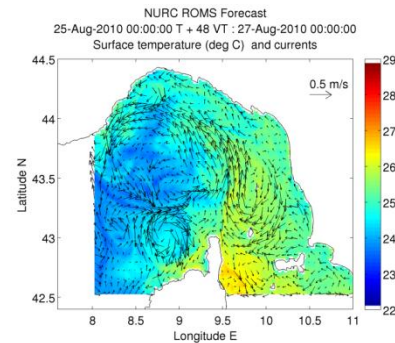# Operational glider adaptive sampling during REP10 experiment in the Ligurian Sea

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Context and objectives

Adaptive sampling:

Problem of "predicting the types and locations of observations that are expected to be most useful, based on given estimation objectives and the constraints of the available assets." (Lermusiaux et al., 2007)

Our objectives:
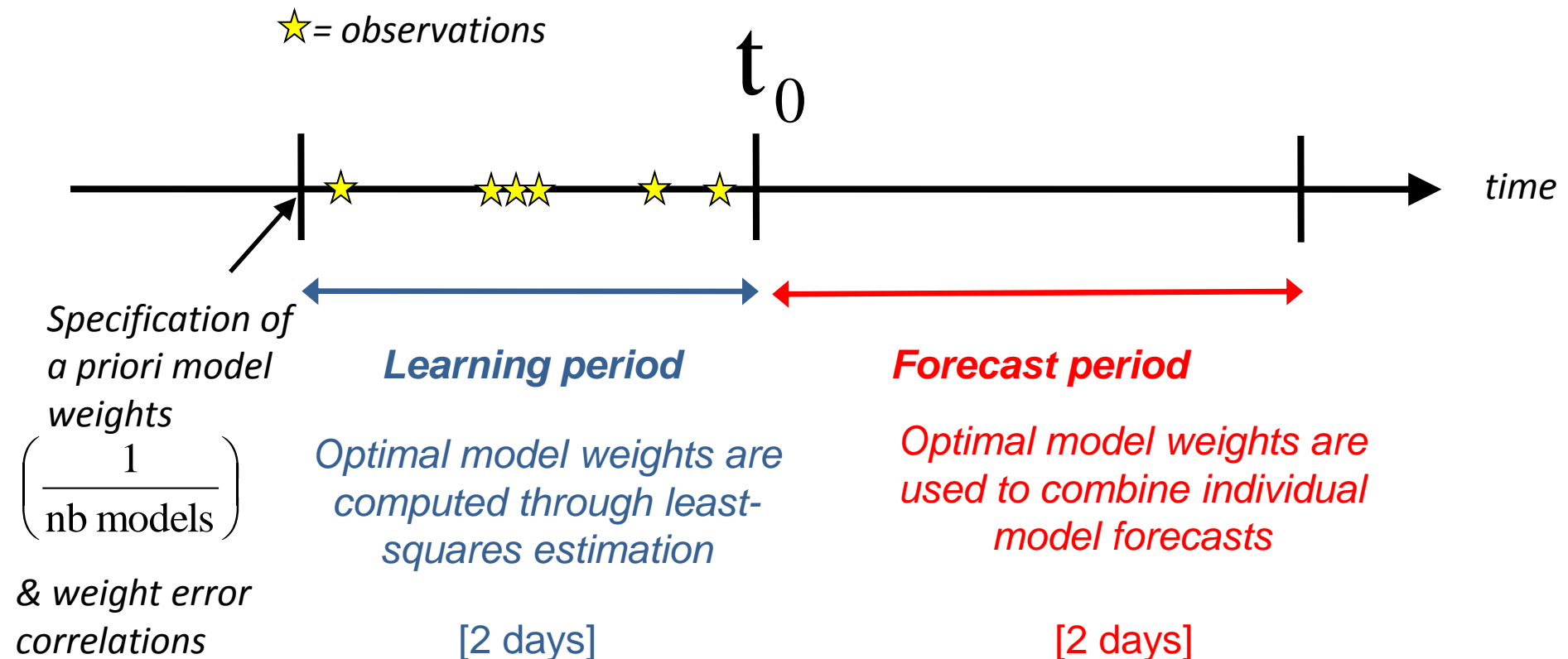
1) Evaluate various optimal statistical criteria for adaptive sampling of a single glider.

2) Evaluate the benefits of adaptive sampling for a single glider in a real scenario.
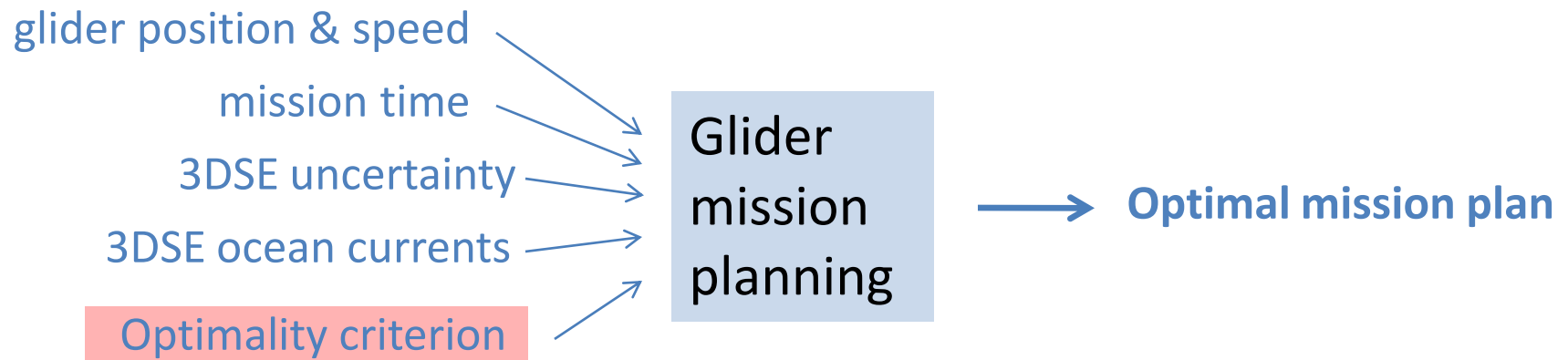
3D super-ensemble (3DSE)

3DSE = linear combination of multiple model forecasts aiming at generating one single improved forecast.

[one weight per model and per 3DSE grid point]

Models used here: NCOM (NRL), MARS3D (PREVIMER) and ROMS (NURC).

$\bigstar$ *= observations*

t_0

time

Specification of a priori model weights

$$\left(\frac{1}{nb\ models}\right)$$

& weight error correlations

Learning period

Optimal model weights are computed through least-squares estimation

[2 days]

Forecast period

Optimal model weights are used to combine individual model forecasts

[2 days]

Glider mission planning

glider position & speed

mission time

3DSE uncertainty

3DSE ocean currents

Optimality criterion

Glider mission planning

→ **Optimal mission plan**

Three possible criteria for optimality:

1) **A-optimality**: minimize the trace of the error covariance matrix

2) **E-optimality**: minimize the maximum eigenvalue of the error covariance matrix

3) **G-optimality**: minimize the maximum value of error variances
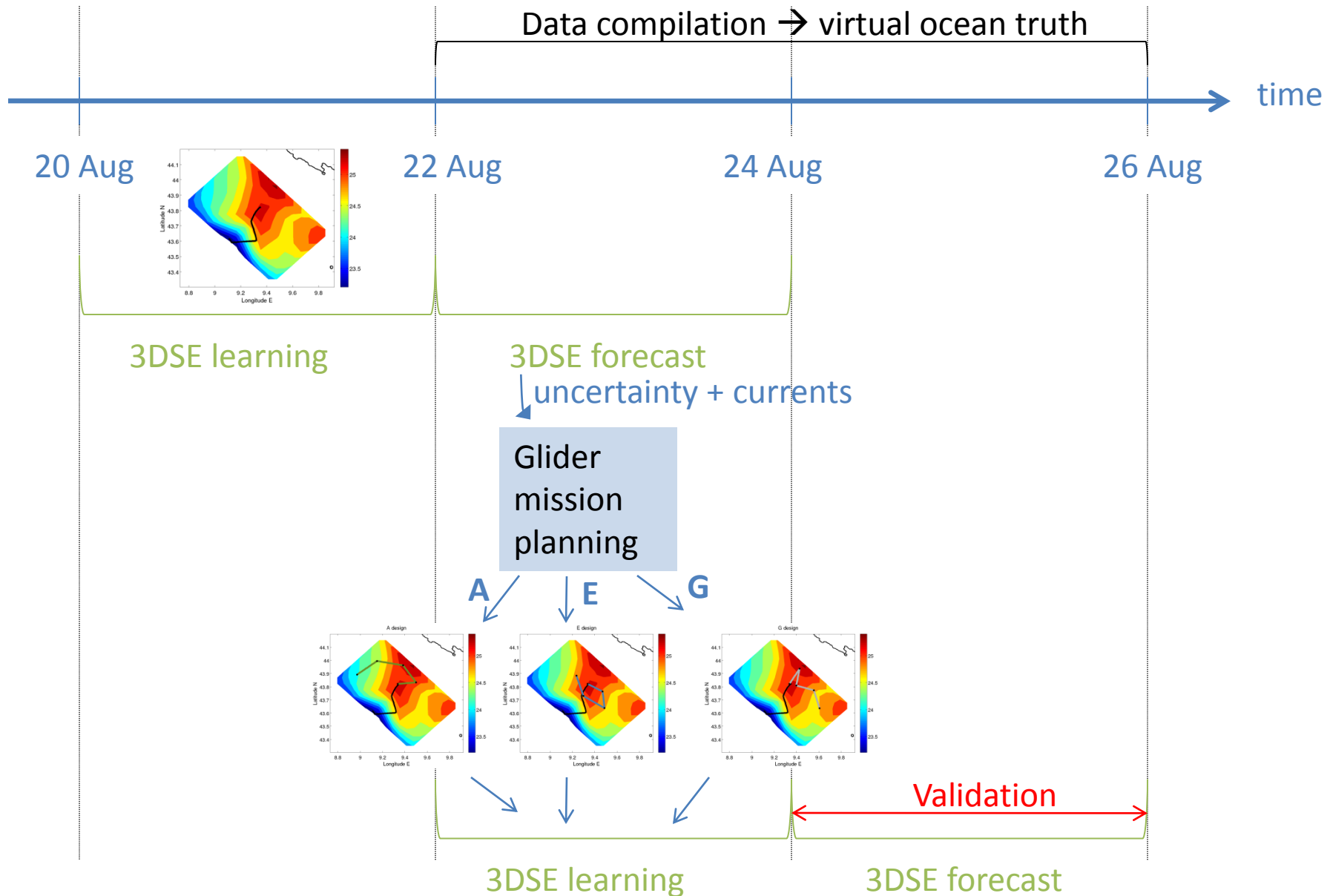
Evaluation of optimal designs

Strategy: work with a "virtual stationary ocean truth" to simulate glider data and evaluate results.

A 3D observation field is generated by compiling all available observations (CTD, glider, surface CTD, ScanFish, drifter SST, OSTIA SST) from 22 to 25 August.
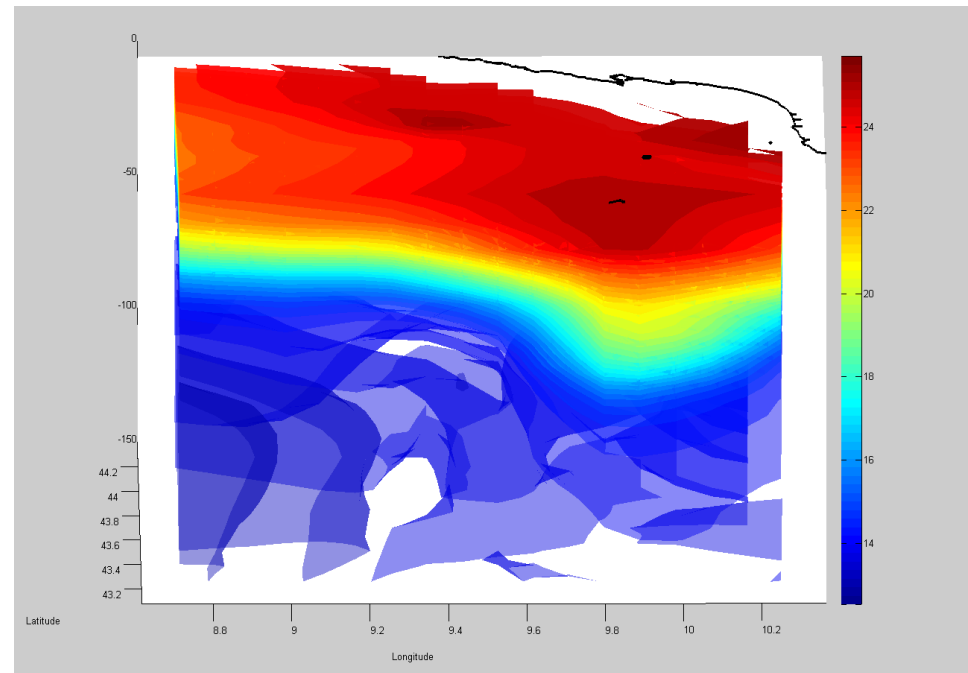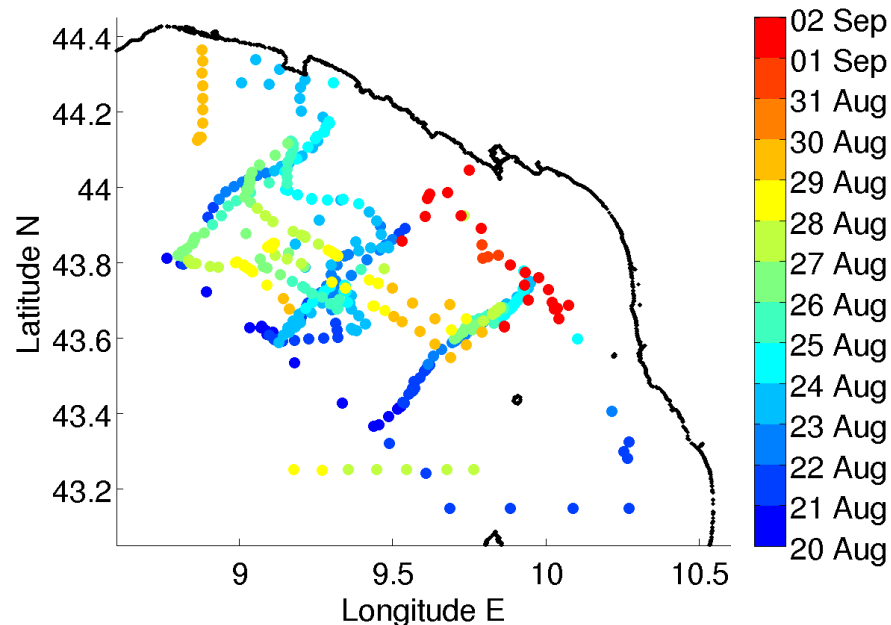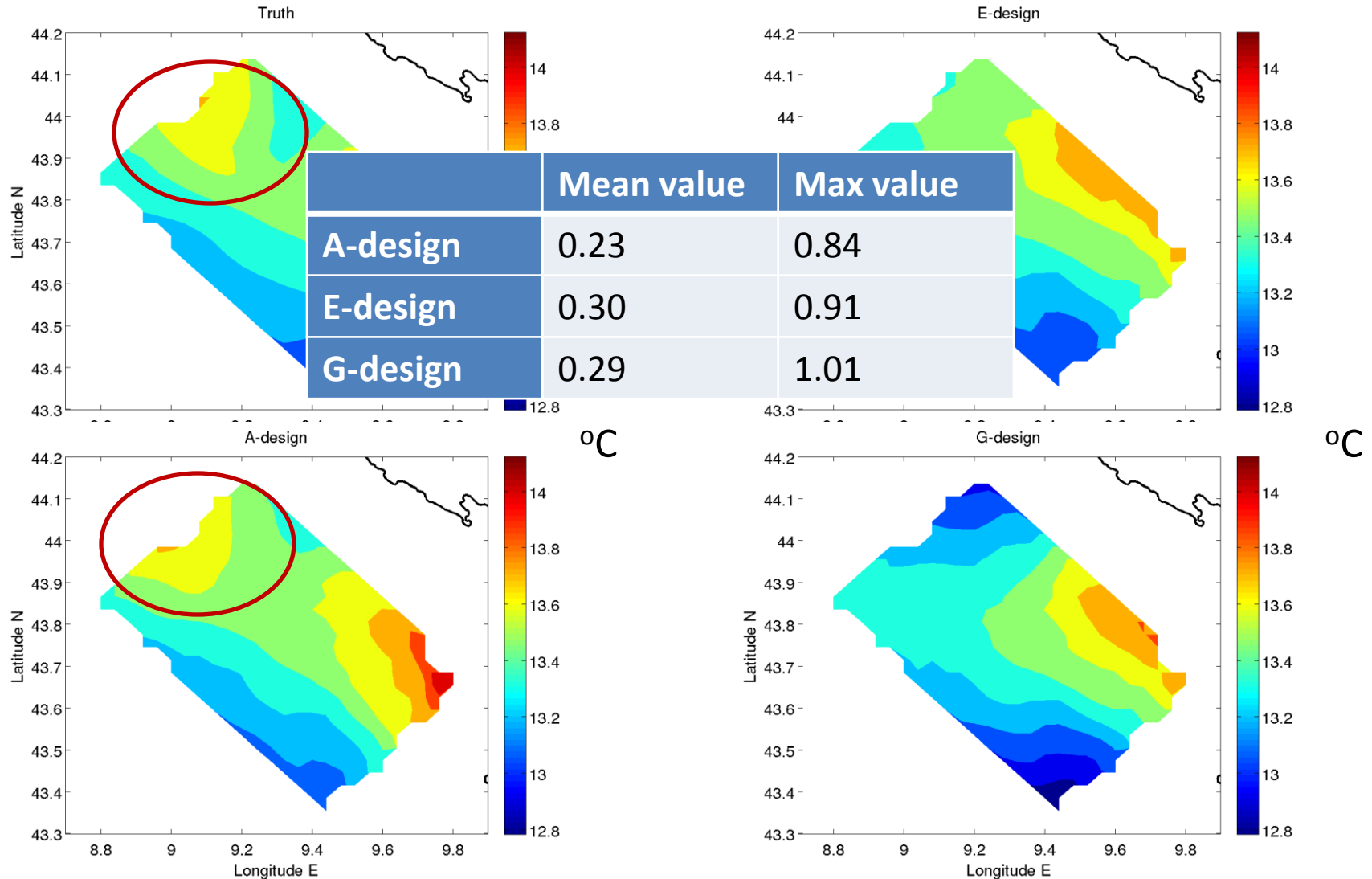

Regularized MAP-MRF reconstruction (Alvarez 2011, IEEE J. Ocean Eng., in press)

Evaluation of optimal designs

Data compilation → virtual ocean truth

time

20 Aug   22 Aug   24 Aug   26 Aug

3DSE learning   3DSE forecast
                       uncertainty + currents

Glider
mission
planning

A   E   G

3DSE learning   3DSE forecast

Validation

Mean temperature [24 -26 Aug.] at 140m depth.

|	Mean value	Max value
A-design	0.23	0.84
E-design	0.30	0.91
G-design	0.29	1.01

REP10 real-time adaptive sampling

Strategy:

(i) The A-optimality criterion is used to guide glider *GRETA* to reduce 3DSE uncertainties in a given denied area from 20 to 26 Aug.

(ii) During the same period, a second glider (*LAURA*) flies in the same area but controlled by the Naval Research Laboratory ("random sampling" from the point of view of 3DSE).

(iii) Two 3DSE forecasts are run assimilating either GRETA or LAURA.

(iv) Independent data from CTDs, gliders, OSTIA SST, ship surface CTD and ScanFish are used to evaluate the forecasts.
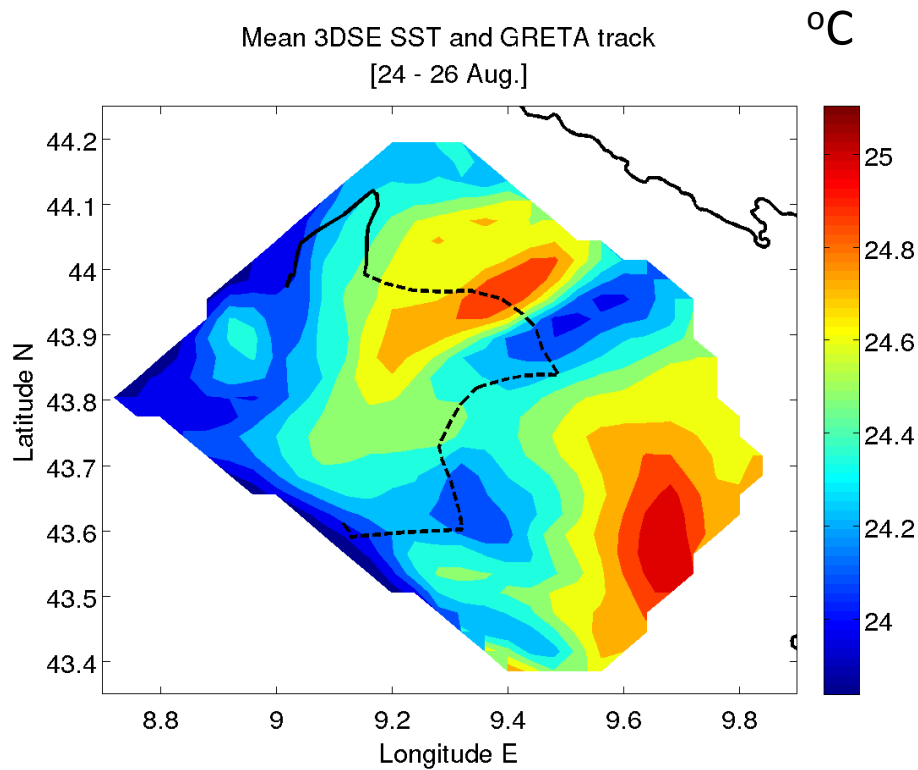
REP10 real-time adaptive sampling
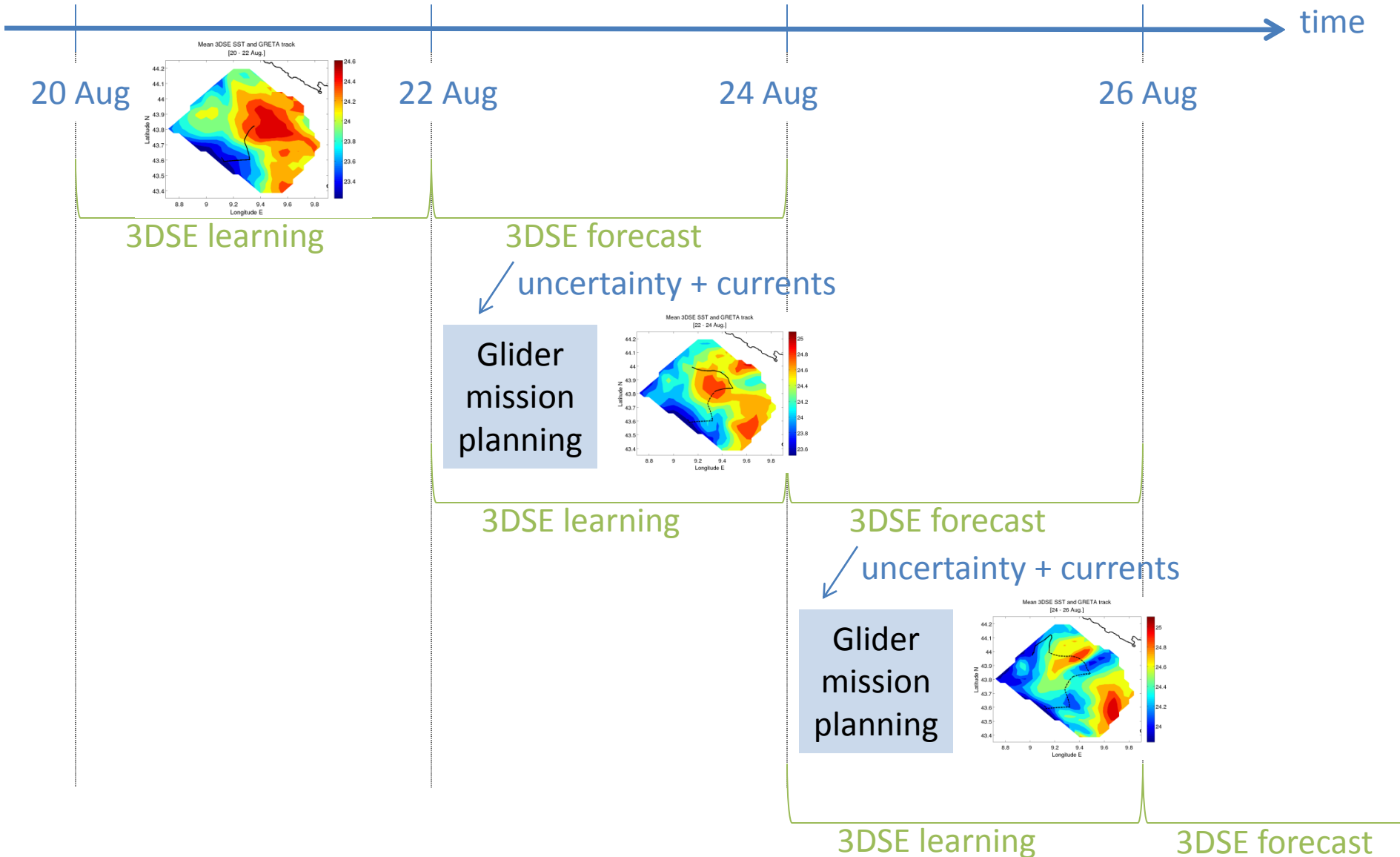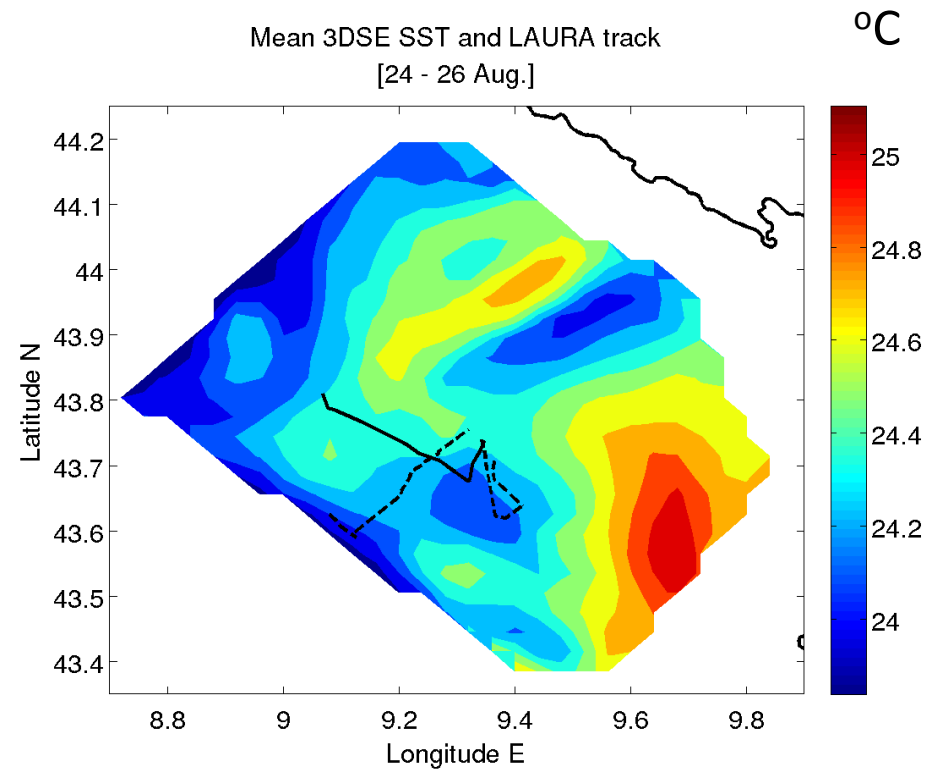
REP10 real-time adaptive sampling

Glider tracks

3DSE forecast error
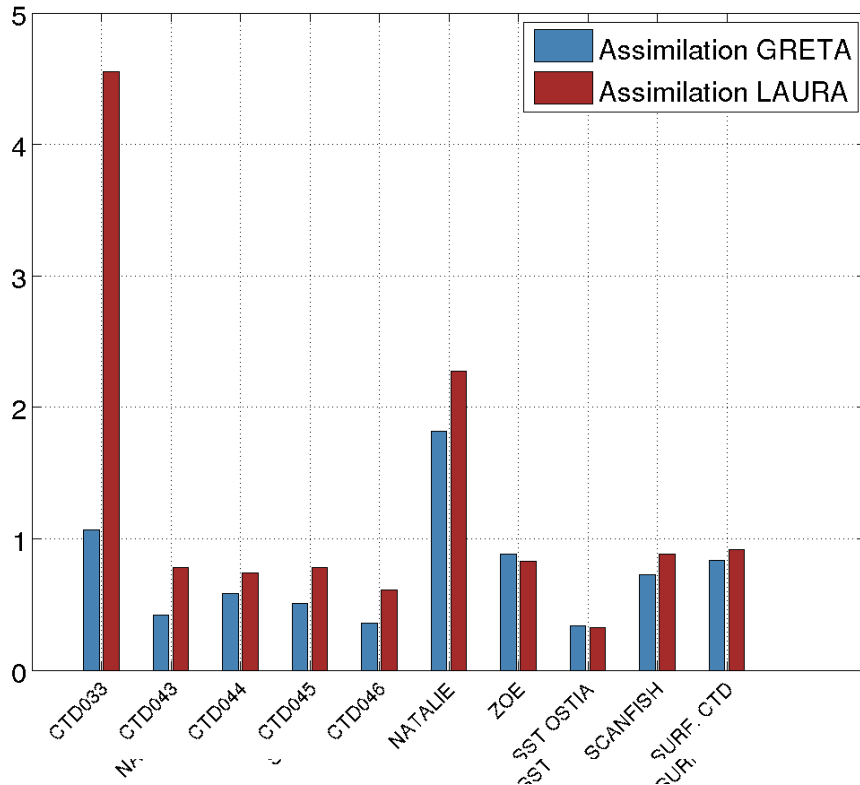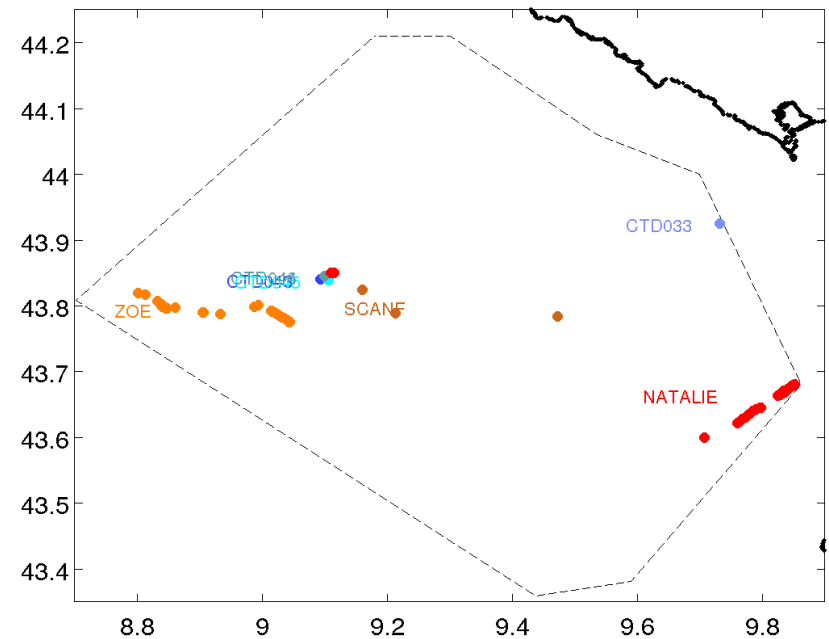
Reduction of the temperature RMSD with adaptive sampling

Conclusions

❖ In a virtual adaptive sampling experiment, the A-optimality criterion (minimizing the trace of the error covariance matrix) provides the best uncertainty reduction for the adaptive sampling of a single glider.

❖ A real-time operational single glider adaptive sampling exercise has been successfully carried out during REP10 experiment in the Ligurian Sea.

Forecast evaluation shows:

 - a reduction of the model theoretical uncertainty

 - a reduction of the model forecast RMSD against observations

thanks to the adaptive sampling.