Ocean surface currents:

What can we do with Earth Observations ?

G. Larnicol, G.Dibarboure, Y Faugère, I Pujol,
S Labroue, C Dufau, MH Rio,...
Space Oceanography Division, CLS

cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

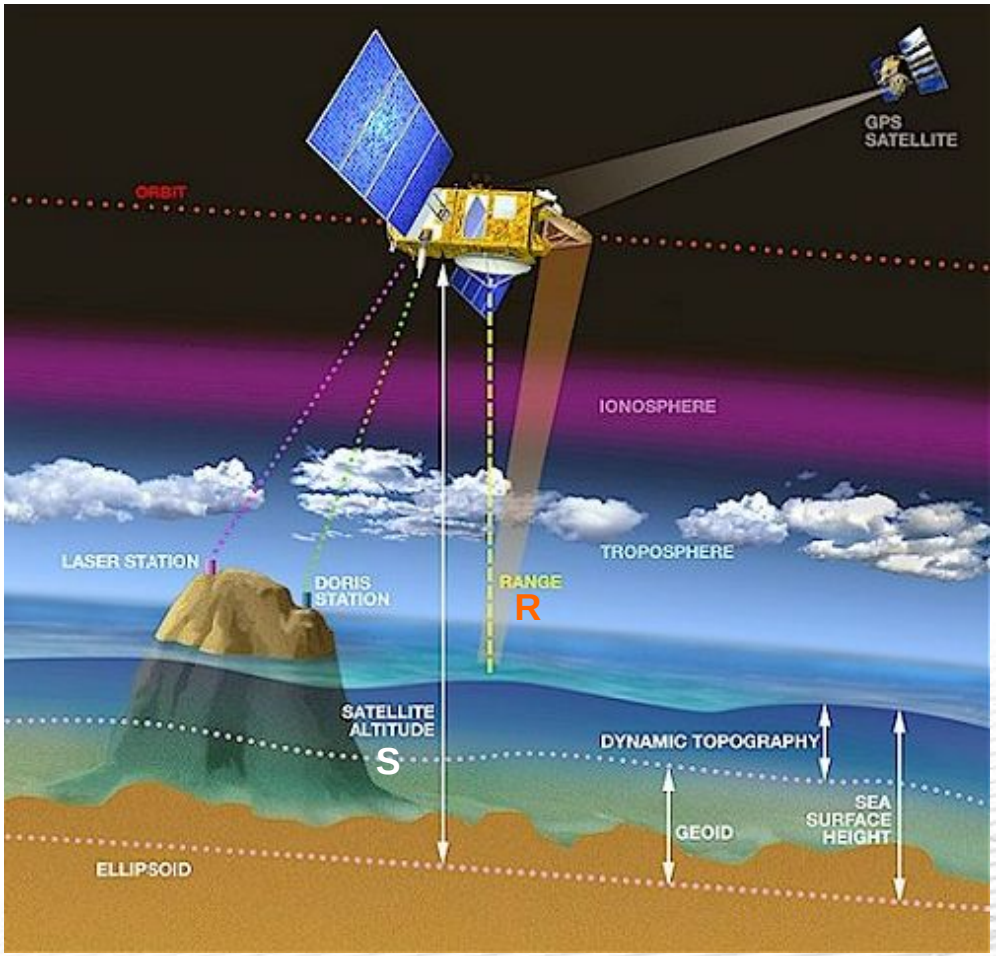
esa European Space Agency

myOcean

CLS COLLECTE LOCALISATION SATELLITES

Principle of the altimeter measurement

Sea Surface Height (SSH) $= S - R - \sum Corr.$



Altitude of the ocean surface respect to a reference ellipsoid

= Geoid + Dynamic Topography

Geoid = +/- 100 m (no ocean motion)

Oceanic circulation and its variability = +/- 1 m

Altimeter processing : The DUACS system

Dynamic Topo = MDT + SLA

SLA = SSH- MSSH

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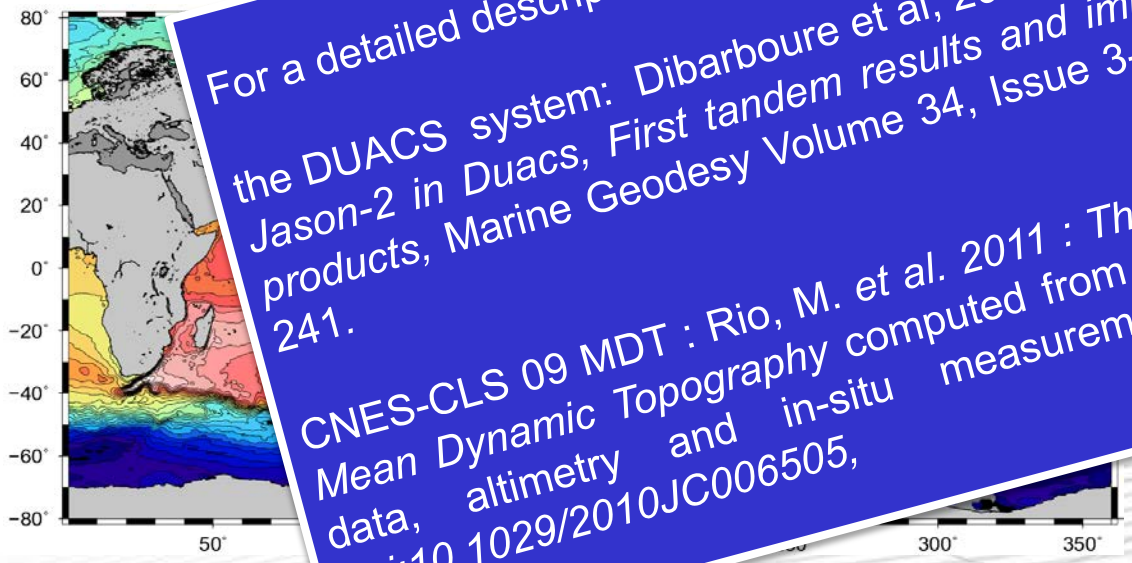
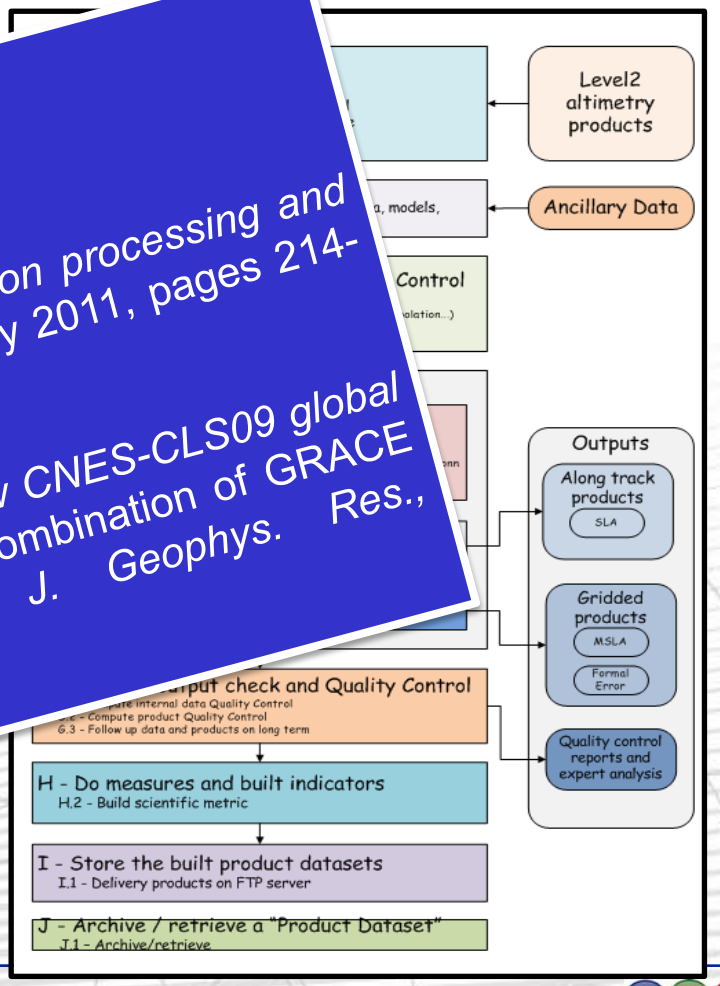
CNES C

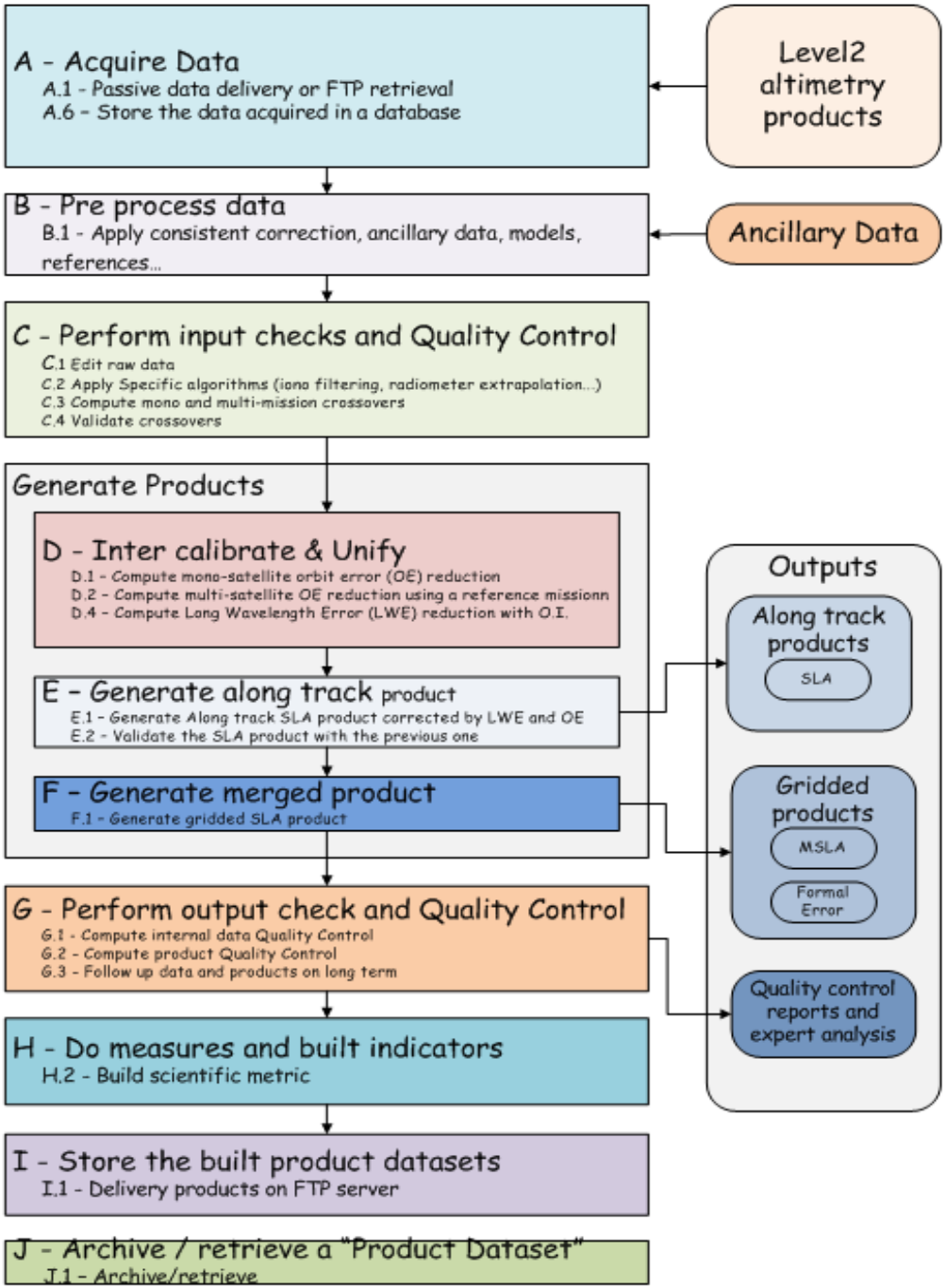


For a detailed description of :

the DUACS system: Dibarboure et al, 2011: Jason-2 in Duacs, First tandem results and impact on processing and products, Marine Geodesy Volume 34, Issue 3-4, July 2011, pages 214-241.

CNES-CLS 09 MDT : Rio, M. et al. 2011 : The New CNES-CLS09 global Mean Dynamic Topography computed from the combination of GRACE data, altimetry and in-situ measurements. J. Geophys. Res., doi:10.1029/2010JC006505,

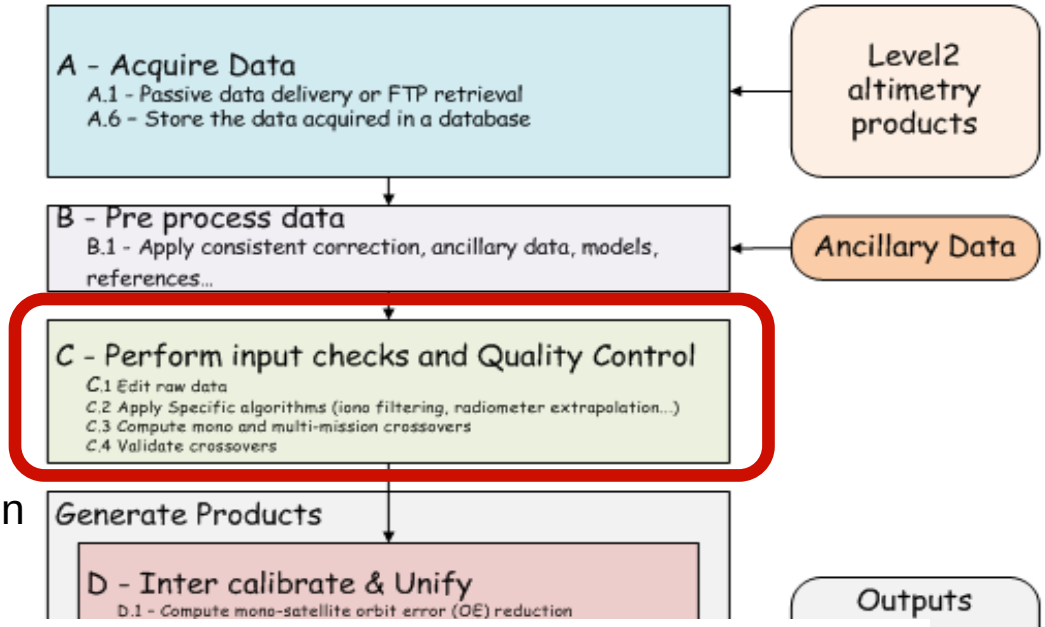


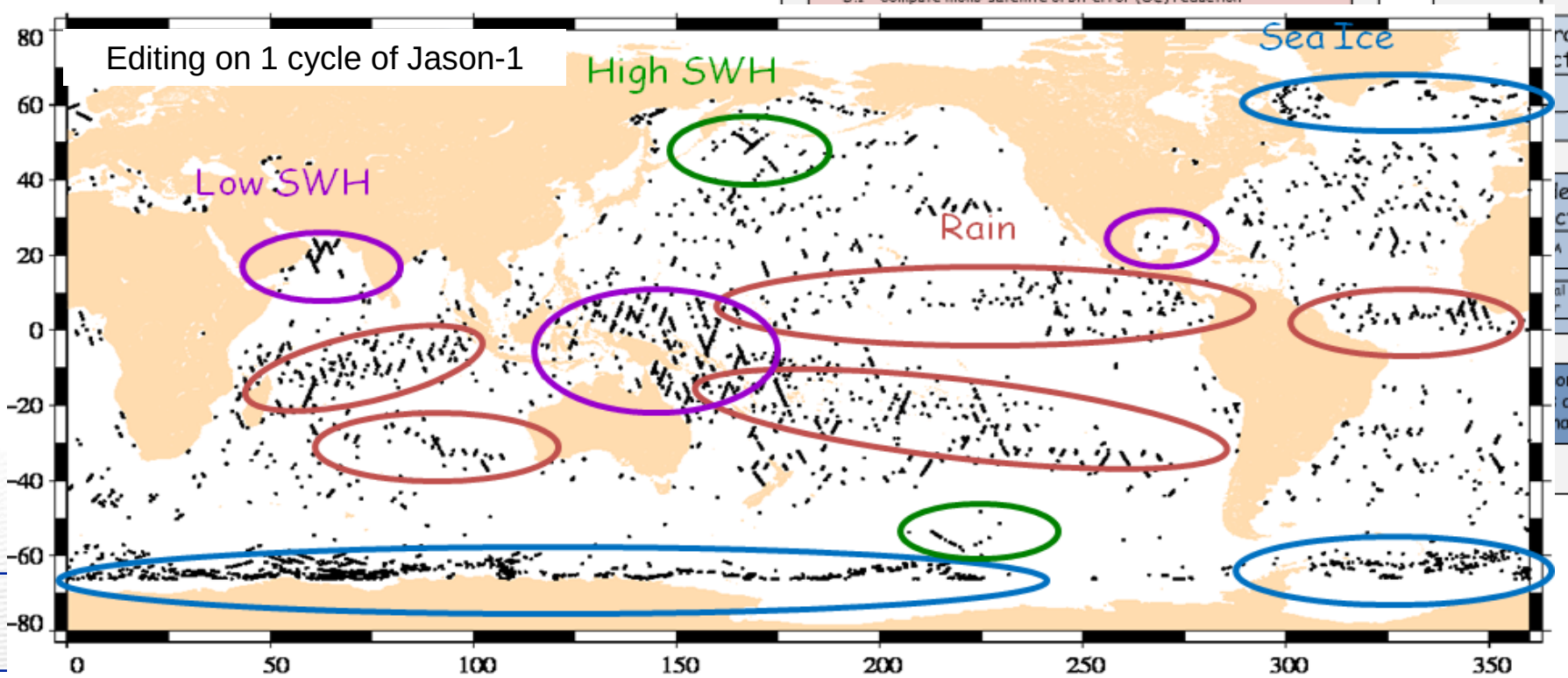

A - Acquire Data
A.1 - Passive data delivery or FTP retrieval
A.6 - Store the data acquired in a database
Level2 altimetry products
B - Pre process data
B.1 - Apply consistent correction, ancillary data, models, references...
Ancillary Data
C - Perform input checks and Quality Control
C.1 Edit raw data
C.2 Apply Specific algorithms (iono filtering, radiometer extrapolation...)
C.3 Compute mono and multi-mission crossovers
C.4 Validate crossovers
Generate Products
D - Inter calibrate & Unify
D.1 - Compute mono-satellite orbit error (OE) reduction
D.2 - Compute multi-satellite OE reduction using a reference missionn
D.4 - Compute Long Wavelength Error (LWE) reduction with O.I.
E - Generate along track product
E.1 - Generate Along track SLA product corrected by LWE and OE
E.2 - Validate the SLA product with the previous one
F - Generate merged product
F.1 - Generate gridded SLA product
G - Perform output check and Quality Control
G.1 - Compute internal data Quality Control
G.2 - Compute product Quality Control
G.3 - Follow up data and products on long term
H - Do measures and built indicators
H.2 - Build scientific metric
I - Store the built product datasets
I.1 - Delivery products on FTP server
J - Archive / retrieve a "Product Dataset"
J.1 - Archive/retrieve
Outputs
Along track products
SLA
Gridded products
MSLA
Formal Error
Quality control reports and expert analysis

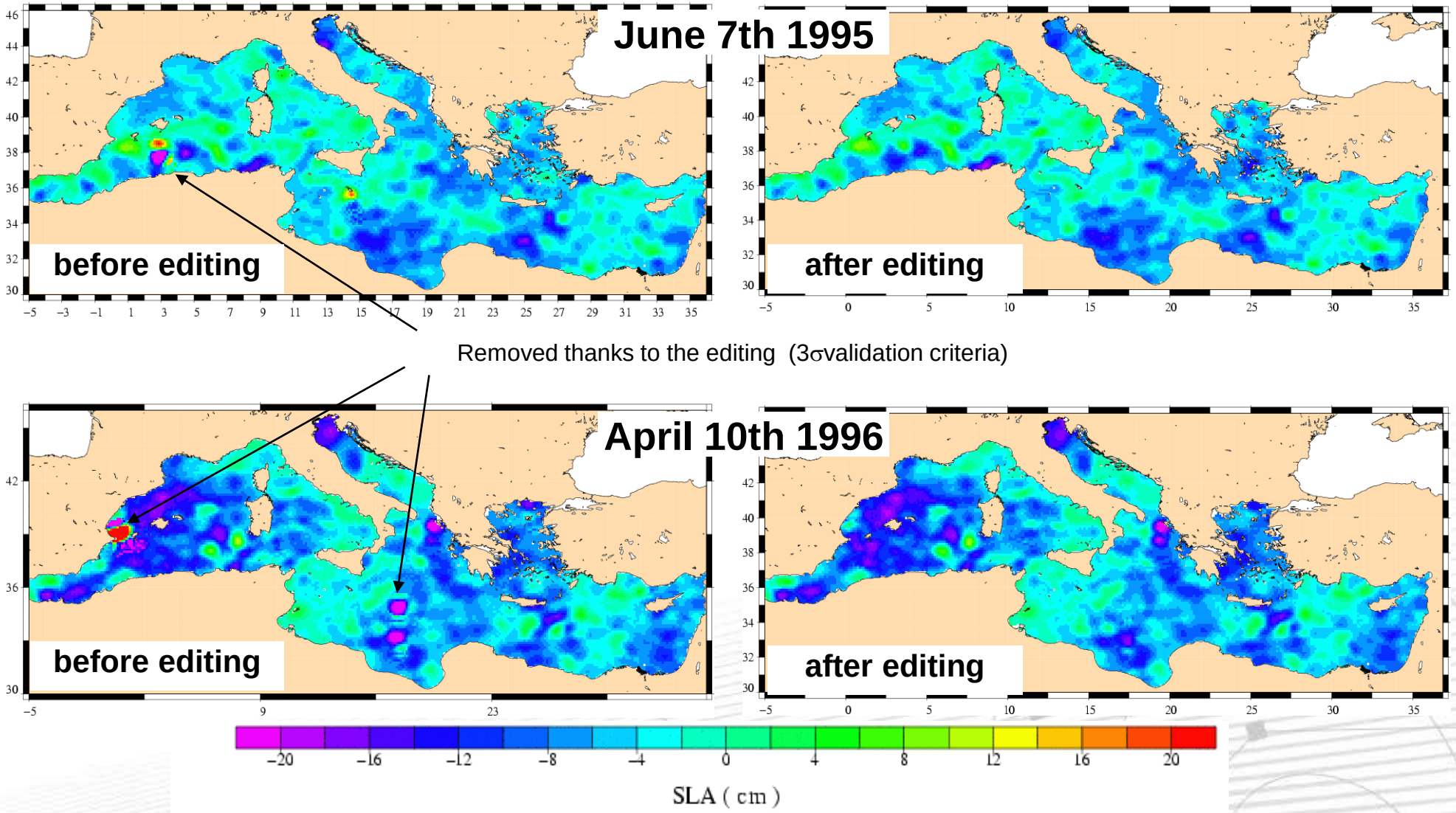
Quality Control is a critical process to obtain consistent input data before products generation

- Editing: detect and remove the erroneous measurements. This a critical process!

- Various algorithm applied
- Automated editing tuned for open ocean application => reject a small % of the dataset

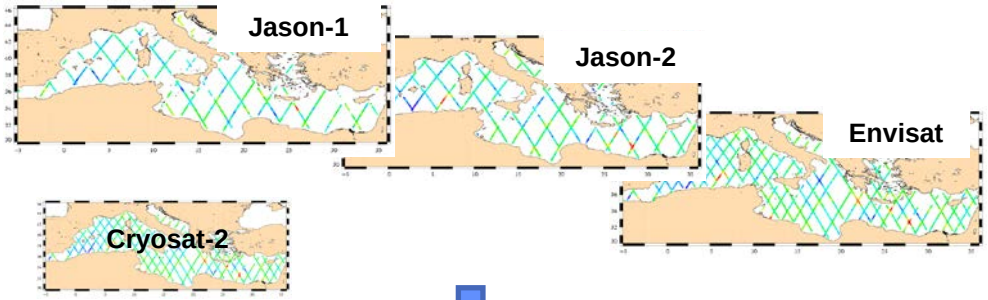





June 7th 1995
before editing
after editing
Removed thanks to the editing (3σvalidation criteria)
April 10th 1996
before editing
after editing
SLA (cm)

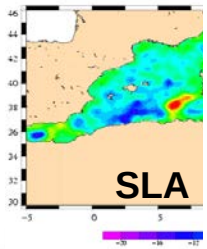
Altimetry products are geostrophic current

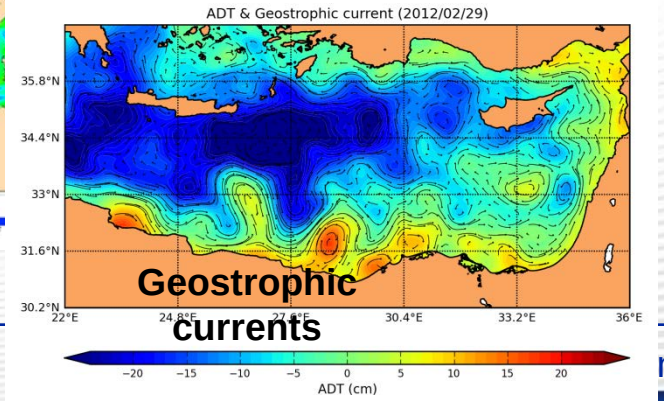
•Multimission merging is based on an optimal interpolation using an a priori knowledge of the covariance of the sea level and the measurement errors



Optimal interpolation method

Le Traon et al., 1998; Le Traon&Dibarboure, 1999; Ducet et al. 2000;





Geostrophic currents

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Outputs

Along track products
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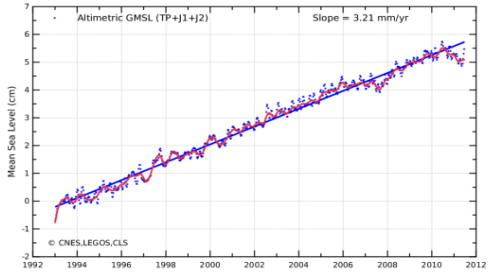
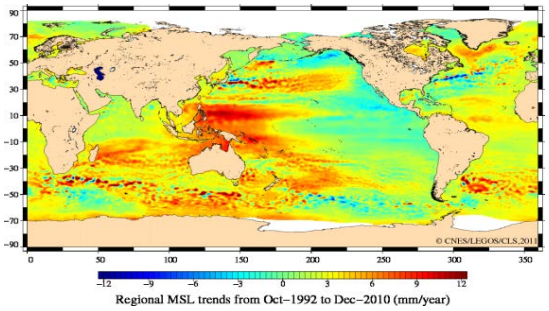
Formal Error

Quality control reports and expert analysis

An unprecedented data set covering a large spectra of applications…

Mean Sea Level Rise

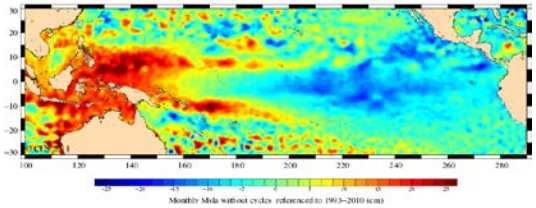


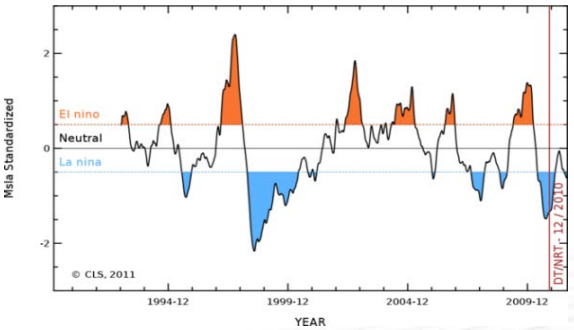


Regional MSL trends from Oct–1992 to Dec–2010 (mm/year)

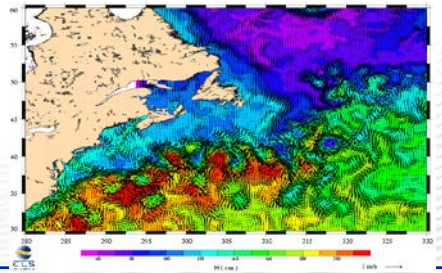
Seasonal to interannual

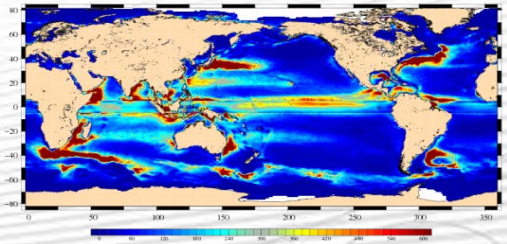
El nino/La Nina





Mesoscale





Since 1992, altimetry (T/P, ERS-1/2, ENVISAT, J1/J2, GFO) has provided global products of sea level and surface currents

Along track = 1 point every 7 km
Maps= 1/3° weekly/daily

Altimetry has proven its capacity to monitor the ocean variability

OSTST;OceanObs
15 years of progress in radar altimetry (2006,coming 20YPRA, 2012…)

See reviews and in particular Morrow and Le Traon (2006)

Status

Altimetry is good observing system for space scale >100 km and time scale >week

Altimeter observing system partially covers mesoscale spectra (space scales of 50-500 km, time scales of 10-100 days) :

performance depends from satellite configuration (2 to 5 missions)
Le Traon et al, (2002), Brachet et al., (2004), Pascual et al. (2005)

presence of noise at small scale (instrument and corrections)

performance degraded close to coast

Ways of improvement ?

What can we do for scales lower than 100km, week ?

How can we complete the signal observed by altimetry (geostrophy) ?

Ways of improvement ?

How can we complete the signal observed by altimetry ?

A lot of initiative will be presented during this meeting :

Ekman current : talk MH Rio (SURCOUF), K. Dohan (OSCAR)

Synergy between in-situ and space observations :
initiative on specific component deduced from SAR, SST, OC

Assimilation in ocean model: talk E. Dombrowsky (MyOcean), B. Levier (mercator), …

Ways of improvement ?

What can we do for scales lower than 100km, week ?

Level 3 products (along track):

→ improve the standard processing for global but also for coastalt area (PISTACH, COASTALT)

→ develop and test new instruments (SAR altimetry as Cryosat-2)

Level 4 products (maps)

→ refine the processing to access to HR signal (regional products)

→ improved the satellite constellation to obtain a better temporal and spatial sampling (SWOT, Iridium)

Mean Dynamic Topography

→ HR resolution geoid : GRACE, GOCE

→ use of in-situ observations

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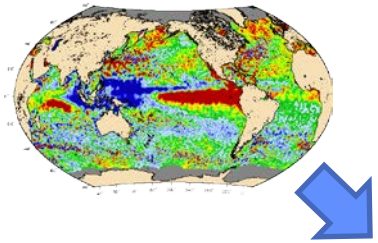
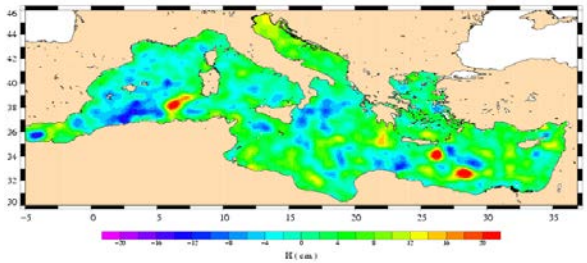
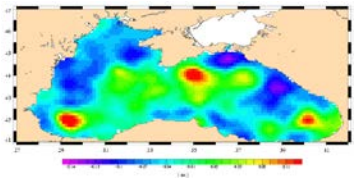
Towards regional products: HR maps

Global products



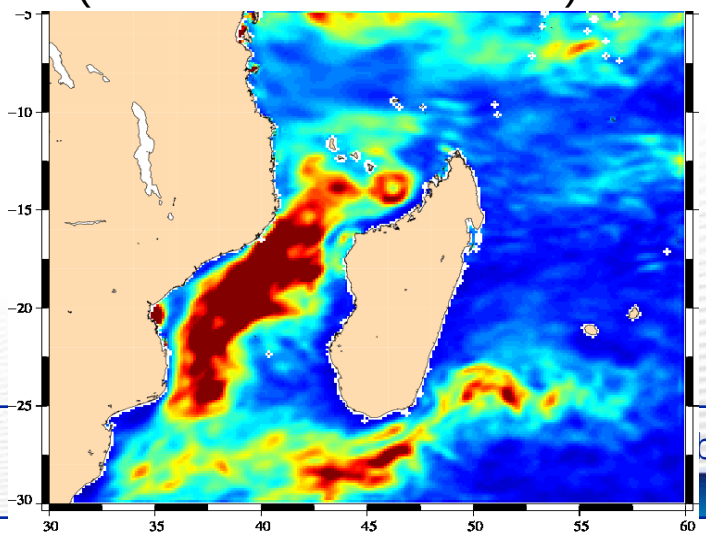
Med (MFSTEP/EC) &Black Sea (MyOcean/EC)



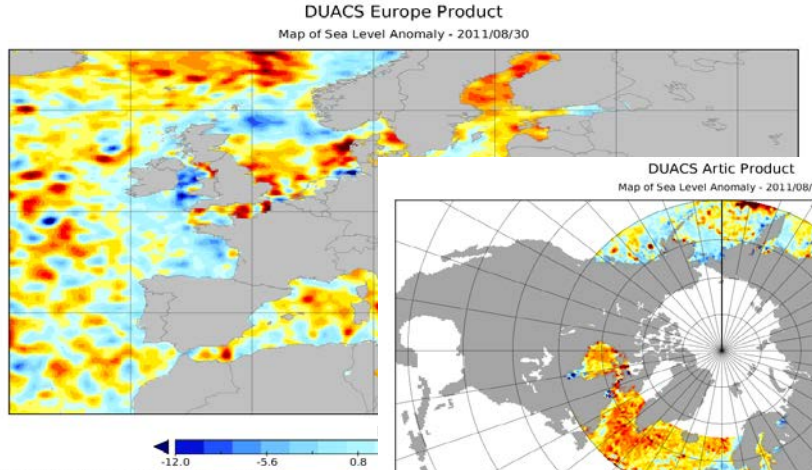


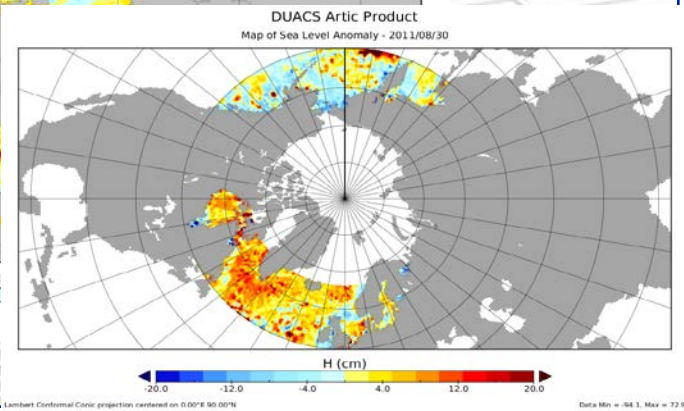
Mozambique

(AMESD Eumetsat/CNES)

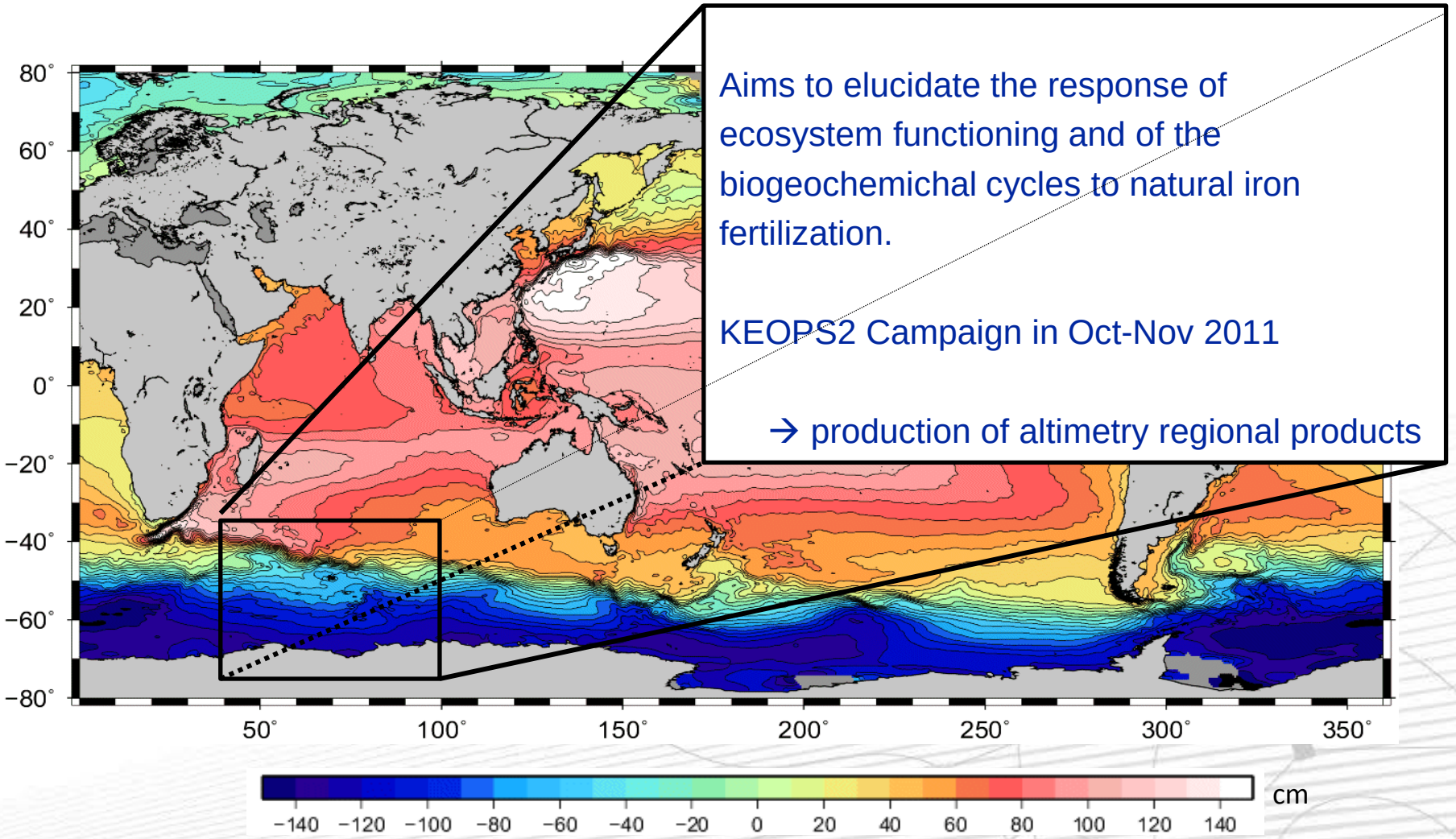


Europe & Arctic (MyOcean/EC)





Exemple of KEOPS project



Aims to elucidate the response of ecosystem functioning and of the biogeochemichal cycles to natural iron fertilization.

KEOPS2 Campaign in Oct-Nov 2011

→ production of altimetry regional products

F. D'Ovidio (LOCEAN)
See http://www.com.univ-mrs.fr/~queguiner/KEOPS_2.html

Example of KEOPS project

Way of improvement for HR maps of SLA (regional products)

- specific regional editing
- adapted filtering and sub-sampling,
- specific covariance model
  - two-steps mapping (Dessurget et al. 2011)

Example of KEOPS project

Way of improvement for HR maps of SLA (regional products)

with specific regional editing

with adapted filtering and sub-sampling,

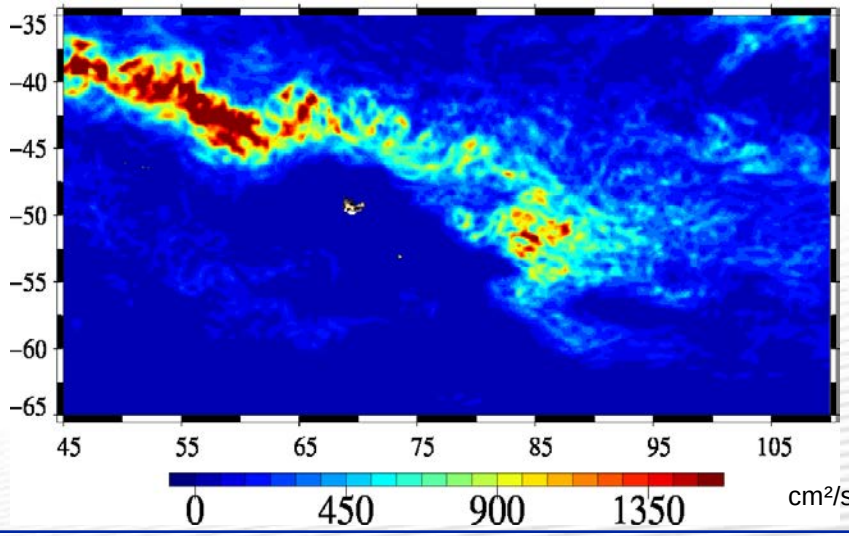
with specific covariance model

two-steps mapping (Dessurget et al. 2011)

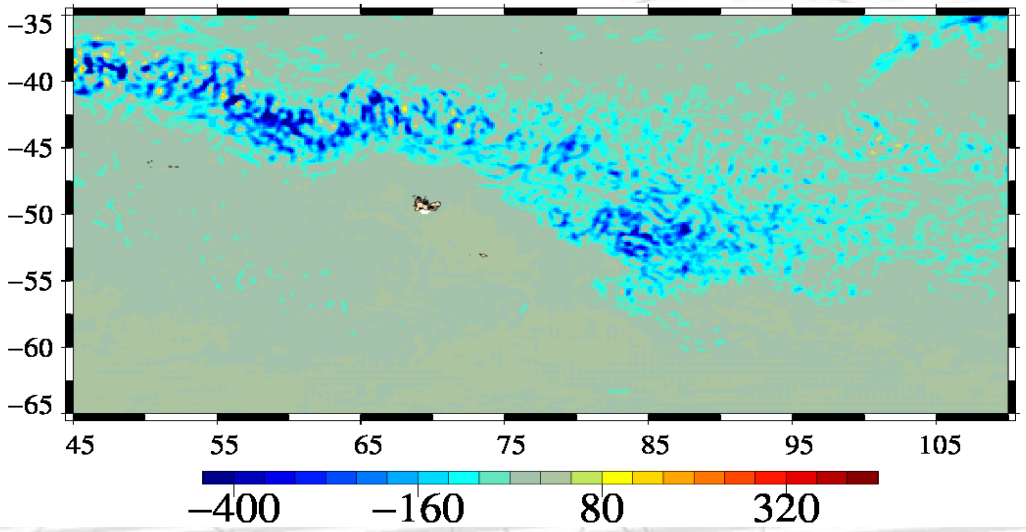
➔ Daily 1/8° maps

➔ Operationaly produced for the KEOPS campaign

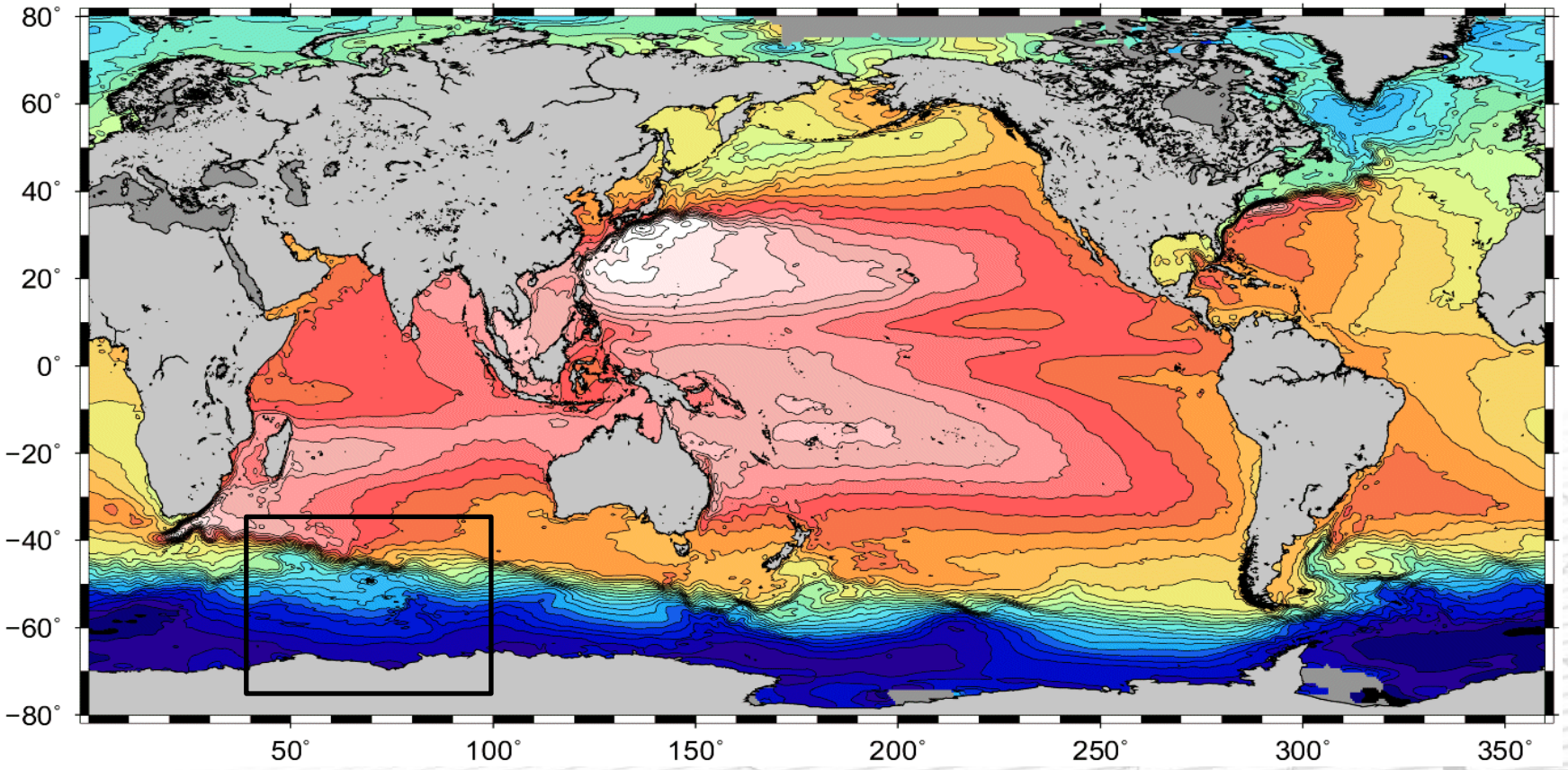
Mean EKE from the regional products (avril-November 2009)



Differences with global products



Improvement of MDT

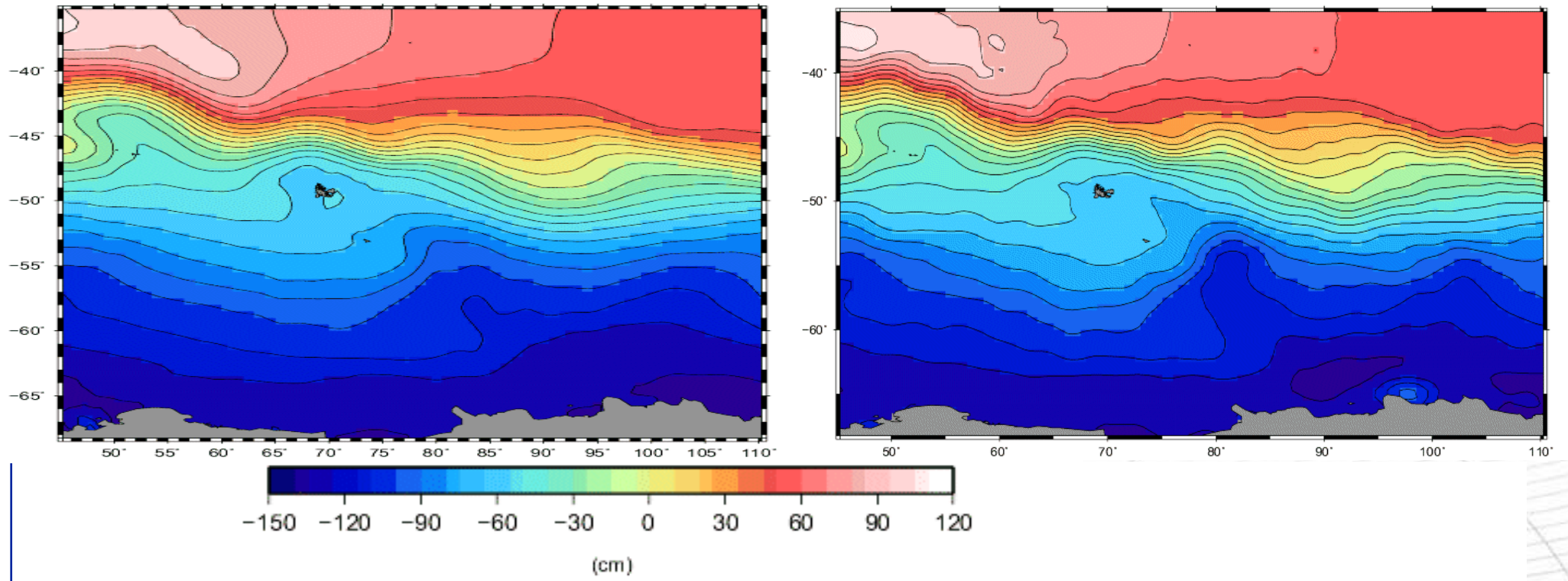


→ Impact of GOCE that allows us to significantly improve the first guess (see talk R. Bingham)
→ Use of additional in-situ observations that is indispensable to introduce small scale features in the MDT (Rio et al, Maximenko et al., papers)

MDT: Exemple of KEOPS project

MSS CLS01-GRACE 400km

MSS CLS11-GOCO02S 250km



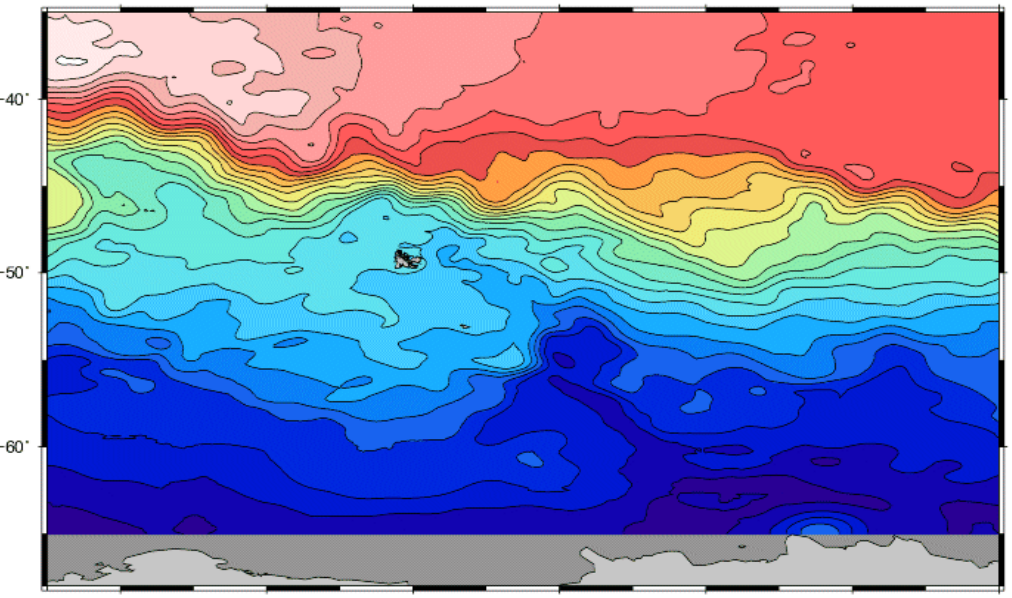
(talk R Bingham

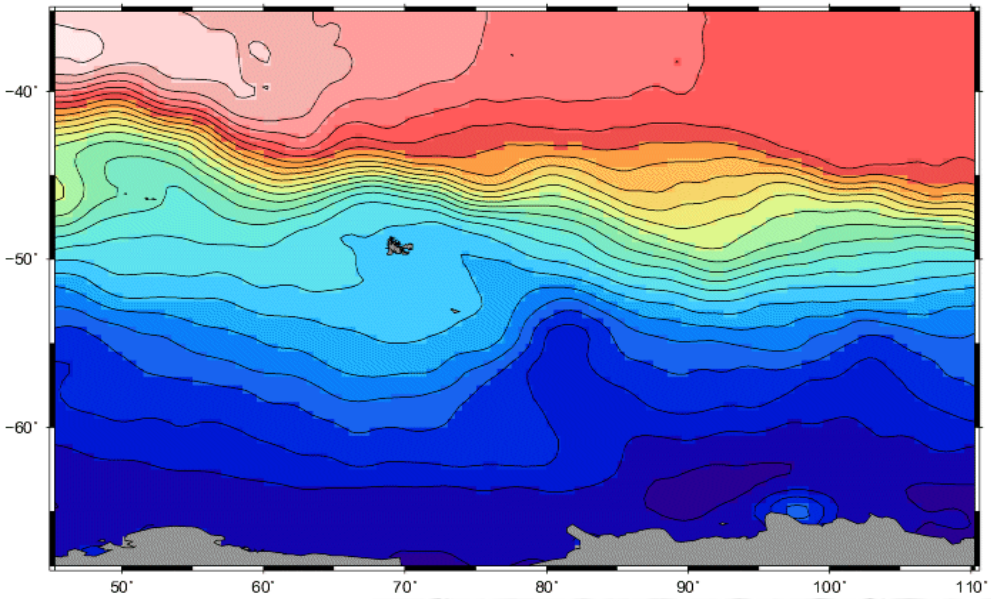
cm

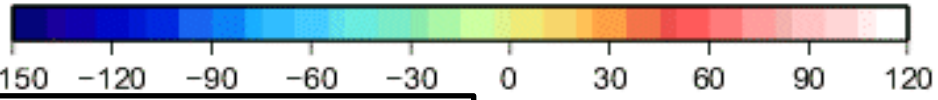
MDT: Exemple of KEOPS project

CMDT : KEOPS V1.0

MSS CLS11-GOCO02S 250km





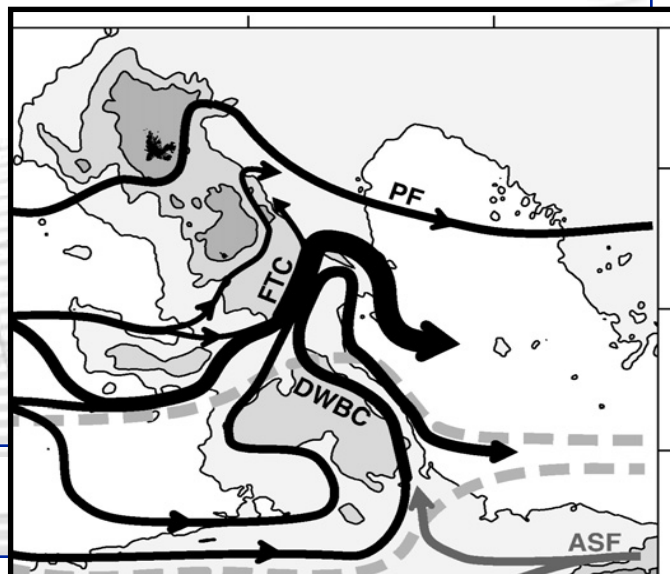


New MDT based on GOCE

+ adapted filtering

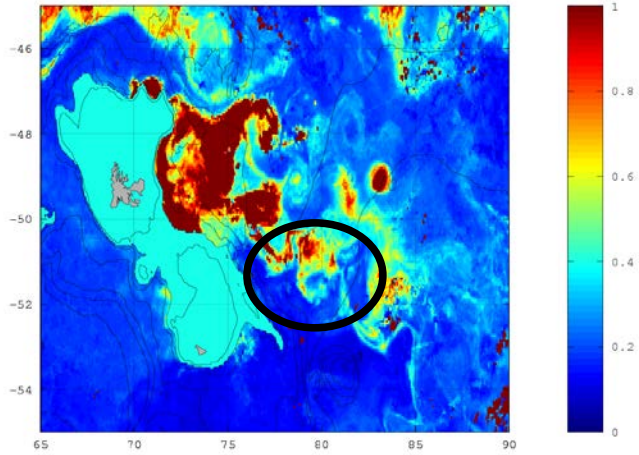
+ additional data (T/S et drifters)

+ specific Ekman model (1/8° resolution)

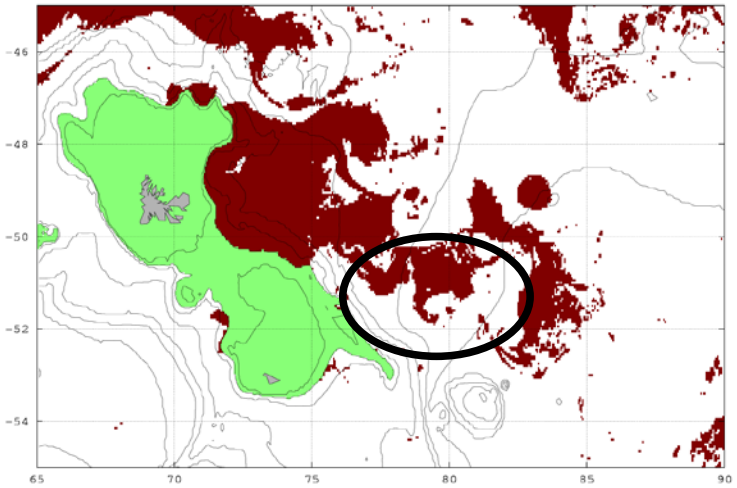


11/11/2011

A **Ocean color**

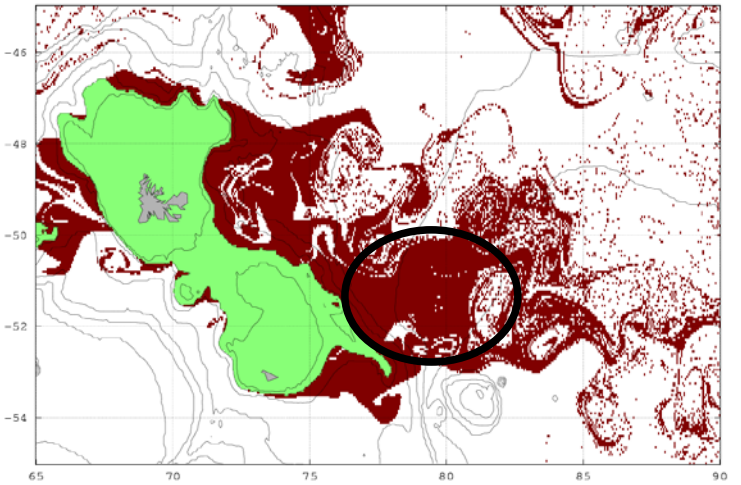


Ocean color (threshold)

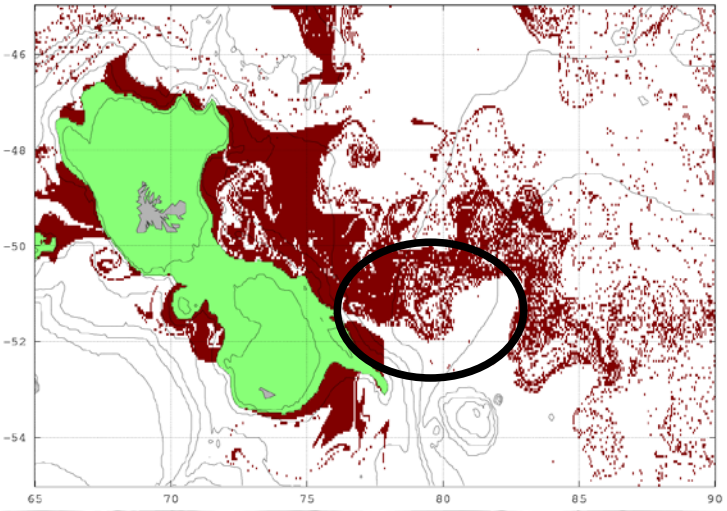


(B) the pattern of the chlorophyll plume (obtained by setting a threshold on (A)).

C **Prediction using global product**



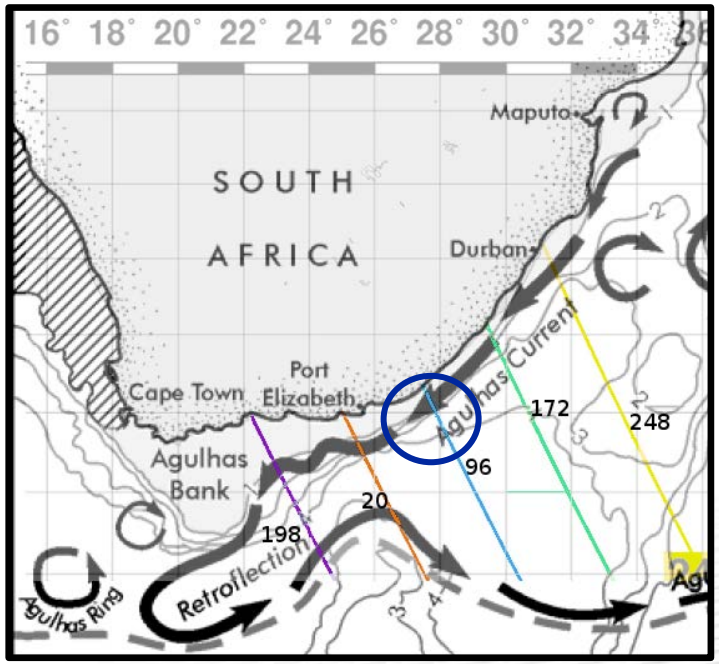
D **Prediciton using regional product**

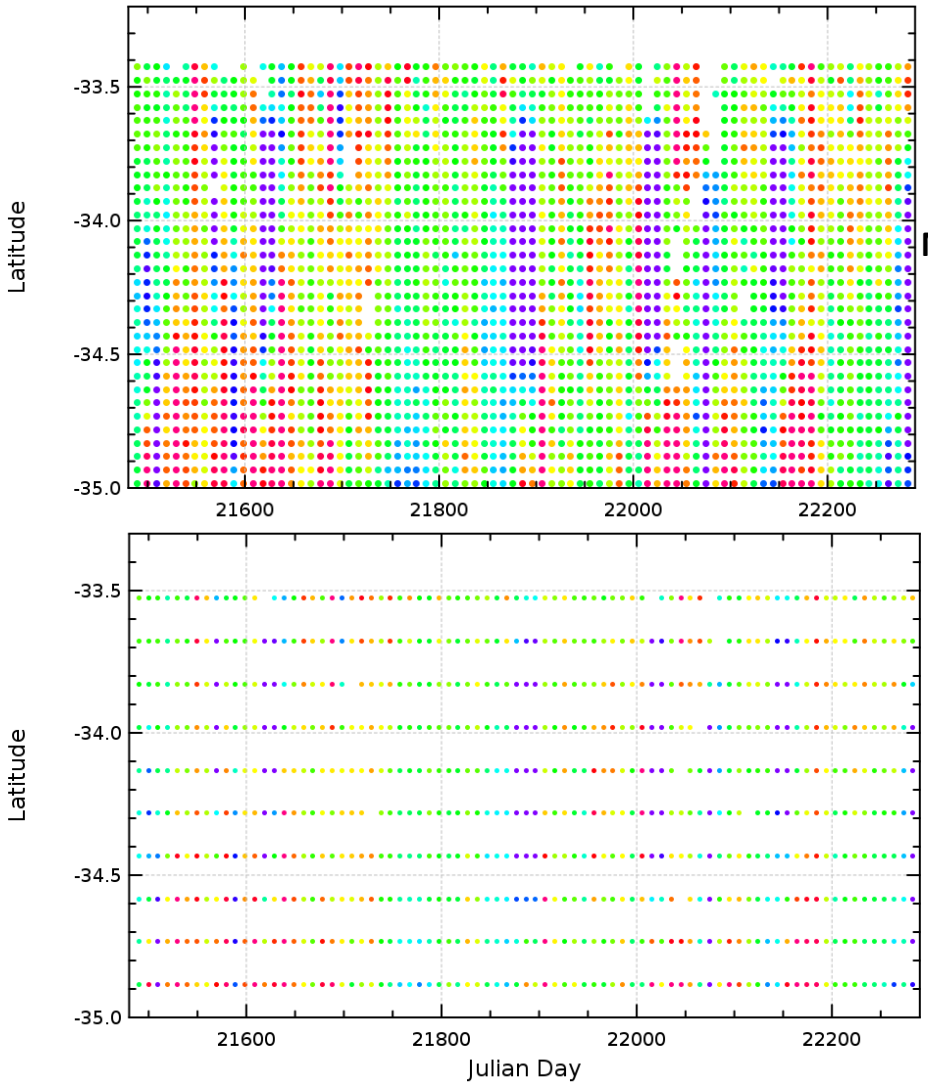


(C-D) Prediction of the bloom extension by a model driven by AVISO altimetry data.

Along track improvements: PISTACH initiative

Two along-track products of SLA are available trough the AVISO website in DT :

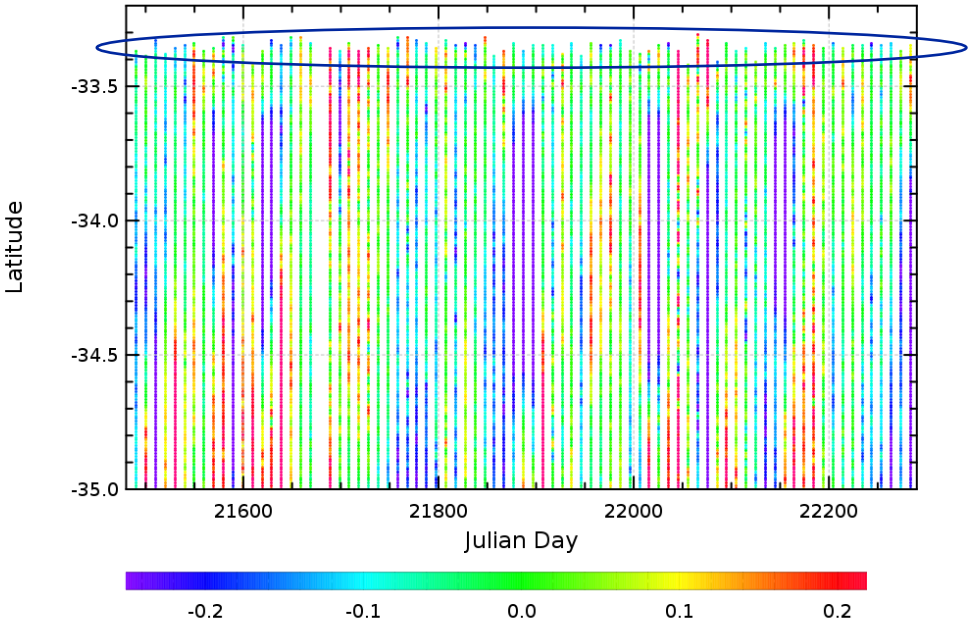




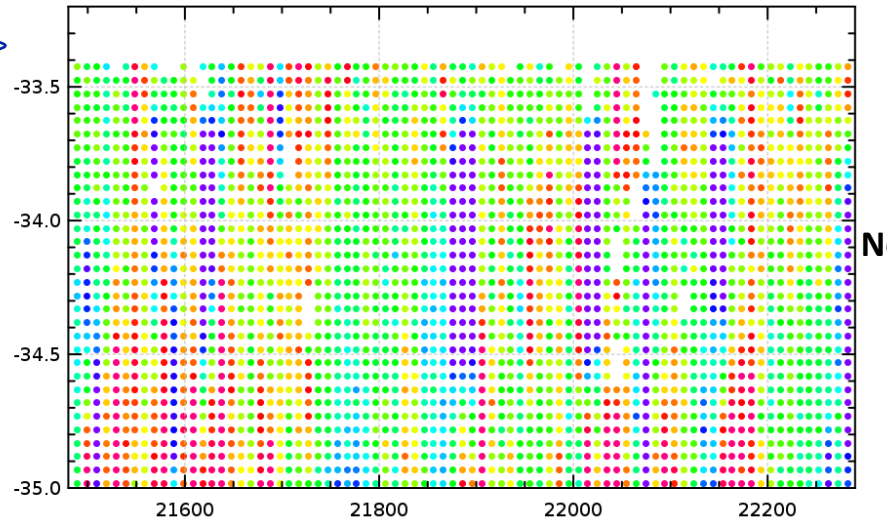
AVISO DT-SLA Not filtered 1hz

classical AVISO DT-SLA Filtered (100km) Sub-sampled (21km)

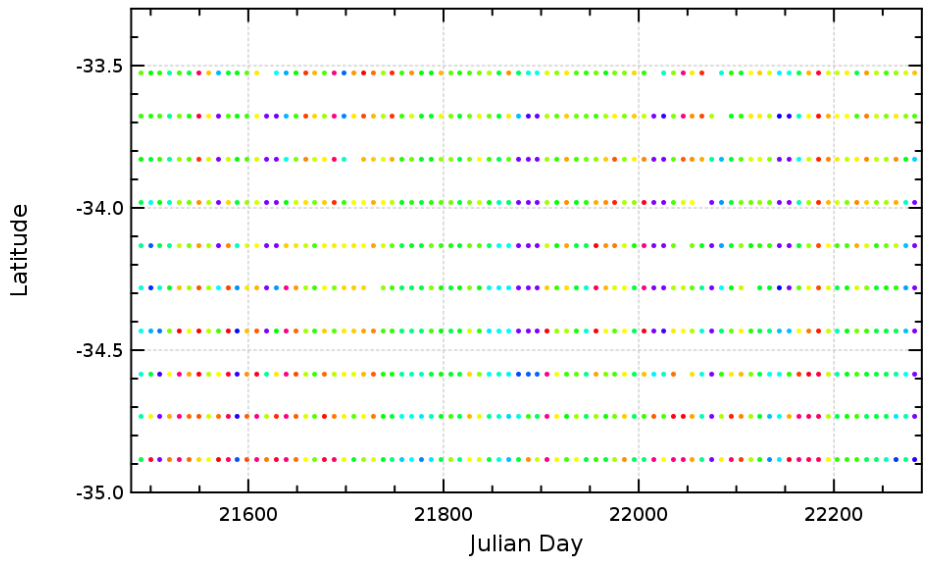
PISTACH vs. Classical altimeter SLA



PISTACH
NRT-SLA
6km filtered
5hz



AVISO
DT-SLA
Not filtered
1hz



classical
AVISO
DT-SLA
Filtered
(100km)
Sub-sampled
(21km)

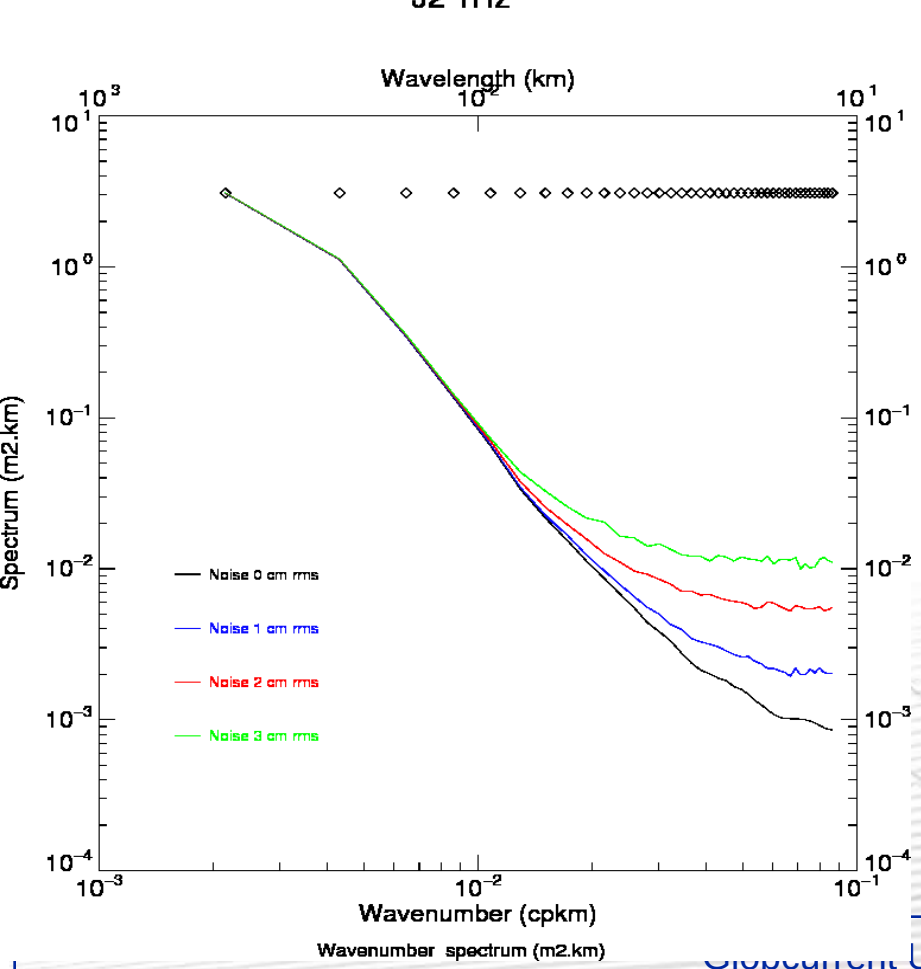
M. Cancet talk: Gulf of Mexico

What are we measuring from 10 to 100 km ?

→Improve standard processing :

retracking, editing, filtering, improve corrections

error (noise or correlated) remains



→New instruments:
In theory SAR altimetry (Cryosat) will allow to observe 15 to 100 km wavelengths (1-3 km numerical resolution)

→Need to really characterise and understand the instrumental errors but also errors associated to the corrections (wet tropo, iono, SSB,…)

variable in time & space

→ Need to understand what are the characteristics of altimeter observing system to capture (sub)-mesoscale ocean dynamics

(talk P. Klein).

Conclusion

Altimetry is a robust and accurate observing system for surface currents for scale > [100 km, week]

This products are available under a specific data policy through AVISO (CNES) and recently MyOcean (EU FP-7)

What can we do for scales lower than 100km, week ?

Level 3 products (along track):

→ improve the standard processing for global and coastalt area

→ develop and test new instruments (SAR altimetry as Cryosat-2)

Level 4 products (maps)

→ refine the processing to access to HR signal (regional products)

Expected outcome of the meeting:

What are the priority for users ?