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Does the hemispheric energy balance set the mean location of ITCZ?

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The Earth's energy balance has been studied for many decades and yet a number of challenges remain in quantifying it globally and in understanding its behavior regionally. Recent studies combine the total and atmospheric heat budgets derived from satellite-based TOA irradiances and atmospheric reanalysis, respectively, to infer the hemispheric surface heat budget as their residual. Here, we propose an approach that takes the perspective of the ocean, deriving the multi-annual surface net heat flux as the residual of the hemispheric ocean heat storage (OHS) and the cross-equatorial ocean heat transport (COHT). The latter is taken from ocean reanalysis (i.e. ECCOv4 and ORA-S4), while the OHS is derived from in-situ temperature profiles covering the ARGO period 2005-2015. Notable features of the hemispheric energy balance established is the dominance of the Southern hemispheric OHS (0.9 Wm-2) and the slight inter-hemispheric energy imbalance that yields a net cross-equatorial heat transport from the Southern to the Northern hemisphere. This is achieved by the oceans transporting about 0.2-0.4 PW northward across the equator, accompanied by a slight southward transport of heat by the atmosphere (0.1-0.2 PW).

The main features of the hemispheric energy balance portrayed here are largely in line with earlier estimates and represent the energetic framework within which the tropical circulation acts to distribute heat across the equator. In present-day conditions, the ITCZ is located slightly North of the equator at about 7 N in the multi-annual mean, indicating that the southern Hadley Cell fluxes heat across the equator towards the Southern hemisphere. It has been proposed in recent studies that the global mean northward COHT plays a role in setting the ITCZ location, a relationship that we examine by analysis of an observation-based (GPCP, TRMM, ERA-I) dataset of ITCZ location and ocean heat transport from reanalysis. Additionally, we examine the co-variability of ITCZ location and other energy budget components as well to elucidate on the energetic drivers of tropical large-scale circulation.

We find the direction of COHT and ITCZ location in the Indo-Pacific to be largely anti-correlated, both showing significant inter-annual variability that is likely driven by SST variability linked to ENSO. As expected, the Atlantic sets the global mean northward COHT and shows much less inter-annual variability. From this alone, there is evidence that, at least locally, the COHT is not the only driver of ITCZ location in the Pacific.