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The Atmospheric Energy and Hydrological Cycles in ECMWF Reanalyses

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Analysing the long term time averaged atmospheric energy and hydrological cycles in atmospheric datasets provides a simple means of measuring the consistency and quality of these datasets. For the energy cycle, we assume that the long term change in storage of the total energy of the atmosphere is small. Energy is absorbed at the TOA at low latitudes, some of which is lost to the surface while the remainder is transported to high latitudes and then, augmented by energy from the surface, is lost to space. The net energy gain to the atmosphere at low latitudes should match the transport from low to high latitudes which, in turn, should match the net energy lost from the atmosphere at high latitudes. For the purposes of this study, we have defined the low latitudes to be between 40N and 40S with the high latitudes encompassing the remainder of the planet, which includes the higher latitudes of both hemispheres. For the hydrological cycle, we assume that the long term change in storage of the total column water vapour of the atmosphere is small. The excess of evaporation compared to precipitation over ocean should match the transport from ocean to land which, in turn, should match the excess of precipitation compared to evaporation over land. Here, we study these cycles as depicted by the ECMWF Interim Reanalysis (ERA-Interim) and ERA-40 for the 20 year period 1989-2008. Although better than in ERA-40, the transport of energy in ERA-Interim does not agree well with the net gain of energy at low latitudes and the net loss of energy at high latitudes unless various corrections are made to the data. These corrections consist of constraining the TOA global energy balance and the surface oceanic energy balance to be zero, constraining the surface energy balance everywhere over land to be zero and mass adjusting the energy transports. The result is an energy transport of 9.5 PW. However, the meridional gradient of the TOA energy balance in ERA-Interim is weaker than in CERES data, so either these transports are at least 10% too weak or the meridional gradient of the energy balance at the surface is too weak. The oceanic E-P and P-E over land are about 15% larger than the 1.1 Tg/s transport of water vapour from ocean to land.