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Earth System Science Panorama

(The News, Events, Discoveries Awareness and Researches on Earth, Climate, Planetary and Environmental Sciences)

Natural Disasters of 2022

COP27 brought climate change and its impacts to the forefront of global discussions in 2022. Natural disasters continue to escalate in frequency and intensity, directly linked to climate change. The costs—both economic and human—are mounting. Extreme weather events, such as floods, droughts, and earthquakes, disproportionately affect vulnerable regions, particularly in developing countries where infrastructure and disaster resilience are often lacking.

The floods in India and Nigeria, for example, led to devastating loss of life, displacement of millions, and destruction of property. Uganda's droughts put immense pressure on water and food resources, aggravating humanitarian crises. Meanwhile, the earthquake in Afghanistan underscored how climate-related disasters compound challenges in already fragile states.

As climate change accelerates, these events aren't just isolated incidents; they're becoming the new normal. Countries across the globe, especially in the Global South, are calling for stronger action on climate financing, adaptation, and resilience-building to mitigate the impacts of these disasters. The need for global solidarity and financial commitments, such as those emphasized in COP27, is urgent to help vulnerable nations recover and build back stronger against future disasters.

Flood Havocs throughout globe

Flood kills 182 in Afghanistan: Reuter report says, Afghanistan was host to unseasonal heavy rainfall throughout the month of August,2022 and the results were catastrophic: At least 182 Afghans lost their lives in the ensuing floods and landslides. **Flooding in India Takes at Least 192 Lives:** India's June to September monsoon season of 2022 featured, much like the previous year, above-average rainfall, according to CNN. Among the most affected areas was the northeastern state of Assam, where flooding and landslides killed at least 192 people, according to the Times of India. **South African Flooding Kills an Estimated 461 People:** In early April,2022 heavy rain fell on South Africa's Eastern Cape – including parts of Durban, the country's third most populous city – causing flooding and landslides, and killing an estimated 461 people, according to government officials. Months on from the disaster, more than 70 are still missing and thousands are without permanent housing. **Floods in Nigeria Kill at Least 612 :**Nigeria's rainy season, which spans June to November, was among the deadliest in more than a decade, with floods causing at least 612 deaths across the nation and displacing a further 1.4 million people, according to Nigerian officials. According to a report released by the World Weather Attribution, the flooding in Nigeria and elsewhere in West Africa was made "80 times more likely" by climate change. **Floods Kill at Least 233 in Brazil** Just two months into the year, heavy rains pelted the Brazilian town of Petropolis. Flood waters and mudslides surged through the mountainous town, taking at least 233 lives, according to the BBC. Once a preferred summer residence for Brazil's emperors during the country's imperial period, Petropolis has now spent the last few months recovering from the devastating flooding. **Pakistan Floods Kill at Least 1,739:**From June to October,2022 record-breaking flooding washed away thousands of homes and took the lives of at least 1,739 people in Pakistan, according to official estimates. Courtesy: https://www.usnews.com/the-deadliest-natural-disasters-in-2022

Causes of Floods and their Management and control

Floods are a recurring and significant natural disaster in India, impacting both rural and urban areas. Floods cause immense economic losses in terms of **damage to infrastructure, crops, homes, and public utilities**. They also lead to **loss of life** and displacement of people. Regular floods in India affect agriculture, a major source of livelihood, resulting in significant economic setbacks. Here's a overview of **floods**, their **causes**, management, and **control measures**:

Causes of Floods in India:

1. Massive Rainfall: Excessive monsoonal rains often lead to river overflow.
2. Overflowing of Rivers: Heavy rainfall causes rivers to exceed their capacity, leading to floods.
3. Collapsed Dams: Dam failures or breaches due to pressure or poor maintenance can lead to sudden flooding.
4. Snowmelt: In northern regions, melting snow increases river flow, especially in spring and summer.
5. Deforestation: The reduction of tree cover decreases the absorption of rainwater, leading to surface runoff.
6. Climate Change: Increased instances of unpredictable and intense rainfall are linked to climate change.

Flood Control and Management:

Effective flood management involves a combination of structural and non-structural measures. Some of the main measures include:

1. Structural Measures:
    - Construction of Dams and Reservoirs: These help store excess water during the monsoon and release it gradually.
    - Building Dykes and Embankments: These protect areas from river overflow.
    - Redirecting Excess Water to Canals and Floodways: To manage excess river flow, canals are used to divert water.
    - Groundwater Replenishment: Excess water can be used to recharge groundwater levels.
    - Self-Closing Flood Barriers (SCFB): A flood defense system designed to protect from floods due to heavy rainfall or melting snow.
2. Non-Structural Measures:
    - Flood Forecasting and Warning: Early prediction helps reduce damage. The Central Water Commission (CWC) plays a key role in this.
    - Flood Plain Zoning: Regulating settlements in flood-prone areas.
    - Flood Proofing: Measures such as raising buildings or constructing barriers.
    - Disaster Preparedness Plans: Integrated solutions involving the government and communities to respond efficiently to floods.

Flood management requires a master plan for each basin. Key strategies include:

- Providing flood-cushioning in reservoirs to prioritize flood control.
- Emphasizing modern forecasting systems and expanding their coverage.
- Establishing stringent regulations on settlements and economic activities in flood-prone zones.

The government has also promoted initiatives like Sponge Cities to improve urban flood management by rejuvenating water bodies and improving rainwater absorption.

Conclusion:

Floods are a recurring disaster in India, requiring a comprehensive approach for control and management. The key lies in both technological advancements like improved forecasting and regulatory measures like flood zoning, along with community preparedness. These combined efforts can mitigate the risks and reduce the economic loss associated with floods in the country.

Overview of Urban Flooding in India

Urban flooding is an inundation of land in built-up areas, where excessive rainfall or drainage system failure overwhelms the capacity of infrastructure to handle the water flow. This type of flooding is a significant issue in densely populated cities, affecting both lives and economic infrastructures.

Causes of Urban Flooding:

Urban flooding can result from various factors, including:

1. Flash Floods: Sudden intense rainfall causing rapid water accumulation.
2. Melting of Snow: Especially in regions near mountainous areas, contributing to excess water flow.
3. Damaged Sewer Systems: Blocked or broken sewer systems that fail to drain water properly.
4. Overflow from Drainage Systems: Storm drains and sewers often lack the capacity to handle large volumes of water during heavy rains.

Exacerbating Factors:

1. Paved Streets and Roads: Urban areas with impermeable surfaces prevent rainwater from infiltrating the ground, leading to higher surface runoff.
2. Urbanization: The expansion of cities often involves encroachment on natural drainage systems, reducing their ability to manage excess water.
3. Improper Waste Disposal: Dumping waste in stormwater drains significantly reduces their capacity to channel rainwater, leading to frequent blockages and overflow.

Urban Flooding in India:

India has experienced severe urban flooding in several major cities, including:

- Mumbai Floods of 2005
- Kolkata Floods of 2007
- Delhi Floods of 2009
- Bangalore Floods of 2015
- Hyderabad Floods of 2020

Flooding reaches its peak during the monsoon, but urban factors such as storm surges, dam water mismanagement, and rapid urbanization have worsened the situation. Climate change further amplifies the problem with increased rainfall intensity and rising sea levels threatening coastal cities.

Key Factors Leading to Urban Flooding:

1. Overwhelmed Drainage Systems: Old or insufficient stormwater systems struggle to cope with high-intensity rainfall.
2. Irregular Urban Planning: Unregulated expansion and encroachment eliminate natural water channels.
3. Solid Waste Dumping: Improper disposal of domestic and industrial waste into drains reduces their capacity to manage excess water.
4. Encroachment on Floodplains: Uncontrolled urbanization has led to the occupation of flood-prone areas, increasing the risk of flooding.

Steps to Mitigate Urban Flooding:

1. Building Away from Floodplains: New constructions should be located away from areas with a high flood risk.
2. Geospatial Analysis: Advanced technology helps identify flood-prone zones to regulate construction and plan drainage systems.
3. Regulating Existing Constructions: Structures in flood-prone zones should be monitored, and steps taken to improve flood resilience.
4. Enhancing Drainage Capacity: Increasing the capacity of stormwater systems and integrating new technology can help manage excess rainfall.
5. Green Infrastructure: Installing features like rain gardens, green roofs, and rainwater harvesting systems in buildings helps absorb excess water, reduces runoff, and stores water for dry seasons.

Government Initiatives:

- Sponge Cities Mission: Encourages cities to absorb and manage rainwater through sustainable urban planning.
- Atal Mission for Rejuvenation and Urban Transformation (AMRUT): Aims to improve urban infrastructure, with a focus on water supply and stormwater drainage systems to prevent urban flooding.

Sponge Cities Mission in India - Need, Significance, and Benefits

The concept of sponge cities has gained prominence, especially in India, due to the rising instances of urban flooding. The term "sponge city" refers to an urban environment designed to manage water efficiently by absorbing, filtering, and reusing rainwater. With the growing impact of climate change, increasing urbanization, and inadequate urban planning, Indian cities like Hyderabad, Chennai, Mumbai, and Gurugram have faced catastrophic floods in recent years. This highlights the urgent need for India to adopt the sponge city model.

What are Sponge Cities?

A sponge city is designed to mimic natural water cycles. It incorporates permeable infrastructure, such as rain gardens, rooftop gardens, and permeable pavements, to absorb rainwater. The collected water can be reused or allowed to recharge aquifers. Additionally, green spaces like parks, ponds, and interconnected waterways act as storage and filtration systems for rainwater, helping to prevent waterlogging, reduce runoff, and improve water quality.

Need for Sponge Cities in India

India is facing recurrent urban flooding, exacerbated by the following factors:

1. Poor land use policies: Construction on wetlands, ponds, and other natural water-absorbing areas reduces the capacity of cities to manage water.
2. Inadequate drainage systems: Most cities lack proper drainage infrastructure, leading to an inefficient waste of rainwater, which is often directed into drains and rivers instead of being absorbed or stored.
3. Rapid urbanization: With growing urban expansion, more impermeable surfaces like concrete are replacing natural ecosystems, reducing water absorption capacity.
4. Climate change: Extreme weather patterns, such as heavy rainfall and storms, are becoming more frequent, intensifying the challenges of urban flooding.

How Sponge Cities Mission in India Can Help

- Water Conservation: Sponge cities capture rainwater, which can be reused for irrigation, flushing, cleaning, and even treated for drinking.
- Aquifer Recharge: By allowing rainwater to infiltrate the soil, sponge cities can replenish urban aquifers, ensuring a sustainable water supply.
- Flood Management: Through the natural retention and slow release of rainwater, sponge cities can mitigate the severity of floods.
- Environmental Benefits: Increased green spaces not only reduce flood risks but also improve air quality, reduce urban heat islands, and enhance biodiversity.

Sponge Cities Mission in India – Way Forward

To address urban flooding, India needs a focused urban policy, like the Sponge Cities Mission, modeled after successful initiatives such as the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and the Smart Cities Mission. Implementing these strategies can help cities become more resilient to climate change while improving overall water management.

Significance of Sponge Cities

1. Water Resource Augmentation: Sponge cities retain rainwater within their boundaries, reducing dependence on external water sources.

2. Flood Prevention: Properly implemented, sponge cities reduce the frequency and severity of urban flooding.
3. Climate Resilience: By managing water effectively, sponge cities lower carbon emissions, help fight climate change, and reduce the urban heat island effect.
4. Improved Quality of Life: Green spaces and better water management enhance the livability of urban areas, benefiting both humans and ecosystems.

Incorporating the sponge city concept into India's urban development strategy is crucial for addressing the increasing threat of floods and making cities more sustainable and resilient. This topic is essential for competitive exams like UPSC as it touches upon issues of urban planning, disaster management, and environmental sustainability. Educating the public about the dangers of settling in flood-prone areas is critical. Building community awareness will help avoid risks associated with low-lying regions and improper urban planning.Urban flooding is an increasingly critical issue that demands comprehensive solutions combining government action, sustainable urban planning, and public awareness. By taking the necessary preventive measures, cities can become more resilient and reduce the economic and human toll of these disasters.

Implementation Strategy in India

- Green Infrastructure: The mission promotes the use of green infrastructure like parks, wetlands, rain gardens, and green roofs to manage stormwater.
- Permeable Surfaces: Roads and pavements are designed to allow water infiltration, reducing runoff.
- Urban Lakes and Wetlands: Restoration and conservation of natural water bodies are critical to improving water retention and biodiversity.
- Community Engagement: Public awareness campaigns and community involvement in local water management are key to ensuring the success of the Sponge Cities Mission.

In summary, the Sponge Cities Mission in India is an essential initiative to address the twin challenges of urban flooding and water scarcity. By integrating nature-based solutions with urban planning, this mission holds promise for creating climate-resilient, sustainable, and livable cities across the country.

Courtesy:https://plutusias.com/sponge-cities/ http:// Byju's .com

Drought crisis and water scarcity in 2022

The severe global drought conditions experienced in 2022, driven by climate change. Drought and extreme heat affected regions across four continents—Asia, Africa, Europe, and North America—worsening water shortages, impacting agriculture, and fueling natural disasters like wildfires and floodsIn **Asia**, India and Pakistan endured intense heat waves in March, exacerbated by climate change, leading to forest fires and glacier melt. In **China**, record droughts caused the Yangtze River to dry up, affecting hydropower, drinking water, and agriculture.**Africa's** Horn region faced its longest drought in 40 years, impacting millions and risking famine in Kenya, Ethiopia, and Somalia. This drought has deepened food insecurity and created severe humanitarian crises. In **Europe**, 2022 was the continent's worst drought in 500 years. Key rivers like the Po and the Danube shrank, damaging crops and water supplies. In **North America**, the U.S. Southwest endured a "megadrought" that pushed reservoirs like Lake Mead and Lake Powell to historic lows, threatening water and power supplies across multiple states. These observations show how rising global temperatures, exacerbated by climate change, intensify drought conditions, threatening ecosystems, human health, and food security. Courtesy: Denise Chow ,NBC news ,2022.**Drought Leads to More Than 200 Deaths in East Africa:** Much of East Africa has been experiencing what the U.N. has called the "worst drought in over forty years," putting millions at risk of starvation. Figures vary, but both local and international officials place the death toll from hunger above 200 in northeastern Uganda alone, Reuters reports. Some estimates place the drought's present toll as high as one life lost every 36 seconds, accounting for data gaps. With crop production halved in certain areas, high levels of malnutrition are expected to persist into 2023, says the European Commission.

Tropical Storm Megi Kills 214 in the Philippines

Tropical Storm Megi struck the Philippines on April 10,2022. Though not the sole storm to batter the islands this year – 20 on average touch the country annually – Megi was this year's most destructive, with at least 214 deaths attributed to it, according to the country's Natural Disaster Risk and Management Council.

GeoChronicle Panorama, Vol. 2, No.1, December 2022 pp.50-64
Earthquake havocs

A magnitude-5.6 earthquake shook the town of Cianjur in western Indonesia on Nov. 21, killing at least 334 people, according to the most recent estimates. Due to its position in the Pacific "Ring of Fire," where tectonic collisions are common, earthquakes are frequent in Indonesia. **Earthquake in Afghanistan Kills at Least 1,036:**On June 21, a magnitude-5.9 earthquake struck eastern Afghanistan, causing landslides, destroying thousands of homes and killing an estimated 1,036 people, according to the UN. The earthquake, the deadliest in decades in Afghanistan, adds to a litany of challenges – from social strife to hunger – that have plagued the country since the fall of Kabul to the Taliban last year.

Manipur Landslide

A large landslide occurred in Noney district of the Indian state of Manipur near the Tupul railway construction site in the night of 30 June 2022. It killed 58 people and three people were missing. Eighteen people were injured. Twenty-nine Indian Army personnel and 29 civilians were among the deceased. The initial eight confirmed fatalities were members of the Territorial Army. The group acted as security personnel for a railroad construction that would connect Jiribam railway station to Manipur's capital city Imphal. The landslide occurred near the Ijei river where it created a dam. The landslide was attributed to weak soil due to prolonged exposure, rain and human factors. **Experts** at Manipur University said that nearly all landslides in the region have been caused by the poor lithology—fractured rocks, steep slopes and unstable mass were contributing factors. It was likely that the water-clogged soil liquefied and destabilized, causing the landslide.

- **Recent Discovery of Palm fossils proves Himalayas rose from Tethys Sea**

  Ritesh Arya shows the 4-ft fossil that reinforces the theory that the Himalayas rose out of the Tethys Sea

Noted geologist Ritesh Arya has discovered a 20 million-year-old, four-foot-long fossil of palm leaves from the fragile rocks of Ladakh — a finding that reinforces the theory that the towering peaks of Himalayas have emerged from the Tethys ocean. The reason behind believing the Tethys ocean theory, Arya said, was because the present-day Himalayas were not formed 20 million years ago. Arya has discovered the fossil with two large leaves on a fragile rock surface. He said the fossil would have to be protected as it represented the near-coastal environment of Ladakh millions of years ago. He said this plant was not found anywhere in the Himalayas. "The fossil has been found from the Tethyan sediments of Ladakh, when I was searching for specimens for a geological museum and laboratory that I have established a few days ago at a school in Ladakh. Tethys was once separating India from Tibet in geological history till 20 million years ago. The presence of fossils of palm from the sediments of Indus molasse in Ladakh clearly shows Ladakh Himalayas were once below the sea. Probably the area till sediments from where the fossils were found were below the sea. Palm fossils represent near-coastal environment," said Arya. Arya added the large size of the actual specimens of fossils showed that conditions at the time of deposition would have been hot and humid, similar to equatorial climatic conditions. Coutresy: Tribune News Service.

Drone-based surveys of mineral deposits

The rising demand for raw materials, such as rare earth elements and lithium, makes the exploration and extraction of mineral deposits critical. Identification of Earth's hidden treasures is becoming increasingly difficult, owing to the continued depletion of easily accessible deposits and the social stigma surrounding mining activities. Efficient methods that minimise invasive and costly drilling are key for the discovery of potentially profitable mineral resources. However, a gap in observation scales remains. Traditional ground-based surveys (such as rock and soil sampling), although detailed, can only cover some 15–30 kilometres per day, and large-scale mapping via helicopter, plane and satellite fails to provide sufficient resolution to efficiently map small-scale (<1 km2) geological features.

Drones present the perfect trade-off between coverage and scale of observation, and are essential when ground access is impossible, dangerous or logistically costly. Drones can carry lightweight sensors that, for example, capture changes in the Earth's magnetic field as well as a continuous spectrum of reflected sunlight in the visible and near-infrared regions (hyperspectral imaging). Subtle variations in the measured properties can be used to determine the abundance and composition of key minerals at Earth's surface. For example, specific spectral absorption features and magnetic anomalies could indicate the presence of iron alteration related to mineralisation. The hyperspectral and magnetic data collected by the drones can be used alongside high-resolution true-colour cameras or laser-scanning sensors to place

mineral deposits into a 3D geographical context. Therefore, economic mineral deposits can be identified down to depths of several hundred meters.

Drones are becoming important tools for mineral exploration by contributing to the safe, efficient and sustainable provision of the high-tech metals that are required by modern society. For example, drone- based hyperspectral imaging has been used to rapidly map rare-earth-element-rich minerals in Namibia. In addition, in Greenland, drone-based magnetic surveys were deployed to identify sub- surface ore potential at a fraction of the cost of traditional surveys. Drones have the potential to provide non-invasive and eco-friendly platforms from which the environmental impact of exploration and mining activities (such as soil erosion, acid mine drainage and vegetation stress) can be assessed.

Courtesy Robert Jackisch,2020, Nature Reviews Earth and Environment ,Vol.1,P. 187

Voyager 2 finds extra layer outside solar system

Nasa's Voyager 2 probe exited our solar system nearly a year ago, becoming the second spacecraft to ever enter interstellar space.It followed six years behind its sister spacecraft, Voyager 1, which reached the limits of the solar system in 2012. But a plasma-measuring instrument on Voyager had been damaged, so that probe could not gather crucial data about the transition from our solar system into interstellar space. Voyager 2 completed the set of data. Scientists shared their findings , via five papers published in 'Nature Astronomy'.

The analyses indicate that there are mysterious extra layers between our solar system's bubble and interstellar space. Voyager 2 detected winds — flows of charged gas particles that come from the sun — leaking from the solar system. Just beyond the solar system's edge, these solar winds interact with interstellar winds: gas, dust, and charged particles flowing through space from supernova explosion millions of years ago.

The new boundary layers suggest there are stages in the transition from our solar bubble to the space beyond that scientists did not previously understand.

On November 5, 2018, Voyager 2 left what's known as the "heliosphere", a giant bubble of charged particles flowing out from the sun that sheathes our solar system. In doing so, the probe crossed a boundary area called the "heliopause". In that area, the edge of our solar system's bubble, solar winds meet a flow of interstellar wind and fold back on themselves.

Both Voyager probes measured changes in the intensity of cosmic rays as they crossed the heliopause, along with the transition between magnetic fields inside and outside the bubble. But because so much of the transition from our solar system to the space beyond is marked by changes in plasma (a hot ionized gas that's the most abundant state of matter in the universe), Voyager 1's damaged instrument had difficulty measuring it .Now, the new measurements from Voyager 2 indicate that the boundaries between our solar system and interstellar space may not be as simple as once thought. Nasa's Voyager 2 probe exited our solar system nearly a year ago, becoming the second spacecraft to ever enter interstellar space.

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Indian scientists discover 28 new Milky Way stars

A team of scientists at Aryabhatta Research Institute of Observational Sciences (ARIES) in Nainital has identified 28 new variable stars in the halo or outer part of the Milky Way galaxy, nearly 60,000 light years away in the constellation Coma Berenices, visible in the northern night sky.

The brightness of variable stars fluctuates with time due to change in emitted light, with the periodic swelling and shrinking of stars changing the quantum of light reaching earth. A team of scientists at Aryabhatta Research Institute of Observational Sciences (ARIES) in Nainital has identified 28 new variable stars in the halo or outer part of the Milky Way galaxy, nearly 60,000 light years away in the constellation Coma Berenices, visible in the northern night sky. The brightness of variable stars fluctuates with time due to change in emitted light, with the periodic swelling and shrinking of stars changing the quantum of light reaching earth. Using a powerful 3.6-metre optical telescope, the Devasthal Optical Telescope (DOT), the scientists conducted photometric observations to discover the stars.

The stars were found in globular cluster NGC 4147; a globular cluster is a large but compact cluster of stars around a galactic core and is spherical in shape. Typically a globular cluster has very old stars. The detailed findings are to be published in next month's Astronomical Journal. The findings were published on May 20 on arXiv, a respected and well-used online archive for research. The DOT telescope has made it possible to study the magnetic field structure of stars and the evolution of the Milky Way, and search for extra solar planets and stars in the outer region and the halo of the Milky Way. "The halo of a galaxy is a nearly spherical region surrounding the galaxy like diffuse light when seen from a distance. Only about 1% of a galaxy's mass resides in its halo area, and coupled with low brightness, the observation of stars in halos is very difficult. This is why our finding holds much significance. Also, due to the old age of stars in the halo area of our galaxy, studying stars in this area helps scientists to figure out the evolutionary history of the Milky Way," said Sneh Lata, a scientist at ARIES who worked on the project. "We are proud of our team for making this discovery," said Wahab Uddin, director, ARIES.

ARIES, located on a hill near Nainital, conducts research on solar, planetary, stellar, galactic and extragalactic astronomy. The first successful Indian optical observation of the afterglow of the gamma-ray burst was carried out from ARIES in 1999

.Courtesy: neeraj Santoshi, Hindustan Times

Earth's Magnetic Field Could Change 10 Times Faster Than We Thought, Scientists Say Magnetic field shields us from harmful radiation and helps keep atmosphere in place, as well as being key to navigation. The Earth's magnetic field could change 10 times faster than previous thought, scientists have said. **Using computer simulation of the iron deep beneath our feet that influences how the magnetic field appears to us, they showed that it could move around much more quickly than we had realised.**

The discovery could have important implications for our understanding of some of the most fundamental processes that power life on Earth: the magnetic field is not only used in compasses and for navigation, but helps protect us from radiation coming from space and keeps our atmosphere in place.

The magnetic field is generated and regulated by a swirling flow of molten metal that creates the Earth's outer core. As the liquid iron moves around, it creates electric currents that power the magnetic field that is used on the surface.

Scientists are nowadays able to measure and track the changes as the flowing iron move around and alter the field, using satellites and other technology. But it is more difficult to understand its movements in the past, since it changes on a much longer time-scale than our relatively very recent technology. Earth's magnetic field weakening, causing chaos for satellites. Attempts to understand the change through history has relied on much more imperfect data, such as using both natural and human-made evidence to make inferences about the magnetic fields through its long history. But that remains difficult and the accuracy of those techniques is disputed.

The new study instead used computer simulations to understand how the field could be generated, and gave it data that shows how the Earth's magnetic field may have changed over the last 10,000 years.

Courtesy : Andrew Griffin

How did the chemical makeup of our planet's core shape its geologic history andhabitability?

Life as we know it could not exist without Earth's magnetic field and its ability to deflect dangerous ionizing particles from the solar wind and more far-flung cosmic rays. It is continuously generated by the motion of liquid iron in Earth's outer core, a phenomenon called the geodynamo.

Despite its fundamental importance, many questions remain unanswered about the geodynamo's origin and the energy sources that have sustained it over the millennia.

New work from an international team of researchers, including current and former Carnegie scientists Alexander Goncharov, Nicholas Holtgrewe, Sergey Lobanov, and Irina Chuvashova examines how the presence of lighter elements in the predominately iron core could affect the geodynamo's genesis and sustainability. Their findings are published by Nature Communications.

Our planet accreted from the disk of dust and gas that surrounded our Sun in its youth. Eventually, the densest material sank inward in the forming planet, creating the layers that exist today -- core, mantle, and crust. Although, the core is predominately iron, seismic data indicates that some lighter elements like oxygen, silicon, sulfur, carbon, and hydrogen, were dissolved into it during the differentiation process.

Over time, the inner core crystallized and has been continuously cooling since then. On its own, could heat flowing out of the core and into the mantle drive the geodynamo? Or does this thermal convection need an extra boost from the buoyancy of light elements, not just heat, moving out of a condensing inner core?

Understanding the specifics of the core's chemical composition can help answer this question.

Silicates are predominant in the mantle, and after oxygen and iron, silicon is the third-most-abundant element in the Earth, so it is a likely option for one of the main lighter elements that could be alloyed with iron in the core. Led by Wen-Pin Hsieh of Academia Sinica and National Taiwan University, the researchers used lab-based mimicry of deep Earth conditions to simulate how the presence of silicon would affect the transmission of heat from the planet's iron core out into the mantle.

"The less thermally conductive the core material is, the lower the threshold needed to generate the geodynamo," Goncharov explained. "With a low enough threshold, the heat flux out of the core could be driven entirely by the thermal convection, with no need for the additional movement of material to make it work."The team found that a concentration of about 8 weight percent silicon in their simulated inner core, the geodynamo could have functioned on heat transmission alone for the planet's entire history.Looking forward, they want to expand their efforts to understand how the presence of oxygen, sulfur, and carbon in the core would influence this convection process.The authors were supported by the Academia Sinica, the Ministry of Science and Technology of Taiwan, the National Natural Science Foundation of China, the Foundation for the Advancement of Outstanding Scholarship, the Chinese Academy of Science, the U.S. National Science Foundation, the Army Research Office, the Deep Carbon Observatory, and the Helmholtz Young Investigators Group.

Source: Wen-Pin Hsieh, Alexander F. Goncharov, Stéphane Labrosse, Nicholas Holtgrewe, Sergey S. Lobanov, Irina Chuvashova, Frédéric Deschamps, Jung-Fu Lin. Low thermal conductivity of iron-silicon alloys at Earth's core conditions with implications for the geodynamo. Nature Communications, 2020; 11 (1)

Geoscientists create deeper look at processes below Earth's surface with 3D images

Geoscientists at The University of Texas at Dallas recently used massive amounts of earthquake data and supercomputers to generate high-resolution, 3D images of the dynamic geological processes taking place far below the Earth's surface.

In a study published April 29 in Nature Communications, the UT Dallas research team described how it created images of mantle flows in a subduction region under Central America and the Caribbean Sea using a computationally intensive technique called a full waveform inversion (FWI).

"This is the first comprehensive seismic study to directly image 3D mantle flow fields in actual subduction environments using advanced FWI technology," said Dr. Hejun Zhu, corresponding author of the study and assistant professor of geosciences in the School of Natural Sciences and Mathematics. Dr. Jidong Yang, who earned his PhD in geosciences from UT Dallas in May, and Dr. Robert Stern, professor of geosciences, are the study's co-authors.

Dynamic Earth

Between the relatively thin layer of the Earth's crust and its inner core lies the thickest part of the planet, themantle. Over short time periods, the mantle can be considered solid rock, but on the geological time scale of millions of years, the mantle flows like a viscous fluid.

Earth's crust is broken into pieces called tectonic plates. These plates move across and into the mantle very slowly -- about as fast as fingernails grow. At regions called subduction zones, one plate descends under another into the mantle.

"The sinking of oceanic plates into the Earth's mantle at subduction zones is what causes the Earth's tectonic plates to move and is one of the most important processes taking place in our planet," Zhu said. "Subduction zones are also the source of many natural hazards, such as earthquakes, volcanoes and tsunamis. But the pattern of mantle flow and deformation around descending plates is still poorly understood. The information our techniques yield is crucial for understanding our dynamic planet."

Data-Intensive Research

Zhu and his colleagues tackled the problem using a geophysical measurement called seismic anisotropy, which measures the difference in how fast mechanical waves generated by earthquakes travel in different directions inside the Earth. Seismic anisotropy can reveal how the mantle moves around the subducting plate. Similar technology is also used by the energy industry to locate oil and gas resources.

"When a diver dives into water, the water separates, and that separation in turn affects the way the water moves around the swimmer," Zhu said. "It's similar with oceanic plates: When they dive into hot mantle, that action induces mantle separation and flow around the plates."

The research team created the images using high-fidelity data recorded over a 10-year period from 180 earthquakes by some 4,500 seismic stations located in a grid across the U.S. The numerical calculations for the FWI algorithm were performed on

the high-performance computing clusters at the National Science Foundation (NSF)-supported Texas Advanced Computing Center at UT Austin, as well as on supercomputers at UT Dallas.

"Previously we couldn't 'see' under the Earth's surface, but by using this technology and this very wonderful data set, we are able to delineate the 3D distribution of various seismic phenomena and tell at what depths they are occurring," Zhu said.

Gone to Pieces

The images confirmed that the plates in the study region are not large, solid pieces but rather are fragmented into smaller slabs.

"This looks different from the textbook depictions of tectonic plates coming together, with one solid piece of oceanic plate descending under another solid piece," Zhu said. "Some researchers have hypothesized that this fragmentation occurs, and our imaging and modeling provides evidence that supports that view."Zhu's 3D model shows complex mantle flow patterns around a number of descending fragments and in the gaps between slabs. Such chunky, fragmented pieces are seen in regions throughout the world, Zhu said.In the northwestern U.S., for example, the Juan de Fuca Plate is also fragmented into two pieces where it descends under the North American Plate in the Cascadia subduction zone, an area where strong earthquakes have occurred over the centuries."We know that most earthquakes happen at the interface between a slab and the mantle. If there is a gap between these fragments, what's called a window region, you wouldn't expect earthquakes there," Zhu said. "If you look at the earthquake distribution along the Cascadia subduction zone, there is a span where you do not have earthquakes. That is probably a region where there is a gap in the subducting oceanic plate."The Middle America Trench that we studied has its own unique, dynamic properties. In the future, we plan to shift our attention to other subduction zones, including the Kermadec-Tonga subduction zone in the region of the Australian and Pacific plates."The research was funded by a grant to Zhu from the NSF's Division of Earth Sciences.Courtesy: Amanda Siegfried,NSF Division of Earth Sciences.

Producing ammonia with a much smaller carbon footprint (Innovative Research on air pollution, 2020)

Ammonia is the second most commonly produced chemical in the world and an important component of most fertilizers, but current industrial processes to make ammonia produce several millions of tons of carbon dioxide-a potent greenhouse gas-each year.

Now, researchers led by Meenesh Singh, assistant professor of chemical engineering at the University of Illinois Chicago College Of Engineering, describe a new process to produce ammonia with a potentially much lower carbon footprint. They report their findings in the journal ACS Catalysis.

Nitrogen gas is one of the components used to make ammonia, but because nitrogen bonds in nitrogen gas are very stable, a lot of energy is needed to break them so the nitrogen can bind to hydrogen to produce ammonia.

"Current methods to make ammonia from nitrogen are very energy-intensive and require the burning of fossil fuels to generate enormous amounts of heat, and this produces a lot of greenhouse gas as a byproduct," said Singh.

Singh and colleagues have developed a new method to produce ammonia that relies on the use of a mesh screen coated in copper -- a catalyst that helps bind nitrogen to hydrogen to make ammonia. The electrification of the screen helps drive the reactions. Pure nitrogen gas is pushed through the screen and then interacts with water, which provides the hydrogen. Even though Singh's process uses similar amounts of energy compared to the traditional process, it requires far less fossil fuels than traditional methods -- just enough to electrify the screen. "The electricity can come from solar or wind energy, which would really make a huge difference in reducing greenhouse gas emissions," said Singh. "Even modern electricity-generating power plants are highly efficient, and if the grid is powered conventionally, our process still uses less fossil fuels and generates less harmful greenhouse gases than conventional ammonia production."Currently, Singh's process produces 20% ammonia and 80 percent hydrogen gas. "We are hoping to increase the production of ammonia, but our early efforts so far are promising, and the savings in the carbon emissions are still significant if you were to scale up our process to produce large amounts of ammonia," **A provisional patent for the new process has been filed by the UIC Office of Technology Management.**Singh's group is now looking at using air -- instead of purified nitrogen gas -- as a source of nitrogen for producing ammonia using their unique method. "Using air would give us even more savings when it comes

to greenhouse gases because we're using readily available air instead of nitrogen gas, which needs to be purified and bottled."Courtesy Sharon Parmet.

Global methane emissions soar to record high

Global emissions of methane have reached the highest levels on record. Increases are being driven primarily by growth of emissions from coal mining, oil and natural gas production, cattle and sheep ranching, and landfills.Between 2000 and 2017, levels of the potent greenhouse gas barreled up toward pathways that climate models suggest will lead to 3-4 degrees Celsius of warming before the end of this century. This is a dangerous temperature threshold at which scientists warn that natural disasters, including wildfires, droughts and floods, and social disruptions such as famines and mass migrations become almost commonplace. The findings are outlined in two papers published July 14 in Earth System Science Data and Environmental Research Letters by researchers with the Global Carbon Project, an initiative led by Stanford University scientist Rob Jackson.

In 2017, the last year when complete global methane data are available, Earth's atmosphere absorbed nearly 600 million tons of the colorless, odorless gas that is 28 times more powerful than carbon dioxide at trapping heat over a 100-year span. More than half of all methane emissions now come from human activities. Annual methane emissions are up 9 percent, or 50 million tons per year, from the early 2000s, when methane concentrations in the atmosphere were relatively stable.

In terms of warming potential, adding this much extra methane to the atmosphere since 2000 is akin to putting 350 million more cars on the world's roads or doubling the total emissions of Germany or France. "We still haven't turned the corner on methane," said Jackson, a professor of Earth system science in Stanford's School of Earth, Energy & Environmental Sciences (Stanford Earth).

Emissions around the globe

Methane emissions rose most sharply in Africa and the Middle East; China; and South Asia and Oceania, which includes Australia and many Pacific islands. Each of these three regions increased emissions by an estimated 10 to 15 million tons per year during the study period. The United States followed close behind, increasing methane emissions by 4.5 million tons, mostly due to more natural gas drilling, distribution and consumption."Natural gas use is rising quickly here in the U.S. and globally," Jackson said. "It's offsetting coal in the electricity sector and reducing carbon dioxide emissions, but increasing methane emissions in that sector." The U.S. and Canada are also producing more natural gas. "As a result, we're emitting more methane from oil and gas wells and leaky pipelines," said Jackson, who is also a senior fellow at Stanford's Woods Institute for the Environment and Precourt Institute for Energy.Europe stands out as the only region where methane emissions have decreased over the last two decades, in part by tamping down emissions from chemical manufacturing and growing food more efficiently. "Policies and better management have reduced emissions from landfills, manure and other sources here in Europe. People are also eating less beef and more poultry and fish," said Marielle Saunois of the Université de Versailles Saint-Quentin in France, lead author of the paper in Earth System Science Data.

Possible solutions

Tropical and temperate regions have seen the biggest jump in methane emissions. Boreal and polar systems have played a lesser role. Despite fears that melting in the Arctic may unlock a burst of methane from thawing permafrost, the researchers found no evidence for increasing methane emissions in the Arctic -- at least through 2017.Human driven emissions are in many ways easier to pin down than those from natural sources. "We have a surprisingly difficult time identifying where methane is emitted in the tropics and elsewhere because of daily to seasonal changes in how waterlogged soils are," said Jackson, who also leads a group at Stanford working to map wetlands and waterlogged soils worldwide using satellites, flux towers and other tools.According to Jackson and colleagues, curbing methane emissions will require reducing fossil fuel use and controlling fugitive emissions such as leaks from pipelines and wells, as well as changes to the way we feed cattle, grow rice and eat. "We'll need to eat less meat and reduce emissions associated with cattle and rice farming," Jackson said, "and replace oil and natural gas in our cars and homes."Feed supplements such as algae may help to reduce methane burps from cows, and rice farming can transition away from permanent waterlogging that maximizes methane production in low-oxygen environments. Aircraft, drones and satellites show promise for monitoring methane from oil and gas wells. Jackson said, "I'm optimistic that, in the next five years, we'll make real progress in that area."Rob Jackson is Stanford's Michelle and Kevin Douglas Provostial Professor. Co-authors of the paper in *Environmental Research Letters* are affiliated with Laboratoire des Sciences du Climat et de environment. at Universite Paris-Saclay; the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Canberra,

Australia; the NASA Goddard Space Flight Center; the European Commission Joint Research Centre; the Center for Global Environmental Research at the National Institute for Environmental Studies and the Meteorological Research Institute in Ibaraki, Japan; the TNO Department of Climate Air & Sustainability in Utrecht, The Netherlands; and the Finnish Meteorological Institute in Helsinki, Finland. The research received support from the Gordon and Betty Moore Foundation, Stanford University, the Australian Government's National Environmental Science Programme's Earth Systems and Climate Change Hub (JGC) and Future Earth Courtesy: Josie Garthwaite

Extreme warming of the South Pole

The South Pole has been warming at more than three times the global average over the past 30 years, according to research led by Ohio University professor Ryan Fogt and OHIO alumnus Kyle Clem.

Fogt, professor of meteorology and director of the Scalia Laboratory for Atmospheric Analysis, and Clem coauthored a paper with an international team of scientists published in the journal Nature Climate Change on the findings. According to the study, this warming period was mainly driven by natural tropical climate variability and was likely intensified by increases in greenhouse gas.Clem, a current postdoctoral research fellow in climate science at Victoria University of Wellington in New Zealand, is the lead author of the study and studied under Fogt for both his bachelor's and master's degrees at Ohio University."I've had a passion for understanding the weather and fascination of its power and unpredictability as far back as I can remember," Clem said. "Working with Ryan I learned all about Antarctic and Southern Hemisphere climate, specifically how West Antarctica was warming and its ice sheet was thinning and contributing to global sea level rise. I also learned that Antarctica experiences some of the most extreme weather and variability on the planet, and due to its remote location we actually know very little about the continent, so there are constant surprises and new things to learn about Antarctica every year."The Antarctic climate exhibits some of the largest ranges in temperature during the course of the year, and some of the largest temperature trends on the planet, with strong regional contrasts. Most of West Antarctica and the Antarctic Peninsula experienced warming and ice-sheet thinning during the late 20th century. By contrast, the South Pole -- located in the remote and high-altitude continental interior -- cooled until the 1980s and has since warmed substantially. These trends are affected by natural and anthropogenic climate change, but the individual contribution of each factor is not well understood.Clem and his team analyzed weather station data at the South Pole, as well as climate models to examine the warming in the Antarctic interior. They found that between 1989 and 2018, the South Pole had warmed by about 1.8 degrees Celsius over the past 30 years at a rate of +0.6 degrees Celcius per decade -- three times the global average.The study also found that the strong warming over the Antarctic interior in the last 30 years was mainly driven by the tropics, especially warm ocean temperatures in the western tropical Pacific Ocean that changed the winds in the South Atlantic near Antarctica and increased the delivery of warm air to the South Pole. They suggest these atmospheric changes along Antarctica's coast are an important mechanism driving climate anomalies in its interior.Clem and Fogt argue that these warming trends were unlikely the result of natural climate change alone, emphasizing the effects of added anthropogenic warming on top of the large tropical climate signal on Antarctic climate have worked in tandem to make this one of the strongest warming trends worldwide."From the very beginning, Kyle and I worked very well together and were able to accomplish more as a team than we were individually," Fogt said. "We have published every year together since 2013, with one of our continuing collaborations being the annual State of the Climate reports. Our work on this project together each year ultimately led to this publication documenting the warming at the South Pole, however, most importantly for me, apart from being a fantastic scientist and collaborator, my family and I are both honored to consider Kyle one of our closest friends."

Courtesy: Ryan Fogt,Ohio University,2020
Super Typhoon “GONI”(2020)

A super typhoon has barrelled into the eastern Philippines on 1st November 2020 bringing “catastrophic” winds and intense rains as hundreds of thousands of people (nearly 10 lakhs) were evacuated along its projected path including the capital, Manila. Officials said at least 10 people had been killed, nine of them in the hard-hit province of Albay. Al Francis Bichara, the governor of Albay, said the dead included a father and son who were in a rural community hit by mudflows and boulders swept down from Mayon Volcano by heavy rains.Villagers fled to safety as the typhoon approached, but the two apparently stayed put, he said. “The child was found 15km (9 miles) away,” Bichara told DZMM radio.Al Francis Bichara, the governor of Albay, said the dead included a father and son who were in a rural community hit by mudflows and boulders swept down from Mayon Volcano by heavy rains.Villagers fled to safety as the typhoon approached, but the two apparently stayed put, he said. “The child was found 15km (9 miles) away,” Bichara told DZMM radio.

One of the most powerful typhoons in the world this year, Goni has evoked memories of Typhoon Haiyan in November 2013, which left more than 7,300 people dead and missing, flattened entire villages, swept ships inland and displaced more than five million in the central Philippines.. "We're expecting major damage." Typhoon Goni hit the island province of Catanduanes at dawn with sustained winds of 225 kilometres (140 miles) per hour and gusts of 280 kph (174 mph) – equivalent to a Category-5 hurricane – but weakened later in the day as it traversed the main island of Luzon. "Within the next 12 hours, catastrophic violent winds and intense to torrential rainfall associated with the region of the eyewall and inner rain bands of the typhoon will be experienced," the Philippine weather agency said in an urgent advisory.It said Catanduanes and four other provinces will be the first hit, including Albay, where tens of thousands of villagers have been moved to safety, especially near the active Mayon volcano, where mudflows have caused deaths during past storms. Residents have been warned of likely landslides, significant flooding, storm surges of more than five meters (16 feet) and ferocious wind that can blow away shanties.

Between 19 million and 31 million people could be affected, including those in danger zones, the disaster management agency said.

Residents living along a coastal community evacuate in Manila, Philippines on Sunday, November 1, 2020 .The winds are fierce. We can hear the trees being pummelled. It's very strong," Francia Mae Borras, 21, told the AFP news agency from her home in the coastal city of Legazpi in Albay province.The roofs of two evacuation centres were ripped off by the force of the wind and the occupants movedto the ground floors, Albay provincial public safety chief Cedric Daep told DZBB radio station.**Super Cyclone Amphan** (2020) Highlights: Amphan leaves trails of destruction in India and Bangladesh. **Super Cyclonic Storm Amphan** was a powerful and catastrophic tropical cyclone that caused widespread damage in Eastern India, specifically West Bengal, and also Bangladesh on **20th May 2020**. It was the strongest tropical cyclone to strike the Ganges Delta since Sidr of the 2007 seasonand the first super cyclonic storm to have formed in the Bay of Bengal since the 1999 Odisha super cyclone. It was also the fourth super cyclone that hit West Bengal since 1582, 1737, 1833 and 1942, as well as being one of the strongest storm to impact the area. Causing over US$13 billion of damage, Amphan is also the costliest cyclone ever recorded in the North Indian Ocean, surpassing the record held by Cyclone Nargis of 2008.The first tropical cyclone of the 2020 North Indian Ocean cyclone season, Amphan originated from a low-pressure area persisting a couple hundred miles (300 km) east of Colombo, Sri Lanka, on 13 May 2020. Tracking northeastward, the disturbance organized over exceptionally warm sea surface temperatures; the Joint Typhoon Warning Center (JTWC) upgraded the system to a tropical depression on 15 May while the Indian Meteorological Department (IMD) followed suit the following day. On 17 May, Amphan underwent rapid intensification and became an extremely severe cyclonic storm within 12 hours.Thus ,Amphan made landfall near Bakkhali in West Bengal at 2:30 p.m. IST on 20 May, buffeting the region with strong winds and heavy rains.Coastal areas in West Bengal comprising East Midnapur, North 24 Parganas, South 24 Parganas, Kolkata, Hooghly and Howrah as well as Odisha were affected by the cyclone. It also caused significant destruction in Bangladesh.The cyclone has claimed at least 106 lives, leaving a trail of destruction in WB, Odisha and Bangladesh. PM Modi surveyed affected regions in West Bengal and Odisha, and announced Rs 1,000 crore assistance to West Bengal and Rs 500 crore assistance to Odisha. The cyclone weakened into a deep depression and caused rainfall and winds in NE states. Around 6.58 lakh people have evacuated in Bengal and Odisha. The meteorological department chief said that a slight delay in the onset of monsoon in Kerala can be expected as a result of Amphan and will arrive on Kerala's coast on June 5.

Lessons from cyclones Amphan and Nisarga for India's disaster management plan

Impacts of two tropical cyclones, Nisarga in Maharashtra and Gujarat and Amphan in West Bengal and Odisha, have reinforced the urgency of climate adaptation and building resilience into urban and environmental planning for coastal megacities. The two states and their respective capitals – Mumbai and Kolkata – are currently grappling with overlapping disasters – extreme weather events and Covid- 19, against the backdrop of environmental degradation with choking rivers and wetlands and mangroves that buffer from cyclones shrinking due to urbanisation and expansion. Exposed to rising sea levels and high population density, the low-lying cities are prone to flooding during the monsoon which has set in.

The revised height of World's highest peak, Mount Evererestis 8,848.86 mts: Nepaland

China say jointly.

The revised height of Mount Everest is 8,848.86 meters (29,032 feet), announces Nepal and China on 8th December 2020 after joint measurement of the world's highest peak. "8848.86 metres is the newly-measured height of Mount Everest," said Nepal's Foreign Minister.The Nepal government decided to measure the exact height of the mountain amid debates that there might have been a change in its height due to various reasons, including the devastating earthquake of 2015. According to the earlier measurement done in 1954 by Survey of India, the height of Mt. Everest was 8,848 meters The department had started measuring the height of the Everest two years ago.

Compilation and revamping

Dr.B.Mishra