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Changes in Tropical Cyclones Associated with Climate Oscillations

by

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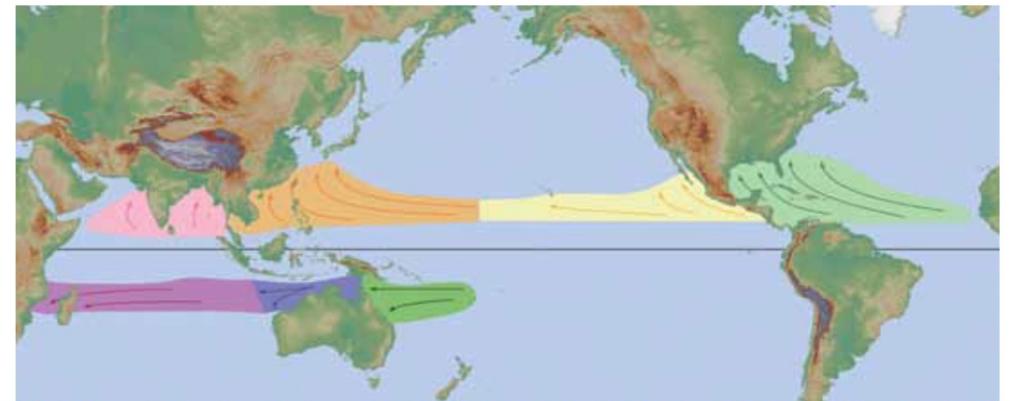
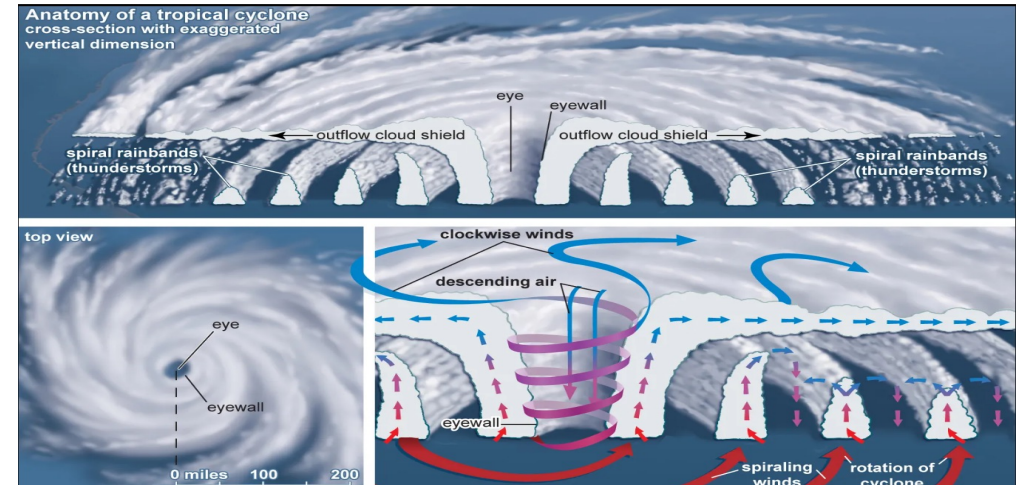
Thai Meteorological Department

Outline

- Tropical cyclones
- Climate Oscillations
- Climate Oscillations 's impact on tropical cyclones
- Conclusion

Tropical cyclones

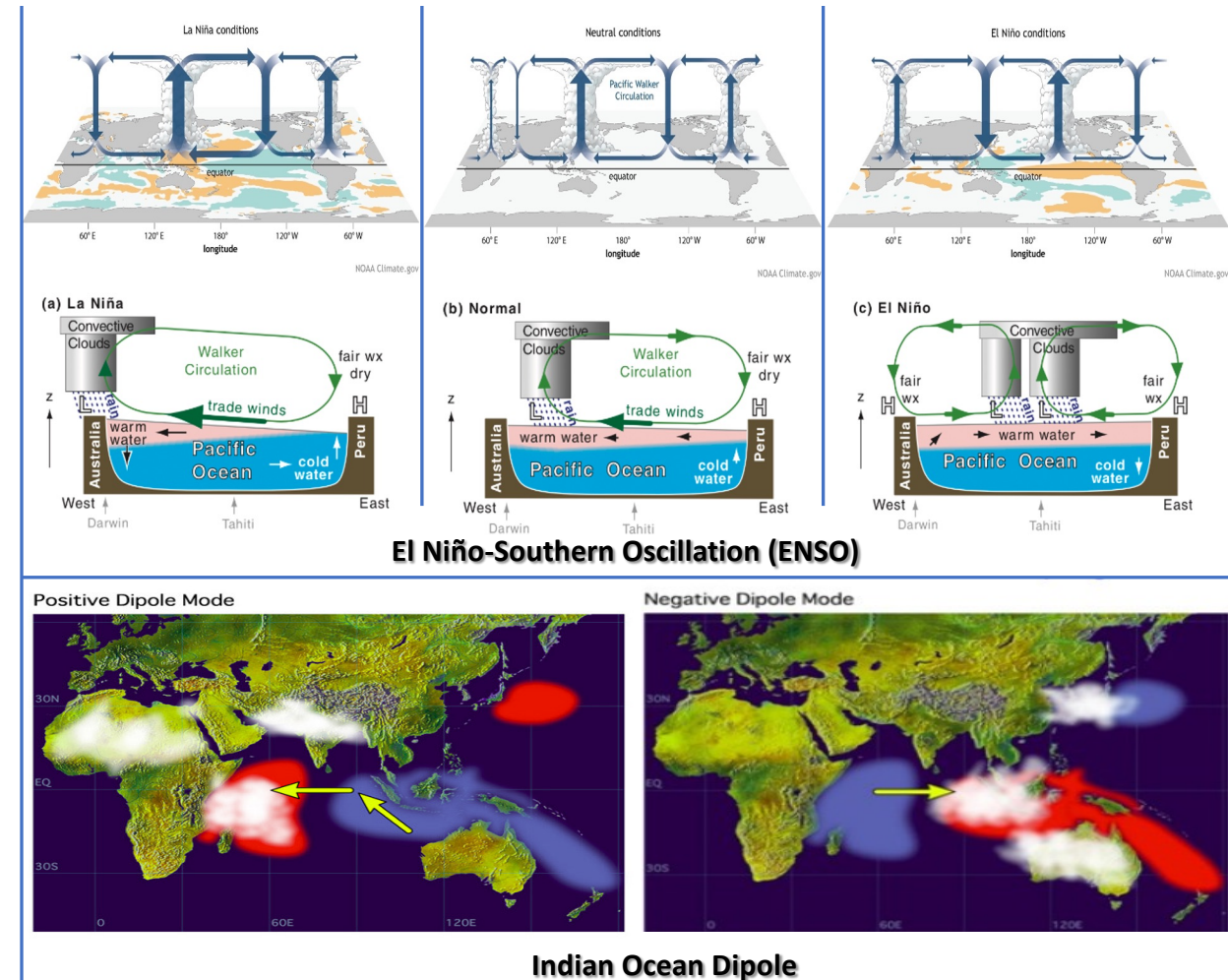
- Tropical cyclones are powerful and destructive weather phenomena that can cause widespread devastation when they make landfall.
- A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originates over tropical or subtropical waters and has a closed low-level circulation.
- Tropical cyclones rotate counterclockwise in the Northern Hemisphere.
- Tropical cyclones forming between 5 and 30 degrees North latitude typically move toward the west.
- Sometimes the winds in the middle and upper levels of the atmosphere change and steer the cyclone toward the north and northwest.
- When tropical cyclones reach latitudes near 30 degrees North, they often move northeast.



Tropical Cyclone formation regions with mean tracks (courtesy of the NWS JetStream Online School)

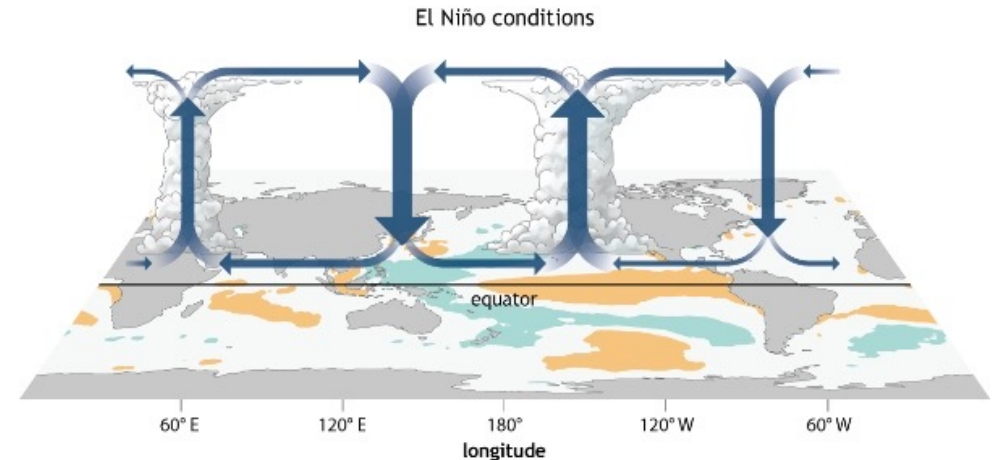
Climate oscillations

- Climate oscillations, such as the El Niño-Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD), can have a significant impact on the development and behavior of tropical cyclones.
- Climate oscillations are the naturally reoccurring changes of earth's climate that are associated with the interactions of atmospheric and oceanic conditions and occur over different geographic scales and time periods. These changes in air pressure, sea temperature, and wind direction over oceans have a defined impact on global weather patterns.
- They can influence factors such as sea surface temperatures, wind patterns, and atmospheric stability, all of which are important for the formation, intensification and direction of tropical cyclones.

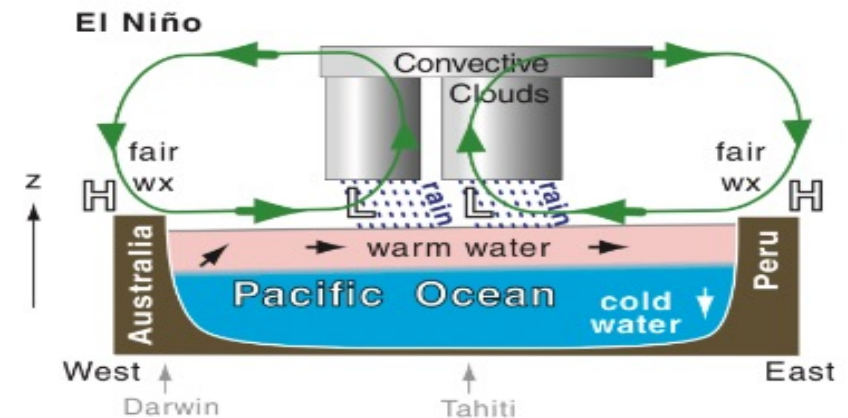


El Niño event's impact on tropical cyclones

- During El Niño events, sea surface temperatures in the central and eastern tropical Pacific Ocean are warmer than usual.
- This increase in ocean temperatures can lead to changes in atmospheric circulation patterns, which in turn can affect the development of tropical cyclones.
- El Niño conditions are associated with a decrease in the number of tropical cyclones.

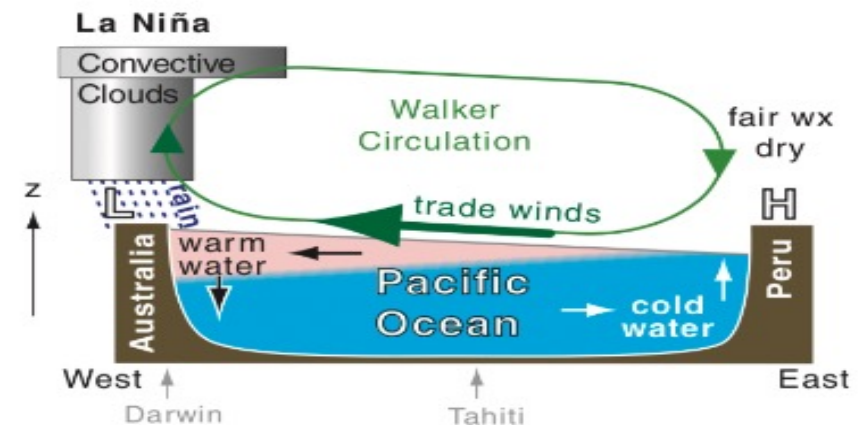
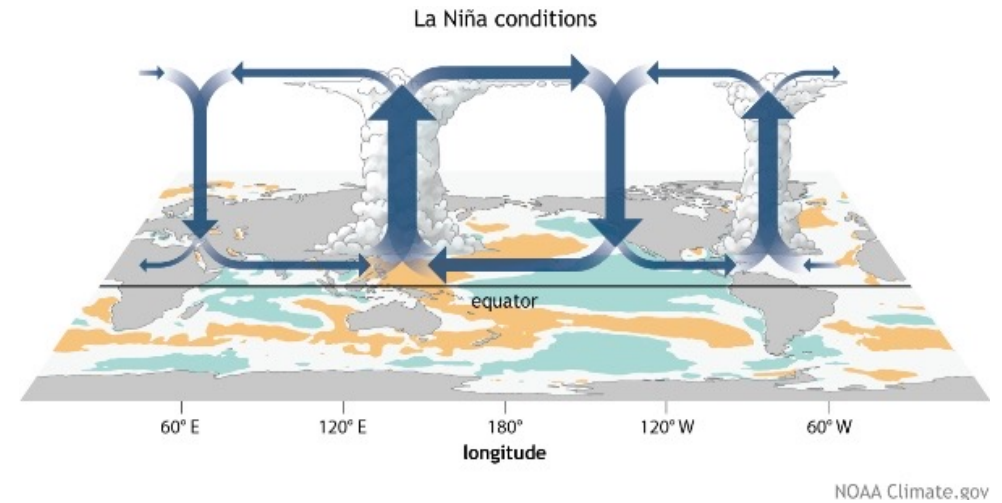


NOAA Climate.gov



La Niña event's impact on tropical cyclones

- Conversely, during La Niña events, sea surface temperatures in the central and eastern tropical Pacific Ocean are cooler than usual.
- This cooling of the ocean can also impact atmospheric circulation patterns and the formation of tropical cyclones.
- In certain regions, such as the western North Pacific, La Niña conditions can lead to an increase in the number of tropical cyclones.



ENSO's impact on tropical cyclones

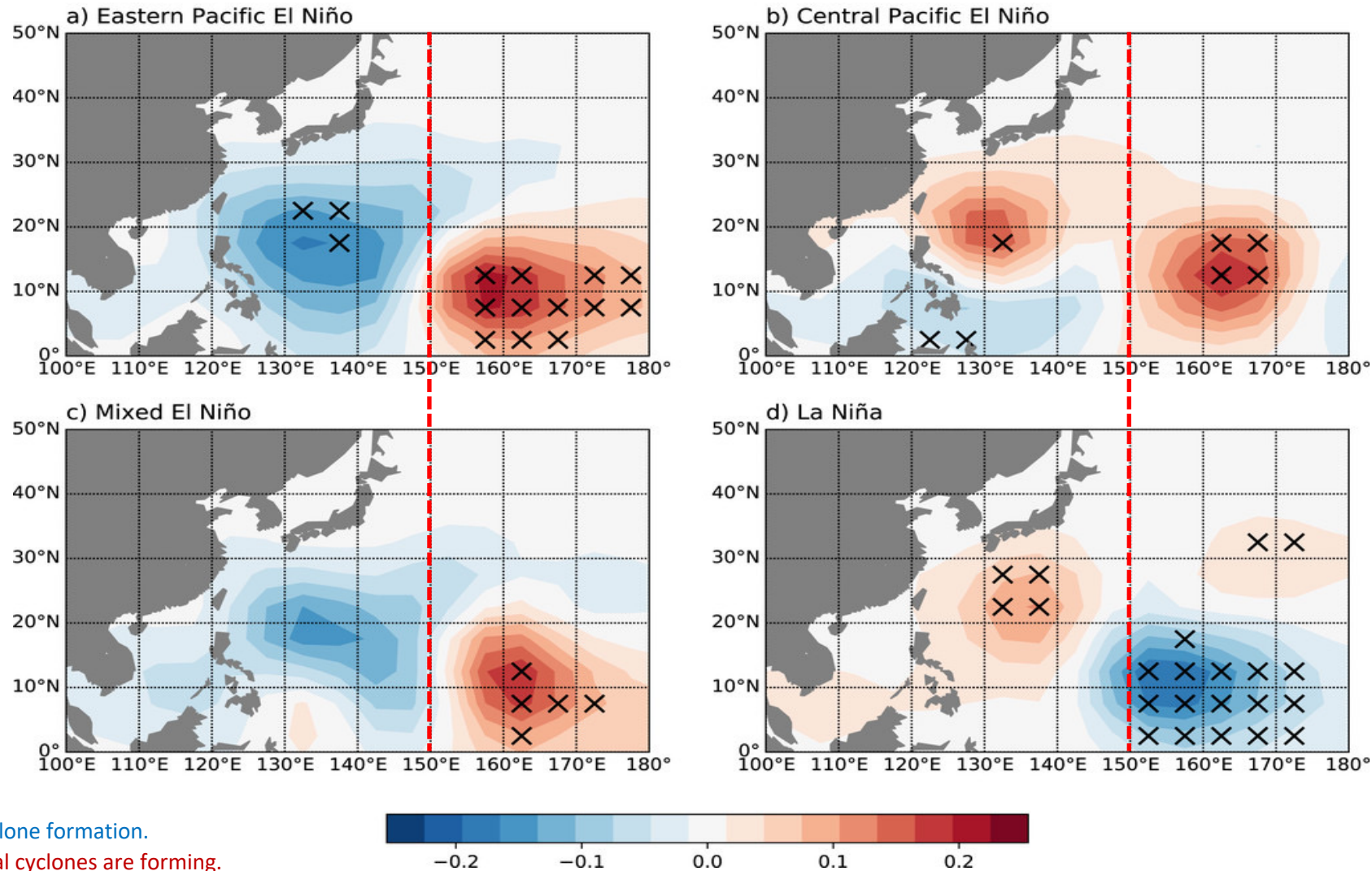
In this paper, list of The western North Pacific (WNP) tropical cyclone seasons from 1970 to 2019 that were categorized as EPE, CPE, ME, and La Niña and we will divide the El Niño phenomenon into 3 types, classified by areas where sea surface temperature has the highest values that are different from normal values.

- Eastern Pacific El Niño (EPE)
- Central Pacific El Niño (CPE)
- Mixed El Niño (ME)

ENSO type	Years
EPE	1972, 1982, 1997, 2009, 2014, 2015
CPE	1994, 2004, 2006, 2018, 2019
ME	1977, 1986, 1987, 1991, 2002
La Niña	1970, 1971, 1973, 1974, 1975, 1984, 1985, 1988, 1998, 1999, 2000, 2007, 2010, 2011

Source: <https://journals.ametsoc.org/view/journals/clim/33/18/jcliD200162.xml>

Genesis Density Anomaly



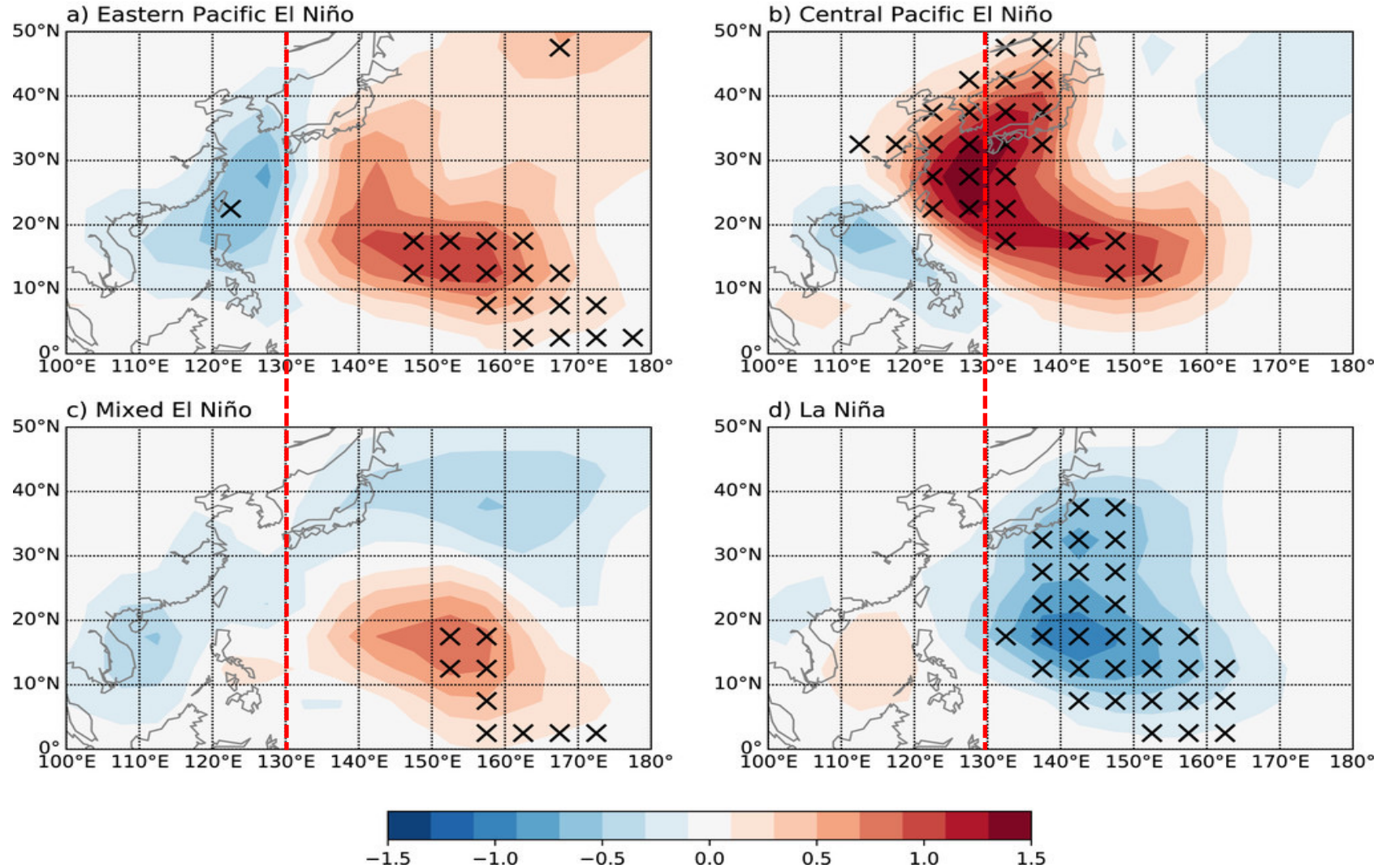
The blue areas are less tropical cyclone formation.

The red area is where more tropical cyclones are forming.

Average genesis density anomalies in June–November over a $5^\circ \times 5^\circ$ grid for (a) EPE, (b) CPE, (c) ME, and (d) La Niña years.

Black crosses denote that anomalies are significantly different from zero at the 0.05 level.

Track Density Anomaly

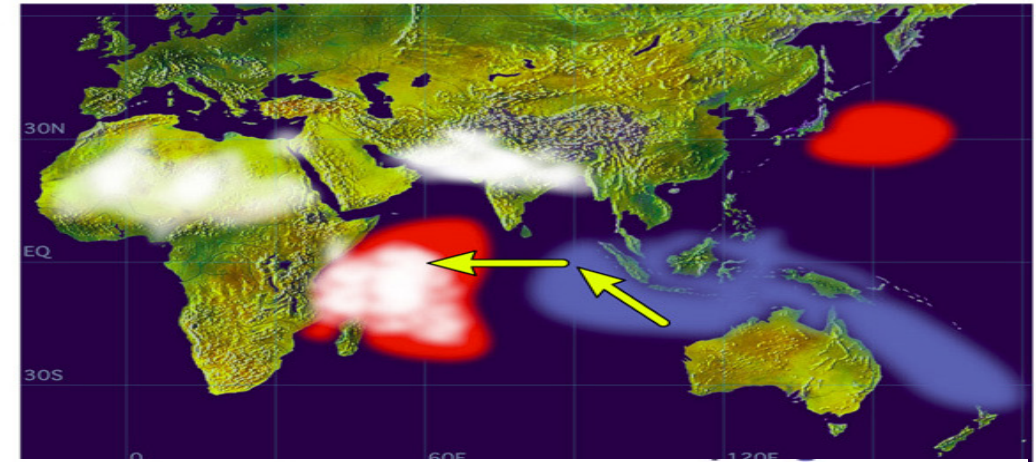


As in Fig. 3, but for the track density anomaly

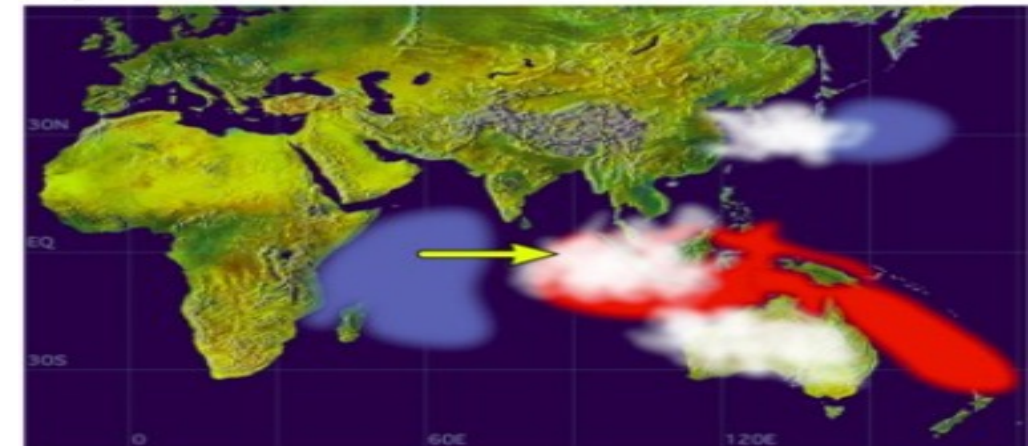
Indian Ocean Dipole's impact on tropical cyclones

- The IOD is a climate phenomenon characterized by the difference in sea surface temperatures between the western and eastern parts of the Indian Ocean.
- When the IOD is in a positive phase, with warmer waters in the western Indian Ocean and cooler waters in the eastern Indian Ocean, it can lead to an increase in tropical cyclone activity in the region.
- Conversely, a negative phase of the IOD can result in fewer tropical cyclones.

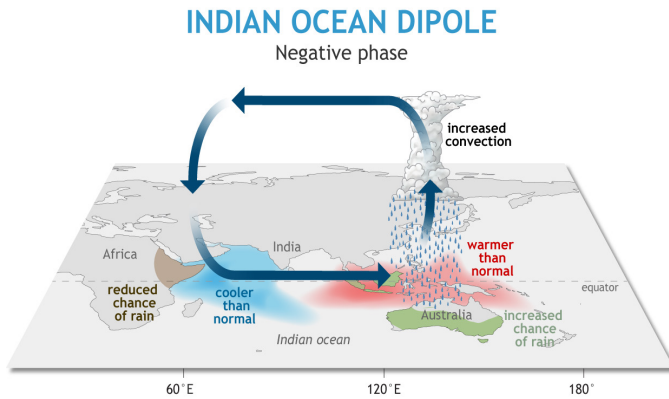
Positive Dipole Mode



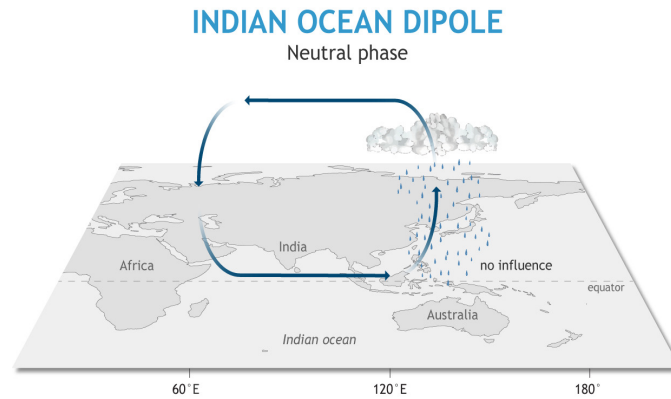
Negative Dipole Mode



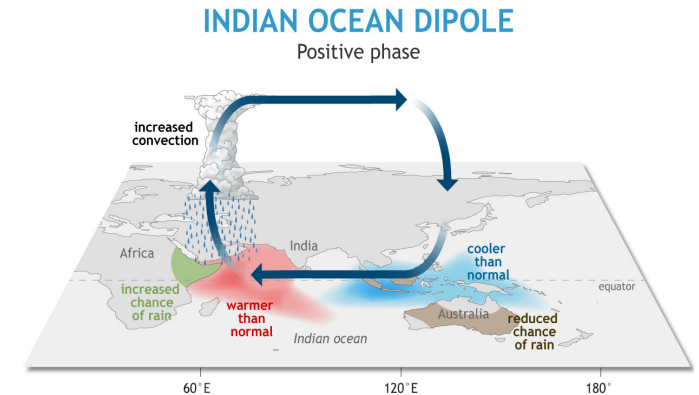
Negative Phase



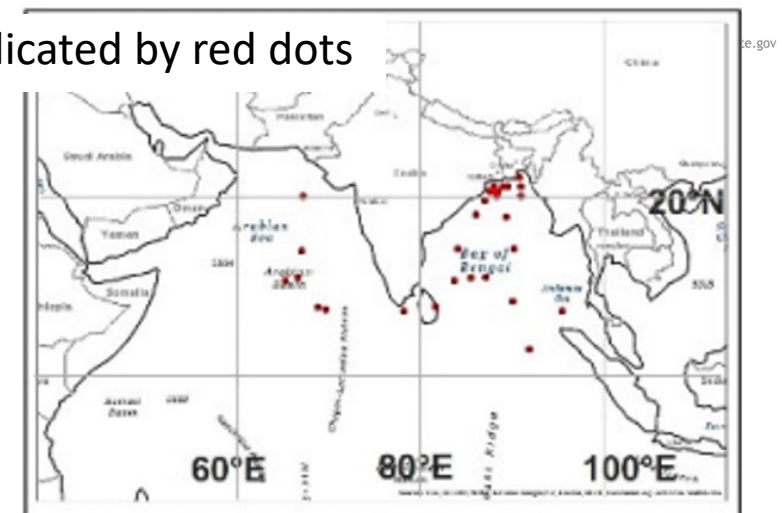
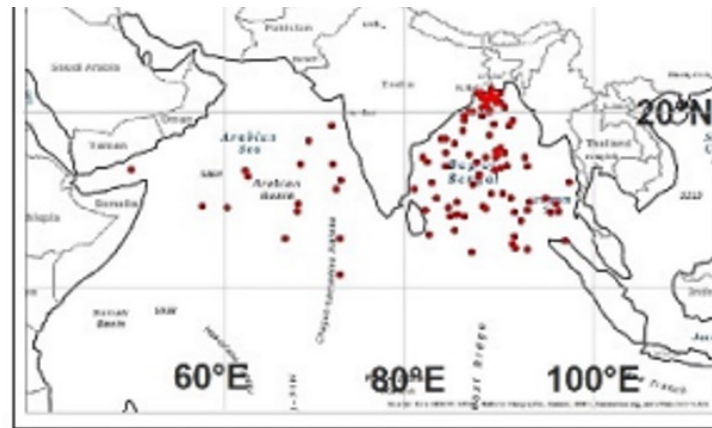
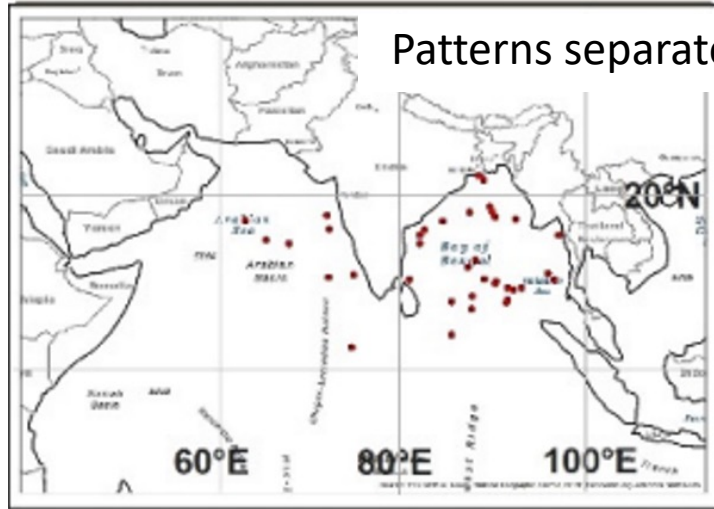
Neutral Phase



Positive Phase



Patterns separated by IOD phase: TC genesis locations indicated by red dots



- Genesis locations are more dispersed in negative phase years, whereas genesis locations in positive years tend to cluster in the northern part of the Bay of Bengal.
- The neutral phase exhibits both some clustering of genesis locations in the north of the Bay of Bengal and some more evenly dispersed genesis locations.

Source: <https://www.mdpi.com/2073-4433/13/9/1421>

Conclusion

The study of changes in tropical cyclones associated with climate oscillations is a complex and evolving field of research. By gaining a better understanding of how these oscillations influence tropical cyclones, we can improve our ability to mitigate the impacts of these destructive storms and protect vulnerable communities from their devastating effects.