Joining Land and Sea using the Global Navigation Satellite System (GNSS)

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Joining Land and Sea using a Single GNSS station

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Tide gauges measure relative sea level

There is a need to tie tide gauges with GNSS

- Colocation of tide gauges and GNSS
- GNSS within a few kilometers of tide gauges

An acoustic tide gauge monitors the harbor at Burnie on the northern coast of Tasmania, Australia. To its right, a special pillar has a GNSS antenna on top. Credit: © Commonwealth of Australia (Geoscience Australia) 2016.

https://eos.org/opinions/why-we-must-tie-satellite-positioning-to-tide-gauge-data

Coastal GNSS stations can be used as ‘absolute’ tide gauges

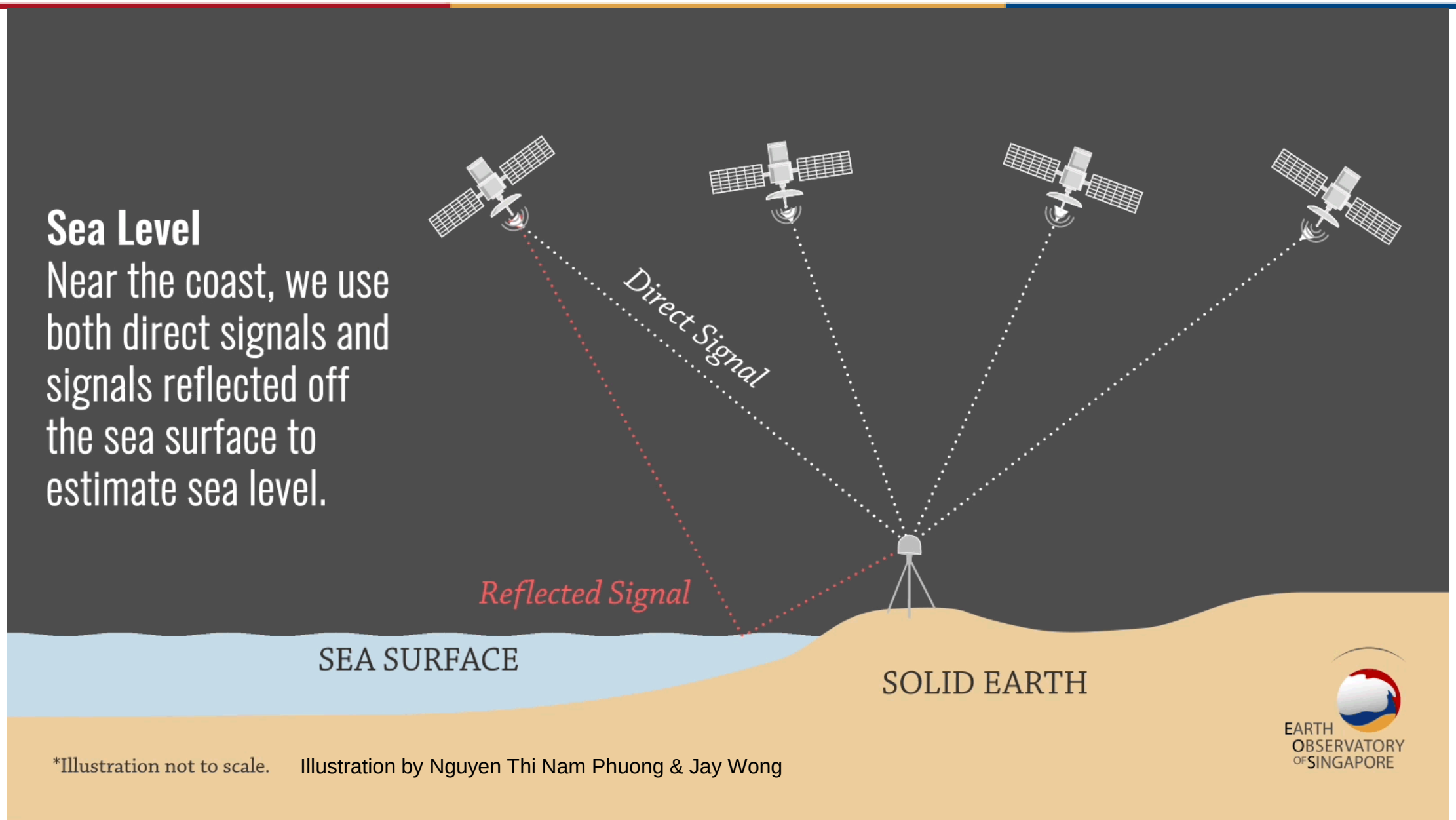
EOS GNSS station in Taiwan

EOS GNSS station in Singapore

https://www.ntu.edu.sg/news/detail/harnessing-satellite-tech-to-study-changes-in-land-height-and-sea-levels

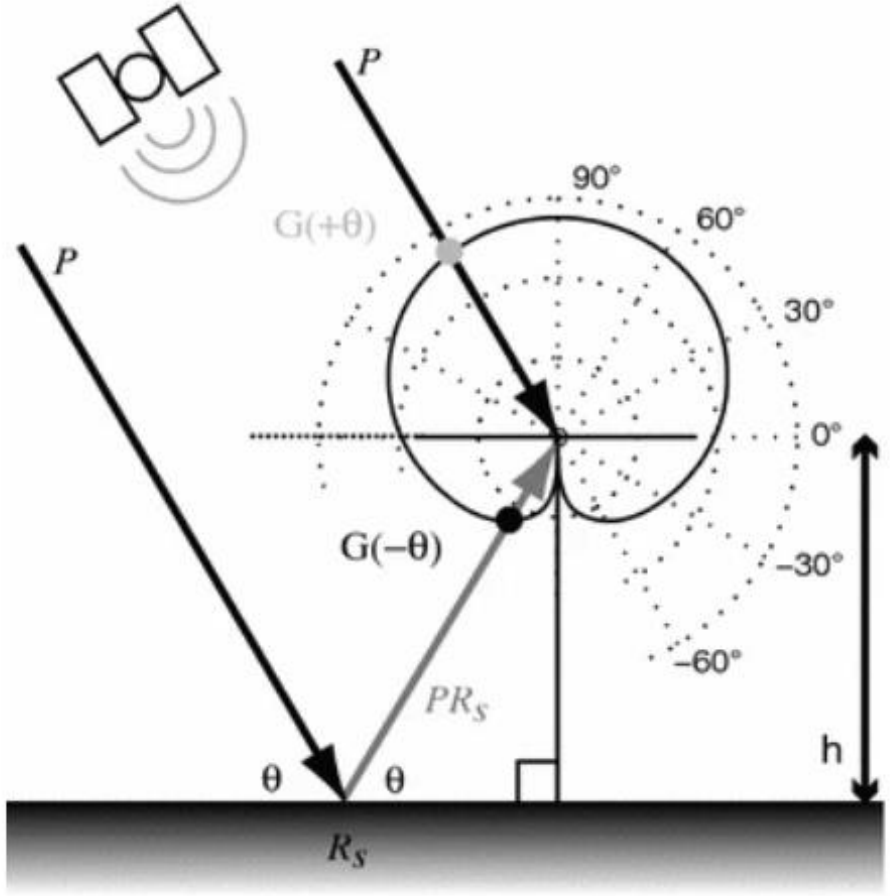
Photo by Pyae Sone AUNG

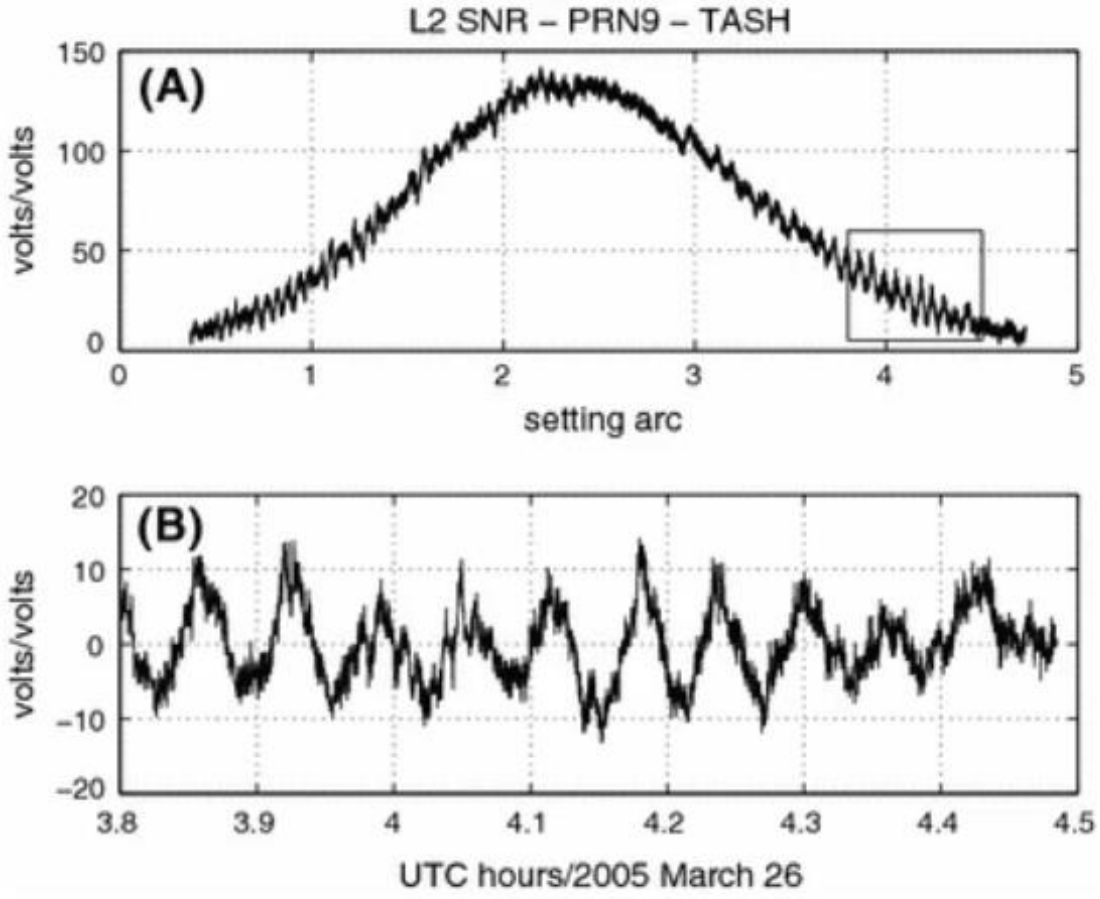
GNSS Interferometric Reflectometry (GNSS-IR): Use reflected signals to measure sea level



GNSS-IR uses multipath signals to measure sea level

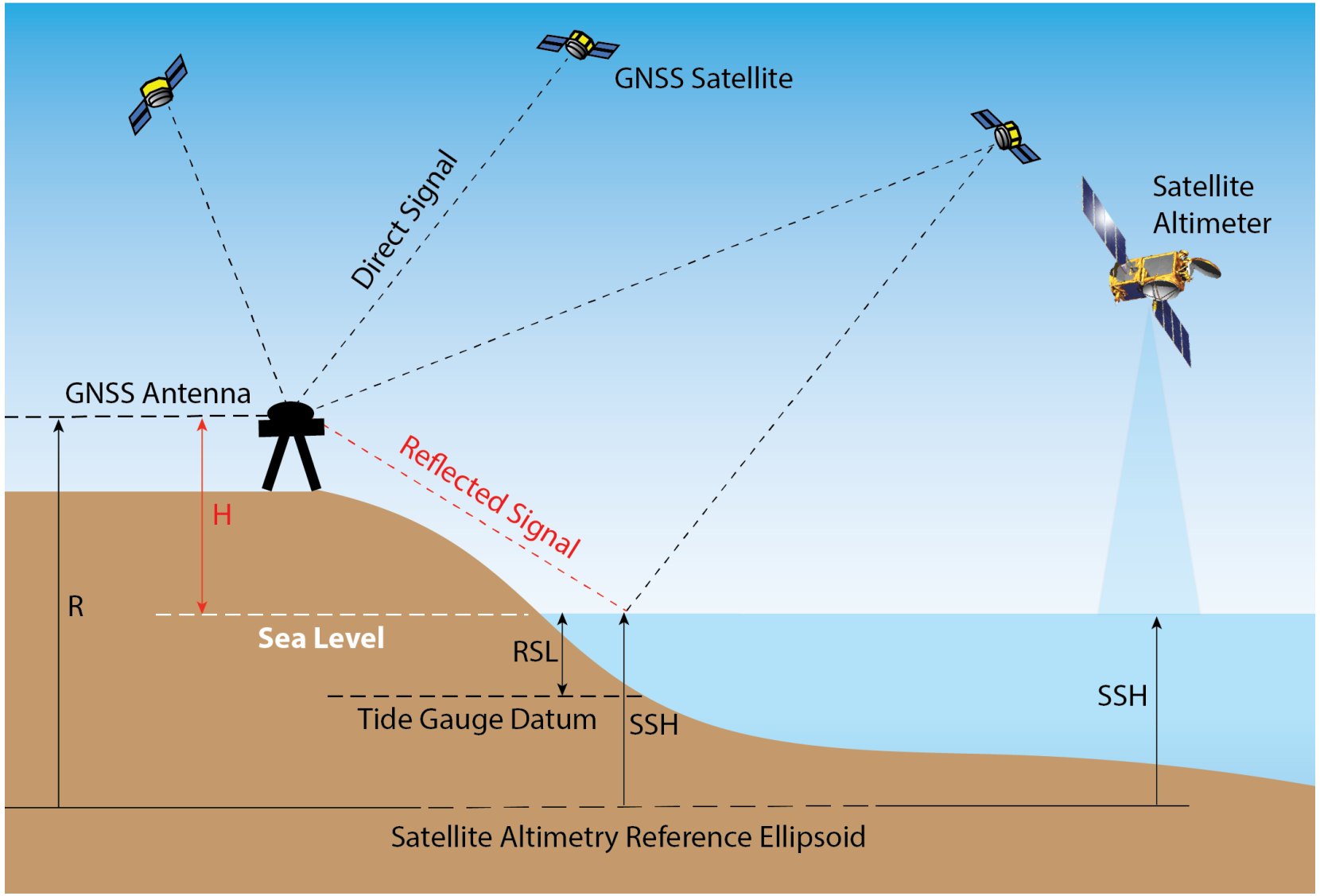
The GNSS signals may bounce off other surfaces before arriving at the antenna. This results in multipath “noise”. Multipath causes oscillations in the GNSS signal-to-noise ratio (SNR) data at low elevations.





Larson et al., 2008

A single GNSS station can measure both vertical land motions and sea level changes



GNSS-IR – Relative sea level

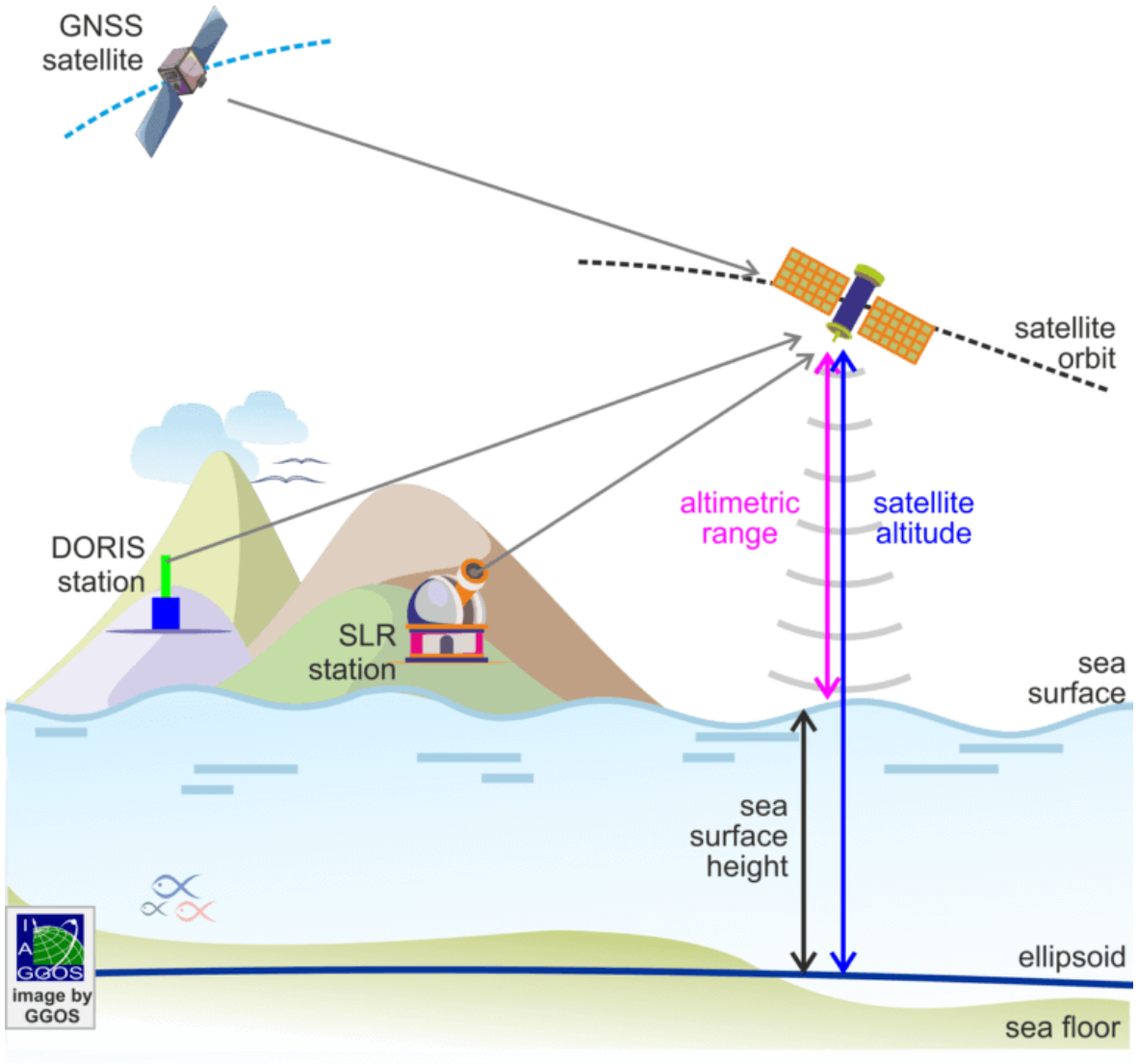
GNSS positioning – Vertical Land motions

GNSS & GNSS-IR – Absolute sea level

Sea Surface Heights
SSH = R - H

Peng et al. 2021

Satellite Radar Altimetry



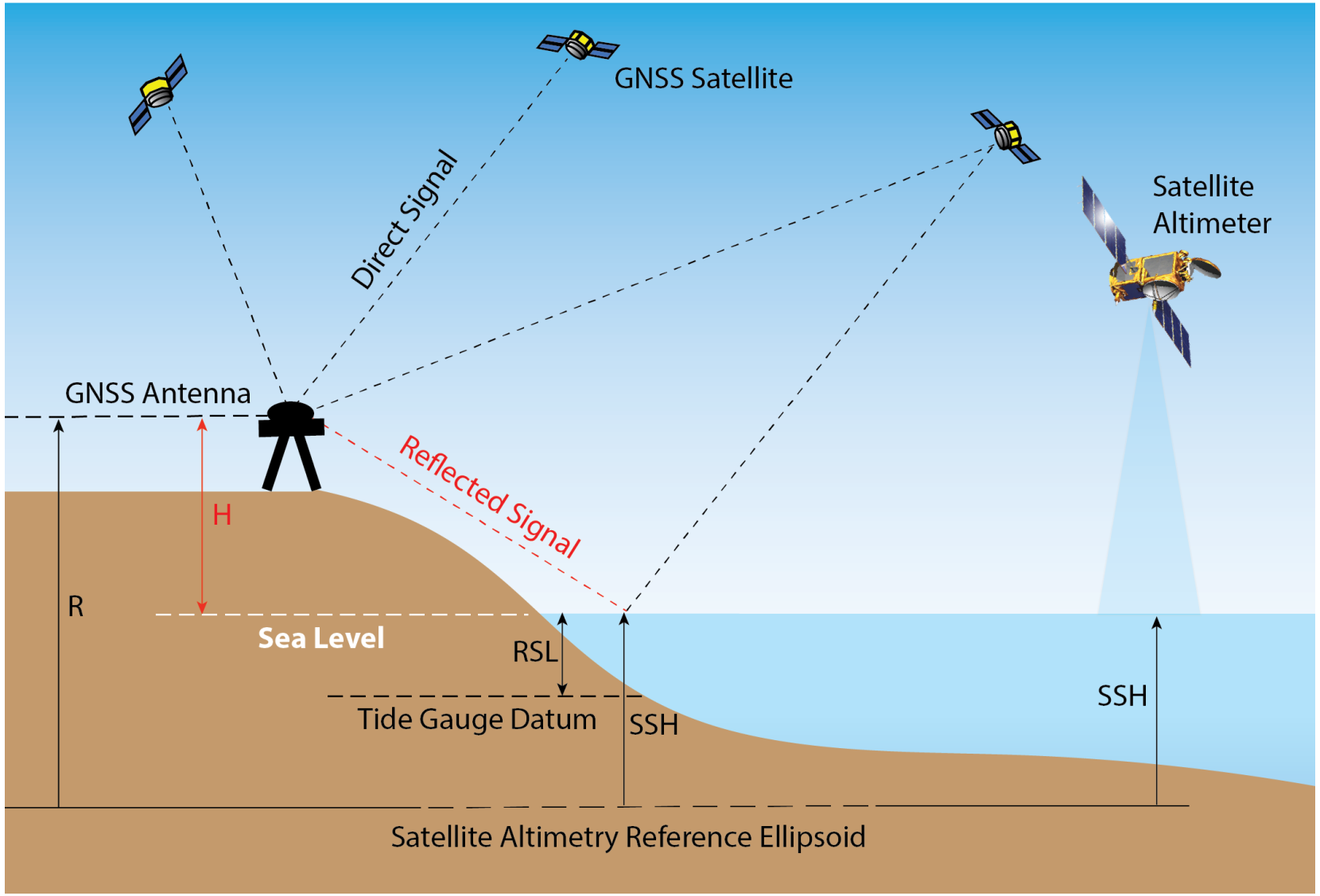
https://ggos.org/item/satellite-altimetry/

Satellite altimeters measure the distance between the satellite and the sea surface, providing global sea level data.

- **Strengths**: Satellite altimetry measures absolute sea level change for the whole ocean.
- **Limitations**: Record since only 1992 and doesn't measure day-to-day changes in sea level.

https://earth.gov/sealevel/about-sea-level-change/how-we-measure/dive-deeper/

A single GNSS station can measure both vertical land motions and sea level changes



GNSS-IR – Relative sea level

GNSS positioning – Vertical Land motions

GNSS & GNSS-IR – Absolute sea level

Sea Surface Heights
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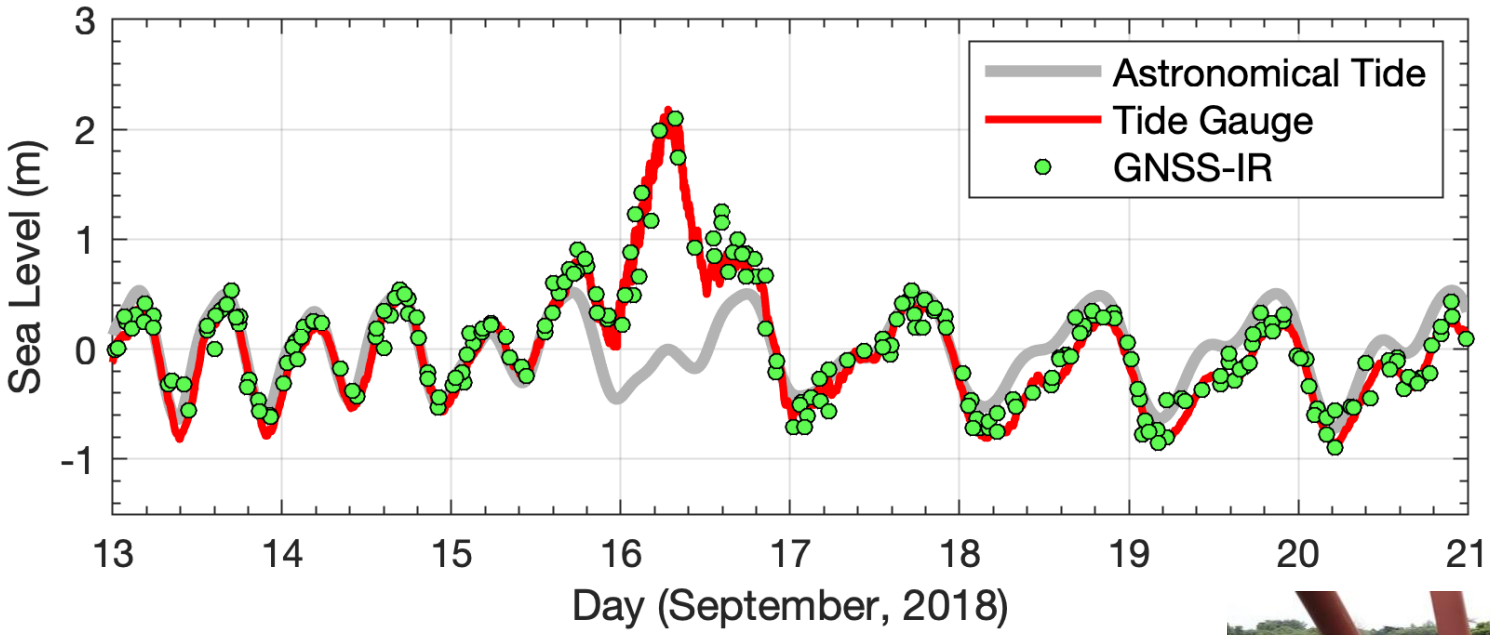
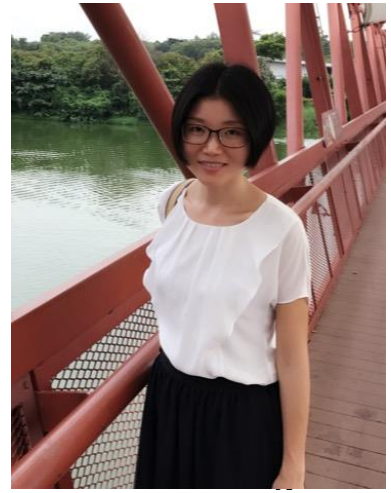
Peng et al. 2021

GNSS-IR can measure storm surges



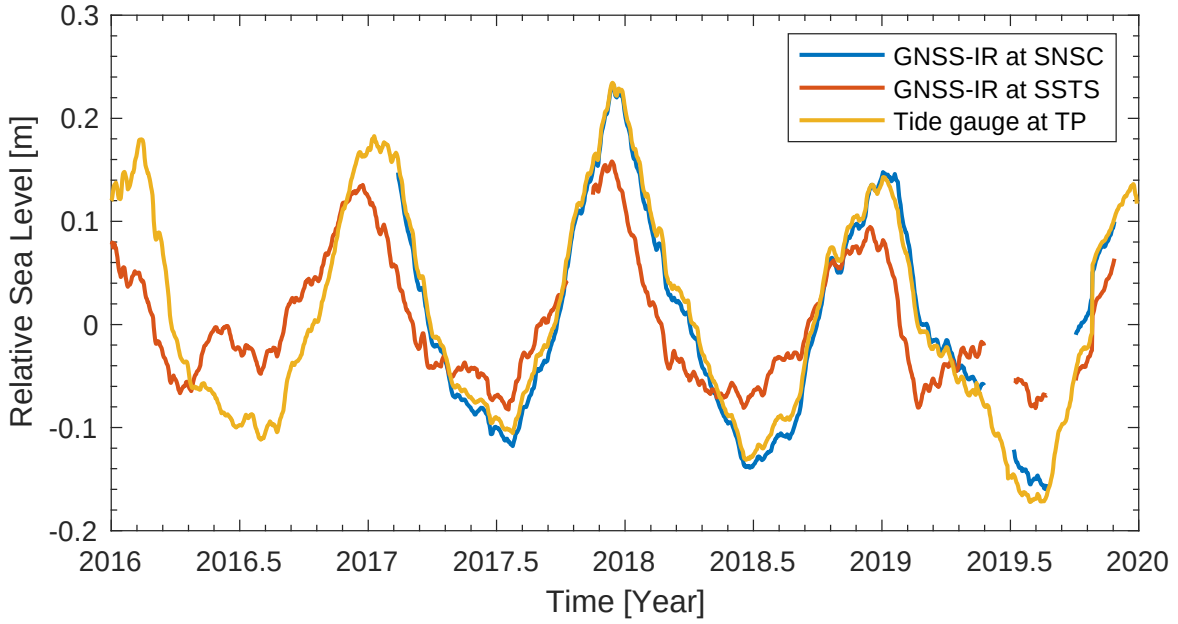
GNSS reflection data recorded the storm surge from Typhoon Mangkhut, which hit Hong Kong on 16 September 2018.

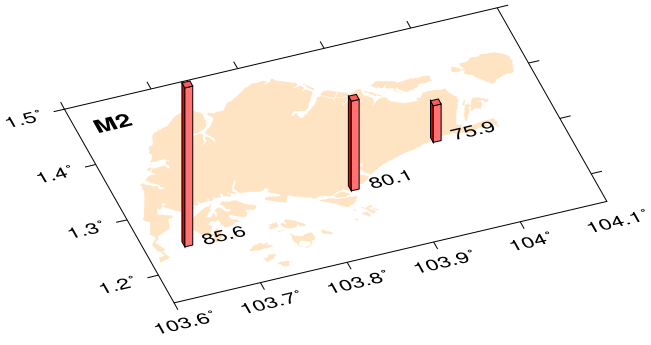
Peng et al. 2019

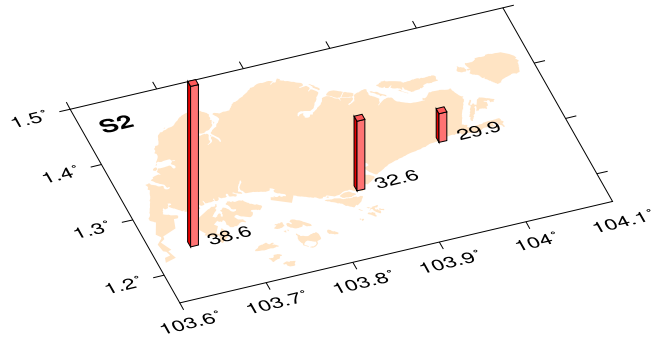


Dr Dongju PENG

SiReNT sea-level observations reveal tidal transition and monsoon effects in the Singapore Strait

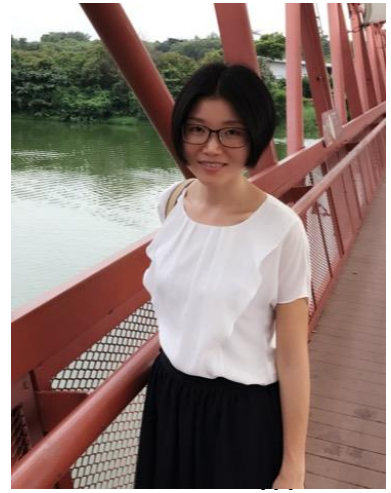






SiReNT - Singapore Satellite Positioning Reference Network by the Singapore Land Authority (SLA)

Peng et al. 2023



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GNSS-IR can play a useful role in joining land and sea

Tide Gauges

Satellite Altimetry

GNSS positioning & GNSS-IR

The Geoid

A Unified Global Height System

Many GNSS-IR stations already exist in Indonesia

Sea-level variations from co-located tide gauge and GNSS stations using GNSS-Reflectometry in Indonesia

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Evaluation of GNSS reflectometry method for sea level estimation in Indonesia

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Analysis of Water Level Monitoring using GNSS Interferometric Reflectometry in River Waters

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Syetiawan et al. 2022

Build a stronger GNSS geoscience community in Southeast Asia

2022 Geodesy Short Course: **GNSS Interferometric Reflectometry (GNSS-IR)**