Stormwatch

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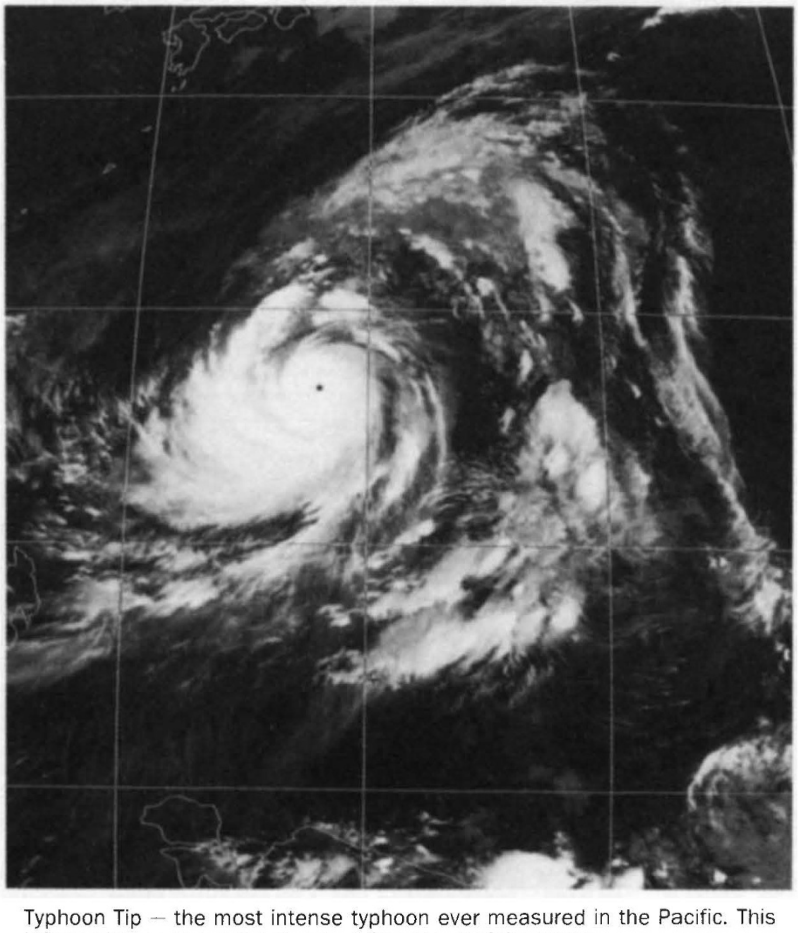
Watching the World's Weather. By W. J. Burroughs. *Cambridge University Press: 1991. Pp.196. £17.50, $24.95.*

SATELLITE images of the weather can be seen every day on our television screens, but what can be learned from them? On a superficial level, we are able to watch storms develop, track hurricanes (clearly identifiable by their catherine-wheel-like structure), and even perceive the plumes of smoke from burning oil fields. But how do forecasters use satellites to predict the weather, and has their arrival significantly improved our weather forecasts? Burroughs sets out to address these questions and others by providing an interesting, but rather pedagogical, account of the development of the field of satellite meteorology, together with an appraisal of the role of satellites in studies of climate change, and a considered look at the prospects for the future.

For those not familiar with the physical processes that are responsible for generating the weather patterns, Burroughs provides a succinct introduction. The underlying principle is that the Earth must be in radiative balance with the Sun — simply put, this means that the amount of solar radiation absorbed by the atmosphere and surface of the Earth must equal the amount of terrestrial radiation emitted — and for this balance to be achieved, large amounts of energy have to be transported through the atmosphere. So, armed with a basic understanding of the "global weather machine", both the science and technology aspects of satellite meteorology are then described in detail and can be easily understood.

The first photographs of weather systems were obtained in 1947 from a camera strapped to a V2 rocket, and by 1960 the first operational satellite was in orbit. The images transmitted to Earth were of immediate use in providing images of the developing weather, but to improve forecasts significantly, satellite instruments had to be able to provide accurate and reliable measurements of temperature, humidity, pressure, rainfall and wind speed.

As Burroughs explains, and indeed as one might imagine, determining the temperature of the atmosphere is actually quite a complicated business, as temperature does not vary with height in a simple way: in the lower atmosphere (the troposphere), temperature decreases approximately linearly with height, because energy is transferred mainly by convective processes, whereas immediately above the troposphere, radiative processes dominate and the temperature remains more or less constant with height. Above about 100 km, temperature starts to increase with height. This is a very simplistic description of the temperature profile of the atmosphere, because clouds, weather systems, extremely cold regions on the Earth's surface (the Arctic and Antarctic, for example) all serve to perturb the profile; but the complexity of measuring the temperature should at least be clear. By making clever use of the fact that the amount of energy radiated by gases in the atmosphere is a function of their temperature, instruments have been designed to measure the upwelling radiation received at the satellite over a range of wavelengths. If the atmosphere absorbs strongly at a particular wavelength, then most of the radiation measured will come from the higher levels of the atmosphere. Correspondingly, if the atmosphere absorbs weakly, then the radiation received comes from near the Earth's surface. Hence each wavelength used yields valuable information about a certain section or slice of the atmosphere. To retrieve a complete temperature profile, a number of different wavelengths must be used, preferably in both the infrared and microwave regions of the spectrum. A similar principle is adopted to retrieve the humidity (water vapour) profile of the atmosphere.



Typhoon Tip — the most intense typhoon ever measured in the Pacific. This infrared image shows the clearly defined 'eye' of the storm.

In contrast, to deduce wind speed, wave height and the strength of ocean currents, for instance, radar systems are used, which send out pulsed beams of microwave radiation. By comparing the characteristics of the reflected pulse with those of the incident beam, estimates of these properties can be made.

As well as measuring the upwelling radiation, and hence determining the temperature and humidity profiles, some satellite instruments have been designed to examine the properties of the sunlight reflected from the surface of the Earth, allowing estimates to be made of the biological productivity of the oceans, the extent of different types of vegetation, and the areal coverage of sea ice and snow. Satellites can therefore be used to monitor both local and global changes in the environment over a period of years — an invaluable capability for those interested in examining the climate response to increasing concentrations of gases such as carbon dioxide and methane.

The potential value of satellite observations is clear, but there have been considerable problems in exploiting the data to the full in weather forecasting, as Burroughs makes clear. To analyse the date and combine the satellite measurements with ground-based observations has put computer science to the test. Indeed, only relatively recently, with the advent of more powerful computers and more sophisticated analytical techniques, have satellite data started to make their presence felt.

Watching the World's Weather is certainly informative, and honest about the limitations of satellite data as well as the undoubted benefits. The occasionally rather dry prose is leavened by the inclusion of some spectacular satellite pictures of storms and hurricanes. The satellite image on the television screen will never seem quite the same again. □

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