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Topological Origin of Geophysical Waves.

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The concept of topologically-protected transport along the edge of physical systems was born three decades ago in the context of quantum Hall electronics. Waves are protected from disorder and backscattering when emerging at the boundary separating bulk materials characterized by different topological invariants. Physicists realized recently that topological protection applies to virtually all areas of physics from photonics, to cold atoms, to classical mechanical systems, and have related these properties to the presence of broken discrete symmetries. However the interplay between discrete symmetries and topology have so far played little role in thinking about the fluid dynamics of oceans and atmospheres.

We show that, as a consequence of the rotation of the Earth that breaks time reversal symmetry, equatorially trapped Kelvin and Yanai waves have a topological origin, manifesting as edge modes in a rotating shallow water model [1]. Thus the oceans and atmosphere of Earth naturally share basic physics with topological phases of matter. As equatorially trapped Kelvin waves in the Pacific ocean are an important component of the El Niño Southern Oscillation and the Madden-Julian Oscillation, our results demonstrate that topology plays a surprising role in Earth's climate system.

[1] **Delplace, P., Marston, J.B., Venaille, A.**, *Topological Origin of Equatorial waves*, **2017, Science 358, 6366, pp. 1075-1077**