Carbon isotope (^{14}C and ^{13}C) exchange processes in the biosphere: case study of the Plitvice Lakes

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Content

- Why carbon isotopes (^{13}C and ^{14}C)?
- Exchange processes of ^{13}C and ^{14}C in the system
  - atmospheric CO_2 – terrestrial plants/soil
  - Atmospheric CO_2 – dissolved inorganic carbon (DIC) in the water – aquatic plants

Why carbon isotopes (^{13}C and ^{14}C)?

Carbon isotope	Characteristic	Natural distribution	Measurement technique	Application
^{13}C	stable, isotope fractionation in nature	~1.1%	Mass spectrometry	- origin of carbon in the nature - environmental study- carbon isotope exchange processes
^{14}C	β radioactive half-life 5730 yr	~10^{-10} %	LSC, AMS	- radiocarbon dating - environmental study - palaeoclimatic study

^{14}C

^{14}C activity – percent of modern carbon

$$a^{14}C = \frac{A_t}{A_0} \times 100\ \%\ (pmC)$$

^{14}C age – years BP

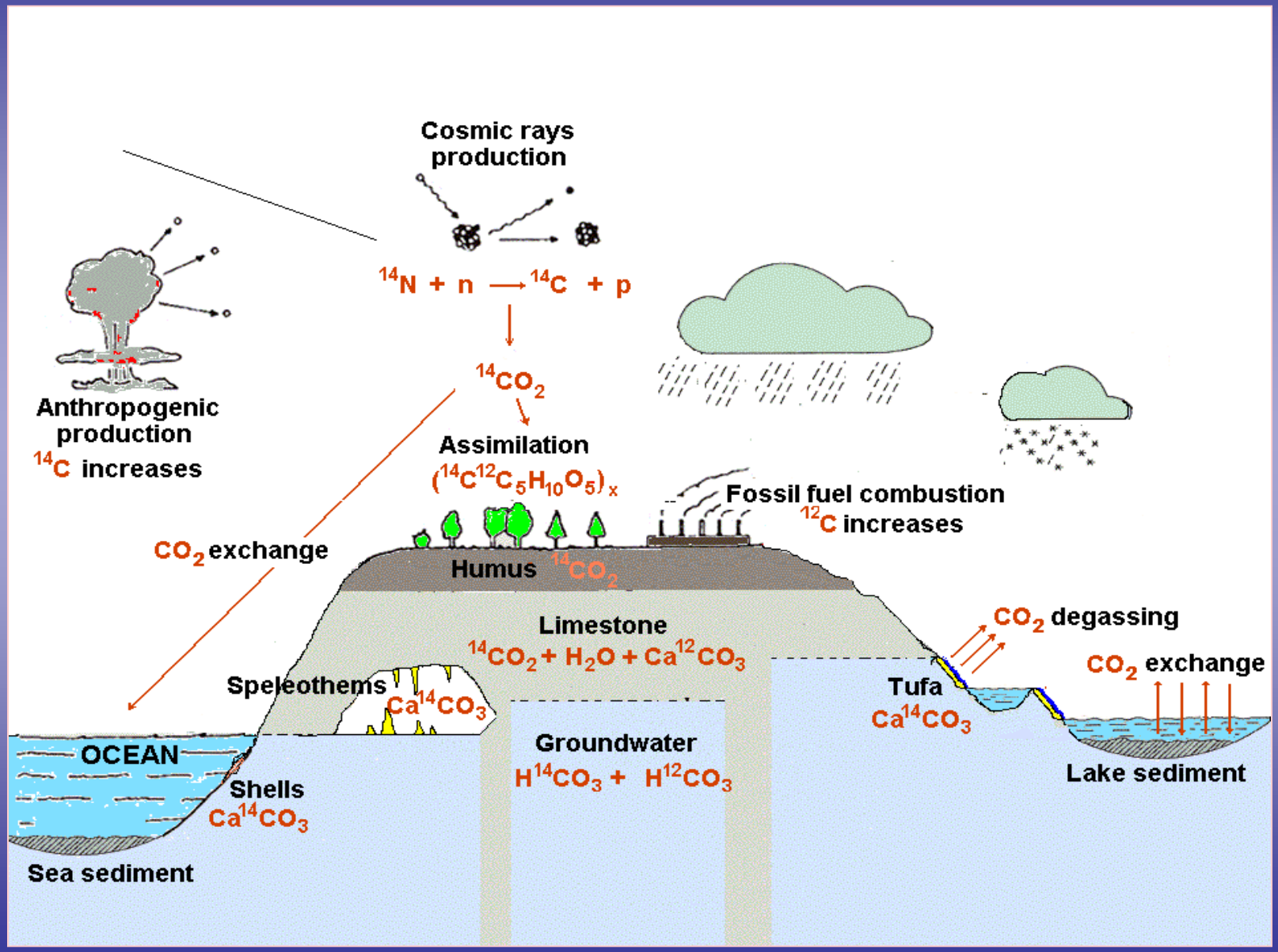
$$t = -8030 \ln \frac{A_t}{A_0}$$

^{13}C

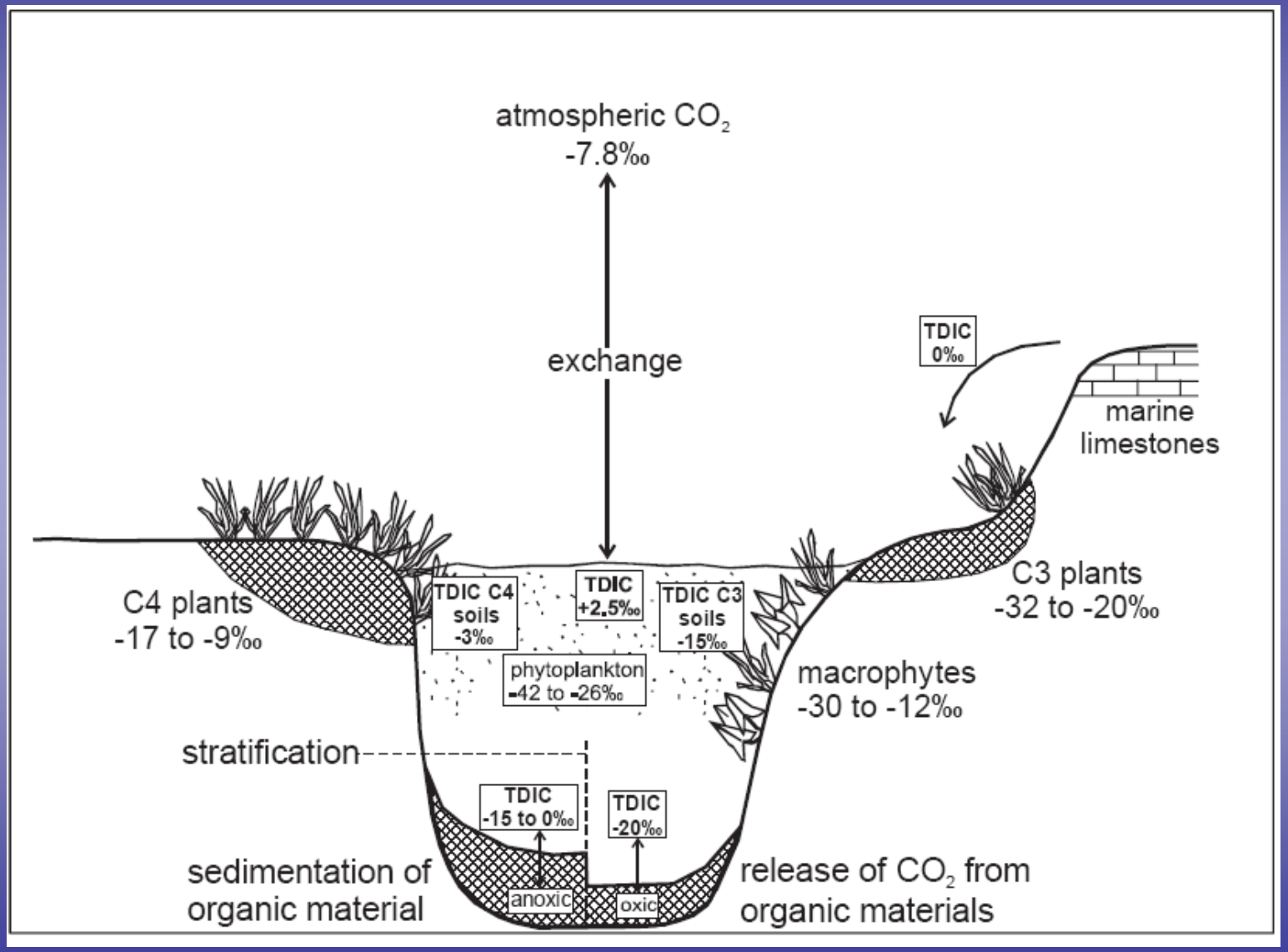
Measurement of $^{13}C/^{12}C$ ratio

$$\delta^{13}C = \frac{R_{sample} - R_{standard}}{R_{standard}} \qquad R = \frac{^{13}C}{^{12}C}$$

Carbon ^{14}C cycle in the nature

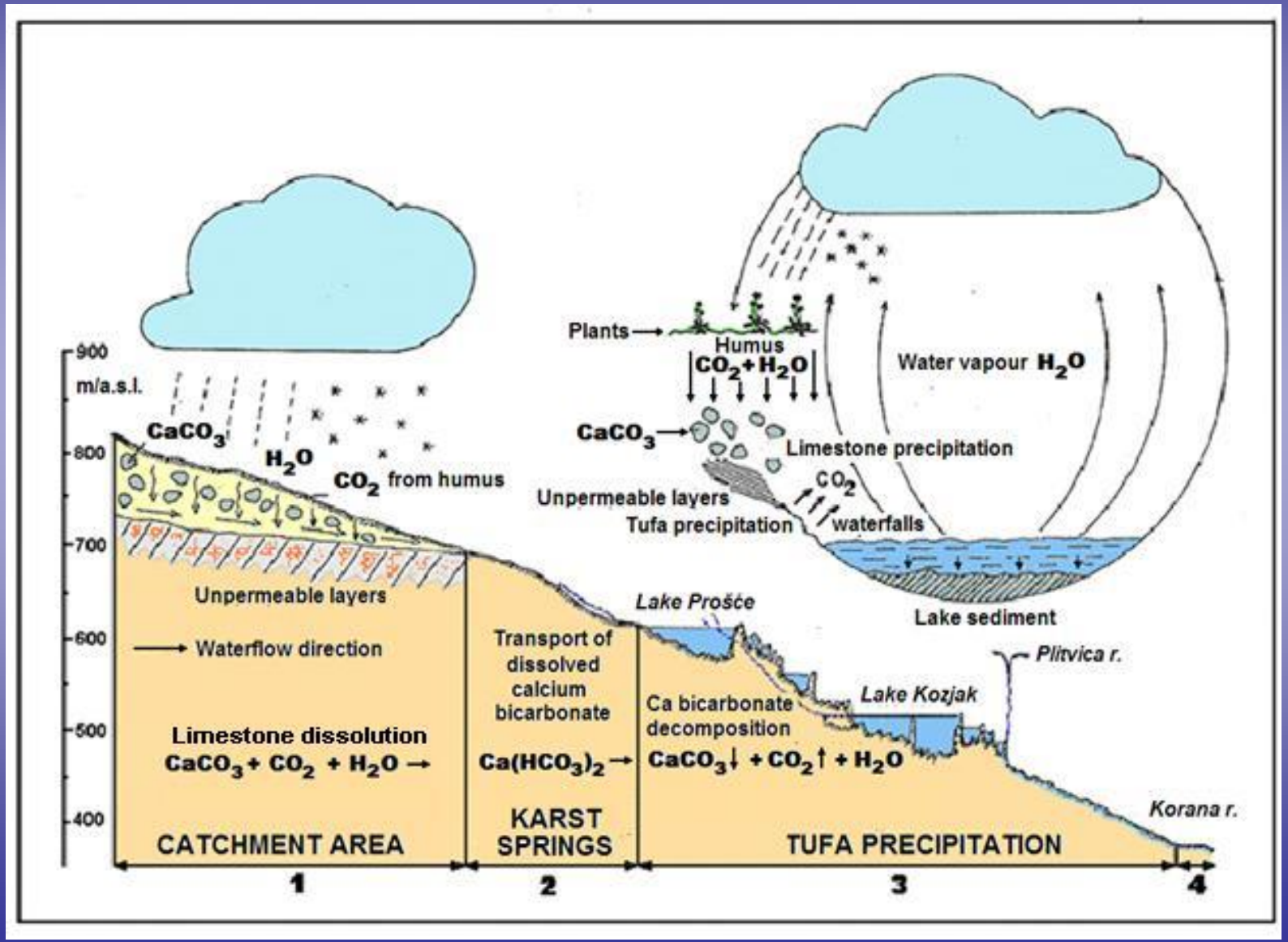


Distribution of carbon stable isotope ^{13}C ($\delta^{13}C$ values) in the environment

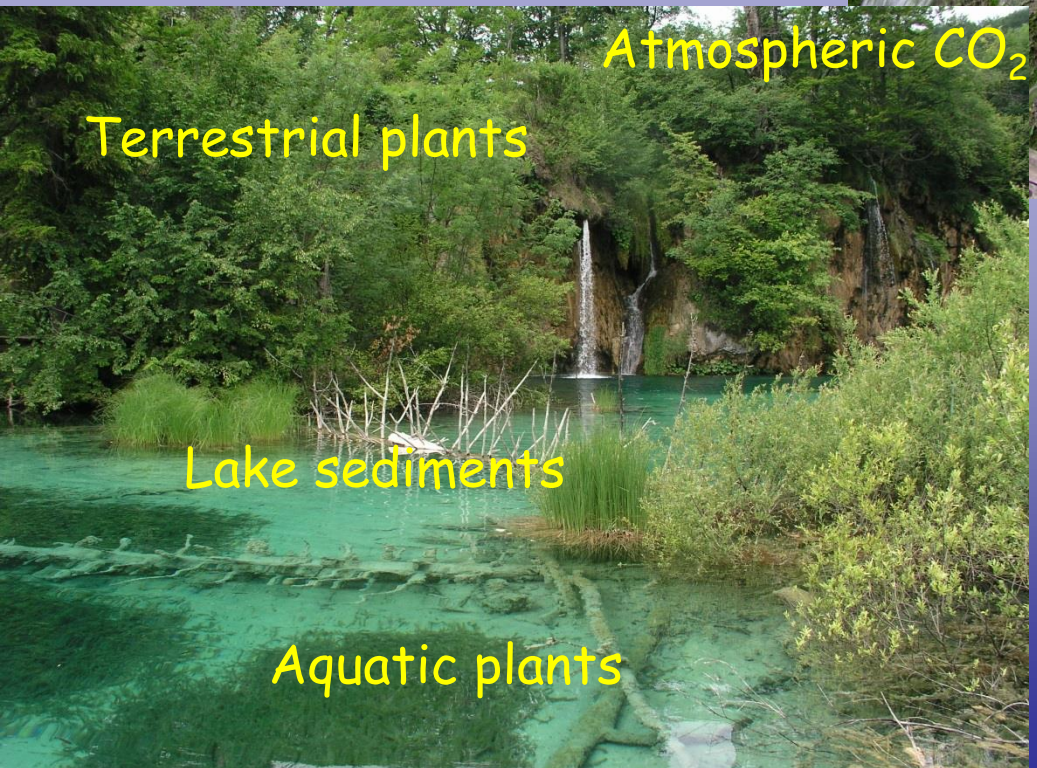


After Leng and Marshal (2004)

Geochemical cycle of carbon in the karst environment
Case study: Plitvice Lakes

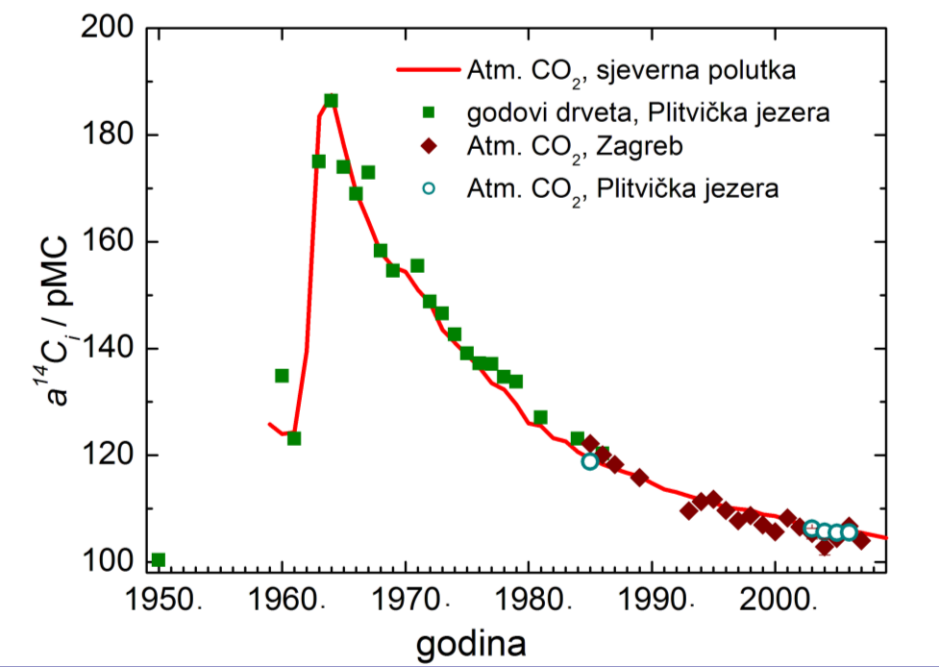


Distribution of carbon isotopes ^{14}C (a ^{14}C) and ^{13}C ($\delta^{13}C$) in the Plitvice Lakes system



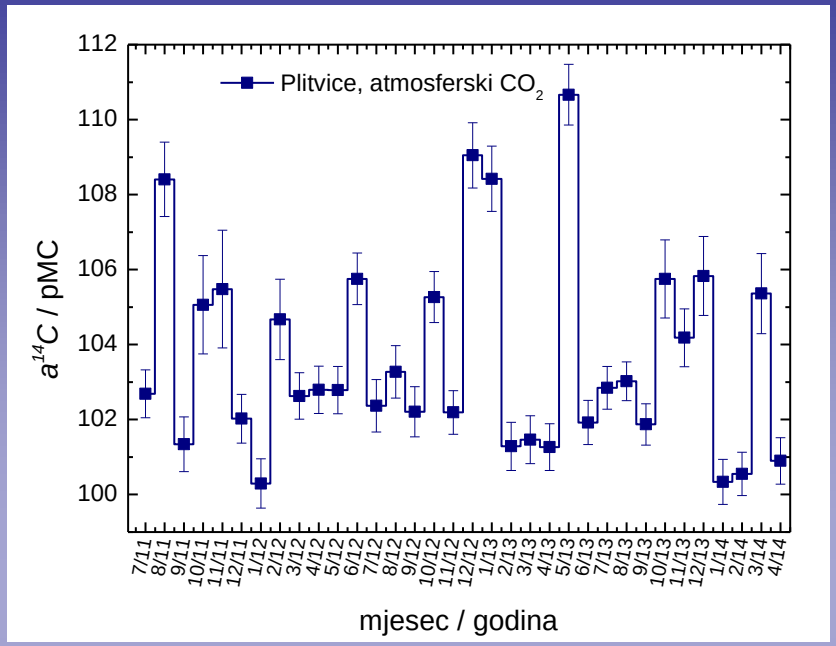
Environmental study:
- anthropogenic contamination
- carbon exchange processes

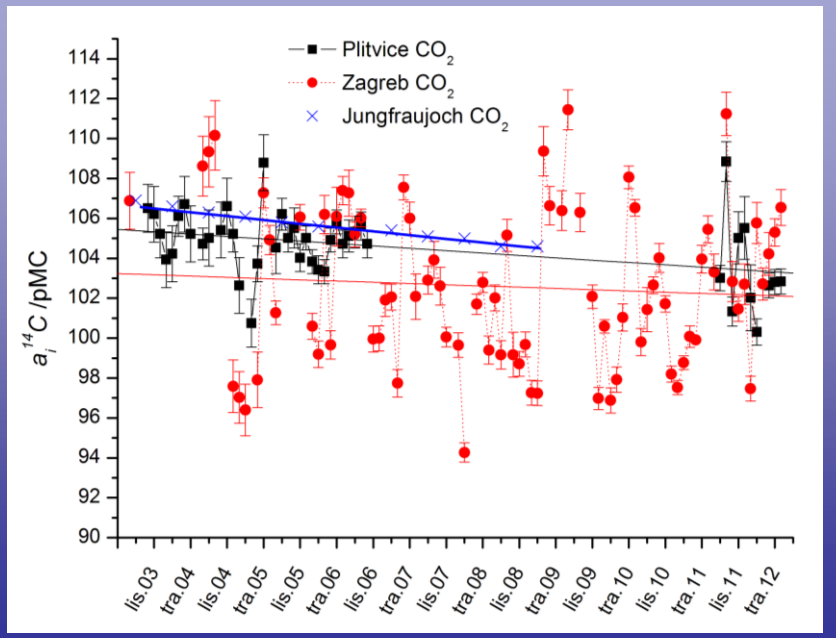
^{14}C activity of the atmospheric CO_2



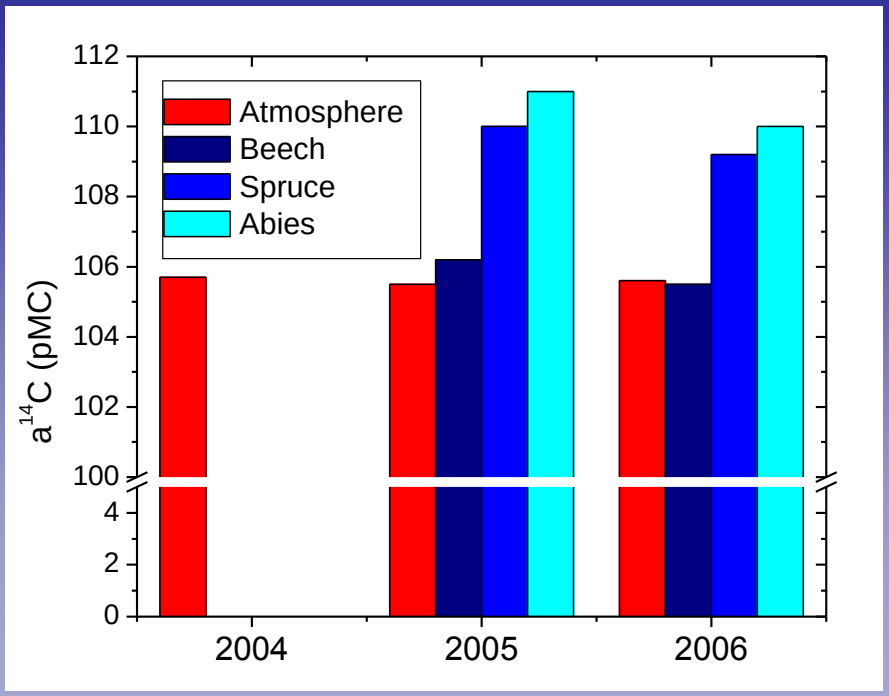
Anthropogenic ^{14}C production by thermonuclear weapon tests in the 1960s

Monthly a^{14}C values in the Plitvice Lakes, 2011 – 2014.



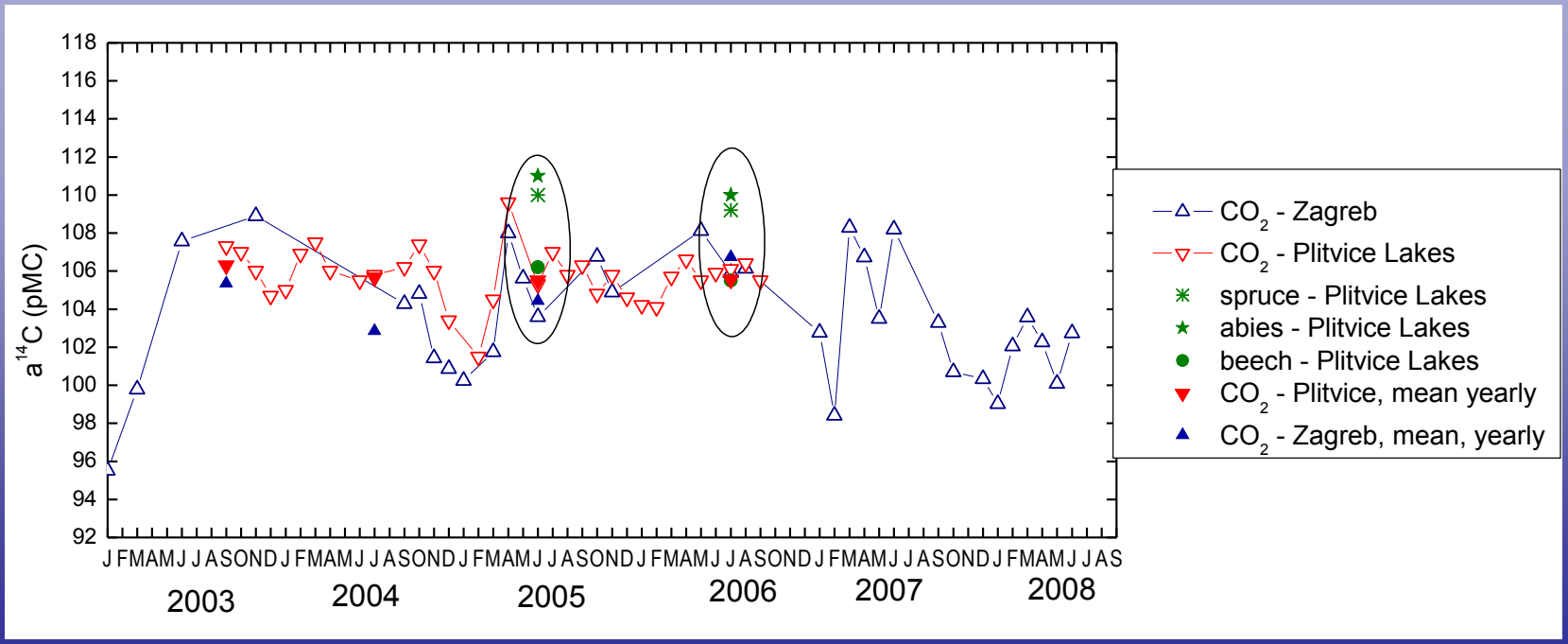


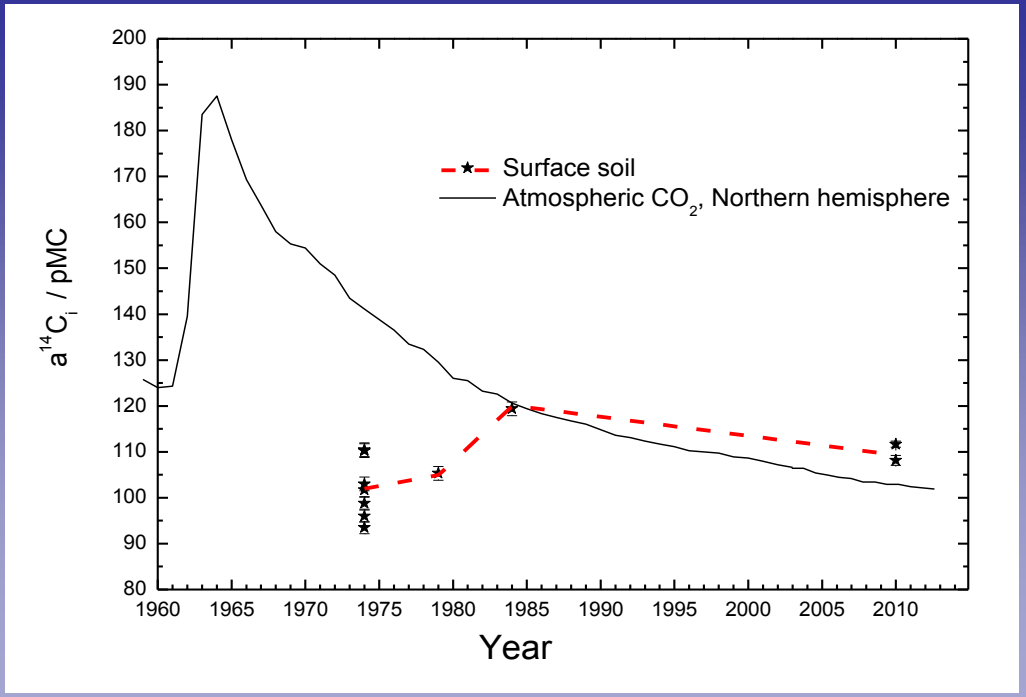
Comparison of the average yearly a^{14}C values in Plitvice, Zagreb and referent station Jungfraujoch, 2003 – 2012.



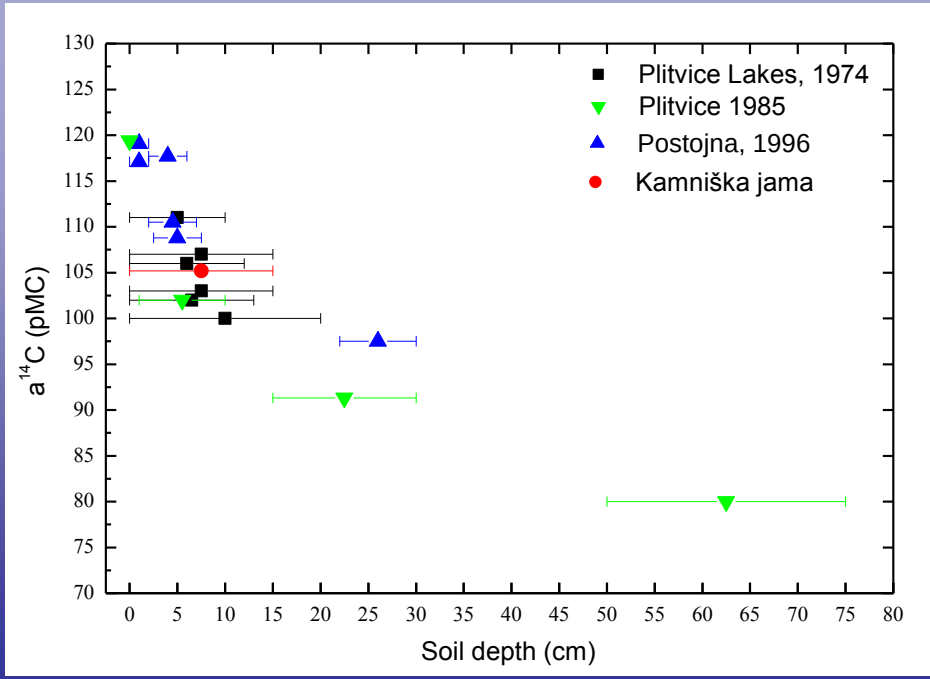
^{14}C activity of terrestrial plants – leaves/needles

Comparison of $a^{14}C$ of trees with $a^{14}C$ of atmospheric CO_2





^{14}C activity of top soil in the Plitvice Lakes area



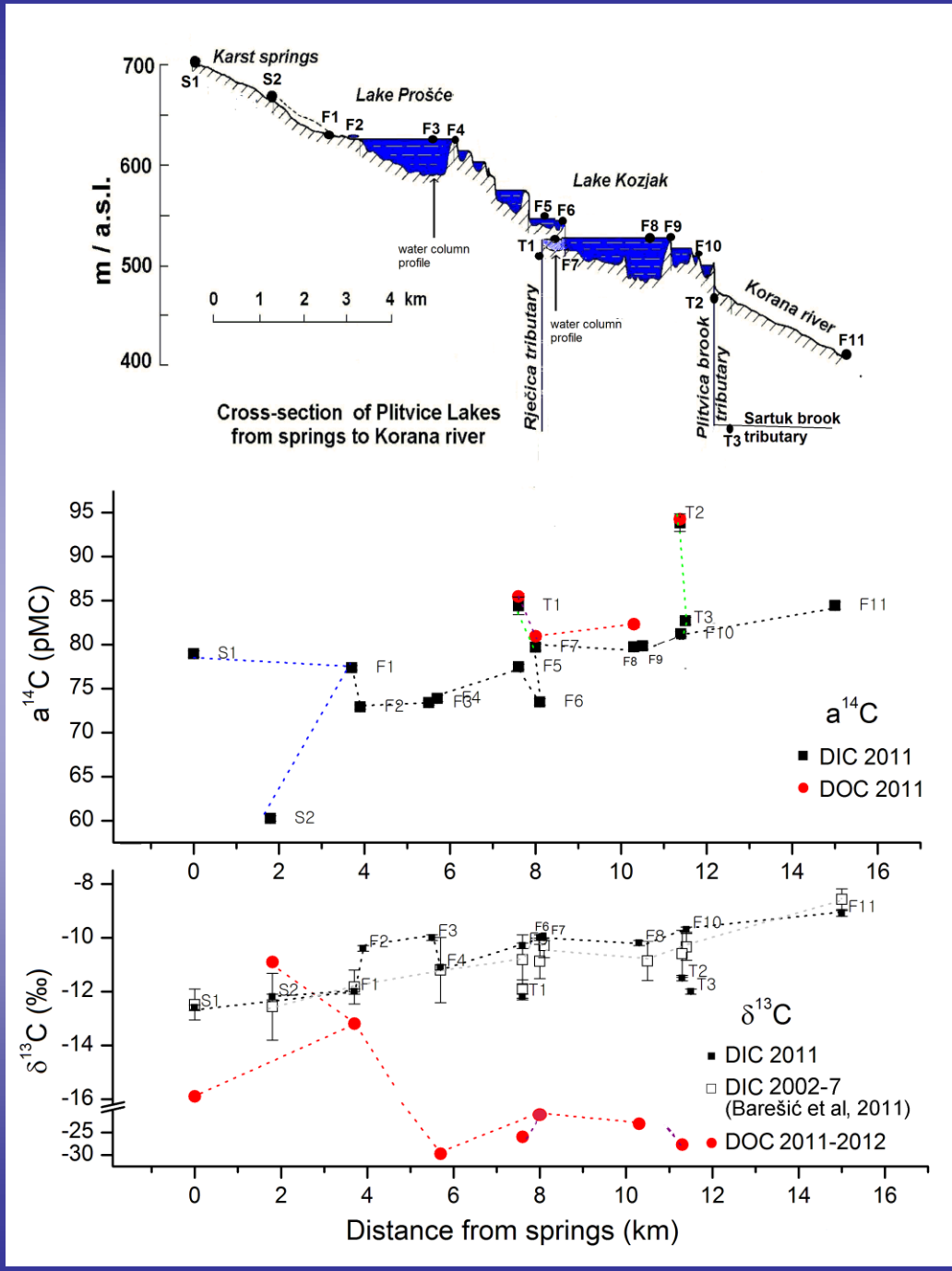
^{14}C activity of soil from different locations

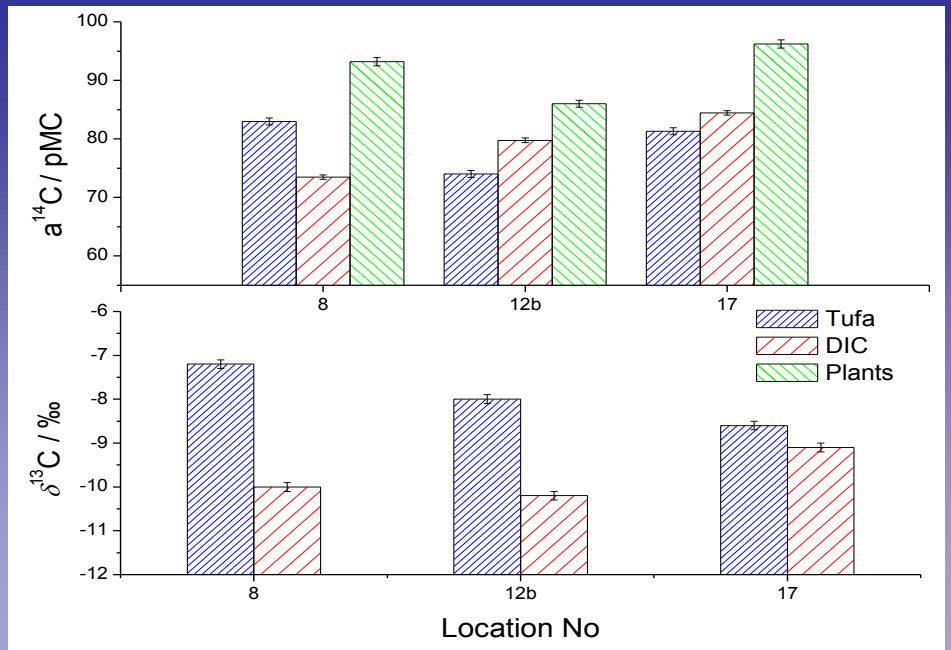
^{14}C activity and $\delta^{13}C$ values in water (DIC and DOC)

Increase of $a^{14}C$ and $\delta^{13}C$ of DIC in downstream flow in the Plitvice Lakes system is the result of:

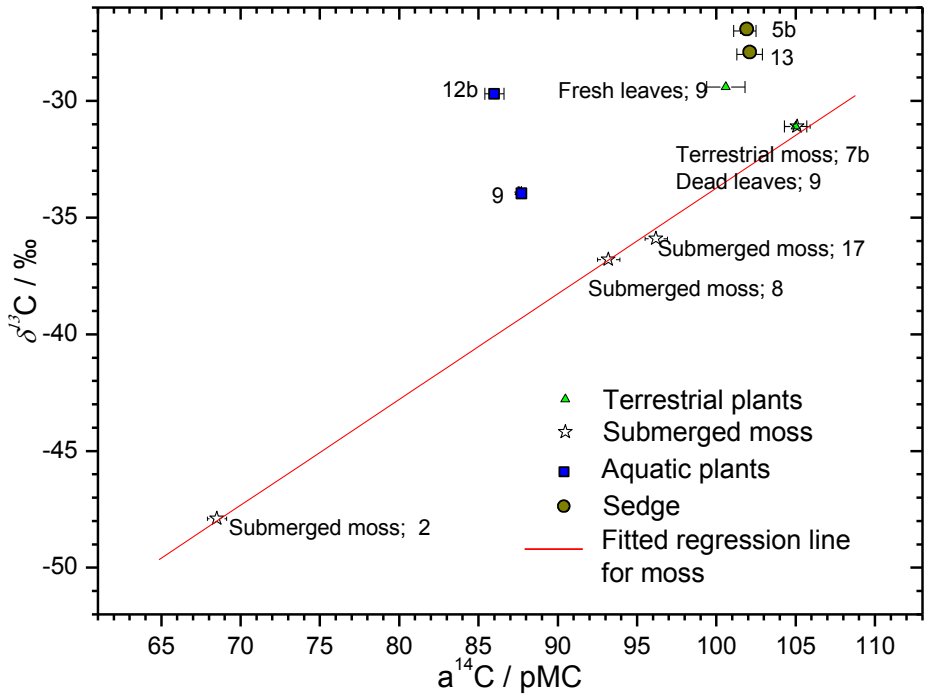
- Carbon isotope exchange of DIC with atmospheric CO_2
- process of photosynthesis in the lake waters

Strong interaction between DIC and DOC in lake waters

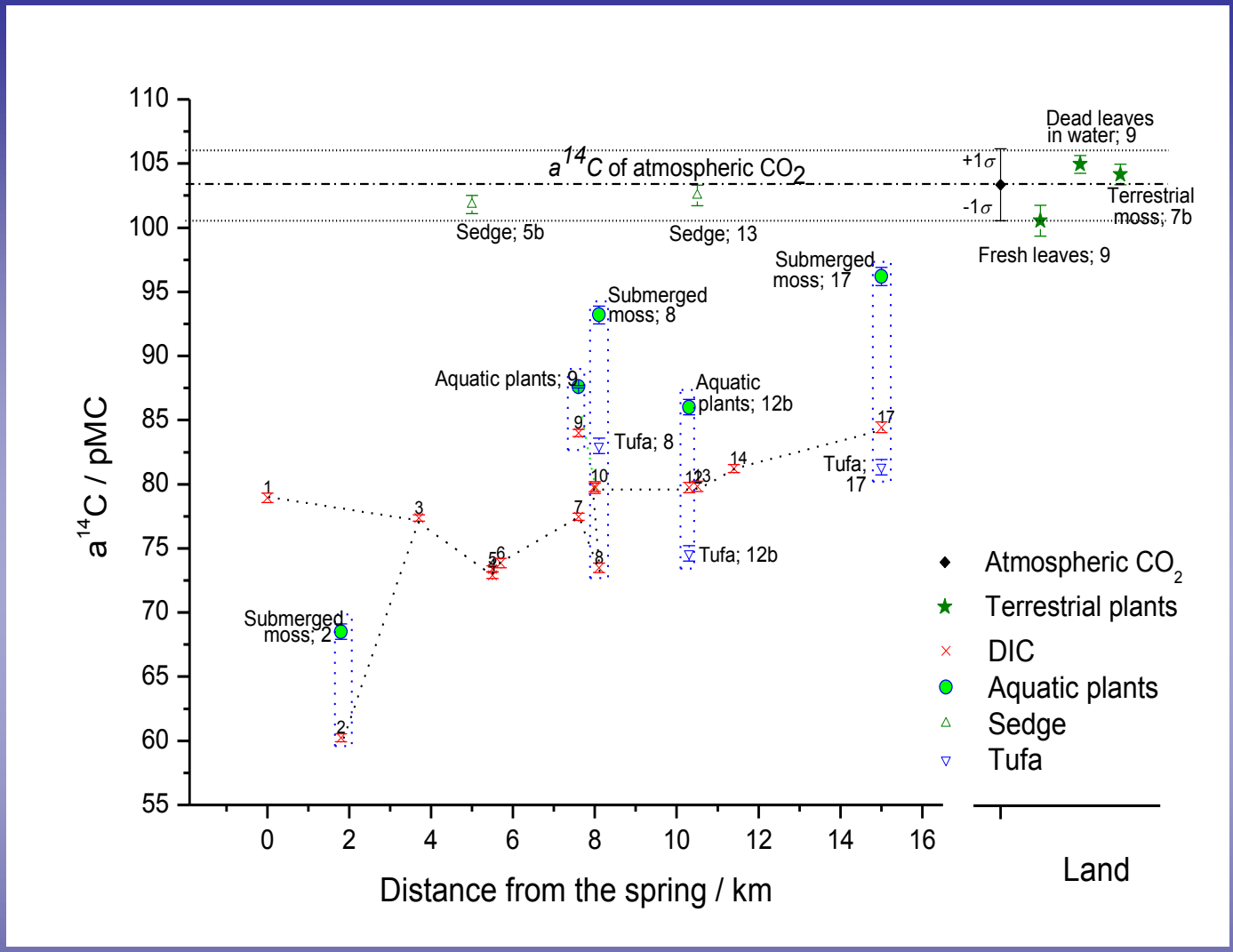




$a^{14}C$ and $\delta^{13}C$ of tufa, DIC and aquatic plants from the Plitvice Lakes water at 3 locations

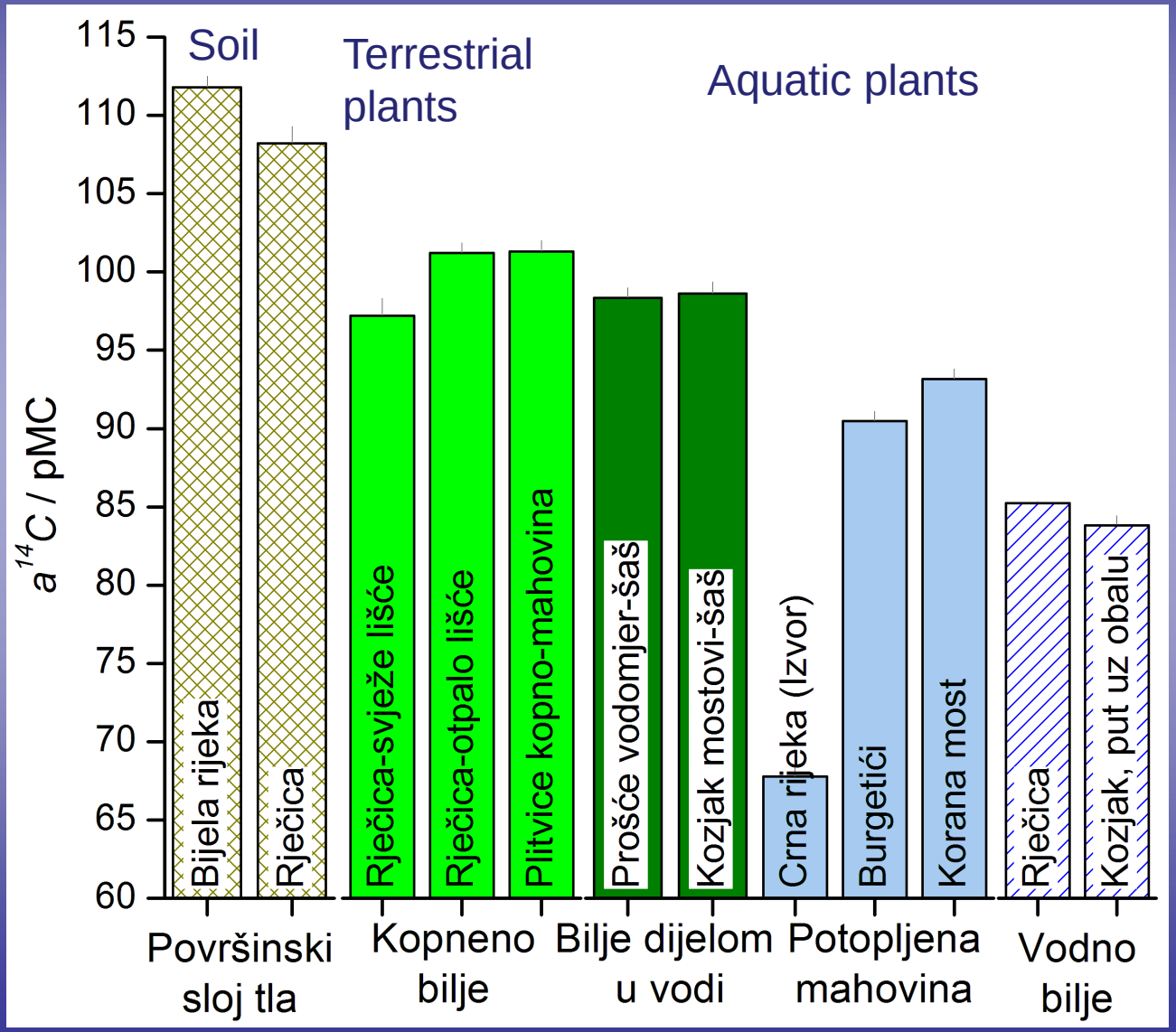


Relation between $\delta^{13}C$ and $a^{14}C$ of different plants from the Plitvice Lakes area



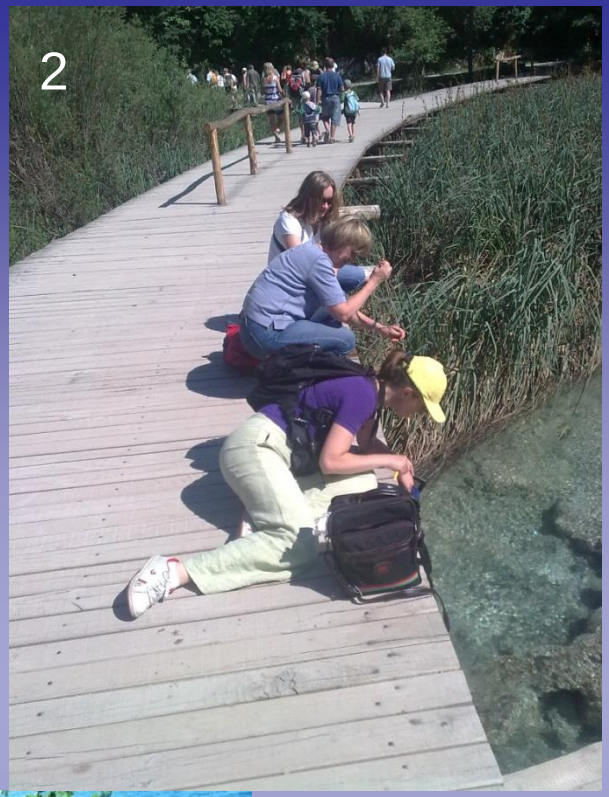
^{14}C activity of different plants, DIC and tufa in correlation with a^{14}C of atmospheric CO_2 and with the distance from the springs of the Plitvice Lakes (downstream direction).

^{14}C activity in soil, terrestrial and aquatic plants collected in the Plitvice Lakes area



Concluding remarks:

- ^{14}C activity and $\delta^{13}C$ values of different plants collected in the Plitvice Lakes area and their correlation with atmospheric CO_2 and DIC showed which processes and/or sources of carbon were involved in formation of carbon isotope composition of the biosphere of the karst area.
- ^{14}C activity of terrestrial and marsh plants partly submerged in the water followed ^{14}C activity of the atmospheric CO2. Aquatic plants completely submerged in the lake waters showed different ^{14}C activity depending on the sampling location and their $a^{14}C$ correlated with the $a^{14}C$ of DIC, but the values were about10 pMC higher than those of DIC. Top 20 cm of surface soil, represented the average of organic material (humus) deposited in several years and $a^{14}C$ was slightly higher than that of atmospheric CO_2 in the last year.
- $\delta^{13}C$ values of measured samples correlated with the origin of carbon in different materials. For the plants which used atmospheric CO_2 for photosynthesis, terrestrial plants and marsh (sedge), $\delta^{13}C$ values ranged from -31‰ to -27‰. For aquatic plants $\delta^{13}C$ values varied in a wide range from -48‰ to -30‰, showing that the source of carbon was mainly DIC in water. Plants partly consuming CO_2 from atmosphere and partly from DIC, e.g. moss from the waterfalls, have less negative $\delta^{13}C$ values and higher ^{14}C activity than the aquatic plants.



Sampling of:
1. and 2. Water
3. Soil
4. Aquatic plants

Acknowledgement

Research was supporetd by the project with the Plitvice National Park: *Influence of environmental and climate changes on the biologically induced calcite precipitationin in form of tufa of lake sediment at the Plitvice Lakes* (2011-2013).