Using HFR data to validate FES2014 tidal currents

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Introduction

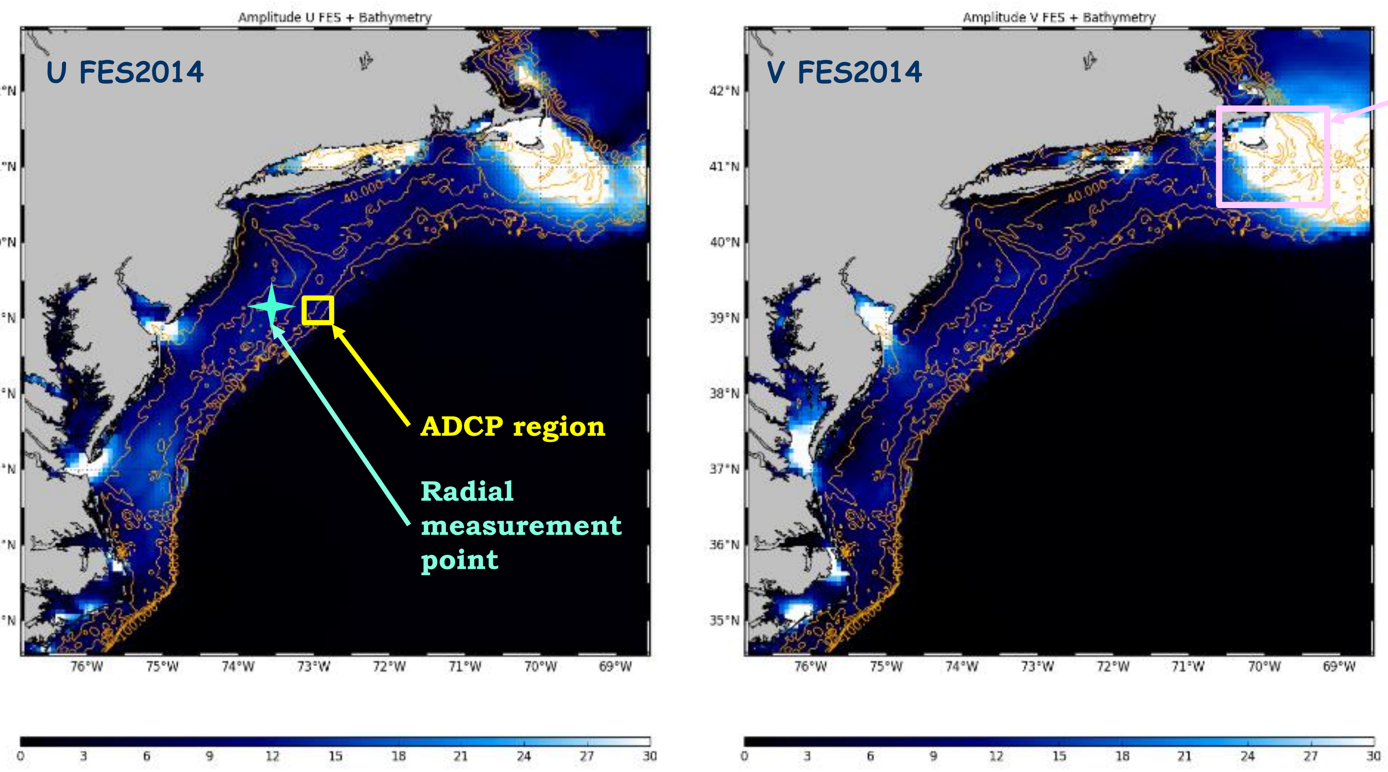
In order to access the targeted ocean signal, altimeter measurements are corrected for several geophysical parameters among which the ocean tide correction is one of the most critical. The accuracy of tidal models has been much improved during the last 20 years, and in this context, a new global tidal model FES2014, has been developed and finalized in 2016 (available on AVISO website : https://www.aviso.altimetry.fr/en/data/products/auxiliary-products/global-tide-fes.html.) FES2014 takes advantage of longer altimeter time series, improved modelling and data assimilation techniques, a corrected bathymetry field, a higher resolution mesh and a larger assimilation dataset. The model tidal elevations have been extensively validated using in situ and altimetric measurements, showing a great improvement in coastal and shallow water regions (Carrere et al. 2016,2017). A validation of tidal currents has been performed around Australia using some ADCP data (Cancet et al., 2017). In this study, we use HFR radar databases from MARACOOS and SCRIPPS networks to perform comparisons with FES2014 tidal currents on a wide area of the Eastern coast of the US. A comparison with another global ocean model TPXO8 and some in situ measurements is also proposed.

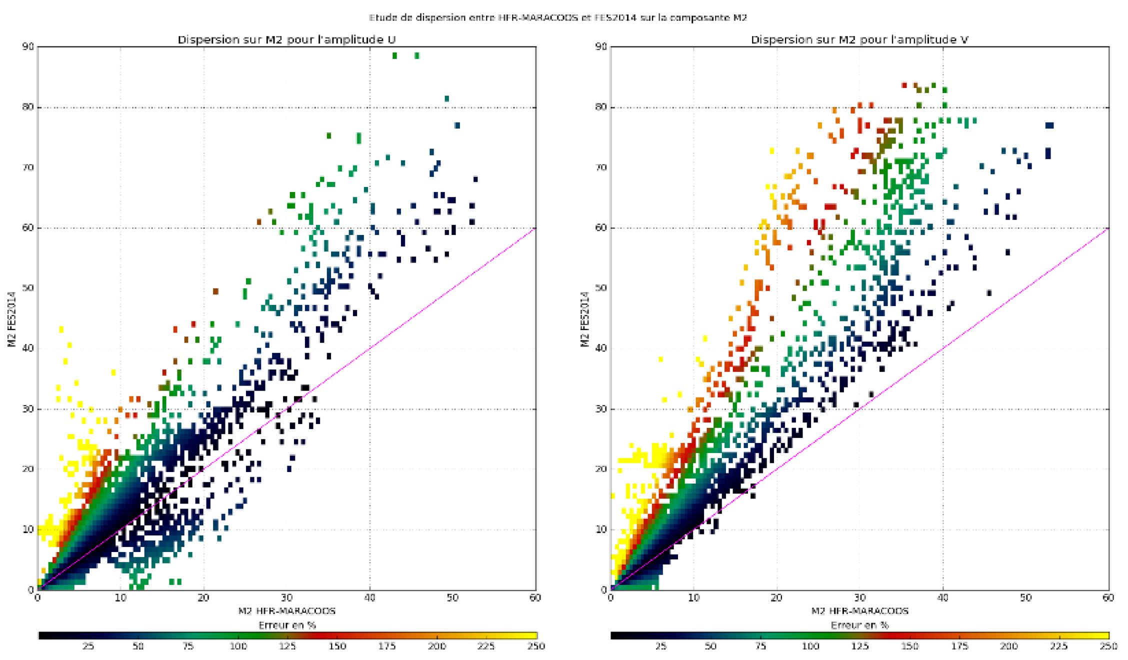
Processing the HFR data for tidal estimation

- **Data Selection:**
  - data selection depends of available period
    - **MARACOOS** : 8 years available -> if at least 1 year of hourly sampling, time series is kept
    - **SCRIPPS** : 6 years available -> if at least 1 year of hourly sampling, time series is kept
- **Harmonic analysis:** using Utide library in Python
- **Plotting ellipse:** using a CLS proprietary software - SiMi

M2 tidal currents amplitude

M2 currents amplitude from FES2014 are plotted in blue (cm/s) – orange curves give bathymetry contours: tidal currents are intensified at the entrance of the different bays of the area, in most part of the Long Island bay; very strong tidal currents are also visible south of Cape Cod and Nantucket island (~70-90 cm/s) and until farther from the coast on the shallow shelf region. Elsewhere on the shelf, tidal currents remain weaker (10-20 cm/s).

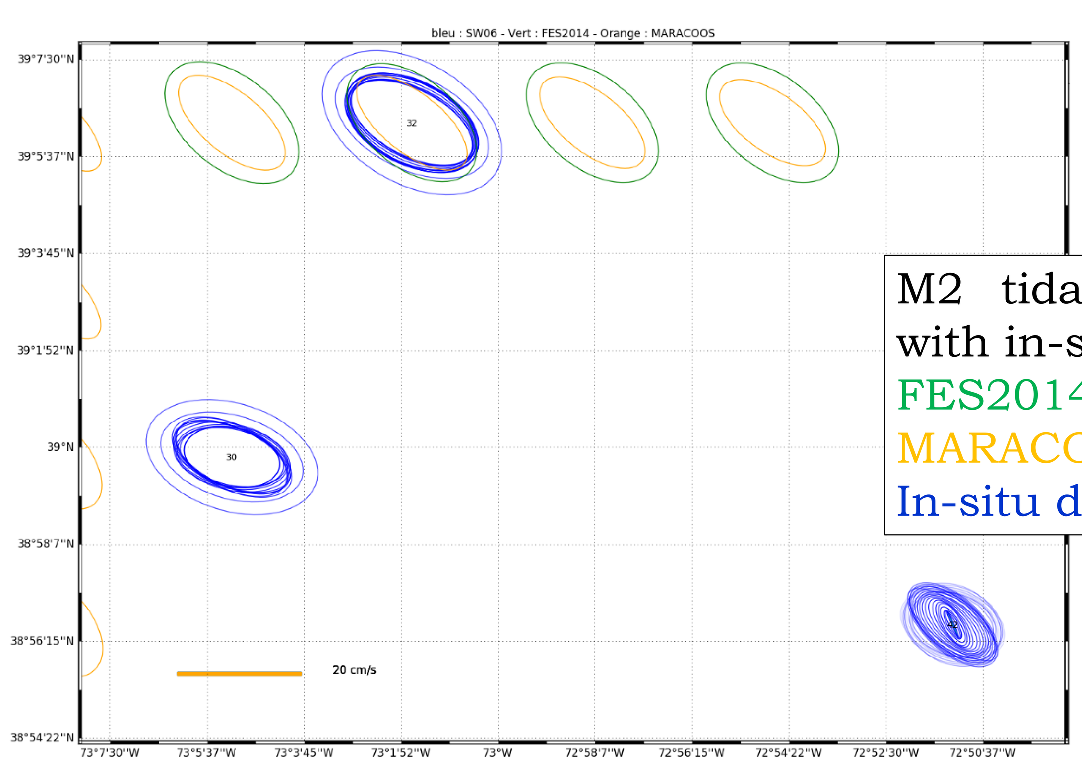




Dispersion diagram comparing M2 tidal current amplitudes from MARACOOS and FES2014: the distribution is better centered for U, but the model globally tends to overestimate the tidal currents on the studied area. Comparison with SCRIPPS gives similar results except a slightly better centered dispersion for V.

Comparison with ADCP

Some ADCP data are available in the region (cf yellow square on above M2 map; SW06 database provided by J. Wikin). ADCP and HFR ellipses show a good agreement in amplitude and direction for the M2 current; the rotation of the tidal current is weak on the water column on this region except for the most easterly point which is also the deepest one. Model still overestimates the M2 currents, but direction is fine.



M2 tidal ellipses comparison with in-situ ADCP:
FES2014(green)
MARACOOS (orange)
In-situ data (blue)

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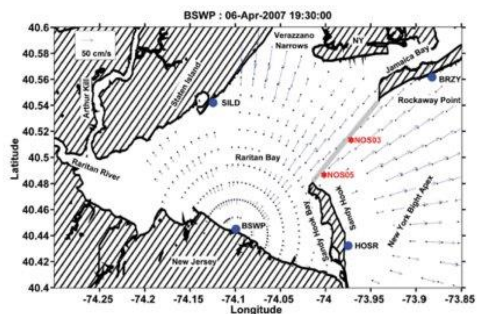
Description of HFR databases

HFRs give high-frequency measurement of the ocean surface current (2m depths) with one hour sampling; the instruments are mostly located in coastal areas and at least 2 radar sites are generally settled close one to each other. The institutions responsible for the radars process the rough datasets and provide two types of data :

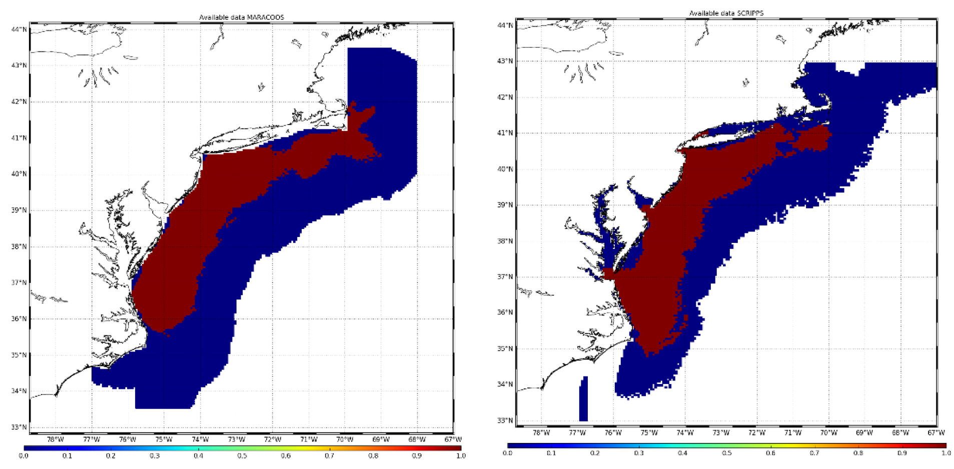
- **Radial database**: current's characteristics (speed and direction) are determined on the measurement radials on concentric circles around each radar site;



- **Total database** is available on a regular grid after optimal interpolation of the radials data; several OI process can be used (GOPALAKRISHNAN G & BLUMBERG A, 2011; LIU et al. 2014). The OI can affect the high-frequency tidal currents.

Two different datasets have been used in the present study: MARACOOS (Mid-Atlantic Regional Association Coastal Ocean Observing System) and SCRIPPS. A test at one radial point has also been performed.

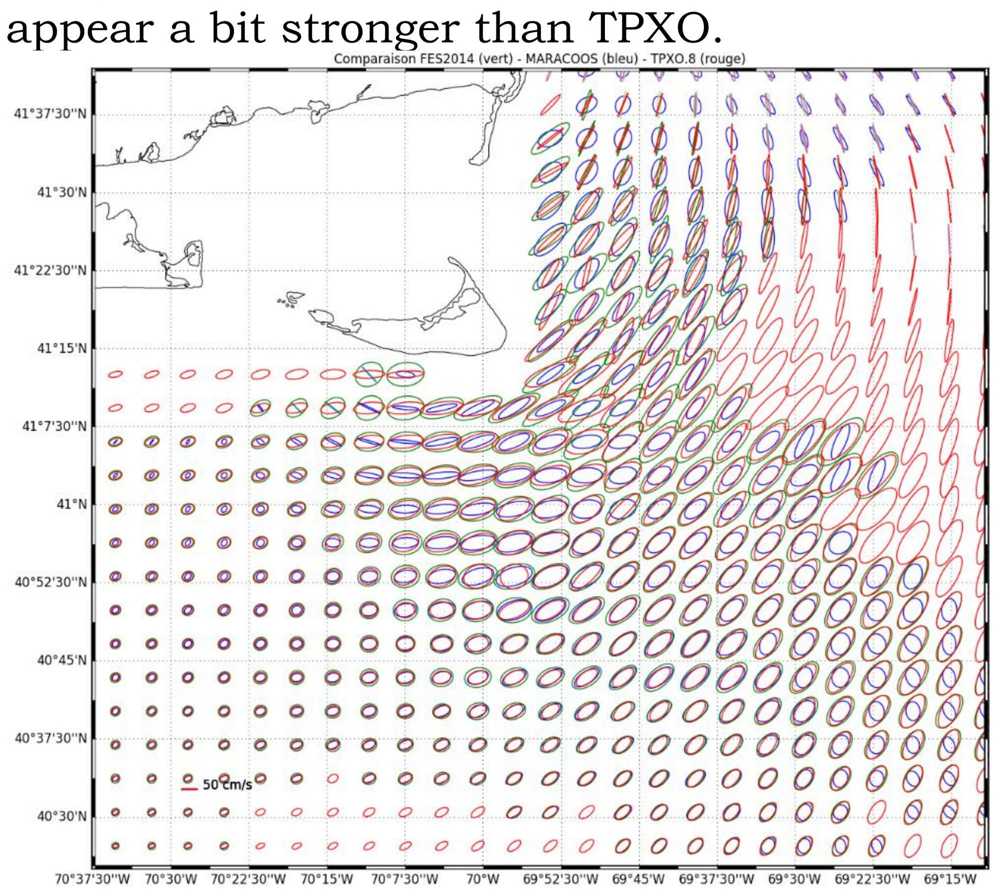
MARACOOS & SCRIPPS (USA)
Radar CODAR
Total data - 2 types of interpolation
Data selected for the analysis are plotted in red



M2 tidal currents ellipses

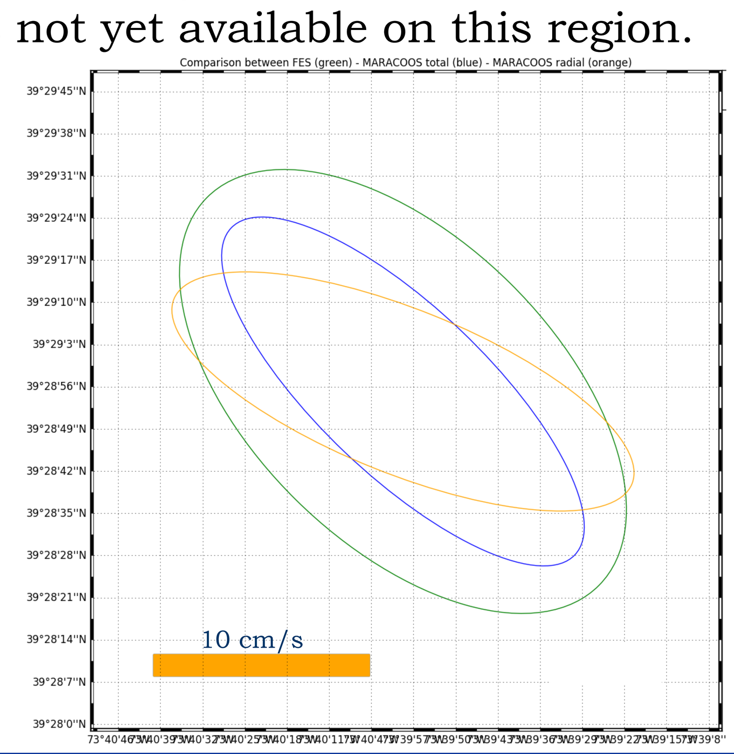
We compare M2 ellipses from FES2014, TPXO.8 and HFR MARACOOS data (zoom done on the pink square localized on M2 map on left). Close to the coast and in the northern part of the area, models and HFR are quite different, likely due to measurement errors (radials not perpendicular) and also model errors. South and east of the Nantucket island, models and data have consistent directions and amplitudes, although the models overestimate the currents by 10-30%. FES2014 amplitudes appear a bit stronger than TPXO.

M2 tidal ellipses:
FES2014(green)
TPXO.8(red)
MARACOOS (blue)



One point with perpendicular radial measurements is available on the area (cf green star on M2 amplitude map). It is used to estimate the error of the interpolation method on the region: amplitudes of radials and totals are nearly identical, but an error of ~20° in direction is found between both estimations. FES2014 current is closer to the total data in this case, but this is an area with small tidal currents. An analysis on a stronger tidal current area would be valuable, but a wider radial database is not yet available on this region.

M2 tidal ellipses on a single radial point:
FES2014 (green)
Radial (orange)
MARACOOS Totals (blue)



Conclusion and perspectives

• This analysis shows the interest of using HFR database for estimating tidal currents and to validate tidal models: although being local measurements depending on local institutions, HFR deployements cover wider coastal/shallow water regions compared to ADCPs.
•Comparison with FES2014 and TPXO8 models shows a good agreement with HFR, but also an overestimation of the currents by the models on the studied area.
• Comparison of the total database with a radial direct measurement shows uncertainty on the tidal current direction's estimation between both databases; more tests are being performed on a another region of interest where both databases are available (Iroise Sea, in collaboration with LEGOS).