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Energetics of climate models: net energy balance and meridional enthalpy transport

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We analyze the publicly released outputs of the simulations performed by climate models (CMs) in preindustrial (PI) and Special Report on Emissions Scenarios A1B (SRESA1B) conditions. In the PI simulations, most CMs feature biases of the order of 1 W m -2 for the net global and the net atmospheric, oceanic, and land energy balances. This does not result from transient effects but depends on the imperfect closure of the energy cycle in the fluid components and on inconsistencies over land. Thus, the planetary emission temperature is underestimated, which may explain the CMs' cold bias. In the PI scenario, CMs agree on the meridional atmospheric enthalpy transport's peak location (around 40°N/S), while discrepancies of $\sim$20% exist on the intensity. Disagreements on the oceanic transport peaks' location and intensity amount to $\sim$10° and $\sim$50%, respectively. In the SRESA1B runs, the atmospheric transport's peak shifts poleward, and its intensity increases up to $\sim$10% in both hemispheres. In most CMs, the Northern Hemispheric oceanic transport decreases, and the peaks shift equatorward in both hemispheres. The Bjerknes compensation mechanism is active both on climatological and interannual time scales. The total meridional transport peaks around 35° in both hemispheres and scenarios, whereas disagreements on the intensity reach $\sim$20%. With increased CO 2 concentration, the total transport increases up to $\sim$10%, thus contributing to polar amplification of global warming. Advances are needed for achieving a self-consistent representation of climate as a nonequilibrium thermodynamical system. This is crucial for improving the CMs' skill in representing past and future climate changes.