Determination of an age model based on the analysis of the δ ^{18}O cyclicity in a tropical glacier

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Abstract
Introduction
Section snippets
References (56)
Recommended articles (6)

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Abstract

Oxygen isotopes δ^{18}O from a 13 m ice core derived from the Antisana volcano ice cap (0° 28′S, 78° 08′W), Ecuador, were analyzed to generate an age model based on isotopic fluctuations. The inferred age model spans c. 3.6 years, from 1993 to mid-1996, and corresponds to 3.6 cycles of isotopic fluctuations driven by seasonal changes in precipitation in western Amazonia. A logarithmic transformation (LT) was performed on the ice core density data to remove the compression effect of accumulated snow affecting the temporal fluctuation of the isotopic signal. A wavelet analysis run on the decompressed isotope signal (LT) showed periodicities of 80, 40, and 20 corresponding to 12, 6, and 3 months, respectively. The results were compared against the isotopic record from the Chimborazo ice core data to validate its temporal match with a hydrological year. The LT isotopic signal showed a significant correlation with the Chimborazo isotopic data ($r = 0.69$ and p-value<0.001). The methodology applied in this study allowed the reconstruction of 3.6 cycles (3.6 years), showing that age models can be derived from ice cores using oxygen isotope annual fluctuations in tropical glaciers.

Introduction

Ice cores are exceptional archives that record climatic information in the accumulated ice (Bradley, 1999; Delmas, 1994; Thompson et al., 1998, 2003, 2011; Vuille et al., 2003a). Ice cores are particularly good at recording precipitation changes based on the fluctuations of oxygen isotope ratio $^{18}O/^{16}O$ (Ginot et al., 2002; Thompson et al., 1979, 1998). However, paleoclimate records such as ice cores require the development of an age model to make inferences about the temporality of observed events. The annual fluctuation on the $^{18}O/^{16}O$ ratio is a potential candidate to develop age models, particularly in shallow cores where compression remains a simple process.

In the Tropics, ice cores are extracted within the accumulation zone in glaciers, where ice melting and sublimation rates are extremely low (Basantes-Serrano et al.,