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The physical mechanisms behind dynamic contributions to future precipitation changes

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Future changes in precipitation have been shown to have contributions from both thermodynamic and dynamic processes. The spatial pattern of change and much of the regional uncertainty in projections of precipitation changes in particular at tropical latitudes are dominated by the dynamic contributions. It is therefore critical to better understand the ingredients of the dynamical contributions to rainfall change. In the present climate, most of the precipitation in the tropics can be associated with convergence lines at sub-daily scale. Over longer time- and space-scales these features organize and form well-known convergence zones, such as the Inter-tropical Convergence Zone (ITCZ) and South-Pacific Convergence Zone (SPCZ) that dominate longer-term rainfall variability. Given the primary role convergence lines play in triggering convection, it is likely that they are involved in the coupled rainfall–circulation changes that constitute the dynamic component of future rainfall changes. We provide, for the first time, evidence that the dynamic component of future precipitation changes in the tropics is to first order the result of changes to the occurrence and strength of convergence lines. We develop a simple linear model relating convergence line frequency and strength to precipitation and show that it successfully reconstructs the observed precipitation. We then exploit the physical relationship the model represents to predict future precipitation changes based on GCM predictions of changes in the occurrence and strength of convergence lines. We show that the so-predicted rainfall change is equivalent to the dynamical component of rainfall change identified in earlier studies that are based on very different decomposition methods. Furthermore, we find that the difference between the total rainfall change in GCMs and that predicted from changes in convergence lines, strongly resembles the thermodynamic component identified by other methods. This provides evidence that convergence lines are the key dynamic ingredient to future rainfall changes, through changes in both their occurrence and strength. More reliable predictions of future rainfall therefore require the reliable simulation of the relatively short-lived weather features of convergence lines in the tropics in GCMs.