• A new approach to blend measurements from multiple sensors and platforms (*in situ* and satellite)
  – SST
  – Wind

• Numerical modeling to enable forecast
  – Current state-of-the-art in ocean modeling: from global climate to coastal upwelling and eddies
  – Data assimilation: Enable forecasting
    • Models to fill in the data gaps
    • Data to reduce the model uncertainties
    • Forecast uncertainty as important as forecast itself

• Concluding remarks
Motivation and Approach for SST Blending

\[ J = \frac{1}{2} (T - T_b)^T B^{-1} (T - T_b) + \frac{1}{2} \sum_{s=1}^{S} (H_s T - T_s)^T R_s^{-1} (H_s T - T_s) \]

Input: \( T_b \) (1st guess), \( B \) (1st guess error), \( T_s \) (Obs), \( R_s \) (Obs error), \( s=1,S \) (number of sensors/platforms)

Problem: Min(J), what is T? (Chao et al., GRL, 2003)

Output: T (blended SST; essentially a weighted average)

Unique features: multiple measurements with different resolutions; weighted by data errors; uncertainty estimate for the blended SST
Demonstration of the Blended SST Product during August 2003

COAMPS WIND STRESS AT M2

M2 (122.378° W, 36.697° N)
A Real-Time Wind Demo for Monterey Bay
(http://cimt.jpl.nasa.gov)

Unique features:
• In situ & Model
• Real-time monitoring
• Validation of models
• Forecast (2-day)
Ocean has multiple scales in both time and space: From Global Conveyor Belt to El Nino, PDO & Coastal Ocean.

- **10-km; hours/days**
- **100-km; years**
- **1000-km, decades**
Eddy-Resolving Ocean Modeling at 12.5-km

Columbia Computer (NASA Advanced Computer System) SGI Altix 10,000+ processors ranked #4 the fastest supercomputer on Earth
“Remote” Forcing: El Nino’s influence on the California Current System
Pacific Decadal Oscillation (PDO)’s Impact on California Coastal Ocean Circulation & Fishery

(Chao et al., GRL, 2001)

Climatic Effects on Columbia River Chinook

Pacific Northwest Index and abundance of Columbia River upriver bright spring Chinook track each other. Salmon and the PNI are 5-year running averages.
NCEP SST EOF 1 Roms

SST EOF 1 Roms

EOF1 comparison between NCEP and ROMS above 20N

NCEP (28.1456%)

ROMS (20.1677%)
What is the resolution requirement for coastal models?

(R. Davis, SIO)
Multi-scale (or “nested”) ROMS modeling approach is developed in order to simulate the 3D ocean at the spatial scale (e.g., 1-km) required to resolve coastal upwelling and eddies.
Integrating Data with Models (or Data Assimilation) for Retrospective Analysis or Real-Time Nowcast/Forecast

3-dimensional variational (3DVAR) method:

\[ J = 0.5 \, (x-x^f)^T \, B^{-1} \, (x-x^f) + 0.5 \, (h \, x-y)^T \, R^{-1} \, (h \, x-y) \]

\[ X^a = x^f + \delta x^f \]

y: observation  
x: model

12-hour forecast  
3-day forecast

Initial condition  
6-hour assimilation cycle

Aug.1 00Z  
Aug.1 06Z  
Aug.1 12Z  
Aug.1 18Z  
Aug.2 00Z  
Time
Can we deliver observational data and model predictions in real-time?
Are the model nowcast and forecast any good?
How to sustain such an integrated system?
Model Skill Assessments

Observed M1 Temperature Aug 2003

Reanalysis M1 Temperature Aug 2003

Observed M1 Salinity Aug 2003

Reanalysis M1 Salinity Aug 2003

OBS

ROMS
Three Level Nested Prince William Sound ROMS Model
SST shaded Relieved with SSH

9-km

3-km

1-km

Level 0

Level 1

Level 2
• Concept proposed in 1920s, but the major breakthrough was not made until late 1950s when the first electronic computer was used for weather forecast

• Very short-range forecasts (0–12 hour)
  – Considerable skill and utility, especially for predictions of the evolution and movement of large- and medium-sized weather systems

• Short-range forecasts (12–72 hour)
  – Forecasts of how much precipitation will fall in the 36-60-hour time frame are now more accurate than 12-36-hour predictions were during the late 1970s.

• Medium-range forecasts (3–7 days into the future)
  – Skillful day 7 forecasts will be possible in the future given the steady improvements in computer models, observational approaches, and forecast strategies.

• Extended-range forecasts (week 2)
  – The predictability of the day-to-day weather for periods beyond day 7 is usually small. Statistical forecast of the mean conditions for the 8-14-day period might be possible.

• Monthly and seasonal forecasts
  – No verifiable skill exists or is likely to exist for forecasting day-to-day weather changes beyond two weeks: “butterfly” effect (or chaos) rules.