Assimilation of altimetry in a mesoscale model of northeast New Zealand waters: Upwelling, uplift and fertilization of the coastal ocean in a western boundary current

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Abstract

Altimeter sea surface height observations in the East Auckland Current, New Zealand, are projected to sub-surface temperature and salinity variability and show an easterly wind-forced eddy signal that is assimilated into a regional mesoscale model of deep-ocean shelf-interaction.

In northeast New Zealand waters vertical elections in the East Auckland Current are significantly influenced by SST and SSH observed hydrographic data. Cross-shelf intrusion of subtropical water into the coastal zone of northeast New Zealand is evident from alongshore wind and surface temperature data. These satellite-derived 3-dimensional temperature and salinity analyses are assimilated in a 4-dimensional variational system (ROMS) regional oceanic modeling system of near waters using an intertemporal optimization scheme (Dombrowsky and De Mey, 1989).

The model components: observational studies of remote physical, biological, and geoclimatic deep-ocean shelf-interaction.

1. Oceanographic setting and motivation

The East Auckland Current (EAC) is a component of the western boundary current of the South Pacific subtropical gyre, especially by the Tasman Front (TF), and carries warm Tasman Sea water advected along New Zealand's northeast coast.

Together, these processes regulate fertile northeast New Zealand coastal waters, and intra-annual variability in primary production appears related to these upwelling and spilt circulation mechanisms. Seasonal stratification and tidal forcing influence cross-shelf fluxes.

Data assimilation is modelled in a western boundary current and adjacent shelf circulation. Heterogeneity is produced of interannual variability in this mesoscale circulation and associated upwelling and spilt processes. Thus, the model comprises observational studies of regional physical, biological, and geoclimatic deep-ocean shelf-interaction.

2. Subsurface projection of satellite data using EOFs

Satellite SST and SSH, with EOF mode structures, give 3-dimensional T (T(X,Y,Z)) model skill.

The computational scheme has the form:

\[ \text{ea} = \frac{1}{n} \sum_{i=1}^{n} \left( T_{\text{CTD}} - T_{\text{EOF}} \right)^2 \]

where the normalization is a priori errors of the subsurface projection is inferred by estimating subsurface projection errors of the analysis.

\[ \text{ea} = \frac{1}{n} \sum_{i=1}^{n} \left( T_{\text{CTD}} - T_{\text{EOF}} \right)^2 \]

Typically, a 5-km resolution model (ROMS: Regional Oceanic Modeling System) of local waters (ECE) eddies inhibit the formation of North Cape (NCE) and East Cape (ECE) eddies - inhibit the formation of

3. 3. ROMS: Regional Ocean Modeling System

ROMS features: Primitive equations; terrain-following coordinate system; operational surface fluxes; 4th-order numerical advection on bottom boundary layers.

Vertical discretization: 20 levels; Inflow/outflow radiation modeling; regular Boussinesq approximation: Coriolis effective; gravitational body forces.

Time stepping: 4th-order predictor-corrector; Runge-Kutta RK5 (40506); 4th-order Runge-Kutta.

Wind-stress (units: Pa m s^{-1}) is set to 1.0 in depth < 100 m, as data is not assimilated on the shelf or in the coastal region.

SST observations and model along Whangarei section (location on map below).

Note: SST/SSST are not assimilated in areas shallower than 50 m.

ROMS shows relatively similar cooling and warming responses in coastal waters.

Downwelling and upwelling conditions for wind-stress anomalies and wind speeds.

AHLOR SST

Whangarei section (top: alongshore wind. bottom: temperature)

4. Results

A statistically-based analysis scheme has been developed to infer mesoscale submarine temperature and salinity variability from satellite SST and SSH observations. The method uses "skill" in 800 km below the surface.

By quantifying the subsurface analysis skill, an objective estimate of the expected error is formed that is subsequently used as a priori estimate of data error in a data assimilating regional model (ROMS) for northeast New Zealand waters.

The model assimilates satellite SSH and SST, compared to shipboard ADCP (vectors) and CTD profiles, at the shelf edge due to uplift of isotherms in the surface layer.

Typically, 0.2 below 600 m depth, in the coastal region, the observations are assimilated in the assimilation model is out of gradient mean climate.

\[ \text{ ea }^2 = \frac{1}{n} \sum_{i=1}^{n} \left( T_{\text{CTD}} - T_{\text{EOF}} \right)^2 \]

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Summary

A statistically-based analysis scheme has been developed to infer mesoscale submarine temperature and salinity variability from satellite SST and SSH observations. The method uses "skill" in 800 km below the surface.

By quantifying the subsurface analysis skill, an objective estimate of the expected error is formed that is subsequently used as a priori estimate of data error in a data assimilating regional model (ROMS) for northeast New Zealand waters.

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