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## **How the Rate of Volcanism Initiated the Medieval Warm Period and Controlled Its Periods of Drought**

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In 1991, 17 Megatons of SO<sub>2</sub> erupted by Pinatubo was oxidized to form a 99% pure sulfuric acid/water aerosol layer in the lower stratosphere. This aerosol reflected and absorbed energy from the sun, cooling the earth 0.4°C for three years. During the Medieval Warm Period, most large volcanic eruptions are contemporaneous with short-term decreases in Northern Hemisphere temperature determined using high-resolution proxy data (Mann and Jones, 2003).

When such large eruptions occur more frequently than every few years, however, the oxidizing capacity of the atmosphere is exceeded, greenhouse gases accumulate, and the earth warms. Periods of high rates of volcanism can be measured by sulfate deposits in layers of ice in Greenland. Some 1529 ice layers examined in the GISP2 drill hole cover the past 3500 years with the average layer representing 2.26 years. Only 27% of these ice layers contained “volcanic” sulfate and there were only 3 instances where more than 6 contiguous layers contained “volcanic” sulfate: 179-140 BC (16 layers), the onset of the Roman Climate Optimum, 818-840 AD (11 layers), the onset of the Medieval Warm Period, and 1929-1984 AD (34 layers), the onset of the modern warming period caused by anthropogenic SO<sub>2</sub>. The greatest concentration of contiguous layers with evidence of volcanism since 110 ka is 22-7 ka, the period of most rapid warming following the Last Glacial Maximum.

When no large volcanic eruptions occur for decades, greenhouse gases are oxidized, cooling the atmosphere and causing drought. For example, the tree-ring reconstructed Palmer Drought Severity Index for part of Colorado (40N, 110W) (Cook and Krusic, 2004) during the Medieval Warm Period is positive when contemporaneous with volcanic eruptions in the GISP2 core and negative with lack of eruptions. The longest periods of continuous drought with no volcanism are from 941-959, 1028-1053, 1124-1148, and 1150-1164 AD.