

## 6.5 Ocean Comprehensive Analysis System

The Ocean Comprehensive Analysis System is an operational ocean data assimilation system designed to analyze and predict eddy-scale oceanic phenomena, such as the Kuroshio, Oyashio and mid-scale eddies in the seas adjacent to Japan (Kamachi et al., 2001, 2004). An ocean general circulation model for the North Pacific between 13°N and 55°N from 119°E to 108°W is used for this system. The horizontal grid interval is 0.25° in both latitude and longitude in the area between 23°N and 45°N west of 180°E, and larger in the lateral boundary area. The vertical grids for temperature, salinity and horizontal current are at depths of 10, 35, 70, 115, 170, 235, 310, 400, 500, 600, 700, 800, 925, 1100, 1350, 1750, 2250, 2750, 3250, 3750 and 4500 m, and those for vertical current are at the interleaved depths.

The model is operated as assimilation, nowcast and forecast runs. In the assimilation run, the nudging method is adopted to restore the model-simulated subsurface temperature and salinity to the objectively-analyzed ones, which are described in the following paragraphs. The restoring is conducted in 5-day cycle with the restoring force for the first 3 days, and without the restoring force for the following 2 days. The wind data from JMA's operational atmospheric model is used to calculate the surface momentum flux. The surface heat flux and water flux are applied by restoring to the analyzed sea surface temperature (MGDSST: see section 6.2.1) and salinity at the surface level of the aforementioned analyzed salinity. The assimilation run can represent ocean conditions of 4 days before the operation date at first, because of a time lag of data collection. The nowcast run is operated with only surface restoring forces for the next 11 days from the assimilated states. The forecast run is operated with predicted surface restoring forces as if the anomalies persist, for the next 50 days from the assimilated conditions.

In-situ data and satellite altimeter data are used to produce the restoring forces of subsurface temperature and salinity (Fig. 6.5.1). Major *in-situ* data sources are the BATHY, TESAC and BUOY messages distributed through the Global Telecommunication System (GTS) of the WMO and data reports delivered to JMA by facsimile, postal mail and e-mail from domestic oceanographic organizations.

The multi-resolution space-time optimum interpolation of the sea surface heights is the first step of the objective analysis (Kuragano and Kamachi, 2000, 2003). The satellite altimeter measures sea surface height for the whole ocean more uniformly and densely than *in-situ* observations. The sea surface height is the reflection of subsurface temperature and salinity conditions. The Jason-1 altimeter data are used. One of the analysis scales of the multi-resolution optimum interpolation is spatially large one for the basin scale variation, and the other is spatially small one for mid-scale ocean eddies dominating over the middle and high latitudes. The *in-situ* subsurface temperature and salinity are also optimally interpolated into grid points down to 2000 m depth, but only for spatially large scale (Kuragano et al., 2001). The first guess of the optimum interpolation is obtained from the nowcast run. Sea surface dynamic height calculated from the interpolated subsurface temperature and salinity is not consistent with interpolated sea surface height, because of the analysis error. Therefore, in order to make the large-scale subsurface temperature and salinity more consistent with sea surface height, they are adjusted by composing vertical temperature-salinity orthogonal functions, which had been statistically determined a priori from World Ocean Atlas 1994 (Levitus et al., 1994; Levitus and Boyer, 1994). The first mode had been determined as the correlation function from sea surface

dynamic height to subsurface temperature and salinity. The higher modes are determined as empirical orthogonal functions of the residual temperature and salinity variations, so that the higher modes are independent of sea surface height. The amplitude of the first mode is determined mainly by the interpolated sea surface height, and residual modes are by the interpolated temperature and salinity.

The small-scale sea surface heights are vertically projected into subsurface temperature and salinity, and added to large-scale temperature and salinity fields. In the seas adjacent to Japan, where the richest *in-situ* subsurface temperature coverage is achieved, the subsurface temperature is corrected by optimum interpolation of residual temperature from the above temperature field, to better describe the important small-scale phenomena, such as the movement of the Kuroshio front.

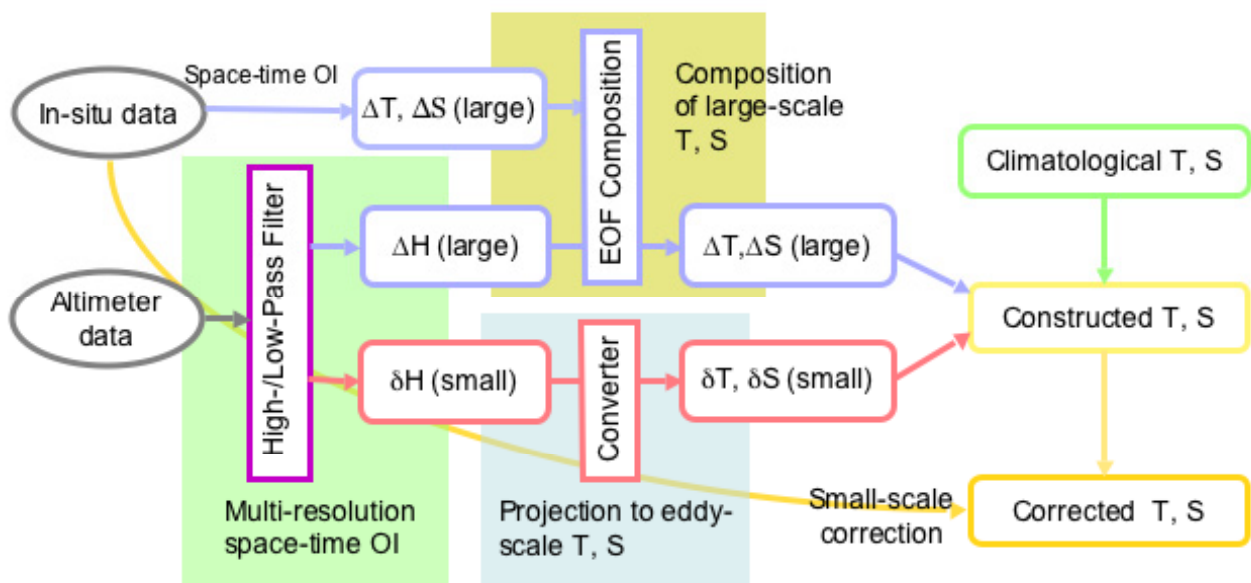


Fig. 6.5.1 Data processing of the objective analysis. ‘H’ indicates sea surface height, ‘T’ temperature, ‘S’ salinity, ‘ $\Delta$ ’ large-scale anomaly, and ‘ $\delta$ ’ eddy-scale anomaly. ‘OI’ denotes the optimum interpolation.

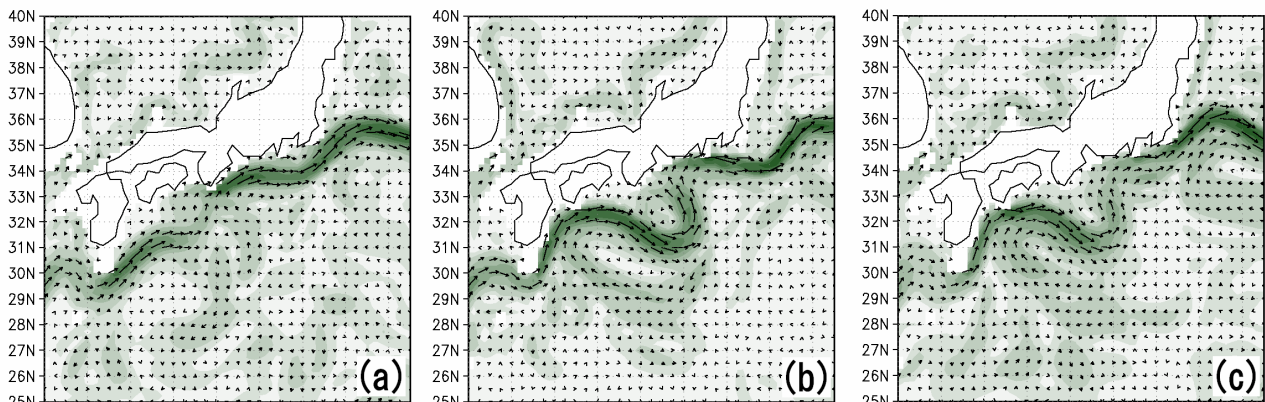


Fig. 6.5.2 Current fields at a depth of 70 m. Initial condition obtained for May 10, 2004 (a), predicted condition for August 8, 2004 (b), and analyzed condition for August 8, 2004 (c).

Fig. 6.5.2 shows the predicted current field at a depth of 70 m for August 8, 2004, which was calculated by the forecast run from the initial condition of March 10, 2004. The assimilated current field of August 8 is also shown in the figure. The figure shows that the development of the Kuroshio large meander was successfully predicted in the forecast run. The results of the operational assimilation, nowcast and forecast runs are provided on JMA's web site and those of assimilation and nowcast runs on the NEAR-GOOS RRTDB (<http://goos.kishou.go.jp/>).

## References

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