



## **Coupled ocean-atmosphere models feature systematic delay in Indian monsoon onset compared to their atmosphere-only component**

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In this study we examine monsoon onset characteristics in 20th century historical and AMIP integrations of the CMIP5 multi-model database. We use a period of 1979-2005, common to both the AMIP and historical integrations. While all available observed boundary conditions, including sea-surface temperature (SST), are prescribed in the AMIP integrations, the historical integrations feature ocean-atmosphere models that generate SSTs via air-sea coupled processes. The onset of Indian monsoon rainfall is shown to be systematically earlier in the AMIP integrations when comparing groups of models that provide both experiments, and in the multi-model ensemble means for each experiment in turn. We also test some common circulation indices of the monsoon onset including the horizontal shear in the lower troposphere and wind kinetic energy. Since AMIP integrations are forced by observed SSTs and CMIP5 models are known to have large cold SST biases in the northern Arabian Sea during winter and spring that limits their monsoon rainfall, we relate the delayed onset in the coupled historical integrations to cold Arabian Sea SST biases. This study provides further motivation for solving cold SST biases in the Arabian Sea in coupled models.