Reconstruction of sea surface temperature and salinity for the Medieval Climatic Anomaly using a long-lived fossil coral collected at Ishigaki Island, southwestern Japan

*Osamu Abe[1], Maki Morimoto[2], Ryuji Asami[3], Takeshi Nakatsuka[1,4]

1. Graduate School of Environmental Studies, Nagoya University, 2. School of Education, Gifu University, 3. Graduate School of Science, Tohoku University, 4. Research Institute for Humanity and Nature

The period between 950 and 1250CE is called as the Medieval Climate Anomaly (MCA; Masson-Delmotte et al., 2013), at the time when the warmer climate seemed dominant globally (Bradley et al., 2003). Recent investigations based on the proxy record such as tree-ring widths, speleothems, ice cores, and historical documents indicated that a significant climate change occurred during the latter half of the 10th century. Mann et al. (2009) found that an increase of the average air temperature in the northern hemisphere at the late 10c. coincided with an increase of sea surface temperature at northern subpolar oceans. Yan et al. (2011) indicated that atmospheric environments in the equatorial Pacific shifted from the La Nina like condition to the El Nino like condition around 1000CE. In East Asia, Zhang et al. (2008) and Ge et al. (2013) described that the activity of East Asian Summer Monsoon (EASM) had been enhanced during the late 10c., then the climate in China shifted to warmer and wetter. Whereas Lie et al. (2014) showed that the EASM had been weakened during the 11th century. In addition, the climate in southern China was reported as relatively dry (Chen et al., 2015).

These studies demonstrated that a large climatic shift occurred around 1000CE, however, most of them have relied on records collected on land. There is little long-term high-resolution marine record during the MCA.

We reconstructed sea surface temperature (SST) and salinity with a temporal resolution of one month for 300 years using a long-lived fossil coral collected at Ishigaki Island, southwestern Japan. Based on the U/Th dating in the youngest part of the coral skeletons as well as the band counting, this coral sample had lived between 845 and 1130CE, largely covered the MCA period. Skeletal Sr/Ca and oxygen isotopic composition were analyzed for about 4,000 samples.

The empirical equations between Sr/Ca and water temperature; between oxygen isotopic composition of coral skeleton and seawater, and water temperature, were established using the present coral records, observed water temperature and oxygen isotopic composition of seawater. With these equations and the relationship between seawater salinity and oxygen isotopic composition, proposed by Abe et al. (2009), SST and seawater salinity from 845 to 1130CE were reconstructed from the fossil coral Sr/Ca and oxygen isotopic composition.

Through the entire period, average summer and winter SSTs were 2 and 1 deg. C higher than the present, respectively. In addition, SST increased significantly after 1040CE; 0.9 for the annual average, 0.7 for summer and 1.1 for winter. Salinity also increased after 990CE; 0.8 all for the annual average, summer and winter. Salinity was significantly higher through the entire period than the present, however, its absolute value seems unconfirmed yet.

Increasing SST and salinity found in this study during ca. 1000 and 1130CE were consistent with the weakening of EASM during the 11th and 12th centuries shown by Liu et al. (2014). They argued the weakening occurred as a consequence of weakening of the solar activity and the decrease of SST at the western Pacific warm pool. In this study region, the decrease of precipitation during the Baiu period induced the increase of salinity as well as local SST increase due to the decrease of the cloud cover. Our results were also consistent with the warming of China in the late 10c. (Ge et al., 2013), and a drier condition in southern China (Chen et al., 2015).

The periodicity of SST and salinity based on the spectral analysis will be discussed in the presentation.

Keywords: Coral annual bands, Medieval Climate Anomaly

