INTERNATIONAL CONFERENCE ON
MOUNTAINS AND CLIMATE CHANGE

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Mountain waters fragile ecosystem not just water reserve

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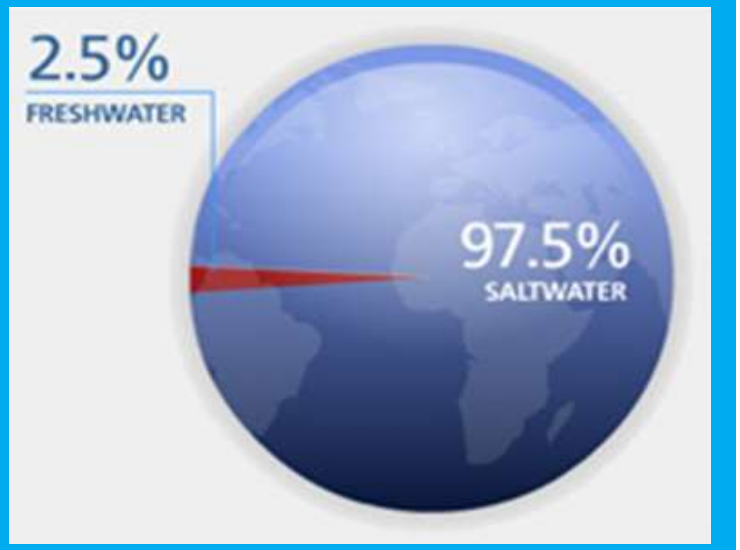
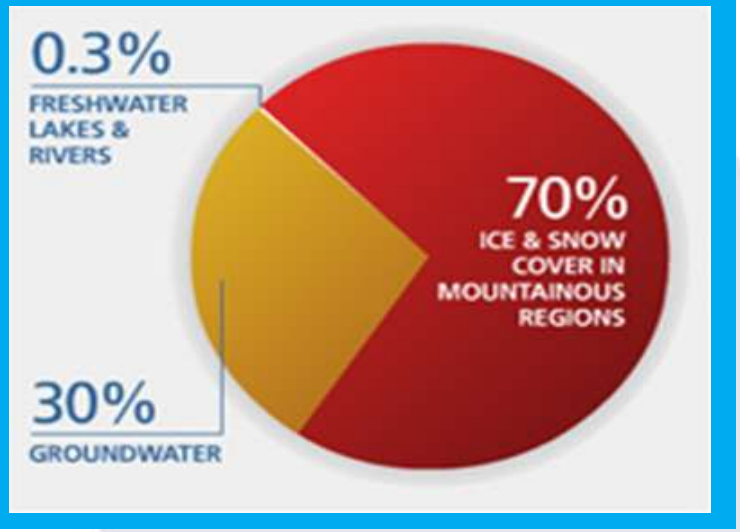
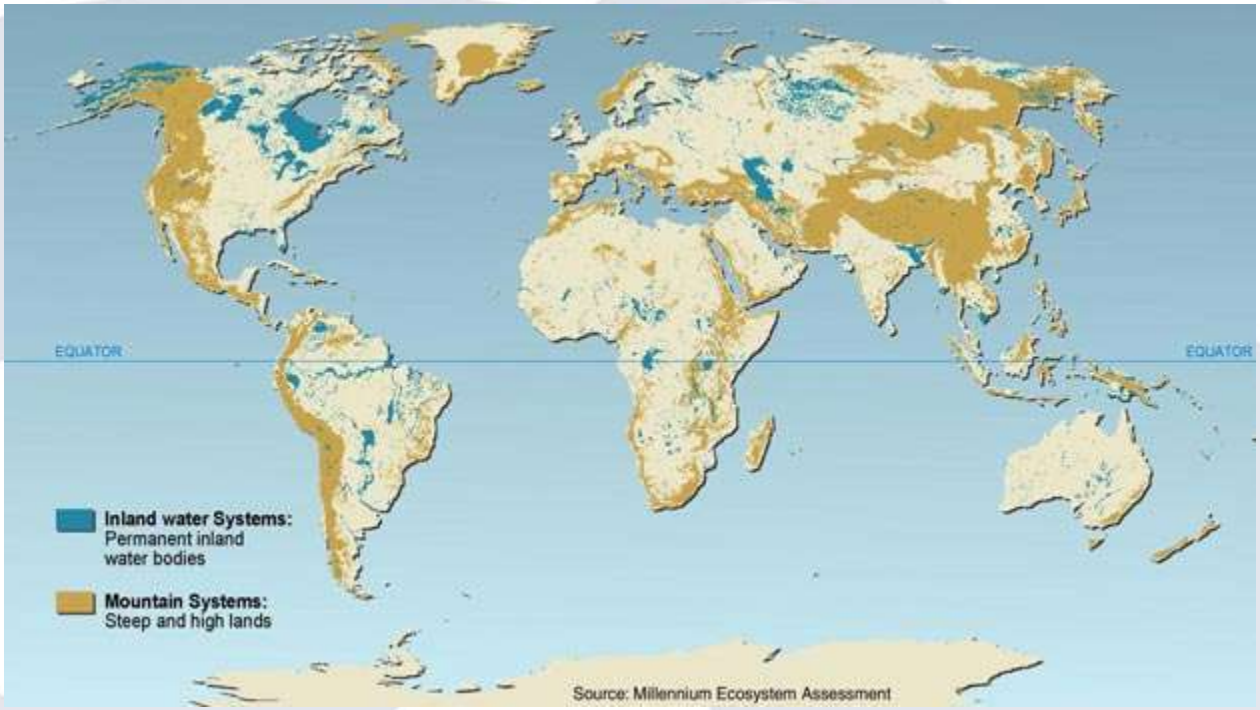
I.S.E

IRSA
CNR

Water world


2.5%
FRESHWATER
97.5%
SALTWATER


0.3%
FRESHWATER
LAKES &
RIVERS
70%
ICE & SNOW
COVER IN
MOUNTAINOUS
REGIONS
30%
GROUNDWATER



Water for People

Mountains capture water from the atmosphere and store it as snow and ice that supplies streams and rivers throughout the year. Half the world's population depends on mountains for their drinking water or hydroelectric power.

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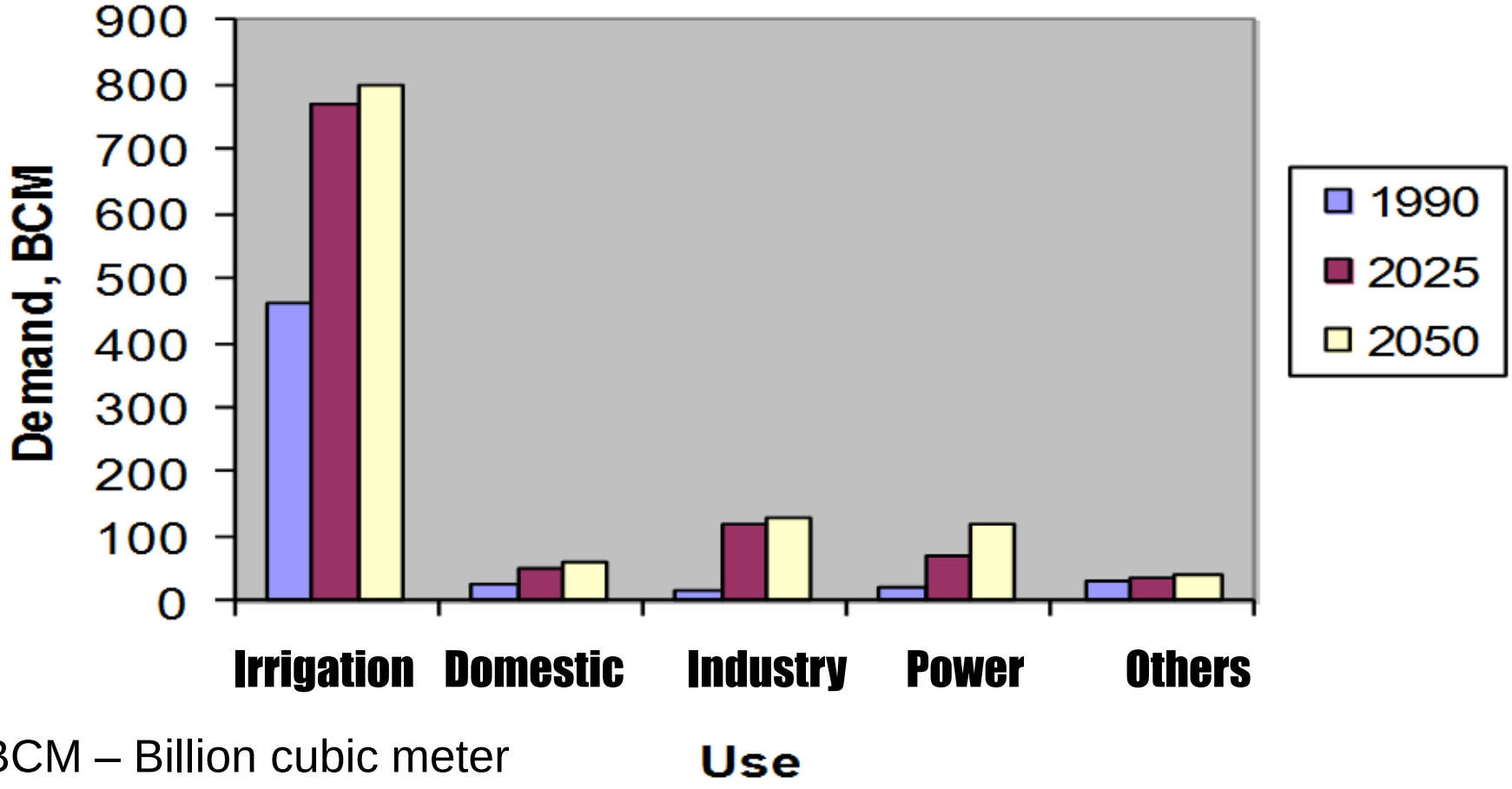
The blue Planet – How come we lack of sufficient Water Supply?

Source: http://true101story.com/wp-content/uploads/2010/04/eath-hands.jpg

???

Source: http://omiusajpic.org/files/2011/05/2935018067_cec6254493.jpg

Water demand: double in the next 40 years



BCM – Billion cubic meter

Increasing Water Scarcity

Drivers:
- Population growth
- Change in living standards
- Uncontrolled pollution
- Climate change

(INFORESOURCES FOCUS 2006)

Growing
water scarcity
in various regions of the world

As of today, **1.2 billion** of the world's population are affected by water scarcity

(WBCSD 2009)

UNEP

Convention on Biological Diversity

….the supply and quality of water are **becoming increasingly insecure** for all uses.

Ecosystems function as a "**natural water infrastructure**".

Degradation of natural infrastructure is often the root cause of disasters and/or contributes to the scale of impacts.

The Rio+20 outcome document ("The Future We Want") highlighted the importance of water to the sustainable development agenda. It also in paragraph 122, made an important leap in understanding: "We recognize the key role that ecosystems play in maintaining water quantity and quality and support actions within respective national boundaries to protect and sustainably manage these ecosystems."

Why studying remote lakes?

They are relevant elements of the mountain landscape, with a primary touristic ad recreational importance and a role as biodiversity pool

Strongly dependent on catchment characteristics (morphology, land cover), they rapidly respond to changes in atmospheric inputs and meteorology

Harsh climatic condition, a long period of ice cover and the low nutrient levels act as limiting factors for primary production

Trophic webs are relatively simple with respect to low altitude lakes, so that alpine lakes are often used as “natural laboratories” to test ecological theories

Remote lakes as early-warning indicators

Not affected by direct anthropogenic forcings (e.g. waste water discharge, agriculture)

Subject to the deposition of pollutants transported with air masses from industrialised areas in the lowlands

The vulnerability of mountain lakes makes them suitable "early warning" indicators of changes in atmospheric deposition of air pollutants and in the regional climate

Forcings

- ✓ Acidification
- ✓ Climate change
- ✓ Deposition of organic pollutants and heavy metals
- ✓ Excess of N input from the atmosphere

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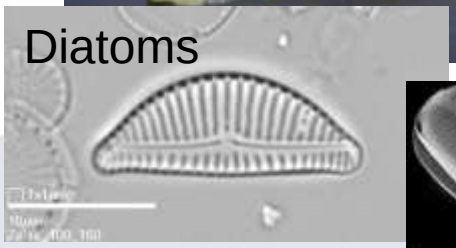
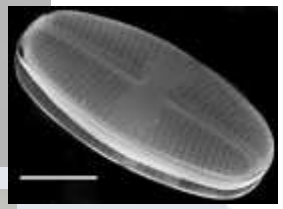
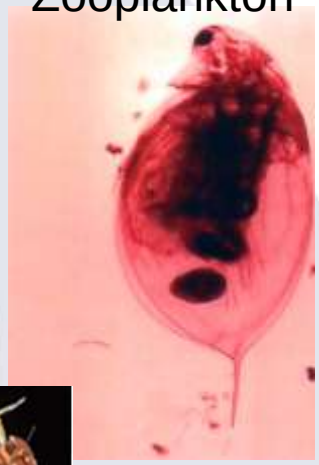
Variables







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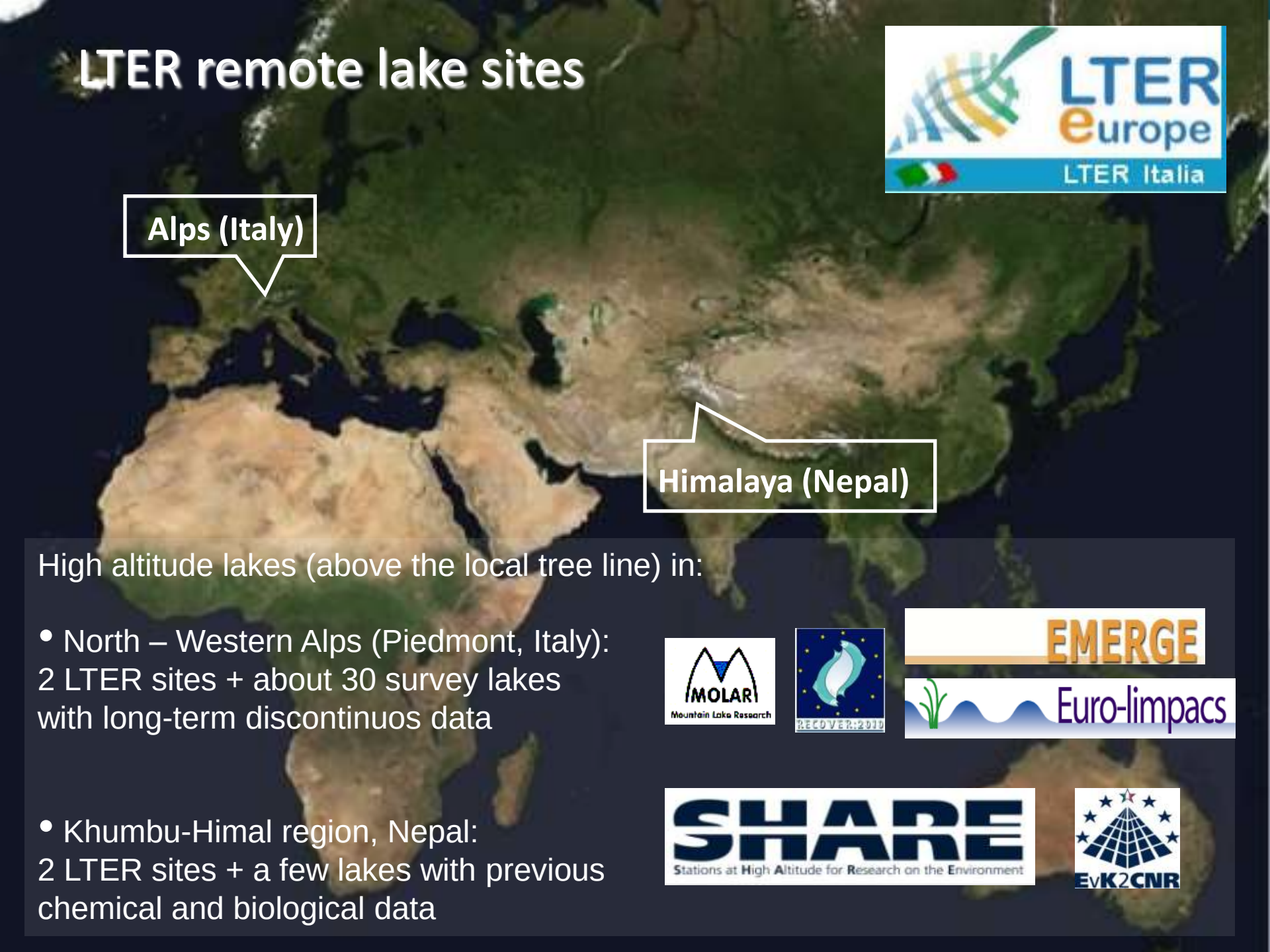
LTER remote lake sites



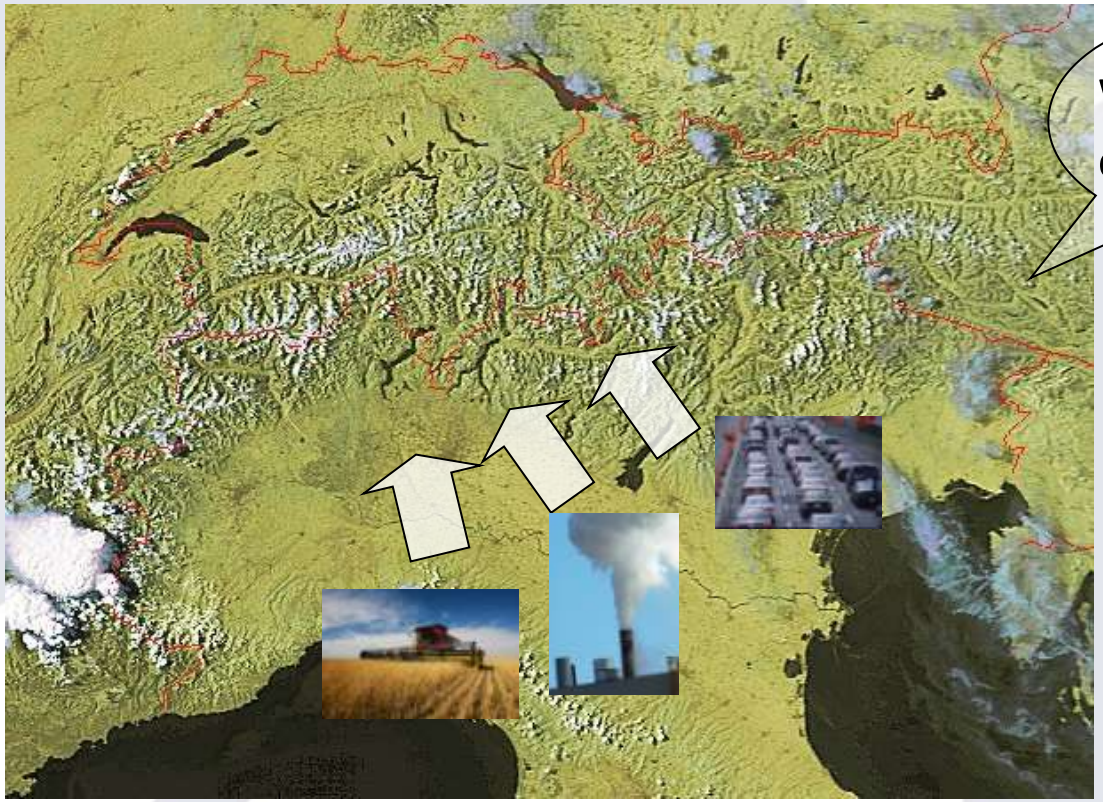
High altitude lakes (above the local tree line) in:

- North – Western Alps (Piedmont, Italy):
2 LTER sites + about 30 survey lakes
with long-term discontinuos data

- Khumbu-Himal region, Nepal:
2 LTER sites + a few lakes with previous
chemical and biological data

Long-range trasboundary air pollution

Air pollutants can be trasported for hundreds of kilometers from source areas in the lowlands (e.g. the Po Plain in Italy) to remote areas, and here deposited trough rain and snow



What happens on the Alps?

High concentration of air pollutants
+
High amount of precipitation
=
High deposition of pollutants

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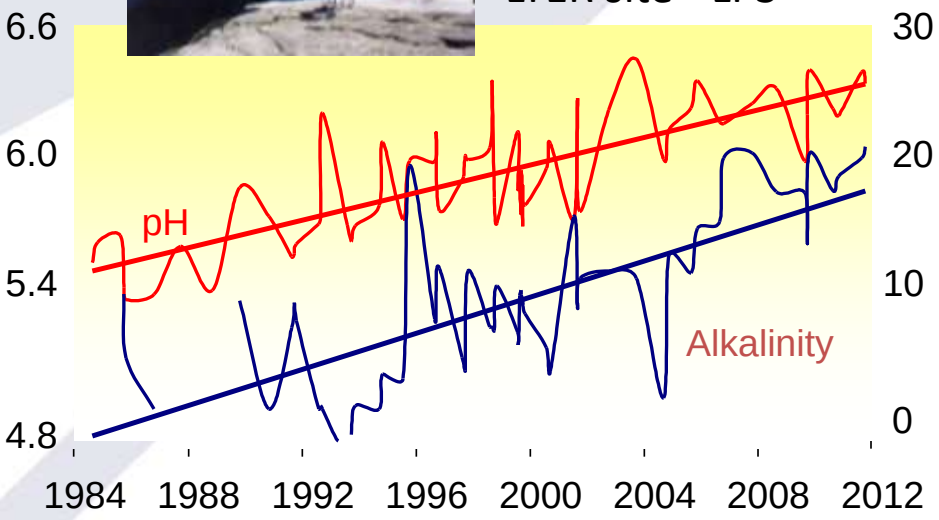
Acidification recovery of mountain lakes: a success story

Emission reduction



Deposition are no more acidic, thanks to the reduction in the emission of S and N oxides into the atmosphere.

However, they are still a vehicle of pollutants (trace metals, POPs, nitrogen compounds) to remote ecosystems

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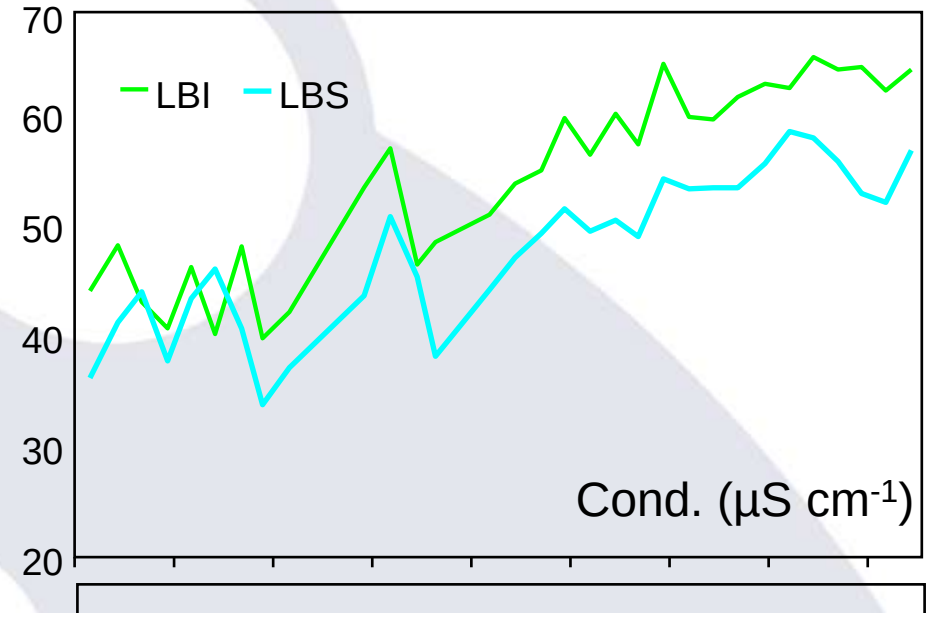
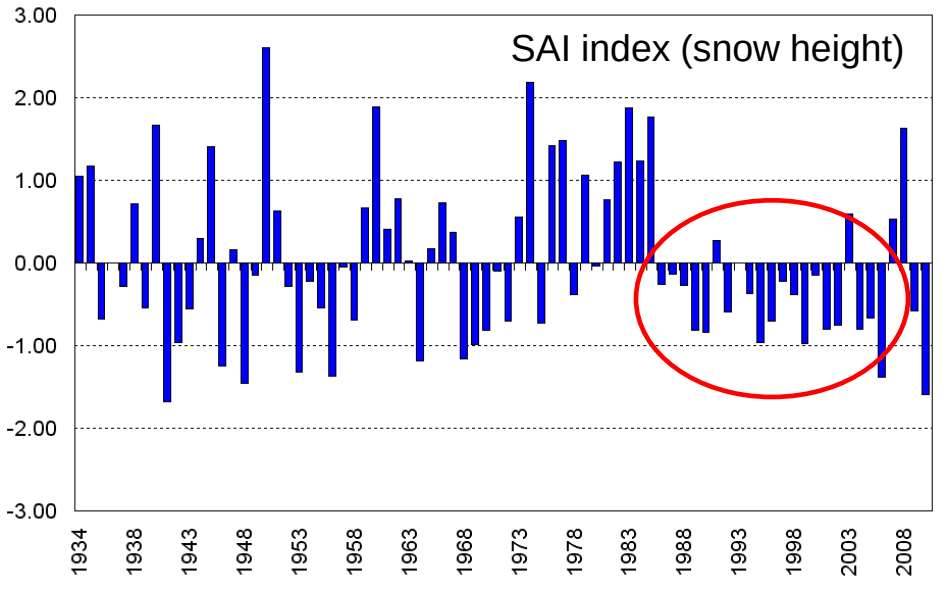
Long-term changes at mountain lakes - Climate change





Increasing solute content in the lakes due to enhanced weathering rates and solute export from the catchment

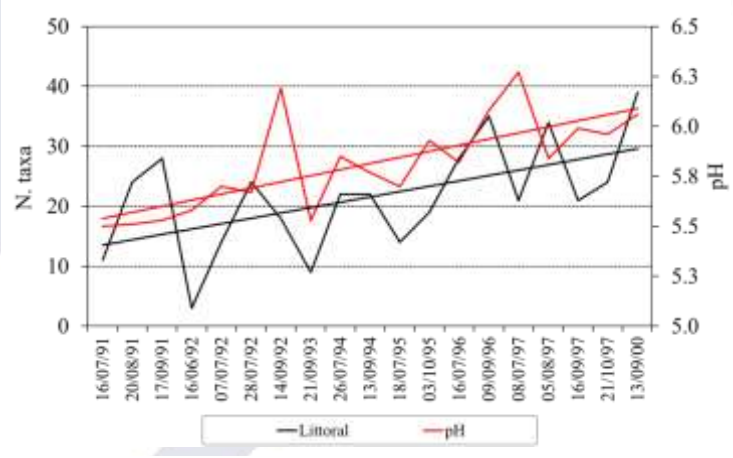
An indirect effect (less snow on the ground, both as amount and duration) of climate warming is probably the main factor responsible for these changes

Rogora et al. 2003. Water Air, soil pollution

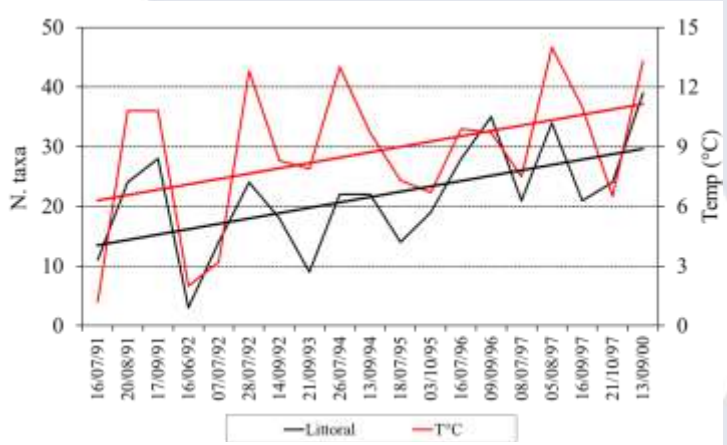
Long-term researches on macroinvertebrates

The effects of anthropogenic pressures (e.g. acidification, climate change) on macroinvertebrates are analyzed through the disappearance of more sensitive and the appearance of more tolerant taxa

Non-biting midges are mainly used in these studies, because they proved to be powerful bioindicators among aquatic insects



Recovery of macroinvertebrates diversity from acidification



Increase in macroinvertebrates taxa as a result of increased temperatures

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Pyramid Lakes, Khumbu Valley, Himalayas (Nepal) – LTER IT011

Upper Pyramid Lake (LCN9, 5213 m a.s.l.)

Lower Pyramid Lake (LCN10, 5067 m a.s.l.)

Long-term chemical and biological data (zooplankton, benthos) since 1990
+ palaeolimnological studies

EvK2CNR

SHARE
Stations at High Altitude for Research on the Environment

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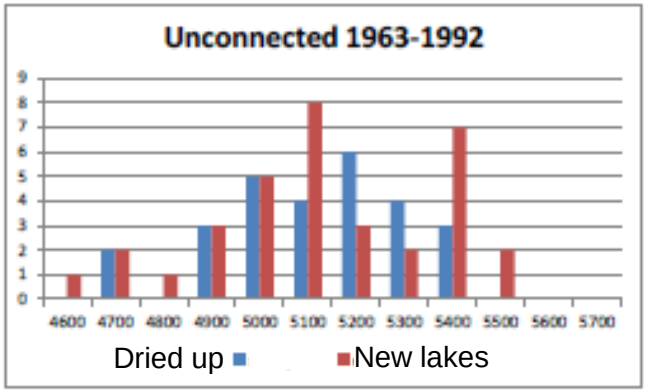

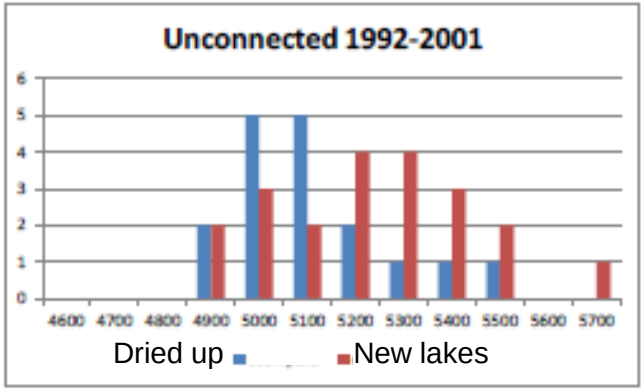

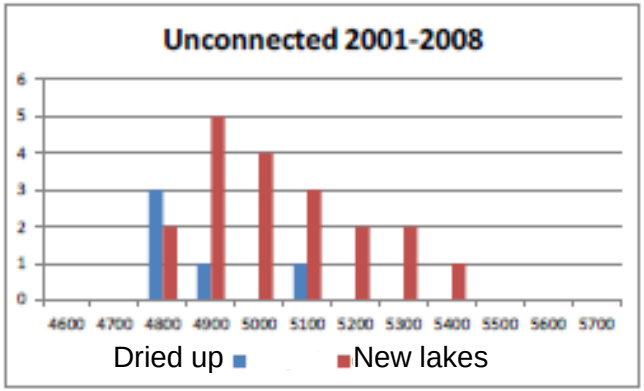

Remote lakes as early-warning indicators

The distribution of lakes in the Sagarmatha reconstructed from satellite images analysis shows a marked changes over a period of 40 years, an increase in the formation of new lakes due to glaciers withdrawal and melting

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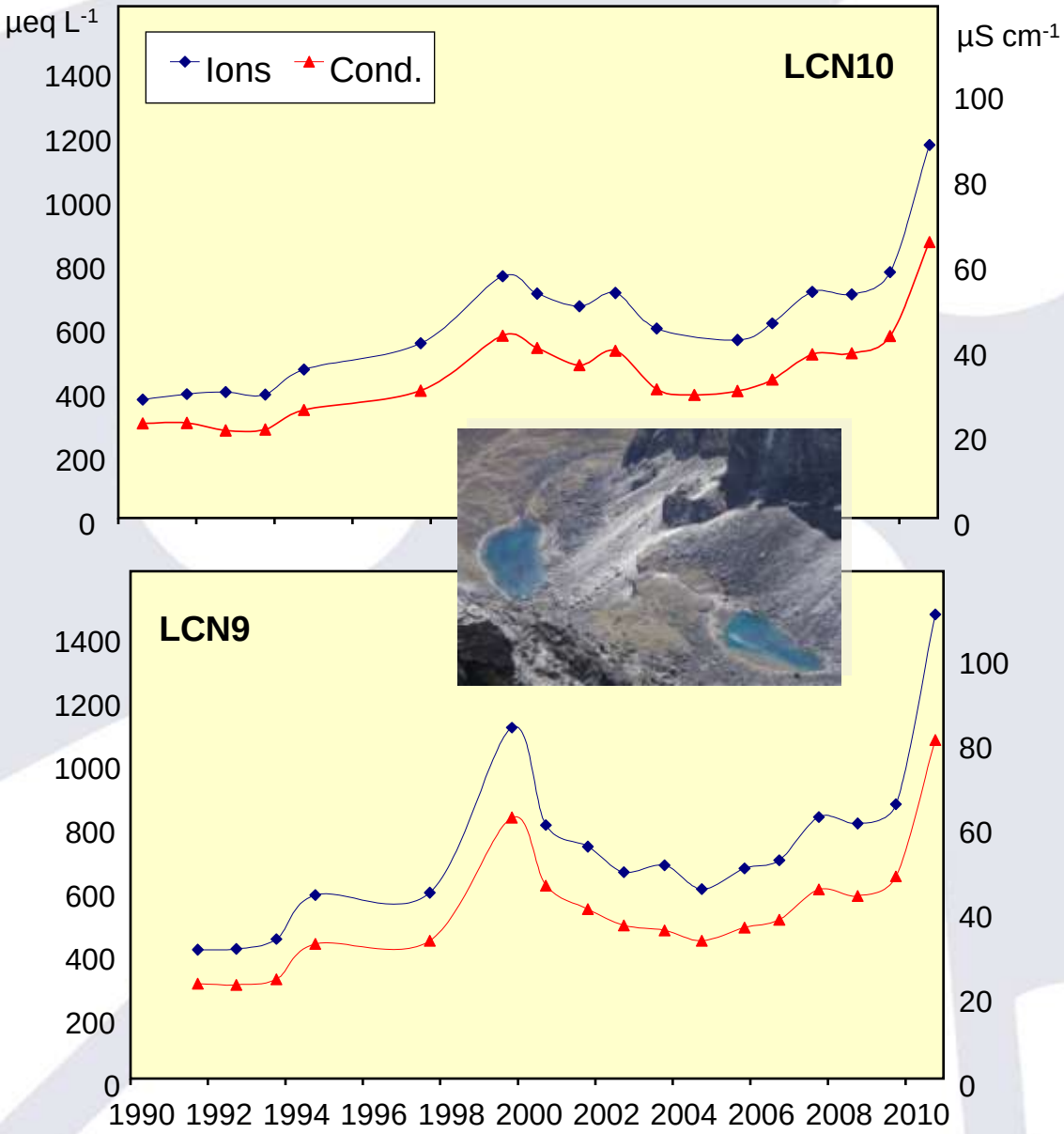
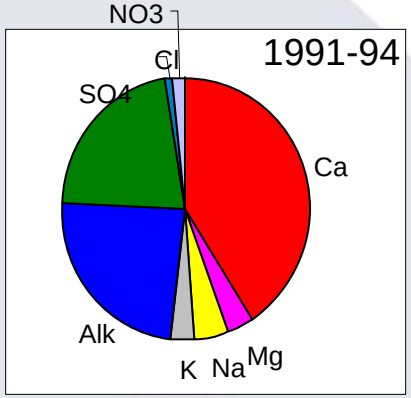
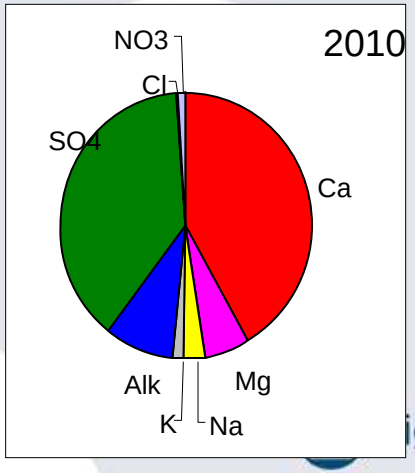
Long term changes in the chemistry of Pyramid lakes



Major ions and conductivity are increasing in the lakes, and even the relative proportion of ions is changing





Long-term researches on zooplankton at Pyramid Lakes

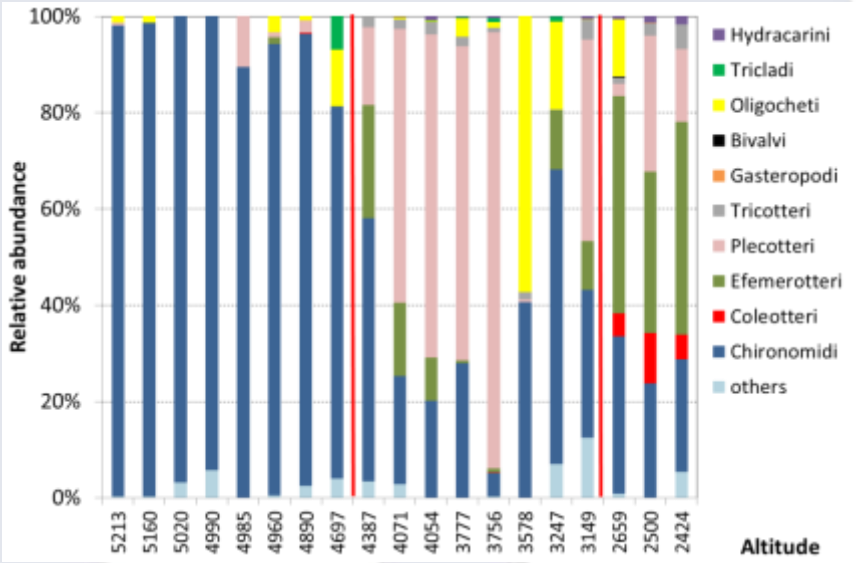
Investigation on the life cycle and the autoecology of zooplankton to increase our knowledge on their vulnerability to environmental change and on adaptation mechanisms

Evaluation of the potential represented by the “egg banks”: the diapausing egg bank can influence the rate and direction of population, community, and ecosystem response to climatic change

Viable *H. bulgarica* resting egg recovered from the topmost 2 cm section of the sediment core Lake CDN70 94/1, as old as 35 years

Manca et al. 2006. J. Limnol.

Spatial distribution of riverine macroinvertebrates - Khumbu Valley, Himalayas (Nepal)



Glacier retreat and altered thermal and hydrological regime of rivers and streams are one of the main cause of potential biodiversity loss where cold-stenothermal invertebrate fauna is threatened by extinction.

Stream fauna of Nepal was studied considering altitudinal gradients, and streams with different origin (glacier-fed and snow-fed, outlets and inlets of lakes), in relation to physico-chemical features.

Taxonomic richness and relative abundance are changing in relation to the decrease of meltwater (snow- and glacier-melt) contributions to rivers and as a consequence to the decrease of altitude.

These systems are clean and uncontaminated waters, and may therefore be used by local populations as adequate supply of drinking water.

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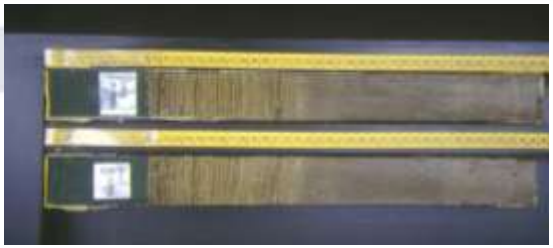
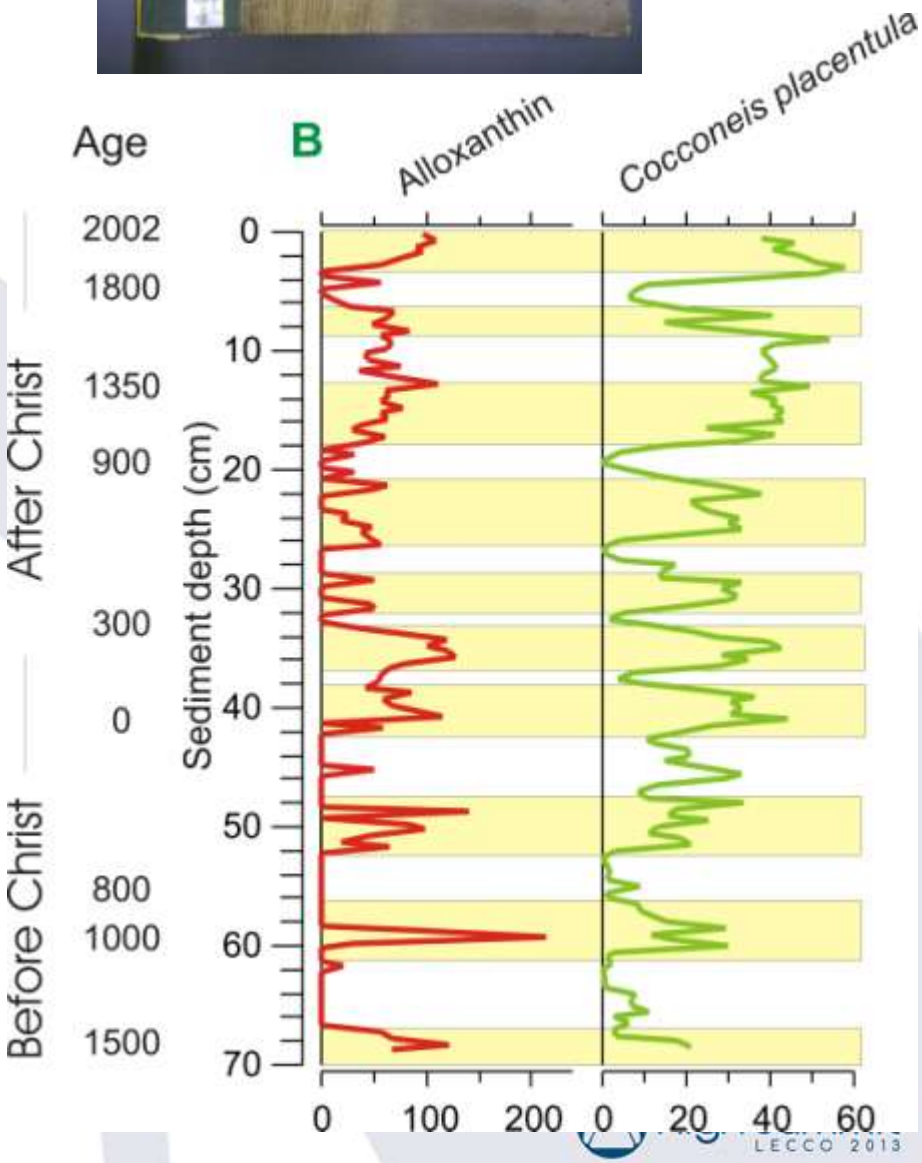
Palaelimnological studies at Pyramid lakes

Schematic reconstruction of different climatic phases as recorded from a diatom and an algal carotenoid





The two proxies are strongly correlated and their values are high during warmer climatic periods. The data confirmed a period of recent warming.

Paleolimnological results support the evidence of a strong variability in lake chemistry, which in turn drives the variability in lake production and the composition of algal assemblages

Message to take home

The lakes clearly respond to changes in atmospheric deposition chemistry, so that they can be used to assess the effects of measures for emission reductions (e.g. international protocols)

The lakes are also sensitive to climate change. Snow cover is an important driving factor, together with temperature change (affecting ice cover duration, weathering rates, biological processes in soil and water)

While model-drawing scenarios of change for temperature, precipitation, water availability and sea level rise are increasingly more accurate and spatially defined, we know very little about the potential for species adaptation and the expected changes in species distribution, overall biodiversity and its organization.

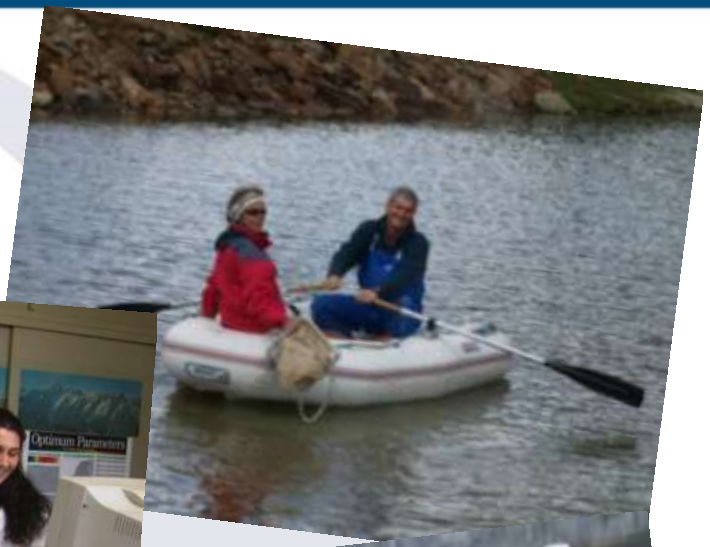
There is a need for maintaining long-term ecological research at remote sites, including biological investigation, to detect possible effects of anthropogenic pressures on biodiversity and ecosystem services

Thanks to:

The staff of CNR ISE and CNR IRSA

The staff at the Ev-K2-CNR Pyramid Observatory

… and all the people involved in sampling and field work



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Thanks for your attention