EGU24-2062, updated on 15 Aug 2024
https://doi.org/10.5194/egusphere-egu24-2062
EGU General Assembly 2024
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Interactions of warm cloud, precipitation, and local forcings over the Great Barrier Reef: Insights from convection-permitting simulations

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The important role of warm clouds in regulating the regional energy balance and ocean temperature, that are directly linked to the thermal coral bleaching events, has been increasingly recognised over the Great Barrier Reef (GBR). These shallow clouds, however, are by their nature sensitive to perturbations in both their thermodynamic environment and microphysical background. In this study, we employ the Weather Research and Forecasting (WRF) model with a convection-permitting configuration at 1 km resolution to examine the interactions between the warm clouds and different local forcings over the GBR. A range of local forcings including local aerosol loading, coastal topography, and sea surface temperature (SST) is examined.

Our simulations show a strong response of cloud microphysical properties, including cloud droplet number concentration (CDNC), liquid water path (LWP), and precipitation to the changes in atmospheric aerosol population over the GBR. Higher CDNC and LWP correlated to increased aerosol number concentration leads to a rise in shortwave cloud radiative effect, though the magnitude is small, over both the mountains and upwind over the GBR. While cloud fraction shows little responses, a slight deepening of the simulated clouds is evident over the upwind region in correspondence to the increased aerosol number concentration. A downwind effect of aerosol loading on simulated cloud and precipitation properties is further noted. In consideration of the coastal topography, cloud fraction and accumulated precipitation are strongly sensitive to orographic forcing over the GBR. Orographic lifting and low-level convergence are found to be crucial in explaining the cloud and precipitation features over the coastal mountains downwind of the GBR. However, clouds over the upwind ocean are more strongly constrained by the trade wind inversion, whose properties are, in part, regulated by the coastal topography. Finally, on the scales considered in our study, the warm cloud fraction and the ensuant precipitation over the GBR show only a small response to the local SST forcing, with this response being tied to the simulated cloud type.