



**Report of the United Nations Secretary-General on
Oceans and the Law of the Sea 2020
“Sea-level rise and its impacts”**

**Contribution by the World Meteorological Organization (WMO)
(due January 20, 2020)**

(i) Understanding sea-level rise: its causes and effects

● **Global climate statement on sea level rise**

For more than 25 years, WMO has issued an *Annual Statement of the Global Climate* based on data provided by National Meteorological and Hydrological Services and other national and international organisations. The [WMO Provisional Statement on the State of the Global Climate in 2019](#) (released in December at the 25th Conference of the Parties of the UNFCCC, Madrid, Spain), indicates that:

- Sea level has increased throughout the satellite altimetry record, but the rate has increased over that time, due partly to melting of ice sheets on Greenland and Antarctica.
- In October 2019, the global mean sea level reached its highest value since the beginning of the high-precision altimetry record (January 1993).
- As the ocean warms, sea levels rise. This rise is further increased by melting of ice on land, which then flows into the sea. Short-term trends in sea level are modulated by transitions between La Niña and El Niño, a cooling and warming, respectively of the central and eastern Pacific Ocean surface temperature.
- During the period of the Northern Hemisphere Autumn of 2019, the global mean sea level reached its highest value since the beginning of the high-precision altimetry record (January 1993).

The 2019 Provisional Statement has a section dedicated to sea level rise (pp 8-9):

In 2019, sea level has continued to rise. In October 2019, the global mean sea level reached its highest value since the beginning of the high-precision altimetry record (January 1993). The average rate of rise is estimated to be 3.24 ± 0.3 mm/yr over the 27-year long period, but the rate has increased over that time. Increased ice mass loss from the ice sheets is the main cause of the global mean sea-level acceleration. Interannual variability in sea-level rise is mainly driven by the El Niño Southern Oscillation (ENSO). During El Niño, water from tropical river basins on land is transferred to the ocean (e.g., in 1997, 2012 and 2015). During La Niña, the opposite occurs, with a transfer of water from the ocean to land (e.g., in 2011). Sea level rise is not regionally

uniform. The strongest regional trends in the southern hemisphere are east of Madagascar in the Indian Ocean, east of New-Zealand in the Pacific Ocean, and east of Rio de la Plata/South America in the south Atlantic. In the northern hemisphere, an eastward, elongated pattern is also seen in the north Pacific. A previously-strong pattern seen in the western tropical Pacific over the first two decades of the altimetry record is now fading, suggesting that it was not a long-term signal. Non-uniform sea level trends are dominated by geographical variations in ocean heat content but also depend on processes involving the atmosphere, geosphere and cryosphere’.

The source of sea level rise is considered to be a combination of ice melt from glaciers, ice sheets and as well, thermal expansion from the ocean warming. Eustatic changes from land movement (e.g. tectonic) also contributes. The contribution of land ice melt from the world glaciers and the ice sheets has increased over time and now dominate the sea level budget, rather than thermal expansion.

Also in 2019, the WMO published '[The Global Climate in 2015-2019](#)'. This Report showed that over the five-year period May 2014 -2019, the rate of global mean sea-level rise has amounted to 5 mm per year, compared with 4 mm per year in the 2007-2016 ten-year period. This is substantially faster than the average rate since 1993 of 3.2 mm/year.

- **Observations and Research: Climate and Ocean**

The global mean sea level change provides a measure of the net change in ocean mass due to melting of glaciers and ice sheets, changes in terrestrial water resources, as well as net change in ocean volume due to thermal expansion. Several WMO co-sponsored observation and research programmes linked to both climate and ocean are contributing knowledge to this.

[GCOS](#)

WMO is a co-sponsor (along with the UNESCO Intergovernmental Oceanographic Commission (IOC), United Nations Environment Program (UN Environment), and International Science Council (ISC)) for the **Global Climate Observing System (GCOS)**. The GCOS Secretariat is based at the WMO in Geneva. GCOS regularly assesses the status of global climate observations and produces guidance for its improvement. GCOS expert panels maintain definitions of Essential Climate Variables (ECVs). They identify gaps by comparing the existing climate observation system with these ECVs. ECVs are the observations required to systematically observe Earth's changing climate. GCOS considers 'sea level' as one of the most important Essential Climate Variables (ECV). The expert panels regularly develop plans on how to sustain, coordinate and improve physical, chemical and biological observations. The observations supported by GCOS contribute to solving challenges in climate research and also underpin climate services and adaptation measures, including for the challenge of sea level rise.

[GCW](#)

The **Global Cryosphere Watch (GCW)** is a cross-cutting mechanism that brings together international observations and research on the past, present and future state of the world's cryosphere. Its data products and services are intended to support scientific progress and environmental policy developments related to the cryosphere, which includes snow cover, glaciers, ice caps, permafrost, sea ice, freshwater ice and icebergs

around the globe. It was established by the WMO, with the secretariat based at the WMO in Geneva. With the clear links between melting ice sheets/glaciers and resultant sea level rise, the Global Cryosphere Watch is informing the knowledge and rate of change in the cryosphere and subsequently a critical activity for estimating the projected rate of changes in sea level in the future. Understanding the causes of these changes, and resulting impacts allows policy makers to evaluate options to adapt.

GOOS

The **Global Ocean Observing System (GOOS)** is a co-sponsored programme between WMO, UNESCO-IOC, UN Environment and ISC. GOOS is a sustained collaborative system of ocean observations, encompassing in situ networks, satellite systems, governments, UN agencies and individual scientists. It is organized around a series of components undertaking requirements assessment, observing implementation, innovation through projects, and a core team. Working closely with GCOS, GOOS has outlined 'Essential Ocean Variables' (EOVs), of which 'sea surface height', 'sea surface temperature' and 'sub-surface temperature' are also important ones with direct link to research and understanding of global sea level rise and its impacts.

GLOSS

The **Global Sea Level Observing System (GLOSS)**, a component of the GOOS, is establishing a well-designed, high-quality sea level observing network to support a broad research and operational user base using 290 tide gauge stations over 90 countries and territories around the world. The GLOSS Sea Level Observations Team (otherwise known as a 'Group of Experts') has been working consistently with the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) and its Observations Programme Support Centre (JCOMMOPS) to support coordination for this important sea level observations work.

A 'Sea Level Data Archaeology Workshop' will be held March 2020, Paris, France under the auspices of the UNESCO-IOC and GLOSS. The main objective is to bring together experts concerned with sea level data rescue activities to explore the potential for a more sustained programmatic approach to cooperation at the international level.

WCRP

A number of research activities are being undertaken by the WMO/IOC-UNESCO/ISC **World Climate Research Programme (WCRP)**, including its Grand Challenge on "Sea Level Rise and Regional Impacts", and activities focussed on such themes as the role of the polar regions on sea level rise.

The WCRP Grand Challenge on Regional Sea Level Change and Coastal Impacts

meets urgent societal needs for useful information on sea level involving a cross section of core projects and working groups. The overarching goal of this WCRP research effort, led by WCRP's Core Project 'Climate and Ocean Variability, Predictability and Change' (CLIVAR) as a Research Focus, is to establish a quantitative understanding of the natural and anthropogenic mechanisms of regional to local sea level variability; to promote advances in observing systems required for an integrated sea level monitoring; and to foster the development of sea level predictions and projections that are of increasing benefit for coastal zone management. It has created an opportunity to respond to the challenges of sea level through international scientific and technical cooperation whilst developing close interaction with relevant coastal stakeholders, which is also helping to

develop the capacity of countries to adapt. A major conference will be held in Singapore in July 2022 focusing on this effort.

The Ice Sheet Mass Balance and Sea Level ([ISMASS](#)) project is to promote the research on the estimation of the mass balance of ice sheets and its contribution to sea level; The Ice Sheet Model Inter-comparison Project (ISMIP) activity fills a need for international coordination in the evaluation and testing of large-scale ice sheet models and the development of consistently-applied test cases and diagnostics.

OOPC

The **Ocean Observations Panel for Physics and Climate (OOPC)** - secretariat also based in the GCOS office at WMO - has the role of providing scientific recommendations and reviewing the implementation of the ocean observations required for climate in support of its 3 sponsors: GCOS, GOOS, and the WCRP. Through this, the OOPC also supports the work contributing to observations and research into the state of global sea level.

Satellites

As noted above, sea level continues to rise at an accelerated rate as shown by altimeter satellites. The total elevation of the global mean sea level over the altimetry era (since January 1993) has reached 90 mm. To monitor this situation, WMO works closely with the global space agencies communities (the Coordination Group of Meteorological Satellites – CGMS, and the Committee on Earth Observation Satellites – CEOS) with the membership covering all national and global operational space agencies. Significant sources of information are at the following websites:

[AVISO satellite altimetry data website](#)
[Jason-3 satellite for sea level rise](#)

IPCC Special Report on the Ocean and Cryosphere

The [Intergovernmental Panel on Climate Change \(IPCC\)](#) is the United Nations scientific body for assessing the science related to climate change. It is co-sponsored by WMO and UN Environment, with the secretariat based at the WMO in Geneva. Experts from around the world form the Working Groups are investigating the science. In 2019, the IPCC released the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), which was prepared following an IPCC Panel decision in 2016. Regarding Sea Level, the report clearly indicates that:

- The Global Mean Sea Level (GMSL) is rising, with acceleration in recent decades due to increasing rates of ice loss from the Greenland and Antarctic ice sheets (very high confidence), as well as continued glacier mass loss and ocean thermal expansion.
- Increases in tropical cyclone winds and rainfall, and increases in extreme waves, combined with relative sea level rise, exacerbate extreme sea level events and coastal hazards (high confidence).

Further information can be found in the [SROCC Full Report](#) and the [Summary for Policy Makers](#) .

(ii) Observed and projected environmental, social and economic impacts and resulting challenges relating to sea-level rise;

- **Sea level rise and impacts in coastal areas**

Rising sea levels have significant impacts along coasts. These impacts include the physical/environmental impacts, and as well, resulting social and economic challenges to coastal communities.

In addition to the WMO activities outlined above, WMO recognises the challenges to coastal areas and vulnerable communities living and or/with livelihoods reliant on the coastal zone. Of note, coastal inundation is one of the priority areas being addressed by WMO, to assist Members to improve resilience to coastal flooding whilst reducing the impact of these disasters.

Coastal inundation - on various time scales - occurs from multiple sources, including from storm surges, swell, seiching, inland river flooding on the coast, tides, sea level rise and even tsunamis. With predicted rising sea levels, coastal floods will be exacerbated with potentially more land becoming inundated. In the face of a changing climate, storms and extreme maritime weather (including tropical cyclones) are becoming more frequent and intense, which is resulting in more frequent and severe coastal flooding and erosion events - especially in soft sedimentary coastal zones. Similarly, accelerated sea level rise will mean larger swathes of coastal land will be flooded during these events, exacerbating coastal erosion and loss of land and direct impact to property, infrastructure, livelihoods and life along the coast.

Economic losses in coastal zones are particularly associated with tropical cyclones. The 2017 Atlantic hurricane season was one of the most devastating on record with more than US\$ 125 billion in losses associated with Hurricane Harvey alone. On the Indian Ocean, in March and April 2019, unprecedented and devastating back-to-back tropical cyclones hit Mozambique. Related to this, the WMO Secretary-General (and co-chair of the Science Advisory Group of the UN Climate Summit) stated that:

["Sea level rise has accelerated and we are concerned that an abrupt decline in the Antarctic and Greenland ice sheets...will exacerbate future rise. As we have seen this year with tragic effect in the Bahamas and Mozambique, sea level rise and intense tropical storms led to humanitarian and economic catastrophes".](#)

(iii) Opportunities in responding to those challenges, including through cooperation and coordination at all levels on scientific, technical, technological, and financial aspects and capacity-building

As detailed above, WMO has been responding to the challenges of accelerated sea level rise, to support WMO Members, through cooperation and coordination internationally across scientific, technical, technological and capacity development. Further examples beyond the ongoing activities/initiatives previously mentioned include:

Coastal Inundation

Efforts to improve early warnings for coastal inundation have been a focus of WMO for the past decade through the [Coastal Inundation Forecasting Demonstration Project \(CIFDP\)](#). The CIFDP was successfully completed in Bangladesh, the Caribbean, Indonesia and Fiji demonstrating the value of considering multiple sources of coastal inundation in a Multi-Hazard Early Warning System (MHEWS). It included consideration of sea level impacts, including projected future rise and impacts on coastal flooding. Building on the success of the CIFDP, WMO will continue in the future 'Coastal Inundation Forecasting Initiatives' (CIFI). This will ensure vulnerable coastal countries are able to strengthen their early warning systems for coastal hazards. WMO is also working with the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG) in relation to this. Ultimately, the CIFI will be integrated into broader MHEWS for all types of flooding and severe weather impacts.

WMO is committed to developing the capacity of its Members to improve awareness of coastal hazards (inclusive of sea level impacts). One such initiative is the public awareness coastal flooding video launched by WMO to support vulnerable coastal communities in the Pacific Islands, and which will be expanded soon to other regions of the world.

WMO is also currently developing a capacity development course specifically aimed at strengthening the capacity of National Meteorological and Hydrological Services responsible for marine and coastal services. Developing the capacity of these Members to deliver robust coastal services will ensure understanding and adaptation to the impacts from issues such as accelerated sea level rise.

JCOMMOPS

JCOMMOPS is a focal point for implementation and operation of relevant in situ observing platforms. The Centre which is located in Brest (France) is funded with voluntary contributions from IOC/UNESCO and WMO Member States, and is the international center of excellence that provides vital services to monitor, coordinate, and integrate across an expanding network of global oceanographic and marine meteorological observing communities. JCOMMOPS will continue to monitor and report on the status of the global ocean observing system networks, to ensure the transmission and timely exchange of high quality metadata associated with the observational data, and to use its central role to support efficient observing system operations and data delivery to users across climate, operational services, and ocean health.

WMO-IOC Joint Collaborative Board

WMO works in close collaboration with UNESCO-IOC as outlined above with the numerous co-sponsored programmes. To strengthen this partnership, a new structured WMO-IOC Joint Collaborative Board (JCB) was formed in 2019 through joint decision by both the 18th World Meteorological Congress and the 30th IOC Assembly. It is a high-level coordination mechanism with broader engagement of the key relevant bodies of the WMO and IOC, to ensure improved coordination and collaboration on important topics of joint interest, including observations, services, research and capacity development. The JCB will provide guidance to ensure that the joint work between WMO and IOC already on the topic of sea level rise and its impacts will continue, whilst responding to the

needs of the WMO and IOC Members/Member States, and overall UN frameworks such as the Sustainable Development Goals.

WMO/IMO Symposium on Extreme Maritime Weather

WMO and the International Maritime Organisation (IMO) jointly organized the first [International Symposium on Extreme Maritime Weather: Towards the Safety of Life at Sea and a Sustainable Blue Economy](#) in October 2019, at the IMO Headquarters, London. The Symposium was a key platform for WMO and IMO to identify best practices and improve services for safety and risk reduction, emergency response, sustainable shipping practices and greater collection and sharing of ship observations. One key concern raised during the Symposium was the need for more information about the impacts of weather on infrastructure and vessels at berth in relation to ports and harbours, especially in the face of changing climate with sea level rise. This will be investigated in the coming two years ahead of the 2nd WMO/IMO Symposium, anticipated in 2021.

- **[UN Decade of Ocean Science for Sustainable Development](#)**

WMO is committed to contributing to the UN Decade of Ocean Science for Sustainable Development (2021 to 2030) and is currently considering its role and areas of input. The work by WMO on the topic of sea level rise and impacts, in collaboration with other partners such as IOC, IMO, UN Environment, and ICS is expected to form an integral part of this Decade.