Oceans as Climate Regulators

Because of their large size and the water's physical properties, oceans act as important climate modulators on the earth. The temperatures in the vicinity of the oceans are generally moderate, warmer in winter and cooler in summer in comparison to the interior of the continents. The oceans' effects on climate are explored in more detail in the following sections.

The Oceans' Heat Content

Much work is underway to determine the ocean's heat content (HC). The ARGO floats mentioned are measuring several parameters, including temperature, salinity, and oxygen levels.

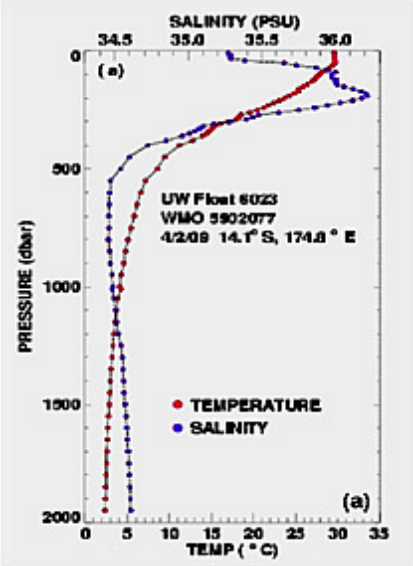

Figure 34. Profiles of temperature and salinity from UW float 6023 (WMO 5902077) from the southern Pacific near the islands of Samoa, recorded in April 2009. [Source: https://abstracts.congrex.com/scripts/jmevent/abstracts/FCXNL-09A02a-1727773-1-CWP_Argo.pdf].

Figure 34 gives an example. The depth is given in units of pressure (dbar). One dbar equals close to 1 m depth. This graph shows a typical temperature profile for tropical ocean water. Near the surface, the water

temperature (bottom scale) is close to 30 °C. It decreases with depth to reach a near constant value of 2 °C at a depth of approximately 500 m. The salinity curve is similar, except for the surface water, where it is lower than at 200 m depth. The total variation of the salinity however is very small (5%) compared to that of the temperature.

With an average ocean depth of approximately 4,000 m, it is obvious that a temperature change of, for example, one degree Celsius in the warmer surface part (say down to a depth of 100 m) could only change the heat content of the oceans by 1/40th. However, as the ocean surface temperature is also rapidly declining with distance from the equator, this fraction is actually much lower than that.

The Gulf Stream

The Gulf Stream is a large ocean current in the Atlantic. It brings warm ocean water from the Sargasso Sea off the coast of central America to the west coast of Europe with a current approaching 1 m/s in velocity. Without this continuous stream of relative warm ocean water, the climate in western and central Europe would be much colder than it is. For example, the British Isles would experience prolonged and cold winters, such as found along the shores of, say Labrador in North America, or the coast of Siberia north of Vladivostok.

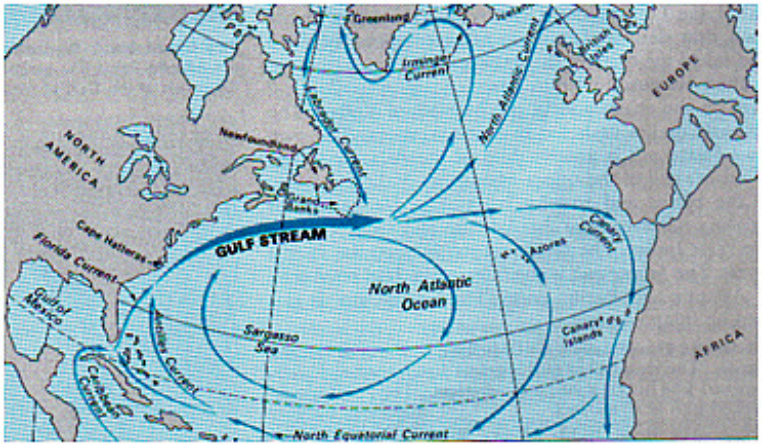

Figure 35. Major ocean currents in the Atlantic. [Source: http://www.robinsonlibrary.com/geography/oceanography/dynamics/gulf.htm].

A slightly different cause-effect relationship is offered by R. Saeger, who opines that the warming influence of the Gulfstream is not conferred by the current itself, but by the loss of buoyancy through increased salinity resulting from a higher rate of evaporation from the warmer Gulfstream surface water. Figure 35 shows the major ocean currents in the Atlantic. [Source: http://www.americanscientist.org/issues/pub/2006/4/the-source-of-europes-mild-climate/1]

The Gulfstream confers other beneficial effects upon Europe. Because of the warmer surface water, more evaporation occurs which sends beneficial rains to Europe's soil. That in turn provides for good conditions for plant growth and extensive agriculture.

In short, the Gulfstream is absolutely vital to Europe. If it were to decrease in intensity or change its trajectory the consequences would likely be catastrophic for much of the region.

There have been theories advanced that the decline of Arctic sea ice would result in lower salinity of the ocean surface water in the Arctic, which could change the size, and direction of the Gulfstream. Recent observations, however, point to the opposite. The *Bipolar Atlantic Thermohaline Circulation Project* (BIAC) is a cooperative research project of several Norwegian universities. In 2007, it reported that the warm West-Spitsbergen current (a part of the Gulfstream) is appearing near the surface at 79° N, i.e. further north than in years past. Consequently, the fjord ice on Svalbard is disappearing at great speed. [Source: http://www.unis.no/60_NEWS/6030_Archive_2007/n_11_05_[-]07_warmer_gulfstream/warmer_gulfstream_waters_110507.htm].

In summary, the fears of a disappearing or slowing Gulfstream have been found to be a false alarm.

El Niño and its Sister, La Niña

El Niño is the term used for an extensive warming of the Pacific surface water between the Asian and South American continents. It occurs in somewhat irregular intervals and to variable degrees every few years. This (Spanish) term indicates the appearance of such events commonly coinciding with the anniversary of the birth of Christ, that is at the end of the month of December. The figure below shows such an event, as seen from NASA satellites in December 1997.

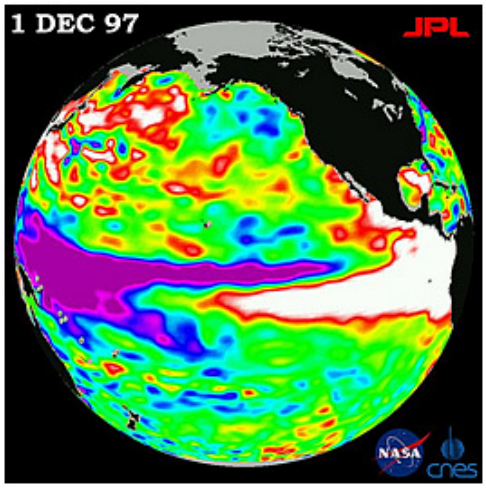

Figure 36. Pacific surface water temperature in December 1997. The large purple coloured wedge extending eastward from Asia indicates relatively dense (cold) water, the large white coloured one extending westward from south America indicates relatively low-density (warm) water. This image is obtained from satellite recordings of sea surface water elevation relative to normal average sea surface elevation. [Source: http://www.jpl.nasa.gov].

In years of pronounced El Niño events, the surface waters off the shores of South America are warmer than usual and prevent or curtail the cold waters of the Pacific Humboldt Current to bring fresh nutrient-laden waters to the surface. That in turn, prevents the appearance of large algae blooms, which would feed the local aquatic food chain. The resulting decline in the ocean's abundance of anchovies causes severe lack of food for seabirds and other creatures living off this resource.

El Niño events, once thought to affect only the areas in the near vicinity, such as the coast of Peru, have now been associated with major temperature and weather conditions over the winter months in all of North America as well. Environment Canada states that "There have been 17 El Nino 'episodes' since 1950, with most of those years resulting in milder than normal conditions for many regions of Canada." While this may be so, Environment Canada's ability to forecast long-term (seasonal) weather conditions has not improved noticeably. In fact their (as well as those of US government weather service) seasonal predictions

are more likely to be wrong than ever before. (For more on this see also the chapter on Weather).

The opposite of the El Niño is La Niña, that is a relative cooling of the surface waters off Peru. It occurs more or less alternating with the former. Most La Niña episodes last about nine to 12 months, although some events persist for as long as 2 years. Just like the occurrence of El Niño, La Niña events are cyclical, recurring every 3 to 5 years, but the interval can vary from two to 10 years.

La Niña normally exerts much less of a global impact than El Niño, enhancing conditions that are more or less normal. Thus, under La Niña's grip, normally wet Indonesia becomes wetter, and winters in Canada are often colder and snowier than normal. North America typically feels the effects of La Niña during the winter and early spring. Wetter-than-normal conditions occur across the Pacific Northwest, British Columbia and Alaska. On the other hand, it delivers drier, warmer and sunnier weather along the southern tier of the United States from California through Texas to Florida. [Source: D. Phillips, *The Canadian Encyclopedia*, http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Para[-]ms=A1ARTA0009207].

Hurricanes and Typhoons

Large, ocean-surface water-driven cyclones determine the northern hemisphere's weather patterns in every late-summer to late-fall season. Some of these cyclones, termed hurricanes in America and typhoons in Asia, stretch for many hundreds of kilometers. Their centers, termed the "eye of the storm," move at some speed across the oceans, picking up additional energy from the warm water, and unleash their fury on the continent when they make landfall.

Hurricanes occur at irregular intervals, rarely more than one at a time in the Atlantic. In some years, they do not develop to full-blown hurricanes but are recorded as tropical depressions (of air pressure) or tropical storms. Even in such mild forms, they can bring torrential rains and strong winds to some regions.

One of the most severe hurricanes in recent history, Hurricane Katrina, hit the City of New Orleans in the state of Louisiana, USA, at the end of August 2005. The figure below shows a satellite image of the

hurricane before making landfall. The winds were ferocious with speeds up to 257 kilometers per hour (160 miles per hour) and stronger gusts. The loss of life and property damage from Katrina was extensive.

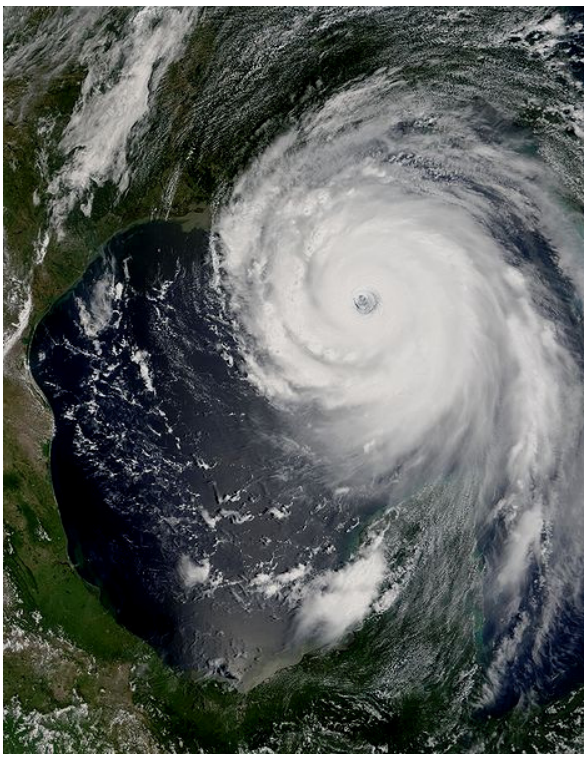

Figure 37. Hurricane Katrina, satellite image taken on 28 August 2005, showing its extent over the western part of the Gulf of Mexico, just prior to its landfall near New Orleans.

Hurricanes typically start their life during the months of September to November off the west coast of Africa and move across the Atlantic towards the Gulf of Mexico. On traversing this large body of warm ocean water, thus gaining energy, they develop steadily into larger storms with enormous winds and equally large amounts of rain in their clouds. When they hit the continental shores, the wind speeds generally decrease and the clouds drop out as rain.

The appearance of hurricanes in the Gulf of Mexico is almost an annual event. In the spring of 2006, however, both the US and Canadian weather services predicted an even wilder season for that year with hurricanes galore. In fact, not a single hurricane was recorded in 2006. So much for the long-term seasonal weather forecasts.

In Asia, the cyclones are called typhoons (sometimes also spelled taifuns). They are no less powerful and destructive natural forces than the hurricanes in North America. In fact, because the Pacific Ocean is an even larger body of water, the cyclones developing there could well be more forceful. Typhoons are known to occur during every month of the year, but they are most prevalent in the late summer to fall period.

Typhoons develop in the equatorial regions of the Pacific and typically travel westward towards China and then in northerly direction. The following figure shows typhoon tracks for the year 2008.

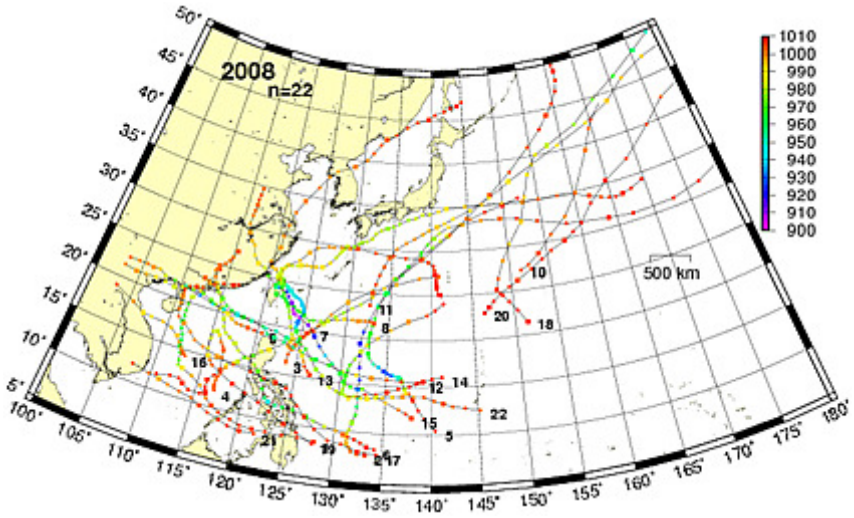

Figure 38. Pacific typhoon tracks for the year 2008. [Source: Japan Meteorological Agency, RSMC Tokyo - Typhoon Center. The scale on the right hand side indicates the associated atmospheric pressure; http://www.cosmic.ucar.edu/~iwabuchi/typhoon/typhoon_track.html .

The University of Hawaii maintains a worldwide general tropical storm advisory system and other records freely accessible on the Internet. It can be found at http://www.solar.ifa.hawaii.edu/Tropical/ .

Sea Level

Some countries have expressed great concern about rising ocean water levels. The countries which would be affected most are island nations, such as the Maldives in the Indian Ocean, and in the Micronesian archipelago in the Pacific Ocean. To raise the world's attention to the perceived problem, the government of the Republic of the Maldives, held a cabinet meeting under water on Oct. 17, 2009, see Figure 39 below.

In order to get the proper perspective on the perceived problem of the Maldives being drowned by a rising sea, it is important to review relevant facts.

The Maldives consist of 1,100-plus individual atolls distributed over an area of 90,000 km^2. The mean and highest elevation above sea level is only 1.5 and 2.3 m, respectively. Obviously, any significant rise of the ocean level would impact that nation.

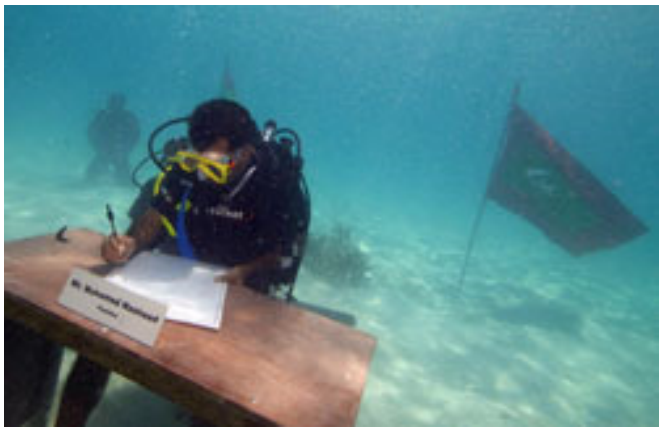

Figure 39. Photograph of the Maldives president Mohamed Nasheed signing a resolution calling for nations to reduce carbon emission at the underwater cabinet meting of the Maldives government, 17 October 2009. [Source: http://www.inpui.com/2009/10/worlds-first-underwater-cabinet-meeting.html].

The Maldives have been inhabited for well over 2,000 years. During these times, ocean levels have repeatedly changed, up and down, as evident from drill cores from several sites. The last major change was in

the 1970's, when the water level fell 20 cm. It has remained constant since then [Source: www.climatechangefacts.info/ClimateChangeDocu[-]ments/NilsAxel Mornerinterview.pdf].

The author of these findings has also published a letter to the government of the Maldives (Oct. 20, 2009), contradicting the claims and fears about the rising sea level, as made by alarmists [available at http://network.nationalpost.com/np/blogs/fpcomment/archive/tags/Nils-Axel+M_26002300_246_3B00_rner/default.aspx]. Some of his findings are repeated below [Source: *The Australian*, November 04, 2009]:

> *Fact number 1: During the past 2000 years, sea levels have fluctuated with 5 peaks reaching 0.6 m to 1.2 m above present sea level. Fact number 2: From 1790 to 1970 sea levels were about 20 cm higher than today. Fact number 3: In the 1970s, the sea level fell by about 20 cm to its present level. Fact number 4: Sea levels have remained constant for the past 30 years 'implying that there are no traces of any alarming ongoing sea level rise'.*

And in the reporter's own words:

> *Fact number 5 (and I am paraphrasing here): The notion presented by the President of the Maldives that his country will be flooded is bunkum.*

Similar myths about drowning islands in the oceans are perpetuated by others, particularly about some of the Pacific islands in Micronesia. For example, the island nation of Tuvalu consists of nine low-lying atolls with a total area of just 26 square kilometers. Tuvalu and similar island nations including Kiribati, Vanuatu, the Marshall Islands, the Cook Islands, Fiji and the Solomon Islands are all said to be susceptible to a sea level rise. However, actual tide gauge recordings substantiate no recent change of their elevation above the sea.

It is well known that many of the ocean island nations are actively encouraging tourism. The concurrent development fosters an unsustainable level of groundwater extraction for potable water (more on that in the section on Aquifers). Just like in some of the arid areas on the continents, this leads eventually to land subsidence.

Freshwater

There is much concern about freshwater, both about water quality and water quantity. Despite being two separate issues, they sometimes go hand in hand, especially in arid areas. With some generalization, where water is in short supply, it often is also of poor quality. The reason is not difficult to understand. Water drawn from underground has been there for a while. That allows dissolution of salts and minerals in the rocks. Some of those materials can make the water inadequate for consumption by humans or livestock. Even irrigating agricultural fields with such may introduce too a high a burden for some plants.

Politics

Interest in water concerns first and foremost water quantity. Various financial advisors think that in the future that access to sufficient freshwater will become more important than access to energy.

Politically, it has already been of concern where it is in short supply. For example, withdrawal of water from the Colorado River in the USA has been of concern to Mexico where it enters the Gulf of California. In the Near East, access to freshwater resources is even more limited. Recently Syria and Jordan ratified a number of accords concerning shared freshwater resources.

The *Africa Water Network* [http://www.africawaternetwork.org] with over twenty member countries states their goal as follows:

> *We [are] committed to fighting against all forms of water privatization and commercialization, resist prepaid meters, and recognize water as a human right. To achieve this we promote alternatives and public investments in water.*

Water Physics

People living in latitudes higher than approximately 30° N, and below 30° S, usually experience snow and ice regularly as part of their

winter seasons. For those living in tropical and subtropical areas, these natural phenomena are essentially unknown, other than in the form of some ice cubes in their freezer.

Figure 40. An iceberg. [Photo, courtesy of Environment Canada; http://ice.ec.gc.ca.].

Water is one of very few liquids known to man, which expands on freezing, and therefore floats on the surface of any remaining unfrozen liquid. This rare property has tremendous consequences for life on earth. Not only does it provide a firm surface for polar bears, penguins, seals, or man to wander about the frozen ice, it provides a strong insulating effect against any colder air above. Therefore, even in the depth of an Arctic winter with -40 °C day and night, the ice rarely gets any thicker than 12 m or so. If the ice were not floating but sinking to the bottom, large portions of the polar regions' water would freeze solidly to the bottom.

The process of freezing water to ice releases a large amount of energy (80 kcal/kg), though not as much as is required to be added to convert water to steam (539 kcal/kg). Of course, the identical amount of energy is required to melt the ice, or is released upon condensation of steam to water, respectively.

Ice is essentially pure (but frozen) freshwater, even that forming on highly saline seas, as in the Arctic.

Though "rock hard," in fact, ice is able to slowly change its shape under pressure. This is happening in continental ice sheets and glaciers.

These ice masses continuously move downhill until they reach an area warm enough to melt or to break apart. The ice sheets of Greenland and