Ocean currents may stabilise climate

Compensating for changes could moderate the extent of change, says s ananthanarayanan

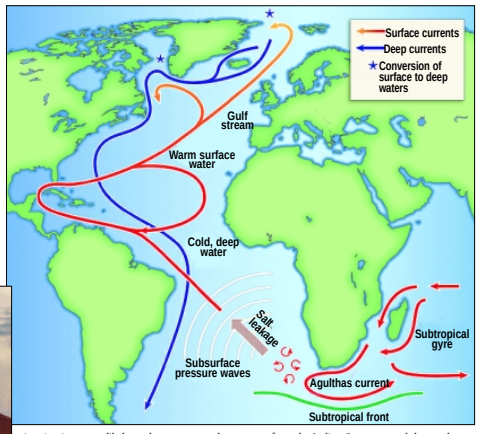
THE atmosphere and earth's water bodies account for only about 0.025 per cent of the planet's mass. But the water and the atmosphere are at the surface, while earth's bulk is buried kilometres underground. Hence, water and the atmosphere have the main effect on life on the surface.

The atmosphere's role in capturing the sun's heat and the global warming, as greenhouse gases increase, has been topical for two decades. But the total mass of the atmosphere alone is just 0.37 per cent of the mass of the water on earth's surface. With the large area of contact of the earth's water surface with the atmosphere, it is evident that the dynamics of the water mass would have a large role in climatic stability.

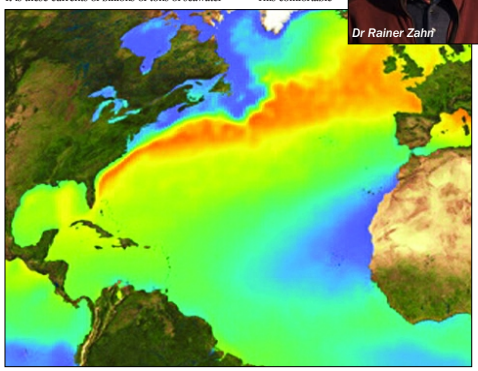
While the air in the atmosphere rises and falls and moves across the earth in the form of the great winds, driving rainfall and storms, the water mass is also in motion in the form of tides as the earth rotates, and different parts of the planet face the sun and moon, in waves that we see at the surface and great flows, over hundreds of kilometres, mostly below the surface of water and driven by differences of temperature and salinity. It is these currents of billions of tons of seawater cools, and even freezes, it cannot carry its load of dissolved salts and the water below the surface gets more saline!

This saline water, at its greatest density at four degrees Celsius, sinks to the bottom and begins to flow south. The flow sets up an underwater stream towards the equator, with a compensating surface level flow along the east coast of North America, the Gulf Stream, in a system called the *Atlantic Meriodonal Overturning Circulation.*

This flow of warm water into the northern Atlantic is of great value to coastal Europe. The temperature in the UK, which is warmed by ocean flows, for instance, is a good five to six degrees Celsius warmer than many places, like the Labrador coast, at the same latitude. Even coastal Norway, at a latitude above 57° North, does not get frozen over, thanks to the warm ocean current.




Dr Rainer Zahn


Will the Gulf Stream slow down, freeaing the UK and northern Europe?

Global warming

This comfortable situation is seen as likely to change as a result of global warming. Rising temperatures would speed up the melting of glaciers and deposit huge quantities of fresh water in the northern Atlantic. This would reduce the salinity of seawater, prevent the great sink and disrupt the convection circuit that drives the deep-sea stream towards the equator, which draws in the warm, nearer-the-surface stream from the tropics.

The effect of global warming on the UK and surrounding parts of Europe could thus be that while the rest of the world grows warmer, this part of the world actually grows colder! There are fears that the UK may see climate like they have in Alaska! And the other effect would be that with cooler seawater, there would be a drop in rainfall and humidity, affecting crops and livestock, maybe even the flows in the major European rivers, with more dry spells in the Mediterranean region.

It is in this context that a study by an international team of marine scientists on global warming affecting other ocean currents in ways that add to and compensate the falling Atlantic salinity has been greeted with some comfort. The team, led by Dr Rainer Zahn of the University of Barcelona, have in *Nature* published their report on *Agulhas leakage*, an ocean stream that crosses over from the Indian Ocean around the southern tip of the African continent to pump high salinity into the *Amoc* and keep it going!

Agulhas current

The *Agulhas* is a powerful ocean current that flows from Mozambique down the eastern coast of Africa till Cape Agulhas, the dividing point of the Indian and Atlantic Oceans. The stream gathers a flow of 25 million cubic metres per second from the East Madagascar current, five million cubic metres per sec from the Mozambique current, its own 35 million cubic metres per second and transports in all some 100 million cubic metres per second. This is a huge water flow, comparable to the Gulf Stream itself, which starts off as 30 million cubic metres per second and grows to 150 million cubic metres per second. The total flow of fresh water into the sea from all the rivers in the world, in comparison, is one million cubic metres per sexond.

When the Agulhas current clears the African continent, it encounters the powerful *Antarctic cirumpolar* current and some 85 per cent of the Agulhas stream is deflected back into the Indian Ocean. Then some 15 million cubic metres per second crosses into the Atlantic, some 10 million cubic metres per second being warm, salty water from the Agulhas. This input, known as the *Agulhas leakage*, is an important source of heat, promoting evaporation of the Atlantic waters, a key factor in maintaining the Atlantic Meridional Overturning Circulation.

The findings of the group, which includes scientists from the USA, Germany, The Netherlands, the UK and Spain, is that the *Agulhas leakage* is a crucial component in the cycle, which would grow stronger with increasing flow from the Indian Ocean stream. As global warming, which affects the Indian Ocean too, would directly increase the Agulhas leakage, this is then a factor that could mitigate, if not eliminate the effect of reducing the effect of rising meltwater in the North Atlantic!

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that have stabilised coastal temperatures and influenced the growth of civilisations by moderating the climate and also by enabling navigation.

A well known ocean current is the *Gulf Stream*, which flows from the Gulf of Mexico and into the northern Atlantic Ocean. This ocean current is known to start, in fact, at the western coast of North Africa, flow across the Atlantic and circulate in the warm waters of the Gulf of Mexico. It is here, with warm waters rising and forming a density gradient, that the stream becomes visible at the surface. This was discovered as early as 1513. But the start of the stream is way up in the northern Atlantic, where the surface of the water is cooled by Arctic winds and its own evaporation. When it cools below four degrees Celsius, water begins to expand instead of contracting and remains at the surface. At the same time, as it

The Sverdrup

THE volume of water transported by ocean currents is measured in a unit called *Sverdrup*. A Sverdrup is equal to a million cubic metres of water transported in a second. The maximum transport by the Gulf Stream is thus 150 Sv and of the Agulhas current, 100 Sv. In contrast, the total water transported to the sea by all the rivers of the world in about one Sv.

The name "Sverdrup" is in honour of Harald Ulrik Sverdrup (1888-1957), a Norwegian oceanographer and meteorologist and scientific director of the North Polar expedition of Roald Amundsen aboard the *Maud* from 1918 to 1925.

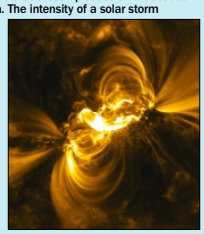
Solar flare-up

Being the largest explosion in the solar system, a sunstorm releases as much energy as 1,000 billion atom bombs exploding together. The good news is that India lies in the equatorial region where such phenomena does not occur, writes vibha varshney

ON 13 February 2011, the sun unleashed a massive solar flare. Three more followed on 7, 9 and 19 March. Flares originate from sunspots — areas on the sun's surface that have high magnetic activity. These flares and other solar activities throw ionised gases or plasma towards earth. The plasma has an electromagnetic field which, when it interacts with earth's magnetic field, gives rise to a solar storm. Being the largest explosion in the solar system, a storm releases as much energy as 1,000 billion atom bombs exploding together. This can knock out satellites, affecting telecommunications, power grids and causing blackouts and disturbing transport and finance systems.

The sun's magnetic activity rises and falls in a fairly regular 11-year cycle. The highs are full of sunspots, the lows see less or no sunspots. At present, the sun is in the midst of an active phase of a solar cycle. This is called solar cycle 24, counting since 1755 when recording of solar sunspot activity began. According to scientific data, many solar storms are expected in the near future since the current cycle is reaching its peak. In August 2010, the first storm of solar cycle 24 occurred. Before this, there was such a storm in December 2006.

The good thing is that these episodes did not cause much destruction. The intensity of a solar storm depends on the direction of the plasma's electromagnetic field. If it is parallel to earth's magnetic field, the charged particles have no affect. The bad thing is that a massive solar storm can cause mayhem. The recent Japan crisis, for instance, showed how power outages can affect functioning of a nuclear power plant. The storms result in huge monetary losses, too.



A storm in January 1994 affected Canada's two telecommunication satellites. The first satellite was recovered in a few hours but nearly $50 million was spent to repair the second one. Airlines in the USA had to alter their high latitude routes because a solar storm in October 2003 affected high frequency communications in the country. The rerouted flights cost airline firms about $100,000 per flight. The firms suffered similar losses during a January 2005 storm. The 13 February 2011 solar storm was mild but affected China's shortwave radiocommunications system.

The loss is expected to be more now since the world is more dependent on satellites and telecommunications. The installation of shields to satellites and transmission lines can prevent damage from solar storms. Better monitoring of flares is also an option as satellites and grids can be shut down before a solar storm to minimise damage. The National Oceanic and Atmospheric Administration – a US federal agency — can predict the occurrence of a solar storm one to three days before. On 6 February this year, the National Aeronautics and Space Administration launched two spacecraft to enable constant imaging of the full solar sphere for the next eight years. It has also asked the US government for $622.3 million to study space weather for 2012.

But India is relatively safe from the sun's fury as it lies in the equatorial region where solar storms do not reach. In India, the sun is studied only for research purposes, says PK Manoharan, head of the Tata Institute of Fundamental Research's radio astronomy centre in Udhagamandalam, Tamil Nadu.

CSE/Down To Earth Feature Service

Micro-movements

Physical and chemical factors induce changes in the synthesis of vital metabolites in bacterial cultures, writes tapan kumar maitra

UNDER the influence of physical and chemical effects some cells assume the form of large spheres, thickened filaments, flask-shaped formations and branchings resembling fungal mycelia. Acetic acid bacteria under the effect of a temperature of 41°Celsius easily form very long, strongly swollen filaments. The cultivation of these bacteria at ordinary temperatures is accompanied by the appearance of rod-shaped forms.

Gamaleia observed morphological changes in a number of microbes, eg the formation of giant spheres, amoeboid forms, thickened filaments, etc. He named this phenomenon heteromorphism that arises due to the adaptation of bacteria to unusual environmental conditions. Heteromorphism easily occurs under the influence of lithium salts, phage, caffeine, sulphonamides, antibiotics and different types of irradiation.

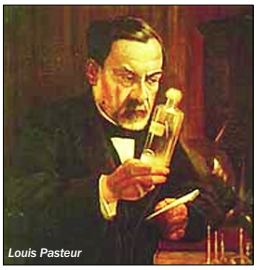
Heteromorphism is usually often observed when the culture ages. The elongated forms of cocci (1), filamentous forms of the colibacilli (2), filamentous forms and branched forms of tubercle bacilli (3-4); the flask-shaped, filamentous, yeast-like, and coccus-like forms of diphtheria bacilli. The variation of morphological forms is most distinctly expressed in mycoplasmas and L-forms of bacteria.

Scientists call intra-species polymorphism the law of homologous series in hereditary variation. Its essence consists in similar traits being manifested now and again in some varieties or races that had originated from one and the same species and, less frequently, in the progeny of remote species. It was established that genetically related species are characterised by similar and parallel series of hereditary forms. Not only genetically related species but genera, too, display resemblance in the series of hereditary variation.

The law of homologous series may also be applied in relation to micro-organisms. It was described in Ascomycetes and Basidiomycetes organisms, algae, bacteria and protozoa. The parallel variation is proof of the repeated character of variation cycles in different families and genera. Mimicry (the imitation of one species by another in shape and colour) and convergence (similarity in signs) are considered common phenomena of the repetition of forms characteristic of the whole organic world and particularly in micro-organisms that were found to possess structures (antigens) in common with animal and human cells.

Other traits (affinity for dyes, formation of flagella, cilia, spores and capsules and the structure of the hereditary apparatus) are also subject to variation. It should be noted that any change in the morphological features is attended by change in physiological properties, too. Therefore, the subdivision of the types of bacterial variation into morphological, cultural, enzymatic, biological is conventional and facilitates illustrative discussion of the multiform material on the subject.

Besides morphological deviations in microbes, changes are often observed in the cultural properties. Scientists have established that the cultures of one and the same species of bacteria may differ among themselves. When a pure culture is seeded onto a solid nutrient medium, different forms of colonies of two main types are produced: a) smooth, S-forms and b) rough, R-forms. Between these two types of colonies there are transitional, unstable forms and more often O-forms. The difference between S- and R-


Louis Pasteur

forms is not only limited to the forms of the colonies, but includes other characters. This kind of variation is known as dissociation. In some cases the formation of daughter colonies is observed. There are other forms of colonies like D-colonies (dwarf) and G-colonies (gonidial) that originate on the surface or margin of normal colonies and L-colonies.

Under the influence of antibiotics and chemotherapeutic substances, X-rays, ultraviolet irradiation and other effects, the need for certain amino acids and growth factors in some microbes appears, which the original cultures did not require. These varieties, which for their development require special conditions, are known as auxotrophic in contrast to original strains — prototrophic. Thus, auxotrophs differ from prototrophs in that part of their metabolic processes is blocked and they lack the ability to synthesise the necessary metabolites. Thus, for example, after the effect of X-rays on E. coli, it began to require for its growth many factors (casein hydrolysate or yeast extract) while the original strain could develop in a synthetic medium in which amino acids and vitamins (minimal medium) were absent. Auxotrophic variants lost the ability to synthesise leucine or vitamin B_1 and their growth depended on the presence of a certain substrate containing the amino acid leucine and vitamin B_1.

One of the means of revealing auxotrophic variants is the use of penicillin which has a bactericidal effect only on cells in the state of division. Blocking can be reproduced in relation to tryptophan, atranil acid and other factors.

Physical and chemical factors can induce different changes in the ability to synthesise important metabolites in bacterial cultures. These changes take place under the effect of the mechanisms concerned with genetic information.

Variation in microbes is not limited to the morphology, size or cultural characters, but includes other properties. Of special theoretical and practical interest is the variation of enzymatic ability in bacteria and their adaptation to the changed internal and external environmental conditions. The addition of a definite substance to the medium may cause activation of the enzyme otherwise latent. For example, the induction of the biosynthesis of the ferment b-galactozydaze in E. coli may be reproduced by cultivating it in the presence of lactose. The ability for induction is determined by the nucleoid genes and the presence of the inducing factor in the external environment.

The catalytic activity of bacteria can be increased many times by adding substrates inducing the synthesis of enzymes in the corresponding conditions of cultivation (certain amount of vitamins, definite pH level and degree of aeration). By the action of certain toxic substances on bacteria it is possible to deprive them of their ability to produce various enzymes. The cultivation of Clostridium perfringens on a medium with a low content of iron brings about a decrease in the enzymatic ability of the microbe. Thus enzymatic activity is variable and can be lost or gained. The loss of enzymatic activity may be constant or temporary.

Under the effect of an unusual metabolite (inducer or repressor) induction or repression of the synthesis of a definite enzyme takes place. The production of enzymes (specific proteins) takes place according to genetic processes in the cell. They are governed by the general laws of protein synthesis.

Of great interest is the problem concerning the possibility of the production of adaptive enzymes not only in intact cells, but in their protoplasts. The production and disappearance of adaptive enzymes is a widespread phenomenon among micro-organisms.

A rather important circumstance is that in pathogenic microbes under the effect of different factors, the degree of pathogenicity is altered. The decrease in pathogenicity of microbes while retaining the ability to cause immunity was noticed long ago. Louis Pasteur was the first to succeed in reproducing these properties in 1881 and altered forms of pathogenic microbes were.

In 1881, Pasteur devised a method of preparing live vaccine against anthrax. He obtained it by exposing a culture of anthrax bacilli to high temperature. During 12 to 24 days of cultivation at 42-43°Celcius the bacilli lost the ability to cause the disease in animals when injected subcutaneously.

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