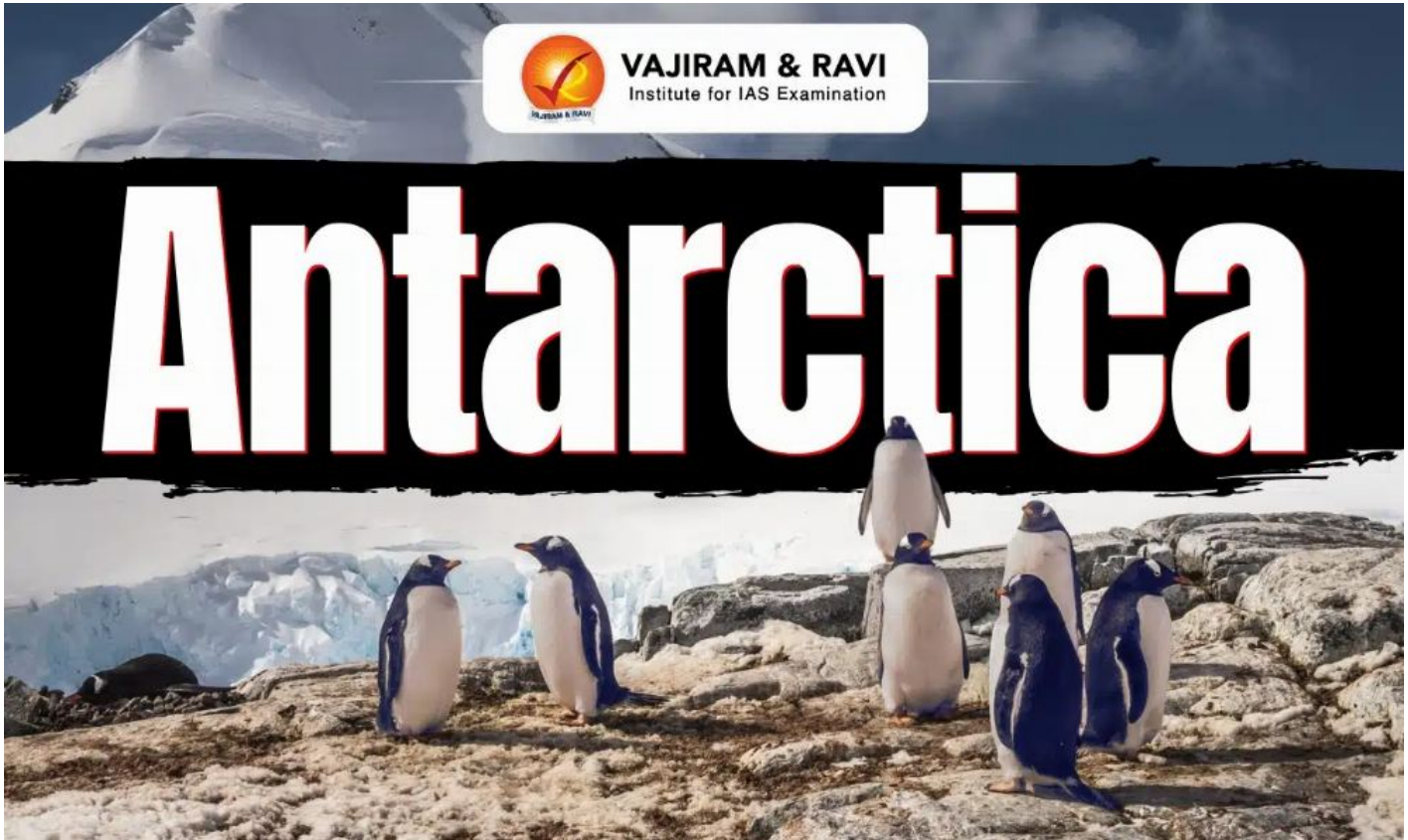


Antarctica, Geography, Climate, Biodiversity, Resources, Role

August 7, 2026 • vajiramandravi.com



Antarctica is **Earth's southernmost continent**, centred on the **South Pole** and almost entirely covered by a vast ice sheet. It is the coldest, driest and windiest continent on Earth and plays a crucial role in regulating the global climate, ocean circulation, sea levels and biodiversity. Although it has no permanent human population, Antarctica is one of the world's most important regions for scientific research and international cooperation.

About Antarctica

Antarctica is a unique continent protected under an international treaty system dedicated to peace, science and environmental conservation.

- **Antarctica** is the **fifth-largest continent**, covering about 14 million km², and is surrounded by the Southern Ocean.
- **Nearly 98% of the continent is covered by ice, containing about 90% of the world's ice** and nearly 70% of Earth's freshwater.

- Unlike the **Arctic**, which is an ocean surrounded by land, **Antarctica is a landmass** surrounded by the Southern Ocean.
- Antarctica has **no permanent residents**; only scientists and support personnel live at research stations throughout the year.
- The continent experiences polar day during summer and polar night during winter due to the Earth's axial tilt.
- Geologically, Antarctica was once part of the **Gondwana Supercontinent**, explaining the presence of coal and other mineral deposits beneath its ice.
- Antarctica is governed under the **Antarctic Treaty System (ATS)**, which reserves the continent for peaceful purposes and scientific research.

Antarctica Physical Geography

Antarctica's geography is dominated by massive ice sheets, glaciers, mountains and frozen deserts.

Location and Extent:

- Antarctica lies almost entirely south of the Antarctic Circle (66°33' S) and surrounds the South Pole.
- It is completely enclosed by the Southern Ocean, which connects the Atlantic, Indian and Pacific Oceans.
- During winter, expanding sea ice almost doubles Antarctica's effective area.

Climate: Antarctica has the harshest climate on Earth because of its high latitude, thick ice cover and high elevation.

- It is the **coldest continent**, with **temperatures falling below -80°C** in the interior during winter.
- The lowest natural temperature ever recorded on Earth (-89.2°C) was observed at Vostok Station.
- Antarctica is also the **driest continent**, receiving less precipitation than many hot deserts, making it a polar desert.
- Strong **katabatic winds**, produced by cold dense air flowing downhill from the interior, make it the windiest continent.
- Coastal regions are relatively warmer and receive more snowfall than the interior.

Antarctic Ice Sheet: The Antarctic Ice Sheet is the largest single mass of ice on Earth.

- It is divided into the **East Antarctic Ice Sheet** and the **West Antarctic Ice Sheet**, separated by the **Transantarctic Mountains**.
- The East Antarctic Ice Sheet is larger and relatively more stable.
- The West Antarctic Ice Sheet is more vulnerable because much of it rests below sea level and is exposed to warming ocean waters.
- Complete melting of the Antarctic Ice Sheet could raise global sea levels by about 58 metres over geological timescales.

Major Relief Features:

- The Transantarctic Mountains divide Antarctica into East and West Antarctica.

- **Mount Vinson** (4,892 m) is **Antarctica's highest peak** and one of the Seven Summits.
- **Lake Vostok**, buried beneath the ice sheet, is one of the world's largest subglacial freshwater lakes.

Major Ice Shelves: Ice shelves are floating extensions of glaciers that help slow the movement of inland ice into the sea.

- Ross Ice Shelf is the world's largest ice shelf.
- Ronne-Filchner Ice Shelf is the second largest.
- The Larsen Ice Shelf has experienced repeated collapse due to rising temperatures, making it an important indicator of climate change.
- The **Thwaites Glacier ("Doomsday Glacier")** is one of the most closely monitored glaciers because its instability could significantly accelerate future sea-level rise.

Antarctic Oceanography

The Southern Ocean surrounding Antarctica is central to Earth's climate and marine ecosystems.

Southern Ocean

- The Southern Ocean surrounds Antarctica and extends south of 60° South latitude.
- It links the Atlantic, Indian and Pacific Oceans into a single marine system.
- It absorbs vast amounts of atmospheric heat and carbon dioxide, helping regulate the global climate.
- It supports one of the world's richest marine ecosystems despite extreme conditions.

Antarctic Circumpolar Current (ACC)

- The **Antarctic Circumpolar Current** is the **world's strongest ocean current**.
- It flows continuously from west to east around Antarctica without obstruction from land.
- It prevents warm tropical waters from reaching Antarctica and connects the world's major oceans.
- It plays a major role in the global transport of heat, nutrients and carbon.

Antarctic Bottom Water (AABW)

- Antarctic Bottom Water forms when sea ice freezes and rejects salt (brine rejection), creating cold, dense water that sinks to the ocean floor.
- It drives the global thermohaline circulation, influencing climate and ocean conditions worldwide.

Antarctic Convergence (Polar Front)

- The Antarctic Convergence is the boundary where cold Antarctic waters meet warmer sub-Antarctic waters.
- It creates nutrient-rich conditions that support abundant marine life.

Sea Ice

- Antarctic sea ice forms from frozen seawater and expands in winter before retreating in summer.
- It reflects solar radiation through the albedo effect, helping regulate Earth's temperature.
- It provides essential breeding and feeding habitats for penguins, seals and other Antarctic wildlife.

Antarctica Biodiversity

Although Antarctica has an extreme environment, it supports a unique ecosystem adapted to freezing conditions.

- Vegetation mainly consists of **lichens, mosses, algae and fungi**, while only Antarctic hair grass and Antarctic pearlwort are native flowering plants.
- Most Antarctic wildlife depends on the nutrient-rich Southern Ocean, which supports **penguins, seals, whales, seabirds and fish**.
- **Antarctic krill (*Euphausia superba*)** is the **keystone species** of the Southern Ocean food web, sustaining **whales, seals, penguins and seabirds**.
- **Emperor Penguin** is the only penguin species that breeds during the Antarctic winter, making it highly dependent on stable sea ice.

Antarctica's biodiversity provides valuable evidence of changing ocean conditions and the impacts of climate change on polar ecosystems.

Antarctica Resources

Although Antarctica possesses significant natural resources, international agreements strictly regulate their use to protect its fragile environment.

- **Freshwater:** Antarctica stores nearly 70% of the world's freshwater in the form of ice.
- **Fisheries:** The Southern Ocean supports valuable fisheries, particularly Antarctic krill and Patagonian toothfish, managed under international conservation measures.
- **Mineral Resources:** Coal, iron ore, copper and hydrocarbons are believed to exist, but commercial mining is prohibited under the Madrid Protocol (1991).
- **Scientific Resources:** Antarctica serves as a natural laboratory for research on climate change, glaciology, geology, astronomy, oceanography and biodiversity, with Antarctic ice cores preserving Earth's climatic history for hundreds of thousands of years.

Antarctica and Climate Change

Antarctica is one of the regions most vulnerable to climate change, and changes occurring here have far-reaching consequences for global sea levels, weather patterns and marine ecosystems.

- **Accelerating Ice Loss:** The Antarctic Ice Sheet, particularly the West Antarctic Ice Sheet, is losing ice due to rising air and ocean temperatures.
- **Thwaites Glacier:** The "Doomsday Glacier" is retreating rapidly and is considered one of the greatest long-term threats to global sea-level rise because it supports large parts of the West Antarctic Ice Sheet.
- **Ice Shelf Collapse:** The collapse of ice shelves such as the Larsen Ice Shelf reduces the natural barrier that slows glaciers, allowing them to flow more quickly into the ocean.
- **Sea-Level Rise:** Melting Antarctic land ice is a major contributor to global sea-level rise, threatening coastal cities, islands and delta regions worldwide.

- **Southern Ocean Warming:** The Southern Ocean is absorbing excess atmospheric heat and carbon dioxide, affecting ocean circulation, marine ecosystems and the formation of Antarctic Bottom Water.
- **Declining Sea Ice:** Recent years have witnessed record-low Antarctic sea-ice extent, reducing Earth's albedo and affecting the habitats of penguins, seals and other marine species.
- **Threat to Biodiversity:** Changes in sea ice and ocean temperature are reducing Antarctic krill populations, disrupting the Southern Ocean food chain.
- **Global Climate Regulator:** Antarctica reflects large amounts of solar radiation and drives global ocean circulation, making its stability essential for Earth's climate system.
- **Ozone Hole:** Antarctica experiences a seasonal ozone hole caused by ozone-depleting substances. The **Montreal Protocol (1987)** has significantly reduced these substances, and scientific assessments indicate gradual recovery of the ozone layer, making it a successful example of global environmental cooperation.

India's Antarctic Programme

India is an active participant in Antarctic research and governance through a long-standing polar research programme.

- India launched its first Antarctic Expedition in 1981.
- India became a Consultative Party to the Antarctic Treaty in 1983, enabling participation in Antarctic decision-making.
- The programme is coordinated by the **National Centre for Polar and Ocean Research (NCPOR)**, Goa, under the **Ministry of Earth Sciences**.
- India has established **Dakshin Gangotri (1983), Maitri (1989) and Bharati (2012), with Maitri and Bharati currently operational**.
- Major research includes climate change, glaciers, geology, oceanography, biodiversity, atmospheric sciences and the Indian monsoon.
- **Indian Antarctic Act, 2022** is India's first dedicated law governing Indian activities in Antarctica. It aligns domestic law with the Antarctic Treaty System, regulates expeditions through a permit system and strengthens environmental protection.

Antarctic Treaty System (ATS)

The Antarctic Treaty System governs Antarctica through international cooperation, ensuring that the continent remains dedicated to peace and science.

Antarctic Treaty (1959)

- Signed in 1959 and entered into force in 1961.
- Originally signed by 12 countries; today it has 50+ Parties, including about 29 Consultative Parties with decision-making powers.
- Reserves Antarctica exclusively for peaceful purposes and scientific research.
- Prohibits military activities, weapons testing and nuclear explosions.
- Guarantees freedom of scientific research and encourages international cooperation.
- Freezes territorial disputes without recognising or rejecting sovereignty claims.

Territorial Claims

- Seven countries have territorial claims in Antarctica: United Kingdom, Argentina, Chile, Australia, New Zealand, France and Norway.
- The Antarctic Treaty suspends these claims, preventing sovereignty disputes from affecting peaceful cooperation.

Madrid Protocol (1991)

- Designates Antarctica as a “Natural Reserve devoted to Peace and Science.”
- Prohibits commercial mineral exploration and mining.
- Requires environmental impact assessments for all activities.
- Includes a review clause after 2048, making future governance an important geopolitical issue.

CCAMLR

- The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) regulates fisheries in the Southern Ocean using an ecosystem-based approach.
- Its headquarters are located in Hobart, Australia.

SCAR

- The Scientific Committee on Antarctic Research (SCAR) coordinates international scientific research and advises Antarctic Treaty meetings.

Protected Areas

- The Madrid Protocol provides for Antarctic Specially Protected Areas (ASPAs) and Antarctic Specially Managed Areas (ASMAs) to conserve ecologically and scientifically important regions.

Importance of Antarctica

Antarctica is vital for Earth’s environmental stability and global scientific research.

- **Global Climate Regulator:** Antarctica reflects solar radiation and helps regulate global temperatures through the albedo effect.
- **Sea-Level Stability:** The Antarctic Ice Sheet stores most of the world’s freshwater, making its stability essential for preventing rapid sea-level rise.
- **Driver of Ocean Circulation:** Formation of Antarctic Bottom Water powers global thermohaline circulation and influences climate worldwide.
- **Climate Archive:** Antarctic ice cores preserve records of Earth’s climate extending back hundreds of thousands of years.
- **Biodiversity Hotspot:** The Southern Ocean supports unique marine ecosystems centred on Antarctic krill.
- **Scientific Laboratory:** Antarctica provides unparalleled opportunities to study climate change, geology, astronomy, glaciology and marine ecosystems.
- **Indian Monsoon Research:** Antarctic climate and ocean processes influence global atmospheric circulation, improving understanding of the Indian monsoon.

- **International Cooperation:** Antarctica remains one of the world's best examples of peaceful scientific collaboration among nations.

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