Coastal altimetry: impact of geophysical corrections near the coast

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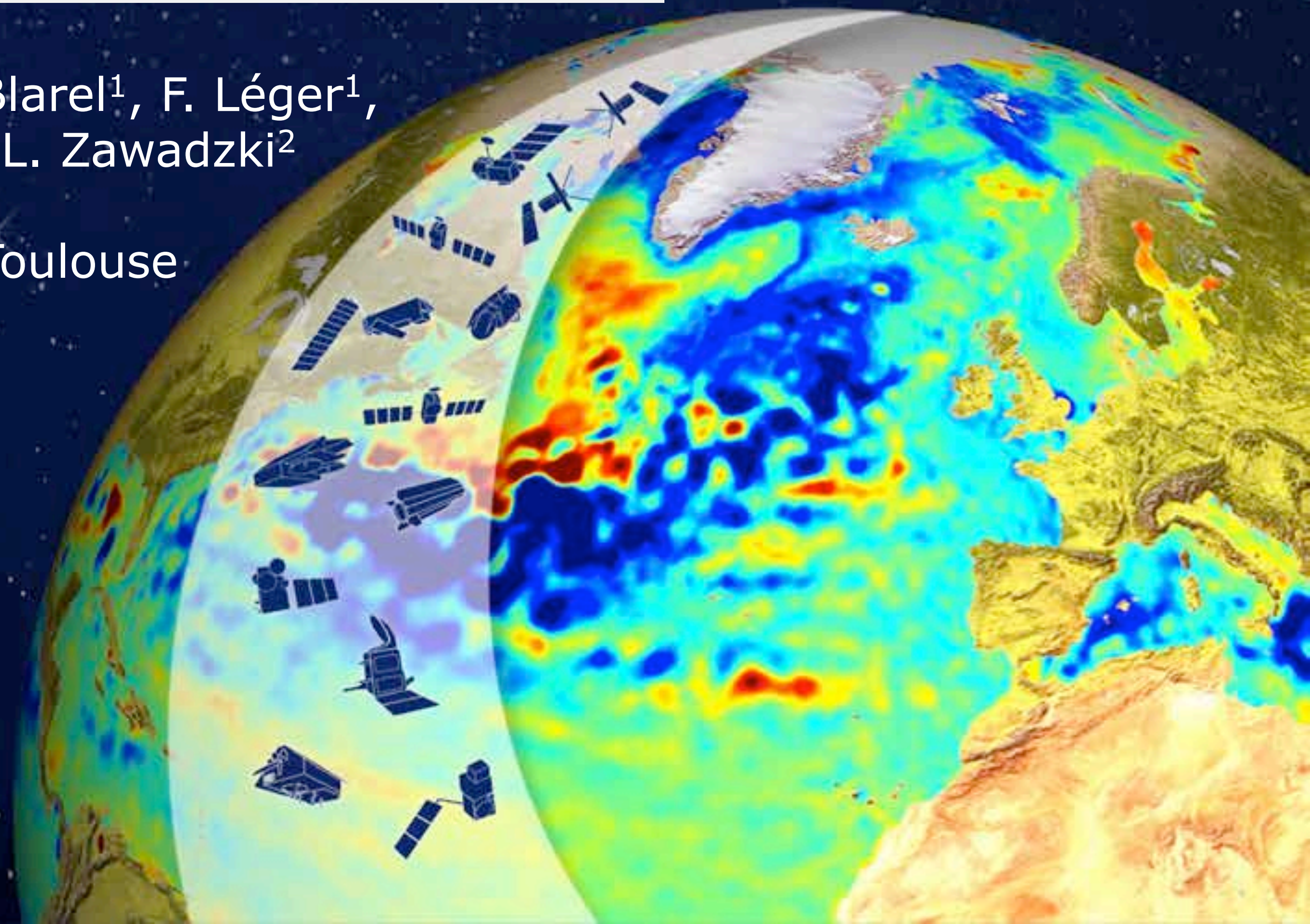
LEGOS/CTOH & CLS, Toulouse



Objective

Evaluate the accuracy of the different altimetry corrections when approaching the coast & the impact of their errors.

- if important variability: is it SLA or a correction ?
- which correction deserves our attention ?

Outline

- Problem definition
- Methodology
- Results
- Summary and perspectives

Problem definition

$$\mathrm{SSH} = \mathrm{Altitude} - \mathrm{Range} - \sum_i \mathrm{Corr}_i$$

where $\mathrm{Corr}_i = \{ h_{iono}, h_{dry}, h_{wet}, h_{EM}, h_{otide}, h_{stide}, h_{oload}, h_{ptide}, h_{baro} \}$

h_{iono} : ionospheric correction

h_{dry} : dry tropospheric correction

h_{wet} : wet tropospheric correction

Environmental corrections

h_{EM} : EM-bias or SSB correction

Sea state corrections

h_{otide} : ocean tide correction

h_{side} : solid Earth tide correction

h_{oload} : ocean loading correction

h_{ptide} : pole tide correction

h_{baro} : inverted barometer correction

Geophysical corrections

- **The SSH accuracy also strongly depends on the correction quality**

Problem definition

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h_{iono} : ionospheric correction

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h_{baro} : inverted barometer correction

Geophysical corrections

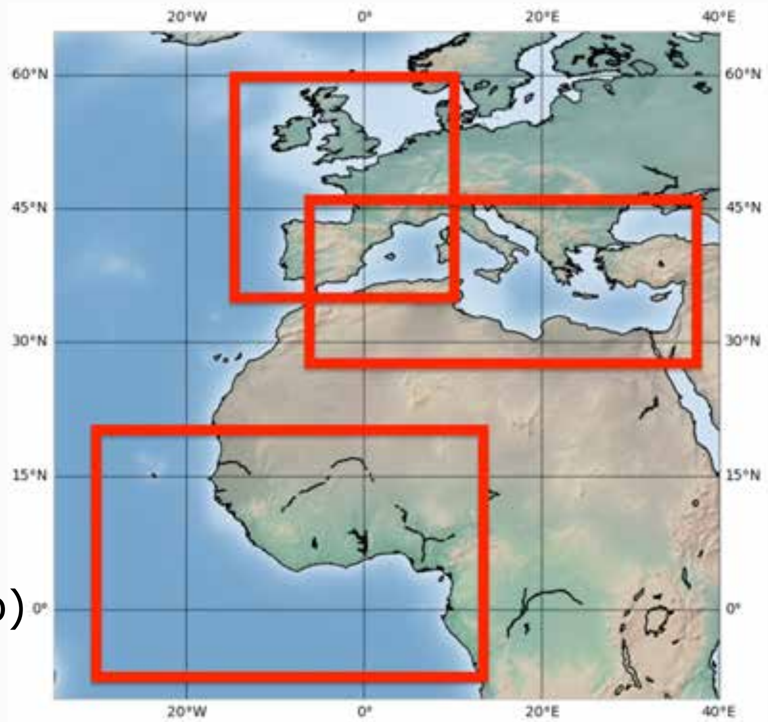
➢ **Some corrections are more difficult to compute in the coastal areas and may lead to stronger SSH errors (see also Andersen and Sharroo., 2011)**

Objective & methodology

What is the impact of the errors associated to geophysical corrections on SL variations observed in the coastal ocean ?

Mission: Jason 2 GDR-D from cycle 1 to cycle 296 (July 2008 - July 2016)

- **Corrections analyzed**:
  - Wet tropospheric correction: radiometer, model and GPD+ considered
  - Dry tropospheric correction (ECMWF ERA)
  - SSB (GDR-D)
  - Ionospheric correction: alt, GIM model
- **Study areas:**
  - Mediterranean Sea (microtidal)
  - North East Atlantic
  - West Africa
- **Data:**
  - tide: FES14 from RADS
  - dry: ecmwf_era solution from RADS
  - GPD+: data from Aviso+/CTOH (U. Porto)
  - all others: Jason-2 GDR-D



Uncertainties: ensemble-like approach

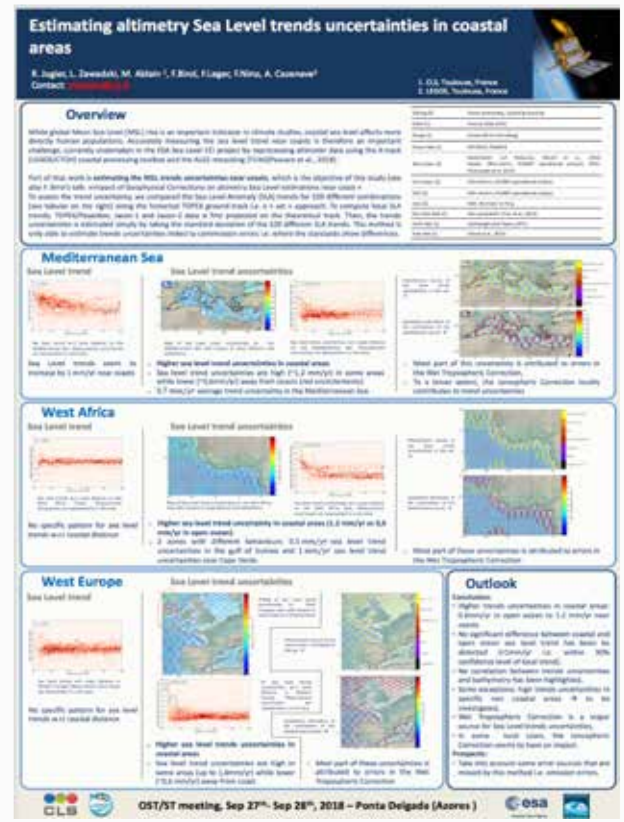
Ensemble-like approach

One approach to quantify uncertainties is taking into account the population of all possible SLA calculations. For each version *j*:

$$\mathrm{SLA} = \mathrm{Altitude} - \mathrm{Range} - \sum_i \mathrm{Corr}_i - \mathrm{MSS}$$

Example: for *wet_tropo:*

$SLA^{(1)}$ with *wet_tropo_rad*
$SLA^{(2)}$ with *wet_tropo_model*
$SLA^{(3)}$ with *wet_tropo_gpd*



This approach is explored in the poster by Jugier et al. (ERR_003)

Variability as proxy for errors

How do we evaluate an error if there is no reference value ?

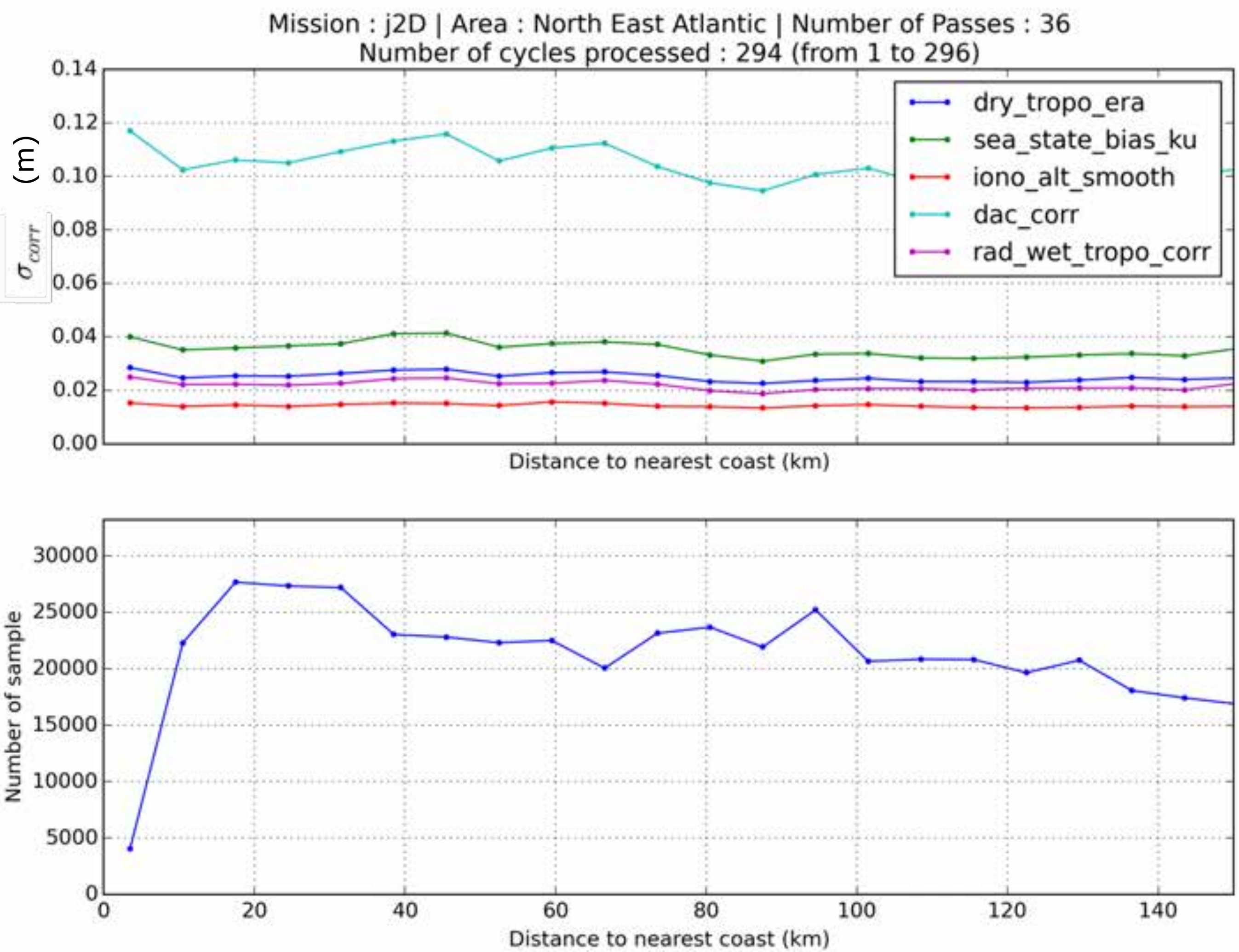
Frequently, the *sd* is used as a ***proxy*** for error. We assume changes are slow, and that most of the value jitter is the consequence of measurement errors.

In coastal zones, we believe this is NOT necessarily the case and the observed variability can be the consequence of real coastal dynamics.

What is the ***relative*** importance of a correction with respect to the SLA ?

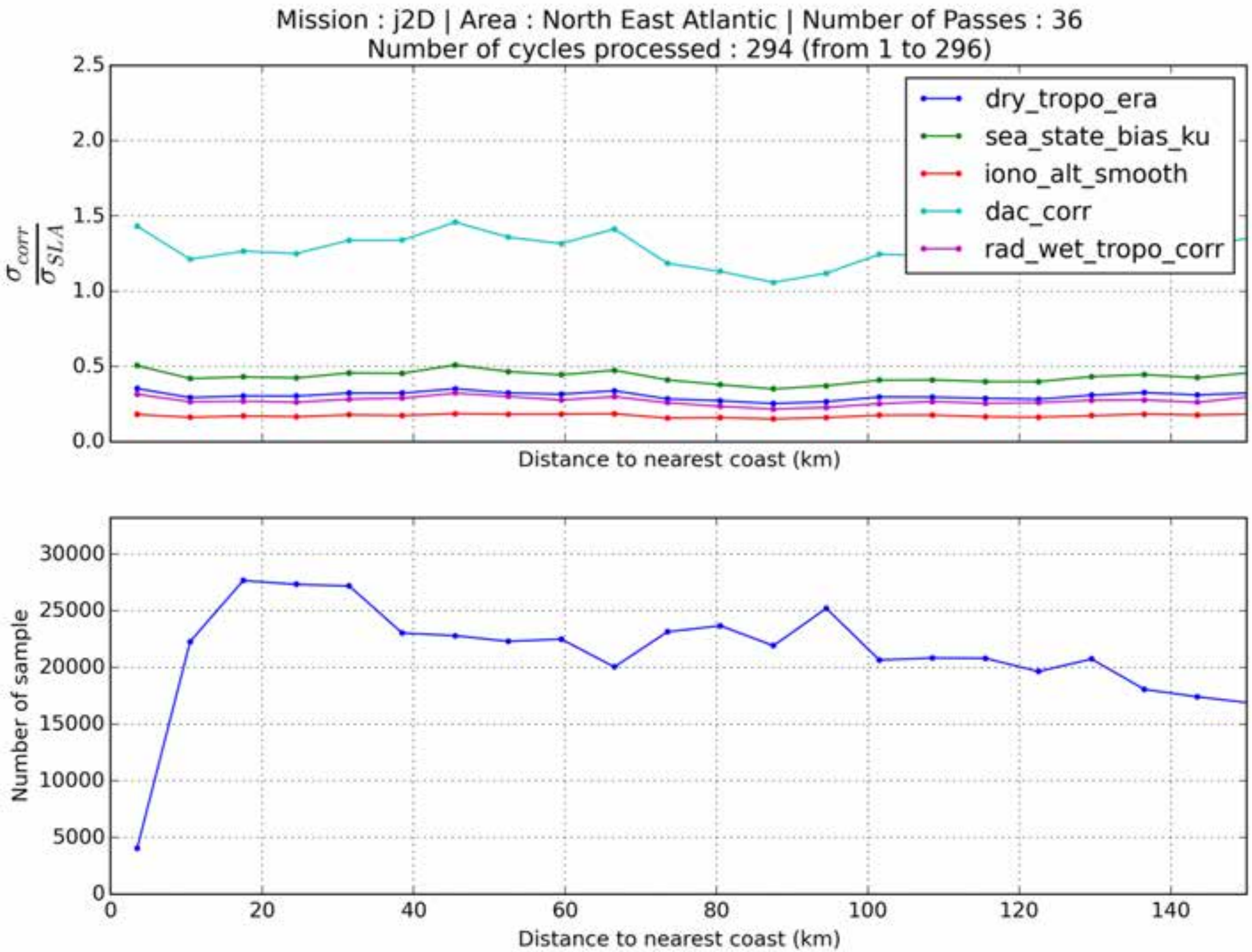
And with respect to other corrections ?

Variability(sd) ~ distance to coast



Equivalent
in all 3 zones

Relative Variability[sd/sd(SLA)] ~ dist2coast



Equivalent
in all 3 zones

Relative importance of corrections

Of the corrections we have studied, the main variability of SLA in the 3 regions is the consequence of

- **SSB** correction: GDR
- **Wet** troposphere correction:
  - radiometer
  - model
  - GPD (U. Porto)
- **Dry** troposphere correction: ERA ECMWF
- **Iono**spheric correction:
  - alt (dual frequency)
  - gim

Parameters that remained fixed throughout: tide (FES14), range (MLE4), pole_tide, earth_tide, altitude, mss (CLS15)

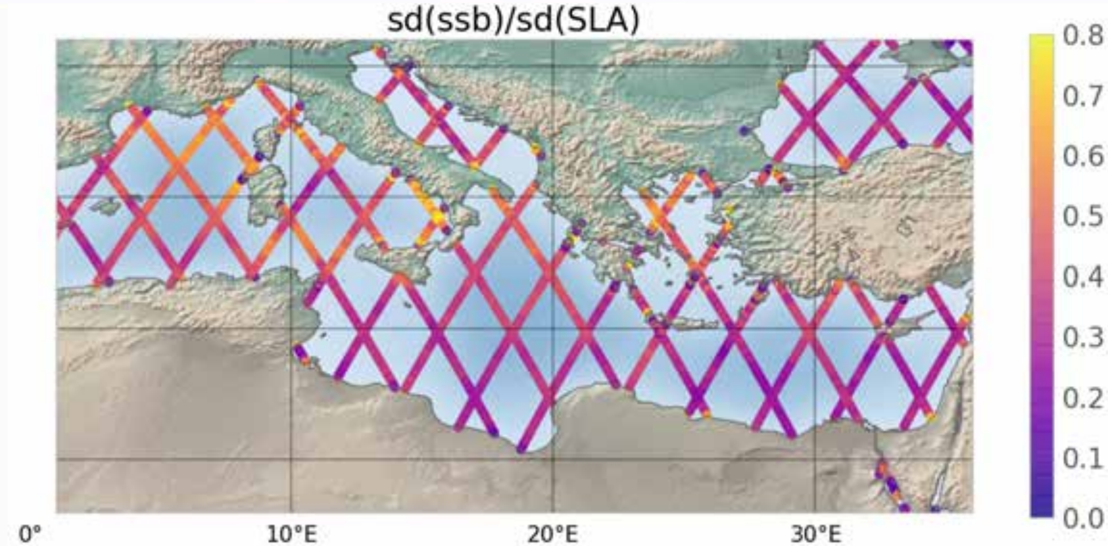
SSB relative variability

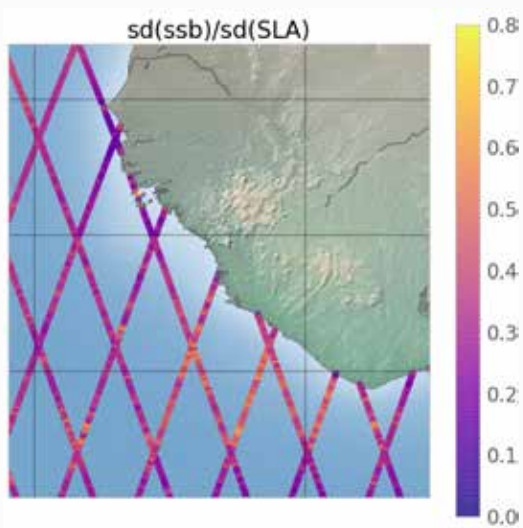
Med: high variability near the coasts

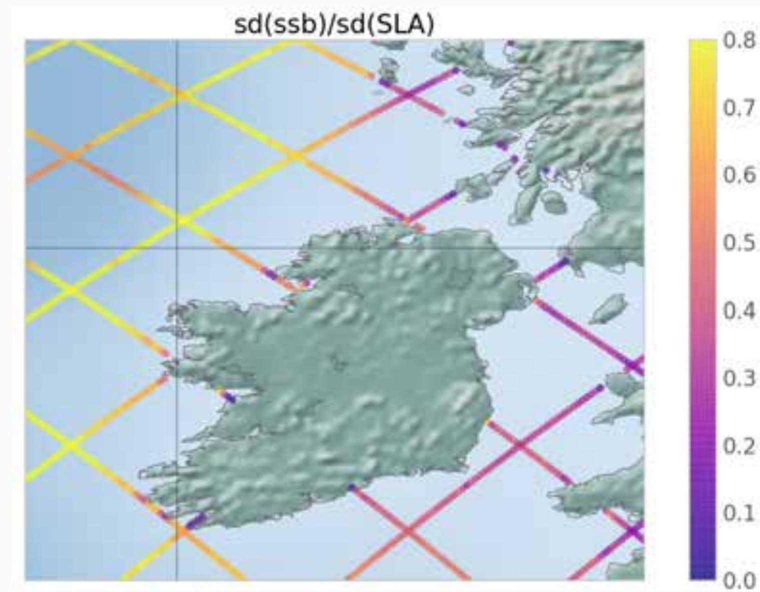
Waf: significant in coastal areas

NEA: significant impact in some coasts.

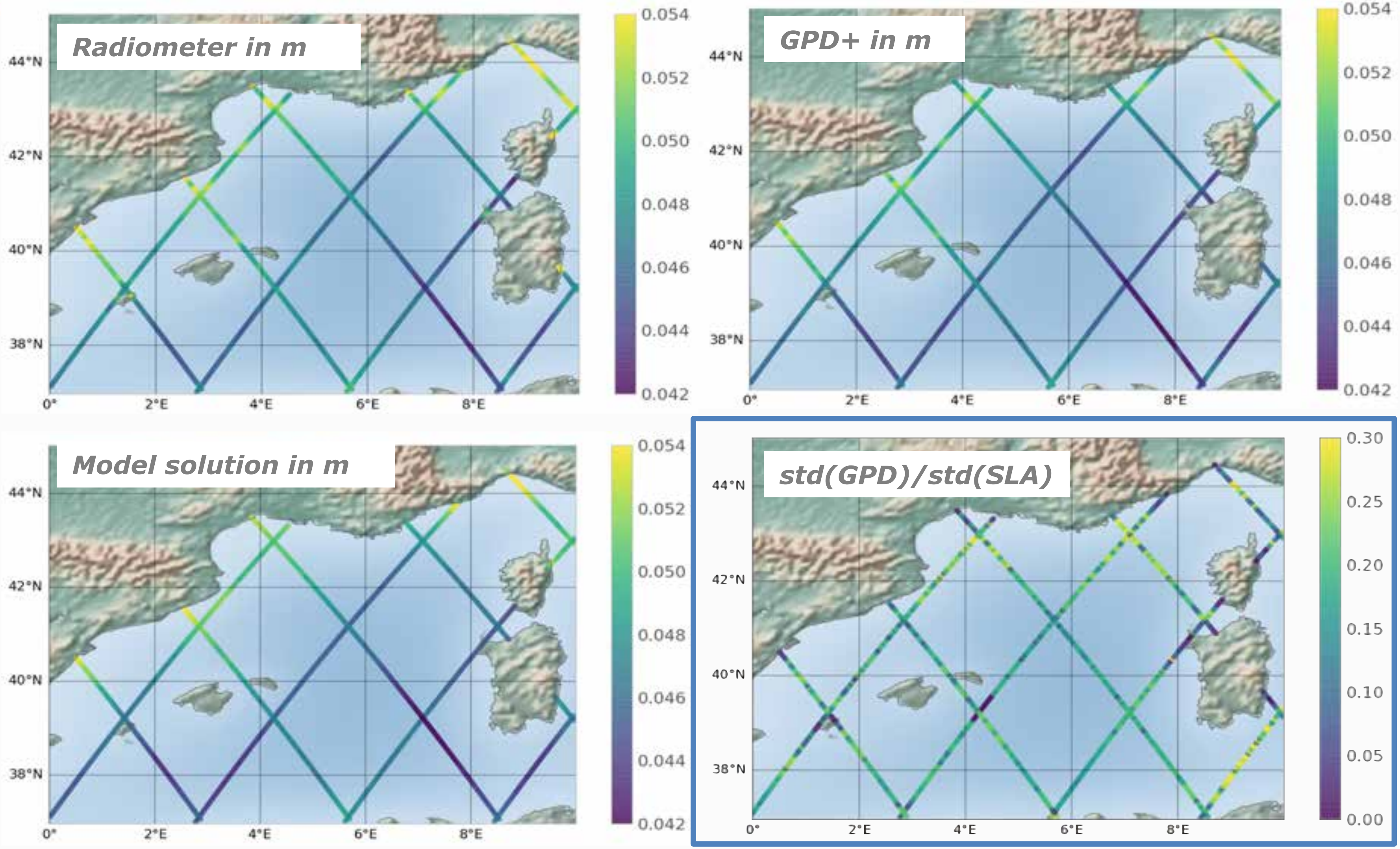
Local errors have impact on SLA computation







WTC – rad vs model vs gpd (J2 cycles 1-296)



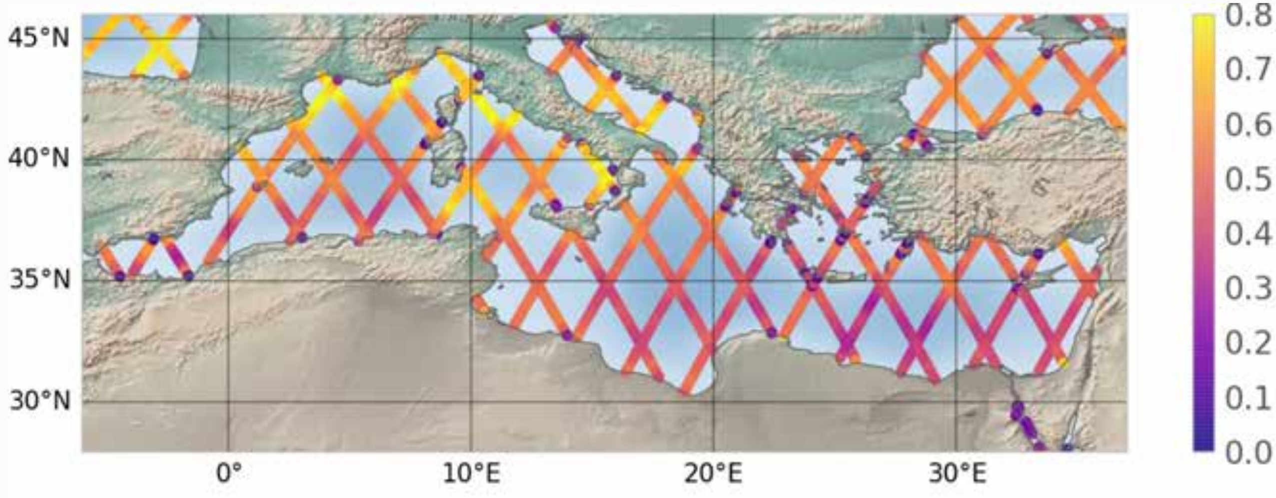
GPD+ is more stable and has locally a lower rms than radiometer by 5-10 mm

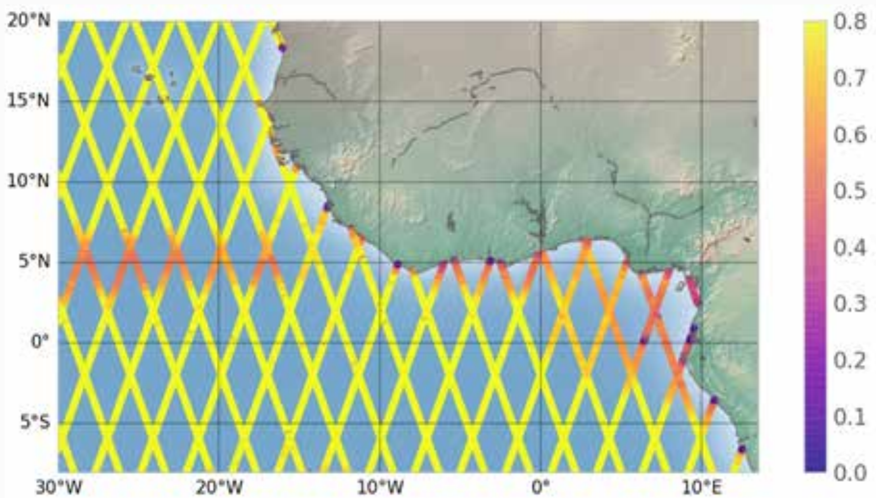
WTC – Relative variability, all zones (GPD)

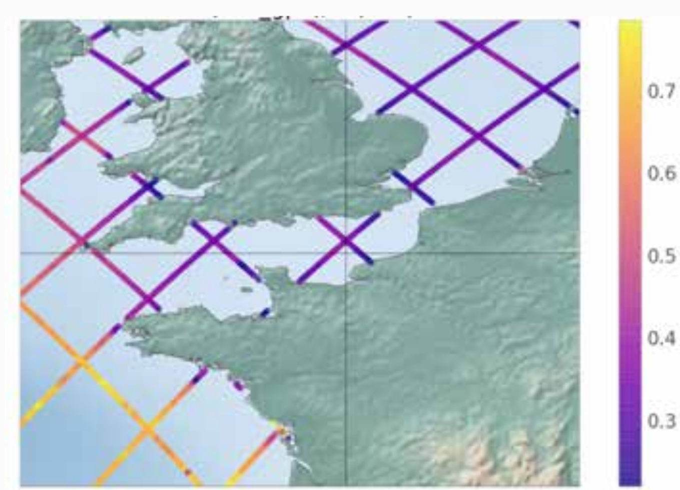
Med: high variability near the coasts

Waf: high variability tropical zone, *less* near coasts

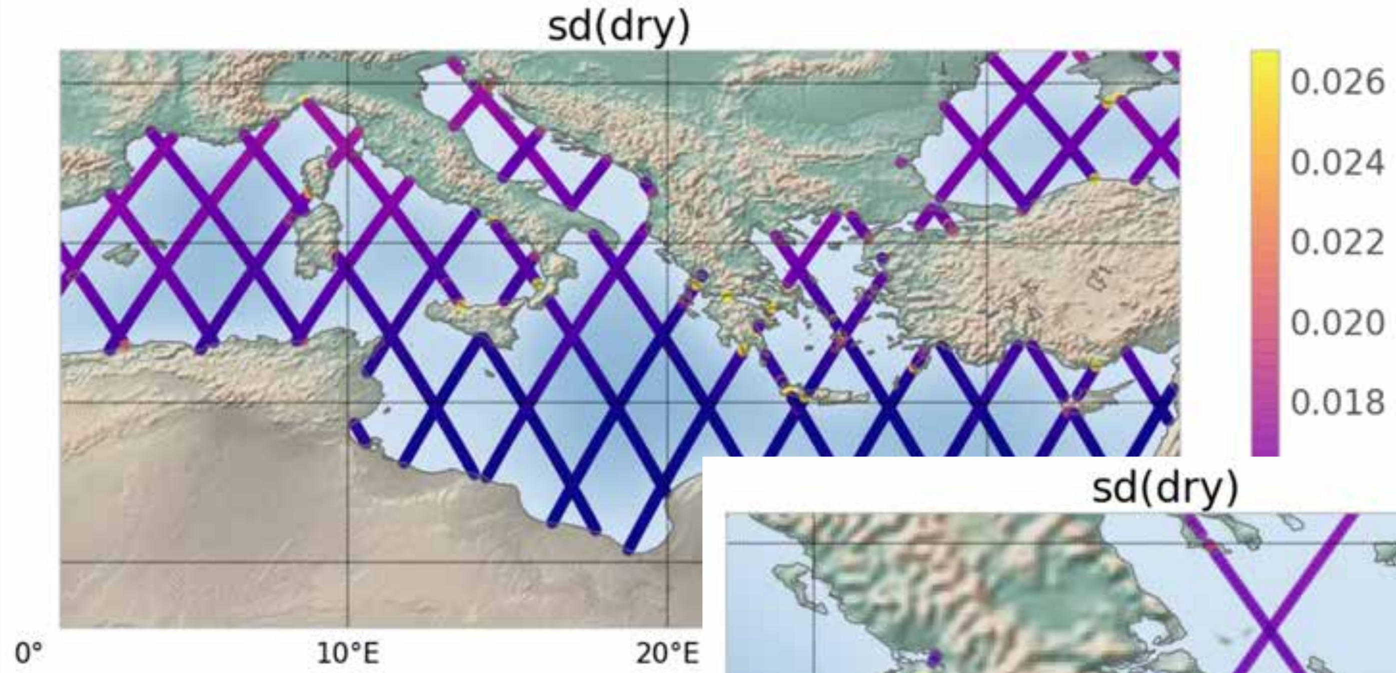
NEA: less impact near coasts.







DTC – variability

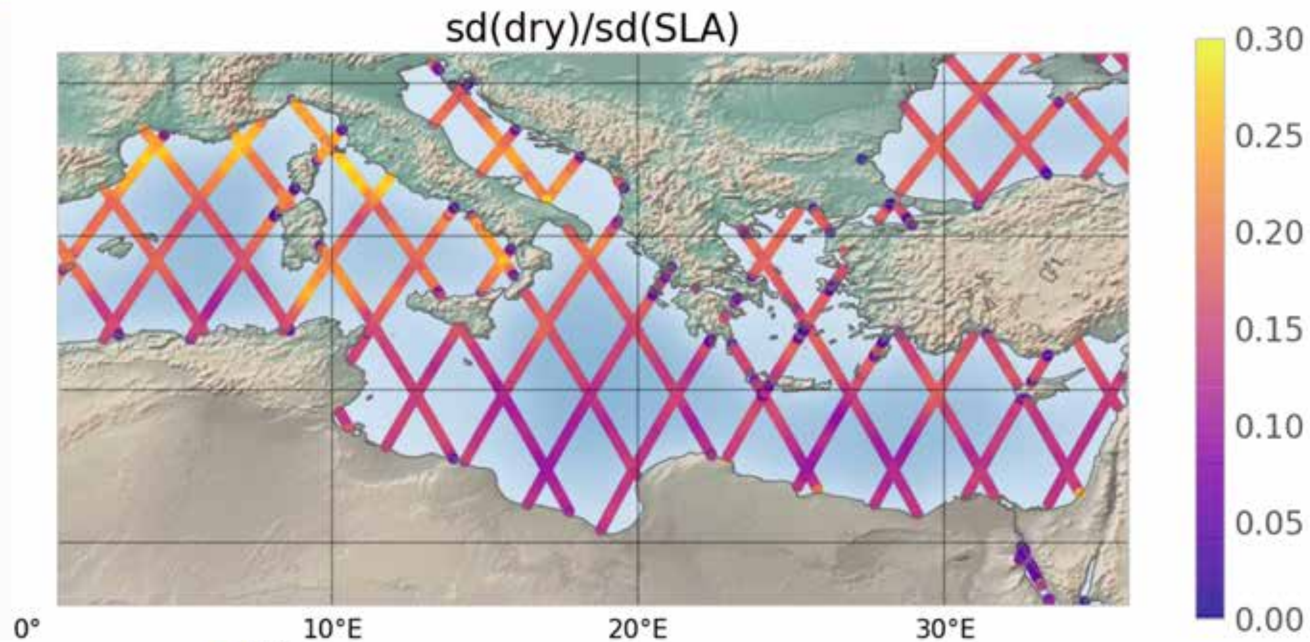


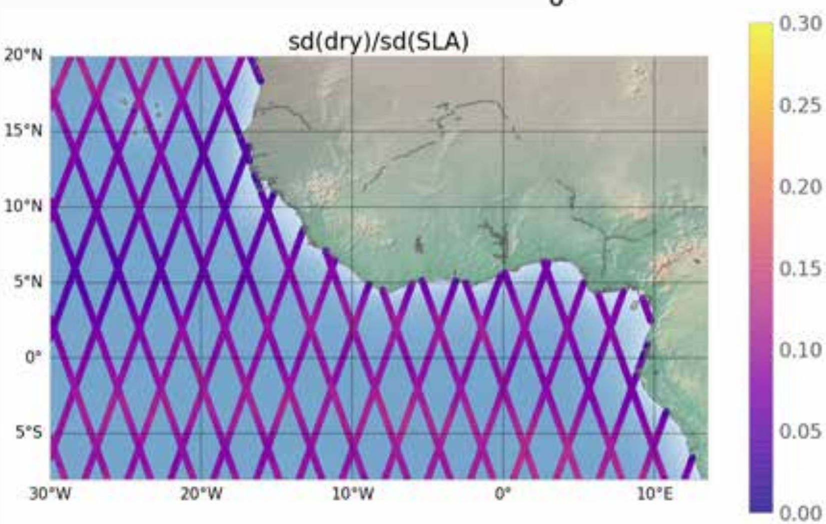
Med: problems near coasts: wrong sea surface level most probably.

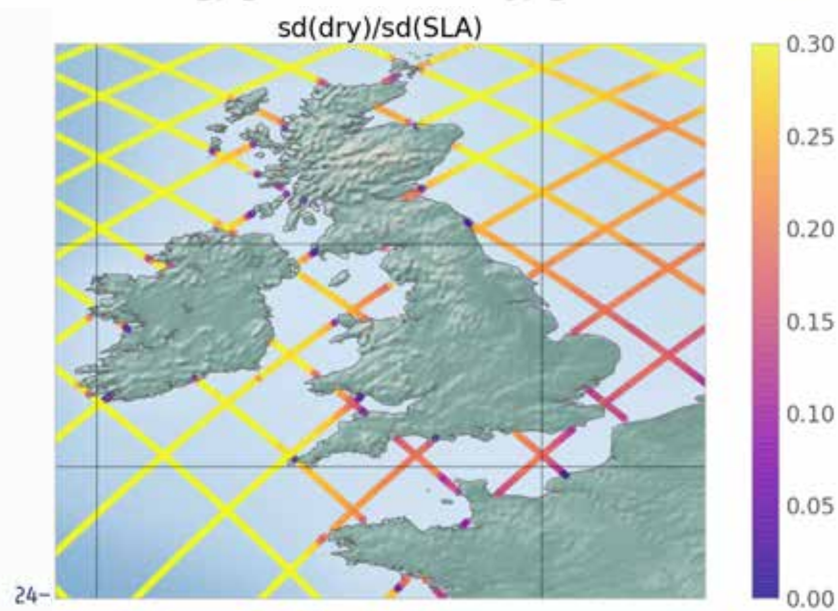
Med: problems near coasts: wrong sea surface pressure most probably.

NEA: same

WAF: low incidence in tropical zone







DTC – relative variability

Med: problems near coasts: wrong sea surface pressure most probably.

NEA: same

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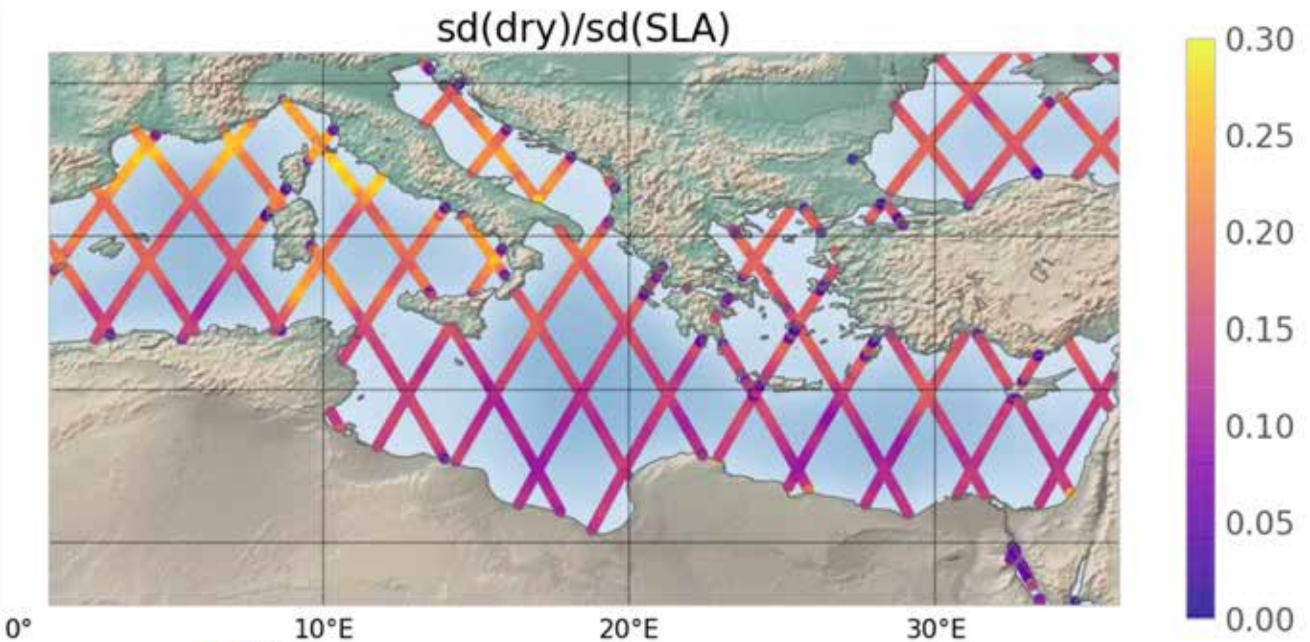
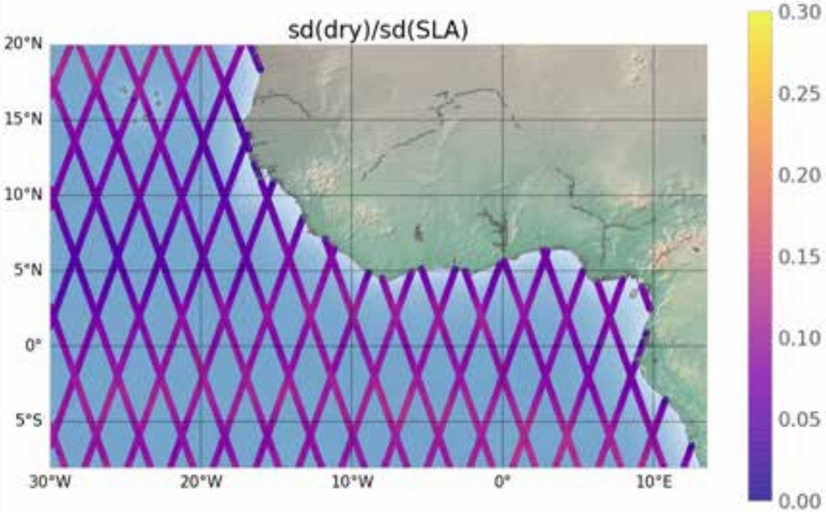
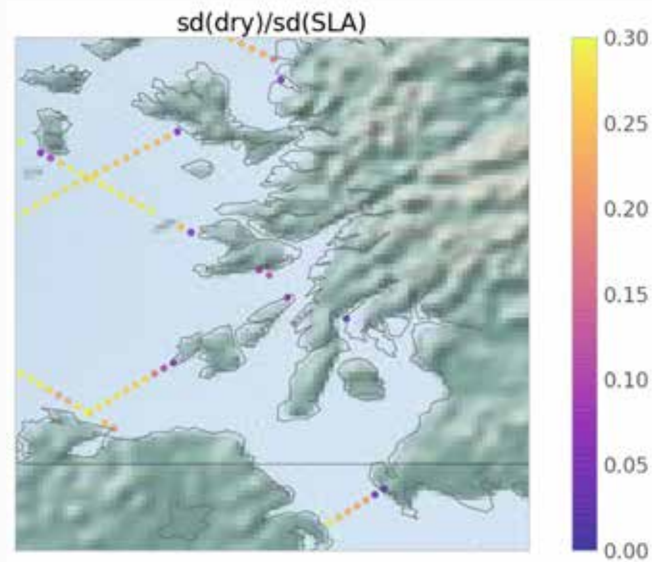
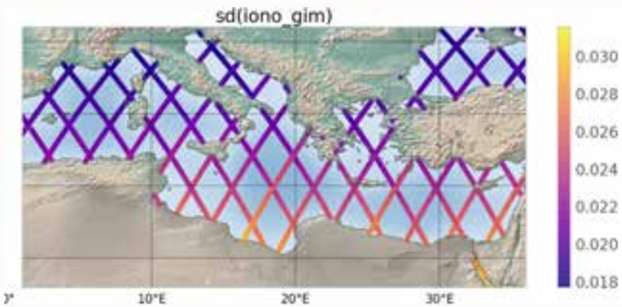
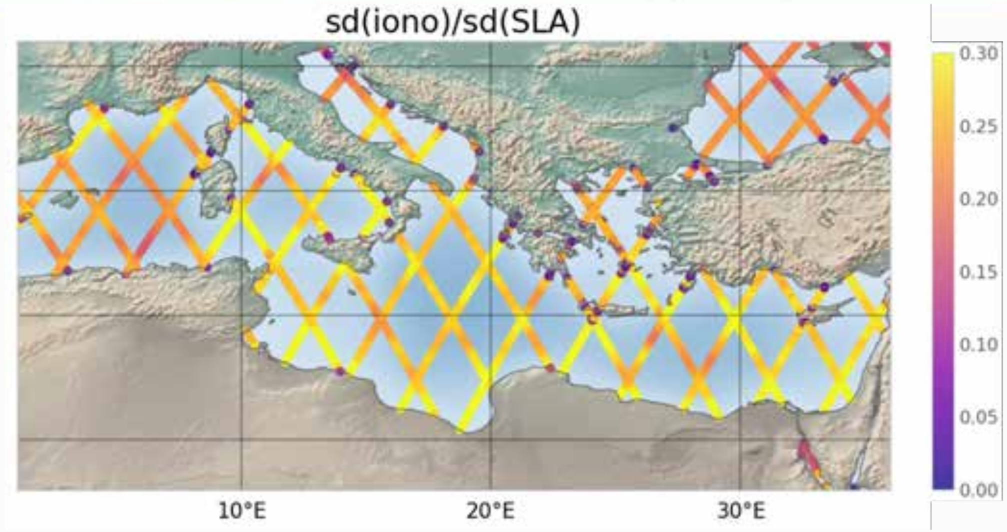




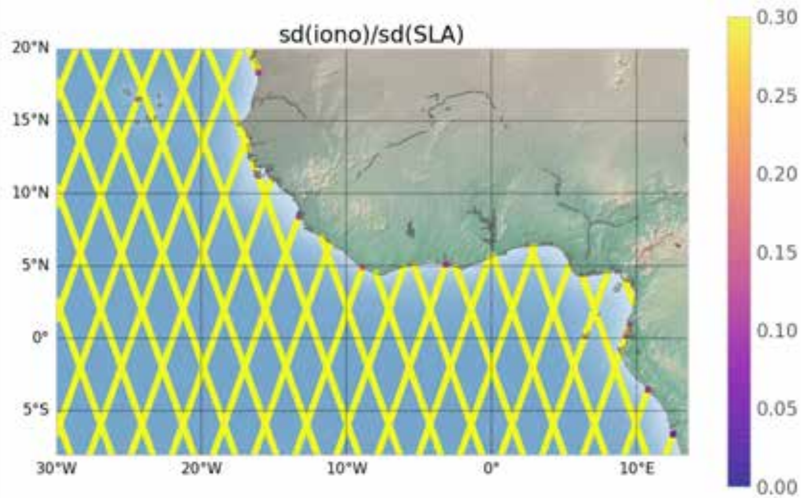


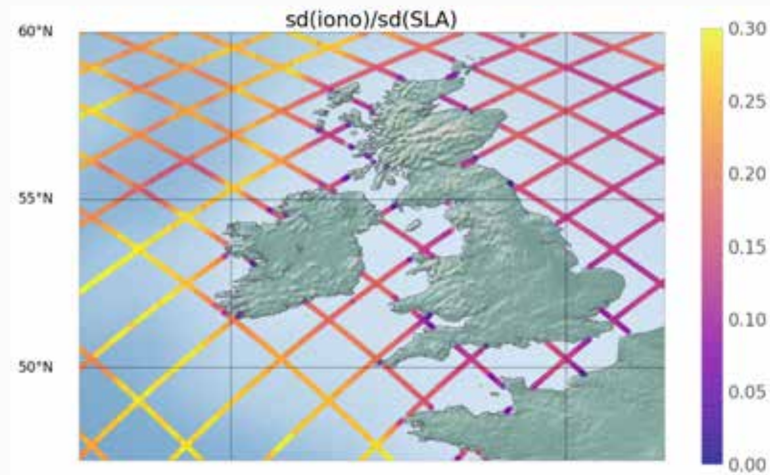
Ionospheric Correction (GIM) – relative variability



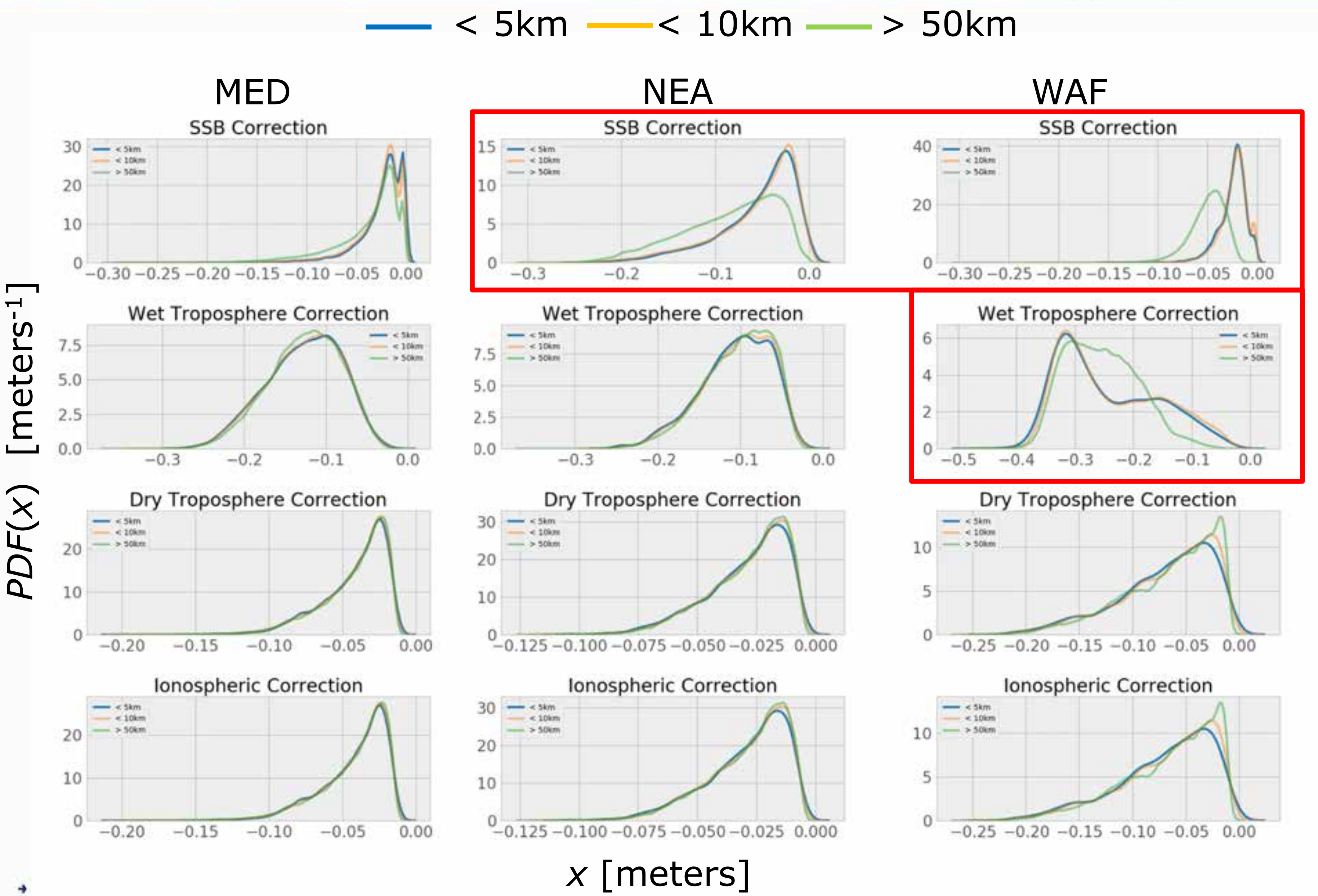


Compared to GIM the dual frequency solution induces ~2 cm more rms on coastal sea level variations (residual outliers): impact on computations





PDF and Distance to the coast



Summary

Radiometer wet tropospheric correction : significant errors and impact on coastal SL estimations

- Between 0.5 and ~1 cm rms more on coastal sea level variations compared to GPD+ (may have significant impact on coastal current computation)

→ GPD+ seems to be a good solution for coastal applications

SSB: significant errors, locally

- Local errors may lead to larger coastal sea level variations (significant impact on coastal current computation)
- Significant fraction of SLA variability, and locally near the coast

Dual frequency ionospheric correction: must be smoothed before used (Loess cutoff @180 km)

- ~2 rms more on coastal sea level variations compared to GIM

→ GIM seems to be a good solution for coastal applications in the absence of a good editing strategy

Tidal/DAC correction:

- No significant impact in the mediterranean microtidal area. But very important in NEA. DAC correction is very significant also.

Dry topospheric correction:

- Usually low, but locally can have surprising behaviour (surface pressure ≠ SLP): persistent low variability may indicate systematic error.

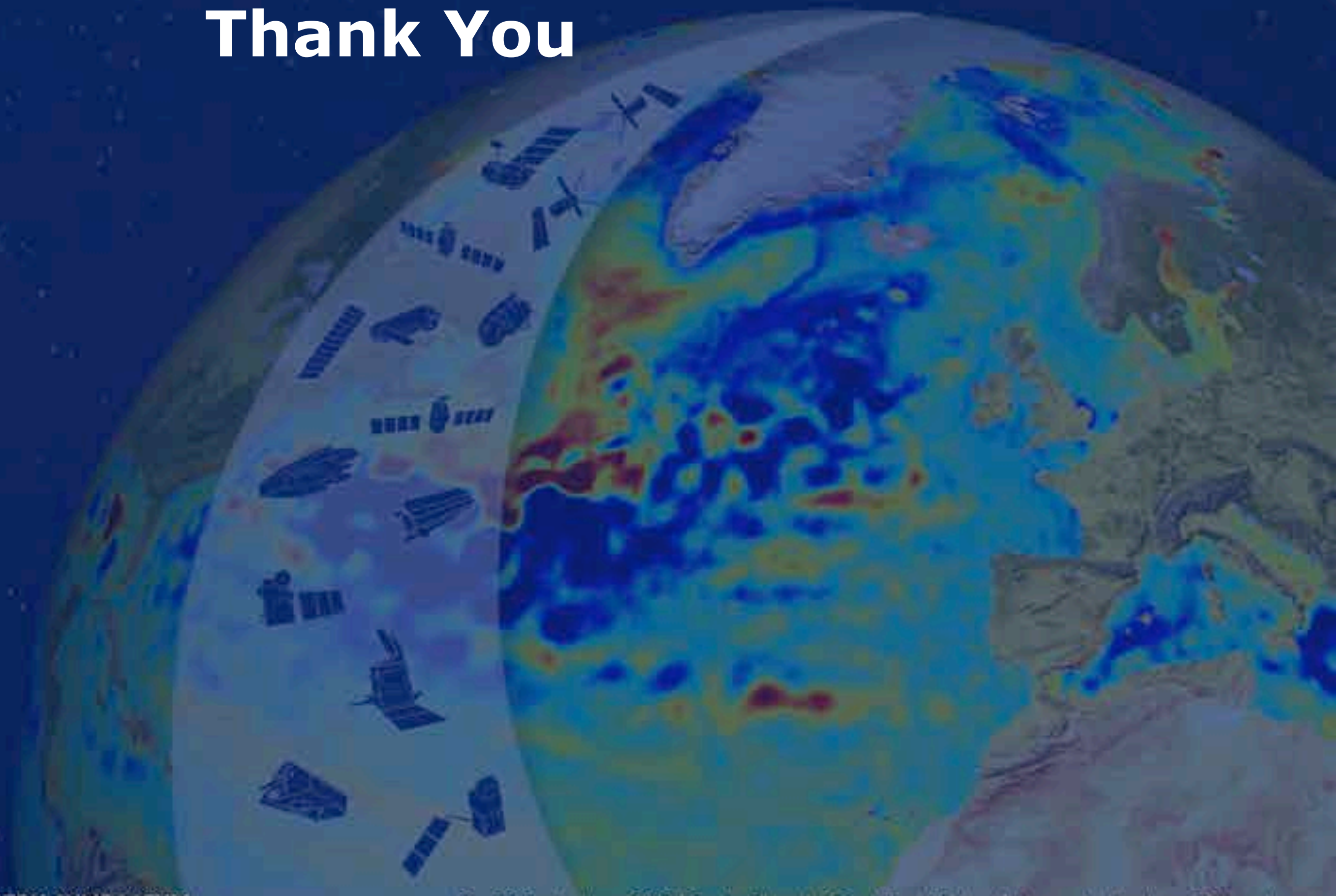
Conclusions and perspectives

- The study areas are particular examples and results may vary in other zones.
- SSB is one of the most critical corrections as a function of the coastal area considered and more research efforts are needed.
- Systematic errors in dry tropospheric correction seem to exist, and low variability in a point is an indication that it is the case.

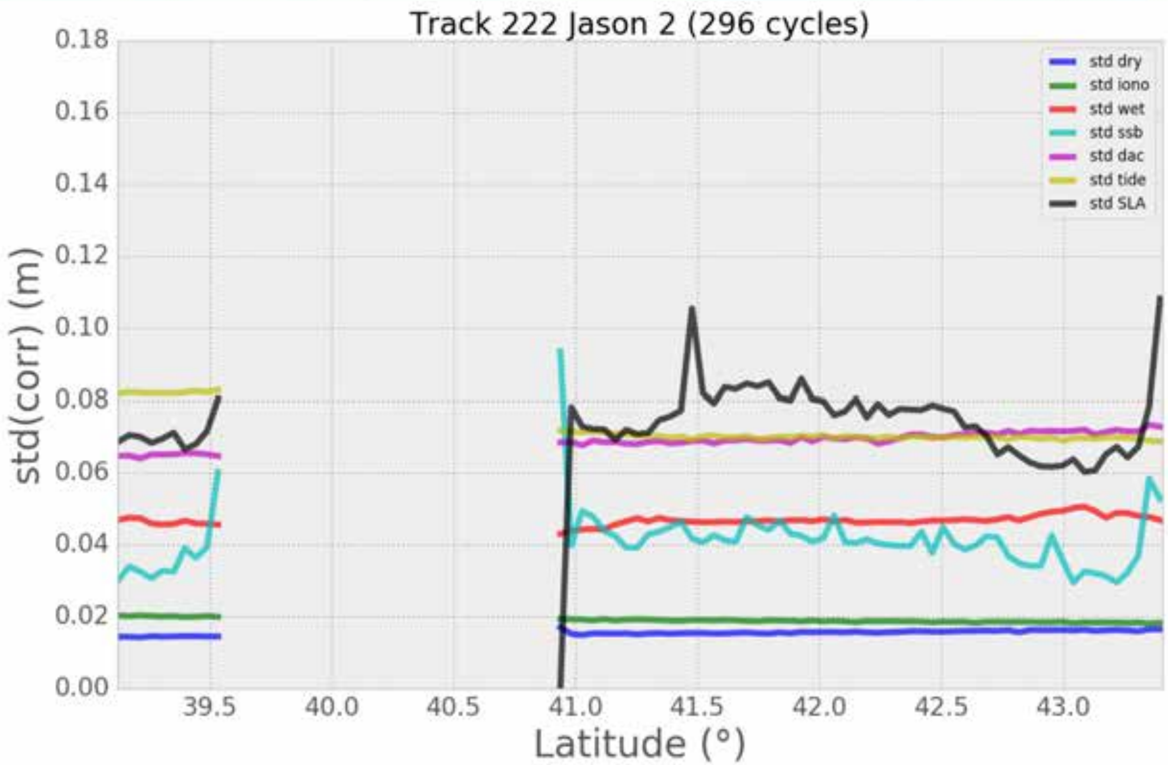
We should continue to:

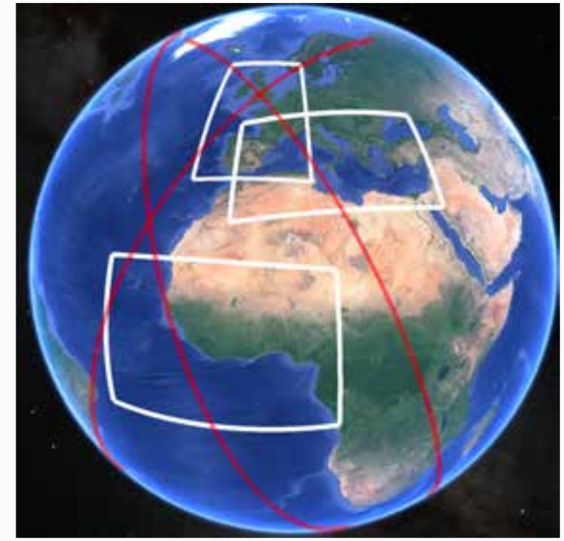
- Investigate & understand the origin of the coastal errors/bias/variations associated to the different corrections and their effects on trends. Work is underway to reach this goal.
- Evaluate/quantify the coastal error budget associated to each geophysical correction (not only on SL estimations but as a function of the application if possible…)

Thank You

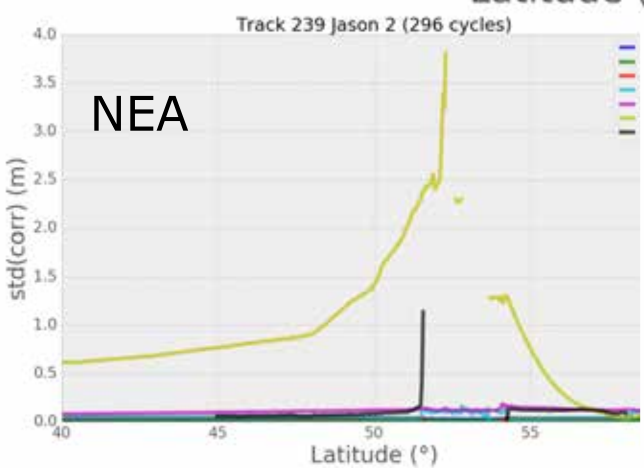


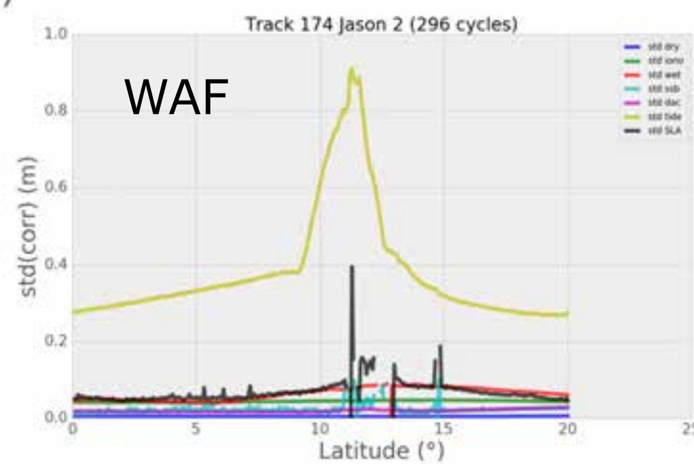
Stdev of corrections, along-track





dry: ecwmf_era
iono: gim
wet: gpd
ssb: mle4
dac: mog2d
tide: fes14





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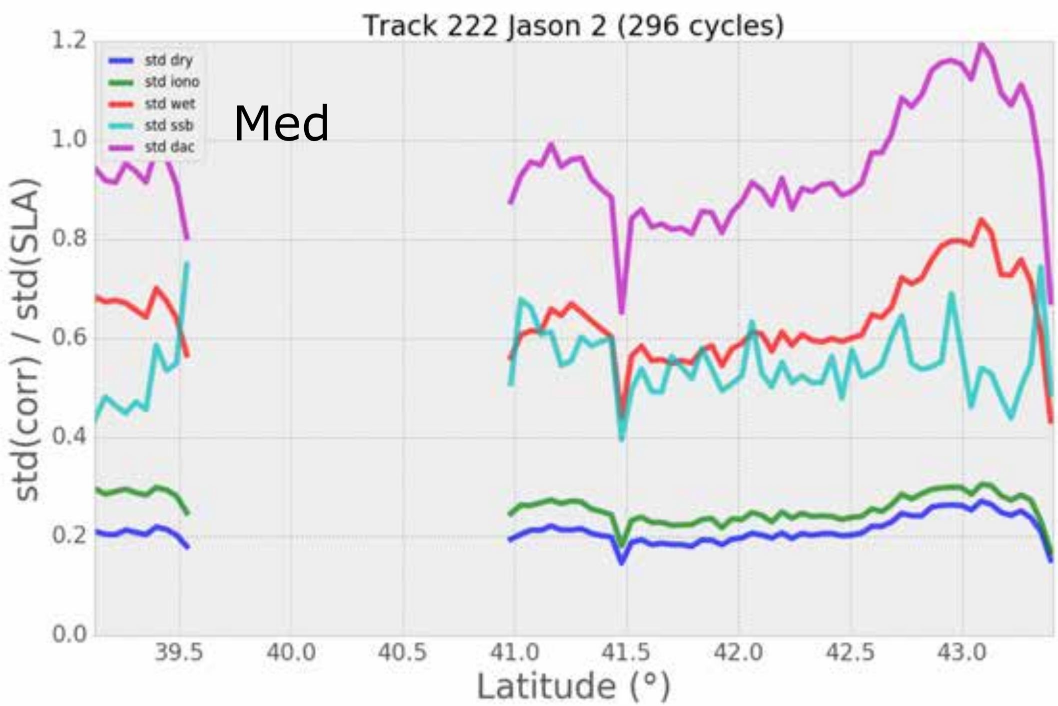
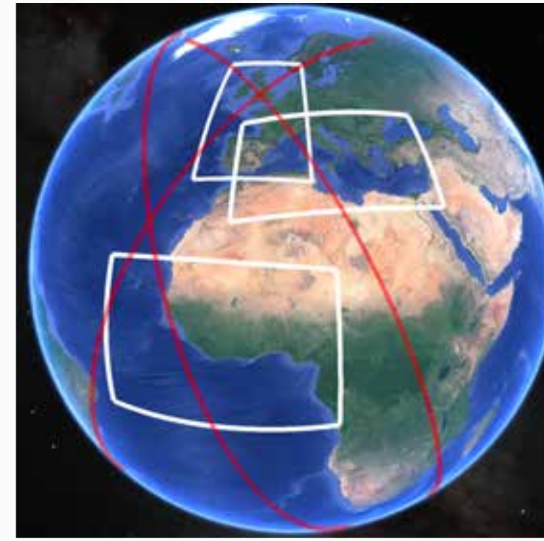
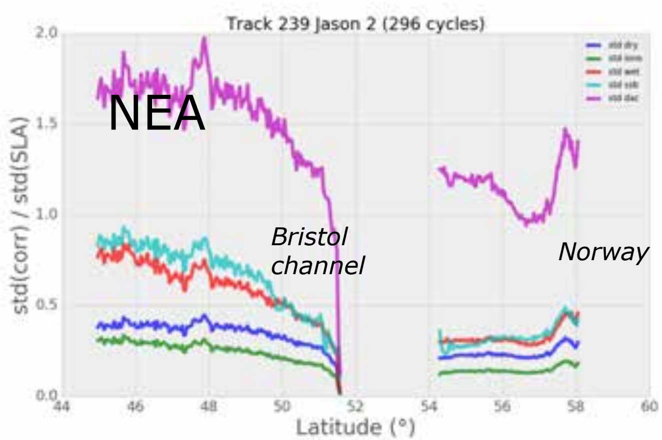
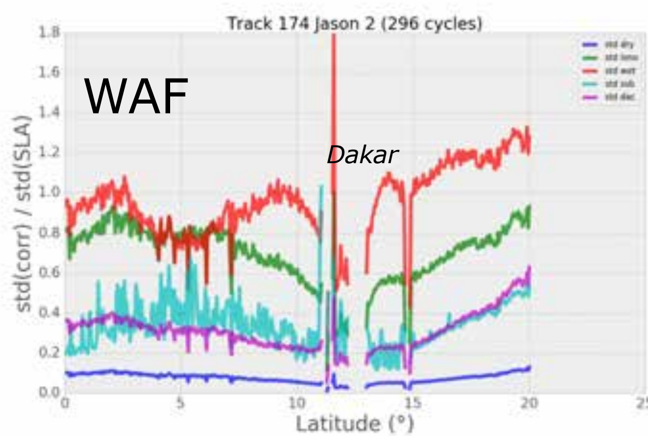




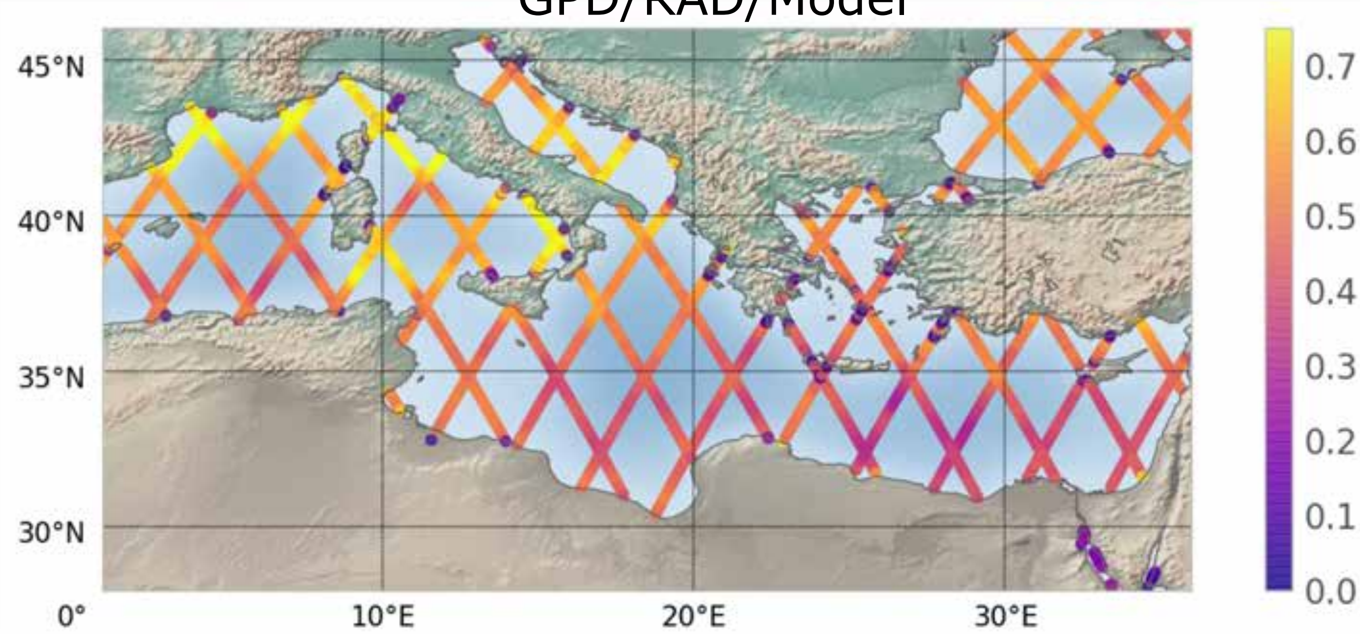


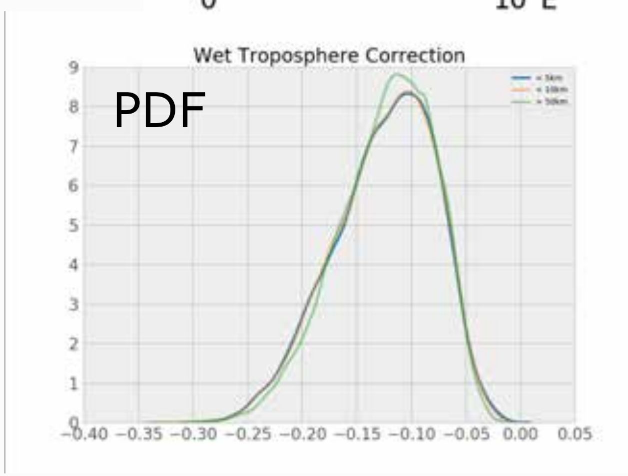


dry: ecwmf_era
iono: gim
wet: gpd
ssb: mle4
dac: mog2d
tide: fes14

WTC – Mediterranean sea

GPD/RAD/Model

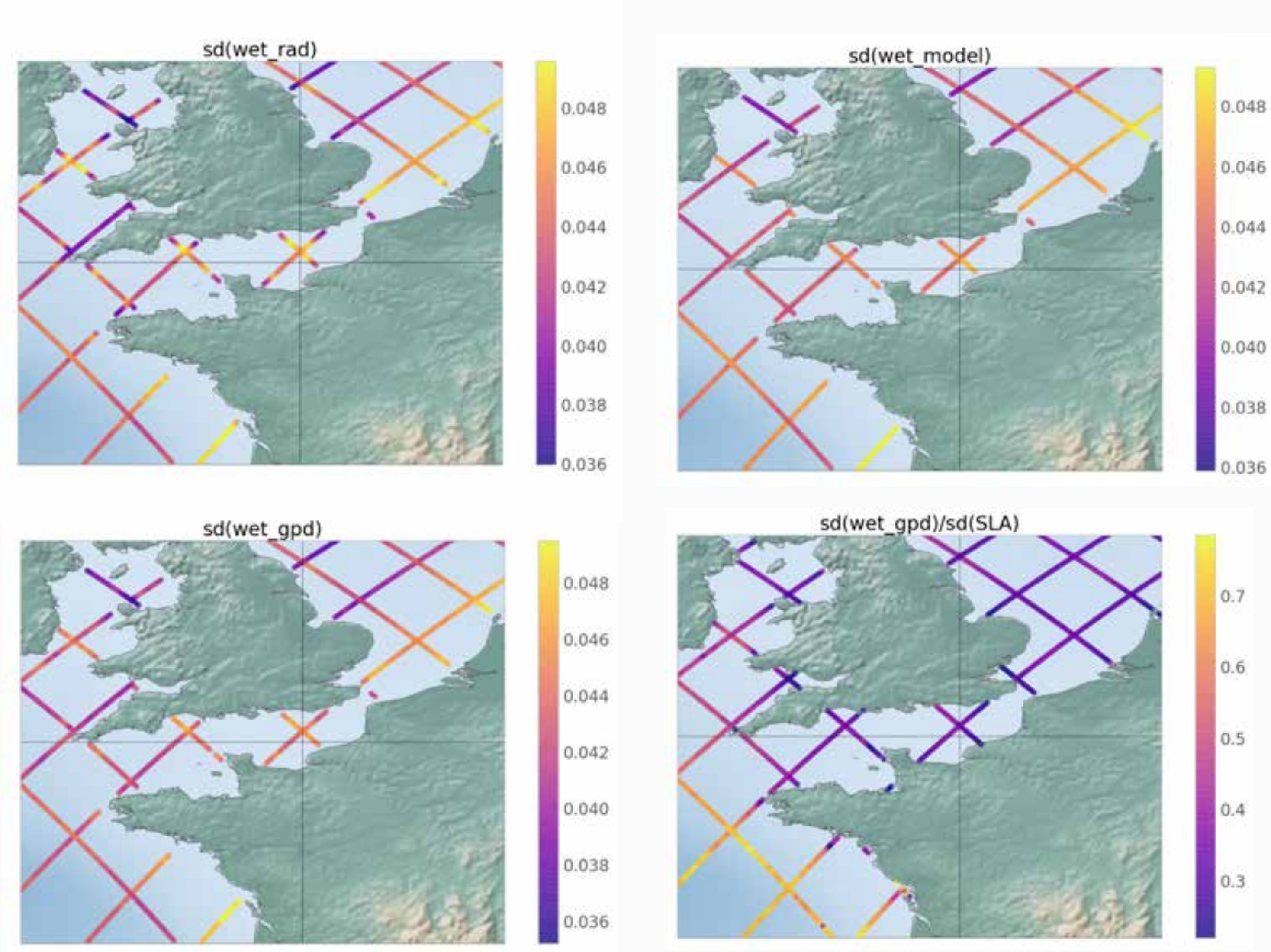




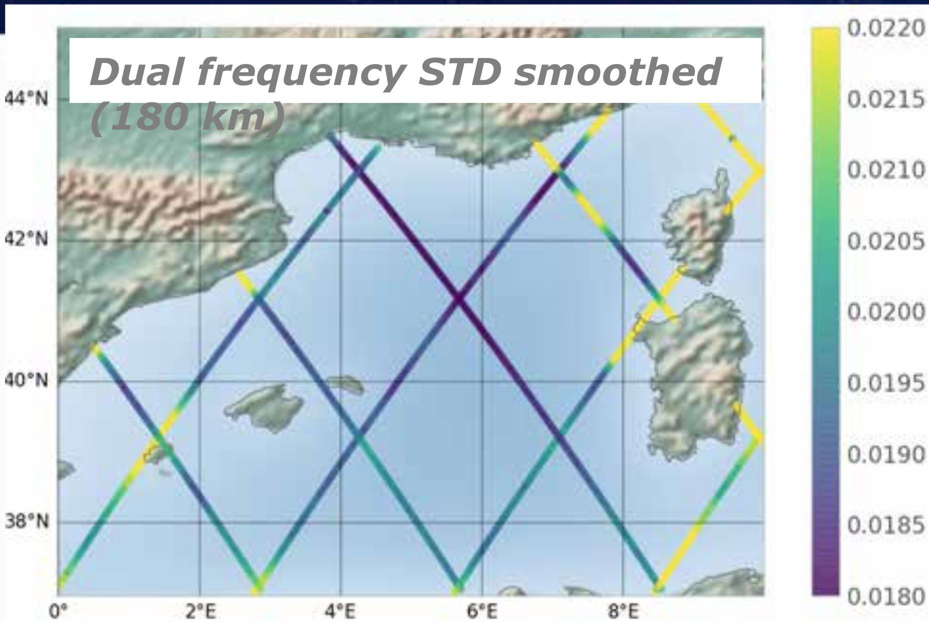
Zoom

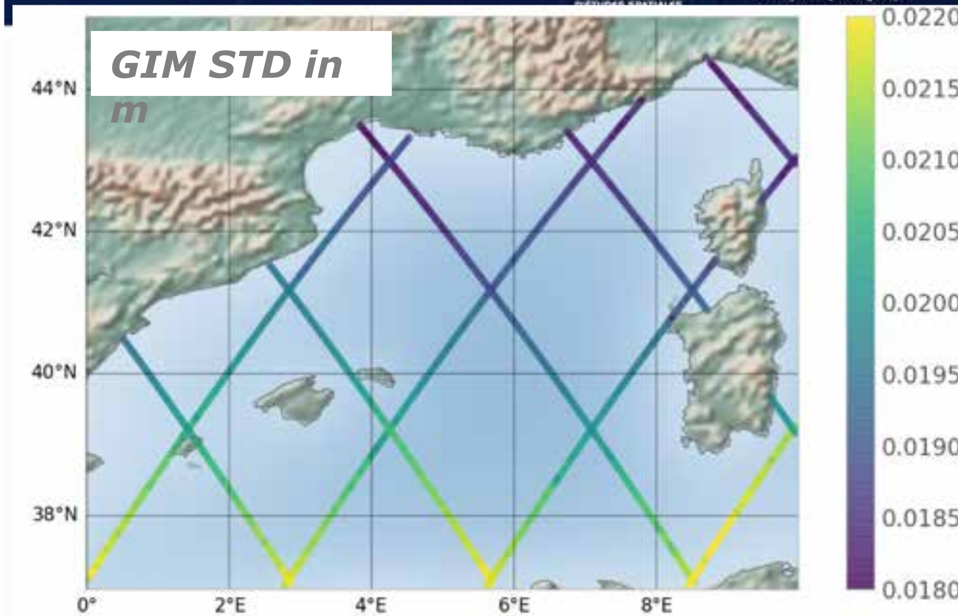
GPD RAD

WTC – North East Atlantic



Ionospheric correction





Compared to GIM the dual frequency solution induces ~2 cm more rms on coastal sea level variations (Ligurian sea): impact on coastal current computations. ➔ ***Residual outliers***

The use of the GIM correction seems to be a better option unless an effective edition strategy is used.

The variability of Iono can account to up to **30% of SLA's variability**