Rainy days in a changing world

Man-made warming of the earth may be stabilising the monsoon, says s ananthanarayanan


Tim Eglinton


Ponton Camilo and Liviu Giosan examining a core sample.

ALTHOUGH this is no reason to welcome global warming, it is an observation that arises from a study of rainfall and the vegetation that it has supported across the Indian subcontinent for the past 4,000 years. The study is reported by Camilo Ponton of the Woods Hole Oceanographic Institution, Massachusetts, and colleagues, in their paper, "Holocene Aridification of India" in the journal, *Geophysical Research Letters*.

India lies at the same latitude as the Sahara desert but thanks to the monsoon, it has nurtured a rich civilisation and now supports a billion people. And yet these annual rains have played tricks over the centuries, with frequent series of dry years and famine, and it is still the timing and adequacy of rainfall, each year, that determines the economic wellbeing of the country. For all the importance of being able to tell in advance how good the coming year will be, records of the relevant conditions and the nature of the rains in past years are scanty and incomplete.

One key region that indicates how the monsoon will be in the rest of the peninsula is the *Core Monsoon Zone*, a region in the central part of India. "If you know what's happening there, you know more or less what's happening in the rest of India," says Camilo Ponton. "Our biggest problem has been a lack of evidence from this region to extend the short, existing records."

The study, which was designed by co-authors geologist Liviu Giosan and geochemist Tim Eglinton, is to determine the 10,000-year record of variations in rainfall, to trace the path of increasing aridity and its impact on populations in the CMZ, and hence in India. The word *Holocene* is Greek for "entirely recent" and is the name of the geological epoch from some 12,000 years ago to the present.

The primary source of evidence that was used was the chronological record of the vegetation in central India, as revealed from the silt deposited in the sea by the Godavari river, which drains the area. The team made use of ocean-bed cores recovered by sinking hollow pipes deep into the seabed, in the course of the Indian government's Gas Hydrate Programme, where international experts participated. Over several months of exploring, the cores used in the study were extracted from a spot in the Bay of Bengal, just where the Godavari emerges from the region that receives most of the rainfall of the subcontinent.

"We are fortunate to have this core from close to the river mouth, where it accumulates sediment very fast," says Ponton. "Every centimetre of sediment contains 10-20 years' worth of information. So it gives us the advantage of high temporal resolution to address the problems."

The layers of the sediment core contain microscopic remains from trees, grasses and shrubs that lived in the river valley, as well as remnants of plankton fossils found in the sea at the time the sediment formed. These layers constitute a record of the land vegetation as well as the quality of sea water, to present a time-line of the rainfall during the 10,000-year period.

The story the sediment tells is straightforward — from 10,000 years ago, till about 4,500 years ago, the Godavari drained an area that was rich in plants that thrive in humidity. And then, in marked steps, starting about 4,500 years ago and again about 1,700 years ago, the remains are of plants that are aridity-adapted — which says that central India (the CMZ) became drier. The record of plankton fossils is in agreement with the story told by plant remains. The record of the sea also reveals periods of sharp variation in salinity, which indicate changes in the quantity of water poured in by the Godavari — the sea gets saltier during spells of low rainfall but fresher when there is abundant rain. These highs and lows of salinity also agree with the records in the width of tree rings and cave stalagmites, which vary with rainfall.

When a picture began to emerge from the record of plant remains, Giosan called in archeo-botanist Dorian Fuller. "What the new paleo-climatic information makes clear is that the shift towards more arid conditions around 4,000 years ago corresponds to the time when agricultural populations expanded and settled village life began," says Fuller of the Institute of Archaeology, University College, London. "Arid-adapted food production is an old cultural tradition in the region, with cultivation of drought-tolerant millets and soil-restoring bean species. There may be lessons to learn here, as these drought-tolerant agricultural traditions have eroded over the past century, with a shift towards more water and chemical intensive forms of modern agriculture."

The increasing aridity dating some 4,000 years ago suggests what may have befallen India's early civilisations. The Indus Valley grew more arid and the Harappan civilisation could not adapt and disappeared. But in central and south India, the decline of tropical forests enabled people to access more land. While settlements grew, the series of droughts that set in, starting about 1,700 years ago, was the incentive to develop rain-collecting water tanks and develop crops that had low water demands.


Pushpendra Kumar of India's Oil and Natural Gas Commission, co-author of the paper, and Jim Brewton of the US Geological Survey, with the core sample.

Lessons for the future

The study has created a valuable record of the aridity or otherwise over the decades, which can be correlated with other indicators of climate, like the mean temperatures and atmospheric composition. Global warming is likely to affect rainfall in a number of ways. Apart from rising sea levels and inundation, there would also be changes in temperature gradients and ocean and atmospheric currents. The record of how rainfall varied with a great variety of conditions would help form a picture of how it may behave in new conditions.

"How the monsoon will behave in the future is highly controversial. Our research provides clues for modelling and that could help determine whether the monsoon will increase or decrease with global warming," says Ponton.

"We found that when the Asian continent is least heated by the sun the northward movement of the rain appears to hesitate between the Equator and Asia, bringing less rain to the north," says Giosan. "The fact that long droughts have not occurred over the last 100 years or so, as humans started to heat up the planet, but did occur earlier, suggests that we changed the entire monsoon game, and may have inadvertently made it more stable!"

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Safe for the moment

The legendary Einstein's theory holds up and binay malakar **keeps his fingers crossed till a recheck is done in May**

IT seems Albert Einstein's reputation has been restored — at least, for the time being, given that this legendary physicist's fate will be tested again come May. In September and, again, in November last year, scientists involved in the Oscillation Project with Emulsion-Racking Apparatus experiment at the European Council for Nuclear Research (Cern) in Geneva, while trying to identify the appearance of a tau neutrino ($?\tau$) from a pure muon neutrino ($?\mu$) beam, observed that pesky neutrinos, while travelling from the source at Cern to a detector 732 km away at the Gran Sasso laboratory in Italy, appeared to have outraced the speed of light (bunches of photons) by 0.00000006 seconds.

The Cern scientists then claimed that neutrinos – weakly interacting, electrically neutral elementary subatomic particles with a very small but non-zero mass — arrived 60 nanoseconds earlier than the 2.3 milliseconds taken by light to traverse that distance. This then implied that one of the postulates of Einstein's more than 100-year-old theory of special relativity —that nothing could move faster than light in a vacuum — had come under a death threat.

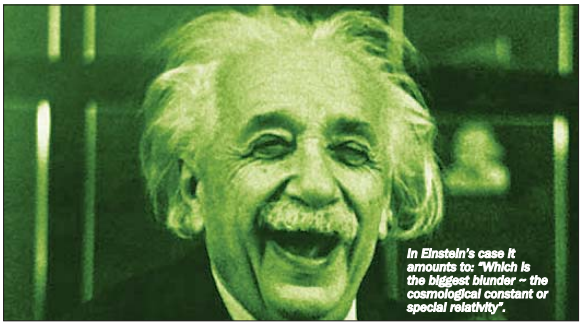
However, on 22 February 2012, scientists identified two possible effects that could have influenced the neutrino timing measurement during the controversial Opera experiments done last year. In fact, they are now planning to run the tests with short pulsed beams in May after confirmation of the following two systematic errors/effects:

- That the optical fiber connector which brought the external Global Positioning System signal to the Opera master clock may not have been functioning correctly when the measurements were taken; and
- Scientists could have overestimated, exactly the opposite of the first case, the time of the flight of neutrinos due to an oscillator used to provide the time stamps for GPS synchronisations.

The first effect (the faulty optical fiber connection) appeared likely to be more significant in the faster-than-light (superluminal) neutrinos' finding of the original experiment. It could have led to underestimating the time of the neutrinos' flight through the earth's crust.

So did the neutrinos exceed the speed of light in a vacuum? Or, equivalently, would Einstein's special relativity theory have to be disregarded to, at least, save the concept of causality which says that "causes precede effects, wherever you are"? We will have to wait till May. What is very important, and interesting as well, is that if particles do travel faster than light then time could effectively be reversed – and we could get younger as time elapses!

What was supposed to be the "biggest blunder" of his life in 1935 now turns out to be right. Einstein, in 1917, supposed the universe to be static and unchanging — the way it looked to astronomers at the time. In fact, Einstein then inserted a term, called the "Cosmological constant", into his theory of general relativity to force the equations to predict a stationary universe in keeping with the physicists' thinking at the time. But when it became clear that the universe was not actually static but was instead expanding, Einstein was forced to abandon the "Cosmological constant", calling it the "biggest blunder" of his life.


In Einstein's case it amounts to: "Which is the biggest blunder – the cosmological constant or special relativity".

In exactly the same way, some 400 years ago, Galileo, Copernicus and Kepler were forced to abandon their theological geocentric view of the universe — a view in which earth is regarded as being at the centre – against the view of the universe in which the sun is taken to be at the centre, as the Church believed then.

Scientists recently revived Einstein's cosmological constant to explain a mysterious force, called dark energy, that seems to be counteracting gravity – causing the universe to expand at an accelerating pace. What's actually happening is that as time evolves the subject itself is getting more and more refined and this refinement is simply due to the invention of more and more sophisticated technologies and/or instruments. Perhaps we are getting closer to the absolute truth. This year thus promises to be an eventful one: first, because conclusive proof of the existence or non-existence of the Higgs boson is expected to be confirmed and, second, whether neutrinos are really moving a bit faster than light will be rechecked.

Until this comes about in May this year, we should keep our fingers crossed.

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A programmed process

tapan kumar maitra explains microtubule assembly from tubulin dimers

MICROTUBULES are structures that are universally present in the cytoplasm of eukaryotic cells. They were first observed in axon protoplasm by Franchi in 1953. Since most microtubules are rather labile and do not respond well to many fixatives, intensive studies began only after 1963 with the introduction of *glutaraldehyde* fixation in electron microscopy.

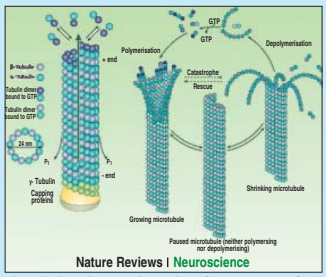
Cytoplasmic microtubules are uniform in size — about 25nanometres in outer diameter and several micrometres in length — and remarkably straight. In a cross-section, they show a dense wall about six nanometres thick and a light centre. The wall consists of individual linear or spiralling filamentous structures of about five nanometres in diameter. In a cross-section, there are usually 13 of these filaments, arranged with a centre-to-centre spacing of 4.5 nanometres. All microtubules seem to have nearly the same physiological characteristics though they differ in other respects, such as in their resistance to various treatments.

Microtubules are composed of protein sub-units that are rather similar, even though they are found in a variety of cell types. The term *tubulin* is used to designate the principal protein of *cilia*, *flagella* and *cytoplasmic* microtubules. Tubulin is a dimer of 110,000-120,000 daltons. In most cases, its two monometers are of different kinds but are similar in molecular weight. The eight-nanometre spacing along the longitudinal axis of microtubules probably reflects the pairing of the two types of tubulin monometers. One dimer of tubulin binds to a molecule of ^{3}H-colchicine, and this property is used to assay for this protein.

The assembly of microtubules from the tubulin dimers is a specifically oriented and programmed process, as with the production of enzymes the quantity of polymerised tubulin varies according to the need for it in the cell. Normally microtubules are in equilibrium with free tubulin; phosphorylation of the tubulin monometers by a cyclic AMP-dependent Kinase favours the polymerisation. The assembly of tubulin is polarised, meaning that the dimers assemble at one end of the microtubule while they disassemble at the other end. When colchicine binds to tubulin, the assembly process is inhibited but disassembly continues, so that eventually the microtubules are completely depolymerised.

Microtubules contain other proteins that are collectively called Microtubule-Associated Proteins, several of which are in a high molecular weight range (-280,000 daltons) and are involved in microtubular assembly. Highly purified tubulin does not polymerise into microtubules.

In the cell there are sites of orientation, such as *centrioles* and the basal bodies of cilia, from which the process of polymerisation is directed in some way. Cytoplasmic microtubules often extend radially from nucleus and appear as straight or curved filaments that seem to terminate near the cell surface. The filaments disappear when treated with colcemid (a derivative of colchicines) or when cooled, and they reappear if the conditions are reversed. This has revealed that



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microtubules arise near the nucleus, from one or two focal points corresponding to the centrosomal (ie, centriole-containing) region or centrosphere. Many such observations have suggested that the centrosphere is the main microtubule organising centre. In cells about to enter mitosis, the cytoplasmic microtubules disappear and are replaced by those integrating the spindle and asters. In cells transformed by a virus or by certain chemicals, the microtubules are disorganised and sometimes disappear entirely.

Functions of cytoplasmic microtubules

Mechanical: The shape of some cell processes or protuberances has been correlated with the orientation and distribution of microtubules. They are considered to be the framework that determines cell shape and the distribution of its content.

Their integrity is necessary to maintain the characteristic shape of many cells and the rigidity of elongated structures. A clear example of such structures would be the axons and dendrites of neurons.

Morphogenesis: Related to their mechanical function is the role that microtubules play in the shaping of the cell during differentiation. The morphogenetic changes that occur during spermiogenesis provide an interesting example. The elongation that takes place in the nucleus of the spermatid is accompanied by the production of an orderly array of microtubules that are wrapped around it.

Cellular polarity and motility: The determination of the intrinsic polarity of certain cells in also related to the mechanical function of microtubules. Treatment of various culture cells with colcemid generally results in a change of motion; although certain forms of motion persist, the directional gliding of the cell, for example, is replaced by a random movement.

Circulation and transport: Microtubules may also be involved in the transport of macromolecules within the cell; to this end, they probably form channels in the cytoplasm. One example of an association between microtubules and the transport of particulate material occurs in the melanocyte, in which the melanin granules have been observed to move between channels created by the microtubules in the cytoplasmic matrix.

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