Estimating Satellite Product Uncertainty using In Situ Data

1) Define a VIIRS Proxy Data Stream

2) Define the required in situ data stream for Cal/Val

3) Tuning of algorithms and LUTS (Vicarious calibration and SDR feedback)

4) Ocean Algorithm, stability evaluation and uncertainty

5) Product validation and product long-term stability

6) Satellite inter-comparisons, robustness, seasonal and product stability

Presenter/Affiliation: C. Trees & A. Alvarez, NURC

Performers: Violeta Sanjuan Calzado and Giuliana Pennucci

Thrust area: 5) Product Validation;

Award date: Dec 1, 2009

Total Man-Months Effort:

FY09	FY10	FY11
1.0	12.0	12.0

Estimating Satellite Product Uncertainty using In Situ Data

Project Objectives

1. **Ship cruise data (SST and Ocean Color) matchups with satellite imagery (Ligurian Sea)**
2. **Develop software for determining covariance fields from SST & ocean color data.**
3. **Determine optimal in situ sampling strategy to provide the best field estimation at some predetermined uncertainty level.**

Milestones / Deliverables

		FY 09 1 2 3 4	FY10 1 2 3 4	FY11 1 2 3 4
1.	Cruises (Ligurian Sea) Select sites & match-ups	C S	C R C	C R C
2.	Review and test optimization techniques		S S	C
3.	Use VIIRS proxy to estimated product retrieval uncertainties		S	C
4.	Develop tool for best placement in situ data			S C

Major FY09 Challenges/Issues

None - Only 6 months into the contract

Major Progress

- ✓ **Matchups**
- ✓ **Covariance maps using automated GUI**
- ✓ **CalVal Cruises in the Ligurian**

Estimating Satellite Product Uncertainty using In Situ Data

Collaboration and Coordination with Inside and Outside Activities

INSIDE:

R. Arnone, G. Fargion, C. Trees, Ondrusek, R. Stumpf

OUTSIDE:

ONR – Code 32 Optical Program (Ackleson)

NASA: AERONET Zibordi

Transition Partners

Leveraged RDT&E Projects

6.1 ONR – OPERA modeling funding (S. Harper)

NURC SPOW 2010 and 2011 Cruises Optics profiling and a fleet of optical equipped gliders.

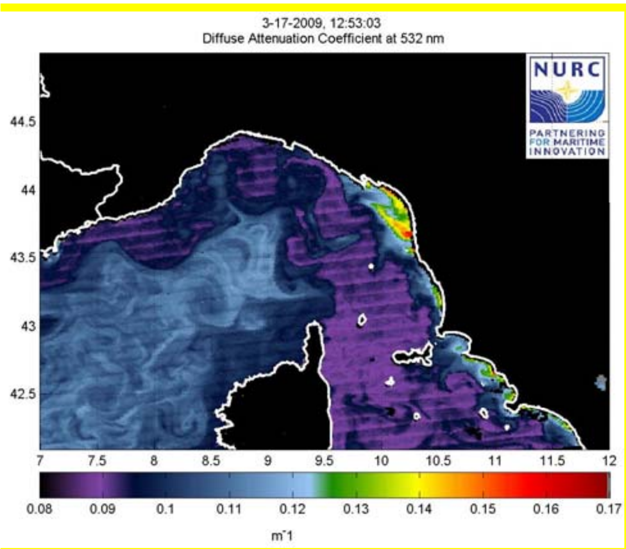
International Partnerships

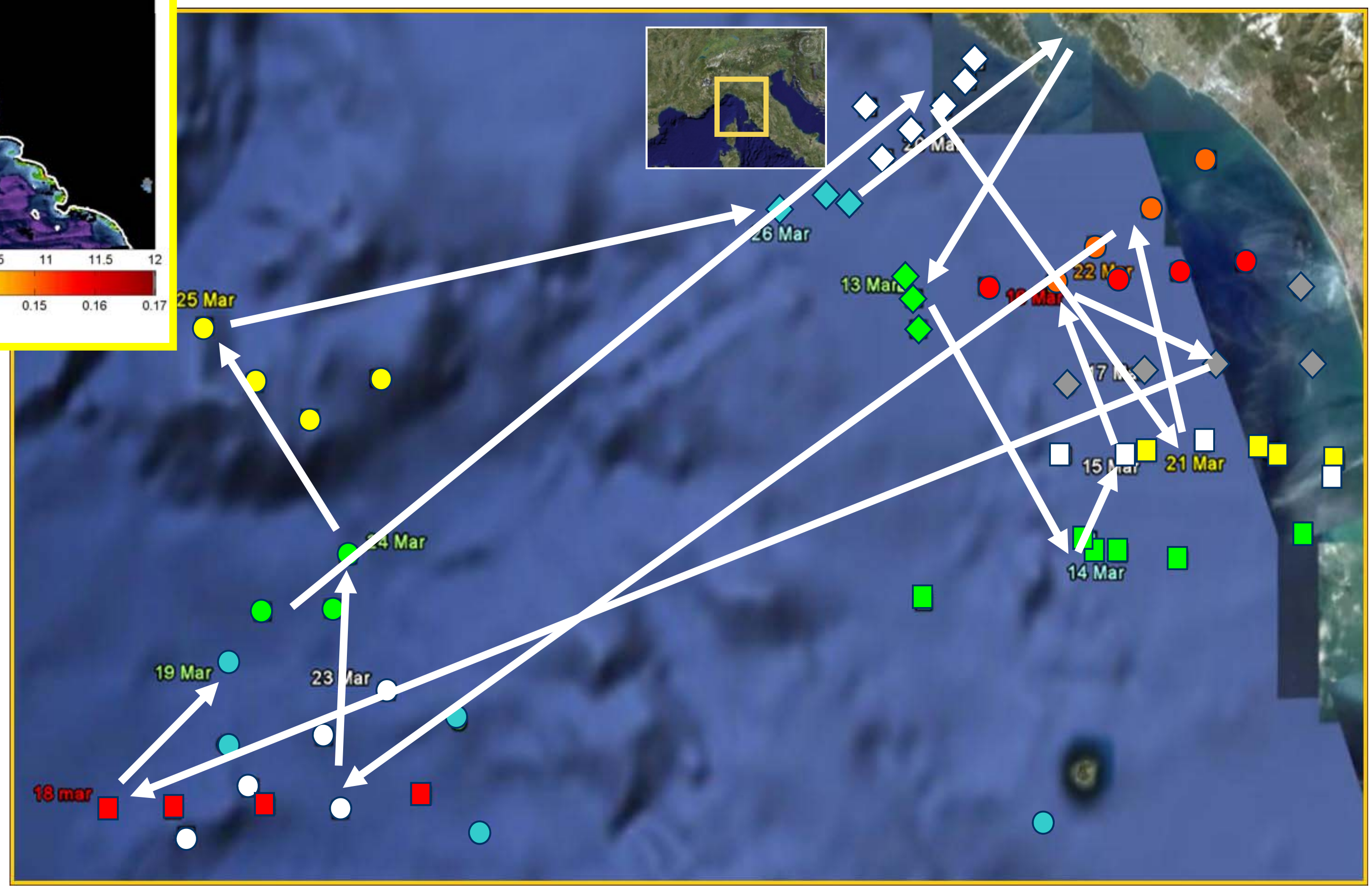
JRC – (G. Zibordi)

Un Strathyclde – (D. McKee)

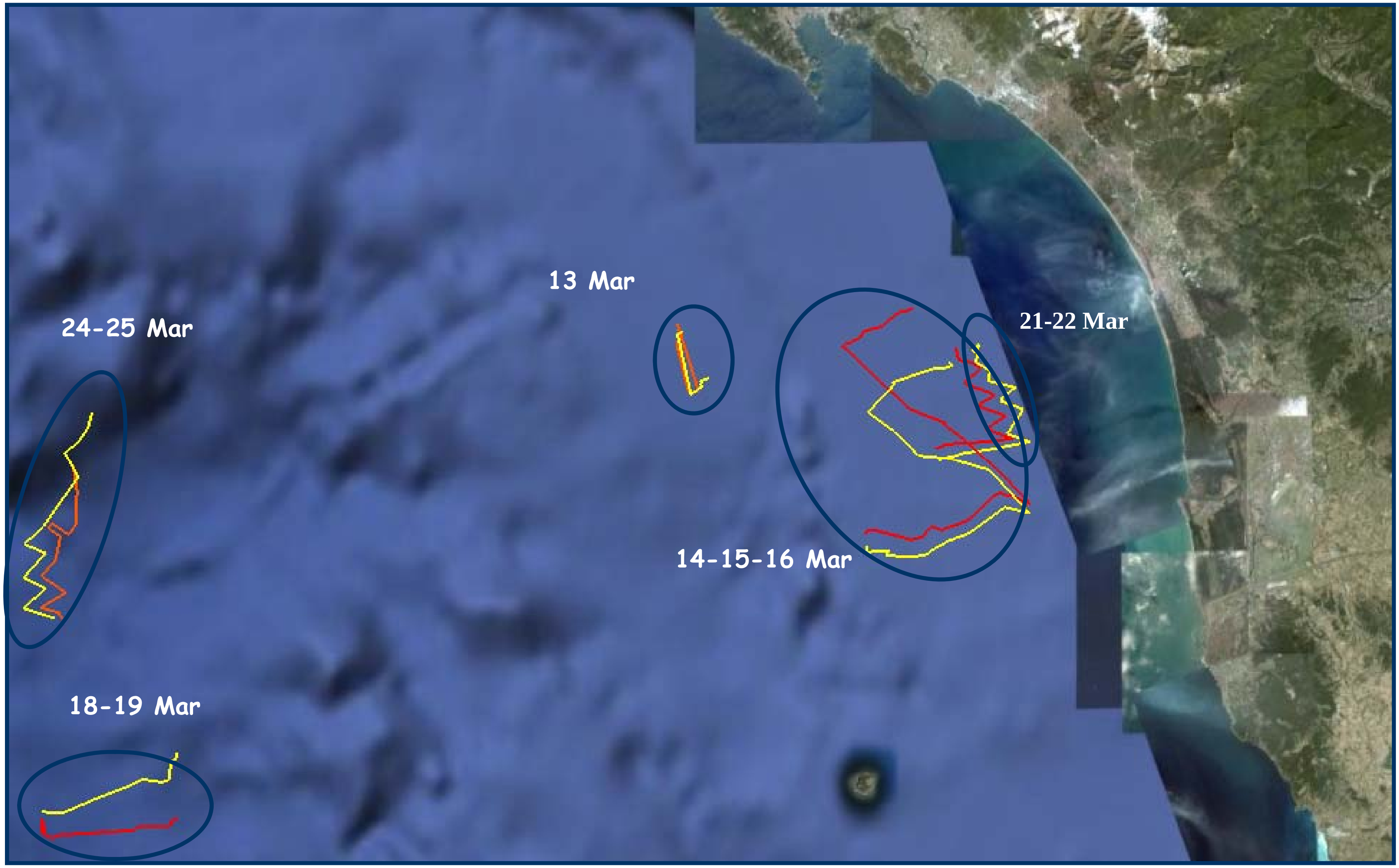
WetLABS – (M. Twardowski)

BP09 Stations (Mar 09)





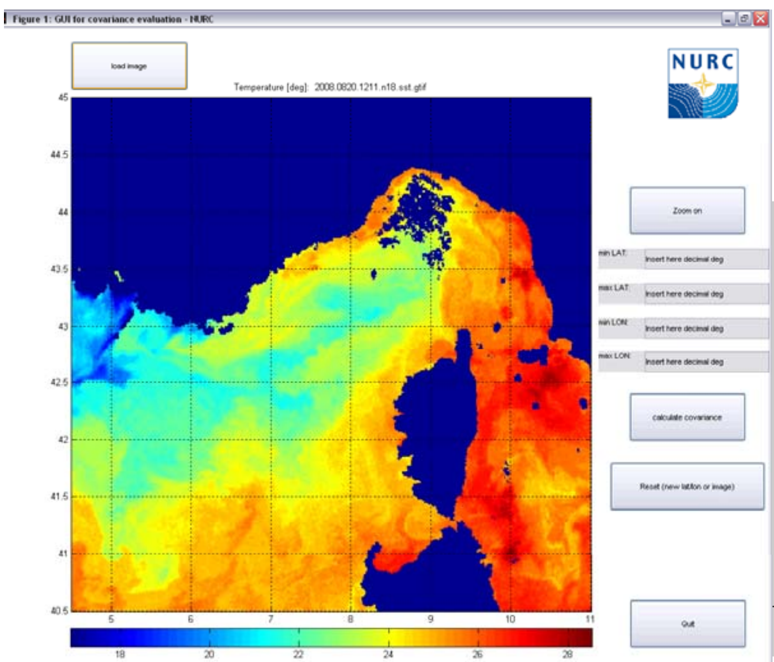
Glider Tracks BP09

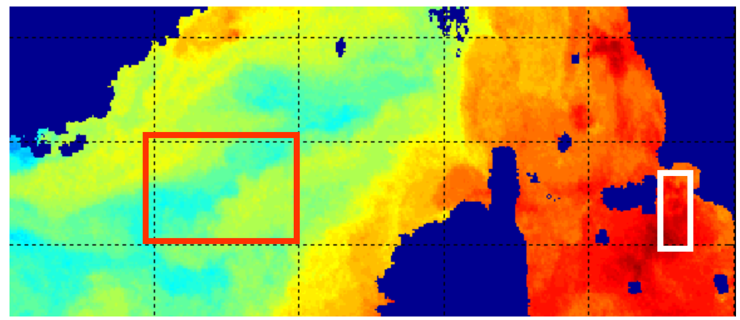


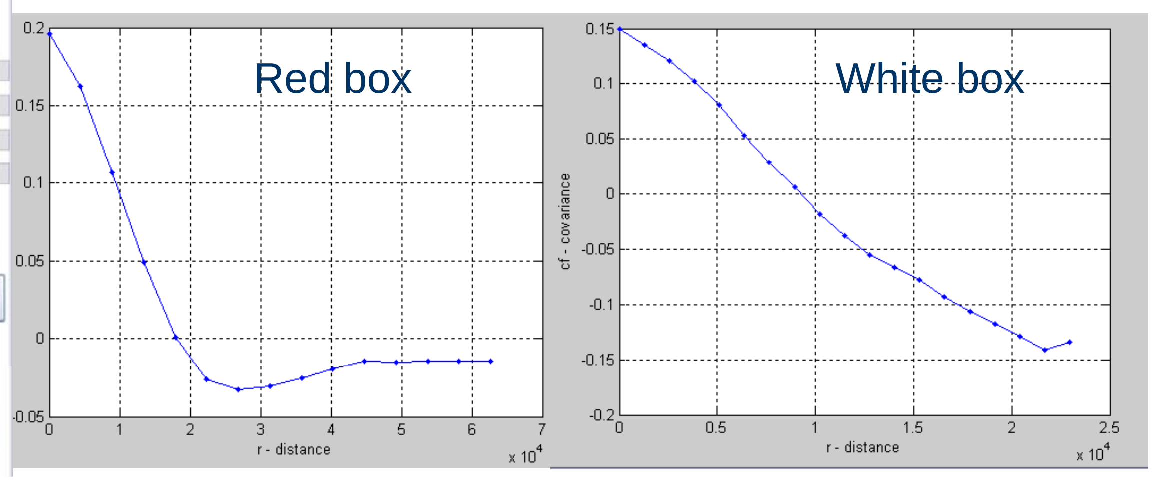
Estimating Satellite Product Uncertainty using In Situ Data

Milestone 1. Develop software (version 1) for automatically computing SST and ocean color covariance from MODIS imagery

A Graphical user Interface-GUI has been developed to provide a user friendly tool to facilitate data analysis. It incorporates a special module to deal with high resolution data.







Estimating Satellite Product Uncertainty using In Situ Data

Milestone 2. Define the variability in the estimated covariance fields of SST and Ocean color imagery between daily satellite acquisitions at the same geographical location

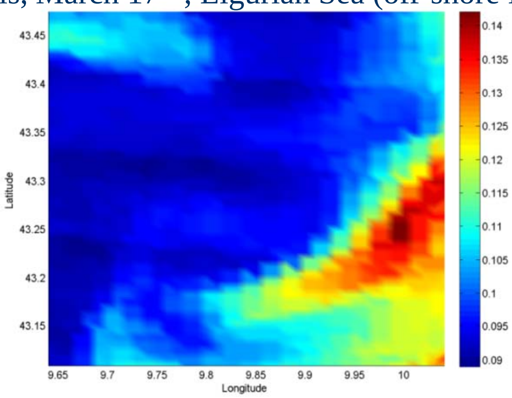
Pending of algorithmic development in milestone 3

Estimating Satellite Product Uncertainty using In Situ Data

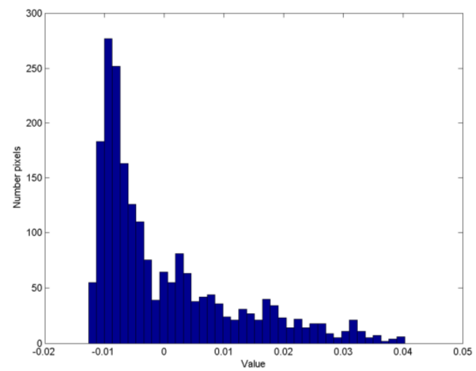
Milestone 3. Test optimization engines for highlighting optimal placement of trajectories for observational platforms (gliders, moorings etc)

3.1 Algorithm for estimating intrinsic spatial variability a satellite observed field

Modis, March 17th , Ligurian Sea (off-shore Livorno)



K 532



Histogram of pixel values

A method has been developed to get the best decomposition of the observed field $\psi(\vec{x})$ into a spatially varying mean $\overline{\psi}(\vec{x})$ and a gaussian noise $\varepsilon(\vec{x})$. The approach is based on an anisotropic diffusion operator:

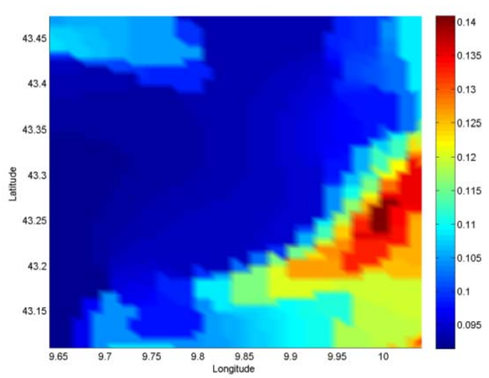
$$\psi(\vec{x},t)=\psi(\vec{x},0)+\int_0^t \nabla\bullet\left(e^{-\left(\frac{\|\nabla\psi\|}{K}\right)^2}\nabla\psi\right)dt$$

The operator preserves front structures. The integration time t and constant K are obtained from an optimization process that looks for a residual field with kurtosis =3, skewness=0 and mean=0 (Gaussian)

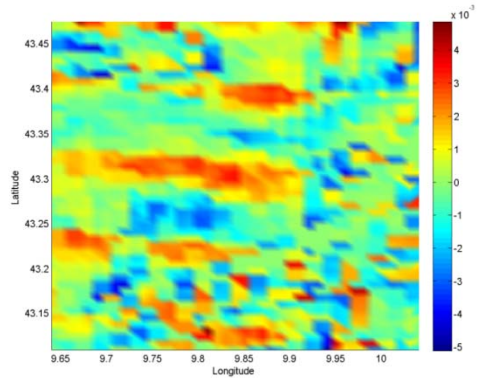
Estimating Satellite Product Uncertainty using In Situ Data

Milestone 3. Test optimization engines for highlighting optimal placement of trajectories for observational platforms (gliders, moorings etc)

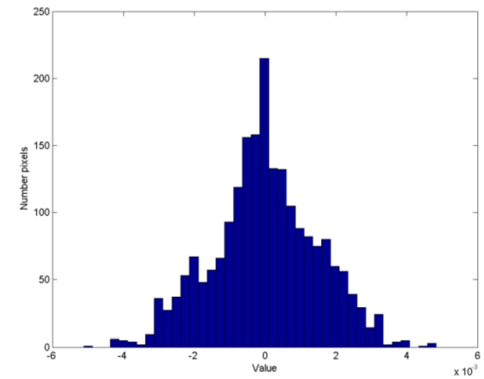
3.1 Algorithm for estimating intrinsic spatial variability a satellite observed field



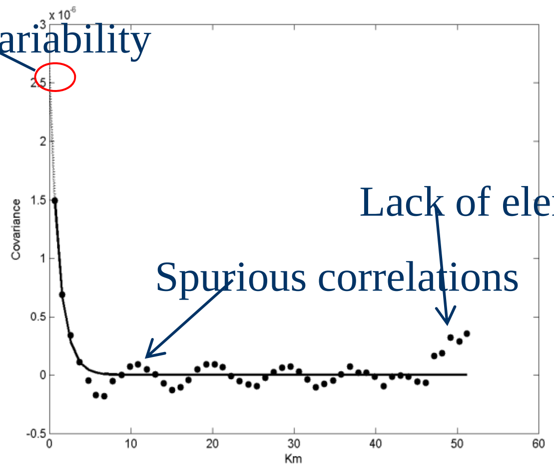
Spatially varying mean



Residual field



Histogram residual field



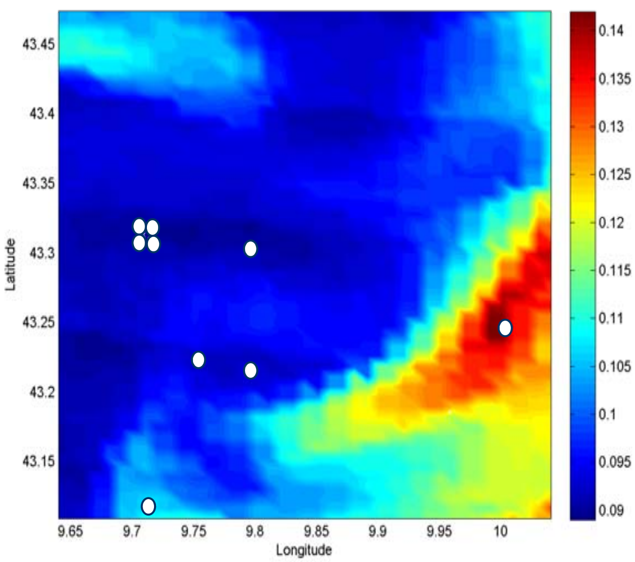
$$C_{\varepsilon}\left(\left\|\vec{x}-\vec{x}'\right\|\right) = 2.6\,10^{-6} e^{-\frac{\left\|\vec{x}-\vec{x}'\right\|}{1200}}$$

Estimating Satellite Product Uncertainty using In Situ Data

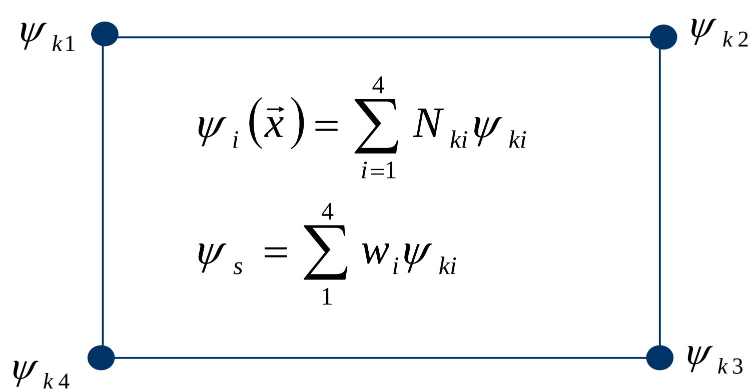
Milestone 3. Test optimization engines for highlighting optimal placement of trajectories for observational platforms (gliders, moorings etc)

3.2 Algorithm for fusing satellite and in situ observations

$$P(\psi|\psi_s,\psi_i) \propto \underbrace{e^{-\sum\frac{(\psi_s-\psi)^2}{\sigma_s^2}-\sum\frac{(\psi_i-\psi)^2}{\sigma_i^2}}}_{P(\psi_s,\psi_i|\psi)} \times \underbrace{e^{-\sum\sum(\psi-\overline{\psi})C_\varepsilon^{-1}(\psi-\overline{\psi})}}_{P(\psi)}$$



Observations



$$\psi_i(\vec{x}) = \sum_{i=1}^{4} N_{ki}\psi_{ki}$$

$$\psi_s = \sum_{1}^{4} w_i\psi_{ki}$$

Pixel description in a finite element framework

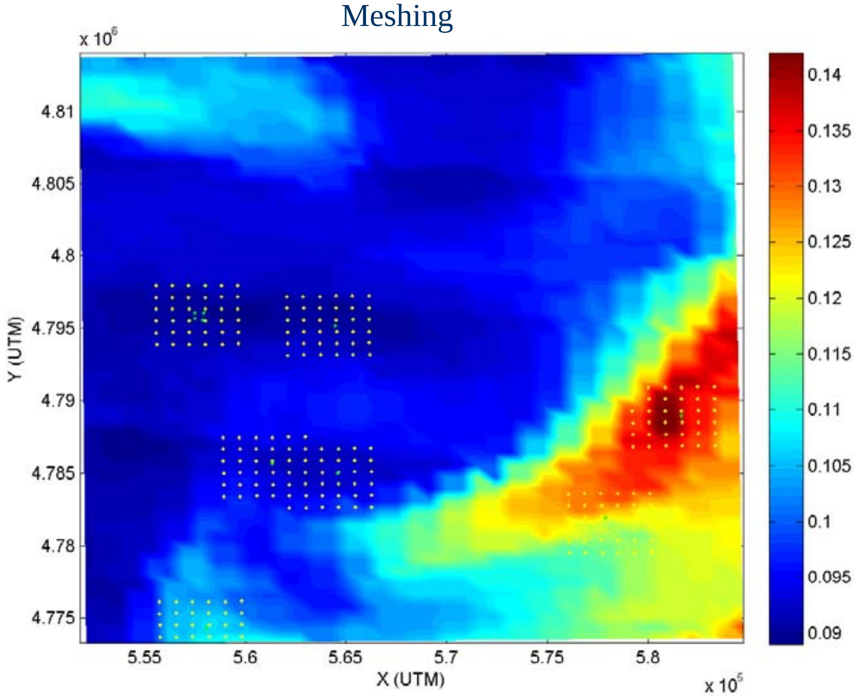
Estimating Satellite Product Uncertainty using In Situ Data

Milestone 3. Test optimization engines for highlighting optimal placement of trajectories for observational platforms (gliders, moorings etc)

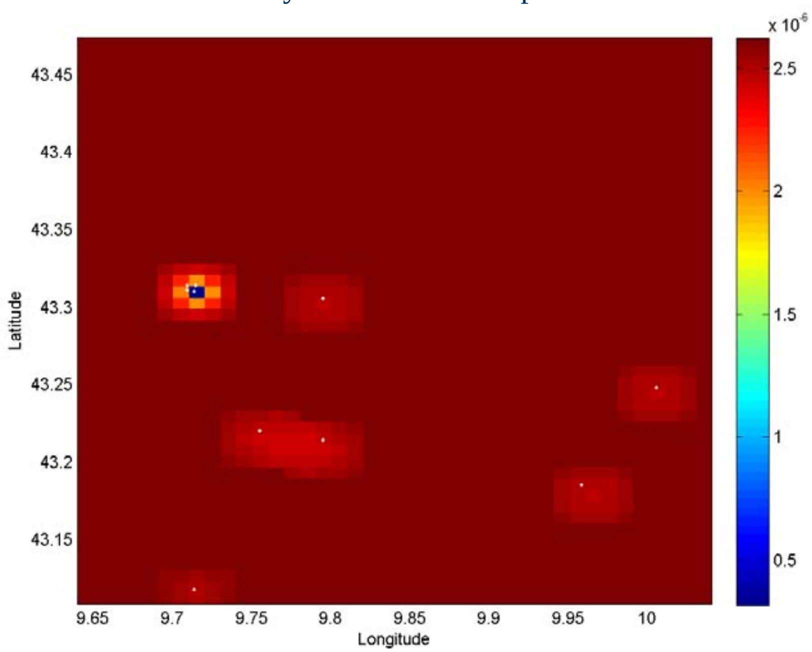
3.2 Algorithm for fusing satellite and in situ observations

$$P(\psi_k) \propto e^{-(\psi_{obs} - H\psi_k)^T \Sigma_{obs}^{-1} (\psi_{obs} - H\psi_k) - (W\psi_k - \overline{\psi})^T C_\varepsilon^{-1} (W\psi_k - \overline{\psi})}$$

Meshing



Uncertainty of the estimated product

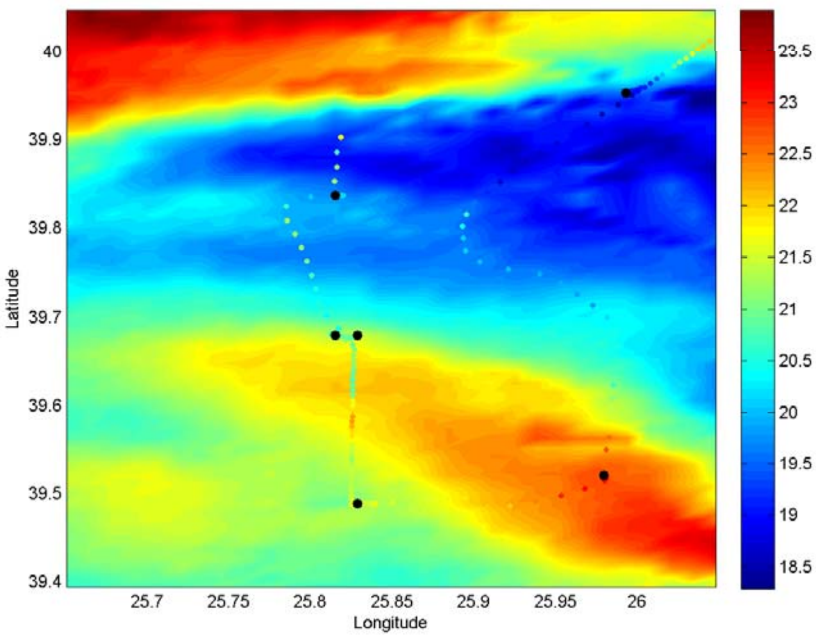


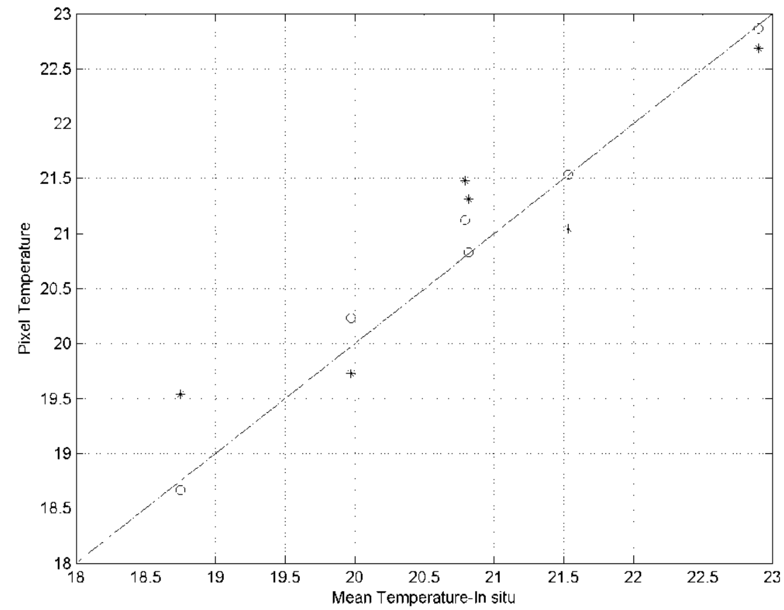
Estimating Satellite Product Uncertainty using In Situ Data

Milestone 3. Test optimization engines for highlighting optimal placement of trajectories for observational platforms (gliders, moorings etc)

3.3 Algorithm initial validation

TSS08, August 28th Marmaran Sea





Satellite SST and surface temperature samples

Estimating Satellite Product Uncertainty using In Situ Data

FY 10 - MILESTONES **(Deliverables)** **Plans**

- ***Milestone 1.*** Version 2 of the software for satellite image analysis and covariance computation. Started
- ***Milestone 2.*** Application of Version 2 to daily satellite data to analyze time variability in the spatial covariance in different geographical locations. Not Started.
- ***Milestone 3.*** Ending the theoretical and computational approach for data fusion. Validation of the procedure with sea trials (ODAS buoy and gliders). Coupling with optimizing engines (already developed). Encoding into portable and operational format. Started.

Estimating Satellite Product Uncertainty using In Situ Data

Status and Issues:

- Deliverable: 1. Assemble a time series of Ocean Color and SST satellite product from several regions

  Completed

Estimating Satellite Product Uncertainty using In Situ Data

Status and Issues:

- Deliverable: 2. Develop software for automatically computing SST and color covariance for MODIS imagery (Version 2)
  1. June 2010
  2. Development status: 60% completed
  3. Major technical issues and their impacts:

  Recognition of different data formats – improve portability

  Adequate geographic projection-extend present UTM projection

  Robustness- Must be robust to a wide range of cases

  Possible introduction of anisotropy in the covariance structure.

Estimating Satellite Product Uncertainty using In Situ Data

Status and Issues:

- Deliverable: 3. Determine the variability in the estimated covariance fields of SST and ocean color imagery between daily satellite acquisitions at the same geographical location at specific Aeronet/Sea Prism, ship and MOBY sites
  1. Not started
  2. Starting in June
  3. Major technical issues and their impacts:

  Adequacy of the isotropic model- incorporation of anisotropic covariances

  Time scale- daily, weekly, monthly

Estimating Satellite Product Uncertainty using In Situ Data

Status and Issues:

- Deliverable: 4. Test and evaluate several optimization engines (Genetic algorithms, simulated annealing, etc) for optimal placement of in situ observational resources
  1. June 2010
  2. Development status: 90% completed
  3. Major technical issues and their impacts:

  Vectorization of cost functions- Reduce optimization time

  Appropriate initialization-Finding the global minimum