



Introduction to Meteorology

24 Atmosphere–Ocean interaction (1)

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. Atmosphere and Ocean

Learning objectives



1. Describe the atmosphere–ocean interaction.
2. Describe the energy transport by the atmosphere and ocean.

Learning Activities

1. Atmosphere and Ocean

The atmosphere mainly receives energy from the surface. The ocean also receives the energy from the sea surface through radiation, rainfall, evaporation, wind, and so on. In other words, the sea surface acts as an energy source for the atmosphere and ocean, and the interaction between the two is done through the sea surface.

Because the sea surface temperature (SST) varies by regions, the uneven distribution of the sensible and latent heat release causes differential heating of the atmosphere which induces atmospheric circulation. This atmospheric circulation causes ocean and coastal currents, which in turn changes the SST.

The atmosphere and the ocean are constantly changing by influencing each other, which is called the atmosphere–ocean interaction.

Learning Activities

1. Atmosphere and Ocean

1) Influence of the ocean

Seawater shows a marked difference in physical and thermal properties when compared with rocks and soils that make up the land. In particular, the heat capacity of seawater is much larger than that of air or land. Therefore, the ocean temperature does not vary as much as the atmosphere.

The averaged atmospheric pressure shows a consistent pattern over a season. During summer, the land absorbs more solar energy, and the temperature rises easily, while the ocean temperature does not rise quickly because of its large heat capacity. The resulting thermal difference between land and ocean drives atmospheric circulation with upward motion over the land and downward motion over the ocean. As a result, low-pressure systems can be found over land and high-pressure systems over the ocean. It is the opposite during winter.

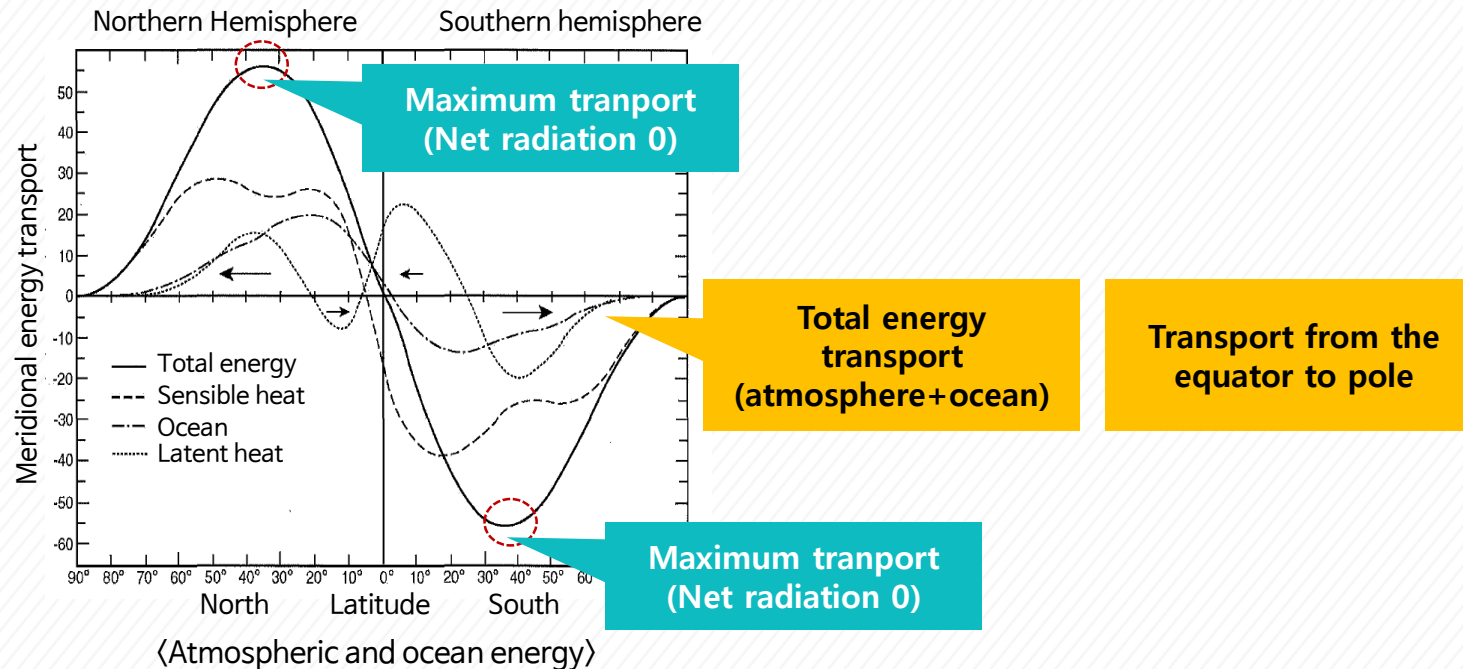
The term monsoon comes from seasonal variations in winds (though it is often extended to precipitation). Monsoons arise from seasonal reversals in heating and temperature gradients between land and ocean. Ocean not only induces temperature gradient with land but also changes the characteristics of the air parcel. In particular, during summer, heat and water vapor are supplied from the sea surface, so that a warm and moist air over the ocean is transported to the land by monsoon wind, making the climate hot and humid. The rainy season in South Korea, Japan, and China is also caused by the monsoon flow.

Learning Activities

1. Atmosphere and Ocean

2) Energy transport by the atmosphere and ocean

Solar energy is absorbed more in low latitudes, but less in high latitudes. Therefore, low latitude regions have an energy surplus, whereas high latitude regions have an energy deficit. Such energy imbalance induces the large-scale circulation. Both atmosphere and ocean transport the heat and moisture from low to high latitudes to keep the balance.



Learning Activities

1. Atmosphere and Ocean

2) Energy transport by the atmosphere and ocean

The energy transport of the atmosphere and the ocean is illustrated in the figure. The thick solid line shows the total energy transport (the sum of the atmospheric and the oceanic transport), indicating that the total energy transport is from the equator to the poles. The maximum transport occurs at about 38 degree latitude where the net radiation reaches zero.

The total energy transport is contributed by the atmosphere and the ocean. The energy transport by the atmosphere can be divided into sensible heat flux by the warm air advection and latent heat flux by the advection of moisture. The contribution of the sensible heat flux dominates over other terms. It transports heat from lower to higher latitudes. The latent heat flux energy is transported from subtropics to tropics and from mid-latitude to high-latitude. The equatorward transport of latent heat flux is caused by the low-level equatorward flow associated with the Hadley circulation.

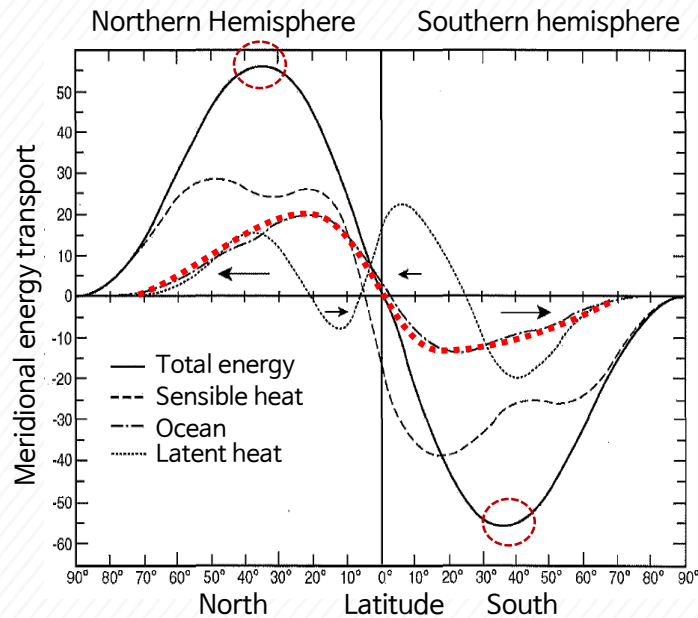
Ocean transport is the transport of energy by the ocean currents. On the western boundary of oceans, there is usually a narrow and strong current that flows from the equator to the pole. Such currents are called the western boundary currents (e.g., the Kuroshio Current, Gulf Stream, Brazil Current). On the other hand, broad and slow equatorward currents can be found in the eastern boundaries.

The clockwise currents (counterclockwise in the Southern Hemisphere) move warm water in the equatorial region to the poles and cold water in the polar regions to the equator. In other words, it plays a role of mixing warm water and cold water. The ocean transports the surplus energy of the equatorial region to the polar region by such mixing.

Learning Activities

1. Atmosphere and Ocean

2) Energy transport by the atmosphere and ocean



〈Energy transport by atmosphere and ocean〉

Energy transport by the ocean

From the equator to polar regions

magnitude is not negligible compared to the atmospheric transport



Ocean not only induces atmospheric circulation but also maintains global energy balance by its circulation

In the figure, the dashed line shows the energy transport by the ocean. A distinct poleward transport is shown of which magnitude is not negligible compared to the atmospheric transport. Ocean induces not only atmospheric circulation but also maintains global energy balance by its circulation.

Summary

1. Atmosphere and Ocean

- The atmosphere and the ocean are constantly changing by influencing each other, which is called the atmosphere–ocean interaction.
- Transport by the atmosphere: The energy transport by the atmosphere can be divided into sensible heat flux by the warm air advection and latent heat flux by the advection of moisture. The contribution of the sensible heat flux dominates over other terms and transports heat from lower to higher latitudes.
- Transport by the ocean: energy transport by ocean currents.