Energy transports in the Hadley circulation and global monsoon

Kevin E. Trenberth

National Center for Atmospheric Research[1]

P. O. Box 3000
Boulder, CO 80307

The vertically-integrated atmospheric energy and heat budgets will be presented with a focus on the transports and divergences of dry static energy, latent energy, and their sum, the moist static energy, as well as their partitioning into the within-month transient and quasistationary components. The latter includes the long-term mean and interannual variability and, in the tropics, corresponds to the large-scale overturning global monsoon and the embedded Hadley and Walker circulations. In the extratropics, it includes the quasi-stationary planetary waves, which are primarily a factor in the Northern Hemisphere winter.

Observations show that not only is the total poleward heat transport continuous with latitude, so too is the atmospheric transport. Yet the mechanisms for carrying out the transport vary greatly. The large-scale overturning Hadley circulation is dominant in low latitudes while the baroclinic transient eddies, assisted by the quasi-stationary planetary waves in the Northern Hemisphere winter, are dominant in mid-latitudes. So how is it that the poleward heat transports are so seamless? Most theories have an abrupt cut off at 31° latitude at the poleward edge of the Hadley circulation for the heat transport. The Hadley cell overturning is driven by heating in the deep tropics and cooling in the subtropics and transports dry static energy polewards. However, the upward branch is driven by the equatorward transport and convergence of latent energy (moisture) which greatly diminishes the net energy transport. We show that the subtropical cooling arises from heat transport to higher latitudes by quasi-horizontal air flow in the transient baroclinic eddies and, although infrared radiative cooling to space is important, it should be thought of as a consequence of the circulation and not a fundamental driver.

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