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The flow of energy through the climate system and changes with global warming

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A review is first given of the mean and annual cycle of energy flowing through the climate system, and its storage, release, and transport in the atmosphere, ocean, and land surface as estimated with recent observations. Of the roughly 175 Petawatts coming into the planet, about 120 are absorbed and drive the weather and climate system through the unequal distribution with latitude and between land and ocean. We are able to close the energy budget reasonably well, although largest errors are determined to be in changes in ocean heat content, especially south of about 35^{o}S. The winter hemisphere atmospheric circulation is identified as the dominant contributor to poleward energy transports outside of the Tropics (6 to 7 PetaWatts), with summer transports being relatively weak ($\sim$3 PW) slightly more in the Southern Hemisphere and slightly less in the Northern Hemisphere. Ocean transports outside of the Tropics are found to be small ($<$2 PW) for all months. The current imbalance in radiation at the top-of-atmosphere (about 0.5 PW) owing to human-induced increases in greenhouse gases means that the atmosphere, land and ocean are warming up, and ice is melting, leading to a rise in sea level. This comes about from increasing greenhouse gases in the atmosphere, notably carbon dioxide, from human activities. The interference with the natural flows of energy is a factor of 60 or so larger than the direct energy released by human activities. A brief outline will be given of the resulting climate change underway and projections for the future.