# Temperature, Salinity, Deposits of Ocean and Ocean Currents

Check out Previous Years Prelims Questions Trends- Temperature ,Ocean Currents

**Which one of the following factors is responsible for the change in the regular direction of the ocean currents in the Indian Ocean?** ***[1997]***

(a) Indian Ocean is half an ocean

(b) Indian Ocean has monsoon drift

(c) Indian Ocean is a land-locked ocean

(d) Indian Ocean has greater variation in salinity

**Estuaries possess distinct blooms of excessive growth of a pigmented dinoflagellates. These blooms are called *[1998]***

(a) red tides (b) sea tides

(c) black tides (d) sea flowers

**In the given map, which one of the following pairs of ocean currents are shown?** ***[1999]***

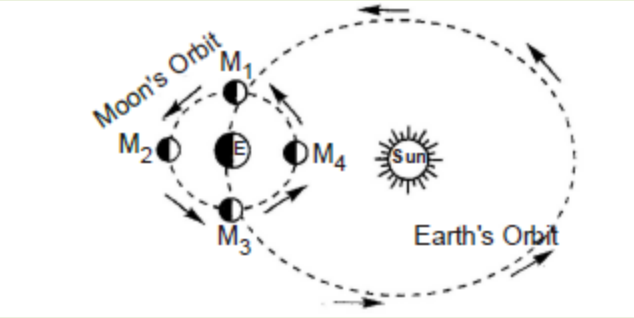
(a) Benguela and Falkland

(b) Canary and Humboldt

(c) Agulhas and Guinea

(d) Benguela and Guinea

**At which one of the following positions shown in the diagram will the height of the ocean tide be maximum?** ***[1999]***




(a) Ml (b) M2

(c) M3 (d) M4

**Consider the following statements:** ***[2000]***

1. Tides are of great help in navigation and fishing.
2. High tide enables big ships to enter or leave the harbour safely
3. Tide prevents siltation in the harbours
4. Kandla and Diamond Harbour are tidal ports

Which of these statements are correct?

(a) 1 and 4 (b) 2, 3 and 4

(c) 1, 2 and 3 (d) 1, 2, 3 and 4

**Consider the following statements:** ***[2002]***

1. Ocean currents are slow-surface movement of water in the ocean.
2. Ocean currents assist in maintaining the Earth's heat balance
3. Ocean currents are set in motion primarily by prevailing winds
4. Ocean currents are affected by the configuration of the ocean

Which of these statements are correct?

(a) 1 and 2 (b) 2, 3 and 4

(c) 1, 3 and 4 (d) 1, 2, 3 and 4

**For short-term climatic predictions, which one of the following events, detected in the last decade, is associated with occasional weak monsoon rains in the Indian sub-continent?** ***[2002]***

(a) La Nina

(b) Movement of Jet Stream

(c) El Nino. and Southern Oscillations

(d) Greenhouse effect at global level

**A new type of El Nino called El Nino Modoki appeared in the news. In this context, consider the following statements: *[2010]***

1. Normal El Nino forms in the Central Pacific Ocean whereas El Nino Modoki forms in Eastern Pacific Ocean
2. Normal El Nino results in diminished hurricanes in the Atlantic Ocean but El Nino Modoki results in a greater number of hurricanes with greater frequency.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

**La Nina is suspected to have caused recent floods in Australia. How is La Nina different from El Nino ?**

1. La Nina is characterized by unusually cold ocean temperature in equatorial Indian Ocean whereas El Nino is characterized by unusually warm ocean temperature in the equatorial Pacific Ocean.
2. El Nino has adverse effect on south-west monsoon of India, but La Nina has no effect on monsoon climate. *[2011 - I]*

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

**On the planet earth, most of the freshwater exists as ice caps and glaciers. Out of the remaining freshwater, the largest proportion *[2013 - I]***

(a) is found in atmosphere as moisture and clouds

(b) is found in freshwater lakes and rivers

(c) exists as groundwater

(d) exists as soil moisture

**In the South Atlantic and South-Eastern Pacific regions in tropical latitudes, cyclone does not originate. What is the reason?** ***[2015 - I]***

(a) Sea surface temperatures are low

(b) Inter-Tropical Convergence Zone seldom occurs

(c) Coriolis force is too weak

(d) Absence of land in those regions

**What explains the eastward flow of the equatorial counter-current?** ***[2015 - I]***

(a) The Earth's rotation on its axis

(b) Convergence of the two equatorial currents

(c) Difference in salinity of water

(d) Occurrence of the belt of calm near the equator

**With reference to 'Indian Ocean Dipole (IOD)‘ sometimes mentioned in the news while forecasting Indian monsoon, which of the following statements is/are correct? [2017-I]**

1. IOD phenomenon is characterized by a difference in sea surface temperature between tropical Western Indian Ocean and tropical Eastern Pacific Ocean.
2. An IOD phenomenon can influence an El Nino's impact on the monsoon.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

- **Current Events- Hydrosphere**

# Atlantic Meridional Overturning Current

- **Atlantic Meridional Overturning Current (AMOC)** is thought to be slowing down for the last 15 years, which could have drastic consequences on global climate.
- Atlantic Meridional Overturning Current is the large system of ocean currents operating in the Atlantic Ocean.
- It circulates the waters between the north and the south.
- It ensures the oceans are continually mixed, and heat and energy are distributed around Earth.
- Warming as a result of climate change, the Indian Ocean is causing a series of cascading effects that is providing AMOC a "jump start".
- As warm water flows northwards in the Atlantic, it cools, while the evaporation increases its salt content.

- Low temperature and high salt content raise the density of the water, causing it to sink deep into the ocean.
- The cold, dense water deep below slowly spreads southward.
- Eventually, it gets pulled back to the surface and warms again and, the circulation is complete.
- This continual mixing of the oceans, and distribution of heat and energy around the planet, contribute to global climate.


North Atlantic
Deep Water
North Atlantic
Current
Gulf Stream
©nature

# Indian Ocean Role

- As the Indian Ocean warms faster and faster, it generates additional precipitation.
- This draws more air from other parts of the world to the Indian Ocean, including the Atlantic.
- With so much precipitation in the Indian Ocean, there will be less precipitation in the Atlantic Ocean.
- Less precipitation will lead to higher salinity in the waters of the tropical portion of the Atlantic.
- This saltier water, as it comes north via AMOC, will get cold much quicker than usual and sink faster.
- This would act as a jump start for AMOC, intensifying the circulation.

- **The name La Niña originates from Spanish, meaning "the little girl", analogous to El Niño meaning "the little boy".**

# El Nino

## 1. Normal Conditions

- In a normal year, a surface **low-pressure** develops in the region of **northern Australia and Indonesia** and a **high-pressure** system over the **coast of Peru**.
- As a result, the **trade winds** over the Pacific Ocean move strongly from **east to west.**
- The easterly flow of the trade winds carries warm surface waters **westward**, bringing **convective storms (thunderstorms)** to Indonesia and coastal Australia.
- Along the coast of Peru, cold bottom **cold nutrient-rich water wells up** to the surface to replace the warm water that is pulled to the west.

- **Walker circulation**

- The Walker circulation (Walker cell) is caused by the pressure gradient force that results from a **high-pressure system over the eastern Pacific Ocean**, and a **low-pressure system over Indonesia.**

# During El Nino year

- In an El Niño year, air pressure drops over large areas of the central Pacific and along the coast of South America.
- The normal low-pressure system is replaced by a weak high in the western Pacific (the **southern oscillation**).
- This change in pressure pattern causes the **trade winds to be reduced — Weak Walker Cell.** Sometimes Walker Cell might even get reversed.

- The warmer waters had a **devastating effect on marine life** existing off the coast of Peru and Ecuador.
- Fish catches off the coast of South America were lower than in the normal year.
- **Severe droughts occur in Australia, Indonesia, India and southern Africa.**

- The formation of an **El Niño (circulation of surface ocean current)** is linked with Pacific Ocean circulation pattern known as the **southern oscillation (circulation of atmospheric pressure).**
- Southern Oscillation, in oceanography and climatology, is a coherent inter-annual **fluctuation of atmospheric pressure** over the tropical Indo-Pacific region.
- El Nino and Southern Oscillation coincide most of the times hence their combination is called **ENSO – El Nino Southern Oscillation.**

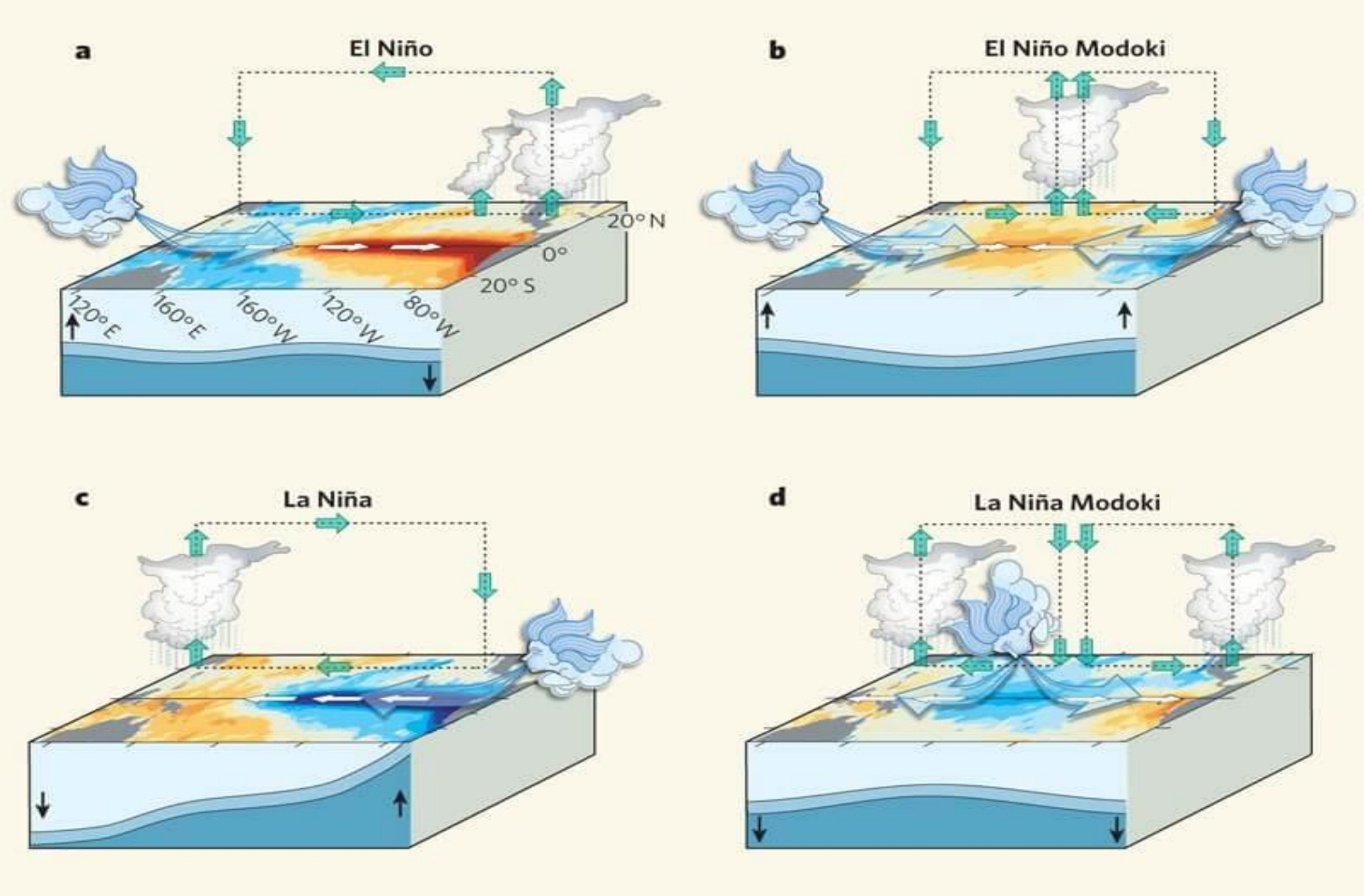
- **El Nino impact on Indian Monsoons**

- El Nino and Indian monsoon are **inversely related**.
- The location of low-pressure and hence the rising limb over Western Pacific is considered to be conducive to good monsoon rainfall in India.
- **Its shifting eastward** from its normal position, such as in El Nino years, **reduces** monsoon rainfall in India.

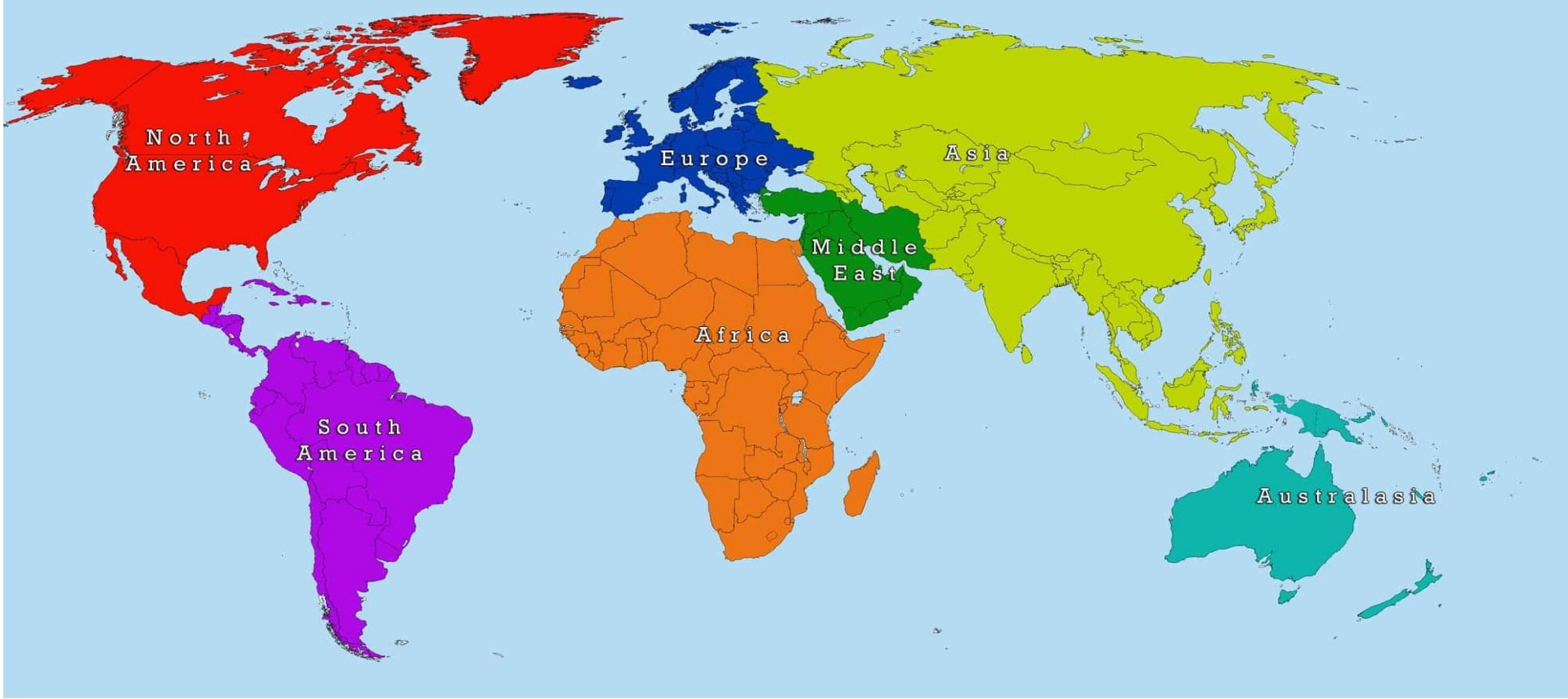
- After an El Niño event weather conditions usually return back to normal.
- However, in some years the trade winds can become **extremely strong** and an abnormal accumulation of cold water can occur in the central and eastern Pacific.

- This event is called a La Niña.
- **abnormally heavy monsoons in India and Southeast Asia**

- El Niño Modoki is associated with **strong anomalous warming in the central tropical Pacific and cooling in the eastern and western tropical Pacific**.
- Such zonal gradients result in anomalous **two-cell Walker Circulation** over the tropical Pacific, with a wet region in the central Pacific and dry region in the western and eastern Pacific.




By SudarshanGurjar

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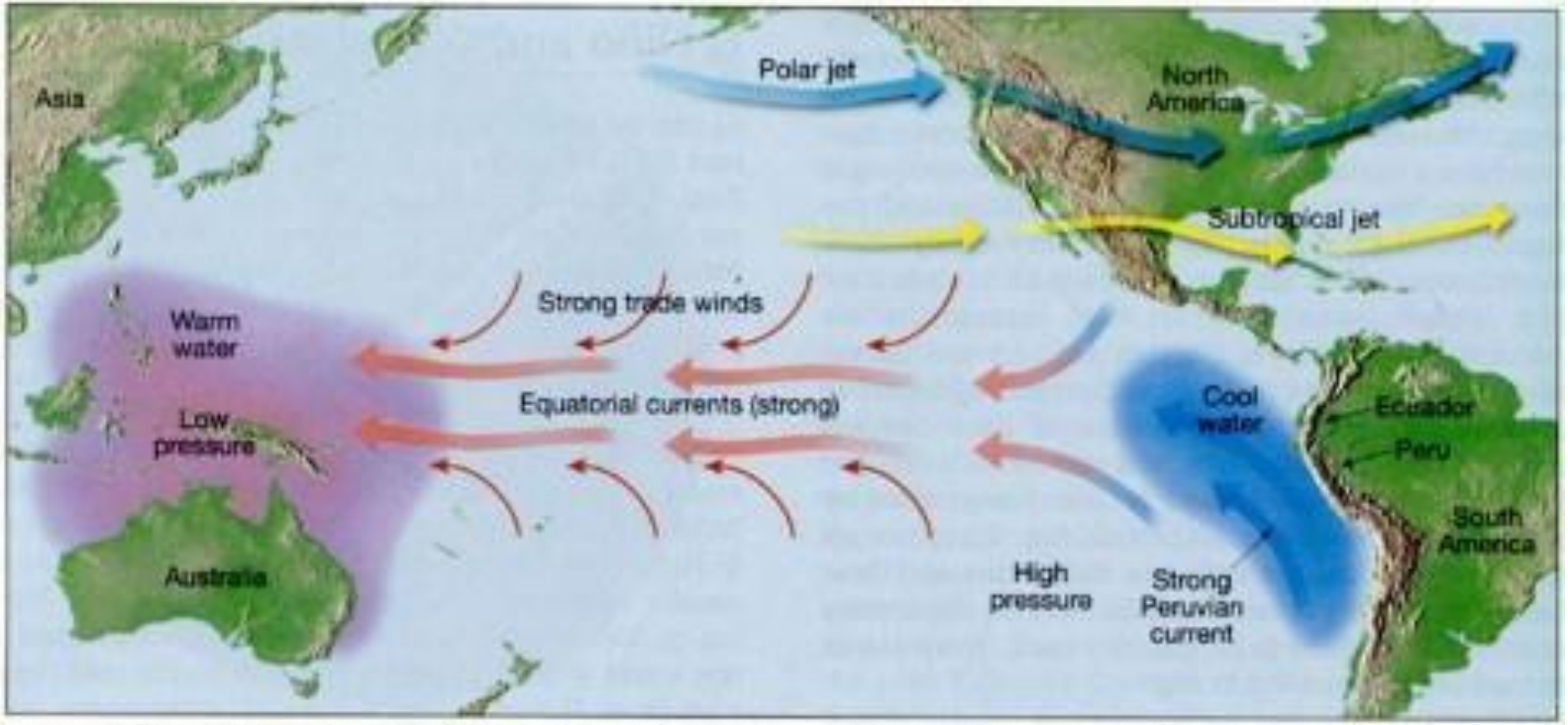


Fig.6 Normally, the trade winds and strong equatorial currents flow toward the west. At the same time, an intense Peruvian current causes upwelling of cold water along the west coast of South America.

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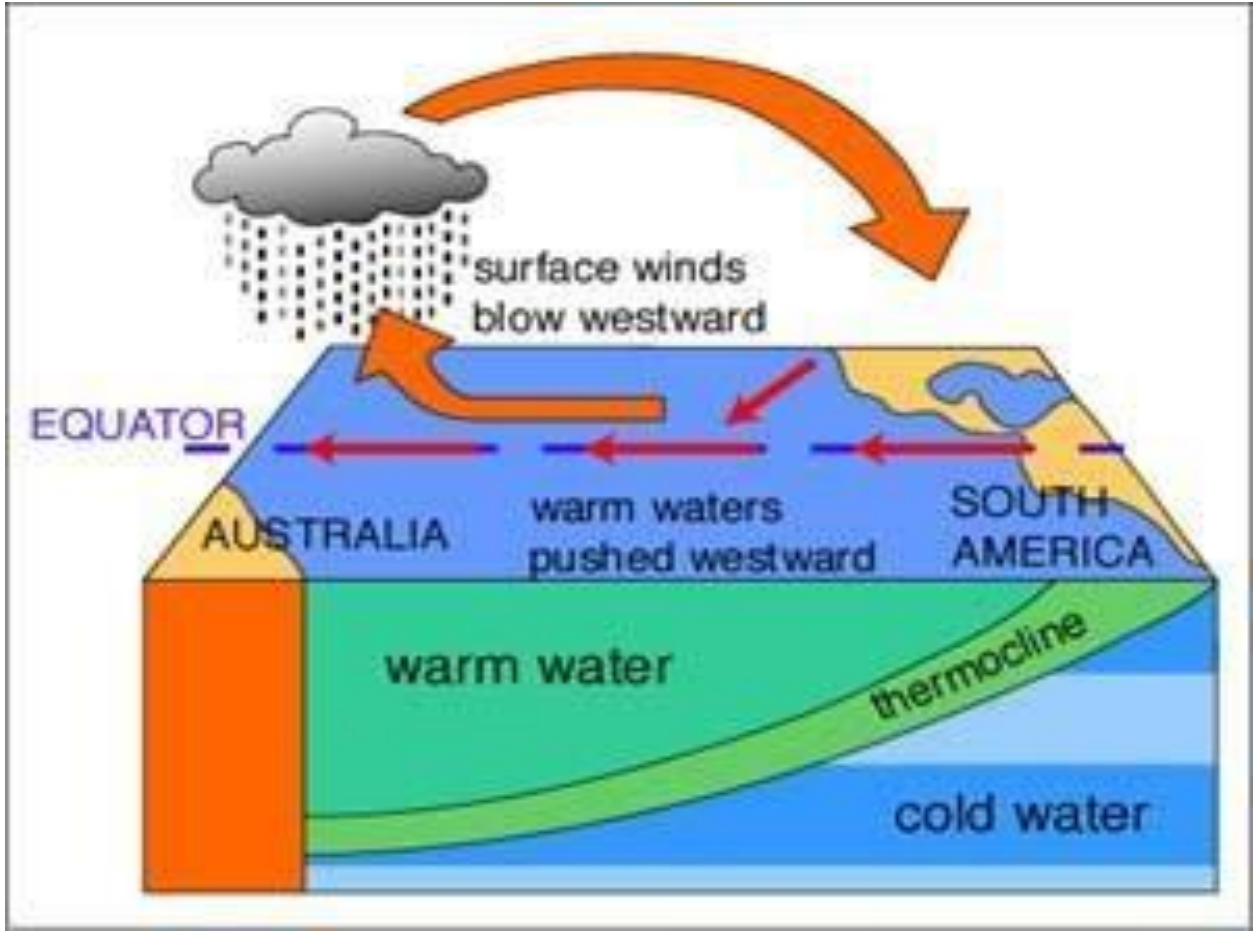


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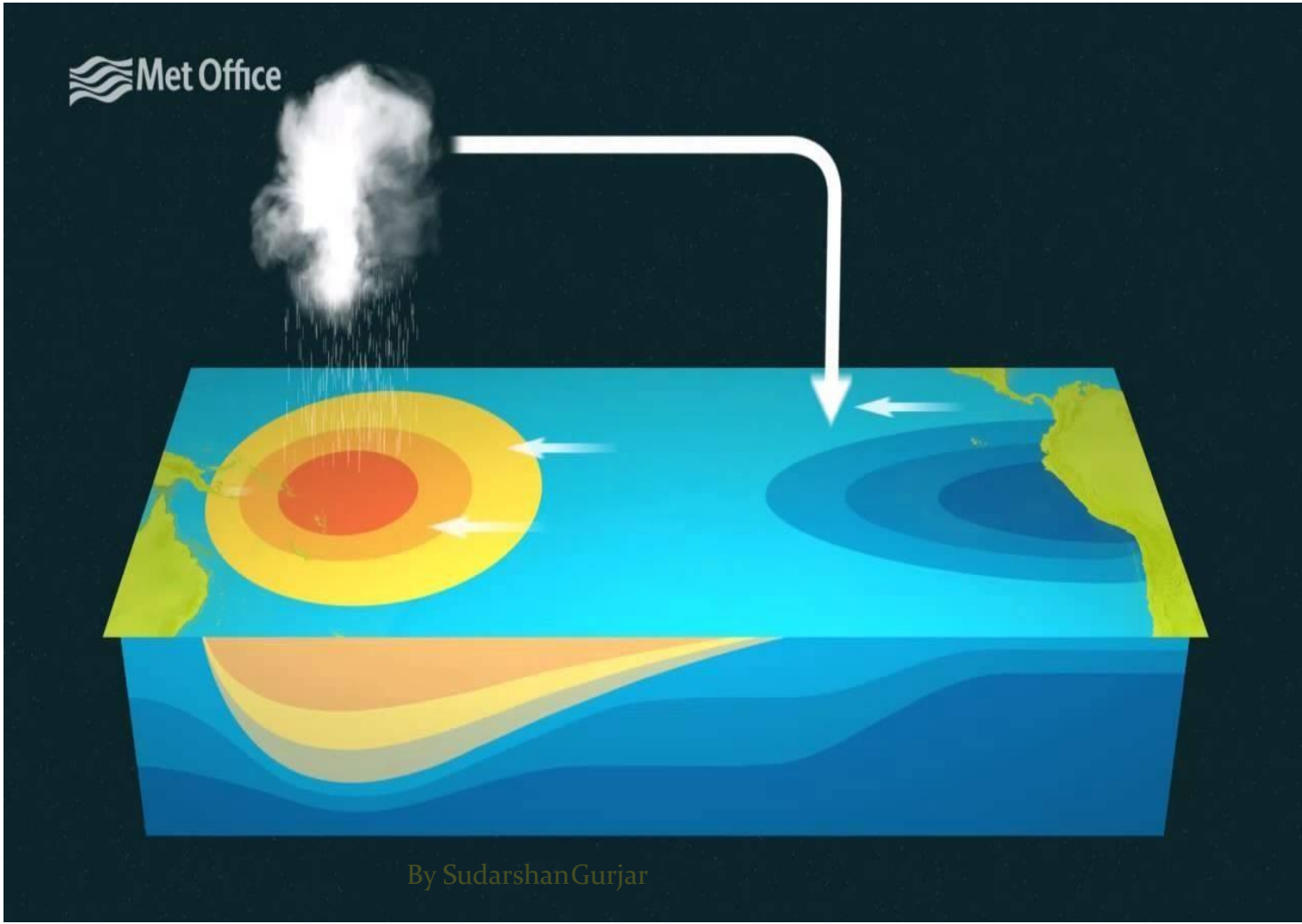


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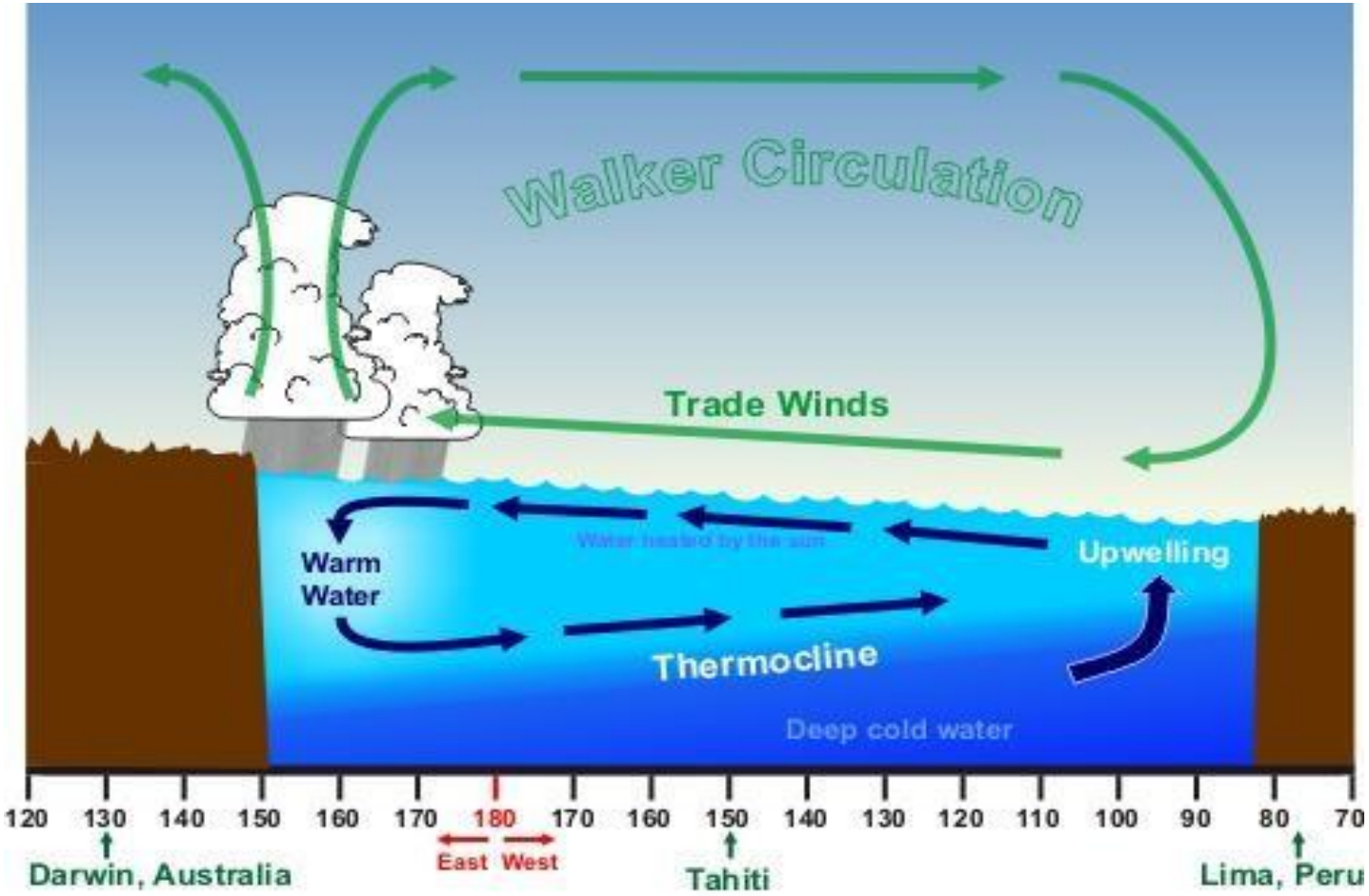


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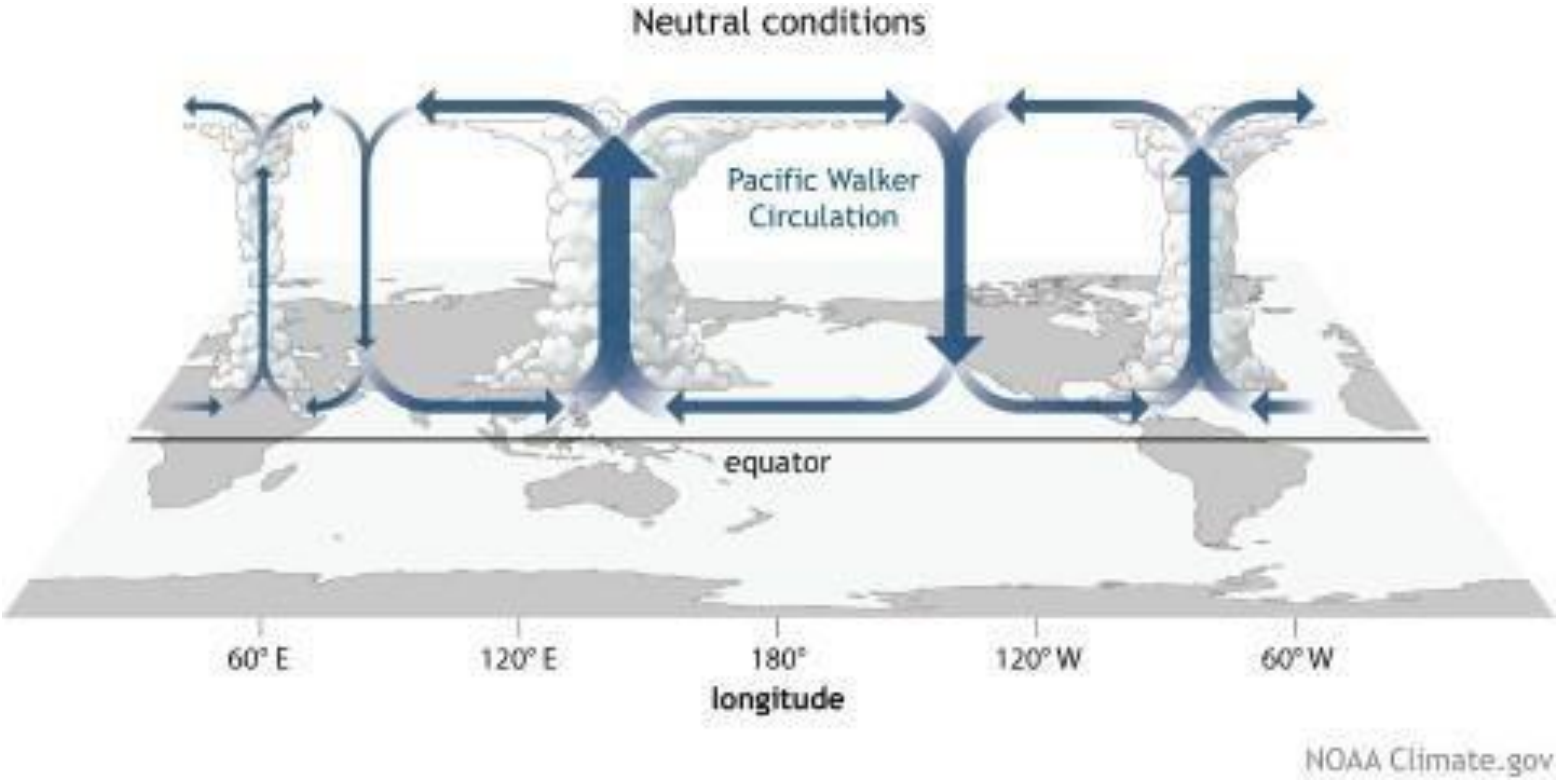


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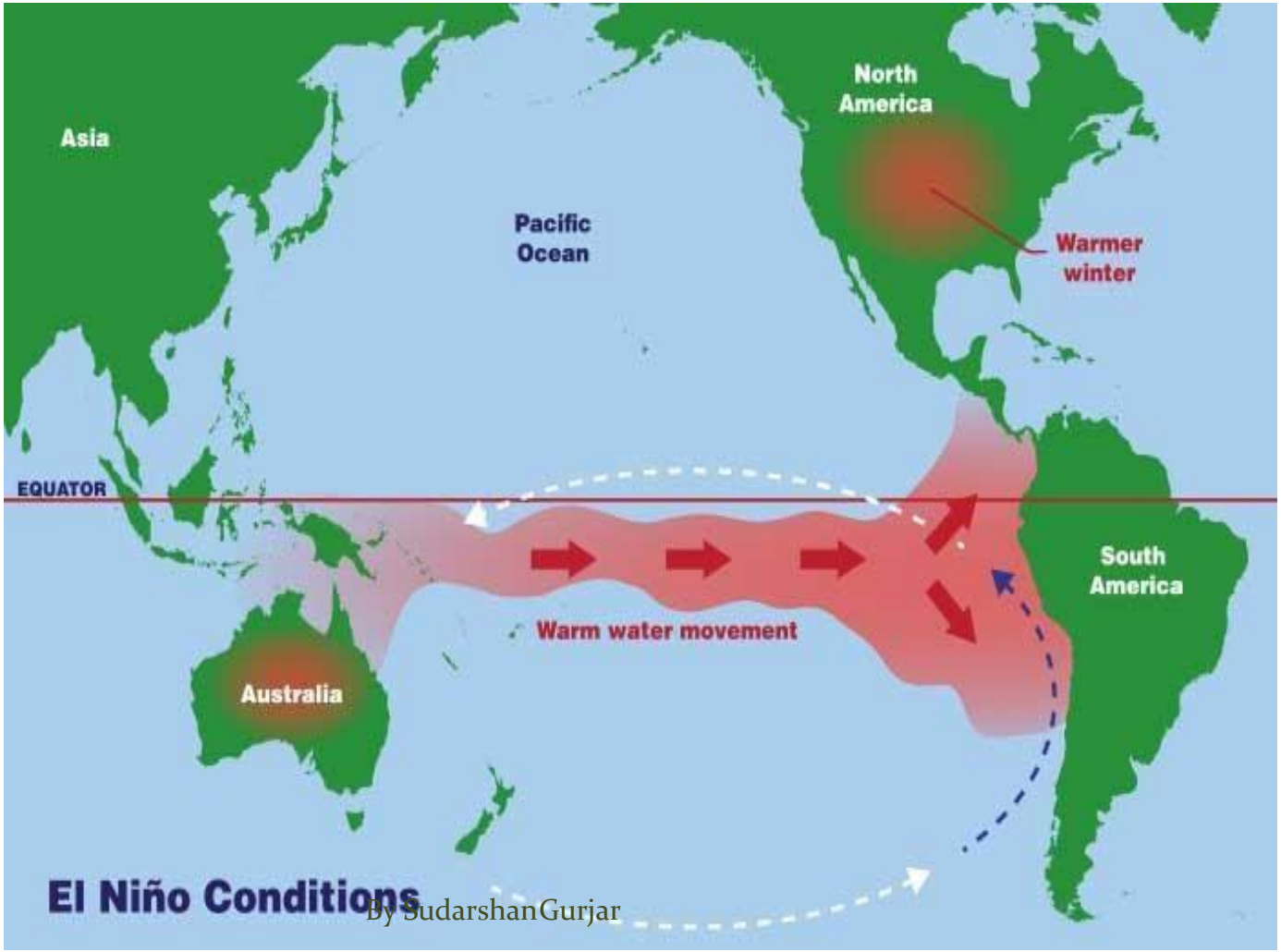


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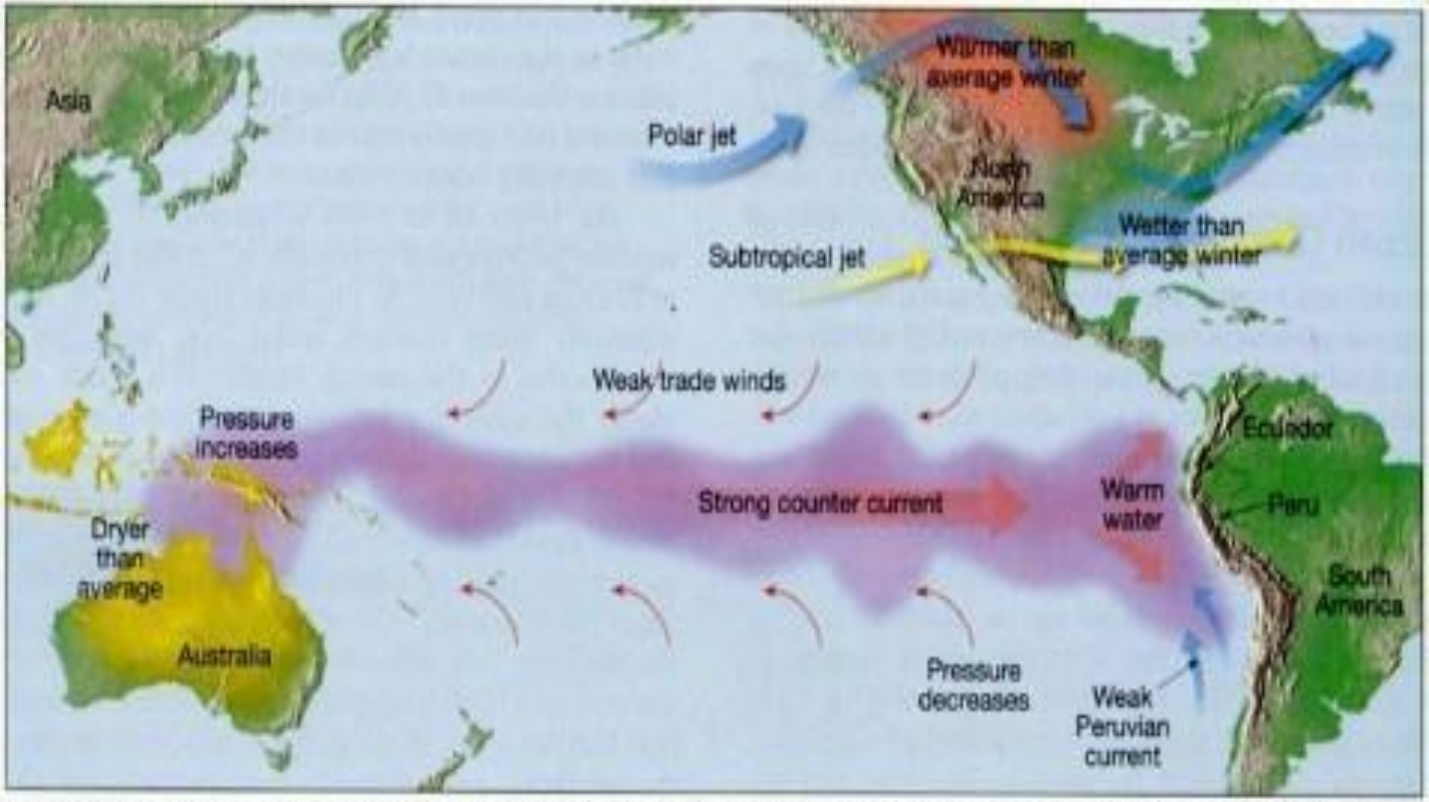
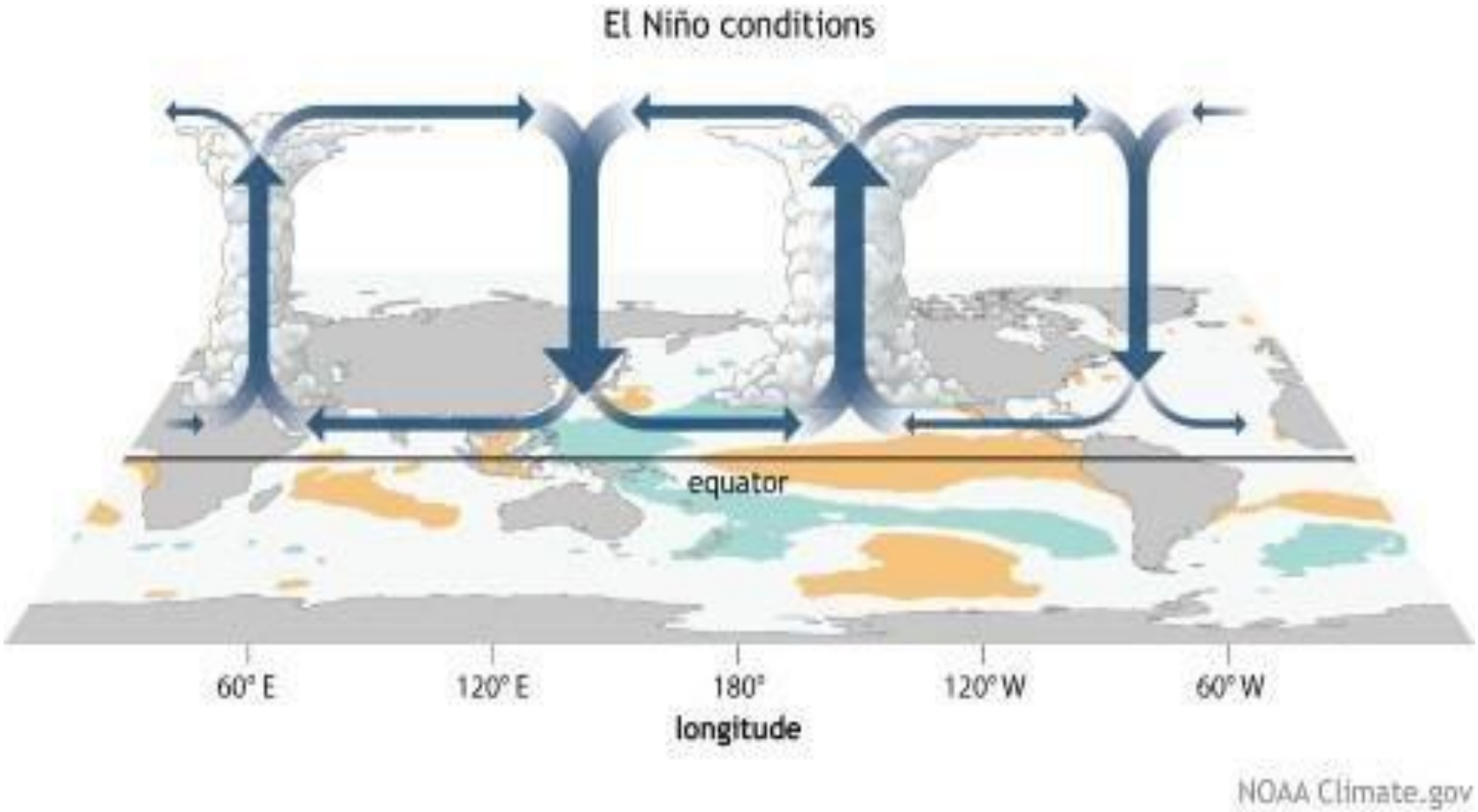



Fig.14 Upon the advent of an ENSO event, the pressure over the eastern and western Pacific flip-flops. This causes the trade winds to diminish, leading to an eastward movement of warm water along the equator. As a result, the surface waters of the central and eastern Pacific warm, with far-reaching consequences to weather patterns.

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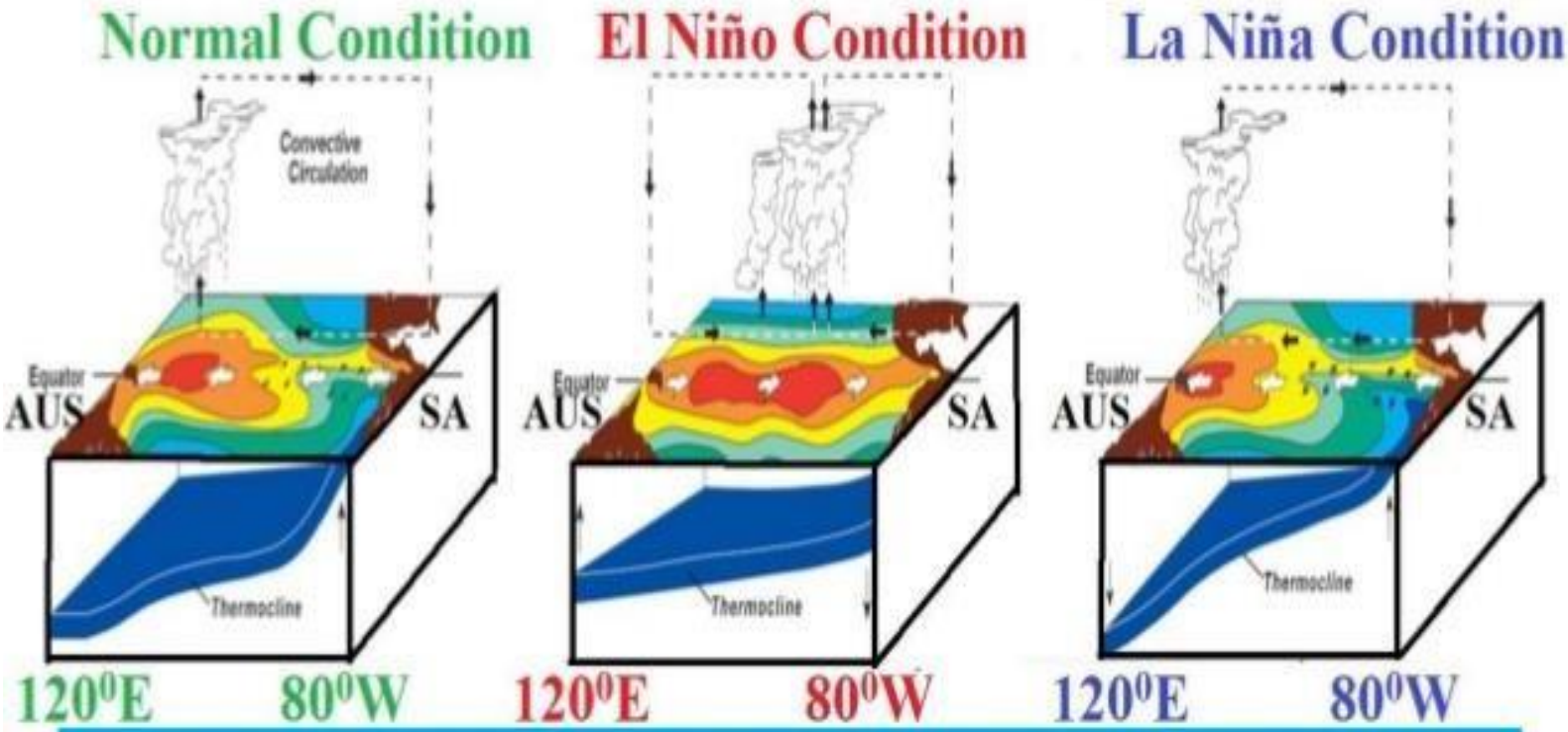
# What happens during these events?

# Mechanism (How??)




Cartoon of wind circulation during Normal, El Niño and La Niña condition

Figure 21

http://www.pmel.noaa.gov/tao/proj_over/diagrams/

By SudarshanGurjar

## **Definition of The Madden-Julian Oscillation (Roland Madden** and **Paul Julian)**

- The MJO can be defined as an **eastward moving 'pulse' of clouds, rainfall, winds and pressure near the equator** that typically recurs every 30 to 60 days.

- It's a traversing phenomenon and is **most prominent over the Indian and Pacific Oceans.**

- **How does it work?**

- A region of enhanced tropical precipitation is first obvious over the western Indian Oceans, which spreads eastwards into the warm waters of the tropical Pacific.
- This pattern of tropical precipitation will in general lose its identity as it moves over the cooler waters of the eastern Pacific, before returning eventually over the Indian Ocean once more.

A wet phase of improved convection (rainfall) is trailed by a dry phase, where rainstorm movement is suppressed(no precipitation). Each cycle lasts around 30-60 days and there are 8 phases

**Eight phases/stages of MJO are:**

- **Stage 1** – Enhanced convection (precipitation) creates over the western Indian Ocean.
- **Stage 2 and 3** – Enhanced convection (precipitation) moves gradually eastwards over Africa, the Indian Ocean and parts of the Indian subcontinent.
- **Stage 4 and 5** – Enhanced convection (precipitation) has achieved the Maritime Continent (Indonesia and West Pacific)
- **Stage 6, 7 and 8** – Enhanced precipitation moves further eastward over the western Pacific, in the long run vanishing in the focal Pacific.
- The next MJO cycle begins.

## MJO and Indian Monsoon

The improved precipitation period of the MJO can also bring the onset of the Monsoon seasons around the world. On the other hand, the suppressed convection stage can delay the beginning of the Monsoon season.

Presence of MJO over the Pacific Ocean alongside an El Nino is adverse for Monsoon downpours.

It has also been established that if the periodicity of MJO is about 30 days, at that point it brings great precipitation during the Monsoon season. There is proof that the MJO impacts the El Nino Southern Oscillation (ENSO) cycle. It doesn't cause El Nino or La Nina, however it can add to the speed of advancement and force of El Nino and La Nina scenes.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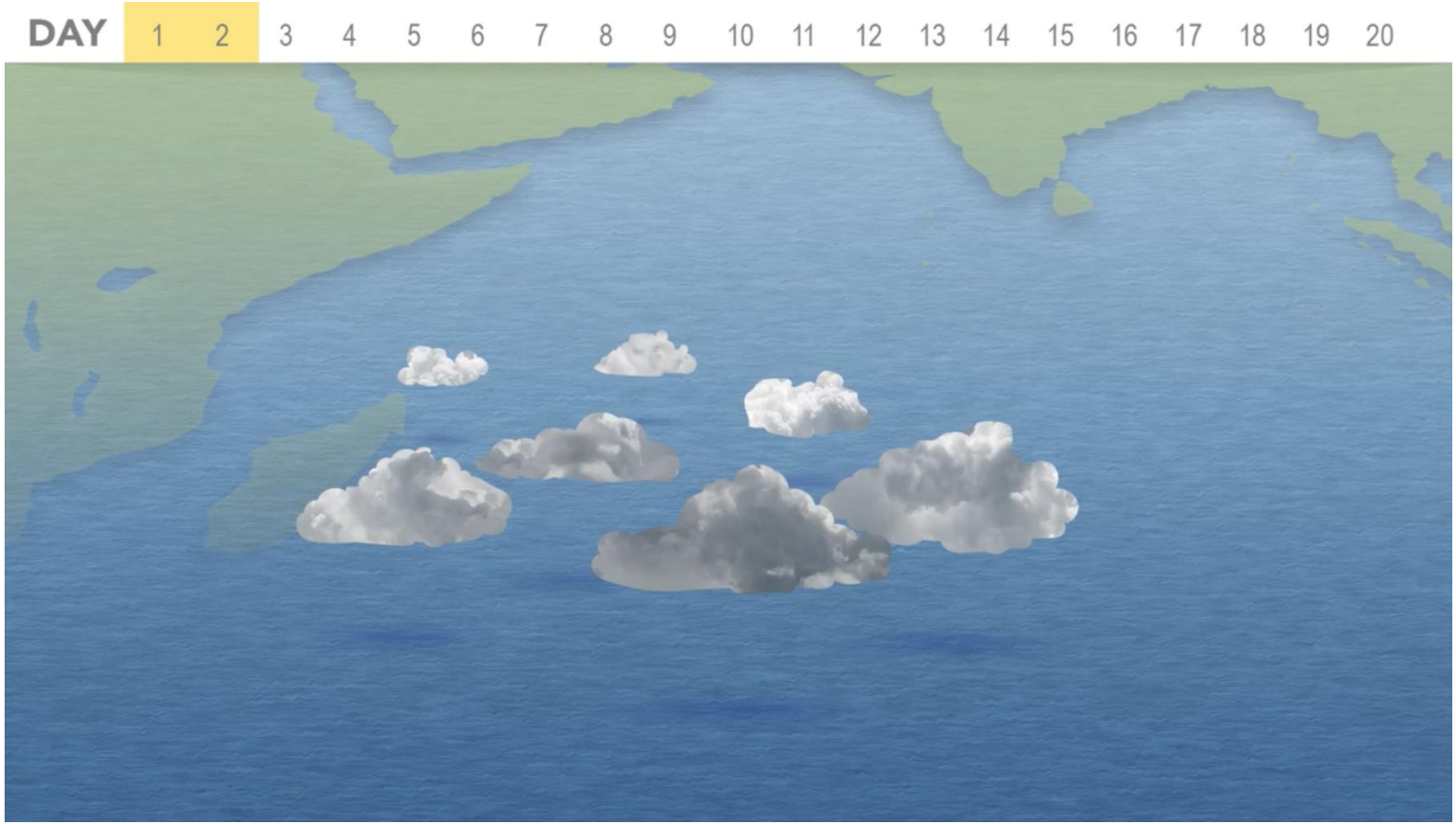


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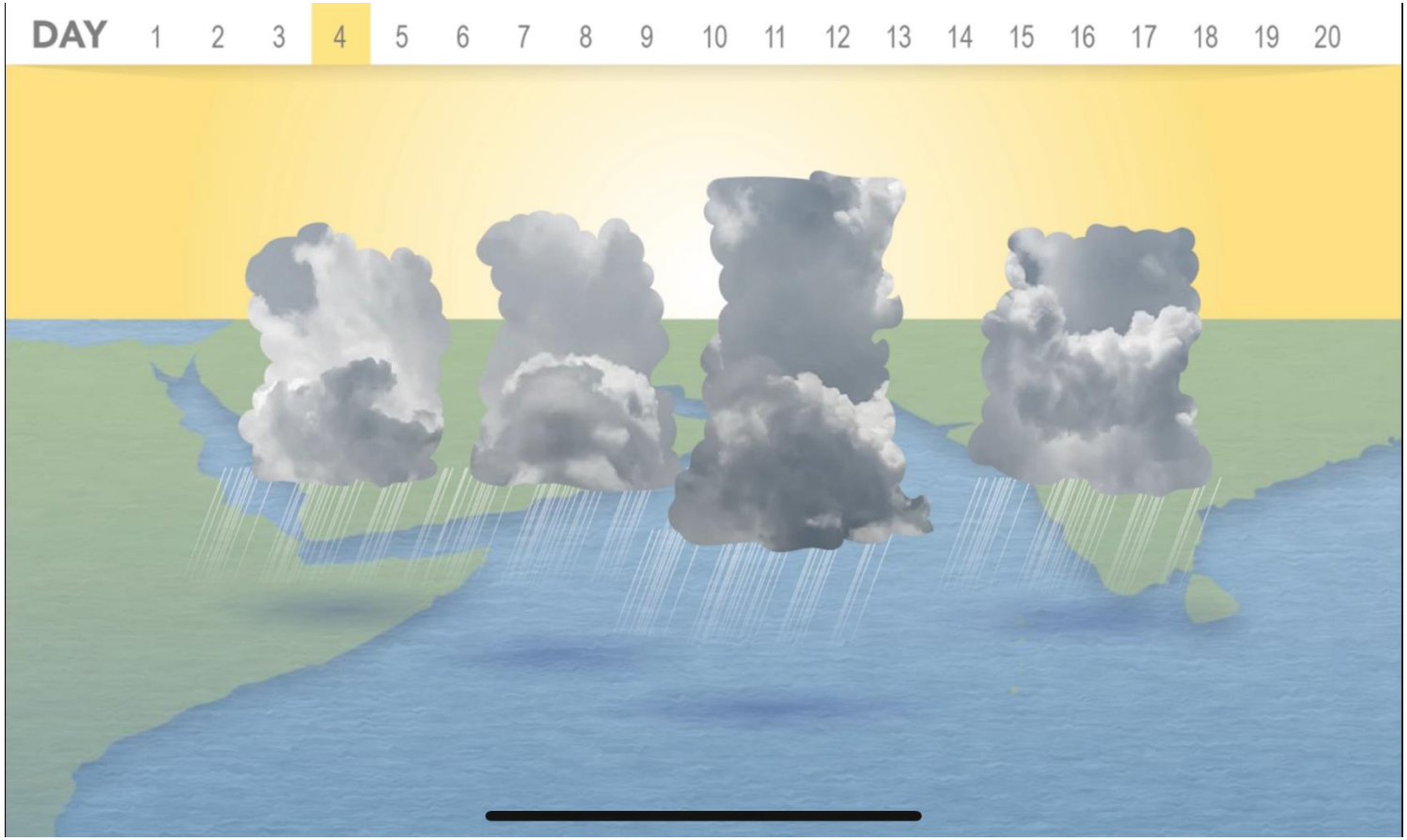


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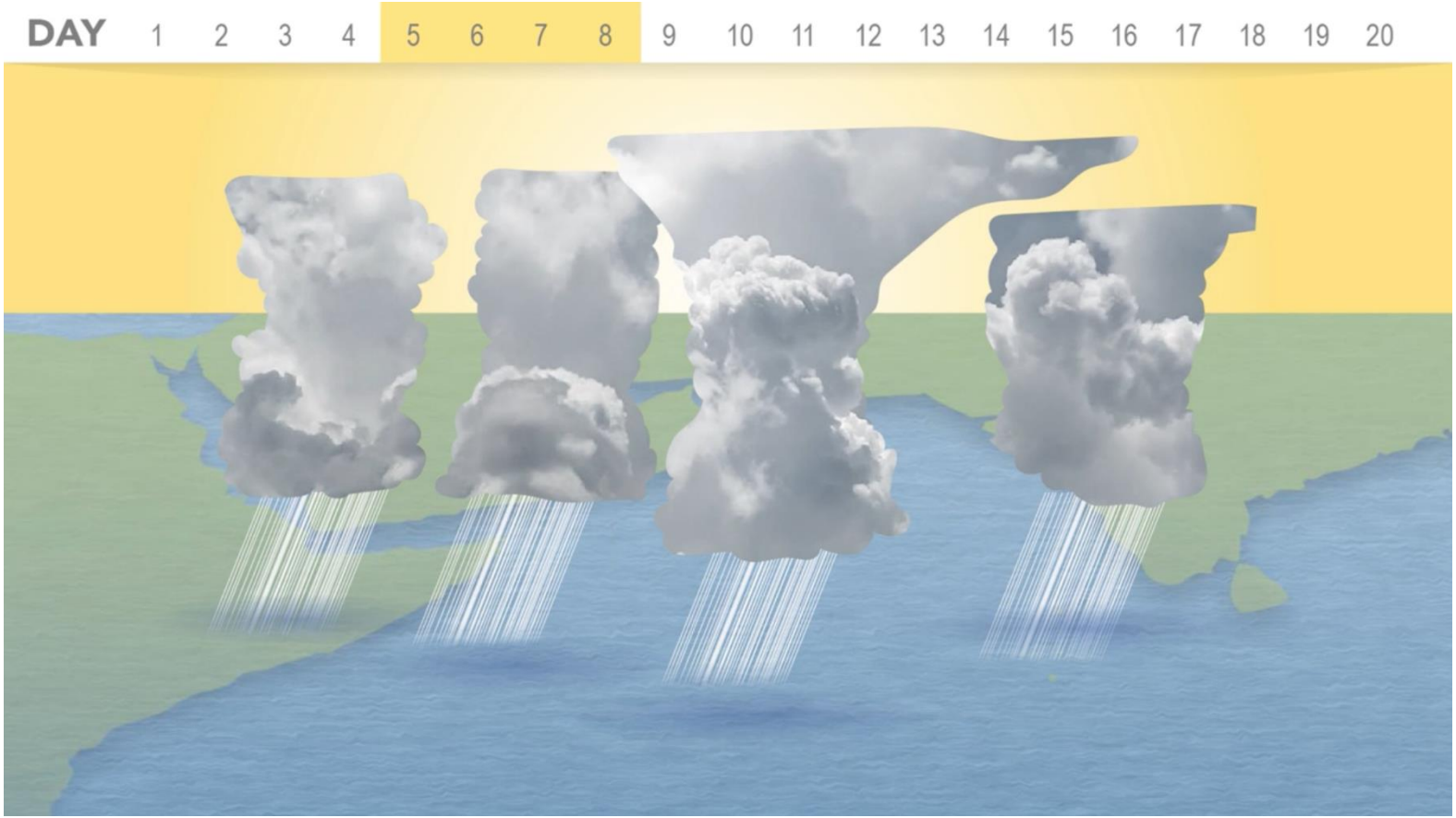


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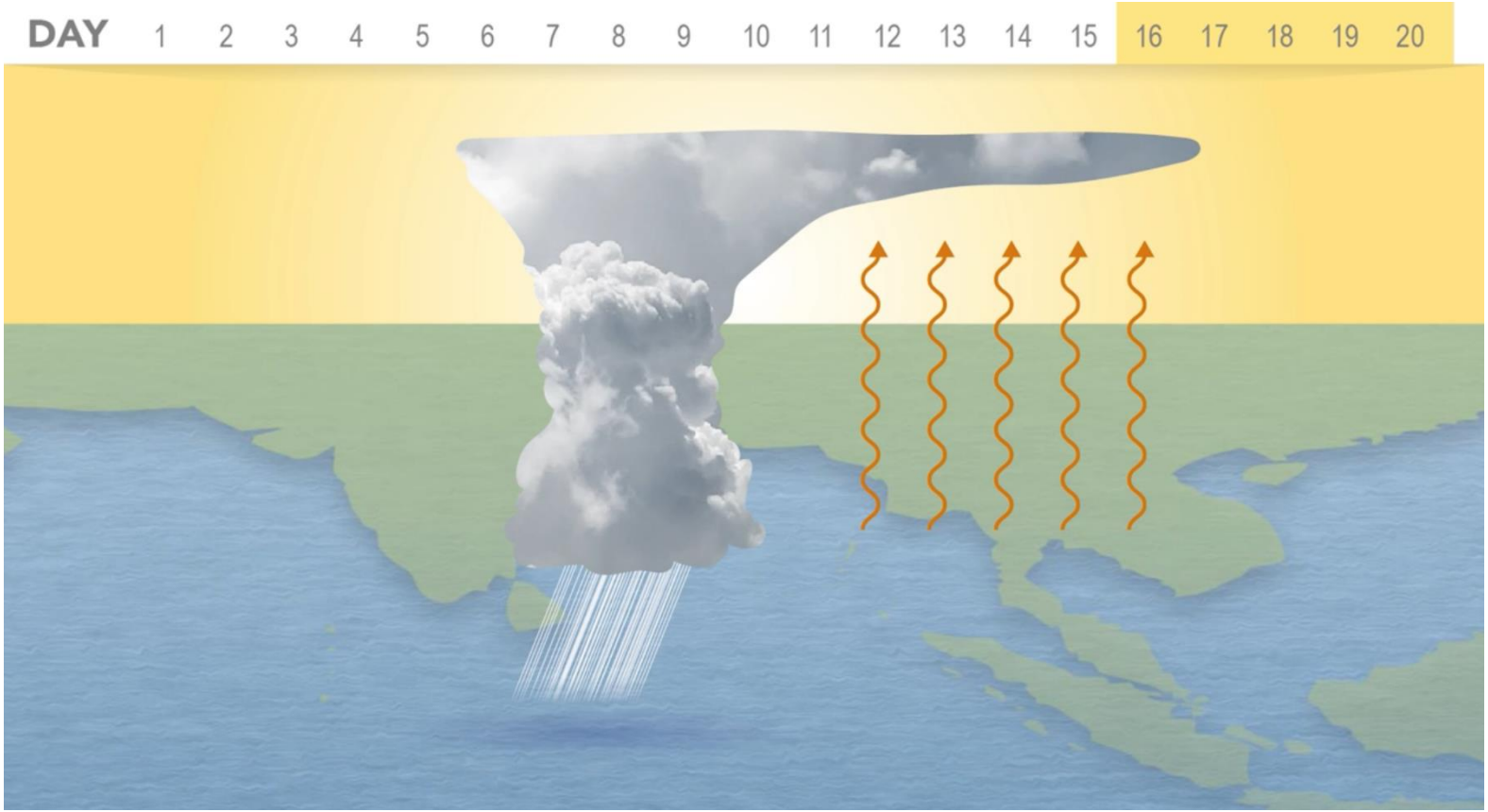


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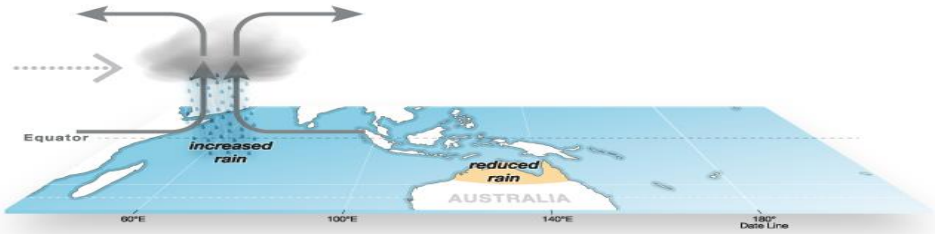
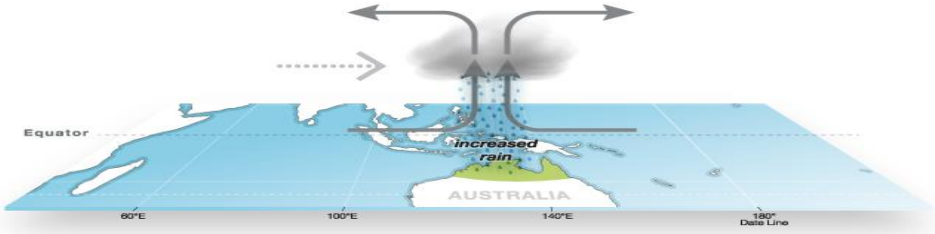
# Madden–Julian Oscillation (MJO)

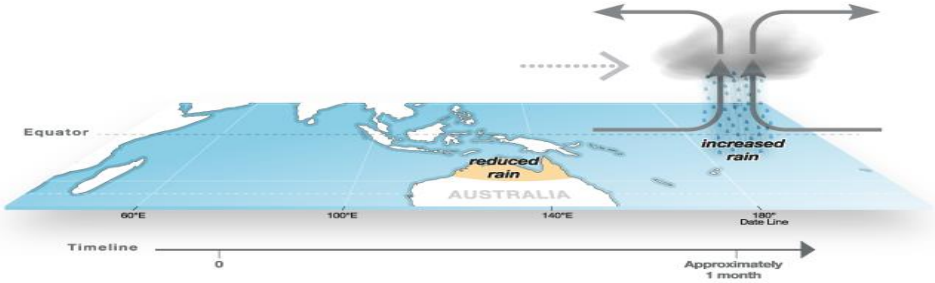
## Example cycle: Week 1




## Example cycle: Week 2-3




## Example cycle: Week 4-5



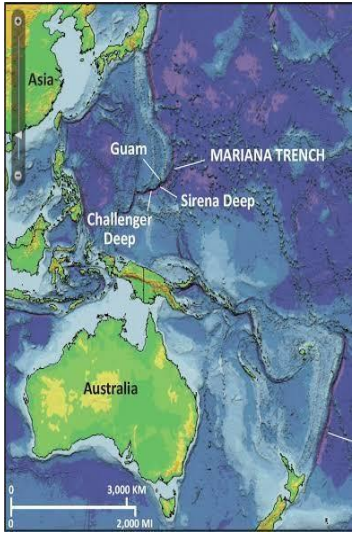

Australian Government
Bureau of Meteorology

Challenger Deep: the deepest spot in the ocean

- **Kathy Sullivan, known as the first American woman to walk in space has also become the first woman to reach a Challenger Deep.**

## About Challenger Deep

- **Location ➔ It is the deepest known point in the Earth's oceans with a depth of around 10,984m.**
- **It is located in the Western Pacific Ocean at the southern end of the Mariana Trench near the Mariana Islands group**



- **Significance of Deep Ocean Areas ➔**
- **Finding out about the deep ocean areas can potentially reveal new sources for medical drugs, food, energy resources and other products.**
- **It can also help to predict earthquakes and tsunamis and help us understand how we are affecting and getting affected by the Earth's environment.**

# Temperature Distribution of Oceans

- The study of the temperature of the oceans is important for determining the movement of large volumes of water .
- Type and distribution of marine organisms at various depths of oceans, climate of coastal lands etc.
- **Source of Heat in Oceans**
- The sun is the principal source of energy (Insolation).
- The ocean is also heated by the inner heat of the ocean itself (earth's interior is hot.

# Factors Affecting Temperature Distribution of Oceans

- **Insolation:** The average daily duration of insolation and its intensity.
- **Heat loss:** The loss of energy by reflection, scattering, evaporation and radiation.
- **The presence of submarine ridges and sills [Marginal Seas]:** Temperature is affected due to lesser mixing of waters on the opposite sides of the ridges or sills.

- **The shape of the ocean:** The latitudinally extensive seas in low latitude regions have warmer surface water than longitudinally extensive sea [Mediterranean Sea records higher temperature than the longitudinally extensive Gulf of California]..
- Whereas the enclosed seas in the high latitudes have lower temperature than the open seas.
- **The enclosed seas** (Marginal Seas – Gulf, Bay etc.) in the low latitudes record relatively higher temperature than the open seas

- **Local weather conditions such as cyclones.**
- **Unequal distribution of land and water:** The oceans in the northern hemisphere receive more heat due to their contact with larger extent of land than the oceans in the southern hemisphere.
- **Prevalent winds** generate horizontal and sometimes vertical ocean currents:
- The winds blowing from the land towards the oceans (off-shore winds-moving away from the shore) drive warm surface water away from the coast resulting in the upwelling of cold water from below Contrary to this, the onshore winds (winds flowing from oceans into continents) pile up warm water near the coast and this raises the temperature.

- **Ocean currents:** Warm ocean currents raise the temperature in cold areas while the cold currents decrease the temperature in warm ocean areas.
- **Gulf stream (warm current)** raises the temperature near the eastern coast of North America and the West Coast of Europe while the **Labrador current (cold current)** lowers the temperature near the north-east coast of North America (Near Newfoundland).
- All these factors influence the temperature of the ocean currents locally.

# Vertical Temperature Distribution of Oceans

- **Photic or euphotic zone** extends from the upper surface to ~200 m.
- The photic zone receives adequate solar insolation.
- **Aphotic zone** extends from 200 m to the ocean bottom.
- This zone does not receive adequate sunrays.

- **Thermocline**
- The profile shows a boundary region between the surface waters of the ocean and the deeper layers.
- The boundary usually begins around 100 – 400 m below the sea surface and extends several hundred of meters downward.
- This boundary region, from where there is a rapid decrease of temperature, is called the **thermocline**.
- About 90 per cent of the total volume of water is found below the thermocline in the deep ocean.

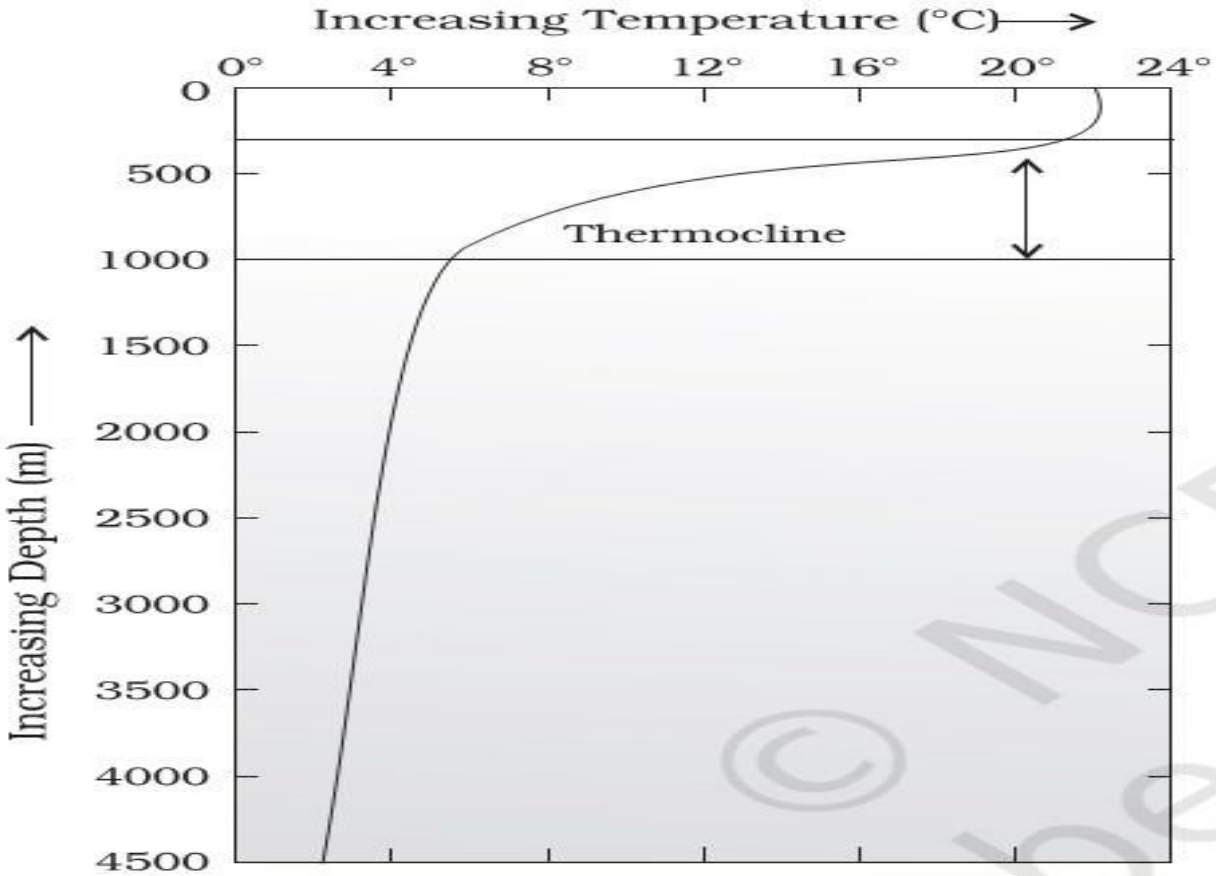



**Figure 13.3 : Thermocline**

# Ocean Salinity

- Salinity is the term used to define the total content of dissolved salts in sea water.
- It is calculated as the amount of salt (in gm) dissolved in 1,000 gm (1 kg) of seawater.
- It is usually expressed as parts per thousand or ppt.
- **Role of Ocean Salinity**
- Salinity determines compressibility, thermal expansion, temperature, density.
- It also influences the composition and movement of the sea water.

- Share of different salts is as shown below—
- **Sodium chloride — 77.7%**
- **Magnesium chloride—10.9%**
- **Magnesium sulphate —.4.7%**
- **Calcium sulphate — 3.6%**
- **Potassium sulphate — 2.5%**
- **Factors Affecting Ocean Salinity**
- The salinity of water in the surface layer of oceans depend mainly on **evaporation and precipitation.**

- Wind, also influences salinity of an area by transferring water to other areas.
- The ocean currents contribute to the salinity variations.
- Salinity, temperature and density of water are interrelated.
- Hence, any change in the temperature or density influences the salinity of an area.

Highest salinity in water bodies
Lake Van in Turkey (330 °/₀₀),
Dead Sea (238 °/₀₀),
Great Salt Lake (220 °/₀₀)

**Table 13.4 : Dissolved Salts in Sea Water (gm of Salt per kg of Water)**

| | |
|---|---|
| Chlorine | 18.97 |
| Sodium | 10.47 |
| Sulphate | 2.65 |
| Magnesium | 1.28 |
| Calcium | 0.41 |
| Potassium | 0.38 |
| Bicarbonate | 0.14 |
| Bromine | 0.06 |
| Borate | 0.02 |
| Strontium | 0.01 |

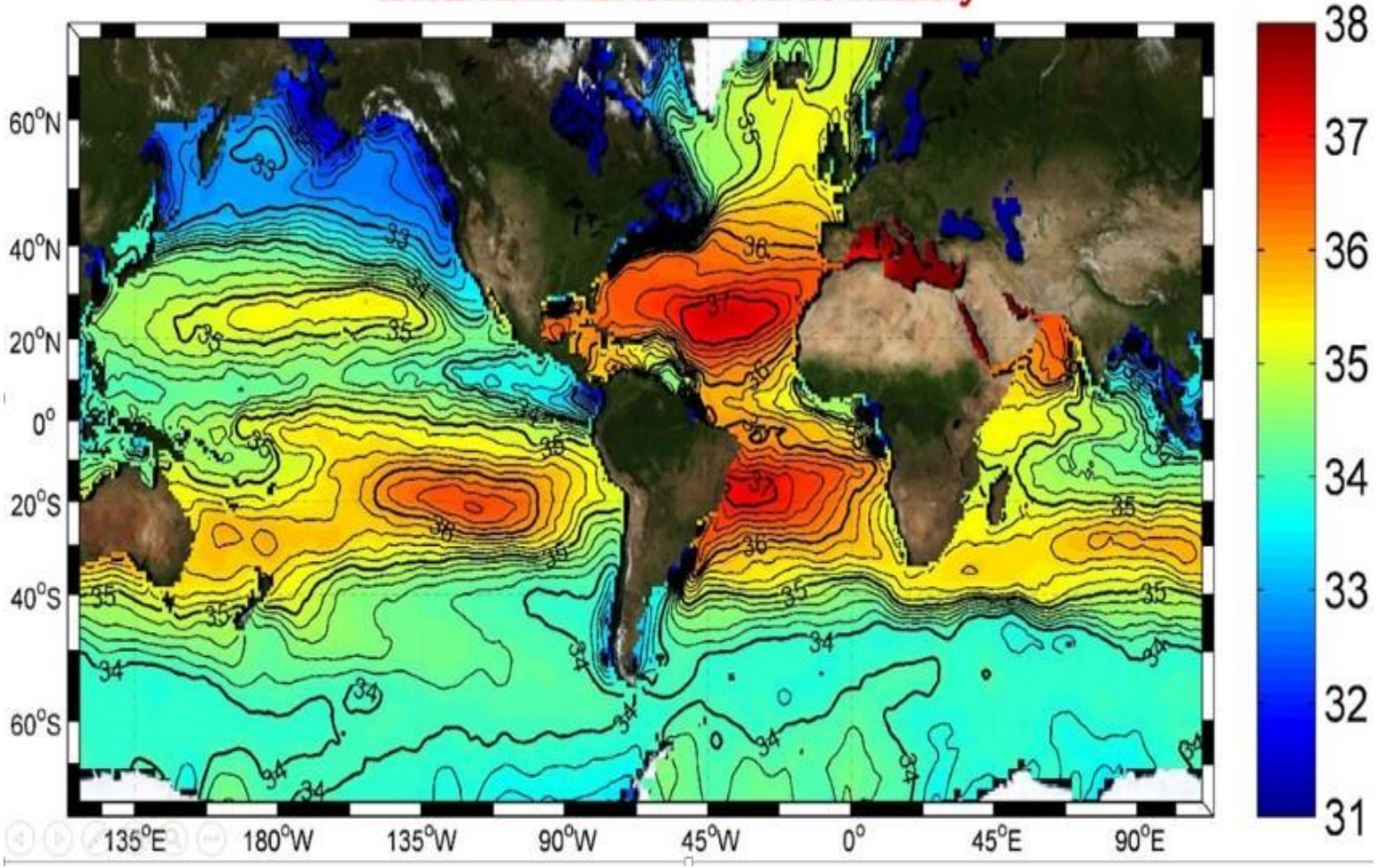
# Horizontal distribution of salinity

- **High salinity regions**
- In the land locked Red Sea (don't confuse this to Dead Sea which has much greater salinity), it is as high as 41.
- In hot and dry regions, where evaporation is high, the salinity sometimes reaches to 70.
- **Comparatively Low salinity regions**
- In the estuaries (enclosed mouth of a river where fresh and saline water get mixed) and the Arctic, the salinity fluctuates from 0 – 35, seasonally (fresh water coming from ice caps).

- **Pacific**
- The salinity variation in the Pacific Ocean is mainly due to its shape and larger areal extent.

- **Atlantic**
- The average salinity of the Atlantic Ocean is around 36-37.
- The equatorial region of the Atlantic Ocean has a salinity of about 35.
- Near the equator, there is **heavy rainfall**, high relative humidity, cloudiness and calm air of the doldrums.
- The polar areas experience very little evaporation and receive large amounts of fresh water from the melting of ice.
- This leads to low levels of salinity, ranging between 20 and 32.
- Maximum salinity (37) is **observed between 20° N and 30° N and 20° W – 60° W**. It gradually decreases towards the north.

# Horizontal distribution of salinity



- **Indian Ocean**
- The average salinity of the Indian Ocean is 35.
- The low salinity trend is observed in the Bay of Bengal due to influx of river water by the river Ganga.
- On the contrary, the Arabian Sea shows **higher salinity** due to high evaporation and low influx of fresh water.

- **Marginal seas**
- **The North Sea**, in spite of its location in higher latitudes, records higher salinity due to more saline water brought by the North Atlantic Drift.
- **Baltic Sea** records low salinity due to influx of river waters in large quantity.
- The **Mediterranean Sea** records higher salinity due to high evaporation.
- Salinity is, however, very low in **Black Sea** due to enormous fresh water influx by rivers.

- **Inland seas and lakes**
- The salinity of the inland Seas and lakes is very high because of the regular supply of salt by ' the rivers falling into them.
- Their water becomes progressively more saline due to evaporation.
- For instance, the salinity of the **Great Salt Lake** , (Utah, USA), the **Dead Sea** and the **Lake Van** in Turkey is 220, 240 and 330 respectively.
- The oceans and salt lakes are becoming more salty as time goes on because the rivers dump more salt into them, while fresh water is lost due to evaporation.

- **Cold and warm water mixing zones**
- Salinity decreases from 35 – 31 on the western parts of the northern hemisphere because of the influx of melted water from the Arctic region.

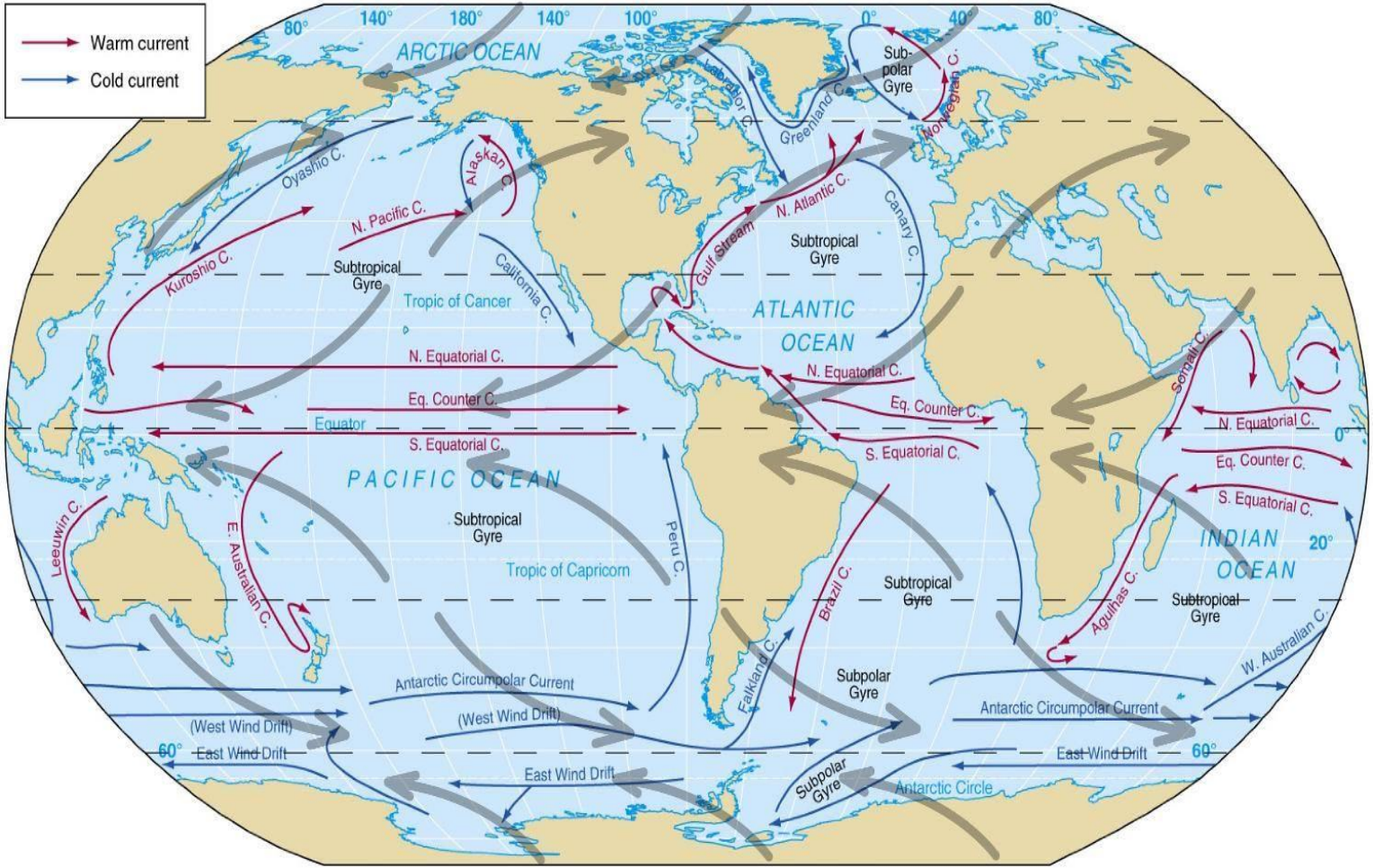
- Ocean currents are influenced by types of forces namely:
- **heating by solar energy;**
- **wind**
- **gravity**
- **Coriolis force.**
- **Temperature difference**
- **Salinity difference**

- **Influence of gravity**
- Gravity tends to pull the water down to pile and create **gradient variation**.
- **Influence of Coriolis force**
- The Coriolis force intervenes and causes the water to move to the **right** in the northern hemisphere and to the **left** in the southern hemisphere.
- These large accumulations of water and the flow around them are called **Gyres**.
- These produce large circular currents in all the ocean basins. One such circular current is the **Sargasso Sea**.

- **Temperature difference** and **salinity difference** are the secondary forces.
- Differences in water density affect **vertical mobility** of ocean currents (vertical currents).
- Water with high salinity is denser than water with low salinity and in the same way cold water is denser than warm water.
- Denser water tends to sink, while relatively lighter water tends to rise.
- Cold-water ocean currents occur when the cold water at the poles sinks and slowly moves towards the equator.
- Warm-water currents travel out from the equator along the surface, flowing towards the poles to replace the sinking cold water.

# General Characteristics of Ocean Currents

- Characteristics of Ocean Currents arise due to the interplay of the above-mentioned factors.
- **The general movement of the currents in the northern hemisphere is clockwise and in the southern hemisphere, anti-clockwise.**
- This is due to the **Coriolis force which is a deflective force and follows Ferrel's law**.
- A notable exception to this trend is seen in the northern part of the Indian Ocean where the current movement changes its direction in response to the **seasonal change in the direction** of monsoon winds.


Warm current
Cold current
ARCTIC OCEAN
Sub-polar Gyre
Norwegian C.
Greenland C.
Labrador C.
Oyashio C.
Alaskan C.
N. Pacific C.
Kuroshio C.
Subtropical Gyre
California C.
Tropic of Cancer
Gulf Stream
N. Atlantic C.
Canary C.
Subtropical Gyre
ATLANTIC OCEAN
N. Equatorial C.
Eq. Counter C.
Equator
S. Equatorial C.
N. Equatorial C.
Eq. Counter C.
S. Equatorial C.
Somali C.
N. Equatorial C.
Eq. Counter C.
S. Equatorial C.
PACIFIC OCEAN
Subtropical Gyre
Tropic of Capricorn
Leeuwin C.
E. Australian C.
Peru C.
Brazil C.
Subtropical Gyre
Falkland C.
Subpolar Gyre
INDIAN OCEAN
Agulhas C.
Subtropical Gyre
W. Australian C.
Antarctic Circumpolar Current
(West Wind Drift)
East Wind Drift
Antarctic Circumpolar Current
East Wind Drift
Subpolar Gyre
Antarctic Circle
80°
140°
180°
140°
100°
0°
40°
80°
20°
0°
60°
60°

- **The warm currents move towards the cold seas and cool currents towards the warm seas.**
- In the lower latitudes, the warm currents flow on the **eastern shores** and cold on the western shores
- The situation is reversed in the higher latitudes.
- The warm currents move along the western shores and the cold currents along the eastern shores.
- **Convergence:** warm and cold currents meet.
- **Divergence:** a single current splits into multiple currents flowing in different directions.

- **The shape and position of coasts play an important role in guiding the direction of currents.**
- The currents flow not only at the surface but also below the sea surface (due to salinity and temperature difference).
- For instance, heavy surface water of the Mediterranean Sea sinks and flows westward past Gibraltar as a sub-surface current.

# Effects of Ocean Currents

- Ocean currents have a number of direct and indirect influences on human activities.
- **Desert formation**
- Cold ocean currents have a direct effect on **desert formation** in west coast regions of the **tropical and subtropical continents**.
- There is **fog** and most of the areas are **arid due to desiccating effect (loss of moisture)**.

- **Rains**
- Warm ocean currents bring rain to coastal areas and even interiors. Example: Summer Rainfall in **British Type climate**.
- Warm currents flow parallel to the east coasts of the continents in tropical and subtropical latitudes.

- This results in warm and rainy climates.
- These areas lie in the western margins of the subtropical anti-cyclones.
- **Moderating effect**
- They are responsible for moderate temperatures at coasts.
- [North Atlantic Drift brings warmness to England. Canary cold current brings cooling effect to Spain, Portugal etc.]

- **Fishing**
- Mixing of cold and warm ocean currents bear richest fishing grounds in the world.
- Example: Grand Banks around Newfoundland, Canada and North-Eastern Coast of Japan.
- The mixing of warm and cold currents help to replenish the oxygen and favor the growth of **planktons**, the primary food for fish population.
- The best fishing grounds of the world exist mainly in these mixing zones.

- **Drizzle**
- Mixing of cold and warm ocean currents create foggy weather where precipitation occurs in the form of drizzle [Newfoundland].
- **Climate**
- Results inWarm and rainy climates in tropical and subtropical latitudes [Florida, Natal etc.].
- Cold and dry climates on the western margins in the sub-tropics due to desiccating effect,
- Foggy weather and drizzle in the mixing zones,
- Moderate clime along the western costs in the sub-tropics.

- **Tropical cyclones**
- They pile up warm waters in tropics and this warm water is the major force behind tropical cyclones.

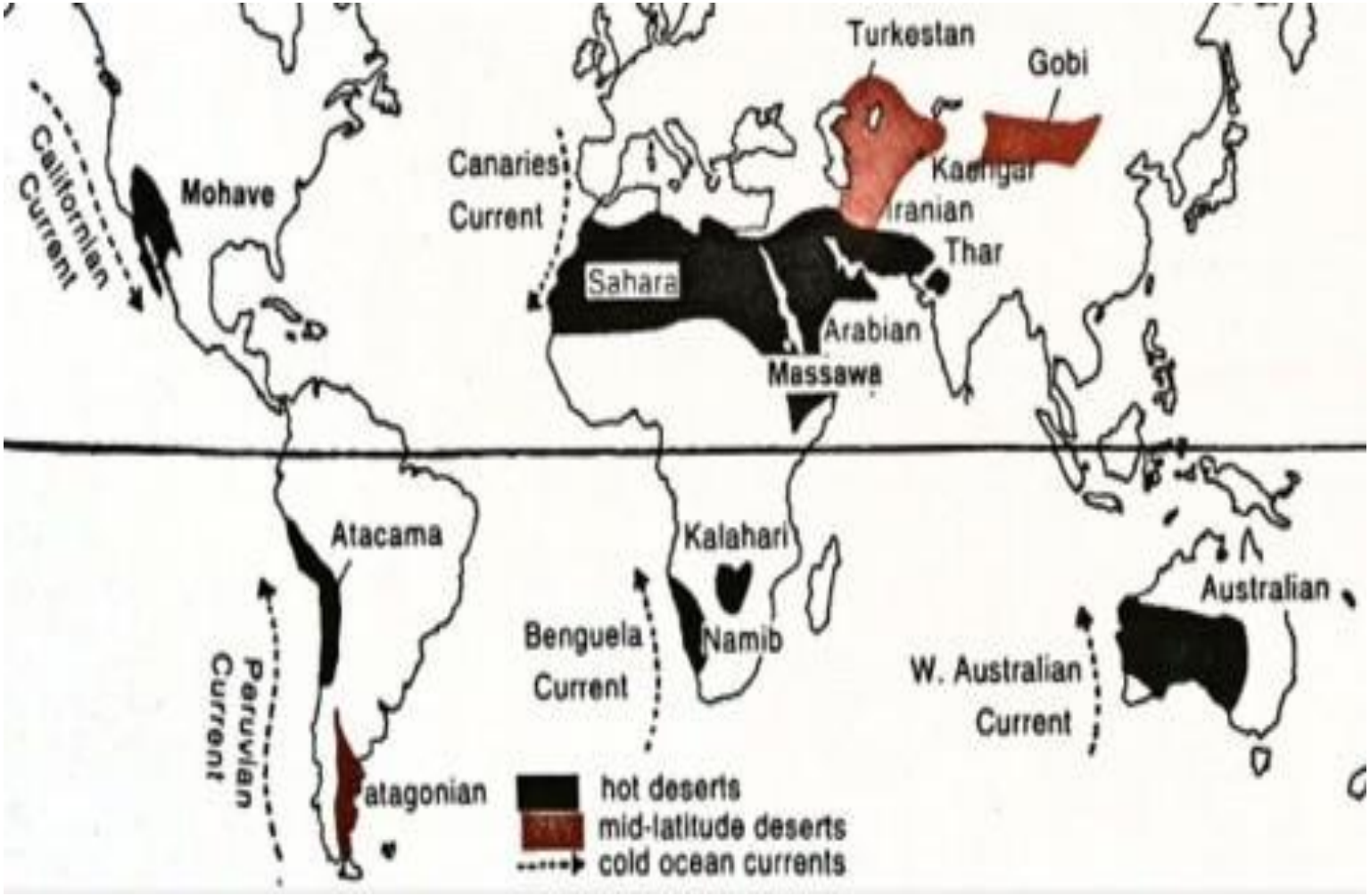
- **Navigation**
- Currents are referred to by their "drift". Usually, the currents are strongest near the surface and may attain speeds over five knots (1 knot = ~1.8 km).
- [At depths, currents are generally slow with speeds less than 0.5 knots].
- Ships usually follow routes which are aided by ocean currents and winds.
- Example - If a ship wants to travel from Mexico to Philippines, it can use the route along the North Equatorial Drift which flows from east to west.
- When it wants to travel from Philippines to Mexico, it can follow the route along the doldrums when there is counter equatorial current flowing from west to east.

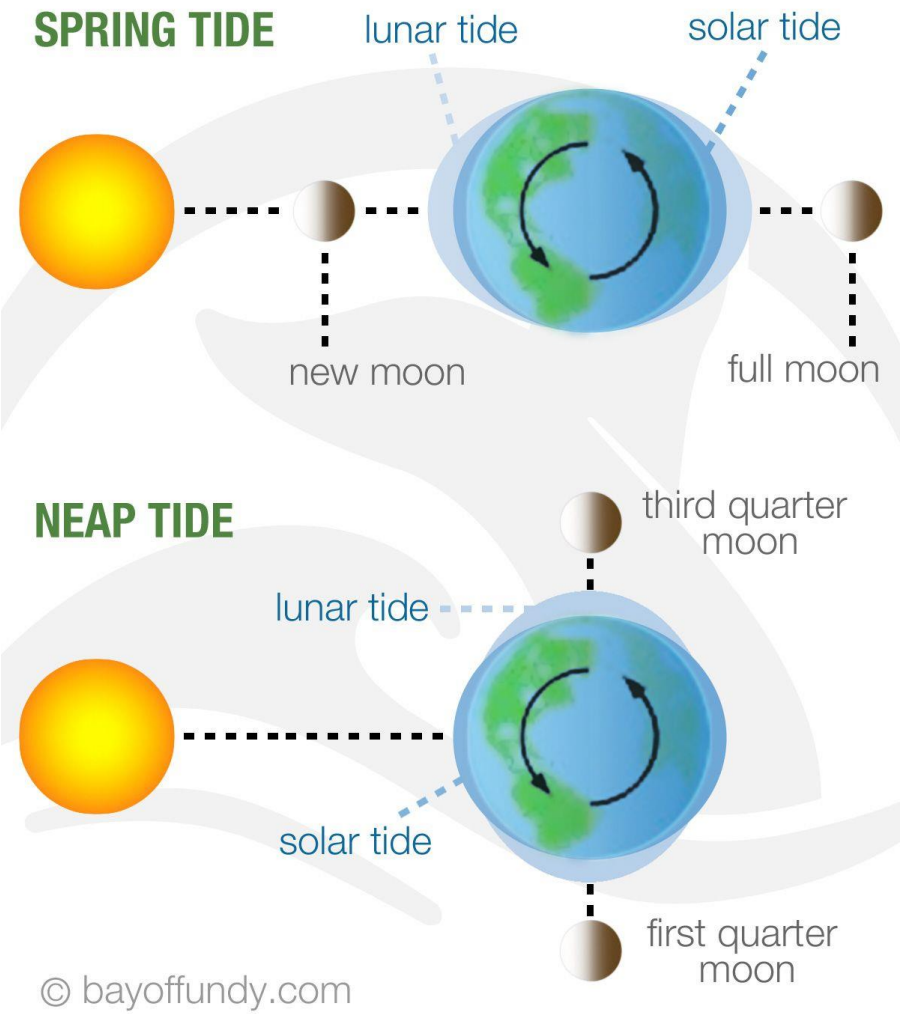
# Desert Formation and Ocean Currents

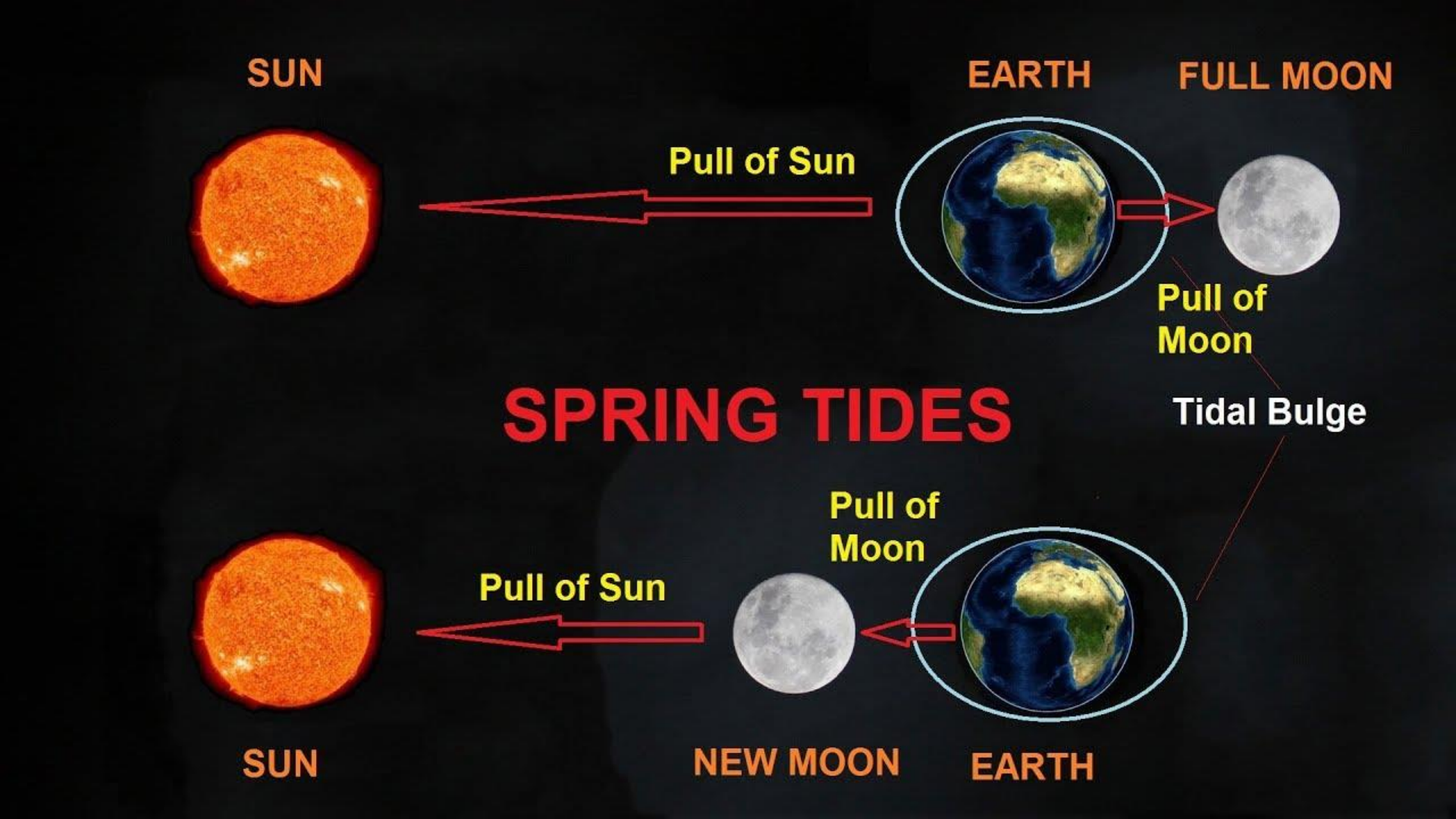
- **Major hot deserts are located between 20-30 degree latitudes and on the western side of the continents. Why?**
- The aridity of the hot deserts is mainly due to the effects of off-shore Trade Winds, hence they are also called **Trade Wind Deserts.**
- The major hot deserts of the world are located on the western coasts of continents between latitudes 15° and 30°N. and S (Question asked in Previous Mains Exam).
- They include the biggest Sahara Desert (3.5 million square miles).
- The next biggest desert is the Great Australian Desert.

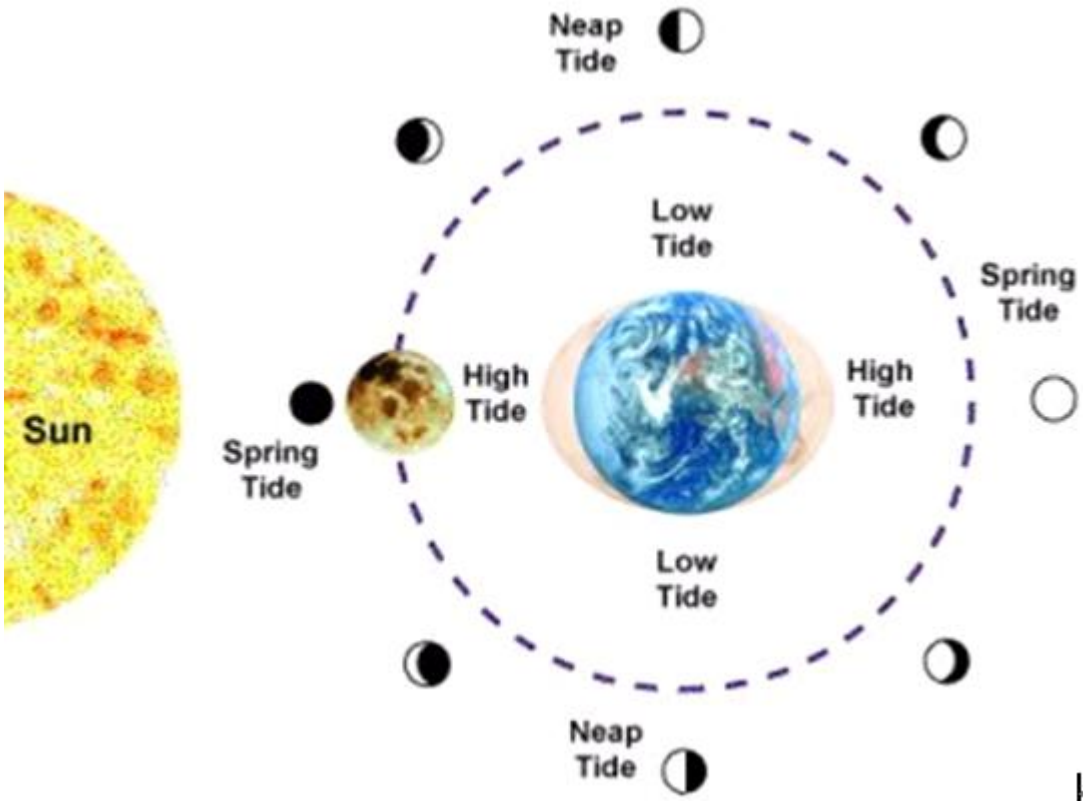
- The other hot deserts are the Arabian Desert, Iranian Desert, Thar Desert, Kalahari and Namib Deserts.
- The hot deserts lie along the Horse Latitudes or the Sub-Tropical High Pressure Belts where the air is descending, a condition least favorable for precipitation of any kind to take place.
- The rain-bearing Trade Winds blow **off-shore** and the Westerlies that are on-shore blow outside the desert limits.
- Whatever winds reach the deserts blow from cooler to warmer regions, and their relative humidity is lowered, making condensation almost impossible.
- There is scarcely any cloud in the continuous blue sky.

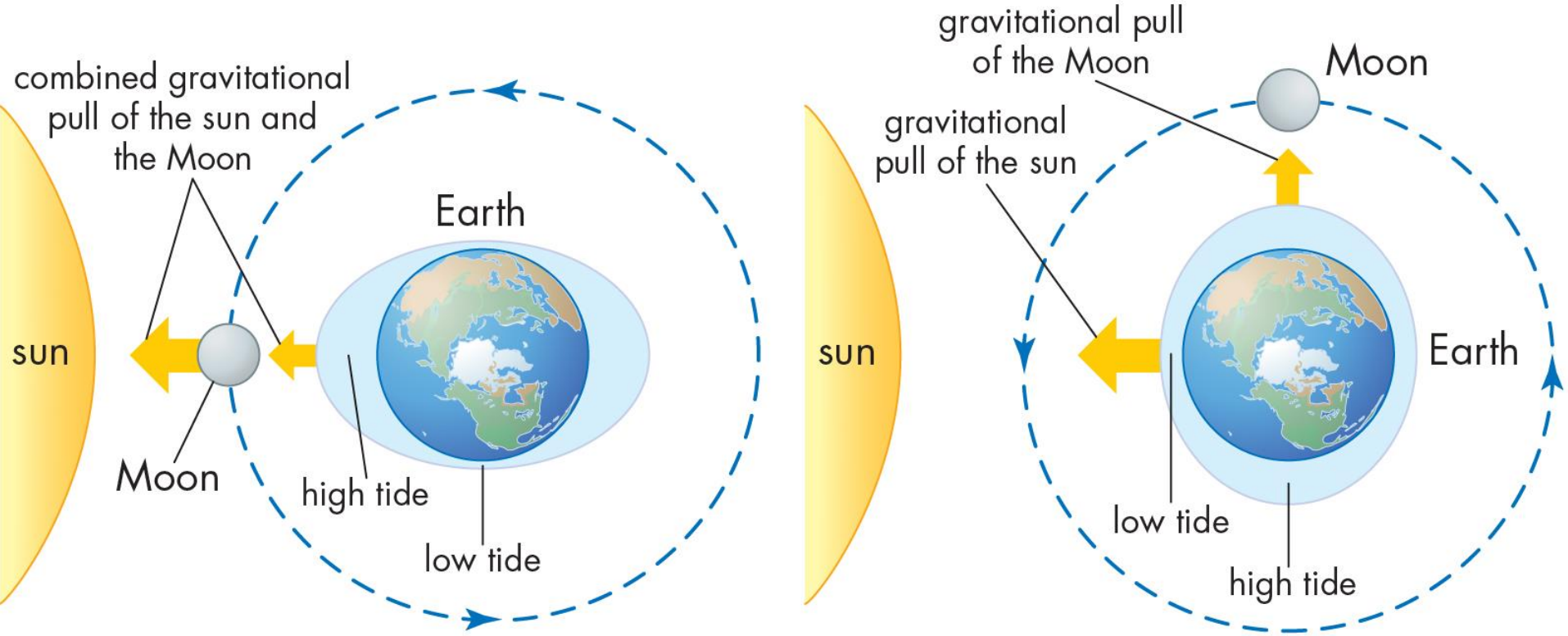
- The relative humidity is extremely low, decreasing from 60 per cent in coastal districts to less than 30 per cent in the desert interiors.
- Under such conditions, every bit of moisture is evaporated and the deserts are thus regions of permanent drought.
- Precipitation is both scarce and most unreliable.
- On the western coasts, the presence of cold currents gives rise to **mists and fogs** by chilling the on-coming air.
- This air is later warmed by contact with the hot land, and little rain falls.
- The **effect** of the cold Peruvian Current along the Chilean coast is so pronounced that the mean annual rainfall for the Atacama Desert is not more than 1.3 cm.


Turkestan
Gobi
Canaries
Current
Kashgar
Iranian
Thar
Mohave
Californian
Current
Sahara
Arabian
Massawa
Atacama
Kalahari
Australian
Benguela
Current
Namib
W. Australian
Current
Peruvian
Current
Patagonian
hot deserts
mid-latitude deserts
cold ocean currents


SPRING TIDE
lunar tide
solar tide
new moon
full moon
NEAP TIDE
third quarter moon
lunar tide
solar tide
first quarter moon
© bayoffundy.com


SUN
EARTH
FULL MOON
Pull of Sun
Pull of Moon
Tidal Bulge
SPRING TIDES
Pull of Moon
Pull of Sun
SUN
NEW MOON
EARTH


Neap
Tide
Low
Tide
Spring
Tide
Sun
Spring
Tide
High
Tide
High
Tide
Low
Tide
Neap
Tide



•The height of rising water (high tide) varies appreciably depending upon the position of sun and moon with respect to the earth. **Spring tides** and **neap tides** come under this category.

**Spring tides**

•The position of both the sun and the moon in relation to the earth has direct bearing on tide height.
•When the sun, the moon and the earth are in a straight line, the height of the tide will be higher.
•These are called **spring tides** and they occur **twice a month**, one on **full moon period** and another during **new moon period**.

**Neap tides**

•Normally, there is a **seven day interval** between the spring tides and neap tides.
•At this time the sun and moon are at **right angles** to each other and the forces of the sun and moon tend to counteract one another.
•The Moon's attraction, though more than twice as strong as the sun's, is diminished by the counteracting force of the sun's gravitational pull.
•Like spring tides, these tides also occur **twice a month.**

# Perigee and apogee of moon

- Once in a month, when the moon’s orbit is closest to the earth **(perigee)**, unusually high and low tides occur. During this time the tidal range is greater than normal.
- Two weeks later, when the moon is farthest from earth **(apogee)**, the moon’s gravitational force is limited and the tidal ranges are less than their average heights.

# Perigee and Apogee of earth

- When the earth is closest to the sun **(perihelion)**, around **3rd January** each year, tidal ranges are also much greater, with unusually high and unusually low tides.
- When the earth is farthest from the sun **(aphelion)**, around **4th July** each year, tidal ranges are much less than average.

# Ebb and Flow/Flood

- The time between the high tide and low tide, when the water level is **falling**, is called the **ebb.**
- The time between the low tide and high tide, when the tide is **rising**, is called the **flow or flood.**

# Flood and Ebb Currents

- **Flood** current is when the tide is coming in.
- **Ebb** current is when the tide is going out