Groupe de travail sur l'assimilation de données dans le Golfe de Gascogne et mers côtières

(WG on data assimilation in the BoB and coastal seas)

Pierre De Mey, LEGOS, Toulouse

Sorry for
French ←→ English
acrobatics…

Conseil Scientifique du Groupe Mission MERCATOR-CORIOLIS, Toulouse, 19-20 mai 2011
Réunion annuelle EPIGRAM, Ile de Ré, 30 mai – 1er juin 2011

Le groupe de travail / The WG

- Sujet: Assimilation de données dans les mers côtières et de plateau, avec un focus particulier sur le Golfe de Gascogne
  - Aspects scientifiques
  - Aspects stratégiques

- Action conjointe GMMC/EPIGRAM, 2010-2012
  - Soutien GMMC (missions: 10k€/2 ans)
  - Soutien complémentaire EPIGRAM

- Réunions du GdT ouvertes à toute personne intéressée, travaillant sur tout système d'assimilation dans le GdG ou d'autres régions côtières

Outils et configurations / Tools and configurations

Groups	Configurations	Assimilation
LEGOS / NOVELTIS (De Mey, Ayoub, Lamouroux, Lyard)	• SYMPHONIE 3km BoB + Celtic Sea, Obc PSY2v3 + FES (LEFE/ASSIM config.) • Several TUGO2D configs	• AEnKF (BELUGA) • SpEnOI • ARM • Data: ALT, SST, (tg, radars)
SHOM (Baraille, Hoang, Morel)	• HYCOM 1.8km BoB, Obc MERCATOR + tides	• Reduced-order scheme based on AF and Schur vectors • Data: ALT, SST
PREVIMER / ACTIMAR (Dumas, Cranéguy, Heyraud, Reynaud, Charria)	• « MANGA »: MARS3D 4km GdG + Celtic Sea + Channel, Obc MERCATOR + tides	• EnKF (NERSC) • ARM (coll. NOVELTIS+LEGOS) • Data: SST, ++
LEGI (Brasseur, Brankart)	• HYCOM, several configs. 1/3°-1/15° incl. BoB	• SEEK, Ensemble methods, Truncated Gaussian filter • Data: profiles, ++
MERCATOR Océan / CLS / LEGOS (Testut, Benkiran, Quattrocchi, Léger)	• NEATL12 v2, Obc GLORYS1V1 + FES2004 • BISCAY36, Obc PSY2v3 + FES2004	• SAM-2 (anomaly-based SEEK) • Stoch.Mod. (→ AEnKF) • Data: ALT, SST, profils

Assimilation de données dans l'océan côtier / DA in the coastal ocean

- Problème d'AD spécifique / A specific DA problem
  - HR, HF, marées, couplages, OBC, guide d'ondes, non-homogénéité statistique etc.
- Communauté nettement plus réduite que celle des modélisateurs côtiers / A relatively small-size community
- Intérêt stratégique de l'AD pas encore totalement clair, notamment vis-à-vis des autres forçages / Strategic interest of DA still unclear relatively to other forcings
  - Autres forçages: Càl latérales, fleuves, atmosphère (plateaux)
  - Autres développements de R&D: Evolutions numériques, résolution, forçages, bathymétrie, etc.
  - Intérêt prédictif
  - Cadre théorique de l'assim permettant de faire autre chose qu'assimiler
    - Sensibilité
    - Performance de réseaux d'obs

Le GdT: 3 objectifs principaux / WG objectives

- Encourager les échanges au sein du GdT (ou externes) / Encourage *exchanges*

- Dégager des axes d'étude prioritaires sur l'AD dans l'océan côtier, notamment à destination des A/O / *Prioritise research*
  - Spécificité: études régionales sur GdG et R&D (→ LEFE/ASSIM, GMMC)
  - Angle de vue par processus (→ EPIGRAM)
  - Intérêt stratégique de l'AD vs. autres efforts (→ GMMC, ops)

- Préparer un projet permettant à une communauté encore embryonnaire de trouver ses marques et de progresser / Prepare a *project*

Agenda

- Réunion 1, 21 septembre 2010, Toulouse
  - Prise de connaissance des études en cours dans les différentes équipes
  - Identification de préoccupations communes et de questions à élucider
  - Homework → réunion 2

- Réunion 2, 22-23 septembre 2011, station Ifremer de l'Houmeau
  - Représentation multivariée des s/e d'erreur, processus d'erreur importants
  - Discussion sur les orientations et sujets d'étude prioritaires
  - Discussion sur les contours d'un projet + dimensionnement en CDDs

- Réunion 3, 1er semestre 2012 (date à affiner en fonction des A/O)
  - Avancement scientifique
  - Préparation de la suite.

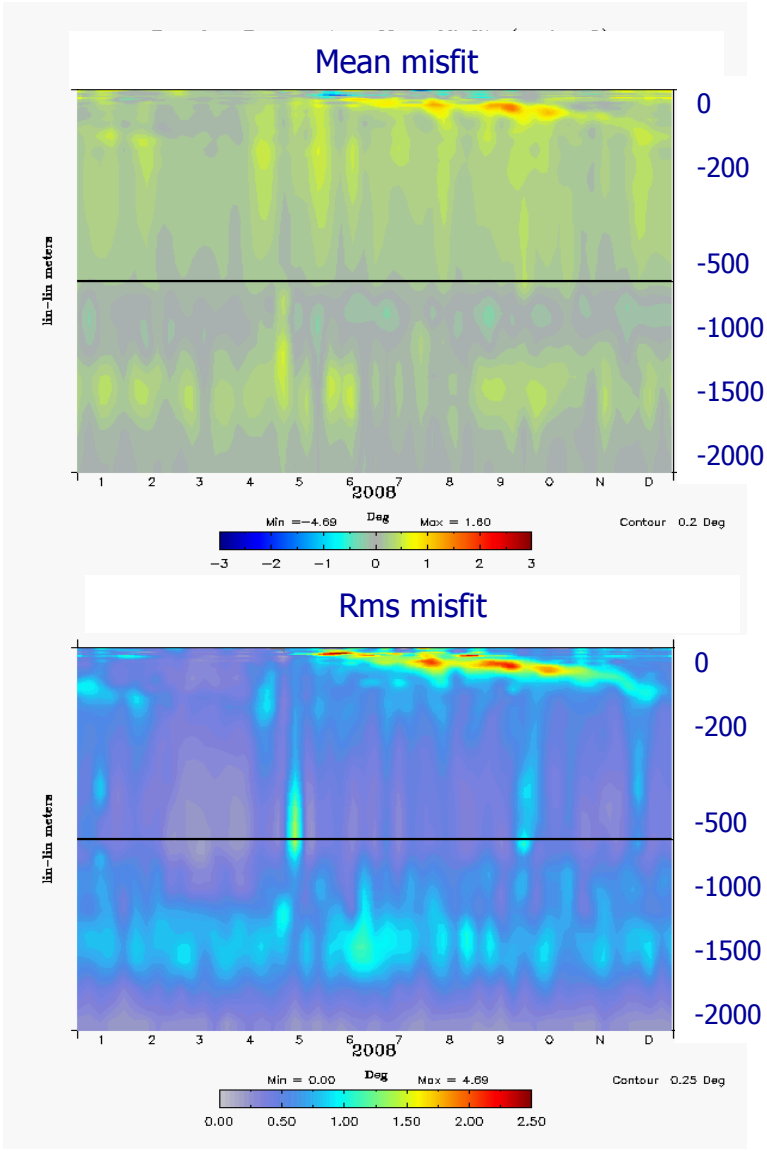
Quelques préoccupations communes / A few common issues
(cf. CR Réunion 1, sept. 2010 / identified at 1st meeting)

- Identification des processus d'erreur dominants / Dominant error processes
  - P.ex. forçages atm. HF: impact des forçages, processus couplés (ex: upwelling)
  - P.ex. erreurs de représentativité (SWH, dérive de Stokes, biais dans ROFI…)
  - Saisonnalité des erreurs… Estimation de paramètres… Etc.
- Méthodologie
  - Assimilation en présence de marée et de dynamique HF sur le plateau, detiding
  - Coût des méthodes d'ensemble
  - Utilisation des obs. « côtières »: marégraphes, radars HF, mouillages insulaires, RECOPESCA
  - Performances et degré de sophistication des schémas en milieu ouvert/ rapide/non gaussien/biaisé
  - Comparaison des codes, p.ex. NERSC EnKF vs. BELUGA AEnKF
  - Comparaison des modes opératoires: fréquence d'assimilation, assimilation d'altimétrie ou pas, correction ou pas des vitesses, nbre de membres, etc.
- Besoins des opérationnels / Specific needs of CO forecasting
  - Types de variables à prédire (surtout superficielles), prévision de maxima

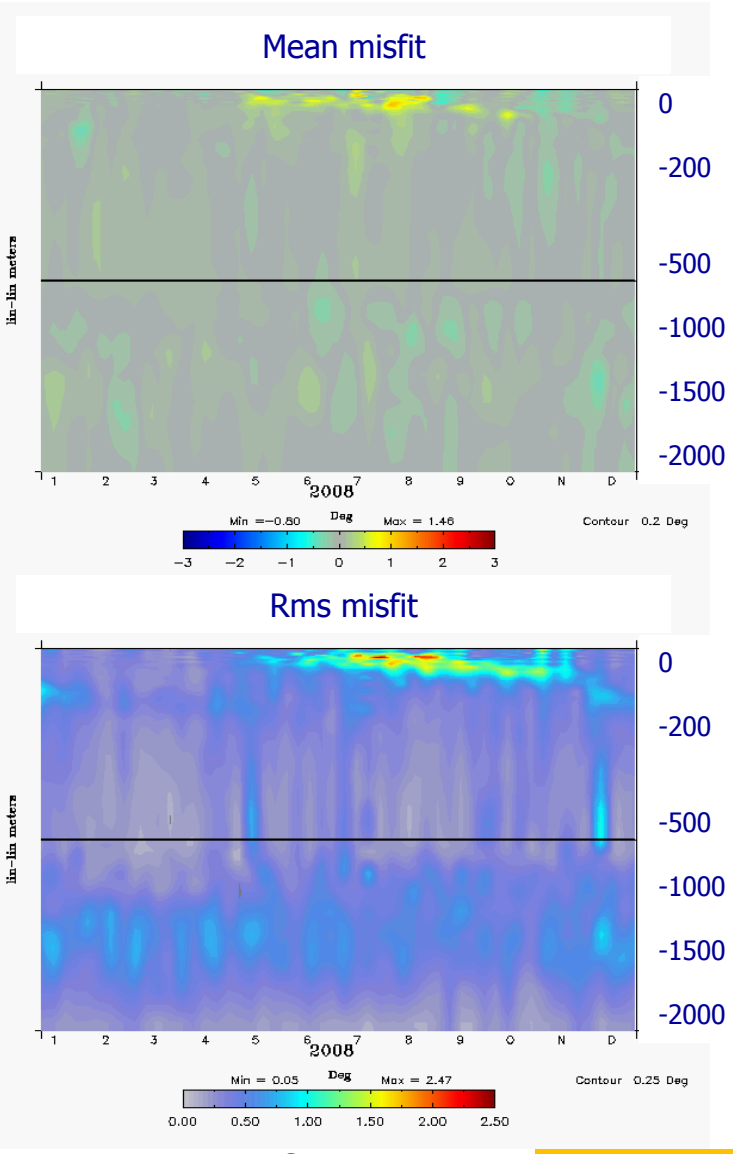
A few illustrative examples…

- Regional scale DA
- Tidal estimation
- Parameter estimation
- Representers (influence fcns. of observations)
- Array design
- Ensemble consistency analysis (validation of 2^{nd}-order moments)

NEATL12/SAM-2 -- Perf Diags on T
Impact of assimilation



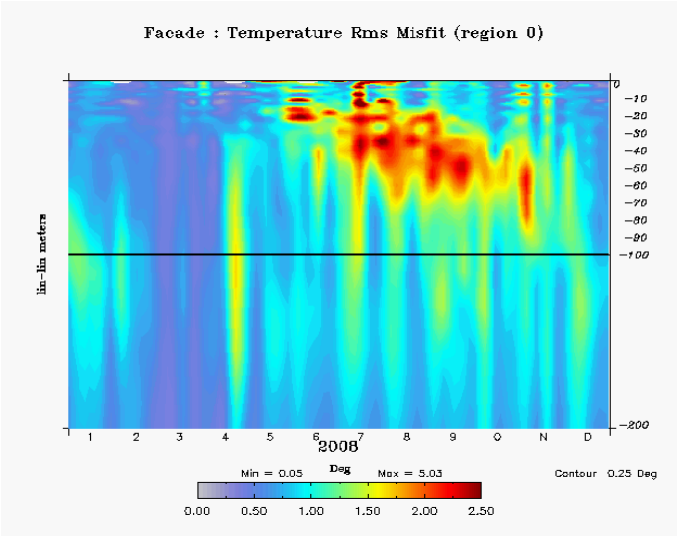
Free_Run



Ref_Run

(Benkiran/CLS)

NEATL12/SAM-2 – Perf Diags on T
Impact of forcing frequency (3h)

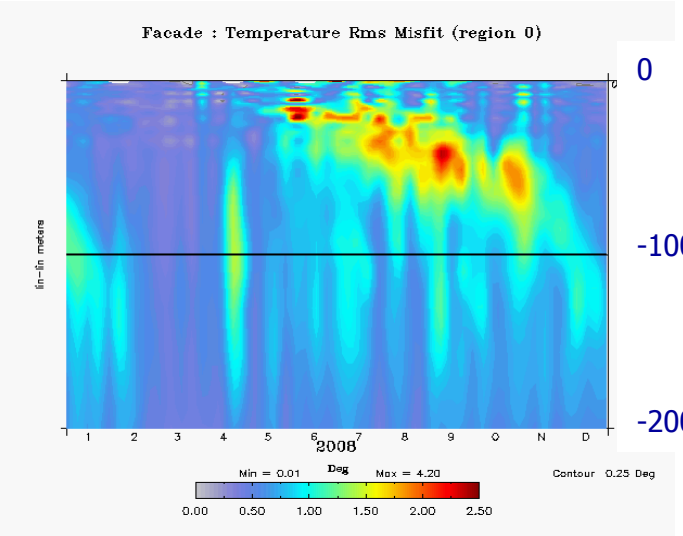


0

-100

-200

Reference run



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-100

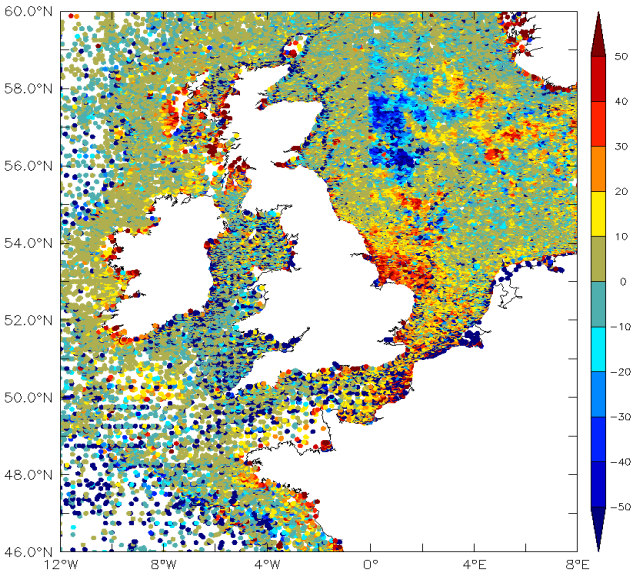
-200

Hfreq forcings run

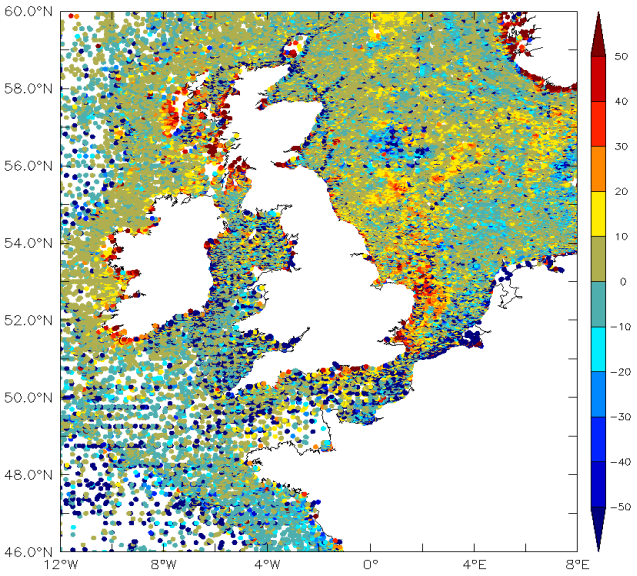
(Benkiran/CLS)

(Lyard et al./LEGOS)

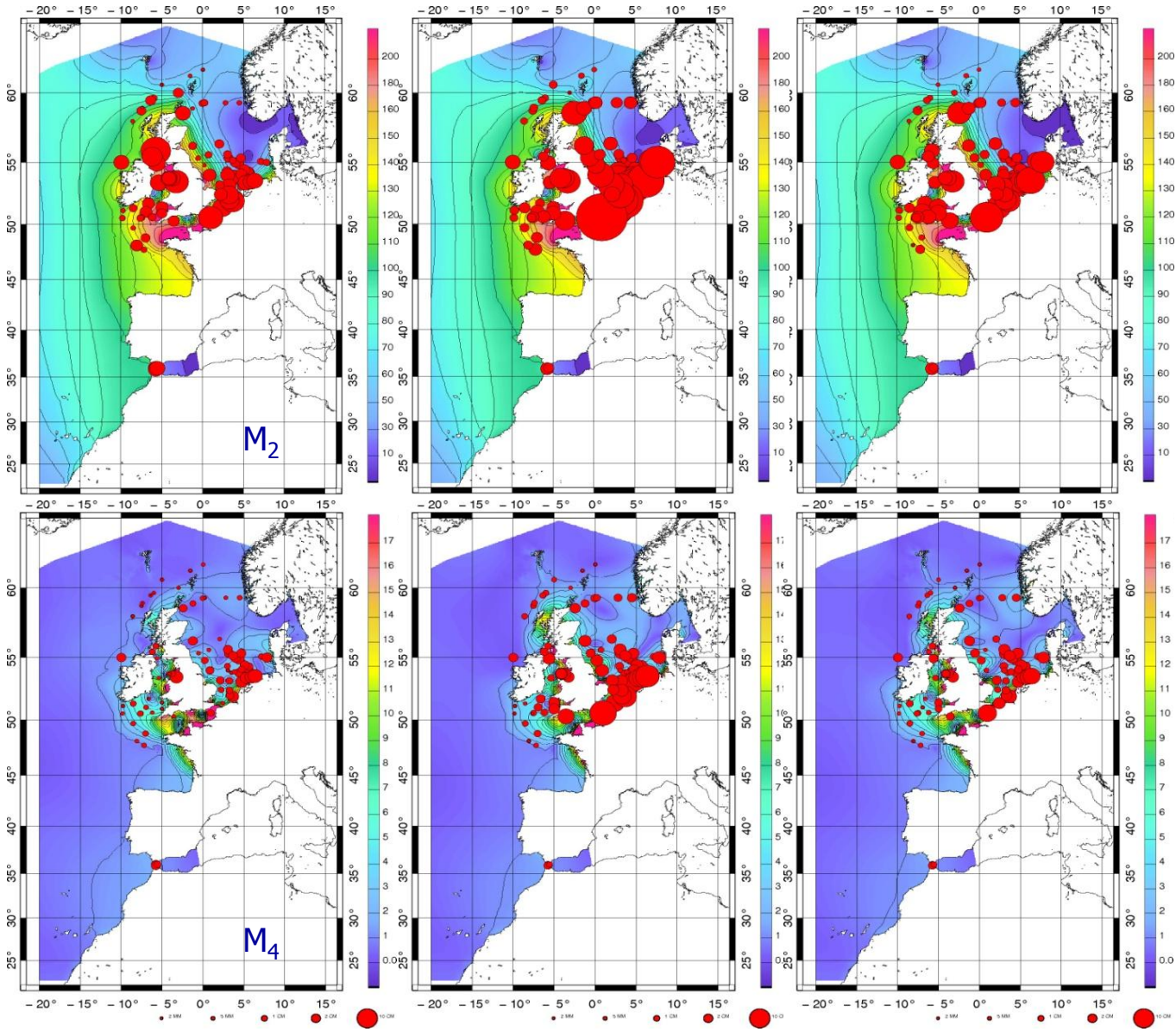
Strategy: bathymetry accuracy vs. assimilation



Bathymetry Version-2009 versus XBTs depth



Bathymetry Version-2010 versus XBTs depth



NEA-COMAPI (assimilated)

Bathymetry Version-2009

NEA-COMAPI (hydrodynamic)

Bathymetry Version-2009

NEA-COMAPI (hydrodynamic)

Bathymetry Version-2010

Polychromatic data assimilation

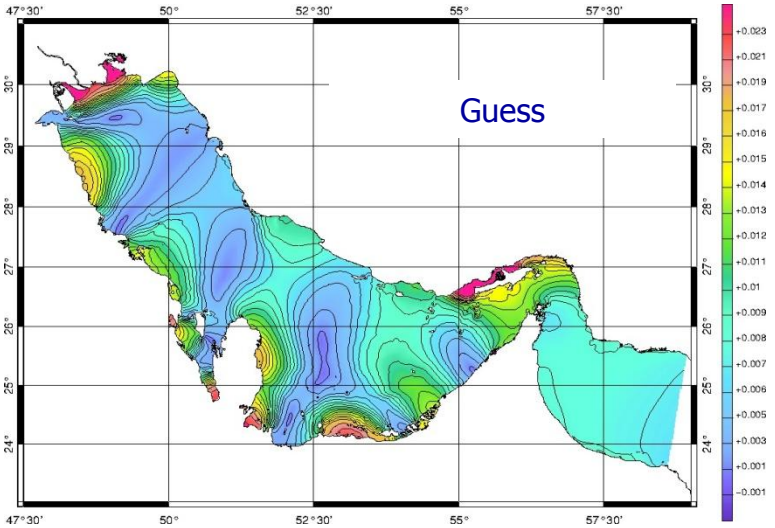
Non-linear constituents:

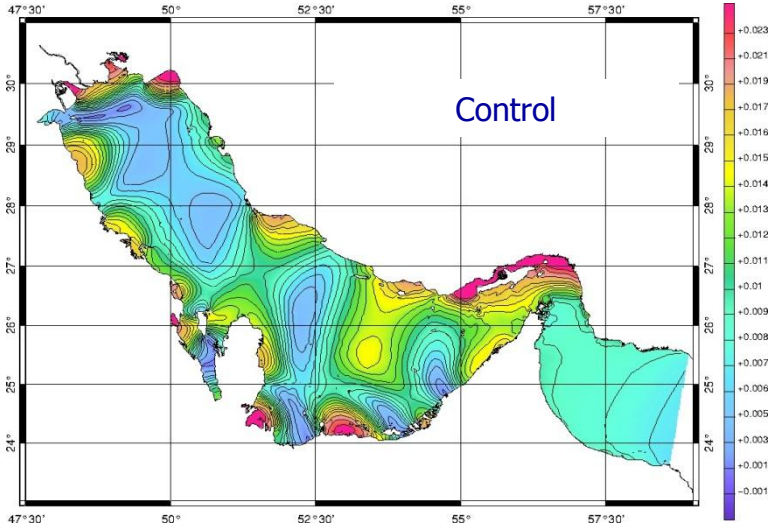
- O(1) amplitude/noise ratio in altimetry
- strongly correlated with generating astronomical tides

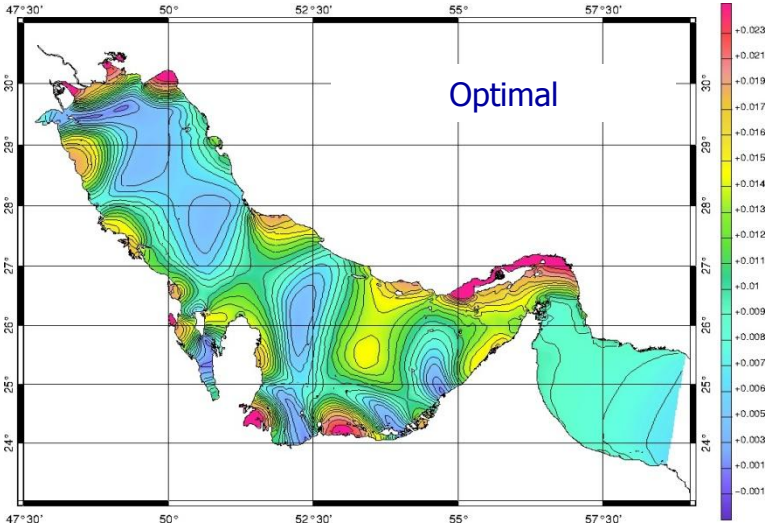
Polychromatic data assimilation

=

simultaneous data assimilation of several tidal waves to control minor constituents with major constituents data through their tight correlations





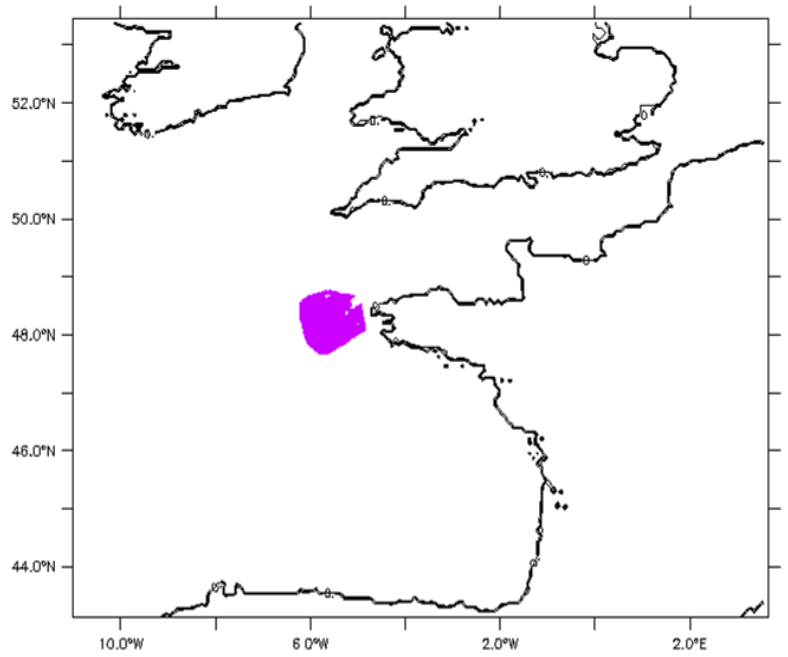


Guess, control and optimal M_4 solution obtained from a M_2,S_2, M_4, MS_4 polychromatic data assimilation (OSSE exercise); no data given for M_4 and MS_4. Control and optimal almost identical !!!

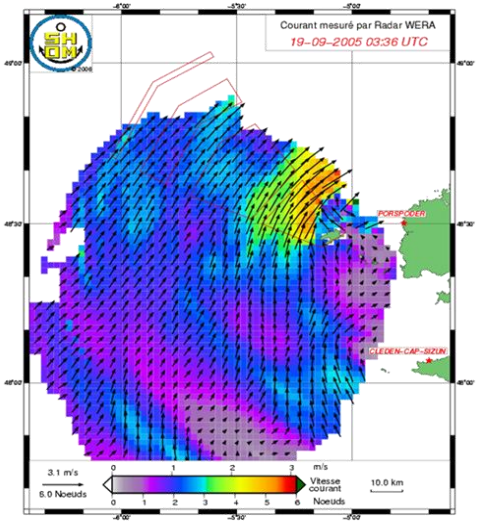
(Lyard et al./LEGOS)

C_d estimation

- Bottom drag coefficient important for tidal estimates
- HF radar observations ➔ estimate surface tidal currents
- Variational approach: estimate $C_d(x,y)$ or C_d(seafloor type) which minimises a cost function
- Correct phases
- Ph.D. to start on subject

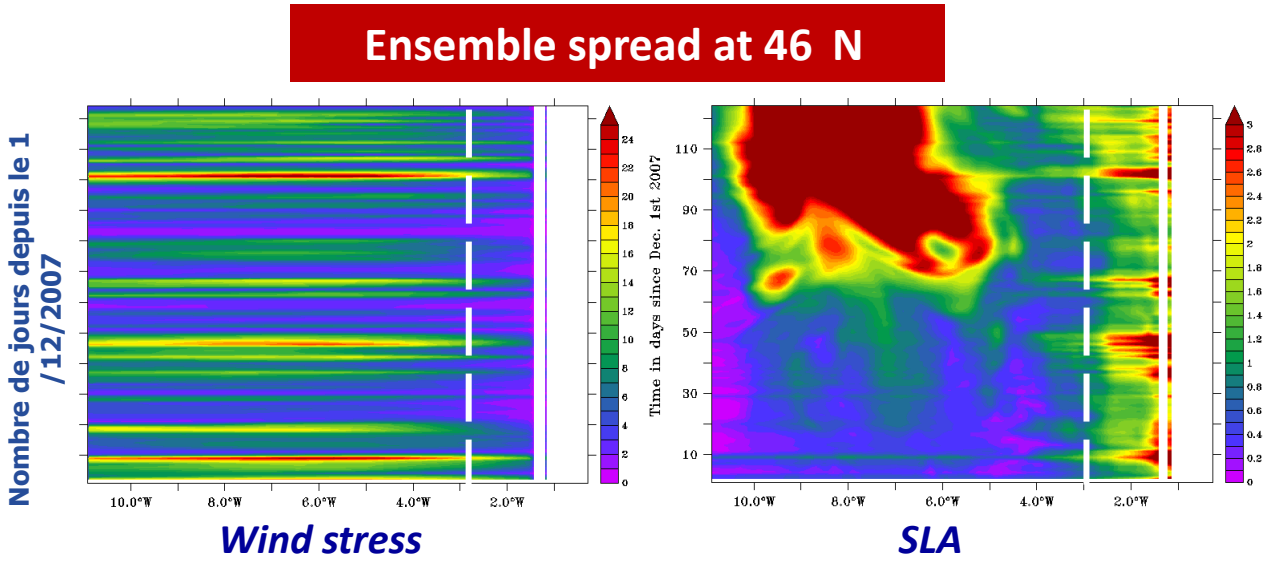


HF radar coverage



(Baraille et al./SHOM)

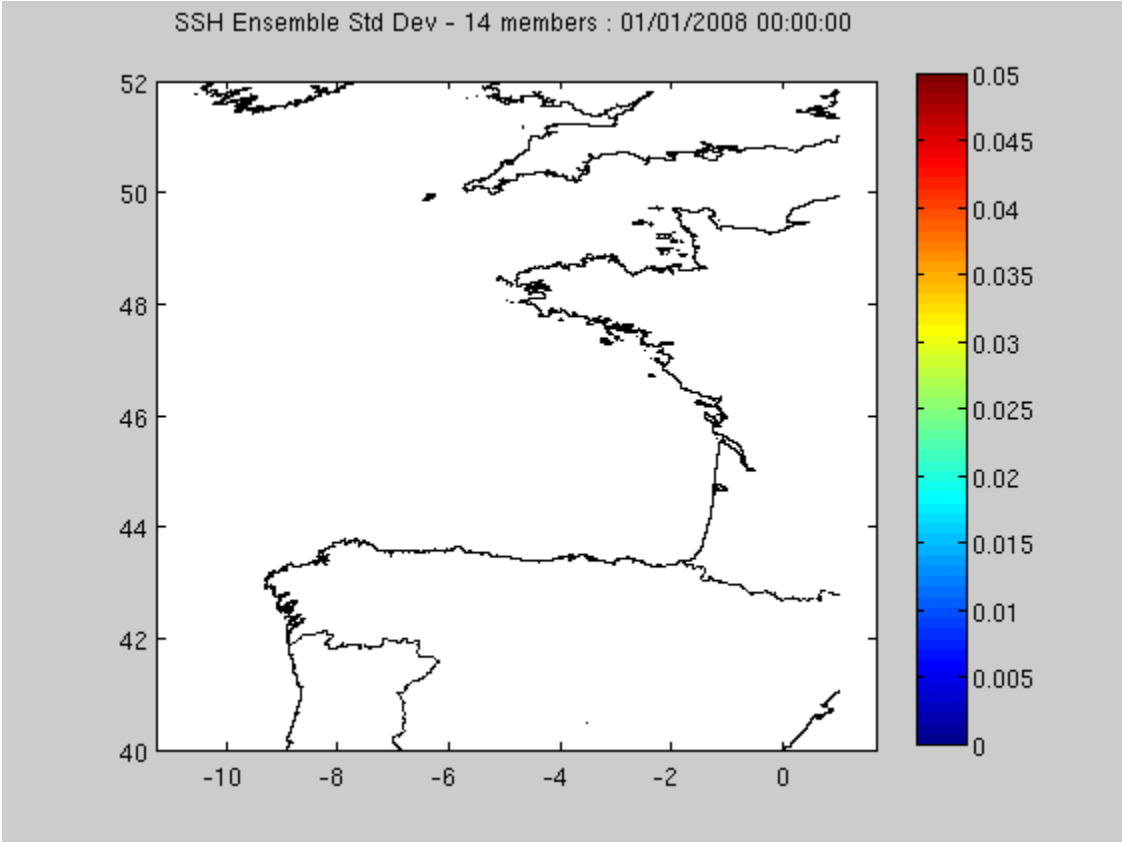
Stochastic modelling forced by wind uncertainties



(Ayoub, De Mey/LEGOS, Lamouroux/NOVELTIS)

Ensemble spread(t) in SLA (January 2008) -- a proxy of prior state error variance

- Error-subspace response to wind errors: a mix of mesoscale turbulence, Kelvin/shelf waves, water pile-up on shelves (including English channel, aligned with dominant winds axis) – spot the fast, elusive Kelvin waves along the Spanish coast!
- SST Ensemble spread(t) [not shown] also contains Galician upwelling errors

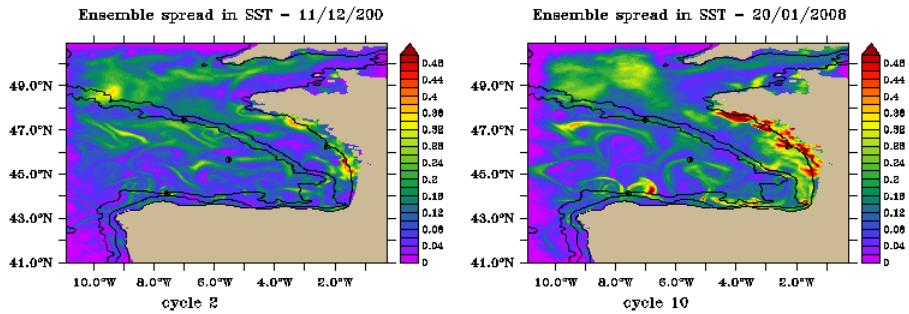


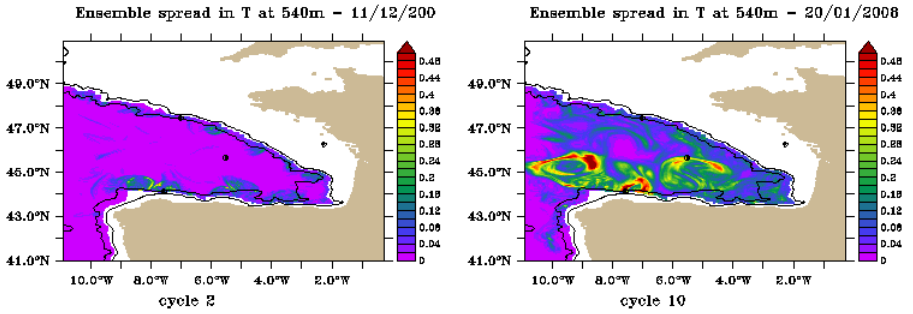
MOVIE: SLA Ensemble Std.dev. January 1-31, 2008

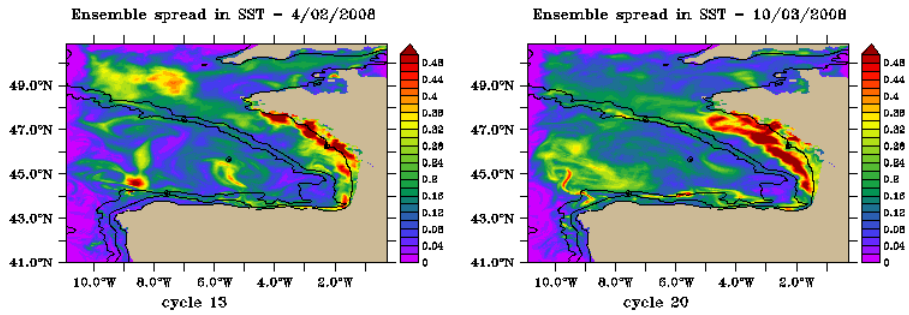
(Ayoub, De Mey/LEGOS, Lamouroux/NOVELTIS)

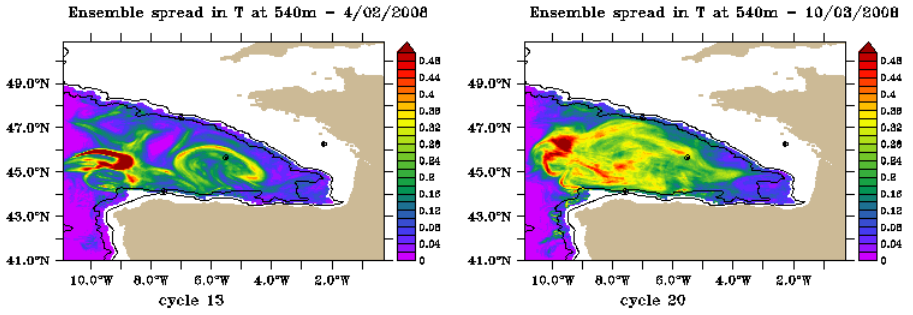
Ensemble spread as a function of time: SST, T540

- Wind velocity errors
- Structures slowly fill up above the abyssal plain, in particular sprouting from the North Iberian shelf
- The response on the shelf is more quickly established and more time dependent





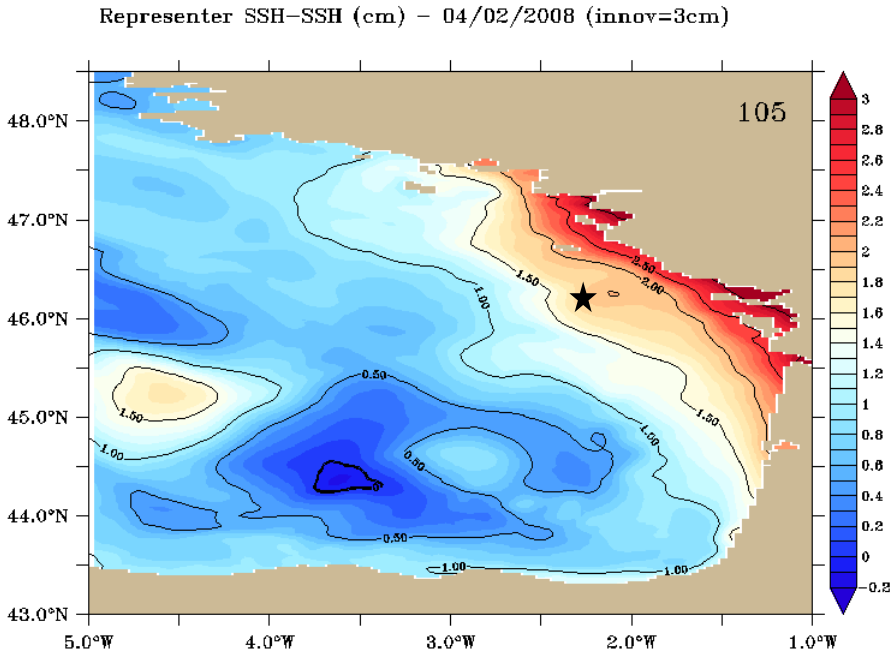


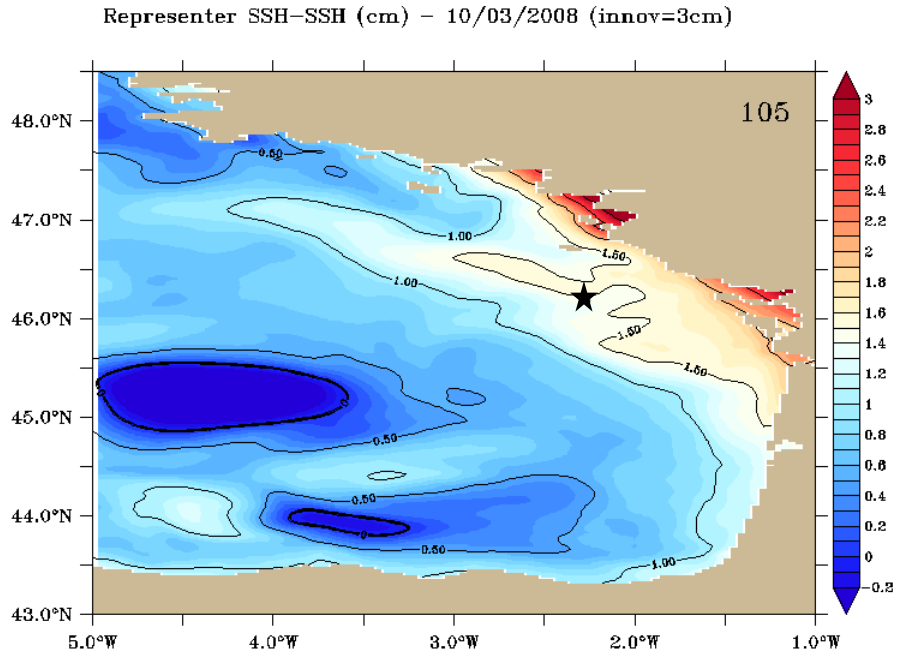


(Ayoub, De Mey/LEGOS, Lamouroux/NOVELTIS)

Representers of SSH on top of the South Armorican shelf

- Mostly a shelf-wide response (correlations with abyssal plain variables are probably artefacts)
- High temporal variability





(Ayoub, De Mey/LEGOS, Lamouroux/NOVELTIS)

Representers of SST observations (2004) – zero-lag T(z)

July 17

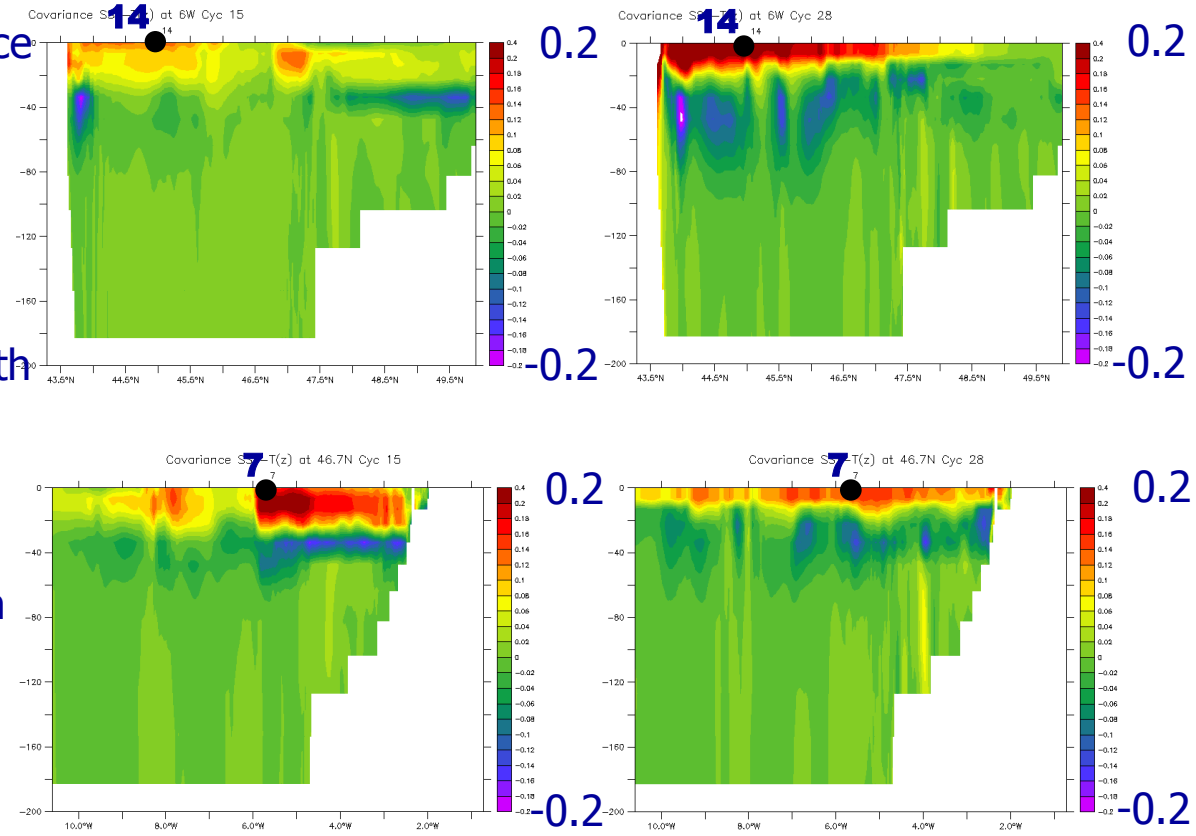
July 30

surface

Abyssal Plain f(lat)

200m depth

Armorican Shelf Break f(lon)



Vertical sections:

- Covariance sign change across seasonal thermocline indicates that error subspace contains processes changing its depth… and that such processes have an SST signature (consistent w/Andreu-Burillo et al., GRL 2002)
- Time variations of representers are mostly due to changes in ocean state (circulation, thermocline)

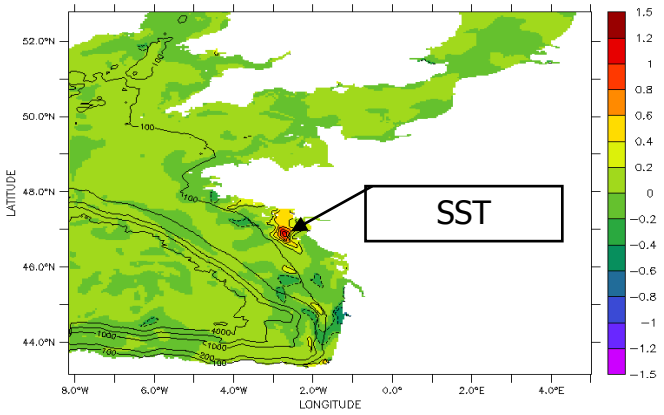
(Ayoub, De Mey/LEGOS, Lamouroux/NOVELTIS)

Representers of SST observations (2004) – zero-lag T(z)

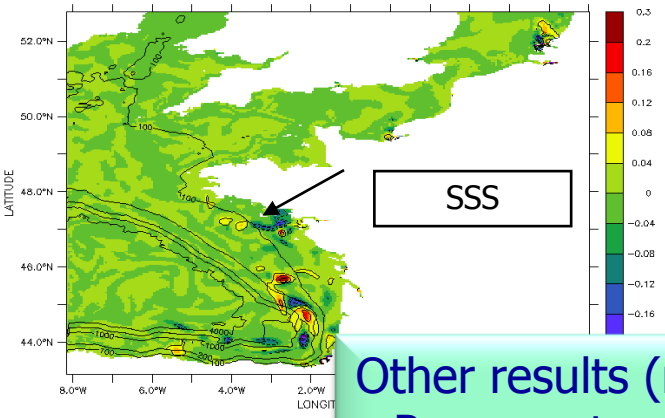
Error sources for Ensemble generation:

- ECMWF Ensembles: 50 members
- MARS3D parameters: Cd, TKE paremeters, solar light penetration, horizontal viscosity

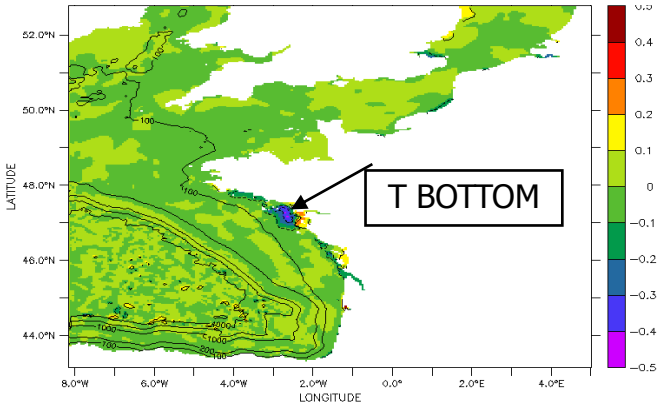
REPRESENTERS(Loire SST) [summer 2006]



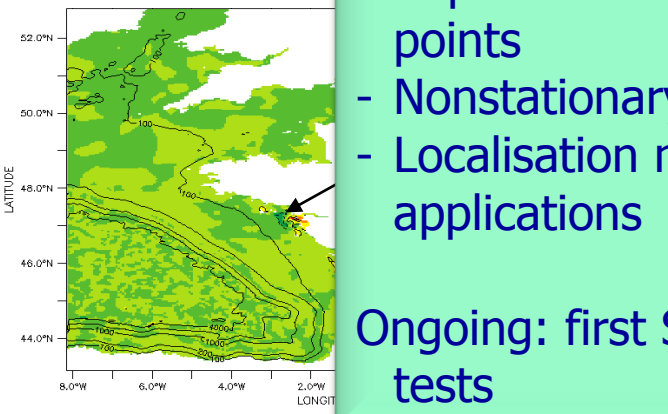
REPRE(SST,SST)



REPRE(S



REPRE(SST,TBOT)



REPRE(SST,SBOT)

Other results (not shown):

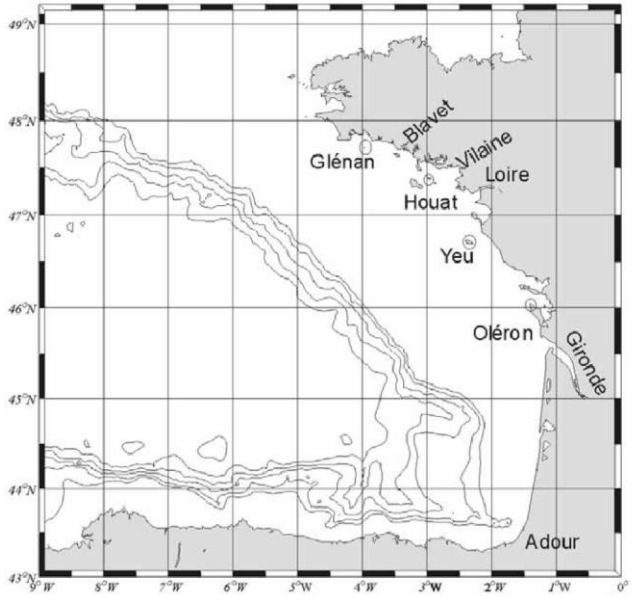
- Representers at offshore points
- Nonstationary covariances
- Localisation needed for DA applications

Ongoing: first SST assimilation tests

(Cranéguy et al./ACTIMAR, Dumas/PREVIMER)

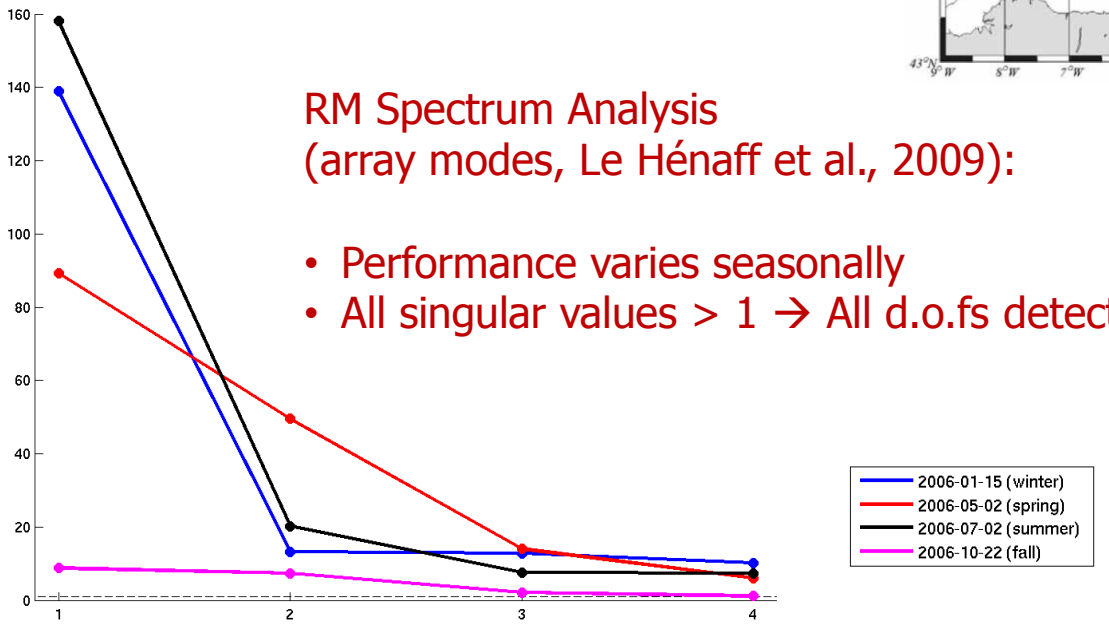
Ensemble-based Array design -- Island-based moorings

Réseau des Iles
Bouées SMATCH (T,S)



MARS3D Ensemble simulations – Error sources considered:

- Wind
- Extinction coefficient
- Turbulent mixing
- Bottom drag

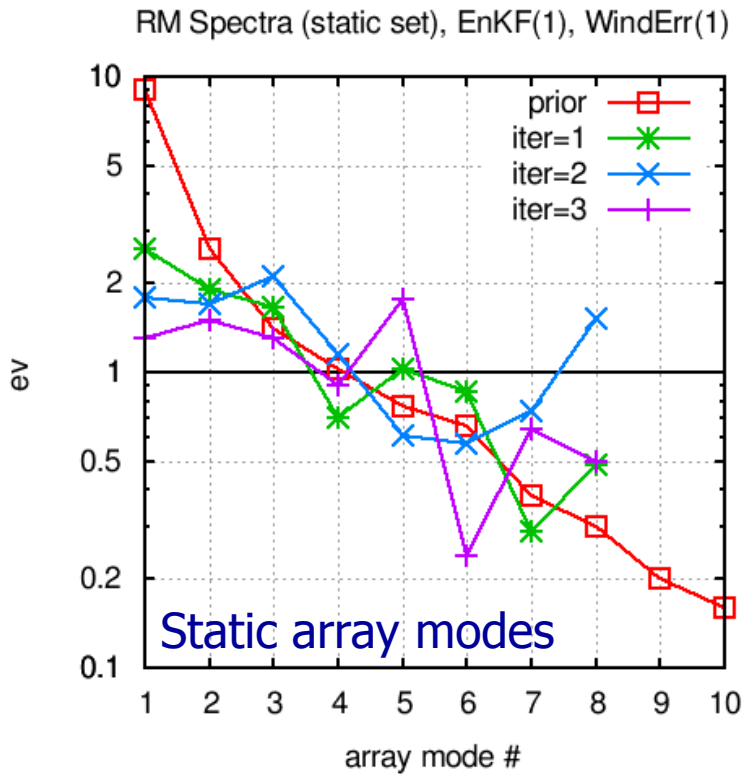


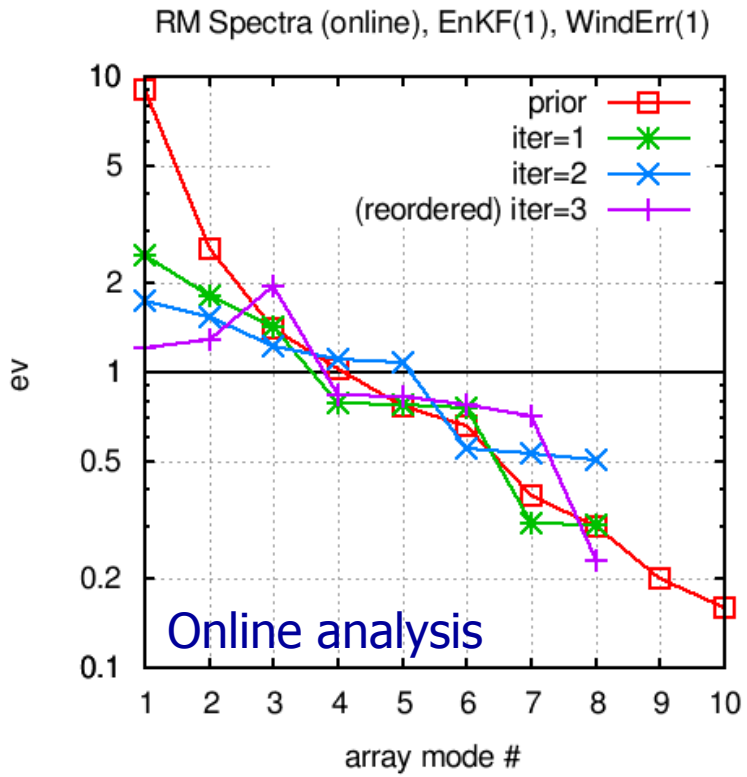
RM Spectrum Analysis
(array modes, Le Hénaff et al., 2009):

- Performance varies seasonally
- All singular values > 1 → All d.o.fs detected

(Charria/PREVIMER, De Mey/LEGOS)

RM Spectrum analysis: online analysis with AEnKF





SWOT, Gaussian wind errors, 10-day assim cycles (invariant **H**):

- Spectra whiten in detectable range (array info being extracted)
- Swing & Meso1 array modes evolve slowly throughout regime changes
- Confirm that SWOT alone exhibits useful performance at constraining Swing & Mesoscale error processes, more marginal perf. for HF on shelf

(De Mey/LEGOS)

Ensemble spread (Forecast error) consistency with innovation

WINTER

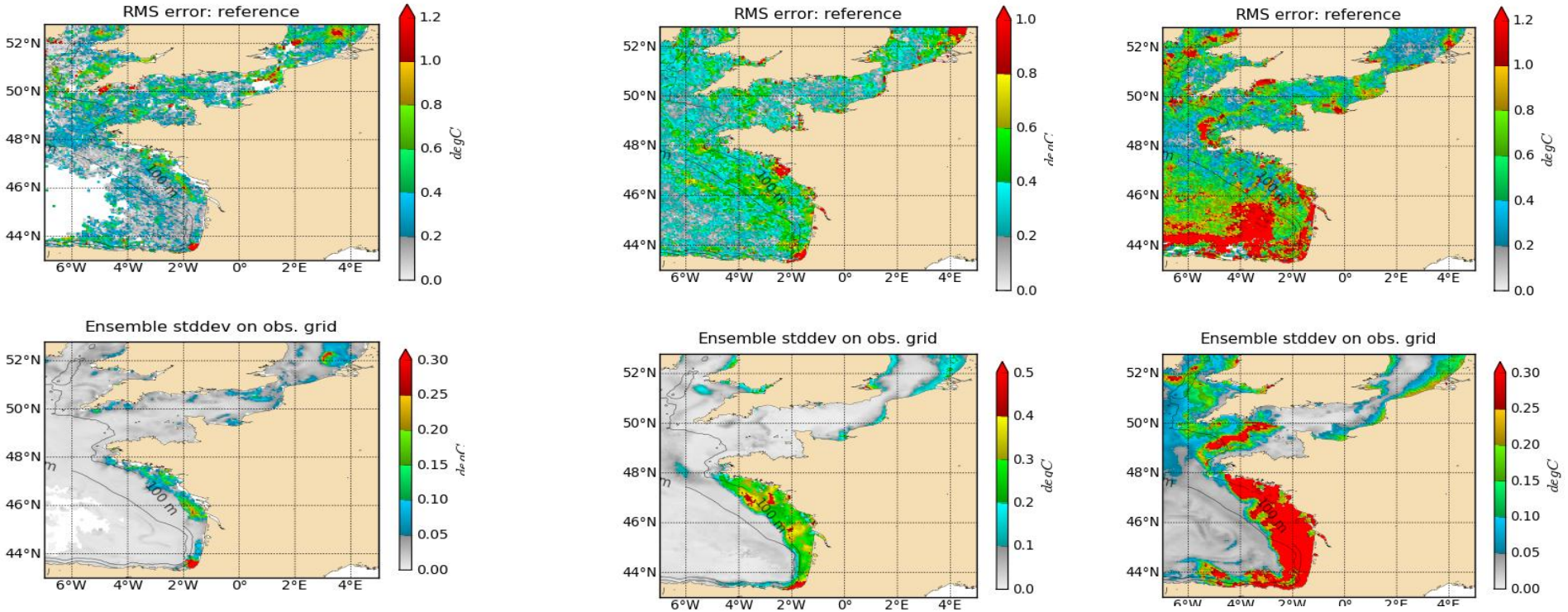
2006-01-16 – 2006-02-01

SPRING

2006-04-17 – 2006-05-11

SUMMER

2006-07-02 – 2006-07-18

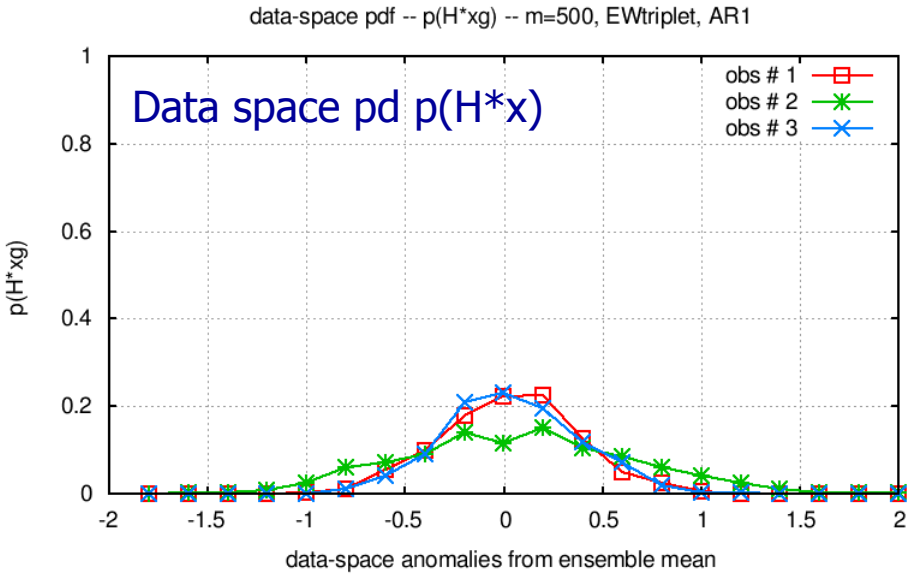


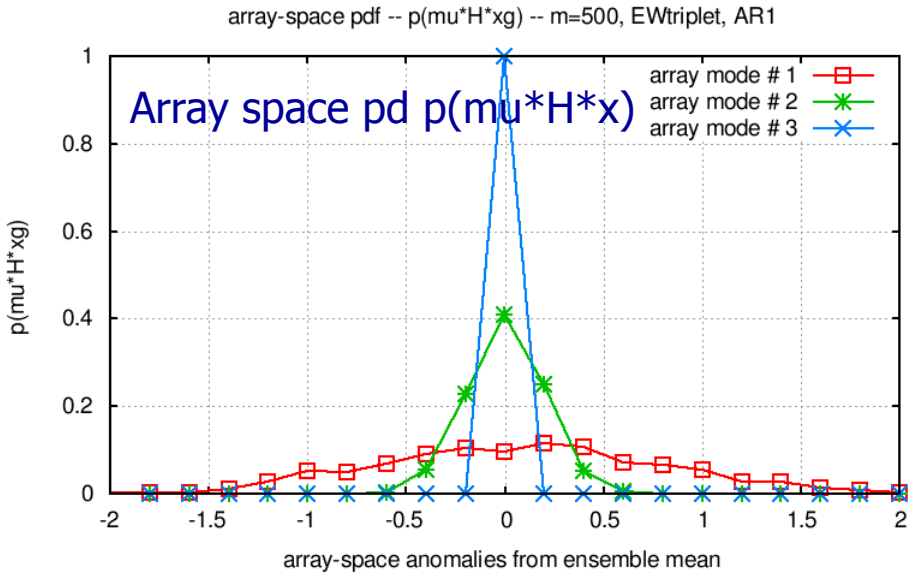
On shelves: SST Ensemble spread underestimates error, but reasonable spatial distribution (especially in winter + spring)

(Cranéguy et al./ACTIMAR, Dumas/PREVIMER)

(Towards) array-space consistency analysis

- Goal: check whether pd's of model forecast and observations are consistent weo (visually, through reliability scores, etc. – not the topic here)
  - Data space vs. array space
- Low-order array-space forecast pd's have broadest base (by design)
  - Hierarchize consistency checks from easiest to hardest to pass





EW triplet, stationary/correlated AR process, 500 members

(De Mey/LEGOS)

La suite… une ébauche à discuter / What next? (1/2)

- Interactions
  - Niveau national / National level
    - GMMC → PPR?
    - EPIGRAM → suite (ANR)?
    - LEFE/ASSIM → outils
    - COMODO → stratégie (« favoriser l'émergence d'un ensemble d'outils ») + cas-tests
    - SIROCCO → outils
    - TOSCA: voir SWOT
  - Niveau européen / European level
    - JERICO → array design
    - SANGOMA → outils
  - Niveau international / International level
    - SWOT: accompagnement du raffinement d'échelles spatiotemporelles → impact++
    - OceanView Coastal Ocean and Shelf Seas Task Team (COSS-TT) → projet pilote

- Opportunités de calendrier à étudier

La suite… une ébauche à discuter / What next? (2/2)

(now in terms of a national initiative)

- But: permettre à une communauté encore embryonnaire de trouver ses marques et de progresser
- Volet d'un projet EPIGRAM-2 (ANR) ou PPR GMMC?
  - Volet "Prédicibilité" centré sur des processus (méso/subméso, fronts, marée/HF, effets des ondes internes, Navidad, etc.)
    - Impact de stratégies de modélisation, de forçages
    - Impact du downscaling (et des produits assimilés à grande échelle)
    - Apport de l'assimilation (diverses techniques/physiques)
    - Impact de la stratégie d'observation pour l'assimilation
    - Eventuellement possibilité de soumettre indépendamment dans un cadre SWOTST
  - PPR GMMC (avec Previmer)
    - Idem mais dans la config opérationnelle
- Nombre de CDDs à évaluer

- Mode EP-2: plus axé études scientifiques amont, configurations multiples
- Mode PPR: plus axé OO, config unique, durée limitée (soutien Previmer → 2013)