



# ***Optimum mission planning for a network of gliders***

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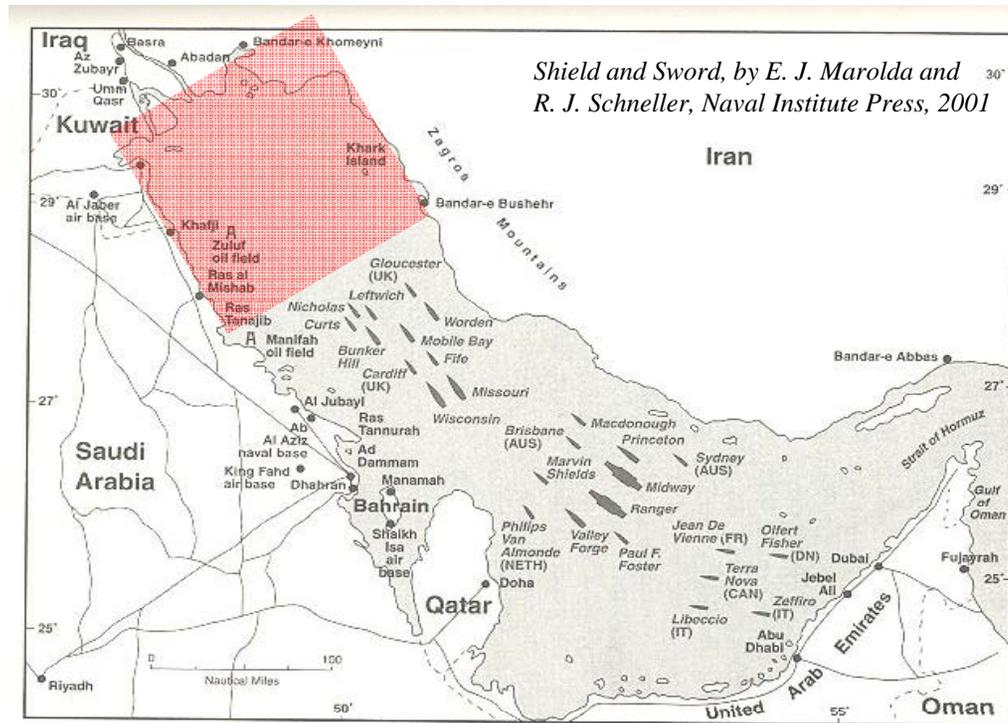
# Outline



- Introduction
- Glider Mission Planner
- Performance in REP10
- Conclusions



# Introduction

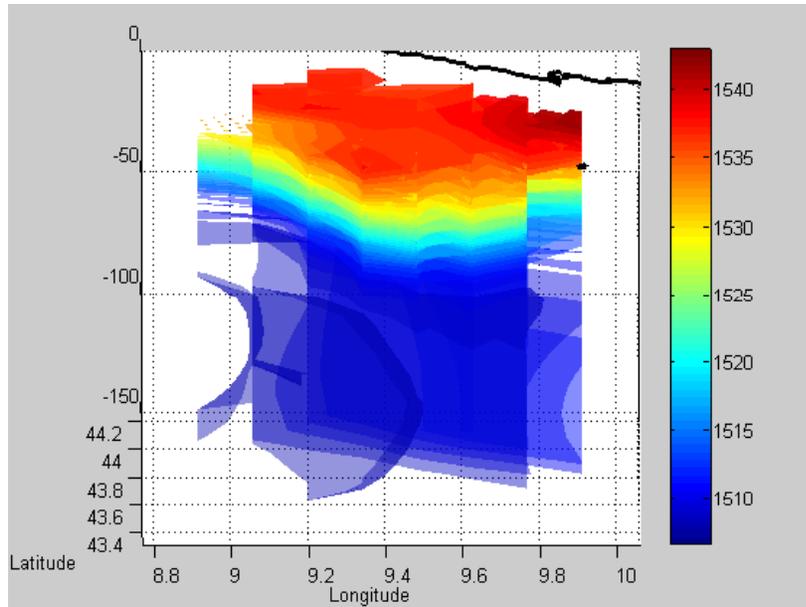


UN Naval Forces in the Persian Gulf, 17 January 1991 (position of ships approximate)

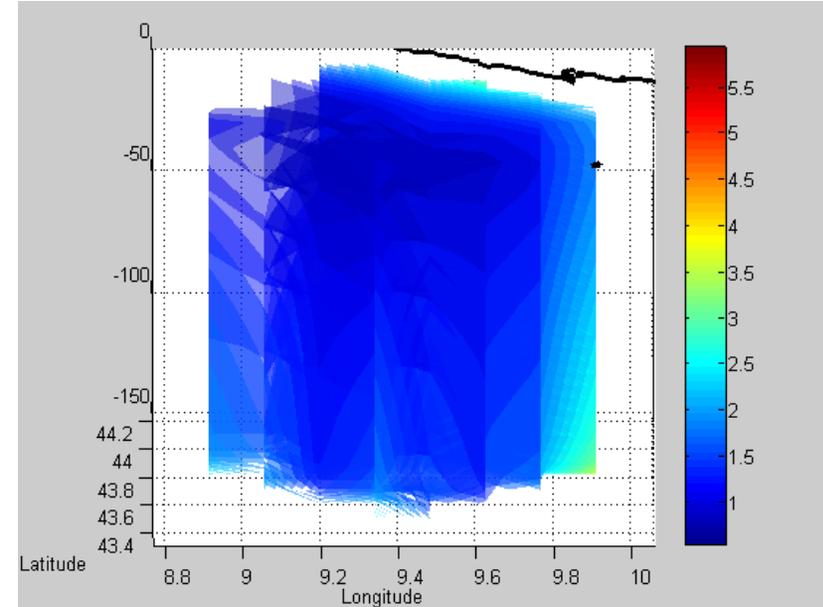
*To exploit glider technology to derive and use environmental knowledge in denied areas to create a tactical advantage and make the warfighter's mission more effective and more efficient*



# Introduction



*Sound speed conditions during August 20<sup>th</sup> -22<sup>nd</sup> reconstructed from data gathered by 4 gliders*

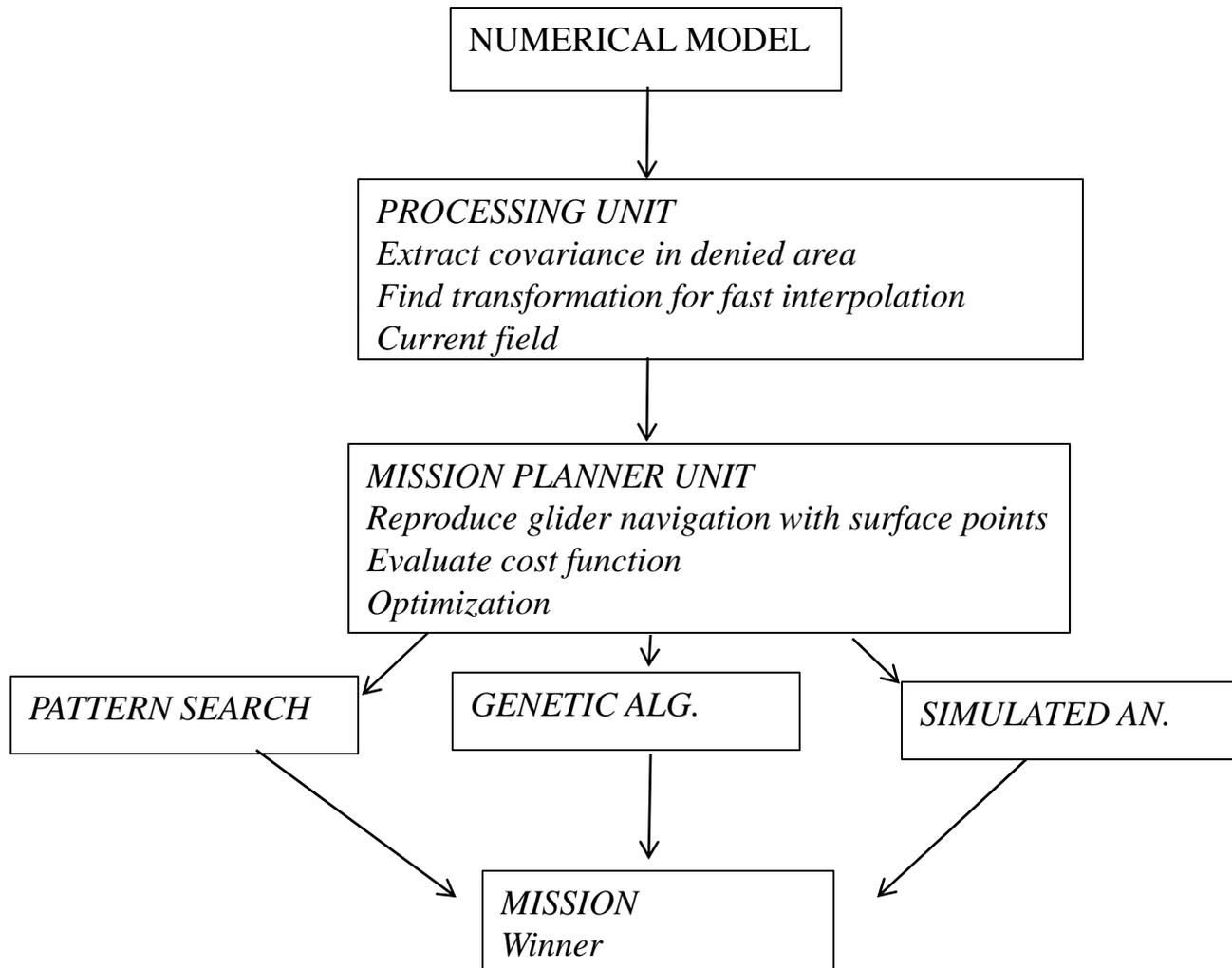


*Estimated error of reconstructed sound speed conditions during August 20<sup>th</sup> -22<sup>nd</sup>*

*When observational resources are limited it is required to find optimum cast strategies to maximize the information content of the collected data using modest surveying time.*



# Glider Mission Planning



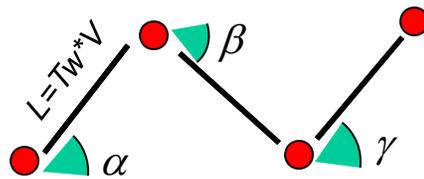


# Glider Mission Planning

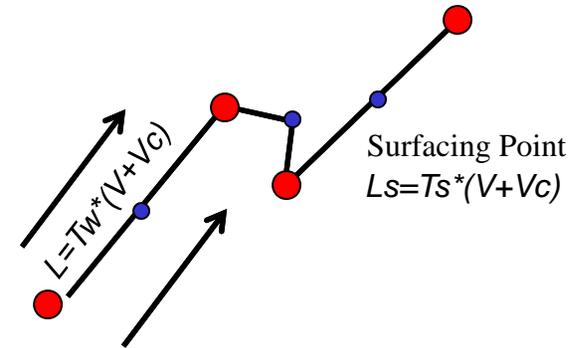


## Trajectories

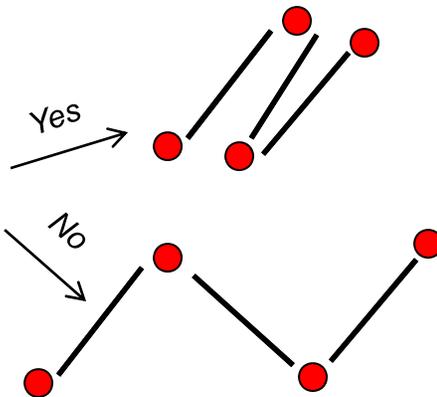
Number of gliders  
Initial Position  
Speed  
Total mission time  
Time between waypoints  
Surface time



Currents



Outside ops area?  
Sensor clusterization?



Cost Function  $1e20$

Cost Function Computation

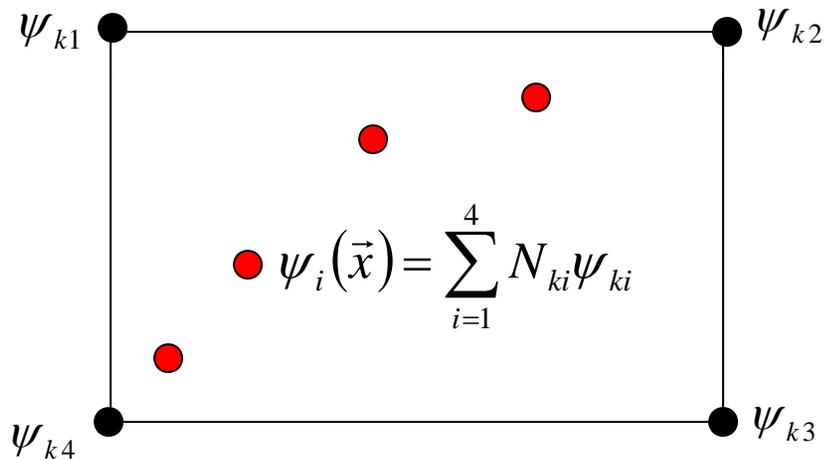


# Glider Mission Planning



## Cost Function

$$P(\psi_k) \propto e^{-\left(\psi_{obs} - H\psi_k\right)^T \Sigma_{obs}^{-1} \left(\psi_{obs} - H\psi_k\right) - \left(\psi_k - \bar{\psi}\right)^T C_M^{-1} \left(\psi_k - \bar{\psi}\right)}$$



$\psi_k$  Field values at the grid nodes,

$H = [N]$  Observation matrix,

$\Sigma_{obs}$  Observation error matrix

$\psi_{obs} = [\psi_i]$  Vector of observations

## A- Optimal Design

$$\text{Arg min}(\text{Trace}(C_M - C_M H^T [H C_M H^T + \Sigma_{obs}]^{-1} H C_M))$$

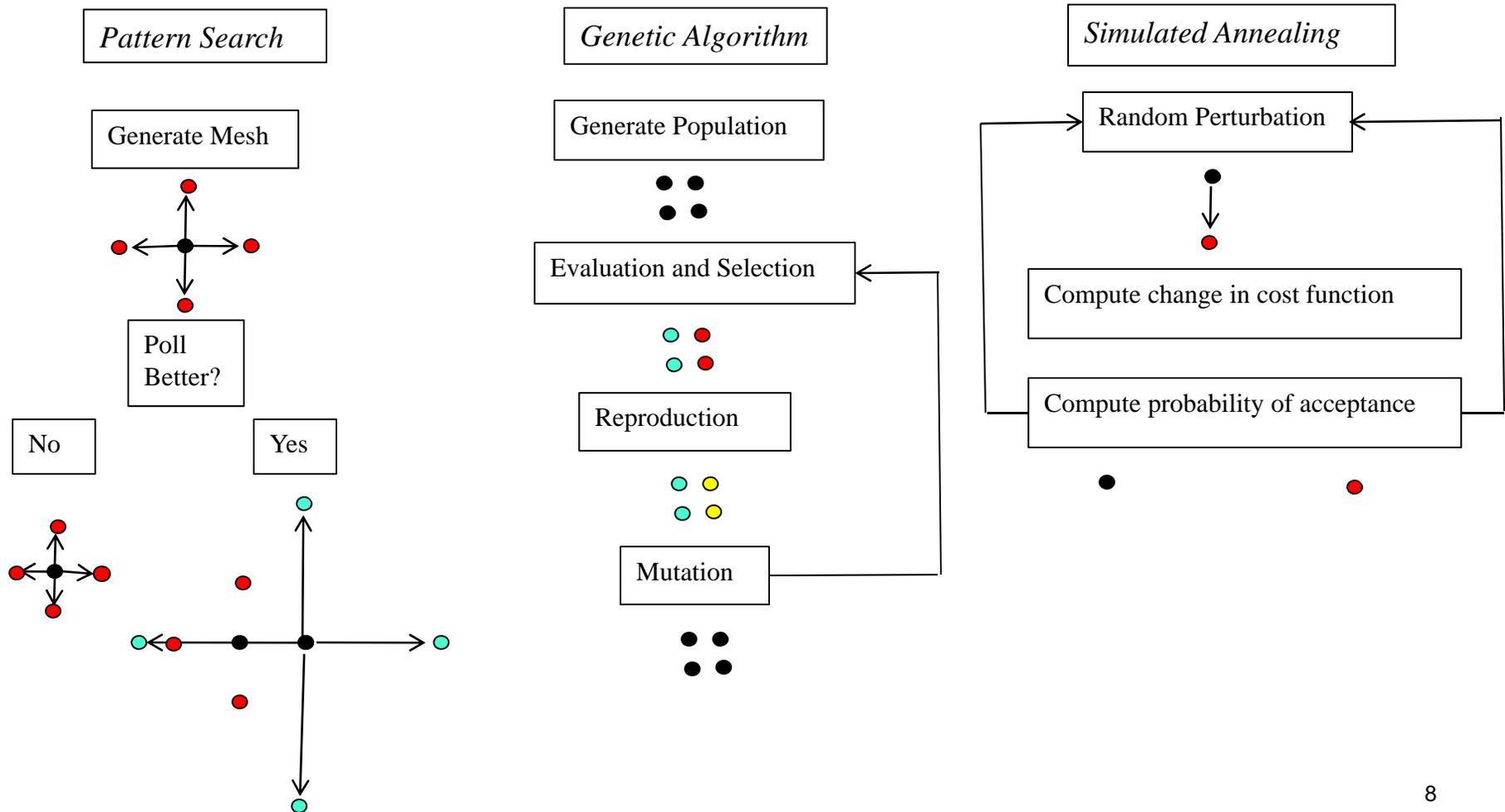
Pre-conditioning could be needed



# Glider Mission Planning



## Optimization

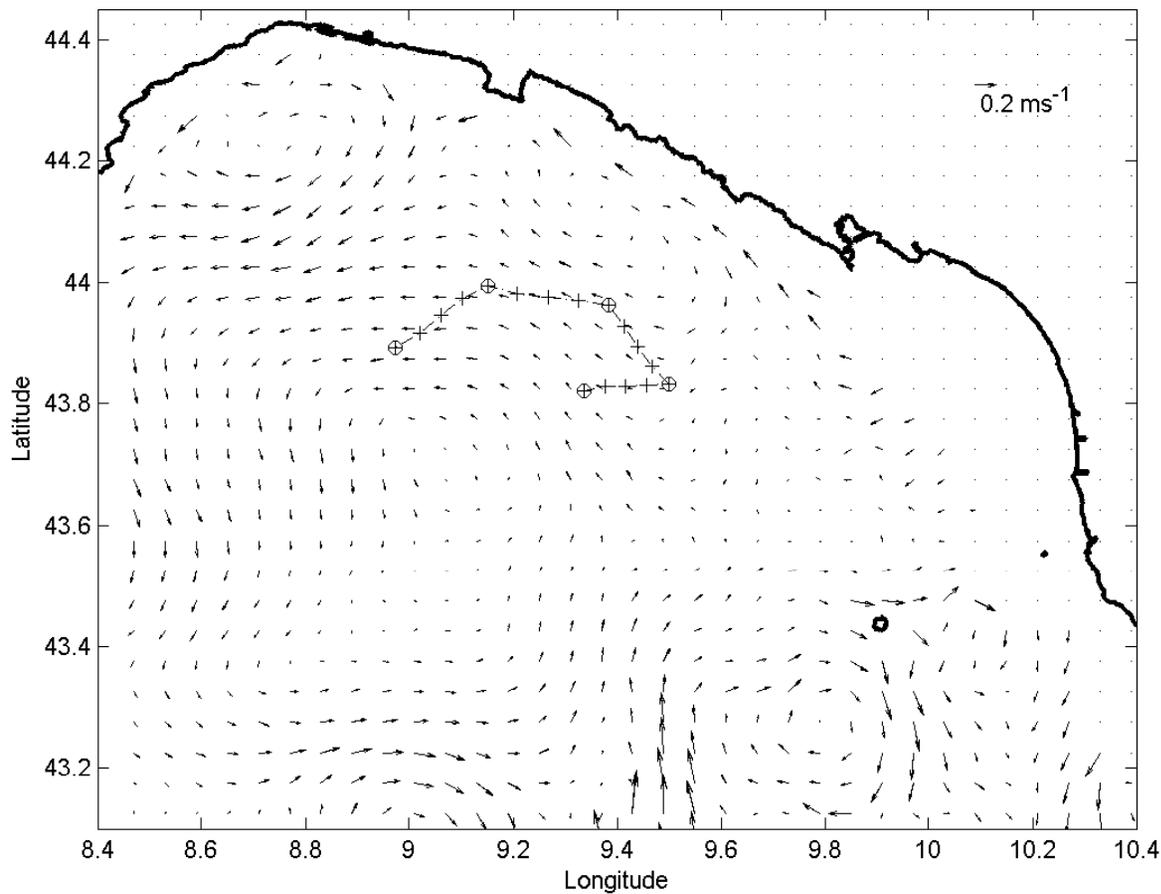




# *Glider Mission Planning*



*Mission plan for August 22<sup>nd</sup> -24<sup>th</sup>*



*Gliders: 1  
Speed: 0.38 m/s  
Total mission time=48 h  
Time between waypoints=12 h  
Surfacing Time=3 h  
Sensor clusterization parameter=6 Km  
Sampling Resolution= 500 m*



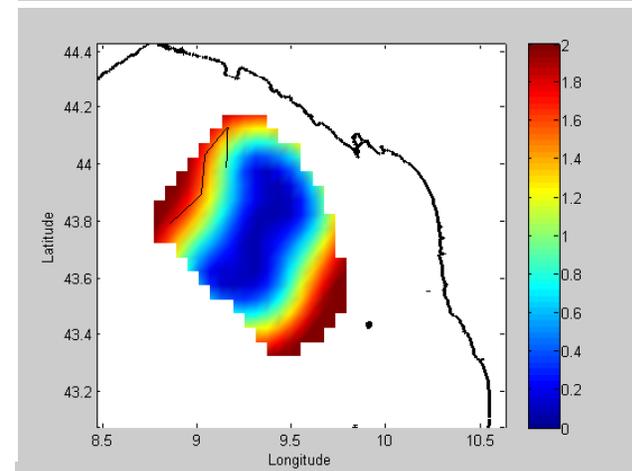
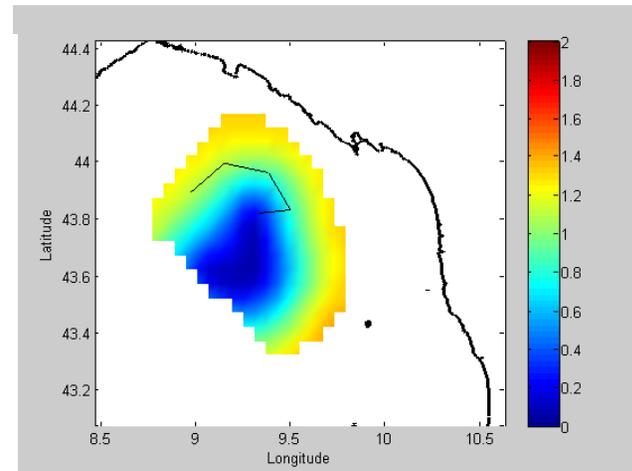
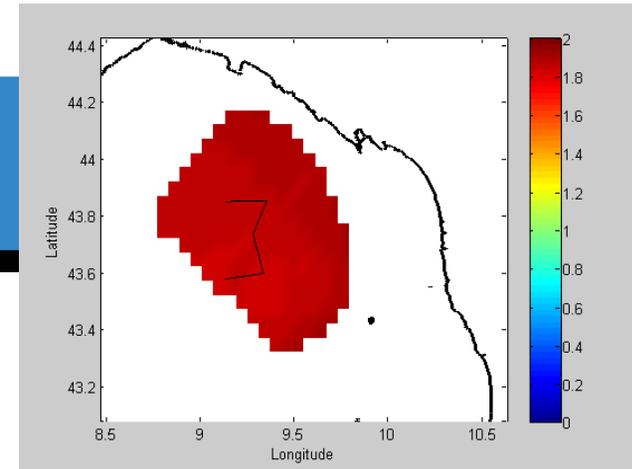
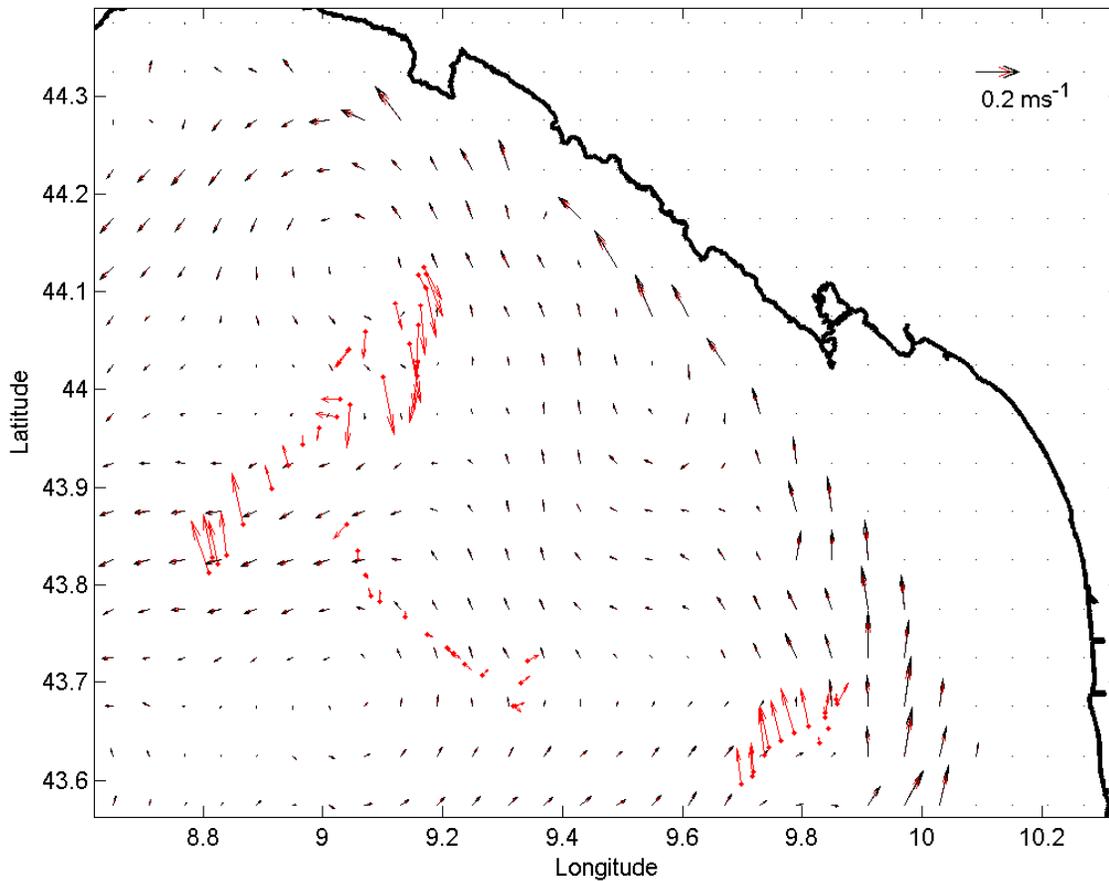
# Performance in REP10

## Model Forecast for August 20<sup>th</sup> -22<sup>nd</sup>

- Vertically integrated current field
- Covariance of the ensemble

## Mission planner

- Glider mission for August 20<sup>th</sup> 22<sup>nd</sup>

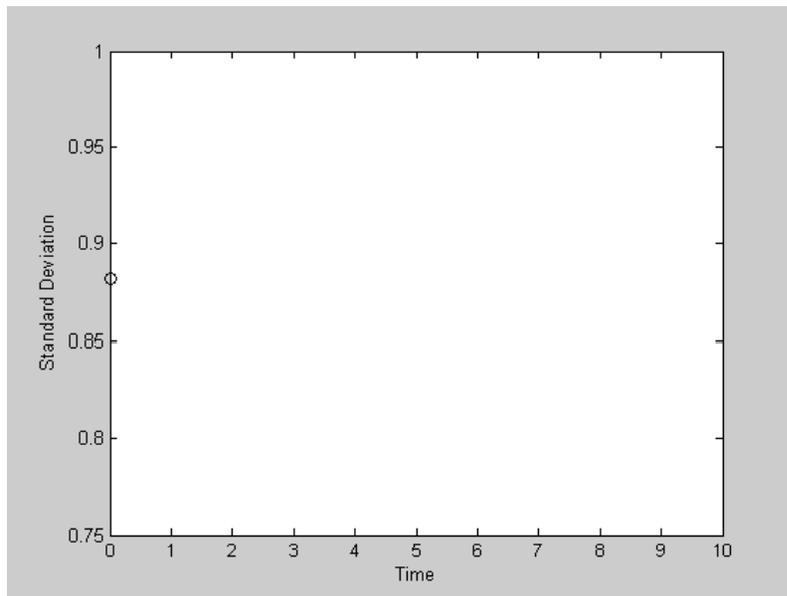




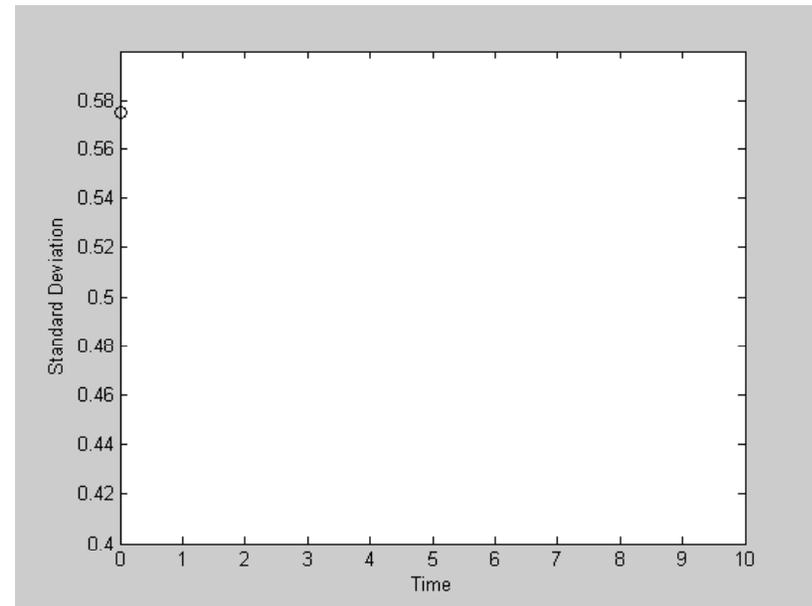
# Performance in REP10



Optimization Mission Aug 20<sup>th</sup> -22<sup>nd</sup>



Optimization Mission Aug 22<sup>nd</sup> -24<sup>th</sup>



Pattern search — Genetic Algorithm — Simulated Annealing —



# Conclusion



- *Adaptive sampling is required when observational resources are limited*
- *An optimization engine is required to search for an optimal experimental design*
- *Results show that the performance of pattern search is superior to genetic algorithms and simulated annealing*
- *Adaptive sampling requires an appropriate assimilation scheme that allows corrections in the current field*