Determining and Monitoring Sea Level in the Caribbean using Satellite Altimetry

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Overview

- ✓Introduction
- ✓Sea Level Monitoring
- ✓Caribbean Sea level Monitoring
- ✓Satellite Altimetry
- ✓Determining MSL
- ✓Conclusion

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Introduction

- ✓Sea level change has been a significant issue throughout the course of time.
- ✓Small Island Developing States (SIDS) are particularly vulnerable to the effects of climate change and sea level rise due to their relative isolation, small land masses and concentration of population and infrastructure in coastal areas.

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Sea Level Monitoring

- ✓ Nature and quality of sea level monitoring, depends on the types of tools used.
- ✓ Critical for determining and predicting changes and trends in the sea level.
- ✓ Unfortunately, long term consistent sea level monitoring has been lacking in the Caribbean.

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Caribbean Sea Level Monitoring

- ✓ The Caribbean is plagued by problems of sporadic distribution, faulty equipment, discontinuous results
- ✓ Coverage time periods too short to account for climatic variations, creating gaps in Mean Sea Level (MSL) data.
- ✓ Over the past 20 years, some 70 sea level gauge stations have been installed in the Caribbean and surrounding countries.

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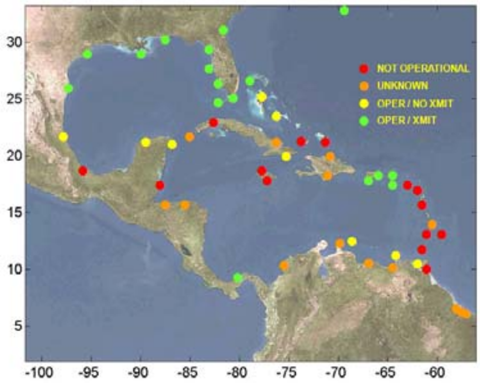
Caribbean Sea Level Monitoring



- ✓ However, only 44 (2005) of these stations have been identified as functioning, of which only 17 are capable of contributing sea level data.

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Caribbean Sea Level Monitoring

- ✓ The island of Bequia represents the shortcomings of the present state of sea level monitoring in the Caribbean.
  - ➢ No installed tide gauge
  - ➢ No long term tide data
  - ➢ No updating/referencing to benchmarks
  - ➢ No maintenance of vertical datum
  - ➢ No reliable determination of MSL

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Caribbean Sea Level Monitoring

- ✓ Assess the impact of sea level rise and coastal innundation on island of Bequia.
- ✓ A digital elevation model was created which includes a predictive sea level of 0.4 metres above the mean.
- ✓ However, the lack of consistent long term tide gauge measurement, detracts much from the models predictive capabilities.

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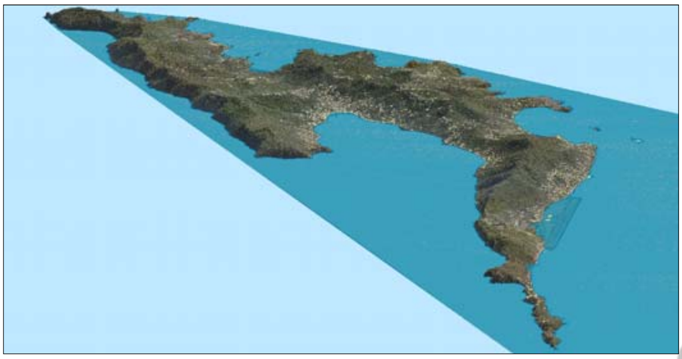
Caribbean Sea Level Monitoring



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Satellite Altimetry

- ✓ Satellite altimetry has developed into an established technology for measuring sea level
- ✓ In contrast to the sparse network of coastal tide gauges, measurements of sea level from satellite altimetry provide near global and homogenous coverage of the world's oceans.

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Satellite Altimetry

✓ The spatial and temporal distribution of altimetric data means that it has the potential to address many of the problems that plague tide gauge installation, distribution and maintenance.

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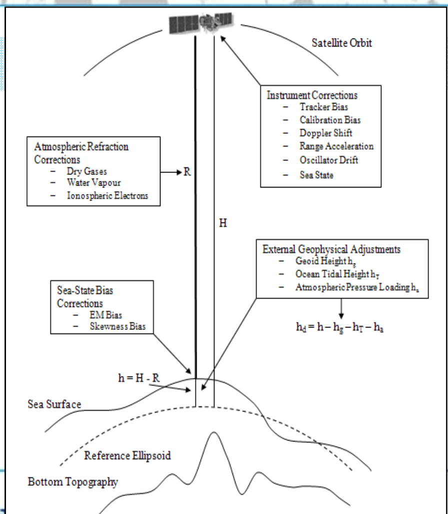

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Satellite Altimetry

- ✓ Altimetry uses pulse-limited radar to measure the altitude of the satellite above the closest point of the sea surface, R.
- ✓ Global precise tracking coupled with orbit dynamic calculations are used to determine the height of the satellite above the ellipsoid, H.
- ✓ The difference between these two measurements results in the height of the sea surface, h.

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- ✓ Assessment of the performance of Satellite Altimetry vs tide gauges in the Caribbean

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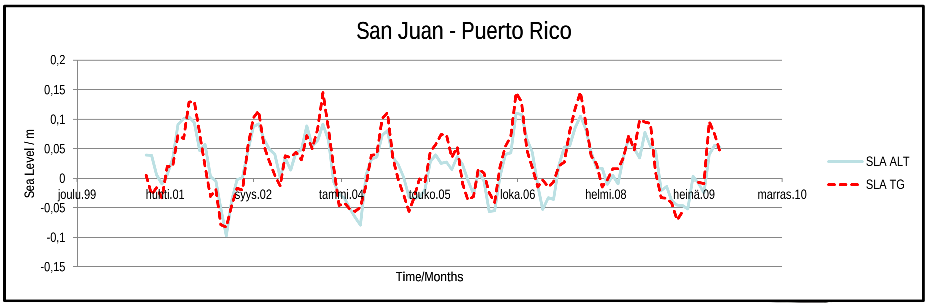
Satellite Altimetry



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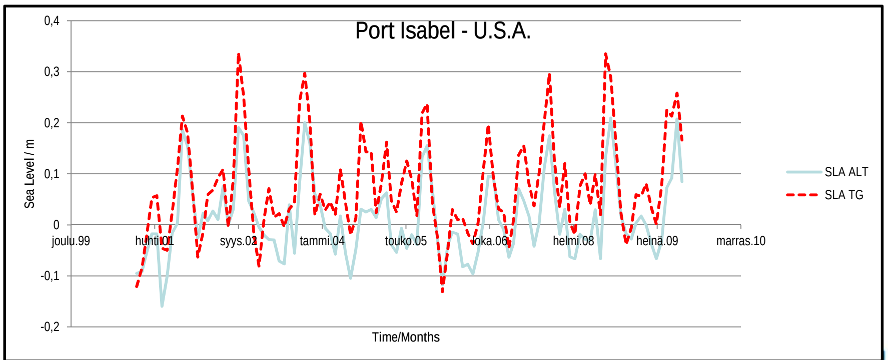
Satellite Altimetry



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Station Location	Sea Level Change Rates (mm yr^{-1})		Differences (mm yr^{-1})
	Tide Gauge	Satellite Altimetry	
Sabine Pass, Tx	4.58	3.87	0.71
Port Isabel, Tx	7.14	7.80	0.66
Apalachicola, Fl	3.55	4.45	0.90
Clearwater Beach, Fl	7.88	7.86	0.02
Key West, Fl	6.09	6.34	0.25
Grand Isle, Lo	3.27	3.18	0.09
Isabela De Sagua, Cuba	0.97	0.85	0.12
San Juan, Puerto Rico	-1.92	-1.07	0.85

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Station Location	Max (m)	Min (m)	Mean (m)	RMS (m)
Sabine Pass, Tx	0.3210	0.0011	0.0203	0.0718
Port Isabel, Tx	0.2020	0.0017	0.0737	0.0782
Apalachicola, Fl	0.2188	0.0004	0.0160	0.0567
Clearwater Beach, Fl	0.1711	0.0010	0.0280	0.0568
Key West, Fl	0.1492	0.0008	0.0243	0.0548
Grand Isle, Lo	0.1497	0.0001	0.0088	0.0542
Isabela De Sagua, Cuba	0.1701	0.0002	0.0731	0.0724
San Juan, Puerto Rico	0.0667	0.0003	0.0206	0.0249

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Determining MSL

- ✓ 2 major processes to integrate
  - ✓ Short term (1 month) tide data & satellite altimetry

1. Create Network – Setup a network of tide gauges along the coasts of Bequia with collocated G.P.S. stations in the vicinity to establish tidal benchmarks.
2. Make Observations – Log water level data at six minute intervals for the period of a month.

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Determining MSL

3. Tabulate the Tide - Once the 6-minute interval data are quality controlled and any small gaps filled, the data is processed by tabulating the high and low tides and hourly heights for each bday. Tidal parameters from these daily tabulations of the tide are then reduced to mean values.

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Determining MSL

4. Compute Tidal Datums - Reduction of the tidal datums is determined directly by averaging values of the tidal parameters over the one month period.
5. Use an altimetric derived model for the Sea Surface Topography (SST) for the network of tide gauge stations and then adjust the network (Sideris and Fotopoulos, 2006).

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Determining MSL

6. Compute Bench Mark Elevations - Once the tidal datum is computed from the tabulations, the elevations are referenced to the bench marks established on the land using the elevation differences established by differential leveling between the tide gauge “zero” and the bench marks (NOAA, 2003).

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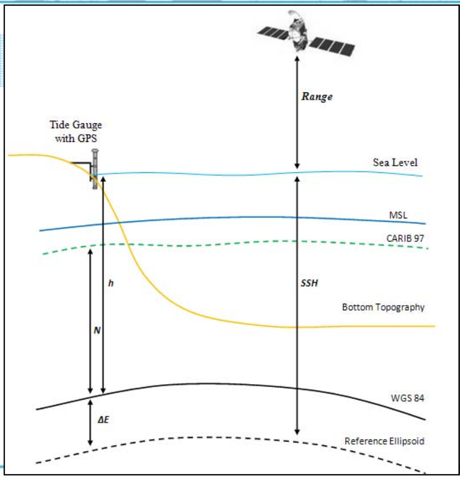

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Conclusion

- ✓ Considering the vulnerability of the region to changes in sea level, the definition of the vertical datum is a major concern.
- ✓ This critical issue however has largely been overlooked because of the difficulty in establishing and maintaining adequate tide gauges.

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Conclusion

- ✓ Satellite altimetry provides consistent accuracy, coverage, and independent space-based measurements in a geocentric reference frame.
- ✓ Combined with short term tide gauge data we have all the components necessary for the practical realization of a vertical datum.

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Merci
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Bedankt
Takk
感謝您
Terima Kasih
谢谢
Grazie
ขอบคุณ
Спасибо
Thank You
Kiitos
Tak
Teşekkür Ederiz
감사합니다
Gracias
Dziękujemy
Σας ευχαριστούμε

We welcome your questions and comments

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