The State of the Art in Surface Current Estimation from Remote Sensing and In Situ Observations

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The empirical estimation of surface currents in the upper few meters of the ocean has recently seen significant advances in remote sensing and in situ instrumentation. In this review, we survey these advances and present the outlook for improvements in the next decade. Here, we concentrate on surface currents measured from the surface to depths of 10's of meters, although most of the techniques discussed concentrate on the upper meters. During the last decade, measurements of surface currents using coastal HF radar has become operational and the physics of the measurement better understood, to the level where HF radar estimates of surface currents close to the coast are widely available for many places in the US and Europe. The use of Doppler shifts in the surface wave spectra due to surface currents has also become operational, and the estimation of vertical shear in the upper few meters is now used experimentally using optical polarimeters. On a parallel development, the use of pencil beam Doppler scatterometers has opened the way for wide swath ocean surface current estimates. These measurements have been demonstrated using the NASA DopplerScatt system and, for near nadir incidence, the NASA AirSWOT and European KaRadoc systems. Spaceborne versions of these systems, enabling global estimation of surface currents, have been proposed as the US Wind and Currents Mission (WaCM) concept or the European Sea surface KInematics Multiscale monitoring (SKIM) mission concept. In situ instrumentation for measuring surface currents has also improved significantly in the last decade. Notably, technological advances combining GPS tracking and improved hydrodynamic design has led to a new generation of surface drifters, developed under the Consortium for Advanced Research on Transport of Hydrocarbon in the Environment (CARTHE), or using disposable thin surface drifters to sample the upper centimeters. Beyond the near surface, Lagrangian floats have enabled following 3-dimensional motions of water packets. Finally, a new generation of autonomous vehicles, wave gliders or Sail Drones, now allows for remote in situ collection of surface currents by coordinated arrays of assets. Finally, traditional Acoustic Doppler Profilers (ADCPs) have increased in sensitivity and ability to measure near surface.