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The representation of the Eastern Pacific Stratus Deck/Cold Tongue/ITCZ complex in the WRF model: sensitivity to planetary boundary layer and cumulus parametrizations

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The tropical eastern south Pacific, home to strong air-sea interactions, is an important region to understand global climate variability and change. However, the simulation of key regional phenomena, the Intertropical Convergence Zone (ITCZ) in a near-equator belt and the persistent boundary layer cloud deck over South Eastern (SE) Pacific, remains a challenging issue for climate modeling. Indeed, current general circulation models suffer the double ITCZ syndrome and strongly underestimate the fraction of boundary layer clouds.

The atmospheric models are believed to be an essential cause of these biases, although coupled ocean-atmosphere feedbacks may amplify them. The nature of the atmospheric processes controlling regional climate differs dramatically between (1) the ITCZ region characterized by warm Sea Surface Temperature (SST), low-level moisture convergence and associated atmospheric convection and (2) the tropical regions to the south (as well as to the north) associated with “cold” SST and large-scale free-tropospheric subsidence that favor developing of a well-mixed boundary layer capped by sharp temperature and moisture inversion and topped by stratocumulus clouds.

In this study, we use the regional atmospheric model WRF version 3.5.1 to investigate the sensitivity of the atmospheric component of the Eastern Pacific Stratus Deck/Cold Tongue/ITCZ complex to a combination of cumulus and Planetary Boundary Layer (PBL) parametrizations, based on 5 cumulus (new and old Kain-Fritsch, Bets-Miller-Janjic, Grell 3D, Tiedke) and 5 PBL (Yonsei University, Asymmetric Convective Model version 2, Mellor–Yamada–Janjic, Mellor–Yamada–Nakanishi–Niino and Washington University) schemes. Two one-month periods, March 2007 and October 2008, are chosen to represent two contrasted seasons. The objective is to provide insights into the regional interactions between convective rain in the ITCZ, the characteristics of the meridional overturning flow (shallow and deep) and the thermal structure of the marine atmospheric boundary layer from the SE Pacific to the ITCZ. Subsequent work will focus on the air-sea interactions using WRF coupled to the regional oceanic model ROMS.