Wasatch Front Winter Inversion Vertical Profile Air Sampling
Utah Division of Air Quality Research Grant
Project Period: December 20th, 2014 to March 30th, 2015
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Abstract / Project Description

The HARBOR team (http://harbor.weber.edu) will measure at least PM2.5, NO2, and ozone in a vertical column from ground level to 1,000 feet above ground. Measurements will be made at a minimum of two locations: downtown Ogden at Grant and 32nd St. and at Weber State University's Science Lab. These two locations are at elevations of 1,316 meters (4,317 ft) and 1,448 meters (4,750 ft).

The choice of downtown Ogden allows us to do a measurement at a Utah Division of Air Quality monitoring site which will give us a ground measurement for comparison.

Measurements will be made before, during and immediately after a winter inversion event. Two measurements per day will be made, one in the morning and one at approximately 4 p.m. to match up with the NOAA radiosonde launches. If possible, more than one inversion will be measured.

These measurements will be made using a moored aerostat balloon system on a 1,000 foot tether.

An expanded mission will make at least one set of measurements along a roughly north-south line starting in Weber County at the Harrisville DAQ station and doing as many DAQ stations as possible to at least the Hawthorne station in Salt Lake City. These will be done as quickly as possible in one day so that the air columns can be compared over a distributed area. If possible, these measurements will be done both during and outside of an inversion event.

Note: Coordination is being done with the Federal Aviation Authority (FAA). The FAR (Federal Aviation Regulation) Title 14, Chapter I, Subchapter F, Part 101, Subpart B, states that no moored balloon may be flown more than 500 feet above ground or within 500 feet of the cloud base, among other requirements. We are working with the FAA and expect to obtain a waiver on these limitations. The worst case scenario is that we'll be limited to 500 feet above ground.

Background

The Utah Division of Air Quality has significant infrastructure for ground level measurements along Utah's Wasatch Front. However, the number of measurements that have been done above ground level are limited. The University of Utah Atmospheric Sciences Department has done some previous measurements but those did not have as many gas sensors on board. Those measurements were also closer to the ground.

Discussions with the Division of Air Quality's atmospheric modeling group have resulted in the measurements being proposed here. Specifically, we want to obtain column measurements

during an inversion. Ideally, we would fly from ground level to either the top of the inversion or at least 1km above the ground. However, the local air space is very crowded with civilian, commercial, and military aircraft which limits the amount of time and size of balloon that can be safely used along the Wasatch Front. Aviation safety and coordination with the FAA will ultimately define the altitude and duration of our air sampling flights.

Weber State University's HARBOR program has seven years of flight experience with free flying weather balloons bearing atmospheric monitoring equipment. Most of those flights are over the Uinta Basin from ground level to the middle of the stratosphere. We have also done several flights with moored balloons. Standard moored balloons are very susceptible to wind, so we will be obtaining a specially designed balloon with a wing (looks like a skirt) called an aerostat. Aerostats are also designed for repeated use, which will reduce costs. The Kingfisher aerostat is commonly used by the US military for surveillance missions and are rated for up to 30 MPH winds and for operations when it is precipitating rain or snow. (Obviously, no flights will be made during thunderstorm conditions.)

Figure 1. Kingfisher aerostat. The model being used for these measurements is 8 feet in diameter and 7 feet tall with a 1.5 to 2kg payload capacity.

Weber State University Physics and Electronics Engineering students have designed a new gas monitoring system that currently measures PM2.5, NO2, and O3, along with temperature, pressure, humidity, and GPS position. Our goal is to also have VOC (volatile organic compounds), SO2, CO2, and NH3 gases being measured. The sensors are being calibrated at the DAQ facility in West Valley City. The point to doing as many flights as possible from existing DAQ sites is to aid in the calibration by having a ground measurement that can be compared to heavier (and more precise) instrumentation.

One of the missions of the HARBOR program is science outreach. To this end we will coordinate measurements with any elementary schools located near the DAQ air monitoring sites. The goal is to help get these children interested in STEM (Science, Technology, Engineering, and Math) fields. To this end we are currently building a live data download link that will allow us to show bystanders the data as we collect it.

Objective/ Scope of Work

Weber State University's Physics Department's HARBOR program will generate a data product from data collected before, during, and after at least one winter inversion. Those measurements will be done at a minimum of two locations: a Weber County DAQ air monitoring site and at the University.

An expanded program will involve flights along a north-south line along the Wasatch Front in Weber, Davis, and Salt Lake counties at the Utah DAQ air monitoring sites. A minimum of one run will be done.

In both cases we plan to do significantly more flights covering more terrain and more than one inversion. This mostly depends on the availability of the undergraduate students who staff the HARBOR flight systems.

Deliverables

We will provide the Utah Division of Air Quality's Technical Analysis group (air quality modeling) with a set of vertical column measurements taken twice a day during at least one inversion event. This will also include a set of measurements taken before and after the inversion.

Additionally, we will provide at least one set of column measurements taken on the same day along the Wasatch Front from Harrisville to Salt Lake City at the encompassed DAQ air monitoring locations. If possible, we will do this more than once and in different weather conditions.

All data will be delivered as quickly as possible after each flight. The format of those data will be coordinated with DAQ personnel. After the winter inversion season is over, a report will be generated with a summary of the data and results along with plans for future measurements and modifications. A collected data set will be supplied electronically.

Schedule and Project Milestones

Mid-December, 2014: Finish construction and calibration of the gas sensor system.
December 22, 2014 – January 19, 2015: Assemble the aerostat, trailer, and ground support systems. Make preliminary measurements to be used for finalizing the equipment.
January 19, 2015 – March 15, 2015: Measure at least one full inversion event and complete at least one north-south measurement profile.

Budget

Primary Mission

Aerostat, spectra tether line, winch, emergency deflation device, rigging	$6,000
Launch support trailer with power, helium, and aerostat cradle and cover	$1,000
Helium (1.25 tanks per fill, $100/tank, 12 fills)	$1,500
University vehicle rental	$500
Undergraduate student staffing	$1,000
University Indirect Charges on salaries, wages, and benefits	$100
Total	**$10,100**

All efforts will be made to reduce the number of helium fills needed. It is hoped that the aerostat trailer system will allow us to only refill the aerostat once every few days.

Expanded Mission

Undergraduate student staffing	$1,000
Faculty time	$500
Helium (1.25 tanks per fill, $100/tank, 8 fills)	$1,000
University vehicle rental	$500
University Indirect Charges on salaries, wages, and benefits	$150
Total	**$3,150**

We anticipate multiple helium fills due to longer travel distance on higher speed roads. It is not known if we can trailer the inflated aerostat on major roads. We will also need multiple university vehicles so we can have our support trailer and additional tanks of helium shuttled between the university and the measurement sites.