The Southern Ocean: A Driver of Global Climate

How does the Southern Ocean influence climate? The Southern Ocean plays two important roles in Earth's climate: it contributes to ocean circulation, transporting heat from the equator to the poles, and it stores about 50% of the ocean's carbon, mitigating climate change.

Ocean circulation distributes heat from the equator to the poles. The equator and mid-latitude regions of the earth receive much more direct sunlight than polar and high latitude regions. See Figure 1. Between 0 and 30° latitude, the Earth's surface receives more radiation than it releases. Meanwhile, between 30° and 90°, the Earth releases more radiation than it receives from the sun. How can this be?

The answer is that the coupled atmosphere/ocean system transfers heat from the equatorial regions to the poles, ultimately cooling the equator and warming the higher latitudes. Without this system, tropical areas would be even warmer than they are today, and high latitudes would be even colder. Thus, the ocean is one of the primary controls on global climate.

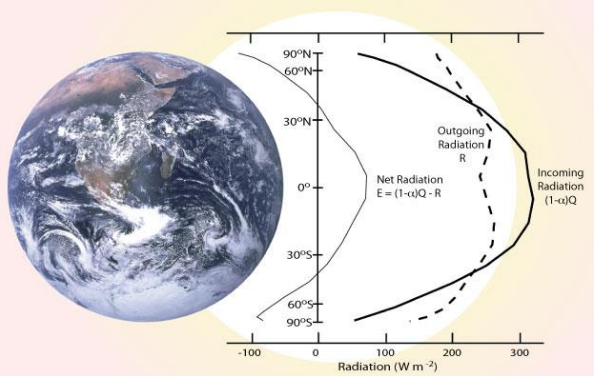

Figure 1. The Earth's radiative balance with respect to latitude.

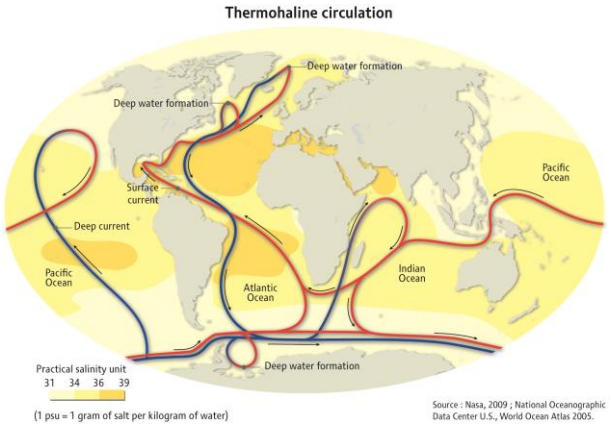

Figure 2. The global thermohaline circulation.

The thermohaline circulation controls the vertical movement of water in the ocean. There are two types of ocean circulation: the wind-driven surface (horizontal) currents such as the Gulf Stream, and the vertical thermohaline circulation. The thermohaline circulation is the process by which warm water flows towards the poles, loses its heat to the atmosphere, and sinks, forming deep water that will eventually return once again to the surface. The name "thermohaline" comes from the two primary controls on water density – "Thermo" for heat, and "haline" for salt. Cold, salty water is more dense than warm, fresh water.

The Southern Ocean is a central hub for the thermohaline circulation. The surface layers of the ocean are warmed by solar radiation, and so in most regions of the world surface waters cannot sink due to colder, denser waters below. In the Southern Ocean, however, surface formation of sea ice (which is completely fresh) leaves behind cold, extremely saline surface waters. These high-density surface waters make the Southern Ocean a primary location for deep water and intermediate water formation. Figure 3 shows the numerous water parcels that sink and rise in the Southern Ocean, ultimately contributing to the worldwide distribution of heat from the equator to the poles.

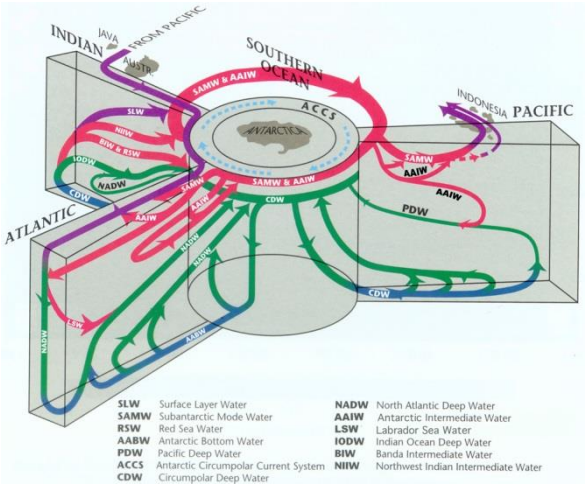

Figure 3. The Southern Ocean's crucial role in vertical ocean circulation.

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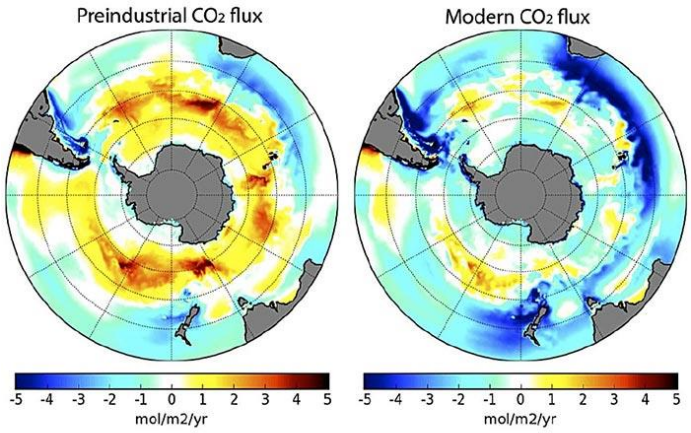

Figure 4. The change in the annual air-sea Southern Ocean CO_2 flux between an average preindustrial year and a modern year, as modeled by CM2.6. Red indicates a release of carbon that has been upwelled from the deep ocean into the atmosphere, while blue indicates oceanic uptake of carbon. The Southern Ocean currently moderates atmospheric warming by acting as a large sink of anthropogenic carbon.

The Southern Ocean sequesters carbon dioxide, mitigating climate change. The cold temperatures and massive extent of the Southern Ocean make it one of the world's largest carbon sinks. Figure 4 shows that in modern times, the Southern Ocean has absorbed much more CO_2 than it has released. In fact, although the Southern Ocean only represents 25% of global ocean volume, it absorbs about 50% of ocean CO_2. The SOCCOM project will help scientists understand the mechanisms behind this massive sequestration and how the Southern Ocean may continue to help mitigate the effects of climate change in the future.