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Study on the Vertical Ozone Distribution Characteristics in the Kaohsiung and Pingtung Area During the KPEx Experiment

Abstract

The sea breeze is a mesoscale weather system that significantly influences the vertical distribution of air pollutants, complicating source attribution. Pollutants aloft can be transported to the surface through vertical mixing or circulation, resulting in unpredictable surface concentrations. However, the lack of observations from multiple sites has limited our understanding of the full three-dimensional ozone transport and distribution. To address this, the Kao-Ping Experiment (KPEx) conducted in February to March 2024 employed extensive observations including lidar, radiosondes, UAVs, and aircraft to investigate ozone vertical distribution in the Kao-Ping area. This study focuses on surface measurements and two UAV-based ozone and meteorological observations, conducted at a coastal industrial site (Linyuan) and an inland site (Wanluan), to characterize surface pollution features and the vertical ozone structure within the planetary boundary layer.

Surface measurements indicate higher concentrations of ozone precursors and ozone in Linyuan, likely due to industrial emissions, ozone formation sensitivity analysis further suggests that ozone formation in Linyuan is VOC-limited, consistent with characteristics typically observed near emission sources. Moreover, Linyuan shows stronger correlations between ozone and radiation (e.g., $R^2 = 0.56$ during IOP2), suggesting more active photochemical ozone production in the coastal area. Wind pattern analysis reveals that in Linyuan, up to 70% of the positive ozone deviations occur under westerly and southeasterly flows, indicating increases associated with sea breeze circulation. In contrast, about 70% of the negative deviations are linked to northerly and southerly winds, likely reflecting background flow conditions. Regarding vertical structure, classification analysis identifies four distinct ozone scenarios. Among them, the multi-layer type is shaped by sea breeze circulation and stable atmospheric stratification, which trap pollutants and recirculate relatively clean air from inland to the coast, leading to ozone accumulation in the mid-level atmosphere. This study shows that Linyuan experiences strong local ozone formation and significant surface transport and vertical accumulation under sea breeze and return flow conditions, highlighting its importance for ozone pollution management.

Keyword

Tropospheric ozone
Ozone formation sensitivity