Coherent considerations for DPOI-KDOI-CMOI connecting with AAO on environmental ecosystem in the Southern Ocean

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Large change of environment (climate-ocean) and ecosystem in the Antarctic/Southern Ocean happens frequently in recent decades (as general reviews, Turner *et al*., 2009; Rintoul *et al*., 2012; IPCC, 2001, 2007, 2013). A key factor that brings the change of the environmental ecosystem in the Southern/Antarctic Ocean seems to be a large change of the circum-westerlies around the Antarctica connecting with Antarctic Oscillation (AAO) alias Southern Annular Mode (SAM).

We are interested in the relationships between climate-ocean environment and the ecosystem of Antarctic krill, a keystone species in the Antarctic Ocean (Fig. 1). A fundamental issue is how to take approaches for understanding of the relationships between climate, ocean and krill ecosystem in various specific phenomena.

Naganobu *et al*. (1999) found a significant correlation between krill recruitment and DPOI (Drake Passage Oscillation Index; a climate environmental index determined from sea level pressure differences between Rio Gallegos at the southern part of South America and Esperanza Station at the tip of the Antarctic Peninsula) in time-series variability. The strength of the westerlies affects krill recruitment; years with the strong westerlies resulted in high krill recruitment, and years with the weak westerlies resulted in low krill recruitment. IPCC (2001) evaluated DPOI as an environmental index associated with the Antarctic ecosystem.

We therefore tried similar approaches on climate indexes in the other regions by further extension for KDOI (Kerguelen Islands - Davis Station Oscillation Index) in the Indian sector and CMOI (Christchurch - McMurdo Station Oscillation Index) in the Pacific sector of the Southern Ocean. In addition, we examined relationships between these regional OIs and AAOI (AAO Index) (Fig. 1).

We had found that singly-KDOI during 2006 and 2013 showed the variability of upward trend with approximately 4-year periodicity (Naganobu *et al*., 2014). Here are the correlations between DPOI, KDOI and AAOI (except CMOI under analysis). Time series of DPOI and AAOI, 12-month running mean, indicated the strong correlation (R=0.53) with approximately 4-year periodicity during 2006 and 2014 (Fig. 2). Similarly, KDOI and AAOI indicated the strong correlation (R=0.86) (Fig. 3). AAOI in the whole scale is closely related to DPOI and KDOI (and probably CMOI) in the each regional scale. We proceed with these coherent approaches for DPOI-KDOI-CMOI connecting with AAOI on the environmental ecosystems in the Antarctic/Southern Ocean.

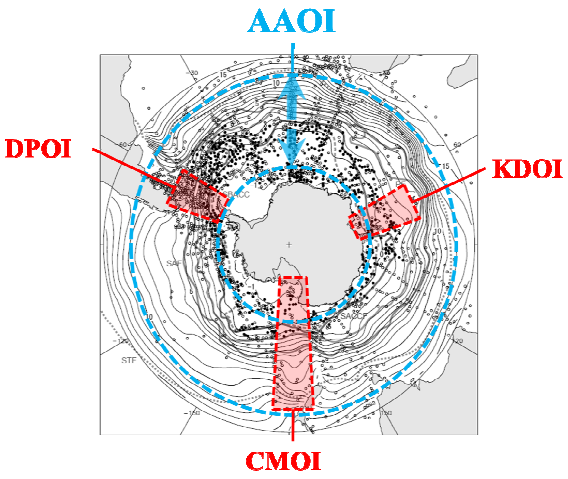

Fig. 1: DPOI-KDOI-CMOI connecting to AAOI with Antarctic krill distribution and MTEM-200 (Mean TEMperature from the surface to 200m, ℃) including multiple oceanic fronts.

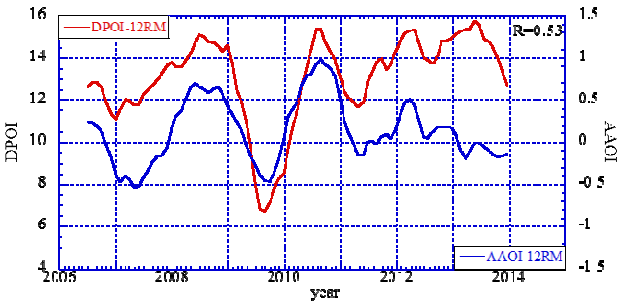

Fig. 2: Time series of DPOI and AAOI, 12-month running mean from 2006 to 2014.

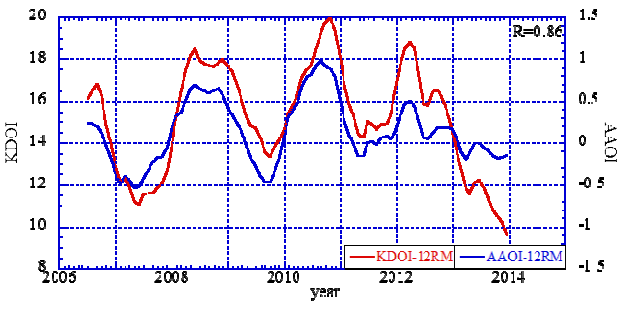

Fig. 3: Time series of KDOI and AAOI, 12-month running mean from 2006 to 2014.