Science Last Fortnight

Bay of Bengal Weather

Indigenised drifting buoys

Surface temperatures and sea currents are important for meteorological predictions. These parameters can be estimated from satellite data. But estimates do not match the accuracy needed for improved weather forecasting. So satellite data need to be calibrated against *in situ* data from ships and drifting buoys in the sea.

India used to buy drifting buoys for conducting experiments, especially in the Bay of Bengal where tropical cyclones threaten coastal districts. Position information from the commercial buoys is acquired only four to six times per day and that too with a time delay of a few hours. This is not enough to distinguish small eddy currents in the sea.

So scientists at the National Institute of Ocean Technology, Chennai designed an improved drifting buoy in 2012: a spherical float of less than half a metre diameter housing all necessary equipment. To survive in the sea, the buoy is coated with antifouling agents and ultraviolet protection. A stainless steel wire attached to it carries a temperature sensor to measure sea-surface temperature. This tether also carries temperature and pressure sensors to acquire data from up to a depth of 15 metres. At the end of the tether, there is a disc-type frame on a windowed cylindrical holey sock drogue – a mechanism to stabilise the buoy. Almost half the buoy is submerged in the sea so that wind does not affect movement.

Between 2012 and 2016, the scientists tested the performance of these indigenous drifting buoys. With the help of Indian satellite telemetry, the buoys provided near real-time high resolution data of currents every hour.

The team then compared near-surface current data from an indigenous drifting buoy with that from the Russian-made drifting buoy. The buoys were deployed one after the other with a time delay of about 10 minutes in March when the East India Coastal Current becomes stronger and winds in the region are weak.

Both buoys took similar trajectories with some variations in the path but seemed to converge, though with some time delay. The scientists report a strong agreement of ocean current measurements between the data from the two buoys.

Deploying more drifting buoys will provide higher rates of position sampling in the Indian Ocean and help with more precise mapping of ocean surface water circulation, say the scientists.

Indigenising and improving the technology will help improve meteorological forecasts and benefit the shipping industry. A patent has been filed for the new design of the drifting buoy.

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Exploring Deep-sea Fish Diversity

The deep sea, the ocean's lowest layer, starts at a depth of 200 metres. Deep-sea research reveals rich biodiversity, contrary to earlier assumptions based on the absence of light and oxygen. However, this research is expensive, and requires a skilled workforce. So, information on the biodiversity of deep-sea regions in India is scarce.

During April 2016, a team of Indian scientists went on a research expedition aboard the *Sagar Sampada*, a research vessel managed by the Centre for Marine Living Resources and Ecology, Ministry of Earth Sciences.

They explored the sea around the Andaman and Nicobar Islands using a specialised trawl to catch the demersal fish – the fish living close to the ocean floor. On the deck, the scientists sorted the fish into groups based on the taxonomic identification. After a preliminary sorting, ambiguous species were taken to the laboratory for detailed analysis. One fish, especially, puzzled the scientists – a specimen from a depth of 332 metres in the North-eastern Indian Ocean region, near the north of the Car Nicobar Island.

The fish was reddish dorsally, but had a whitish belly. After taking detailed morphometric and meristic measurements to identify the species, the team compared these with already reported related species in the genus.

Image: Sileesh Mullasseri

After laborious double checking, last fortnight, these scientists, along with a group from the Zoological Survey of India, reported the identity of the fish – *Bembradium magnoculum. Bembradium* is from the Greek for anchovies, which this fish resembles, and magnoculum for its big eyes. The fish species was first reported near Thailand a month ago, says Aneesh Kumar, CMLRE, Kochi.

The biodiversity in the deep ocean in Indian areas still remains unexplored. And the *Sagar Sampada* is the only fishery research vessel in India. There is a need for more research vessels to create a comprehensive database of life in the deep seas around India, says Sileesh Mullasseri, KUFOS.

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Cyclones and Chlorophyll Blooms

In the Indian Ocean

Cyclones, besides creating havoc on land, induce intense mixing in oceans. The mixing churns the water column and brings nutrients to the surface. Surface waters, receiving maximum sunlight, are conducive for marine primary production leading to chlorophyll blooms. Do all cyclones lead to increased blooms equally?

Neethu Chacko from the National Remote Sensing Centre, Hyderabad investigated twenty-eight cyclones reported in the Indian Ocean during 1999–2016 using satellite and meteorological data. She explored the relationship between cyclones and chlorophyll blooms using scatter plots

and correlation analysis. On comparison, Neethu found that speed, rather than intensity, influenced the blooms. Slower cyclones induced intense blooms. This, she says, is because slow-moving cyclones impart more momentum into the ocean. This results in the vertical mixing of deeper water into the surface layers.

She further compared bloom magnitude with ocean pre-conditions – the depth to which the upper water column is mixed and the nutrient gradient depth where nutrient concentrations begin to increase from low surface values. These parameters are reportedly favourable for blooms. Among the twenty-eight cyclones, slow moving-cyclones along with pre-existing shallow mixed layer and nutrient gradient depths induced stronger chlorophyll blooms.

So, even weaker tropical cyclones can induce strong chlorophyll blooms under favourable conditions. And not all strong cyclones induce blooms.

The meteorology department may use such cyclone characteristics and pre-existing ocean conditions to alert fishermen about algal blooms. Since algal blooms attract fish, and later, their predators, post-cyclone conditions provide happy hunting grounds for the fisheries industry.

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Biodiversity from Space

Conserving alpine habitats

Image: C. P. Singh

The Himalayas are home to a large number of endemic species. It is difficult to assess the impact of climate change on the biodiversity in these areas using traditional field investigation, especially in the upper reaches where alpine vegetation flourishes. Thankfully, we can distinguish between different types of vegetation using reflected spectra from remote sensing satellites.

The Resourcesat-2 satellite, for example, has two linear imaging self-scanning sensors that provide data with less than six metres and a little more than 20 metres resolution – adequate to examine biodiversity at a landscape level, since both fine-scale information and large area coverage are provided.

Jakesh Mohapatra and team from the Space Applications Centre, ISRO, Ahmedabad, collaborated with scientists from the University of Kashmir and the Gujarat University, to study the alpine vegetation of the western Himalayas using imagery acquired from the Resourcesat-2 satellite. They selected four summits in the Gulmarg region, Kashmir. All four summits were more than 3500 metres above sea level and were not easily accessible for human interventions.

The team used spectral values from satellite pictures to assess diversity in the alpine ecosystem. They corroborated these results with data collected from the field. Vegetation on the slopes would vary depending on the availability of sunlight and water, which, in turn, depend on the direction of the slopes.

So, for collecting field data, the researchers divided each summit into eight summit area sections: four covering the area at 5 metre contours from the highest summit point and another four covering the area below the 5 metre contour and above a 10 metre isocline for the north, east, south and west aspects. They listed the plants found there and recorded the area covered in units of one square metre. They could list 127 species including vascular plants, bryophytes and lichens, in August, the peak season for vegetation growth in Gulmarg.

The team found a wide variation in species richness among the summits. Though there was only a little more than 200 metres difference in the heights of the summits, there was a drop of more than 25% in species richness from lower to higher summits.

Though the southern aspect gets more sunshine, lower summits are subject to shadows from higher summits and this can often lead to lower vegetation growth even in southern aspects, the researchers say. The southern aspect, though favourable for vegetation growth, showed less biodiversity. The microclimate and soil characteristics, therefore, play important roles in determining diversity, say the researchers.

According to the team, the spatial resolution of satellite data might not correspond to the spatial heterogeneity of actual field data. However, remote sensing data can provide a relative measure of species diversity and map the vegetation at different spatial and temporal scales – information necessary for prioritising areas for conservation, say the researchers.

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Drought Tolerance

How parched sugarcane revives

Sugarcane, an important cash crop, occupies the largest area under cultivation in the world. The crop demands a higher amount of water than most others. It is sensitive to drought especially during the tillering and growth phases. However, some cultivars are more resistant than others to drought stress. What are the biochemical, molecular and physiological mechanisms characteristic of relatively drought resistant sugar cultivars?

A. Selvi and a team of women scientists from the Sugar Breeding Institute, Coimbatore set out to understand the various responses of sugarcane cultivars locally adapted to drought. They grew six cultivars, some of them drought resistant and some very sensitive, in pot culture.

Sixty days after planting, the researchers subjected the cultivars to drought stress by withholding water. And measured various parameters on the 2nd, 6th and 10th day. They then supplied water to the plants to see how they recover from drought conditions.

Mild wilting, whole leaf rolling and dying tissues were the common symptoms. The tolerant ones recovered very quickly on rehydration.

Biochemical analysis showed that osmoregulators such as proline and trehalose increased in drought-

tolerant cultivars. The enzymes involved in the synthetic pathways of these chemicals also showed an increase.

Chlorophyll degradation and the leakage of ions from cells were noted in drought-sensitive cultivars. Relative water content and chlorophyll stability was higher in drought-tolerant ones. In fact, chlorophyll stability could be considered a distinguishing character of drought-resistant varieties.

The reactive oxygen species generated due to drought stress led to the increased production of malondialdehyde and lipid peroxidase, which led to membrane instability. Superoxide dismutase, the enzyme that reduces the harm done by reactive oxygen species increased more in drought-tolerant varieties than in susceptible ones.

In all cultivars, many genes were upregulated due to drought stress, including the late embryogenesis abundant protein which inhibits protein aggregation, dehydrins, invertase, calmodulins and several other well-known drought-responsive genes. However, these genes quickly came to normal levels of expression in drought-resistant varieties on rehydration.

This understanding of how sugarcane responds to drought and rehydration will be useful in developing hybrids using tolerant parental sources. It can also help target genes for developing drought-resistant transgenics.

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Bacterial Wilt Resistance

Markers in eggplant

Bacterial wilt in brinjal is caused by *Ralstonia solanacearum*, a soil-borne bacterium that leads to reduced growth and yield. Some varieties are more resistant to this disease. Though researchers have tried to identify the genes involved, the genetics of resistance is still not very clear. Under such conditions, we could use markers that are linked to resistance genes to identify plants that are resistant to bacterial wilt for propagation.

Image: Scot Nelson via Flickr

Recently, a team from the Indian Institute of Horticultural Research, Bengaluru reported identifying markers linked with disease resistance. They used four brinjal varieties: bacterial wilt resistant CARI-1 and IIHR-7 and susceptible Rampur Local and IIHR-108. They crossed the two resistant varieties with the two susceptible ones to study genetics of the trait. Then they examined the DNA of the four original parents, their corresponding next generation crosses with simple sequence repeats, or SSR markers – a total of 390 SSR markers.

The researchers artificially inoculated the plants with the pathogen by axil puncturing and soil drenching. Then, they studied the percentage of disease incidence by phenotyping. And using bulk segregation of the second generation, they identified four that could be used as markers linked to bacterial wilt resistance genes. The identified markers effectively correlated and co-segregated in all hybrid individuals.

The team found that the genetic inheritance followed a simple Mendelian pattern of 3 (resistant) : 1 (susceptible) in the second generation. This suggests that perhaps the trait is controlled by a single gene, say the researchers.

These markers might hold the key to bacterial wilt resistance in other eggplant varieties. So now it is easy to identify the resistant varieties and to breed them for propagation, says D. C. L. Reddy, Indian Institute of Horticultural Research, Bengaluru.

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Adulteration in Black Gram

Identification by DNA barcoding

Black gram is a highly-priced legume grain. Hence, it is susceptible to adulteration in the market. It is not easy to detect adulteration when black gram powder is mixed with white pea powder or with refined wheat flour. So a sensitive, reliable and robust method for detecting food adulteration is needed.

Dhanashree Amane and Laxmi Ananthanarayan from the Institute of Chemical Technology, Mumbai developed a DNA barcoding tool to detect adulterating species in black-gram food products.

The team procured black gram from a pulses improvement project. They crushed the seeds to split them into dal using mortar and pestle. The dal and the white pea, the most common adulterant, were cleaned, washed with water and air-dried. Both were then ground to fine flour separately.

Then, they collected black gram products from the market – refined wheat flour and white pea, black gram flour, *papad*, *papad atta* and instant *medu vada* mix. These included 11 different brands.

Thamizhpparithi Maari

The fine ground powdered flours were homogenized in liquid nitrogen and processed for genomic DNA isolation. They amplified and sequenced the extracted genetic material.

The duo used three barcoding loci sequences: a chloroplast genic region, an intergenic-spacer and nuclear ITS1 and ITS4 rDNA sequences. Out of the three loci, chloroplast and the intergenic-spacer region loci showed sensitivity for detecting adulteration in black gram flour.

The analysis revealed the presence of refined wheat flour in one of the papad samples. The DNA barcoding method could identify black gram flour adulterated with 5% of refined wheat flour and white pea flour.

In comparison to conventional analytical methods, DNA-based tests are quick, easy and reliable for detecting plant-based adulterants and authenticating food.

'The quality and authenticity of a food commodity is a prerequisite to boost and sustain trade in the market', says Laxmi Ananthanarayan, Institute of Chemical Technology.

'The technology is now simple enough to be adopted by traders. In fact, many food products are now covered by DNA barcoding technology', adds Dhanashree Amane, her colleague.

The cat of technology transfer seems to waiting to be belled. Not by mice but by human entrepreneurs.

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Climate Smart Agriculture
Increases Crop Productivity

Rice and wheat, occupying 13.5 million hectares in the western Indo-Gangetic plains, meet the present food demands of India, Pakistan, Nepal and Bangladesh. According to some estimates, India requires 60% more agricultural production by 2050 to meet the needs of the burgeoning population. But, intensive practices followed by the burning of crop residues have led to soil erosion and environmental pollution.

Researchers from the ICAR-Central Soil Salinity Research Institute collaborated with the Sri Karan Narendra Agricultural University, Rajasthan and the International Maize and Wheat Improvement centres in New Delhi, Bangladesh and Nepal to assess the impact of Climate Smart Agriculture in the western Indo-Gangetic plains for increasing crop productivity.

The approach integrates zero tillage, crop residue retention in the field, water and nutrient management, crop diversification and communication, to achieve sustainable intensification of the rice–wheat system.

From 2009 to 2013, the team conducted field experiments at Karnal, Haryana. They tried different scenarios of crop production in a randomised block design with production scale plots of two thousand square metres. Scenario one was rice–wheat with conventional tilling and crop residue removal. Scenario two: rice-wheat–mungbean with transplanted rice and mungbean–wheat with drill seeding with zero tillage and residue retention. Scenario 3: a rice-wheat-mungbean system with zero tillage at all stages and retention of residue. Scenario 4: a maize–wheat–mungbean system, with no tillage, drill seeding and retention of residue.

The soil carbon increased highest in scenario 4 followed by 3. Dehydrogenase activity, indicating microbial action, was highest in scenario 3. The microbial population in the first 15 centimetres of the soil was highest in scenario 4, followed by scenario 2. These microbes fixed atmospheric nitrogen and decomposed crop residues leading to increased carbon and nitrogen availability to plants. This increased water and nutrient retention in the soil, eventually leading to 20% higher crop productivity. And reduced soil erosion and pollution due to crop residue burning.

Zero tillage when combined with residue retention and crop rotation can produce equivalent or greater yields than conventional methods, say the scientists. In the long run, it is sustainable to adopt climate smart practices. The last part of the programme is transferring the agricultural protocols to the farmers.

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Suicide by Hanging
Media to blame?

Reducing the availability of pesticides appears to have led to a fall in suicide by ingesting the lethal chemicals. But what about suicide by hanging?

Rakhi Dandona, from the Public Health Foundation India, Gurugram and researchers from the US, the UK and Australia teamed up to look into method specific suicide in India from 2001 to 2014. They took data for the period from the National Crime Records Bureau to calculate trends in method specific suicide rates by sex, age-group, and geographical region. After adjusting for errors, the researchers examined associations between state-level indicators of economic development, education, agricultural pesticide use and religious factors.

For both sexes, states with a high proportion of Hindus had higher rates for insecticide poisoning and self-immolation, they found. For all methods, the rates were highest for men between 30 and 59 years. In women, however, rates tended to decline with age.

In more economically developed states, the rates were two to four times higher for all methods for both men and women. In states with higher literacy also, there was a greater risk of suicides.

Agricultural states had higher rates of suicides with insecticide for both sexes. Suicide by self-immolation was higher among females. In less agricultural states, the team noticed higher hanging rates in males.

Overall, between 2010 and 2014, there was a decline in the use of insecticides, self-immolation and other methods while hanging as method increased. The tendency was more prominent among males – more than 50% increase – than among females.

Suicide by hanging is over-reported and sensationalised in the media. There is evidence to suggest that such media reports can encourage imitation suicides. The team suggests that responsible reporting and representation of suicide by hanging in the media could be useful to reduce the tragedy. Though there are guidelines for media reporting of suicide, Indian media, in general, has been lax in adhering to guidelines. The other suggestion put forward by the researchers is to make the fixtures for ceiling fans such that they cannot support the weight of human beings.

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Reports by: **Pavithra P. Nayak, Gita, G. Sharath Chandra, Ravi Mishra**, **S. Pandian, Sanghamitra Deobhanj, Rekha R. Warrier, Sileesh Mullasseri** and **Archana Singh**

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scienceandmediaworkshops@gmail.com