El Niño

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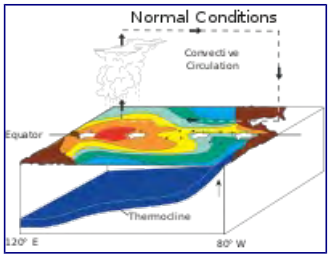
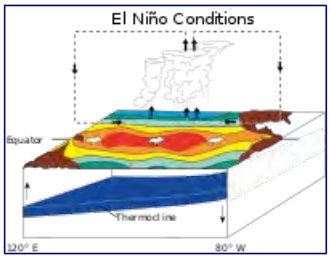
Warm phase of a cyclic climatic phenomenon in the Pacific Ocean
For other uses, see El Niño (disambiguation).



Normal Pacific pattern: Warm pool in the west drives deep atmospheric convection. Local winds cause nutrient rich cold water to upwell along South American coast. (NOAA / PMEL / TAO)



El Niño conditions: Warm water and atmospheric convection move eastwards. In strong El Niños deeper thermocline off S. America means upwelled water is warm and nutrient poor.

El Niño (/ɛl ˈniːn.joʊ/; Spanish: [el ˈniɲo]) is the warm phase of the El Niño Southern Oscillation (commonly called ENSO) and is associated with a band of warm ocean water that develops in the central and east-central equatorial Pacific (between approximately the International Date Line and 120°W), including off the Pacific coast of South America. El Niño Southern Oscillation refers to the cycle of warm and cold temperatures, as measured by sea surface temperature (SST) of the tropical central and eastern Pacific Ocean. El Niño is accompanied by high air pressure in the western Pacific and low air pressure in the eastern Pacific. The cool phase of ENSO is called "La Niña" with SST in the eastern Pacific below average and air pressures high in the eastern and low in western Pacific. The ENSO cycle, both El Niño and La Niña, cause global changes of both temperatures and rainfall.[1][2]

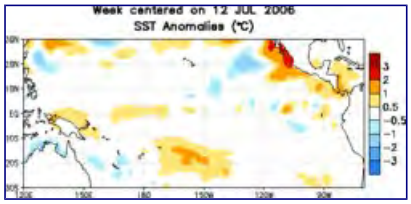
Developing countries that are dependent upon agriculture and fishing, particularly those bordering the Pacific Ocean, are usually most affected. In American Spanish, the capitalized term "El Niño" refers to "the boy", so named because the pool of warm water in the Pacific near South America is often at its

warmest around Christmas.[3] The original name, "El Niño de Navidad", traces its origin centuries back to Peruvian fishermen, who named the weather phenomenon in reference to the newborn Christ.[4][5] "La Niña", chosen as the 'opposite' of El Niño, literally translates to "the girl".

Contents

Concept[edit]

Originally the term *El Niño* applied to an annual weak warm ocean current that ran southwards along the coast of Peru and Ecuador at about Christmas time.[6] However, over time the term has evolved and now refers to the warm and negative phase of the El Niño Southern Oscillation and is the warming of the ocean surface or above-average sea surface temperatures in either the central and eastern tropical Pacific Ocean.[7][8] This warming causes a shift in the atmospheric circulation with rainfall becoming reduced over Indonesia and Australia, while rainfall and tropical cyclone formation increases over the tropical Pacific Ocean.[9] The low-level surface trade winds, which normally blow from east to west along the equator, either weaken or start blowing from the other direction.[8]



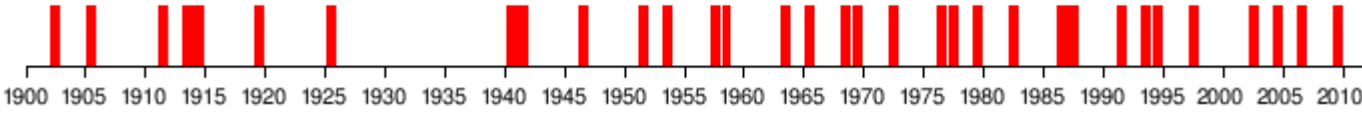
Loop of warming sea surface temperature (SST) anomalies in the Tropical Pacific

Historically, El Niño events are thought to have been occurring for thousands of years.[10] For example, it is thought that El Niño affected the Moche in modern-day Peru, who sacrificed humans in order to try to prevent the rains. Scientists have also found the chemical signatures of warmer sea surface temperatures and increased rainfall caused by El Niño in coral specimens that are around 13,000 years old.[11] In around 1525 when Francisco Pizarro made landfall on Peru, he noted rainfall occurring in the deserts which subsequently became the first written record of the impacts of El Niño.[11] Modern day research and reanalysis techniques have managed to find at least 26 El Niño events since 1900, with the 1982-83, 1997–98 and 2014–16 events among the strongest on record.[12][13][14]

Currently, each country has a different threshold for what constitutes an El Niño event, which is tailored to their specific interests.[15] For example, the Australian Bureau of Meteorology looks at the trade winds, SOI, weather models and sea surface temperatures in the Nino 3 and 3.4 regions, before declaring an El Niño.[16] The United States Climate Prediction Center (CPC) and the International Research Institute for Climate and Society (IRI) looks at the sea surface temperatures in the Niño 3.4 region, the tropical Pacific atmosphere and forecasts that NOAA's Oceanic Niño Index will equal or exceed +.5 °C (0.90 °F) for several seasons in a row.[17] However, the Japan Meteorological Agency declares that an El Niño event has started when the average five month sea surface temperature deviation for the NINO.3 region, is over 0.5 °C (0.90 °F) warmer for six consecutive months or longer.[18] The Peruvian government declares that a coastal El Niño is under way if the sea surface temperatures in the Niño 1 and 2 regions equal or exceed +.4 °C (0.72 °F) for at least three months.

There is no consensus on if climate change will have any influence on the occurrence, strength or duration of El Niño events, as research supports El Niño events becoming stronger, longer, shorter and weaker.[19][20]

Occurrences[edit]



A timeline of all the El Niño episodes between 1900 and 2016.[12][13]

El Niño events are thought to have been occurring for thousands of years.[10] For example, it is thought that El Niño affected the Moche in modern-day Peru, who sacrificed humans in order to try to prevent the rains.[21]

It is thought that there have been at least 30 El Niño events since 1900, with the 1982–83, 1997–98 and 2014–16 events among the strongest on record.[12][13] Since 2000, El Niño events have been observed in 2002–03, 2004–05, 2006–07, 2009–10 and 2014–16.[12]

Major ENSO events were recorded in the years 1790–93, 1828, 1876–78, 1891, 1925–26, 1972–73, 1982–83, 1997–98, and 2014–16.[22][23][24][*verification needed*][*needs update*]

Typically, this anomaly happens at irregular intervals of two to seven years, and lasts nine months to two years.[25] The average period length is five years. When this warming occurs for seven to nine months, it is classified as El Niño "conditions"; when its duration is longer, it is classified as an El Niño "episode".[26]

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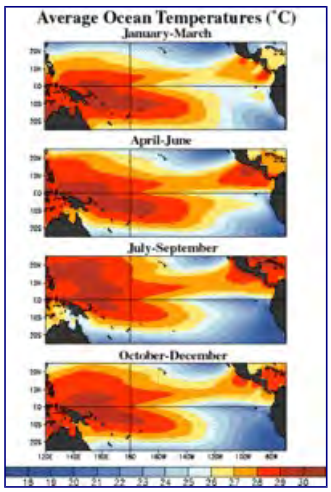
During strong El Niño episodes, a secondary peak in sea surface temperature across the far eastern equatorial Pacific Ocean sometimes follows the initial peak.[27]

Cultural history and prehistoric information[edit]



Average equatorial Pacific temperatures

ENSO conditions have occurred at two- to seven-year intervals for at least the past 300 years, but most of them have been weak. Evidence is also strong for El Niño events during the early Holocene epoch 10,000 years ago.[28]

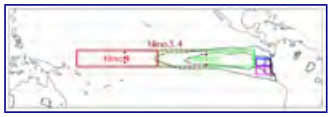
El Niño may have led to the demise of the Moche and other pre-Columbian Peruvian cultures.[29] A recent study suggests a strong El-Niño effect between 1789 and 1793 caused poor crop yields in Europe, which in turn helped touch off the French Revolution.[30] The extreme weather produced by El Niño in 1876–77 gave rise to the most deadly famines of the 19th century.[31] The 1876 famine alone in northern China killed up to 13 million people.[32]

An early recorded mention of the term "El Niño" to refer to climate occurred in 1892, when Captain Camilo Carrillo told the geographical society congress in Lima that Peruvian sailors named the warm north-flowing current "El Niño" because it was most noticeable around Christmas.[33] The phenomenon had long been of interest because of its effects on the guano industry and other enterprises that depend on biological productivity of the sea.

Charles Todd, in 1888, suggested droughts in India and Australia tended to occur at the same time;[34] Norman Lockyer noted the same in 1904.[35] An El Niño connection with flooding was reported in 1894 by Víctor Eguiguren [es] (1852–1919) and in 1895 by Federico Alfonso Pezet (1859–1929).[36][37] In 1924, Gilbert Walker (for whom the Walker circulation is named) coined the term "Southern Oscillation".[38] He and others (including Norwegian-American meteorologist Jacob Bjerknes) are generally credited with identifying the El Niño effect.[39]

The major 1982–83 El Niño led to an upsurge of interest from the scientific community. The period 1991–1995 was unusual in that El Niños have rarely occurred in such rapid succession.[40] An especially intense El Niño event in 1998 caused an estimated 16% of the world's reef systems to die. The event temporarily warmed air temperature by 1.5 °C, compared to the usual increase of 0.25 °C associated with El Niño events.[41] Since then, mass coral bleaching has become common worldwide, with all regions having suffered "severe bleaching".[42]

Diversity[edit]


Map showing Niño3.4 and other index regions

It is thought that there are several different types of El Niño events, with the canonical eastern Pacific and

the Modoki central Pacific types being the two that receive the most attention.[43][44][45] These different types of El Niño events are classified by where the tropical Pacific sea surface temperature (SST) anomalies are the largest.[45] For example, the strongest sea surface temperature anomalies associated with the canonical eastern Pacific event are located off the coast of South America.[45] The strongest anomalies associated with the Modoki central Pacific event are located near the International Dateline.[45] However, during the duration of a single event, the area with the greatest sea surface temperature anomalies can change.[45]

The traditional Niño, also called Eastern Pacific (EP) El Niño,[46] involves temperature anomalies in the Eastern Pacific. However, in the last two decades, nontraditional El Niños were observed, in which the usual place of the temperature anomaly (Niño 1 and 2) is not affected, but an anomaly arises in the central Pacific (Niño 3.4).[47] The phenomenon is called Central Pacific (CP) El Niño,[46] "dateline" El Niño (because the anomaly arises near the dateline), or El Niño "Modoki" (Modoki is Japanese for "similar, but different").[48][49][50][51]

The effects of the CP El Niño are different from those of the traditional EP El Niño—e.g., the recently discovered El Niño leads to more hurricanes more frequently making landfall in the Atlantic.[52]

There is also a scientific debate on the very existence of this "new" ENSO. Indeed, a number of studies dispute the reality of this statistical distinction or its increasing occurrence, or both, either arguing the reliable record is too short to detect such a distinction,[53][54] finding no distinction or trend using other statistical approaches,[55][56][57][58][59] or that other types should be distinguished, such as standard and extreme ENSO.[60][61]

The first recorded El Niño that originated in the central Pacific and moved toward the east was in 1986.[62] Recent Central Pacific El Niños happened in 1986–87, 1991–92, 1994–95, 2002–03, 2004–05 and 2009–10.[63] Furthermore, there were "Modoki" events in 1957–59,[64] 1963–64, 1965–66, 1968–70, 1977–78 and 1979–80.[65][66] Some sources say that the El Niños of 2006-07 and 2014-16 were also Central Pacific El Niños.[67]

Effects on the global climate[edit]

El Nino affects the global climate and disrupts normal weather patterns, which as a result can lead to intense storms in some places and droughts in others.[68][69]

Tropical cyclones[edit]

Most tropical cyclones form on the side of the subtropical ridge closer to the equator, then move poleward past the ridge axis before recurving into the main belt of the Westerlies.[70] Areas west of Japan and Korea tend to experience much fewer September–November tropical cyclone impacts during El Niño and neutral years. During El Niño years, the break in the subtropical ridge tends to lie near 130°E, which would favor the Japanese archipelago.[71]

Within the Atlantic Ocean vertical wind shear is increased, which inhibits tropical cyclone genesis and intensification, by causing the westerly winds in the atmosphere to be stronger.[72] The atmosphere over the Atlantic Ocean can also be drier and more stable during El Niño events, which can also inhibit tropical cyclone genesis and intensification.[72] Within the Eastern Pacific basin: El Niño events contribute to decreased easterly vertical wind shear and favours above-normal hurricane activity.[73] However, the impacts of the ENSO state in this region can vary and are strongly influenced by background climate patterns.[73] The Western Pacific basin experiences a change in the location of where tropical cyclones form during El Niño events, without a major change in how many develop each year.[72] As a result of this change Micronesia is more likely to be affected by several tropical cyclones, while China has a decreased risk of being affected by several tropical cyclones.[*citation needed*] A change in the location of where tropical cyclones form also occurs within the Southern Pacific Ocean between 135°E and 120°W, with tropical cyclones more likely to occur within the Southern Pacific basin

than the Australian region.[9][72] As a result of this change tropical cyclones are 50% less likely to make landfall on Queensland, while the risk of a tropical cyclone is elevated for island nations like Niue, French Polynesia, Tonga, Tuvalu and the Cook Islands.[9][74][75]

Remote influence on tropical Atlantic Ocean[edit]

A study of climate records has shown that El Niño events in the equatorial Pacific are generally associated with a warm tropical North Atlantic in the following spring and summer.[76] About half of El Niño events persist sufficiently into the spring months for the Western Hemisphere Warm Pool to become unusually large in summer.[77] Occasionally, El Niño's effect on the Atlantic Walker circulation over South America strengthens the easterly trade winds in the western equatorial Atlantic region. As a result, an unusual cooling may occur in the eastern equatorial Atlantic in spring and summer following El Niño peaks in winter.[78] Cases of El Niño-type events in both oceans simultaneously have been linked to severe famines related to the extended failure of monsoon rains.[22]

Antarctica[edit]

Many ENSO linkages exist in the high southern latitudes around Antarctica.[79] Specifically, El Niño conditions result in high-pressure anomalies over the Amundsen and Bellingshausen Seas, causing reduced sea ice and increased poleward heat fluxes in these sectors, as well as the Ross Sea. The Weddell Sea, conversely, tends to become colder with more sea ice during El Niño. The exact opposite heating and atmospheric pressure anomalies occur during La Niña.[80] This pattern of variability is known as the Antarctic dipole mode, although the Antarctic response to ENSO forcing is not ubiquitous.[80]

Regional impacts[edit]

Observations of El Niño events since 1950, show that impacts associated with El Niño events depend on what season it is.[81] However, while certain events and impacts are expected to occur during events, it is not certain or guaranteed that they will occur.[81] The impacts that generally do occur during most El Niño events include below-average rainfall over Indonesia and northern South America, while above average rainfall occurs in southeastern South America, eastern equatorial Africa, and the southern United States.[81]

Australia and the Southern Pacific[edit]

During El Niño events, the shift in rainfall away from the Western Pacific may mean that rainfall across Australia is reduced.[9] Over the southern part of the continent, warmer than average temperatures can be recorded as weather systems are more mobile and fewer blocking areas of high pressure occur.[9] The onset of the Indo-Australian Monsoon in tropical Australia is delayed by two to six weeks, which as a consequence means that rainfall is reduced over the northern tropics.[9] The risk of a significant bushfire season in south-eastern Australia is higher following an El Niño event, especially when it is combined with a positive Indian Ocean Dipole event.[9] During an El Niño event, New Zealand tends to experience stronger or more frequent westerly winds during their summer, which leads to an elevated risk of drier than normal conditions along the east coast.[82] There is more rain than usual though on New Zealand's West Coast, because of the barrier effect of the North Island mountain ranges and the Southern Alps.[82]

Fiji generally experiences drier than normal conditions during an El Niño, which can lead to drought becoming established over the Islands.[83] However, the main impacts on the island nation is felt about a year after the event becomes established.[83] Within the Samoan Islands, below average rainfall and higher than normal temperatures are recorded during El Niño events, which can lead to droughts and forest fires on the islands.[84] Other impacts include a decrease in the sea level, possibility of coral bleaching in the marine environment and an increased risk of a tropical cyclone affecting Samoa.[84]

Africa[edit]

In Africa, East Africa — including Kenya, Tanzania, and the White Nile basin — experiences, in the long rains from March to May, wetter-than-normal conditions. Conditions are also drier than normal from December to February in south-central Africa, mainly in Zambia, Zimbabwe, Mozambique, and Botswana.

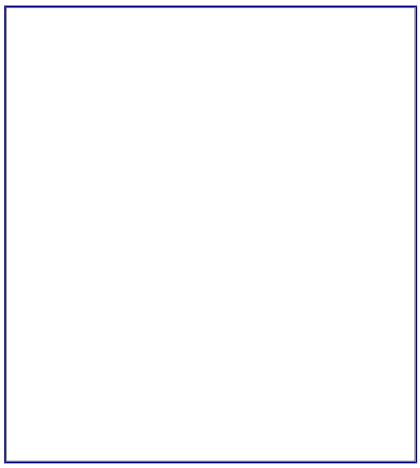
Asia[edit]

As warm water spreads from the west Pacific and the Indian Ocean to the east Pacific, it takes the rain with it, causing extensive drought in the western Pacific and rainfall in the normally dry eastern Pacific. Singapore experienced the driest February in 2014 since records began in 1869, with only 6.3 mm of rain falling in the month and temperatures hitting as high as 35 °C on 26 February. The years 1968 and 2005 had the next driest Februaries, when 8.4 mm of rain fell. [85]

Europe[edit]

El Niño's effects on Europe are controversial, complex and difficult to analyse, as it is one of several factors that influence the weather over the continent and other factors can overwhelm the signal.[86][87]

North America[edit]



Regional impacts of warm ENSO episodes (El Niño)
See also: Effects of the El Niño–Southern Oscillation in the United States

Over North America, the main temperature and precipitation impacts of El Niño, generally occur in the six months between October and March.[88][89] In particular the majority of Canada generally has milder than normal winters and springs, with the exception of eastern Canada where no significant impacts occur.[90] Within the United States, the impacts generally observed during the six-month period include; wetter-than-average conditions along the Gulf Coast between Texas and Florida, while drier conditions are observed in Hawaii, the Ohio Valley, Pacific Northwest and the Rocky Mountains.[88] Over California and the South-Western United States, there is a weak relationship between El Nino and above-average precipitation, as it strongly depends on the strength of the El Niño event and other factors. [88]

The synoptic condition for the Tehuantepecer is associated with high-pressure system forming in Sierra Madre of Mexico in the wake of an advancing cold front, which causes winds to accelerate through the Isthmus of Tehuantepec. Tehuantepecers primarily occur during the cold season months for the region in the wake of cold fronts, between October and February, with a summer maximum in July caused by the westward extension of the Azores High. Wind magnitude is greater during El Niño years than during La Niña years, due to the more frequent cold frontal incursions during El Niño winters.[91] Its effects can last from a few hours to six days.[92] Some El Niño events were recorded in the isotope signals of plants, and that had helped centifics to study his impact.[93]

South America[edit]

Because El Niño's warm pool feeds thunderstorms above, it creates increased rainfall across the east-central and eastern Pacific Ocean, including several portions of the South American west coast. The effects of El Niño in South America are direct and stronger than in North America. An El Niño is associated with warm and very wet weather months in April–October along the coasts of northern Peru and Ecuador, causing major flooding whenever the event is strong or extreme.[94] The effects during the months of February, March, and April may become critical along the west coast of South America, El Niño reduces the upwelling of cold, nutrient-rich water that sustains large fish populations, which in turn sustain abundant sea birds, whose droppings support the fertilizer industry. The reduction in upwelling leads to fish kills off the shore of Peru.[95]

The local fishing industry along the affected coastline can suffer during long-lasting El Niño events. The world's largest fishery collapsed due to overfishing during the 1972 El Niño Peruvian anchoveta reduction. During the 1982–83 event, jack mackerel and anchoveta populations were reduced, scallops increased in warmer water, but hake followed cooler water down the continental slope, while shrimp and sardines moved southward, so some catches decreased while others increased.[96] Horse mackerel have increased in the region during warm events. Shifting locations and types of fish due to changing conditions provide challenges for fishing industries. Peruvian sardines have moved during El Niño events to Chilean areas. Other conditions provide further complications, such as the government of Chile in 1991 creating restrictions on the fishing areas for self-employed fishermen and industrial fleets.[*citation needed*]

The ENSO variability may contribute to the great success of small, fast-growing species along the Peruvian coast, as periods of low population removes predators in the area. Similar effects benefit migratory birds that travel each spring from predator-rich tropical areas to distant winter-stressed nesting areas.[*citation needed*]

Southern Brazil and northern Argentina also experience wetter than normal conditions, but mainly during the spring and early summer. Central Chile receives a mild winter with large rainfall, and the Peruvian-Bolivian Altiplano is sometimes exposed to unusual winter snowfall events. Drier and hotter weather occurs in parts of the Amazon River Basin, Colombia, and Central America.[*citation needed*]

Effects on humanity[edit]

Economic effect[edit]

El Niño has the most direct impacts on life in the equatorial Pacific, its effects propagate north and south along the coast of the Americas, affecting marine life all around the Pacific. Changes in chlorophyll-a concentrations are visible in this animation, which compares phytoplankton in January and July 1998. Since then, scientists have improved both the collection and presentation of chlorophyll data.

When El Niño conditions last for many months, extensive ocean warming and the reduction in easterly trade winds limits upwelling of cold nutrient-rich deep water, and its economic effect on local fishing for an international market can be serious.[95]

More generally, El Niño can affect commodity prices and the macroeconomy of different countries. It can constrain the supply of rain-driven agricultural commodities; reduce agricultural output, construction, and services activities; create food-price and generalised inflation; and may trigger social unrest in commodity-dependent poor countries that primarily rely on imported food.[97] A University of Cambridge Working Paper shows that while Australia, Chile, Indonesia, India, Japan, New Zealand and

South Africa face a short-lived fall in economic activity in response to an El Niño shock, other countries may actually benefit from an El Niño weather shock (either directly or indirectly through positive spillovers from major trading partners), for instance, Argentina, Canada, Mexico and the United States. Furthermore, most countries experience short-run inflationary pressures following an El Niño shock, while global energy and non-fuel commodity prices increase.[98] The IMF estimates a significant El Niño can boost the GDP of the United States by about 0.5% (due largely to lower heating bills) and reduce the GDP of Indonesia by about 1.0%.[99]

Health and social effects[edit]

Extreme weather conditions related to the El Niño cycle correlate with changes in the incidence of epidemic diseases. For example, the El Niño cycle is associated with increased risks of some of the diseases transmitted by mosquitoes, such as malaria, dengue, and Rift Valley fever[100]. Cycles of malaria in India, Venezuela, Brazil, and Colombia have now been linked to El Niño. Outbreaks of another mosquito-transmitted disease, Australian encephalitis (Murray Valley encephalitis—MVE), occur in temperate south-east Australia after heavy rainfall and flooding, which are associated with La Niña events. A severe outbreak of Rift Valley fever occurred after extreme rainfall in north-eastern Kenya and southern Somalia during the 1997–98 El Niño.[101]

ENSO conditions have also been related to Kawasaki disease incidence in Japan and the west coast of the United States,[102] via the linkage to tropospheric winds across the north Pacific Ocean.[103]

ENSO may be linked to civil conflicts. Scientists at The Earth Institute of Columbia University, having analyzed data from 1950 to 2004, suggest ENSO may have had a role in 21% of all civil conflicts since 1950, with the risk of annual civil conflict doubling from 3% to 6% in countries affected by ENSO during El Niño years relative to La Niña years.[104][105]

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- FAO response to El Niño
- Latest El Niño/La Niña Watch Data from NASA JPL's Ocean Surface Topography Mission
- El Niño and La Niña from the 1999 International Red Cross World Disasters Report by Eric J. Lyman.
- Ocean Motion: El Niño
- El Niño Theme Page A comprehensive resource
- What is El Niño?

- Kelvin Wave Renews El Niño — NASA, Earth Observatory image of the day, 2010, 21 March
- Current Operational SST Anomaly Charts - OSPO - NOAA OSPO[*permanent dead link*]
- Climate Prediction Center: ENSO Diagnostic Discussion
- Weather maps - Southeast Asia - meteoblue

- **v**
- **t**
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Climate oscillations

Climate oscillations	• 8.2 kiloyear event • Antarctic Circumpolar Wave • Antarctic oscillation • Arctic dipole anomaly • Arctic oscillation • Atlantic Equatorial mode • Atlantic multidecadal oscillation • Earth's axial tilt • Bond event • Dansgaard–Oeschger event • Diurnal cycle • Diurnal temperature variation • El Niño–Southern Oscillation (El Niño - La Niña) • Equatorial Indian Ocean oscillation • Glacial cycles • Indian Ocean Dipole • Madden–Julian oscillation • Milankovitch cycles • Monsoon • North Atlantic oscillation • North Pacific Oscillation • Orbital forcing • Pacific decadal oscillation • Pacific–North American teleconnection pattern • Quasi-biennial oscillation • Seasonal lag • Seasons • Solar variability

- **v**
- **t**
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Physical oceanography

Waves	• Airy wave theory • Ballantine scale • Benjamin–Feir instability • Boussinesq approximation • Breaking wave • Clapotis • Cnoidal wave • Cross sea • Dispersion • Edge wave • Equatorial waves

- Fetch
- Gravity wave
- Green's law
- Infragravity wave
- Internal wave
- Iribarren number
- Kelvin wave
- Kinematic wave
- Longshore drift
- Luke's variational principle
- Mild-slope equation
- Radiation stress
- Rogue wave
- Rossby wave
- Rossby-gravity waves
- Sea state
- Seiche
- Significant wave height
- Soliton
- Stokes boundary layer
- Stokes drift
- Stokes wave
- Swell
- Trochoidal wave
- Tsunami
  - megatsunami
- Undertow
- Ursell number
- Wave action
- Wave base
- Wave height
- Wave power
- Wave radar
- Wave setup
- Wave shoaling
- Wave turbulence
- Wave–current interaction
- Waves and shallow water
  - one-dimensional Saint-Venant equations
  - shallow water equations
- Wind wave
  - model

Circulation

- Atmospheric circulation
- Baroclinity
- Boundary current
- Coriolis force
- Coriolis–Stokes force
- Craik–Leibovich vortex force
- Downwelling
- Eddy
- Ekman layer
- Ekman spiral
- Ekman transport
- El Niño–Southern Oscillation
- General circulation model

- Geochemical Ocean Sections Study
- Geostrophic current
- Global Ocean Data Analysis Project
- Gulf Stream
- Halothermal circulation
- Humboldt Current
- Hydrothermal circulation
- Langmuir circulation
- Longshore drift
- Loop Current
- Modular Ocean Model
- Ocean dynamics
- Ocean gyre
- Princeton ocean model
- Rip current
- Subsurface currents
- Sverdrup balance
- Thermohaline circulation
  - shutdown
- Upwelling
- Whirlpool
- World Ocean Circulation Experiment

Tides

- Amphidromic point
- Earth tide
- Head of tide
- Internal tide
- Lunitidal interval
- Perigean spring tide
- Rip tide
- Rule of twelfths
- Slack water
- Tidal bore
- Tidal force
- Tidal power
- Tidal race
- Tidal range
- Tidal resonance
- Tide gauge
- Tideline
- Theory of tides

Landforms

- Abyssal fan
- Abyssal plain
- Atoll
- Bathymetric chart
- Coastal geography
- Cold seep
- Continental margin
- Continental rise
- Continental shelf
- Contourite
- Guyot
- Hydrography
- Oceanic basin
- Oceanic plateau

	• Oceanic trench • Passive margin • Seabed • Seamount • Submarine canyon • Submarine volcano
Plate tectonics	• Convergent boundary • Divergent boundary • Fracture zone • Hydrothermal vent • Marine geology • Mid-ocean ridge • Mohorovičić discontinuity • Vine–Matthews–Morley hypothesis • Oceanic crust • Outer trench swell • Ridge push • Seafloor spreading • Slab pull • Slab suction • Slab window • Subduction • Transform fault • Volcanic arc
Ocean zones	• Benthic • Deep ocean water • Deep sea • Littoral • Mesopelagic • Oceanic • Pelagic • Photic • Surf • Swash
Sea level	• Deep-ocean Assessment and Reporting of Tsunamis • Future sea level • Global Sea Level Observing System • North West Shelf Operational Oceanographic System • Sea-level curve • Sea level rise • World Geodetic System
Acoustics	• Deep scattering layer • Hydroacoustics • Ocean acoustic tomography • Sofar bomb • SOFAR channel • Underwater acoustics
Satellites	• Jason-1 • Jason-2 (Ocean Surface Topography Mission)

- Jason-3

Related

- Argo
- Benthic lander
- Color of water
- DSV *Alvin*
- Marginal sea
- Marine energy
- Marine pollution
- Mooring
- National Oceanographic Data Center
- Ocean
- Ocean exploration
- Ocean observations
- Ocean reanalysis
- Ocean surface topography
- Ocean thermal energy conversion
- Oceanography
- Pelagic sediment
- Sea surface microlayer
- Sea surface temperature
- Seawater
- Science On a Sphere
- Thermocline
- Underwater glider
- Water column
- World Ocean Atlas

- **Category**
- **Commons**

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- **t**
- **e**

Global warming and climate change

Temperatures

- Brightness temperature
- Effective temperature
- Geologic record
- Hiatus
- Historical climatology
- Instrumental record
- Paleoclimatology
- Paleotempestology
- Proxy data
- Record of the past 1,000 years
- Satellite measurements

Causes

Anthropogenic (caused by human activity)

- Attribution of recent climate change
- Aviation
- Biofuel

- Black carbon
- Carbon dioxide
- Deforestation
- Earth's energy budget
- Earth's radiation balance
- Ecocide
- Fossil fuel
- Global dimming
- Global warming potential
- Greenhouse effect
- (Infrared window)
- Greenhouse gases
- (Halocarbons)
- Land use, land-use change, and forestry
- Radiative forcing
- Tropospheric ozone
- Urban heat island

Natural

- Albedo
- Bond events
- Climate oscillations
- Climate sensitivity
- Cloud forcing
- Cosmic rays
- Feedbacks
- Glaciation
- Global cooling
- Milankovitch cycles
- Ocean variability
  - AMO
  - ENSO
  - IOD
  - PDO
- Orbital forcing
- Solar variation
- Volcanism

Models

- Global climate model

History

- History of climate change science
- Atmospheric thermodynamics
- Svante Arrhenius
- James Hansen
- Charles David Keeling

Opinion and climate change

General

- Environmental ethics
- Media coverage of climate change
- Public opinion on climate change
- (Popular culture)
- Scientific opinion on climate change
- Scientists who disagree with the mainstream assessment

- Climate change denial
- Global warming conspiracy theory

By country & region

- Africa
- Arctic
- Argentina
- Australia
- Bangladesh
- Belgium
- Canada
- China
- Europe
- European Union
- Finland
- Grenada
- Japan
- Luxembourg
- New Zealand
- Norway
- Russia
- Scotland
- South Korea
- Sweden
- Tuvalu
- United Kingdom
- United States

Politics

- Clean Power Plan
- Climate change denial
- (Manufactured controversy)
- Intergovernmental Panel on Climate Change (IPCC)
- March for Science
- People's Climate March
- United Nations Framework Convention on Climate Change (UNFCCC / FCCC)
- Global climate regime

Potential effects and issues

General

- Abrupt climate change
- Anoxic event
- Arctic dipole anomaly
- Arctic haze
- Arctic methane emissions
- Climate change and agriculture
- Climate change and ecosystems
- Climate change and gender
- Climate change and poverty
- Drought
- Economics of global warming
- Effects on plant biodiversity
- Effects on health
- Effects on humans
- Effects on marine mammals

- Environmental migrant
- Extinction risk from global warming
- Fisheries and climate change
- Forest dieback
- Industry and society
- Iris hypothesis
- Megadrought
- Ocean acidification
- Ozone depletion
- Physical impacts
- Polar stratospheric cloud
- Regime shift
- Retreat of glaciers since 1850
- Runaway climate change
- Sea level rise
- Season creep
- Shutdown of thermohaline circulation

By country

- Australia
- South Asia
  - India
  - Nepal
- United States

Mitigation

Kyoto Protocol

- Clean Development Mechanism
- Joint Implementation
- Bali Road Map
- 2009 United Nations Climate Change Conference

Governmental

- European Climate Change Programme
- G8 Climate Change Roundtable
- United Kingdom Climate Change Programme
- Paris Agreement
  - United States withdrawal
- Regional climate change initiatives in the United States
- List of climate change initiatives

Emissions reduction

- Carbon credit
- Carbon-neutral fuel
- Carbon offset
- Carbon tax
- Emissions trading
- Fossil fuel phase-out

Carbon-free energy

- Carbon capture and storage
- Efficient energy use
- Low-carbon economy
- Nuclear power
- Renewable energy

Personal

- Individual action on climate change
- Simple living

Other	• Carbon dioxide removal • Carbon sink • Climate action • Climate Action Plan • Climate change mitigation scenarios • Climate engineering • Individual and political action on climate change • Reducing emissions from deforestation and forest degradation • Reforestation • Urban reforestation

Proposed adaptations

Strategies	• Damming glacial lakes • Desalination • Drought tolerance • Irrigation investment • Rainwater storage • Sustainable development • Weather modification
Programmes	• Avoiding dangerous climate change • Land allocation decision support system

- ☐ Glossary
- ☐ Index
- ☐ Climate change
- ☐ Global warming
- ☐ Portal

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- Physical oceanography
- Natural history of the Americas
- Natural history of Oceania
- Effects of global warming
- Climate patterns
- Weather hazards
- Spanish words and phrases

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- CS1 maint: Multiple names: authors list
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- Use dmy dates from June 2015
- All pages needing factual verification
- Wikipedia articles needing factual verification from July 2015

- Wikipedia articles in need of updating from July 2015
- All Wikipedia articles in need of updating
- Interlanguage link template link number
- All articles with unsourced statements
- Articles with unsourced statements from April 2016
- Commons category link is locally defined
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- Articles with dead external links from December 2017
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- Articles containing video clips

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- Bân-lâm-gú
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- Беларуская
- Беларуская (тарашкевіца)
- Български
- Boarisch
- Bosanski
- Brezhoneg
- Català
- Čeština
- Cymraeg

- Dansk
- Deutsch
- Eesti
- Ελληνικά
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