

Absolute Sea Level Maps for the Kuroshio Extension

The extension of the Kuroshio Current lies at the crossroad of processes that govern the dynamics of one of the strongest western boundary currents of the World Ocean and that control the large-scale interannual variability in the North Pacific. The tremendous complexity of currents in this region stems from the strong interaction between an active eddy field and narrow wind-driven, inertial jets with their associated sharp fronts and steep bottom topography. This makes for a region with the largest mesoscale variability in the North Pacific.

In order to develop $\frac{1}{4}^\circ$ spatial resolution maps of the mean and the eddy circulations that existed in the Kuroshio Extension (KE) from 1992 to 2000 (25–42°N, 142–180°E) and a mean, absolute sea-level map, **Nikolai Maximenko** (IPRC) and **Peter Niiler** (Scripps Institution of Oceanography) used Argo fixes from 804 Surface Velocity Programme drifters, merged sea level anomaly data from the Centre National d'Etudes Spatiales – Archivage Validation et Interprétation des données des Satellites Océanographiques (AVISO), and hydrographic data from the 1998 World Ocean Dataset of NOAA's National Oceanographic Data Center. The mean absolute sea level map that has been developed by these scientists provides an important reference for satellite altimetry.

Measurements of drifter velocity at 15 m and temperature at 200 m depths (Figure 3a) show three nearly stationary meanders (at 143, 149 and 153.5°E) in the KE jet that end in a 300-km northward deflection east of the Shatsky Rise at 160°E. (The interannual trends in mesoscale variance in the AVISO data noticed earlier by Ducet and LeTaon, 2001, are absent along the path of the meandering KE jet). The drifter mean-eastward surface transport between 28°N–40°N at 152°E is 12.2 (+/-2.6) Sv/100 m and agrees with the geostrophic estimates of 10 Sv/100 m in the 1980–1982 current meter data at 4000 m and 1200 m depths. Three anticyclonic circulations are found in a larger area south or southeast of the Kuroshio (20–45°N, 120–180°E); the most southern eddies near Daito Island (not shown; approximately at 26.5°N, 130°E) is a new discovery. Very few drifters with drogues attached have crossed the Kuroshio front—5 out of 337 released south of 35°N crossed into the subpolar gyre water, and 3 of the 182

released north of 35°N or in the East China Sea crossed into the subtropical gyre. This finding indicates little mixing of these water masses.

The geostrophic currents observed in the AVISO data of the KE region and the drifter velocities (from which high-frequency motions were filtered out and Ekman drift subtracted) correlate at $r = 0.8$. Two main error sources in the mean fields were (1) the non-uniform temporal distribution of drifter data in the area of strong interannual variability; and (2) the difference between the eddy-kinetic energies computed from the AVISO and the drifter data, which reached $\pm 20\%$. The latter problem results from the fact that the eddies on either side of the KE tend to be of opposite sign. The eddies south of the KE were mainly cyclonic with a pronounced sea-level depression; those north of the KE were mainly anticyclonic. The most energetic eddies formed by separating from the meandering KE jet. In general, the eddies have rotational velocities about 20% larger in the north and 20% smaller in the south than estimated from geostrophy.

The absolute sea level map shown in Figure 3b was developed as follows: The amplitudes of the AVISO geostrophic currents were adjusted with concurrent drifter observations and used to compute an unbiased mean geostrophic circulation and quasi-geostrophic Reynolds' stresses in the KE region. (The principal axes of the eddy Reynolds' stresses were found to be oriented along the unbiased mean velocity vectors within the meandering KE jet.). The time-mean horizontal momentum balance equation, which includes both the mean and eddy momentum convergences, was then solved to compute the map in Figure 3b and its uncertainty (which has a mean value of 2.4 cm). Statistical analysis revealed an important contribution to the momentum balance from the Bernoulli and eddy terms at particular locations.

Figure 3c illustrates a good correspondence between drifter trajectories and concurrent absolute sea level, the drifters appearing to follow sea level contours. A mean absolute sea level map of the KE region, supplemented by 10-day maps of the same fields, will shortly be available to the public on the APDRC server (see p. 19).

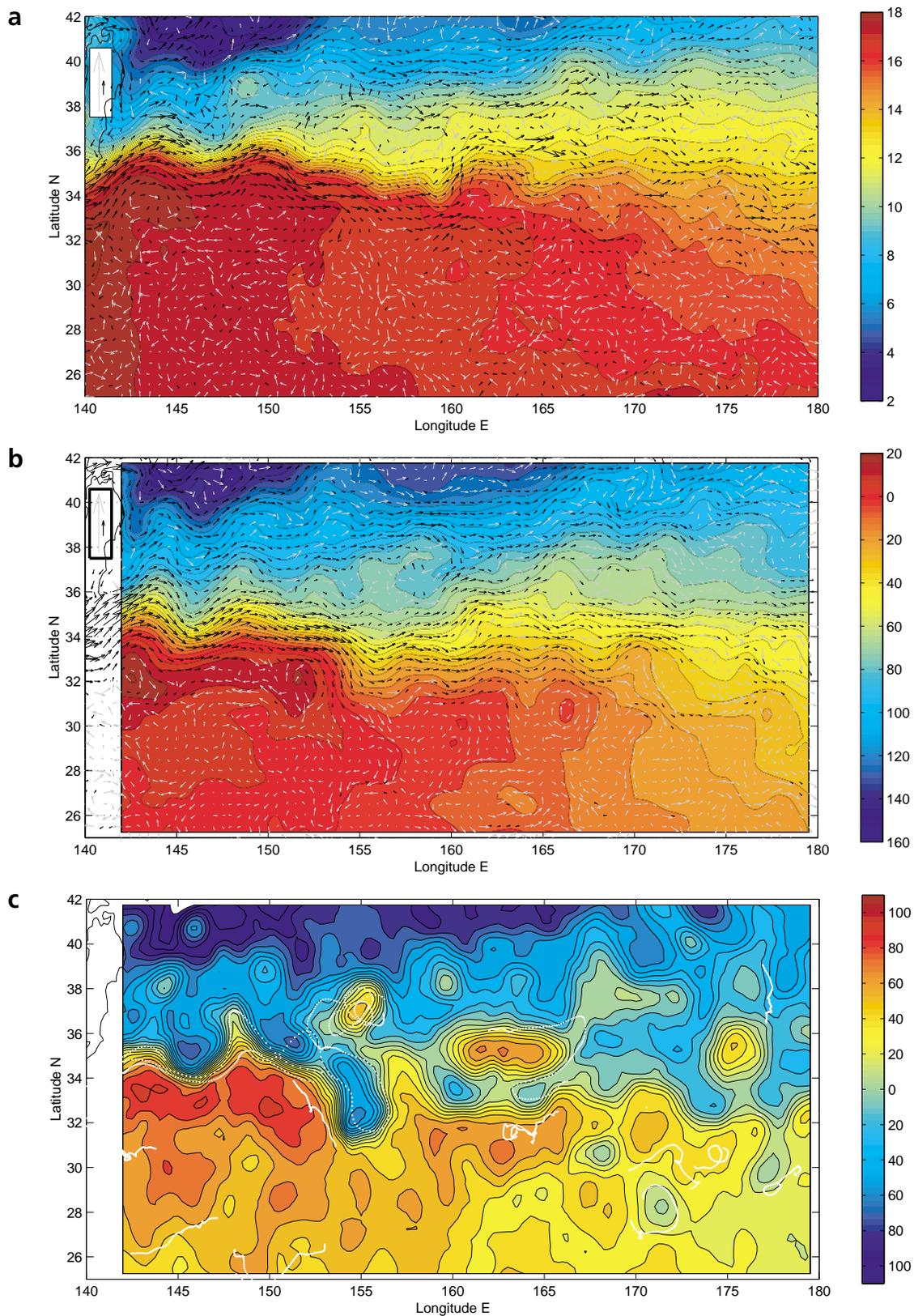


Figure 3. Kuroshio Extension Region: (a) Mean temperature at 200 m depth with contour interval 1°C. Vectors are 1/4 degree-mean drifter velocities smoothed to 1/2 degree spatial resolution. Velocities larger/smaller than 10 cm/s are shown in black/grey color. In the box, 50 cm/s scales are shown. (b) Mean sea level at contour interval 5 cm and mean unbiased velocities at 15 m depth scaled as in panel a. (c) Absolute sea level on December 6, 1993 computed from AVISO MSLA data referenced to mean sea level shown in panel b. Contour interval is 10 cm. White dots mark 6-hourly positions of all drogued drifters from November 16, 1993, through January 15, 1994.