What Cosmic Rays Deep Underground Can Tell Us About The Weather

Cosmic-rays detected half a mile underground in a disused U.S. iron-mine can be used to detect major weather events occurring 20 miles up in the Earth's upper atmosphere, according to a new study published in *Geophysical Research Letters* and led by scientists from the UK's National Centre for Atmospheric Science (NCAS) and the Science and Technology Facilities Council (STFC).

The study shows how the number of high-energy cosmic-rays reaching a detector deep underground, closely matches temperature measurements in the upper atmosphere (known as the stratosphere).

For the first time, scientists have shown how this relationship can be used to identify weather events that occur very suddenly in the stratosphere during the Northern Hemisphere winter. These events can have a significant effect on the severity of winters we experience, and also on the amount of ozone over the poles - being able to identify them and understand their frequency is crucial for informing our current climate and weather-forecasting models to improve predictions.

[Video]...

http://www.scientificblogging.com/news_releases/what_cosmic_rays_deep_underground_can_tell_us_about_weather

Video of Sudden Stratospheric Warming occurring in the Southern Hemisphere (see ozone patterns for September 25th 2002). This is the only such event recorded in the Southern Hemisphere (they normally occur in the northern hemisphere)

Working in collaboration with a major U.S.-led particle physics experiment called MINOS (managed by the U.S. Department of Energy's Fermi National Accelerator Laboratory), the scientists analysed a four-year record of cosmic-ray data detected in a disused iron-mine in the U.S. state of Minnesota.

What they observed was a strikingly close relationship between the cosmic-rays and stratospheric temperature - this they could understand: the cosmic-rays, known as muons are produced following the decay of other cosmic rays, known as mesons. Increasing the temperature of the atmosphere expands the atmosphere so that fewer mesons are destroyed on impact with air, leaving more to decay naturally to muons. Consequently, if temperature increases so does the number of muons detected.

What did surprise the scientists, however, were the intermittent and sudden increases observed in the levels of muons during the winter months. These jumps in the data occurred over just a few days. On investigation, they found these changes coincided with very sudden increases in the temperature of the stratosphere (by up to 40 oC in places!). Looking more closely at supporting meteorological data, they realised they were observing a major weather event, known as a Sudden Stratospheric Warming. On

average, these occur every other year and are notoriously unpredictable. This study has shown, for the first time, that cosmic-ray data can be used effectively to identify these events.

Lead scientist for the National Centre for Atmospheric Science, Dr Scott Osprey said: “Up until now we have relied on weather balloons and satellite data to provide information about these major weather events. Now we can potentially use records of cosmic-ray data dating back 50 years to give us a pretty accurate idea of what was happening to the temperature in the stratosphere over this time. Looking forward, data being collected by other large underground detectors around the world, can also be used to study this phenomenon.”

Dr Giles Barr, co-author of the study from the University of Oxford added: “It's fun sitting half a mile underground doing particle physics. It's even better to know that from down there, we can also monitor a part of the atmosphere that is otherwise quite tricky to measure”.

Interestingly, the muon cosmic-ray dataset used in this study was collected as a by-product of the MINOS experiment, which is designed to investigate properties of neutrinos, but which also measures muons originating high up in the atmosphere, as background noise in the detector. Having access to these data has led to the production of a valuable dataset of benefit to climate researchers.

Professor Jenny Thomas, deputy spokesperson for MINOS from University College London said “The question we set out to answer at MINOS is to do with the basic properties of fundamental particles called neutrinos which is a crucial ingredient in our current model of the Universe, but as is often the way, by keeping an open mind about the data collected, the science team has been able to find another, unanticipated benefit that aids our understanding of weather and climate phenomena.”

Dr Osprey commented: “This study is a great example of what can be done through international partnerships and cross-disciplinary research. One can only guess what other secrets are waiting to be revealed.”

Article: Sudden stratospheric warmings seen in MINOS deep underground muon data. Osprey, S.M. et al., Geophys. Res. Lett., doi:10.1029/2008GL036359, in press.