CLIMATE CHANGE 1995

The Science of Climate Change

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Contribution of Working Group I
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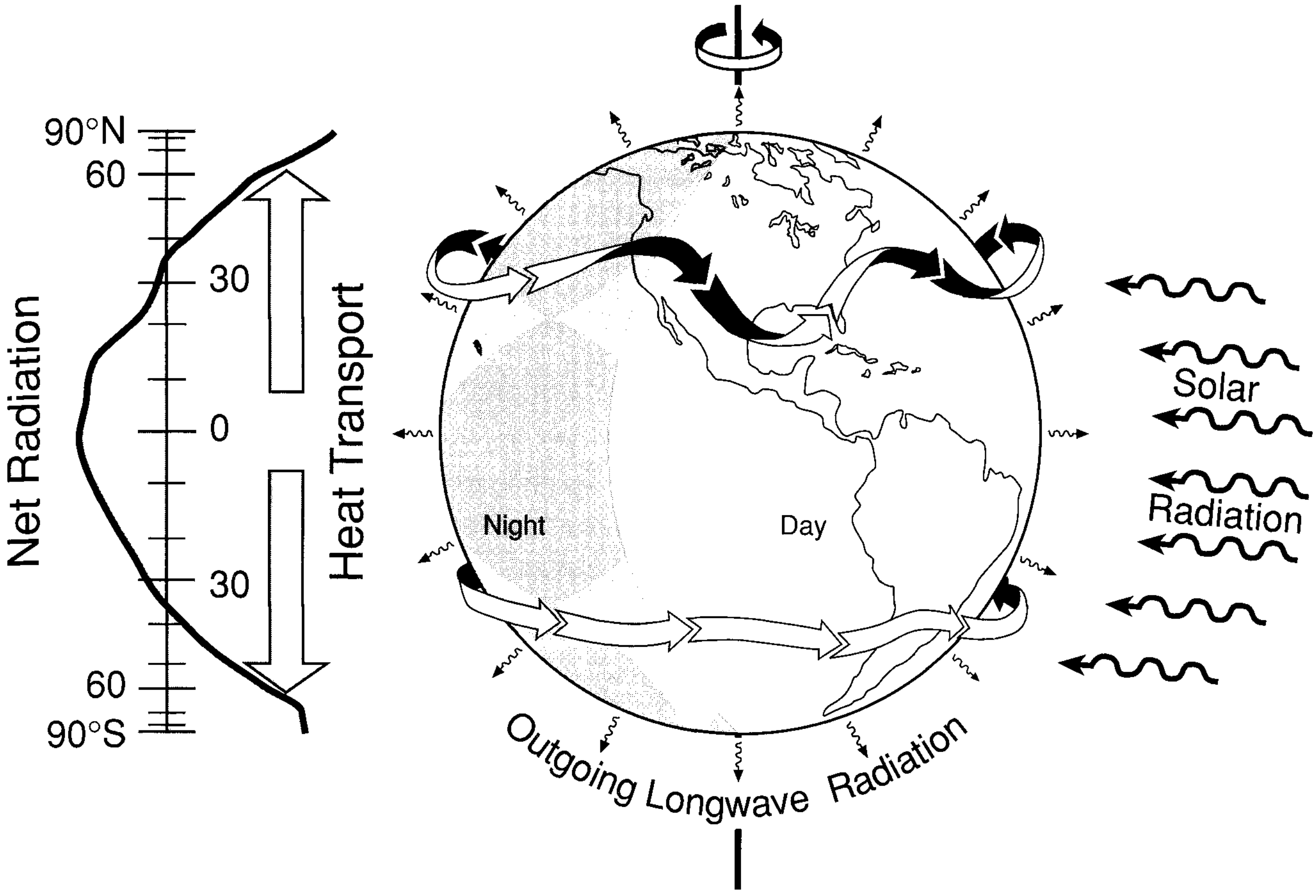

Figure 1.2: The incoming solar radiation (right) illuminates only part of the Earth while the outgoing long-wave radiation is distributed more evenly. On an annual mean basis, the result is an excess of absorbed solar radiation over the outgoing long-wave radiation in the tropics, while there is a deficit at middle to high latitudes (far left), so that there is a requirement for a poleward heat transport in each hemisphere (arrows) by the atmosphere and the oceans. This radiation distribution results in warm conditions in the tropics but cold at high latitudes, and the temperature contrast results in a broad band of westerlies in the extra-tropics of each hemisphere in which there is an embedded jet stream (shown by the "ribbon" arrows) at about 10 km above the Earth's surface. The flow of the jetstream over the different underlying surface (ocean, land, mountains) produces waves in the atmosphere and adds geographic spatial structure to climate. The excess of net radiation at the equator is 68 Wm^{-2} and the deficit peaks at -100 Wm^{-2} at the South Pole and -125 Wm^{-2} at the North Pole; from Trenberth and Solomon (1994).

time half the Earth is in night (Figure 1.2) and the average amount of energy incident on a level surface outside the atmosphere is one quarter of this or 342 Wm^{-2}. About 31% of this energy is scattered or reflected back to space by molecules, microscopic airborne particles (known as aerosols) and clouds in the atmosphere, or by the Earth's surface, which leaves about 235 Wm^{-2} on average to warm the Earth's surface and atmosphere (Figure 1.3).

To balance the incoming energy, the Earth itself must radiate on average the same amount of energy back to space (Figure 1.3). It does this by emitting thermal "long-wave" radiation in the infrared part of the spectrum. The amount of thermal radiation emitted by a warm surface depends on its temperature and on how absorbing it is. For a completely absorbing surface to emit 235 Wm^{-2} of thermal radiation, it would have a temperature of about -19°C. This is much colder than the conditions that actually exist near the Earth's surface where the annual average global mean temperature is about 15°C. However, because the temperature in the troposphere – the lowest 10-15 km of the atmosphere – falls off quite rapidly with height, a temperature of -19°C is reached typically at an altitude of 5 km above the surface in mid-latitudes.

1.2.2 The Greenhouse Effect

Some of the infrared radiation leaving the atmosphere originates near the Earth's surface and is transmitted relatively unimpeded through the atmosphere; this is the