The Lechuguilla Air Circulation Study

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The Lechuguilla Air Circulation Study is a project to map the barometric and non-barometric air circulation patterns in Lechuguilla and create an accurate model of airborne heat and water transport, including the affects of surface weather.

Introduction

Lechuguilla is a large cave system located in Carlsbad Caverns National Park with over 100 miles of passageway and over 1500 feet of vertical extent. Air movement has often been noted in the cave. In addition to the normal barometrically driven airflows in the main passageways leading to the entrance, other airflows appear deep within the cave system, far from any known entrance. Some airflows appear to be unidirectional, but little is actually know about these air currents. It has been hypothesized that there are permanent convection cells deep in the cave and that there may be considerable air exchange with the outside, but there is little data to support these theories or enable the two conditions to be separated.

The purpose of this project is to methodically map the airflows in the cave and to collect enough data to be able to accurately model the airflow based on thermal gradients, moisture gradients and interactions with the surface air mass.

Why is airflow important? There are many processes in the cave that cannot be well understood until the airflows are well understood. These include lake level changes, geological processes that formed the cave that may still be at work and the biological processes that have only recently been discovered. Knowing the airflow will also assist the exploration effort by identifying new airflows where major passage is not known to exist.

Methodology

The data collection will be done by a network of in-cave environmental monitoring stations that will record wind, temperature, humidity, barometric pressure, human presence and time to a very high accuracy.

The study will progress by placing enough monitoring stations in a new study area to be able to accurately model the airflow in that area. Large rooms and complex passages will require a higher monitoring station density than a long simple passage. Once sufficient data has been collected, most monitoring stations will be moved to the next adjacent study area, leaving only a sparse network of monitoring stations at critical locations.

The length of time a passage will be studied depends upon evidence of outside air interactions. If there are no variations noted in the initial study period, than we may conclude the airflow in that area is stable and not interacting with the surface and the monitoring stations may be moved to the next study area. However, if outside air interaction can be demonstrated, than the study time

will have to be extended to account for seasonal variations. It may also necessitate additional monitoring stations to track down the source of the surface interactions.

Our starting hypothesis is that the minimum study period for an area will be 3 months and the maximum study period will be one year. We recommend the data be collected from every monitoring station on a 3 to 4 month cycle and that the data undergo a preliminary analysis in the cave. In-cave analysis will maximize the opportunity to get the most useful data with the fewest trips.

As this study will require collecting data over an extended period of time, provisions should be made for including additional personnel to ensure its long term success.

Instrumentation

The draft design specification for the environmental monitoring station is available at:

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http://www.hdssystems.com/AirStudyStationSpec.pdf
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Each monitoring station will be designed to collect a minimum of 12 months of continuous data and store it in non-volatile memory. This long time period is necessary to allow for trip scheduling and to minimize the chance of gaps in the data if a trip is delayed. The primary limit affecting longevity is battery power.

The current conditions will be sampled every 10 minutes. Each sample will include station location, date and time, wind speed and direction, wet and dry bulb temperatures, barometric pressure and a human presence detected flag. All monitoring stations will be uniquely identified, time synchronized, precisely aligned and located to maximize the usefulness of their data. Their location must be exactly noted on both plan and profile maps.

The accuracy (repeatability) of the data is very important to the success of this project. The target accuracies (repeatabilities) are 1mm/S for wind, 0.001 degree C for wet and dry bulb temperatures and 0.01 millibars for barometric pressure. Synchronization across all monitoring stations should be maintained within 15 seconds.

Data samples will be stored as uncompressed ASCII text using fixed width fields, field delimited and terminated with an end-of-line sequence. Each sample will be about 75 bytes long. Data volume is not considered an issue while ease of data interpretation is. At a 10 minute sampling interval, data space required is 450 bytes per hour, 11K bytes per day, 320K bytes per month and 3.8M bytes per year. Data volume does not include configuration and health monitoring comments, which are expected to add about 10% to the data volume.

The project will require 20 monitoring stations for the study. However, the Cave Resources Office has asked for additional monitoring stations to be placed in Carlsbad Caverns. These extra monitoring stations can also serve the purpose of hot spare units in case a failure is discovered during a data gathering trip.

Publishing

The investigators shall retain a copyright on all raw data, intermediate reports and final reports generated as part of this study. However, as a condition of being allowed to perform this study, the investigators shall grant the Park a license to use the data and reports without restriction for any purpose other than for sale.

The Park shall be provided with a complete set of any raw data, intermediate reports and final reports that are generated as part of this project by the investigators. The Park shall be provided with said data and reports at the sole expense of the investigators.

The investigators shall be free to publish data and reports resulting from this study, and are encouraged to publish said data and reports for the benefit of all concerned. These publications may be offered for sale to recover costs incurred during the study and subsequent publication.

Funding

The environmental monitoring stations are estimated to cost about $1600 each ($4500 list), quantity 20, excluding the cost of development and labor. As a result, I will be looking for grants and corporate sponsorship to assist in the development and acquisition of hardware.

Funding organizations shall be recognized in all reports. Further, major funders will have the option of having their logo placed on monitoring stations used in the study.

Participants

Henry Schneiker has over 25 years experience as computer and electronic engineer with strong background in business, project management and accounting. Henry has designed, prototyped, tested, documented and manufactured many products including complex software and hardware systems. Henry owns and has operated a private engineering firm for the last 18 years. Henry has over 30 years of caving experience and has been involved as a research assistant for various projects including Life in Extreme Environments (NASA) and Kartchner Caverns environmental baseline study and bat research.

Glenn Hamblin. Electronic engineer with strong experience in instrumentation, embedded controllers and networking. Glen has over 15 years experience in designing, prototyping, testing, documenting and overseeing the manufacture of hardware devices including industrial instrumentation, embedded hardware and software and device drivers.

Bob Buecher is a registered professional engineer and land surveyor in Tucson, Arizona. He was Project Manager for the Pre-development Baseline Study for Kartchner Caverns, in southern Arizona. There he directed studies of the cave microclimate, geology, mineralogy, biology, hydrology, geophysics, and mapping of the cave. The cave has a maternity colony of cave myotis (*Myotis velifer*) and the study stressed low disturbance techniques to monitor the bat population. He has been technical assistant on a 12-year study of the endangered nectar bat (*Leptonycteris corosoe*) in two roosts at Fort Huachuca, Arizona. He was also technical assistant on a Bureau of Land Management project to monitor 4 cave myotis roosts in the Guadalupe Mountains, New Mexico. He has designed and built cave gates, motion sensors, and bat counters to be used in remote sites.

Debbie Buecher holds a B.S. degree in biology and is currently pursuing a Master's degree in Wildlife Ecology in the Renewable Natural Resources Department at the University of Arizona. She has worked on bat research for 15 years throughout the United States. She worked for 16 years as a civil designer and was cartographer and hydrologist on the Pre-development Baseline Study for Kartchner Caverns, Arizona. Her current research involves analysis of species diversity, activity patterns and diet analysis between bats in a natural Sonoran Desert riparian corridor and an urbanized setting. Little is known regarding the impact of urbanization on desert bat communities and the results of her work should provide information for resource managers developing long-term management plans in the southwest.