Ministry for the Environment
Manatū Mō Te Taiao

FACT SHEET 5

This is one of a series of fact sheets developed to accompany *Preparing for coastal change*, and provide further information on elements of coastal processes.

Storm surge

This fact sheet outlines the processes that create **storm surge***, which can contribute to flooding at the coast.*

Processes that create storm surge

Storm surges are temporary increases in ocean and estuary water levels caused by storm conditions that last from hours to days. Storm surge is a combination of two weather and ocean processes:

- low barometric (air) pressure allows sea levels over a large area (100 square kilometres or more) to rise above the pre-storm sea level. This is known as the *inverted barometer effect*, and results in approximately a 1-centimetre rise in sea level for every 1 hPa drop in barometric pressure below normal
- strong, persistent winds blowing onshore cause water to 'pile up' against the coast, raising water levels (figure 1). Because of the Coriolis effect[1], winds that blow along New Zealand's shores in an anticlockwise direction (that is, with the coast on the left) also cause water to pile up. Similarly, both onshore and anticlockwise winds can 'hold up' water levels in estuaries.

Wind and air pressure effects

The combination of the wind and air pressure effects can vary greatly, depending on the type of weather system. During low-pressure systems that arrive from the tropics, which rotate clockwise, the effect of air pressure generally contributes at least half of the height of a storm surge hitting New Zealand's east coast.

In the case of a low-pressure trough that is blocked by a stationary or slow-moving area of high pressure, prolonged winds blow over large distances (large *fetch*[2]). These winds can drive large surges that have a relatively small air pressure component. One example is the storm that hit Tararu (in the Firth of Thames) on 12 June 2006. A cold front brought heavy rain and severe north-westerly gales, with wind speeds of up to 23 metres per second around the time the storm surge peaked, contributing a wind surge of 0.8 metres to the total storm surge height of 0.97 metres.

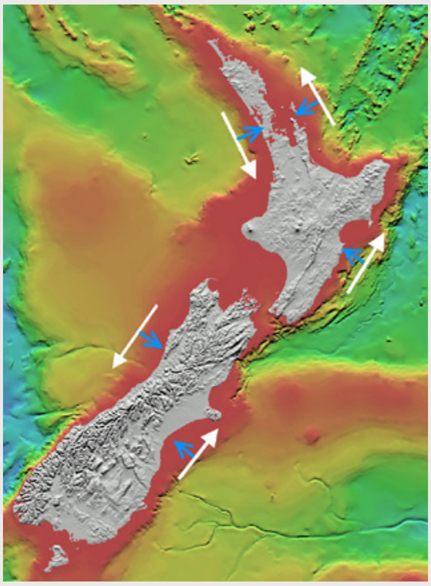


Figure 1: Alongshore wind directions (white arrows) around New Zealand that contribute onshore water level set-up (blue arrows) to storm surge.

Source: NIWA

1 The Coriolis effect occurs when a mass moving in a rotating system experiences a force (the Coriolis force) acting perpendicular (at 90 degrees) to the direction of motion and to the axis of rotation. On the Earth, this means that moving objects in the southern hemisphere tend to be deflected to the left, and to the right in the northern hemisphere.

2. The distance of continuous open water.

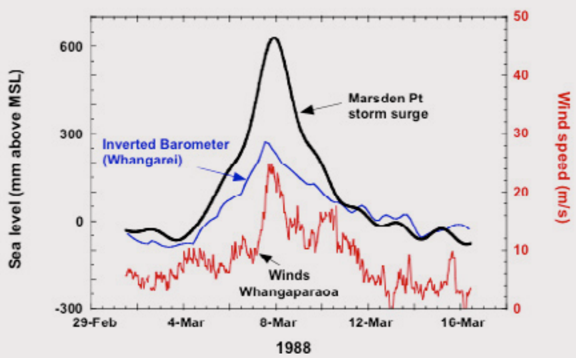
Different coasts, different surges

Storm surge height rarely exceeds 0.6 metres on open coasts around New Zealand, and is usually much smaller. However, they can be higher in some estuaries and harbours. The largest recorded is a 0.90 metre storm surge in Kawhia Harbour on 6 May 2013, followed closely by a 0.88 metre surge in Tauranga Harbour during Cyclone *Giselle* in April 1968.

The main factor that determines whether a high storm surge will cause flooding on low-lying land is whether it coincides with high spring or perigean tides.

Figure 2: Cyclone *Bola*, one of the most damaging cyclones to hit New Zealand in recent decades, tracked southwards over New Zealand in early March 1988.

At Marsden Point, the storm surge measured over 0.6 metres (black line). At its peak, approximately 50 per cent was due to the inverted barometer effect (blue line), with the remainder due to the influence of the strong east-north-east winds (red line).



Storm tide and storm surge monitoring

Data on tides and storm surges is captured at 16 sea level monitoring sites around the New Zealand coast. Data for the previous 5 days is available from: www.niwa.co.nz/our-services/online-services/sea-levels.

Published in December 2017 by the
Ministry for the Environment INFO 778e