FESTIVAL DELLO SVILUPPO SOSTENIBILE 2017 PROMOSSO DA ASviS

RUS Rete delle Università per lo Sviluppo Sostenibile — CITTÀ STUDI CAMPUS SOSTENIBILE — POLITECNICO MILANO 1863

29 maggio 2017

Festival dello Sviluppo Sostenibile

Politecnico di Milano | Piazza Leonardo da Vinci, 32 | Edificio 3 | **Aula De Donato**

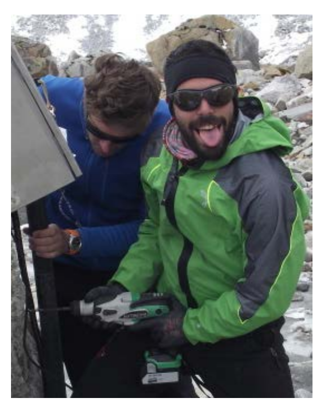
Convegno

"Il clima del futuro, i ghiacci del pianeta e noi"

L'impatto della riduzione dei ghiacci sulle risorse idriche: le Alpi e….

[The impact of ice down wasting on water resources: the Alps and..]

Daniele Bocchiola, Andrea Soncini, Gabriele Confortola, Renzo Rosso.



PARTNER: enel, UniCredit, Unipol, WIND, 3

MAIN MEDIA PARTNER: Rai

MEDIA PARTNER: la Repubblica, TGR

CON LA COLLABORAZIONE DI: CONI, Laterza Agorà, sky CINEMA HD

CON IL CONTRIBUTO DEL MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

Politecnico di Milano,

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Motivation

PNAS

Contribution potential of glaciers to water availability in different climate regimes

Georg Kaser, Martin Großhauser, and Ben Marzeion[1]

Institut für Geographie, Universität Innsbruck, Innrain 52, 6020 Innsbruck, Austria

Edited by Roger G. Barry, University of Colorado, Boulder, CO, and accepted by the Editorial Board October 12, 2010 (received for review June 11, 2010)

Although reliable figures are often missing, considerable detrimental changes due to shrinking glaciers are universally expected for water availability in river systems under the influence of ongoing global climate change. We estimate the contribution potential of seasonally delayed glacier melt water to total water availability in large river systems. We find that the seasonally delayed glacier

periods in a region coincide, the production of melt water and the increase of water storage occur at the same time, reducing the effect of seasonally delayed water release from the glaciers. The relative impact of glacier melt during wet and warm periods is further decreased through the general increase in water availability from precipitation.* Therefore, melt water runoff matters

ological cycle in regions
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winter and early
ge capacities are not
-sixth of the Earth's
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high confidence and

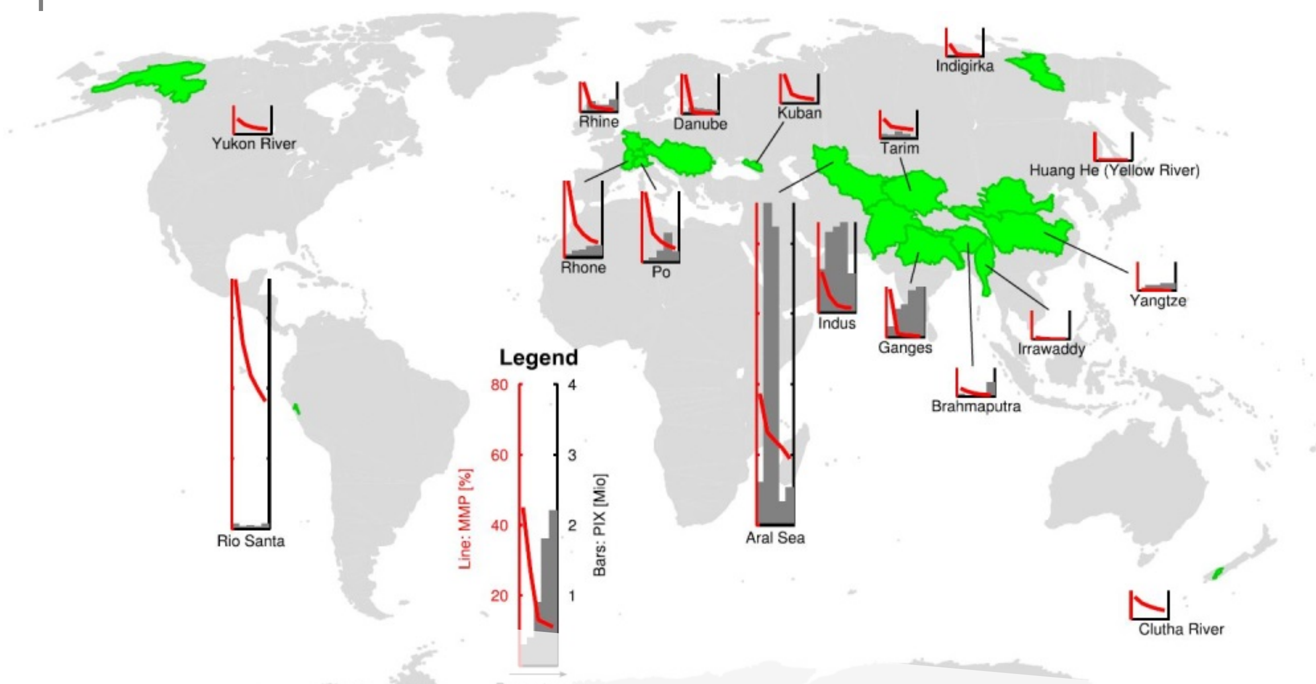


Table 1. Climatological and geographical characteristics of the river basins shown in Figs. 1 and 2, sorted by the PIX

Basin name	Basin area, km²	Glacier area, km²	Glacier area, %	Population, 10^6	PIX, 10^6
Aral Sea	1,234,075	11,319	0.92	41.01	10.29
Indus	1,139,814	20,325	1.78	211.28	4.82
Ganges	1,023,609	12,659	1.24	448.98	2.40
Po	73,297	818	1.12	16.55	0.81
Rhone	97,702	1,162	1.19	10.12	0.57
Rhine	190,713	459	0.24	59.07	0.52
Yangtze	1,746,593	1,895	0.11	383.04	0.37
Brahmaputra	527,666	16,118	3.05	62.43	0.31
Danube	794,133	617	0.08	81.38	0.31
Tarim	1,053,180	20,494	1.95	9.22	0.30
Rio Santa	11,901	503	4.23	0.57	0.27
Kuban	59,120	215	0.36	3.45	0.05
Huang He	988,702	172	0.02	162.70	0.02
Indigirka	341,577	338	0.10	0.04	0.00
Irrawaddy	410,376	25	0.01	35.26	0.00
Yukon River	830,257	9,070	1.09	0.13	0.00
Clutha River	17,182	147	0.86	0.03	0.00

ADAPTATION ??

Climate change in the Alps

Evidence from present knowledge indicates European Alps are undergoing **noticeable and measurable** transient climate change and their hydrological cicle is impacted

Thermal shift within Alps since 1980s, albeit sinchronous with global warming, seems at least twice as much global climate signal, and the Alps underwent more than +2°C increase of lowest temperatures dyring XX century, with substantially unchanged precipitation, but with a marked decrease of snowfall (*e.g.* Diaz & Bradley, 1997; Beniston, 2000; Beniston et al, 2003).

Some past activity @ POLIMI (+ UNIMI)

2007-2009 CARiPANDA, Cambio climatico e risorsa idrica nel Parco Naturale dell'Adamello, Fondazione Cariplo.

2009-2010 Budget idrologica del ghiacciaio Dosdè (Valtellina, Italy). LEVISSIMA Italia.

2010-now. IDRO-STELVIO. Una rete idrometrica per il Parco dello Stelvio, Finanziato da Parco Stelvio.

2010-2012. SHARE-Stelvio. Un Parco – Osservatorio per lo studio dei Cambiamenti Climatici e Ambientali in alta quota. Regione Lombardia.

2010-2013. Share-Paprika. Effects of climate change on water resources in the Karakoram range (Pakistan, Asia). EVK2CNR

2010-2013. SEED, Social, Economic and Environmental Development for the realization of Central Karakorum National Park (CKNP). EVK2CNR

2011-2013. I-CARE. Impact of Climate change on Alpine water REsources: the case of Italy and Switzerland. 5x1000 Politecnico di Milano.

2012. Programa plan de acción para la conservación de glaciares ante el cambio climático. Dirección General de Aguas, Chile.

2014-2015. Dudh Koshi Hydrology. A hydrological modeling framework for the Dudh Koshi catchment, Sagarmata National Park.

fondazione cariplo


PROGETTI DI RICERCA "5 PER MILLE JUNIOR" Anno 2009

Proposal:

I CARE

Impact of Climate change on Alpine water REsources
the case of Italy and Switzerland

Keywords: climate change, alpine area, water resources

Proposer:
Daniele Bocchiola, Mat. 10170

Duration: 24 months

Partners

University Milano

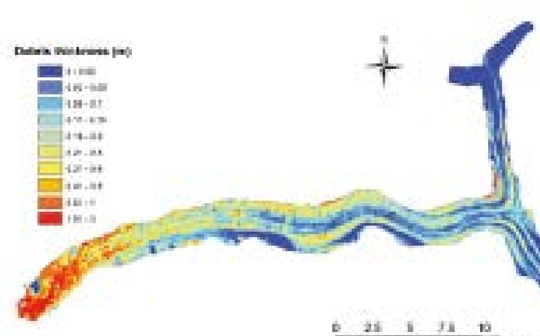
Eidg. Inst. für schnee und lawinenforschung, SLF Davos

University Torino

Stakeholders

EDISON Company of Italy

ENEL Company of Italy



seed Social Economic Environmental Development
A project funded by the Governments of Italy and Pakistan

EvK2CNR

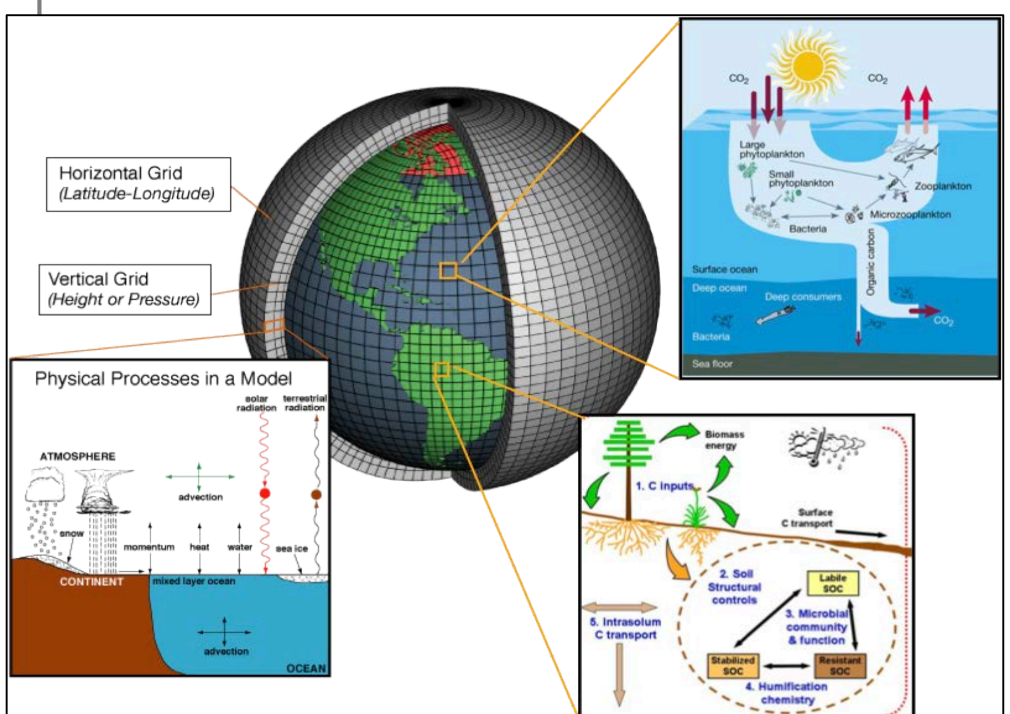
Climate-Lab

Interdipartmental Lab, call 2016, Depts DICA, DEIB, DASTU, ABC

Recently Politecnico di Milano joined CMCC Foundation (Centro Euro-Mediterraneo sui Cambiamenti Climatici), an institution with large experience in the field of climate/ocean/landscape modeling, and in general of climate change mitigation, and adaptation.
Climate-LAB mission is to (contribute to) initiate a cooperation in this area between Polimi personnel (Depts.) working in the field of climate change, and with CMCC

Scientific purpose:

1) Monitoring of key variables/processes at urban, regional, basin scale;
2) Providing services for those interested in climate change impact assessment.

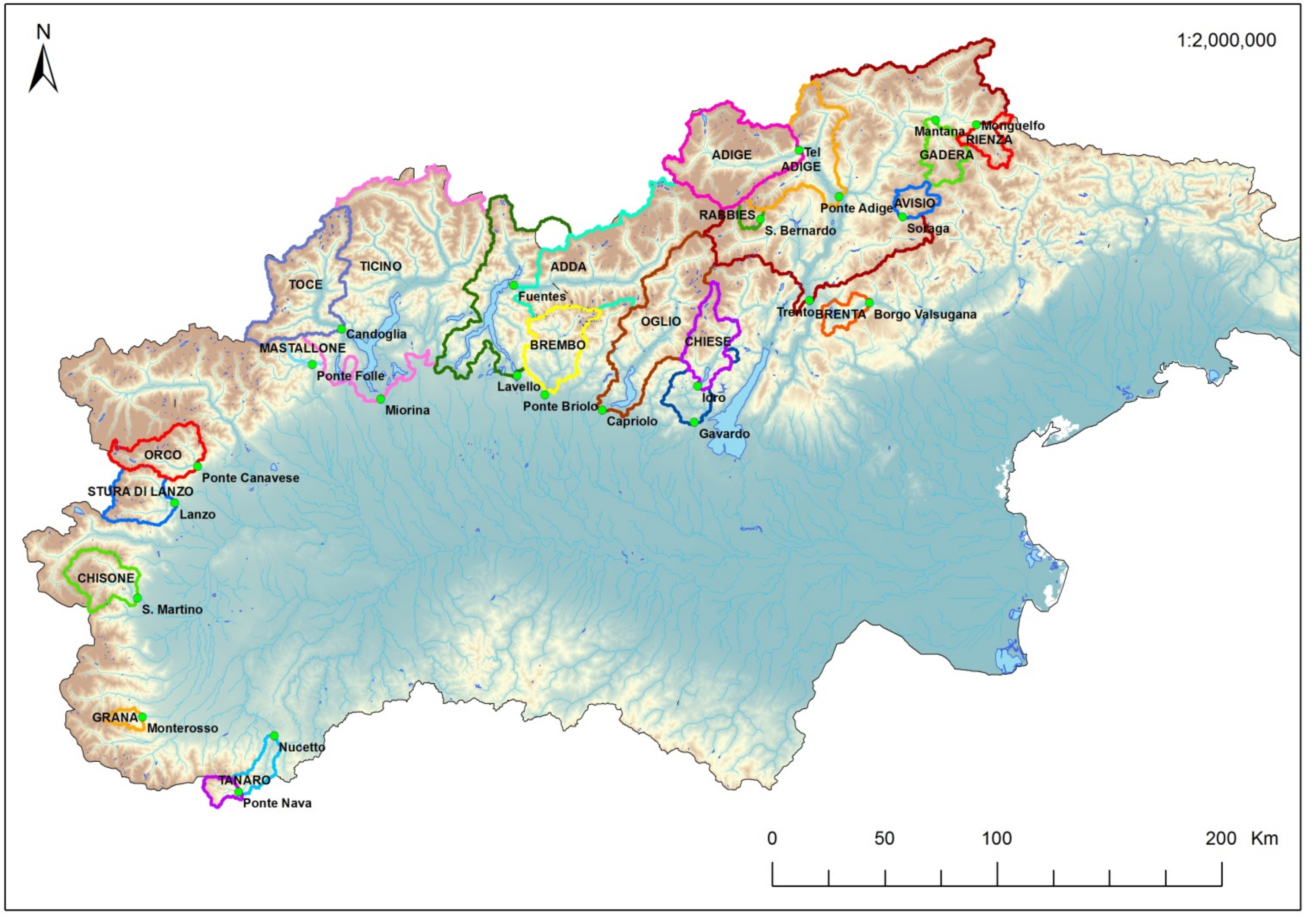


Pieces of evidence-1

The large scale: Italian Alps

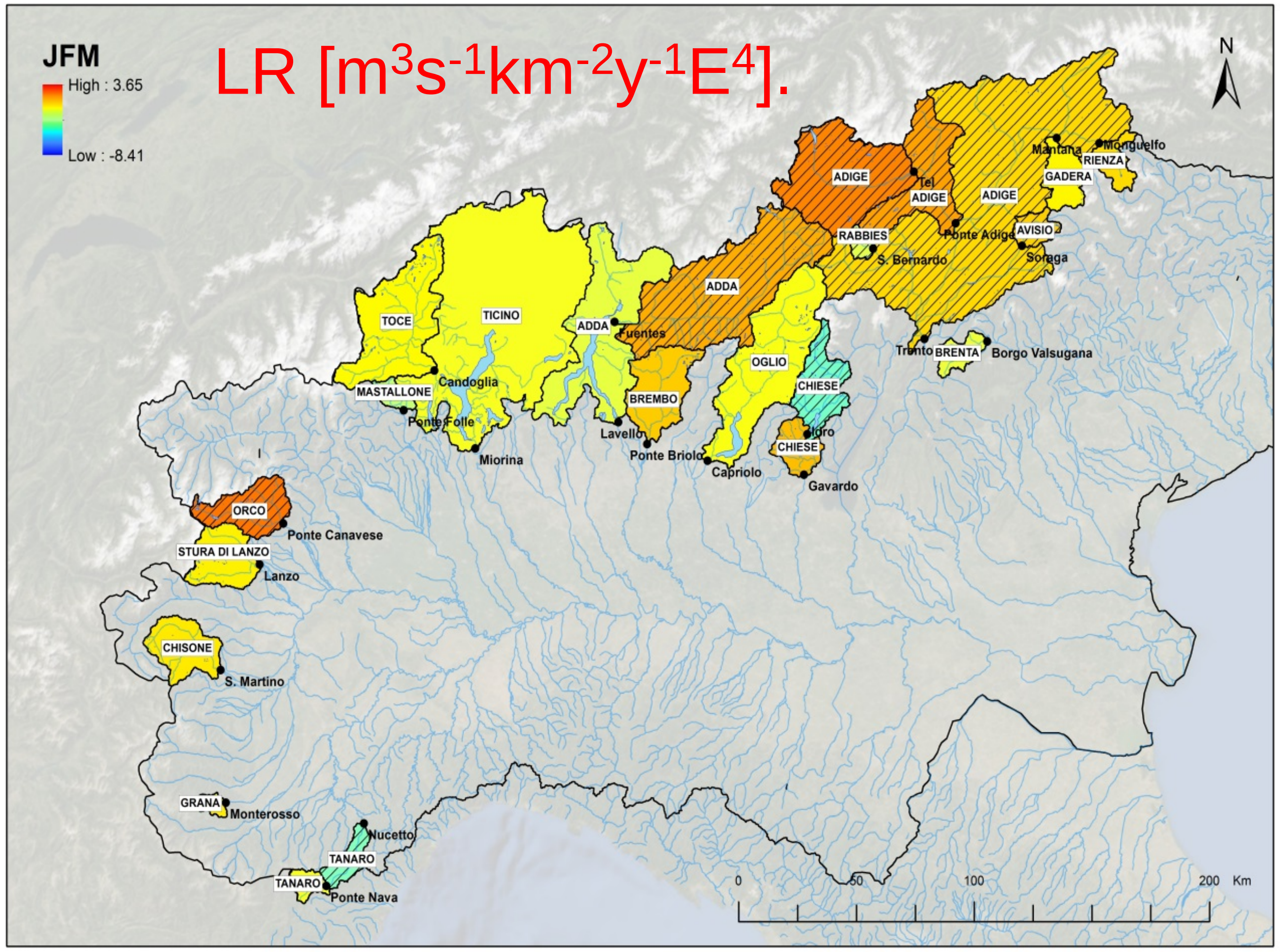
Question(s)

1) Did hydrological cycle change in Italian catchments lately ?
2) Drivers of this change ?



We sistematically investigated long term (1921-2011, with variable length of data series) changes of yearly and seasonal discharges of 23 Alpine rivers in Northern Italy, to evidence non stationarity, and trends using linear regression, and Mann Kendall test, traditional and progressive.

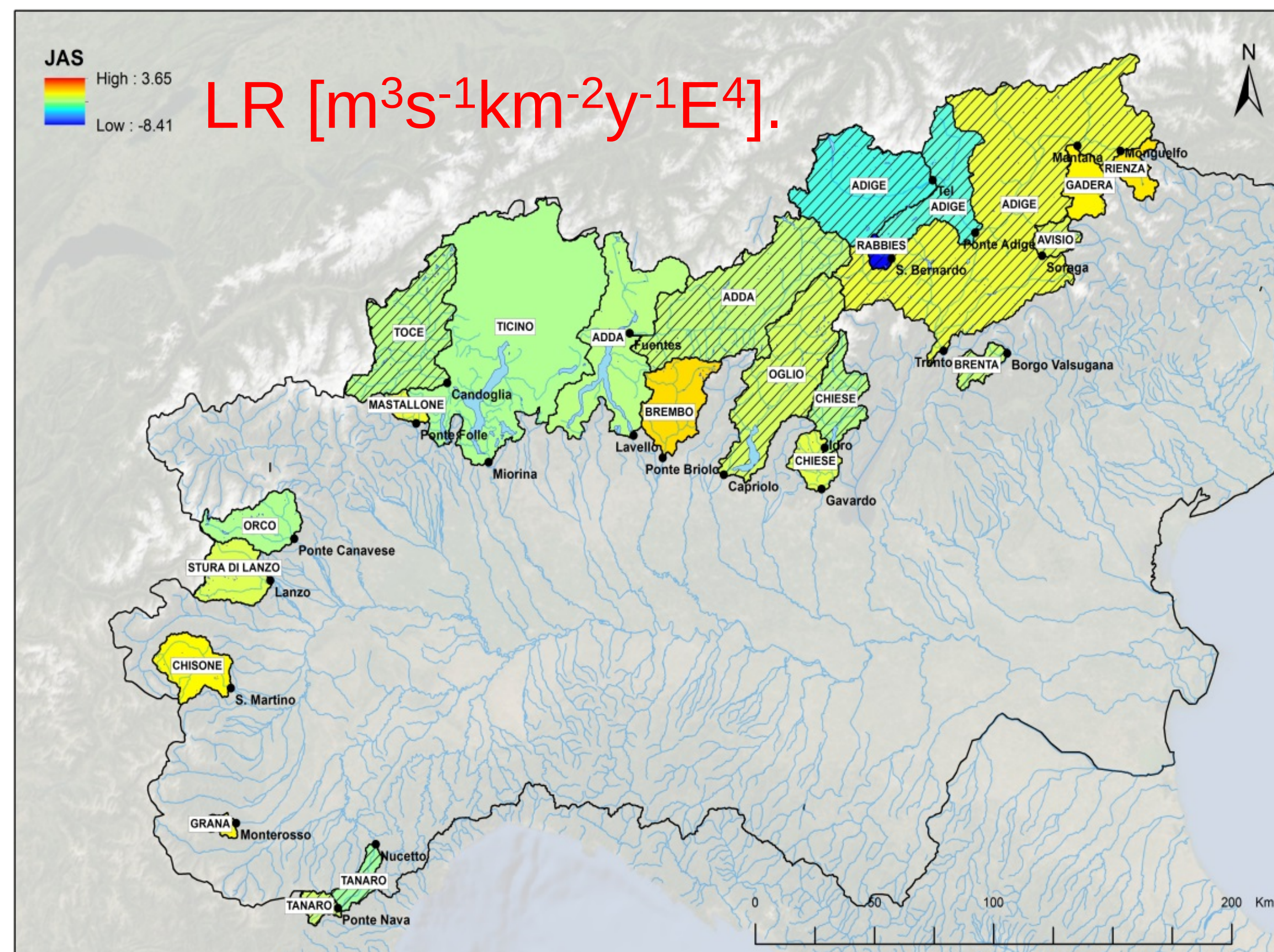
Pieces of evidence-1



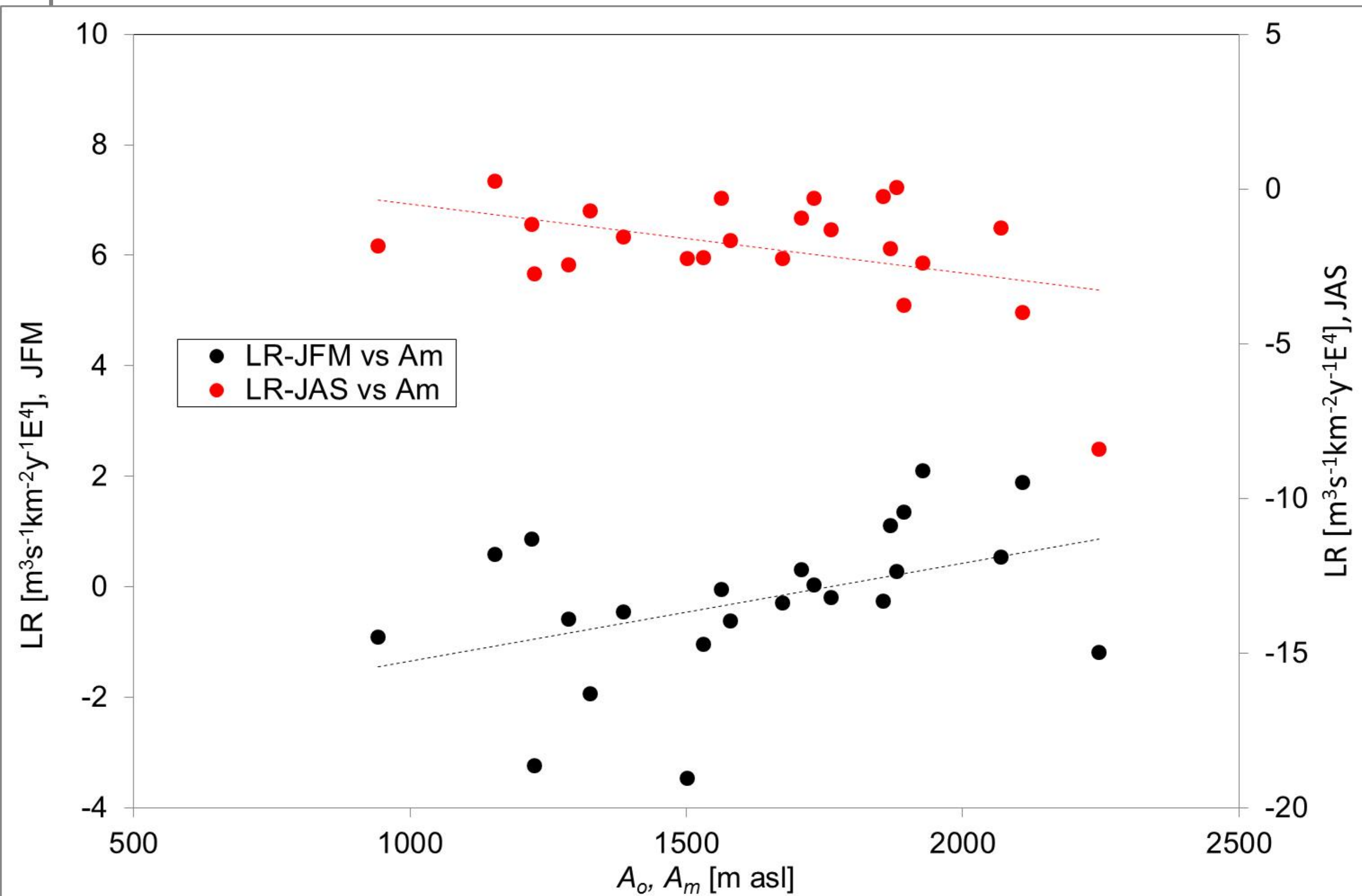
For specific (i.e. per contributing area) <u>winter decrease is seen below 1800 m asl or so, while increase is found above</u>, and the more Northern the larger the increase. Specific discharges during spring mostly decrease in time, and more so for increasing outlet altitude, while <u>summer specific discharges always decrease</u>, and more notably with increasing altitude of the contributing catchment.

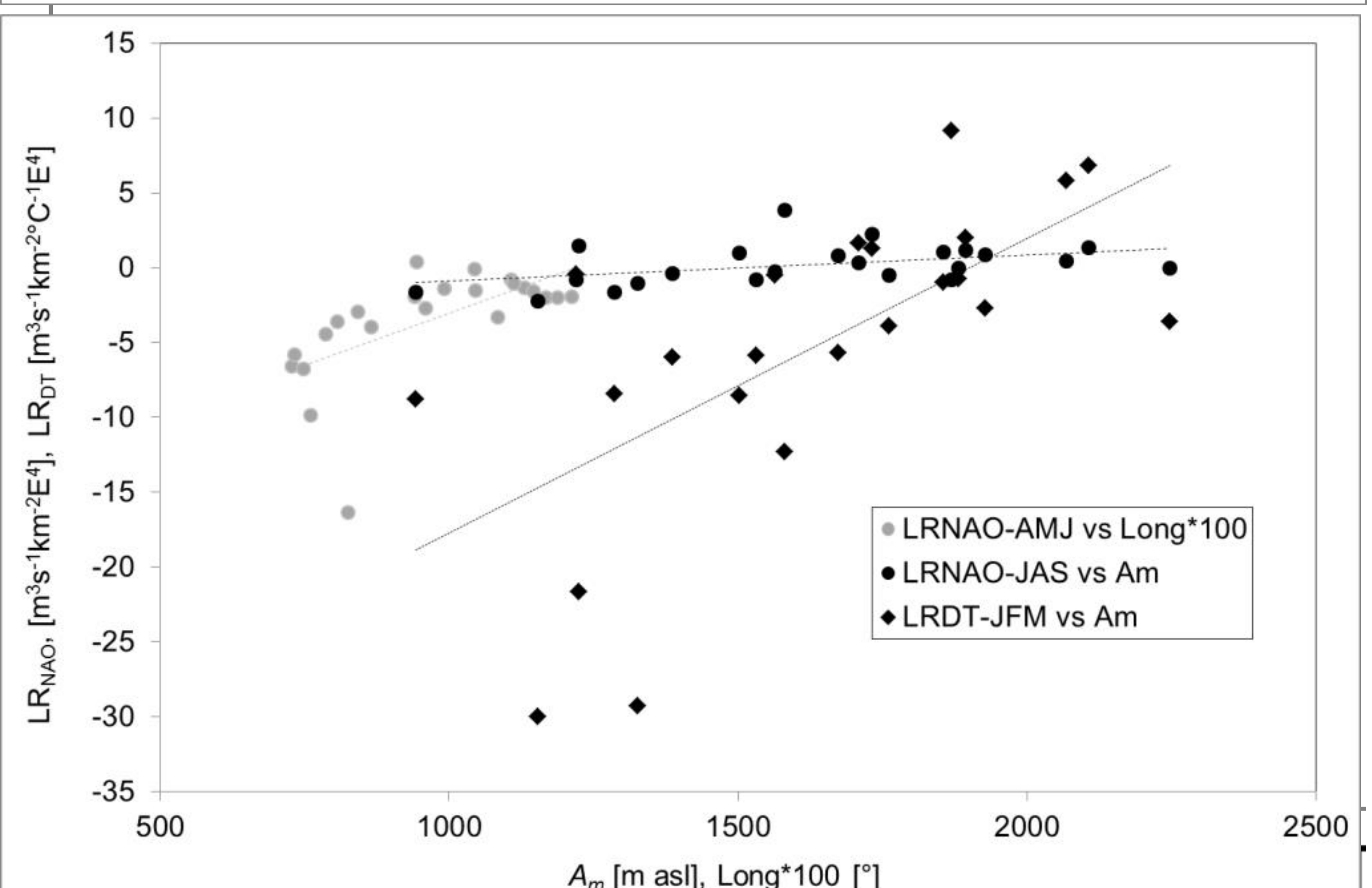
Hydrological changes in the Alpine stream water resourcess

REGULATION ?????



Pieces of evidence-1





A_0 is outlet altitude
A_m is average altitude

NAO and global thermal anomalies DT are correlated against the rate of variation of hydrological fluxes, with the intensity of correlation linked to altitude and longitude. The observed trends may be explained by:

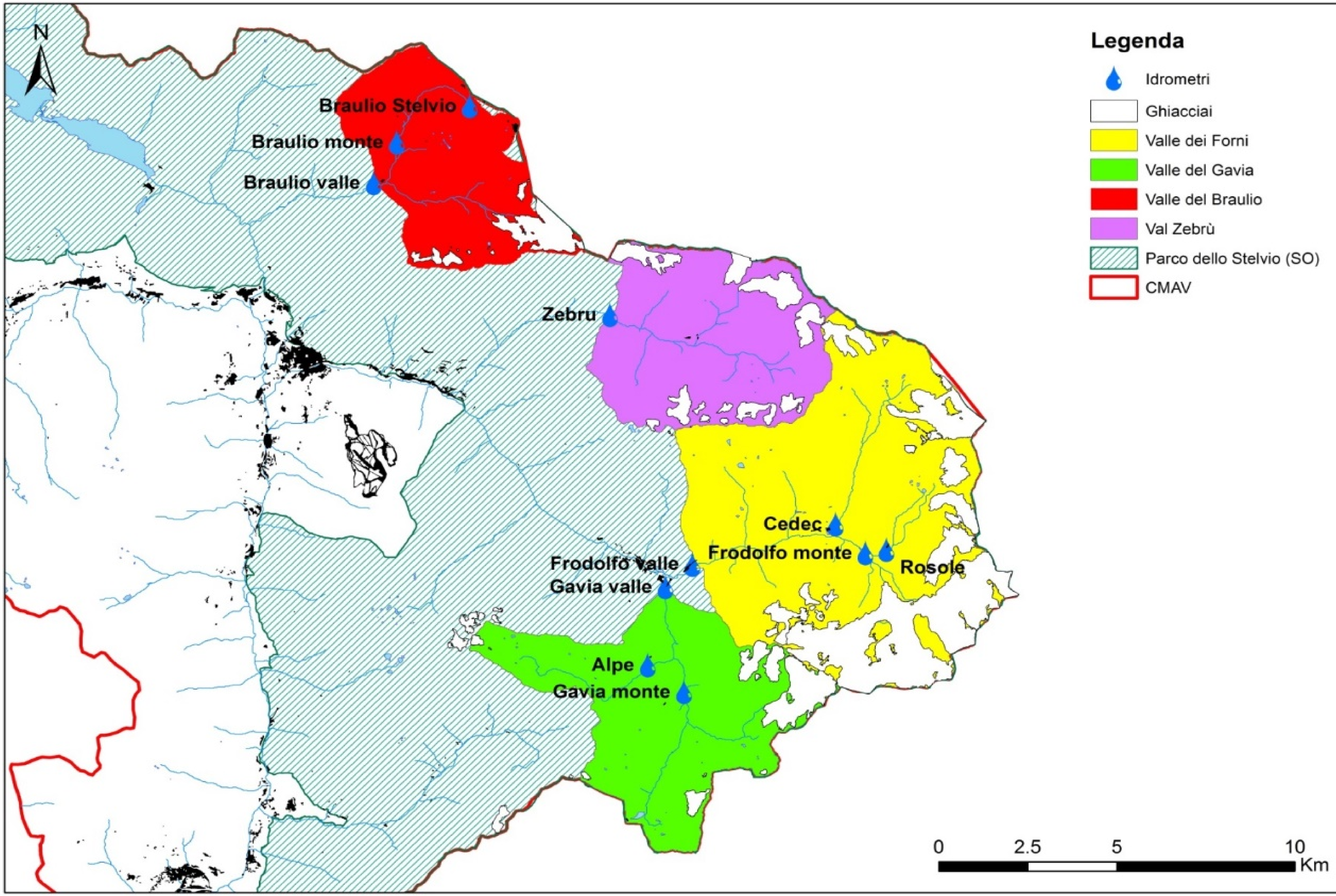
i) Trading of rainfall for snowfall during winter, resulting into larger flows, and affecting more highest catchments and Northern areas,
ii) Lack of snow cover at thaw, and shrinking of ice covered areas, decreasing melt water deliver during spring, and summer, more evident at the highest altitudes, and
iii) Increase of evapotranspiration driven by temperature, leading to increased soil moisture uptake and decreased in stream fluxes at the intermediate altitudes.

EDUCATED GUESS !!!!

Long is Longitude
NAO is northern atlantic oscillation
DT is global thermal anomaly

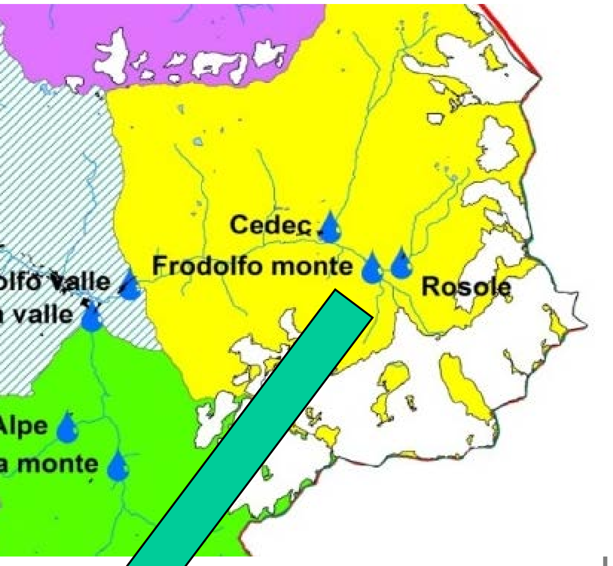
Pieces of evidence-2

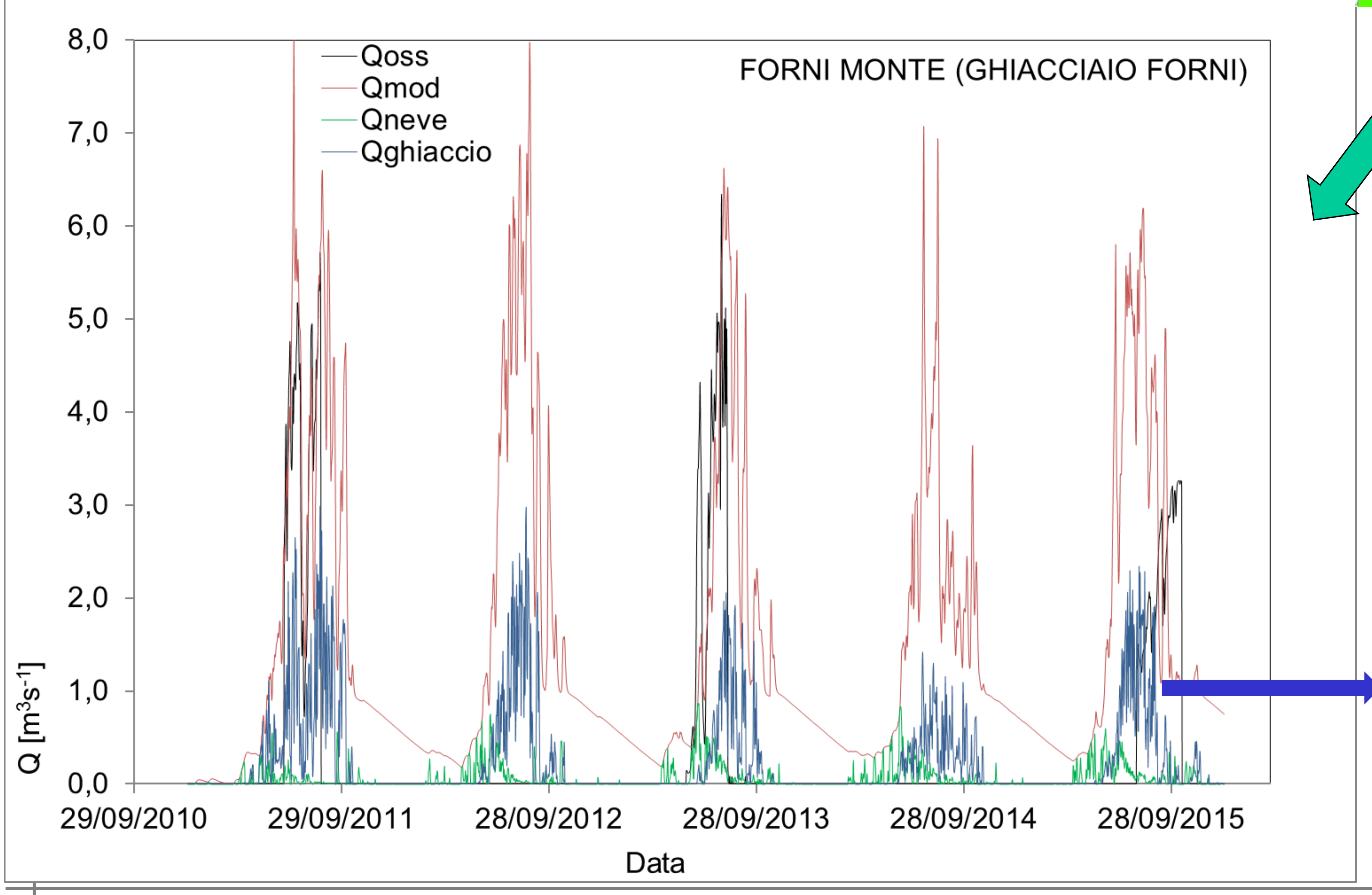
Idrostelvio 2010 - ??; or the local scale



Pieces of evidence-2

We are now able to model streamflows in the Park





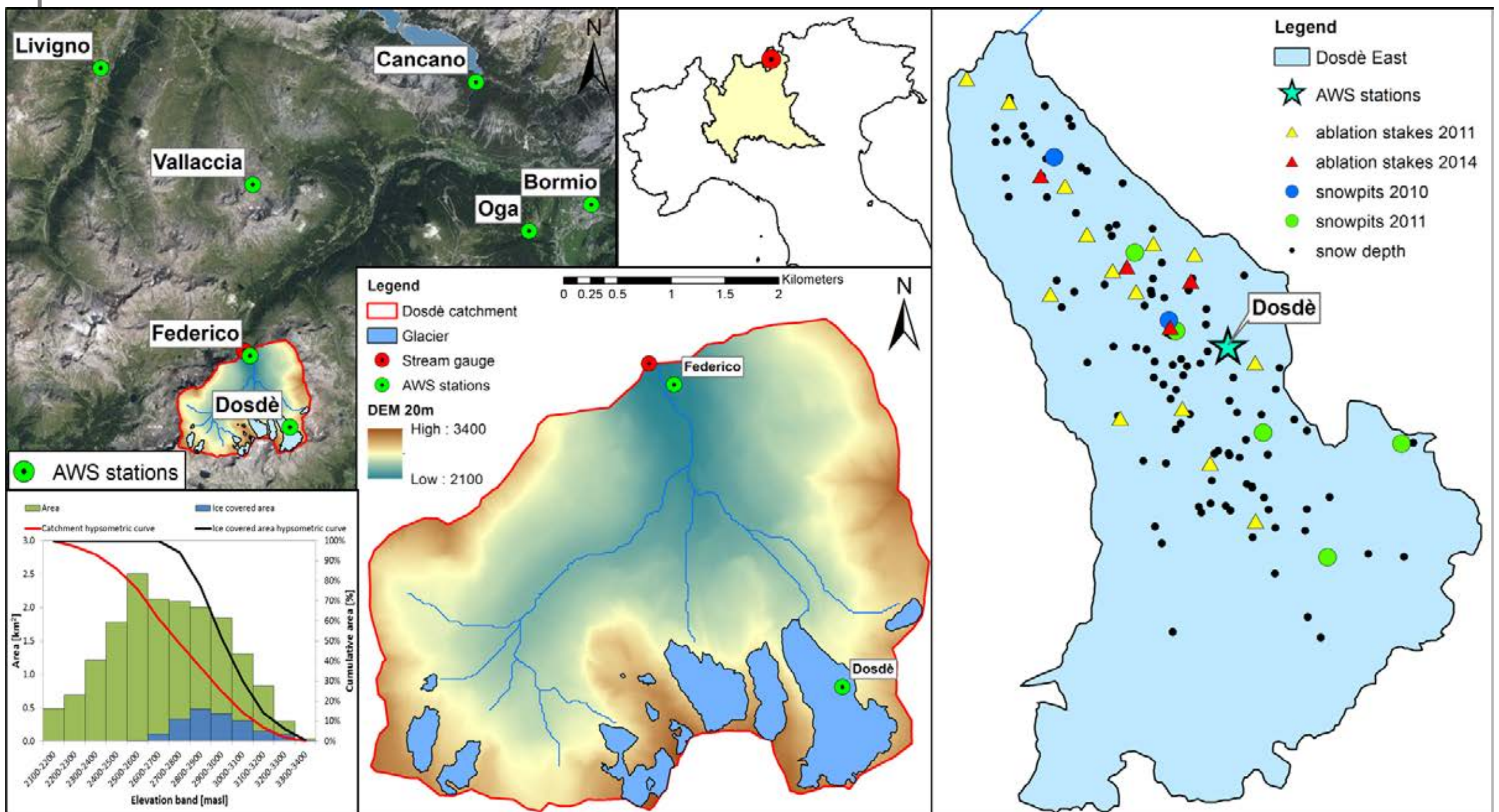
Ghiacciaio dei Forni !!!
Ca. 10 km^2

Pieces of evidence-3

The Dosdè project: Febbre glaciale !!! ; or the contribution of cryosphere to hydrology

Question

1) Can we track glaciers' mass balance, and contribution to hydrology ?

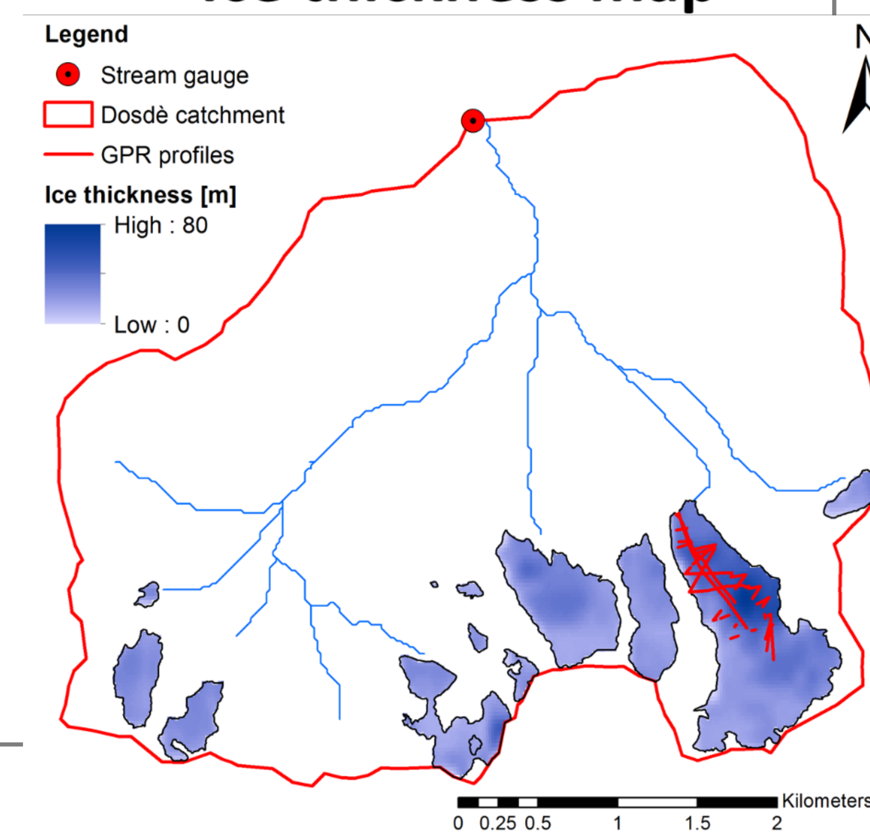


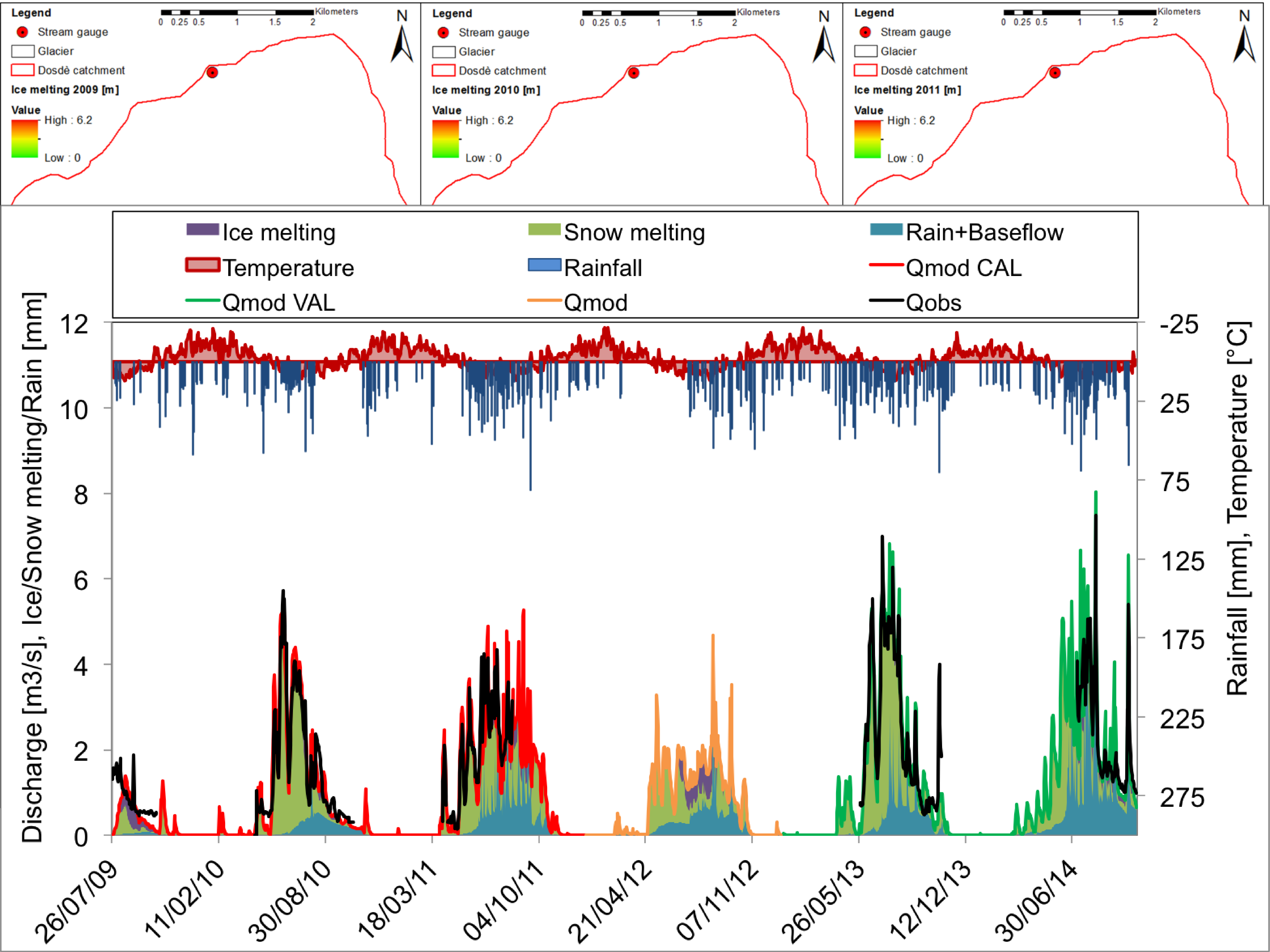
2009-now !!

tremendous field effort

AWSs stations, valley, supraglacial, hydro station (2000 m a.s.l.), snow pits,
ablation stakes, GPR thickness surveys, modeling…

Ice thickness map




Legend
Stream gauge
Glacier
Dosdè catchment
Ice melting 2009 [m]
Value
High : 6.2
Low : 0
Kilometers
0 0.25 0.5 1 1.5 2
N
Legend
Stream gauge
Glacier
Dosdè catchment
Ice melting 2010 [m]
Value
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Value
High : 6.2
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Kilometers
0 0.25 0.5 1 1.5 2
N
Ice melting
Snow melting
Rain+Baseflow
Temperature
Rainfall
Qmod CAL
Qmod VAL
Qmod
Qobs
Discharge [m3/s], Ice/Snow melting/Rain [mm]
Rainfall [mm], Temperature [°C]
12
10
8
6
4
2
0
-25
25
75
125
175
225
275
26/07/09
11/02/10
30/08/10
18/03/11
04/10/11
21/04/12
07/11/12
26/05/13
12/12/13
30/06/14

A glance into the (likely) future

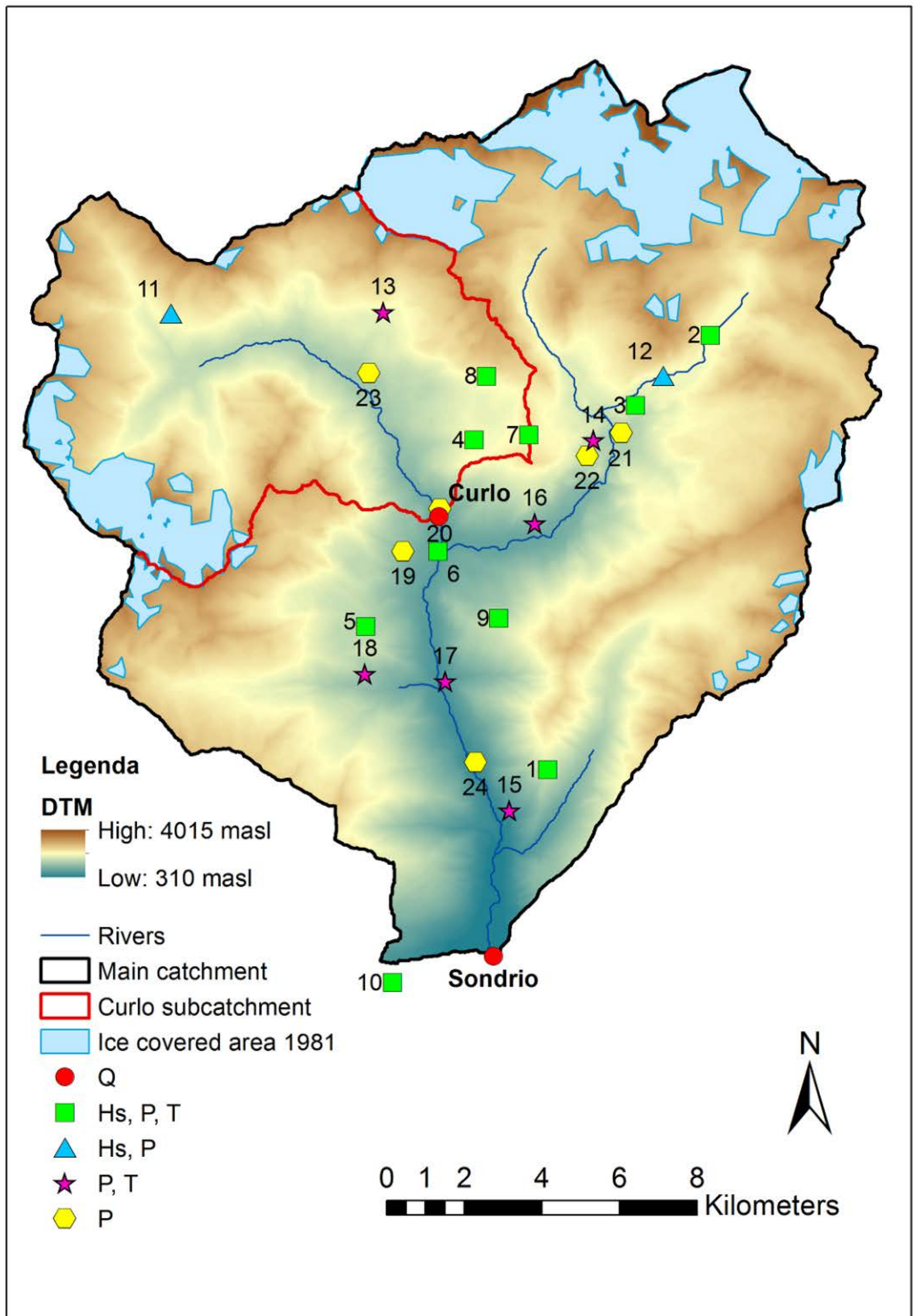
Question

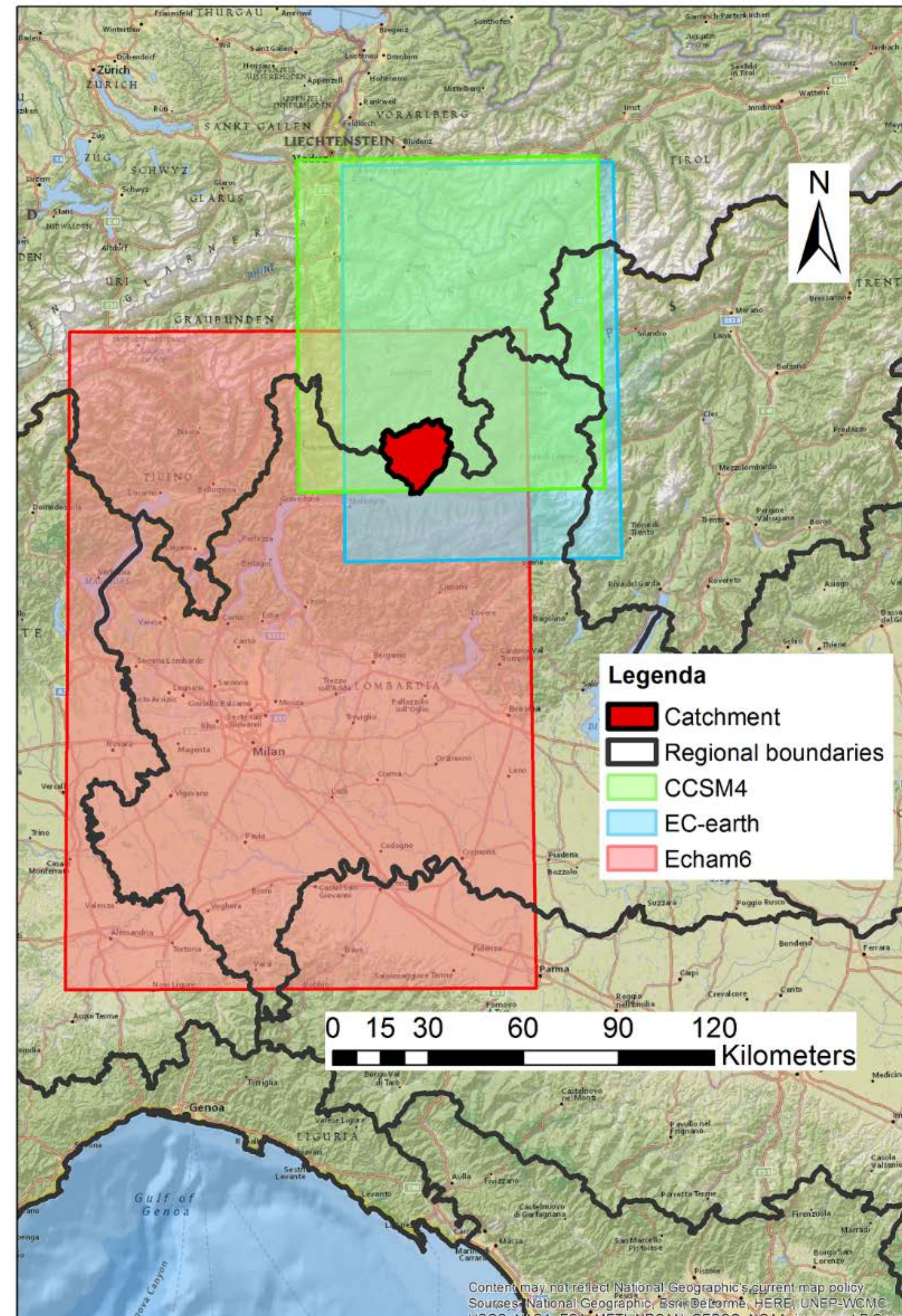
1) Can we project forward future cryospheric/hydrologic behaviour ?

Bernina-Mallero case study

Heavily regulated

Little hydrological information !





A glance into the (likely) future

Ice mass budget can be deduced remotely

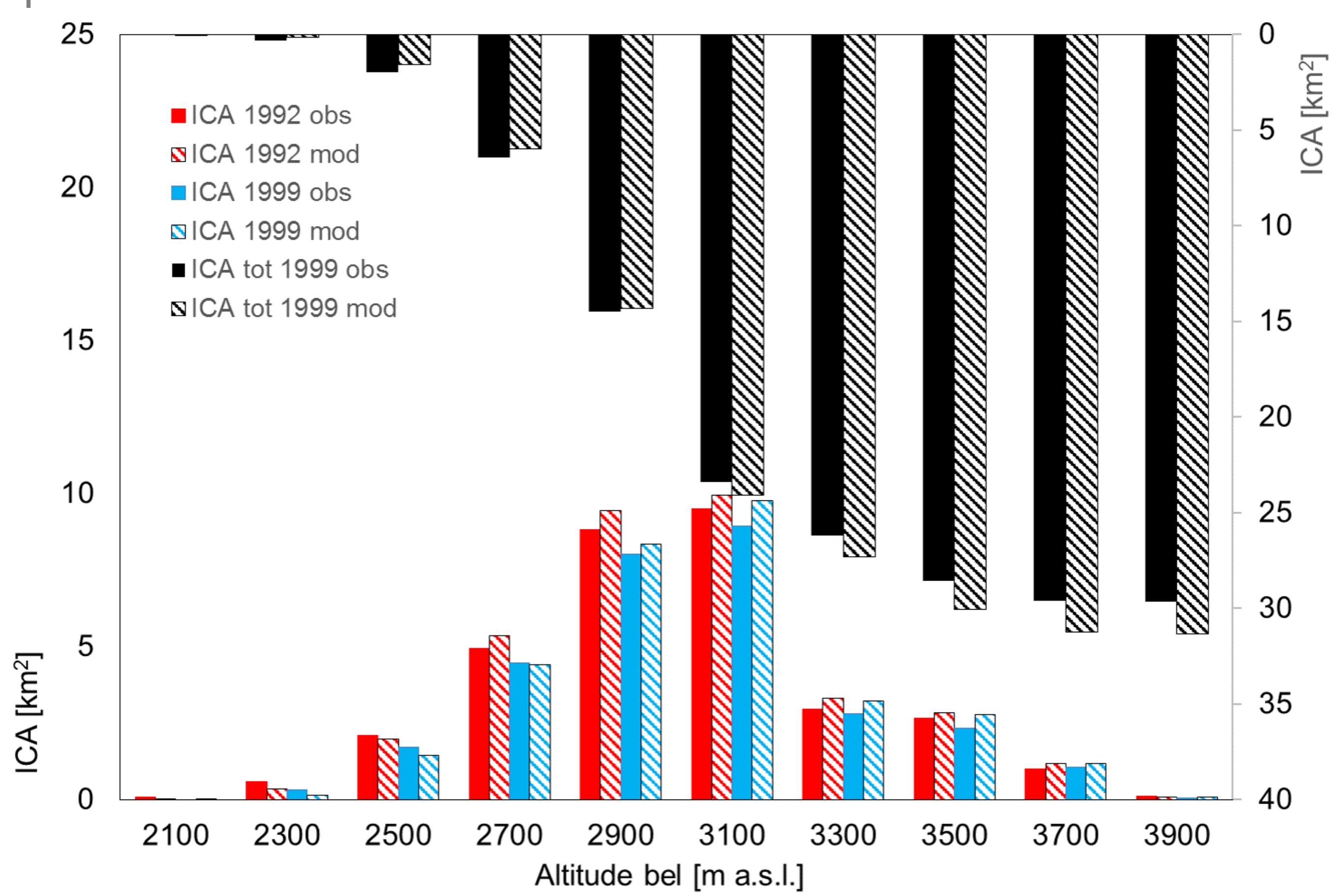
DEM 2007- DEM 1981 = IWE_m

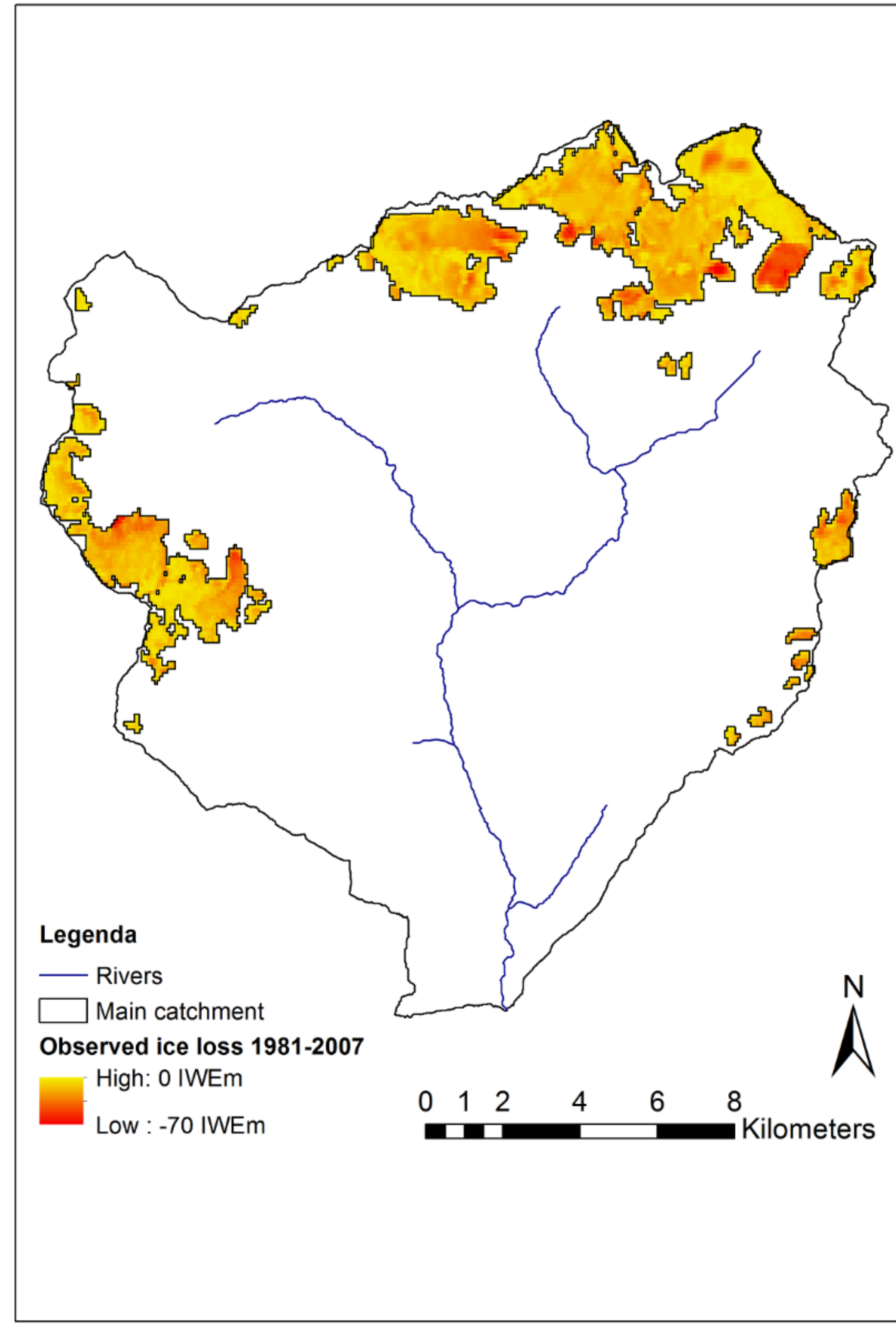
Altitude difference can be used to assess ice melt in water equivalent.
Ice/snow melt can be modelled using mixed approaches, using temperature *T*, radiation global *G*

$$M_{ci,s} = \left(TMF_{ci,s}\left(T - T_{th}\right) + RMF_{ci,s}\left(1 - \alpha_{ci,s}\right)G\right) \; if \; T \geq T_{th}$$

$$M_{ci,s} = 0 \qquad if \; T < T_{th}$$

Difference of ice covered area ICA can be used to validate modeling

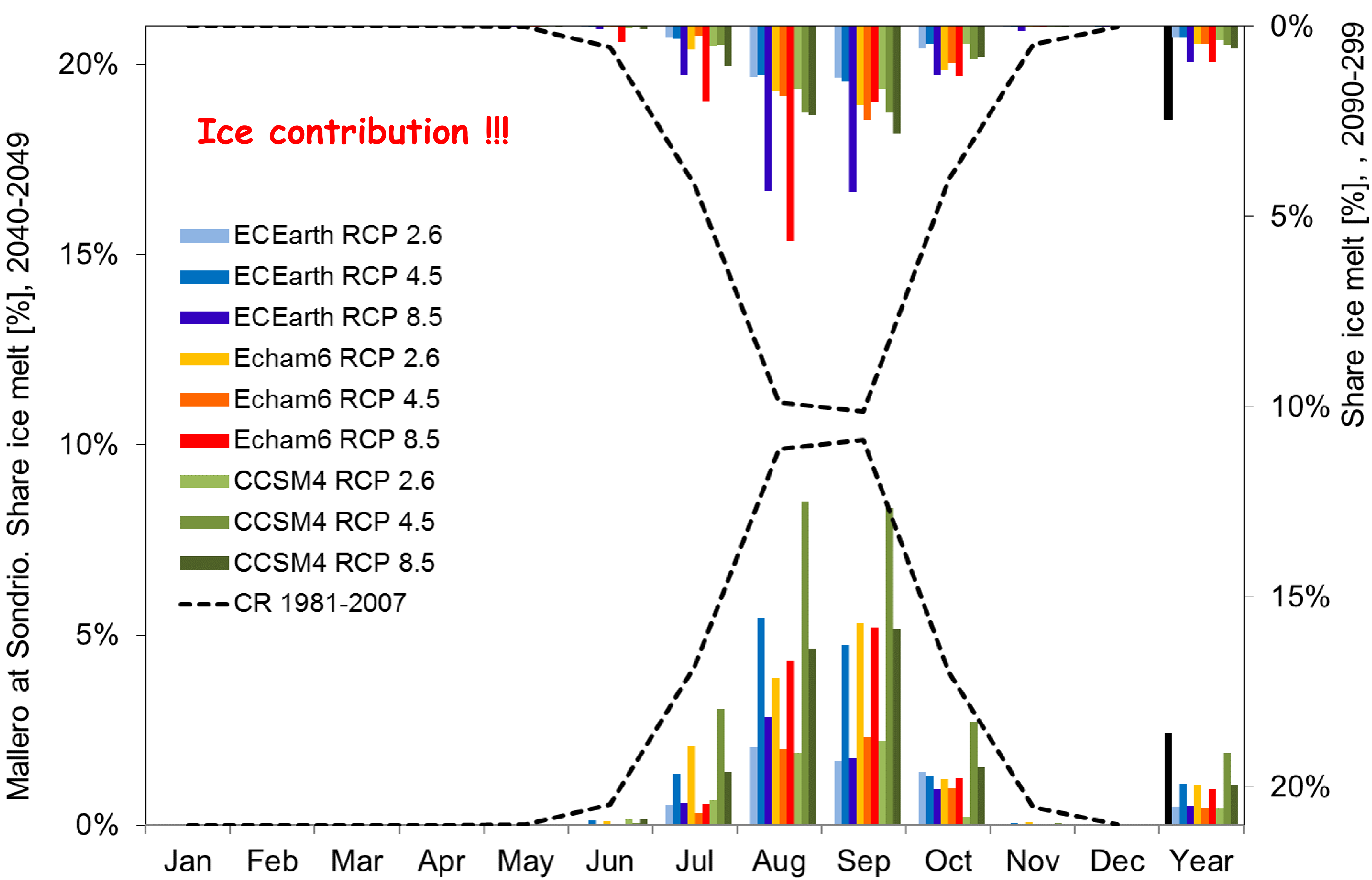




Ice covered area at each altitude 1992-1999

A glance into the (likely) future

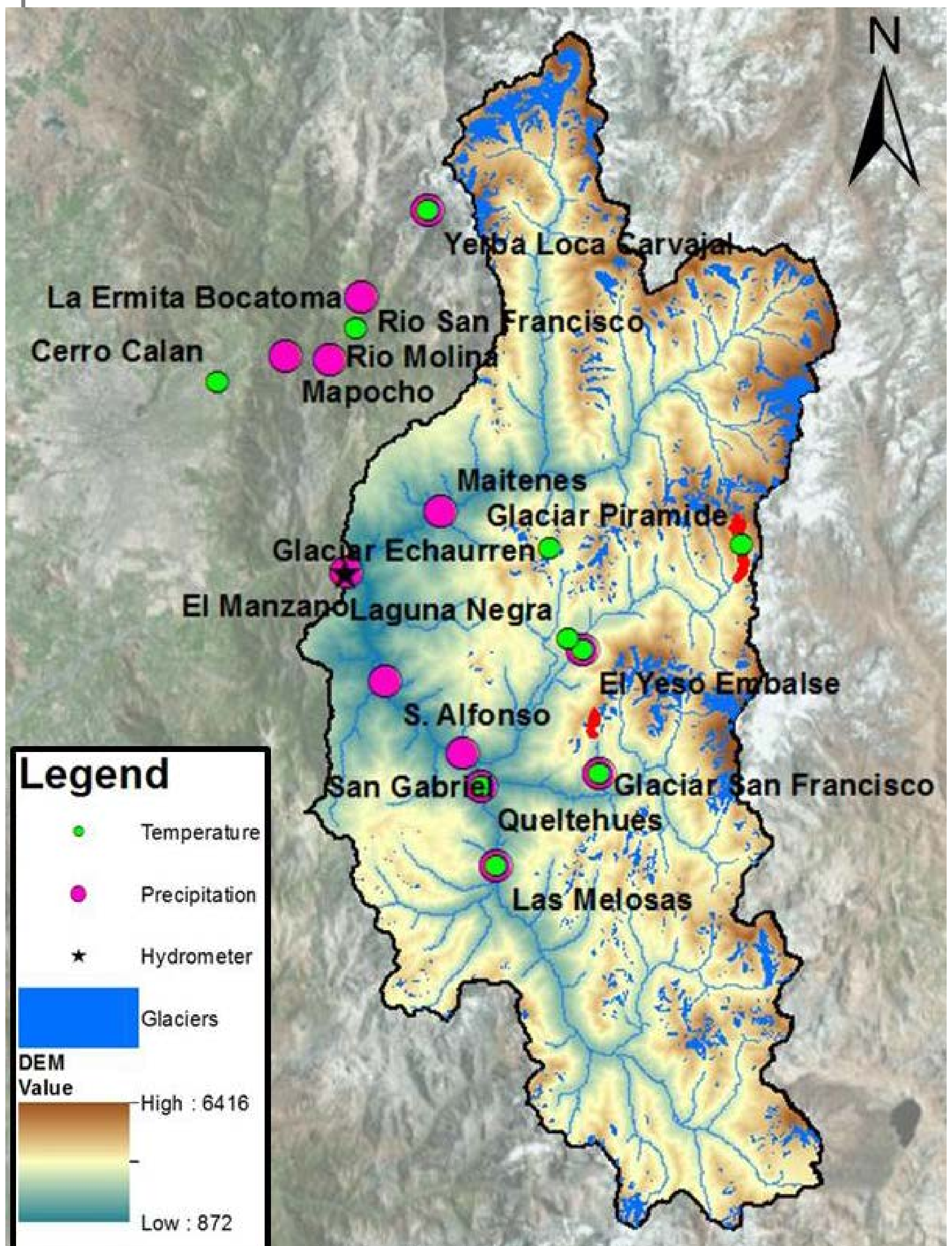
Using IPCC projected climate scenarios we can then project forward the fate of the cryosphere, and of water resources

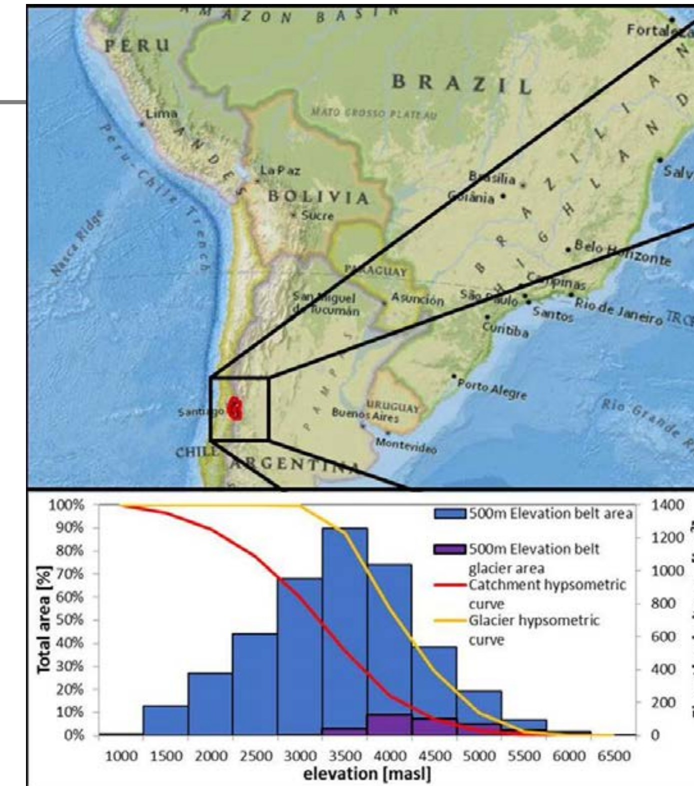


And worldwide ???

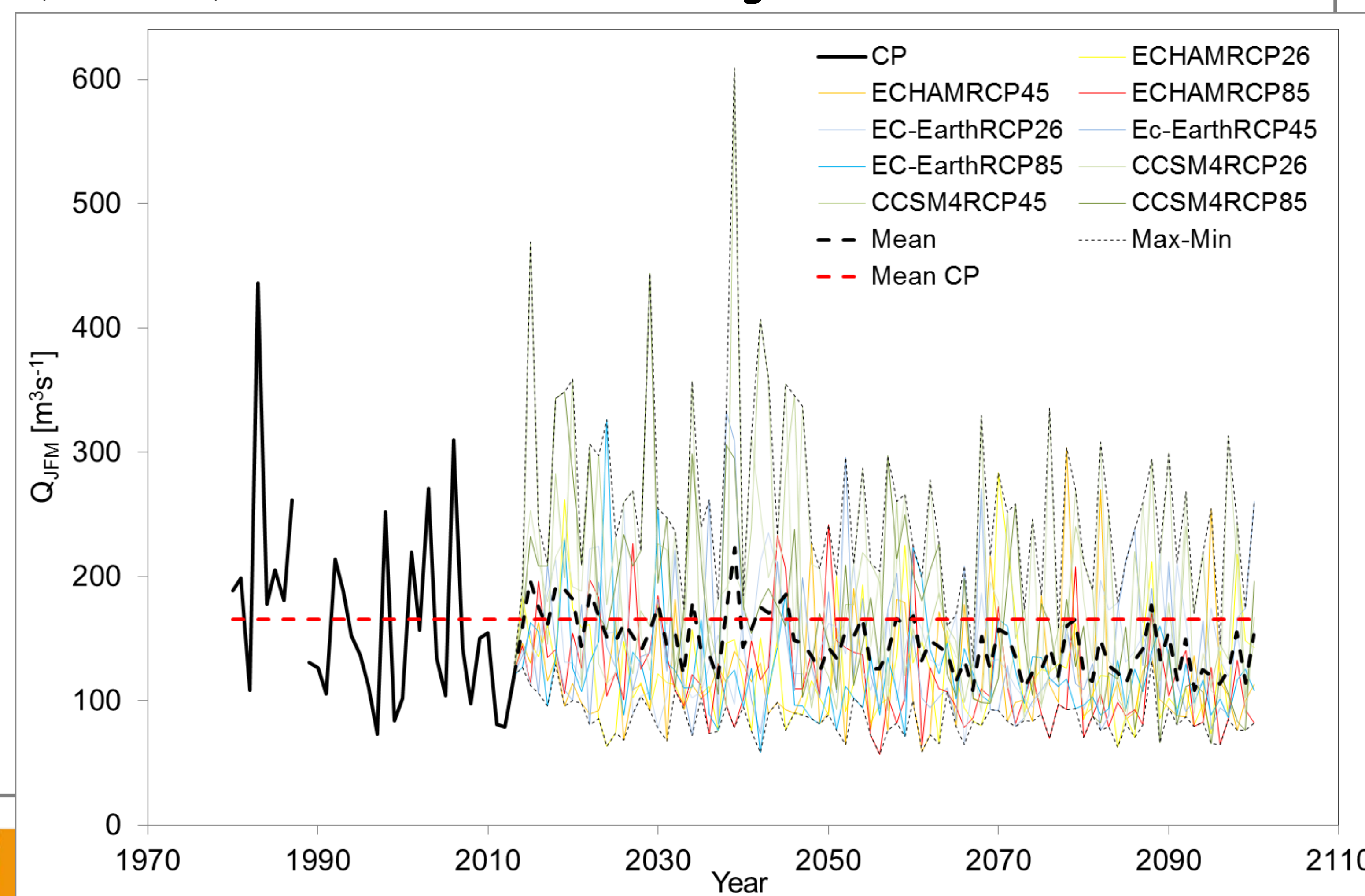
Chile: large monitoring, high altitude network

Case study: Maipo river, Santiago





(Austral) summer flow decreasing until 2100

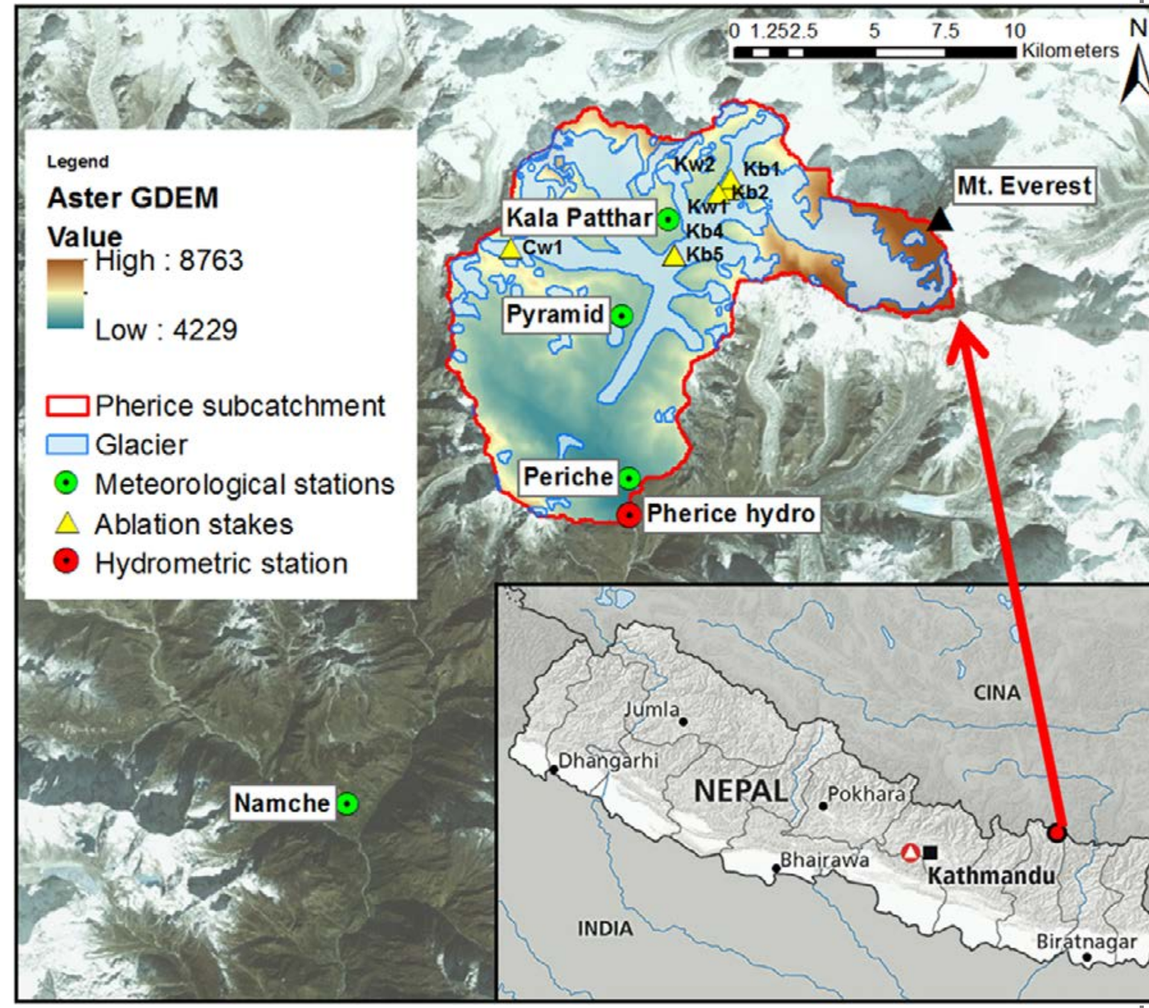


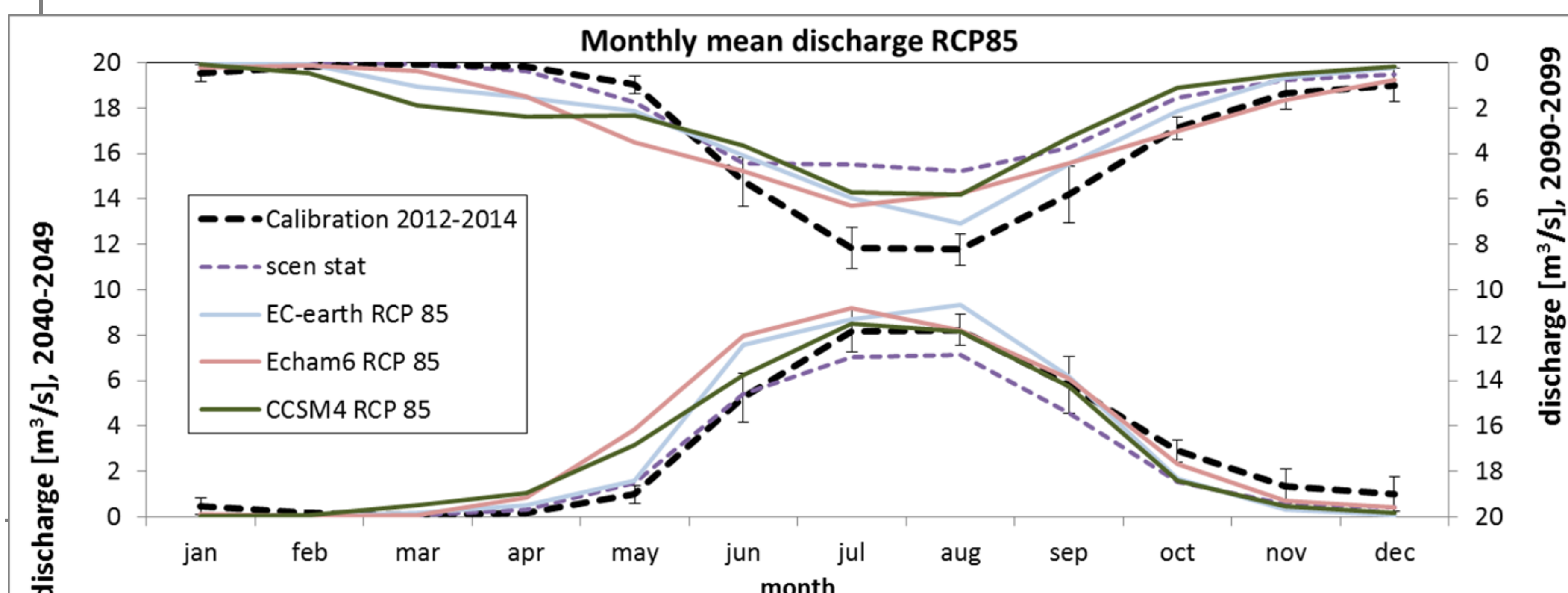
And worldwide ???

Southern Himalaya (Nepal): loose high altitude hydrological network, some AWS stations

Case: the Dudh Koshi catchment, Everest region

Activity in cooperation with EVK2CNR, Pyramid Lab (5050 m a.s.l.)

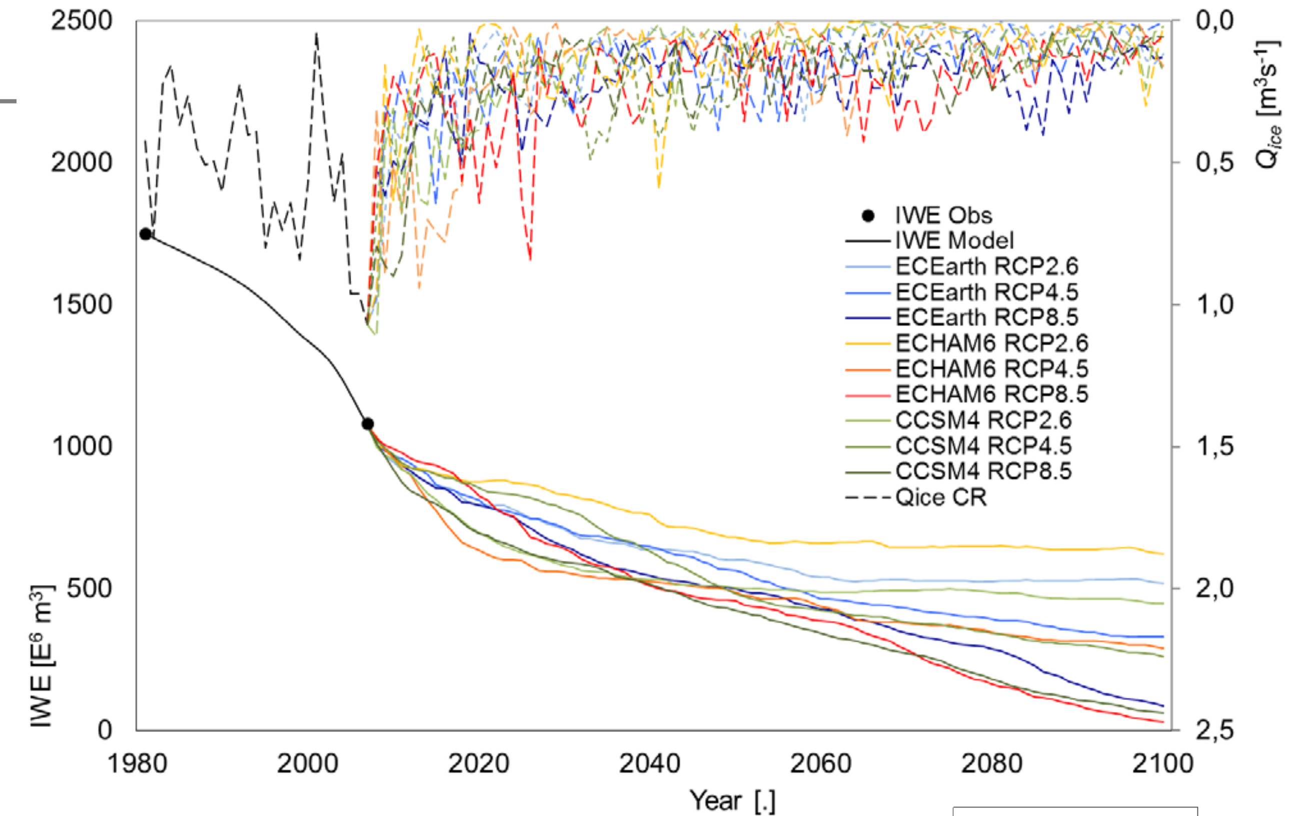


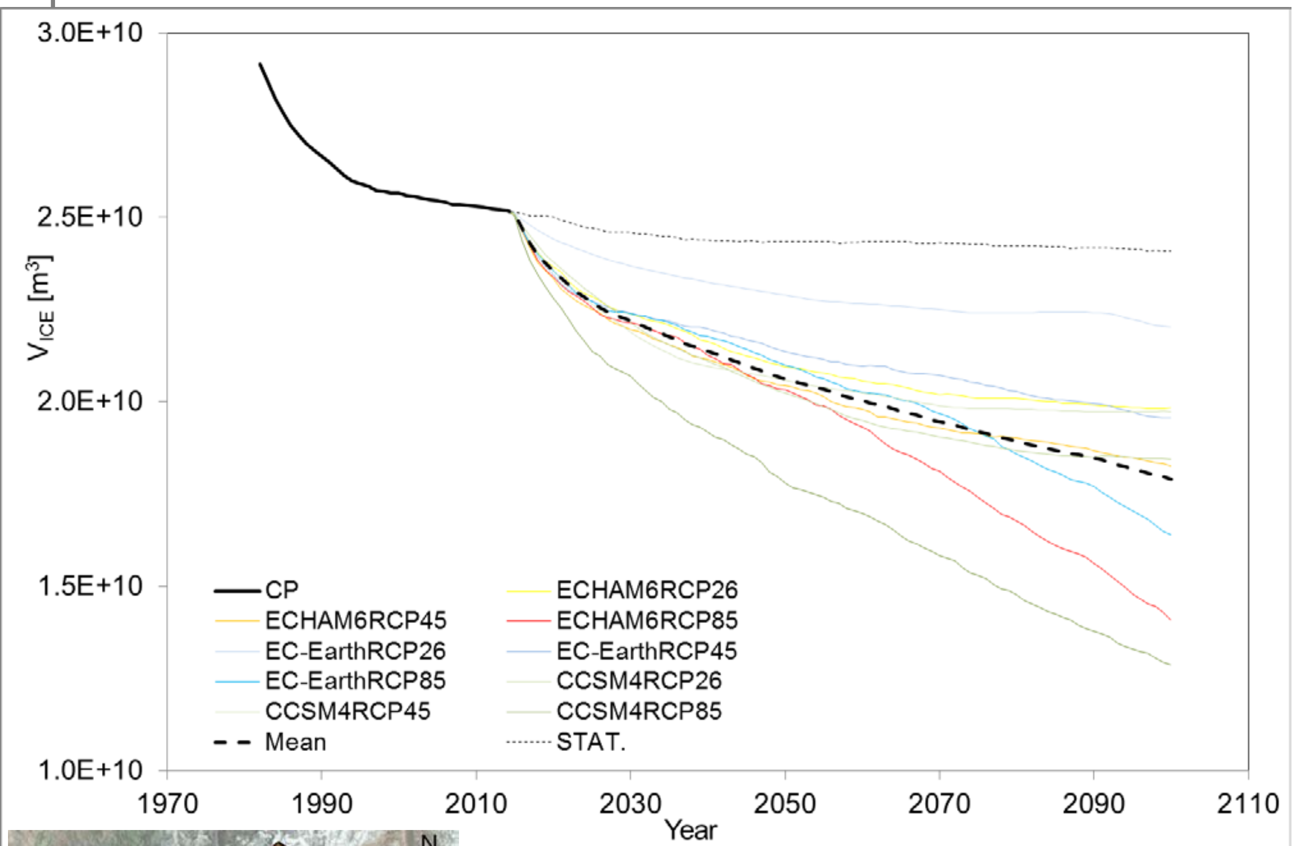


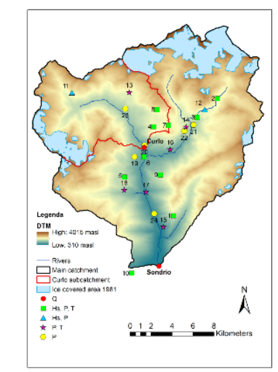
Stream flows at 2100 largely decreasing

And worldwide ???

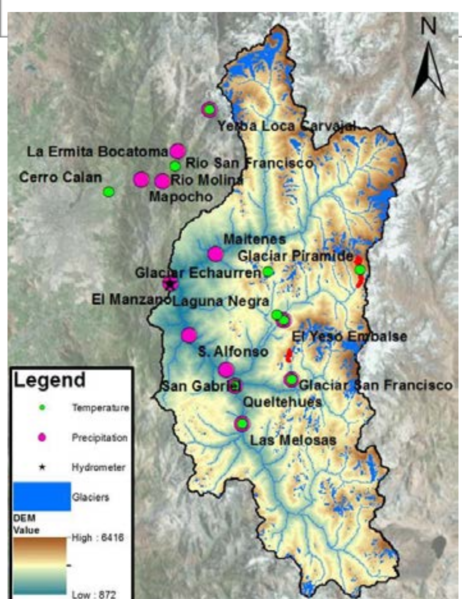
A comparison of (projected) glaciers' evolution in these three areas

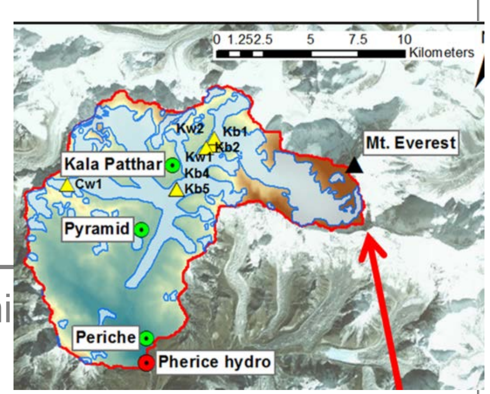


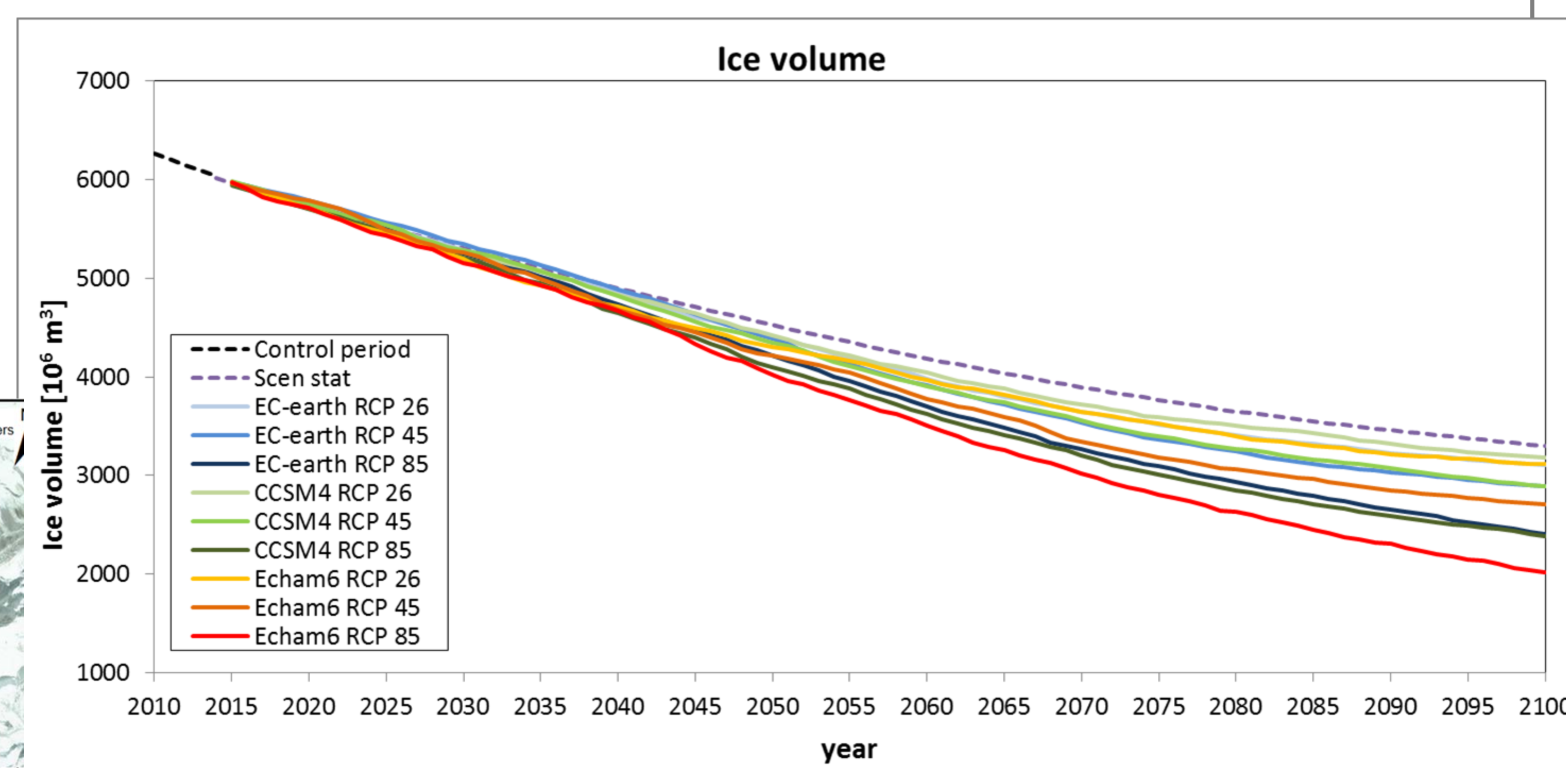




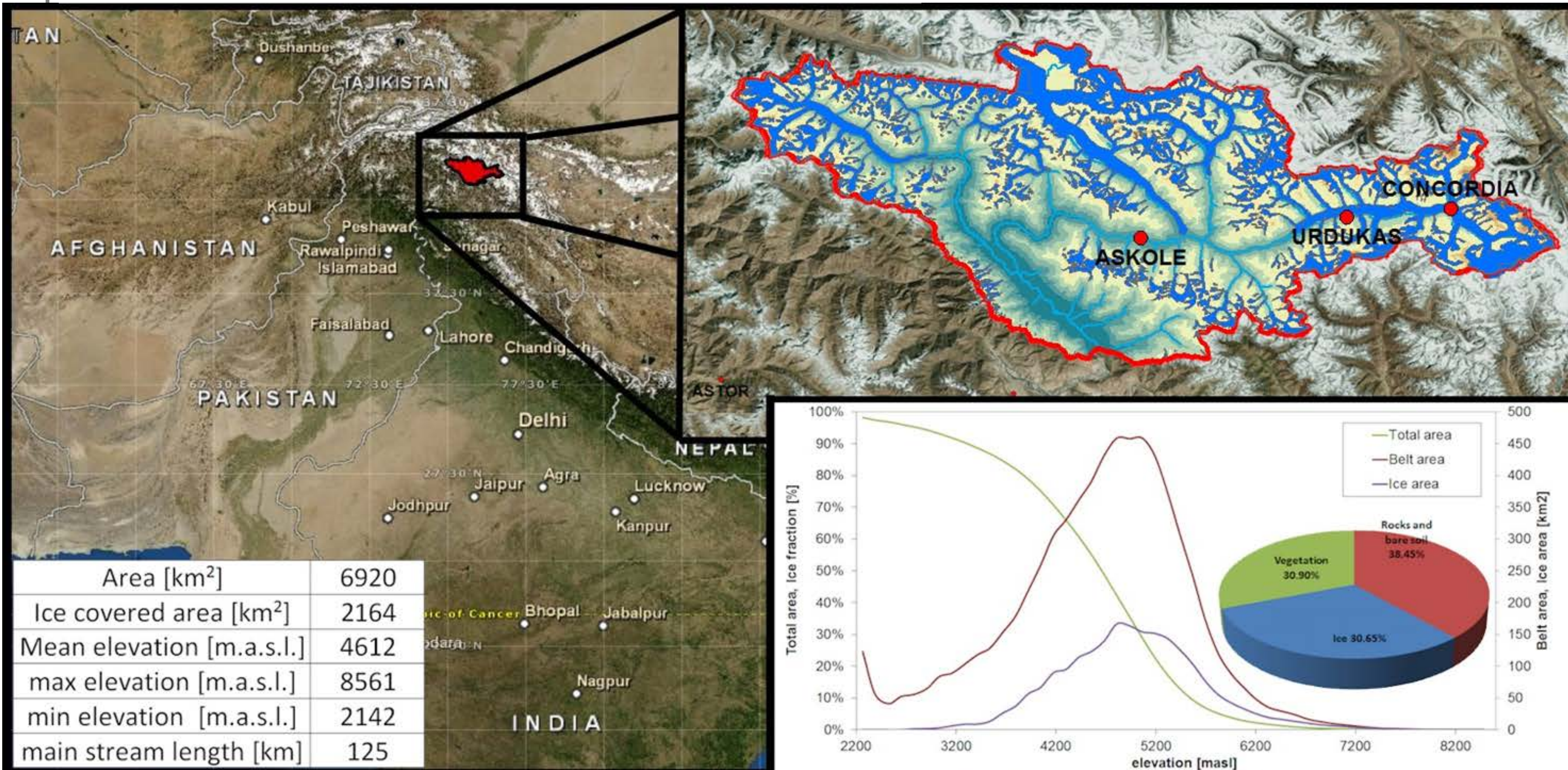
Different stages of the same process ???





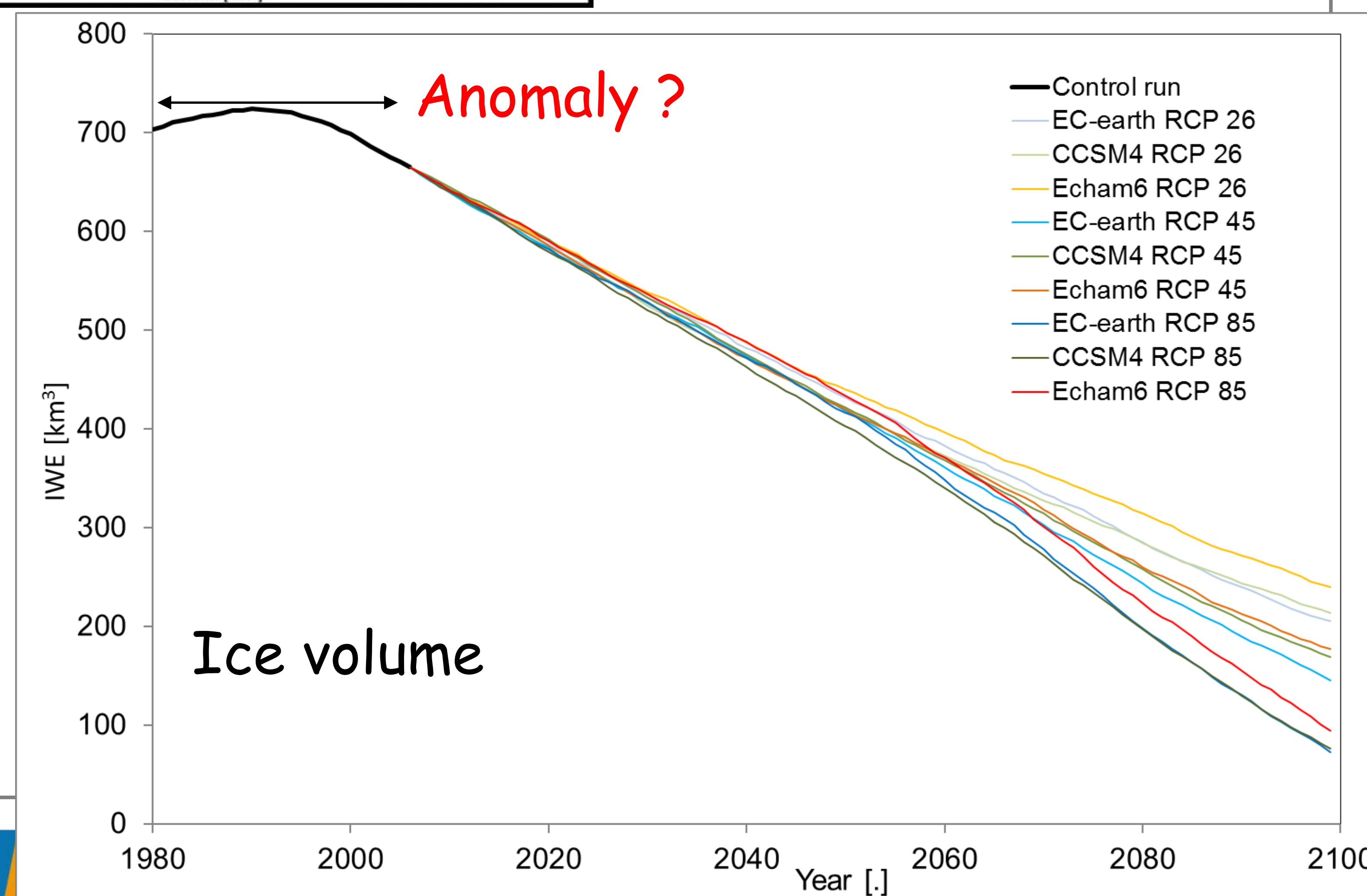


The Karakoram anomaly ???



Area [km^2]	6920
Ice covered area [km^2]	2164
Mean elevation [m.a.s.l.]	4612
max elevation [m.a.s.l.]	8561
min elevation [m.a.s.l.]	2142
main stream length [km]	125

We studied shigar river at the toe of K2



Conclusions (so to speak !!)

- Recent studies provided clues of modified hydrological cycle in the Alps of Italy, shrinking of ice covered areas, and shorter snow cover duration.

- Decreased snowfall per increased temperatures results into increased fall and winter floods, and subsequently earlier melt and decreased instream flows in summer.

- Projected hydrological behavior until half century of instream flows for a some case study catchments in the Alps (e.g. Serio, Oglio, Mallero, Adda) displays potentially enhanced trends as reported above, with very large shrinking of ice covers, and noticeable shifts of hydrological cycle, with potential fallout on water resources, and the riverine environment.

- Water management for agriculture/hydropower during summer will be affected.

- Worldwide continental glaciers are similarly undergoing (and will undergo) a phase of retreat, and subsequent hydrological changes, albeit with different timing.