Abstract View

Journal of Physical Oceanography
Article: pp. 1258–1273 | Full Text | PDF (1.29M)

The Three-Dimensional Chaotic Transport and the Great Oce

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(Manuscript received June 17, 1996, in final form December 23, 1996)

DOI: 10.1175/1520-0485(1997)027<1258:TTDCTA>2.0.CO;2

ABSTRACT

The aim of this paper is to renew interest in the Lagrangian view of global and basin ocean circulations and its implications in physical and biogeochemical ocean processes. The paper examines the Lagrangian transport, mixing, and chaos in a simple, laminar, three-dimensional, steady, basin-scale oceanic flow consisting of the gyre and the thermohaline circulation mode. The Lagrangian structure of this flow could not be chaotic if the steady oceanic flow consists of only either one of the two modes nor if the flow is zonally symmetric, such as the Antarctic Circumpolar Current. However, when both the modes are present, the Lagrangian structure of the flow is chaotic, resulting in chaotic trajectories and providing the enhanced transport and mixing and microstructure of a tracer field. The Lagrangian trajectory and tracer experiments show the great complexity of the Lagrangian geometric structure of the flow field and demonstrate the complicated transport and mixing processes in the World Ocean. The finite-time Lyapunov exponent analysis has successfully characterized the Lagrangian nature. One of the most important findings is the distinct large-scale barrier—which the authors term *the great ocean barrier*—within the ocean interior with upper and lower branches, as remnants of the Kolmogorov–Arnold–M invariant surfaces. The most fundamental reasons for such Lagrangian structure are the intrinsic na time mean, global and basin-scale oceanic flow: the three-dimensionality and incompressibility givin and to the great ocean barrier, respectively. Implications of these results are discussed, from the gr conveyor hypothesis to the predictability of the (quasi) Lagrangian drifters and floats in the climate

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