Geophysical Research Abstracts
Vol. 21, EGU2019-17145, 2019
EGU General Assembly 2019

Why the wiggles? A study of an unstable front and the birth of submesoscale turbulence

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A high-resolution satellite image that reveals undulations, or wiggles, along the edge of an ocean front is examined in concert with hydrographic measurements in an effort to understand generation mechanisms for submesoscale eddies. The infrared satellite image consists of ocean surface temperatures at approximately 400-m resolution over the midlatitude North Atlantic. Concomitant altimetric observations coupled with regular spacing of the temperature anomalies (hereafter eddies) suggest the eddies result from mesoscale stirring, filamentation, and subsequent frontal instability. While horizontal shear or barotropic instability (BTI) is one mechanism for generating such eddies, we conclude from linear theory coupled with in situ measurements that mixed layer or submesoscale baroclinic instability (BCI) is a more plausible explanation for the observed submesoscale structures. Here, we assume that the frontal disturbance remains in its linear growth phase and is accurately described by linear dynamics. This result likely has greater applicability to the open ocean—i.e. regions where horizontal shear is reduced relative to its value along coasts and within strong current systems. Given that such waters comprise an appreciable percentage of the ocean surface, and that energy and buoyancy fluxes differ under these two mechanisms (i.e. BTI and BCI), this result has wider implications for proper representation of energy and buoyancy fluxes within ocean models.

The study is fun in that it makes use of two forms of satellite observations (polar-orbiting and geosynchronous), in situ observations, and a bit of theory. It is also relevant in that it relates to a topic first discussed by Munk et al. [2001] and Eldevik and Dysthe [2002], among others. Finally, it has something to say about the utility of thermal imagery for submesoscale (< 30 km) studies when combined with a complementary, secondary dataset.