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Shallow marine cloud topped boundary layer in atmospheric models

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A common problem in many atmospheric models is excessive expansion over cold water of shallow marine planetary boundary layer (PBL) topped by a thin cloud layer. This phenomenon is often accompanied by spurious light precipitation. The “Cloud Top Entrainment Instability” (CTEI) was proposed as an explanation of the mechanism controlling this process in reality thereby preventing spurious enlargement of the cloudy area and widely spread light precipitation observed in the models. A key element of this hypothesis is evaporative cooling at the PBL top. However, the CTEI hypothesis remains controversial. For example, a recent direct simulation experiment indicated that the evaporative cooling couldn’t explain the break-up of the cloudiness as hypothesized by the CTEI.

Here, it is shown that the cloud break-up can be achieved in numerical models by a further modification of the nonsingular implementation of the Mellor-Yamada Level 2.5 turbulence closure model (MYJ) developed at the National Centers for Environmental Prediction (NCEP) Washington. Namely, the impact of moist convective instability is included into the turbulent energy production/dissipation equation if (a) the stratification is stable, (b) the lifting condensation level (LCL) for a particle starting at a model level is below the next upper model level, and (c) there is enough turbulent kinetic energy so that, due to random vertical turbulent motions, a particle starting from a model level can reach its LCL. The criterion (c) should be sufficiently restrictive because otherwise the cloud cover can be completely removed. A real data example will be shown demonstrating the ability of the method to break the spurious cloud cover during the day, but also to allow its recovery over night.