Impact of Ocean Currents on Wind Stress in the Tropical Indian Ocean

Neethu Chacko[1], Meer M Ali[2,3] and Mark A Bourassa[2,4]

1. Regional Remote Sensing Centre-East, National Remote Sensing Centre, ISRO, Kolkata, West Bengal 700156, India
2. Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL, 32310
3. Andhra Pradesh State Disaster Management Authority, Kunchanapalli, Andhra Pradesh 522501, India
4. Department of Earth, Ocean and Atmospheric Science, Florida State University, Tallahassee, FL 32310

Motivation and objectives

This study examines the effect of surface currents on the bulk algorithm calculation ofwind stress estimated using the scatterometer data during 2007–2020 in the Indian Ocean. In the study region as a whole, the wind stress decreased by 5.4% by including currents in the wind stress equation. The most significant reduction in the wind stress is found along the most energetic regions with strong currents such as Somali Current, Equatorial Jets, and Agulhas retroflection. The highest reduction of 11.5% is observed along the equator where the Equatorial Jets prevail.

A sensitivity analysis has been carried out for the study region and for different seasons to assess the relative impact of winds and currents in the estimation of wind stress by changing the winds while keeping the currents constants and vice versa. The inclusion of currents decreased the wind stress (consistent with scatterometer winds) and this decrease is prominent when the currents are stronger. This study showed that the equatorial Indian Ocean is the most sensitive region where the current can impact wind stress estimation. The results showed that uncertainties in the wind stress estimations are quite large at regional levels and hence better representation of wind stress incorporating ocean currents should be considered in the ocean/climatic models for accurate air-sea interaction studies that are not based on remotely sensed winds.

The inclusion of surface currents into the bulk formula for wind stress modifies Equation (1) to

$$\tau = \rho_a C_d \, |\vec{U}_w - \vec{U}_o| \, (\vec{U}_w - \vec{U}_o) \quad (2)$$

where, U_w-U_o is the difference between the surface wind (U_w) and ocean current (U_o) vectors. Our surface relative winds come from ASCAT on METOP-A and METOP-B. These are added to OSCAR currents to determine Earth relative winds.

Impact on the wind stress

Region of interest	$\tau_{no\text{-}Cur}$ (N/m²)	τ_{Cur} (N/m²)	τ_{Cur} - $\tau_{no\text{-}Cur}$ (N/m²)	% Difference
Basin Average	0.06448	0.06073	−0.00282	−5.81%
Somali Current (43˚E-64˚E; 0-15˚N) region	0.06264	0.05665	−0.00599	−9.56%
Equatorial Jet (60˚E-90˚E; 2˚S-2˚N) region	0.03145	0.02644	−0.00501	−15.93%

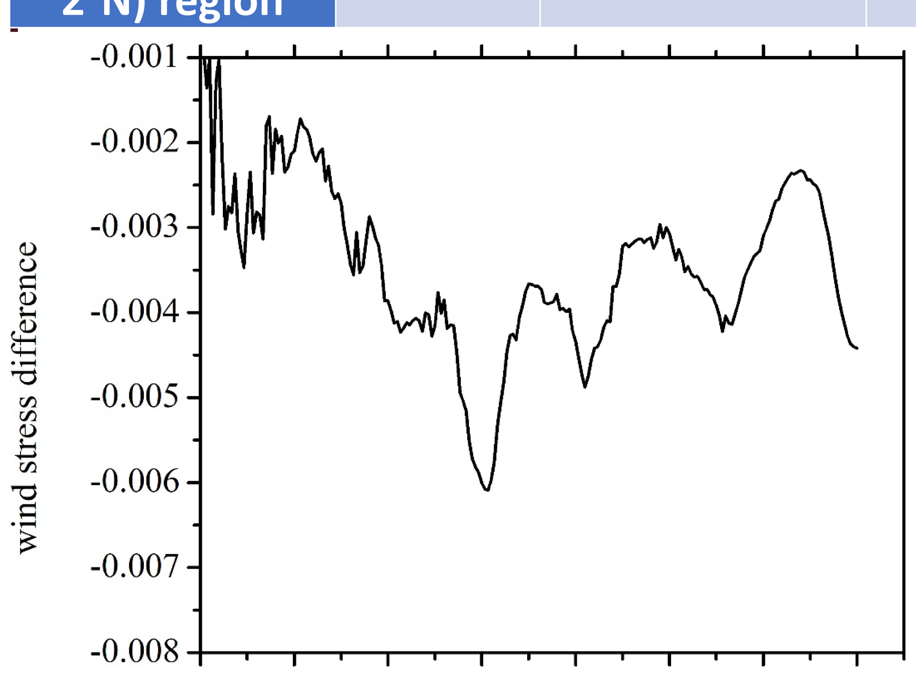

Figure 2. Zonal average of wind stress difference (τ_{Cur}-$\tau_{no\text{-}Cur}$; N/m²) in the tropical Indian Ocean, for the Equatorial jet region listed above.

Map of Mean Annual Stresses and Stress Difference

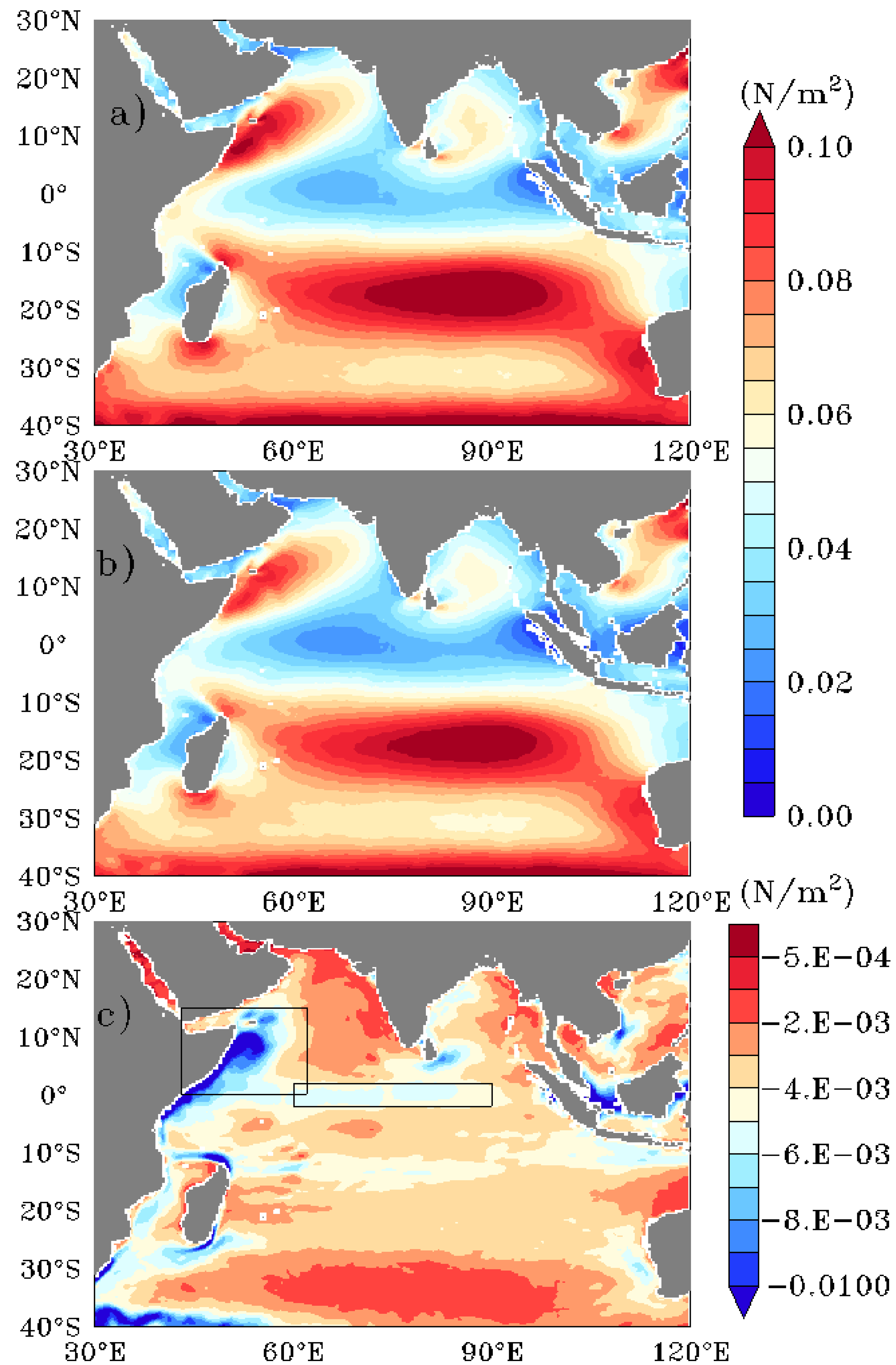

Fig. 2. Wind stress (N/m²) estimated (**a**) without currents, (**b**) with currents, and (**c**) difference between the two wind stresses (**b-a**). The regions off Somali Coast and equatorial Indian Ocean are shown as boxes in Fig. (**c**).

Monthly Changes in Stress & Stress Curl

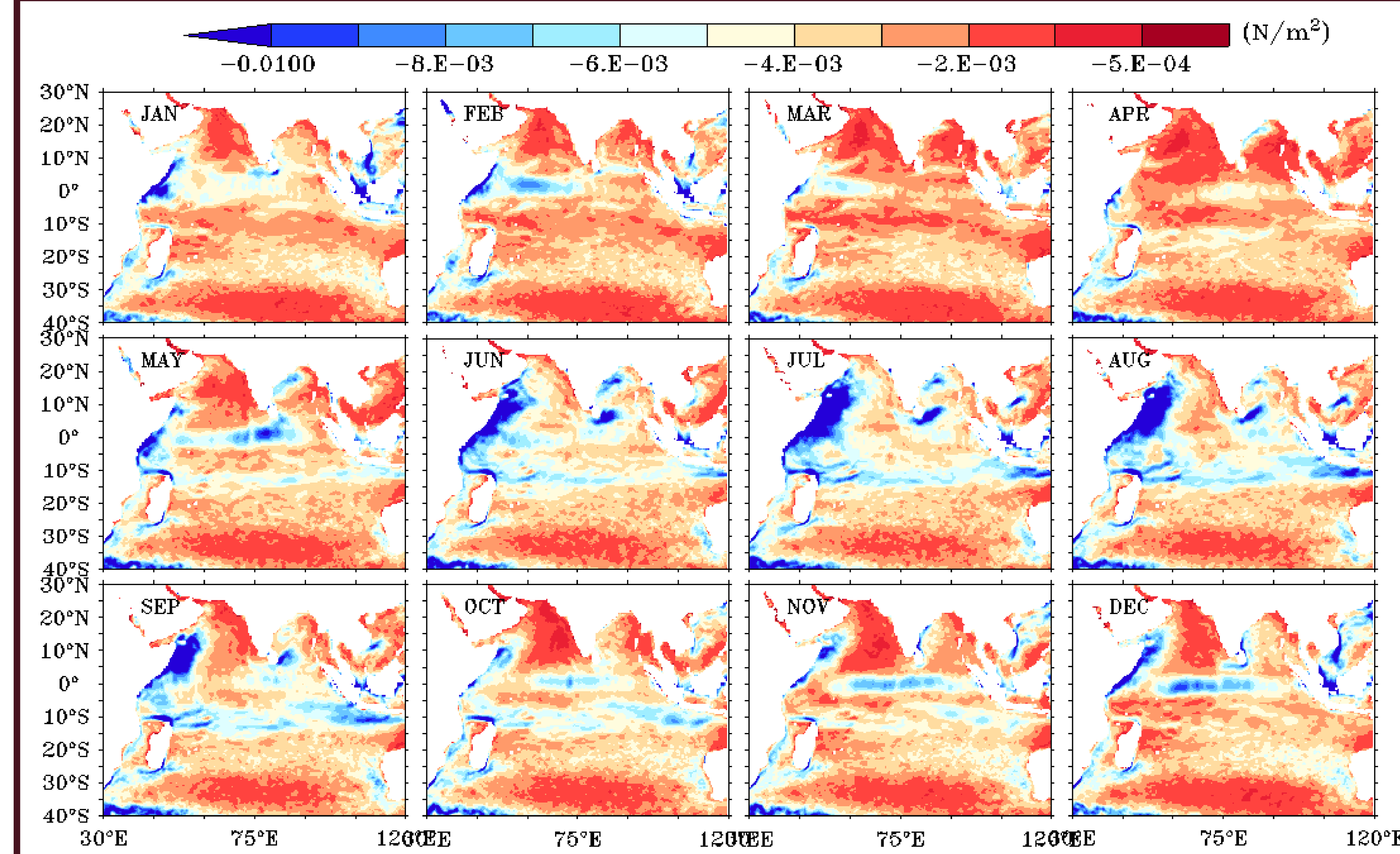

Fig. 3. Seasonal and spatial distribution of the difference between the two wind stress estimations (τ_{Cur} - $\tau_{no\text{-}Cur}$) averaged over 2007–2020.

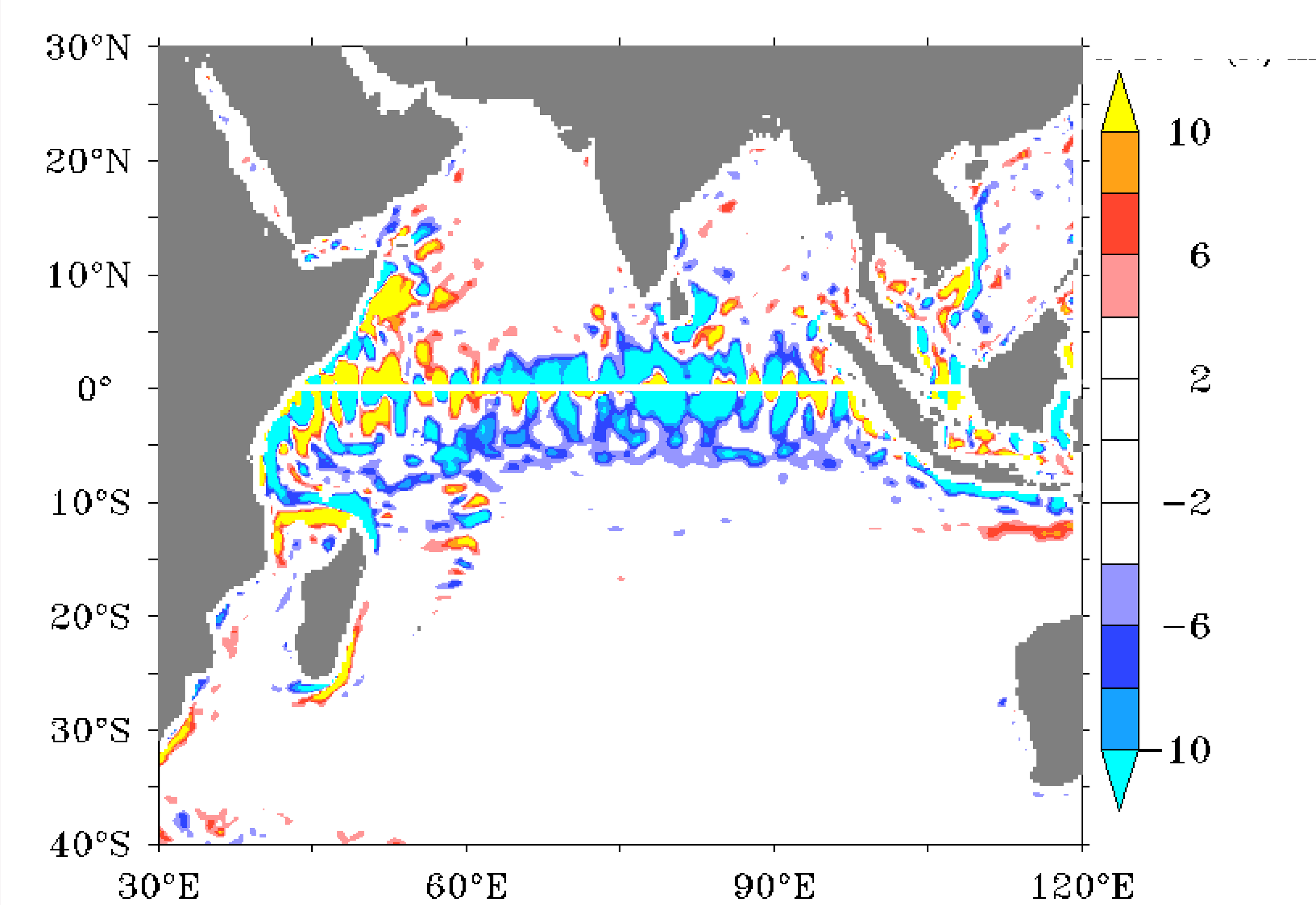

Figure 4. Average annual difference between the wind stress curl estimated with and without the inclusion of surface currents (τ_{Cur} - $\tau_{no\text{-}Cur}$) during 2007–2020.

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