The Indian monsoon, the primary source of rainfall for the Indian subcontinent, occurs during the boreal summer (June to September) and contributes approximately 80% of the region's annual rainfall. The variability of the monsoon –including the onset date, seasonal rainfall totals and active/break periods- significantly impacts the agricultural and industrial sectors, affecting the livelihoods of over a billion people. Accurate subseasonal to seasonal forecasting of the monsoon is crucial to mitigating adverse meteorological events associated with the monsoon, such as occurrences of extreme precipitation or droughts. Due to the large roles played by general circulation models in weather and climate prediction, a significant amount of research is dedicated to model development and improvement. This study aims to identify and quantify model biases in predicting the onset of the Indian monsoon and introduces a novel method for calculating convective timescales. These timescales serve as a metric for model comparison and as indicators of regime change.

Using the Weather Research & Forecasting (WRF) model, we simulate the Indian monsoon onset and transition to full monsoon. While large-scale circulation patterns are generally well-captured, biases remain in simulating precipitation and relative humidity, especially over oceanic regions.. The timing and transitions of the Indian monsoon in the WRF model align favourably to observations. A moisture budget analysis is used to derive a vertical convective flux between the upper and lower troposphere, linking it to total column moisture content to compute a convective timescale. The results show that the transition from pre-onset to full monsoon corresponds with a reduction in convective timescales by a factor of two.