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The annual cycle of the ITCZ and its changes under CO_2 quadrupling in the TRACMIP ensemble

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TRACMIP, the "Tropical Rain belts with an Annual cycle and Continent - Model Intercomparison Project" is an ensemble suite of five experiments using idealized aquaplanet and land setups. It includes 14 atmospheric GCMs coupled to a motionless slab ocean and forced with diurnally and annually varying insolation and can be used to explore the dynamics of tropical rainfall to quadrupling CO_2 in a set up in which the energy balance of the surface is closed. Here we focus on changes in the annual mean and seasonal response of the zonal mean ITCZ.

The ensemble-mean response of the annual mean ITCZ to CO_2-induced warming is to shift to the north. This shift is an amplification of the asymmetry of the basic state, which has a warmer Northern Hemisphere. Yet, the spread across models is large and can be linked to the scatter in the inter-hemispheric warming; the magnitude of the shift is also modulated by the input of energy into the equatorial atmosphere, which varies greatly across models. Overall, the inter-model scatter in the annual mean changes in the position of the ITCZ is explained, in terms of variance explained, equally well by changes in the latitude of the energy flux equator and in the magnitude of the atmospheric energy flux across the equator.

The ITCZ shift is not uniform across the year: it is strongest during spring (when the climatological ITCZ is furthest to the south in these setups). The width of the ITCZ (defined as the region of net precipitation) is decreased in the annual mean,because of the sharp reduction in Southern Hemisphere precipitation during spring, but it actually increases during most months of the climatology.

We further explore how well the energetic framework works in explaining forced changes in the seasonal cycle of the ITCZ and we diagnose what role changes in gross moist stability play in changing the seasonal relationship between energy transport and ITCZ position as the climate warms.