



THE MARS-3D DATA ASSIMILATIVE SYSTEM : ACHIEVEMENTS AND FUTURE PLANS



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Outline

- Context and Motivation
- Achievements : *Bay of Biscay*
- Future work

GODAE (2007)

1. “can enhance the quality and performance of the coastal systems”

estimation of past (*hindcast*)

climatologies, extreme events, observation design

present (*nowcast*)

and future conditions (*forecast*)

search and rescue, pollution control, coastal flooding,

2. “provides associated measures of uncertainty”

3. Some open issues

Complex physics and range of scales of variability

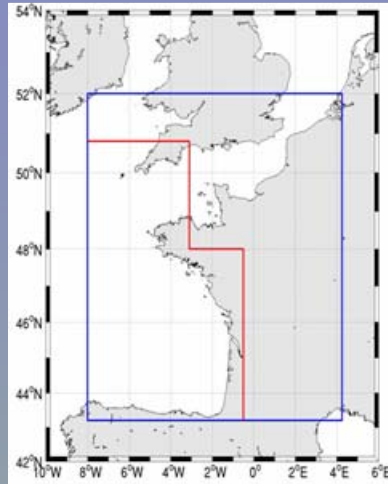
Characterisation and specification of model error

Non-Gaussian Errors and Bias

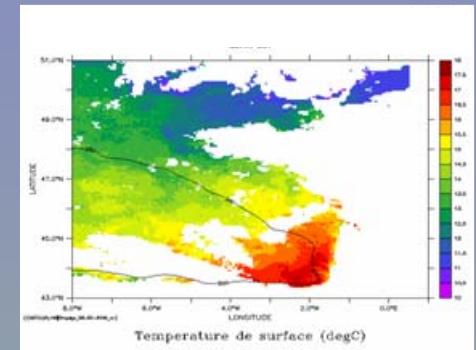
Still in its infancy

Development and validation of a MARS3D multivariate sequential data assimilation system

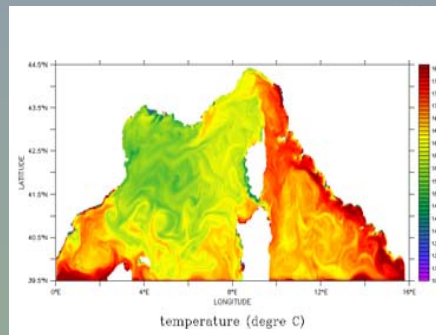
Bay of Biscay
Channel



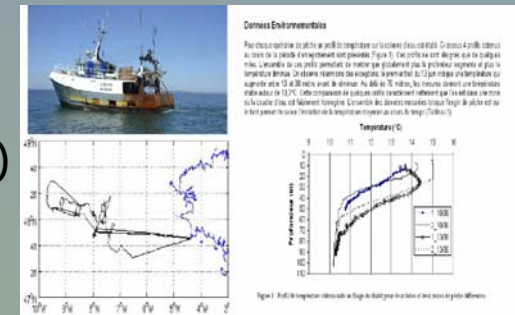
SST



North-Western
Mediterranean Sea



In situ
measurement (T-S)



R&D Project (2007, 2008-2012), Previmar

Where are we today ?

Mediterranean Sea

forecast error due to Wind speed error

Test Period Summer

Bay of Biscay

investigate the potential of multivariate sequential data assimilation of SST to improve T-S model predictions over the shelf

Test Periods Spring & Summer

Data

Assimilation

SST : SEVIRI (0 h)

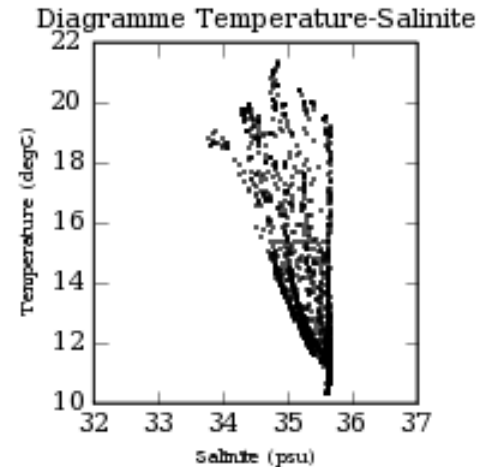
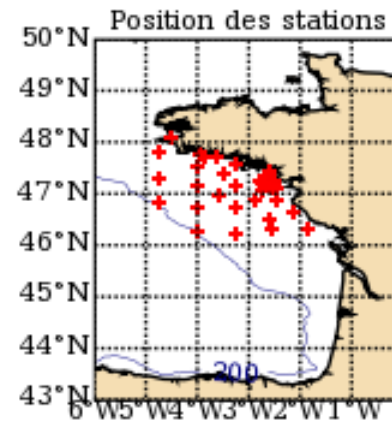
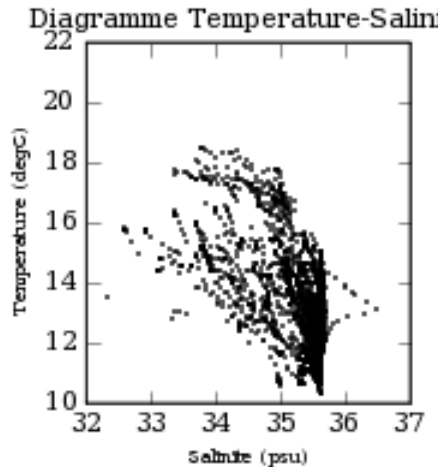
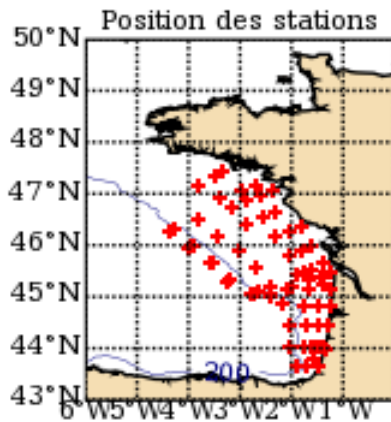
Validation

SST : SEVIRI (0h)

Vertical profiles of T-S over the shelf

PELGAS (1-31 May 2006)

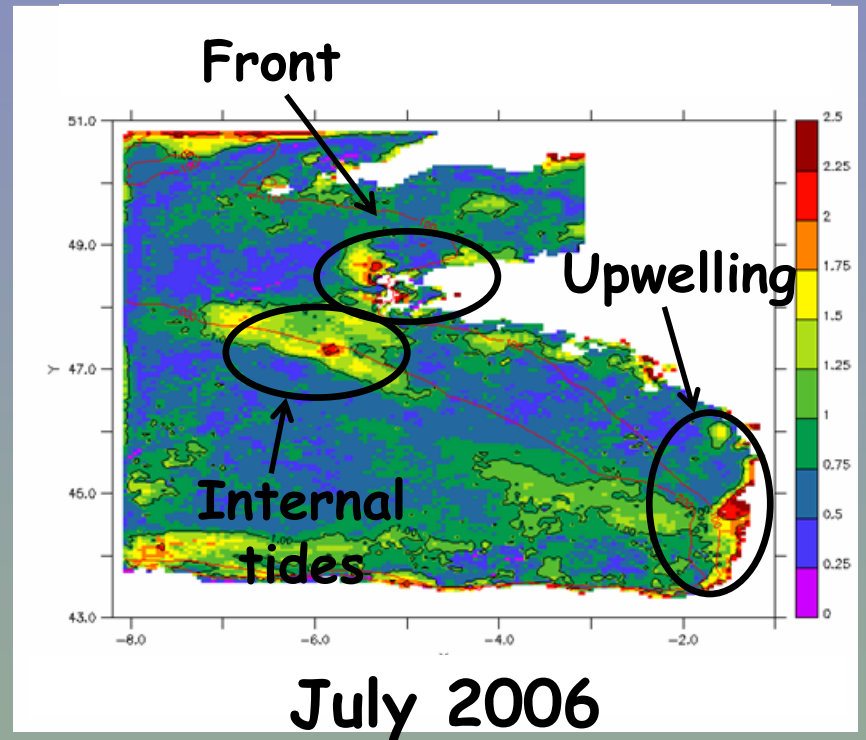
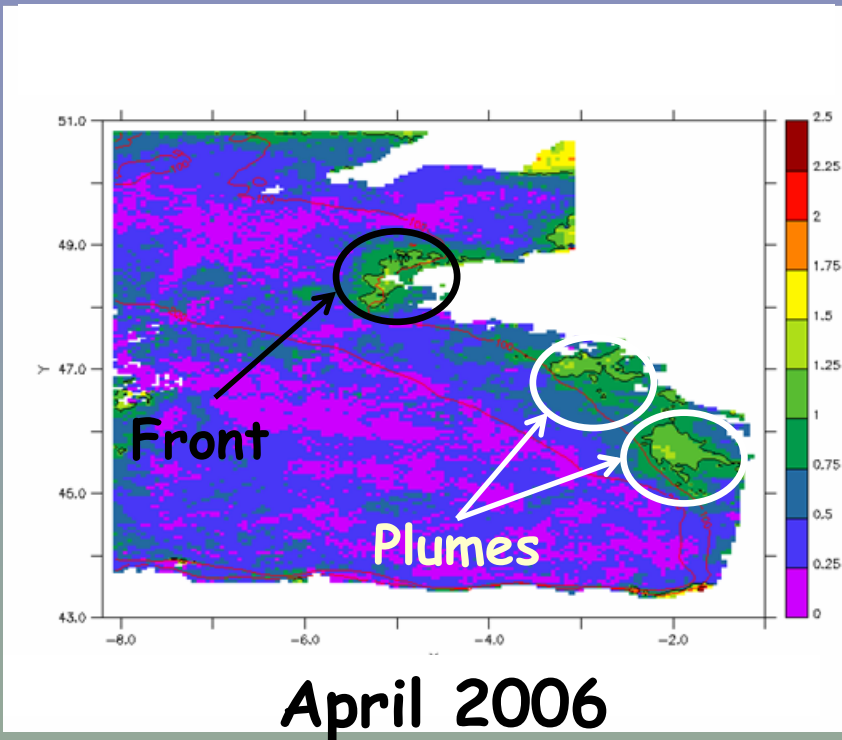
HABIT (6-12 July 2006)



Control Run

Sea Surface Temperature

$$\text{RMSe} = \left[\frac{1}{N} \sum_{i=1:N} (\text{SST}^O_i - \text{H.SST}^F_i)^2 \right]^{0.5}$$



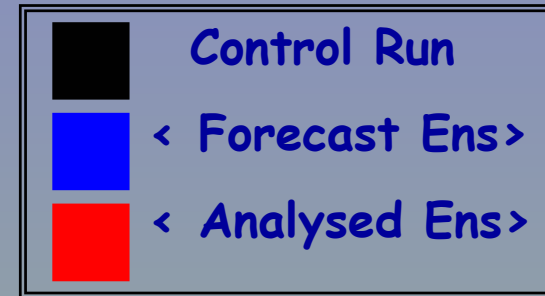
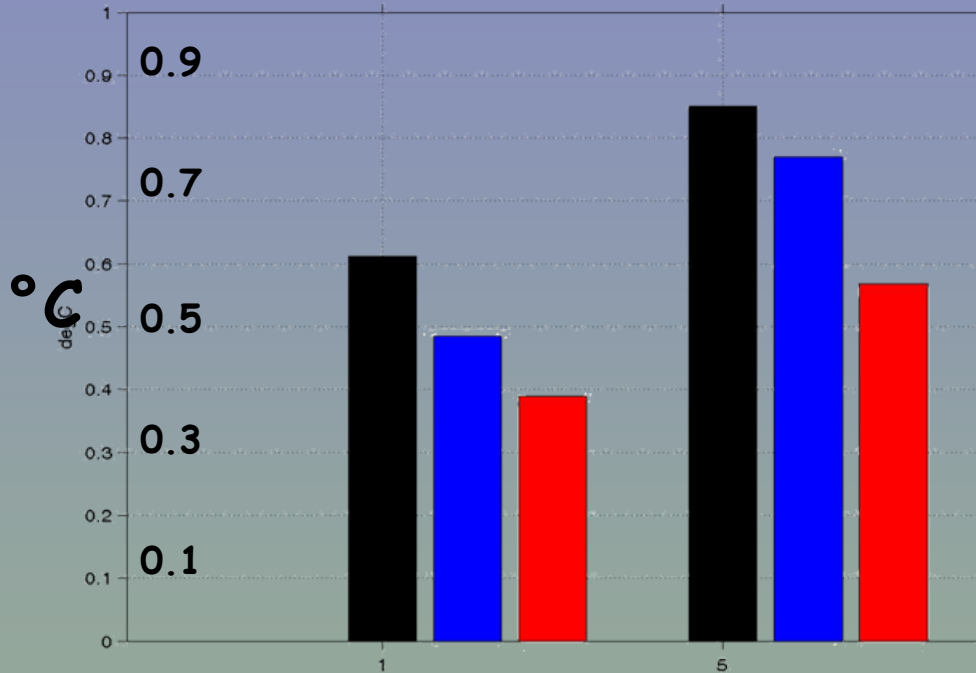
Model Error: seasonality

Data Assimilation Experiments

Initial Error	not very sensitive
Model Error Sources	Model parameters (turbulence, extinction coefficient) Wind speed (δU_{10} , δV_{10} ~ EOF of ARPEGE error)
Control vector	$X = (T, S, dk)$ with dk : light extinction coefficient error
Observation	SST SEVIRI $R = s Id$ (instrumental+representative)
DA Scheme	Ensemble Kalman Filter (EnKF, Evensen, 2003)
Analysis	every 3 days
Experiments	Spring : April - May 06 Summer : June - July 06
Ensemble Size :	30 members Computational cost (3 days forecast) ~ 1h45 (Caparmor Phasis 1) ~ 15' - 30' (Caparmor Phasis 2)

- Overall Statistics : Spring & Summer experiments
- Detailed Results : Spring experiment

RMS Error (continental shelf)



Spring

Summer

Forecast
Analysis

21%
35%

9%
33%

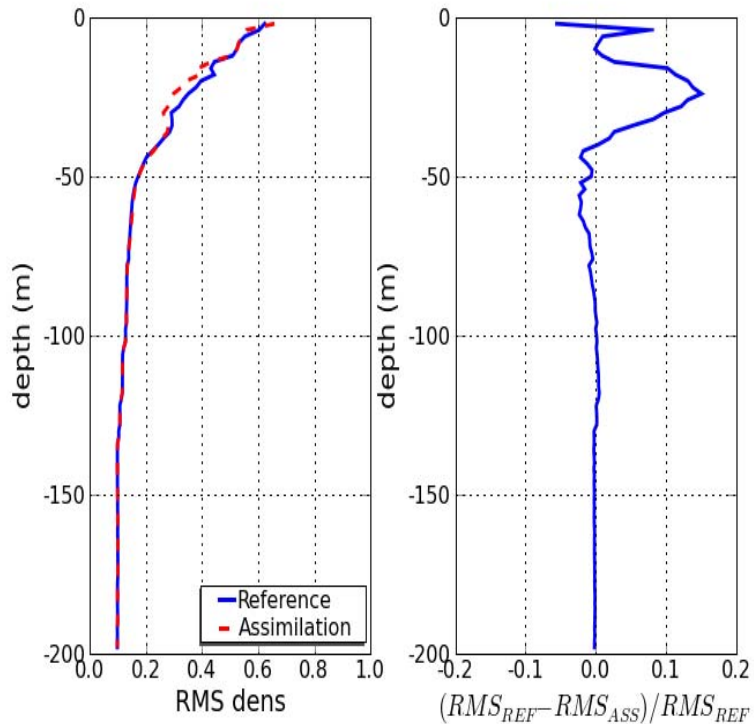
RMS error

Control Run & Ensemble Mean Forecast

Spring experiment

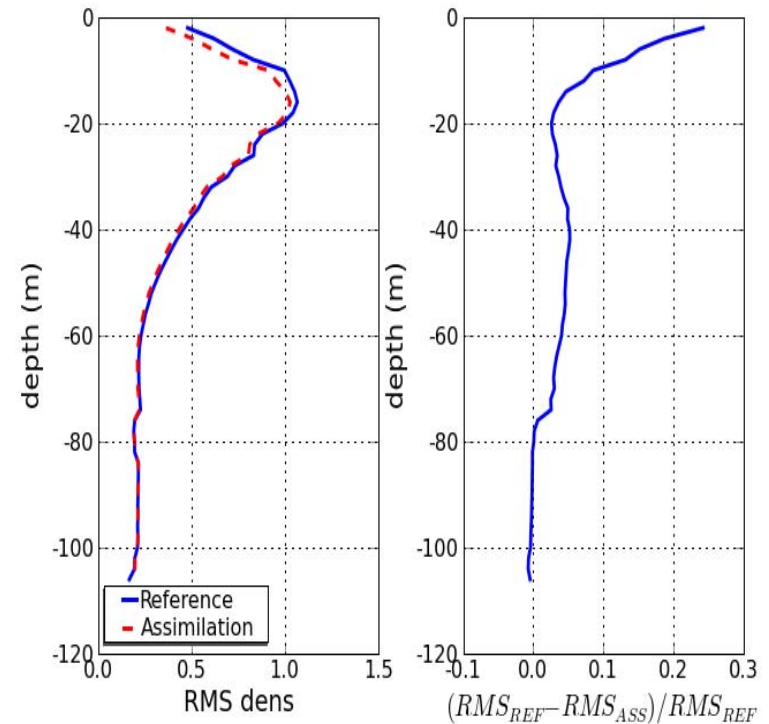
Summer experiment

Cas CAS9.98_A3.5 - Ecart RMS / PELGAS en densite



Effectiveness

Cas CAS19.98_A2.2 - Ecart RMS / HABIT en densite



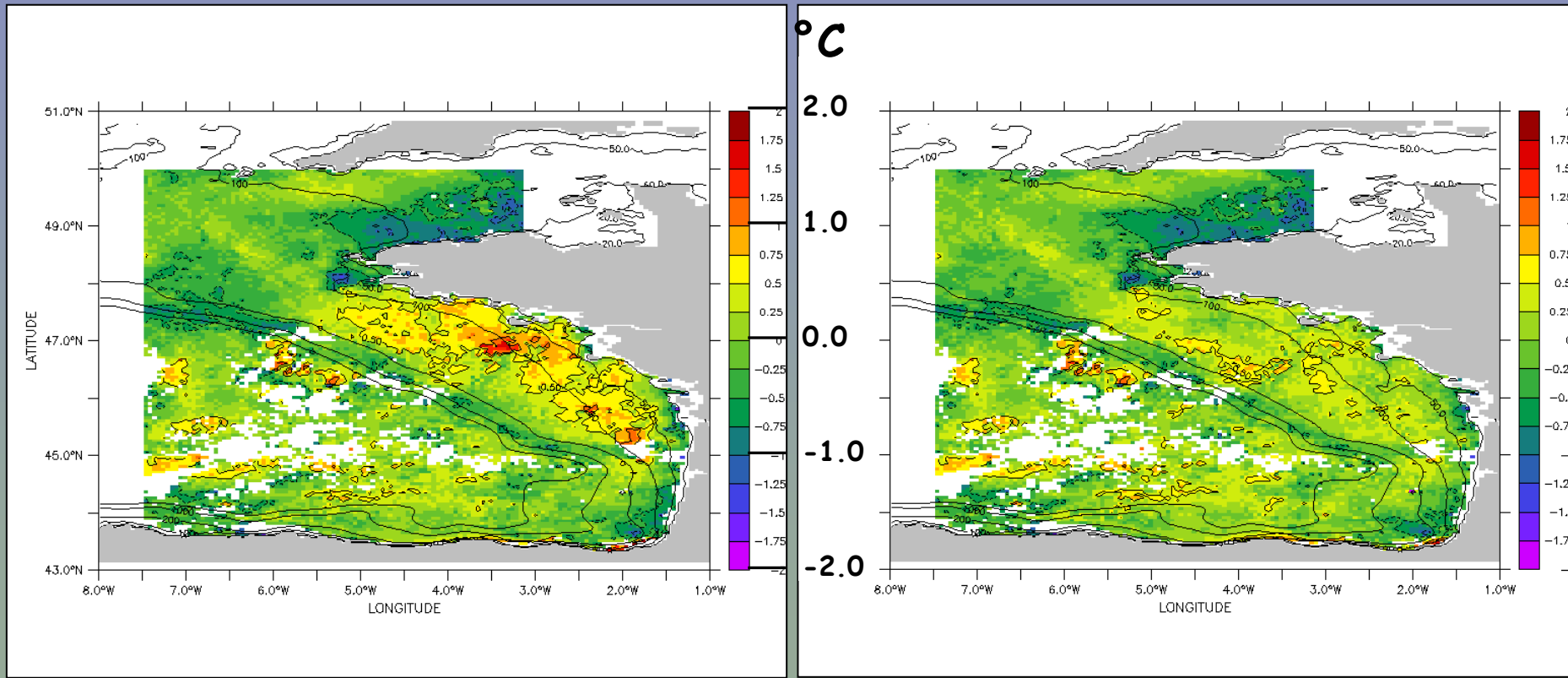
Effectiveness

- Overall Statistics : Spring & Summer experiments
- Detailed Results : Spring experiment

Bias

Control Run

Ensemble Mean Forecast



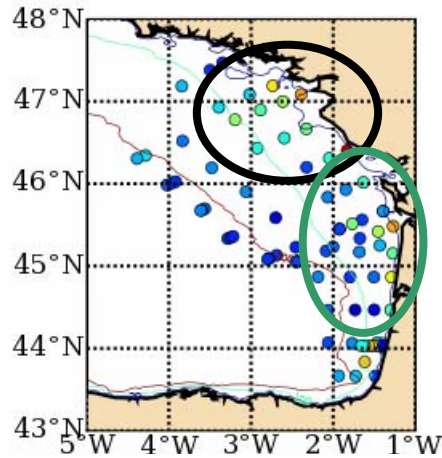
Shelf : Bias ~ 0-1°C (\diamond 1.25°C)

Bias ~ 0-0.5°C (\diamond 0.75°C)

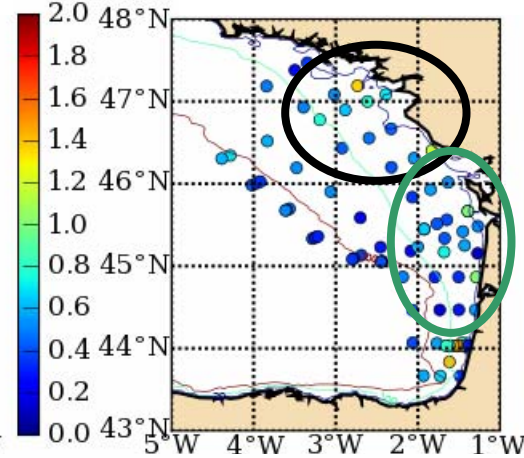
Spring Experiment Vertical Profiles of T-S

Vertical Profile of Temperature : RMS error

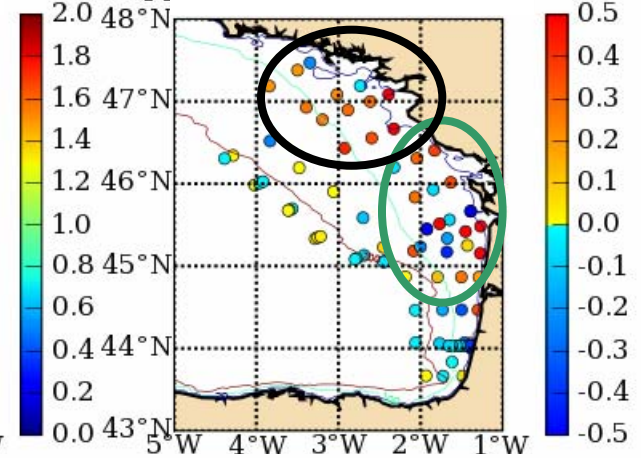
Control Run



Ens-M Forecast

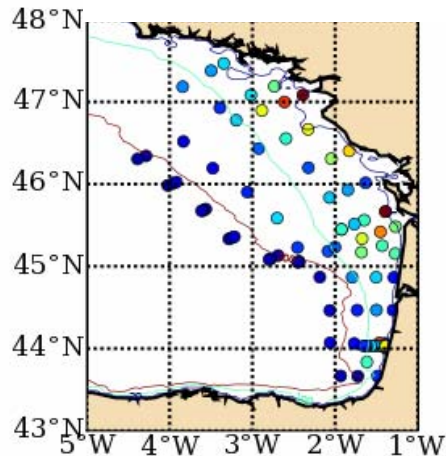


Effectiveness

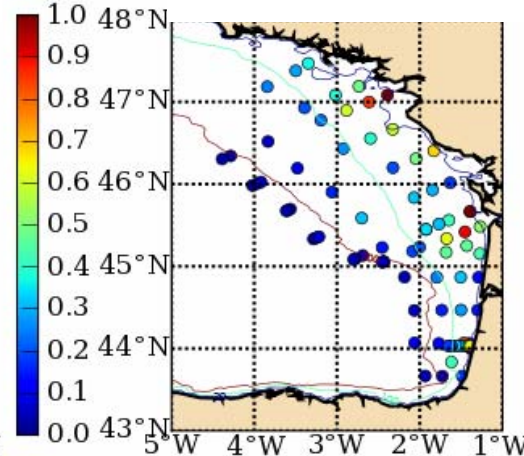


Vertical Profile of Salinity : RMS error

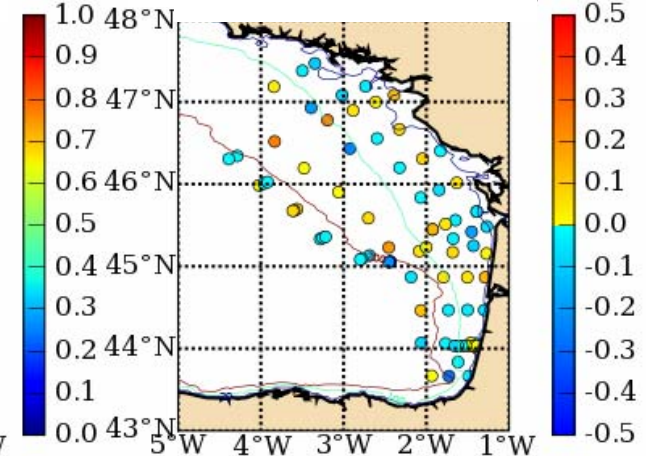
Control Run



Ens-M Forecast



Effectiveness



Spring Experiment

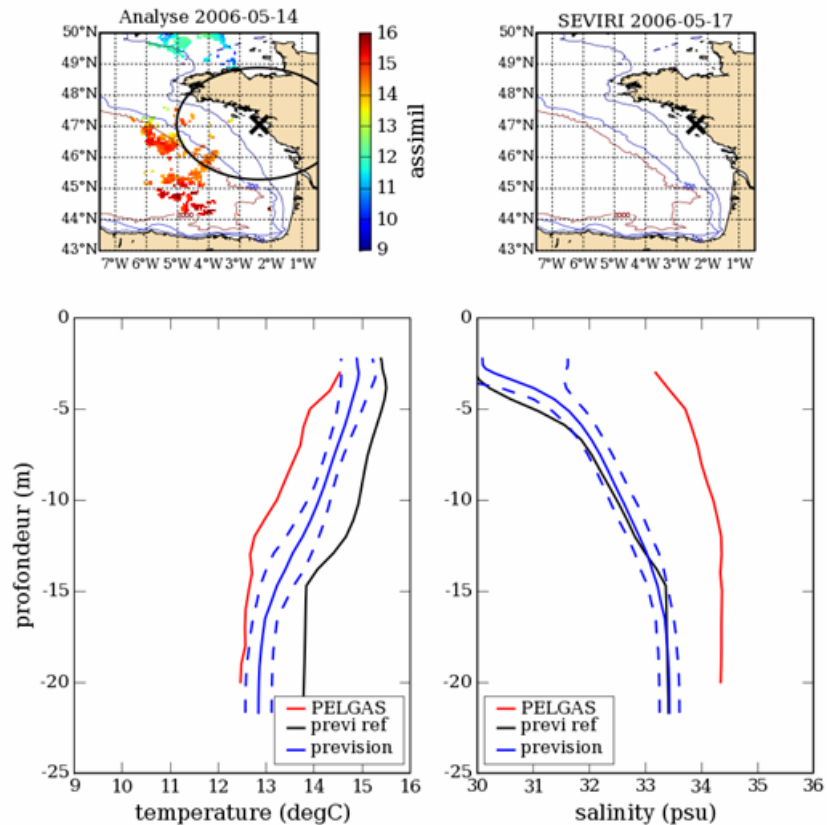
T-S LOIRE Plume

Nearshore

Offshore

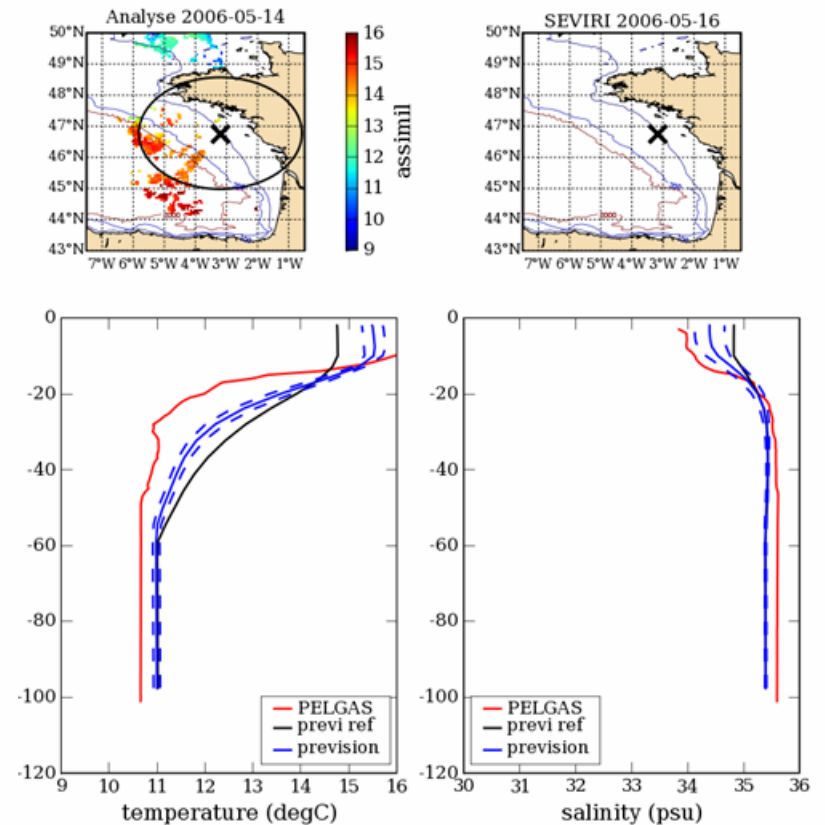
Validation du CAS9.98_A3.5 avec la campagne PELGAS

Comparaison entre PELGAS Station 358 47°05'N 02°23'W 2006-05-17 00:00
et MARS 3D GDGE-ASST 47°05'N 02°24'W 2006-05-17 00:00



Validation du CAS9.98_A3.5 avec la campagne PELGAS

Comparaison entre PELGAS Station 355 46°46'N 03°11'W 2006-05-16 00:00
et MARS 3D GDGE-ASST 46°46'N 03°11'W 2006-05-16 00:00

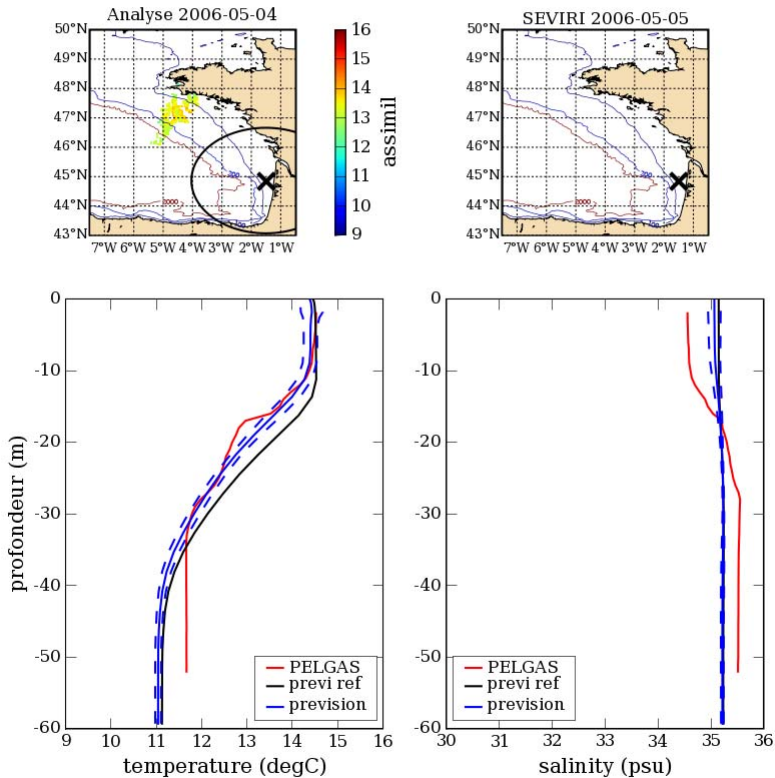


Results Spring Experiment T & S GIRONDE Plume

Nearshore

Validation du CAS9.98_A3.5 avec la campagne PELGAS

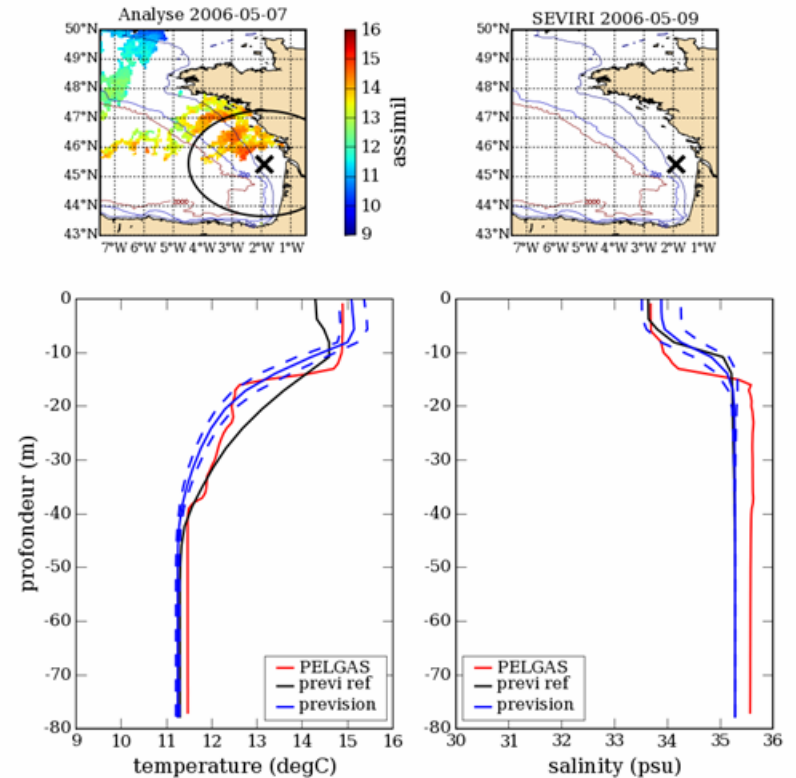
Comparaison entre PELGAS Station 287 44°51'N 01°30'W 2006-05-05 00:00
 et MARS 3D GDGE-ASST 44°51'N 01°31'W 2006-05-05 00:00



Offshore

Validation du CAS9.98_A3.5 avec la campagne PELGAS

Comparaison entre PELGAS Station 310 45°26'N 01°55'W 2006-05-09 00:00
 et MARS 3D GDGE-ASST 45°26'N 01°56'W 2006-05-09 00:00



Future Work

SST

Effectiveness (Forecast) ~ 10-20 %

Efficient: spring & plumes

Uncertainty :

consistency (spring)

underestimated (summer)

Vertical Profile of T-S

20 to 10 % (mainly Mixed Layer)

Loire plume (Gironde plume)

Basque area

underestimated

TODAY

Dual State & parameter estimation

Bias estimation / Model error source : 2D extinction coefficient /
Uncertainty

TOMORROW

Assimilation of SST into the Bay of Biscay & Channel Model

DAY AFTER TOMORROW

Assimilation of T-S & Mediterranean System

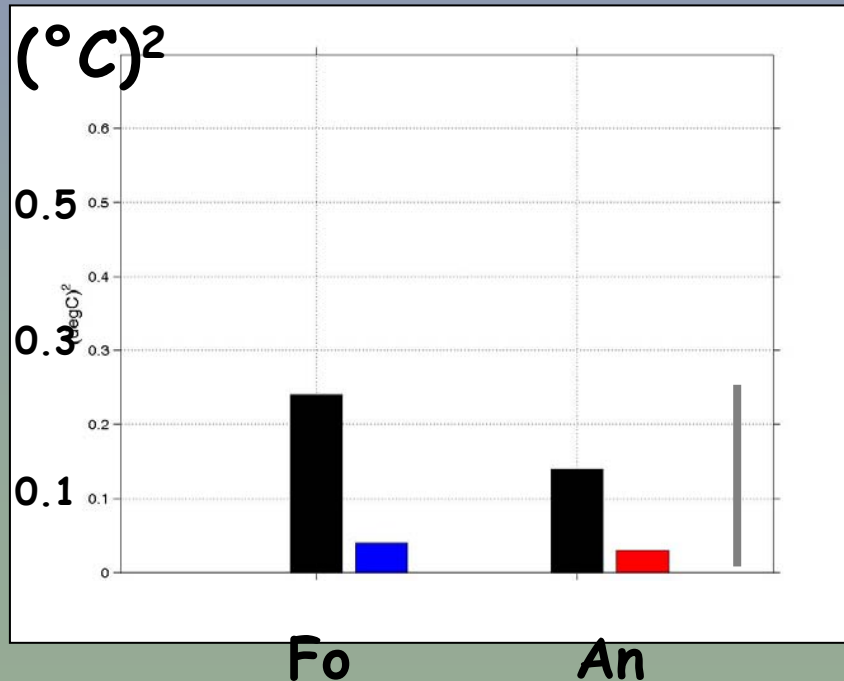
Thank you for your attention

Statistical Consistency

$$\langle \mathcal{M}_{\text{obs}}^2 \rangle = \langle (\gamma_m - d)^2 \rangle - \langle \mathcal{M}_m^2 \rangle \text{ with } \mathcal{M}_{\text{obs}} \sim 0.5 \text{ } ^\circ\text{C}$$

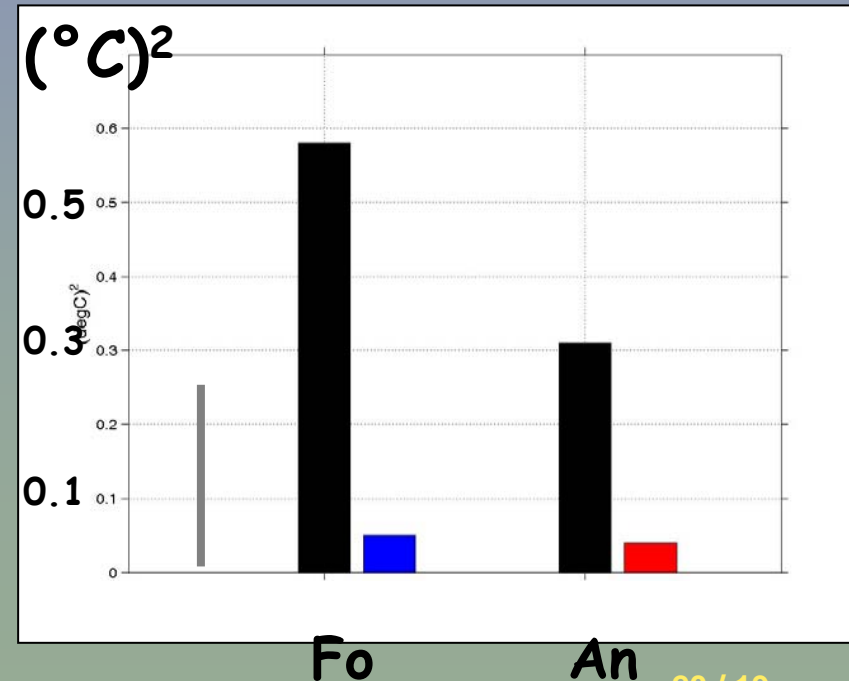
Spring

Consistent over the shelf



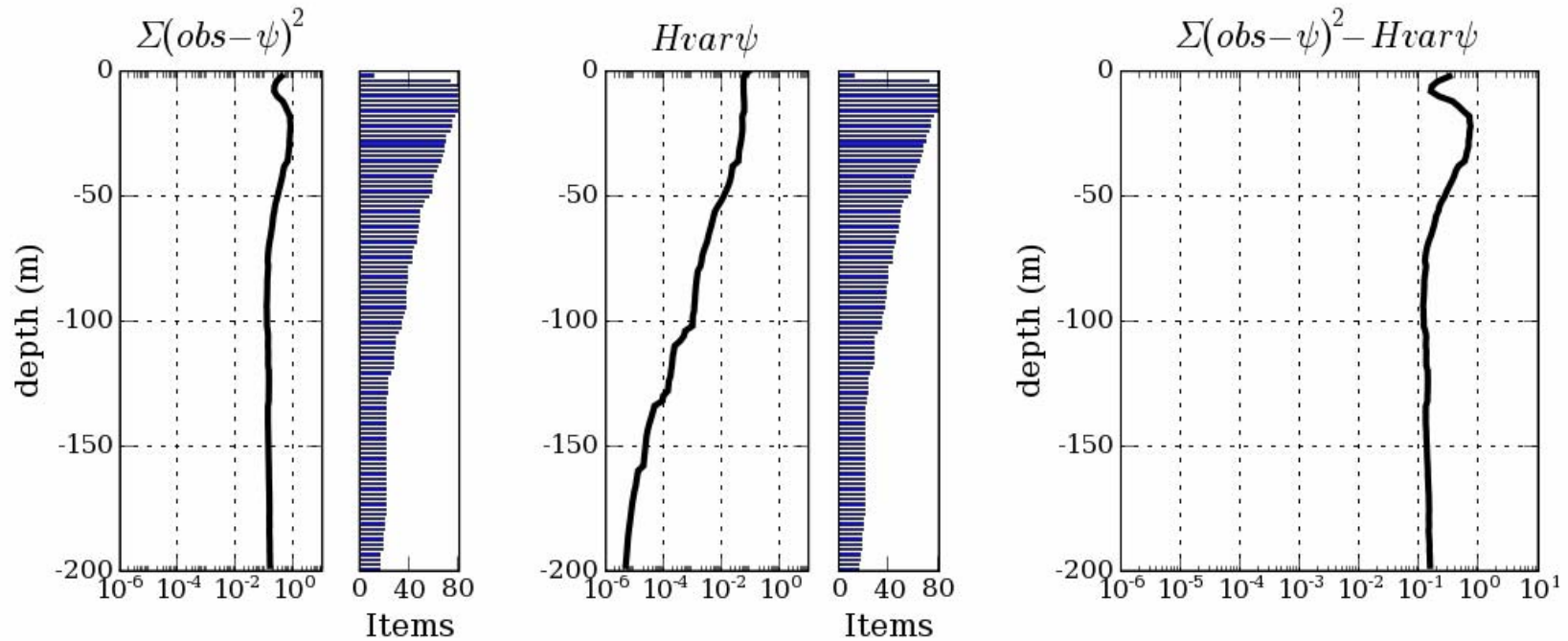
Summer

Model errors still to be found



Statistical Consistency

over the first 50-75 meters



Computational Cost

ENKF ~ FORECAST STEP

~ (NRENS/2) * computational cost of a member

CAPARMOR (Phasis 1)

1 node, 4 cores (2 dual-core intel xeon 5160 : 3.00 GHz,
12G Flops/Core, 3T Flops/rack)

3-days (8-days) FORECAST [MPI-16]

Walltime	CAPARMOR Phasis 1	CAPARMOR Phasis 2
30'	NRENS = 8 (3)	NRENS = 34 – 68 (12 -25)
1h	NRENS = 17 (6)	NRENS = 68 – 137 (25-51)
2h	NRENS = 34 (12)	NRENS = 137-274 (51-102)

Ensemble Kalman Filter

Monte Carlo simulations (*Evensen, 2003*)

multivariate time-dependent DA scheme

ensemble of possible states

