Pierre De Mey’s slides for the oceanography breakout session

Sorry not to be with you and have a good meeting

Keep clicking to make messages appear
We are starting to get a good idea of the errors we must aim at correcting in coastal models with the help of satellite altimetry.
Instantaneous ensemble variance: a proxy of model error variance

Bay of Biscay 3D model 30m temperature ensemble variance, July 30, 2004

What is this? Near-surface temperature ensemble variance in response to atmospheric forcing errors. It is a proxy of the actual model errors. It has the fine time/space scales of a tracer and is a mix of shelf, shelf-break, upwelling, and mesoscale responses.

Relevance to WATER-HM? Questions 1 (mesoscale) and 2 (coastal). We need to constrain those fine error scales.

(after Le Hénaff & De Mey, 2008)
Non-local, structured errors in coastal current

EOF-1 79.8 %

EOF-2 11.0 %

EOF-3 4.9 %

(Jordà et al., 2006)
Non-local, structured errors in coastal current

**What is this?** Ensemble multivariate EOFs in the Catalan Sea coastal current in response to coastal current inflow perturbations (mimicking downscaling errors).

**Relevance to WATER-HM?**
Question 2 (coastal). SLA errors are small-scale (O(40km)) and strongly correlated to fine-scale (u,v,T,S) 3-dimensional errors which we can expect to correct through wide-swath altimetry assimilation.

(Jordà et al., 2006)
Non-local, structured errors in coastal current

EOF-1 79.8 %

EOF-2 11.0 %

EOF-3 4.9 %

(Jordà et al., 2006)
Activation of coherent error features by storms

**What is this?** The SLA component of a particular ensemble EOF in response to atmospheric forcing errors. It is a proxy of the actual model errors. As the time series shows, it is activated during the July 7-8 storm and is characterized by a shelf-wide response, a surge response, and a mesoscale response with O(1day) time scale.

**Relevance to WATER-HM?** Questions 1 (mesoscale), 2 (coastal) and 3 (storm-related). We expect a wide-swath altimeter to consistently constrain the fine-scale, multivariate ocean response to those fast events, and hopefully better predict the associated phenomena.
Cross-scale correlations in the coastal ocean
Shelf break exchanges in error subspace

Ensemble-time EOF-1 16-Nov-1999 12Z00 -- State vector: (SLA_{HF}, U_b, SLA_{IB}, \tau)

(Lamouroux and De Mey, 2007)
Cross-scale correlations in the coastal ocean
Shelf-break exchanges in error subspace

What is this? The BT transport, high-frequency SLA, and inverted-barometer SLA components of a particular ensemble EOF in response to atmospheric forcing errors. It is a proxy of the actual model errors. As the bottom right panel shows, the situation is that of a southwesterly wind blowing towards the English Channel. The top right panel shows water piling up in the channel. The left panel shows the corresponding fine-scale exchanges through shelf-break canyons and around capes.

Relevance to WATER-HM? Questions 2 (coastal) and 3 (storm-related). We expect a wide-swath altimeter to resolve fast time scales in straits and semi-enclosed seas to constrain the variability of exchanges between shelf and deep ocean.

(Lamouroux and De Mey, 2007)
Cross-scale correlations in the coastal ocean
Shelf break exchanges in error subspace

Ensemble-time EOF-1 16-Nov-1999 12Z00 -- State vector: \( (SLA_{HF}, U_b, SLA_{IB}, \tau) \)

Scaled transport

\( SLA_{HF} \)

\( SLA_{IB} \)

(Lamouroux and De Mey, 2007)
2: A single wide-swath instrument on a JASON-type orbit would significantly constrain the coastal ocean mesoscale and coastal current variability.
Wide-swath vs. nadir in Bay of Biscay
Stochastic modelling with atm. forcing perturbations in 3D BoB

Top: Wide Swath (4 dof’s)
Mid: WS over deep ocean (2 dof’s)
Bottom: JASON (1 dof)

Scaled RM spectra

Array Modes -- SLA

Mode 1
Mode 2
Mode 3

“Slosh”  Meso1  Meso2

(after Le Hénaff & De Mey, 2008)
What is this? The RM spectra plot on the left shows the number of degrees of freedom of model (forecast) error which can be detected by a particular array amidst observational noise. This is done by counting eigenvalues above 1. This is shown for three arrays (legend). Representer matrices are calculated by stochastic modelling with atmospheric forcing errors.

Relevance to WATER-HM? Questions 1 (mesoscale) and 2 (coastal). One Wide-Swath altimeter on a JASON orbit detects 4 degrees of freedom, while one nadir instrument (JASON) detects only one. The more d.o.f.’s are detected, the more consistent the model constraint through assimilation will be.

(after Le Hénaff & De Mey, 2008)
Wide-swath vs. nadir in Bay of Biscay
Stochastic modelling with atm. forcing perturbations in 3D BoB

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Scaled RM spectra

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“Slosh”
Meso1
Meso2

(after Le Hénaff & De Mey, 2008)
What is this? The “array modes” of model error corresponding to the spectra to the left.

For each array, mode 1 is mostly water sloshing around between shelf and deep-ocean domains; modes 2 and 3 are a mix of mesoscale response, slope current variability and shelf processes.

Relevance to WATER-HM? Questions 1 (mesoscale) and 2 (coastal). As seen on the left panel, JASON can only detect (and constrain) the “slosh” mode. One needs a wide-swath instrument to detect (constrain) all three modes + a 4th one not shown. In this way, one can objectively demonstrate that a wide-swath instrument is needed to constrain the coastal ocean mesoscale and coastal current variability. (A collaboration between LEGOS and OSU’s OST proposals is envisaged on this topic)
Wide swath: degradation due to roll errors

What is this? Scaled RM spectra for one wide-swath track in the Bay of Biscay without, and with, along-track correlated roll errors.

Relevance to WATER-HM? Questions 1 (mesoscale) and 2 (coastal). As long as we have a good idea of the along-track period of the roll errors, the effect of those errors is limited (1 detected eigenvalue drop). However yaw errors will have state-dependent (therefore shorter) along-track correlation scales and will be more difficult to separate from coastal processes.

(after Le Hénaff & De Mey, 2008)
Summary

- The knowledge of coastal circulation is critical to many applications (ecosystem management, water quality, disaster prevention, transportation). These applications by themselves are beyond the scope of this mission, but we believe that a wide-swath altimeter would provide solid scientific foundations towards those objectives.
- We are starting to get a good idea of the errors we must aim at correcting in coastal models with the help of satellite altimetry.
- A single wide-swath instrument on a JASON-type orbit would significantly constrain the coastal ocean mesoscale and coastal current variability.
- Yaw errors may be more difficult to separate from coastal processes than roll errors.
- Swath overlap is a desired feature to maximize revisit time and better constrain the higher-frequency part of the spectrum of coastal processes.
Thanks.