Group work for the lecture Environmental Sensing and Modeling in winter semester 2021/22

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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. As a first task please download the current NO_2 data for all five Munich stations (available as csv or xls file) from the LfU homepage.
2. Afterwards, please convert the mass densities ($\frac{\mu g}{m^3}$) in the downloaded files to mixing ratios (unit: ppb).
3. As a next step, you should plot the NO_2 mixing ratios of the last 48 hours for all five stations in **one** plot.
4. Please 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 whole day and is there another effect that also needs to be considered?
5. Your last task in this homework is to plot a concentration map for Munich with a resolution of 1 $km \times 1$ km and an overall dimension of 20 $km \times 20$ km. As you have only five stations, it is necessary to use an interpolation algorithm for the remaining locations:
   a) As a preparation task, you have to average the 48 concentration values of each station to obtain one concentration value each.
   b) Please 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 IDE: 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) In the end, please find a way to 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.).