Assimilation of alongtrack SSH altimetry in a coastal ocean circulation model off Oregon

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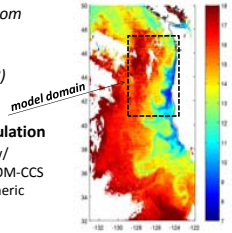
Supported: ONR, NOAA-CIOSS, NOAA-IOOS/NANOOS

Coastal transition zone (CTZ):
interior ocean adjacent to the shelf where dynamics are dominated by jets and eddies energized by currents separated from the shelf

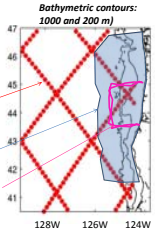
The use of alongtrack SSH altimery in the CTZ:
-Feature tracking
- Model-data verification
-Data assimilation = synthesis of SSH and other observations in a circulation model

Energetic jets separated from the shelf in the CTZ are apparent in this GOES SST daily composite (24/07/08)



Oregon coastal ocean circulation model: based on 3D ROMS, w/ boundary conditions from NCOM-CCS (Shulman et al., NRL), atmospheric fields from NOAA NAM

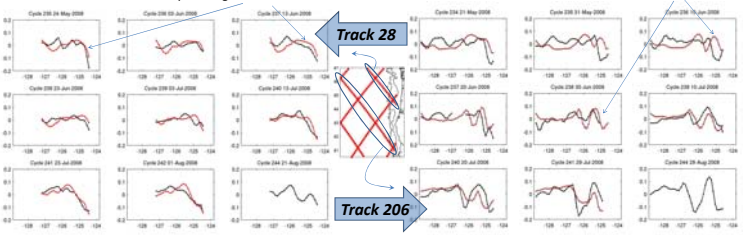
Observations available for model-data synthesis in 2008:
-SSH altimetry
-HF radar surf. currents, daily (Kosro)
-Glider T/S sections, 3-day (Barth, Shearman)
-sat. SST, coastal SSH gauges, moorings



Variability associated with processes originated on the shelf – in alongtrack SSH altimetry:
*Shown: alongtrack-demeaned AVISO Absolute Dynamic Topography (**black**), model (**red**), May-Aug '08*

SSH slope is associated with southward coastal current and upwelling in summer

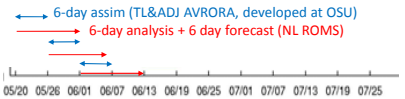
SSH variability can also be associated with jets and eddies in the coastal transition zone



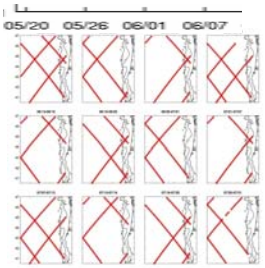
SSH Variability in the costal ocean model is comparable to the AVISO observations. Assimilation of these observations can potentially improve model prediction and provide information about covariability of observed SSH and unobserved 3D oceanic variables

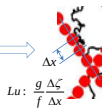
Data assimilation experiment (May-Jul 2008):

- SSH altimetry is assimilated in a series of 6-day time windows using a representer-based variational approach (Bennett, 2002).
- In each window, initial conditions are corrected using a multivariate error covariance C_0 (providing a geostrophically balanced correction, after Weaver et al. 2005)
- The mean level in observations and model are not directly compatible (e.g., ROMS is a Boussinesq model and does not describe seasonal thermal expansion). Instead of fitting the model SSH to the data, we fit the SSH slope (in other words, the surface geostrophic current derived from the alongtrack data is assimilated)
- Nonlinear model: ROMS, at 6-km horizontal resolution
- Data assimilation system: uses tangent linear and adjoint code AVRORA (developed at OSU)
- The optimal solution minimizes the cost functional (norms are weighted by the inverse model and data error covariances):



Tracks available in each 6-day assim. window: Very limited data set





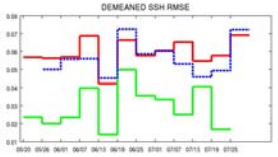
$$J(u) = (u(0) - u_0^{PRIOR})^T C_0^{-1} (u(0) - u_0^{PRIOR}) + (d - Lu)^T C_d^{-1} (d - Lu)$$

Norm² of the distance from prior initial conditions

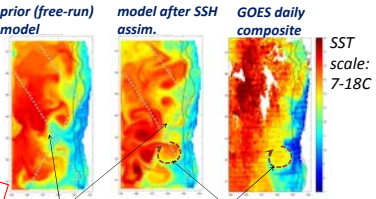
Norm² of the distance between model and data

Results of the test assimilating alongtrack SSH altimetry (May-Jul 2008)

*Time-series of model RMS error against demeaned SSH: **prior model**, model after assimilation (analysis), 6-day forecast*



Effect of alongtrack SSH altimetry assimilation on model SST (daily ave, 24 July 2008)



Assimilation of alongtrack SSH altimetry impacts prediction of SST: *better qualitative agreement with sat. SST*

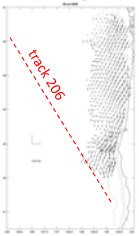
Improvement of the offshore front extent

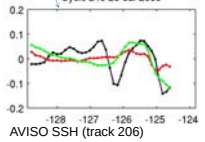
An eddy in the assimilation solution and sat. SST, but not in the prior model

Stronger effect if more data available? – (2009: Jason 1/2, 2019: Wide-swath)

In a test of assimilation of HF radar surface currents (7/19-20, 2008), SSH altimetry is not assimilated, but used for verification:

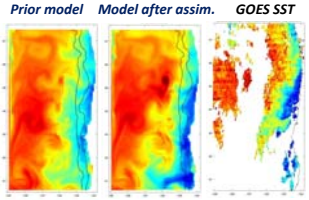
Assimilated surface currents, data courtesy PM Kosro, OSU





AVISO SSH (track 206)
Prior model
Model after HF radar assim.

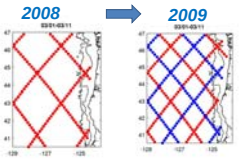
Effect on model SST (Jul 21, 2008)



After velocity assimilation, in this particular case:
stronger upwelling, consistent with verification SSH and SST data

Implementation in a forecast model will involve combined SSH & velocity assimilation

In 2009, SSH altimetry observation density (Jason-1, Jason-2) has doubled
Current research is approaching assimilation of the new data sets to demonstrate the value of improved data resolution for coastal ocean prediction



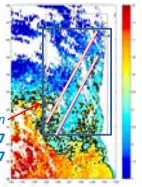
Jason1 and 2: same tracks

Jason 1 and 2: interleaved tracks

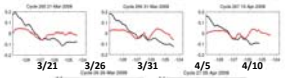
Data along neighboring tracks (J-1 and J-2) show differences in the SSH gradient associated with California Current System meandering.

Alongshore pressure gradient, resolved in observations, can affect the undercurrent intensity and coastal jet separation.

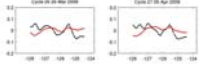
GOES SST, 3/23/2009



Jason-1, tr. 247: Higher SSH over a warmer area => large gradient along the track



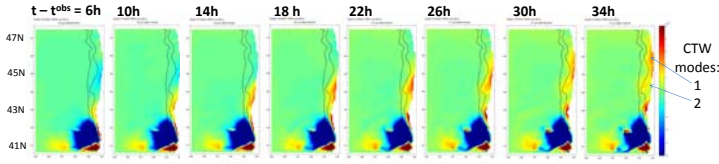
Jason-2, tr. 247: smaller gradient over a cold water area



AVISO
model

Representer functions (prior model error covariances) can be computed using our variational approach to analyze zones of influence of observations on the multivariate model state (in 3D and time)

Snapshots of the representer (SSH field) corresponding to the observation of the SSH slope: near-stationary correction near obs. location (circle) + correction propagating alongshore with baroclinic coastally trapped waves (CTW): $c_1 \approx 3$ m/s



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