# Supplementary materials for "Warm winters challenge the cultivation of temperate species in South America – a spatial analysis of chill accumulation"

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## Supplementary materials

The following document offers supplementary information on the materials and methods as well as the results for the work "Warm winters challenge the cultivation of temperate species in South America – a spatial analysis of chill accumulation" by Fernandez et al. (2021). The work was published in the journal Climatic Change under the doi: doi. As mentioned in the main text, all scripts and analyses are available in a public repository (https://github.com/EduardoFernandezC/chill_south_america).

## Additional information on the weather stations used in the study

In this study, we used 158 weather stations located in South America as sources of on-site data. We estimated historic chill and projected chill levels under future scenarios for each of these weather stations. In a later step, we used the weather stations to interpolate winter chill across the continent. In Table S1, we show information regarding the weather stations (coordinates, elevation, database, among others).

Table S1. Information on the weather stations used for interpolating Safe Winter Chill across South America

| Station name | Country | Database [a] | Latitude | Longitude | Elevation above sea level (m) | Data complete (%) [b] |
|---|---|---|---|---|---|---|
| **Matecana** | Colombia | GSOD | 4.81 °N | 75.74 °W | 1346.0 | 91.71 |
| **El Dorado International** | Colombia | GSOD | 4.70 °N | 74.15 °W | 2548.4 | 99.44 |
| **Alfonso Bonilla Aragon International** | Colombia | GSOD | 3.54 °N | 76.38 °W | 963.8 | 96.43 |
| **Boa Vista** | Brazil | GSOD | 2.85 °N | 60.69 °W | 84.1 | 94.78 |
| **Val de Cans International** | Brazil | GSOD | 1.38 °S | 48.48 °W | 16.5 | 99.40 |
| **Simon Bolivar International** | Ecuador | GSOD | 2.16 °S | 79.88 °W | 5.8 | 97.72 |
| **Santarem** | Brazil | GSOD | 2.42 °S | 54.79 °W | 60.4 | 98.74 |
| **Eduardo Gomes International** | Brazil | GSOD | 3.04 °S | 60.05 °W | 80.5 | 99.87 |
| **Ponta Pelada** | Brazil | GSOD | 3.15 °S | 59.99 °W | 81.4 | 98.77 |
| **Pedro Canga** | Peru | GSOD | 3.55 °S | 80.38 °W | 35.1 | 90.43 |
| **Coronel Francisco Secada Vignetta International** | Peru | GSOD | 3.79 °S | 73.31 °W | 93.3 | 99.85 |
| **Alfredo Vasquez Cobo** | Colombia | GSOD | 4.19 °S | 69.94 °W | 84.4 | 97.98 |
| **Capitan Fap Guillermo Concha Iberico** | Peru | GSOD | 5.21 °S | 80.62 °W | 35.4 | 92.70 |
| **Capitan Jose A Quinones Gonzales International** | Peru | GSOD | 6.79 °S | 79.83 °W | 29.6 | 97.37 |
| **Capitan Carlos Martinez de Pinillos** | Peru | GSOD | 8.08 °S | 79.11 °W | 32.3 | 95.08 |
| **Capitan Fap David Abenzur Rengifo International** | Peru | GSOD | 8.38 °S | 74.57 °W | 156.4 | 96.49 |
| **Heroes del Acre** | Bolivia | GSOD | 11.04 °S | 68.78 °W | 271.9 | 92.78 |
| **Jorge Chavez International** | Peru | GSOD | 12.02 °S | 77.11 °W | 34.4 | 94.69 |
| **Deputado Luis Eduardo Magalhaes** | Brazil | GSOD | 12.91 °S | 38.33 °W | 19.5 | 99.75 |
| **Teniente Alejandro Velasco Astete International** | Peru | GSOD | 13.54 °S | 71.94 °W | 3310.1 | 99.77 |
| **Pisco International** | Peru | GSOD | 13.74 °S | 76.22 °W | 11.9 | 99.81 |
| **Rurrenabaque** | Bolivia | GSOD | 14.48 °S | 67.48 °W | 202.0 | 90.70 |
| **Teniente AV Jorge Henrich Arauz** | Bolivia | GSOD | 14.82 °S | 64.92 °W | 155.1 | 95.32 |

| Station name | Country | Database [a] | Latitude | Longitude | Elevation above sea level (m) | Data complete (%) [b] |
|---|---|---|---|---|---|---|
| **Marechal Rondon** | Brazil | GSOD | 15.65 °S | 56.12 °W | 188.1 | 92.94 |
| **Presidente Juscelino Kubitschek** | Brazil | GSOD | 15.86 °S | 47.91 °W | 1060.4 | 99.87 |
| **Rodriguez Ballon** | Peru | GSOD | 16.34 °S | 71.58 °W | 2561.8 | 95.21 |
| **El Alto International** | Bolivia | GSOD | 16.51 °S | 68.19 °W | 4061.5 | 99.70 |
| **Jorge Wilsterman** | Bolivia | GSOD | 17.42 °S | 66.18 °W | 2548.1 | 99.55 |
| **El Trompillo** | Bolivia | GSOD | 17.81 °S | 63.17 °W | 417.9 | 94.99 |
| **Coronel Carlos Ciriani Santa Rosa International** | Peru | GSOD | 18.05 °S | 70.28 °W | 468.8 | 93.30 |
| **Chacalluta** | Chile | GSOD | 18.35 °S | 70.34 °W | 50.9 | 99.91 |
| **Chacalluta Arica Ap.** | Chile | CR[2] | 18.35 °S | 70.34 °W | 63.0 | 100.00 |
| **Azapa** | Chile | CR[2] | 18.52 °S | 70.18 °W | 365.0 | 95.86 |
| **Codpa** | Chile | CR[2] | 18.83 °S | 69.74 °W | 1870.0 | 93.49 |
| **Goiabeiras** | Brazil | GSOD | 20.26 °S | 40.29 °W | 3.4 | 98.61 |
| **Campo Grande** | Brazil | GSOD | 20.47 °S | 54.67 °W | 558.7 | 99.79 |
| **Diego Aracena Iquique Ap.** | Chile | CR[2] | 20.54 °S | 70.18 °W | 52.0 | 100.00 |
| **Chiu-Chiu** | Chile | CR[2] | 22.34 °S | 68.64 °W | 2524.0 | 91.46 |
| **El Loa Calama Ad.** | Chile | CR[2] | 22.50 °S | 68.91 °W | 2293.0 | 99.60 |
| **Galeao Antonio Carlos Jobim** | Brazil | GSOD | 22.81 °S | 43.24 °W | 8.5 | 99.88 |
| **Santos Dumont** | Brazil | GSOD | 22.91 °S | 43.16 °W | 3.4 | 97.65 |
| **Viracopos** | Brazil | GSOD | 23.01 °S | 47.13 °W | 661.4 | 99.74 |
| **Londrina 2** | Brazil | GSOD | 23.33 °S | 51.13 °W | 569.1 | 97.42 |
| **Cerro Moreno International** | Chile | GSOD | 23.44 °S | 70.44 °W | 138.7 | 99.74 |
| **Teniente Col Carmelo Peralta** | Paraguay | GSOD | 23.44 °S | 57.43 °W | 77.1 | 91.69 |
| **Cerro Moreno Antofagasta Ap.** | Chile | CR[2] | 23.45 °S | 70.44 °W | 113.0 | 99.99 |
| **Congonhas** | Brazil | GSOD | 23.63 °S | 46.66 °W | 801.9 | 99.81 |
| **Jujuy** | Argentina | GSOD | 24.39 °S | 65.10 °W | 920.2 | 99.17 |
| **Salta** | Argentina | GSOD | 24.86 °S | 65.49 °W | 1246.0 | 93.61 |
| **Silvio Pettirossi International** | Paraguay | GSOD | 25.24 °S | 57.52 °W | 89.0 | 99.60 |

| Station name | Country | Database [a] | Latitude | Longitude | Elevation above sea level (m) | Data complete (%) [b] |
|---|---|---|---|---|---|---|
| **Afonso Pena** | Brazil | GSOD | 25.53 °S | 49.18 °W | 910.7 | 99.62 |
| **Cataratas International** | Brazil | GSOD | 25.60 °S | 54.49 °W | 239.9 | 93.50 |
| **Cataratas del Iguazu** | Argentina | GSOD | 25.74 °S | 54.47 °W | 279.2 | 95.00 |
| **Formosa** | Argentina | GSOD | 26.21 °S | 58.23 °W | 59.1 | 96.53 |
| **Posadas** | Argentina | GSOD | 27.39 °S | 55.97 °W | 131.1 | 99.27 |
| **Corrientes** | Argentina | GSOD | 27.45 °S | 58.76 °W | 61.9 | 95.29 |
| **Resistencia** | Argentina | GSOD | 27.45 °S | 59.06 °W | 52.7 | 99.67 |
| **Hercilio Luz** | Brazil | GSOD | 27.67 °S | 48.55 °W | 6.1 | 96.60 |
| **Santiago del Estero** | Argentina | GSOD | 27.77 °S | 64.31 °W | 199.9 | 98.77 |
| **Catamarca** | Argentina | GSOD | 28.60 °S | 65.75 °W | 463.9 | 97.79 |
| **Santa Juana** | Chile | CR[2] | 28.67 °S | 70.66 °W | 560.0 | 98.36 |
| **Reconquista aero** | Argentina | GSOD | 29.18 °S | 59.70 °W | 48.0 | 92.65 |
| **El Trapiche** | Chile | CR[2] | 29.37 °S | 71.12 °W | 300.0 | 94.68 |
| **La Rioja** | Argentina | GSOD | 29.38 °S | 66.80 °W | 437.7 | 98.95 |
| **Paso de los Libres** | Argentina | GSOD | 29.69 °S | 57.15 °W | 70.1 | 98.80 |
| **Ceres** | Argentina | GSOD | 29.88 °S | 61.95 °W | 88.0 | 98.25 |
| **La Florida** | Chile | GSOD | 29.92 °S | 71.20 °W | 146.6 | 98.29 |
| **La Florida La Serena Ad.** | Chile | CR[2] | 29.92 °S | 71.20 °W | 142.0 | 99.94 |
| **Salgado Filho** | Brazil | GSOD | 29.99 °S | 51.17 °W | 3.4 | 95.53 |
| **La Ortiga** | Chile | CR[2] | 30.19 °S | 70.48 °W | 1560.0 | 97.34 |
| **Artigas International** | Uruguay | GSOD | 30.40 °S | 56.51 °W | 128.0 | 92.38 |
| **Paloma embalse** | Chile | CR[2] | 30.70 °S | 71.04 °W | 320.0 | 96.46 |
| **Presidente General Don Oscar de Gestido** | Uruguay | GSOD | 30.98 °S | 55.48 °W | 223.0 | 94.92 |
| **Cogoti embalse** | Chile | CR[2] | 31.01 °S | 71.09 °W | 740.0 | 96.72 |
| **Comodoro Pierrestegui** | Argentina | GSOD | 31.30 °S | 58.00 °W | 34.1 | 98.47 |
| **Ambrosio L.V. Taravella** | Argentina | GSOD | 31.32 °S | 64.21 °W | 488.9 | 99.53 |
| **Nueva Hesperides International** | Uruguay | GSOD | 31.43 °S | 57.98 °W | 57.0 | 98.52 |
| **San Juan** | Argentina | GSOD | 31.57 °S | 68.42 °W | 597.1 | 99.24 |
| **Illapel Dga** | Chile | CR[2] | 31.64 °S | 71.19 °W | 290.0 | 97.26 |
| **Sauce viejo** | Argentina | GSOD | 31.71 °S | 60.81 °W | 17.1 | 90.39 |

| Station name | Country | Database [a] | Latitude | Longitude | Elevation above sea level (m) | Data complete (%) [b] |
|---|---|---|---|---|---|---|
| **General Urquiza** | Argentina | GSOD | 31.80 °S | 60.48 °W | 74.1 | 90.33 |
| **La Tranquilla** | Chile | CR[2] | 31.90 °S | 70.67 °W | 1000.0 | 97.36 |
| **Los Condores** | Chile | CR[2] | 32.11 °S | 71.31 °W | 190.0 | 92.50 |
| **Alicahue** | Chile | CR[2] | 32.34 °S | 70.75 °W | 750.0 | 95.19 |
| **Marcos Juarez** | Argentina | GSOD | 32.68 °S | 62.16 °W | 110.0 | 98.58 |
| **Paso de los Toros** | Uruguay | GSOD | 32.80 °S | 56.52 °W | 75.0 | 94.93 |
| **El Plumerillo** | Argentina | GSOD | 32.83 °S | 68.79 °W | 704.1 | 99.69 |
| **Vilcuya** | Chile | CR[2] | 32.86 °S | 70.47 °W | 1100.0 | 96.14 |
| **Quillota** | Chile | CR[2] | 32.90 °S | 71.21 °W | 130.0 | 94.67 |
| **Rosario** | Argentina | GSOD | 32.90 °S | 60.78 °W | 25.9 | 98.03 |
| **Gualeguaychu** | Argentina | GSOD | 33.01 °S | 58.61 °W | 22.9 | 98.59 |
| **Rio Cuarto Area de Material** | Argentina | GSOD | 33.08 °S | 64.26 °W | 420.9 | 98.56 |
| **Lliu-Lliu embalse** | Chile | CR[2] | 33.10 °S | 71.21 °W | 260.0 | 95.64 |
| **Lago Peñuelas** | Chile | CR[2] | 33.15 °S | 71.56 °W | 360.0 | 95.69 |
| **San Luis** | Argentina | GSOD | 33.27 °S | 66.36 °W | 709.9 | 97.19 |
| **Pudahuel Santiago** | Chile | CR[2] | 33.39 °S | 70.79 °W | 482.0 | 100.00 |
| **Arturo Merino Benitez International** | Chile | GSOD | 33.39 °S | 70.79 °W | 474.0 | 99.85 |
| **Cerro Calan** | Chile | CR[2] | 33.40 °S | 70.54 °W | 848.0 | 99.95 |
| **Los Panguiles** | Chile | CR[2] | 33.44 °S | 71.03 °W | 190.0 | 92.77 |
| **Quinta Normal Santiago** | Chile | CR[2] | 33.44 °S | 70.68 °W | 527.0 | 99.99 |
| **Eulogio Sanchez Tobalaba Ad.** | Chile | CR[2] | 33.45 °S | 70.55 °W | 650.0 | 96.95 |
| **Santo Domingo Ad.** | Chile | CR[2] | 33.66 °S | 71.61 °W | 75.0 | 99.48 |
| **Pirque** | Chile | CR[2] | 33.67 °S | 70.59 °W | 659.0 | 90.81 |
| **Villa Reynolds** | Argentina | GSOD | 33.73 °S | 65.39 °W | 484.9 | 89.82 |
| **Laguna de los Patos International** | Uruguay | GSOD | 34.46 °S | 57.77 °W | 21.0 | 94.06 |
| **Rocha** | Uruguay | GSOD | 34.48 °S | 54.30 °W | 18.0 | 98.03 |
| **Junin** | Argentina | GSOD | 34.55 °S | 60.93 °W | 79.9 | 99.21 |
| **Aeroparque Jorge Newbery** | Argentina | GSOD | 34.56 °S | 58.42 °W | 5.5 | 95.79 |
| **San Rafael** | Argentina | GSOD | 34.59 °S | 68.40 °W | 752.9 | 98.82 |

| Station name | Country | Database [a] | Latitude | Longitude | Elevation above sea level (m) | Data complete (%) [b] |
|---|---|---|---|---|---|---|
| **Ministro Pistarini** | Argentina | GSOD | 34.82 °S | 58.54 °W | 20.4 | 99.62 |
| **Carrasco International** | Uruguay | GSOD | 34.84 °S | 56.03 °W | 32.0 | 99.95 |
| **General Freire Curico Ad.** | Chile | CR[2] | 34.97 °S | 71.22 °W | 225.0 | 99.93 |
| **Potrero Grande** | Chile | CR[2] | 35.18 °S | 71.10 °W | 445.0 | 98.58 |
| **Talca U.C.** | Chile | CR[2] | 35.44 °S | 71.62 °W | 130.0 | 91.30 |
| **Malargue** | Argentina | GSOD | 35.49 °S | 69.57 °W | 1430.1 | 94.76 |
| **Colorado** | Chile | CR[2] | 35.64 °S | 71.26 °W | 420.0 | 90.11 |
| **Parral** | Chile | CR[2] | 36.19 °S | 71.83 °W | 175.0 | 91.62 |
| **Digua embalse** | Chile | CR[2] | 36.26 °S | 71.55 °W | 390.0 | 99.58 |
| **Santa Rosa Aero** | Chile | CR[2] | 36.57 °S | 64.27 °W | 192.0 | 91.12 |
| **Bernardo O'Higgins Chillan Ad.** | Chile | CR[2] | 36.59 °S | 72.04 °W | 151.0 | 99.95 |
| **Santa Rosa** | Argentina | GSOD | 36.59 °S | 64.28 °W | 192.0 | 97.85 |
| **Carriel Sur International** | Chile | GSOD | 36.77 °S | 73.06 °W | 7.9 | 99.69 |
| **Carriel Sur Concepcion** | Chile | CR[2] | 36.78 °S | 73.06 °W | 12.0 | 100.00 |
| **Diguillin** | Chile | CR[2] | 36.87 °S | 71.64 °W | 670.0 | 96.42 |
| **Tandil** | Argentina | GSOD | 37.24 °S | 59.23 °W | 175.0 | 97.84 |
| **Mar del Plata** | Argentina | GSOD | 37.93 °S | 57.57 °W | 21.6 | 98.40 |
| **Traiguen** | Chile | CR[2] | 38.26 °S | 72.65 °W | 234.0 | 92.61 |
| **Comandante Espora** | Argentina | GSOD | 38.73 °S | 62.17 °W | 75.0 | 97.08 |
| **Maquehue Temuco Ad.** | Chile | CR[2] | 38.77 °S | 72.64 °W | 92.0 | 98.65 |
| **Presidente Peron** | Argentina | GSOD | 38.95 °S | 68.16 °W | 272.8 | 97.07 |
| **Neuquen** | Argentina | SMN – INTA | 38.95 °S | 67.97 °W | 271.0 | 99.22 |
| **Ascasubi** | Argentina | SMN – INTA | 39.38 °S | 62.62 °W | 22.0 | 97.95 |
| **Pichoy Valdivia Ad.** | Chile | CR[2] | 39.65 °S | 73.08 °W | 21.0 | 99.88 |
| **Adolfo Matthei** | Chile | CR[2] | 40.59 °S | 73.11 °W | 55.0 | 91.68 |
| **Canal Bajo Osorno Ad.** | Chile | CR[2] | 40.60 °S | 73.06 °W | 61.0 | 99.22 |
| **Viedma** | Argentina | SMN – INTA | 40.85 °S | 63.02 °W | 7.0 | 96.88 |
| **Gobernador Castello** | Argentina | GSOD | 40.87 °S | 63.00 °W | 6.1 | 93.54 |
| **San Carlos de Bariloche** | Argentina | GSOD | 41.15 °S | 71.16 °W | 846.1 | 97.72 |

| Station name | Country | Database [a] | Latitude | Longitude | Elevation above sea level (m) | Data complete (%) [b] |
|---|---|---|---|---|---|---|
| **Maquinchao** | Argentina | SMN – INTA | 41.25 °S | 68.73 °W | 887.0 | 97.13 |
| **El Tepual Puerto Montt Ap.** | Chile | CR[2] | 41.44 °S | 73.10 °W | 85.0 | 99.98 |
| **El Tepual International** | Chile | GSOD | 41.44 °S | 73.09 °W | 89.6 | 99.47 |
| **Esquel** | Argentina | GSOD | 42.91 °S | 71.14 °W | 798.9 | 95.97 |
| **Futaleufu Ad.** | Chile | CR[2] | 43.19 °S | 71.85 °W | 347.0 | 93.38 |
| **Almirante Zar** | Argentina | GSOD | 43.21 °S | 65.27 °W | 43.0 | 98.09 |
| **Trelew** | Argentina | SMN – INTA | 43.23 °S | 65.32 °W | 10.0 | 99.39 |
| **Teniente Vidal Coyhaique Ad.** | Chile | CR[2] | 45.59 °S | 72.11 °W | 310.0 | 100.00 |
| **Comodoro Rivadavia** | Argentina | GSOD | 45.78 °S | 67.47 °W | 57.9 | 98.49 |
| **Balmaceda Ad.** | Chile | CR[2] | 45.91 °S | 71.69 °W | 517.0 | 99.96 |
| **Balmaceda** | Chile | GSOD | 45.92 °S | 71.69 °W | 524.9 | 96.82 |
| **Chile Chico Ad.** | Chile | CR[2] | 46.58 °S | 71.69 °W | 306.0 | 93.62 |
| **Lord Cochrane Ad.** | Chile | CR[2] | 47.24 °S | 72.59 °W | 204.0 | 95.89 |
| **San Julian** | Argentina | GSOD | 49.31 °S | 67.80 °W | 57.9 | 93.07 |
| **Torres del Paine** | Chile | CR[2] | 51.18 °S | 72.97 °W | 25.0 | 91.93 |
| **Rio Gallegos** | Argentina | GSOD | 51.61 °S | 69.31 °W | 18.6 | 98.06 |
| **Carlos Ibáñez del Campo International** | Chile | GSOD | 53.00 °S | 70.86 °W | 42.4 | 99.13 |
| **Punta Arenas** | Chile | CR[2] | 53.00 °S | 70.84 °W | 38.0 | 99.97 |
| **Punta Arenas 2** | Chile | CR[2] | 53.12 °S | 70.88 °W | 5.0 | 99.96 |
| **Rio Grande 2** | Argentina | GSOD | 53.78 °S | 67.75 °W | 19.8 | 94.93 |

[a] GSOD: Global Summary Of the Day; CR[2]: Center for Climate and Resilience Research; SMN – INTA: National Weather Service and National Institute of Agricultural Technology

[b] Mean percentage of data complete (minimum and maximum temperatures) between 01-01-1980 and 31-12-2017 for the period May 1 – August 31 (4,674 intended measurements)

**Additional information on the General Circulation Models used for future projections**

For future scenarios, we downloaded temperature projections from the ClimateWizard database. ClimateWizard contains future projections from 15 General Circulation Models (GCMs). In Table S2 we provide some basic information on the names of the models as well as the reference and/or link to the specific climate model.

Table S2. General Circulation Models used to assess future chilling scenarios. Adapted from Fernandez et al. (2020c)

| **Model name** | **Abbreviation** | **Reference and/or link** |
|---|---|---|
| Beijing Climate Center – Climate System Model 1.1 | bcc-csm1-1 | Wu (2012) http://forecast.bcccsm.ncc-cma.net/web/channel-43.htm |
| Geophysical Fluid Dynamics Laboratory – Earth System Models | GFDL-ESM2G | Delworth et al. (2006) https://www.gfdl.noaa.gov/earth-system-model/ |
| | GFDL-ESM2M | |
| | GFDL-CM3 | Donner et al. (2011) |
| Institute of Numerical Mathematics Climate Model version 4 | inmcm4 | Volodin et al. (2010) |
| Institute Pierre – Simon Laplace – Climate Model 5[a] | IPSL-CM5A-LR | https://cmc.ipsl.fr/ipsl-climate-models/ipsl-cm5/ |
| | IPSL-CM5A-MR | |
| Community Climate System Model 4 | CCSM4 | http://www.cesm.ucar.edu/models/ccsm4.0/ |
| Community Earth System Model version 1 – BioGeoChemical model enabled | CESM1-BGC | Lindsay et al. (2014) |
| Beijing Normal University – Earth System Model | BNU-ESM | Ji et al. (2014) |
| Canadian Earth System Model 2 | CanESM2 | Chylek et al. (2011) |
| Model for Interdisciplinary Research On Climate – Earth System Model | MIROC-ESM | Watanabe et al. (2011) |
| Centre National de Recherches Météorologiques – Climate Model 5 | CNRM-CM5 | http://www.umr-cnrm.fr/spip.php?article126&lang=en |
| Australian Community Climate and Earth-System Simulator 1.0 | ACCESS1-0 | Bi et al. (2013) |
| Commonwealth Scientific and Industrial Research Organisation – Mark3.6.0 | CSIRO-Mk3-6-0 | Rotstayn et al. (2010) |

**Comparison between WorldClim and on-site data**

We compared the monthly minimum and maximum temperatures for July from the WorldClim database to the on-site data. We set a threshold of 2 °C to retain weather stations and include only representative data in the interpolation procedure. In Fig. S1, we show the overall correlation among databases for minimum and maximum temperatures in July.

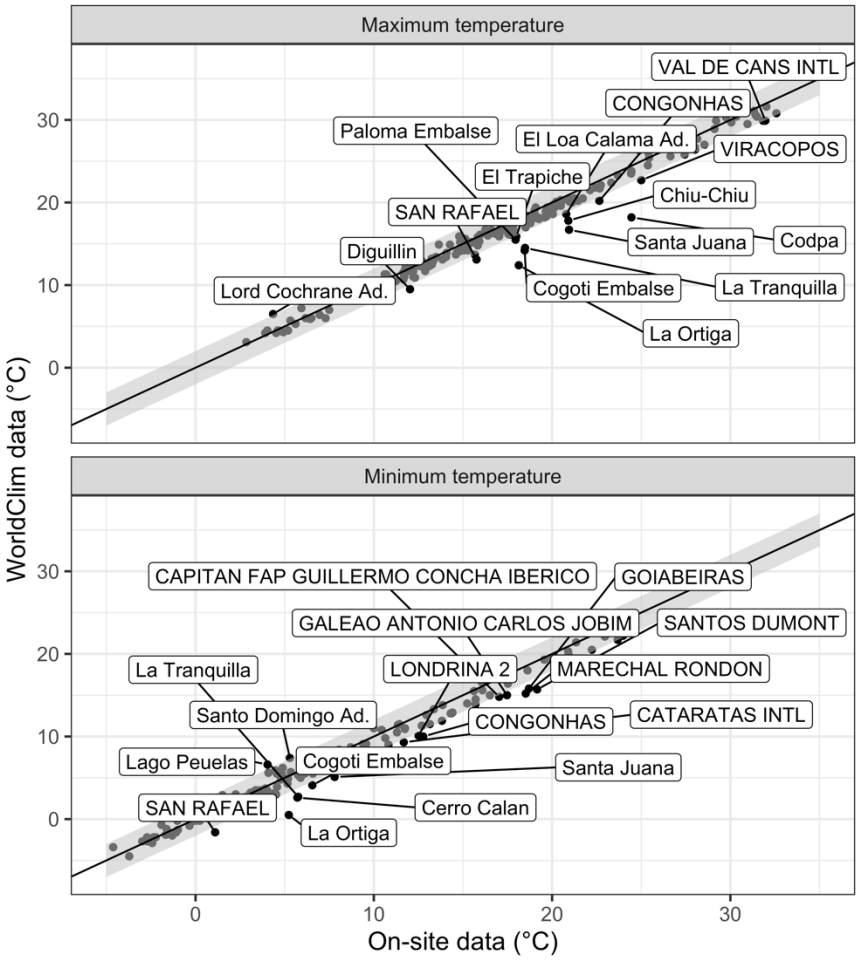


Figure S1. Correlation between data from the WorldClim database and on-site weather stations for minimum (lower panel) and maximum (upper panel) temperatures. The grey ribbon represents the threshold (2 °C) used to retain representative weather stations. The labels mark the weather stations removed at this point of the analysis

**Exclusion of regions falling outside the 3D correction model**

We excluded from the analysis the regions of South America for which the combination of monthly minimum and maximum temperatures in July showed no values for Safe Winter Chill. In Fig. S2, we show the cells (black dots) falling outside the 3D correction model implemented for each scenario evaluated. Most likely, the regions represented by the dark dots in the upper right corner of the plot show a rather tropical climate (northern South America) whereas the regions represented by the dots in the lower left corner show cold climates in the south of South America as well as areas near the Andes.

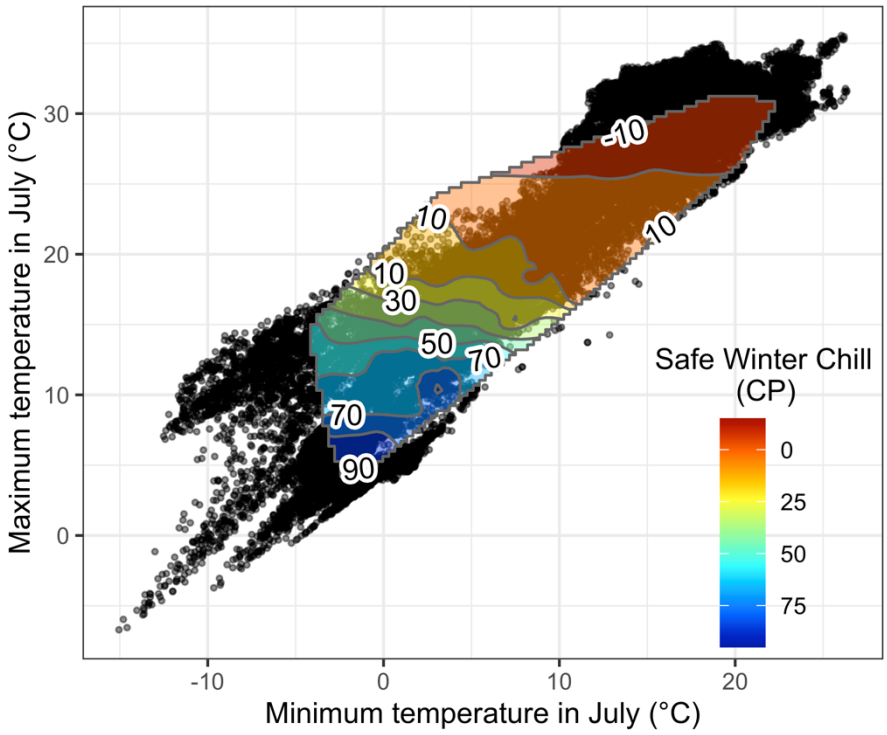


Figure S2. Three-dimensional correction model implemented to obtain SWC values from monthly extremes. The contour surface represents the relationship between the co-variables and SWC from the weather stations, whereas the dark dots represent the combination for monthly extremes in every cell of South America. The dots falling outside the contour surface are shown with a hatched layer in the main maps

**Predictors of Safe Winter Chill**

Among the proxies evaluated, the means of daily minimum and maximum temperature in July showed the strongest correlation with accumulation of Safe Winter Chill (Fig. S3).

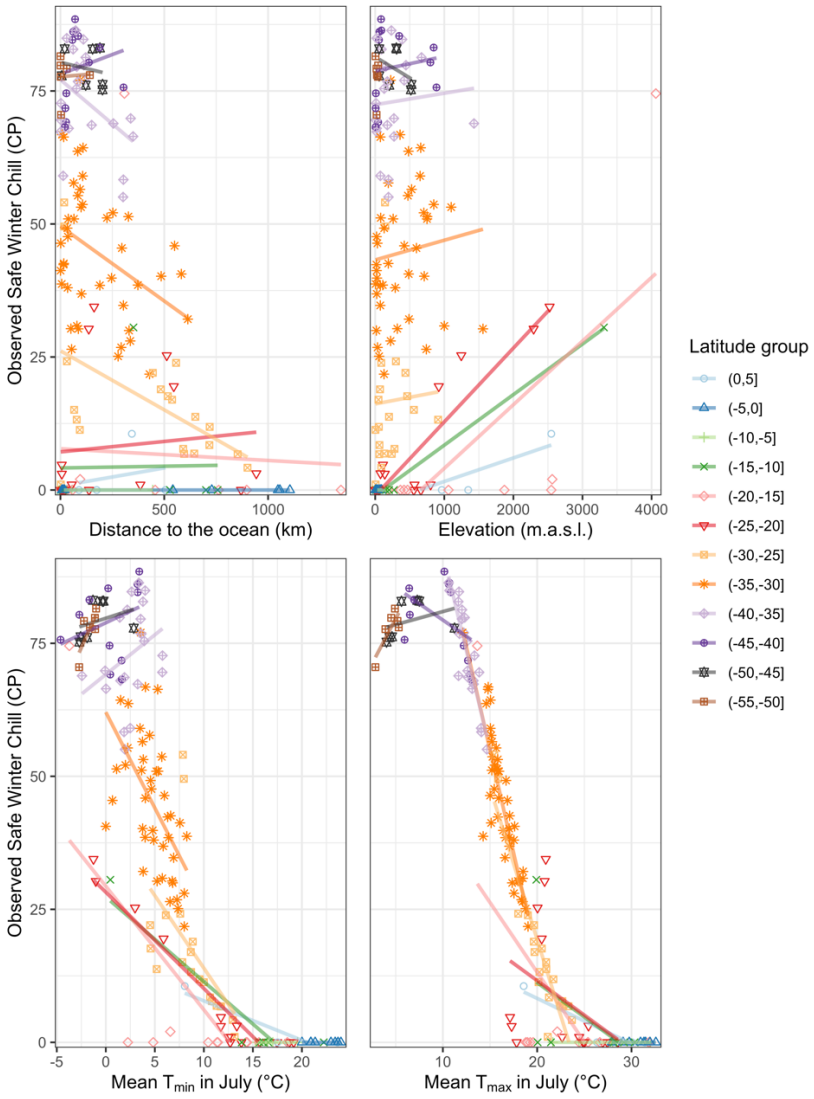


Figure S3. Correlation analysis between four variables and Safe Winter Chill in South America. We show the distance to the ocean (in km) and elevation above sea level (in m) on the x-axes of the upper panels and the means of daily minimum and maximum temperature in July on the x-axes of the bottom panels. On the y-axis of all panels, we show observed SWC computed in Chill Portions according to the Dynamic Model. The color legend represents different groups according to the latitude of the weather stations. The lines in each panel represent the linear relationship between SWC and the variables for each latitude group

**Additional figures for future scenarios**

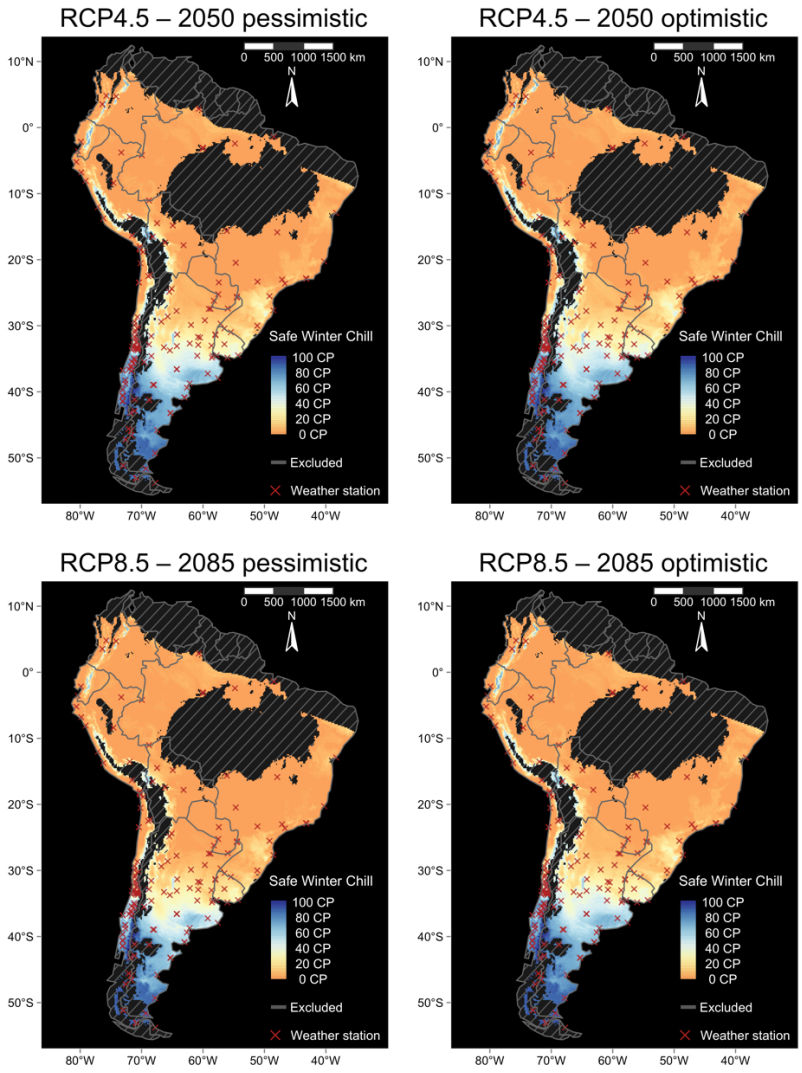


Figure S4. Projections of Safe Winter Chill (SWC in Chill Portions – CP according to the Dynamic Model) for South America for two global warming scenarios. In the first row ('RCP4.5 – 2050 pessimistic' and 'RCP4.5 – 2050 optimistic' panels), we show SWC estimated for a moderate warming scenario by the near future using two climate model classes. In the second row ('RCP8.5 – 2085 pessimistic' and 'RCP8.5 – 2085 optimistic' panels), we show SWC estimated for a strong warming scenario for the far future using two climate model classes. 'Pessimistic' and 'optimistic' labels represent the 15th and 85th quantile of the SWC distribution across the 15 General Circulation Models (see supplementary Table S2) used in this analysis. The grey hatched areas ('Excluded' in the legend) in the maps represent regions where the combination of mean daily minimum and maximum temperature in July fell outside the boundaries of the 3D correction model for the respective scenario. The red crosses represent the location of the weather stations used in the analysis

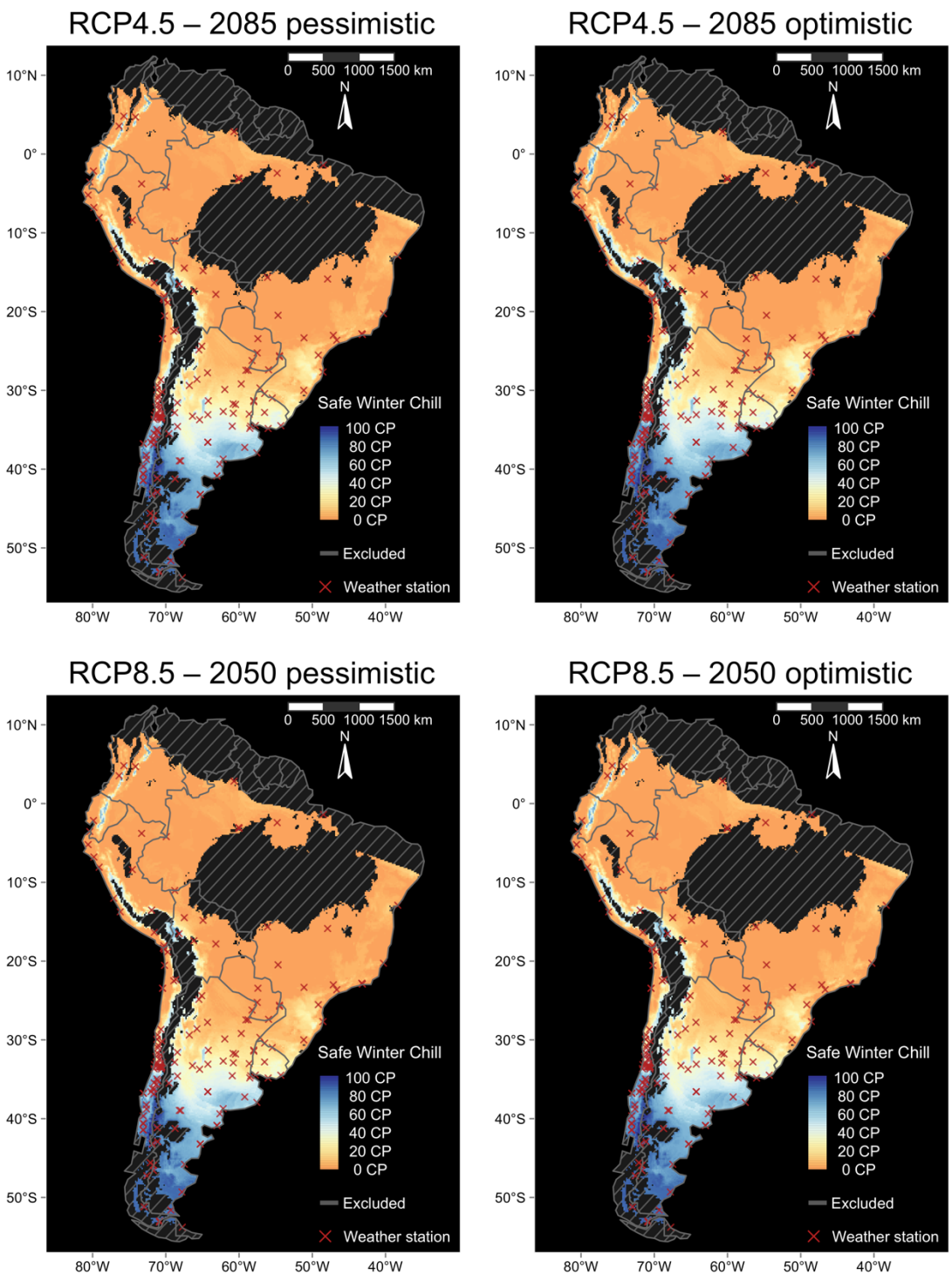


Figure S5. Projections of Safe Winter Chill for South America under two global warming scenarios and time horizons. For the full caption, please refer to Fig. S4

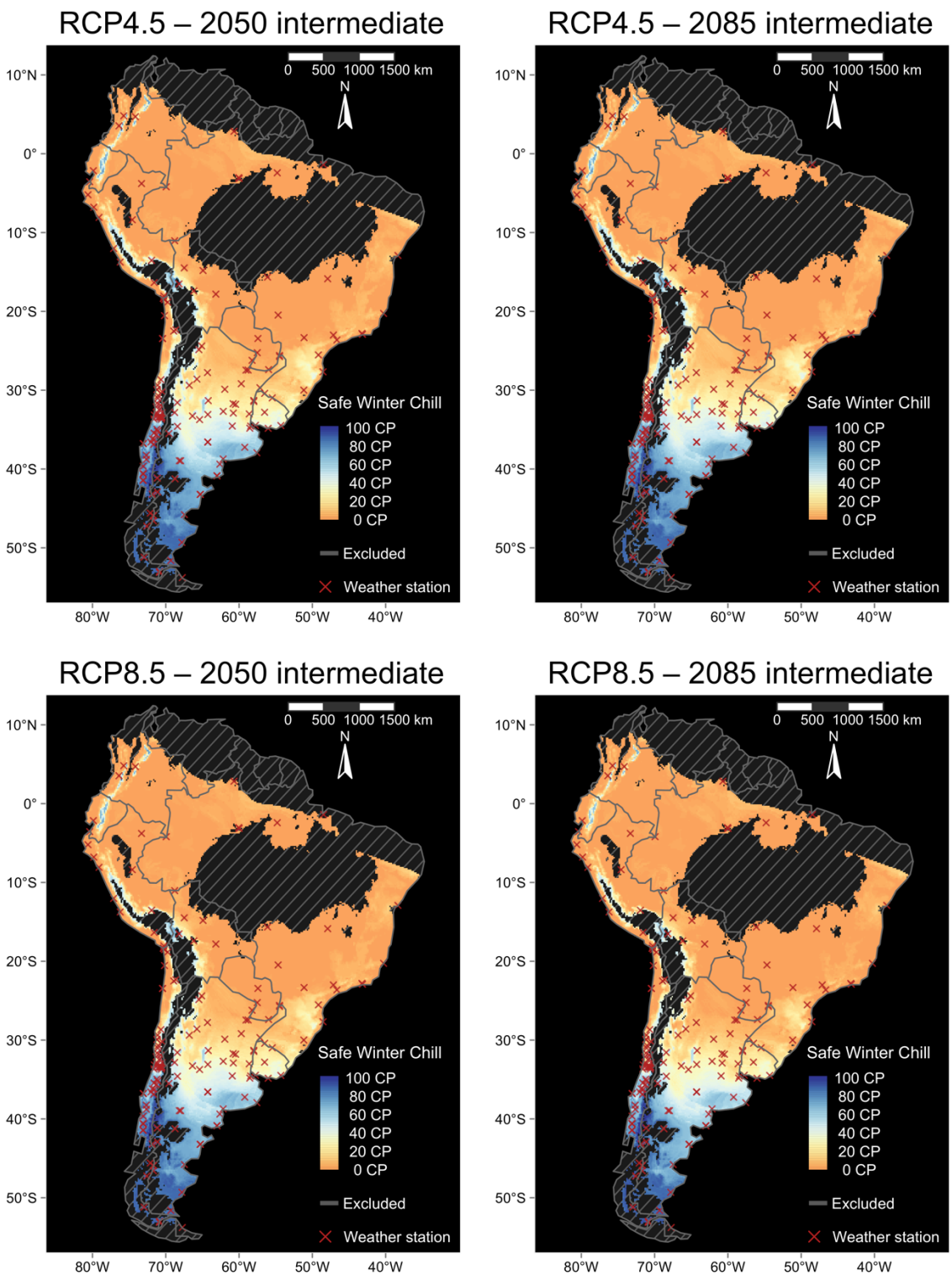


Figure S6. Projections of Safe Winter Chill for South America under two global warming scenarios and time horizons. For the full caption, please refer to Fig. S4

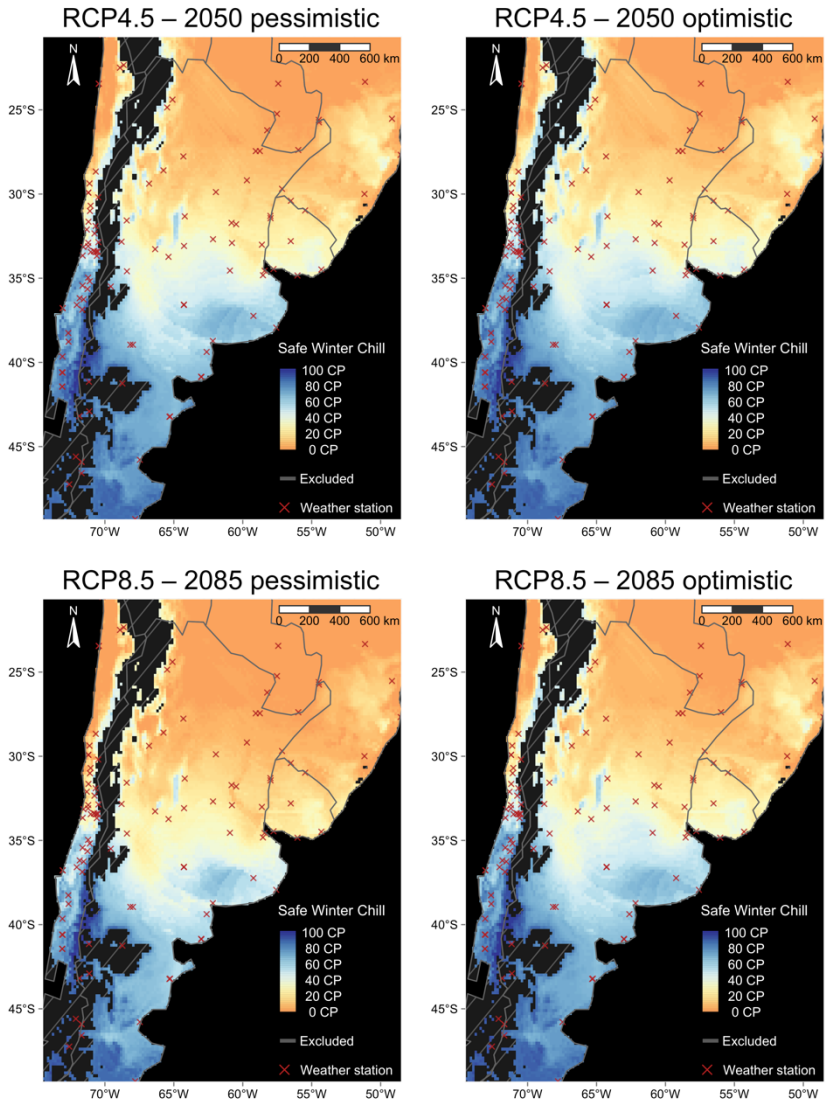


Figure S7. Projections of Safe Winter Chill (SWC in Chill Portions 398 – CP according to the Dynamic Model) for southern South America for two global warming scenarios. In the first row ('RCP4.5 – 2050 pessimistic' and 'RCP4.5 – 2050 optimistic' panels), we show SWC estimated for a moderate warming scenario by the near future using two climate model classes. In the second row ('RCP8.5 – 2085 pessimistic' and 'RCP8.5 – 2085 optimistic' panels), we show SWC estimated for a strong warming scenario for the far future using two climate model classes. 'Pessimistic' and 'optimistic' labels represent the 15th and 85th quantiles of the SWC distribution across the 15 General Circulation Models (see supplementary Table S2) used in this analysis. The grey hatched areas ('Excluded' in the legend) in the maps represent regions where the combination of mean daily minimum and maximum temperature in July fell outside the boundaries of the 3D correction model for the respective scenario. The red crosses represent the location of the weather stations used in the analysis

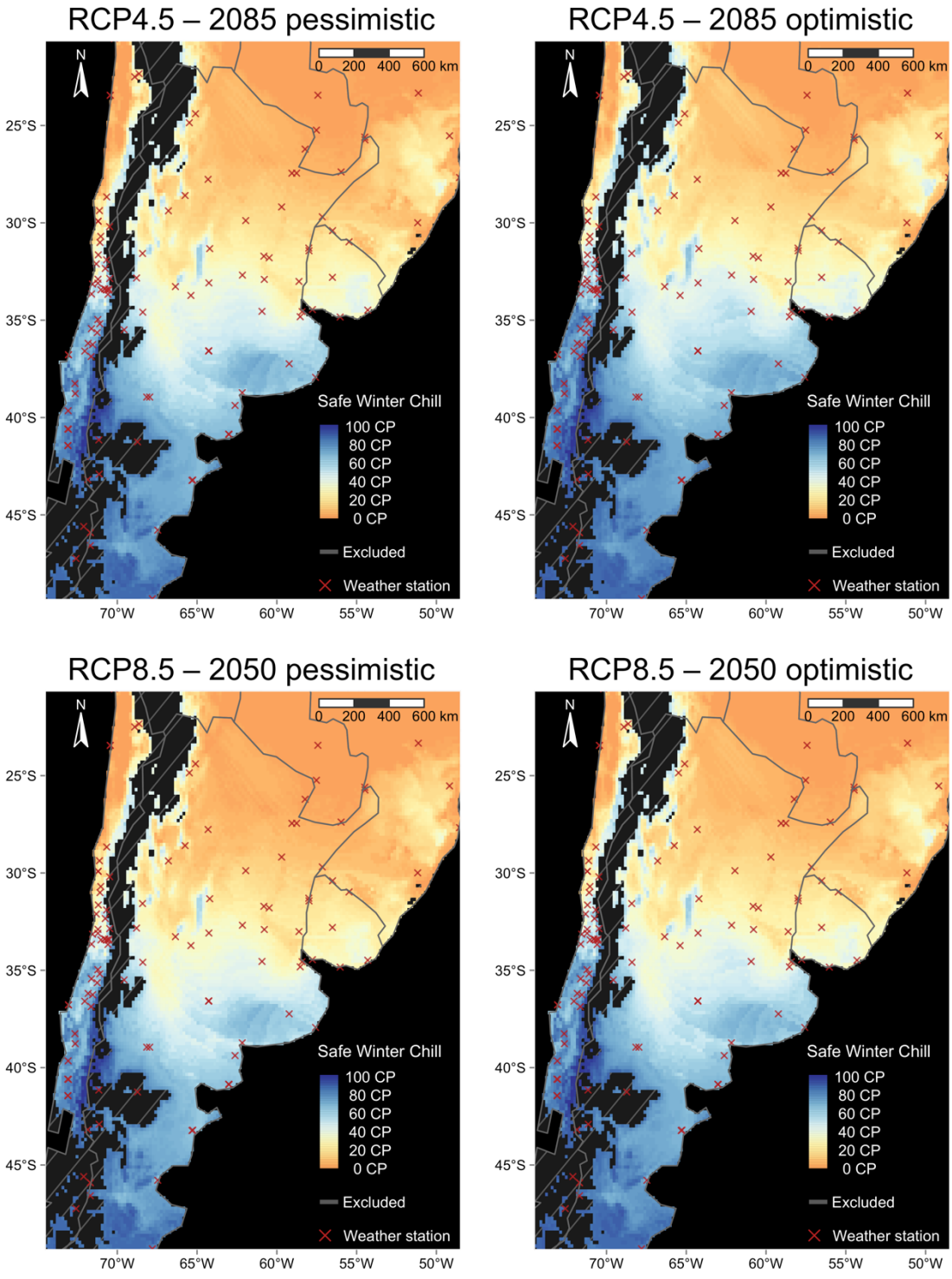


Figure S8. Projections of Safe Winter Chill for southern South America under two global warming scenarios and time horizons. For the full caption, please refer to Fig. S7

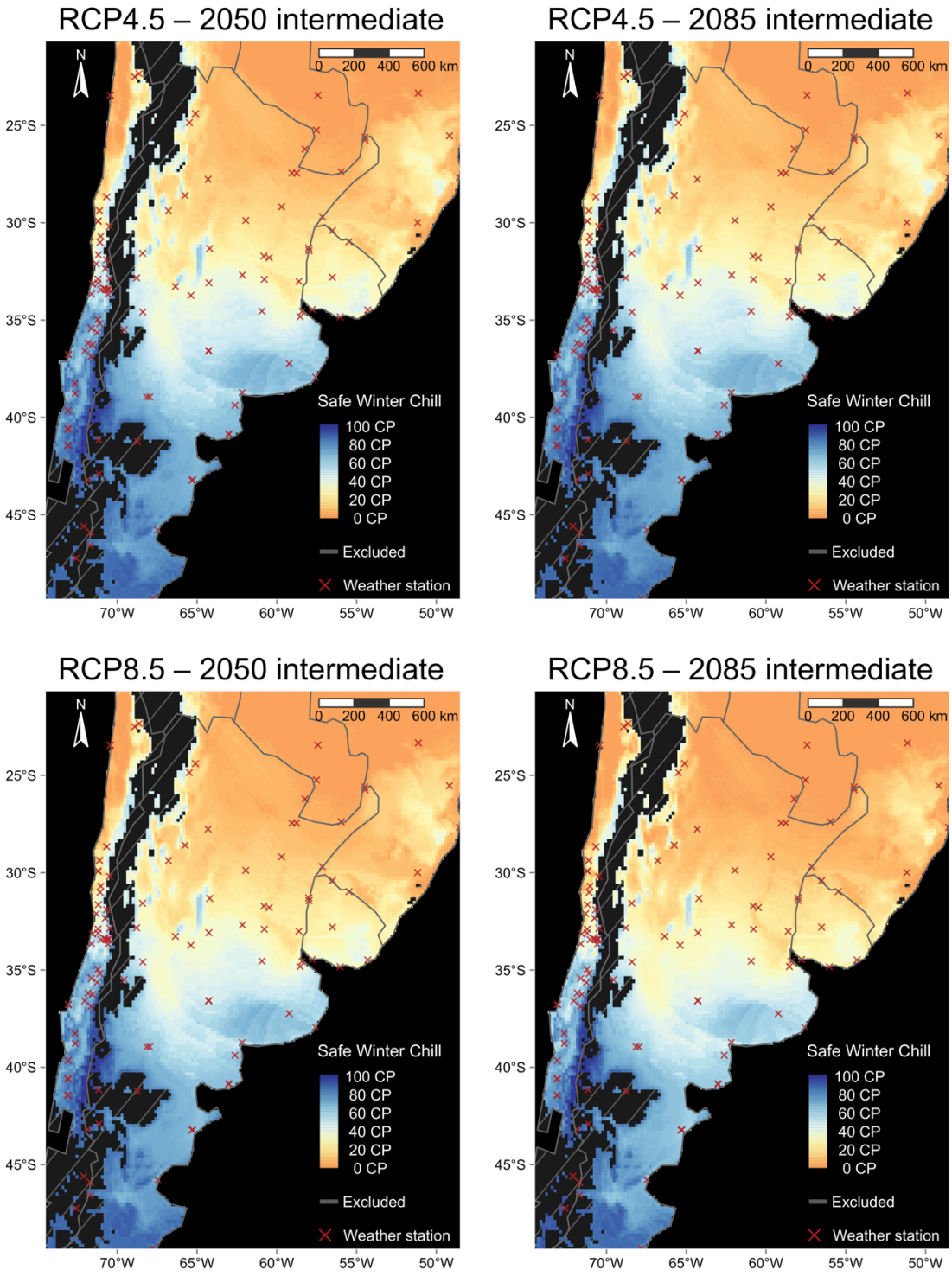


Figure S9. Projections of Safe Winter Chill for southern South America under two global warming scenarios and time horizons. For the full caption, please refer to Fig. S7

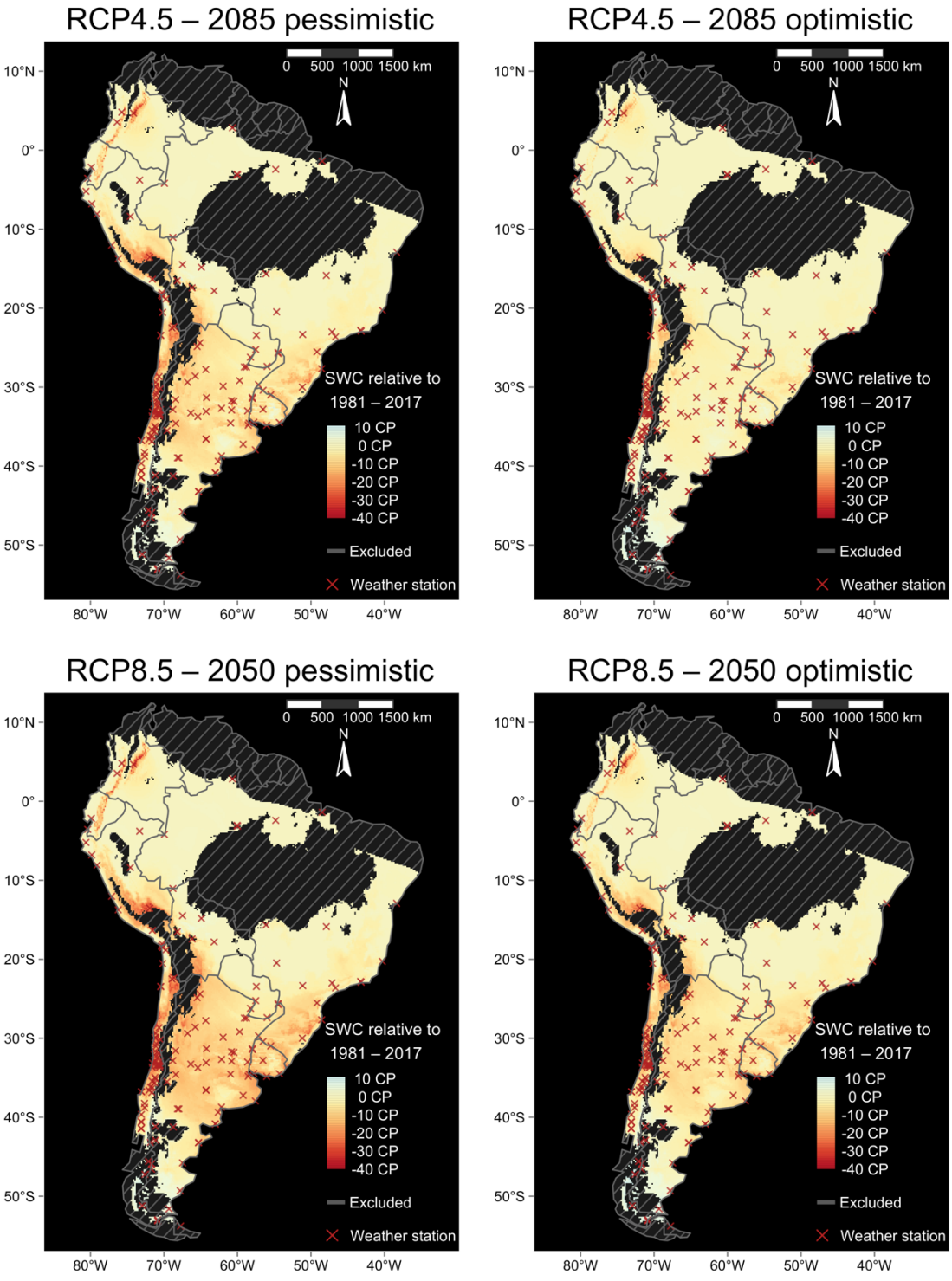


Figure S10. Change in Safe Winter Chill for South America compared to 1981 – 2017 under two global warming scenarios and time horizons. For the full caption, please refer to Fig. 5 in the main manuscript

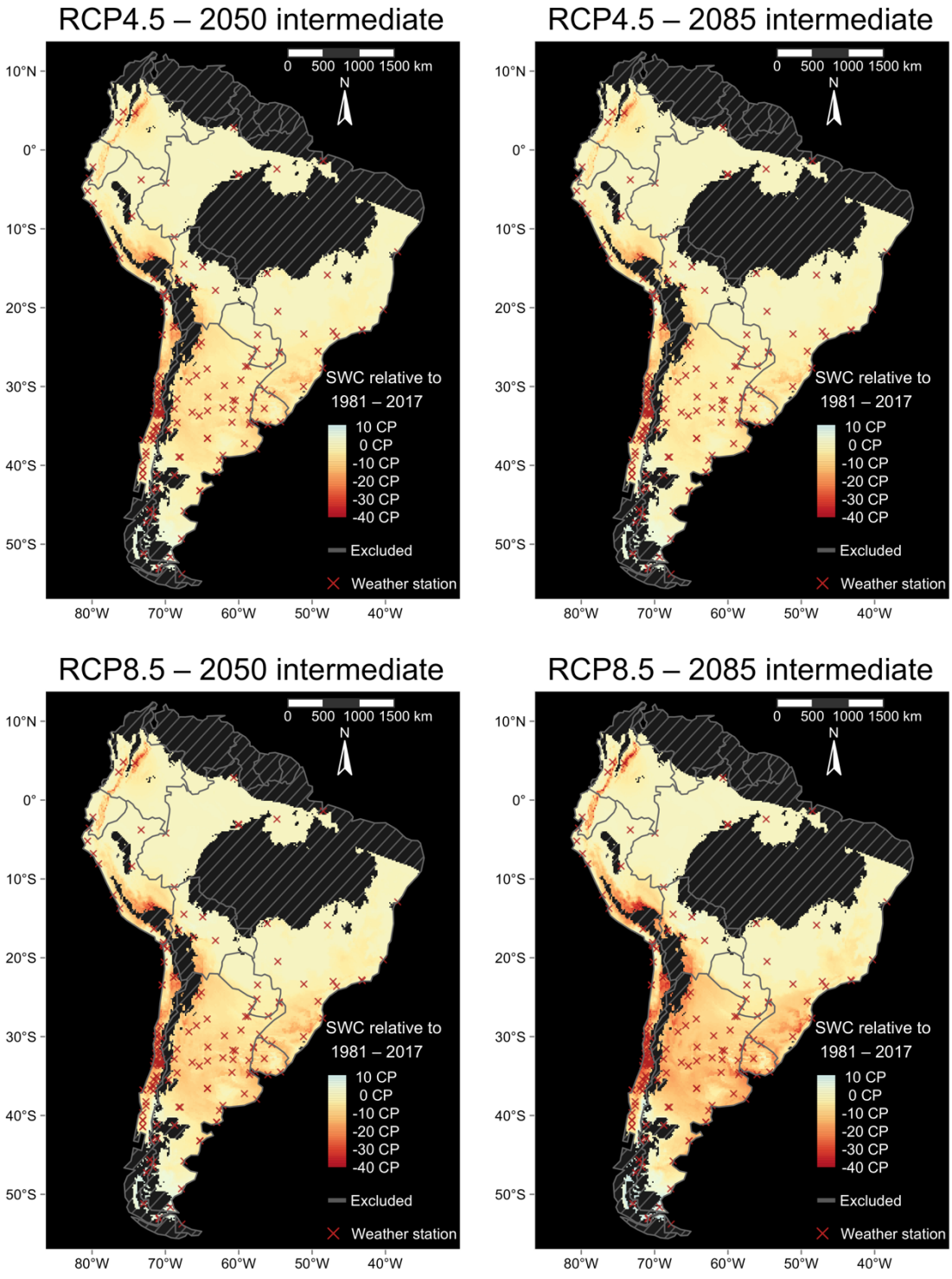


Figure S11. Change in Safe Winter Chill for South America compared to 1981 – 2017 under two global warming scenarios and time horizons. For the full caption, please refer to Fig. 5 in the main manuscript