Stratospheric data aid climate forecasts

Including the upper atmosphere in weather models helped understanding of rare Antarctic event.

BY DYANI LEWIS

For the past month, a rare atmospheric phenomenon has been brewing above Antarctica, raising temperatures in the upper atmosphere by 40 degrees and threatening to reverse the direction of a powerful jet stream for only the second time since records began.

At the first signs of this event, known as sudden stratospheric warming, Eun-Pa Lim, a climate scientist at the Australian Bureau of Meteorology in Melbourne, plugged the rising temperatures into a model she had designed that forecasts short-term climate over the Southern Hemisphere (E.-P. Lim et al. J. Geophys. Res. Atmos. 123, 12002–12016; 2018). The model predicted that the warming above Antarctica will drive hot, dry winds across eastern Australia over the next three months.

The forecast has excited meteorologists because it shows how far the field has come in understanding the stratosphere — the second major layer of Earth’s atmosphere — and its effects on weather.

For decades, meteorologists thought weather was mostly driven by what was happening in the troposphere, the layer between the stratosphere and Earth’s surface. Then, in 2001, daily stratospheric weather maps revealed how the two regions interact (M. P. Baldwin and T. J. Dunkerton Science 294, 581–584; 2001). Now these interactions are being included in models such as the one designed by Lim to forecast short-term climate — conditions occurring between a 7–10-day weather forecast and the following 3 months — around the world. For instance, meteorologists can now predict how conditions in the stratosphere will affect a climatic phenomenon that drives heavy rainfall in the United States in winter.

“We have a much better understanding of how the stratosphere affects the weather at the surface,” says Adam Scaife, head of long-range forecasting at the Met Office Hadley Centre for Climate Science and Services in Exeter, UK.

Improved accuracy and confidence in such forecasts makes a big difference to government agencies preparing for heatwaves or fires, as well as to farmers, such as those in drought-affected eastern Australia, when planning irrigation or herd-mustering schedules, says Lim.

Sudden stratospheric warming events are common in the Northern Hemisphere, occurring every second year, on average, but they are rare in the Southern Hemisphere. The first such event recorded in the south, in 2002, took scientists by surprise.

Even if they had known it was coming,
models back then couldn’t have predicted how the abrupt warming in the stratosphere might affect the weather, says Harry Hendon, head of climate processes at the Australian Bureau of Meteorology.

Climate models have improved significantly over the past 15 years, partly driven by faster, cheaper computers. They’re also much better at combining sources of observational data, such as satellite measurements of stratospheric temperature and atmospheric humidity.

Such advances helped meteorologists to forecast the start of the current stratospheric warming about a week in advance. The events typically start towards the end of winter, when mountains or the contrast between warm ocean temperatures and cold land masses generate continental-scale atmospheric disturbances known as Rossby waves. If these are large enough, they can reach into the stratosphere and break like a wave over a beach, compressing and warming the air in the stratosphere above the pole. This pressure can force the strong stratospheric winds encircling the pole — the polar-night jet stream — to abruptly slow and reverse, changing from being westerly winds to flowing in an easterly direction, says Scaife.

A complete reversal has not yet occurred in the current event, but wind speeds have already plummeted. Scientists at the Bureau of Meteorology don’t know exactly what sparked this year’s event, but they predict that it will be stronger than in 2002 — and so have a greater effect on the weather.

**MEDICINE PRIZE**

**Biologists who decoded oxygen sensing win Nobel**

**Laureates’ discovery underpins understanding of diseases such as anaemia and cancer.**

**BY HEIDI LEDFORD & EWEN CALLAWAY**

A trio of researchers has won the 2019 Nobel Prize in Physiology or Medicine for describing how cells sense and respond to changing oxygen levels by switching genes on and off — a discovery that has been key in understanding human diseases such as cancer and anaemia.

The three scientists are cancer researcher William Kaelin at the Dana-Farber Cancer Institute in Boston, Massachusetts; physician-scientist Peter Ratcliffe at the University of Oxford, UK, and the Francis Crick Institute in London; and geneticist Gregg Semenza at Johns Hopkins University in Baltimore, Maryland.

The team also won the Albert Lasker Basic Medical Research Award in 2016.

Their work has helped researchers to understand how the body adapts to low oxygen levels by, for example, cranking out red blood cells and growing new blood vessels.

“This is a fundamental discovery that they’ve contributed to,” says Celeste Simon, a cancer biologist at the University of Pennsylvania in Philadelphia. “All organisms need oxygen, so it’s really important.”

“The field really coalesced around this discovery, which was dependent on each one of their findings,” says Randall Johnson, a physician-scientist at the University of Cambridge, UK, and the Karolinska Institute in Stockholm, and a member of the Nobel Assembly. “This really was a three-legged stool.”

**OXYGEN DEPRIVATION**

The body’s tissues can be deprived of oxygen during exercise or when blood flow is interrupted, such as during a stroke. Cells’ ability to sense oxygen is also crucial for the developing fetus and placenta, as well as for tumour growth, because the mass of rapidly growing cells can deplete oxygen in a tumour’s interior.

In work conducted in the 1990s, the scientists discovered the molecular processes that cells go through to respond to oxygen levels in the body. They found that central to this is a mechanism involving proteins called hypoxia-inducible factor (HIF) and VHL.

Semenza and Ratcliffe studied the regulation of a hormone called erythropoietin (EPO), which is crucial for stimulating the production of red blood cells in response to low oxygen levels. Semenza and his team identified a pair of genes that encode the two proteins that form the protein complex HIF; which turns on certain genes and boosts EPO production when oxygen is low.

Meanwhile, Kaelin showed that a gene called VHL also seemed to be involved in how cells respond to oxygen. Kaelin was studying a genetic syndrome called von Hippel-Lindau’s disease; families with the disease carry mutations in VHL, and the condition raises the risk of certain cancers.