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Energetic constraints on the width of the ITCZ: theory and simulations

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The intertropical convergence zone (ITCZ) has been the focus of considerable research in recent years, with much of this work focusing on how the latitude of maximum tropical precipitation responds to natural climate variability and to radiative forcing. The width of the ITCZ, however, has received little attention despite its importance for regional climate and for our understanding of tropical dynamics.

Here we investigate the width of the ITCZ in simulations with an idealized general circulation model over a wide range of climates. The ITCZ displays rich behaviour as the climate is varied, widening with warming in cool climates, narrowing in temperate climates, and maintaining a relatively constant width in hot climates. Theoretical scalings for (a) the area of the ITCZ relative to the area of the neighboring descent region and (b) the sensitivity of the ITCZ area to changes in climate are derived. The width of the ITCZ is found to depend primarily on four quantities: the net energy input to the tropical atmosphere, the advection of moist static energy by the Hadley circulation, the transport of moist static energy by transient eddies, and the gross moist stability. Different processes are important for the ITCZ width in different climates, with changes in gross moist stability generally having a weak influence relative to the other processes. The results are used to identify and analyse the physical mechanisms responsible for the robust narrowing of the ITCZ in comprehensive climate-model simulations of warming climates.