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Dynamic circulations and Windward Flow over Reunion Island

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Numerical Weather Prediction models still have difficulties to predict local-scale phenomena, such as thermal breezes circulation. They are local driven wind systems that form over coastal zones (sea/land breeze) or mountainous terrain (slope/valley breeze), produced by the buoyancy effects associated with the diurnal cycle of heating and cooling of the lower atmospheric layers (Zardi et Whiteman, 2013). These circulations can drive abrupt changes that generate localized wind gusts, extreme precipitation, air pollution episodes in the lower layers, or sea state perturbations.

The characteristics of the volcanic and tropical island of Reunion Island (Indian Ocean, 21°07'S, 55°32'E) offer an exceptional natural field of investigation for these process studies. The meteorological circulations on Reunion Island have been extensively studied by Lesouëf et al. (2010), Durand et al. (2014), Tulet et al. (2017), Foucart et al. (2018), and Réchou et al. (2019). These works show that the island is affected by a regime of southeast trade winds, which is intense in winter (June-August) and moderate to weak in summer (December to February). This weather regime is the cause of intense winds on the southwest and northeast edges of the island and a branch of northwesterly leeward circulation forcing in the northwest of the island (Maïdo area). In this region, thermal circulations are added to this regional circulation. This return loop occurs almost daily in this part of the island in the boundary layer. The oceanic air masses are advected on the slopes of the Maïdo area by the sea and valley breezes. This convection on the mountain slopes causes an almost daily formation of clouds, which are generally weakly developed vertically and generally with low water content.

An intensive measurement campaign BIOMAÏDO (Bio-physicochemistry of tropical clouds at Maïdo) took place from 11 March to April 7, 2019, at Réunion 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 the evolution of the boundary layer, and the macro and micro-physical properties of clouds.

In this study, we detail and analyze the dynamics circulations using the observations of the campaign and compare them to a high-resolution (100m horizontal resolution) numerical simulation with the Meso-NH model. Such a model turned during the selected days in which a dynamical connection between the sites was found (Rocco et al., 2022).

The preliminary results have shown that a vertical resolution smaller than a few meters (~1m) is needed to capture the katabatic flows and the structure of the valley boundary layer, these

circulations have an abrupt variation (~1 hour) and the anabatic flow takes nearly 1 h to arrive to the top of the mountain.

The temporal and spatial structure of this breezes regimes is analyzed with the use of the wet bulb potential temperature (Davies-Jones., 2007), and the turbulence kinetic energy budgets determined by the numerical model; this study aims to quantify which processes have the most important role during the diurnal breeze evolution.