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Report on Sea Level Observing Activities in Hong Kong, China

Dickson D. S. Lau

Hong Kong Observatory

Address: 134A Nathan Road, Kowloon, Hong Kong, China

Tel.:+852 2926 8245, Fax:+852 2302 4521. Email: dslau@hko.gov.hk

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1. Introduction

Hong Kong is located on the coast of southern China. The eastern side of Hong Kong is open to influences of the coastal cold current that carries colder water from the East China Sea along the Taiwan Strait to the south China coast in winter, and the Kuroshio current that transports warm water from the Pacific across the Luzon Strait into the South China Sea in springtime. During summer months, the Hainan current that carries warm water up to the northeastern coast of the South China Sea prevails. The western side of Hong Kong is at the Pearl River Estuary. Fresh water discharge via the Pearl River Estuary and sedimentation distribution at the Estuary exert an influence on the Hong Kong waters. This influence declines from west to east. The western part of Hong Kong waters is estuarine while the eastern part is predominantly oceanic; between the two is a region of mixing (Wong et al., 2003; Fyfe et al., 2000). Hong Kong is vulnerable to sea flooding due to storm surges associated with the close passage of tropical cyclones over the northern part of the South China Sea. A recent example is Super Typhoon Mangkhut which brought record-breaking storm surge levels and massive flooding to Hong Kong in September 2018 (Figure 1).

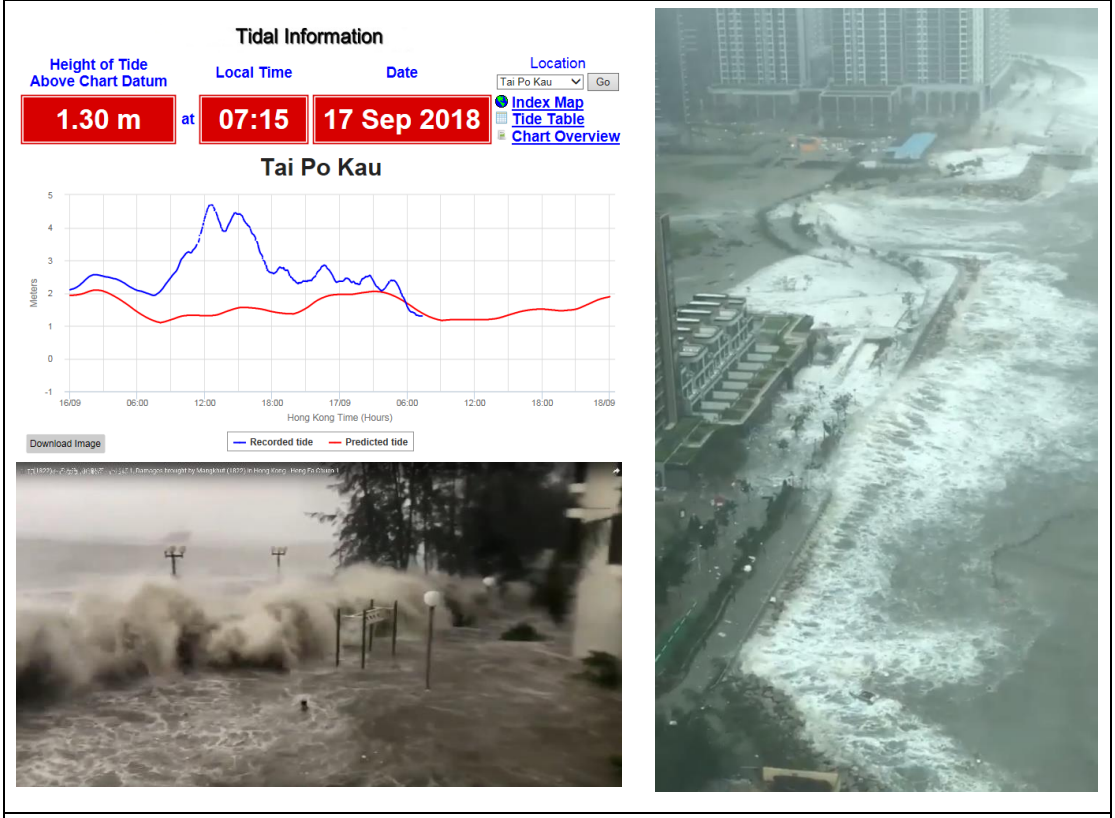

Figure 1. Massive flooding in Hong Kong caused by extreme storm surge due to Super Typhoon Mangkhut in September 2018.

2. Tide Gauge Network in Hong Kong

Tide measurement using automatic tide gauges started in the 1950s. There are twelve tide gauge stations in Hong Kong jointly operated by the Hong Kong Observatory (HKO), Marine Department, Drainage Services Department and Airport Authority Hong Kong (Figure 2). They are used to monitor the tidal variation including storm surge and sea level heights at various locations in Hong Kong. Out of the 12 stations, HKO operates six tide gauges at the following locations: Quarry Bay, Shek Pik, Tai Miu Wan, Tai Po Kau, Tsim Bei Tsui and Waglan Island. The station at Quarry Bay (QUB) measures the sea level of the Victoria Harbour. Combining with the sea level data measured at North Point (NP) which was located about 500 meters to the west of QUB and decommissioned in 1986, the NP/QUB dataset consists of the longest record of over 60 years' measurements and serves as the reference sea level in Hong Kong. QUB is currently registered on the core network of the Global Sea Level Observing System (GLOSS).

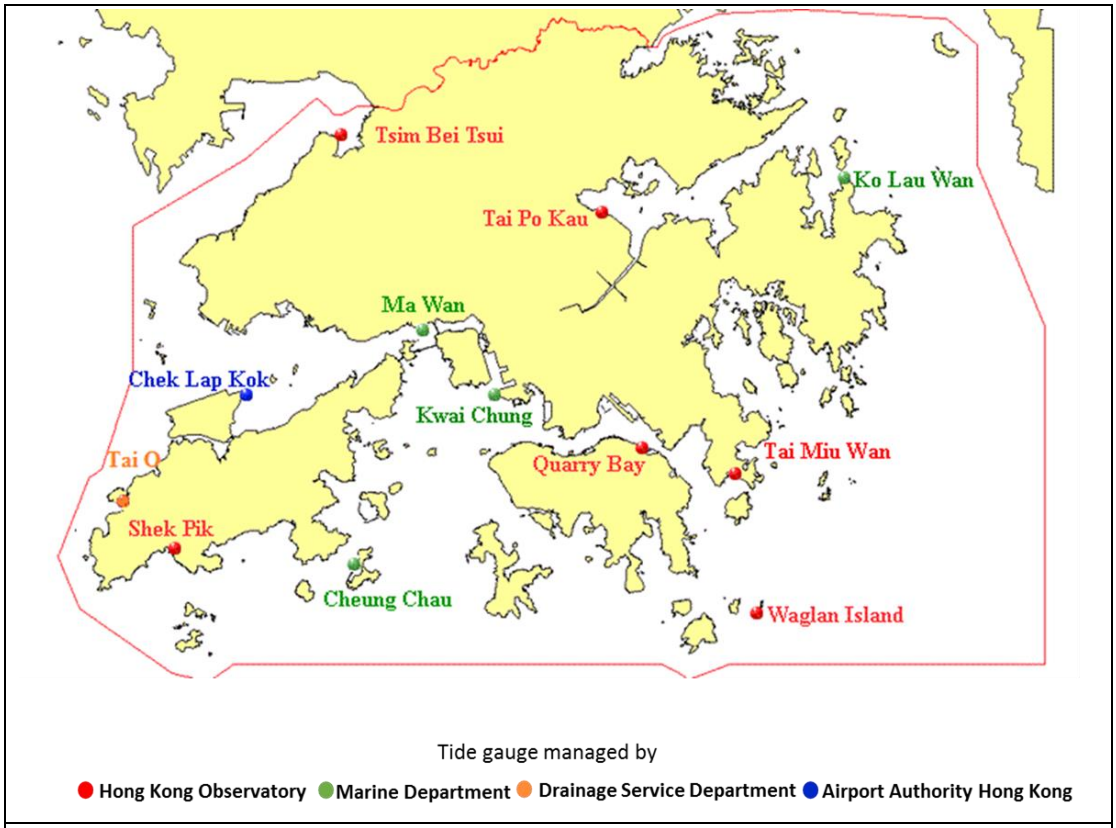

Figure 2. Location of tide gauge stations in Hong Kong.

Table 1: Information on the position of the gauges and the data period

Tide Gauge Station	Position		Tide Gauge Type	Data Available from
	Latitude N	Longitude E		
Quarry Bay (QUB) (GLOSS station)	22°17′28″	114°12′48″	Sea level pressure transducer	Jan 1986[#]
Shek Pik (SPW)	22°13′13″	113°53′40″	Sea level pressure transducer	Jan 1998
Tai Miu Wan (TMW)	22°16′11″	114°17′19″	Sea level pressure transducer	Jan 1996
Tai Po Kau (TPK)	22°26′33″	114°11′02″	Sea level pressure transducer	Dec 1963
Tsim Bei Tsui (TBT)	22°29′14″	114°00′51″	Sea level pressure transducer	Dec 1974
Waglan Island (WGL)	22°10′59″	114°18′10″	Sea level pressure transducer	Dec 1976

[#]The tide gauge at North Point started operation in October 1952. The tide gauge was relocated to Quarry Bay due to reclamation at North Point in 1985.

3. **An overview of Gauge Technology in the Network**

The network of HKO tide gauges consists of two types of sensors, namely pneumatic type and sea level pressure transducer. Located mostly at piers, the tide gauges measure the sea level in metres above the Chart Datum, which is 0.146 metre below the Hong Kong Principal Datum[1]. Data resolution is one minute. Hourly sea level is computed by averaging the last five 1-minute data ending on the hour. Annual mean sea-levels are computed based on available hourly sea level data while other tidal statistics such as highest high water, lowest low water and maximum range are based on available 1-minute data. The tide data are transmitted to HKO at one-minute intervals via telephone circuits or radio links.

4. **An overview of the GNSS Technology in the Network**

With the assistance of the Hong Kong Civil Engineering and Development Department (CEDD), tide gauge benchmarks were installed at HKO tide gauge stations for monitoring land settlement at the stations. The heights of tide gauge benchmarks were measured at half-yearly intervals by precise levelling, a land surveying technique based on trigonometric calculations, against the Hong Kong survey benchmark.

HKO has also been operating two GNSS stations to monitor crustal movement at Shek Pik Tide Station (SPW1) and Tate's Cairn (TC01) since 2006. TC01 station is installed with a Leica GRX1200Pro receiver and high precision GNSS antenna (Leica AT504 until May 2013 and was replaced with AR25 in October 2013). This station, situated on the bedrock of the hilltop of Tate's Cairn, is in continuous operation to transmit hourly data to HKO through the intranet for monitoring the long-term vertical land displacement in Hong Kong. Due to large-scale refurbishment of SPW1, the operation of GNSS measurement at Shek Pik has been suspended since 2017 and is expected to be reinstated upon the completion of site works in around 2020.

5. **An overview of Data Availability**

The real-time tide observation data recorded at the 12 tide gauge stations in Hong Kong are available on "Tidal Information" webpage of HKO website which can be accessed at https://www.weather.gov.hk/tide/marine/realtide.htm. The information is displayed on a GIS-based map with the latest tide heights and time series of all tide gauge stations (upper panel, Figure 3). This information can be used for storm surge, tsunami and long-term sea level monitoring. Tidal predictions for 14 selected locations in Hong Kong for the next three years are posted on the "Predicted Tide" webpage at https://www.weather.gov.hk/tide/predtide.htm. The tidal information is

[1] The datum of Hong Kong survey benchmark, which is about 0.88 metre below the Yellow Sea Datum.

also accessible via HKO's highly popular mobile application "MyObservatory" (bottom panel, Figure 3), and the hourly predicted data in text format can be downloaded from the Hong Kong Government's open data sharing platform DATA.GOV.HK .

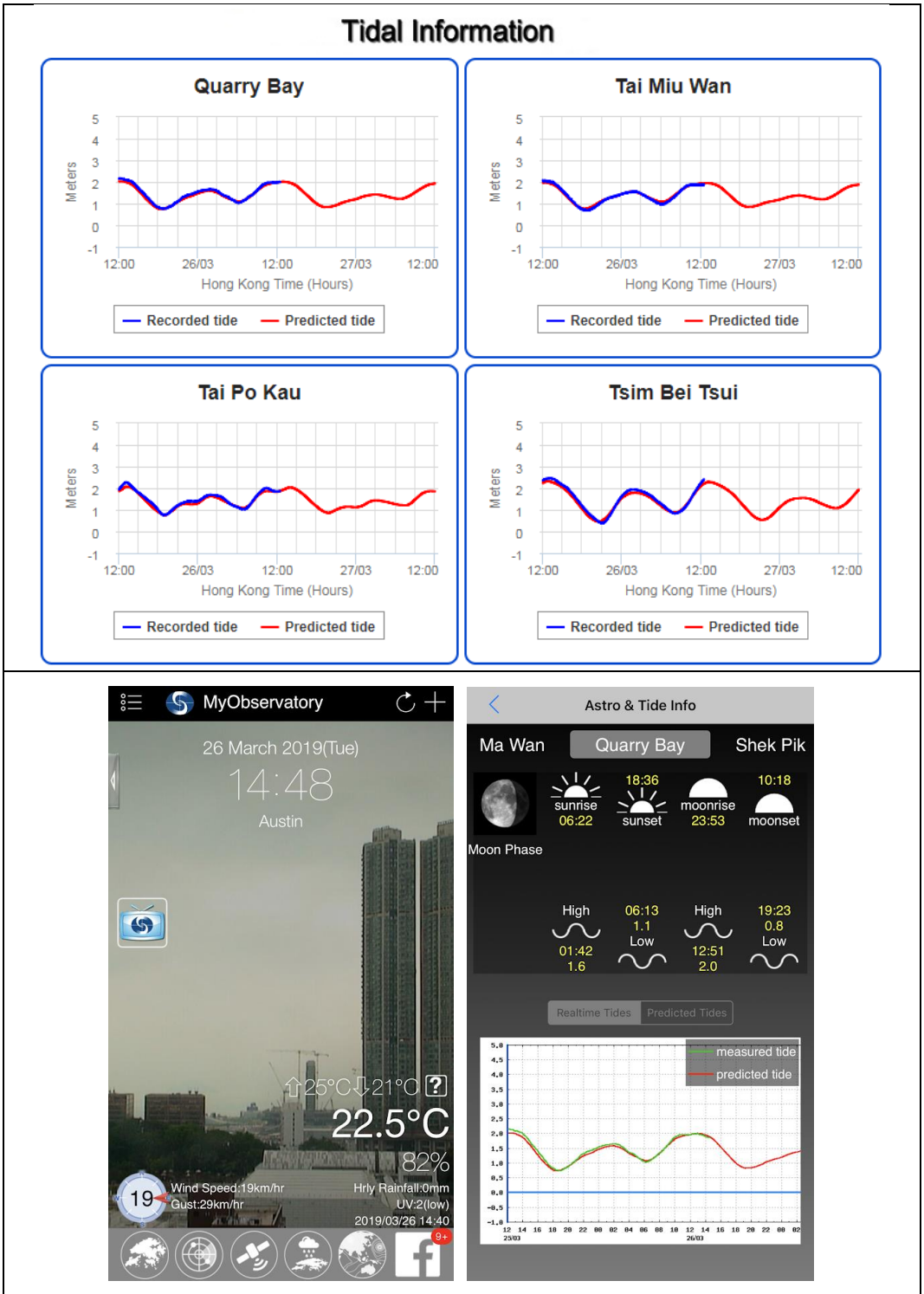

Figure 3. Time-series of real-time tide measurements displayed on HKO website (upper panel) and screenshot of the "MyObservatory" mobile application showing the tidal information at Quarry Bay (bottom panel).

6. **Monitoring of Long-Term Sea Level Change**

Tide gauge records in Victoria Harbour since 1954 demonstrate an unambiguous rise of the mean sea level during this period. There was a rise of the sea level from 1990 to 1999 and a moderate decline thereafter. The trend is similar to that observed by satellite remote sensing over the South China Sea and that recorded by tide gauges at other coastal stations in the region. On average, the mean sea level in Victoria Harbour rose at a rate of 31 mm per decade during 1954-2018 (Figure 4).

Arising from global warming, the annual mean sea level in Hong Kong and its adjacent waters are expected to rise by 0.63 - 1.07 m in 2081-2100 relative to the average of 1986-2005 under the high greenhouse gas concentration (He et al., 2016).

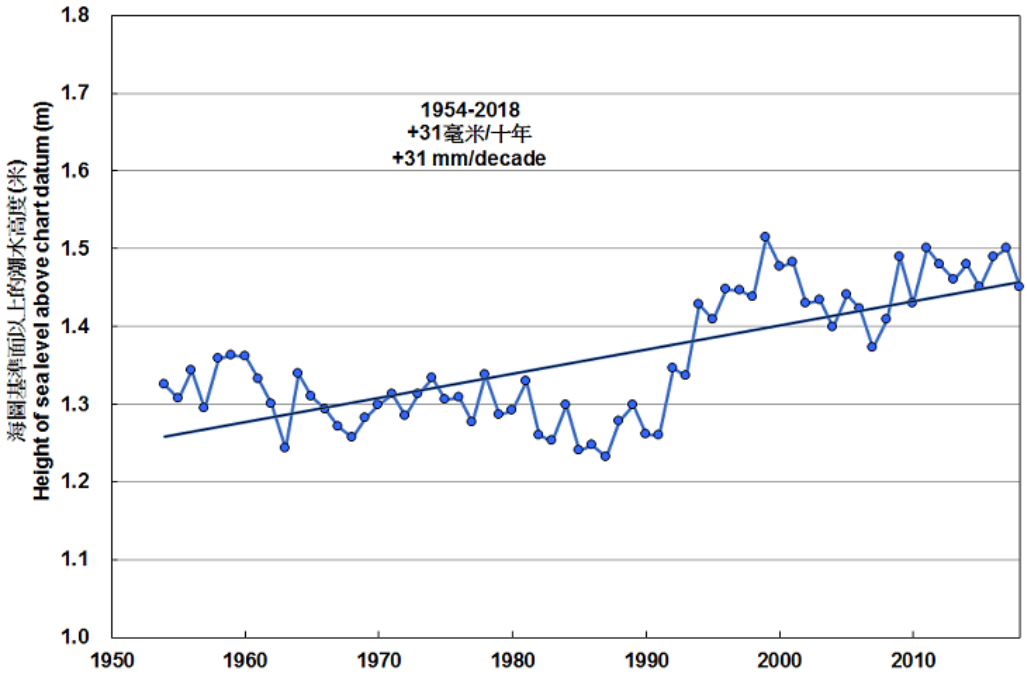

Figure 4. Annual mean sea level at Victoria Harbour (1954-2018).

References:

Fyfe, J.A., R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk, 2000: The Quaternary Geology of Hong Kong (2000), Civil Engineering and Development Department of the Government of the Hong Kong Special Administrative Region.

He, Y.H., H.Y. Mok, and Edwin S.T. Lai, 2016: Projection of sea-level change in the vicinity of Hong Kong in the 21st century, Int. J. Climatol. 36: 3237-3244, doi:10.1002/joc.4551.

Wong, W.T., K.W. Li & K.H. Yeung, 2003: Long Term Sea Level Change in Hong Kong, Hong Kong Meteorological Society Bulletin, Vol. 13, p. 24-40. (Available online at https://www.weather.gov.hk/publica/reprint/r556.pdf.)