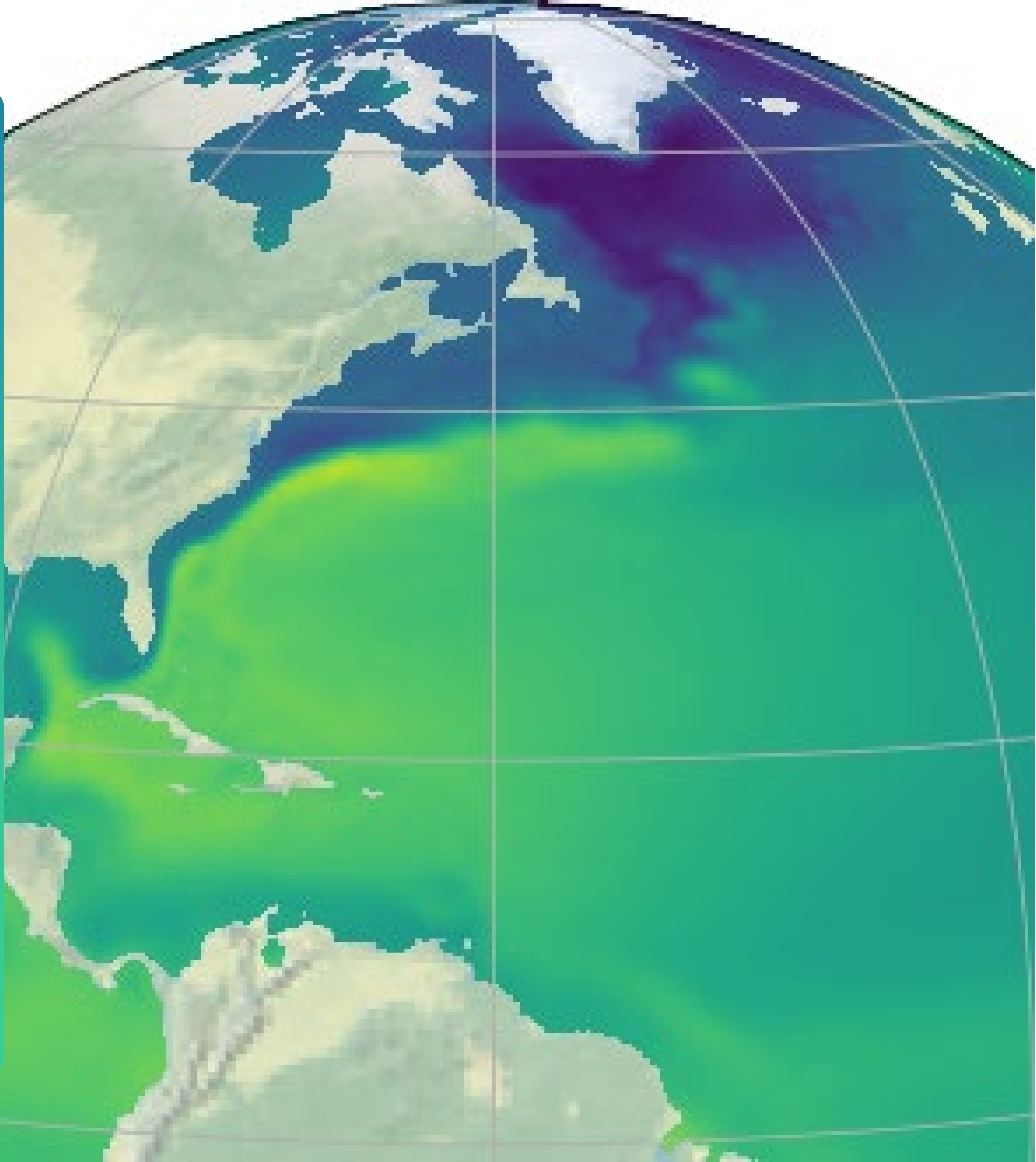
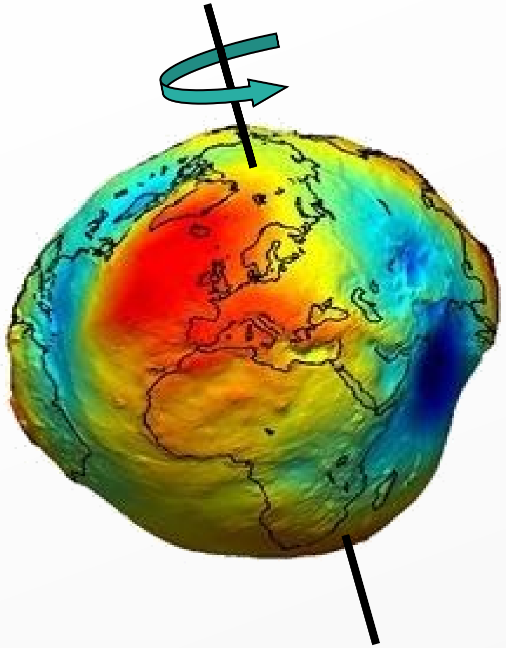
Combining coastal altimetry data with High Frequency radar, drifters and hydrological profiles data to estimate a Mean Dynamic topography on the Mid Atlantic Bight

Solène Jousset (CLS), Sandrine Mulet (CLS), John Wilkin (Rutgers University), Eric Greiner (CLS), Gerald Dibarboure (CNES) and Nicoals Picot (CNES)

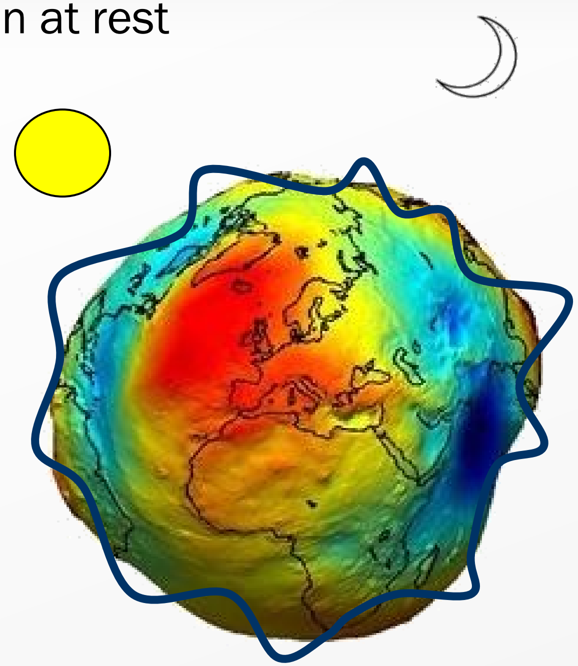


Height referenced to which surface ?

→ **Geoid** = surface of the ocean at rest



Geoid



Ocean at rest, submitted only to the Earth's gravity field

Dynamic of the ocean → **A**bsolute **D**ynamic **T**opography (ADT)

ADT = SLA + MDT

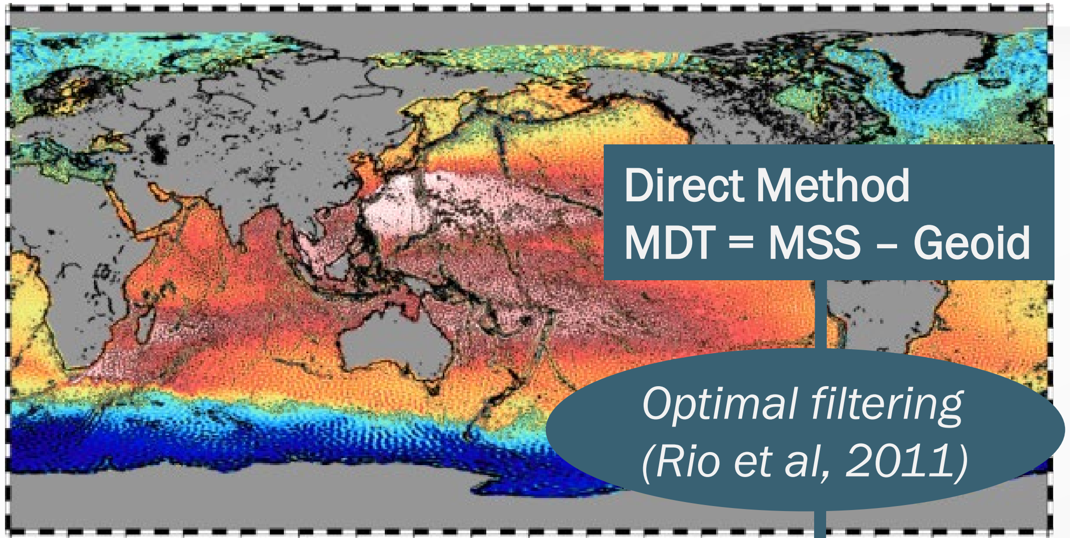
Sea Level Anomalies

Altimetric product

Mean Dynamic Topography

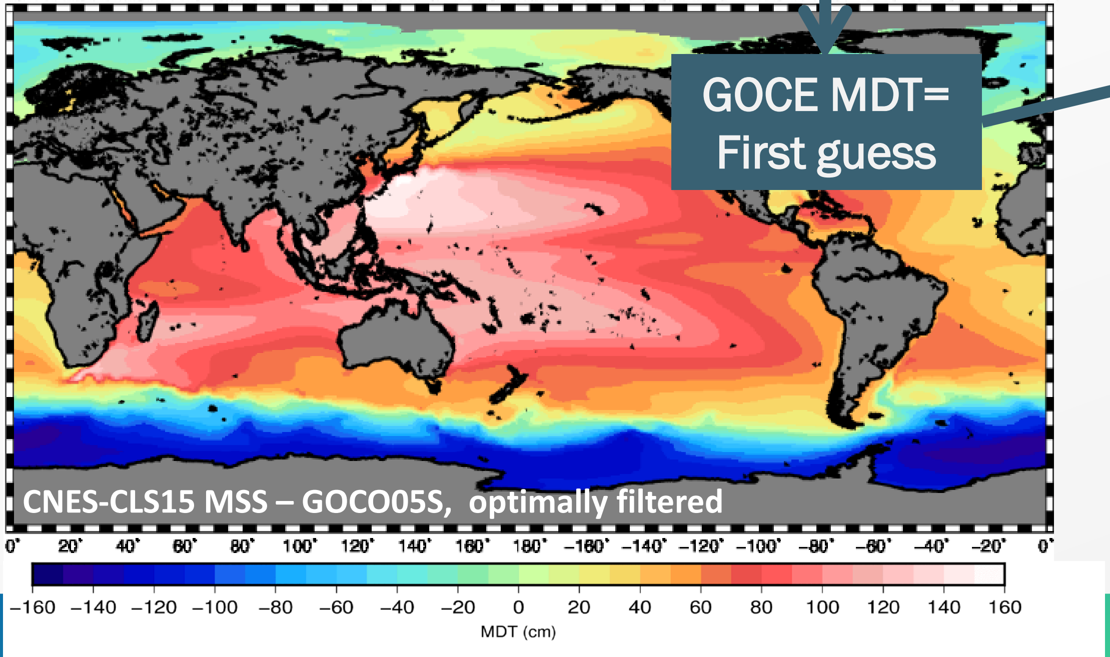
Need to be estimated !

MDT estimation method



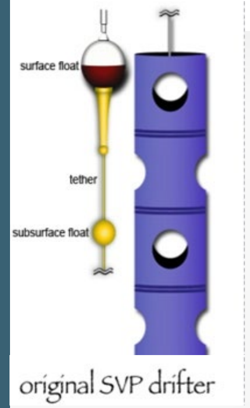
Direct Method
MDT = MSS – Geoid

Optimal filtering
(Rio et al, 2011)



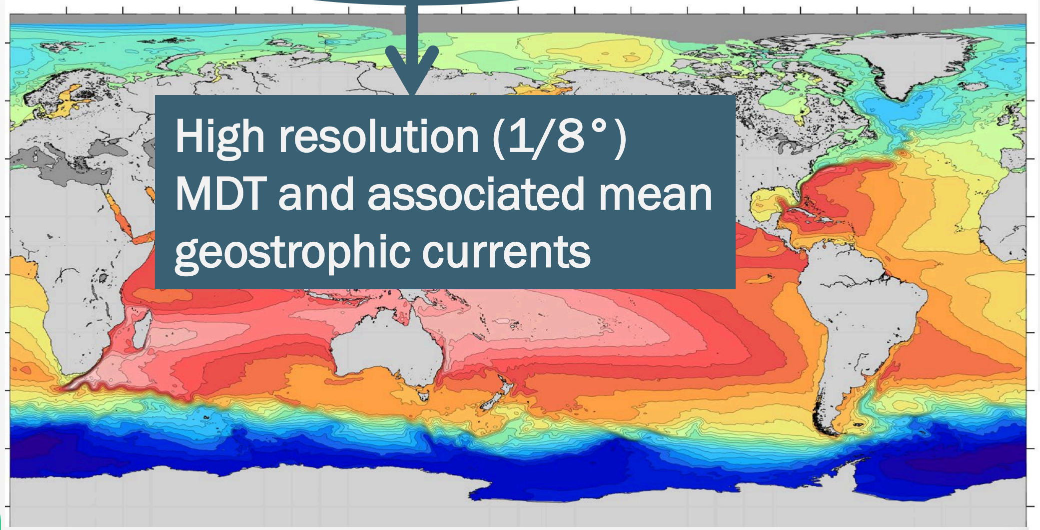
GOCE MDT=
First guess

Synthetic Method:
The short scales of the MDT (and corresponding geostrophic currents) are estimated by combining altimetric anomalies and in-situ data (Argo floats, drifting buoys)



Multivariate
Objective Analysis

Rio and Hernandez, 2004
Rio et al, 2005, 2011, 2014



High resolution (1/8°)
MDT and associated mean geostrophic currents

MDT CNES-CLS18 : last available MDT in global

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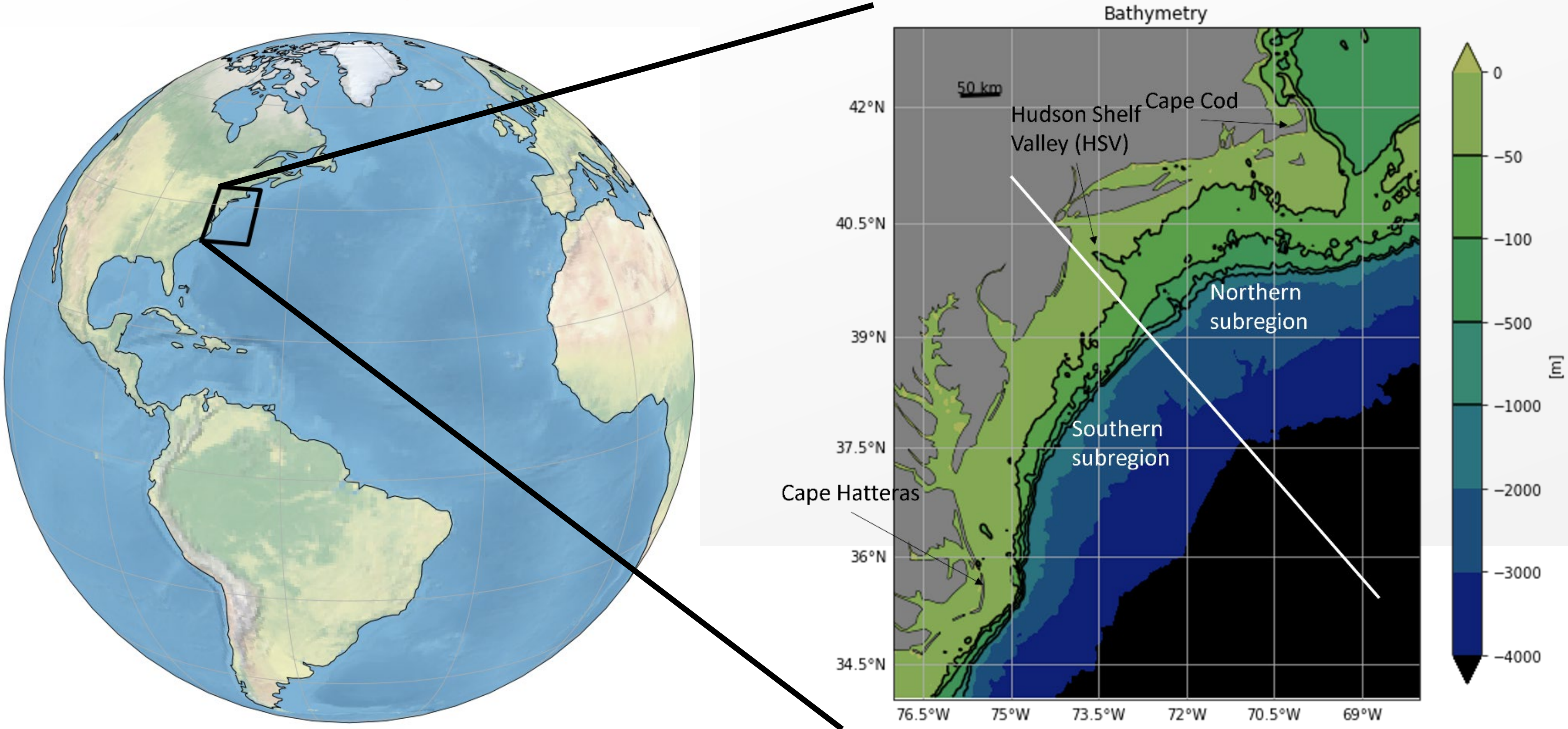
MDT in Mid Atlantic Bight (MAB)

- Objective: to improve the MDT in the coastal zone (Preparation of the new global MDT CNES-CLS2022)
- How to do it? Add coastal data: test the contribution of current data estimated by High Frequency (HF) radar in the Mid Atlantic Bight (area well observed by U.S. HF radars)



1. First-guess
2. In-situ data processing
3. Additional data in Mid Atlantic Bight : HF radar data
4. Final MDT analysis
5. Conclusions

1. **First-guess**
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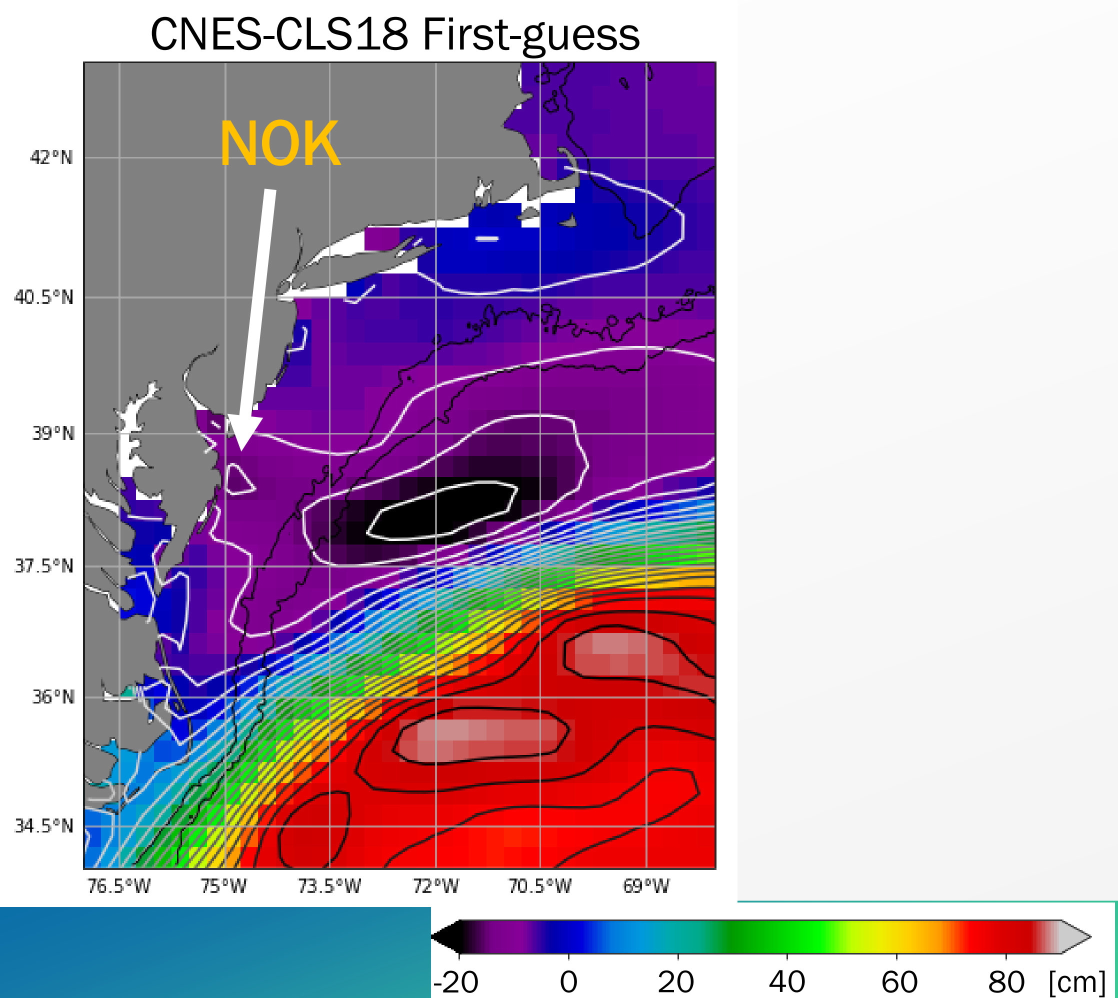
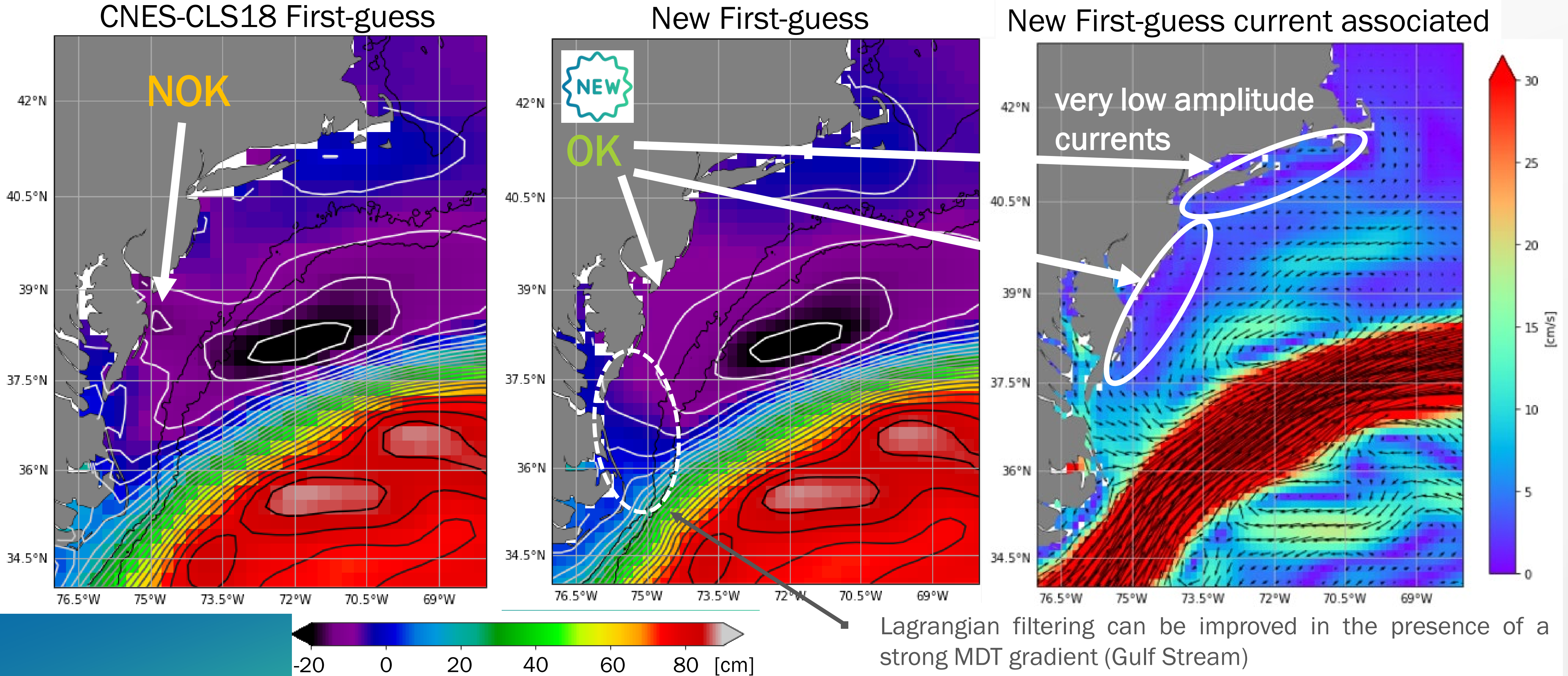
Improved first-guess with Lagrangian filtering

➢ Very noisy MDT at the coast with current lines perpendicular to the coast (not realistic)



Improved first-guess with Lagrangian filtering

- Very noisy MDT at the coast with current lines perpendicular to the coast (not realistic)
- Lagrangian filtering to improve near shore current lines and to reduce normal geostrophic speed associated



Lagrangian filtering can be improved in the presence of a strong MDT gradient (Gulf Stream)

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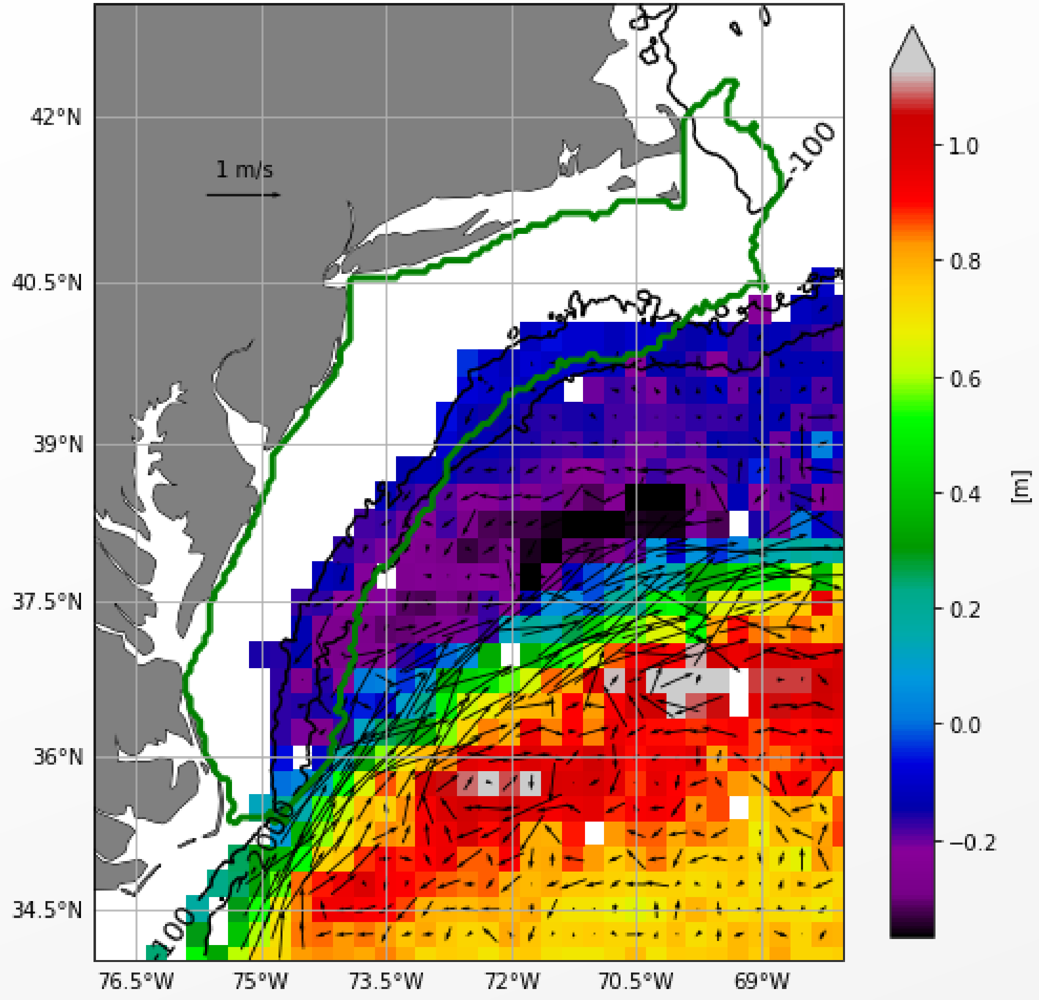
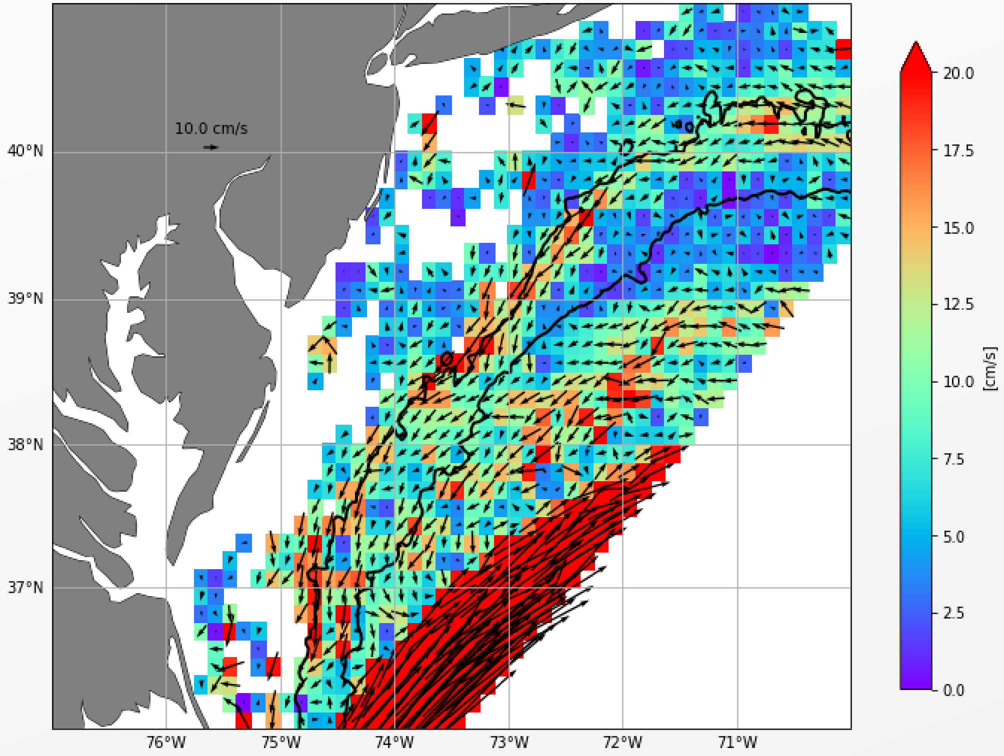
Synthetic mean heights and velocity

- **In-situ data are processed to be consistent in terms of physical content with altimetry**

Mean Synthetic Heights 1/4° from T/S profiles



Mean Synthetic Velocities 1/8° from drifters



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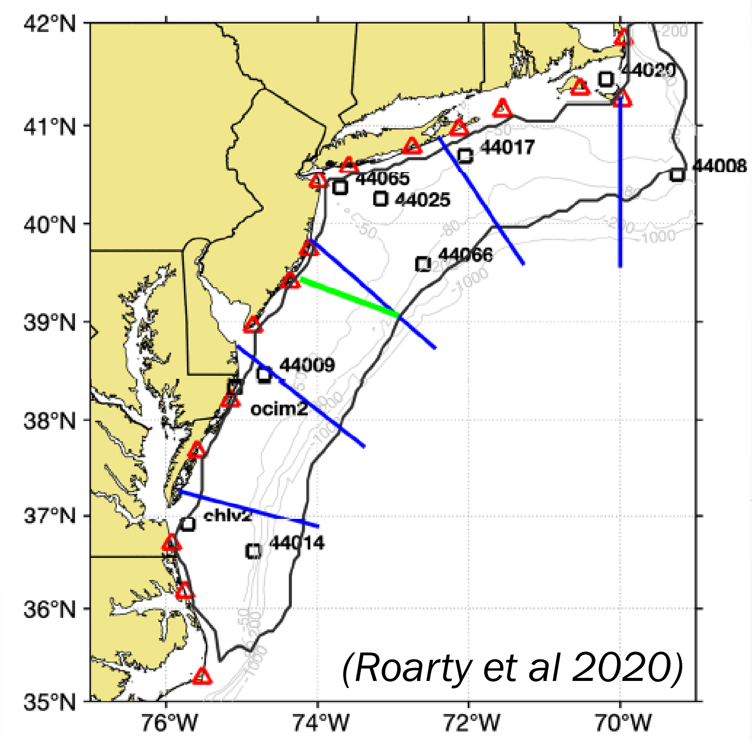
Processing of current data estimated by HF radar



△ 16 5-MHz-SeaSondes (CODAR) from **2007 to 2016**

http://tds.marine.rutgers.edu/thredds/cool/codar/cat_totals.html

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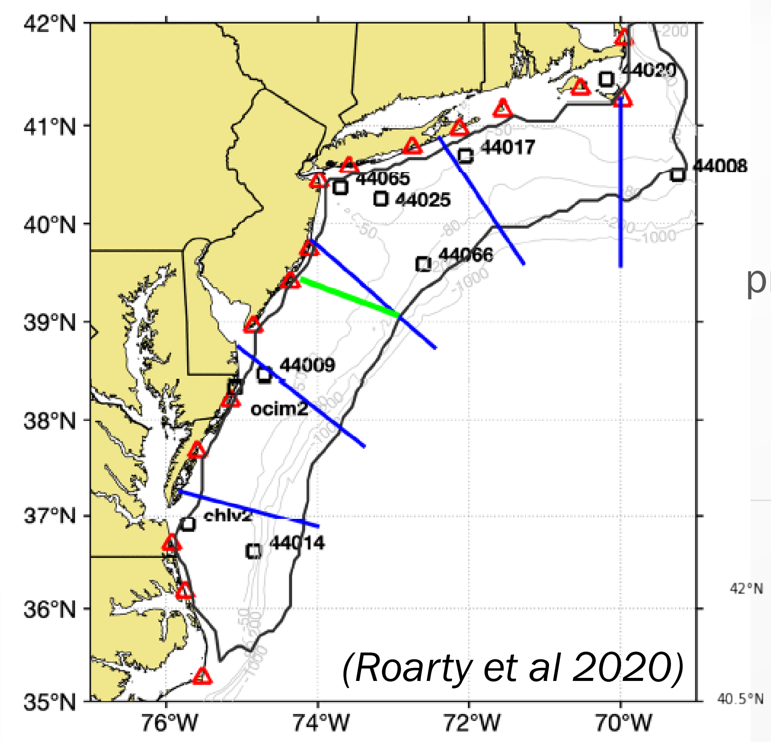

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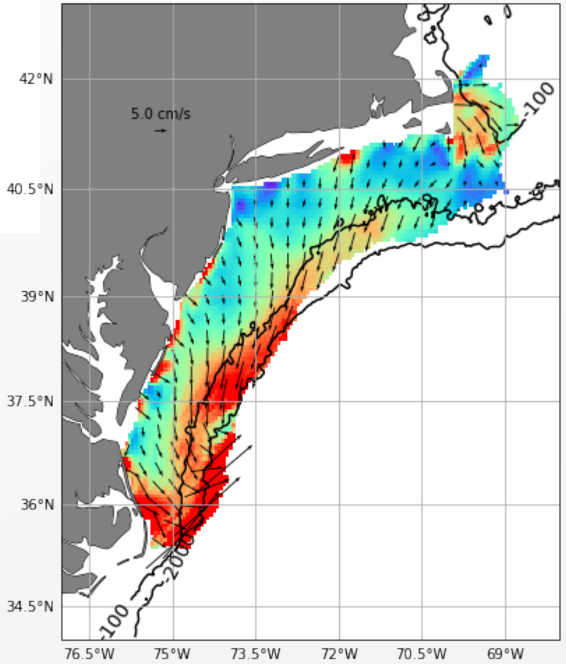
November 2006 – December 2016

Mean HF radar currents processed by **Rutgers University**: detited, filtered currents (high frequency signal removed) *Roarty et al 2020*

U_{Radar} 2007-2016



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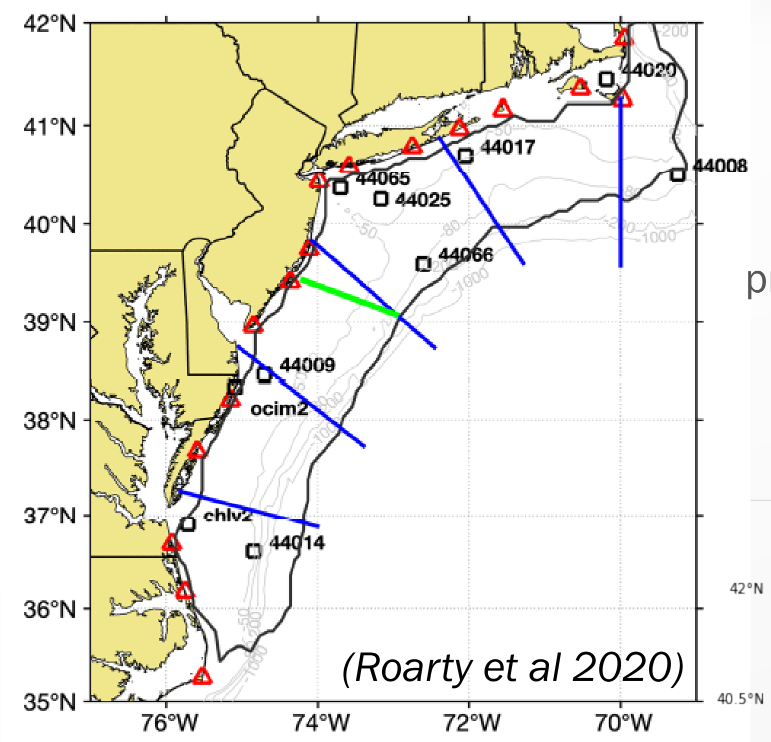

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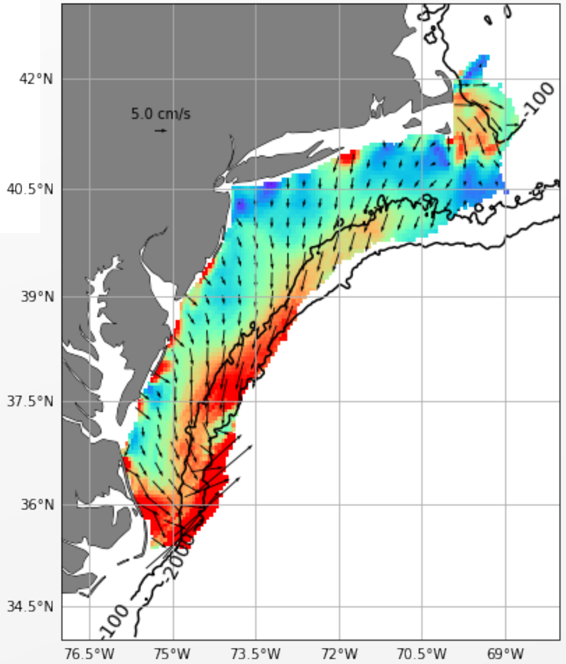
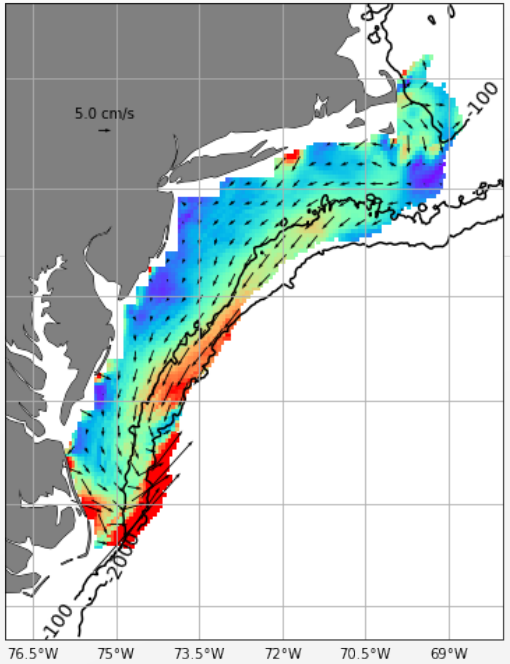


Remove Ekman mean currents

U_{Radar}-U_{Ekman} 2007-2016



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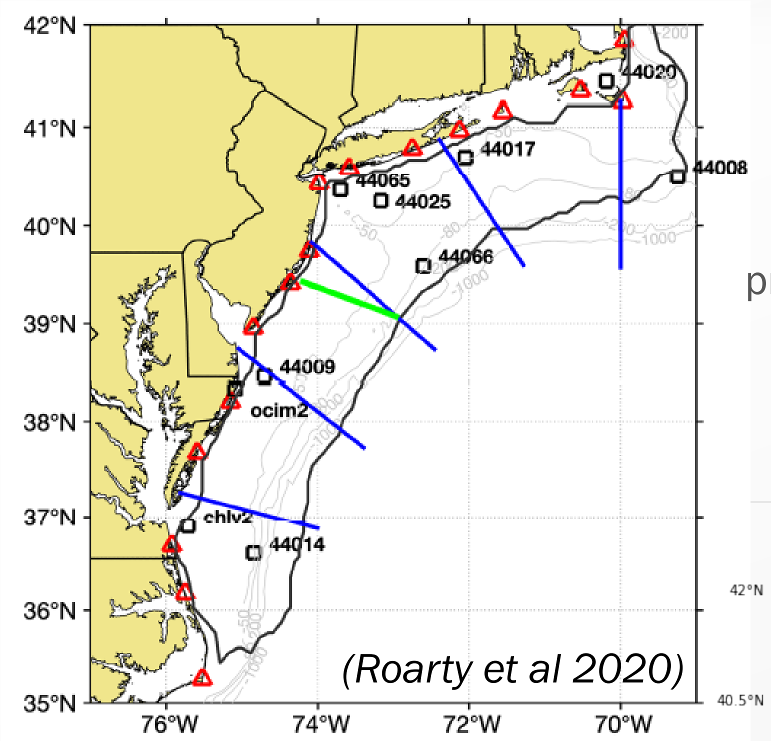
Processing of current data estimated by HF radar



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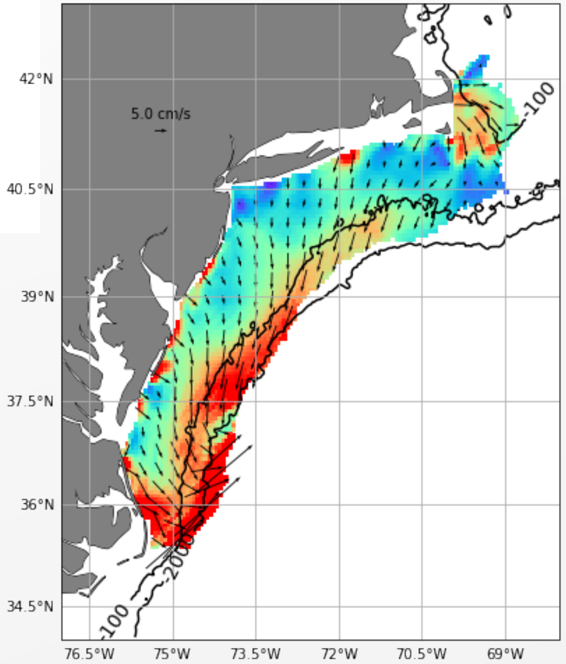

Remove Ekman mean currents

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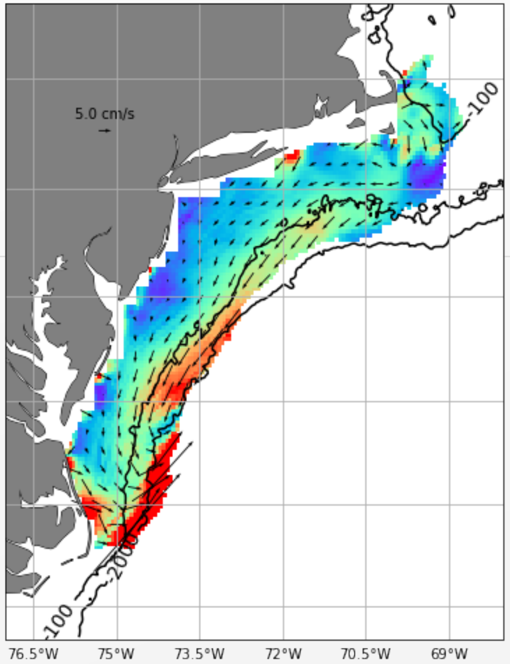
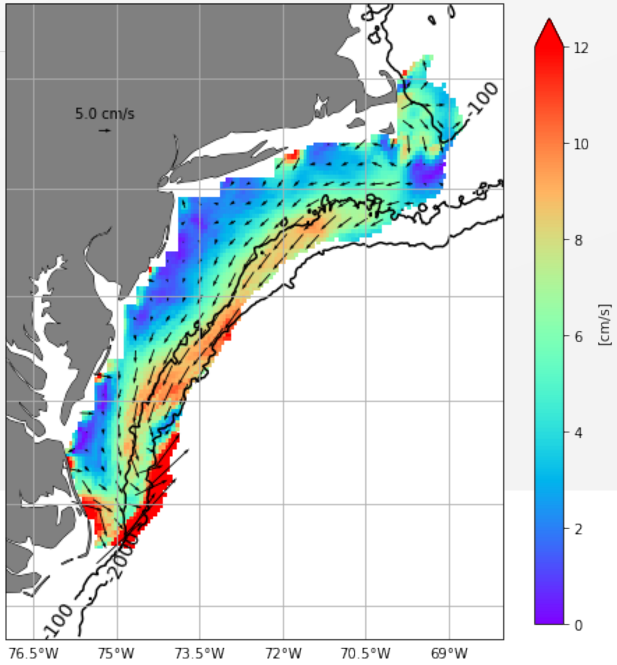


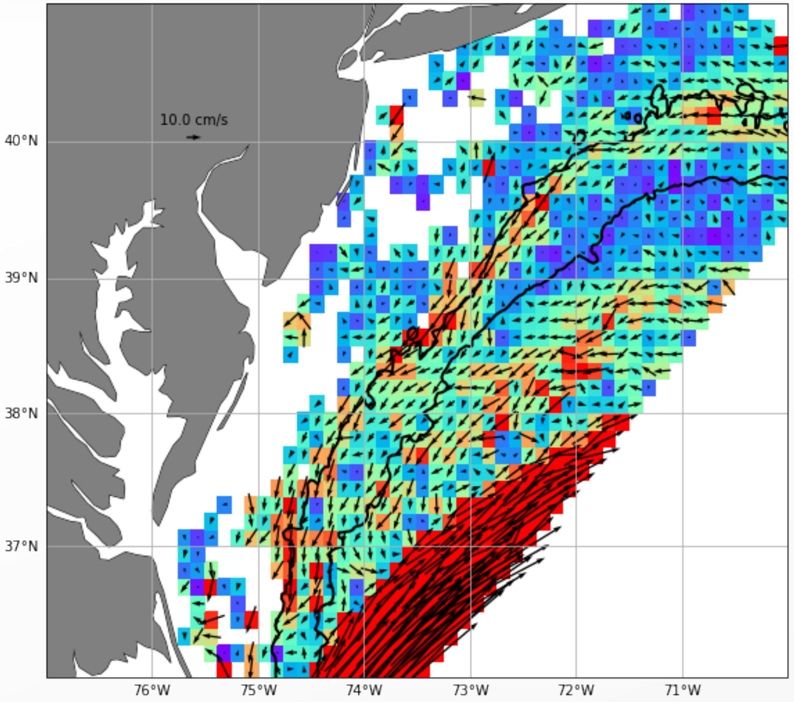
Re-reference radar data mean on the period 1993-2012

U_{Radar}-U_{Ekman} 1993-2012

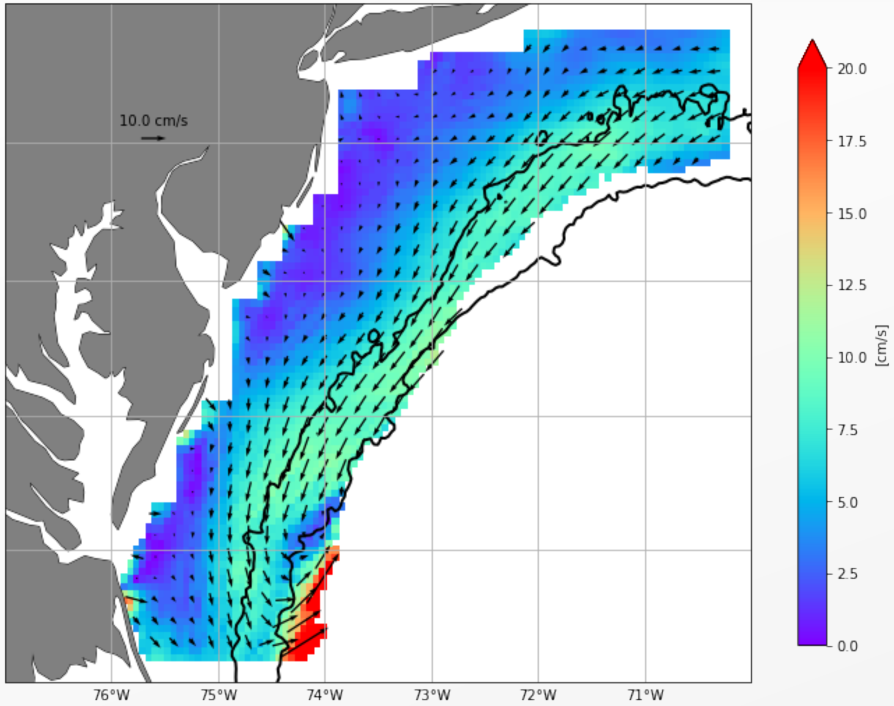


Comparison of radar/drifters currents

Drifters 1/8° 1993-2012



Radar-Ekman 1993-2012



- Current along the shelf-break seen by drifters more intense and narrower than in the HF radar current

➢ Which data should we trust the most?

  ➢ We have chosen to rely more on HF radars because there is much more data

How to explain the differences between the two data sets ?

- Sampling:
  - Poor seasonal sampling for near-shore drifters (only summer and fall observations) and on the shelf-break (only spring observations)
  - For radars on the shelf-break: only winter observations
- Drifters have a tendency to accumulate in this front because of convergence and subduction, so there may be a sampling bias toward a narrow jet. [J. Wilkin].

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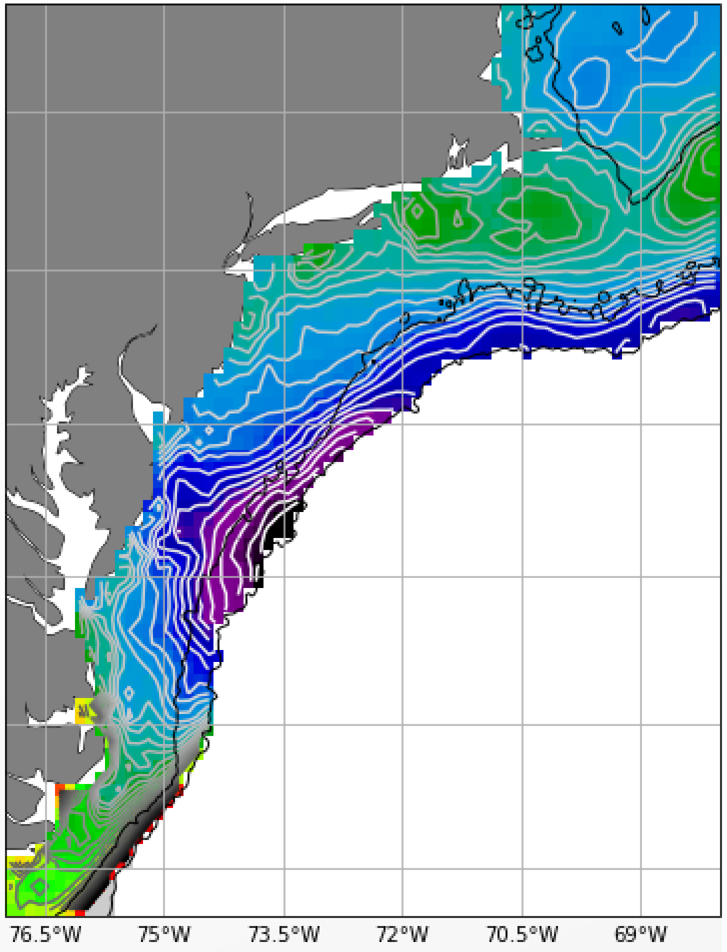
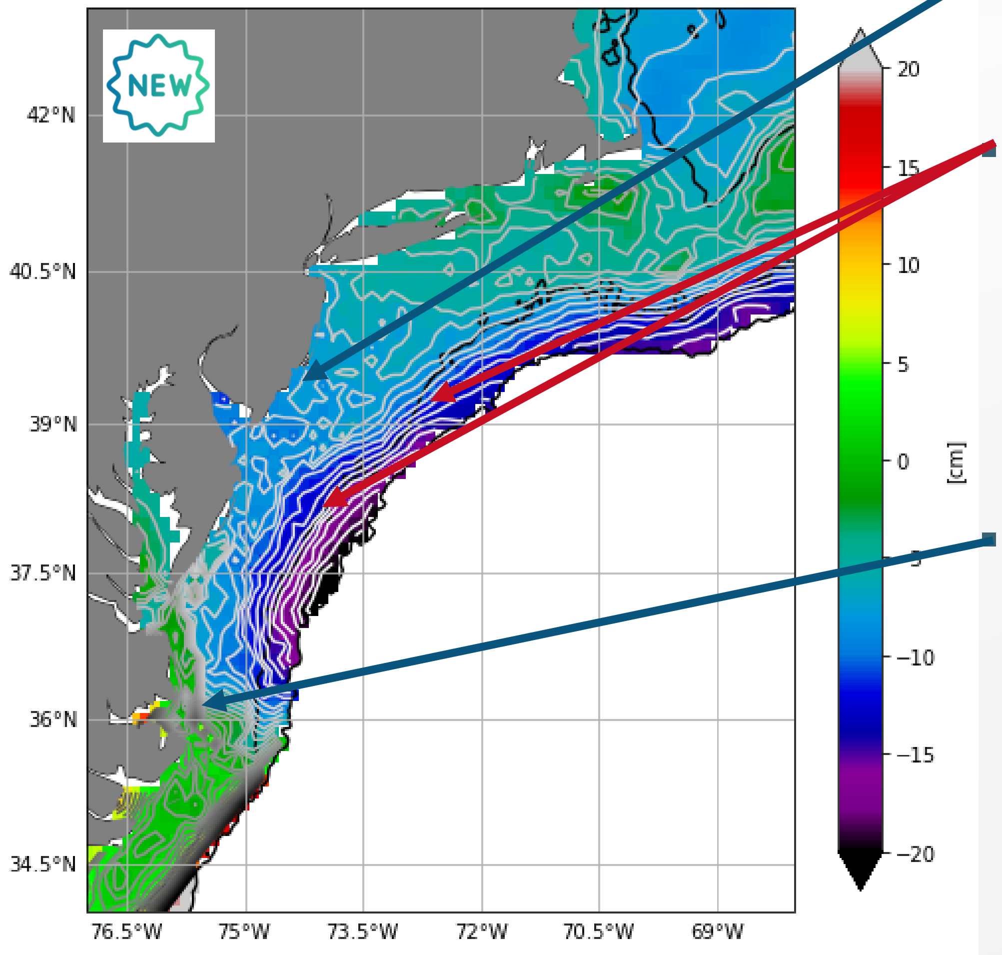
The new CNESCLS2022β MDT vs the CNESCLS-18 MDT

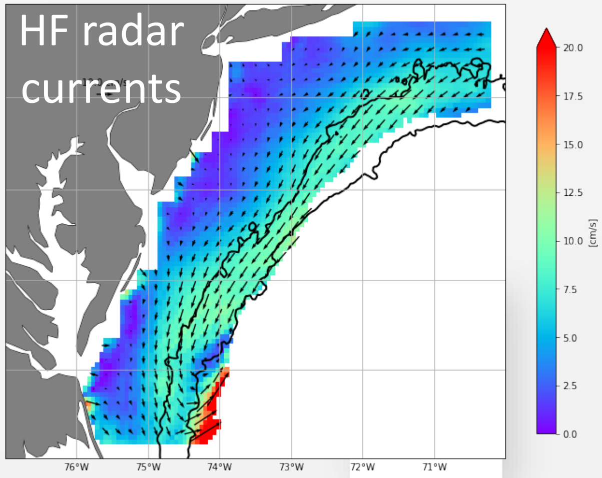
CNES-CLS18



CNES-CLS 2022β



- No appreciable across-shelf gradient near the coast but very weak currents > **very influenced by the first-guess**
- A more organized across-shelf gradient following the shelf-break, suggestive of a more continuous mean flow along this region from 70W to 74W, **which is an improvement over the MDT CNES-CLS18** thanks to HF radar currents.
- Sharp gradient, behavior related to the first-guess because no data close to the coast



The contours are drawn every 1cm

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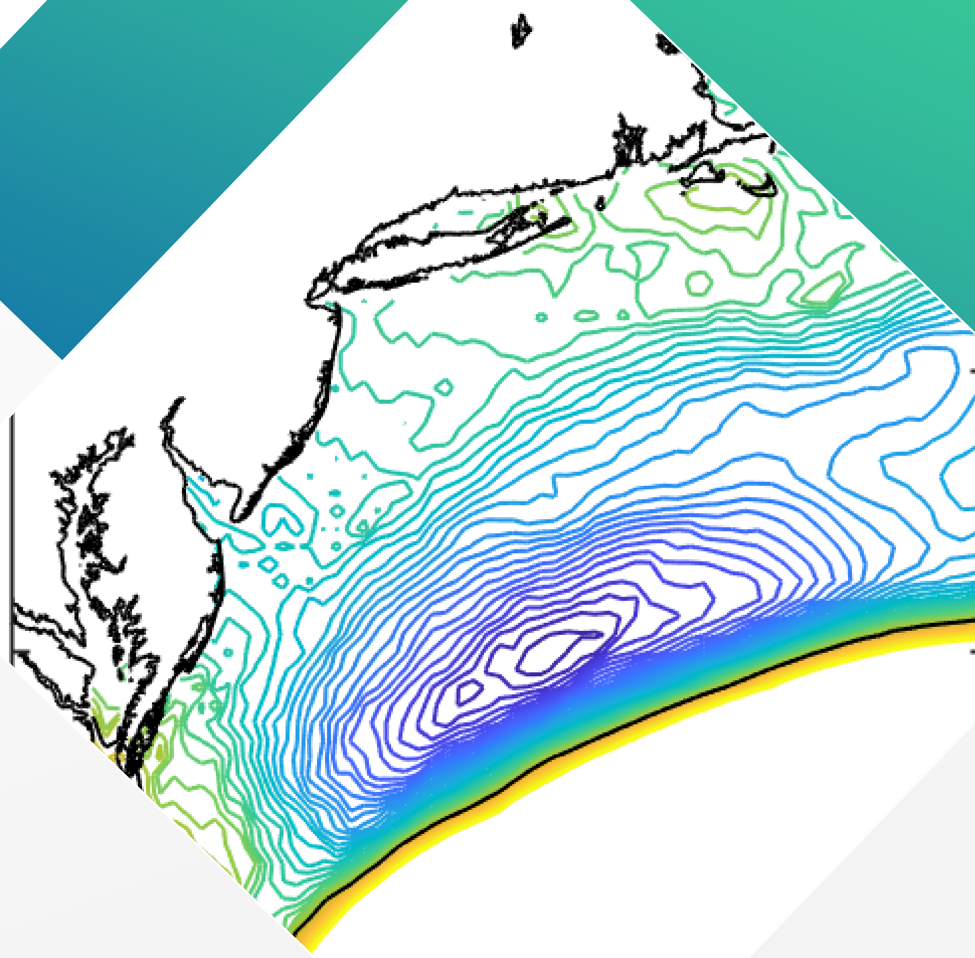
Conclusions

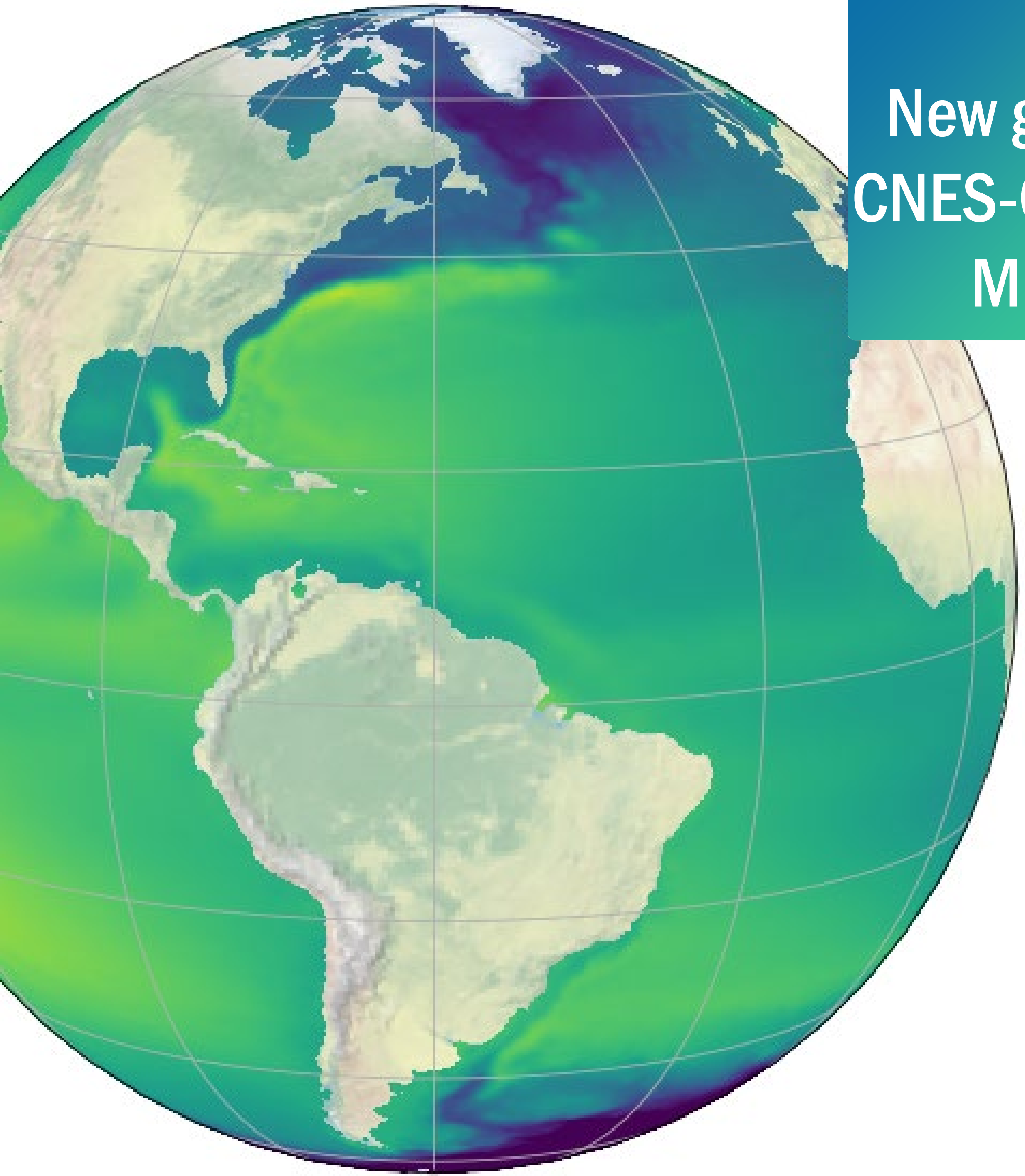
HF radar currents (and drifters currents) are not able to correct the first-guess near the coast → **it is essential to improve the coastal first-guess**

The contribution of HF radar data allows a **better representation of the shelf-break current**

Perspectives: using HF radar data globally

- **Substantial pre-processing** (here favourable case because data already detided, filtered and averaged)





New global CNES-CLS22 MDT

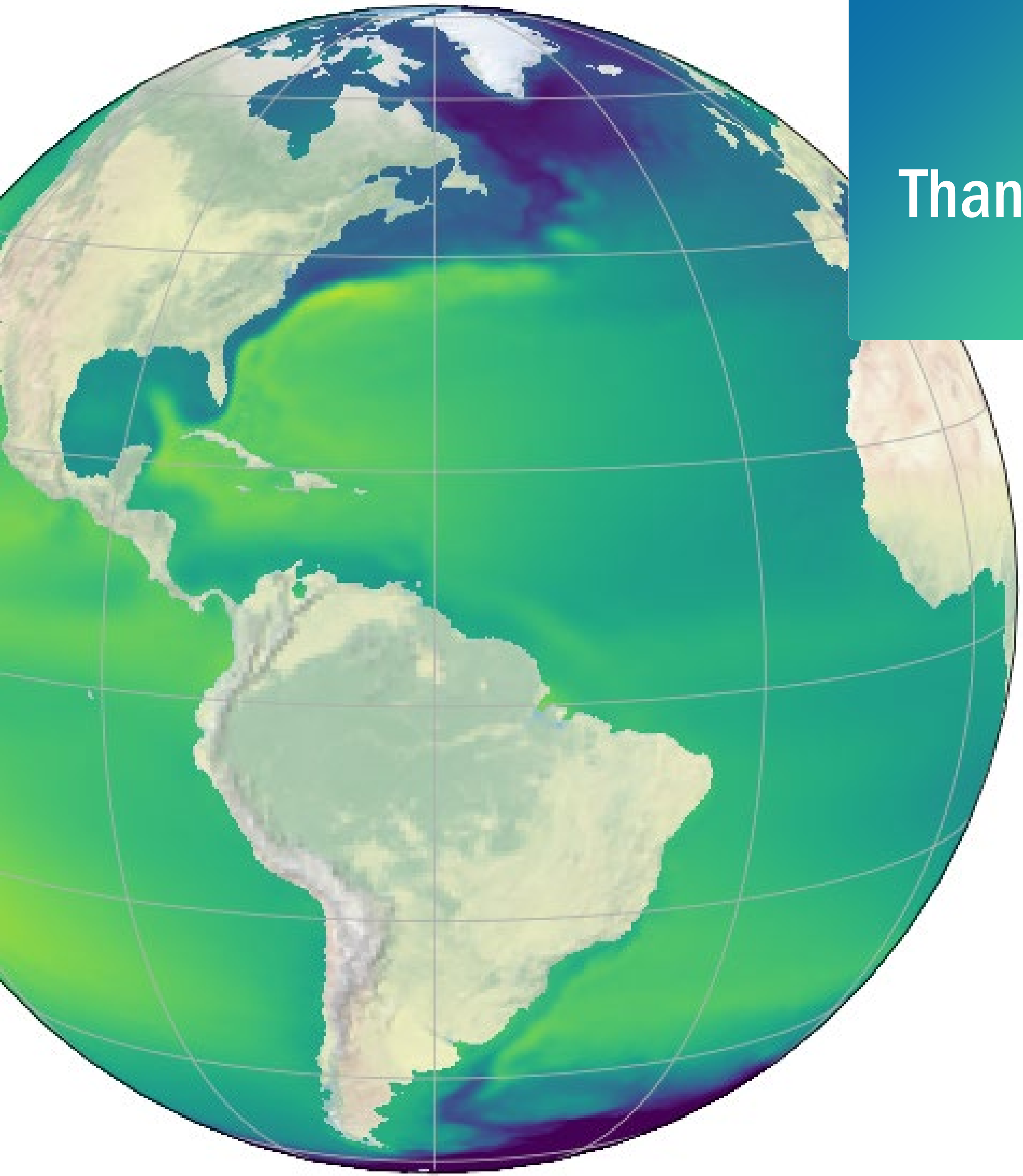
End of June 2022 — Beta version

Validation/feedbacks by beta users

- If you are interested to be beta tester, let me know **sjousset@groupcls.com**

End of 2022 — Final version end of 2022

sjousset@groupcls.com

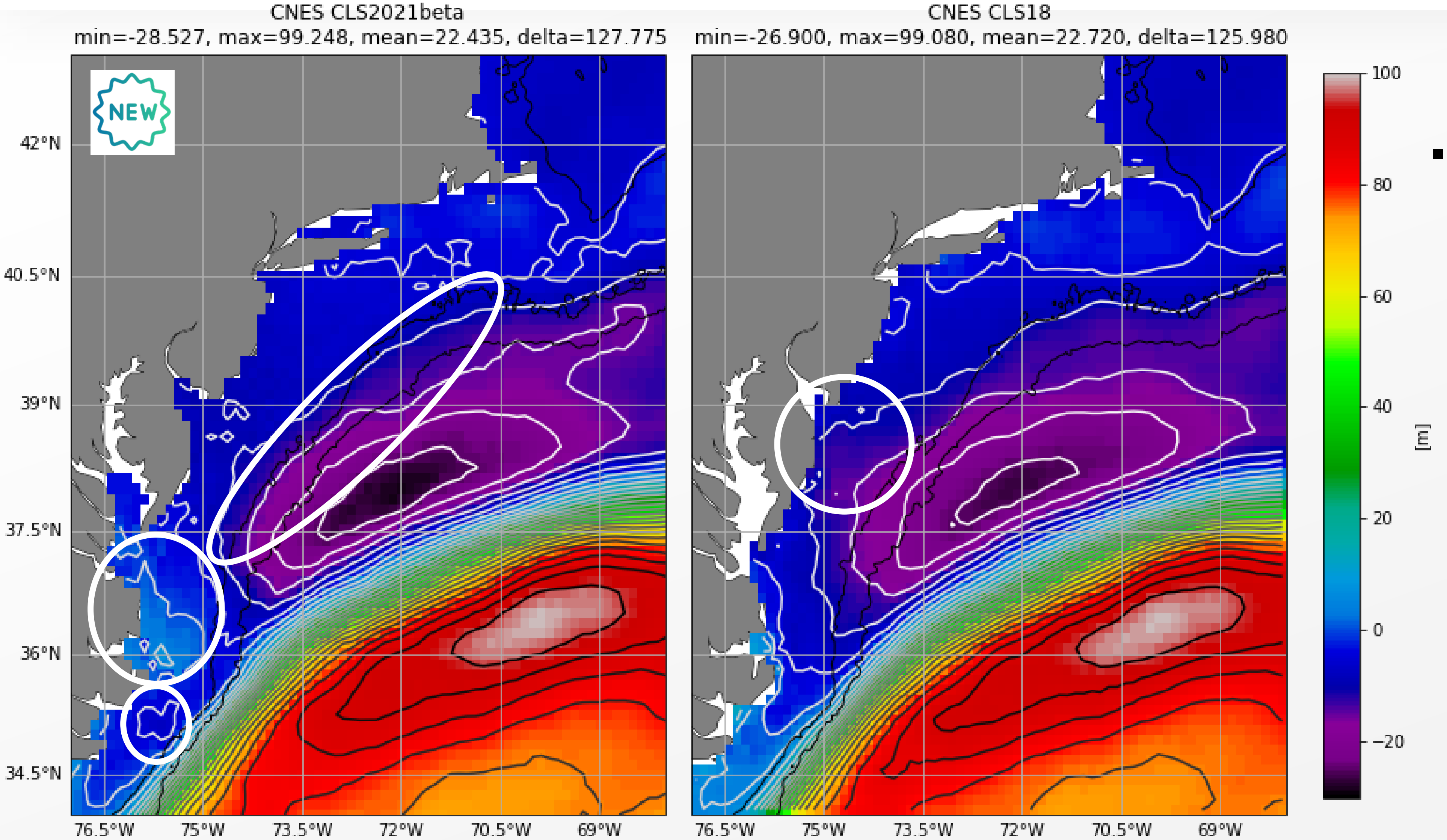


Thank you

sjousset@groupcls.com

Backup slides

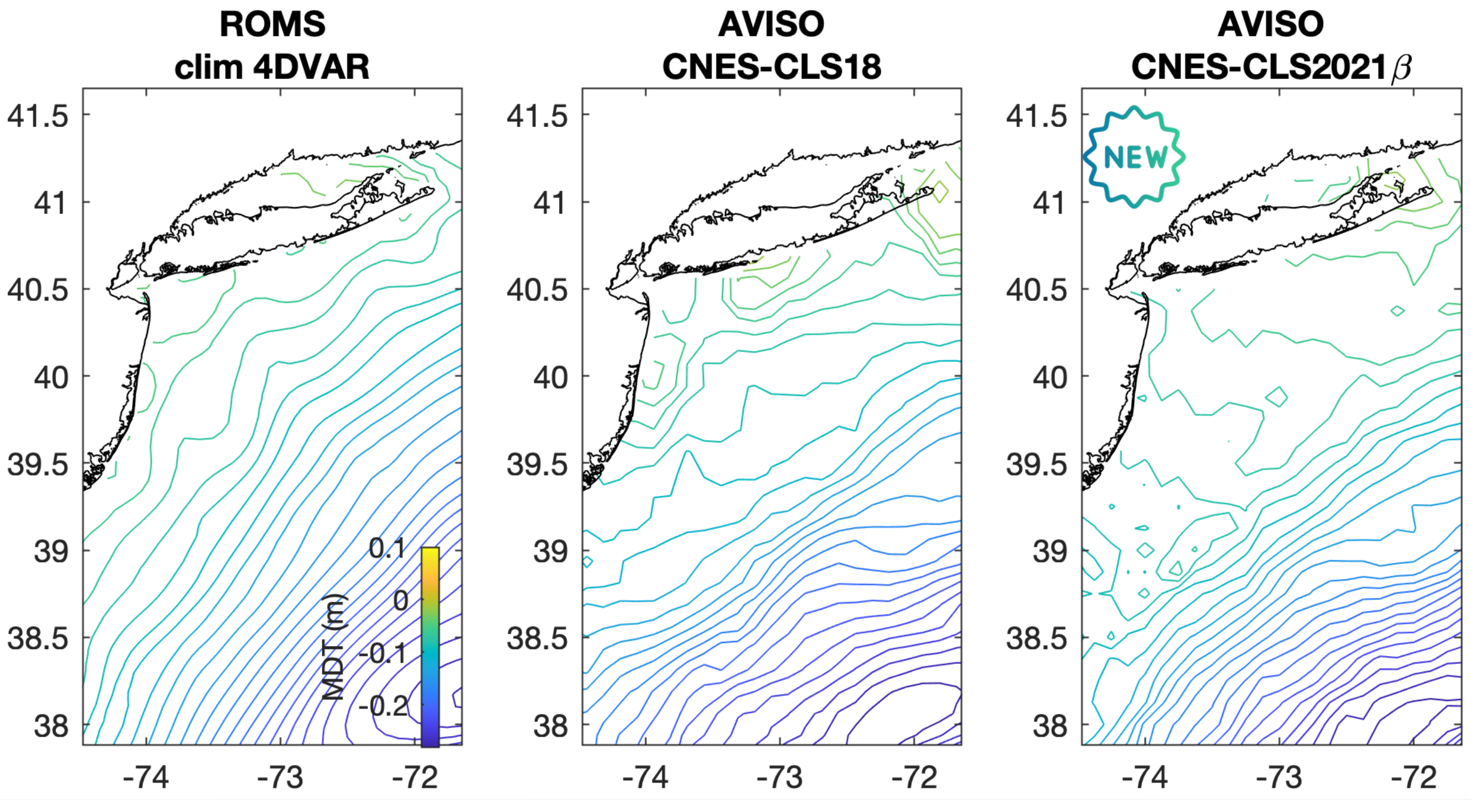
The new CNESCLS2021β MDT vs the CNESCLS-18 MDT



- Differences on the continental shelf

The contours are drawn every 5cm

The new CNESCLS2021β MDT vs the CNESCLS-18 MDT



- <u>NORTH inland plateau (bathy<30m):</u>

There is **no gradient perpendicular to the coast**, but there should be, since the mean flow is always southwest. [J. Wilkin]

This should be visible if the aeostrophic signals are well suppressed from the HF radar.

➢ Improving near-shore radar processing! The Ekman model used is not efficient enough in this area.

➢ Make a model from HF-radar

"ROMS clim 4DVAR" is the MDT used in the operational forecast system, calculated using the same methodology described in Levin* et al. (2018) but for a larger model domain that includes the Gulf of Maine.

Levin, J., J. Wilkin, N. Fleming and J. Zavala-Garay, (2018), Mean circulation of the Mid-Atlantic Bight from a climatological data assimilative model, Ocean Modelling, 128, 1-14, doi:10.1016/j.ocemod.2018.05.003

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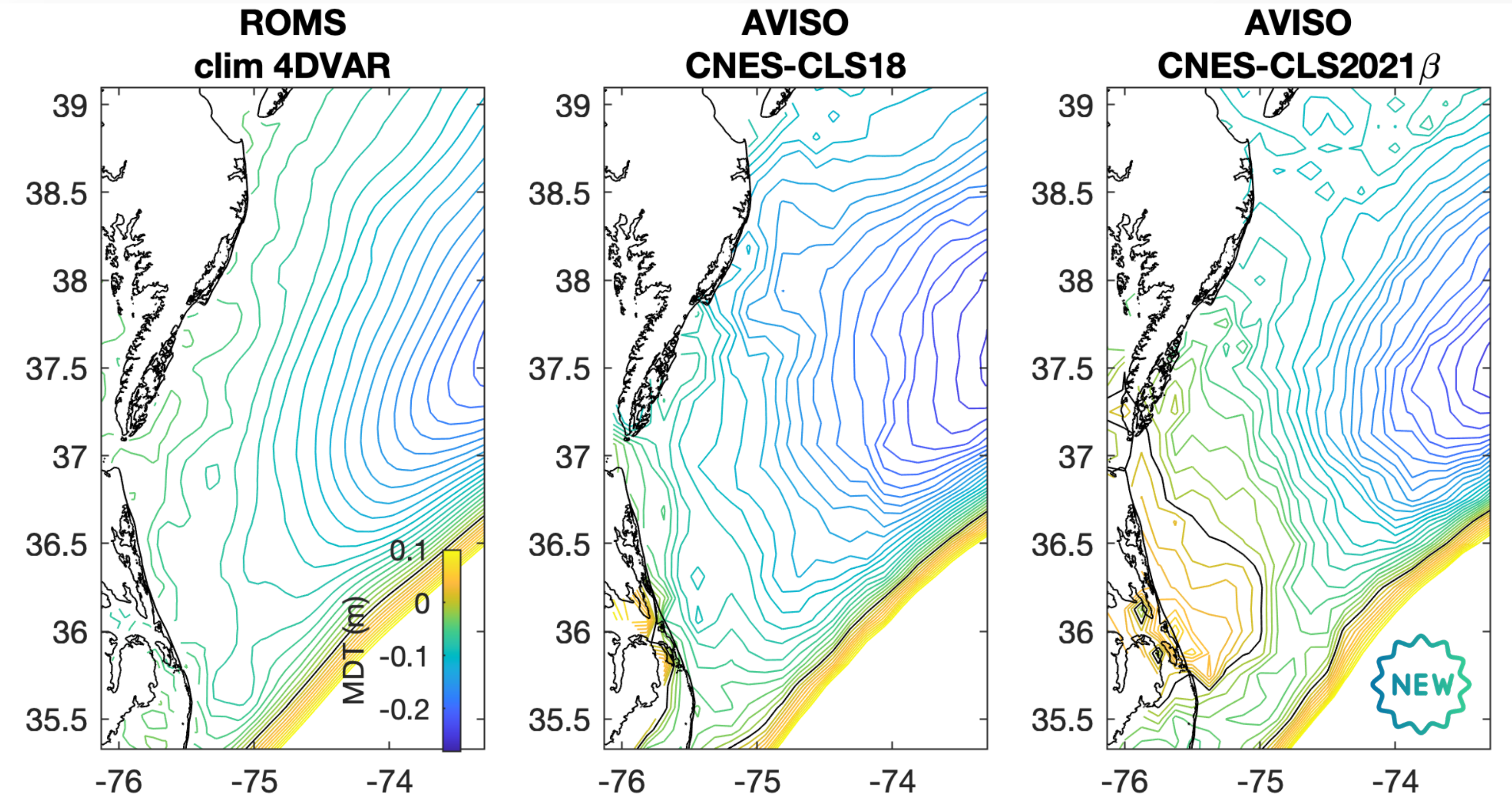
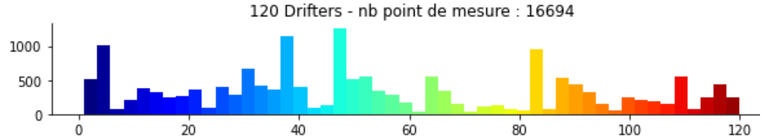
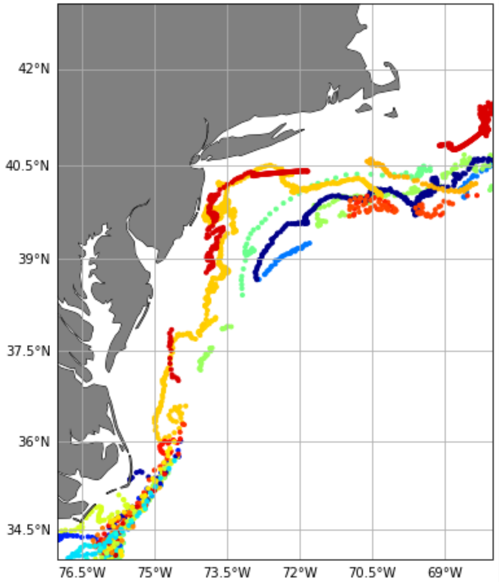


- <u>In the south:</u>
  - Sea level CNES-CLS2021β **takes a local maximum north of Cape Hatteras**, which does not seem dynamically reasonable.
  - Recent work by the PEACH program has added mooring data and repeated glider transects in this region and suggests that MAB waters are moving offshore at about 36-36.5N. -> on this point, the CNES-CLS18 seems better than the CNES-CLS2021β [J. Wilkin]

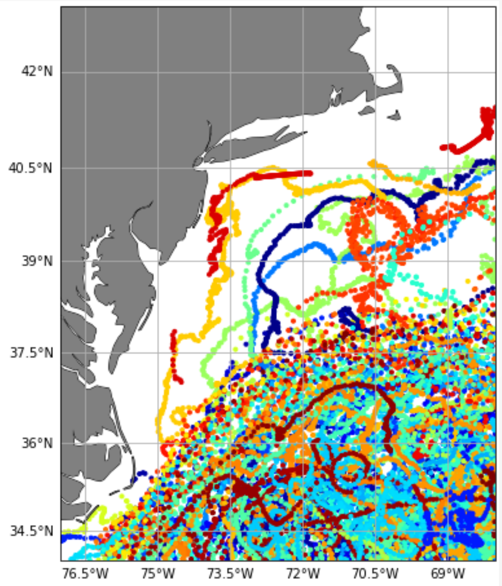
Levin, J., J. Wilkin, N. Fleming and J. Zavala-Garay, (2018), Mean circulation of the Mid-Atlantic Bight from a climatological data assimilative model, Ocean Modelling, 128, 1-14, doi:10.1016/j.ocemod.2018.05.003

Validation with independant drifters [2017-2019]





Drifters number	60	Measurement number	2094	
name	U rmsd [cm/s]	U corr	V rmsd [cm/s]	V corr
CNESCLS18	19.297	0.759	20.663	0.797
CNESCLS2021beta	19.413	0.755	20.913	0.792



nb drifter	120	nb points	16735	
name	U rmsd [cm/s]	U corr	V rmsd [cm/s]	V corr
CNESCLS18	21.629	0.886	21.509	0.827
CNESCLS2021beta	21.649	0.885	21.584	0.826

- No real differences between the new MDT and the global MDT compared to independent drifters
- Bias of this comparison: on the continental shelf we trust more the HF radars which give a mean current different from the drifters

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