Supplement of

Age of the Tibetan ice cores

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Two-parameter flow model (2p model)

The 2p model is based on a simple analytical expression for the decrease of the annual

layer thickness $L_{(z)}$ (m w.e.) with depth:

$$L_{(z)} = b \left(1 - \frac{z}{H}\right)^{p+1}$$

where z is depth (m w.e.), H the glacier thickness (m w.e.), b the annual accumulation

(m w.e.) and p a thinning parameter (dimensionless). The age $T_{(z)}$ as a function of

depth can be calculated when the inverse layer thickness is integrated over depth:

$$T_{(z)} = \int \frac{dz}{L_{(z)}} = \frac{1}{b} \int \left(1 - \frac{z}{H}\right)^{-p-1}$$

Solving the integral and setting the age at the surface to be T (0) = 0, the final

age-depth relation is obtained:

$$T_{(z)} = \frac{H}{bp} \left[\left(1 - \frac{z}{H}\right)^{-p} - 1\right]$$

The thinning rate (vertical strain rate) is the first derivative of the layer thickness:

$$L'_{(z)} = \frac{dL_{(z)}}{dz} = -\frac{b(p+1)}{H}\left(1-\frac{z}{H}\right)^p$$

The model has two degrees of freedom, the net annual accumulation rate b and the

thinning parameter p, both of which are assumed to be constant over time. This allows

us to fit the model by a least squares approach through the available reference

horizons if the glacier thickness H is known (if drilled to the bedrock) or can be

reasonably well estimated (e.g. from radar sounding). In order not to overweigh the

data from the deepest horizons, the model is fitted using the logarithms of the age

values (Uglietti et al., 2016).

The Kesang stalagmite core

The Kesang Cave is located in the Tekesi County, the western China (42°52′ N, 81°45′

E, ~2000 m a.s.l., Fig. 1). Eight samples from Kesang Cave were used to establish the

Kesang $\delta^{18}O$ record with three covering the Holocene and five covering the rest of the

Pleistocene portion. The Kesang stalagmite $\delta^{18}O$ records characterize a dynamic

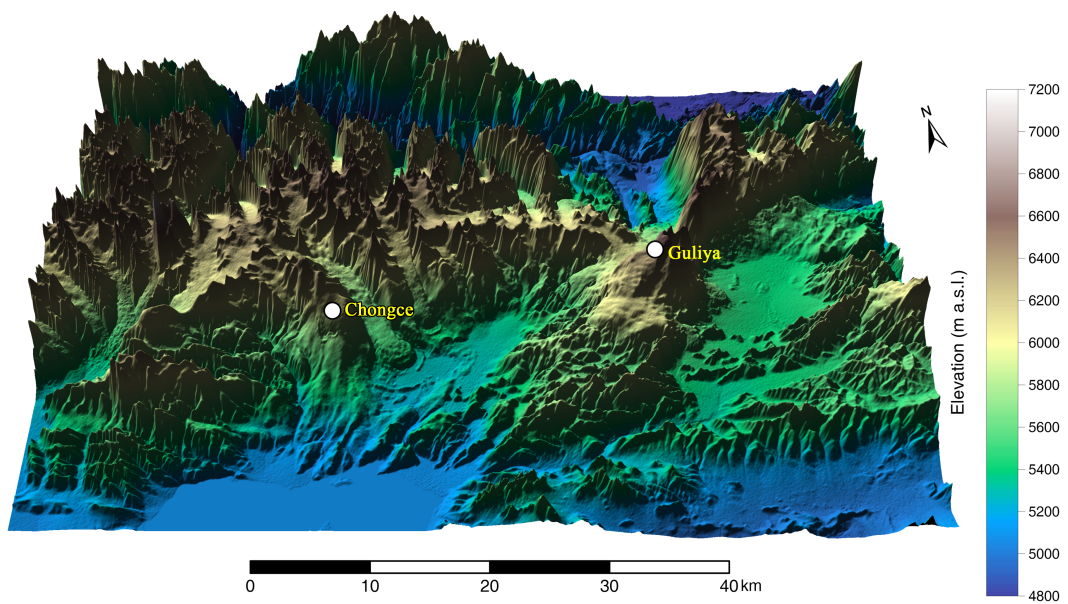precipitation history over most of the past 500,000 years (Cheng et al., 2012).

Figure S1: Three-dimensional topography for the locations of the Chongce and the

Guliya ice caps. It was constructed from the Shuttle Radar Topography Mission

(SRTM) digital elevation data, available from the Consultative Group for

International Agricultural Research-Consortium for Spatial Information (CGIAR-CSI)

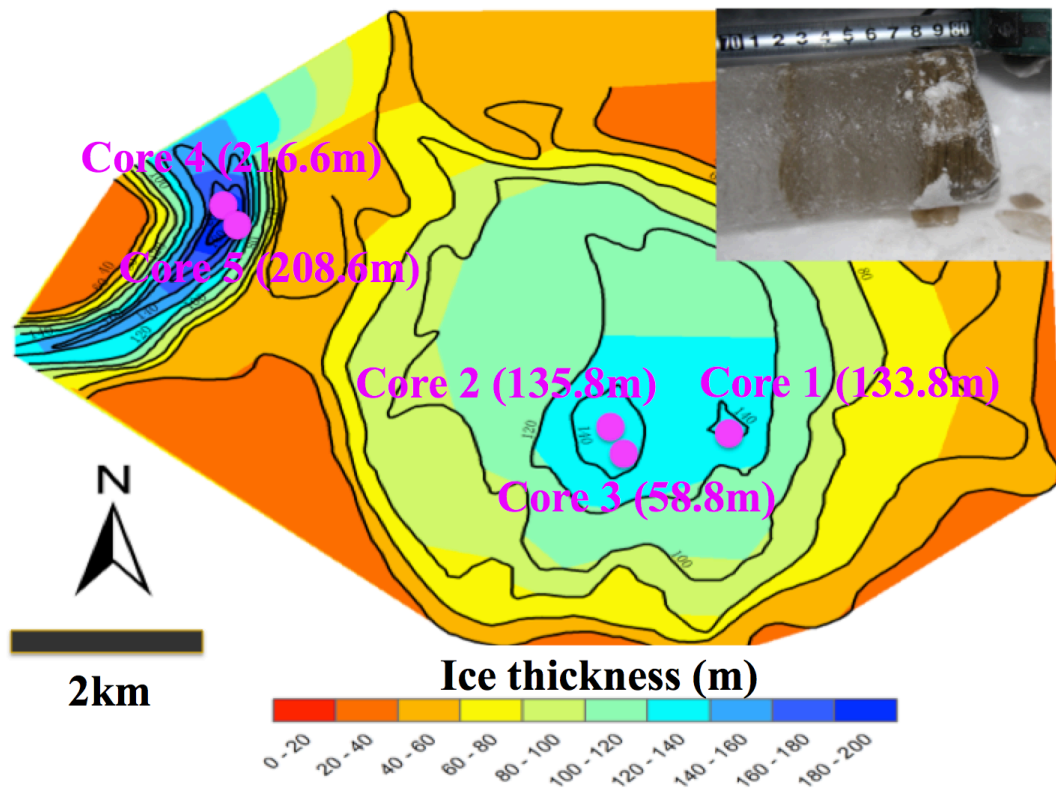at http://srtm.csi.cgiar.org/.

Figure S2: Map showing the ice thickness of the Chongce ice cap with drilling sites.

Core 1 (133.8 m) and Core 2 (135.8 m) to bedrock and Core 3 (58.8 m) were drilled

in 2012. Core 4 (216.6 m) and Core 5 (208.6 m) to bedrock were drilled in 2013. Inset

picture shows the bottom section of Core 2. The ice thickness was measured by

ground penetrating radar with relatively high accuracy. For instance, the thickness

measured at the drilling site of the 216.6 m core is ~214 m.