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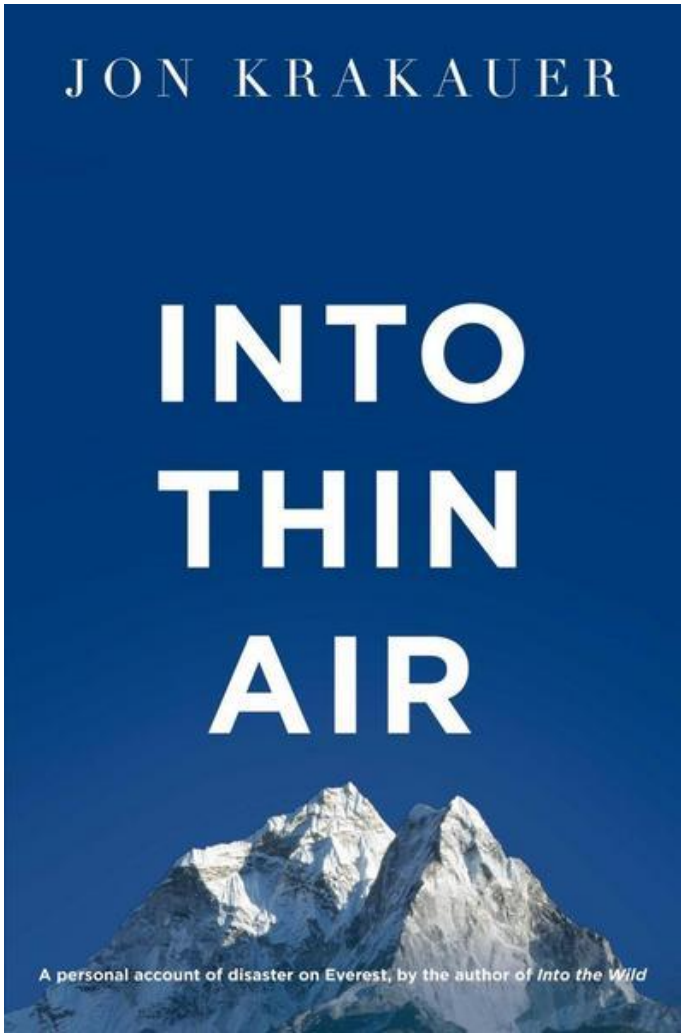
PSI

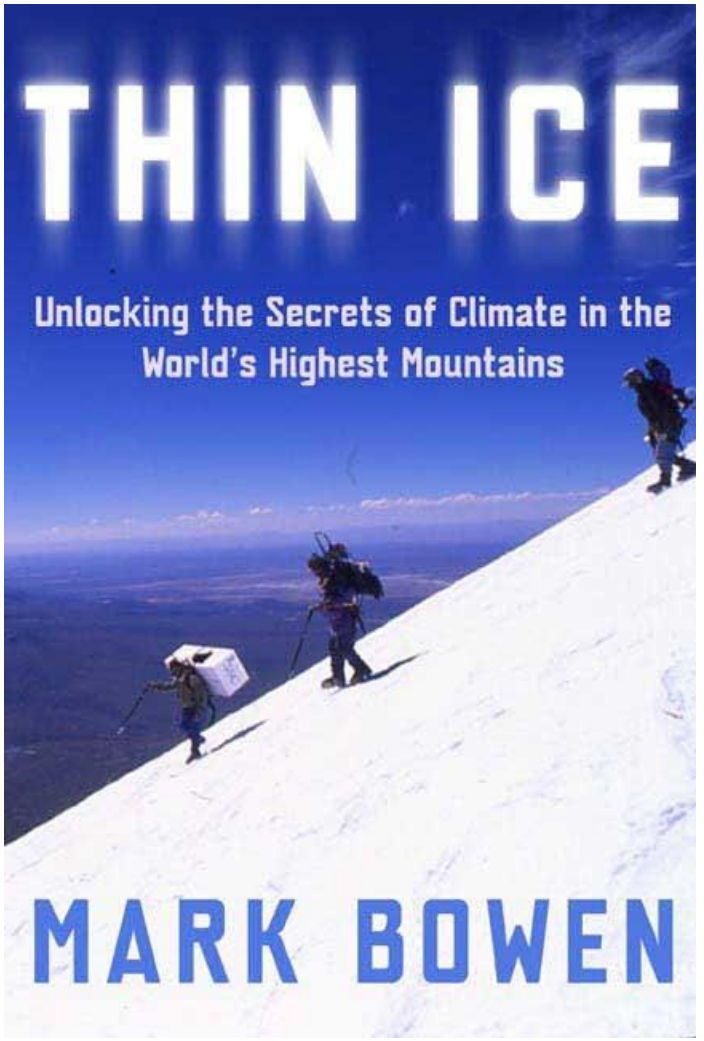
Photo Alexey Nagaev

Margit Schwikowski :: Laboratory of Environmental Chemistry:: Paul Scherrer Institut

Into thin ice: Unlocking the secrets of past environmental changes from glacier ice cores

Swiss Global Change Day, 7 February 2019


JON KRAKAUER
INTO THIN AIR
A personal account of disaster on Everest, by the author of *Into the Wild*


THIN ICE
Unlocking the Secrets of Climate in the World's Highest Mountains
MARK BOWEN

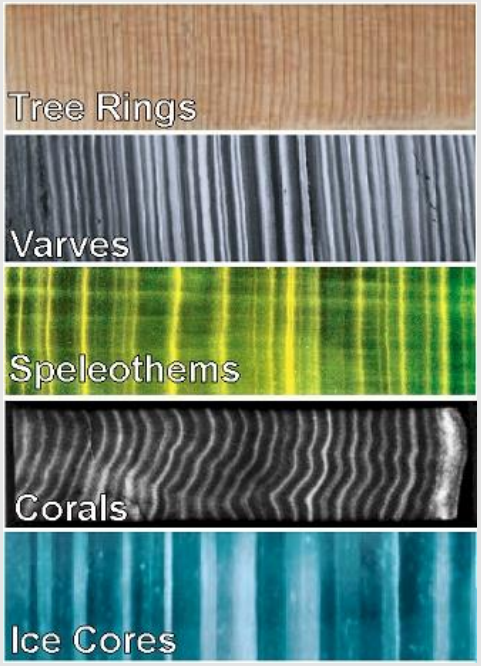
PAUL SCHERRER INSTITUT

Content

Why do we need ice cores?

Short record of instrumental data (150 years)

Proxy data from natural archives are needed

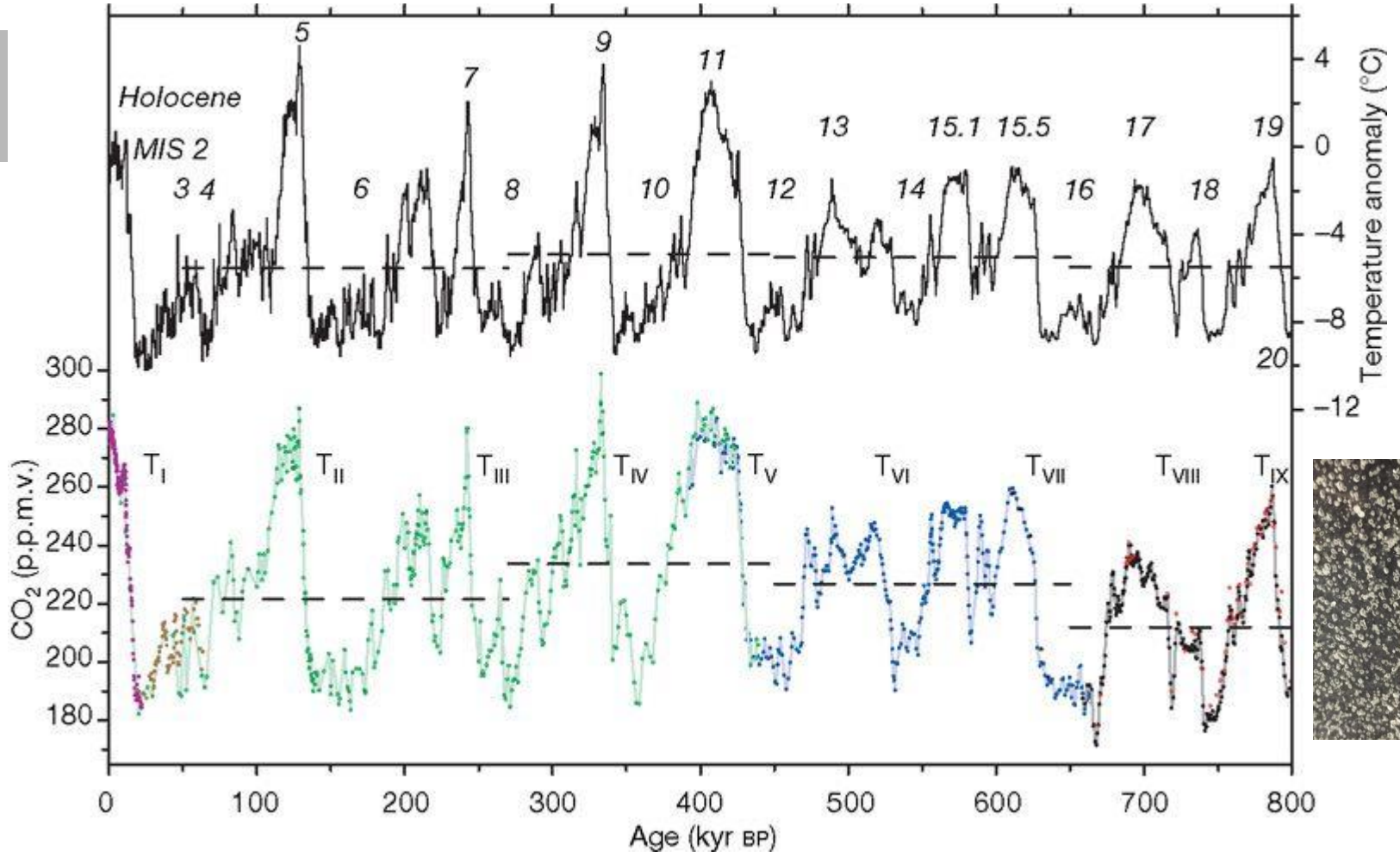


Pages Newsletter, 2003

Ice cores allow to reconstruct

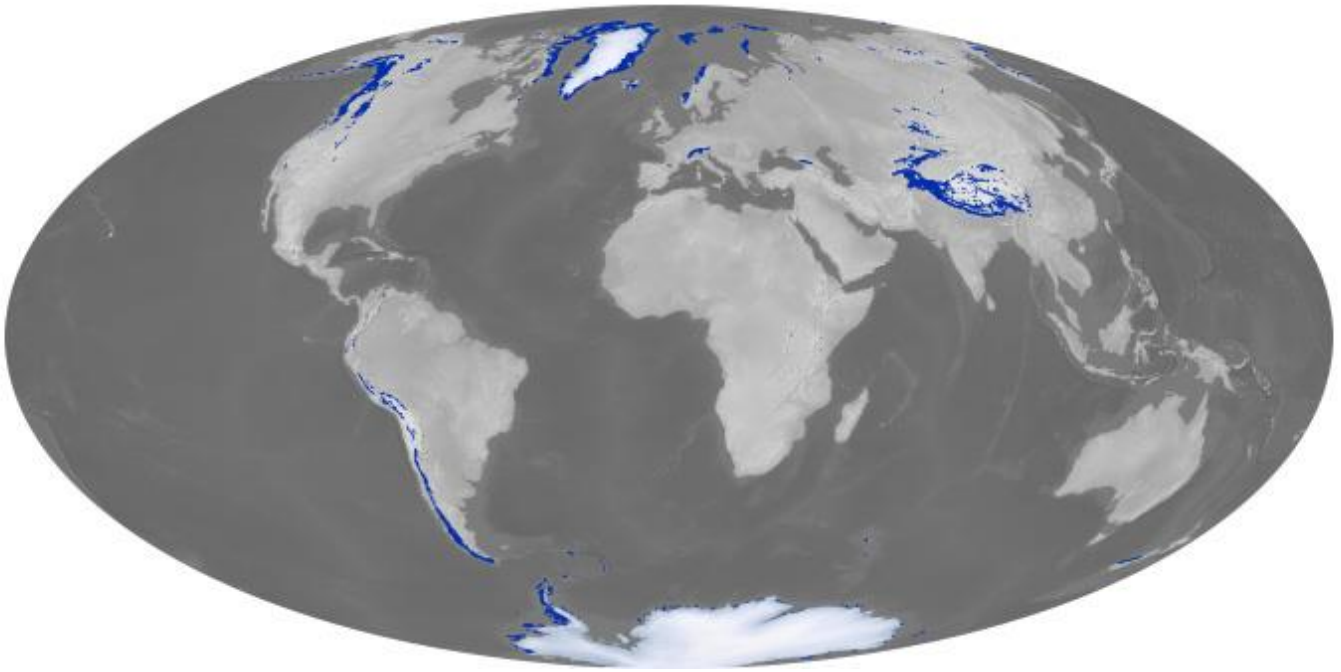
- Greenhouse gases
- Air pollution
- Temperature
- Precipitation
- Volcanic activity
- Atmospheric circulation
- Solar variability
- and more…

800‘000 years of temperature and CO_2



D. Lüthi, M. Le Floch, B. Bereiter, T. Blunier, J.-M. Barnola, U. Siegenthaler, D. Raynaud, J. Jouzel, H. Fischer, K. Kawamura, T.F. Stocker, Nature 2008

Ice archives on earth



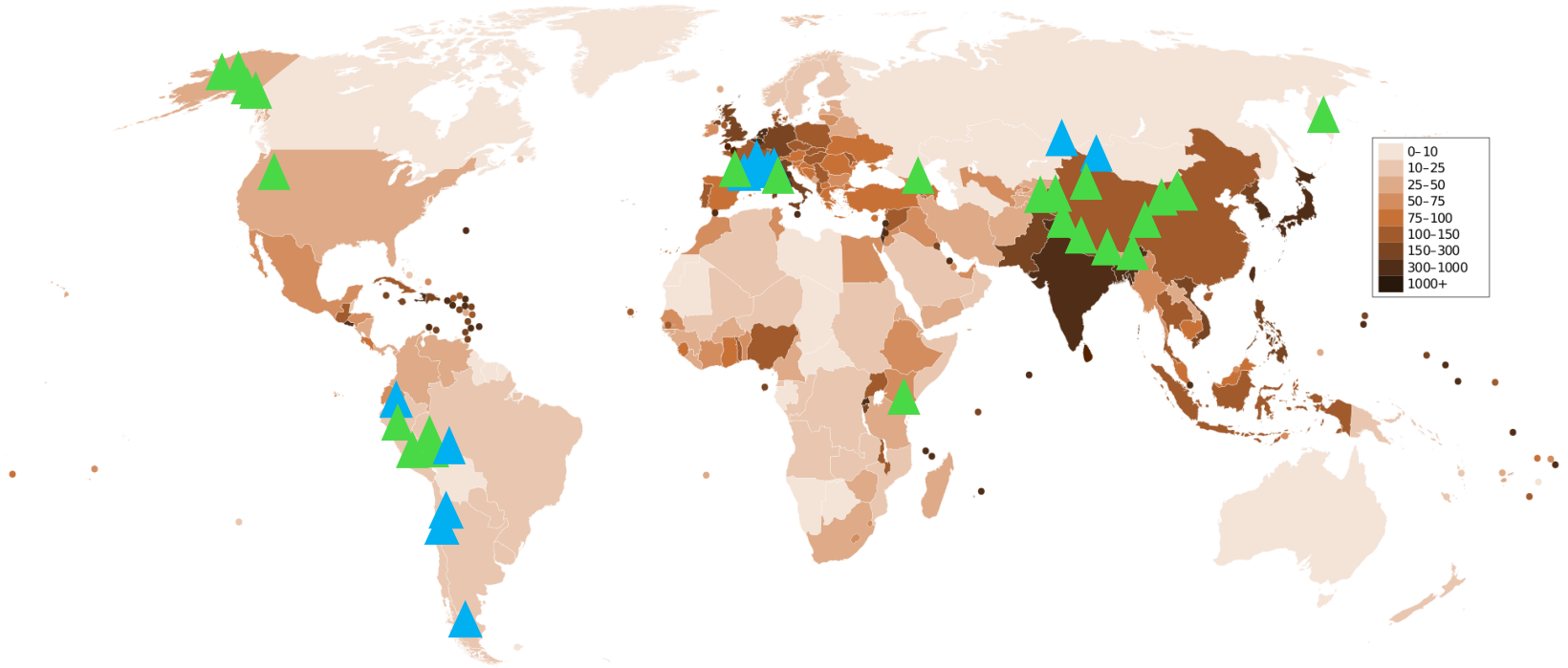
Polar ice shields ⟷ **High-alpine glaciers**

Global/Hemispheric signal

Closer to populated regions
Closer to emission sources
Local/regional signal

https://earthobservatory.nasa.gov/images/83918/the-randolph-glacier-inventory/

Population density
High alpine ice core locations



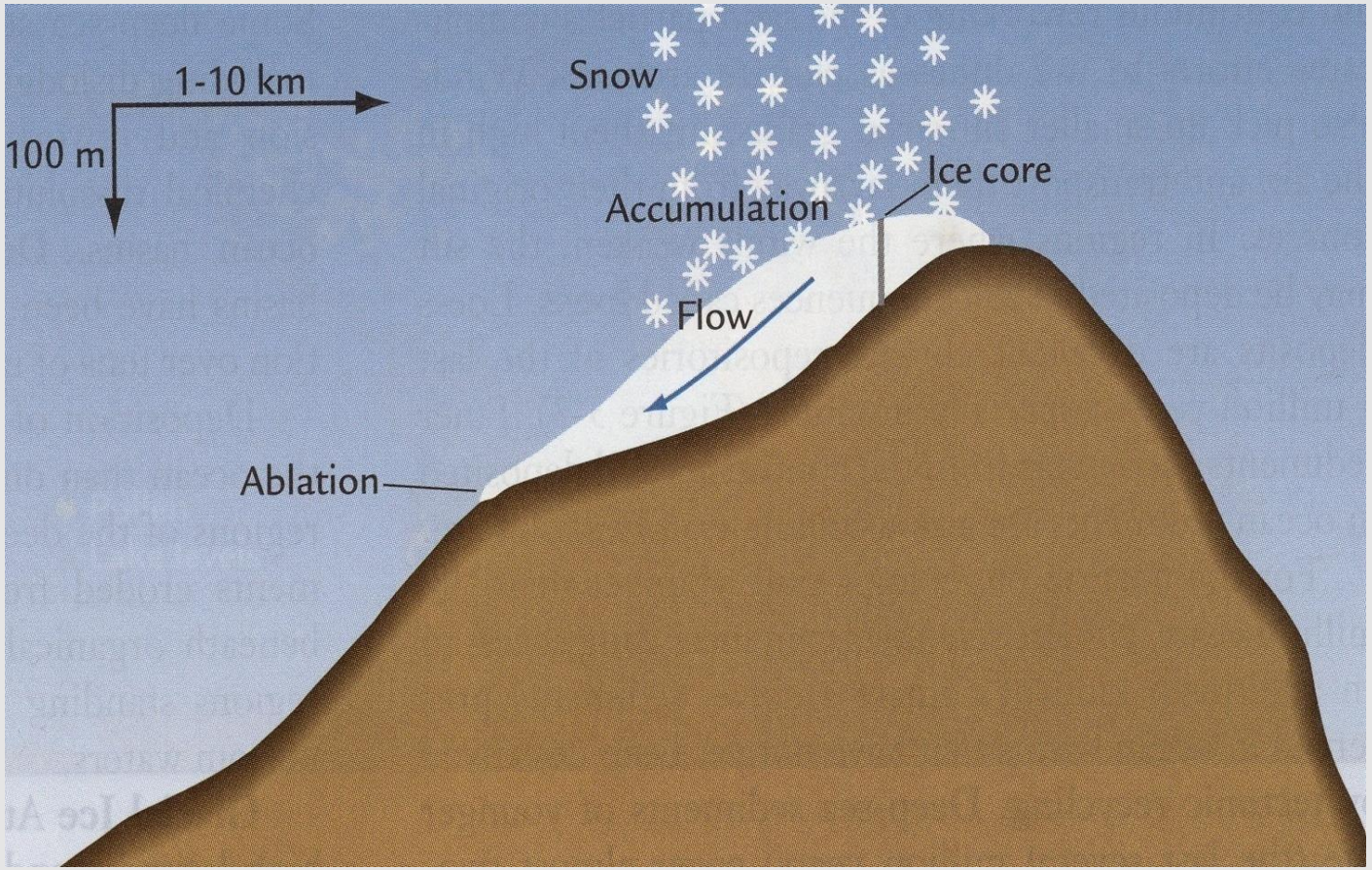
▲ Our projects

https://en.wikipedia.org/wiki/Population_density

Alpine versus Polar

	Alpine glaciers	Polar ice sheets
Thickness	50 to 300 m	> 3,000 m
Time scales	100-10,000 years *500,000 years (Guliya)	130,000-800,000 years
Ice temperature	-18°C to 0°C	-56°C to -15°C
Elevation	3,900 to 7,200 m	2,480 to 3,233 m
Drilling	Dry hole, weeks Alpine style Small teams	Drilling fluid, several seasons Expedition style Large international operations

Alpine glaciers as natural archives



W.F. Ruddiman, Earth's Climate

Ice core drilling on high-alpine glaciers

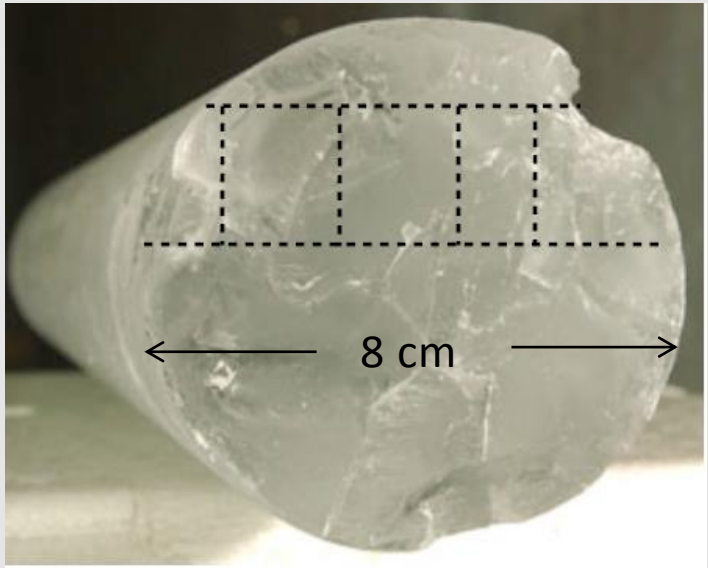
Modular designed drill (electromechanical/ thermal) allowing transport by porters or pack animals

Work under extreme high-altitude conditions (above 5500 m): Easy to use and fast system for harsh conditions

Mercedario, Central Andes, 6100 m

Tsambagarav, Mongolia, 4100 m

From the ice core to the sample



Most cited study on alpine ice cores

RESEARCH ARTICLES

Late Glacial Stage and Holocene Tropical Ice Core Records from Huascarán, Peru

L. G. Thompson[1], E. Mosley-Thompson[2], M. E. Davis[3], P. -N. Lin[3], K. A. Henderson[1], J. Cole-Dai[3], J. F. Bolzan[1], K. -b. Liu[4]
+ See all authors and affiliations

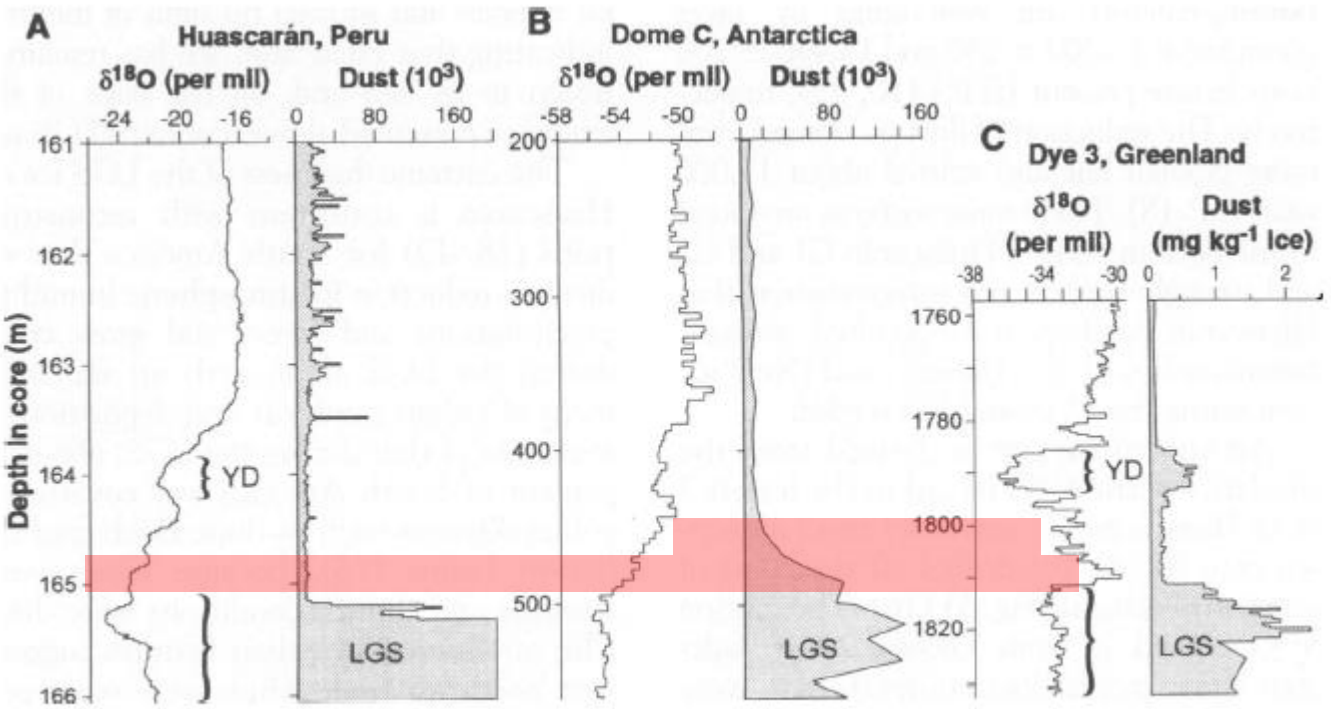
Science 07 Jul 1995:
Vol. 269, Issue 5220, pp. 46-50
DOI: 10.1126/science.269.5220.46

Article | Info & Metrics | eLetters | PDF

Abstract

Two ice cores from the col of Huascarán in the north-central Andes of Peru contain a paleoclimatic history extending well into the Wisconsinan (Würm) Glacial Stage and include evidence of the Younger Dryas cool phase. Glacial stage conditions at high elevations in the tropics appear to have been as much as 8° to 12°C cooler than today, the atmosphere contained about 200 times as much dust, and the Amazon Basin forest cover may have been much less extensive. Differences in both the oxygen isotope ratio $\zeta^{18}O$ (8 per mil) and the deuterium excess (4.5 per mil) from the Late Glacial Stage to the Holocene are comparable with polar ice core records. These data imply that the tropical Atlantic was possibly 5° to 6°C cooler during the Late Glacial Stage, that the climate was warmest from 8400 to 5200 years before present, and that it cooled gradually, culminating with the Little Ice Age (200 to 500 years before present). A strong warming has dominated the last two centuries.

Most cited study on alpine ice cores



SCIENCE • VOL. 269 • 7 JULY 1995

European air pollution

Sulphate

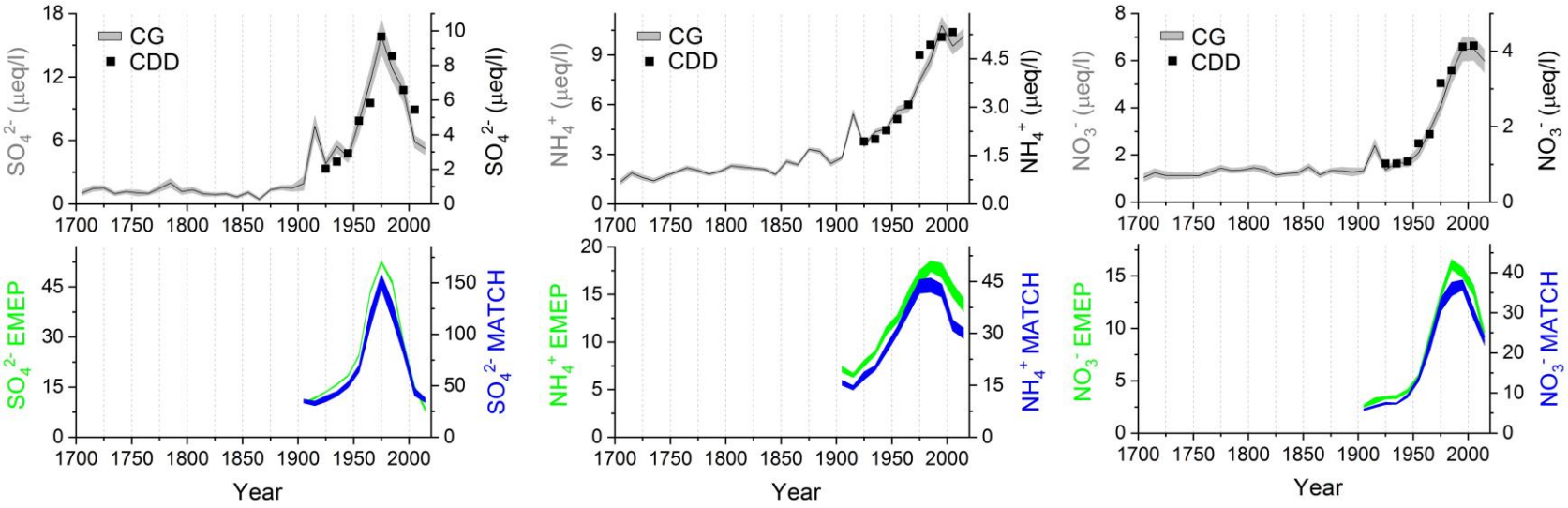
Fossil fuels

Ammonium

Agriculture

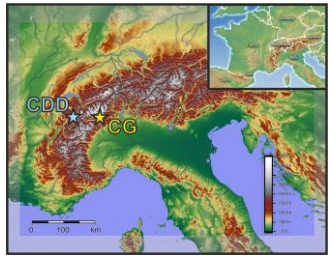
Nitrate

Energy production
Traffic



Two glaciers and two ice cores (Colle Gnifetti, Col du Dôme)

Two different laboratories

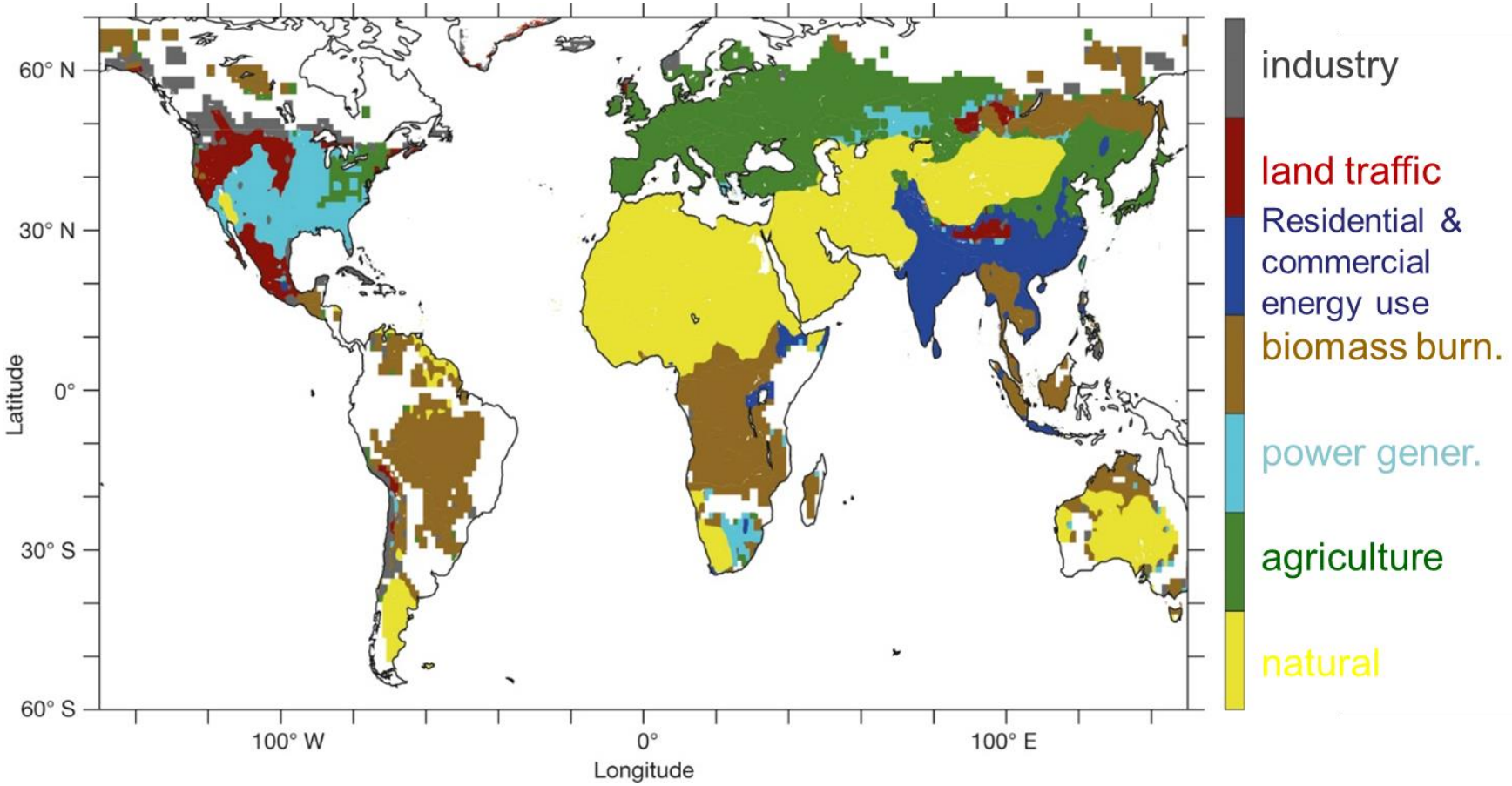


M. Engardt, D. Simpson, M. Schwikowski, L. Granat, Tellus 2017

S. Preunkert, M. Legrand, D. Wagenbach, J. Geophys. Res., 2001

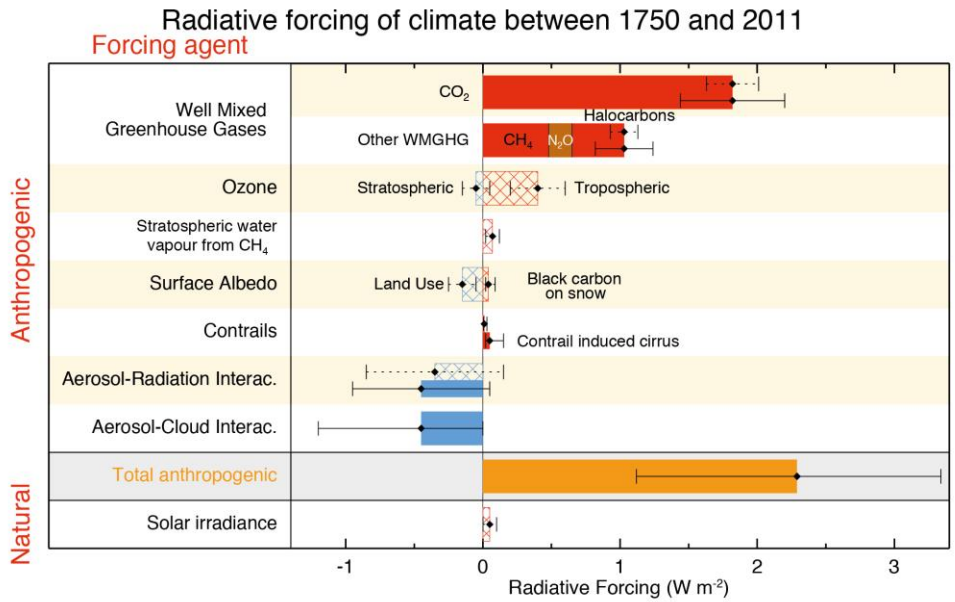
S. Preunkert, D. Wagenbach, M. Legrand, J. Geophys. Res., 2003

Main sources for increased mortality linked to outdoor pollution

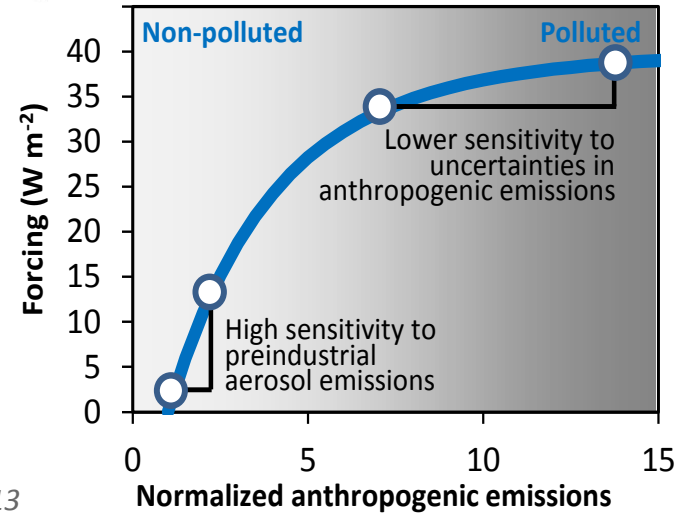


J Lelieveld *et al. Nature* **525**, 367-371 (2015) doi:10.1038/nature15371

Impact of aerosols on climate

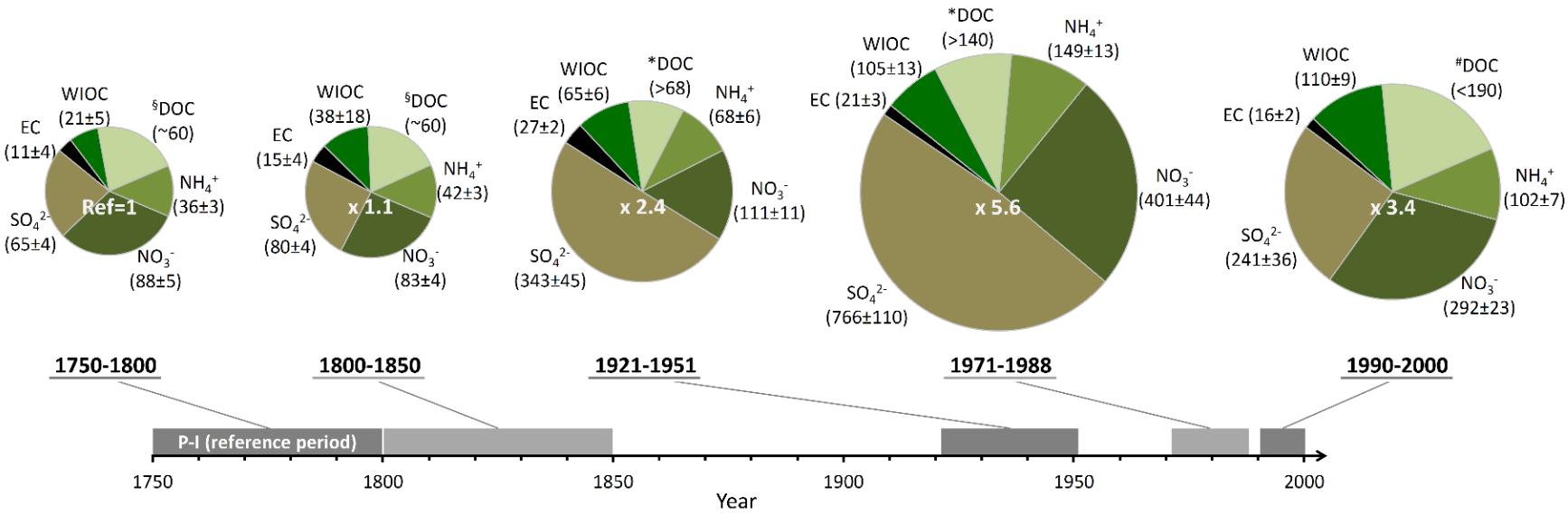


Intergovernmental Panel on Climate Change (IPCC) 2013



Carslaw et al., 2013

Preindustrial-industrial changes of aerosol concentration and composition



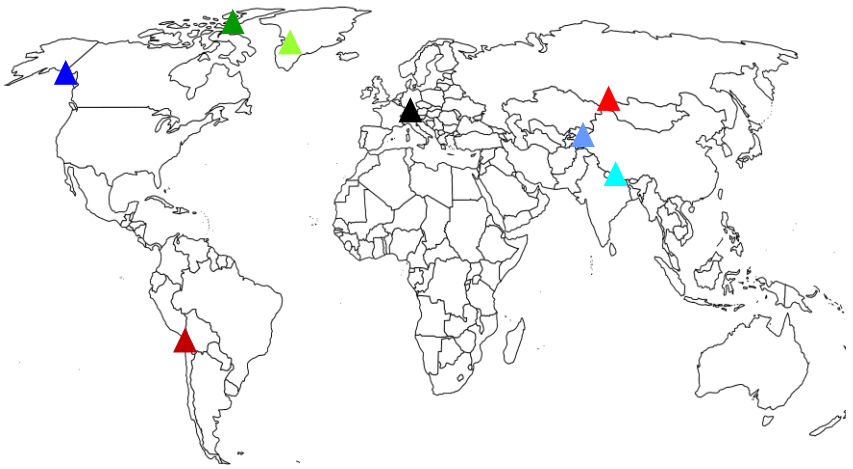
Carbonaceous particles: organic (water-soluble and insoluble) and elemental carbon

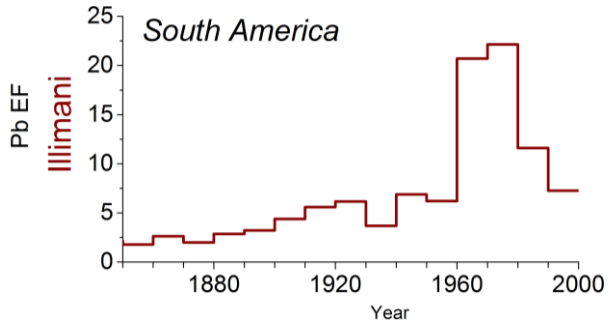
Inorganic secondary aerosol: sulphate, nitrate, ammonium

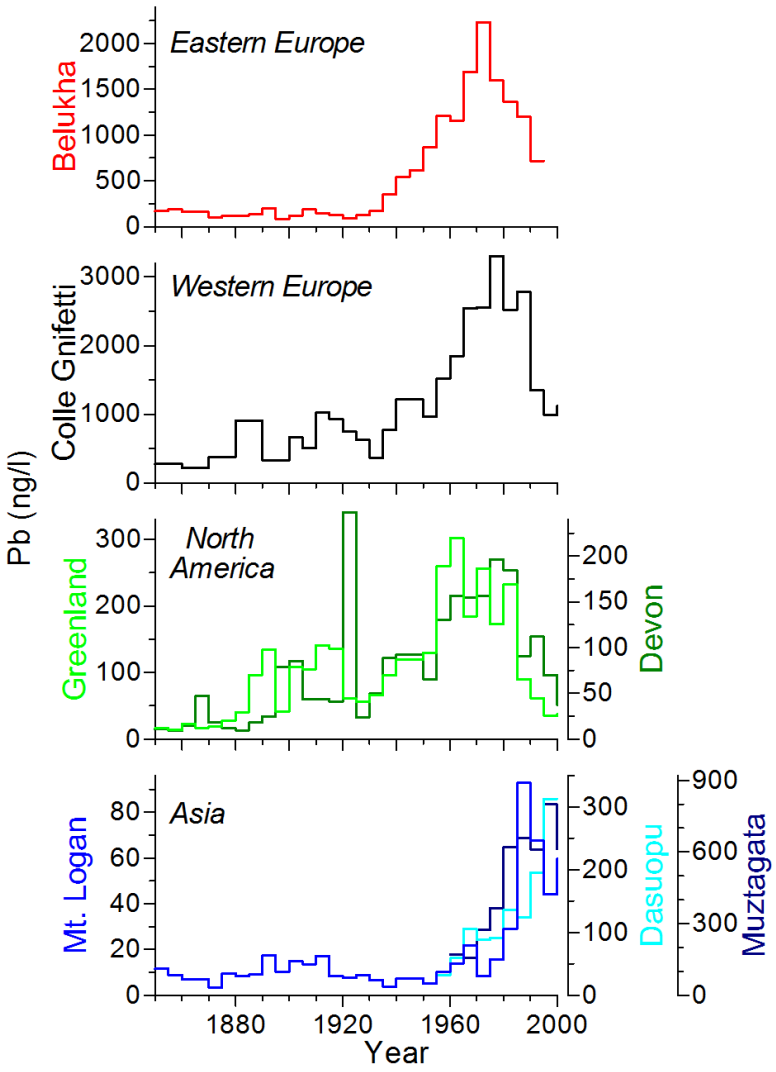
Not included: mineral dust

F. Cao, Y.-L. Zhang, L. Wacker, S. Szidat, G. Salazar, M. Schwikowski, T. M. Jenk, in preparation

Regional differences in the trends of the lead (Pb) Sources: mining, coal combustion, leaded gasoline

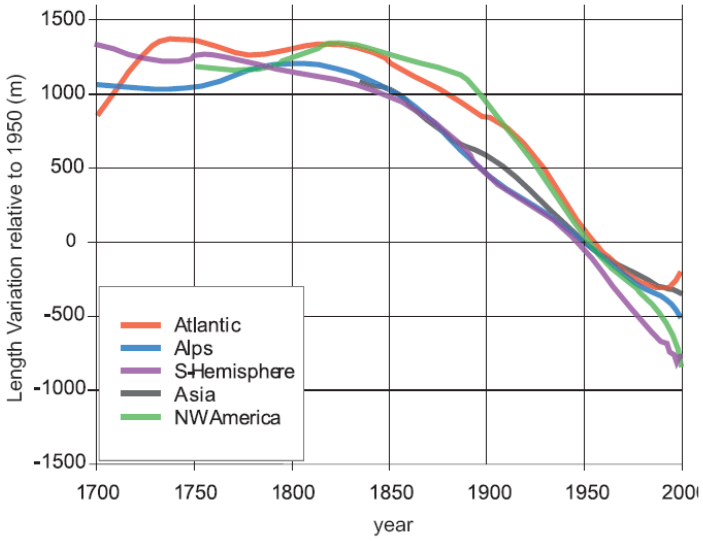


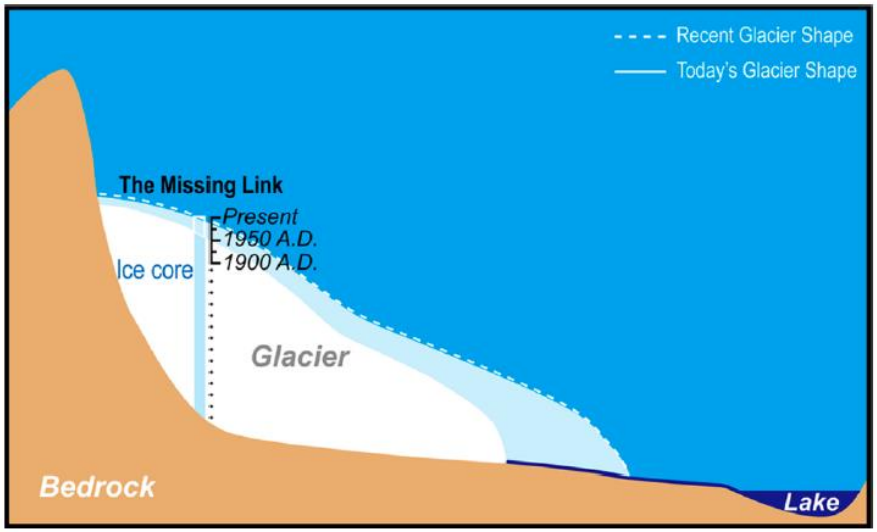




A. Eichler, L. Tobler, S. Eyrikh, G. Gramlich, N. Malygina, T. Papina, M. Schwikowski, Environ. Sci. Technol., 2012

Mountain glaciers are retreating worldwide



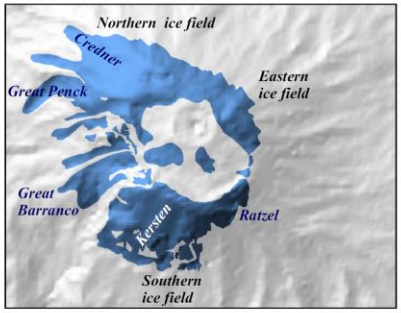


Oerlemans, 2005

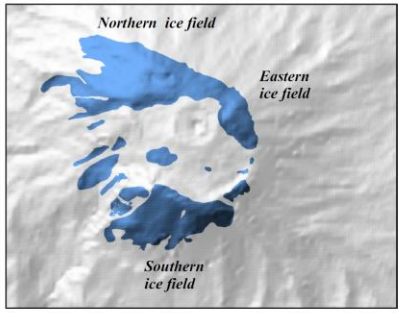
This is a major challenge the scientific community is facing, since glacial-archived information forming one of the best libraries of past climatic and environmental changes is under threat of being lost forever.

Q. Zhang, S. Kang, P. Gabrielli, M. Loewen, M. Schwikowski, Environ. Sci. Technol., 2015

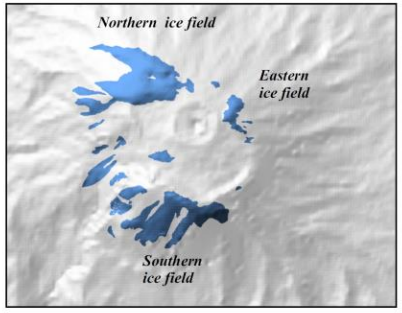
Iconic example: Kilimanjaro plateau glaciers



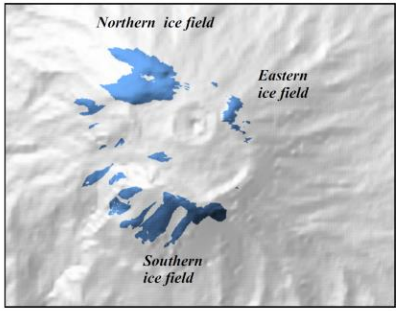
(a) 1912



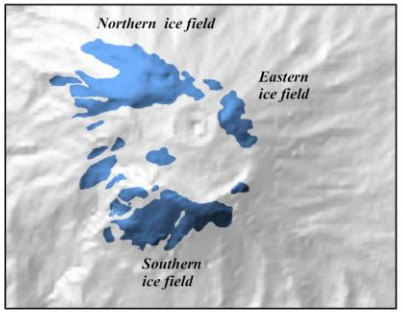
(b) 1962



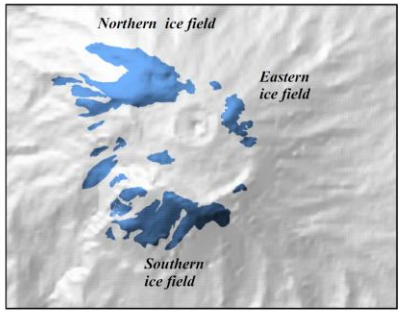
(e) 1992



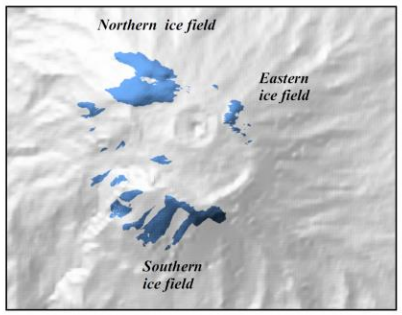
(f) 2000



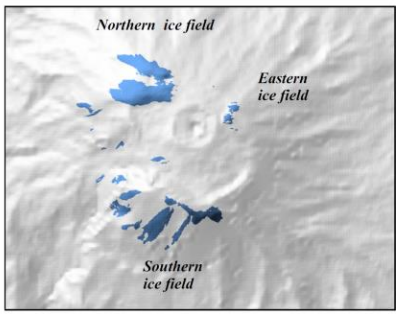
(c) 1975



(d) 1984

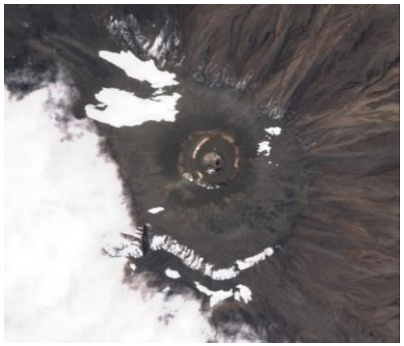


(g) 2003



(h) 2011

Loss of about 85% of the ice cover over the last 100 yrs



Cullen et al., 2013

Sentinel 2 image 9.1.2018

Ice Memory Initiative

As an international initiative ICE MEMORY aims at collecting heritage ice cores from the world's key endangered glaciers. By creating an international ice core repository in Antarctica, the heritage cores will be stored under safe conditions and under international governance, to provide high-quality samples for ice core science to be conducted by future generations of scientists throughout the world.
Partners: CNRS, IRD, Université Grenoble Alpes, National Research Council of Italy, Ca' Foscari University of Venice, Paul Scherrer Institute in Switzerland, IPEV (French Polar Institute), Italian Antarctic research programme (PNRA)

UNESCO acknowledged the scientific and cultural heritage significance of glaciers as well as the relevance of the ICE MEMORY initiative and encouraged the international community to take swift action.

Ice core drilling missions
Col du Dôme (2016), Illimani (2017), Belukha, Elbrus (2018) →Kilimanjaro 2019

https://fondation.univ-grenoble-alpes.fr/menu-principal/nos-projets/preservation-des-patrimoines/ice-memory-in-english-/ice-memory-in-english--81152.kjsp