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Reconstruction of long-term variability of the solar activity based on geomagnetic field intensity and flux of cosmogenic nuclides

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Recently, a possible link between solar activity and climate variation in decadal and century scales has been debated (e.g., Rind, 2002). Moreover, the past variability of solar activity has been reconstructed by flux of cosmogenic nuclides (C^{14}, Be^{10}, etc.) recorded by tree rings and ice core, suggesting their linkage in longer time scale (Beer et al., 2006). However, the variability of the total solar irradiance over a typical 11-year solar cycle is only approximately 0.1% (Froehlich, 2006), which is too small to explain the observed climate variations (Foukal et al., 2006). On the other hand, there are other ways that solar variability may affect climate, such as a terrestrial amplifier of the spectral irradiance variations (Haigh et al., 1996), or an indirect mechanism driven by the solar activity. The later can be realized by galactic cosmic rays (GCRs) via the ionization effect in the atmosphere. GCRs induced ionization is the principle source of the ionization of the low and middle atmosphere and can slightly modulate cloud formation, which is likely to affect climate through changes in transparency/absorption/ reflectance (e.g., Svensmark, 1997). Because the flux of GCRs is modulated by solar magnetic activity, this phenomena provides a possible link between solar variability and climate.

On the other hand, the flux of GCRs is not only controlled by solar activity, but also by the strength of the geomagnetic field largely. When the geomagnetic field intensity is low, GCRs can more easily penetrate into the Earths atmosphere and then increase the production of cosmogenic nuclides, such as Be^{10}. In the last two decades, paleomagnetic studies on marine sediments have revealed long-term and large-amplitude variations on the geomagnetic field intensity (e.g., Guyodo and Valet, 1999). This indicates that reconstruction of the past variability of solar activity using the flux change of cosmogenic nuclides urgently needs correction by the geomagnetic field intensity. Moreover, the variation of the geomagnetic field intensity could also affect on cloud formation and climate, in especially longer time scale. However, most of the reconstructions of past solar activity have not been sufficiently corrected by the geomagnetic field intensity because of the lack of high-resolution and high-precision reconstructions. Therefore, a highly accurate reconstruction of the past solar activity using cosmogenic nuclides corrected by a high-resolution geomagnetic field intensity record is needed in order to understand the relationship among the climate, sun, and geomagnetic field.

Here, we propose that the possible connections among the climate, sun, and geomagnetic field should be assumed to be one of the main challenges in the next IODP phase. Although, conventional piston coring strategy is limited by time coverage especially in case of higher sedimentation rate, new drilling plans in IODP are able to recover long-term sedimentary records with high sedimentation rate in order to provide high-resolution cosmogenic nuclides (in this case Be^{10}) and geomagnetic field intensity variability. Because very limited input of terrestrial materials is needed for cosmogenic nuclides analysis, preferable drilling sites are thought to be open ocean area except the west wind belt zones. Moreover, equatorial zone is suitable for this study because of higher sedimentation rate originated to high biological productivity. These new drilling plans in IODP will arrow to reconstruct the long-term solar activity in high accuracy that is needed for test the possible connections among the climate, sun, and geomagnetic field.