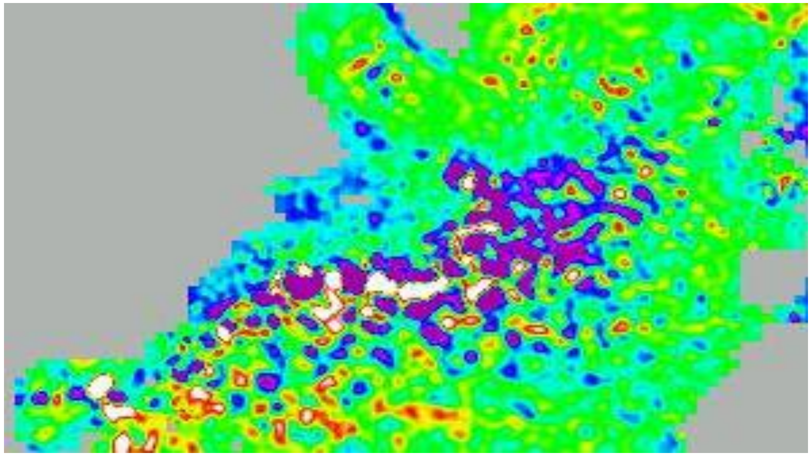
Some perspectives for the future high resolution altimetry products

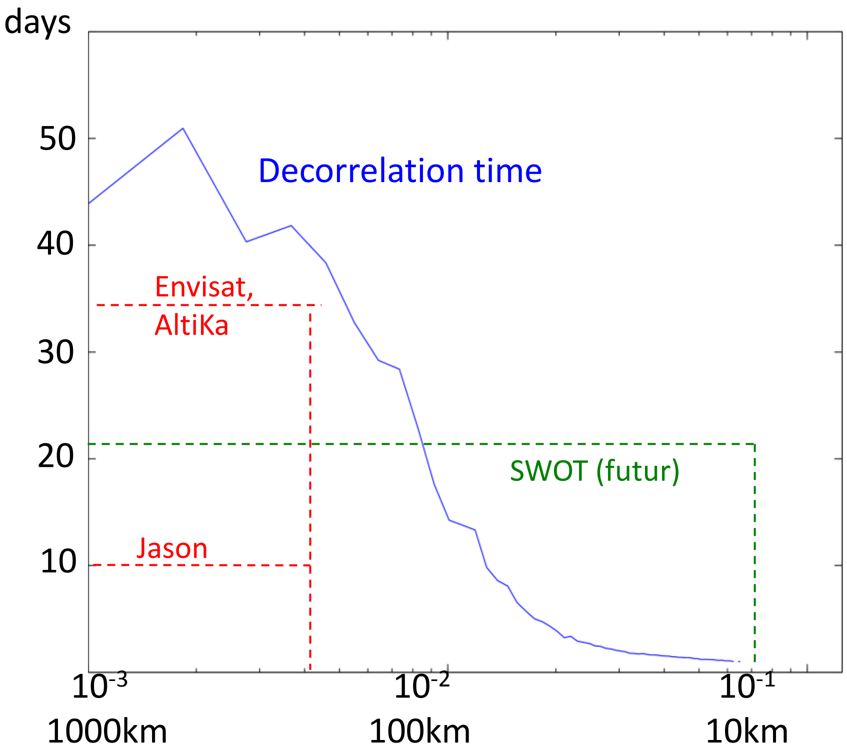
Clement Ubelmann (JPL), Patrice Klein (Ifremer)
and Lee-Lueng Fu (JPL)

The conventional altimetry and 2D products

- Resolution limited to ~80km along track
- Resolution limited to ~250km in 2D → large mesoscale



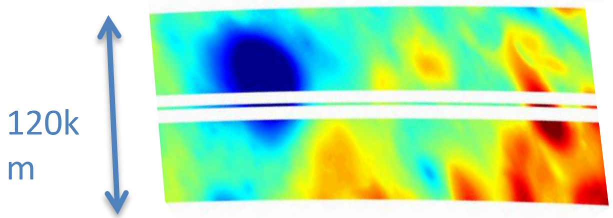
Aviso map of 2D altimetry



Jason orbits (10 days, ~100km inter-track) are very well suited for large mesoscale observation: optimal sampling in time vs space

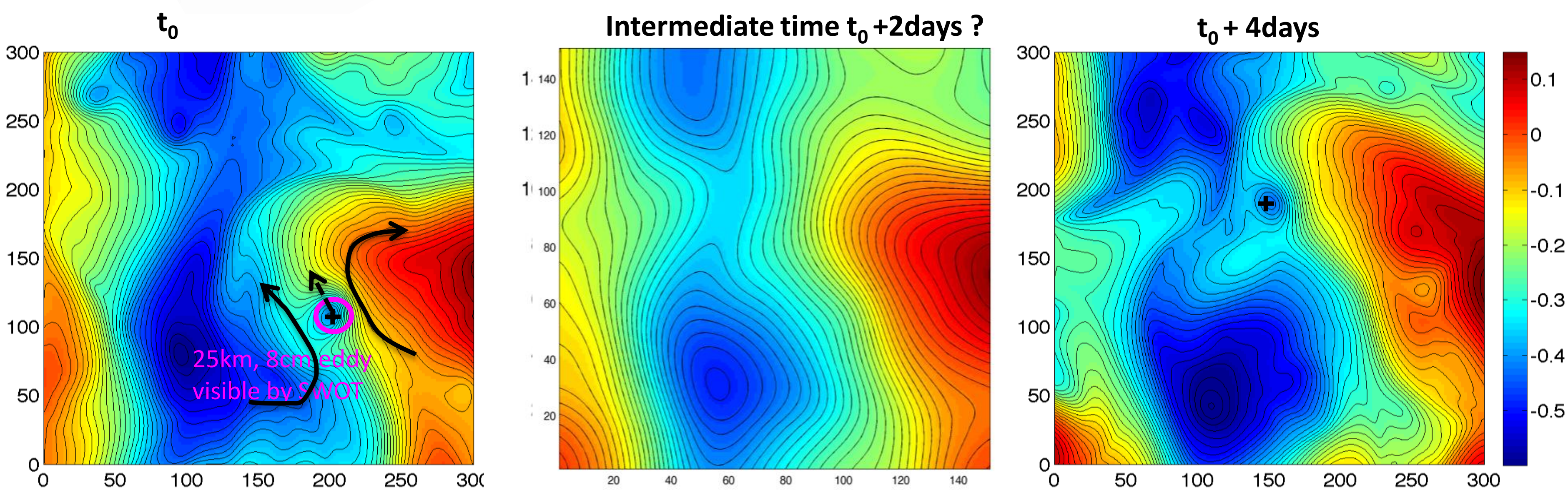
→ Optimal interpolation methods have been very successful to produce 2D continuous gridded products

The next generation of altimeters



Expected resolution down to 15km wavelength

The time revisits (up to 20 days) will be long compared to the time evolution of the signal…



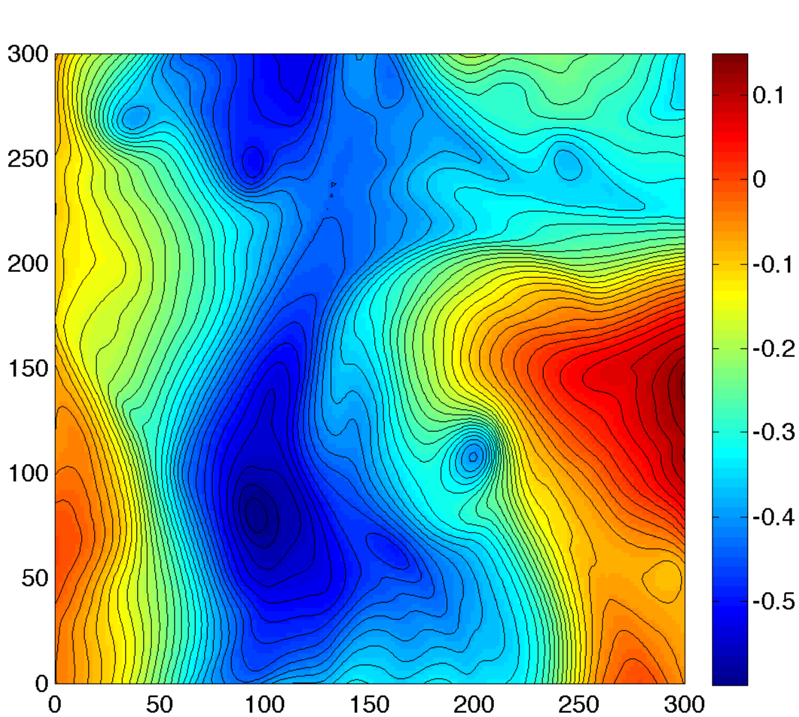
For the perspective of 2D continuous gridded products: classical interpolation method would not work for short mesoscales (30-100km)…

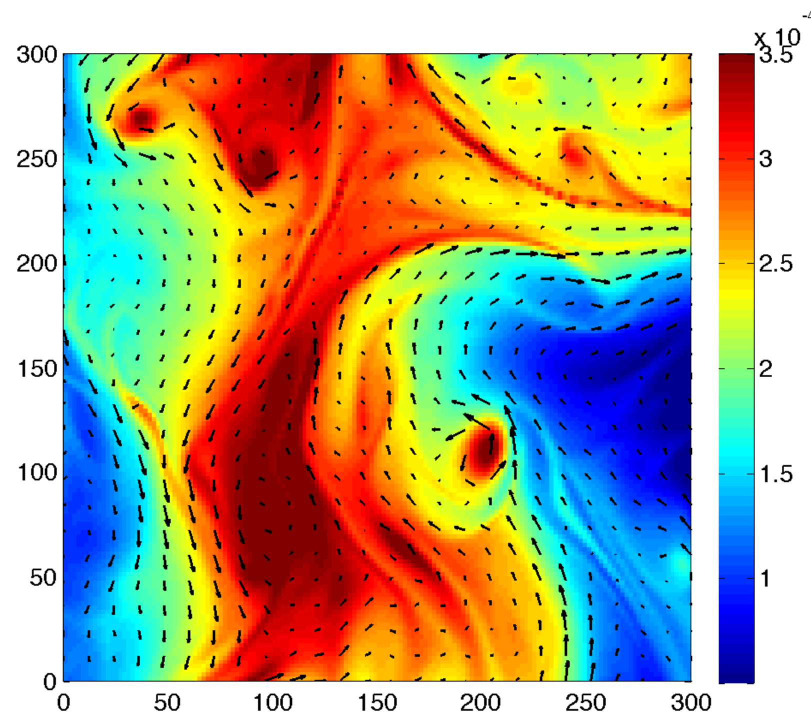
A first order of SSH motion should be predictable from the SSH itself

Can we make a simple dynamic scheme to propagate the SSH in time? What drives the advection of the small structures by the larger ones?

Method: potential vorticity conservation

- q in an equivalent 1 ½ layers shallow-water QG model (SWQG): $q=g/f0(\nabla^2 SSH-1/Lr^2 SSH)$
Single parameter: Lr
- q in SQG framework. Single parameter: N





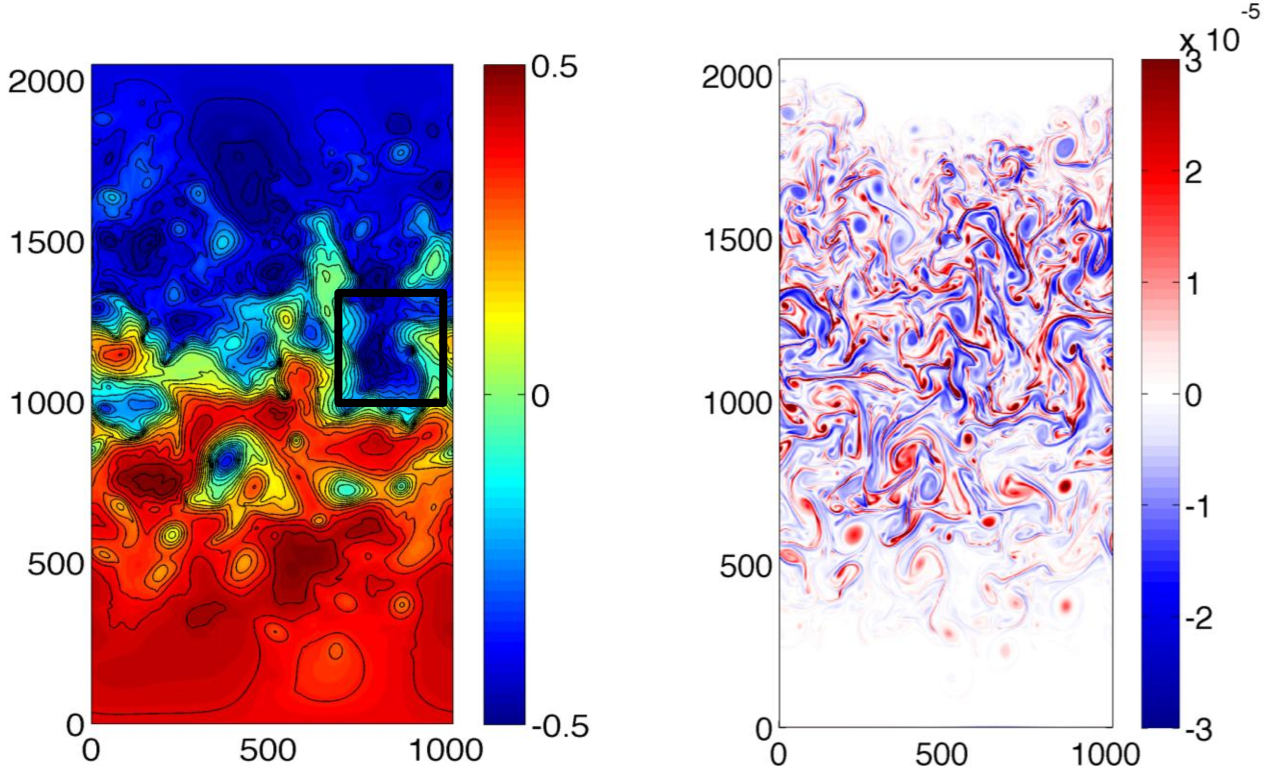
SSH(t) ⟶ Ug(t),Vg(t), q(t)→q(t+1)

SSH(t+1) ⟵ Elliptic inversion

→ Very cheap to run, initialized with only SSH + 1 physical parameter only (Lr)
→ Does the job of advecting little structures by larger ones
→ can be run backward and forward (reversibility) between two SSH images separated in time

First experimental setup:

Our “truth”: a full 3D model.
100 layers, 2km horizontal resolution

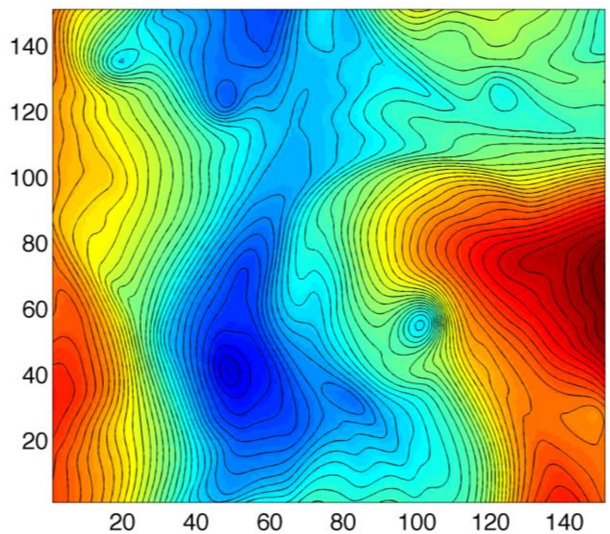


This model contains the 3D dynamic. West boundary current.

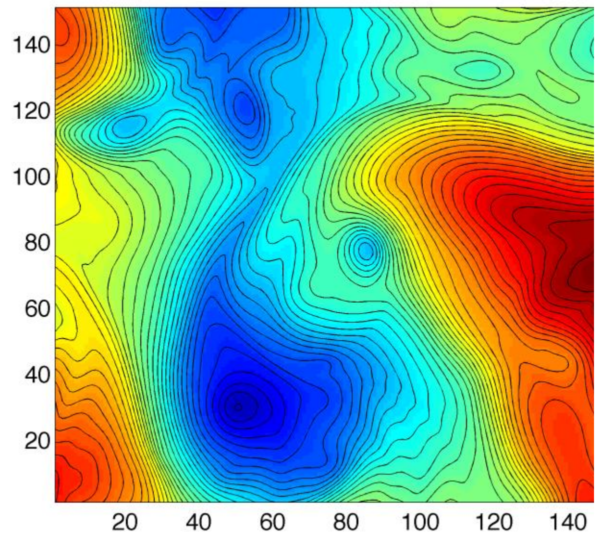
Now let’s try to reconstruct the SSH between two snapshots applying backward and forward SWQG

Results: reconstruction of SSH at intermediate time

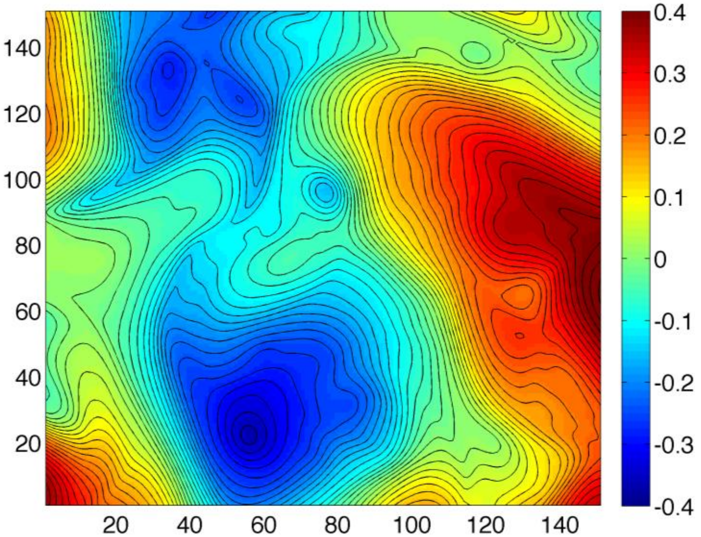
Truth at t_0



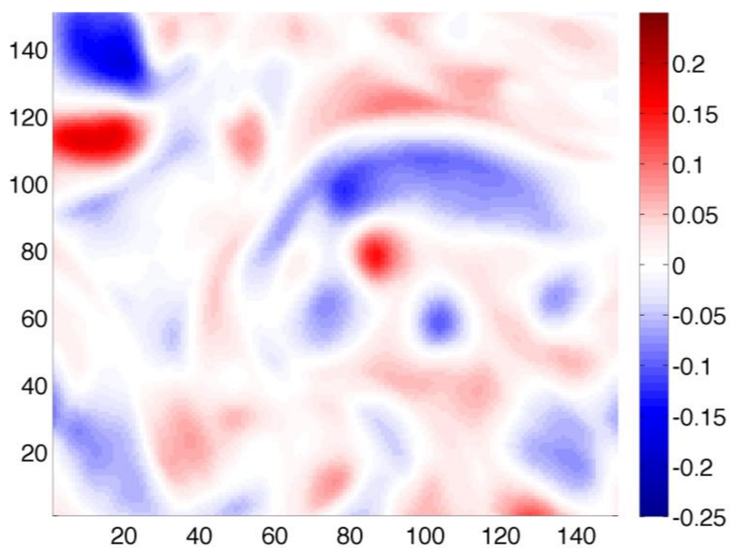
Truth at t_0+ 2day



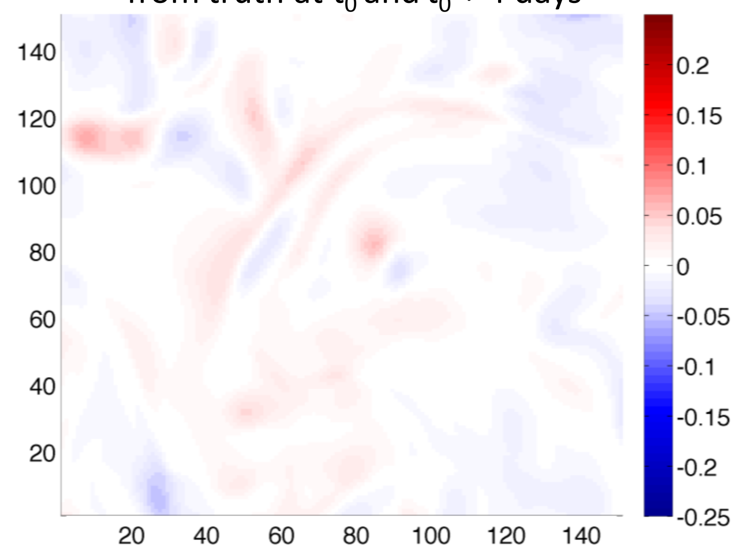
Truth at t_0 + 4 days



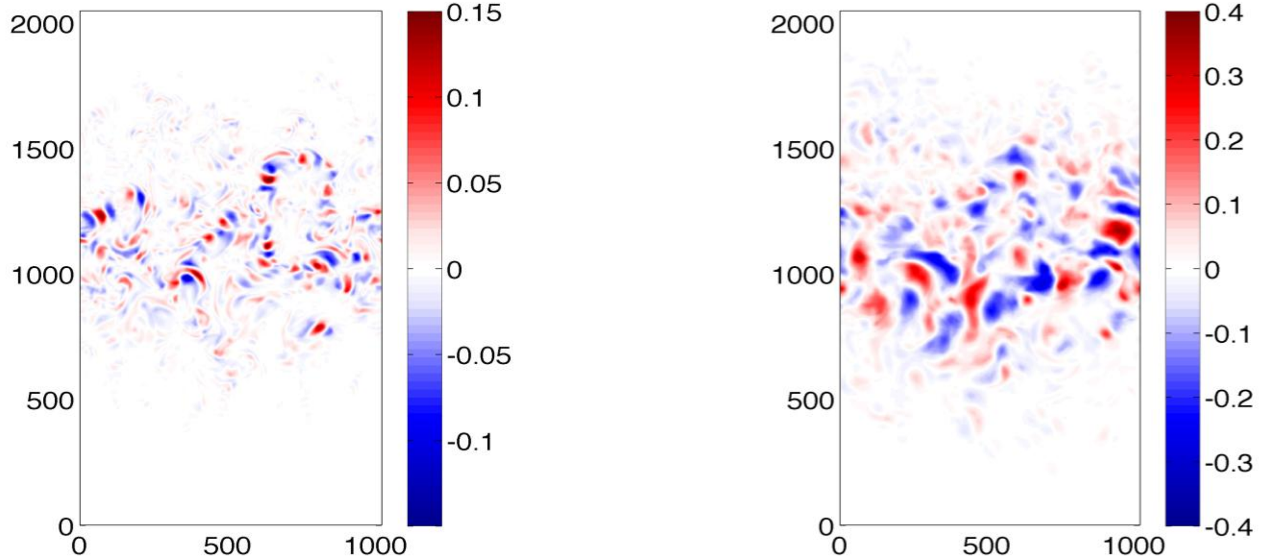
Linear interpolation at t_0 + 2 day
from truth at t_0 and t_0 + 4 days



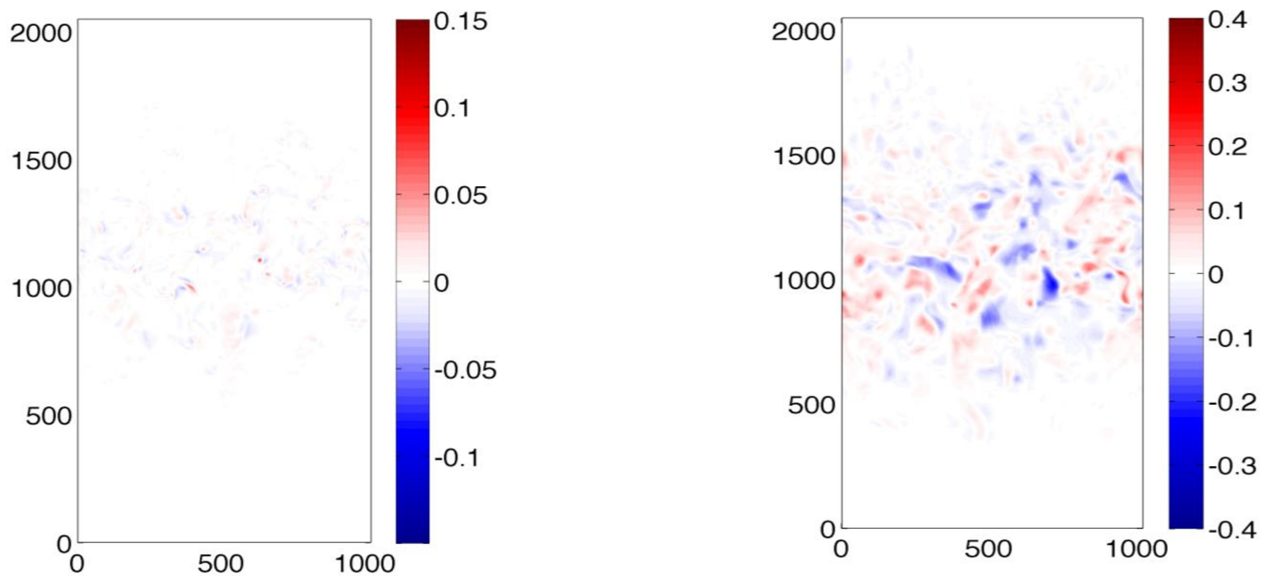
Dynamic interpolation at t_0 + 2 day
from truth at t_0 and t_0 + 4 days



For different time intervals:

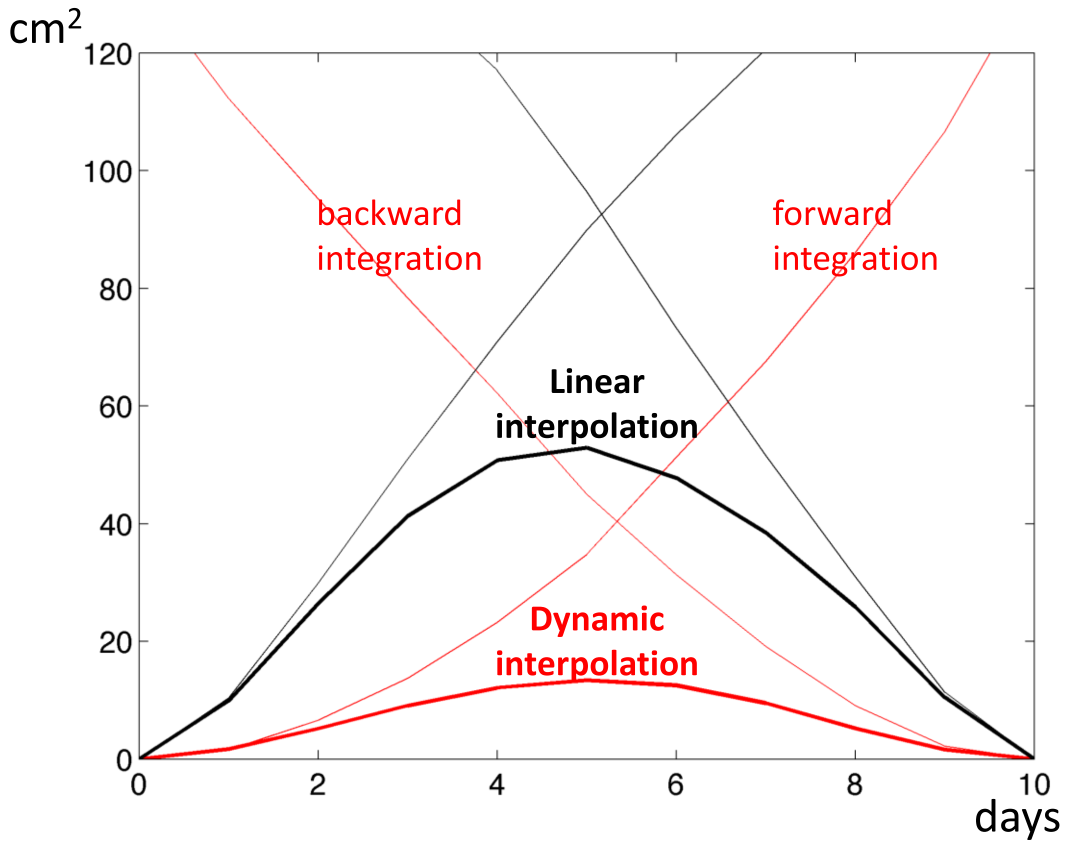


Residual error of linear interpolation in a 3 days period (1) and 10 days period (2)



Residual error of dynamic interpolation in a 3 days period (1) and 10 days period (2)

Error growth

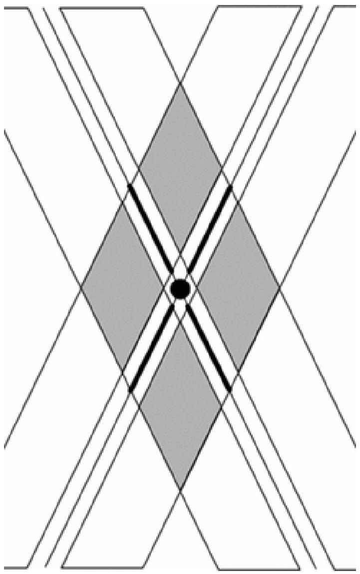


- Strong error reduction by combining the forward and backward solution.

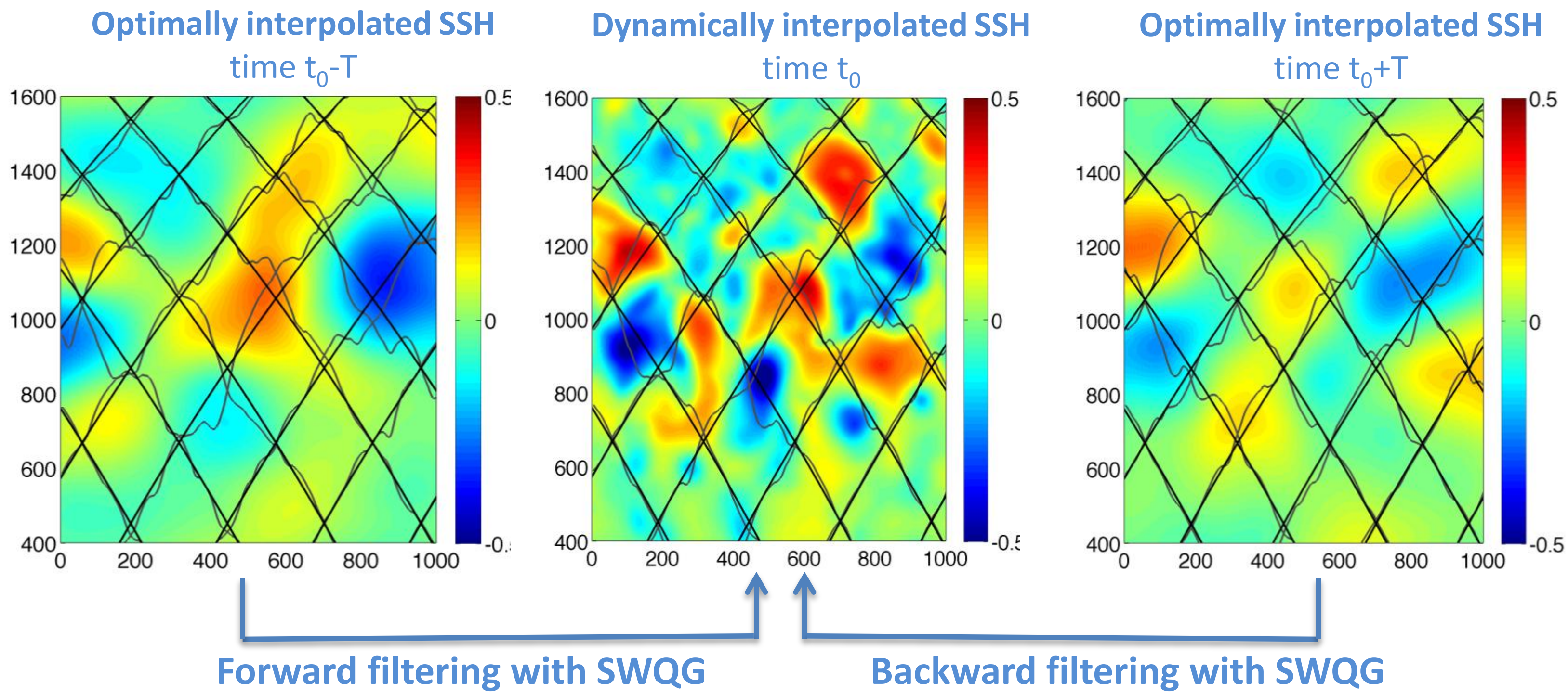
Application to SWOT data

- SWOT image: discontinuities + noise. SWQG with a data assimilation scheme is probably needed (see next slide)

- From the direct SWOT image (120km wide) form Cross-track CAL/VAL



Application to existing along-track data ?



- Along-track data assimilation in the SWQG/SQG 2D model. Forward and backward filtering
- Possibility to control the model parameter: Lr in the QG case and N in the SQG case
- Cryosat: high resolution, quiasi-synoptic image, 30-day subcycle → good case
- OSSEs experiment

Conclusions

- **“Dynamic interpolation” : intermediate approach between optimal interpolation and 3D assimilated OGCM**

  → OI: Not able to fill observation gaps beyond the decorrelation scale

  → 3D models: rely on unobserved 3D state and physical parameters → not self contained

- **DI: Relies on universal physics (self contained)**

- **Good skills →10-20 days : the short mesoscale SSH motion is well explained at the first order by PV conservation in a 1 layer QG mode. Beyond 20days, energy cascades or external forcing (both not accounted here) certainly dominate.**

Perspectives:

- The application to along-track altimetry will be explored soon…
- Good framework to explore the capabilities/limits of QG/SQG over the ocean at different scales…