Alexander Kurapov,
P. Ted Strub,
P. Yu, S. Erofeeva

NOOA collaborators: E. Maturi, A. Harris,
L. Miller (NOAA/NESDIS/STAR),
D. Foley (CoastWatch), A. MacFadyen (ORR)

Cooperative Institute for Oceanographic Satellite Studies

GOES-R3 Dynamics: Estimating Sea Surface Velocity From Sequential GOES SST – Part II: Data Assimilation

Project goal:

Evaluate methods to estimate Sea Surface Velocity (SSV) from sequential Sea Surface Temperature (SST) fields, by assimilating SST in a regional ocean circulation model.

Accomplishments:

- **The regional ocean model of circulation off Oregon has been developed.**
- **Hourly GOES SST has been assimilated into this model using a 4-D variational technique. Not only model temperature, but also near-surface velocities are corrected, using model dynamical constrains**
- **4DVAR provides space- and time-interpolation of the noisy and sparse hourly GOES SST fields, synthesis with other data (altimetry, coast-based HF radar surface velocities, etc.)**
- **The data assimilative model has been run in real-time as a component of the NANOOS regional observing system, providing improved conditions for coastal ocean forecasts**

Accomplishments anticipated at end of year 2:

- **Coastal SSV and SST fields from the (GOES-SST) data-assimilating model forecasts are made available through the IOOS/NANOOS web site. An MS student will begin a project to evaluate the existing products and suggest improvements, tailored to the needs of local fishers**
- **The forecast model domain will be extended to include the WA coast. The new set-up will include the Columbia River fresh water discharge. Impact of boundary conditions from the global HYCOM (which is becoming a standard NOAA forecast model) will be evaluated. The case assimilating GOES SST in combination with glider hydrographic transects will be prepared. This will give us chance to provide in-situ verification of the satellite SST.**

Initial feedback from potential users:

- **Very positive feedback from different members of the fishing community, working through the West Coast NOAA/NESDIS CoastWatch office and the NOS/IOOS Regional Association. Fishers have requested fairly simple changes to the presentations of SST and velocity, as well as suggesting new products**

- **The surface current forecast fields have been tested with the NOAA ORR GNOME oil spill software. Based on these tests, we have set-up an OpenDAP server that holds current ocean forecasts. The NOAA ORR lab in Seattle has had immediate access to our forecasts and is able to use them in case of emergency.**

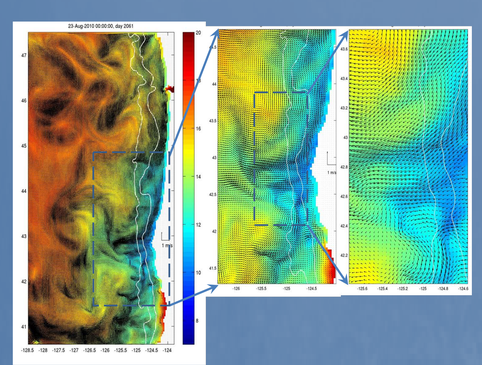
What could be accomplished with a 3rd year of funding:

- **Extend the domain of the model and data assimilation to 34°-50°N**
- **Include the Columbia River discharge in the forecasts.**
- **Test synthesis of GOES SST with new data types (CryoSat altimetry, VIIRS SST, glider hydrographic sections)**
- **Work with a MS student to address the needs of new users**

Surface velocities and SST are dynamically coupled

(geostrophy, thermal wind balance, upwelling, advection)

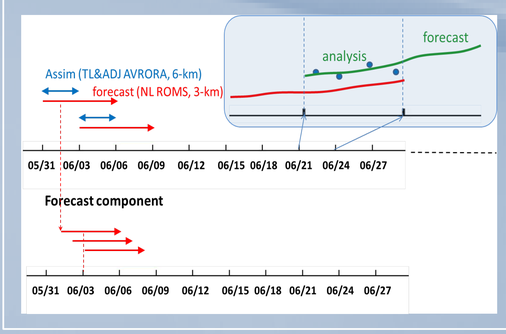
Shown is the daily ave forecast SST (color) and surface velocities (vectors) off Oregon, 23 Aug 2010

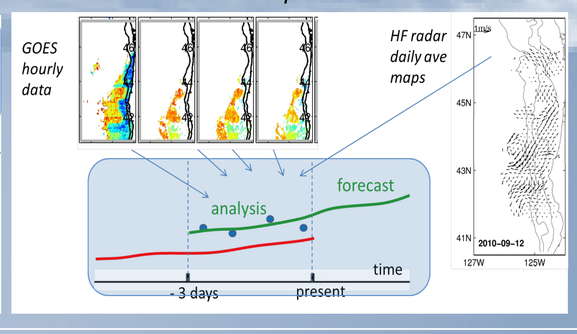


Assimilation Methodology

- Sequential implementation of 4DVAR

At the beginning of each assimilation window, initial conditions are corrected. The analysis/forecast model fits the data closer than the prior.





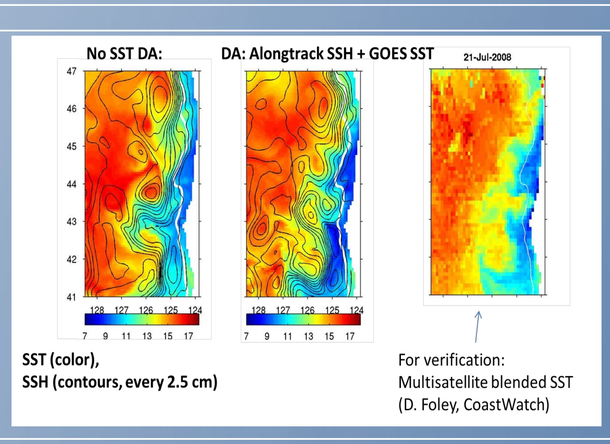
Forecast nonlinear model: Regional Ocean Modeling System (ROMS)

Finding model correction requires repeated implementation of the tangent linear model and its adjoint (TL&ADJ codes AVRORA have been developed at OSU)

GOES SST assimilation effect on sea surface height variability (geostrophic current component)

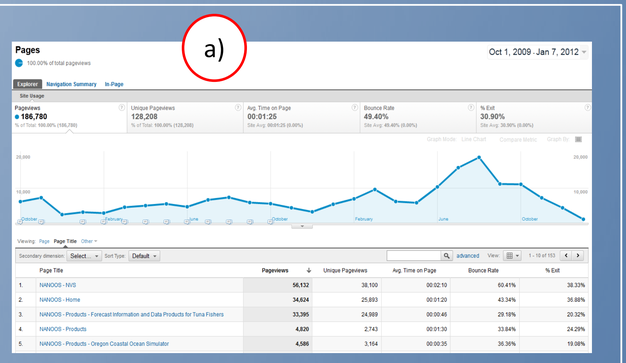
Shown (for July 21, 2008):
(left) The SST (color) and SSH (contours) in the model that did not assimilated SST,
(middle) Model SST and SSH after hourly GOES SST was assimilated,
(right) For comparison, multi-satellite blended product

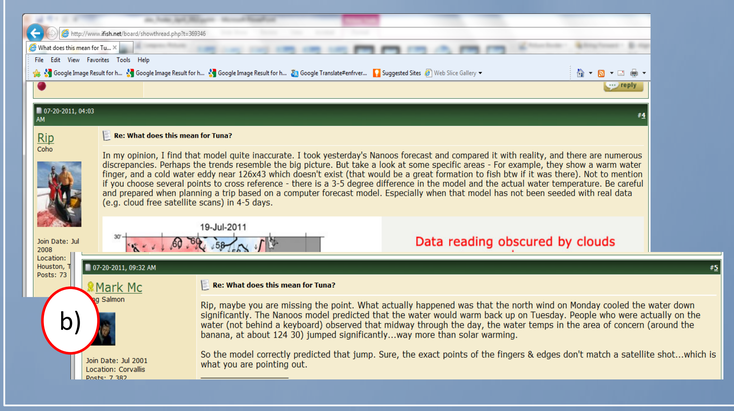
The surface geostrophic current is along SSH contours, affected by SST assimilation

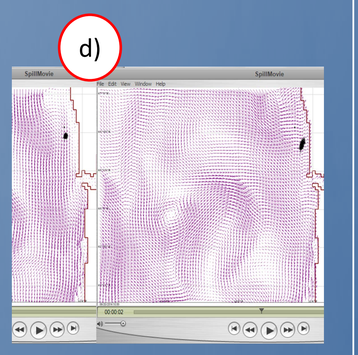


Growing user base:

a) NANOOS online visualization system navigation summary shows that tuna forecast pages are most popular.
b) Fishermen's blogs reflect their interest in the SST forecasts.
c) The owner of a charter boat company has posted a tutorial movie on their site about how to use SST forecasts
d) Velocity forecasts have been tested with NOAA ORR oil spill software.

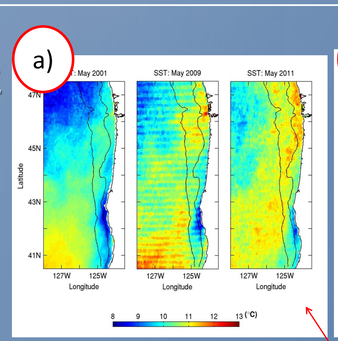


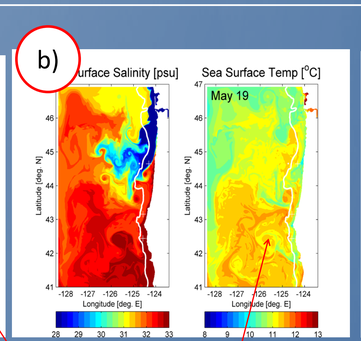


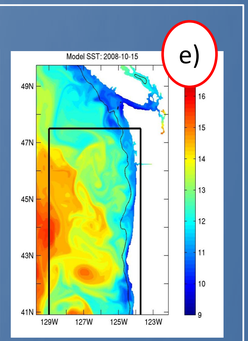


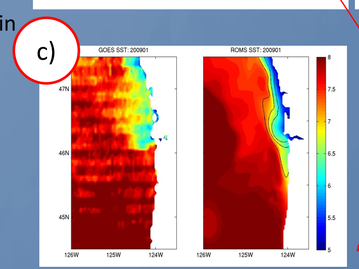
Future research directions:

a) Inter-annual differences observed in monthly GOES SST in May ('01, '09, '11) may be associated with intensity of the Columbia River fresh water discharge
b) 1-km resolution model simulations (Osborne, OSU) show events of warmer SST in the area of the plume in summer (left: SSS, right: SST)
c) A colder SST in the area of the Columbia R. plume in winter (left: GOES SST, right: model – Jan. 2009 average)
d) Tidal modulation of the plume structure in the model SST
e) The effort is ongoing to develop a 2-km assimilative model in the extended domain (the box shows the present domain size).
f) To study effects of climate variability on coastal environment off Oregon, we have analyzed the 2-km resolution model in an even larger domain (P. Fayman, OSU). Assimilation of SST in a domain of this size would be possible.

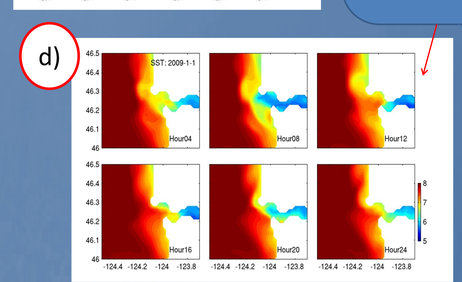


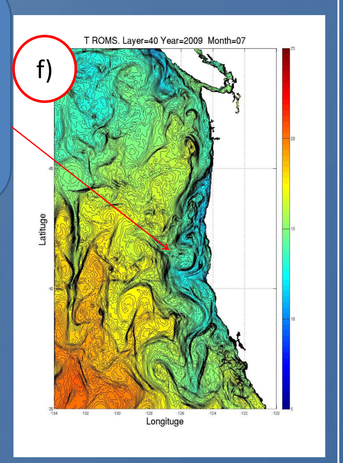






Opportunities for higher resolution GOES-R:
submesocale eddies, river plumes, fronts, tidally dominated flows





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