J. Ind. Geophys. Union, 29(2) (2025), 81-85
https://doi.org/10.71122/JIGU.29(2)2025.009

Examining the salinity changes at different depths in the Indian Ocean prior to summer monsoon season and its connection to monsoon arrival in India: A case study

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ABSTRACT

The Indian Ocean interacts intricately with the atmosphere, and its features, such as sea surface temperature and salinity. The Indian Ocean can influence the monsoon's onset, intensity, and duration. This study examines the fluctuation of the salinity in the Indian Ocean throughout the onset phase over the Indian Peninsula, with a focus on the Kerala coast. The study makes use of daily averaged reanalysis data from 1992 to 2017 from the Ocean Reanalysis System 5 (ORAS) of the European Centre for Medium-Range Weather Forecasts (ECMWF). Considerable variations in salinity have been seen in the Indian Ocean prior to the onset of the monsoon. Higher salinity levels are found in the top subsurface layers of the western Indian Ocean, namely the Arabian Sea, whereas lower salinity concentrations are found in the equivalent layers of the eastern Indian Ocean, which include the Bay of Bengal. The salinity gradient between the Arabian Sea and Bay of Bengal decreases with depth due to the inflow of freshwater into Bay of Bengal through river discharge. The peak salinity is localized in a specific region, adjacent to the Somalia and Kenya coastlines, within depths ranging from 20 to 80 meters from March to the first week of May. Subsequently, this region of heightened salinity, extends to depths ranging from 50 to 90 meters. During the pre-monsoon months of the early onset year, intense evaporation leads to immense moisture in the atmosphere. Conversely, moisture is low during normal onset and late onset years, with wind-driven moisture transport towards the Kerala coast.

Keywords: Indian Ocean, Summer Monsoon, Sea Surface Temperature, Salinity, Kerala Coast

INTRODUCTION

The Indian Summer Monsoon is a crucial meteorological phenomenon that profoundly shapes India's climate and agricultural productivity (Gadgil and Rupa Kumar, 2006). It describes the precipitation that falls across the Indian subcontinent as a result of the seasonal reversal of winds, which usually occurs from June to September (Goswami et al., 1999; Krishnan et al., 2013). According to the Indian meteorological calendar, the onset of the Indian Summer Monsoon over southern India, also known as Monsoon Onset over Kerala, signifies the beginning of the rainy season (Ananthakrishnan and Soman, 1988). The onset of the Indian monsoon is accompanied by significant transformations in atmospheric circulation patterns. This dramatic shift includes major changes in wind patterns, pressure systems, and overall atmospheric flow across the region (Ananthakrishnan et al., 1983). The Southwest Monsoon Current, which flows generally eastward in the northern Indian Ocean throughout the summer, circles around Sri Lanka and enters the Bay of Bengal after traveling eastward south of India (Vinayachandran et al., 1999). The onset dates of the monsoon over Kerala, show a strong positive correlation with how often the zonal index at 500 hPa level occurs in the region between 160°E-45°W and 35°N-70°S (Bhatla and Chattopadhyay, 2003). Small changes in the commencement date, can have a significant impact on particularly sensitive areas even if the monsoon season's total average rainfall is normal (Raju et al., 2007). Bhatla et al. (2016a) examined changes in surface meteorological fields and approximated surface heat fluxes associated with the onset of the summer monsoon seasons based on 50-year data collected over India from 1957 to 2006. There are some impact of Madden Julian Oscillation on onset of Indian Summer Monsoon studied by Bhatla et al. (2017). The annual fluctuation of sea surface salinity anomalies moves earlier than that of sea surface temperature anomalies in similar places because of changes in wind stress and freshwater flow (Yuan et al., 2018). Some studies have also been carried out by modelling to simulate the onset of monsoon over India (Bhatla et el., 2015, 2016b, 2019). Fasullo and Webster (2003) utilized vertically integrated moisture transport, while Taniguchi et al. (2010) observed a strong link between rapid wind speed increases and the sudden start of the rainy season. Wang et al. (2009) suggested a straightforward definition based solely on the 850 hPa wind field. The factors affecting salinity changes with depth in the Indian Ocean during monsoon season, are complex and vary across different oceanic regions (Skliris et al., 2014). To create an extended time series of Indian Summer Monsoon onset dates, using a consistent and objective method, researchers have investigated defining the onset through algorithms using pre-satellite era variables such as precipitation, moisture transport, and wind (Ordoñez et al., 2016).

Our study focuses on analyzing the year-to-year changes in salinity throughout various depths of the Indian Ocean, exploring both the patterns and underlying reasons for these variations. We also examined how these salinity changes influence the timing of the monsoon's arrival in India. Understanding these salinity fluctuations prior to the monsoon