Project seeks monsoon storm source

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This monsoon season will be like no other, according to Joseph Zehnder, a meteorologist with Arizona State University. The reason is because it will be studied more extensively than any other monsoon season.

Beginning this July, Zehnder will lead a team of nearly 20 researchers to study the formation of monsoon storms in the Santa Catalina Mountains near Tucson, Ariz. Using an armada of instrumentation on land and flying or floating overhead, the team will train digital cameras, sounding balloons and a specially instrumented airplane, on the genesis of monsoon thunderstorms.

The data they record will allow them to build accurate representations of the very beginnings of the monsoon storms, which sometimes develop into chaotic and hard to predict wind, dust and rain storms throughout southern Arizona. It will be the first time researchers will pinpoint the crucial first stages of monsoon storm formation, Zehnder said.

“The very first stages of thunderstorm development are seen as critical to their formation, long before they become chaotic and violent storms, but very little is known about these early stages of cloud and storm development,” Zehnder said. “It is impossible to study this early stage without knowing where the storms will develop. Since the clouds form very reliably over the mountain peaks, they provide us with a natural cloud laboratory.

“We will be able to sample the environment before the clouds form and monitor their growth and the way they modify their environment,” Zehnder explained. “The sampling from prior to the cloud formation until the development of a thunderstorm hasn't been done before.”

“The data we collect will increase our understanding of the onset and development of summer monsoon storms in Arizona,” Zehnder added. “We expect that this information will help weather forecasters improve their short-term forecast models as well as longer range climate models.”

The Cumulus, Photogrammetric In-Situ and Doppler Observations project will consist of coordinated observations using pairs of stereo cameras, a network of surface weather stations, GPS-based vertical sounding systems and the specially instrumented aircraft. This summer's field studies are the culmination of a three-year study, in which the researchers developed stereo analysis techniques for analyzing the cloud formation and refined the photogrammetric techniques. Preliminary work has given the researchers an idea of how to place cameras for optimal imagery.

The researchers will be installing equipment at the end of June. The project will run from July 1 to Aug. 31, with an intensive operation period of July 18 to Aug. 17.

“We are trying to unravel and understand natural phenomena, which ultimately we want to mathematically model,” said Anshuman Razdan, director of the Imaging and 3D Data Exploitation and Analysis Lab (I3DEA) and associate professor in the Division of Computing Studies at ASU's Polytechnic campus. Razdan also is a researcher at ASU's Partnership for Research in Spatial Modeling (PRISM), which will be doing much of the data collection and image processing for the project. “The better understanding we can glean from the images and 3D reconstruction, the better information we can provide Prof. Zehnder in his modeling effort.”

Summer thunderstorms over the mountains in the desert southwest build slowly and in stages in spite of unstable conditions. The "sky islands" of the desert southwest serve as a natural laboratory for the study of cumulus clouds owing to the development in a fixed location under the influence of heating and moisture transport.

"The interaction between the clouds and the environment (wind and temperature profiles) is important in reality and it is not captured well in the models," Zehnder said.

The team – which includes researchers from ASU, University of Wyoming, the U.S. National Center for Atmospheric Research, University of Arizona, University of Miami and the University of Alabama-Huntsville – will use a wide range of instruments and deployments to obtain data. The $1.3 million project is funded through the U.S. National Science Foundation.

A network of 10 surface weather stations will be located at the base of the mountains. Four of the stations will be equipped with additional sensors to monitor surface heat and moisture transport in addition to meteorological conditions, Zehnder said.

Surface stations located around the base of the Santa Catalina Mountains will measure the upslope transport of warm and moist air. Conditions at the top of the mountains will be monitored by a 30-m tower located at the top of Mt. Bigelow.

There will be five digital cameras located at various points around the mountains as well to record storm formation and transport.

Changes to moisture and temperature above the mountains will be monitored via two mobile balloon-based sounding systems. These systems will use instrument packages that measure temperature and moisture content and are tracked via global positioning systems.

Additional details on the conditions above the mountains, as well as internal structure of the clouds will be obtained with the University of Wyoming's King Air airplane outfitted with 95 GHz (W-band) Wyoming Cloud Radar, which is capable of 30 m resolution. The radar will reveal details of circulations within the surrounding clouds.

Results of the work will include several time-lapse movies of monsoon storm formation with computer-aided animations and scientific data transposed over the digital images to show cloud structure and dynamics. The researchers will have multiple sources of the same data with cross validation that should result in 3-D images and plots of the monsoon as it first fires up through completion of violent storm surges.

Zehnder said the work has the goal of improving short-term predictions of weather during monsoon storms, and to help weather forecasters feel less at the mercy of what can be a chaotic, hit or miss monsoon storm season.

“The models we use for weather forecasting and large-scale climate forecasting have assumptions in them on the rate of initial cloud development that are based for the most part on observations. Details of the relation between cloud development and environmental conditions are still not well understood,” Zehnder said. “We have the potential for capturing data in several different media and modes on the initial cloud development and we could make those models much more accurate for future forecasts.”

Razdan and research scientist Jiuxiang Hu have developed novel algorithms for stereo reconstruction and increasing the accuracy in depth measurement of large-scale objects that are far from the camera.

“Such interdisciplinary collaboration is key to solving complex problems such as this one,” Razdan said. “The exciting part is that our algorithms developed for this project can be applied to other problems in the geo-spatial domain.”

Source: Arizona State University