Climate change

Heat and light

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An unexplained anomaly in the climate seems to have been the result of bad data

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CLIMATOLOGY is an inexact science at the best of times. Unfortunately it has become, over the past couple of decades, a politically charged one as well. As the debate about global warming—and what, if anything, to do about it—has gathered pace, uncertainties in the data that would be of merely academic interest in other disciplines have acquired enormous practical significance. And one of the most curious uncertainties of all is the apparent discrepancy between what is happening to temperatures at the Earth's surface and what is happening in the troposphere—the lowest layer of the atmosphere, and thus the part that is in contact with that surface.

The troposphere is where most of the air is found and where most of the weather occurs. Computer models predict that, if global warming is really happening, temperatures in the troposphere should rise along with those on the surface. Recorded surface temperatures are, indeed, rising. However, both data from weather balloons and observations made by satellites suggest that temperatures in the troposphere have remained constant since the 1970s. Over the tropics they may even have dropped. This counter-intuitive result has caused sceptics to question how much warming, if any, is actually going on.

There are, of course, three possibilities. One is that the sceptics are right. A second is that the models are wrong. And the

third is that there is something wrong with the data. Three papers published in this week's issue of *Science* suggest that the third possibility is the correct one.

Day and night

The first of these studies, conducted by Steven Sherwood of Yale University and his colleagues, examined data from weather balloons. For the past 40 years, weather stations around the world have released these balloons twice a day at the same time—midday and midnight Greenwich Mean Time. Each balloon carries a small, expendable measuring device called a radiosonde that sends back information on atmospheric pressure, humidity and, most importantly for this study, temperature.

Unfortunately, data from radiosondes come with built-in inaccuracies. For example, their thermometers, which are supposed to be measuring the temperature of the air itself (that is, the temperature in the shade) are often exposed to, and thus heated by, the sun's rays. To compensate for this, a correction factor is routinely applied to the raw data. The question is, is that correction factor correct?

Dr Sherwood argues that it is not. In particular, changes in radiosonde design intended to reduce the original problem of over-heating have not always been accommodated by reductions in the correction factors for more recently collected data. Those data have thus been over-corrected, reducing the apparent temperature below the actual temperature.

Dr Sherwood and his colleagues hit on a ruse to test this idea. Because weather stations around the world release their balloons simultaneously, some of the measurements are taken in daylight and some in darkness. By comparing the raw data, the team was able to identify a trend: recorded night-time temperatures in the troposphere (night being the ultimate form of shade) have indeed risen. It is only daytime temperatures that seem to have dropped. Previous work, which has concentrated on average values, failed to highlight this distinction, which seems to have been caused by over-correction of the daytime figures. When the team corrected the erroneous corrections, the result agreed with the models of the troposphere and with records of the surface temperature. The improvement was particularly noticeable in the tropics, an area that had previously appeared to have high surface temperatures but far cooler tropospheric temperatures than had been expected.

The second piece of work looked at satellite measurements of tropospheric temperatures. For the past two decades, microwave detectors, placed on a series of satellites flying in orbits that take them over both poles, have been used to calculate the troposphere's temperature. (Microwaves radiated from the atmosphere contain a host of information about its temperature and humidity.) Here, too, the data are problematic. Because the satellites are looking down through the whole atmosphere, measuring the temperature of the troposphere requires subtracting the effects of the stratosphere—the atmospheric layer above it. But when this has been done, the result suggests, like the over-corrected data from the radiosondes, that the troposphere is cooling down relative to the surface.

However, Carl Mears and Frank Wentz of Remote Sensing Systems, a firm based in Santa Rosa, California, think that this trend, too, is an artefact. It is caused, they believe, because the orbital period of a satellite changes slowly over that satellite's lifetime, as its orbit decays due to friction with the outer reaches of the atmosphere. If due allowance is not made for such changes, spurious long-term trends can appear in the data. Dr Mears and Dr Wentz plugged this observation into a model, and the model suggested that the apparent cooling the satellites had observed is indeed such a spurious trend. Correct for orbital decay and you see not cooling, but warming.

The third paper, by Ben Santer of the Lawrence Livermore National Laboratory in California and his colleagues, argues that it is, indeed, errors in the data that are to blame for disagreements between the predictions of computer models about how the troposphere should behave and what the weather balloons and satellites actually detect. Dr Santer's team compared 19 different computer models. All agreed that the troposphere should be getting warmer. Individual models have their individual faults, of course. But unless all contain some huge, false underlying assumption that is invisible to the world's climatologists, the fact that all of them trend in the same direction reinforces the idea that it is the data which are spurious rather than the models' predictions.

It is, nevertheless, doubtful that these papers will end the matter. Studying the climate is a hard problem for three reasons. The system itself is incredibly complex. There is only one such system, so comparative studies are impossible. And controlled experiments are equally impossible. So there will always be uncertainty and therefore room for dissent. How policymakers treat that dissent is a political question, not a scientific one.