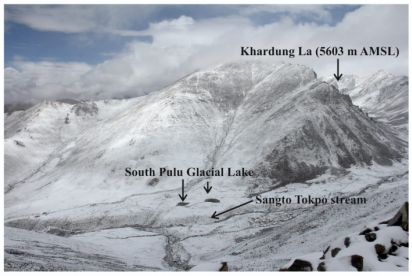
Current Science Reports

Trans-Himalayan Climatic Records

4100 year data from lake sediment

Ladakh, in the Trans-Himalaya region, receives monsoon rains in summer and plenty of snowfall from November to April due to the Westerlies. Snow melt and rain carry sediments into the South Pulu Lake, a small high altitude water body that freezes during winter. These sediments are a clue to the past climate in the Ladakh-Karakoram region.



So Binita Phartiyal and team from the Birbal Sahni Institute of Palaeosciences, Lucknow, along with scientists from the Agharkar Research Institute, Pune and the Institute of Tibetan Plateau Research, Beijing, collected 68 sediment samples from a pit dug in the lake surface when it was dry.

Using accelerator mass spectrometry, the researchers determined the radiocarbon dates from selected samples and found that the deepest sediment section represented the past 4134 years or so – around the beginning of the Meghalayan age. The topmost sediments were from about 266 years ago.

The sedimentation rate was higher from about 4134 years ago to about 2823 years before present. Then it decreased substantially till about 2546 years ago. It decreased even more from the last 2446 years to 266 years ago. This highlighted major climatic shifts in the region during the last 4134 years.

To understand the climatic variability, the researchers used different proxies. Higher clay content signals wetter climate. Higher amounts of silt and fine sand are brought in by wind during drier climate. Signs of diatoms, bacteria, spores of fungi, algae and plant detritus are clues for reconstructing the past ecology of the region. The biochemical and mineral content at different depths of sediments provide further clues. The researchers used all proxies available to reconstruct the past climate in the region. They were thus able to identify five climatic zones in the last 4134 years.

For nearly 400 years, from 4134 to 3720 years before the present, climatic conditions show a typical northern hemispheric climate, dominated by the Westerlies – winds from the Mediterranean. Just after the 200 year dry period of the Meghalayan, the region seems to have slowly become wet and cold, allowing algae and aquatic plants to thrive in the South Pulu Lake. The presence of charcoal signalled human activity in the region during this time.

From 3720 to 3124 years ago, the region became warm and moist. Early Vedic texts, written around that time, record torrential rains.

Then it became cold till about 3000 years ago. Glaciers advanced and the region became more arid during the late Vedic period. Algal and microbial activity decreased due to the development of anoxic conditions. But there was still some human activity in the region as signalled by charcoal and the presence of specific diatomic species.

Then came a period of about 360 years when the lake became stressed and a cold climate prevailed in the region, spelling doom for the ancient civilisation.

This was followed by a 360 year period – from the Buddha's time to the Mauryan Empire – with a warmer climate and relatively higher water levels in the lake. The North Atlantic forcing reduced and the Indian monsoon reigned supreme during this period.

Between 2166 and 516 years ago, a moderately warm climate prevailed. This is further evidenced by signs of local and regional trade. The term Pulu in Ladakhi means resting place for shepherds grazing their livestock in summer. The anthropogenic influence suggests that the region was perhaps linked to the silk route connecting Central Asia, China and Tibet. There was a short spell of cold after this.

'Now we see that the Westerlies contribute a little more than a quarter and the monsoon supplies the rest of the moisture in the region. But, evidently, the relative contributions have shifted dramatically, many times in the past,' says Balasubramanian Karthick, Agharkar Research Institute, Pune.

'The strengthening of the monsoon and intense precipitation is leading to landslides, debris flows and avalanches, reducing intra-boundary trade,' says Binita Phartiyal, Birbal Sahni Institute of Palaeosciences, Lucknow.

The researchers suggest that future climatic modelling should take these empirical findings into account.

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Nocturnal Ionospheric Anomalies

Observations over Bhopal

An increase in the electron count in the ionosphere, extending from about 60 to 350 kilometres above sea level, is primarily caused by the sun's rays, especially UV radiations. So, why is it that, on some nights, the electron count increases at night, especially near the magnetic equator?

To solve this puzzle, a multi-frequency global positioning system was installed at the Government Maharani Laxmi Bai Girls PG College, Bhopal in 2016. Ever since, researchers from the Institute of Excellence Higher Education, Bhopal and the Vikram Sarabhai Space Centre, Thiruvananthapuram have been collaborating to monitor ionospheric anomalies there.

The signals of the global positioning system change phase and slow down when passing through the

ionosphere. If we use multiple frequencies in the GPS, the electron density can be estimated. The team had a GPS with three different frequencies. The receiver tracked signals from 6 different global navigation satellite systems at different elevation angles from May 2016 to August 2017. Thus the team recorded 105 anomalous increases and decreases of vertical total electron count in the ionosphere – more than 80% occurred before midnight and the remaining, post-midnight. The team found that more night-time anomalies happened in summer than in winter or in the equinox seasons.

'Whenever the solar zenith angle or the radiation flux changes, the ionosphere changes,' says Surabhi Sahu, Government Maharani Laxmi Bai Girls PG College.

It is well known that the ionosphere is influenced by solar activity and the consequent disturbances in the earth's magnetic field. So the team also tracked these parameters. They observed that the occurrence of increased vertical electron content had a strong negative correlation to solar activity. However, peak amplitude, the duration to reach half amplitude, and time of peak enhancement showed strong dependence on solar activity.

'Only percentage occurrence of the event and peak amplitude depended on magnetic activity,' observes Sudhir Jain, Institute of Excellence Higher Education, Bhopal.

During the day, photons break atoms into charged particles in the ionosphere. Winds along the equator circulate the ions, creating eastward-directed electric fields and currents. The primary current, the equatorial electrojet, travels along the magnetic equator, creating a circular movement of ions, resulting in a fountain-like effect. During the night, this ionic fountain movement is reversed.

'The reverse ionic fountain effect combined with equatorial wind movement creates an electrodynamic drift which causes the post-sunset enhancement of vertical total electron content observed in the anomaly crest region at Bhopal,' explains R. K. Choudary, Vikram Sarabhai Space Centre, Thiruvananthapuram.

The data accumulated from such observations, over multiple cycles of solar activity, will one day delineate the exact contributions of the sun's radiations and solar wind-ionospheric coupling to explain the nocturnal ionospheric anomalies near the magnetic equator.

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Characterising Vegetation

Using Sentinel-2 data

To manage and conserve forests, we have to characterise the vegetation there. However, in complex terrains with heterogeneous climates, as in the Himalayas, the task is quite challenging. The development of satellite sensing could, to some extent, overcome the problem. But the interpretation of satellite imageries to derive information about vegetation communities is a laborious process. And that is where artificial intelligence can help.

But which algorithm to use, wondered Arun Pratap Mishra from the Botanical Survey of India, Dehradun. Earlier studies show good results from using the random forest algorithm to classify land cover. But it has never been used to classify vegetation communities in the western Himalayan foothills. So Arun collaborated with scientists from the Indian Institute of Remote Sensing, to tackle the lacuna.

The researchers chose satellite images from Sentinel-2 which revisits the same location every five days. They took data from 22 January to 5 May 2018 – a time when the large scale greening of the area due to the monsoon is reduced, highlighting vegetation characteristics more clearly.

Sentinel-2 scans the earth in 13 bands. The team removed data from bands that monitor aerosols, water vapour, clouds, etc. Then, they resampled the data from the remaining ten bands at a ten-metre resolution. In the images, they selected a region in the Nandhaur Wildlife Sanctuary and the Terai-East Forest Division in Dehradun to test how the random forest algorithm could help map vegetation community characteristics. For classification, they chose to target 17 classes representing dominant forests, mixed forests, scrubs, grasslands, etc.

The random forest is a supervised classifier. It creates regression trees from randomly selected variables. Trees that make wrong classifications have to be pruned. So, in April 2019, the team also gathered field inventory data from 28 inventory plots in mixed forests as well as pure stands, plantations, scrub and grasslands as ground truth points.

They created a classification using images of a single date as well as multi-date imageries, using a subset of ground truth data for training, retaining the rest for validation.

From the simulation, the researchers found that 500 regression trees and 100 iterations were adequate for the classification.

Images from April performed best when they used single date imagery. But classification using multi-date imagery from January and April gave even higher accuracy. Most classes of single tree stands could be recognised with more than 70% accuracy and mixed forests with more than 80% accuracy.

Topographic variables such as slope, elevation, aspect and wetness index influence vegetation. So the team took digital elevation data from the Shuttle Radar Topographic Mission and used topographical variables as inputs for the model. Now, many classes could be predicted with 100% accuracy. However, the accuracy of predicting grasslands and eucalyptus plantations remained low.

'Combining multi-date imageries with the random forest classifier model is quite useful for classifying forest communities and mapping and monitoring habitats over large inaccessible areas,' says Arun, Botanical Survey of India, Dehradun.

Stakeholders in forest management can now use these techniques to map vegetation communities in other, not easily accessible, forest areas. And researchers need to

figure out the variables needed to increase the accuracy of prediction for eucalyptus plantations and grasslands.

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Groundwater Recharge Zones

Identification in Latur district

Latur district, in Maharashtra, frequently faces severe water scarcity. It is a drought-prone region and the groundwater level has been lowering continuously due to the overexploitation of groundwater. The region receives an annual average rainfall of only about 724 millimetres. So proper strategies and planning are needed for groundwater recharge. The first step, of course, is to identify potential groundwater recharge zones.

Groundwater recharge depends on many factors: soil, slope, drainage, geological and geomorphological features, land use and land cover… Vishal Sagar Navane and Sanat Nalini Sahoo from the NIT Rourkela collected the digital elevation model of the area from the Shuttle Radar Topography Mission, a soil map from the National Bureau of Soil Survey and Land Use, a geomorphological map from the Maharashtra Remote Sensing Applications Centre, a geological map from the Geological Survey of India, and a land cover and use map from Landsat 8 to create thematic map overlays on a GIS platform. They also input data on premonsoon and post-monsoon groundwater depths and proximity to surface water bodies.

Thus they had eight thematic layers containing 29 features. They assigned a numeric value of weight for each feature based on their relative importance for groundwater recharge. The team finalised the weights, with suggestions from experts in groundwater hydrology, literature reviews and based on personal judgement.

The groundwater potential map thus generated indicates that more than 70% of the district has poor to moderate potential for groundwater recharge. However, in the northeast and some small parts of the central, east and northwest part of the district, they identified areas that are good. The east and northeast had some very good zones for groundwater recharge. The zones that are excellent for the purpose are confined to a small area in the central part of Latur.

The researchers identified ideal sites for artificial groundwater recharge structures by superimposing maps for slope, lineament, land-use/land-cover and drainage of second-, third- and fourth-order streams. They recommend check dams, percolation tanks and nala bunds as artificial recharge structures at suitable sites.

Administrators, NGOs and people at Latur now need to protect these sites from potential groundwater contaminants and construct water recharge structures to overcome scarcity and to mitigate the socio-economic effects of recurrent drought.

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Natural Antioxidant for Ghee

Plant extracts for preservation

Image: Neha Sonal via Wikimedia Commons

The White Revolution flooded the market with milk and the dairy industry in India has flourished. The production of ghee, an Indian favourite, has gone up to nearly 170 thousand metric tonnes in 2020. However, the ghee consumption pattern does not increase that rapidly. So a lot of ghee has to be stored for longer. Under storage, lipids in ghee slowly oxidise. Ghee then smells unpleasant and tastes sour. It has turned rancid. Rancidity can be prevented by adding antioxidants. But chemically synthesised antioxidants can cause skin allergies, gastrointestinal problems and even cancer.

So, Shryiesh Patel and Smitha Balakrishnan from the Anand Agricultural University, Gujarat, explored a variety of plant sources with antioxidant properties as a solution.

They prepared methanol extracts from the powdered form of 15 plants and tested the extracts for their ability to scavenge the free radicals that form in ghee. The tamarind seed extract turned out to be the best with nearly 90% radical scavenging.

Next, the team analysed the phenolic content of the extracts. Tamarind seeds had the highest value for phenols, followed by catechu and harde, suggesting that stability against the oxidation of lipids is perhaps directly related to the levels of phenolic content.

But plant extracts may affect ghee taste and colour. To double check, the researchers prepared ghee, added the extracts and kept the mixture at 80 degrees centigrade for 10 days. Storage under such high temperatures is similar to storage for long duration.

During the 10-day storage, every two days, trained panellists gave scores for the flavour and colour of the samples. Initially, ghee without antioxidants had better flavour. But, after 4 days, those with catechu, tamarind and jamun extracts had a higher flavour score than the control. At the end of 10 days, ghee with plant extracts had better flavour.

During the 10-day storage, the researchers also checked for the formation of peroxides in the samples. Though all the 15 plant extracts reduced the formation of peroxides, tamarind seeds, catechu and nagkesar extracts performed the best.

Though ghee colour with extracts had poorer scores than the control sample with no antioxidants, extracts of tamarind seeds, catechu, harde and nagkesar are effective for retarding the oxidative deterioration in ghee.

‘So plant sources can potentially enhance ghee shelf life,’ says Shryiesh Patel, Anand Agricultural University, Gujarat.

‘The extracts may also help reduce food deterioration in other foods. They could even enhance health-

related properties,' says Smitha Balakrishnan, his colleague.

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Tuberculosis X-ray Abnormalities

Detection using machine learning

Tuberculosis kills more people than any other single infectious disease in the world. To detect tuberculosis, chest X-rays are an established diagnostic method. However, the manual interpretation of the X-rays requires highly skilled radiologists. This hinders early diagnosis in many high TB burden countries like India. Moreover, the complex anatomical structures in the lung lead to variability in the opinions of even trained radiologists. Diagnostic features such as anatomical shape and textures are difficult to define perfectly.

Image: Basem Abbas via Wikimedia Commons

Along with machine learning techniques, developments in X-ray technologies such as digitalisation and image quality improvements provide an opportunity for the early diagnosis of tubercular pathologies. While reviewing existing methods, researchers from NIT Raipur and the Pt Jawahar Lal Nehru Memorial Medical College realised that though shape and texture-based features make a remarkable contribution to the automatic analysis of X-ray images, they are not adequate for such systems to find applications in clinical settings.

So they used a hierarchical feature extraction and classification scheme that mimics the expert radiologist interpretation procedure in their automated computer-aided diagnostic systems.

The scientists took two popular tuberculosis-chest X-ray image datasets publicly available from the National Library of Medicine, USA.

They had three hypotheses to mimic the radiologist's interpretation. The first was that extracting different features from adjusted lung fields at different hierarchies would improve detection performance.

To examine the hypothesis, the researchers used hierarchical feature extraction and classification schemes. The feature extraction ignored the geometrical shape characteristics of lung fields and the results showed that the use of the texture feature alone led to poor performance.

Their second hypothesis was that distinguishing the geometric characteristics of X-ray images from normal characteristics can help identify tuberculosis-related pathologies.

To test this, the team classified extracted features using the support vector machine classifier, a supervised machine learning method. They extracted 17 features that proved useful for identifying abnormalities. The researchers found that geometrical features show better performance than the statistical texture feature.

Their third hypothesis was that the combination of derived shape-based geometrical features and statistical texture features would improve the performance of detection. To examine this hypothesis, the team combined shape features and statistical features in their inputs to a support vector machine classifier. The combination significantly improved classification accuracy.

Upon evaluating the prototype with different performance evaluation matrices, they found that the performance was better than that of existing methods: an accuracy of more than 95% for the Montgomery dataset and more than 99% for the Shenzhen dataset. The model could easily identify various pathologies, caused by TB, such as pleural effusion, infiltration, fibrosis, hila enlargement and dense consolidation.

'Further research is required to integrate patient metadata with the computer-aided diagnosis so that the tool can be deployed in clinical settings,' says Tej Bahadur Chandra, NIT Raipur.

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Reports by: **Ravi Mishra, Monisha Chetia, D. C. Jhariya, K. Sri Manjari, Shwetakshi Mishra** and **Sileesh Mullasseri**

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scienceandmediaworkshops@gmail.com