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Shenandoah Trip Paper

I visited Shenandoah National Park on April 11, 2009 to investigate the Education in Complex Terrain (EDUCT) experiment, conducted by the National Center for Atmospheric Research and University of Virginia. This multi-purpose experiment, which ran from April 6-11, sought to expose almost sixty visiting students to atmospheric measurement techniques and to investigate the diurnal behavior of the air closest to the surface in mountainous terrain. This so-called atmospheric boundary layer shows a decrease in temperature with increasing altitude during the day, but overnight develops a region of air near the surface called an inversion, where temperature instead increases with height. The top of the inversion, then, has the maximum air temperature and is called a thermal belt. Over flat terrain, this thermal belt is well above the surface, but in complex terrain, it may come in contact with the slope of the mountain. These phenomena, on which relatively little study has been done, were the focus of EDUCT's exploratory goals. Questions included how deep inversions were, how long they lasted, how often thermal belts formed along the slope, how weather conditions affected the formation of thermal belts and inversions, and what measurement techniques were most suitable for exploring these topics.

We came from the east of the park, through Sperryville, VA, and arrived at 8:30 AM. The whole eastern slope of the Blue Ridge Mountains was blanketed in fog, with visibility only about 50 feet. We first visited the UVA research facility in the Pinnacles area, which consists of an instrument-laden tower and a shed to house the data collection equipment. Of particular importance to this study was a LIDAR (Light Detection and Ranging) system connected to a data-collecting computer. The entire setup costs about $200,000. LIDAR works by firing a laser beam into the atmosphere twenty times per second, and detecting whether light is reflected or "backscattered" by particles in the atmosphere. The backscatter pattern can reveal whether particulate matter, or aerosols, is present in the atmosphere, and their relative concentration.

At about 9:15 AM, we traveled west of the mountains to the park headquarters, where NCAR's instruments were set up. As soon as we were descending the slope, the fog disappeared. This was because wind from the east blows air inland from the ocean, and it may be blocked by the mountains. Nighttime inversions can help trap the dammed air by isolating it from the rest of the atmosphere. This was a striking example of the unique and disruptive effects that mountains can have on the weather.

At NCAR's site, the launch of a radiosonde attached to a weather balloon was demonstrated by scientist Bill Brown and technician Lou Verstraete. A radiosonde is a small disposable measurement device that includes a temperature probe, a humidity sensor, a GPS antenna to calculate wind speed and direction, and a pressure sensor to calculate the altitude, since air pressure decreases at a known rate with height. The balloon is filled with about 30 cubic meters of helium gas The device transmits the data via radio to a receiver on the ground, which uses the data to create a vertical profile of the atmosphere called a sounding. A radiosonde costs about $200, and requires about $30 worth of helium to inflate the balloon. According to Brown, two to eight soundings are required to capture the general behavior of the lower atmosphere over the course of a day.

NCAR's other measurements were taken using their Mobile Integrated Sounding System (MISS), which is a trailer set up with a suite of meteorological instruments. They use a specialized type of LIDAR called a ceilometer, which is designed to detect the height of clouds in the sky. This is much "cheaper" than the model UVA uses, and costs about $25,000. The trailer also includes a radar unit which fires radio waves 2 or 3 kilometers into the air at three different angles. By trigonometrically interpreting the radio waves that are bounced back, the scientists can construct a vertical profile of the wind speed and direction. This equipment costs $300,000. Finally, the trailer is equipped with a $5000 weather station that measures humidity, temperature, dew point, rainfall rate, rainfall intensity, wind speed, and wind direction. The entire MISS trailer is worth $500,000.

UVA also had a remote weather station in operation at this location. This was equipped with a temperature sensor, rain gauge, radiometer and pyranometer (both of which measure incoming solar radiation), wind vane and cup anemometer (measures wind speed and direction), and sonic anemometer (more accurately measures wind). The wind vane is a long, rotating piece of material that points in the direction the wind is blowing, while the cup anemometer consists of three cups on spokes. The faster the wind blows, the faster the cups spin. The sonic anemometer consists of three speakers pointing towards three microphones, with each set oriented ninety degrees from the other two sets. The speakers emit sound waves which are picked up by the microphone, and the time difference between making and receiving the sound is recorded. Wind will affect the amount of time the sound wave takes to travel, so the instrument can calculate the speed and direction of the wind. The entire setup, including a $3,000 datalogger, costs about $15,000.

The EDUCT experiment was a good opportunity to witness science outside the classroom. It provided insight into the way various instruments work, and how a field campaign is set up and organized. It also demonstrated that a considerable amount of funding is required for such studies. On the scientific end, some of the initial observations will lead to new questions that will hopefully be explored in a long-term field study in Shenandoah National Park.

Photographs

Tower at Pinnacles

UVA LIDAR. The small hole is the transmitter and the large hole is the receiver.

The top box maintains a constant temperature inside the LIDAR, the middle box controls the laser firing, and the bottom is the CPU for data collection.

NCAR Mobile Integrated Sounding System trailer

NCAR ceilometer

NCAR radar unit

NCAR weather station

MISS control room. The screen is displaying real-time radar data

Weather balloon before launch

Weather balloon after launch

UVA weather station