CLIMATE IMPACTS

Thermal threshold

Proc. Natl Acad. Sci. USA **106,** 15594–15598 (2009)

Crop yields in the United States — the world's largest exporter of agricultural products — could fall as much as 82 per cent by 2100 if temperatures rise sharply, according to a new study.

Wolfram Schlenker of Columbia University, New York, and Michael Roberts of North Carolina State University in Raleigh examined the effects of growing-season temperatures on corn, soybean and cotton yields in the US using agricultural records and detailed weather data collected between 1950 and 2005. They found a nonlinear relationship between temperature and productivity: yields increased modestly until a threshold temperature was reached at 29 °C for corn, 30 °C for soybean or 32 °C for cotton, after which they declined. This was true for all regions of the US, including the warmer southern states. Using a global climate model, Schlenker and Roberts found that if temperatures rise slowly, yields could fall 30 to 46 per cent by 2100, but that the drop could be as much as 82 per cent under a rapid warming scenario.

The study, however, did not account for gains in productivity caused by elevated CO_2 concentrations, which may at least partially offset any decline in yield due to warming.

Anna Armstrong

CLIMATE VARIABILITY

Bucking the trend

Science **325,** 1236–1239 (2009)

The rapid Arctic warming documented in the twentieth century comes on the heels of a 2,000-year-long cooling trend, finds new research. The study, which is the first to resolve temperature in the region on a decade-by-decade basis over the past two millennia, provides new evidence that recent warming is the result of greenhouse gas emissions.

Darrell Kaufman of Northern Arizona University and colleagues compiled data from tree rings, ice cores and lake sediments to reconstruct temperature trends across the region. The reconstructions reveal that, on average, temperatures cooled by 0.22 ± 0.06 °C per thousand years over the past two millennia. The researchers attribute this trend to cyclical changes in the Earth's orbit around the sun, which have caused less sunlight to reach high northern latitudes during summer months over the past few thousand years. A climate model simulation supports their conclusion.

Although the cooling orbital cycle continued, by the twentieth century human-induced warming became the dominant influence on the climate. Arctic summers during the mid-twentieth century were 0.7 °C warmer than would have been expected on the basis of the cooling trend alone, and four of the five hottest decades of the 2,000-year reconstruction occurred between 1950 and 2000.

Alicia Newton

CRYOSPHERE

High altitude

Geophys. Res. Lett. **36,** L17701 (2009)

A new study adds to the evidence that glaciers in high mountain regions are under threat from climate change. The altitude at which temperature reaches 0 °C — known as the freezing-level height — indicates whether high-elevation glaciers are likely to lose mass through surface melting.

Now Raymond Bradley at the University of Massachusetts in Amherst and colleagues show that freezing-level height has risen over most of the tropical Andes during the past three decades. Their finding is consistent with observed changes in surface temperature and upper-air data in the region, which has experienced a temperature increase of 0.1 °C per decade over the past half-century. Strikingly, they find that the summit of the Quelccaya ice cap in Peru — the largest body of ice in the tropics — frequently experiences daily maximum temperatures above freezing between October and May. At the ice-cap margin at 5,200 metres, temperatures rise well above freezing for much of the year.

The authors say this phenomenon is likely to be affecting other high-elevation glaciers in Ecuador, Peru and Bolivia, with potentially serious implications for the region's water supply.

Olive Heffernan

ENERGY

Price of power

Science **325,** 1378–1380 (2009)

By taking full advantage of its wind resources, China has the potential to relinquish its dependence on coal, say researchers. China currently builds the equivalent of two coal-fired power plants per week to feed its growing appetite for electricity.

Using meteorological data from varied sources, Michael McElroy of Harvard University in Cambridge, Massachusetts, and colleagues mapped out wind speeds across China and identified the spots where turbines could generate enough electricity

to make a profit, given the current price of wind-based electricity. Deploying farms in the windiest areas would be most cost-effective, at 5.8 US cents per kilowatt-hour or less, and could displace 23 per cent of the nation's current coal-fired electricity. But if turbines were also installed in less optimal areas, they could meet the entire projected electricity demand in 2030 — twice current consumption — at a cost of 7.6 cents per kilowatt-hour. Though more expensive, this is still competitive with current prices.

China clearly has the wind capacity to replace coal, but doing so would cost trillions. A more tractable goal, say the authors, would be to reduce the growth of power-sector emissions 30 per cent by 2030, which could be achieved with a $900-billion investment in wind energy.

Anna Barnett

ATMOSPHERIC SCIENCE

Balanced budget

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J. Geophys. Res. **114,** D17107 (2009)

Scientists have devised a novel, more exact way of gauging the effect of aerosols on the Earth's climate. Their study confirms that anthropogenic aerosols in the atmosphere cool the planet but rules out some of the upper estimates of the extent to which the tiny airborne particles can temper warming.

Daniel Murphy of the US National Oceanic and Atmospheric Administration and colleagues took a unique, observation-based approach to calculating the aerosol effect: they treated the Earth's energy budget like a bank account, albeit a complex one. Using the simple physical principle of conservation of energy, they calculated all the known drivers of climate change since 1950, such as greenhouse gases, volcanic eruptions and solar variations. This 'credit' was then compared to the sum of the 'debits' — that is, the heat content of the Earth and the amount of energy released back into space. Once everything had been totalled, they found that there was a missing cooling factor. This missing debit — about 1.1 watts per square metre between 1970 and 2000 — can primarily be attributed to the direct and indirect forcing of aerosols from human sources such as pollution and biomass burning.

The team's new calculation increases confidence in our understanding of this aspect of the climate system.

Alicia Newton

BIOLOGY

Meat-eater's malady

Food Res. Int.
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The quality of meat — from pork chop to rump steak — will deteriorate as the world warms, says animal physiologist Neville Gregory of the Royal Veterinary College in London. Gregory's conclusion, based on a review of experimental and field observations of animals, adds to the evidence that climate change will adversely affect the human diet.

Gregory found that extreme summer temperatures could increase the mortality of pigs, poultry, sheep and cattle, particularly during transport to the slaughter-house. As well as early mortality, animals will be more likely to suffer the direct effects of heat stress on organ and muscle metabolism, such as dehydration and lactic acid build-up. These effects can persist after death, leading to paler, moister pork and tougher, darker steak. Carcasses could also become more susceptible to contamination by *E. coli* and salmonella in a warmer world, says Gregory.

The solution will involve a shift in management practices — cooling animals before slaughter, for example, or switching to more heat-tolerant breeds, such as *Bos indicus* cattle. But some of these strategies might affect other aspects of meat quality, such as taste, warns the author, who says that experience will be vital in gauging the most appropriate strategies.

Anna Armstrong