Abstract View

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The Annual March of the Heat Budget of the North and Tropical Atlantic Oceans

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ABSTRACT

This paper documents the annual march of the following processes for the 70° N–20°S region of the Atlantic, including the Gulf of Mexico and Caribbean Sea: net surface heat gains (monthly mean time-scale), subsurface heat storage change (bimonthly), divergence of the “vertically and zonally integrated net meridional heat transport” VZINMHT; (bimonthly). Results for the first three parameters are presented as averages for 10° (5°) zones of the extratropics (tropics)l the VZINMHT's are for the zones' bounding latitude circles.

The net surface heat gain is residually-estimated from sea-air heat exchange calculations. The extratropical North Atlantic is a net loser of heat to the atmosphere for the year as a whole. It experiences a very short period (May–August) of surface heat uptake, during which the maximum rate is as high as 110–130 W m^{-2}, and a more lengthy surface heat loss, much of which exceeds 100 W m^{-2} and has a 190–250 W m^{-2} extreme. The tropical Atlantic undergoes a more subdued, and sometimes more irregular, annual march of this process. Between 20°N–5°S the ocean surface gains heat throughout all or almost all of the year, but generally at much lower rates than in the extratropics. April–September surface heat losses between 5–20°S are balanced by October–March gains. Estimation of the subsurface heat storage change is made using 233 957 soundings for the decade 1967–76, a 5° latitude-longitude square spatial resolution, and 14 oceanic layers between the surface and 500 m. Extratropical warming is largely confined to May–August, appears to reach 400 m in some zones, and generally totals 150–225 W m^{-2}. The maximum cooling in this region tends to occur in November–December and, with the exception of 30–40° N, extends to 500 m and totals 250–350 W m^{-2}. Between 30–40°N the storm change is strongly concentrated above 100 m. The annual cycle of this process is more varied and irregular, and of smaller amplitude, in the tropical belt.

The VZINMHT divergence is obtained as the difference between the rates of net surface heat gain and subsurface heat storage change. The extratropical zones import heat throughout all or almost all of January–October, generally at rates of 50–150 W m^{-2}. Only in November–December (40–70°N) and January–February (40–50°N) is this region suggested to export, heat, a result that is rather uncertain. The tropical VZINMHT divergence pattern is dominated by export, especially between 25°N–10°S. The VZINMHT is estimated by successive southward integration of its divergence from assumed near-zero 70°N boundary conditions, a procedure whose uncertainty increases in the same direction and becomes large in the tropics. Northward VZINMHTs prevail throughout the study region during all or almost all of January–October. They tend to be largest in the tropics ($150–250\times10^{13}$ W), especially during July–October, and experience pronounced extratropical decreases, often between 30–50°N. The November–December VZINMHT is suggested to be directed southward throughout much or even all of the study region, and to increase in this direction to a 10–20°S maximum of almost 300×10^{13} W. However, this result is considered extremely tentative. The annual average VZINMHT is accordingly directed northward at all latitudes. It increases from $50–80\times10^{13}$ W at 20°S to a $107–115\times10^{13}$ W maximum in the northern tropics, and then decreases strongly poleward of 30°N, especially between 30–40°N.

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