Current Science Reports

Solar Cycles
Forecasting sunspot number

The sun exhibits an average 11-year periodicity in its activity, observed since the 17th century. The 1755–1766 cycle is numbered as one. Presently, we are at the beginning of the 25th solar cycle, which started in December 2019.
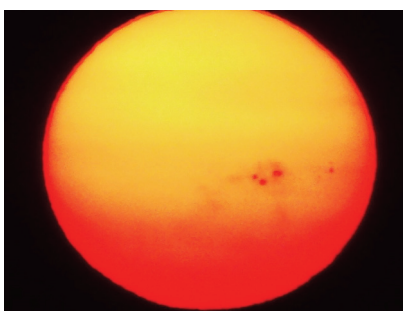

Image: Slav via Wikimedia Commons

The sun constantly emits electromagnetic radiation and energetic charged particles as solar wind. These energetic particles vary with solar activity and they are extremely harmful to space missions. The electric currents that vary in time, generated through these particles, can also trigger electricity and communication failures on the earth.

So, several models have been developed to forecast solar cycles – some based on statistics of past solar activity and some on the dynamo theory of solar activity. However, uncertainty in the models is still very high. And most forecasts are limited to only the next cycle.

Recently, Bharati Kakad and Amar Kakad from the Indian Institute of Geomagnetism, Mumbai proposed a new data-based model to forecast two cycles in advance.

The duo used both daily and monthly sunspot number data from the database of the Royal Observatory of Belgium. They clubbed the data of even numbered cycles with the data of the next cycle.

From the data, they extracted information on the area under the curve of each solar cycle, its length and peak. They used the monthly smoothed sunspot data from cycles 2 to 24 to build their model but, for the daily data, they considered cycles 10 to 24, since the daily data prior to cycle 9 was deficient. Surprisingly, the area under the curve calculated from both types of data did not differ much.

'The area under the curve of a solar cycle is directly proportional to its peak sunspot number,' says Amar Kakad.

'If we start from an even numbered cycle, we find a relationship between the sum of peak solar spot numbers, the difference between the areas under their curves and the sum of their durations,' says Bharati.

'Moreover, the area under the curve in even-numbered solar cycles is less than that of the following odd-numbered solar cycles. From the data available, we could figure out the exact relationship,' adds Amar.

From these three relationships, the researchers could forecast the peak solar spot number for cycle 25, using data from cycles 22 and 23, and the known variables of cycle 24. Cycle 25 will be about 12% weaker than cycle 24, they say.

Their model also suggests that cycles 26 and 27 will be similar or slightly stronger than cycles 24 and 25.

This means that we have three more solar cycles that are relatively weak, allowing us more than three decades to step up space explorations.

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Collapse of Konark Temple
Due to neotectonic activity?

The main part of the 13th century Konark sun temple, on the Odisha coast, is dilapidated. Theories for the collapse abound. But they are based on legends and folklore.

William Kumar Mohanty and team from IIT Kharagpur recently came up with a scientifically feasible explanation: neotectonics.

Their solution explains another important mystery: the disappearance of the Chandrabhaga. The river once flowed next to the temple.

The team used satellite imagery and ground-based measurements of magnetic and gravitational anomalies to understand the region's geological and geomorphological features. And a 3D gravity inversion model to probe subsurface lineaments or faults.

Manipulating satellite images and overlaying them on Google Earth, they discovered the palaeochannels of the Mahanadi's distributaries. Thus, they not only found the channel through which the Chandrabhaga once flowed, but also the shifting of the channels of the Kushabhadra, west of Konark and the Kadua, to the east. While the Kadua reversed its path in the past, the Chandrabhaga left only marshy wetland to the temple's southwest.

The team did a field study to confirm the findings.

'Ox bow patterns left behind during the shifting of the rivers are tell-tale clues, confirming revelations from satellite image manipulation,' says Subhamoy Jana.

Combining gravity anomaly and magnetic anomaly measurements, the team detected possible subsurface faults.

'High gravity anomalies suggest uplifted zones and low anomalies suggest subsided zones,' explains Saibal Gupta.

The region's morphometry confirmed their findings on uplift and subsidence.

Now, the problem was to confirm suspected subsurface faults in the Konark temple's vicinity: especially one that had a north-east to south-west direction and another that had a north-west south-east direction. This is where 3-D modelling helped.

'The faults extend around 2.75 to 4.5 kilometres below the surface,' says Prakash Kumar.

Image: Suraj via Pixahive

Alluvium in the region rests on the Rajmahal traps, formed by volcanic eruptions 117 million years ago, when

the Indian plate was in the southern Indian Ocean. The layers in the Mahanadi basin show four distinct periods of formations: 7000 to 6000, 2300 to 750 and 750 to 50 years before the present and 50 years ago to now.

'Konark was built on a tectonically active region. Seismic amplification of unconsolidated sediments may have weakened the temple's basement, leading to gradual collapse,' says William Kumar Mohanty.

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Lessons in Soil Conservation
From Nagpur's orange orchards

Nagpur, famous for oranges, receives plenty of rainfall during the monsoon. But, due to the region's uneven terrain, surface runoff washes nutrients away and leaves the soil dry.

Trenches and bunds can help reduce runoff and mulching conserves rain water in such areas. Do they increase the yield and quality of the oranges, commensurate with the toil and costs involved?

Researchers from the ICAR-Indian Institute of Water Management, Bhubaneshwar and the ICAR-Central Citrus Research Institute, Nagppur recently reported the results of their seven-year long investigations.

For the experiments, they selected a plot of about a hectare with 320 mandarin plants. The researchers measured rainfall using rain gauges. Using plastic tanks at the end of each plot, they also measured runoff.

Sediment in the runoff was also measured. Though there was an average of about 860 millimetres of rain, nearly 60% of the water was running off, due to low percolation and the clayey nature of the soil. Soil loss due to erosion was more than 8 tonnes per hectare. Loss of nutrients was also high.

The researchers divided the study area into equal plots and executed different soil and water conservation methods. Continuous trenches of a little more than half a metre depth following the contours and staggered trenches in zigzag manner needed to be compared. The soil extracted from the trenches was used to make bunds on the downstream side of the trenches.

Such steps can reduce runoff. But adding grass mulch into trenches can also trap moisture and help increase soil carbon content, improving the soil's productivity. So they used these treatments also for comparison.

Soil erosion was effectively stopped by both continuous and staggered trenches during the winter rains. But, during the monsoon, that was not the case. Continuous trenching with grass mulching performed best, reducing the runoff to about 31%. And soil erosion to less than four tonnes per hectare. While nutrient loss was reduced, the soil organic carbon increased due to grass mulching.

Soil water content during January–May increased significantly in all treatments but, with mulching, it was 20% more than without mulching. So fruit fall decreased.

The yield increased by 53% with continuous trenching and mulching, while the need for water reduced by more than 30%. The fruits were juicier and had higher ascorbic acid content.

But the costs involved in the conservation treatments – are they worth it?

The researchers analysed. Sustainable yield index was best for continuous trenching with grass mulch. Though the energy input was greatest for this treatment, the outcome in terms of the yield, improvement in soil quality, reduction in water use, etc. makes it worth the effort.

Not only mandarin farmers in Nagpur, but also fruit farmers in the Deccan plateau region need to chew on this food for thought.

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Iodine Deficiency Disorder
Salt iodisation in Gonda district

Iodine is an essential micronutrient. Its deficiency can cause goitre, hypothyroidism and various developmental problems in children. The WHO recommends a dietary allowance of 100 to 150 milligrams of iodine per day. Iodised salt in the diet can fulfil this requirement. So, iodised salt was made mandatory by the National Iodine Deficiency Disorder Control Program, initiated by the Government of India, and the universal salt iodisation programme.

A survey conducted in Gonda district, Uttar Pradesh, in 1982 showed a prevalence of 60%. By 2009, it reduced to 31%. How does Gonda district fare now?

To assess, Saroj K. Mishra and team from the Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow randomly selected nine schools there.

They recruited nearly a thousand boys and girls, aged between 6 and 12. The researchers assessed goitre by palpitation, and thyroid volume by ultrasound examination. There was about 5% decline in the total goitre rate, signalling the impact of the universal salt iodisation programme in the Gonda district.

The team quantified iodine concentration in urine samples and found adequate levels of iodine.

They also measured iodine content in salt from the households of the selected children. Though some households still use loose crystal salt with negligible iodine content, more than 80% of salt samples were iodized.

To encourage more households to use iodised salt and to prevent iodine deficiency disorder relapse, the investigators recommend efforts to create awareness, ensuring an adequate supply of packed iodised salt, and regular monitoring and evaluation.

These recommendations can also be implemented by concerned authorities in 337 other districts listed in 2017 by the Government of India as endemic areas of iodine deficiency disorder.

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Food Addiction
And academic performance

Food addiction can cause weight gain but, for many, food addiction does not necessarily result in obesity. Why? Mental activity is a high energy consuming process and glucose is the main source of energy for the brain.

To investigate the possible relationship between food addiction and academic performance among students, Amit K. Trivedi from the Mizoram University collaborated with researchers from Russia.

They selected a sample population of about 3400 school going and university students in Russia and in India.

The participants provided information on their sex, age, height and weight, from which the researchers calculated the body mass index.

Image: Mohand1995 via Wikimedia Commons

They collected the grade point average of each participant for the quarter preceding the study and categorized them as low, medium and high.

The researchers administered a 25 point questionnaire, the Yale Food Addiction Scale, to assess food addiction among the participants.

A statistical analysis of the data collected was revealing. In both Russia and India, the frequency of food addiction is higher among university students than in schoolchildren.

School and university students living in large cities had a higher frequency of food addiction. Food addiction in students from India is two times higher than in their peers from Russia.

Among participants with food addiction without signs of obesity, academic performance was higher. Thus, among high academic performers, food addiction did not result in high body mass index.

'More successful students find it more difficult to resist food temptations possibly because intense mental work may deplete inhibitory control,' says Amit, Mizoram University.

Academic professionals and parents should, therefore, consider the level of cognitive activities when intervening to regulate the food habits of children.

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Chitosan Biopolymer Films
With garlic peel extracts

Chitosan is a non-toxic, odourless, film-forming and environment-friendly polymer, abundant in crustacean exoskeletons and in fungi. The material is amenable to the production of films for packaging.

Garlic peel is known to have antioxidant properties but is mostly discarded as waste. Can incorporating garlic peel extracts in chitosan polymer make it a better fit for food packaging?

Recently, researchers from the Indian Institute of Chemical Technology, Mumbai and the Indian Institute of Handloom Technology, Guwahati teamed up to try the combination.

They dried and powdered garlic peels and mixed the powder with distilled water to make extracts of varying concentrations. Using the extracts, the researchers cast films with 2% chitosan solution.

With increasing garlic extract concentration, the solid content in the chitosan film increases and so does its thickness, they found.

Adding garlic peel extracts enhanced the strength and flexibility of the films. This could be because of the hydrogen bonding of phenols in the extracts with chitosan, say the researchers.

Thermal analysis showed that the films can bear temperatures up to 326°C. So, garlic extracts do not reduce thermal stability.

The team placed the films over white paper and photographed them to examine colour and opacity. A computer colour matching system was used to check for the colour.

'Pure chitosan film has a yellow tint. Adding garlic peel extract increased the tint and opacity of the film,' says Babita U. Chaudhary, ICT Mumbai.

The researchers checked the film's capacity to inhibit the growth of *Klebsiella pneumoniae* and *Staphylococcus aureus.*

'The film made up of 6% garlic peel extract and 2% chitosan had the highest antimicrobial activity,' says Ashis N. Banerjee, IIHT Guwahati.

The team covered apple pieces with different films for two hours. Apple pieces in films with garlic extract did not get discoloured. However, pieces covered with pure chitosan film turned brown.

Finally, the researchers checked the film's cytotoxicity.

'Chitosan films with garlic peel extracts showed no cytotoxicity,' says Shweta Lingayat, ICT Mumbai.

'Garlic peel extract-based chitosan film has the potential to replace single-use plastics for food packaging,' says Ravindra D. Kale, ICT Mumbai.

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Algae for Bioremediation
And potential biofuel

Physical, chemical and bacterial bioremediation require oxygen and produce another kind of waste in the form of biomass. Algae-based processes, however, produce oxygen. And many strains are potential biofuel candidates. Can we combine both, using biofuel-suitable algae for bioremediation?

A multi-institutional endeavour by researchers from the Birsa Institute of Technology Sindri, Dhanbad, the Birla Institute of Technology-Mesra, Ranchi, IIT-BHU, Varanasi, and the University of Delhi, along with collaborators from UK and Saudi Arabia, chose *Spirogyra*.
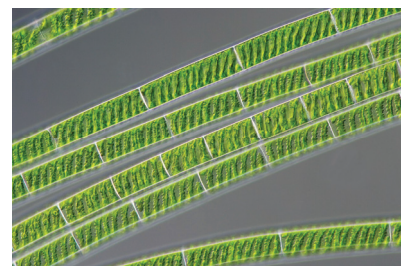

Image: Wiedhopf via Wikimedia Commons

The algae have high amounts of volatile matter. This, along with low nitrogen–sulphur and high carbon–hydrogen concentration, observed during elemental analysis, indicated biofuel potential.

Using Fourier transform infrared spectroscopy, the team found various functional groups in the alga – functional groups that can bind actively to contaminants.

To test the potential of the alga for bioremediation, the researchers selected methylene blue dye and hexavalent chromium metal ion contaminants.

They added fresh algae to the contaminants in glass flasks. In the presence of sunlight, the algal biomass increased and the contaminants decreased with time.

Using a UV–Vis spectrophotometer, the researchers measured decolourization: 50% within 40 minutes of treatment. Overall, 20 grams per litre

algae remediated 91% in 5 hours of the 75 parts per million dye solution.

Removing half of the chromium ions, however, took four days. To remove more than 90% of the metal from a 10 parts per million solution, it took 10 days.

The researchers noticed a decrease in adsorption with further increase in algal concentration. Theoretically, they found that faster and more effective physical adsorption occurs first. Then there is slower chemical adsorption, dependent on the algae's metabolism.

To recover the cost of bioremediation, polluting industries can now choose to make biofuel.

Motivation Detection
Using EEG signal analysis

When motivated, students generally learn better than when they lack motivation. But motivation is an abstract category. How can we objectively detect motivation?

Can electroencephalograms that record brain activity be used for the purpose? Which part of the brain can provide reliable information? Which frequencies provide better clues? And what type of feedback provides better motivation – negative or positive?

Recently, researchers from the Jadavpur University, Kolkata collaborated with researchers from Singapore and Norway to make a prodigious attempt to detect the motivation of students.

They used a game-based approach to provide negative, positive and no feedback and used EEG signals to record the results.

The researchers designed a computer based three-card memory game. There were three versions: One which gave no feedback at all, one which provided positive sound and text feedback for success in matching the cards and increased the score by one. The third started with a score of 13, gave negative feedback for errors made and reduced the score by one.

They selected 30 healthy student volunteers for the experiments and ten each played the different versions of the game. The game also included a break with neutral music before the participants resumed the game.

The researchers used an electroencephalography machine to record the electrical activity of the participants' brains during the whole process. There were two possibilities. One was to record frontal lobe asymmetry – a left sided asymmetry is known to signal approach motivation and a right sided asymmetry, avoidance motivation. The other was to look for emotional valence: left-sided activation in the frontal and anterior temporal region for positive emotions and corresponding sites on the right, for negative emotions.

There was a possibility that both motivation and emotion were connected. So the researchers also tested a combination of the two after the recordings.

Then there was a need to select the frequencies involved. The researchers chose to focus on alpha and beta rhythms.

The data from 30 participants is not adequate to train most deep learning algorithms. The researchers chose the residual-in-residual convolutional neural network, with a proven ability to learn using small datasets. They used 80% of the data for training, 10% for validation and the remaining for testing.

Frontal asymmetry gave the best clues, providing an accuracy of more than 80%. Adding emotional valence improved the results only mildly.

Rewarding with positive feedback proved to be better for motivating than punishing with negative feedback. Negative feedback was better than no feedback.

'Our results are important not only for researchers inquiring into motivation and emotion, but also for educators,' says Soham Chattopadhyay, Jadavpur University.