

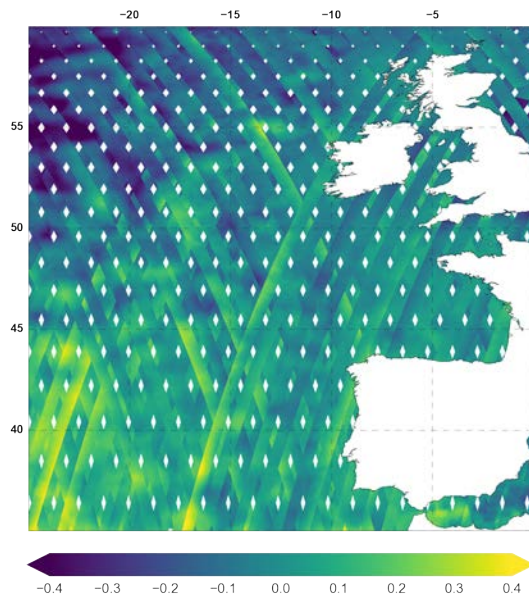
RECONSTRUCTION OF 2D AND 3D OCEAN  
CIRCULATION FROM SWOT:  
ADVANCES OF THE 2016-2019 SCIENCE TEAM,  
AND REMAINING ISSUES

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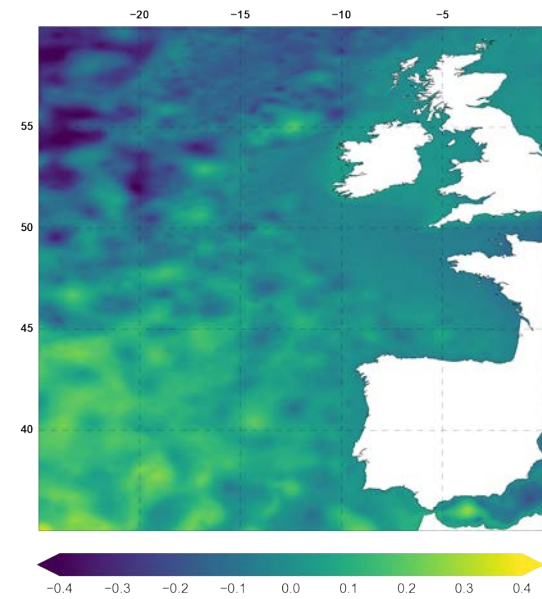
E. Cosme, S. Gille, P.-Y. Le Traon, B. Qiu  
(coordinators of the reconstruction session and  
contact points if you think we missed something)

# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)



21 days of SWOT SSH data



Daily SSH field

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)

Reconstruction-from-SWOT main issues:

- Presence of small-scale and large-scale, structured noise
- Presence of HF signal from internal tides
- High spatial resolution vs low temporal resolution

Resulting to:

- A large diversity of challenges and sub-challenges
- A large diversity of approaches and methods
- Remaining open questions

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)

Preparation of the direct  
assimilation with 3D model  
coupling all components (and  
waves)  
*Gille et al, Heimbach et al, ECCO  
consortium*

MITgcm, 4DVar...

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)

Preparation of the direct  
assimilation with 3D model  
coupling all components (and  
waves)

**Gille et al, Heimbach et al**, ECCO  
consortium

MITgcm, 4DVar...

Brown, fat arrow:  
process investigated

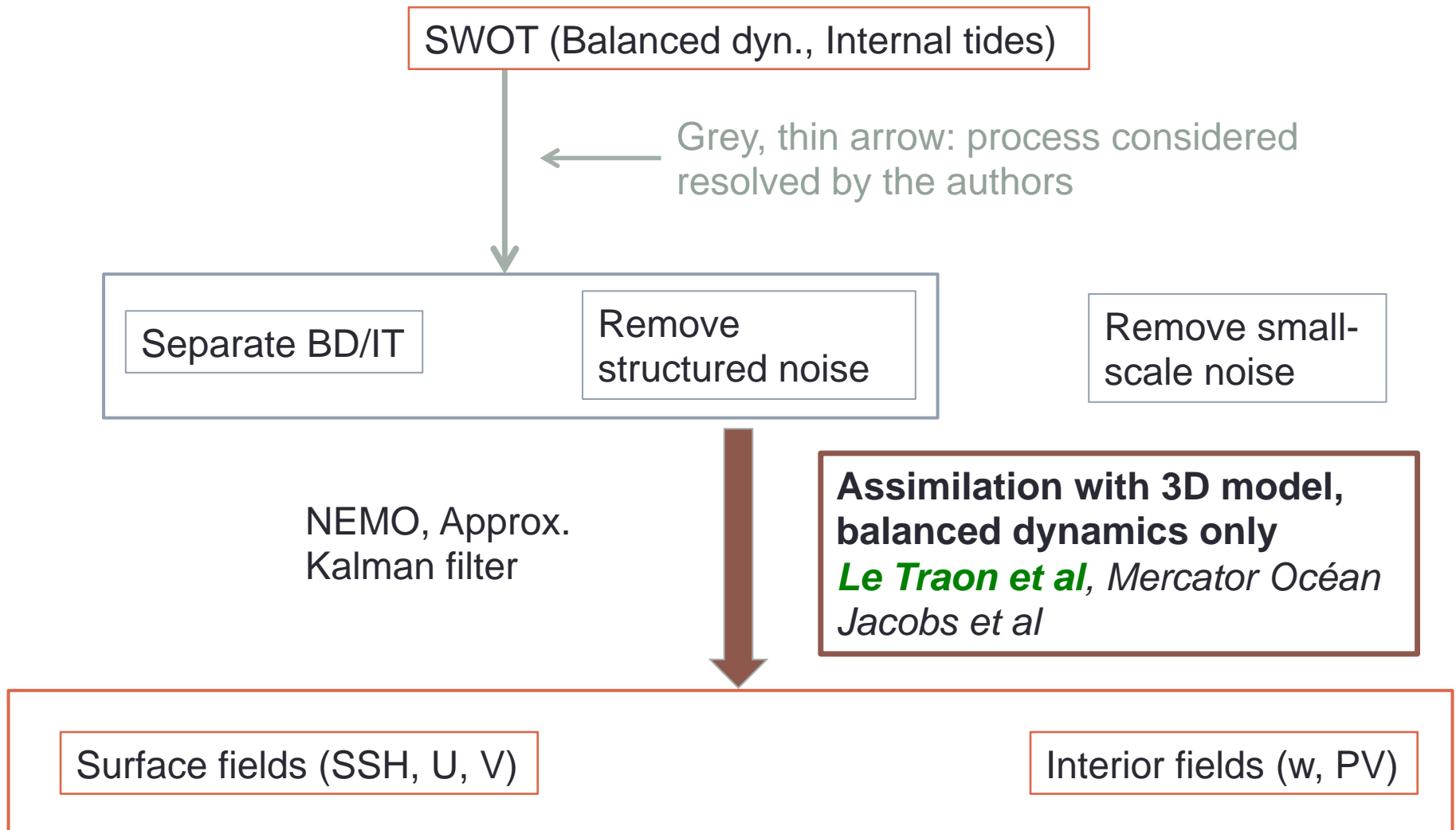
Names: speakers, project PIs, or  
“contact points”

Green, bold names:  
Talks this week. No details  
in this presentation.

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions

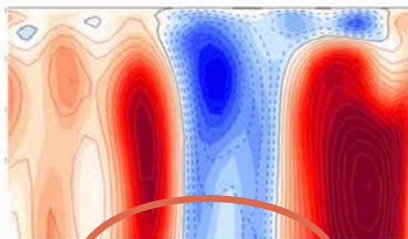


# Reconstruction steps: contributions

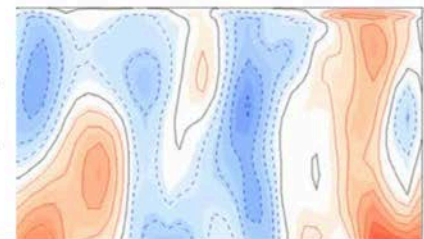
## Vertical Velocity Impact : Section N-S at 10.5°W; [51°N-55°N]; 08/11/2009...



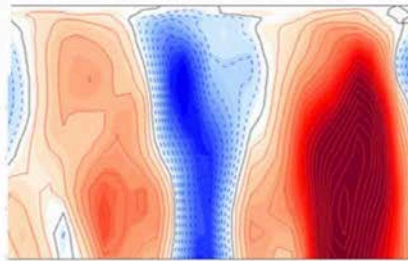
A: Vertical Velocity at 10.5°W, 08/11/2009  
NatRun : IBI36



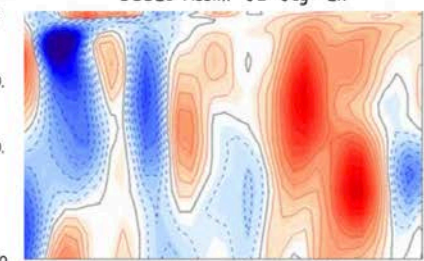
B: Vertical Velocity at 10.5°W, 08/11/2009  
OSSE0 : Free Model (Control)



D: Vertical Velocity at 10.5°W, 08/11/2009  
OSSE3 : Assim SWOT+ J2+ J1g + En



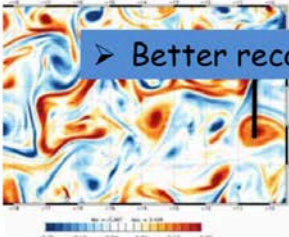
C: Vertical Velocity at 10.5°W, 08/11/2009  
OSSE1 : Assim J2+ J1g + En



es)

ocess  
d

Relative Vorticity : NatRun



➤ Better reconstruction of vertical and horizontal velocity in the deep ocean

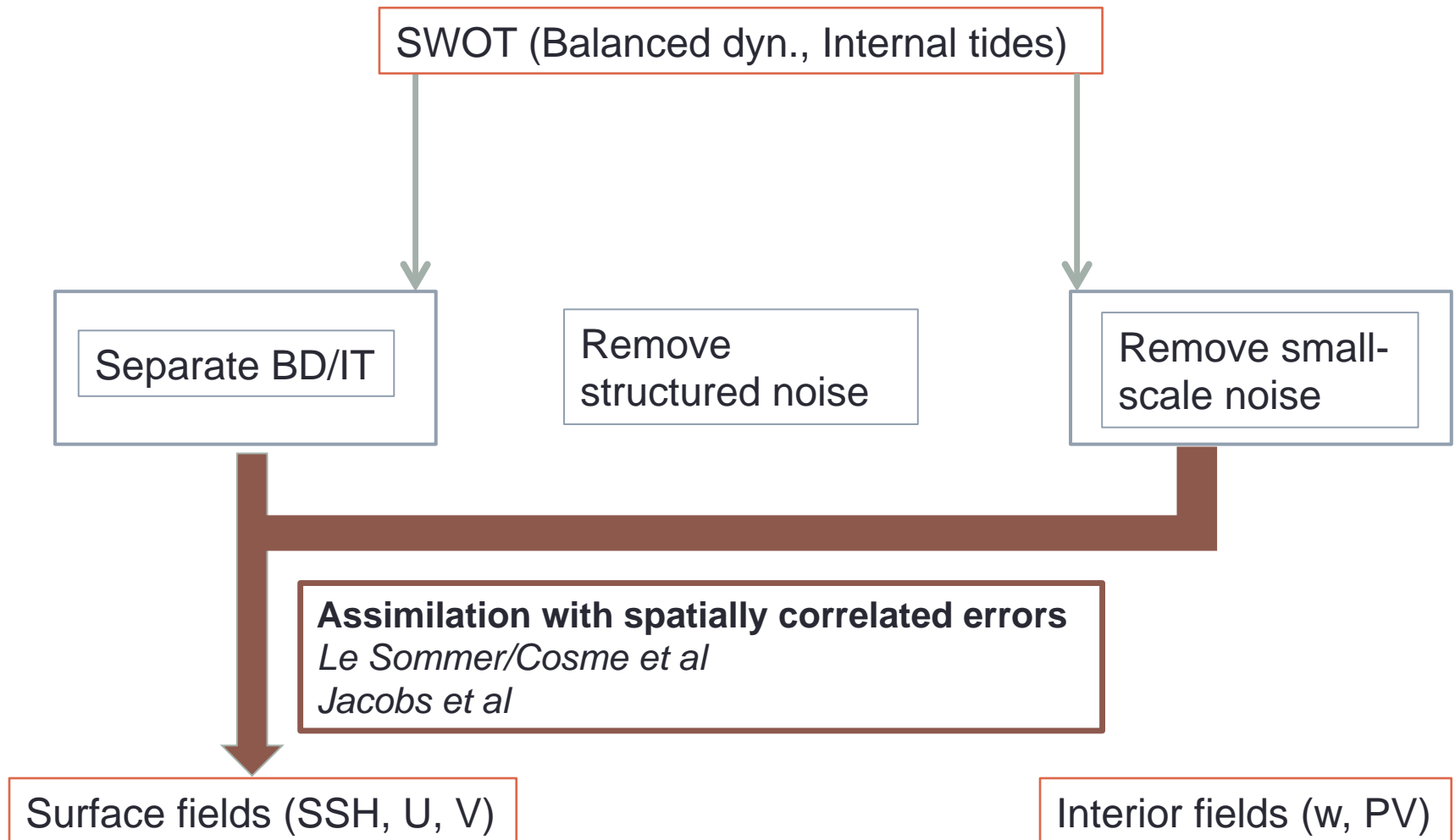
Remove small-scale noise

ion with 3D model,  
dynamics only  
*et al*, Mercator Océan  
*al*

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions





# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)

Separate BD/IT

Remove structured noise

Remove small-scale noise

## Improving mapping techniques

*Ubelmann et al, dynamical interpolation, QG model*

**Archer et al** (*Fu*), 2DVar, no model (persistence)

**Le Guillou et al** (*Le Sommer/Cosme*), Back-and-Forth nudging, QG model

**Manucharyan et al** (*Lapeyre*), Machine Learning

**Sinha & Abernathey** (*Smith*), Machine Learning

**Qiu et al**, *OI*

Surface fields (SSH, U, V)

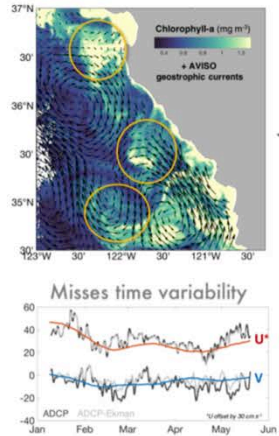
Interior fields (w, PV)

# Reconstruction steps: contributions

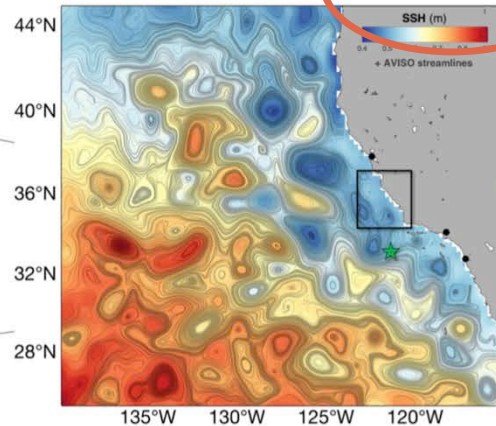
## AVISO (CURRENT)

Archiving, Validation, and Interpretation of Satellite Oceanographic data

Misses Smaller Eddies



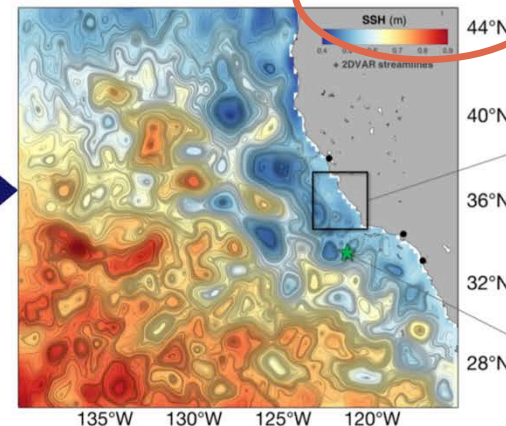
AVISO resolves scales down to ~170 km



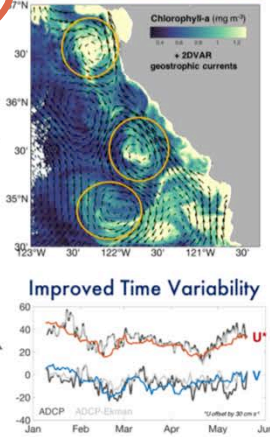
## 2DVAR (NEW)

2-Dimensional Variational Data Assimilation

2DVAR resolves scales down to ~100 km



Resolves Smaller Eddies



### Improving mapping techniques

*Ubelmann et al*, dynamical interpolation, QG model

*Archer et al* (Fu), 2DVar, no model (persistence)

*Le Guillou et al* (Le Sommer/Cosme), Back-and-Forth nudging, QG model

*Manucharyan et al* (Lapeyre), Machine Learning

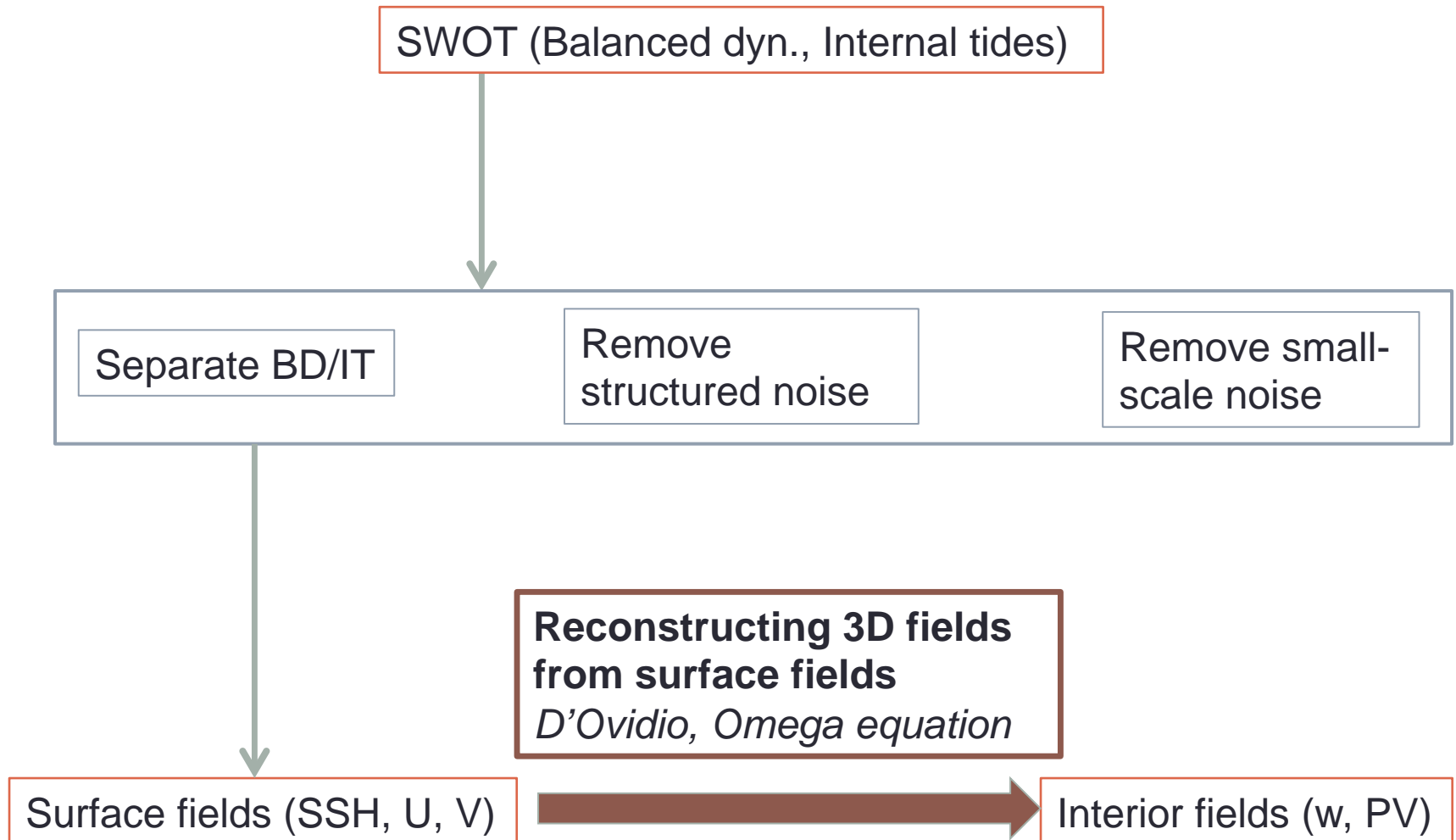
*Sinha & Abernathey* (Smith), Machine Learning

*Qiu et al*, OI

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions



# Reconstruction steps: contributions

OMGT (D'ARVIDIO, 2011)

## Conclusions

**Is the Omega equation the good framework for the experimental calculation of vertical velocities ?**

- **Not really !**

- *The omega equation doesn't reproduce well the submesoscale vertical velocity (below few tens of kilometers) in any dynamical regime.*
- *In some regimes these small mesoscale and submesoscale (below 40 km) features account for up to 30 % of the variance of the field.*
- The vertical velocity inferred from the omega equation represents well the mesoscale energetic patterns. Structures larger than 40 km tend to have a spectral coherence above 0.6



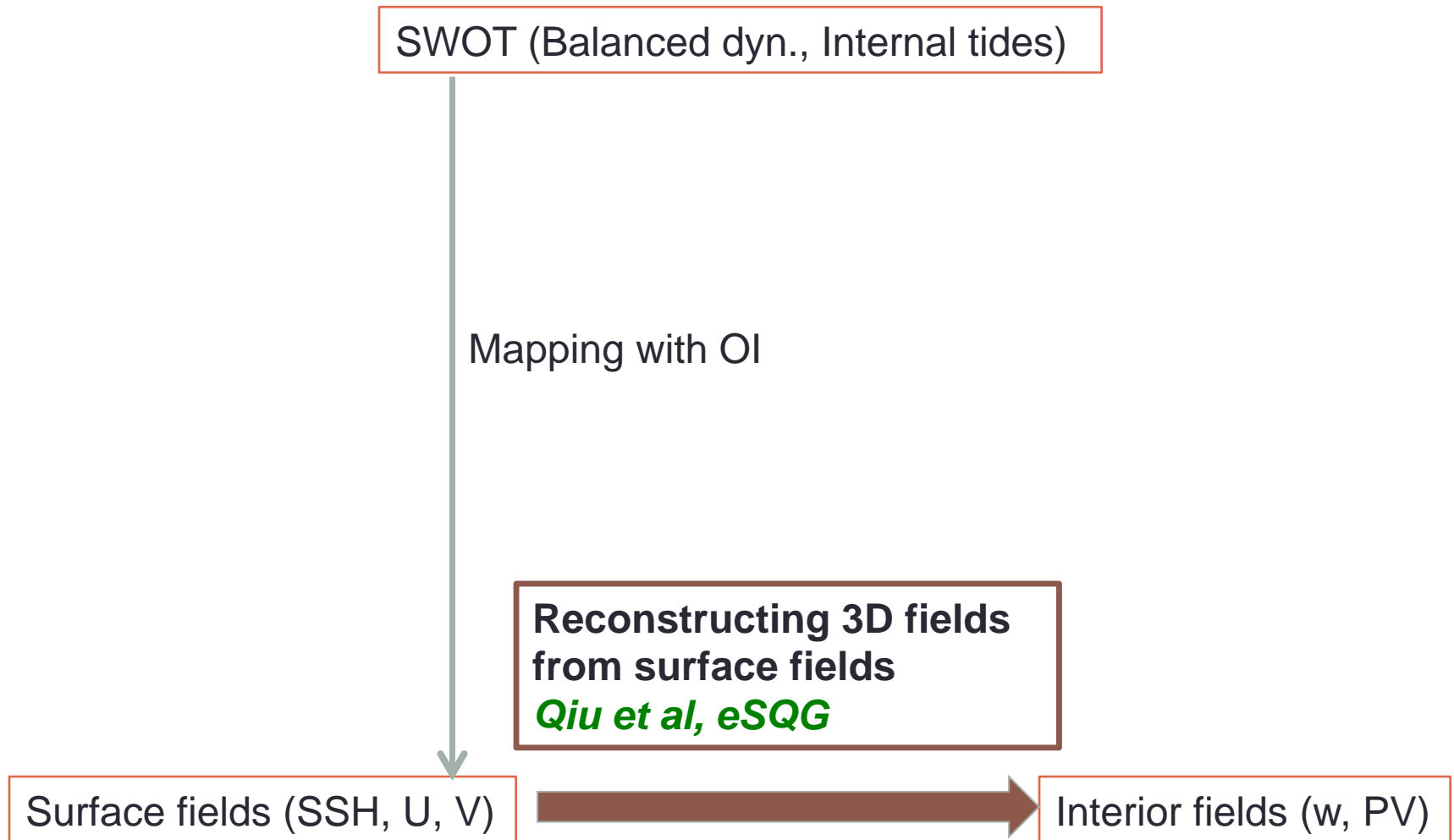
**Reconstructing 3D fields  
from surface fields**  
*D'Ovidio, Omega equation*

Surface fields (SSH, U, V)

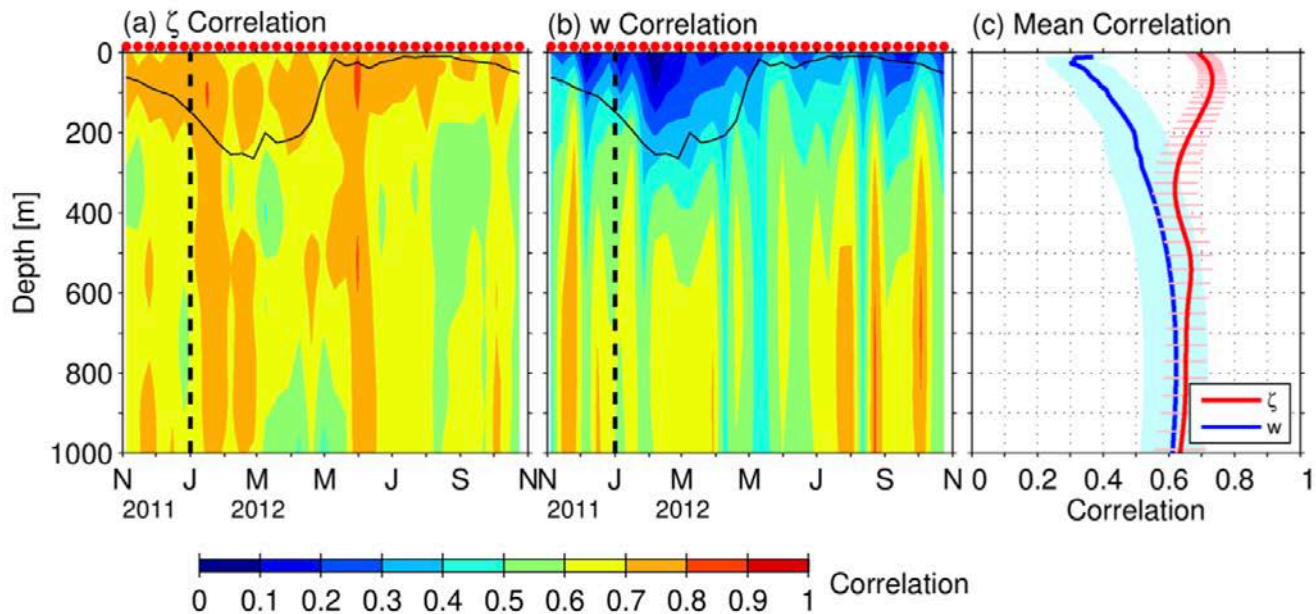


Interior fields (w, PV)

# Reconstruction steps: contributions



## Reconstructed $w$ & $\zeta$ correlations as a function of time



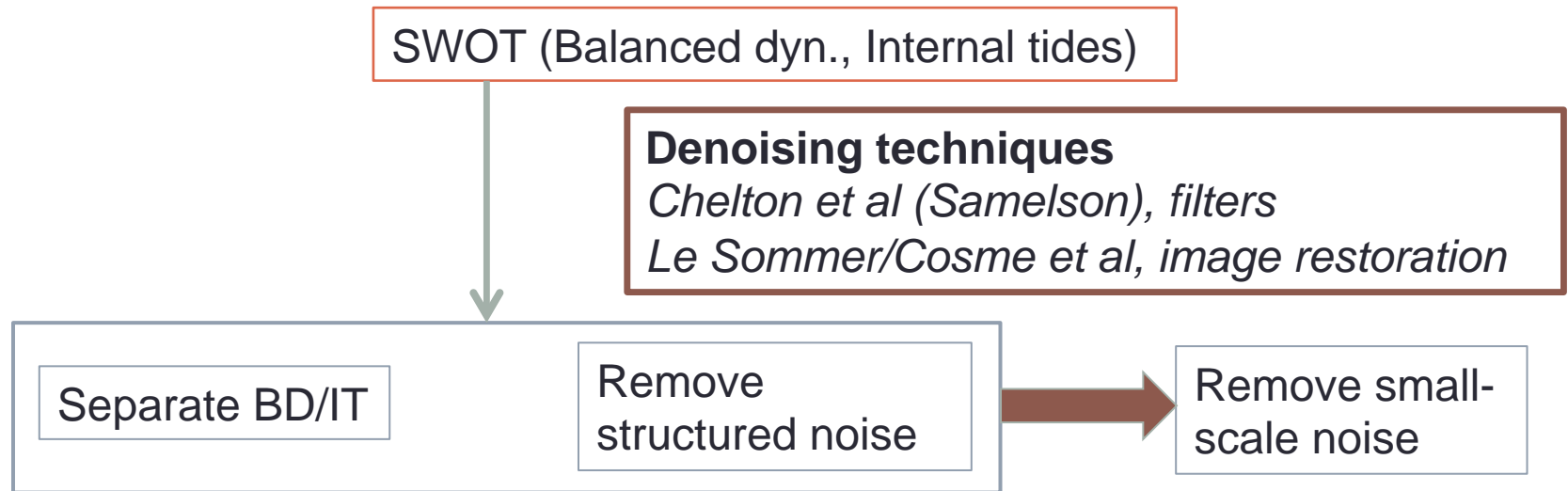
eSQG  
reconstruct  
using **SWOT-**  
**measured**  $\eta$

Reconstructing 3D fields  
from surface fields  
*Qiu et al, eSQG*

Surface fields (SSH, U, V)

Interior fields ( $w$ , PV)

# Reconstruction steps: contributions



Surface fields (SSH, U, V)

Interior fields (w, PV)

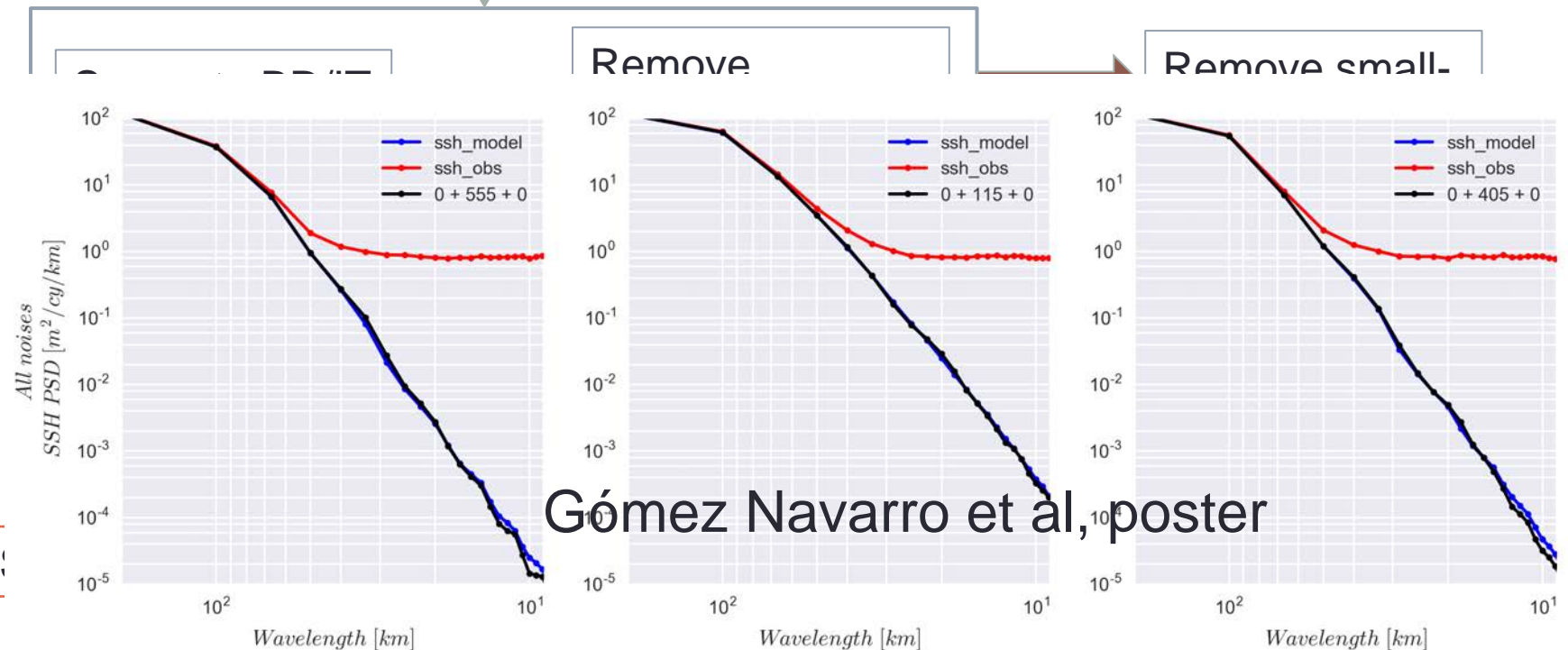
# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)

## Denoising techniques

*Chelton et al (Samelson), filters*

*Le Sommer/Cosme et al, image restoration*



Gómez Navarro et al, poster



# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)

**Detrending technique**  
*Le Guillou & Metref* (Le Sommer/  
Cosme)

Separate BD/IT

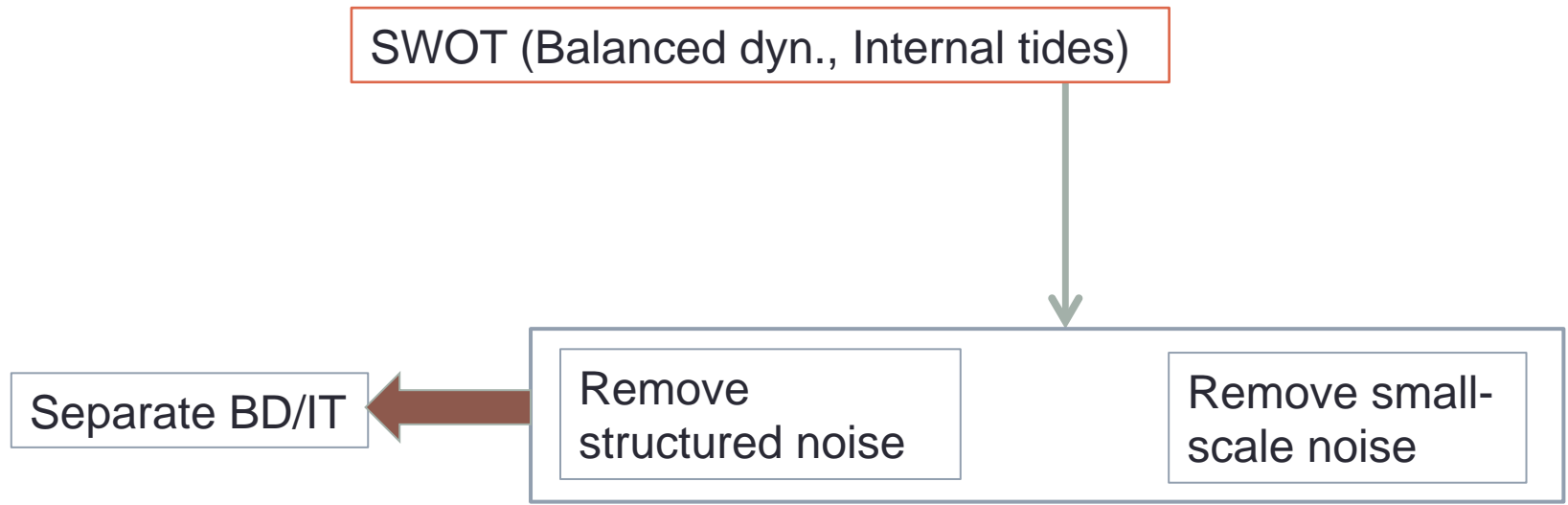
Remove  
structured noise

Remove small-  
scale noise

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions



## Signal separation

*Ponte et al (Arduin): SST, QG theory*

*Wang et al (Fu): SST, QG theory, interior data*

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)

A big remaining issue.

Splinter session 4 dedicated to it.

Talk by A. Ponte on the state of the art.

Remove small-scale noise

## Signal separation

*Ponte et al (Ardhuin): SST, QG theory*

*Wang et al (Fu): SST, QG theory, interior data*

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Reconstruction steps: contributions

SWOT (Balanced dyn., Internal tides)

Multi-sensor approaches:  
Considered by many authors  
Essential!

Surface fields (SSH, U, V)

Interior fields (w, PV)

# Conclusions

- All issues and related smaller challenges have been/are being tackled. Significant progress have been made on all items
- Mapping: many approaches tested, no consensus yet. Need to compare methods at some point. Explore coastal and low-lat regions.
- The Internal Tide separation problem still remains a particularly open issue
- The BD+IT Assimilation has not yet been implemented
- No clear end-to-end demonstration of reconstruction so far (i.e., from SWOT data made from a recent version of the simulator and with tides, to 3D datasets)