Evidence of in situ cirrus formation in the tropical tropopause layer over the southwestern Indian Ocean

A 1-km deep cirrus is observed in the tropical tropopause layer (TTL) over the southwestern Indian Ocean using data from a balloon launched on Reunion Island on 11th January 2019 during the CONCIRTO field campaign. The balloon is equipped with COBALD (Compact Optical Backscatter and Aerosol Detector) and CFH (Cryogenic Frost point Hygrometer) sondes. COBALD retrievals show an increase in the backscatter measured between the ascent and the descent at 16.5 km altitude. This is most likely due to ice crystals growth. Concomitant with the backscatter signal, RHi computed from the CFH measurements of water vapor mixing ratio reaches up to 150%, which indicates that the environment can support the initial crystals growth.

According to the Lagrangian dispersion model FLEXPART (FLEXible PARTicle), the air mass sampled by the sondes had remained over the southwestern Indian Ocean for the past few days, suggesting that the cirrus formed in situ. Furthermore, the observed rise rate increase of 2 - 3 m/s just below the cold point is consistent with a strong wave event, which would be very supportive for the high RHi allowing ice particles to form.

A convection-permitting simulation with the mesoscale model Méso-NH has been performed with fine horizontal (2.5 km) and vertical (100 m in the TTL) resolutions, with the aim to determine the processes leading to the cirrus formation. The aerosol-microphysics interaction is allowed in the simulation, with several aerosol species that can serve as cloud condensation nuclei or ice forming nuclei, in order to represent both homogeneous and heterogeneous nucleation processes. In the simulation, eastward moving cold temperature anomalies related with convection over Madagascar and moisture advection from the south of Reunion Island are at the origin of ice formation.

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