MIT researcher uses lightning as a framework for monitoring global atmospheric change

February 17, 1998

PHILADELPHIA, Penn.--With an aluminum ball on a 10-meter pole planted in a desolate Rhode Island forest, MIT researcher Earle R. Williams can tell you when a red jellyfish-shaped glow flashes in the night sky thousands of miles away.

That fleeting glow, called a sprite, is the signature of a mother of a thunderstorm that occurs in the wee hours of the morning in the Earth's upper atmosphere.

Sprites are just one of the many atmospheric phenomena Williams can "observe" from the single station in Rhode Island. By keeping track of tiny variations in the amplitude of the planet's natural electromagnetic variations, Williams is able to monitor huge thunderstorms called mesoscale convective systems that cause positive ground flashes and sprites. The more continuous background radiation is dominated by ordinary tropical thunderstorms, which appear to respond sensitively to surface air temperature.

Principal research associate in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology, Williams will present a talk on the global electrical circuit in a symposium, "Atmospheric Electricity: The Legacy of Benjamin Franklin," at the annual meeting of the American Association for the Advancement of Science on Tuesday, February 17.

A signal from above

The Earth's weather, confined between two electrical conductors (the earth's surface and the ionosphere), produces direct current that feeds into the electrical circuit that surrounds the planet like a halo.

The weather also produces lightning, which fills the cavity under the ionosphere with extremely low frequency radiation called Schumann resonances.

Four years ago, with MIT meteorology graduates Robert Boldi, Stan Heckman and Dennis J. Boccippio, Williams erected his detection apparatus in relatively unpopulated West Greenwich, R.I., far from the interfering noise and hubbub of Cambridge, Mass.

The goal was to capture the very small signal of the Schumann resonances. This oscillation of energy, trapped between the Earth and the ionosphere, pulses like a giant tuning fork at a remarkably consistent 8 Hz. You can detect its presence with sensitive magnetometers.

"The cavity between the Earth and the ionosphere sets up a resonant waveguide for the Schumann resonances, which gets 'plucked' every time there is lightning," Williams said. "The big storms that cause sprites pluck it most strongly."

Taking advantage of the Schumann resonances and the global electrical circuit that co-exist in the 80-kilometer-high spherical cavity between the ground and the ionosphere, Williams gets a rare, Earth-bound view of the entire planet at once.

"The global circuit provides a natural framework for monitoring the entire planet from single measurement sites" like the one in Rhode Island, Williams said.

His more than three years of data provide the most comprehensive record of global lightning activity to date. This continual measurement of the global circuit provides a framework for monitoring changes in convective weather around the planet.

Because of the connection between the frequency of lightning and temperature, Williams' data also provides evidence for global temperature change, which can be analyzed by day or by season. The 1972 El Nino, for instance, appears to have caused a substantial blip in the global circuit.

"This is an inexpensive, natural framework for monitoring the whole planet," he said.

The planet electric

Ben Franklin's belief that the world was naturally electrified led him to tie a metal key to a kite to prove that lightning is really a string of electricity.

The Earth's abundance of saltwater and generally high water content make it a good conductor. Because the air is a poor conductor, the atmosphere acts as an insulator.

But while Ben Franklin speculated about a global circuit in the 1700s, his information was incomplete without the knowledge of another conductor above the atmosphere. That conductor--the ionosphere--wouldn't be discovered for another 150 years.

In an electric circuit, positive and negative charges flow in a loop from one end of the source of electricity to the other.

If the charges come in contact with a conductor, the negatively charged electrons travel through the material to neutralize any positive charges. This movement of electrons through a conductor, like water through a hose, is called Direct Current (DC).

While man-made electricity is produced by batteries and motors and uses metals and other substances as conductors, the natural electricity surrounding the planet needs no human intervention to replenish itself.

Without some source of electric charge, "you would expect the Earth's negative charge to leak away and make the planet neutral. But that didn't happen," Williams said.

What Franklin didn't know is that thunderstorms are the power supply for the 250,000 volts between the Earth and the highly conductive ionosphere and the 1,000-ampere current that flows through the atmosphere in response to this voltage difference.

This current flows up through all the thunderstorms, outward into the ionosphere and then back to Earth in the fair-weather regions of the world to return to the thunderstorm sources through the conductive Earth.

While working in Darwin, Australia, Williams noticed that the frequency of lightning seemed to be related to the surface air temperature. This gave him the idea of using global circuit measurements as a diagnostic for global temperature change.

MIT home
news office
room 11-400
77 massachusetts avenue
cambridge, ma 02139-4307
617-253-2700
newsoffice@mit.edu