THE CONTRIBUTION OF CHEMICAL WEATHERING ON ATMOSPHERIC CO_2 CONCENTRATION: PERSPECTIVES IN A CONTEXT OF CLIMATE CHANGE

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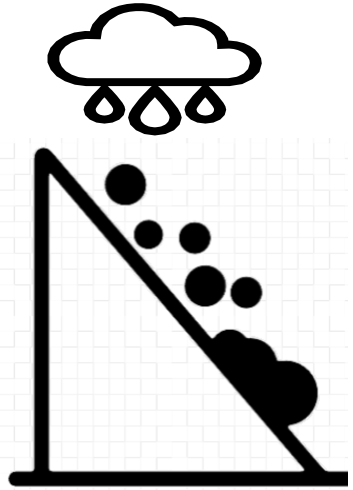
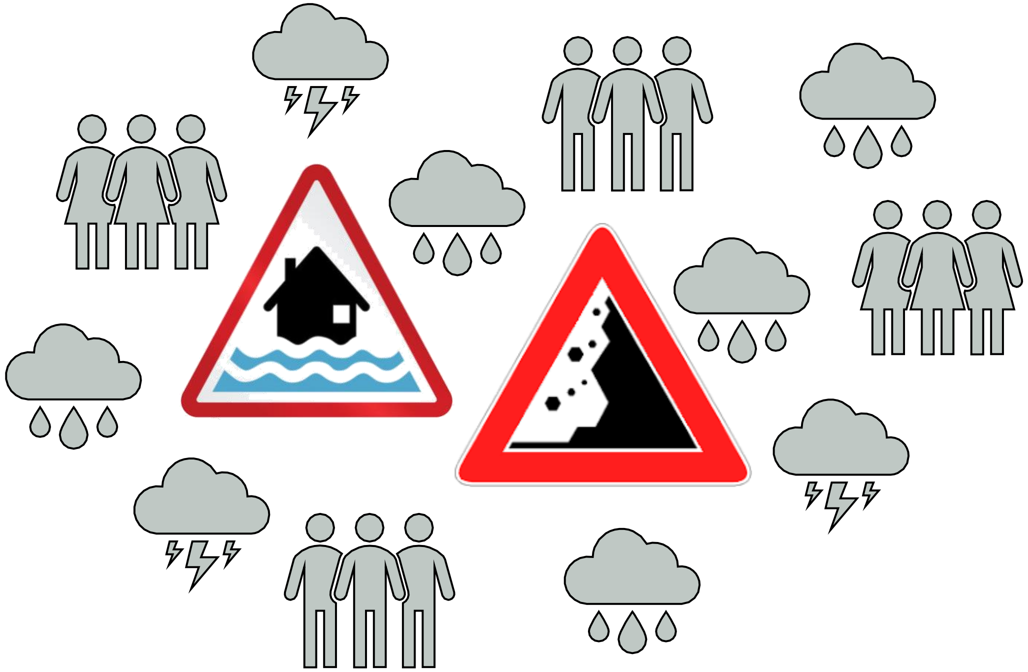
Geo-hydrological risks are influenced by **precipitation** and by **distribution/abundance of the population**.

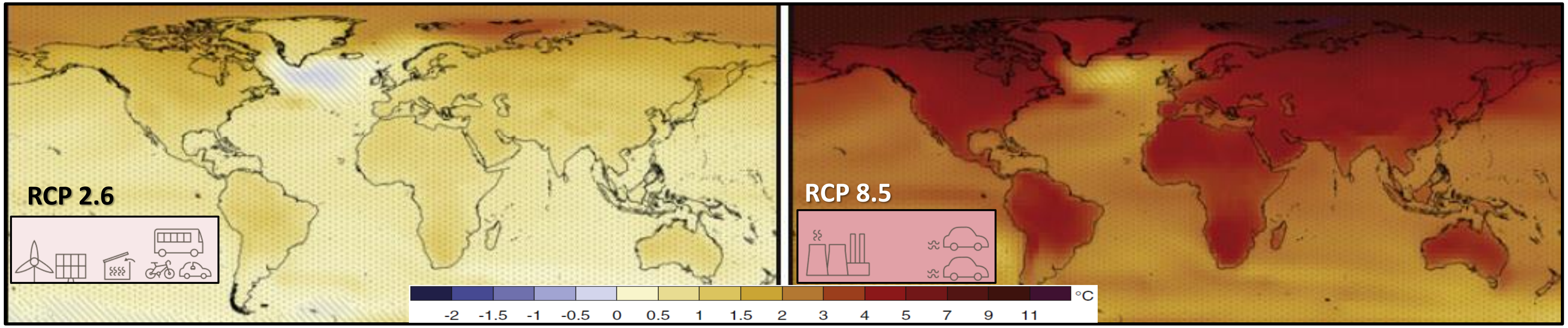




Precipitation (directly) and **distribution/abundance of population** (indirectly) are affected by **climate** and their variations may influence the **geo-hydrological risks**.

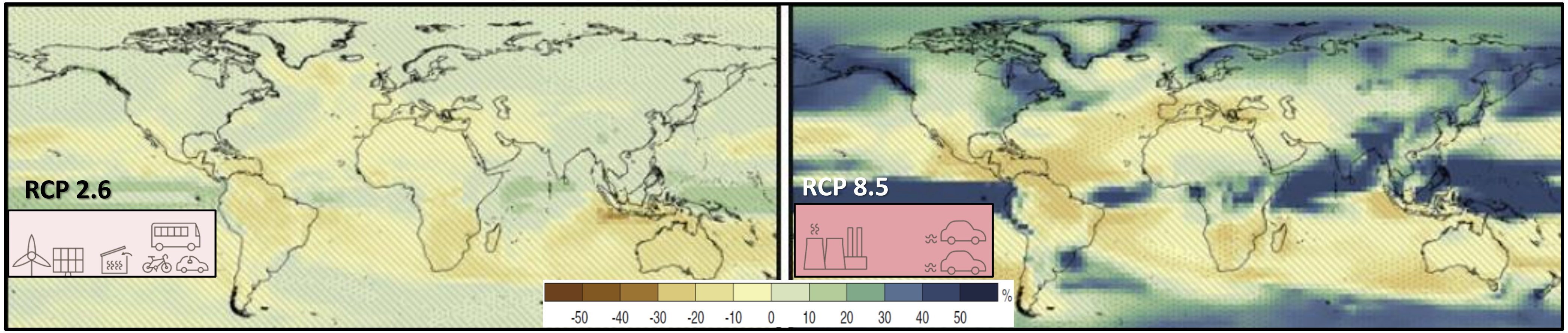
The **average temperature is projected to** increase in **many regions** under **all emission scenarios**.

Change in average surface temperature (1986-2005 to 2081-2100)



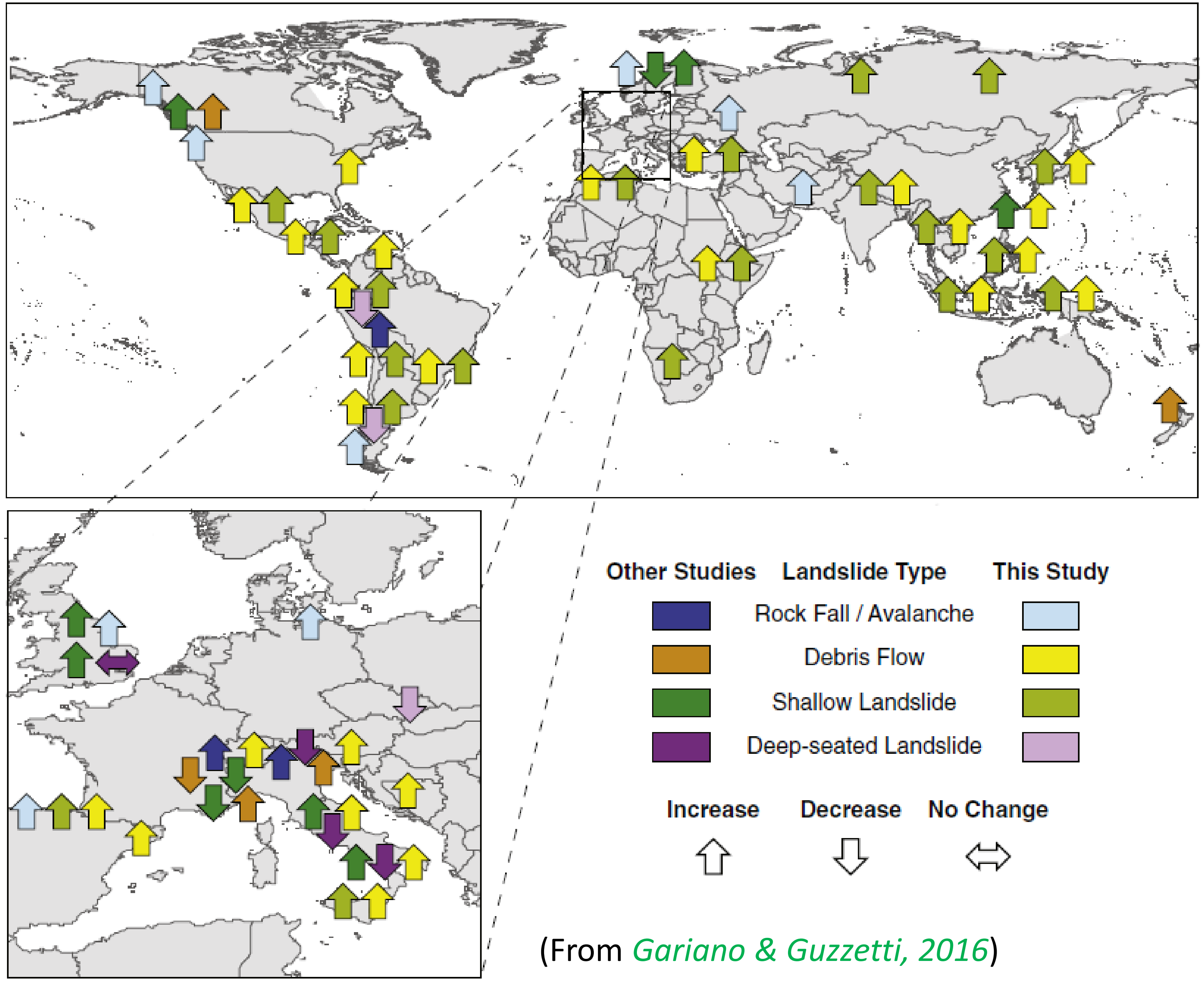
In **many areas**, **extreme precipitation** events will become **more intense and frequent**.

Change in average precipitation (1986-2005 to 2081-2100)



(*IPCC; 2014*)

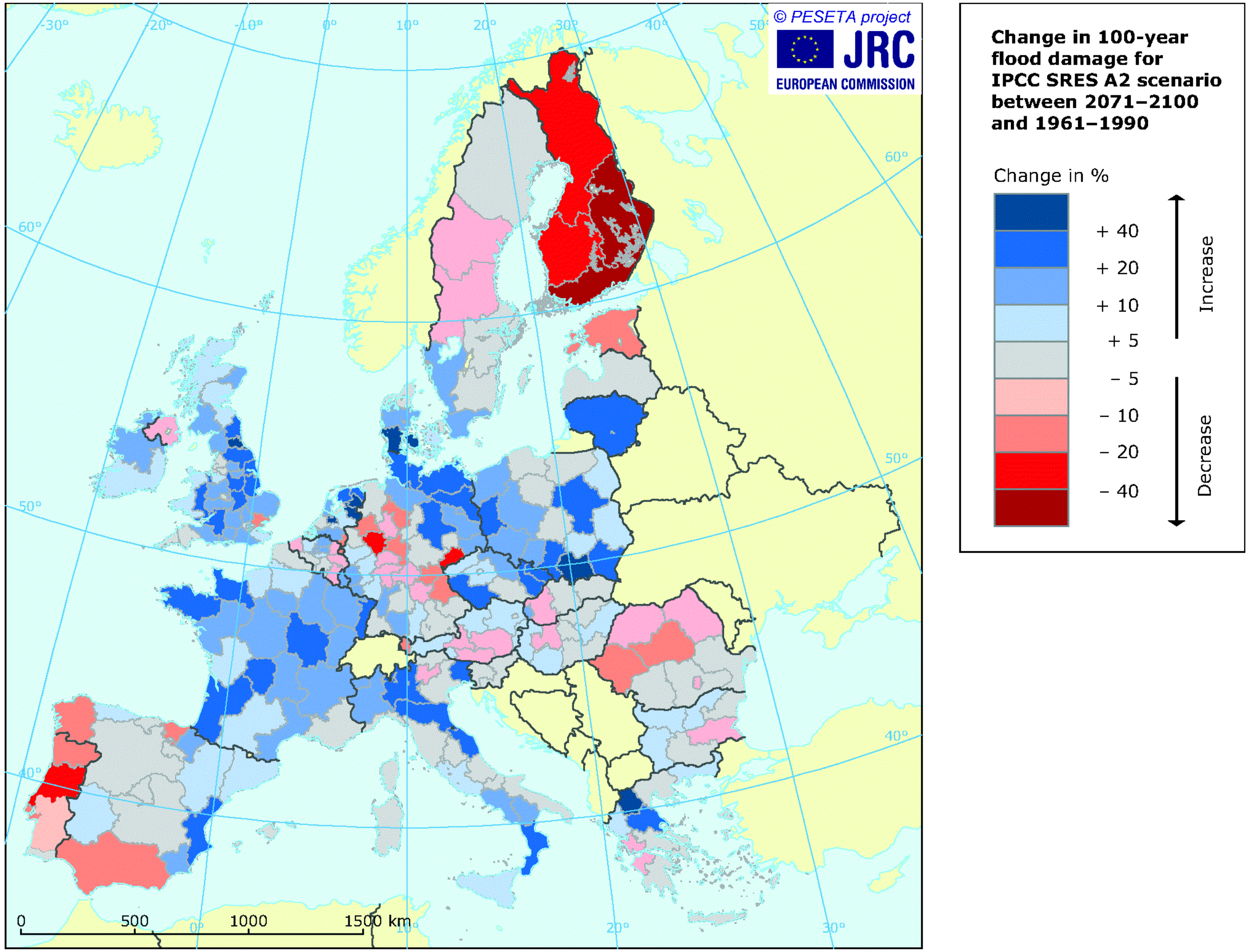
Impact of *climate change* on *landslides* and *floods* occurrence

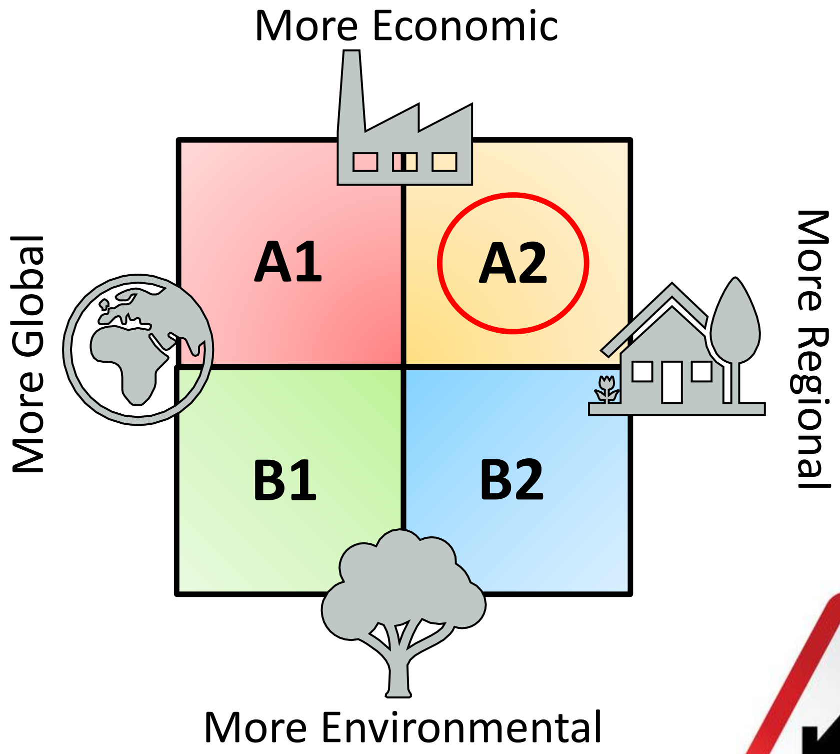


(From *Gariano & Guzzetti, 2016*)

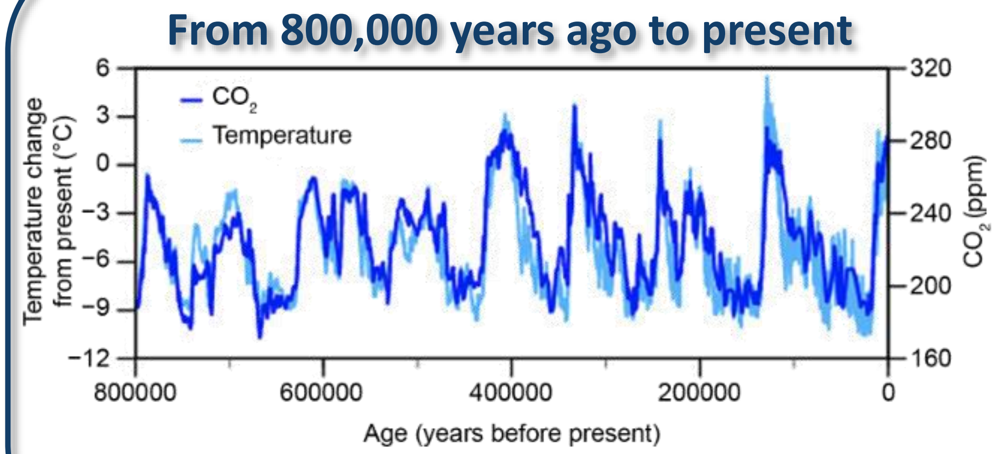
Frequency/intensity increase of rainstorms, will **increase shallow landslides** (rock falls, debris flows and debris avalanches).

Projected change in **damage of river floods** with a **100-year return period** between 2071-2100 and 1961-1990. Model calculation using the **IPCC SRES scenario A2**



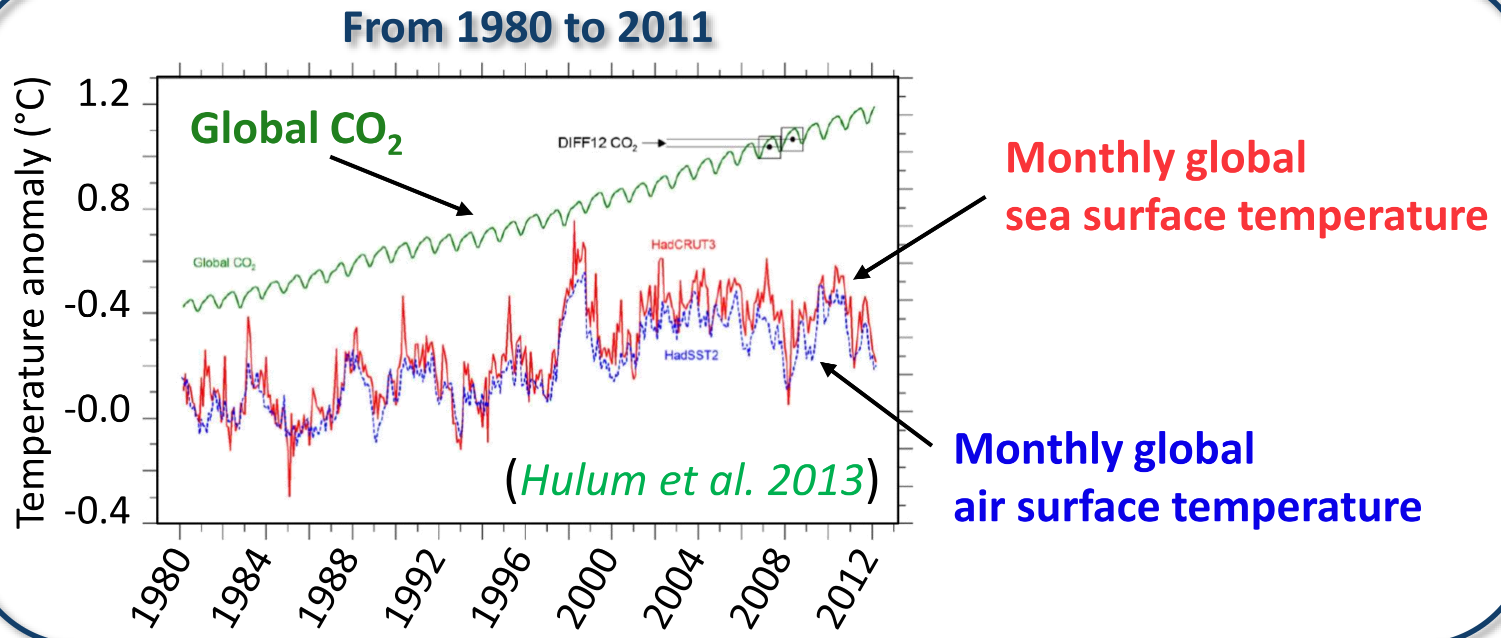


Atmospheric CO_2 and temperature variations



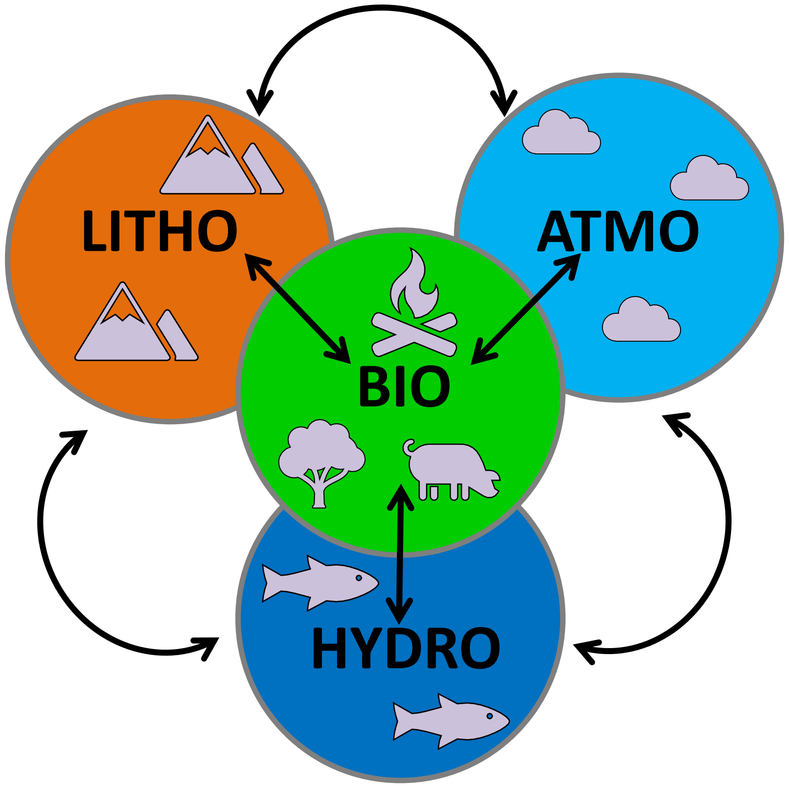
(*Jouzel et al. 2007; Lüthi et al. 2008*)

Several studies highlights a **correlation** between **air/sea temperature** and **atmospheric CO_2 concentration** at **different time scale**.



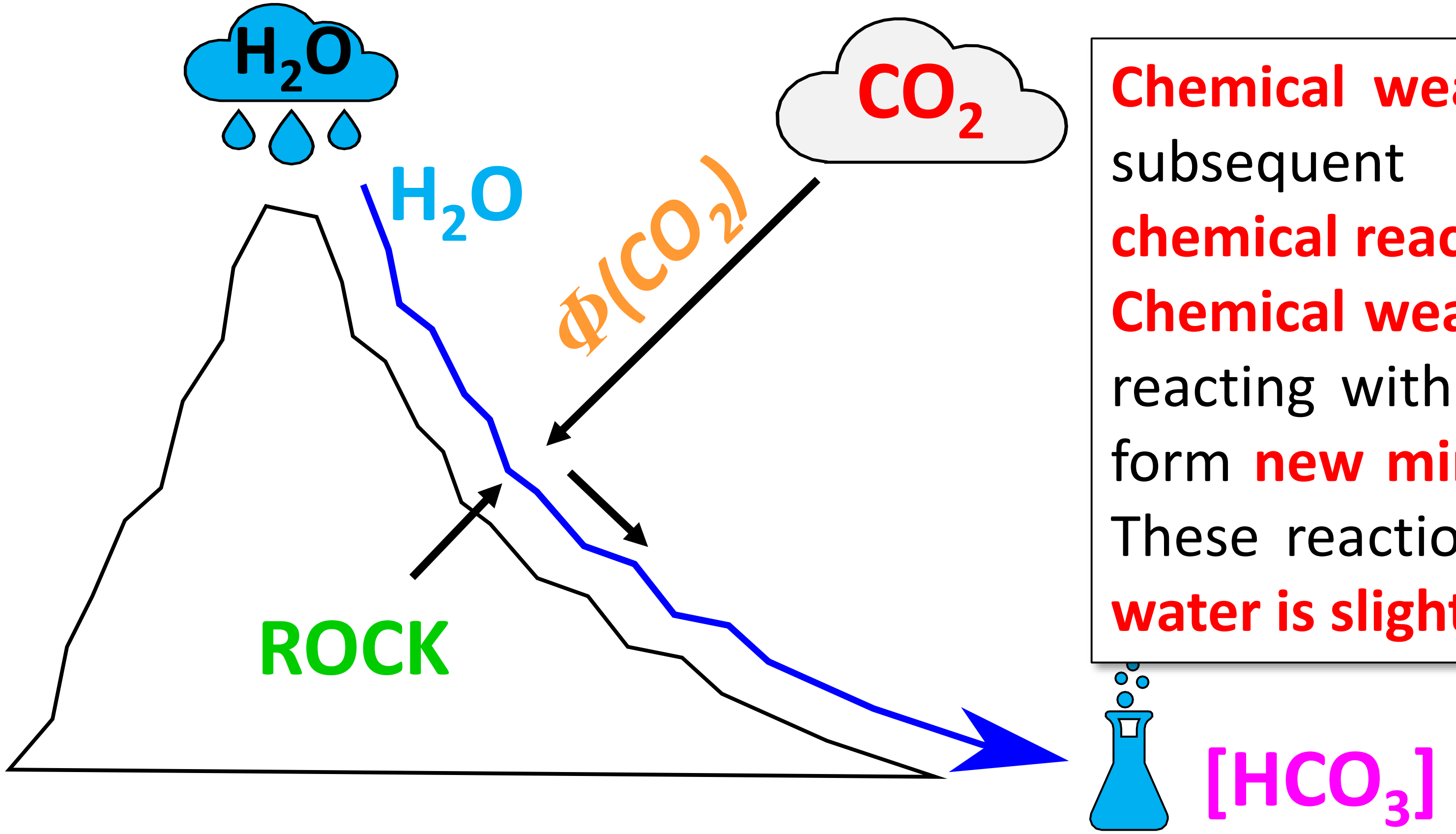
(*Hulum et al. 2013*)

Carbon migrates continuously among **lithosphere**, **atmosphere**, **biosphere**, and **hydrosphere**.



Knowing the **natural phenomena of production / migration of carbon** allows us to **better understand** the **impacts of anthropogenic emissions**, responsible of the recent climate change, that **overlap with natural contributions**.

(*e.g. Berner et al., 1983; Berner, 1991; 1994*; 2004; 2006; *Berner & Kothavala, 2001*)



Chemical weathering is the **weakening** and subsequent **disintegration** of **rock** by **chemical reactions**.
Chemical weathering is caused by **rain water** reacting with the **mineral grains in rocks** to form **new minerals (clays)** and **soluble salts**. These reactions occur particularly when the **water is slightly acidic**.

Chemical weathering of carbonate and silicate,
that consume atmospheric CO_2 increasing water alkalinity,
is an important sink of atmospheric CO_2.

(e.g. *Mackenzie & Garrels, 1966*; *1971*; *Meybeck, 1987*; *Probst, 1992*; *Gaillardet et al., 1999*; *Berner et al., 1983*; *Berner, 1991*; *1994*; *2004*; *2006*; *Berner & Kothavala, 2001*)

The global carbon cycle

(e.g. *Mortatti & Probst, 2003*; *Donnini et al., 2016*; *Donnini et al., 2020*)

Carbonate minerals

Calcite dissolution:

$CaCO_3 + CO_2 + H_2O \leftrightarrows Ca^{++} + 2HCO_3^-$

Dolomite dissolution:

$CaMg(CO_3)_2 + 2CO_2 + 2H_2O \leftrightarrows Ca^{++} + Mg^{++} + 4HCO_3^-$

Silicate minerals

Albite into kaolinite:

$2NaAlSi_3O_8 + 2CO_2 + 11H_2O \leftrightarrows Al_2Si_2O_5(OH)_4 + 2HCO_3^- + 2Na^+ + 4H_4SiO_4$

K-feldspar into montmorillonite:

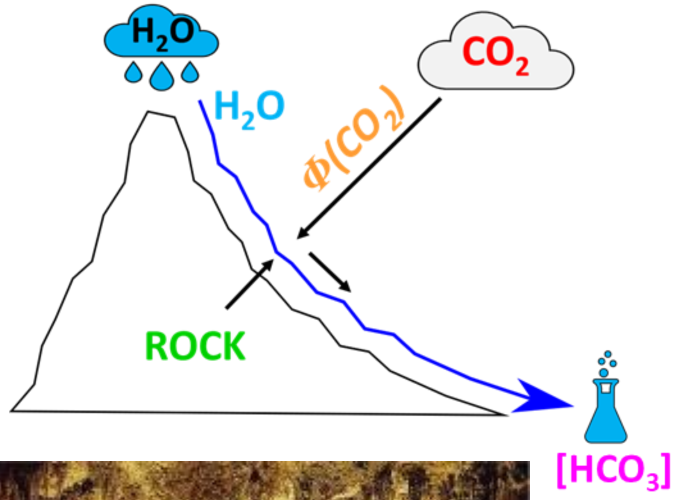
$2KAlSi_3O_8 + 2CO_2 + 6H_2O \leftrightarrows Al_2Si_4O_{10}(OH)_2 + 2HCO_3^- + 2K^+ + 2H_4SiO_4$

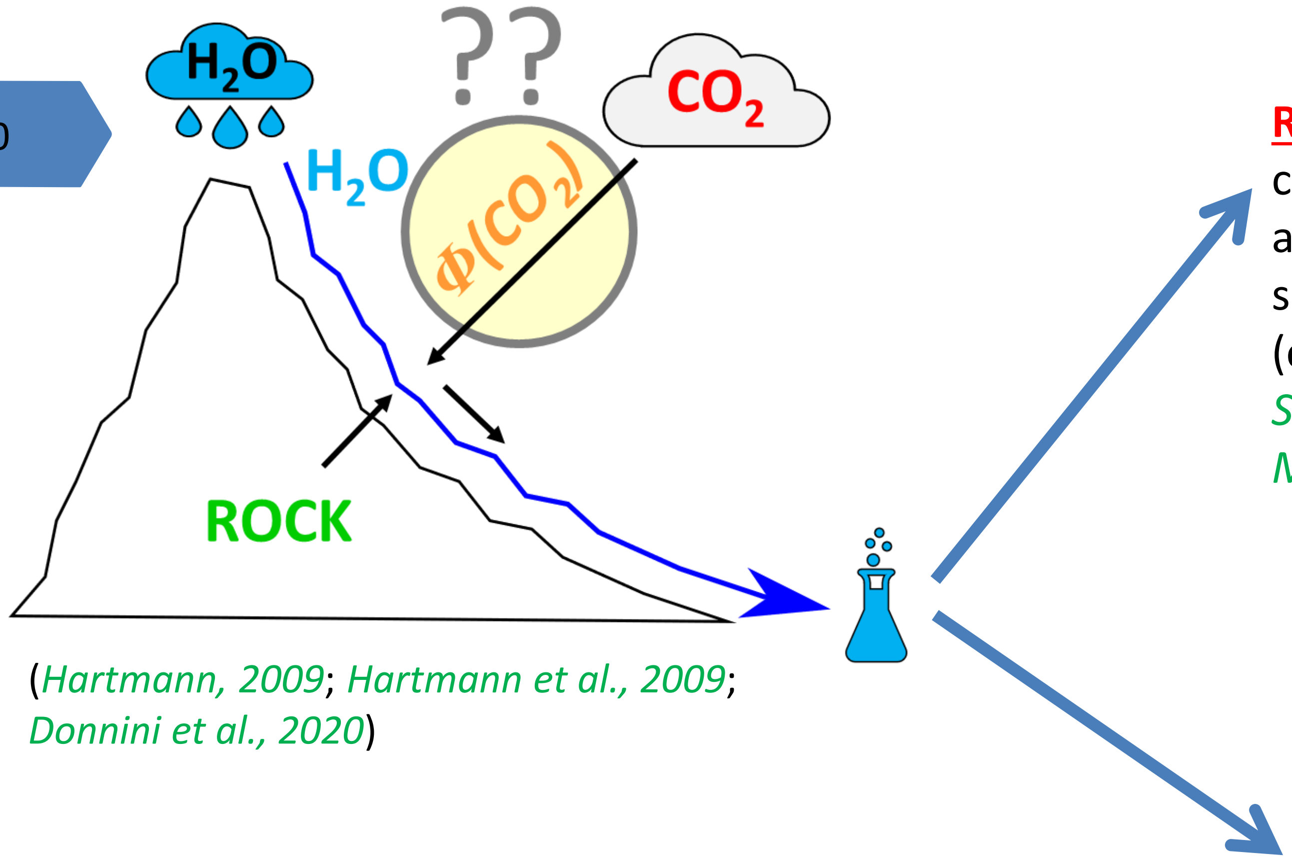
Ca-plagioclase into kaolinite:

$CaAl_2Si_2O_8 + 2CO_2 + 3H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 2HCO_3^- + Ca^{++}$

Olivine weathering:

$Mg_2SiO_4 + 4CO_2 + 4H_2O \rightarrow 2Mg^{++} + 4HCO_3^- + H_4SiO_4$

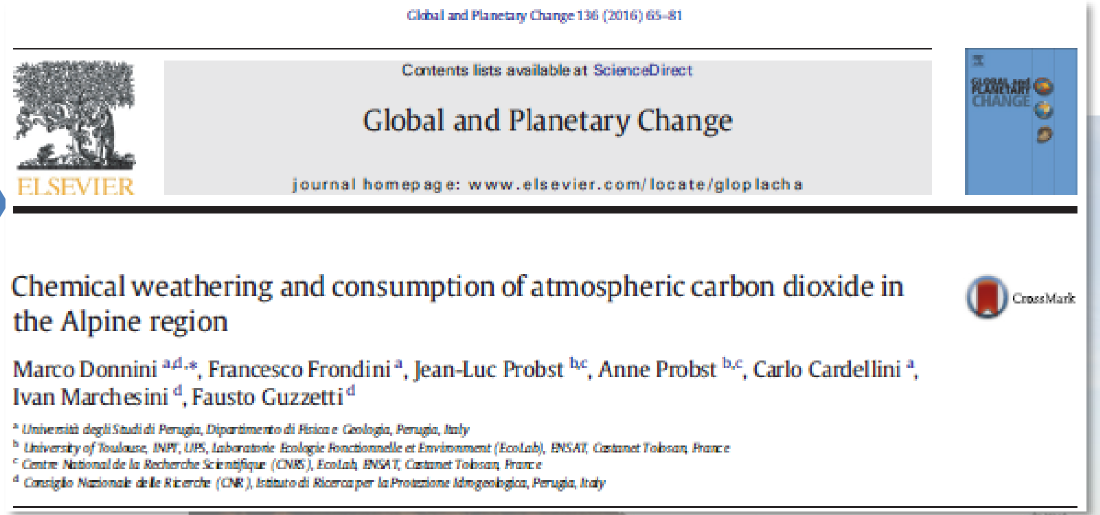




(*Hartmann, 2009*; *Hartmann et al., 2009*; *Donnini et al., 2020*)

Reverse method starts from the knowledge of the concentration of **Na**, **K**, **Ca** and **Mg** in river waters to which a series of **"corrections"** is applied (for example the subtraction of the rain and pollution).
(e.g. *Probst et al., 1994*; *Amiotte-Suchet, 1995*; *Amiotte-Suchet and Probst, 1996*; *Boeglin and Probst, 1998*; *Mortatti and Probst, 2003*; *Donnini et al., 2016*)

Forward method starts from the knowledge of the **HCO_3** concentration in river waters.
(e.g. *Bluth and Kump, 1994*; *Amiotte-Suchet and Probst, 1993a*, *1993b*, *1995*; *Probst et al., 1994*; *Amiotte-Suchet et al., 2003*; *Hartmann, 2009*; *Hartmann et al., 2009*; *Donnini et al., 2020*)



Global and Planetary Change 136 (2016) 65–81
Contents lists available at ScienceDirect
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Chemical weathering and consumption of atmospheric carbon dioxide in the Alpine region

Marco Donnini [a,d,*], Francesco Frondini [a], Jean-Luc Probst [b,c], Anne Probst [b,c], Carlo Cardellini [a], Ivan Marchesini [d], Fausto Guzzetti [d]

[a] Università degli Studi di Perugia, Dipartimento di Fisica e Geologia, Perugia, Italy
[b] University of Toulouse, INPT, UPS, Laboratoire Ecologie Fonctionnelle et Environnement (EcoLab), ENSAT, Castanet Tolosan, France
[c] Centre National de la Recherche Scientifique (CNRS), EcoLab, ENSAT, Castanet Tolosan, France
[d] Consiglio Nazionale delle Ricerche (CNR), Istituto di Ricerca per la Protezione Idrogeologica, Perugia, Italy

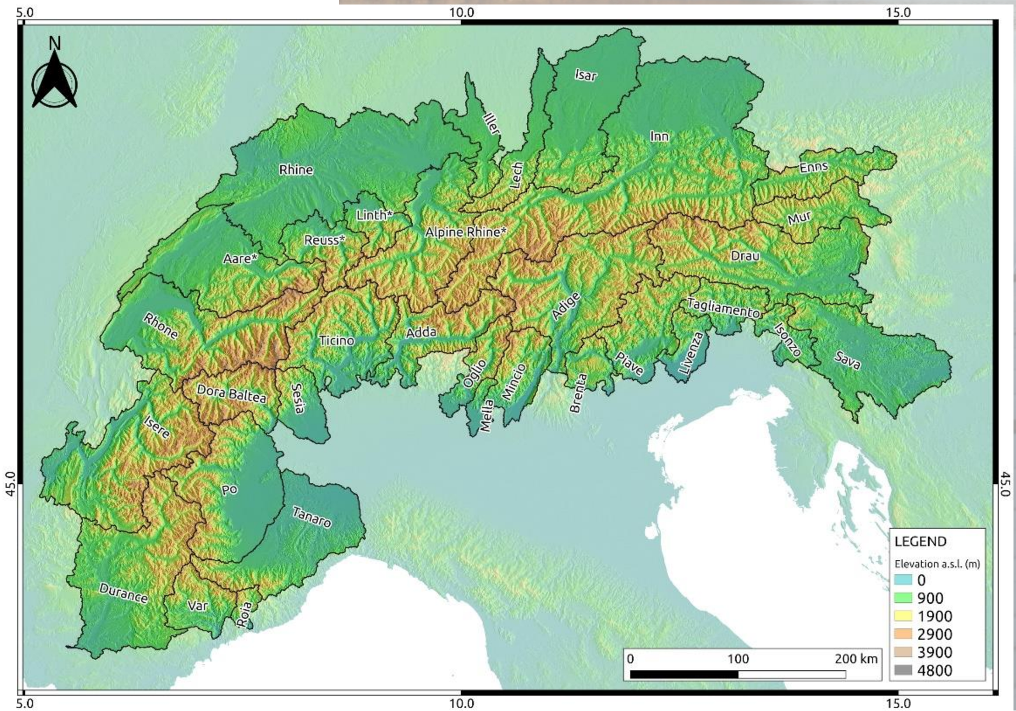
CO_2 consumption in Alpine region

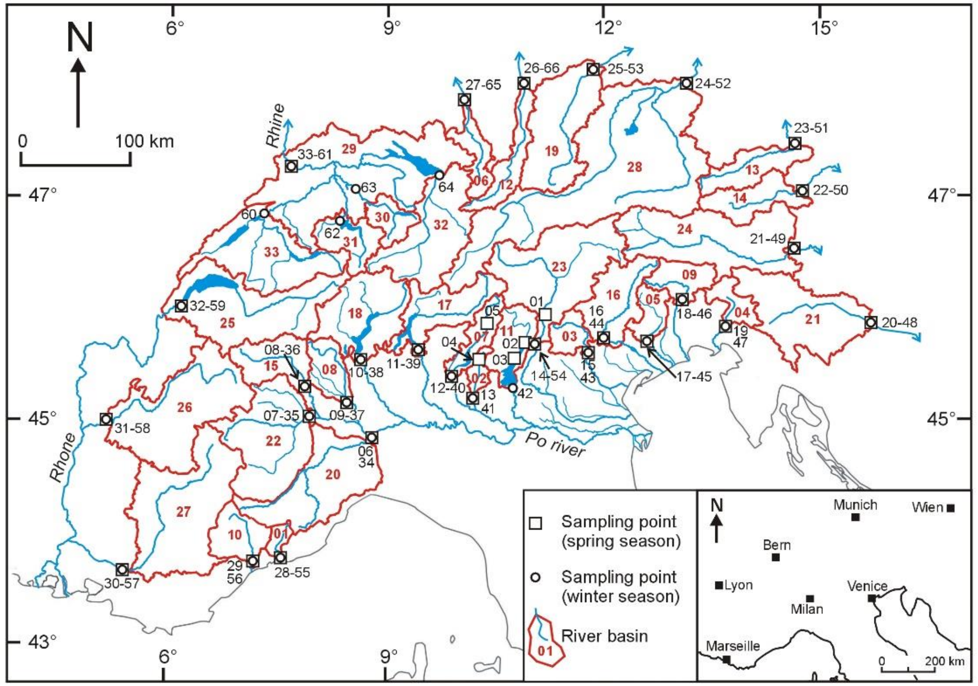
REVERSE METHOD (*Donnini et al., 2016*)

<u>34 river basins</u>

<u>2 sampling campaigns</u>:

- ✓ **Spring season (Frebruary - June 2011)**
- ✓ **Winter season (December 2011 - March 2012)**





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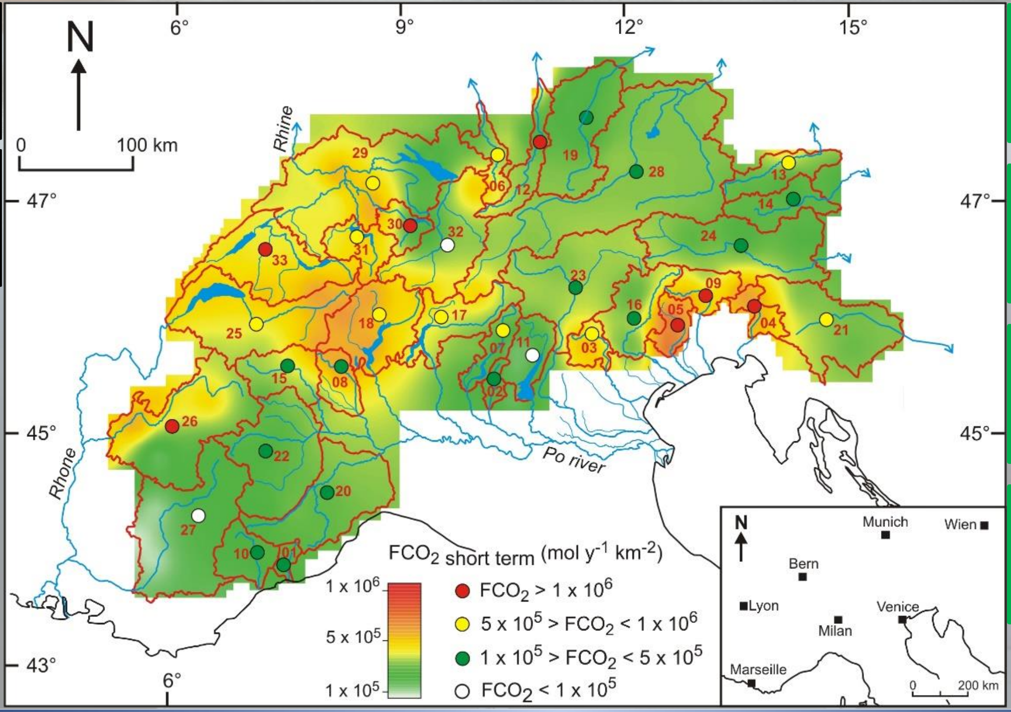
$\Phi(CO_2) = 5.35\times10^5$ mol y^{-1} km^{-2} (winter season)

$\Phi(CO_2) = 4.69\times10^5$ mol y^{-1} km^{-2} (spring season)



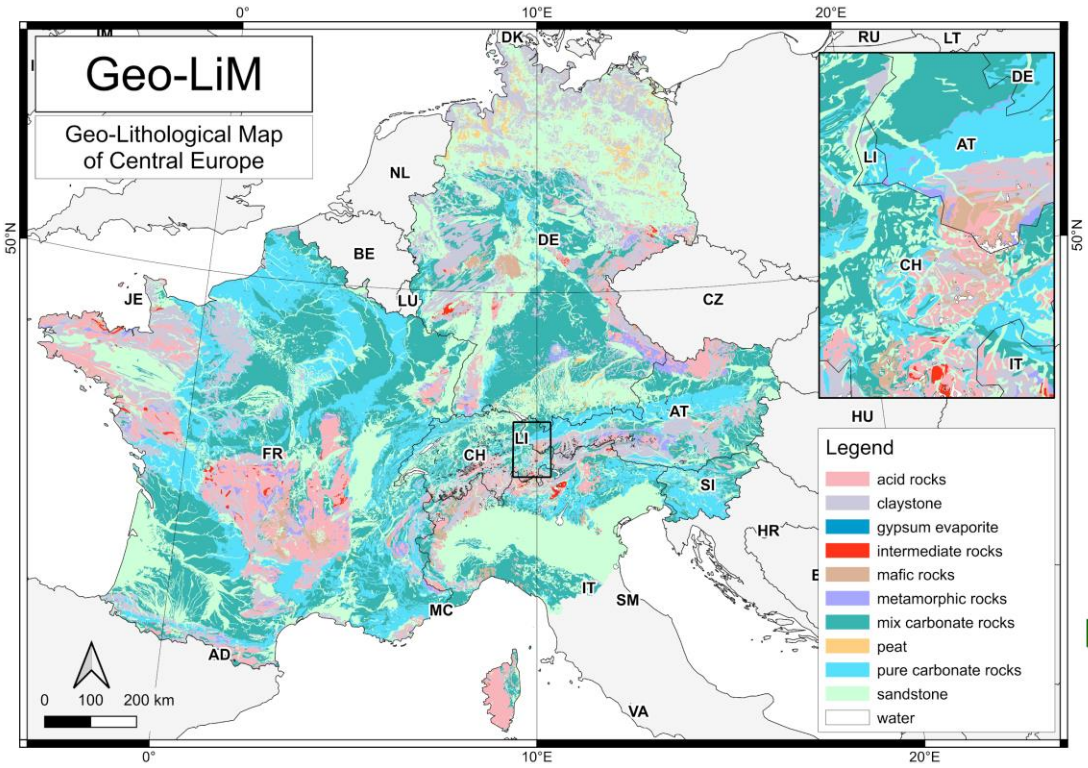
$\Phi(CO_2) = 2.46\times10^5$ mol y^{-1} km^{-2} (*Gaillardet et al., 1999* - World average)

$\Phi(CO_2) = 8.56\times10^5$ mol y^{-1} km^{-2} (*Gaillardet et al., 1999* - Rhone)

$\Phi(CO_2) = 5.42\times10^5$ mol y^{-1} km^{-2} (*Gaillardet et al., 1999* - Rhine)

$\Phi(CO_2) = 1.12\times10^6$ mol y^{-1} km^{-2} (*Gaillardet et al., 1999* - Po)

CO_2 consumption in Alpine region




JOURNAL OF MAPS
2020, VOL. 16, NO. 2, 43–55
https://doi.org/10.1080/17445647.2019.1692082

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Geo-LiM: a new geo-lithological map for Central Europe (Germany, France, Switzerland, Austria, Slovenia, and Northern Italy) as a tool for the estimation of atmospheric CO_2 consumption

Marco Donnini[a], Ivan Marchesini[a] and Azzurra Zucchini[b]

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PDF

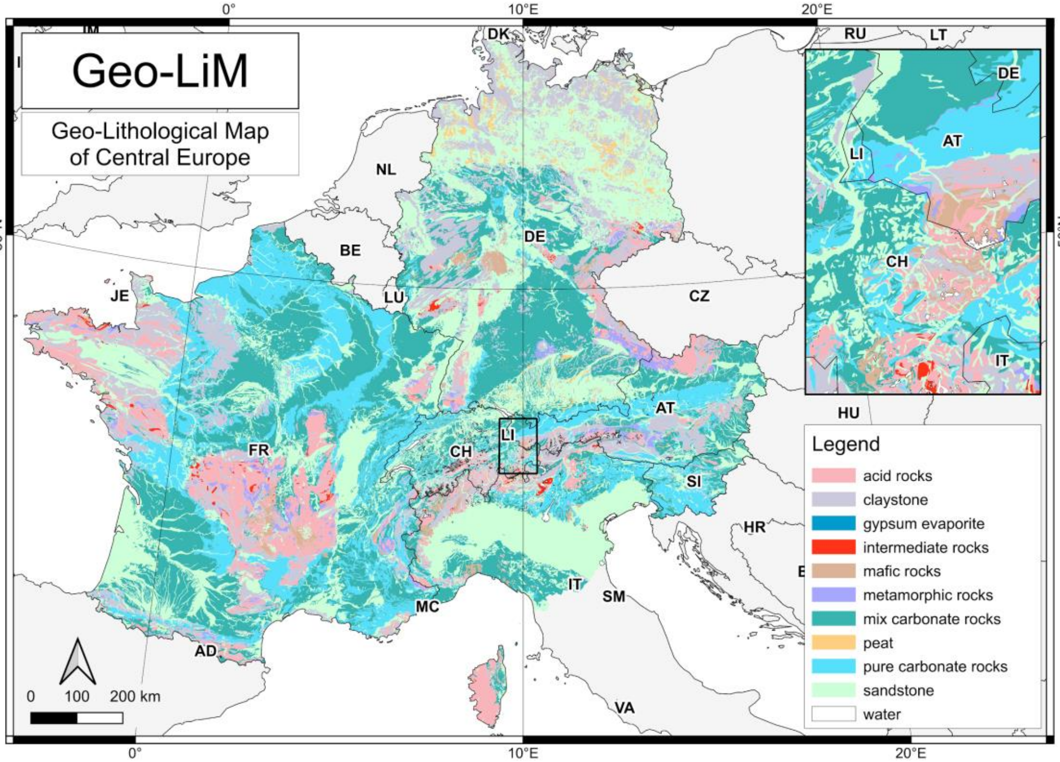
SHP

GeoLiM (Geo-Lithological Map of Central Europe) released in:
http://doi.org/10.5281/zenodo.2432045.
together with:

(i) the <u>original national geological maps</u>

(ii) the <u>procedures for the classification and the union of the original maps</u>

CO_2 consumption in Alpine region



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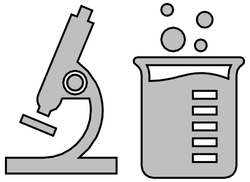
The "**metamorphic rocks**" category was used **only when information on protoliths were unavailable or unclear**.

- Acid rocks
- Mafic rocks
- Intermediate rocks
- Pure carbonate
- Mix carbonate
- Gypsum
- Sandstone
- Claystone
- Peat
- Metamorphic rocks

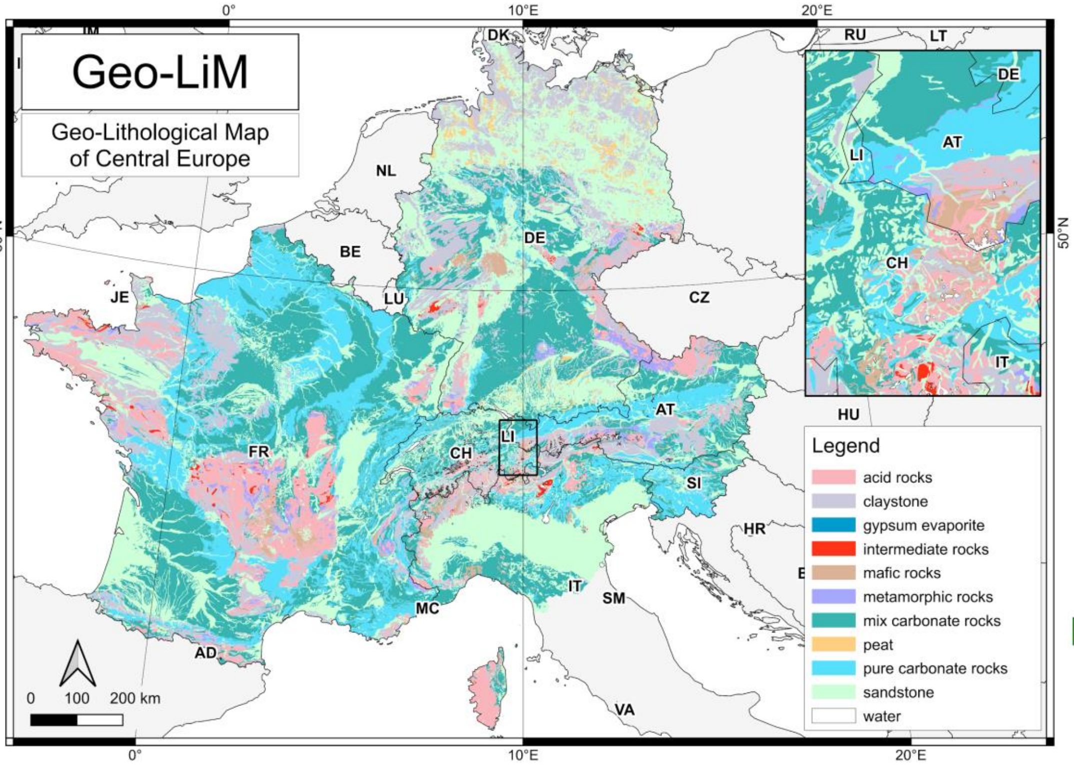


Marble → Pure carbonate rocks

Orthogneiss → Acid rocks

Schists → Claystone

CO_2 consumption in Alpine region



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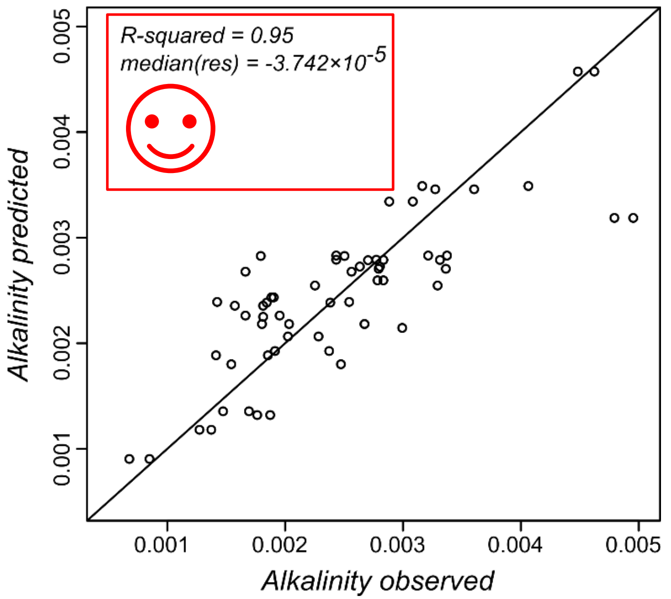
Metamorphic rocks in Alps ≈2%

Considering the more recent global lithological (***Hartmann & Moosdorf 2012***), metamorphic rocks represent **25.84%** of the Alps.

Geo-LiM were used to investigate the relationship among **alkalinity**, **lithology** and **atmospheric CO_2 consumption** in **Alps** by applying an approach derived from ***Hartmann et al. (2009)***

CO_2 consumption in Alpine region



FORWARD METHOD (*Donnini et al., 2020*)

34 river basins

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RESEARCH ARTICLE | FEBRUARY 04, 2020

A new Alpine geo-lithological map (Alpine-Geo-LiM) and global carbon cycle implications

Marco Donnini; Ivan Marchesini; Azzurra Zucchini

GSA Bulletin (2020) 132 (9-10): 2004–2022.

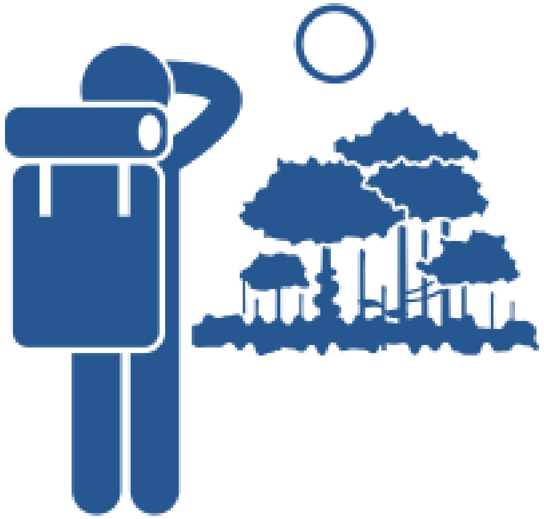
https://doi.org/10.1130/B35236.1 Article history

The **highest CO_2 consumption** could be explained by the fact that **in the study area "sandstone" is composed by a relevant carbonate component**

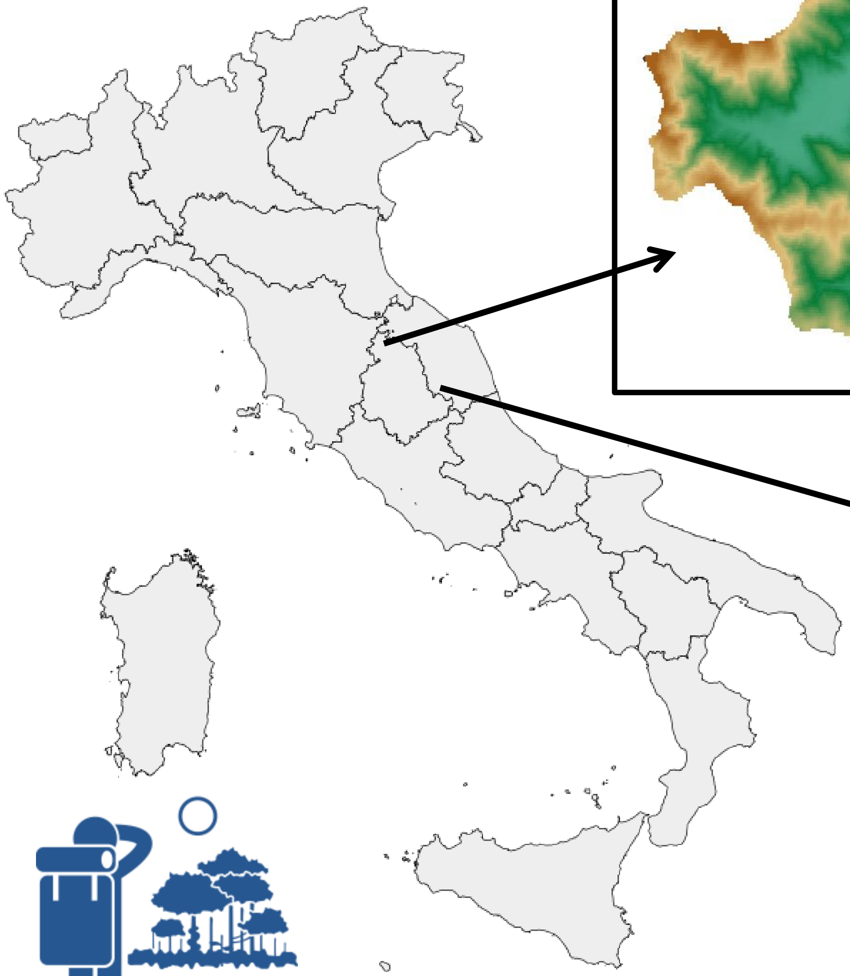
Future perspectives:

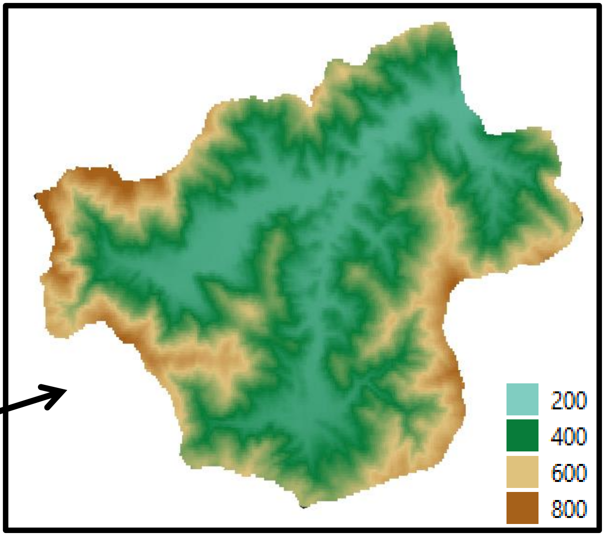
- Investigate the **annual and inter-annual variations** of **wetharing processes** and the **related atmospheric CO_2 consumption**;

- Investigate the role of **fluid residence time** and **catchment scales** in controlling the **chemical composition of rivers** and the related **atmospheric CO_2 consumption**.



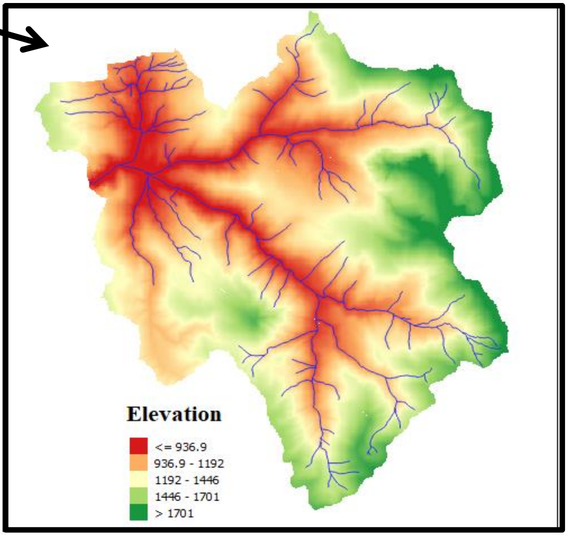
Annual and inter-annual variation on CO_2 consumption





Niccone catchment (Upper Tiber Valley)

- 13 Km^2 surface area
- Hilly morphologies
- Clayly lithologies
- Runoff: mostly from surface water pools

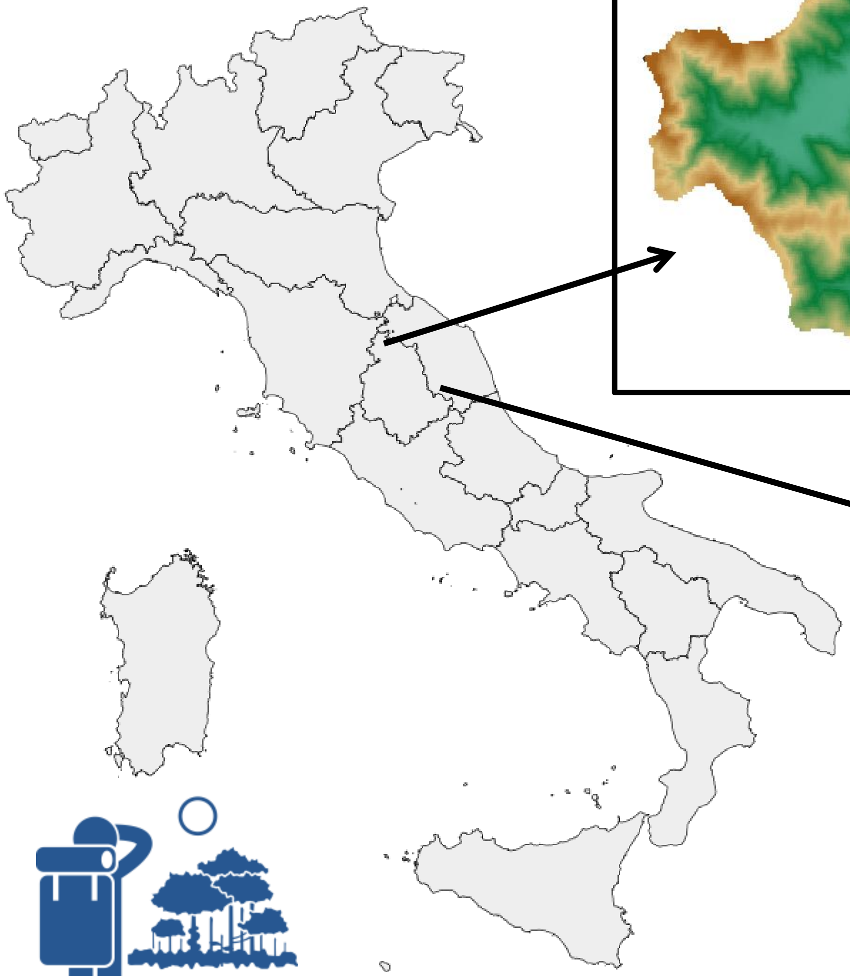


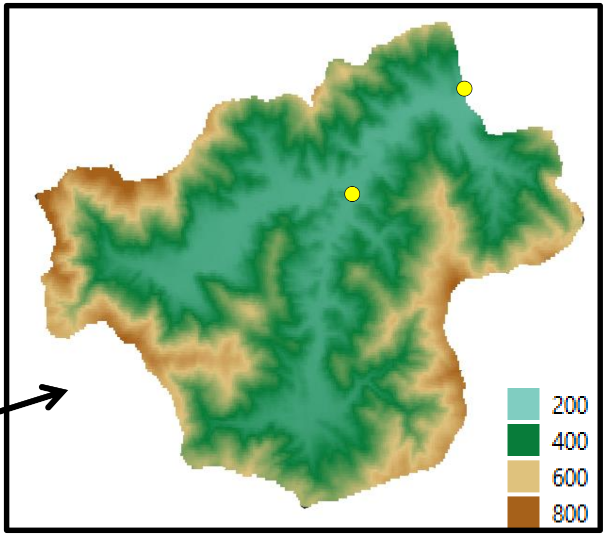
Upper Nera catchment (Sibillini Mountains)

- 135 km^2 surface area
- Mountainous morphologies
- Carbonate lithologies
- Runoff: mostly from groundwater

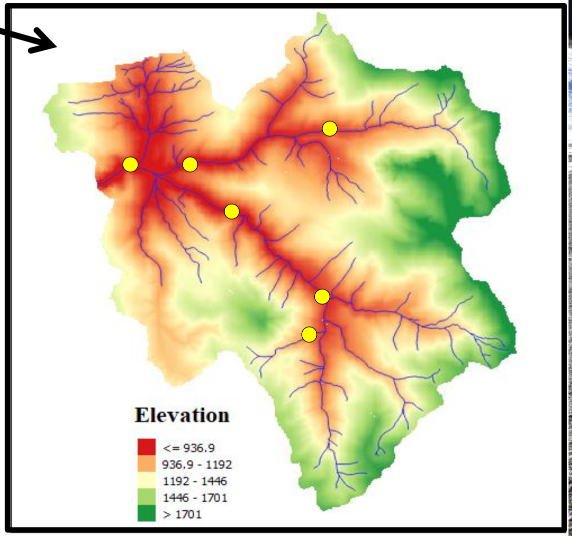
Annual and inter-annual variation on CO_2 consumption

Ongoing activities:
sampling systematically variable over time and space

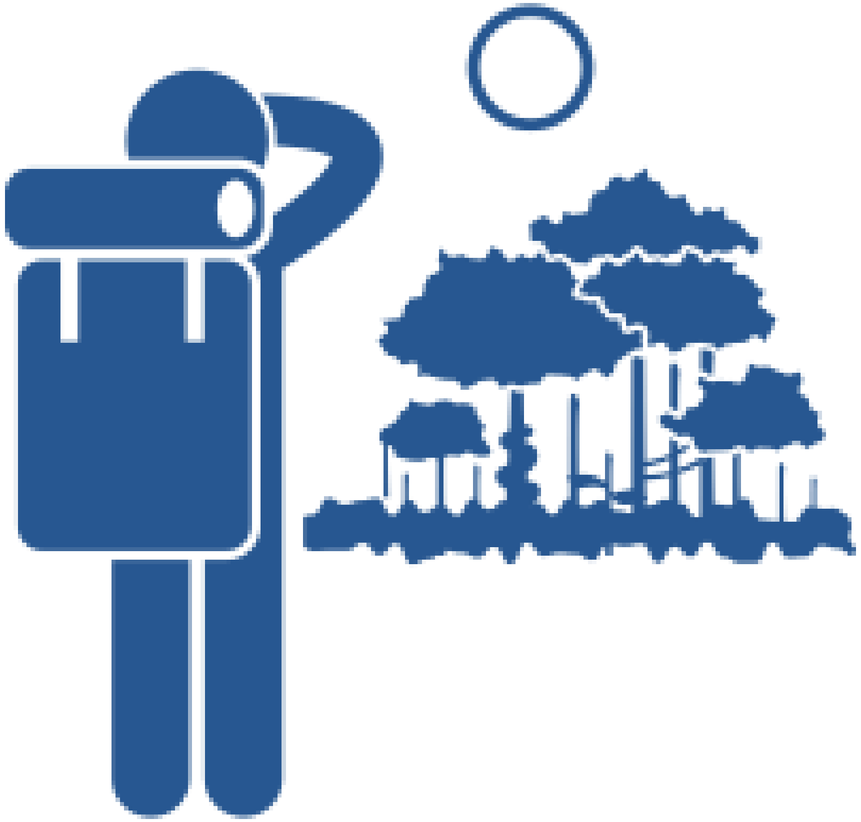


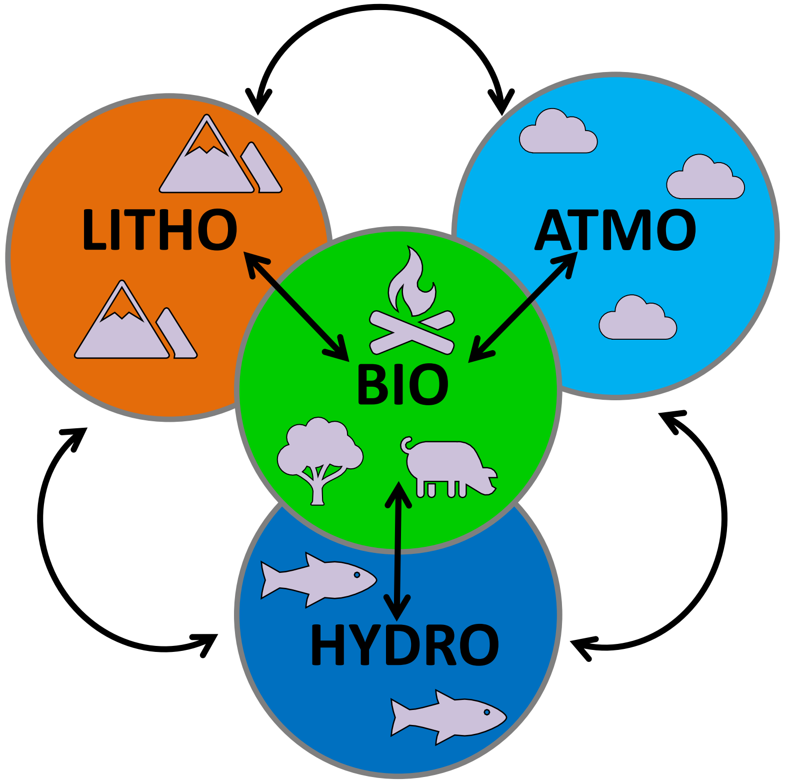


Sampling point

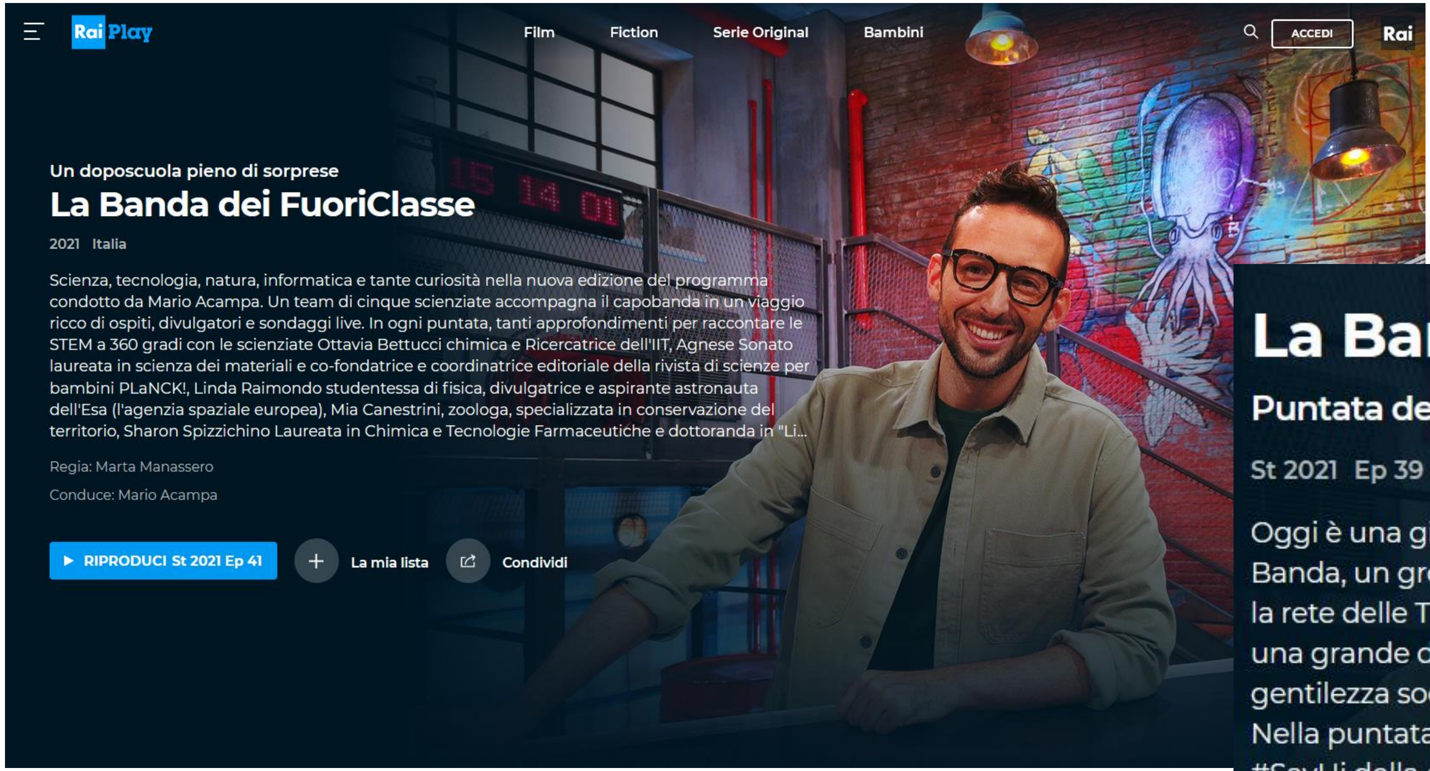


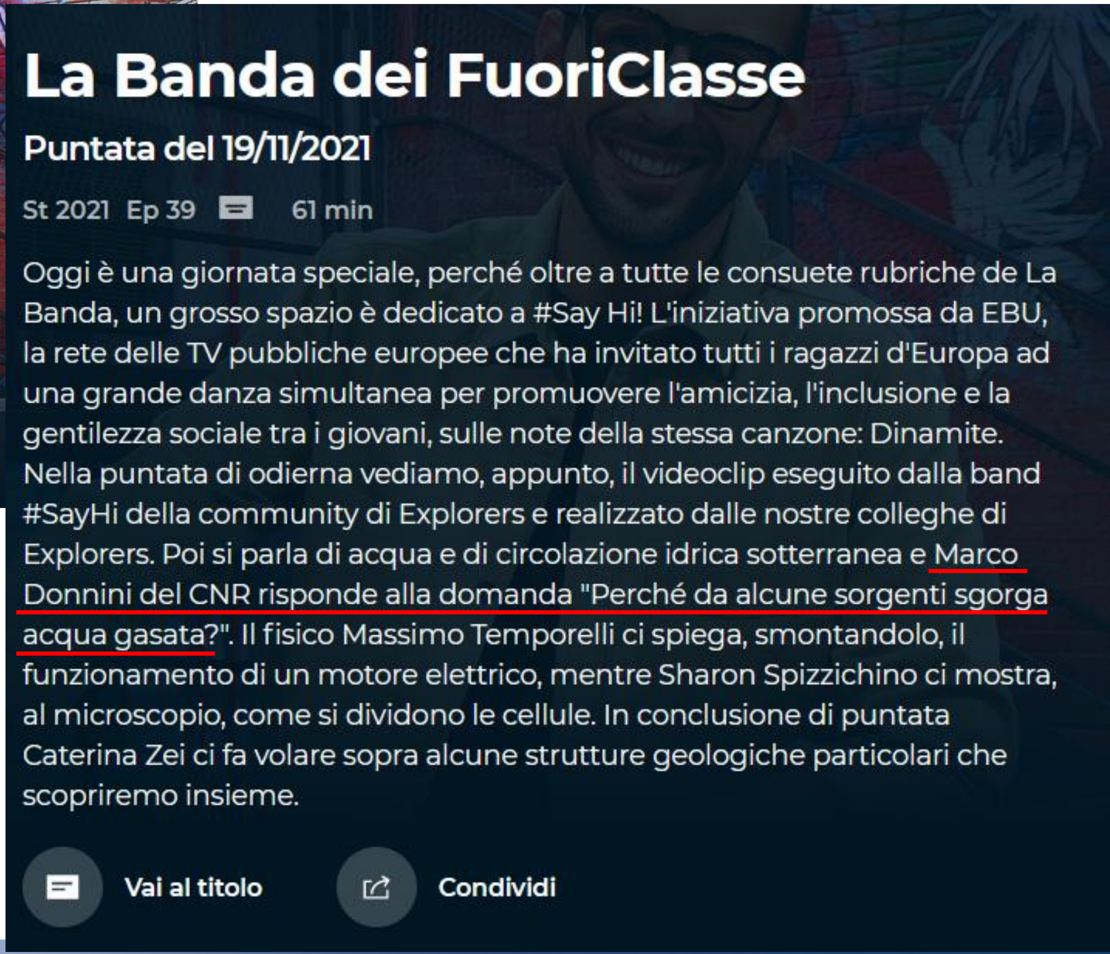
How can weathering processes vary in a context of climate change?





Communication of geo-hydrological risks and related uncertainties





Thank you for your attention

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