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Mini Review

Oceans Role in Global Climate

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Abstract

Despite ocean playing a significant role in global climate, its associated heat energy with atmosphere interaction are not well examined. Here we discuss the overview of energy interaction among sun, ocean and atmosphere and its associated global climate variation.

Keywords: Ocean; climate; heat energy; energy exchange

Introduction

Covering 71% of Earth's surface, the world oceans have two-way interactions with global weather and climate:

a. Impact of oceans weather on local to global climate scales and

b. Impact of ocean properties by the global climate changes.

Seawater has a high heat capacity and fluidity render, which can absorb, store and transport the heat supplied by the sun, hence play a significant role in our climate system. While the other major fluid (atmosphere) has limited intrinsic heat capacity, thus relying upon the moisture content supplied by the ocean for its a substantial fraction and heat support. An estimated mean density and total heat capacity of the ocean compared with the atmosphere are summarizing in Table 1, suggesting the ocean contains heat capacity over 1000 times more than those of an atmosphere. The ocean's large capacity of heat absorption assures essentials of the global ocean in controlling the temperature of our planet on diurnal to continental time scales. Changes in the surface air temperature are depending on the rate of ocean mixing and advection, which is currently served to delay the greenhouse gas-imposed global temperature changes. Thus, heat content in the ocean emerged as the most critical aspect of heat storage on earth [1]. In addition to this, another ocean property of absorbing solar radiation also contributes significantly. That is the dark blue ocean that has a low albedo or reflectivity therefore readily socks heat on its upper tens of ocean surface. More importantly, in the ocean, climate regulation impacts strongly in the high latitudes, where the bright ice drastically changes the albedo of the ocean from highly absorbing to reflecting on the incoming solar energy. Therefore, the extent of sea ice has a significant effect on the climate system, that is the decreasing of ice covers, leads to more heating of the ocean and further declining in the sea ice [2], whereas, the increasing sea ice leads to decreasing heat content of the ocean. Such ice-albedo feedback is a significant factor during the "Snowball Earth" climate in the past.

Table 1: Mass and heat capacity of the ocean and atmosphere [3].

	Total Mass	Unit Heat Capacity	Total Heat Capacity
Atmosphere	5.148×10^{18} kg	993 J kg^{-1} K	5.1×10^{21} J kg^{-1}
Ocean	1.366×10^{21} kg (=1.3324×1018 m^3 × 1,025 kg= m^{-3})	3985 J kg^{-1} K	5.4×10^{24} J kg^{-1}

The shortwave radiation from the sun is heating the earth and maintains its temperature by longwave radiation into space. The longwave radiation is quite uniform because it depends on the fourth power of the absolute temperature, and surface temperature variations are small in absolute terms. However, the shortwave radiation comes directly to tropics compare to higher latitudes; thus, there is net energy fluctuation that provides a tropical surplus and polar deficit. The two primary components of our planet's climate, the ocean, and the atmosphere must transport heat from tropics to higher latitudes by moving their fluids around. The ocean can do this with its large heat capacity with relatively small water velocities, and therefore much higher velocities are needed in the atmosphere. It is known that wind velocities drive the oceans, but we have to recognize that it also the extraction of the ocean by latent and large heat fluxes that drive the atmosphere. An accurate statement is "initially sun heats the ocean, then the ocean heat and moisture the atmosphere, that is powering the winds responsible for the ocean circulation".

In the ocean, heat is absorbed in lower latitudes and eastern sections of the ocean basin, while heat is lost to the atmosphere at higher latitudes and on the western side of the basin. The east-west asymmetry is because of the ocean's anticyclonic wind-driven circulation, i.e., western boundary currents carry tropical heats to higher latitudes, where it transferred to the atmosphere. The mixing-driven based thermohaline circulation also plays an important role, whereby energy from winds and tides causes downwelling mixing of heat and upwelling of cold water [3]. These processes imposed meridional temperature gradient and would carry heat poleward even of the winds ceased blowing. The thermohaline circulation also causes the ocean heat anomaly (ENSO- El Niño-Southern Oscillation) in the tropical Pacific Ocean, which has a significant impact on the global weather, ocean conditions and marine ecosystem. In the ocean occurrence of dominate meridional heat transport at low latitudes transfer the heat to atmosphere at mid-latitude though western boundary currents (e.g., Kuroshio, Gulf Stream). These energy transfers mostly accomplished by latent heat flux from ocean to atmosphere, which can be either "cash in" the latent heat energy as rainfall that offers adiabatic heating of the atmosphere at height, or it can carry moisture further poleward, in where the precipitation exceeds evaporation. As mentioned, the ocean and atmosphere have to exchange a significant amount of energy from the tropical region to polar to satisfy the global radiation budget.

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