Year-long eddy covariance surface fluxes from a Bay of Bengal mooring compared with operational monsoon mission models

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The National Monsoon Mission programme of the Ministry of Earth Sciences, Government of India, was launched in 2012 to improve Indian monsoon forecasts from short-range to seasonal timescales using dynamical models. Two models, namely, the Climate Forecast System version 2 (CFSv2) from the United States National Centers for Environmental Prediction, and United Kingdom's UKMET Office unified model, were implemented and improvements were made. The initial climatologies of the seasonal predictions showed many biases, including cold biases in the sea surface temperature over the tropical Indian Ocean. The Air-sea flux parametrization schemes used in these models, which were not verified under the monsoonal conditions over the North Indian Ocean due to the lack of relevant *in situ* observations, were among the possible causes of the bias. To test this, an ocean moored buoy with instrument packages for complete surface energy balance, including eddy-covariance flux sensors, was deployed in the North Bay of Bengal from July 2019 to August 2020. The present article compares measured and model scheme predicted surface fluxes. The surface shear stress is well predicted in both models. The heat loss due to evaporation of water is over-estimated in the 8 to 38 W m^{-2} range depending on the parametrization scheme used. The present version of the scheme implemented in CFSv2 has the smallest bias. Whereas a bias of 8 W m^{-2} in evaporative heat loss falls in the range of its measurement uncertainty limits, scope for further refinement exists.

Keywords: Eddy correlation method, flux parametrization, latent heat flux, monsoon mission, moored buoy, sea-air flux

VARIATIONS in the summer monsoon rainfall on sub-daily to inter-annual timescales affect nearly 23% of the world population that inhabits the Indian subcontinent. The Ministry of Earth Sciences (MoES), Government of India, launched the National Monsoon Mission (NMM) programme in 2012 to improve monsoon forecasts from short-range to seasonal timescales using dynamical models[1,2]. Under the NMM programme, two models, namely, the Climate Forecast System version 2 (CFSv2) from the National Centers for Environmental Prediction, USA, and the NCMRWF Unified Model (NCUM) of UKMET Office, UK, were adapted, run and improvements attempted at the Indian Institute of Tropical Meteorology (IITM), Pune and the National Centre for Medium Range Weather Forecasting (NCMRWF), Noida, respectively. The initial climatologies of the seasonal predictions showed many biases, including cold biases in the sea surface temperature (SST) over the tropical Indian Ocean[3]. Among the key suspects were air-sea interface fluxes whose parametrization schemes used in the NMM models were not validated for the North Indian Ocean owing to a lack of relevant *in situ* observations. To address this, observational studies of the atmosphere and ocean involving collaboration between India and the United States [Ocean Mixing and Monsoon (OMM), funded by India, Air-Sea Interaction Research Initiative (ASIRI) for Bay of Bengal and Monsoon Intra-Seasonal Oscillations in the Bay of Bengal (MISO-BoB), both funded by USA], were carried out over the Bay of Bengal (BoB) (special issue of *Oceanography*, Vol. **29**, 2016). An important part of this collaboration was the deployment of a moored buoy with Woods Hole Oceanographic Institution (WHOI) Improved Meteorology (IMET) sensor package, in the North BoB from December 2014 to January 2016 by the US team[4]. The instruments mounted on the buoy collected surface variables at a 1-minute interval. That data facilitated the estimation of surface energy budgets on seasonal and annual time scales solely based on observational data in the BoB[4].

With the data archived at 1-minute and longer time intervals, sensible heat flux (SHF), latent heat flux

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