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Tracer-Revealed Biogeochemical Fluxes: Kuroshio Dynamics and Land-Ocean interaction in Asian Marginal Seas

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Accelerating climate change and expanding anthropogenic pressures are disturbing hydrological regimes and biogeochemical cycling patterns, critically impacting the oceanic structure and ecosystems of Asia's marginal seas. In this presentation, the scientific imperative focuses on quantifying terrestrial-marine material fluxes, specifically through two uncharacterized mechanisms:

1. Kuroshio Nutrient Transport Dynamics

Functioning as a western boundary current, the Kuroshio delivers nutrient-rich subsurface waters to continental shelf regions, a process modulated by topographic interactions, stratification regimes, and turbulent mixing dynamics. Conventional methodological approaches incompletely capture the spatiotemporal variability of water-mass and material fluxes, introducing significant uncertainties into macro- and micronutrient budget estimates.

2. Nonlinear Land-Ocean Coupling

Land-to-ocean material transfer is governed by synergistic controls:

- Physical mixing of water masses from multiple sources, including riverine/submarine groundwater discharge, pore water, and Kuroshio-derived waters.
- Biogeochemical processes, such as flocculation, redox-driven scavenging, and organic matter remineralization.

Chemical tracers developed under GEOTRACES and allied research initiatives provide robust tools for identifying and quantifying water mass mixing and material transport across diverse spatiotemporal domains. Our methodology leverages multi-tracers - including radiocesium, oxygen/sulfur isotopes, neodymium-radium isotopes, and rare earth element signatures - to systematically resolve these complex marine processes.

1) Half of the nutrients in the subsurface water (at a depth of 400m) underwent long-distance transport from the Kuroshio's region of origin to the East China Sea and the Tsushima Strait.

2) The contribution rates of various nutrient sources – including Kuroshio Intermediate/Subsurface Water, Taiwan Warm Current, pore water, coastal water, and regeneration processes – across the East China Sea continental shelf were quantified.

3) Oxygen-depleted water near the seafloor, exiting from the estuary to the shelf edge, was controlled primarily by pore water inputs and secondarily by organic matter remineralization processes.

Our chemical tracer integration methodology enables the quantification of water mass mixing ratios and material fluxes with process-driven efficiency, generating insights for weathering processes and ecological modeling. This approach establishes a globally applicable framework, particularly for resolving biogeochemical budgets in shelf-sea environments.