Current Science Reports

Extreme Climatic Events
Moisture in the atmosphere

Water vapour in the atmosphere regulates precipitation. In recent years, changes in precipitation patterns have caused extreme climatic events like droughts and floods. Moisture evaporating from water bodies stays in the atmosphere for different durations. How does moisture residence time influence such extreme events?

To investigate, K. Koteswara Rao, Azim Premji University, Bengaluru collaborated with BHU, IITM Pune, the SRM Institute of Science and Technology, Chennai and Brazilian researchers.

They used climatic data over the Indian landmass from 1986 and projected the scenario till 2100. To minimize uncertainty in the results, they used the monthly average residence time of moisture from nineteen models with different resolutions.

They estimated and projected the residence time of moisture for 2016–2035, 2046–2065 and 2080–2099. The mean monthly average atmospheric residence time showed a steady increase from 9.32 to 10.86 days.

The increase in moisture residence time increases the absorption of solar irradiance, resulting in increased temperature. And the rise in temperature enhances atmospheric water holding capacity, say the researchers.

The moisture evaporated from tropical oceans tends to gyrate clockwise in the northern hemisphere due to the Coriolis force generated by the rotation of the earth. These gyres become larger as they move north and eastward and increase in altitude. They interact with the high altitude jet streams to resonate and amplify into planetary waves. The researchers found an association of the quasi resonant amplification of Rossby waves with increased moisture stay time in the tropical regions.

'Sometimes these waves are very slow, causing long residence of moisture in June over the Western Ghats,' says Koteswara Rao. This, the researchers say, is the reason for the heavy rains in August 2018 in Kerala.
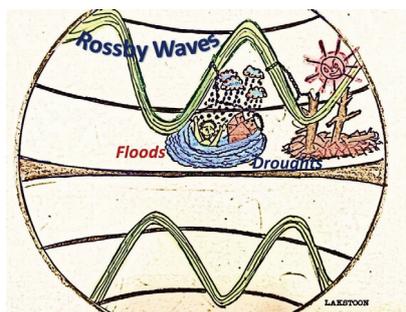
Cartoon credit: Lakshmi Kumar

While the increase in moisture residence time may cause floods in one region, it can also cause droughts in others.

'Prolonged dry spells in June affect the agricultural activities of the *Kharif* season over India. So a clearer understanding of the process is important,' says Lakshmi Kumar, SRM Institute of Science and Technology, Chennai.

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Chitosan-Based Hydrogel
Rapid blood clotting

Haemorrhage or uncontrollable bleeding is a major problem in surgery. The haemostatic properties of chitosan, an abundant polysaccharide, can accelerate wound healing by blood coagulation. Motivated by this idea, researchers from the Amrita Vishwa Vidyapeetham, Kochi, took up the challenge of enhancing the healing properties of chitosan hydrogel.

For rapid coagulation, it is useful to neutralise the anions in blood plasma. The team chose potassium aluminium sulphate, an astringent which would precipitate proteins and cause vasoconstriction, supplementing the properties of chitosan hydrogel.

They added calcium since it is known that calcium ions activate the conversion of fibrinogen into fibrin – essential for forming blood clots. The team tested the composite hydrogel containing chitosan, potassium aluminium sulphate and calcium.

'Our *in-vitro* studies showed that the chitosan-based hydrogel was cyto- and haemo-compatible,' says Ullas Mony, a team member.

The team also experimented on liver and femoral artery haemorrhage models in rats, *in-vivo,* using the composite hydrogel. The hydrogel, with 2% chitosan and 0.25% each of potassium aluminium sulphate and calcium, aided the formation of stable clots with least time and blood loss compared to commercial haemostatic agents.

'The hydrogel can potentially be used to stop low pressure bleeding conditions during dental, dermal and gastrointestinal surgeries,' says Praveen Kerala Varma.

'In high pressure bleeding, including vascular injuries, however, the gel may not be useful. It is not a good sealant,' says Jayakumar Rangasamy.

'Our studies were done only in small animals. So more tests are needed before clinical applications,' adds M. Nivedhitha Sundaram, his colleague.

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Handwriting Classification
Identifying gender

Gender-based writer recognition systems help in forensic investigations. Usually, well-organised, neat, and regular handwriting are characteristics of women, whereas men tend to have messy, spiky, and uneven handwriting.

Existing gender recognition systems are not very accurate. How can we improve writing recognition systems, wondered Payal Maken and Abhishek Gupta from the Shri Mata Vaishno Devi University, Jammu and Kashmir. To find out, they extracted and pre-processed nine handwriting features from 282 handwriting samples obtained from the dataset.

An analysis of the features suggested that men tend to have straight or right titled bigger-sized handwriting. Women usually have a small-sized, left-titled style. A pixel counting algorithm suggested that men have a larger pixel count than women, possibly due to handwriting size.

The team then tested the ability of the Support Vector Machine, Logistic Regression, and K-Nearest Neighbour algorithm to recognise gender from the extracted features.

The Support Vector Machine classifier correctly predicted nearly 60% of the handwriting.

Logistic Regression had nearly 63% accuracy whereas K-nearest Neighbour was lowest – 56%. To enhance accuracy, the duo combined predictions from all three.

'The combination provided an accuracy of nearly 66 per cent,' says Payal Maken, Shri Mata Vaishno Devi University, Jammu and Kashmir.

'Correct gender prediction through handwriting is important for forensics. And to identify the authors of manuscripts in palaeography,' says Abhishek Gupta, her mentor.

Searching for COVID 19 Drugs
In-silico study for drug repurposing

The COVID 19 virus packs an RNA genome in nucleocapsid proteins. The virus envelope contains many embedded proteins, two of which play important roles in infection: the spike protein that interacts with a cell surface receptor, ACE2, and the serine protease 2, that helps the virus fuse into the cell.

Researchers from the Manipal Academy of Higher Education, Karnataka started searching for candidate drugs that can target these two proteins of SARS-CoV-2.
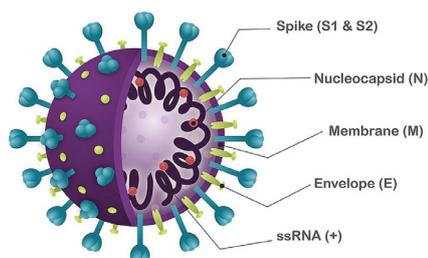
SARS-CoV-2
Image: Santos I A et al via Wikimedia

The sequence and structure of the spike protein is now easily available. The researchers imported the amino acid sequence of the transmembrane serine protease 2 from the uniprot.org database. And the protein structure of ACE2 was accessed from the rcsb.org protein data bank archive.

Then, using molecular docking software, they checked the interactions of the two target proteins with the chemical structure of about 2800 approved drugs. Six, they found, bind to the two proteins. Valrubicin and lopinavir had the least toxicity among the six. And they bind well to both targets on the virus.

'Currently approved antiviral agents like remdesivir and favipiravir do not provide adequate relief. So valrubicin and lopinavir need to be tested as possible alternative therapeutic agents for COVID-19,' says Yogendra Nayak, Manipal Academy of Higher Education.

The candidate drugs identified by *in-silico* methods now need to go through *in-vitro*, *in-vivo*, and rigorous clinical trials before they are approved for use against SARS-CoV-2.

Cucumber Cultivation
Root knot nematodes

Cucumber cultivation in India covers around 44,000 hectares, producing more than 600,000 tonnes. Cucumber crops suffer huge losses due to *Meloidogyne incognita,* tiny worms in the soil that infect roots, forming knots which reduce the flow of water and nutrients to the plant.

Using chemical pesticides to address the issue is dangerous since cucumbers are eaten raw. Soil bacteria such as *Providencia vermicola*, *Pseudomonas putida* and *Pseudomonas fluorescens* are known to protect plants from pathogens and promote growth.

R. V. Vyas and team from the Anand Agricultural University, Gujarat have isolated and characterised strains of these rhizobacteria. 'These strains have different modes of action and a combination of the strains promotes plant growth and protects against pathogens,' says Yogeshvari K. Jhala.

Meanwhile, Harsha Shelat and colleagues at the same university have been studying plant extracts for use as biopesticides. What if bacterial and plant extracts are used together? Would that protect cucumber crops better and improve yield?

The two groups of researchers collaborated to use neem, besharam and mustard cake extracts as they contain compounds that facilitate the growth of bacteria. The team tested the cocktail of the three bacterial strains along with the plant extracts against the root knot nematode. They also tested the bacterial and plant extracts separately and in different combinations.

The combination of all bacteria and plant extracts provided the best protection. Pot as well as field experiments showed the efficient control of the root-knot nematodes. Nematode egg hatching was reduced to a minimum. This kept the population low when the fortified bacterial consortium was applied to the soil.

The bacteria rapidly colonise the soil and produce a spectrum of secondary metabolites that act against nematodes and other pathogens. The plant extracts give additional protection.

Image: Anita Sarkar via pixhive

'We get healthier cucumbers using the fortified consortium. It is an economical and environment-friendly solution to root knot nematode infections in crops,' says R. V. Vyas.

The formulation can work on many other economically important crops that are infested by the root knot nematode. However, commercial preparation and sale is regulated by the Central Insecticides Board & Registration Committee.

Liquefied Petroleum Gas Detection
Nanocomposite-based sensor

Liquefied petroleum gas is inflammable. Explosions and fires caused by LPG leaks claim many lives every year.

Inorganic metal oxide-based sensors can be used for leakage detection; but high operational temperatures and brittleness limit their application. So, researchers have shifted to conducting polymers which can sense gases. The complex polymer, poly (3,4-ethylene dioxythiophene) : poly

(4-styrenesulfonic acid), which researchers simplify into PEDOT : PSS, has been shown to be a good alternative.

Oxygen vacancy defects in PEDOT : PSS convert LPG into water and carbon dioxide, increasing the resistance. But the increase is only marginal. Moreover, the films have poor conductivity.

Apsar Pasha, from the Ghousia College of Engineering, Karnataka in collaboration with researchers in Saudi Arabia have now tweaked the sensor polymer for better performance. They added dimethyl sulfoxide, a polar solvent, and prepared a PEDOT : PSS sensing film on a polyester substrate, to create a flexible sensor.

'Cross linking the conducting polymer with dimethyl sulfoxide improves the mechanical property,' explains Apsar Pasha, Ghousia College of Engineering, Karnataka.

This improved the charge carrier transport but the researchers were not satisfied with the results. To improve sensing properties further, they added tin oxide nanopowder to prepare a p–n heterojunction type of sensing film and poly vinyl alcohol to hold it together.

'The interaction of LPG with the p-type composite polymer induces holes at the p–n heterojunction interface. As a result, there was an appreciable increase in resistance,' explains Hanadi A. Almukhlifi, University of Tabuk, Saudi Arabia.

But these films showed reduced conductivity. So the researchers treated them with sulphuric acid, which enhanced the conductivity.

Then, they designed a sensing setup: a sealed chamber with flow controllers for the gas and a device to measure resistance coupled to the film by gold electrodes.

They estimated the sensitivity by the sudden increase or decrease in resistance when LPG is turned on or off. The film showed significant variation in resistance and, hence, high sensitivity – about 30% even at a very low concentration of 10 parts per million (ppm) of LPG. It increased to nearly 80% at a concentration of 100 ppm. The sensitivity was stable under varying humidity and mechanical deformations.

The detection limit of the nanocomposite at room temperature is far below the concentrations when explosions happen. So it can be used for the early detection of leakage and to avoid LPG explosions.

Road Accident Forecasting
Hybrid machine learning

Annually, road accidents claim more than a million lives worldwide, reports the WHO. So avoiding accidents is top priority. But how? Traffic accidents depend on the kind of road, lighting and weather conditions, intersections on roads, pedestrian crossings... Age of drivers, day of week, etc. also seem to be factors in accident data. So forecasting road accidents is complex.

Sharut Gupta from IIT Delhi and scientists from France used artificial intelligence to tackle the problem. They accessed actual road accident data from the Department of Transport, UK.

Data from 2017 contained information on accidents, vehicles type and casualties. There were 31 features related to accidents, 22 to vehicle and driver and 15 to victims. (Don't you wish India had such a database?)

The researchers first pre-processed the data to remove erroneous or corrupted data and attributes. Accident severity was classified as: no injury, non-incapacitating injury and incapacitating injury. Since people don't usually report accidents when no one is injured, the first class of accident severity was not adequately documented. So, the researchers used an upsampling technique to balance the data.

Now the problem was assigning weights to the attributes. The researchers used a random forest model to select the most relevant feature attributes. The mixture of these attributes increases the probability of accidents. So, the team used the statistical Gaussian Mixture Model, an iterative way of finding the maximum likelihood of a function. This ranked the features in terms of their importance in causing accidents.

To use the features and data to forecast accidents, the team trained a support vector classifier. Then, they used it to predict possible scenarios in which accidents can occur. The hybrid model was 86% accurate, way ahead of individual models.

Some of the forecasts were intuitively understandable. For example, driving at more than 90 kilometres per hour on Saturdays has the probability of an accident with incapacitating injury. But the hybrid model provides more than mere intuition offers. It can help forecast traffic accidents before they occur.

As the world is moving towards automated driverless cars, Sharut and team's work provides indicators to make journeys safer.

Live Streaming Content
Potential for addiction

Live streaming is becoming a popular way of entertainment that provides easy and flexible access to better and diverse content. The number of Indian users viewing live streaming has been increasing and it has grown during lockdown. In some young users, this has become an addiction requiring medical help to control the urge.

Researchers from the Jaipuria Institute of Management, Noida in collaboration with Universities in Serbia and Spain recently assessed the impact of continued streaming on user performance and behaviour.

The investigators circulated a questionnaire to 2000 smartphone users – students and professionals living in Delhi. From those who responded they selected 869 who met their criteria, between the ages of 18 and 35 years.

The respondents represented a mix of Indian population who had come from different parts of the country to study or to work.

The researchers found that interactive live streaming content helps users adapt easily to this technology. The main motivation is to experience something different and innovative. Streaming content often stimulates user sentiments or emotions of

excitement and pleasure which drives them to continue using streaming services.

More than 7% of the respondents were watching streaming content for five hours or more. And nearly 15% were glued to the screen for three to five hours, say the researchers. Streaming addiction – more than four hours of viewing streaming content – makes users reduce social interactions and avoid real-life issues.

While the socialisation necessary for the development of young people is severely restricted due to the pandemic, interventions may perhaps be needed post-COVID, for many to recover from streaming addiction.

Smart Windows for All Weather
An electrotuneable design

Sunlight's visible spectrum provides brightness and infrared radiation heats the surroundings. Smart windows can selectively filter the radiations to control the temperature and brightness indoors. This can save a lot of energy spent on lighting as well as heating and cooling systems.

Available designs are mainly summer oriented, complex and expensive. So, the challenge is to devise simpler and cheaper ones suitable for all kinds of weather.

Debabrata Sikdar and his student, Ashish Kumar Chowdhary, from IIT Guwahati have now designed smart windows with an electric switch, which can be tuned based on the requirement. Their design has two metallic layers with an electro-optic polymer as a dielectric in between. Electro-optic materials change their refractive index when voltage is applied which can, in turn, change the wavelengths of light that are transmitted.

When no voltage was applied, the structure permitted both brightness and heat. At negative voltage, only brightness could pass and, at positive voltage, only heat could pass. So, windows can be switched based on the weather condition and requirement.

For the metallic layers, they used gold and silver but they also tested cheaper alternatives based on copper, and a few transparent metal oxides. The researchers then added a silica glass layer in their theoretical model. The transmission spectra and overall performance was unaffected.

This design is cheaper, suitable for all seasons and offers easy transmission of light. Smart windows can also reflect non-solar radiations from heated buildings nearby in summer.

'Our smart glasses can be integrated into advertising screens, electronic curtains, and skylight panels,' says Ashish Kumar Chowdhary, IIT Guwahati.

'With aluminium oxynitride as metal layers, the glasses can be used in fighter aircraft, military vehicles and submarine applications too,' adds Debabrata Sikdar, his mentor.

Indian Political Economy
Focus on coal

The coal power industry has been a major player in the Indian economy for decades. It provides energy independence and employment. However, it is also responsible for air pollution and greenhouse gas emissions.

Image: Ramkumar via Wikimedia Commons

There are cheaper and cleaner renewable energy alternatives but we mostly continue to rely on coal for power.

Recently, Rohit Chandra from IIT Delhi collaborated with researchers from Germany to analyze the political economy of the Indian power sector with specific focus on coal. They conducted structured interviews with twenty-eight energy experts and policymakers in Delhi.

The team grouped results in three main categories: providing sufficient and cheap electricity, promoting domestic industries and personal interests, and mitigating air pollution and climate change. Their analysis shows that India's dependence on coal is driven by the direct involvement of the government in the power sector.

Though, with the power sector liberalization in the early 2000s, private companies also heavily invested in coal projects, even in 2020, planned coal-fired power plants are publicly funded, with a view to satisfying the objectives of ensuring the long-term security of supply and energy independence.

Besides, there are additional drivers for the on-going coal deployment. In addition to power generation, the team finds that publicly owned companies in India create employment and economic opportunities, which lead to evident dependencies on coal.

The researchers found that political factors were often as important as economic and technological factors in power sector development. Environmental concerns are important, but not significant enough to overcome the need of coal for power generation. Coal mining is essential to India's political economy because it is an important source of revenue.

Coal is a limited resource and will be exhausted in the future. Consequently the power sector will be helpless to fulfil the continuously increasing demand for electricity. So, there is a strong need to encourage sustainable and environment-friendly renewable energy for power generation.

Reports by: **Ravi Mishra, Ravindra Jadav, Khuban Buch, G. Sharath Chandra, D. C. Jhariya, Shwetakshi Mishra, Archana Singh, Sileesh Mullasseri**, **Aradhana L. Hans** and **Pushp Sen Satyarthi**