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台風および冬季対流時における新型鉛直混合スキームの性能
The performances of improved vertical mixing scheme in the typhoon and winter convection cases in Japan Sea

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The vertical turbulent mixing in ocean mixed layer plays a crucial role in transferring momentum and heat across the air-sea interface. Therefore, the turbulent mixing scheme to parameterize this process is very important in the ocean mixed layer modeling.

The mixed layer scheme by Mellor and Yamada (1982) (hereafter MY82 scheme) has been widely used in a variety of numerical models. However, numerous numerical studies indicate a significant defect of the MY82 scheme, which is a slow growth and shallow mixed layer because the dependency of turbulent length scale on stability is ignored (Sun and Ogura, 1980; Martin, 1985; Kantha and Clayson, 1994). To fix this problem, Nakanishi and Nino (2009) developed an improved MY82 scheme (hereafter MYNN scheme) which incorporated the effects of buoyancy and stability on the turbulent length scale. Another improvement is that the empirical constants are determined by LES database. The MYNN scheme has been applied in various atmospheric circulation models successfully. In this study, we apply the MYNN scheme as an ocean mixed layer scheme in an ocean circulation model and check its performance.

We consider two situations. One is to study the response of the mixed layer to a super typhoon 'Maemi' which passed through the Japan Sea in September, 2003. The other is to study the response of the mixed layer to the strong cooling and wind forcing in winter from November in 2010 to February in 2011, which induce strong convection in the northern part of the Japan Sea. A 3D z-coordinate ocean circulation model, the RIAM Ocean Model (RIAMOM), with 1/12 degree horizontal resolution and 36 vertical levels is used to investigate the performances of the MYNN scheme for typhoon and winter convection cases.

For the typhoon case, hourly MSM-JMA forcing data (wind stress, humidity, air temperature and so on) are used in the model. The surface heat flux is estimated by bulk method without surface relaxation. While, for the winter convection case, the model is run from November 2010 to February 2011 during which the winter weather condition is very hard due to the strong La Nina event. The other conditions are same with the typhoon cases.

The results in both cases show that in experiments with the MY82 scheme, the SSTs are obviously warmer than those in experiments with the MYNN scheme, which were still warmer than observations. The area-averaged SST with the MY82 scheme is about 0.25 degree higher than that of MYNN experiment in the typhoon case. Meanwhile, in the winter convection case, the improved mixing scheme generates a 0.2 degree colder area-averaged SST than the MY82 scheme. The higher SST in the experiments with the MY82 scheme implies that downward transports of the momentum and heat from the surface layer are generally weaker than the experiments with the MYNN scheme. Further analyses show that the mixed layer and the turbulent kinetic energy develop very well in the experiments with the MYNN scheme. As a summary, the MYNN scheme contributes to a certain extent to overcome the weak points of the MY82 scheme such as an insufficient growth of the mixed layer and underestimate of the turbulent kinetic energy through the enhanced transports of the momentum and heat downward from the surface layer. The results in this study imply that the MYNN scheme has a good performance compared with the original MY82 scheme in the ocean mixed layer modeling.

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