EDUCT – Education in Complex Terrain - Shenandoah National Park April 6-11, 2009

Alex D’Ambrosio

Purpose

The EDUCT experiment was conducted in Shenandoah National Park from two locations, Park Headquarters and Pinnacles Overlook. The experiment was a week-long field campaign headed by Professor Stephan De Wekker, one of his graduate students Temple Lee, and six undergraduate students enrolled in his mountain meteorology class. Joining the professor and his students, atmospheric scientists from the National Center for Atmospheric Research (NCAR) arrived on Sunday April 6th with hundreds of thousands of dollars worth of specialized equipment to probe the mountain atmosphere. The instruments that NCAR brought along would be used in correlation with instruments De Wekker previously owned, in an attempt to test several hypothesis’s and gain knowledge concerning the mountain climate of the Appalachian Mountain Range.

Instrumentation

The field study was centered around our ability to acquire aid from the National Center for Atmospheric Research in the form of instruments and their operators. During this week in April, NCAR provided us with a mobile weather station, dubbed the “MISS”, for probing the mountain atmosphere in Shenandoah National Park.

Shenandoah National Park

MISS stands for Mobile Integrated Sounding System and was developed to be a mobile, rapidly deployable (setup time: one half hour) vehicle used for making measurements of the overhead atmosphere. The rig contained three fixed instruments used for measuring the atmosphere, a Radar Wind Profiler – a vertically pointing UHF clear-air radar for measuring winds, precipitation, and temperature aloft, a Ceilometer – a vertically pointed laser instrument that determines the height of a cloud base by measuring the time required for a pulse of light to be backscattered, and small tower-based weather system used to measure winds, temperature, humidity, pressure, solar radiation and rain at the MISS site.

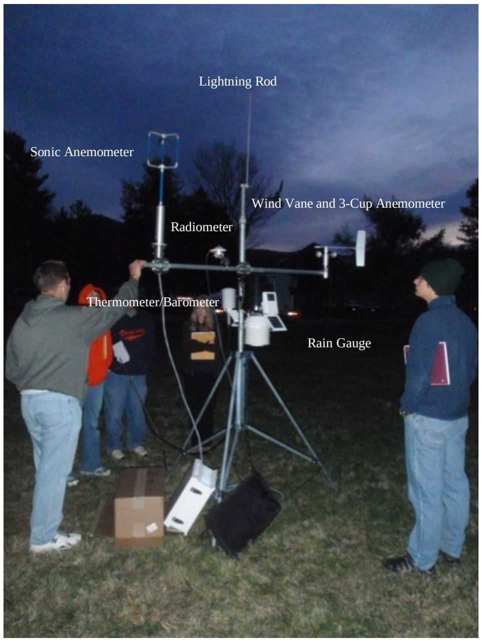
At the rear of the trailer there is a generator-powered cabin which is home to the brains of the mobile weather station. The cabin is full of computers analyzing streaming data received from the instruments on board and presenting it in a useable form. A GPS Advanced Upper-Air Sounding System (GAUS) is located within the cabin giving the MISS an ability to launch weather balloons measuring wind, pressure, temperature and humidity up to 60,000 feet into the stratosphere several times a day. The data from these launches are used to produce upper air soundings.

Mobile Integrated Sounding System (MISS)

All-in-all, the MISS is a very expensive piece of equipment costing upwards of $400,000.

- Radar Wind Profiler: $200,000
- Ceilometer: $25,000
- Tower Weather Station: $5,000
- GAUS Balloons: $20,000
- Computer Systems: $100,000

Aside from the MISS, De Wekker’s instruments included 10 HOBOs – used for collecting measurements of temperatureand humidity at fixed positions over a period of time, a temporary weather station – with the general temperature, , humidity, precipitation, wind speed and direction, incoming radiation measurements and a sonic anemometer – used to measure wind, momentum, and sensible heat fluxes. De Wekker also had his own radiosonde system (less expensive than NCAR’s) to be used with weather balloons.



Temporary Weather Tower

Not far from the NCAR site, data was also received from a meteorological tower in the Pinnacles Overlook area of Shenandoah National Park. The 15 meter tall tower reaching above the tree line contained sonic anemometers, a rain gauge, a CO_2 and H_2O gas analyzer – used to obtain CO and CO_2 profiles, a net radiometer – used to measure net radiation, and temperature, humidity, and wind measurements at three different levels on the tower.

Pinnacles Meteorological Tower (15 meters)

Questions

Many questions were formed previous to the week of the experiment as to what our data would discover. The known properties of temperature change over height was the focus of many questions such as, how deep will the temperature inversion formed overnight be? How long after sunrise will it be until the surface-based temperature inversion breaks up? And how often and under what conditions does a thermal belt form?

Questions formed about what events could take place during a poor weather event in the mountain environment were also asked. Can a thermal belt form if there is cloud cover? Can a surface-based temperature inversion form if there is cloud cover over night? And can a thermal belt form under high wind circumstances?

There were even several questions about the abilities of instruments on the MISS as well as at the Pinnacles Tower. Can the Ceiliometer detect the base of the clouds during heavy precipitation? Can the Radar Wind Profiler detect wind speed if there is a lack of aerosols in the air? And are the less expensive radiosondes owned by Professor De Wekker as accurate as the more expensive Vaisala radiosondes owned by NCAR?

As a group, we formed several hypothesis after discussing possible outcomes for our experiment and again, temperature inversions were a large part of our discussion. We hypothesized that the deepest inversion layer would be present during clear nights as compared to cloudy nights and we stated that on cloudy days, the surface-based temperature inversion would break up slowly or not at all. We also stated that a higher moisture content in the atmosphere would result in a weaker temperature inversion at the surface, due to the specific heat properties of water vapor affecting the air temperature.

Wednesday April 8, 2009

We arrived at park headquarters where the MISS and our temporary weather station were set up at 6:35am on Wednesday morning. The sun was just peaking over the horizon, but it was still fairly dark outside. The weather conditions were mostly cloudy and the forecast had called for scattered flurries. The temperature was hovering around 32ºF.

Mostly Cloudy – 7:00am

We first approached our temporary weather tower which was malfunctioning and tried to figure out what it was not logging data. Temple set to work attempting to repair logger in order for us to receive data from the sonic anemometer, radiometer and wind vane while Suzanne and I calibrated the Davis weather station products also attached to the tower.

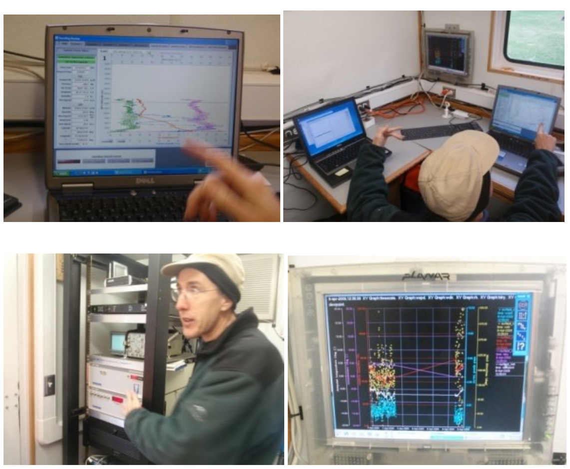
At 6:45am the NCAR scientists mobilized setting up the MISS and Professor De Wekker arrived shortly after at 7:00am.

The weather station was put on hold as we prepared a radiosonde launch. For this launch we attached one of the more expensive Vaisala radiosondes, that NCAR provided, to one of our own less expensive versions hoping to see if measurements from the different radiosondes gave similar data. We wanted to know if the more expensive radiosondes were worth the extra money, or if the less expensive ones worked just fine.

After preparation was complete the balloon was launched. Unfortunately our radiosonde failed, so the test was inconclusive, but we learned field work is very frustrating in this sense because many times experiments do not work out as planned, or the atmosphere does not cooperate. Fortunately the NCAR radiosonde was a success and a sounding of the atmosphere above the park was assembled.


Radiosonde Launch (Top left to bottom right: Professor De Wekker and Temple initializing radiosonde – NCAR attaching the two radiosonde – Radiosondes attached, ours right NCAR's left – Radiosonde launch.)

Once the balloon launch was over, Professor De Wekker drove to Pinnacles, the sight of his meteorological tower, to prepare the instruments there, while our group stayed and questions the NCAR scientists about the MISS. We were allowed into the cabin onboard where the data is processed, so we were able to see real-time readouts from the ceilometer, radar wind profiler and the tower weather station. We learned that the MISS is on the road for up to 3 months at a time chasing storms, researching mountain weather, and educating school groups like ours. The MISS was very useful last winter chasing snow storms and learning about the vertical profile or these winter systems. We were also told that the NCAR scientists would be involved with the VORTEX projects chasing tornadoes over the summer researching the properties of an air mass out in front of supercell thunderstorms.



Onboard the MISS (Top left to bottom right: Live streaming radiosonde data – Ceilometer data left screen and radiosonde data right screen – Lou showing us the radiosonde amplification and GPS hardware – Temperature, dew point, relative humidity, wind speed and direction readouts.)

Around 10:00am the group made our way up Skyline Drive to the Pinnacles tower in Shenandoah National Park. Here we were able to climb the 15 meter tall tower and examine the instruments attached. A new instrument that we did not have at our disposal at park headquarters was an open path gas analyzer that is used to measure fluxes of CO_2 and H_2O. Data from the tower was sent to a shed on the ground that housed the computers that processed and stored the information. The shed also contained the LIDAR that Professor De Wekker owned. It is highly sensitive and is able to see concentrations of aerosols in the atmosphere several kilometers above the mountain top.

Pinnacles tower instruments (Top left to bottom right: 3-cup anemometer with computer shed in background – LIDAR – Net radiometer – On the left, open path gas analyzer; on the right, sonic anemometer.)

The Pinnacles tower was the last stop on our trip to the park, but not the end of the experiment. The EDUCT project did not end until Saturday, the 11th of April with a full week's worth of data that has yet to be analyzed.