JPSS SST assimilation in the US West Coast Ocean Forecast System (WCOFS)

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Academic partners: A. Moore (UCSC), J. Wilkin (Rutgers U.), S. Erofeeva (Oregon State U.)

WCOFS domain & dynamics (3D & nonlinear):

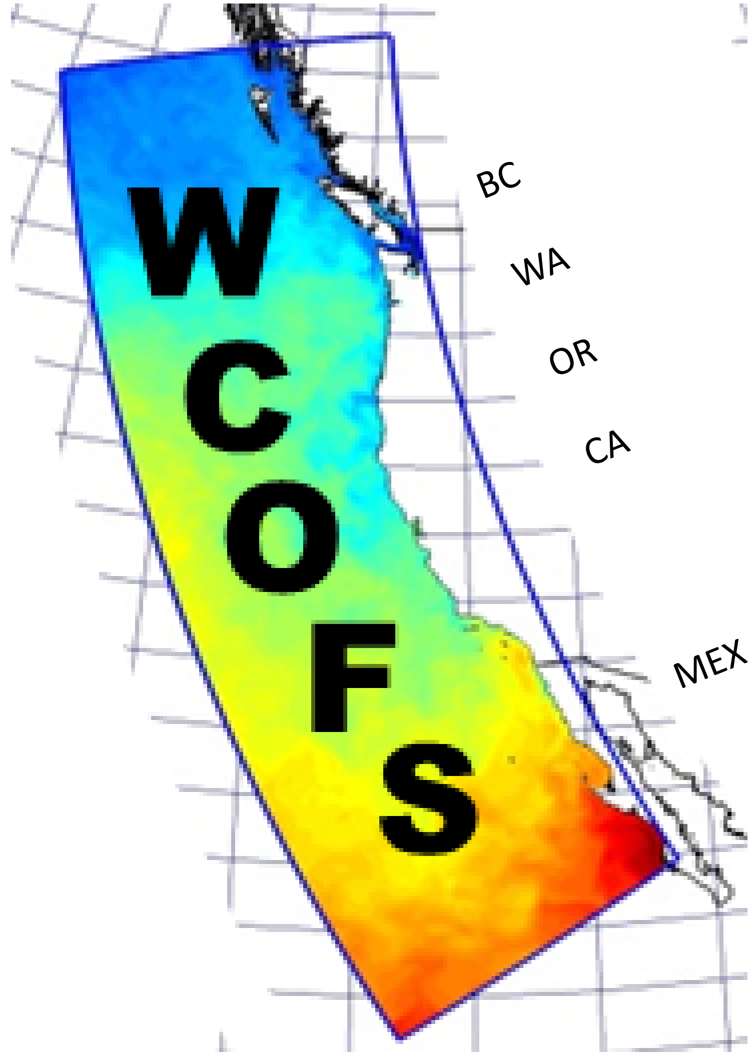
- North Pacific Current enters the domain between 45-50N (off OR-WA) and splits into the southward flowing California Current System and northward flowing Alaskan Stream

- Shelf (CA-OR-WA): seasonal wind-driven upwelling and downwelling

- Coastal currents instabilities and separation into the adjacent interior ocean

- Coastally trapped waves propagating from south to north

- River influences



Goal: 3-7 day forecasts of oceanic conditions (coastal sea level, currents, oceanic fronts, etc.), constrained by data assimilation (DA)

Data assimilation: Optimally combine a 3D ocean dynamical model and available observations from different platforms

=> Improved initial conditions for the forecasts

Motivation for operational prediction (shelf currents, coastal sea level, SST, fronts):

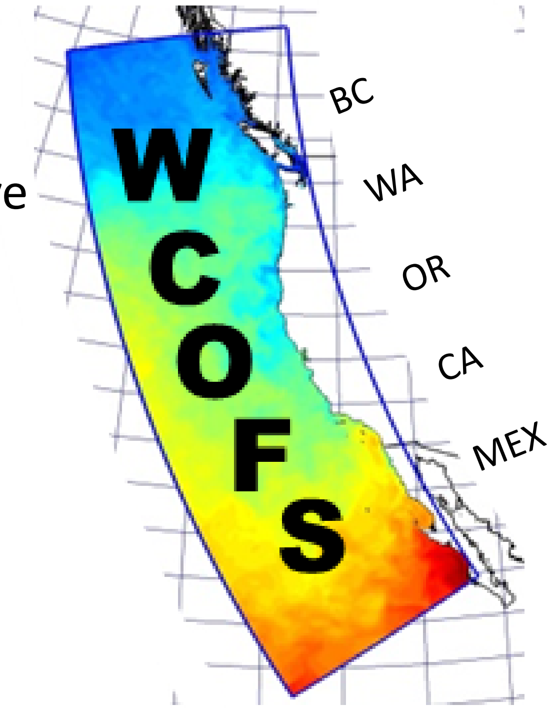


- national security,
- navigation,
- search and rescue,
- environmental hazard response (oil spills, marine debris, etc.),
- fisheries,
- coastal weather prediction,
- beach erosion,
- recreation,
- new business opportunities,
- public health,
- education,
- local community involvement,
- new technology development, etc.



Credit : Eric Mortenson, Doug Beghtel /The Oregonian, www.naturalbuy.com, USCG, http://i.livescience.com/, Grantham et al. (2002)

WCOFS:



Model dynamics are based on the Regional Ocean Modeling System (ROMS): 3D, fully nonlinear, primitive equations, hydrostatic & Boussinesq approximations, vertical turbulence parameterization scheme

Horizontal resolution: 2-km
Vertical resolution: 40 terrain-following layers

Forcing:
- Surface winds and heat flux (12-km NOAA NAM)
- @open boundary: global model (HYCOM/RTOFS)
  + tides (Oregon State Tidal Inverse Soft.)
- River inputs: Columbia R., Fraser R., small rivers in Puget Sound

(Assimilation: at 4 km horizontal resolution, interpolate correction to the 2-km grid for forecasts)

WCOFS development, focus areas:

1. Skill assessments for the hindcast solution (2009-2014), improvements in the model formulation:

   Kurapov, A.L., S. Y. Erofeeva, and E. Myers, 2017: Coastal sea level variability in the US West Coast Ocean Forecast System (WCOFS), Ocean Dynamics, 67: 23. doi:10.1007/s10236-016-1013-4

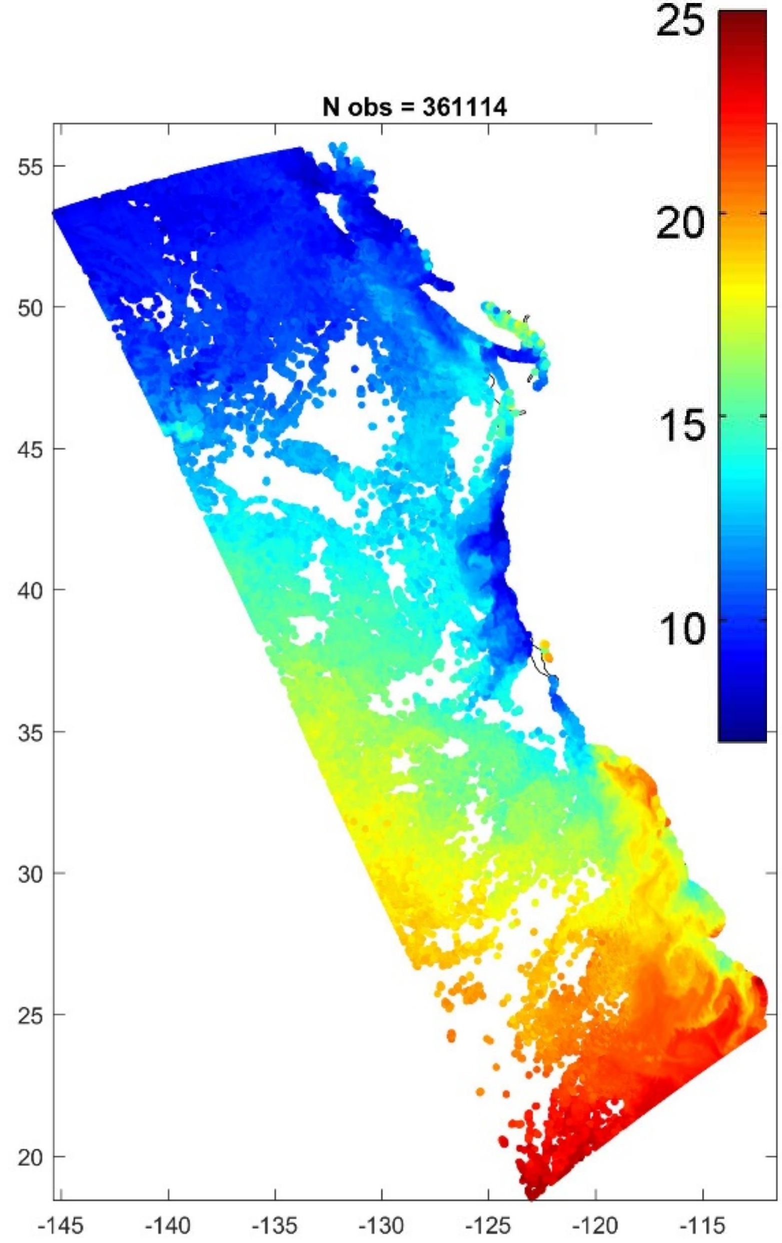
   Kurapov, A. L., N. Pelland, and D. L. Rudnick, 2017: Seasonal and interannual variability in oceanic properties along the US West Coast continental slope: inferences from a high-resolution regional model, J. Geophys. Res., in press

2. Real-time WCOFS without assimilation (w/ Jiangtao Xu, CO-OPS)
3. Data assimilation, hindcast experiments (feasibility, forecast metrics, cost-benefit analyses)

Jets and eddies are observable:

- Satellite SST
- Satellite altimetry
- Land-based HF radar surface currents

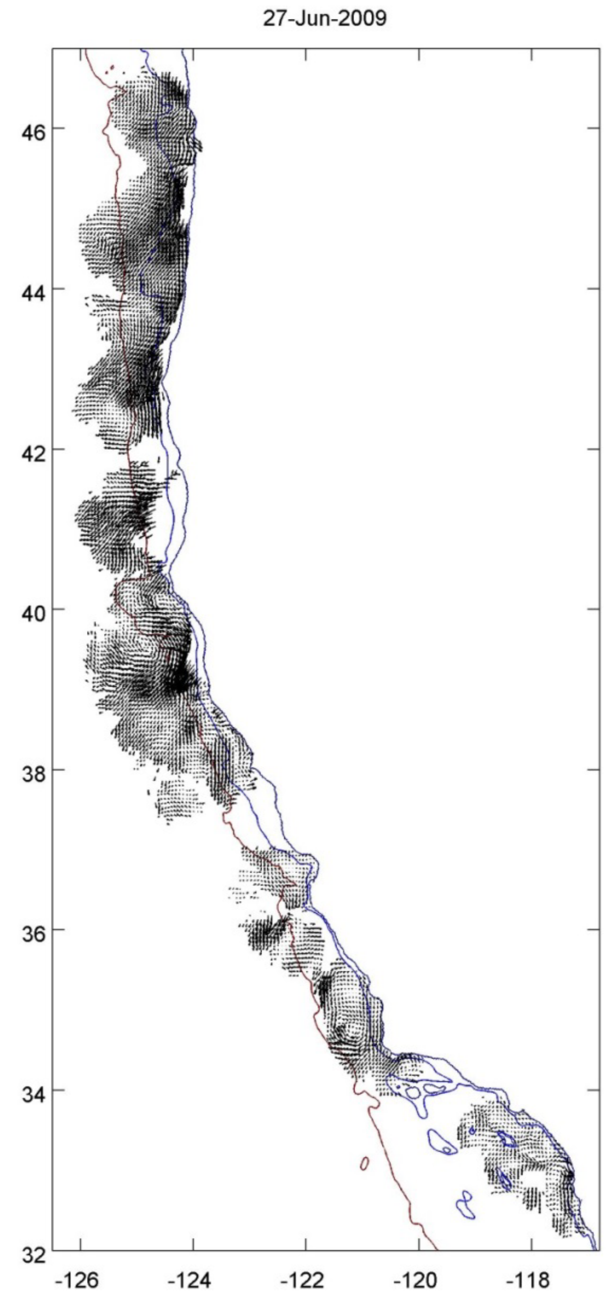
+ glider T & S vertical sections, Argo T & S profiles



JPSS L3U, 1-3 Jun 2014

HF radar surface currents (can be used for assimilation or forecast verification)

(we have tried assimilation of hourly data maps, 6-km resolution)



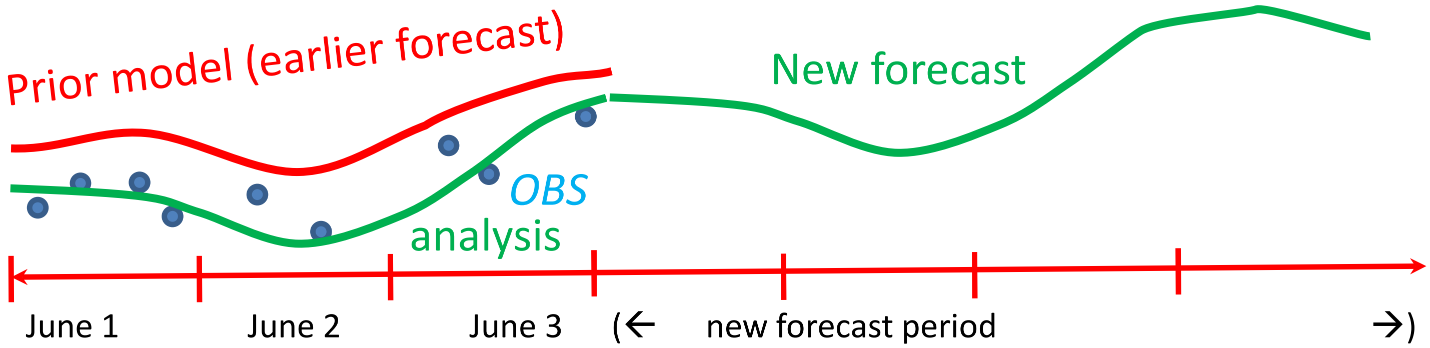
WCOFS4 DA Test, 3-day assimilation window

Observations:

- SST: JPSS VIIRS L3U (Ignatov et al., NOAA/NESDIS/STAR)
- SSH: Alongtrack altimetry, (1Hz/6 km alongtrack resolution, Jason, Cryosat, etc.)

Assimilation methodology, 4DVAR:

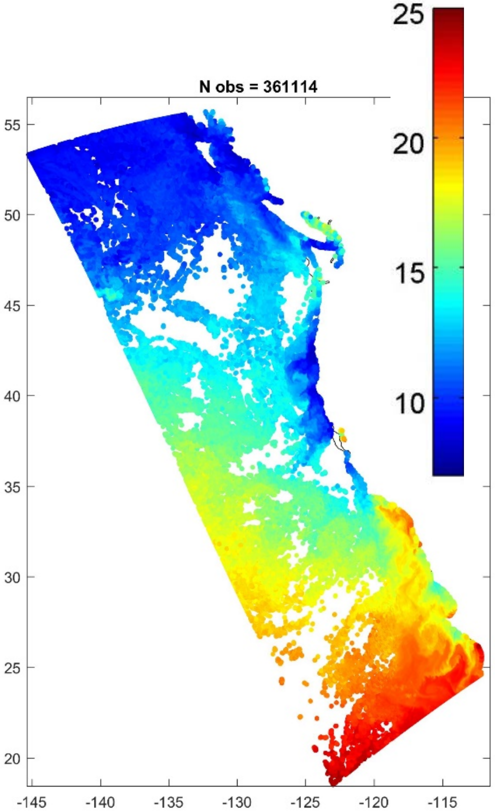
Cost function = || model deviation from prior ||² + || model – obs ||² → min



(a) Over a given time interval (here, 3 days: June 1-3) use available observations and **the adjoint model** to correct initial conditions for the analysis (here, at the beginning of June 1)

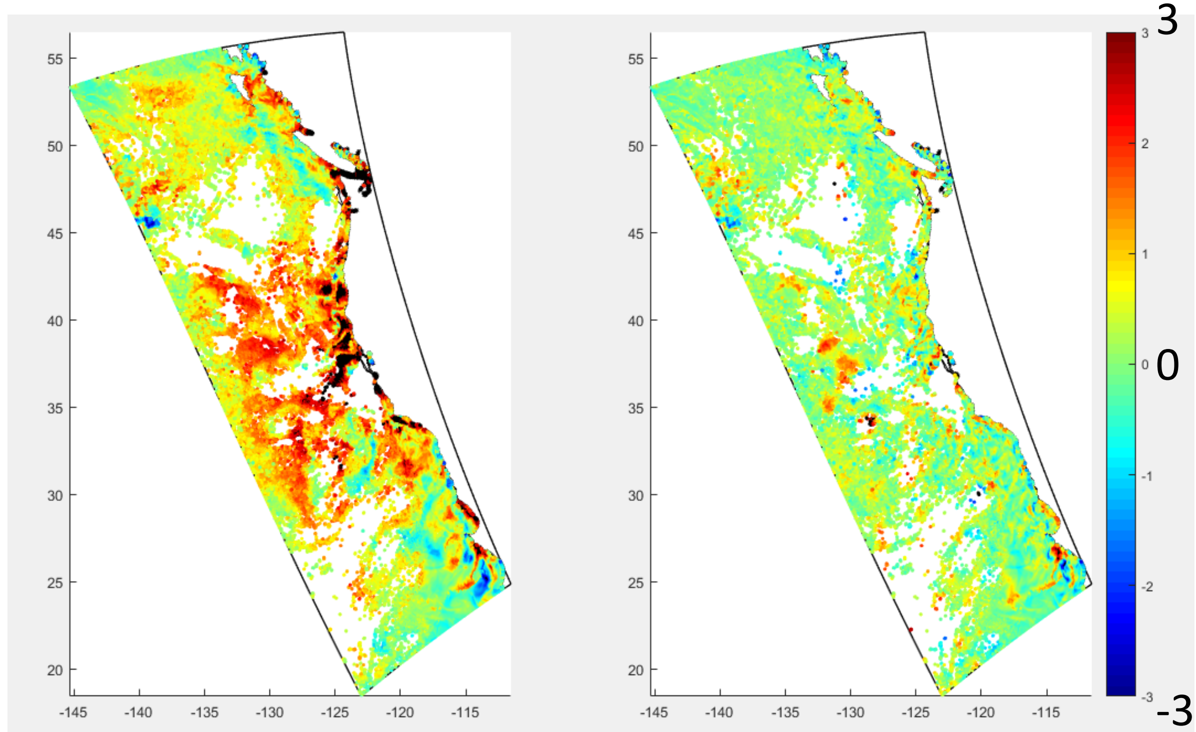
(b) The analysis provides improved initial conditions for new forecast (6/4-7)

SST: All obs in the 3-day interval



Data fit, SST (model-observation difference, degrees C)

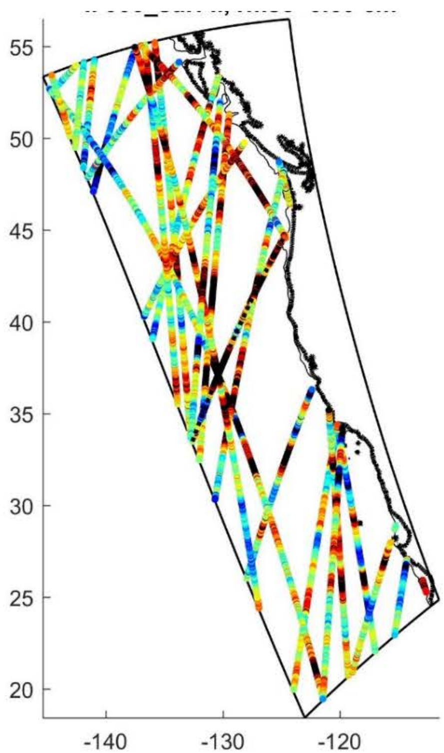
Before DA (rmse=1.19) After DA (rmse = 0.55°C)



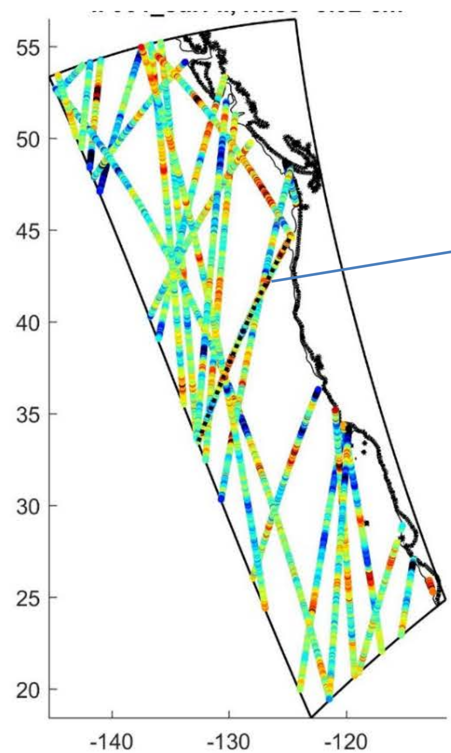
DA: Cooling at the surface. Correction of the SST front locations

Data fit, SSH (non-tidal, model-observation difference, m)

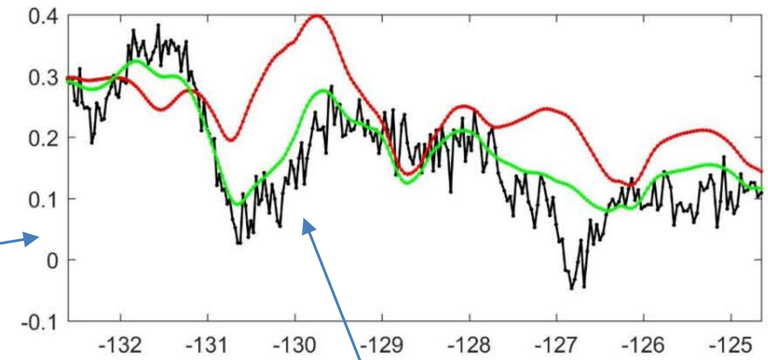
No DA (rmse=6.60 cm)

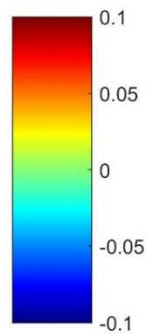


DA (rmse = 3.92 cm)



Alongtrack SSH (m): ***OBS***, ***no DA***, ***DA***





DA: improved representation of the slope of the ocean surface => surface eddies and jets

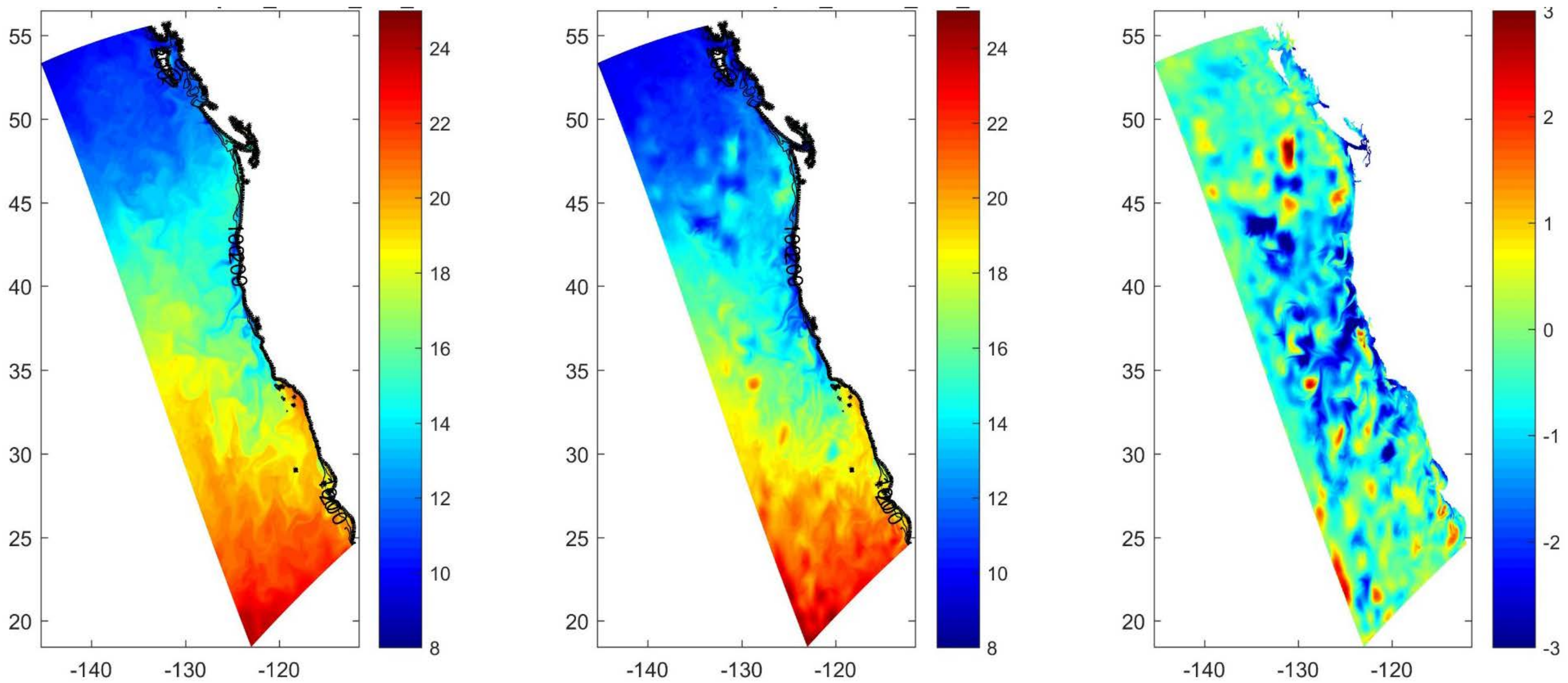
(All the tracks in the 3-day exp.: color shows model-obs difference)

DA IMPACT: SST

cooling the surface (compensate to weaker than observed upwelling)

(SST, 6/3/2014 00UTC:

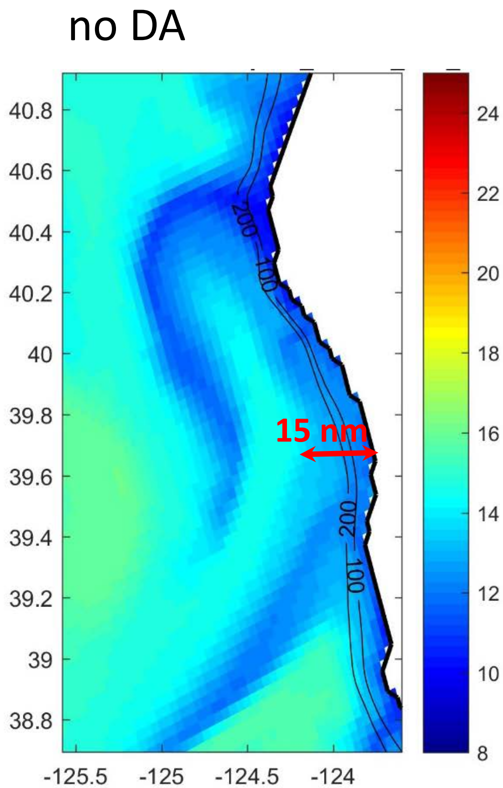
no DA DA difference: DA – no DA, degr C

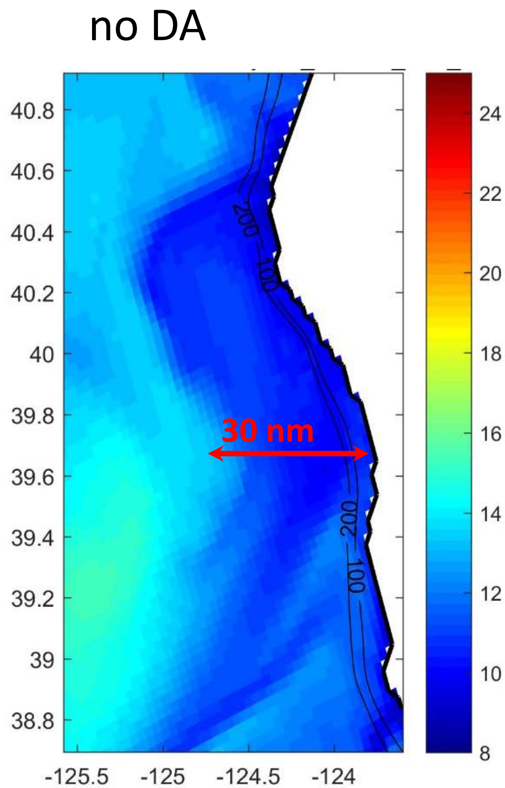


Impact of SST assimilation, front location of C. Mendocino (CA)

Fishermen have been using SST forecasts to guide their operations… the SST front is where tuna are likely

In the figure: model without assimilation will suggest a 2 hour trip to the front, while the actual front is much farther, a 4 hour trip (at traveling at a speed of 7.5 knots)





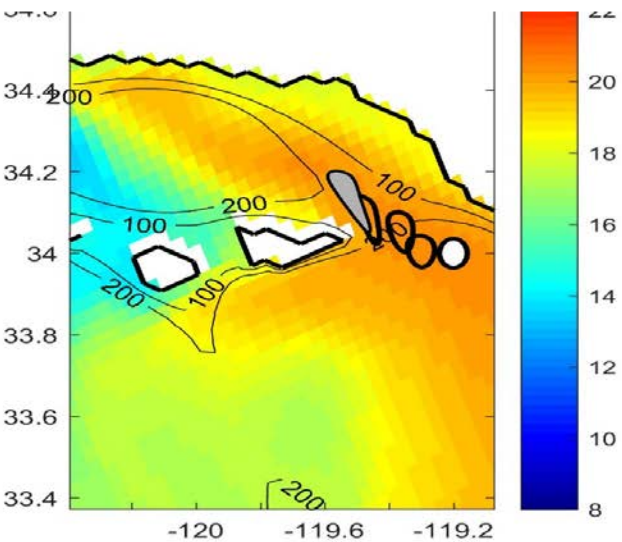
Note: the offshore front location changes appreciably over 2-3 days. 3-day forecasts will be valuable.

Strongest currents are along the front (up to 2 knots): use to optimize routes

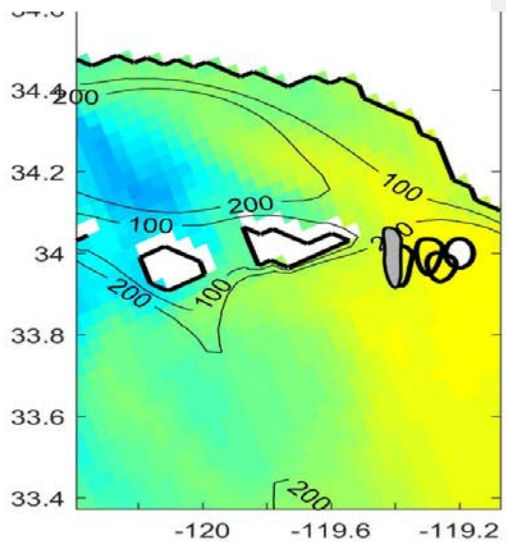
DA Impact, “oil slick” dispersion in Santa Barbara Channel
Background color: <u>SST</u> (shown on Jun 3, 2016)

A patch is released on the surface and its contour is tracked using model (uv) for 2 days (6/2-3)
WHITE: beginning (4-km radius disk), GRAY: 48 hours later

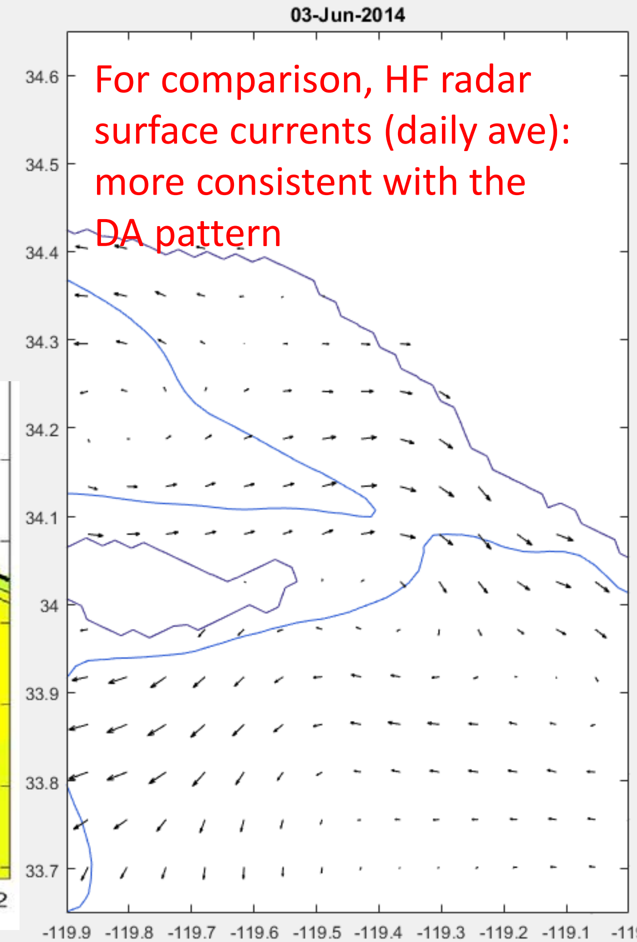
No DA



DA



For comparison, HF radar surface currents (daily ave): more consistent with the DA pattern



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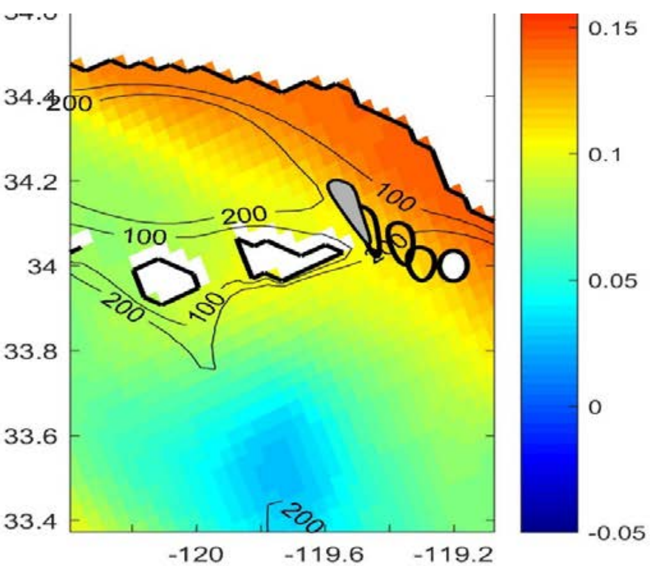
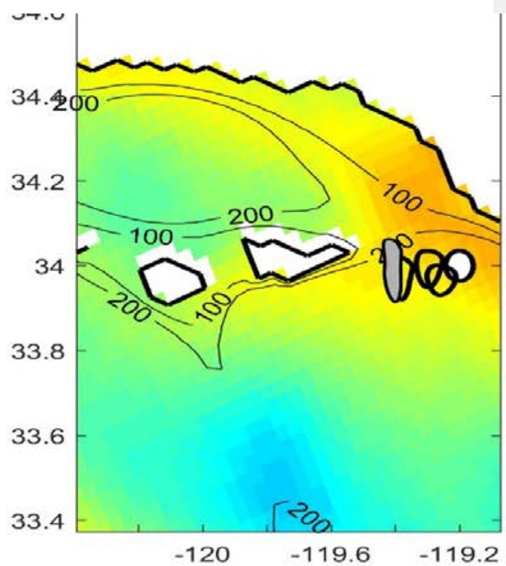
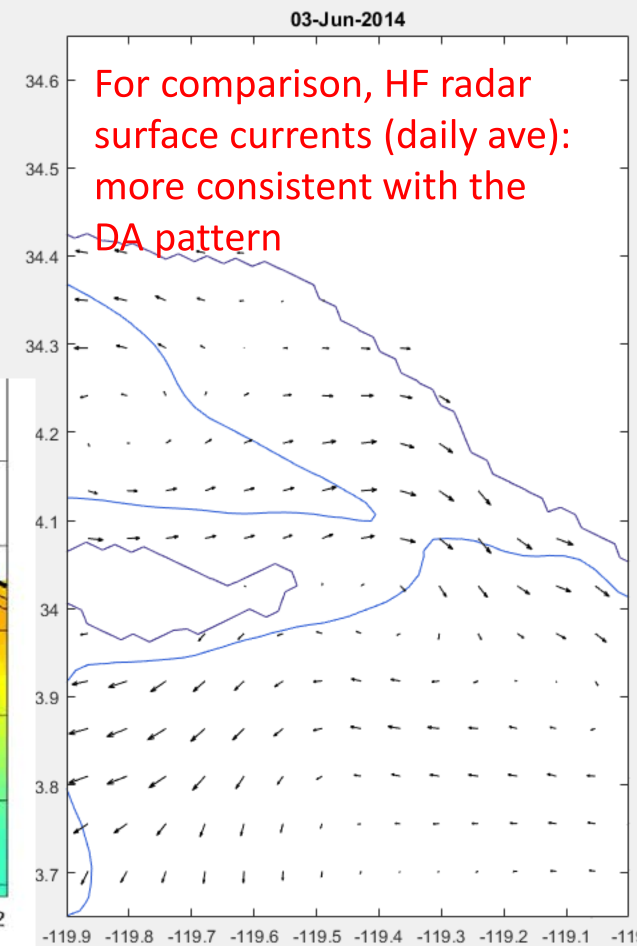


DA





SUMMARY:

JPSS L3U SST will be assimilated into the WCOFS using 4DVAR, providing

- Improved 3-day forecasts of SST and other oceanic variables
- Synthesis of SST with other observational data
- Gap-free maps of SST (dynamically based time and space interpolation of the SST data)

Initial assimilation tests using JPSS L3U SST show impact on the front location and surface material transports, relevant for navigation, fisheries, and environmental hazard response

Users & uses of WCOFS forecasts:

- Search & rescue
- Environmental hazard response (e.g., NOAA ORR)
- Fisheries (industry, management)
- Onshore pathogens transport
- Navigation