



Supplement of

A century of sea-level change in Ireland (1925–2024)

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Digitization of Dún Laoghaire, Cork, and Tarbert Historical Records

Historical data for Dún Laoghaire (formerly Kingstown) span 1925–1931 and were obtained from McLoughlin et al. (2024). Additional data for 1932–1933 were recovered from raw marigrams; however, these records are less complete because of degraded trace quality, particularly in 1933, when frequent clock stoppages affected the record. Only June–August were digitized for these years. This seasonal restriction may introduce sampling bias; however, because the analysis focuses on multi-year sea-level trends and tidal statistics, any seasonal signal is expected to have a limited influence on the results. Marigrams were digitized at hourly intervals using WebPlotDigitizer (Rohatgi, 2024), employing the full-grid method described by McLoughlin et al. (2024) for severely distorted images, with an estimated positional accuracy of approximately 1 cm.

To the southwest of Ireland, tide-gauge data for Cork were obtained from Port of Cork engineers and archival reports. The dataset includes measurements from Tivoli Port for 1971–1974, 1976–1977, and 1981–1984, together with more recent records from a modern tide gauge for 2001–2005 and 2010–2011. The 2001–2005 and 2010–2011 Tivoli records were already available digitally and therefore did not require manual digitization. The 1970s and 1980s records were in marigram (pencil trace) format (Figure S1), with measurements spanning 06:00–06:00 the following day in most images. They were digitized at hourly intervals using WebPlotDigitizer (Rohatgi, 2024) with the reduced grid method described by McLoughlin et al. (2024), achieving an accuracy of approximately 1 cm (0.01 m) per measurement.

Complementing these data, tide-gauge measurements spanning several months, from October 1976 to January 1977, were obtained from a Cork Harbour pollution report for Monkstown (O’Sullivan, 1977). These pen-trace records were digitized at hourly intervals, with time steps from 00:00 to 23:00 (i.e., 24 hourly values per day). All data were standardized to hourly intervals for consistency. Modern OPW tide-gauge measurements from Ringaskiddy (2012–2021) and Currach Club (2022–2024) were included in the record.

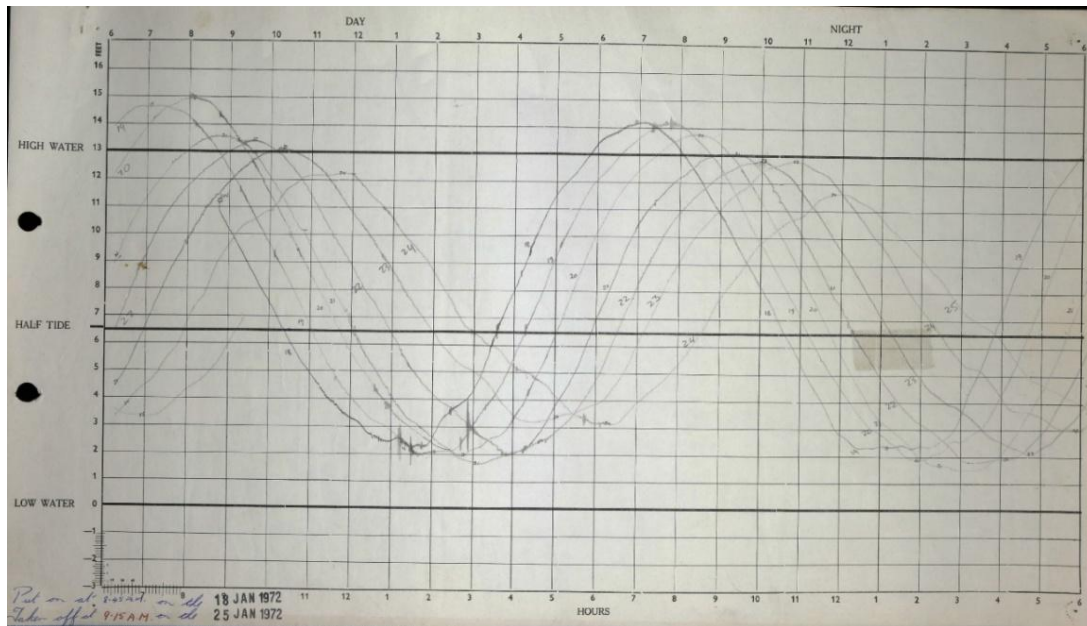
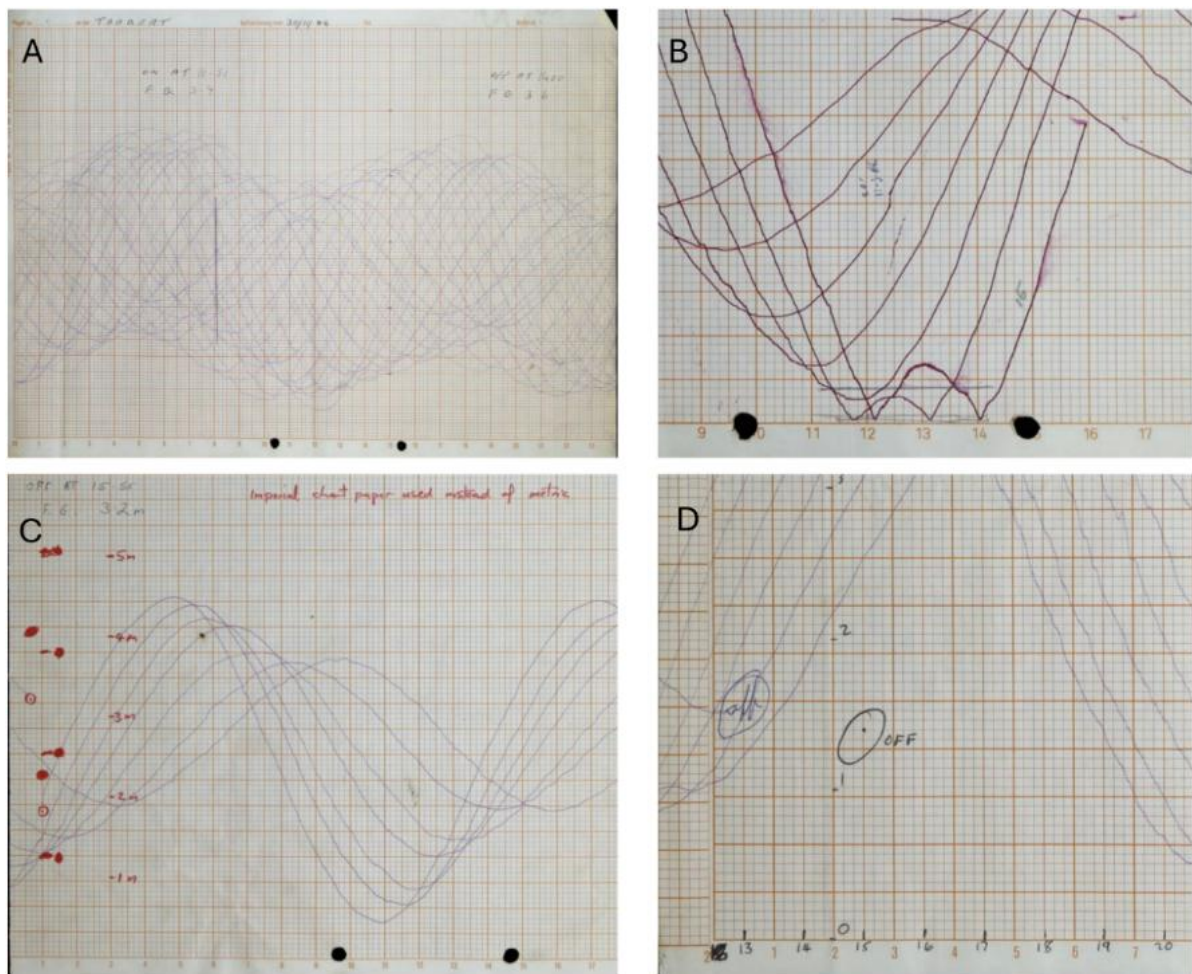


Figure S1. Example of a Cork marigram with a pencil trace. The X-axis represents time from 06:00–06:00 the following day, and the Y-axis shows water level in feet relative to chart datum (CD). Dates are indicated above the pencil traces. Data courtesy of Port of Cork engineers (personal communication, 2022).

An additional dataset spanning 1964–1986 for Tarbert Island, Kerry, representing the longest tide-gauge record from the southwest of Ireland included in this study, was provided in feet (1964–1977) and metres (1979–1986) relative to OD Poolbeg, with data from 1978 omitted due to extensive gaps and poor quality. Timing offsets were noted throughout the digitization process but were generally minor and tended to balance out overall. Some handwritten notes were difficult to interpret, and the data were therefore left unchanged, as they appeared in only one or two images. In rare cases of duplicate-dated traces, where uncertainty existed regarding the correct trace, only one was retained. Additionally, some dates were estimated when information was absent. While these instances could affect dataset accuracy, they are fully documented for transparency (Figure S2A–D). Figure S2A shows marigrams spanning up to one month, an issue also reported by Latapy et al. (2023) when tide sheets were not changed regularly; such records were excluded from digitization.



45 **Figure S2. Examples of marigrams requiring careful digitization: (A) Tarbert marigram**
spanning nearly one month, making accurate digitization nearly impossible; (B) Daily
low tides intercepting or approaching the X-axis, requiring manual correction; (C)
Variations in graph paper type and unit scaling, with conversion factors indicated (e.g.,
one metre = four or 3.2 grid boxes); (D) Visible timing offsets requiring alignment
50 **corrections based on handwritten X-axis annotations. Data courtesy of the OPW**
(personal communication, 2024).

The Tarbert dataset presented significant challenges, particularly timing offsets and related errors. Traces at the beginning or end of marigrams were occasionally discarded if severely misaligned with the hourly grid, even when the opposite end aligned correctly. Testing
55 marigrams from 1964 and 1965 revealed deviations from the correct hourly intervals; however, the mean offset per marigram was typically within 1 cm.

Marigrams from the 1960s and 1970s often exhibited low tides that touched or nearly touched the X-axis before rebounding upward (Figure S2B). In these cases, manual correction was applied: the difference between the rebound peak and the base point on the X-axis was

60 measured and subtracted to improve tidal estimates. This potential datum inconsistency was
restricted to the earlier record, as observations after 1979 were digitized in metres relative to
Ordnance Datum Poolbeg (OD Poolbeg). On imperial chart paper, one metre was represented
by four grid boxes, whereas on metric chart paper, the spacing of the grid resulted in roughly
3.2 boxes per metre (Figure S2C). This difference reflects the design of the chart grids, not a
65 scaling error.

Timing offsets between the recorded hour and the digitized hourly grid occasionally caused
recorded times to deviate by up to ~30 minutes (Figure S2D). Analysis of each marigram
showed that the corresponding mean water-level offset remained within 20 mm, which was
considered acceptable given the combined uncertainties associated with digitization and
70 instrumentation. Because annual mean values are computed as temporal averages over
extended periods encompassing many tidal cycles, these temporal misalignments are expected
to have a negligible effect on the resulting sea-level record, and are therefore unlikely to
materially affect the long-term RSL reconstruction.

The tidal images were generally of excellent quality and were digitized using WebPlotDigitizer
75 (Rohatgi, 2024). Although some manual adjustments were necessary, where handwritten notes
or other anomalies occurred, most of the data—despite bends in the images—could be digitized
directly without employing the grid or reduced grid method described by McLoughlin et al.
(2024). The digitization process itself was estimated to introduce an uncertainty of
approximately 1 cm; however, accounting for additional factors such as timing offsets and
80 necessary adjustments, an overall uncertainty of ± 2 cm was assigned to the Tarbert dataset.
Where historical notes or metadata provided clear evidence for corrections, these were applied
transparently during digitization. Where annotations or potential adjustments could not be
independently verified, the data were retained in their original digitized form to avoid
introducing unsupported corrections. These potential sources of uncertainty are therefore
85 incorporated into the assigned measurement uncertainty. For Tarbert, Carrigaholt data (2019–
2024) were used to supplement the modern observations because of the proximity of the coastal
tide gauge and its comparable tidal regime.

Datum Adjustments

Sea-level records were standardised to Ordnance Datum Malin (OD Malin; also referred to as
90 ODM). Where necessary, records originally referenced to Ordnance Datum Belfast (OD

Belfast) or Ordnance Datum Dublin (ODD; i.e., OD Poolbeg) were converted to OD Malin using station-specific datum relationships and associated metadata.

For Malin Head, the PSMSL Revised Local Reference (RLR) data (PSMSL, Holgate et al., 2013) were first converted from millimetres to metres. A PSMSL RLR datum offset of 3.977 m was then applied following the station-specific RLR procedure, and an additional datum correction of 3.136 m was applied based on the OPW OD Malin datum information for the historical gauge datum established in 2004 and used until the 2018 datum update. The Malin Head benchmark offset of 3.06 m was not used, as it aligns the series only to the local benchmark and not fully to the national OD Malin vertical datum. These corrections, with a total adjustment of 7.113 m, were subtracted from the RLR series to align the data with both the local tide-gauge reference and the OD Malin datum. These adjustments are critical for accurate sea-level reconstruction and rely on detailed historical datum documentation to ensure vertical consistency. For Portrush, following the PSMSL, 8.600 m was subtracted from the data, with an additional 1.604 m and 0.037 m (37 mm) added to reference the Ordnance Datum Malin Head (OD Malin). The additional adjustment of 0.037 m represents the mean vertical separation between Ordnance Datum Belfast (OD Belfast) and Ordnance Datum Malin (OD Malin), with OD Belfast being 37 mm below OD Malin (Prendergast, 2004).

In Belfast, a separation of -2.01 m between Chart Datum (CD) and Ordnance Datum Belfast (OD Belfast) (National Tidal and Sea Level Facility, 2025) was applied to convert elevations referenced to CD to OD Belfast. The resulting OD Belfast elevations were subsequently transformed to Ordnance Datum Malin (OD Malin) by applying a $+0.037$ m adjustment. The same vertical datum conversion procedure was applied to the Bangor BODC data, using the -2.01 m CD-to-OD Belfast adjustment (National Tidal and Sea Level Facility, 2025) and the $+0.037$ m OD Belfast-to-OD Malin adjustment.

To the east of Ireland, the Dún Laoghaire sea-level data were adjusted following McLoughlin et al. (2024). The Dún Laoghaire local datum is 2.722 m above OD Malin; subtracting the local Chart Datum (CD) offset of 1.75 ft (0.533 m) gives a correction of 2.189 m, which was subtracted from the records to convert them to OD Malin. Similarly, the Dublin Port PSMSL data (1938–2000) were converted to OD Malin using a sequence of benchmark and datum adjustments. These comprised subtracting 6.017 m from the 10.594 m elevation below the primary benchmark (BM, TGZ 1978), adding 0.238 m to account for the difference between BM 1895 and the TGZ Port Datum 1977, subtracting 0.436 m because the 1938–1977 records

were referenced to a Port Datum 0.436 m above Poolbeg OD, and adding 2.722 m to account for the Dún Laoghaire datum. The resulting net correction was 7.101 m, which was subtracted from the PSMSL data to convert them to metres OD Malin.

All Cork data were adjusted to OD Malin following the procedure outlined below. Records at Tivoli and Monkstown, originally referenced to Ordnance Datum Dublin (ODD), were converted to OD Malin by subtracting 2.69 m, using the Cobh Poolbeg–Malin Head transformation value from the OPW vertical datum transformation table (OPW, personal communication, 2024). This regional datum transformation was chosen because it provides a consistent Cork-area conversion to OD Malin, whereas the 2.752 m adjustment reported by Pugh et al. (2021) represents a site-specific historical ODD–OD Malin relationship derived from the Passage West benchmark network.

Prior to conversion, site-specific adjustments were applied:

- For the 1970s Tivoli records, a correction of +0.174 m (0.57 ft) was applied based on contemporary notes (Figure S3A).
- For the 1980s Tivoli data, a correction of –0.13 m was applied, consistent with gauge documentation indicating the instrument was set 0.13 m below Admiralty Datum; this offset provided the best alignment with regional tide records (Figure S3B).

Modern Tivoli data from the early 2000s were adjusted by +0.13 m (National Tidal and Sea Level Facility, 2025; Figure S3C) prior to applying the 2.69 m datum conversion to OD Malin. Following these corrections, the data were referenced to OD Malin. Irish Water (2005) documents a 0.13 m offset relative to Ordnance Datum (Dublin) at both Cobh and Ringaskiddy, supporting the application of the National Tidal and Sea Level Facility datum-conversion approach to the nearby Tivoli data, with a +0.13 m adjustment from chart datum.

In the absence of a site-specific datum, the Tarbert records were assumed to be referenced to ODD (Ordnance Datum Poolbeg; Figure S3D). Using this assumption, nearby datums were considered: Shannon is 2.705 m above ODD and Ballybunion is 2.704 m above ODD (OPW, personal communication, 2024). Based on this consistency, a subtraction of 2.705 m was applied to convert the Tarbert data from ODD to OD Malin.

Modern Kilrush Lough tide-gauge data (2018–2024; Marine Institute) are referenced to OD Malin; however, comparison with the datum-adjusted Tarbert record indicated a residual datum discrepancy of approximately 5–10 cm. Consequently, the Kilrush record was not incorporated

into the extension of the Tarbert time series. Instead, Carrigaholt tide-gauge data (2019–2024) were used, as comparison with the overlapping Tarbert observations showed no evidence of a systematic datum offset.

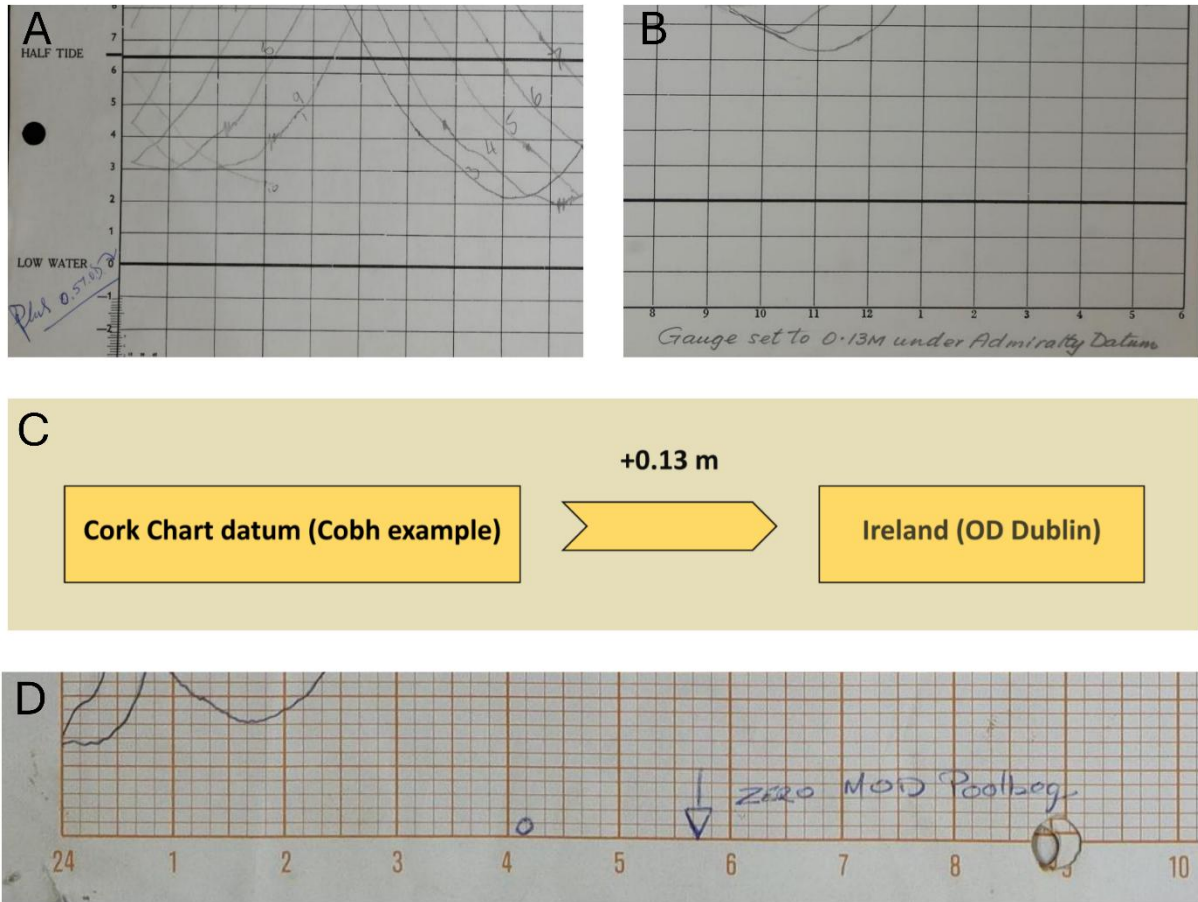


Figure S3. Datum adjustments applied to Cork (Tivoli) and Tarbert sea-level records at different periods: (A–C) Tivoli data—(A) 1970s corrected by +0.174 m (0.57 ft). (B) 1980s corrected by –0.13 m, consistent with gauge documentation and regional tide alignment. (C) Early-2000s Tivoli data adjusted by +0.13 m, using the Cobh chart-datum-to-OD Dublin relationship as supporting datum context and following the National Tidal and Sea Level Facility datum-conversion approach (2025). Author-created schematic. (D) Tarbert records shown relative to ODD (0 m, OD Poolbeg), an assumed datum reference. Note: 1964–1977 data were originally in feet relative to OD Poolbeg. (A–B, courtesy of Port of Cork engineers, personal communication, 2022; D, data courtesy of the OPW, personal communication, 2024).

Datum corrections of 2.732 m for Galway (Nimmo’s Pier) and 2.703 m for Rossaveel were subtracted to convert the datasets to Ordnance Datum Malin Head (OD Malin) (OPW, personal communication, 2024). BODC data for Galway, adjacent to Galway Harbour, indicate that the

1967 and 1968 records are referenced to Ordnance Datum Newlyn (ODN). These records were converted to OD Malin by subtracting 2.732 m. In contrast, the 1969 and 1970 records, also reported in metres, appeared higher than the 1967 and 1968 values. Metadata indicate that these records required 3.048 m to be subtracted to align them with the benchmark (TGZ; Table S1). Following this adjustment, a further 2.732 m was subtracted to reference the records to OD Malin. The 1973 and 1974 records were converted to Ordnance Datum Malin (OD Malin) by applying a datum correction of 2.703 m.

Table S1. BODC metadata table showing datum relationships for Galway (British Oceanographic Data Centre, 2026). Values from 1967–1968 are aligned with OD Malin (0.000 m offset). For 1969–1970, TGZ was –3.048 m; subtracting 3.048 m aligns these years with the earlier records.

Galway (Eire) Site History

Full site history and benchmark not yet available.

Datum Information

Year	Data rel to ACD	Data rel to ODN	Data rel to TGZ	TGZ rel to ODN	TGZ rel to TGBM	ACD rel to ODN
1967	0.201	0.000	0.000	0.000	not available	-0.201
1968	0.201	0.000	0.000	0.000	not available	-0.201
1969	-2.847	-3.048	-3.048	0.000	not available	-0.201
1970	-2.847	-3.048	-3.048	0.000	not available	-0.201

All modern sea-level data from the NTGN (OPW and MI) for the available sites were already fully referenced to OD Malin.

Validation of Tide Gauge Data: Historical and Modern Records

For the Belfast record, 1925 was chosen as the starting point instead of 1901–1902 because the earlier observations contained frequent gaps and inconsistencies, while retaining an approximately 100-year overlap with the Dublin Port (including Dún Laoghaire) record for comparison. Figures presented in this section show the raw monthly mean tide-gauge records used for quality control and validation. No atmospheric, seasonal, or long-term trend corrections were applied at this stage; these adjustments are introduced in the subsequent analysis section. The Belfast tide-gauge record (Murdy et al., 2015) was generally consistent from 1925 to 2010, with M2 tidal amplitudes typically ranging between approximately 1.13

195 and 1.24 m. Phase lags occasionally fell outside the typical range (311.4° – 325.4°), but no sustained shifts were observed that would indicate datum instability or long-term timing errors. The period 1989–2000 corresponds to the operation of the Valeport BTH 700 tide gauge (TG4) at Milewater Basin, Belfast Harbour, during harbour redevelopment (Murdy et al., 2015), and was therefore examined in greater detail. Following the removal of missing and poor-quality
200 data, the record for this period was retained for subsequent analysis. Timing offsets were identified in several years. Where consistent phase lag shifts were observed relative to other years, adjustments were applied to align the records temporally. These offsets were corrected by applying a one-hour time shift to segments of the record exhibiting timing misalignment. Most corrections occurred in data from the late 1980s to 2000, although occasional adjustments
205 were also required in earlier parts of the record (e.g., 1963).

To assess the internal consistency of the Belfast tide-gauge record, annual M2 tidal amplitudes were estimated using harmonic regression and compared with a fitted 18.61-year lunar nodal cycle. The close correspondence between the observed annual M2 amplitudes and the expected nodal modulation indicates that the dominant tidal signal is generally preserved throughout the
210 record, with no evidence of sustained major timing, processing, or data-quality inconsistencies. Annual M2 tidal amplitudes ranged between approximately 1.13 and 1.24 m over the record, showing a multi-decadal variability consistent with the expected 18.61-year lunar nodal cycle (Figure S4). Observed values closely follow the fitted nodal signal, with typical differences of only a few centimetres. Larger deviations occur mainly during periods of reduced data
215 coverage, particularly in the mid-to-late 1980s, and do not persist over time. These periods coincide with operational changes at the Valeport BTH 700 tide gauge (TG4) at Milewater Basin, Belfast Harbour during harbour redevelopment (Murdy et al., 2015). The Belfast tide-gauge record shows no abrupt shifts or long-term departures, with only minor variability consistent with expected observational uncertainty. Overall, the record is suitable for tidal
220 analysis and reconstruction of long-term sea-level changes.

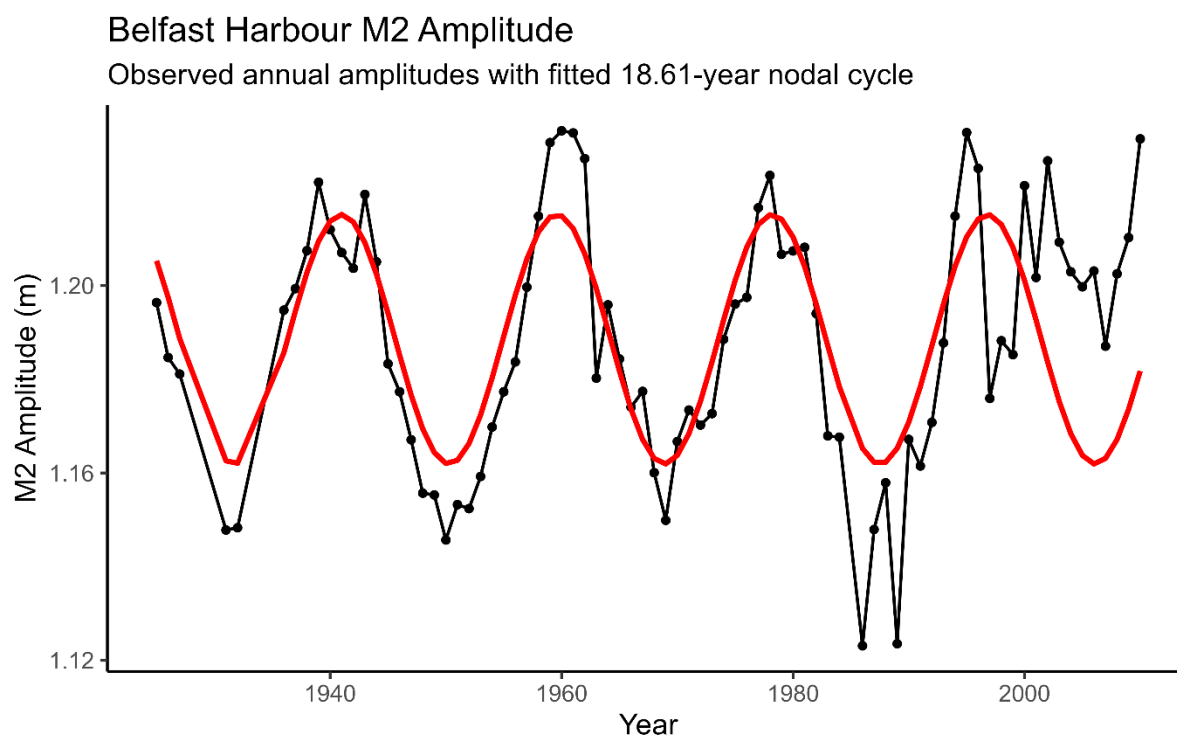


Figure S4. Annual M2 tidal-amplitude estimates derived from harmonic analysis of the Belfast tide-gauge record (1925–2010), with the corresponding fitted 18.61-year lunar nodal cycle (nodal fit) shown for comparison.

Years in which Belfast M2 tidal amplitudes fell outside the 1.13–1.24 m range were examined at monthly resolution, including assessment of both individual months and consecutive multi-month periods exhibiting departures from this range. Individual months or periods were excluded only where additional evidence indicated reduced data reliability. Statistical outlier detection was performed jointly for the Belfast and Bangor records due to their close geographical proximity. Monthly mean values exceeding ± 4 standard deviations (SD) from the station mean were considered potential outliers and assessed before exclusion. Although individual months in 1985 did not exceed the ± 4 SD threshold for monthly MSL values, the annual mean was notably elevated relative to surrounding years. Given this elevated annual behaviour, 1985 was conservatively excluded from the analysis as a potential data-quality issue. A summary of all periods omitted due to data-quality concerns, together with the rationale for their exclusion and any supplementary records incorporated, is provided in Table S2. The M2 phase lag and amplitude records (Panels A and B), following removal of potentially erroneous data, are shown in Figure S5. Period bins differ between tide-gauge plots and reflect differences in data availability and record length. The boxplots (Panel C) summarise variability within each data segment rather than applying identical time periods across stations.

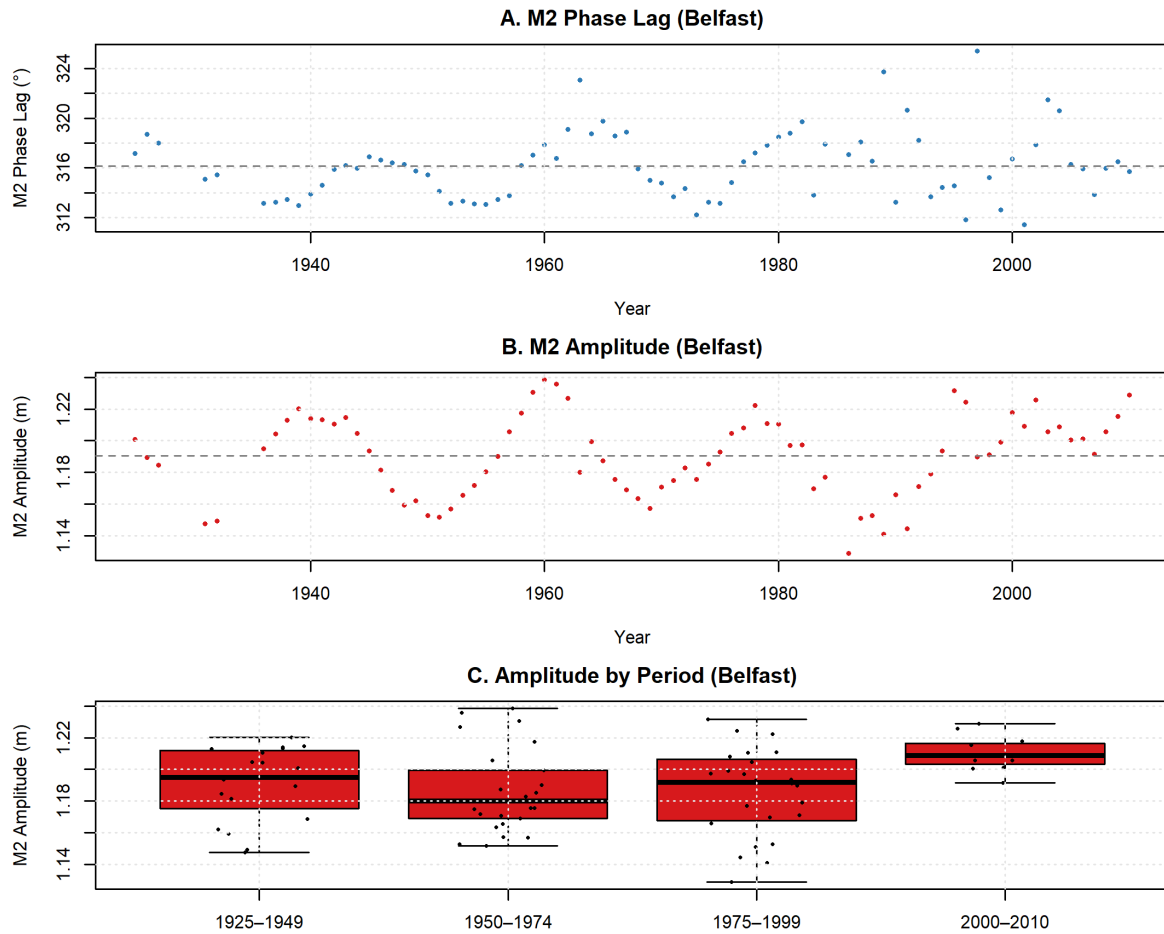


Figure S5. (A) M2 phase lag, (B) M2 amplitude, and (C) M2 amplitude by period (boxplot). Minor deviations are evident during the late 1980s, coinciding with the removal of low-quality data, intermittent data gaps, and operational changes associated with Belfast Harbour redevelopment. Overall, the dataset is considered suitable for RSL analysis.

The Bangor record was used to extend the Belfast record beyond 2010 owing to the proximity of the stations and their comparable tidal characteristics. The Bangor dataset was obtained from the British Oceanographic Data Centre (BODC) for 2011–2024; however, only 2011–2022 were retained for the primary RSL analysis following quality control. Following consultation with BODC, we were advised that data from approximately 2016 onwards remained flagged as suspect and could potentially contain unresolved quality issues. Consequently, the hourly observations were independently inspected and quality-controlled before use (BODC, personal communication).

To assess the suitability of the hourly observations for use in this study, the record was inspected and compared across the full observation period. Most observations fell within the range -0.1

to 4.5 m relative to the unadjusted local datum prior to conversion to OD Malin. Following inspection of the hourly data, observations exceeding 4.5 m or below -0.1 m were removed as spurious values. This quality-control procedure identified 728 hourly observations requiring removal over the ~ 15 -year record, including isolated positive excursions exceeding 4.5 m (with maximum values exceeding 10 m) and 11 negative excursions below -0.1 m. A subsequent spot inspection of the monthly record identified March 2011 as having a tidal amplitude outside the expected range, and this month was therefore omitted from the analysis.

Despite the hourly quality-control results, the annual mean sea levels in the final years of the record were notably elevated. The annual mean increased from 0.105 m in 2021 to 0.148 m in 2022, before rising sharply to 0.226 m in 2023 and 0.255 m in 2024. These values represent the highest annual means in the record, highlighting the pronounced elevation in sea level during 2023 and 2024. Overall, this represents an increase of approximately 15 cm between 2021 and 2024. Given the documented BODC warning that observations from approximately 2016 onwards remained potentially suspect, and the substantial influence of these recent observations on the estimated long-term RSL trend, 2023–2024 were conservatively excluded from the primary RSL analysis. This exclusion was treated as a precautionary data-quality decision rather than as evidence that the observations were statistical outliers.

Further validation of the resulting quality-controlled record was undertaken through harmonic analysis of the M2 tidal constituent. The resulting annual M2 phase lags showed a smooth temporal evolution, ranging from 315.30° to 319.90° (2011–2022). Annual M2 amplitudes remained within the range 1.15–1.20 m (2011–2022), indicating relatively stable tidal characteristics at the site (Figure S6). The phase lags and M2 amplitudes show broad agreement with those observed at Belfast, supporting the suitability of the quality-controlled Bangor record.

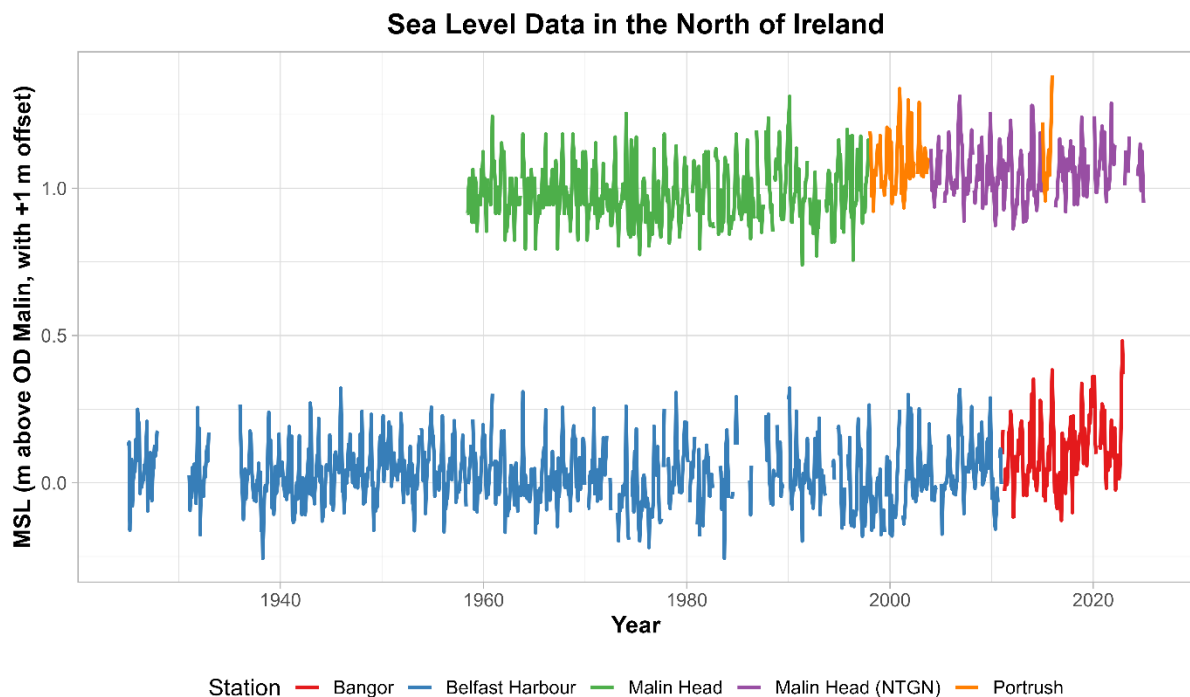


Figure S6. Annual M2 tidal constituent characteristics for the Bangor tide-gauge record (2011–2022): (A) M2 phase lag, (B) M2 amplitude, and (C) distribution of M2 amplitudes by period shown as boxplots. The consistent temporal behaviour of the M2 constituent provides an independent assessment of the stability and reliability of the record following quality control.

The Malin Head record contains known data issues in the late 1990s and early 2000s. Hogarth et al. (2020) identified gauge malfunctions between 1998 and 2003 and suggested that the nearby Portrush record could be used to replace problematic portions of the Malin Head series. In addition, while the Malin Head data used in this study were obtained from the PSMSL, BODC documentation for this tide gauge identifies instrument problems beginning in December 1991. These included inaccurate recordings following the detachment of the bubble-pot during a storm, a subsequent gauge breakdown in early 1992, and a 6 cm calibration offset identified in 1993 for which the timing of the error could not be established (British Oceanographic Data Centre, 2026). Consequently, December 1991 was omitted, while February–August 1993 were excluded from the Malin Head record as a conservative quality-

control measure in light of the documented calibration uncertainty in 1993 and the comparatively low monthly mean sea-level values observed during this period. Portrush data were therefore used for 1998–2003 to supplement the Malin Head record, together with data for 2015. Modern NTGN data for Malin Head (OPW, 2004–2008; MI, 2009–2024) were then used to complete the record (MI, 2025; OPW, 2025).

A one-hour timing offset was identified in the Malin Head OPW record between 2004 and 2006 and corrected by shifting timestamps by one hour to ensure consistency with the expected tidal phase lag. Insufficient observations were available for the Malin Head record in 2022 and 2023. Although the Portrush record contained at least three consecutive months of observations during this period and therefore met the minimum observation threshold for inclusion, it was not used as a supplement because substantial gaps remained throughout the year. Given the discontinuous nature of the record and the presence of missing monthly observations in the surrounding years within the PSMSL record, the Portrush data were considered insufficiently continuous to provide a consistent representation of the period. Statistical outlier detection was applied to further validate the data. Monthly mean values exceeding ± 4 SD from the station mean were considered potential outliers and assessed before exclusion; however, no values exceeded this threshold. April 2024 was removed prior to statistical outlier detection because of an identified data spike. Statistical outlier detection was performed separately for the supplementary Portrush station because of its different geographical setting, and no outliers were identified. The verified Malin Head record, together with other tide-gauge records from Northern Ireland, is shown in Figure S7.



320 **Figure S7. Monthly MSL values for tide gauges in and around Northern Ireland, divided**
into two groups as described in the text. For clarity, Malin Head and Portrush records
have been offset by +1 m relative to Belfast and Bangor. All records are referenced to OD
Malin, including Bangor and Portrush, which were used to supplement the Belfast and
Malin Head records.

325 The Dublin Port tide gauge on the east coast (PSMSL, 1938–2001) exhibits unusual variations
from the 1970s to the early 1990s (Shoari Nejad et al., 2022). Statistical outlier detection using
a threshold of ± 4 SD from the station mean identified November 1990 as a potential outlier,
which was subsequently removed from the analysis. The updated time series for 1938–2001 is
shown in Figure S8. Due to slight differences between the Dublin Port record and the
330 supplementary harbour records, as well as potential site-specific variability, statistical outlier
detection was performed independently for each station (Dublin Port, Dún Laoghaire, Howth,
and Arklow).

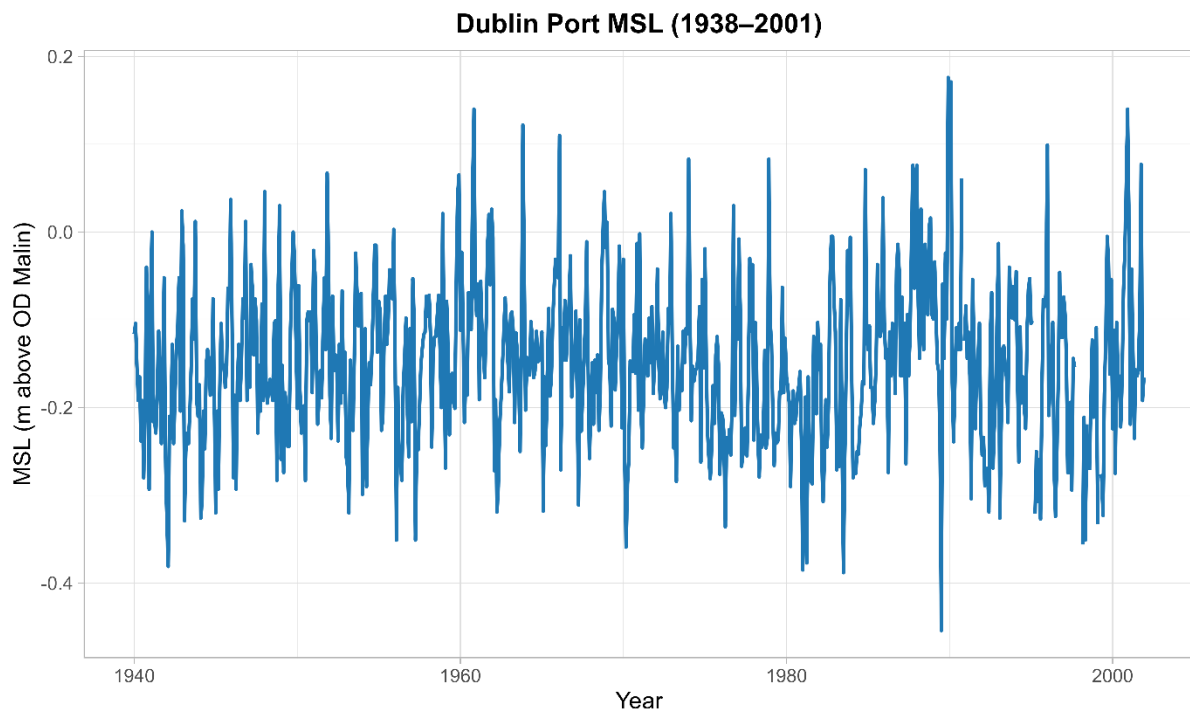


Figure S8. Monthly MSL values from the Dublin Port tide gauge (1938–2001), showing periods of lower or higher monthly means, particularly from the mid-1970s to early 1990s.

Digitized Dún Laoghaire data for June–August 1932 and 1933 were of good quality, with M2 amplitudes of 1.25 m and phase lags of 326.7° (1932) and 324.6° (1933), closely aligning with McLoughlin et al. (2024). No monthly mean exceeded ± 4 SD from the overall mean.

To construct a near-continuous century-long sea-level record, modern tide-gauge data from NTGN OPW Arklow (2003–2006) and the earlier MI Howth series (2007–2018), as used by Shoari Nejad et al. (2022) and McLoughlin et al. (2024), were integrated with the historical Dún Laoghaire (1925–1933) and Dublin Port (1938–2001) datasets. A later MI digital tide-gauge series provided additional Howth observations from 2018 onward. Comparison with the earlier Howth series indicated an apparent discontinuity around 2018. Consequently, the earlier Howth series was retained for 2007–2018, while the later MI digital series was incorporated from 2019–2024. This approach avoided introducing an apparent discontinuity into the combined series while maximising temporal coverage and maintaining consistency between the Howth observations. Statistical outlier detection was then applied to the monthly MSL record using a ± 4 SD threshold relative to the station mean. No outliers were identified.

For the south-west coast, the Cork dataset required several adjustments during validation, including computation of M2 amplitudes and phase lags. At Monkstown, 1976 fell within the expected M2 phase-lag range, with a phase lag of 153.1° (expected range: 144.4 – 154.1° ; Pugh

et al., 2021). The corresponding M2 amplitude for this year is 1.39 m; however, this estimate is based on a limited record covering only October–December and may therefore deviate slightly from nearby tide gauge records. Tivoli initially showed phase lags of 167–175°, indicating a systematic daylight-saving-time (DST)-related offset, which was corrected by shifting timestamps back 1 h during late-March to October periods. Post-correction, Tivoli phase lags ranged between 150.9° and 153.8°. November and December 1982 were excluded, as their amplitudes fell outside the expected ~1.37–1.49 m range.

Modern Tivoli data (2001–2005, 2010–2011) generally agreed in amplitude (~1.40–1.47 m) and phase lag (~150.3°–162.25°).

NTGN OPW Ringaskiddy (2012–2021) and Currach Club (2022–2024) data were incorporated to further complete the Cork record. M2 amplitudes ranged ~1.40–1.49 m and phase lags ~144.1°–152.2°, consistent with Tivoli and Monkstown.

Following checks of M2 amplitudes and phase lags in the Tivoli and Monkstown datasets, and statistical outlier detection using a ± 4 SD threshold applied to all monthly mean observations up to 2024, no observations were identified as requiring exclusion. While the phase lags show some deviation in the 2000s for Tivoli, the M2 amplitudes remain in close agreement, ranging from approximately 1.39 to 1.49 m. This consistency suggests a stable tidal signal and supports the suitability of the dataset for reconstructing historical RSL changes. The M2 amplitudes and phase lags for the Cork dataset are shown in Figure S9. The M2 amplitude record exhibits multi-decadal variability consistent with the 18.6-year lunar nodal cycle where observations are available. However, because data gaps (particularly in the 1990s) prevent a continuous time-series analysis, we rely on the observed timing of the data clusters to support nodal modulation as the primary driver rather than constructing a continuous nodal model.

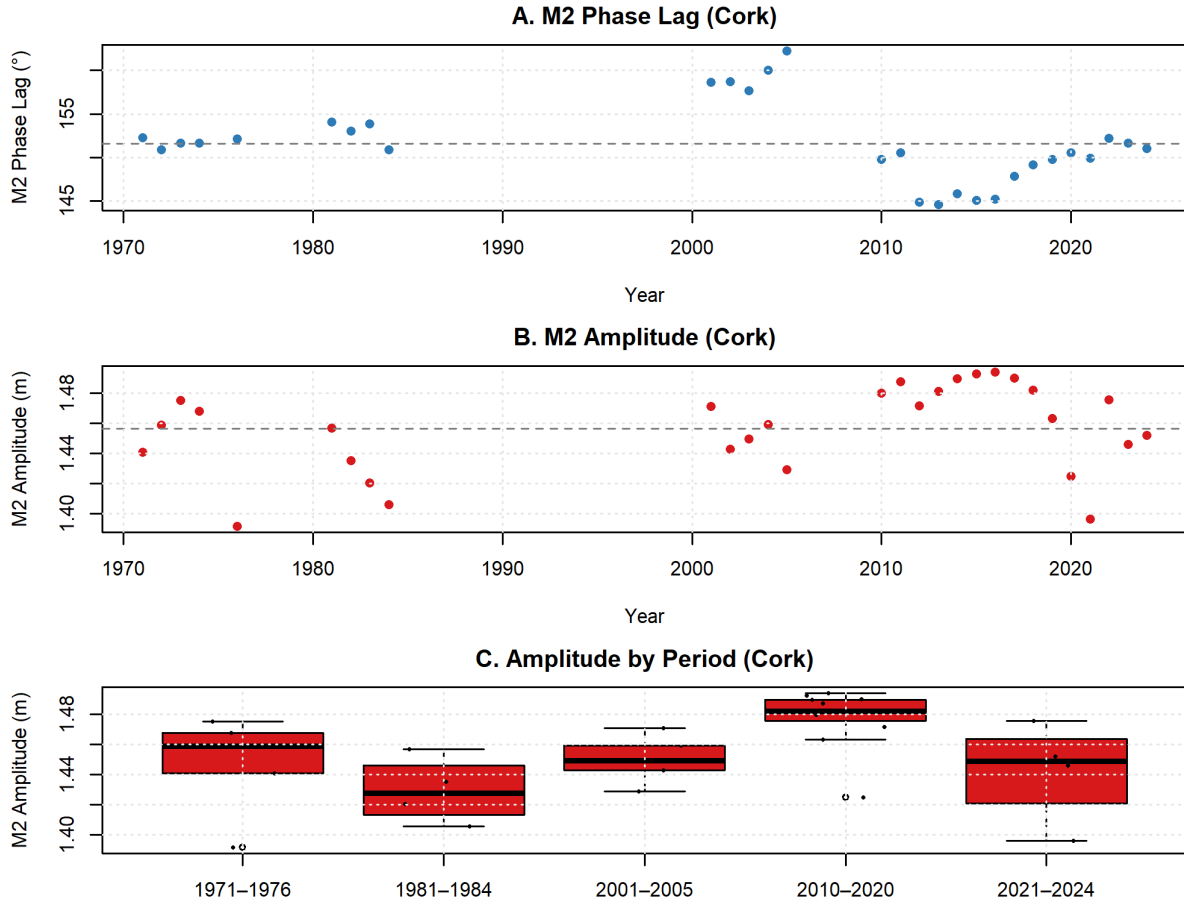


Figure S9. (A) M2 phase lag, and (B) M2 amplitude for the Cork dataset and, (C) M2 amplitude by period (boxplot). The largest deviations from the long-term mean occurred in the M2 phase lag record during the early 2000s, suggesting a small timing offset that remains after the removal of potentially erroneous data. Nevertheless, M2 amplitudes remain relatively stable over the observation period. Overall, the dataset was retained and therefore included in the RSL reconstruction.

The Cork record (combined stations Tivoli, Ringaskiddy, and Currach Club) referenced to Ordnance Datum Malin (OD Malin) is shown in Figure S10. Months identified as poor quality based on erroneous M2 amplitudes were excluded prior to the final reconstruction (Table S2).

To assess tidal characteristics in the south-west of Ireland, Tarbert and Carrigaholt were compared. Tarbert exhibited M2 amplitudes of ~ 1.55 – 1.66 m with phase lags of $\sim 145.9^\circ$ – 156.2° , while Carrigaholt (NTGN OPW modern data, 2019–2024), located ~ 22 – 23 km across the estuary, showed comparable amplitudes of ~ 1.43 – 1.52 m and phase lags of $\sim 141.4^\circ$ – 143.3° . The observed amplitude variability may reflect differences in hydrodynamic conditions within the Shannon Estuary system, as well as gaps in the observational records. Years with amplitudes

395 outside these ranges were inspected individually. Months contributing to deviations outside the
accepted range were excluded from the analysis, and where an entire year fell outside the
accepted range, the full year was excluded. A localised datum issue affecting the Carrigaholt
record during August–December 2020 was identified during routine quality-control
assessment, and these data were excluded from subsequent analysis.

400 The comparable M2 amplitudes and phase lags indicate broadly consistent tidal characteristics
between the sites, supporting the use of nearby records as supplementary observations where
datum compatibility can be demonstrated. Although Carrigaholt is located closer to the estuary
mouth and may therefore experience slightly different hydrodynamic conditions than Tarbert,
it remained the most compatible supplementary record. Carrigaholt was therefore selected for
405 extending the Tarbert time series because it provided a nearby record with no apparent
systematic datum offset relative to Tarbert. More inland sites, including Foynes and Kilrush,
were not incorporated because, despite being referenced to OD Malin, comparisons with the
Tarbert record indicated relative datum differences that could not be confidently reconciled.
Furthermore, monthly MSL comparisons showed closer agreement between Carrigaholt and
410 Tarbert than with alternative nearby records, providing additional support for its selection.

Prior to direct comparison, the Tarbert dataset (1964–1986) exhibited systematic timing offsets,
including a recurring one-hour discrepancy between late March and October due to uncorrected
daylight saving time (DST), and a continuous one-hour offset from 1968 to 1970, expressed in
GMT. Timestamps were corrected by shifting them back one hour during DST periods and
415 from 1968 through October 1971, resulting in the loss of approximately one hour of
observations in each year requiring correction.

Data from 1984–1986 were omitted because M2 amplitudes consistently fell below the
expected range of 1.55–1.66 m, reaching between ~1.3–1.50 m; the corrected Tarbert time
series is shown in Figure S10. Statistical outlier detection was performed separately for Tarbert
420 and Carrigaholt due to the temporal separation between the records (Tarbert ending in 1983;
Carrigaholt beginning in 2019) and potential site-specific differences in observed variability;
no outliers were identified.

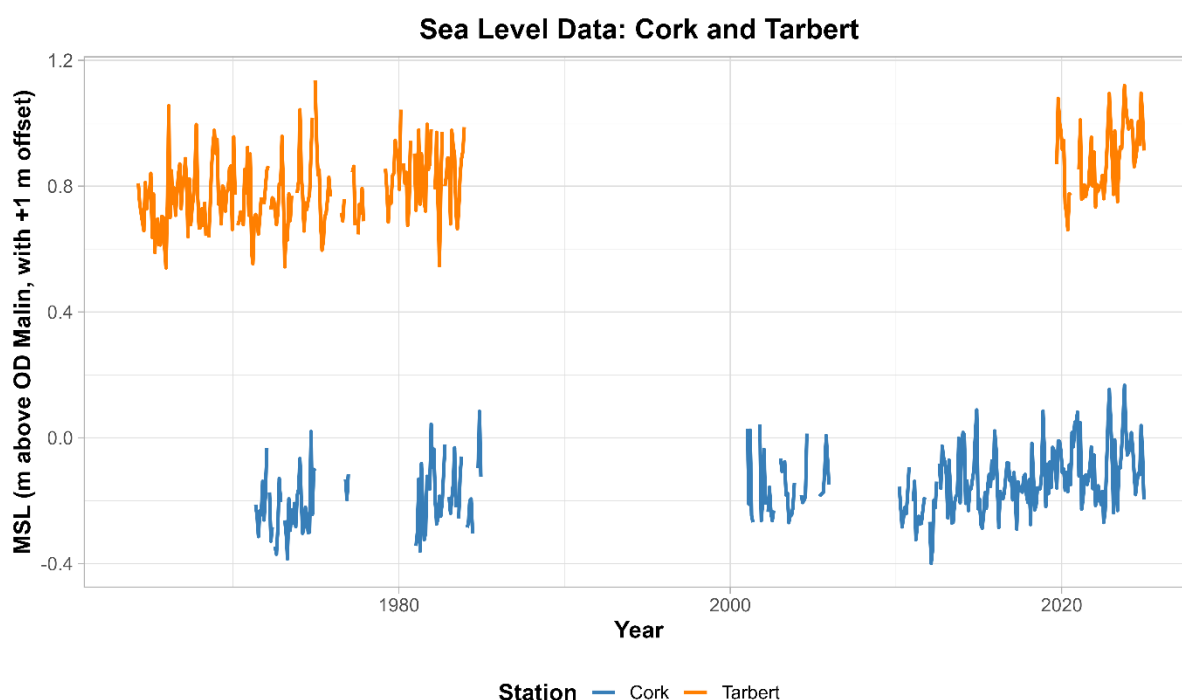


Figure S10. Sea-level records from the Tarbert record (Tarbert, 1964–1983, combined with Carrigaholt, 2019–2024) and from Cork (Tivoli, Currach Club, and Ringaskiddy), merged into continuous time series for display purposes. All records were referenced to Ordnance Datum Malin (OD Malin), with a 1 m vertical offset applied to the Tarbert/Carrigaholt series for visual separation.

In western Ireland, the Galway record was assessed using both historical and modern datasets. The BODC data from Galway (1967–1970) and Rossaveel (1973–1974) contained some missing values, particularly in 1967, 1970, 1973, and 1974. However, only minimal poor-quality data required exclusion from the records. Selected hourly observations from Galway during the 1968–1970 period were excluded on a small number of days where data-quality concerns were identified. Modern Galway data (2007–2024) were supplemented with NTGN MI observations to fill gaps and extend the record. Comparison of tidal harmonics between the 1967–1970 BODC dataset, observations from Rossaveel (1973–1974), and modern Galway records revealed only minor differences. M2 tidal amplitudes were slightly higher in the modern record (~1.46–1.59 m) than in the BODC data (~1.44–1.48 m), but overall the amplitudes remained in close agreement. Phase lags differed more substantially (~137.2°–142.3° vs. ~124°–128.8°); however, these differences were considered during tidal-quality assessment and did not provide evidence of a systematic issue affecting the MSL records. Details of omitted and supplemented data are provided in Table S2; Galway and Rossaveel were analysed together for outlier detection, with no outliers identified.

Table S2. Tide-gauge periods excluded due to data-quality concerns and supplementary records incorporated into the analysis. Short periods of sparse data coverage (<3 consecutive months) are not listed. Some excluded periods noted here may not have contributed to the final monthly-mean dataset because they did not meet the minimum data-availability thresholds.

Tide Gauge	Years/Months Omitted	Quality Issue	4-SD Outlier Detection	Supplement and Replacement Data
Malin Head	December 1991; February–August 1993; 1998–2003; April 2024.	Potential poor-quality data. An isolated monthly MSL value was identified during visual and statistical quality control.	No outliers detected.	Portrush PSMSL 1998–2003 and 2015; Malin Head OPW and MI 2003–2024.
Belfast	August–September 1972; 1985; October–December 1989. Bangor: March 2011; 2023–2024.	M2 amplitudes outside expected range; 1985: elevated annual MSL; 2023–2024: BODC quality warning and elevated MSL.	No outliers detected.	Bangor BODC substituted for 2011–2022.
Dublin Port	Dublin Port: November 1990; Howth: 2018 from later MI digital series.	Dublin Port: Monthly MSL values exceeding ± 4 SD from the mean. Howth: apparent discontinuity around 2018 between series.	Dublin Port: November 1990.	Dún Laoghaire 1925–1933; Arklow OPW 2003–2006; earlier MI Howth series 2007–2018; later MI digital series 2019–2024 (Arklow 2003–2024 used for baseline offset).
Cork	1982 (November–December); 2001 (June–September); 2002 (March, September–December); 2004 (March); 2010 (February, November–December).	Monthly M2 amplitudes outside the expected annual range (~ 1.39 – 1.49 m) were excluded.	No outliers detected.	Ringaskiddy OPW 2012–2021; Currach Club OPW 2022–2024
Tarbert	1974 (November); 1976 (October–November); 1977 (June); 1978; 1979 (January–February); 1982 (January); 1984–1986; Carrigaholt August–December 2020.	Monthly means resulting in annual amplitudes outside the expected Tarbert range (1.55–1.66 m) were excluded. Localised datum issue identified during quality-control assessment in Carrigaholt.	No outliers detected.	Carrigaholt OPW 2019–2024.
Galway	1968–1970 (selected hours on some days omitted).	Poor-quality observations identified through historical tide-gauge record quality flags; affected periods were excluded from analysis.	No outliers detected.	Galway 2007–2024.

Given the length and complexity of the reconstructed records, occasional monthly-scale anomalies may persist despite the application of multiple independent quality-control procedures (Table S2). However, sensitivity checks and comparisons with overlapping records indicate that any remaining inconsistencies do not materially affect the resulting long-term RSL estimates.

Modern NTGN Tide Gauge Data: Quality Control and Corrections

Modern tide gauges still produce raw records that may contain inaccuracies and require validation (Aarup et al., 2019). All modern datasets obtained from the NTGN (MI and OPW) included quality flags indicating good, poor, or cautionary data. The absence of a “good” flag does not necessarily indicate erroneous observations; rather, it indicates that the data should be treated with caution. Independent quality checks were conducted, including computation of M2 tidal constituents and comparison with co-located records where available. Monthly mean outliers exceeding ± 4 SD from the station mean were assessed for each tide-gauge record. No statistical outliers were identified, aside from the previously noted data spikes in the Howth and modern Malin Head records, which were removed prior to analysis.

A consistent datum offset between the overlapping Arklow and Howth series was identified, likely arising from differences in vertical referencing (e.g., GNSS-derived heights relative to a geoid model rather than conventional levelling). The offset was quantified using the mean monthly discrepancy over the overlap period (2007–2024) and applied to the full Arklow series (2003–2024) to align it with the Howth datum. Statistical outlier detection was applied to the Arklow 2003–2024 record using a threshold of ± 4 SD from the station mean. No outliers were identified. Only the 2003–2006 observations were used in the present analysis, with no outliers within this interval. The corrected Arklow series (2003–2006) was then employed to extend the Dublin Port record into the early 2000s. Following these procedures, all modern NTGN sea-level observations evaluated in this section—including the previously identified Cork (Tivoli) data from the early 2000s—met the quality-control and consistency criteria applied in this study (Figure S11).

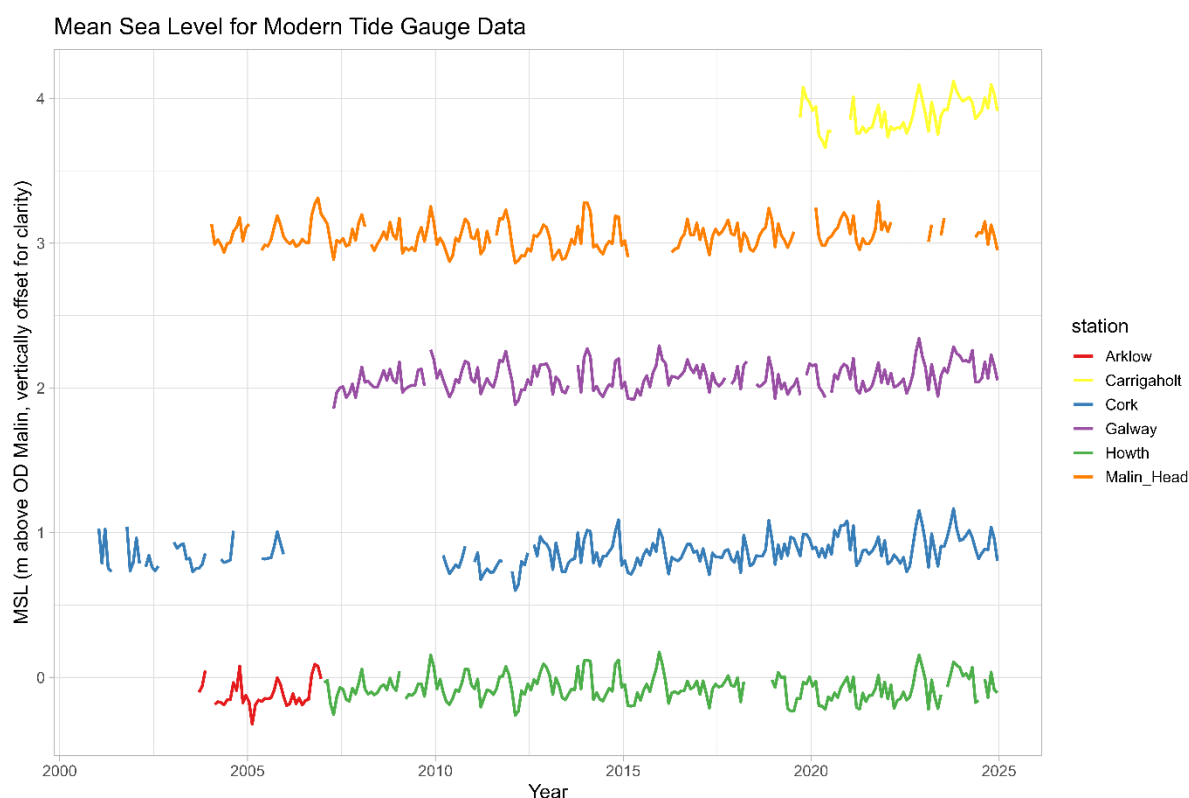


Figure S11. Tide-gauge records (2000s) for Arklow, Howth, Galway, Carrigaholt, and Malin Head. Each time series has been vertically offset for plotting clarity; Arklow and Howth are shown together after applying a fixed datum offset to align them.

As an additional validation step, the Dublin Port dataset was compared with Shoari Nejad et al. (2022) to assess alignment with the corresponding historical record. The comparison showed a mean difference of 0.018 m and a standard deviation of 0.019 m. No obvious discontinuities were observed, with the largest change between consecutive overlapping observations being 0.075 m, providing no evidence of a systematic datum-related inconsistency.

Satellite Altimetry–Tide Gauge Comparison

For validation of the tide-gauge sea-level records, observations were compared with satellite altimetry (1993–present) from the Copernicus Climate Change Service (C3S, 2018). Following the Alt–TG comparison framework described by Ray et al. (2023), gridded sea-level anomaly data were used as an independent reference dataset to assess consistency in sea-level variability, trends, and potential reference-level instability through satellite altimetry–tide gauge (Alt–TG) comparisons. Satellite altimetry values were extracted from the nearest available grid point to each tide-gauge location to provide a consistent spatial basis for comparison between the two

observing systems. Validation was restricted to stations with sufficient temporal overlap with satellite altimetry, including Belfast, Malin Head, Dublin Port, Cork, the Carrigaholt (Tarbert extension), and Galway. For the Malin Head series, observations recorded at Portrush (1998–2003 and 2015) were excluded from the analysis because the change in measurement location introduced additional uncertainty when comparing the tide-gauge observations with the satellite altimetry grid point. Observations from Malin Head in 2022 and 2023 were also omitted because only a few sparse months of data were available for these years. Similarly, the Arklow record (2003–2006), although corrected for its baseline offset to Howth, was excluded from the Dublin Port series because of the separation between the measurement locations.

Across the six stations, satellite altimetry and tide-gauge observations showed positive temporal correlations, with Pearson correlation coefficients ranging from 0.55 to 0.77 (Figure S12). The highest correlation was observed at Belfast ($r = 0.77$), while Galway showed the lowest ($r = 0.55$). Carrigaholt showed a moderate positive correlation ($r = 0.68$), indicating similar temporal variability between the two records over the overlapping period. Differences between the Alt–TG sea-level trends varied between stations, reflecting differences between geocentric satellite altimetry measurements and relative sea-level measurements from tide gauges, together with contributions from coastal ocean variability and spatial mismatch between gridded satellite observations and point-based tide-gauge measurements. These differences are expected because satellite altimetry and tide gauges sample sea level at different spatial scales and within different reference frameworks.

Satellite altimetry measures sea surface height relative to a geocentric reference frame, whereas tide gauges measure relative sea level with respect to local land-based benchmarks and are therefore sensitive to local VLM and datum definitions. Stations influenced by complex coastal geometry (e.g., estuarine and harbour environments) may exhibit reduced correlation compared with more open-coast sites, reflecting differences in spatial representativeness between gridded satellite observations and point-based tide-gauge measurements rather than necessarily indicating errors in either dataset.

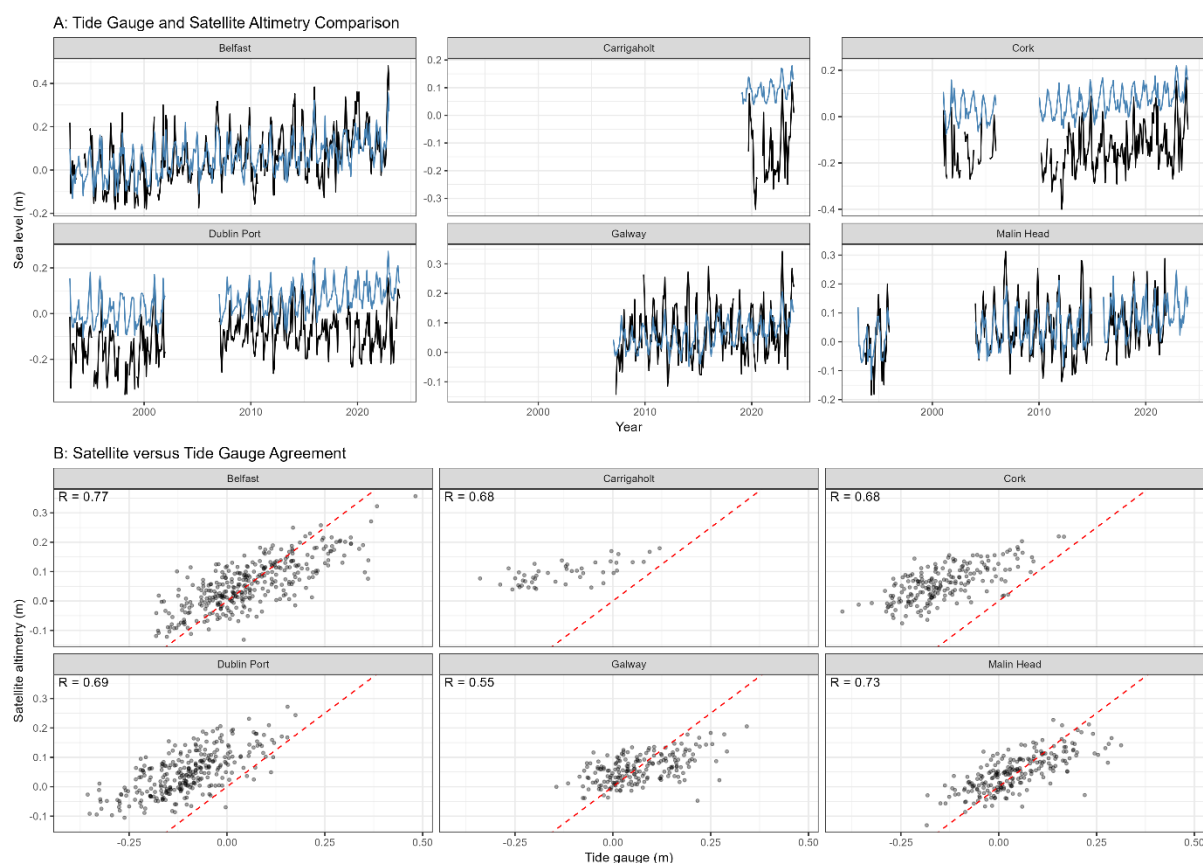


Figure S12. Comparison of in situ tide-gauge MSL records, adjusted to the Malin Head datum, and satellite altimetry observations at six Irish coastal stations (Belfast, Malin Head, Dublin Port, Cork, Galway, and Carrigaholt (Tarbert extension)). (A) Monthly tide-gauge MSL values (black) and nearest-grid-point satellite altimetry sea-level anomaly estimates (blue) over the overlapping satellite altimetry period. (B) Corresponding scatter plots of satellite altimetry observations against tide-gauge MSL values, with the dashed line indicating the 1:1 relationship. Pearson correlation coefficients (R) are shown for each station.

The relative difference between satellite altimetry and tide-gauge trends (satellite – tide gauge) was calculated for each station to assess divergence between the two observing systems (Table S3). Differences were generally small across most stations, with the longer records showing differences ranging from -1.18 mm yr^{-1} at Belfast to $+1.64 \text{ mm yr}^{-1}$ at Galway. Close agreement was observed at Cork ($+0.35 \text{ mm yr}^{-1}$) and Dublin Port ($+0.29 \text{ mm yr}^{-1}$), with Malin Head also showing a relatively small difference ($+0.45 \text{ mm yr}^{-1}$). Carrigaholt, used as an extension of the Tarbert record, showed the largest difference ($-12.32 \text{ mm yr}^{-1}$), reflecting the sensitivity of the short 2019–2024 overlap period rather than a long-term disagreement between the datasets. Despite this larger trend difference, Carrigaholt showed a moderate positive

540 correlation between satellite altimetry and tide-gauge observations ($r = 0.68$), indicating that the two records captured comparable temporal variability over the overlapping period. However, this discrepancy is likely attributable to the short duration of the Carrigaholt record (September 2019–December 2024) rather than a systematic difference between the two observing systems. Sensitivity testing using equivalent short time windows at other stations

545 produced similarly large trend differences. For example, restricting the Malin Head record to 2019–2024, while accounting for the missing observations in 2022 and 2023, resulted in a trend difference of approximately $-10.27 \text{ mm yr}^{-1}$, while Galway showed a difference of approximately -13 mm yr^{-1} over the same period. These results indicate that short-term variability and limited record length can substantially influence trend comparisons over short

550 intervals. The observed differences are consistent with the expected uncertainties associated with comparing point-based tide-gauge measurements and gridded satellite altimetry observations, particularly in complex coastal environments where local hydrodynamic variability, coastal proximity, and spatial sampling differences may influence agreement between the two observing systems. As emphasised by Ray et al. (2023), Alt–TG differences

555 can arise from multiple non-instrumental sources, particularly near the coast where satellite and tide-gauge measurements represent different spatial scales.

Table S3. Comparison of linear sea-level trends from tide-gauge records and satellite altimetry over the overlapping satellite era. Differences are calculated as satellite altimetry trend minus tide-gauge trend. Note: Difference values are based on unrounded trend estimates and may differ slightly from the rounded values shown.

560

Station	Tide gauge	Satellite	Difference
Belfast	6.16	4.97	−1.18
Cork	4.19	4.55	+0.35
Dublin Port	3.75	4.04	+0.29
Galway	3.28	4.92	+1.64
Malin Head	2.52	2.96	+0.45
Carrigaholt	23.46	11.14	−12.32

The differences between altimetry-derived and tide-gauge trends were generally small across the five longer records, ranging from -1.18 to $+1.64 \text{ mm yr}^{-1}$, and are consistent with

discrepancies expected from differences in coastal ocean dynamics, spatial sampling between
565 gridded satellite observations and point-based tide gauges, and uncertainties associated with
coastal altimetry (Ray et al., 2023). Carrigaholt, which has a substantially shorter record,
showed a larger trend difference of $-12.32 \text{ mm yr}^{-1}$.

Independent assessment of the Cork datum adjustment provides additional support for the
adopted vertical referencing approach. Using the 2.752 m datum reported by Pugh et al. (2021)
570 produces a Cork tide-gauge trend difference of approximately 2 mm yr^{-1} (tide gauge minus
satellite). In contrast, the OPW-sourced datum produces closer agreement with modern
observations from Ringaskiddy and Currach Club, providing additional support for the adopted
datum alignment.

Atmospheric Correction Model Selection and Validation

575 Predictors and their associated reanalysis grid points were selected individually for each tide-
gauge station to reflect differences in local weather patterns and coastal geography.
Correlations between observed water level and atmospheric predictors (pressure anomaly
 $P'_i(t)$, $\tau_x(t)$, $\tau_y(t)$) varied among stations, reflecting differences in local geography, coastal
orientation, and exposure to prevailing winds (Pugh & Woodworth, 2014). Annual and
580 semiannual harmonic terms were also initially included in the multiple regression to account
for seasonal variability. Predictors that were not statistically significant ($p \geq 0.05$) were omitted
from the final model, while all statistically significant predictors ($p < 0.05$) were retained (Table
S4). The contributions of the statistically significant predictors retained in the final model were
removed from the observed water level, while the regression intercept was retained to preserve
585 the original vertical reference level.

Table S4. Regression terms included in atmospheric corrections for each tide-gauge site.

Legend: Included = term included in the regression; Omitted = term not included.

Site	$P'_i(t)$	$\tau_x(t)$	$\tau_y(t)$	$\sin\left(\frac{2\pi t}{365.25}\right)$	$\cos\left(\frac{2\pi t}{365.25}\right)$	$\sin\left(\frac{2\pi t}{182.63}\right)$	$\cos\left(\frac{2\pi t}{182.63}\right)$	Notes / Supplement
Malin Head	Included	Omitted	Included	Included	Omitted	Included	Omitted	Supplemented by Portrush
Portrush	Included	Omitted	Included	Included	Omitted	Included	Omitted	Supplement to Malin Head
Belfast	Included	Included	Included	Included	Included	Included	Omitted	Supplemented by Bangor data
Bangor	Included	Omitted	Included	Included	Omitted	Omitted	Omitted	Supplement to Belfast
Dublin Port	Included	Included	Included	Included	Omitted	Included	Omitted	Supplemented by data from Dún Laoghaire, Arklow and Howth
Howth	Included	Included	Included	Included	Included	Included	Omitted	Supplement to Dublin Port
Arklow	Included	Omitted	Included	Included	Omitted	Omitted	Omitted	Supplement to Dublin Port
Dún Laoghaire	Included	Omitted	Omitted	Included	Included	Omitted	Omitted	Supplement to Dublin Port
Cork	Included	Included	Included	Included	Included	Included	Omitted	Supplemented by Ringaskiddy and Currach Club
Tarbert	Included	Omitted	Included	Included	Included	Omitted	Included	Supplemented by Carrigaholt
Galway	Included	Included	Included	Included	Omitted	Omitted	Omitted	Supplemented by data from Rossaveel and Galway Harbour

- 595 • Note: Atmospheric corrections used the full Portrush record (1998–2015), while subsequent analysis used only the 1998–2003 and 2015 tide-gauge observations.

To assess the effect of atmospheric adjustments on tide-gauge records, the mean and standard deviation (SD) of both the original and atmosphere-adjusted water levels were computed. These metrics provide a quantitative measure of the change in variability following atmospheric adjustment. Results for all stations are summarized in Table S5. The atmospheric correction consistently reduced variability across all tide-gauge sites, as indicated by decreases in SD, consistent with the removal of pressure- and wind-driven variability captured by the

600

regression model. Changes in the mean water level were generally small, reflecting the removal of atmospheric contributions, with slightly larger adjustments observed at Dublin Port.

Table S5. Mean and standard deviation of observed and atmospherically adjusted MSL levels at all tide-gauge sites. SD = standard deviation.

Site	Mean Water Level	SD Water Level	Mean Atmosphere-	SD Atmosphere-
	OD Malin (m)	(m)	Adjusted (m)	Adjusted (m)
Malin Head	0.00	0.10	-0.01	0.06
Portrush	0.09	0.10	0.05	0.03
Belfast	0.03	0.10	0.03	0.05
Bangor	0.11	0.12	0.07	0.06
Dublin Port	-0.15	0.09	-0.20	0.05
Howth	-0.07	0.09	-0.12	0.04
Arklow	-0.11	0.09	-0.15	0.02
Dún Laoghaire	-0.22	0.08	-0.20	0.06
Cork	-0.15	0.10	-0.13	0.06
Tarbert	-0.19	0.12	-0.20	0.09
Galway	0.06	0.10	0.03	0.06

Including the atmospheric pressure anomaly term enables the regression to capture the local expression of the inverted barometer effect, which typically alters water levels by ~10 mm per mbar (Pugh et al., 2021), resulting in broadly consistent reductions in short-term variability (SD) and slight changes in mean water level at most tide-gauge sites in this study. Similar to Thompson (1980), the regression estimates site-specific sensitivity to atmospheric pressure directly from observations. The resulting residuals represent sea-level variability with the estimated atmospheric pressure effect removed. Figure S13 illustrates this atmospheric correction at Dublin Port, showing how the regression reduces the influence of pressure-driven variability on observed water levels.

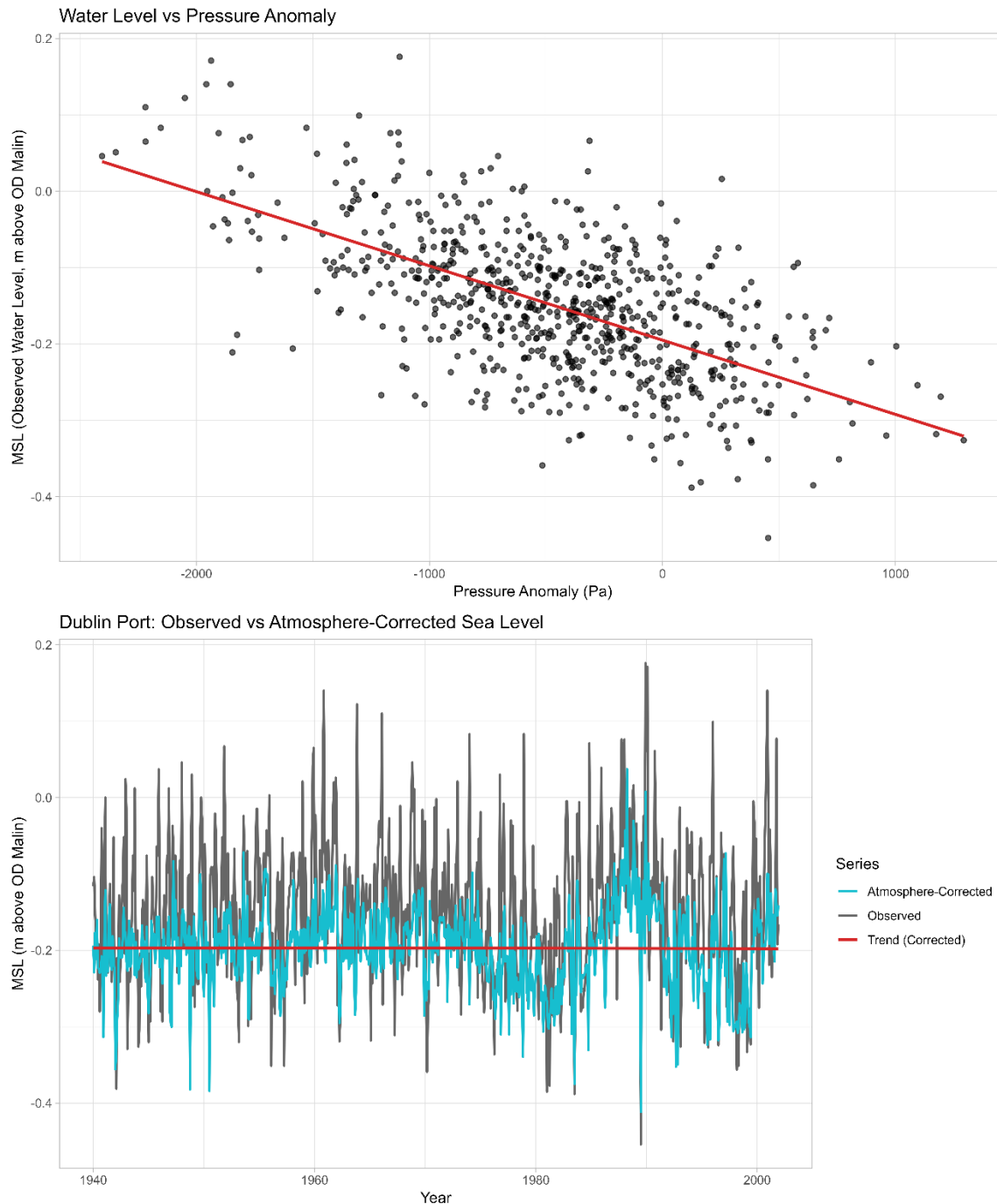


Figure S13. Atmospheric pressure correction applied to Dublin Port. Top: Observed monthly mean water level versus atmospheric pressure anomaly, showing a negative correlation ($r = -0.613$, $p < 2.2 \times 10^{-16}$), consistent with an inverse-barometer response in which higher atmospheric pressure is associated with lower sea level. The fitted linear regression shows the observed relationship between atmospheric pressure anomaly and sea level. Bottom: Observed and atmosphere-corrected monthly mean water levels, showing the corrected series after removal of the estimated atmospheric-pressure contribution.

Tide-Gauge Station Selection and Atmospheric Corrections

Atmospheric corrections were applied to tide-gauge records across Ireland, with the reanalysis product selected according to record period and the available temporal and spatial resolution. Sea-level variability is strongly influenced by atmospheric conditions, particularly atmospheric pressure (Johansson et al., 2022; Pham et al., 2024; Dangendorf et al., 2024).

- Long historical sea-level records from Belfast and Dún Laoghaire/Dublin Port were corrected for atmospheric variability using atmospheric fields from the Twentieth Century Reanalysis Version 3 (20CRv3; NOAA/CIRES/DOE, 2025; Slivinski et al., 2019). For Belfast and Dún Laoghaire, monthly surface pressure and 10 m wind components were calculated as the unweighted arithmetic mean of all reanalysis grid cells located within approximately a 1° radius of each station. Grid-cell selection used a latitude-adjusted distance metric, with longitude differences scaled by the cosine of the station latitude. This spatial averaging reduces sensitivity to individual reanalysis grid cells and provides a regional estimate of atmospheric forcing relevant to coastal sea-level variability. The Belfast record covers 1925–2010, while the Dún Laoghaire record covers 1925–1933, with Dublin Port observations incorporated for 1938–1939.
- Post-1940 stations: Bangor, Malin Head, Portrush, Cork, Tarbert, Galway, the post-1940 Dublin Port record, Arklow, and Howth were corrected using the ERA5 reanalysis (Hersbach et al., 2023), which has a spatial resolution of 0.25° . For each station, ERA5 grid points within $\pm 0.25^\circ$ in longitude and latitude of the tide-gauge location were evaluated, and the grid point showing the highest Pearson correlation between surface-pressure anomalies and the tide-gauge record over the common overlap period was selected. Surface pressure and concurrent 10 m wind components were extracted from this selected grid point. The 10 m zonal (u) and meridional (v) wind components were converted to zonal and meridional wind stress using the approach of Smith (1980).

To assess the sensitivity of the derived relative sea-level (RSL) trends to atmospheric adjustment and the choice of atmospheric reanalysis dataset, a sensitivity analysis was undertaken. The Belfast record was evaluated using the 20CRv3 reanalysis for 1925–2010, with the Bangor extension evaluated using the ERA5 reanalysis for 2011–2022. The Dublin record was similarly evaluated using the 20CRv3 reanalysis for the Dún Laoghaire-based early 1925–1939 segment and the ERA5 reanalysis for the Dublin Port record from 1940–2024. The Dún Laoghaire-based early 1925–1939 segment comprises available Dún Laoghaire

observations from 1925–1933, supplemented by Dublin Port observations for 1938–1939 to provide a consistent early-period segment for sensitivity assessment. Simple linear trends were calculated for both the original and atmosphere-adjusted sea-level series to quantify the effect of these adjustments on the estimated RSL rates. No fixed offset was applied between records corrected using different atmospheric datasets, as differences between datasets were treated as a source of methodological uncertainty rather than a constant correction.

The results show that atmospheric corrections had a relatively small effect on the estimated Belfast trend, changing it by 0.08 mm yr^{-1} over 1925–2010. The shorter Bangor extension showed a larger absolute difference of 1.07 mm yr^{-1} between uncorrected and corrected trends, with the trend increasing from 8.10 to 9.18 mm yr^{-1} . For the Dún Laoghaire-based early segment, comprising the available 1925–1933 Dún Laoghaire observations and the 1938–1939 Dublin Port observations, the 20CRv3-adjusted trend increased from 2.92 to 4.46 mm yr^{-1} ($+1.54 \text{ mm yr}^{-1}$). In contrast, the longer Dublin Port ERA5 period (1940–2024) showed little change, from 1.03 to 0.98 mm yr^{-1} (-0.05 mm yr^{-1}). The larger change during the shorter 20CRv3 period may reflect greater sensitivity to short-term atmospheric variability and uncertainty in the fitted regression. These differences reflect the sensitivity of the calculated trends to the atmospheric adjustment derived from the selected reanalysis dataset and the length of the observational record, rather than indicating the need for a systematic correction between datasets. The primary RSL trends therefore use the original sea-level records, with atmosphere-corrected trends retained as a sensitivity assessment (Table S6).

Table S6. Comparison of linear RSL trends before and after atmospheric adjustment for the Belfast, Bangor, Dún Laoghaire-based early segment, and Dublin Port records. Note: Differences use unrounded trend estimates and may differ slightly from the rounded values shown.

Station	Period	Dataset	Raw RSL trend (mm yr ⁻¹)	Atmosphere-corrected RSL trend (mm yr ⁻¹)	Difference (mm yr ⁻¹)
Belfast	1925–2010	20CRv3 reanalysis	−0.18	−0.09	+0.08
Bangor	2011–2022	ERA5 reanalysis	8.10	9.18	+1.07
Dún Laoghaire-based early segment	1925–1939	20CRv3 reanalysis	2.92	4.46	+1.54
Dublin Port	1940–2024	ERA5 reanalysis	1.03	0.98	−0.05

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