



## IMMC 2019 Greater China Problem D (Winter Season)

### Positioning and Treatment of Air Pollution Sources

With the intensively increasing of human industrial and social activities, air pollutants such as fine particulate matter PM<sub>2.5</sub> have caused atmospheric haze, and the situation of air pollution control has become increasingly severe. In order to make effective efforts to monitor and control the emission of atmospheric pollutants, a city asks your team to assist its environmental protection agency to locate the air pollution sources and make recommendations on the air pollution control policy.

For the convenience of positioning, we can grid the layout of a city with a matrix of  $101 \times 101$  (each grid unit length is 1 km). Your team learned from the environmental agency that there are three separate sources that emit atmospheric pollutants, assuming that weather factors such as temperature and humidity remain unchanged when the pollutants diffuse in the atmosphere.

**Question 1:** Under the condition of no wind, the distribution of atmospheric pollutants detected by the environmental agency within 100 hours of emission by the pollution sources is shown in **Figure D.1**. The specific values of pollutants corresponding to the city layout grid are given by the Excel file [D01.xlsx](#). (The value indicates the number of concentration units.) Correspondingly, please build a mathematical model to position the three sources of air pollution.

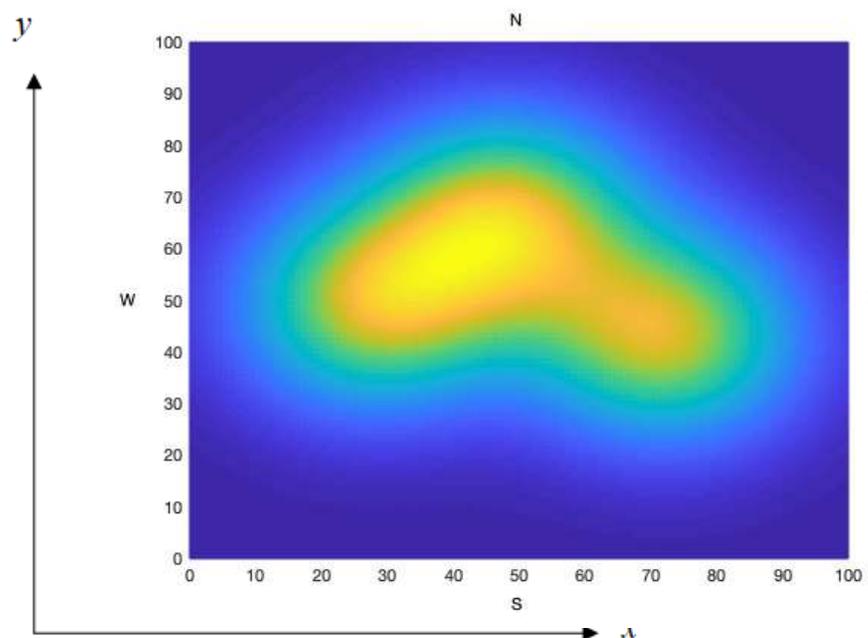
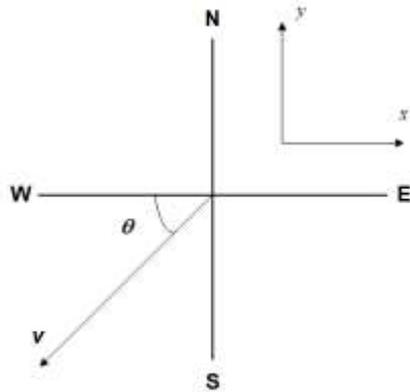


Figure D.1

**Question 2:** Atmospheric pollutants are also often affected by wind during emission. On the basis of Question 1, it is assumed that the wind factor does not affect the discharge of the pollution by the sources and only drifts the diffusion of the pollutants; at the same time, it is assumed that  $v$  is



the wind velocity,  $t_v$  is the time affected by the wind velocity (unit: hour), and  $\theta$  is the angle of the direction of wind (for example, the wind direction angle is shown in **Figure D.2** is generally expressed as the west-south angle,  $\theta$ ).



**Figure D.2**

On the basis of your model for Question 1, please formulate the equation of the diffusion of the atmospheric pollutants under the influence of wind, and compute the values of pollutants by the three sources of pollution lasting for 150 hours under the wind with the velocity of 0.2 km / hour (wind direction: west to south 30 degrees) blowing for 40 hours. (Please fill the values of pollutants into the spreadsheet of Excel file [D02.xlsx](#), rounded to two decimal places.)

**Question 3:** In order to improve the living environment, the environmental agency uses the limited fund to make the city's feasibility plan for emission reduction and pollution control of the primary pollutants. It plans to reduce 245 units of concentration of atmospheric pollutants through its five-year plan control and treatment; the annual budget for treatment is composed of two parts: comprehensive treatment expenses and special treatment expenses.

It is estimated that for every unit of concentration reduction of atmospheric pollutants, it needs one unit of expenses for the comprehensive treatment (one million Yuan per unit of expenses) in the current year; whereas the expenses for special treatment (unit: million Yuan) is 0.005 times the square of the concentration of atmospheric pollutants reduced in the current year. Considering that the government still needs to pay the corresponding interest of bank loan at the end of the fifth year, assuming that the interest rate of the 5-year loan is 6.4%), please make fiscal policy recommendation for the 5-year plan of air pollution control and treatment on the basis of your calculation of the minimum total expenses by the government agency. In your policy suggestion, please give the annual budget and annual objection indicator of air pollution reduction.

**Submission:** Your solution paper should include a 1-page Summary Sheet. The body cannot exceed 20 pages for a maximum of 21 pages with the Summary Sheet inclusive. The appendices and references should appear at the end of the paper and do not count towards the 21 pages limit. Please submit the spreadsheet of the computing results of Question 2 together with the solution paper in the zipped file.