

Ocean and Hydrologic Variability Over Thousands to Millions of Years

David M. Anderson

NOAA's National Climatic Data Center, Boulder, CO

Paleo proxies spanning periods thousands to millions of years before present reveal the response of the hydrologic cycle to large changes in ocean temperature and circulation, in some cases ten times larger than the $\pm 0.5^{\circ}\text{C}$ changes observed in ocean temperature during the past 150 years. Over the past 3 million years the high latitudes have cooled and zonal and meridional temperature gradients have intensified. Ice Age cycles dominate the variability of the past 1 million years, superimposed with cyclic changes in the seasonal distribution of solar radiation. During the Ice Ages abrupt changes in the monsoons are apparent. The amplitude of abrupt changes are reduced during warm interglacial times. In the past, when the oceans have warmed they have warmed most at high northern latitudes. The Inter-tropical convergence zone migrates towards the warmer hemisphere, the summer monsoon strengthens, and indirect evidence reveals more water vapor in the atmosphere. Cooler climates were dry and dusty, with weaker monsoon circulation. While not a direct analog for the future, these variations illuminate important connections between the oceans and the hydrologic cycle and provide some indication of the changes that may accompany future warming.