# ROE model User Guide

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ROE
Real-time on-road emission model

This is an on-road emission calculation model

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0. Preparing the Python environment

This model is established and run in Python3.
Internet access is requested for crawler module to obtain the traffic data from ITS.

1. Crawling data

In this current version, the crawler module is design for Gaode map.
The module folder is '***gaode-crawler'***

***1) crawler-traffic-speed.py***

This is the main script of the crawler module. In this script, four options should be modified by users based on the actual situation:

'*path*' is the option for setting the output file path.
'*apikey*' is the option for setting the Gaode map API key which is for accessing the data for Gaode. To obtain the key, please Register an account at https://lbs.amap.com/.
'*citycode*' is the option for setting the city identifier. Please refer the citycode table.
'*target_area*' is the option for setting the crawling area. Four parameters are need for this option. ('*left bottom lon, left bottom lat, right top lon, right ton lat*')

***2) LocaDiv.py***

This script is designed for separating the target area into multiple small areas because the Gaode API has a limitation that each request area could not larger than 100km$^2$. Thus, this script could solve this problem if the target area is larger than the limitation. In this script, the small area size could be set in *'lon_len'* and *'lat_len'*.

***3) coordTrans.py***

This script is designed for coordinate transformation. The coordinate would be transformed to WGS84.

2. Processing the traffic data for emission calculation

2.1 Preparing for the base road map

After obtaining the traffic speed from API, the data need to be processed for emission calculation. A road map should be prepared for matching the road information and traffic information because those data from Gaode API do not have the street information (e.g. road type, road length). The street information could be obtained from OpenStreetMap dataset. To match the street information more effective with the traffic information, using GIS software is recommended for this spatial analyst.

This street information should be placed in the folder **'*base_info*'**.
The file is named by ***'base_road_map.csv'***.

2.2 Preparing for the vehicle fleet information

The vehicle fleet information is essential for emission calculation. Vehicle number, fuel type and emission standard information for each type of vehicle should be prepared in the model. In current version of ROE model, the uniform percentages for vehicle type, fuel type and emission standard are used in every street segment.

The vehicle fleet information should be placed in the folder **'*base_info*'**.

1) Vehicle number for each classification should be placed in file ***'vehicle_fleet.csv'***. The content of this file should contain the vehicle type name and their number in two columns with header line. More details could be found in the template files.

2) fuel type percentage should be placed in file ***'fuel type.csv'***. The content of this file should contain the vehicle type name and fuel type percentages in *n+1* columns with header line (*n* represents the number of fuel type). The percentages of all fuel types are required for each type of the vehicle. More details could be found in the template files.

3) emission standard percentage should be placed in file ***'emission_standard_percentage.csv'***. The content of this file should contain the vehicle type name and emission standard percentages in m+1 columns with header line (m represents the number of emission standard). The percentages of all emission standards are required for each type of the vehicle. More details could be found in the template files.

2.3 Preparing for the emission factors

The emission factors in ROE model are from the Ministry of Ecology and Environment of the People's Republic of China (MEP) Technical Guide of Air Pollutant Emission Inventory for On Road Vehicles (MEP, 2014).

The emission factors should be placed in the folder **'*base_info*'**.

1) Emission factors should be placed in file ***'On Road Hot Emission Factor Chinese.csv'***. The content of this file should contain the *vehicle type name, vehicle fuel type, vehicle size segment, emission standard, emission control technology, pollutant type and emission factor* in six columns with header line. More details could be found in the template files.
2) HC evaporation emission factors for petrol vehicle should be placed in file ***'evaporation-emission-factor.csv'***. The content of this file should contain the *vehicle type name, vehicle fuel type, vehicle size segment, temperature range, and HC evaporation factor* in five columns with header line. More details could be found in the template files.

2.4 Preparing the Traffic volume data

1) Matching the temporal frequency

The temporal frequency of traffic data should be processed and match the temporal resolution that the users need.

This script is placed in in the folder ***'calculation\script'.***
This script is named by ***'speed_mean.py'.***

In this script, the traffic data would be processed in hourly.
Options *start_day* and *end_day* should be modified to set the time period of the script running.
Option *step_in_hour* is the temporal frequency of traffic data (e.g. the *step_in_hour*=12 means temporal frequency of traffic data is every 5-minute)

Option *work_path* is for setting the working directory.
Option *data_path* is for setting the traffic data directory.
Option *output_path* is for setting the output directory for this script.
Option *road_map_file* is the file path of base road map.

2) Calculating the traffic volume
the traffic volume should be calculated by the traffic speed using the traffic speed-flow model.
The traffic volume calculation script is placed in the folder ***'calculation\script'***
This script is named by ***'flow_calculation.py'.***

This script uses the Underwood volume calculation model (Underwood, 1961) and model is described by the following equation:

$$\mathrm{V} = k_m u \ln \frac{u_f}{u},$$

In the flow calculation script, the macroscopic fundamental diagram parameters of k and $u_f$ could be modified if users have their own data.

Options *start_day* and *end_day* should be modified to set the time period of the script running.
Option *work_path* is for setting the working directory.
Option *data_path* is for setting the traffic data directory.
Option *output_path* is for setting the output directory for this script.
Option *road_map_file* is the file path of base road map.

3. Calculating the emission data
After preparing the traffic data and vehicle fleet information, users can the emission calculation script to establish the emission data.

The emission calculation script is placed in the folder ***'calculation/script/'***
This script is named by ***'emission_cakculation-china.py'***.

In this script,
Option *work_path* is for setting the working directory.
Option *base_info_path* is for setting the base info files directory.
Option *road_map_file* is the file path of base road map.
Option *data_path* is for setting the traffic data directory.

Option *output_path* is for setting the output directory for this script.
Options *start_day* and *end_day* should be modified to set the time period of the script running.

It's should be noted that,
The *vehicle_fleet_flag_segment, vehicle_fleet_flag, fuel_type_flag, emission_standard_flag* and *the species_flag* must match the information in those base_info files.

The emission calculation script is depended on another script that considering the correction factors of the emission factor. Users could modify these correction factor based on the actual situation. The correction factors could be referred in the MEP Technical Guide. (MEP, 2014).
This script is placed in the folder ***'calculation/script/'***
This script is named by ***'ef_equation_china.py'***.

4. Post-processing the emission data

After calculating the emissions, ROE provides some post-processing scripts for outputting the emission information and modifying the format for air quality models.

The post-processing scripts are placed in the folder ***'post-script'***

***1) Modify_emis.py***

This script is designed to modify the emission format from ROE to MUNICH model.
In this script,
Option *work_path* is for setting the working directory.
Option *data_path* is for setting the input emission data directory.
Option *output_path* is for setting the output directory for this script.

***2) Road_type_flow.py***

This script is designed to output the traffic flow data for each type of the road.
In this script,
Option *work_path* is for setting the working directory.
Option *data_path* is for setting the input traffic flow data directory.
Option *output_path* is for setting the output directory for this script.

***3) Road_type_speed.py***

This script is designed to output the traffic speed data for each type of the road.
In this script,
Option *work_path* is for setting the working directory.
Option *data_path* is for setting the input traffic speed data directory.
Option *output_path* is for setting the output directory for this script.

Folder tree:

```
ROE
├──── base_info
│     ├── base_road_map.csv
│     ├── emission_standard_percentage.csv
│     ├── evaporation-emission-factor.csv
│     ├── fuel_type_percentage.csv
│     ├── On Road Hot Emission Factor Chinese.csv
│     └── vehicle_fleet.csv
├──── calculation
│     ├── emission_hour
│     ├── flow_hour
│     │     └── plot_flow.m
│     ├── script
│     │     ├── ef_equation_china.py
│     │     ├── emis_calculation-china.py
│     │     ├── flow_calculation.py
│     │     └── speed_mean.py
│     └── speed_hour
│           └── plot_speed.m
├──── gaode-crawler
│     ├── coordTrans.py
│     ├── crawler-traffic-speed.py
│     ├── gaode-city-code
│     │     └── AMap_adcode_citycode.xlsx
│     ├── LocaDiv.py
│     └── output
├──── post-script
│     ├── modify_emis.py
│     ├── road_type_flow.py
│     └── road_type_speed.py
└──── user_guide-v1.1.pdf
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Reference

MEP: Technical Guide of Air Pollutant Emission Inventory for On Road Vehicles (Trial), Beijing, China., 2014.

Underwood, R. T.: Speed, volume, and density relationship: quality and theory of traffic flow, Yale Bur. Highw. Traffic, 141–188, 1961.