

# Climate Change



# The Greenhouse Effect

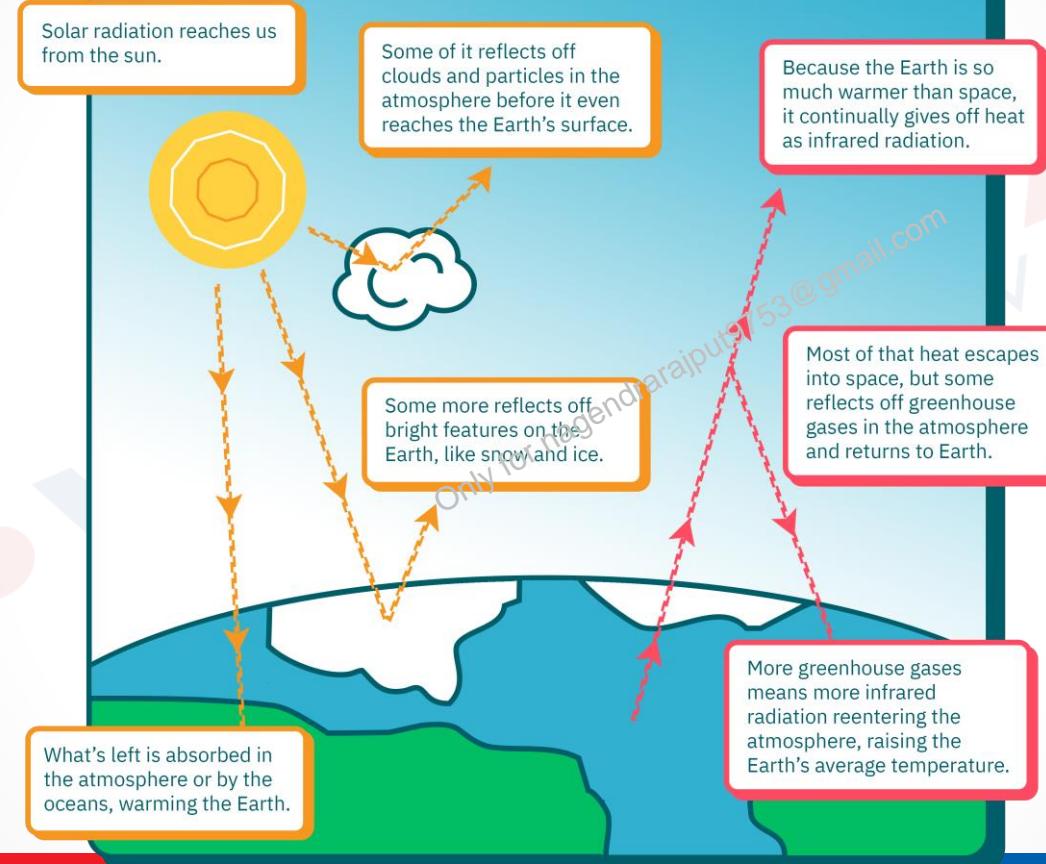
Some solar radiation is reflected by the Earth and the atmosphere.

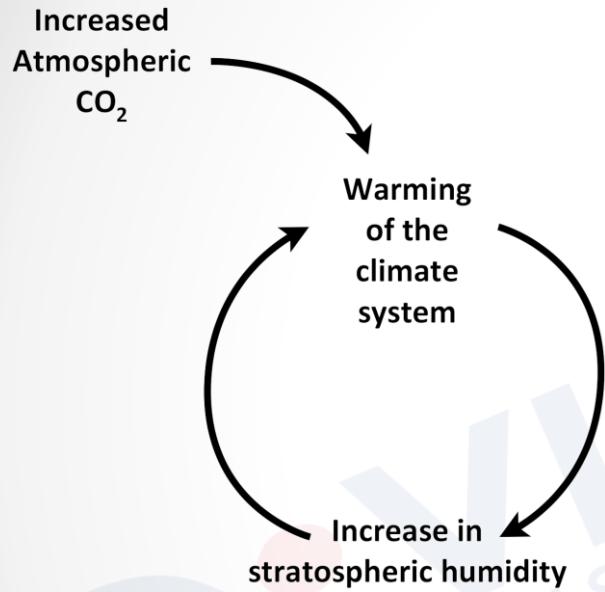
Some of the infrared radiation passes through the atmosphere. Some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.

Most radiation is absorbed by the Earth's surface and warms it.

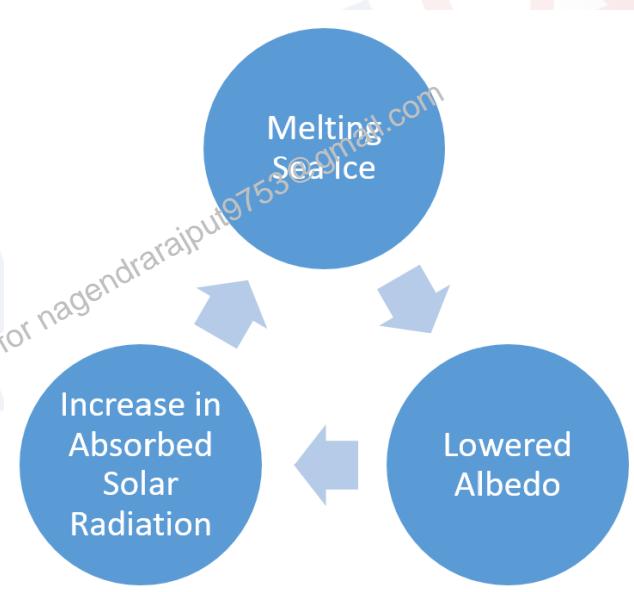
Infrared radiation is emitted by the Earth's surface.

## How does energy enter and leave the atmosphere?



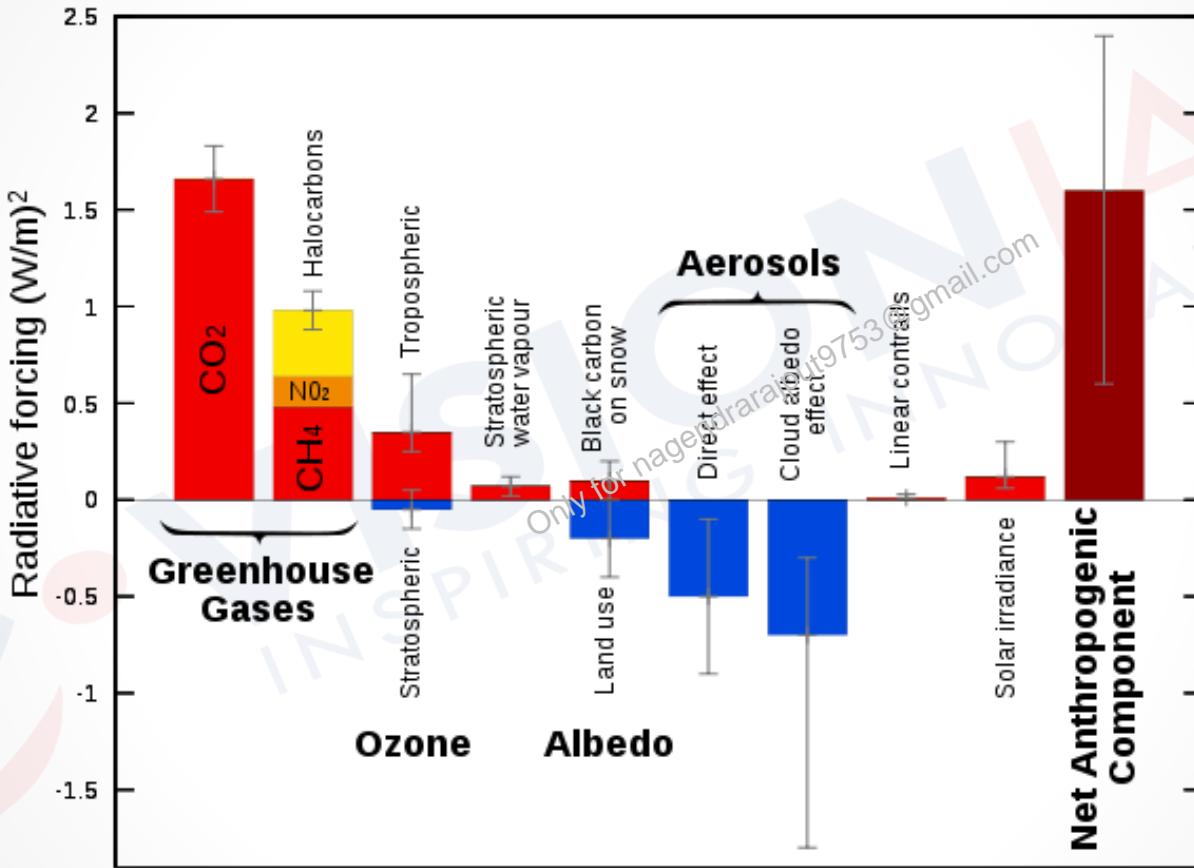


## Water vapor Feedback

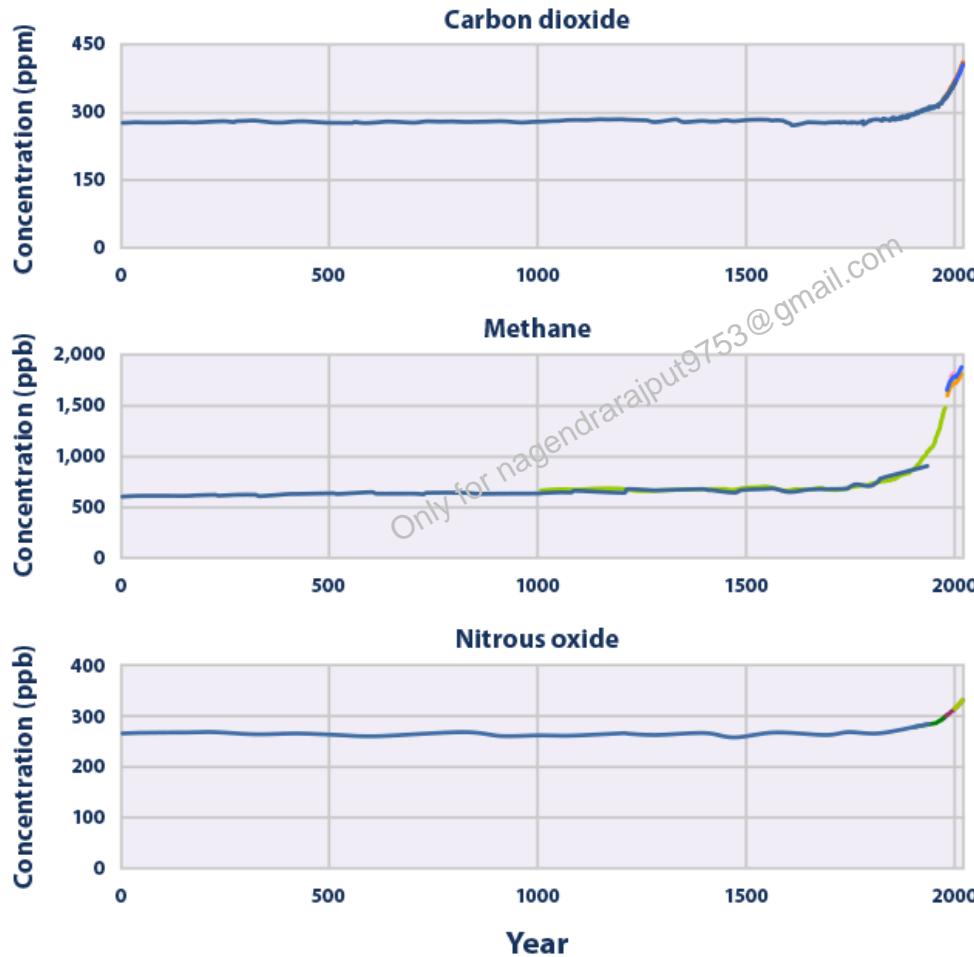


## Ice Albedo Feedback

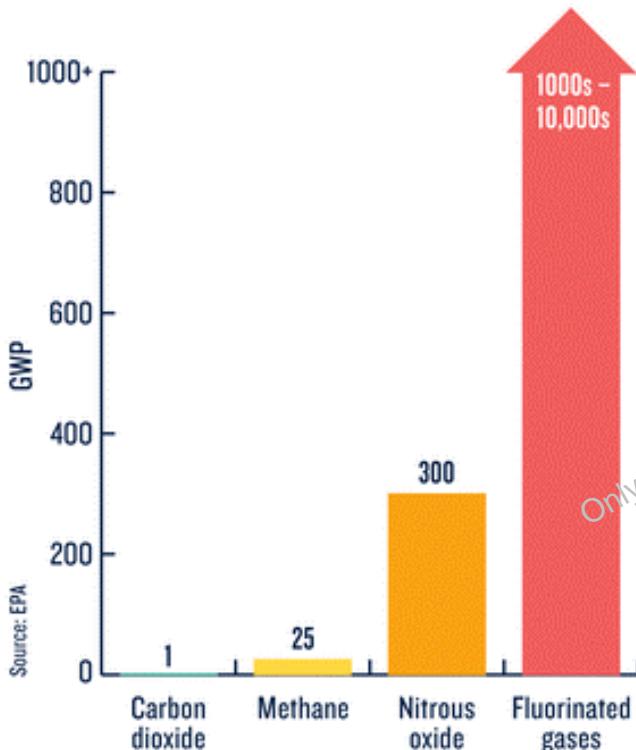
# Radiative Forcing Components



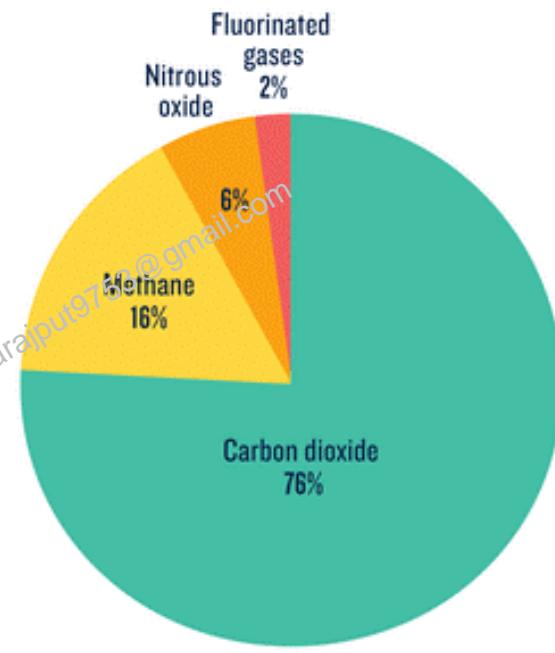
## Global Atmospheric Greenhouse Gas Concentrations Over Time



# HOW GREENHOUSE GASES WARM OUR PLANET



The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.



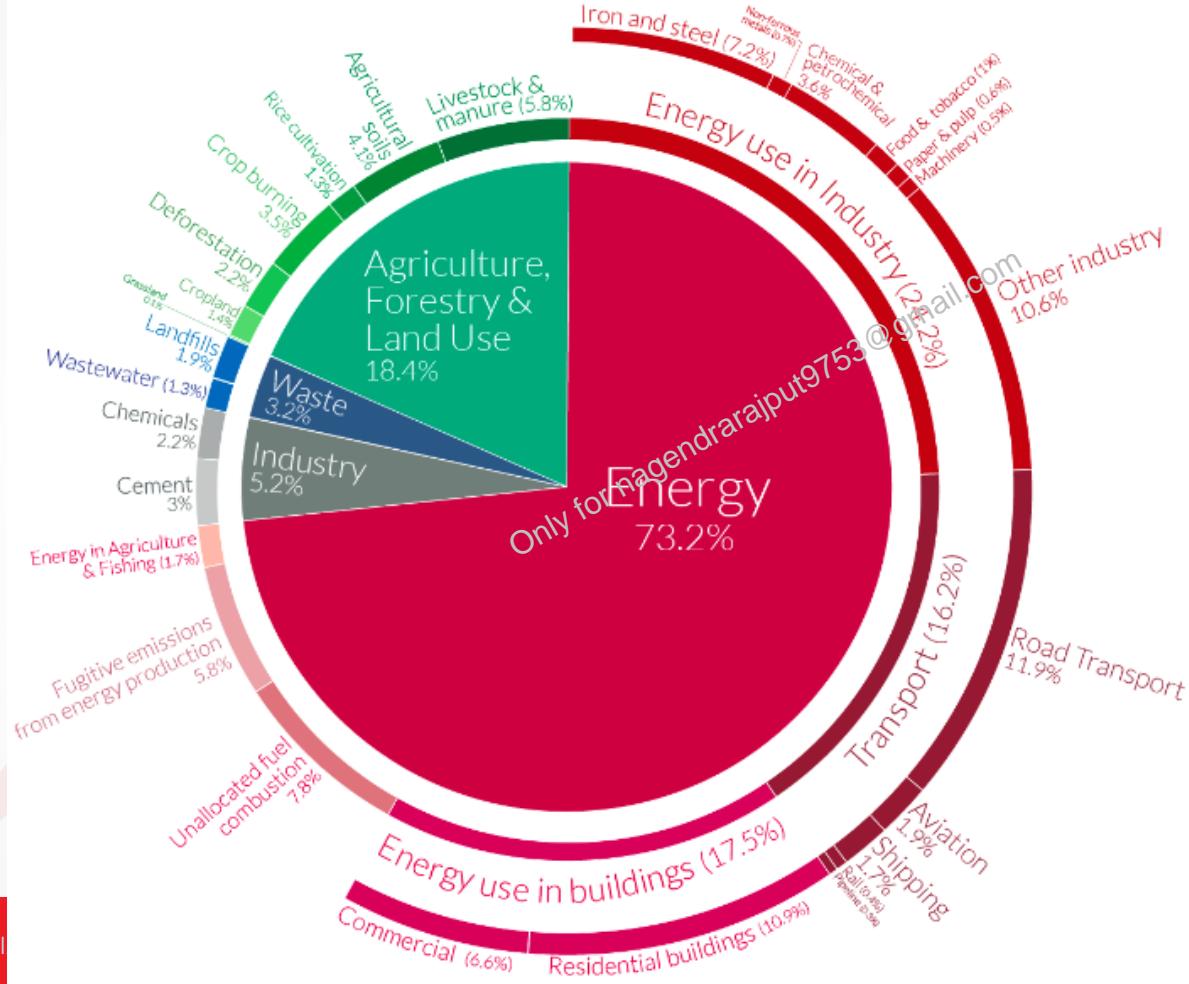
How much each human-caused greenhouse gas contributes to total emissions around the globe.

# Global Warming Potential

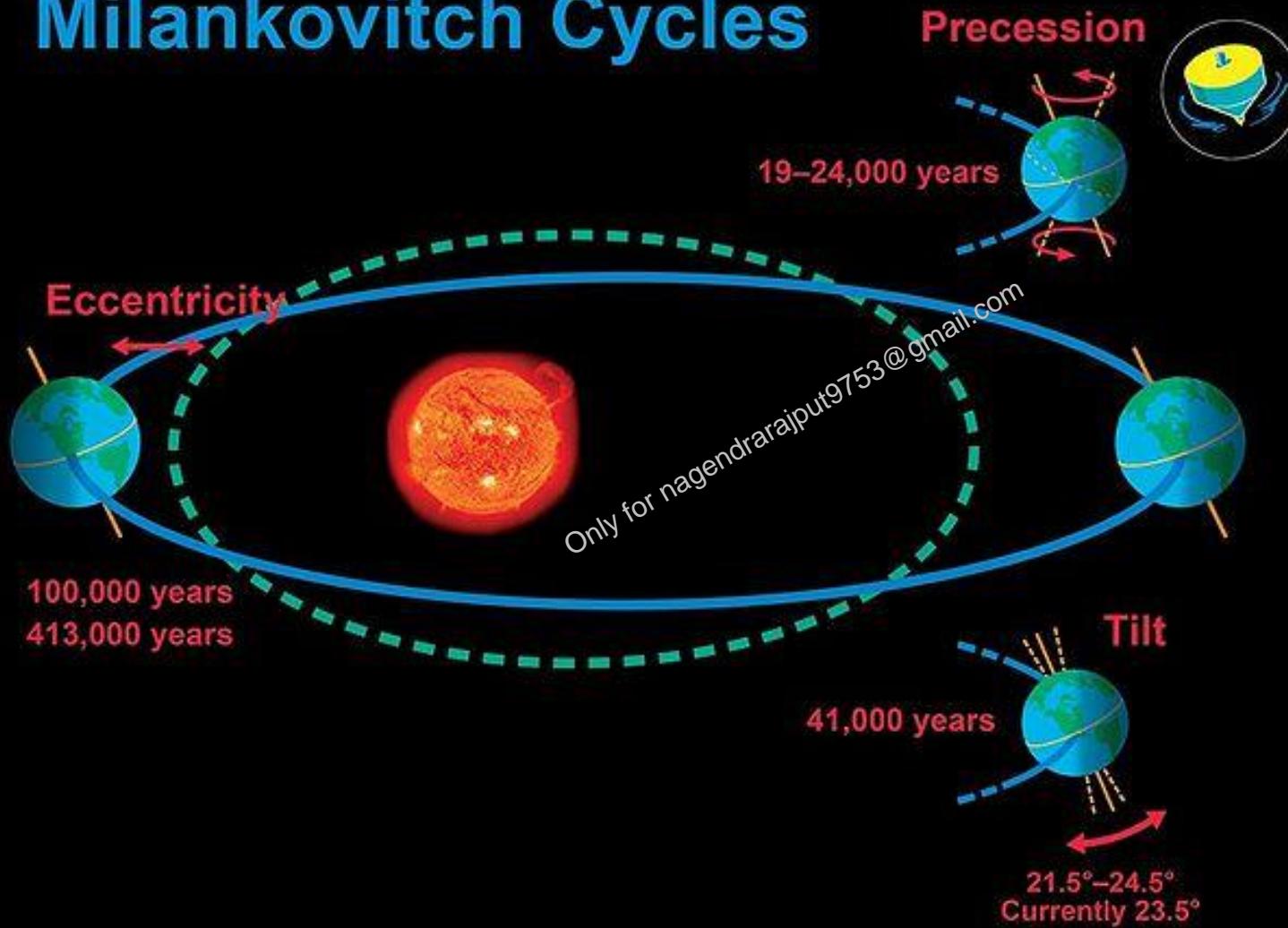
GHG	Atmospheric Concentration	Atmospheric Lifetime	Global Warming Potential (Over a 100 year period)
Carbon Dioxide ( $\text{CO}_2$ )	76%	1000's of years	1
Methane ( $\text{CH}_4$ )	16%	10 years	25
Nitrous Oxide ( $\text{N}_2\text{O}$ )	6%	> 100 years	298
Fluorinated Gases	2%	1,000 - 10,000 years	1,000 - 10,000

# Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO<sub>2</sub>eq.



# Milankovitch Cycles





Sea Ice Melt



Ice Sheet Disintegration

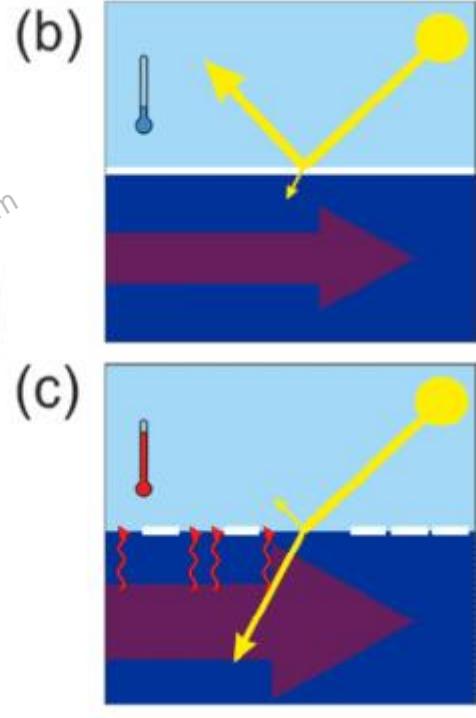
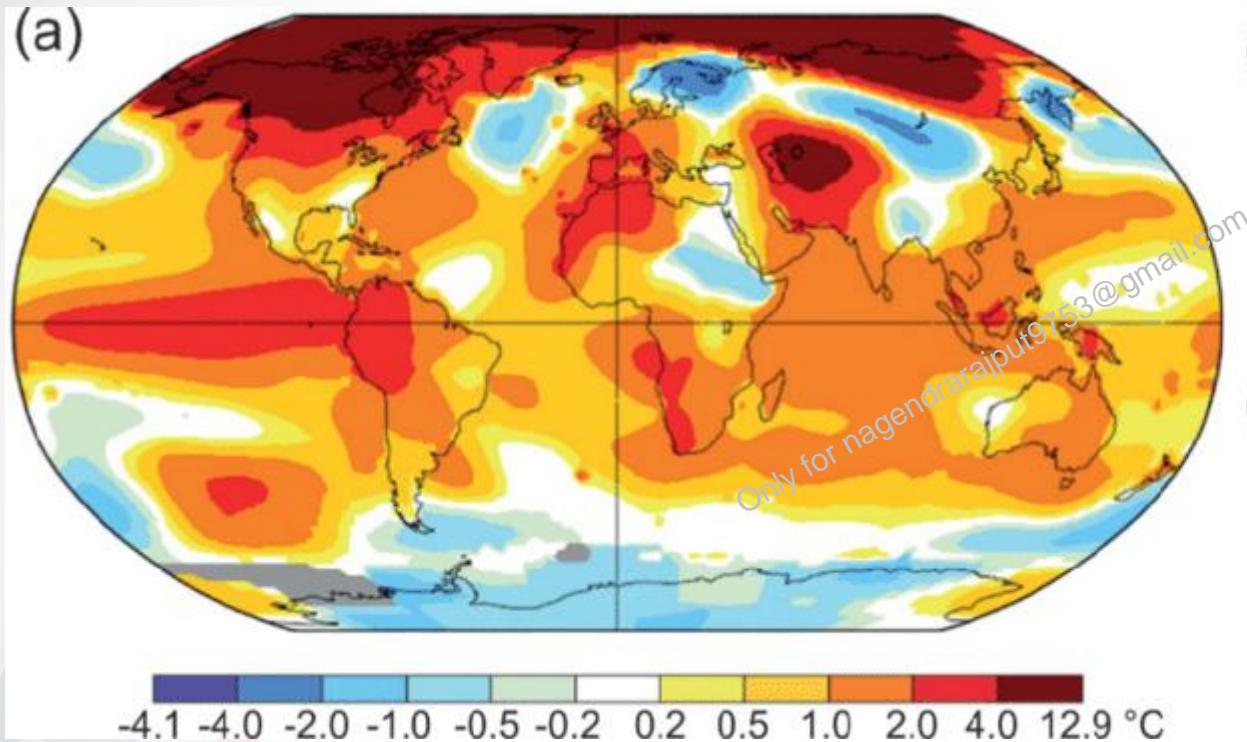


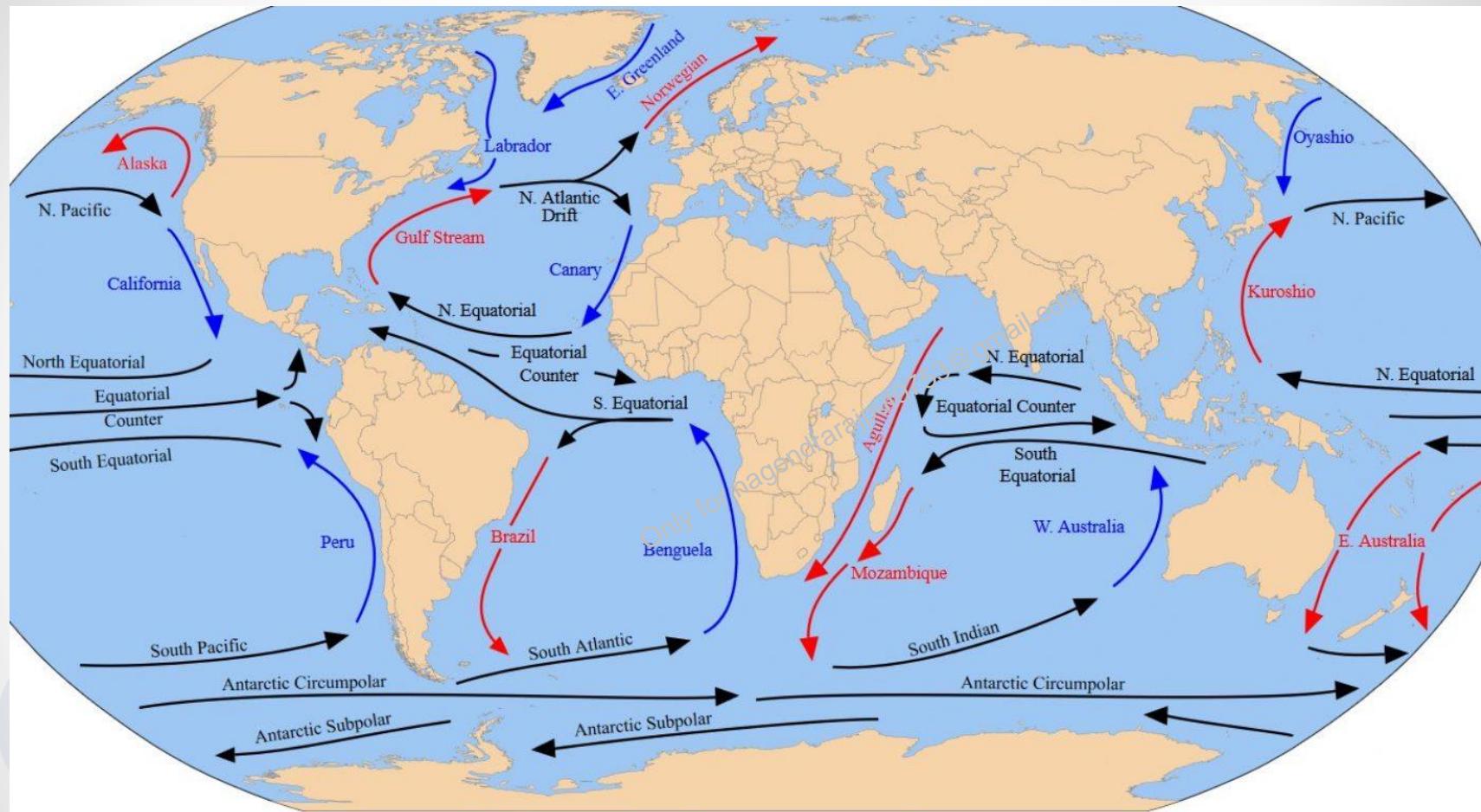
Permafrost Thawing

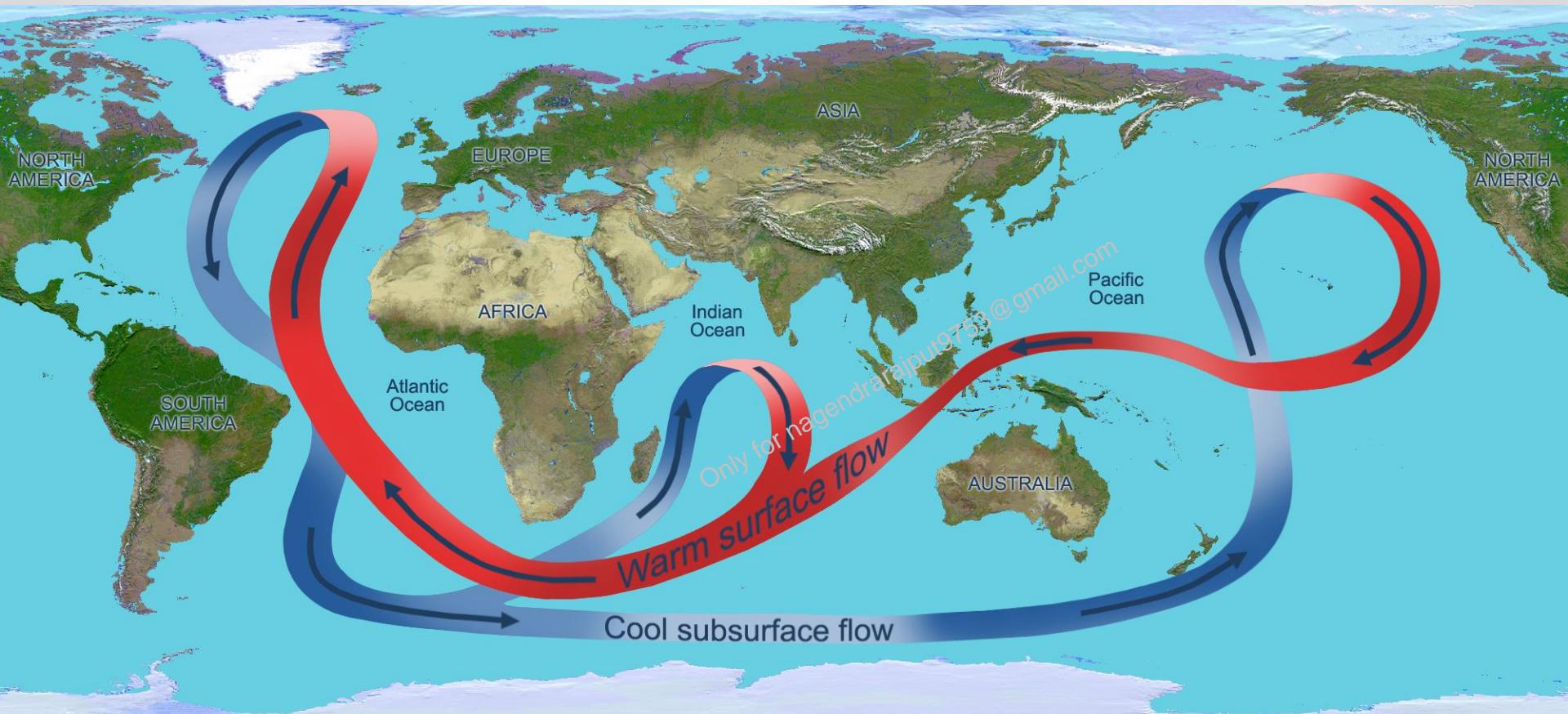


Melting Glacier

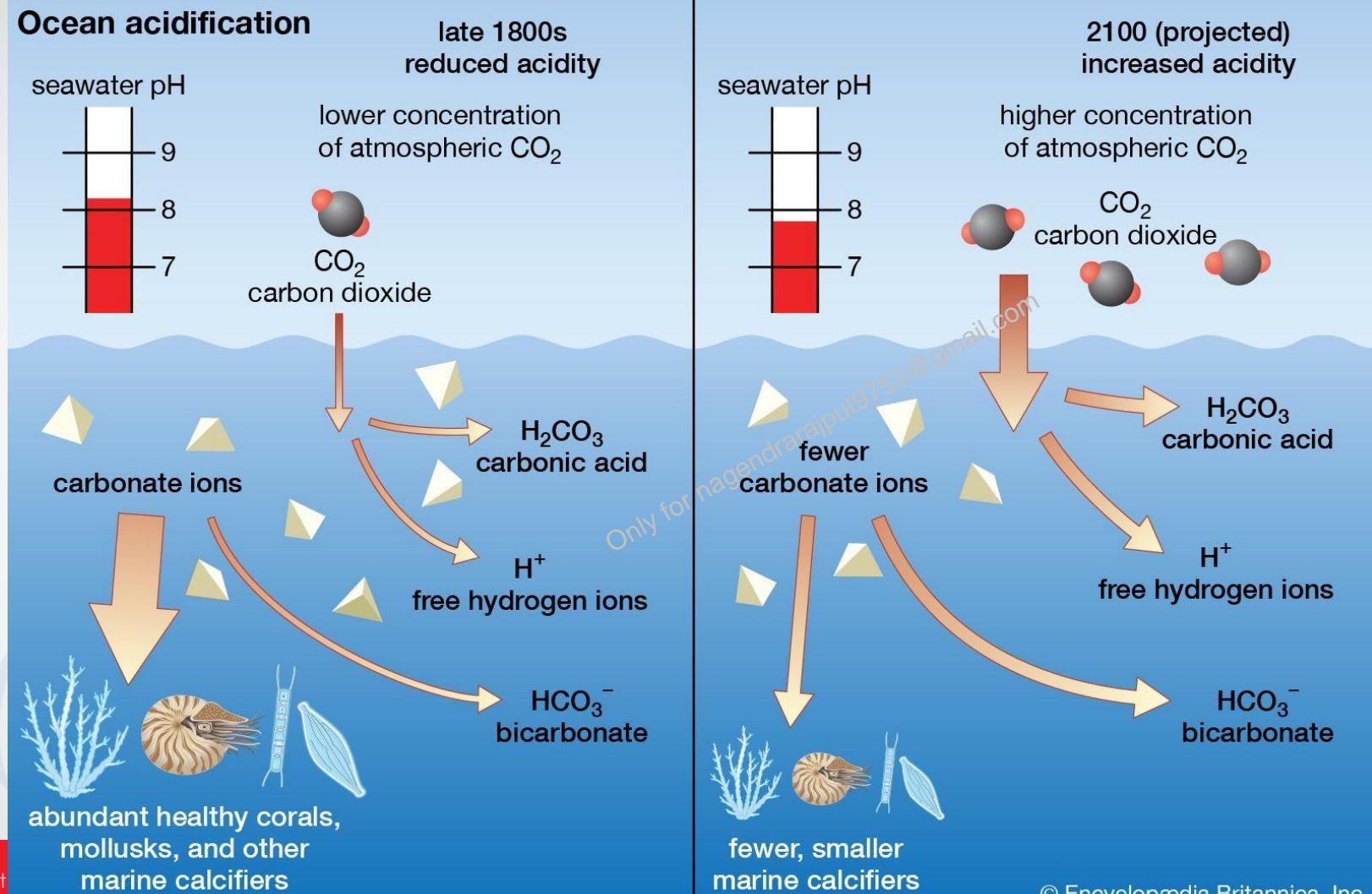


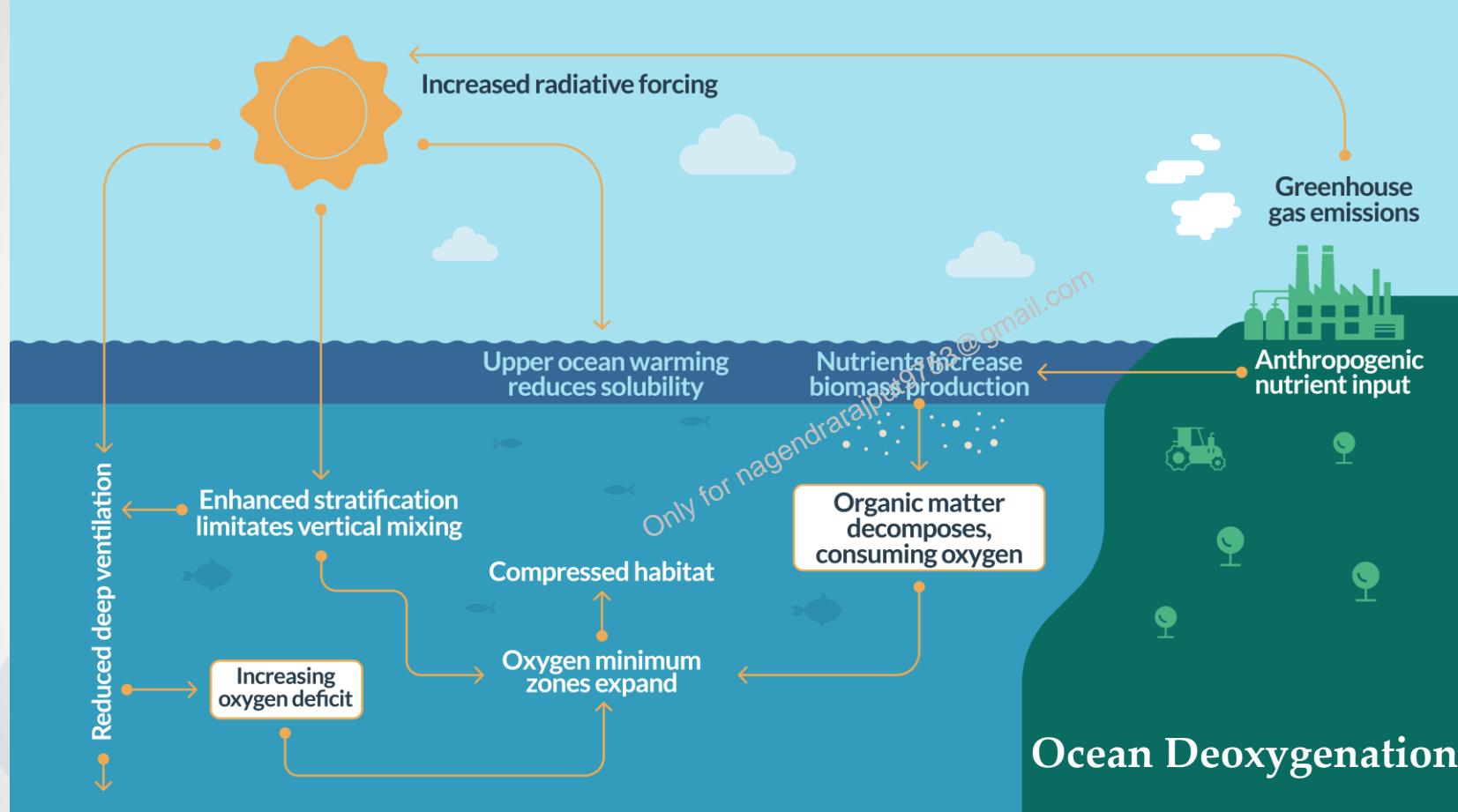






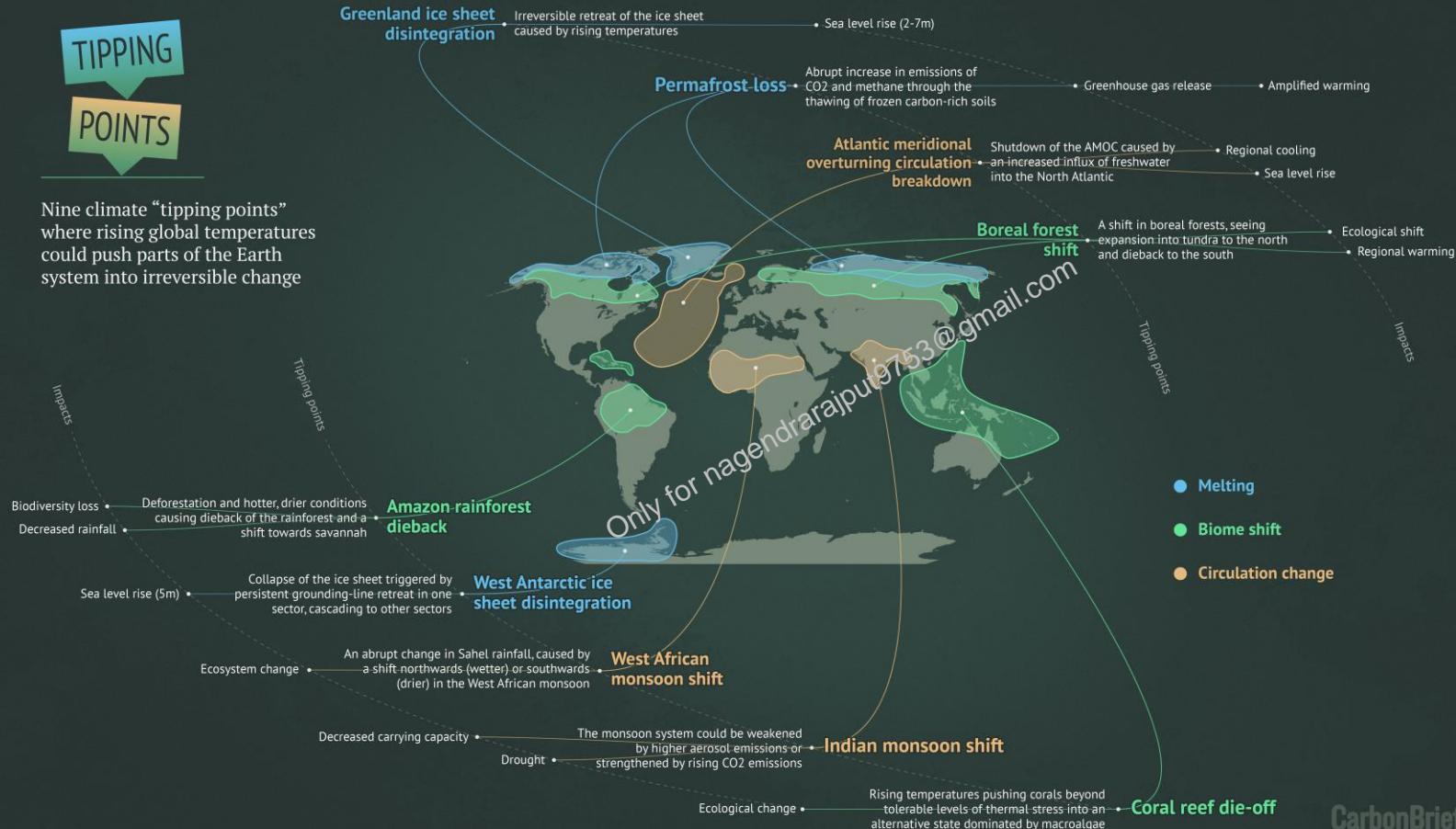
## Ocean acidification



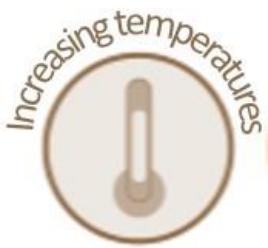


# TIPPING POINTS

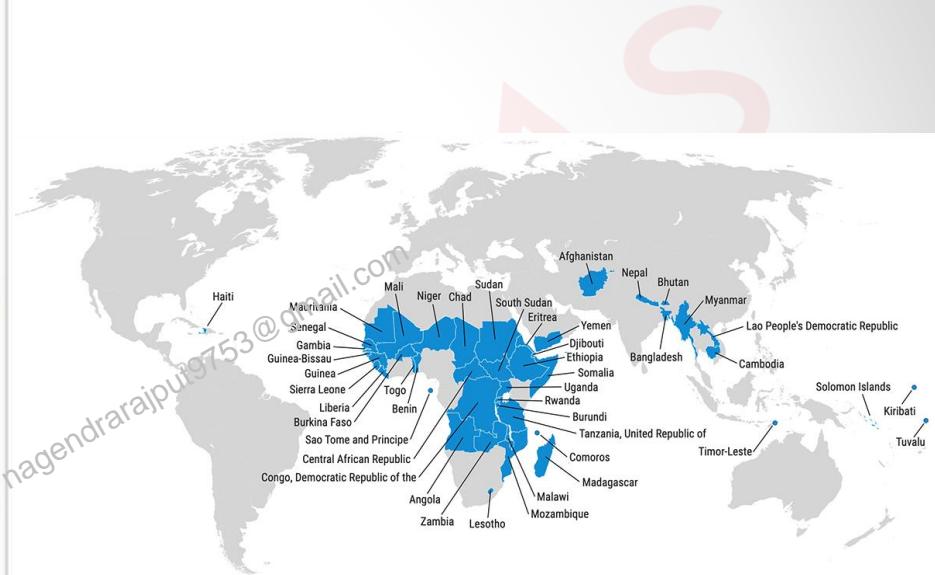
Nine climate “tipping points” where rising global temperatures could push parts of the Earth system into irreversible change

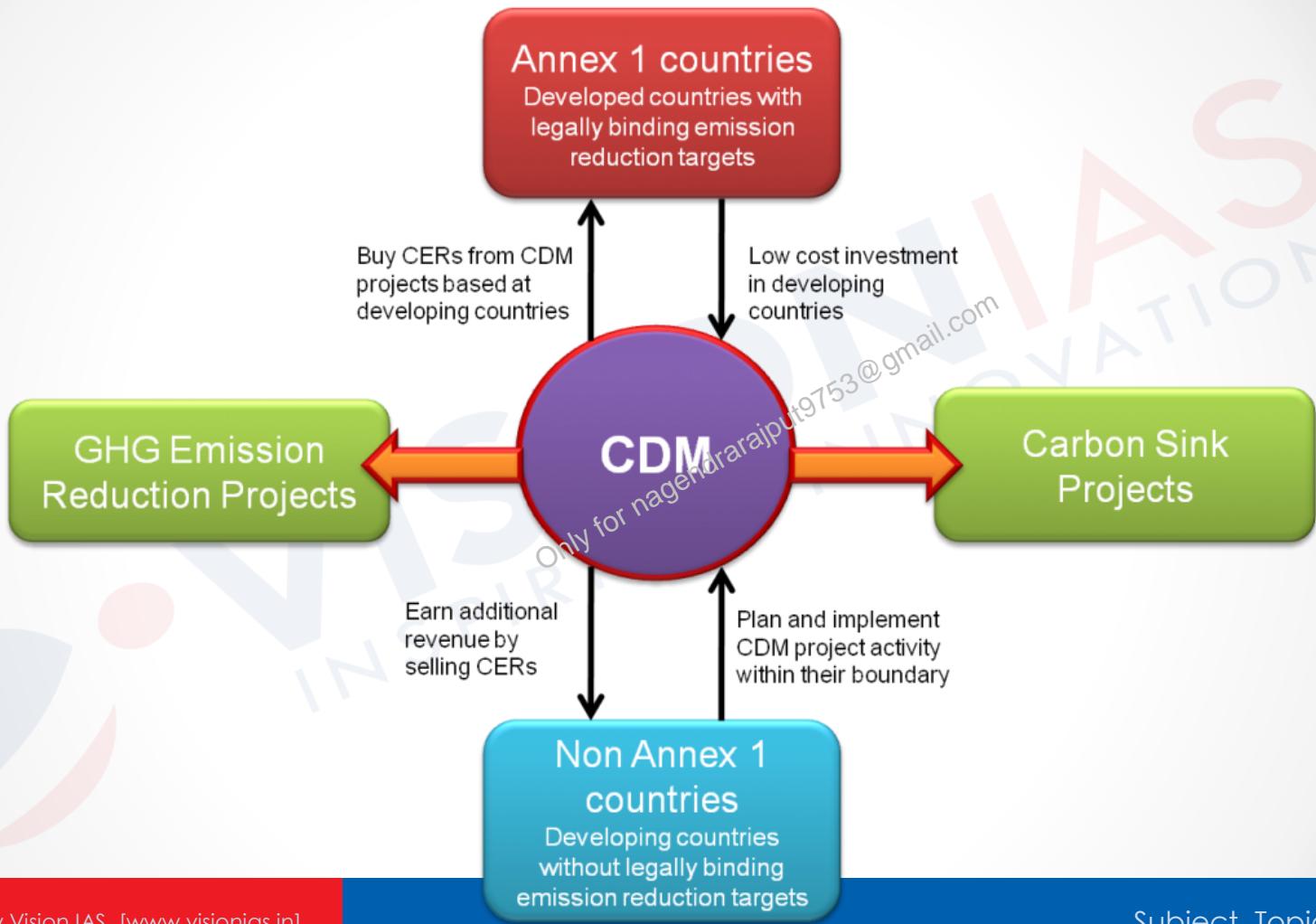


# Slow Onset Events



	Rapid-onset event	Slow-onset process
Type of event/process	Single, discrete events	Gradual, creeping, incremental process
Timeframe	<p>Occur within days or hours</p> <p>Clearly identifiable start and end point</p>	<p>Slowly unfolding over years, decades, or centuries</p> <p>Might accelerate over time (e.g. SLR)</p> <p>Gradual manifestation</p> <p>Creeping and gradual, no clearly identifiable start and/or end point</p>
Predictability	<p>Not foreseeable regarding their frequency and intensity</p>	<p>Slow-onset processes, per se, are foreseeable phenomena, but:</p> <p>(1) they interact with anthropogenic parameters and external stressors, resulting in uncertainty about concrete impacts;</p> <p>(2) their manifestation differs at the local level</p>
Impacts	<p>Highly visible impacts</p> <p>Major damage in a very short time</p> <p>Limited to a specific geographical area</p>	<p>Damage through creeping environmental transformation or degradation</p> <p>Gradual impact over a longer period of time</p>
Level of impacts	Appears at local, national, and regional scale	Potentially spread out over larger geographical areas up to the global level





a



Investment



Germany/UK

Emission rights

e.g. China

CDM

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b



Investment

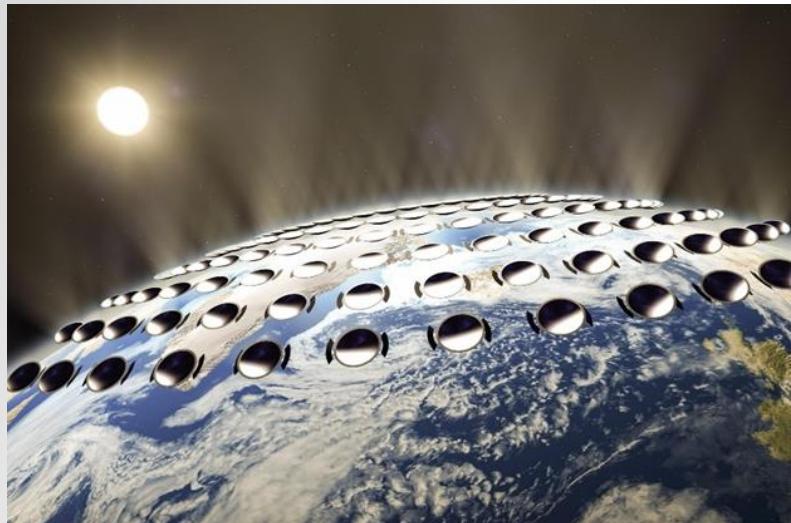


Germany/UK

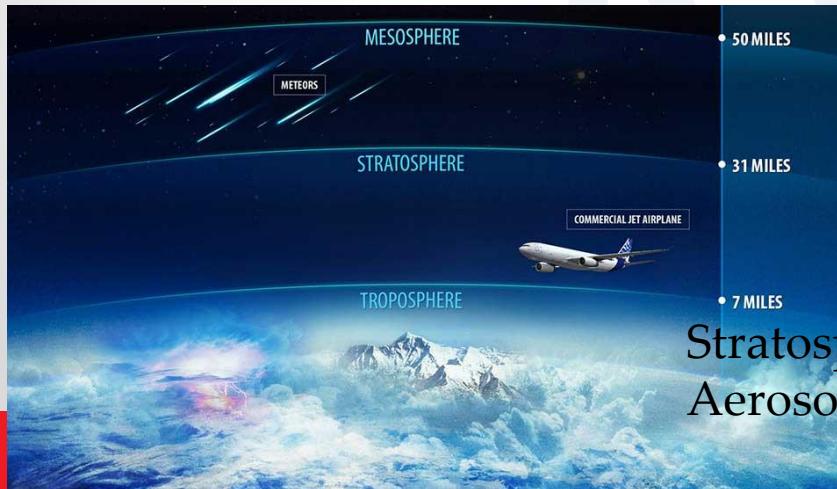
Emission rights

e.g. Russia

Joint Implementation



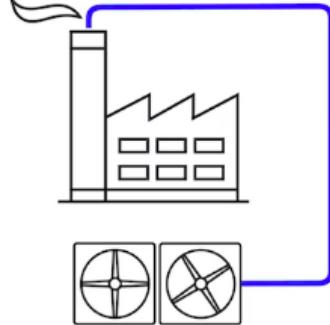
## Space Reflectors



## Marine Cloud Brightening

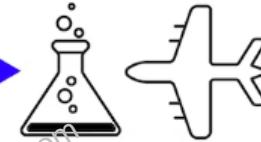
## Capture

Capturing CO<sub>2</sub> from fossil or biomass-fuelled power stations, industrial facilities, or directly from the air.



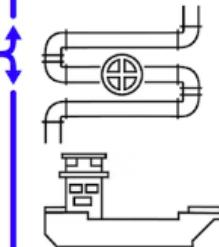
## Use

Using captured CO<sub>2</sub> as an input or feedstock to create products or services.



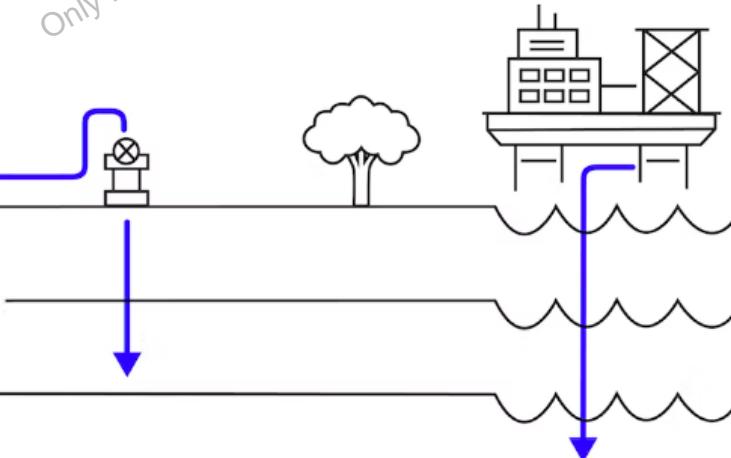
## Transport

Moving compressed CO<sub>2</sub> by ship or pipeline from the point of capture to the point of use or storage.

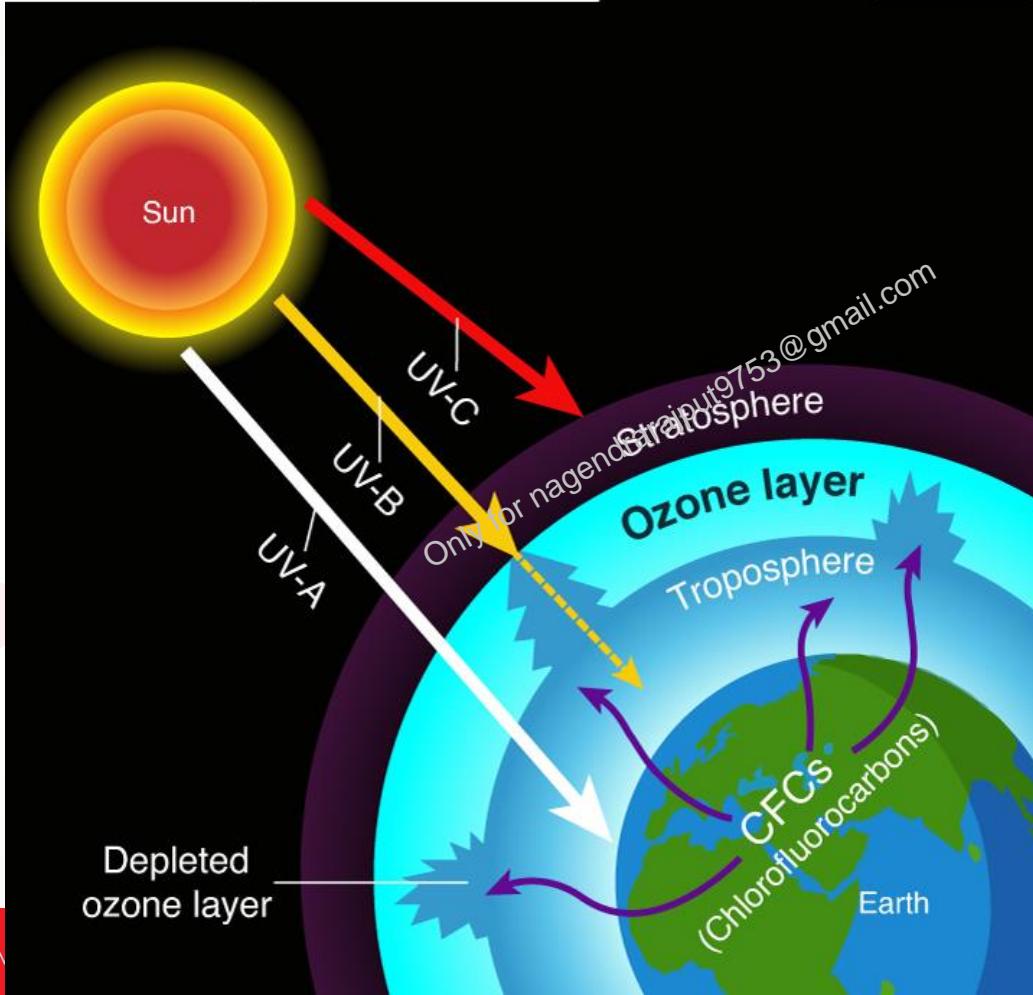


## Storage

Permanently storing CO<sub>2</sub> in underground geological formations, onshore or offshore.



# Ozone Layer Depletion





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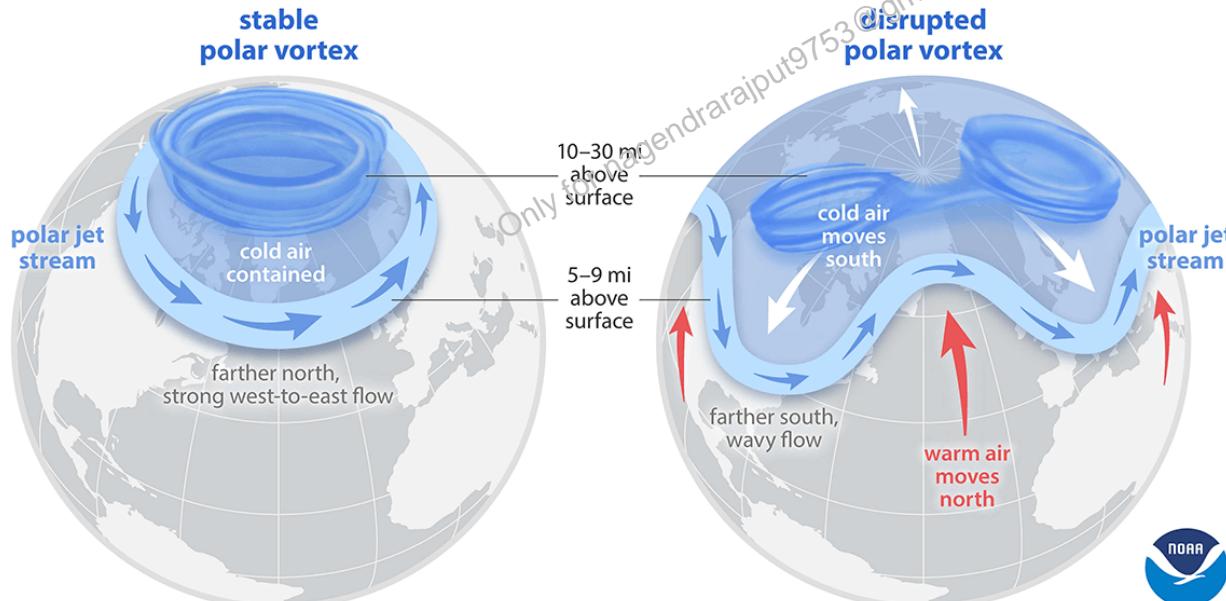
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E

# Understanding the polar vortex

The Arctic polar vortex is a strong band of winds in the stratosphere, surrounding the North Pole 10–30 miles above the surface.

The polar vortex is far above and typically does not interact with the polar jet stream, the flow of winds in the troposphere 5–9 miles above the surface. But when the polar vortex is especially strong and stable, the jet stream stays farther north and has fewer "kinks." This keeps cold air contained over the Arctic and the mid-latitudes warmer than usual.

Every other year or so, the Arctic polar vortex dramatically weakens. The vortex can be pushed off the pole or split into two. Sometimes the polar jet stream mirrors this stratospheric upheaval, becoming weaker or wavy. At the surface, cold air is pushed southward to the mid-latitudes, and warm air is drawn up into the Arctic.



height  
(km)

80

50

30

20

10

0

pressure  
(hPa)

0.01

1

10

30

100

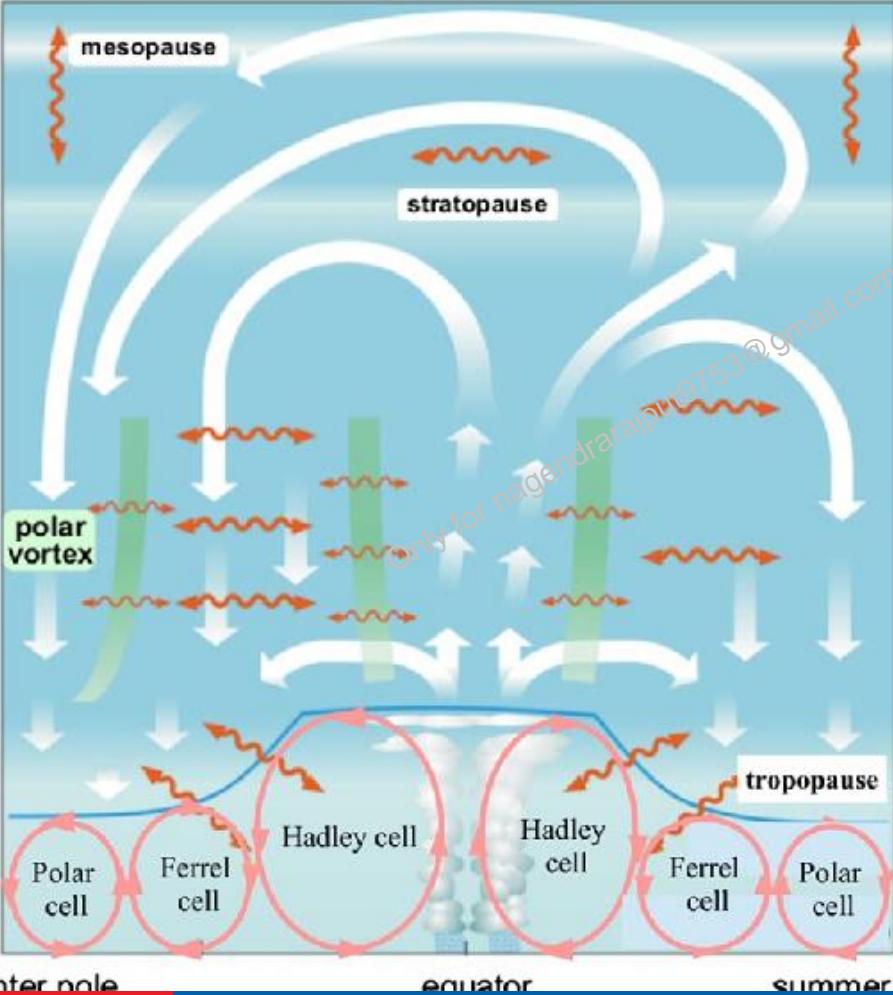
300

1000

winter pole

equator

summer pole



## Brewer-Dobson circulation

**4.** उष्णकटिबंधीय देशों में खाद्य सुरक्षा पर जलवायु परिवर्तन के परिणामों की विवेचना कीजिए।

(उत्तर 150 शब्दों में दीजिए)

Discuss the consequences of climate change on the food security in tropical countries.  
(Answer in 150 words) 10

Paper 1 2023

**18.** जलवायु परिवर्तन पर अंतर-सरकारी पैनल (आइ० पी० सी० सी०) ने वैश्विक समुद्र-स्तर में 2100 ईस्वी तक लगभग एक मीटर की वृद्धि का पूर्वानुमान लगाया है। हिन्द महासागर क्षेत्र में भारत और दूसरे देशों में इसकी क्या प्रभाव होगा?

(उत्तर 250 शब्दों में दीजिए)

The Intergovernmental Panel on Climate Change (IPCC) has predicted a global sea level rise of about one metre by AD 2100. What would be its impact in India and the other countries in the Indian Ocean region?  
(Answer in 250 words) 15

Paper 3 2023

**Q17.** ग्लोबल वार्मिंग (वैश्विक तापन) की चर्चा कीजिए और वैश्विक जलवायु पर इसके प्रभावों का उल्लेख कीजिए। क्योटो प्रोटोकॉल, 1997 के आलोक में ग्लोबल वार्मिंग का कारण बनने वाली ग्रीनहाउस गैसों के स्तर को कम करने के लिए नियंत्रण उपायों को समझाइए।  
Paper 3 2022

(250 शब्दों में उत्तर दीजिए)

Discuss global warming and mention its effects on the global climate. Explain the control measures to bring down the level of greenhouse gases which cause global warming, in the light of the Kyoto Protocol, 1997. (Answer in 250 words) 15

**Q17.** संयुक्त राष्ट्र जलवायु परिवर्तन फ्रेमवर्क सम्मेलन (यू.एन.एफ.सी.सी.सी.) के सी.ओ.पी. के 26वें सत्र के प्रमुख परिणामों का वर्णन कीजिए। इस सम्मेलन में भारत द्वारा की गई वचनबद्धताएँ क्या हैं ?

(250 शब्दों में उत्तर दीजिए)

Describe the major outcomes of the 26<sup>th</sup> session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). What are the commitments made by India in this conference ? (Answer in 250 words)

Paper 3 2021

15

**Q5.** मरुस्थलीकरण के प्रक्रम की जलवायिक सीमाएँ नहीं होती हैं। उदाहरणों सहित औचित्य सिद्ध कीजिए। (150 शब्दों में उत्तर दीजिए)

The process of desertification does not have climatic boundaries. Justify with examples. (Answer in 150 words)

Paper 1 2020

10

**Q4.** वैश्विक तापन का प्रवाल जीवन तंत्र पर प्रभाव का, उदाहरणों के साथ, आकलन कीजिए।

(150 शब्दों में उत्तर दीजिए)

Assess the impact of global warming on the coral life system with examples.

(Answer in 150 words) 10

Paper 1 2019

**Q8.** हिमांक-मंडल (क्रायोस्फ़ेयर) वैश्विक जलवायु को किस प्रकार प्रभावित करता है ? (150 शब्द)

How does the cryosphere affect global climate ? (150 words)

Paper 1 2017

17. ‘जलवायु परिवर्तन’ एक वैश्विक समस्या है। भारत जलवायु परिवर्तन से किस प्रकार प्रभावित होगा? जलवायु परिवर्तन के द्वारा भारत के हिमालयी और समुद्रतटीय राज्य किस प्रकार प्रभावित होंगे? (उत्तर 250 शब्दों में दें)

‘Climate change’ is a global problem. How India will be affected by climate change? How Himalayan and coastal states of India will be affected by climate change? (Answer in 250 words)

15

Paper 3 2017

**Q20.** भारतीय उप-महाद्वीप में घटती हुई हिमालयी हिमनदियों (ग्लेसियर्स) और जलवायु परिवर्तन के लक्षणों के बीच सम्बन्ध उजागर कीजिए।

Bring out the relationship between the shrinking Himalayan glaciers and the symptoms of climate change in the Indian sub-continent. **Paper 1 2014**

13. क्या यू० एन० एफ० सी० सी० के अधीन स्थापित कार्बन क्रेडिट और स्वच्छ विकास योग्यताओं का अनुसरण जारी रखा जाना चाहिए, यद्यपि कार्बन क्रेडिट के मूल्य में भारी गिरावट आयी है? आर्थिक संवृद्धि के लिए भारत की ऊर्जा आवश्यकताओं की दृष्टि से चर्चा कीजिए।

Should the pursuit of carbon credits and clean development mechanisms set up under UNFCCC be maintained even though there has been a massive slide in the value of a carbon credit? Discuss with respect to India's energy needs for economic growth. **Paper 3 2014**

The formation of ozone hole in the Antarctic region has been a cause of concern. What could be the reason for the formation of this hole ?

- (a) Presence of prominent tropospheric turbulence; and inflow of chlorofluorocarbons
- (b) Presence of prominent polar front and stratospheric clouds; and inflow of chlorofluorocarbons
- (c) Absence of polar front and stratospheric clouds; and inflow of methane and chlorofluorocarbons
- (d) Increased temperature at polar region due to global warming

**2011**

Regarding “carbon credits”, which one of the following statements is *not* correct ?

- (a) The carbon credit system was ratified in conjunction with the Kyoto Protocol
- (b) Carbon credits are awarded to countries or groups that have reduced greenhouse gases below their emission quota
- (c) The goal of the carbon credit system is to limit the increase of carbon dioxide emission
- (d) Carbon credits are traded at a price fixed from time to time by the United Nations Environment Programme

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**2011**

Human activities in the recent past have caused the increased concentration of carbon dioxide in the atmosphere, but a lot of it does not remain in the lower atmosphere because of

1. its escape into the outer stratosphere.
2. the photosynthesis by phytoplankton in the oceans.
3. the trapping of air in the polar ice caps.

Which of the statements given above is/are correct ?

- (a) 1 and 2
- (b) 2 only
- (c) 2 and 3
- (d) 3 only

**2011**

Consider the following statements :

Chlorofluorocarbons, known as ozone-depleting substances, are used

1. in the production of plastic foams
2. in the production of tubeless tyres
3. in cleaning certain electronic components
4. as pressurizing agents in aerosol cans

Which of the statements given above is/are correct?

- (a) 1, 2 and 3 only
- (b) 4 only
- (c) 1, 3 and 4 only
- (d) 1, 2, 3 and 4

**2012**

The acidification of oceans is increasing. Why is this phenomenon a cause of concern?

1. The growth and survival of calcareous phytoplankton will be adversely affected.
2. The growth and survival of coral reefs will be adversely affected.
3. The survival of some animals that have phytoplanktonic larvae will be adversely affected.
4. The cloud seeding and formation of clouds will be adversely affected.

Which of the statements given above is/are correct?

- (a) 1, 2 and 3 only
- (b) 2 only
- (c) 1 and 3 only
- (d) 1, 2, 3 and 4

**2012**

The increasing amount of carbon dioxide in the air is slowly raising the temperature of the atmosphere, because it absorbs

- (a) the water vapour of the air and retains its heat
- (b) the ultraviolet part of the solar radiation
- (c) all the solar radiations
- (d) the infrared part of the solar radiation

**2012**

With reference to 'Global Environment Facility', which of the following statements is/are correct?

- (a) It serves as financial mechanism for 'Convention on Biological Diversity' and 'United Nations Framework Convention on Climate Change'
- (b) It undertakes scientific research on environmental issues at global level
- (c) It is an agency under OECD to facilitate the transfer of technology and funds to underdeveloped countries with specific aim to protect their environment
- (d) Both (a) and (b)

**2014**

The scientific view is that the increase in global temperature should not exceed 2 °C above pre-industrial level. If the global temperature increases beyond 3 °C above the pre-industrial level, what can be its possible impact/impacts on the world?

5

1. Terrestrial biosphere tends toward a net carbon source.
2. Widespread coral mortality will occur.
3. All the global wetlands will permanently disappear.
4. Cultivation of cereals will not be possible anywhere in the world.

Select the correct answer using the code given below.

5

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**2014**

- (a) 1 only
- (b) 1 and 2 only
- (c) 2, 3 and 4 only
- (d) 1, 2, 3 and 4

Consider the following statements regarding 'Earth Hour' :

1. It is an initiative of UNEP and UNESCO.
2. It is a movement in which the participants switch off the lights for one hour on a certain day every year.
3. It is a movement to raise the awareness about the climate change and the need to save the planet.

Which of the statements given above is/are correct?

- (a) 1 and 3 only
- (b) 2 only
- (c) 2 and 3 only
- (d) 1, 2 and 3

**2014**

**2015**

Which one of the following is associated with the issue of control and phasing out of the use of ozone-depleting substances?

- (a) Bretton Woods Conference
- (b) Montreal Protocol
- (c) Kyoto Protocol
- (d) Nagoya Protocol

Which of the following statements regarding 'Green Climate Fund' is/are correct?

1. It is intended to assist the developing countries in adaptation and mitigation practices to counter climate change.
2. It is founded under the aegis of UNEP, OECD, Asian Development Bank and World Bank.

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

**2015**

- The term 'Intended Nationally Determined Contributions' is sometimes seen in the news in the context of
- (a) pledges made by the European countries to rehabilitate refugees from the war-affected Middle East
  - (b) plan of action outlined by the countries of the world to combat climate change
  - (c) capital contributed by the member countries in the establishment of Asian Infrastructure Investment Bank
  - (d) plan of action outlined by the countries of the world regarding Sustainable Development Goals

2016

What is/are the importance/importances of the United Nations Convention to Combat Desertification?

1. It aims to promote effective action through innovative national programmes and supportive international partnerships.
2. It has a special/particular focus on South Asia and North Africa regions, and its Secretariat facilitates the allocation of major portion of financial resources to these regions.
3. It is committed to bottom-up approach, encouraging the participation of local people in combating the desertification.

Select the correct answer using the code given below.

- (a) 1 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

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**2016**

**30. Consider the following pairs :**

<i>Terms sometimes seen in the news</i>	<i>Their origin</i>
1. Annex-I Countries	: Cartagena Protocol
2. Certified Emissions Reductions	: Nagoya Protocol
3. Clean Development Mechanism	: Kyoto Protocol

**2016**

Which of the pairs given above is/are correctly matched?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 3 only
- (d) 1, 2 and 3

## What is 'Greenhouse Gas Protocol'?

- (a) It is an international accounting tool for government and business leaders to understand, quantify and manage greenhouse gas emissions
- (b) It is an initiative of the United Nations to offer financial incentives to developing countries to reduce greenhouse gas emissions and to adopt eco-friendly technologies
- (c) It is an inter-governmental agreement ratified by all the member countries of the United Nations to reduce greenhouse gas emissions to specified levels by the year 2022
- (d) It is one of the multilateral REDD+ initiatives hosted by the World Bank

**2016**

With reference to the Agreement at the UNFCCC Meeting in Paris in 2015, which of the following statements is/are correct?

1. The Agreement was signed by all the member countries of the UN and it will go into effect in 2017.
2. The Agreement aims to limit the greenhouse gas emissions so that the rise in average global temperature by the end of this century does not exceed 2 °C or even 1.5 °C above pre-industrial levels.
3. Developed countries acknowledged their historical responsibility in global warming and committed to donate \$100 billion a year from 2020 to help developing countries to cope with climate change.

Select the correct answer using the code given below.

- (a) 1 and 3 only
- (b) 2 only
- (c) 2 and 3 only
- (d) 1, 2 and 3

**2016**

In the context of mitigating the impending global warming due to anthropogenic emissions of carbon dioxide, which of the following can be the potential sites for carbon sequestration ?

1. Abandoned and uneconomic coal seams
2. Depleted oil and gas reservoirs
3. Subterranean deep saline formations

**2017**

Select the correct answer using the code given below :

- (a) 1 and 2 only
- (b) 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

**2017**

With reference to 'Global Climate Change Alliance', which of the following statements is/are correct?

1. It is an initiative of the European Union.
2. It provides technical and financial support to targeted developing countries to integrate climate change into their development policies and budgets.
3. It is coordinated by World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).

Select the correct answer using the code given below :

- (a) 1 and 2 only
- (b) 3 only
- (c) 2 and 3 only
- (d) 1, 2 and 3

Which of the following statements best describes “carbon fertilization”?

- (a) Increased plant growth due to increased concentration of carbon dioxide in the atmosphere
- (b) Increased temperature of Earth due to increased concentration of carbon dioxide in the atmosphere
- (c) Increased acidity of oceans as a result of increased concentration of carbon dioxide in the atmosphere
- (d) Adaptation of all living beings on Earth to the climate change brought about by the increased concentration of carbon dioxide in the atmosphere

**2018**

**2018**

“Momentum for Change : Climate Neutral Now” is an initiative launched by

- (a) The Intergovernmental Panel on Climate Change
- (b) The UNEP Secretariat
- (c) The UNFCCC Secretariat
- (d) The World Meteorological Organization

In the context of which of the following do some scientists suggest the use of cirrus cloud thinning technique and the injection of sulphate aerosol into stratosphere?

- (a) Creating the artificial rains in some regions
- (b) Reducing the frequency and intensity of tropical cyclones
- (c) Reducing the adverse effects of solar wind on the Earth
- (d) Reducing the global warming

2019

Which of the following statements are correct about the deposits of 'methane hydrate'?

1. Global warming might trigger the release of methane gas from these deposits.
2. Large deposits of 'methane hydrate' are found in Arctic Tundra and under the seafloor.
3. Methane in atmosphere oxidizes to carbon dioxide after a decade or two.

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2019

Select the correct answer using the code given below.

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

**2020**

Which one of the following statements best describes the term 'Social Cost of Carbon' ?

It is a measure, in monetary value, of the

- (a) long-term damage done by a tonne of CO<sub>2</sub> emissions in a given year.
- (b) requirement of fossil fuels for a country to provide goods and services to its citizens, based on the burning of those fuels.
- (c) efforts put in by a climate refugee to adapt to live in a new place.
- (d) contribution of an individual person to the carbon footprint on the planet Earth.

## What is blue carbon?

- (a) Carbon captured by oceans and coastal ecosystems
- (b) Carbon sequestered in forest biomass and agricultural soils
- (c) Carbon contained in petroleum and natural gas
- (d) Carbon present in atmosphere

2021

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The ‘Common Carbon Metric’, supported by UNEP, has been developed for

- (a) assessing the carbon footprint of building operations around the world
- (b) enabling commercial farming entities around the world to enter carbon emission trading
- (c) enabling governments to assess the overall carbon footprint caused by their countries
- (d) assessing the overall carbon footprint caused by the use of fossil fuels by the world in a unit time

**2021**

**2022**

“Climate Action Tracker” which monitors the emission reduction pledges of different countries is a :

- (a) Database created by coalition of research organisations
- (b) Wing of “International Panel of Climate Change”
- (c) Committee under “United Nations Framework Convention on Climate Change”
- (d) Agency promoted and financed by United Nations Environment Programme and World Bank

**Consider the following :**

- 1. Aerosols**
- 2. Foam agents**
- 3. Fire retardants**
- 4. Lubricants**

**In the making of how many of the above  
are hydrofluorocarbons used?**

- (a) Only one**
- (b) Only two**
- (c) Only three**
- (d) All four**

**2023**

Consider the following statements :

Statement-I :

Carbon markets are likely to be one of the most widespread tools in the fight against climate change.

Statement-II :

Carbon markets transfer resources from the private sector to the State.

Which one of the following is correct in respect of the above statements?

- (a) Both Statement-I and Statement-II are correct and Statement-II is the correct explanation for Statement-I
- (b) Both Statement-I and Statement-II are correct and Statement-II is not the correct explanation for Statement-I
- (c) Statement-I is correct but Statement-II is incorrect
- (d) Statement-I is incorrect but Statement-II is correct

With reference to the Earth's atmosphere, which one of the following statements is correct?

- (a) The total amount of insolation received at the equator is roughly about 10 times of that received at the poles.
- (b) Infrared rays constitute roughly two-thirds of insolation.
- (c) Infrared waves are largely absorbed by water vapour that is concentrated in the lower atmosphere.
- (d) Infrared waves are a part of visible spectrum of electromagnetic waves of solar radiation.

2023

Consider the following activities :

1. Spreading finely ground basalt rock on farmlands extensively
2. Increasing the alkalinity of oceans by adding lime
3. Capturing carbon dioxide released by various industries and pumping it into abandoned subterranean mines in the form of carbonated waters

How many of the above activities are often considered and discussed for carbon capture and sequestration?

- (a) Only one
- (b) Only two
- (c) All three
- (d) None

**2023**