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

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We analyze the PCMDI/CMIP3 simulations performed by climate models (CMs) using pre-industrial and SRESA1B scenarios. Relatively large biases are present for most CMs when global energy budgets and when the atmospheric, oceanic, and land budgets are considered. Apparently, the biases do not result from transient effects, but depend on the imperfect closure of the energy cycle in the fluid components and on inconsistencies over land. Therefore, the planetary emission temperature is underestimated. This may explain the CMs' cold bias. In the pre-industrial scenario, CMs agree on the location in the mid-latitudes of the peaks of the meridional atmospheric enthalpy transport, while large discrepancies exist on the intensity. Disagreements on the location and intensity of the oceanic transport peaks are serious. With increased CO_2 concentration, a small poleward shift of the peak and an increase in the intensity of the atmospheric transport of up to 10% are detected in both hemispheres. Instead, most CMs feature a decrease in the oceanic transport intensity in the northern hemisphere and an equatorward shift of the peak in both hemispheres. The Bjerkens compensation mechanism is active both on climatological and interannual time scales. The peak of the total meridional transport is typically around $35°$ in both hemispheres and scenarios, whereas disagreements on the intensity are relevant. With increased CO_2 concentration, the total transport increases by up to 10%, thus contributing to polar amplification. Advances in the representation of physical processes are definitely needed for providing a self-consistent representation of climate as a non-equilibrium thermodynamical system.