UNITED NATIONS GLOBAL GEODETIC CENTRE OF EXCELLENCE

MODERNISING GEOSPATIAL REFERENCE SYSTEM CAPACITY DEVELOPMENT WORKSHOP

Joining Land and Sea

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HOW

Day 3, Session 2 [3_2_1]

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Joining Land and Sea using geodesy

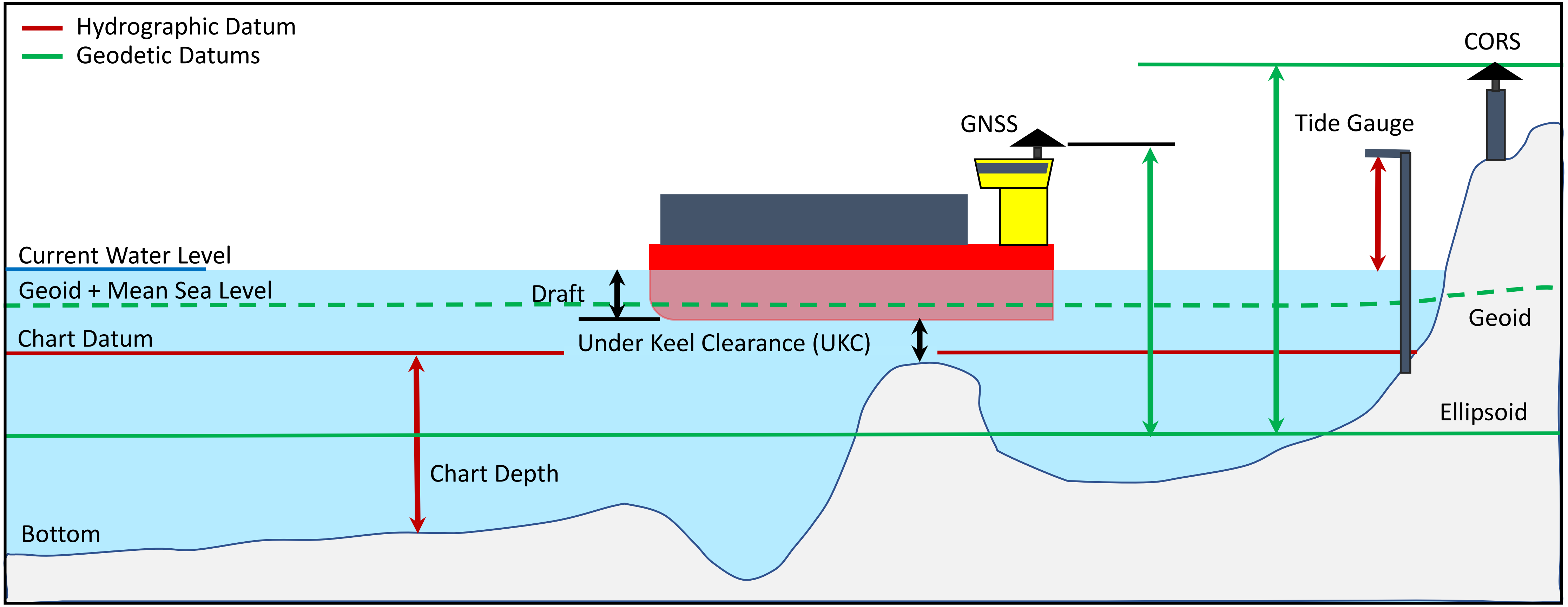
Solution – use the geoid as the primary height reference surface and link all other surfaces (ellipsoid, MSL, HAT, LAT, MDT …) to the geoid.

- POSITIVES
  - Physical height reference surface – water always flows downhill
  - Exists onshore and offshore

  (No other surfaces meet these two criteria)

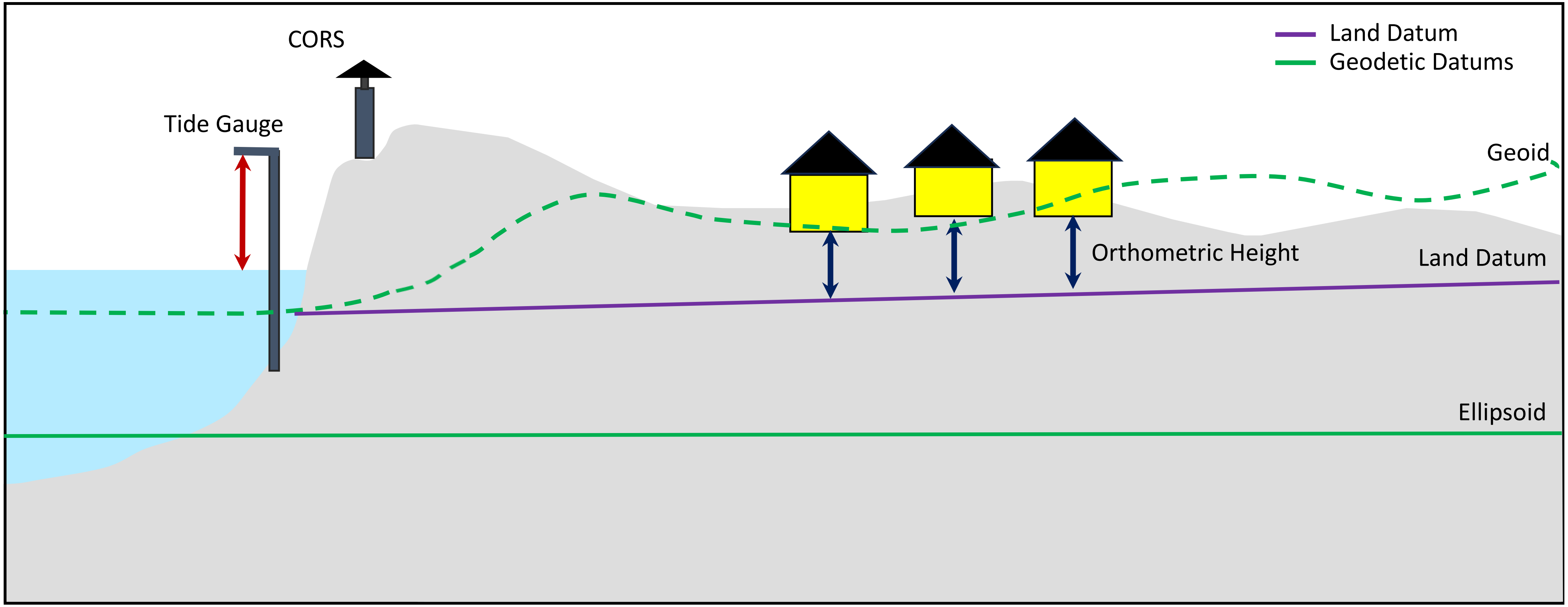
- CHALLENGES
  - Global geoid model has absolute accurate of ~20 cm (relative accuracy is better than this)
  - Local / Regional geoid models require airborne and terrestrial gravity data which can be expensive
  - Development of hydroid models to convert between MSL, LAT etc. and the geoid are challenging (but necessary for every primary reference surface)

The Sea

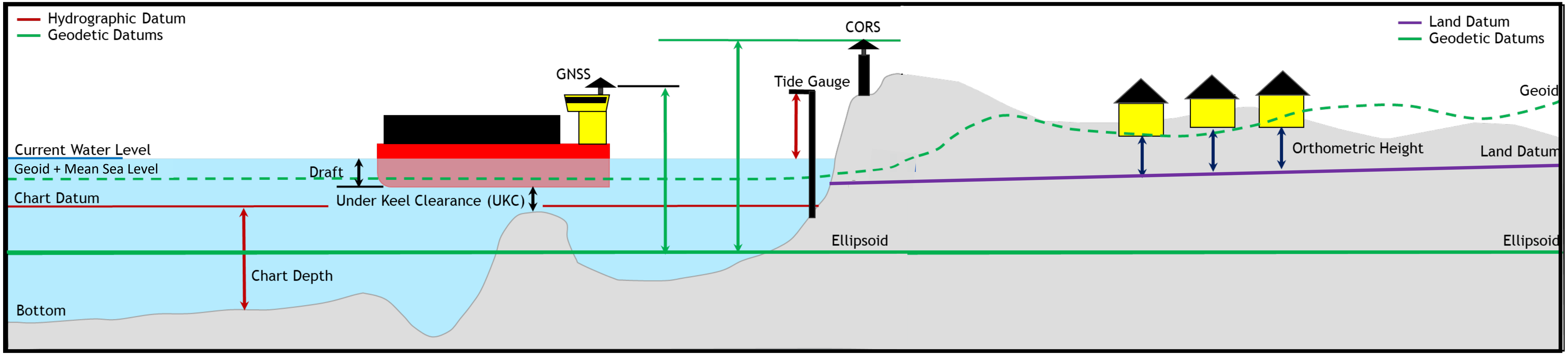


Hydrographic Datum
Geodetic Datums
CORS
GNSS
Tide Gauge
Current Water Level
Geoid + Mean Sea Level
Draft
Chart Datum
Under Keel Clearance (UKC)
Geoid
Ellipsoid
Chart Depth
Bottom

The Land


CORS
Land Datum
Geodetic Datums
Tide Gauge
Geoid
Orthometric Height
Land Datum
Ellipsoid

Joining Land and Sea using geodesy



STRONGER.
TOGETHER.

Example: Pacific Island Countries

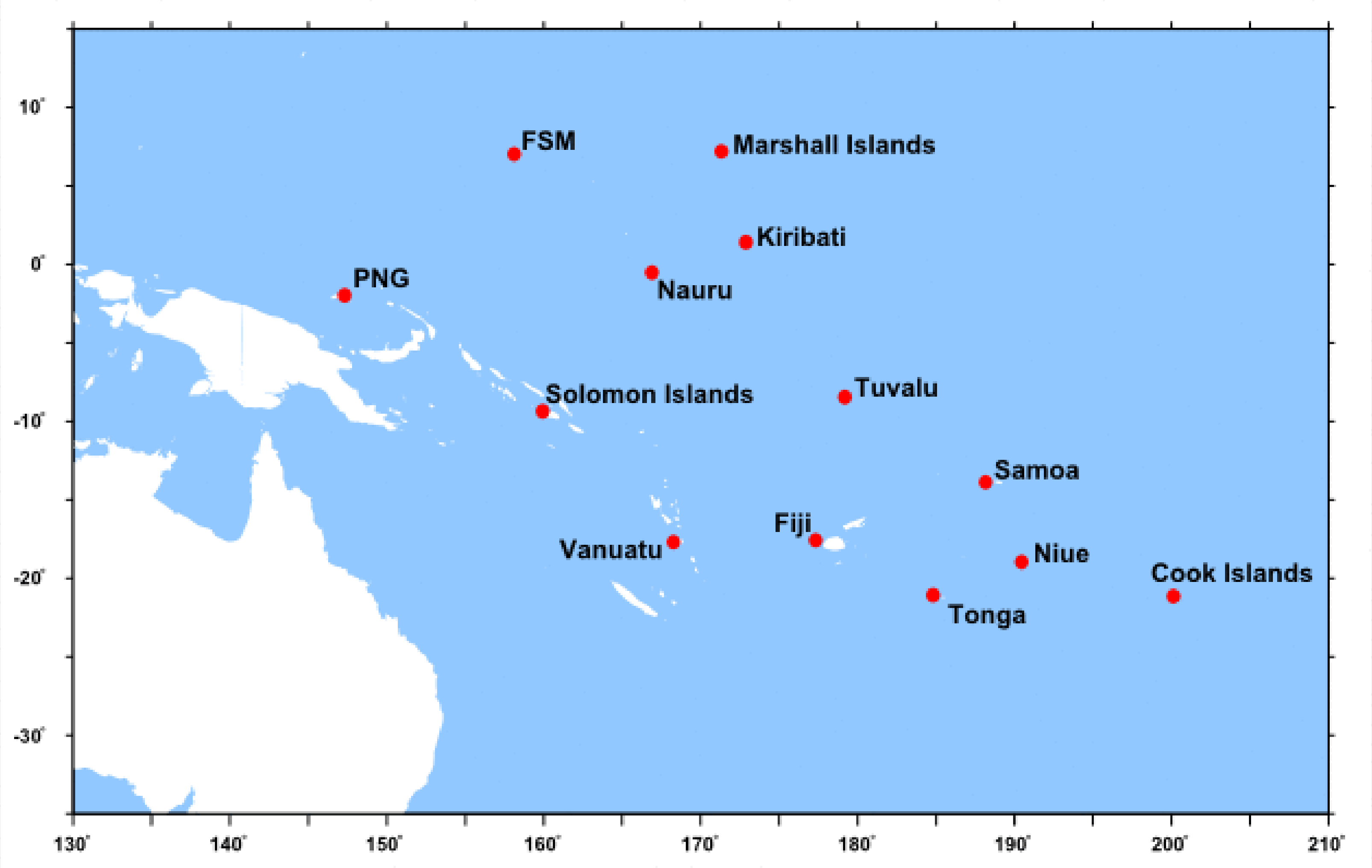


Figure 1: The 13 Pacific Island countries hosting both GNSS and tide gauge infrastructure are the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Nauru, Niue, Papua New Guinea, Republic of Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

- Australia has been supporting 13 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) project which is 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 in each of the 13 PICs. The land motion data is collected continuously at one or two Global Navigation Satellite System (GNSS) stations in each of the 13 PICs.

- The height difference between the tide gauges and GNSS stations is observed once every 18 months (approximately). The data is then analysed to produce sea level information-based products (e.g. tide calendars) and to inform about motion of the land (e.g. for coastal infrastructure

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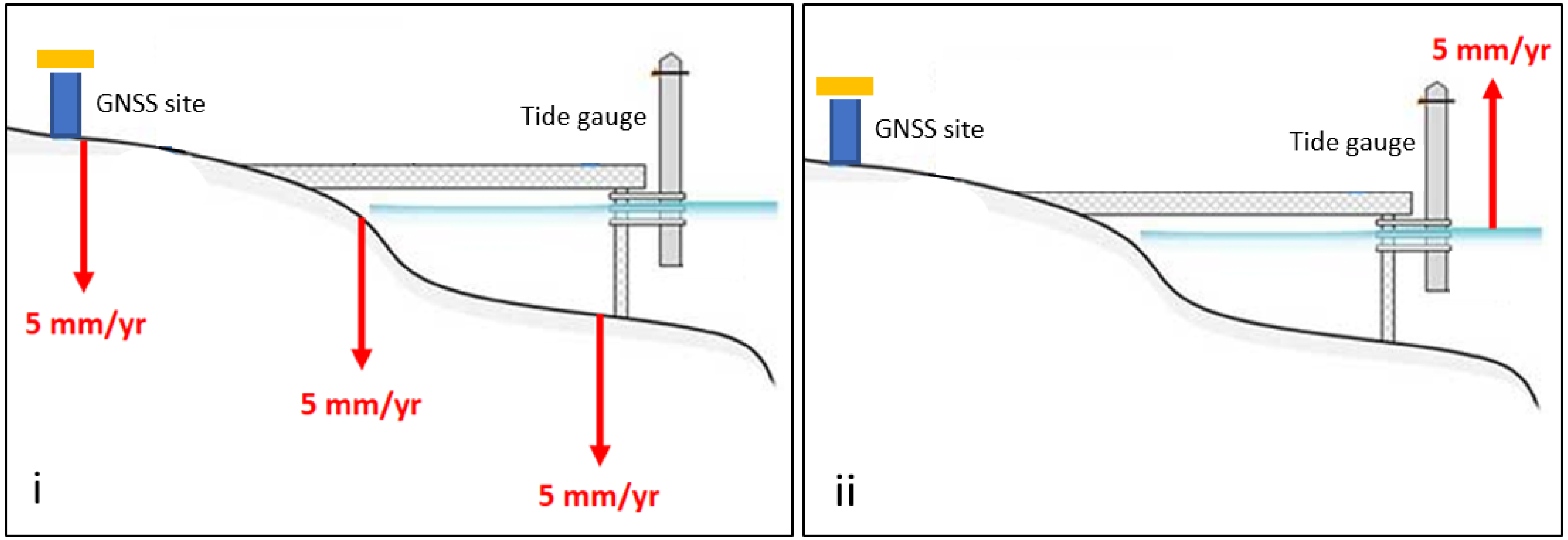
Example: Pacific Island Countries

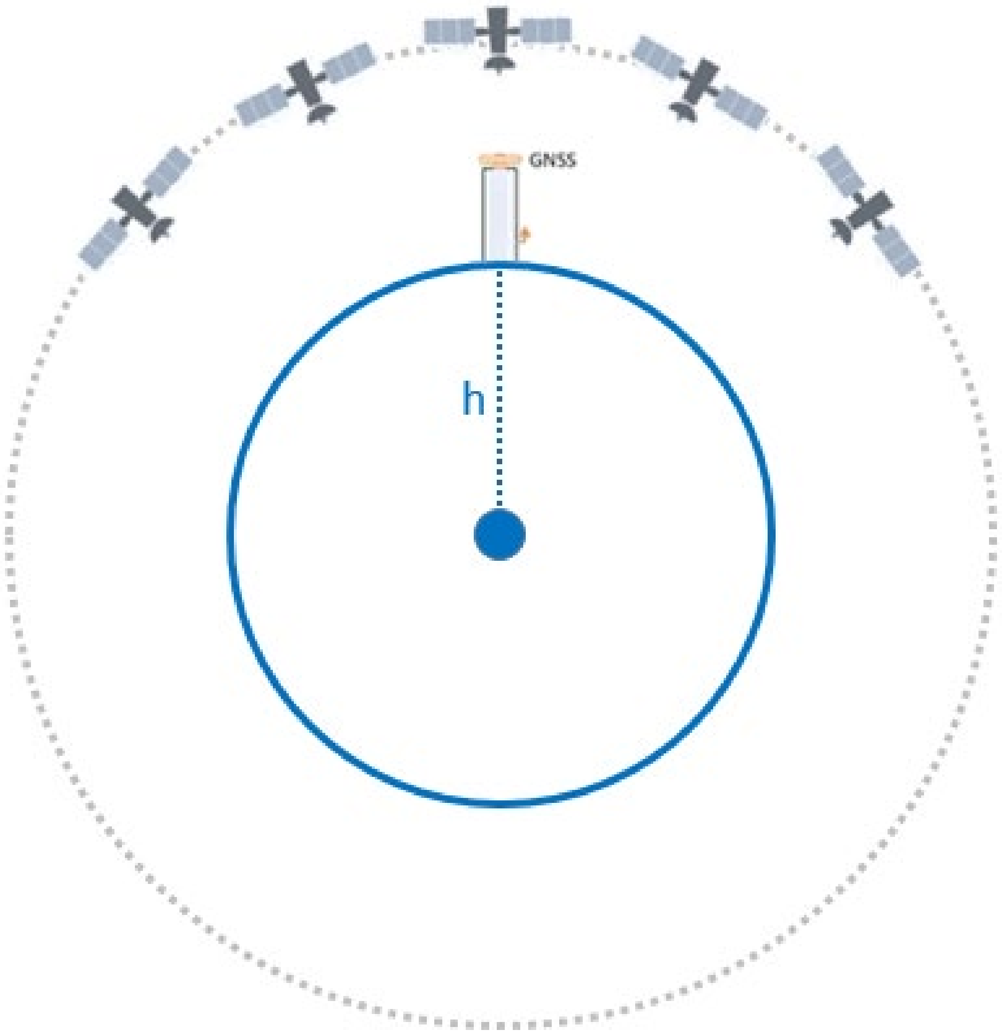


[i] land subsiding at a rate of 5 mm/yr with no change to absolute sea level; [ii] absolute sea level rising by 5 mm/yr and no movement of the land.

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, the sea level is rising by 5 mm/yr, or some combination of both.

Example: Pacific Island Countries



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 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.

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Example: Pacific Island Countries

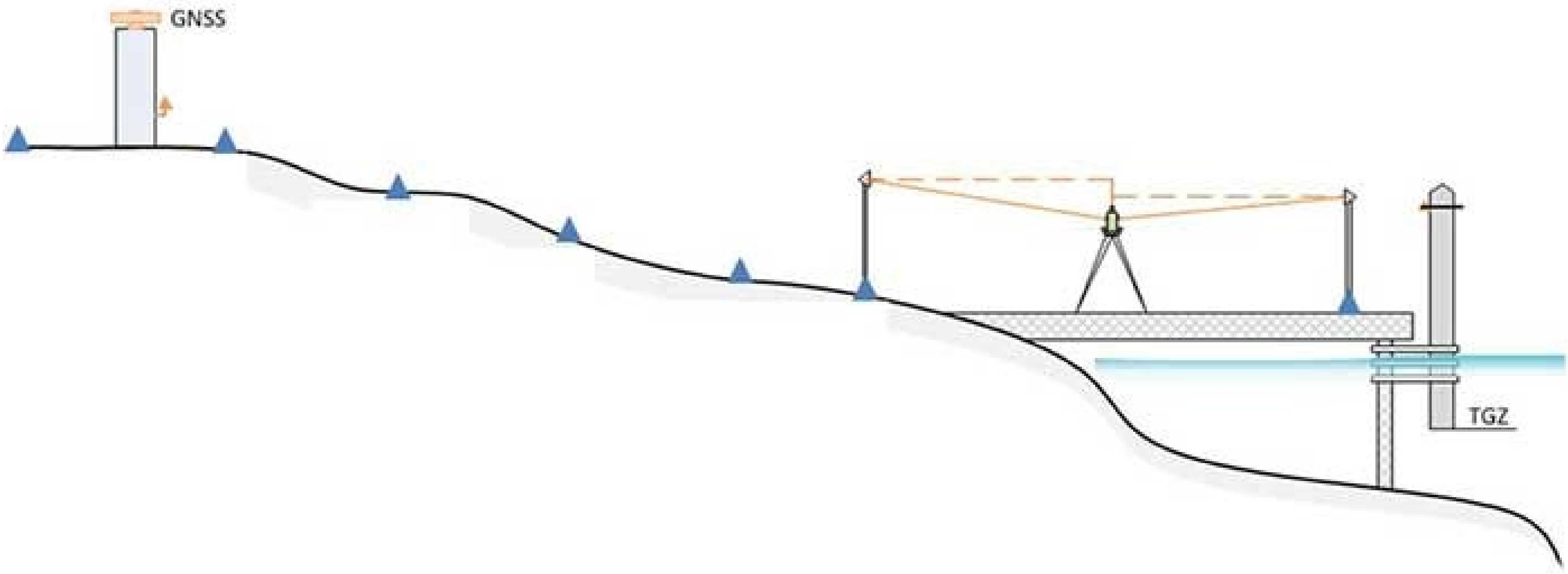

Figure 6: Levelling is undertaken every 18 months to compute the difference in height between the GNSS site and tide gauge. The blue triangles represent stable survey marks in the ground. Observations are made between each of the survey marks and added together to compute the difference in height between the GNSS site and tide gauge.

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4.7 Samoa

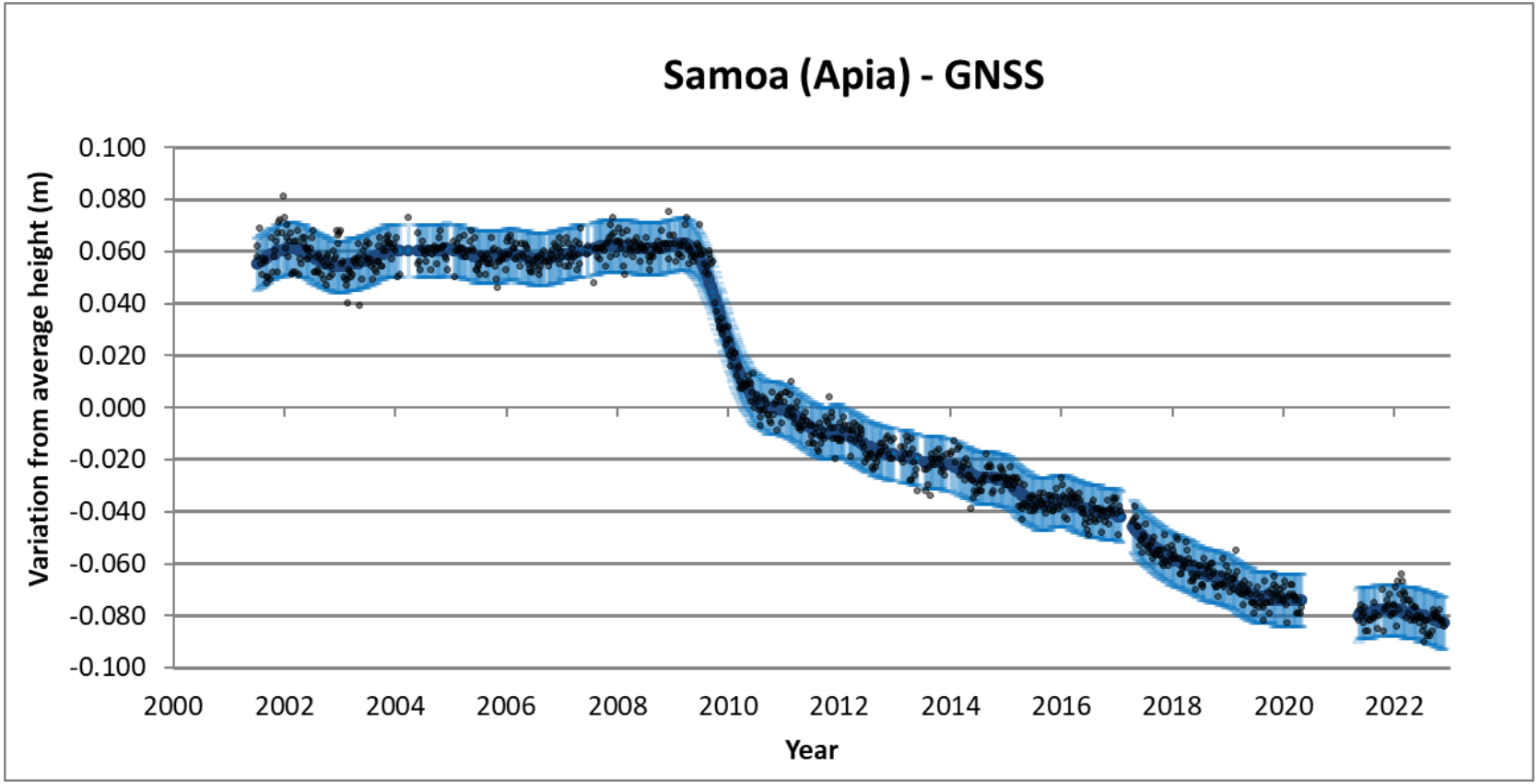

Figure 19: Change in the height of the GNSS site with respect to the centre of the Earth. The grey dots are the height of the GNSS site every week with respect to the centre of the Earth. The dark blue line is a smoothed representation of the weekly data and the light blue error bars show the 95% Confidence Interval.

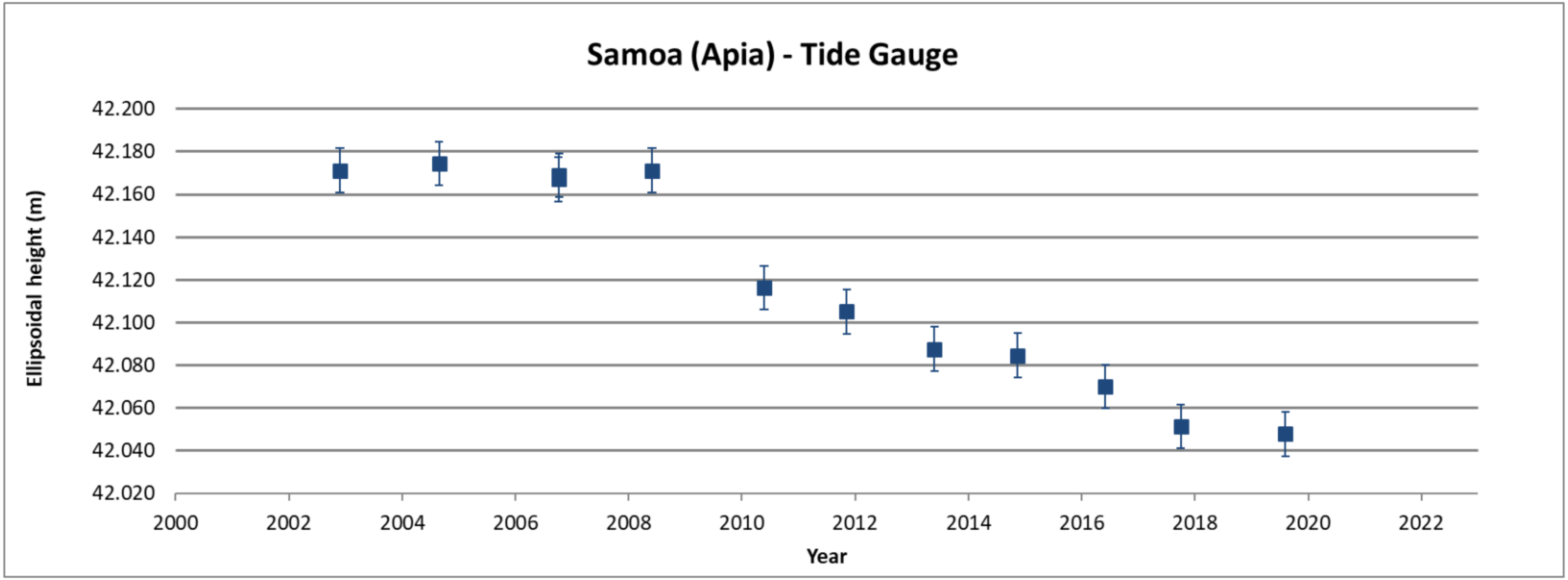

Figure 20: Change in the ITRF2020 ellipsoidal height of the tide gauge. The error bars show the 95% Confidence Interval.

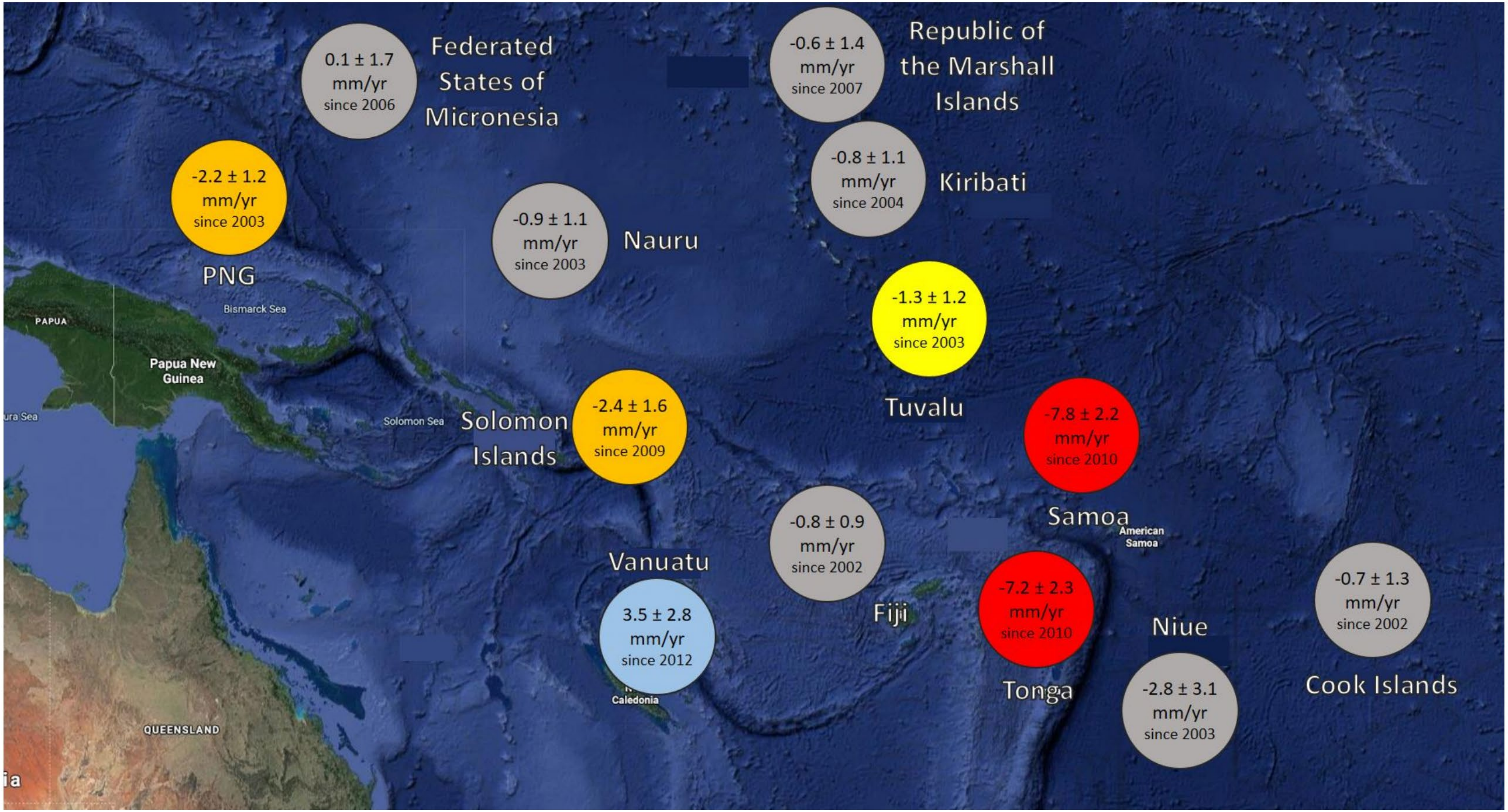

Figure 1: Absolute vertical rate of movement of the tide gauge in Pacific Island countries. For example, in Solomon Islands, -2.4 mm/yr represents the rate of movement of the tide gauge and ± 1.6 mm/yr represents the uncertainty in the rate of movement. Grey circles represent sites which have an absolute 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.