ASSESSING THE SPATIAL-TEMPORAL WAVE ENERGY CHARACTERISTICS ALONG THE SOUTHEAST COAST OF CHINA IN A WAVE SIMULATION STUDY

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The objective of this study is to evaluate exploitable wave power in the South China sea, especially along the southeast coast, from a 10-year hindcast simulation of ocean waves. Based on wind speed and wind direction data from meteorological stations in the South China Sea, an evaluation of three reanalysis data products, namely ERA5, CFSv2, and CCMP, was conducted using correlation coefficients, bias, and other performance indexes. Overall, the wind field of the ERA5 dataset performed the best.

Based on comparison of different products of winds, wind fields from the ERA5 dataset was employed to drive a third-generation wave spectrum model for simulating long-term waves along the coastal regions of China. The governing equation in the form

$$\frac{\partial N}{\partial t}+\frac{\partial}{\partial x}c_x N+\frac{\partial}{\partial y}c_y N+\frac{\partial}{\partial \sigma}c_\sigma N+\frac{\partial}{\partial \theta}c_\theta N=\frac{S}{\sigma} \quad (1)$$

solves the action density spectrum $N(\sigma,\theta)$, which is obtained by dividing the wave energy spectrum $E(\sigma,\theta)$ with the relative frequency σ and ensures conservation of wave energy. The wave energy level is related to $E(\sigma,\theta)$ (Shi et al. 2022) and can be evaluated by the wave energy flux (Sheng and Li 2017):

$$J=\rho g\int_0^{2\pi}\int_0^{\infty} C_g(\sigma,\theta)E(\sigma,\theta)d\sigma d\theta \quad (2)$$

where θ is the wave propagation direction. After thorough validation of wave parameters, the wave energy was assessed and its spatiotemporal variations were analyzed.

By investigating the multi-year average distribution (Figure 1) and seasonal changes in terms of wave power density, wave energy stability, exploitable time, and development potential, the results revealed that the maximum annual cumulative wave energy along the 50-meter isobath concentrated in the range of significant wave heights between 1 to 4 meters and periods of 5 to 9 seconds. With the exception of the Beibu Gulf, the multi-year average wave height in other sea areas was greater than 1.5 m, with wave energy of approximately 10 KW/m or above. The wave spectrum density reached its maximum in the Taiwan Strait and the western waters of Guangdong, exhibiting a distribution of greater wave energy and more concentrated wave direction bins. Among them, the wave energy resources in eastern Guangdong were the most abundant, reaching approximately 130 MW/m (Figure 2). Moreover, the swells play a key role in the Guangdong coast, with wave directions ranging from south-southwest to south.

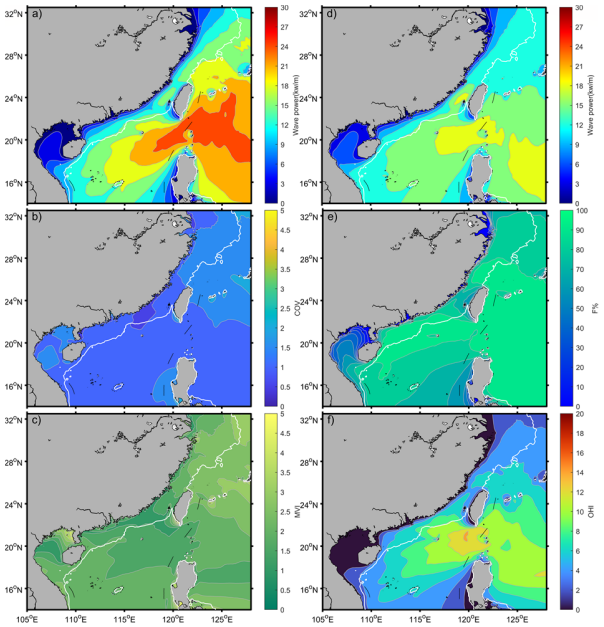

Figure 1 - Spatial distribution of a) annually average wave energy flux (KW/m); b) coefficient of variation; c) the monthly variability index; d) annually average effective wave energy flux (KW/m); e) occurrence frequency of effective wave energy flux; and f) the optimum hotspot identifier between 2013 and 2022

The spatial distribution of wave energy in different seasons (Figure 3) was generally consistent with previous findings, except for higher wave energy density to the east of the Taiwan Island during summer months (JJA), which was attributed to inter-annual variations influenced by tropical cyclones in the western North Pacific.

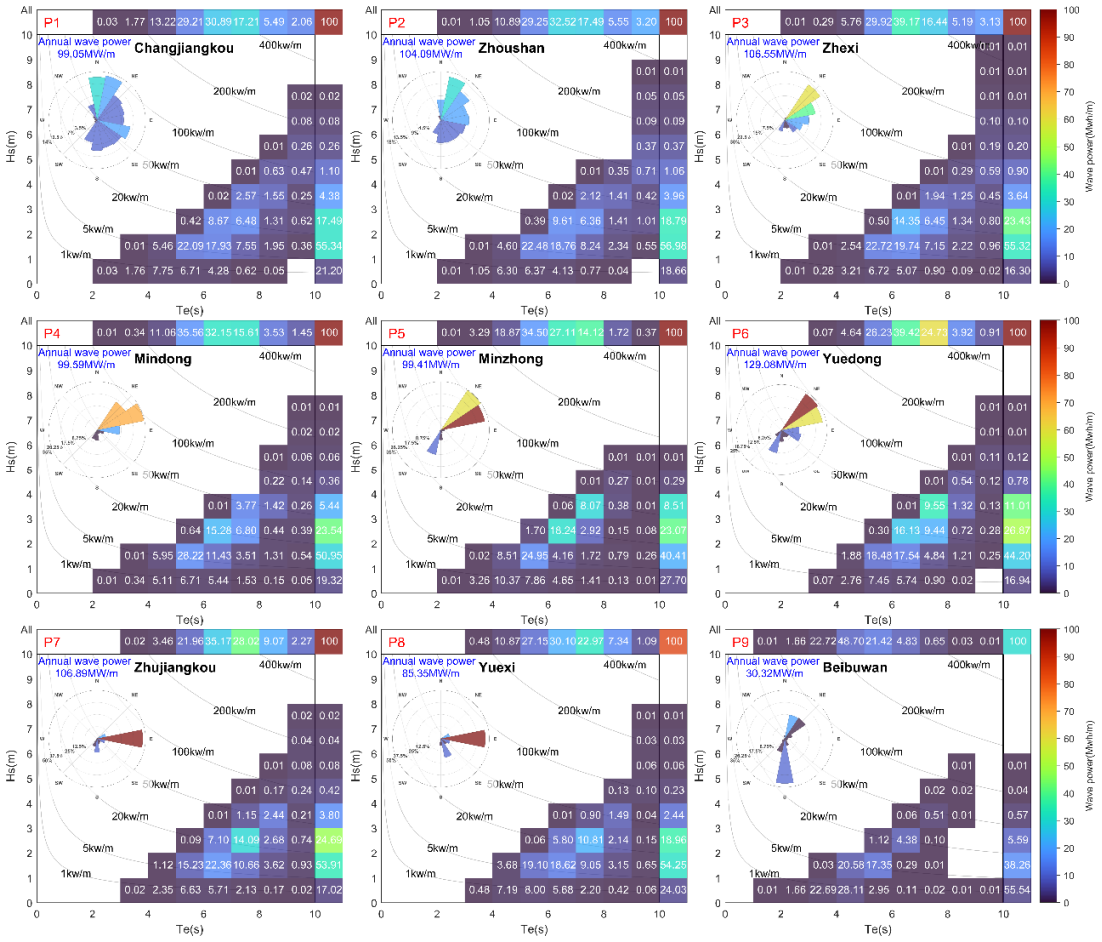

Figure 2 - Wave energy diagrams of the annual energy corresponding to sea states in different $H_s - T_e$ bins at selected hotspot sites. The top left subplots in each plot depict the directional distribution of wave energy.

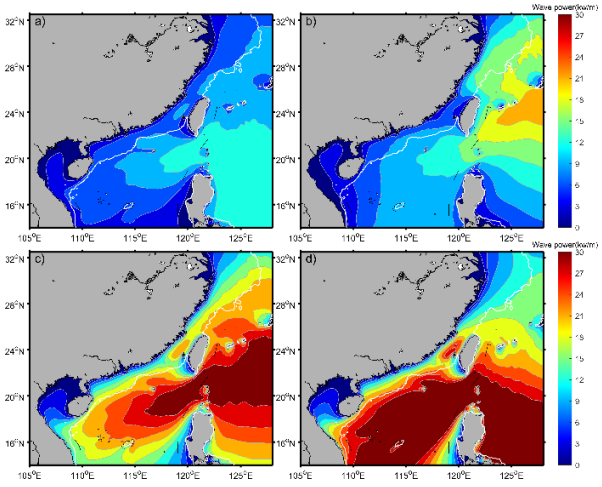

Figure 3 - Seasonal distribution of average wave energy flux (KW/m) in a) spring, b) summer , c) autumn and d) winter during period of 2013-2022

In summary, the wave energy along the southeastern coast of China exhibits a pattern of higher energy in the south than in the north, greater energy in offshore areas compared to nearshore areas, and higher energy in winter than in summer. Among them, the wave energy in eastern Guangdong coast demonstrates higher stability, longer exploitable duration, and greater development potential.

REFERENCES

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