SOLAR LINKAGES TO ATMOSPHERIC PROCESSES

Solar Linkages to Atmospheric Processes is an International Polar Year project investigating the links between changes in solar output, and weather and climate.

Ever since the early 1800s when William Herschel, the Astronomer Royal, noted an anti-correlation between the price of wheat and the number of sunspots, many researchers have reported apparent links between solar and weather-related variables. Unfortunately, the research field of solar-terrestrial linkages is littered with examples of poor statistical analyses. Many claims of correlations have been reported and almost as many have been refuted by additional data and further analysis.

The energy associated with variations in the sun's output are small compared with the total energy it supplies, and to the energy accumulated within the global weather system. As a result, a mechanism through which solar variations can influence the weather has been difficult to find.

A number of hypotheses linking solar variability and weather have been proposed, including through changes in ozone concentration and heating in the stratosphere, and fluctuations in energy output during the 11-year solar cycle. More controversially, cosmic rays (radiation from space) vary in intensity by about 15% over a solar cycle and have been reported to be correlated with cloud formation. A variation in cloud formation can influence weather and climate by altering the fraction of solar energy reflected or absorbed by the lower atmosphere.

Through the Solar Linkages to Atmospheric Processes project, scientists at the Australian Antarctic Division will look at one mechanism by which cosmic rays may be linked to cloud formation – the global atmospheric circuit.

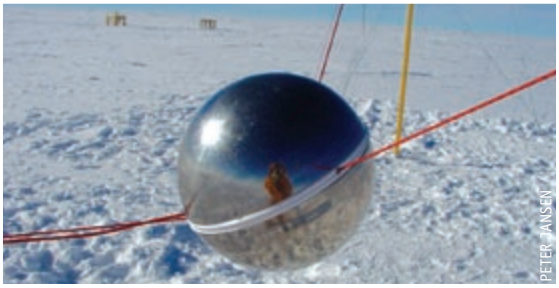
Lightning is the component of the global atmospheric circuit we are most familiar with, and is the visual representation of current flowing upwards to the thunderclouds. Thunderstorms are the 'batteries' in the global atmospheric circuit, which drive current from the ground to the lower reaches of the ionosphere, some 80 km above.

While thunderstorms and strongly electrified clouds are the dominant controllers of the global atmospheric circuit, in the polar regions the interaction of the solar wind and the Earth's magnetic field – the same process that leads to the aurora (seen here over Newcomb Bay at Casey) – also contributes to this circuit

The current returns from the ionosphere to the earth, completing the circuit in a less spectacular 'drizzle' over the portion of the globe not covered by thunderstorms. Cosmic rays dominantly control atmospheric conductivity and thus modulate the current that flows in the global circuit.

Scientists have proposed that the global atmospheric circuit influences cloud development by initiating a range of microphysical processes. These include electrical influences on the formation of cloud aerosols in the atmosphere, which may affect cloud lifetime, ice formation and precipitation.

GARY BURNS



PETER JANSEN

The Air-Earth Current Meter deployed at Vostok. This instrument measures the miniscule current (about 6 picoamps per square metre) flowing from the ionosphere to the ice through the suspended split-sphere. A picoamp is 10^{-12} of an ampere – approximately 160 000 000 000 times smaller that the current through a 60 watt light bulb.

CHRIS WILSON

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Since 1998 we have been studying the atmospheric circuit at Vostok, in Antarctica, and have recently published a paper showing a link between the solar wind (charged particles streaming away from the sun's surface) and pressure at ground level. Additionally, our measurements demonstrated the enhanced influence of the global thunderstorms on pressure in a manner consistent with the cloud microphysics mechanism. If this hypothesis is confirmed, then the influence of this microphysics mechanism extends globally, via the atmospheric circuit and cosmic ray modulation. It also provides a link between equatorial thunderstorms and polar clouds.

Through our International Polar Year project, we will make measurements of the global atmospheric circuit on the Antarctic plateau, to increase our understanding of the links between the atmospheric circuit, solar variability and weather.

Instruments for measuring the atmospheric circuit at Vostok have recently been upgraded, and we hope to deploy further instrumentation at Concordia and South Pole. The British Antarctic Survey deployed instrumentation at two sites in Western Antarctica in 2006-07, and plans an additional deployment in 2007-08. Measurements at even these few sites will enable us to significantly improve our understanding of the global atmospheric circuit by resolving the major drivers (thunderstorms and the solar wind) and enable us to better test the hypothesis that the atmospheric circuit influences cloud microphysics.

The Electric Field Mill deployed at Vostok measures the vertical electric field (volts/metre).

A global circuit model is under continuing development and data from our project will be compared with model predictions, to confirm or refine our understanding of the processes involved. The global model will also enable us to extend our measurements, to better predict global and climate duration implications.

The atmospheric circuit is expected to be strongly influenced by climate change. Thunderstorm activity is strongly dependent on summer equatorial temperatures, and global lightning activity is expected to increase by the order of 10% for a 1°C increase in average temperatures. Measurements made during the International Polar Year of the annual-seasonal diurnal variations of the global contribution of the meteorological batteries, will provide a reference against which future climate variation can be determined.

GARY BURNS

More detail of the scientific aims of our project is provided at http://globalcircuit.phys.uh.edu/SLAP/SLAP_web_content.htm, which also includes updates of the most recent nine days of atmospheric circuit measurements at Vostok.

Gary Burns
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