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Atmospheric nanoparticle observations in the low free troposphere during upward orographic flows at Izaña Mountain Observatory

S. Rodríguez[1,2], Y. González[1], E. Cuevas[1], R. Ramos[1], P. M. Romero[1], J. Abreu-Afonso[1,2,3], and A. Redondas[1]

[1]Izaña Atmospheric Research Centre, AEMET, Associated Unit to CSIC "Studies on Atmospheric Pollution", La Marina 20, Planta 6, E38071, Santa Cruz de Tenerife, Canary Islands, Spain

[2]University of Huelva, Associated Unit to CSIC "Air Pollution", Campus El Carmen, E21071, Huelva, Spain

[3]Institute for Environmental Assessment and Water Research IDAEA, CSIC, Jordi Girona 18, E08034, Barcelona, Spain

Abstract. This study investigates the processes and conditions favouring the formation of nanoparticles (diameter<10 nm) which are frequently observed on high mountains reaching the low free troposphere. This was done through an analysis of a data set collected at Izaña Global Atmospheric Watch Observatory (Canary Islands; 2367 m above sea level). This high mountain supersite is located well above the stratocumulus layer characteristic of the subtropical oceanic tropospheres. At night, when the catabic flow regime is well established, free troposphere aerosols were measured. The development of orographic buoyant upward flows during daylight resulted in an increase of water vapour, SO_2 and NO_y concentrations. These ascending airflows perturbed the free troposphere and resulted in high concentrations of 3–10 nm particles (N_{3-10}) due to new particle formation. An analysis of the 5-min average time series allowed the identification of two main types of N_{3-10} event. In Type I events a linear relationship between N_{3-10} and SO_2 was observed (r^2 coefficients 0.70–0.95 and a mean slope of 11 cm^{-3} ppt^{-1} for 5-min averaged data; SO_2 concentrations from tens to hundreds of ppt). These particles seem to be formed during upward transport (probably within or after the outflows of clouds typically located below Izaña). During Type II events, no correlation between SO_2 and N_{3-10} was observed and 3–10 nm particles were formed in-situ at noon and during the afternoon due to the condensation of vapours linked to photochemistry. New particle formation was observed almost every day owing to the favourable conditions associated with the entry of boundary layer air in the low free troposphere, even if SO_2 concentrations are rather low at Izaña (tens to hundreds of ppt). The low surface area of pre-existing particles, low temperature and high radiation intensity clearly favoured the formation of nanoparticles. The low surface area of pre-existing particles in the upward flows is furthered by in-cloud particles scavenging in the stratocumulus layer typically located below Izaña. The higher temperature and the presence of coarse Saharan dust particles decrease the efficiency of the new particle formation mechanisms in summer. Thus, the "N_{3-10} versus SO_2" slope (for r^2>0.7 cases) was higher in autumn and winter (~15 cm^{-3}

ppt^{-1} as average) than in summer (2–8 cm^{-3} ppt^{-1}). These field observations suggest that elevated mounts that reaches the free troposphere may act as source regions for new particles.

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