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LUONNONTIETEELLINEN KESKUSMUSEO
NATURHISTORISKA CENTRALMUSEET
FINNISH MUSEUM OF NATURAL HISTORY

AJOITUS
DATERING
CHRONOLOGY

SUBARCTIC TREES AS ENVIRONMENTAL DATA ARCHIVE

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PHOTOSYNTHESIS STORES INFORMATION

Photosynthesis uses carbon dioxide (CO_2) and water (H_2O) and triggered by light convert them to photosynthates to form plant structure. Atmospheric CO_2 brings in stable carbon isotopes ($^{12,13}C$) and trace amounts of radiocarbon (^{14}C) produced by cosmic-ray interactions. Oxygen isotopes ($^{16,18}O$) are involved through water uptake. Climatic and environmental information is stored into plant structure through this process.

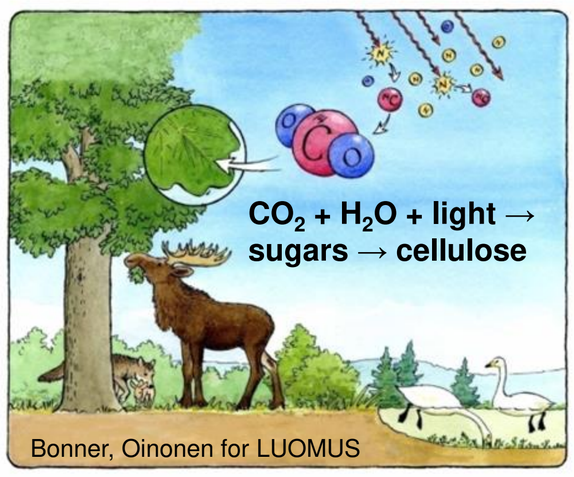

Figure 1 Photosynthesis stores information.

7600 YEARS OF CLIMATE

Lake-side trees from northern lakes have received always enough water and also CO_2. Therefore, carbon isotopic ratio is governed strongly by sunlight intensity. Thus, 7600 year long $\delta^{13}C$ time series tell about sunlight intensity and cloudiness.

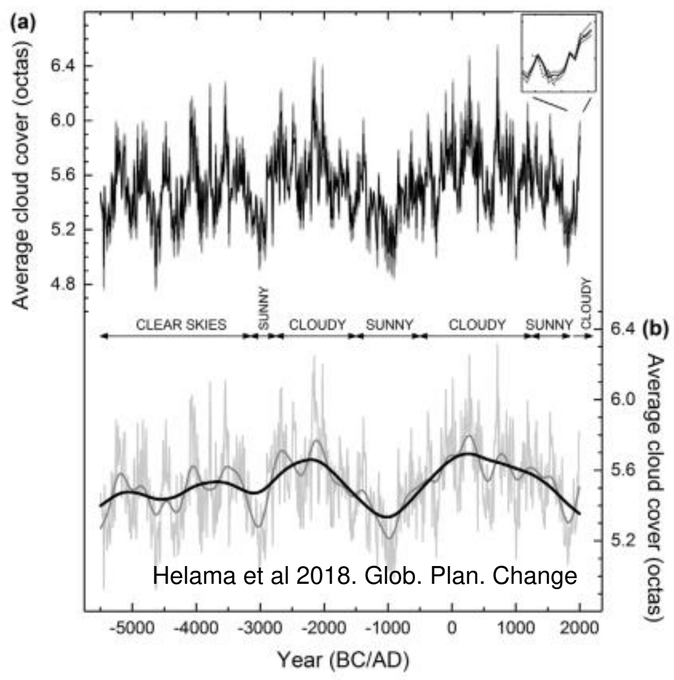

Figure 3 Growth conditions have been reconstructed for the past 7600 years.

PARTICLES FROM SUN

In AD774 Sun bursted particles into atmosphere. This superstorm is visible particularly well in northern trees, since Earth's magnetic field guides particles through polar areas. We suspect that the fast stratosphere-troposphere exchange in polar areas is also contributing to this. The recent Carrington event of AD1859 indicates similarly – urging for more dynamic models to understand atmospheric carbon cycle.

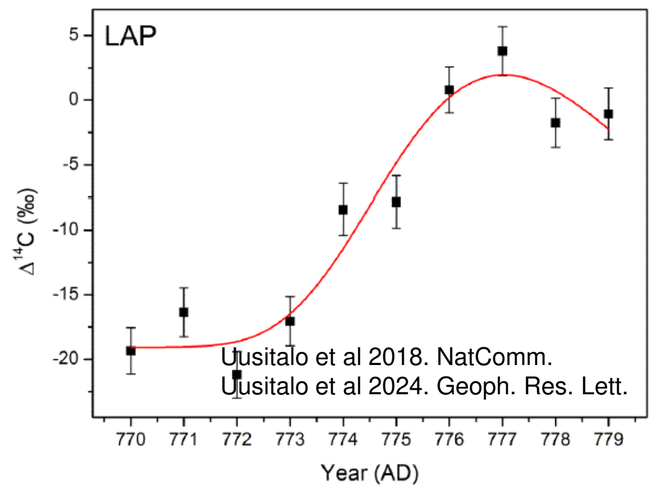

Figure 5 Northern trees record ^{14}C increases caused by solar events.

MEMORY STOCKS OF NATURE

7,600-year annual tree-ring chronology of *Pinus sylvestris* has been established from Northern Finland (~68°N). Three consortium projects between University of Helsinki and Natural Resources Institute Finland (2011 onwards) has been conducted based on this environmental data archive. Analyses of ring width, wood density, and isotopic ratios reveal temperature, light intensity, cloudiness, moisture information to reconstruct the past growth conditions.

Figure 2 7600-year long tree-ring calendar has been established from northern lakes of Finland.

3-YEAR VOLCANIC WINTER

Within the lake-tree chronology, carbon isotope ratios depend strongly on solar irradiation. Tropic volcanic eruption of AD539/540 hindered sun also in Finland: sunlight intensity dropped by ~25% in Lapland for several years. It is not surprising that Northern sagas (Fimbulvinter), folktales in Buryatia and in Finland tell about times without Sun.

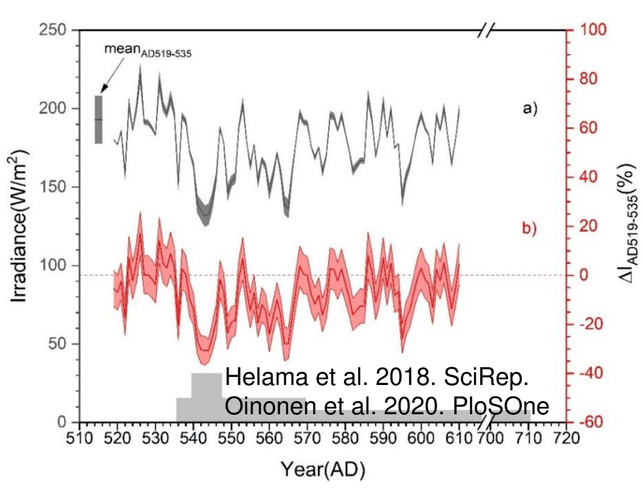

Figure 4 Tropic volcanic eruption reduced drastically sunlight in AD540s.

WORLD-CHANGING EVENTS

Our present WELT project (2023-2027) studies era of 4300 – 3000 calBP. Instead of Meghalayan drought of 4200 calBP influencing the Mediterranean cultures, this era seems to be moist in northern areas and followed by Little Ice Age –type of cold periods. We compare our ring-with and isotope records to archaeological data from Fennoscandia to understand nature-human interactions. Past to Future project participation – organized through CETAF – links our work towards large-scale climatic modellings.

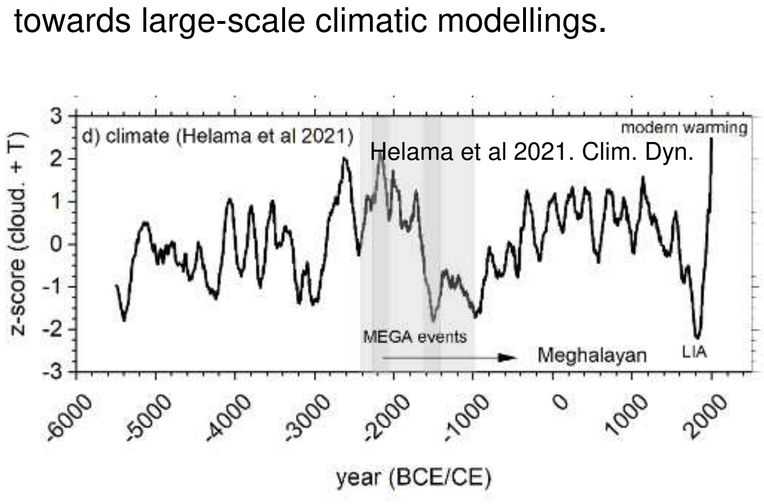

Figure 6 Little Ice Ages in 3600 years back in time.

Research Council of Finland

Luke LUONNONVARAKESKUS

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