

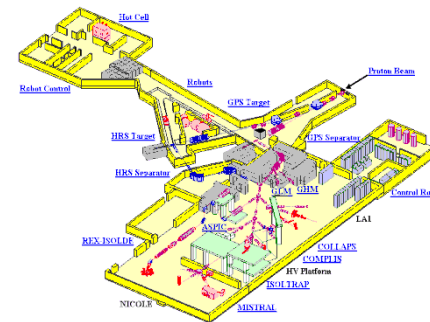
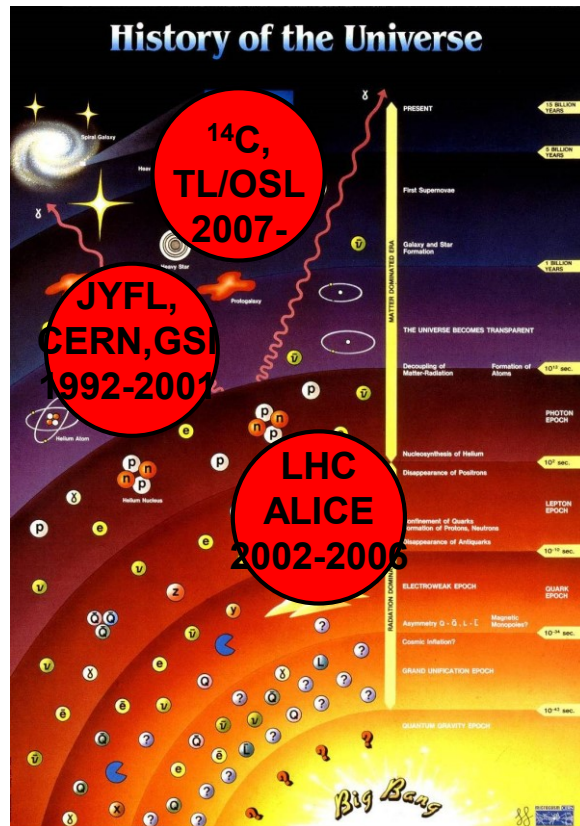
Isotopic signals in tree rings

through CARATE and QUANOMAL projects

Markku Oinonen, L. Arppe, J. Uusitalo in consortium with LuKe group (Mielikäinen, Nöjd, Helama et al)

Laboratory of Chronology - LUOMUS

Time travelling with various methods...



JYFL, CERN

Helsinki Institute of Physics for LHC/ALICE

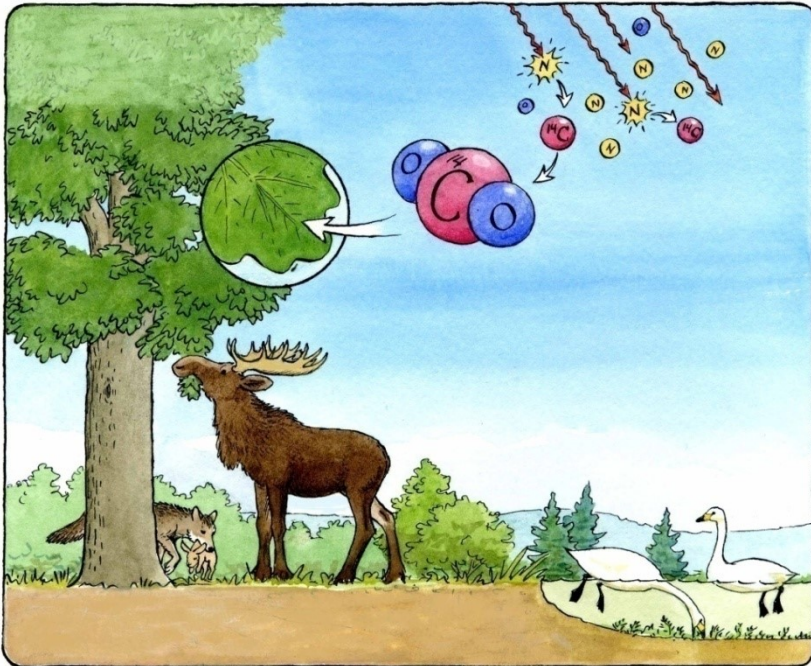


Presently: Quantifying the last 100 000 years by radiocarbon measurements, luminescence dating, stable isotope ratios

Photosynthesis samples carbon

$^{12},^{13},^{14}\text{C}$ from atmosphere to plants

Graphic: H.Bonner, Design: M. Oinonen for Elämän Historia-exhibition / LUOMUS



Stable $^{12},^{13}\text{C}$ and cosmic ray-produced ^{14}C is sampled to trees by photosynthesis

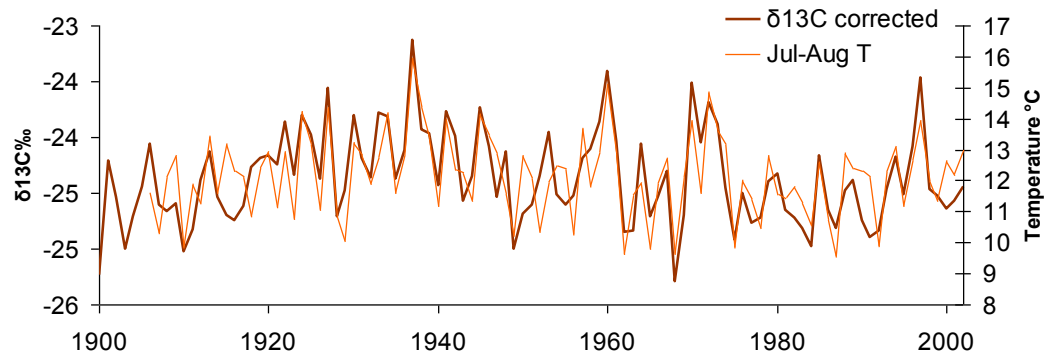
Isotopic signals:

Photosynthetically Active Radiation, temperature, humidity, C cycle → $^{13}\text{C}/^{12}\text{C}$ ratio i.e. $\delta^{13}\text{C}$

CR intensity, Sun, PAR, temperature, humidity, C cycle → $^{14}\text{C}/^{13}\text{C}$ ratio i.e. $\delta^{14}\text{C}$

CARATE - Climatic reconstruction for the last 7500 years

SA supported HY & METLA consortium 2011-2015



Complementary records of climate variability and tree physiological response to climate by carbon isotopes – improved understanding of tree rings as paleoecological proxies

Sample material: subfossil pine (*Pinus sylvestris*) trees from Finnish Lapland covering the past 7500 years

21000 isotopic measurements produced, 9 papers coming out

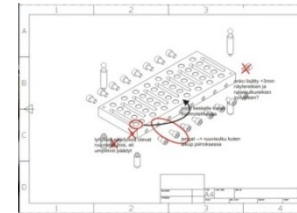


Cellulose factory

160 tree-ring samples in a week



- 1) Manually sliced 2-50 mg samples including both early- and latewood
- 2) α -cellulose extracted with MSISS (Multiple Sample Isolation System for Solids) Wieloch et al., 2011
- 3) Homogenization with ultrasound probe

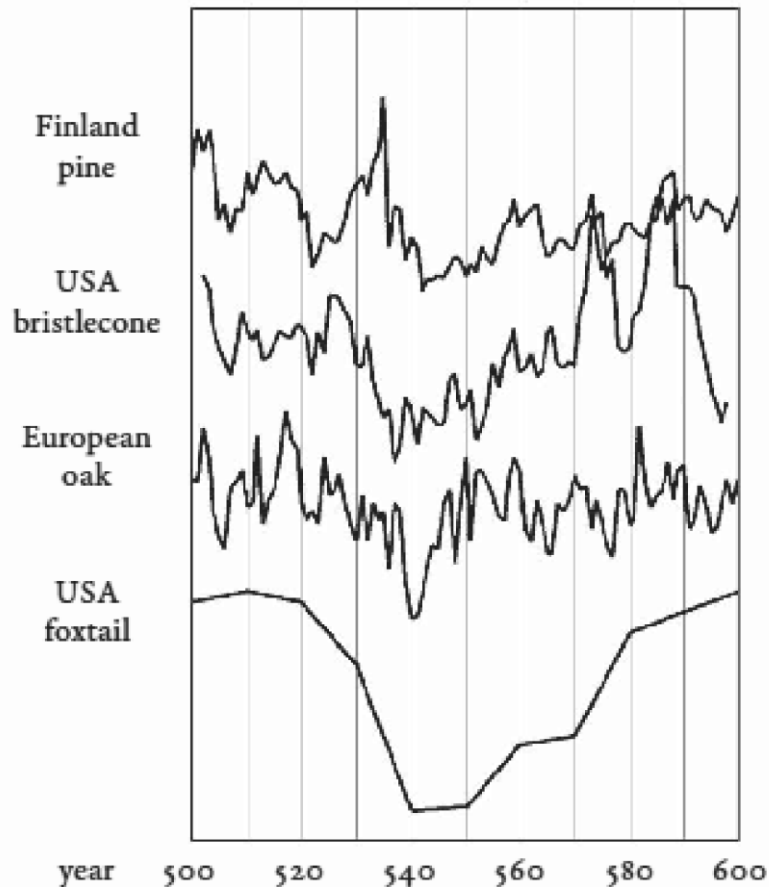


- 4) For $\delta^{13}\text{C}$:
 - 70 μg samples combusted and analysed via EA-IRMS for samples run in duplicate
 - typical reproducibility of samples better than $\pm 0.13\text{‰}$
- 5) For $\delta^{14}\text{C}$:
 - 5-10 mg samples combusted by CTC method, converted to graphite targets and analysed at the Helsinki AMS facility
 - precision $\pm 3\text{‰}$

MSISS-system by Potsdam Dendro Lab: Wieloch et al., 2011, Dendrochronologia 29, 115-117

Mystery cloud of 536-537AD

Historical and scientific evidence



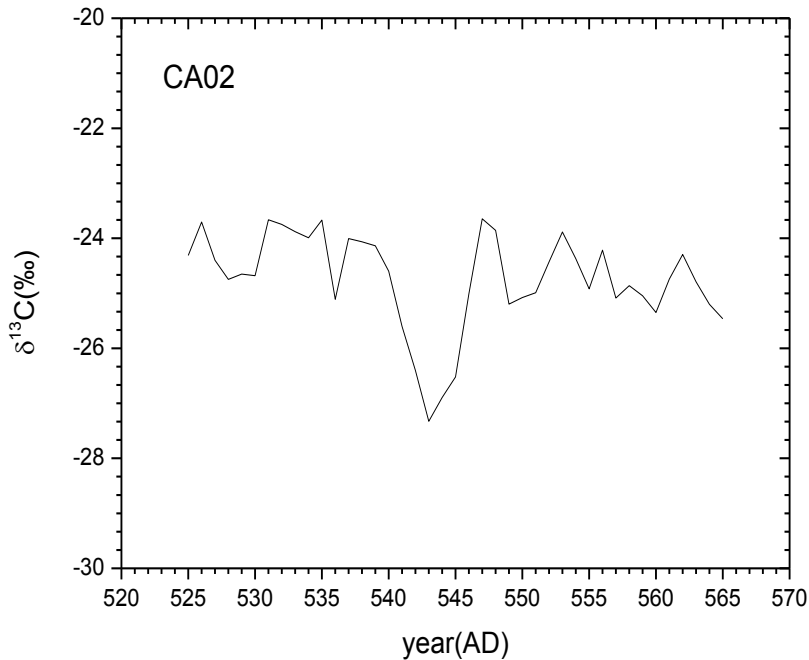
Historical evidence from
Mediterranean sources:
sunlight was hindered by 18
months

Arjava A 2005. *Dumbarton Oak Papers* 59: 73-94; Rampino et al 1988. *Ann. Rev. Earth Planet. Sci* 16: 73-99; Keys, D P 2000. *Catastrophe: an investigation into the origins of the modern world*. ISBN 0-345-40876-4.

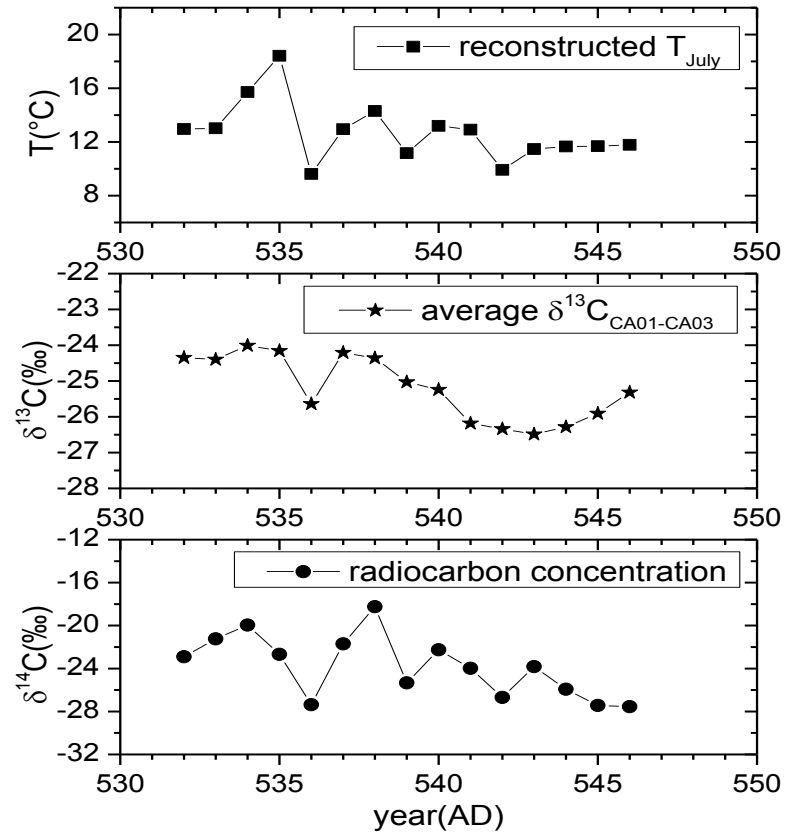
Anomaly seen in tree-ring data
throughout
the northern hemisphere
Baillie M G L 1994. *Holocene* 4:212-217 and
refs therein.

Tree-rings record the climate anomaly

$\delta^{13}\text{C}$, $\delta^{14}\text{C}$ and ring-widths from Lapland



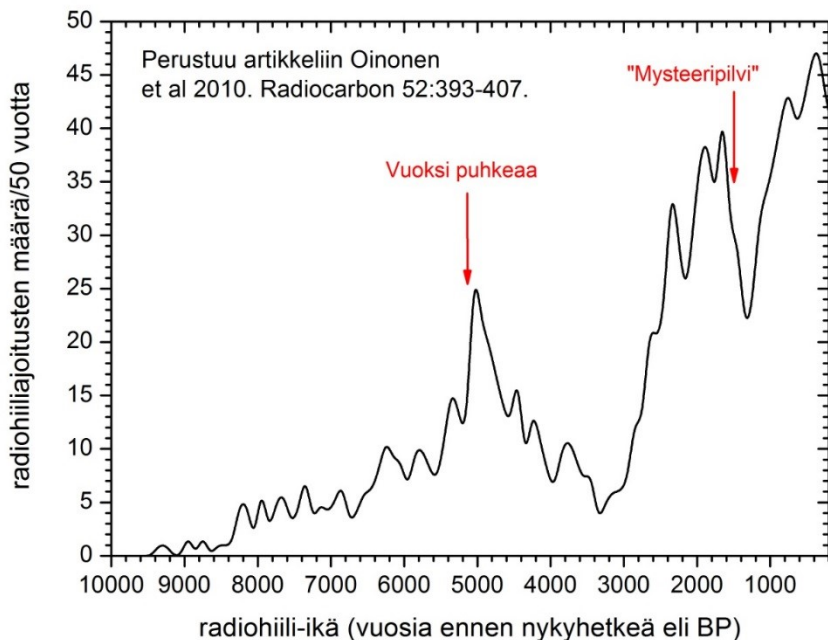
$\delta^{13}\text{C}$ (and $\delta^{14}\text{C}$) sensitive to PAR (Loader et al 2013. QSR 62: 97-113) → consistent with light intensity loss due to the cloud → primary productivity?



Oinonen, Arppe, Helama, Mielikäinen et al 2015. To be published

SA QUANOMAL 2015-2019

Anomalies and primary productivity



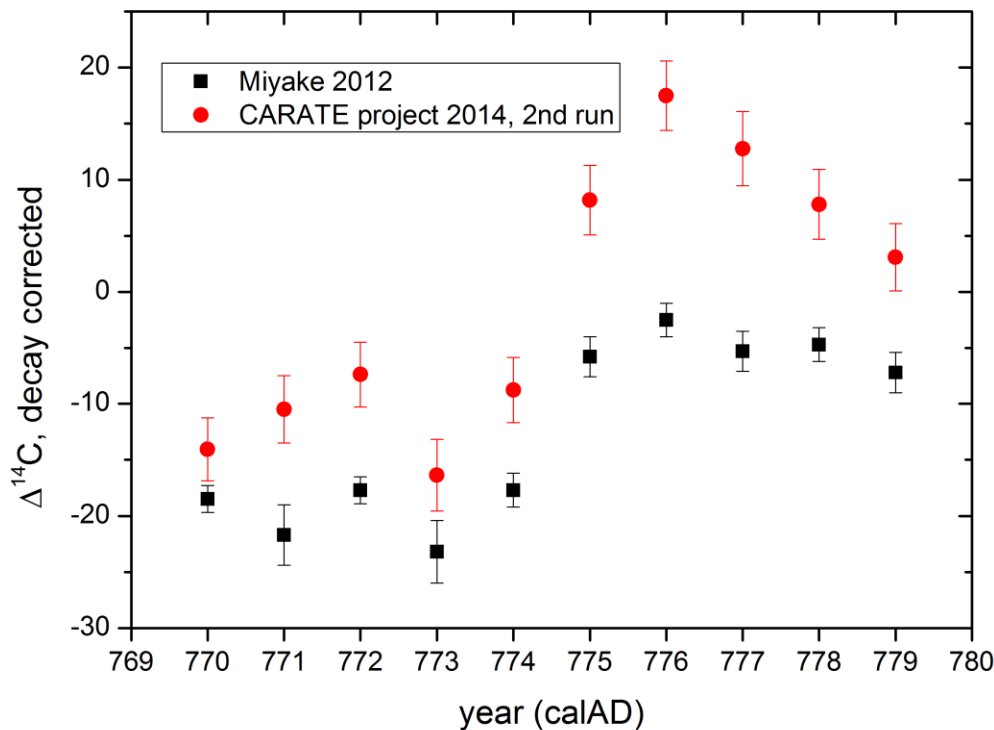
Multi-proxy characterization of environmental anomalies from Santorini to 20th century (1902-03) by using ring-width, isotopic and density data

Correlate PAR with isotopic data to get calibration for PAR loss during the past volcanic anomalies → how this has affected to primary productivity?

Environment – human interaction studies of LUOMUS

775 AD anomaly in Lapland

Polar enhancement?



Cosmic or solar origin of a sudden ¹⁴C increase in tree-rings in 775AD?

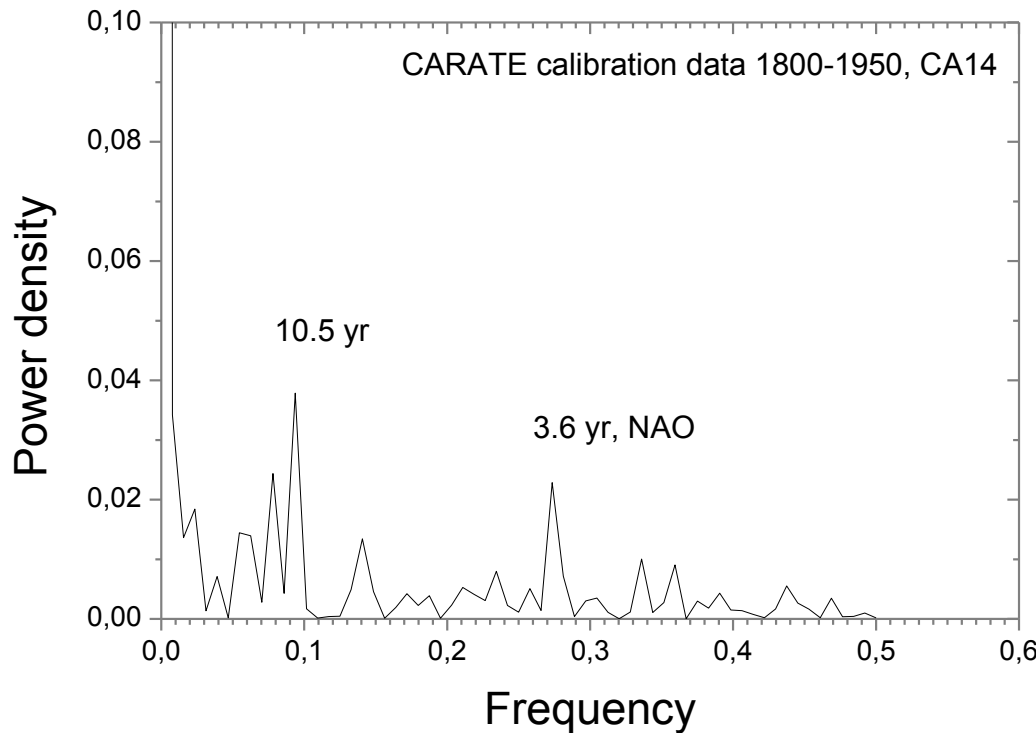
CARATE: visible in Arctic tree-rings

Discussing the data with Ilya Usoskin: polar enhancement?

Continues with QUANOMAL with multiproxy approach

Miyake F et al. 2012. *Nature*, 486, pp. 240–242. Usoskin IG et al. 2013. *Astron. Astrophys.*, 552, L3.

Cyclic $\delta^{13}\text{C}$ records



Stable carbon isotopic spectra reveal cyclic behavior

3.6 year cycle → NAO

10.5 year cycle → solar

Isotopic signals contains multitude of environmental information

Ogurtsov M, Sonninen E, Hilasvuori E, Koudriavtsev I, Dergachev V, Jungner H 2011. Variations in tree ring stable isotope records from northern Finland and their possible connection to solar activity. *Journal of Atmospheric and Solar - Terrestrial Physics* 73(2-3): 383-387. <http://dx.doi.org/10.1016/j.jastp.2010.02.020>.

In future

Quantifying the Past as a theme

Interested in environment – human interaction studies

Strong consortium of UH and LuKe (former METLA) to use Inari and Salla tree-ring chronologies (southern Finland?)

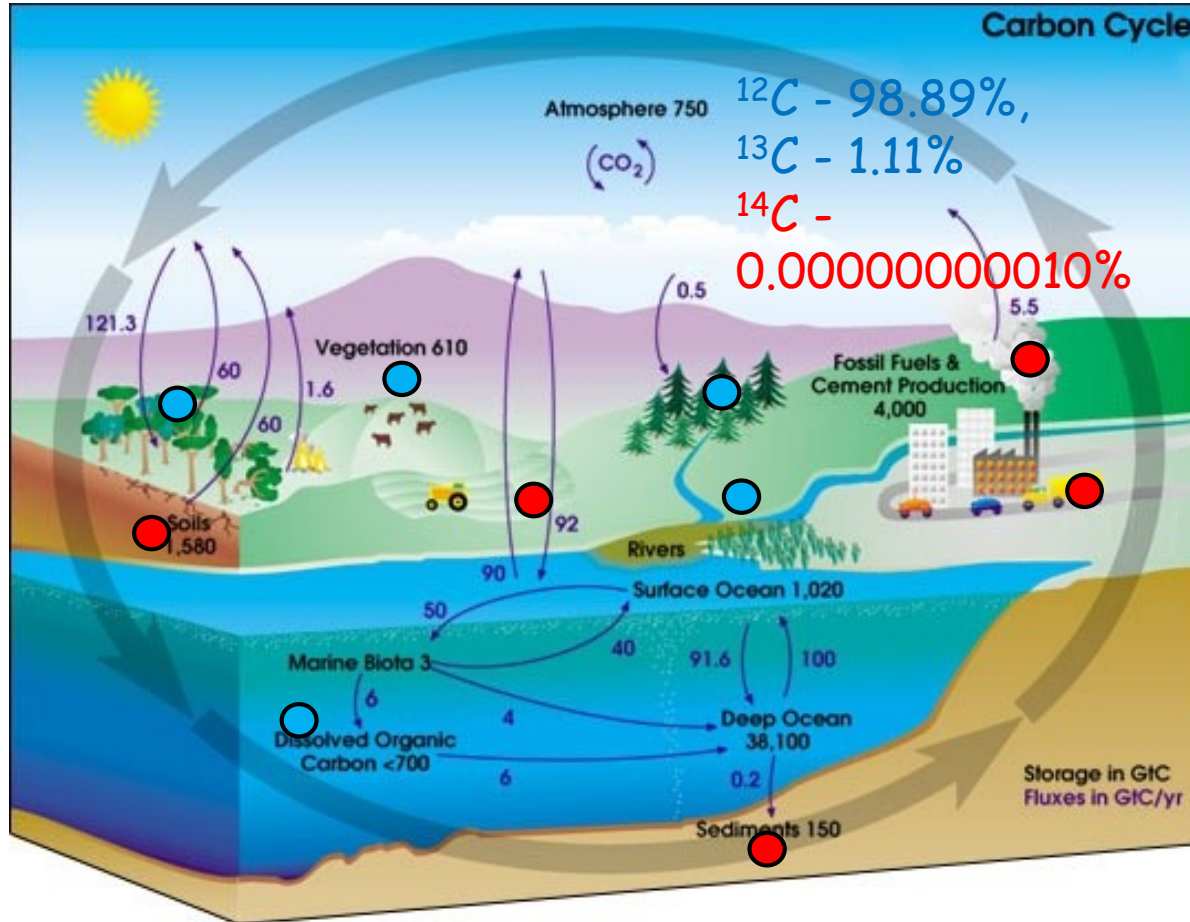
Measurement facilities available for large sets of isotopic and radiocarbon data (sample treatment, IRMS, high-quality ^{14}C -AMS)

Hopefully more co-operation with the RESOLVE community

THANK YOU

Union of carbon isotopes

stable and cosmogenic



- Stable isotopes:
- a) fractionation normalization for ^{14}C
- b) origin of carbon and processes within the cycle

Radiocarbon:
 provides timeline

Studies within
 biospheric cycles (C,
 H_2O , N)

Mystery cloud of 536-537AD

Historical evidence

"the sun was dark and its darkness lasted for eighteen months...light was only a feeble shadow"

John of Ephesos on Mesopotamia

"...the air is dense of rising moisture – as happened...for a nearly a whole year as Belisarius held the consular office..."

John Lydos on Constantinople

Fimbulvinter of 3 years in Nordic sagas, "one lived without Sun, without Moon..." in Finnish folklore

after Rampino et al 1988. Ann. Rev. Earth Planet. Sci 16: 73-99; Keys, D P 2000. *Catastrophe: an investigation into the origins of the modern world*. ISBN 0-345-40876-4.; Gräslund, B. & Price, N. 2012. Antiquity 86: 428-443.; Arjava A 2005. Dumbarton Oak Papers 59: 73-94.; SKVR search 11/2013, <http://dbgw.finlit.fi/skvr/>.