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Quelccaya firn core shows dust concentration related to climatic variability

Content

The Quelccaya Ice Cap (QIC) is positioned at the northern edge of the Altiplano in the Cordillera Vilcanota (southern Peru) and is the world's largest tropical ice cap. The region belongs to the outer tropics, characterized by a tropical climate during the austral summer (high precipitation, wet season) and subtropical conditions during the austral winter (little to no precipitation, dry season). The major level of precipitation during austral summer is associated with the South American Summer Monsoon. Past studies recognized that moisture sources from the east are modulated by El Niño Southern Oscillation (ENSO). A recent firn/ice core with 22.7m was recovered at QIC (13°56'S, 70°50'W, 5.670 m.a.s.l.) during an expedition in 2018 to the local. The melting and percolation through the firn attenuate the seasonal variation of stable isotope and ions signals, particularly at the end of the twentieth-century record, becoming the dust seasonality as one of the latest reliable information preserved for this period.

A set of 183 samples selected for dust analysis was measured using the Coulter Counter technique in a class 100 clean room at Eurocold Laboratory (University Milano-Bicocca). The instrument (Coulter Counter Multisizer IV, 400-channels) was calibrated and set to detect particles with a diameter between 2 μm to 60 μm. We defined three groups with distinct ranges: fine particle (FPP, 2–10 μm), coarse particle (CPP, 10–20 μm), and giant particle (GPP, 20–60 μm).

We assessed 14 years of dust profile, and concentration measured in the samples ranged from 617–23,176 ppb/mL. The mean seasonal value of dust concentrations during dry and wet seasons was 6807 (± 1786) ppb/mL and 2181 (± 456) ppb/mL, respectively. Up to 2012, the annual mean dust of the FPP group was 952 (± 171) ppb/mL, while CPP and GPP had average concentrations of 1,231 ± 301 and 1,436 ± 266 ppb/mL, respectively. From 2013, FPP became the dominant group with a concentration increase of 54.7%, while CPP and GPP showed decreases of 5.62 and 21.8%, respectively. From 2015 to 2016, during a strong El Niño, there was a 55% dust increase above average during the wet season. A dust concentration increase coincided with the recent inversion from the Pacific Decadal Oscillation (PDO) cold phase (2005–2013) to the PDO warm phase (2014–2017). A significant increase in FPP is noted during the PDO warm phase. The direct relationship is supported by a positive correlation ($r = 0.70$, $p < 0.005$) during 2003–2017 period. The westerly flow is enhanced during the PDO/ENSO warm phase (dry condition), facilitating the regional transport of material from Altiplano to the QIC since higher dust availability occurs during the drier period. We investigated the relationship during 2003–2016 between FPP dust concentration during the wet seasons period and the suspended sediments concentrations. The dust at QIC and Madeira river suspended sediments load is well related during the high-water discharge months.

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Track Classification: High-alpine ice cores