Spatial-temporal variation of winter warm spells in Italy over the period 1993-2022

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INTRODUCTION

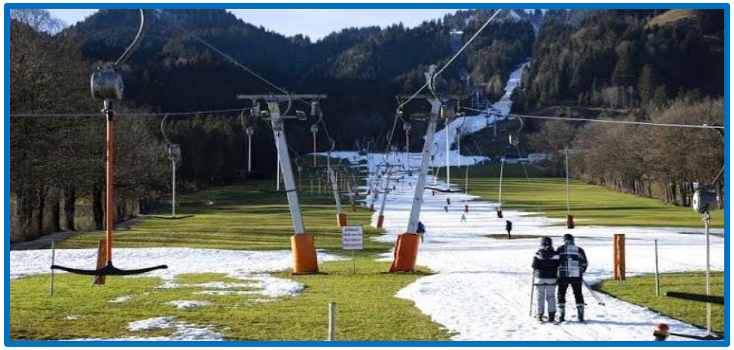
Climate change

Rising temperatures

Increased frequency of extreme weather events
(droughts, floods, **heat waves**)

during **summer**...

...but also, during **winter**



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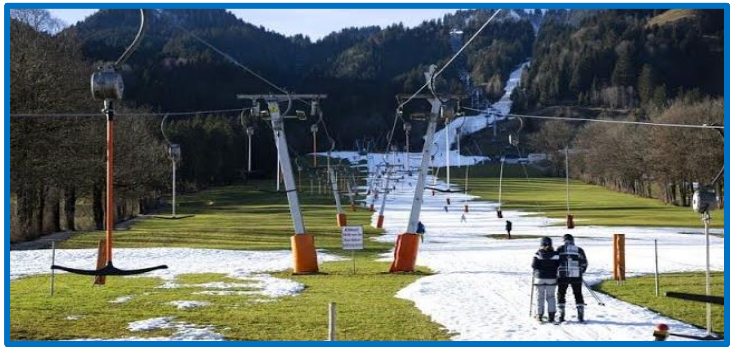


WINTER WARM SPELLS

Winter Warm Spell (WWS)

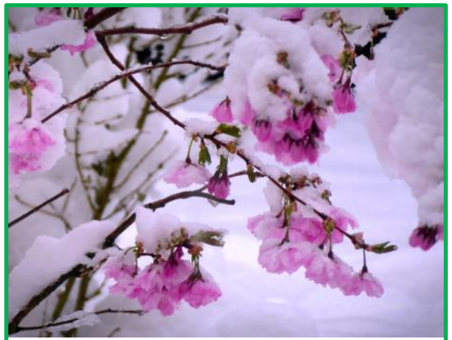
"sequence of at least __six consecutive days__ when the daily maximum temperature ($TX_{i,j}$) on the i-th day during j-th period __exceeds the calendar day 90th percentile__ of the base period ($TX90_{i,ref}$)"

Expert Team on Climate Change Detection and Indices (ETCCDI)
Karl et al., 1999

unlike summer heat waves, WWS are still scarcely studied!
Shabbar and Bonsal, 2003; Tomczyk et al., 2019

__Ecosystems__: variation in balance of species
Sippel et al., 2017

__Agriculture__: earlier germination
Flanigan et al., 2020



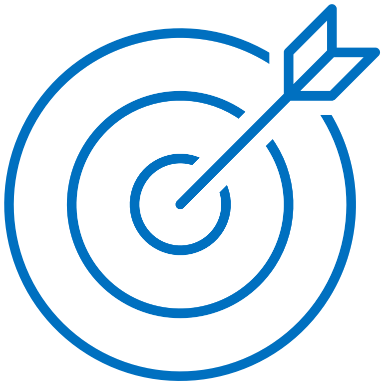
__Vegetation__: early flowering
Walck et al., 2011

__Insects__: change in demographic rates and community structure
Ma et al., 2015

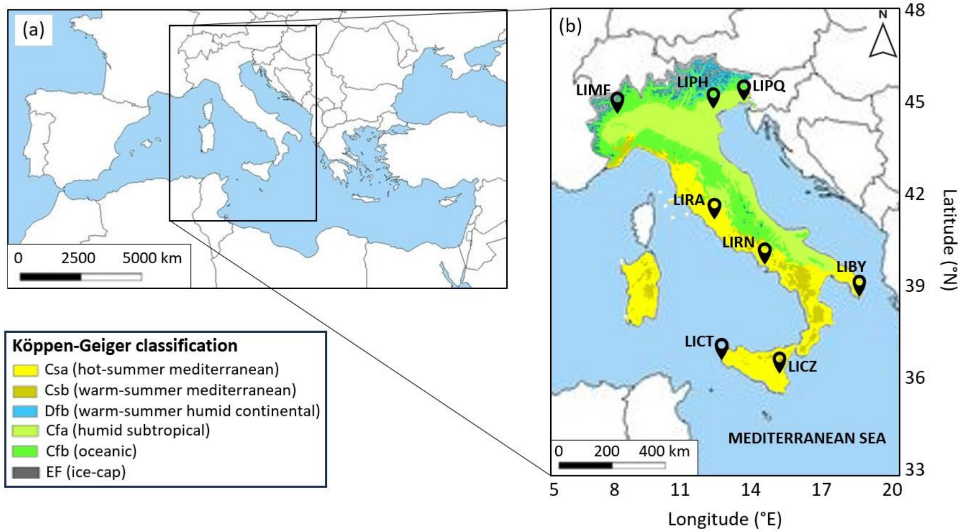
OBJECTIVES

The main aims of this contribution are:

- ❖ to analyse the temporal and spatial variability of WWS based on wintertime daily maximum temperature observations collected at eight sites of the Italian peninsula over the period 1993-2022;
- ❖ to assess how the reduction of the WWS period length threshold influences the identification of the events.



STUDY AREA AND IN-SITU OBSERVATIONS



Variable:
In-situ daily maximum temperature (TX)

Period:
Boreal meteorological winter (01/12-28/02, DJF) 1993-2022

Sites:
airport stations providing TX time series over the years 1993-2022

Station	ICAO code	Lat. (°N)	Lon. (°E)	Altitude (m a.s.l.)	Köppen-Geiger climate class	Percentage of missing data during DJF	
Trieste - Ronchi dei Legionari	LIPQ	45.83	13.47	12	Cfa	2.2%	North
Treviso - Sant'Angelo	LIPH	45.65	12.19	17	Cfa	2.8%	
Torino - Caselle	LIMF	45.20	7.65	302	Cfb	2.9%	
Roma - Ciampino	LIRA	41.80	12.60	130	Csa	2.9%	Central
Napoli - Capodichino	LIRN	40.89	14.29	90	Csa	4.8%	
Santa Maria di Leuca	LIBY	39.82	18.35	112	Csa	3.7%	South
Trapani - Vincenzo Florio	LICT	37.91	12.49	7	Csa	2.1%	
Sigonella	LICZ	37.40	14.92	24	Csa	0.2%	

IDENTIFICATION OF WINTER WARM SPELLS

WINTER WARM SPELL → **sequence of at least six consecutive days when the daily maximum temperature ($TX_{i,j}$) on the i-th day during j-th period exceeds the calendar day 90th percentile of the base period ($TX90_{i,ref}$).**

Expert Team on Climate Change Detection and Indices (ETCCDI)
Karl et al., 1999

The 90th percentile is calculated for each calendar day by considering a 5-day window centred on a given day, as required by ETCCDI.

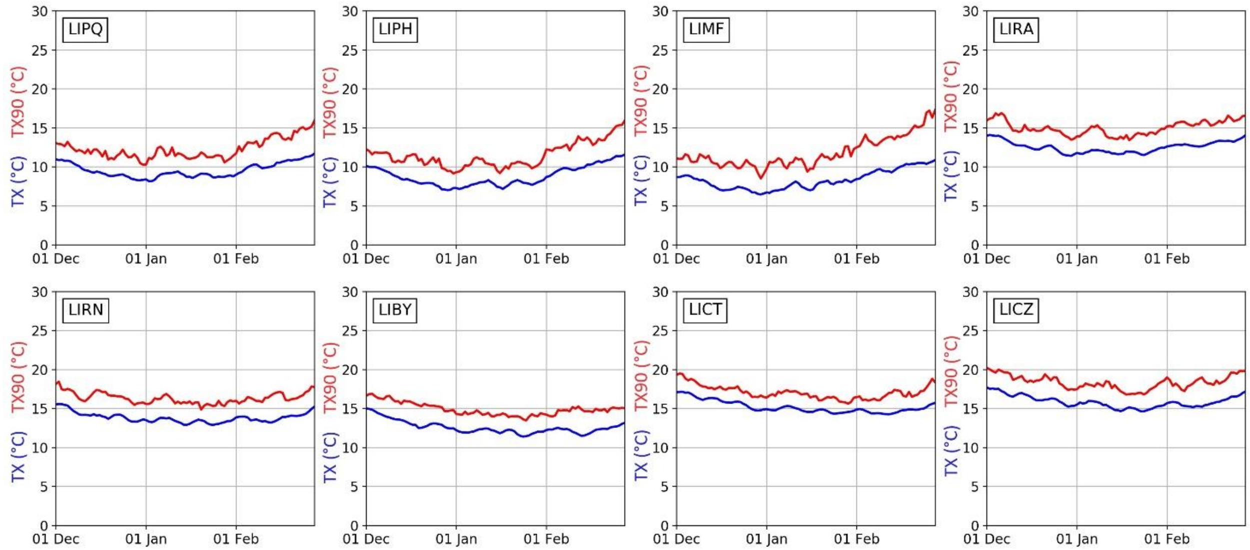
Base period: 1993-2022

For each station, the following ETCCDI climate indices have been computed:

- **TX90P**: annual count of days when the daily maximum air temperature ($TX_{i,j}$) on the i-th day during j-th period exceeds the calendar day 90th percentile centred on a 5-day window for the base period ($TX90_{i,ref}$).
- **WSDI (WARM SPELL DURATION INDEX):** annual count of days meeting the aforementioned definition of warm spell. The count is limited to the winter period (DJF).

TEMPORAL TRENDS OF WINTERTIME TX

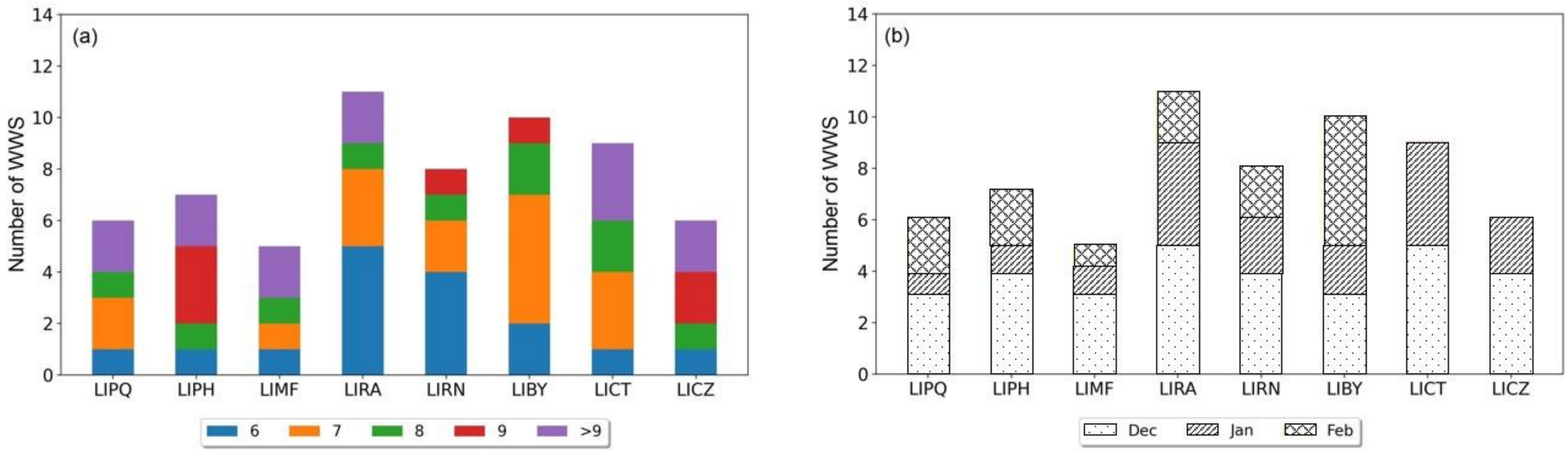
Average daily maximum temperature (TX, blue lines) and 90th percentile of TX (TX90, red lines) for the eight selected stations over the DJF months of the period 1993-2022.



Results of Seasonal Kendall (SK) test for TX. The values of Kendall correlation coefficient (τ), SK slope, and intercept of Kendall-Theil Robust Line are given. Results refer to the DJF months of the period 1993-2022.

Station	τ	SK slope (°C/year)	Intercept (°C)	Trend	
LIPQ	0.10	0.01	9.3	↑	North
LIPH	0.07	0.00	9.0	↑	
LIMF	0.08	0.01	7.3	↑	
LIRA	0.11	0.01	12.4	↑	Central
LIRN	0.04	0.00	14.0	↑	
LIBY	0.05	0.00	13.0	↑	South
LICT	0.00	0.00	15.0	↔	
LICZ	0.08	0.00	16.0	↑	

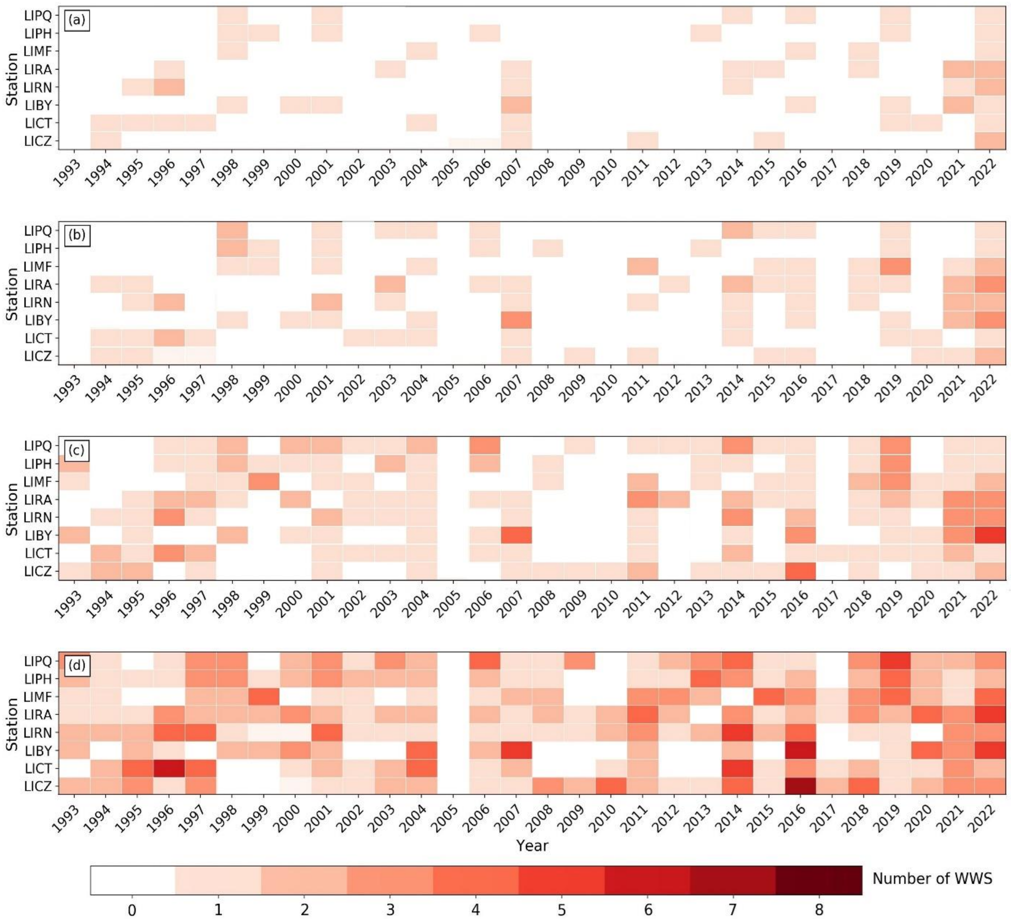
DETECTION OF WINTER WARM SPELLS



Number of WWS (vertical axis) by (a) duration, expressed in days, and (b) month of occurrence in the winters 1993-2022. Stations are listed in decreasing order of the latitude from left to right.

- Six- and seven-day WWS mainly occurred in central-southern Italy (LIRA, LIRN, LIBY), where they represent about 70% of the total events
- All stations except LIRN and LIBY were subjected to two or three WWS lasting more than nine days
- December is the month during which up to 50% of recorded WWS occurred (except LIBY)
- In northern and central Italy, WWS have a similar temporal distribution. In southern Italy greater temporal heterogeneity is detectable

TEMPORAL VARIATIONS IN WWS OCCURRENCE



Temporal changes in WWS events fixing the temporal threshold at (a) six, (b) five, (c) four, and (d) three days.

	WWS duration				
Station	6 days	5 days	4 days	3 days	
LIPQ	5	11	29	57	North
LIPH	7	10	24	50	North
LIMF	5	15	24	48	North
LIRA	11	18	32	60	Central
LIRN	8	15	26	53	Central
LIBY	10	15	28	48	South
LICT	9	13	25	51	South
LICZ	6	11	26	59	South

- ❖ As expected, the number of events and WSDIT increase as the time threshold decreases
- ❖ During the winter of 2005, no WWS lasting at least 3 days were recorded at any site
- ❖ Even by lowering the temporal threshold, only one WWS that involved the whole Italian territory is identified (26-31 December 2022)

CONCLUSIONS AND REMARKS

- During wintertime, TX assume a **statistically significant increase** in most of the sites selected, showing the highest growth rate in northern and central Italy
- Although exceeding the 90th percentile of TX is quite frequent, **only one WWS** that **affected the entire Italian territory** was identified
- WWS are most likely to **occur during December**

In orographically heterogeneous areas, the ETCCDI definition of WWS allows to capture synoptic scale events, losing information on moderate WWS (lasting at least 3 days).

For the investigation of complex orographic areas, it is suggested to reduce the period length threshold for the identification of winter warm spells to three days.

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RESEARCH ARTICLE

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Winter warm spells over Italy: Spatial–temporal variation and large-scale atmospheric circulation

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Thank you for your attention!

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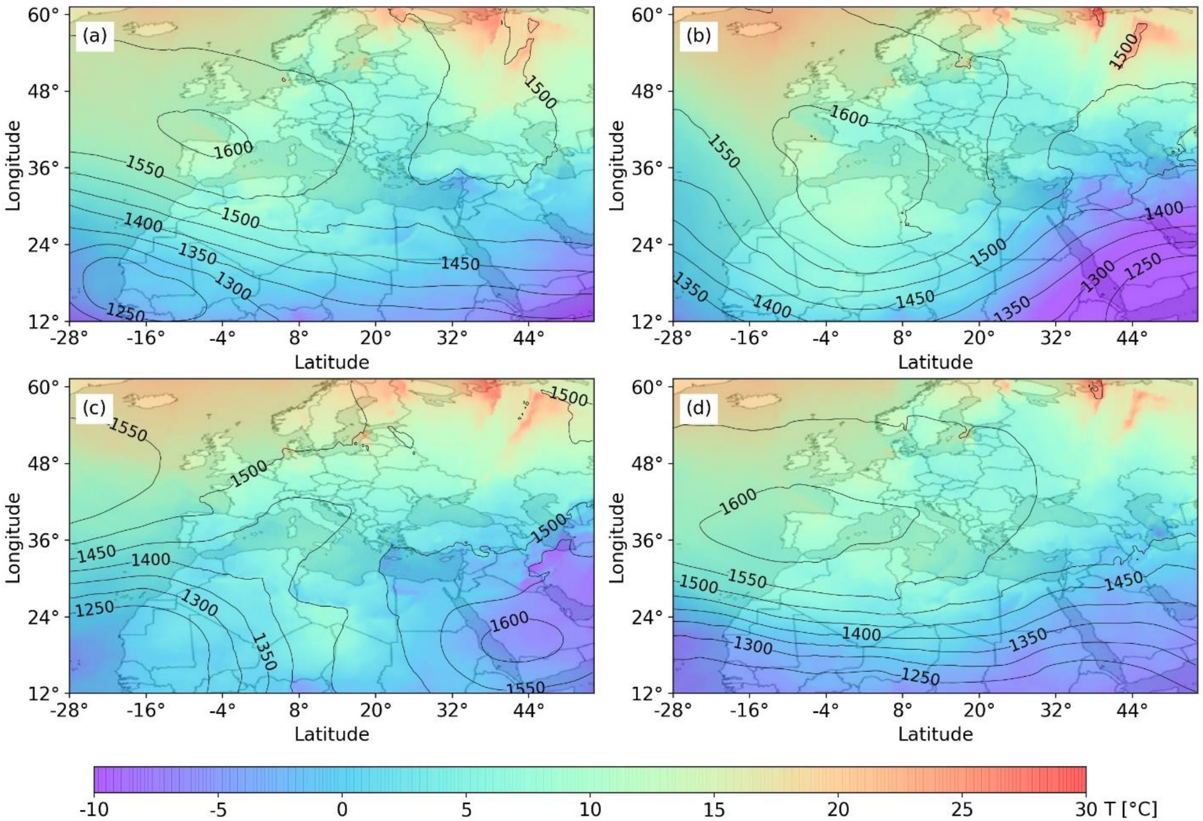
SYNOPTIC-SCALE CONDITIONS DURING SELECTED WWS

- WWS over **Italian peninsula** (all the sites selected): **26-31 December 2022** → panel (a)
- WWS in **Northern Italy** (LIPQ, LIPH, LIMF): **13-21 February 1998** → panel (b)
- WWS in **Central Italy** (LIRA, LIRN): **09-14 January 1996** → panel (c)
- WWS in **Southern Italy** (LIBY, LICT, LICZ): **18-23 January 2007** → panel (d)



Average ERA5 geopotential heights (black lines) and air temperature (colour shades) at 850 hPa for the selected events. Charts refer to 12:00 UTC.

- ❖ Quite similar synoptic conditions in all events selected: an anticyclonic system centred on western Mediterranean, or a high-pressure promontory might extend from North Africa
- ❖ The spatial extension of WWS might be related to the interaction with local circulation and orography.
- ❖ The persistence of this synoptic scenario in winter can also favour the development of atmospheric stagnation and the accumulation of atmospheric pollutants near the ground