学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Separation methods of the internal climate variability and externally forced response, and their applications to the decadal climate variability in the tropical ocean-atmosphere.
（外部強制応答と内部気候変動の分離手法とその熱帯大気海洋系における
10年周期気候変動への応用）

The present study performed inter-comparisons of methods to remove the externally forced response (EFR) from the observed records by examining remaining decadal anomalies over the Indo-Pacific sector as the internal climate variability (ICV). A warming trend of sea surface temperature (SST) in recent decades is quite pronounced in the Indian Ocean than in the other tropical basins. Therefore, the EFR and the ICV over the Indian Ocean have comparable variances and mixed in the observed SST records. While the previous studies attempted to obtain the cross-basin relationship of the decadal SST variability between over the Pacific and over the Indian Ocean, those results depended on separating treatments of the ICV and the EFR. Here, the present study compared the methods of the ICV and EFR in the observations.

Three methods were applied as follows. (i) MG method utilized the multi-model ensemble mean of global mean surface temperature (MG) as a representative index of the externally forced component, and then removed the regressed components of each variable at each grid point onto the MG. (ii) LT method is a conventional detrend method by which a linear trend on each variable at each grid point is removed. (iii) ML method calculate time series of the MME on each variable at each grid point based on the selected simulations, and then remove its time series from the observed records at the same grid points.

While the EOF analyses of remaining SST and sea level pressure (SLP) anomalies over the Pacific does not make much difference among the three methods, MG method is most likely to successfully remove the global warming signal contained in the observed records over the Indian Ocean. As a result, the leading EOFs and their associated PCs represent the background physics of the large-scale air–sea interactions in any analysis domain by MG method. In addition, since the most coherent pattern of the cross-basin interaction between the Pacific and Indian Ocean was obtained by MG method, these results mean the advantage of MG method.

Inter-comparisons of the methods based on the 50-member historical simulations from Model for Interdisciplinary Research on Climate version 6 (MIROC6) indicated that MG method largely suppressed ICVs contained in each member by estimating EFRs via the MG. Whereas, the ensemble mean at local grid point insufficiently suppressed ICVs contained in each member. When analyzing large ensemble data of at least less than 172 members, it is recommended to employ the ensemble mean among the EFRs estimated by MG method at each member, to estimate the impact of external forcing.

An analysis onto the extracted ICV in the observed records by MG method shows positive correlation of decadal temperature anomalies over the upper Indian Ocean and the IPO index. In the positive (negative) phase of the IPO, intensification (weakening)

of the surface ocean circulation over the Indian Ocean has a significant contribution in forming positive (negative) temperature anomalies of upper layers. Such advection effect associated with the enhanced (reduced) surface winds over the Indian Ocean overwhelms the damping effect of surface heat flux on local SST. Whereas the dominant effects of atmospheric processes often observed in the climate variabilities on inter-annual time scales, the present study indicates the relative importance of oceanic processes in decadal variabilities.