Seasonal Variability of Wave States and Their Influence on Air-Sea Fluxes in the Northern Indian Ocean

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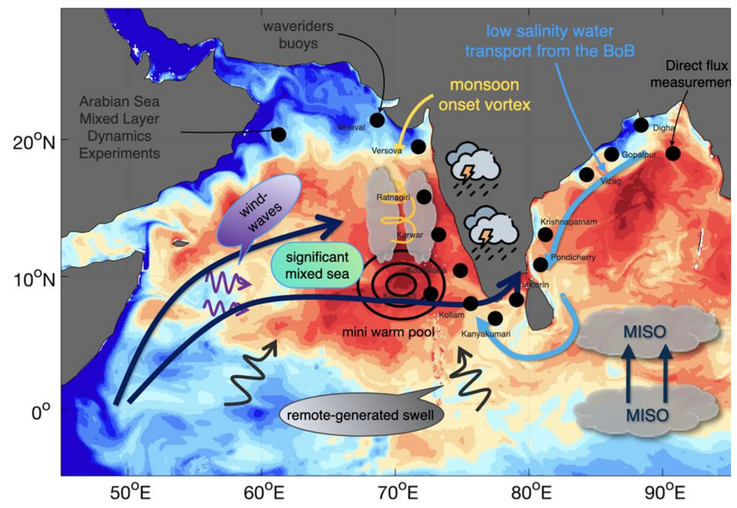
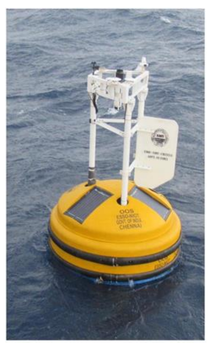
INTRODUCTION

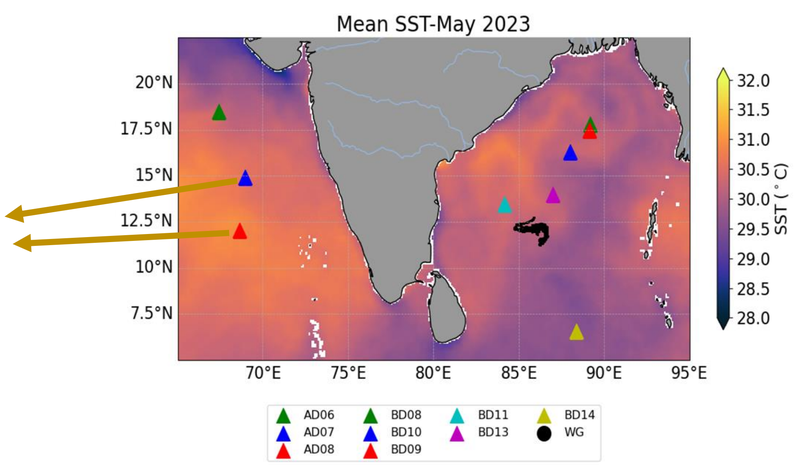


- **Monsoon-driven freshwater influx** driven by **eddies and coastal currents** creates intense **salinity stratification** in the Northern Indian Ocean (NIO), suppressing **wind-induced vertical mixing**.
- During **weak-wind spring intermonsoon periods**, **high net heat fluxes** and **low vertical mixing** trigger NIO Mini Warm Pools."
- These reservoirs fuel **Diurnal Warm Layers** (***Kerhalkar et al. 2026***) and provide the energy for the **rapid intensification of severe tropical cyclones**.
- The NIO is a unique environment where **seasonally reversing local monsoon winds** frequently interact with **persistent, remote swells** from the **Southern Ocean**.

RESEARCH OBJECTIVES

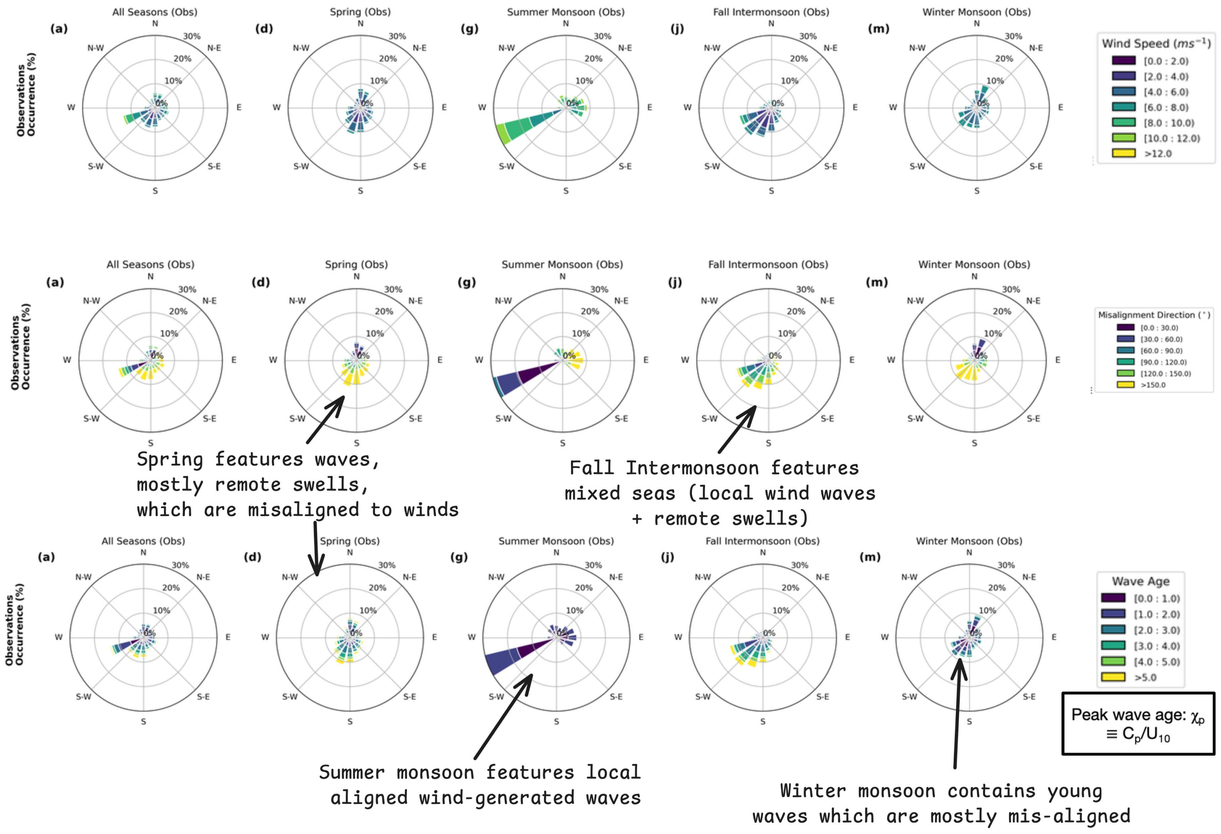


Venkatesan et al 2021.



- Determine the climatological prevalence of **wind-wave misalignment** in the **NIO**, specifically assessing its frequency during the **formation of the NIO mini-warm pool**.
- Quantify the impact of **wind-wave misalignment** on **surface wind stress** and subsequently on **SST evolution** during the formation of the NIO mini-warm pool.

WAVE ROSES AT AD07



IMPACT OF MISALIGNMENT ON WIND STRESS

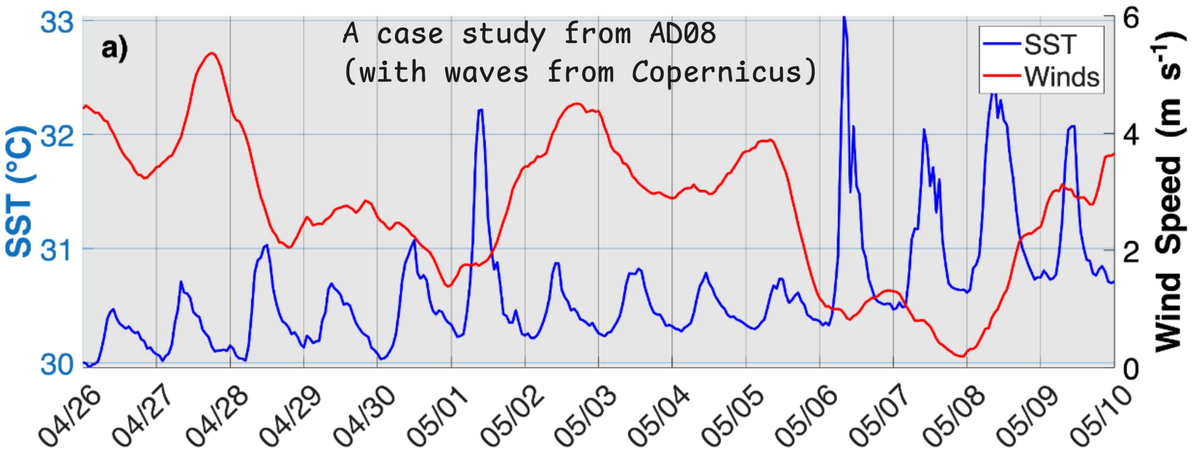
$$\tau = \rho_a C_D U_r^2 \qquad U_a - U_o$$

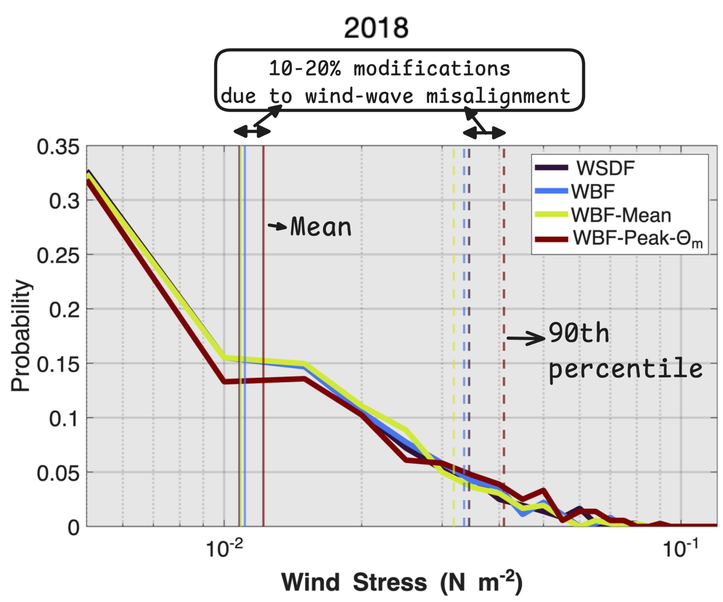
$$C_D = \left[\frac{\kappa}{ln(z/z_o) - \psi_m(z/L)}\right]^2 \longrightarrow z_o = z_o^{smooth} + z_o^{rough}$$

Calculated in COARE algorithm

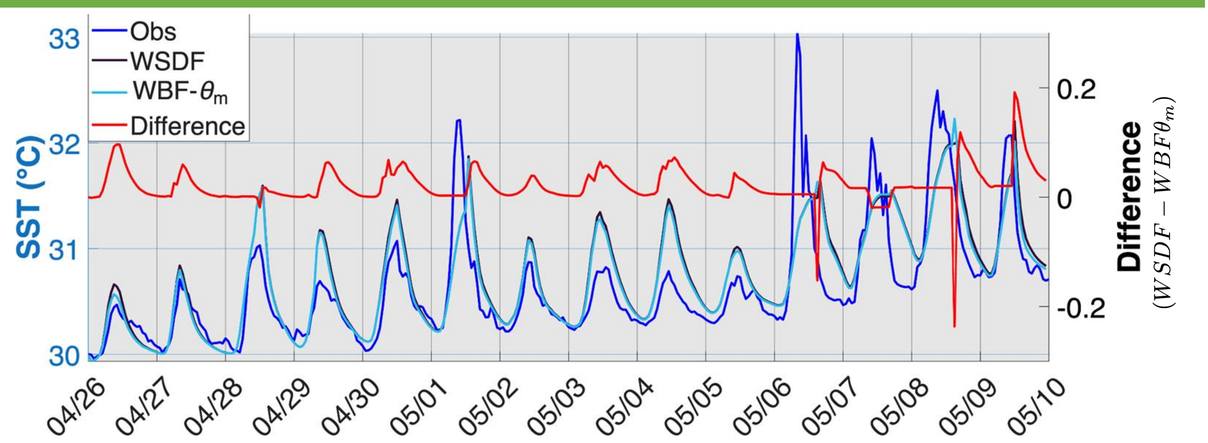
IMPACT OF MISALIGNMENT ON WIND STRESS (CONTD.)

S.no	Case	z_o^{rough} formulation	Reference
1	WSDF	$\alpha \frac{u_\star^2}{g}$ $\quad \alpha = mU_{10N} + b$	*Charnock (1955), Edson et al. (2013)*
2	WBF	$H_s.0.09.\left(\frac{u_\star}{c_p}\right)^2$	*Edson et al. (2013)*
3	WBF-m	$H_s.0.39.\left(\frac{u_\star}{c_m}\right)^{2.6}$	*Sauvage et al. (2023)*
4	WBF−Θ	$H_s.0.09.cos(a\theta)\left(\frac{u_\star}{c_m}\right)^{Bcos(b\theta)}$	*Sauvage et al. (2023)*





IMPACT OF MISALIGNMENT ON SST



- **1-D modeling experiments** using **K-ε mixing scheme** in **General Ocean Turbulence Model (GOTM)** reveal that modified wind stresses **mutes the diurnal cycle of SST** (no significant impact on baseline SST).
- **Variations in diurnal SST** are driven less by changes in surface heat flux and **more by altered vertical mixing resulting from modified wind stress**.

TAKE-AWAY MESSAGES

- **Wind-Wave misalignment** due to the influence of **remote swells** is a common feature within the **Northern Indian Ocean**, especially within the mini-warm pool.
- **Modified wind stress formulations** impact the **diurnal evolution of SST** due to modified **vertical mixing**.