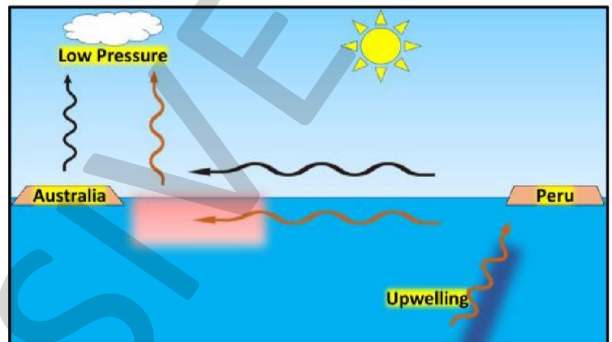
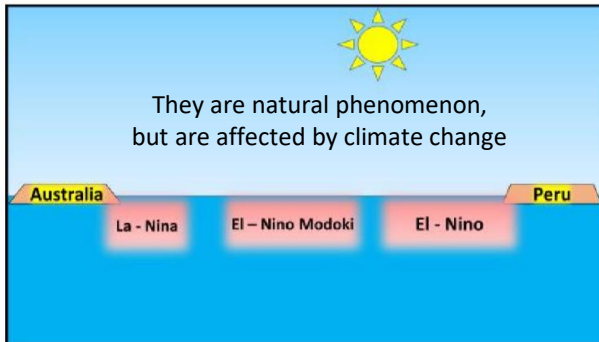




**Triple dip La Nina**

Also see class-4 page-51

- La Nina for 3 consecutive years
- It recently occurred during 2020-2022
- It is the first TDLN of 21<sup>st</sup> century, and third since 1950.
- It temporarily slowed down global warming, but it cannot stop global warming in long term.



- ❑ La Nina is called as cold phase of ENSO
- ❑ El Nino is called as warm phase of ENSO

**La Nina**

large-scale cooling of ocean surface temperature in central & eastern equatorial Pacific Ocean. Impact:

- More rain in SE Asia & Australasia
- Less rain in Africa & USA

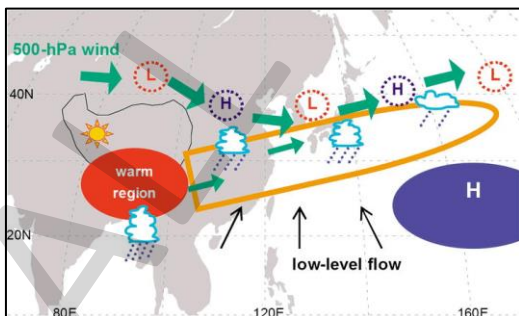
**El Nino and La Nina**

- El Nino is more frequent than La Nina
- But there is no fixed schedule
- They usually occur in 2-7 years and usually last for 9-12 months

**Meiyu front**

**Meiyu front / baiu front**

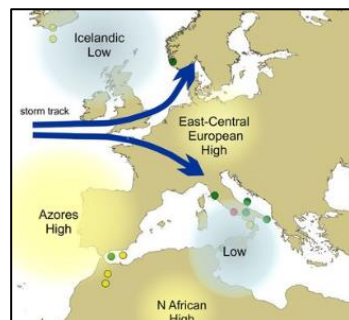
- ❑ It is an almost stationary weather front on east coast of China
- ❑ Its active phase reduces rain in India, increases rain in China



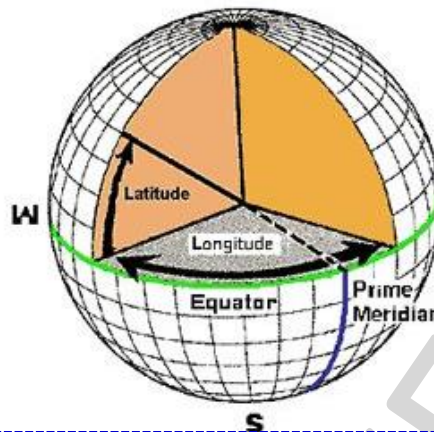
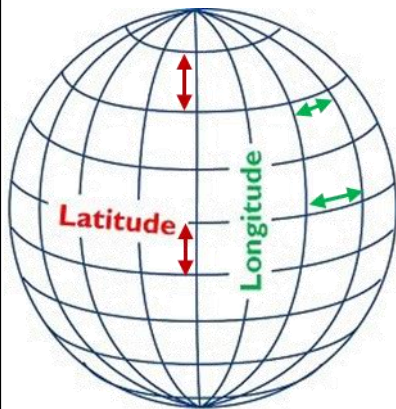
**Azores High**

**Azores high / Bermuda high**

- ❑ high-pressure in subtropical region of eastern North Atlantic Ocean
- ❑ It creates extremely dry winter in eastern Mediterranean area (Iberian peninsula)



## Geographic coordinate system



Trick to remember:  
 Longitude : लाइन लॉग है  
 Latitude : लाइन लेट गई है

- ❖ **Longitude** is angular distance from prime meridian
- ❖ **Latitude** is angular distance from equator

- Salinity is affected by change in Latitude
- Tropical areas are hotter than polar areas due to change in Latitude

**If Superman covers a particular latitude within a few seconds, what will he notice more?**

- ✓ Difference between day and night
- X Difference between warm and cold



**If Superman covers a particular longitude within a few seconds, what will he notice more?**

- X Difference between day and night
- ✓ Difference between warm and cold

Latitudes	Longitudes (Meridians)
They run in East-West direction	They run in North-South direction
They measure distance in North-South direction from 90°N → 0 → 90°S	They measure distance in East-West direction from 180°W → 0 → 180°E
They are of different length	They are of equal length
Distance between latitudes remains same everywhere (111 km between consecutive latitudes)	Distance between longitudes decreases towards poles (111 km at equator, zero km at poles)

### Prelims 1995

The standard time of following countries is ahead of or behind GMT depending on whether they are East or West of the longitude passing through Greenwich.  
 (1) Cuba (2) Greece (3) Iraq (4) Costa Rica (5) Japan  
 Which one of the following sequential orders gives the correct arrangement of the countries according to their standard time from ahead to behind GMT?  
 (a) 5, 3, 2, 1, 4 (b) 2, 4, 1, 3, 5 (c) 4, 1, 3, 2, 5 (d) 3, 5, 4, 1, 2

### Prelims 2008

Which one of the following Straits is nearest to the International Date Line?  
 (a) Malacca Strait  
 (b) Bering Strait  
 (c) Strait of Florida  
 (d) Strait of Gibraltar

### Prelims 1993

Time of which of the following places is equal to the time of GMT  
 1. Accra                      2. Dublin  
 3. Madrid                     4. Lisbon  
 Use the code below to select the correct answer:  
 (a) 1, 2 and 3                (b) 1, 3 and 4  
 (c) 1, 2 and 4                (d) 2, 3 and 4  
 Madrid has UTC+1

### Prelims 2007

Which one of the following cities does not have the same clock time as that of the other three Cities at any given instant?  
 (a) London (UK)  
 (b) Lisbon (Portugal)  
 (c) Accra (Ghana)  
 (d) Addis Ababa (Ethiopia)  
 Addis Ababa UTC+3

### Prelims 1994

A plane starts flying from 30° northern latitude and 50° eastern longitude and lands at the opposite end of the earth, where will it land  
 (a) 30° Northern latitude, 50° Western longitude                (b) 30° Southern latitude, 50° Western longitude  
 (c) 50° Northern latitude, 30° Western longitude                (d) 30° Southern latitude, 130° Western longitude

**I read I forget, I see I remember** | See explanation of this PDF on **YouTube** [www.youtube.com/c/allinclusiveias](http://www.youtube.com/c/allinclusiveias)

**Prelims 1994**

When it is noon along 82° 30' E longitude along what degree of longitude it will be 6.30 a.m.?

- (a) at 165° East
- (b) at 67° 30' West
- (c) at 0° East or West
- (d) at 82° 30' West

**Prelims 1998**

When there is noon at I.S.T. meridian, people at another place of the Earth are taking their 6 O' clock morning tea. The longitude of the place is :

- (a) 17°30'E
- (b) 7°30' W
- (c) 172°30'E
- (d) 90°W

**Prelims 1997**

If the earth's direction of rotation is reversed, what should be the IST when it is noon at the International Date Line?

- (a) 06:30 hrs
- (b) 05:30 hrs
- (c) 18:30 hrs
- (d) 17:30 hrs

**UTC** - Coordinated Universal Time

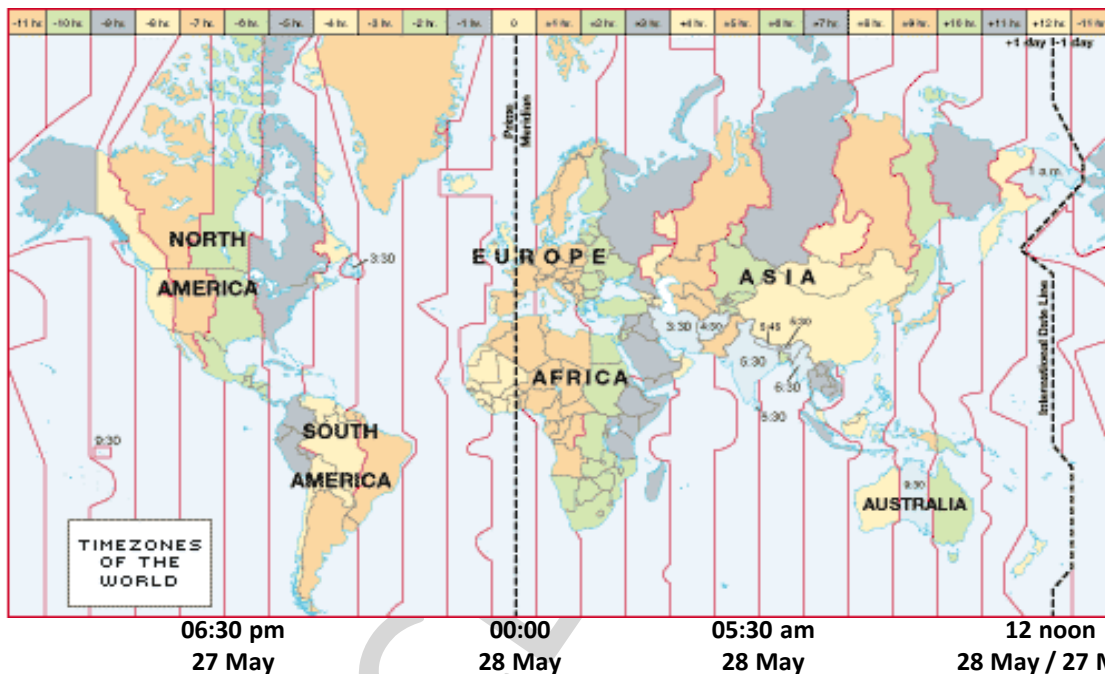
**GMT** - Greenwich Mean Time (same as UTC)

**IST** - Indian Standard Time (5:30 hours ahead of UTC)

**24 hour** change in local time = **360°** change in longitude

**1 hour** change in local time = **15.0°** change in longitude

**5.5 hour** change in local time = **82.5°** change in longitude



**Prime Meridian**

It is near Royal Observatory, Greenwich, in London, England

**Time zone lines are not straight**

- Countries themselves decide their standard time zone
- Hence, most of the time zone lines, including IDL, are zigzag

**International Date Line**

It was established in 1884  
It has no legal international status

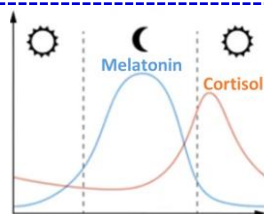
Crossing IDL from west to east, decreases date by one day  
Crossing IDL from east to west, increases date by one day

**Jet lag**

A sleep disorder that affect those who quickly travel across multiple time zones

**Daylight saving**

Advancing clocks (typically by one hour) during warmer months so that darkness falls at a later clock time



**Circadian Rhythm**

- 24-hour internal clock in brain
- It regulates cycles of alertness and sleepiness, by responding to light changes in our environment

**Two time zones for India ?** (suggested by many scientists) (not important for Prelims)

- India is geographically the second-largest country (after China) to not have multiple time-zones.
- 30 degree difference in East-West should mean two hours gap.
- India has just one time zone (IST is 5:30 hours ahead of UTC)
- This causes problem in Circadian Rhythm in NE and A&N

# Ocean Energy

THE HINDU

National Institute of Ocean Technology to set up green, self-powered desalination plant in Lakshadweep

The NIOT is providing potable water in six islands of Lakshadweep using Low Temperature Thermal Desalination technology

March 16, 2023 10:14 pm | Updated March 17, 2023 05:07 pm IST - NEW DELHI

## Prelims 2008

Where was the first desalination plant in India to produce one lakh litres freshwater per day based on low temperature thermal desalination principle commissioned?

- (a) Kavaratti (b) Port Blair (c) Mangalore (d) Valsad

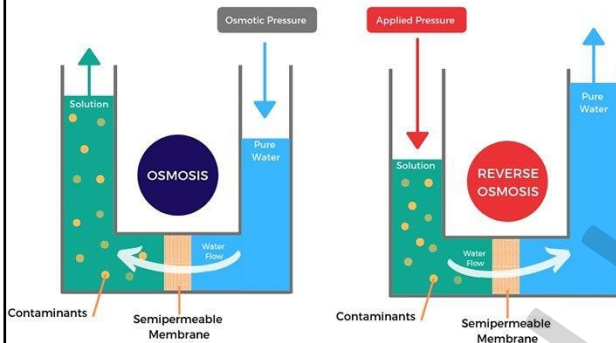
- LTTD uses temperature difference (nearly 15°C) in ocean water at surface and at depths of about 600 feet.
- But it needs diesel power to reduce water pressure
- Now, in new plant, diesel power may not be required.
- NIOT (under MoES) is implementing the project

## National Institute of Ocean Technology

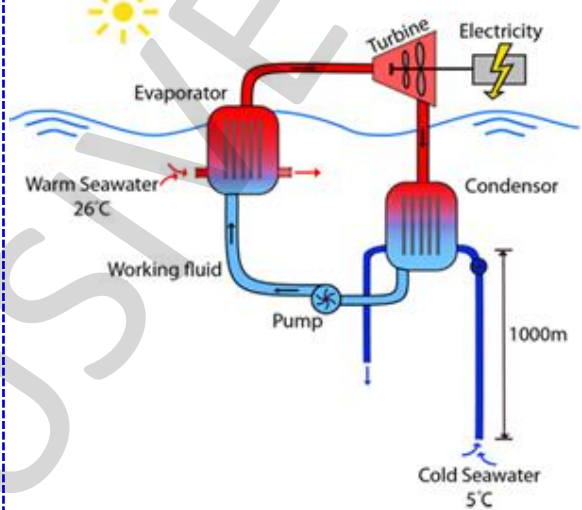
established in 1993, HQ Chennai, under Ministry of Earth Sciences

### Desalination by RO

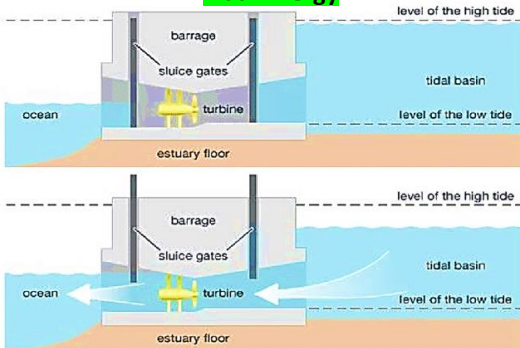
#### Osmosis And Reverse Osmosis



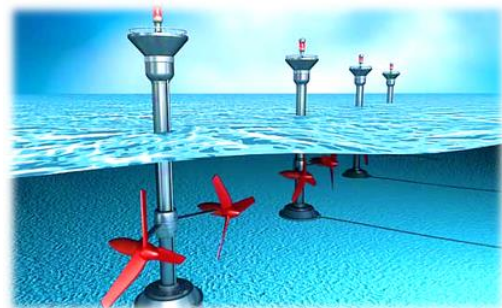
### Ocean Thermal Energy Conversion



### Tidal Energy

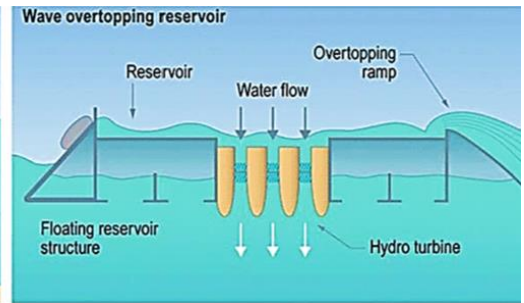
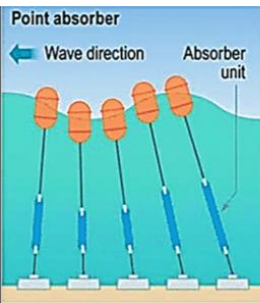


### Ocean Current Energy



### Ocean Wave Energy

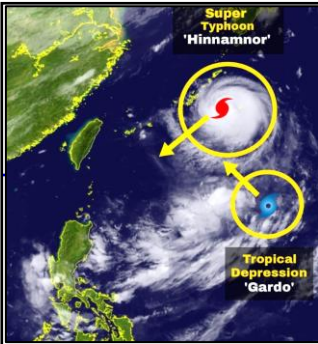
**Sindhuja-1**  
Ocean Wave Energy Converter developed by IIT Madras



I read I forget, I see I remember

See explanation of this PDF on [YouTube](https://www.youtube.com/c/allinclusiveias) www.youtube.com/c/allinclusiveias

# Cyclone



### Fujiwhara Effect (page-50)

Recently, it was observed with cyclones Hinnamnor/Henry and Gardo

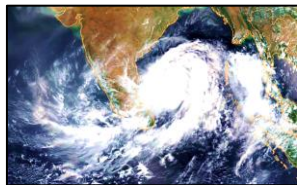
### Saffir-Simpson scale

- It classifies tropical cyclones into **5 categories** (Category-1 to Category-5), based only on maximum sustained wind speed.
- Not to be confused with Simpson desert, which is in central Australia



Cyclone	Landfall	Year
Mocha	Myanmar	2023
Sitrang	Bangladesh	2022
Jawad	West Bengal	2021
Yaas	Odisha	2021
Fani	Odisha	2019
Asani	Andhra	2022
Gulab	Andhra	2021
Mandous	Chennai	2022

Cyclone	Landfall	Year
Tauktae	Gujarat	2021
Maha	Gujarat	2019
Nisarga	Mumbai	2020



### Dvorak technique

- It is used to **estimate intensity** of tropical cyclones
- It is **based on** visible and infrared **images** captured by satellites
- It gives **T-number** (Tropical no.) and **CI-number** (Current Intensity) to cyclone
- It was developed in 1970s by an American meteorologist



### Re-curving of cyclone

- It means cyclone is **changing its path**
- Example: In northern hemisphere, Cyclone which was moving west, would move north, and then east.
- Such cyclones are usually more stronger, because they stay in water, for longer time.

### Cyclone Freddy (Feb-March 2023)

- It was a **category 5** tropical cyclone
- It travelled through Southern Indian Ocean for 5 weeks
- It made two landfalls - first **Madagascar**, then **Mozambique**
- It was the **longest-lasting** tropical cyclone ever recorded worldwide.
- It was the **highest ACE (energy)** producing tropical cyclone ever recorded worldwide.



### Cyclone Ilsa

- It was a **category 5** tropical cyclone
- It hit Western **Australia** in April 2023





### Bomb Cyclone

- aka Rapid extratropical cyclone development
- It occurs when a midlatitude cyclone rapidly intensifies, with pressure dropping at least 24 millibars over 24 hours.
- It usually occurs in winter in mid-latitudes.

### THE HINDU

#### What is lake-effect snow? A climate scientist explains

Bitter cold air sweeps across the relatively warmer Great Lakes, it sucks up more and more moisture that falls as snow

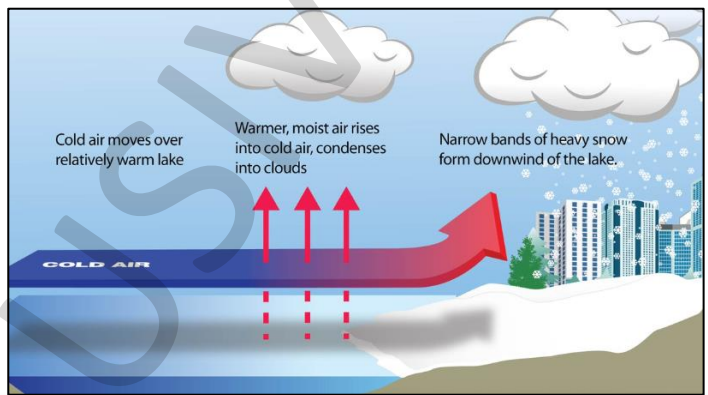
November 19, 2022 12:15 pm | Updated 04:21 pm IST

### Lake effect snow

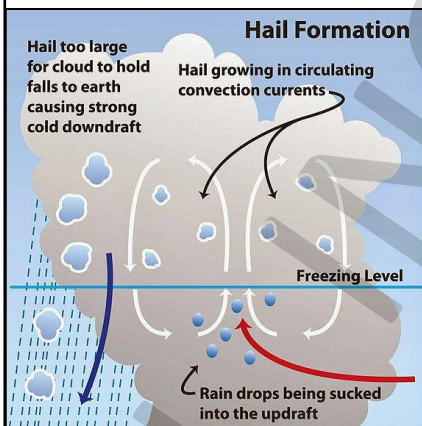
- It is common in Great Lakes region during winter
- Cold air mass from land (High Pressure area), comes over warm lakes (low pressure area)
- Cold air, heated by lake, picks up more moisture, and rises upwards, forming clouds.
- The area may experience heavy snowfall, while sun may still be shining in nearby areas.

### Great Lakes

- Five interconnected freshwater lakes
- They connect to Atlantic Ocean via Saint Lawrence River
- Only Lake Michigan is entirely in USA



### Hailstones



#### How Hailstorm occurs

- Updraft carries water droplets above freezing level in atmosphere (temperature drops with height)
  - Water droplets freeze, falls down, more water condenses on them
  - Updraft again carries them upwards, and size grows layer by layer
  - When it becomes too heavy, it comes down as hails
- See Lightning during thunderstorm on page-46

#### Favourable Conditions

- High surface temperature and strong updraft
- High amount of water content in atmosphere
- Great vertical extent of cumulonimbus cloud, above and below freezing line

Hail is bigger in size, as it has multiple layers of ice



Sleet is smaller in size, as it is simply frozen raindrops

# IUGS

**The Indian EXPRESS**  
JOURNALISM OF COURAGE

**Mawmluh Cave in Meghalaya, one of UNESCO's 'First 100 IUGS Geological Sites' in the world**

New Delhi | October 4, 2022 19:00 IST

*It is believed to be the fourth longest cave in the Indian subcontinent with a total length of 7 km of cave passages*

**First 100 Geological sites**  
To celebrate the 60<sup>th</sup> anniversary, IUGS has published a list of 100 sites, which are significant in development of the earth sciences

**International Geological Congress**

- every 4 years by IUGS
- 1878 : 1<sup>st</sup> congress in France
- 1964 : 22<sup>nd</sup> congress in Delhi
- 2022 : 36<sup>th</sup> in Delhi (virtually)  
Theme "Geosciences: The Basic Science for a Sustainable Future"



### International Union of Geological Sciences

- It is an international non-governmental organization
- founded in 1961 in Paris, France. Now its Secretariat is in Beijing, China
- Geological Society of India produces and distributes the Union's quarterly journal, entitled Episodes
- IUGS is a joint partner with UNESCO for the International Geoscience Programme (IGCP) and also participates in the Global Geoparks Network

### UNESCO Global Geoparks

- It is a network of geoparks (and also an agency of UNESCO)
- Established in 1998/2004/2014/2015
- How many? 177 in 46 countries
  - Most in China
  - None in India, USA, Australasia, Antarctica
- This designation is reviewed every four years
- Common sense: UNESCO gives designation, and helps the countries. It does not own or control the parks.

### Some sites which India wants in UNESCO Global Geoparks list

- Dinosaur Fossil National Park in Bagh, Madhya Pradesh
- Erra Matti Dibbalu (coastal red sediment mounds) in Andhra
- Natural Rock Formations at Mangamaripeta Andhra
- Borra Caves in Andhra

### Global Boundary Stratotype Section and Point

- It is an internationally agreed reference point on geologic time scale
- It is defined by International Commission on Stratigraphy, a part of IUGS

1961 : IUGS formed  
1974 : International Commission on Stratigraphy, as part of IUGS  
2009 : Anthropocene Working Group, as part of ICS

### Krem Puri

Sandstone cave, Khasi hills, Meghalaya  
World's longest sandstone cave (24 km)

### Krem Mawmluh / Krem Mawkhyrdop

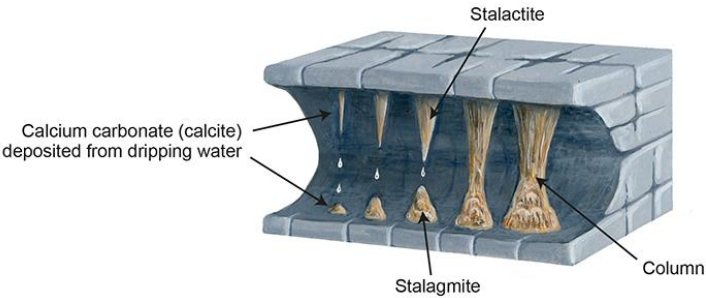
Limestone cave, Khasi Hills, Meghalaya  
4<sup>th</sup> longest cave in Indian subcontinent

### Krem Liat Prah

Limestone cave, Jaintia Hills, Meghalaya  
South Asia's longest natural cave (34 km)

### Speleothems

stalactites, stalagmites, columns, drapes



# Meghalayan Age

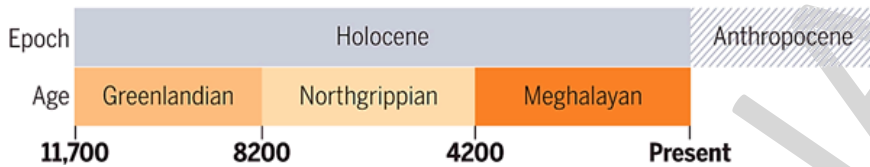
### Meghalayan Age

- It began 4,200 years ago, with a 200 year long drought.
- It severely impacted agricultural based societies that developed after end of last Ice Age.
- Many civilisations in Egypt, Greece, Syria, Palestine, Mesopotamia, Indus Valley, Yangtze Valley collapsed.
- It is the only age which began with a cultural shift caused by a global climatic event.
- Its evidence was found in a stalagmite in Krem Mawmluh cave in Meghalaya

**Eon**  
 v  
**Era**  
 v  
**Period**  
 v  
**Epoch**  
 v  
**Age**

**Meghalayan Age**

- ❑ International Commission on Stratigraphy officially ratified it in 2018, (along with Greenlandian and Northgrippian ages)
- ❑ Its Global Boundary Stratotype Section and Point (GSSP) is a stalagmite in Krem Mawmluh Cave



A portion of an Indian stalagmite that defines the beginning of the Meghalayan Age

*This is a part of chronostratigraphic chart, published by International Commission on Stratigraphy*

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	GSSP	numerical age (Ma)
Phanerozoic	Cenozoic	Quaternary	Holocene	Meghalayan	↗	present
				Northgrippian	↗	0.0042
				Greenlandian	↗	0.0082
			Pleistocene	Upper	↗	0.0117
				Middle	↗	0.126
				Calabrian	↗	0.781
			Pliocene	Gelasian	↗	1.80
				Piacenzian	↗	2.58
				Zanclean	↗	3.600
				Messinian	↗	5.333
		Tortonian		↗	7.246	
		Neogene	Miocene	Serravallian	↗	11.63
				Langhian	↗	13.82
				Burdigalian	↗	15.97
				Aquitanian	↗	20.44
	↗			23.03		

**EXTRA INFORMATION**

**Holocene extinction**

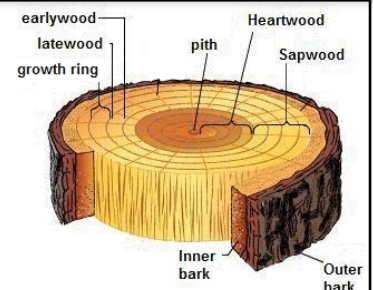
- aka Anthropocene extinction
- It is another name of **6th mass extinction** (see page-29)

**Hangenberg crisis**

- Hangenberg event / end-Devonian extinction
- It was a **mass extinction** event **35 crore years ago** (at end of Devonian Period)
- Its evidence has been found at Hangenberg Shale in **Germany**

**Tree rings**

- **Dendrochronology** is study of tree rings.
- Tree rings provide snapshot of Earth's **past climate**.
- Tree rings are formed due to difference in tree **growth rate**.
- You can know the **age of a tree** by counting the number of rings in its stem.
- 6<sup>th</sup> Asian Dendrochronology **conference** was organised in **Lucknow** in **2019**.



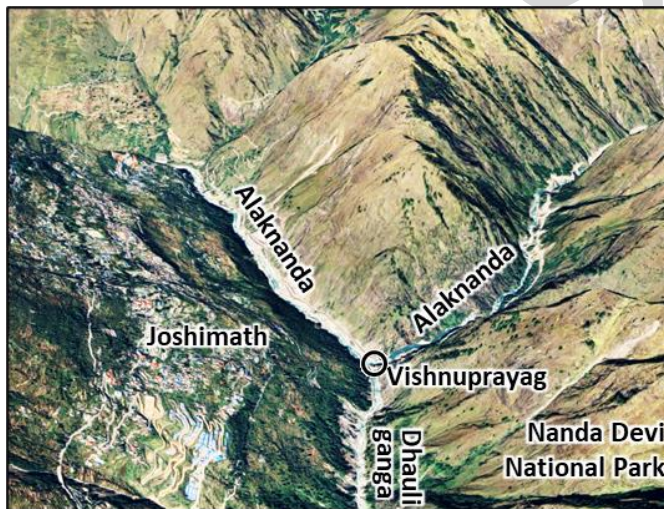
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## Joshimath

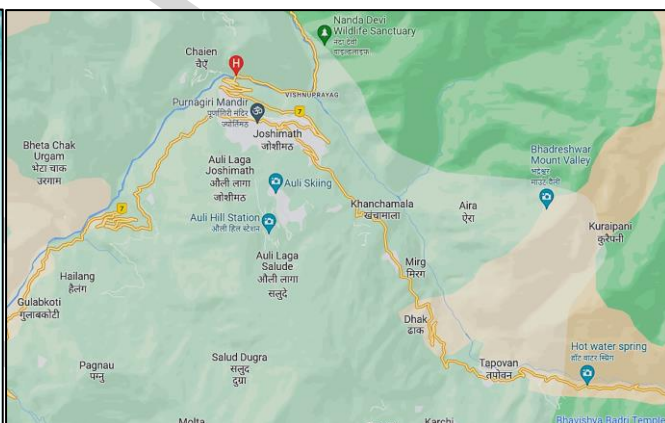
### Joshimath / Jyotirmath

- It is on Rishikesh-Badrinath National Highway (NH-7)
- It falls in high-risk seismic Zone-V (on Vaikrita Thrust fault line)



### SATOPANTH GLACIER

- It is in Uttarakhand
  - It is source of Alaknanda
- Satopanth → Badrinath → Panchprayag  
(Vishnu – Nanda – Karna – Rudra – Dev)



### 1976 - Mishra Committee

- Joshimath is made on remains of an old landslide (see moraine on page-48)
- Undercutting by rivers Alaknanda and Dhauliganga is also doing damage
- Joshimath will sink if construction does not stop

### 2022 - Joshimath is sinking

- Unauthorised construction → unstable slope
- Char dham highway → More tourists → more infra for tourists → more pressure on land
- Tapovan Vishnugad Hydro project → Tunnel made near Joshimath → It punctured underground aquifer

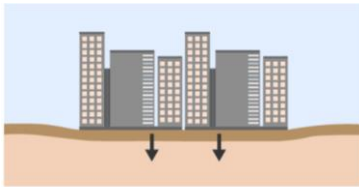
### Char Dham Highway

- Under-construction highway to connect four holy places in Uttarakhand
- Yamunotri, Gangotri, Kedarnath, Badrinath (see river map on page-26)

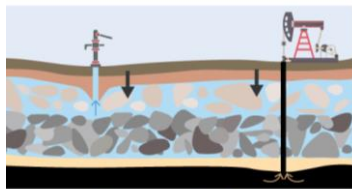
### Four Mathas by Adi Shankaracharya:

- Jyotir matha, Uttarakhand
- Govardhan matha in Puri, Odisha
- Sarada/Kalika Matha in Dwaraka, Gujarat
- Sringeri Sharda peetham in Chikmagalur, Karnataka

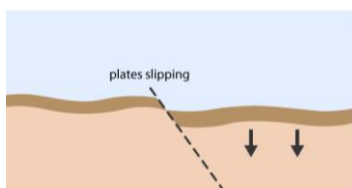
## Reason for Land subsidence



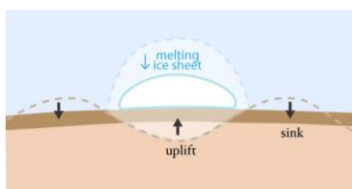
**Infrastructural load**  
the weight of buildings causes compaction



**Resource extraction**  
e.g. groundwater, oil and gas



**Tectonic movements**  
e.g. earthquakes



**Melting ice sheets**  
the ground around the melting ice sheet shifts

## Land subsidence

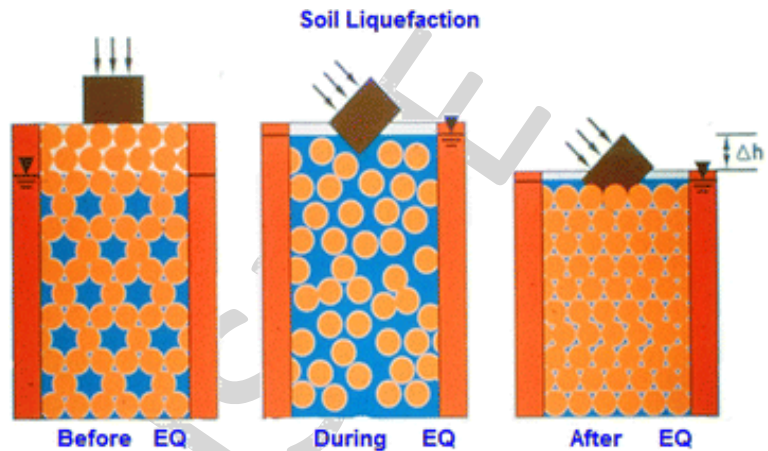
*Both land subsidence and land sliding are happening at Joshimath*

### Landslide

- ❖ It happens on slopes. There is both vertical and horizontal movement.
- ❖ Reason: unstable slope

### Land subsidence

- ❖ There is vertical movement downwards.
- ❖ Reason: Removal of underground material



*Which country is shifting its capital due to land subsidence?*

Indonesia: Jakarta to Nusantara  
(IR class-2 page-29)

*Central Building Research Institute*

- It comes under CSIR
- 1947, Roorkee (Uttarakhand)

Recently seen in USA

## Derecho



- It is a straight-line wind storm associated with fast-moving thunderstorms
- It causes strong winds, heavy rains, and flash floods.
- It usually occurs during summer
- In Straight-line storms, winds have no rotation
- They travel hundreds of miles and cover a vast area.

### Why sky turns green

- Water in thunderstorm scatters away all lights, except blue.
- So, blue colour penetrates down the storm cloud.
- Blue mixes with yellow (of afternoon) to produce green colour.

## Damini

### Damini app

- It is a lightning alert app, developed by IITM-Pune and ESSO
- It monitors lightning activity throughout India
- It alerts user about lightning which occurred in last few minutes at his location

**IITM** - Indian Institute of Tropical Meteorology

**ESSO** - Earth System Science Organization

*Both of them are under Ministry of Earth Sciences*

I read I forget, I see I remember

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