform

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Overview

01 Background

02 Challenges in transport emission quantification

03 Key technologies in transport emission monitoring

04 Application

Background

Why do we need a transport emission model ?

Vehicle emission accounts for more than **40%** of air pollution in Shenzhen

The government of Shenzhen issued "The Plan of Air Quality Improvement in Shenzhen 2017-2020"

◆ Strengthening the prevention and control of vehicle exhaust pollution

- Improving standards for vehicle emissions
- Promoting the use of new-energy vehicles
- Setting up low emission areas

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Background

What we expect to do: build a **localized emission model**

- to quantify transport emissions
 - to evaluate the impact of policy and planning
 - to support decision making
- In **June 2013**, a cooperation contract between Transport Commission of Shenzhen Municipality and German Federal Ministry of the Environment was signed — Support for traffic congestion alleviation and low-carbon transport system establishment in Shenzhen



giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH



深圳市城市交通规划设计研究中心有限公司
SHENZHEN URBAN TRANSPORT PLANNING CENTER CO.,LTD

Background

- In **2014**, the first **real-time monitoring platform** in China was established

■ Achievements

- Traffic demand model
- Traffic status evaluation
- Emission factors database
- Traffic emission model



Real-time traffic emission monitoring platform v1.0

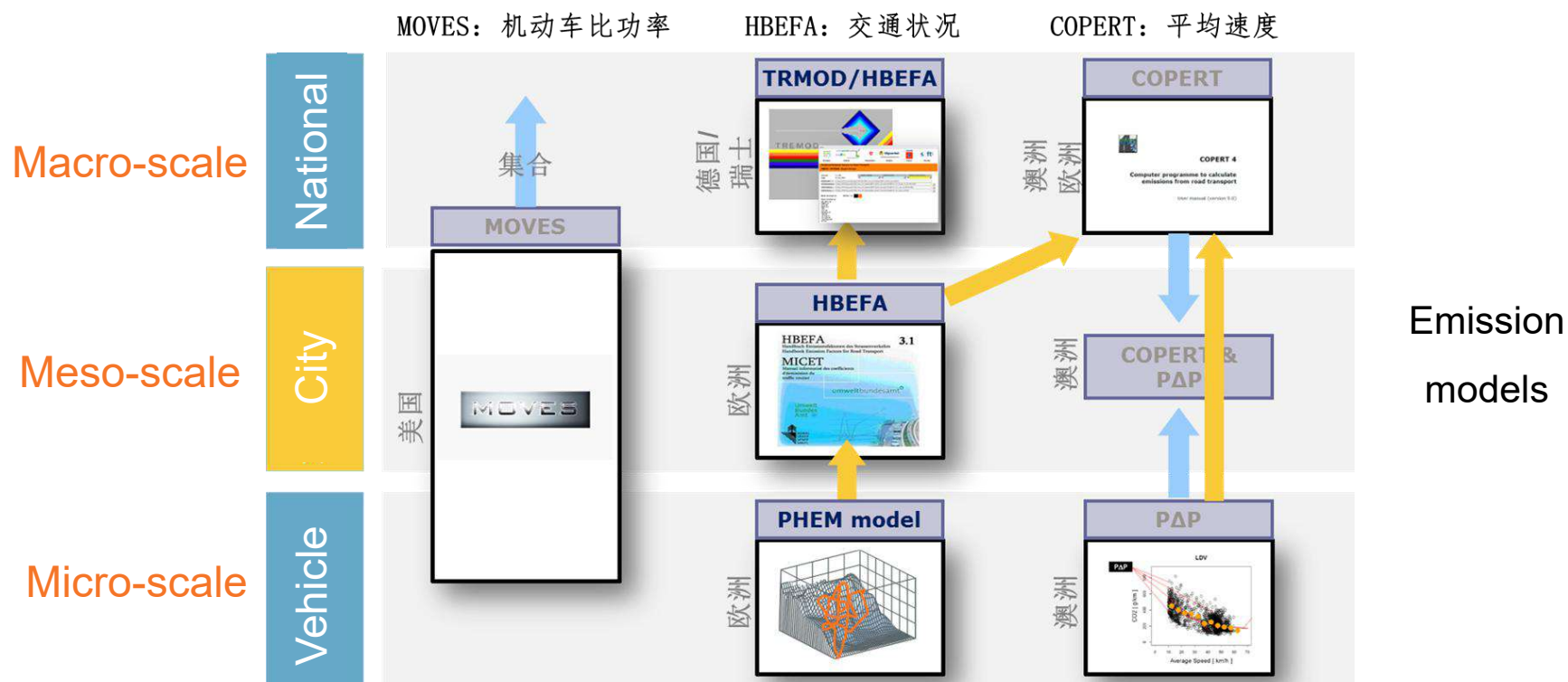
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Challenge 2: How to quantify emissions of multiple transport modes

Emissions from aircrafts and ships should also be evaluated for a comprehensive understanding of emission from transportation section

- Emission from aircraft can be calculated by LTO (Landing and Take-off) cycle and the engine emission databank (provided by ICAO), flight information from the airport is also needed.
- Emission from ports and ships: emission factor database, ship's information, dynamic data...



Challenge 3: How to evaluate the impact on environment

Emission ≠ Air pollution

- Pollutant concentration causes the direct impact on public health
- Pollutants dispersion affected by the meteorological factors (temperature, wind, etc.)



Emission on the road

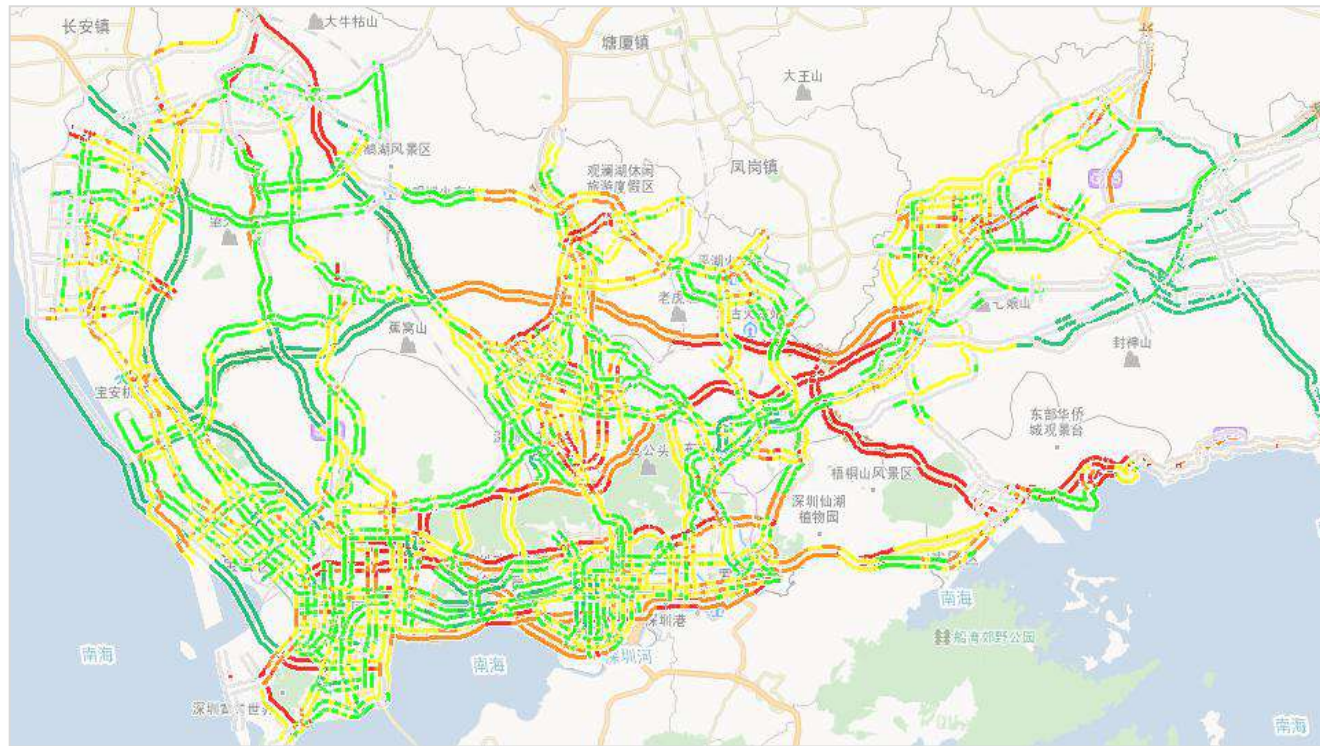


Pollutants disperse in the air

Challenge 4: How to verify the model

The emission & pollution results should be verified by on-road measurement

- Large-scale of experiment should be conducted to form a closed loop monitoring and evaluation system



Emission by model calculation

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Key Technologies

1. Multi-source traffic big data fusion

2. Traffic emission model refinement

3. Emission model localization

4. Real-time monitoring

5. Pollutant dispersion model

6. Verification: on-road measurement

1. Multi-source traffic big data fusion

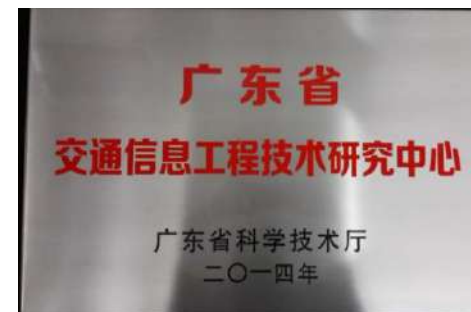
- R & D Center of Transportation Industry of Integrated Traffic Big Data

Processing and Application Technology, Ministry of Transport, PRC



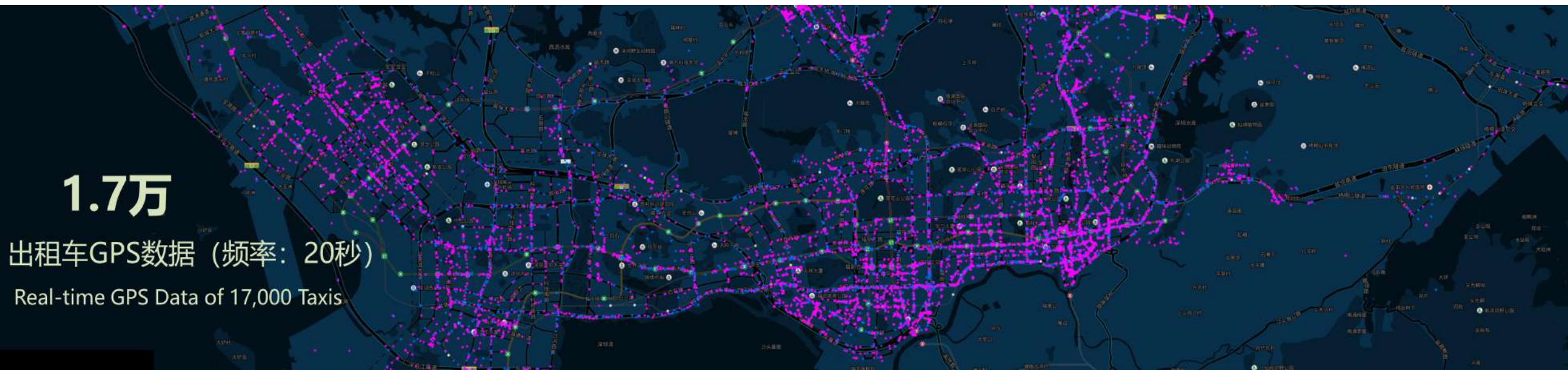
- Shenzhen Transportation Carbon Emission Engineering Laboratory

- Shenzhen Key Laboratory of Traffic Information and Traffic Engineering



- Guangdong Research Institute of Transport Information

17,000 Taxis GPS Data (update every 20 sec)



1.7万

出租车GPS数据 (频率: 20秒)

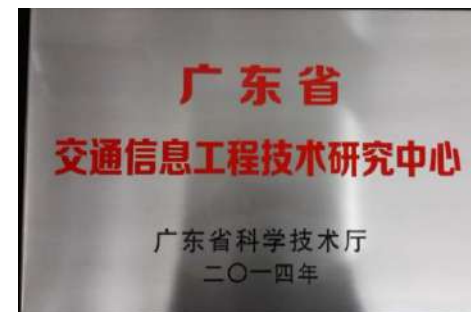
Real-time GPS Data of 17,000 Taxis

1. Multi-source traffic big data fusion

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Processing and Application Technology, Ministry of Transport, PRC

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15,000 Buses GPS Data (update every 15 sec)

1.5万

公交车GPS数据 (频率: 15秒)

Real-time GPS Data of 15,000 Buses



1. Multi-source traffic big data fusion

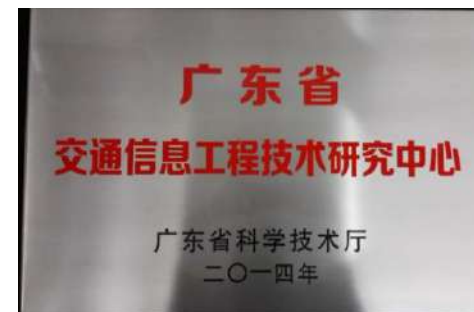
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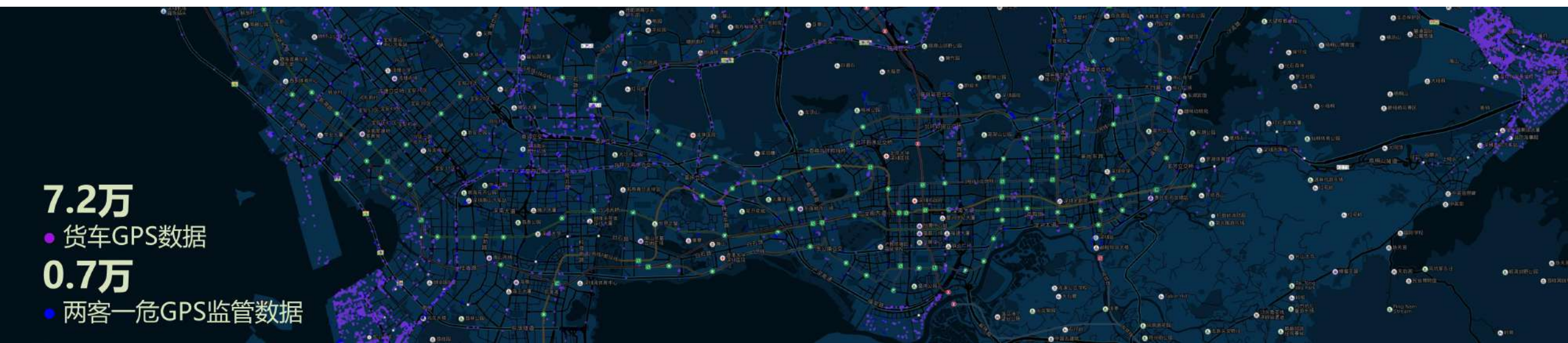
- Shenzhen Transportation Carbon Emission Engineering Laboratory

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- Guangdong Research Institute of Transport Information

72,000 Trucks GPS Data (update every 5 min)



7.2万

● 货车GPS数据

0.7万

● 两客一危GPS监管数据

1. Multi-source traffic big data fusion

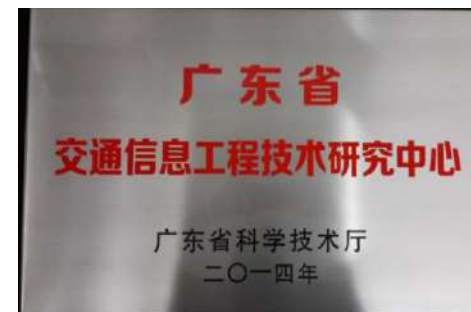
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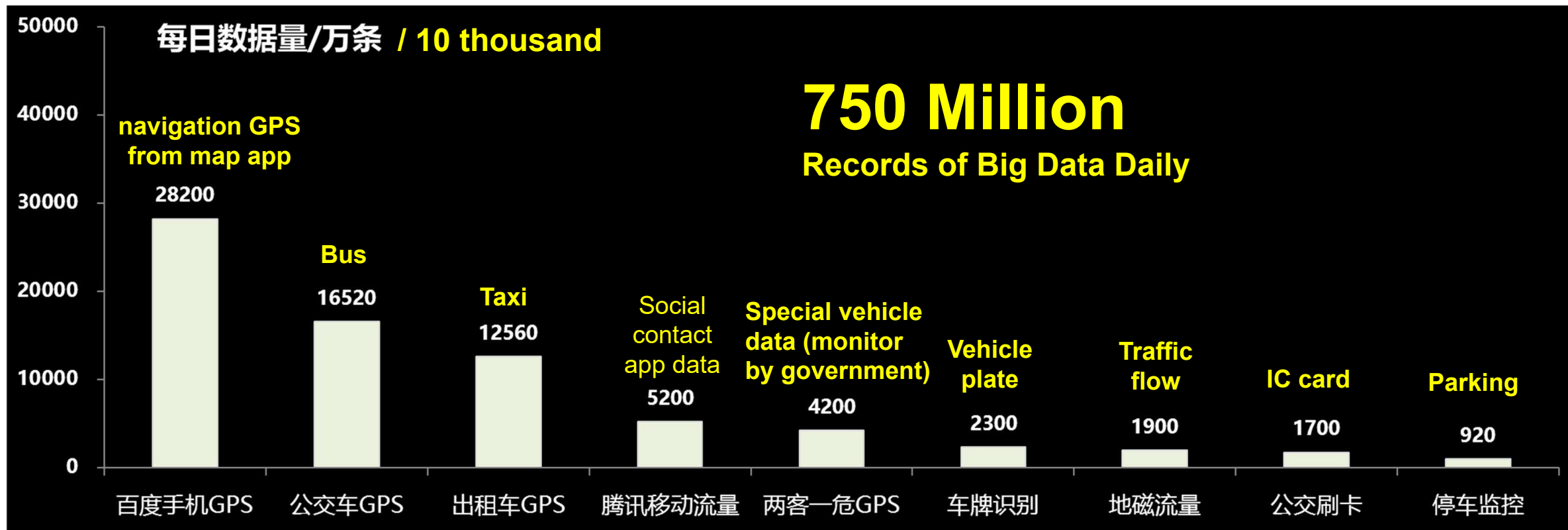


Navigation GPS data (update every 1 sec)



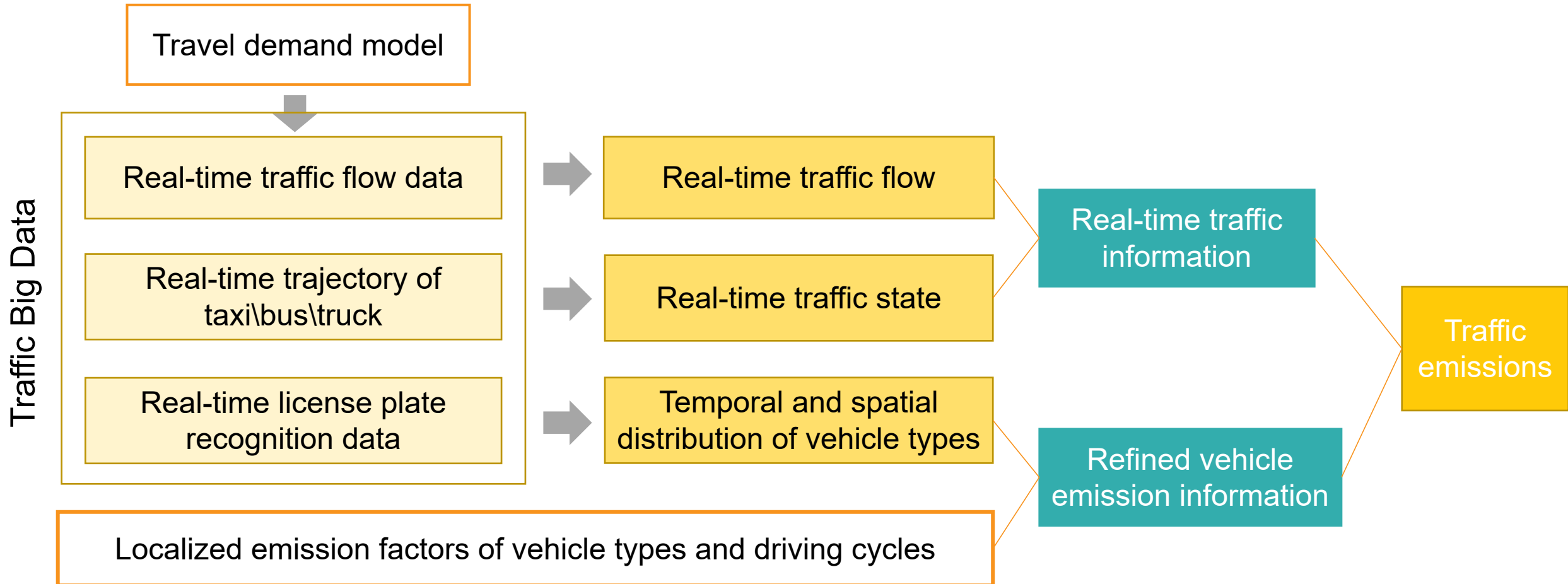
1. Multi-source traffic big data fusion

- Multi-source data: data from government, user-generated data
- Dynamic traffic data: taxi/bus/truck GPS data, navigation GPS data from app etc.



2. Traffic emission model refinement

- The ‘ **from bottom to up** ’ model was based on the emission of every single vehicle
- The detailed emission information can be obtain in various scales



3. Emission model localization

■ Why should be localized?

Emission factors are calculated by the HBEFA (Europe)

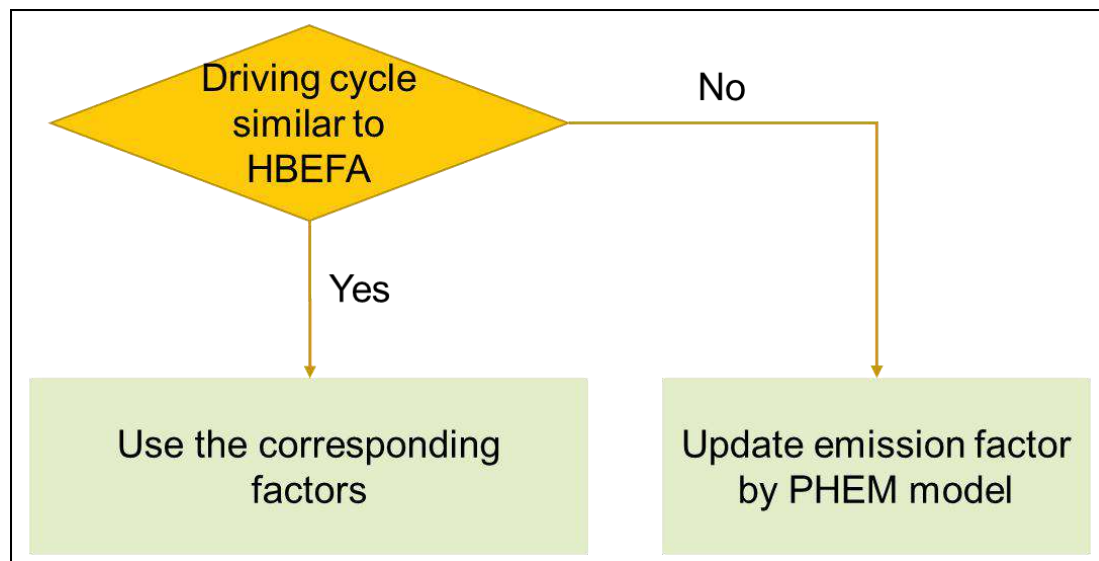
Similar in fuel standards and emission standards

Different in traffic state, fleet composition, driving behavior

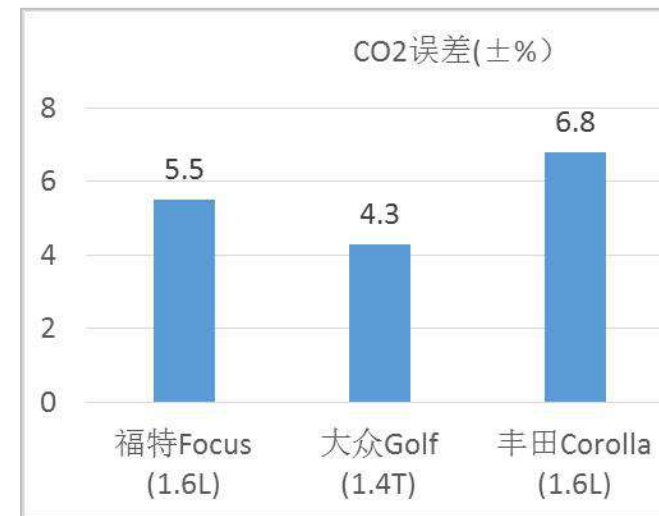
} Europe and China

■ What should be localized?

Characteristics of travel and traffic \ Driving cycles \ Emission factors



Shenzhen HBEFA

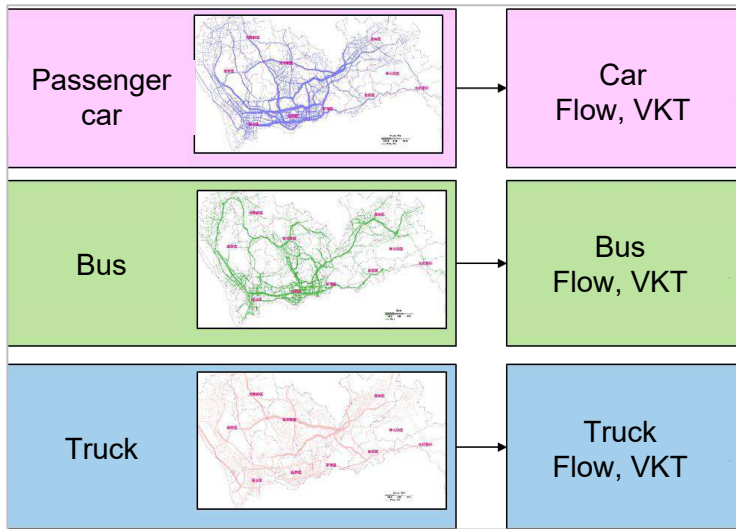


The gap between Shenzhen HBEFA and PHEM measurement < 10%

3. Emission model localization

① Localization of characteristics of travel and traffic

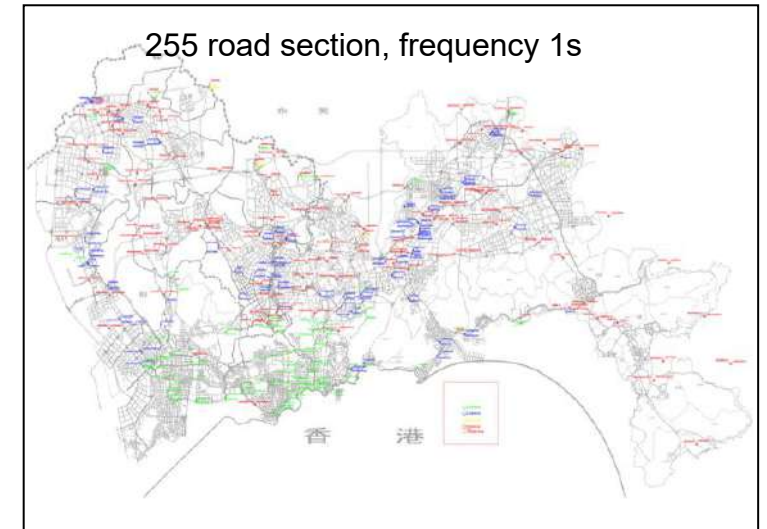
- Travel demand: obtain the **traffic flow and vehicle kilometers of travel (VKT)** of car/bus/truck by integrated multi-modal transport model
- Traffic state: obtain the real-time **traffic flow, speed and level of service(LOS)** by traffic index system, license plate recognition etc.



Shenzhen integrated multi-modal transport model



Shenzhen road traffic index system

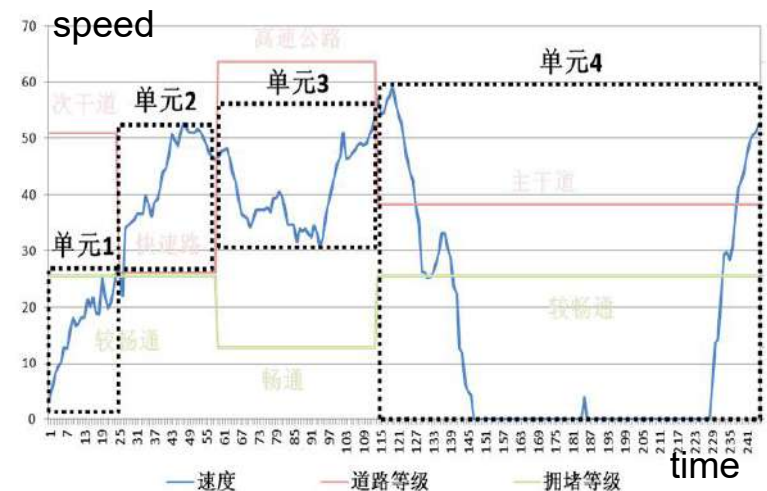
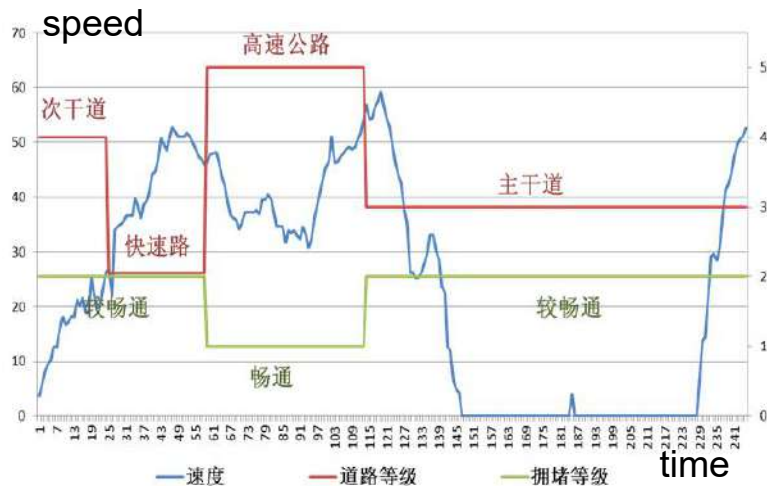


License plate recognition system from traffic police bureau

3. Emission model localization

② Driving cycle localization

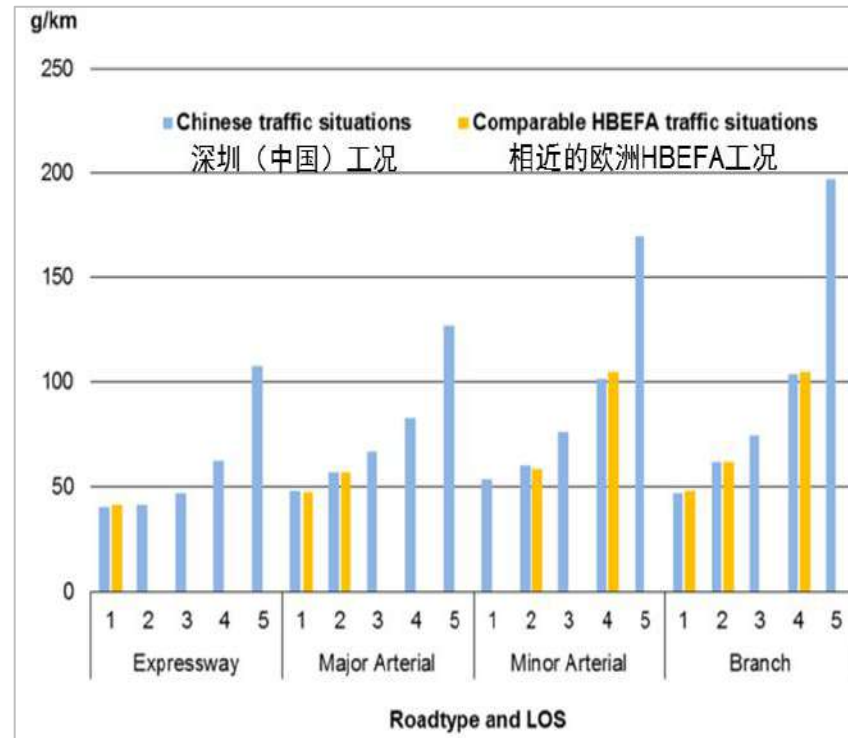
- More than 6000 hours GPS data was collected to get the typical driving cycles in Shenzhen
- 4 types of road: expressway, major arterial, minor arterial, branch;
- 5 levels of service: free flow, heavy traffic, saturated traffic, stop-and-go, heavy stop-and-go;



3. Emission model localization

③ Traffic emission factors localization

- Input the typical **driving cycles** of Shenzhen into the PHEM model
- Emission factor database: **4500 factors in total**, 1500 for each type of vehicles (car/bus/truck)

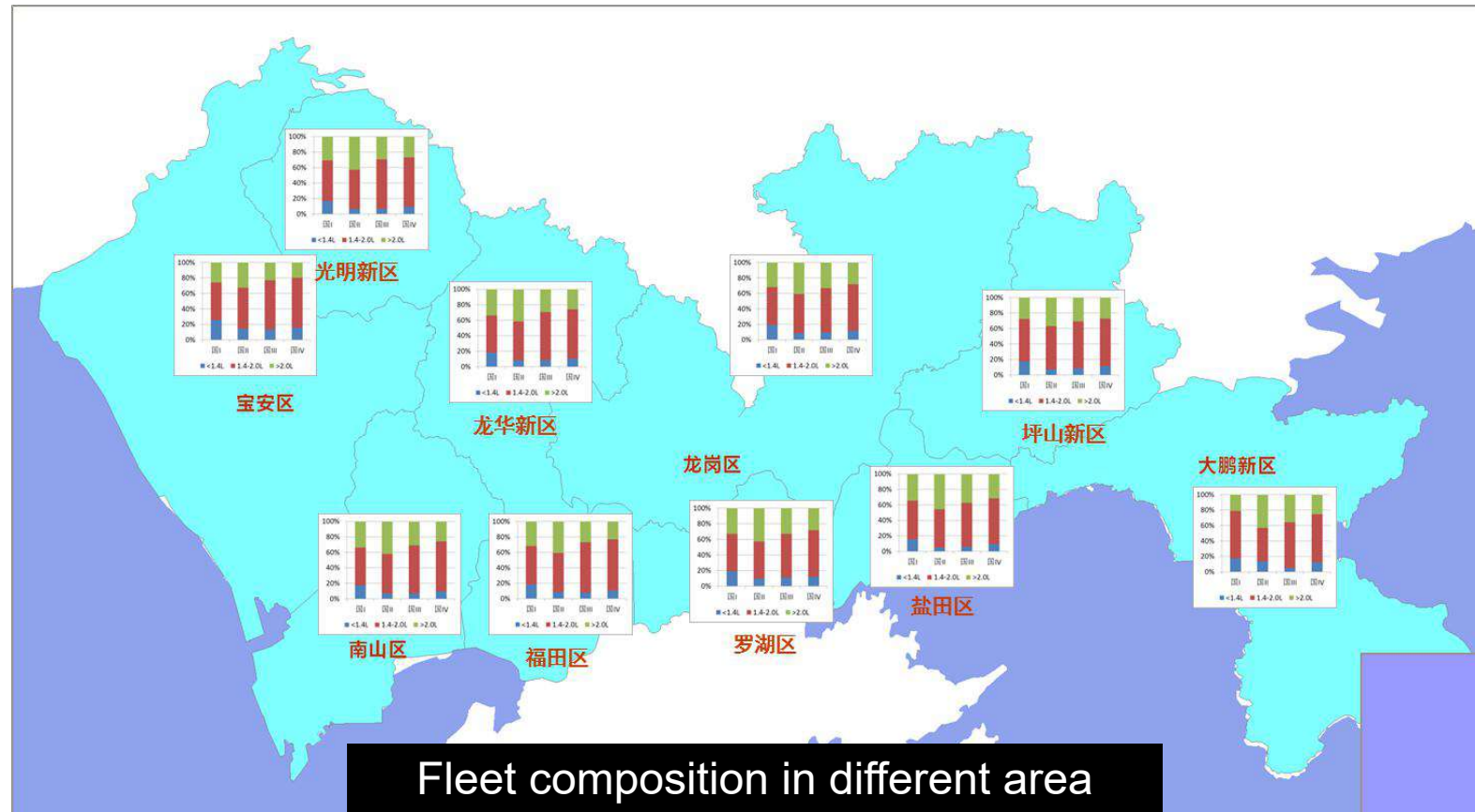


Driving cycles comparison between
HBEFA and Shenzhen

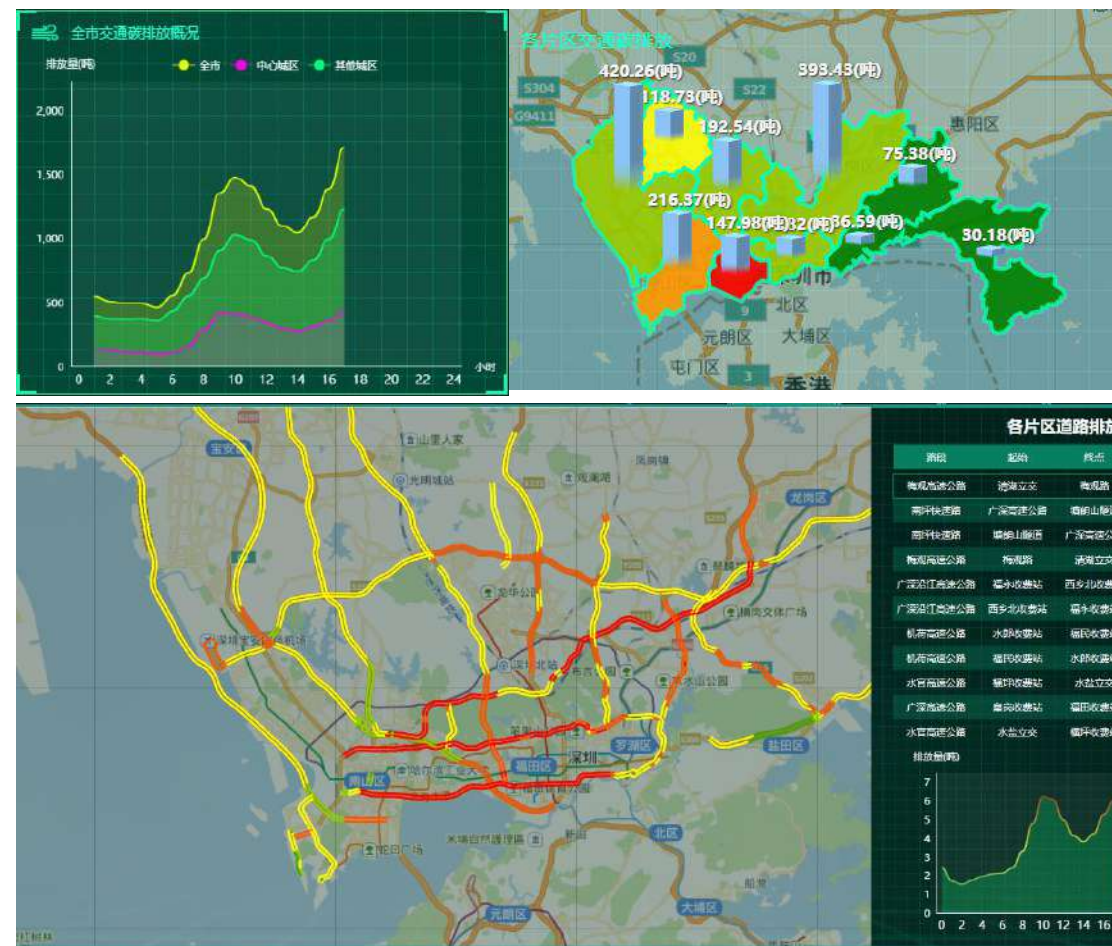
3. Emission model localization

④ Fleet composition localization

- Extracting the fleet composition by license plate recognition and vehicle inspection and maintenance record.
- Vehicles of the fleet is divided according to the vehicle types, ages, displacement, fuels, emission standard.

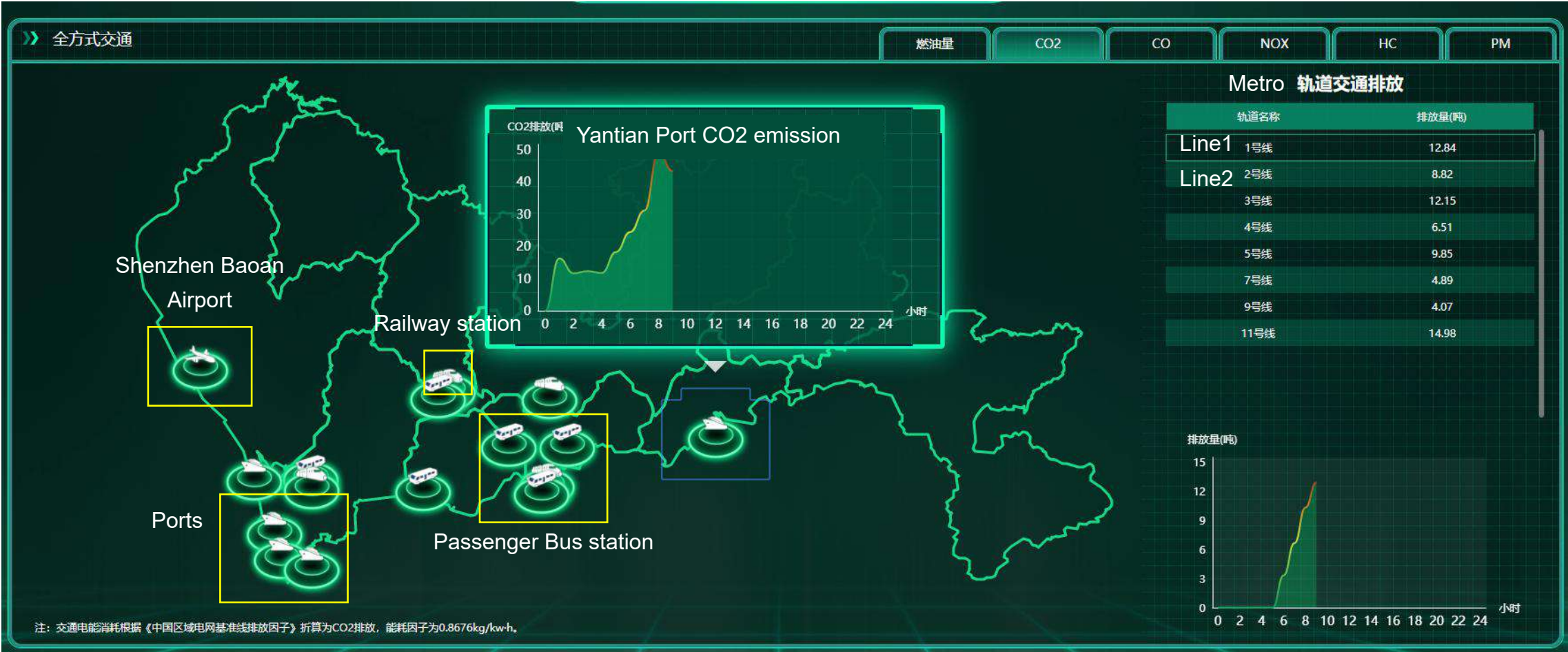


- Fuel consumption and emission dynamically evaluation
- Various information providing for the government and the public



4. Real-time monitoring

- Fuel consumption and CO2 emissions of multiple transportation modes are integrated

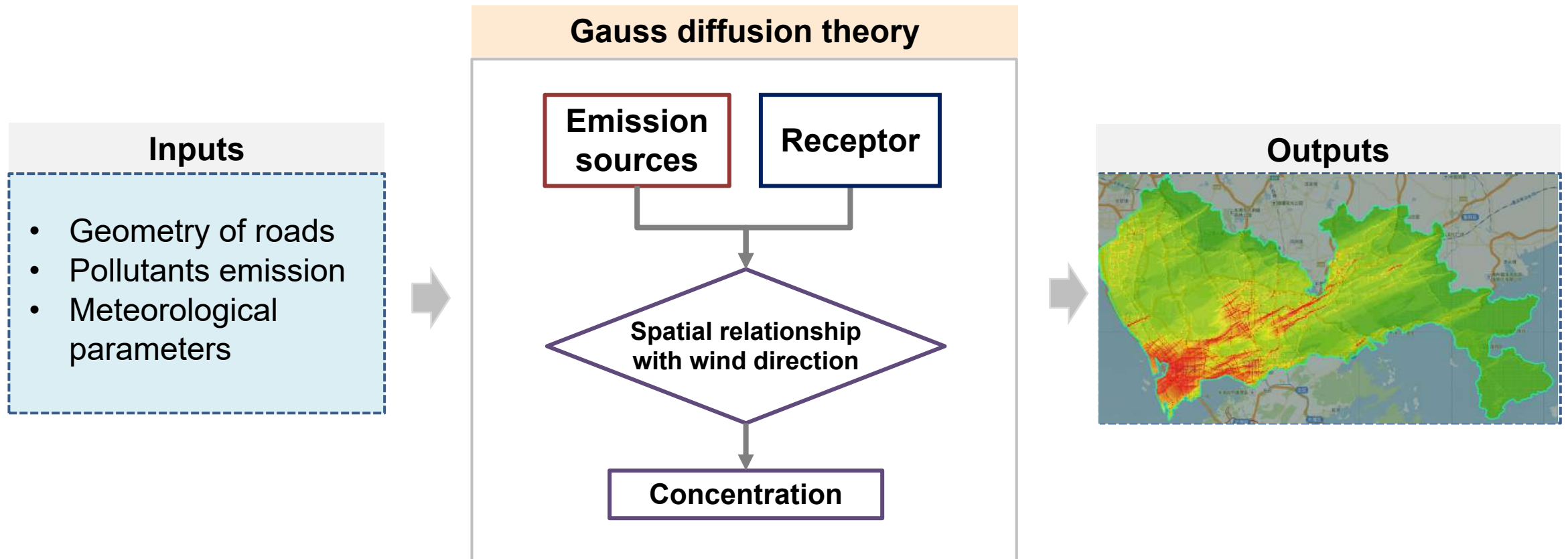


Real-time traffic emission monitoring platform v2.0

5. Pollutant dispersion model

Gauss diffusion theory is applied to build the dispersion model of traffic emissions

- Evaluating pollutions caused by traffic emission in city scale
- Modelling pollution distribution dynamically corresponding to real-time emission monitoring

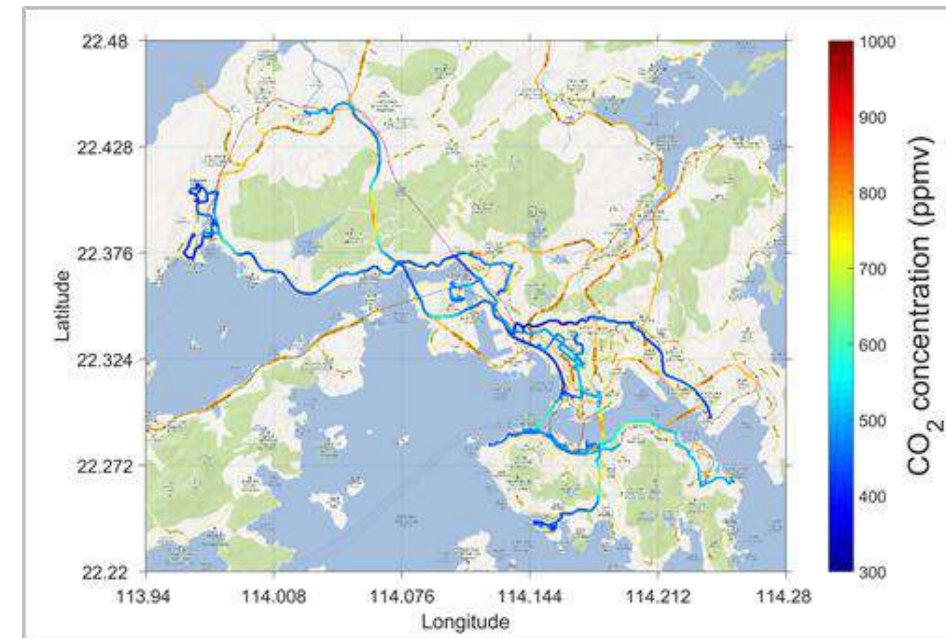
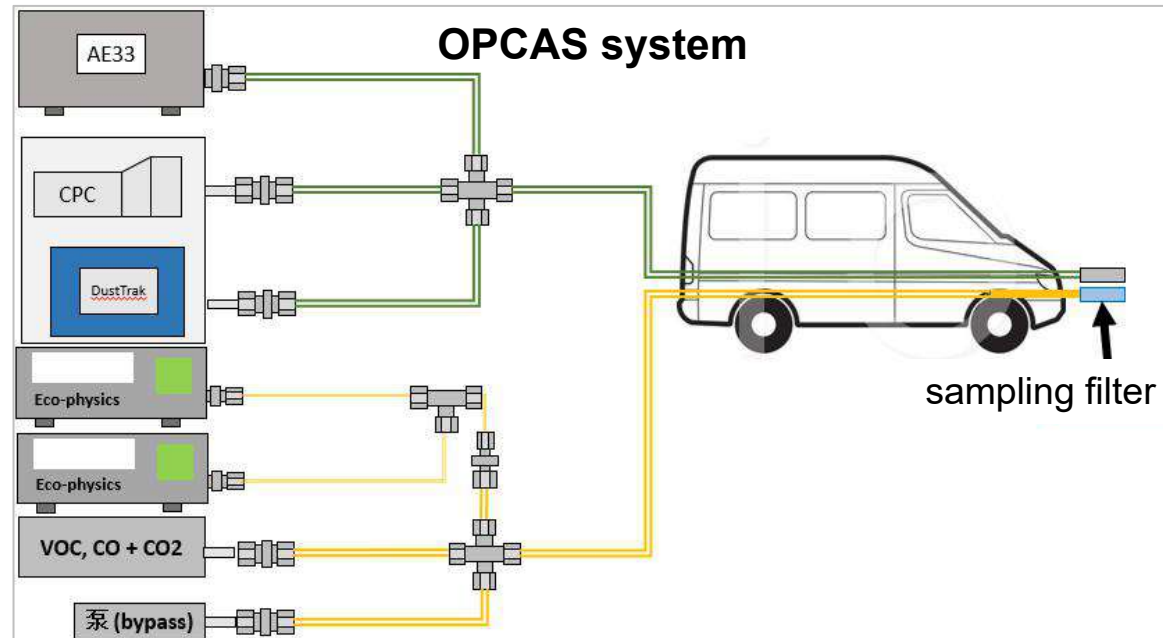


6. Model verification

Mobile on-road environment monitoring

On-road Plume Chasing and Analysis System (OPCAS)

- Roadside fixed-point monitoring
- on-road environment monitoring
- Tracing measurement of emission from the car in front



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Application

**1. Emission quantification and
monitoring tool**

2. Transport planning & policy

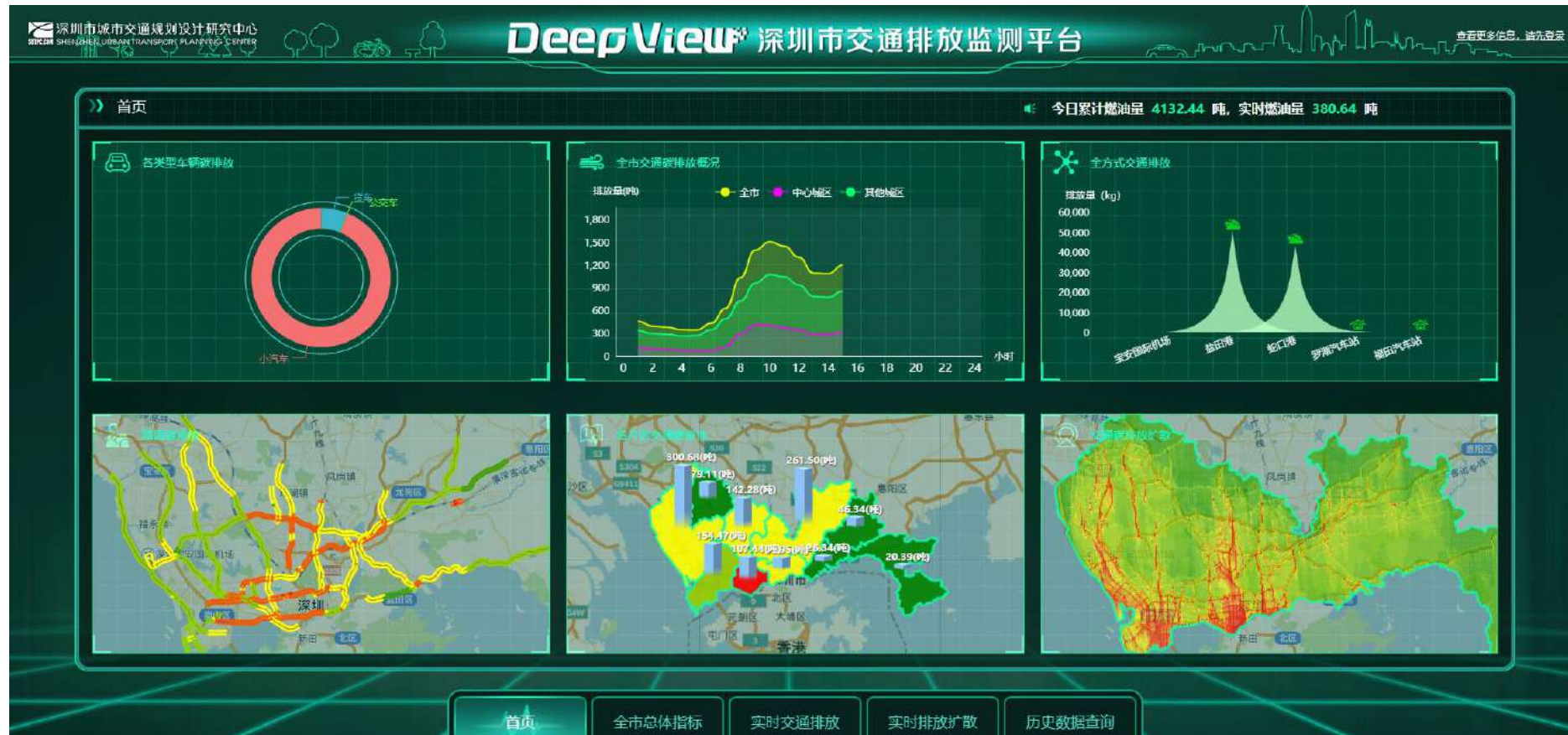
3. Environmental policy

**4. Transport-environment
information to the public**

1. Emission quantification and monitoring tool

① Real-time monitoring of multi-modes transportation

- Emissions from roads, airports, ports and hubs
- Spatial and temporal distribution



Real-time traffic emission monitoring platform v2.0

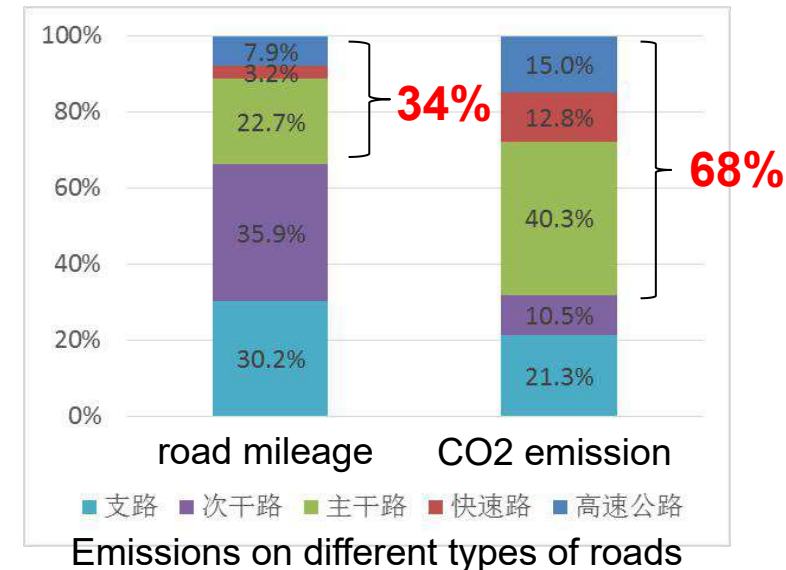
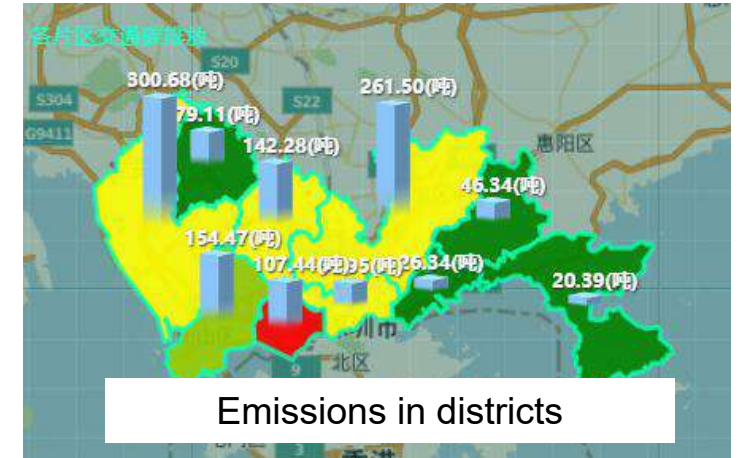
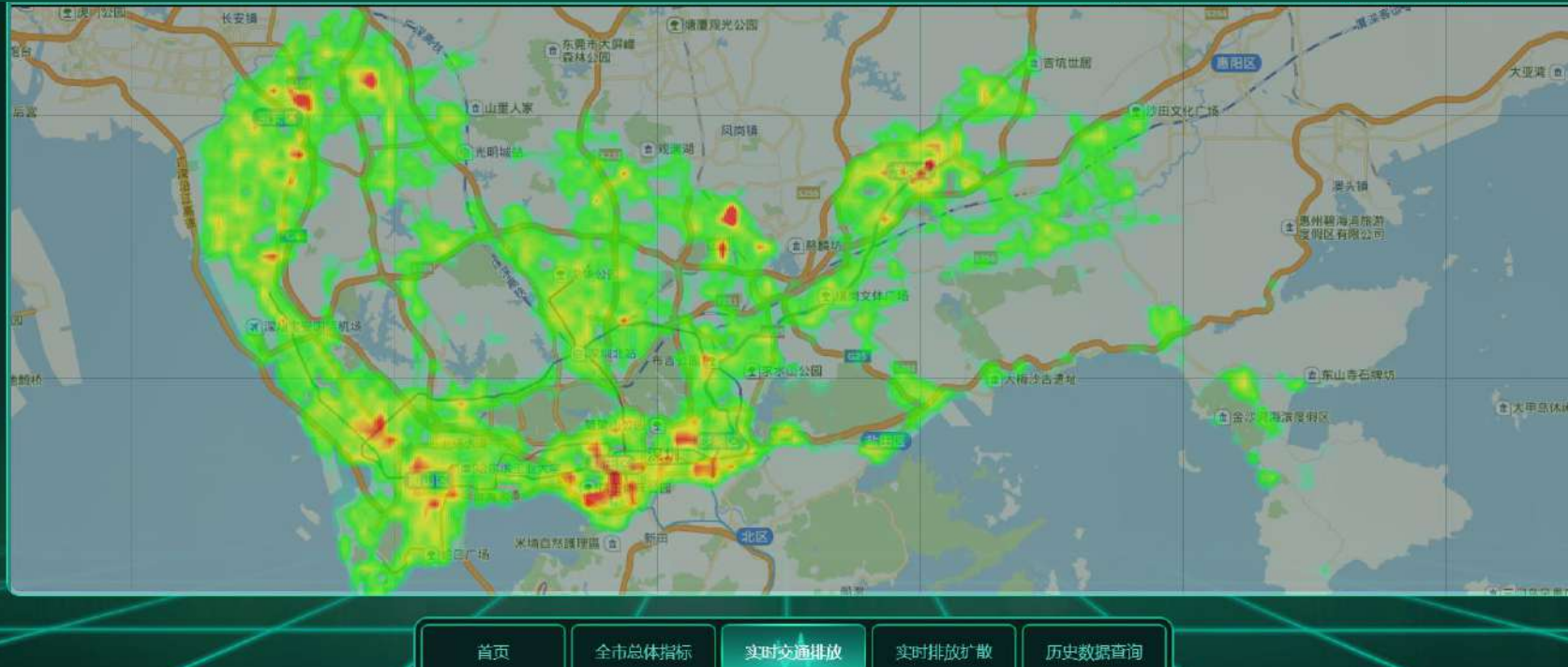
1. Emission quantification and monitoring tool

② Provide emission information to government

- In multi-scale: vehicle – road – district – city

On a workday

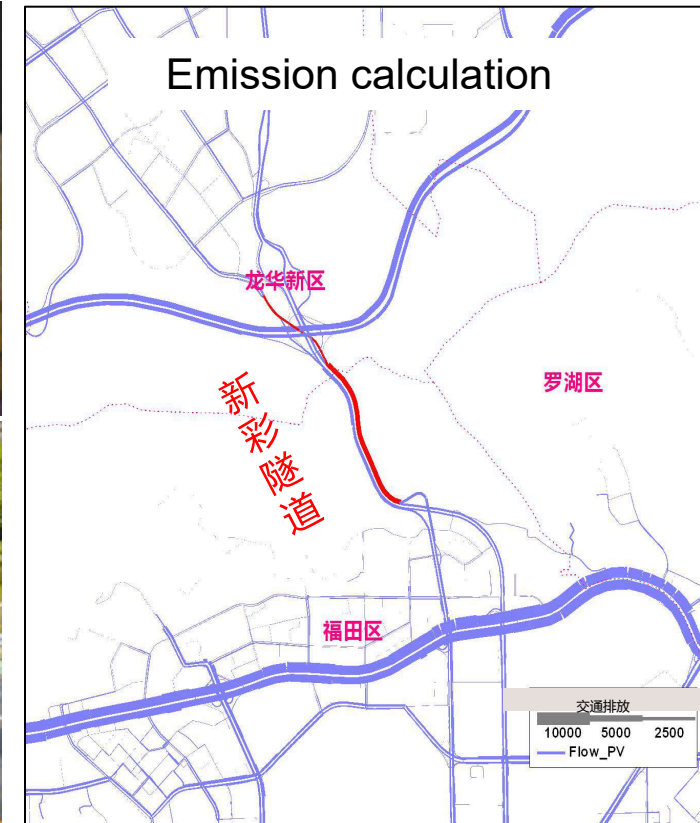
~7000 tons of fuel consumption and ~**23,000** tons of CO₂ emission from all vehicles in Shenzhen, equivalent to the absorption of **1,308** sq.km green space



2. Transport planning & policy

① Evaluate environmental impacts of transport construction projects

- Xincai tunnel reduced the carbon dioxide along the corridor by 12%, and increased speed in the AM peak hour by 13.7% and in the PM peak hour by 7.0%.

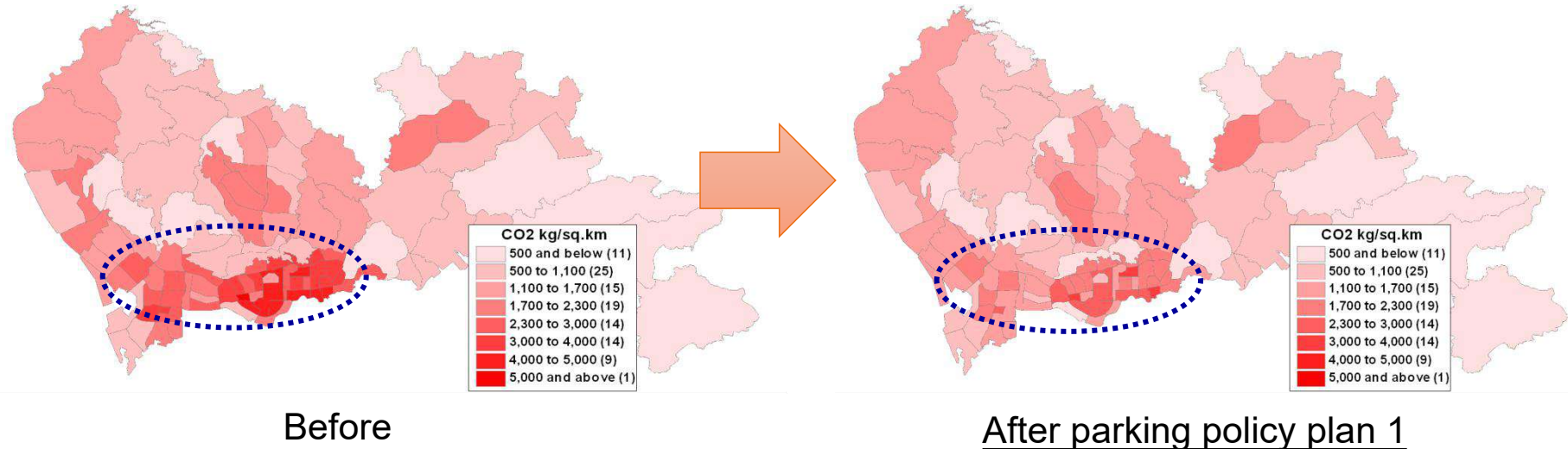


2. Transport planning & policy

② Evaluate traffic management policy

- The environmental beneficial of parking charge policy: carbon dioxide emission reduced by 22%

Plan 1 方案一				Plan 2 方案二			
征收时段	收费标准（元/半小时）			征收时段	收费标准（元/半小时）		
	一类区域	二类区域	三类区域		一类区域	二类区域	三类区域
工作日（7:00-21:00）	6	4	2	工作日（全天）	5	3	2
非工作日（7:00-21:00）	3	2	1	非工作日（全天）	3	2	1
碳排放测试	比现状下降22.30%			碳排放测试	比现状下降21.50%		

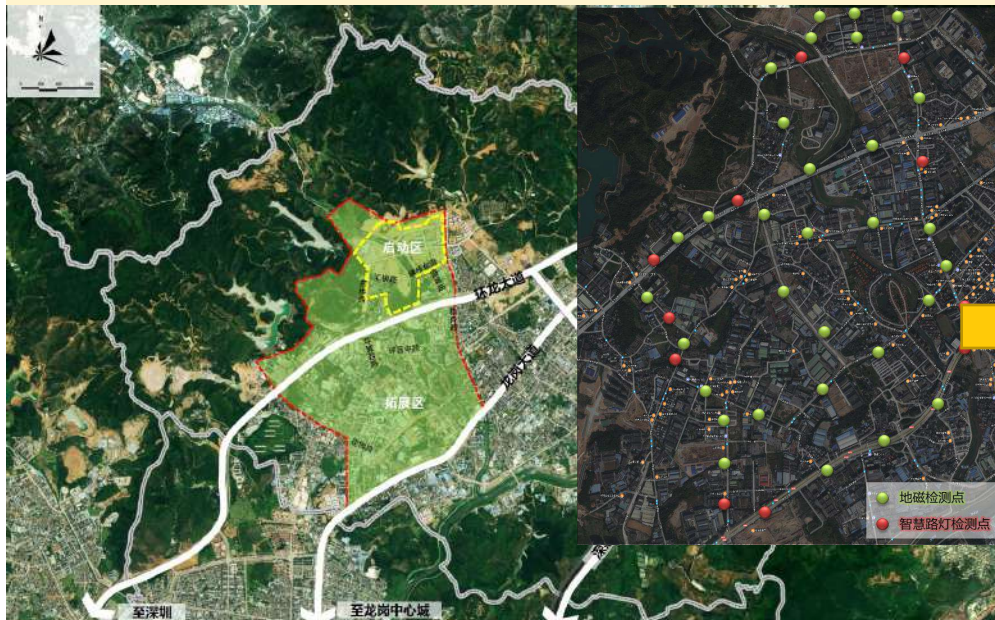


3. Environmental policy

① Set up low emission zone \ low carbon zone

- Shenzhen is planning to build low emission zone in the former special region, central town of Baoan and central town of Longgang

Shenzhen International Low Carbon City
(Longgang district)



Carbon Emission Monitoring Platform



3. Environmental policy

② Support carbon trading in transportation industry

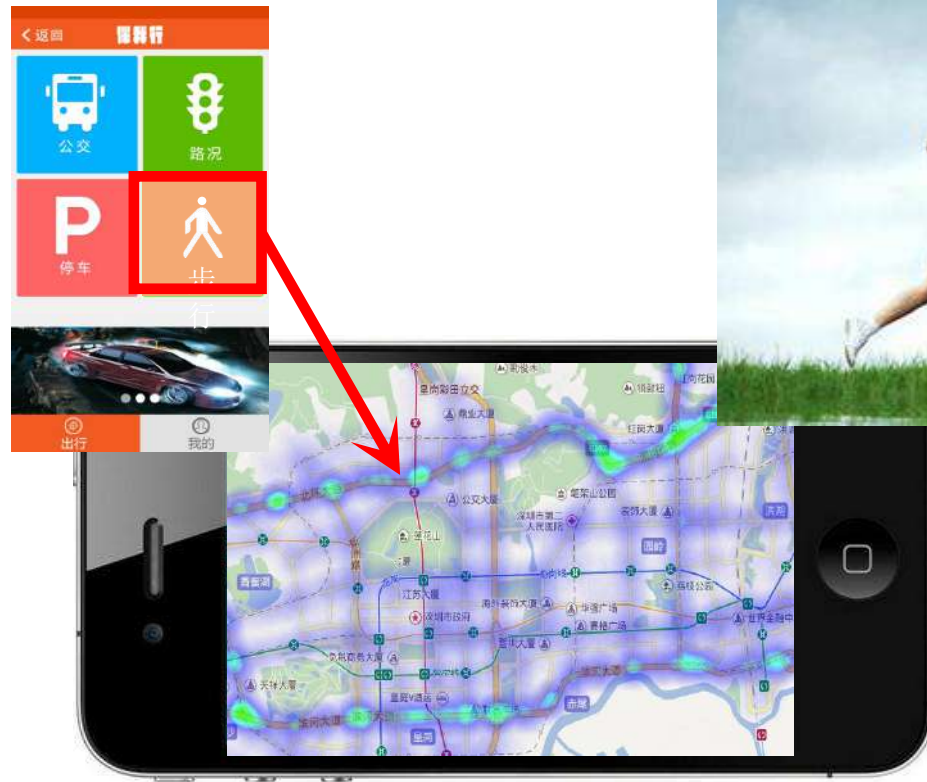
- Quantify the reduction of carbon emission of transport enterprises (freight, public transport), compensate and encourage them to use green vehicles / adopt low-carbon approaches



Shenzhen carbon trading system is one of the first carbon trading systems in china, which was open on 2010-9-30

4. Transport-environment information to the public

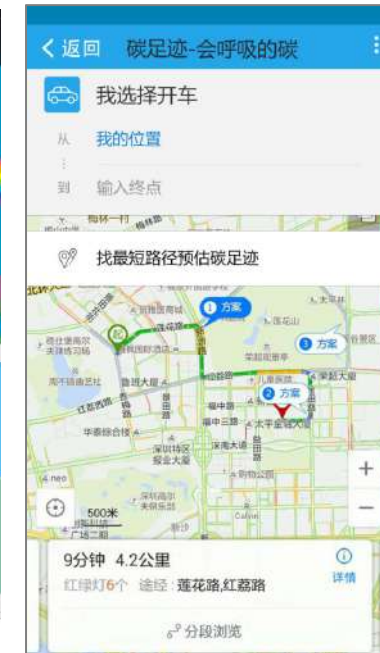
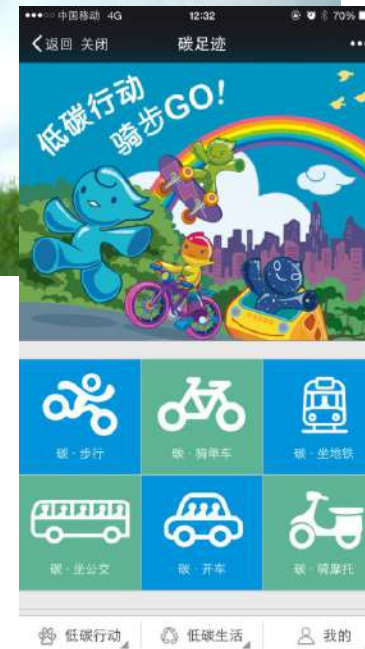
- Help citizen to avoid exposition in polluted air, to choose green travel route



Traffic emission visulization



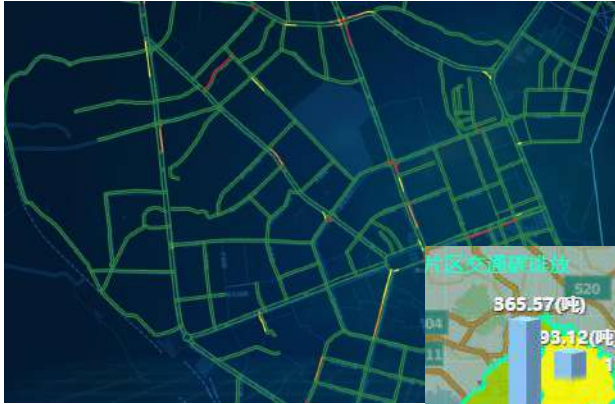
Outdoor fitness



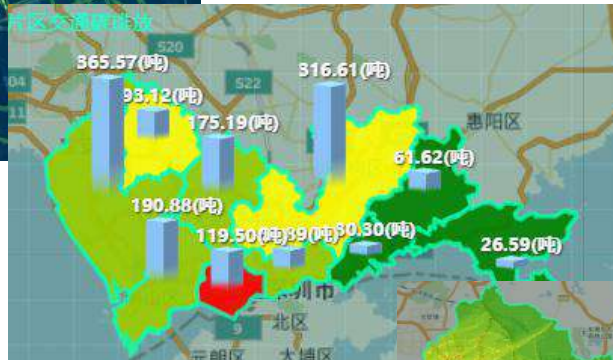
App - **Carbon Footprint**

4. Transport-environment information to the public

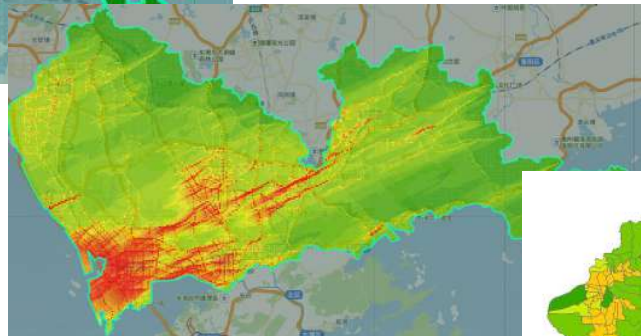
■ Reveal a chain effect of travel demand on population exposure



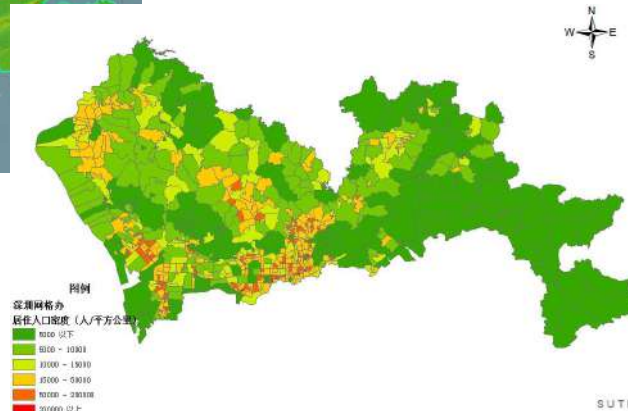
Traffic activities



Emissions



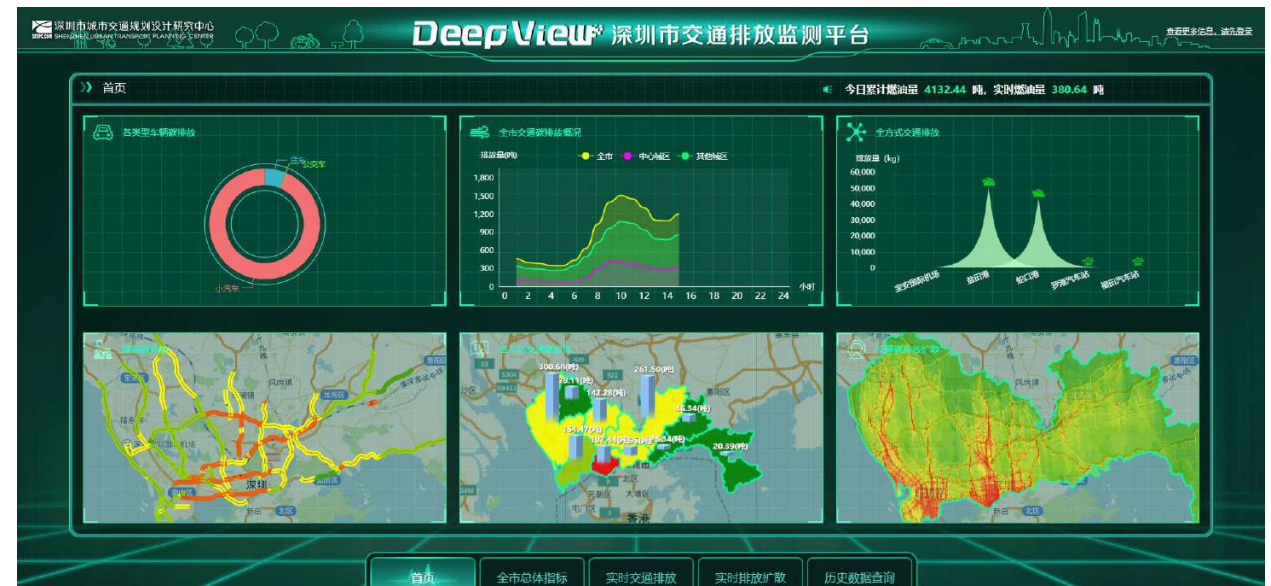
Concentrations



Population exposure

Conclusion

- Quantifying and monitoring emissions based on traffic big data
- Emissions of multi-modes transport and air pollution modelling are integrated in a platform
- Providing various and useful information to promote the development of low-carbon transportation





Thank you



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