

Current Science Reports

Sudden Stratospheric Warming *Comparing north and south*

The stratosphere where planes like to go to avoid turbulence is about ten to fifty kilometres above the surface of the Earth. This layer of the Earth's atmosphere is generally stable. And usually very cold. However, there can be abrupt increases in the stratosphere's temperature during winter.

Such sudden stratospheric warmings are common in the northern hemisphere but rarer in the southern hemisphere.

In August 2019, however, there was such an Antarctic event. It was classified as minor as per the standard World Meteorological Organization definition: it merely reversed the temperature gradient between 60 degrees latitude and the pole.

Still, given its rarity in the southern hemisphere, Kalyan Bhuyan and Bitap Raj Kalita at Dibrugarh University set their Ph.D. scholar, Jinee Gogoi, the goal of comparing this minor stratospheric warming with one that occurred in the northern hemisphere in 2013. Besides the reversal of the temperature gradient at the pole, zonal wind at stratospheric heights changed direction from westerly to easterly, classifying the 2013 warming event as a major event.

The researchers collaborated with a researcher in Germany to investigate the responses of the earth's ionosphere during the minor Antarctic warming of 2019 and the major Arctic event that occurred in 2013.

They analysed data collected from ground-based instruments, satellite observations and computer simulations to understand how the two events affected the electron density distribution in the ionosphere. They also collected datasets from different sources, including GPS receivers, magnetometers and radar systems.

Using the ionosonde data from Oki-nawa in the northern hemisphere and from Darwin in the south, representing magnetic conjugate locations, the researchers examined the peak electron density of the F2 region of the iono-

sphere during both events. They took into consideration the possible influence of solar flux and magnetic storms which could also impact the ionosphere to eliminate confounding factors. Both warming events showed a depletion at the onset and then a significant increase in the total electron count of the ionosphere. The deviation was higher over Darwin. The 2013 event caused an increase in electron count at night, while the 2019 event in the northern hemisphere showed daytime enhancements.

Despite its classification as minor, the 2019 Antarctic event showed a large stratospheric temperature deviation of about 46 degrees, comparable to major events in the northern hemisphere. The zonal wind also showed remarkable deviation from the climatological value. Though it did not change direction, the duration of the zonal wind anomaly was comparable to those in major events.

The polar vortex over Antarctica split and took a longer time to come back to normal during the 2013 warming than the disturbed polar vortex over the Arctic in response to the 2019 event.

'An exceptionally strong planetary wave was observed during the 2019 event, potentially influencing the overall dynamics of the atmosphere-ionosphere system,' explains Kalyan Bhuyan.

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Cold Waves in India *Understanding the dynamics*

Almost every winter, north India experiences severe cold waves that impact the health of humans, livestock and agriculture. Are there specific atmospheric and geographical factors that contribute to the development of these cold waves?

A group of researchers from IISER, Mohali collaborated with a colleague in Brazil to study the dynamics of cold waves over north India. To get a long-term picture of cold wave events, they collected data on the atmospheric conditions there from weather stations, satellites and reanalysis datasets for the period 1982–2020.

In those 38 years, the researchers identified 82 cold wave events in north India. On the basis of temperature, duration, and spatial extent, 54 cold waves were classified as normal and eight as intense.

To identify typical atmospheric patterns associated with each type of cold wave event, the researchers averaged atmospheric variables such as wind, pressure and temperature before, during and after each cold wave type.

Ten days before normal cold waves, they could see an anticyclonic anomaly over the west of India moving towards the east till the second day before the cold wave. Around the same time, a trough with cyclonic circulation was seen over north India, moving towards the east.

Northerly winds from the higher latitudes of Siberia followed on the rear end of this trough, bringing the normal cold waves. First into Afghanistan and then into Pakistan before reaching northern parts of India.

'In other words, normal cold waves seem to be influenced by western disturbances,' says K. S. Athira, IISER Mohali.

The intense cold waves appear to follow a different pattern.

Six days before the intense cold waves, a ridge develops over the Ural region. High pressure blocks low pressure areas on both sides of the ridge, pushing the cold northerly air from higher to lower latitudes over East Asia. This cold air over the Ural region moves down south and, in a few days, reaches north India.

The researchers noticed a greater atmospheric instability in intense cold waves.

To identify changes in cold waves over time, they analysed the frequency, duration and intensity of the cold waves, as well as western disturbance events using the Mann-Kendall test. There was a significant decrease in the frequency, duration and intensity of cold waves. The frequency of western disturbances was also reduced.

The researchers also noticed that cold waves occur more often and last

longer during La Niña when the average sea surface temperature in the equatorial Pacific Ocean is lower than normal.

The researchers then checked whether there is a link between arctic warming and cold wave intensity with the help of the Arctic amplification index – a measure of how fast the Arctic is warming. Faster warming over the Arctic region than in the Northern hemisphere seemed to contribute to more intense cold waves.

'This may explain the recent decline in the number of cold wave occurrences in North India,' says Raju Attada, IISER Mohali.

Understanding the dynamics of cold waves can help accurate forecasting, days before such events, to facilitate adequate preparedness in north India.

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Forest Characterization

Using satellite data

Forests store nearly half of the planet's terrestrial carbon and provide habitats to countless species. However, accurately monitoring and characterising these vast ecosystems is challenging, especially across large and remote areas. Traditional methods often rely on ground-based surveys, which are time-consuming, expensive and limited in their scope.

However, advances in satellite technology are now offering new and powerful tools for characterising forests. The synthetic aperture radar provides detailed information about the earth's surface, regardless of cloud cover or weather conditions. The Earth Observation Satellite-04 launched by ISRO has a synthetic aperture radar that provides high-quality images. It has C-band, a radio spectrum with wavelengths of the order of five centimetres, which interacts with leaves and twigs.

Recently, researchers from ISRO explored the potential of synthetic aperture radar data to explore forest canopy density and above-ground biomass as well as to characterise forests and phenology – changes in the characteristics of leaves, senescence, flowering, fruiting, etc.

They tracked changes in the radar signal backscatter to identify periods of

leaf growth, greening and senescence in a forest in Madhya Pradesh, throughout the year.

Earth Observation Satellite-04 data successfully captured the forest's phenological cycle.

'The C-band synthetic aperture radar is sensitive to leaf water content and canopy structure, making it ideal for monitoring seasonal changes in vegetation,' says Sudhakar Reddy Chintala, ISRO, Hyderabad.

For the above-ground biomass, the researchers analysed the satellite data of two mangrove islands in the Sundarbans delta, focusing on canopy density and heterogeneity. The above-ground biomass was estimated using statistical models.

Earth Observation Satellite-04 data accurately characterized the canopy density and heterogeneity of the mangroves, consistent with field measurements.

To capture the aboveground biomass information missed by C-band, the researchers combined Earth Observation Satellite-04 C-band data with L-band data from another satellite. The L-band synthetic aperture radar has a wavelength of the order of 24 centimetres which penetrates deeper into dense canopies, unhindered by leaves and twigs.

Combining C-band and L-band data significantly improved biomass estimation accuracy compared to using C-band data alone.

The synergistic use of different synthetic aperture radar frequencies can enhance forest biomass assessment, particularly in regions with low to moderate biomass, say the researchers.

The methods used can help forest managers monitor forest health, phenology and biomass to improve management and conservation strategies.

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Heterosis Breeding

Enhanced chilli production

Chilli farmers face two main problems. The chilli leaf curl disease, a viral infection spread by whiteflies, often damages a whole field of chilli plants. And anthracnose, caused by the fungus, *Colletotrichum capsici*, can spoil chillies before and after harvest, wast-

ing the effort, time and money of chilli farmers.

Is it possible to breed chillies that are resistant to these two infections?

Researchers at the Bidhan Chandra Krishi Viswavidyalaya, West Bengal recently reported success.

They crossed 6 genetically diverse parents to produce 15 first filial generation hybrids. Then they evaluated the performance of the crosses.

To check resistance against the chilli leaf curl virus, they tested the progeny every 30 days.

Hybrids from crossing Bidhan Chilli 4 with Chilli 38-Ragi or Pant C 1 showed the most tolerance to the viral infection.

To check resistance against anthracnose, the researchers infected ripe chilli fruits harvested from the plants they had crossed. Again, hybrids from crossing Bidhan Chilli 4 with Chilli 38-Ragi or Pant C 1 showed maximum tolerance.

When breeding chillies for disease resistance, there may be a loss of other desirable traits. Consumers seek chillies rich in ascorbic acid for health benefits, chillies high in oleoresins for flavour and those with high capsaicin content for spiciness while farmers want greater chilli yield.

So the researchers examined these traits and the genes involved in the traits. They found that non-additive gene action controls the inheritance of most traits including resistance against anthracnose and chilli leaf curl. But capsaicin content was additive, making the spicy chillies even more spicy.

Hybrids from crossing Bidhan Chilli 4 with Chilli 38-Ragi and Pant C 1 showed the maximum tolerance to the infections, while retaining flavour and heat quotient.

'It is possible to produce commercial chillies using hybrid vigour,' says Solanki Bal, Bidhan Chandra Krishi Viswavidyalaya.

'The disease tolerance of heterotic hybrids and yield can be increased further by isolating pure lines,' adds Chandan Karaka, Bidhan Chandra Krishi Viswavidyalaya.

By putting these results into practice, farmers can save their chilli crops and improve their income.

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Enhancing Lung Cancer Prognosis *Tailoring models for diversity*

It is not certain whether the existing risk models for lung cancer prediction are applicable to genetically diverse populations, as found in Asia. The risk factors and outcomes may be different among different ethnic groups.

To address this issue, Prakash Gupta, Healis – Sekhsaria Institute for Public Health, Navi Mumbai worked with researchers from various countries to evaluate the performance of 11 established lung cancer prediction models in a cohort of about 2 lakh Asian ever-smokers.

Among the 11 contenders, the Lung Cancer Death Risk Assessment Tool emerged as the best performer for both lung cancer incidence and lung cancer death.

The Prostate, Lung, Colorectal and Ovarian Cancer Screening Trial Models demonstrated commendable calibration overall, with an expected-to-observed ratio of more than 1 with a 95% confidence level. However, these models underestimated lung cancer risk in Asians reporting less than 10 smoking pack-years and for those who had quit smoking for 20 years or more.

So the researchers developed the Shanghai models, refining risk prediction specifically for Asians. These models, built on insights from two well-characterized population-based prospective cohorts, displayed marginal improvements in discrimination for lung cancer death and incidence.

The Shanghai models consistently outperformed their Western counterparts in predicting lung cancer risk among low-intensity smokers and long-term quitters in the Asian context.

The study underscores the importance of tailoring risk prediction tools to the unique characteristics of diverse populations while enhancing the precision of lung cancer prognosis in Asian communities.

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Bacteria Help Nature *Removing harmful textile dye*

Metanil yellow dye is commonly used in the textile industry. It is highly toxic to humans and to aquatic life and is often used illegally in turmeric to give

bright colour to a low quality product. People get exposed to the dye through polluted water which is often released into water bodies by textile industries. Studies confirm that the textile industry is the cause of approximately one-fifth of global freshwater pollution.

Many researchers have tried to detoxify dyes using plants, synthetic materials and microbes. But there is a catch: the detoxification procedure can lead to the generation of harmful secondary waste.

Kavita Kulkarni and her team at the Bharti Vidyapeeth, Pune decided to try *Trichoderma* and *Azotobacter*, common biofertilisers also used for the bioremediation of several toxins.

Why not use them to remove metanil dye from water?

The team's *Trichoderma* formulation consisted of five species blended with talc powder. *Azotobacter chroococcum* was mixed with lignite.

Different amounts of these biofertilisers were added to distilled water containing metanil yellow dye. After two hours, the solutions were evaluated to find out how much dye the mixture had absorbed.

The researchers performed energy dispersive X-ray spectrometry for *Azotobacter* and *Trichoderma* solutions before and after adsorption to identify the composition of the elements present in the water.

The harmful elements of the dye were absent in the solution after adsorption, suggesting that the bacteria had used the dye for growth.

Both bacteria had successfully removed over 95% of the metanil yellow dye from the solution.

One gram of *Trichoderma* could remove 30 milligrams of the dye from the solution. With *Azotobacter*, this went up to 50 grams.

Calculations showed that *Azotobacter* removed 99% of the dye and *Trichoderma* 98%.

Can the biofertilisers be reused?

The researchers found that *Azotobacter* could be reused seven times and *Trichoderma* five times without any reduction in their efficiency.

Both the biofertilisers could easily be used for agriculture after using them for dye removal.

These biofertilisers are currently available at 80 rupees per kilogram. So textile industries and wastewater treatment plants can easily use these microbes for treating dye-contaminated wastewater.

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Moringa oleifera Extracts *For dopamine detection*

Dopamine is a neurotransmitter which regulates brain functioning and mental health. So detecting and measuring dopamine is crucial for diagnosing and treating various neurological and psychological disorders.

To detect dopamine, there are electrochemical sensors that use zinc oxide nanoparticles for better specificity. But making them involves hazardous chemicals.

Bioactive components in plant extracts can scaffold the production of zinc oxide nanoparticles. Can we use plant extracts to convert zinc oxide into dopamine sensors?

G. Lakshmi Priya and colleagues, Vellore Institute of Technology, Chennai collaborated with researchers from Australia to find out.

They chose the leaf extract of *Moringa oleifera*, a plant with many bioactive metabolites, to develop dopamine sensors.

They heated the leaf extract and added zinc nitrate hexahydrate as precursor to synthesize zinc oxide nanoparticles which were reduced and stabilized by the leaf extract. The mixture was then heated to form a thick, yellow paste. This paste was heated for two hours in a furnace at 400°C to separate the zinc oxide nanoparticles.

Using these nanoparticles, the researchers modified a glassy carbon electrode to fabricate the sensor. They analysed the sensor's response to dopamine using cyclic voltammetry and differential pulse voltammetry, and calculated its limit of detection, sensitivity and selectivity.

The sensor could detect dopamine at a concentration as low as 0.1 micromolar!

It responded within a few seconds and had good selectivity towards dopamine.

To evaluate real-time dopamine detection, the team used the sensor in

urine and blood serum under controlled conditions. The fast response of the sensor-enabled real-time monitoring of dopamine levels.

'The biosensor focuses on environmental sustainability,' says M. Manikandan, Vellore Institute of Technology.

Biosensor manufacturers and researchers can now exploit the possibilities of plant extracts for environmentally friendly sensor fabrication.

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Graphene-based Technology

Taping solar energy

When light at specific wavelengths interacts with gold nanoparticles, strong electromagnetic fields are produced on the surface. This phenomenon, surface plasmon resonance, boosts light absorption.

Recently, researchers from the Dharmasinh Desai University and the Marwadi University, Gujarat collaborated with colleagues in Saudi Arabia to harness the power of surface plasmon resonance using the advantages of graphene: a graphene monolayer in the solar absorber facilitates the transfer of harvested energy, enhancing the efficiency of the absorber.

The researchers used the COMSOL Multiphysics programme to design the graphene-based surface plasmon resonance solar absorber.

The design consisted of a layered structure: a chromium substrate, a gallium arsenide layer, a graphene monolayer and a gold layer.

Using atomic layer deposition, the researchers deposited the gallium arsenide layer onto the chromium substrate and used laser-assisted chemical vapour deposition to deposit the graphene

monolayer over the gallium arsenide layer. E-beam lithography was used to etch the gold coating.

The researchers then simulated the interaction between the layered structure and planar light of wavelengths ranging from 200 to 700 nanometres.

They tested the efficiency of their solar absorber system using the absorption spectra of the solar absorber in their computational model.

The researchers found that the resonator attains a solar energy absorptance of about 99% which peaks at about 500 nanometres.

Industry or startups can use this information to make an efficient solar absorber system.

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Emojis at Work

Effective communication?

Emojis are popular. Some evoke positive feelings and signal interest especially in casual settings.

But is it wise to use emojis in professional settings?

A. Jenifer Arokia Selvi, Y. Poondy Rajan and B. Aiswarya at Loyola Institute of Business Administration, Nungambakkam developed a teaching case based on a situation.

The case study involved two main characters: the manager of a business team, and an employee working under him.

The manager often uses emojis and smileys in his text messages. His go-to emojis are the thumbs up icon and the clapping hands icon to encourage team performance and show appreciation.

The employee, who had spent five years in the organization, felt encour

aged and appreciated. However, during company appraisals, she did not get what the manager's emojis had led her to expect.

She complained to the HR manager who called in the employee's manager. The manager explained that he used emojis as modest expressions of gratitude for ordinary jobs. His justification was that emojis were routine signs of appreciation and that year-end comprehensive assessments were different in nature.

The HR manager cited a dispute in Canada which established that emojis have strong meanings and even legal validity. The judgement established that the thumbs up icon is equivalent to a digital signature. The HR manager suggested using emojis sparingly in professional communication, as they can be ambiguous.

The researchers used psychology to explore factors influencing the manager's adoption of new technology in the workplace. They also used an operant conditioning theory to focus on his behaviour modification based on the consequences of emoji use.

They found that the manager used emojis even with no context or requirement. Using the case study, the researchers established that using emojis can become a habit. Since emojis are powerful, they need to be used with caution, especially in professional settings.

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