

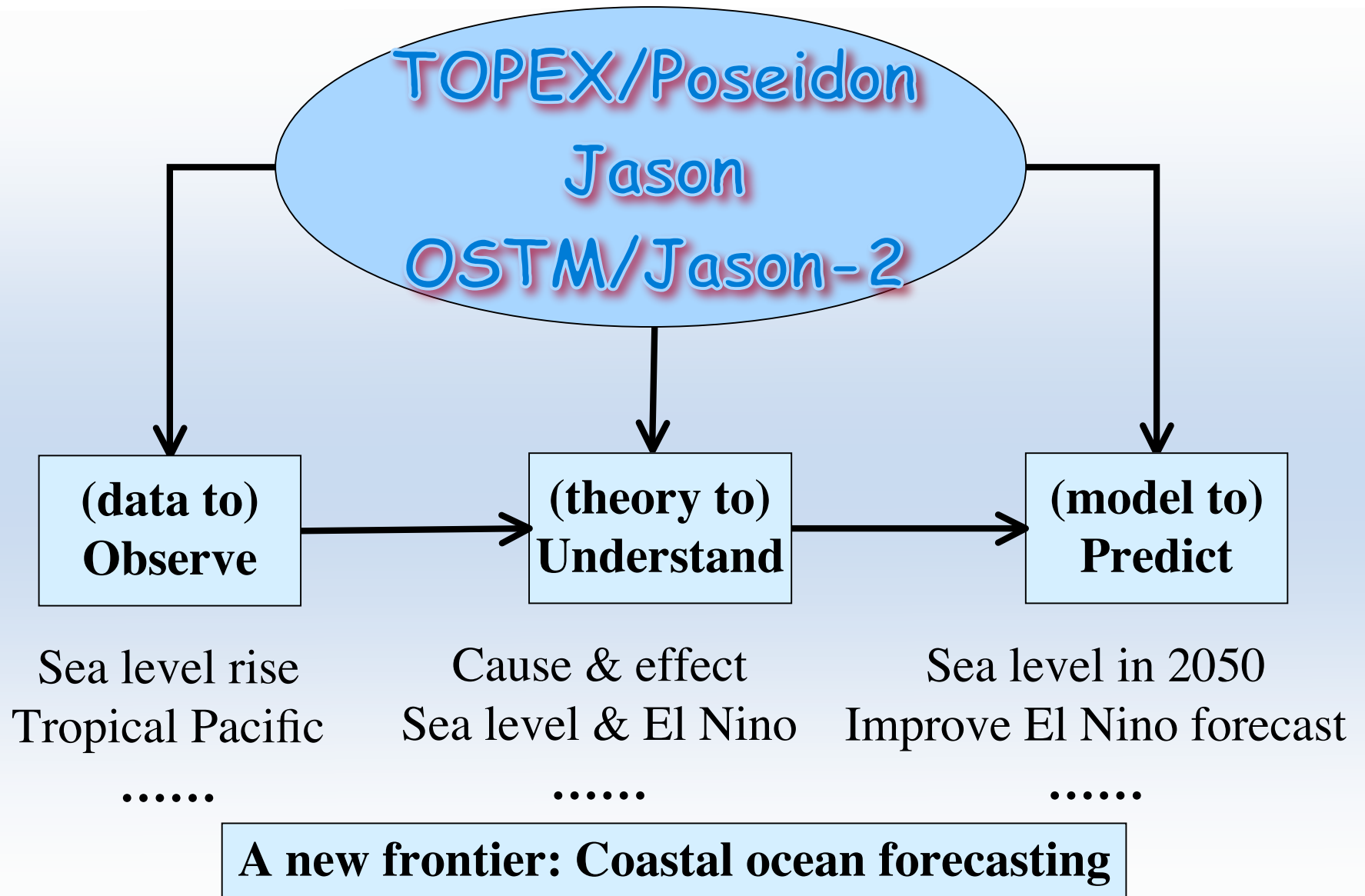
Coastal Ocean Modeling, Data Assimilation and Forecasting

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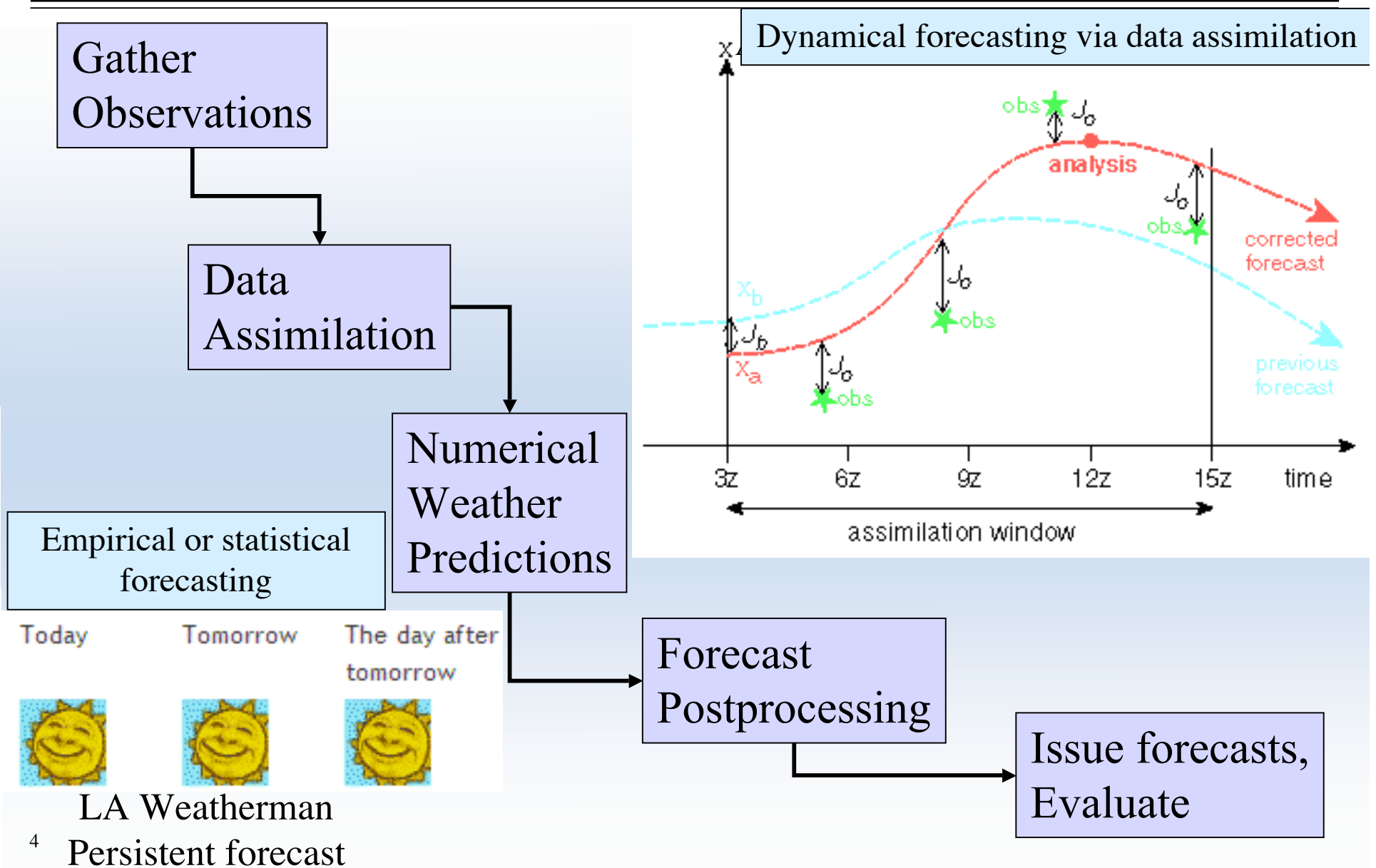
Satellite Altimetry to enable new Science and Applications



Why do we need to forecast the coastal ocean?

- Important
 - Public access: Over 50 percent of the American people live within 50 miles of the ocean
 - Resources: Ocean activities contribute ~\$100B and support ~2M jobs
 - Habitats: Over 75 percent of the commercially important fish species
- Needs to observe, understand and ultimately predict
 - The oceans drive weather and climate, so if we understand the oceans better, we should be able to better forecast weather/climate
 - Our nation's security, environment, and economy all depend on our ability to understand, monitor, manage, and adapt to changes in our oceans and Great Lakes
 - We know little about the oceans, yet they impact us everyday
 - Our planet is changing quickly in ways that will impact everyone, but exactly how remains unclear

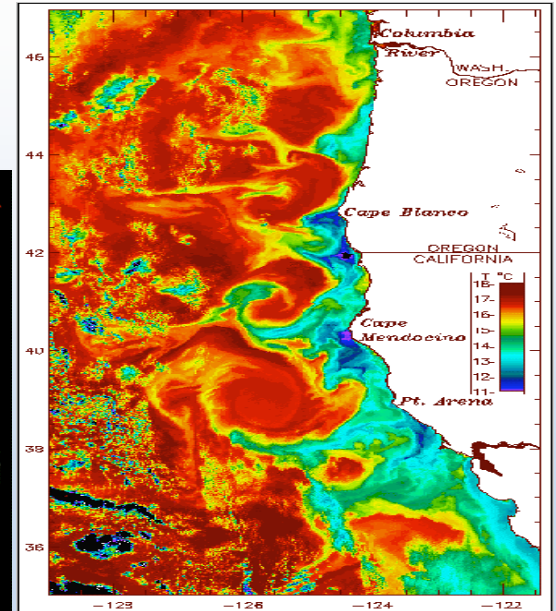
Coastal Ocean Forecasting is similar to Weather Forecasting, but.....unique and complex



Challenge I: Multi-Scale Coastal Ocean

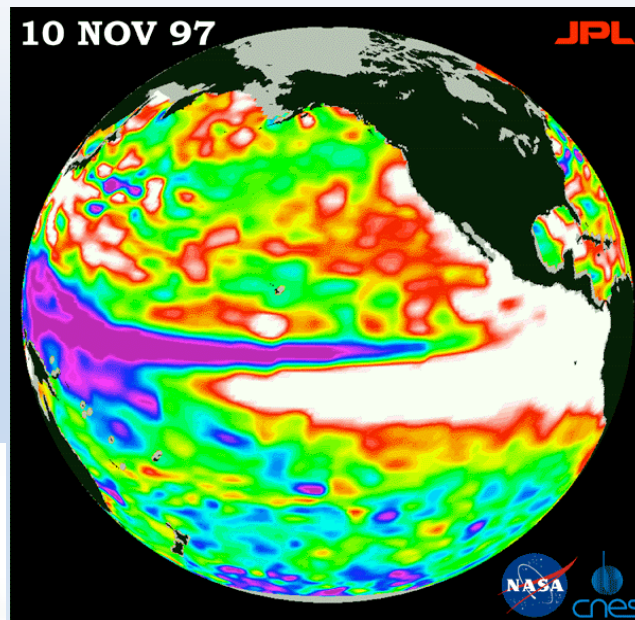
Coastal, regional to global scales

Eddies and Upwelling



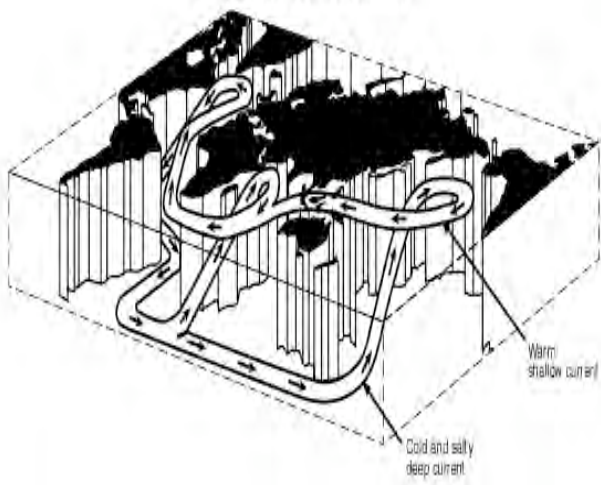
10 km; hours/days

Climate Variability: El Nino/La Nina Pacific Decadal Oscillation



100 km; years

Global Conveyor Belt & Climate Change

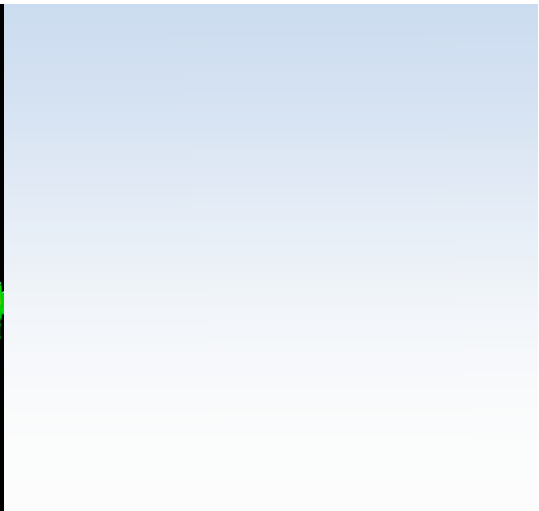
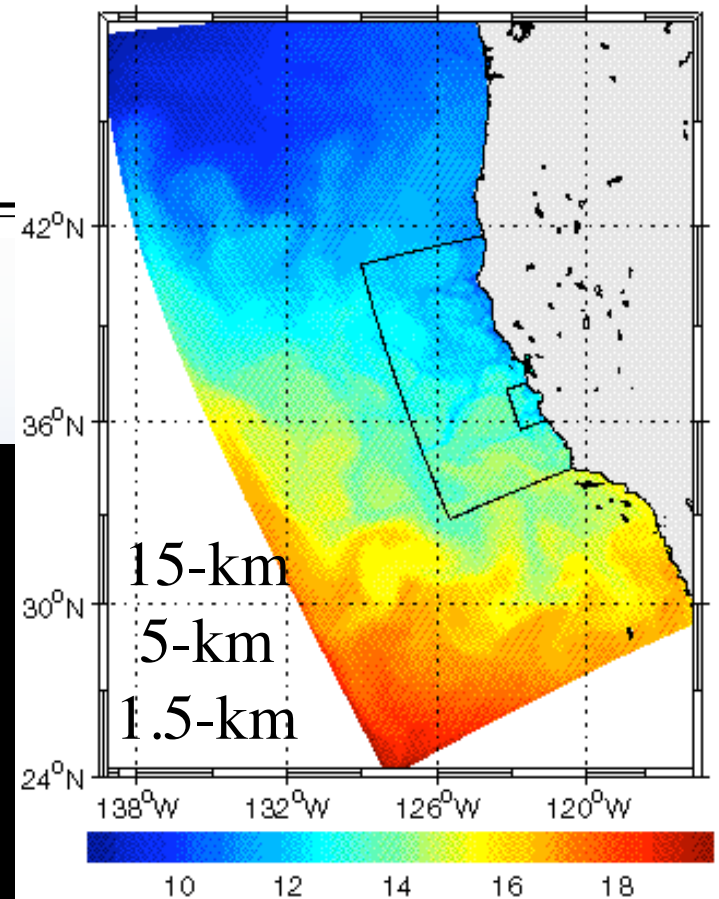
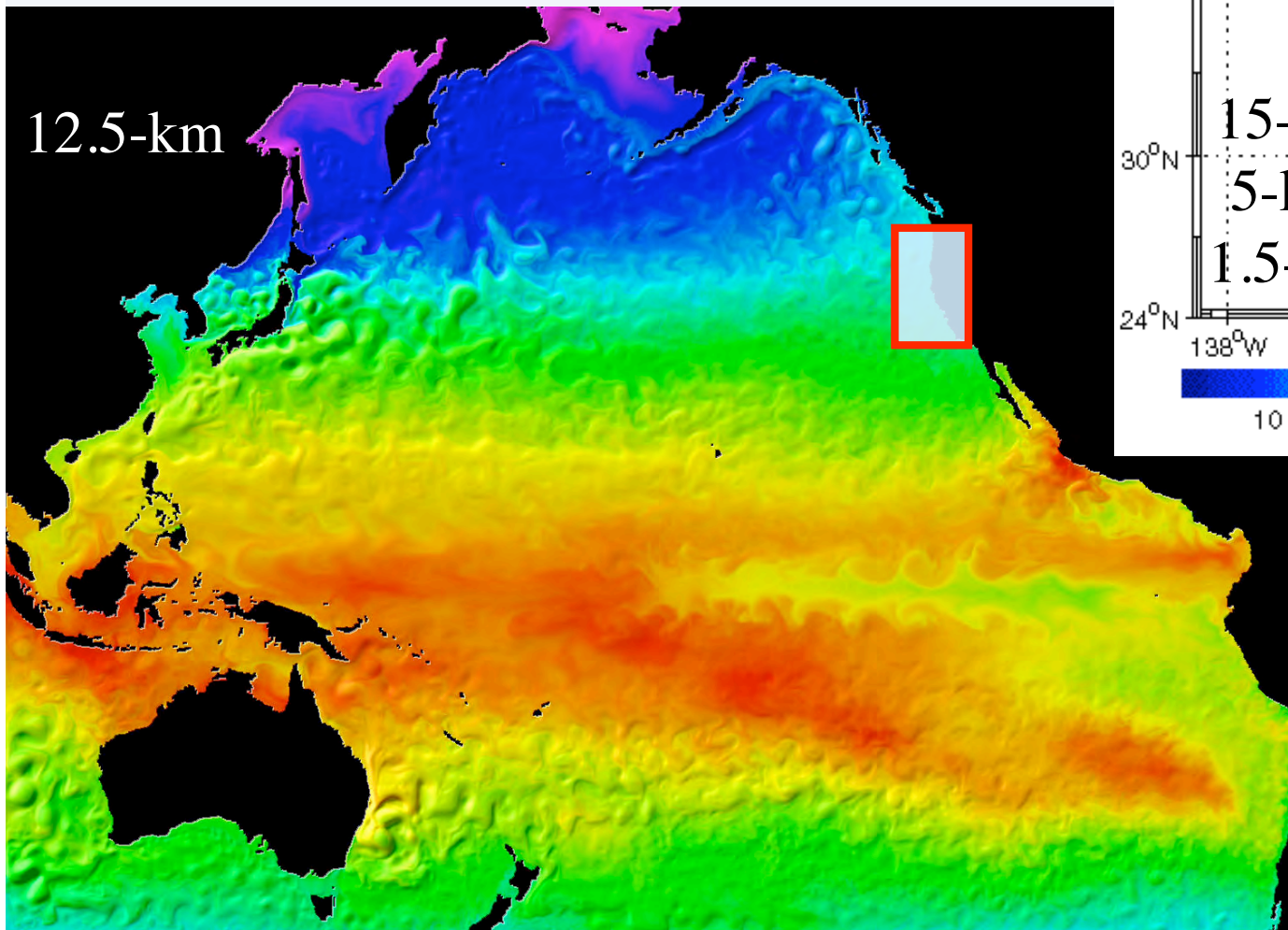


1000 km, decades

Two-Way Interactions

Regional Ocean Modeling System (ROMS)

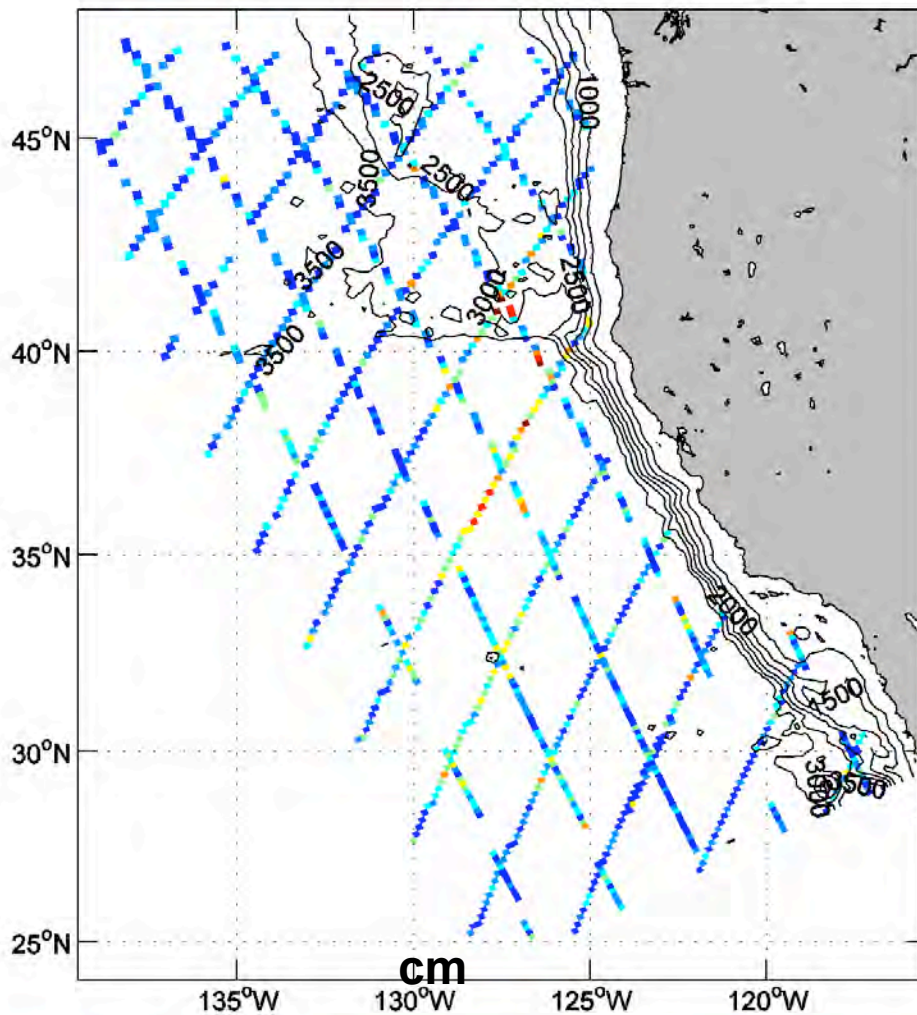
**Multi-scale modeling:
From climate to coastal eddies**



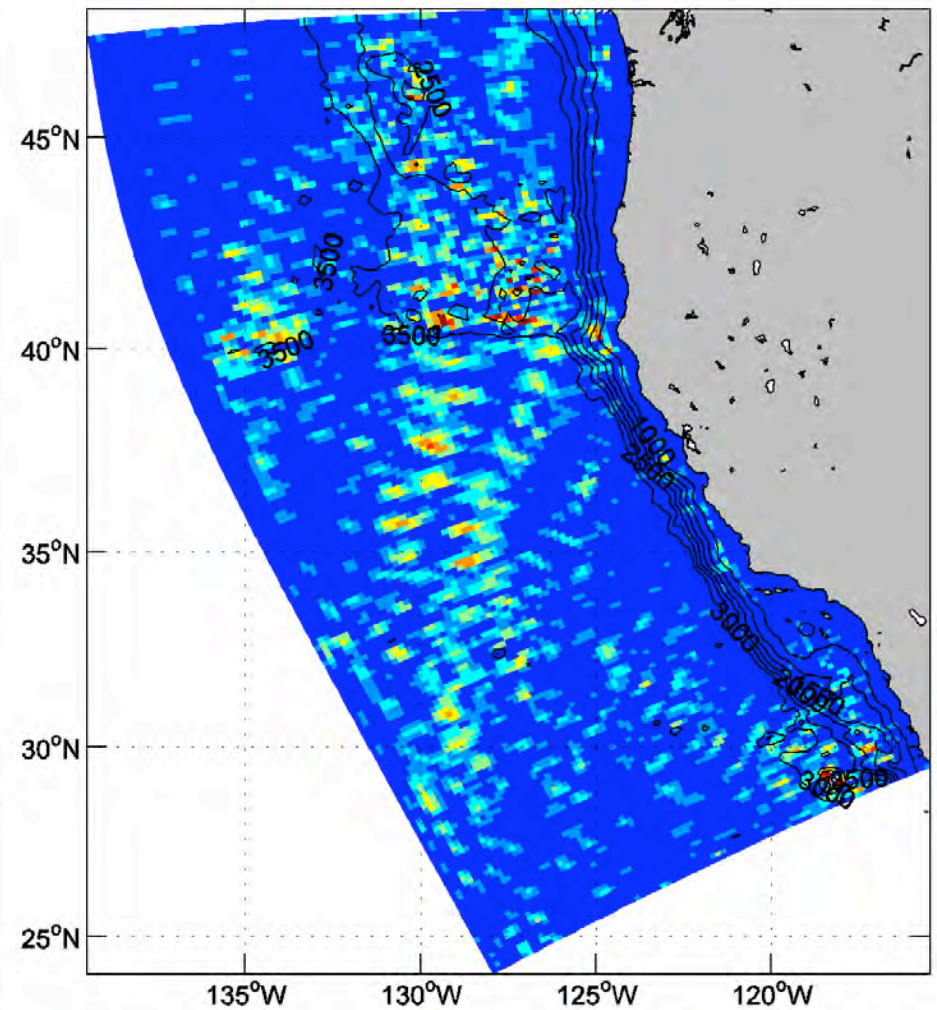
Challenge II: Lack of data in coastal zones

Baroclinic Tides (M2) Derived from Altimetry and ROMS

M2 Internal Tide Amplitude from T/P (cm)



M2 Internal Tide Amplitude from ROMS (cm)



Advanced Data Assimilation: 3DVAR to assimilate in situ and satellite measurements

$$x = \begin{pmatrix} \zeta \\ u \\ v \\ T \\ S \end{pmatrix} = \begin{pmatrix} x_\zeta \\ x_{uv} \\ x_{TS} \end{pmatrix} = \begin{pmatrix} x_\zeta^f + \Pi \delta x_{TS} + \delta x_{a\zeta} \\ x_{uv}^f + \Gamma \delta x_{TS} + \Phi_a \delta x_{a\psi\chi} \\ x_{TS}^f + \delta x_{TS} \end{pmatrix}$$

$$\delta x_{uv} = \Gamma \delta x_{TS} + \Phi_a \delta x_{a\psi\chi}$$

$$\delta x_{uv}^G = \Gamma \delta x_{TS} \quad \text{Geostrophic balance}$$

$$\delta x_\zeta = \Pi \delta x_{TS} + \delta x_{a\zeta}$$

$$\delta x_\zeta^S = \Pi \delta x_{TS} \quad \text{Vertical integral of the hydrostatic equation}$$

$$\delta x_{a\psi\chi} \quad \text{ageostrophic streamfunction and velocity potential}$$

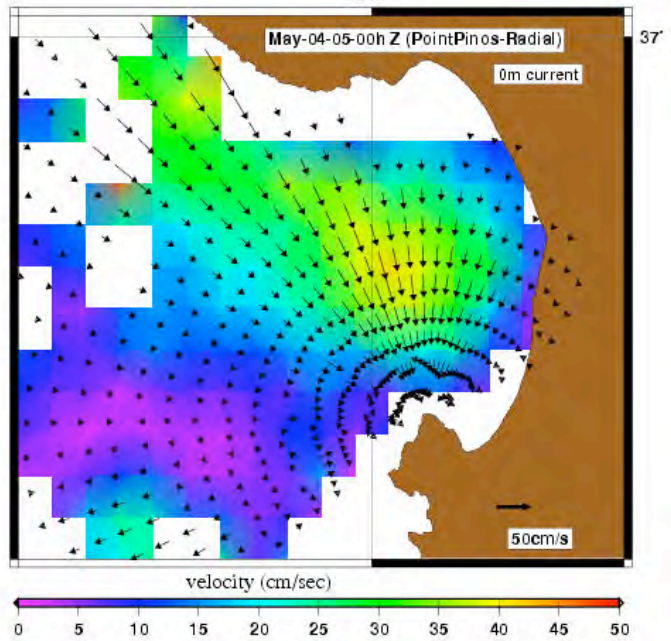
Five Control Variables:
 Temperature: δT
 Salinity: δS
 Non-steric SSH: $\delta X_{a\zeta}$
 Ageostrophic streamfunction: $\delta X_{a\psi}$
 Ageostrophic velocity potential: $\delta X_{a\chi}$

(Li and Chao et al., JGR, 2008)

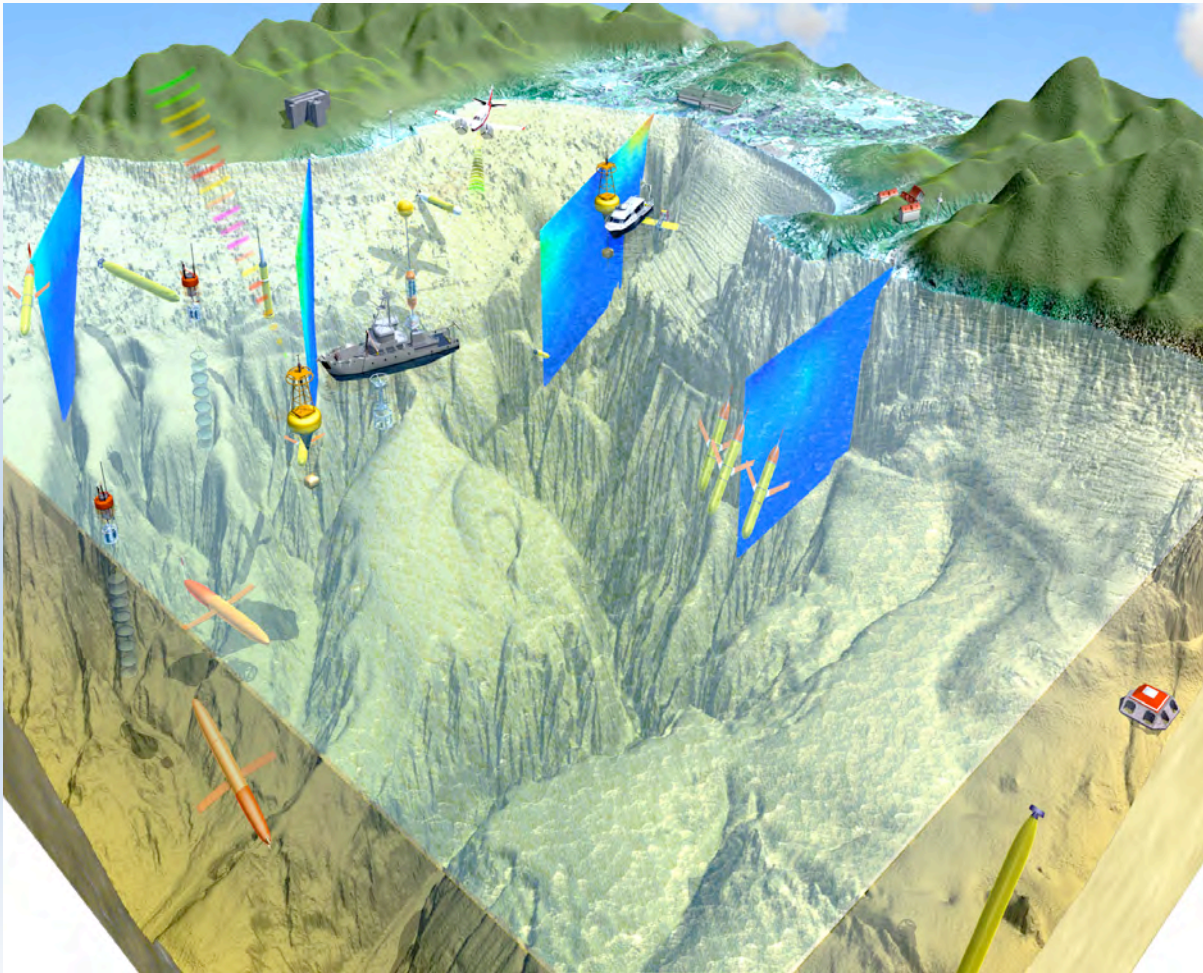
California Coastal Ocean Example (<http://www.cocmp.org>)



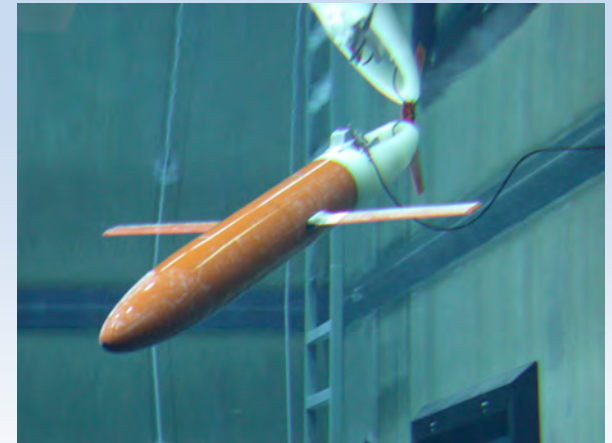
The SeaSonde® HF Radar Receive Antenna



Emerging Autonomous Underwater Vehicle (AUV) glider technology to observe the 3D Ocean

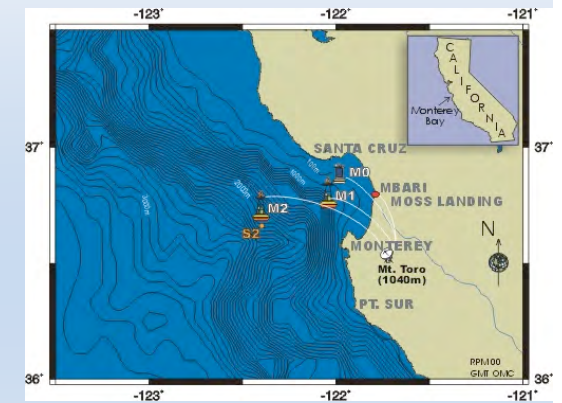
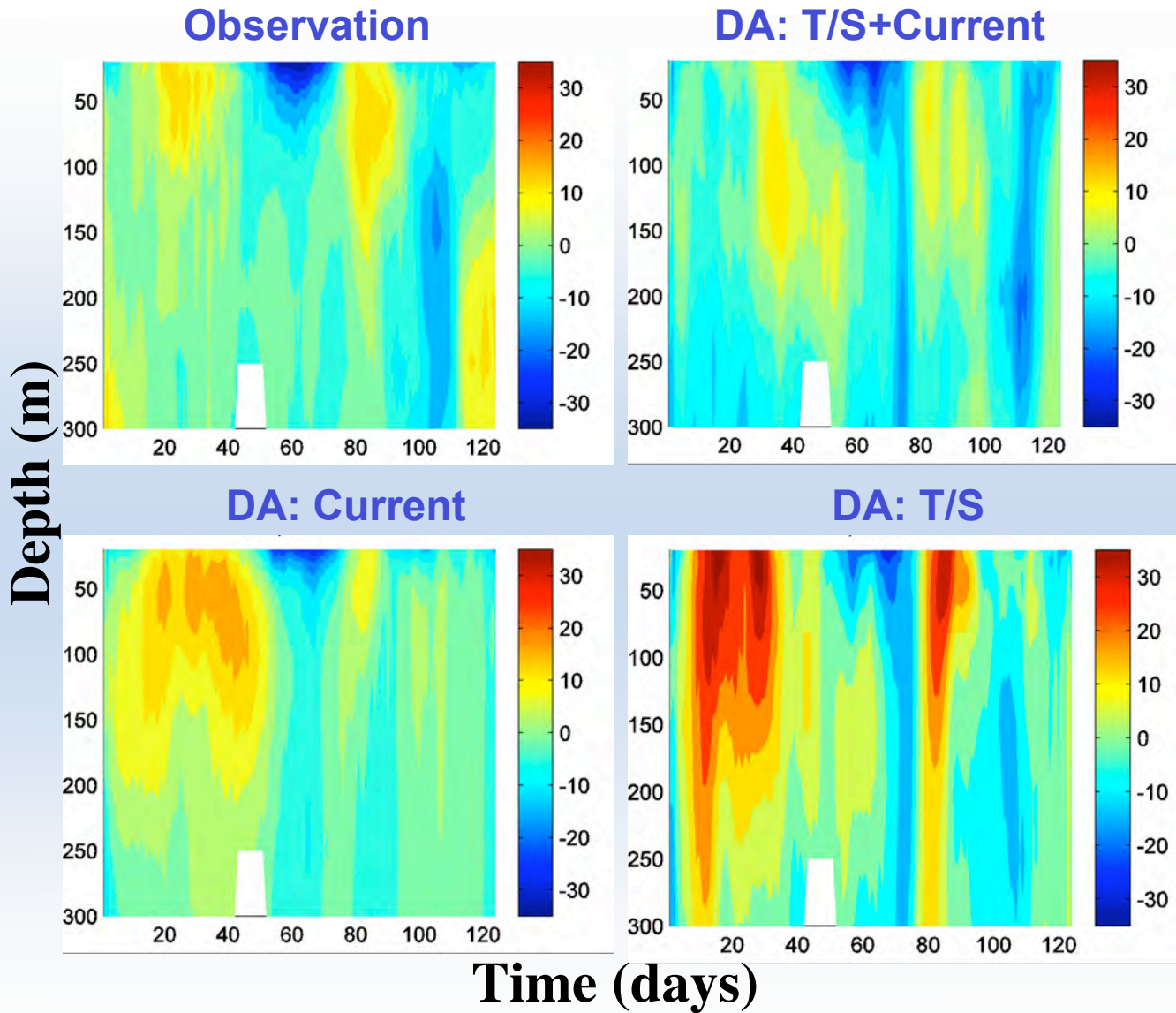


0-200 m Slocums



0-700 m Sprays

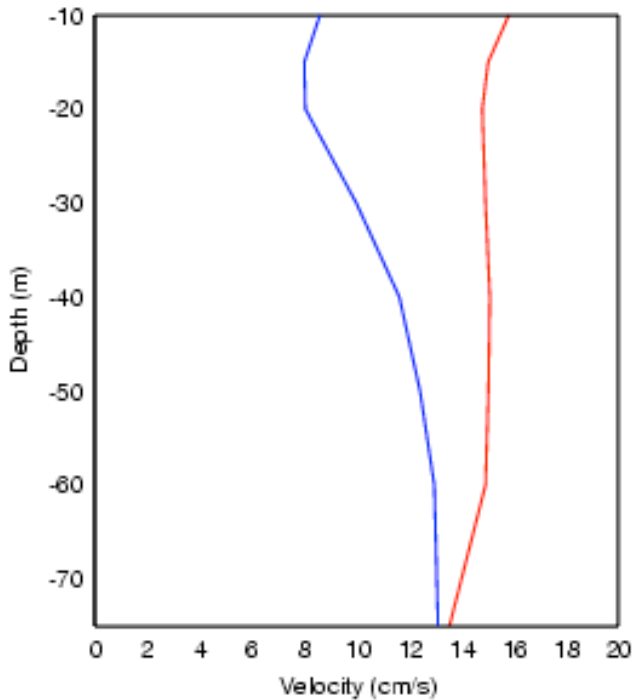
Impact of Ocean Current Assimilation: Independent data validation



Impact of Surface Current Data Assimilation on Nowcast

RMS

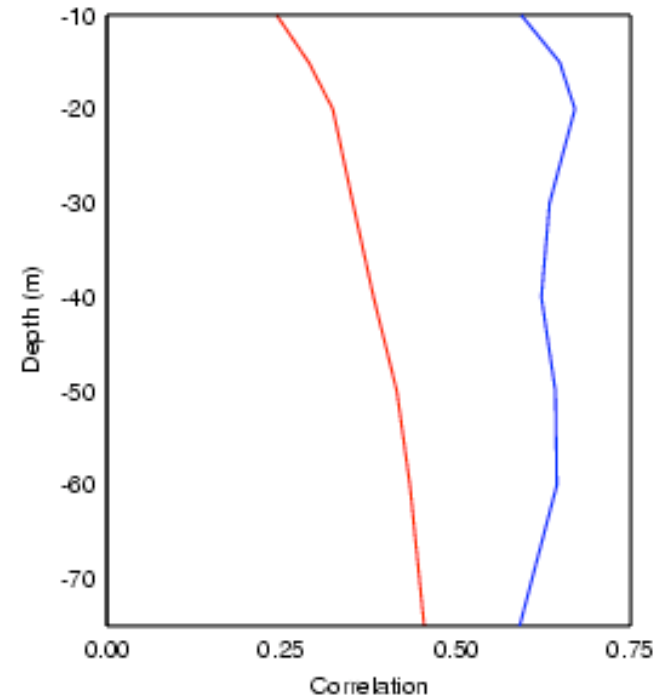
HF (Blue), Analysis (Red) RMS Errors in ADCP2 Zonal Velocity Aug 2006



ROMS w/o
sfc currents

Correlation

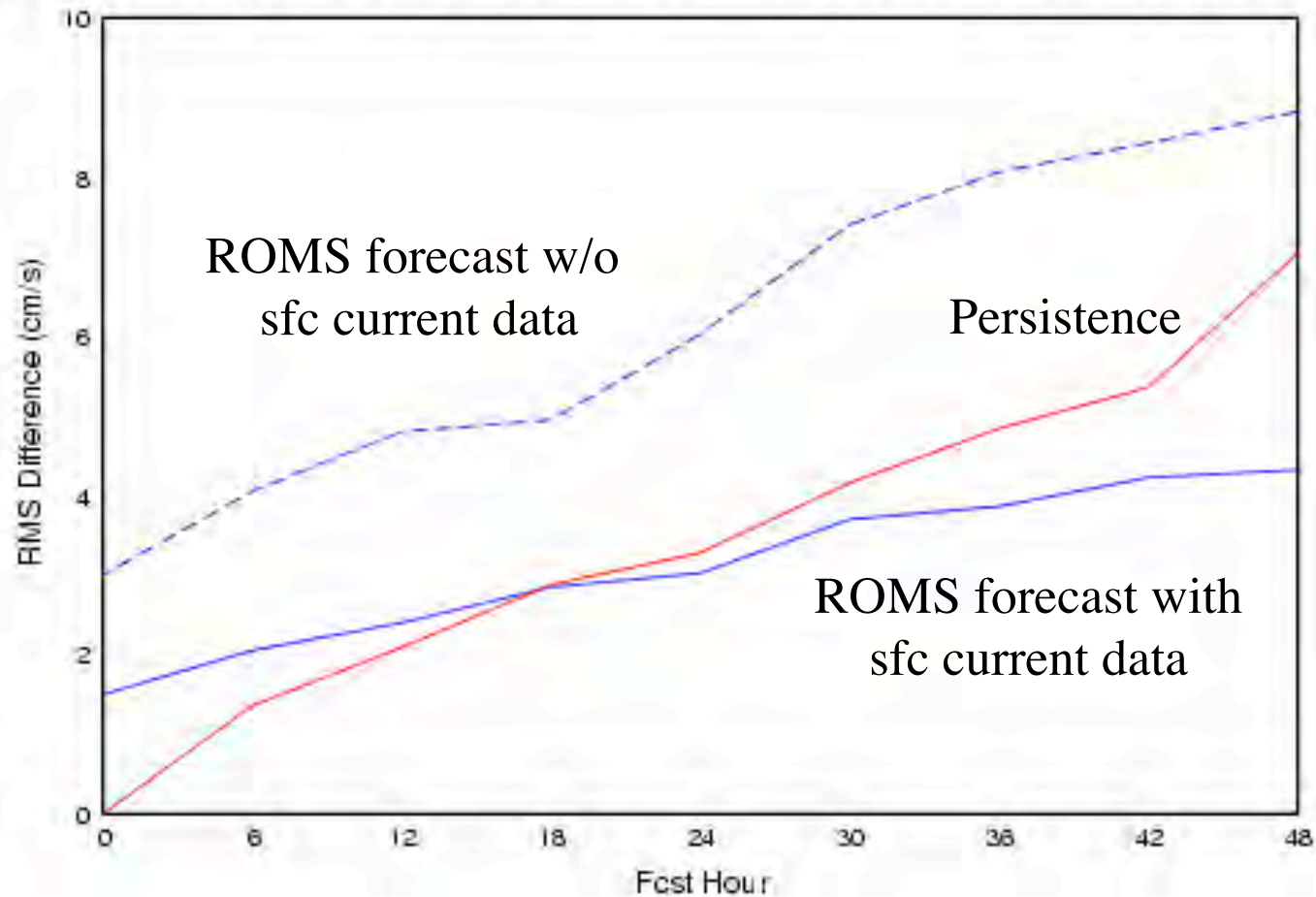
HF (Blue), Analysis (Red) Correlation with ADCP2 Zonal Velocity Aug 2006



ROMS with
sfc currents

Impact of Surface Current Data Assimilation on Forecast

RMS Difference of ROMS HF Fcst/No HF Fcst (Blue/Blue Dashed) and Persistence (Red) for ADCP2 Depth-Averaged V



Real-Time Modeling, Data Assimilation and Forecasting

<http://ocean.jpl.nasa.gov/SCB>

View Nowcast and Forecast

June 2008

Su	M	T	W	Th	F	S
01	02	03	04	05	06	07
08	09	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

ROMS Nowcast

- Temperature
- Salinity
- Current
- Sea Surface Height

Assimilated Data

- HF Radar
- SIO Glider
- AVHRR SST
- SHIP SST

MM5

- Wind

ROMS vs. Data

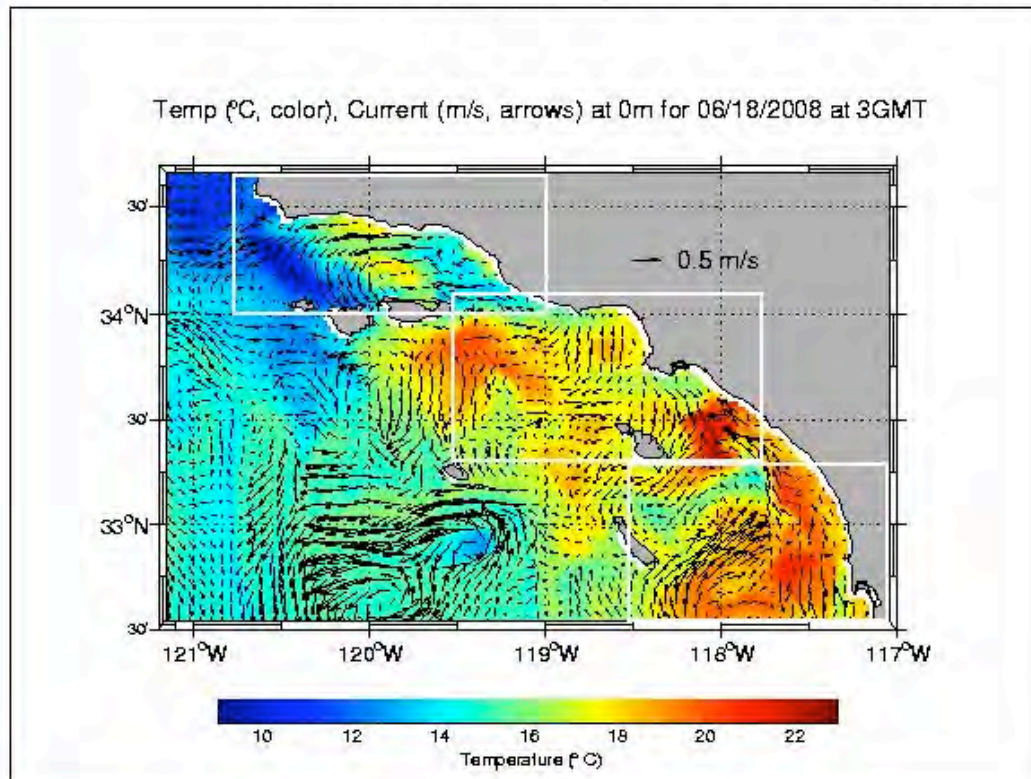
- Tide Gauge
- HF data and ROMS data

Temperature Nowcast

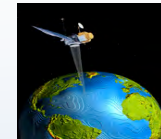
The Southern California Bight (SCB) ocean forecasting system is based on the Regional Ocean Modeling System (ROMS). The ROMS configuration ... [more](#)

File Name	File Size	Download	View
<input checked="" type="checkbox"/> scb_das_2008061803.nc	9090756	http	Header LAS Image
scb_das_2008061809.nc	9090756	http	Header LAS Image
scb_das_2008061815.nc	9090756	http	Header LAS Image

Click inside the white boxes in the images below to zoom in on sub-regions of the domain



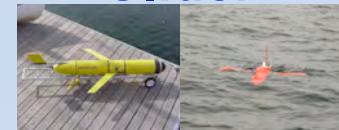
Satellites



Aircraft



Glider



In-situ



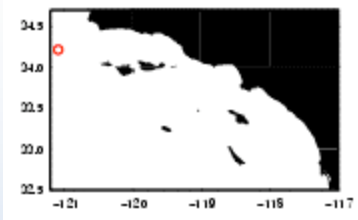
HF Radar



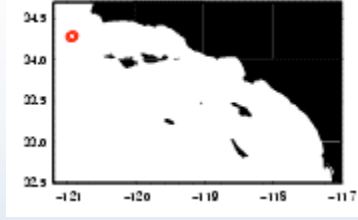
AUV glider is used for data assimilation and verification

<http://ourocean.jpl.nasa.gov/SCB>

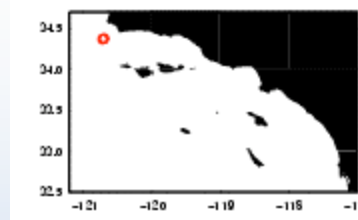
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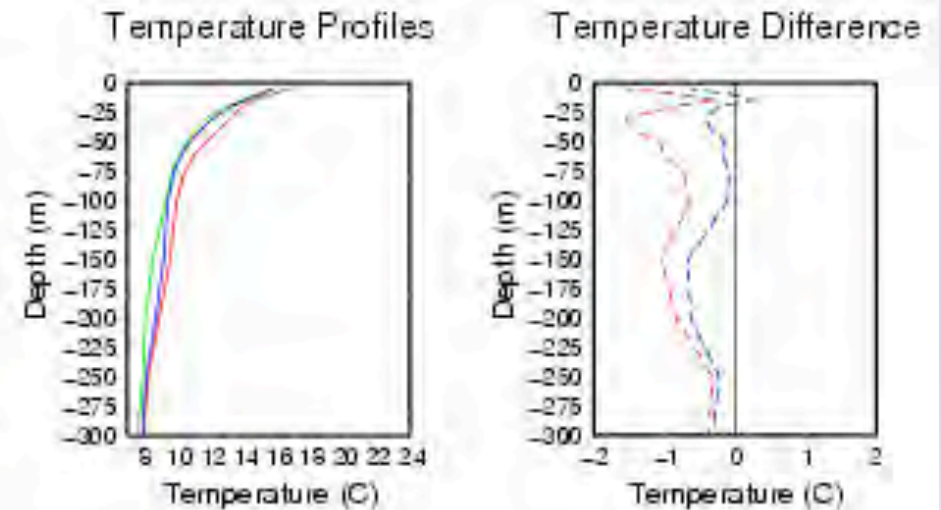
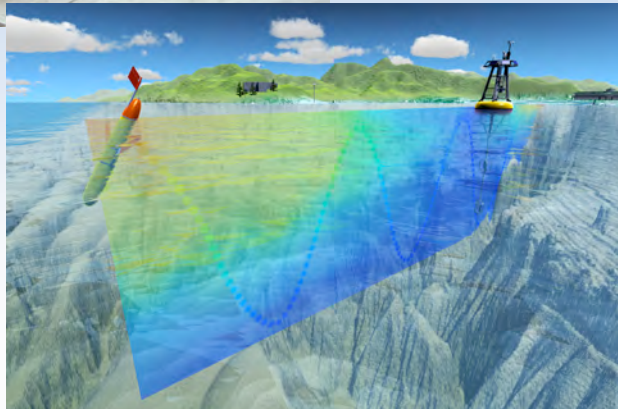
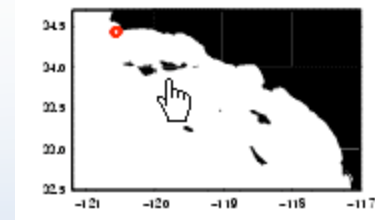
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2/17



2/18



Obs, before & after DA

Coastal Ocean Forecast Customers (and growing) within Southern California

- Beach goers, surfers
- Sailing, fishing, boating
- Divers
- Marine professionals



NORTH SAN DIEGO



MORRO BAY



ORANGE COUNTY



SAN DIEGO

Next Generation Altimetry Satellite (SWOT) to enable future ocean forecasting any where & any time to serve broader application users

