SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Theme # 2.3

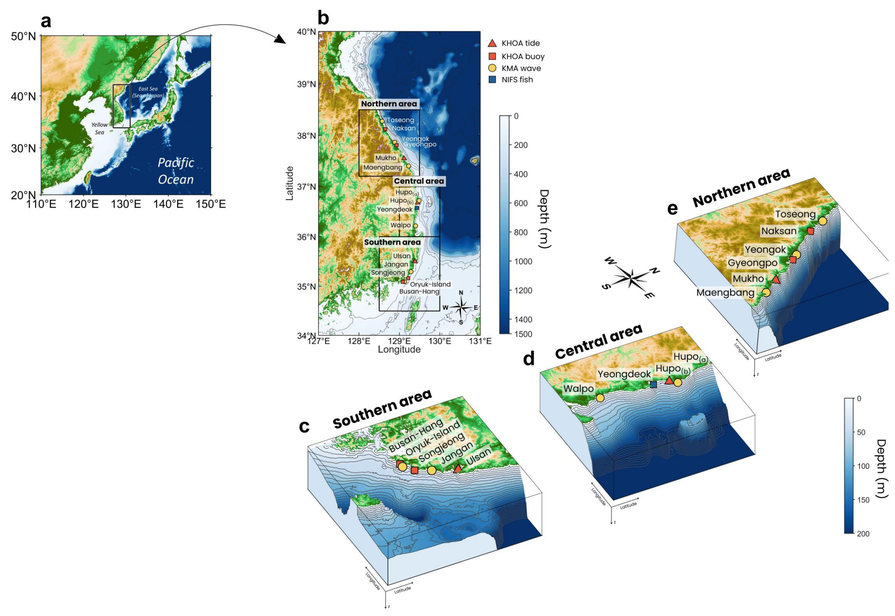
Understanding Local Characteristics and Dynamic Mechanisms of Cold Water Events: A Focus on the Eastern Coast of Korea

Introduction

The emergence of cold water triggered by coastal upwelling exerts diverse impacts on the marine environment. It transports nutrients from deeper layers to the surface, leading to localized phytoplankton blooms. However, the abrupt change in water temperature can cause mass mortality of aquaculture species, resulting in significant economic losses. It can also hinder summer tourism by limiting beach activities and causing discomfort to swimmers, and it contributes to the formation of sea fog, increasing the risk of maritime accidents. Therefore, sudden temperature changes should be continuously monitored and managed. The eastern coast of the Korean Peninsula shows distinguishable characteristics within a relatively short north-south spatial range, characterized by differences in coastline orientation, bathymetric slope, coastal topography, water stratification, and background currents. Nevertheless, many previous studies have employed a wind-derived upwelling index to detect cold water, which often does not correspond well with sea surface temperature in the study area. This inconsistency results from differences between the commonly used Eastern Boundary Upwelling Systems and the regional upwelling systems. Thus, this study proposes a novel approach for objective cold water detection, aligned with regional characteristics, and elucidates the regional heterogeneity in the occurrence mechanisms identified by this method. Based on the distinct characteristics, the study identified three separate areas—Northern, Central, and Southern—along the eastern coast of the Korean Peninsula. In these areas, cold water occurrence was driven by different primary dynamic mechanisms: topographic effects in the Northern area, migratory extratropical cyclones in the Central area, and the East Asian Summer Monsoon in the Southern area. The required wind stress intensity and duration for temperature reduction varied significantly depending on the driving mechanism. Additionally, the intensity, duration, and rate of temperature decrease exhibited distinct characteristics across the different origins. Considering the proposed findings, integrating the identified characteristics and origins offers specific insights that can enhance the precision of environmental monitoring and inform the development of more effective management strategies.

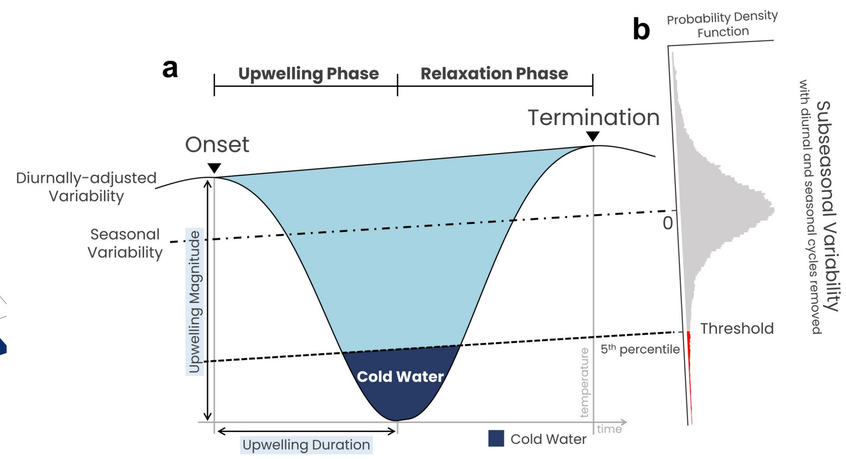
Materials & Methods

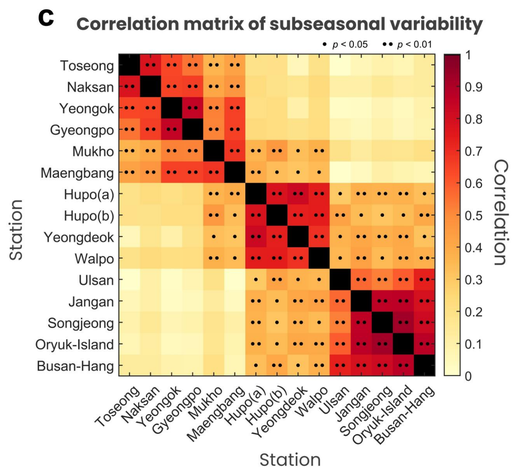
Study Area



- This area is **smaller** compared to typical Eastern Boundary Upwelling regions.
- The **coastline orientation** divides into three different areas.
- These three areas also have differences in **bathymetry, mixed layer depth, and background currents**.

Cold Water Detection Method



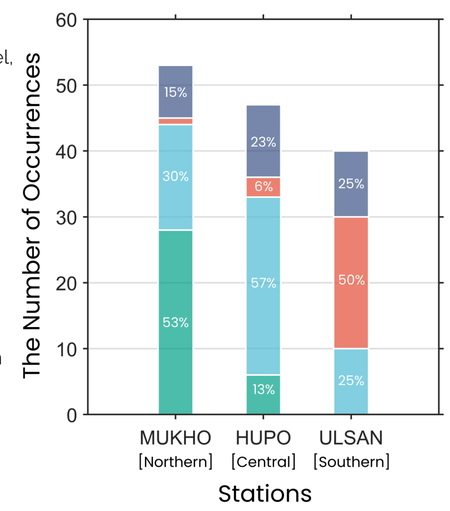


- We define cold water events as occurrences where **the natural variability of sea temperature** becomes **exceptionally low**.
- The correlation matrix indicated **three well-defined groups** that correspond to the previously defined regions.

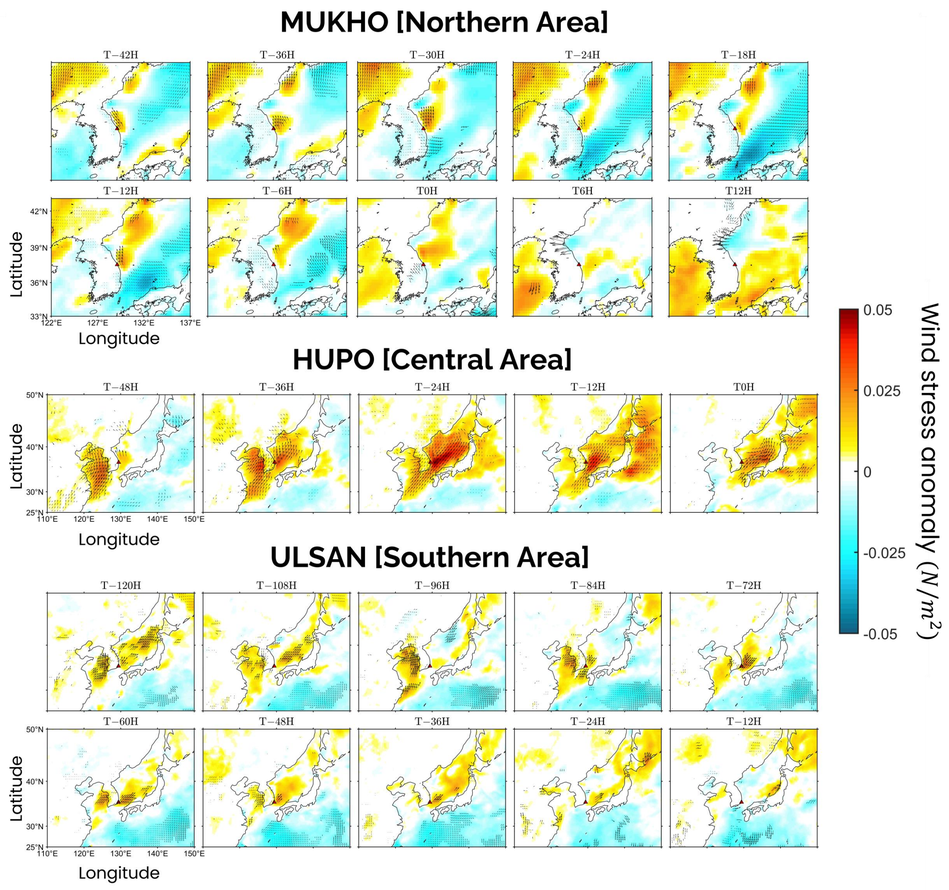
Dynamic mechanisms

- **Topographic Effect**: A northern area, where mountainous terrain influences the wind patterns. high-pressure anomaly forms over the East Sea at the mean sea level, creating a short but intense period of alongshore wind stress. This phenomenon is primarily observed in the northern area, where mountainous terrain influences the wind patterns.
- **Extratropical Cyclone**: Extratropical cyclones originating in China propagate northeastward, crossing the Korean Peninsula and creating upwelling-favorable alongshore wind stress along the east coast. The movement of these cyclones is clearly visible in the 850 hPa geopotential height anomaly.
- **East Asia Summer Monsoon**: During the summer, high pressure over the Northwestern Pacific and low pressure over Eurasia generate the southwest monsoon, creating sustained alongshore wind stress in the southern area. This has been widely cited in previous studies as a primary driver of cold water events.
- **Tropical Depression/Typhoon**: Tropical depressions or typhoons from the western Pacific can pass over the Korean Peninsula, inducing strong shear stress along the east coast, leading to cold water events.

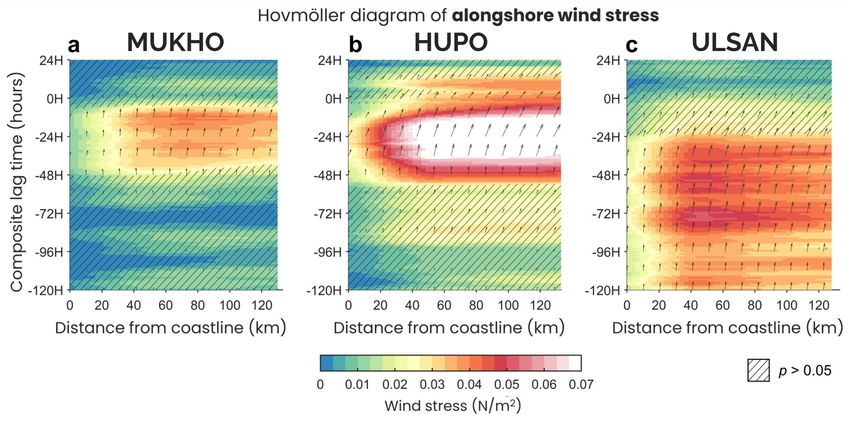
The occurrences of dynamic mechanism



Results & Discussion



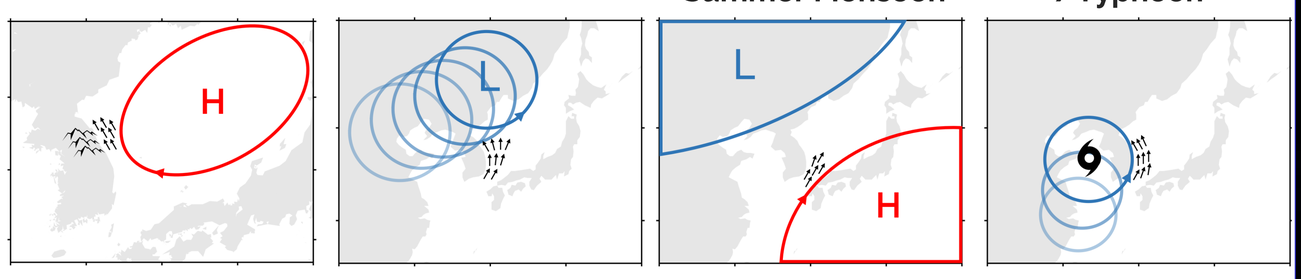
Hovmöller diagram of **alongshore wind stress**



Conclusion

- Cold water occurrence, as a type of natural hazard, requires subseasonal to seasonal forecasting and continuous monitoring.
- We proposed a **novel objective criterion for cold water detection** that had not been previously suggested.
- Through this new method, we identified region-specific cold water occurrence mechanisms along the eastern coast of the Korean Peninsula that had not been reported before: ***topographic effects*** in the Northern area, ***migratory extratropical cyclones*** in the Central area, and the ***East Asia Summer Monsoon*** in the Southern area.
- We are confident that the dynamics proposed in this study will provide substantial benefits on prediction and response efforts.

Schematics of Dynamic mechanism



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