



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT OF A CROSS-BORDER
MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention

The impacts of climate change on ecosystems and biosphere

Roberta Bottarin

Institute for Alpine Environment, EURAC research, Bozen/Bolzano (I)

Alpine Spring Festival , March 2013

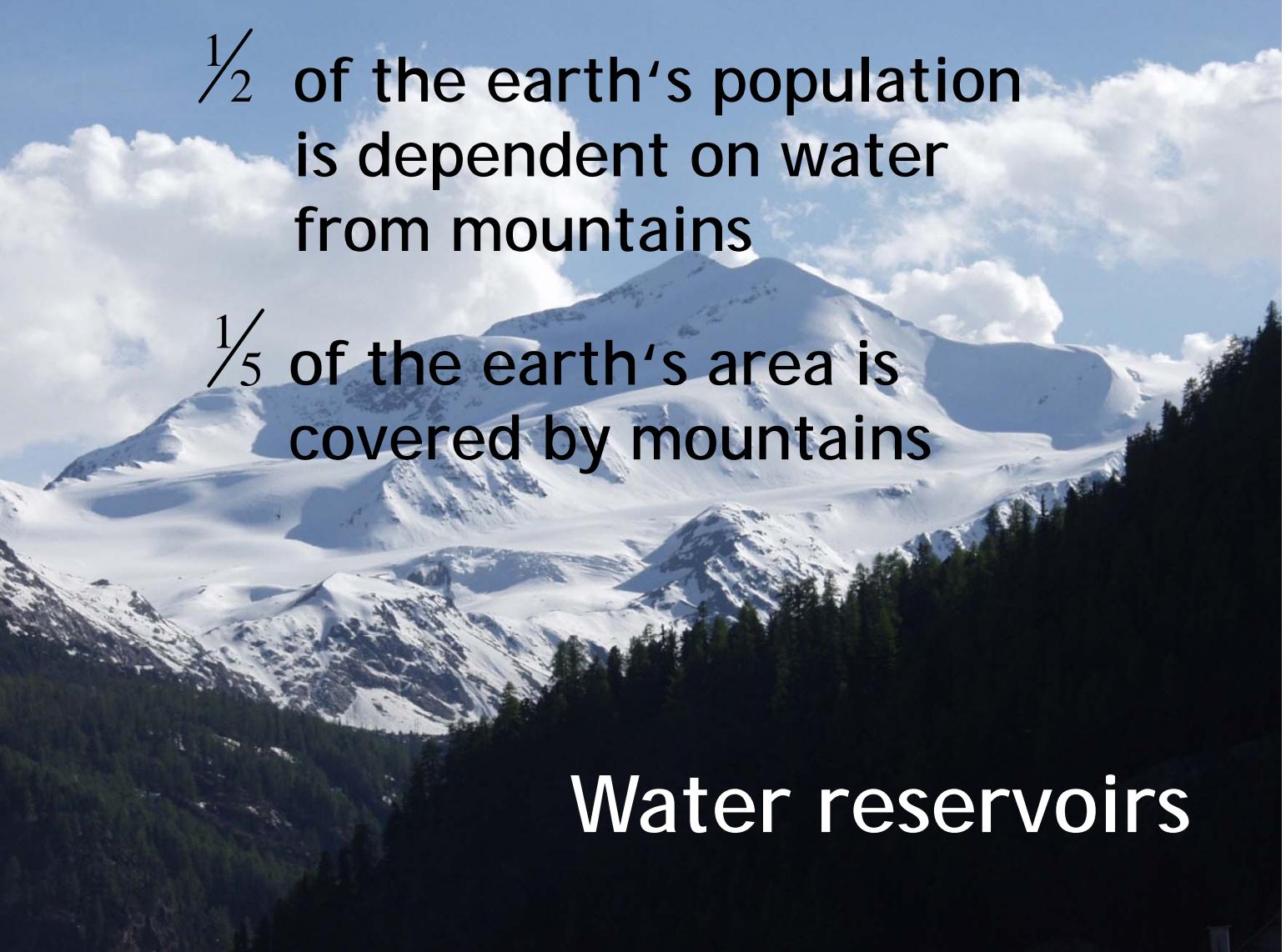


ALPINE CONVENTION

Permanent Secretariat of the Alpine Convention

info@alpconv.org

www.alpconv.org



$\frac{1}{2}$ of the earth's population
is dependent on water
from mountains

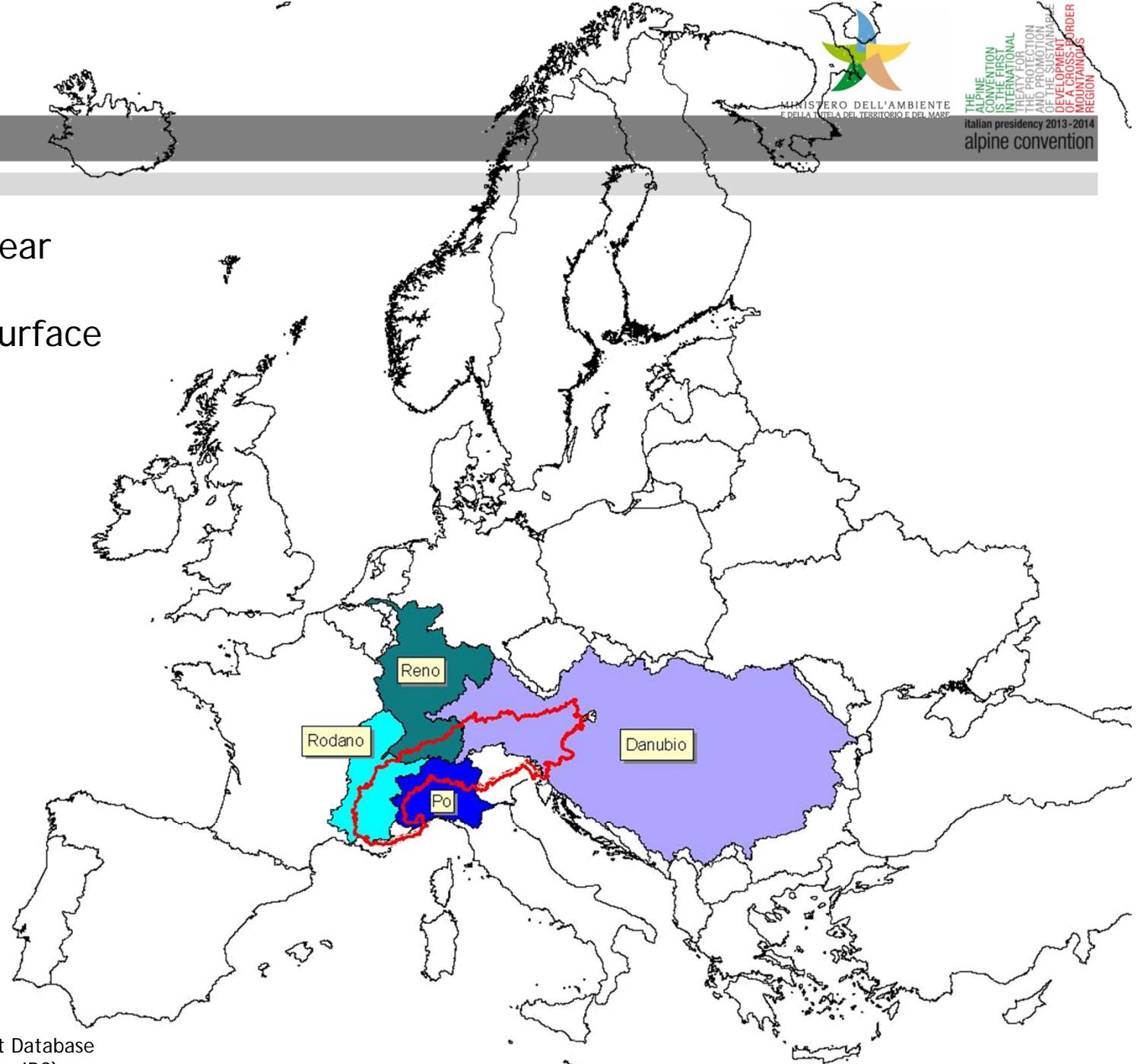
$\frac{1}{5}$ of the earth's area is
covered by mountains

Water reservoirs

200 billion m³ / year

1.160.000 km²

21% of Europe's surface



Source: COR River and Catchment Database
JRC/LMU © European Commission - JRC



THE ALPINE CONVENTION IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS- BORDER MOUNTAIN REGION
Italian presidency 2013-2014 alpine convention

The Alps



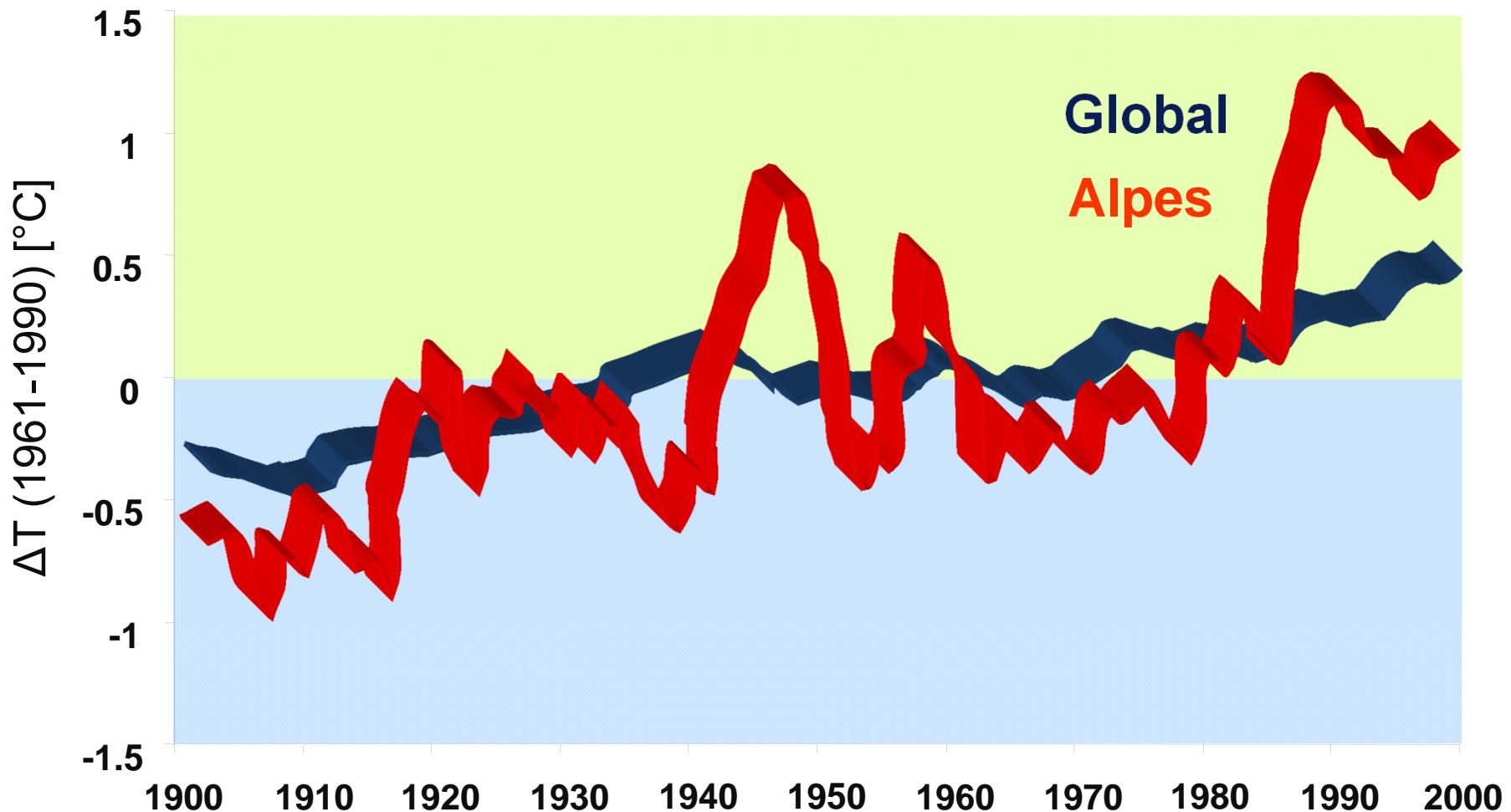
MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention

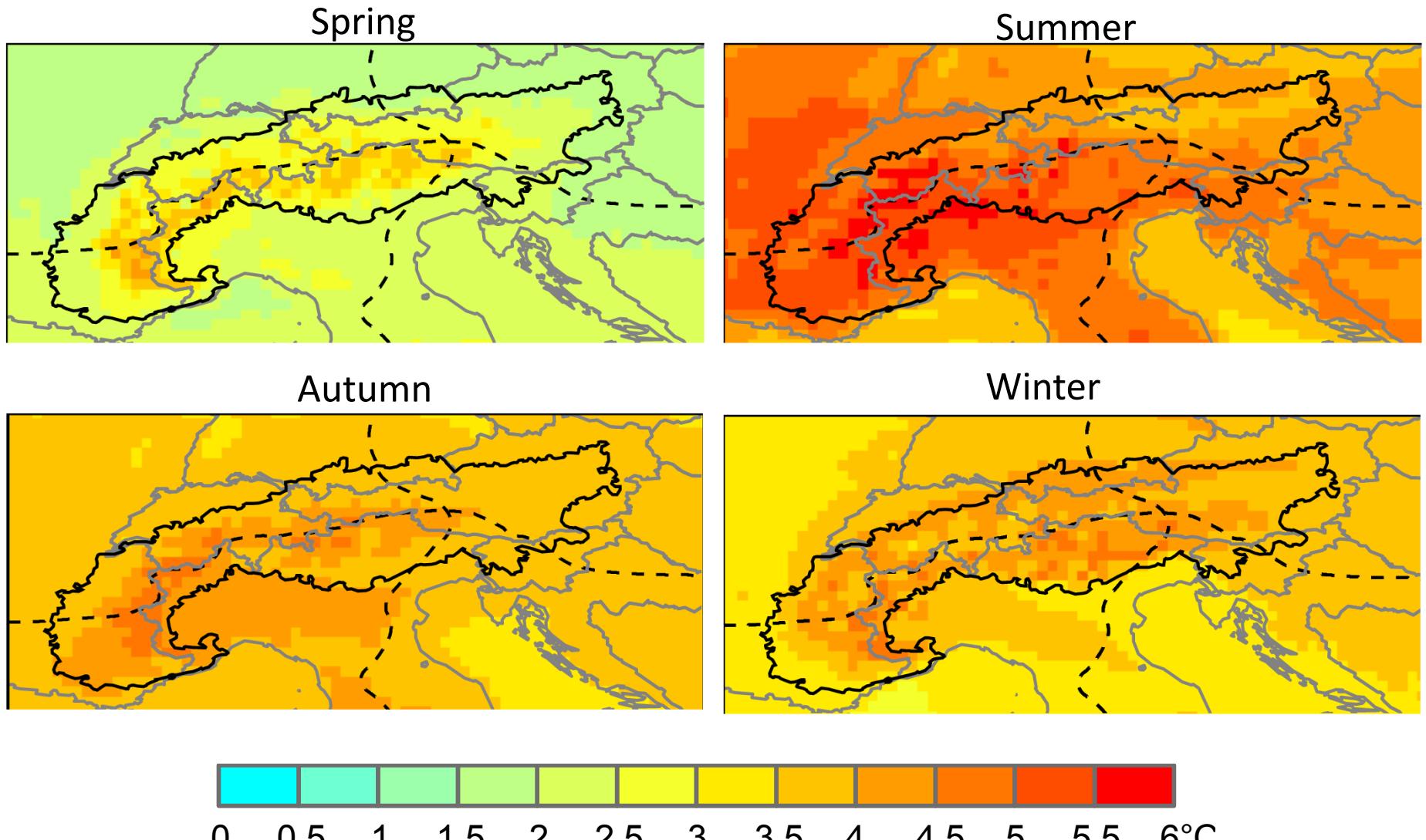
10,000 km of water courses

7,300,000 km

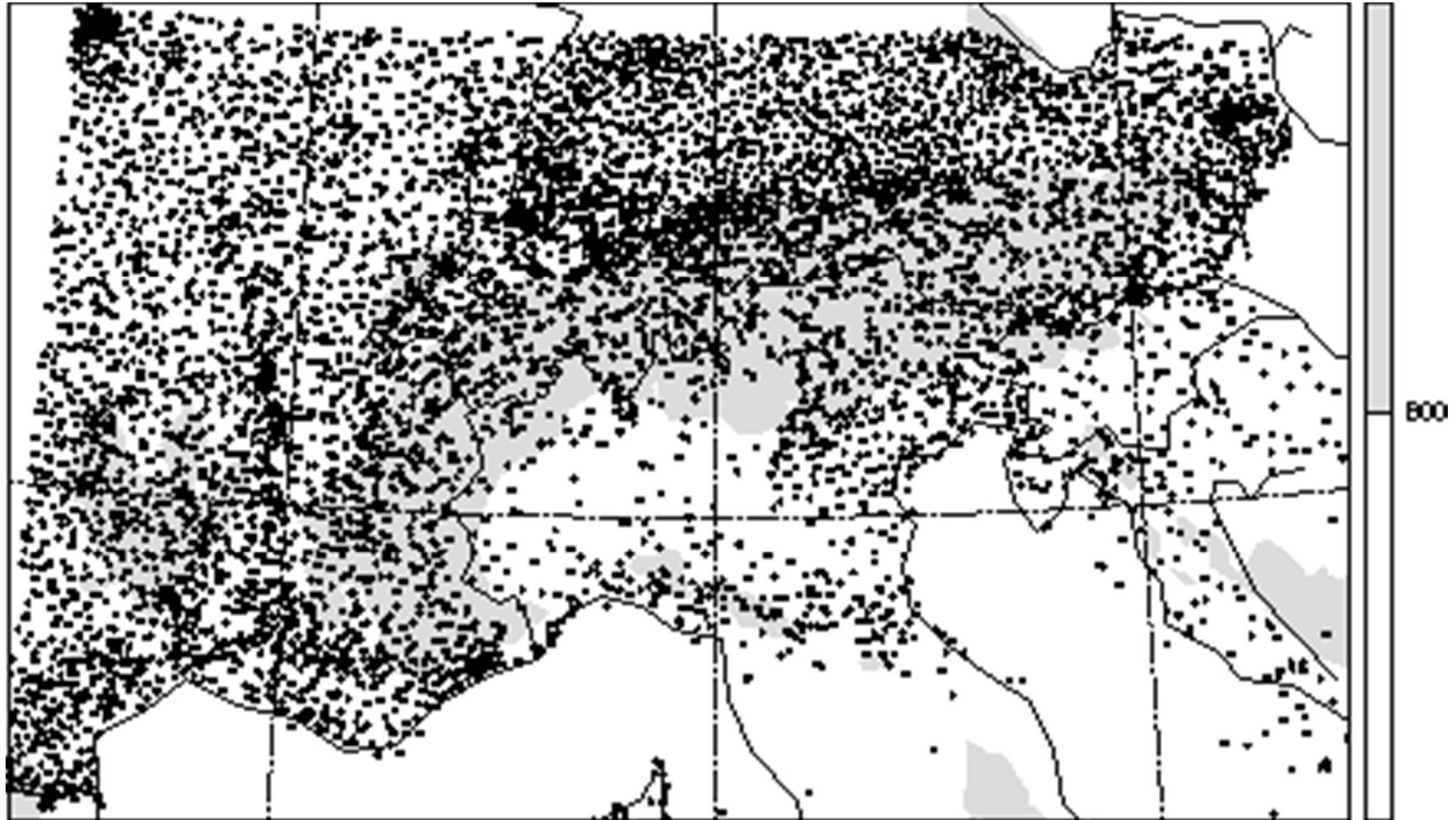




Future scenarios: temperature increase (2071-2100)

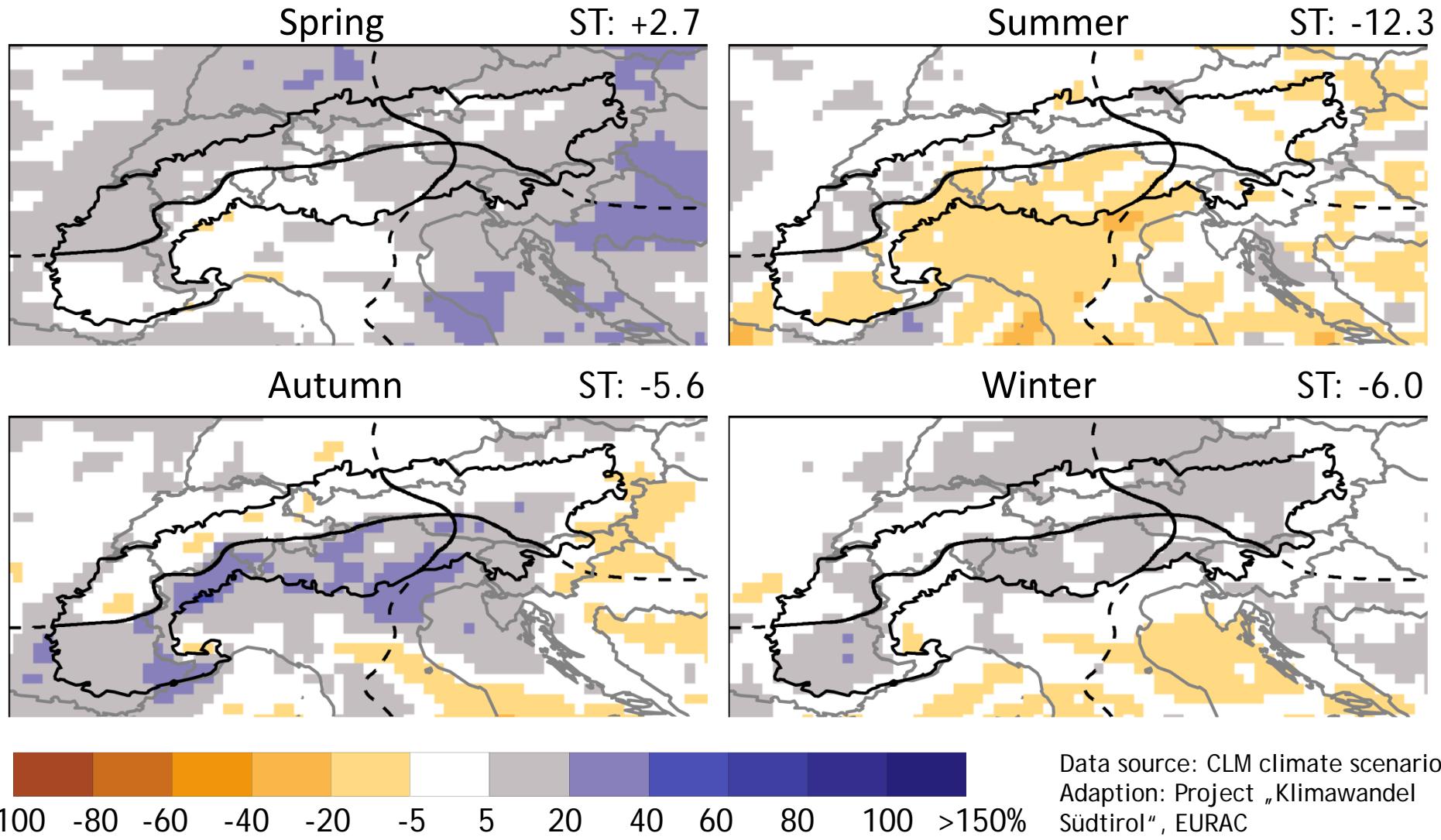


Source: CLM climate scenarios



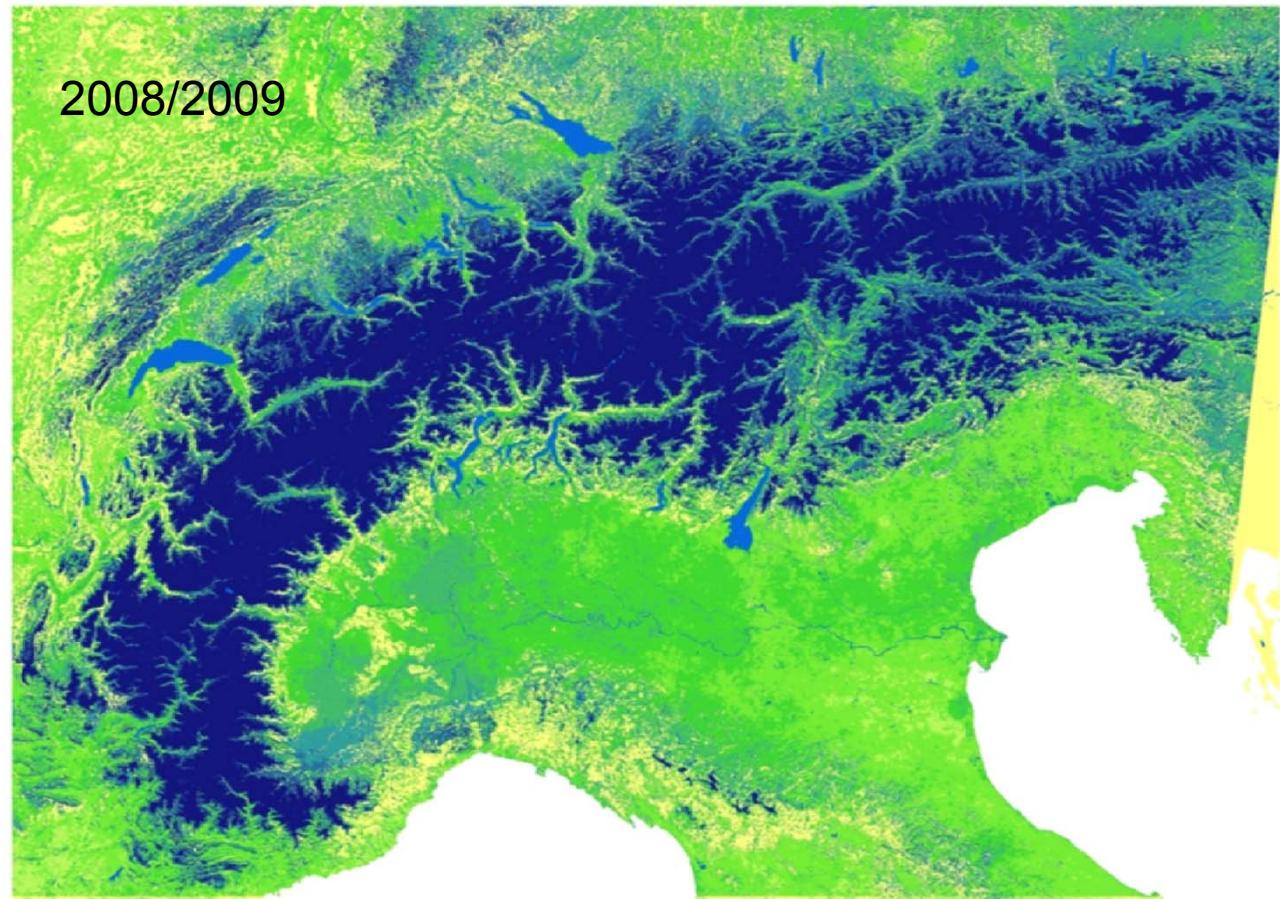
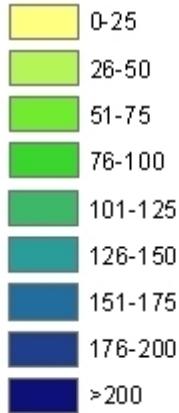
Future scenarios: changes in precipitation 2031-2061 [%]

R. Bottarin

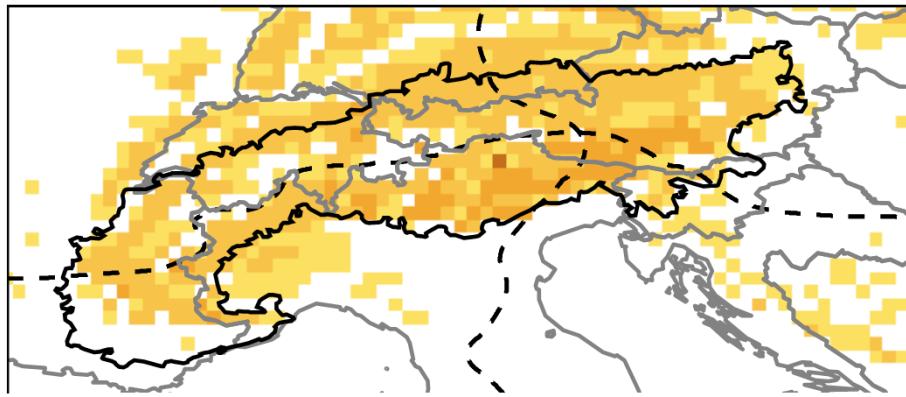


Snow Cover Duration

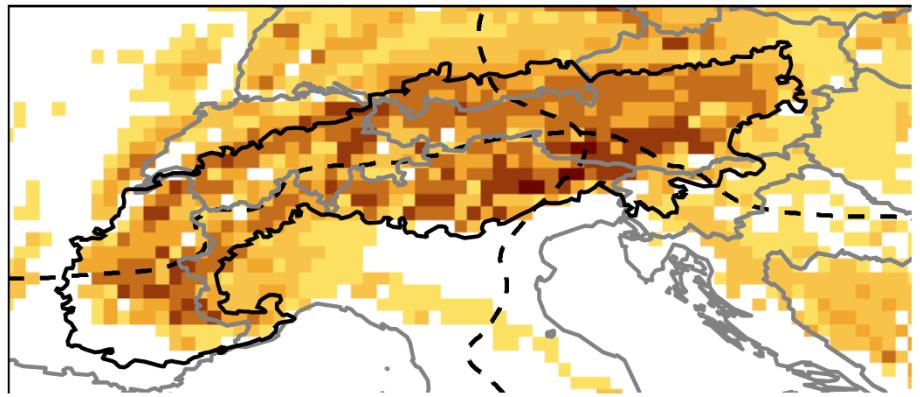
R. Bottarin

Snow Cover Duration

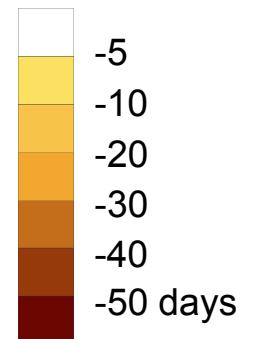
Future scenarios: reduction in snow cover duration (days)



2031 – 2061



2071 – 2100



Rise of snowline ca. 150m per 1° C

Reduction in snow volume in the Alps assuming $+4^{\circ}$ C:

-90% - 1000m

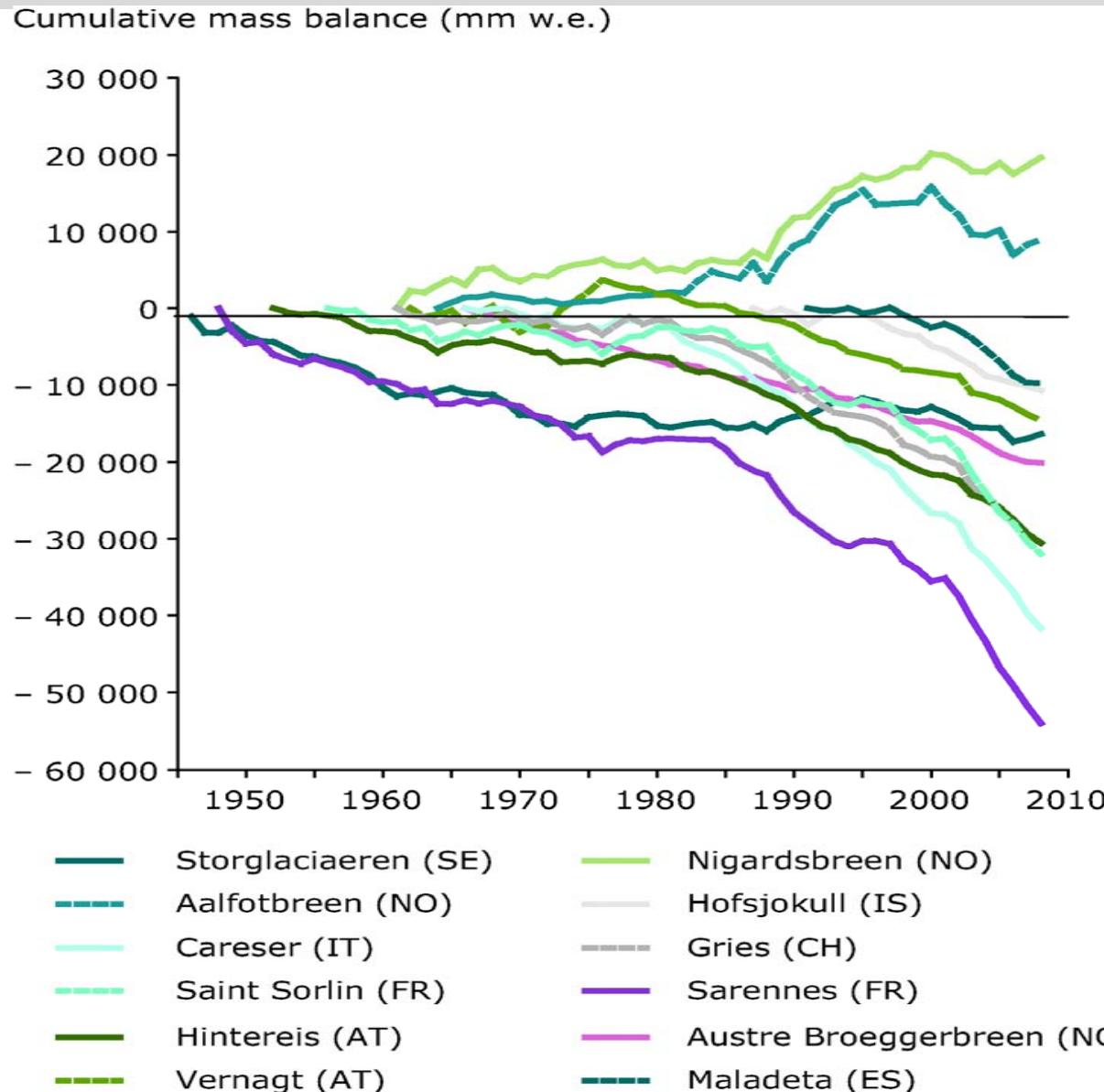
-50% - 2000m

-35% - 3000m (Beniston, 2003)

Source: CLM climate scenarios

Retreat of glaciers

R. Bottarin



Retreat of glaciers: Tschierva Glacier (Engadine, Switzerland)

R. Bottarin



Photo: Max Maisch
University of Zurich, Switzerland

Rock glaciers/permafrost

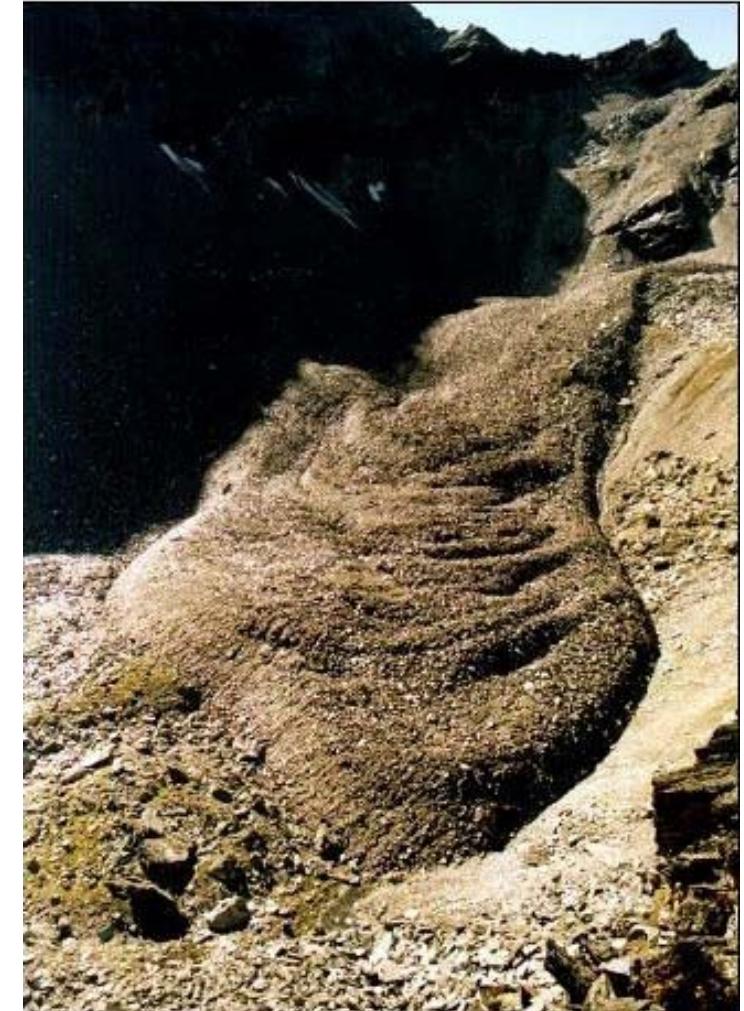


MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT OF A CROSS-BORDER
MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention

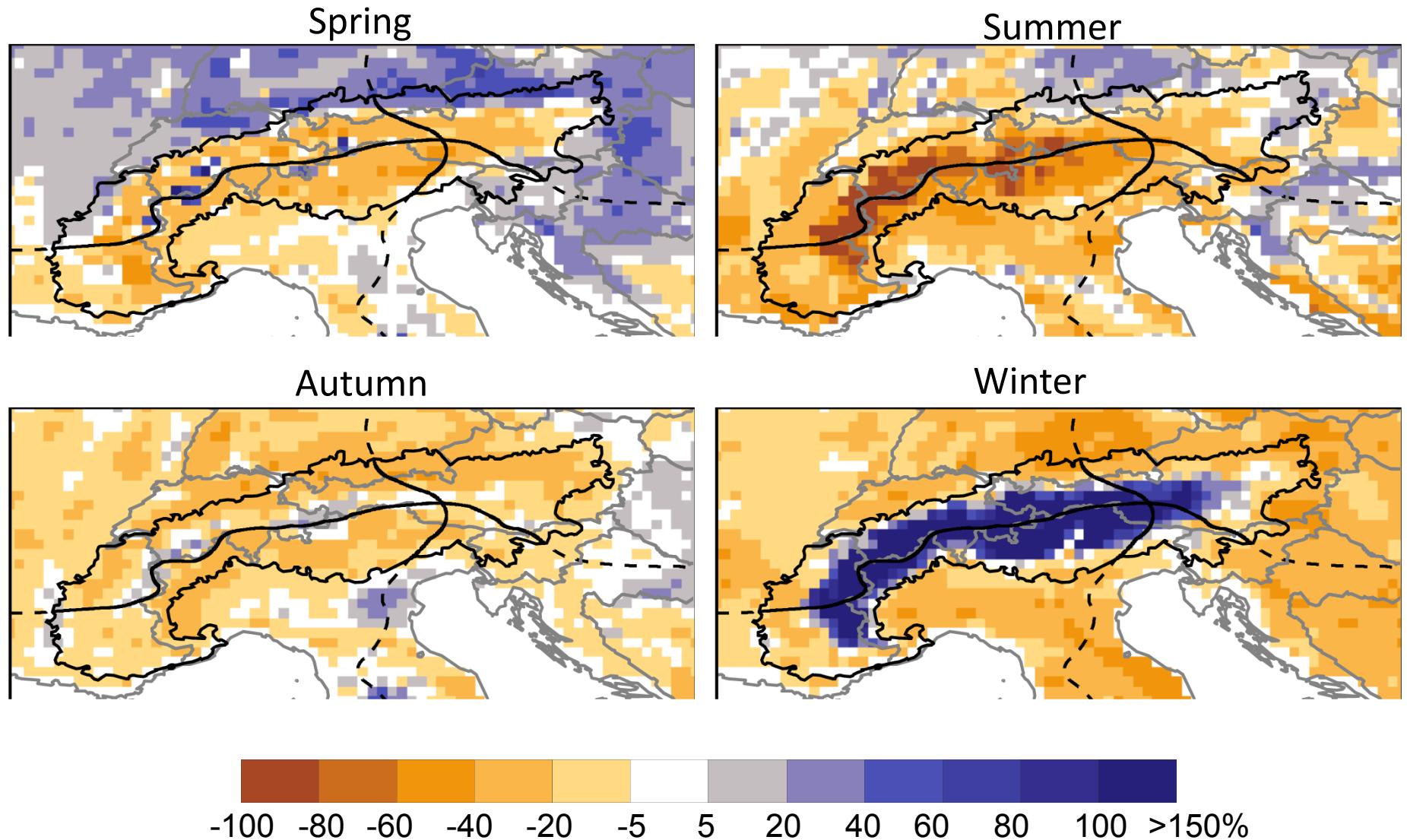


Active rock glacier in Muragl valley
© Christine Rothenbühler, Academia Engiadina



© V. Mair, rock glacier in the upper Rosim valley, Martell valley

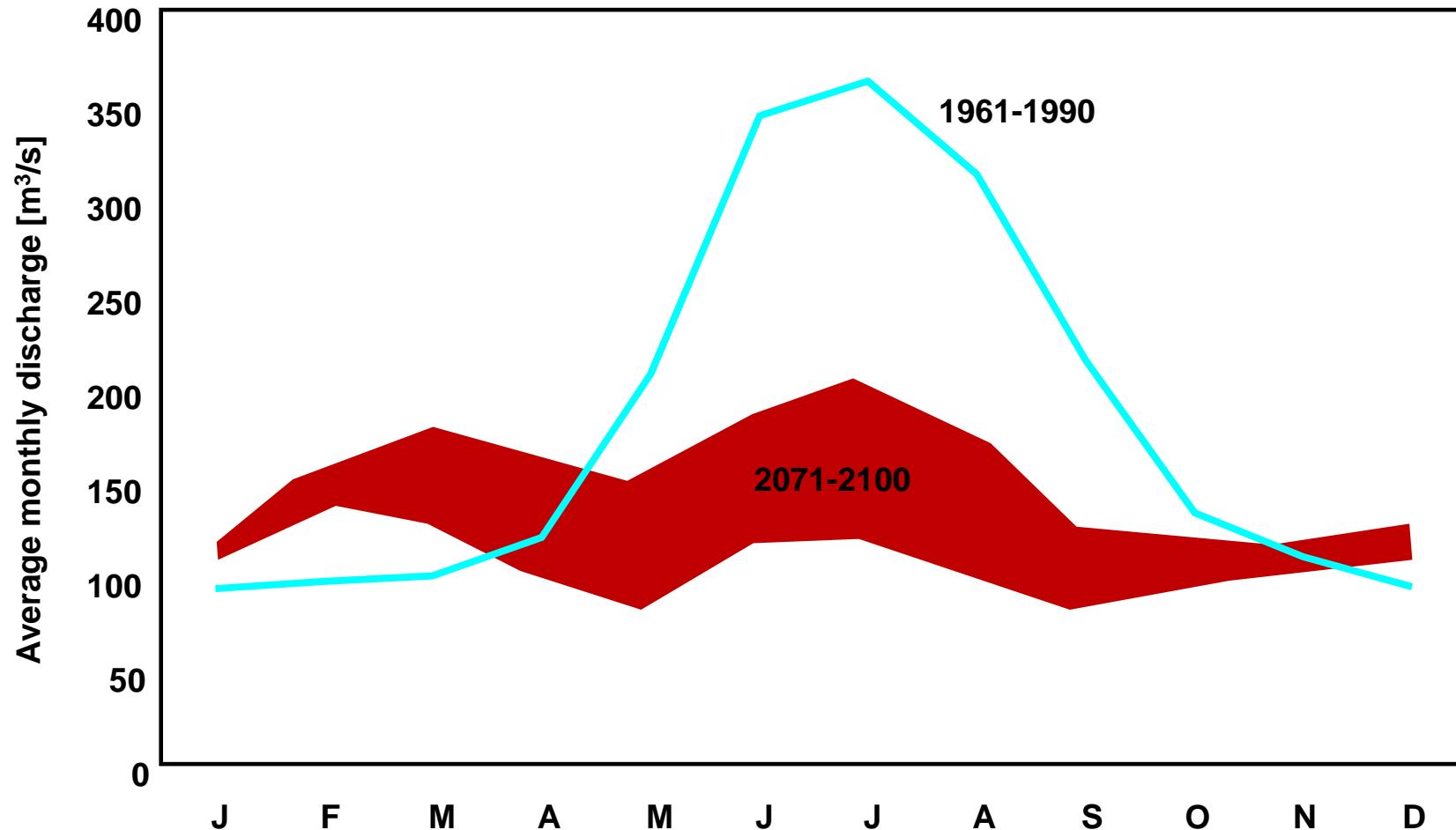
R. Bottarin



Source: CLM climate scenarios

Discharge: the example of the river Rhône

R. Bottarin

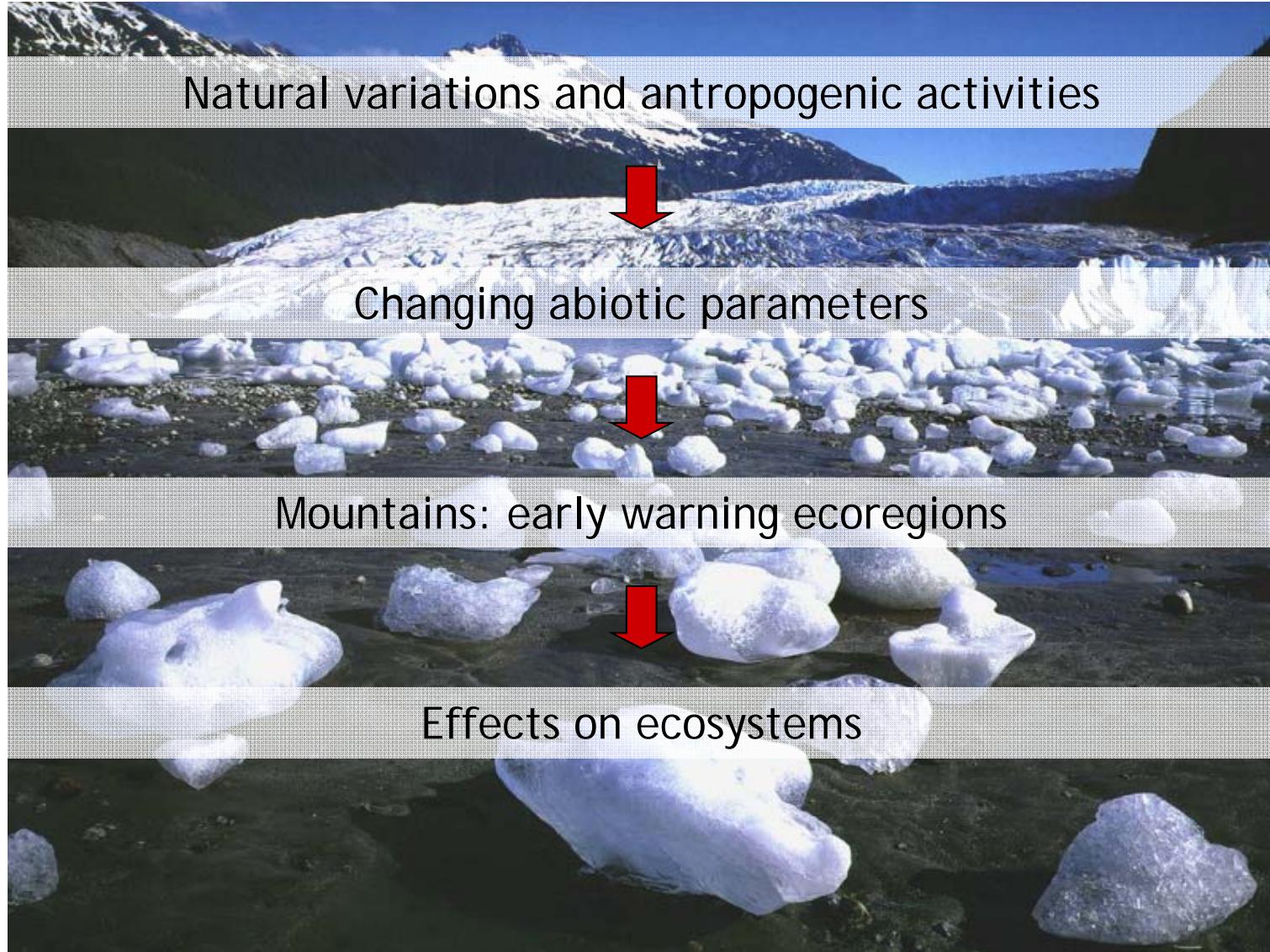


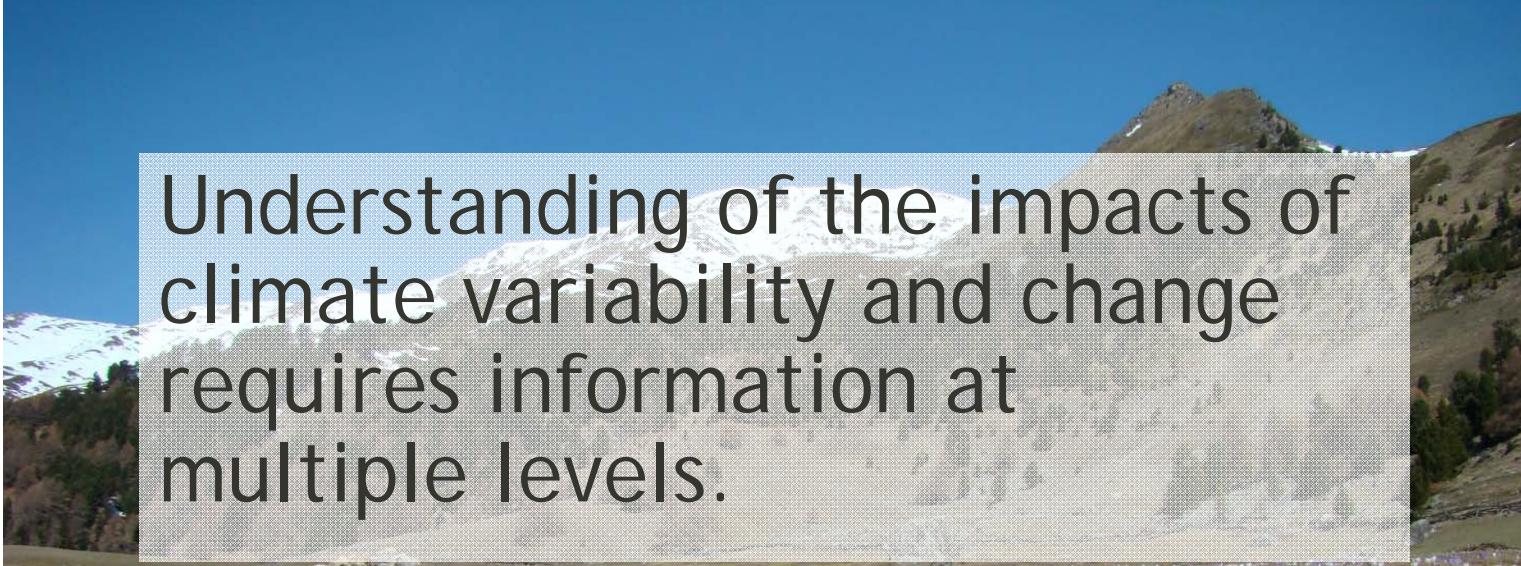
Source: Beniston, 2010

R. Bottarin



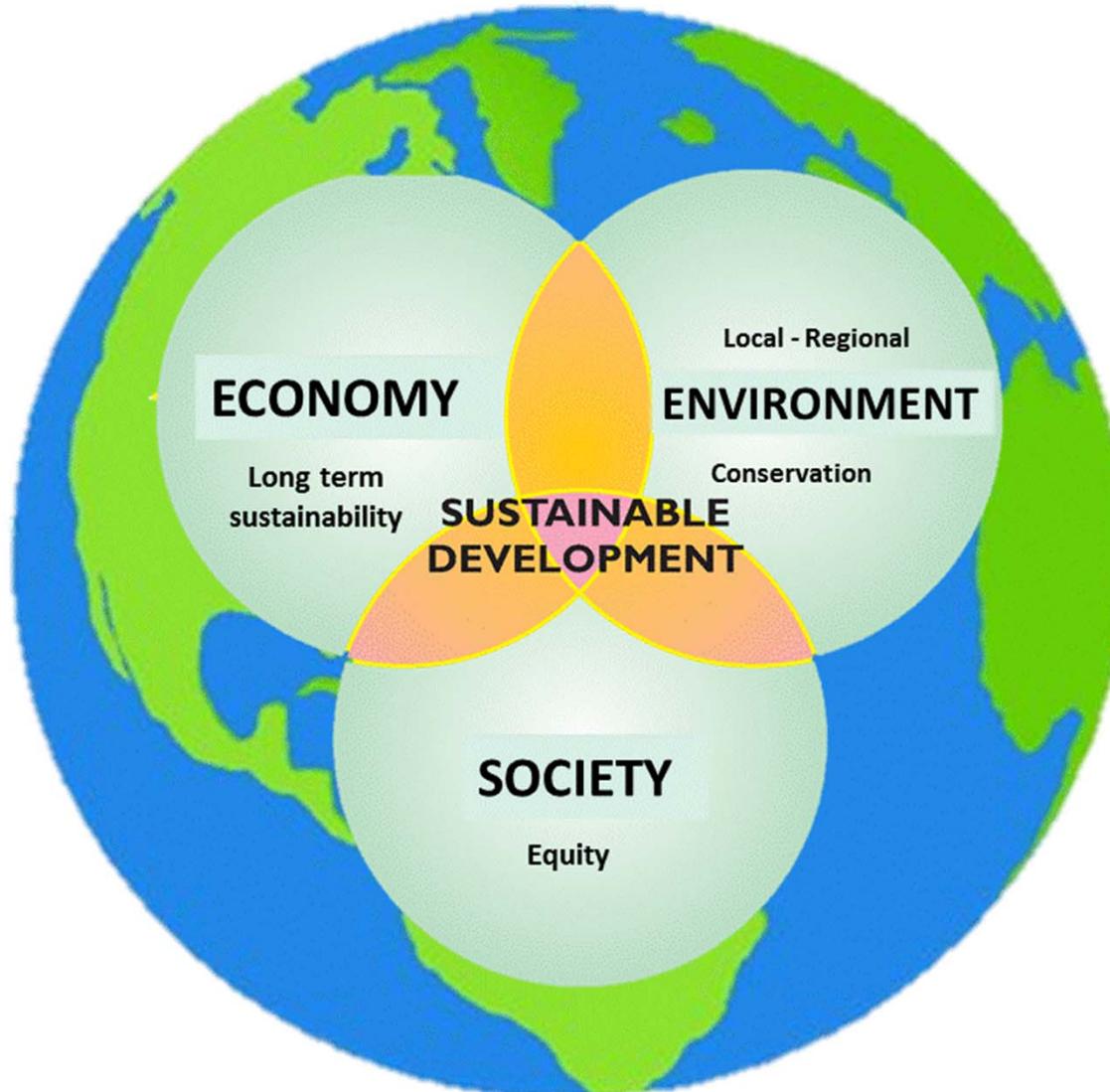
Photo: G. Niedrist, EURAC





Understanding of the impacts of climate variability and change requires information at multiple levels.





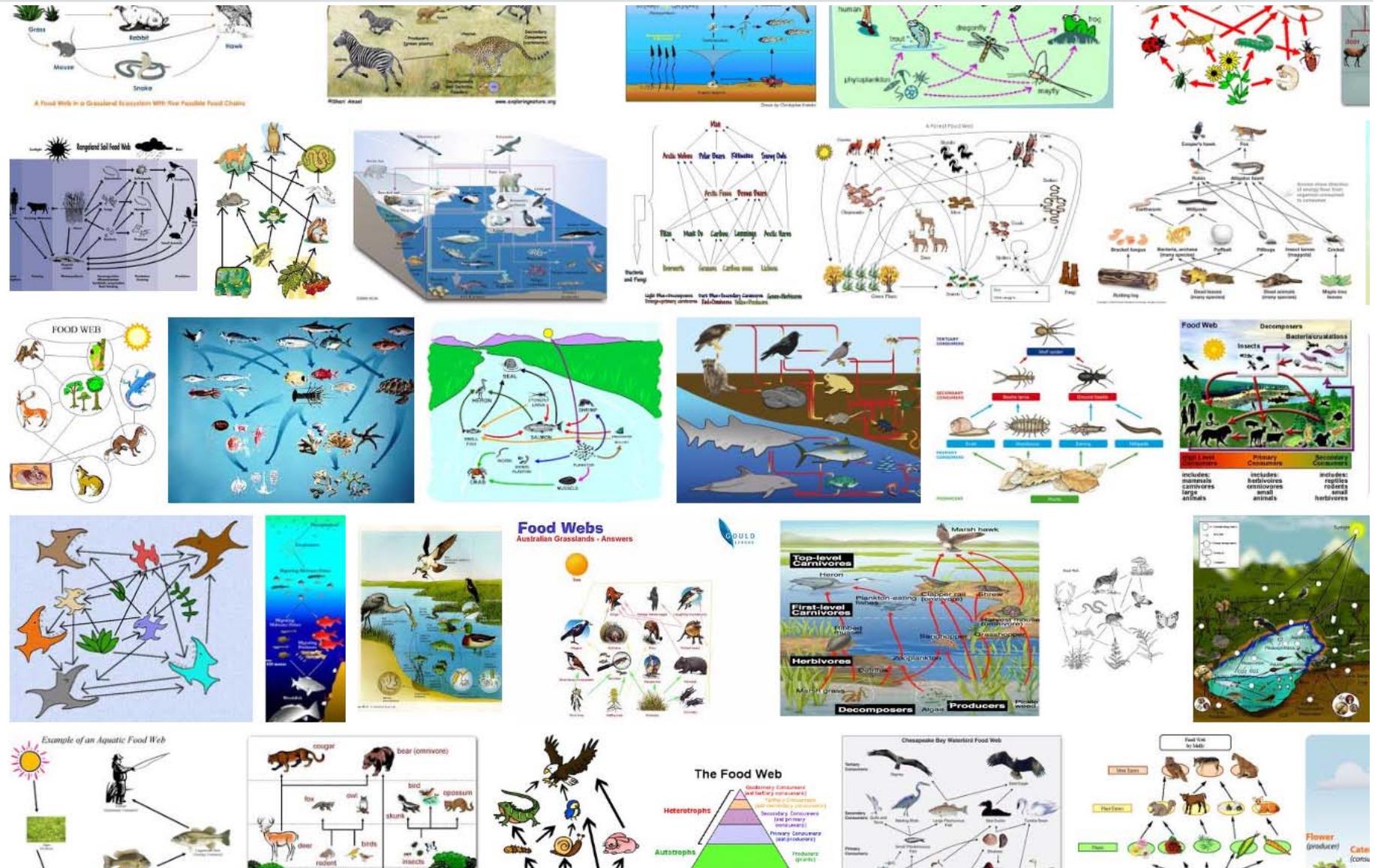


Food Webs



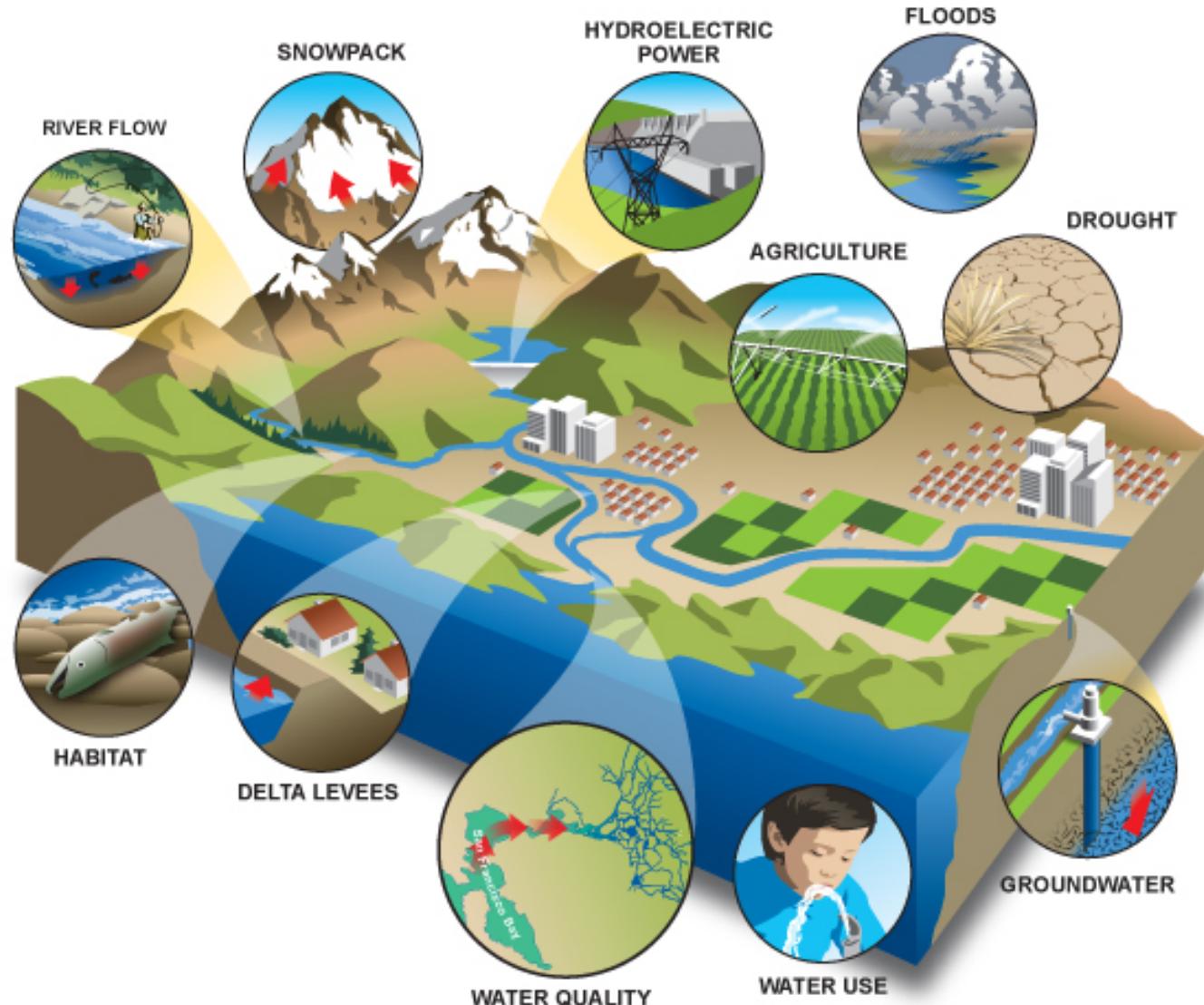
MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF A CROSS-BORDER MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention

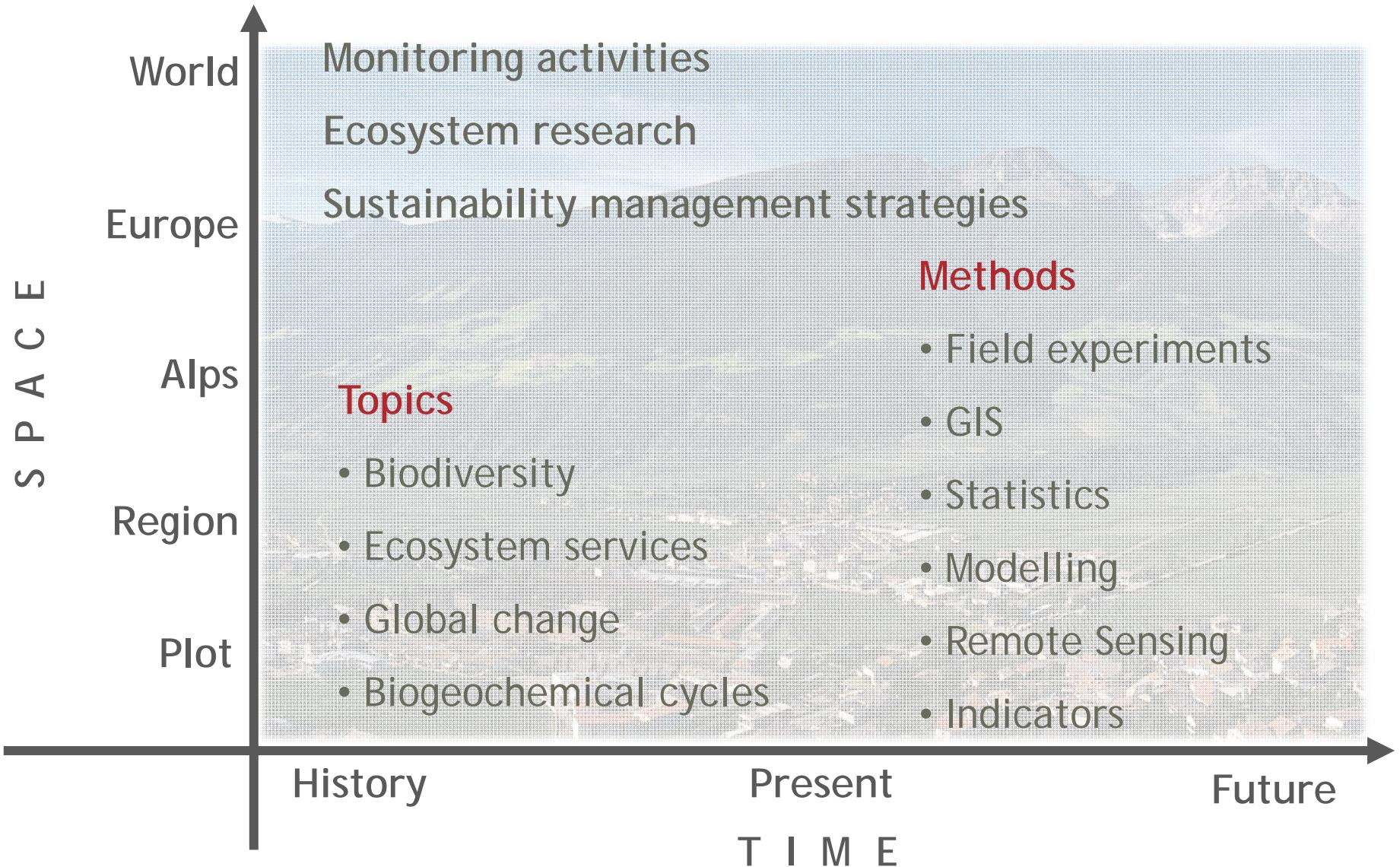


Consideration of mountain-specific issues

R. Bottarin



Some fields of research





... aquatic ecosystems



... terrestrial ecosystems



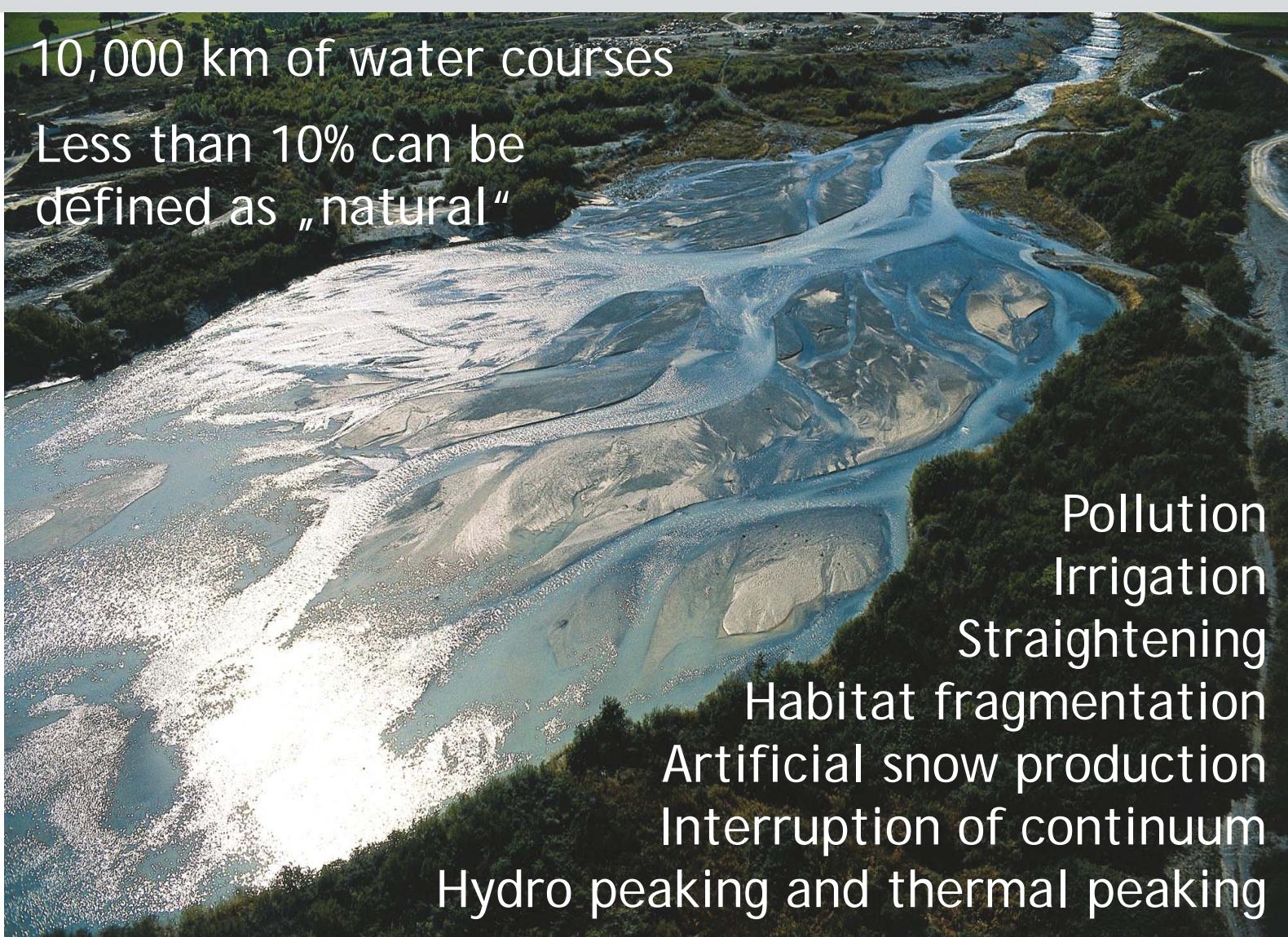
... landscapes



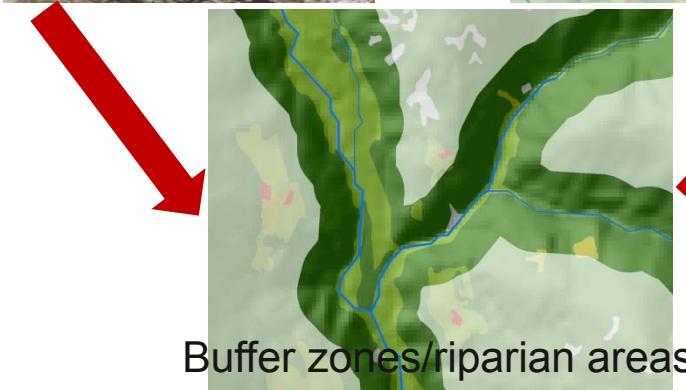
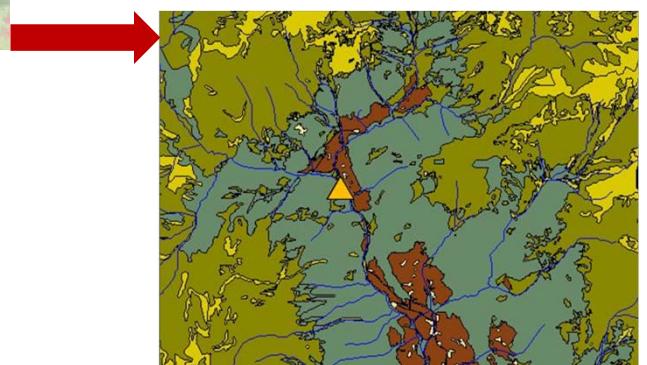
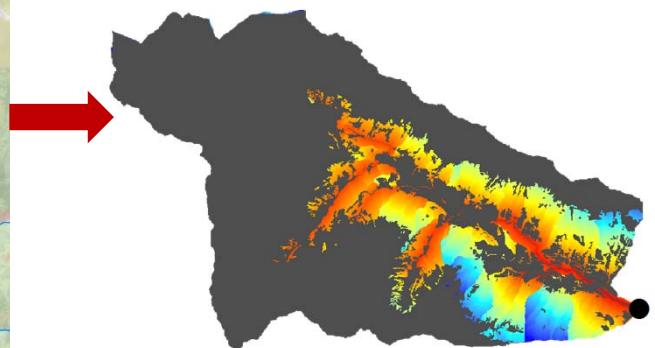
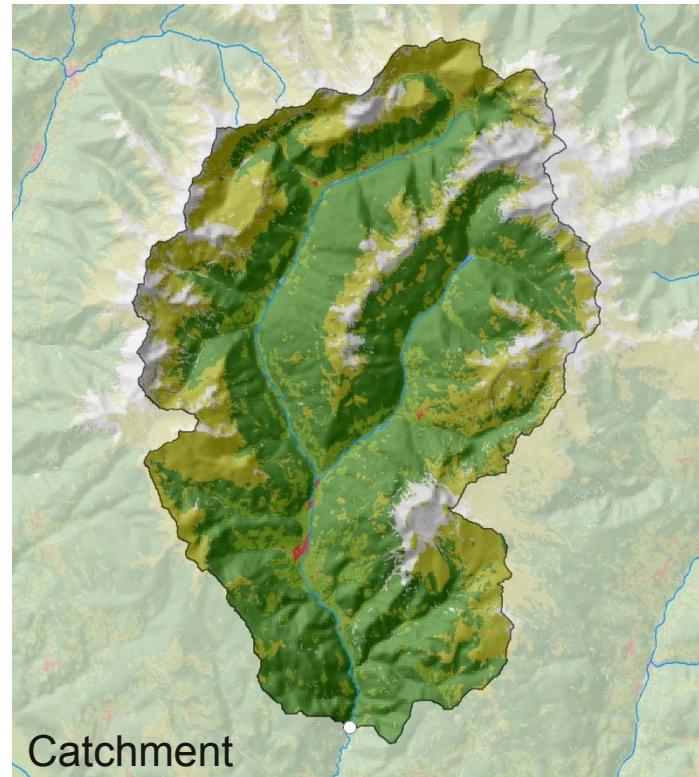
... society

Effects on aquatic ecosystems





Catchment analysis



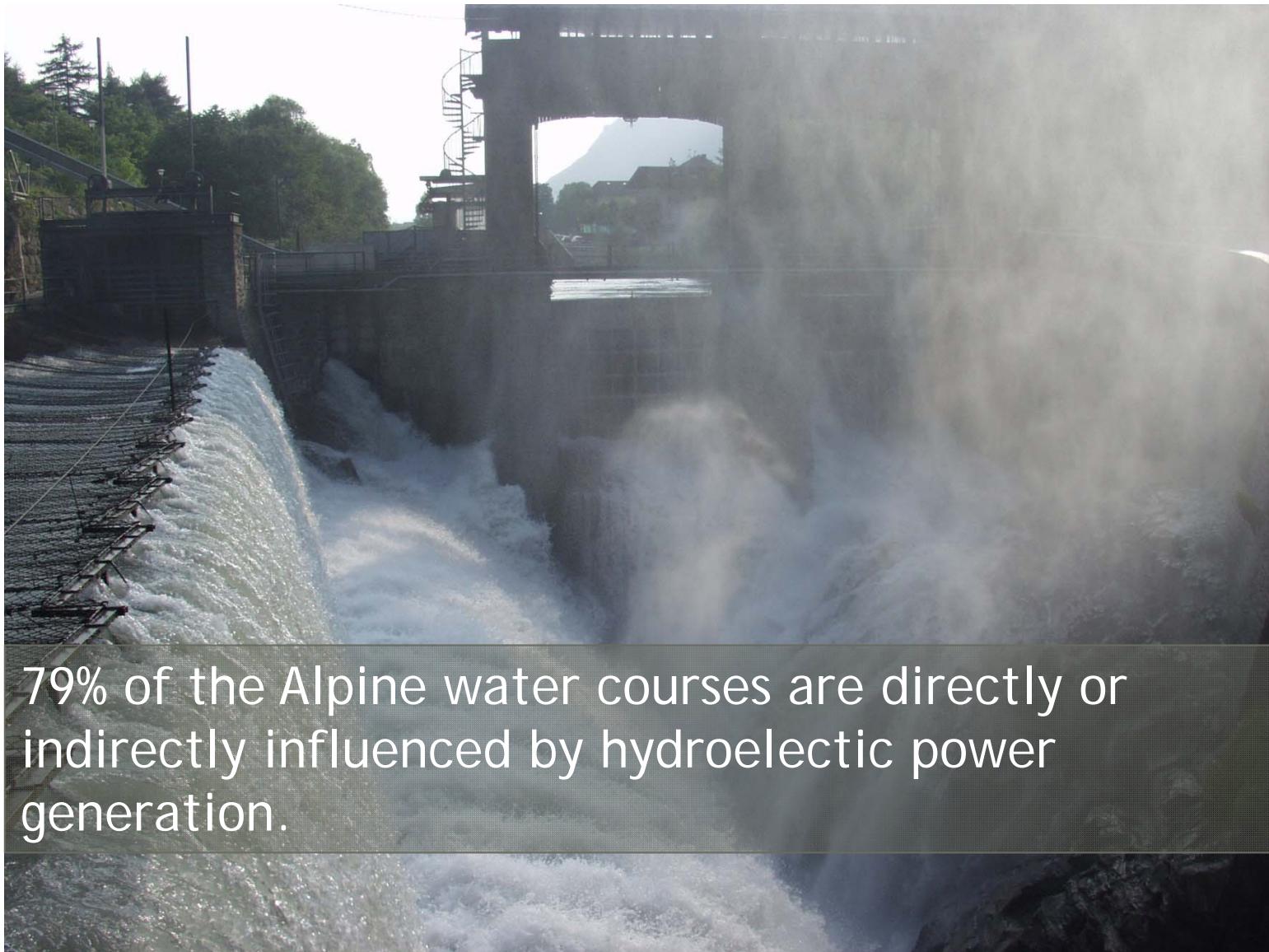
The Adige River



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

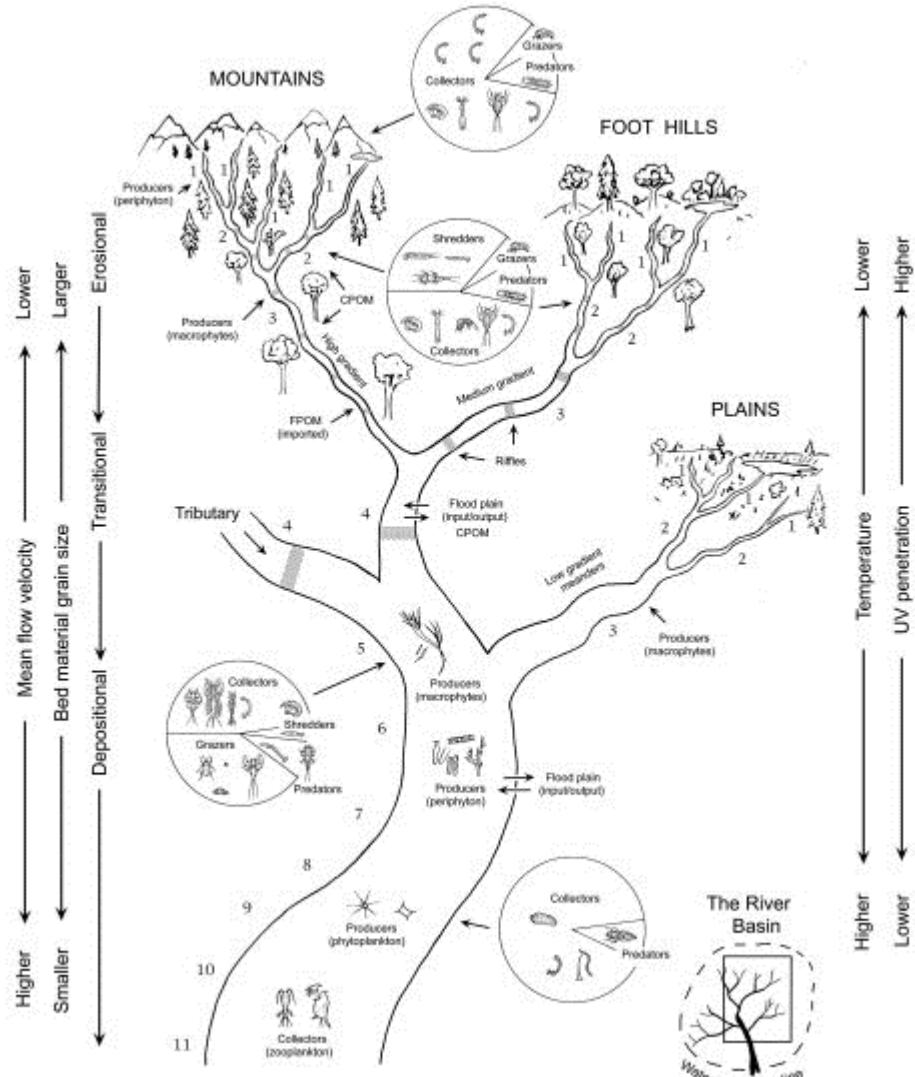
THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR
THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION
alpine convention
Italian presidency 2013-2014





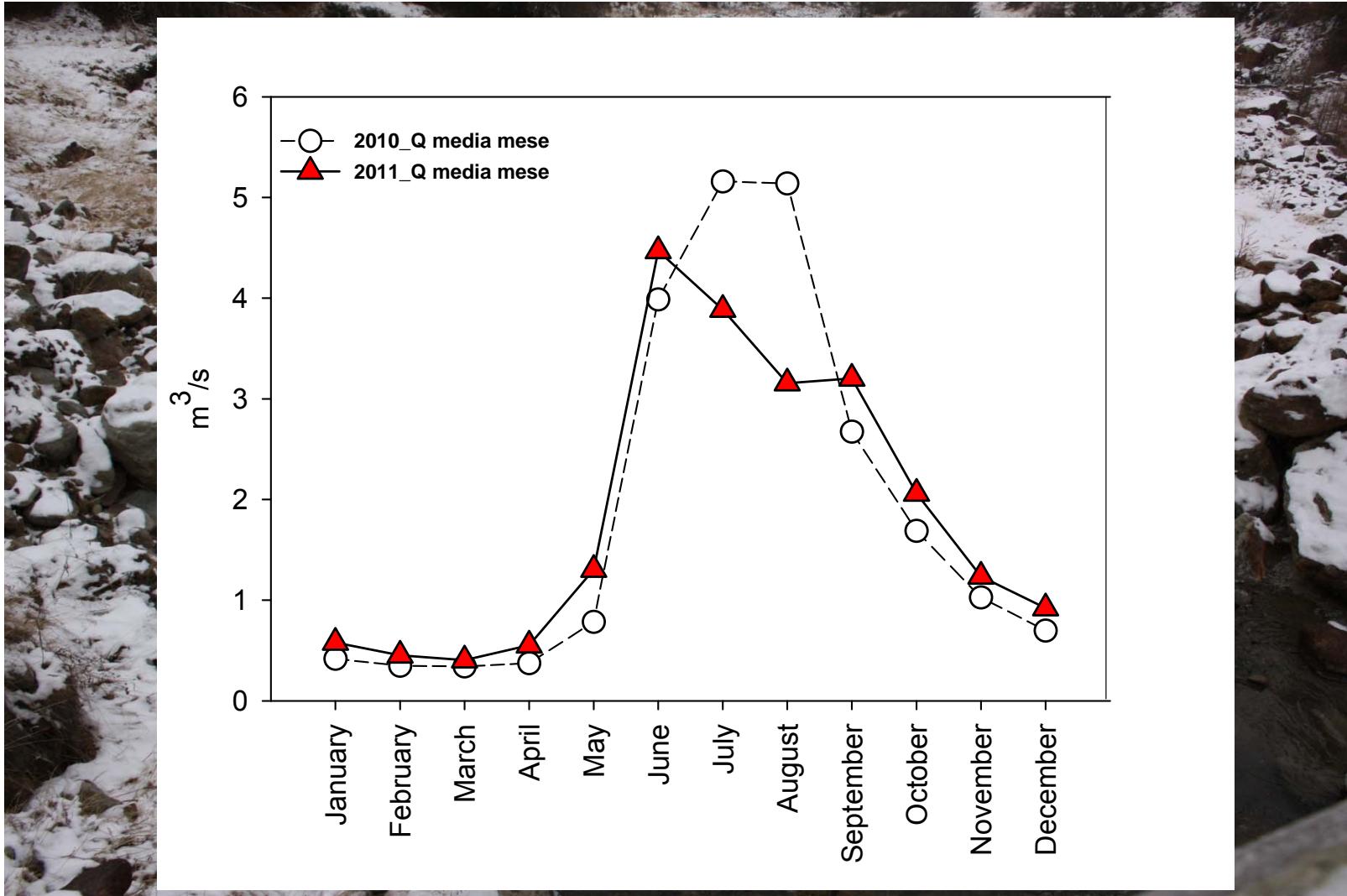
79% of the Alpine water courses are directly or indirectly influenced by hydroelectric power generation.

River continuum



Discharge monitoring

R. Bottarin



Biological analysis in headwaters

R. Bottarin

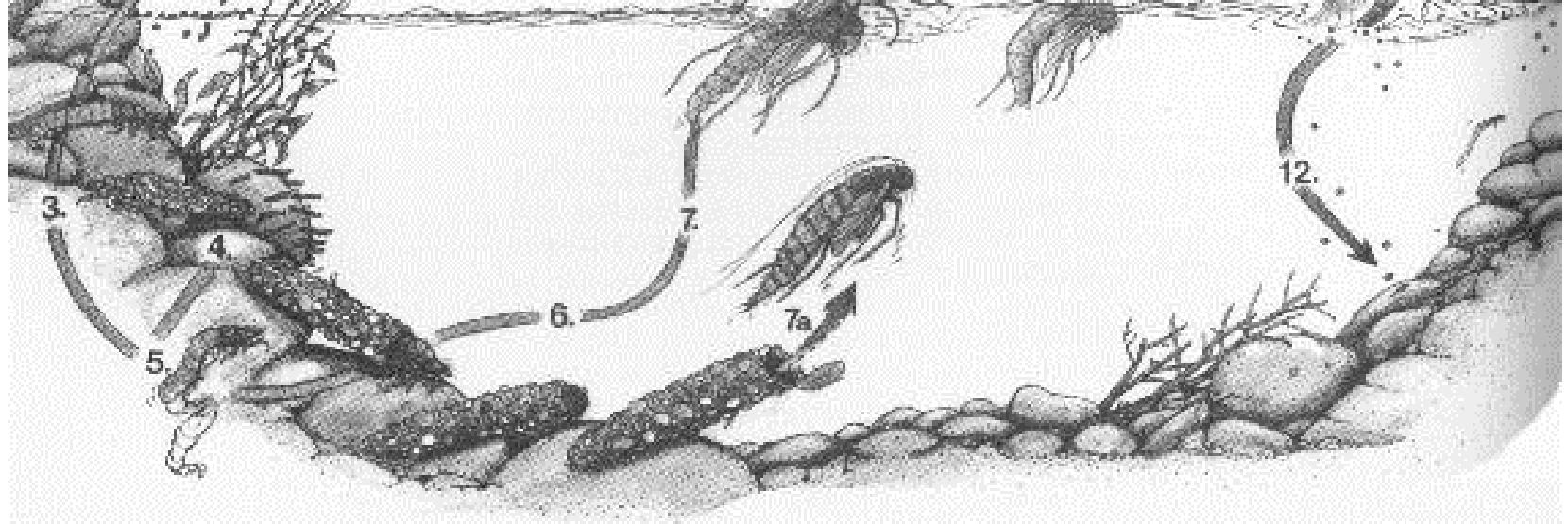


MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR
THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT OF A CROSS-BORDER
MOUNTAINOUS REGION
alpine convention
italian presidency 2013-2014

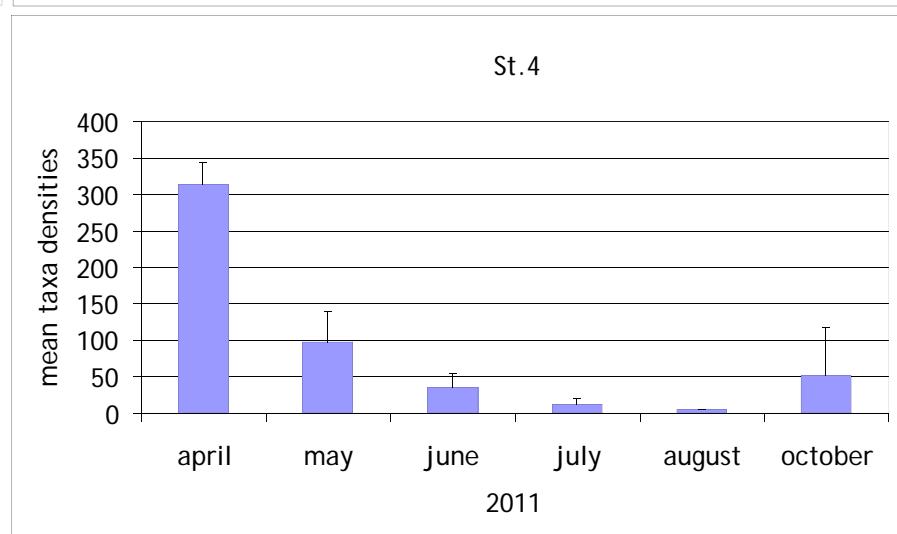
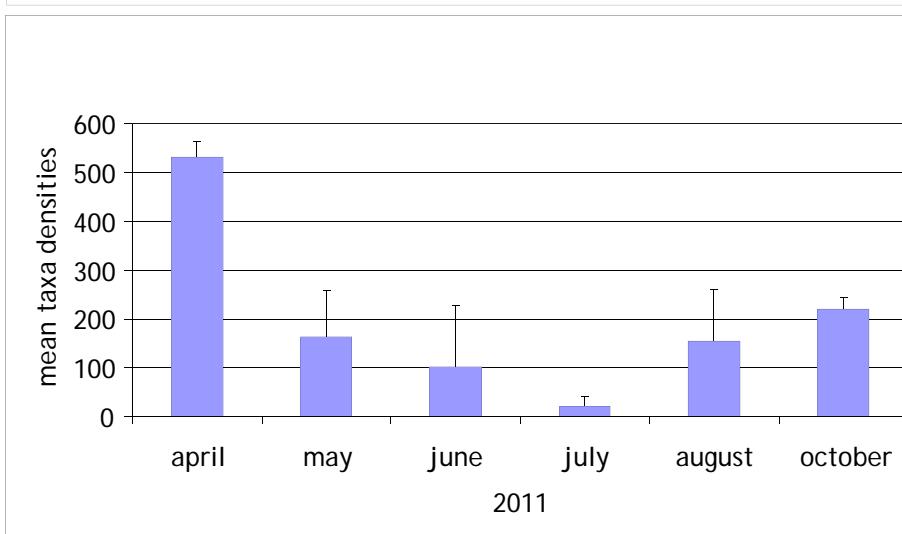
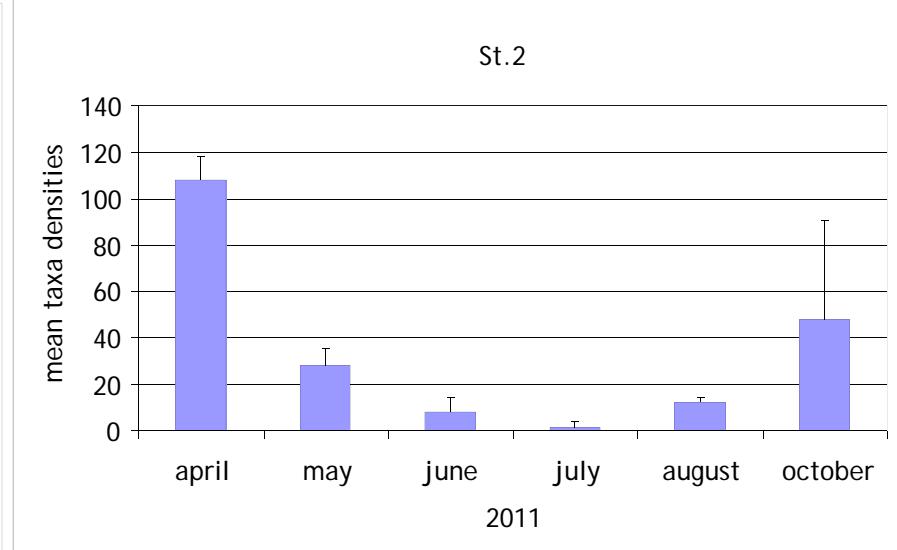
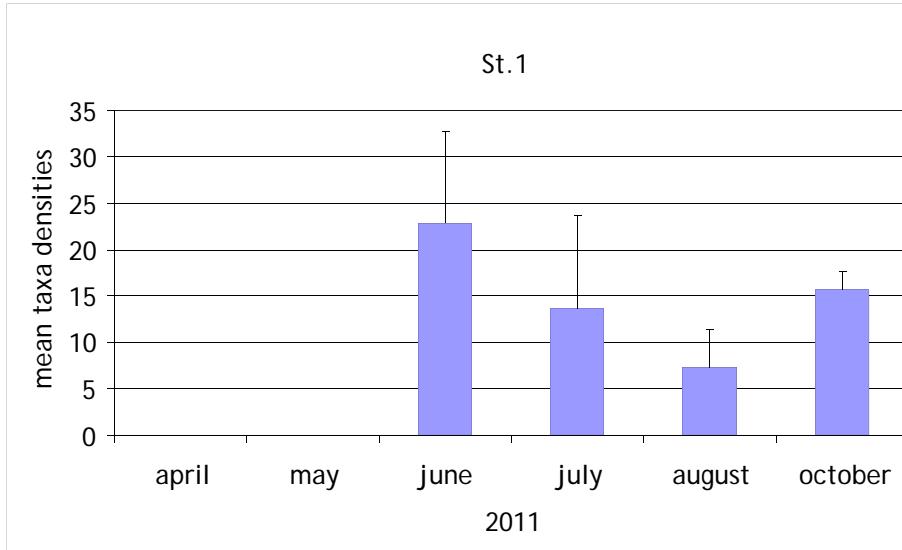


Trichoptera



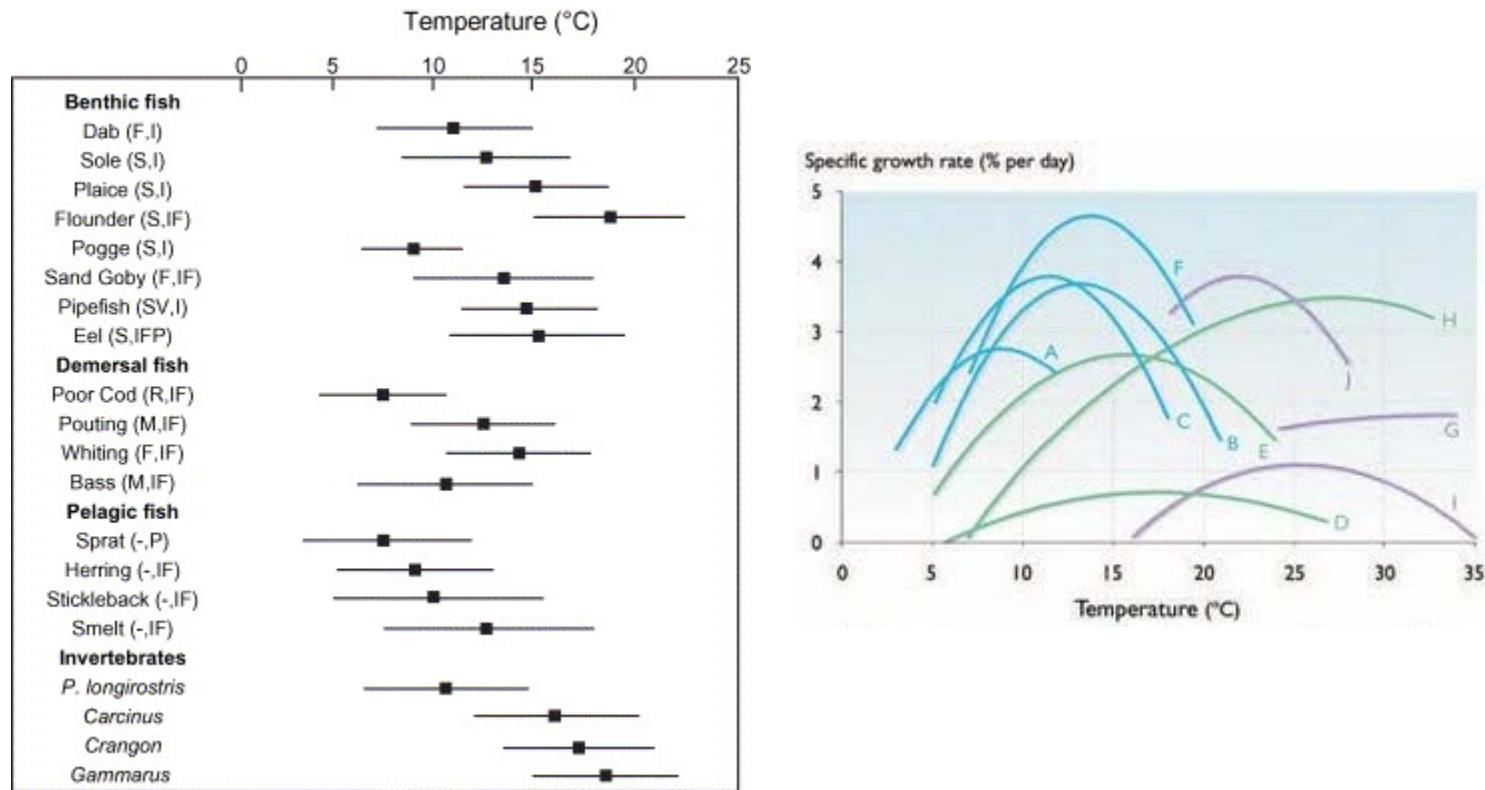
Density of interstitial meiofauna

R. Bottarin



Shift in thermal optima

R. Bottarin



High alpine glacial lakes

R. Bottarin



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention





Effects on aquatic ecosystems

Changing chemico-physical concentrations of lakes

Volume of lakes, new habitats

Water quality

Changing discharge trends

Interruption of river continuum (hydro-power, irrigation, dams)

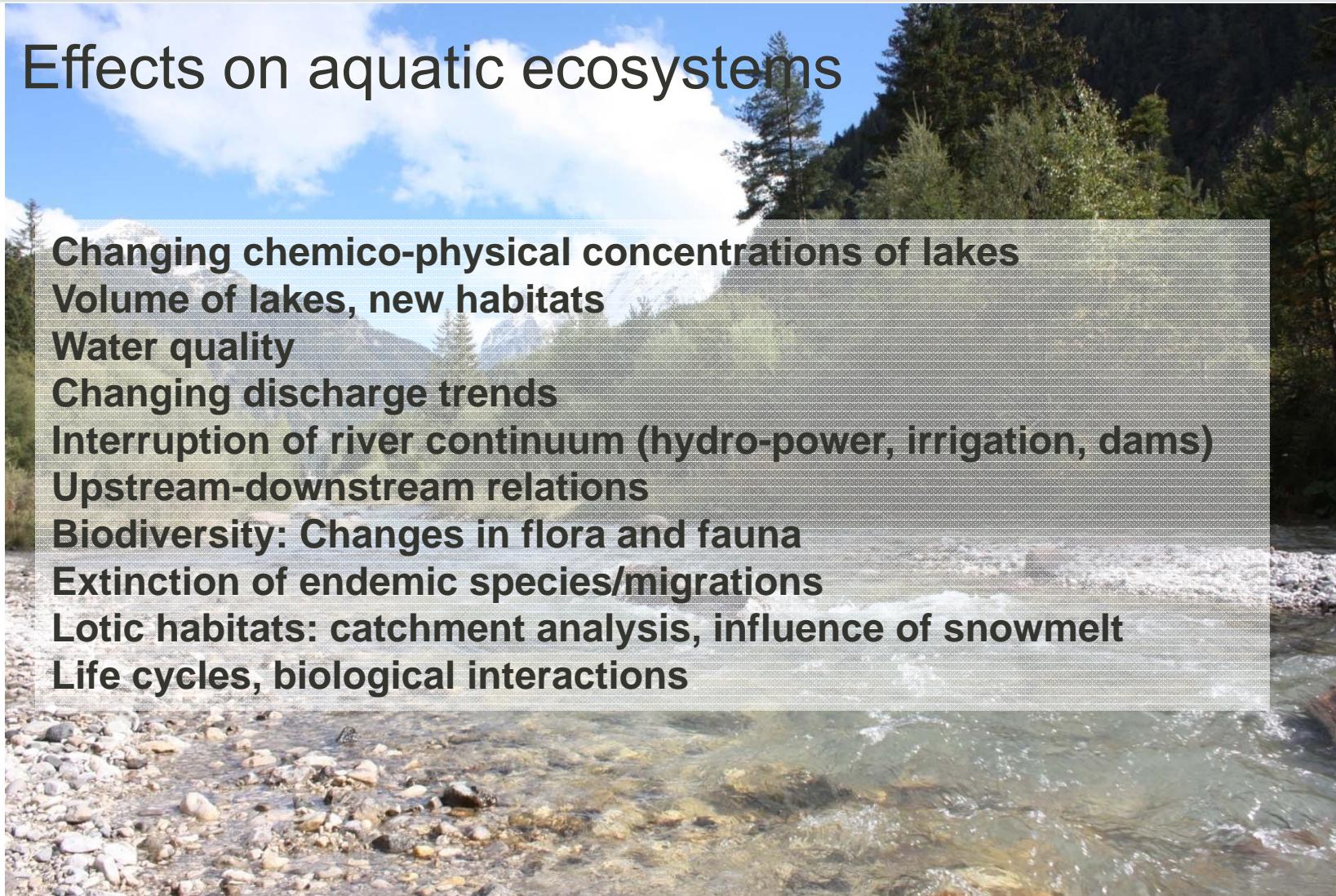
Upstream-downstream relations

Biodiversity: Changes in flora and fauna

Extinction of endemic species/migrations

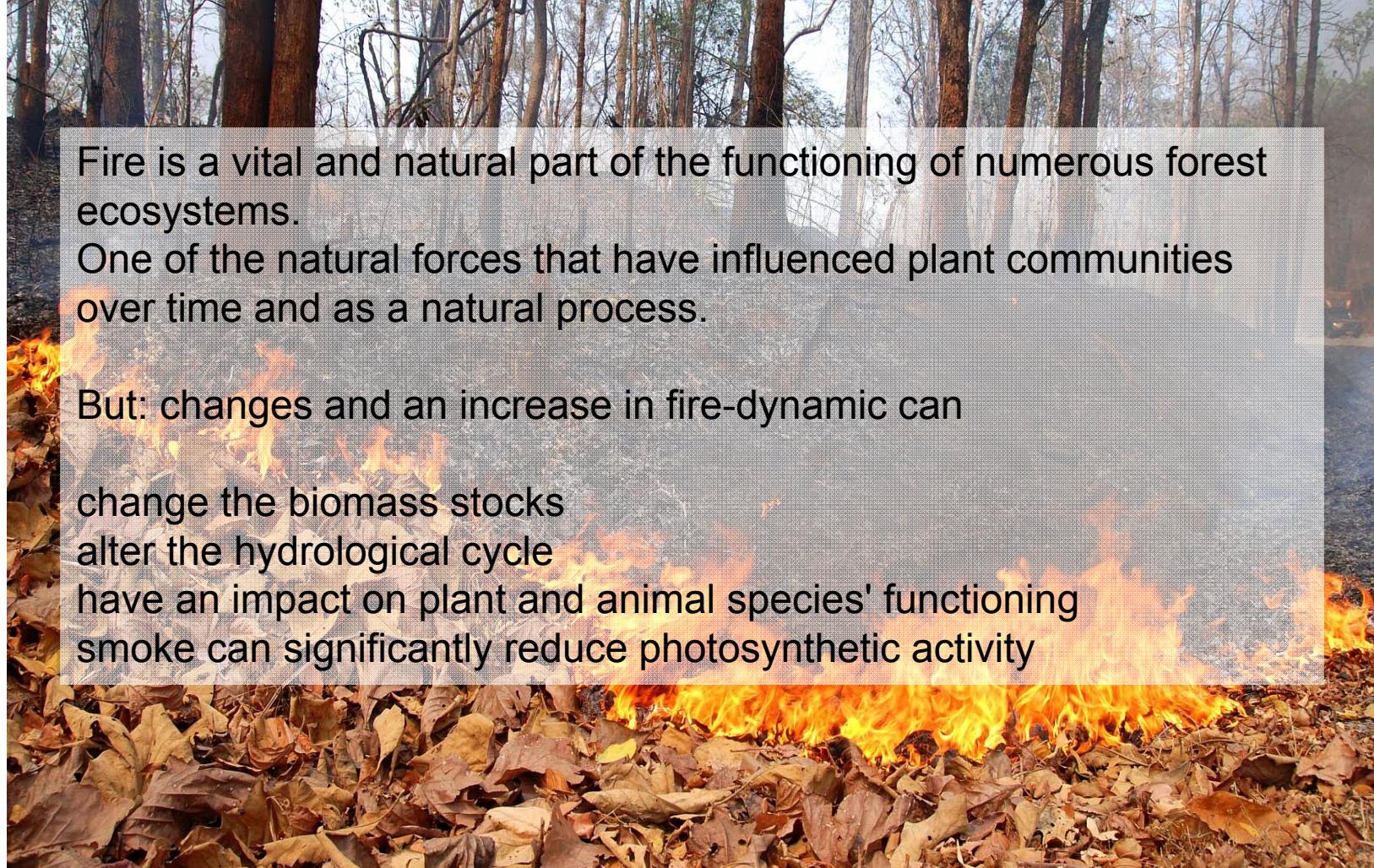
Lotic habitats: catchment analysis, influence of snowmelt

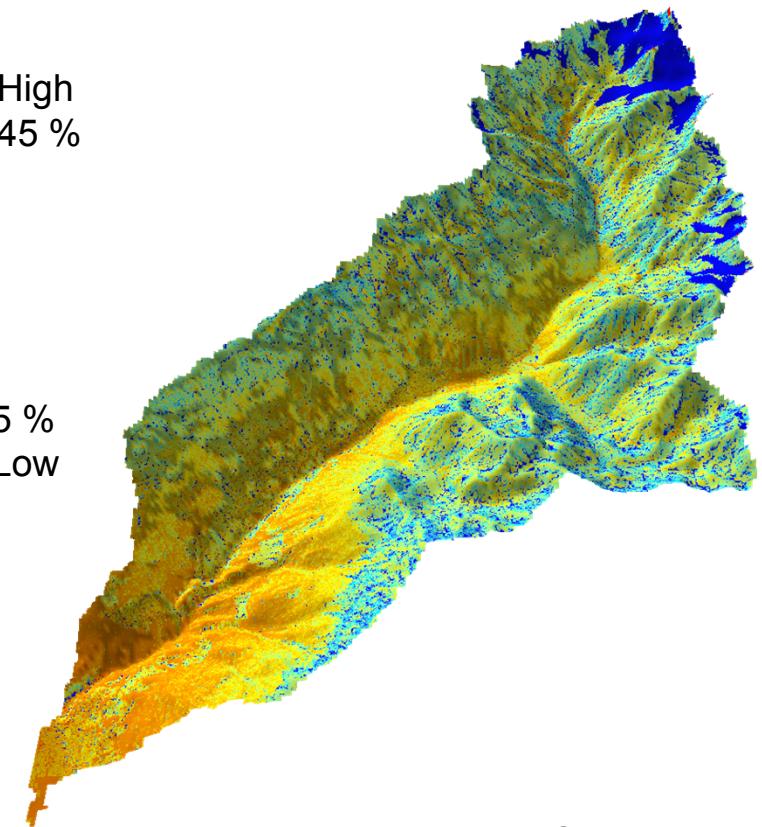
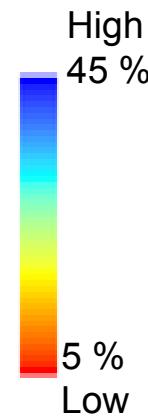
Life cycles, biological interactions



Effects on terrestrial ecosystems







e.g. Matsch Valley, South Tyrol:
Soil water content
July 2009, Klimawandel, EURAC

Transplantation experiments

R. Bottarin



Source: G. Niedrist, EURAC



Effects on terrestrial ecosystems

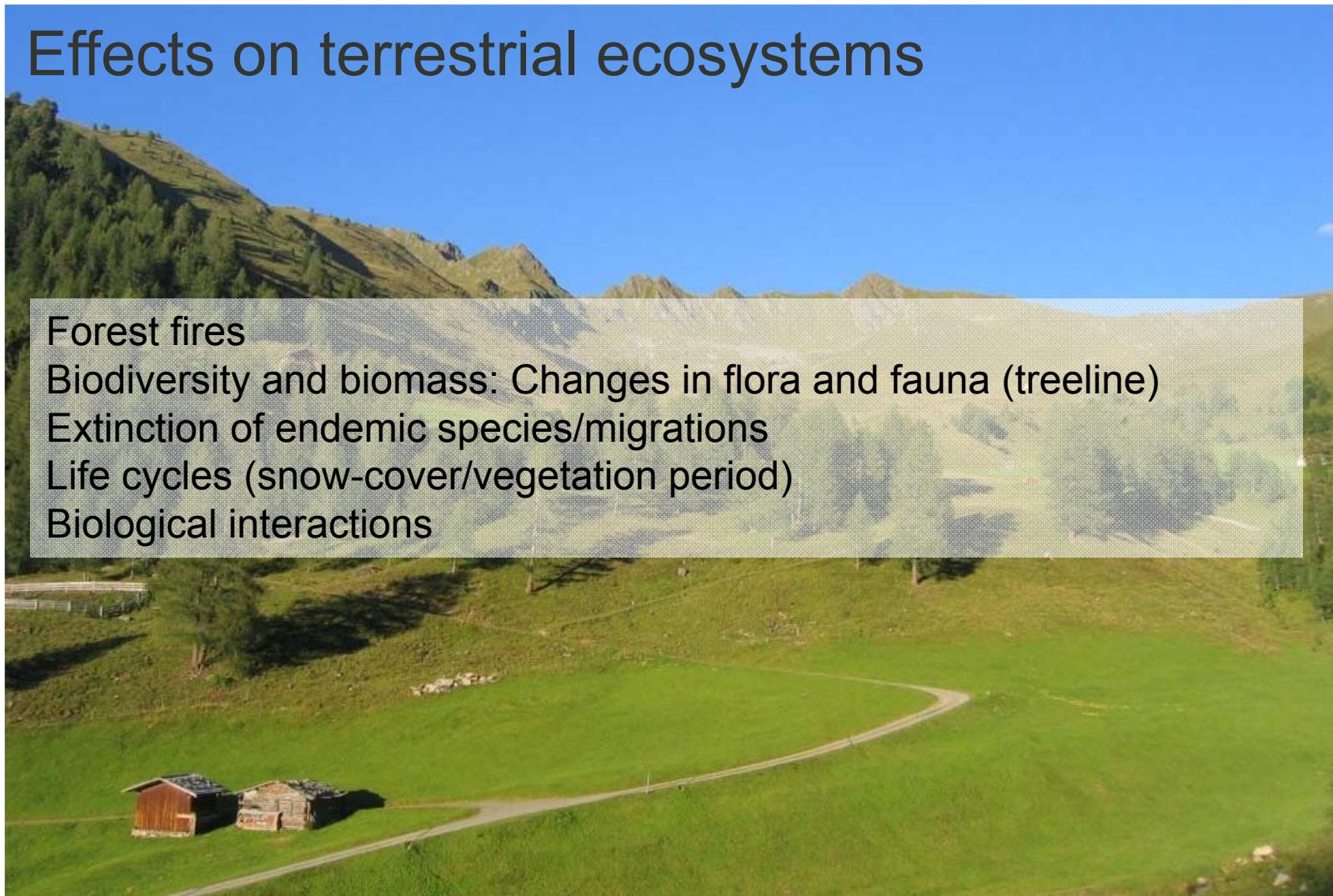
Forest fires

Biodiversity and biomass: Changes in flora and fauna (treeline)

Extinction of endemic species/migrations

Life cycles (snow-cover/vegetation period)

Biological interactions



Effects on landscapes



Rhône Glacier



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR
THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT OF A CROSS-BORDER
MOUNTAINOUS REGION
alpine convention
italian presidency 2013-2014



R. Bottarin



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention



Tschierva glacier, Swiss Alps
1880



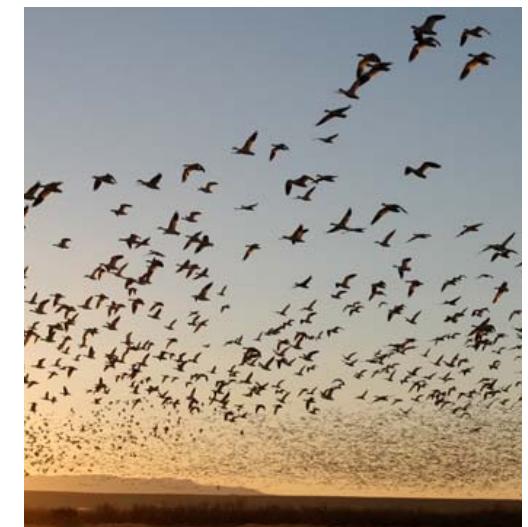
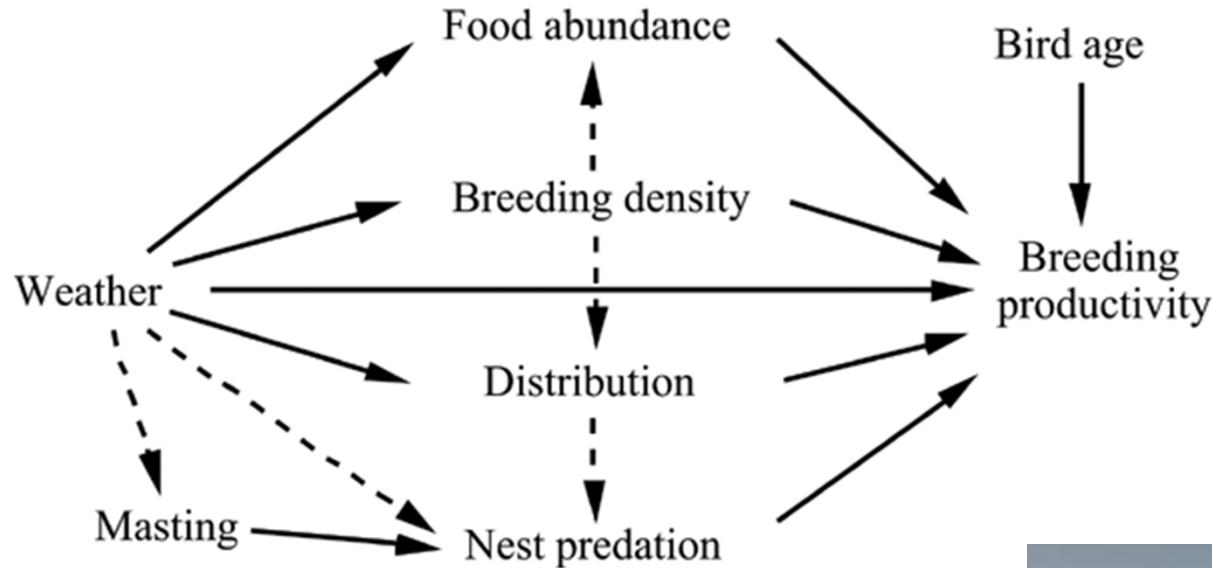
Creation of new landscapes



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

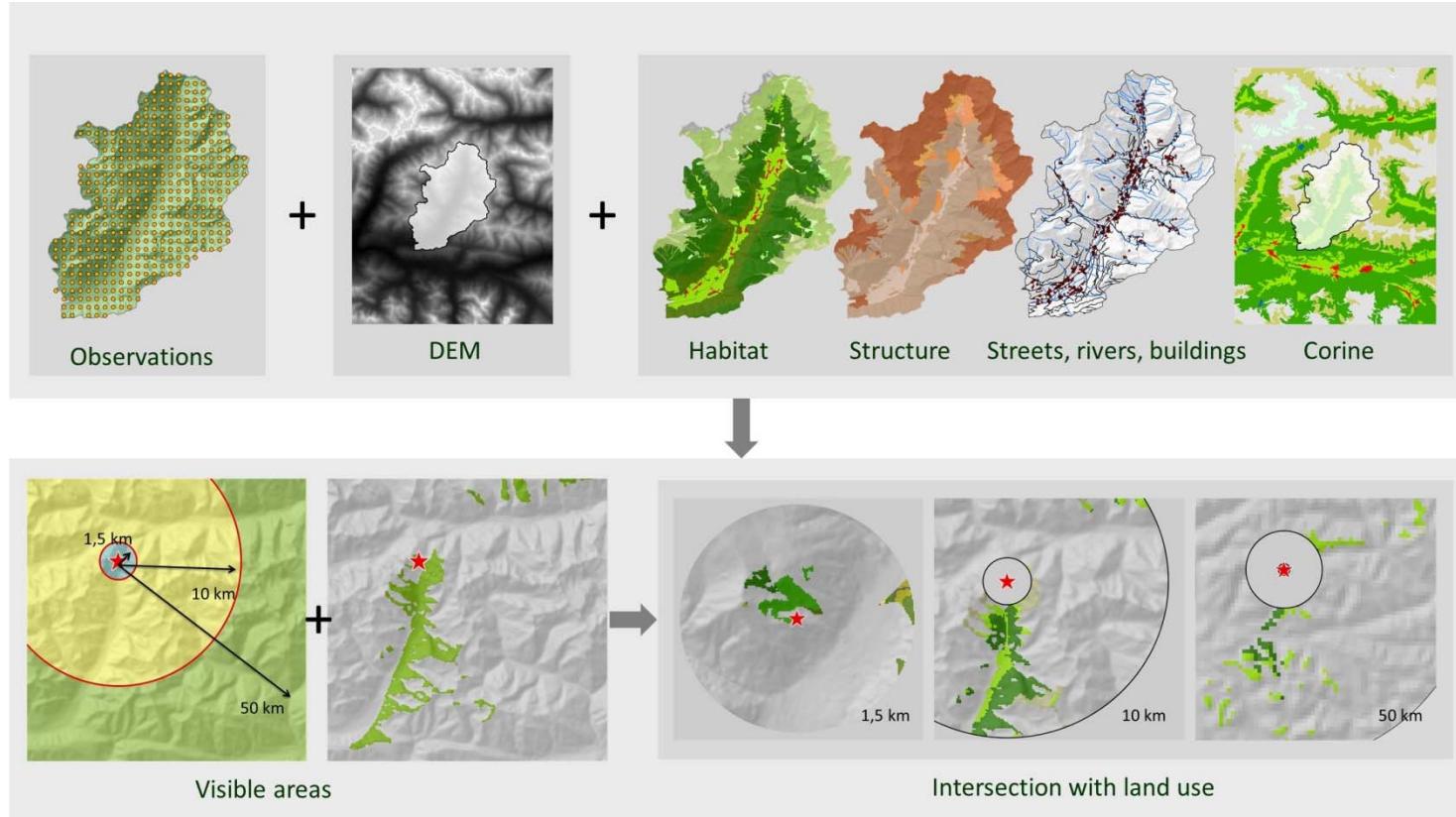
THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
italian presidency 2013-2014
alpine convention





Measuring landscape value and change

R. Bottarin

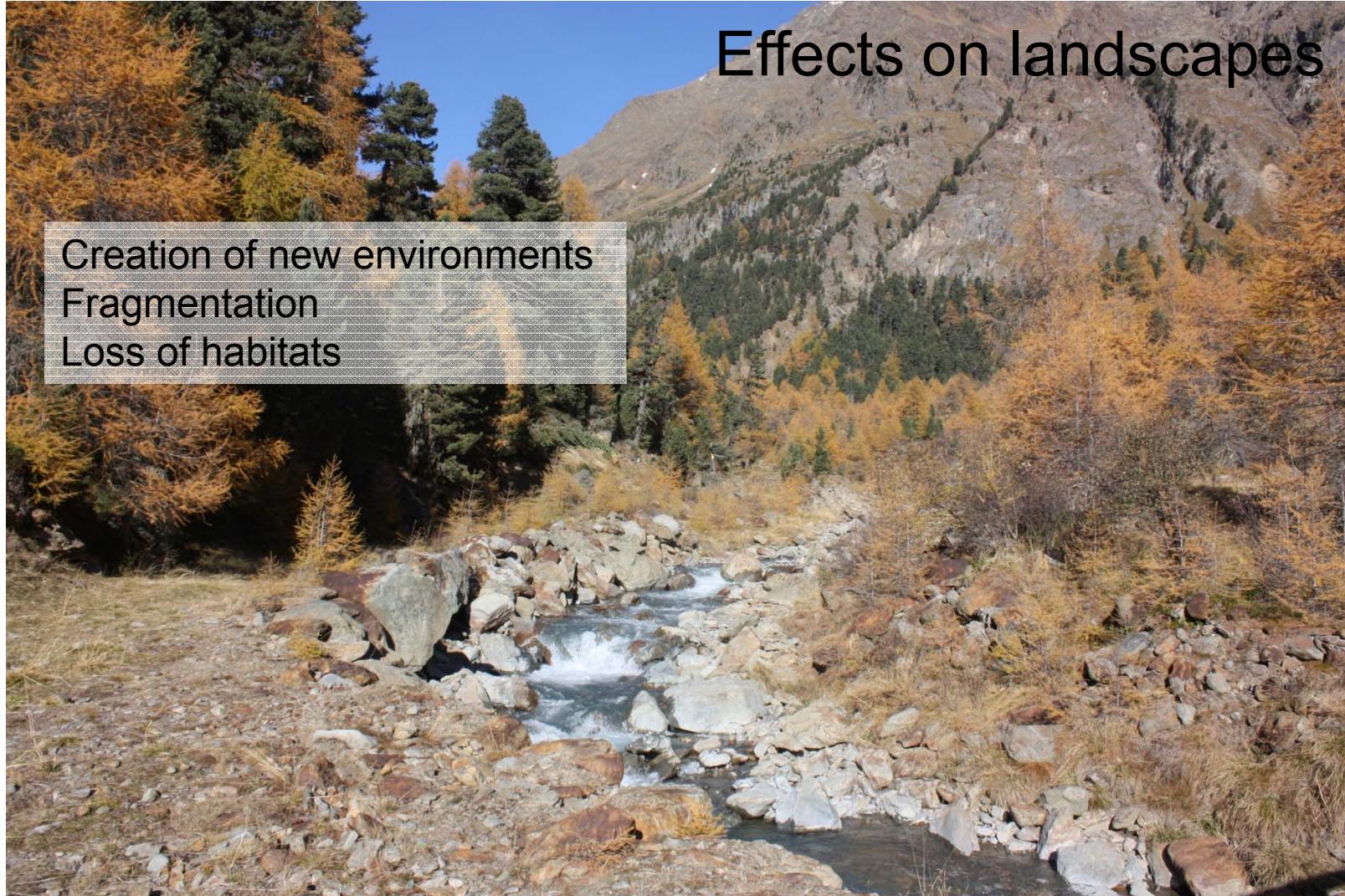


Source: Uta Schirpke, EURAC



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT OF A CROSS-BORDER
MOUNTAINOUS REGION
alpine convention
italian presidency 2013-2014





Effects on society

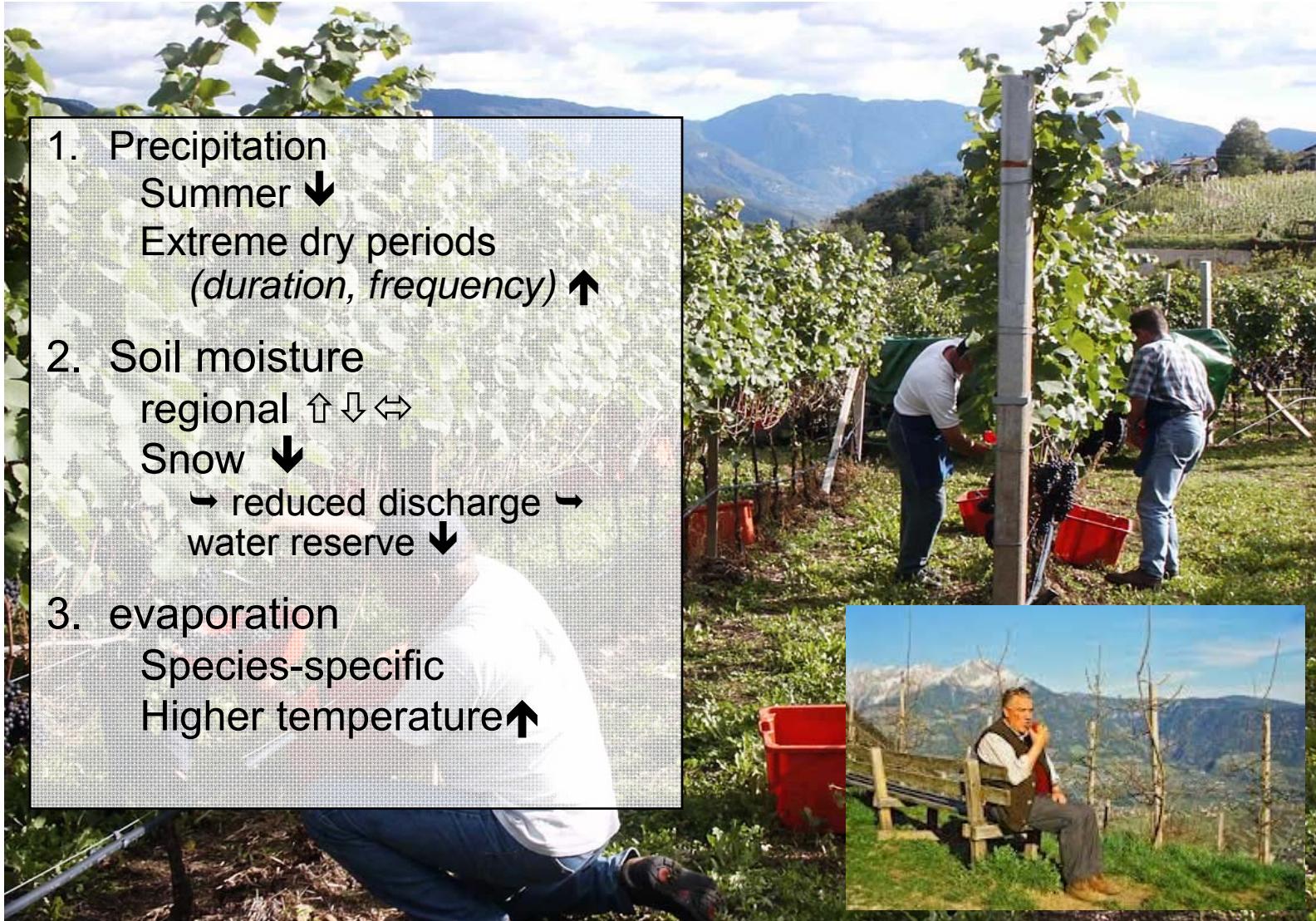
Drinking water supply



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention





Agriculture



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
italian presidency 2013-2014
alpine convention



Changes in temperature and rainfall can compromise agricultural production in many regions.

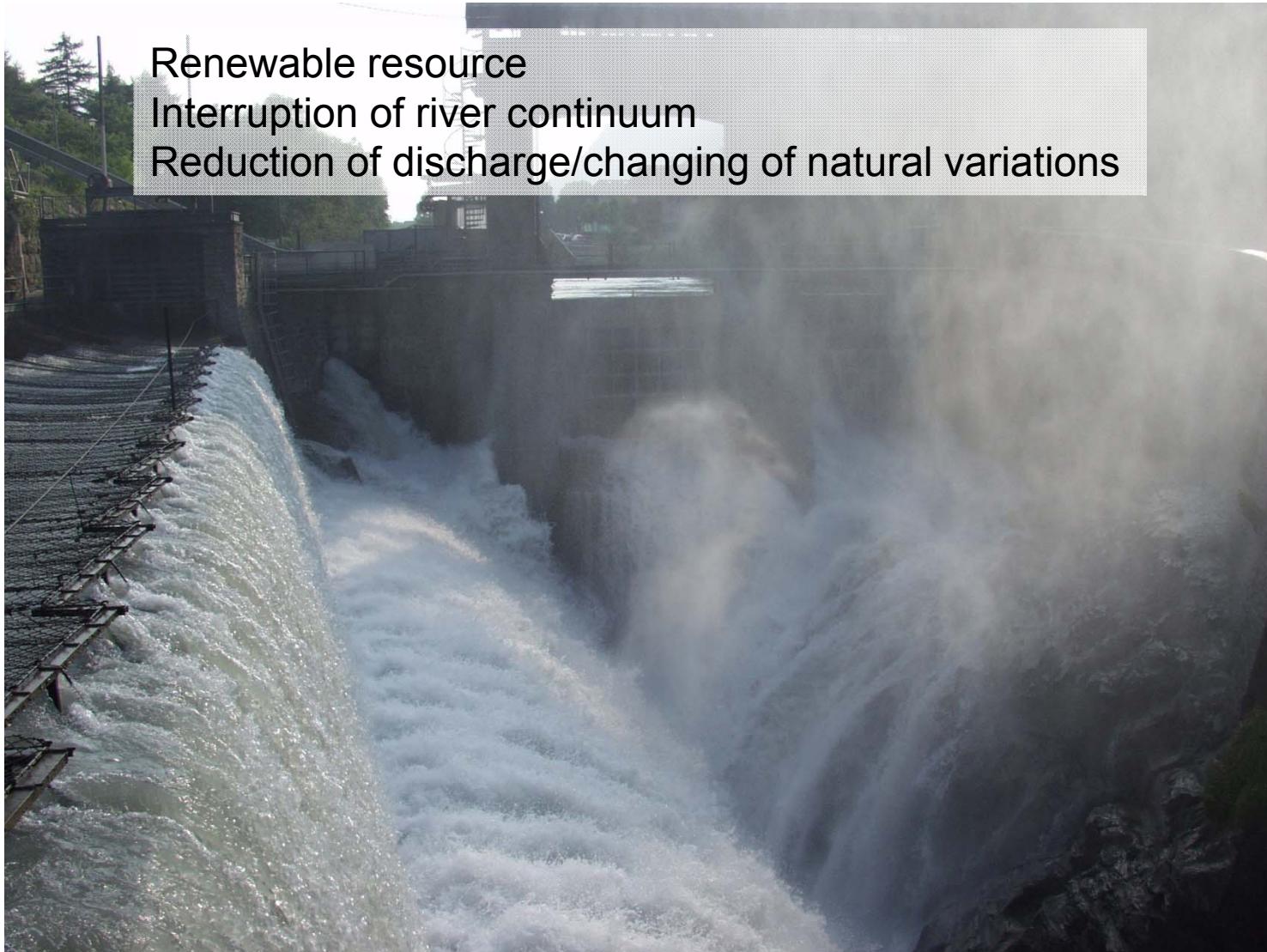
Energy



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention

Renewable resource
Interruption of river continuum
Reduction of discharge/changing of natural variations



Recreative Value

R. Bottarin



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR
THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION
alpine convention
italian presidency 2013-2014



Artificial snow



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention

Increased technical equipments
Higher abstractions and retention of water





MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR
THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT OF A CROSS-BORDER
MOUNTAINOUS REGION
alpine convention
Italian presidency 2013-2014



Natural hazards



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR
THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION
alpine convention
italian presidency 2013-2014



Natural hazards



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL
TREATY FOR THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT OF A CROSS-BORDER
MOUNTAINOUS REGION
alpine convention
italian presidency 2013-2014





- Air Quality
- Clean water
- Sufficient food
- Control of infectious diseases
- Availability of shelter
- malnutrition, diarrhea, respiratory diseases, water-borne and insect-transmitted diseases.

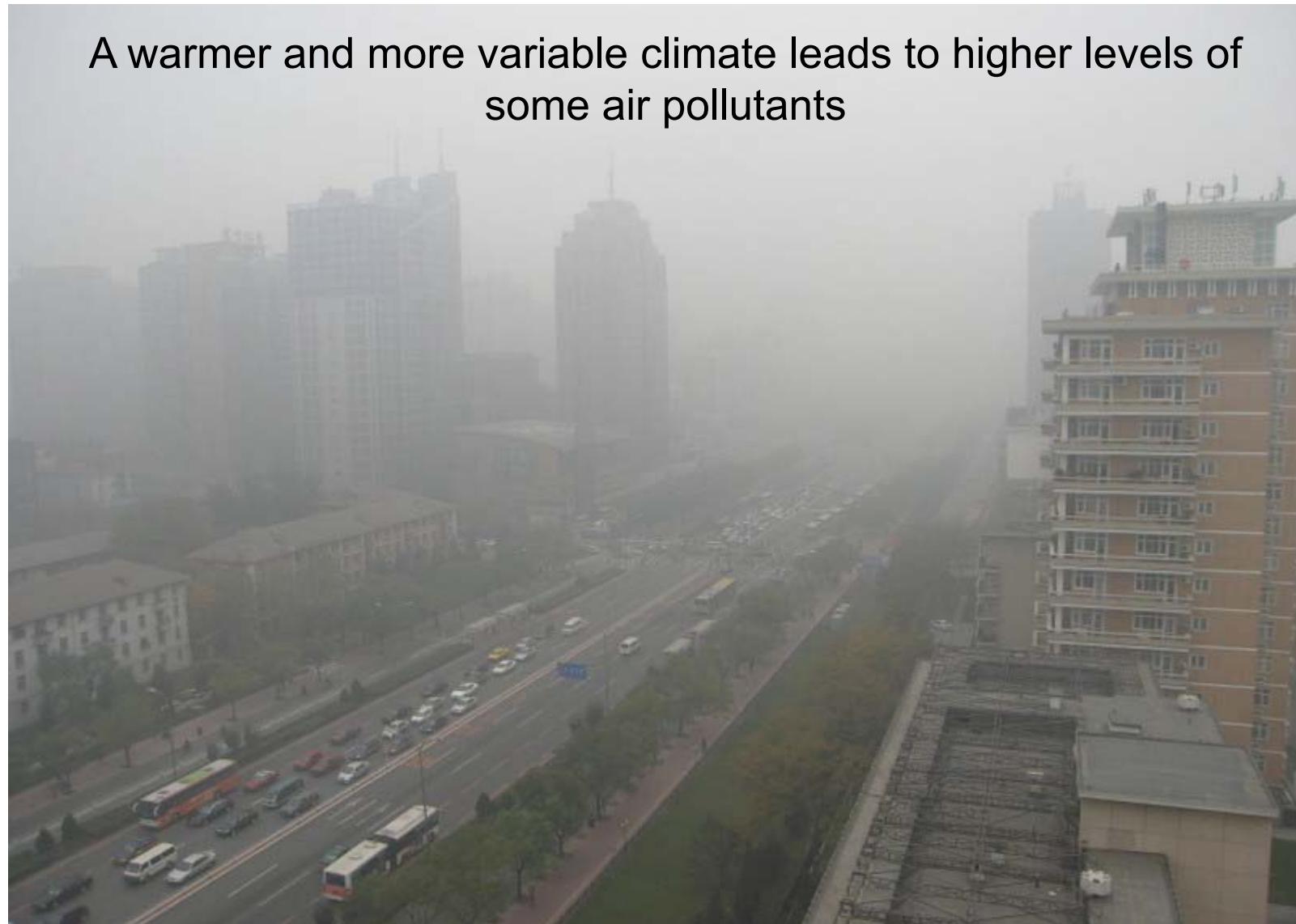
Air pollution



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
Italian presidency 2013-2014
alpine convention

A warmer and more variable climate leads to higher levels of some air pollutants





The rates and ranges of transmission of infectious diseases through unclean water and contaminated food increases.



Effects on society

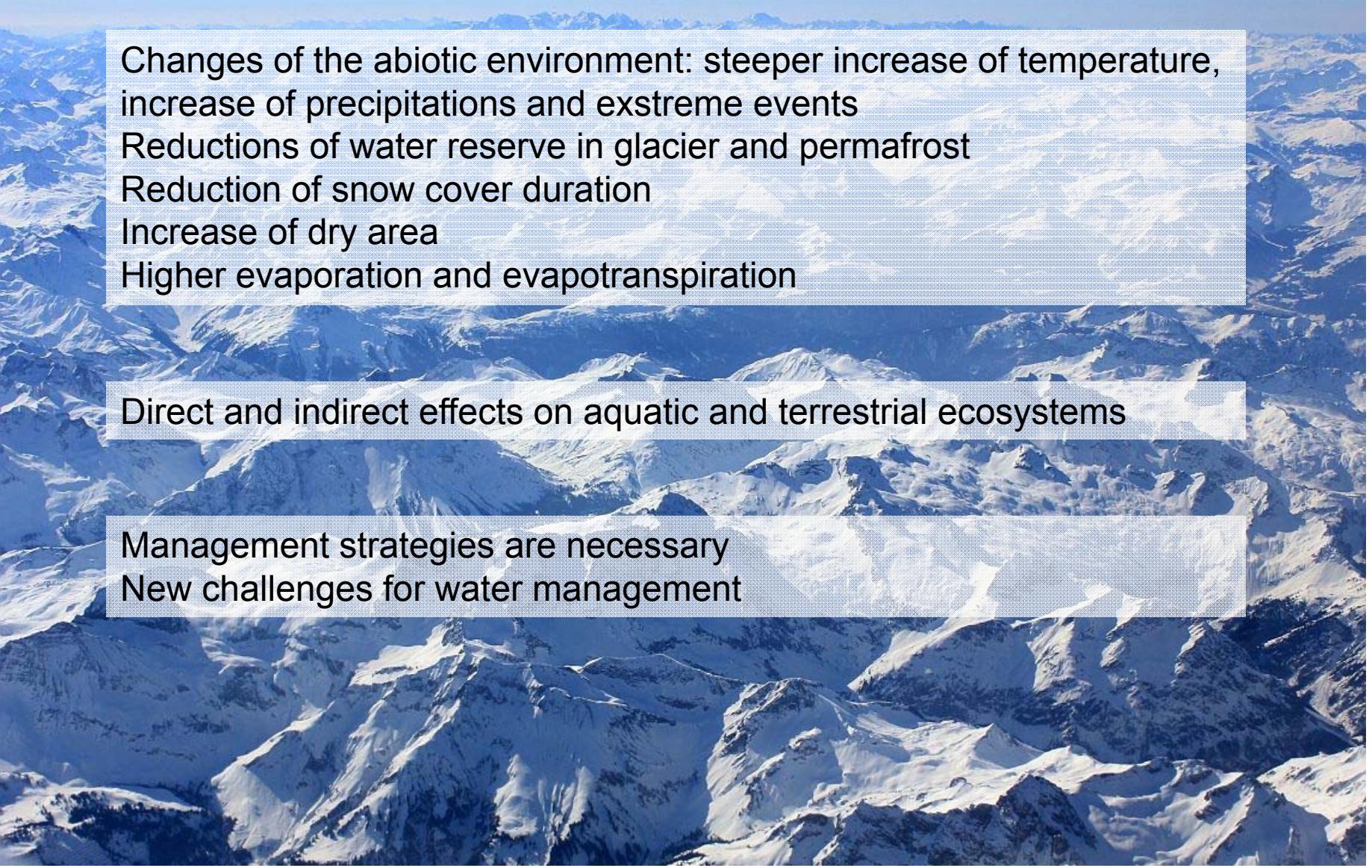
- Water supply
- Agriculture/crop production/biomass
- Energy
- Tourism
- Natural hazards
- Health

Concluding observations



MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

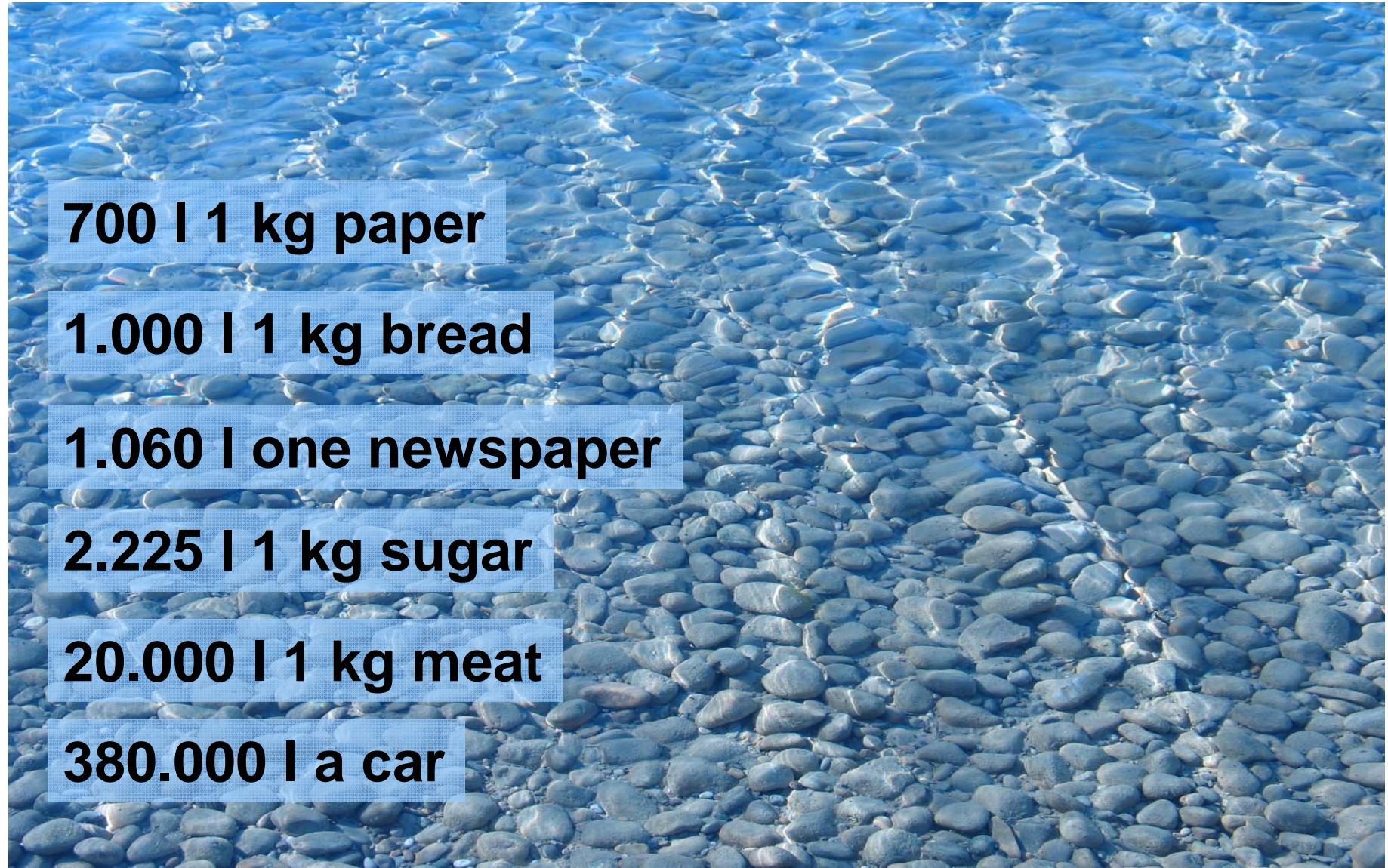
THE ALPINE CONVENTION
IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAIN REGION
Italian presidency 2013-2014
alpine convention



Changes of the abiotic environment: steeper increase of temperature,
increase of precipitations and extreme events
Reductions of water reserve in glacier and permafrost
Reduction of snow cover duration
Increase of dry area
Higher evaporation and evapotranspiration

Direct and indirect effects on aquatic and terrestrial ecosystems

Management strategies are necessary
New challenges for water management





Thank you for your attention

