Across all future IPCC Shared Socioeconomic Pathways, the strength of the Atlantic Meridional Overturning Circulation (AMOC) is projected to decline. However, there is much less certainty about the impacts of AMOC decline further afield. Evidence from paleoclimate archives and simulations suggests eastern African monsoons weakened under periods of high meltwater forcing in the North Atlantic, particularly during the most recent deglaciation. To explore the dynamics of this high- to low-latitude teleconnection, we use a compilation of ~30 sea surface temperature (SST) records from the tropical Indian Ocean spanning the last 30 ka. The zonal Indian Ocean SST gradient calculated from this compilation shows a remarkable similarity with North Atlantic $^{231}$Pa/$^{230}$Th records of AMOC strength, particularly during intervals of variable meltwater forcing such as the Younger Dryas, Bølling-Allerød, and Heinrich stadials. A weaker AMOC is associated with cooler western Indian Ocean and a warmer eastern Indian Ocean, suggesting a tight linkage between AMOC strength and zonal Indian Ocean variability. To better understand this teleconnection, we analyzed a meltwater single-forcing scenario from a transient simulation of the Last Glacial Maximum to present (TraCE, 22ka-0ka). Under simulated meltwater forcing events, the tropical zonal Indian Ocean SST gradient intensifies (i.e., relative cooling in the west and warming in the east), in agreement with SST paleorecords. This response stems from an intensification of the subtropical high over Southern Europe which drives northerly surface wind anomalies across Arabia and the Horn of Africa, with cooler Northern Hemisphere anomalies extending as far south as Madagascar. This cools the surface western Indian Ocean, particularly in the Arabian Sea, enhancing the Bjerknes feedback and strengthening the Walker circulation across the basin. This effect is strongest in austral summer (DJF) when the Somali Jet reverses and northerly winds advect cool northern air into the deep tropics. Anomalous northerly winds and western Indian Ocean cooling were also found to be common feature of eight hosing experiments under preindustrial boundary conditions from the North Atlantic Hosing Model Intercomparison Project (NAHosMIP). Overall, we hypothesize an atmospheric mechanism connecting the high-latitude North Atlantic and tropical Indian Ocean under meltwater forcing, with the western Indian Ocean playing an outsized role in steepening the zonal SST gradient across the basin which weakens monsoon systems in eastern Africa.