



# Development of an urban scale air quality forecasting system with EMEP and EPISODE model Wuhan, China

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NILU

14 Oct. 2015

EMEP training course, [met.no](http://met.no)

# Project overview

- Partners

  - NILU - Norwegian Institute for Air Research

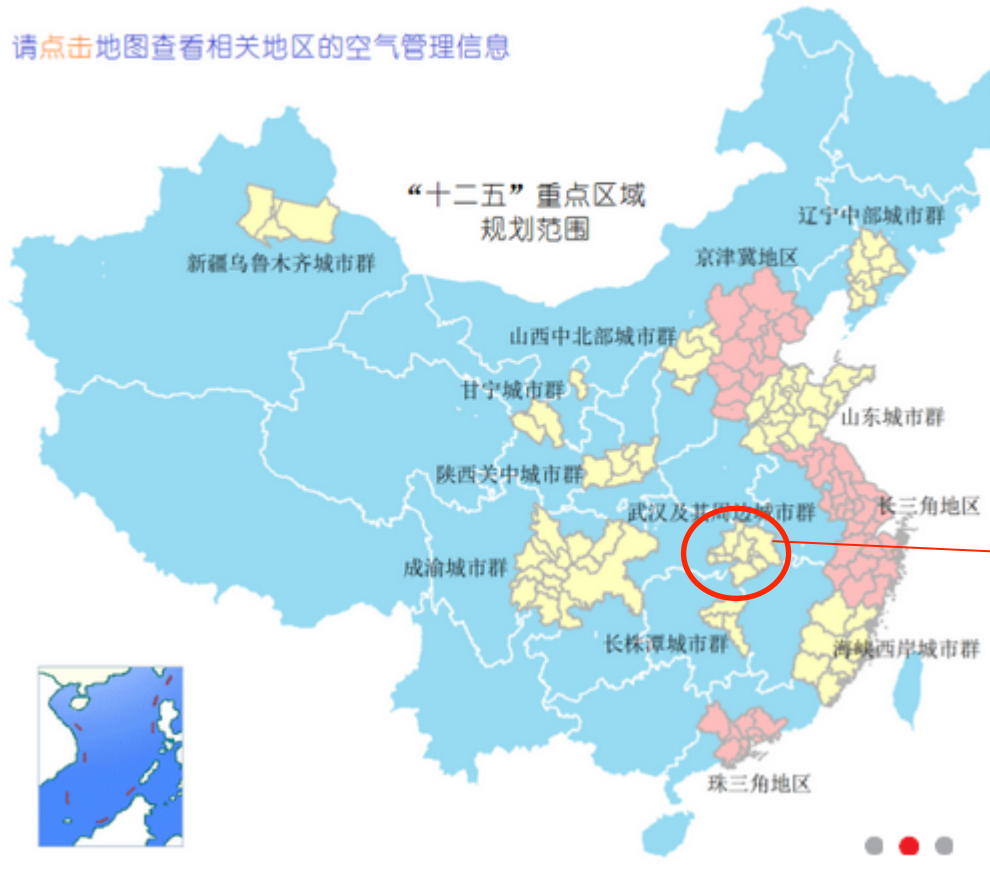
  - HBEMC - Hubei Environmental Monitoring Center

- Project period

  - 24 months (2013-2014)

# CITY CLUSTERS IN CHINA

请点击地图查看相关地区的空气管理信息



# WUHAN “1+8” CITY CLUSTER



Within 100km distance

	Population (2010)
Wuhan	9.78 mill. (8.484 km <sup>2</sup> )
Ezhou	1.05 mill.
Huanggang	6.16 mill.
Huangshi	2.43 mill.
Xiaogan	4.81 mill.
Xianning	2.46 mill.
Xiantao	1.18 mill.
Tianmen	1.42 mill.
Qianjiang	0.95 mill.

# Air quality monitoring network in Hubei

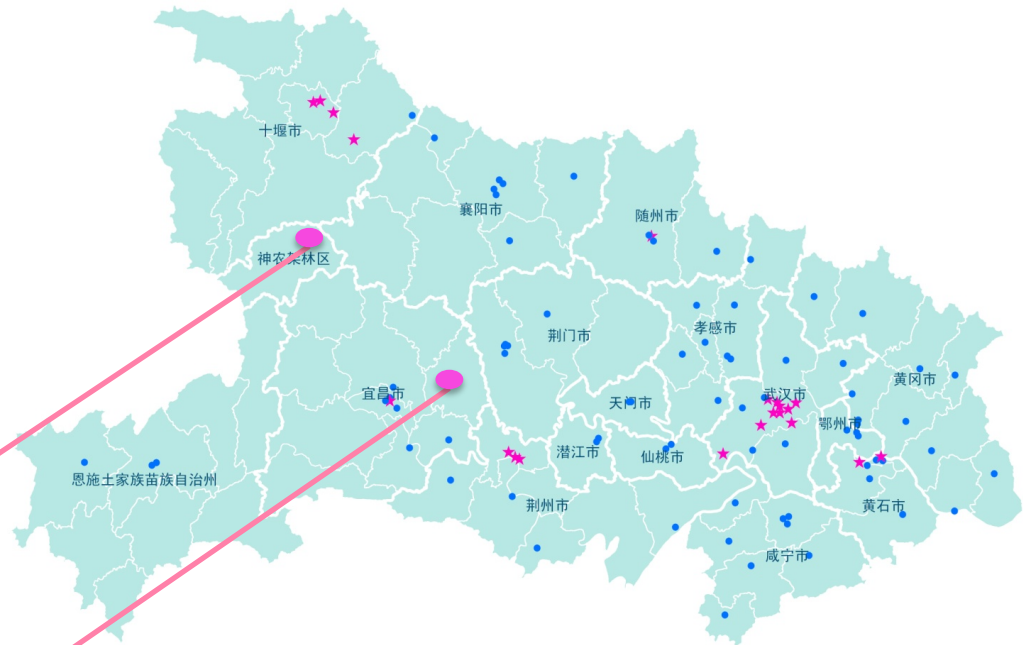
Hubei has established 100 AQ monitoring stations by the support of the central and provincial government special funds .

Including 2 regional background stations

**Shennongjia**  
background station

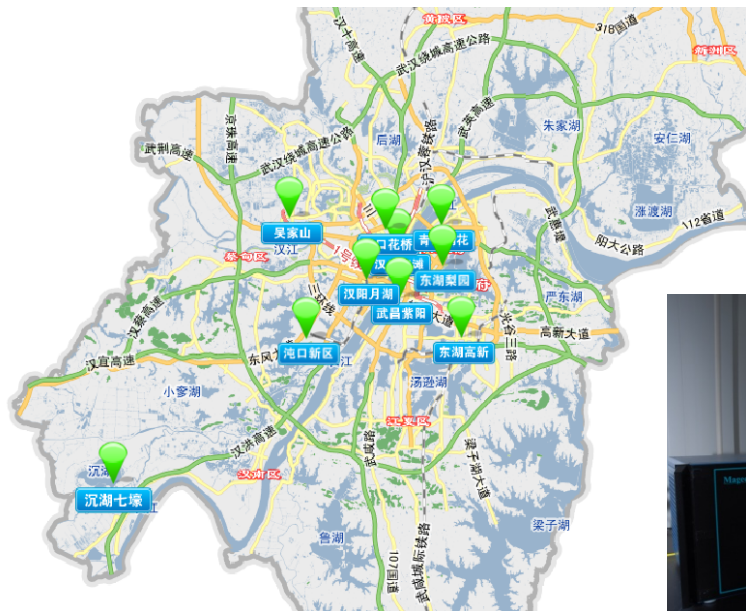


**Zhongxiang**  
background station



**Hubei Ambient Air Quality Monitoring System**

**SO<sub>2</sub>, CO, NO/NO<sub>2</sub>/NO<sub>x</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, O<sub>3</sub>**  
**SO<sub>2</sub>, NO/NO<sub>2</sub>/NO<sub>x</sub>, PM<sub>10</sub>**



10 AQ stations in Wuhan  
 SO<sub>2</sub>, CO, NO/NO<sub>2</sub>/NO<sub>x</sub>, PM<sub>10</sub>,  
 PM<sub>2.5</sub>, O<sub>3</sub> + more



black carbon



0.25 μm -32.0μm



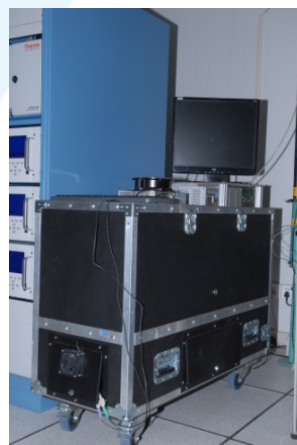
PM<sub>1</sub>



Wind Speed、 Wind direction、 Temperature、 Atmospheric pressure、 Relative humidity



NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub>, CO



CO<sub>2</sub>, CO, CH<sub>4</sub>, N<sub>2</sub>O



VOCs



Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>  
 NO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, NH<sub>4</sub><sup>+</sup>



Cd, Cr, As, Hg, Pb



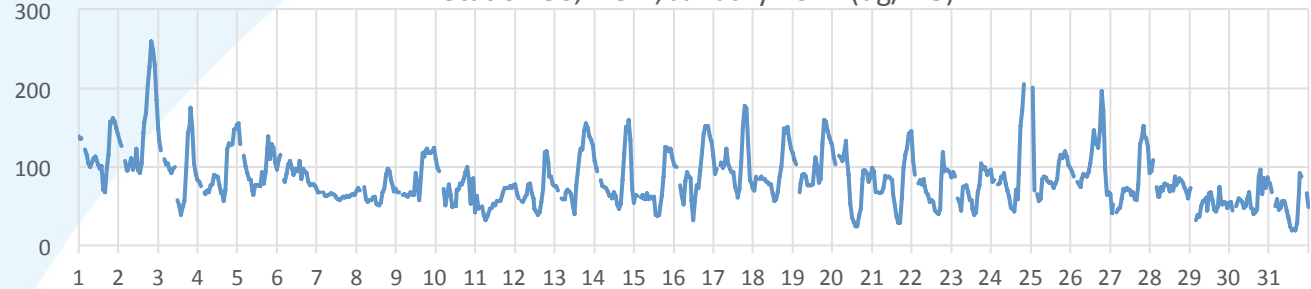
# Air quality situation in Wuhan



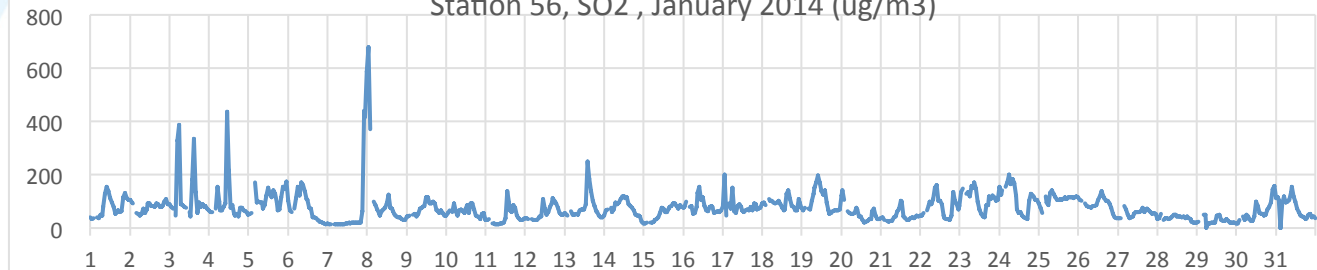
Station 56, PM2.5 , January 2014 (ug/m3)



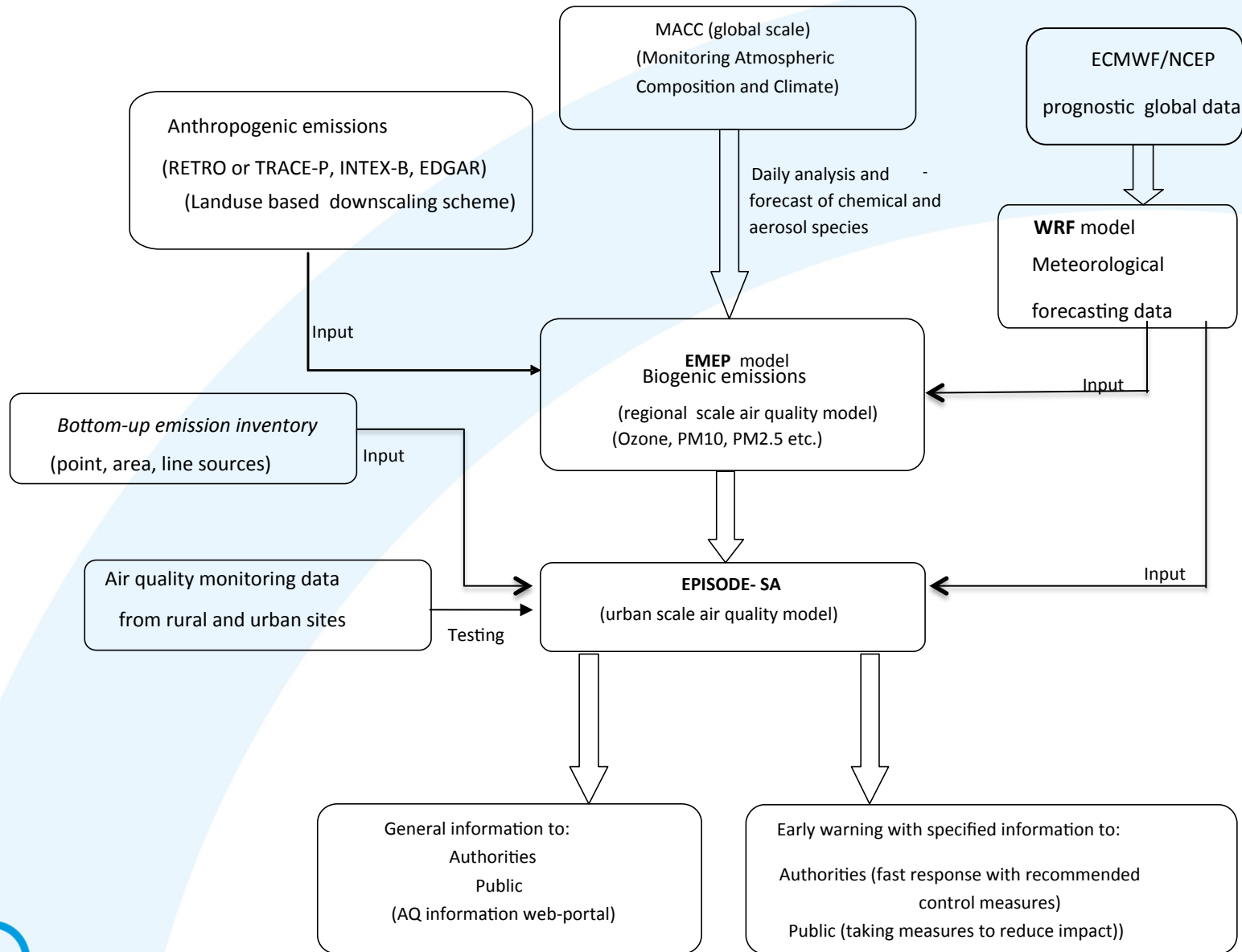
Station 56, NO2 , January 2014 (ug/m3)



Station 56, SO2 , January 2014 (ug/m3)

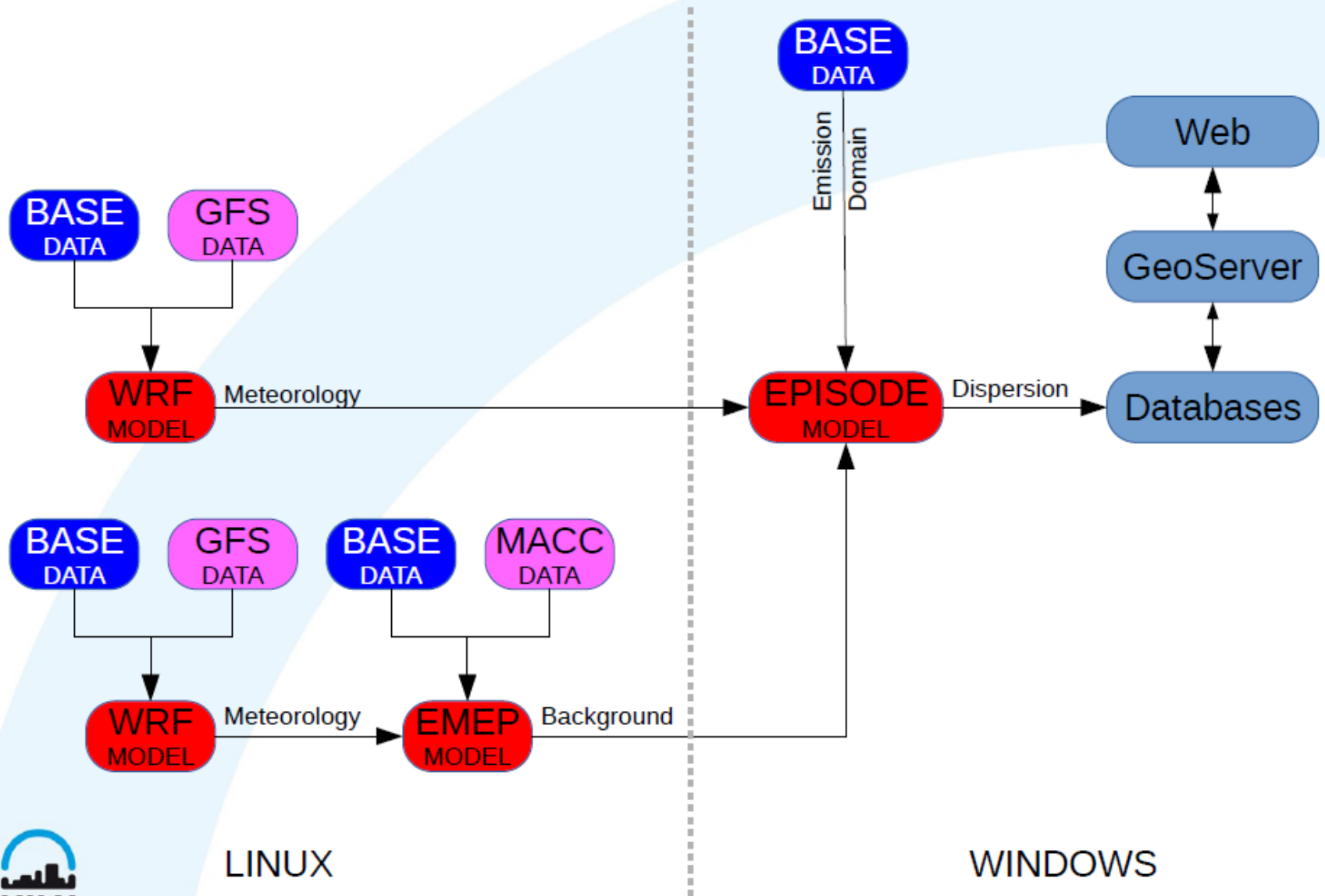


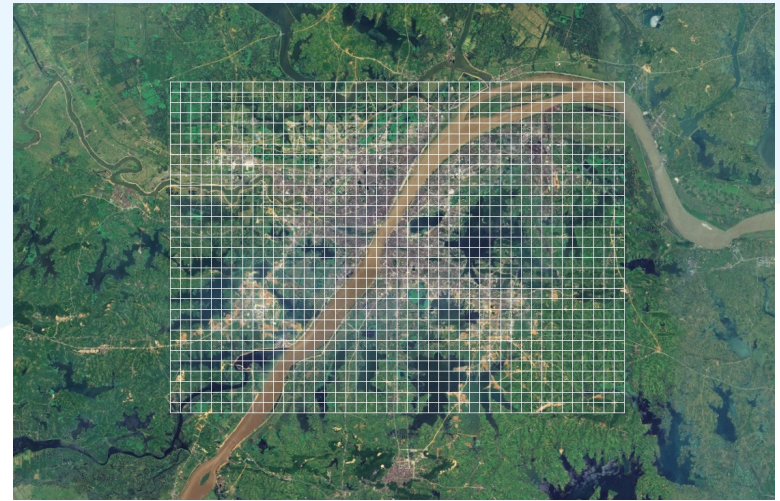
# Forecast System Overview





# DATA CONNECTIVITY OVERVIEW





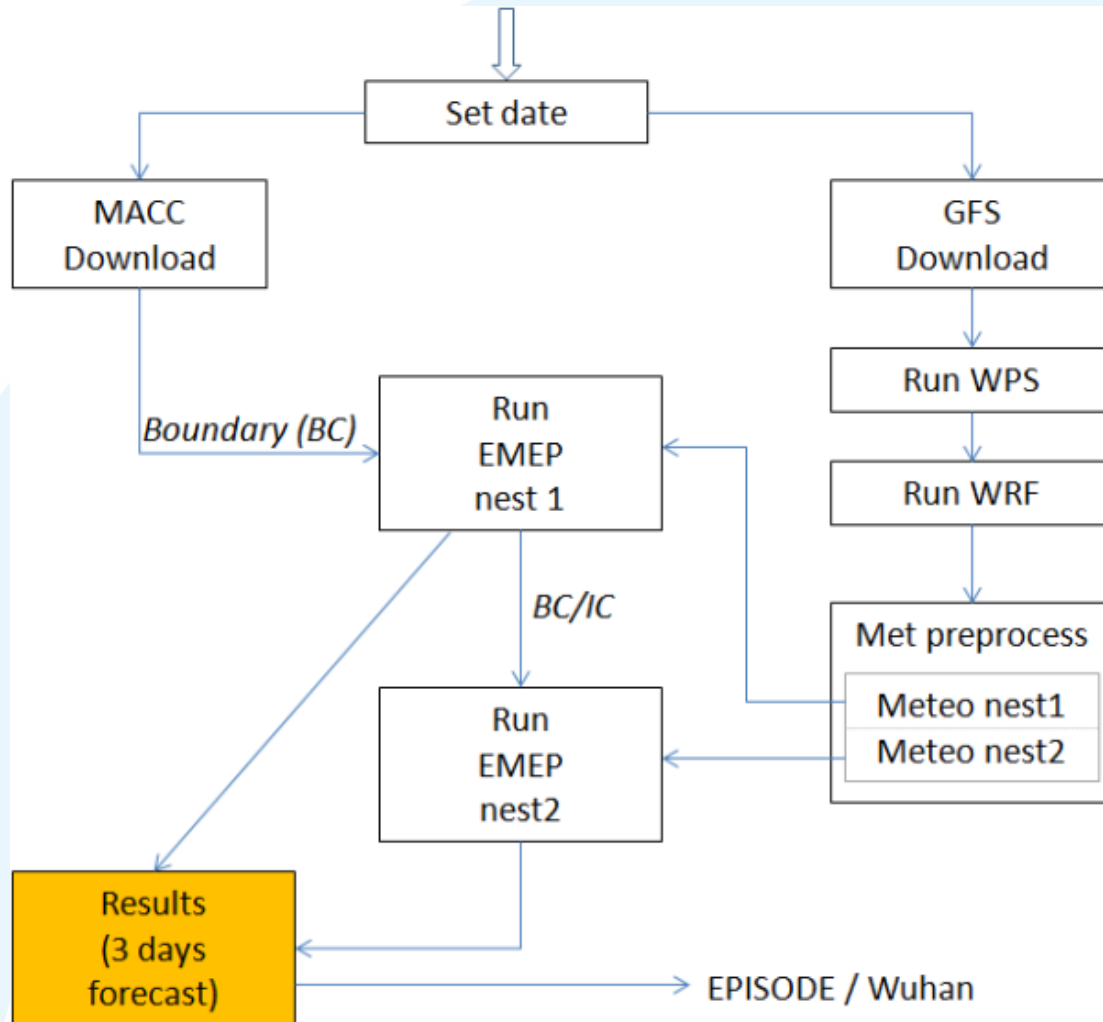
***WRF-EMEP model domains: two nests ( $0.5^\circ$  and  $0.1^\circ$  resolution)***

***Boundary conditions: MACC***

***WRF-EPISODE model domains: domains (5km and 1km)***

***Boundary conditions: EMEP***

# WRF-EMEP flowchart



# WRF Configuration (WRF for EPISODE)

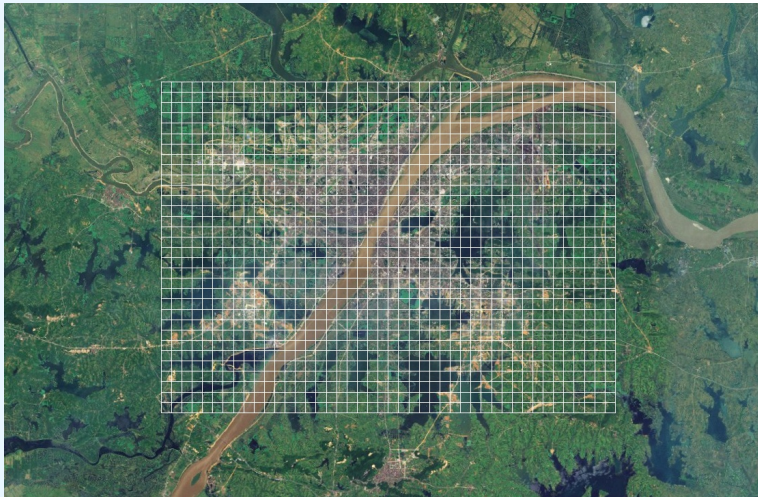
mp_physics scheme)	= 6,	6, (WRF single-moment 6-class	←	Six-class scheme that includes: vapour, rain, snow, cloud ice, cloud water and graupel.
ra_lw_physics	= 1,	1, (RRTM scheme)	←	Radiative flux divergence and surface downward longwave radiation
ra_sw_physics	= 1,	1, (Dudhia scheme)	←	Friction velocities and exchange coefficients. To be uses with YUS scheme
sf_sfclay_physics	= 1,	1, (MM5 similarity, Monin-Obukhov)	←	4-layer soil temperature and moisture model with canopy moisture and snow cover prediction
sf_surface_physics	= 2,	2, (Noah Land Surface Model)	←	Vertical sub-grid-scale fluxes due to eddy transports in the whole atmospheric column
bl_pbl_physics	= 1,	1, (Yonsei University scheme)	←	Sub-grid-scale effects of convective and/or shallow clouds. Not recommended in grids < 5km
cu_physics	= 0,	0, (none)	←	

# Emission inventory



EMEP domains  
*(0.5° and 0.1° resolution)*

**EDGAR v4.2**



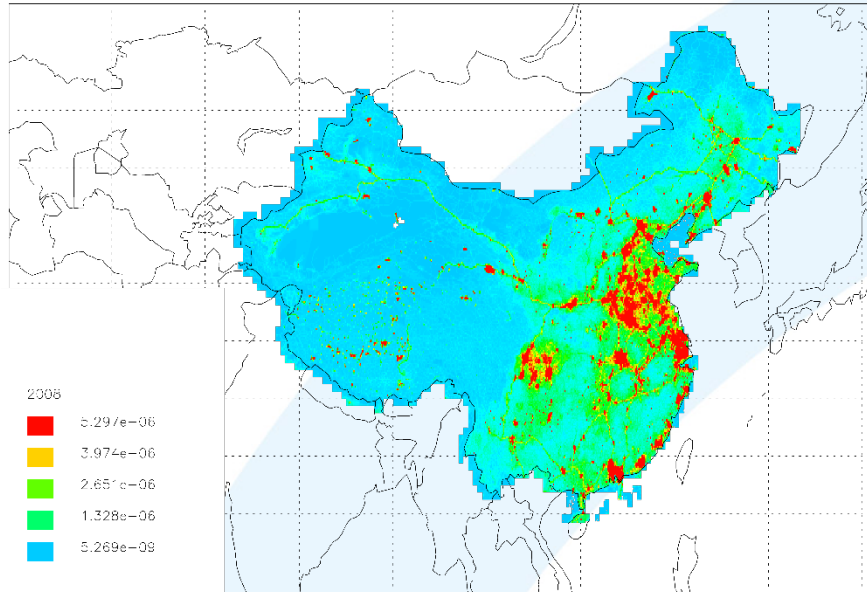
EPISODE domain  
*(1km resolution)*  
*Detailed bottom-up emissions  
and down-scaling*

# Regional Emission inventory overview for China

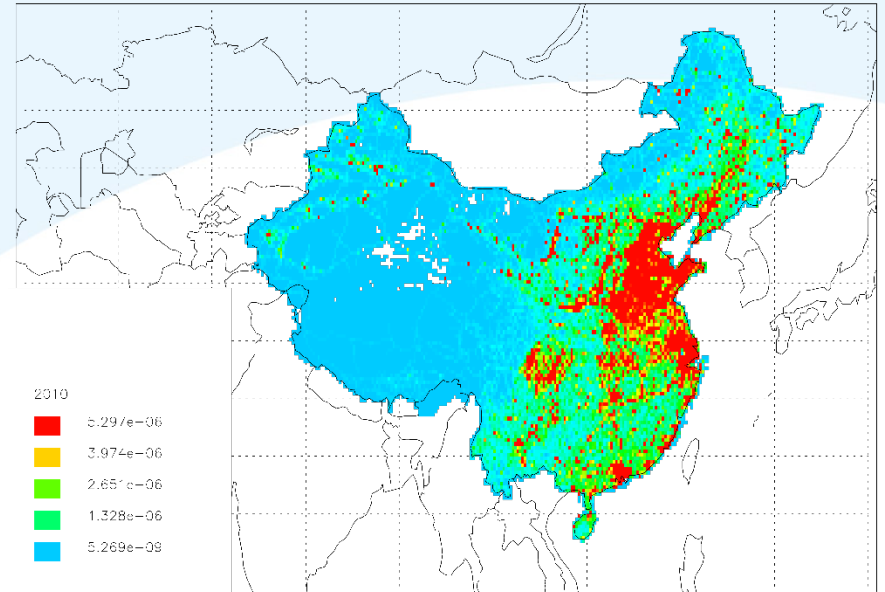
Category	Required (EMEP/Hubei)	Available for downscaling			
		EDGAR v4.2	INTEX-B	REAS	RETRO
Spatial Resolution	5 x 5 km (?)	0.1 deg x 0.1 deg	0.5 deg x 0.5 deg	0.5 deg x 0.5 deg	0.5 deg x 0.5 deg
Domain	Hubei Province	Global	Asia	Asia	Global
Time range	Most up to date	1970-2008	2006	1980-2020 (base years 1995 & 2000)	1960-2000
Temporal Sampling	Annual	Annual	Annual	Annual	Monthly
Data format	ASCII?	NetCDF	ASCII	ASCII (NASA Ames)	NetCDF
Units	tons/gridcell/year	kg m-2 s-1 (CF)	tons/gridcell/year	tons/gridcell/year	kg m-2 s-1 (CF)
Species	NOx	yes	yes	yes	yes
	PM10	yes	yes		no
	PM2.5	no	yes		no
	SOx	yes (SO2)	yes (SO2)	yes (SO2)	no
	CO	yes	yes	yes	yes
	NH3	yes	no	yes	no
	NMVOC	yes (lumped)	yes (30 VOC species)	yes	no
Sectors	SNAP	UNFCCC	power, industry, residential, and transportation (For VOCs: power plants (pow), industry (ind), residential biofuel (dob), residential fossil fuel (dof), residential non-combustion (dop), and transportation (tra))	None, totals only	Power, industrial, residential, traffic, biogenic, ships



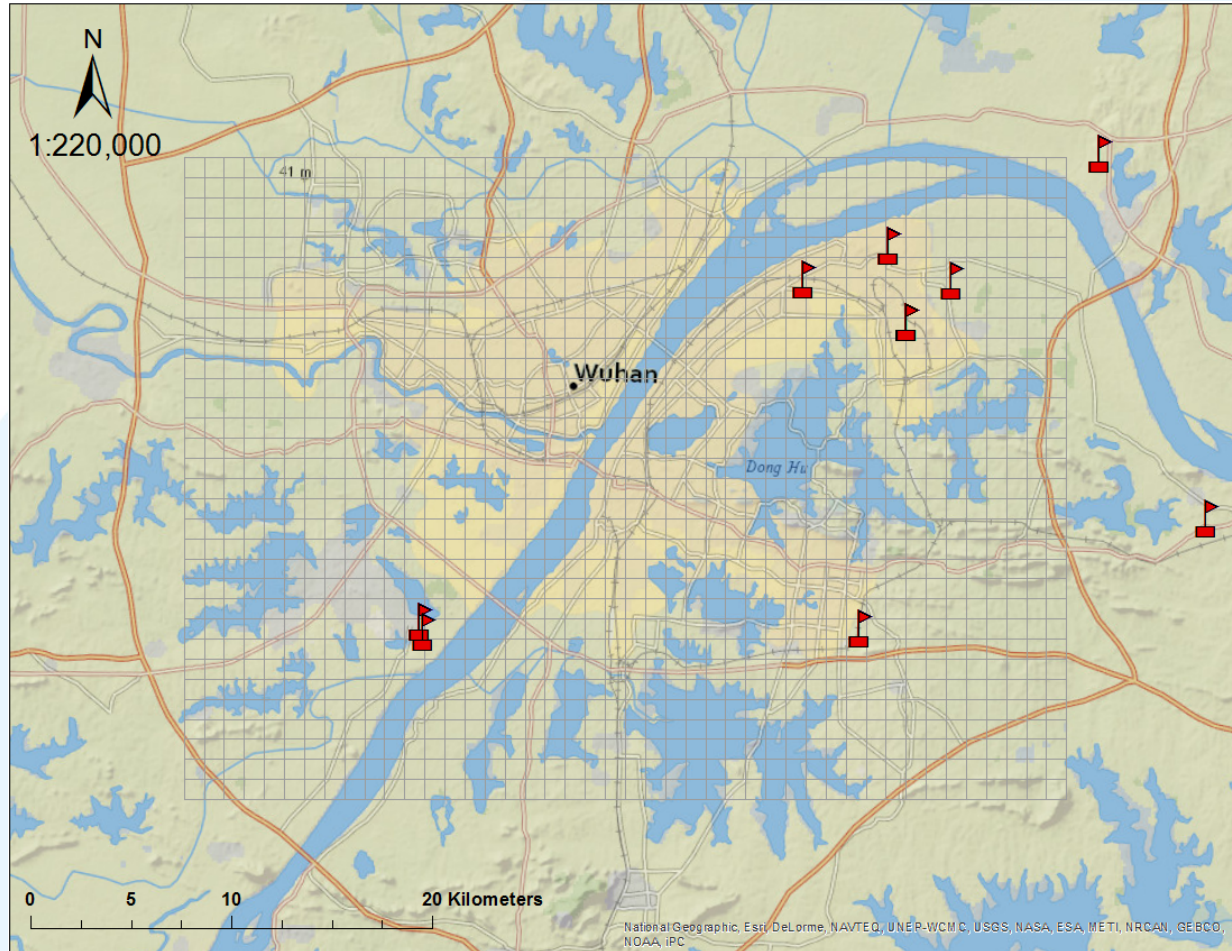
EDGAR NOx Sum - 20903.9 ktonnes



VIC NOx Sum - 28490.3 ktonnes



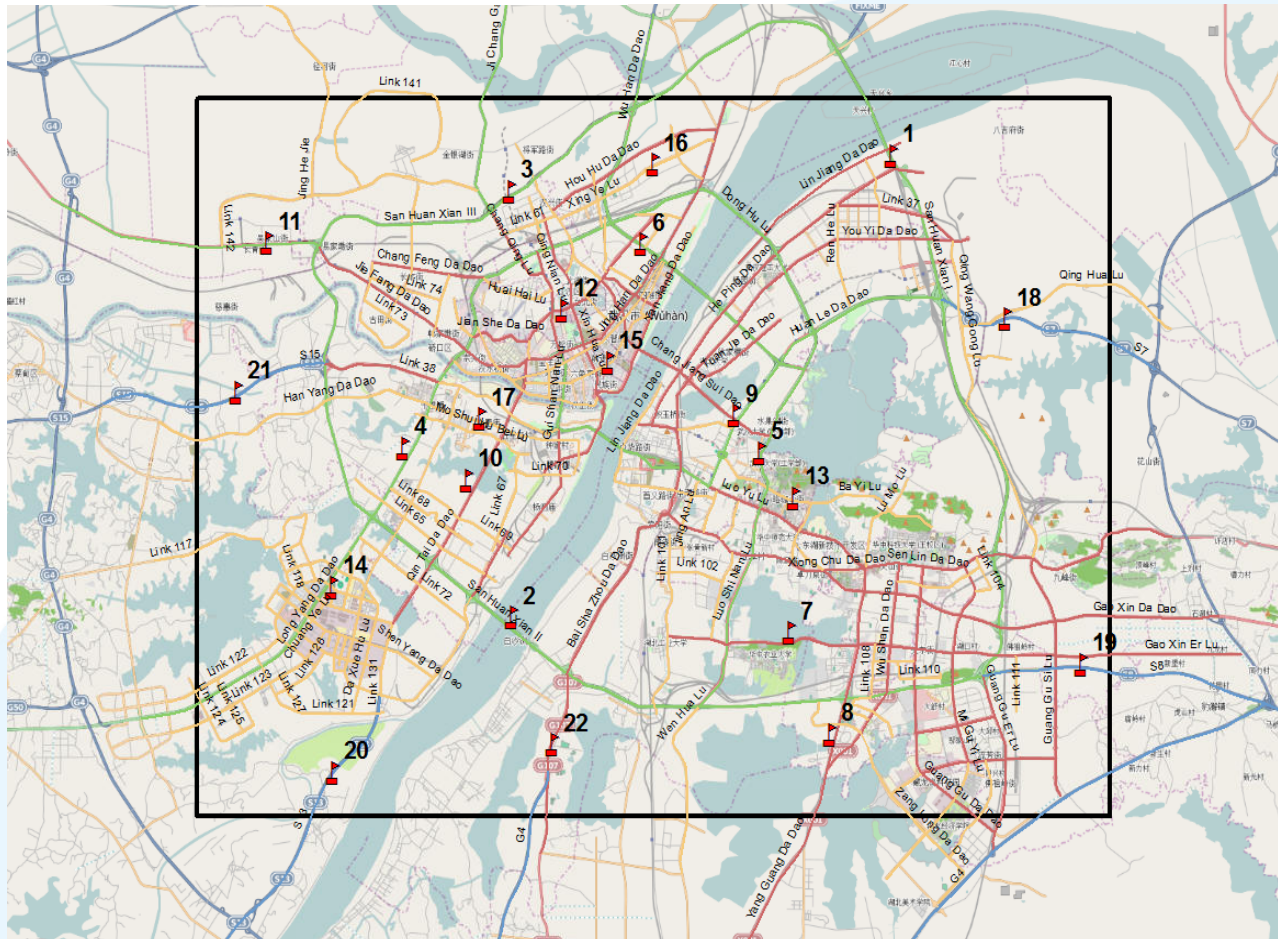
# Point Sources - Industry



- 53 stacks (9 key industries)

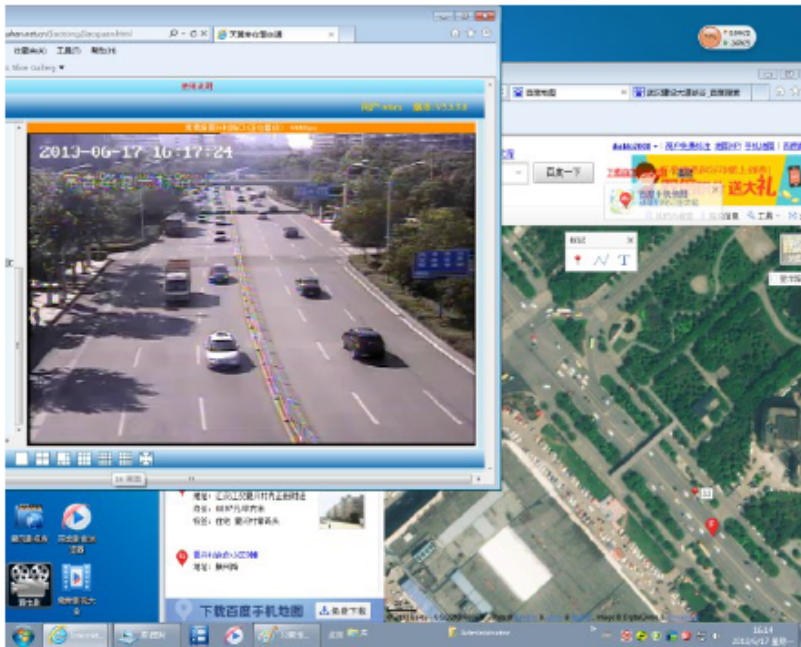


# Line Sources – Traffic

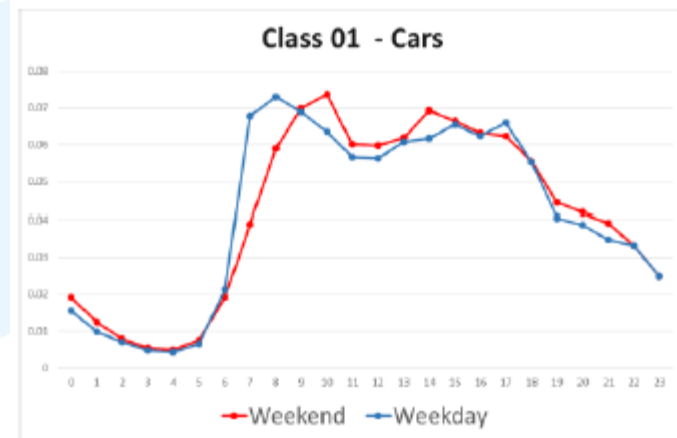


Emissions from traffic are calculated for 142 major roads in Wuhan, based on number of cars, type of cars, speeds, use of fuel, distribution of vehicles, emission factors for different vehicles etc..

# Line Sources – Traffic

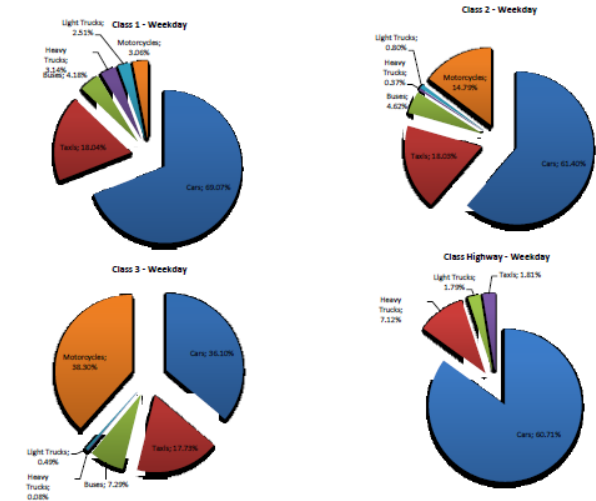


## Time Variation



Cars    Taxis    Buses    Heavy Trucks    Light Trucks    Motorcycles

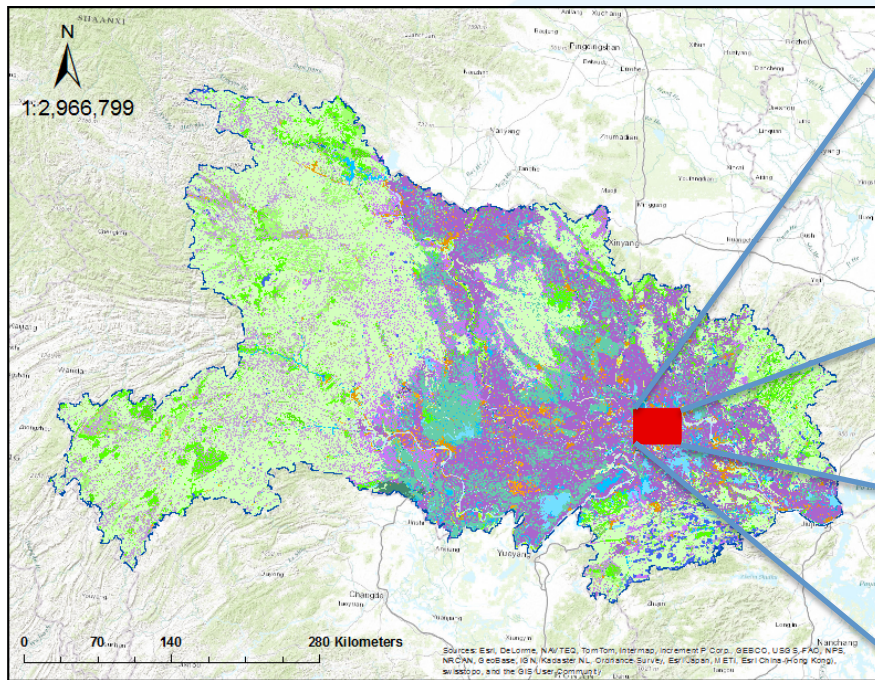
Traffic counting for different road class, vehicle class has been done for 22 selected roads.



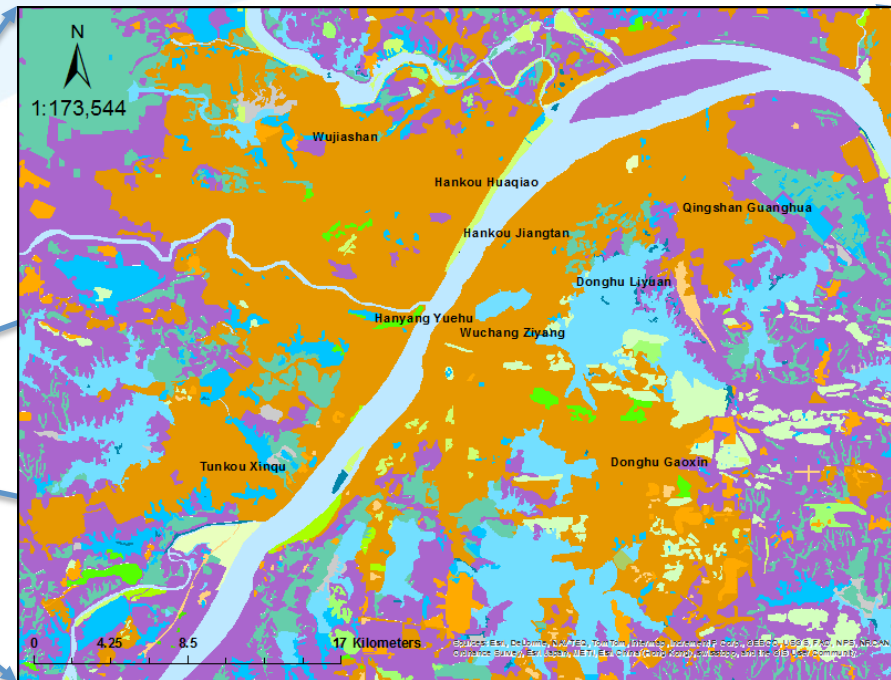
## Vehicle distribution

# Landuse Data

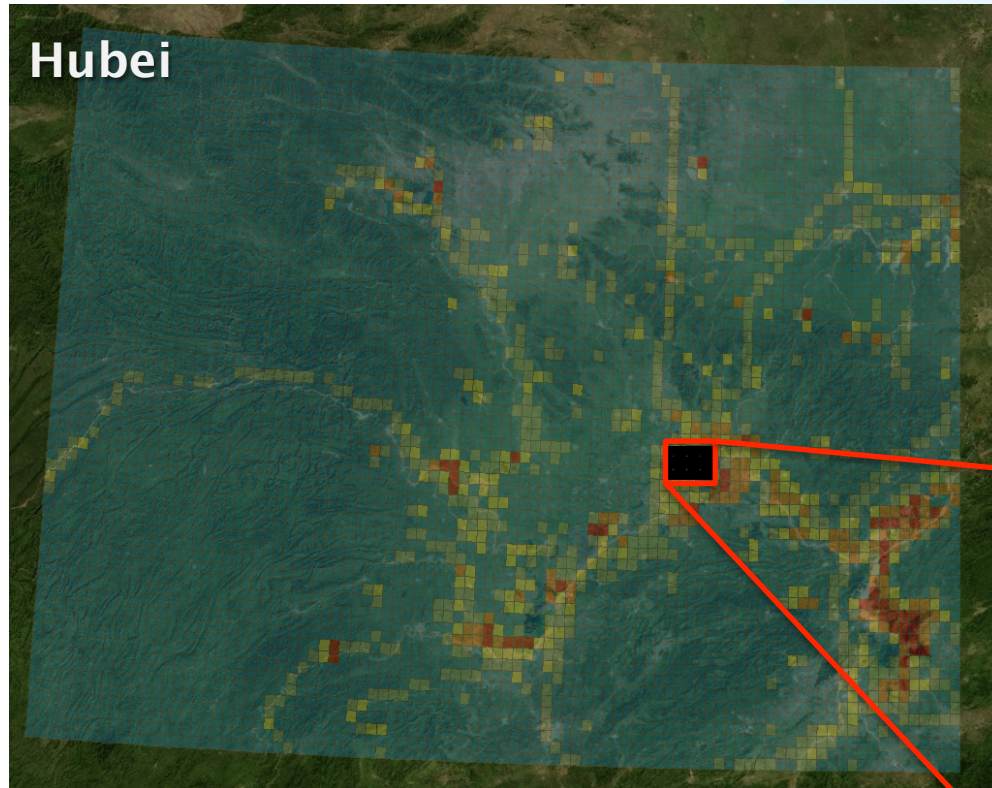
## HUBEI



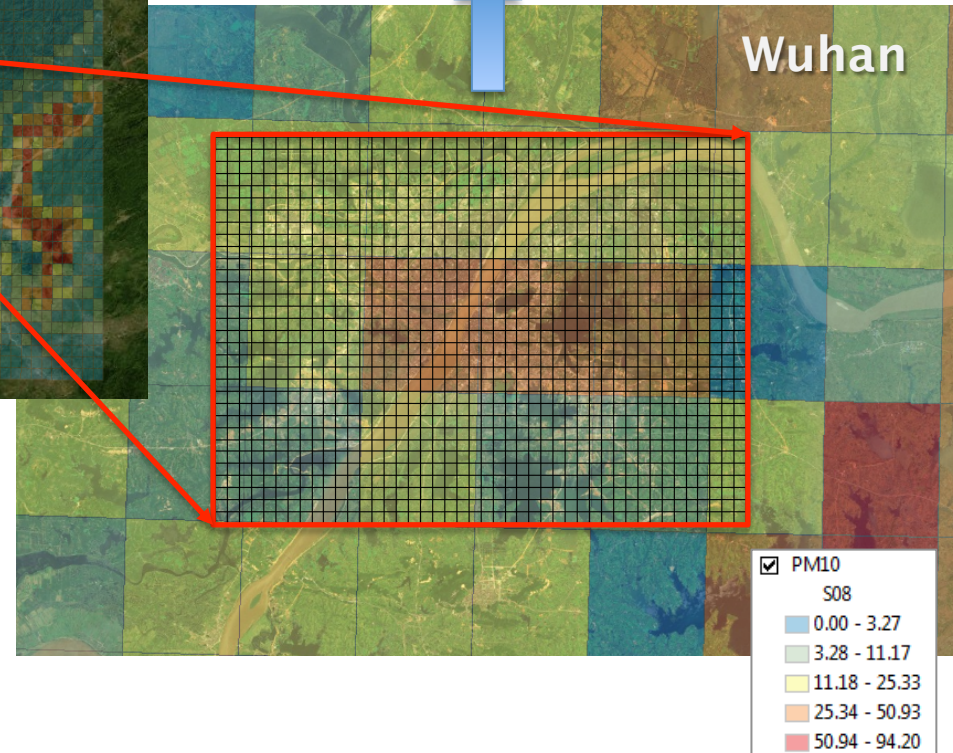
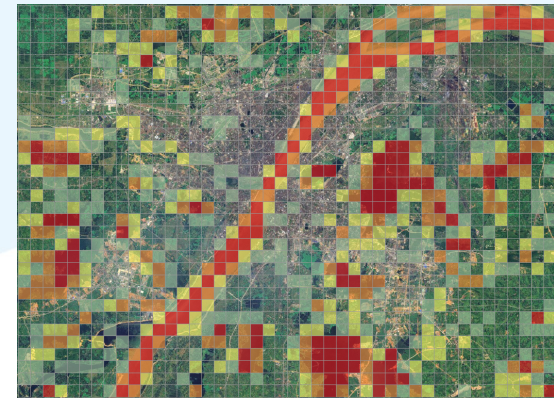
## WUHAN



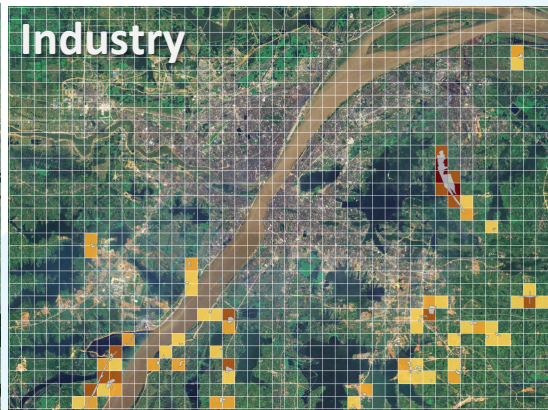
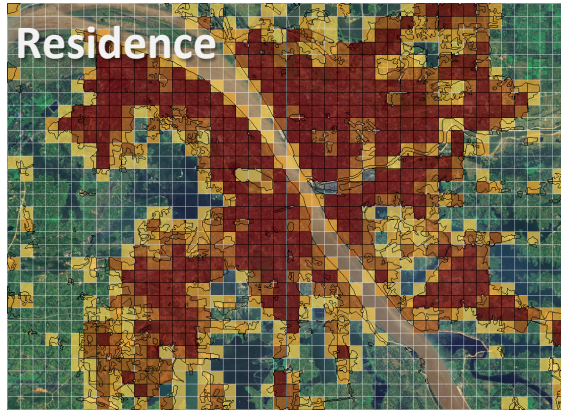
# An example: EDGAR ver 4.2 emission database



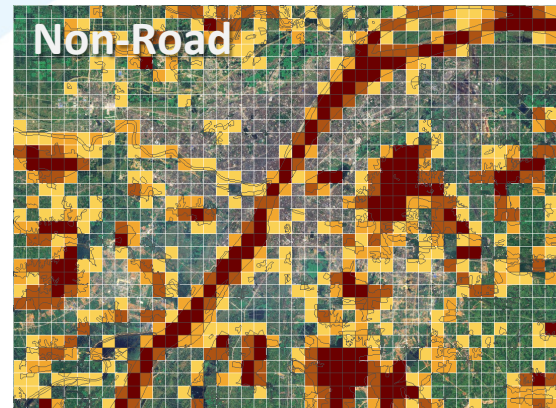
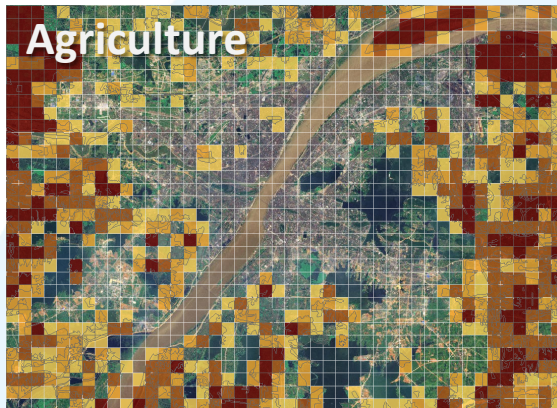
PM10 - S08: Non-Road



# Area weight distribution – Wuhan, China

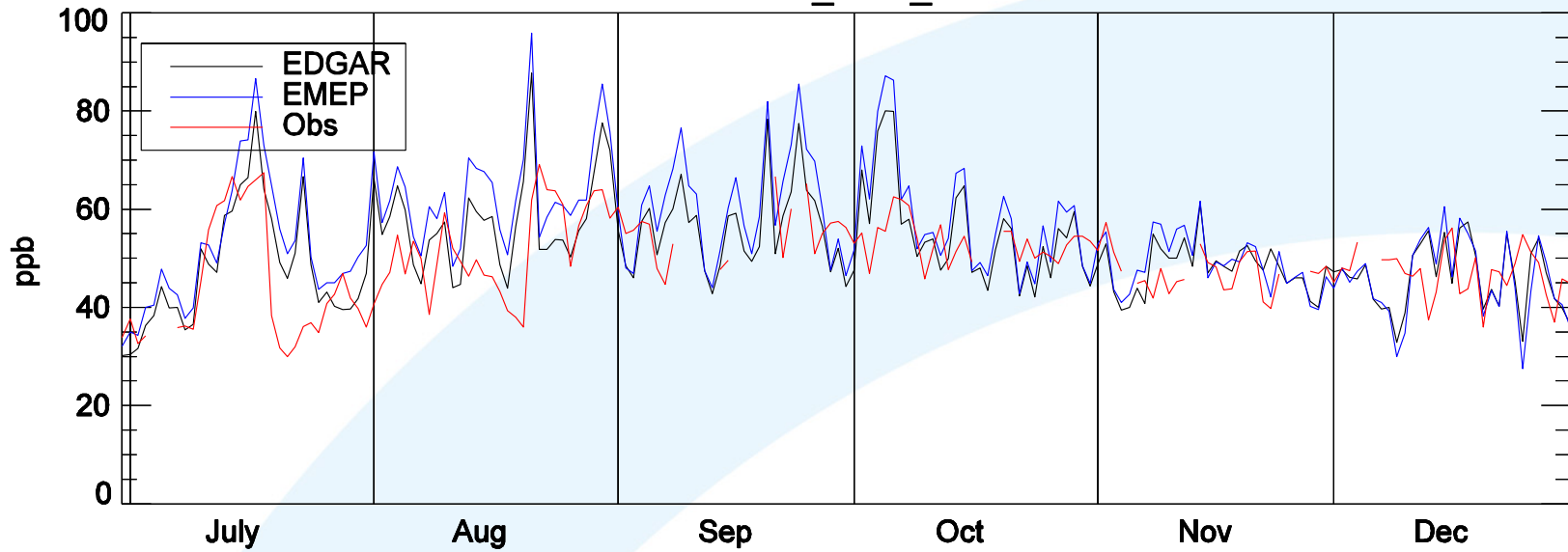


Downscaling

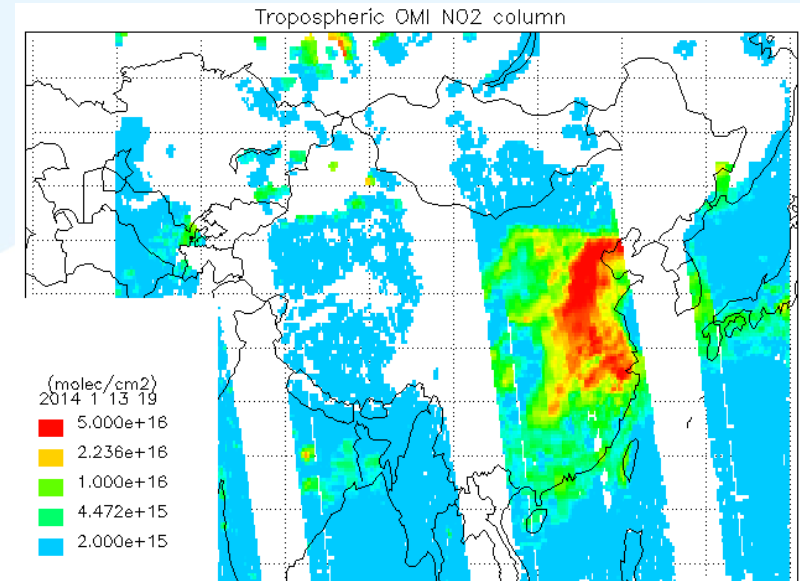
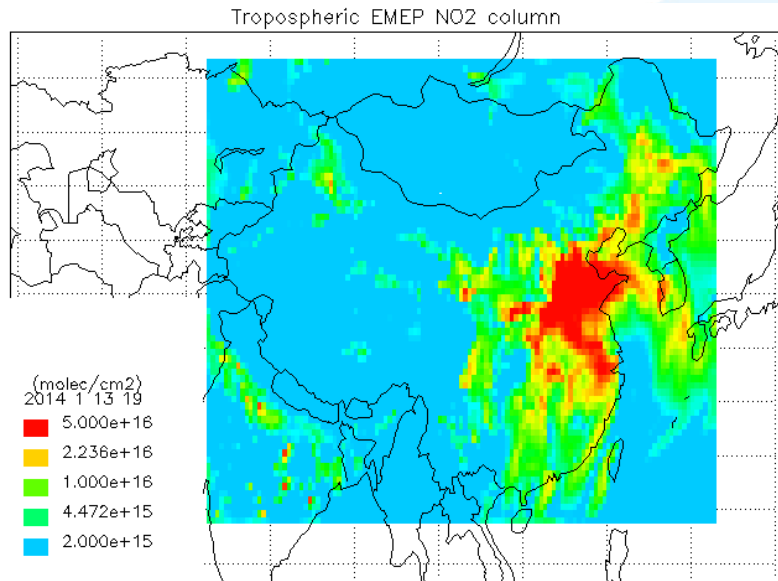


(tons/year)	Residence	Industry	Agriculture	Non-Road
NOx	1221.18	15766.13	133.88	3460.69
PM10	3345.68	39719.24	110.78	278.77
PM2.5	3082.22	20376.84	22.52	264.12
SOx	2766.10	3662349.86	0.93	1919.62

# SURF\_PPB\_O3



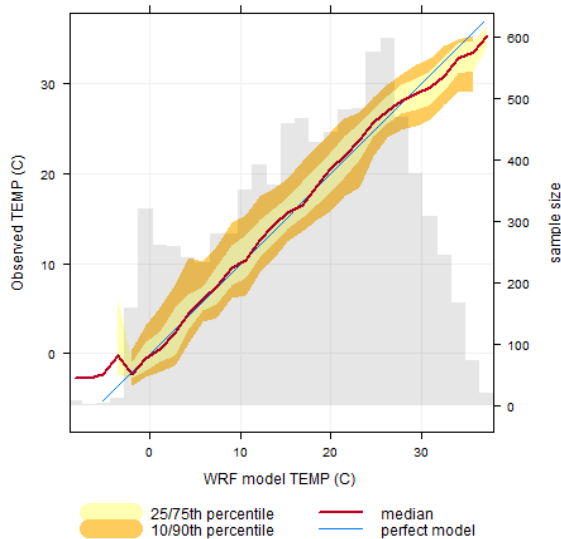
Time series of daily average O<sub>3</sub> from Shen Nong Jia in 2012: Observations (red curve) and WRF-EMEP model simulation with EDGAR emission (black curve) and EMEP global emission (blue curve)



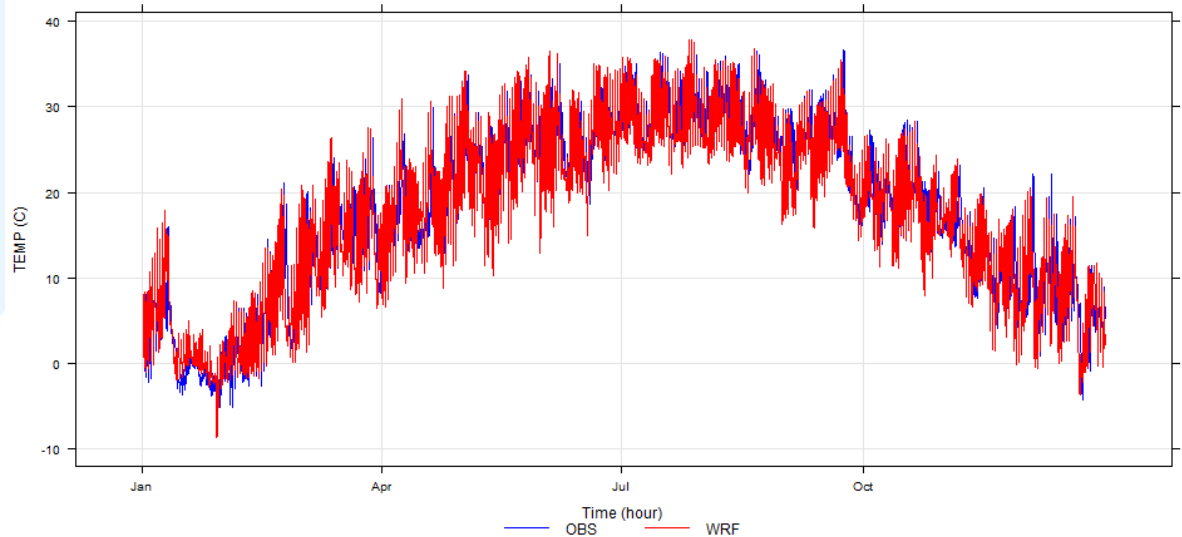
Tropospheric NO<sub>2</sub> column 13. January 2014 from WRF-EMEP (left panel) and OMI (right panel)

# WRF Model vs Observations

Conditional quantile TEMP at Wuhan 20080101-20081231 (hour)



Time series TEMP at Wuhan 20080101-20081231 (hour)



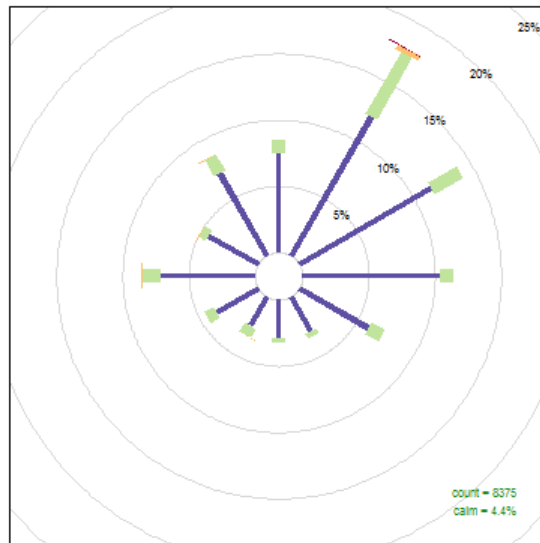
Temperature shows a good agreement between model and observations



# WRF Model vs Observations

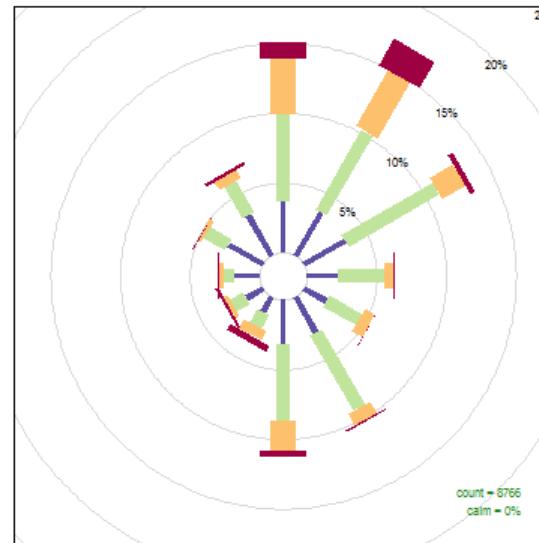
Location - MET station (before moving)

Wind rose obs. at Wuhan 20080101-20081231 (hour)



0-2 2-4 4-6 6-6.2  
Wind speed  
(m s<sup>-1</sup>)  
Frequency of counts by wind direction (%)

Wind rose WRF at Wuhan 20080101-20081231 (hour)



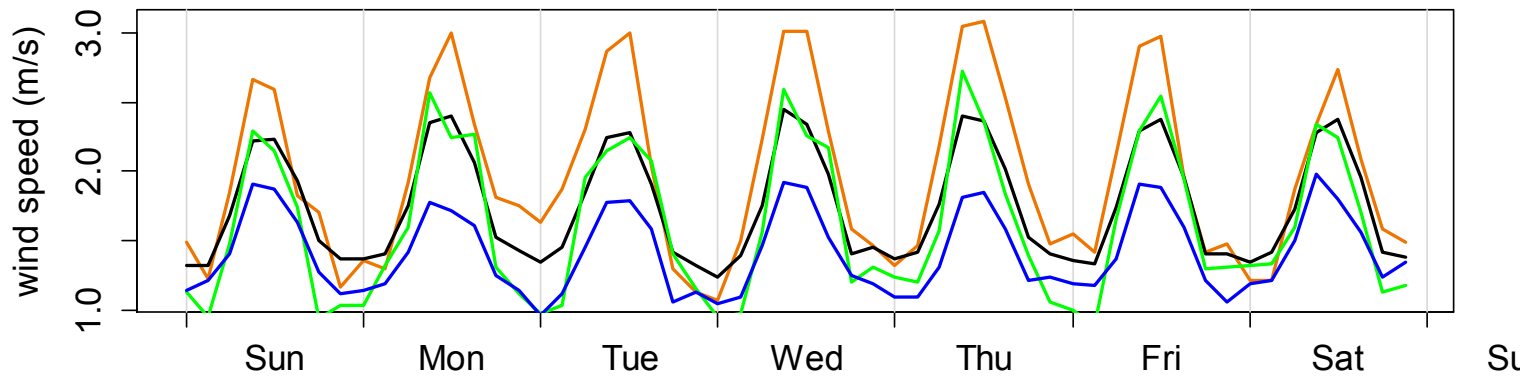
0-2 2-4 4-6 6-10.924  
Wind speed  
(m s<sup>-1</sup>)  
Frequency of counts by wind direction (%)

Wind Direction is in good agreement. Overestimation on % of N and S winds, and underestimation of W and E.

Wind Speed is overestimated in all the directions

# How representative are the years 2008, 2013 and 2014?

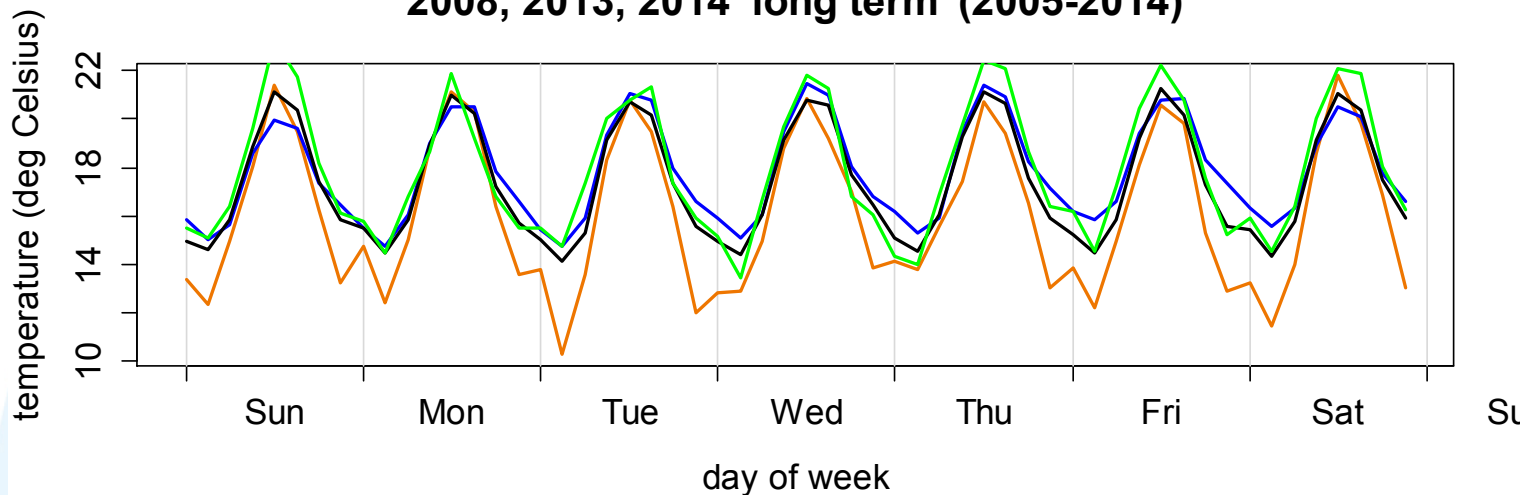
2008, 2013, 2014, 'long term' (2005-2014)



'long term' data series 2005 - 2014 MET station

2008  
2013  
2014

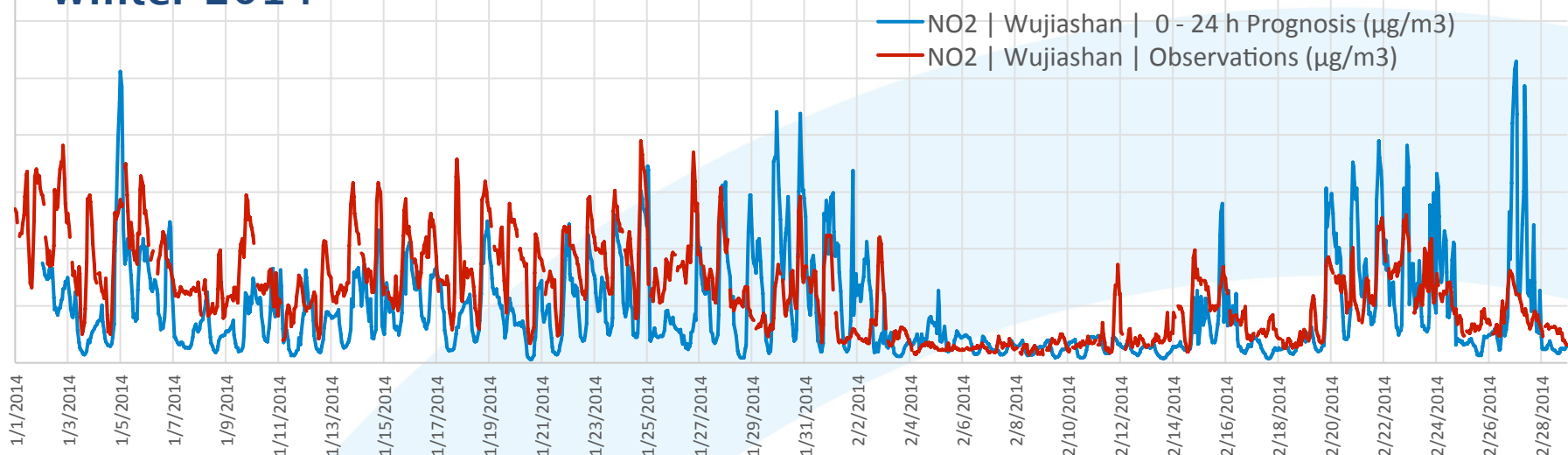
2008, 2013, 2014 'long term' (2005-2014)



day of week

# Winter 2014

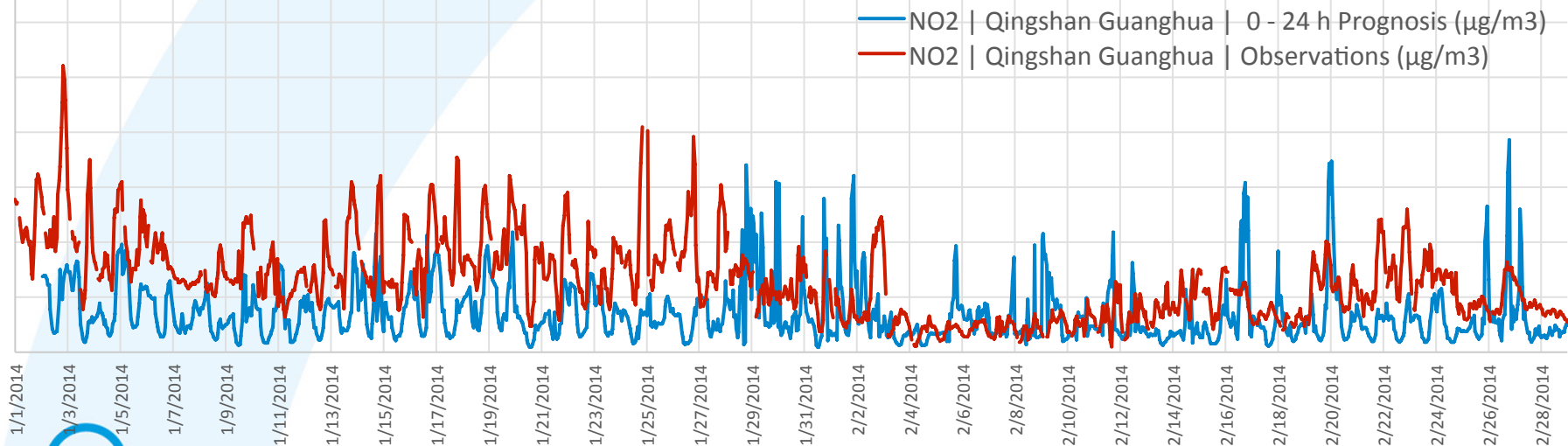
## NO<sub>2</sub> (µg/m<sup>3</sup>) Wujiashan Jan-Feb 2014



Wujiashan: much traffic

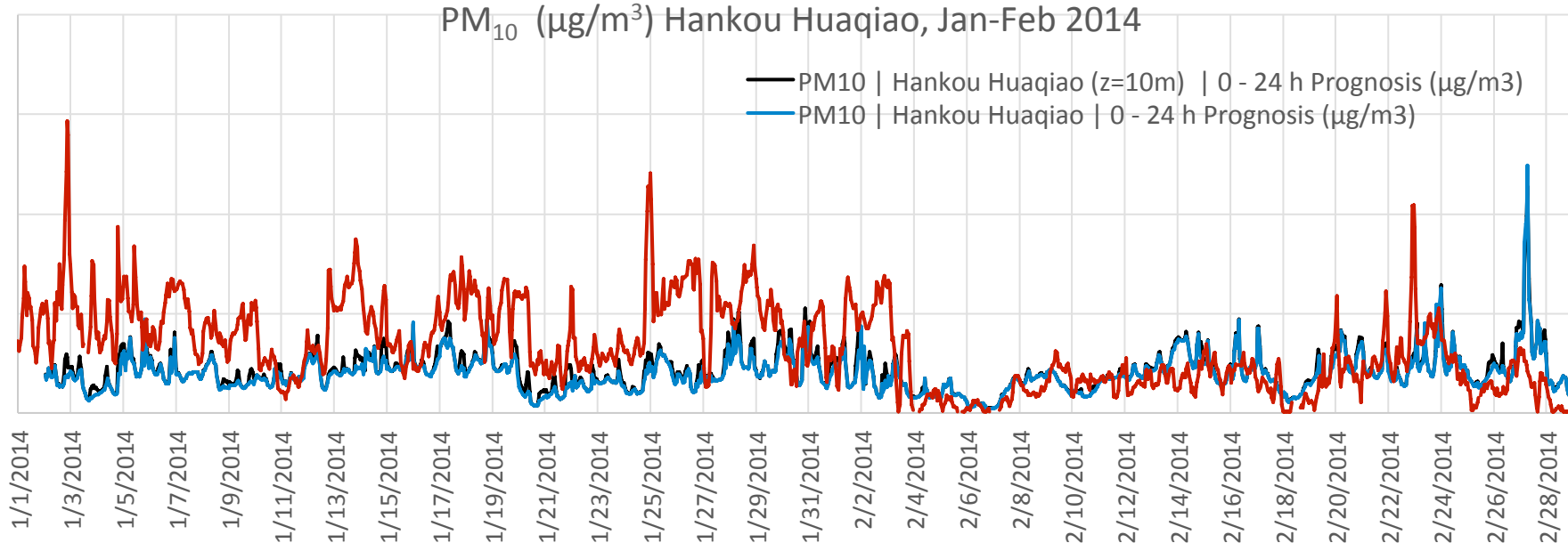
Qingshan Guanghua: less traffic

## NO<sub>2</sub> (µg/m<sup>3</sup>) Qingshan Guanghua



PM<sub>10</sub> (µg/m<sup>3</sup>) Hankou Huaqiao, Jan-Feb 2014

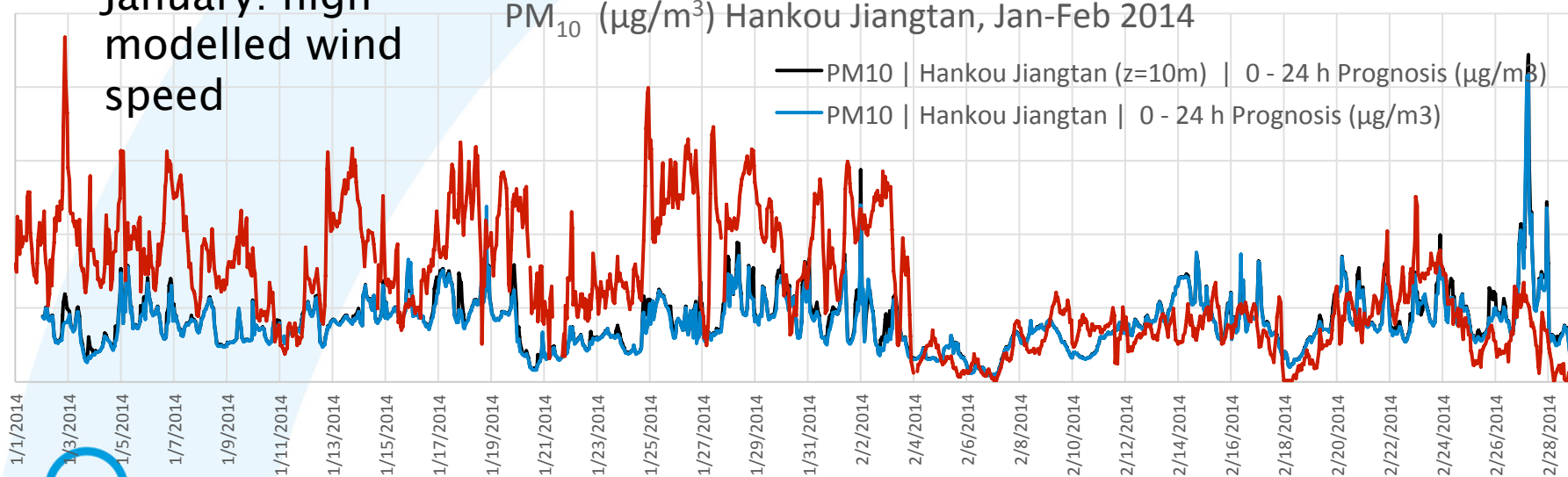
— PM10 | Hankou Huaqiao (z=10m) | 0 - 24 h Prognosis (µg/m<sup>3</sup>)  
— PM10 | Hankou Huaqiao | 0 - 24 h Prognosis (µg/m<sup>3</sup>)



January: high modelled wind speed

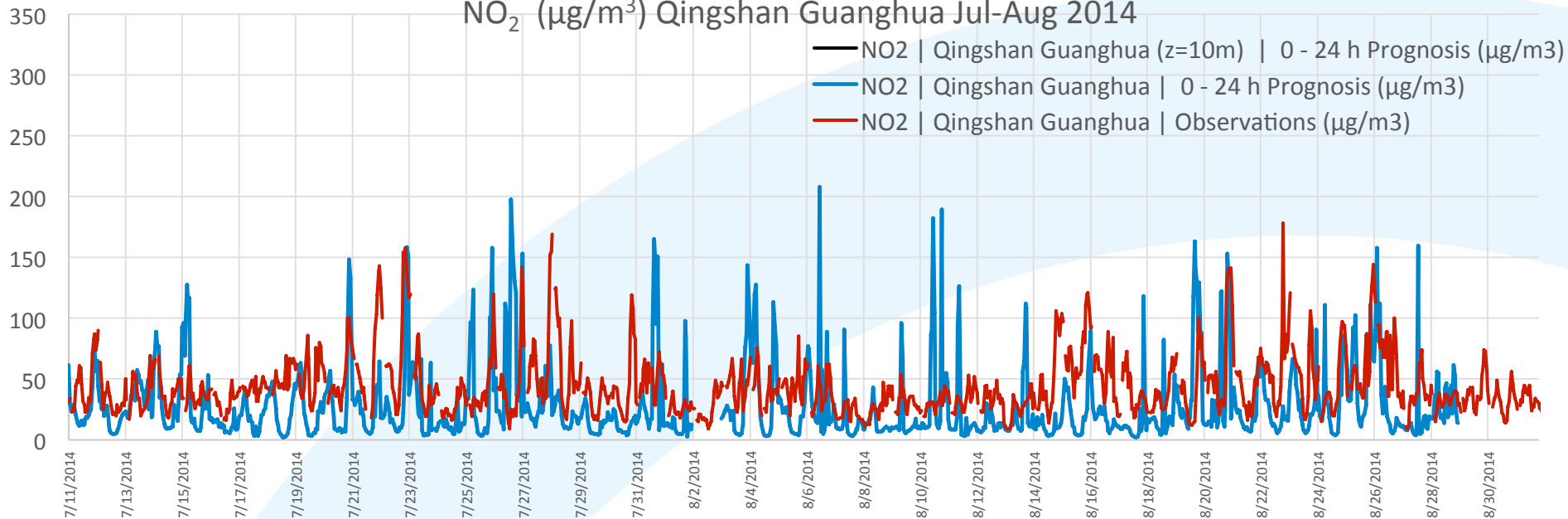
PM<sub>10</sub> (µg/m<sup>3</sup>) Hankou Jiangtan, Jan-Feb 2014

— PM10 | Hankou Jiangtan (z=10m) | 0 - 24 h Prognosis (µg/m<sup>3</sup>)  
— PM10 | Hankou Jiangtan | 0 - 24 h Prognosis (µg/m<sup>3</sup>)

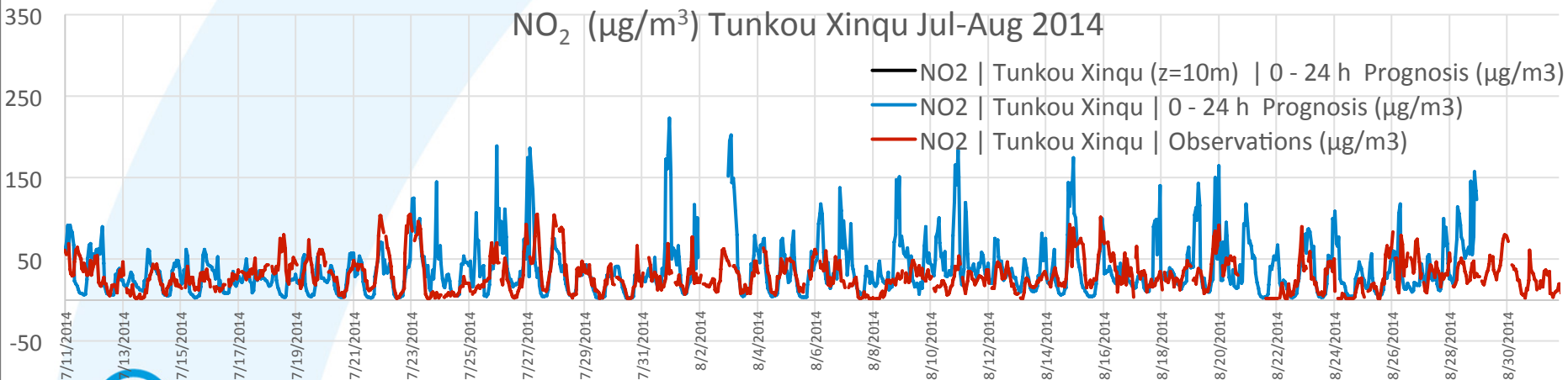


# Summer 2014

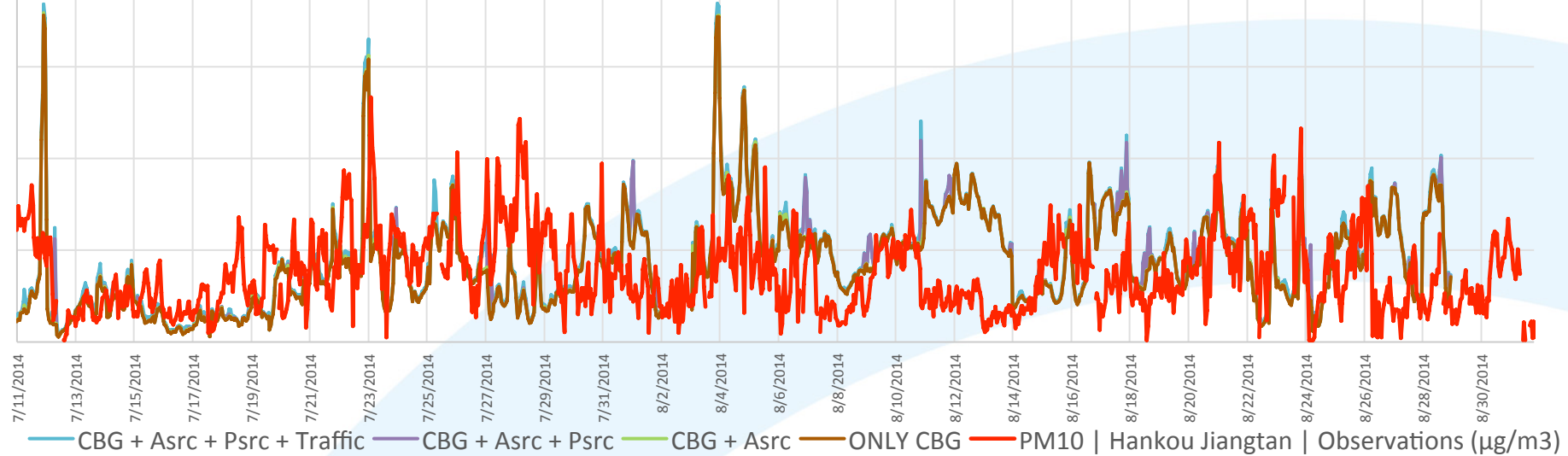
## NO<sub>2</sub> (µg/m<sup>3</sup>) Qingshan Guanghua Jul-Aug 2014



## NO<sub>2</sub> (µg/m<sup>3</sup>) Tunkou Xinqu Jul-Aug 2014

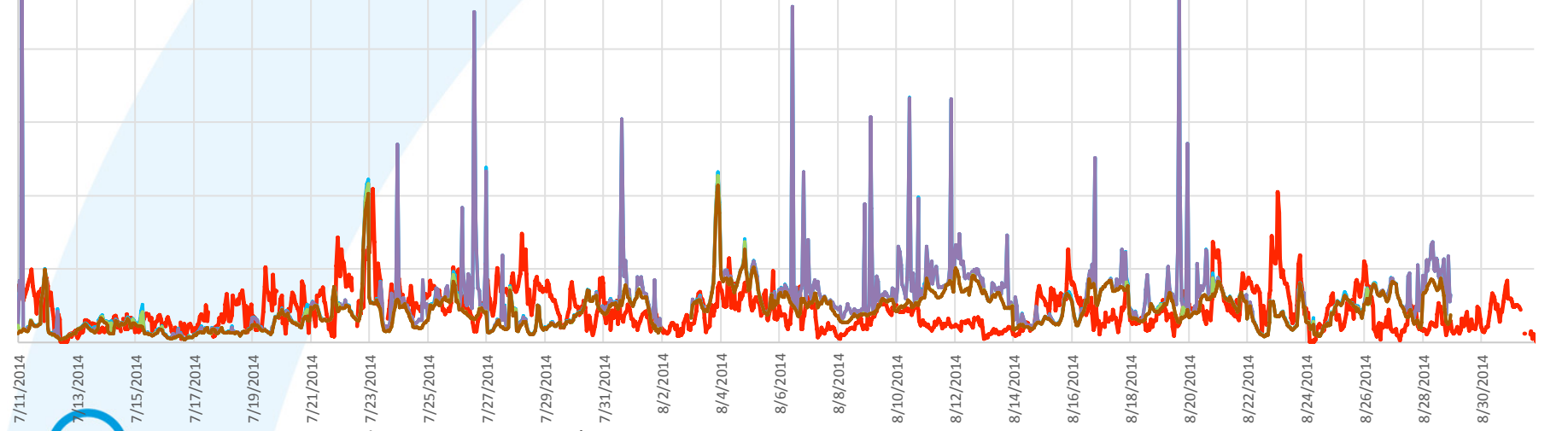


### PM10 ( $\mu\text{g}/\text{m}^3$ ) Hankou Jiangtan Jul-Aug 2014



— CBG + Asrc + Psrc + Traffic — CBG + Asrc + Psrc — CBG + Asrc — ONLY CBG — PM10 | Hankou Jiangtan | Observations ( $\mu\text{g}/\text{m}^3$ )

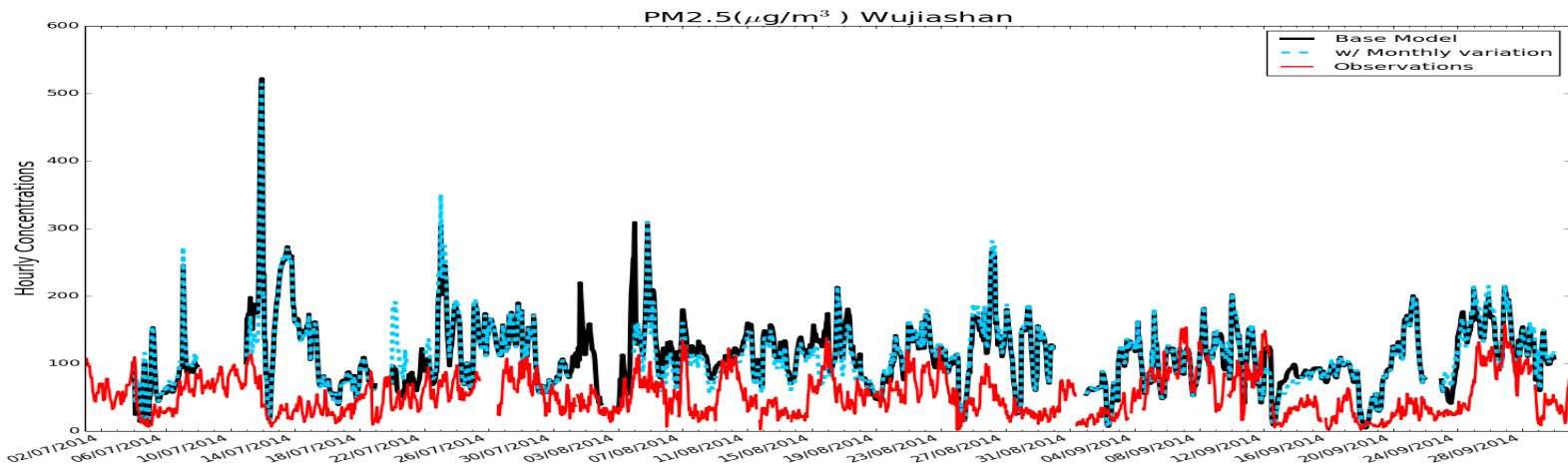
### PM10 ( $\mu\text{g}/\text{m}^3$ ) Qingshan Guanghua Jul-Aug 2014



— PM10 | Qingshan Guanghua | Observations ( $\mu\text{g}/\text{m}^3$ ) — CBG + Asrc + Psrc + Traffic — CBG + Asrc + Psrc — CBG + Asrc — ONLY CBG

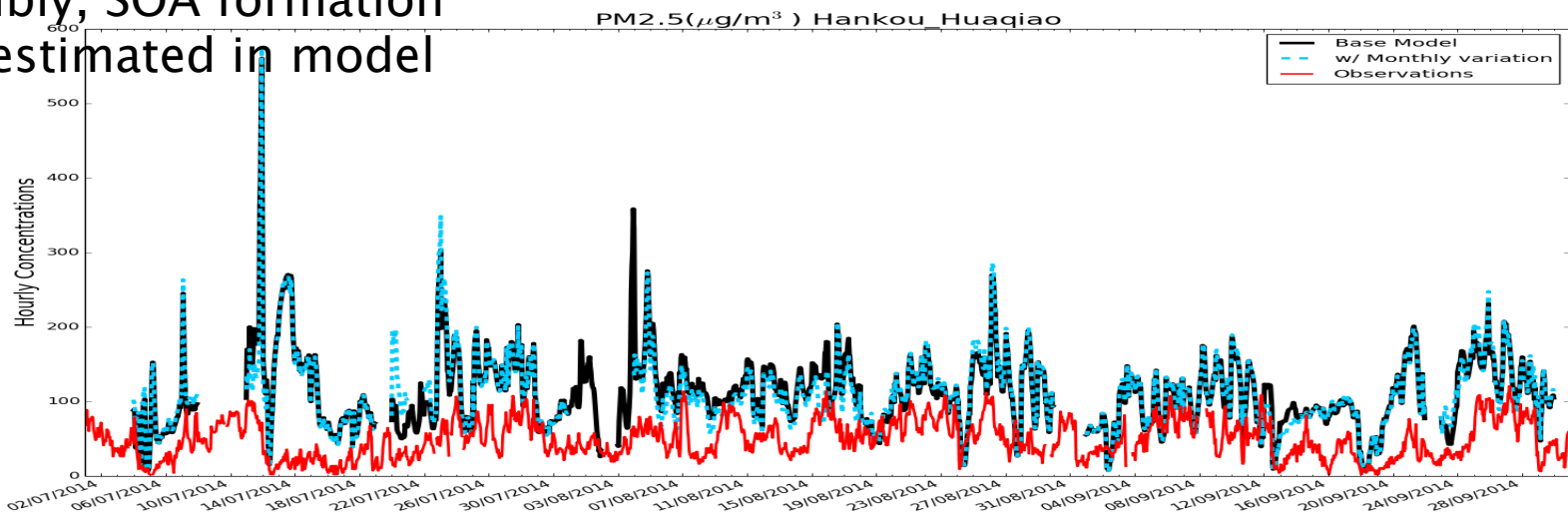


# PM2.5, Wujiashan, Jul-Sep 2014



Overestimation of PM2.5 concentration.  
Possibly, SOA formation overestimated in model

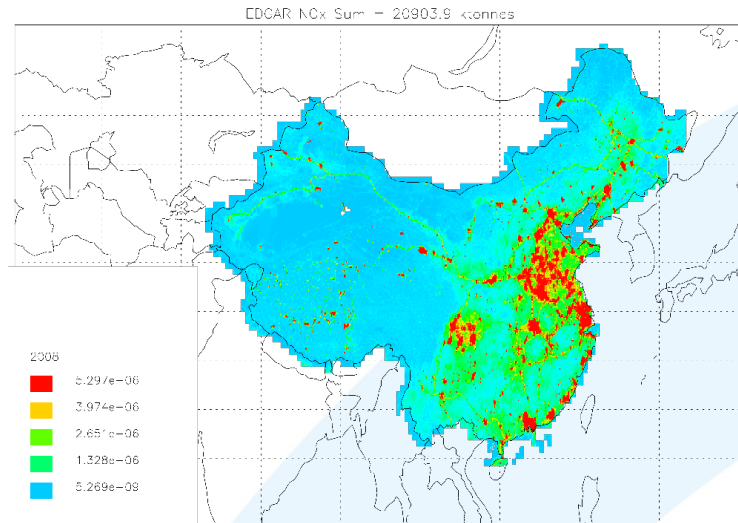
# PM2.5, Hankou Huangqiao, Jul-Sep 2014



- Test and set optimal WRF parameters for China
- Improve both regional and local emission inventories
- Less experience in running the EMEP model outside Europe:
  - Biogenic VOC emission: other vegetation species than in Europe
  - Wind blown dust: requires detailed knowledge about the soil
  - Point source in EMEP model
- Needs for improvement of AQ forecasting system (input/output, structure, emission modules, result presentations etc. )
- Different infrastructures in China



# Project: Multi-pollutant Control, China

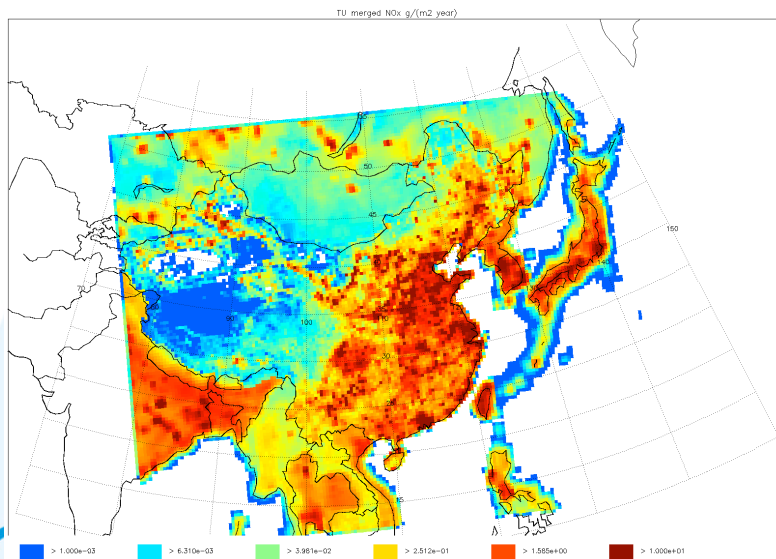


EMEP global (year?)

Lat/lon,  $0.5^\circ \times 0.5^\circ$ , annual totals for each of 10 source sectors, NO<sub>x</sub>, SO<sub>x</sub>, NMVOC, PM<sub>2.5</sub>, PM<sub>10</sub>, ...

EDGAR (2008)

Lat/lon,  $0.1^\circ \times 0.1^\circ$ , annual totals for each of 10 source sectors, NO<sub>x</sub>, SO<sub>x</sub>, NMVOC, PM<sub>10</sub>, ...



Tsinghua data for 2012, 36 km x 36 km, Lambert conformal proj.

daily files with hourly emission data for NO, NO<sub>2</sub>, SO<sub>2</sub>, sulfate, and a number of separate NMVOCs (XYL, IOLE, ETOH ...etc)

# Prognosis data

Forecasting Visualization | Prognosis | Model evaluation

Area: Hubei | MapQuest

15.11. 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08  
16.11. 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08

Source: EMEP

Parameters: N02

Type: Field

Meteorology: None

Start

Forecasting AQI

Current hour  
93 - PM2.5 (Good)

Next hour  
93 - PM2.5 (Good)

Today  
82 - PM2.5 (Good)

AQI	Level
0-50	Excellent
51-100	Good
101-150	Lightly Polluted
151-200	Moderately Polluted
201-300	Heavily Polluted
300+	Severely Polluted

Source: EPISODE  
EPISODE  
EMEP

Parameters: N02  
N02  
PM2.5  
PM10  
Temperature

Type: Field  
Field  
Receptor  
Line

Meteorology: None  
None  
Wind

# Prognosis data

- Forecasting Visualization
- Prognosis
- Model evaluation

Area

Hubei MapQuest

15.11. 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07  
16.11. 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07

Source:

EMEP

Parameters:

NO2

Type:

Field

Meteorology:

None

Start

Forecasting AQI

Current hour

93 - PM2.5 (Good)

Next hour

93 - PM2.5 (Good)

Today

82 - PM2.5 (Good)

AQI	Level
0-50	Excellent
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## Forecasting AQI

Current hour

93 - PM2.5 (Good)

Next hour

93 - PM2.5 (Good)

Today

82 - PM2.5 (Good)

AQI

Level

0-50

Excellent

51-100

Good

101-150

Lightly Polluted

151-200

Moderately Polluted

201-300

Heavily Polluted

300+

Severely Polluted

-19 19-20 20-21 21-22 22-23 23-24  
-19 19-20 20-21 21-22 22-23 23-24



# Prognosis data

- Forecasting Visualization
- Prognosis
- Model evaluation

Area

Hubei MapQuest

- 15.11 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20 20-21 21-22 22-23 23-24
- 16.11 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20 20-21 21-22 22-23 23-24

Source:

EMEP

Parameters:

PM2.5

Type:

Field

Meteorology:

None

Stop Resume

Forecasting AQI

Current hour

94 - PM2.5 (Good)

Next hour

94 - PM2.5 (Good)

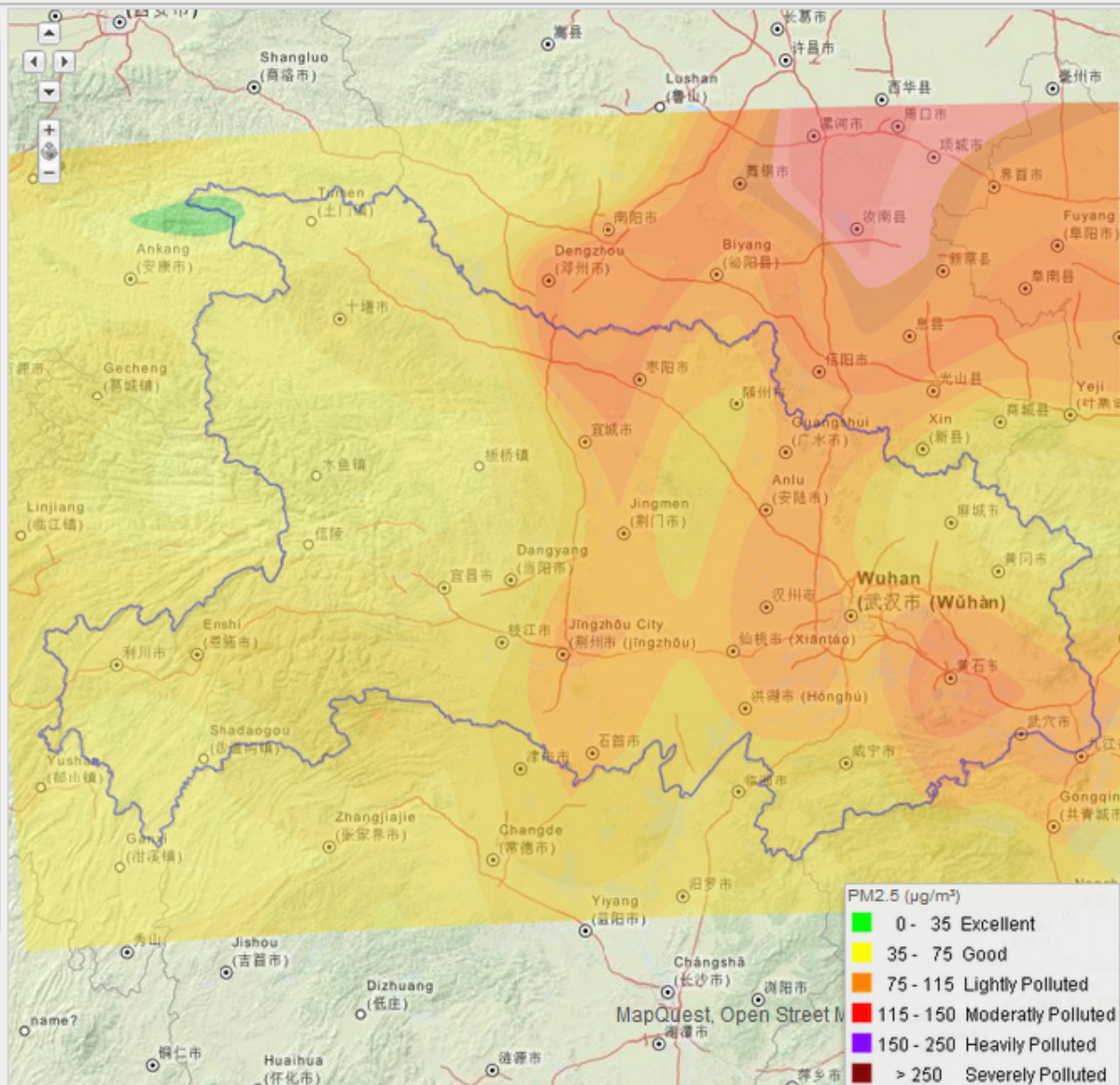
Today

82 - PM2.5 (Good)

AQI

Level

0-50	Excellent
51-100	Good
101-150	Lightly Polluted
151-200	Moderately Polluted
201-300	Heavily Polluted
300+	Severely Polluted



PM2.5 (µg/m³)

0 - 35	Excellent
35 - 75	Good
75 - 115	Lightly Polluted
115 - 150	Moderately Polluted
150 - 250	Heavily Polluted
> 250	Severely Polluted

# Prognosis data

Forecasting Visualization Prognosis Model evaluation

Area

Wuhan Open Street Map

15-11 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 **18-19** 19-20 20-21 21-22 22-23 23-24  
 16-11 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20 20-21 21-22 22-23 23-24

Source:

EPISODE

Parameters:

NO2

Type:

Field

Meteorology:

None

Stop

Resume

Forecasting AQI

Current hour

93 - PM2.5 (Good)

Next hour

93 - PM2.5 (Good)

Today

82 - PM2.5 (Good)

AQI Level

0-50 Excellent

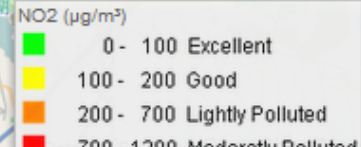
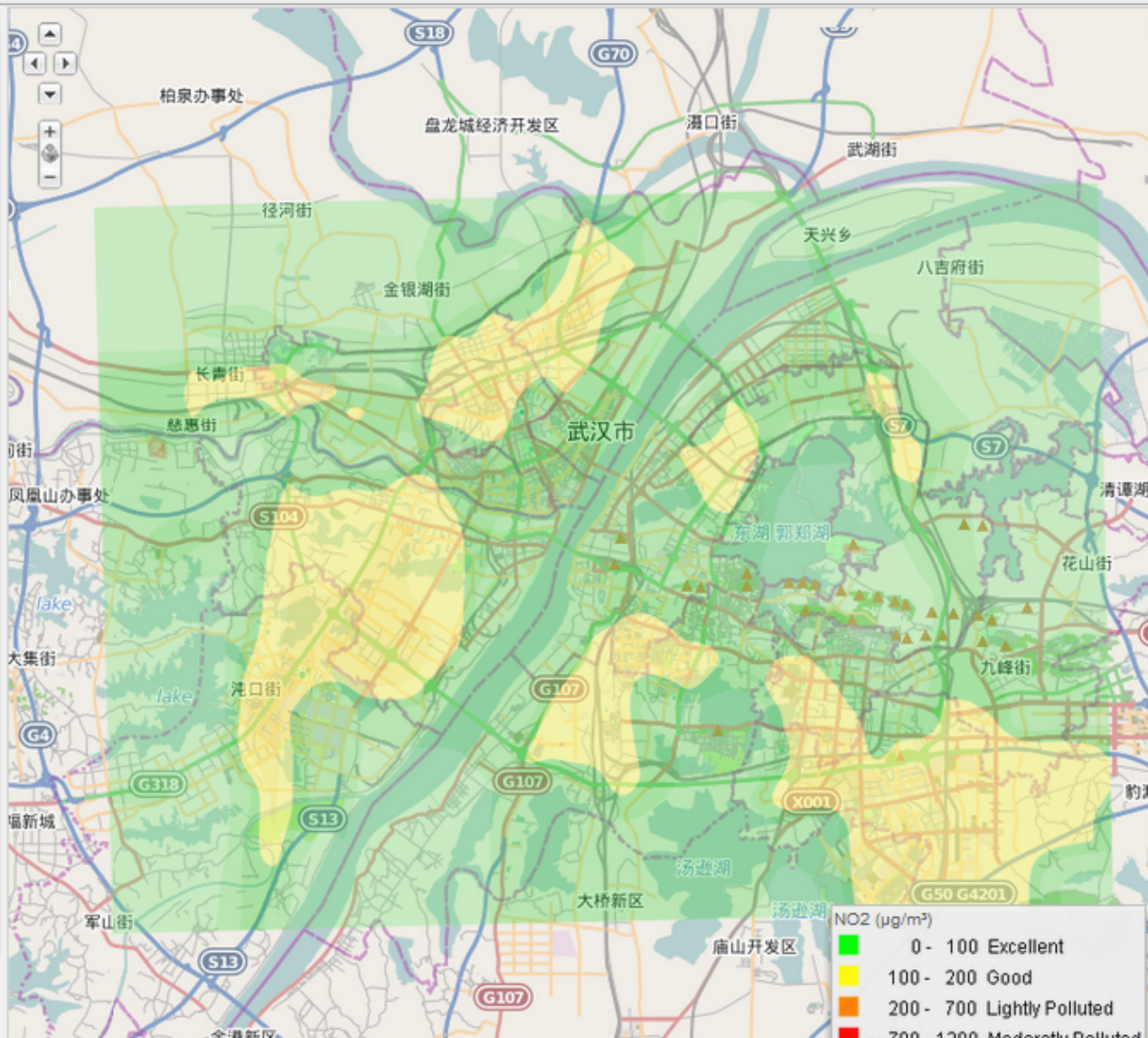
51-100 Good

101-150 Lightly Polluted

151-200 Moderatly Polluted

201-300 Heavily Polluted

300+ Severely Polluted



## Prognosis data

### Forecasting Visualization

Area

Wuhan

15.11. 00-01 01-02 02-03 0

16.11. 00-01 01-02 02-03 0

Source:

EPISODE

Parameters:

NO2

Type:

Receptor

Meteorology:

None

Stop

Resume

### Forecasting AQI

Current hour

94 - PM2.5 (Good)

Next hour

94 - PM2.5 (Good)

Today

82 - PM2.5 (Good)

### Forecasting Visualization

### Prognosis

### Model evaluation

Area

Wuhan

Open Street Map

16.11. 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20 20-21 21-22 22-23 23-24

17.11. 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20 20-21 21-22 22-23 23-24

Source:

EPISODE

Parameters:

PM2.5

Type:

Receptor

Meteorology:

None

Stop

Resume

### Forecasting AQI

Current hour

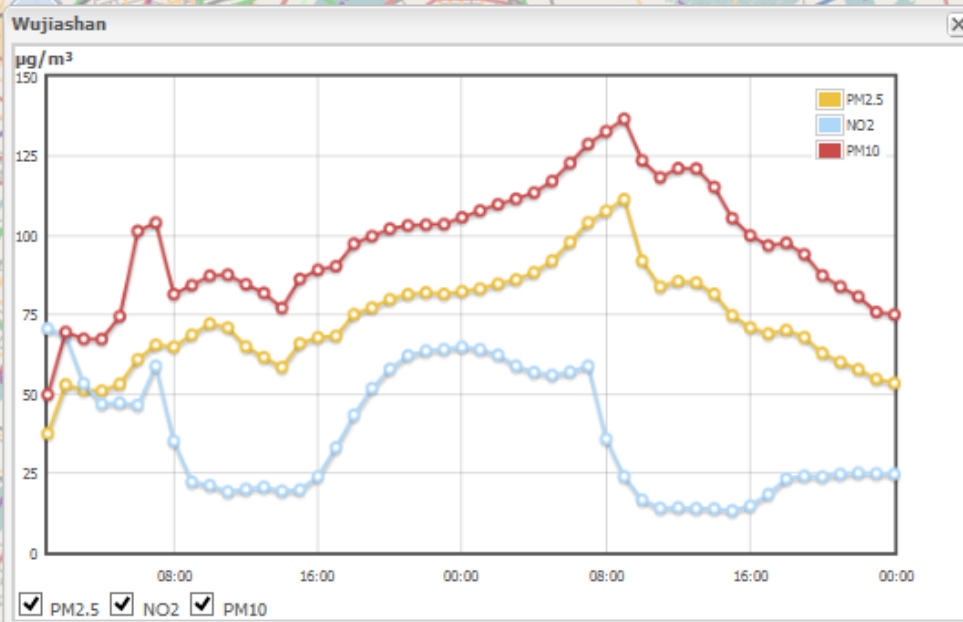
0 - null (Excellent)

Next hour

0 - null (Excellent)

Today

106 - PM2.5 (Lightly Polluted)



PM2.5  NO2  PM10

庙山开发区

0...35

35...75

75...115

115...150

Prognosis data

Prognosis data

Forecasting Visualization   Prognosis   Model evaluation

Area  
 Wuhan   Open Street Map

16.11.	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
17.11.	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24

Source: EPISODE

Parameters: PM2.5

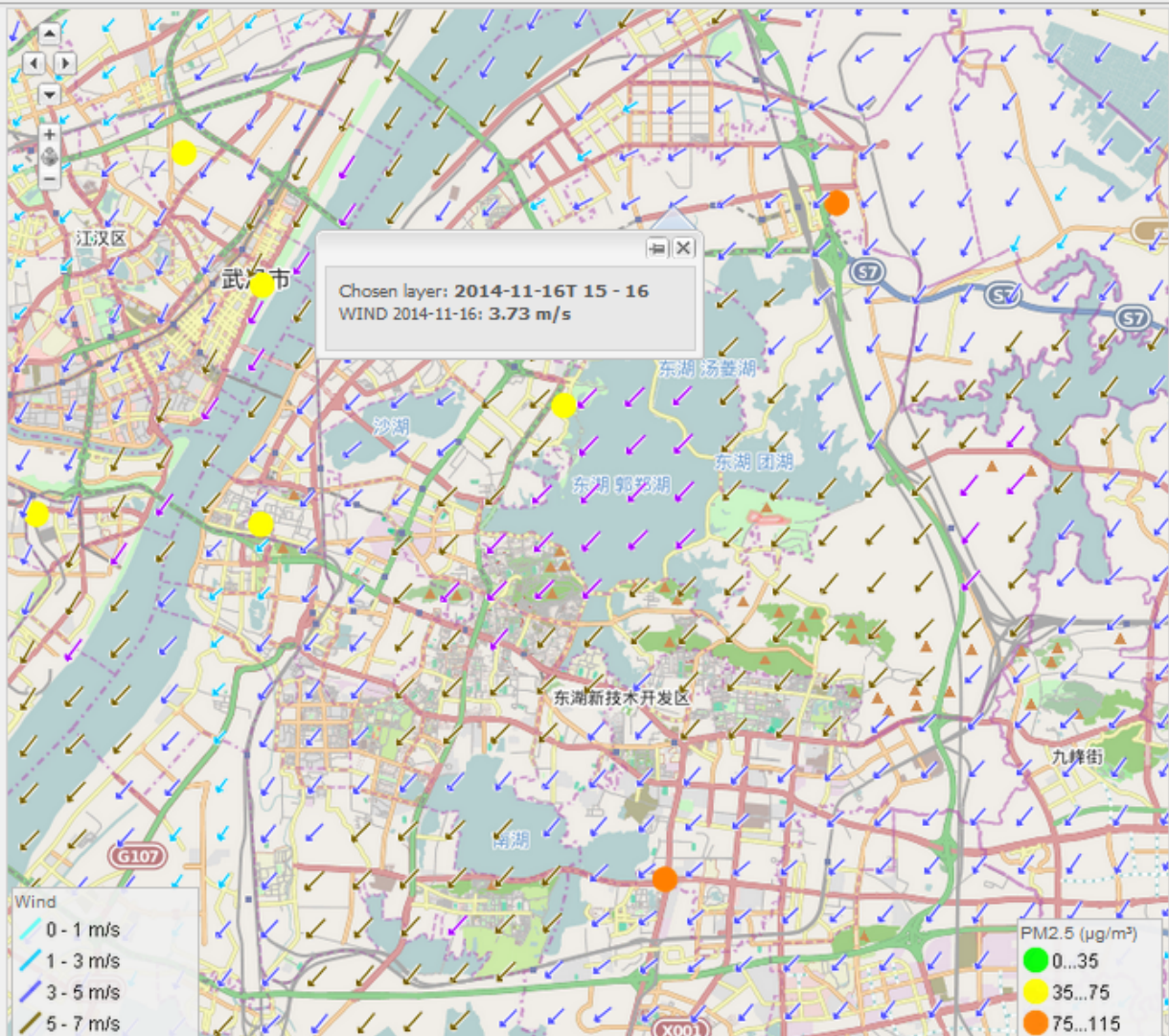
Type: Receptor

Meteorology: Wind

Stop   Resume

Forecasting AQI

Current hour	0 - null
Next hour	0 - null (Excellent)
Next hour	0 - null
Today	0 - null (Excellent)
Today	106 - PM2.5 (Lightly Polluted)



Area: Wuhan

16.11.   17.11.

Source: EPISODE

Param: PM2.5

Type: Receptor

Meteor: Wind

Stop

Forecasting AQI

Current hour: 0 - null

Next hour: 0 - null

Today: 106 -

## View time values

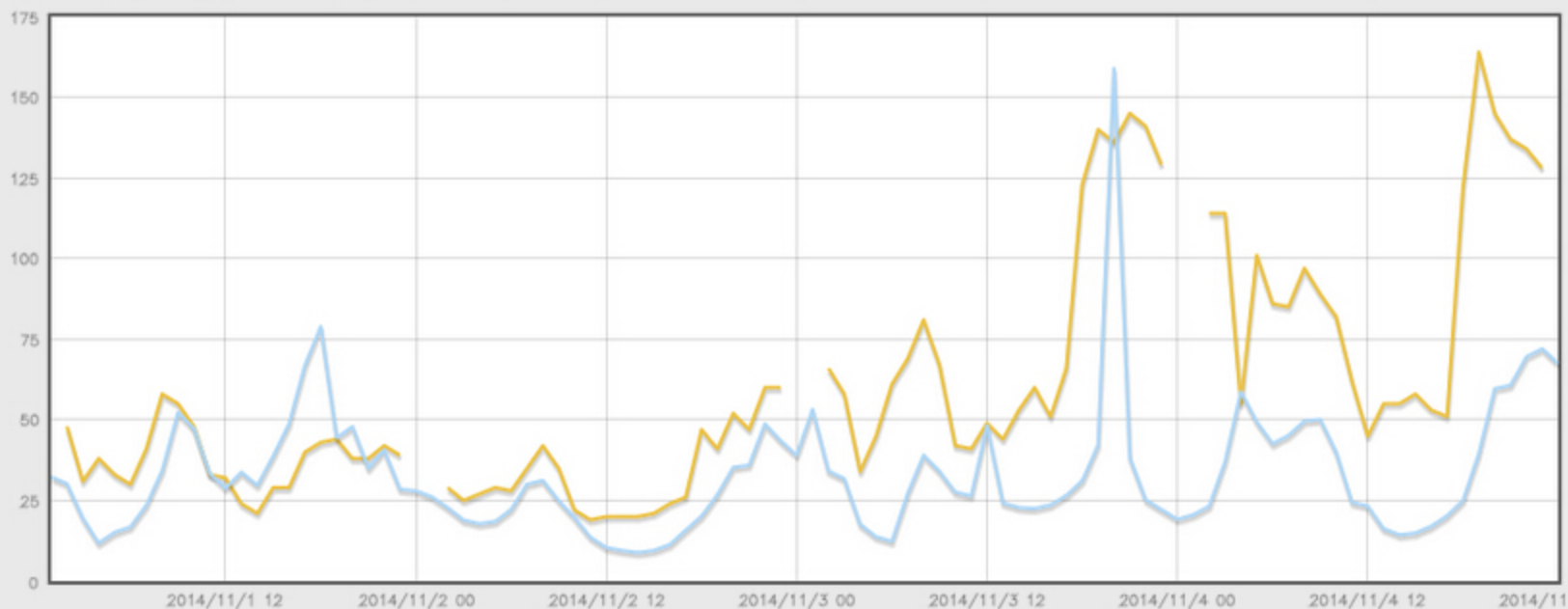
Forecasting Visualization

Prognosis

Model evaluation

Hanyang Yuehu | NOx

Hanyang Yuehu - Model | NO2



Edit selection

Export: 

Station	Component	Date	Value	Coverage
Hanyang Yuehu	NOx	01/11/2014 01:00	-9900.00	0
Hanyang Yuehu	NOx	01/11/2014 02:00	48.00	100
Hanyang Yuehu	NOx	01/11/2014 03:00	31.00	100
Hanyang Yuehu	NOx	01/11/2014 04:00	38.00	100
Hanyang Yuehu	NOx	01/11/2014 05:00	33.00	100
Hanyang Yuehu	NOx	01/11/2014 06:00	20.00	100



# THANKS!

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