Group work for lecture Environmental Sensing and Modeling in summer semester 2024

Prof. Dr.-Ing. Jia Chen
M. Sc. Florian Dietrich

Professorship for Environmental Sensing and Modeling
Technical University of Munich

Submission date:
July 30, 2024

Exercise 1 NO_x concentration mapping

The Bavarian environmental agency ("Bayerisches Landesamt für Umwelt", LfU) is measuring the point concentrations of air pollutants such as NO_x, O_3 or PM_{10} at five stations in and around Munich (see also the attached kmz file which can be opened e.g. by Google Earth):

- Landshuter Allee (LHA)
- Stachus (STA)
- Lothstraße (LOT)
- Allach
- Johanneskirchen

The data of those measurement stations is publicly accessible on their homepage (`https://www.lfu.bayern.de/luft/immissionsmessungen/messwerte/stationen`). There you can find the data of the last 48 hours for all Bavarian air quality sensor stations. Furthermore, we are also providing the traffic data (amount of cars per hour passing the closest traffic light) of the three inner city stations (LHA, STA and LOT).

For the following tasks you should use a programming language of your choice (e.g. MATLAB, Python, etc.):

1. Download the current NO_2 data for all five Munich stations (available as csv or xls file) from the LfU homepage.
2. Convert the mass densities ($\frac{\mu g}{m^3}$) in the downloaded files to mixing ratios (unit: ppb).
3. Plot the NO_2 mixing ratios of the last 48 hours for all five stations in **one** plot.
4. Explain the daily cycle and the differences between the sites that you can observe in the plot. You can use the provided traffic data for that purpose. Is there a correlation between traffic and NO_2 concentration for the entire day and is there another effect that also needs to be considered?
5. Your last task is to plot a concentration map for Munich with a resolution of 1 km × 1 km and an overall dimension of 20 km × 20 km. As you have only five stations, it is necessary to use an interpolation algorithm for the remaining locations:
   a) As a preparation task, please average the 48 concentration values of each station to obtain one concentration value each (48 h average).
   b) Use a simple interpolation algorithm (e.g. inverse distance weighting, IDW) to calculate the concentrations in the remaining 395 grid cells (matrix dimension: $20 \times 20 = 400$).

      Hint for IDW: The concentration c at a point x (x_{lat}, x_{lon}) can be calculated as a weighted sum of the five measured concentrations c_i:

      $$c(x) = \begin{cases} \frac{\sum_{i=1}^{5} w_i(x) c_i}{\sum_{i=1}^{5} w_i(x)} & \text{if } d(x, x_i) \neq 0 \\ c_i & \text{if } d(x, x_i) = 0 \end{cases} \tag{1}$$

      $w_i(x)$ represents a weighting factor which is anti proportional to the distance d (e.g. Euclidean distance, unit: km) between the measurement site i and the current location x.

      $$w_i(x) = \frac{1}{d(x, x_i)} \tag{2}$$

   c) Plot the concentration map with a suited color bar (e.g. green for low and red for high concentrations) and overlay it with a map of the city (e.g. Google Maps/Earth, OpenStreetMap, MATLAB worldmap, etc.).