Application of Multivariate Optimum Interpolation to Ocean Surface Current Analysis

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Data assimilation is an essential component of a coastal ocean prediction system. By assimilating ocean observations, the ocean forecast can be continuously re-initialized. In a forecast mode, the prediction system can be used for storm surge forecast, search and rescue mission, and oil spill response. In a hindcast mode, the prediction system provides a dynamically consistent analysis of the ocean variables, which can be used in estimates of particle trajectory, pollutant dispersal, and material transport.

The shore-based HF radar is perhaps the most exciting recent development of coastal ocean monitoring system. It is capable of measuring surface currents in real-time over a 50-km range with a 2-3 km resolution. The new, long-range radar from CODAR may further extend the offshore coverage to 200 km. Such system offers immense potential for use in coastal ocean prediction. The challenge is to find a modeling strategy that can best utilize the HF-radar surface current information.

There are two important considerations in dealing with HF-radar surface ocean current measurements. First, the radar observations contain small-scale, high frequency 'noises', which must be removed to make the observations more compatible with model dynamics. This requires pre-processing of surface current data with a dynamically consistent spatial 'filter'. Second, the observed surface currents need be projected to the ocean interior to make the data assimilation more effective. This requires knowing the relationship between surface currents and the internal dynamics.

Multiple Optimum Interpolation (MOI) is a powerful objective analysis method used in meteorology. For a set of scattered synoptic observations of ocean current and (when available) geopotential, the MOI can obtain consistent estimates of both streamfunction and velocity potential fields, without the need to estimate (the relatively noisy) gridpoint divergence and vorticity. This is achieved by assuming a generalized random scalar field and using optimum linear estimation theory. The method can also incorporate the geopotential observations.

The MOI analysis is illustrated using the HF-radar surface current and the moored current meter observations from the Santa Barbara Channel (SBC). The mooring data were acquired as part of the SBC Circulation Study, organized by Clinton Winant of Scripps Institution of Oceanography (SIO). The field study included 10 current-meter moorings, each equipped with two current meters at 5 and 45 m and a thermister chain. From each mooring, surface (5 m) currents and geopotentials (dynamic heights) are obtained. A full-year data is used in the surface current analysis. The SBC Circulation Study also made several surface drifter releases. The drifter data, too, are incorporated in the analysis.

The HF-radar data were acquired as part of the South Central California CODAR Project, conducted by Libe Washburn of UC Santa Barbara (UCSB), using the CODAR Sea Sonde system. The surface current observations cover an area of about 40x50 km with a 2x2 km resolution. A one-month analysis of surface current field is obtained.

The MOI analysis provides a dynamically consistent ocean surface current field, which can be gainfully used in the data assimilation. One simple approach is to project the surface geopotential to subsurface temperature field. This can be achieved by using the observed correlation between geopotential and temperature, or by rearranging the isotherms following simple conservation principle. Other possibilities also can be explored. For example, the analyzed surface velocity field may be projected directly to the subsurface flow field.