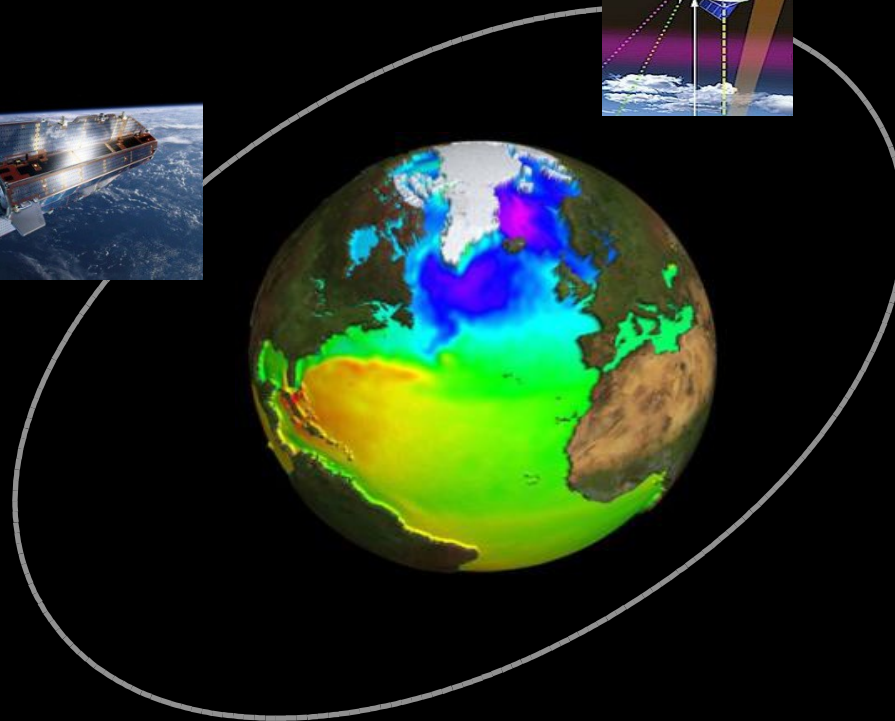
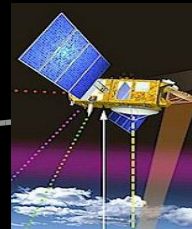


Mapping of the Absolute Dynamic Topography from multi-satellite along track Sea Surface Height and GOCE geoid height: a direct method

S. Mulet, M.-H. Rio, M.-I. Pujol, Y. Faugère, G. Dibarboure
CLS, rue Hermès, Ramonville Saint-Agne, France

R. Morrow
LEGOS, avenue Edouard Belin, Toulouse, France



Mapping of the Absolute Dynamic Topography from multi-satellite along track Sea Surface Height and GOCE geoid height: a direct method

Sea Surface Height Geoid

$$ADT = SSH - N$$

Direct Method

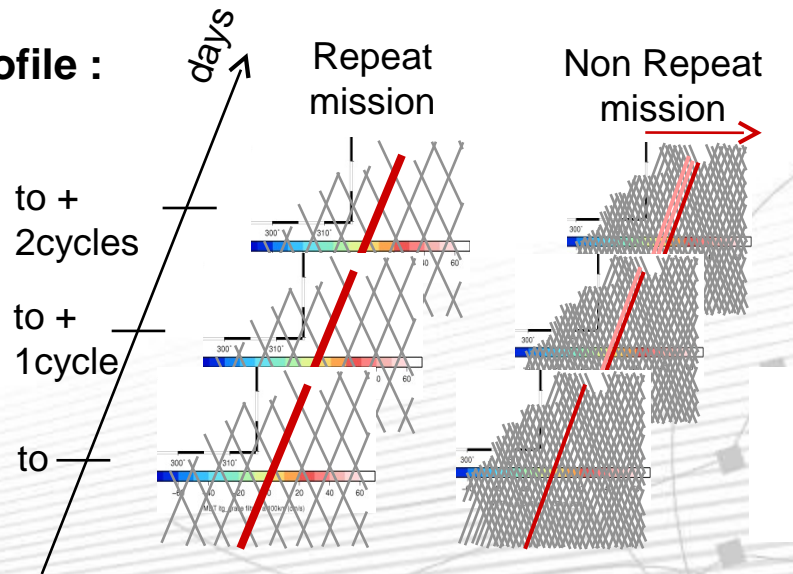
N not known with enough accuracy

$$ADT = MDT + SLA$$

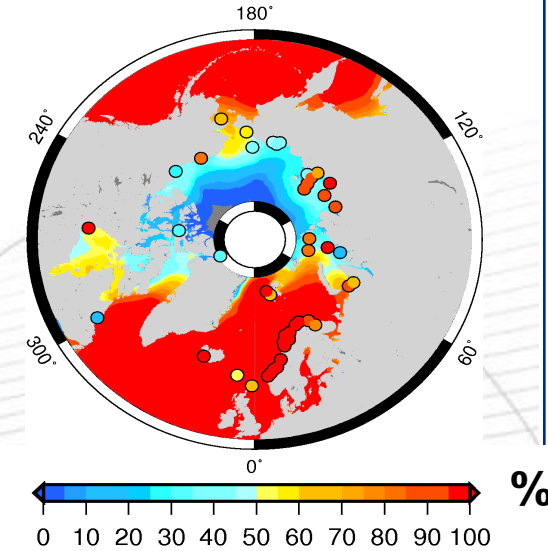
Classical Method

Along track SLA = SSH - MeanProfile :

- Mean Profile (repeat mission)
 - MSS (non-repeat mission)
- error (Dibarboure et al., 2012)
- Arctic, seasonal bias



Data coverage in the Arctic Ocean
(percentage of monthly grids with a valid measurement)

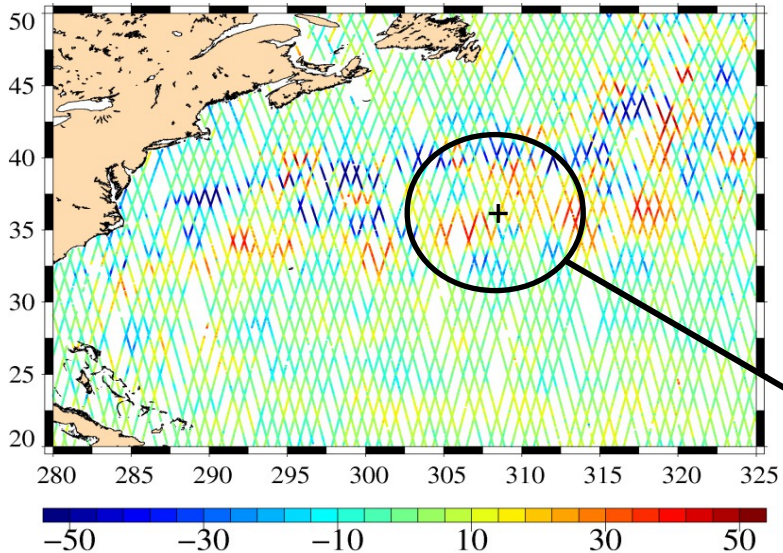


Courtesy of P. Prandi (Prandi et al., 2012)

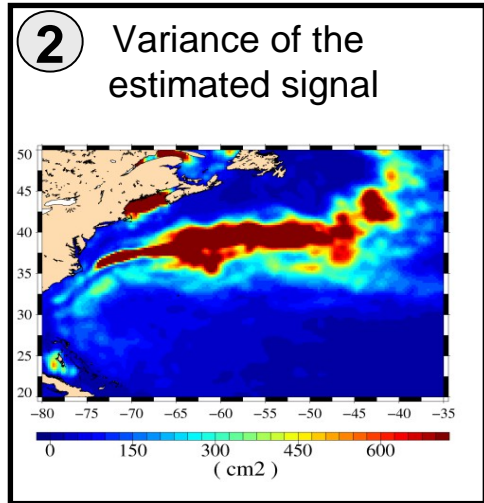
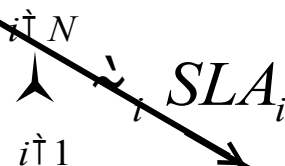
SLA Mapping



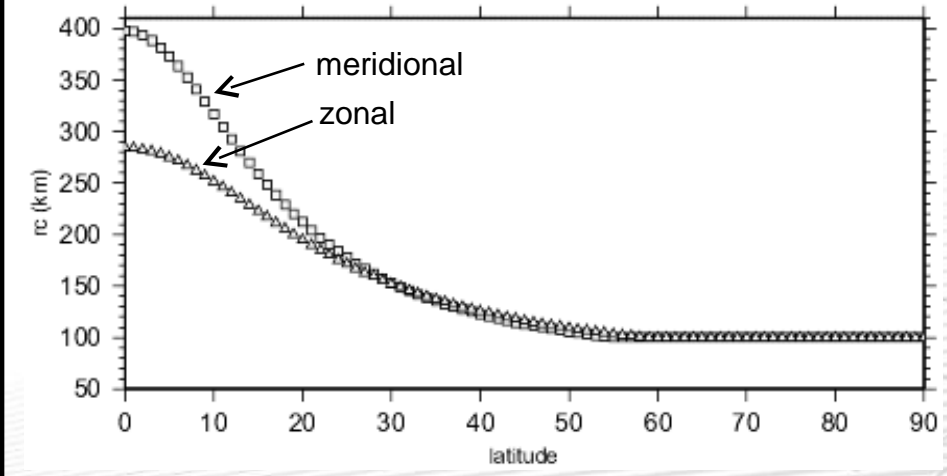
SLA Along Track



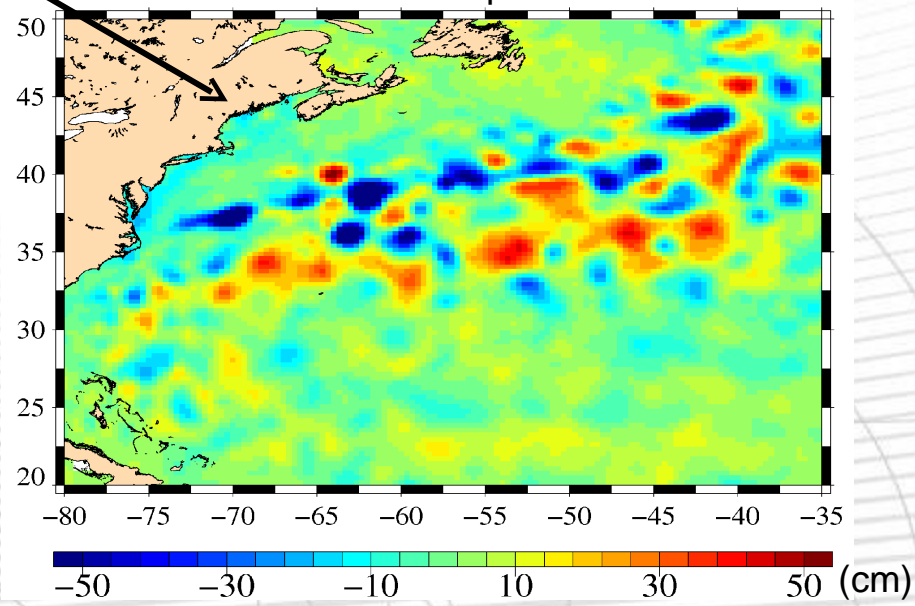
1 Observation error



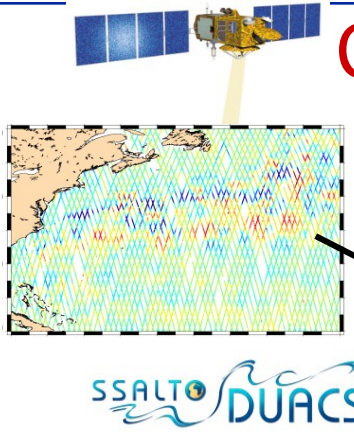
3 Correlation [point to be estimated-observation]
Correlation radius :



SLA Map



Classical method mapping scales vs GOCE scales



Altimetry

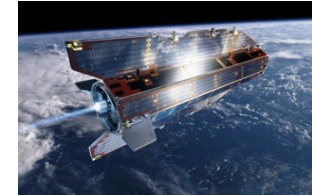
$$ADT = MDT + SLA$$

Classical method

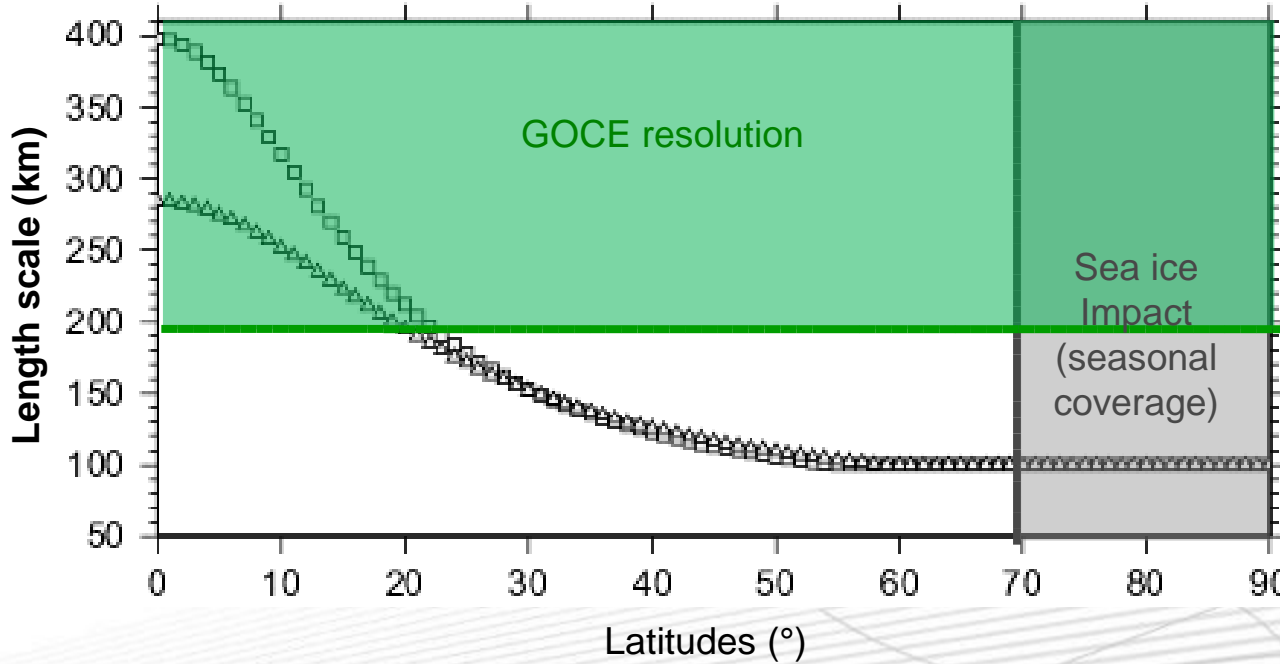
Geodesy – GOCE

$$ADT = SSH - N_{GOCE}$$

Direct method



SLA Correlation radius



$\lambda > 200$ km
Length scale
resolved by GOCE

$\lambda < 200$ km
Length scale
NOT resolved by GOCE

- ✓ Tropical band (20S-20N) : OK
- ✓ middle and high lat : $R_c \times 2$
- **Mapping[$ADT = SSH - N_{GOCE}$]**

Mapping of the Absolute Dynamic Topography from multi-satellite along track Sea Surface Height and GOCE geoid height: a direct method

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- ❑ Comparison with classical method
 - EGM_TIM_R3 (Pail et al., 2010)
 - GOCE only DO 250 (80 km)
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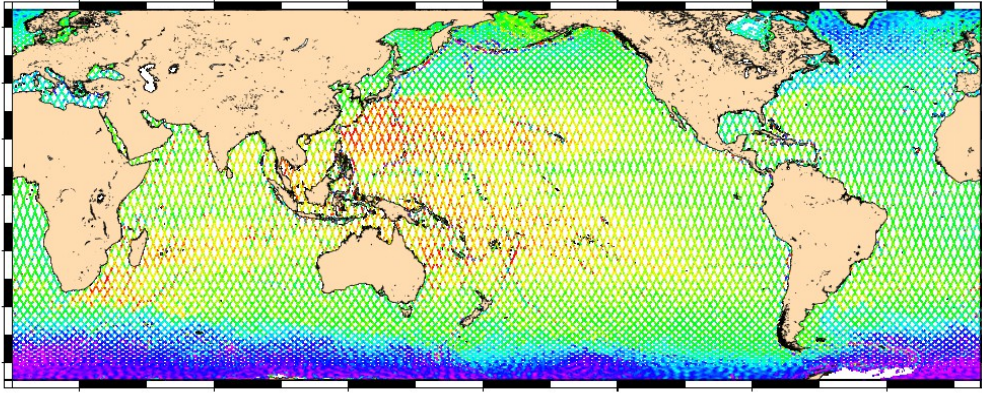
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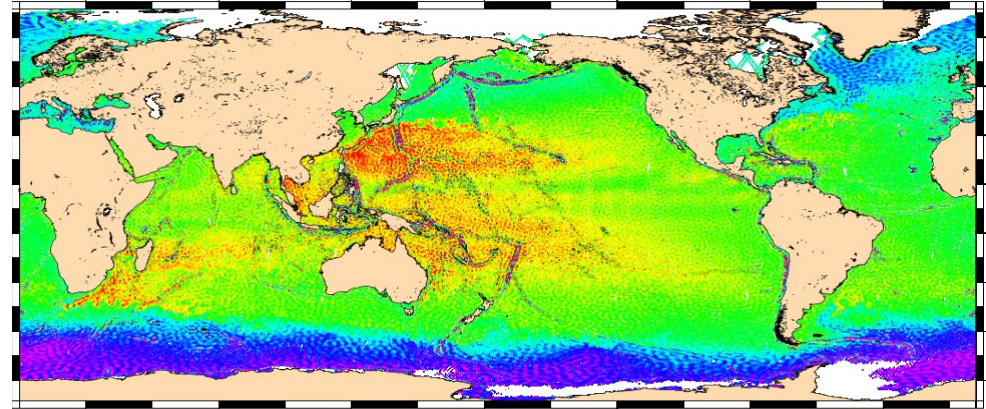
Method to map SSH-N

□ OBSERVATIONS (around 07/01/2004) : $ADT = SSH - EGM_TIM_R3$

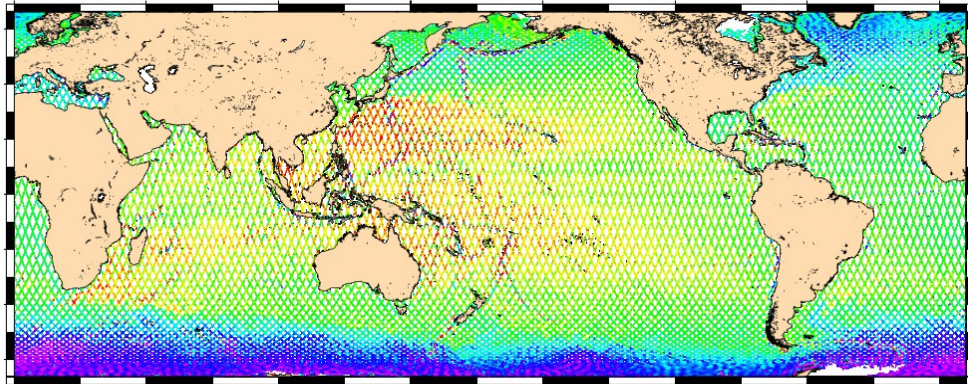
TP



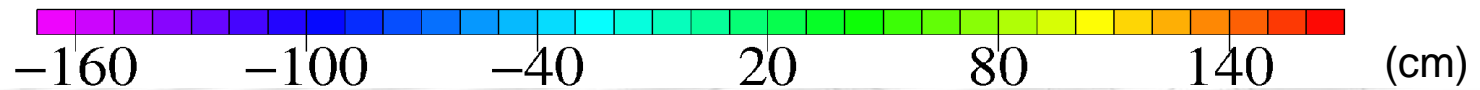
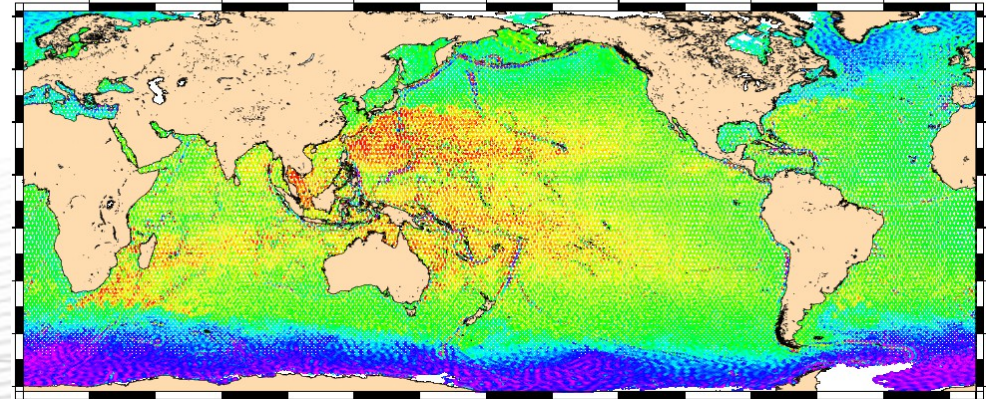
Envisat



J1



G2

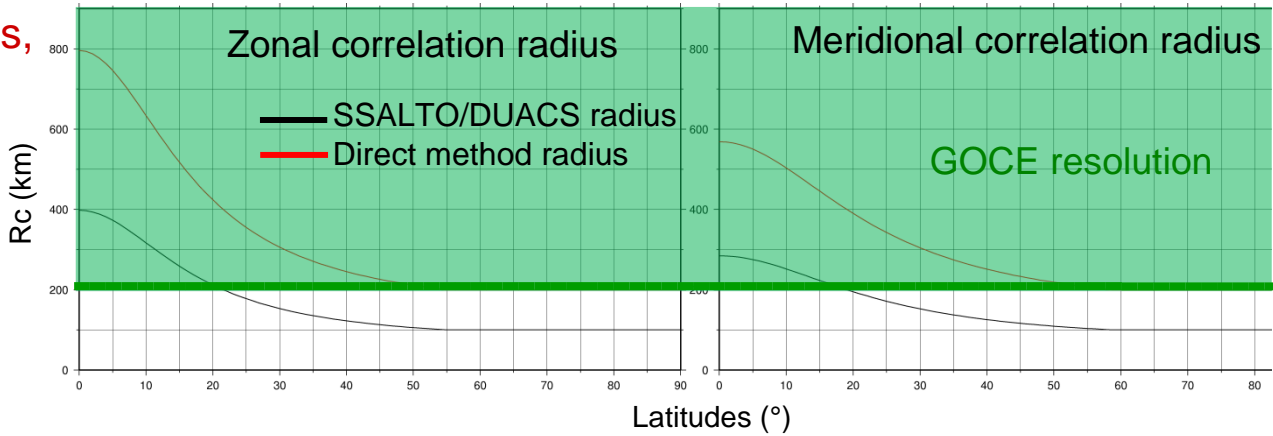


Method to map SSH-N

Combination using objective analysis, **3 ingredients** :

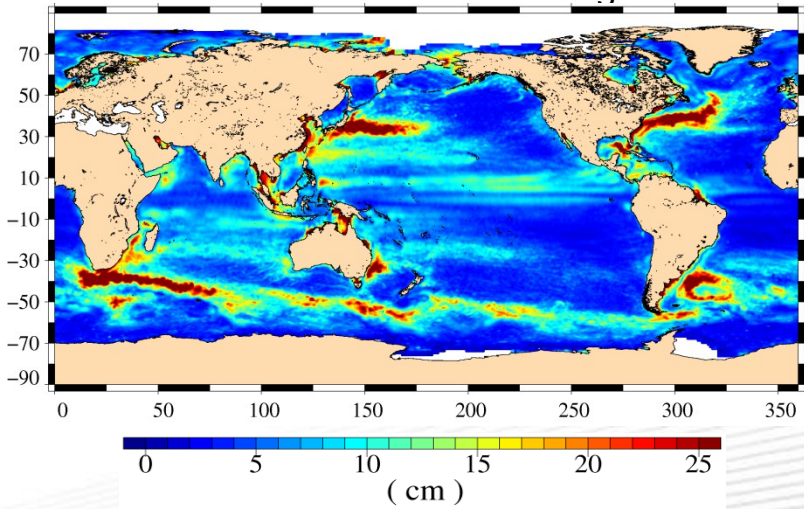
$$\sum_{i=1}^N \sim_i ADT_i$$

1 Correlation radius :



2 Variance

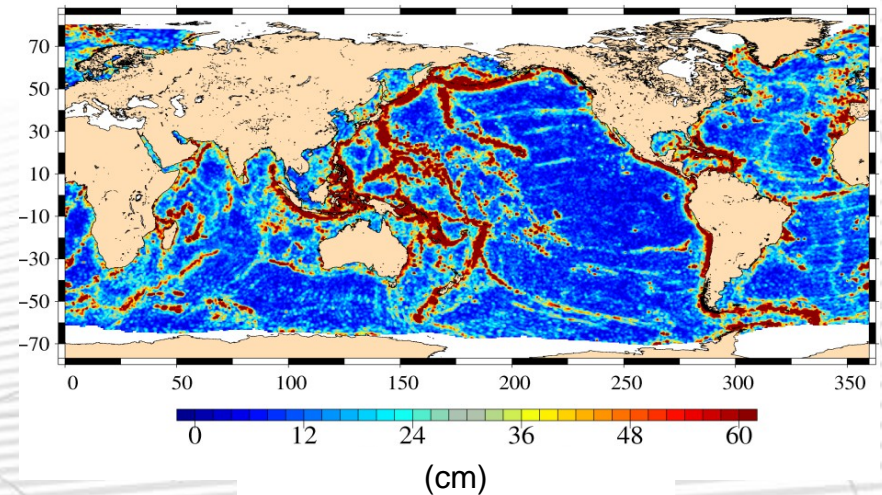
Standard deviation of the signal



3 Observation's error. Use apriori field GLORYS (Ferry et al, 2012)

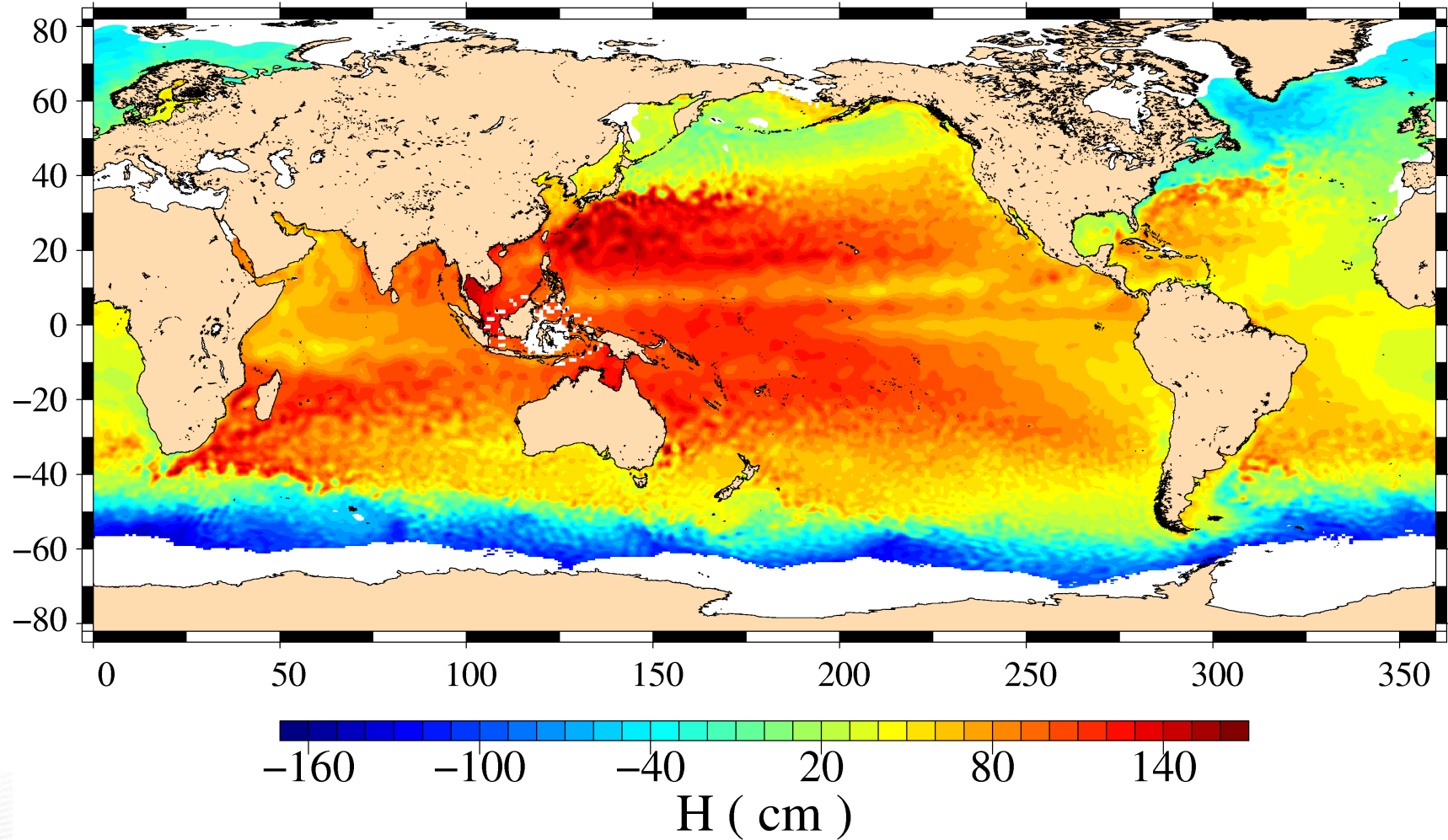
$$ADT_{obs} = SSH - N \quad \text{to be compared with} \quad ADT_{apriori}$$

Observation error : [SSH - EGM-TIM-R3] vs ADT_{GLORYS}



Method to map SSH-N

□ Result : map of [SSH – EGM_TIM_R3] the 07/01/2004



Mapping of the Absolute Dynamic Topography from multi-satellite along track Sea Surface Height and GOCE geoid height: a direct method

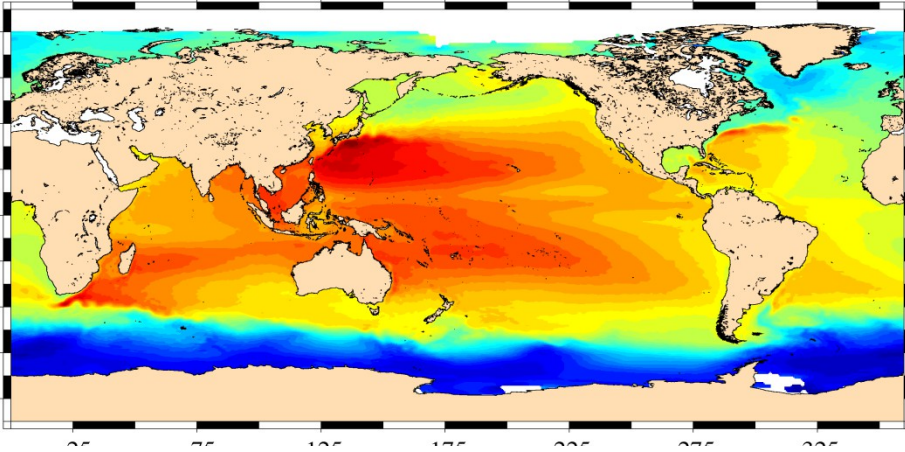
- ❑ Direct method – Mapping SSH-N (= ADT)
- ❑ **Comparison with classical method**
 - **EGM_TIM_R3 (Pail et al., 2010)**
 - **GOCE only DO 250 (80 km)**
 - **Eigen6C (Förste et al., 2011)**
 - **GRACE + GOCE + surface data**
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- ❑ Conclusions, perspectives

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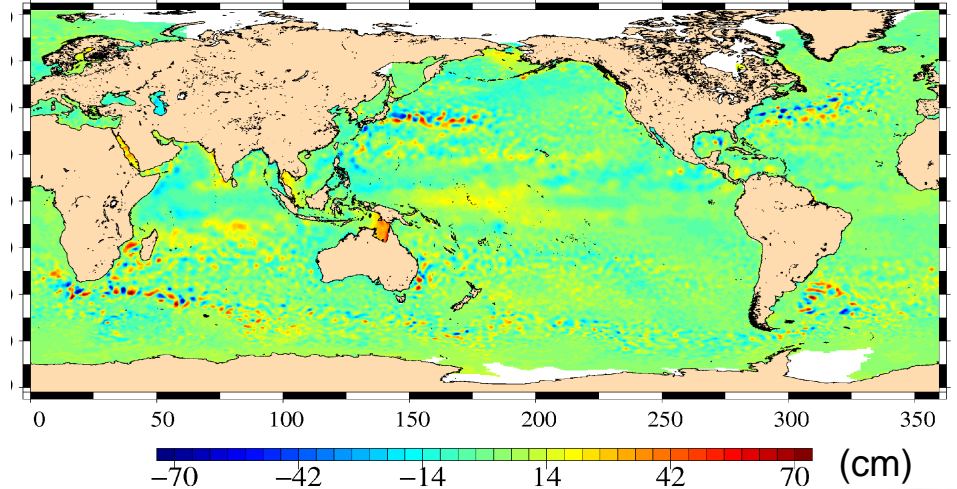
• **Förste, C.**, Bruinsma, S., Shako, R., Marty, J-C, Flechtner, F., Abrikosov, O., Dahle, C., Lemoine, J.-M., Neumayer, K.H., Biancale, R., Barthelmes, F., König, R., Balmino, G., **2011**. EIGEN-6 - A new combined global gravity field model including GOCE data from the collaboration of GFZ-Potsdam and GRGS-Toulouse; Geophysical Research Abstracts, Vol. 13, EGU2011-3242-2, EGU General Assembly

Comparison with classical method

MDT CNES_CLS09 (Rio et al, 2011)



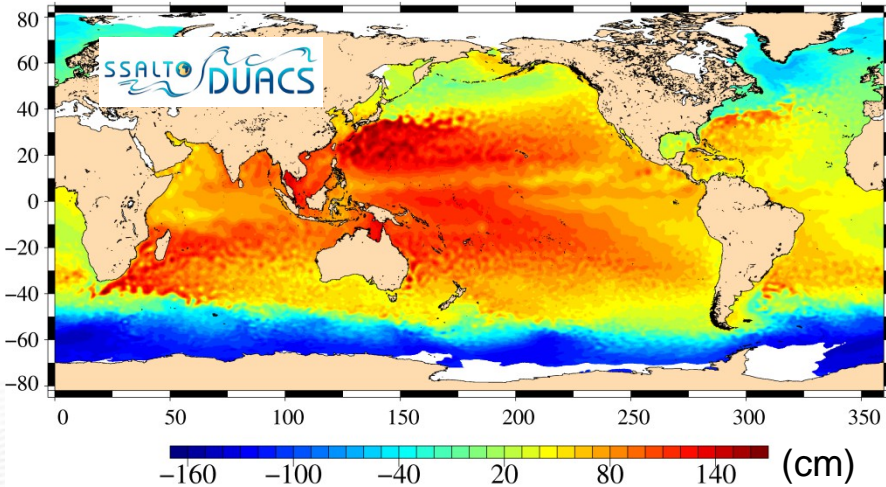
SLA



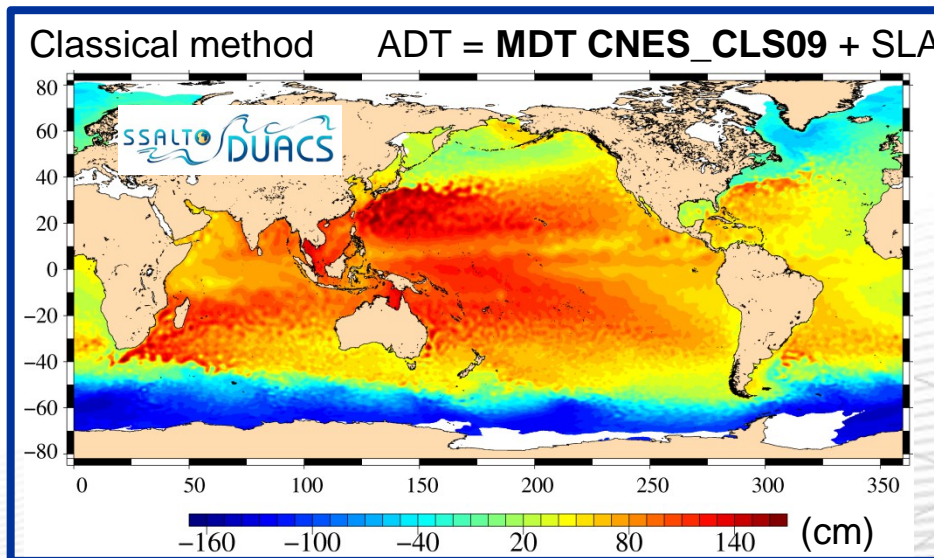
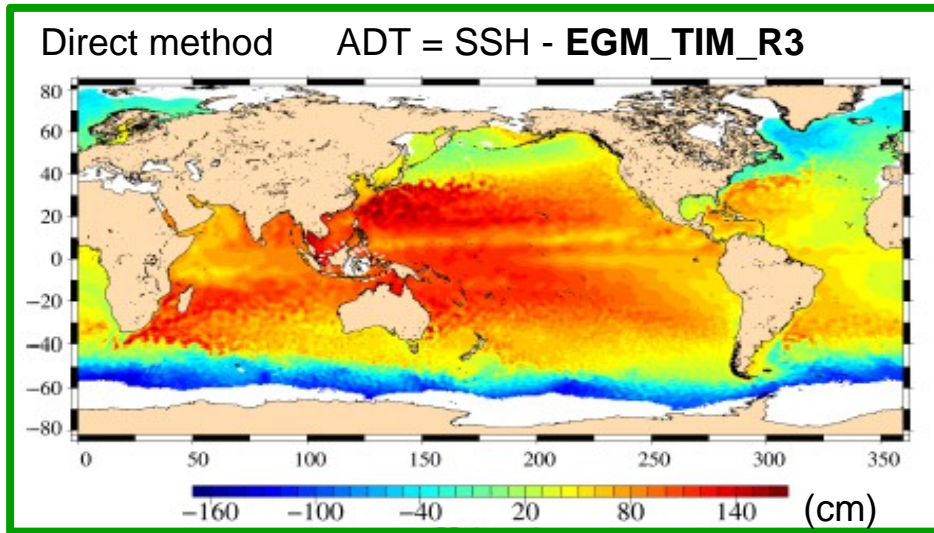
+

= ADT

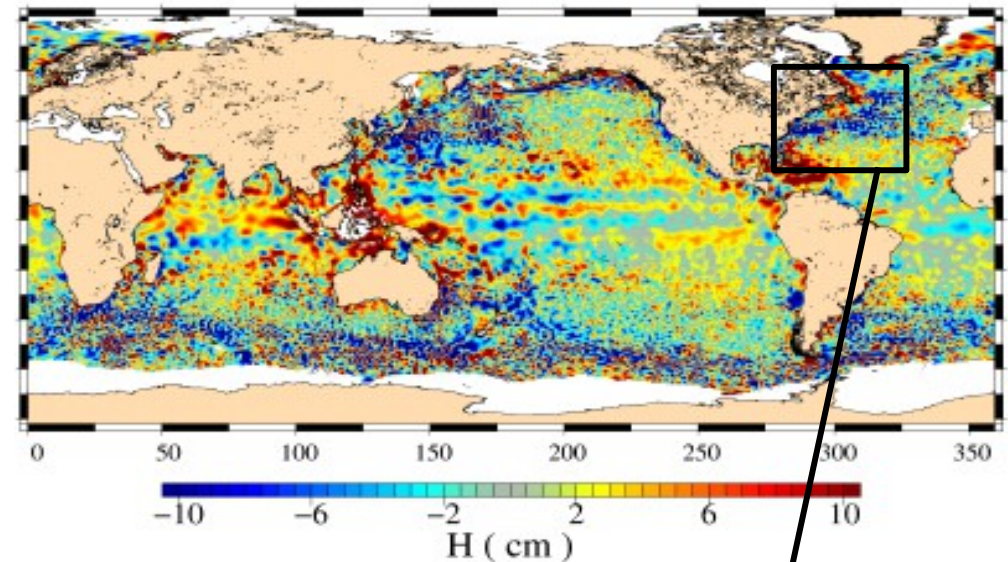
Classical method $ADT = MDT\ CNES_CLS09 + SLA$



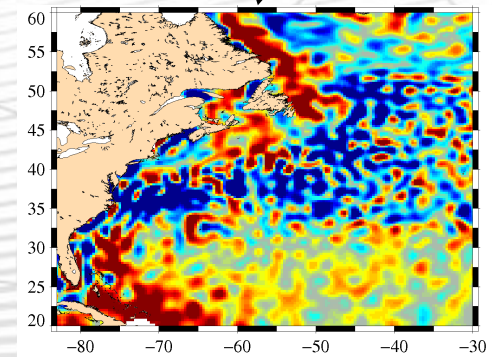
Comparison with classical method



Difference at same scales
Direct method – classical method



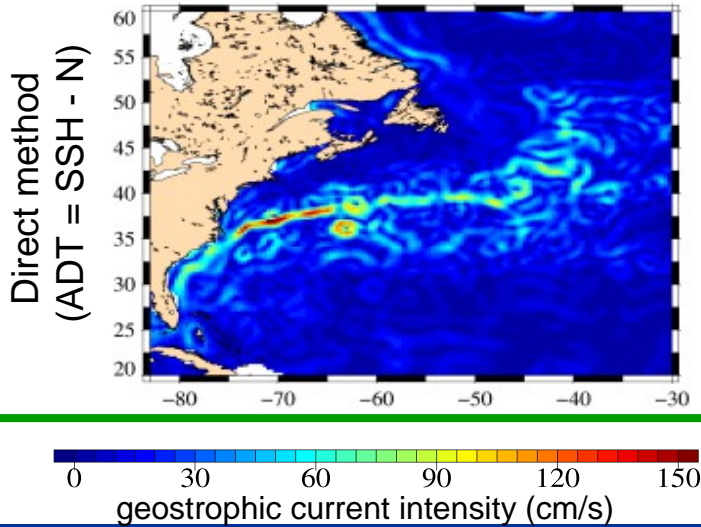
Mean : 0.5 cm \rightarrow no biais
Std : 6.3 cm



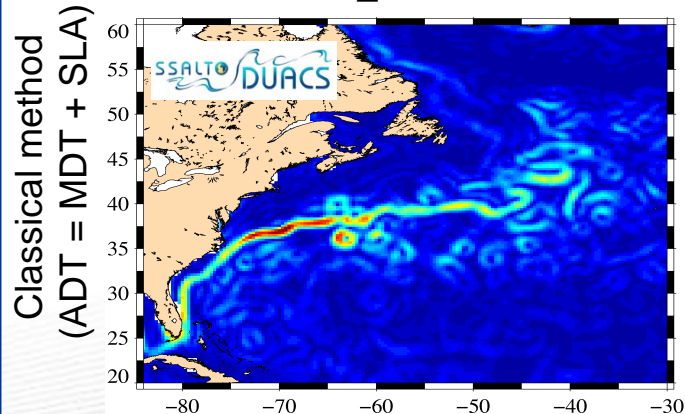
Comparison with classical method

□ EGM_TIM_R3; GOCE only (Pail et al., 2010)

ADT EGM_TIM_R3



MDT CNES_CLS 09 + SLA



→ Oceanic current well resolved with good intensity

→ Because of residual noise, florida current, meanders not well resolve

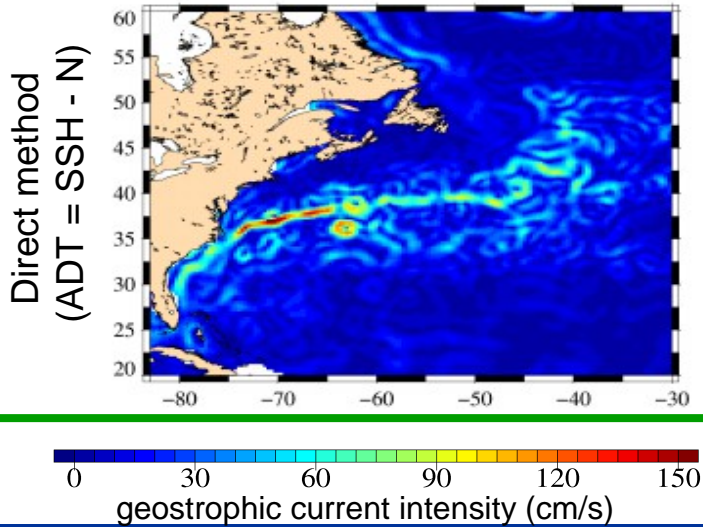
→ Ideas to improve

- correlated error
- pre pocessing
- combined geoid

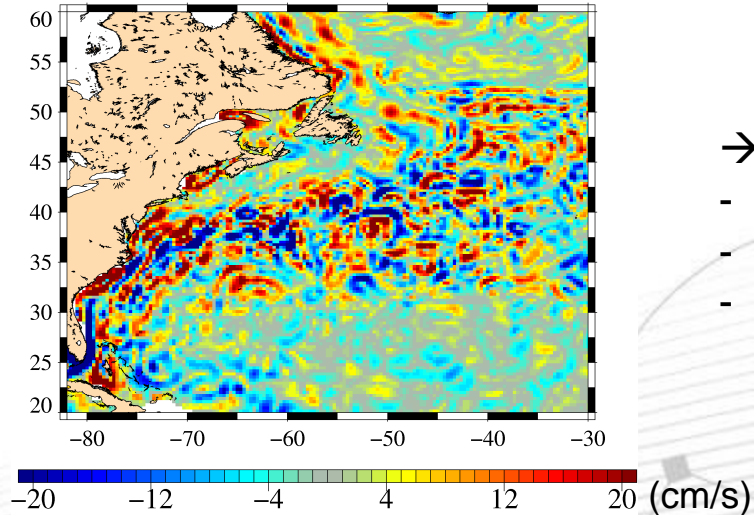
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ADT EGM_TIM_R3



Difference at same scales
Direct method – classical method



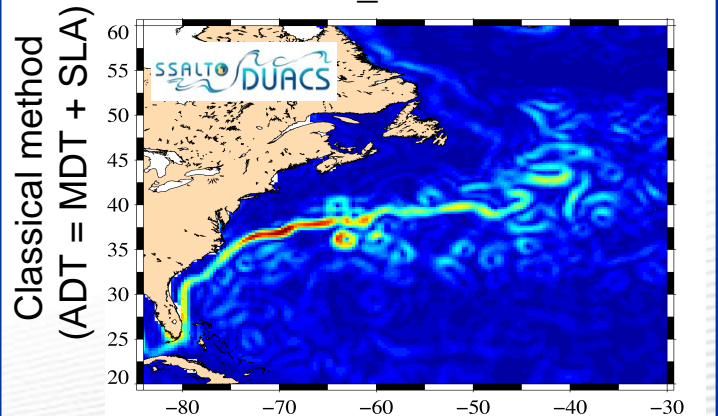
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- correlated error
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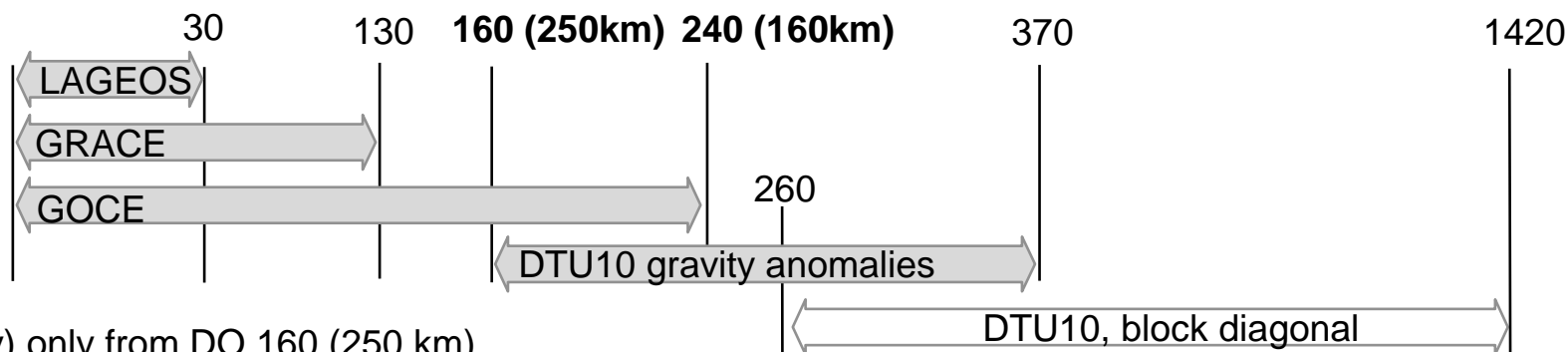
MDT CNES_CLS 09 + SLA



Comparison with classical method

❑ EIGEN6C ; GRACE + GOCE + surface data (Förste et al.,2011)

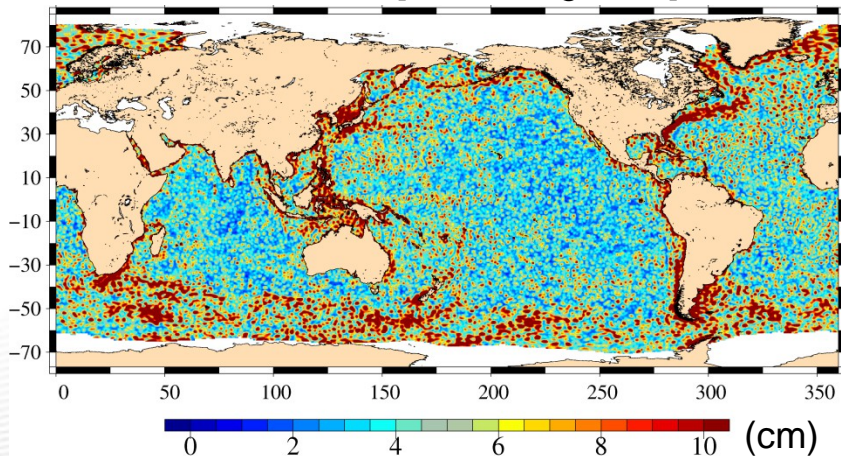
Spherical harmonic degree:
(equivalent length scales)



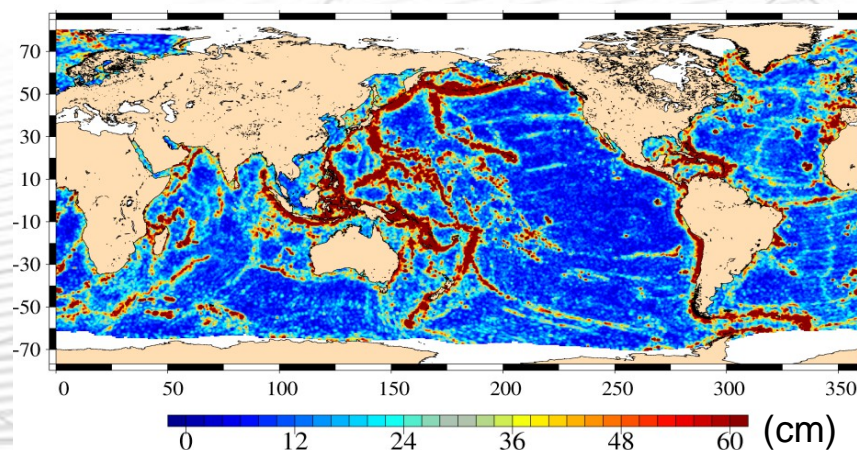
- Surface data (altimetry) only from DO 160 (250 km)
- GOCE with an important contribution to DO 240 (160 km)

→ **At length scales larger than 200 km: - GOCE contribution only**
- altimetry helps only to reduce omission errors

Observation error of [SSH – Eigen6C]



Observation error of [SSH – EGM_TIM_R3]



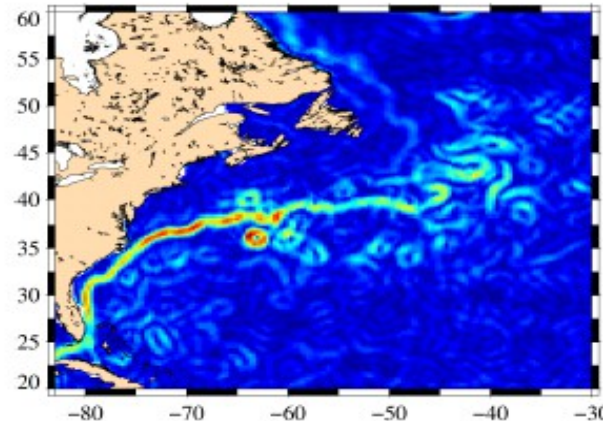
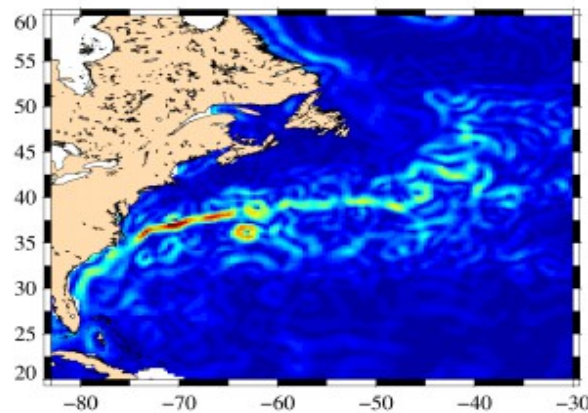
Comparison with classical method

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ADT EGM_TIM_R3

ADT EIGEN6C

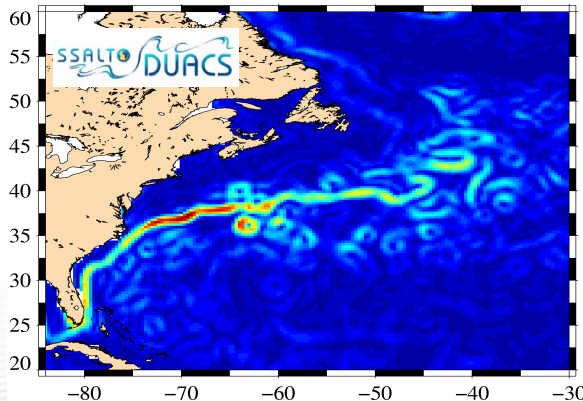
Direct method
(ADT = SSH - N)



0 30 60 90 120 150
geostrophic current intensity (cm/s)

Classical method
(ADT = MDT + SLA)

MDT CNES_CLS 09 + SLA



OSTST, Venice, September 2012

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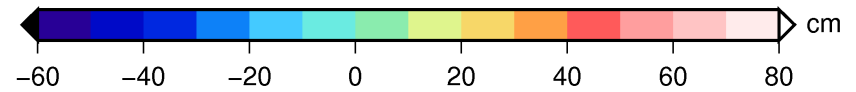
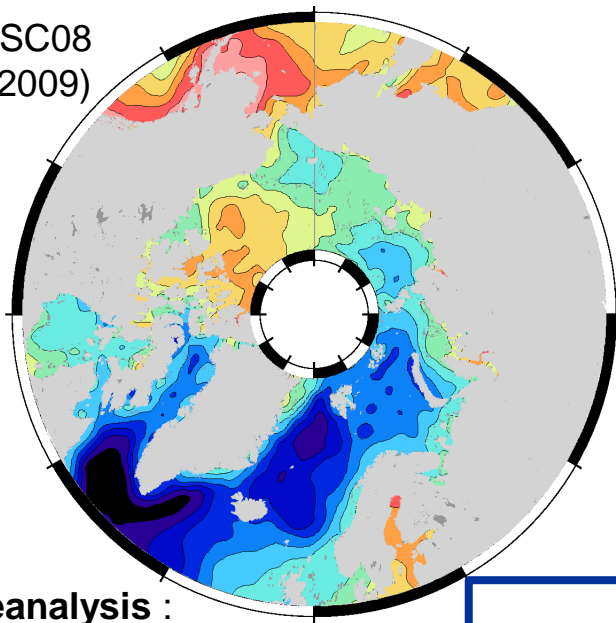
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- ❑ **Conclusions, perspectives**

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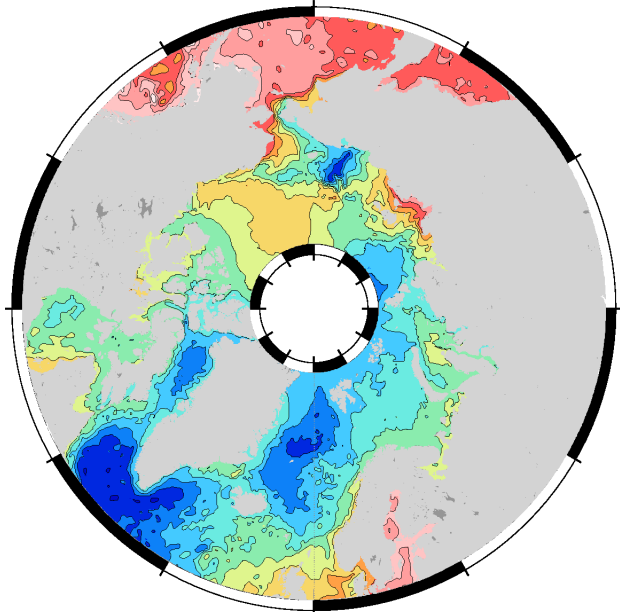
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Absolute Dynamic Topography in the Arctic Ocean (5 september 2007)

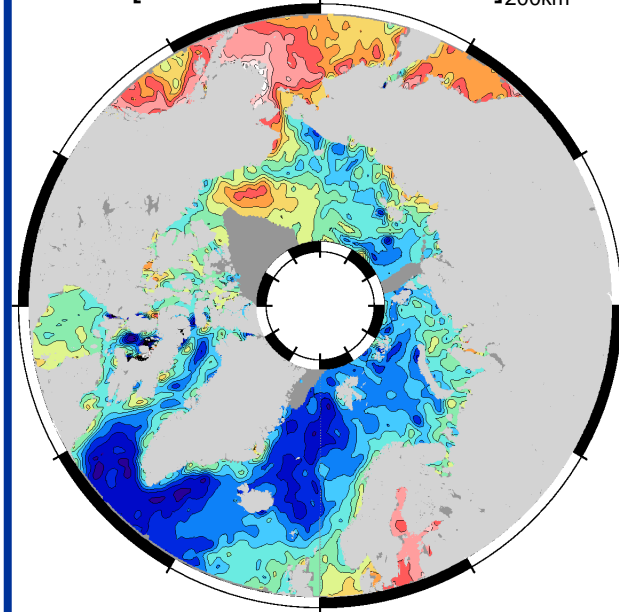
MDT DNSC08
(Andersen et al., 2009)



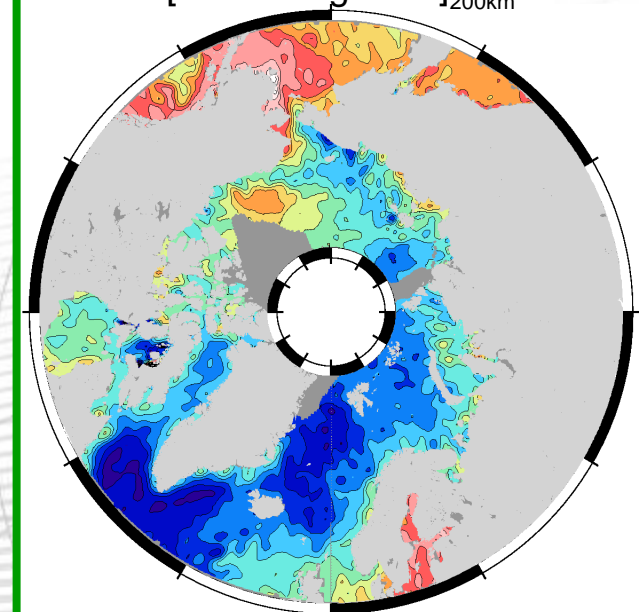
Model reanalysis :
ADT GLORYS2V1



Classical method :
[MDT DNSC08 + SLA]_{200km}



Direct method :
[SSH - Eigen6C]_{200km}



ADT (5 sept. 2007)

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Conclusions, perspectives

Mapping directly SSH – N:

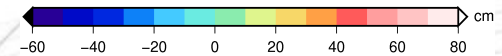
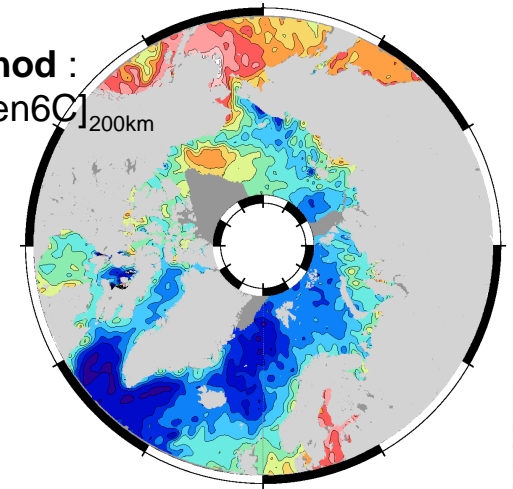
- Very encouraging
- Circulation well resolved
- Improvement with the use of Eigen6C
- GOCE open new perspectives : Arctic Ocean

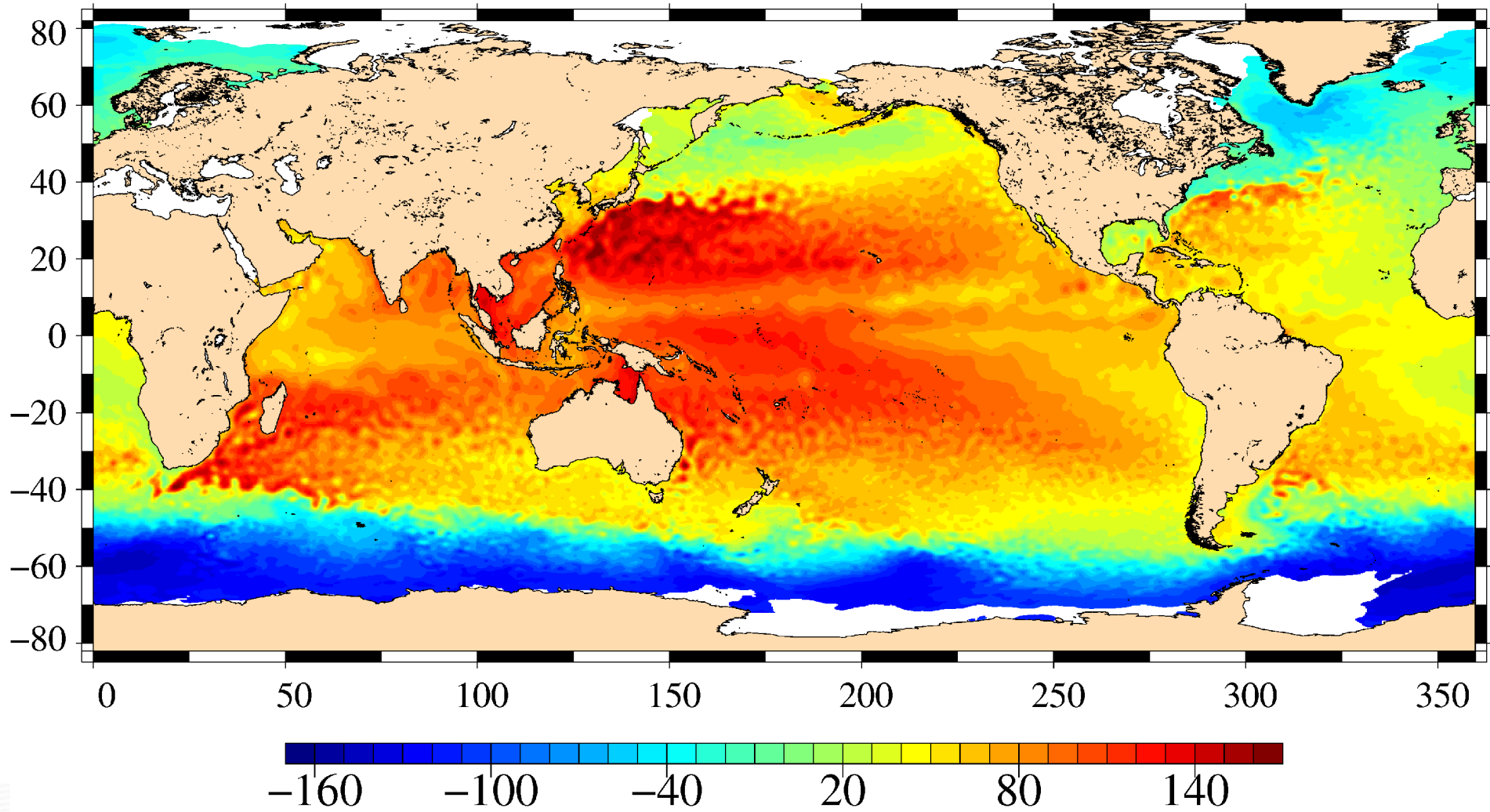
➤ Perspectives

- Keep on reducing noise
 - improve the method
 - pre processing
 - improve geoid model (new gravity gradient processing)
- Validation over a time period and comparison with independent data
- Study of a ADT time series in the Arctic Ocean

Direct method :

[SSH – Eigen6C]



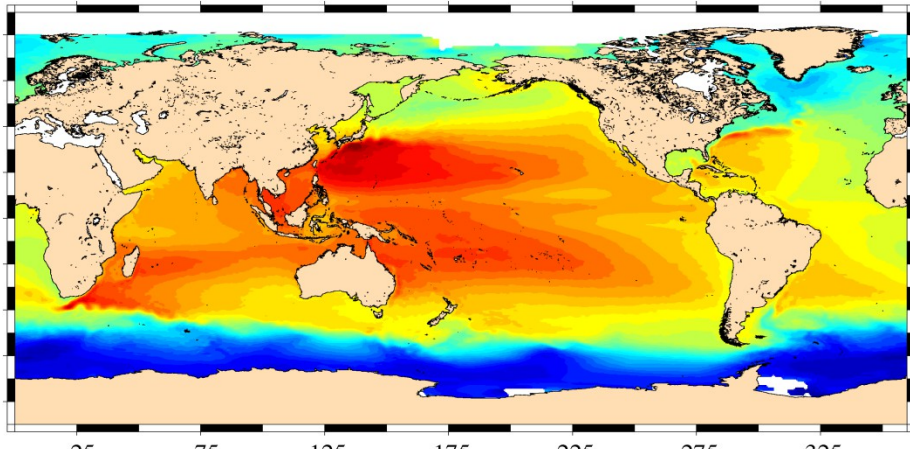


OSTST, Venice, September 2012

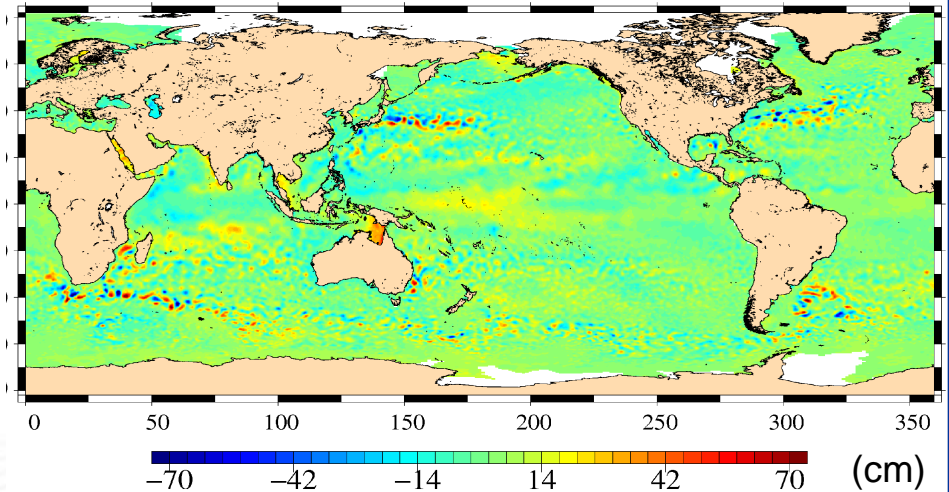
Comparison with classical method

$$ADT = MDT + SLA$$

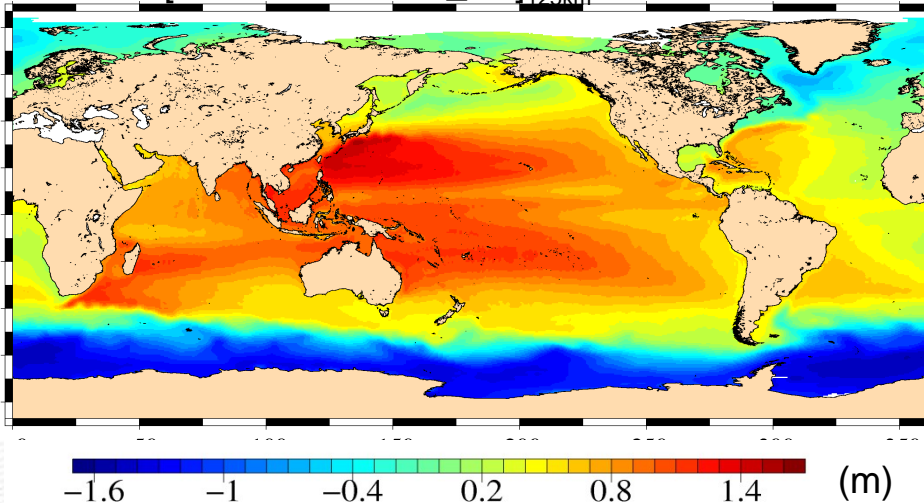
MDT CNES_CLS09



SLA



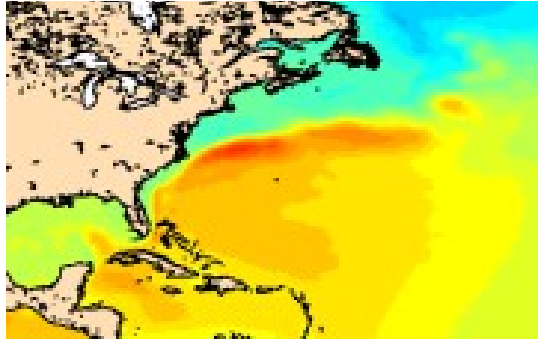
MDT [MSS - EGMTIM_R3]_{125km}



Comparison with classical method

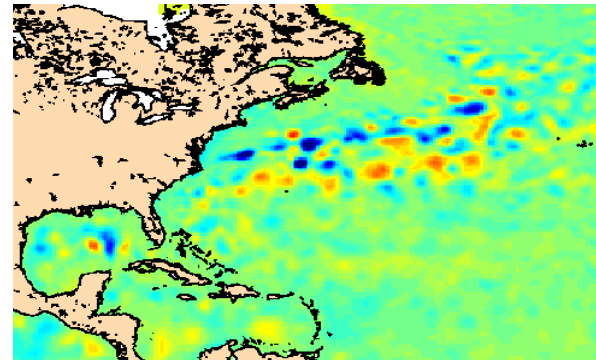
$$\text{ADT} = \text{MDT} + \text{SLA}$$

MDT CNES_CLS09

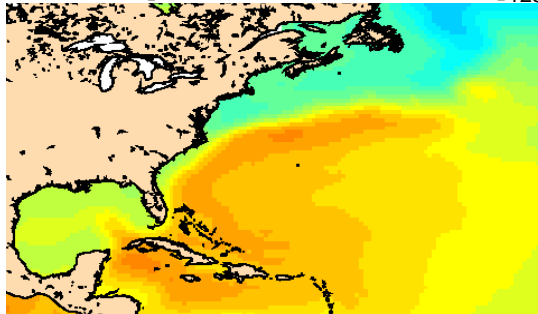


SSALTO
DUACS

SLA



MDT [MSS - EGMTIM_R3]_{125km}



+

=

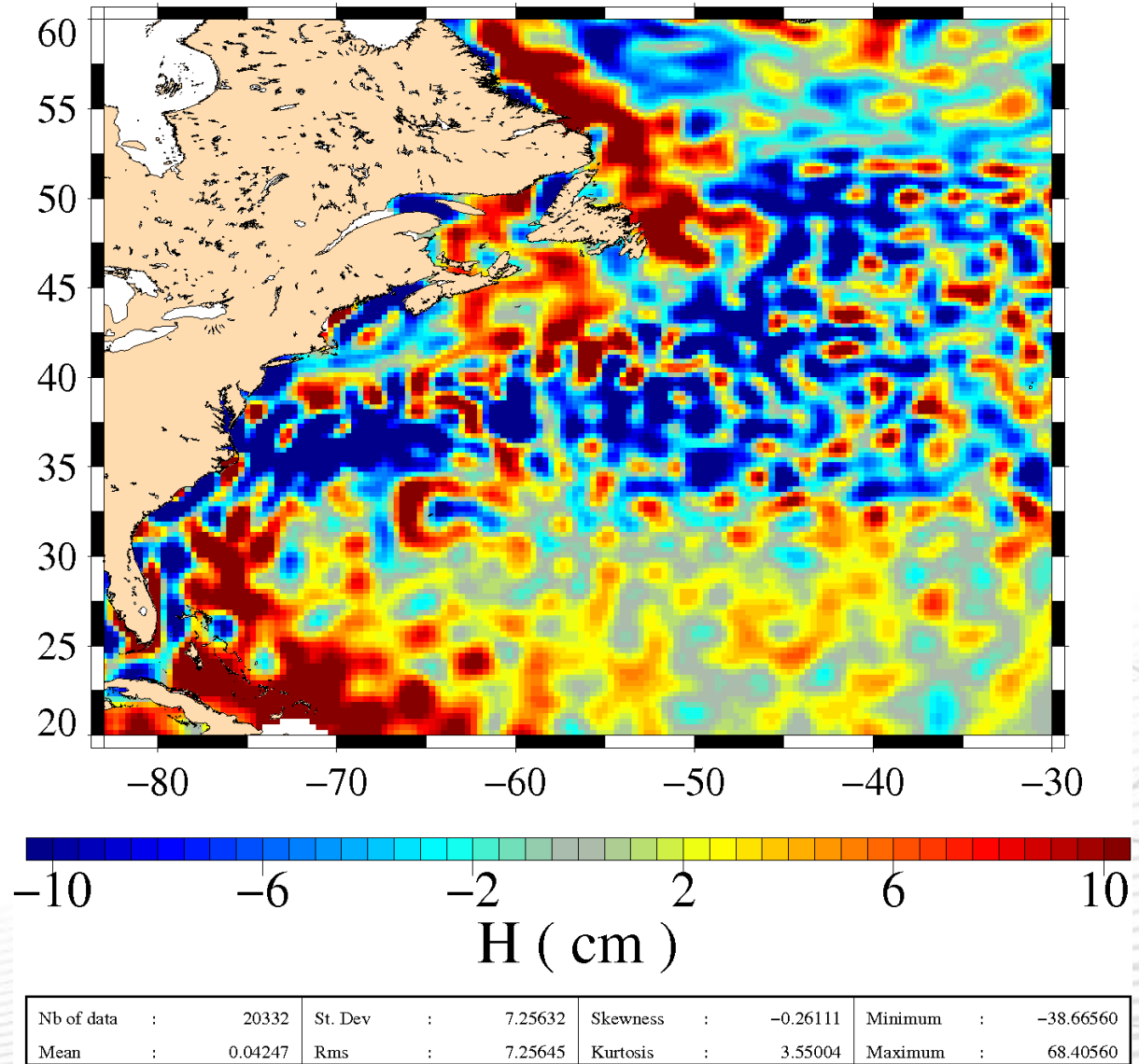
ADT

(Classical method)

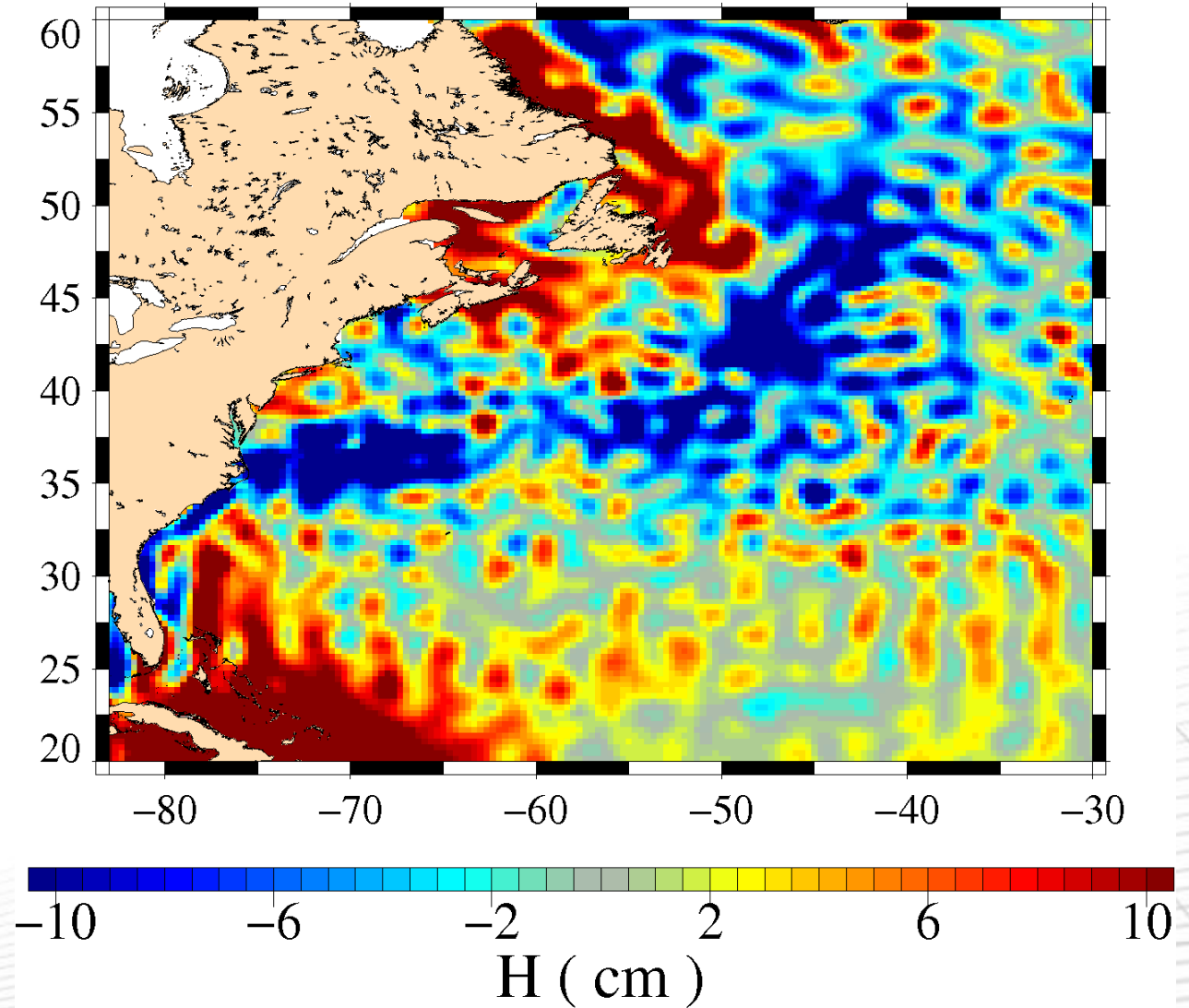
-70 -42 -14 14 42 70 (cm)

-1.6 -1 -0.4 0.2 0.8 1.4 (m)

ADT directe EgmTim –
ADT CNES_CLS09
2Rc

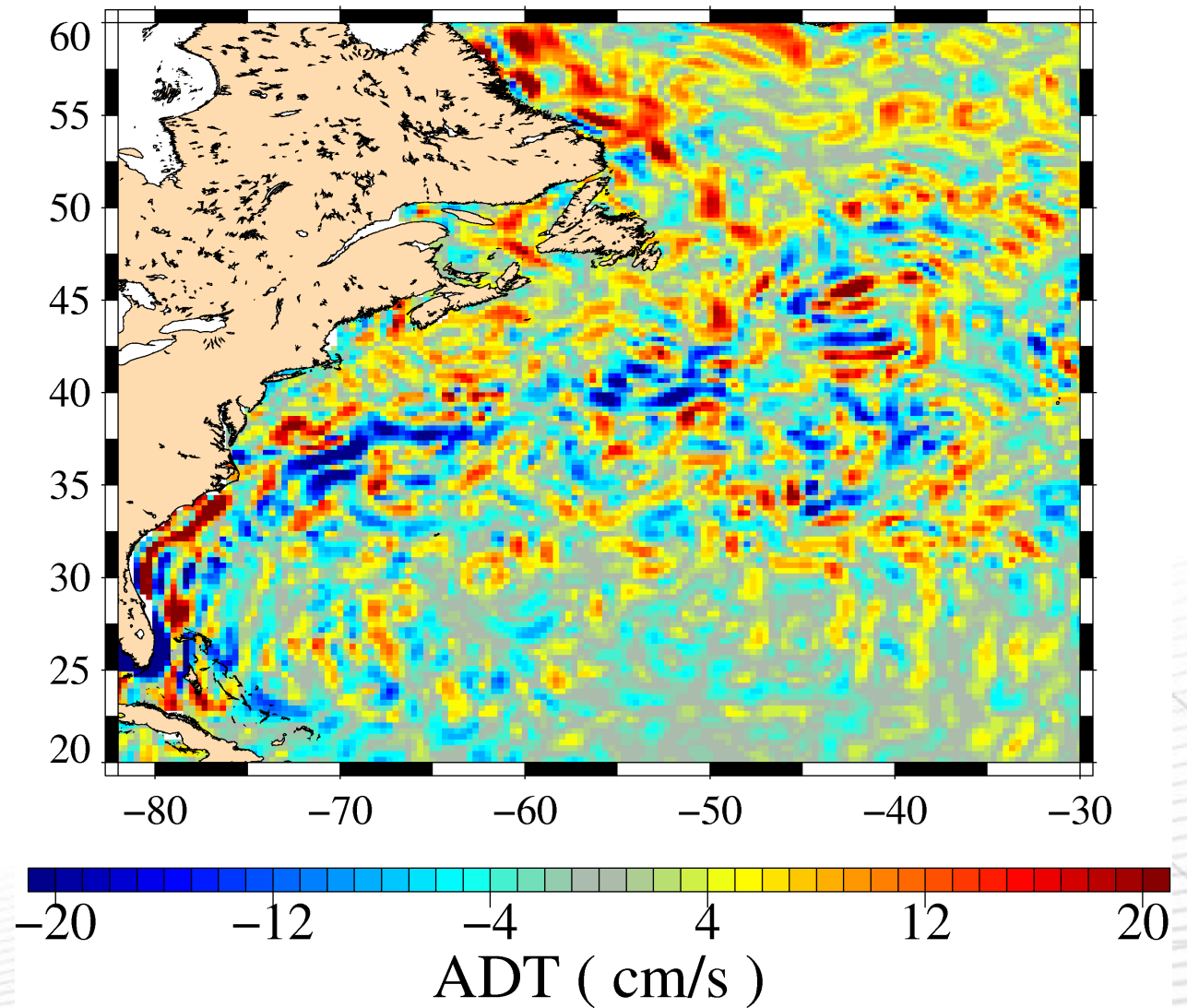


ADT directe Eigen6C
- ADT CNES_CLS09
2Rc



Nb of data	: 20391	St. Dev	: 7.182026	Skewness	: 0.497051	Minimum	: -30.013199
Mean	: 0.539738	Rms	: 7.202279	Kurtosis	: 2.795793	Maximum	: 49.926601

ADT directe Eigen6C
- ADT CNES_CLS09
2Rc

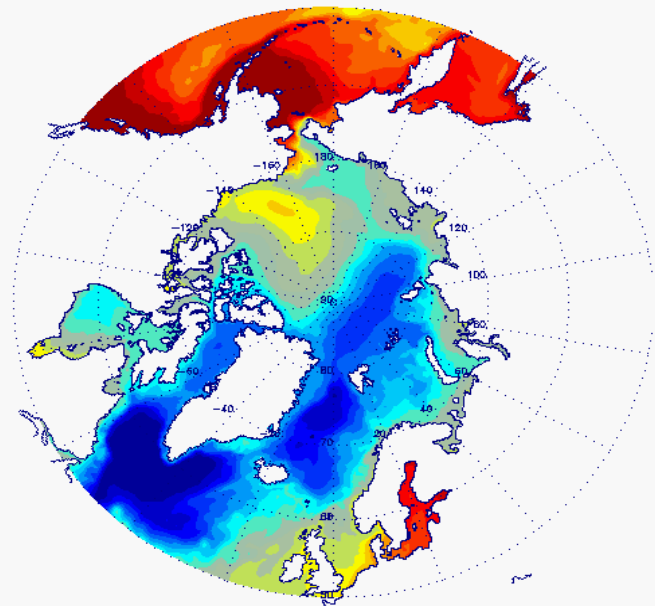


Nb of data	: 19992	St. Dev	: 6.741677	Skewness	: -0.670260	Minimum	: -93.809464
Mean	: 1.235908	Rms	: 6.854026	Kurtosis	: 8.923184	Maximum	: 44.739624

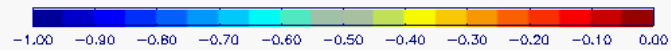
Réanalyses sur Arctique = assimilation SST, SLA, **pas d'assimilation in situ et pas d'assimilation de glace de mer.**
SLA modèle est fonction du forçage atmosphérique et de la divergence du courant de surface.

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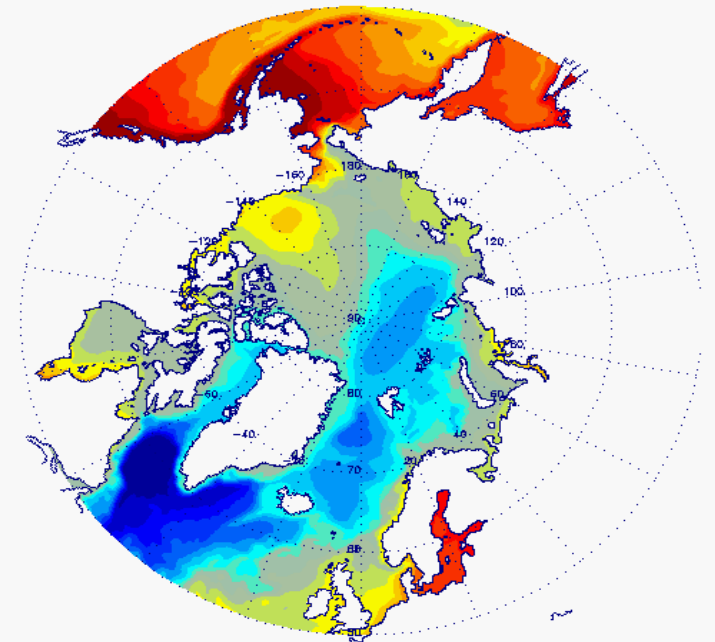
Moyenne SSH 1993-2009



'Réanalyses'



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Run libre

