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Possible Datum Errors at Tide Gauges Detected by Satellite Altimetry: Some Case Studies

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Two examples of altimetry vs. tide gauges

Poor agreement: Easter Island



RMS difference = 5.1 cm

Good agreement: Majuro

RMS difference = 1.8 cm

The following case studies employ only GOOD stations.

Our approach to Vertical Land Motion from Alt – TG $\Delta H = H_{\rm A} - H_{\rm TG}$

ALTIMETRY

Gridded data from Aviso (CMEMS) or MEaSUREs 0.25° (or finer), near global, every 5 days (or faster)

TIDE GAUGE

Daily means (after anti-aliasing low-pass filter; UHSLC – RQDS) "Corrected" for consistency with altimetry – DAC, long-period tides, pole tide 15- to 40-day smoothing for consistency with altimetry

DIFFERENCE ($\Delta H = H_A - H_{TG}$)

5-day sampling

Remove seasonal cycle (not of interest here)

Select series with lowest RMS from dozens of Δ*H* series

- different grid elements near tide gauge
- different TG smoothing

Datum problems identified subjectively,

but analyzed objectively: Least-squares jumps + trends



Don't forget tide corrections to TG data! Especially node tide.

18.6-year node tide

(self-consistent equilibrium) Elevation when lunar node $N = 0^{\circ}$



N = 0° in years 1969, 1987, 2006, 2025, 2043,...



Neglecting this TG adjustment results in a false trend over 10 years of ~1.6 mm/y. And double that in polar regions.

Santa Cruz, Galapagos



Estimated	Time	DUACS	Μ
adjustments	1998.00	-10 ± 4	-9
(mm)	2008.00	33 ± 3	25

VLM

	(mm
BEFORE	+0.42 ±
1995-1998	-1.94 ±
1998-2008	-0.61 ±
2008-2019	-1.37 ±
AFTER	-1.07 ±
GPS GLPS	-1.27 ±

EAS

- ± 6
- 5 ± 5

Notes:

Final adjusted series remarkably low noise and linear. High quality results, and more consistent with GPS.





Ponta Delgada, Azores



Estimated adjustments (mm)

Time	DUACS	M
2008.00	-24 ± 8	-35

VLM

	(mm
BEFORE	-1.92 ±
1995-2007	+0.17 ±
2008-2019	+0.57 ±
AFTER	+0.36 ±
GPS PDEL	-1.64 ±
DORIS PDOC	-1.52 ±

EAS

 5 ± 9

Notes:

GPS and DORIS stations colocated, 1.61 km from tide gauge.





Dakar, Senegal



Estimated	Time	DUACS	Μ
adjustment (mm)	2005.0	40 ± 8	20

EAS

± 10

VLM

	(mm)
BEFORE	+2.24 ±
1993-2004	-1.15 ±
2007-2019	+0.87 ±
AFTER	-0.01 ±
GPS DAKR	-0.49 ±

Notes:

Left/right trends disagree in sign, but uncertainties are very large. DUACS & Measures disagree, but both yield final VLM near 0, consistent with GPS. Results not clear-cut, but initial large uplift (+2.2 mm/y) not likely.

Yap

Estimated	Time	DUACS	ME
(mm)	2005.87	-18 ± 4	-19

VLM

	(mm/y)
BEFORE	-0.61 ± 0.1
1993-2005	0.40 ± 0.4
2006-2019	0.44 ± 0.4
AFTER	0.42 ± 0.3
GPS none	

EAS

9 ± 5

Papeete, French Polynesia

Estimated	Time	DUACS	Μ
adjustment (mm)	2007.5	18 ± 4	5

VLM

	(mm
BEFORE	-0.88 ±
1993-2007	-1.70 ±
2007-2019	-2.26 ±
AFTER	- 1. 88 ±
GPS PAPE	-1.61 ±

EAS

± 7

Notes:

DUACS & Measures slightly disagree, but both suggest greater subsidence, consistent with GPS.

Rodrigues, Mauritius

Estimated	Time	DUACS	MI
(mm)	2013.83	-32 ± 6	-32

VLM

	(mm
BEFORE	-3.38 ±
1993-2013	-2.36 ±
2014-2018	-2.14 ±
AFTER	-2.36 ±
GPS RDRG	?

 2 ± 6

Notes:

DUACS & Measures agree well. Adjusted trends more consistent. GPS data short and erratic in vertical.

Rodrigues (105)

Update 5/18/2022

- •We determined switches (used by UH for calibrating radar water levels with respect to Station Zero) were likely reversed during an Oct 2013 site visit.
- •Switches are separated by 43 mm, causing sea level bias error of this amount after Oct 2013.
- •UH Fast Delivery data now updated.

https://uhslc.soest.hawaii.edu/stations/?stn=105#datums

Wires from two Switches (likely reversed Oct 2013)

Majuro, Marshall Is.

Estimated	Time	DUACS	MEAS
adjustments	2006.89	56 ± 7	50 ± 7
(mm)	2008.42	-56 ± 7	-49 ± 7

VLM

	(mm/y
BEFORE	-0.33 ±
AFTER	-0.42 ±
GPS MAJB	-0.30 ±

Notes:

Short temporary jump has little impact on overall trend. Possible jump in 2015? It's small (~1 cm) and MEaSUREs disputes it (next slide).

Cocos (Keeling) Is.

Estimated	Time	DUACS	Μ
adjustments	1994.00	-108 ± 8	-104
(mm)	1995.00	97 ± 7	10
()	2000.00	-26 ± 3	-24

4 ± 10

 2 ± 8

 4 ± 4 - quake?

VLM

	(mm)
BEFORE	-2.93 ±
2000-2019	-2.36 ±
AFTER*	-2.39 ±
GPS COCO	-2.35 ±

* if adjusted in 2000.

Notes:

Large ~10 cm offset is confined to calendar year 1994.

Known M8 quake in June 2000; should therefore not be adjusted, but GPS shows no offset in vertical. Summary: pre-2000 data confusing.

So what is to be done about these problems?

One success story – Rodrigues :: Data now fixed and updated in UHSLC archives Majuro and Cocos :: to be ironed out with BOM

What about other stations?

- Requires detailed instrument investigations, as at Rodrigues.
- these altimeter results.
- provided user understands data heritage.

We cannot recommend "adjusting" archived TG data based solely on

However, in many applications, one may profitably use the adjusted data,

extras

Majuro, Marshall Is.

Estimated adjustments (mm)

Time	DUACS	ME
2006.89	56 ± 7	50
2008.42	-56 ± 7	-49

VLM

	(mm/y
BEFORE	-0.44 ±
AFTER	-0.58 ±
GPS MAJB	-0.30 ±

EAS

± 7

± 7

Notes:

No obvious jump in 2015. Shows importance of independent altimeter data!

