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Investigating Cloud Microphysical Properties: A Comprehensive Study Using High-Resolution Numerical Simulations and Observations in the Indian Ocean Region

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Located at 21°07'S, 55°32'E, Reunion Island, a mountainous island in the Indian Ocean, is an extraordinary site for studying the formation and life cycle of slope clouds. The island is influenced by southeast trade winds, reaching peak intensity in winter (June-August) and moderating during summer (December to February). These winds create pronounced conditions along the southwest and northeast edges, accompanied by a leeward circulation in the northwest, notably in the Maïdo area. Sea and valley breezes converge on the slopes of Maïdo, facilitating the advection of oceanic air masses and initiating convection on the mountainous terrain. Duflot et al. (2019) have substantiated that this convective process leads to the daily formation of clouds, typically exhibiting shallow vertical development and containing minimal water content.

An intensive measurement campaign, BIOMAÏDO (Bio-physicochemistry of Tropical Clouds at Maïdo), took place from March 11 to April 7, 2019, at Reunion Island, in order to study the chemical and biological composition of the air mass, the formation processes of secondary organic matter in heterogeneous environments, the dynamics and evolution of the boundary layer, and the macro- and micro-physical properties of clouds.

In this study, cloud microphysical properties are examined and analyzed using observations from the campaign, followed by a comparison with a high-resolution (100m horizontal resolution) numerical simulation with the Meso-NH model. Among the two microphysical schemes (ICE3 and LIMA; Liquid Ice Multiple Aerosol), the model is initialized with the two-moment microphysical scheme LIMA, which is parameterized using aerosol CCN properties initialization derived from ground aerosol measurements (3 modes) and vertical balloon profile aerosol concentrations.

Firstly, a sensitivity study on the microphysical scheme will be presented. It demonstrates that clouds form simultaneously in both schemes. However, clouds exhibit greater vertical development in the ICE3 scheme. Additionally, cloud dissipation occurs an hour earlier in the LIMA scheme.

Subsequently, an analysis through a microphysical variable balance will be conducted to identify the primary thermodynamic processes characterizing the formation and dissipation of slope clouds.