Reconstructing mesoscales to submesoscales in surface ocean tracers using a back and forth Lagrangian advection with altimetric geostrophic velocities

Guillaume Dencausse

Patrice Klein

Thomas Jaud

Pascal Rivière

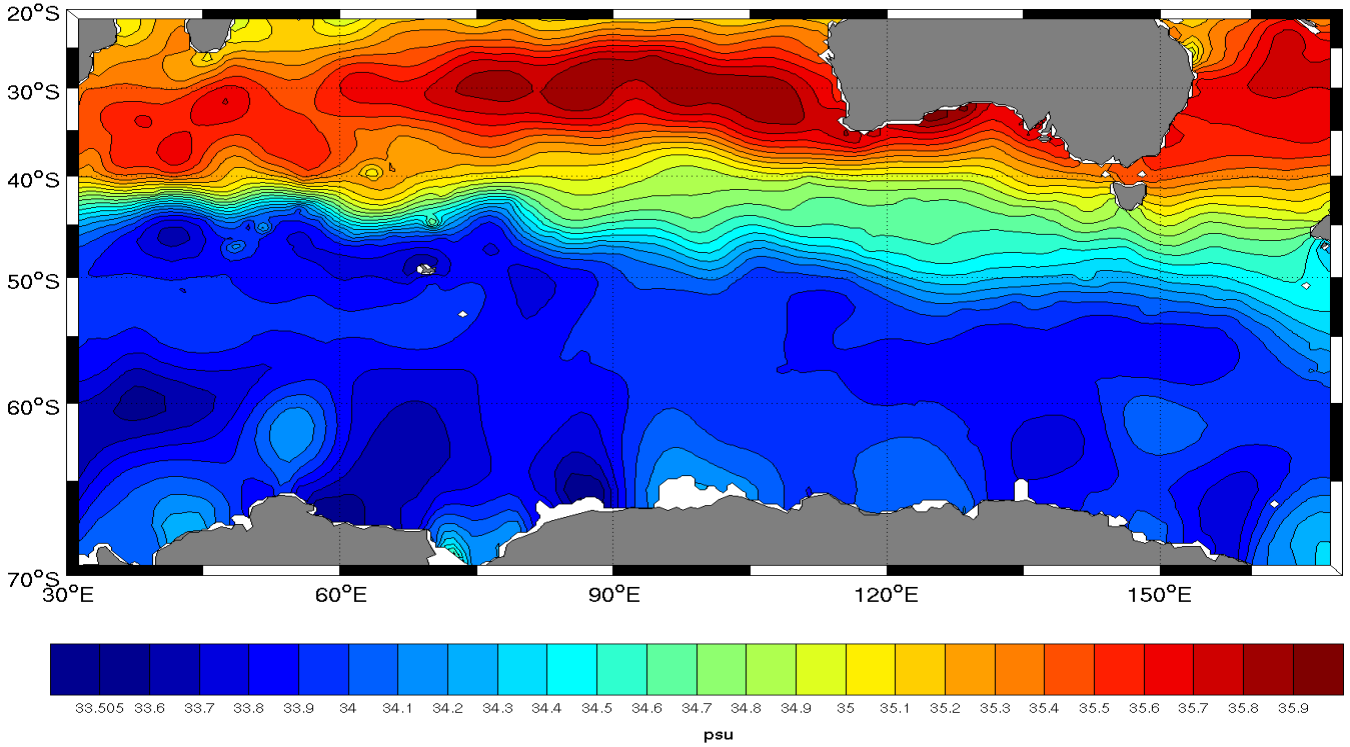
Marine Rogé

Motivations

How well can we reconstruct unresolved scales in large scale tracer using a simple Lagrangian advection with altimetric geostrophic verlocities?

- Large scale I.C. (SSS ~ 200km)
- Mesoscale I.C. (SST~50 km)

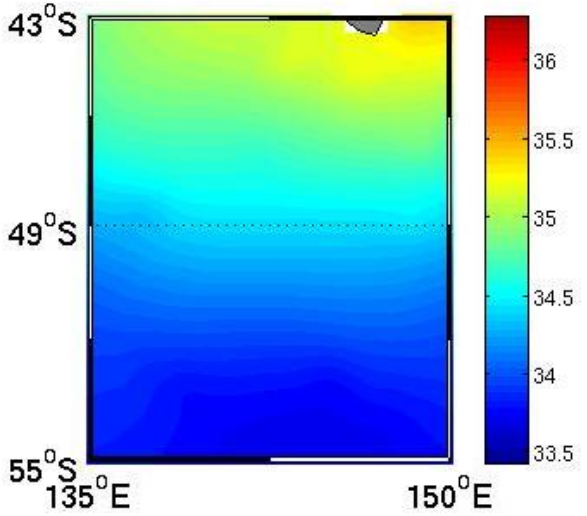
Coriolis SSS on 07/12/2005

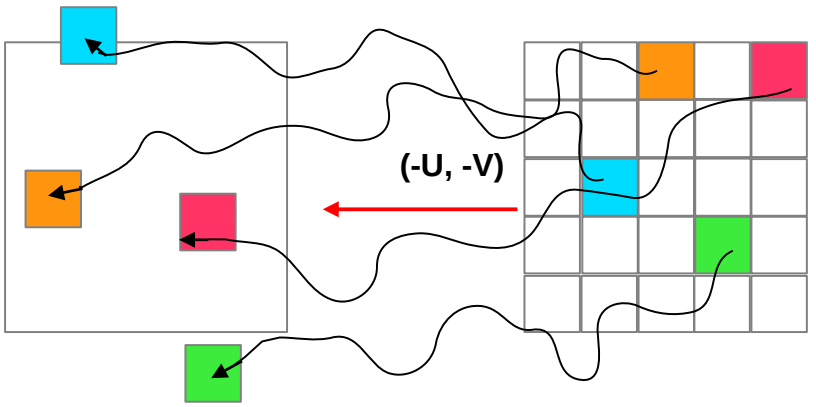


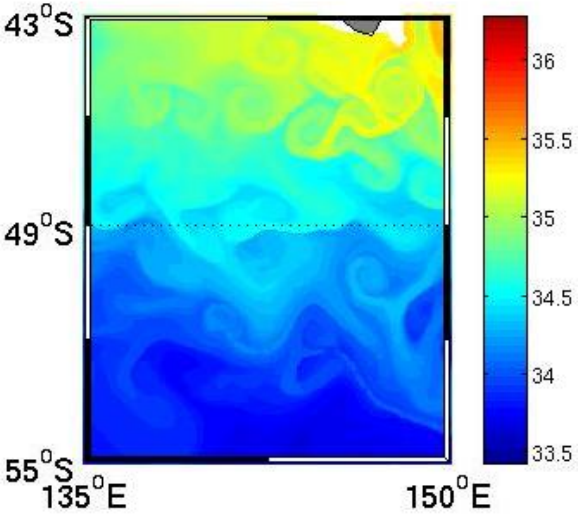
Lagrangian advection with altimetry

Advection technique (D'Ovidio)

- Large scale tracer interpolated onto HR grid
- Particle trajectoires computed (backward) using
  - Altimetric geostrophic velocities (AVISO, weekly 1/3°)
  - dT 3 hours
- Passive transport of tracer







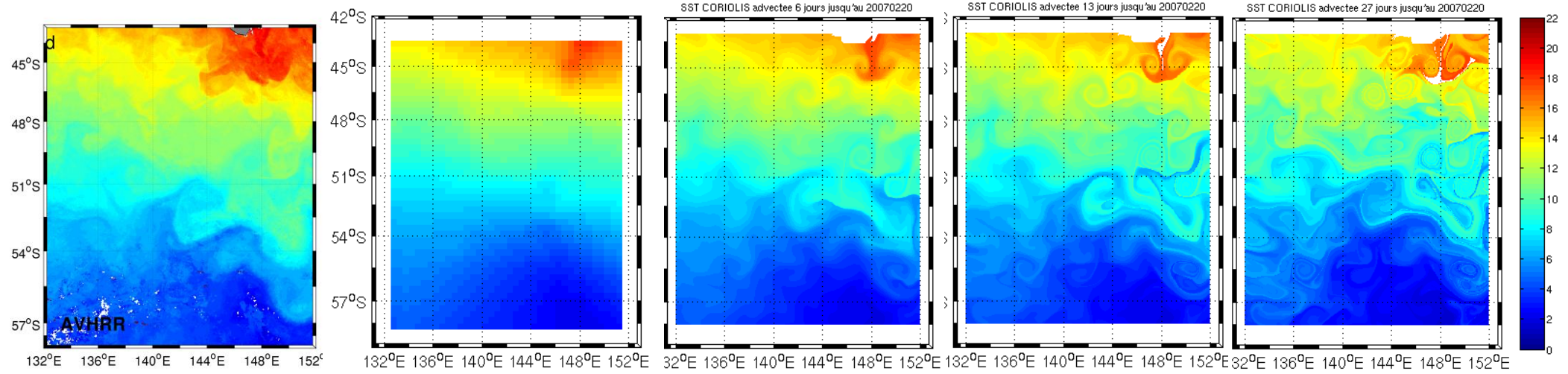
Lagrangian advection with altimetry

Illustration of fine scale development

Coriolis at T-27 days

Coriolis at T-13 days

Coriolis at T-6 days



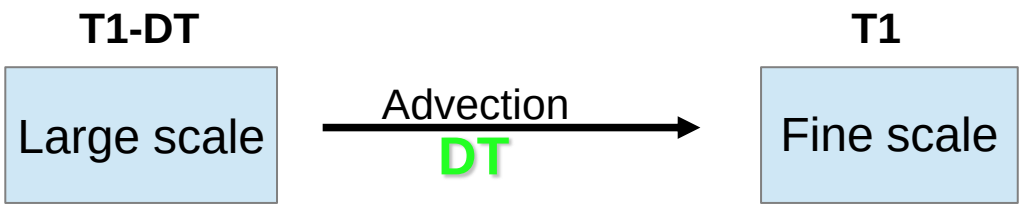
AVHRR SST

Coriolis SST

Advections of Coriolis SST

2 Possible approaches

« Forward »

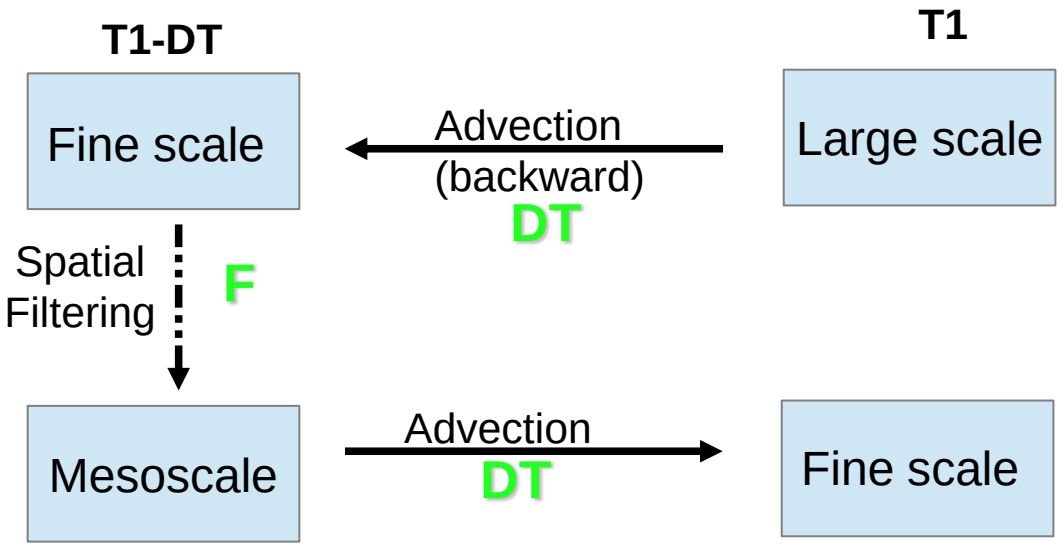


Parameter: DT

Errors:

- missing physics
- errors in velocity fields and advection scheme

« Back & forth »



Parameters: DT , F (Filter scale)

Errors:

- ~~missing physics affecting initial scales~~
- errors in velocity fields and advection scheme
- « information loss » when filtering **F**

Outline

Comparative study of the 2 approaches for SSS type tracer

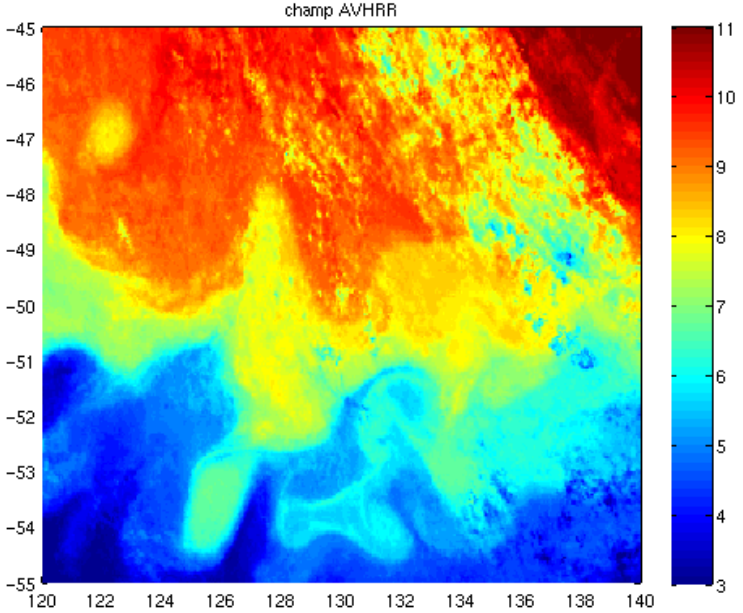
- Parameters analysis (**DT** and **F**)
- Performances and limitations of each
- Conclusions and possible improvements

Comparative study

Setup

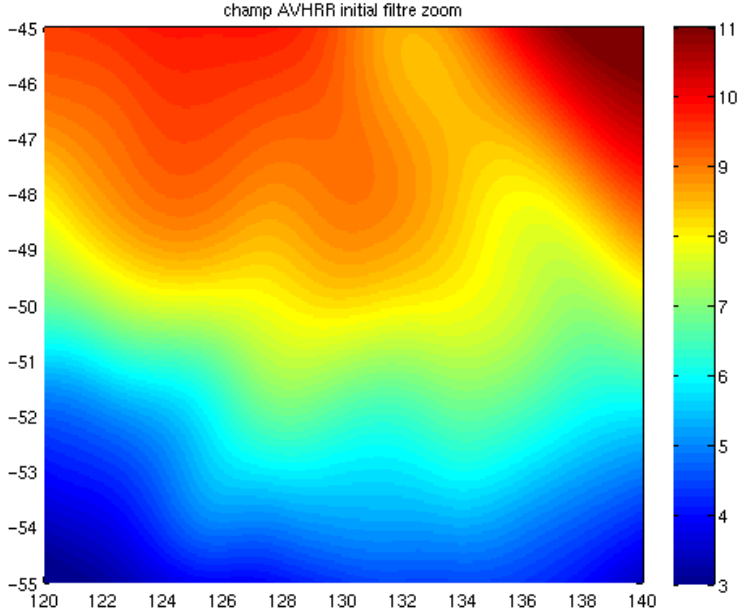
- I.C. from AVHRR HR SST : non-biased tracer
- Gaussian filter ~200 km (SSS type)
- Region of study: ACC (ACC fronts + strong submesoscale activity)

AVHRR



filtrage

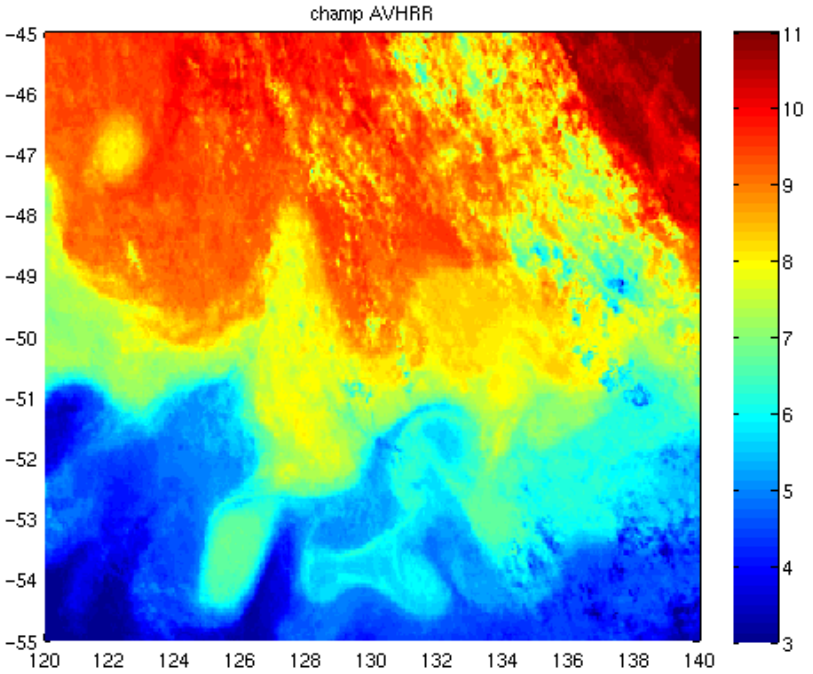
I.C.



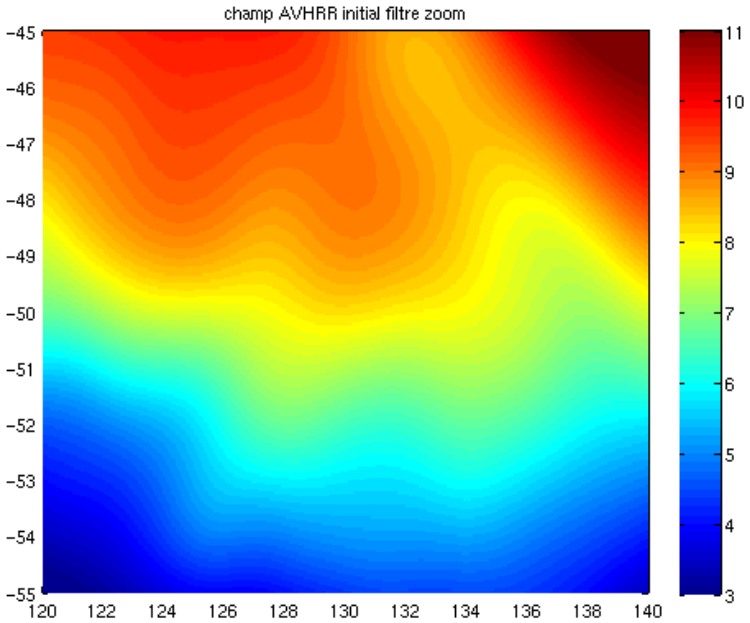
Comparative study

Forward advection

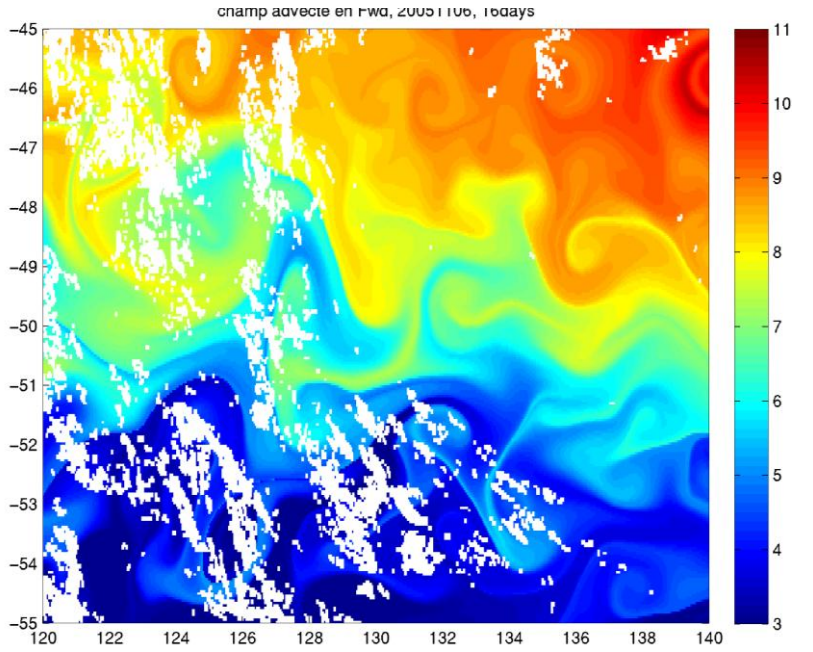
AVHRR



I.C.

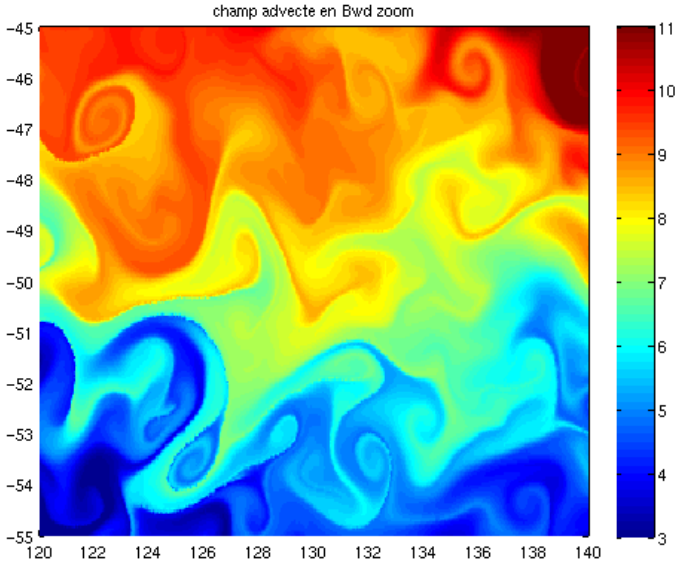


DT=16jrs

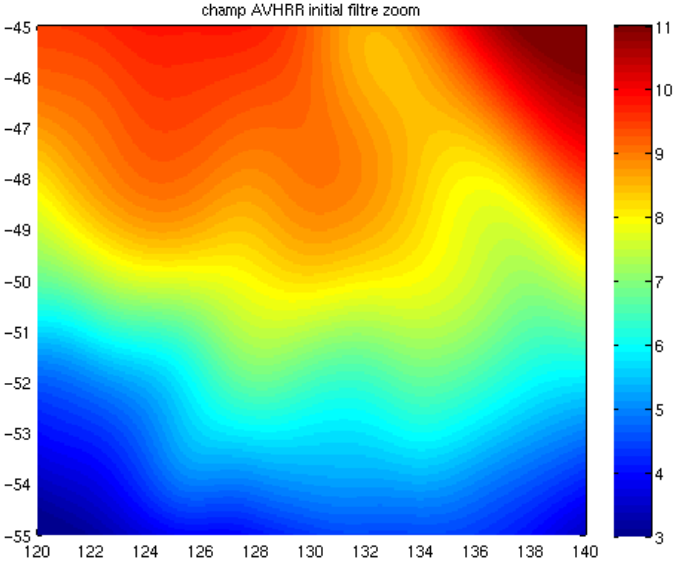


Comparative study

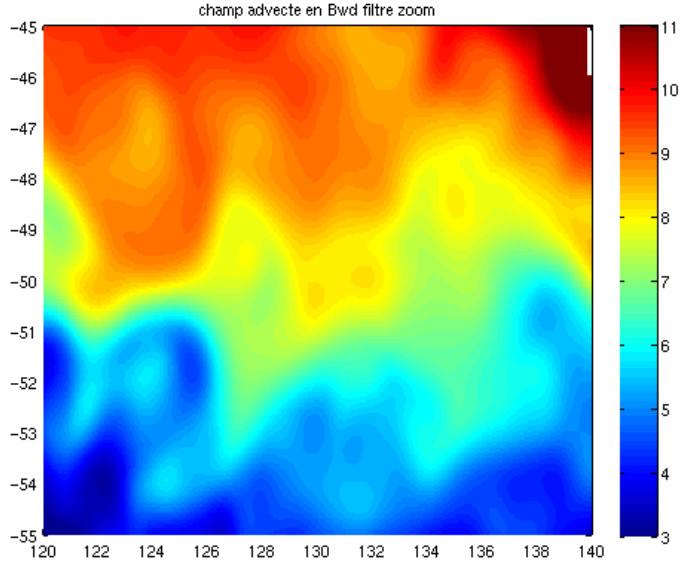
Back & forth advection



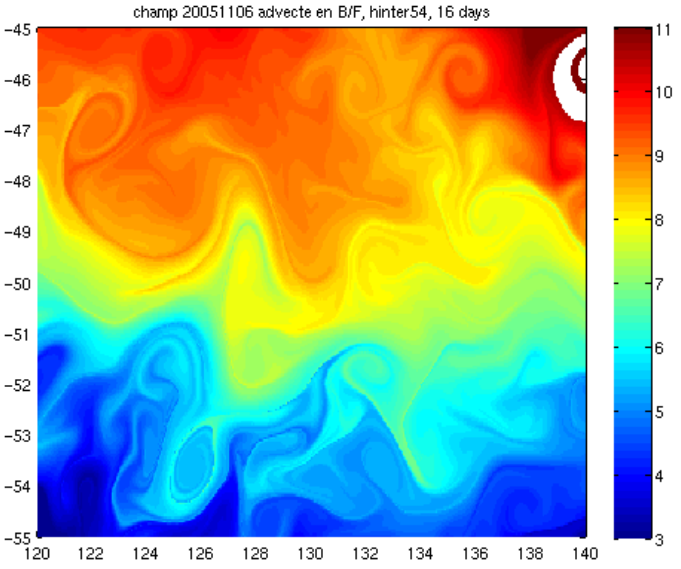
DT=16jrs



F Gaussian (σ=0,36°)



DT=16jrs

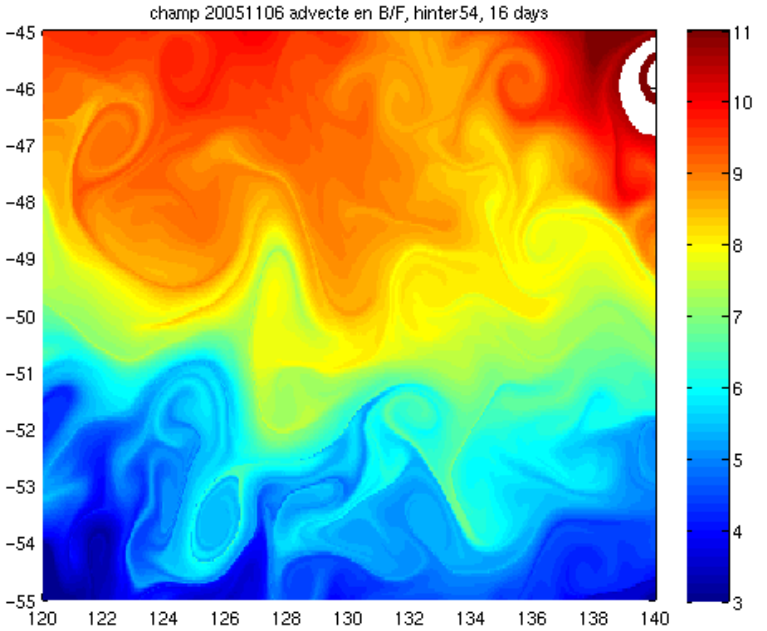


Comparative study

Comparison

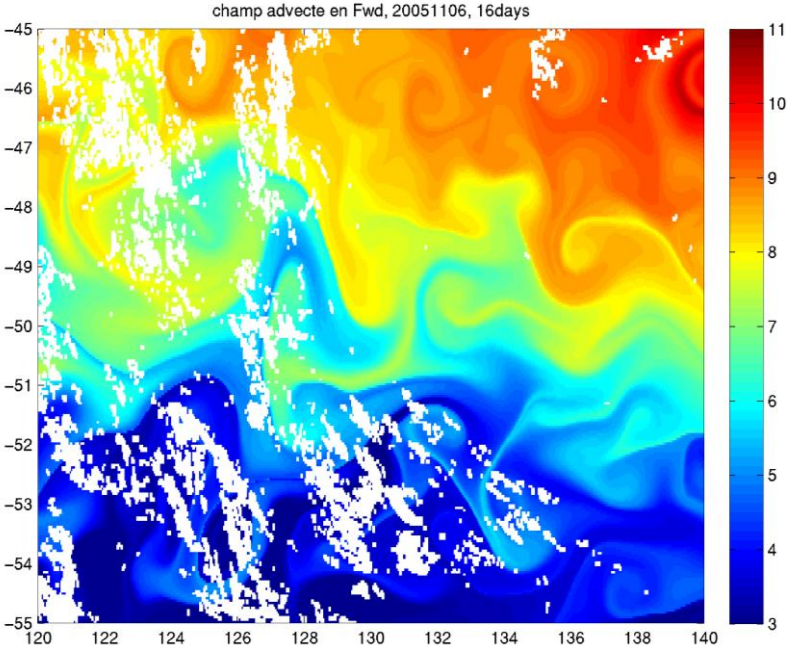
- No large scale bias in B&F
- Finer scales comparable

Back & forth



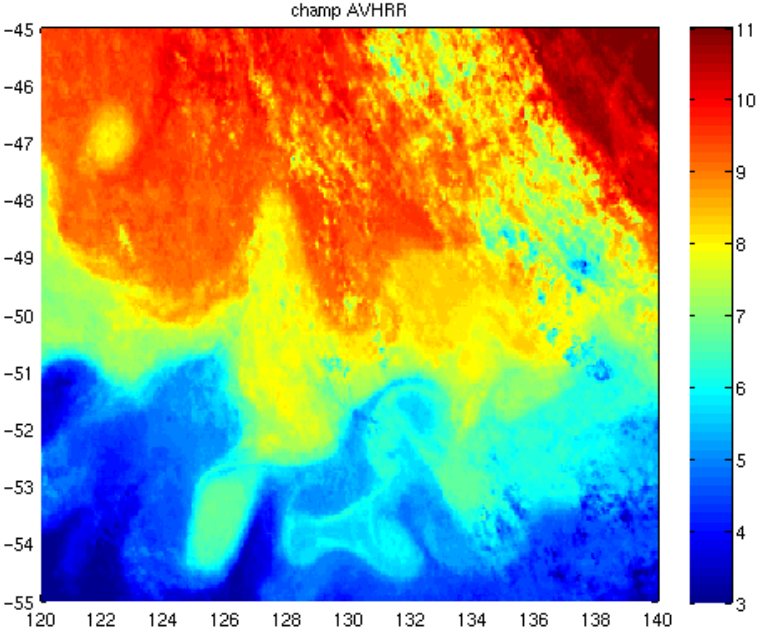
DT= 16jrs ; F (sigma=0,36°)

Forward



DT= 16jrs

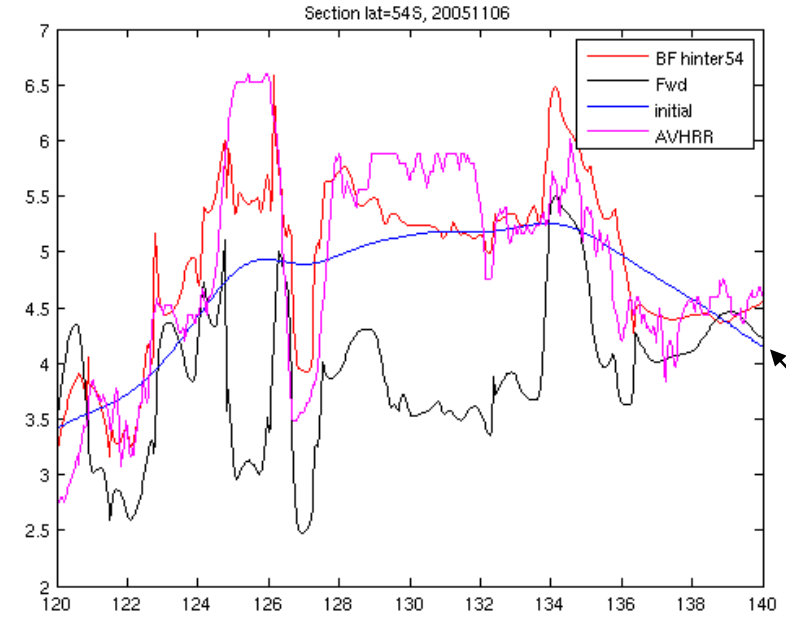
AVHRR

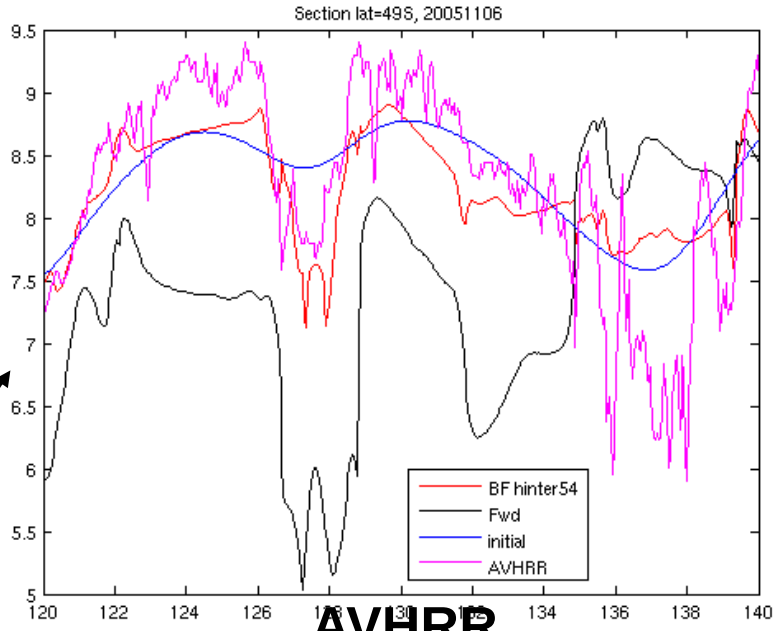


Comparative study

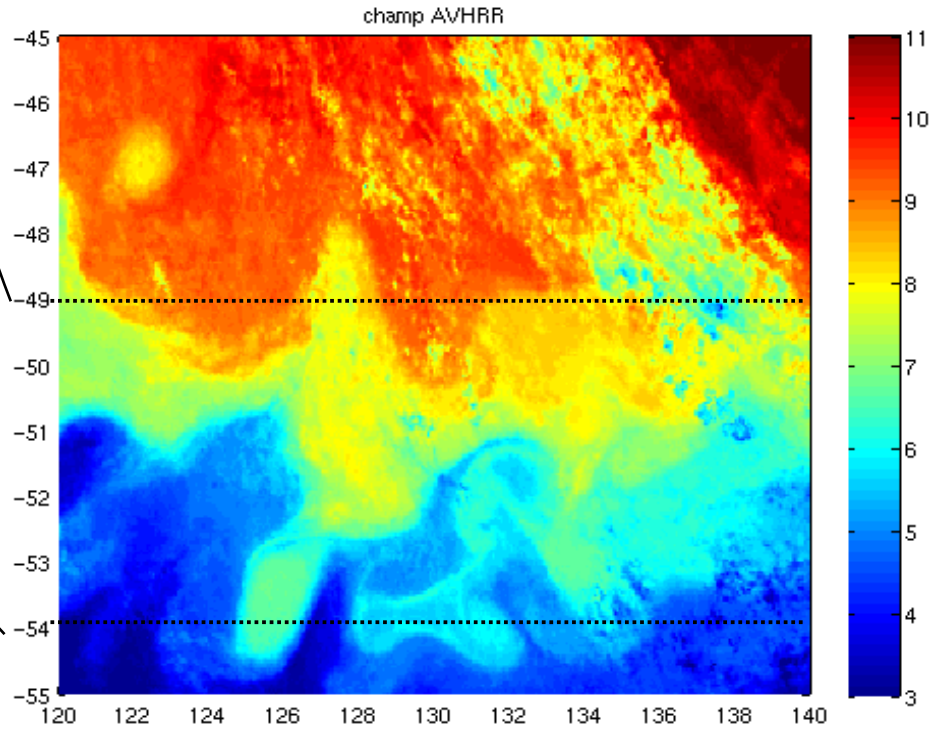
Comparison

- No large scale bias in B&F
- Finer scales comparable





AVHRR

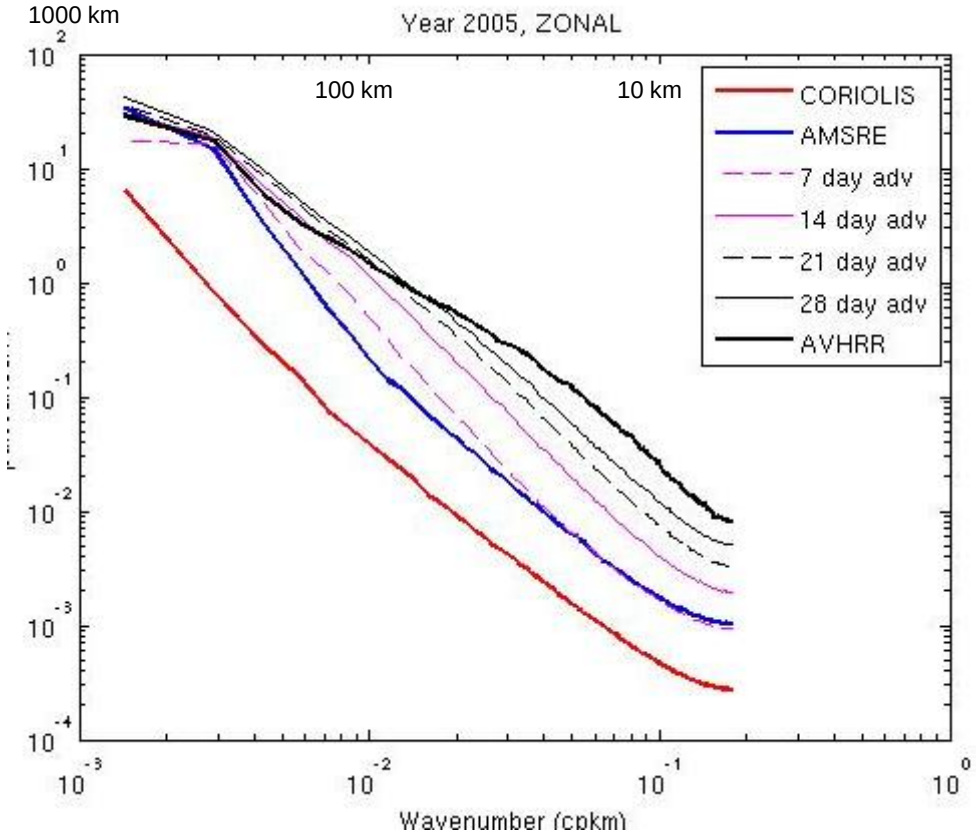


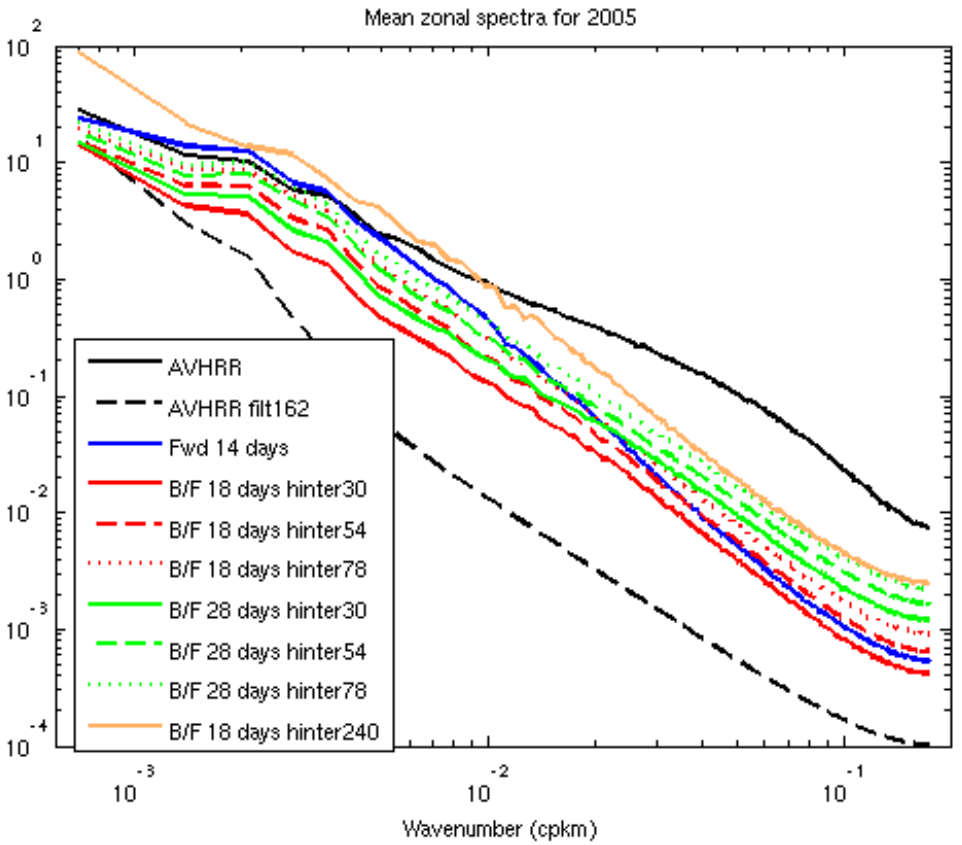
Parameters DT and F

« Forward » advection

- study south of Tasmania: **DT** = **2 weeks**
  - best energy levels of SST spectra
  - good statistical representation of submesoscales

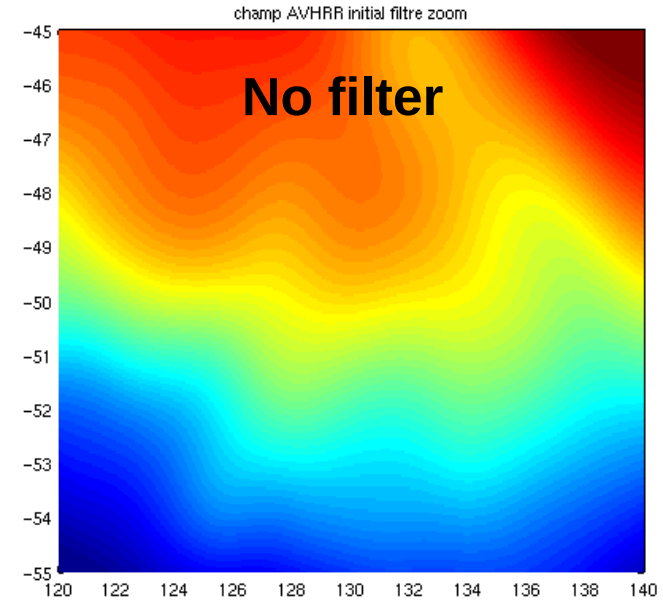
- similar in this ACC region





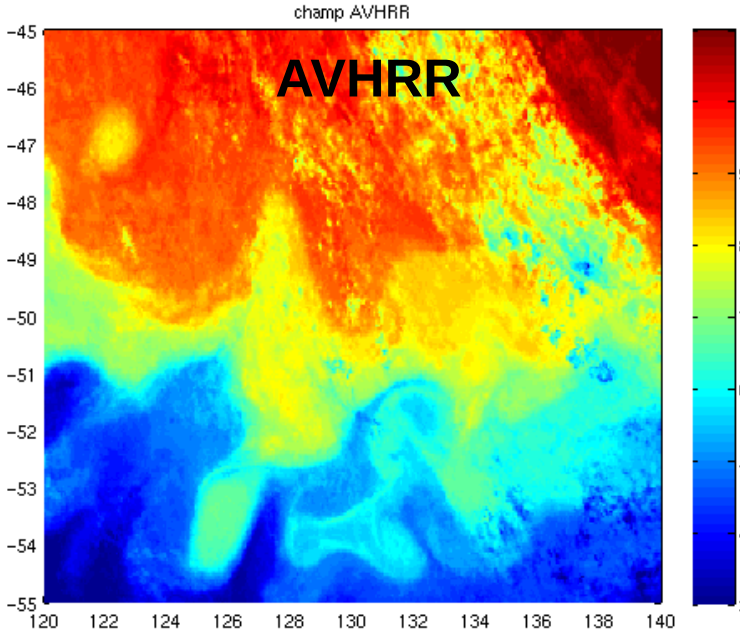
Parameters DT and F

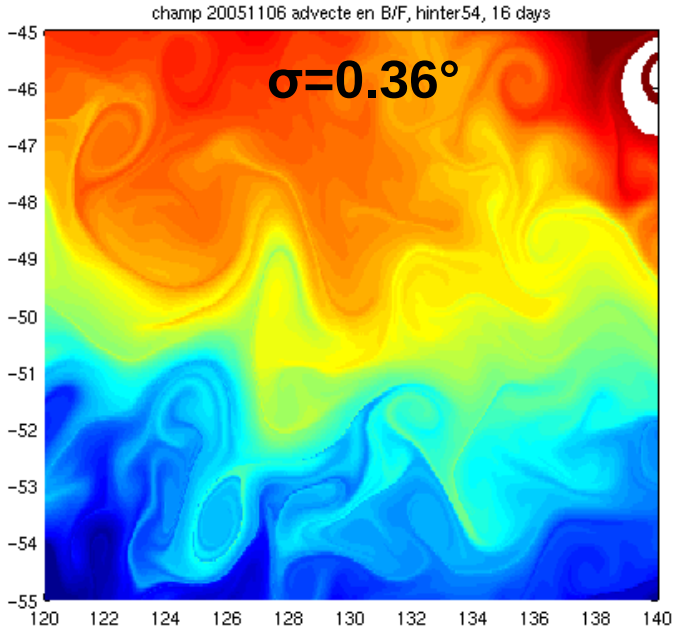
« Back & forth » advection

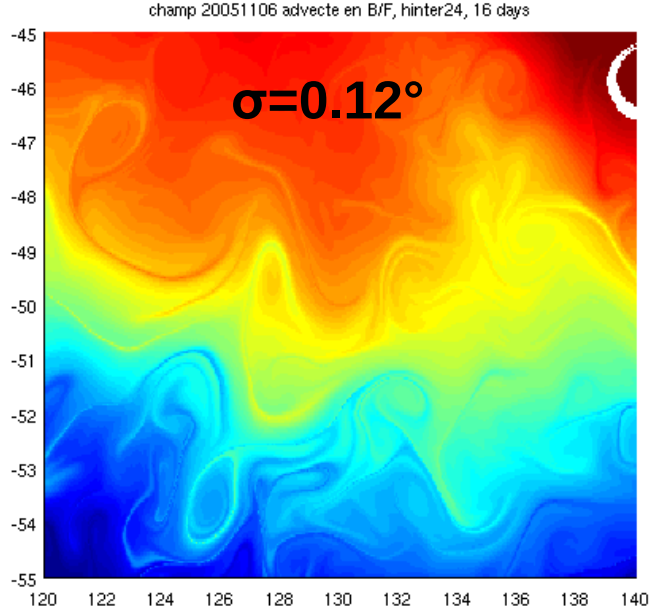


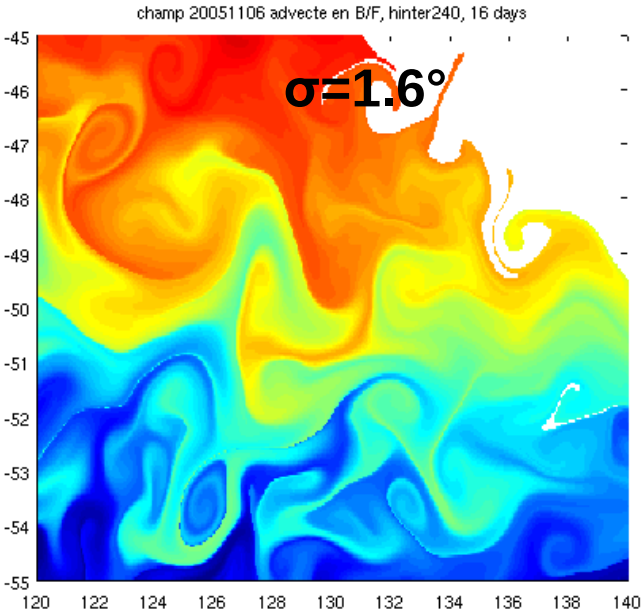
Effect of Filter size F

↗ filtering = ↗ fine scales









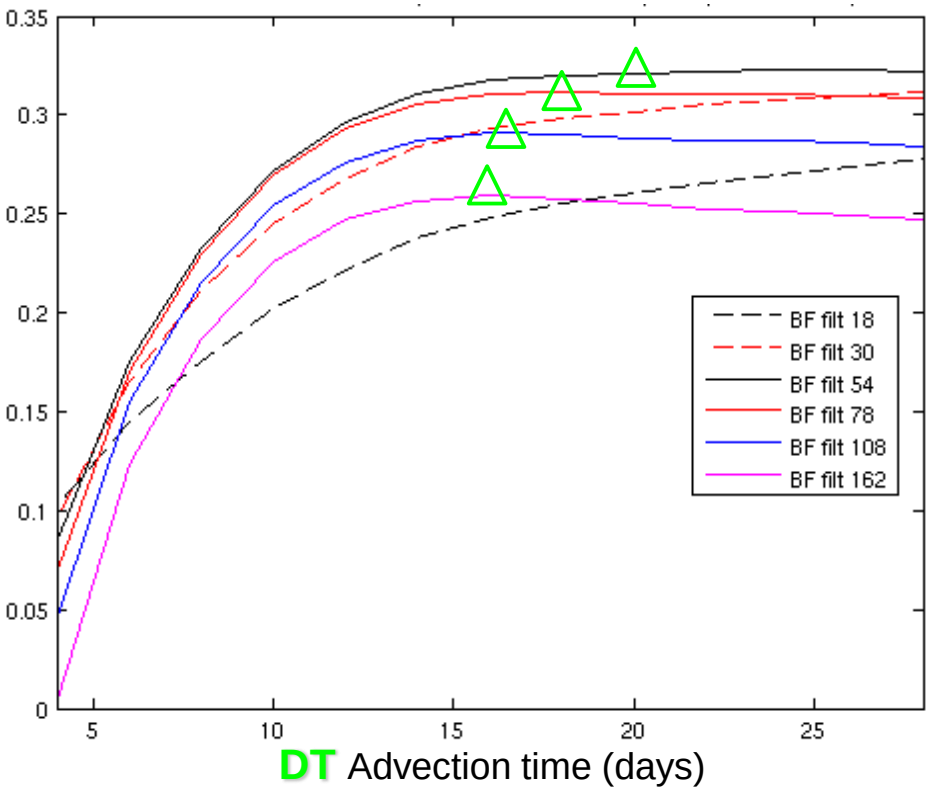
Parameters DT and F

« Back & forth » advection

- Correlation ↗ then ↘ with **F** scale
- Optimum △ at increasing **DT** as **F** decreases

Optimum : **F** ~25km (0,36°), **DT** = 15 to 20 days

Correlation
(Trec-I.C.) and (AVHRR-I.C.)



Analysis of reconstructions

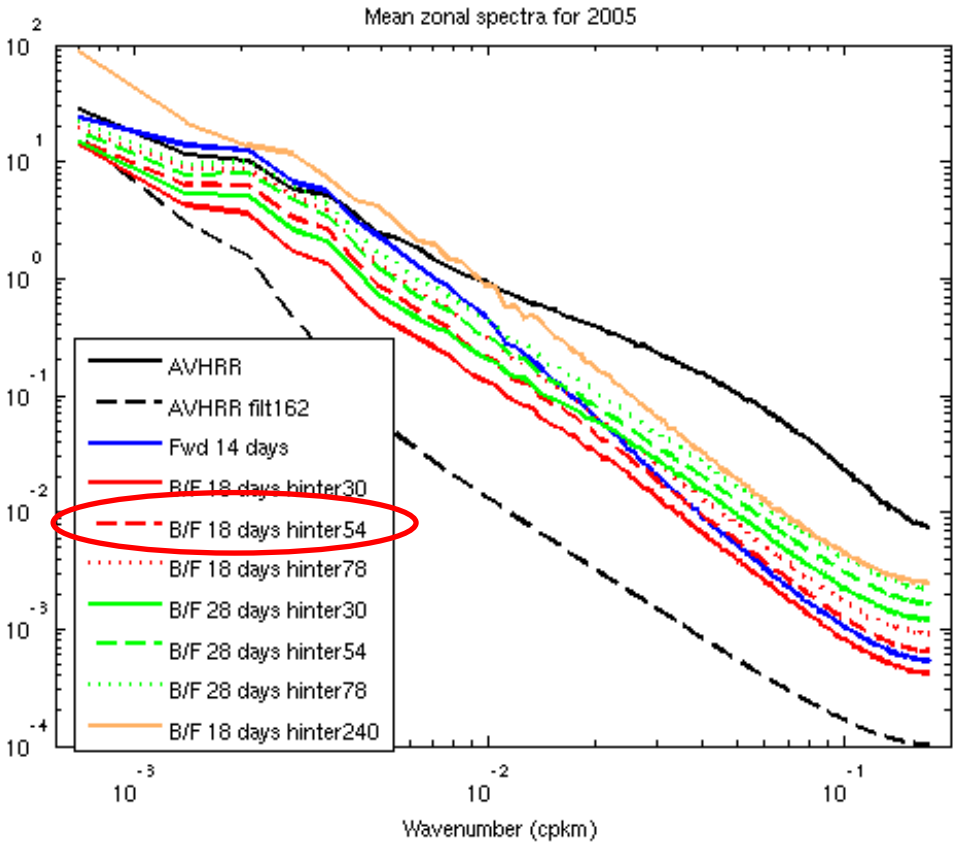
Spectral signature

« Back & forth » advection

-energy injected at all scales as **DT** or **F** increase

- weaker energy at large scales due to intermediate filtering :

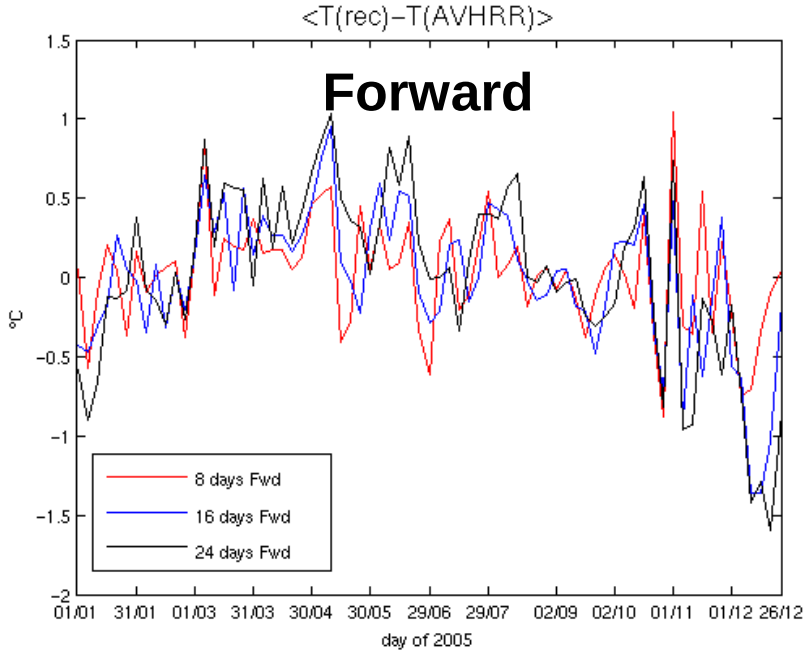
large to submesoscales too « smooth »

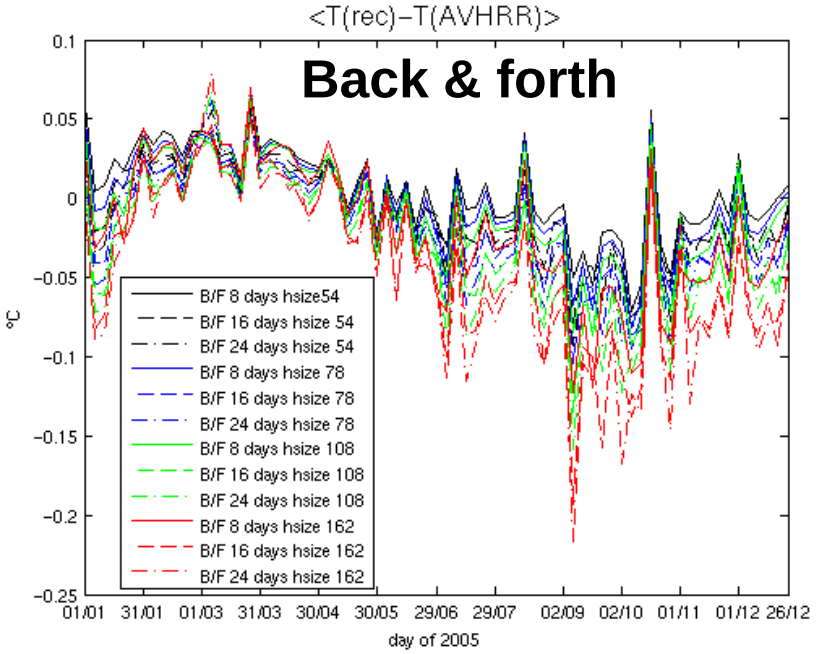


Analysis of reconstructions

Large scale component of bias

Reduction by factor ~10 (elimination of air-sea-fluxes)

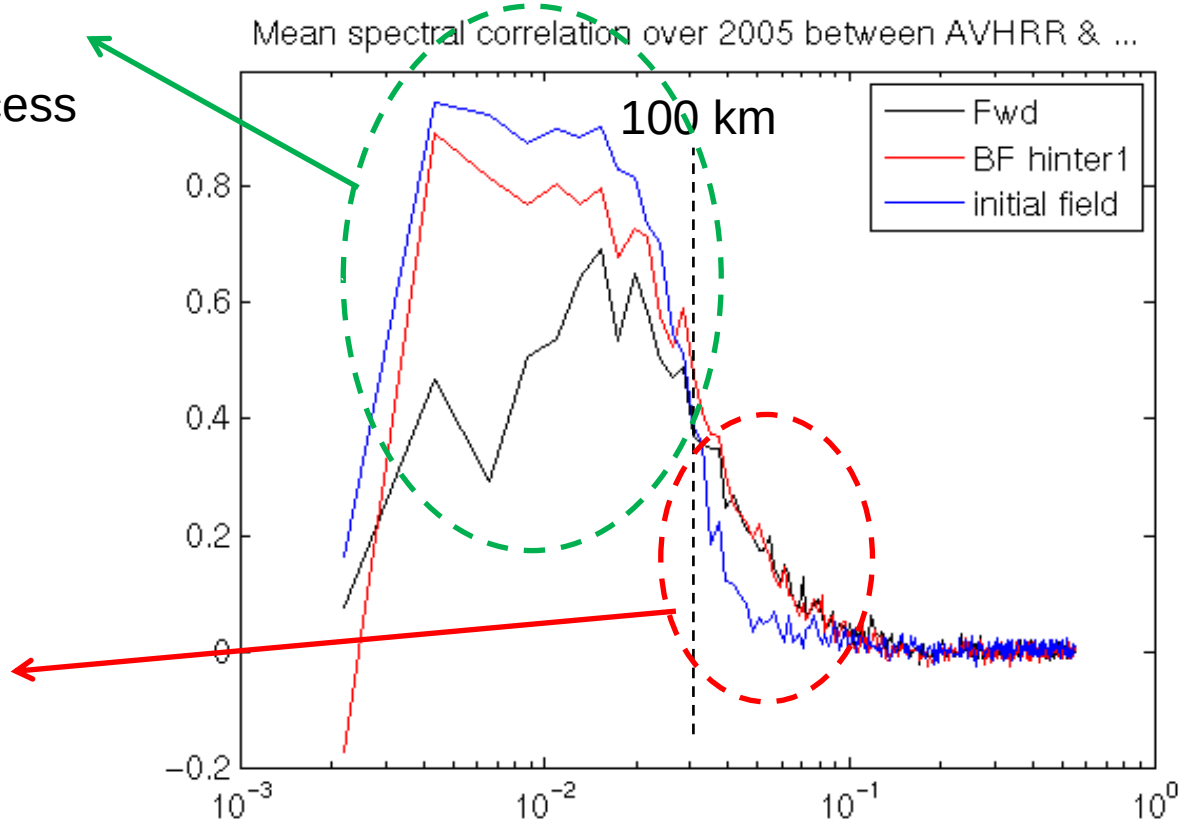




Analysis of reconstructions

Large scales to mesoscales (~100 km)

« Back & forth » better despite excess smoothing (eliminated physics)



Scales <~100 km

Similar improvements

Application to Coriolis products (Marine Rogé)

• ***Applicability to different regions (dynamics) ?***

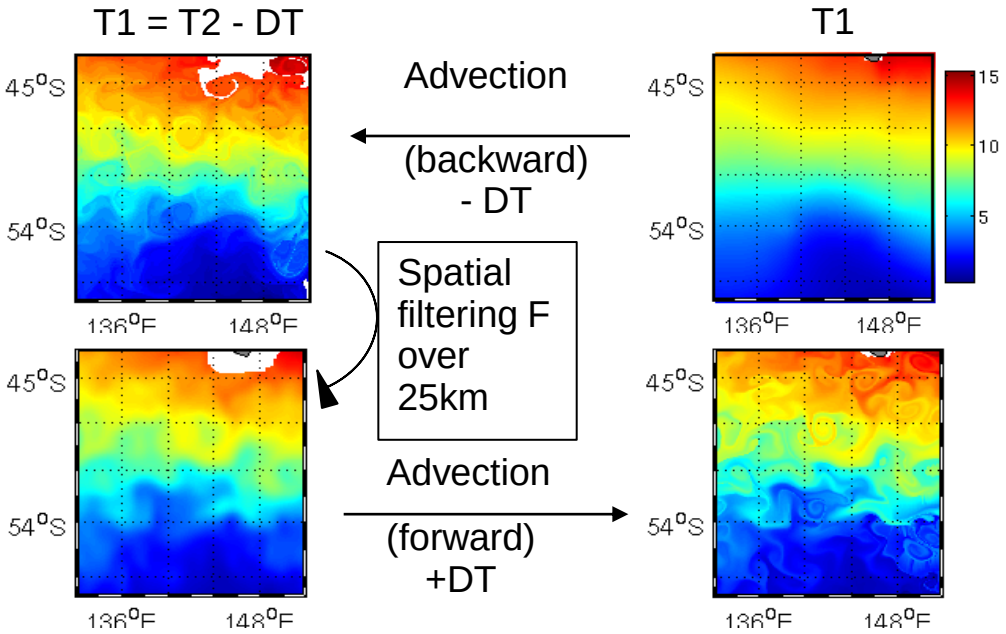
• I.C. Coriolis OA from floats

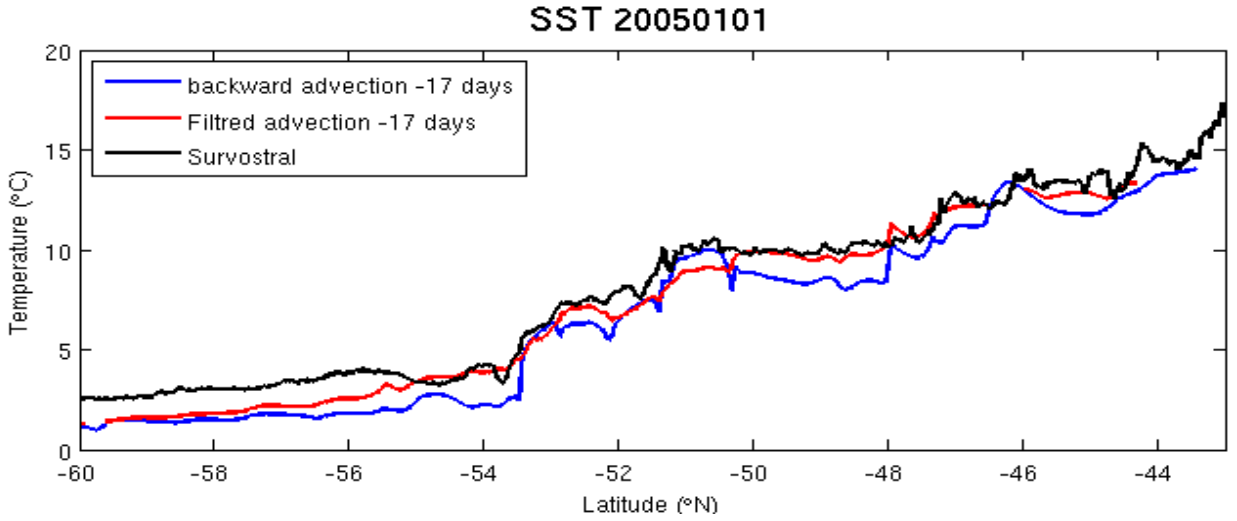
• Analysis & validation with satellite and large in-situ datasets

South of Tasmania

• reduced overall bias

• higher F (35km) for more higher energy



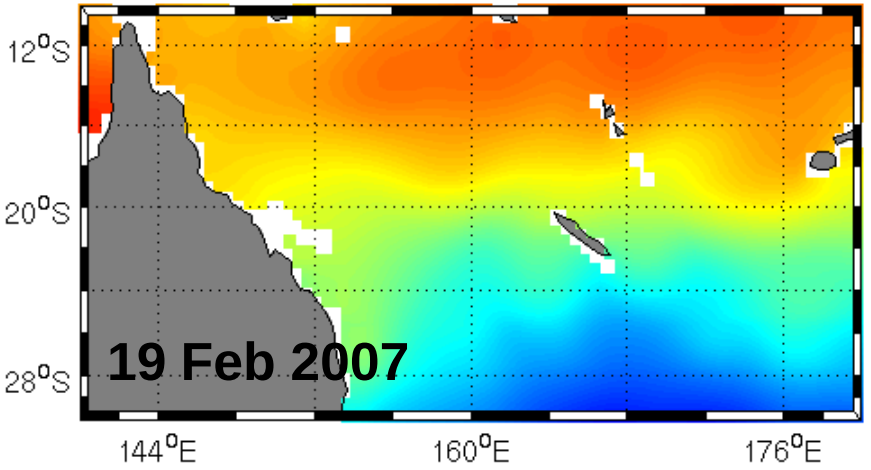


Application to Coriolis products (Marine Rogé)

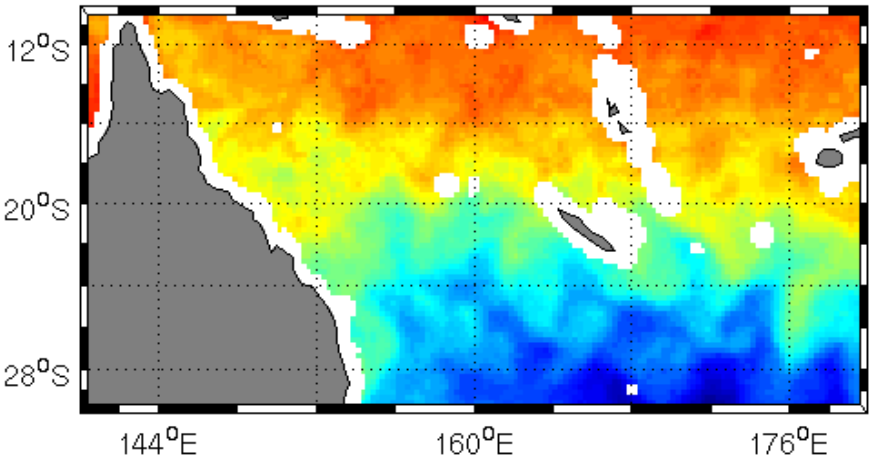
Western Pacific

- more energy could be injected in B & F with larger DT

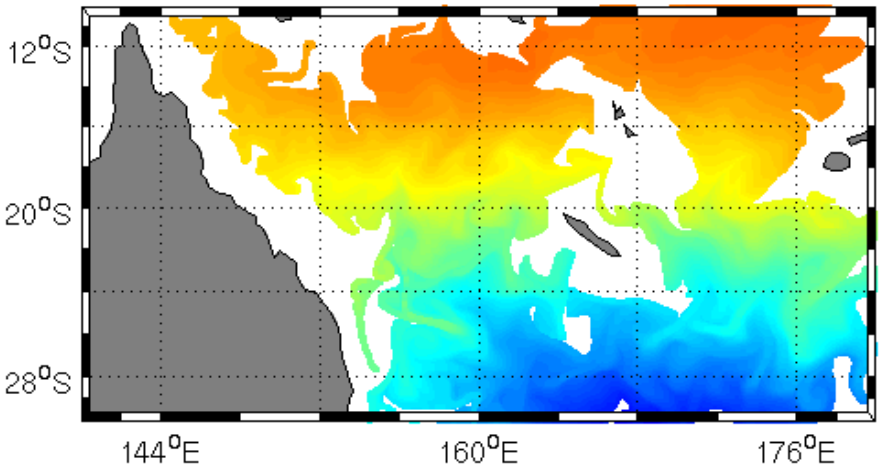
Coriolis



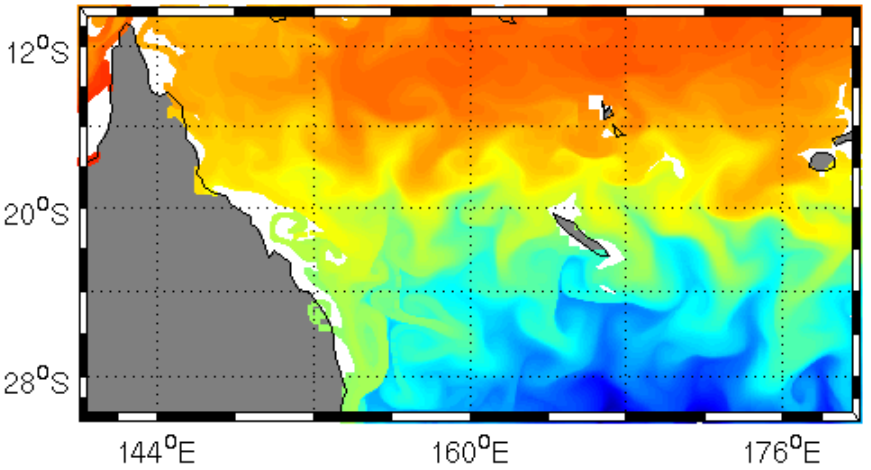
AMSR-E



B & F (12 days, σ(F)=0.36°)



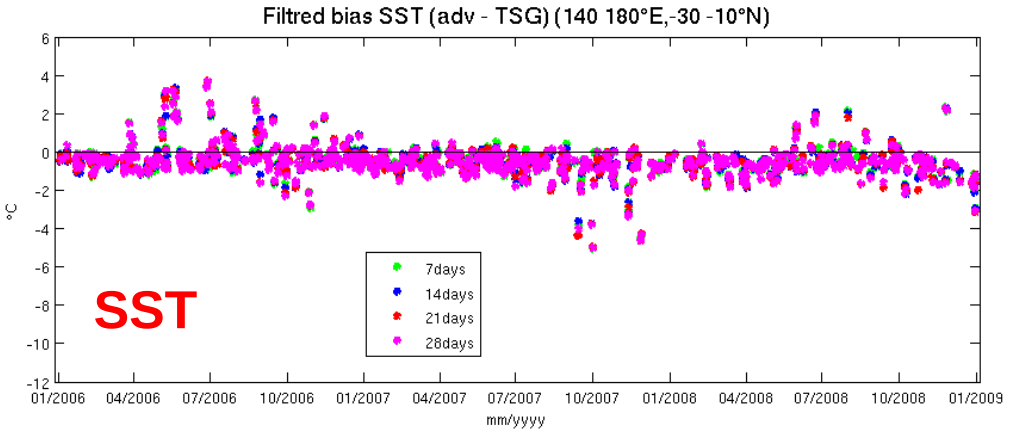
Forward (12 days)

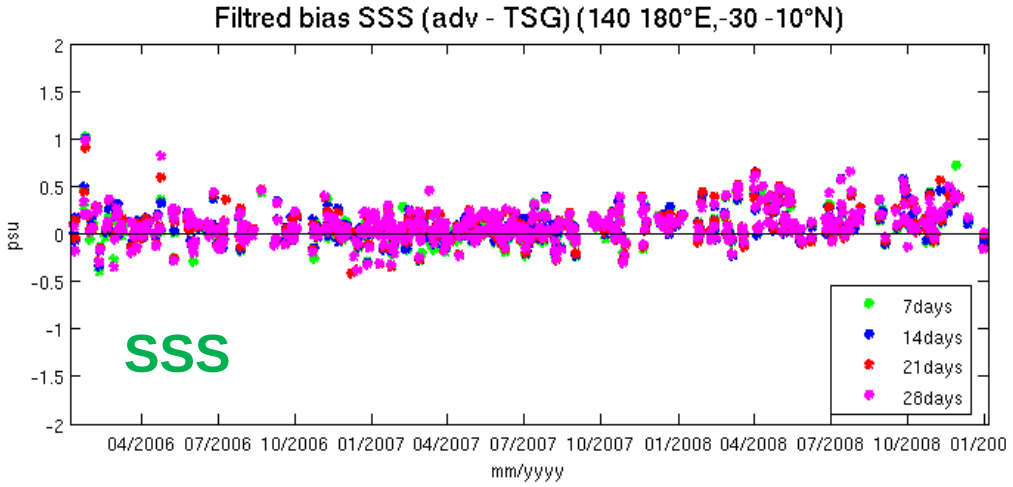


Application to Coriolis products (Marine Rogé)

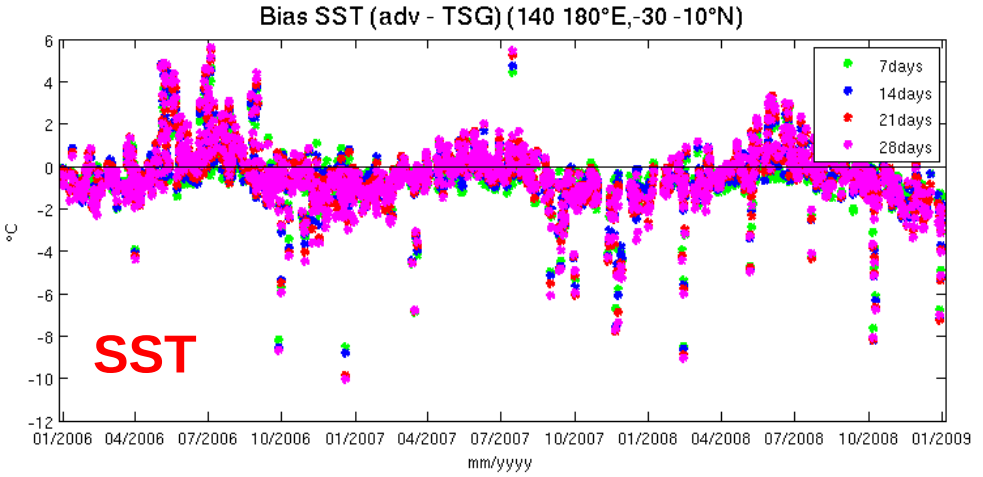
- significant reduction of bias, especially in SST with large seasonal variations
- ongoing analysis for best parameter choices (bias minimization, spectral signature…)

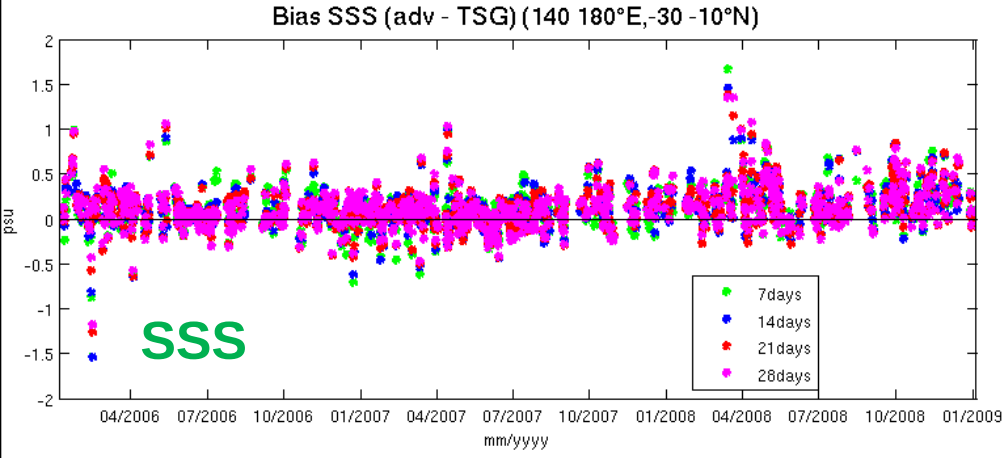
B&F advection





Forward advection

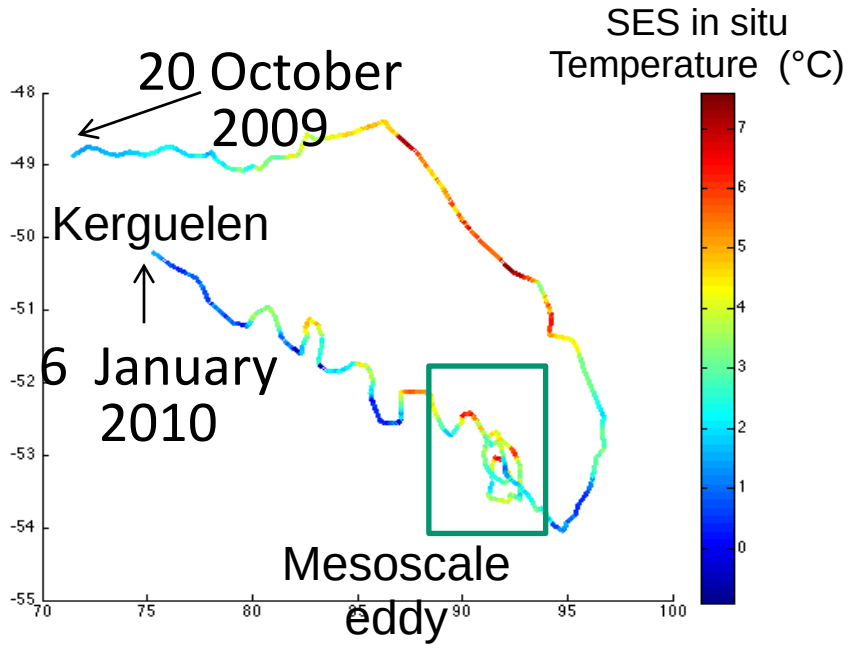


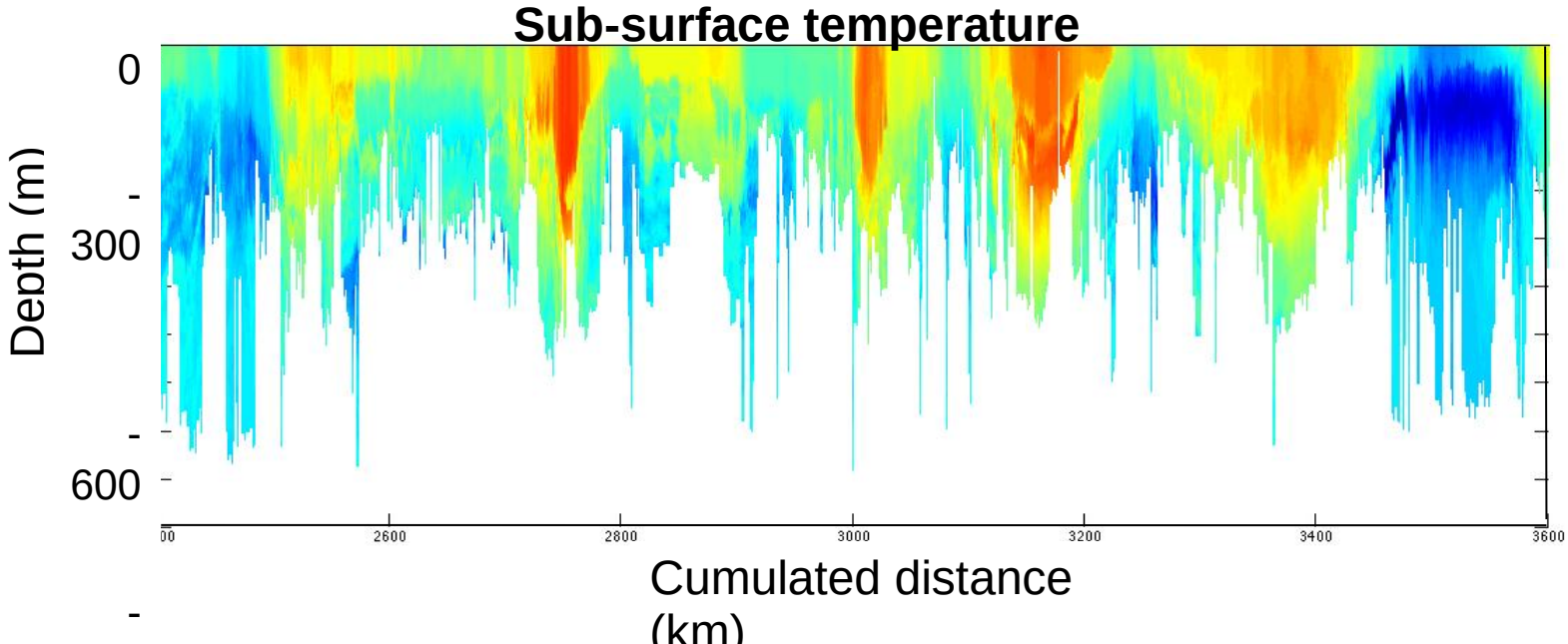


Elephant seals and submesoscales (Thomas Jaud, PhD)

- Equiped with HR instruments
- Behaviour influenced by meso – to submesoscales (in link to vertical velocities at fronts?)

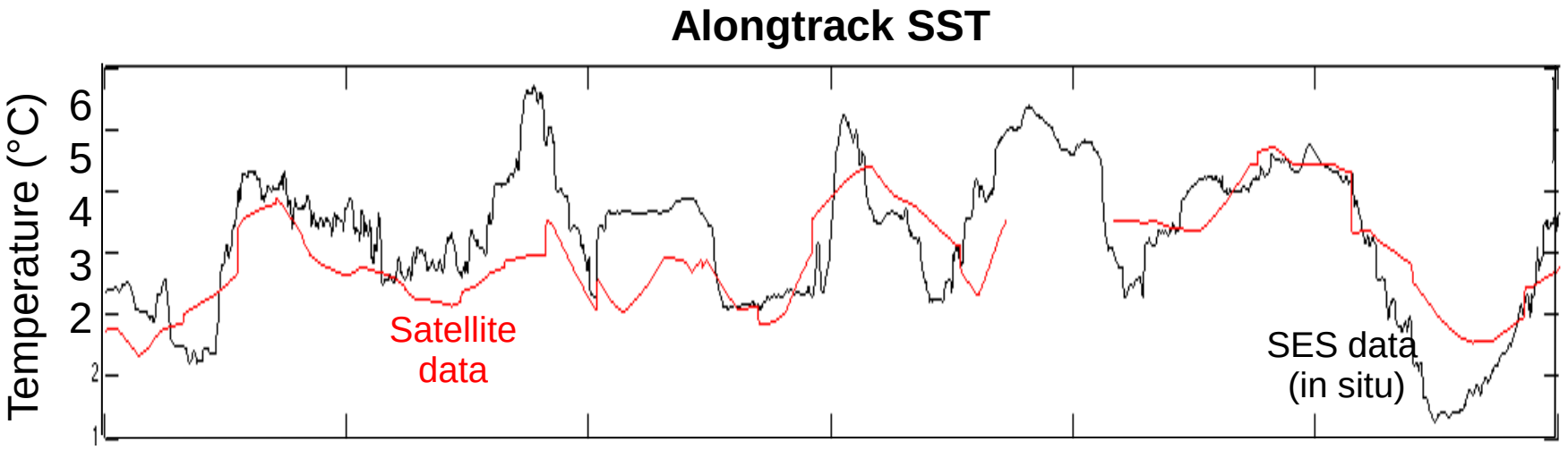
  - Insight into frontal dynamics (vertical velocities) and animal behaviour
  - data can help calibrate and validate 3D reconstructions (SQG…)

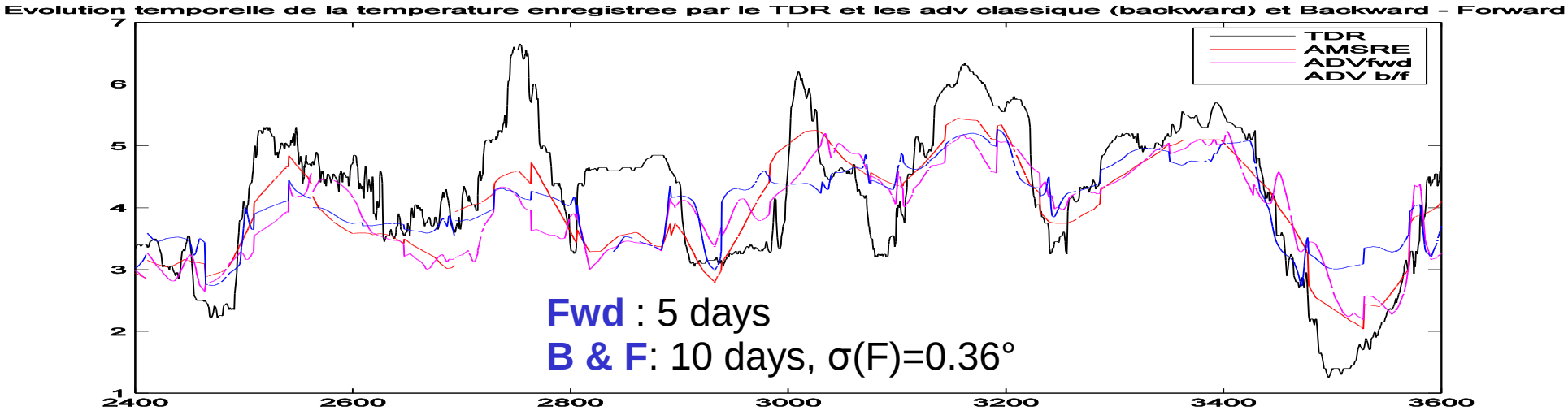




Elephant seals and submesoscales (Thomas Jaud, PhD)

- *But first*, need for better knowledge of fine scales in 2D (AMSR-E insufficient)
- Lagrangian advection of AMSR-E with altimetry: improvements needed (errors in velocity fileds?)





Conclusion

« back & forth » vs « forward » for « SSS type » I.C.

+ Physics affecting tracer resolved in I.C. is eliminated

+ Similar performances in statistical representation of submesoscales

+ Applicable to biogeochemical tracers whose large scale component is NOT primarily governed by horizontal stirring

- Excess smoothing of large scale tracer component

Looking ahead

- Improvement of submesoscale reconstruction (intensity and positioning of fronts)
    - SQG velocity fields from microwave SST?