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A small-scale oceanic eddy off the coast of West Africa studied by multi-sensor satellite and surface drifter data, and by a numerical model

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High-resolution satellite images and oceanographic field measurements have revealed that oceanic eddies with diameters ranging from 1 to several hundred km are ubiquitous phenomena in the World's ocean. While eddies with horizontal scales above 100 km have been studied extensively using altimeter data, only few papers exist dealing with observations of eddies with horizontal scales below 50 km. These small-scale eddies cannot be resolved by conventional altimeters, but they can be observed from space by high-resolution optical/infrared sensors and by synthetic aperture radars (SARs).

In this paper we report about a single small-scale cyclonic (cold) eddy which was generated at the headland of Cap-Vert off the coast of Senegal following a sudden freshening of the trade winds. Due to favorable cloud conditions, we were able to track the time evolution of the eddy for 31 days by satellite images acquired in the visible/ infrared band. Furthermore, the eddy was also imaged during this period by a space-borne SAR. Cold eddies become visible on SAR images via the change in the small-scale sea surface roughness caused by the damping of short surface waves by biogenic surface films or/and by the change of the stability of the air–sea interface. Biogenic surface films consist of surface-active material secreted by biota in the cold eddy.

The satellite data we are using are from the MODIS sensor onboard the American Aqua satellite, the AVHHR sensor onboard the European MetOp satellite, and the Advanced SAR (ASAR) onboard the European Envisat satellite. The sea surface temperature (SST) and chlorophyll-a (CHL) maps derived from MODIS data show that the eddy propagated from its birth place at Cap-Vert in the Senegal upwelling region westward into the open North Atlantic. During the 31 days of satellite observations, the eddy moved 200 km westward thereby carrying nutrients from the upwelling region into the oligotrophic North Atlantic, where it caused enhanced CHL concentration. Maximum CHL concentration was encountered few days after the eddy generation, which is consistent with a delayed plankton growth following nutrient supply into the euphotic zone within the eddy. Furthermore, we recorded the movement of the eddy also by a satellite-tracked surface drifter. To our knowledge, this is the first time that a small-scale eddy has been tracked over such a long time period by high-resolution satellite images and simultaneously by a surface drifter.

Model calculations carried out with the "Mercator" ocean circulation model show that the generation of the small-scale eddy was linked to a sudden increase of the trade winds. This wind event caused enhanced southward flow and upwelling at the coast of Senegal. The model calculations show further that the eddy was generated by flow separation at the headland of Cap-Vert.