# Supplementary materials for 'Winter chill simulations combined with expert knowledge emphasize the vulnerability of temperate fruit orchards in the Mediterranean region'

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## Introduction

In this document, we provide supplementary materials for the work 'Winter chill simulations combined with expert knowledge emphasize the vulnerability of temperate fruit orchards in the Mediterranean region' by Eduardo Fernandez and co-authors. The study is published in the journal Regional Environmental Change under the doi: DOI. We conducted this work in collaboration with researchers from northern and southern Spain, Tunisia, Morocco and Germany under the umbrella of an international project (AdaMedOr) funded by the Partnership for Research and Innovation in the Mediterranean Area (PRIMA).

Compared to previous similar studies, we provide now an analysis that combines the spatial interpolation of winter chill accumulation in the Mediterranean region under future scenarios with expert's knowledge regarding the impacts of climate change on temperate orchards as well as future concerns of farmers cultivating temperate species. Our approach allowed us to frame and contextualize the results of our chill estimations, potentially contributing to the development of management strategies to adapt Mediterranean orchards to future climate conditions.

We offer figures that were not included in the main manuscript, as well as additional information about the weather stations used for the analysis.

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## Weather stations used in the analysis

For this study, we used 387 weather stations as primary sources of minimum and maximum temperature records between 1974 and 2020. In the following table (Table S1), we provide the name, location (coordinates) and percentage of data complete for each weather station.

Table S1: Weather stations used as primary sources of minimum and maximum temperature records between 1974 and 2020 in the Mediterranean basin

| Name | Country | Latitude (dec. degrees) | Longitude (dec. degrees) | Data complete Tmin (%) | Data complete Tmax (%) |
|---|---|---|---|---|---|
| Kharga | Egypt | 25.45 | 30.53 | 77.8 | 77.8 |
| Luxor Intl | Egypt | 25.67 | 32.71 | 93.3 | 93.4 |
| Wejh | Saudi Arabia | 26.20 | 36.48 | 94.5 | 94.5 |
| Asyut Intl | Egypt | 27.05 | 31.01 | 84.0 | 83.9 |
| In Amenas | Algeria | 28.05 | 9.64 | 93.0 | 93.0 |
| Minya | Egypt | 28.08 | 30.73 | 76.6 | 76.6 |
| Baharia | Egypt | 28.33 | 28.87 | 70.5 | 70.5 |
| Tabuk | Saudi Arabia | 28.36 | 36.62 | 96.0 | 96.0 |
| Hon | Libya | 29.12 | 15.95 | 70.2 | 70.2 |
| Siwa | Egypt | 29.20 | 25.48 | 72.2 | 72.3 |
| Eilat | Israel | 29.56 | 34.96 | 99.3 | 99.4 |
| Al Jouf | Saudi Arabia | 29.78 | 40.10 | 91.8 | 91.9 |
| Cairo Intl | Egypt | 30.12 | 31.41 | 99.7 | 99.7 |
| Ghadames East | Libya | 30.15 | 9.71 | 75.7 | 75.7 |
| El Golea | Algeria | 30.57 | 2.86 | 98.1 | 98.1 |
| Arar | Saudi Arabia | 30.91 | 41.14 | 93.0 | 93.1 |
| Ouarzazate | Morocco | 30.94 | -6.91 | 98.1 | 98.1 |
| Alexandria Intl | Egypt | 31.18 | 29.95 | 95.6 | 95.6 |
| Sirte | Libya | 31.20 | 16.58 | 77.8 | 77.8 |
| Port Said | Egypt | 31.27 | 32.30 | 71.5 | 71.5 |
| Menara | Morocco | 31.61 | -8.04 | 99.7 | 99.7 |
| Bechar | Algeria | 31.65 | -2.27 | 98.9 | 98.9 |
| Oued Irara | Algeria | 31.67 | 6.14 | 95.6 | 95.7 |
| Turaif | Saudi Arabia | 31.69 | 38.73 | 97.2 | 97.2 |
| El Borma | Tunisia | 31.70 | 9.26 | 70.2 | 70.3 |
| Moulay Ali Cherif | Morocco | 31.95 | -4.40 | 90.9 | 90.9 |
| Marka Intl | Jordan | 31.97 | 35.99 | 99.4 | 99.4 |
| Ben Gurion | Israel | 32.01 | 34.89 | 99.5 | 99.5 |
| Benina Airport | Libya | 32.10 | 20.27 | 86.9 | 86.9 |
| Misurata | Libya | 32.24 | 15.02 | 81.3 | 81.3 |
| Safi | Morocco | 32.28 | -9.23 | 91.6 | 91.6 |
| Remada | Tunisia | 32.31 | 10.38 | 96.0 | 96.0 |
| Beni-Mellal | Morocco | 32.37 | -6.40 | 93.2 | 93.3 |
| Noumerat | Algeria | 32.38 | 3.79 | 98.5 | 98.5 |
| Zuara | Libya | 32.56 | 12.06 | 78.8 | 78.8 |
| Mohammed V | Morocco | 33.37 | -7.59 | 99.3 | 99.3 |
| Damascus Intl | Syria | 33.41 | 36.52 | 99.2 | 99.3 |
| Guemar | Algeria | 33.51 | 6.78 | 95.6 | 95.6 |
| Anfa | Morocco | 33.56 | -7.66 | 97.7 | 97.7 |
| El-Bayadh | Algeria | 33.72 | 1.08 | 91.3 | 91.3 |
| Zarzis | Tunisia | 33.88 | 10.78 | 99.8 | 99.8 |
| Gabes | Tunisia | 33.88 | 10.10 | 99.5 | 99.4 |

| Name | Country | Latitude (dec. degrees) | Longitude (dec. degrees) | Data complete Tmin (%) | Data complete Tmax (%) |
|---|---|---|---|---|---|
| Bassatine | Morocco | 33.88 | -5.52 | 92.2 | 92.2 |
| Saiss | Morocco | 33.93 | -4.98 | 93.9 | 93.9 |
| Nefta | Tunisia | 33.94 | 8.11 | 99.6 | 99.6 |
| Sale | Morocco | 34.05 | -6.75 | 95.4 | 95.4 |
| Taza | Morocco | 34.22 | -4.00 | 95.2 | 95.2 |
| Gafsa | Tunisia | 34.42 | 8.82 | 98.5 | 98.5 |
| Akrotiri | Cyprus | 34.59 | 32.99 | 99.5 | 99.5 |
| Djelfa-Tletsi | Algeria | 34.68 | 3.25 | 91.8 | 91.8 |
| Thyna | Tunisia | 34.72 | 10.69 | 99.4 | 99.4 |
| Pafos Intl | Cyprus | 34.72 | 32.49 | 99.5 | 99.5 |
| Angads | Morocco | 34.79 | -1.92 | 98.6 | 98.6 |
| Biskra | Algeria | 34.79 | 5.74 | 97.4 | 97.4 |
| Hama | Syria | 35.12 | 36.75 | 90.9 | 90.9 |
| Cherif El Idrissi | Morocco | 35.18 | -3.84 | 96.7 | 96.7 |
| Melilla | Spain | 35.28 | -2.96 | 99.2 | 99.2 |
| Nikos Kazantzakis | Greece | 35.34 | 25.18 | 99.8 | 99.8 |
| Cheikh Larbi Tebessi | Algeria | 35.43 | 8.12 | 92.4 | 92.5 |
| Lampedusa | Italy | 35.50 | 12.62 | 98.7 | 98.7 |
| Souda | Greece | 35.53 | 24.15 | 98.7 | 98.7 |
| Lattakia | Syria | 35.53 | 35.77 | 90.8 | 90.7 |
| Es Senia | Algeria | 35.62 | -0.62 | 99.4 | 99.4 |
| Monastir-Skanes | Tunisia | 35.67 | 10.75 | 99.5 | 99.5 |
| Kairouan | Tunisia | 35.67 | 10.10 | 99.5 | 99.5 |
| Ibn Batouta | Morocco | 35.73 | -5.92 | 99.6 | 99.6 |
| Luqa | Malta | 35.86 | 14.48 | 99.8 | 99.8 |
| Gibraltar | Gibraltar | 36.15 | -5.35 | 99.8 | 99.8 |
| Kithira | Greece | 36.27 | 23.02 | 96.1 | 96.1 |
| Mohamed Boudiaf Intl | Algeria | 36.28 | 6.62 | 99.7 | 99.7 |
| Silifke | Turkey | 36.38 | 33.93 | 95.4 | 95.4 |
| Diagoras | Greece | 36.41 | 28.09 | 99.8 | 99.8 |
| Jendouba | Tunisia | 36.48 | 8.80 | 99.1 | 99.1 |
| Rota Naval Air Station | Spain | 36.65 | -6.35 | 99.8 | 99.8 |
| Malaga | Spain | 36.67 | -4.50 | 99.8 | 99.8 |
| Cozzo Spadaro | Italy | 36.68 | 15.13 | 98.6 | 98.5 |
| Houari Boumediene | Algeria | 36.69 | 3.21 | 99.6 | 99.6 |
| Soummam | Algeria | 36.71 | 5.07 | 96.3 | 96.3 |
| Milos | Greece | 36.73 | 24.43 | 92.4 | 92.4 |
| Jerez | Spain | 36.74 | -6.06 | 99.5 | 99.5 |
| Pantelleria | Italy | 36.82 | 11.97 | 99.3 | 99.3 |
| Annaba | Algeria | 36.82 | 7.81 | 99.4 | 99.4 |
| Methoni | Greece | 36.83 | 21.70 | 97.2 | 97.2 |
| Almeria | Spain | 36.84 | -2.37 | 99.8 | 99.8 |
| Kelibia | Tunisia | 36.85 | 11.08 | 98.8 | 98.8 |
| Carthage | Tunisia | 36.85 | 10.23 | 99.8 | 99.8 |
| Faro | Portugal | 37.01 | -7.97 | 99.7 | 99.8 |
| Gela | Italy | 37.08 | 14.22 | 96.4 | 96.4 |
| Moron Ab | Spain | 37.17 | -5.62 | 97.5 | 97.6 |
| Granada | Spain | 37.19 | -3.78 | 99.8 | 99.8 |
| Mugla | Turkey | 37.22 | 28.37 | 95.5 | 95.5 |
| Sidi Ahmed Air Base | Tunisia | 37.24 | 9.79 | 99.3 | 99.3 |

| Name | Country | Latitude (dec. degrees) | Longitude (dec. degrees) | Data complete Tmin (%) | Data complete Tmax (%) |
|---|---|---|---|---|---|
| Catania-Sigonella | Italy | 37.40 | 14.92 | 99.5 | 99.5 |
| Sevilla | Spain | 37.42 | -5.89 | 99.7 | 99.7 |
| Catania Fontanarossa | Italy | 37.47 | 15.07 | 99.8 | 99.8 |
| Tripolis | Greece | 37.53 | 22.40 | 97.8 | 97.8 |
| Murcia San Javier | Spain | 37.77 | -0.81 | 99.7 | 99.7 |
| Isparta | Turkey | 37.78 | 30.58 | 97.4 | 97.4 |
| Cordoba | Spain | 37.84 | -4.85 | 98.8 | 98.8 |
| Athinai | Greece | 37.88 | 23.74 | 94.8 | 94.8 |
| Diyarbakir | Turkey | 37.89 | 40.20 | 97.5 | 97.6 |
| Trapani Birgi | Italy | 37.91 | 12.49 | 99.8 | 99.8 |
| Andravida | Greece | 37.92 | 21.29 | 98.8 | 98.8 |
| Alcantarilla | Spain | 37.95 | -1.23 | 96.2 | 96.2 |
| Konya | Turkey | 37.98 | 32.56 | 91.2 | 91.2 |
| Elefsis | Greece | 38.06 | 23.56 | 99.1 | 99.1 |
| Reggio Calabria | Italy | 38.07 | 15.65 | 95.8 | 95.8 |
| Beja | Portugal | 38.08 | -7.93 | 96.5 | 96.5 |
| Palermo | Italy | 38.18 | 13.09 | 99.8 | 99.8 |
| Messina | Italy | 38.20 | 15.55 | 99.3 | 99.3 |
| Alicante_2 | Spain | 38.28 | -0.56 | 99.8 | 99.8 |
| Erhac | Turkey | 38.44 | 38.09 | 99.1 | 99.2 |
| Van | Turkey | 38.47 | 43.33 | 98.7 | 98.7 |
| Cigli | Turkey | 38.51 | 27.01 | 95.2 | 95.2 |
| Elazig | Turkey | 38.61 | 39.29 | 96.4 | 96.4 |
| Usak | Turkey | 38.68 | 29.40 | 97.3 | 97.3 |
| Ustica Island | Italy | 38.70 | 13.18 | 96.2 | 96.2 |
| Afyon | Turkey | 38.73 | 30.60 | 95.0 | 95.0 |
| Erkilet | Turkey | 38.77 | 35.49 | 97.6 | 97.6 |
| Lisboa | Portugal | 38.78 | -9.14 | 99.6 | 99.6 |
| Akhisar | Turkey | 38.81 | 27.83 | 99.2 | 99.2 |
| Ibiza | Spain | 38.87 | 1.37 | 99.8 | 99.8 |
| Lamia | Greece | 38.88 | 22.43 | 93.7 | 93.7 |
| Talavera La Real | Spain | 38.89 | -6.82 | 95.9 | 95.9 |
| Aktio | Greece | 38.92 | 20.76 | 98.5 | 98.5 |
| Albacete | Spain | 38.95 | -1.86 | 99.3 | 99.3 |
| Skiros | Greece | 38.97 | 24.49 | 98.1 | 98.1 |
| Ciudad Real | Spain | 38.98 | -3.92 | 97.8 | 97.8 |
| Crotone | Italy | 39.00 | 17.08 | 96.9 | 96.9 |
| Mitilini | Greece | 39.06 | 26.60 | 99.5 | 99.5 |
| Elmas | Italy | 39.25 | 9.05 | 99.8 | 99.8 |
| Portalegre | Portugal | 39.28 | -7.42 | 96.1 | 96.1 |
| Decimomannu | Italy | 39.35 | 8.97 | 97.8 | 97.9 |
| Caceres | Spain | 39.47 | -6.33 | 98.9 | 98.9 |
| Valencia | Spain | 39.49 | -0.48 | 99.8 | 99.8 |
| Palma De Mallorca | Spain | 39.55 | 2.73 | 99.9 | 99.9 |
| Ioannis Kapodistrias Intl | Greece | 39.60 | 19.91 | 99.8 | 99.8 |
| Balikesir | Turkey | 39.62 | 27.93 | 99.6 | 99.6 |
| Larisa | Greece | 39.65 | 22.47 | 96.6 | 96.6 |
| Erzincan | Turkey | 39.71 | 39.53 | 96.4 | 96.5 |
| Eskisehir | Turkey | 39.78 | 30.58 | 99.7 | 99.7 |
| Sivas | Turkey | 39.81 | 36.90 | 97.2 | 97.2 |

| Name | Country | Latitude (dec. degrees) | Longitude (dec. degrees) | Data complete Tmin (%) | Data complete Tmax (%) |
|---|---|---|---|---|---|
| Santa Maria Di Leuc | Italy | 39.82 | 18.35 | 98.8 | 98.8 |
| Menorca | Spain | 39.86 | 4.22 | 99.8 | 99.8 |
| Cape Bellavista | Italy | 39.93 | 9.72 | 96.8 | 96.8 |
| Etimesgut | Turkey | 39.95 | 32.69 | 96.3 | 96.3 |
| Erzurum | Turkey | 39.96 | 41.17 | 97.1 | 97.1 |
| Cape Palinuro | Italy | 40.02 | 15.28 | 98.5 | 98.5 |
| Esenboga | Turkey | 40.13 | 32.99 | 97.6 | 97.6 |
| Canakkale | Turkey | 40.14 | 26.43 | 99.2 | 99.2 |
| Bursa | Turkey | 40.18 | 29.07 | 99.4 | 99.4 |
| Lecce | Italy | 40.24 | 18.13 | 97.6 | 97.6 |
| Getafe | Spain | 40.29 | -3.72 | 97.6 | 97.6 |
| Bandirma | Turkey | 40.32 | 27.98 | 97.4 | 97.4 |
| Cuatro Vientos | Spain | 40.37 | -3.79 | 92.7 | 92.8 |
| Marina Di Ginosa | Italy | 40.43 | 16.88 | 98.2 | 98.2 |
| Barajas | Spain | 40.49 | -3.57 | 99.9 | 99.8 |
| Torrejon | Spain | 40.50 | -3.45 | 91.3 | 91.3 |
| Grottaglie | Italy | 40.52 | 17.40 | 95.6 | 95.6 |
| Makedonia | Greece | 40.52 | 22.97 | 97.6 | 97.6 |
| Alghero | Italy | 40.63 | 8.29 | 99.4 | 99.4 |
| Casale | Italy | 40.66 | 17.95 | 99.8 | 99.8 |
| Gioia Del Colle | Italy | 40.77 | 16.93 | 97.2 | 97.2 |
| Tortosa | Spain | 40.82 | 0.50 | 93.9 | 94.0 |
| Merzifon | Turkey | 40.83 | 35.52 | 98.7 | 98.7 |
| Dimokritos | Greece | 40.86 | 25.96 | 99.6 | 99.6 |
| Olbia Costa Smeralda | Italy | 40.90 | 9.52 | 95.5 | 95.5 |
| Ponza Island | Italy | 40.92 | 12.95 | 99.2 | 99.2 |
| Salamanca | Spain | 40.95 | -5.50 | 99.4 | 99.4 |
| Ataturk | Turkey | 40.98 | 28.82 | 99.8 | 99.8 |
| Tekirdag | Turkey | 40.98 | 27.55 | 99.0 | 99.0 |
| Trabzon | Turkey | 40.99 | 39.79 | 97.3 | 97.3 |
| Bitola | North Macedonia | 41.05 | 21.37 | 90.3 | 90.3 |
| Grazzanise | Italy | 41.06 | 14.08 | 94.2 | 94.2 |
| Bari | Italy | 41.13 | 16.77 | 99.8 | 99.8 |
| Reus | Spain | 41.15 | 1.17 | 99.0 | 99.0 |
| Porto | Portugal | 41.25 | -8.68 | 99.8 | 99.8 |
| Barcelona | Spain | 41.30 | 2.08 | 99.9 | 99.9 |
| Zonguldak | Turkey | 41.45 | 31.80 | 97.1 | 97.2 |
| Amendola | Italy | 41.54 | 15.72 | 94.1 | 94.1 |
| Latina | Italy | 41.54 | 12.91 | 93.2 | 93.2 |
| Sandanski | Bulgaria | 41.55 | 23.27 | 97.4 | 97.4 |
| Campobasso | Italy | 41.57 | 14.65 | 96.8 | 96.8 |
| Frosinone (It-Afb) | Italy | 41.63 | 13.30 | 91.1 | 91.2 |
| Valladolid | Spain | 41.63 | -4.75 | 99.0 | 99.0 |
| Kurdjali | Bulgaria | 41.65 | 25.38 | 97.7 | 97.7 |
| Pratica Di Mare | Italy | 41.66 | 12.45 | 98.2 | 98.2 |
| Zaragoza Ab | Spain | 41.67 | -1.04 | 99.8 | 99.8 |
| Edirne | Turkey | 41.67 | 26.57 | 97.0 | 97.0 |
| Valladolid_2 | Spain | 41.71 | -4.85 | 98.3 | 98.3 |
| Tbilisi - Lochini Airport | Georgia | 41.75 | 44.77 | 92.4 | 92.4 |
| Ciampino | Italy | 41.80 | 12.60 | 99.7 | 99.7 |

| Name | Country | Latitude (dec. degrees) | Longitude (dec. degrees) | Data complete Tmin (%) | Data complete Tmax (%) |
|---|---|---|---|---|---|
| Fiumicino | Italy | 41.80 | 12.25 | 99.6 | 99.8 |
| Braganca | Portugal | 41.86 | -6.71 | 99.6 | 99.6 |
| Girona | Spain | 41.90 | 2.76 | 99.8 | 99.8 |
| Campo Dell Oro | France | 41.92 | 8.80 | 99.3 | 99.4 |
| Urbe | Italy | 41.95 | 12.50 | 93.8 | 93.8 |
| Skopje | North Macedonia | 41.96 | 21.62 | 99.7 | 99.7 |
| Inebolu | Turkey | 41.98 | 33.78 | 91.8 | 91.8 |
| Sinop | Turkey | 42.03 | 35.17 | 96.9 | 96.9 |
| Plovdiv | Bulgaria | 42.07 | 24.85 | 97.5 | 97.5 |
| Mussala (Top-Sommet) | Bulgaria | 42.18 | 23.58 | 95.7 | 95.7 |
| Kriva Palanka | North Macedonia | 42.20 | 22.33 | 90.3 | 90.3 |
| Vigo | Spain | 42.23 | -8.63 | 99.8 | 99.8 |
| Burgos | Spain | 42.36 | -3.62 | 93.4 | 93.5 |
| Podgorica - Golubovci | Montenegro | 42.37 | 19.25 | 98.5 | 98.5 |
| Rieti | Italy | 42.42 | 12.85 | 92.4 | 92.4 |
| Viterbo | Italy | 42.43 | 12.06 | 95.2 | 95.2 |
| Pescara | Italy | 42.43 | 14.18 | 99.5 | 99.5 |
| Logrono-Agoncillo | Spain | 42.45 | -2.33 | 98.7 | 98.7 |
| Poretta | France | 42.55 | 9.48 | 97.4 | 97.5 |
| Burgas | Bulgaria | 42.57 | 27.52 | 97.7 | 97.7 |
| Leon | Spain | 42.59 | -5.66 | 98.7 | 98.7 |
| Sliven | Bulgaria | 42.67 | 26.33 | 97.5 | 97.5 |
| Rivesaltes | France | 42.74 | 2.87 | 99.3 | 99.6 |
| Pamplona | Spain | 42.77 | -1.65 | 98.4 | 98.4 |
| Vitoria | Spain | 42.88 | -2.72 | 98.6 | 98.7 |
| Santiago | Spain | 42.90 | -8.41 | 99.8 | 99.8 |
| Antichan | France | 43.01 | 1.10 | 99.0 | 99.0 |
| Vladikavkaz | Russia | 43.03 | 44.68 | 93.9 | 93.9 |
| Perugia | Italy | 43.10 | 12.51 | 99.2 | 99.2 |
| Le Palyvestre | France | 43.10 | 6.15 | 96.1 | 96.3 |
| Lourdes | France | 43.18 | -0.01 | 99.4 | 99.5 |
| Salvaza | France | 43.22 | 2.31 | 97.7 | 97.8 |
| Varna | Bulgaria | 43.23 | 27.82 | 97.7 | 97.7 |
| San Sebastian-Igueldo | Spain | 43.30 | -2.03 | 97.8 | 97.8 |
| Bilbao | Spain | 43.30 | -2.91 | 99.8 | 99.8 |
| Oviedo | Spain | 43.35 | -5.87 | 99.3 | 99.3 |
| San Sebastian | Spain | 43.36 | -1.79 | 99.7 | 99.7 |
| La Coruna | Spain | 43.37 | -8.42 | 99.5 | 99.5 |
| Pau Pyrenees | France | 43.38 | -0.42 | 99.6 | 99.7 |
| Santander | Spain | 43.43 | -3.82 | 93.1 | 93.1 |
| Provence | France | 43.44 | 5.21 | 99.5 | 99.6 |
| Sochi | Russia | 43.45 | 39.96 | 97.3 | 97.3 |
| Anglet | France | 43.47 | -1.52 | 99.5 | 99.6 |
| Santander_2 | Spain | 43.48 | -3.80 | 99.5 | 99.5 |
| Asturias | Spain | 43.56 | -6.04 | 99.3 | 99.3 |
| Mediterranee | France | 43.58 | 3.96 | 99.6 | 99.7 |
| Falconara | Italy | 43.62 | 13.36 | 99.7 | 99.7 |
| Blagnac | France | 43.63 | 1.36 | 99.4 | 99.6 |
| Cote D Azur | France | 43.66 | 7.22 | 99.6 | 99.6 |

| Name | Country | Latitude (dec. degrees) | Longitude (dec. degrees) | Data complete Tmin (%) | Data complete Tmax (%) |
|---|---|---|---|---|---|
| Pisa | Italy | 43.68 | 10.39 | 99.8 | 99.8 |
| Kraljevo | Serbia | 43.70 | 20.70 | 95.8 | 95.8 |
| Garons | France | 43.76 | 4.42 | 97.4 | 97.6 |
| Firenze | Italy | 43.81 | 11.20 | 99.8 | 99.8 |
| Sarajevo | Bosnia & Herzegovina | 43.83 | 18.33 | 97.7 | 97.7 |
| Mont De Marsan | France | 43.91 | -0.51 | 97.2 | 97.4 |
| Cape Mele | Italy | 43.95 | 8.17 | 99.7 | 99.7 |
| Rimini | Italy | 44.02 | 12.61 | 97.7 | 97.7 |
| Albenga | Italy | 44.05 | 8.13 | 97.4 | 97.5 |
| St-Auban-Sur-Duranc | France | 44.07 | 6.00 | 96.7 | 96.7 |
| Rosiorii De Vede | Romania | 44.10 | 24.98 | 94.2 | 94.2 |
| Millau | France | 44.12 | 3.02 | 97.8 | 97.8 |
| Caritat | France | 44.14 | 4.87 | 95.8 | 96.0 |
| La Garenne | France | 44.17 | 0.59 | 99.4 | 99.5 |
| Forli | Italy | 44.20 | 12.07 | 95.2 | 95.2 |
| Calarasi | Romania | 44.20 | 27.35 | 97.6 | 97.6 |
| Constanta | Romania | 44.22 | 28.65 | 97.6 | 97.6 |
| Cervia | Italy | 44.22 | 12.31 | 98.5 | 98.6 |
| Mineralnyye Vody | Russia | 44.23 | 43.08 | 99.4 | 99.4 |
| Negotin | Serbia | 44.23 | 22.55 | 92.8 | 92.8 |
| Craiova | Romania | 44.32 | 23.89 | 97.6 | 97.6 |
| Mihail Kogalniceanu | Romania | 44.36 | 28.49 | 94.8 | 94.7 |
| Genova Sestri | Italy | 44.41 | 8.84 | 99.8 | 99.8 |
| Cazaux | France | 44.53 | -1.12 | 96.4 | 96.6 |
| Bologna | Italy | 44.53 | 11.29 | 99.7 | 99.6 |
| Loznica | Serbia | 44.55 | 19.23 | 97.1 | 97.1 |
| Embrun | France | 44.57 | 6.50 | 99.1 | 99.1 |
| Montelimar-Ancone | France | 44.58 | 4.73 | 97.2 | 97.2 |
| Drobeta Turnu Severin | Romania | 44.63 | 22.63 | 99.7 | 99.7 |
| Simferopol' | Ukraine | 44.68 | 34.13 | 99.7 | 99.7 |
| Gourdon | France | 44.75 | 1.40 | 99.2 | 99.2 |
| Beograd | Serbia | 44.82 | 20.31 | 99.8 | 99.8 |
| Merignac | France | 44.83 | -0.72 | 99.5 | 99.7 |
| Piacenza | Italy | 44.91 | 9.72 | 96.5 | 96.5 |
| Torino-Bric Croce | Italy | 45.03 | 7.73 | 94.8 | 94.8 |
| Krasnodar | Russia | 45.03 | 39.15 | 99.7 | 99.7 |
| Vrsac | Serbia | 45.15 | 21.31 | 93.7 | 93.7 |
| Buzau | Romania | 45.15 | 26.82 | 99.7 | 99.7 |
| Sulina | Romania | 45.17 | 29.73 | 98.9 | 98.9 |
| Torino Caselle | Italy | 45.20 | 7.65 | 99.8 | 99.8 |
| Rijeka | Croatia | 45.22 | 14.57 | 91.5 | 91.5 |
| Saint Geoirs | France | 45.36 | 5.33 | 99.3 | 99.5 |
| Villafranca | Italy | 45.40 | 10.89 | 97.7 | 97.7 |
| Kerch | Ukraine | 45.40 | 36.42 | 99.7 | 99.7 |
| Caransebes | Romania | 45.42 | 22.25 | 99.7 | 99.7 |
| Ghedi | Italy | 45.43 | 10.27 | 94.3 | 94.3 |
| Varfu Omu | Romania | 45.45 | 25.45 | 99.3 | 99.3 |
| Galati | Romania | 45.48 | 28.03 | 99.7 | 99.7 |
| Venezia Tessera | Italy | 45.51 | 12.35 | 99.8 | 99.8 |
| Chornomors'ke | Ukraine | 45.52 | 32.70 | 99.6 | 99.6 |

| Name | Country | Latitude (dec. degrees) | Longitude (dec. degrees) | Data complete Tmin (%) | Data complete Tmax (%) |
|---|---|---|---|---|---|
| Boutheon | France | 45.54 | 4.30 | 93.3 | 93.5 |
| Bourg St-Maurice | France | 45.62 | 6.77 | 99.2 | 99.2 |
| Malpensa | Italy | 45.63 | 8.73 | 99.8 | 99.8 |
| Aix Les Bains | France | 45.64 | 5.88 | 96.0 | 96.2 |
| Treviso | Italy | 45.65 | 12.19 | 98.0 | 97.9 |
| Trieste | Italy | 45.65 | 13.75 | 95.1 | 95.1 |
| Chateaubernard | France | 45.66 | -0.32 | 98.9 | 99.0 |
| Bergamo Orio Al Serio | Italy | 45.67 | 9.70 | 99.8 | 99.8 |
| Istrana | Italy | 45.69 | 12.08 | 99.8 | 99.8 |
| Saint Exupery | France | 45.73 | 5.09 | 96.6 | 96.6 |
| Bron | France | 45.73 | 4.94 | 97.7 | 97.9 |
| Sibiu | Romania | 45.79 | 24.09 | 97.3 | 97.3 |
| Auvergne | France | 45.79 | 3.17 | 97.3 | 97.5 |
| Traian Vuia | Romania | 45.81 | 21.34 | 96.7 | 96.8 |
| Ronchi Dei Legionari | Italy | 45.83 | 13.47 | 99.6 | 99.6 |
| Tihoreck | Russia | 45.85 | 40.08 | 90.1 | 90.1 |
| Bellegarde | France | 45.86 | 1.18 | 99.6 | 99.7 |
| Deva | Romania | 45.87 | 22.90 | 95.9 | 95.9 |
| Divnoe | Russia | 45.92 | 43.35 | 99.8 | 99.8 |
| Pecs South | Hungary | 45.99 | 18.24 | 99.8 | 99.8 |
| Lugano | Switzerland | 46.00 | 8.91 | 91.3 | 91.4 |
| Aviano Ab | Italy | 46.03 | 12.60 | 92.4 | 92.4 |
| Primorsko-Ahtarsk | Russia | 46.03 | 38.15 | 91.6 | 91.6 |
| Chassiron | France | 46.05 | -1.42 | 96.7 | 96.7 |
| Palic | Serbia | 46.10 | 19.77 | 96.6 | 96.6 |
| Locarno-Monti | Switzerland | 46.17 | 8.78 | 98.6 | 98.6 |
| Charmeil | France | 46.17 | 3.40 | 95.5 | 95.5 |
| Arad | Romania | 46.18 | 21.26 | 99.8 | 99.8 |
| Baja | Hungary | 46.18 | 19.02 | 96.4 | 96.4 |
| Sion | Switzerland | 46.22 | 7.33 | 99.8 | 99.8 |
| Geneva Cointrin | Switzerland | 46.24 | 6.11 | 99.8 | 99.9 |
| Szeged (Aut) | Hungary | 46.25 | 20.10 | 99.8 | 99.8 |
| Charnay | France | 46.30 | 4.80 | 97.3 | 97.3 |
| Miercurea Ciuc | Romania | 46.37 | 25.73 | 92.4 | 92.3 |
| Odesa Intl | Ukraine | 46.43 | 30.68 | 98.4 | 98.4 |
| Nagykanizsa | Hungary | 46.45 | 16.97 | 99.7 | 99.7 |
| Bolzano | Italy | 46.46 | 11.33 | 96.3 | 96.3 |
| Vidrasau | Romania | 46.47 | 24.41 | 96.6 | 96.6 |
| Tarvisio | Italy | 46.50 | 13.58 | 94.2 | 94.2 |
| Bacau | Romania | 46.52 | 26.91 | 99.7 | 99.7 |
| Jungfraujoch | Switzerland | 46.55 | 7.98 | 97.8 | 97.7 |
| Biard | France | 46.59 | 0.31 | 99.5 | 99.6 |
| Kherson | Ukraine | 46.63 | 32.57 | 99.6 | 99.6 |
| Klagenfurt(Civ-Mil) | Austria | 46.65 | 14.33 | 97.7 | 97.7 |
| Guetsch Ob Andermatt | Switzerland | 46.65 | 8.62 | 99.4 | 99.4 |
| Saint-Sauveur | France | 46.70 | -2.33 | 96.1 | 96.1 |
| Dobbiaco | Italy | 46.73 | 12.22 | 96.9 | 96.9 |
| S. Valentino Alla Muta | Italy | 46.75 | 10.53 | 96.4 | 96.4 |
| Payerne | Switzerland | 46.82 | 6.95 | 99.8 | 99.8 |
| Lienz | Austria | 46.83 | 12.82 | 94.0 | 94.0 |

| Name | Country | Latitude (dec. degrees) | Longitude (dec. degrees) | Data complete Tmin (%) | Data complete Tmax (%) |
|---|---|---|---|---|---|
| Siofok | Hungary | 46.92 | 18.05 | 99.4 | 99.4 |
| Ceahlau Toaca | Romania | 46.98 | 25.95 | 99.7 | 99.8 |
| Chisinau | Moldova | 47.02 | 28.98 | 99.3 | 99.3 |
| Oradea | Romania | 47.02 | 21.90 | 99.7 | 99.7 |
| Mariupol' | Ukraine | 47.03 | 37.50 | 99.1 | 99.0 |
| Bourges | France | 47.06 | 2.37 | 98.9 | 98.9 |
| Szolnok | Hungary | 47.12 | 20.24 | 99.8 | 99.8 |
| Vaduz | Liechtenstein | 47.13 | 9.52 | 99.5 | 99.5 |
| Nantes Atlantique | France | 47.15 | -1.61 | 99.7 | 99.7 |
| Iasi | Romania | 47.18 | 27.62 | 97.1 | 97.1 |
| Zeltweg | Austria | 47.20 | 14.74 | 91.1 | 91.1 |
| Patscherkofel | Austria | 47.22 | 11.47 | 91.9 | 92.0 |
| Saentis | Switzerland | 47.25 | 9.35 | 98.9 | 98.9 |
| Besancon-Thise(Aut) | France | 47.25 | 5.98 | 97.1 | 97.1 |
| Innsbruck | Austria | 47.26 | 11.34 | 97.7 | 97.7 |
| Feldkirch | Austria | 47.27 | 9.62 | 93.2 | 93.2 |
| Longvic | France | 47.27 | 5.09 | 97.5 | 97.7 |
| Szombathely Arpt - Vas | Hungary | 47.28 | 16.63 | 99.5 | 99.5 |
| Belle Ile-Le Talut | France | 47.30 | -3.22 | 99.1 | 99.2 |
| Montoir | France | 47.31 | -2.15 | 92.1 | 92.1 |
| Zuerich-Fluntern | Switzerland | 47.38 | 8.57 | 91.2 | 91.2 |
| Val De Loire | France | 47.43 | 0.73 | 97.5 | 97.5 |
| Ferihegy | Hungary | 47.44 | 19.26 | 99.7 | 99.7 |
| Zurich | Switzerland | 47.47 | 8.55 | 99.8 | 99.8 |
| Beaucouze | France | 47.48 | -0.60 | 95.1 | 95.1 |
| Debrecen | Hungary | 47.49 | 21.61 | 99.7 | 99.8 |
| Bregenz | Austria | 47.50 | 9.75 | 94.5 | 94.6 |
| Aigen-Ennstal (Mil) | Austria | 47.53 | 14.13 | 97.6 | 97.6 |
| Kufstein | Austria | 47.58 | 12.17 | 98.7 | 98.7 |
| Bale Mulhouse | France | 47.59 | 7.53 | 99.7 | 99.7 |
| Sopron | Hungary | 47.68 | 16.60 | 96.8 | 96.8 |
| Satu Mare | Romania | 47.70 | 22.89 | 99.7 | 99.7 |
| Gyor | Hungary | 47.72 | 17.68 | 99.7 | 99.8 |
| Botosani | Romania | 47.73 | 26.65 | 99.8 | 99.8 |
| Lann Bihoue | France | 47.76 | -3.44 | 99.6 | 99.6 |
| Saint Sauveur | France | 47.78 | 6.36 | 94.9 | 95.0 |
| Salzburg | Austria | 47.79 | 13.00 | 97.7 | 97.7 |
| Feuerkogel | Austria | 47.82 | 13.72 | 91.1 | 91.3 |
| Liubashivka | Ukraine | 47.85 | 30.27 | 96.1 | 96.1 |
| Hurbanovo | Slovakia | 47.87 | 18.20 | 99.7 | 99.7 |
| Kekesteto | Hungary | 47.87 | 20.02 | 96.5 | 96.5 |
| Zaporizhzhia Intl | Ukraine | 47.87 | 35.32 | 99.7 | 99.7 |
| Arnage | France | 47.95 | 0.20 | 95.0 | 95.1 |
| Pluguffan | France | 47.98 | -4.17 | 91.2 | 91.2 |
| Nyiregyhaza | Hungary | 47.98 | 21.69 | 96.5 | 96.5 |
| Bricy | France | 47.99 | 1.76 | 99.0 | 99.1 |

## Climate models used in the projections

In Table S2, we show the 15 climate models used in the analysis to obtain future temperature data from the ClimateWizard data base. As described in the main manuscript, we later grouped these models into "pessimistic", "intermediate" and "optimistic" classes according to Safe Winter Chill distributions.

Table S2: Climate models used in the analysis to obtain temperature data under future climate scenarios

| Name | Abbreviation |
|---|---|
| Beijing Climate Center - Climate System Model 1.1 | bcc-csm1-1 |
| Geophysical Fluid Dynamics Laboratory - Earth System Models | GFDL-ESM2G |
| | GFDL-ESM2M |
| | GFDL-CM3 |
| Institute of Numerical Mathematics Climate Model version 4 | inmcm4 |
| Institute Pierre - Simon Laplace - Climate Model 5 | IPSL-CM5A-LR |
| | IPSL-CM5A-MR |
| Community Climate System Model 4 | CCSM4 |
| Community Earth System Model version 1 - BioGeoChemical model enabled | CESM1-BGC |
| Beijing Normal University - Earth System Model | BNU-ESM |
| Canadian Earth System Model 2 | CanESM2 |
| Model for Interdisciplinary Research On Climate - Earth System Model | MIROC-ESM |
| Centre National de Recherches Météorologiques - Climate Model 5 | CNRM-CM5 |
| Australian Community Climate and Earth-System Simulator 1.0 | ACCESS1-0 |
| Commonwealth Scientific and Industrial Research Organisation - Mark3.6.0 | CSIRO-Mk3-6-0 |

## Correction model

As described in the main manuscript, we implemented a spatial interpolation and used a 3D model to correct for large errors that originated from the initial Kriging procedure. This 3D correction model (Fig. S1) consisted of the relationship between the monthly minimum and maximum temperatures in January (x- and y-axis, respectively) and the observed chill in each weather station (color surface). This allowed us to identify the combination of temperatures that was associated with a given amount of chill, which was later extracted from the temperature-interpolated map.

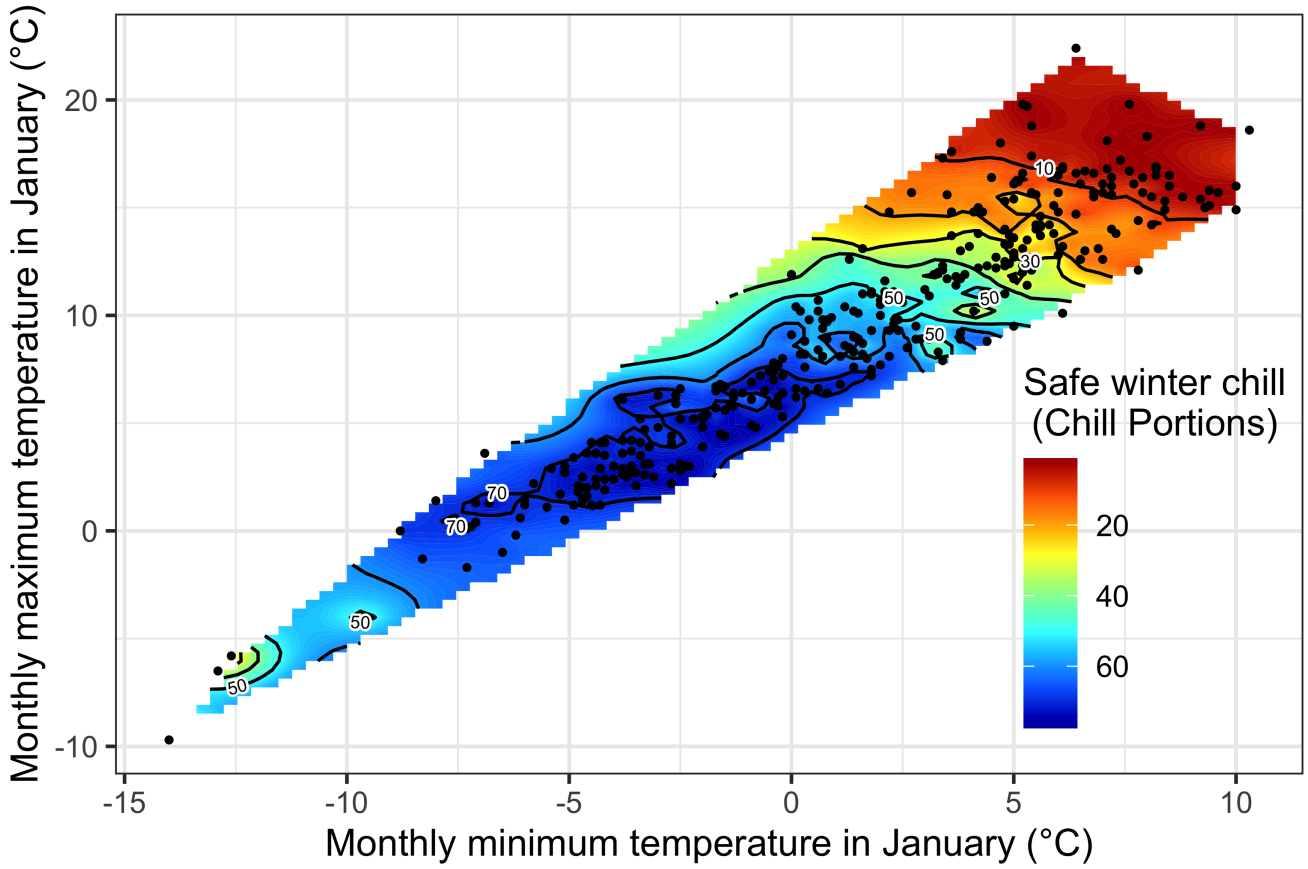


Figure S1: Three-dimensional model used to correct for the inital error generated by interpolating Safe Winter Chill only based on data from the weather stations. In the figure, we show the 3D correction model for the 1975 scenario. Different relationships were established for each of the many scenarios evaluated in this study

## Additional figures

In the following figures, we show the expected change in Safe Winter Chill compared to the baseline period (median SWC across the historic simulated scenarios) for the "pessimistic" and "optimistic" climate model classes for the RCP4.5 and RCP8.5 scenarios by 2050 and 2085. As expected, major chill losses will occur under the "pessimistic" version of the RCP8.5 scenario by 2085, whereas minor changes may be expected by the near future under the RCP4.5 scenario.

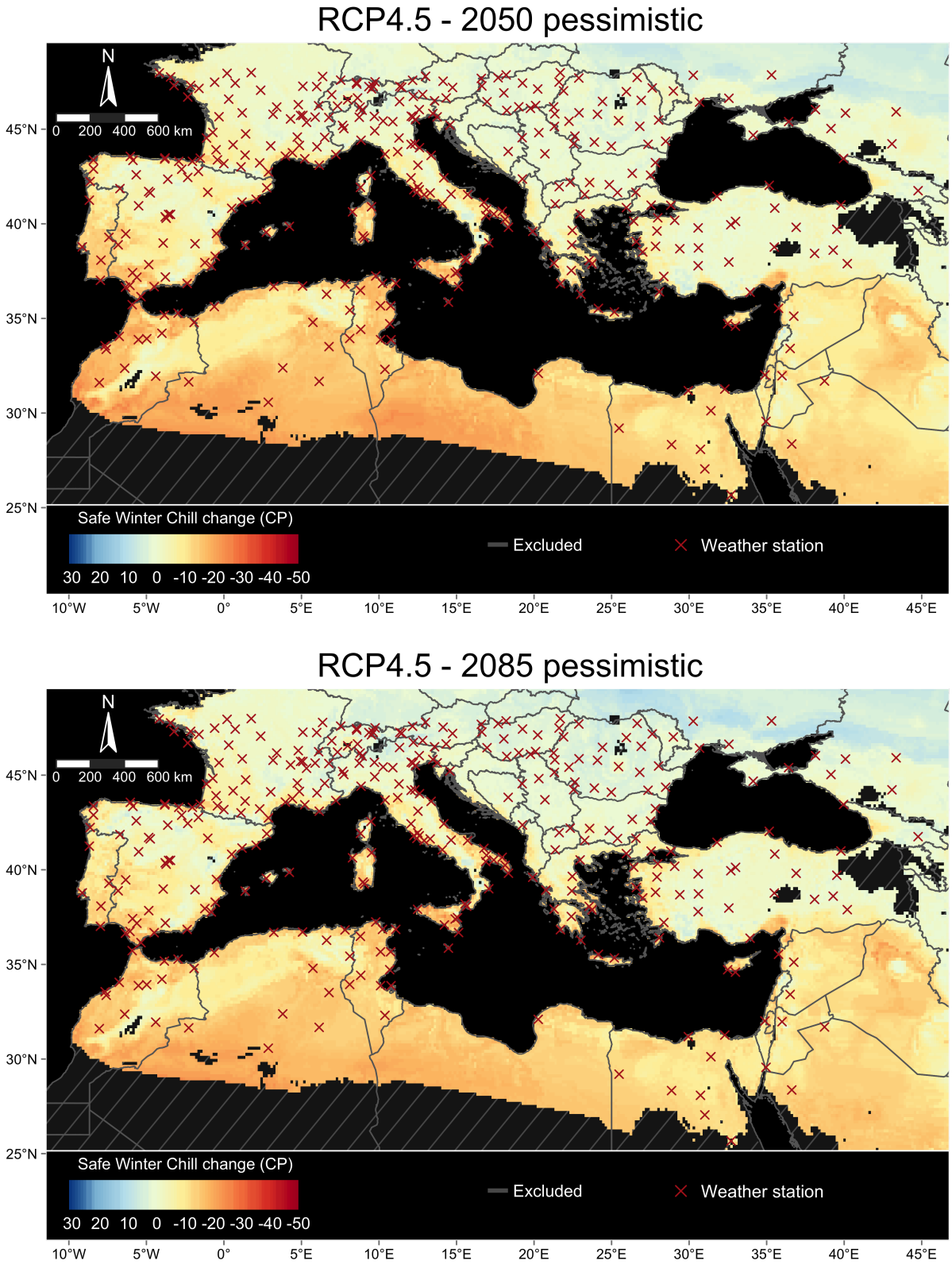


Figure S2: Estimation of Safe Winter Chill change for the Mediterranean region under the RCP4.5 scenario by two time horizons relative to historic simulated scenarios. In both panels, we show the difference in SWC between the respective combination of future scenario and year and the median across historic simulated scenarios between 1975 and 2019. For future scenarios, we used the results of the "pessimistic" climate model class (15th percentile among 15 General Circulation Models). The grey hatched areas in the maps represent regions excluded from the 3D correction model. The red crosses represent the locations of the weather stations used in the analysis

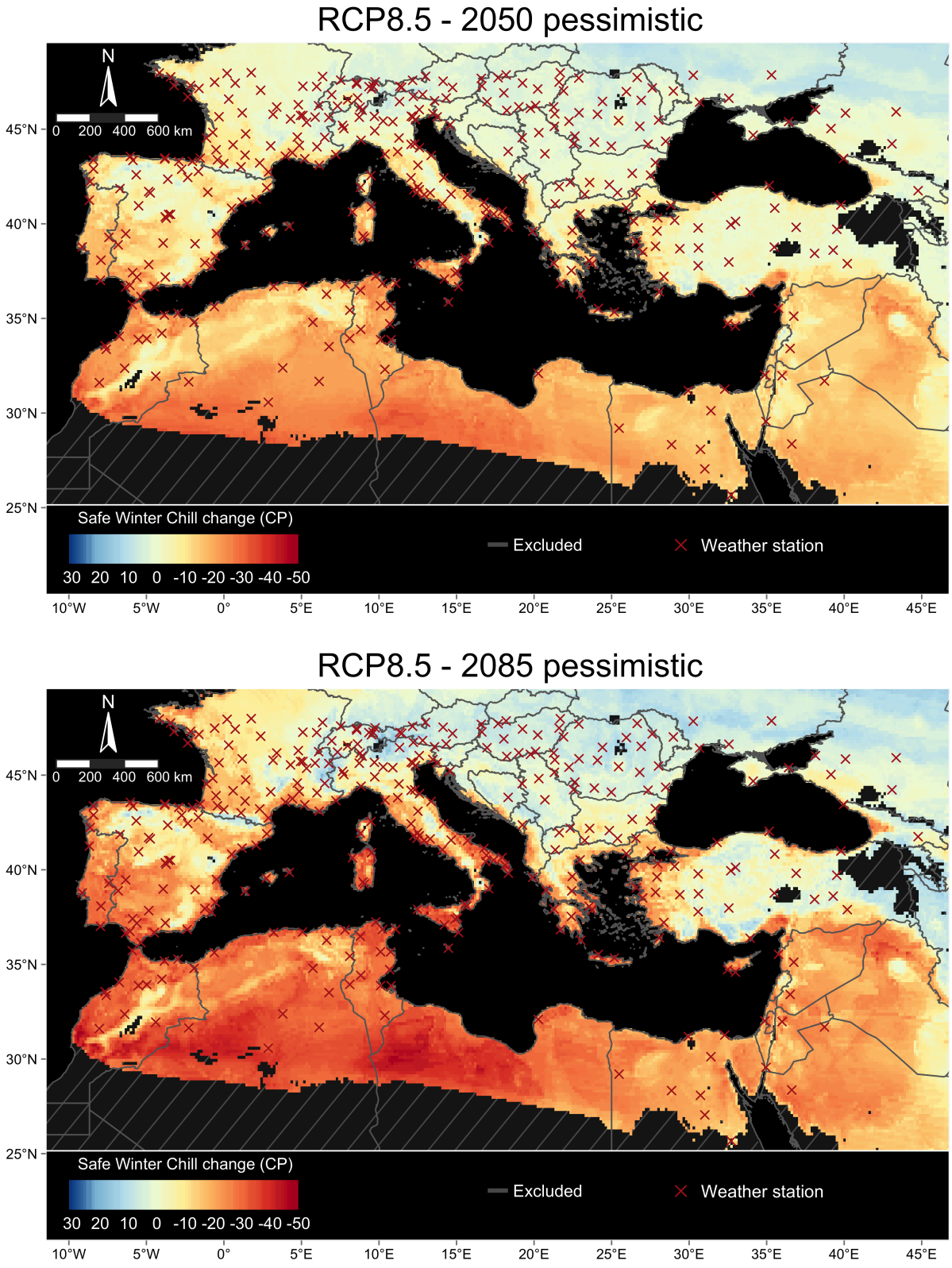


Figure S3: Estimation of Safe Winter Chill change for the Mediterranean region under the RCP8.5 scenario by two time horizons relative to historic simulated scenarios. In both panels, we show the difference in SWC between the respective combination of future scenario and year and the median across historic simulated scenarios between 1975 and 2019. For future scenarios, we used the results of the "pessimistic" climate model class (15th percentile among 15 General Circulation Models). The grey hatched areas in the maps represent regions excluded from the 3D correction model. The red crosses represent the locations of the weather stations used in the analysis

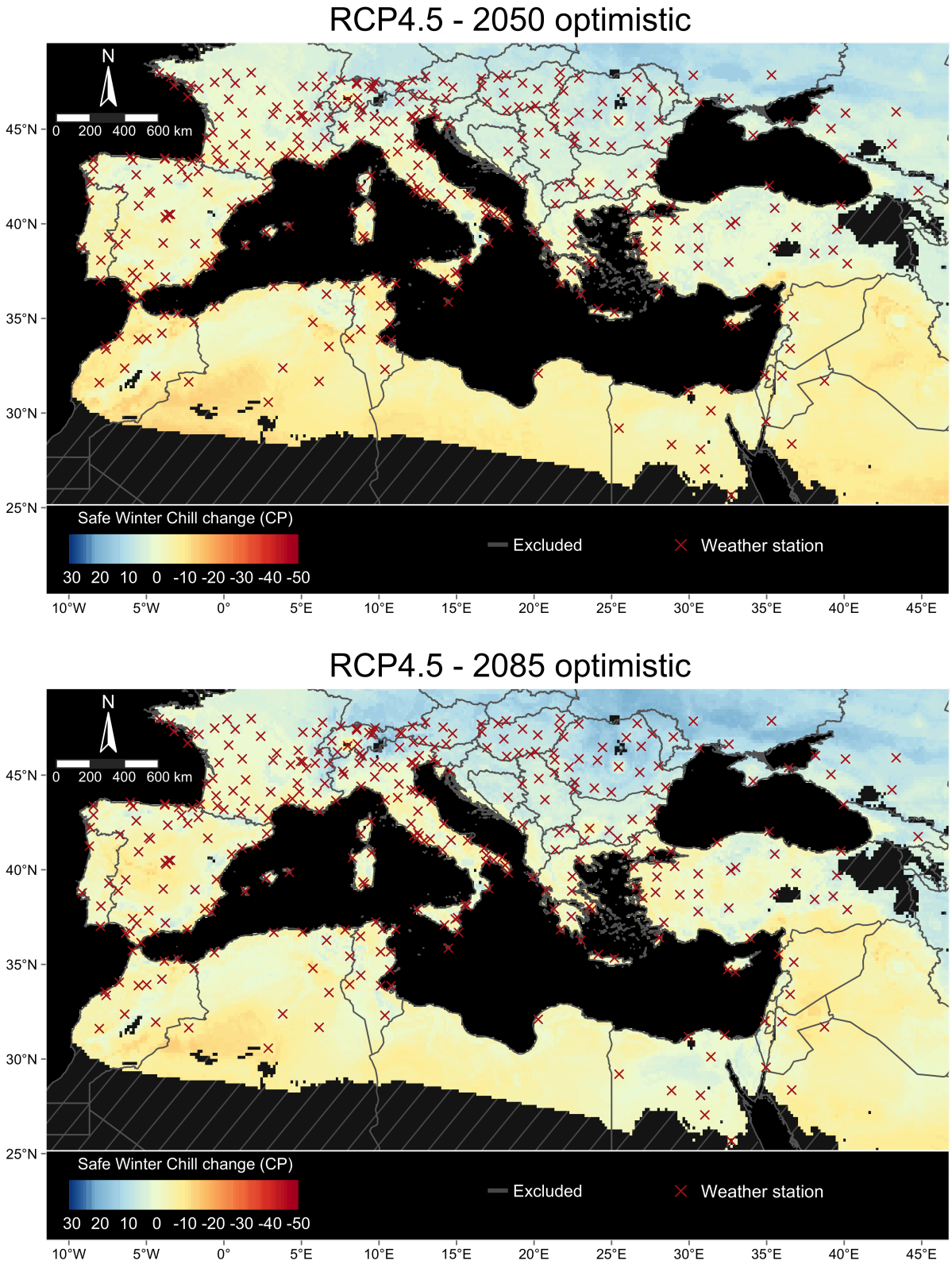


Figure S4: Estimation of Safe Winter Chill change for the Mediterranean region under the RCP4.5 scenario by two time horizons relative to historic simulated scenarios. In both panels, we show the difference in SWC between the respective combination of future scenario and year and the median across historic simulated scenarios between 1975 and 2019. For future scenarios, we used the results of the "optimistic" climate model class (85th percentile among 15 General Circulation Models). The grey hatched areas in the maps represent regions excluded from the 3D correction model. The red crosses represent the locations of the weather stations used in the analysis

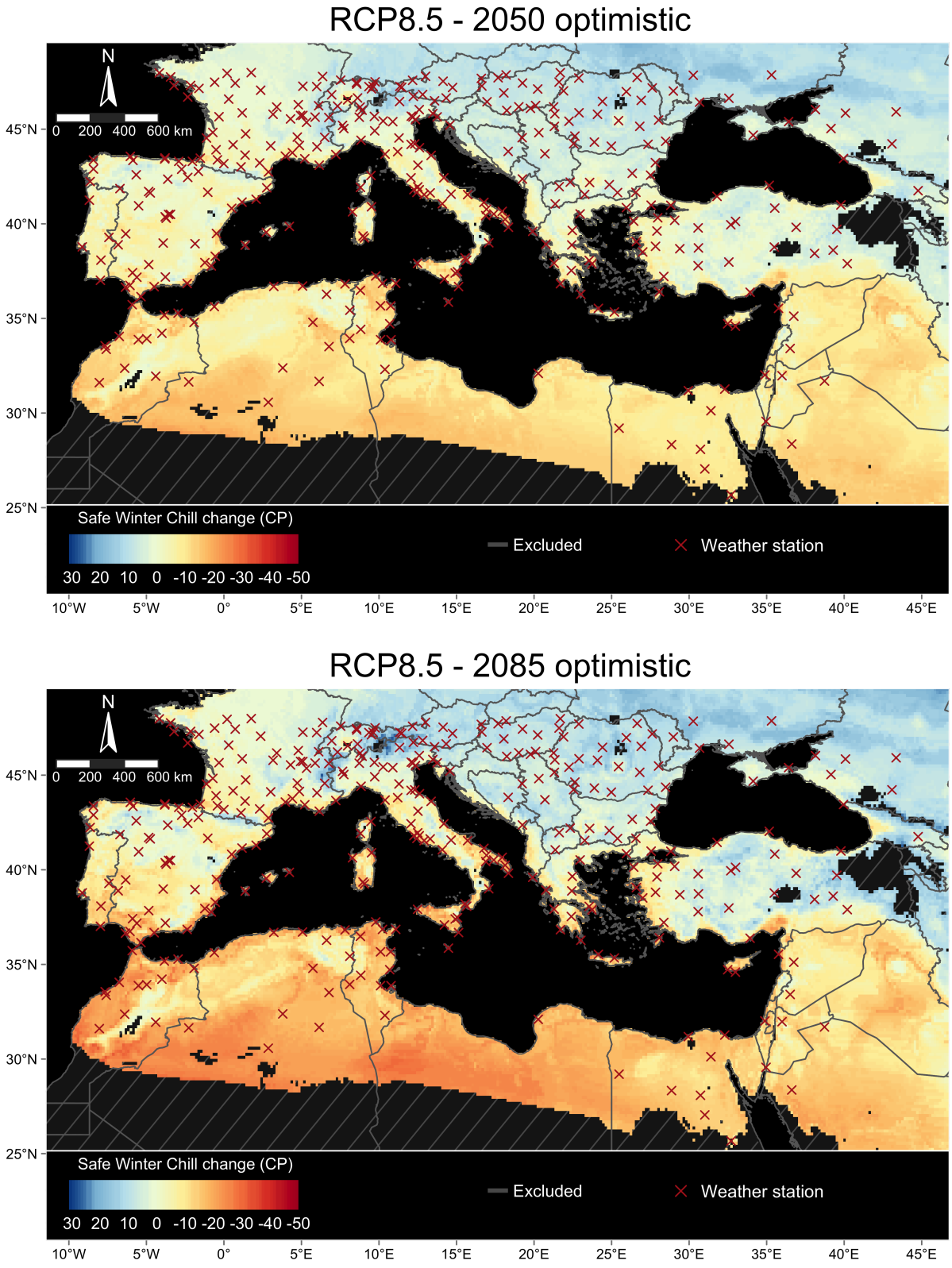


Figure S5: Estimation of Safe Winter Chill change for the Mediterranean region under the RCP8.5 scenario by two time horizons relative to historic simulated scenarios. In both panels, we show the difference in SWC between the respective combination of future scenario and year and the median across historic simulated scenarios between 1975 and 2019. For future scenarios, we used the results of the "optimistic" climate model class (85th percentile among 15 General Circulation Models). The grey hatched areas in the maps represent regions excluded from the 3D correction model. The red crosses represent the locations of the weather stations used in the analysis