UNIVERSITÀ DEGLI STUDI FIRENZE
Da un secolo, oltre.

HR EXCELLENCE IN RESEARCH

Impatti del cambiamento climatico sugli eventi estremi e nella gestione delle dighe

Marco Lompi & Enrica Caporali

OPEN DAY ON DAMS

Dighe e cambiamento climatico: quali sinergie?

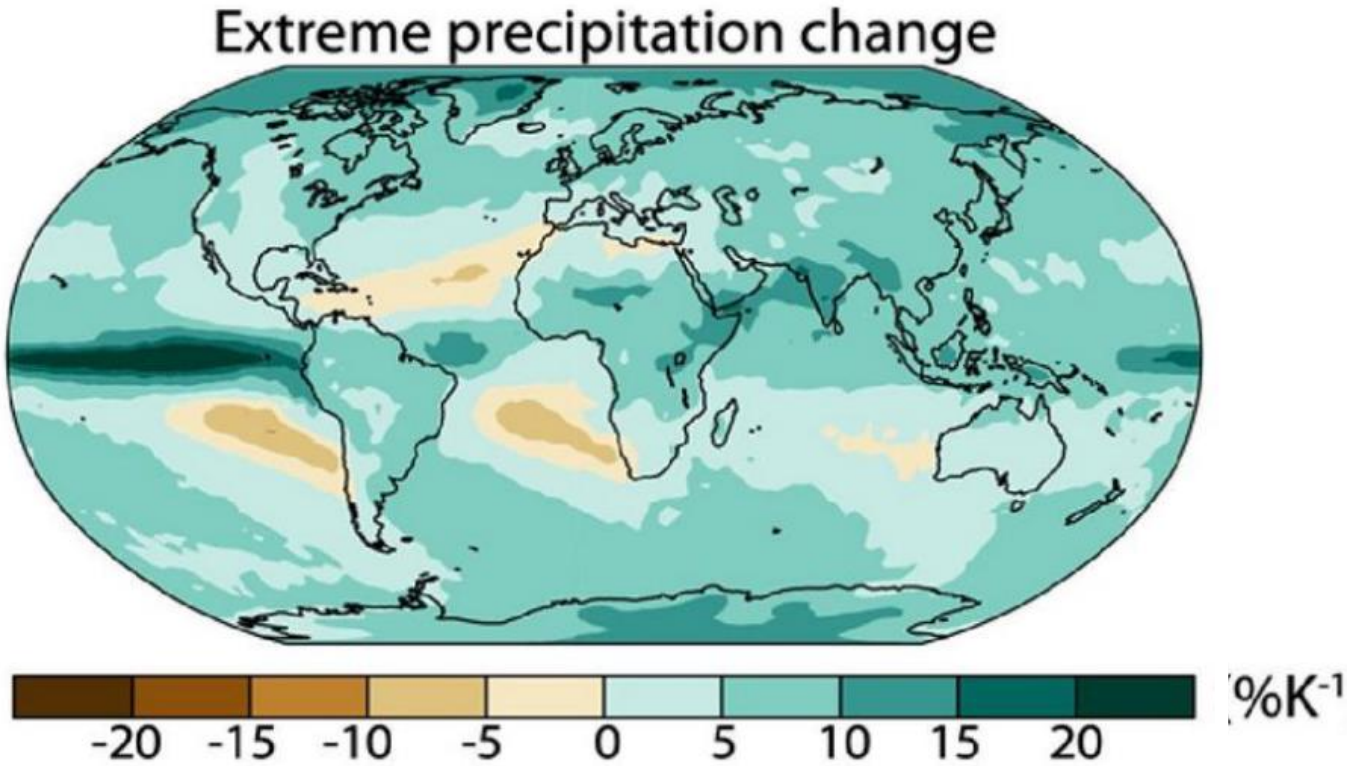
Scuola di Ingegneria – Università degli Studi di Firenze
Via i Santa Marta, 3 – Firenze

31 maggio 2024 – ore 9.30 - 13:30

Climate Change 2022: Impacts, Adaptation and Vulnerability

*The **projected increase in precipitation intensity** (high confidence) **will increase rain-generated local flooding** (medium confidence). Direct flood damages are projected to increase by 4 to 5 times at 4°C compared to 1.5°C (medium confidence)* (IPCC 2022)

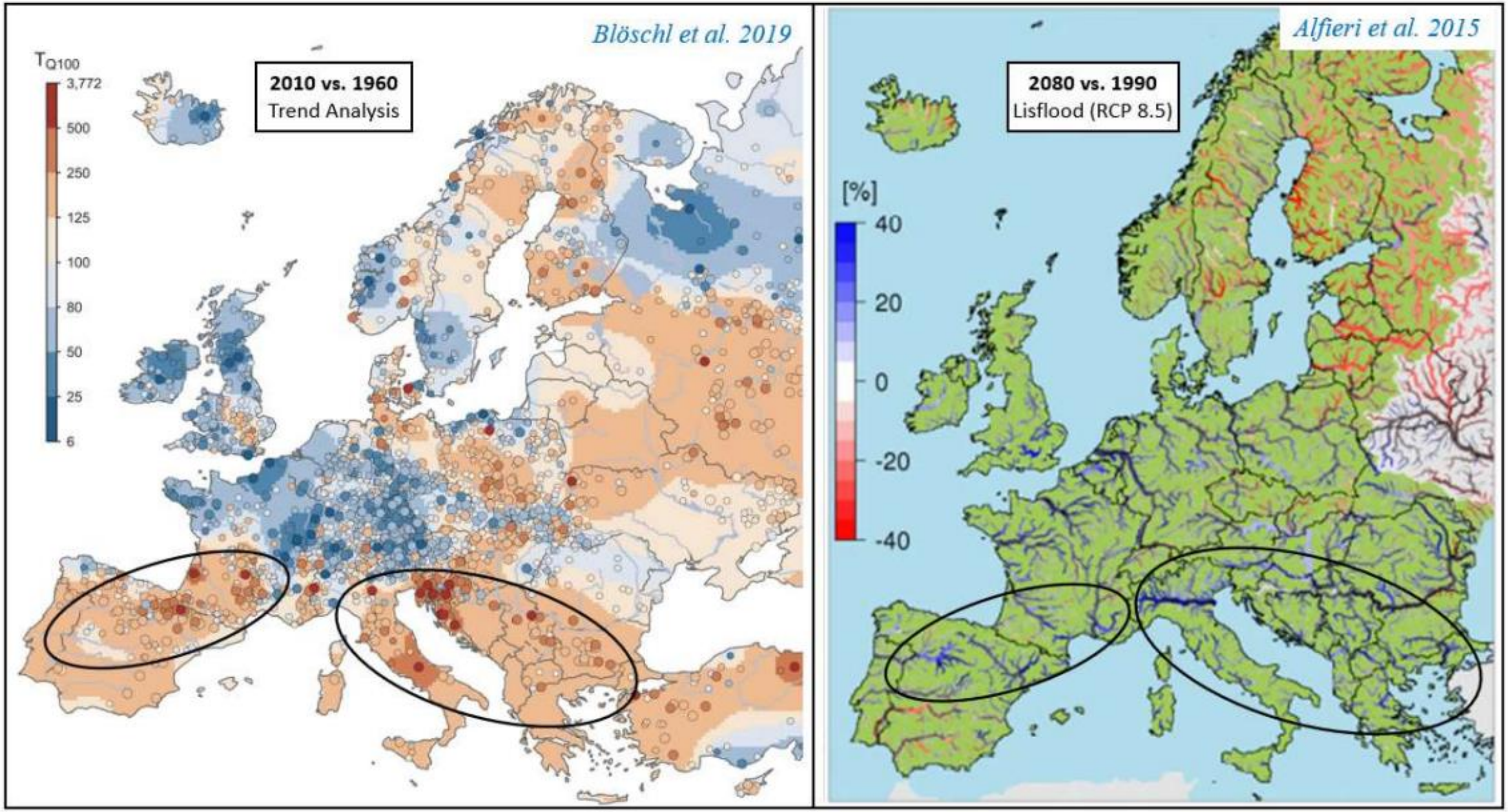
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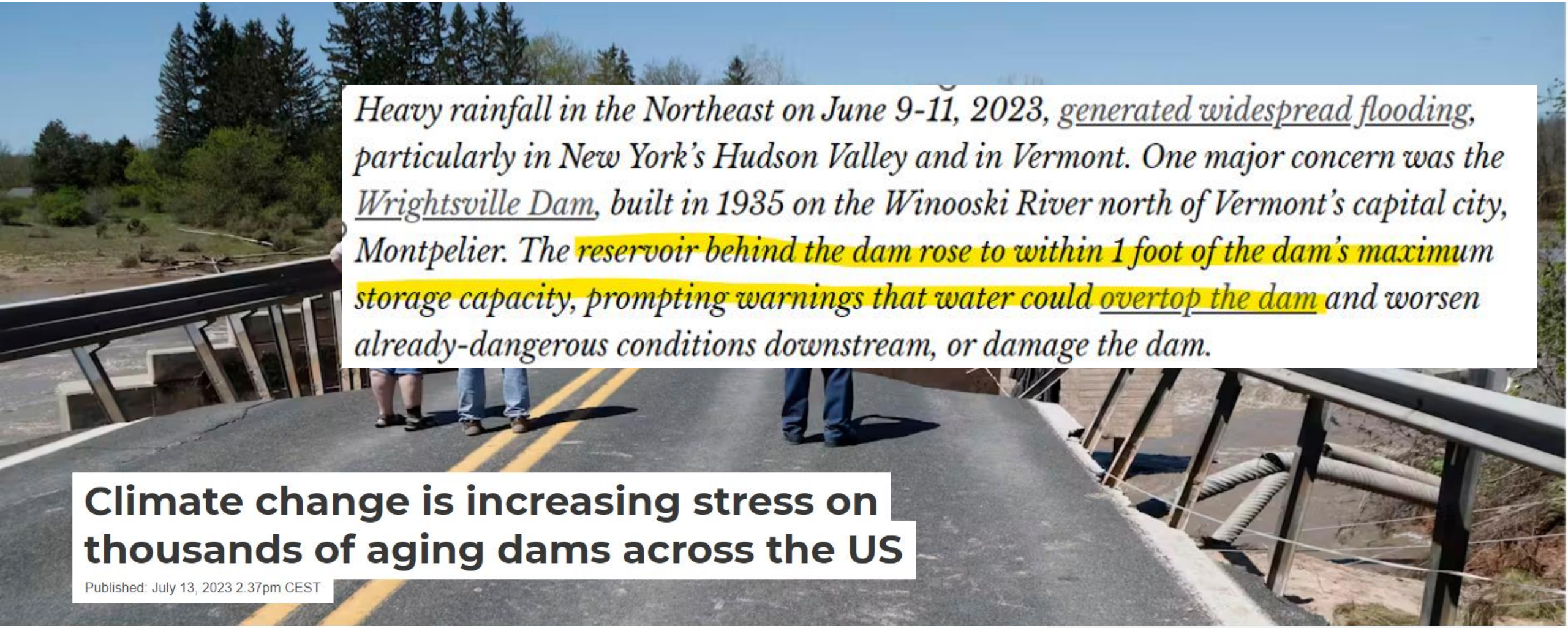


"The increase of precipitation intensities or the number of extreme events has been detected in a warmer climate"

(Donat et al. 2016; Pendergrass et al., 2017; Prein et al. 2017; Li et al. 2019;)

Changes of daily maximum rainfall for 2071–2100 relative to 1976–2005.


Blöschl et al. 2019
T_{Q100}
3,772
500
250
125
100
80
50
25
6
2010 vs. 1960
Trend Analysis
Alfieri et al. 2015
2080 vs. 1990
Lisflood (RCP 8.5)
[%]
40
20
0
-20
-40



Heavy rainfall in the Northeast on June 9-11, 2023, generated widespread flooding, particularly in New York's Hudson Valley and in Vermont. One major concern was the Wrightsville Dam, built in 1935 on the Winooski River north of Vermont's capital city, Montpelier. The reservoir behind the dam rose to within 1 foot of the dam's maximum storage capacity, prompting warnings that water could overtop the dam and worsen already-dangerous conditions downstream, or damage the dam.

Climate change is increasing stress on thousands of aging dams across the US

Published: July 13, 2023 2.37pm CEST

Flood damage in Edenville, Mich., after a dam failed on May 19, 2020. AP Photo/Carlos Osorio

THE CONVERSATION

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Health Space Physics Technology Environment Mind Humans Life Mathematics Chemistry Earth Society

Environment

Catastrophic Libyan dam collapse partly caused by climate change

Recent extreme rainfall that caused flooding across the Mediterranean and contributed to the catastrophic collapse of two dams in Libya was probably made more likely and more intense by climate change

By James Dinneen



Libya, September 2023





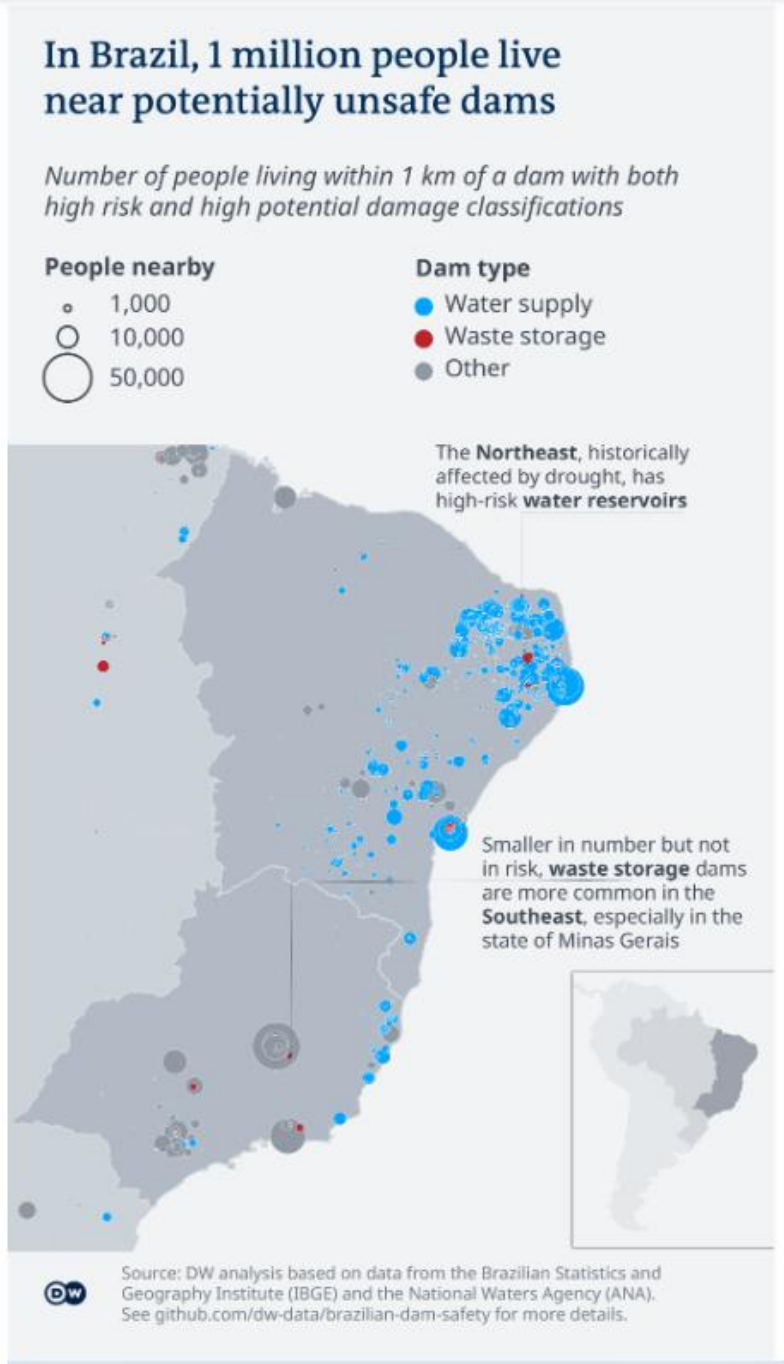
Source: Maxar Technologies

BBC

Statement | Dam collapse in Rio Grande do Sul,



Over the last century, almost **30% of all dam failures worldwide were caused by overtopping** (Jandora et al. 2008), and **floods represent their main driver** (Costa 1985).



BOLETÍN OFICIAL DEL ESTADO
Núm. 89 Miércoles 14 de abril de 2021 Sec. I. Pág. 42480

I. DISPOSICIONES GENERALES

MINISTERIO DE LA PRESIDENCIA, RELACIONES CON LAS CORTES Y MEMORIA DEMOCRÁTICA

5867 *Real Decreto 264/2021, de 13 de abril, por el que se aprueban las normas técnicas de seguridad para las presas y sus embalses.*

13.3 Con independencia de lo anterior, coincidiendo con las revisiones generales de seguridad periódicas, de carácter obligatorio, a que se refiere la Norma Técnica de Seguridad para la explotación, revisiones de seguridad y puesta fuera de servicio de presas, el titular revisará la adecuación del Plan de Emergencia aprobado a las circunstancias existentes y, en la medida que el conocimiento científico y técnico lo permita, la influencia que sobre las previsiones contenidas en él podrían tener los efectos del cambio climático.

– Estudio de impacto del cambio climático en la climatología e hidrología de la cuenca.

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HYDROLOGICAL SCIENCES JOURNAL
https://doi.org/10.1080/02626667.2023.2192873

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Taylor & Francis
Taylor & Francis Group

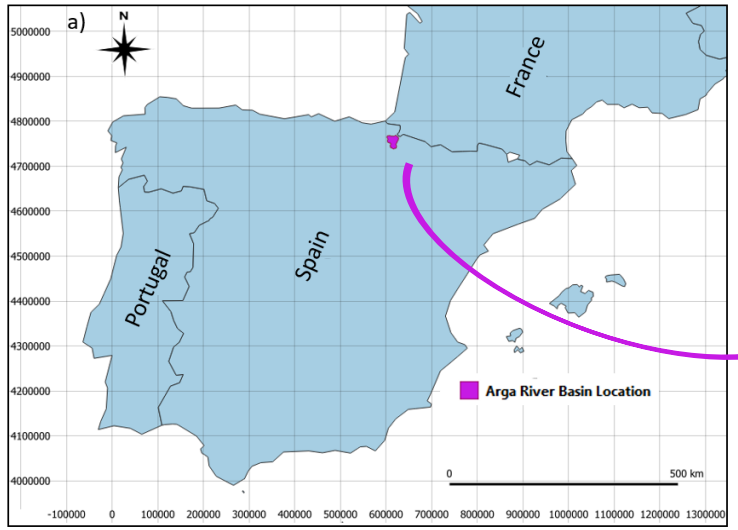
SPECIAL ISSUE: ADVANCES IN STATISTICAL HYDROLOGY - SELECTED CONTRIBUTIONS OF STAHY 2021

OPEN ACCESS Check for updates

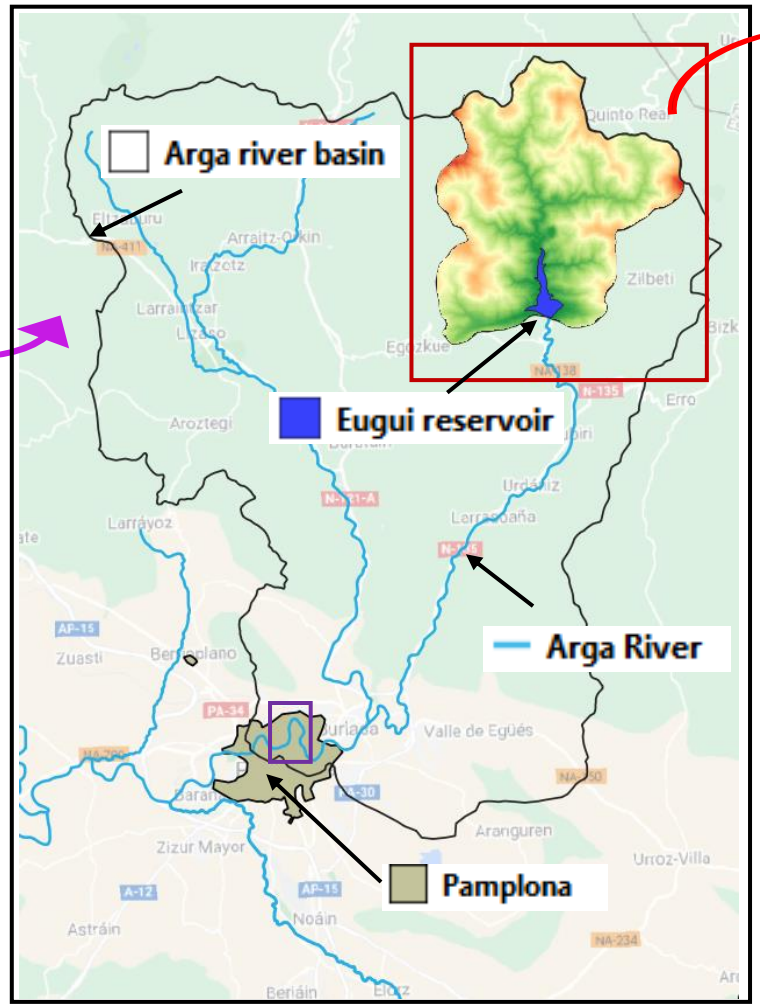
Climate change and hydrological dam safety: a stochastic methodology based on climate projections

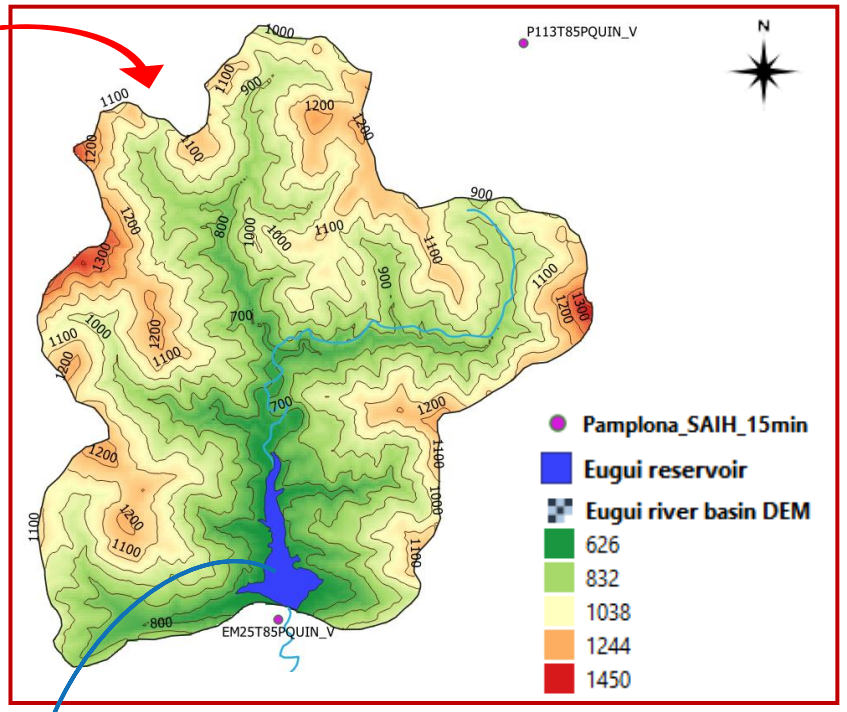
Marco Lompi [a,b], Luis Mediero [b], Enrique Soriano [b] and Enrica Caporali [a]

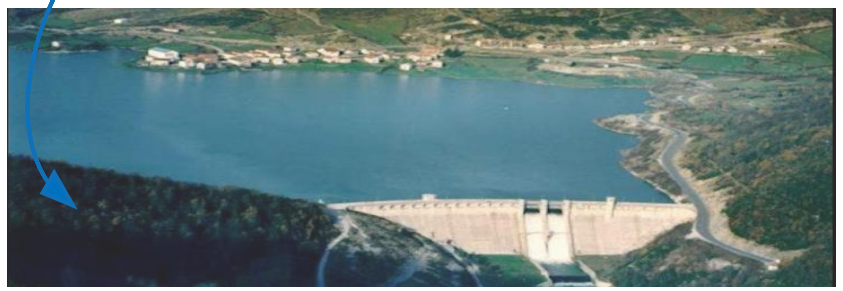
[a]Department of Civil and Environmental Engineering, University of Florence, Florence, Italy; [b]Department of Civil Engineering: Hydraulics, Energy and Environment, Universidad Politécnica de Madrid, Madrid, Spain


a)
N
France
Spain
Portugal
Arga River Basin Location
0
500 km




Arga river basin
Eugui reservoir
Arga River
Pamplona


P113T85PQUIN_V
EM25T85PQUIN_V
N
Pamplona_SAIH_15min
Eugui reservoir
Eugui river basin DEM
626
832
1038
1244
1450

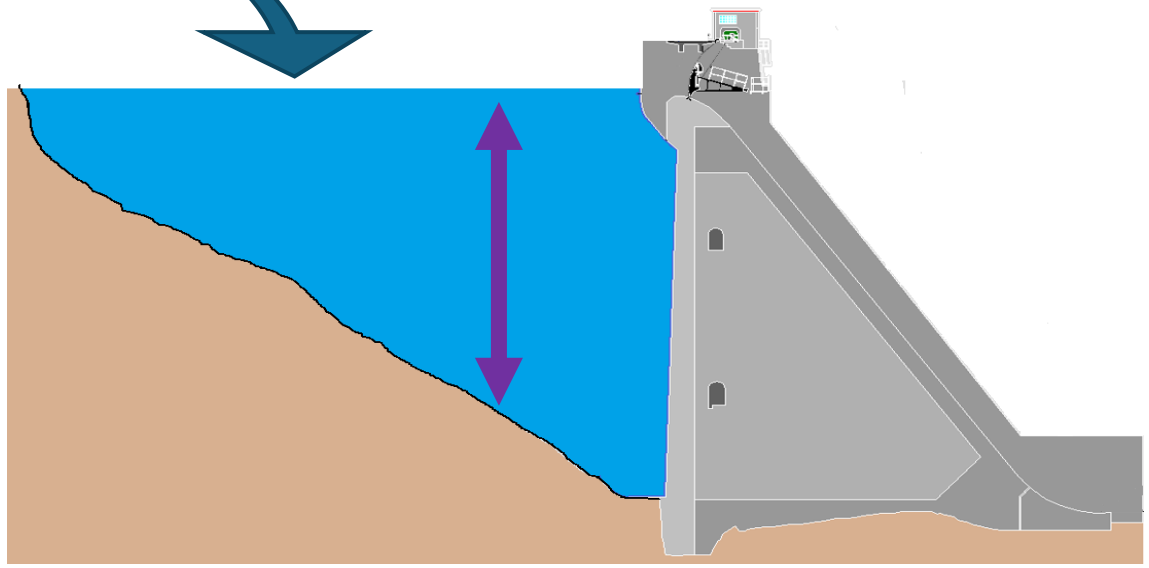


Review article: Climate change impacts on dam safety

(Fluixá-Sanmartín et al., 2018)

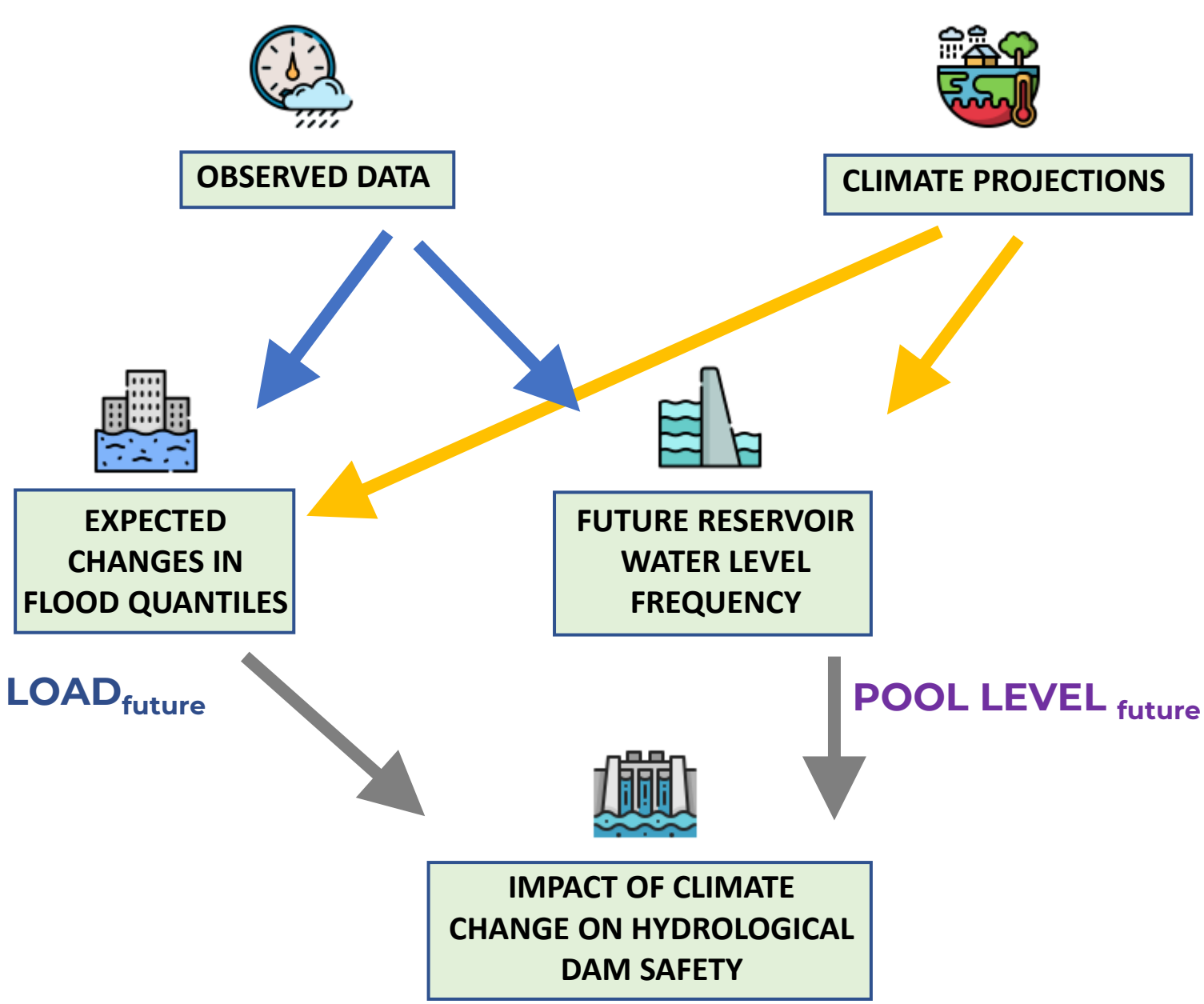
LOAD$_{future}$

Inflow hydrograph

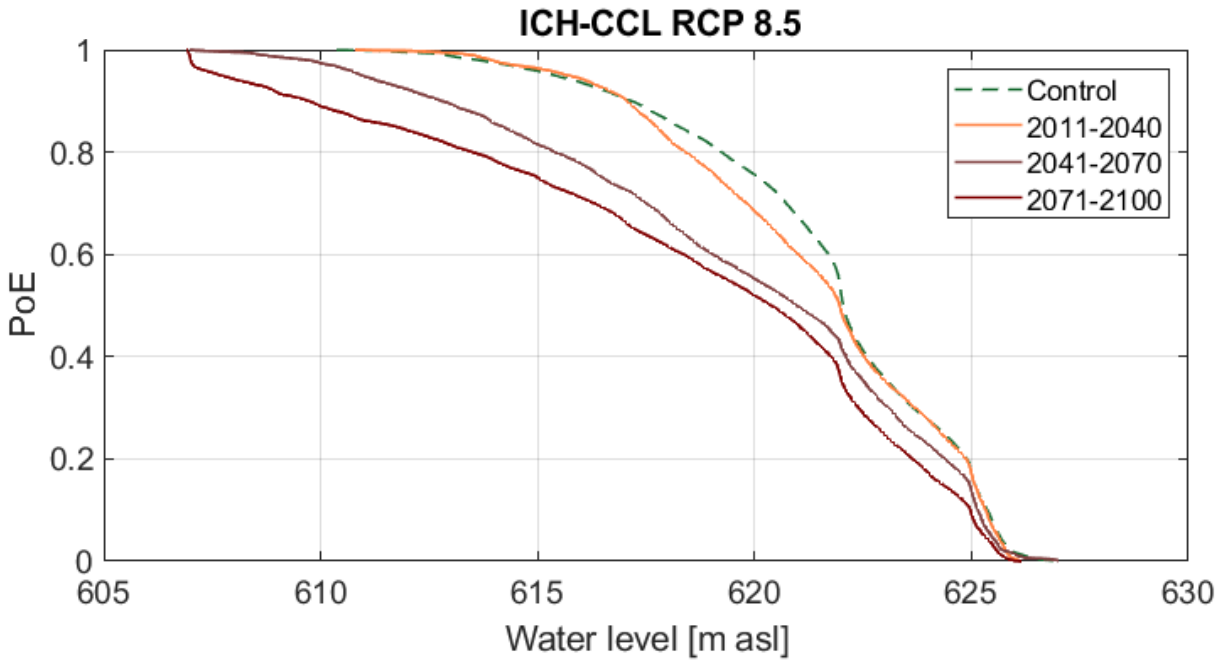


POOL LEVEL $_{future}$

"Most studies tend to focus only on the impact of climate change on the hydrological loads" (Bahls and Holman, 2014; Chernet et al., 2014; Novembre et al., 2015)

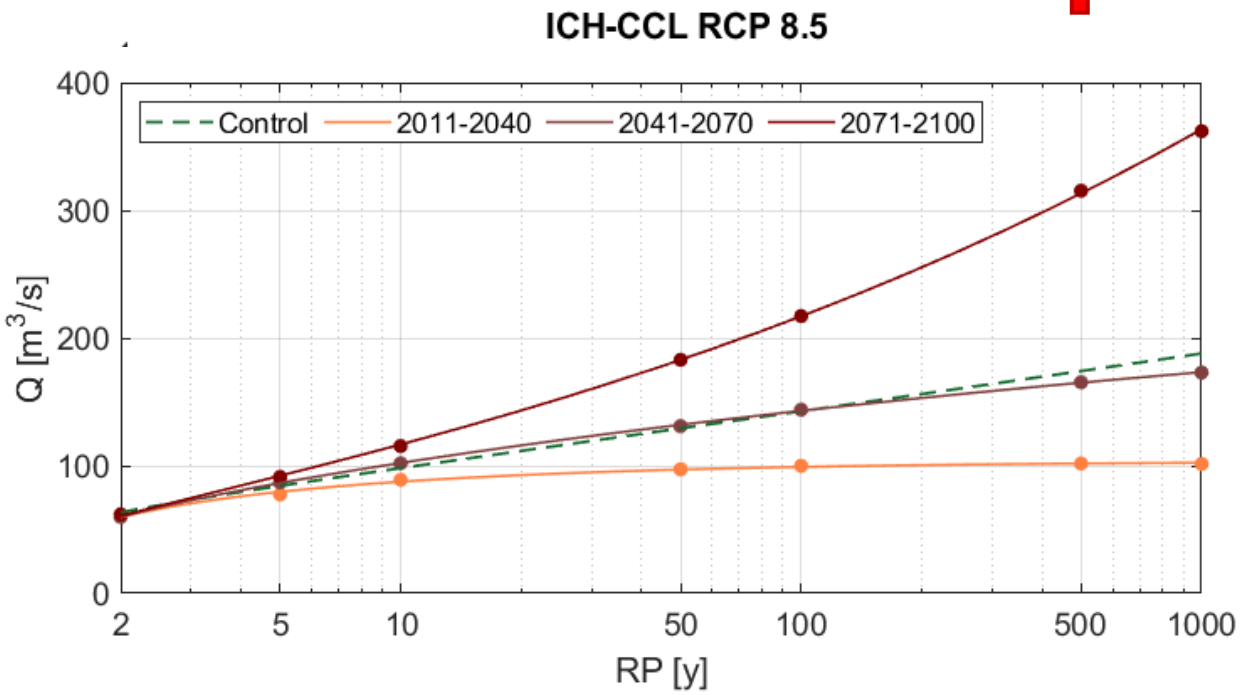

OBSERVED DATA
CLIMATE PROJECTIONS
EXPECTED CHANGES IN FLOOD QUANTILES
FUTURE RESERVOIR WATER LEVEL FREQUENCY
LOAD future
POOL LEVEL future
IMPACT OF CLIMATE CHANGE ON HYDROLOGICAL DAM SAFETY

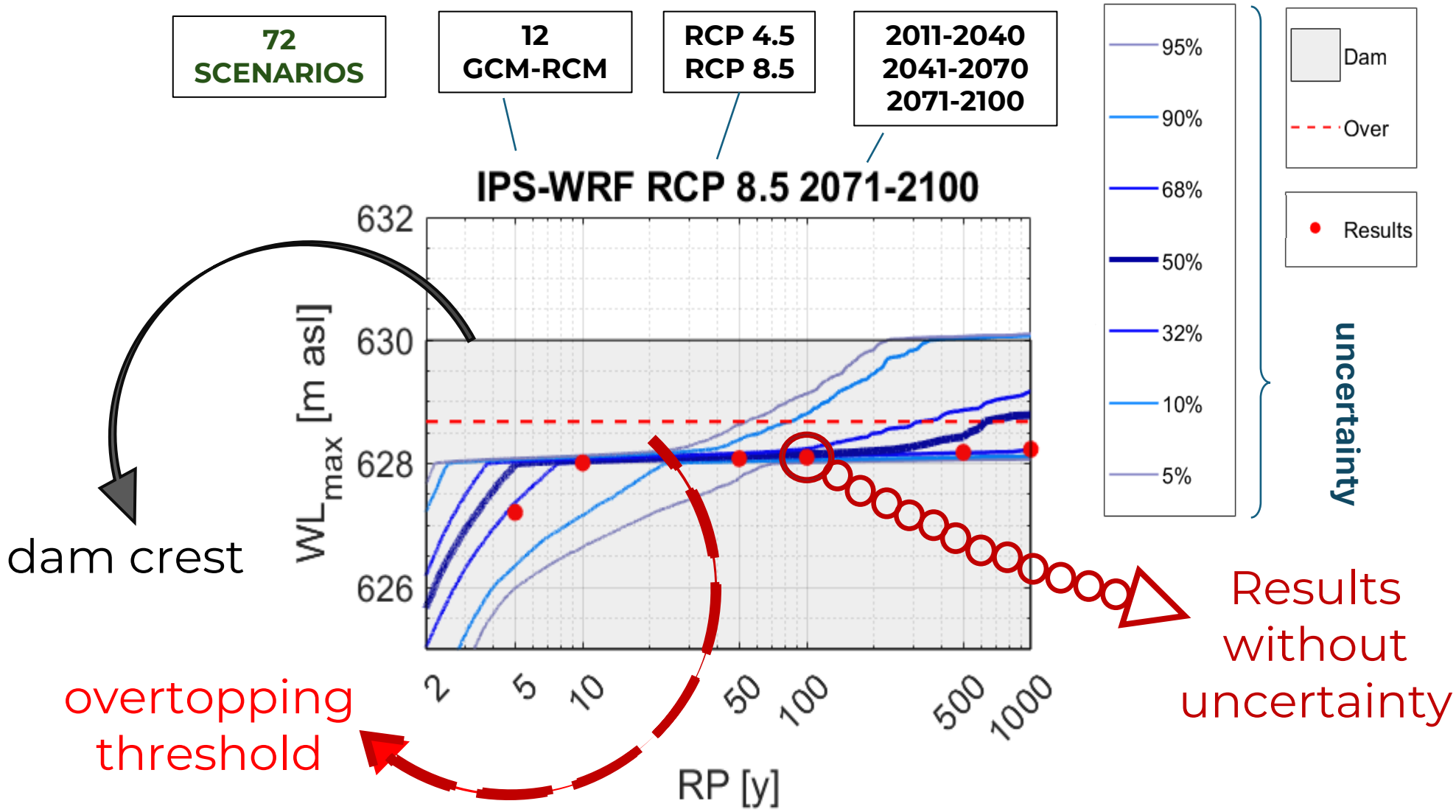




THE INITIAL WATER LEVEL WILL DECREASE IN THE FUTURE

THE INFLOW DISCHARGE OF THE EXTREME EVENTS WILL INCREASE IN THE FUTURE




72
SCENARIOS
12
GCM-RCM
RCP 4.5
RCP 8.5
2011-2040
2041-2070
2071-2100
IPS-WRF RCP 8.5 2071-2100
95%
90%
68%
50%
32%
10%
5%
Dam
Over
Results
uncertainty
dam crest
WLmax [m asl]
632
630
628
626
2
5
10
50
100
500
1000
RP [y]
overtopping
threshold
Results
without
uncertainty

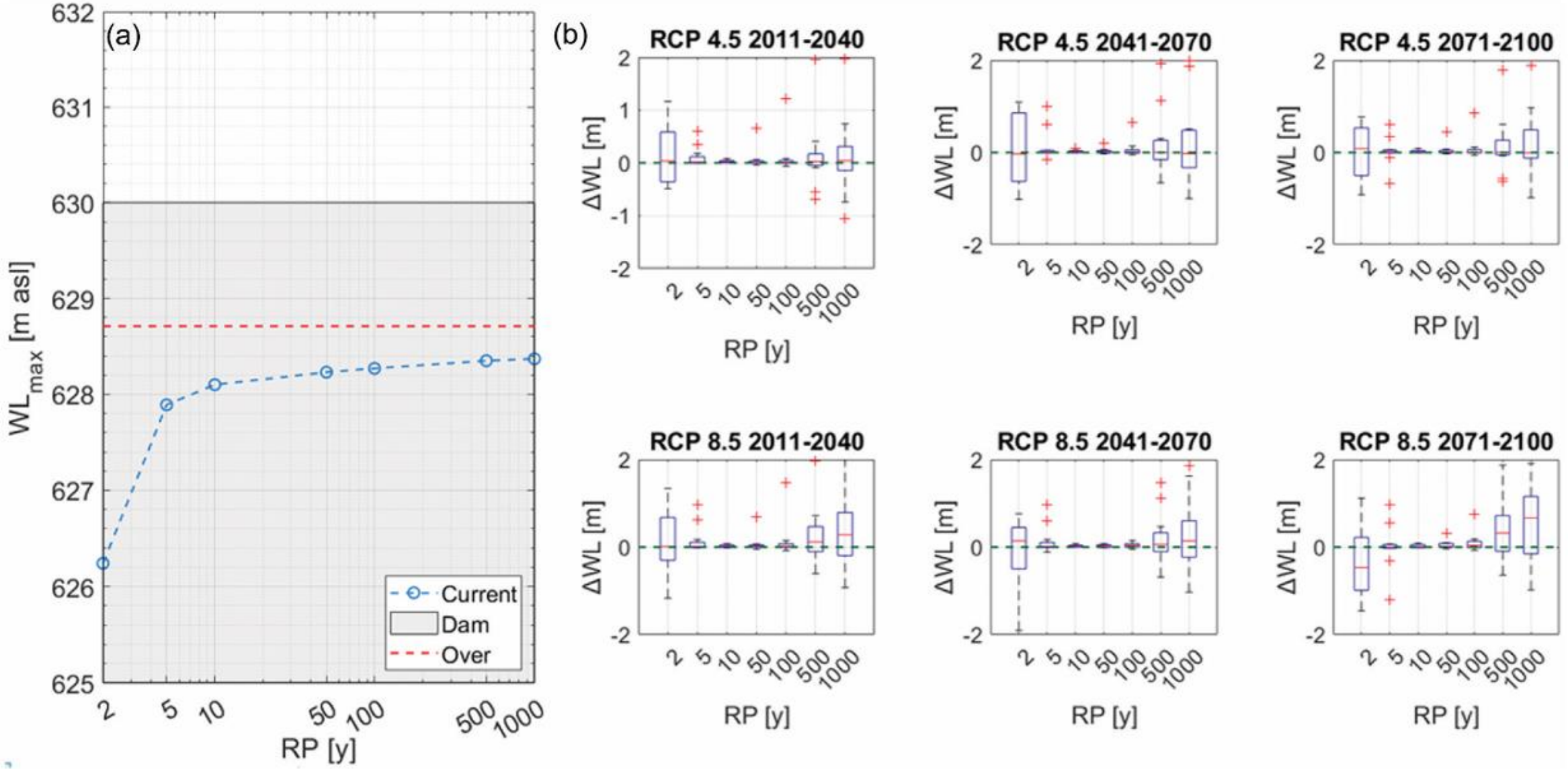


Figure 14. (a) Maximum reservoir water level frequency curve in the current scenario; (b) delta changes in maximum reservoir water levels for the ensemble of 12 climate models considering uncertainty.

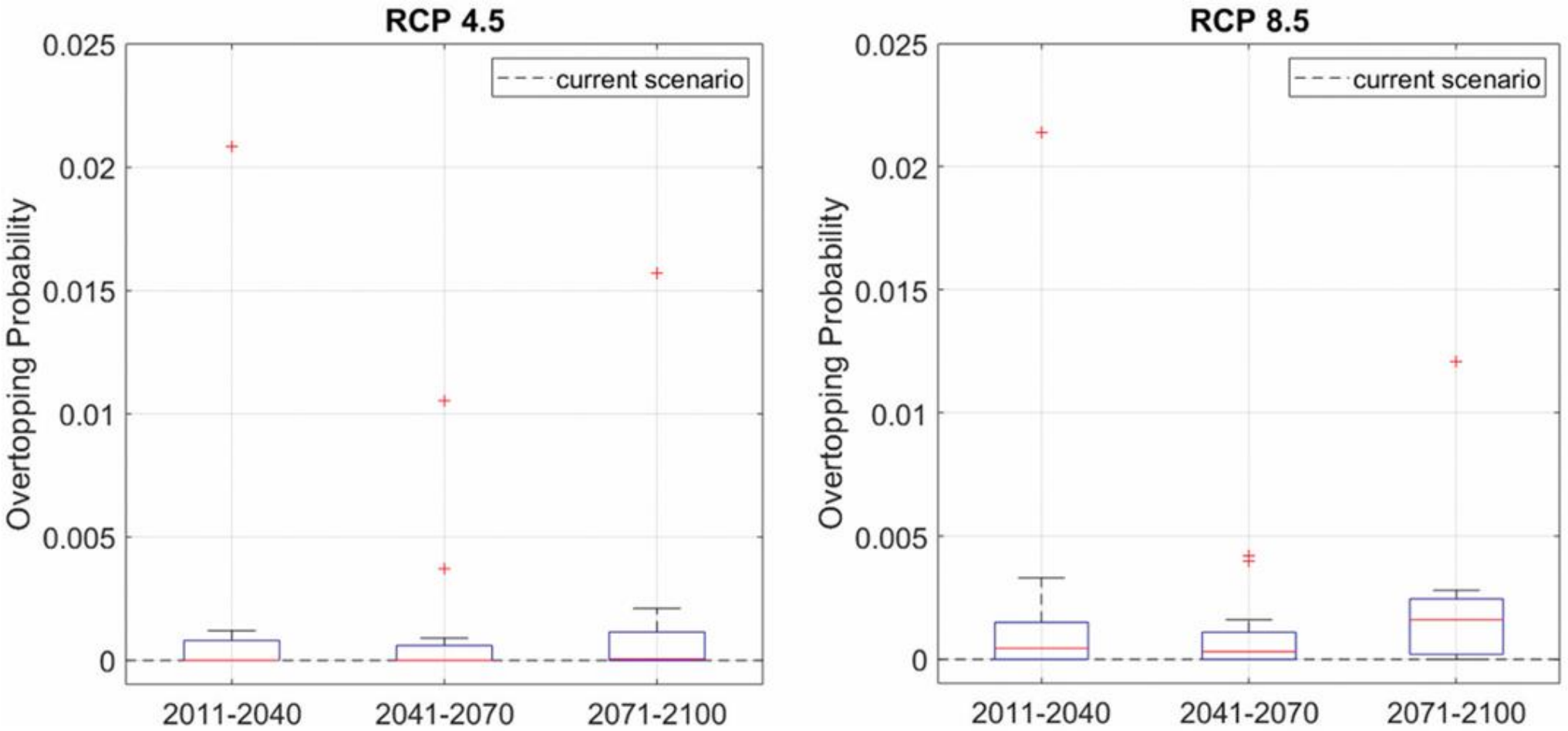


Figure 15. Overtopping probability with the ensemble of the 12 climate models accounting for the uncertainty in the three time windows. (a) RCP 4.5; (b) RCP 8.5. The dashed black line represents the overtopping probability in the current scenario, which is zero as it is lower than 10^{-4}.