



Dipartimento Scienze  
del Sistema Terra  
e Tecnologie per l'Ambiente

The Geoscience paradigm:  
resources, risks and future perspectives

Potenza 19-21 Settembre 2023

## Linking earth sciences, terrestrial ecosystems and social sciences in critical zone study: the project ABRESO (Belmont Forum)

(Sottotitolo) Il Progetto Abreso: il tentativo di mettere in pratica l'inter e la transdisciplinarietà

### The CNR Research Team

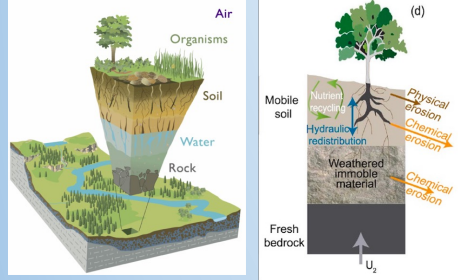


***Pennisi M., Baneschi I.,  
Adamo M.P., Gavrichova O.,  
Maerkel M., Ragazzi E.,  
Richiardi C., Rossi V.,  
Salvadori M., Scartazza A.,  
Vicario S., Zanetti A., Sella L.***

### The Stakeholders



The Critical Zone (CZ) is the system of coupled chemical, biological, physical, and geological processes operating together to support life at the Earth's surface. While our understanding of this zone has increased over the last hundred years, further advance requires scientists to cross disciplines and scales to integrate understanding of processes in the CZ, ranging in scale from the mineral-water interface to the globe. Despite the extreme heterogeneities manifest in the CZ, patterns are observed at all scales. Explanations require the use of new computational and analytical tools, inventive interdisciplinary approaches, and growing networks of sites and people.

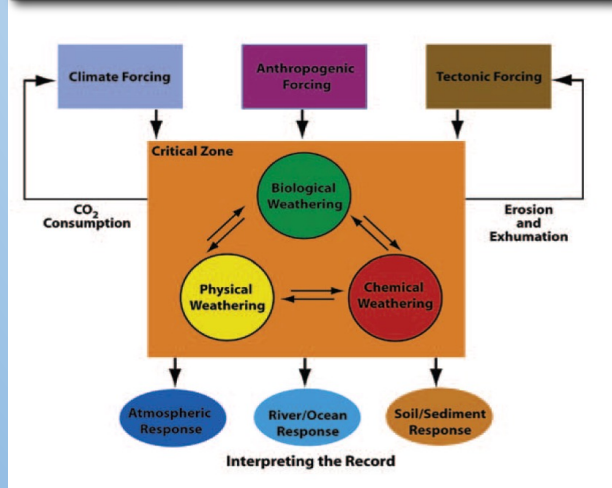


## Critical Zone: where rock meets life

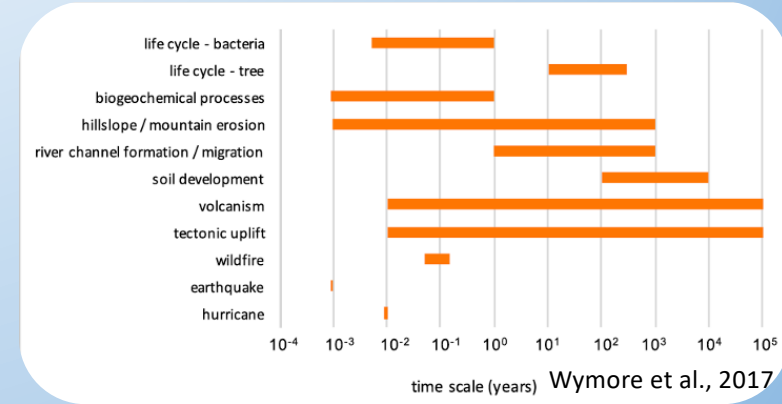
*Elements, October 2007*

Conceptualizing the complex interplay of chemistry, biology, geology and physics within the skin of the Earth system (CZ) forces scientists to work together across disciplines and scales

### The Starting Point (background) (Brantley et al., 2007, Elements)



In *Critical Zone* studies a significant role is played by geology, weathering, geochemistry, hydrology, mineralogy, and other earth science disciplines



Humans are a geological force transforming the Earth's surface. Considering agriculture and mining, the current global erosion rate of Holocene sediment is an order of magnitude higher than the natural erosion rate

Critical zone science is entering its second decade

“A new generation of scientist is emerging trained specifically in *Critical Zone* science and contributing to advances in environmental science across disciplines” Wymore et al., 2017

## Disciplinary Perspectives

A Type of Progression

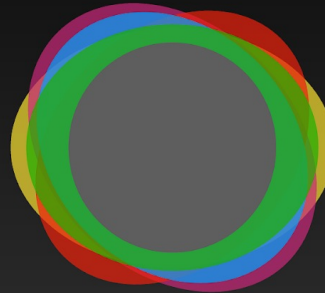
**multi**disciplinary



**inter**disciplinary



**trans**disciplinary



**Multidisciplinarity** draws on knowledge from different disciplines but stays within their boundaries

**Transdisciplinarity** integrates the natural, social, and health sciences in a humanities context, and transcends their traditional boundaries

**Interdisciplinarity** analyzes, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole

Choi and Pak, 2006

# The Belmont Forum

<https://belmontforum.org/>



## ABRESO:

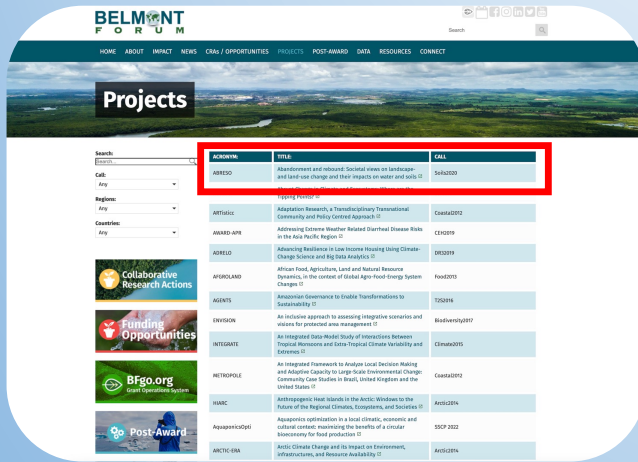
### Abandonment and rebound: Societal views on landscape and land-use change and their impact on water and soils

<https://abreso.psu.edu/overview/italy/>

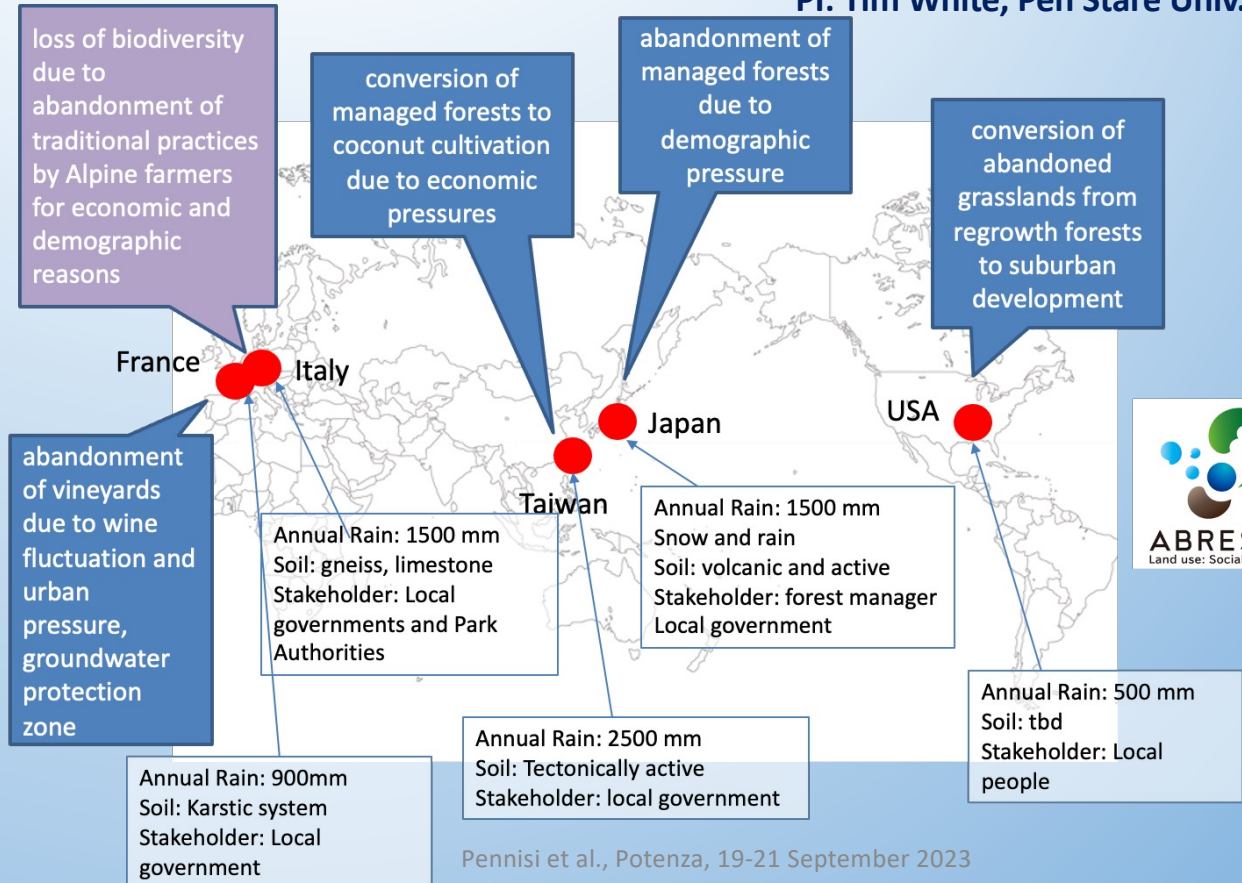
PI: Tim White, Pen State Univ.

### The challenge...

An International partnership that mobilizes funding of environmental change research and accelerates its delivery to remove critical barriers to sustainability



Collaborative Research Action  
2020 – 2024:  
Towards sustainability of soils & groundwater for societal benefit





**ABRESO**  
Abandonment and rebound:  
Societal views on landscape- and land-use change  
and their impacts on water and soils



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# Land abandonment: the Italian Alpine Mountain Perspective

PI: IGG-CNR (M.Pennisi)  
PI Ecosystem : A. Scartazza-Iret  
PI Remote sensing: P. Adamo-IIA  
PI Social Science: L. Sella-IRCrEs

Financial support: DSSTA-CNR

Among the main threats facing the  
Alps land abandonment is the most  
significant

The most evident and resounding is  
the phenomenon of forest  
advancement

This process - widely underestimated  
or even ignored in the Italian  
scientific and political debate -  
constitutes one of the main changes  
in land use with impactful  
transformations of the landscape



Italian sites...

## Noaschetta, Gran Paradiso National Park, Piemonte

Elevation: 1600 m  
Watershed area: 25 km<sup>2</sup>  
Population: 106

Main Lithology: Gneiss



## Val Grande National Park, UNESCO, Piemonte

Elevation: 800-1300 m  
Watershed area: 150 km<sup>2</sup>  
Population: ca. 17

Main Lithology: Micascists



## Tesino (Malga Telvagola) Trentino Alto Adige

Elevation: 1700 m  
Watershed area: 90 km<sup>2</sup>  
Population: 4307

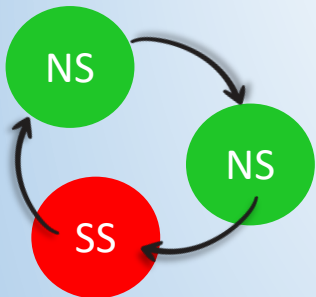
Main Lithology: Carbonates



## CNR-infrastructures in alpine areas:

- IGG: CZ Observatory@Gran Paradiso National Park
- IRET: National Biodiversity Future Center

IIA



## The pillars...

In ABRESO activities are an interplay between three pillars :

- 1) Ground-based Natural Science
- 2) Remote sensing
- 3) Social Science

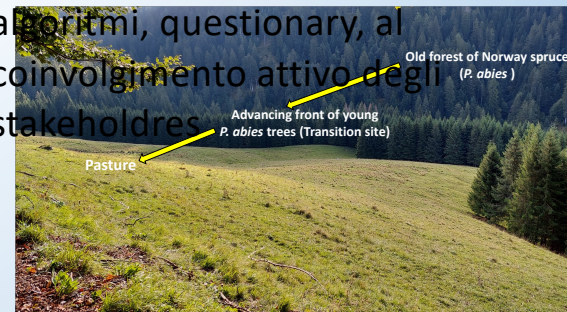
Soil Biogeochemistry  
Geomorphology  
Plant Physiology  
Phenology  
CO<sub>2</sub> flux

Natural  
Science  
&  
Social  
Science

Satellite  
Ortophotos  
Land cover  
Snow cover

Economics of complex systems  
Policy evaluation  
Economic territory planning

Oltre al Covid (remoto), Difficoltà a comprendere l'approccio altrui, al linguaggio, al lavoro di campagna, algoritmi, questionnaire, al coinvolgimento attivo degli stakeholders



**ONE AIM:**  
Analysing  
land use  
change  
& its impacts

**DIFFERENT:**  
- Methods  
- Spatial and temporal scales  
- Meanings  
- Wordings  
- Visions

- Plant Biodiversity and Net Primary Productivity
- Ecosystem and soil carbon fluxes
- Soil carbon (and other nutrients) stocks

## Ground monitoring

- pH, CE, texture, aggregates stability
- Surface Run-off, sediment transport
- Soil erosion
- Soil Organic Carbon (SOC)
- Soil Nitrogen
- C isotope composition (d13C)
- N isotope composition (d15N)



Accumulation chambers



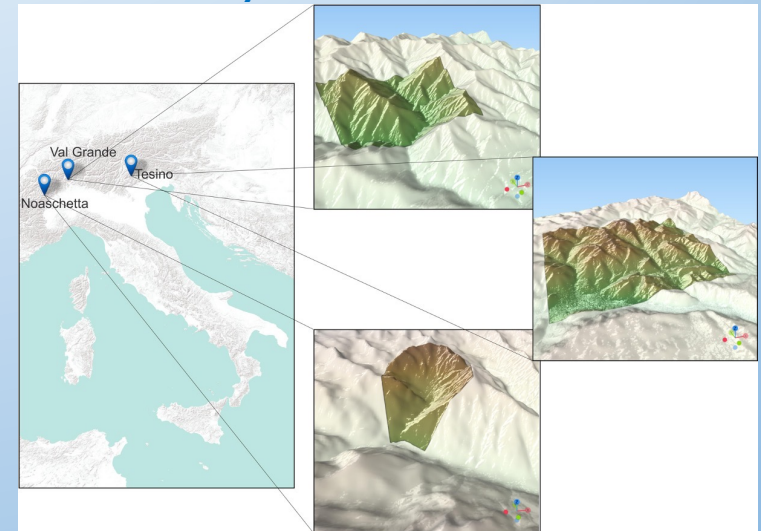
Eddy Covariance station

The tools...



## Remote Sensing

- ❖ Snow cover monitoring in terms of extent and duration
- ❖ Land cover maps and related temporal changes
- ❖ Extraction of Spectral Indices for vegetation and soil analysis over time



# The facilities...

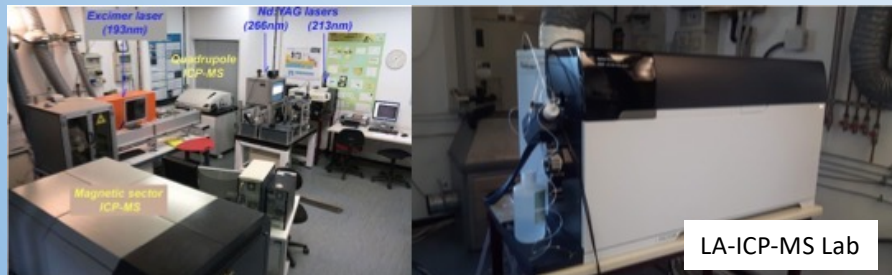
## The new IGG-CNR Neptune-TIMS and Stable Isotope Mass Spectrometry (@Pisa), and LA-ICP-MS & SIMS (@Pavia)



Neptune – TIMS Lab

➔ The **Neptune-TIMS lab** is equipped with a MC-ICP-MS and two Thermal Ionization Mass Spectrometers and clean rooms. **Provides isotopic composition of B, Cr, Sr, Nd, Pb on rock, minerals, and fluid samples**

⬇ The **Stable lab's facilities** allow isotopic composition and content of total hydrogen, nitrogen, sulphur, organic and inorganic carbon (**H, TN, TS, TOC, TIC**) in **solid, liquid and gaseous samples**



LA-ICP-MS Lab



Stable Isotope Lab

➔ The **SIMS laboratory's facility** allows to determine the **in-situ (15-20 μm) composition (from H to U)** of solid matrices



SIMS Lab

EPOS Infrastructure & Trans National Access at the IGG-CNR labs



## Natural Science: Soil Physical, Chemical and Biological Properties

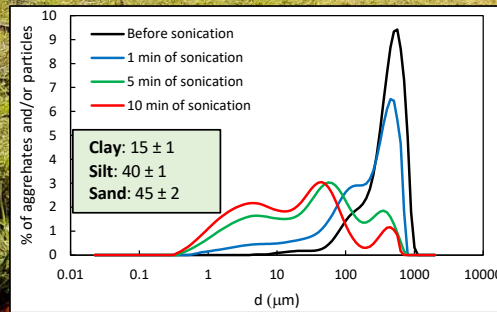
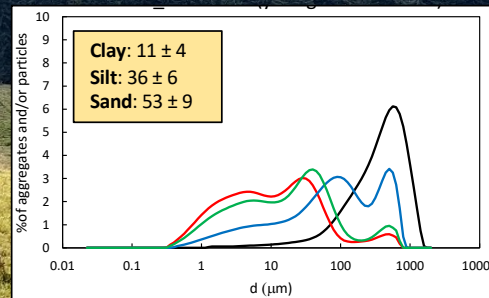
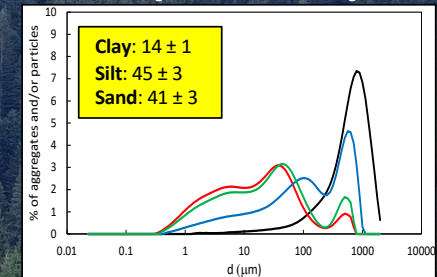
Malga Telvagola  
 (Pieve Tesino)

Preliminary results...

Old forest of Norway spruce  
 (*P. abies*)

Advancing front of young  
*P. abies* trees (Transition site)

Pasture



Particle size distribution in soil aggregates before and after sonication differs in forest and pasture, as well as pH, EC, and enzymatic activities

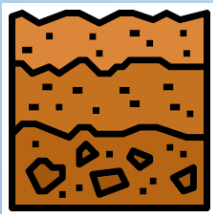
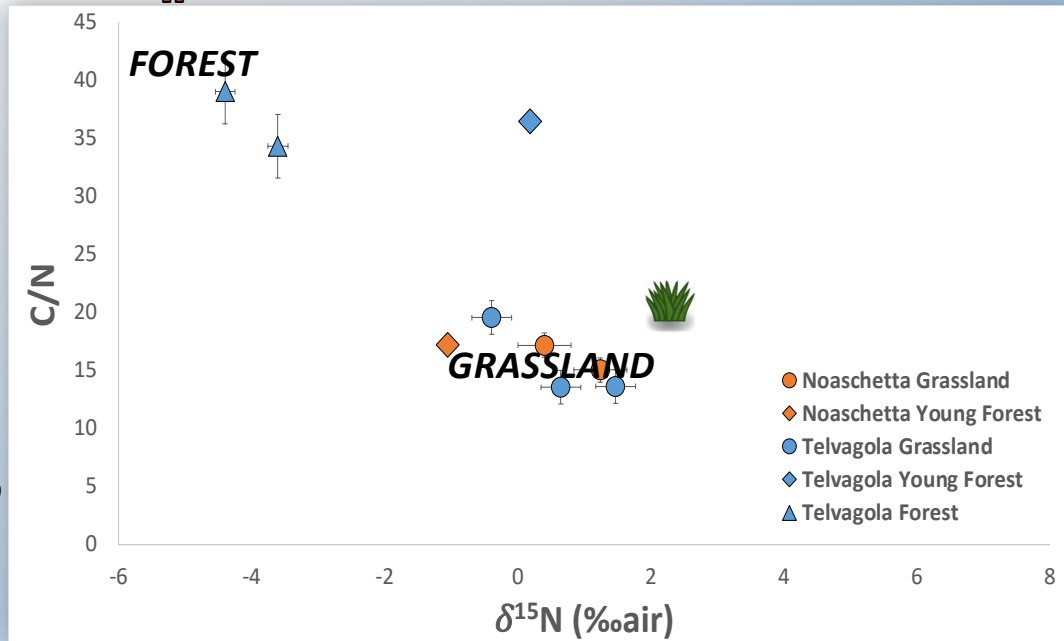
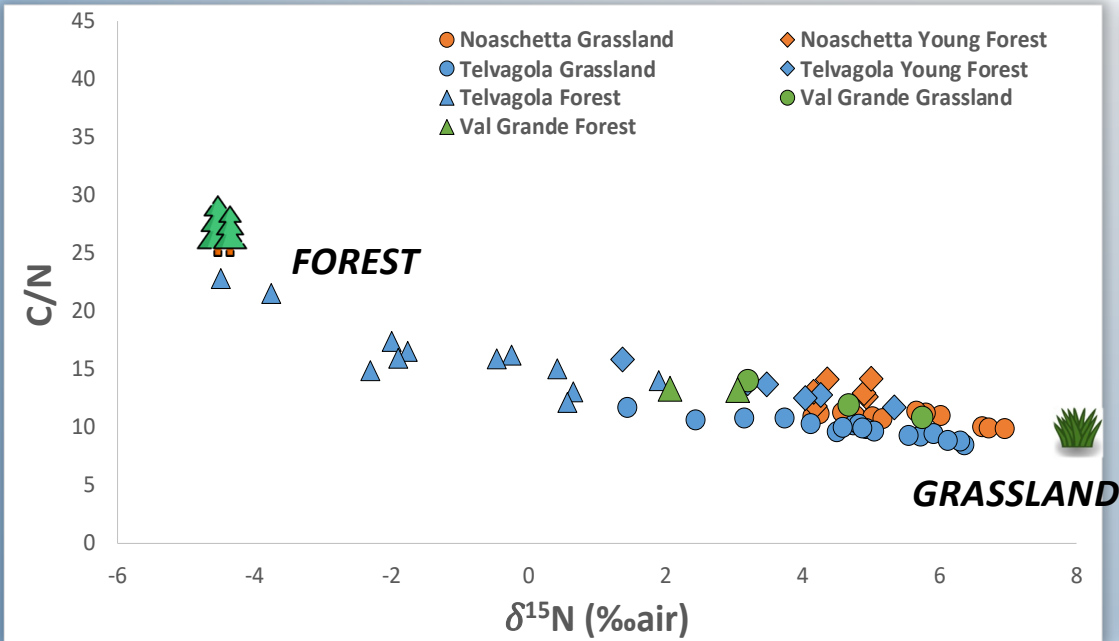
# N-isotopes in the forest - pasture transition

## SOIL

Preliminary results...

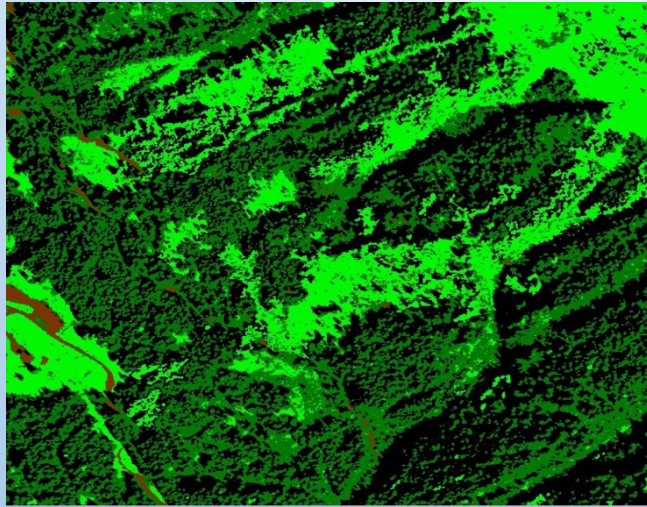


## VEGETATION

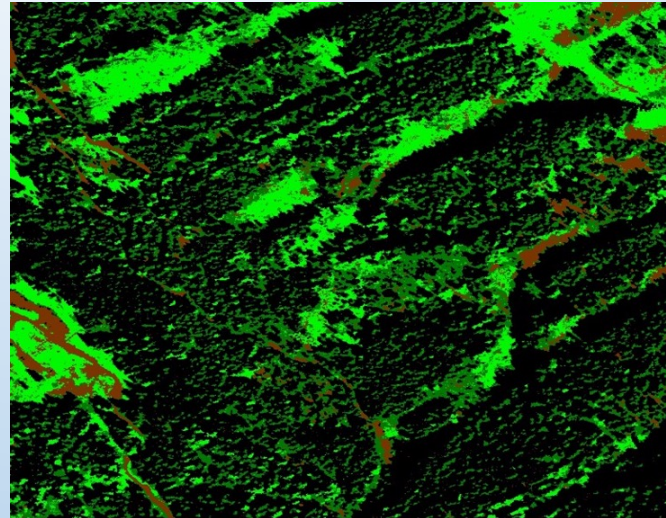


## Natural Science: Forest↔Pasture Transition

Preliminary results...



Pasture area in  
2006 = 17 ha



Pasture area in  
2020 = 10.2 ha

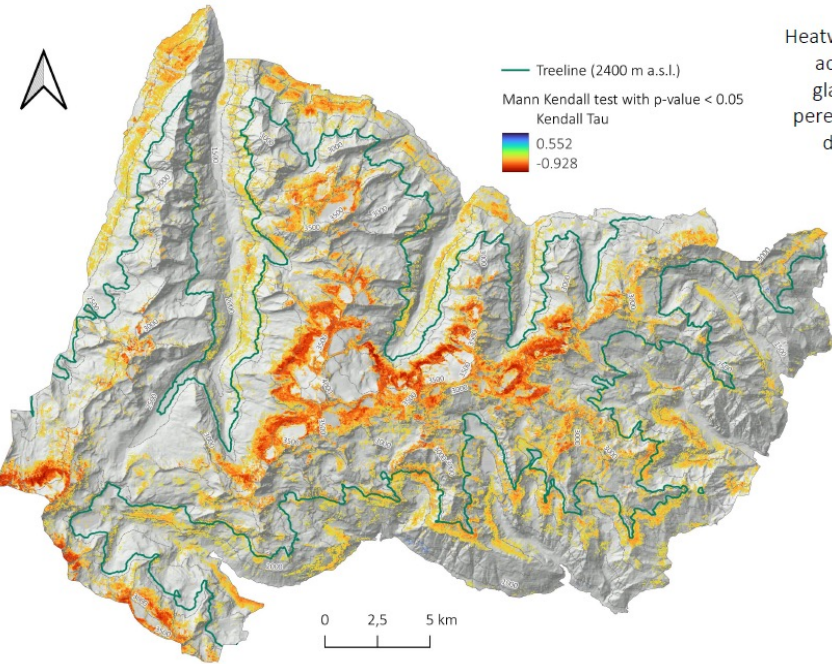
Time series of orthophotos provided by stakeholders

Do stakeholders acknowledge the real dynamics of Forest-Pasture transition?

## Natural Science: SNOW COVER DURATION

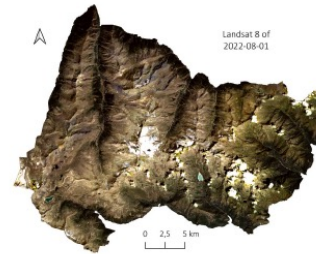
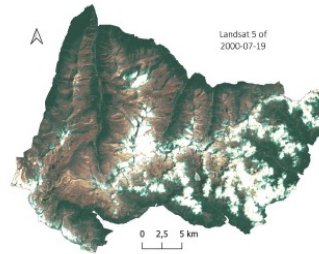
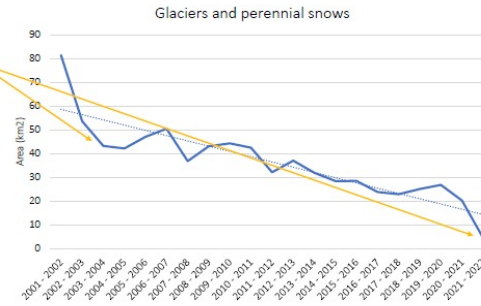
### 4 Snow Cover Duration trend

Mann Kendall test (R package «zyp») was applied to the SCD time series to unveil the presence of monotonic trends.



Heatwaves deeply accelerates glaciers and perennial snows depletion

### Noaschetta, Gran Paradiso



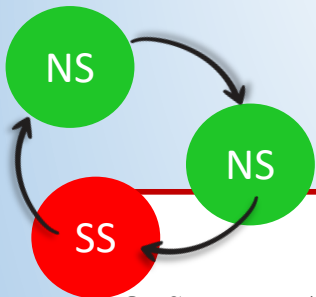
Natural color Landsat scenes

- Snow Cover can affects:
- grazing season (start, duration)
  - phenology and quality of grazing
  - water availability



**Snow Cover Duration vs discharges data (Noaschetta stream; since 2010)**

**Methodology: Gap-filling algorithm based on data fusion of Sentinel-2 + MODIS imagery with Random Forest Integration with Landsat data to extend time series from 2000 to today, at 30 m spatial resolution**



## Co-created research questions

### OBSERVED (NS)

### PERCEIVED (SS)

#### LAND USE CHANGE

*Remote sensing* – land cover maps and temporal changes from the 1990s on

*Ground truth* – plant biodiversity and bio-geochemical cycles

Web-based survey (sites' oversampling)

In-depth interviews to local stakeholders

Analysis of socio-economic secondary data

#### SNOW COVER and GRAZING SEASON

*Remote sensing* – Snow cover monitoring (extent and duration); extraction of time series of spectral indices for vegetation and soil analysis

*Ground truth* – variation on water discharge

Web-based survey (sites)

In-depth interviews to shepherds

*Are shepherds aware of the snow cover effects on*

- *the grazing season (start, duration)?*
- *the phenology and quality of grazing?*
- *water availability?*

#### BIODIVERSITY AND LAND USE (abandonment, grazing, overgrazing)

*Remote sensing* – soil organic carbon, primary productivity extraction

*Ground truth* – carbon and nitrogen cycling, plant physiology, phenology and biodiversity

In-depth interviews to shepherds

*Are shepherds aware of the effect of grazing on*

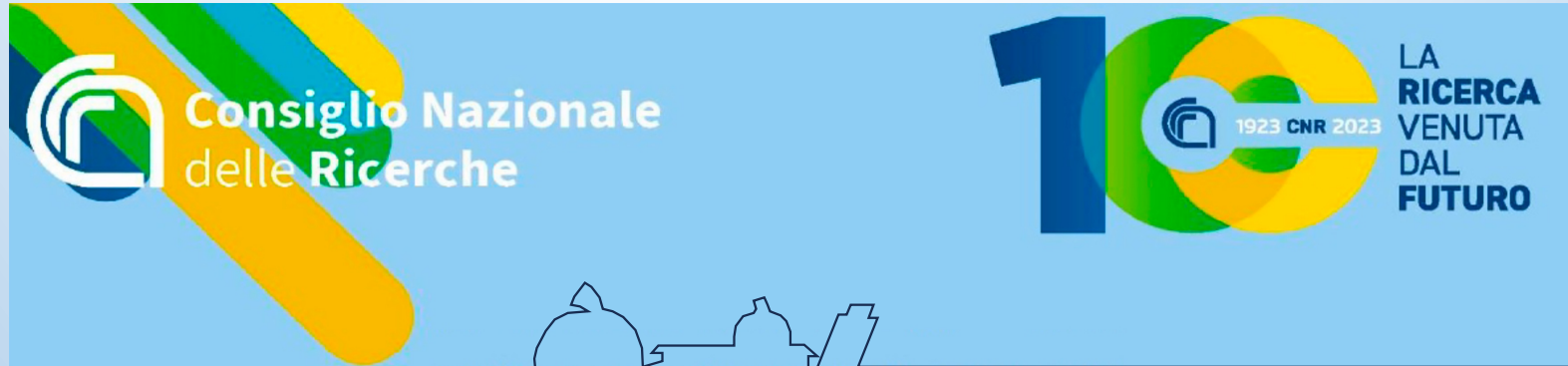
- *biodiversity?*
- *carbon and nitrogen cycles?*

#### LANDSCAPE TRANSITIONS (FOREST ↔ PASTURE)

Orthophotos, satellite imagery, ground truth

In-depth interviews to local stakeholders

Analysis of territorial forest management plans



Verso un nuovo CNR: quali strumenti per affrontare le sfide di una ricerca sempre più interdisciplinare e transdisciplinare

*CNR, Area della Ricerca di Pisa, 26 ottobre 2023 e in streaming*

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**ABRESO**  
Abandonment and rebound:  
Societal views on landscape- and land-use change  
and their impacts on water and soils.

**GRAZIE per l'attenzione**