Assimilation of GOES SST in a coastal ocean forecast model off Oregon

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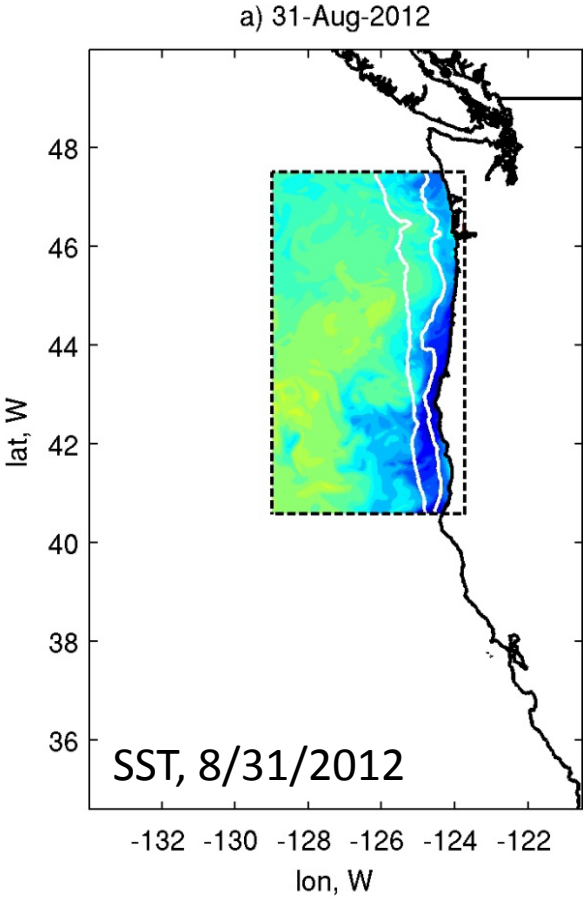
Shown on the right: the model domain (Oregon real-time coastal ocean forecast system, NOAA IOOS – NANOOS)

Model: Regional Ocean Modeling System (ROMS, 3-km resolution, 40 vertical levels)

Kurapov et al., Oc. Dyn. (2009), JGR (2011)
Yu et al., Oc. Mod. (2012)



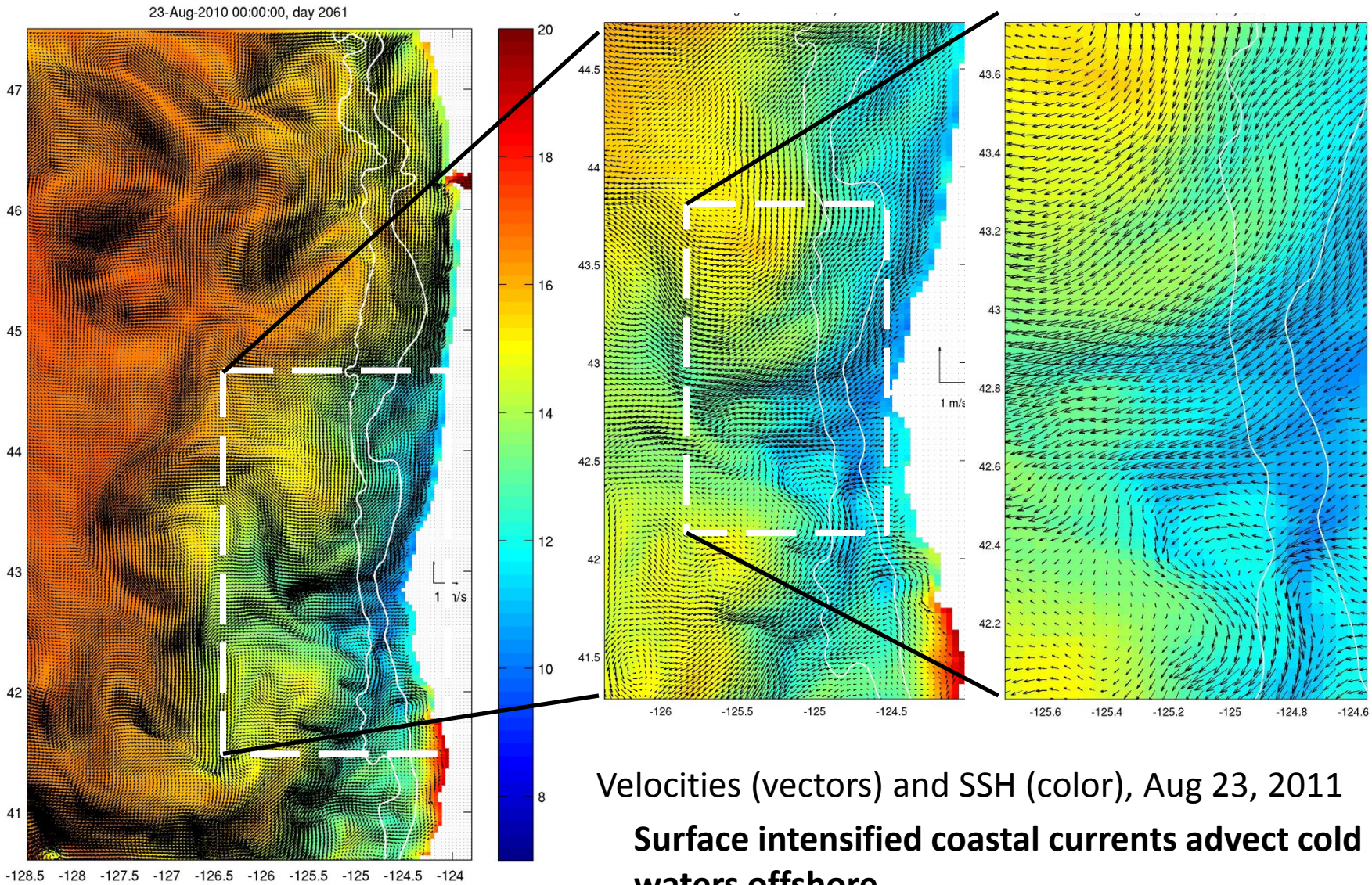
NOAA Support: GOES, GIMPAP, IOOS (via the NANOOS Regional Association)

Motivation:

- environmental hazard response
- search & rescue
- fisheries management
- navigation
- a base for coupled bio-physical forecasts (hypoxia, HAB, etc.)

Photo credits: I. Taylar, NOAA, REUTERS/Beltra, NASA

SST and surface velocity are correlated (advection, geostrophy)

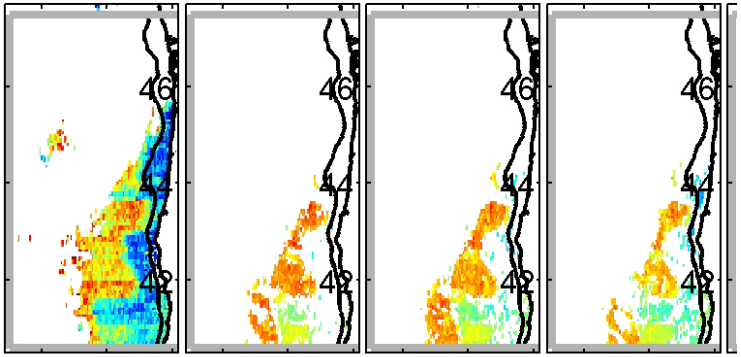


Velocities (vectors) and SSH (color), Aug 23, 2011

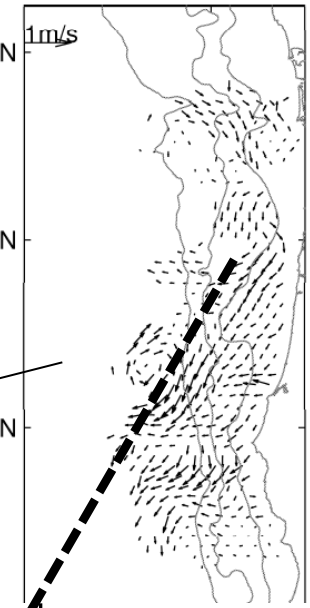
Surface intensified coastal currents advect cold waters offshore

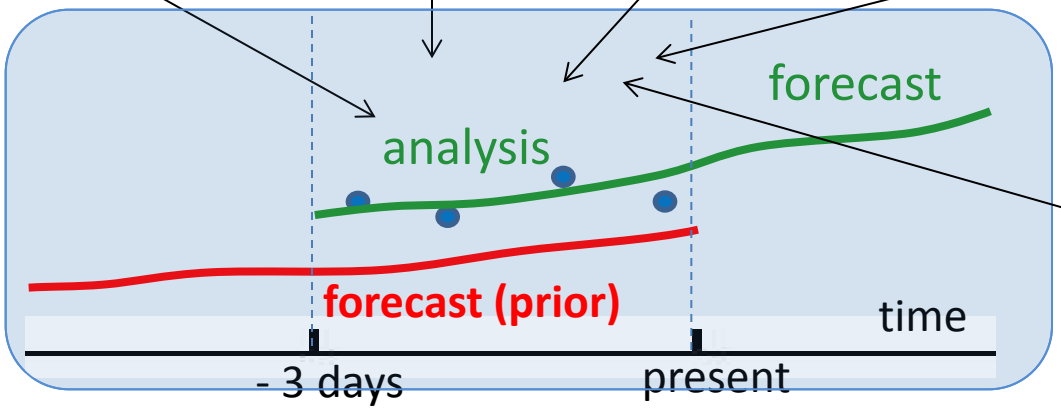
4DVAR = dynamically based time- and space- interpolation of data

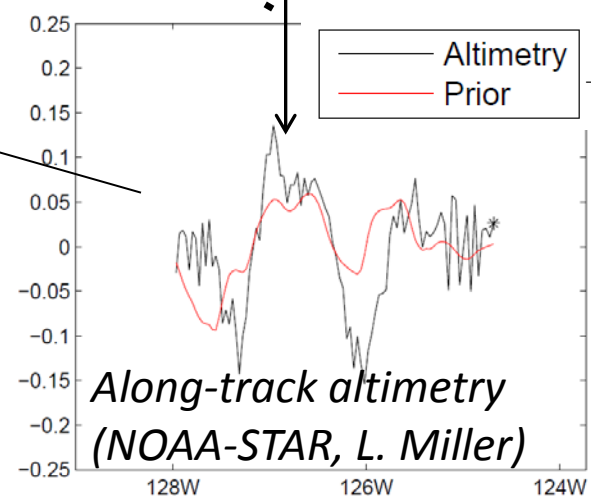
Hourly GOES SST (NOAA-CoastWatch D. Foley)



HF radar daily ave maps (P. M. Kosro)



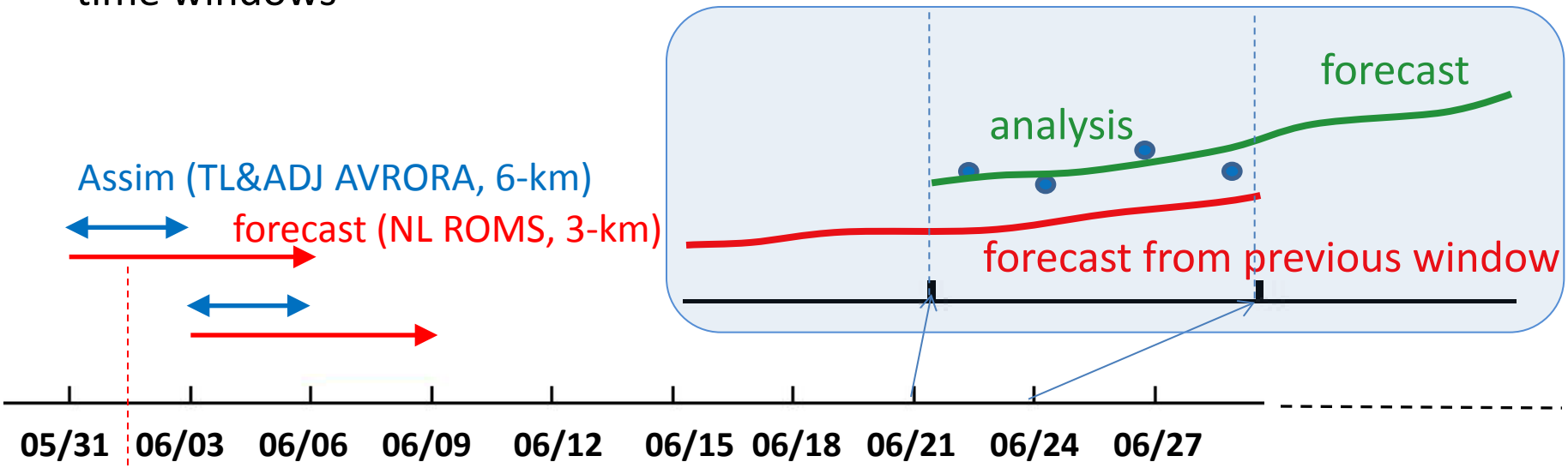




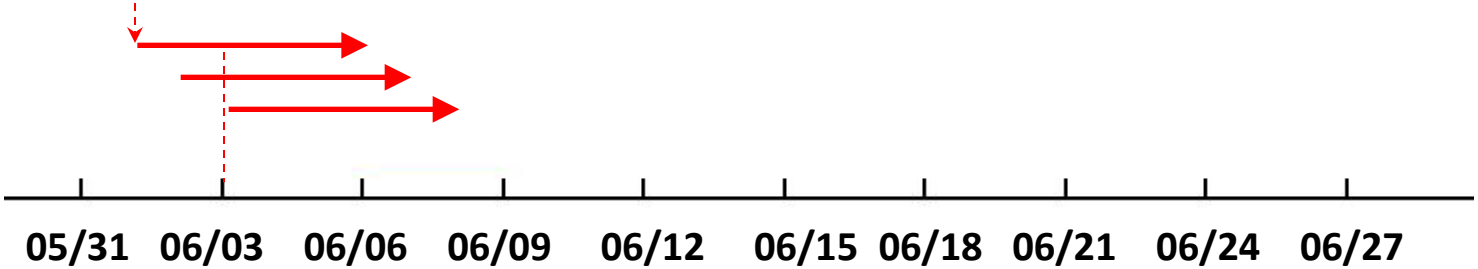
Along-track altimetry (NOAA-STAR, L. Miller)

- Assimilate data in a 3-day interval (TL&ADJ AVRORA)
- Correct initial conditions in the recent past
- Run forecast model (ROMS) with improved initial conditions

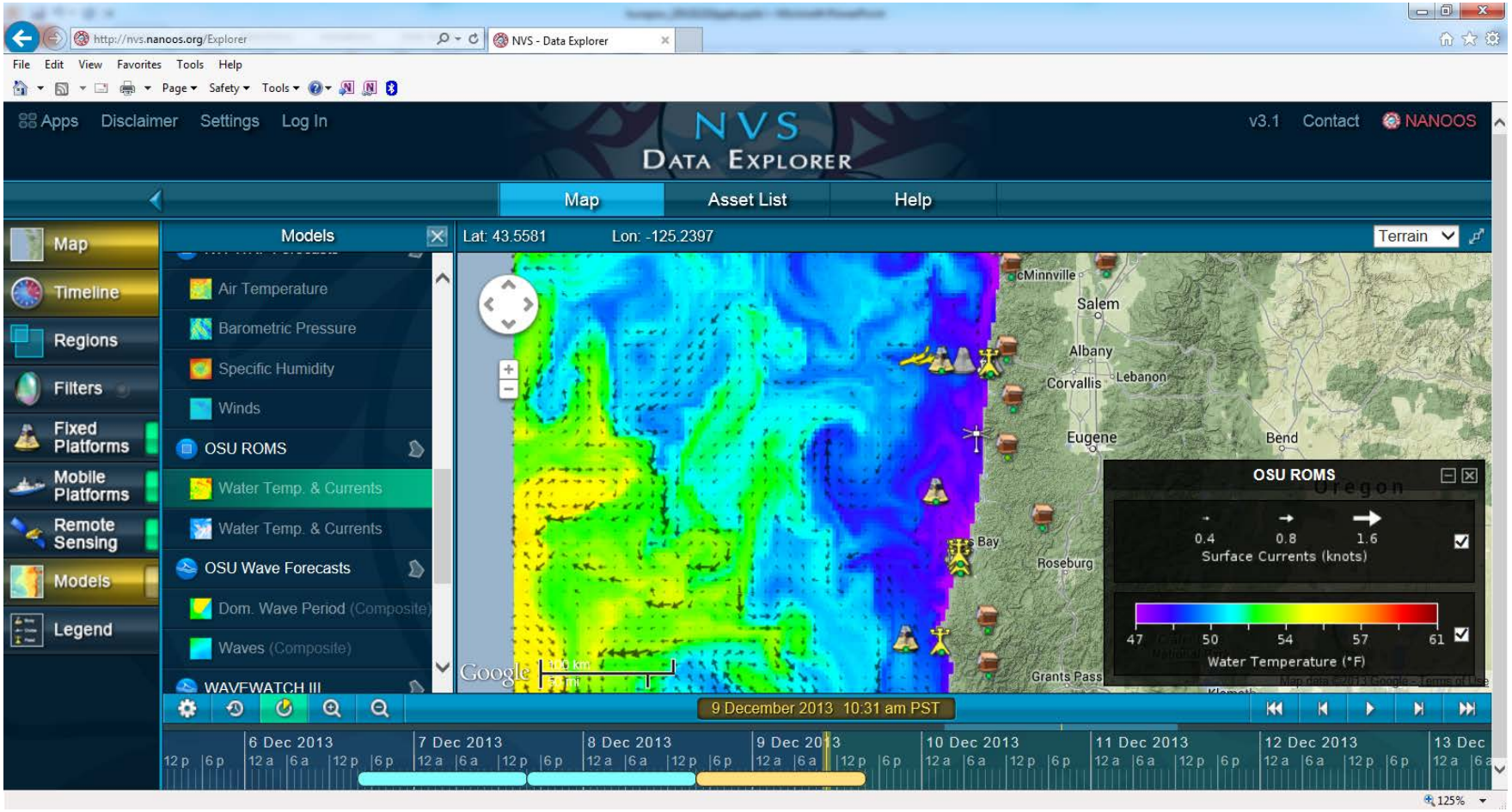
Real-time coastal ocean forecast model: variational DA in a series of sliding time windows



Forecast component



The NANOOS Visualization System:



Re: What does this mean for Tuna?

Rip, maybe you are missing the point. What actually happened w
significantly. The Nanoos model predicted that the water would w
(not behind a keyboard) observed that midway through the day, t
about 124 30) jumped significantly...way more than solar warmin

So the model correctly predicted that jump. Sure, the exact points
what you are pointing out.

Re: What does this mean for Tuna?

It means they are here, drop your key boards and start your engines boys and girls

Users: fishermen

Our model forecasts are currently used by NOAA ORR to track marine debris objects like this, sighted by the Coast Guard.
[Photo courtesy CG and G. Watabayashi]

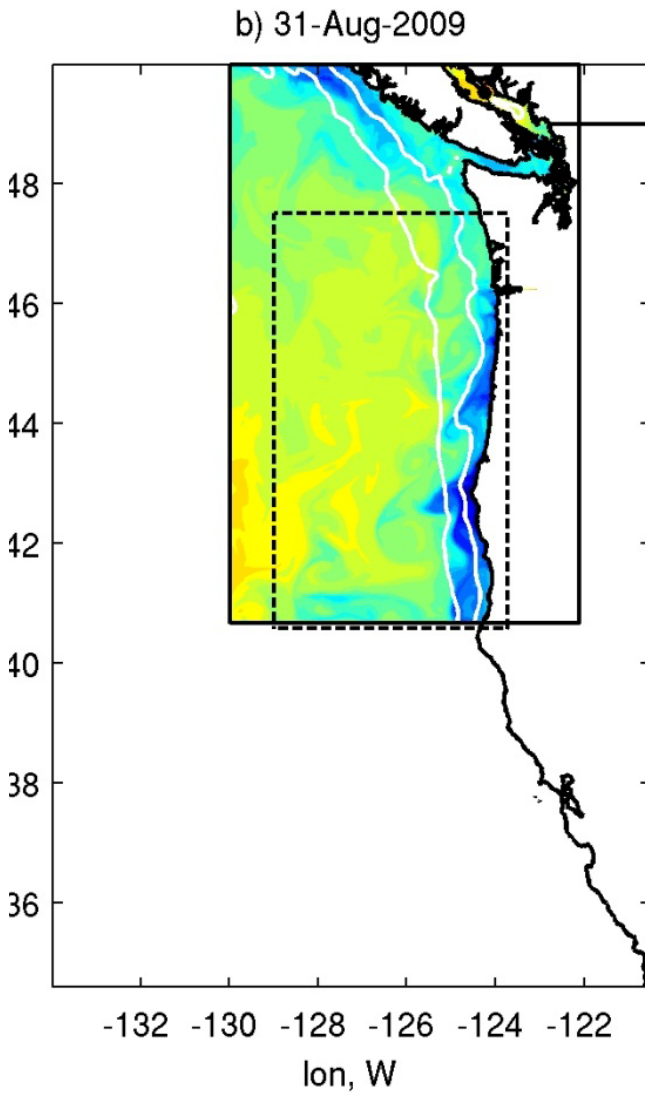
Risks:

- **navigation safety**
- **bio-fouling (invasive species)**

"As long as the object is within the OSU ROMS grid, we will continue to make the model one of the key data sources we tap into…" Glen Watabayashi (NOAA ORR, Seattle)

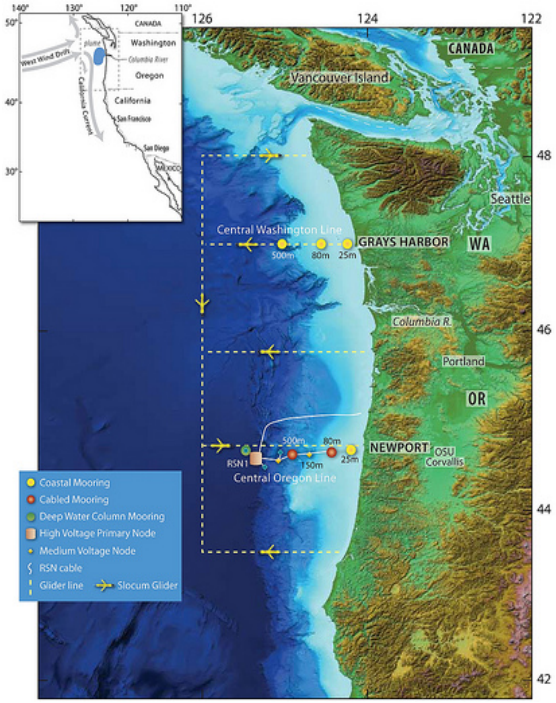
Users: NOAA ORR

Ongoing efforts:



- a larger domain
- a better (2-km) resolution
- *include the Columbia R. discharge*
- include tides
- include assimilation of shelf mooring and glider T and S transects
- *improved ini error covariance*

NS OOI gliders (starting in 2014, J. Barth et al.)

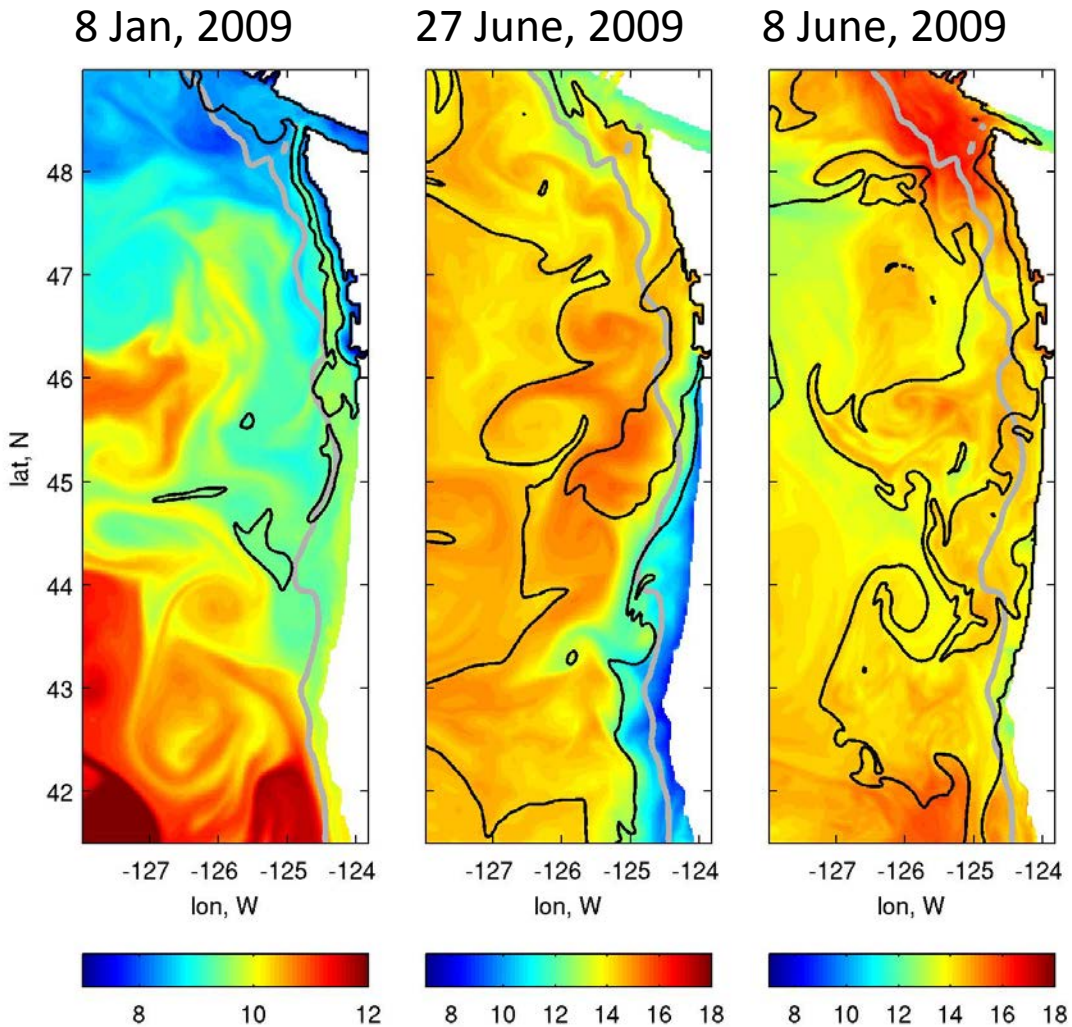


SST (the plume is relatively colder in winter, warmer in summer)

color: SST

black contours
Sea Surface Salinity
(SSS, 32 & 30 psu)

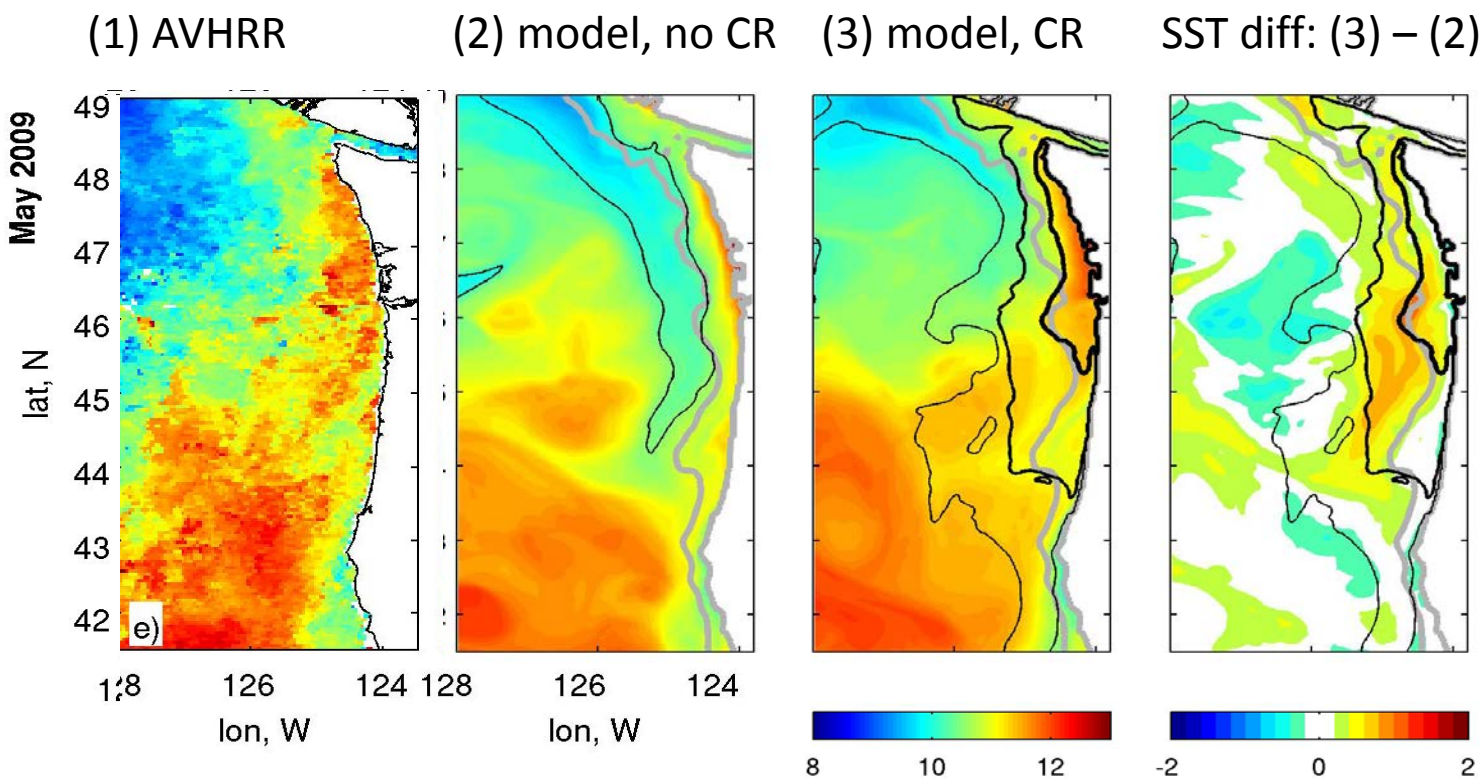
(half-tone contour:
200 m isobath)



(no DA)

Including the Columbia R. discharge helps to remove the model bias:

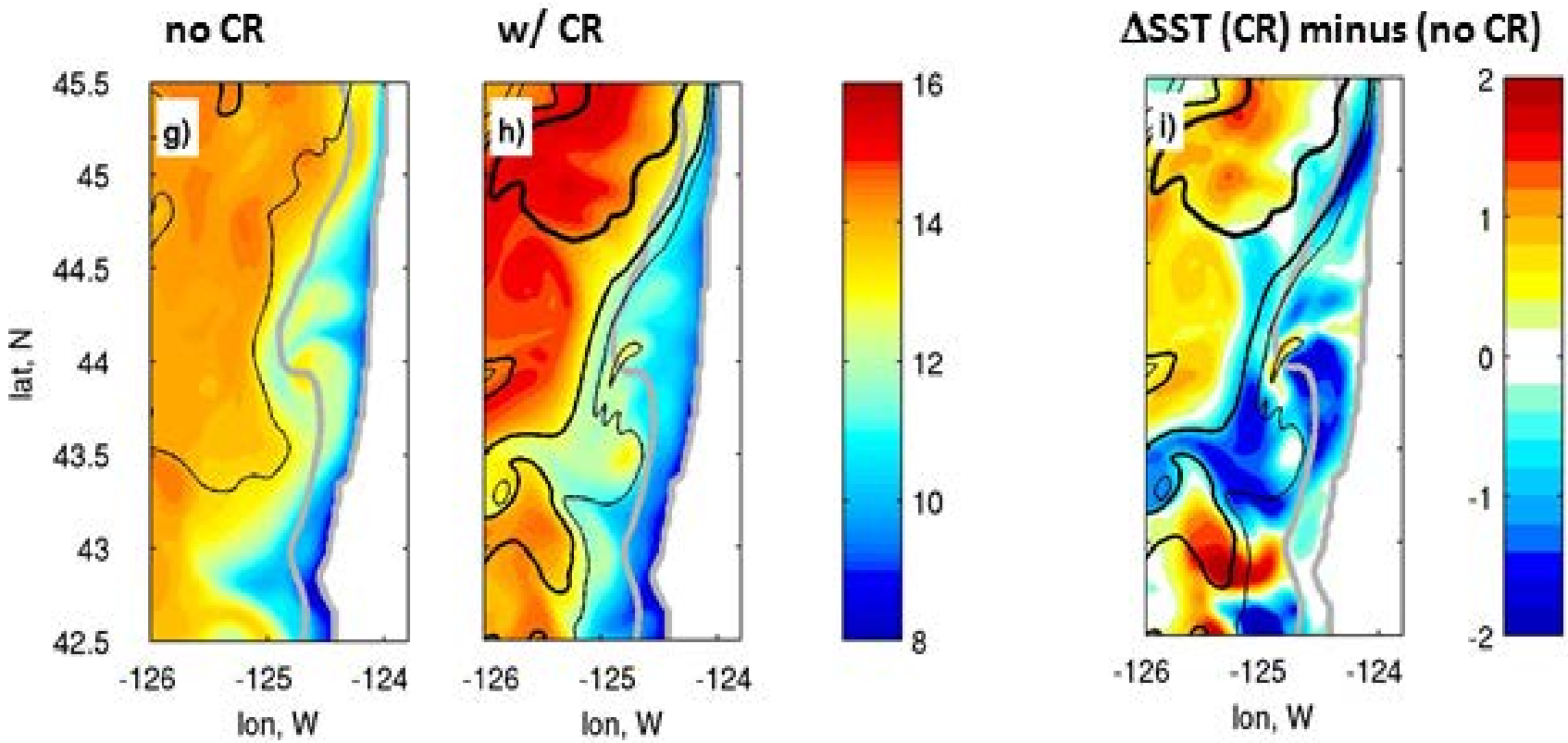
Shown is the May-ave SST (color), SSS (black contours – 28, 30, 32.5 psu)



(no assimilation)

Model w/ CR compared to model w/out CR (summer):

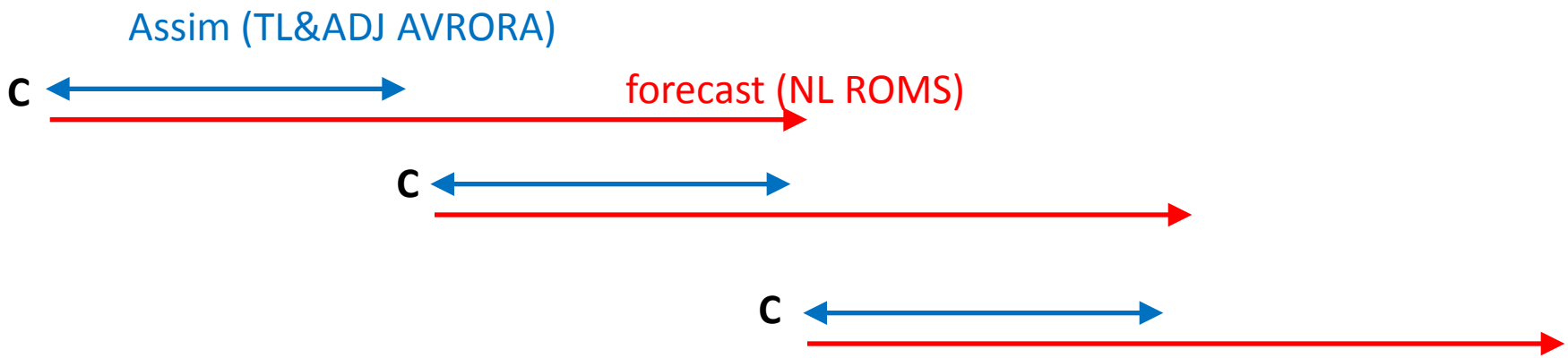
- warmer in the area of the plume
- colder inshore of the plume



CR plume: adds up to 4C contrast in SST across the upwelling front

Including the river plume: challenge for DA

Present application: the same initial error covariance in each assim. cycle



C (using basic dynamical constraints:

- T-S relation
- eqn. of state
- geostrophy
- thermal wind balance)

Is this C satisfactory in the coastal ocean, esp. in presence the river plume?

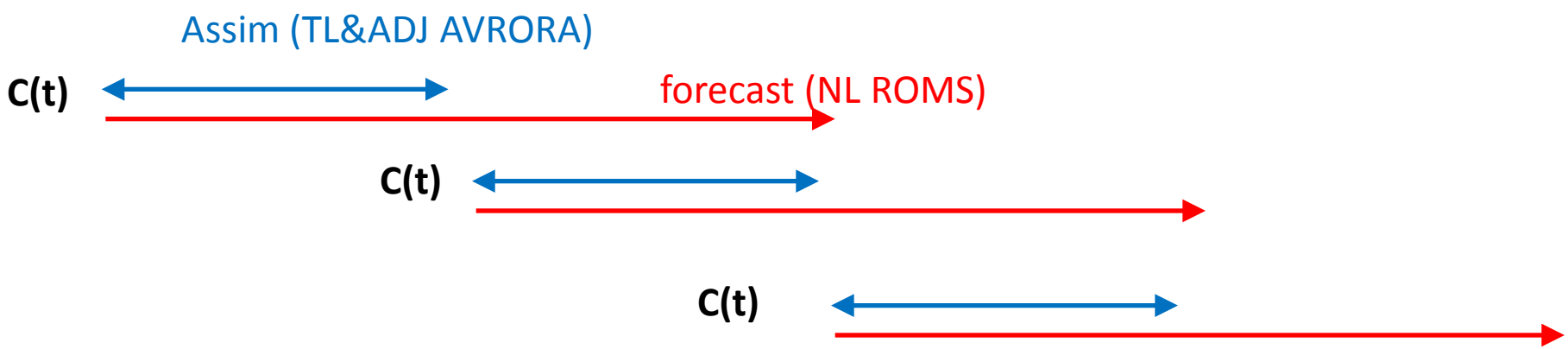
A new approach: Hybrid Ens-4DVAR data assimilation

(testing phase) (I. Pasmans, OSU):

the initial covariance is constructed using an ensemble of forecast solutions (influenced by Milliff et al. QJRMS, 2011)

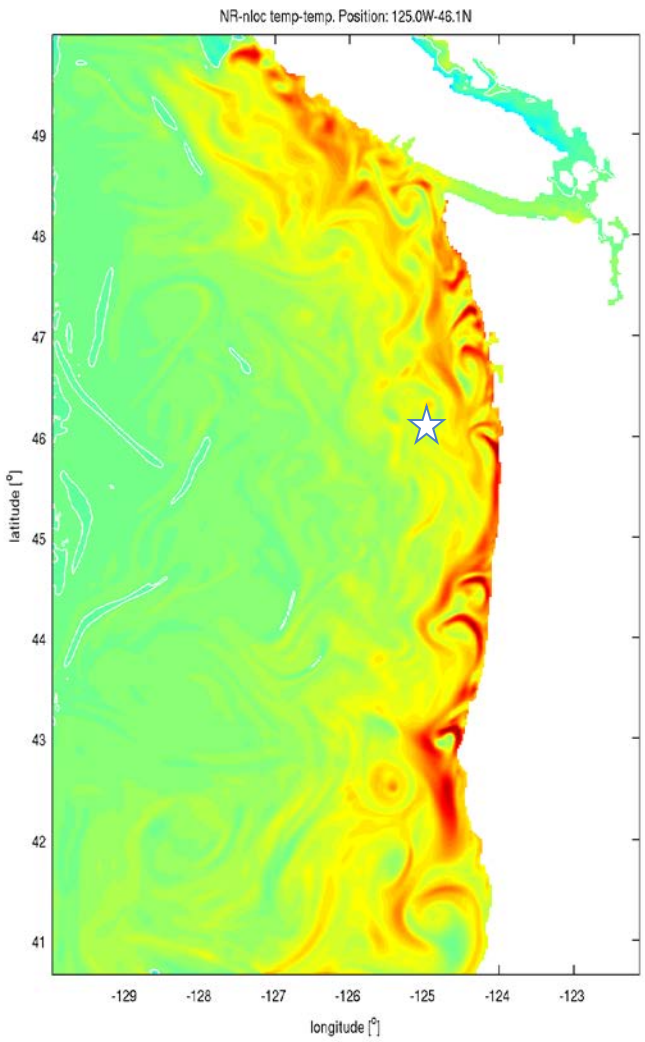
- accounts for inhomogeneous conditions due to the presence of the river plume

50 ens. members (obtained by perturbing surface winds)

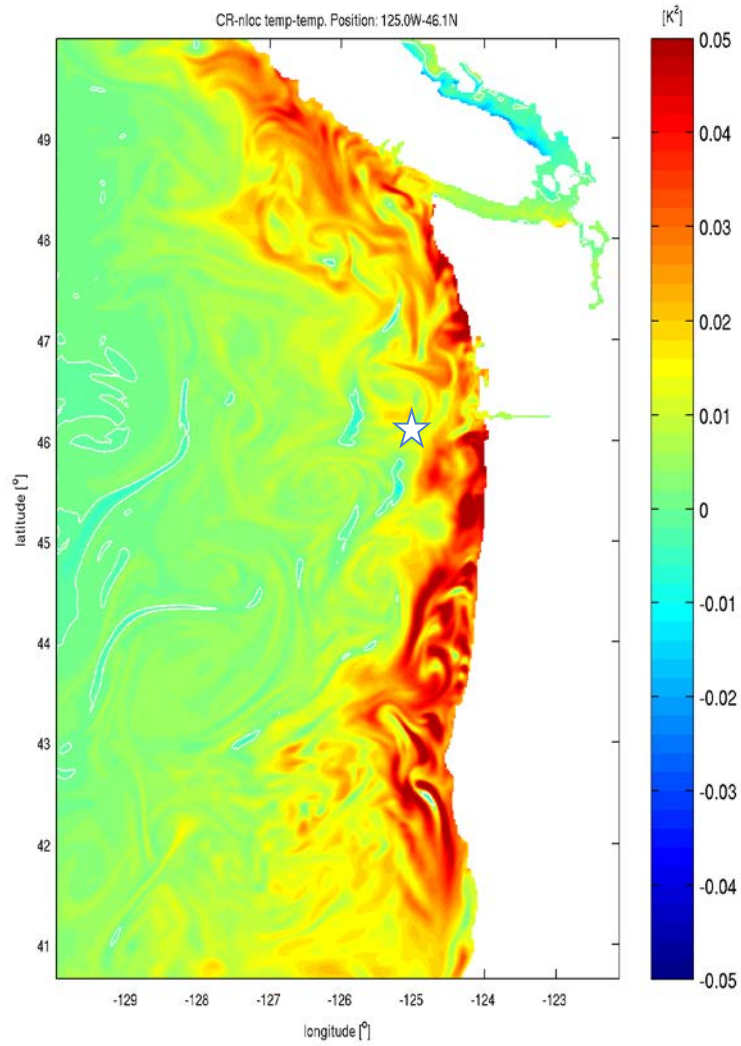


Ensemble T-T covariance (surface):

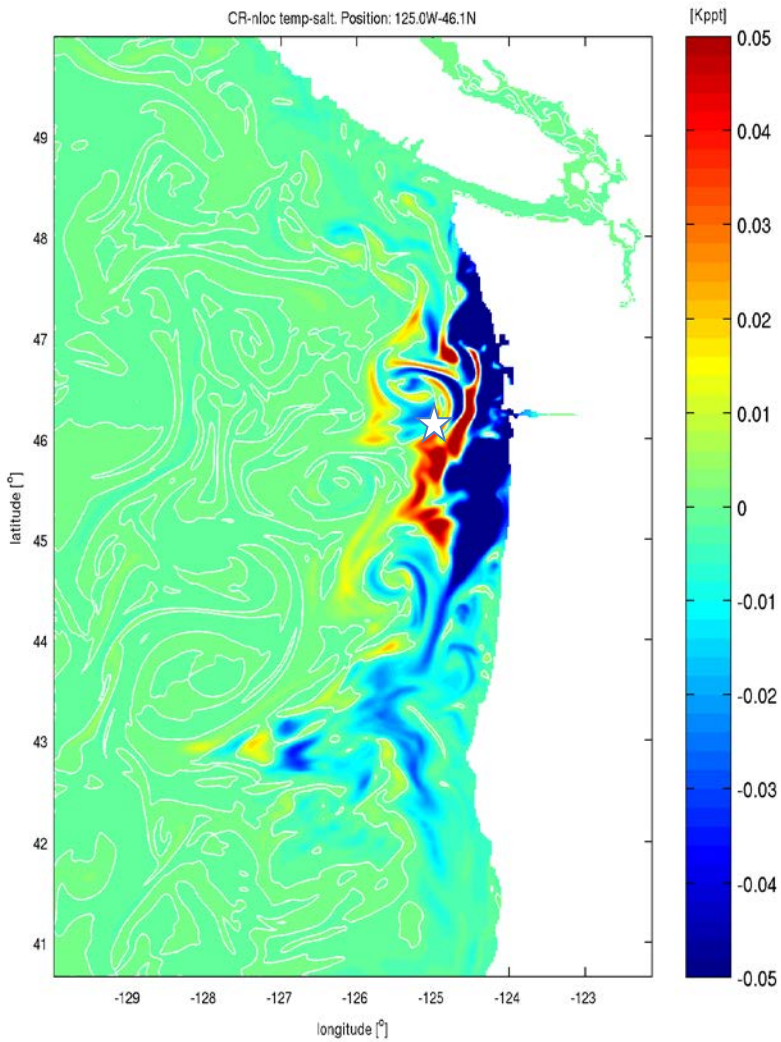
no CR



CR



The ensemble T(xo)-S(x) covariance (surface): (the case w CR)

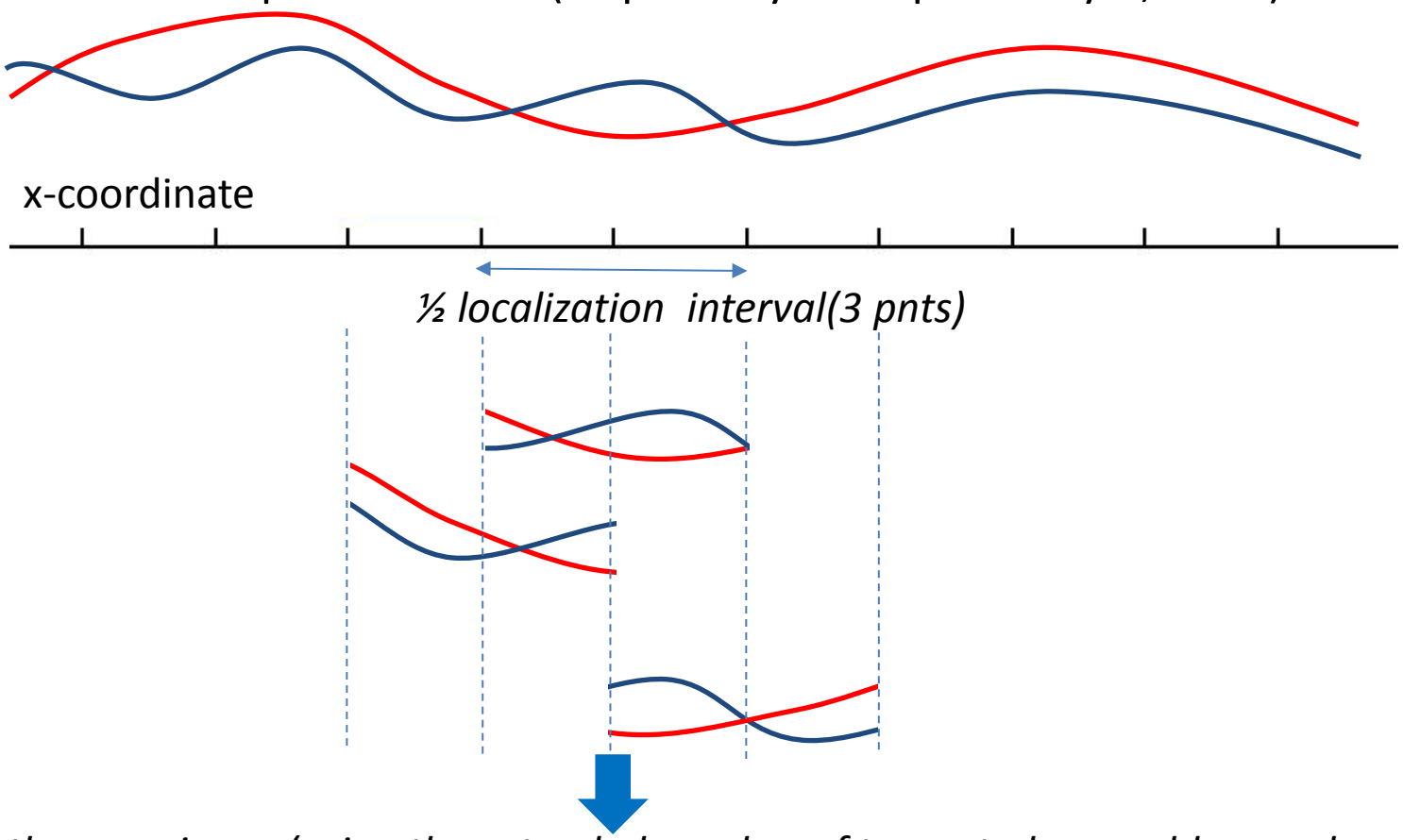


(localization needed)

Localization: to inhibit the effect of distant correlations

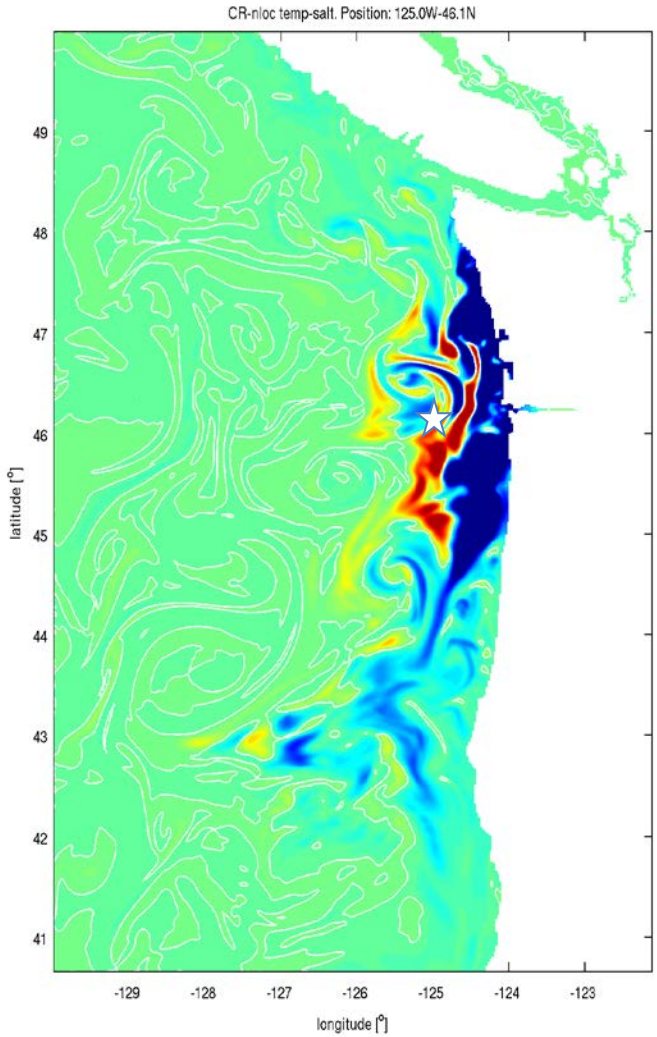
L•C, where L is the localization matrix (symmetric and positive definite) where • is the element-by-element multiplication (the Schur product)

Practical implementation (inspired by Bishop & Hodyss, 2011):

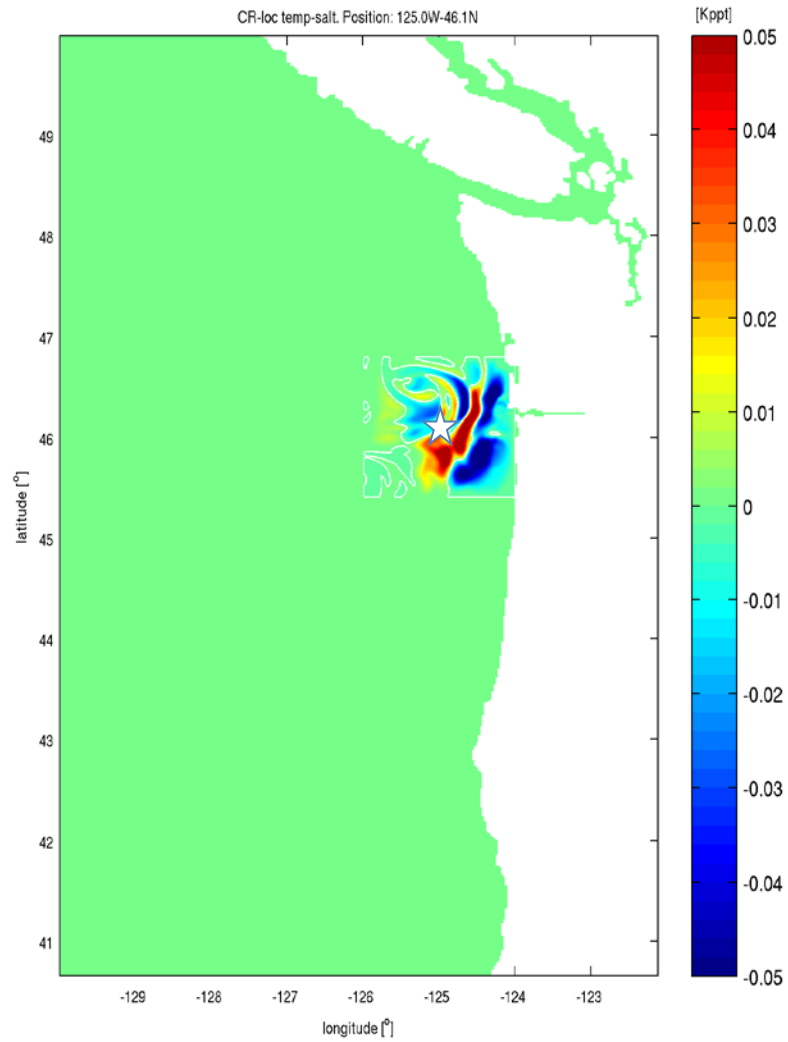


The ensemble T(xo)-S(x) covariance (surface): (the case w CR)

no localization



with localization



SUMMARY:

- Hourly GOES SST has been assimilated in the coastal ocean model off Oregon
- The forecast system has been run in the “quasi”-operational mode (everyday updates of 3 day forecasts of surface currents and SST)
- GOES SST has useful impact on the accuracy of the solution (SST, velocities)
- Forecast users: fishermen, NOAA ORR (w/ GNOME)
- The large river plume (such as Columbia R.) influences SST
- New model version (at testing phase): OR-WA, include the CR plume, hybrid Ens-4DVAR assimilation
- Future directions: understand diurnal variability in SST (model/data), combined satellite/glider (T, S sections) assimilation
- Transition to operations: **W**est **C**oast **O**cean **F**orecast **S**ystem (NOS, JCSDA)