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Analysis of the influence of the climate change on sea level

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Abstract. Rising sea levels are not a direct result of climate change but rather an indirect influence. When ice melts, it releases water into the ocean, which causes it to rise. As the planet warms and glaciers continue to melt, sea levels rise and land elevations increase. As a result of all of these shifts, sea levels are increasing worldwide. Sea level change refers to the increase or decrease in sea level. Meters above a standard, like the geoid or mean sea level, are used to describe the height of the water (MSL). This research uses a literature review approach to investigate the spatial and temporal dynamics of the world's ocean levels. The goal is to supply some background information and recommendations for further study.

Keywords: GMSL, global warming, climate change, MSL.

1. Introduction

Globally, sea levels are rising, and this trend is predicted to last for centuries or even millennia. The primary driver of the increase in global mean sea level is the thermal expansion of ocean water as it warms up due to increased greenhouse gas concentrations in the atmosphere. Around a third of the observed total sea level rise since 1900 can be attributed to the melting of glaciers and ice sheets, amplifying the effect [1]. Land-based ice also makes a negligible contribution, but it has been getting smaller over time. The paper, through a method of literature review, explores the global sea level and its change in space and time. The purpose is to provide some referential advice in this field.

2. The global sea level and its change in time

Sea level is the height of water above a reference level. The reference levels are usually taken to be mean sea levels, which are derived from measurements of ocean surface heights by tide gauges and satellite altimetry. Mean sea level can also be calculated using other methods, such as calculating the difference between observed ocean depth and measured land elevation (elevation being equal to the distance between two points on a contour line) or using data on relative sea-level change (such as that obtained from tide gauge records). The term “sea-level rise” is used when this rise in sea level exceeds 1 m per century. Global mean sea level (GMSL) has increased by about 35 cm over the past 150 years [2]. While some of this increase is likely related to the natural warming due to the exit from the Little Ice Age (extending roughly from 1300 to about 1850), the signature of anthropogenic climate change on sea level is clearly seen. Recent events, from the flooding of Manhattan during Hurricane Sandy in 2012 to the flooding of Venice, Italy, in 2019 that involved a 1.8 m local sea level rise, brought sea level to the forefront of the news [3]. We will see that both natural processes and anthropogenic climate change can contribute to such events. Additionally, evidence from past warm climates suggests the

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potential for a significant sea level rise in response to fairly modest greenhouse warming. Sea level changes involve a wide range of regional and global processes, and we attempt here to understand and quantify the main ones.

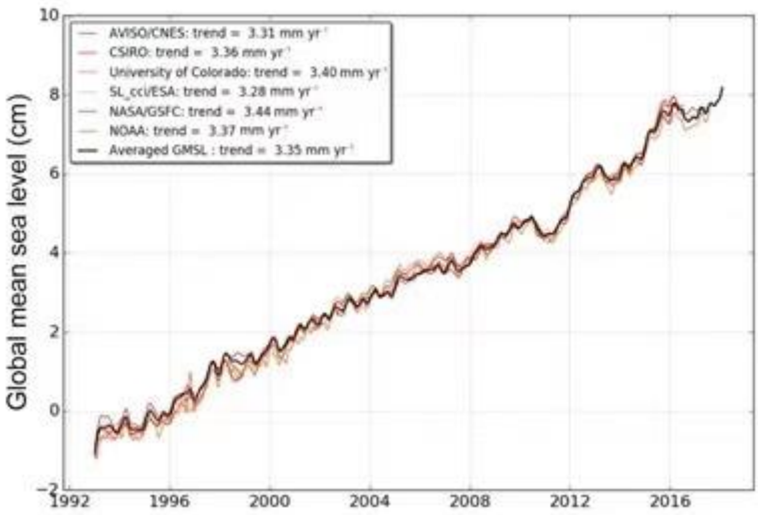

Figure 1. Factors affecting sea level rise [1].

Figure 1 illustrates the significance of the mass contribution of ice sheets, glaciers, and land-based water storage to the ocean. Growing and melting ice sheets and glaciers cause sea levels to rise. Rising sea levels are occurring on a global scale, although at varying rates depending on location. The average annual increase in global mean sea level since 1992 has been roughly 3 millimeters [1]. The impacts of climate change have been felt globally for decades now. Sea level rise is one such impact that will continue to affect coastal communities in the coming years and decade, as temperatures increase and ice melts from glaciers and ice sheets across the globe.

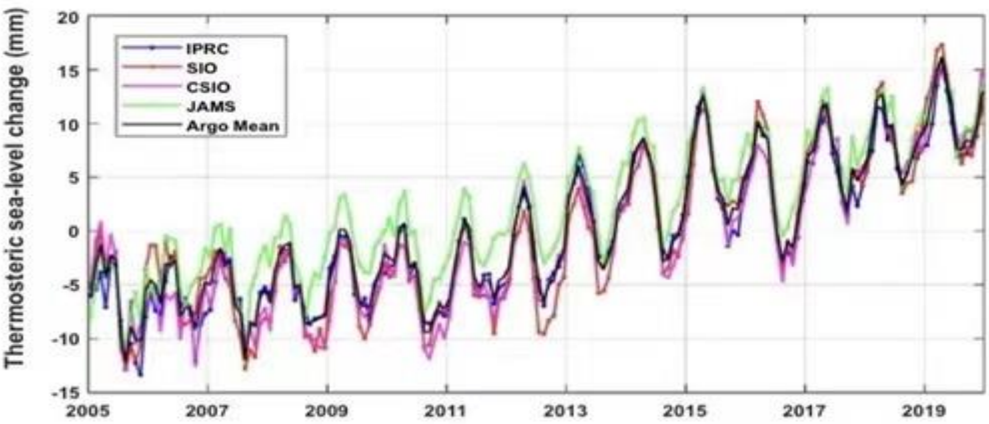

Figure 2. Research fields and methods [4].

Figure 2 illustrates how the study of the global sea level can be divided into two parts: the first part looks at how the sea level has changed over time, and the second part looks at how it has changed over space. The first part mainly focuses on historical data of global sea level, such as tide gauge records from around 1900 to present day, satellite altimetry data from 1960s-1990s, and geological evidence for past changes in ocean circulation [4]. The second part mainly focuses on climate models that simulate future changes of global mean surface temperature (GMST) with different emission scenarios.

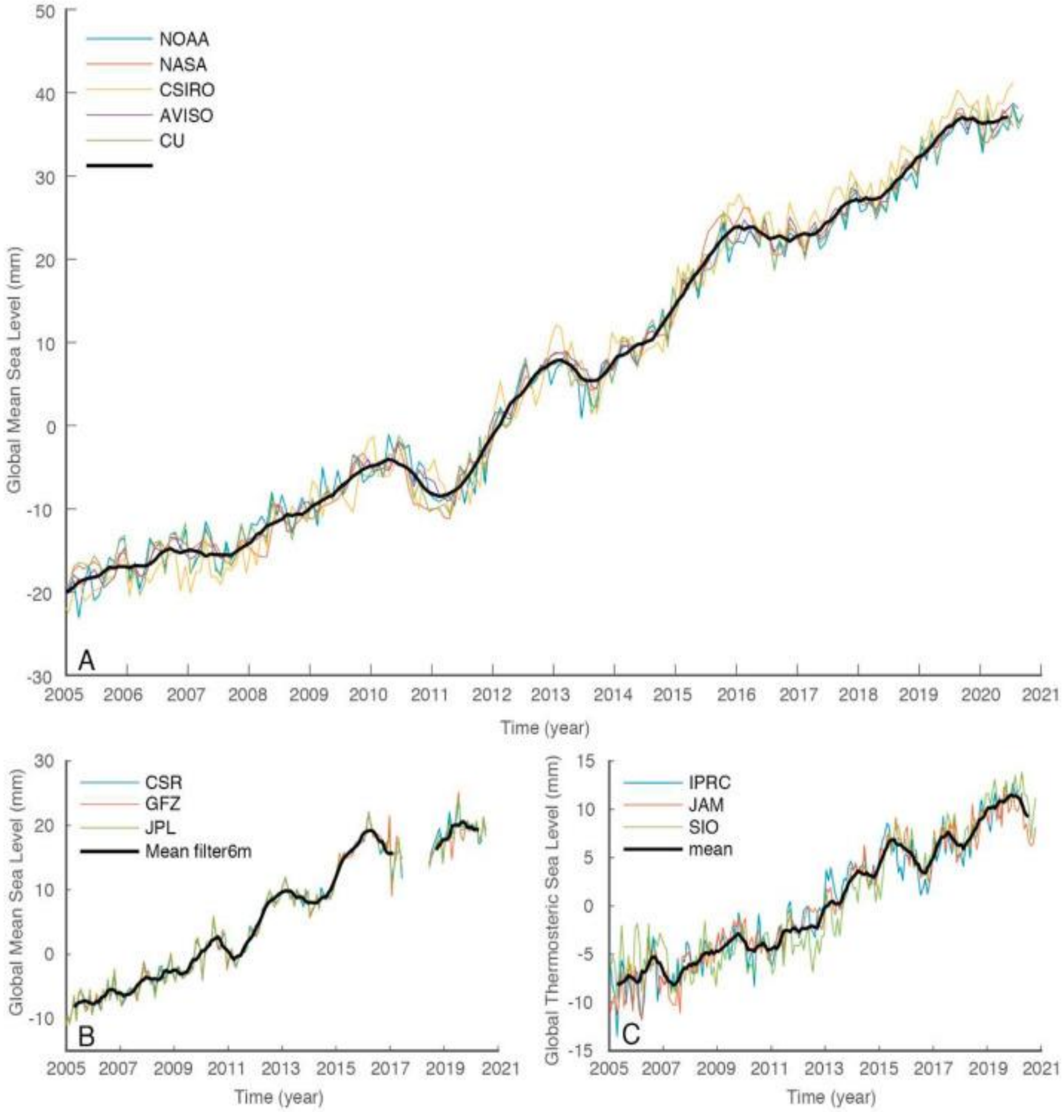

Figure 3. Time series of GMSL change [2].

Figure 3 displays three different projections of the average worldwide sea level rise: After seasonal changes have been subtracted, (A) the statistics of GMSL computed by altimetry; (B) the GMSL problem created by marine change in mass, estimated using GRACE and GRACE-FO statistics based on three different institutes; and (C) the globally averaged thermosteric sea level rise, measured using Argo data given by various institutions. Changes due to the seasons are no longer noticeable. The black lines represent the mean time series for these individuals [2].

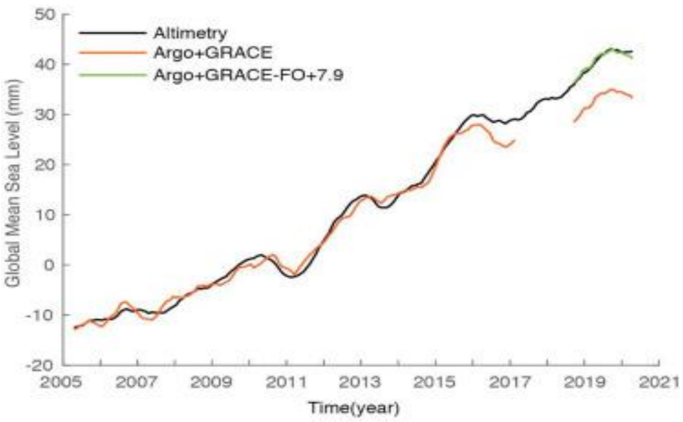

Figure 4. Comparison of GMSL change calculated by altimetry data and the sum of GRACE and Argo [5].

The resulting curves then were standardized with simply a 6-month moving window after taking seasonal changes into account, as illustrated in Figure 4. Although GRACE and GRACE-FO are two distinct satellite missions, they share a lot of the same scientific goals. Both satellites carry a suite of instruments that measure gravity fields in the Earth's free space. The major difference between the two is their orbits: GRACE is in an orbit at about 500 km above Earth while GRACE-FO will be placed into a sun synchronous orbit at about 1,000 km altitude [5]. While this change in orbital height has significant implications for how these satellites observe gravity field changes on Earth, it also opens up new possibilities for studying other bodies in our solar system.

3. The global sea level and its change in space

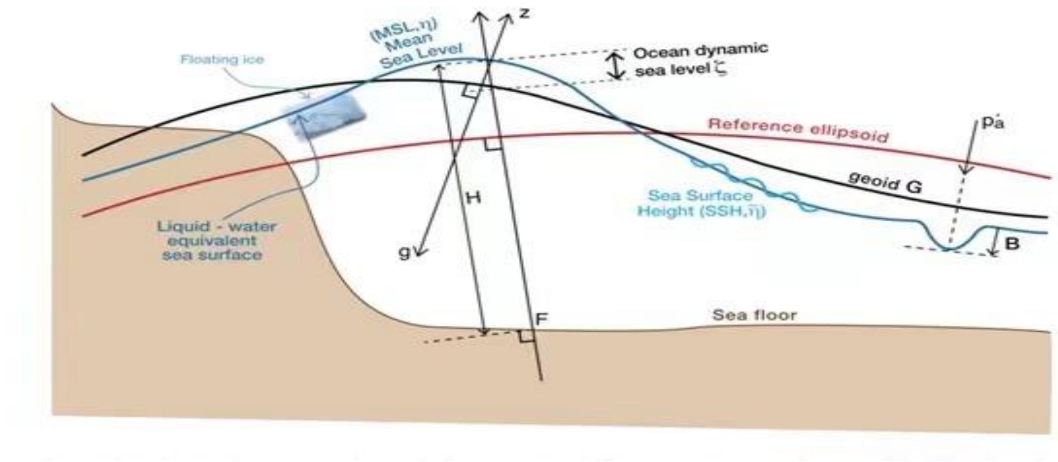

Figure 5. Relationship between surfaces relating to sea level [6].

According to satellite altimetry measurements with opposing barometric corrections, as seen in Figure 5, the sterodynamic radical shift since 1993 has been increasing at a pace of 3.30 mm/year. Water level is the average height of the ocean's surface above a reference point. It can refer to either mean sea level (MSL) or geostationary sea level and is expressed in terms of an altitude or depth (GSL) [6]. The elevation of a point on Earth's surface is the vertical distance between that point and a specified datum such as sea level; it is usually expressed in feet, meters or other units. Sea levels are important for many reasons: The affect tides, waves, currents and erosion by affecting water volume and salinity. They control coastal erosion by changing the reach of rivers.

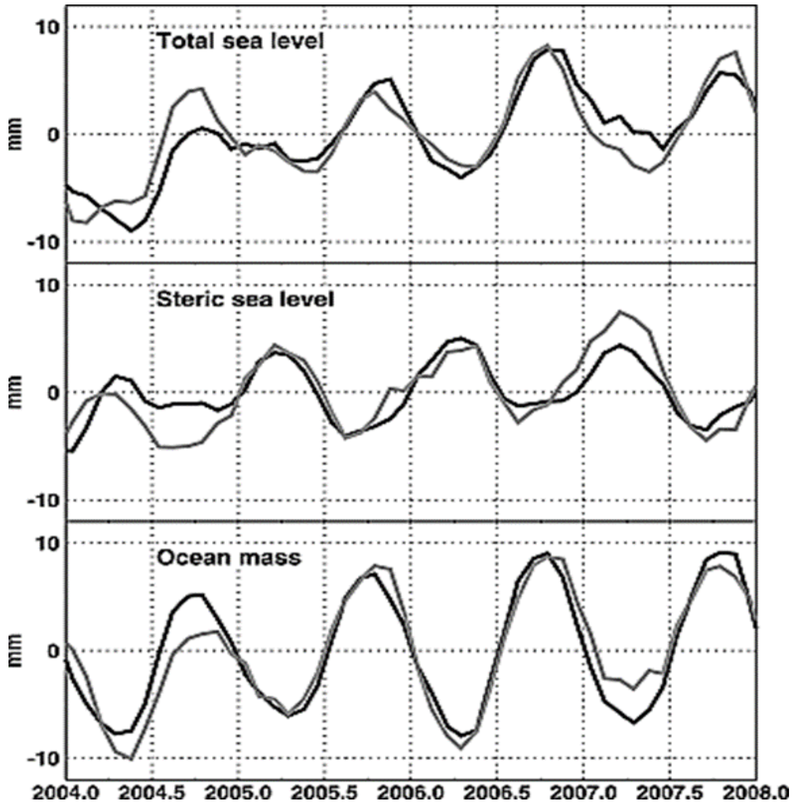

Figure 6. Variability in total global mean sea level and its steric and mass components [6].

As determined by Jason-1, Argo, and GRACE, the black lines in figure 6 highlight the extent sea level (top), steric sea level (middle), and ocean mass (bottom). The gray lines display the implicit fluctuation from the ancillary findings calculated as in figure 6. Each time series receives a 3-month boxcar smoothing.

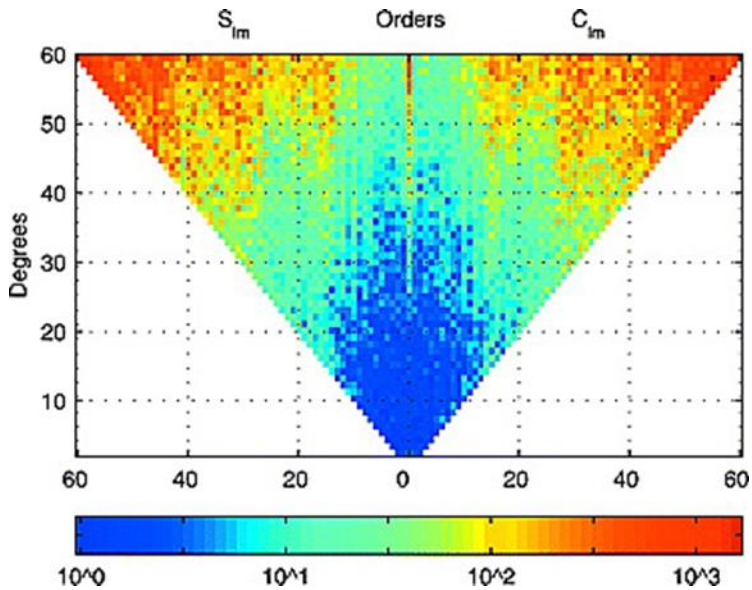

Figure 7. Mean RMS comparisons between the time-variable Stokes coefficients predicted by the model (MLD) and observed by GRACE (GRC) [3].

Figure 7 shows, for every Stokes coefficient Clm or Slm, the proportion between the mean RMS of the 22 GRACE alternatives and the mean RMS of model forecasts over similar time periods. To determine the Stokes number, a set of coefficients are used. It is calculated using the fluid's velocity and density. The stokes number can be calculated using this coefficient. Viscosity is defined as “the ability to resist flow”, which means it depends on the fluid’s resistance to flow, or its friction properties. Viscosity also affects how easily a liquid flows through narrow openings such as pipes and capillaries, thereby affecting heat transfer rates (e.g., in refrigeration systems).

4. Method used to detect sea level

Methods of detecting sea level are mainly based on the change in water depth. The most common method is to measure the distance between a fixed point and an object that moves with respect to the ocean. This is called a tide gauge. Tide gauges can be used for many purposes, including monitoring changes in sea level, measuring ocean currents, or predicting weather patterns.

Tide gauges are typically installed in high places where they can reliably record long-term shifts in sea level caused by global warming and other variables, such as coastal cliffs or offshore islands. However, because of their location and design, these instruments generally cannot provide information about local.

But it is flawed, this type of instrument is designed for measuring high-tide levels only. It is generally used at ports, harbors or river estuaries where large vessels need to pass through during high tides. These gauges are very accurate and reliable as they use mechanical sensors to measure the sea level accurately.

As evidenced by the work of Peltier and coworkers [7], forecasts of glaciations absolute sea level origins can be obtained by solving an integral "Sea Level Equation" where the control variables are latitude, longitude, and time. The relative sea-level record, S (θ, λ, t), is represented as follows.

$$S(\theta,\lambda,t) = C(\theta,\lambda,t)\left[\int_{-\infty}^{t} dt' \iint_{\Omega} d\Omega' \{L(\theta',\lambda',t,)G_{\Phi}^{L}(\gamma,t-t') + \psi^{R}(\theta',\lambda',t')_{R}G_{\varphi}^{T}(\gamma,t-t')\} + \frac{\Delta\Phi(t)}{g}\right]$$

In 1 C(θ, λ, t), the "ocean function" is 1 over the oceans and 0 on land. The coast has a propensity to migrate in reaction to changes in the amount of seawater in the world's oceans, therefore this is a function of time. An highly precise iterative approach [8] can be used to compute the time dependency of "C". L, the surface mass load per unit area, is a function that varies with location and time in 1.

$$L(\theta,\lambda,t) = \rho_I I(\theta,\lambda,t) + \rho_w S(\theta,\lambda,t)$$

In the above equation, ρ_I and ρ_w represent the respective densities of ice and water. In Green functions G_{Φ}^{L} and ${}_{R}G_{\varphi}^{TR}$, the angle ϕ represents the angular separation between the source point located at (θ′, λ′) and the field point located at (θ, λ).

5. Conclusion

The process of the sea level gradually rising is known as sea level rise. It develops gradually over time rather than all at once. The type and size of ice sheets, thermal expansion, melting glaciers, land subsidence, and modifications to ocean circulation patterns are just a few of the variables that affect how quickly things change. The last glacial maximum occurred roughly 10,000 years ago, and since then the sea level has been steadily ascending. In most of the world, this increase is caused by water expanding as it warms as a result of increased greenhouse gas emissions (see global warming). The greenhouse effect contributes to global warming, which in turn causes sea levels to rise. Mean sea level is the average elevation of the world's oceans. It is measured in relation to a standard datum, like the mean sea level in London or Cape Town, and expressed in meters. Since 1900, the average sea level has risen by about

80 cm, and in the decades to come, this rise is predicted to accelerate. As a result, the coastlines of the world are vanishing at an alarming rate. Many nations' coasts have already been inundated, and many more will do so in the future. This has led to a number of problems, including flooding, erosion and loss of biodiversity. The main factors affecting global mean sea level are changes in mass balance, which arise from changes in water storage on land and ice sheets, melting glaciers, thermal expansion of seawater, and thermal expansion of ocean waters.

The variance of the discrepancies between the several datasets that aid in compensating the ensembles is used to estimate the worldwide barystatic sea-level change frequency, which is estimated to be 0.27 mm/year at the 95% confidence level. According to statistical data, the recommended GIA framework put forth by Caron et al. in 2018 can speed the completion of the global sea-level budget by 0.20–0.30 mm/year, which would be the equivalent to neglecting the closely linked component.

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