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When will 100 Global Coastal Cities Be Flooded by the Sea?

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Abstract

This article estimates the years when 100 coastal cities in 55 countries around the world will be flooded by the sea, home to 438 million people in 2024, or about 5% of the world's population. Estimated flood years are obtained by forecasting global ocean mean sea level anomalies, using wavelet analysis up to 2301. Altimetry data are provided by NOAA Laboratory for Satellite Altimetry. 2100 median projections of regional sea level rise for 100 coastal cities, relative to a 1995 to 2014 baseline, provided by the Intergovernmental Panel on Climate Change's Sixth Assessment Report presented through NASA datasets, allow the authors to evaluate how far the sea level of 100 cities will expand in 2100 from the average sea-level for each city and transform the sea level to the scale of the projected sea-level and to obtain an estimated year of flooding for each city. Assuming that the floods correspond to a 1 meter-rise in sea level, the estimated flood years for the 100 cities will range from 2083 for Manila to 2274 for Stockholm with an average flood year average around 2201 for cities like Amsterdam, Dakar, Dalian, Izmir, Lisbon, London, Perth, Rio de Janeiro, Sydney, Taipei, Valencia and Xiamen, close to the average year.

Keywords: *Sea level rise; Flood; Forecast; Wavelet analysis; Burg model.*

1. Introduction

The objective of the paper is to estimate in what years 100 coastal cities in 55 countries around the world will be flooded by the sea, home to 438 million people in 2024 or about 5% of the world population. Estimated years of flooding are obtained by forecasting mean sea level anomalies of the global ocean with wavelet analysis until 2301. A mean sea level anomaly is the difference from an average or baseline, global sea level. One of the most significant potential impacts of climate change is sea level rise, which may cause inundation of coastal areas and islands, shoreline erosion, and destruction of important ecosystems such as wetlands and mangroves. Coastal cities will not be spared by this phenomenon. By 2023, 2.15 billion people were living in the near-coastal zone and 898 million in the low-elevation coastal zone globally or 26.70% and 11.16% of the global population, respectively. Coastal areas are subject to hazards that can have severe impacts due to the high concentration of people and goods in exposed areas. Although climate-induced sea level rise will exacerbate these risks over the 21st Century, future dynamics of socio-economic development will play an important role in determining impacts – as well as adaptation responses – particularly in countries with rapid population growth in low-lying coastal areas (Reimann et al., 2023). This study will focus on the impact of global warming on sea level rise.

2. Literature Review

2.1. Overview of the literature on the Earth's flood

One of the most significant potential impacts of climate change is sea level rise that may cause inundation of coastal areas and islands, shoreline erosion, and destruction of important ecosystems such as wetlands and mangroves. Rostan and Rostan (2023a) assert this connection as global temperatures increase, sea level rises because of a thermal expansion of upper layers of the ocean and melting of glaciers and ice sheets (NOAA, 2024). The cause of global temperature increase is mainly greenhouse-gas emissions.

In 2016, governments around the world ratified the Paris Agreement on climate change, aiming to keep or move major investors away from fossil fuels to save the planet from global warming. In 2017, the One Planet conference was organized to uphold the Paris Agreement by pressuring governments and the World Bank to end subsidies and public financing of fossil fuels (Harvey, 2017).

The UN COP27 on climate change was held in Egypt in 2022. For the first time, COP participants agreed on a loss and damage fund, but no commitment to phase out fossil fuels was taken, which constitutes a rather pessimistic result. It was because voters and politicians place greater importance on immediate issues, such as inflation and the economy, leaving politicians to ignore global warming (Weisman and Ulloa, 2022). "Après moi, le deluge!" ("After me, the flood!") is a saying attributed to Louis the 15th, King of France in the 18th Century. Due to his mismanagement of the kingdom lacking a long-term vision, France experienced the fall of the monarchy during the French Revolution under the reign of his grandson, Louis the 16th, who succeeded him and was guillotined in 1793.

Today, a league of influential politicians, such as American Republicans, including U.S. President Donald Trump, Senator James Inhofe, and American Democrats, including Senator Joe Manchin III or former World Bank President David Malpass, are accused of climate denial when they refused to acknowledge that fossil fuels are warming the planet (Gelles and Rappeport, 2022). "Après

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moi, le deluge!” is their rallying cry to defend the fossil fuel industry responsible for global warming. They claimed that the scientific consensus on global warming was based on a conspiracy. In this context of lobbying and defamation, where the maximization of shareholder wealth takes precedence over environmental issues, newly re-elected President Trump declared a national energy emergency on his first day in office in January 2025, part of a series of pro-fossil fuel actions and efforts to "unleash" already booming U.S. energy production. He reiterated the 2016 Paris withdrawal plan and rolled back emissions standards (Noor, 2025). To counter this mode of thinking, every year, countries that have joined the United Nations Framework Convention on Climate Change (UNFCCC, United Nations, 2024a) meet to measure progress and negotiate multilateral responses to climate change. 198 Parties have joined the Convention nowadays. The first Conference of the Parties (COP) was held in Berlin, Germany 1995. The 28th COP was held at the end of 2023 in Dubai, United Arab Emirates. It included the first Global Stocktake, where States assessed the progress made towards the goals set in the Paris Agreement and charted a course of action. The role of fossil fuels in Gulf economies has made the issue of phasing out fossil fuels a particularly controversial topic at COP28, as phasing out fossil fuels could be very costly for these Gulf countries. COP29 was held in Baku, Azerbaijan, in November 2024. Environmentalists are not convinced of the outcomes of these conferences. Countries and peoples, hit hardest by climate change, are unable to get their voices heard during these Climate summits (Steffen and Niranjan, 2021). Environmentalists say the COP is overwhelmingly white and rich. For these rich and white people work those influential politicians, supporters of the fossil fuel industry, who accuse the spreaders of fake news of harming the industry with false data. Fake news spreaders may include Ekwurzel et al. (2017), who stated that 90 carbon producers contributed approximately 42-50% of the increase in global average temperature during the period 1880-2010. These 90 carbon producers also massively contributed to the observed rise in atmospheric CO2, whose increase is responsible for global warming and the rise of global sea level, according to the paper. Eighty-three of those companies produce coal, oil, and natural gas, while the remaining seven are cement manufacturers. As mentioned earlier, newly re-elected President Trump reiterated the 2016 Paris withdrawal plan in January 2025 and rolled back emissions standards (Noor, 2025). According to an annual United Nations emissions report, the Paris agreement would provide only a third of the greenhouse gas reductions that environmentalists say are needed to avoid catastrophic warming (The Economist, 2017). If all countries (minus the U.S. now), involved in the Paris agreement, meet their commitments by 2030 – which is doubtful –, temperatures should rise at least another 3 degrees Celsius by 2100. How long will the Earth live under the deadly threat of global warming on its inhabitants?

Supporters of President Trump have claimed that global warming predictions are based on computer models that are unreliable predictors. Furthermore, the UN report acknowledged that the Paris climate agreement was flawed. Government leaders in Paris were just pretending since their timid commitments would not prevent global warming and flooding. So, Trump supporters believed he was right to stop pretending. The study by Willner et al. (2018) is one such computer model predicting the end of the world. The study calculates the amount required to maintain a constant risk of large floods over the next 25 years. Willner et al. estimate that global warming is expected to bring more rain, exposing millions of people to river flooding, particularly in America and parts of Asia, Africa, and central Europe. Based on models 10 times more accurate than commonly used climate computer simulations, if action is not taken, the number of people affected by devastating floods could skyrocket. Asia – the continent with the greatest historical risk of high-level flooding – would be hardest hit, with the number of people affected by river flooding expected to rise from 70 million to 156 million by 2040. In August 2022, episodes of massive flooding took place in Asia. Among them, a report that floods affected nearly 500,000 residents in Odisha, eastern India, and some 60,000 people were displaced from their homes. Parts of Vietnam, northern Thailand, border areas of Myanmar, and northern Laos witnessed heavy rains caused by tropical storm Mulan, which caused flooding and landslides, resulting in 5 dead and 4 missing. In Afghanistan, flash floods kill more than 30 people in Parwan (FloodList, 2022). During summer 2023, at least 16 cities and provinces in northeastern China experienced record rainfall and flooding due to Typhoon Doksuri, the 5th typhoon in the Pacific in 2023. Beijing experienced its heaviest rainfall in 140 years. The rain exceeded 60% of a typical ‘ ‘year’s rain in just 83 hours. On Sept. 2, 2023, Typhoon Saola hit southern China, prompting the evacuation of more than 880,000 people, notably in the Hebei Province (Centre for Disaster Philanthropy, 2023). Global warming is also responsible for sea level rise. In 2016, Solomon Islands, an archipelago of six major islands and about 992 small islands, atolls, and reefs located in the Pacific Ocean, lost five of its islands (Albert et al., 2016). In Indonesia, Jakarta, whose metropolitan area is home to about 31 million, representing the second-most populous urban area in the world after Tokyo, is sinking so fast that Jakarta may vanish since the sea level is expected to rise by three feet in the region within the Century (Kimmelman, 2017). In 2024, floods made headlines around the world, with heavy rains causing flooding in the United Arab Emirates, mainly affecting the cities of Dubai and Sharjah, the Northern Emirates, and different areas of the Emirate of Ras Al Khaimah. Dubai flights in the world’s second busiest international airport were delayed or cancelled, while people and students were asked to work and study from home (Salem et al., 2024). In Jordan, Irbid governorates has experienced several flash floods in recent years, which have caused extensive damage to infrastructure and ‘residents’ lives. Al Azzam and Al Kuisi (2023) developed a forecasting model based on the integration of a geographic information system, a watershed modeling system, a hydrological modeling system, and a river analysis system, which shows that in the next thousand years, Irbid governorate will experience persistent floods. People in the low-lying coastal districts of southwestern Bangladesh are particularly exposed to natural disasters such as coastal flooding and sea-level rise, the intensity of which has increased in recent years (Sultana and Hasan, 2024). Texas experienced heavy rainfall in the Houston area and other parts of Southeast Texas, which led to hundreds of rescues, including people, stranded on rooftops (Lozano, 2024). The death toll from the Kenya floods rises to 228 by May 2024. Torrential rains caused widespread flooding and landslides across the country (Miriri et al., 2024). By November 2024, in the Edo State of Nigeria, where crop farming is among the primary sources of income, 42,284 individuals in 7,656 households were affected by the floods (Reliefweb, 2024). Odiana, Mbee, and Akpoghomeh (2023) assessed the flood disaster preparedness and capacity assessment of crop farmers after years of regular flooding. Flood and landslide hit Indonesia's Sulawesi Island, killing 14 (Tarigan, 2024). Weeks of deadly floods triggered by record-smashing rainfall left parts of southern Brazil in disaster (Gilbert, 2024). More than 170 people were killed and nearly 580,000 displaced after storms and floods battered Brazil's southernmost state of Rio Grande do Sul, with local authorities describing it as the worst disaster in the region's history. Climate change has made devastating floods twice as likely (Araujo, 2024). Russia and Kazakhstan suffered the worst flooding in 80 years. Higher-than-usual spring temperatures caused much snow to melt rapidly, inundating parts of both countries (Fedorinova and Gizitdinov, 2024). Flooding hit China's south in June 2024. Heavy rains lashed the southeastern Fujian province and the Guangxi region (Master and Cao, 2024). Flooding, landslides, and damage to infrastructure have been reported following heavy rains affecting Northeastern and Central Switzerland as well as Southern Germany, where floods killed at least four (Swissinfo.ch, 2024). Floods due to intense precipitation are explained by climate change. Warmer oceans due to global warming increase the amount of water that evaporates into the air. When more moisture-laden air moves over land or converges on a storm system, it can produce more intense precipitation, resulting in a flood (EPA, 2024). In addition, as global temperatures increase, sea level rises due to a thermal expansion of the upper layers of the ocean and the melting of glaciers and ice sheets. For example, warmer waters north of Antarctica have melted and weakened the world's largest iceberg, A23a, which broke off the Filchner Ice Shelf in 1986. A23a got stuck on the seabed, then caught in an ocean vortex, but eventually started drifting again, finding itself in January 2025 about 280km from South Georgia island, on a collision course with this island of 3,755km^2, wildlife refuge, where it could run aground and break into pieces, endangering penguins and seals living there (Rannard and Rivault, 2025). Using a wavelet analysis forecasting model applied to global ocean mean sea level anomalies, this paper focuses on the alarming impact of global warming on seas and oceans across the Earth, especially on sea level rise.

Reviewing the literature that presents forecasts of floods in coastal cities, C40 is a global network of nearly 100 mayors of the world's leading cities that are united in action to confront the climate crisis (C40 Cities, 2025). Their article on sea level rise and coastal flooding predicts that by 2050, 800 million people will live in cities where sea levels could rise by more than half a metre. NASA presented a sea level projection tool on https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool based on the U.S. Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report Sea Level Projections with median projections of global and regional sea level rise, relative to a 1995-2014 baseline. The projections span from 2020 to 2150 presented by decades. Many studies address the consequences of floods on coastal cities and how they should prevent flooding but studies that apply a formal methodology to estimate in what years coastal cities will be flooded by the sea are scarce. For example, Kirezci et al. (2020) showed that in the absence of coastal protection or adaptation, and under a medium RCP8.5 scenario, there would be a 48% increase in global land area, a 52% increase in global population, and a 46% increase in global assets exposed to flood risk by 2100. In total, 68% of global coastal flooding will be caused by tides and storms, including 32% by projected regional sea-level rise. But no specific data on coastal cities was provided. Specifically, the present paper focuses on 100 coastal cities, estimating the years when floods will hit them with a sea level rise of 1 and 1.5 meters. The next section focuses on the literature on wavelet analysis applied to forecasting used in this paper.

2.2. Wavelet analysis applied to forecasting

Wavelet analysis has been primarily applied to physical phenomena such as electrical, audio, or seismic signals, which propagate through space in waveforms. Wavelet analysis has also been applied in finance and economics since interest rates, exchange rates, volatility of asset returns, gross domestic product, levels of employment or consumer spending propagate through time in waveforms. For example, Rostan and Rostan (2018a) illustrated the versatility of wavelet analysis to the forecast of financial time series with distinctive properties. The versatility of wavelet analysis was also demonstrated when applied to forecasting the growing number of European Muslim population (Rostan and Rostan, 2019), to assess the financial sustainability of the Spanish pension system (Rostan et al., 2015) as well as the Saudi pension system (Rostan and Rostan 2018b). Extending the analysis to the complex-behaviour of economic signals, wavelet analysis was applied to economic variables subject to common dynamics such as GDP time series that were used to forecast the Spanish economy (Rostan and Rostan, 2018c), as well as Greek (Rostan and Rostan, 2018d), Saudi (Rostan and Rostan, 2021a, 2024b, Rostan et al., 2024), Austrian (Rostan and Rostan, 2020), Persian Gulf (2022a), Turkish (2022b), UK (2022c) Australian (2024a), South Korea's (2023b), Cyprus' (2023c), Brazil's, Mexico's and Argentina's (2024b), Slovenia's (2024d), China's (2025) and the Eurozone's (Rostan et al., 2023) economies. Interest rates were forecasted with wavelet analysis due to their valuable property of propagating through time in waveforms (Rostan et al., 2017). In addition, fossil fuels price estimates (Rostan and Rostan, 2021b), solid waste of OECD countries (2023d), casualties resulting from state-based conflicts (2024e), and population estimates (Rostan and Rostan, 2017) were forecasted with wavelet analysis as well as global temperatures (Rostan and Rostan, 2023a). The methodology of the present paper involves a wavelet analysis forecasting model that generates forecast estimates of mean sea level anomaly of global ocean (annual signals retained) until 2301.

3. Materials and Methods

The aim of the study is to estimate in what years 100 coastal cities will be flooded by 1 to 1.5 meters by the sea. These 100 coastal cities were home to 438 million people in 2024, or about 5% of the world's population. Estimated years of flooding are obtained by forecasting mean sea level anomalies of global ocean with wavelet analysis until 2301. A mean sea level anomaly is the difference from an average, or 1995-2014 baseline, global sea level. Satellite altimeter radar measurements are combined with precisely known spacecraft orbits to measure sea level on a global basis with unprecedented accuracy. The methodology follows 4 steps illustrated in Figure 1.

Step 1:
Forecast between 2024 and 2301, with a wavelet analysis forecasting model, 20,688 global mean sea level anomalies from a 1995-2014 baseline, with a frequency of 5 days. Compute the average μ = 0.5584 meter of 75 global mean sea level anomalies estimates in 2100 with a frequency of 5 days.
Source: 1,489 historical altimetry data from 1992 to 2024 provided by NOAA Laboratory for Satellite Altimetry.
https://www.star.nesdis.noaa.gov/socd/lsa/SeaLevelRise/LSA_SLR_timeseries.php

Step 2:
Gather Nasa Median projections of sea level rise for year 2100 of 100 coastal cities, relative to a 1995-2014 baseline, compute the sample mean $\bar{X}$ and the sample standard deviation s for 100 coastal cities; $\bar{X}$ = 0.6841 and s = 0.2016
Source: 2100 Nasa sea-level projection IPCC 6th Assessment Report
https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool

Step 3:
Normalize each 2100 Nasa Median projection of sea level rise noted X by computing $[X - \bar{X}] / s$ for each city. Convert the NASA 2100 Median projections of sea level rise into the present study's scale for each city using the following equation: $\mu + [X - \bar{X}] / s * s$
Example with the city of Acapulco: $\mu + [X - \bar{X}] / s * s$ = 0.5584 + [1.16 – 0.6841] / 0.2016 * 0.2016 = 1.0343

Step 4:
Compute the Year estimate when each city will be 1 and 1.5 METER-flooded based on the present study's scale and projection. Example with the city of Acapulco: 1 meter – 1.0343 meter = -0.0343; μ + (- 0.0343) = 0.5584 + (– 0.0343) = 0.5241 corresponds to year 2097 in the present study's scale; 1.5 meter – 1.0343 meter = 0.4657; μ + 0.4657 = 0.5584 + 0.4657 = 1.0241 corresponds to year 2209 in the present study's scale.

Figure 1. Flowchart of the methodology from steps 1 to 4.

3.1. Step 1: Forecasting between 2024 and 2301, with a wavelet analysis forecasting model, mean sea level anomalies from a 1995-2014 baseline

The methodology, improved with a de-noising and compression, presented in a seminal paper of Rostan and Rostan (2018a), requires four levels illustrated with data from 1992 to 2024 (1,489 data) with a frequency of 5 to 10 days with an uncertainty of 3–4 mm representing mean sea level anomaly global ocean (annual signals retained), using a reference series of satellite missions that started with TOPEX/Poseidon (T/P) in 1992 and continued with Jason-1 (2001–2013), Jason-2 (2008–2019), Jason-3 (2016–present), and Sentinel-6MF (2020–present) estimate global mean sea level. For information, Jason-3, launched on January 17 2016, was a joint effort between NOAA, the National Aeronautics and Space Administration, France's Centre National d'Études Spatiales or CNES and the European Organisation for the Exploitation of Meteorological Satellites or EUMETSAT (NOAA, 2024).

Figure 2 illustrates the methodology of step 1. The detailed methodology of step 1, applied to temperature anomalies projections, is documented in Rostan and Rostan (2023a).

Steps 2, 3, and 4 are detailed in Table 1 of the Results section.

Level 1: De-noising and Compression of the first-order difference of mean sea level anomalies of global ocean time series

Level 2: Wavelet Decomposition

Level 3: Burg extension of approximations and details

Level 4: Wavelet Reconstruction, i.e. forecasting

Figure 2. Flowchart of the methodology of step 1.

Figure 3 illustrates the historical time series from 1992 to 2024 of 1,489 mean sea level anomalies with a frequency of 5 to 10 days (Source: NOAA/Laboratory for Satellite Altimetry). https://www.star.nesdis.noaa.gov/socd/lsa/SeaLevelRise/LSA_SLR_timeseries.php)

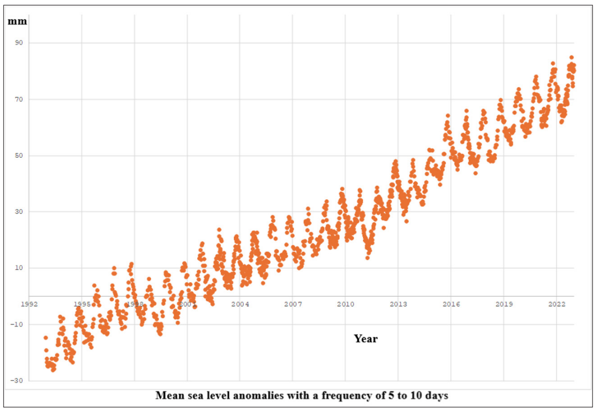

Figure 3. Historical time series from 1992 to 2024 of 1,489 mean sea level anomalies with a frequency of 5 to 10 days (Source: NOAA/Laboratory for Satellite Altimetry https://www.star.nesdis.noaa.gov/socd/lsa/SeaLevelRise/LSA_SLR_timeseries.php)

Figure 4 illustrates the historical time series from 1992 to 2024 of 1,489 mean sea level anomalies with a frequency of 5 to 10 days (Source: NOAA/Laboratory for Satellite Altimetry. https://www.star.nesdis.noaa.gov/socd/lsa/SeaLevelRise/LSA_SLR_timeseries.php) They are combined with the time series of 20,688 estimates of mean sea level anomalies from 2024 to 2301 with a frequency of 5 days obtained with the wavelet analysis forecasting model explained in step 1. The forecasting model, using Matlab, cannot generate 20,688 estimates at once from 1,489 historical data. The forecasting process is divided into 3 steps: 1) estimate 2,200 data from 1,489 historical data, 2) estimate 5,200 data from 3,689 data (2,200 + 1,489), and 3) estimate 13,288 data from 8,889 data (5,200 + 2,200 + 1,489). The total of the estimates is 2,200 + 5,200 + 13,288 = 20,688.

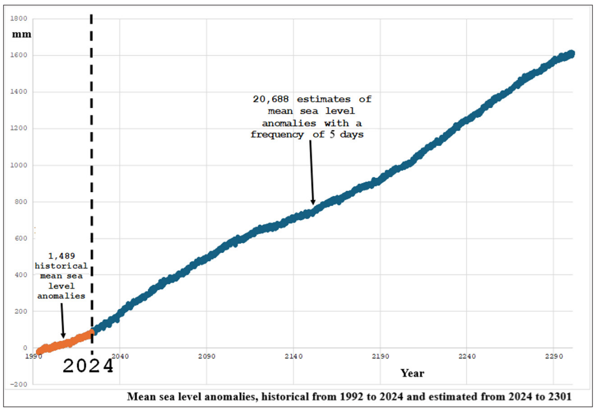

Figure 4. Historical time series from 1992 to 2024 of 1,489 mean sea level anomalies with a frequency of 5 to 10 days (Source: NOAA/Laboratory for Satellite Altimetry https://www.star.nesdis.noaa.gov/socd/lsa/SeaLevelRise/LSA_SLR_timeseries.php) combined with the time series of 20,688 estimates of mean sea level anomalies from 2024 to 2301 with a frequency of 5 days obtained with the wavelet analysis forecasting model explained in step 1.

3.2. Identifying the optimal level of decomposition

This section focuses on the optimal level of decomposition of the wavelet analysis forecasting model (Level 2: Wavelet Decomposition of step 1 presented in Figure 2). For this exercise, the 1,489 historical data are cut into two samples of size two-third and one-third: 997 historical data are used to estimate 497 in-sample data that are compared to the existing set of historical data. 7 models are used with level of decomposition ranging from 1 to 7. Levels 1, 3, 4, 5, 6, 7-decomposition return an error message. Only level 2-decomposition of the wavelet analysis generate estimates. The 2nd level of decomposition is, therefore, used to forecast 20,688 estimates, illustrated in Figure 4.

3.3. Benchmarking the level 2 wavelet analysis forecasting model to Linear and Polynomial extrapolations

20,688 estimates are generated from 1,489 historical data. Two other common methods of forecasting are used: linear and second-order polynomial extrapolations. As illustrated by Figure 5, second-order polynomial extrapolations bracket level 2 wavelet analysis estimates from above and linear extrapolations from below. The wavelet analysis forecasting model can be considered as the average scenario between the other two.

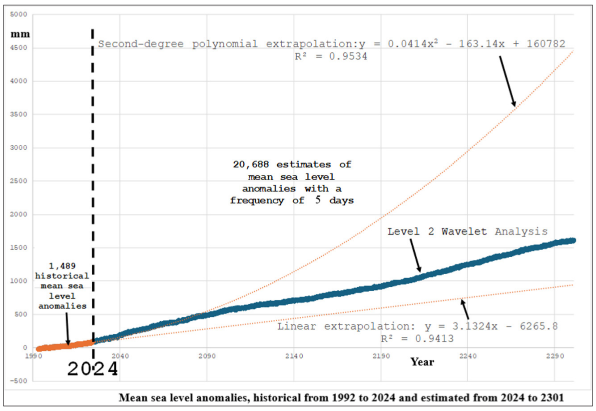

Figure 5. Historical time series from 1992 to 2024 of 1,489 mean sea level anomalies with a frequency of 5 to 10 days (Source: NOAA/Laboratory for Satellite Altimetry https://www.star.nesdis.noaa.gov/socd/lsa/SeaLevelRise/LSA_SLR_timeseries.php) combined with the time series of 20,688 estimates of mean sea level anomalies from 2024 to 2301 with a frequency of 5 to 10 days obtained with the wavelet analysis forecasting model benchmarked to Linear and Second-order polynomial extrapolations.

4. Results

The objective of the paper is to estimate in what years 100 coastal cities in 55 countries around the world will be flooded by the sea, home to 438 million people in 2024, or about 5% of the world's population. These 100 coastal cities can be identified on the map provided by NASA presented as a sea level projection tool on https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool as mentioned earlier. Estimated flood years are obtained by forecasting global ocean mean sea level anomalies with wavelet analysis up to 2301. Altimetry data are provided by NOAA Laboratory for Satellite Altimetry. 2100 median projections of regional sea level rise for 100 coastal cities, relative to a 1995 to 2014 baseline, provided by the Intergovernmental Panel on Climate Change's Sixth Assessment NASA Report, allow the authors to evaluate how far the sea level of 100 cities will expand in 2100 from the average sea-level for each city and transform the sea level to the scale of the projected sea-level relative to a 1995-2014 baseline to obtain an estimated year of flooding for each city. For the decomposition/reconstruction part of wavelet analysis, the 2nd level is used.

Table 1 presents the years in which 100 coastal cities worldwide will be flooded by the sea, using the wavelet analysis model presented in the methodology section, with floods of 1 meter (column 7) and 1.5 meters (column 8) and with information on each city and intermediate results. Used as benchmarks, columns 9 and 10 present the median projections of global and regional sea level rise, for floods of 1 meter and 1.5 meters respectively, provided by the United States Intergovernmental Panel on Climate Change (IPCC, 2025).

Table 1. In what years 100 coastal cities around the world will be flooded by the sea with floods of 1 meter (column 7) and 1.5 meters (column 8) versus IPCC 6th Assessment Report Sea Level Projections of 1 meter (column 9) and 1.5 meters (column 10) with information on each city and intermediate results.

	City	Population in million (1)	Country	Income level (2)	2100 Nasa Median project-tions of sea level rise (3)	Compute (x - x̄) / s (4)	2100 average sea-level projected by the present study (5)	Conver-sion of the NASA scale into the present study's scale (6)	Year-estimate the City will be 1 meter-flooded based on the present study (7)	Year-estimate the City will be 1.5 meter-flooded based on the present study (8)	Year-estimate the City will be 1.0 meter-flooded based on IPCC (9)	Year-estimate the City will be 1.5 meter-flooded based on IPCC (10)
1	Acapulco	1.032	Mexico	Upper-middle-income	1.16	2.3605	0.5584	1.0343	2097	2209	2100	2130
2	Aden	1.116	Yemen	Low-income	0.67	-0.0699	0.5584	0.5443	2206	2278	2130	After 2150
3	Alexandria	5.2	Egypt	Lower-middle-income	0.74	0.2773	0.5584	0.6143	2191	2267	2130	After 2150
4	Amsterdam	0.821	Nether-lands	High-income	0.69	0.0293	0.5584	0.5643	2202	2274	2150	After 2150
5	Antalya	1.372	Turkey	Upper-middle-income	0.74	0.2773	0.5584	0.6143	2191	2267	2130	After 2150
6	Athens	3.154	Greece	High-income	0.48	-1.0124	0.5584	0.3543	2232	After 2301	After 2150	After 2150
7	Auckland	1.692	New Zealand	High-income	0.73	0.2277	0.5584	0.6043	2194	2270	2130	After 2150
8	Bandar Abbas*	0.526	Iran	Upper-middle-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2140	After 2150
9	Baltimore	1.462	US	High-income	0.94	1.2693	0.5584	0.8143	2147	2238	2110	2150
10	Bangkok	11.234	Thailand	Upper-middle-income	1.79	5.4854	0.5584	1.6643	Soon	2073	2070	2090
11	Barcelona	5.711	Spain	High-income	0.75	0.3269	0.5584	0.6243	2191	2267	2130	After 2150
12	Batumi	0.152	Georgia	Upper-middle-income	0.6	-0.4171	0.5584	0.4743	2214	2293	2150	After 2150
13	Belem	2.432	Brazil	Upper-middle-income	0.69	0.0293	0.5584	0.5643	2202	2274	2130	After 2150
14	Belfast	0.647	UK	High-income	0.48	-1.0124	0.5584	0.3543	2232	After 2301	After 2150	After 2150
15	Boston	0.629	US	High-income	0.89	1.0213	0.5584	0.7643	2158	2247	2120	After 2150
16	Buenos Aires	15.37	Argentina	High-income	0.65	-0.1691	0.5584	0.5243	2208	2283	2140	After 2150
17	Busan	3.477	South Korea	High-income	0.73	0.2277	0.5584	0.6043	2194	2270	2130	After 2150
18	Brisbane	2.69	Australia	High-income	0.68	-0.0203	0.5584	0.5543	2203	2277	2130	After 2150
19	Cape Town	4.977	South Africa	Upper-middle-income	0.68	-0.0203	0.5584	0.5543	2203	2277	2130	After 2150
20	Cardiff	0.362	UK	High-income	0.64	-0.2187	0.5584	0.5143	2210	2284	2150	After 2150
21	Cartagena	1.096	Colombia	Upper-middle-income	0.94	1.2693	0.5584	0.8143	2147	2238	2110	2150

Continuing from Table 1. In what years 100 coastal cities around the world will be flooded by the sea with floods of 1 meter (column 7) and 1.5 meters (column 8) versus IPCC 6th Assessment Report Sea Level Projections of 1 meter (column 9) and 1.5 meters (column 10) with information on each city and intermediate results.

	City	Population in million (1)	Country	Income level (2)	2100 Nasa Median project-tions of sea level rise (3)	Compute (x - x̄) / s (4)	2100 average sea-level projected by the present study (5)	Conver-sion of the NASA scale into the present study's scale (6)	Year-estimate the City will be 1 meter-flooded based on the present study (7)	Year-estimate the City will be 1.5 meter-flooded based on the present study (8)	Year-estimate the City will be 1.0 meter-flooded based on IPCC (9)	Year-estimate the City will be 1.5 meter-flooded based on IPCC (10)
22	Chennai	6.6	India	Lower-middle-income	0.57	-0.5659	0.5584	0.4443	2220	2299	2150	After 2150
23	Copenhagen	1.391	Denmark	High-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2150	After 2150
24	Dakar	3.54	Senegal	Upper-middle-income	0.69	0.0293	0.5584	0.5643	2202	2274	2130	After 2150
25	Dalian	6.217	China	Upper-middle-income	0.7	0.0789	0.5584	0.5743	2198	2273	2130	After 2150
26	Davao	1.991	Philippines	Lower-middle-income	0.71	0.1285	0.5584	0.5843	2197	2272	2130	After 2150
27	Doha*	0.665	Qatar	High-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2140	After 2150
28	Dubai*	3.4	United Arab Emirates	High-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2140	After 2150
29	Dublin	1.284	Ireland	High-income	0.6	-0.4171	0.5584	0.4743	2214	2293	2150	After 2150
30	Durban	3.262	South Africa	Upper-middle-income	0.68	-0.0203	0.5584	0.5543	2203	2277	2130	After 2150
31	Edinburgh	0.105	UK	High-income	0.55	-0.6651	0.5584	0.4243	2223	After 2301	After 2150	After 2150
32	Genoa	0.674	Italy	High-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2150	After 2150
33	Gdansk	0.465	Poland	High-income	0.75	0.3269	0.5584	0.6243	2191	2267	2130	After 2150
34	Goteborg	0.638	Sweden	High-income	0.42	-1.3100	0.5584	0.2943	2242	After 2301	After 2150	After 2150
35	Haiphong	1.463	Vietnam	Lower-middle-income	0.5	-0.9132	0.5584	0.3743	2230	After 2301	2130	After 2150
36	Hamburg	1.841	Germany	High-income	0.73	0.2277	0.5584	0.6043	2194	2270	2130	After 2150
37	Havana	2.152	Cuba	Upper-middle-income	0.83	0.7237	0.5584	0.7043	2173	2254	2120	After 2150
38	Helsinki	1.346	Finland	High-income	0.32	-1.8060	0.5584	0.1943	2255	After 2301	After 2150	After 2150
39	Hiroshima	2.062	Japan	High-income	0.95	1.3189	0.5584	0.8243	2146	2236	2110	2140
40	Ho Chi Minh City	9.568	Vietnam	Lower-middle-income	0.5	-0.9132	0.5584	0.3743	2230	After 2301	2130	After 2150
41	Hong Kong	7.726	Hong Kong	High-income	0.68	-0.0203	0.5584	0.5543	2203	2277	2140	After 2150
42	Istanbul**	15.97	Turkey	Upper-middle-income	0.58	-0.5163	0.5584	0.4543	2220	After 2301	2150	After 2150

Continuing from Table 1. In what years 100 coastal cities around the world will be flooded by the sea with floods of 1 meter (column 7) and 1.5 meters (column 8) versus IPCC 6th Assessment Report Sea Level Projections of 1 meter (column 9) and 1.5 meters (column 10) with information on each city and intermediate results.

	City	Population in million (1)	Country	Income level (2)	2100 Nasa Median projections of sea level rise (3)	Compute (x - x̄) / s (4)	2100 average sea-level projected by the present study (5)	Conversion of the NASA scale into the present study's scale (6)	Year-estimate the City will be 1 meter-flooded based on the present study (7)	Year-estimate the City will be 1.5 meter-flooded based on the present study (8)	Year-estimate the City will be 1.0 meter-flooded based on IPCC (9)	Year-estimate the City will be 1.5 meter-flooded based on IPCC (10)
43	Izmir	3.12	Turkey	Upper-middle-income	0.71	0.1285	0.5584	0.5843	2197	2272	2140	After 2150
44	Jacksonville	0.971	US	High-income	0.84	0.7733	0.5584	0.7143	2171	2254	2120	After 2150
45	Jeddah****	4.18	Saudi Arabia	High-income	0.67	-0.0699	0.5584	0.5443	2206	2278	2130	After 2150
46	Karachi	17.649	Pakistan	Lower-middle-income	0.6	-0.4171	0.5584	0.4743	2214	2293	2150	After 2150
47	Kolkata	15.571	India	Lower-middle-income	0.5	-0.9132	0.5584	0.3743	2230	After 2301	2130	After 2150
48	Kuala Lumpur	8.815	Malaysia	Upper-middle-income	0.65	-0.1691	0.5584	0.5243	2208	2283	2150	After 2150
49	Lisbon	3.014	Portugal	High-income	0.71	0.1285	0.5584	0.5843	2197	2272	2130	After 2150
50	London	8.982	UK	High-income	0.67	-0.0699	0.5584	0.5443	2206	2278	2140	After 2150
51	Los Angeles	3.97	US	High-income	0.54	-0.7147	0.5584	0.4143	2225	After 2301	After 2150	After 2150
52	Manila	14.942	Philippines	Lower-middle-income	1.22	2.6581	0.5584	1.0943	2083	2196	2090	2120
53	Marseille	1.635	France	High-income	0.63	-0.2683	0.5584	0.5043	2211	2287	2140	After 2150
54	Miami	0.449	US	High-income	0.85	0.8229	0.5584	0.7243	2169	2251	2120	After 2150
55	Monaco	0.036	Monaco	High-income	0.56	-0.6155	0.5584	0.4343	2221	After 2301	2150	After 2150
56	Mombasa	1.495	Kenya	Lower-middle-income	0.74	0.2773	0.5584	0.6143	2191	2267	2130	After 2150
57	Mumbai	21.673	India	Lower-middle-income	0.58	-0.5163	0.5584	0.4543	2220	After 2301	2150	After 2150
58	Naples	0.954	Italy	High-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2150	After 2150
59	New Orleans	1.021	US	High-income	1.02	1.6661	0.5584	0.8943	2124	2227	2100	2140
60	New York City	19.034	US	High-income	0.93	1.2197	0.5584	0.8043	2152	2239	2110	2150
61	Osaka	18.967	Japan	High-income	1.05	1.8149	0.5584	0.9243	2115	2222	2100	2130
62	Oslo	0.84	Norway	High-income	0.25	-2.1532	0.5584	0.1243	2267	After 2301	After 2150	After 2150
63	Palermo	0.85	Italy	High-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2150	After 2150
64	Panama City	2.015	Panama	High-income	0.74	0.2773	0.5584	0.6143	2191	2267	2130	After 2150

Continuing from Table 1. In what years 100 coastal cities around the world will be flooded by the sea with floods of 1 meter (column 7) and 1.5 meters (column 8) versus IPCC 6th Assessment Report Sea Level Projections of 1 meter (column 9) and 1.5 meters (column 10) with information on each city and intermediate results.

	City	Population in million (1)	Country	Income level (2)	2100 Nasa Median projections of sea level rise (3)	Compute (x - x̄) / s (4)	2100 average sea-level projected by the present study (5)	Conversion of the NASA scale into the present study's scale (6)	Year-estimate the City will be 1 meter-flooded based on the present study (7)	Year-estimate the City will be 1.5 meter-flooded based on the present study (8)	Year-estimate the City will be 1.0 meter-flooded based on IPCC (9)	Year-estimate the City will be 1.5 meter-flooded based on IPCC (10)
65	Perth	2.143	Australia	High-income	0.69	0.0293	0.5584	0.5643	2202	2274	2130	After 2150
66	Philadelphia	3.677	US	High-income	0.92	1.1701	0.5584	0.7943	2154	2242	2110	2150
67	Port Elizabeth	1.312	South Africa	Upper-middle-income	0.72	0.1781	0.5584	0.5943	2196	2270	2130	After 2150
68	Port Said	0.78	Egypt	Lower-middle-income	0.69	0.0293	0.5584	0.5643	2202	2274	2130	After 2150
69	Rangoon	7.36	Myanmar	Lower-middle-income	0.82	0.6741	0.5584	0.6943	2175	2255	2120	After 2150
70	Recife	4.305	Brazil	Upper-middle-income	0.69	0.0293	0.5584	0.5643	2202	2274	2130	After 2150
71	Reykjavik	0.128	Iceland	High-income	0.26	-2.1036	0.5584	0.1343	2266	After 2301	After 2150	After 2150
72	Riga	0.618	Latvia	High-income	0.63	-0.2683	0.5584	0.5043	2211	2287	2150	After 2150
73	Rio de Janeiro	13.824	Brazil	Upper-middle-income	0.7	0.0789	0.5584	0.5743	2198	2273	2130	After 2150
74	Salvador do Bahia	2.9	Brazil	Upper-middle-income	0.7	0.0789	0.5584	0.5743	2198	2273	2130	After 2150
75	San Diego	2.35	US	High-income	0.65	-0.1691	0.5584	0.5243	2208	2283	2140	After 2150
76	San Francisco	0.9	US	High-income	0.63	-0.2683	0.5584	0.5043	2211	2287	2140	After 2150
77	San Jose	0.645	Philippines	Lower-middle-income	0.96	1.3685	0.5584	0.8343	2141	2235	2100	2140
78	Seattle	0.757	US	High-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2150	After 2150
79	Sevastopol	0.401	Ukraine	Lower-middle-income	0.54	-0.7147	0.5584	0.4143	2225	After 2301	After 2150	After 2150
80	Shenzhen	13.312	China	Upper-middle-income	0.6	-0.4171	0.5584	0.4743	2214	2293	2140	After 2150
81	Singapore	6.052	Singapore	High-income	0.65	-0.1691	0.5584	0.5243	2208	2283	2140	After 2150
82	St. Petersburg ***		Russia	Upper-middle-income	0.52	-0.8140	0.5584	0.3943	2227	After 2301	After 2150	After 2150
83	Stockholm	0.975	Sweden	High-income	0.19	-2.4508	0.5584	0.0643	2274	After 2301	After 2150	After 2150
84	Sydney	5.33	Australia	High-income	0.68	-0.0203	0.5584	0.5543	2203	2277	2130	After 2150
85	Tianjin	14.471	China	Upper-middle-income	0.65	-0.1691	0.5584	0.5243	2208	2283	2140	After 2150

Continuing from Table 1. In what years 100 coastal cities around the world will be flooded by the sea with floods of 1 meter (column 7) and 1.5 meters (column 8) versus IPCC 6th Assessment Report Sea Level Projections of 1 meter (column 9) and 1.5 meters (column 10) with information on each city and intermediate results.

	City	Population in million (1)	Country	Income level (2)	2100 Nasa Median project-tions of sea level rise (3)	Compute (x - x̄) / s (4)	2100 average sea-level projected by the present study (5)	Conver-sion of the NASA scale into the present study's scale (6)	Year-estimate the City will be 1 meter-flooded based on the present study (7)	Year-estimate the City will be 1.5 meter-flooded based on the present study (8)	Year-estimate the City will be 1.0 meter-flooded based on IPCC (9)	Year-estimate the City will be 1.5 meter-flooded based on IPCC (10)
86	Taipei	2.766	Taiwan	High-income	0.71	0.1285	0.5584	0.5843	2197	2272	2130	After 2150
87	Thessaloniki	0.815	Greece	High-income	0.75	0.3269	0.5584	0.6243	2191	2267	2130	After 2150
88	Tokyo	37.115	Japan	High-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2140	After 2150
89	Trieste	0.216	Italy	High-income	0.58	-0.5163	0.5584	0.4543	2220	After 2301	2150	After 2150
90	Valencia	0.839	Spain	High-income	0.71	0.1285	0.5584	0.5843	2197	2272	2130	After 2150
91	Valparaiso	1.016	Chile	High-income	0.44	-1.2108	0.5584	0.3143	2238	After 2301	After 2150	After 2150
92	Vancouver	0.678	Canada	High-income	0.41	-1.3596	0.5584	0.2843	2244	After 2301	After 2150	After 2150
93	Varna	0.334	Bulgaria	Upper-middle-income	0.52	-0.8140	0.5584	0.3943	2227	After 2301	After 2150	After 2150
94	Venezia	0.641	Italy	High-income	0.68	-0.0203	0.5584	0.5543	2203	2277	2140	After 2150
95	Visakhapatnam	2.385	India	Lower-middle-income	0.54	-0.7147	0.5584	0.4143	2225	After 2301	2150	After 2150
96	Vung Tao	0.466	Vietnam	Lower-middle-income	0.72	0.1781	0.5584	0.5943	2196	2270	2130	After 2150
97	Washington DC	7.82	US	High-income	0.94	1.2693	0.5584	0.8143	2147	2238	2110	2150
98	Xiamen	4.007	China	Upper-middle-income	0.71	0.1285	0.5584	0.5843	2197	2272	2130	After 2150
99	Yangon	5.71	Myanmar	Lower-middle-income	0.82	0.6741	0.5584	0.6943	2175	2255	2120	After 2150
100	Yantai	2.834	China	Upper-middle-income	0.61	-0.3675	0.5584	0.4843	2214	2289	2150	After 2150
	Total population of 100 cities:	438		Mean of (3):	0.6841			Max:	2274	2299		
				Standard deviation of (3):	0.2016			Min:	2083	2073		
								Mean:	2201	2267		

(1) 2024 population estimate of the city in million.
(2) Income level of the country's economy (2024 World Bank ranking).
(3) 2100 Nasa Median projections of sea level rise, relative to a 1995-2014 baseline.
(4) Compute ($\bar{X}$) / s with X = (3), $\bar{X}$= 3 mean of column (3), s = Standard deviation of column (3).
(5) 2100 average sea-level projected by the present study above the 1995-2014 index average in meter.
(6) Conversion of the NASA scale into the present study's scale for a given City (5)+(4)*s.
(7) Year-estimate the City will be 1 meter-flooded based on the present study's scale and projection.
(8) Year-estimate the City will be 1.5 meter-flooded based on the present study's scale and projection.
(9) Year-estimate the City will be 1 meter-flooded based on the U.S. Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report Sea Level Projections of Median projections of global and regional sea level rise available on https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool.
(10) Year-estimate the City will be 1.5 meter-flooded based on the U.S. Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report Sea Level Projections of Median projections of global and regional sea level rise available on https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool.

Sources: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool
https://www.nestpick.com/2050-climate-change-city-index/
https://www.macrotrends.net/global-metrics/cities/largest-cities-by-population
https://earth.org/data_visualization/sea-level-rise-by-2100-dubai/
https://earth.org/data_visualization/sea-level-rise-by-2100-qatar-and-bahrain/
https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025
(*) Bandar Abbas, Doha, Dubai estimates based on Masirah (Oman) estimate
(**) Istanbul estimate based on Bourgas (Bulgaria) estimate
(***) St. Petersburg estimate based on Primorsk (Russia) estimate
(****) Jeddah estimate based on Aden (Yemen) estimate

Regarding the results in Table 1, it is essential to mention that in addition to sea level rise, flooding comes from heavy rains. In 2024, floods made headlines around the world, with heavy rains causing flooding in the United Arab Emirates, Texas, Kenya, the Indonesian island of Sulawesi, Brazil, Russia, Kazakhstan, China, Switzerland, and Germany. Flooding, due to intense rainfall, can also be explained by climate change. Warmer oceans, due to global warming, increase the amount of water that evaporates into the air. When more moisture-laden air moves over land or converges into a storm system, it can produce more intense precipitation leading to flooding (EPA, 2024). The combined effect of sea level rise and heavy rains, which may cause the floods, were not considered in this article to obtain an estimate of the flood years of 100 cities, but only from the perspective of sea level rise. The estimates of flood years, provided in Table 1, are therefore very conservative. To illustrate this conservative approach, the year-estimate when the City will be 1 meter-flooded based on the present study's scale and projection (column 7) and the year-estimate the City will be 1.5 meter-flooded based on the present study's scale and projection (column 8) have been benchmarked with the year-estimate when the City will be 1 meter-flooded based on Median projections of global and regional sea level rise provided by the U.S. Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report Sea Level Projections (column 9) and the year-estimate the City will be 1.5 meter-flooded based on Median projections of global and regional sea level rise provided again by the US IPCC 6th Assessment Report Sea Level Projections (column 10). Where estimates were available (the IPCC did not provide projections beyond 2150), estimates obtained from wavelet analysis (i.e. the model used by the authors) confirm that they are more conservative, while the IPCC authors estimate that flood dates will occur in the nearer future, on average, for the sample of 100 cities, 57 years earlier for the 1-meter flood estimates and 73 years earlier for the 1.5-meter flood estimates.

5. Discussion and conclusion

This article estimates in what years 100 coastal cities in 55 countries around the world will be flooded by the sea, home to 438 million people in 2024, or about 5% of the world's population. Estimated flood years are obtained by forecasting global ocean mean sea level anomalies with wavelet analysis up to 2301. Altimetry data are provided by NOAA Laboratory for Satellite Altimetry. 2100 median projections of regional sea level rise for 100 coastal cities, relative to a 1995 to 2014 baseline, provided by the Intergovernmental Panel on Climate Change's Sixth Assessment NASA Report, allow the authors to evaluate how far the sea level of 100 cities will expand in 2100 from the average sea-level for each city and transform the sea level to the scale of the projected sea-level relative to a 1995-2014 baseline to obtain an estimated year of flooding for each city. If the floods correspond to a 1 meter-rise in sea level, the estimated flood years for the 100 cities will range from 2083 for Manila to 2274 for Stockholm and the floods will average 2201 for cities, like Amsterdam, Dakar, Dalian, Izmir, Lisbon, London, Perth, Rio de Janeiro, Sydney, Taipei, Valencia, and Xiamen, close to the average year. As global temperatures increase, sea level rises because of a thermal expansion of upper layers of the ocean and melting of glaciers and ice sheets (NOAA, 2024). In addition to sea level rise, flooding comes from heavy rains. In 2024, floods made headlines around the world, with heavy rains causing flooding in the United Arab Emirates, Texas, Kenya, the Indonesian island of Sulawesi, Brazil, Russia, Kazakhstan, China, Switzerland, and Germany. Flooding, due to intense rainfall, can also be explained by climate change. Warmer oceans, due to global warming, increase the amount of water that evaporates into the air. When more moisture-laden air moves over land or converges into a storm system, it can produce more intense precipitation leading to flooding (EPA, 2024). The combined effect of sea level rise and heavy rains, which may cause the floods, were not considered in this article to obtain an estimate of the flood years of 100 cities, but only from the perspective of sea level rise. The estimated flood years provided in the results are therefore very conservative. Benchmarking the year-estimates of flood to the median projections of global and regional sea level rise provided by the US IPCC 6th Assessment Report Sea Level Projections shows that the IPCC authors estimate that flood dates will occur in the nearer future, on average, for the sample of 100 cities, 57 years earlier for the 1-metre flood estimates and 73 years earlier for the 1.5-metre flood estimates. Future will tell which methodology is more accurate.

Looking at the impact on coastal cities, flooding can lead to loss of life, damage to property and infrastructure, road closures, erosion and landslide risks, ineffective flood drainage system, contamination of freshwater supplies, rapid shoreline retreat (Bidorn et al., 2021), and groundwater salinization (Lassiter, 2021). Tools to prevent or delay flooding include flood protection structures such as levees, dikes, polder systems, river embankments, waterway improvements, drainage infrastructure upgrades and pumping stations (Coastal Wiki, 2025). They also include adapting households to flooding by raising floors and adding storeys to their homes. Urban planning can be involved to relocate populations and essential infrastructure to higher ground. Flood forecasting (as in this paper) and early warning systems can be put in place to prepare residents and flood management services.

The cause of an increase of global temperature responsible for floods is mainly greenhouse-gas emissions. Fossil fuels – coal, oil and gas – are, by far, the largest contributor to global climate change, accounting for over 75% of global greenhouse gas emissions and nearly 90% of all carbon dioxide emissions. As greenhouse gas emissions blanket the Earth, they trap the sun's heat (United Nations, 2024b). In 2016, world governments ratified the Paris agreement on climate change with the main objective to keep or to move major investors away from fossil fuels in order to save the planet from global warming. The Conferences of the Parties (COP) assess the progress made towards the goals set in the Paris Agreement and charted a course of action. The 28th COP was held at the end of 2023 in Dubai, United Arab Emirates. The role of fossil fuels in Gulf economies has made the issue of phasing out fossil fuels a particularly controversial topic at COP28, as phasing out fossil fuels could be very costly for these Gulf countries. COP29 was held in Baku, Azerbaijan, in November 2024. Environmentalists are not convinced of the outcomes of these conferences. Countries and peoples hit hardest by climate change are unable to get their voices heard during these Climate summits (Steffen and Niranjan, 2021). Environmentalists point out that COP is overwhelmingly white and rich and in no hurry to prevent the devastating effects of global warming. With so much coal, oil, and gas revenue involved and generated by the fossil fuel industry, the main culprit of global warming. "We are close to the tipping point where global warming will become irreversible" warned late physicist and cosmologist Stephen Hawking in 2017. Critical solutions to stopping global warming and its destructive and pervasive effects lie in the hands of responsible Earthlings and their political representatives.

Declarations

Data Availability Statement

The datasets supporting the findings of this study are openly available from the following sources:

- NOAA Laboratory for Satellite Altimetry: Mean sea level anomaly (global ocean, annual signals retained) derived from altimetry data, available at https://www.star.nesdis.noaa.gov/socd/lsa/SeaLevelRise/LSA_SLR_timeseries.php.
- NASA/IPCC Sea Level Projection Tool: Median projections of regional sea level rise by 2100 for 100 coastal cities, relative to a 1995–2014 baseline, based on the Intergovernmental Panel on Climate Change's Sixth Assessment Report, accessible via https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool.
- Macrotrends Database: Population data for the world's largest cities, available at https://www.macrotrends.net/global-metrics/cities/largest-cities-by-population.

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Competing Interests

The authors declare that they have no competing financial or non-financial interests relevant to the content of this article.

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