



Introduction to Meteorology

25 Atmosphere–Ocean interaction (2)

Introduction



Atmosphere and ocean are closely coupled. In other words, ocean and atmosphere interact with each other and induce climate variabilities. El Niño and La Niña are good examples. El Niño and La Niña have been recognized for hundreds of years, but it was only recently found that they have been caused by the interactions of the atmosphere and the ocean.

Contents



1. El Niño and Southern Oscillation (ENSO)

Learning objectives



1. Describe the characteristics and processes of El Niño and La Niña.

Learning Activities

1. El Niño Southern Oscillation (ENSO)

ENSO is a coupled process between the ocean and atmosphere circulations over the tropical Pacific. ENSO refers to a phase change between El Niño and La Niña with an irregular period.

Learning Activities

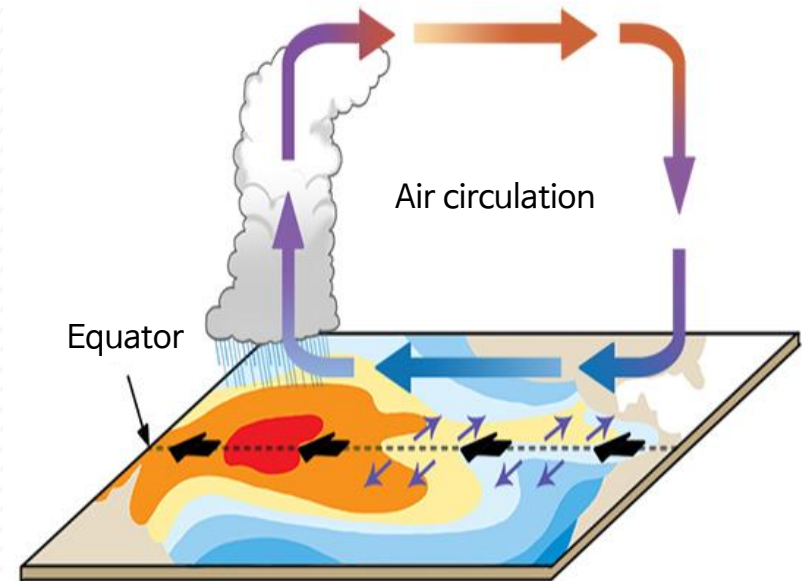
1. El Niño Southern Oscillation (ENSO)

1) Normal conditions

The picture depicts the atmospheric circulation of the Pacific Ocean in normal years. Trade winds are blowing over the equatorial Pacific Ocean, and ocean currents flow from east to west associated with the trade winds. In central to eastern Pacific, cold water from the deep ocean is brought up to the sea surface in order to compensate for the waters flowing westward (upwelling).

Solar radiation continually heats the ocean surface. When the westward moving ocean current reaches the western Pacific, the temperature becomes warmer than the east.

Such large east–west SST gradient induces ascent over the western Pacific and descent over the eastern Pacific, which is called the Walker circulation.



〈Normal conditions〉

Learning Activities

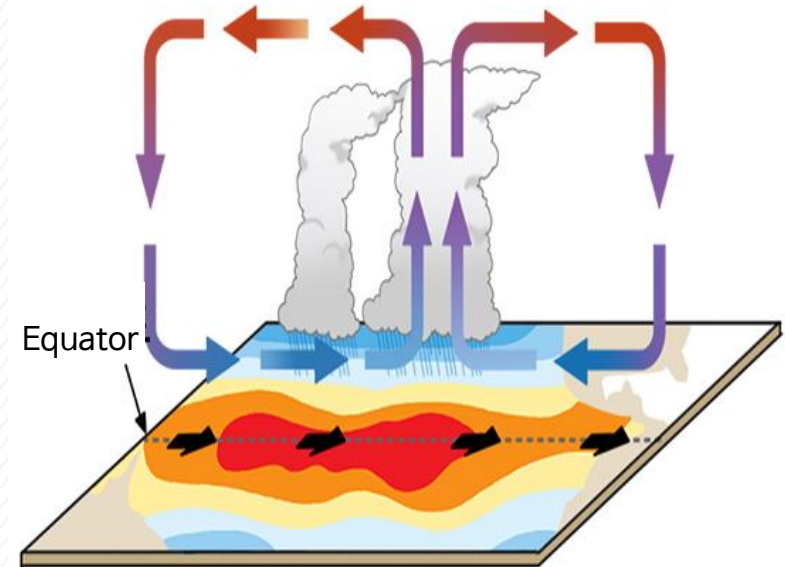
1. El Niño Southern Oscillation (ENSO)

2) El Niño

During the El Niño, the SST in the equatorial eastern Pacific is about 0.5°C above normal for several months.

Weakening of the trade winds results decelerates the ocean current, which reduces the east–west SST gradient and suppresses the upwelling in the eastern Pacific. Weaker upwelling induces warmer SST which in turn weakens the trade wind (positive feedback).

The El Niño refers to the large-scale ocean–atmosphere climate interaction linked to a periodic warming in SST across the central and east-central Equatorial Pacific.

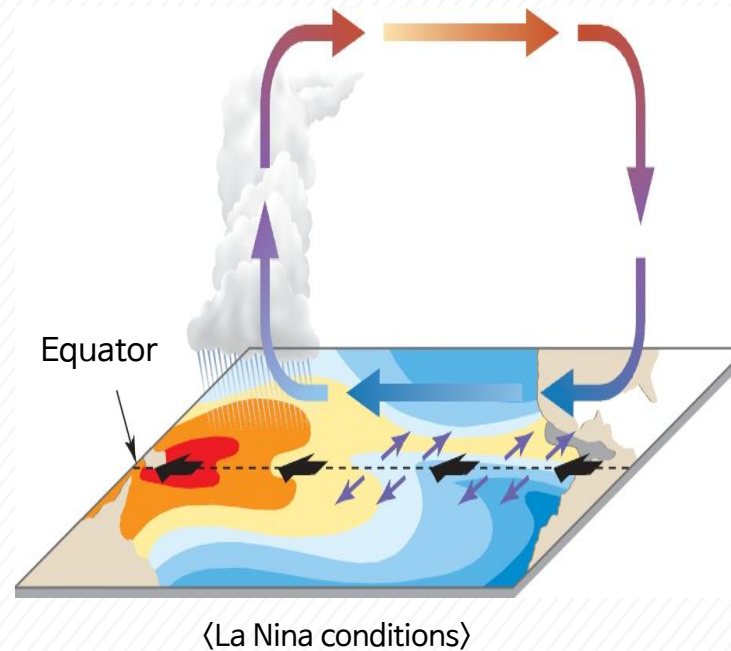


〈El Niño conditions〉

Learning Activities

1. El Niño Southern Oscillation (ENSO)

3) La Nina

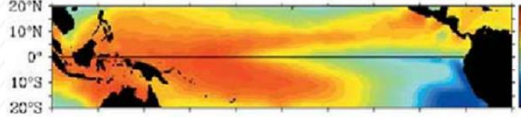
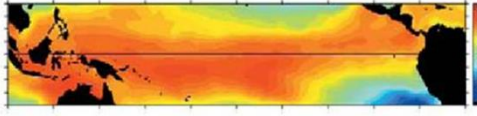
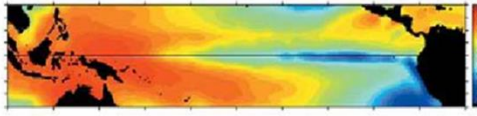


El Niño and La Niña are not independent phenomena, but an oscillation with opposite phases. The period is about 2–7 years. It changes the distribution of SST and pressure across the tropics.

Learning Activities

1. El Niño Southern Oscillation (ENSO)

3) La Nina

Conditions	SST distribution	SST	Sea surface height	Surface pressure	Weather phenomena	
Normal		East Pacific	cool	Low	High	Dry
		West Pacific	Warm	High	Low	Moist
Argon Neon		East Pacific	Warmer	Higher	Lower	Heavy rain, flooding
		West Pacific	Cooler	Lower	Higher	Drought
Xenon Hydrogen		East Pacific	Cooler	Lower	Higher	Drought
		West Pacific	warmer	Higher	Lower	Heavy rain, flooding

The atmospheric and ocean conditions during El Niño and La Niña can be summarized as shown in the table. In El Niño condition, the east Pacific is warmer, sea level is higher, and a lower pressure condition induces heavy rain and flood. The western Pacific is the opposite. In La Niña, east Pacific is cooler, sea level is lower, and drought occurs in association with anomalously high pressure, and vice versa in the western Pacific.

Learning Activities

1. El Niño Southern Oscillation (ENSO)

3) La Nina

ENSO = El Nino + Southern Oscillation



Displacement of convection in the tropics

Learning Activities

1. El Niño Southern Oscillation (ENSO)

4) Southern Oscillation

The Southern Oscillation is a phenomenon in which the pressure of the western Pacific Ocean is increased, and the pressure of the South Pacific Ocean is lowered during the El Niño period. Associated with ENSO driven circulation (and low-level convergence), the location of convection shifts in the tropics. During El Niño, precipitation increases in the tropical central Pacific and the Gulf of Mexico, and decreases in Indonesia, Australia, India, and Amazon.



Eastward displacement of convection during El Niño



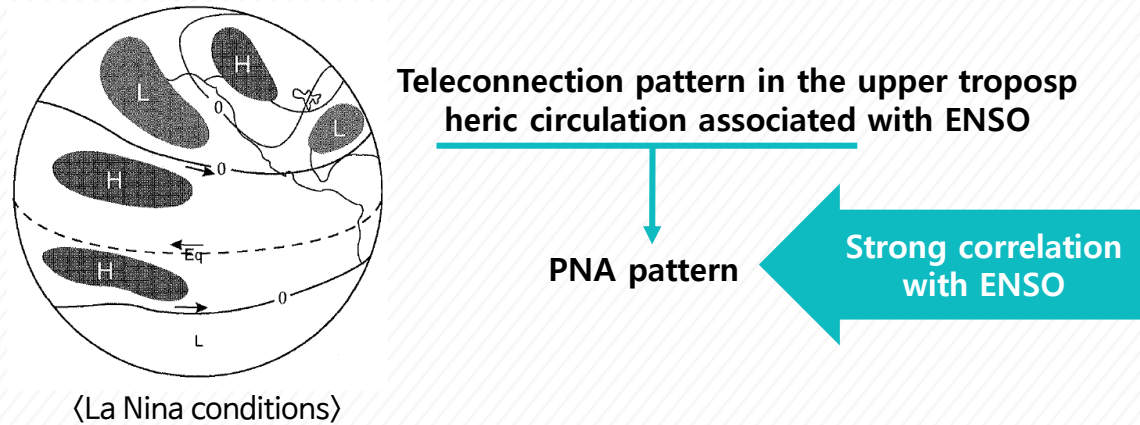
Relatively dry western Pacific

Learning Activities

1. El Niño Southern Oscillation (ENSO)

5) ENSO teleconnection

So, what is the global impact of the ENSO? The Indonesian forest fires that brought enormous damage in 1997 were caused by the El Niño, which moved the rainfall region towards the central Pacific and made the western Pacific relatively dry.



Teleconnection pattern appears in the upper tropospheric circulation field associated with ENSO. The PNA (Pacific North America) pattern is the most prominent teleconnection pattern related to ENSO.

During El Niño, stronger Aleutian Low, an upper-level ridge in the west coast of North America and anomalous cyclonic flow in the southeast US can be observed.

Learning Activities

1. El Niño Southern Oscillation (ENSO)

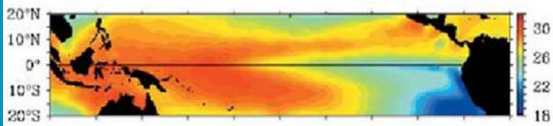
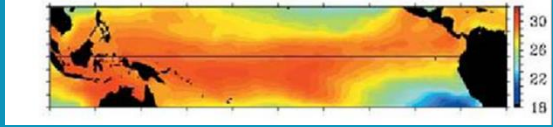
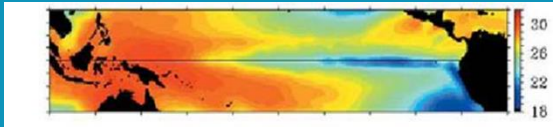
5) ENSO teleconnection

Previous studies have shown that the temperature in Korea during El Niño is higher than normal in winter, and lower than normal in summer (more precipitation in summer). ENSO is also closely related to monsoon. Studies have shown that the East Asia monsoon is highly correlated with ENSO with a lag of 9 months, although such conclusion is keeping updated with the changing climate and increasing observations.

Summary

1. El Nino and Southern Oscillation (ENSO)

- ENSO is a coupled process between the ocean and atmosphere circulations over the tropical Pacific.
- ENSO refers to a phase change between El Niño and La Niña with an irregular period.
- Comparison of El Nino and La Nina

Conditions	SST distribution	SST	Sea surface height	Surface pressure	Weather phenomena	
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