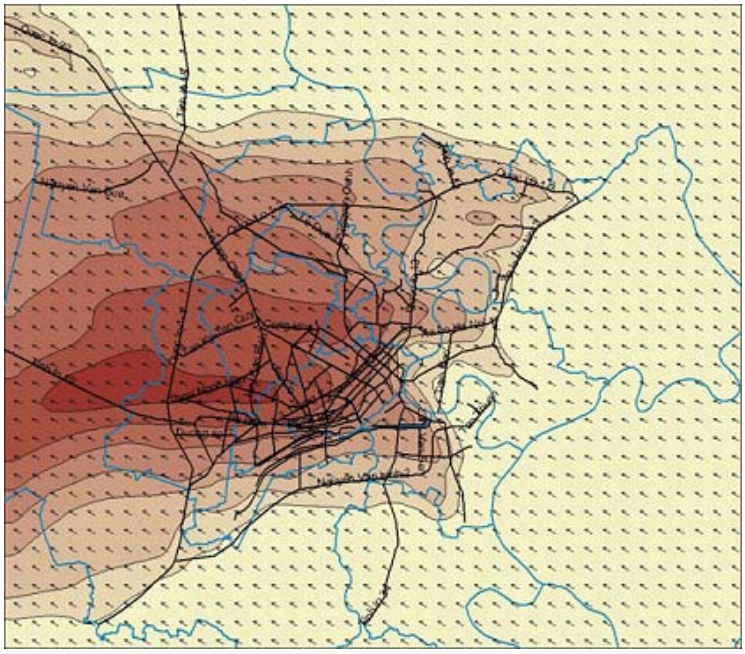
NILU: F 76/2006

NILU: F 76/2006
REFERENCE: Q-303
DATE: December 2006

Modelling air quality in Ho Chi Minh City, Vietnam

Presented at Better Air Quality Conference
Yogiakarta, Indonesia
12-15 December 2006

Bjarne Sivertsen and Vo Thanh Dam



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Modelling air quality in Ho Chi Minh City, Vietnam

Bjarne Sivertsen * and Vo Thanh Dam**
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Abstract:

The Ho Chi Minh City Environmental Protection Agency (HEPA) under DONRE is operating an air quality monitoring and assessment system in Ho Chi Minh City (HCMC). Air pollution dispersion models have been installed as part of the GIS based database and planning tool. This system is based on the NILU developed AirQUIS system.

Air pollution dispersion models have been operated and tested for application in HCMC. Templates and routines for emission inventories have been used to collect emission data and the first model estimated have been presented. Concentration estimates will also be used to evaluate different source's relative importance to the total exposure, impact assessment and to perform optimal abatement planning.

The data collected through the automatic monitoring and telemetric network is being quality controlled and transferred for storage in the AirQUIS database. An automatic air quality index (AQI) generator provides AQI values for traffic and for urban background microenvironments to be displayed daily on the information web site.

The first results from the full application of the system are presented in the paper.

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Keywords: *Air quality models, air quality management system, air quality monitoring and dissemination.*

1 Introduction

To identify and assess the air pollution situation in HCMC and automatic air pollution monitoring and assessment system has been installed and is presently being operated by trained local experts. The key features of the system is the integrated approach that enables the user in a user friendly way to not only access measured data quickly, but also use the data directly in the assessment and in the planning of actions. The demand of the integrated system to enable monitoring, assessment, planning and forecasting has been and will be increasing in the future.

The basic GIS based database and planning tool used in HCMC is based on the NILU developed AirQUIS system. This system has been installed and is being applied in several large urban areas worldwide.

The data collected through the automatic monitoring and telemetric network is being quality controlled and transferred for storage in the AirQUIS database. Statistical programmes for quality control and data representativeness are being used and an automatic air quality index (AQI) generator provides AQI values for traffic and for urban background microenvironments to be displayed on the information web site.

Air pollution dispersion models have also been installed as part of AirQUIS for HCMC. Templates and routines for emission inventories are presently being applied to collect emission data and the first model estimated have been presented. In the near future concentration estimates will be used to evaluate different source's relative importance to the total exposure, impact assessment and to perform optimal abatement planning.

2 The monitoring programme

A total of 9 measurement sites using automatic monitors have been established in Ho Chi Minh City (HCMC). Four of the sites were supported by Danida and installed in 2000, while the remaining five sites have been supported by NORAD and were installed with the support from Norwegian Institute for Air Research (NILU) in 2002. The stations, site characteristics and locations are given in the Table 1 below (Sivertsen et.al 2004).

Table1: Air pollution measurement sites in HCMC, site characteristics and positions.

Stations				Indicators					UTM 84 N	
ID	Code	Name	Charact.	PM10	NO2	SO2	O3	CO	X coordin (m)	Y coordin (m)
1	DO	DOSTE	Traffic		X	X	X	X	684,430	1,192,220
2	HB	Hong Bang	Traffic		X		X	X	681,620	1,189,460
3	TD	Thu duc	Res/Ind		X	X			693,640	1,199,790
4	TS	Tan Son Hoa	Urb Bkg		X	X	X	X	682,830	1,193,930
5	TN	Thong Nhat	Traffic	X	X	X		X	680,690	1,193,530
6	BC	Binh Chanh	Traffic	X	X			X	674,500	1,183,000
7	ZO	Zoo	Urb Bkg	X	X		X		686,420	1,193,370
8	D2	District 2	Res/ind	X	X	X	X		691,160	1,193,510
9	QT	Quang Trung	Urb Bkg	X	X	X	X		677,940	1,200,080

3 Emission data

3.1 Traffic and line sources

The status of the emission inventory consists of 118 main roads. Data have been collected based on manual counting of traffic density flows as well as diurnal variations of traffic flows along all these roads. Variation for each road class and

each vehicle class was collected by a team of student trained and quality controlled by HEPA experts.

These main roads in HCMC have been treated as line sources in the dispersion model.

3.2 Area sources

The side roads have been converted into area sources (Sivertsen et.al, 2005). Area source emissions have been estimated based on the population distribution in each of the Wards of HCMC. Estimated emissions of NOx based on an average emission for NOx from motorbikes of 0.3 g/km.

For District 1 in the central part of HCMC the data looks as shown in the Table below.

Area, Population of regions HCMC

No	Name of District and Ward	Area(Km2)	Population (people)
	HCMC area	**2094.34**	**5 250 257**
I	**District 1**	**7.72**	**226 735**
1	Ward B?n Nghé	2.49	21 429
2	Ward B?n Thành	0.93	21 257
3	Ward Cô Giang	0.36	23 915
4	Ward C?u Kho	0.34	20 584
5	Ward C?u Ông Lãnh	0.23	17 959
6	Ward Đa Kao	1	23 528
7	Ward Nguy?n Thái Bình	0.49	19 441
8	Ward Nguy?n Cư Trinh	0.76	25 914
9	Ward Ph?m Ng? Lão	0.49	22 636
10	Ward Tân Đ?nh	0.63	30 072

These data may also be used to distribute the human generated emissions of particles as area sources. However, more basic information of fuel types and activities has to be obtained first.

3.3 Point sources

A collection of information from major industries and power plants has been the basis for import of emission data for point sources. A total of 70 different industries have been evaluated, which has lead to identification of 125 individual stacks in HCMC.

Most of these sources have low stacks and have no time variations built in.

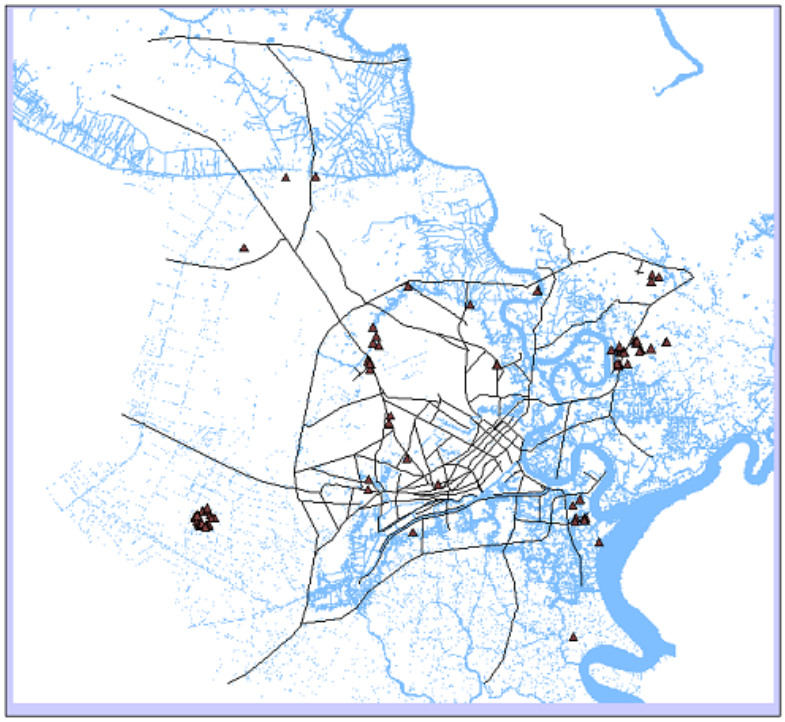


Figure 1: Positions of point and line sources in HCMC

3.4 Emission factors

Emission factors for point and line sources have been based on a study of different emission factors collected from Asian studies. Different factors have been tested and a final proposal ended with using the same Traffic Emission Factor Set (EURO I) as NILU has used in studies in China. This indicated that the NOx emission factor for motorbikes was selected at 0.05g/km instead 0.2 g/km, which has been used in other cities for four-stroke petrol driven motor bikes.

4 Measurement data selected for evaluation

To test and verify the models we have selected a time period with good quality data both for meteorology and air quality.
The time period selected for this purpose was: 1 April to 1 May 2006.

The air pollution cmpounds available for this period was:
ZOO station: O3, NO, NO2, NOx, PM10 (Urb bgr)
D2 station: O3, NO, NO2, NOx, PM10 (Urb bgr)
BC station: CO, NO, NO2, NOx, PM10 (Traffic)
TN station: CO, SO2, PM10 (Traffic)
DO station: O3, NO, NO2, NOx (Traffic)
Met station : WD, WS, Upper Temp, Lower Temp, Pressure, Relative Humidity

All measurement data have been checked by HEPA following the NILU QA/QC procedures. The meteorological data were measured by a new Vaisala type weather station installed by NILU on the 30m tower at the Doste station in November 2005.

5 Model testing and verification

Model tests and verification runs were undertaken at NILU. For these tests different scenarios for NOx emissions and concentrations were selected and the model results were presented based on the AirQUIS GIS platform.

The results were further verified against measurement data and different variables in the model; such as mixing heights, stability parameterisation and wind data were checked. Some adjustments were implemented in order to obtain an operational model for HCMC. The model was also run to estimate NO_2 concentration distributions using a simple ozone chemistry approach.

6 Different scenarios used in the evaluation:

A number of scenarios were identified during the evaluation phase. Specific short term air pollution "episodes" were looked into.
Different emission values for NOx (0.23g/km and 0.05g/km) were studies specifically
Model estimates looking at line sources alone were assessed
Also point sources and area sources were estimated separately to evaluate the relative importance of theses sources and to study the model response

Back in HCMC the model has been used to estimate the PM_{10} concentration distribution over HCMC hour by hour during a time period of a few days. The results of this was presented in the conference.

7 References

Sivertsen, B. and Thanh, T.N. (2004) Ho Chi Minh City Environmental Improvement Project. Air Quality Monitoring Component. Mission 4, April 2004; Status report (QR7-9), Data assessment and training. Kjeller (NILU OR 51/2004).

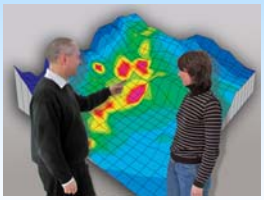
Sivertsen, B., Thanh, T.N., Le, K.V. and Vo, D.T. (2004) The air quality monitoring and management system for HCMC, Vietnam, Presented at the Better Air Quality Conference, Agra, India, December 2004. URL: http://www.cleanairnet.org/baq2004/1527/article-59135.html

Sivertsen, B., Thanh, T.N., Le, K.V. and Vo, D.T. (2005) The air quality monitoring and management system for HCMC, Vietnam. Kjeller (NILU OR 1/2005).

Appendix A

Transparencies presented at the BAQ conference

Modelling air quality in Ho Chi Minh City, Vietnam



*Bjarne Sivertsen **
*Vo Thanh Dam***

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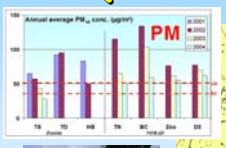
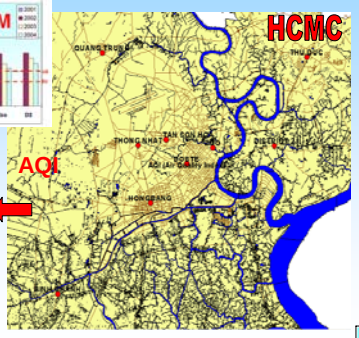
9 AQ Monitoring Sites

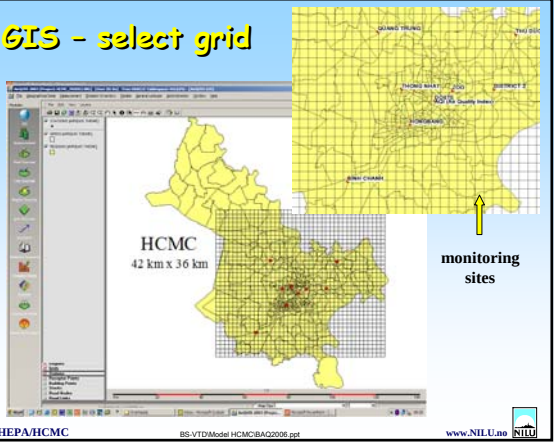




Models available in AirQUIS

- **Emission model**
  - Calculates hourly emissions from area-, line- and point- sources. Stores results as field, line or point data set
- **Wind field model** (MATHEW)
  - Calculates 3-dimensional hourly wind fields from measurements of wind speed and direction, temperature and vertical temperature gradient and a topography field
- **Dispersion model** (EPISODE)
  - Calculates hourly and half hourly concentrations of pollutants in fields, points and along roads
- **Exposure model**
  - Combines air pollution concentrations with population distribution in order to calculate exceedances

GIS - select grid

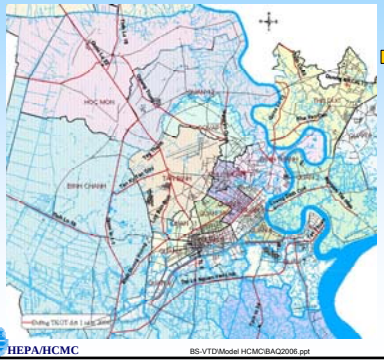


Main sources and emissions in HCMC

Traffic Motor bikes !

Line sources - Area sources - Point sources

Started counting traffic on main roads and streets



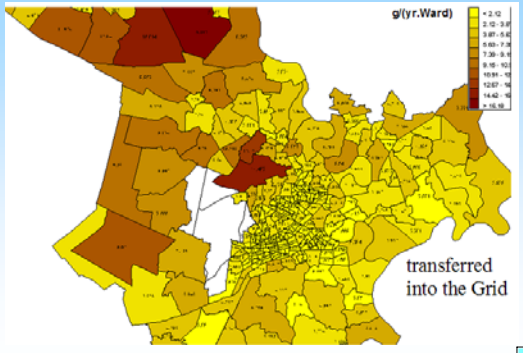
118 main roads have been counted

Remaining traffic
Area source emission estimates

Area, Population of regions HCMC

No	Name of District and Ward	Area(Km2)	Population (people)	NOx emis (kg/yr)
	HCMC area	2094.34	5 250 257	
I	District 1	7.72	226 735	
1	Ward B?n Nghé	2.49	21 429	4443
2	Ward B?n Thành	0.93	21 257	2694
3	Ward Cô Giang	0.36	23 915	1885
4	Ward C?u Kho	0.34	20 584	1577
5	Ward C?u Ông Lãnh	0.23	17 959	1132
6	Ward Đa Kao	1	23 528	3092
7	Ward Nguy?n Thái Bình	0.49	19 441	1788
8	Ward Nguy?n Cư Trinh	0.76	25 914	2968
9	Ward Ph?m Ng? Lão	0.49	22 636	2082
10	Ward Tân Đ?nh	0.63	30 072	3136
II	District 2	49.75	102 301	
1	Ward An Khánh	1.77	16 238	2839
2	Ward An L?i Đông	3.6	6 290	1568
3	Ward An Phú	10.21	7 542	3167
4	Ward Bình An	1.85	10 035	1793
5	Ward Bình Khánh	2.01	7 587	1413
6	Ward Bình Trưng Đông	3.32	8 968	2147
7	Ward Bình Trưng Tây	2.05	11 951	2248
8	Ward Cát Lái	6.62	6 510	2201
9	Ward Th?nh M? L?i	13.01	8 338	3952
10	Ward Th?o Đi?n	3.81	8 548	2192
11	Ward Th? Thiêm	1.5	10 294	1657

Emissions in each Ward (motor bikes only)



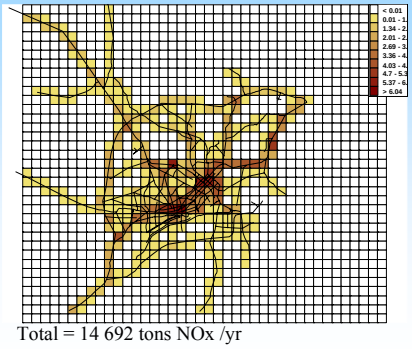
Emission inventory

118 roads
125 stacks
(70 plants and ind.)
all areas

Emission of NOx along 118 roads

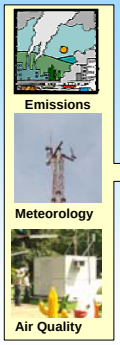
The challenge is to estimate emission factors for HCMC

present factor =0.23 g/km

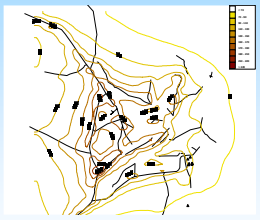


Total = 14 692 tons NOx /yr

Model test and verification



model test verification

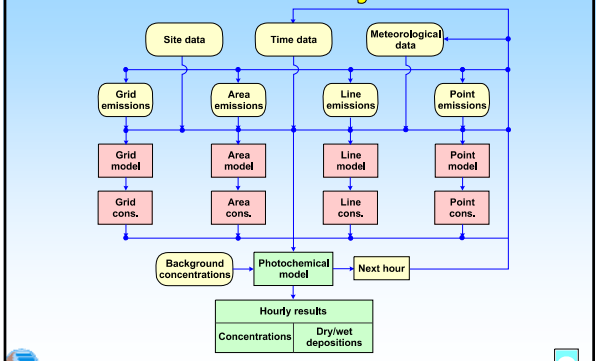


Operational dispersion model

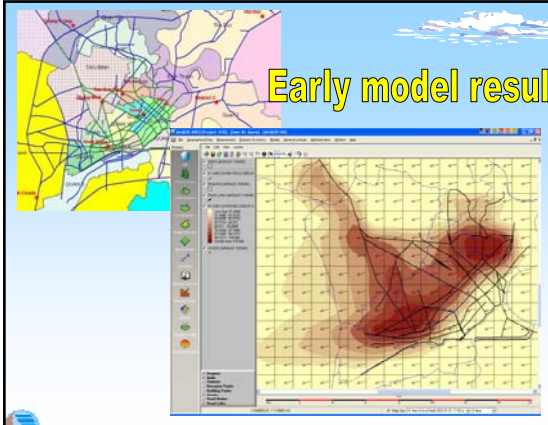
EPISODE models

- A combined 3D Eulerian/Lagrangian model
- Solves the atmospheric (mass) conservation equation in a 3D Eulerian grid
- Contains separate sub-grid models for line and point sources
- Contains a simple photochemical equilibrium model for NO, NO_2 and O_3 (default)
- Contains a complete photochemical scheme for industrial and urban areas (optional)
- Calculates ground level hourly concentrations

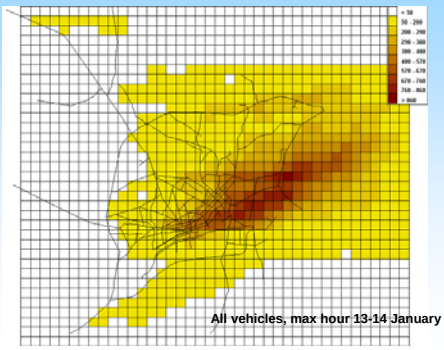
NILU: EPISODE model system



Early model results

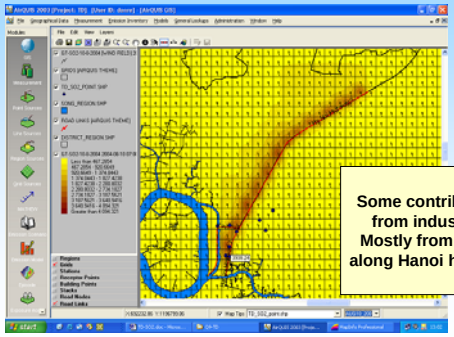


The first test estimates



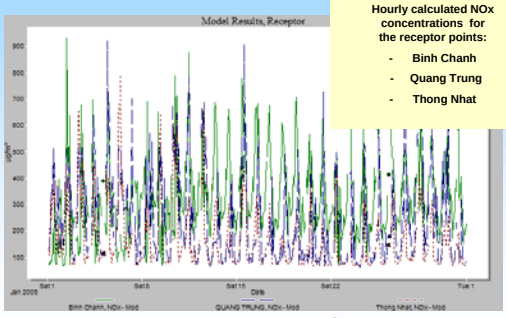
All vehicles, max hour 13-14 January 2005

Estimated SO2 in Thu Duc area



Some contribution from industries
Mostly from traffic along Hanoi highway

Model estimates in 3 receptor point



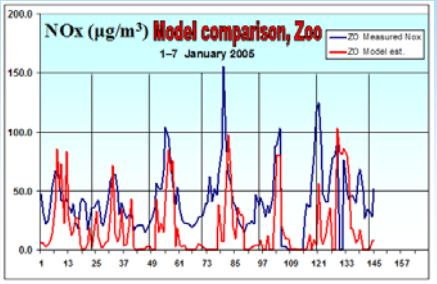
Hourly calculated NOx concentrations for the receptor points:

- Binh Chanh
- Quang Trung
- Thong Nhat

over estimates !

Model estimates for Zoo site January 2005

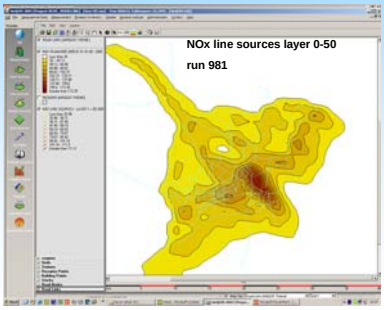
Concentrations for sources close to the Zoo station



Further verifications and tests

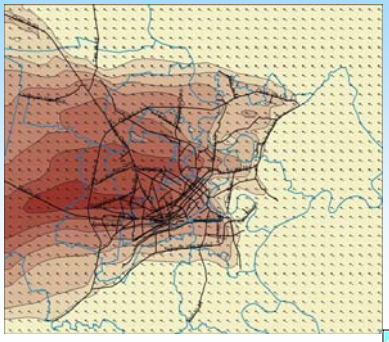
Meteorological data
Stability at surface
Surf. layer heights
Emission factors

NOx now : 30-100 ug/m³



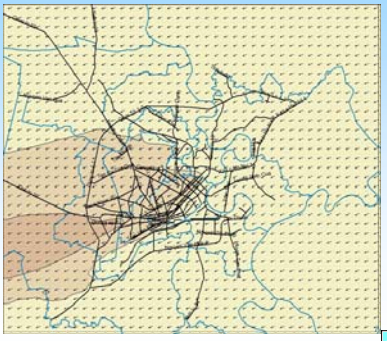
PM_{10} concentrations

PM10 concentrations estimated every hour during 5 Jan. 2005



PM_{10} concentrations

PM10 concentrations estimated every hour during 5 Jan. 2005



Further work is needed

- ✓ Improve input meteorology
- ✓ Stability formulation for HCMC
- ✓ Emission factors for motor bikes in HCMC
- ✓ Complete emission inventory

Goal: Clean air in HCMC

- ✓ evaluate impact of options
- ✓ select cost effective actions
- ✓ estimate future impacts
- ✓ forecast air quality