Geostrophic current speed: From gridded products to high resolution along-track

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The availability of precise MDT such as the Rio 2009 one allows estimating the absolute dynamic topography and thus the determination of absolute geostrophic velocity. Several products are now routinely available to compute $V_g$

- MADT gridded mean absolute dynamic topography (interpolate absolute DT and geostrophic speed) from AVISO
- DT along track, 1hz along track Delay Time sea surface height
- GDR, geophysical data record along track 1Hz and 20hz

How do these products compare for velocity? What is the impact of averaging and gridding, especially when considering strong narrow surface current?
Can we quantify the differences between the current speed estimates?

Test on Topex/Jason pass 020 which intersects the Agulhas current near Port Elizabeth.

Advantages:

- strong permanent current
- Track almost perpendicular to the current (i.e. Good estimation of across-track speed)
- Good Mean Dynamic Topography from SAR data
GDR 1Hz and 20Hz current estimate

Estimation of the absolute geostrophic velocity from sea surface height
First flag SSH data for rain and sigma0 bloom
Then compute the mean sea surface MSS
\[ \text{ADT} = \text{SSH} - \text{MSS} + \text{MDT} \]
MDT mean dynamic topography (Rio or SAR)
Across-track current velocity
\[ V_g = \frac{g}{f} \frac{d \text{ADT}}{dx} \]

Problem: because of differentiation \( V_g \) is very noisy especially at 20Hz
GDR 1Hz and 20Hz current estimate

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Filtering

Filtering should preserve the strong gradient of ADT associated to the strongest current.

Lee filters (Lee, 1981) developed to reduce SAR image speckle noise are based on local statistics (mean, variance) and can be adapted to filter ADT.

The local mean and variance are estimate over 10 -20Hz samples and the samples departing by more than 1.5 std are replaced by the mean and the process is iterated until convergence.
Test of the filter
245 cycles of smoothed along track current
Integration of velocity to compute “true” dynamic topographic
Add noise estimated from real SSH data
Filtering of noisy ADT and comparison with true ADT

Reduce Std from 0.07 to 0.01
Velocity estimates

Compute velocity from noisy and filtered ADT
Filter velocity using lee filter and comparison with true velocity

Reduce std from 1.2 m/s to 0.12 m/s
Comparison of spectral behavior ADT

For shh Lee Filter filters most of the high freq noise in the region not covered by the 1 Hz data.
Comparison of spectral behavior $V_g$

For speed
Still noise for wavelength $<10\text{km}$
Analysis of velocity from the different products

Spectral behavior

![Graph showing spectral behavior of different products]

- Raw dynamic topography
- Lee filtered
- SARmdt
- NRT 1hz
- GDR 1hz

Power vs. wavelength km\(^{-1}\)
Example of lee filtering of ADT
Velocity estimate for 255 cycles of Jason-1 PASS 020
Comparison of the Agulhas current

How do these different products represent the Agulhas current?

We used a Gaussian fit of the current for a better comparison.

Max vel

Width

Lat max
Comparison of Gaussian fit of the Agulhas current

How do these different products represent the Agulhas current. We used a Gaussian fit of the current for a better comparison.

Correlation 20hz-1hz 0.73 20hz-NRT 0.83 20hz-MADT 0.47 1hz-NRT 0.90 1hz-MADT 0.65

Bias & std 20hz-1hz 0.38+- 0.35 m/s 20hz-NRT 0.29 +- 0.28 m/s 20hz-MADT 0.79+-0.53 m/s NRT-MADT 0.29+-0.30 m/s
Comparison of Current parameters

Bias & std 20hz-1hz -7+-4 km 20hz-NRT -4.8+-6.2 km 20hz-MADT -20+-6.8km NRT-MADT -15+-6.2 km

The position of the current max is almost identical between 20hz, 1hz and NRT (corr>.9). For MADT OI smoothed the filed too strongly.

20hz gives a narrower and stronger current.
Comparison of “transport”
Integration of velocity over the width of the current NRT, GDR 1Hz in very good agreement
Some discrepancies between 1Hz and 20 Hz with higher variability for 20 Hz
Transport overestimated by MADT and low frequency variability well reproduced
Conclusion

Estimation of velocity from 20hz possible and pertinent with specific filtering
The comparison between 20 and 1hz estimate shows a good agreement and shows that the smoothing introduced by 1hz averaging leads to an underestimation of velocity and a widening of the current.
20 hz are certainly essential to study mesoscale structure or coastal currents
OI velocity fields gives a very smoothed picture of the reality with reduced temporal and spatial variability. The velocity are underestimated by ~50%. 
Aghullas current (20 Hz Sea surface height, MDT from SAR speed data)