Climatic Modulation of the Euphotic Zone in the Arabian Sea: Multi-Sensor Satellite Evidence from 1998–2023

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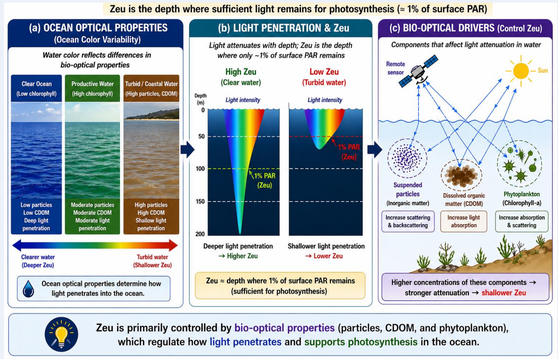
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Scan for Abstract

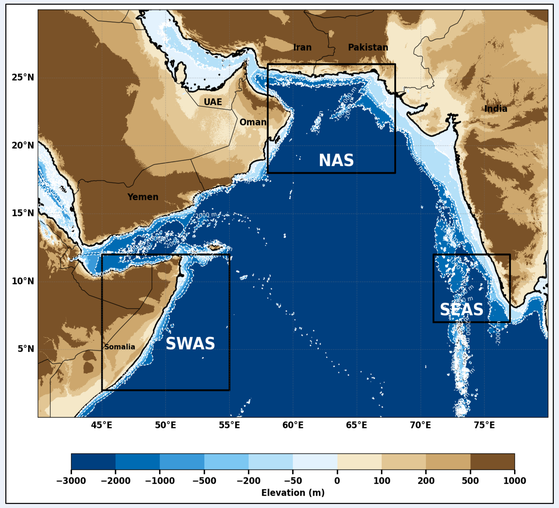
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1. INTRODUCTION

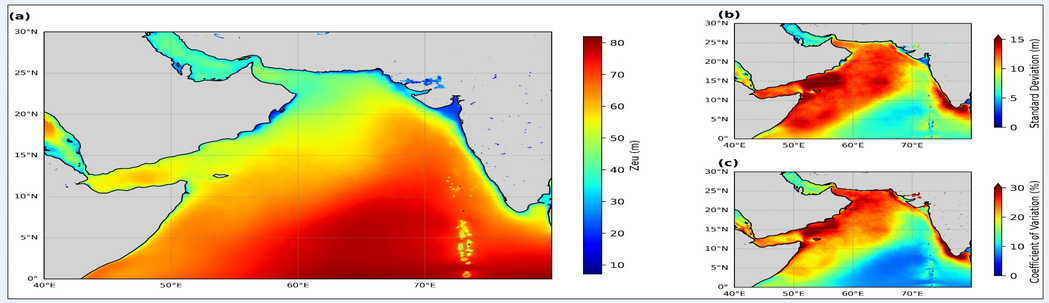


- The uppermost layer of the ocean, is characterized by the presence of most of the visible light, which is available for photosynthesis. It extends from the surface to a depth of 200 m.
- Long-term basin-wide assessment of Zeu variability (1998-2023) and its climatic controls remain limited
- The study investigates the trends, seasonal cycle and climatic linkages of Zeu using multi-sensor satellite data.

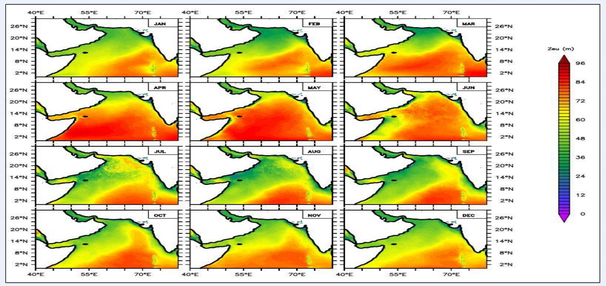
2. STUDY AREA



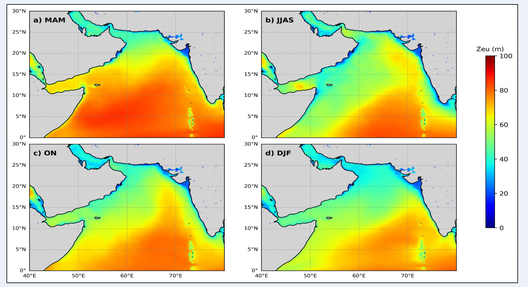
3. MEAN STATE & VARIABILITY OF Zeu (1998 - 2023)



4. MONTHLY CLIMATOLOGY OF Zeu



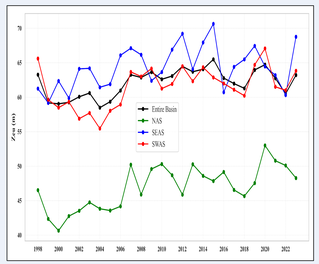
5. SEASONAL VARIABILITY



Monsoonal Forcing || ↑ Coastal & Open-Ocean Upwelling || ❄ Winter Convection & Vertical Mixing
→ Horizontal Advection of Water Masses || Wave- and Tide-Induced Mixing

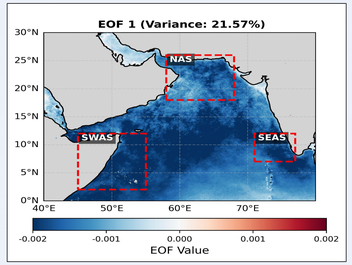
6. INTERANNUAL VARIABILITY, M0DES & CLIMATIC LINKAGES

(a) Interannual time series of Zeu



- **Basin-wide Zeu:** 58–66 m
- **SEAS:** Highest Zeu (59–71 m) → Clearer waters
- **NAS:** Lowest Zeu (40–53 m) → More turbid conditions
- **SWAS:** Comparable to basin mean (55–67 m)

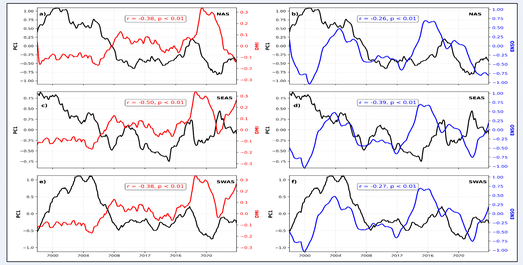
(b) Dominant Spatial Mode (EOF 1)



- EOF1 captures interannual variability (21.57% basin variance)
- Negative spatial loadings across basin → (+PC1 = shallower Zeu | −PC1 = deeper Zeu / clearer waters)
- SEAS most climate-sensitive region

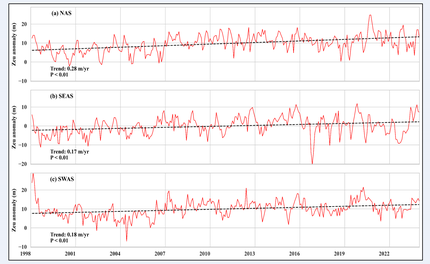
(c) PC1 vs Climatic indices

PC1 vs DMI (IOD) | PC1 vs ENSO



- NAS: Weak direct correlation, but significant lagged response (10 / 8 months) indicating delayed IOD influence.
- SEAS: Strongest negative correlation showing IOD as the dominant driver of Zeu variability.
- SWAS: Significant negative relationship, confirming basin-wide IOD control on Zeu.
- Positive IOD/ENSO → **Deeper Zeu basin-wide**

7. LONG TERM TREND



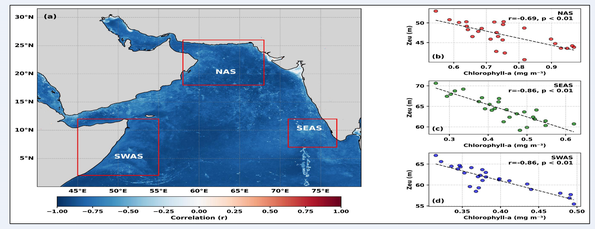
NAS		
JJAS	0.24	< 0.01
ON	0.47	< 0.01
DJF	0.16	< 0.01
MAM	0.11	< 0.01

SEAS		
JJAS	0.13	= 0.13
ON	0.18	= 0.18
DJF	0.14	< 0.05
MAM	O.12	< 0.10

SWAS		
JJAS	0.22	< 0.05
ON	0.25	< 0.05
DJF	0.13	< 0.05
MAM	O.14	= 0.11

*1st column: Season, 2nd Col: Trend (m/year), 3rd Col: P value

8. CHLOROPHYLL – Zeu RELATIONSHIP



9. KEY TAKEWAYS

- First comprehensive quantification of Zeu variability in the Arabian Sea across seasonal, interannual, and long-term timescales using multi-sensor satellite data.
- Zeu shows an overall increasing trend, indicating enhanced water clarity across the Arabian Sea basin.
- Zeu is strongly inversely related to chl-a, highlighting the dominant role of bio-optical processes.
- Interannual variability in the NAS, SEAS, and SWAS is primarily driven by the IOD, followed by the ENSO.
- Regional contrasts are evident: the NAS during the ON season demonstrates the highest positive trend in Zeu.

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← Scan here to read the paper

Shincy, F., Mani Murali, R., & Vidya, P. J. (2026). Variability of euphotic zone depth in the Arabian Sea over the period 1998 2023. Journal of Geophysical Research: Oceans, 131, e2025JC023204

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