Abstract of Doctoral Dissertation

Degree requested: Doctor of Science Applicant's name: Emi Yati

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Marine Ecosystem Variations and Predictability of Sea Surface Temperature in the North Pacific
(北太平洋における海洋生態系の変動と海洋表面水温の予測可能性)

This thesis consists of the analysis of marine ecosystem variability and their relation to large-climate variability and change and the analysis of sea-surface temperature (SST) predictability over the North Pacific (NP) from the latest seasonal forecast systems of European Centre for Medium-Range Weather Forecasts (ECMWF), Deutscher Wtterdienst (DWD) and Centro-Euro-Mediterraneo Sui Cambiamenti Climatici (CMCC). These investigations are motivated to know variability and change of marine ecosystem over the NP associated with its linkage to physical climate in a unified view covering the eastern and western NP and to understand better predictability of the physical condition of the basin.

In the investigation of NP marine ecosystem, 120 marine species time series for zooplankton, invertebrates, small-pelagic fish, groundfish and salmon both in the eastern and western NP basins and 8 physical (climate) indices are analyzed by using multivariate analysis to identify dominant modes of marine ecosystem variability and their relation to physical and climate conditions during 1965-2006. The main analysis method is Empirical orthogonal Function (EOF) of marine ecosystem indices. The results indicate that the time series of the first EOF mode (PC1s) of marine ecosystem indices for the eastern, western and the whole NP are characterized by a long-term trend, accompanied by the decrease of ground fishes, the increase of salmon in both basins, and the increase of most of small pelagic fishes in the western basin. The time series of the second mode (PC2) of eastern NP marine ecosystem indices exhibits multi-decadal variability with two phase reversals, while the western NP PC2 exhibits interdecadal variability with three phase reversals. The all PC1s are correlated with the NP averaged SSTs and also with the global averaged SSTs, thereby suggesting that the gravest mode of the marine ecosystem variations is influenced by the global warming. The eastern NP PC2 is the most strongly correlated with Pacific Decadal Oscillation (PDO), while the western NP PC2 with the North Pacific Gyre Oscillation (NPGO).

In the investigation of SST predictability, prediction skills and their association to the relation among ensemble members and observation is analyzed for January and July forecast with three-month lead time by using 95 members of multi-model ensemble in 1994-2016 from the latest seasonal forecasting systems of ECMWF, CMCC and DWD from Copernicus Climate Change Service (C3S). The prediction skill is measured by temporal correlation between multi-model ensemble mean (MMEM) and observed SSTs at each grid point, referred to as point-wise correlation. Point-wise correlations are high in the eastern and central NP in January and in the eastern NP in July, but low in the Kuroshio-Oyashio extensions (KOE) in both January and July and in the central NP in July. Further analysis reveals that for the high prediction skill areas the spreads among ensemble members are small and the observation can be regarded as an ensemble member. The low prediction skill is associated with either a wide ensemble spread as found for July KOE or the ensemble members failing to capture observed variability as found in the January KOE and in the July central NP. The former case is associated with the strong stochastic components and weak predictable components, whereas the latter case is resulted from biased variations commonly occurring among ensembles.