Société de Calcul Mathématique SA
Tools for decision help
Since 1995

Sea Level

Available data and

critical analysis

Extract of the white paper drawn up by the SCM
First redaction: August 2015

I. Introduction

Human beings are quite naturally interested in the sea level and for a long time have noted that it appears to be rising, but not everywhere and not uniformly. To be precise, the sea level, which rose 120 m in 18,000 years (source: the French Research Institute for Exploitation of the Sea – IFREMER), or 6.6 mm per year, has risen by only 1.2 mm per year (French Naval Hydrographic and Oceanographic Service – SHOM) since 1800, and the rate has not speeded up recently; see [Christy and Spencer].
All these figures should be treated with caution, as the data we have on sea levels 18,000 years ago must be regarded warily. They relate only to a small number of coastal observations. We cannot tell whether the Pacific Ocean was greater or smaller in volume than it is today, nor can we say, in the present day, how it is changing (see below concerning this paradox).

Two kinds of instruments are used:

- Marigraphs, which have been around for 200 years;
- Altimetry satellites, which measure the height of the satellite above the ocean; they have been around for 20 years, namely Topex/Poseidon (1992), Jason 1 (2001), Jason 2 (2008).

The water level varies naturally:

- Due to the tides (lunar attraction)
- Due to wind and storms
- Due to sea currents

This being so, the estimates provided by marigraphs and satellites can be no more than averages, if possible over one year or several years, as phenomena such as El Niño affect the sea level for a year or more.

II. Measurements

All the measuring devices show rising sea levels. The increase is assessed as 1 mm per year in the case of marigraphs and 3 mm per year in that of satellites. The maps show clearly that the rise is not uniform and the rate is not increasing.
The reader needs to be clearly aware of the difficulty of trying to measure annual variations of one or two millimeters in something that varies by several tens of centimeters daily.

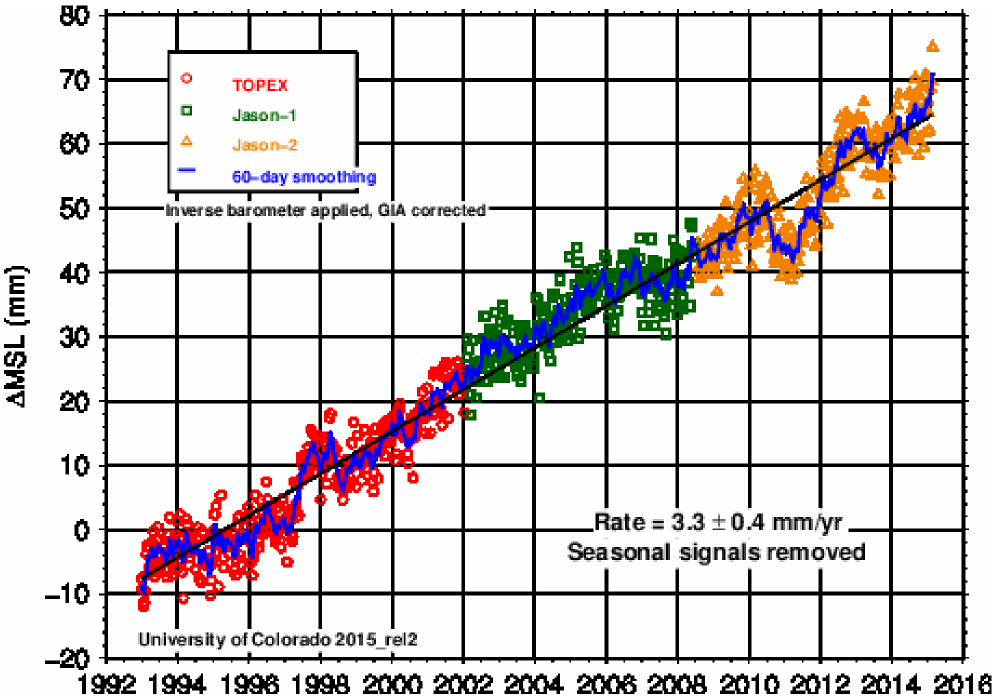

Figure 1: Changing sea levels over time

Here is the general graph supplied by the University of Colorado; see [UC1]. Similar graphs are available for each ocean separately.

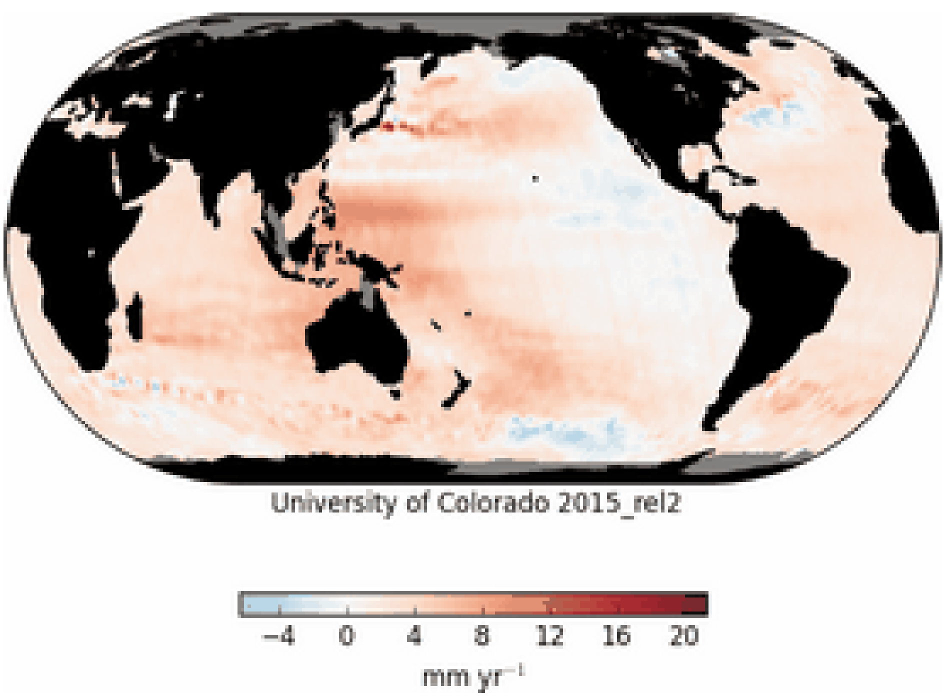

Figure 2: Regional sea level trends

On the map above – see [UC2] – the regions are shown in different colors according to whether ocean levels are rising or falling (red = rising; blue = falling).

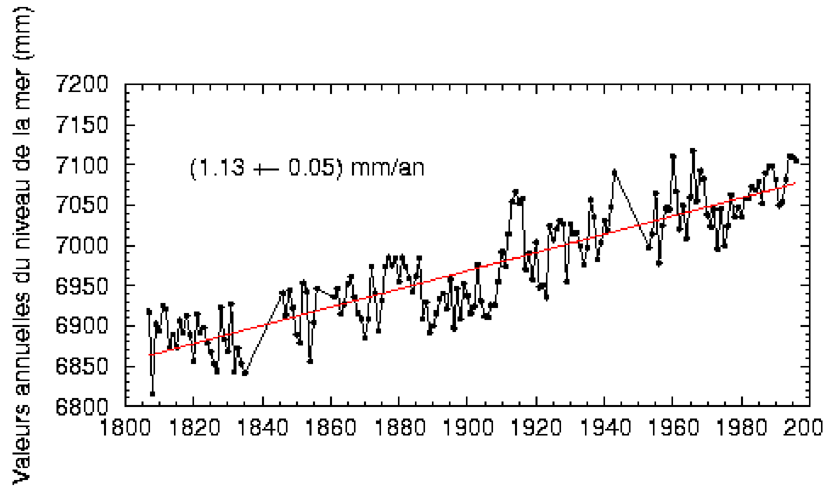

Figure 3: Changing sea levels over time at Brest [Desnoës]

Key :

Valeurs annuelles…	Annual sea level values (mm)

Here are the readings taken by the Brest marigraph over 200 years (source: SHOM, paper by Yves Desnoës). It is very interesting to note peaks (ten or twenty years) and troughs (up to fifty years); see Annex for further details.

But a measurement is not a fact, because:

- Measurements can be marred by errors
- They may not cover the entire phenomenon but only certain aspects or some areas

The inconsistency between marigraphs and satellites may be due to the fact that marigraphs cannot see all the earth's seas, but satellites (limited to latitudes between 66° S and 66° N) are affected by positioning errors in their ground beacons (their measurements are not independent, contrary to what the operators think).
In the case of satellites the observation period is far too short to be able to deduce a trend. It would need hundreds of years, in view of the variability of the phenomena.

III. Attempts at explanation

Most people imagine the Earth as a solid that never changes shape, like a lump of ceramic inlaid with basins forming the oceans. When people are told that the level in the basins is rising, they feel alarmed. As the water cannot come from elsewhere (from space), that

appears to indicate that the water in situ is 'swelling up', or perhaps melting ice is contributing.
In either case, this is attributed to hypothetical 'global warming', for which there is no backing (see our Note to the Secretariat-General for National Defense and Security – SGDN – [BB1], updated 2006) but for which mankind readily takes responsibility.
Let us review these explanations:

A. Thermal expansion

This approach says that if the temperature rises, the oceans will expand. No doubt they will, but the container (the Earth) will expand as well. If we take a ball and draw a basin on top and heat it up, the result is not clear. Depending on the coefficients of expansion used, the volume of the basin will increase faster and the level will drop.

B. Melting ice

First of all, if an iceberg (ice floating in water) melts, that does not alter the sea level. "It is easy to prove that if a lump of pure ice floating on pure water melts, the water level does not change. The fact is that the volume of ice under water corresponds to the volume of liquid water needed to equal the weight of the ice cube." (French Wikipedia on Buoyancy, application to the case of an iceberg). Melting ice at the North Pole cannot therefore alter the sea levels.

Melting ice on land (Greenland, various glaciers, Antarctica) could certainly alter sea levels by several tens of centimeters. Estimates in this respect vary quite a bit, as the true mass of such ice is not known (the estimates have been arrived at simply by multiplying an area by an assumed average height).

However, recent studies published in the context of the Cryosat mission show the opposite trend happening in the Arctic – see [Cryosat].

Another thing affecting sea levels is the warm current known as El Niño.

C. El Niño

In 1982-83, the sea level off Christmas Island in the central Pacific rose by nearly 10 cm. In October the sea level was unusually raised by almost 25 cm over a distance of nearly 6,000 km from the Equator. Whereas it was rising in the eastern Pacific, at the same time it was falling in the western Pacific, exposing (and destroying) the upper layers of the

fragile coral reefs surrounding a number of islands. Surface temperatures in the Galapagos Islands and along the Ecuadorean coast rose from 22°C to over 27°C! (IFREMER).
In order to assess the variations over very long periods, the effects of that current therefore need to be eliminated.

The following facts are well established:

- Earth experienced an ice age some 20,000 years ago (and, apparently, many others before that). Since then the Earth has been slowly warming up, without human beings having anything to do with it. We do not know why these changes happen. Maybe a variation in solar activity is responsible. The arguments based on a change in the Earth's orbit are false (see below).
- The quantity of ice at the poles varies considerably from year to year. This is what Roger Vercel wrote in 1938 in 'A l'assaut des pôles' (Assault on the Poles) (SCM Letter no. 24):

"Actually, something extraordinary is happening: at the same time as the French Empire, the ice shelves have started cracking, breaking up, disappearing… In 1816 and 1817, ice fields drifted as far south as below the 40th parallel, the same latitude as Toledo and Naples! Icebergs 60 meters tall have been reported everywhere in the Atlantic. Those are the pieces of the ice cliffs that gripped the polar lands.

And here we have William Scoresby, the most famous of the English whaling captains, writing to Sir Joseph Banks, one of Cook's companions and himself an Arctic explorer, that for the last two years he, Scoresby, had not found any ice on the coasts of Greenland between 74 and 75 degrees N. Such an opportunity to reach the pole by travelling up the Greenland coast will not come again for a while!"

Conversely, in March 2010, around fifty ships, including ferries carrying thousands of passengers, had to be freed by Swedish icebreakers after being icebound for several hours in the Baltic off Stockholm, a long way south of the pole, at a time of year when there is not normally any ice! (SCM Letter no. 50).

Generally speaking, there are considerable local climate variations in the space of a few hundred years. Vines were grown in the Stockholm area two thousand years ago and when Greenland was discovered (about 1000 AD), it was green. See [Garnier] for a detailed study of the last 500 years.

- Warming by a few degrees will not affect ice melting in the Antarctic, where the temperature is below -40°C.

In conclusion, the variation in the quantity of ice on the planet is widely acknowledged (as certain as one can be on such a matter!). The immediate variability of this phenomenon is so great that measurements over a few hundred years have no significance.

IV. The Earth is not a solid that never changes shape

A. The changing shape of the terrestrial globe

Seeing the terrestrial globe like a 'lump of ceramic' is totally wrong. The Earth's crust is certainly not a solid that never changes shape; on the contrary, it is soft. This is illustrated by the following two facts, which have been definitely proven:

- Instantaneous deformation: it is subject to lunar attraction, which causes its shape to change with each orbit. The vertical extent of this phenomenon (known as the 'earth tide') is between 40 and 80 cm. See [Métivier].

- Long-term deformation: plate tectonics also show that the crust is not rigid. Huge plates between 10 and 100 km thick move about on the surface of the Earth's mantle, which comprises molten rock. These plates bump up against one another and may be thrust upwards. So the level is not constant. The vertical shift may be a few millimeters per year.

B. Universal gravitation

People imagine this in simple terms: the heavier a body, the more it sinks. But that is incorrect: gravitation has to do with TWO masses attracting each other. If one of them decreases, the effect on the other will be felt.

Let us use an example to illustrate this. Let us assume an undersea mountain about 3,000 or 4,000 m below the surface. Most people will say that the water level above the mountain is the same as everywhere else: flat, or rather, spherical. But that is false, as due to its mass, the mountain creates a 'gravitational anomaly': there is a 'hump' which can be detected with sufficiently sensitive equipment. This scientifically clearly proven fact is totally misunderstood by the general public.

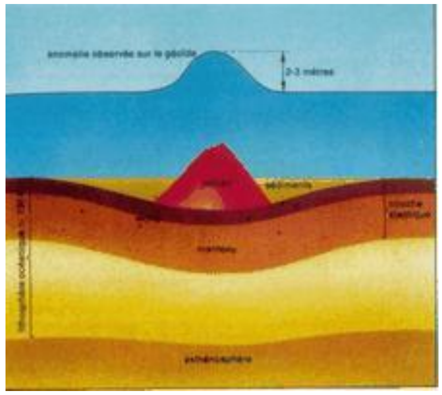

Figure 4: Diagram representing the gravitational anomaly created by an undersea mountain [Desnoës].

Illustration from the paper given by Yves Desnoës (former Director-General of SHOM), SCM Seminar, 2005. See [Desnoës]. In this illustration the 'hump of water' is two to three meters high.

C. Buoyancy

However, gravity provides an understanding of rising sea levels resulting simply from buoyancy. Where the mass is greater (land), the level will sink and where the mass is less (sea), the level will rise.

This is Archimedes' original figure in his treatise 'On Floating Bodies' [Archimedes]. We have an arc of a circle ABC which is the mean land level. On the portion AB we have an ocean and the actual level is A_1B, and on the portion BC we have mountains and the actual level is BC_1. If the whole thing is a fluid (in this case, we would call it 'viscous'), the portion BC_1 will tend to sink and the portion A_1B will tend to rise. Archimedes demonstrates this by considering an internal arc XYZ. In equilibrium, the pressures on the two arcs XY and YZ should be the same.

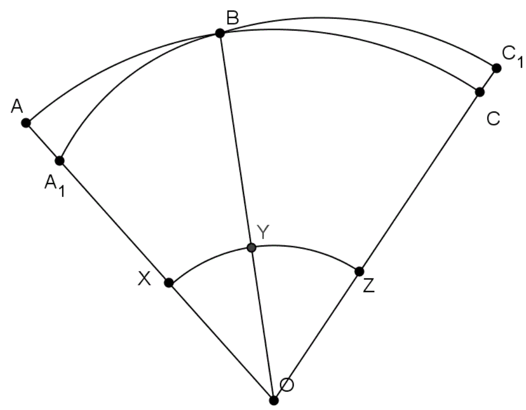

Figure 5: Archimedes' arcs

Equilibrium will be restored if the portion BC_1 sinks and the portion A_1B rises.

D. Variations in the Earth's internal temperature

Temperature variation within the terrestrial globe is a mystery (we are talking here about the interior, not the atmosphere). Simple common sense would tell us that over five billion years it has had plenty of time to cool down. Admittedly, the earth's crust is a good insulator; it ought to be possible to calculate the cooling time needed, on the basis of temperature and thermal conductivity assumptions; a rough calculation is given in Chapter 1, Part Two, below. Some authors also assume that the core is the seat of nuclear reactions that are thought to help maintain the core temperature.
There is no doubt that such reactions exist, but we are not able to assess their quantitative effects. We will return to this in greater detail in Part Two.

If the terrestrial globe is tending to cool down, in cooling it contracts and that contraction will affect the heavier parts of the world more than the lighter ones; this accentuates the previous phenomenon.

Many authors also mention a 'post-glacial rebound'. Due to the warming up that followed the ice age, ice melted and the sea level rose. The ice having melted, the pressure it exerted on the rocks ceased and the rocks tended to rise: this is elasticity at work, and it is thought to have mainly affected those parts of the world in the northern latitudes.

This theory is based almost entirely on models, which are very questionable. In principle, ice melt should affect all those parts of the world that went from a temperature below 0°C to a higher temperature. A sphere has two hemispheres, and it is not clear why a phenomenon like this would affect one more than the other.

E. Abrasion of the land by rivers

Rivers have been flowing for some billions of years, and they carry earth and fragments of rock from the terrestrial areas to the depths of the oceans. Unlike the water cycle, this phenomenon is not reversible. Its effect is that the volume of land under water decreases and matter is deposited on the ocean floors. The quantities involved are considerable, but nowhere have we seen attention paid to this phenomenon.

F. A remark about method

We have not seen any models that have the interior of the terrestrial globe 'communicating' with the surface (apart from the dust generated by volcanoes). Admittedly, the sun plays a prominent part, but it is hard to imagine that the molten magma which the Earth is made of has no effect on the surface temperature. We will come back to this in Part Two.

V. Be careful!

As this issue has taken on a major political dimension, all kinds of statements are made by absolutely anyone at all. Great care is therefore called for when accepting information.

A. Models

Conclusions based on any kind of model should be disregarded. As the SCM specializes in building mathematical models, we should also be recognized as competent to criticize them. Models are useful when attempting to review our knowledge, but they should not be used as an aid to decision-making until they have been validated. Now, validating a climate model requires thousands of years.

B. Measurements

The greatest caution is needed with regard to the conclusions drawn. There may be errors in measuring, but that is not the main issue. In most cases, the number of measurements is far too low to describe the phenomenon in question. They are much too recent (thirty years, sometimes 200 in the case of marigraphs) to take account of phenomena like ice ages.

C. Dishonesty

The level of dishonesty is rising much faster than the sea level. It has totally swept scientific literature, where a good many writers endeavor to produce models showing something worrying. The press disregards all the others and its various organs vie to bring them to public attention.

Here is an extract from SCM Letter no. 18, June 2002:

In late March Mr. Jean François Minster, CEO of IFREMER, appeared on the *Journal de 20 h* program on the TF1 channel. He spoke about a glacier breaking up in Antarctica. This was portrayed as a rare event. He offered it as proof of global warming and referred to sea levels rising "by several tens of centimeters". Those data, presented in this way, are fallacious:

- It is normal for a glacier in Antarctica to break up at that time of year;
- There is no reason to believe that, globally, Antarctic glaciers are retreating.

It is funny that now (in 2015) the IFREMER site makes no more mention of rising sea levels.

The alarmist news is contradicted by the facts:

This is what was written by Pierre Barthélémy in an article in *Le Monde* (December 18, 2005) entitled 'Thousands of refugees soon fleeing the ocean':
"Global warming will lead to the sea level rising by 5 mm per year in the 21st century, three times as fast as in the previous century. The areas most at risk are the Pacific islands, Bangladesh and the major deltas. In August the one hundred or so inhabitants of Lateu, in the Vanuatu archipelago in the South Pacific, made history quite unintentionally. Their village, lying on the Pacific shore on the small island of Tegua, became the first in the world to have to be relocated because of climate change and rising ocean levels. The roots of the coconut palms were under water, cyclones and spring tides were following one another at an unbelievable rate, the little coral reef 1 meter tall, the last line of defense against the waves, had eroded, mosquitoes carrying various diseases were flourishing in the pools of stagnant water… So they had to move some hundreds of meters inland. Lateu today serves as a symbol."

But the sea level has not risen significantly in this part of the world for the last 25 years, as is evident from the local marigraph readings and satellite observations. See [Muller].
Quite the opposite:

A NUMBER of Pacific islands previously thought to be losing ground to rising sea levels caused by climate change have actually grown larger, according to scientists. A study published in this week's *New Scientist* magazine has revealed that despite long-held fears that islands in the Pacific Ocean would be washed away in coming decades due to rising sea levels from global warming, the islands are actually responding to the threat by growing larger. The study of 27 islands by the University of Auckland and the South Pacific Applied Geoscience Commission in Fiji found that over the last 60 years only four of the islands had shrunk, with the others either remaining stable or growing. [Daily Telegraph]

D. Critical analysis

The rising sea level is a basic thesis for journalists, to support the doctrine of global warming. They say, “Look, the sea is rising, and so we are in danger”.
It is perfectly true that the sea level is rising, but essentially this is due to the cooling down of the core of the terrestrial globe which has been taking place gradually for five billion years. As a result of this contraction the lighter areas (the oceans) tend to rise up in relation to the heavier areas (the mountains). This is simply a consequence of buoyancy, and human beings have nothing to do with it.

Annex

I. The sea level at Brest

This is not relevant when considering mean ocean levels (our topic here), but it is relevant in showing the tremendous variability, even over long periods, and the problems of measuring.

Here are the annual data since 1807 (source: SHOM, provided by Yves Desnoës):

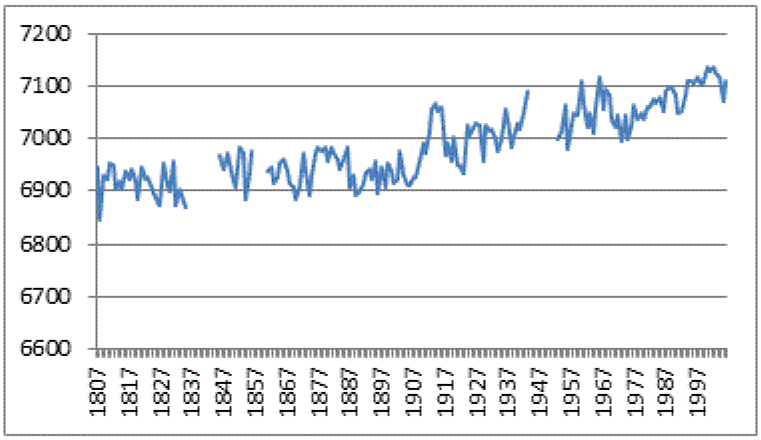

Figure 6: Ocean level records for Brest since 1807 (SHOM)

The very great variability of the annual mean from year to year is probably linked to the variability of the climate. When the atmospheric pressure falls, the sea level rises (the pressure of the column of air is less).

Here are the means for consecutive ten-year periods:

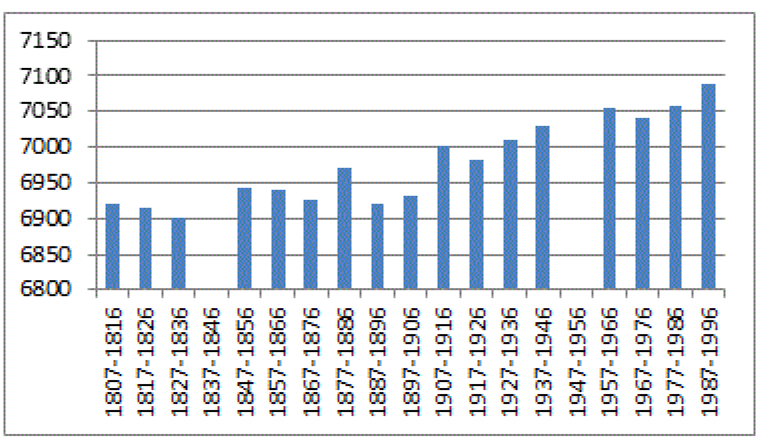

Figure 7: Average ocean level at Brest per decade

It can thus be seen that there are 30-year periods during which the mean level falls. The tremendous variability of the above graph shows that it is not possible to make a reliable forecast for a ten-year period. In the next ten years the level may equally well rise as fall.