Monitoring the mesoscale ocean with multi-satellite altimetric missions: a data assimilation study

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INTRODUCTION :

altimetric observations for operational oceanography

Satellite altimetry:
Provide informations to monitor the mesoscale oceanic activity at a global scale.

Operational context:

Altimetric measurements are assimilated into ocean general circulation models.

- *Is it possible to determine the best altimetric observational scenario to constrain an eddy-resolving ocean model ?*

Operational objectives

Design altimetric data sampling

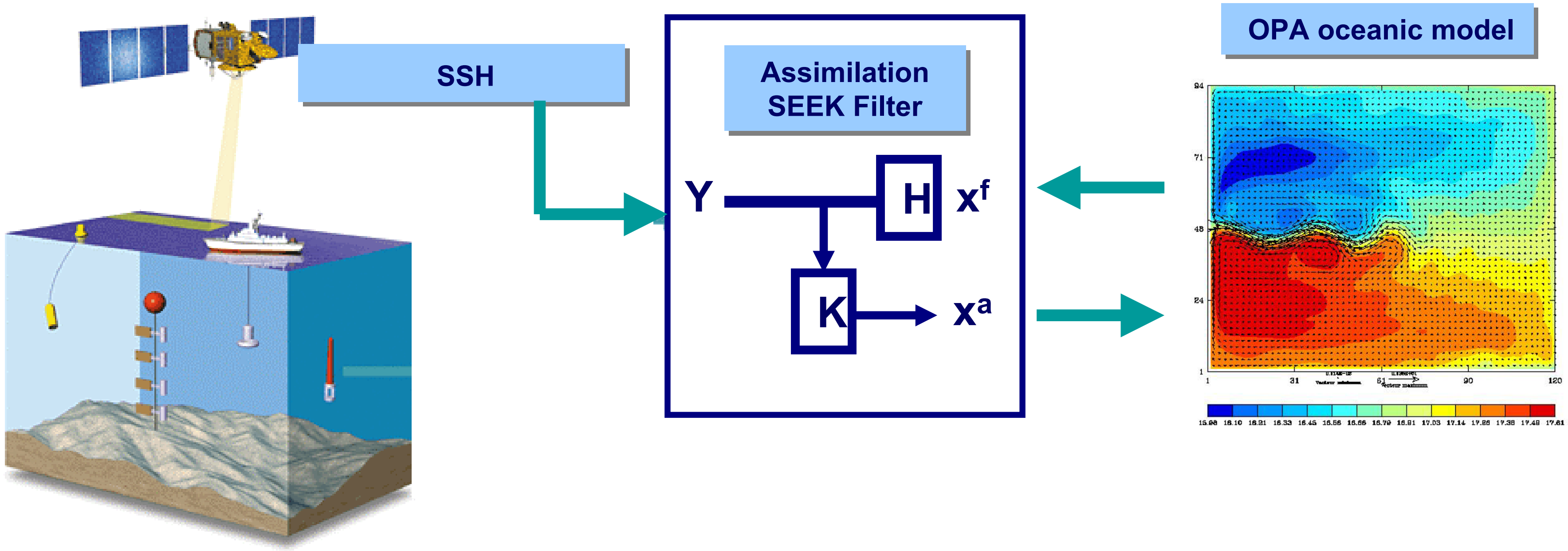
Design assimilation scheme

- *What assimilation scheme to use along track SSH data*
- *How properly estimate all model variables?*
- *What diagnostics?*

Contents

- Objectives of the study
- Tools
    - Circulation model (OPA)
    - Assimilation methodology (SEEK filter)
    - Simulated Observations
- Results
    - Observation system simulation experiments (OSSE)
    - Statistical diagnostics
    - Physical diagnostics
- Conclusions

OBJECTIVES OF THE STUDY



- Assess the ability of mono and multi-satellite missions, present and future, to monitor the mesoscale oceanic circulation
- Using an advanced data assimilation scheme to combine optimally model and observational information
- Study the impact of various observing missions on the model reconstruction.

Circulation model (OPA configuration)

Idealized OPA configuration:

- mid-latitude rectangular box
- driven by zonal winds only
- double gyre circulation
- 1/4° resolution, 11 levels
- zero vertical viscosity and diffusivity
- parameterized horizontal viscosity and diffusivity
- parameterized bottom friction

Eddies generation:

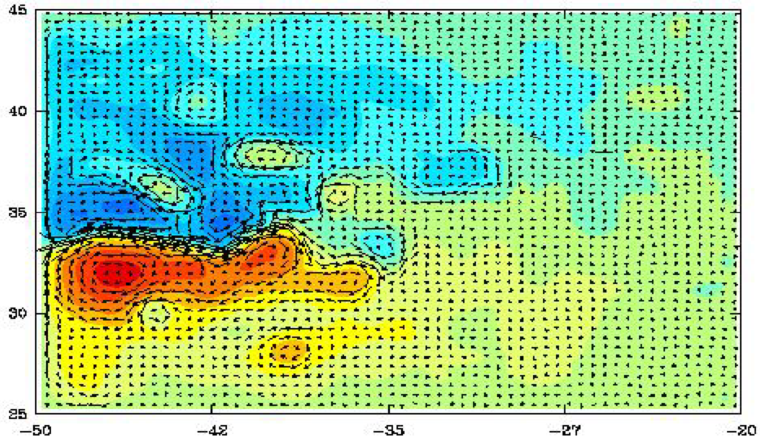
The wind driven double gyre model generates eddies through natural Baroclinic and barotropic insatabilities.

Resolution chosen to resolve the first three baroclinic modes

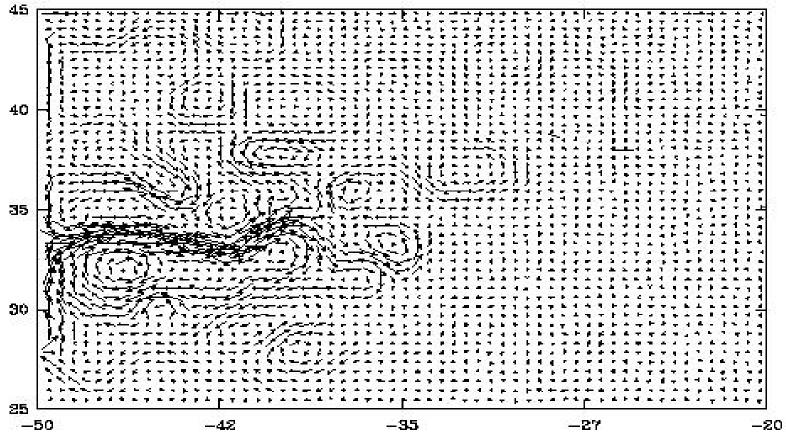
Realistic statistical eddy properties:

R1= 141 km, R2= 71 Km and R3 = 57 Km

Sea surface elevation

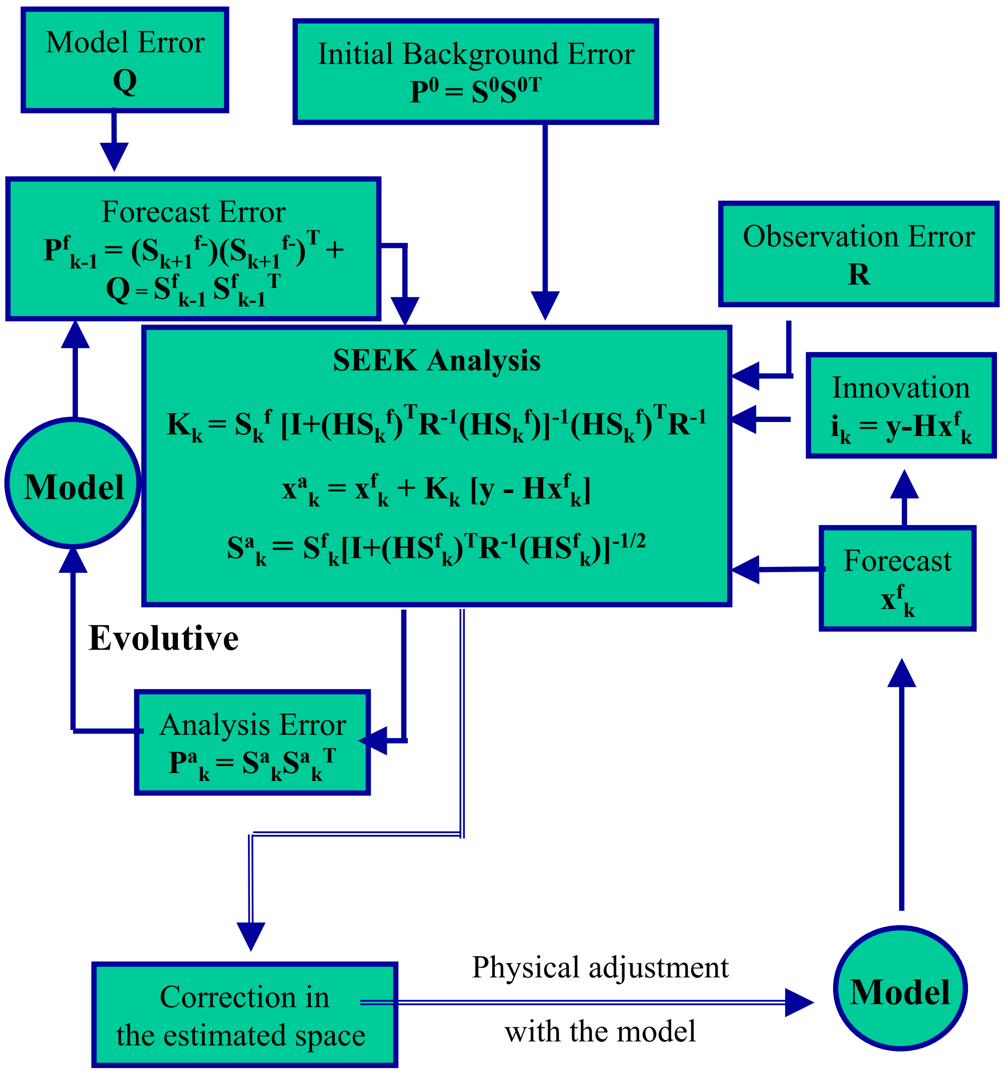


Sea surface velocity



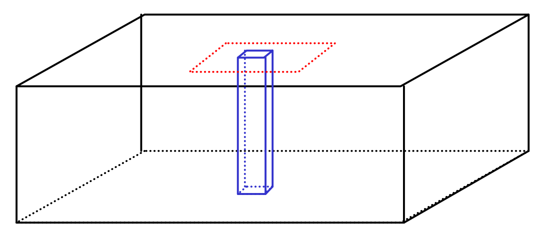
Configuration of the assimilation scheme

The SEEK Filter



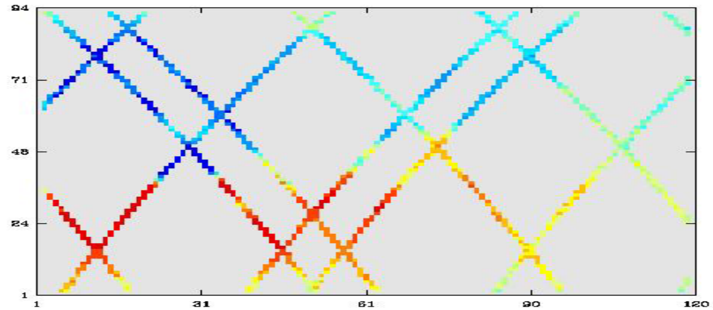
SEEK parameterization	
	OSSE
assimilation window	5days
rank	10
evolutive	yes
adaptive	no
influence bubble	14x14 grid points
initial error modes	EOFs from free run

Local SEEK makes use of the innovation available inside a specified influence bubble

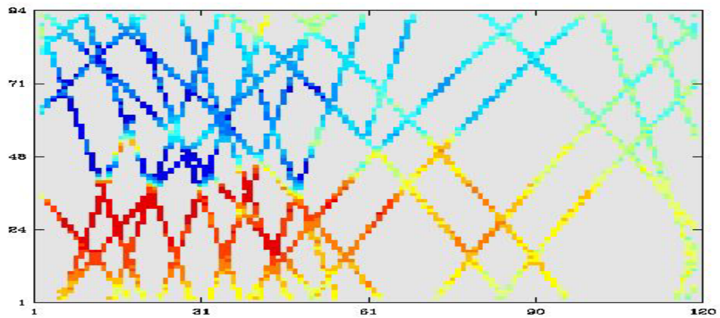


Simulated Observations

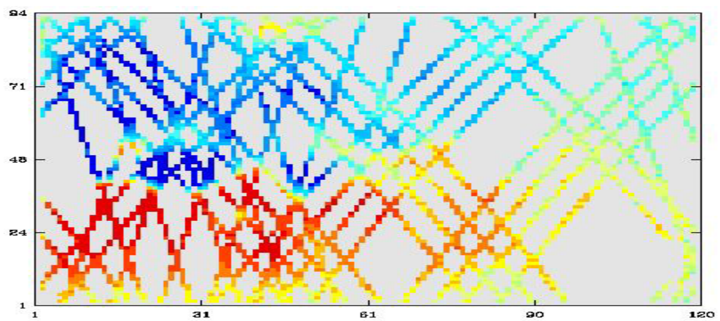
Jason-1



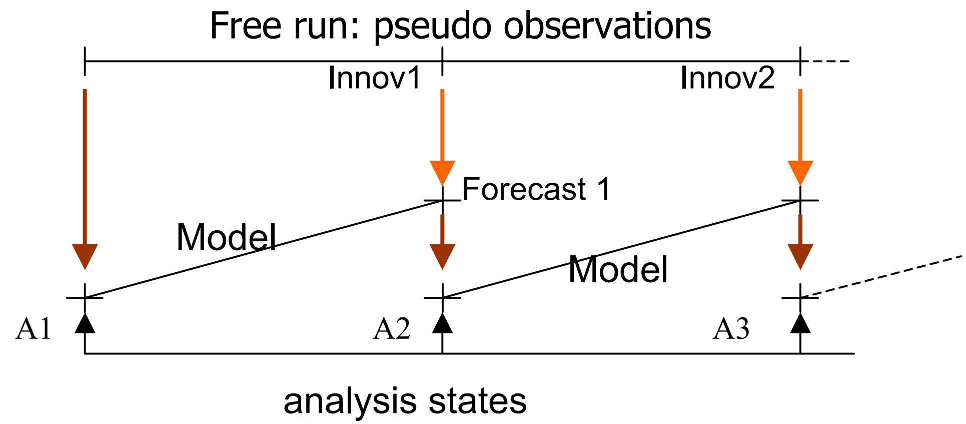
T/P+AltiKa



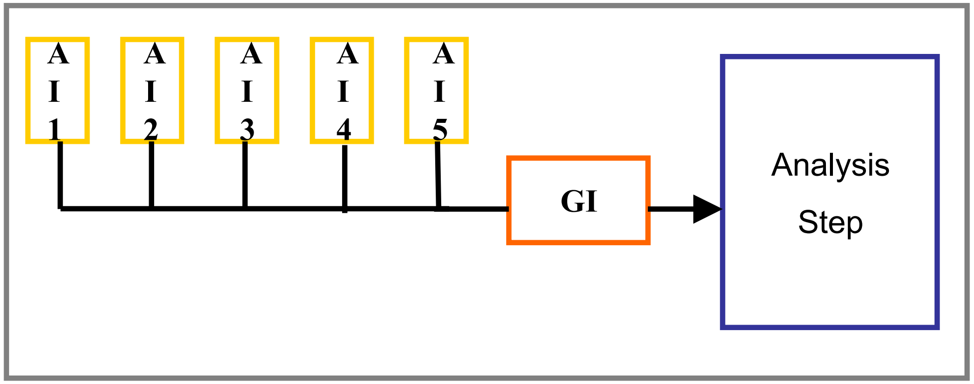
T/P+Jason-1+AltiKa



Sequential assimilation every 5 days



Daily Along-track Innovations (AI) for use during the analysis step



Observation system simulation experiments

Twin assimilation experiments

True Ocean: 1 year of simulation after a 25 years spin up

False Ocean: 1 year of simulation identical to the true ocean but an initial state altered.

Initial condition of the False Ocean:
Based in the first 15 days of the simulation (mean, variance and EOF)

Synthetic observations:
From the true state according to the specific temporal and spatial sampling of the satellite.
A 3cm white noise is added to simulate the measurement error.

Observing system simulation

Present missions:

Topex/Poseidon and *Jason-1*, 10 days of repeat period, high orbit (1336 km).

GFO, 17 days of repeat period, medium orbit (800 km)

Tandem: Jason1-/TP (interleaved)
Jason1-GFO

Future missions:

AltiKa micro-satellite mission project, 35 days of repeat period, low orbit (500 km).

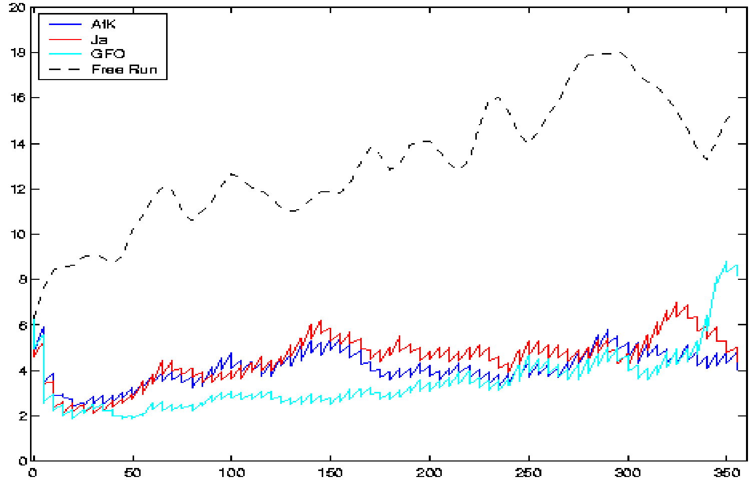
Tandem missions: Spatial offset (SO) and
Time offset (TO)

3 satellite constellations: 3 AltiKa's SO and TO
Jason1-2AltiKa SO
Jason1-2AltiKa TO
Jason1-T/P-GFO
Jason1-T/P-AltiKa

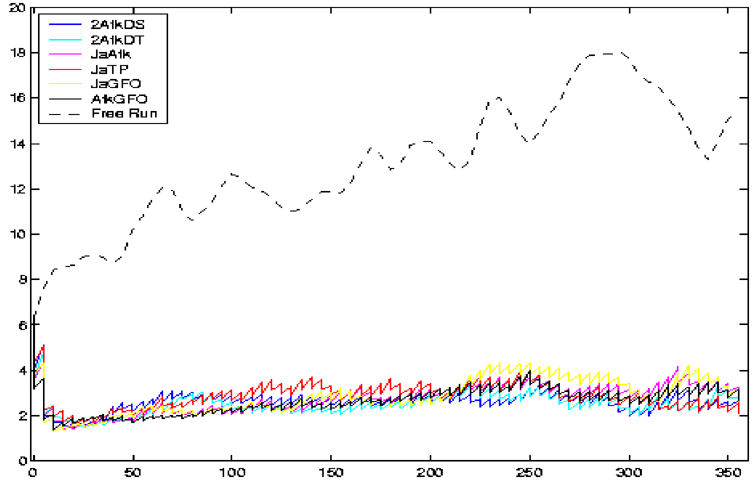
Statistical diagnostics

Time series of SSH RMS differences

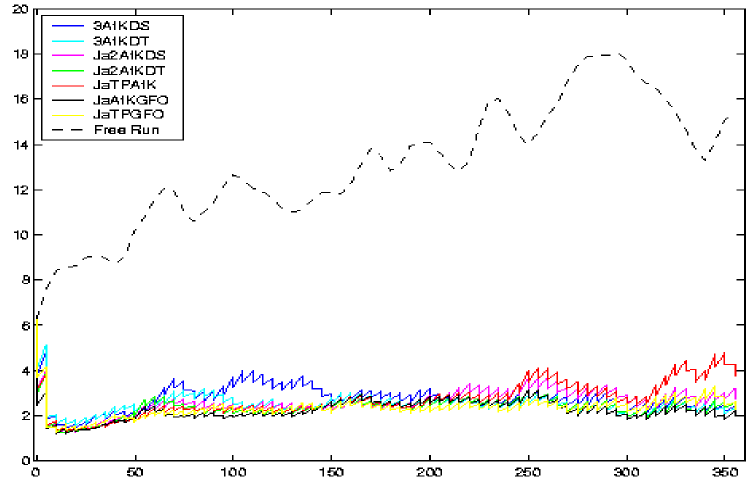
1 satellite



2 satellites



3 satellites

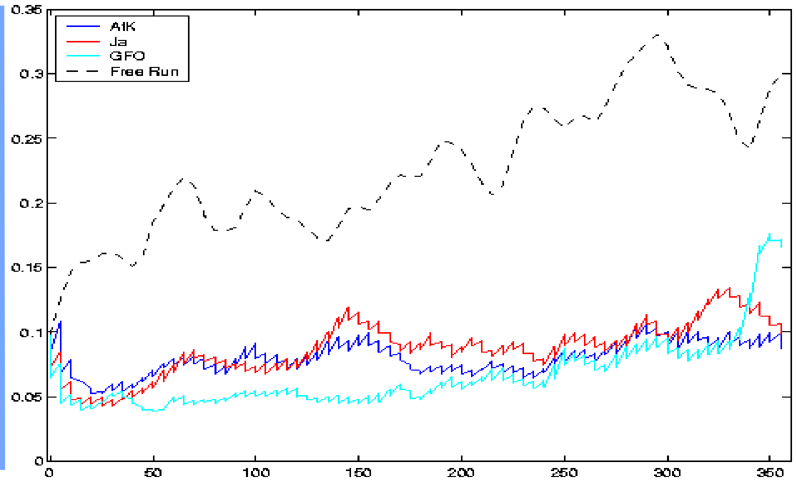


→ **Increasing the number of satellites improves the rms error for the assimilated variable .**
1->2 satellites : 25%
2->3 satellites : 15%

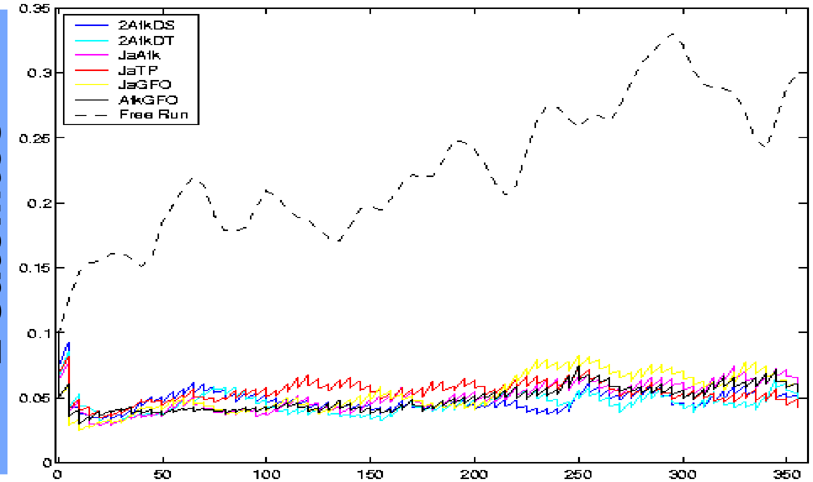
Statistical diagnostics

Time series of Temperature RMS differences

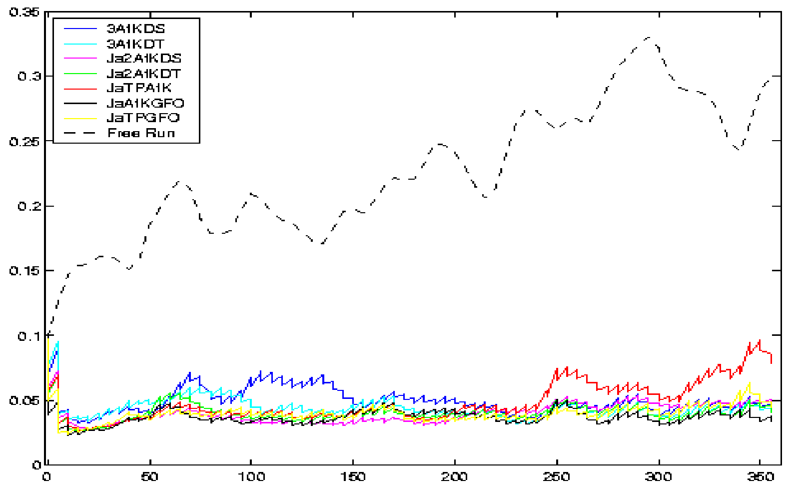
1 satellite



2 satellites



3 satellites



➞ Correction and control of the evolution over non assimilated data.

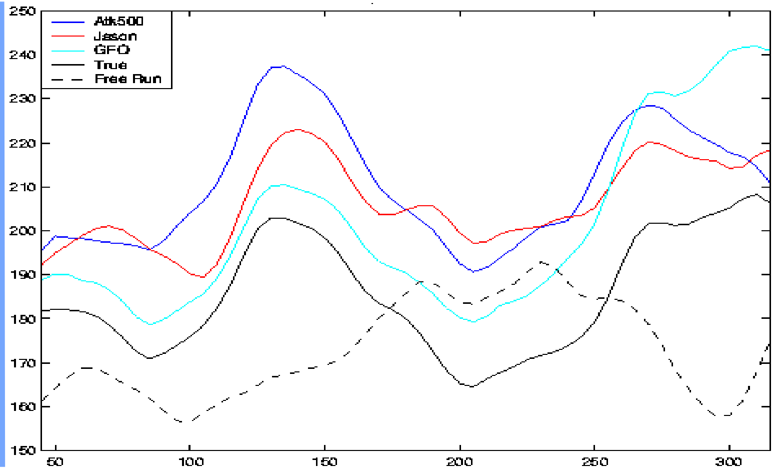
1->2 satellites : 25%

2->3 satellites : 20%

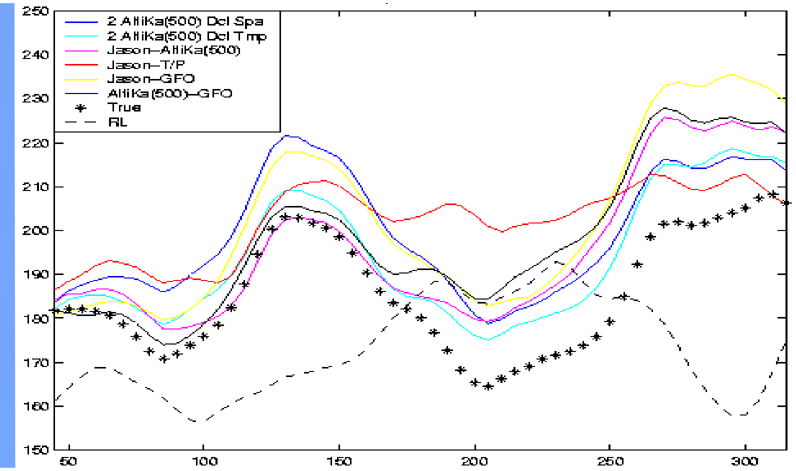
Physical diagnostics

Running mean EKE time series

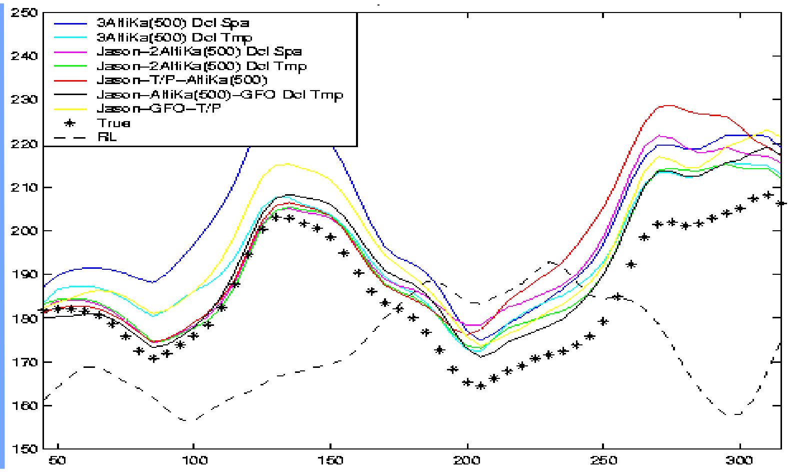
1 satellite



2 satellites



3 satellites



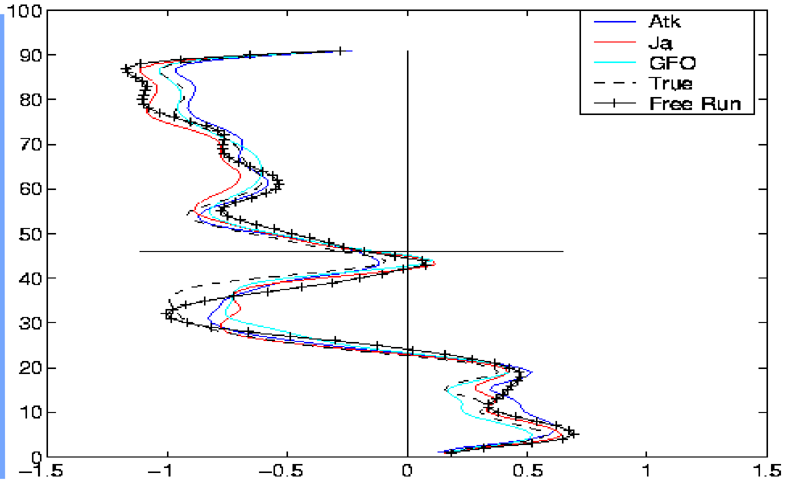
- **Overestimation of the EKE activity is more corrected with a greater number of satellites.**

- **Standard deviation misfit is reduced:**
  1 sat : 60%
  2 sat : 40 %
  3 sat : 30 %

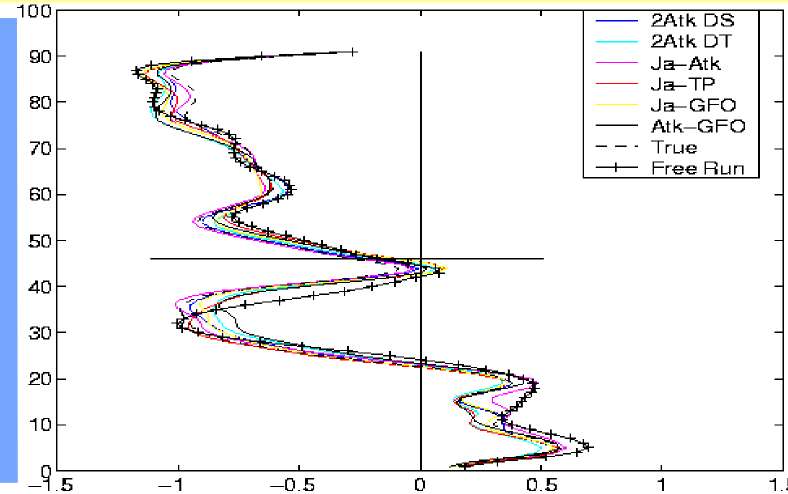
Physical diagnostics

Meridional Eddy induced Heat transport

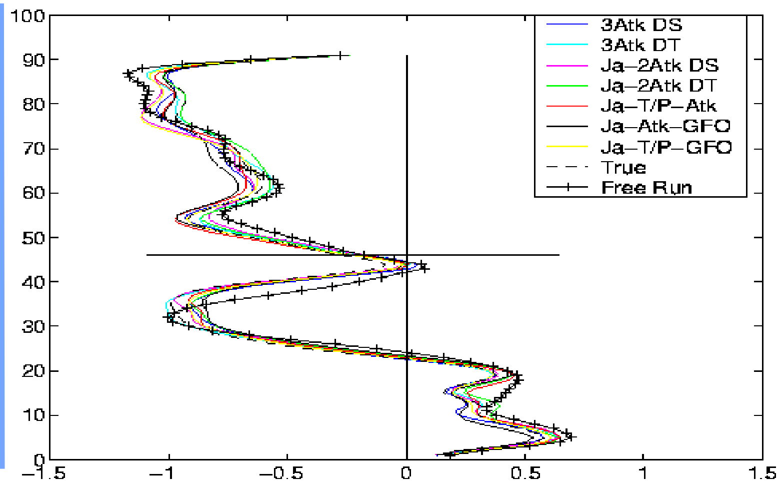
1 satellite



2 satellites



3 satellites



→ **Eddy induced heat transport correction is improved when satellites with the same orbit parameters are used.**

CONCLUSIONS

GENERAL COMMENTS

Using assimilation methods allows us to examine the impact of observational coverage on many various variables of the circulation. From surface to the deep ocean

•The quality of estimation can be sensitive to the choice of the metrics used to evaluate the performance of the observation system.

•The choice of such metrics depends on the operational objectives.

LIMITS

•The addition of a second and then a third satellite contributes significantly to improve the estimation of the mesoscale circulation.

•A three satellite mission seems to be necessary to propagate the observed information to the sub-surface variables .

•Statistical results seems to be more efficient for mixed satellites missions.

•A temporal offset seems to improve the same satellites constellations.

This study has been lead in absence of model error.

In real problems, a better observational coverage may be needed to compensate for inaccuracies in model dynamics.