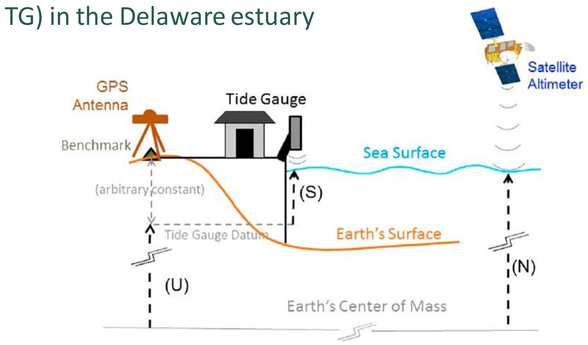
Synthesizing Vertical Land Motion Data for Assessing Relative Sea-Level Rise Uncertainty in Coastal Zones of the New York/New Jersey Megalopolitan Area

BACKGROUND

Current projections, as indicated in the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report, rely solely on tide gauge measurements for Vertical Land Motion (VLM) estimates and Glacial Isostatic Adjustment (GIA) models, neglecting valuable global navigation satellite system (GNSS), interferometric synthetic aperture radar (InSAR) data, or other indirect approaches. Here we assess VLM by calculating the difference between satellite altimetry and tide gauge measurements (ALT-TG) in the Delaware estuary



Woppelmann & Marcos (2016), Review of Geophysics

METHODS

1. Estimate VLM by using the difference between satellite altimetry and tide gauge (ALT-TG)
2. Develop technique to correct for river discharge (Q) influence on VLM estimation
3. Compare ALT-TG VLM estimate with GNSS derived rates

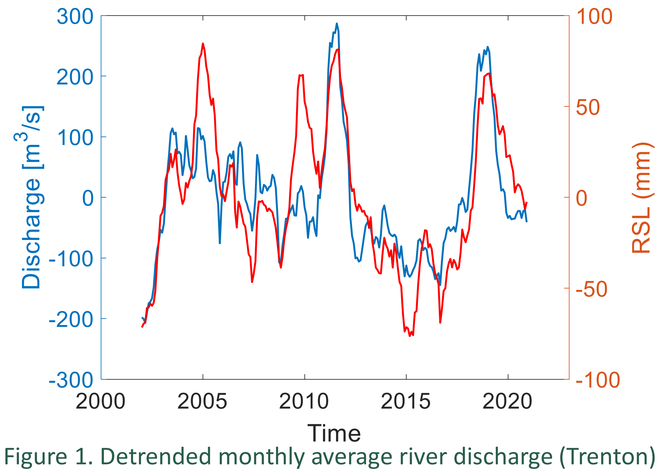


Figure 1. Detrended monthly average river discharge (Trenton) and relative sea-level (Philadelphia) with 13-month moving average, highly correlated 0.68

ESTIMATING VLM USING ALT-TG IN THE DELAWARE ESTUARY

1. Low correlations in the estuary suggest river discharge effects on water levels are not captured by satellite altimetry
2. Satellite altimetry performs well in the open ocean but not as well in estuary

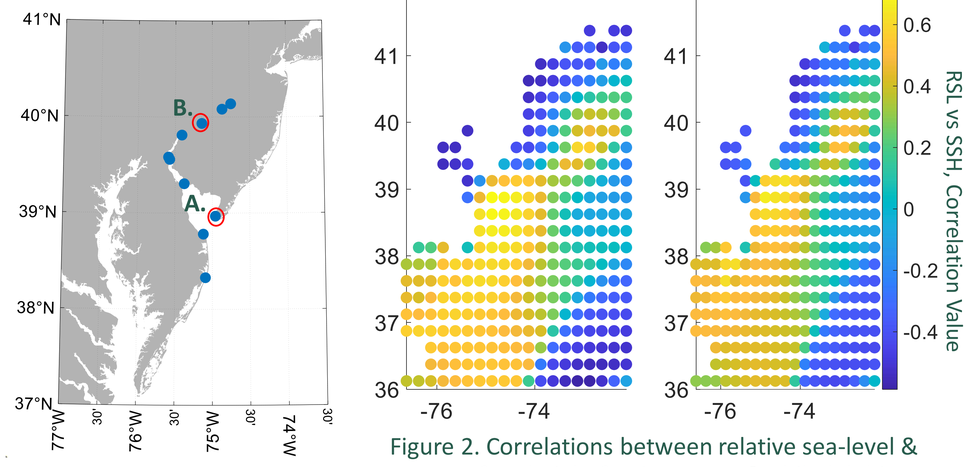


Figure 2. Correlations between relative sea-level & sea surface height for Cape May & Philadelphia.

RIVER DISCHARGE VS TIDE GAUGES & ALT-TG

1. Single open coast sea surface height signal used for all ALT-TG calculations
2. ALT-TG leads to a higher correlation with river discharge

Table 1. Correlations between tide gauges vs river discharge and ALT-TG vs river discharge

Upper estuary ↓ Lower estuary

Station	TG vs Q	ALT-TG vs Q
NEWBOLD	0.86	-0.90
BURLINGTON	0.82	-0.89
PHILADELPHIA	0.68	-0.80
MARCUS HOOK	0.49	-0.60
DELAWARE CITY	0.39	-0.43
REEDY POINT	0.39	-0.43
SHIP JOHN SHOAL	0.29	-0.30
CAPE MAY	0.15	-0.09
LEWES	0.20	-0.19
OCEAN CITY INLET	0.15	-0.11

RIVER DISCHARGE CORRECTION FOR ALT-TG

1. Build a regression model b/w [ALT-TG] and River discharge (Q) such that
2. $[ALT\text{-}TG]_{regression}$ (mm) = Q(m3/s)*slope + y-intercept
3. $[ALT\text{-}TG]_{Q\text{-}corrected} = [ALT\text{-}TG] - [ALT\text{-}TG]_{regression}$

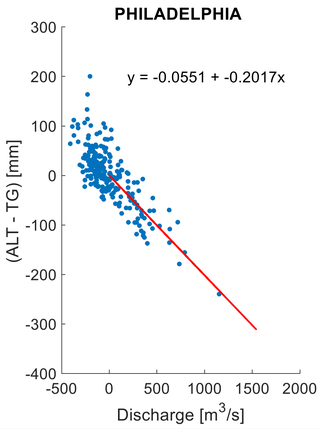


Figure 3. Detrended monthly avg river discharge vs ALT – TG and linear regression equation

RESULTS: VLM RATES FROM GNSS & ALT-TG

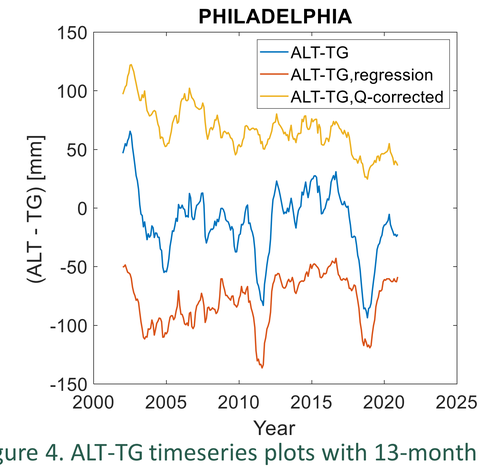


Figure 4. ALT-TG timeseries plots with 13-month moving average

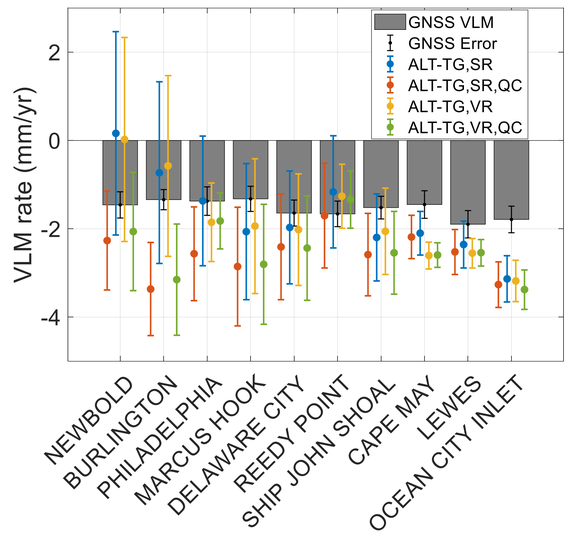


Figure 5. Rates of VLM observed by GNSS (Hammond et al. 2021) and estimated by ALT-TG. The various rates of ALT-TG estimates represent period of same record (SR) (2002 – 2021), varying record (VR), and discharge corrected (QC)

CONCLUSION

Satellite altimetry measurements suffer degradation near coastlines, leading to inaccurate capture of complex dynamics like river discharge effects. Here we demonstrate the river discharge effect on estimates of VLM using ALT-TG. We conclude:

1. Correcting ALT-TG for river discharge leads to a reduced error
2. Correcting ALT-TG for river discharge leads to changes in linear trend estimate
3. Longer records are closer to VLM rate measured by GNSS

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