COSPPac - PSLGM Component

SWPHC 21

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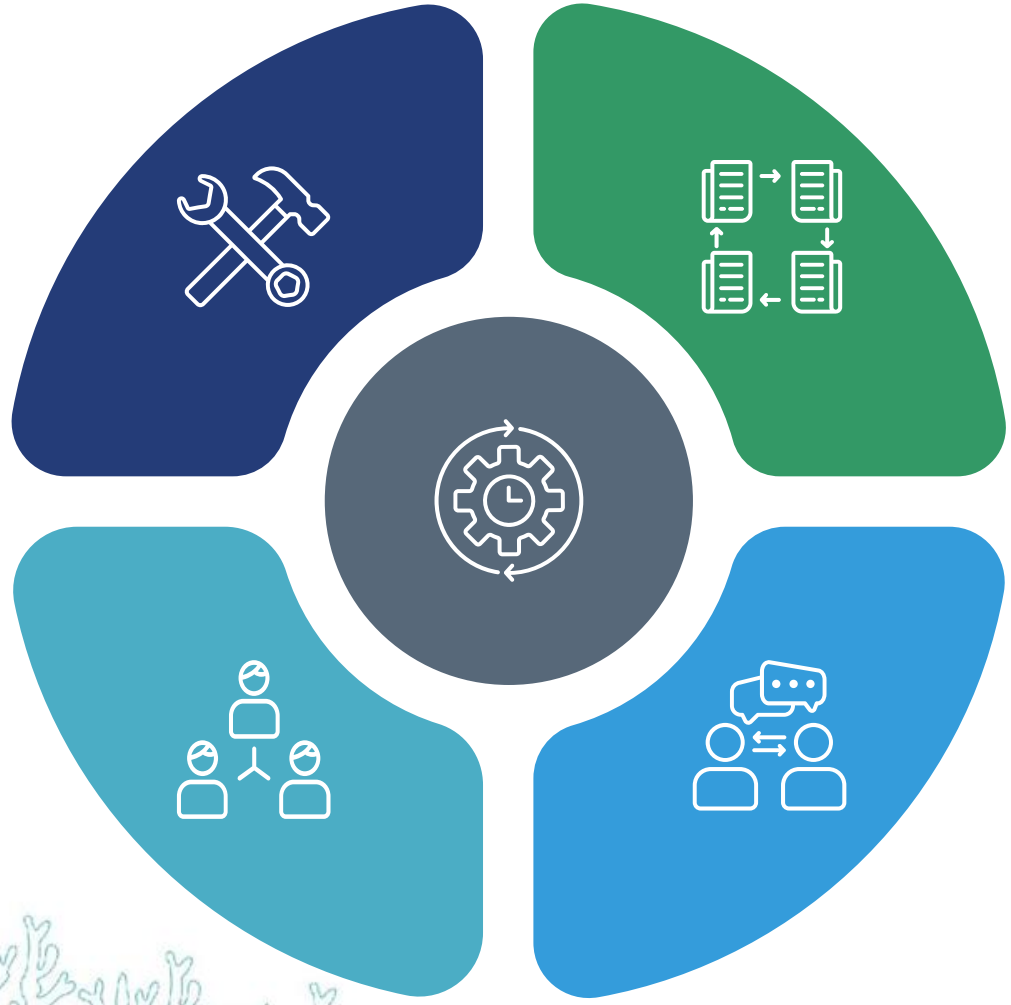
Geoscience Energy & Maritime – Pacific Community (SPC)

Nadi, Fiji. 1st March 2024

30 YEARS 2023
Pacific Sea Level & Geodetic Monitoring

COSPPac3 Five Key Deliverables



INFRASTRUCTURE

Observations infrastructure and data support

PRODUCTS & SERVICES

Data management and Climate and Ocean Products and Services

COMMUNICATIONS

Communications with and between key stakeholders and diverse communities

CAPACITY DEVELOPMENT

Capacity development & training support

GOVERNANCE

Governance, transition and support services

COSPPac Donors, Delivery Partners, and Key Stakeholders

Australian Government
Department of Foreign Affairs and Trade

Australian Aid

NEW ZEALAND
FOREIGN AFFAIRS & TRADE
Aid Programme

Pacific Community
Communauté du Pacifique

SPREP
Secretariat of the Pacific Regional Environment Programme

NIWA
Taihoro Nukurangi
Climate, Freshwater & Ocean Science

Australian Government
Geoscience Australia

Australian Government
Bureau of Meteorology

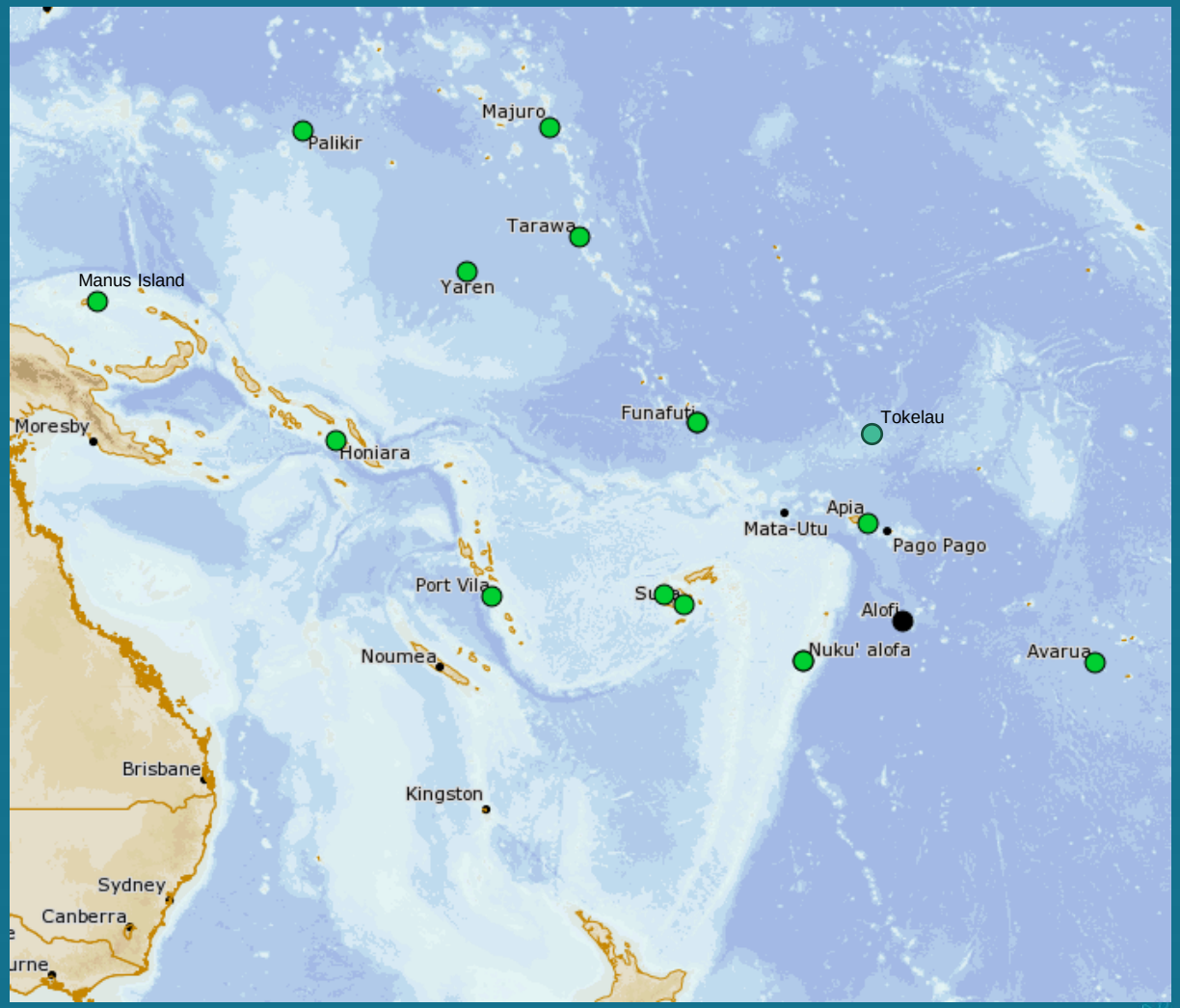
15 Partner Pacific Island Countries & Territories

Began in 1991 as an Australian response to concerns raised by the member countries of the South Pacific Forum over the potential impacts of global warming on climate and sea levels in the Pacific.

Australia has been supporting 15 Pacific Island countries (PICs) to measure, record and analyse long-term sea level and land motion for over 25 years. This is known as the Pacific Sea Level and Geodetic Monitoring (PSLGM) component funded by Australian Aid under the Climate and Oceans Support Program in the Pacific (COSPPac).

The sea level data is collected continuously at one or two tide gauges and land motion data is collected continuously at one or two Global Navigation Satellite System (GNSS) stations in each of the 15 PICs.

Primary goal “to generate an accurate record of variance in long-term sea level for the Pacific and to establish methods to make [these] data readily available and usable by Pacific Island Countries



- Cook Islands
- FSM
- Fiji
- Kiribati
- Marshall Islands
- Niue
- Nauru
- PNG
- Palau
- Samoa
- Solomon Islands
- Tokelau
- Tonga
- Tuvalu
- Vanuatu

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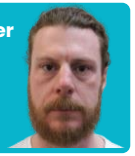

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Pacific Sea Level & Geodetic Monitoring

14 sites across the pacific

- 1 x permanent tide gauge at each, measuring local sea level
- 1 x Constant GNSS COR station at each, measuring local earth movement in an absolute coordinate system
- Regular levelling survey between the tide gauge and GNSS COR stations allow absolute determination of the vertical height of the tide gauges that measure sea level

Vertical motion of Pacific Island tide gauges: combined analysis from GNSS and levelling (GA Record 2020/03) (d28rz98at9flks.cloudfront.net)

GNSS CORS – Land Monitoring Stations

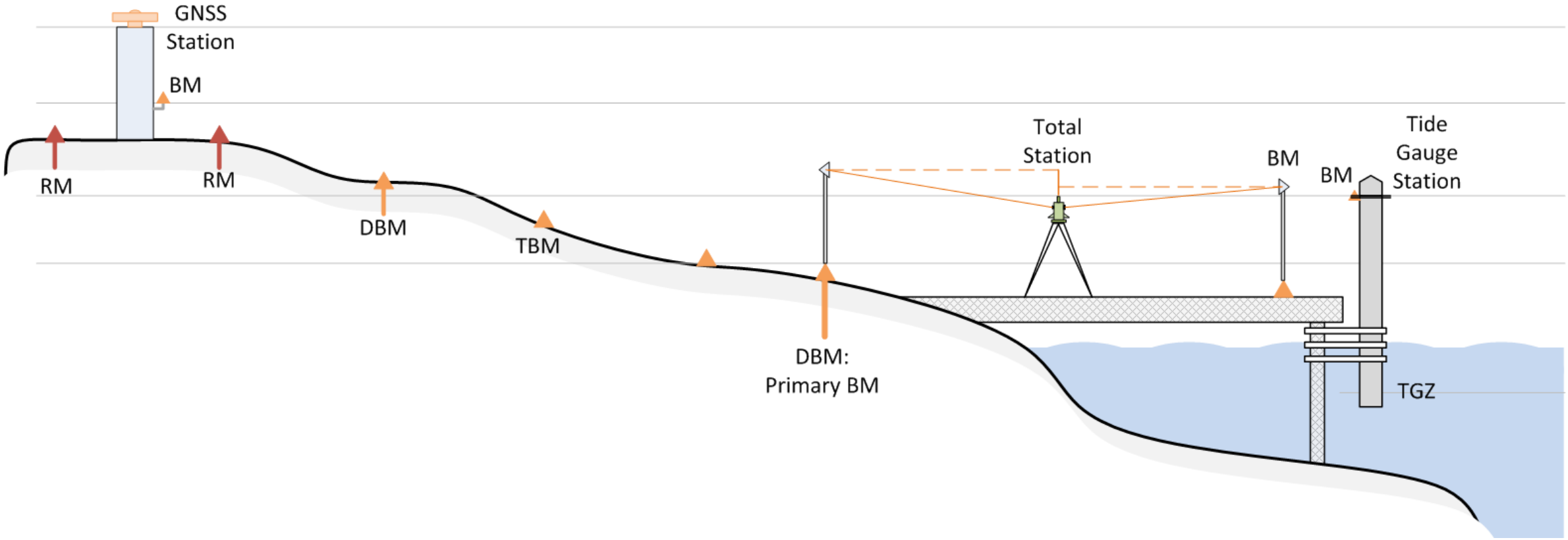
Continuously Operating Reference Station (GNSS) in Lautoka, Fiji.

SEAFRAME – Sea Level Monitoring Stations

Tide Gauge Station in Majuro, Marshall Islands.

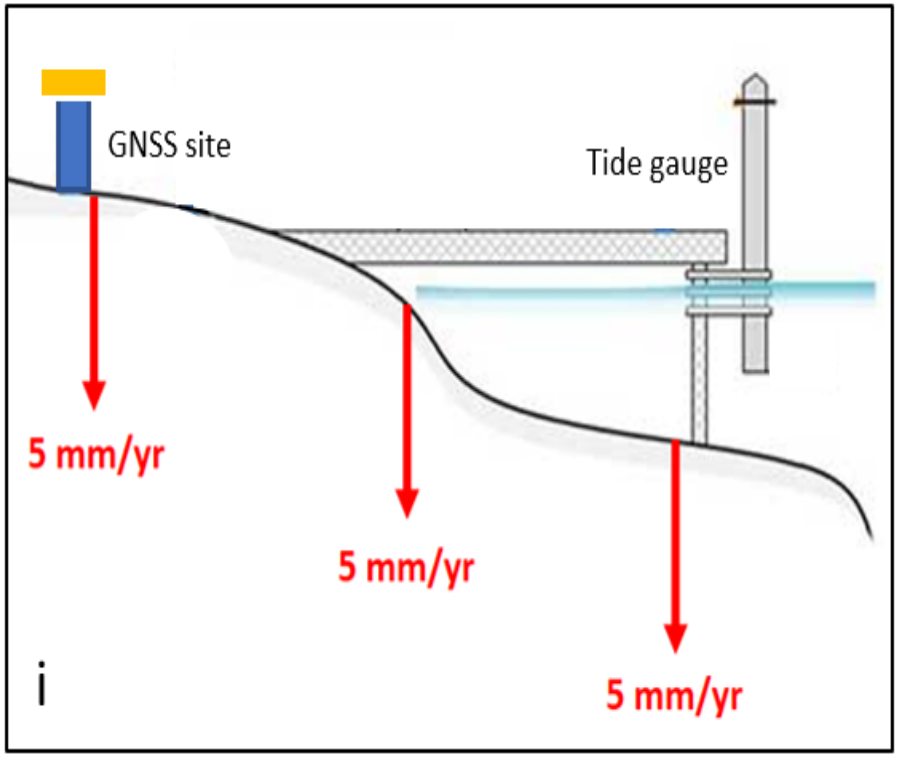
Tide Gauge Station in Nuku'alofa, Tonga.

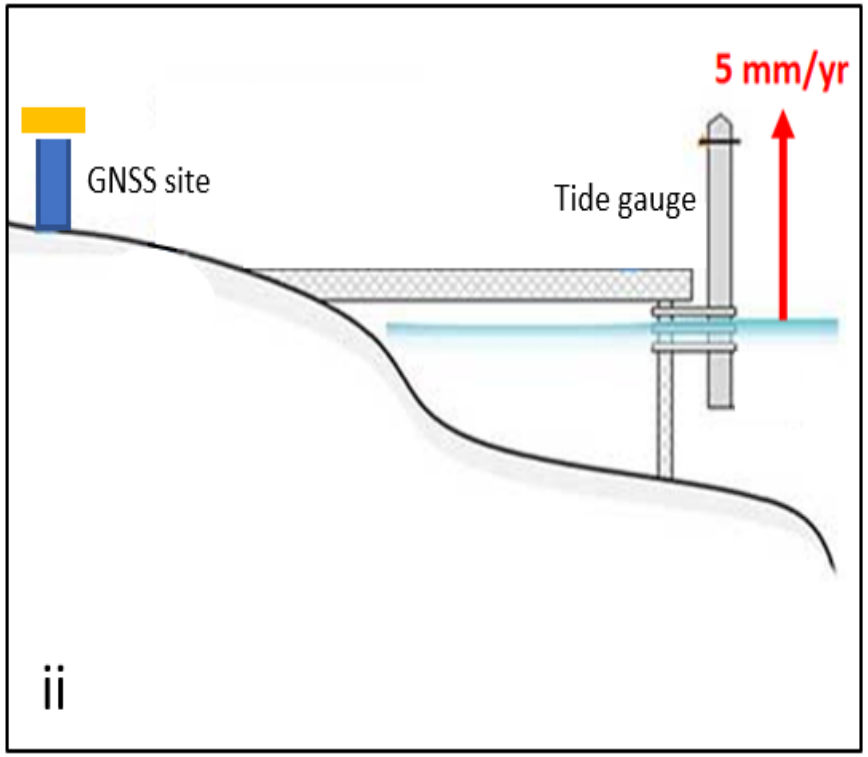
Pacific Sea Level & Geodetic Monitoring



Levelling is undertaken every 18 months to compute the difference in height between the GNSS Site and the Tide Gauge. The orange triangles represent the stable survey marks in the ground. Observations are made between each of the survey marks and added together to compute the difference in height between the GNSS Site and the Tide Gauge

Pacific Sea Level & Geodetic Monitoring



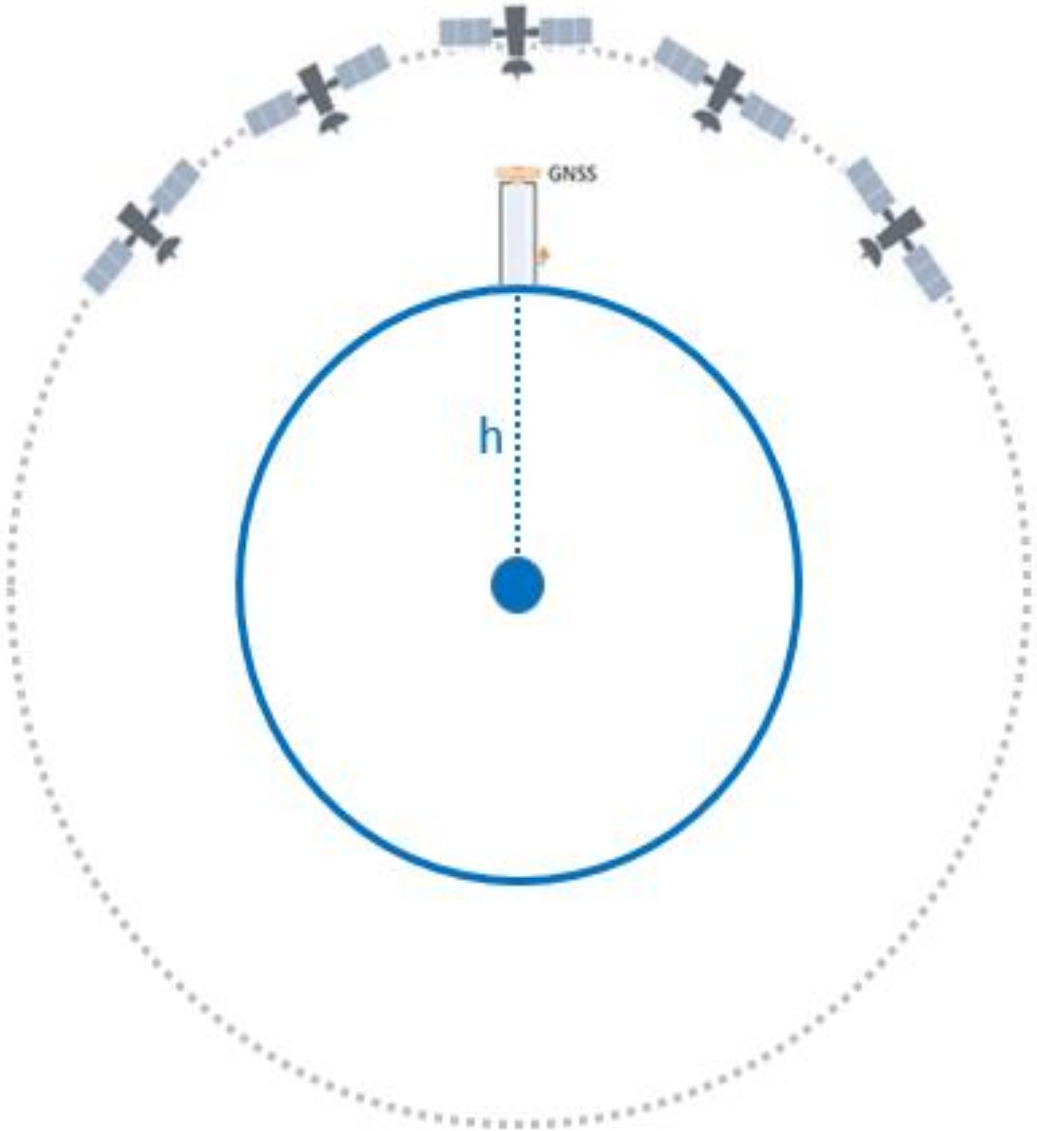


[i] land subsiding at a rate of 5 mm/yr with no change to absolute sea level;

[ii] absolute sea level rising by 5 mm/yr and no movement of the land.

A tide gauge alone cannot differentiate between changes in the sea level height and movement of the land or wharf the tide gauge is attached to.

If a tide gauge is observing 5 mm/yr rise in sea level, we are unable to distinguish whether the land to which the tide gauge is connected is subsiding by 5 mm/yr (Figure i), the sea level is rising by 5 mm/yr (Figure ii), or some combination of both.

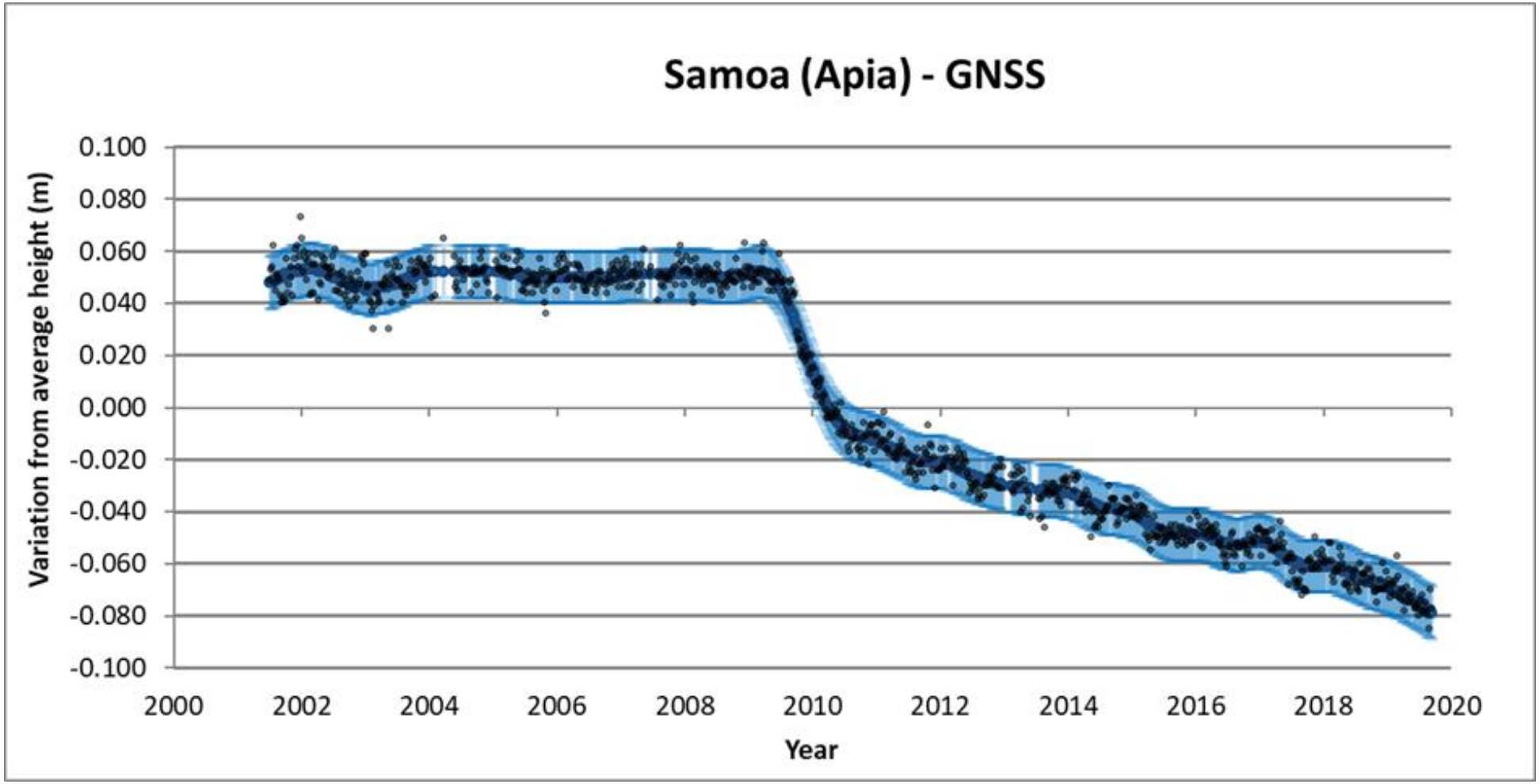


GNSS heights can be measured with respect to the centre of the Earth.

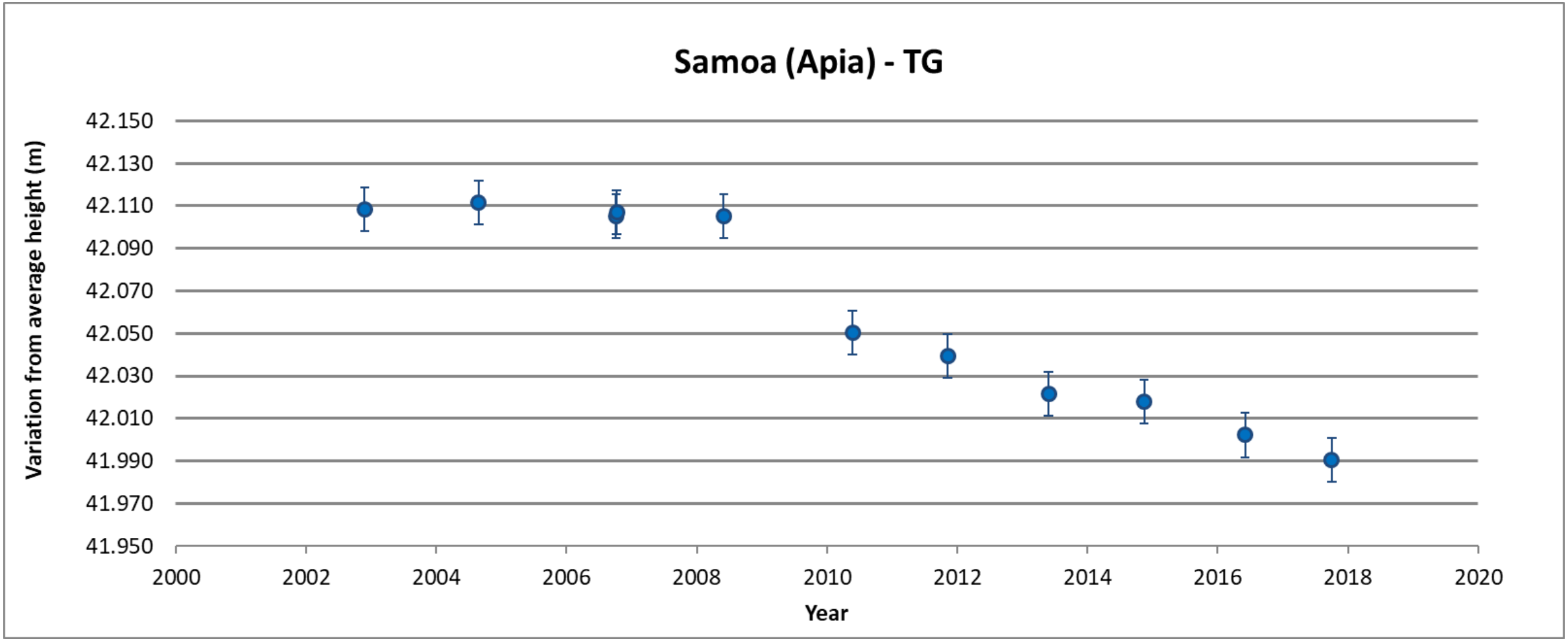
To distinguish between relative and absolute sea level variation from tide gauge data, it is necessary to know the movement of the tide gauge in an absolute frame of reference.

The absolute frame of reference we use is the centre of the Earth.

In the Pacific Island countries described in this report, a GNSS site is located within 1-5 km of the tide gauge. At these GNSS sites, it is possible to determine the absolute height of the GNSS site.

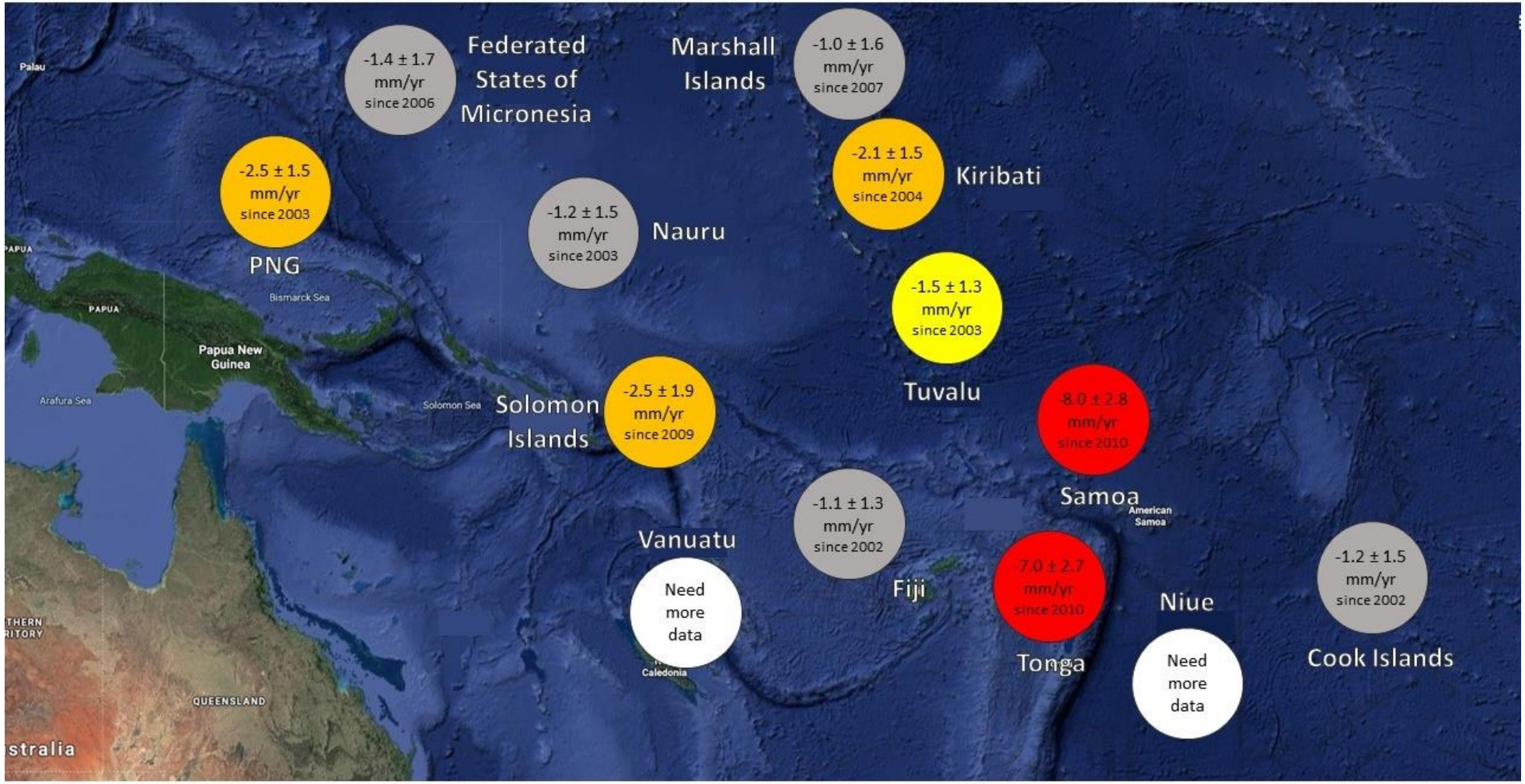


Change in the height of the Apia GNSS site with respect to the centre of the Earth. The black dots are the height of the GNSS site every week with respect to the centre of the Earth. The dark blue line is a smoothed representation of the weekly data and the light blue error bars show the 95% Confidence Interval.



Change in the absolute height of the Apia tide gauge. The error bars show the 95% Confidence Interval.

- Tide gauge movement for absolute sea level analysis between 2002 and 2008 should be assumed to be 0 mm/yr.
- Samoa experienced a magnitude 8.1 earthquake on 29 September 2009. 95
- Tide gauge movement for absolute sea level analysis is -8.0 ± 2.8 mm/yr at 95% Confidence Interval between 2010 and 2018.



Absolute vertical rate of movement of the tide gauge in Pacific Island countries. For example, in Kiribati, -2.1 mm/yr represents the rate of movement of the tide gauge and ±1.5 mm/yr represents the uncertainty in the rate of movement. Grey circles represent sites which have an absolute vertical rate of movement that is not greater than the uncertainty of the data. In these cases, either the absolute vertical rate of movement of the tide gauge is close to zero, or a longer time series of data is needed to better understand the absolute vertical rate of movement of the tide gauge.

Pacific Sea Level & Geodetic Monitoring Surveys

https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/146976

Pacific Sea Level and Geodetic Monitoring Project: Levelling & GNSS Monitoring Survey Report

Tarawa, Kiribati, December 2019

GEOSCIENCE AUSTRALIA
RECORD 2022/24

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Australian Government
Geoscience Australia

1. Pacific Community (SPC), Suva, Fiji
2. Geoscience Australia, Canberra, Australia

3.1.1 PSLGMP Vertical Reference Frame Wiring Diagram

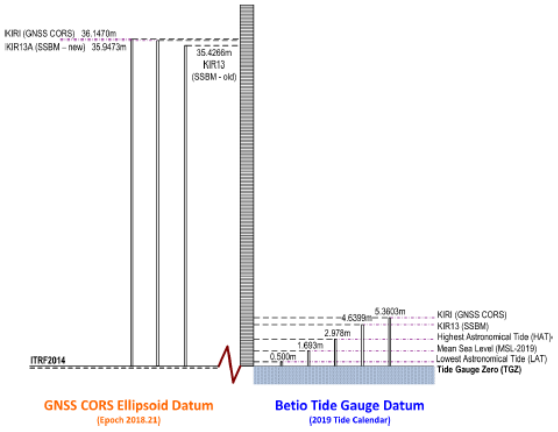


Figure 3.1 Wiring diagram depicting the offsets between surveyed marks. The left-hand side shows the height of the GNSS CORS pillar (KIRI), SEAFRAME sensor reference benchmark (old height; KIR13), SEAFRAME sensor reference benchmark (new height; KIR13A) with respect to the International Terrestrial Reference Frame 2014 at epoch 2018.21. The right-hand side shows the height of KIRI, KIRI13, and tidal datums with respect to tide gauge zero. For more information on tidal datums, please refer to Pacific Sea Level and Geodetic Monitoring Project File information and Instructions (bom.gov.au)

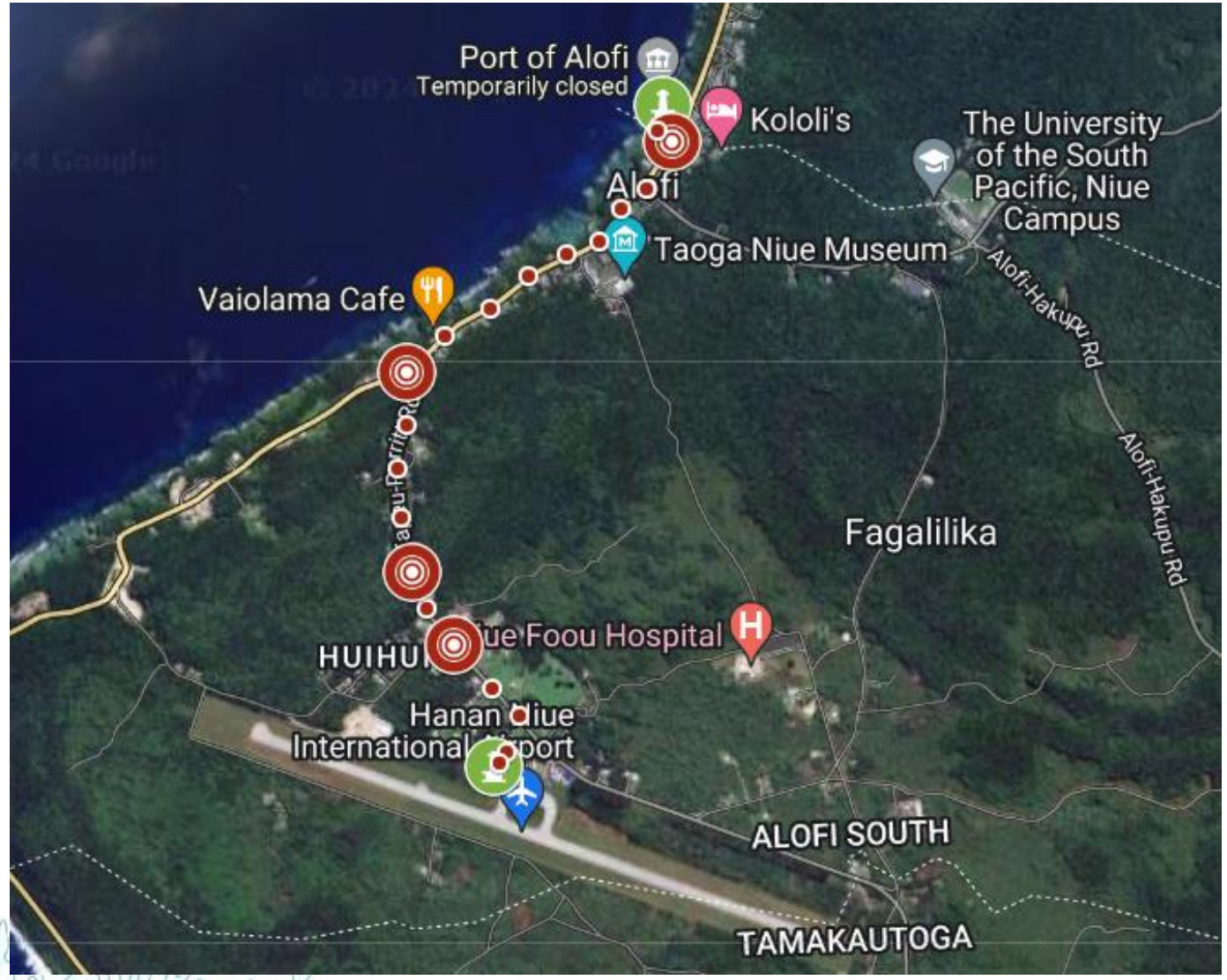
Table 6.1 Comparison of results with 2018 results.

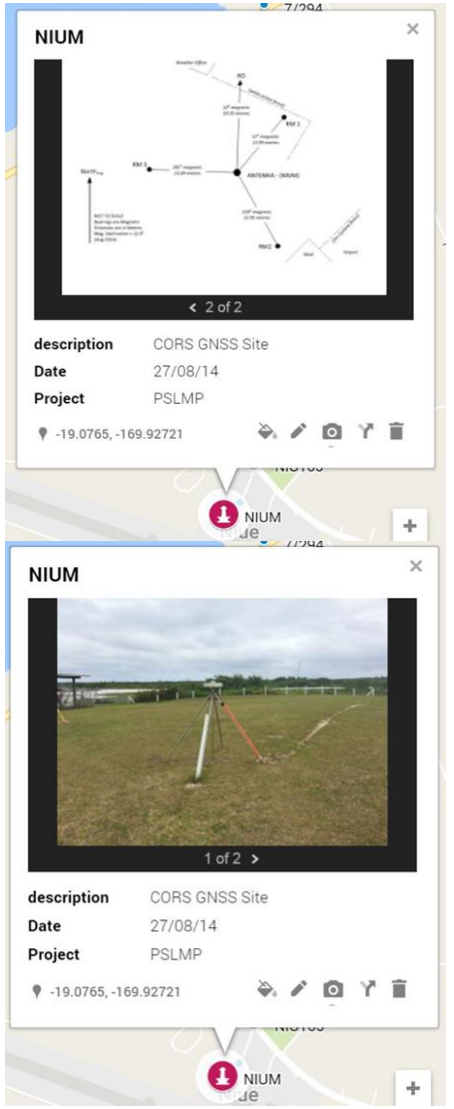
PT ID	Reference ^H (m)	2019.94 Value (m)	Difference
KIRIBM - KIR1	-0.8802	-0.8840	0.0038
KIR1 - TG Plaque BM (KIR12)	0.6871	0.6911	0.0040
KIR1 - TG ref pin (KIR13)	1.0999	1.1065	0.0066
KIR12 - KIR13	0.4128	0.4154	0.0026
KIRI - TG Plaque	-1.1360	-1.1359	-0.0002
KIRI - TG BM	-0.7232	-0.7204	-0.0028
KIRI - TGZ	-5.3533	-5.3505	-0.0028

Table 6.2 List of height differences from KIRIBM to primary benchmarks, and conversion to TGZ & ITRF2014.

PT ID	Reference RL (m)	2019.94 Value (m)	Difference	TGZ	ITRF2014
KIRIBM	0.0000	0.0000	0.0000	4.4174	35.2041
KIR3	-0.8477	-0.8482	-0.0006	3.5692	34.3559
KIR47	-1.1176	-1.1172	0.0004	3.3002	34.0869
KIR2	-1.2299	-1.2319	-0.0020	3.1856	33.9722
KIR46	-1.0333	-1.0344	-0.0011	3.3831	34.1697
KIR1	-0.8802	-0.8840	-0.0038	3.5334	34.3201
KIR49	-0.3900	-0.3924	-0.0024	4.0250	34.8117
KIR12	-0.1931	-0.1930	0.0002	4.2245	35.0112
KIR13	0.2197	0.2225	0.0028	4.6399	35.4266
RM1	-0.8756	-0.8757	-0.0001	3.5417	34.3284
RM2	-0.9129	-0.9129	0.0000	3.5045	34.2912
RM3	-0.8978	-0.8978	0.0000	3.5197	34.3063
KIRI	0.9429	0.9429	0.0000	5.3603	36.1470
KIR13A		0.7432		5.1606	35.9473
TGZ	-4.4104	-4.4076	0.0028	0.0098	30.7965

Geodetic Survey Benchmarks

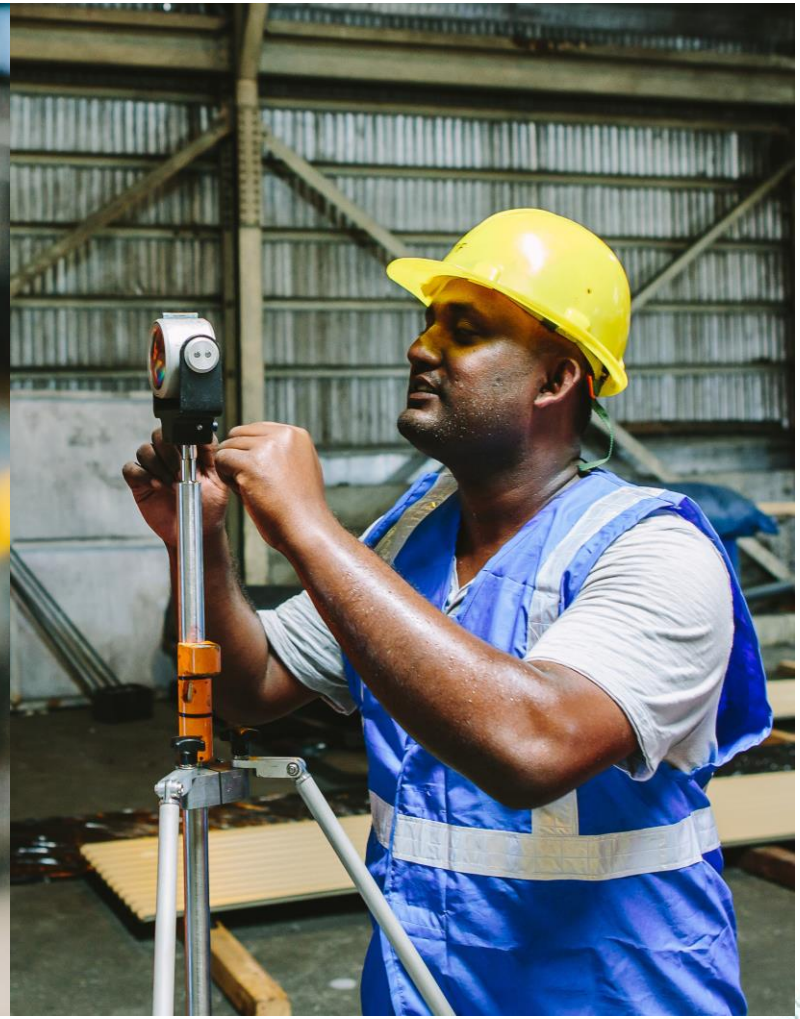




Looking back – Levelling

Digital Level NA 3003 with Invar Starves

Looking now – Levelling



Total Station with Survey Poles

Looking back and now – GNSS CORS

Collaboration

Maintenance and levelling of the Sea Level and GNSS network

The pandemic caused delays to our normal Performance Checks and Upgrades of the sea level network, as well as the Geodetic Levelling from the GNSS pillar to the tide gauge.

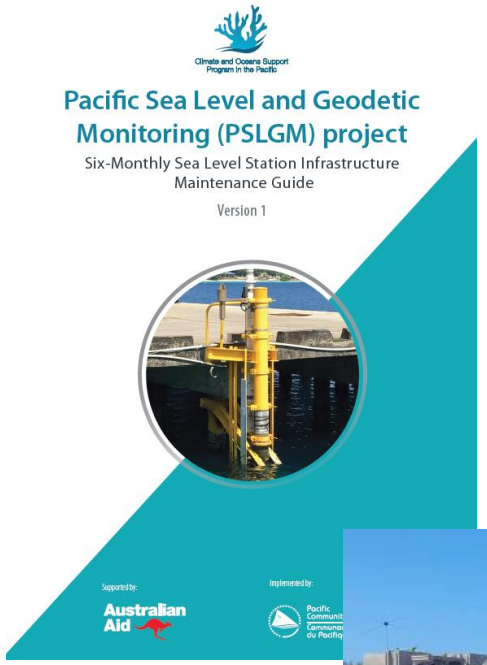
The positive outcome is that the project gained great support from the NMS's and LSD's staff with the 6 Monthly Infrastructure Maintenance to both networks to complete over 100 site visits since 2019. The work with LSD staff has been managed by the SPC survey team to maintain these sites and to be our eyes and ears in your country.

This has increased the local technical and surveyor's capability and built a stronger project partnership.

Also, large part of collaboration between Geoscience Australia and the LSD offices in the last 5 years is the Return To Service assistance with the GA technical desk, which has provided the continued collections of GNSS data.

Collaboration

Maintenance of the Sea Level and GNSS network



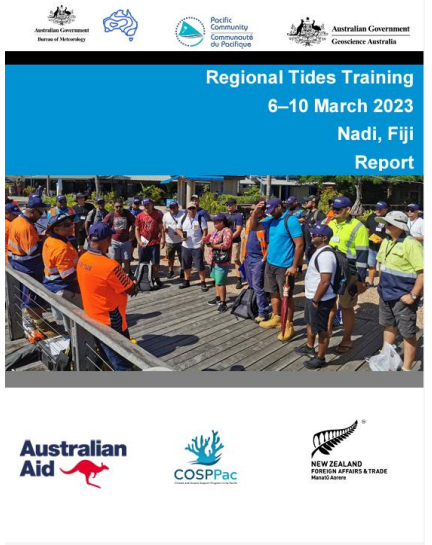
Collaboration

GNSS Refresh Station Upgrades

Capability

First Regional Tides Training

- Training completed in Nadi, Fiji in March 2023
- 41 Participants from 12 countries.
- Field training to demonstrate the installation and commissioning of a portable tide station, which included the recording of manual tide readings every 6 minutes.
- Field training on the use of the survey equipment to record and establish survey benchmarks.
- Visited the Lautoka Sea Level and GNSS COR Station
- Learnt the principles of tidal predictions



Capability

First Regional Tides Training

Initiatives

- Portable tide gauge project to increase tidal predictions for each country over the next 4 years.
- SPC to manage the equipment and siting requirements with NMS's and LSD's.

Achievements

- The Absolute sea level in the Pacific: data and methodology report has been completed. BRR085
- [Absolute sea level in the Pacific: data and methodology (bom.gov.au)]
- [Vertical motion of Pacific Island tide gauges: combined analysis from GNSS and levelling (GA Record 2020/03) (d28rz98at9flks.cloudfront.net)]

Absolute sea level in the Pacific: data and methodology

Jane Warne, Lachlan Nicholls, James Chittleborough, Bill Mitchell, Grant Smith, Herve Damlamian, Zulfikar Begg

September 2023

Vertical motion of Pacific Island tide gauges

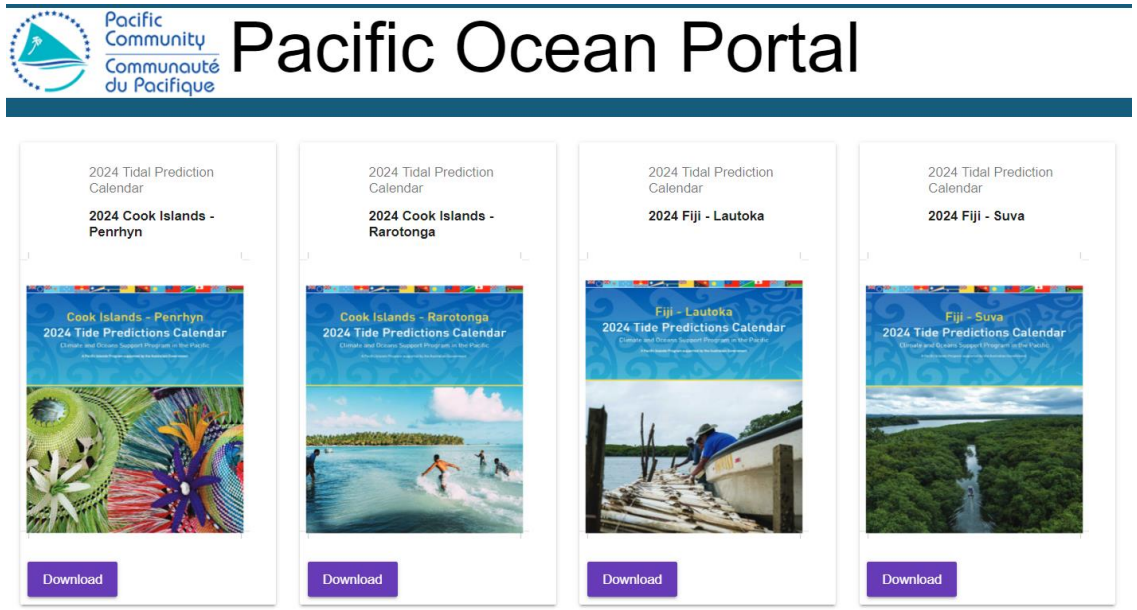
Combined analysis from GNSS and levelling

GEOSCIENCE AUSTRALIA
RECORD 2020/03

N. J. Brown[1], A. Lal[2], B. Thomas[1], S. McClusky[1] and J. Dawson[1], G. Hu[1] and M. Jia[1]

Thank You - Initiatives

- Tidal Calendars [Pacific Ocean Portal (spc.int)]
- COSPPac Pacific Tide App.



Climate and Oceans Support Program in the Pacific