Air Quality: Particulate Matter in the Atmosphere

See following pages for background information, if this is useful. Otherwise, on to the sampling!

Sampling Protocol

1. We ask you to collect PM2.5 data from your school area for (at least) 8-10 days between August 20 2016 and November 30 2016, with instruments to be returned to UNC Charlotte by December 1 2016.

2. In addition to the PM2.5 data, work with your students to separately note (and have someone write down) the following about your sample location:
   a. What time were you sampling and where?
   b. Why were you sampling there?
   c. Temperature
   d. Relative humidity (or the wet-bulb temperature)
   e. Winds (just estimate as weak, steady, or strong)

3. Each day, you should try to get about 3 hours of sampling for about 30 hours of data total but **NEVER** leave the DC1700 in the drizzle or rain (see below). You will have to plan around the weather and wait for good days – check your weather app (weather underground storm app is free) or go to [www.weather.gov](http://www.weather.gov) for official forecasts for your area

4. Concentrate on outdoor locations when compiling collecting 30+ hours of data. If you want to collect from indoor locations, the DC1700 is perfectly capable of doing this, but this should not be thought of as part of the 30 hours. You and your students can investigate something separately about the indoor environment if you want of course. For example, are there more particles from certain objects in the classroom?

5. We also need good metadata or notes to support the other data in steps 1-2. Metadata is additional information about the data collection process that support the numerical data. When you collect your data, you and your students should note (write down) the following:
   a. Are there trees or vegetation in the area?
   b. How close are road? Are there cars or trucks or busses or trains?
   c. Can you smell anything? Smoke, for example?
   d. Does the sky seem hazy? Did it rain recently?

6. Every sample day then requires careful “lab notes” about the data collection. You can then email the notes to me whenever you want and/or upload them to the old Keeping Watch website [http://cstem.uncc.edu/2016-keeping-watch-air-trees](http://cstem.uncc.edu/2016-keeping-watch-air-trees) and I will put them together with the data from the DC1700 that we pick up from you early December
**Introduction**

Most of the air we breathe is made of molecules in gas form – nitrogen (N\(_2\)) and oxygen (O\(_2\)) make up about 99% of that air. Gas molecules are tiny and there are an enormous number of individual molecules in any given volume. Consider a small die that is about 1 centimeter on a side (about as wide as your finger). If we had a “piece” of air as big as that die (1 cubic centimeter), then there would be about \(10^{19}\) molecules of air within that volume! That’s a 10 with 19 zeros behind it.

A small fraction of the air we breathe consists of molecules in solid or liquid form. A large liquid *particle* would be a cloud droplet or rain drop, but these do not remain suspended in air very long due to gravity. The very smallest sized solid and liquid *particles*, however, remain in the air for weeks, months, and even years. Collectively, these small particles are called “aerosols” and also called “particulate matter”. Although all three terms are used interchangeably, for air quality research, often particulate matter (or PM) is what is used.

PM contains solid and liquid particles with diameters that are about 10,000 to 100,000 times the diameter of a typical gas molecule, and there are always far fewer particles in a volume of air than there are gas molecules. If we think about that die that is about 1 centimeter on a side, then within an equal volume of air, a typical number of particles would be 1,000 to 10,000, or over a *quadrillion* times fewer solid/liquid molecules than gas molecules.

There are many natural sources of particles to our atmosphere – dust from deserts, smoke from fires, trees, and more – and largely these sources make up the typical background numbers of particles. However, there are also many particles injected into our atmosphere, or that form in the atmosphere, as a result of human activities. Burning of fossil fuels, agricultural fires, construction, and vehicular traffic are some examples of human sources. Enhancements in the number of particles in the air above the typical numbers have been proven to cause major health problems in humans. Thus, particles are one of the *pollutants* that the Environmental Protection Agency (EPA) monitors and regulates, and the focus of these regulations are largely on the human activities that cause those enhancements.

**Project Background**

The theme of this project is ambient atmospheric sampling of tiny particles in the air, or particulate matter (PM) that arises from natural and human sources. PM is regulated in the USA by the EPA as a “Criteria Pollutant” under the Clean Air Act (CAA), and must be within concentrations specified by the National Ambient Air Quality Standards (NAAQS) for the air quality in a county to be considered acceptable. NAAQS is based on scientific and epidemiological/health research. Counties usually monitor their own pollution using standardized (scientifically traceable) methods and report their data to regulatory agencies. A county that meets the requirements of NAAQS is said to be “in compliance” with the CAA.
NAAQS regulates two categories of PM: PM2.5 and PM10, where PM2.5 is the particulate matter that is made up of particles with diameters less than 2.5 micrometers (2.5 millionths of a meter), and PM10 is the particulate matter made up of particles with diameters less than 10 micrometers (http://www3.epa.gov/pm/). For scale, a human hair is about 50 micrometers, and beach sand is 100 micrometers, so these are very small particles.

PM2.5 can have very different sources than PM10, and enhanced PM2.5 concentrations more severely impact human health, mostly because the smaller particles can pass more deeply into the human respiratory system. Once in the lung tissue, the particles represent foreign bodies within the human body, and our bodies do not react well to foreign bodies.

Since PM2.5 is made of microscopic particles, the exposure to medium to high levels of PM2.5 must be sustained over time for a quantifiable risk to be assessed. The amount of time that determines an acceptable exposure depends on the particular dose – or concentration or amount of PM2.5. Higher concentrations mean that less of an exposure is needed to be deemed unhealthy. NAAQS specifies that an exposure to more than 35 micrograms per cubic meter of PM2.5 over a 24-hour period is unhealthy for the young, old, and those with existing health problems. Health studies look at large populations to relate the risks to the concentration, and this science is translated into policy via the Clean Air Act to protect the air we all breathe.

**Project Description**

The goals of the project are to

1. Characterize PM in an outdoor environment
2. Understand what factors cause PM to fluctuate in that environment
3. Relate the PM values back to PM reported for Mecklenburg County

To achieve the goals, we are asking that data be collected from various school sites in and near Mecklenburg County.

**Data Collection**

The instrument – the device that will used to measure PM – is a Dylos DC1700 Particle Counter. There are weblinks at the end to point you to information from the manufacturer, but this section describes basic features.

The DC1700 pulls air in using a fan, and passes that air through a laser. The laser registers changes to the laser output using a sensor, and this change is used as a way to count the particles in the air. As mentioned above, outside air has thousands of particles (or more) in a volume that is the size of a die, but the DC1700 does not count particles smaller than 0.5 micrometer, so it register far fewer particles because there are far more very small particles than very large particles. The DC1700 will typically find about 5-20 particles in a volume of air the size of a die (5-20 per cubic centimeter), but this number varies considerably. Also, the DC1700 display shows numbers that are in somewhat inconvenient units of particles per hundredth of a cubic
foot, so to get into particles per cubic centimeter (about the size of a die), divide what the DC1700 shows by 283. To avoid division, the corresponding typical values on a DC1700 will show about 2000-4000 particles (per hundredth of a cubic foot).

The DC1700 display shows two numbers that show different particle counts. The first number is the count of all particles larger than 0.5 micrometers. The second is the count of particles larger than 2.5 micrometers. Usually the second number is smaller than the first. To get the count of particles that would be closest to PM2.5, subtract the second (smaller) number from the first.

The DC1700 collects data averaged over 1 minute intervals, and can store 10,000 minutes of data on its internal memory. This is over 160 hours of data (or 7 days running 24 hours a day), so you will not need to download the data yourself. You can review averages of the data via the instrument by pressing the “Mode” button. If you do want to download the data, however, please read the Optional part below.

The DC1700 has an internal battery that can run for about 6 hours continuously. To charge it, turn it off, plug it into the wall, and set the switch to “Battery On/Charge”. This can take about 8 hours, so it’s a good thing to do overnight. When fully charged, the screen should read “Battery Fully Charged”.

**Important:** The DC1700 is NOT WEATHER PROOF and should never be left in the rain or even a light drizzle. Also, while the casing is hard plastic, users should be careful not to drop the DC1700. Treat the instrument like you would your smart phone or any piece of technology.

**Also important:** Do not ever clear the history on the DC1700. There is plenty of memory and you would lose all your work.

**Optional:** You can download the DC1700 data yourself using a USB-Serial cable and a laptop or computer. Follow the download instructions in the User’s Guide which is linked at the end of this file. A data-transfer (USB-Serial) cable will be provided to those who want to analyze the data. Microsoft Excel or Google Sheets is a good way to interface with the data – begin by creating a scatterplot of the particle counts versus time. Dr. Brian Magi can also provide a spreadsheet that converts the data from the DC1700 (PM2.5 particle counts) into air quality relevant data (mass concentration of PM2.5).

**Final Analysis After Data Collection**
Dr. Brian Magi will download the data and convert the particle counts to a PM2.5 mass concentration to be comparable with data that the county collects to report to the EPA. Your data information will be reported back to you after the analysis. Alternatively, I can provide you with a data transfer cable and you can work with the data yourselves.
Resources for Understanding Particulate Matter

4. EPA primer on PM: [http://www3.epa.gov/pm/](http://www3.epa.gov/pm/)
5. CharMeck air quality data: [http://airquality.charmeck.org/](http://airquality.charmeck.org/)
6. NC air quality forecast: [https://xapps.ncdenr.org/aq/ForecastCenter](https://xapps.ncdenr.org/aq/ForecastCenter)
10. Air quality map for the world: [http://aqicn.org/map/](http://aqicn.org/map/)
11. Twitter Beijing data: [https://twitter.com/BeijingAir](https://twitter.com/BeijingAir)
12. Data from USA embassies in China: [http://www.stateair.net/web/post/1/1.html](http://www.stateair.net/web/post/1/1.html)