news and views

Temperatures in the clouds of Venus

from P. J. Houghton

ON board the Pioneer Venus orbiter which encountered the planet Venus on 4 December 1978 was a multi-channel infrared radiometer jointly built by the Jet Propulsion Laboratory, Pasadena, California and the Department of Atmospheric Physics at the University of Oxford. The Oxford contribution to this radiometer is the first British built experiment to leave the vicinity of the Earth and travel to one of the planets. Remote sounding observations with this radiometer have already provided the first information on the temperature structure in the upper Venus atmosphere (Taylor *et al. Science* **203,** 779; 1979). On page 613 of this issue of *Nature* Taylor and his colleagues at the Jet Propulsion Laboratory report some interesting new measurements of the detailed thermal structure of the clouds near the Venus pole which provide important clues to the nature of the circulation of the Venus atmosphere. Investigations from Earth-based telescopes and from spacecraft have demonstrated the very deep, rather uniform cloud cover on Venus, which completely obscures the surface from view. That the cloud droplets mainly consist of sulphuric acid was discovered as a result of the interpretation by Hansen, Arking and Young in 1973 of polarisation observations made at different phases of Venus by the French astronomers Coffeen and Gehrels in 1969. Although the size of the particles, as also deduced from these measurements, turned out to be a few microns only, the question remained as to how the upward motion necessary to maintain the clouds was generated, even though for such small particles the amount of upward motion need only be very small. A further question concerned the location of the compensating regions of downward motion. This week's report gives support to the theory put forward by Murray *et al.* (*J. geophys. Res.* **68,** 4813; 1963) and Suomi and Limaye (*Science* **201,** 1009; 1978) that intense regions of downward motion might be concentrated near the poles. In these regions clearing of the clouds might be expected, which would not be visible from Earth because the polar regions are viewed so obliquely.

The Pioneer 12 orbiter, because it goes nearly over the Venus pole, has provided the first opportunity to observe the polar regions in detail. The infrared radiometer observations clearly show a localised region of much higher temperature than the rest of the cloud cover which has been interpreted as a local clearing of at least the upper half of the cloud layer. The measurements do not rule out a clearing to much deeper levels.

Observations from the infrared radiometer at altitudes of 60–90 km in the Venus atmosphere, well above the main cloud deck, have shown a temperature contrast of about 20 K between equator and pole, with the pole being warmer (Taylor *et al. op. cit.*). The obvious interpretation of these measurements in terms of circulation is of a Hadley type circulation with rising air over the equator, cooling as it rises, and sinking air around the polar regions, warming as it sinks. This is not unlike the thermally driven circulation which occurs in the mesosphere of the Earth's atmosphere where very cold temperatures occur at the mesopause (~85 km altitude) in summer contrasted with much warmer temperatures near the winter mesopause in the other hemisphere. Another important feature of the circulation at those levels above the main cloud deck is the very rapid zonal motion which occurs. Air moves around the planet at a velocity of about 100 ms^{-1}, one rotation of the planet taking about 4 days. This rapid motion ensures that there is little temperature contrast between the day and night side of the planet, as is confirmed by the Pioneer radiometer observations.

The solid surface of Venus rotates only very slowly—once in 243 days—so that the comparatively rapid rotation of higher parts of the Venus atmosphere is particularly intriguing. Schubert and Whitehead in 1969 (*Science* **153,** 71) put forward a possible theory of the mechanisms driving this circulation; they suggested it was induced by a travelling thermal wave induced by the motion of the Sun relative to the atmosphere.

At altitudes above about 90 km in the Venus ionosphere, the thermal contrast between equator and pole largely disappears. Instead at these levels, as is shown again from infrared radiometer measurements, a temperature difference of about 20 K exists between the day and night side of the atmosphere, indicating a mean circulation which is primarily occurring between the warmer sunlit side and the cooler dark side.

It will be interesting to discover, from further work on the data from the infrared radiometer and from the other instruments on the Pioneer 12 orbiter, whether there is any evidence for large scale waves in the atmosphere above the Venus clouds of a similar or different nature to the planetary waves observed in the Earth's atmosphere. A big question which clearly arises is: how are the circulations in different parts of the Venus atmosphere linked? Is the upper atmosphere circulation, for instance, driven from below, or is it driven by heat sources and sinks near the cloud tops? A particularly interesting observation is that the cloud clearing reported in this issue is not actually at the pole but some 10° from it, suggesting that the circulation may have some interesting asymmetrical properties. Clearly a lot remains to be understood that will not only encourage those working on Venus data to extract from it information which will provide clues to some of the intriguing problems of the Venus circulation, but also provide the theoretical modellers with a challenge to fit it all together. As we begin to understand how the motions are organised in the Venus atmosphere, which is so different from our own, we shall in turn acquire deeper insight into what goes on in the atmosphere of the Earth. □

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