Observation of a meteotsunami on the south coast of Ireland

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At 1440 UTC (1540 local time) on Saturday 18 June 2022, when low tide had passed and the tide was due to rise, the water drained from the harbours of Union Hall and nearby Courtmacsherry on the south coast of Ireland (see Figure 1a). Eyewitnesses captured the event on video,[1] with observers remarking that it reminded them of reports of the tide receding ahead of the tsunami in Japan in 2011. The event was captured by the Irish Marine Institute's tide gauge in Union Hall, which recorded a drop in water level of 70cm in 5min. Compared to the normal ebb and flow of tides of ~1cm per minute, this was a dramatic event. The event impacted most of the Irish south coast, from Castletownbere to Dunmore East and onwards to Britain, with reports of unusual tidal behaviour in Pembrokeshire in South Wales (see Sibley, 2022, this issue).

Overview of the event

The south coast of Ireland is characterised by semi-diurnal tides, with a typical spring range of approximately 3m, that originate from the Atlantic and progress eastwards along the south coast. Tidal amplitudes are much smaller on the east coast of Ireland, for example near Wexford (~1.3m), which is close to the southern amphidrome of the Irish Sea. On Saturday 18 June 2022, low tide was recorded at 1230 UTC in Dingle and at 1330 UTC in Union Hall (Figure 1b).

At the same time, atmospheric pressure was rising rapidly at sites across the south of Ireland. Although not strongly noted at the westernmost site in Valentia, a distinct peak in atmospheric pressure progressed eastwards reaching a maximum around 1250 UTC in Sherkin and Johnstown Castle approximately an hour later at 1345 UTC. This oscillation in pressure was sharp, rising and falling by almost 3hPa over the course of an hour.

The onset of the sea level event is visible in the detided record from all tide gauges from Castletownbere to Dunmore East from mid-afternoon (Figure 1d). The largest drop in Union Hall occurred at 1440 UTC, where the levels dropped to 1m below the predicted tide. This is approximately the same timing as the maximum drop that occurred in Dunmore East of 0.7m below the predicted tide. In the aftermath of these large events, large seiching was seen from Castletownbere to Dunmore East. Observers in Union Hall described the tide '*going in and out five times over the course of about three hours*'.[2] This is supported by the data that show large oscillations, including a peak to trough oscillation of 1m around 1700 UTC. Oscillations continued for the rest of the day before attenuating.

The atmospheric pressure ridge propagated southeast across South Wales and the southwest of England. Unusual tidal behaviour was reported in Pembrokeshire, likely associated with the same event (Sibley, 2022, this issue). On the Normandy coast, strong winds were observed rising to 100kmh^{-1} over the course of 5min and resulting in the death of a kitesurfer.[3]

Initial reports

Initial reports in Ireland[4] linked the strange movement of water to a small seismic event that occurred off the Azores on the morning of the 18 June. This attribution does not hold up to scrutiny as (i) the seismic event was small in magnitude (2.7), with typically 6+ needed to generate a tsunami, (ii) the locus of that seismic event was ~1000km away from the south coast of Ireland, so had the seismic events at 0830 and 1030 UTC trig-

[1]https://www.youtube.com/watch?v=QxmiVB30I8c

[2]https://www.irishtimes.com/ireland/2022/06/19/locals-perplexed-by-sight-of-tide-going-the-wrong-way-off-cork-coast/

[3]https://metro.co.uk/video/sudden-strong-winds-rip-beach-normandy-2711733/

[4]https://www.corkbeo.ie/news/local-news/mystery-videos-show-weird-tsunami-24266397

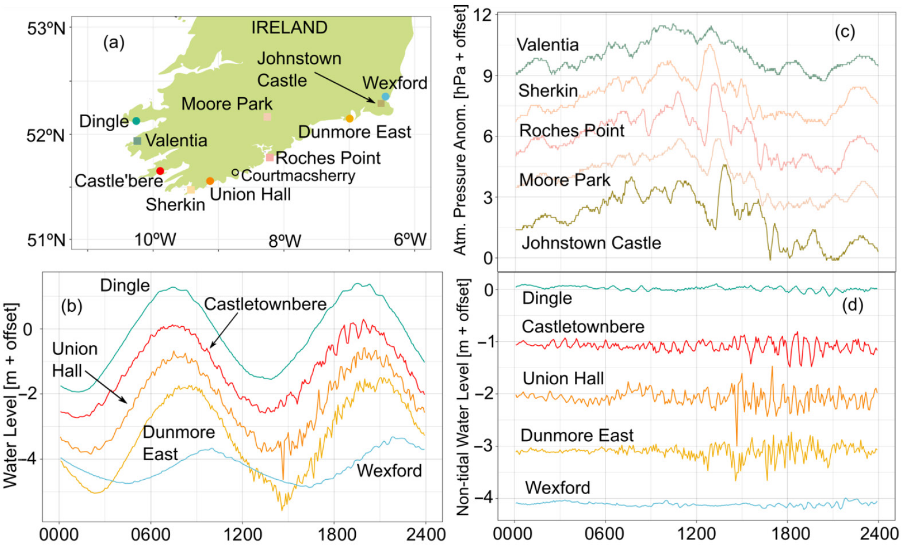

Figure 1. (a) Locations of tide gauges (circles) and meteorological stations (squares) mentioned in the text. Courtmacsherry (black, open circle) does not have an active tide gauge. (b) Total water levels at tide gauge stations on 18 June 2022. Data are relative to Ordnance Datum Malin and subsequent records are offset by 1m for visibility. (c) Atmospheric pressure anomaly at meteorological stations. Subsequent stations are offset by 2hPa for visibility. (d) Non-tidal residual water level at tide gauge stations is calculated by subtracting the predicted astronomical tide. Subsequent stations are offset by 1m for visibility. All times are UTC.

Weather – August 2022, Vol. 77, No. 8

gered a tsunami it would have arrived on the south coast of Ireland earlier in the day, as the typical propagation speed of a tsunami is 800kmh^{-1} and (iii) there was no signature of unusual tidal behaviour on the Portuguese coast or the Atlantic coast of France.

The 1755 Lisbon tsunami is a natural disaster that lives long in the consciousness of residents of the south coast of Ireland. The formation of many beaches along the coast of Cork (near Union Hall) is popularly ascribed to that tsunami (a belief that may not hold up to geomorphological scrutiny). On this occasion, eyewitness statements saying the phenomena reminded them of a tsunami were correct – in terms of water movement, this event had similar wave properties as a seismically-generated tsunami.

Meteorological attribution

The likely explanation for this event was a meteotsunami. Meteotsunamis are atmospherically generated waves in the tsunami frequency band, with periods between 2min and 2h and heights on the order of 0.1–1m that occur over less extensive areas than seismic tsunamis (Monserrat *et al*., 2006). The abrupt rise and fall in atmospheric pressure over the south of Ireland on the 18 June and the absence of any notable seismic event provides a likely explanation for the driver of the waves seen on the Irish south coast. Atmospheric pressure variations of the magnitude and duration observed over the south of Ireland on the 18 June are known to generate meteotsunamis on the northwest European shelf (Williams *et al*., 2019).

Meteotsunamis are surprisingly common occurrences and Ireland is known to experience some of the largest meteotsunamis on the northwest European shelf (Williams *et al*., 2021). The magnitude of approximately 1m recorded at Union Hall would place this event in the top 1% of recorded meteotsunamis (based on a climatology from 2010 to 2017). Meteotsunamis are most common in winter but more commonly observed in summer as wintertime meteotsunamis can be difficult to distinguish from the plethora of waves generated on stormy seas. For example, a likely meteotsunami flooded the Portsalon golf course, on the banks of Lough Swilly, on Ireland's north coast on 21 February 2022 in the wake of Storm *Franklin*.[5] Meteotsunamis were even recorded around the globe following the Hunga Tonga-Hunga Ha'apai eruption on 15 January 2022 with evidence of this event recorded in the Irish tide gauge at Castletownbere.

The extreme water drop and currents associated with the meteotsunami on the Irish south coast on 18 June 2022 posed a substantial risk to smaller craft, pleasure craft (such as kayaks and paddle boarders) and swimmers. Observations of this event were possible due to the high-frequency sampling (every 5 or 6min) of the Irish Marine Institute tide gauge network – other observations sample at a temporal frequency of 15min, such as the UK's National Tides and Sea Level Facility. Ideally, 1min sampling is necessary for identifying and categorising meteotsunamis (Zemunik *et al*., 2022). Likewise, high-frequency meteorological observations are necessary to attribute the driver of this event – no remarkable features were evident in the hourly station data nor on synoptic charts. This highlights the challenges in observing and understanding these phenomena.

Knowledge that meteotsunamis exist and indeed are common (O'Brien *et al*., 2013; Dusek *et al*., 2019; Williams *et al*., 2021) allows for improved understanding of these phenomena. It is possible that some data that recorded abrupt changes in sea level in the past may well have been 'despiked' as outliers. In the age of easy access to smartphones, supporting evidence abounds and meteotsunamis are no longer consigned to a folk tale of the day that the tide 'went the wrong way'.

Acknowledgements

Observation of this meteotsunami was made possible by the high-frequency sampling (5 or 6min) of Irish Marine Institute tide gauges, and rapid analysis of this event was facilitated by the open publication of those data to the Marine Institute's ERDDAP data server (https://erddap.marine.ie/erddap/tabledap/IrishNationalTideGaugeNetwork.html). Specifically, the observation in Union Hall was only possible due to the installation of a tide gauge in November 2020 by Guy Westbrook as part of SFI-funded EirOOS program (Grant No. 18/RI/5731). High-frequency meteorological data was provided by Met Éireann with the help of Rosemarie Lawlor and Ciarán Kelly. G. M. is supported by the Marine Institute funded A4 project (Grant No. PBA/CC/18/01) and the SFI-funded Predicting Sea Levels and Sea Level Extremes for Ireland (Grant No. 20/FFP-P/8610). Open access funding provided by IReL.

[5]https://twitter.com/johnnyshields1/status/1495717053713592324?s=20&t=9JcC5O5aPWIXJE0Jr3uehw

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Meeting report

History of climate science

The meeting began with a recorded introduction by *David Warrilow*, who was unable to attend in person. David gave a brief history of climate science and how this has impacted UK Government Policy over the period since the late 1980s. David expanded on this in a more detailed summary at the end of the meeting. The meeting was recorded by the Royal Meteorological Society and is available online[1].

Sir Brian Hoskins (Imperial and Reading) began the live proceedings by recalling his first talk on climate change in the late 1970s to the Clean Air Society at Scarborough. He briefly discussed the subjects that would be covered during the day, highlighting some of the history of dynamical meteorology

[1]Recording available on the RMetS YouTube channel: https://www.youtube.com/watch?v=iHQ7aD9aAT8.