

Appendix 5: Tools

Tools

1. The Gaussian Plume model

Background:

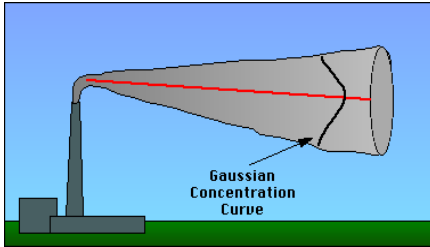


Figure A2. Gaussian concentration curve depicted in a plume coming out of a stack

The Gaussian Plume model is a (relatively) simple mathematical model that is used to estimate concentrations of air pollutants originating from an indicated emitter, in our case CO₂-emission by a CO₂-source. The main assumption of the model is that, over short periods of time, steady state conditions exist with respect to air pollutant emissions and meteorological changes. The air pollution is represented by an idealized plume, which comes from a smokestack and has a given height and a given diameter (Figure A2). Depending on the conditions, the plume will disperse in a certain direction and over a certain surface. The first calculation of the Gaussian Plume model regards the vertical movement of the plume. Assume the investigated source is a coal-burning electricity-producing plant. In this plant, the gases are heated, resulting in

a vertical movement. The hot plume will thus move upwards to some distance above the top of the stack (= the effective stack height). This can be calculated based on the speed with which the gas exits the stack (= the exit velocity), the temperature of the gas and the temperature of the surrounding air. The next calculation of the model regards the dispersion of the plume in three dimensions: the downwind direction, the crosswind direction and the vertical (downwards) direction. The progression in these dimensions depends on the mean wind speed and the relative stability of the surrounding air. The influences of these factors will determine the final dispersion of the emitted CO₂ and the local concentrations of the gas in different areas of the Plume. More information about the Gaussian Plume model can be found here: <http://san.hufs.ac.kr/~gwlee/session9/gaussian.html> Although the model might be relatively simple for mathematicians, it is not that simple for highschool pupils. However, by entering the right data as described under "How to use the Gaussian Plume model", pupils can make dispersion diagrams that can help them to estimate the possibility to measure increased CO₂-concentrations at the station near the identified CO₂-source.

How to use the Gaussian Plume model:

- Go to http://ready.arl.noaa.gov/READY_gaussian.php
- Select: Gaussian model using user-entered data
- Fill in the coordinates of the source that is to be studied: degrees latitude and longitude. Continue
- The next page shows a long list of parameters. Some data are used automatically, for example the 'cloud ceiling' which is set at 2000 foot if unknown. In most cases, pupils will not know the exact value, so do leave it at the set number. Do however change the following parameters, depending on the local situation:
 - Wind direction: it is indicated in degrees (with 0 = Northern Wind, 90 is Eastern Wind, etc.)
 - Wind speed: the default settings are 'knots', but the option 'm/s' can be ticked
 - A nice option: tick the box 'Google Earth' in the field 'Create GIS output of contours?'
- Click 'request dispersion run'. A picture like the one in Figure A3 appears.
- The dispersion diagram shows the dispersion of the plume and the local concentrations
- Below the dispersion diagram, links to other output files are shown.
- Open 'Google Earth Results' for displaying the dispersion diagram on the local map

Based on the obtained dispersion diagram, pupils could estimate how likely it is that they can measure a rise in the CO₂-concentrations originating from emission by the local source.

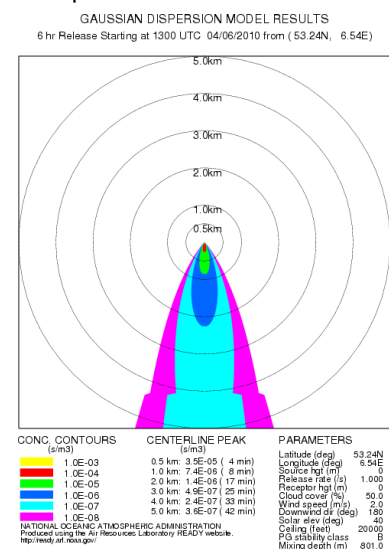


Figure A3. Dispersion as predicted by the Gaussian Plume Dispersion Model

2. Identifying the origin of air packages

Background:

The atmosphere is constantly moving. The air is circulating and an air package is at one moment located here and next it has traveled to somewhere else. By movement of the air packages, the CO₂-content travels with the air. It can therefore be important to know where air packages travel to and where they originate from. At the site of the National Oceanic and Atmospheric Administration (NOAA) in the US, an application from the Air Resource Laboratory enables calculations on where the wind and the air packages come from.

How to determine the origin of air packages:

- Go to http://ready.arl.noaa.gov/HYSPLIT_traj.php
- Select Compute archive trajectories. Click Next
- Select '1' for Number of Trajectory Starting Locations and 'Normal' for Type for Trajectory. Click Next
- Select GDAS (global, 2006-present) for meteorological data
- Fill in the coordinates of the location: degrees latitude and longitude. Continue
- Select a specific week for GDAS1 Meteorological File, Default is the current7days. Click Next
- In this fill in screen only change under Trajectory direction: Forward into Backward
- Click Request trajectory. The model will now calculate and produce a plot which might take a minute
- The plot will show where the air package is coming from at the default height of 500 m. The model can be rerun after changing the scenario, e.g. changing the height