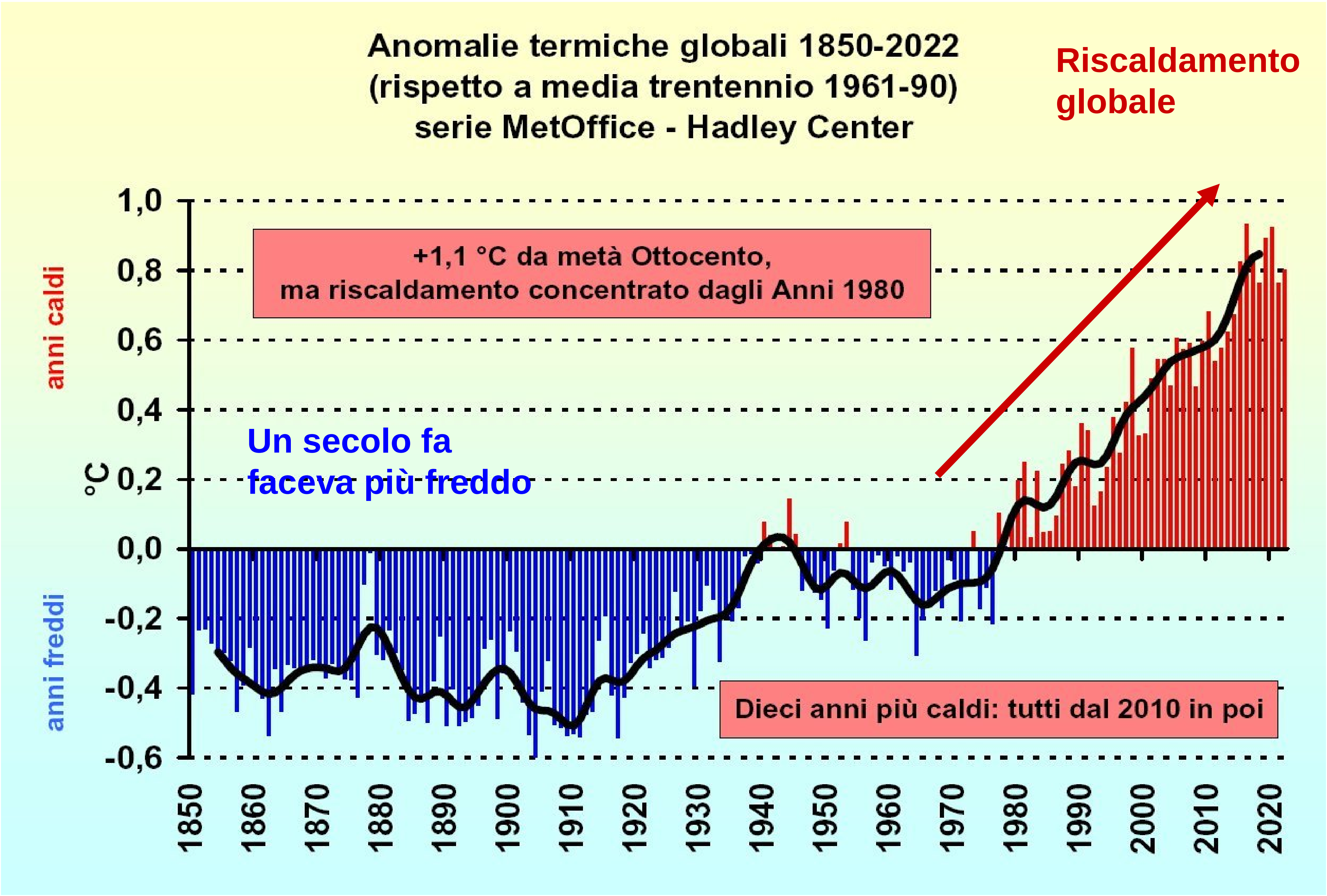
Come sta cambiando il clima della montagna

Luca Mercalli

Presidente
Società Meteorologica Italiana

Torino, 21 marzo 2023

Temperatura in aumento su tutto il pianeta: +1,1°C nell’ultimo secolo



Anomalie termiche globali 1850-2022
(rispetto a media trentennio 1961-90)
serie MetOffice - Hadley Center

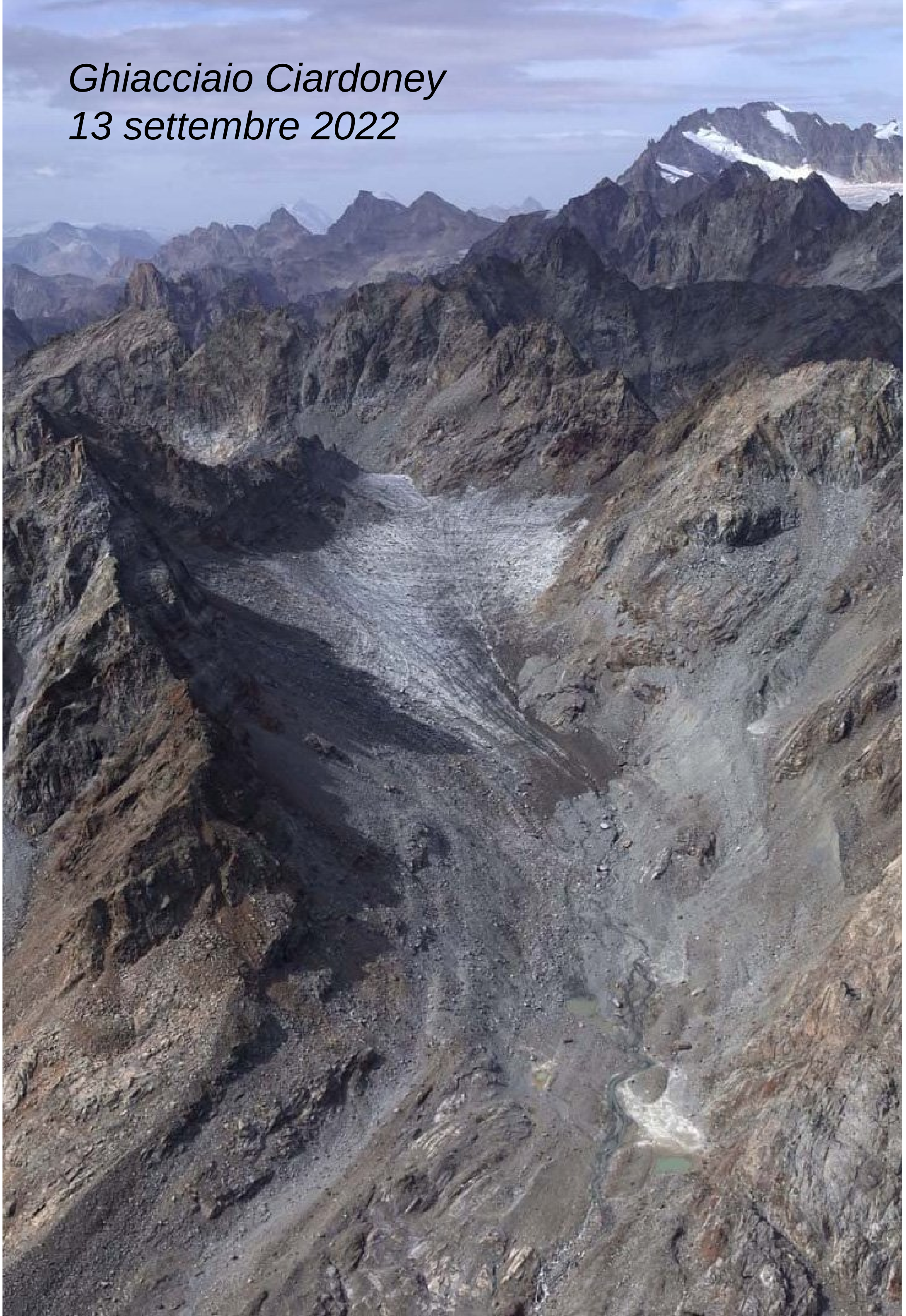
Riscaldamento globale

+1,1 °C da metà Ottocento,
ma riscaldamento concentrato dagli Anni 1980

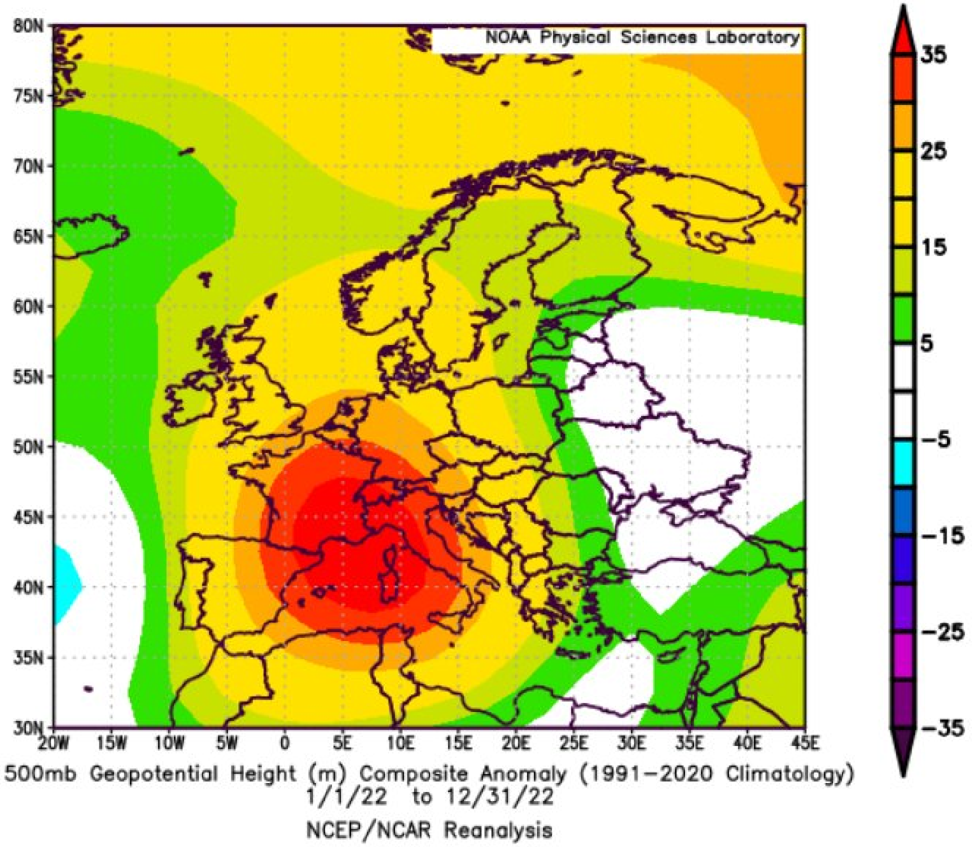
Un secolo fa faceva più freddo

Dieci anni più caldi: tutti dal 2010 in poi

Siamo reduci dall'anno più caldo, più secco e più rovinoso per i ghiacciai delle Alpi


Ghiacciaio Ciardoney
13 settembre 2022

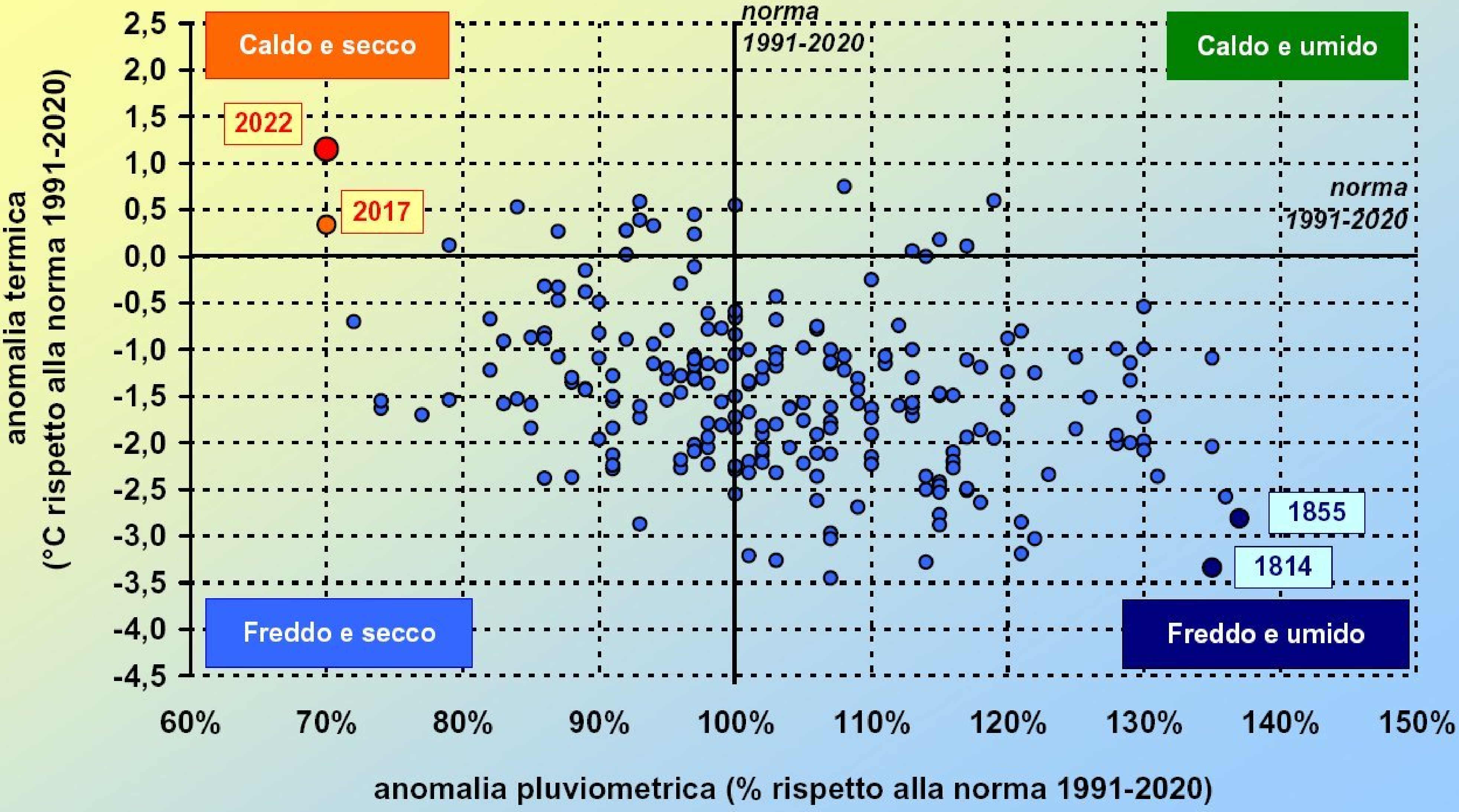
https://psl.noaa.gov


NOAA Physical Sciences Laboratory
80N
75N
70N
65N
60N
55N
50N
45N
40N
35N
30N
20W
15W
10W
5W
0
5E
10E
15E
20E
25E
30E
35E
40E
45E
35
25
15
5
−5
−15
−25
−35

500mb Geopotential Height (m) Composite Anomaly (1991−2020 Climatology)
1/1/22 to 12/31/22
NCEP/NCAR Reanalysis

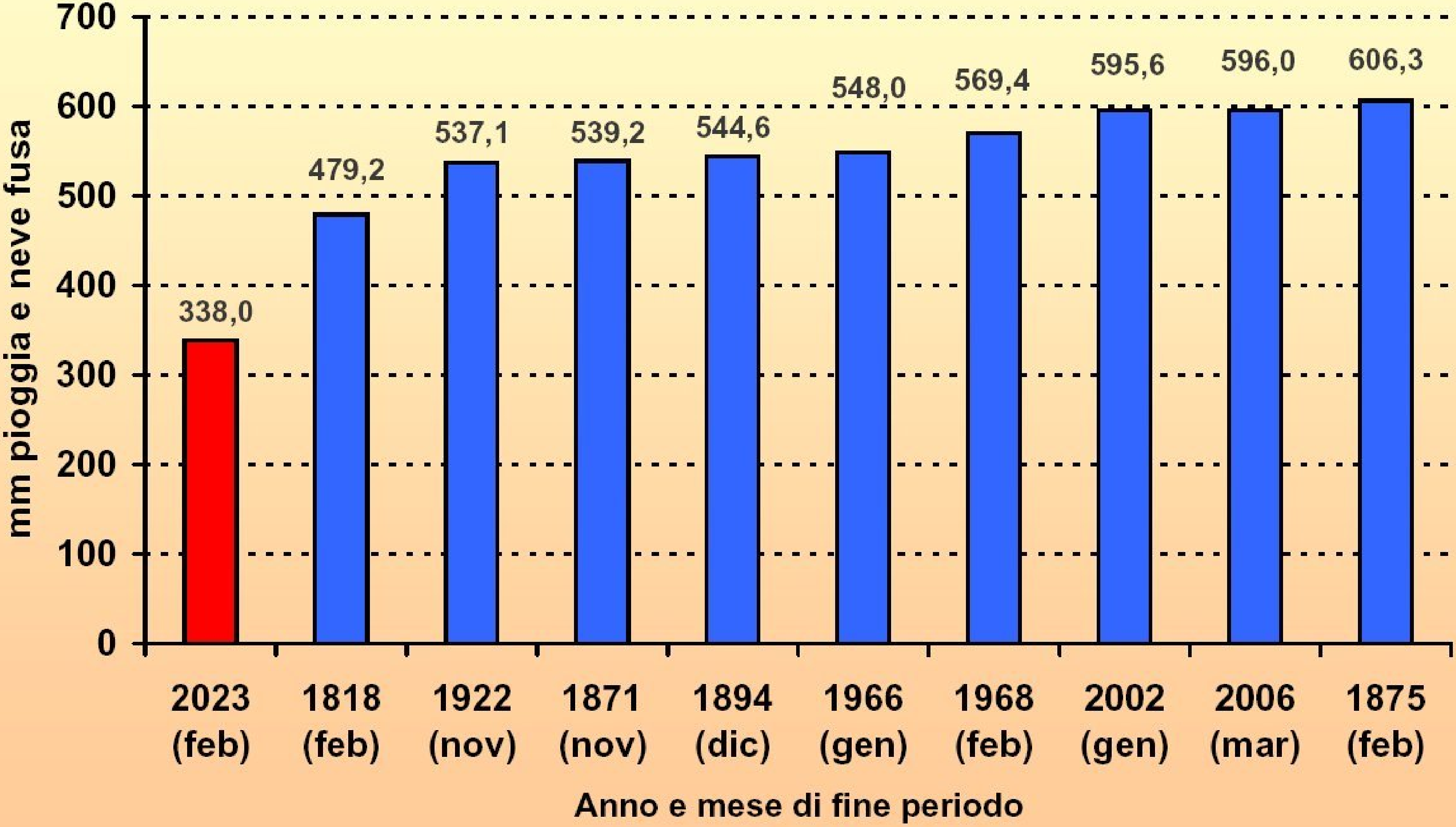
Distribuzione delle anomalie annue di temperatura media e precipitazioni totali in Italia dal 1800 al 2022

(dati CNR-ISAC, elaborazione grafico SMI / Nimbus)

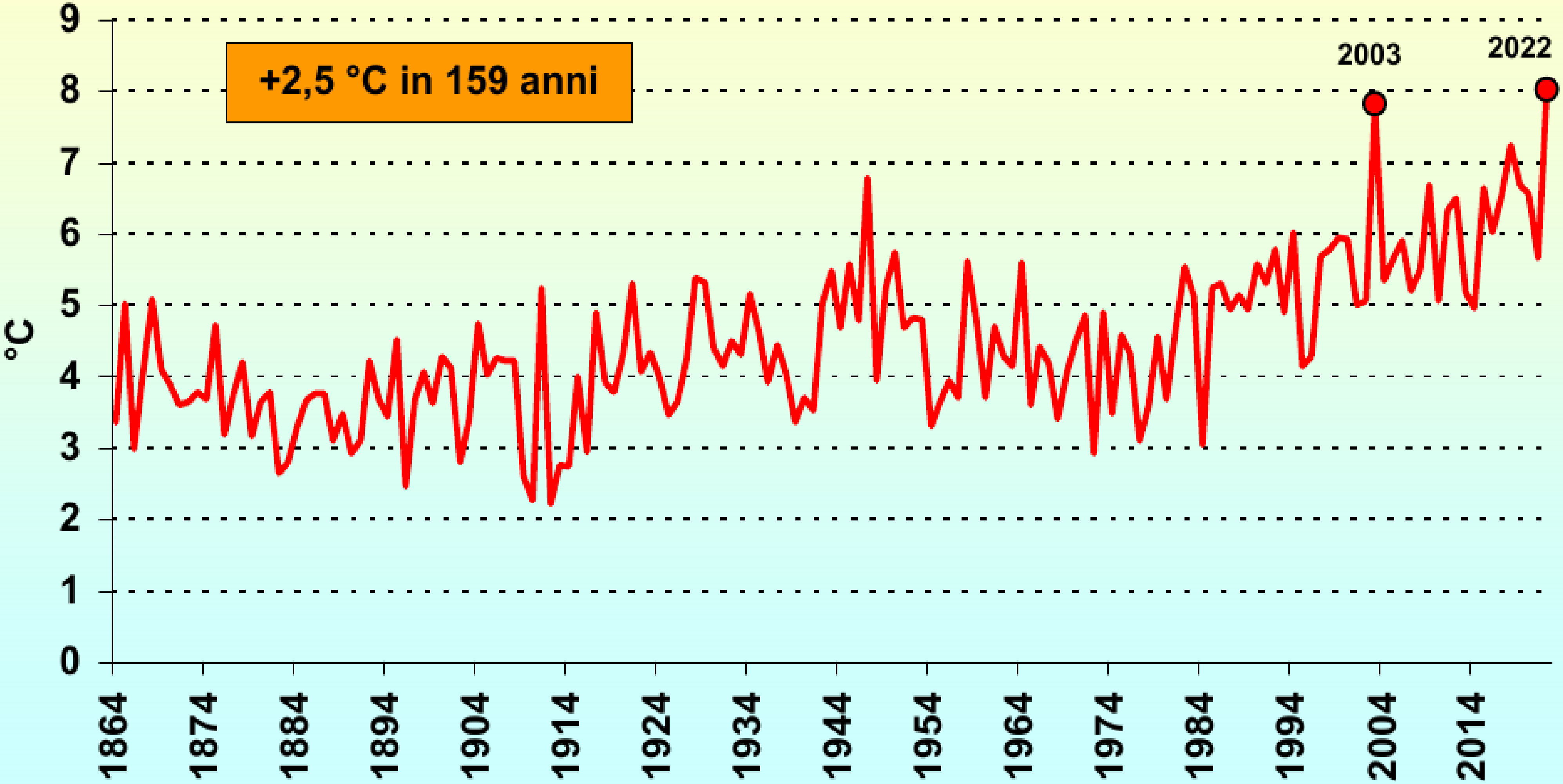


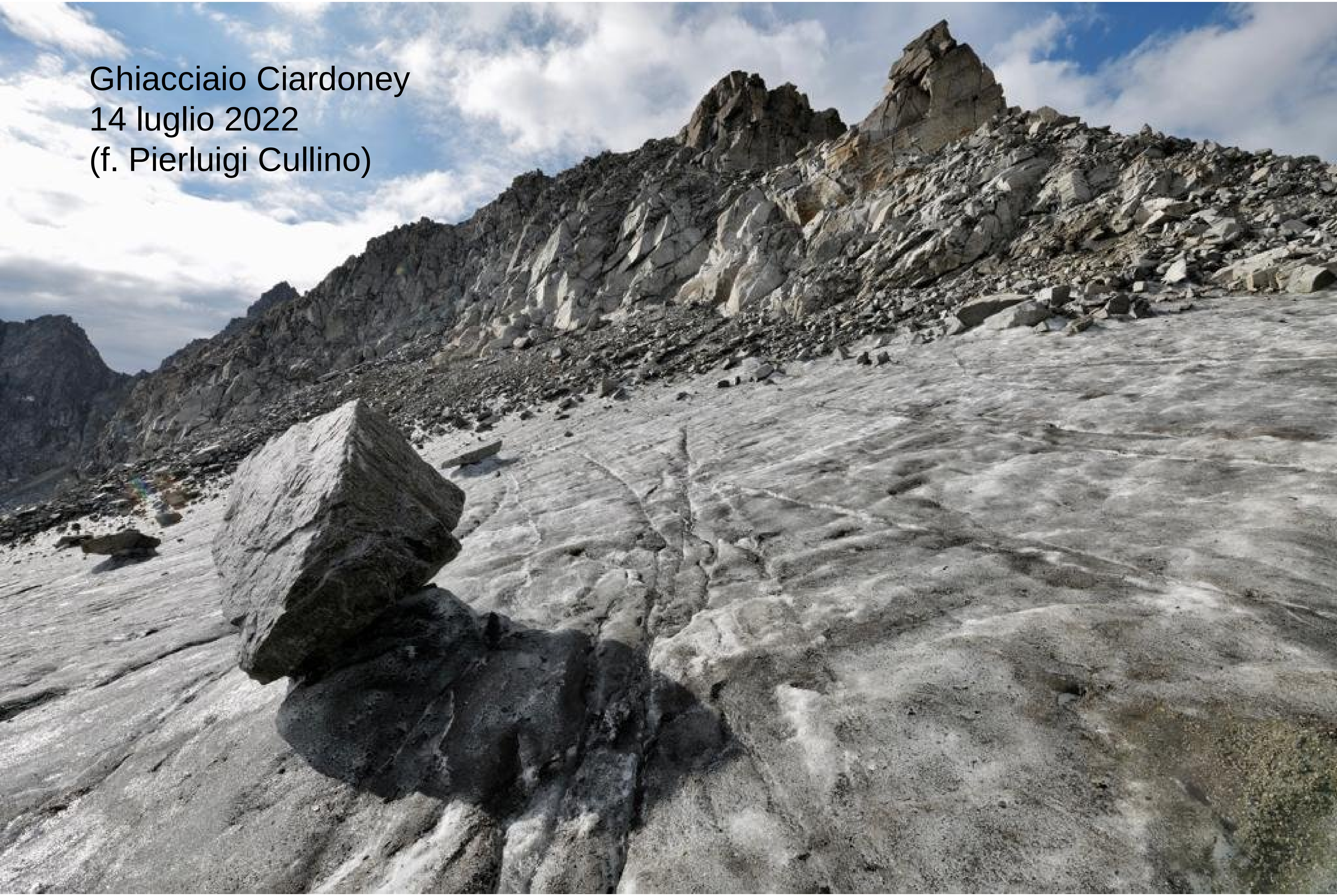
Torino centro - Le sequenze di 15 mesi più secche dal 1802

(dati attuali Arpa Piemonte; analisi storica SMI / Nimbus)

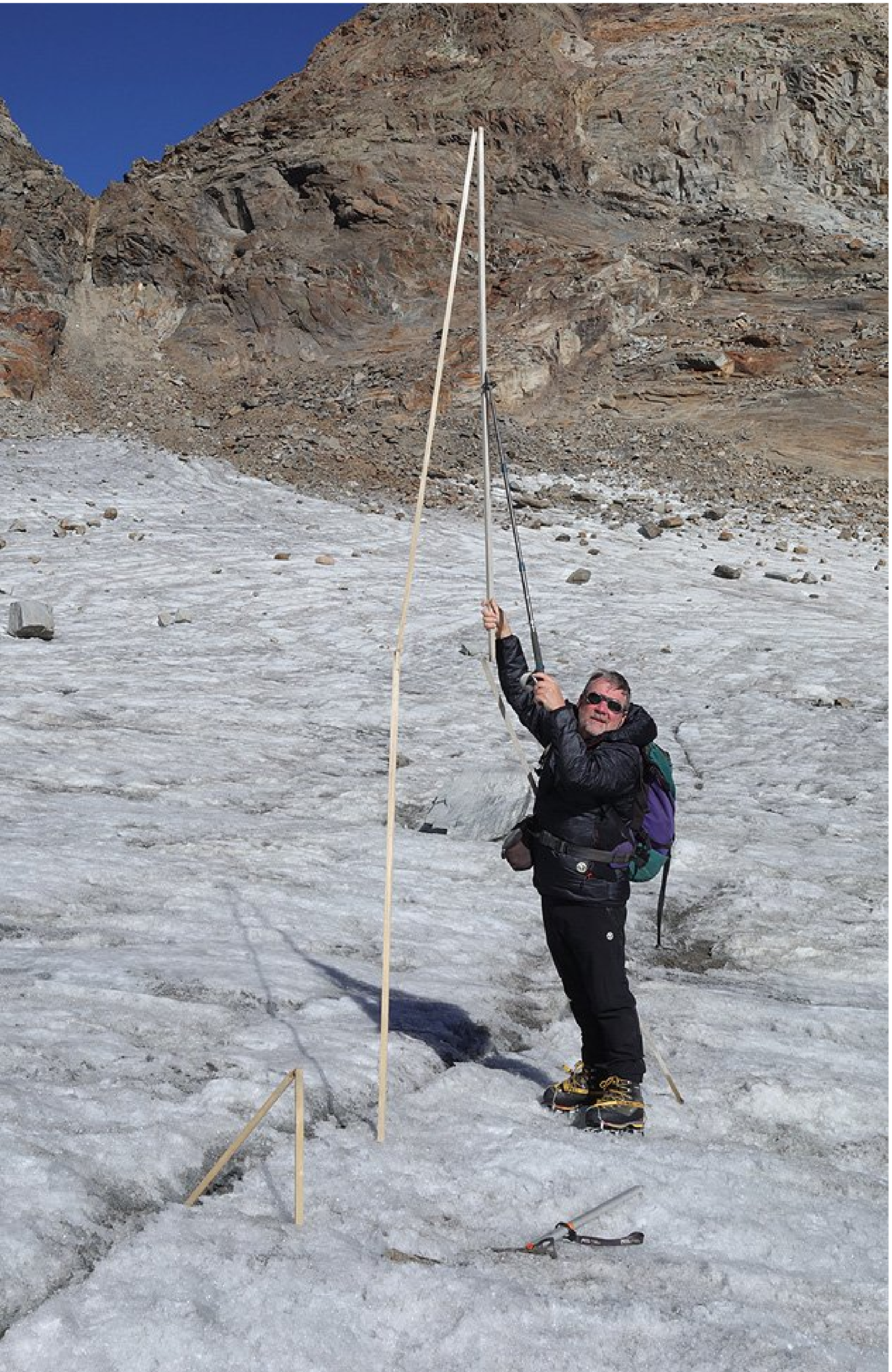


Gran San Bernardo (2472 m) - Temperature medie maggio-settembre dal 1864 al 2022 (serie omogeneizzata; fonte Meteosvizzera)


+2,5 °C in 159 anni

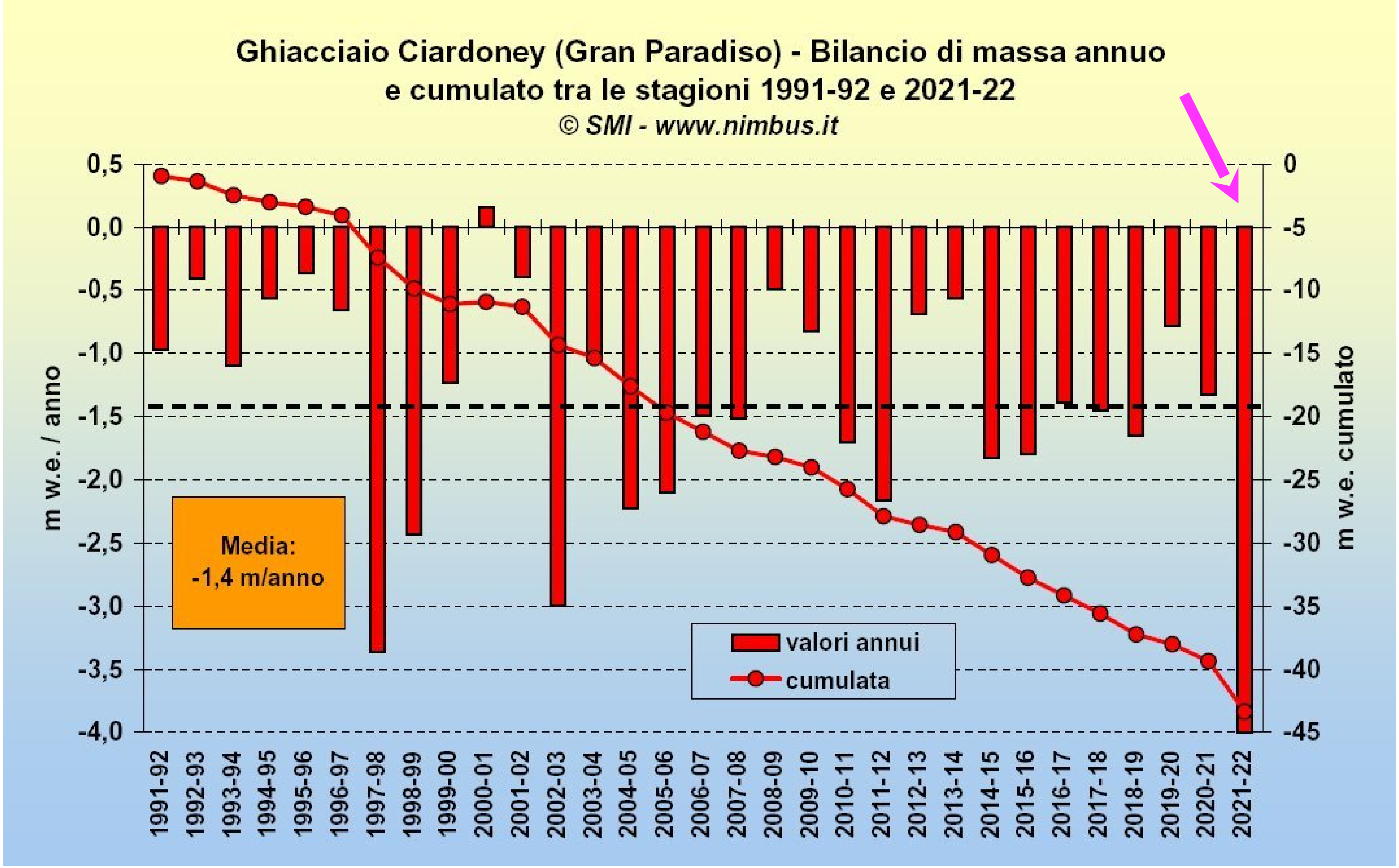


Ghiacciaio Ciardoney
14 luglio 2022
(f. Pierluigi Cullino)



2022: l'annata peggiore
mai documentata
sui ghiacciai di
tutte le Alpi,
4-6 metri di spessore
glaciale persi a quote
di 3000 m,
dal Piemonte,
alla Svizzera, al Tirolo

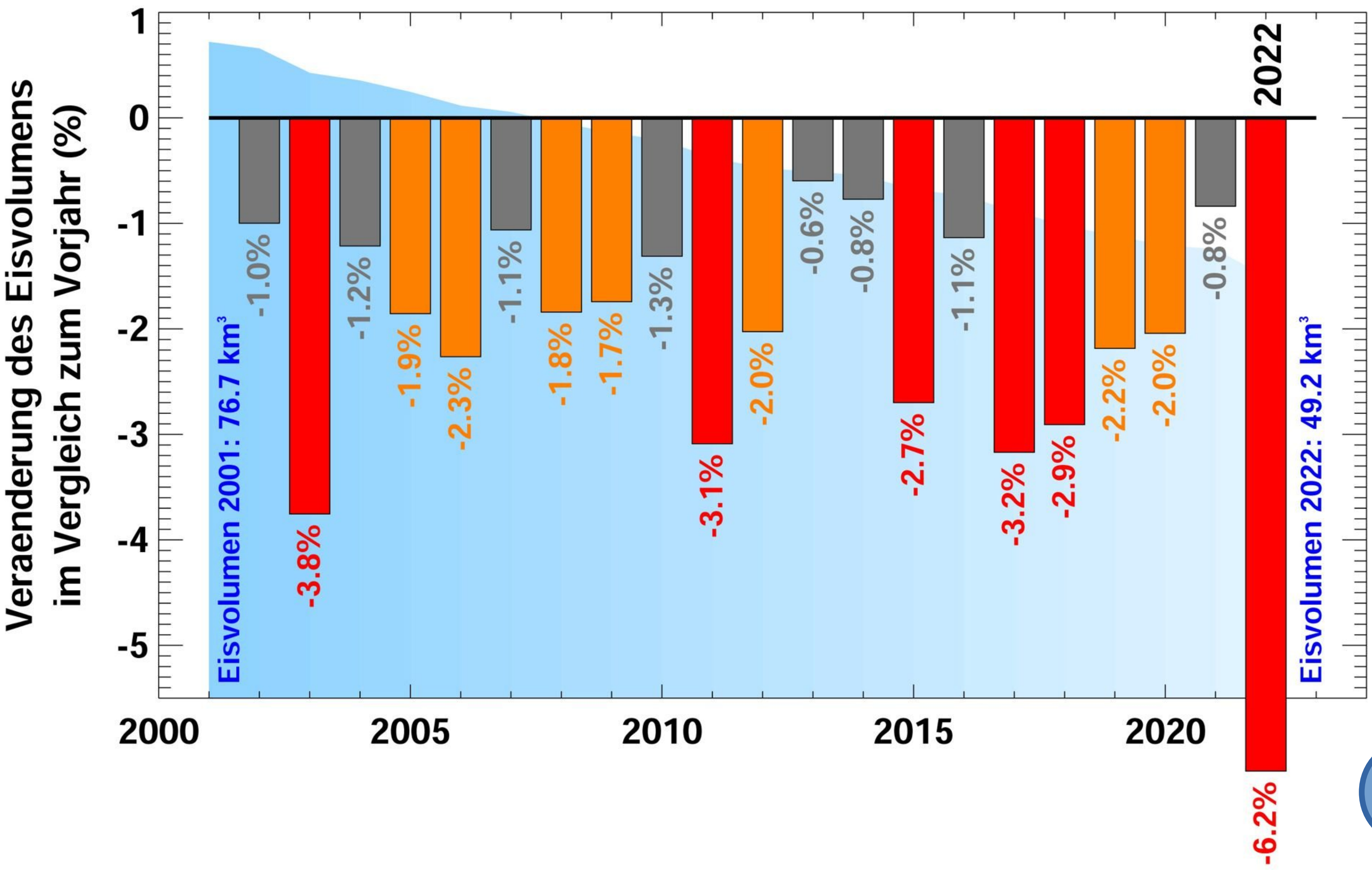
◀ Ghiacciaio Ciardoney,
20 settembre 2022

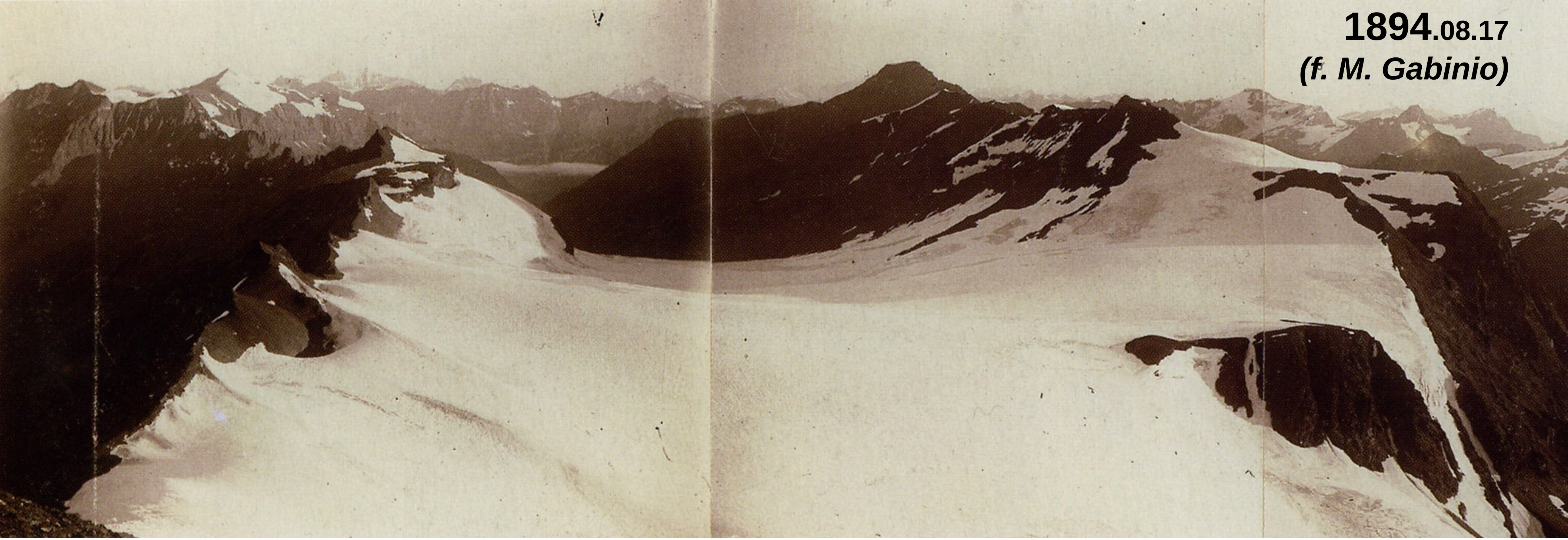

Ghiacciaio Ciardoney (Gran Paradiso) - Bilancio di massa annuo
e cumulato tra le stagioni 1991-92 e 2021-22
© SMI - www.nimbus.it
0,5
0,0
-0,5
-1,0
-1,5
-2,0
-2,5
-3,0
-3,5
-4,0
m w.e. / anno
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
m w.e. cumulato
Media:
-1,4 m/anno
valori annui
cumulata
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22

28.9.2022 | Press release

Worse than 2003: Swiss glaciers are melting more than ever before

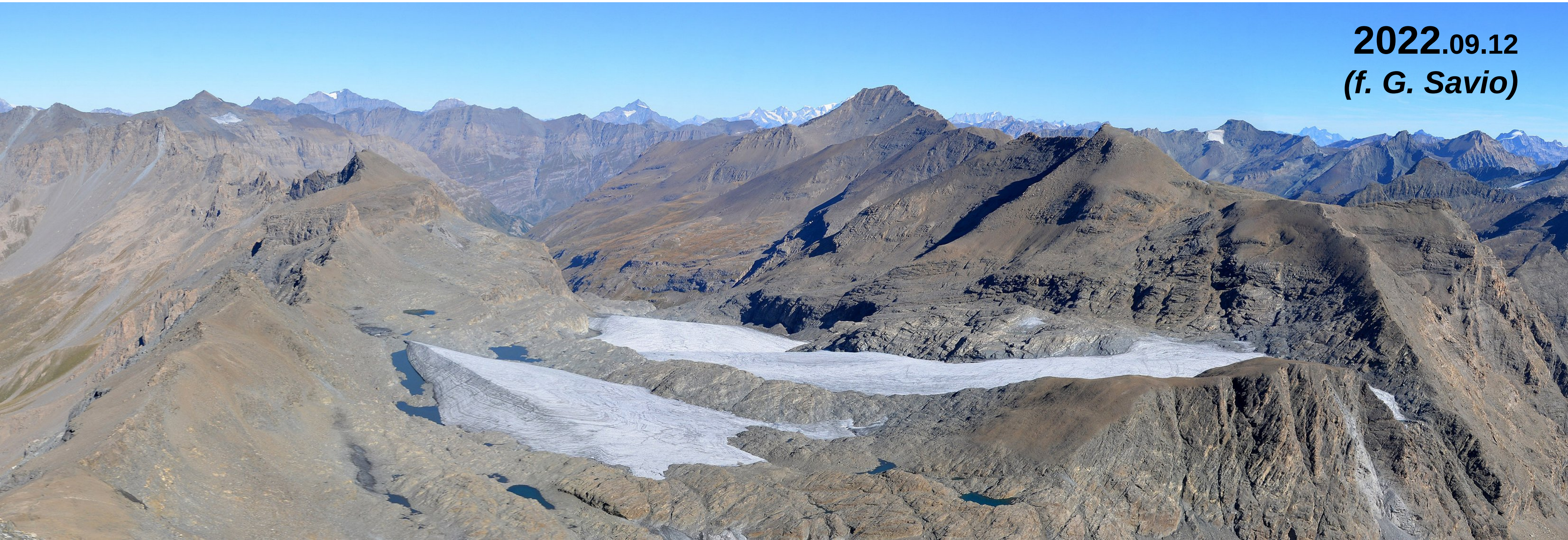
scnat
akademie der naturwissenschaften
académie des sciences naturelles
swiss academy of sciences
accademia di scienze naturali



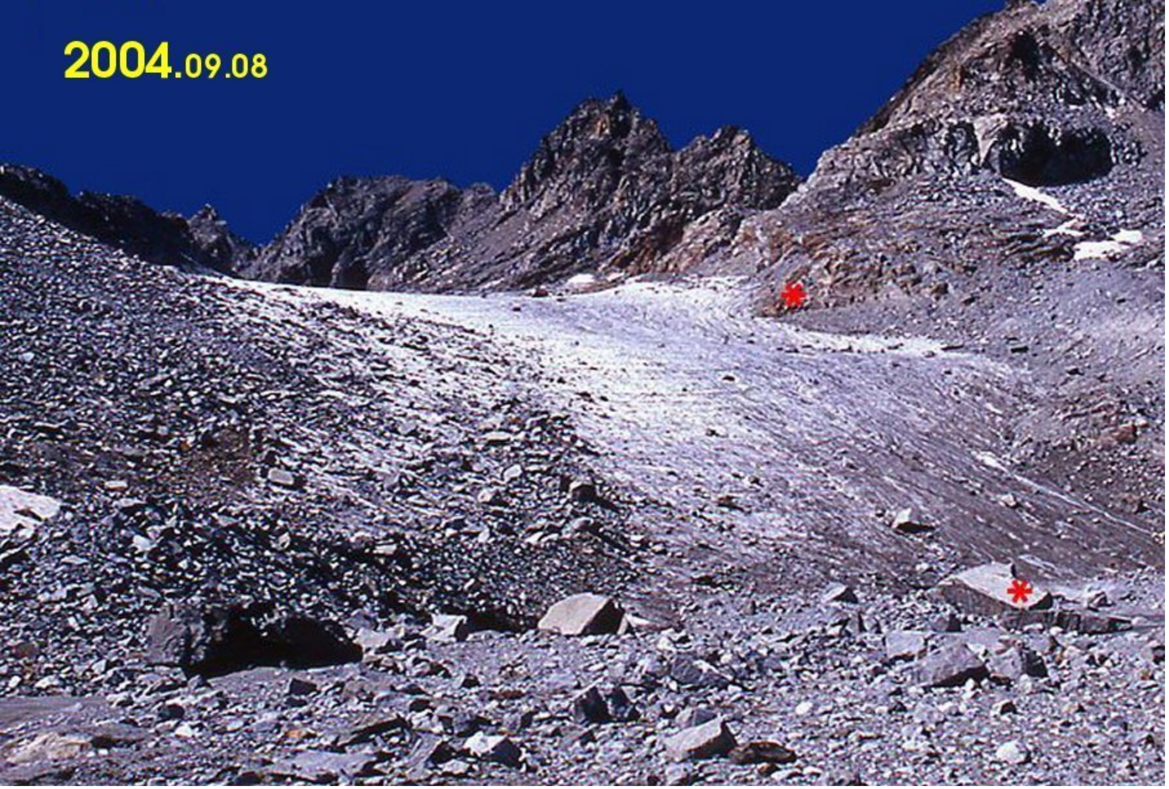


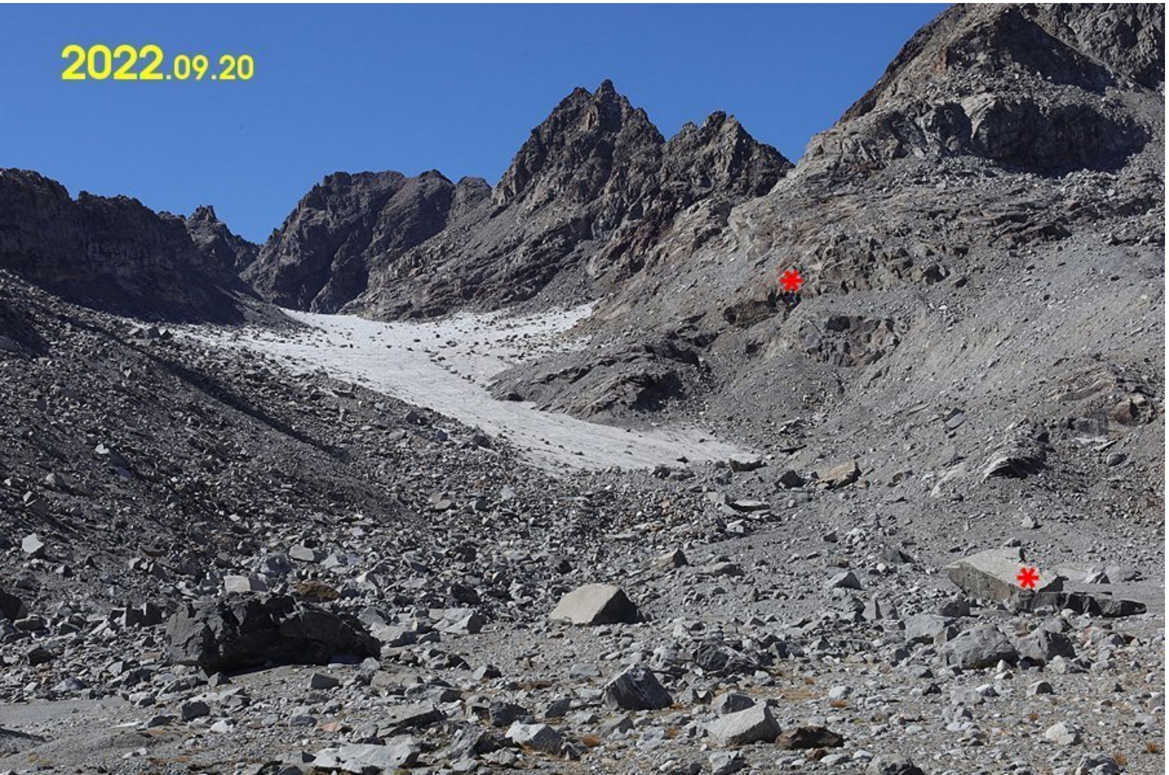
1894.08.17
(f. M. Gabinio)

Ghiacciaio del Rocciamelone



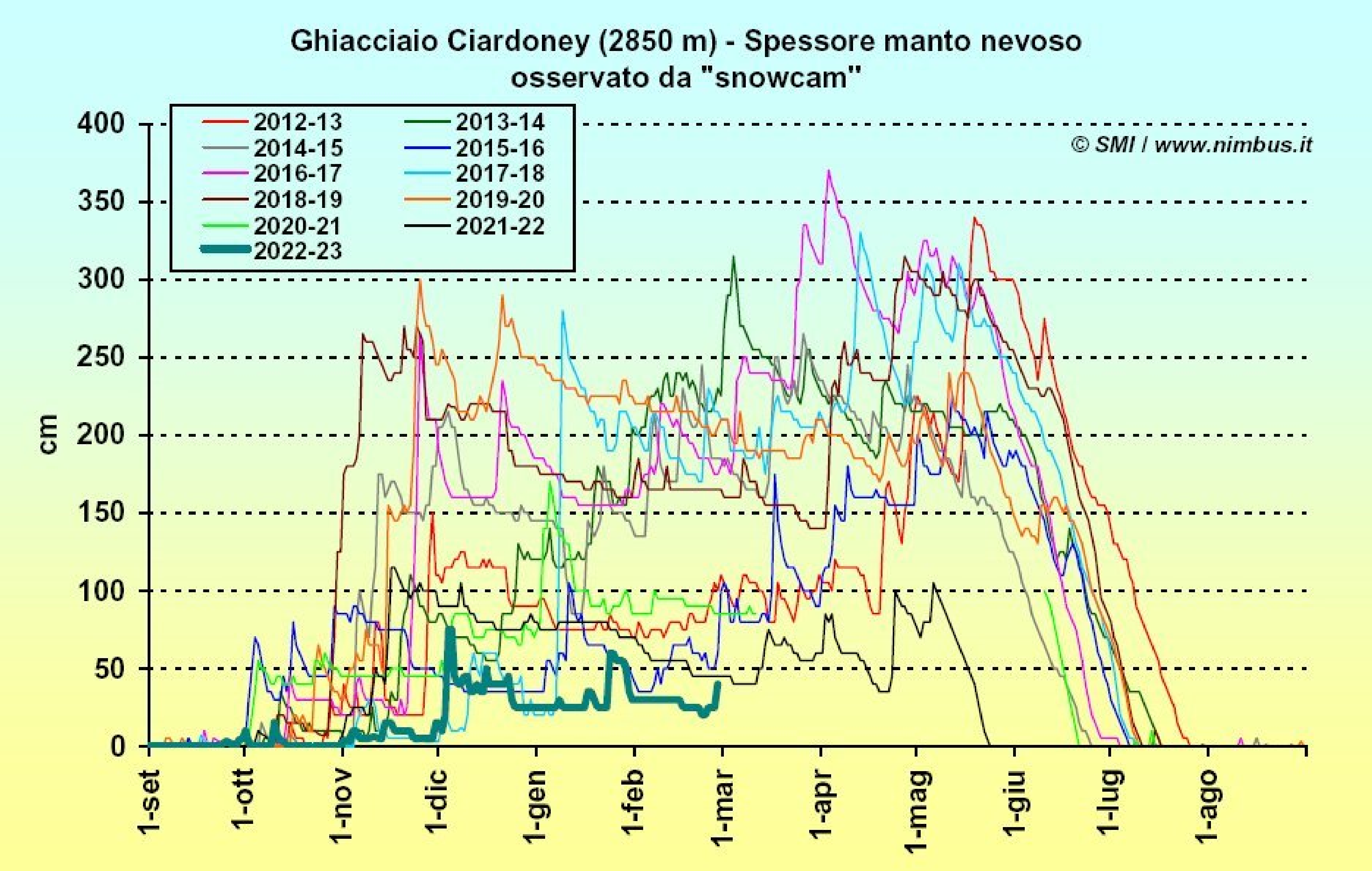
2022.09.12
(f. G. Savio)



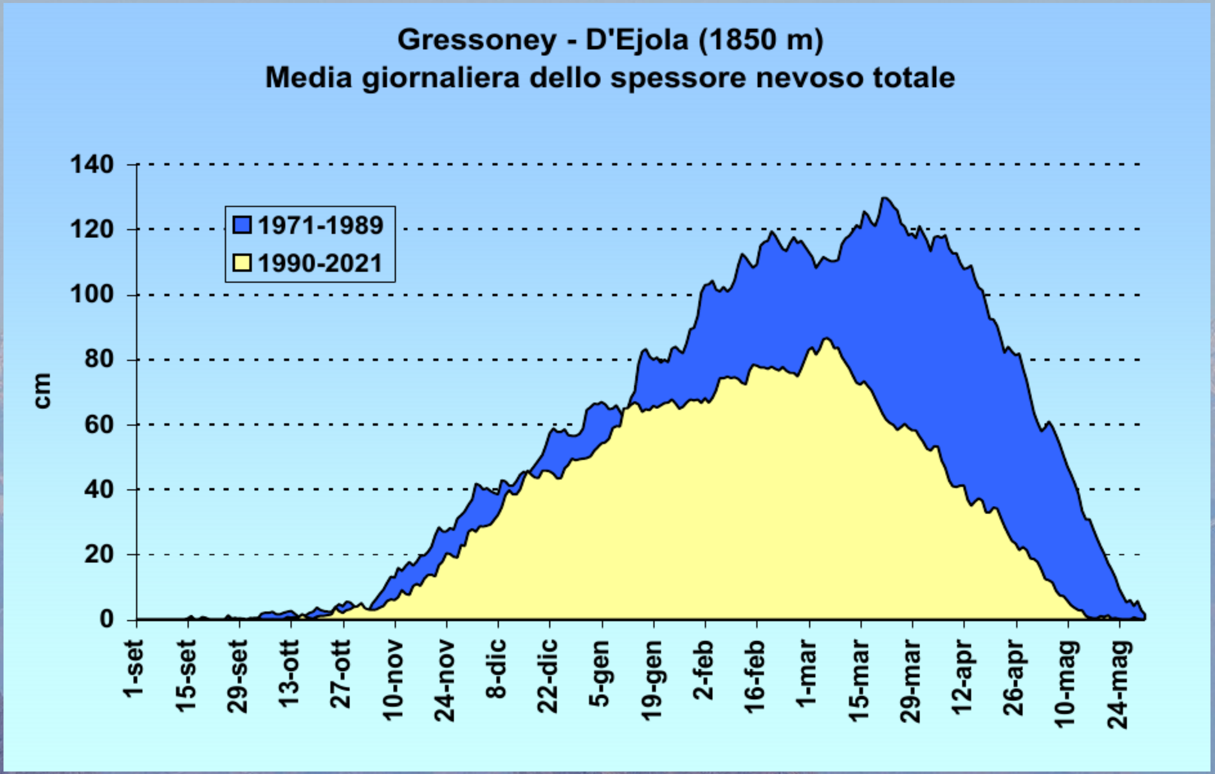


Trasformazioni del territorio montano evidenti anche in pochi anni.

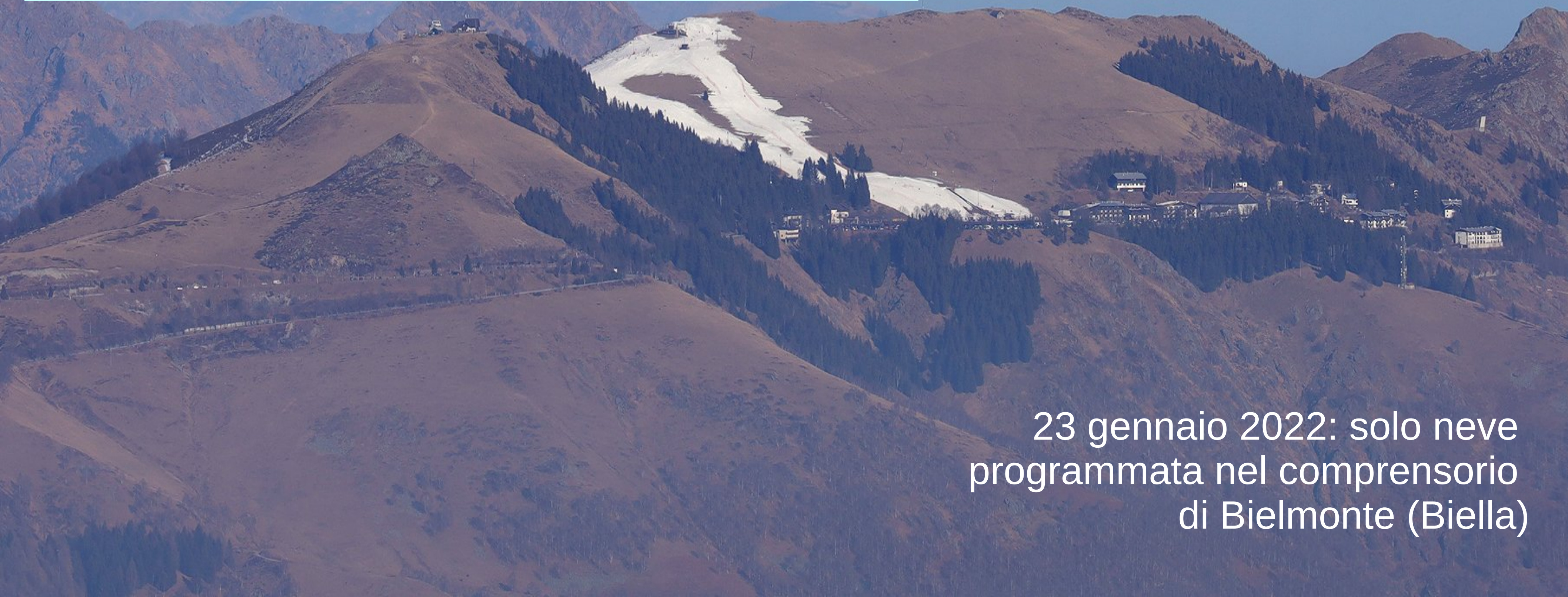
Ghiacciai in totale disequilibrio con
il clima odierno,
privi di alimentazione
e condannati
all'estinzione
entro pochi decenni
sotto i 3500 metri.



Fronte Ghiacciaio Ciardoney (Gran Paradiso): situazione innevamento simile al record negativo di inizio marzo 2022.

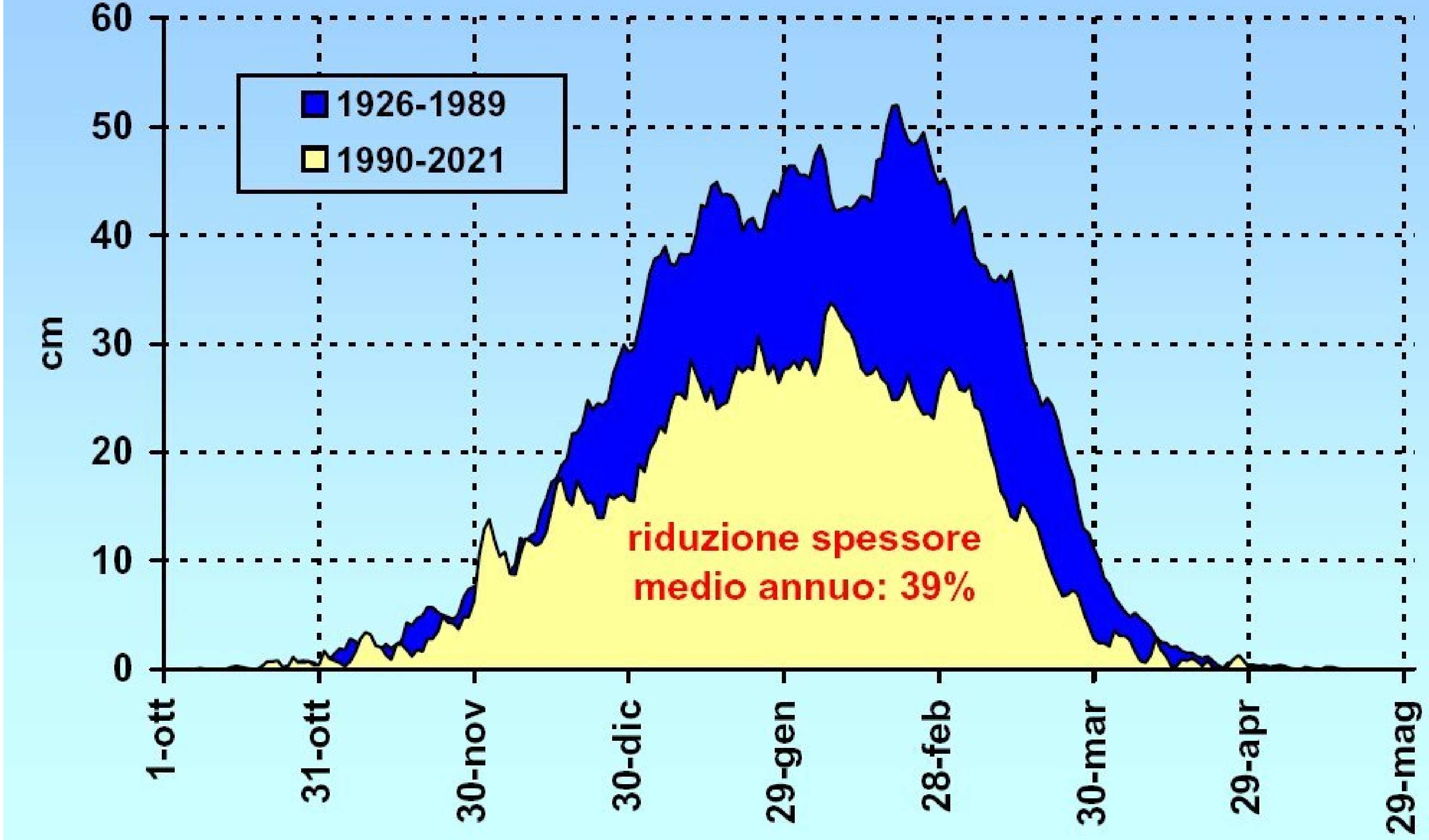


Più caldo
= prevalenza di pioggia a
bassa quota,
e in montagna la neve
fonde più rapidamente.



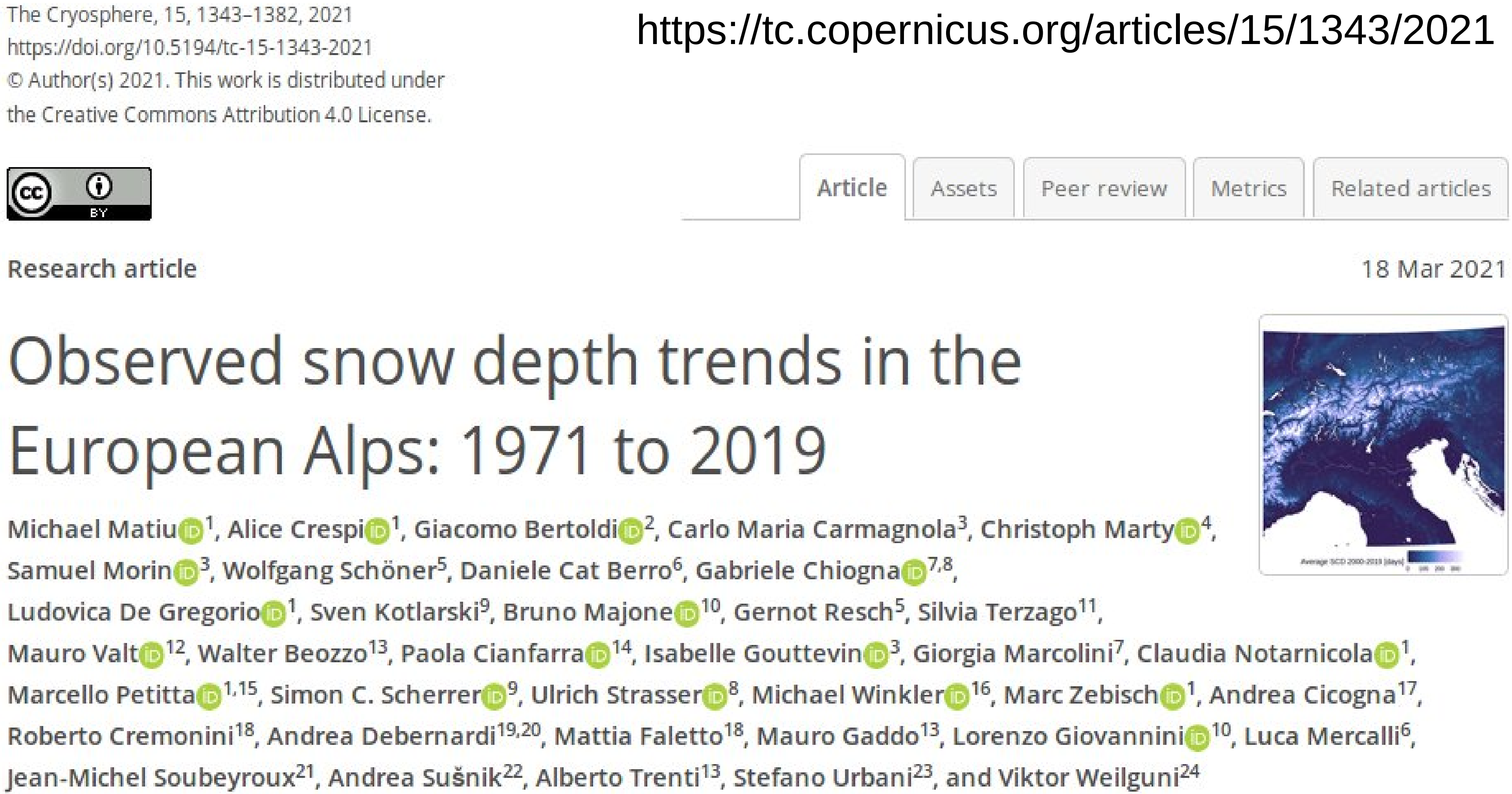
23 gennaio 2022: solo neve
programmata nel comprensorio
di Bielmonte (Biella)

Entracque (950 m) - Media giornaliera dello spessore nevoso al suolo, confronto tra periodi 1926-1989 e 1990-2021



riduzione spessore medio annuo: 39%

https://tc.copernicus.org/articles/15/1343/2021


The Cryosphere, 15, 1343–1382, 2021
https://doi.org/10.5194/tc-15-1343-2021
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the Creative Commons Attribution 4.0 License.

Research article

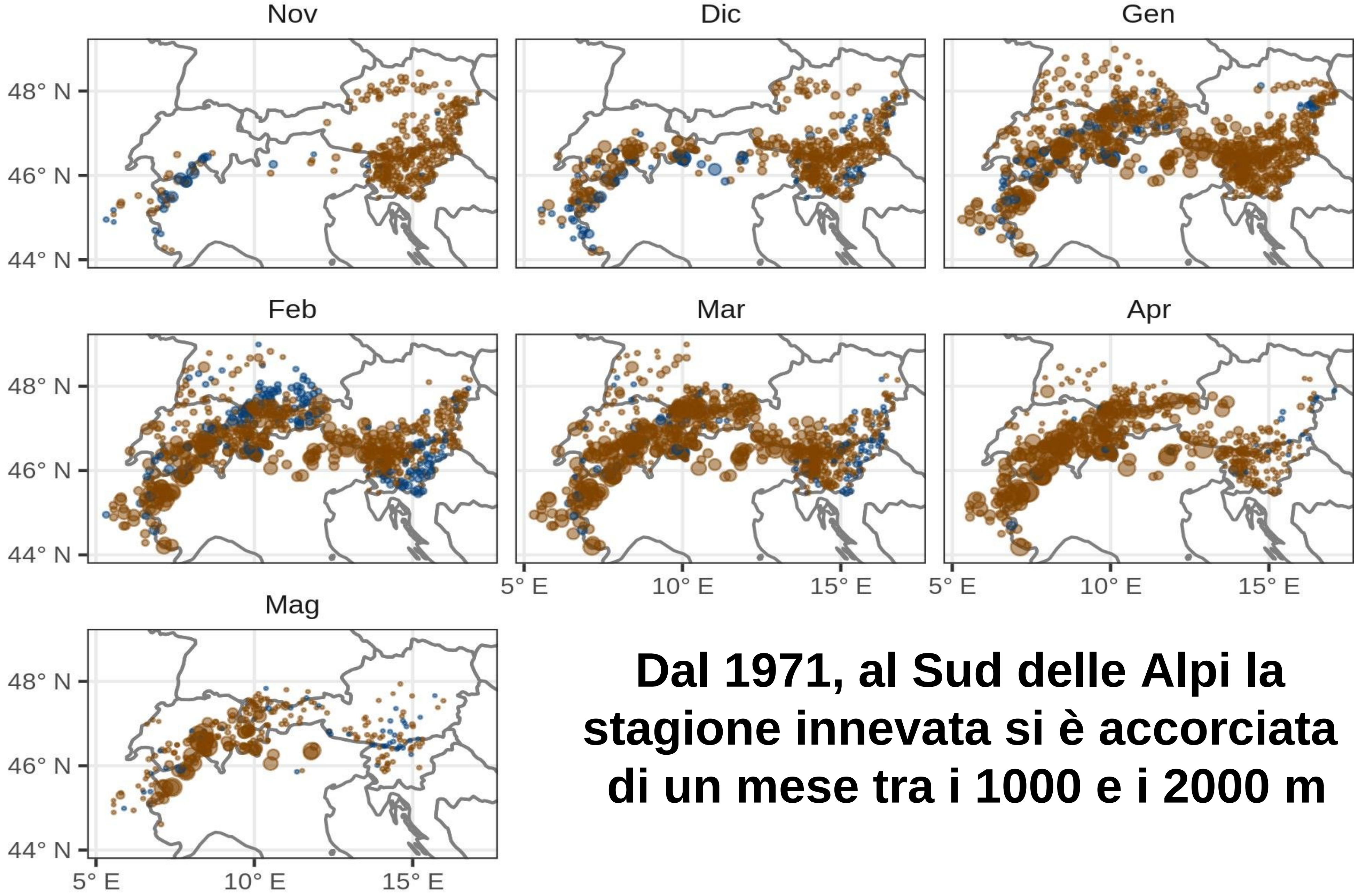
18 Mar 2021

Observed snow depth trends in the European Alps: 1971 to 2019

Michael Matiu[1], Alice Crespi[1], Giacomo Bertoldi[2], Carlo Maria Carmagnola[3], Christoph Marty[4], Samuel Morin[3], Wolfgang Schöner[5], Daniele Cat Berro[6], Gabriele Chiogna[7,8], Ludovica De Gregorio[1], Sven Kotlarski[9], Bruno Majone[10], Gernot Resch[5], Silvia Terzago[11], Mauro Valt[12], Walter Beozzo[13], Paola Cianfarra[14], Isabelle Gouttevin[3], Giorgia Marcolini[7], Claudia Notarnicola[1], Marcello Petitta[1,15], Simon C. Scherrer[9], Ulrich Strasser[8], Michael Winkler[16], Marc Zebisch[1], Andrea Cicogna[17], Roberto Cremonini[18], Andrea Debernardi[19,20], Mattia Faletto[18], Mauro Gaddo[13], Lorenzo Giovannini[10], Luca Mercalli[6], Jean-Michel Soubeyroux[21], Andrea Sušnik[22], Alberto Trenti[13], Stefano Urbani[23], and Viktor Weilguni[24]

Prima analisi dell'evoluzione dell'innevamento sull'intero arco alpino, a cura di EURAC Research, pubblicata a marzo 2021 sulla rivista “The Cryosphere”

Prima analisi dell'evoluzione dell'innevamento sull'intero arco alpino, a cura di EURAC Research (marzo 2021, rivista “The Cryosphere”)


Nov
Dic
Gen
Feb
Mar
Apr
Mag
48° N
46° N
44° N
5° E
10° E
15° E

Dal 1971, al Sud delle Alpi la stagione innevata si è accorciata di un mese tra i 1000 e i 2000 m

https://tc.copernicus.org/articles/15/1343/2021/

nature climate change

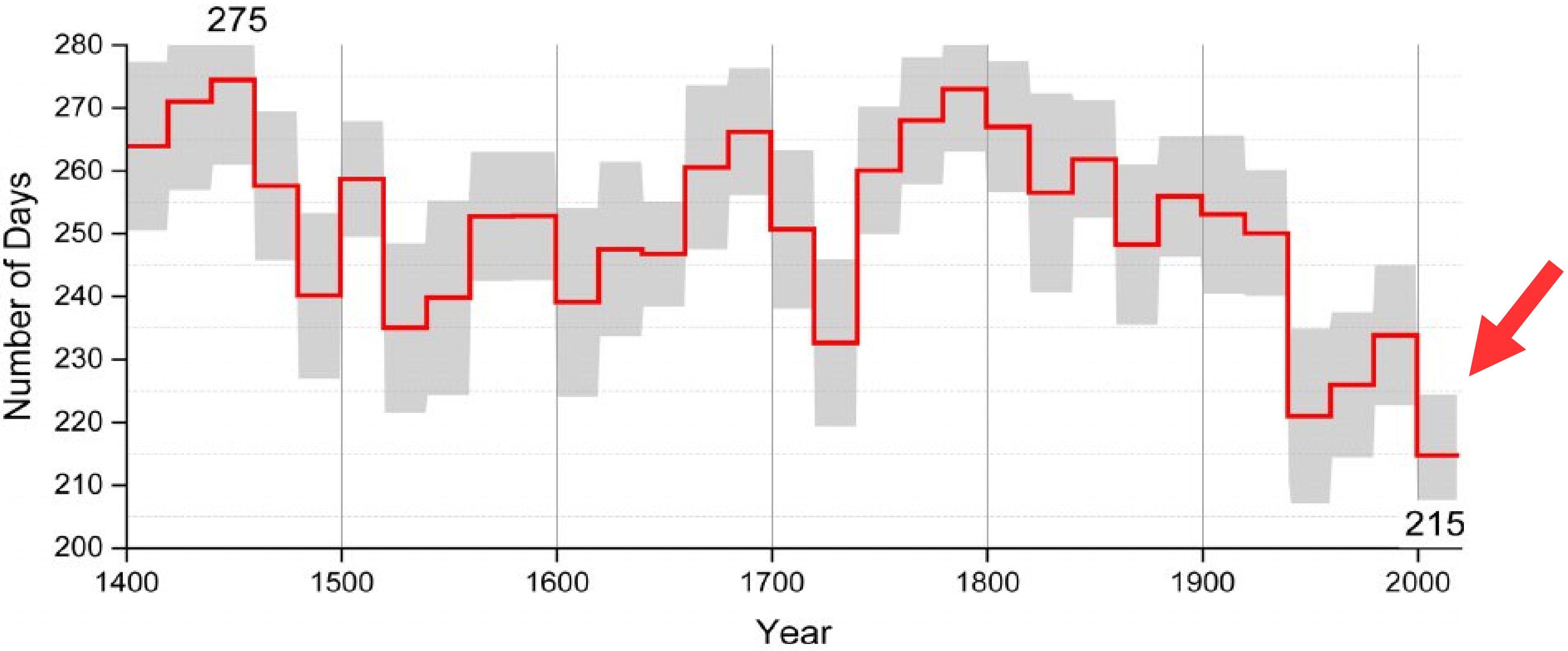
Article https://doi.org/10.1038/s41558-022-01575-3

Recent waning snowpack in the Alps is unprecedented in the last six centuries

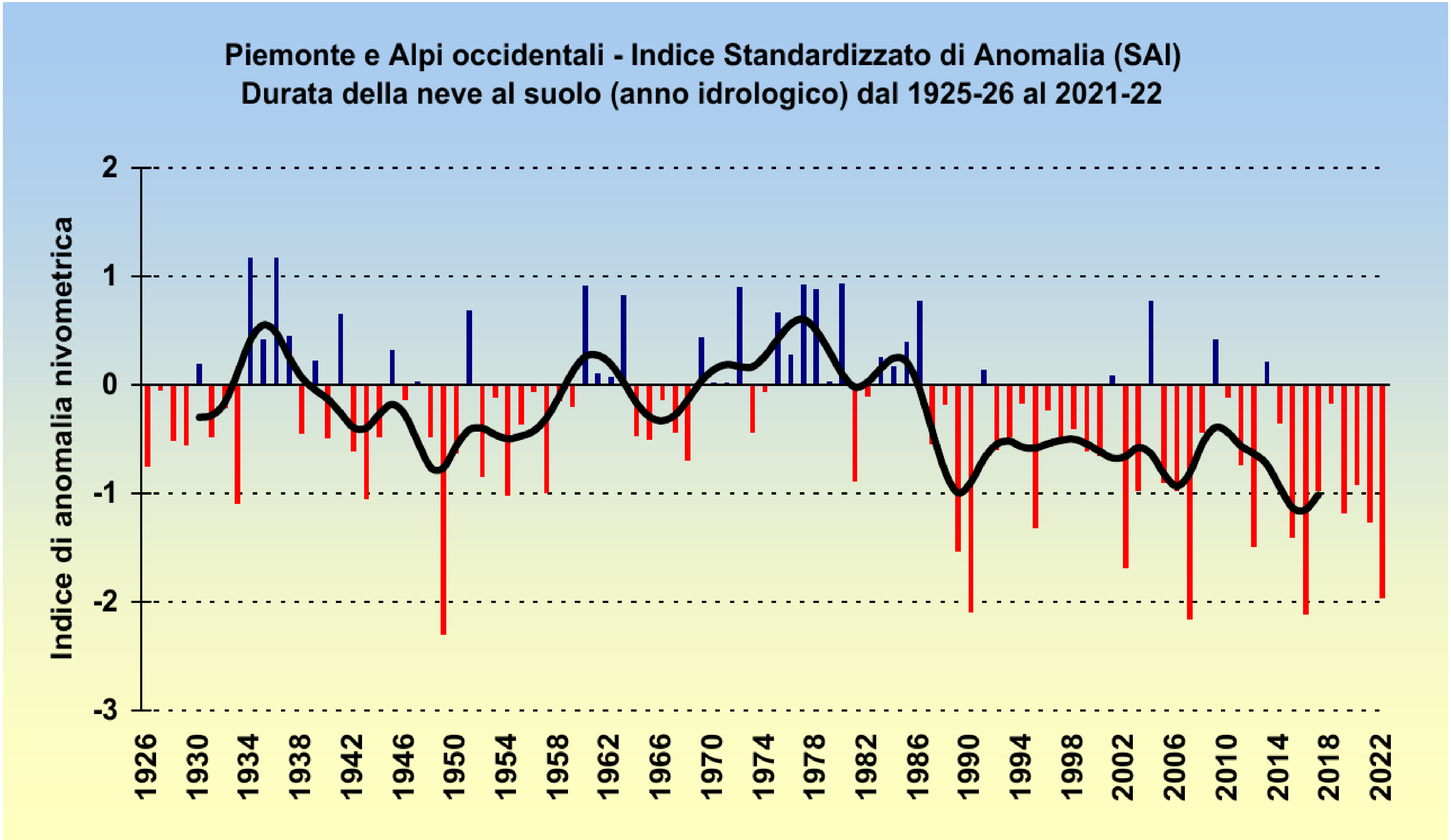
Received: 7 June 2022

Accepted: 6 December 2022

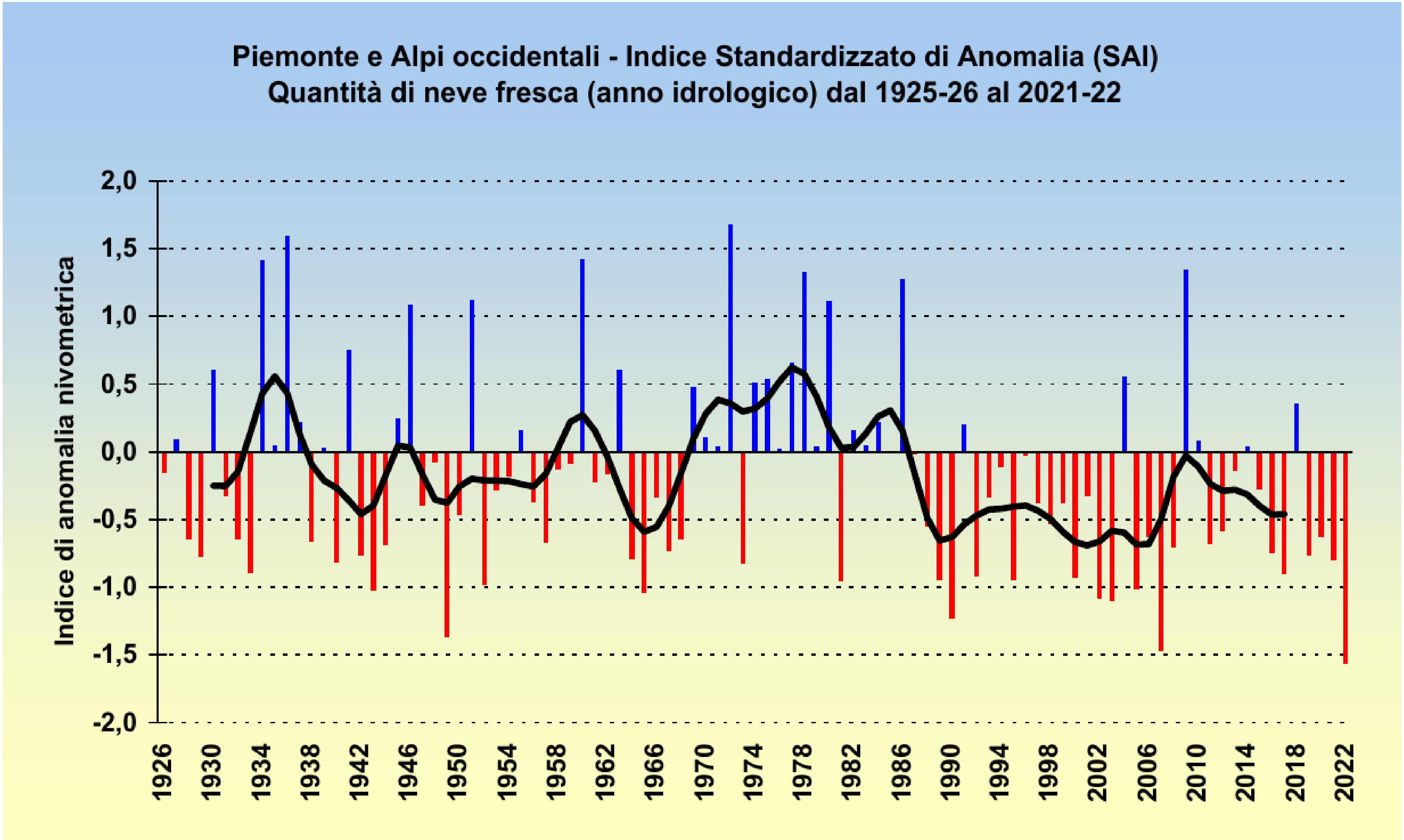
Marco Carrer [1], Raffaella Dibona [1], Angela Luisa Prendin [1,2] & Michele Brunetti [3]



Extended Data Fig. 7 | Decadal variability in the reconstructed snow cover duration. 20-y average of the reconstructed snow cover duration (red line) together with its standard deviation (grey boxes). Values within the plot highlight the two periods with the maximum and minimum duration in the last 600 years.



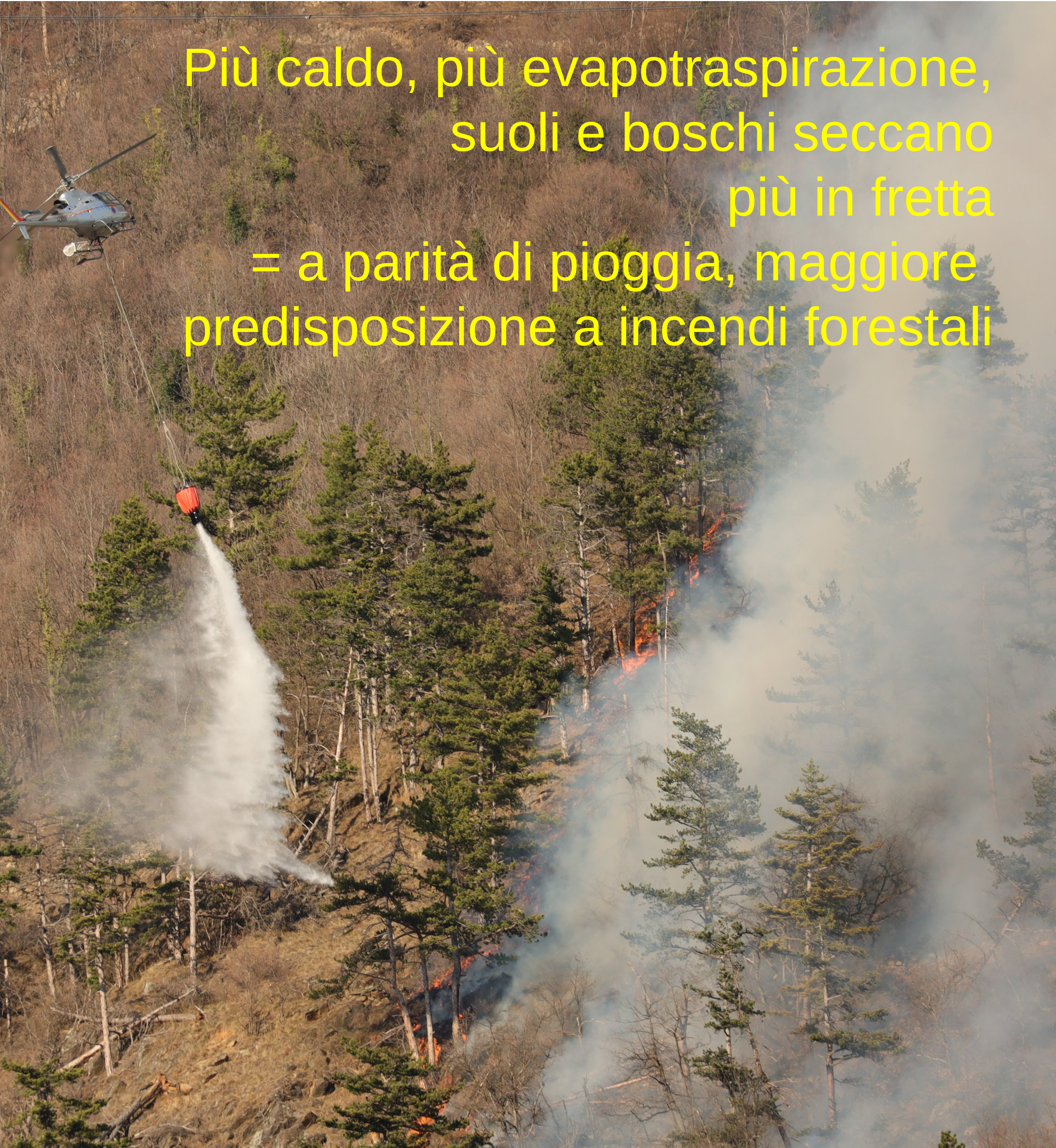
Dagli Anni Novanta, prevalenza di inverni poveri di neve


Piemonte e Alpi occidentali - Indice Standardizzato di Anomalia (SAI)
Quantità di neve fresca (anno idrologico) dal 1925-26 al 2021-22

Non sono mancati inverni recenti ricchi di nevicate (2008-09, 2013-14, 2017-18), ma più sporadici e con rapida fusione estiva

23 febbraio 2022:
Orrido di Chianocco
(Val Susa)

Più caldo, più evapotraspirazione,
suoli e boschi seccano
più in fretta
= a parità di pioggia, maggiore
predisposizione a incendi forestali



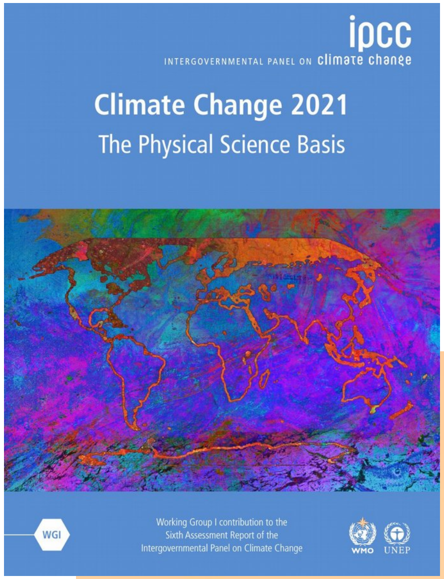
UN environment programme 50 1972-2022

GRID ARENDAL
A UNEP Partner

A RAPID RESPONSE ASSESSMENT

SPREADING LIKE WILDFIRE
THE RISING THREAT OF EXTRAORDINARY LANDSCAPE FIRES

Il futuro: sempre più caldo.
Quanto?
Dipende dalle nostre scelte


ipcc
INTERGOVERNMENTAL PANEL ON climate change

Climate Change 2021
The Physical Science Basis

WGI

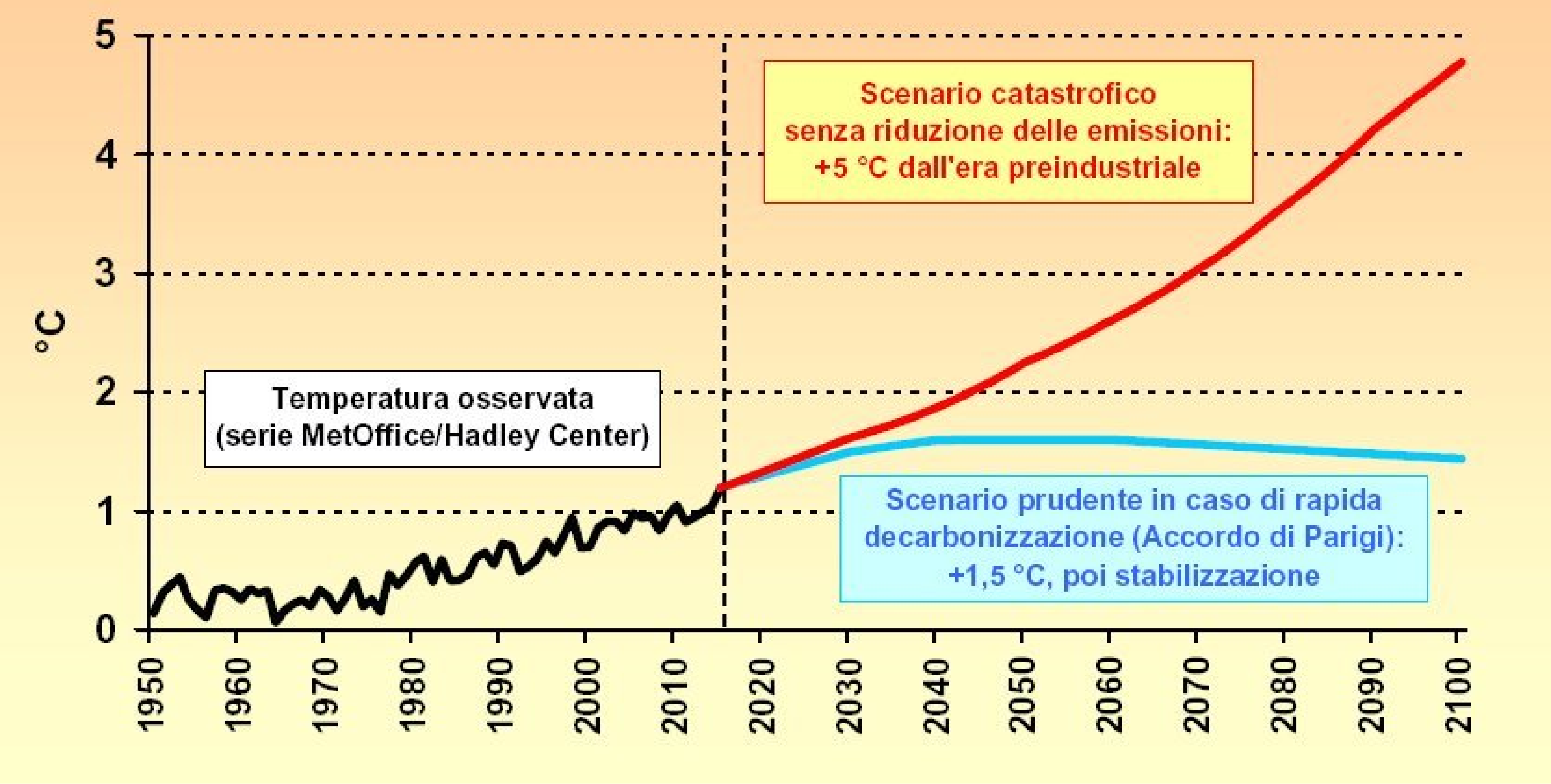
Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

WMO UNEP

Scenari di riscaldamento medio globale

rispetto all'era preindustriale (1850 - 1900)

previsioni future da IPCC, Sesto Rapporto di Valutazione (2021)

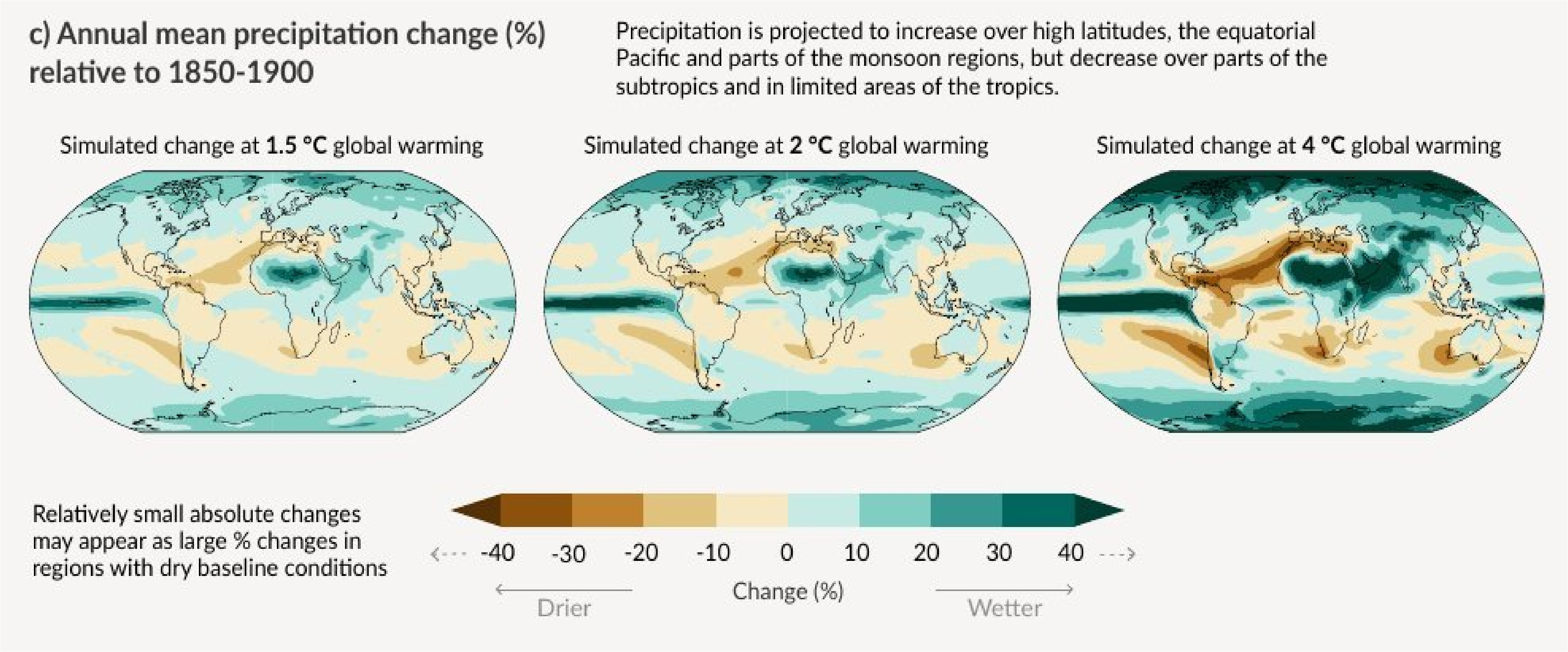


Scenario catastrofico
senza riduzione delle emissioni:
+5 °C dall'era preindustriale

Temperatura osservata
(serie MetOffice/Hadley Center)

Scenario prudente in caso di rapida
decarbonizzazione (Accordo di Parigi):
+1,5 °C, poi stabilizzazione

In futuro, Alpi al confine tra Europa centrale un po' più piovosa e Mediterraneo più secco.
Ma determinante sarà l'evapotraspirazione, in aumento.



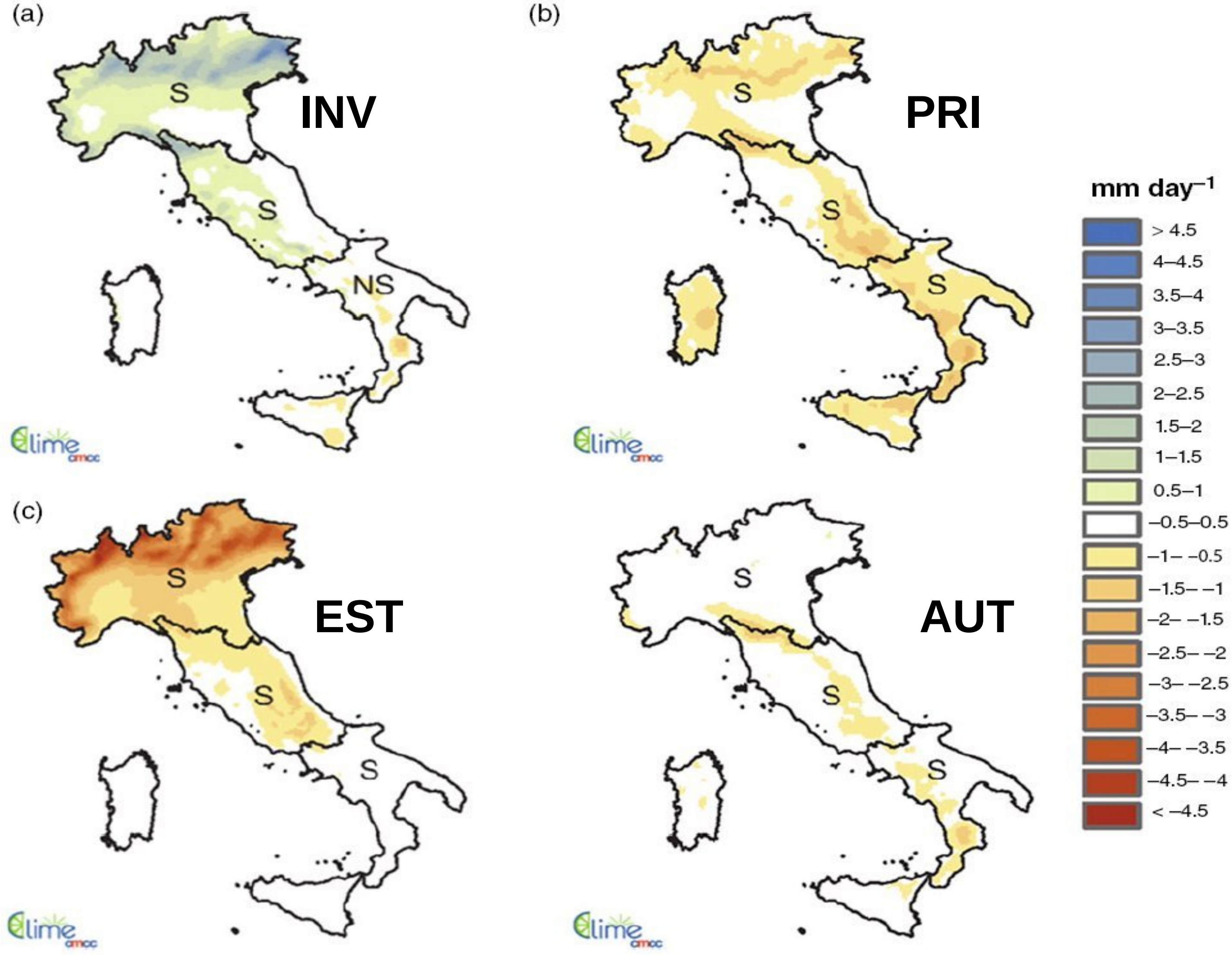
c) Annual mean precipitation change (%) relative to 1850-1900

Precipitation is projected to increase over high latitudes, the equatorial Pacific and parts of the monsoon regions, but decrease over parts of the subtropics and in limited areas of the tropics.

Relatively small absolute changes may appear as large % changes in regions with dry baseline conditions

Simulated change at **1.5 °C** global warming
Simulated change at **2 °C** global warming
Simulated change at **4 °C** global warming
-40
-30
-20
-10
0
10
20
30
40
Change (%)
Drier
Wetter

IPCC, Sixth Assessment Report - WG1, 2021


(a)
S
INV
S
NS
(b)
S
PRI
S
S
(c)
S
EST
S
S
S
AUT
S
S
mm day⁻¹
> 4.5
4–4.5
3.5–4
3–3.5
2.5–3
2–2.5
1.5–2
1–1.5
0.5–1
−0.5–0.5
−1– −0.5
−1.5– −1
−2– −1.5
−2.5– −2
−3– −2.5
−3.5– −3
−4– −3.5
−4.5– −4
< −4.5

Variazione precipitazioni stagionali 2071-2100 (scenario emissioni elevate): inverno più bagnato sulle Alpi (ma nevicate abbondanti solo ad alta quota, pioggia a valle); estate molto più secca (*Bucchignani et al., 2015*)

Ghiacciai confinati sopra i 4000 metri, neve solo per poche settimane in pieno inverno, estati roventi e secche, fasce climatiche spostate verso l'alto di quasi 1000 m, boschi e colture in sofferenza, più incendi...
Le Alpi somiglieranno sempre più alle montagne
del Nord Africa o del Medioriente

The Cryosphere Discuss., doi:10.5194/tc-2017-7, 2017
Manuscript under review for journal The Cryosphere
Discussion started: 27 February 2017

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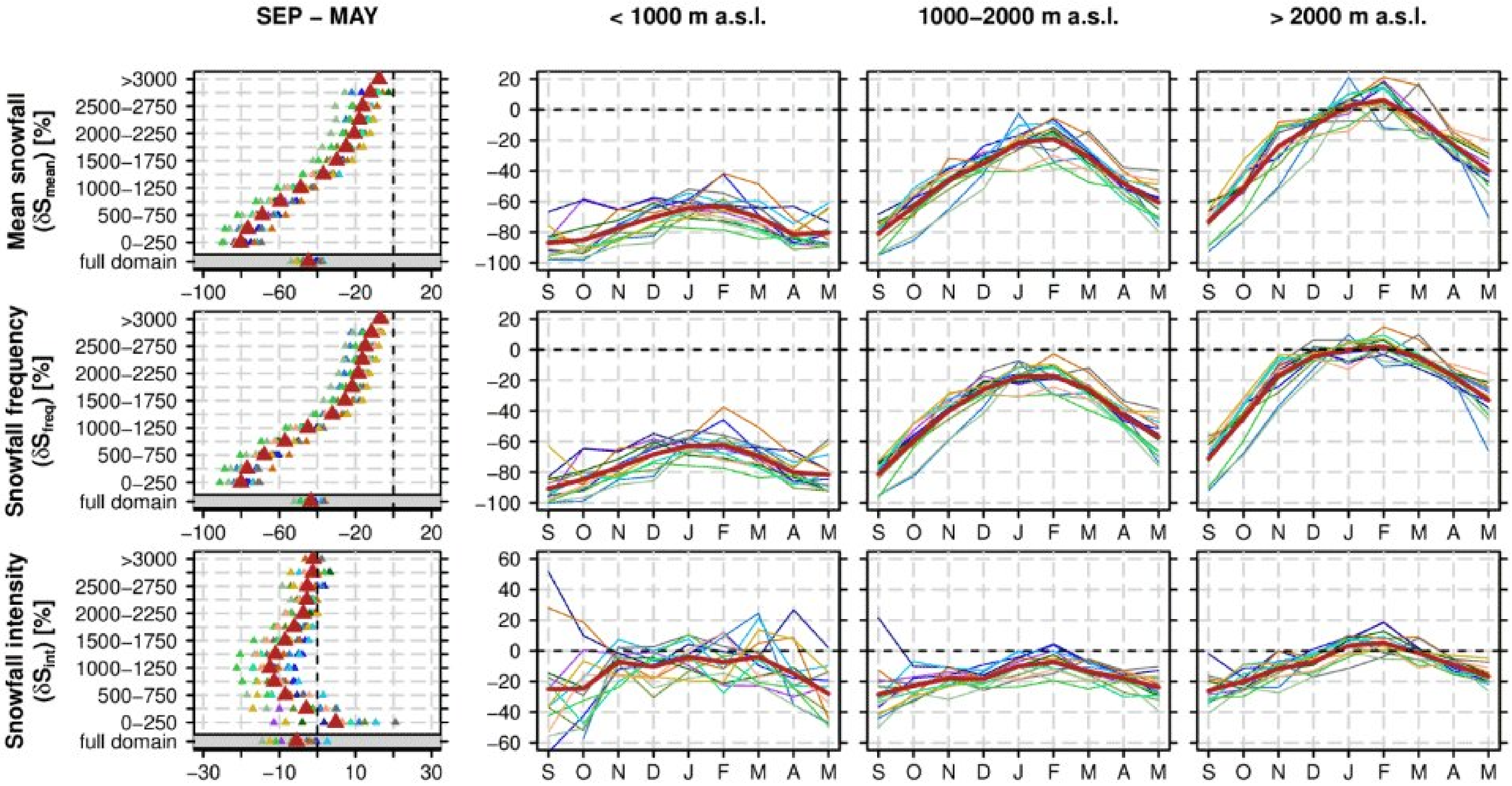
The Cryosphere
Discussions
Open Access
EGU

Snowfall in the Alps: Evaluation and projections based on the EURO-CORDEX regional climate models

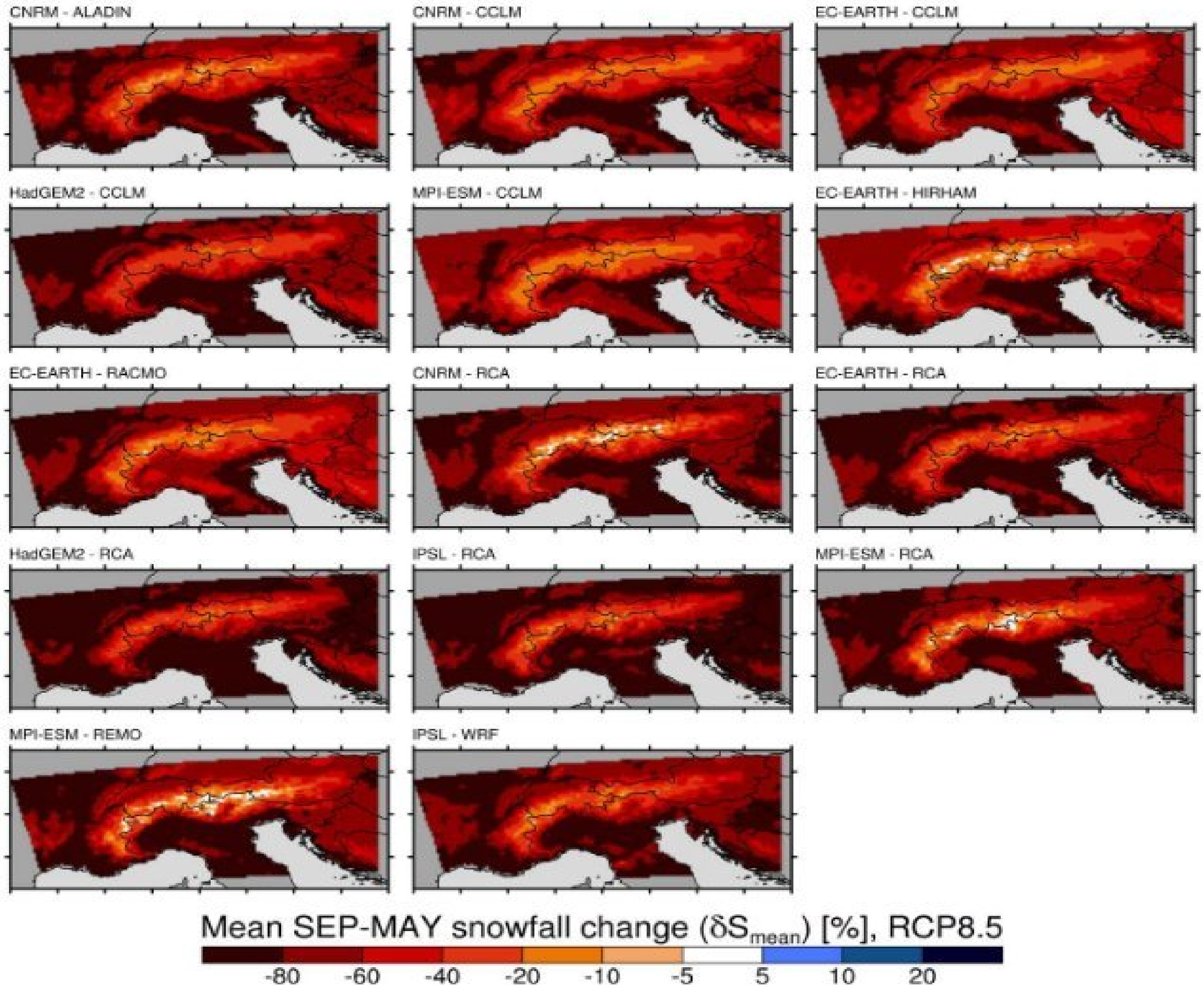
Prisco Frei[1], Sven Kotlarski[2,*], Mark A. Liniger[2], Christoph Schär[1]

[1] Institute for Atmospheric and Climate Sciences, ETH Zurich, 8006, Zurich, Switzerland
[2] Federal Office of Meteorology and Climatology, MeteoSwiss, 8058 Zurich-Airport, Switzerland

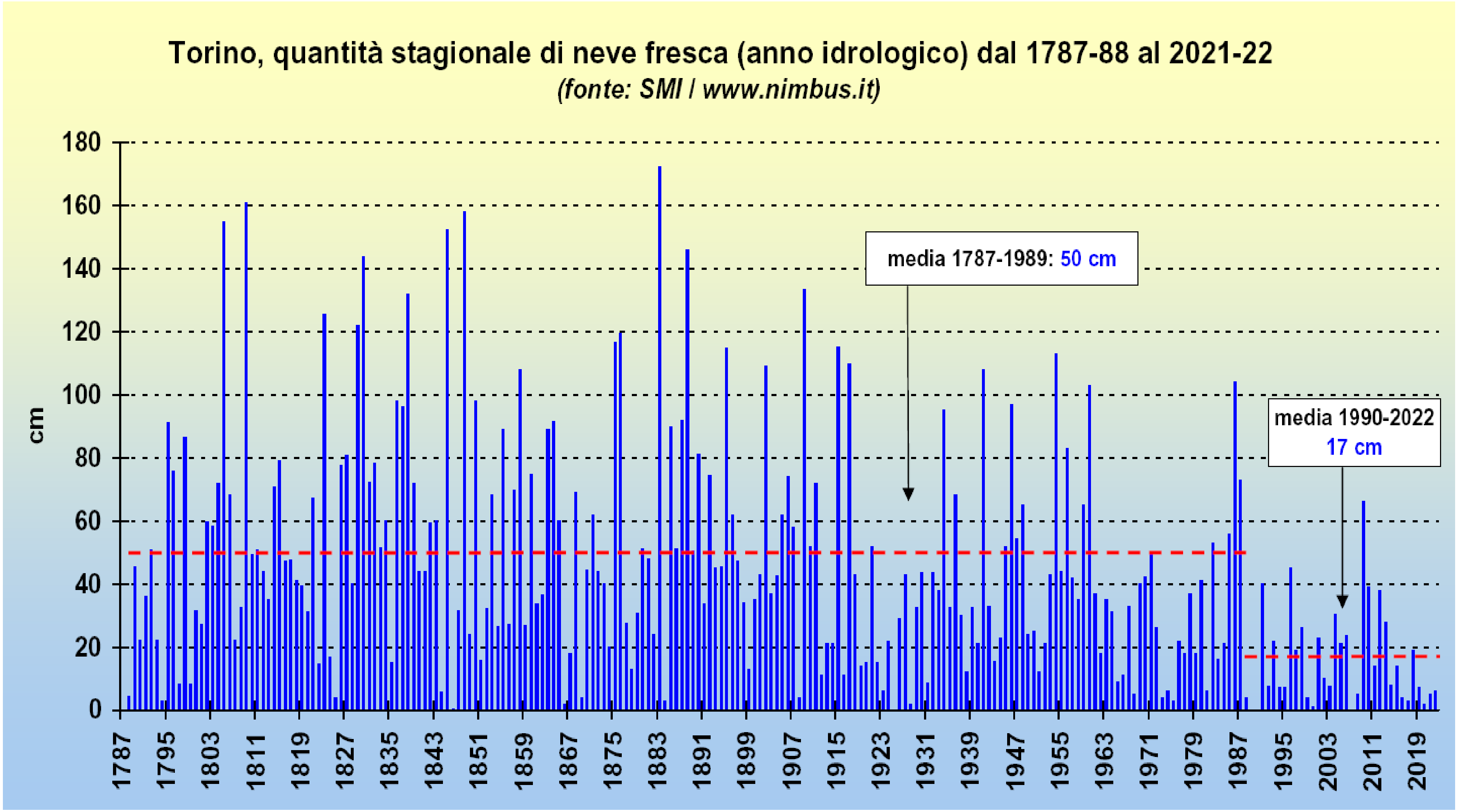
[*] Corresponding author: *sven.kotlarski@meteoswiss.ch*



Effetti del futuro riscaldamento sulle nevicate:
più vistosi a media-bassa quota
e in primavera-autunno


CNRM - ALADIN
CNRM - CCLM
EC-EARTH - CCLM
HadGEM2 - CCLM
MPI-ESM - CCLM
EC-EARTH - HIRHAM
EC-EARTH - RACMO
CNRM - RCA
EC-EARTH - RCA
HadGEM2 - RCA
IPSL - RCA
MPI-ESM - RCA
MPI-ESM - REMO
IPSL - WRF
Mean SEP-MAY snowfall change (δS_{mean}) [%], RCP8.5
-80
-60
-40
-20
-10
-5
5
10
20

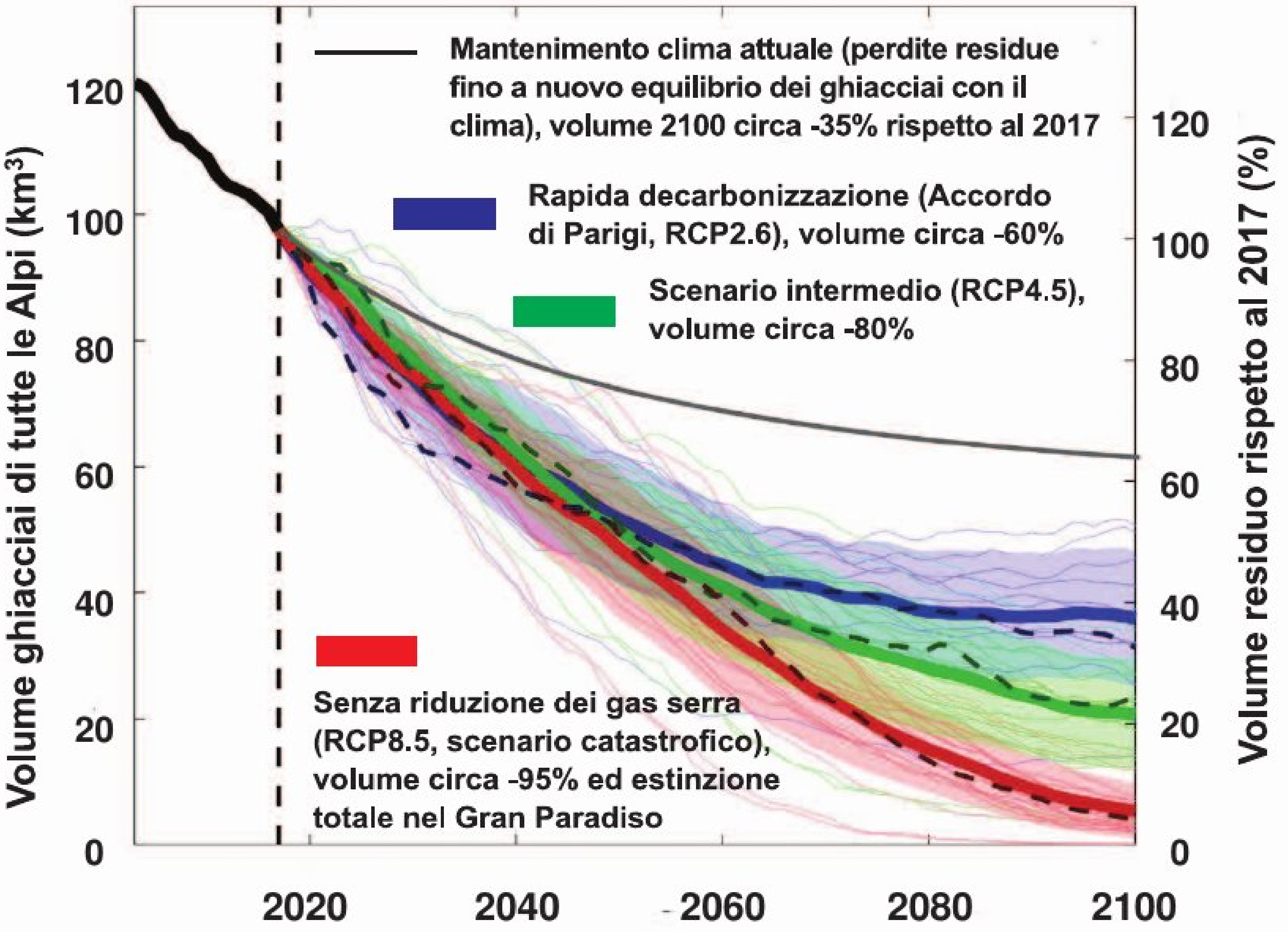
2100: senza tagli alle emissioni serra, neve quasi scomparsa in Pianura Padana (già ora... neve fresca 2011-20 vs 1961-70: -40% a Torino e Milano, -56% a Parma)

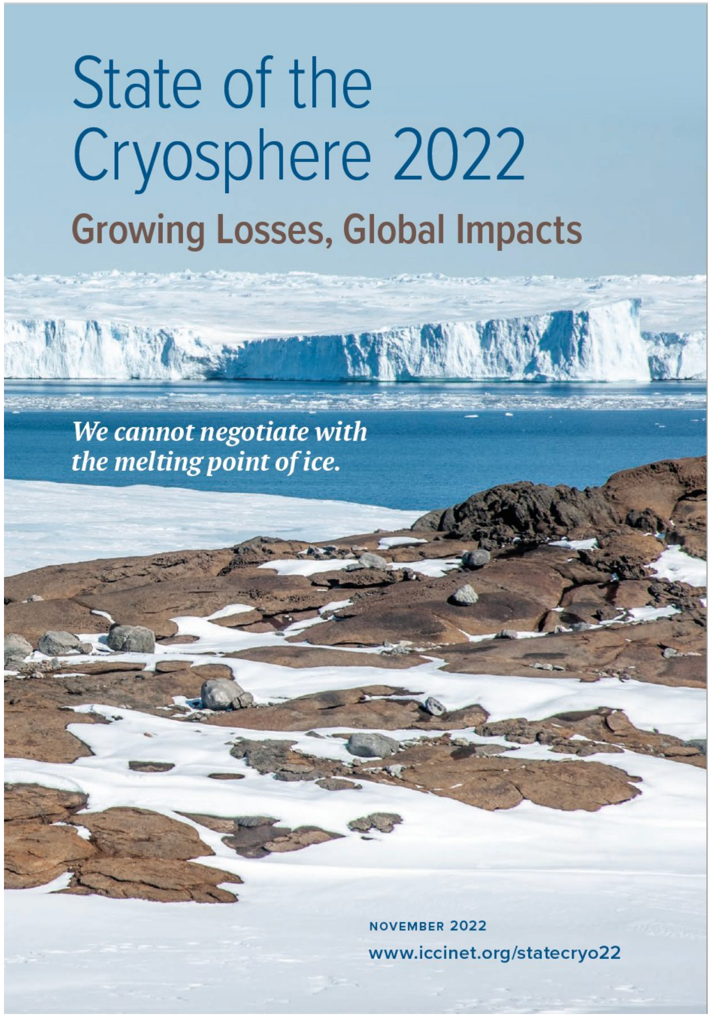


Neve fresca: -66% nel 1990-2022
rispetto al periodo storico 1787-1989

Scenari di deglaciazione sulle intere Alpi

(perdita di volume glaciale, da Zekollari et al., 2019)





State of the Cryosphere 2022

Growing Losses, Global Impacts

We cannot negotiate with the melting point of ice.

NOVEMBER 2022
www.iccinet.org/statecryo22

FIGURE 3-2. **Mid-Latitude Glaciers**

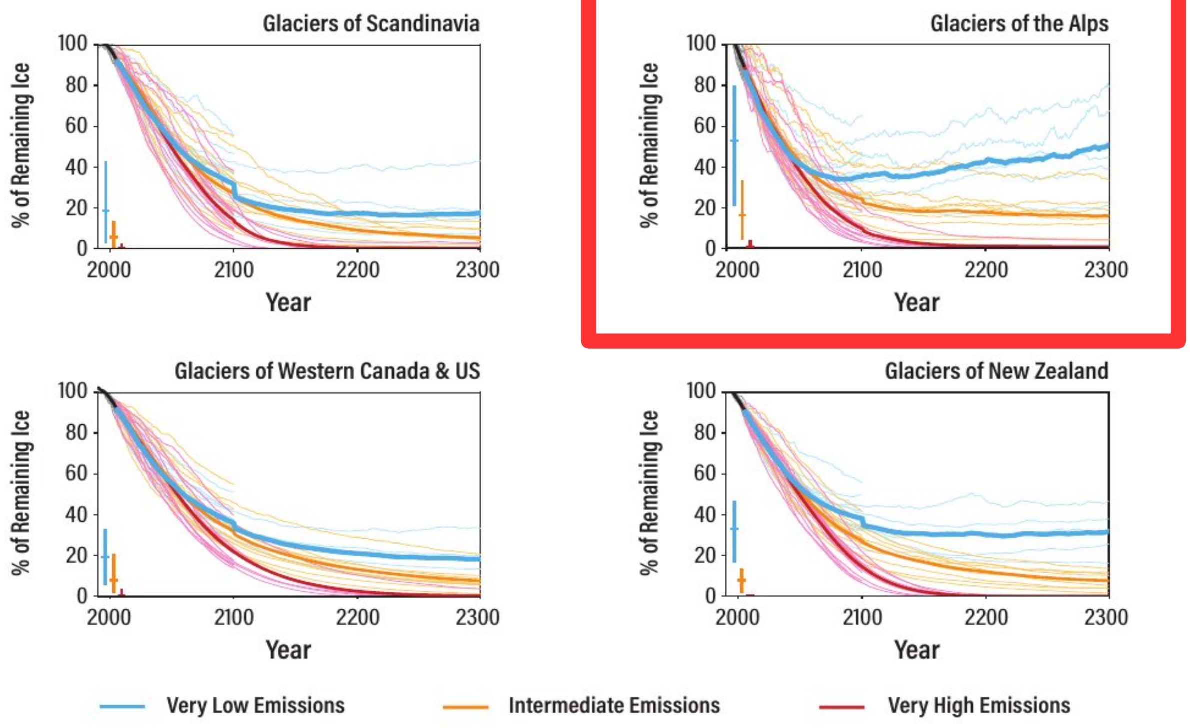
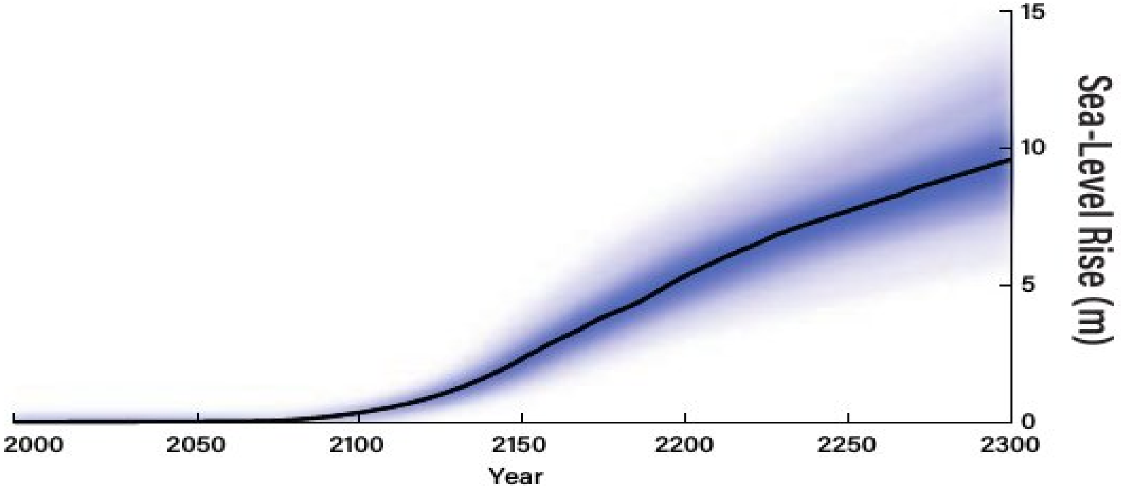


FIGURE 2-8. **Projected Sea-level Rise from Antarctica with High Emissions**



Global Risks Report 2023

WORLD
ECONOMIC
FORUM

Top 10 Risks

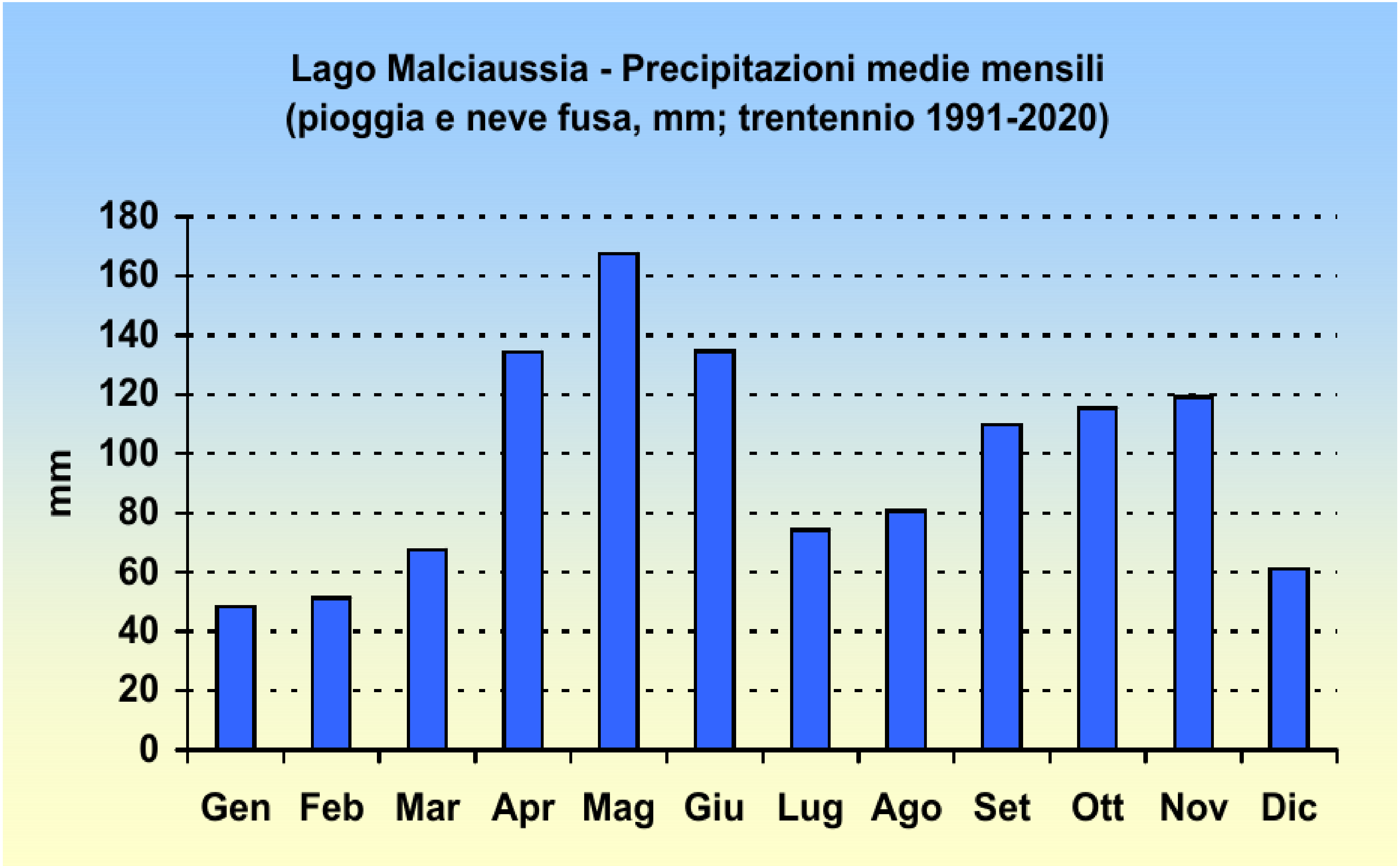
“Please estimate the likely impact (severity) of the following risks over a 2-year and 10-year period”

	2 years		10 years
1	🟥 Cost of living crisis	1	🟩 Failure to mitigate climate change
2	🟩 Natural disasters and extreme weather events	2	🟩 Failure of climate-change adaption
3	🟧 Geoeconomic confrontation	3	🟩 Natural disasters and extreme weather events
4	🟩 Failure to mitigate climate change	4	🟩 Biodiversity loss and ecosystem collapse
5	🟥 Erosion of social cohesion and societal polarization	5	🟥 Large-scale involuntary migration
6	🟩 Large-scale environmental damage incidents	6	🟩 Natural resource crises
7	🟩 Failure of climate-change adaption	7	🟥 Erosion of social cohesion and societal polarization
8	🟪 Widespread cybercrime and cyber insecurity	8	🟪 Widespread cybercrime and cyber insecurity
9	🟩 Natural resource crises	9	🟧 Geoeconomic confrontation
10	🟥 Large-scale involuntary migration	10	🟩 Large-scale environmental damage incidents

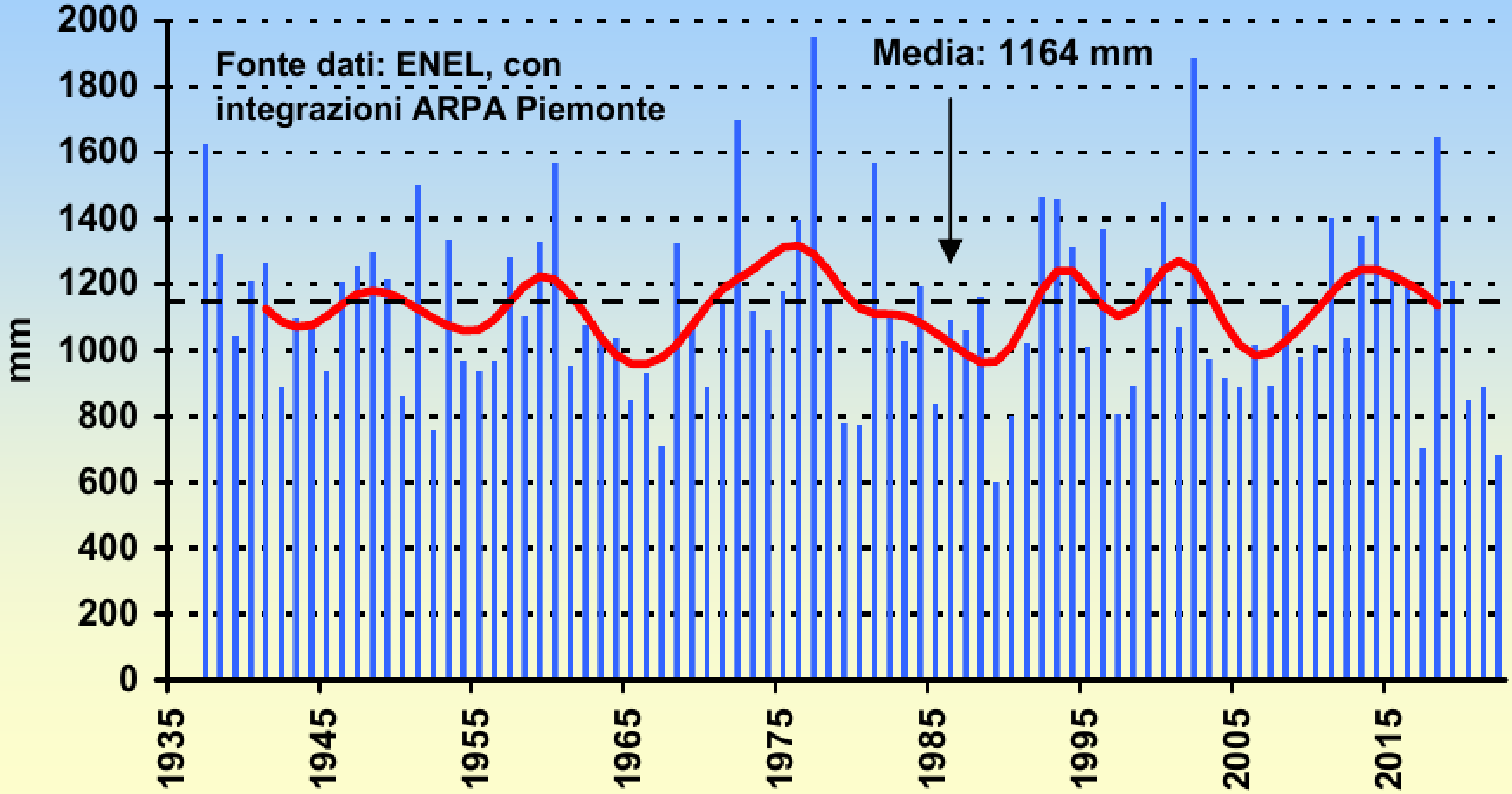
Risk categories

🟦 Economic 🟩 Environmental 🟧 Geopolitical 🟥 Societal 🟪 Technological

Source: World Economic Forum, Global Risks Perception Survey 2022-2023



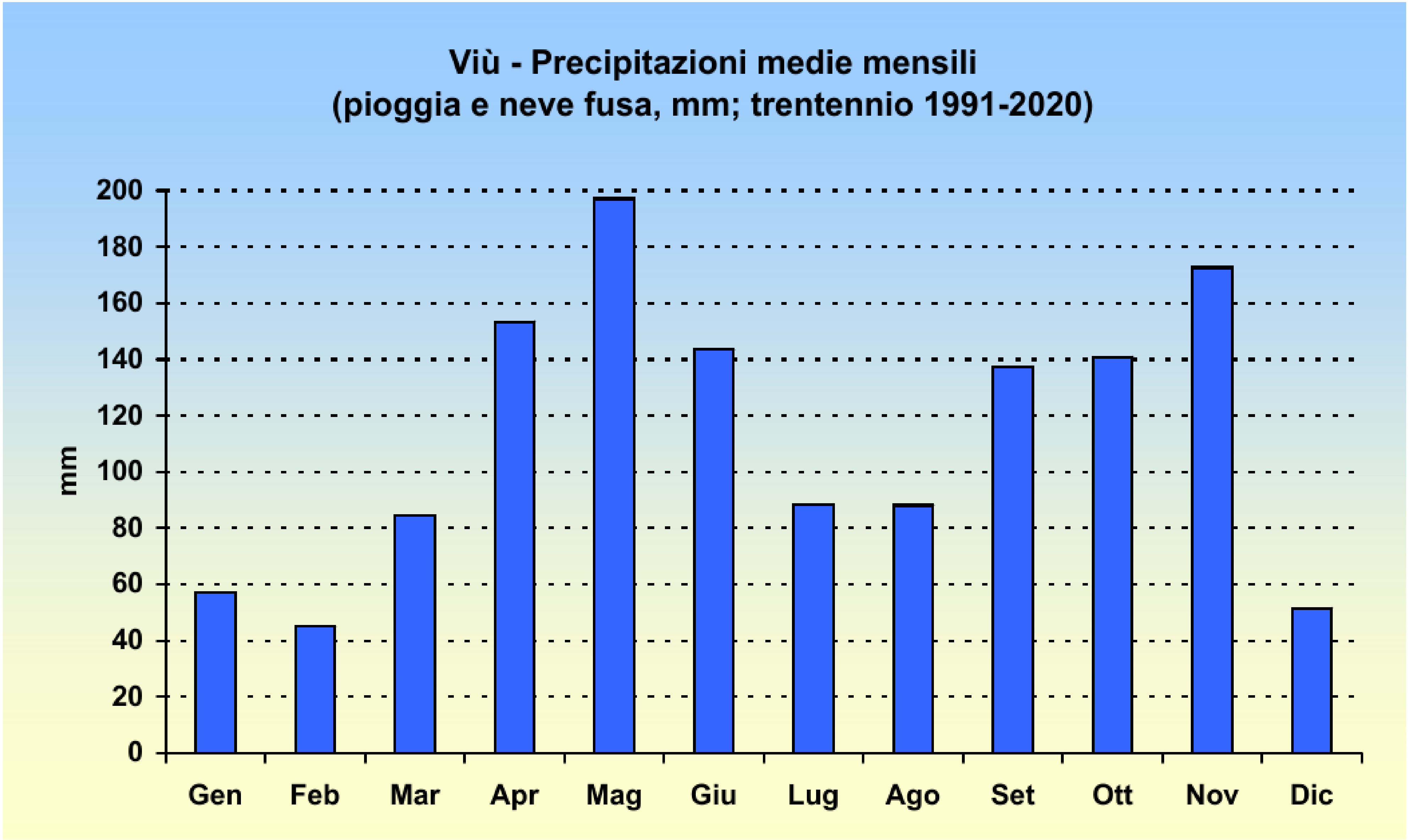
Lago Malciaussia - Precipitazioni medie mensili
(pioggia e neve fusa, mm; trentennio 1991-2020)



Lago Malciaussia - Precipitazioni totali annue
(pioggia e neve fusa, mm)

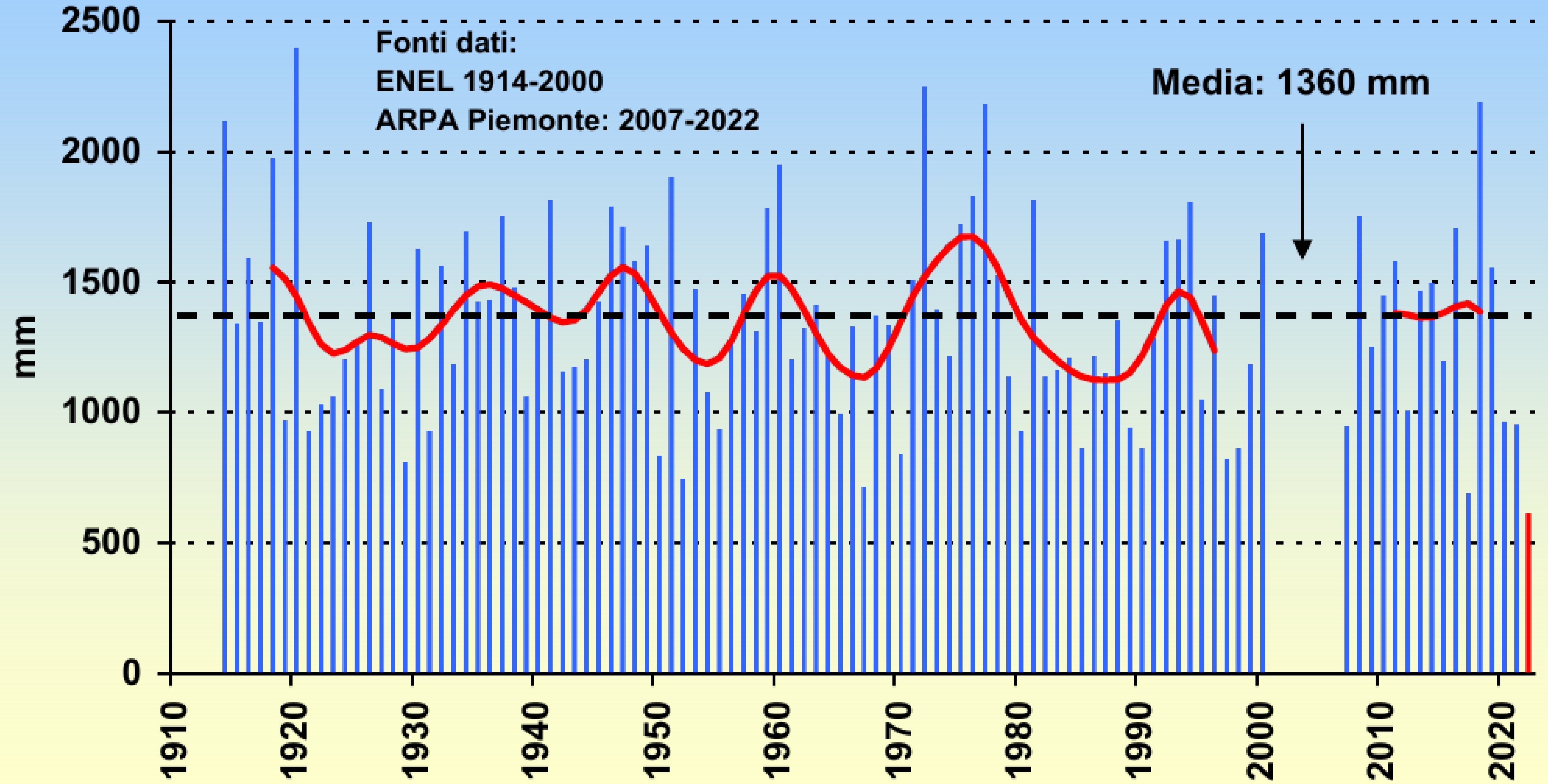
Fonte dati: ENEL, con
integrazioni ARPA Piemonte

Media: 1164 mm



Viù - Precipitazioni medie mensili
(pioggia e neve fusa, mm; trentennio 1991-2020)

Viù (centrale Fucine) - Precipitazioni totali annue
(pioggia e neve fusa, mm)



Fonti dati:
ENEL 1914-2000
ARPA Piemonte: 2007-2022

Media: 1360 mm