SWOT: Coastal Altimetry

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March 1-2, 2010
Arlington, VA

Coastal Issues

- Time and space scales for SSH and Surface Currents
- Magnitude of the signals
- Issues for Coastal Altimetry Observations
- Complementary Measurements
- Modeling and Data Assimilation
- Reanalysis (Process Study) and NRT Forecasting (Applications)
- Special Need for Processing and Distributing Coastal Data

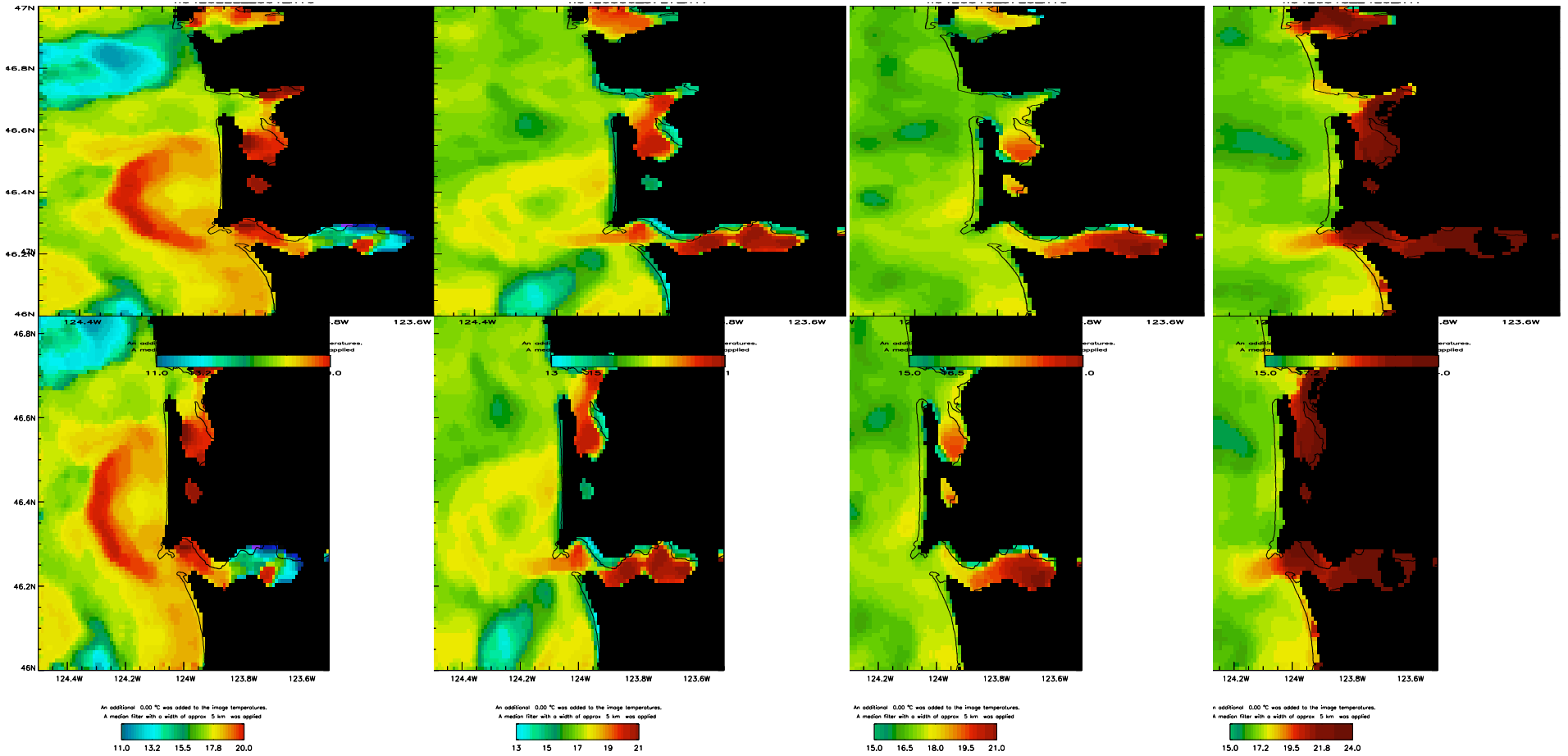
Coastal Issues

What ageostrophic processes occur?

- External tides – SSH ~ 1+ meters; 12-24 hours. River Plumes (Short space scales, SSH scales?). Internal tides and their currents (10's of cm over scales of less than 1 km). *Geostrophic adjustment takes 1-2 inertial periods (12 hrs – 4 days).*
- Ekman surface transports have no SSH signal.

What are typical scales for more geostrophic currents?

- In the inner shelf (0-10 km from the coast; depths less than ~15-50 m), SSH ~ 5-20 cm, with time scales of 1-5 days.
- Over narrow shelves (10-40 km wide), SSH ~ 10-30 cm, with periods of several days or longer.
- Over wide shelves and shelf breaks (10-200 km from the coast), currents can be 10-100 cm/s, SSH ~ 10-50 cm, horizontal scales of 10-100 km.
- In the "Coastal Transition Zone" (30-500 km from the coast), currents of 50-100 cm/s have SSH changes of 20-40 cm over 10-20 km.



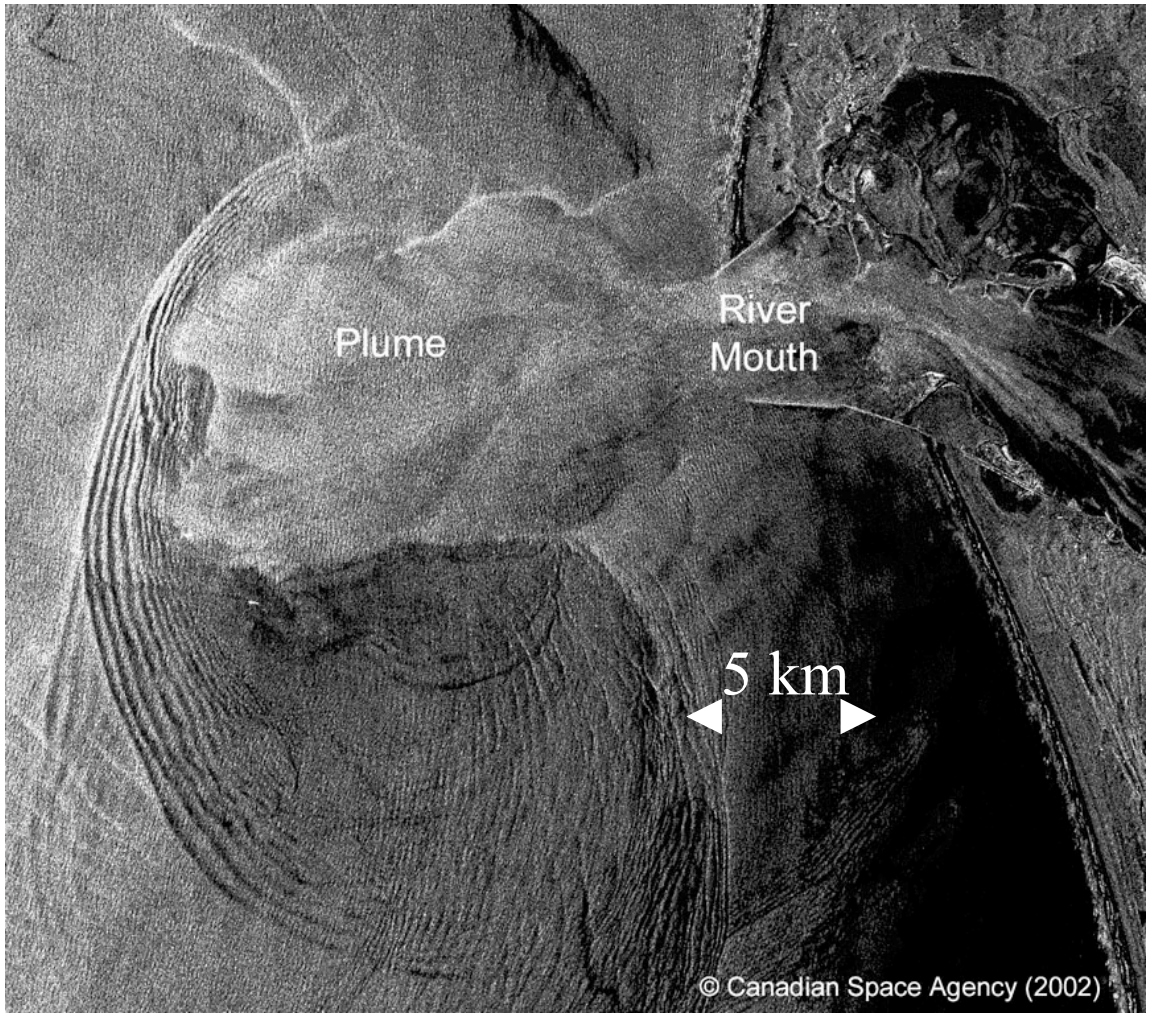
2004, D202, Hr 22 2004, D203, Hr 06 2004, D203, Hr 10 2004, D203, Hr 18

Tidal Excursions of the Columbia River Plume

SSH ~10 cm over 50-100 m

August 20-22, 2004

T. Strub



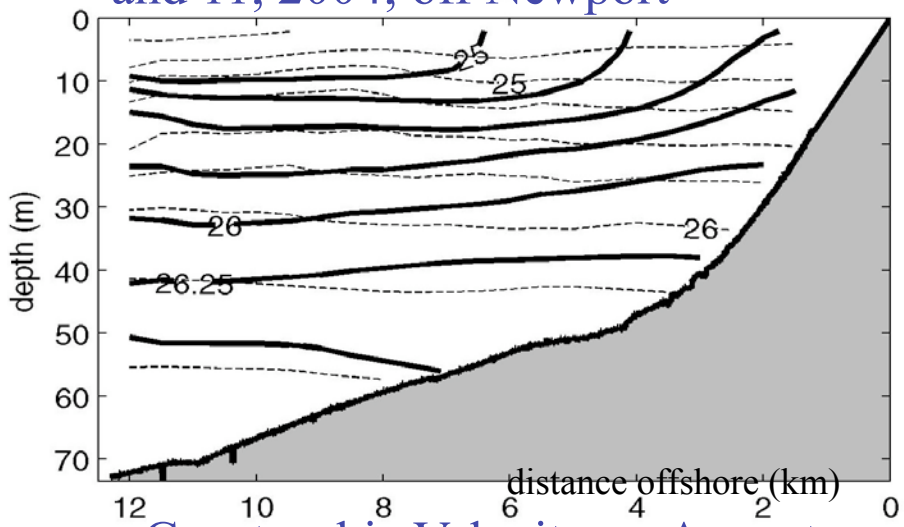
SAR Image of the Columbia River Plume

August 9, 2002

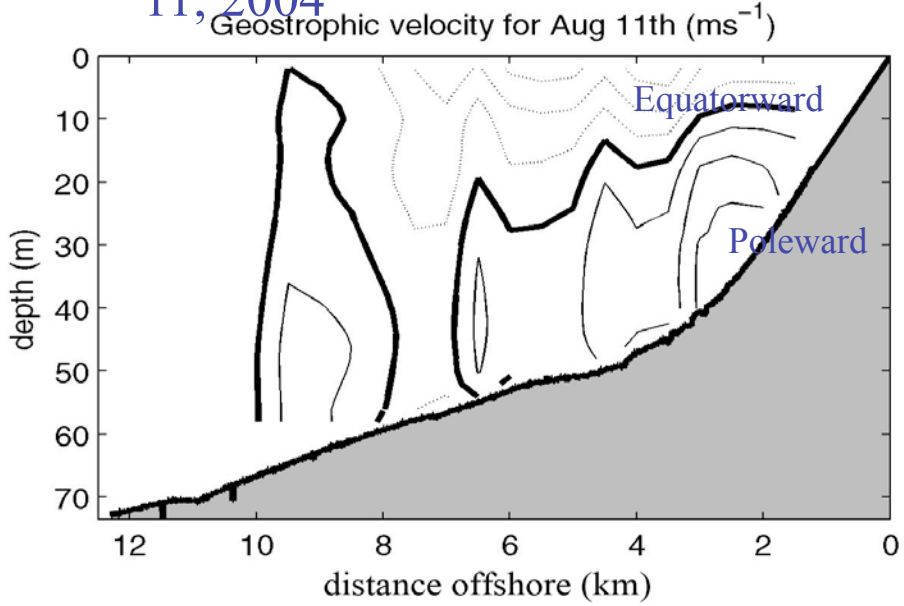
J. Nash

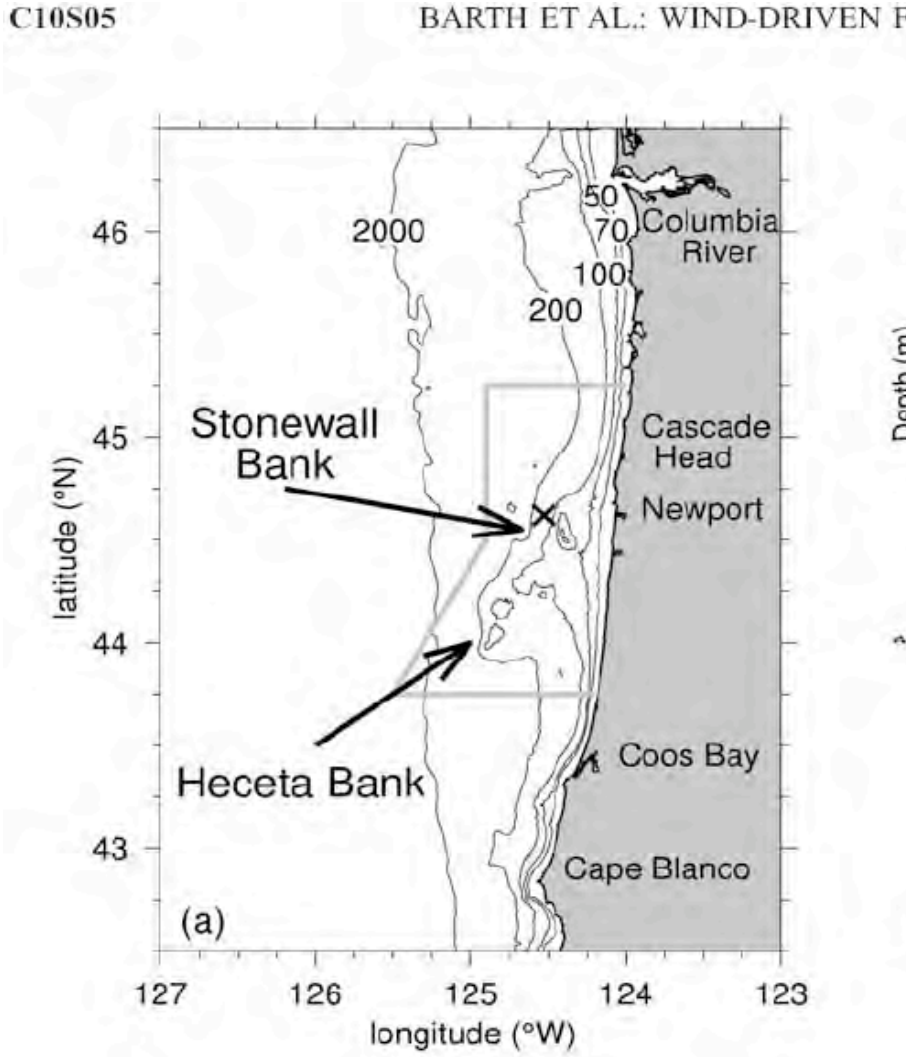
Currents with Horizontal Scales of 5-10 km

Density Sections from August 10 and 11, 2004; off Newport



Geostrophic Velocity on August 11, 2004





A. Kirincich

Winds in 2001

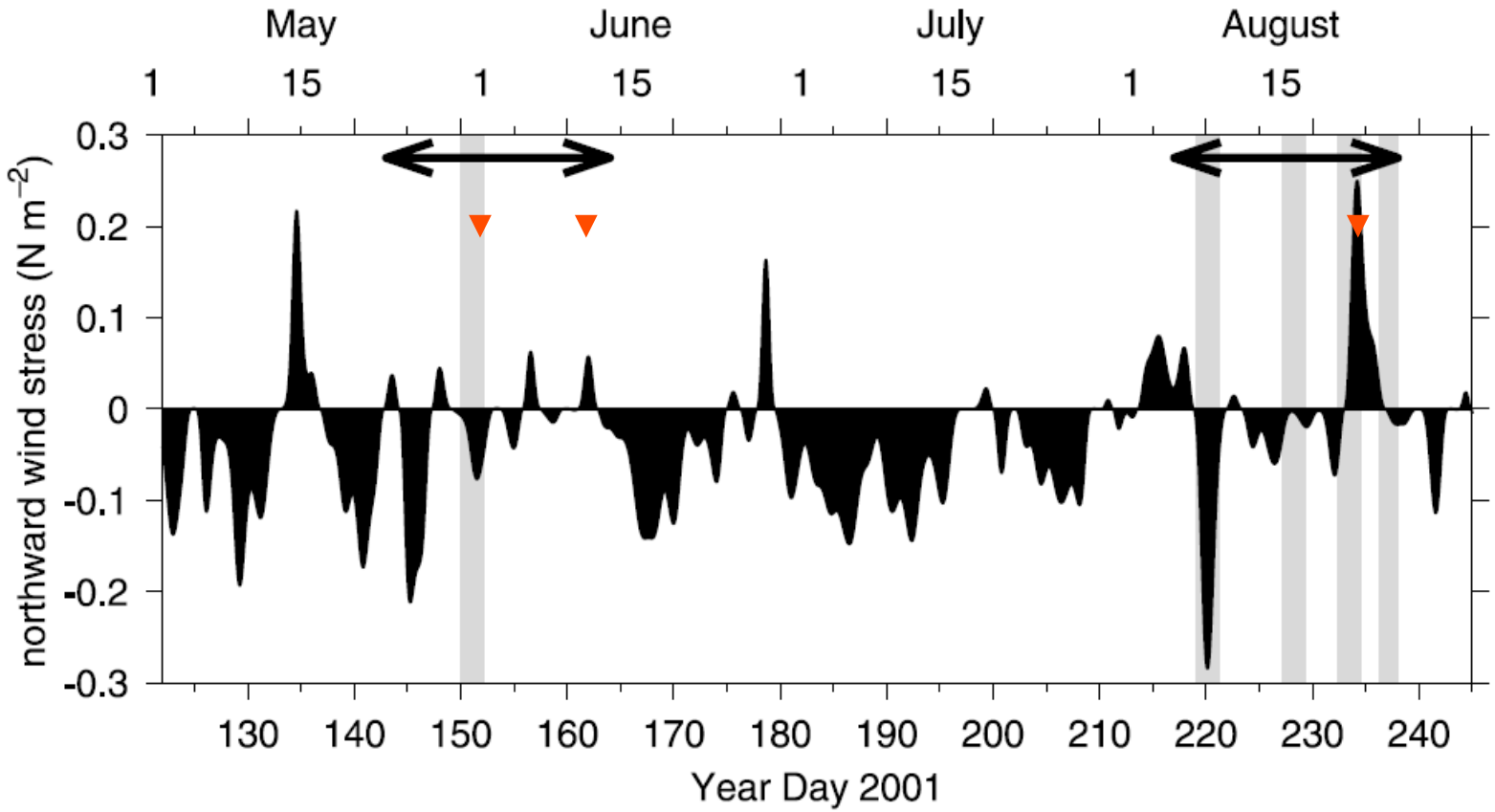


Figure 2. Wind stress calculated from winds measured at NOAA NDBC buoy 46050 off Newport, Oregon. The timing of COAST research cruises is indicated by horizontal double-ended arrows, and shaded bars denote times of individual maps.

J. Barth

June 1, 2001: Currents with Horizontal Scales of 20-40 km

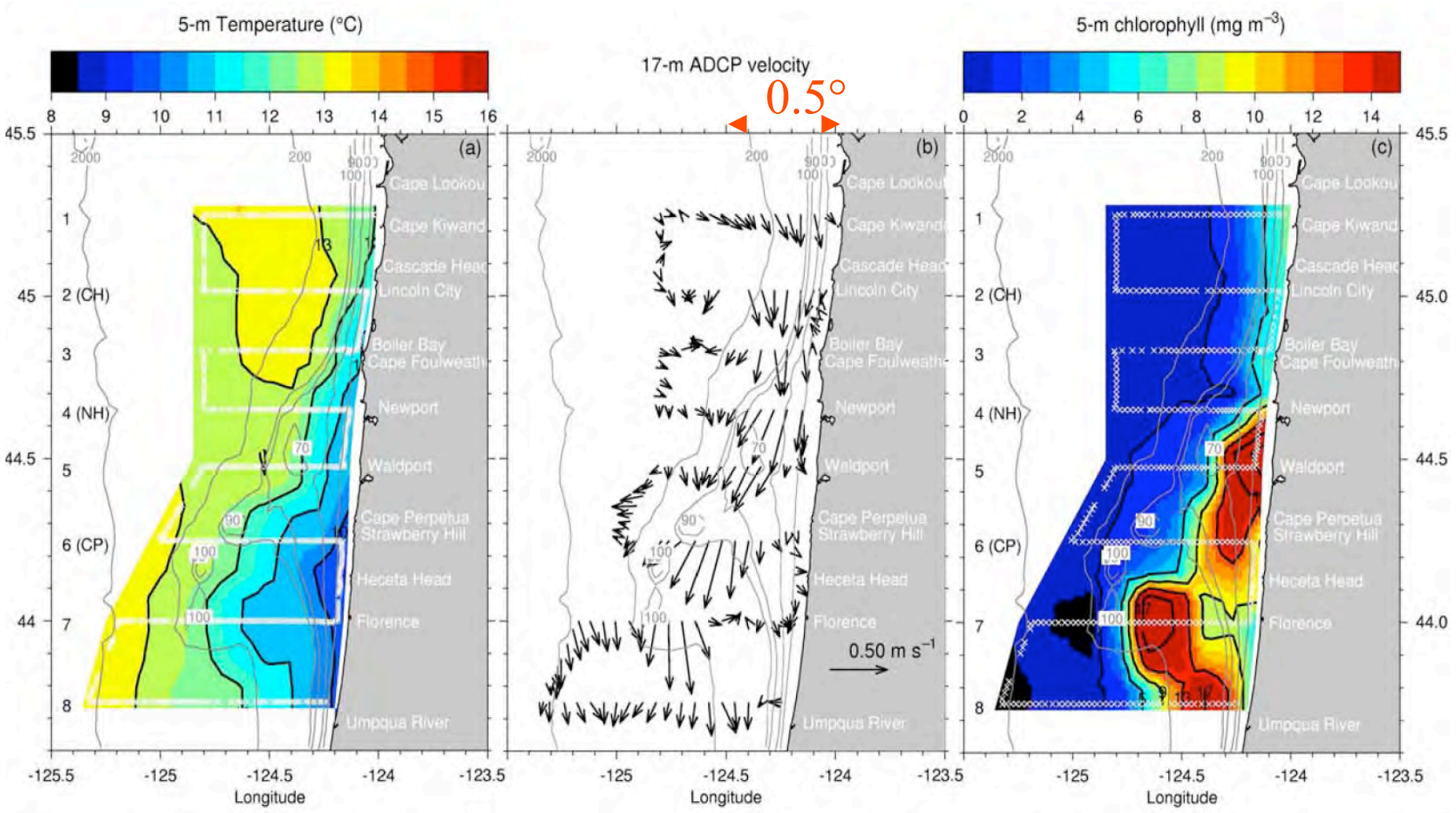
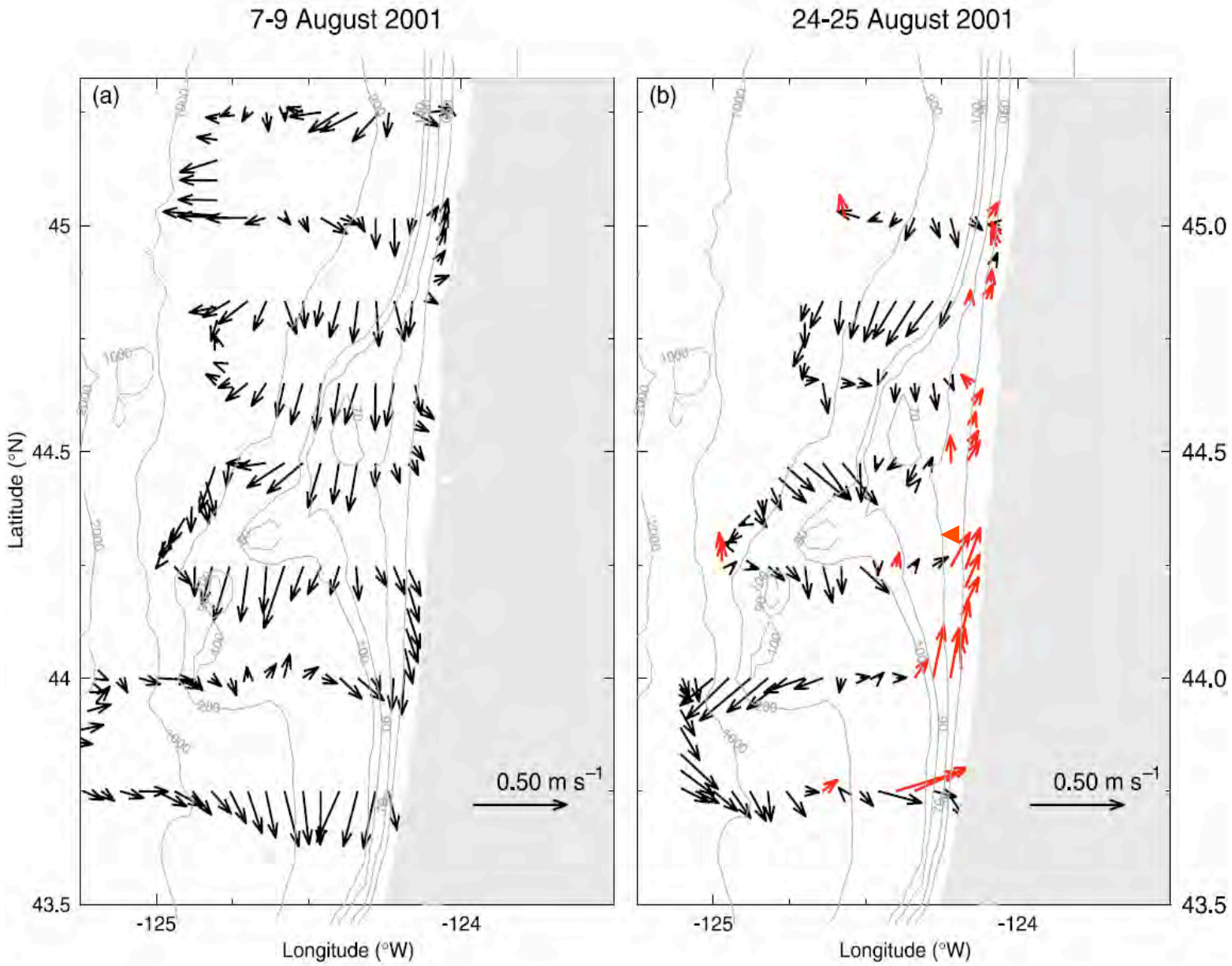


Figure 3. Maps of 5 m temperature (°C), 17 m acoustic Doppler current profiler (ADCP)-derived velocity vectors, and 5 m chlorophyll (mg m^{-3}) from 29 May to 1 June 2001. Measurements from along the ship track are shown as white dots, and east-west line labels appear at left in Figures 3a and 3c. Isobaths are in meters.

J. Barth



Current Reversal

~ 15 km Wide Coastal Jet

Figure 11. Velocity vectors at 25 m during (a) upwelling-favorable (7–9 August 2001) and (b) downwelling-favorable (24–25 August 2001) wind forcing. During downwelling, velocities with a northward component greater than or equal to 0.05 m s^{-1} have been colored red.

J. Barth

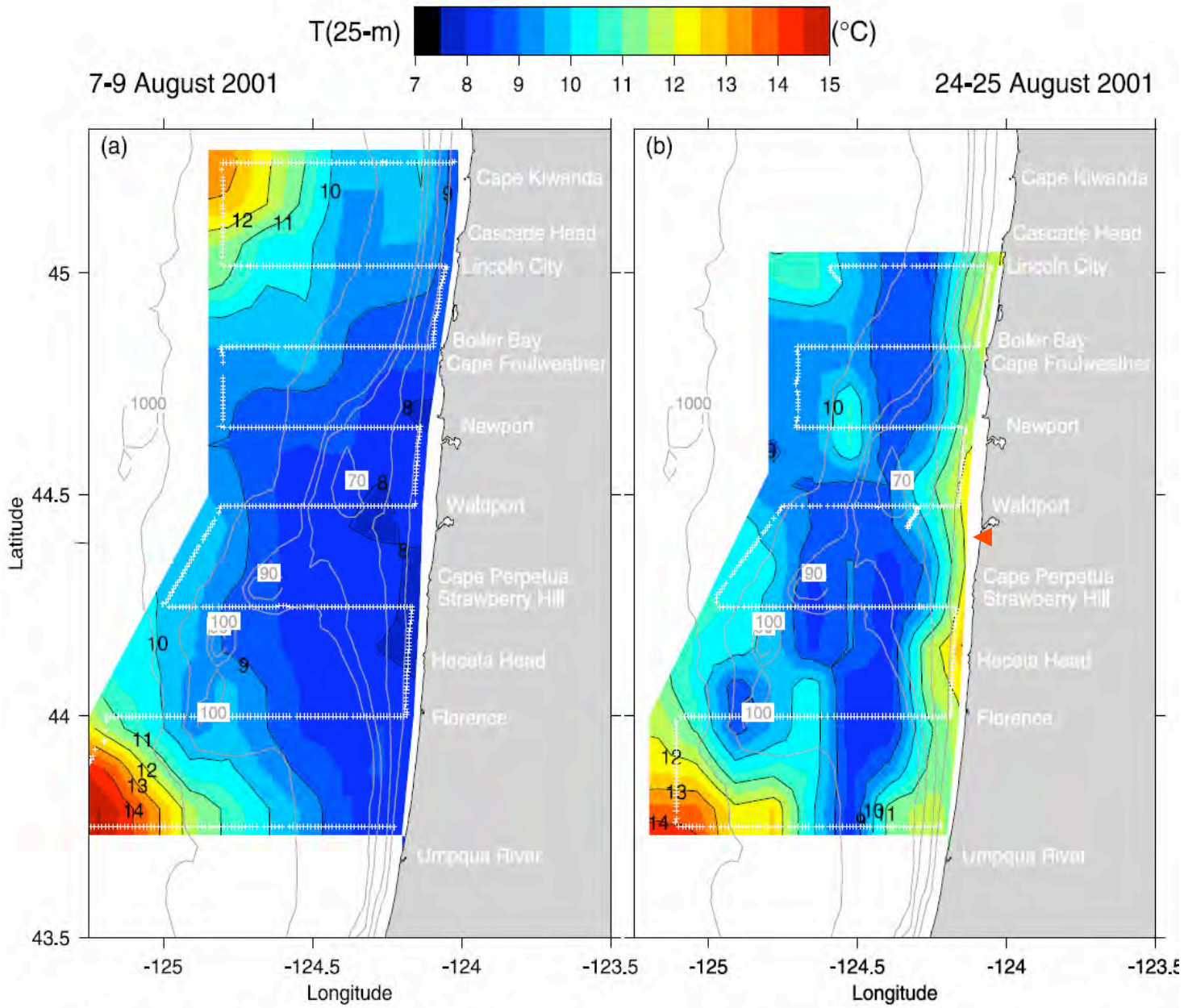


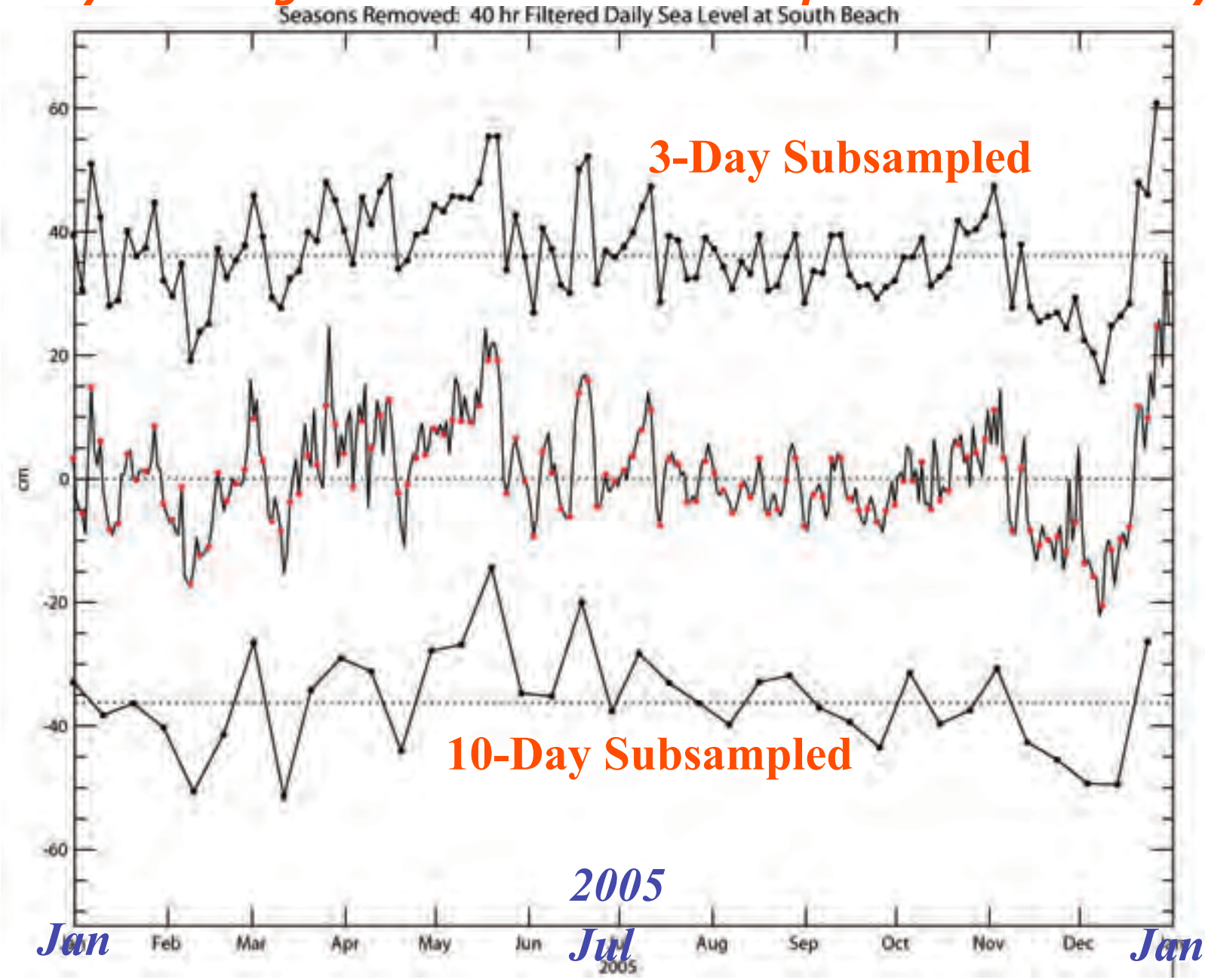
Figure 10. Maps of 25 m temperature (°C) during (a) upwelling-favorable (7–9 August 2001) and (b) downwelling-favorable (24–25 August 2001) wind forcing.

Warm SST in Jet Reversal:

SSH Proxy ~15 km Wide

J. Barth

Daily Tide Gauge Data at Newport, OR: Detided & Seasons Removed
Proxy for Alongshore Currents – Subsampled at 3 and 10 Days



Coastal Issues

- "Corrections" – mostly similar to conventional altimetry?
  - Wet Troposphere: Discussed yesterday – Mostly < 2-5 cm across the swath or when estimated over land-contaminated cells.
  - Sea-State Bias and Other Corrections – Anomalies of several cm have been seen – Is SWH a problem in coastal regions?
  - External Tides: Improved models for tides over shelves are needed, especially over wide shelves. Will SWOT data be used to improve these models?
  - Other HF Signals:
    - Internal tides and other internal waves;
    - Coastal Trapped Waves – wind and tide gauge data may help to model these for some areas

Wet Troposphere Analyses along TOPEX and Jason Tracks (Similar to Shannon Brown's results)

TMR and JMR Wet-Tropo Ranges over 50 km and 120 km

- For this mesoscale region within 300 km of the coast, changes in the wet-tropo path delay are often 0-2 cm over distances of 50-120 km. Errors in velocity would be less than 2-4 cm/s.

- Some gradients, however are up to 5-10 cm over 50-120 km. Errors in velocity could be 10 cm/s.

- These same gradients extend over land, sometimes enhanced by the terrestrial topography.

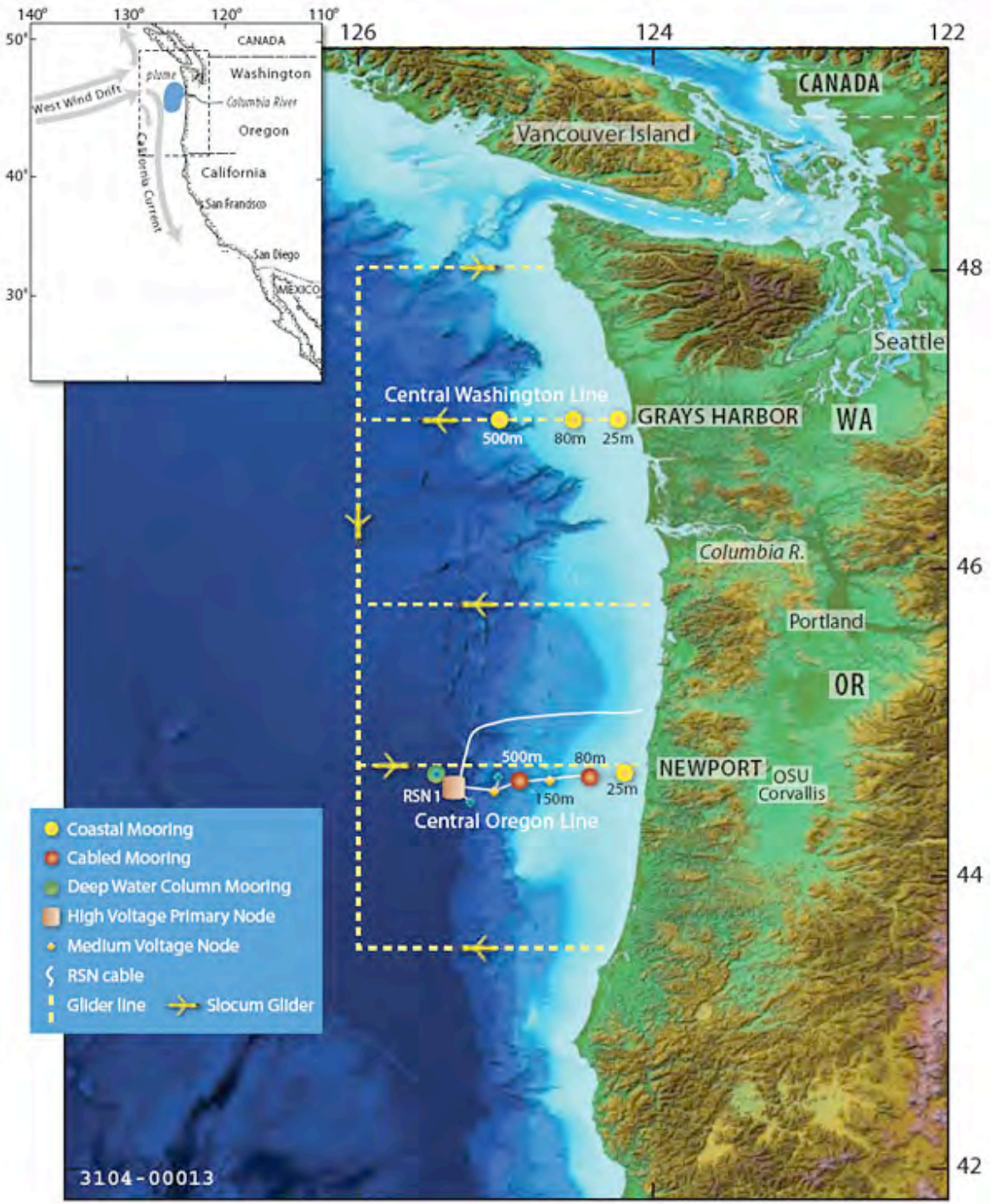
- In mid-ocean, ~ 3-4% of swaths 120 km (50 km) wide have differences of 5 cm (2 cm) in PD somewhere along the swath.

Synergistic data in coastal zones

- Ocean Observing Initiative (OOI), $385M over 5.5 years starting Sept. 2009
- Integrated Ocean Observing System (IOOS), NOAA, $34M for FY2010
- California State invested $21M during 2006-2010
- Emerging technology such as HF radar and Autonomous Underwater Vehicles (AUVs) including gliders

Ocean Observing Initiative (OOI): Global & Regional

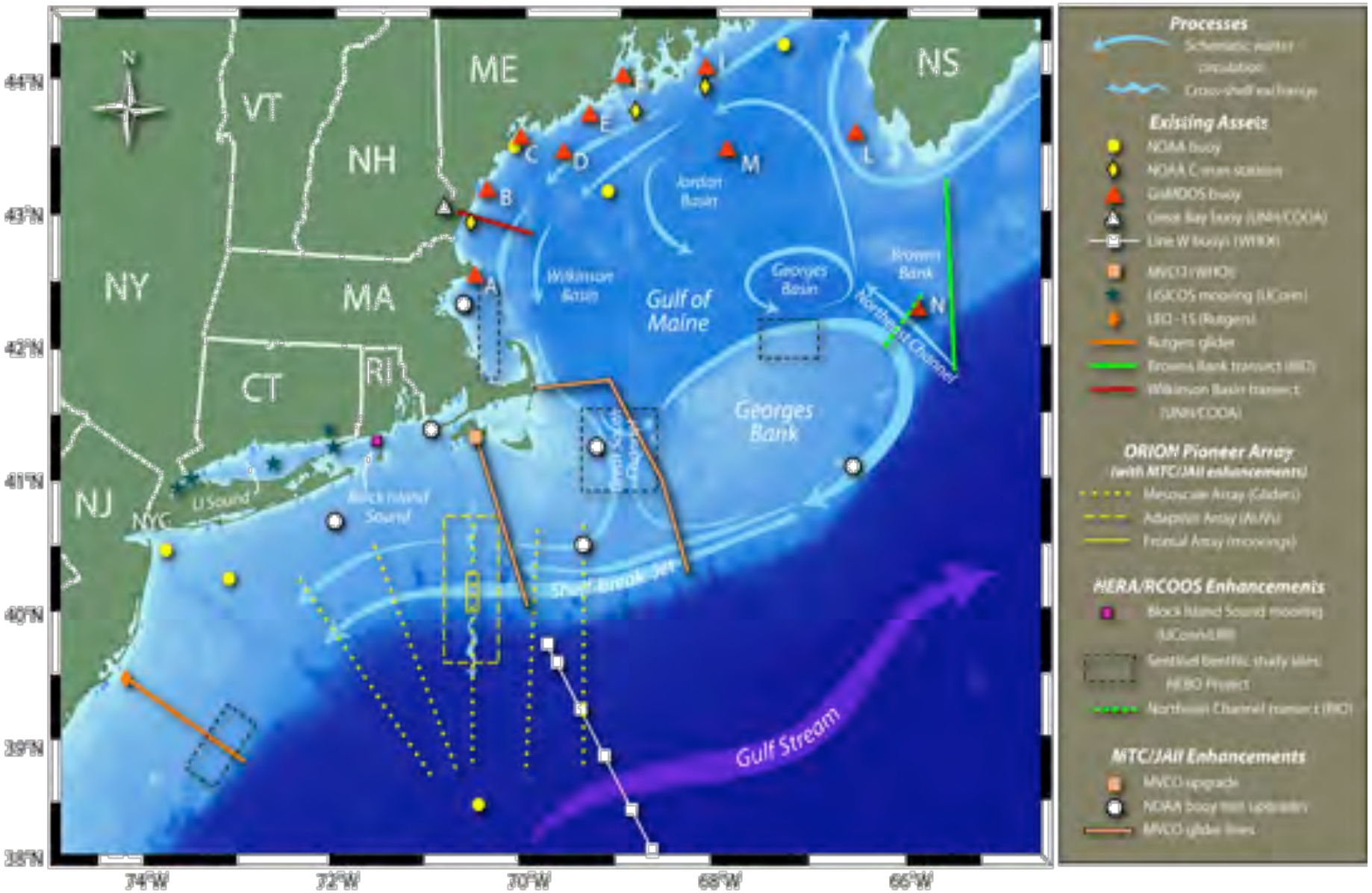
OOI Coastal: Endurance Array



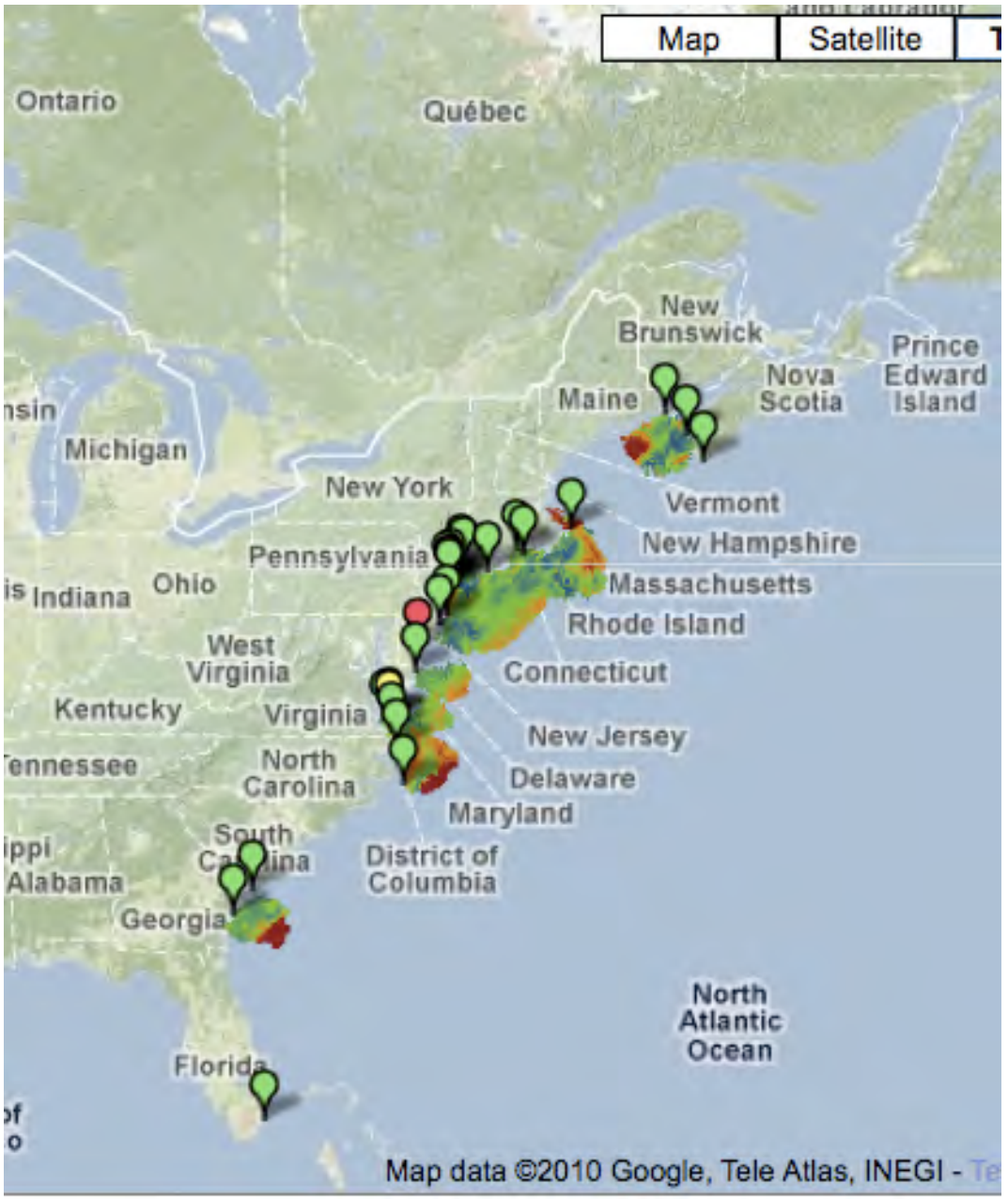
PNW Endurance Array samples coastal to deep-ocean gradients

Newport, OR, and Grays Harbor, WA, sample the productive coastal upwelling ecosystem in two regions differentially influenced by wind forcing and river input

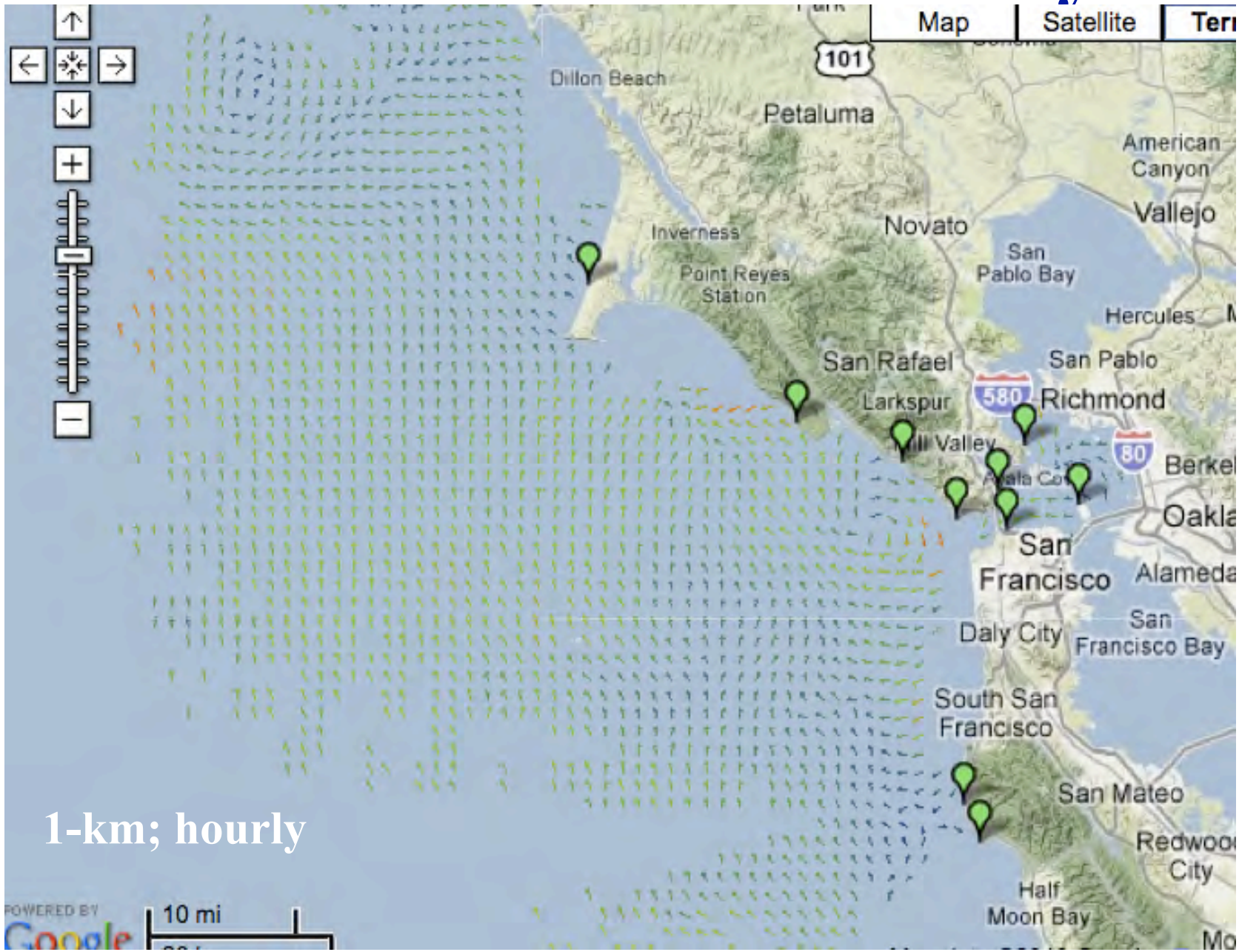
OOI Coastal: Pioneer Array; 5-yr



IOOS National HF Radar Network

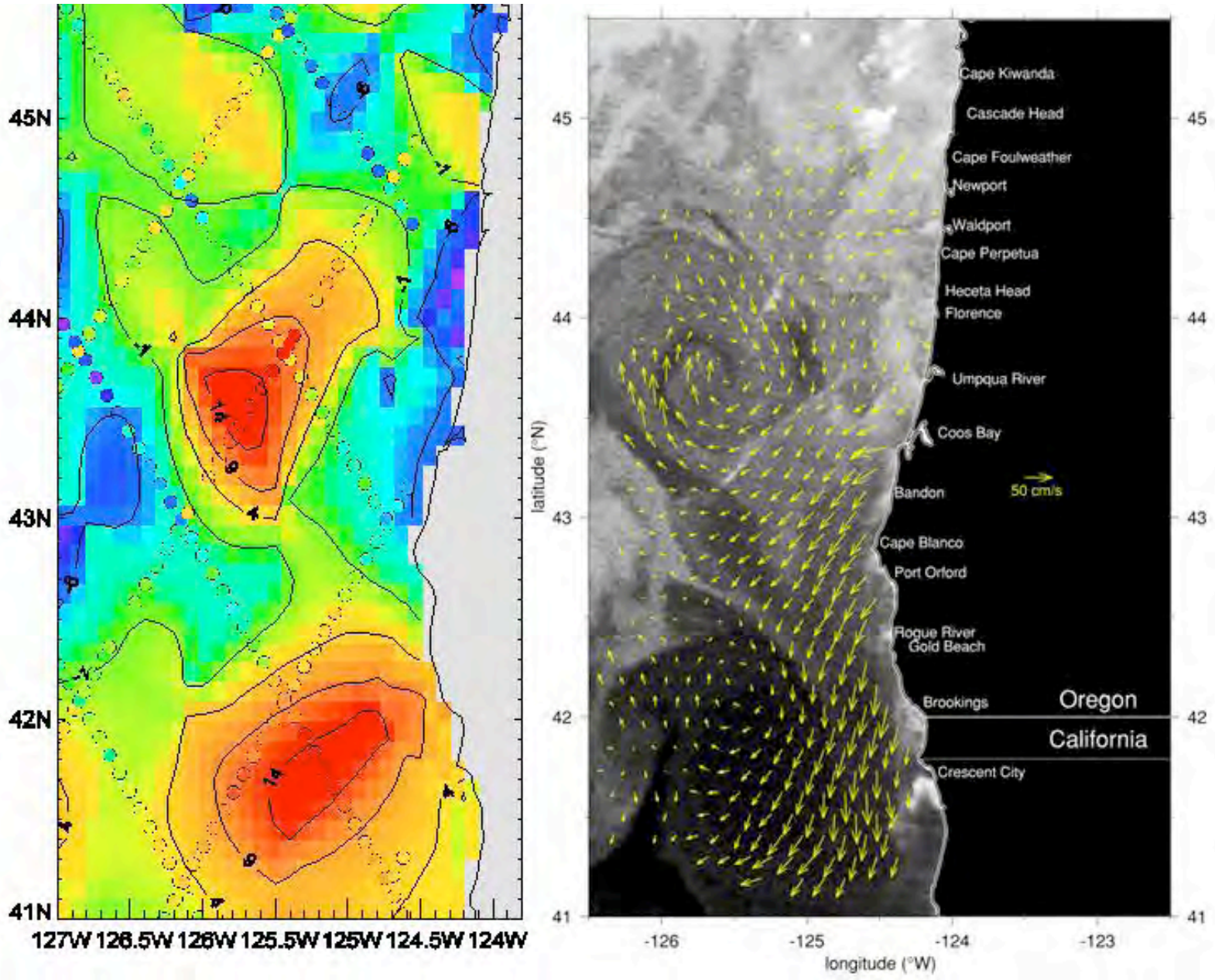


HF Radar: Outside SF Bay

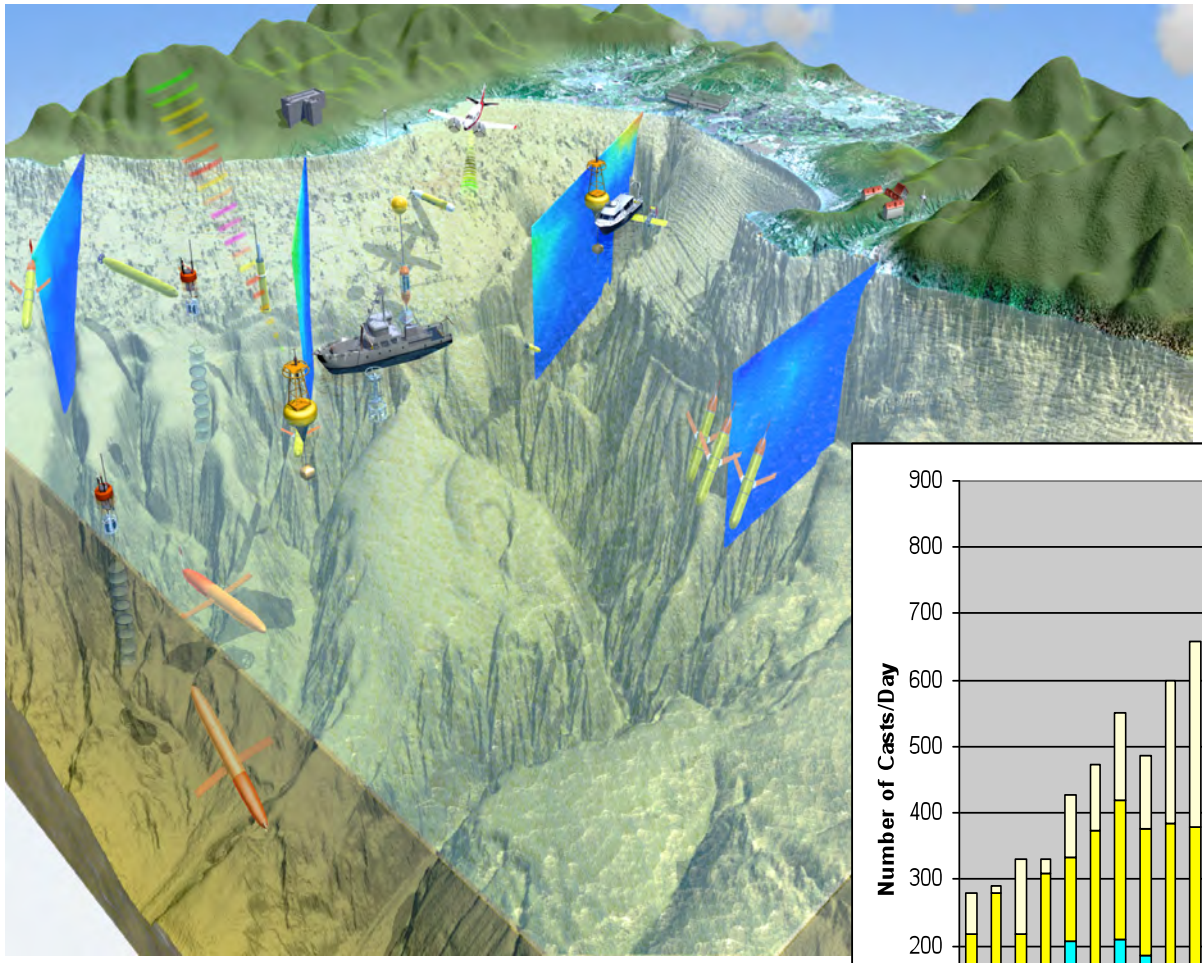


HF Radar: Inside SF Bay

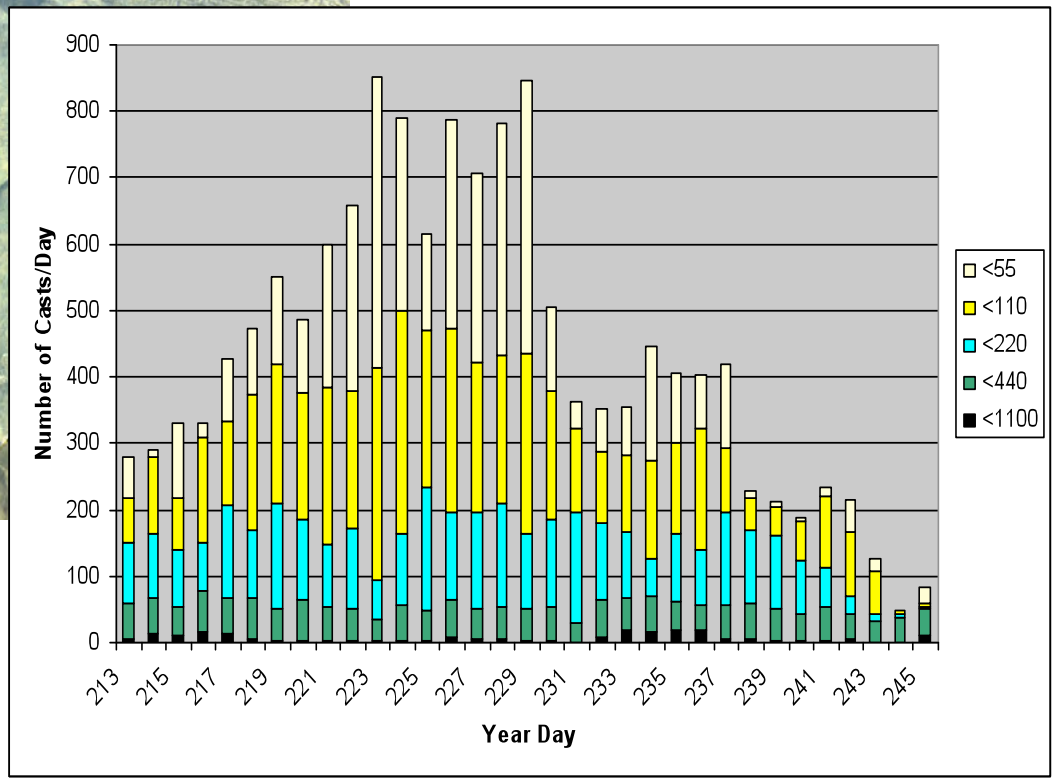
HF Radar: Eastern Boundary Eddies



Coastal Field Experiments



Over sampling during the 3-day repeat phase & prepare for the 22-day repeat



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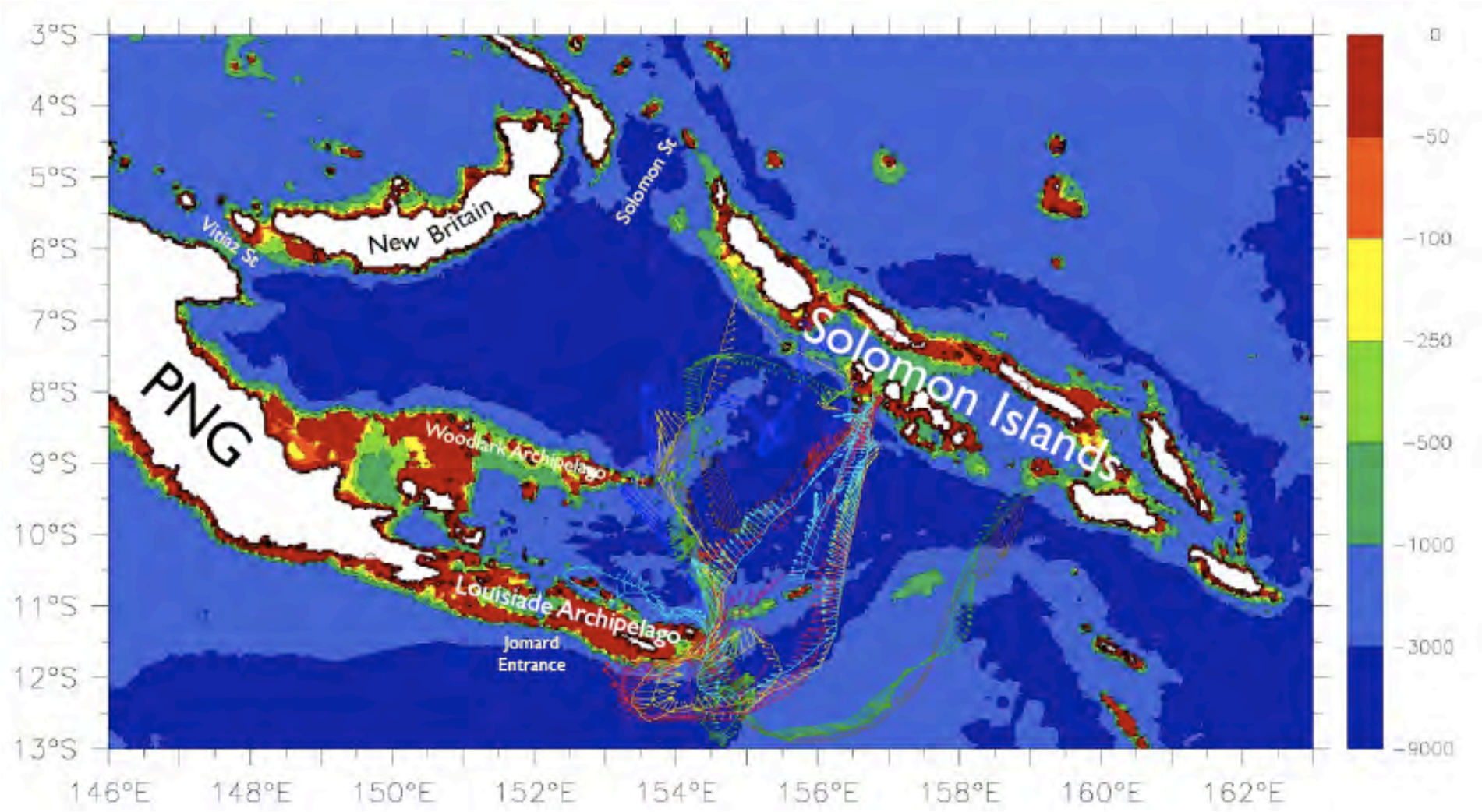
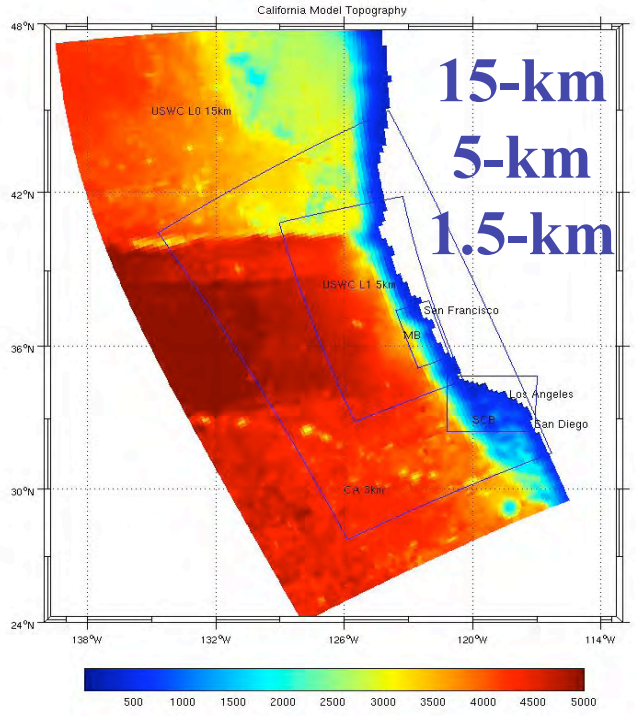
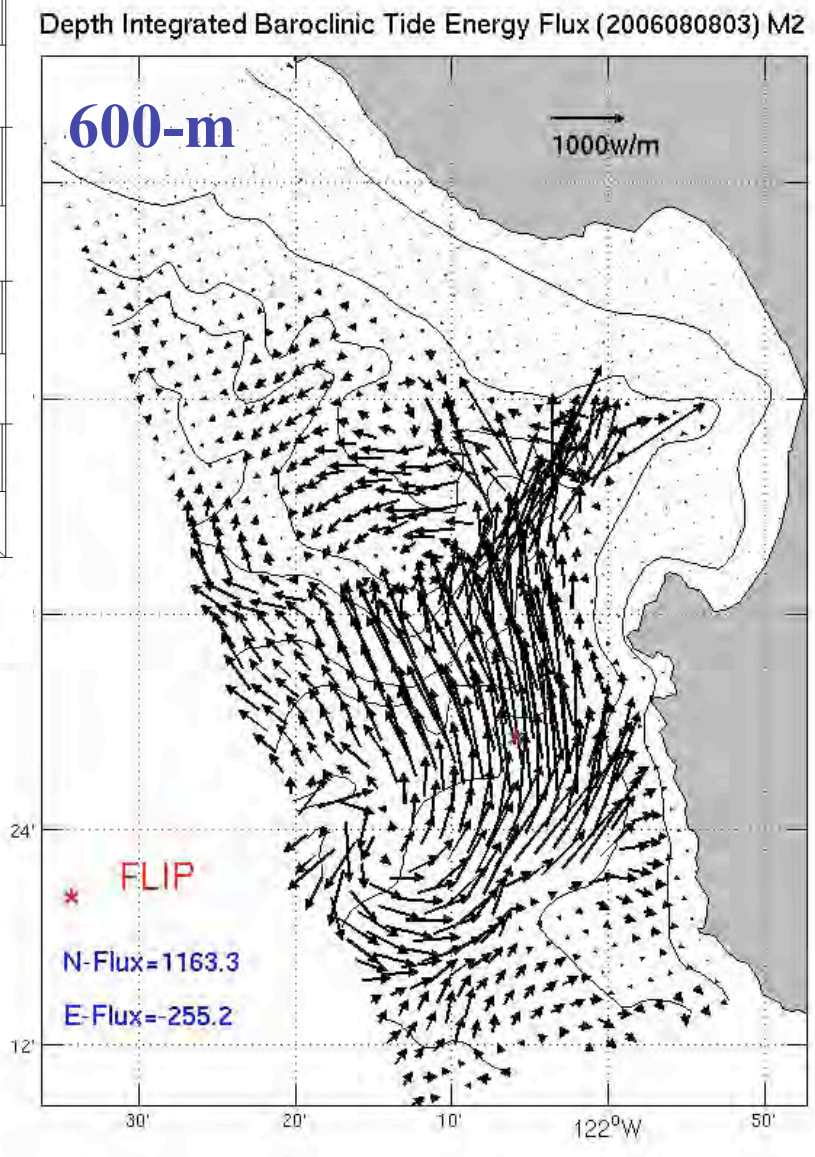


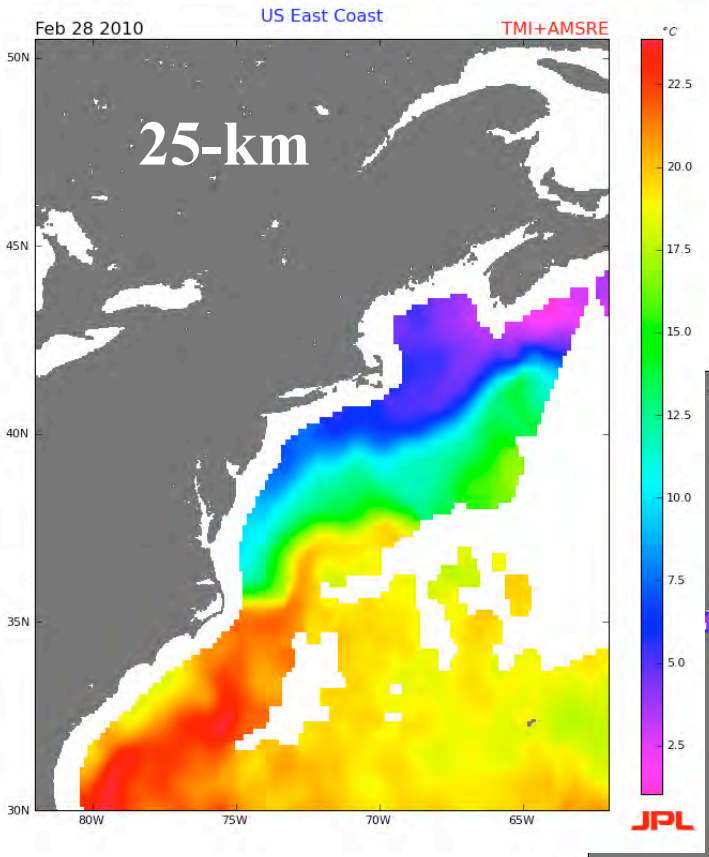
Solomon Sea glider and ROMS modeling studies (UW, JPL, UCLA)
Synergy with CNES effort

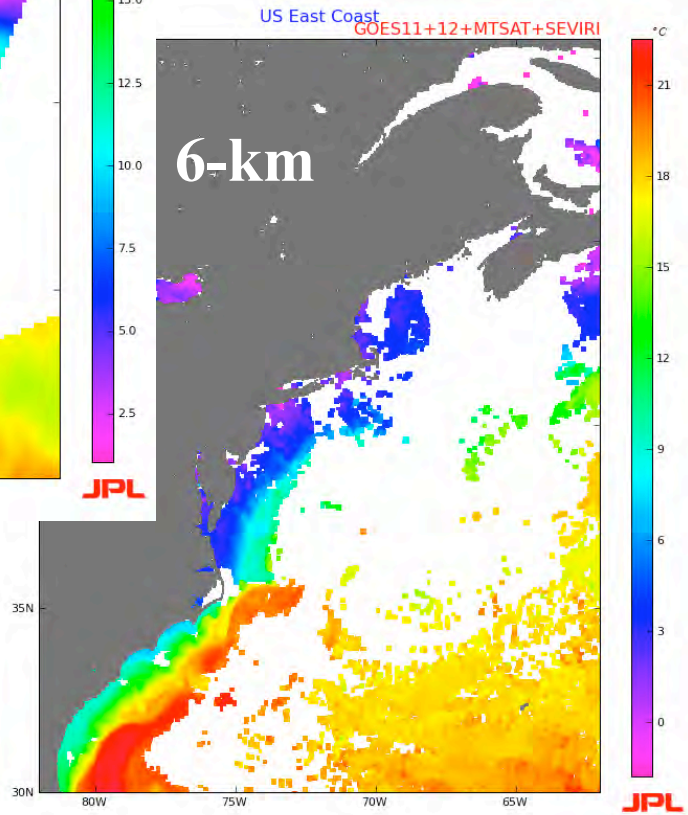
Modeling Approaching SWOT Resolution

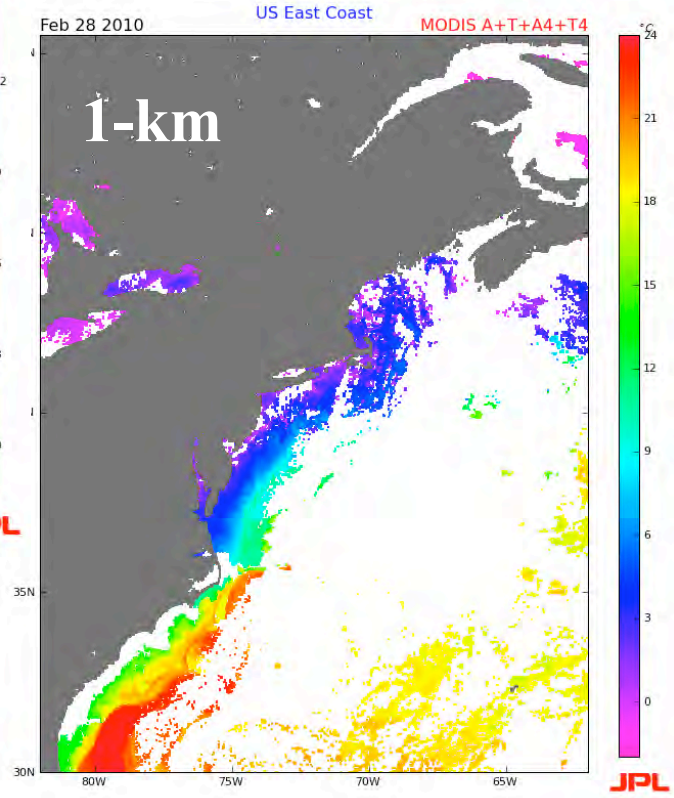




GHRSST multi-resolution SST data







Multi-Scale Data Assimilation

3DVAR Data Assimilation:

at low-Resolution:

$$\min_{x_L} J = \frac{1}{2}(x_L - x_L^f)^T B_L^{-1}(x_L - x_L^f) + \frac{1}{2}(H_L x_L - y_L)^T R_L^{-1}(H_L x_L - y_L)$$

H: mapping from model to observation space

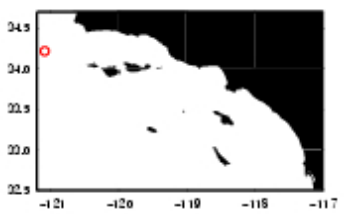
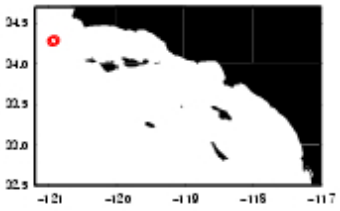
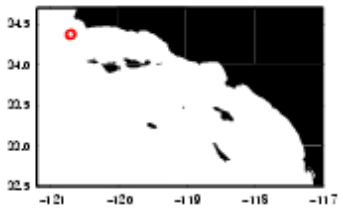
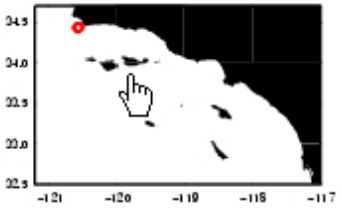
at high-Resolution:

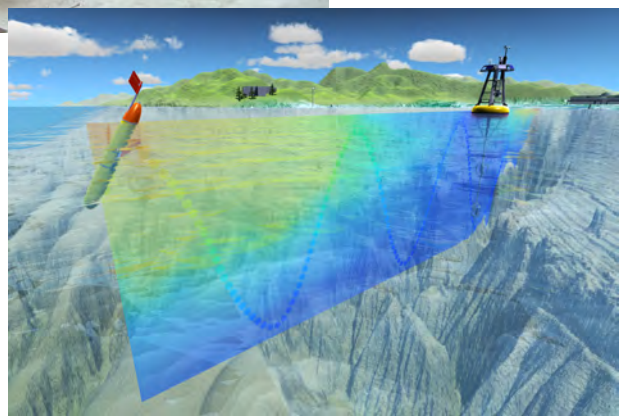
$$\min_{x} J = \frac{1}{2}(x - x_L^{af})^T B_a^{-1}(x - x_L^{af}) + \frac{1}{2}(H_S x_S - y_S)^T R_S^{-1}(H_S x_S - y_S)$$

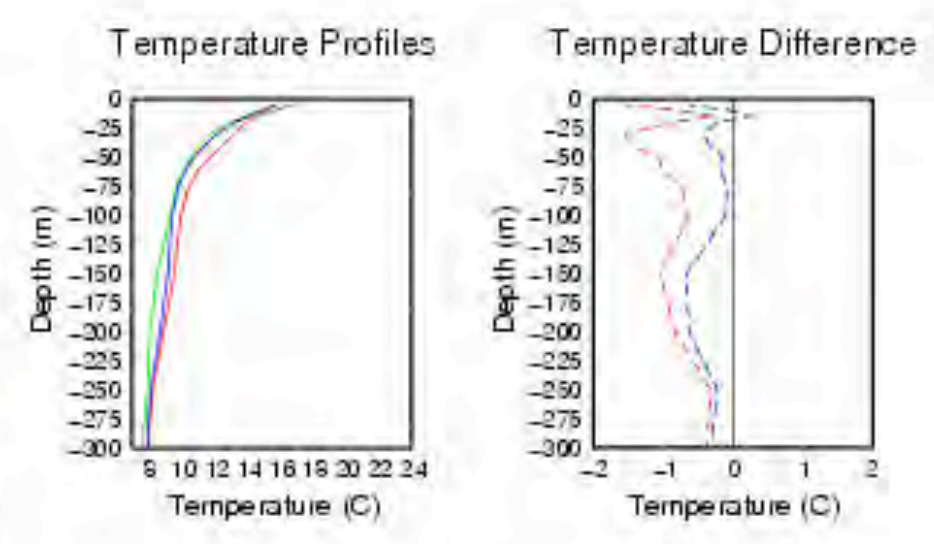
Need both 1-km and higher resolution SWOT data

Gliders to enable NRT Forecast

2/15 2/16 2/17 2/18

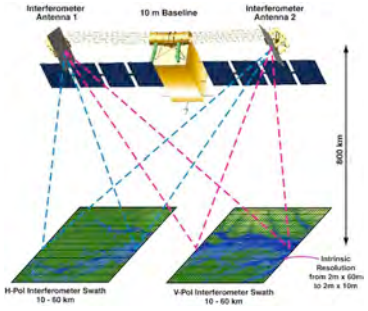




Observation vs. Model before & after data assimilation

NRT SWOT data for applications

Observations

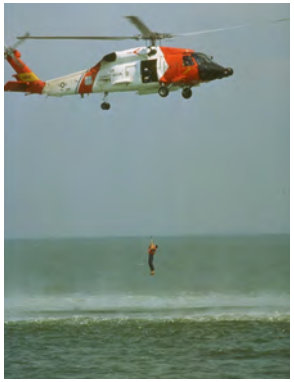


Data Assimilation

Models

Forecasting

Users



Synthesis Products

Feedback

Summary: Coastal Issues

- Coastal SSH & current: magnitude, time & space scales (time is the problem)
- Issues for coastal SSH corrections (similar to nadir ALT except tracking)
- SWOT data will be integrated with complementary measurements (both in situ and remote sensed) and assimilative models for reanalysis & process studies
- Synergy between oceanography and hydrology (rivers and estuaries – Columbia R., Chesapeake Bay, … role for USGS?)
- Dedicated data processing and distribution for coastal applications
  - ✓ Need both 1-km and higher resolution (~100-m) SWOT data
  - ✓ NRT data processing and distribution to enable operational forecasting and applications