論文内容の要旨

A numerical modeling study on the climatic impact of tropical instability waves in the Pacific Ocean
（太平洋における熱帯不安定波の気候影響についての数値モデリング研究）

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Tropical instability waves (TIWs) are equatorial mesoscale eddies observed both in the Pacific and Atlantic Oceans as cusp-shaped frontal waves propagating westward during the second half of the year. It is known that TIWs are produced due both to a barotropic shear of an equatorial current system and to a meridional gradient of density and sea surface temperature (SST) through a baroclinic instability. Because TIWs are an important mechanism for distributing heat in the meridional direction, a detailed understanding of TIWs is necessary. However, little is known about the impact of TIWs on large-scale phenomena such as atmospheric circulation and global climate change. In this study, the climatic impact of TIWs in the tropical Pacific Ocean is investigated using a coupled atmosphere-ocean general circulation model (AOGCM) MIROC. In particular, the following three questions are addressed in this study:

- How significant is the feedback of the TIW-induced atmospheric disturbances to oceanic TIWs?
- How do atmospheric perturbations associated with TIWs modify the atmospheric mean circulation and induce a secondary impact?
- How do TIWs ENSO modify characteristics?

The oceanic part of the high-resolution version MIROC reasonably reproduces TIW features such as temporal and spatial scale, seasonality, energetics, and heat balance. A comparison of energetics among three resolution atmospheric models coupled with the same high-resolution oceanic model confirmed that a high-resolution atmospheric model which is capable to represent the atmospheric responses to TIW-induced sea surface temperature (SST) perturbations simulates a negative feedback to oceanic TIWs. Such negative feedback is not identified in a low-resolution version atmospheric model because of the absence of atmospheric responses. However, the negative feedback effect estimated quantitatively is negligibly small compared with the other energy sources from barotropic and baroclinic instability.

Sensitivity experiments were conducted to address the second question using an uncoupled atmospheric GCM with and without TIW-induced SST perturbations. Their results revealed the significant southward shift of the Hadley cell and the Intertropical Convergence Zone (ITCZ) induced by the poleward eddy fluxes of heat and moisture associated with TIWs. As an additional experiment, sensitivity of the upper ocean to the modified mean wind stress is examined using uncoupled medium-resolution oceanic GCM. Because the mean surface wind converging on the ITCZ is closely related to the equatorial current system, southward shift of mean wind stress curl causes the slowdown of the North Equatorial Counter Current (NECC). As a result, it is suggested that TIWs have a significant impact on oceanic mean field not only through the direct heat transport by oceanic eddies, but also through the atmospheric heat and moisture convergence which weakens the shear between the South Equatorial Current (SEC) and the NECC.

The last question was examined by performing a 100-year integration of the low-resolution MIROC in which the effect of the TIW-induced thermal heating is parameterized. We found that TIW-induced thermal heating has a vital role in increasing ENSO asymmetry due to activated (suppressed) TIW-induced negative feedback during La Niña (El Niño), besides it acts as a negative feedback to El Niño/Southern Oscillation (ENSO) anomalies. Furthermore, the period of ENSO is longthened because the phase speed of the equatorial Rossby wave is reduced through the improvement in background stratification around the off-equatorial thermocline. In addition, TIW's damping effect near the surface results in suppressing a SST mode of ENSO which is known to have higher frequency. These results are consistent with the observed long-term modulation of ENSO and TIWs (the latter is presumed from background state changes) during the 1970's, and have possibility to contribute to the understanding of them.

The above findings revealed that TIWs interact not only with the oceanic local mean state but also with the remote tropical climate. Moreover, the methodologies conducted in this study are applicable to many other tropical frontal waves and contribute to investigate their multi-scale interactions.