Chapter 3

Dire Consequences on Little Shifting of the Earth's Spinning Angle – An Investigation Whether Polar Ice Shrinkage may be the Cause?

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/58708

1. Introduction

Environmentalist and Scientists are now of the opinion that the entire globe may face threats of: fast shrinkage of polar ice due to its melting and may eventually diminish by 2040, fast rise in the sea level, danger for species like: polar bears, penguins etc., northern portion of Canada, USA and UK may be affected by cold waves, heavy snow falls and storms due to shifting and melting of largest ice sheets in the Atlantic sea.

Scientists warn that the warming in the region of Arctic is due to the increment of Permafrost which is also one cause of the Tundra fires. The warming this way cannot be hence reversed and thus the entire Arctic region may turn into a dangerous source of methane from a vast carbon sink in less than a decade.

In view of likely disastrous implications, all the scientists involved, in the research and fieldwork are helping us to understand the growing threat of melting permafrost in the crucial Arctic region. Our Earth planet is on a dangerous course of passing irreversible tipping points with disastrous consequences due to the melting of green land, polar ice and permafrost which in turn releases toxic methane gases, resulting more warming of the atmosphere.

The future of sea level rise cannot be overruled by the ice sheets as they present alarming challenges in predicting their future response. It is calculated by using numerical modeling and as a result alternative approaches have been explored. A generalized approached is required in this matter to estimate their contribution to the sea level in the future.

In view of better identification and prediction of the melting and rising of the sea level a continuous monitoring via satellite is needed, according to the findings published in Nature

Figure 1. The Earth Planet

Geoscience. According to a survey and readings, the ice sheet covering Antarctica and Greenland contain about 99.5 percent of the earth's glacier ice that has the potential to raise the sea level by 63m (about 200 ft.), if melted completely

This entire action may lead to shift of heavy movement of masses of the Arctic sheets to sea and may likely to have an effect on the spinning angle of the earth due to differential changes in masses apart from the above mentioned threats.

2. Earth planet

Among the four largest terrestrial planets comes our earth. It is also the third planet from the Sun and also the densest one. We sometimes refer it as the Blue Planet [1] the Blue Marble, *Terra* or Gaia as shown in Fig.1. The genesis of our earth is estimated around four and a half billion years ago. The life on it initially appeared, as per the readings of the science, in the first billion years [2-5] in the oceans and began to affect its atmosphere and surface, promoting the spreading of aerobic as well as anaerobic organisms and causing the formation of the ozone layer. This ozone layer as well as the earth's magnetic field has the potential to trap the harmful ultra violet rays from the Sun from reaching the earth. Hence, life became possible to flourish on the land as well as in the water [6]. With the capacity of good physical properties and beneficial geological history, life is expanding and growing in its atmosphere.

Lithosphere, one of the geological features of the earth, is divided into several segments and tectonic plates that are formed over a period of many millions of years. Over 70% of the earth's surface is covered with water [7] and the remaining comprise of continents and islands having many lakes and other sources of water that contribute to the hydrosphere. *The earth's poles are mostly covered with thick sheets of ice that is the polar ice packs*. The inner of the earth is the thick layer of solid mantle, solid iron core and liquid outer core that generates the magnetic field.

The tilt of 23.4 degrees in the axis of the earth from its perpendicular of its orbital plane produce seasonal variations on the surface with one tropical year (365.24 solar days) [8]. During one orbit around the Sun, the earth rotates about its own axis 366.26 times creating 365.26 solar days or one sidereal year.

Owing to its feasible life generating conditions, it is a home to millions of species including humans [9]. The mineral resources and the biosphere products contribute much resources that are used to support a global human population [10].

2.1. Shape of the earth planet

An oblate spheroid, that is what the shape of the earth is. Means, it is flattened along the axis and bulged around the equator [11] causing the diameter to be 43 km larger than that of its poles [12].The farthest point from the earth's centre is the Chimborazo volcano in Ecuador [13]. *The average diameter of the reference spheroid is about* 12742 km, *which is approximately 40,000 km/π, as the meter was originally defined as 1/10,000,000 of the distance from the equator to the North Pole through Paris, France* [14].

Since the earth has a tolerance of about one part in about 584, or 0.17%, the local topography deviates from this idealized spheroid only on small scale [15]. The Mount Everest (8848 m above sea level) has been attributed with the largest local deviations in the rocky surface of the Earth and the Mariana Trench (10911 m below local sea level) which together formed the equatorial bulge [16-18].

Some important physical and atmospheric characteristics of the Earth are shown in Table 1. From this data, it is evident that the Earth's radii through Polar and Equatorial are different such as 6356.8 km and 6378.1 km respectively. The polar radius is less than equatorial by 21.3 km or 43 km in diameter. The Earth's mass is 5.97219 x 1024 kgs. Circumferences through the equatorial and the meridional are 40075.017 km and 40007.86 km whereas the total surface area is 510072000 sq.km, out of which the land coverage is by 148940000 km^2 (29.2%) and the water coverage is 361132000 km^2 (70.8 %).

Geo-physical characteristics	
Mean radius	6371.0 km
Equatorial radius	6378.1 km
Polar radius	6356.8 km
Flattening	0.0033528
Circumference	40075.017 km (**equatorial**)

		40007.86 km (**meridional**)	
Surface area		510072000 km^2 148940000 km^2 (29.2%) **land** 361132000 km^2 (70.8 %) **water**	
Volume of the Earth		1.08321×10^{12} km^3	
Mass		5.97219×10^{24} kg 3.0×10^{-6} Suns	
Mean density		5.515 g/cm^3	
Surface gravity		9.780327 m/s2 0.99732 g (**Earth gravity**)	
Moment of inertia factor		0.3307	
Escape velocity		11.186 km/s	
Equatorial rotation velocity		1,674.4 km/h (465.1 m/s)	
Axial tilt		23°26′21.4119″ (23.43°)	
Albedo		0.367 (**geometric**) 0.306 (**Bond)**	
Surface temp.	**min**	**mean**	**max**
Kelvin	184 K	288 K	330 K
Celsius	−89.2 °C	15 °C	56.7 °C
Atmosphere			
Surface pressure		101.325 kPa (at MSL)	
Composition		78.08% nitrogen (N_2) (**dry air**) 20.95% oxygen (O_2) 0.93% argon 0.039% carbon dioxide About 1% water vapor (varies with climate)	

Table 1. Physical and Atmospheric Characteristics of Earth

3. Geomorphology

The surface of the earth, that comprise the action of wind, water, fire, ice and living things, is a combination of the landscapes and geological processes with chemical reactions that form soils and alter material properties and tectonic upliftment. The rate of change of topography under the force of gravity comes under the geological processes. As a matter of fact, the

http://dx.doi.org/10.5772/58708

upliftment of the mountain ranges, the growth of volcanoes, isostatic changes in the land surface and formation of deep sedimentary basins are the result of geological processes. Thus, the earth's surface and its topography are an intersection of climatic, hydrologic and biologic action with geologic processes.

Much of the local climate is modified by topography, for example orographic precipitation which in turn change modifies the topography by changing the hydrologic regime in which it evolves. The intersection of the surface of the earth and the subsurface actions is well illustrated by the broad scale topographies. The geological process is responsible for the upliftment in the mountain belts. The sediments produced after husking of the high uplifted regions are transported and deposited elsewhere off the coast of the landscape [19]. The process of upliftment and deposition and of subsidence and erosion directly affect each other on progressively smaller scales at the involvement of the landforms. The loads of ice sheets, water and sediments can bring topographical changes through flexural isostasy.

Geographical cycle also named as the cycle of erosion is a model of broad scale landscape evolution developed by William Morris Davis between 1884 and 1889 which has been an eludication of the uniformitarianism theory first proposed by James Hutton (1726-1797). Opposing the Davis' model of single upliftment followed by decay, Walther Penck, in 1920, devised a model of cycle of erosion, since he thought that the landform evolution was better elaborated as an alternation between ongoing processes of upliftment and denudation. Since Penck's work could not be translated into English; his ideas could not be recognized for many years

The authors of early 19^{th} century had tried their hands to attribute to the formation of the landscapes under local climate and to the specific effects of glaciations and periglacial processes. Significance of the genesis of the landscapes and the process of the earth's surface across different landscapes under various conditions has been tried and presented in a very well and on a more generalized way by Penck and Davis respectively.

3.1. Processes of geomorphology

The low temperature thermochronology, optically stimulated luminescence dating and cosmogenic radionuclide dating (geochronology) have enabled us to measure the rates at which geomorphic processes occur on geological timescales [20, 21]. Many advanced measurement techniques such as GPS, remotely sensed digital terrain models and laser scanning techniques have permitted quantification and study of geomorphological processes [22]. Further, with the help of modeling technique and computer simulation we know the working process of it.

The geomorphic processes generally listed into:

i. the formation of regolith by weathering and erosion,

ii. the transportation of that material, and

iii. its deposition.

3.2. Glacial processes

Landscape changes happen due to glaciers because the movement of ice down a valley causes abrasion and plucking of the underlying rock and this abrasion further produces fine sediment that is termed as glacial flour. After the abrasion the debris transported by the glacier is called 'moraine'. The erosion of the glaciers are responsible for the formation of the U-shaped valley as seen in Fig.2, as opposed to the V-shaped valleys of fluvial origin [23].

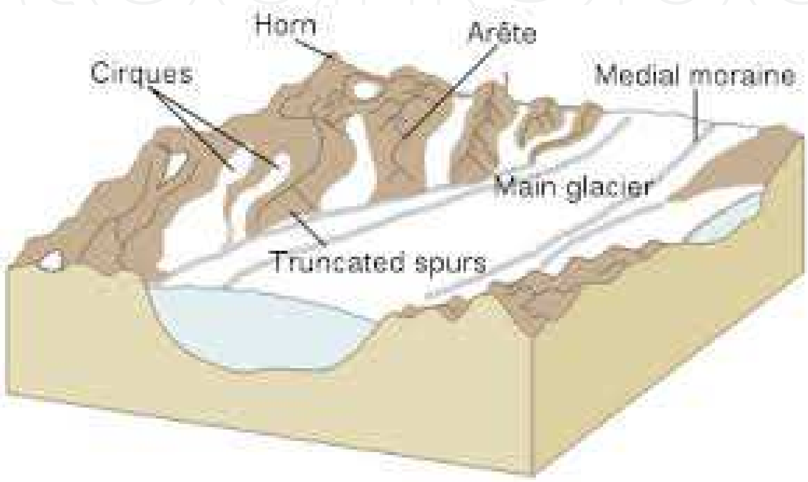

Figure 2. Features of a glacial landscape

Plio-Pleistocene landscape evolution is the one where glacial processes interact with other elements of landscape especially that of the hill slope and fluvial processes and is also responsible for sedimentation in high mountain environments. Elevated landscapes are the feature of recently glaciated environments as compared to those that have never been glaciated. In connection to this, 'paraglacial processes' that have been conditioned by past glaciation comes under 'Nonglacial geomorphic processes'. It contrasts with periglacial processes, which are directly driven by the formation or melting of ice or frost [24].

3.2.1. Glacial mass balance

The movement of a glacier works under the force of gravity. The flow of a glacier is downward because they collect mass (ice) due to the precipitation and wind pressure and get melted in small packs as shown in Fig. 3.

A glacier when in the state of equilibrium does not change in either in steepness or size because it works under the principle of accumulation = ablation. The equilibrium line altitude is because of zero net accumulation or ablation from the altitude. Advancement and recession in a glacier depends upon the changes in the rates of accumulation i.e. if the accumulation area of a glacier shrinks, for example, and the equilibrium line altitude rises, then the glacier will recede [25].

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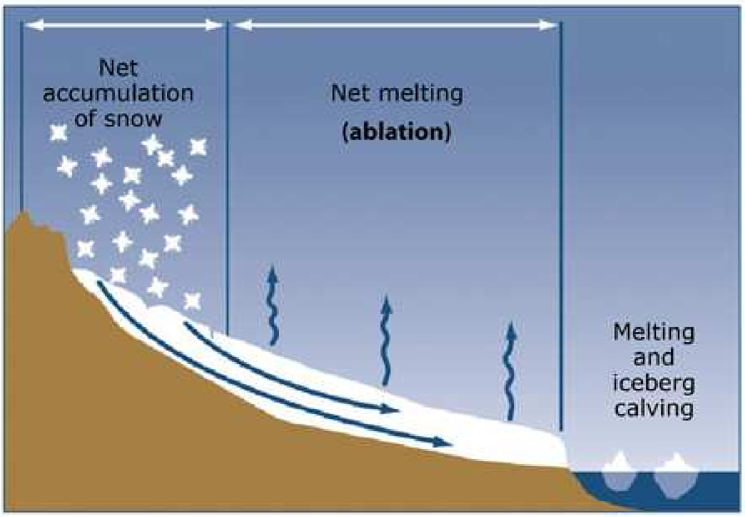
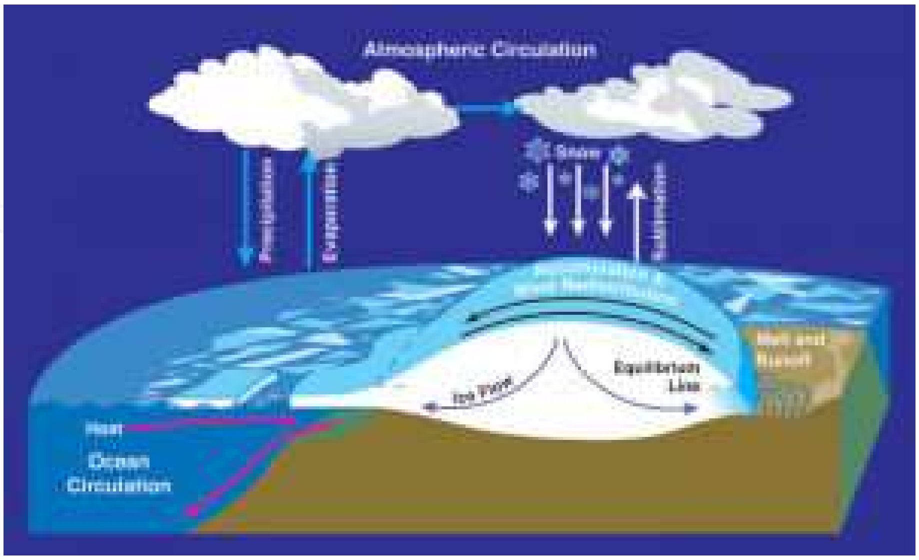


(Source: From the USGS Link: http://pubs.usgs.gov/fs/2009/3046/)

Figure 3. Components of mass balance of a glacier

The mass balance of a glacier is controlled by temperature and precipitation and is calculated by taking the difference between accumulation and ablation. If accumulation is greater than ablation, then the glacier has positive mass balance and will advance. If ablation is greater than accumulation, then the glacier has negative mass balance and will recede.

Gravity accompanied with the mass in a glacier pushes it to flow downward. A receding glacier flows slowly but flows in becoming thin with snout position receding backwards.



(Source: From Wikimedia Commons)

Figure 4. Glacier mass balance and atmospheric circulation by NASA.

The ice discharge from a glacier is by the accumulation and ablation area, thus maintaining a steady-state profile. The velocity of a flowing glacier is controlled by the glacier's mass. Some glaciers have dynamic flow driven by other factors, for example, surging glaciers, tidewater glaciers, ice streams or ice-shelf tributary glaciers.

3.2.2. Ice deformation and sliding

The process of deformation and sliding downwards is how the glaciers move (see Fig.4). The velocity, motion and flow of glacier is controlled under several factors as follow:

- Shape of geometrical formation of ice (thickness, steepness),
- Properties of ice in temperature and density,
- Geometrical valley,
- Conditions of bedrock such as: hard, soft, frozen or thawed bed,
- Hydrology in subglacial manner,
- Terrestrial environment like: land, sea, ice shelf, sea ice, and
- Mass balance in terms of rate of accumulation and ablation.

During the movement of the glaciers, there acts a driving stress. This driving stress, also called gravitational driving stress, is controlled by the density of ice, gravitational acceleration, temperature, ice thickness and ice surface slope. These resistive stresses basically operate at the glacier bed and make *basal drag* or *lateral drag* against the walls of the valley.

Three ways of the movement of glaciers under the driving stress:

i. Creeping due to internal deformation

ii. Sliding of basal

iii. Subglacial deformation under soft bed.

All glaciers flow by creep, but only glaciers with water at their base (temperate or polythermal) have basal sliding, and only glaciers that lie on soft deformable beds have soft sediment deformation. If all three factors are present, one can have the ingredients to contribute to fast ice flow.

4. Ice melt fuels sea level rise concerns

4.1. Satellites monitoring of ice sheets for better prediction about sea level rise

Variations in the earth's gravitational field under changes in mass distribution with the movement of ice slabs into the oceans, is being detected by the satellites of Gravity Recovery and Climate Experiment (GRACE) since 2002. This provides us assistance and data as well, in

http://dx.doi.org/10.5772/58708

monitoring the present condition of the ice sheets, at monthly intervals, under gravitational changes.

Dr. Bert Wouters, a visiting researcher at the university of Colorado, says that in the last few decades, as and when compared for the first few years of the GRACE mission; around 300 billion tonnes of ice is being lost by the ice sheets and its loosing rate is apparently increasing and adding substantial contribution in the sea level rise; almost double in recent years, compared to some few years.

The heavy loss of the ice sheets in the last few decades has not formed any general consensus among the scientists based on observations of the satellites. One agreement related to the loss of the ice sheets is that it may have been due to anthropogenic warming. In other words, natural processes such as severe fluctuations in atmospheric conditions, especially the shifting pressures in the North Atlantic, El Niño and La Niña effects, may have anthropogenic causes, as well as being due to the ocean currents.

"Dr Wouters state that, “if observations span only a few years, such 'ice sheet weather' may show up as an apparent speed-up of ice loss which would cancel out once more observations become available" [26].

The information received from the GRACE mission clearly mentions mass changes to the ice sheets after the comparison of nine years of data by a team of researchers. They detected that the ability to detect accurately an accelerating trend in mass loss depends on the length of the record.

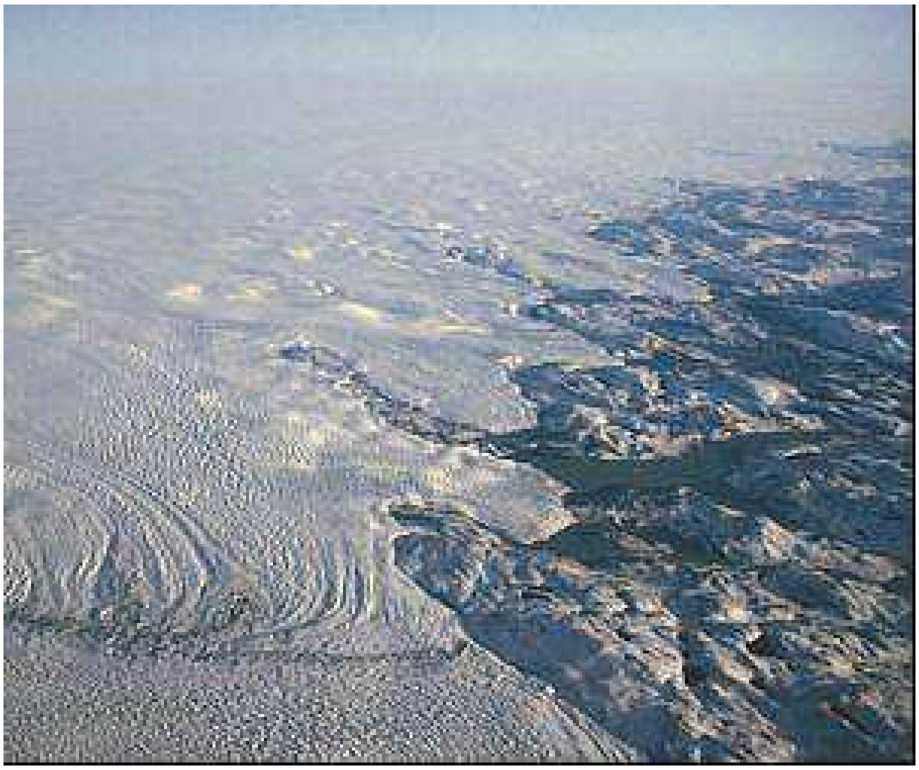


Figure 5. The Satellite Monitoring about Sea Level Rise

The deformation in the ice sheets in the Antarctic region in the last few decades is alarming and its losses are unconvincing. If atmospheric fluctuations would be studied as the cause of the changing trend in the loss of the ice sheets at this region, it would leave a very meagre percent.

The satellite survey and study in the region specifically provides information about the mass loss of the ice sheets in the Antarctic region, and for Greenland, it will require us a time span of about ten years

It could be further added to our study, after the result of the satellite information regarding the mass loss in the ice sheets in the Antarctic region, that a continuous monitoring of the ice sheets through the satellite would be better to identify and predict the melting rate along with the observation in the sea level rise because 99.5 percent of the earth's glaciers of Antarctic and that of Greenland would raise global sea level to about 63m, if melted completely

The rational study regarding the sea level rise due to the ice sheets to 2100 might be 35cm if too high or low. Hence, prediction in the sea level rise, according to the studies, is an alarm for us to lift necessary steps to mitigate the onslaught.

4.2. Polar ice caps melt raises the oceans rise?

The rise rate of about half a degree celsius in the temperature in the last 100 years has no doubt caused Global Warming. Not to say, even half a degree would be enough to affect our planet' life. U.S. Environmental Agency (EPA) has stated in one of its survey report that, in the last 100 years, the sea level has raised from 6 to 8 inches (15 to 20cm) [27]. The rise in the temperature this way has paved the way for the melting of the polar ice sheets and floating icebergs to melt and could be if not on a large be one of the even small causes for the rise in the sea level.

(Source: by Tom Brakefield)

Figure 6. Antarctica accounts for about 90 percent of the world's ice

90 percent of the world's ice, around 2133 meters (7000 fts.) (including 70 percent of fresh water) is ice covered landmass in Antarctica at the south pole (Fig.6). It is hypothetical to say but, if the entire ice gets melt, the level in the seas around it would rise up to 61 meters (200 fts). Since, the average temperature in Antarctica is -37 degrees C, it cannot happen.

It can be said that the amount of ice covered at the Greenland, if gets de-freeze, would raise the level of sea around it to 7 meters (around 20 fts). On being close to the equator, the chances of de-freezing of the ice sheets is more as contrast to that of Antarctica.

The temperature variation of sea water has bigger impact over density of water. It is observed that water is most dense at 4 degrees celsius. The temperature above and below 4 °C, water density decreases and occupies a bigger space; leading to a proportionate rise in the water level in the oceans.

A report issued by the Intergovernmental Panel on Climate Changes of 1995, projected that by 2100, there would be rise of 50 centimeters (20 inches) with the lowest estimation of 15 centimeters (6 inches) and 95 centimeters (37 inches) the highest. This rise will be governed by the melting of glaciers and ice sheets along with the thermal expansion of the oceans. The rise of sea level at 20 inches cannot be considered trivial as far as the coastal regions are concerned, especially during storms, as it can bring havoc to the life and property nearly it.

4.3. New Greenland ice melt

The date of 'Nature Climate Change' of March 16th, 2014 (Sunday) revealed that there is rapid loss of ice sheets, over the past decade due to a rise in air and ocean temperature caused partly by climate change (see Fig.7). The increase in the melt has caused serious concern for the rise in the waters of the sea around the region even faster than projected, threatening the coastal life at large [28].

Shfaqat Khan, a senior researcher of Technical University of Denmark, wonders by saying, "North Greenland is very cold and dry, and is believed to be a very stable area. It is surprisingly to see ice loss in one of the coldest regions on the planet."

As of other glaciers on the island, the stability of the region is more important as it has much deeper attachments to the interior ice sheets. It is also said that, *"If the entire ice sheet were to melt -- which would take thousands of years in most climate change scenarios -- sea levels would rise up to 23 feet, catastrophically altering coastlines around the world."*

8 inches in the sea level rise has been observed globally since the start of 1900 and is projected to have further rise to 3 feet by the end of 2100.

Over three-quarters of the Greenland houses 680,000 cubic miles of ice sheet, stretching up to 3 miles in thickness in all directions finally confluencing at the sea nearby. The glaciers specifically of the southeast and the northwest have dumped enormous amounts of ice into the ocean, in the last 20 years and that has accounted for a more of 15 percent global rise of the sea level.

According to Dr. Shfaqat Khan, "These changes at the margin can affect the mass balance deep in the centre of the ice sheet". Moreover, the creeping rate of the sea levels is 3.2 *mm a year*, to

(Source: Henrik Egede-Lassen)

Figure 7. Helheim glacier in the southeast Greenland.

which Greenland contributes about *0.5 mm*, contrary to the real figure which is significantly higher. They calculate that between April 2003 and April 2012, the region was losing ice at a rate of 10 billion tonnes a year.

4.4. East Antarctic melting could raise sea levels by 10 to 13 feet

The study under Katie Valentine in 'Nature Climate Change' comprising 600 mile Wilkes Basin in the East Antarctica (Fig.8) states that, if the melts of ice would raise the sea level by 10 to 13

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feet [29], it would be alarming and the researchers also find the region vulnerable because of the small 'ice plug' that may melt over the next few centuries. In this addition, East Antarctica could be a large contributor to the sea rise.

Figure 8. Study shows that East Antarctica region is perhaps more vulnerable in causing rise in the world's sea level for thousands of years. A study on Sunday, May 5, 2014 at 9:25 am.(Source: by Katie Valentine)

Matthias Mengel, a leading author in this study says that, "East Antarctica's Wilkes Basin is like a bottle on a slant. Once uncorked, it empties out. However, it is a distant threat." The authors conducting study on it says that warming can be limited to keep the plug in place. This was noted out when the method of simulation was adopted under scenarios with water found to be 1 to 2.5 degrees warmer than what it is today. We can however, on the basis of our observations, say that if, concrete steps are not taken, our planet would come under the hit of another 2 degrees Celsius ' hike adding much to the global warming. When giving a first look at the Wilkies Basin, we can conclude that the East Antarctic region might contribute to the sea level rise, although it is a talk of distant future [30-35].

Anders Levermann told to National Geographic that, "This is unstoppable when the plug is removed." Speed of its removal cannot be expected but, it's definitely a threshold.

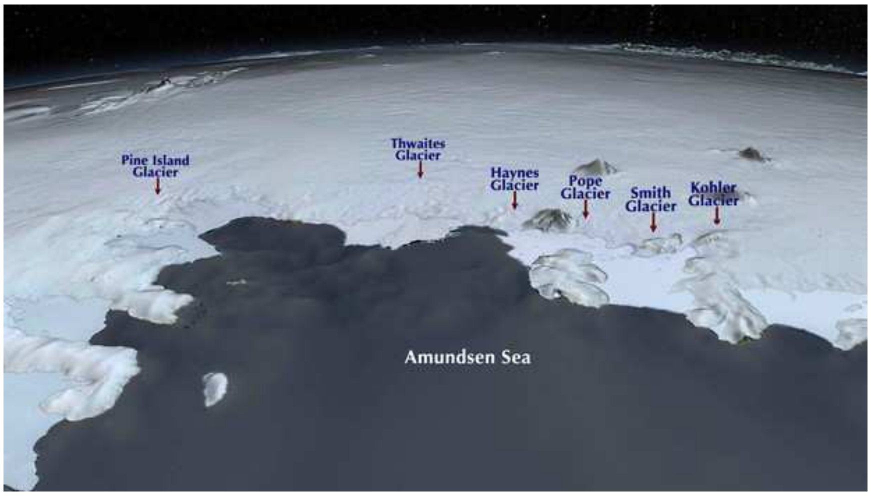
No doubt, if the entire ice of Antarctica would melt, it would raise the sea level to about 188 feet. Another study of 2012 states that over the past decade, Antarctica has lost about 50 percent of the ice cover because Antarctic glaciers have started with irreversible melt which could lead the sea level to rise up to 1 centimeter. In one of the recent studies on the declining of the ice belt at Antarctica, it has come into view that the glaciers in this region have begun with a self-sustained retreat [36-46].

Adding to the study, Eric Steig said that, “These new results show that the degree of melting experienced by the Antarctic ice sheet can be highly dependent on climatic conditions occurring elsewhere on the planet.”

In other very alarming study done by the National Snow and Ice Data Center in Boulder, Colorado, stated in March 2014 that, the region is experiencing the fifth-lowest winter sea-ice cover ever since 1978.

4.5. Passed point of no return of Antarctic glaciers

Two separate teams of scientists cleared that, the glaciers at Antarctica have passed a point of no return and will keep on melting rapidly especially that of the western Antarctica



(Photo: NASA via AFP)

Figure 9. Getty Images by Traci Watson, on May 13, 2014; 9:14 a.m.

The likely result: a rise in global sea levels of 4 feet or more in the coming centuries, says research made public on May 12, 2014, Monday by scientists at the University of Washington, the University of California-Irvine and NASA's Jet Propulsion Laboratory as shown in Fig.9.

Sridhar Anandakrishnan, glaciologist of Pennsylvania State University says that, "It really is an amazingly distressing situation. This is a huge part of West Antarctica, and it seems to have been kicked over the edge."

Studies in progress show that the glaciers are in their stage of collapse and that is inevitable. We cannot reverse the situation. The Thwaites Glacier also known as ‘the river of ice’ is in its early stages of collapse and is almost inevitable. Half a dozen glaciers are dumping ice into the sea with pace which will give a rise of about 4 feet in the sea level, as per Eric Rignot, a glaciologist at the University of California-Irvine and laboratory at NASA’s jet propulsion.

The same claim was made by Rignot at a briefing on May 12, 2014 Monday.

When studied about the retreating of the glaciers, Rignot and his team collected data made available to them through satellites and aircrafts to picture changes in six West Antarctic glaciers and the terrain underlying the massive ice, they found that the glaciers are stretching out and shrinking in volume by dumping mass of ice into the ocean.

Figure 10. Collapse of Thwaites Glacier

At the same time, the portion of each glacier projecting into the sea is being melted from below by warm ocean water as shown in Fig. 10. That leads to a vicious cycle of more thinning and faster flow, and the local terrain offers no barrier to the glaciers' retreat, the researchers report in an upcoming issue of Geophysical Research Letters.

A report in the mid of May 2014 Week's Science says the Thwaites Glacier will collapse, perhaps in 200 years. The paper doesn't specify the amount of sea-level rise associated with Thwaites' demise.

4.6. No way back for west Antarctic glaciers

The data of 19 years in the reported in the journal Geophysical Research Research Letters confirms that the melting of the West Antarctic glaciers are warming up in a speedy way in contrast to less warming of the southern hemisphere.

The West Antarctic ice sheet remained unstable and this had been an element of wonder among the glaciologists. According to the NASA research, there is enough water in the ice sheets of Amundsen Sea that is enough to raise the global sea levels by more than a meter. It is also said that, if the entire ice sheet of West Antarctic region changes to water, it can make the sea level to rise by at least five meters (See Fig.11).

4.6.1. Steady change

The recent study reveals that there is a steady change in the glacial grounding line, that clears us for the movement of the glacier towards the sea where its bottom leaves no abrasion on rock rather starts to float on water. Glacier has the nature to flow towards the sea and bear an iceberg that floats and later melts. Now, this has always been a matter of perplexity whether this process is going to accelerate?

The same is being considered by Eric Rignot, glaciologist at the Nasa Jet Propulsion Laboratory and the University of California, Irvine. Eric Rignot, glaciologist and his research partners estimates that the tidal movement can be responsible for bringing bending lines in the glaciers especially of the West Antarctic. This research was carried out when these glaciers were monitored between 1992 and 2011 on the basis of the data of European Space Agency. Since all the grounding lines had retreated from the sea by more than 30 kilometers. These are a bit hard to study because of their depth at which these are buried i.e. at more than hundreds of meters under the ice sheets.

An important clue can be obtained from the shift of the ice against the tidal waves and its flowing direction. It also signifies the acceleration of melting. It is also taken into consideration that the slow process of movement of the glacier cuts the rise in the sea level and as it inches towards the sea, more ice piles up behind it, collecting into mass.

4.6.2. Speeds up

As the water seeps under the ice sheet, it reduces friction rate and adds speed for the frozen water downstream and the whole glacier picks speed supporting the grounding line to move further upstream. Here, the melting could be slow at pace, but, not stoppable. The same phenomenon has been reported from the glaciers of Greenland

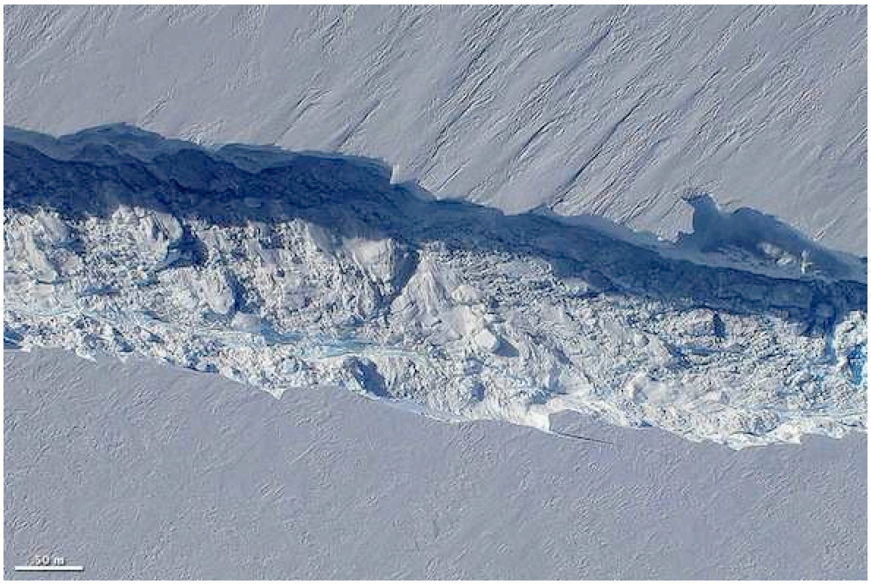


Photo: by NASA (*Source:* Earth Observatory via Wikimedia Commons).

Figure 11. Birth of an iceberg: a massive crack in West Antarctica's Pine Island glacier.

Prof. Rignot has again and again expressed his concern over the retreating of the glaciers of the West Antarctica in pointing out: "At current melt rates; these glaciers will be history within a few hundred years. We've passed the point of no return." So, the collapse of this sector appears inevitable.

5. Antarctic mass variation

We have derived multiple reasons for the mass de-freezing of the ice sheets under Antarctica and is thus giving pace for the ice under it to advance towards the ocean causing huge loss in the ice blocks.

5.1. Warmth in Antarctica

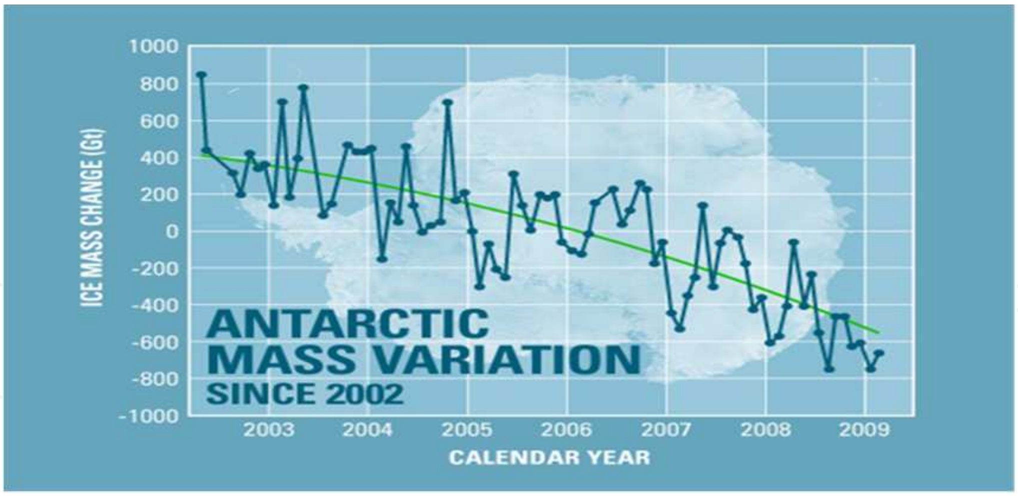
With the ice extension, Antarctica is also losing its ice cover. It seems amazing statement, but, analysis in this concern will certainly help us to find some concrete way in the context of global warming. The ice mass chart from GRACE satellite as shown in Fig.12 (a) and Fig.12 (b) helps us in this illustration.

On the basis of the observations and model studies, it is found that the sea ice is extending in the Antarctic sea despite the warmth in and around the Antarctica region. But, during each winter it allows to grow due to changes in ocean and wind circulation combined with changes in moisture levels. as compared to that of the Southern Hemisphere (SH), it remains cold and allow the ice to extent and grow. It can also be said that the growth of the Antarctica sea ice is likely because of the changes in the wind circulation combined with the moisture levels and that of the ocean currents. Moreover, the changes undergoing in the stratospheric ozone layer may also play significant role in this context.

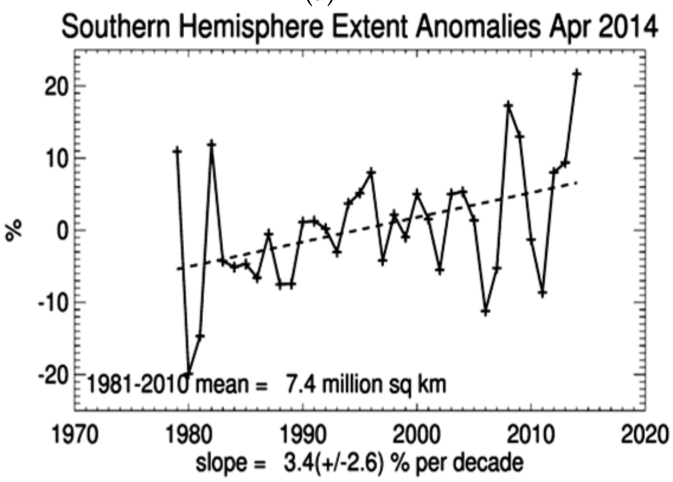
Hypothetical studies observe its happening. Explanation by the studies of Zhang 2007 well contributes to understand the warming concepts in the Antarctic region [47].

An increase in the upper ocean temperature and a decrease in sea ice growth leading to decrease in salt rejection from ice in the upper ocean salinity and density are very clear by the model due to the increase in the surface air temperature and downward longwave radiation. The enhanced thermohaline stratification tends to suppress convective overturning along with the reduction in the salt rejection and upper ocean density, leads to a decrease in the upward ocean heat paving way for sea ice melting. The decrement in the ice melting from the ocean heat flux is faster as compared to the ice growth in the weakly stratified Southern Ocean, leading to an increase in the ice production. This mechanism is the main reason why the Antarctic sea ice has increased in spite of warming conditions both above and below during the period 1979–2004 and the extended period 1948–2004 [48, 49, 50].

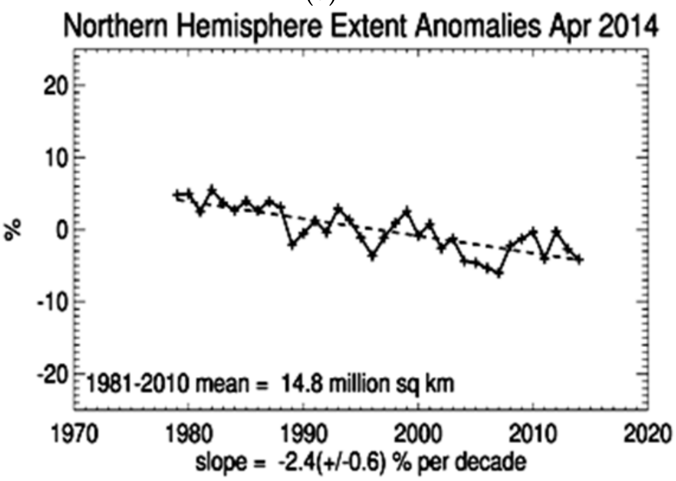
The ice mass extends to grow in the Southern Hemisphere during winters more than the usual days. Whereas, the ice mass, at Antarctica, decreases during the summers, as per the satellite observations.



(a)



(b)



(c)

(Source: http://www.nasa.gov/topics/earth/features/20100108_Is_Antarctica_Melting.html; http://nsidc.org/data/seaice_index/; http://nsidc.org/data/seaice_index/)

Figure 12. (a). Antarctic Ice Mass Loss [manual update]; (b). Antarctic Ice Extent Increase updates annually; (c). Arctic Ice Extent updates annually

http://dx.doi.org/10.5772/58708

It can be concluded, after these kind of researches, that more snow precipitation might be expected in the Antarctica in the future than compared to today's scenario where the ice discharge rate has increased.

This is confirmed by the following data:

- Warming of Antarctica
- Increase in the sea ice of Antarctic
- Decrease in the ice mass of Antarctic land

5.2. Warm Arctic: Causes and concern

Since the Arctic (Northern Hemisphere) acts in the opposite direction regarding ice extent with losing ice mass as shown in Fig.12(c), it is not gaining that much of ice extent as that of the Antarctica. We may say that, because Northern Hemisphere has more land surface than that of the Southern Hemisphere which is mostly water body and ice mass, the two hemisphere acts in two opposite ways.

6. Results and discussion

From the above study, it is seen that the Earth's land [51-53] covers by 148940000 km^2 (29.2%) and water by 361132000 km^2 (70.8 %) that means every mm rise in sea will have a shift of melting ice into water around:

a. Assuming average sea level rise of 0.5mm, then additional water will be added to sea water as under:

- Area of Water=361132000 km^2x 1000 x1000=361132x10^9 sqm per year
- Rise of water=0.5mm/1000=5x10^{-4} m
- Total water added=(361132x10^9 sqm) x (5x10^{-4} m) =1805660x10^5 cum (i.e.180.566 billion tonne)

b. By year 2100, when sea rise is likely to be raised to 3.6 feet=1.1 Meter, then additional water will be added:

- Multiplier = (1.1m x 1000/0.5mm)=2200
- Water will be added=(180.566 billion tonne x 2200)= 397.245 trillion tonne

Thus, such heavy weight shift of (approx.) 400 trillion tonnes minimum or (approx.) 1200-1450 trillion tonnes maximum from polar ice-sea or Northern / Southern coast and green land to sea water, might force to the change in spinning angle of the earth from 23.43 degree to 23.43^0 (+ or -) as seen in Fig. 13. Further detailed analysis is still required or model is to be prepared to find out the exact date and time as to when such situation may arise.

What would be the fate of the Earth and its living creatures, when it happens?

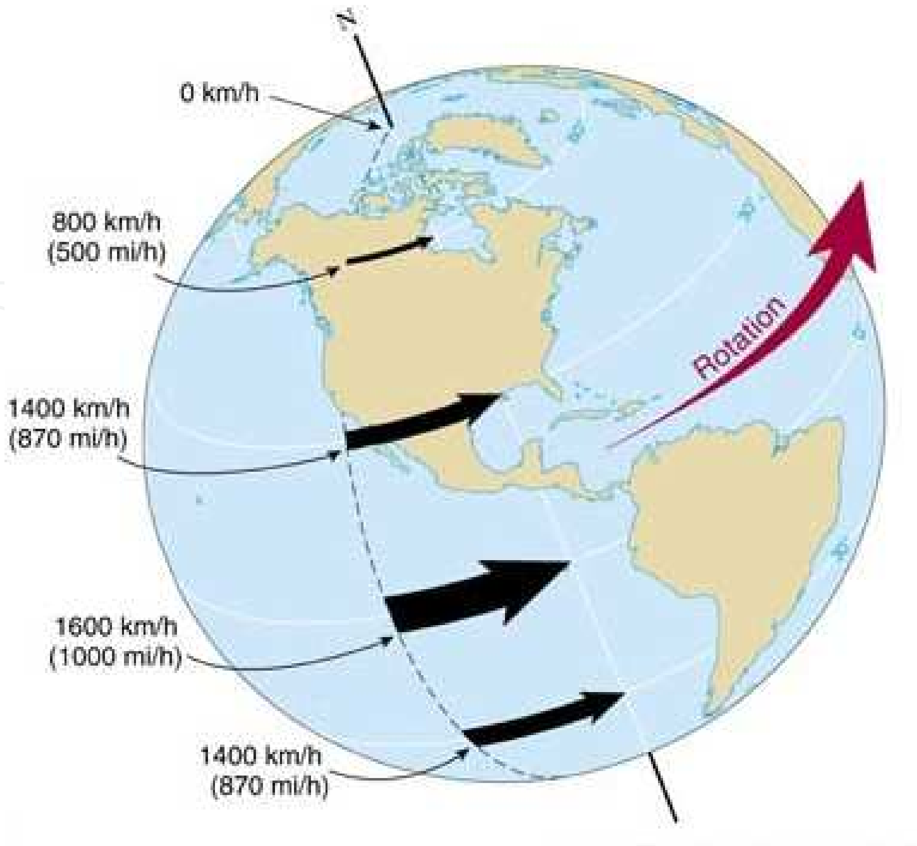


Figure 13. Earth Rotational Angle 23.43^0

7. Conclusions

From the study, it is very much clear that Global Warming is happening and Polar Ice melt / Green land ice melt is continuing fast. This will not only affect our living and developments but have dire impacts on:

- The poles of the earth are patched completely with solid ice that of Antarctica and the sea ice.
- Fast shrinkage of the polar ice will diminish by 2040, fast rise in the Sea Level, danger for species like: polar bears, penguins etc., northern portion of Canada, USA and UK may be affected by cold waves, heavy snow falls and storms due to shifting and melting of heaviest ice sheets in the Atlantic sea. Permafrost may create further warming which cannot be reversed.
- Tectonic movement, wind action, ice, fire, and the living things on the surface with the interference of the atmospheric pressure and temperature combines to make geological structure of the earth and its processes.
- In the landscape change, glaciers play wide role. A gradual movement of ice down the valley causes scraping and sculpting of the underlying rocks producing sediments in the form of glacial flour.

- In the last 100 odd years the sea level has risen to about 6 and 8 inches (15 to 20 cm) due to global warming as being stated by the U.S. Environmental Protection Agency (EPA).
- To an average depth of 2,133 meters (7000 fts), the region of Antarctica is covered with ice and if the entire ice of the region would melt then, the rise in the sea level around it would come to 61 meters (200 fts). Since, the average temperature of Antarctica region is -37 °C, there is no danger of the ice melting.
- Since the sea levels are lifting up at an alarming rate of 3.2 *mm a year* there seem danger of the sea level rise around the world. Greenland region, has contributed in this context to about 0.5 *mm* till now.
- The estimation of the rise of 50 centimeter (20 inches), by 2100, with the lowest of 15 centimeters (6 inches) and the highest of 95 centimeters (37 inches), in the sea level due to the thermal expansion under the ocean and also because of the melting of the glaciers and ice sheets
- The mass of the ice located in Greenland is 680,000 m^3, and it stretches up to 3 miles thick, covering three-quarters of the island. Some of the glaciers, particularly those in the southeast and northwest, have in the past 20 years dumped a increasing amount of ice into the ocean nearby, accounting for the rise of the water level by up to 15 % over the period.
- The planet is on a track to hit 2°C rise in the temperature if major steps to curb climate change aren't taken, and already much of the globe's warming has been absorbed by the oceans.
- Glacier has started a phase of self-sustained retreat and will irreversibly continue its decline. There may be a chance to grow glaciers at northern portion of Canada, USA, UK and may create venerable conditions of snow fall and cold waves in these regions and likely to force for shifting of living population at safer place.
- A calculation shows that between April 2003 and April 2012, the region was losing ice at the rate of 10 billion tons a year.
- By year 2100, if a minimum of **3.6 feet** (1.1 Meter) or maximum 10-13 feet (3.4-4 Meters) sea level rise occurs, then it will have a shift of ice melt into water by **397.245 trillion tonnes** or maximum 1100-1450 trillion tonnes respectively.

Thus, looking into the weight shift from polar (Northern / Southern coast) to sea, it might create change in the spinning angle of the Earth from 23.43 degree to further (+) or (-). The day may be a dark day on the beautiful planet when the entire living creatures may face dire consequences of their end up, provided things are checked and not to go beyond our control today. Try to imagine the consequences, act fast to "Save Earth; Save Life".

Acknowledgements

Enormous and extensive support provided by the management of School of Management Sciences, Lucknow, with a profound guidance under Harcourt Butler Technological Institute, Kanpur, has been a gliding way in accomplishing this project. Author Prof. Bharat Raj Singh

expressed his special tribute to his mother Jagpatti Devi Singh who encouraged him to devote entire life for rendering the services to the human beings, though she had now left us for heavenly abode, leaving behind, her blessings for us.

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