Climate Change Challenges for Alpine Ski Resorts in Western Canada: Future Predicted Changes in Winter Mean Temperature, Winter Snowfall, and Ski Season Length

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Background

- The Intergovernmental Panel on Climate Change (IPCC) concludes that the release of greenhouse gases by humans is responsible for much of the observed climate change seen in the 20th and early 21st centuries.
- Climate models predict that climate change will continue into the 21st century because of the additional release of greenhouse gases by human activities.

Climate Change Impacts

- Future changes in temperature and precipitation will have profound effects on many components of human systems.
- Being able to forecast how human systems will respond to climate change is important for developing mitigation and adaptation strategies.
- One human system that should be influenced by warmer temperatures and changes in precipitation is **recreational alpine skiing**.

Alpine Skiing Requires Cold Temperatures and Adequate Snowfall

Warm Temperatures and Lack of Snow Cypress Ski Resort Feb 7, 2015

(Jonathan Hayward/Canadian Press)

Our Research Work

- Research on the effect of human caused climate change on recreational skiing has mainly been rudimentary.
- The reason for this is the lack of good climate data for analysis.
- The research presented here uses **statistically downscaled climate data** that is spatially interpolated and adjusted for elevation to determine the effect of global warming and changes in precipitation on selected ski resorts in western Canada.

Research Question

How will human caused climate change influence ski resorts in western Canada?

We can test this question by examining historical and future forecasted climate data related to winter mean temperature, winter snowfall, and ski season length.

ClimateBC/NA

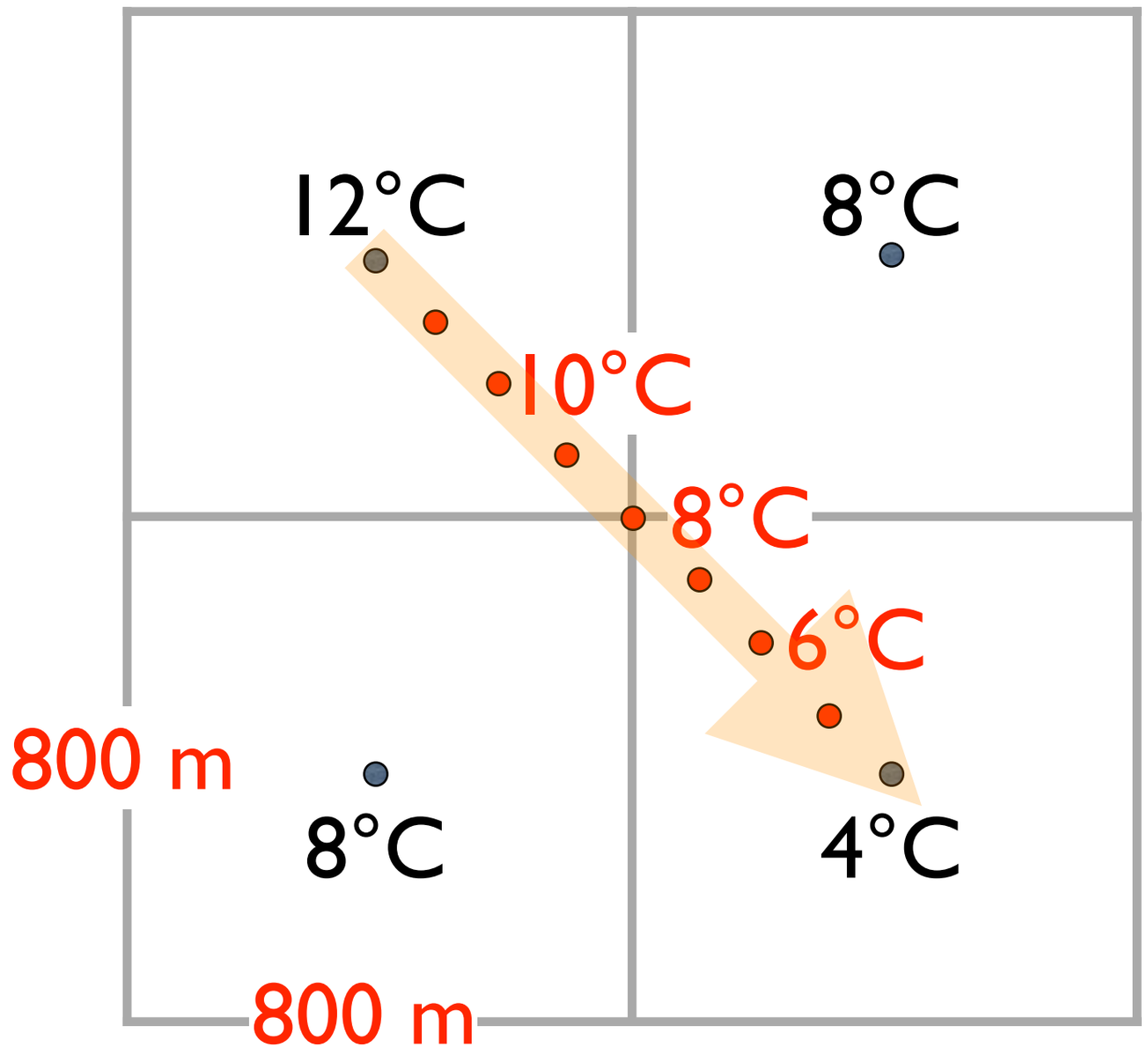
Data for Analyzing the Effects of Climate Change

ClimateBC/NA

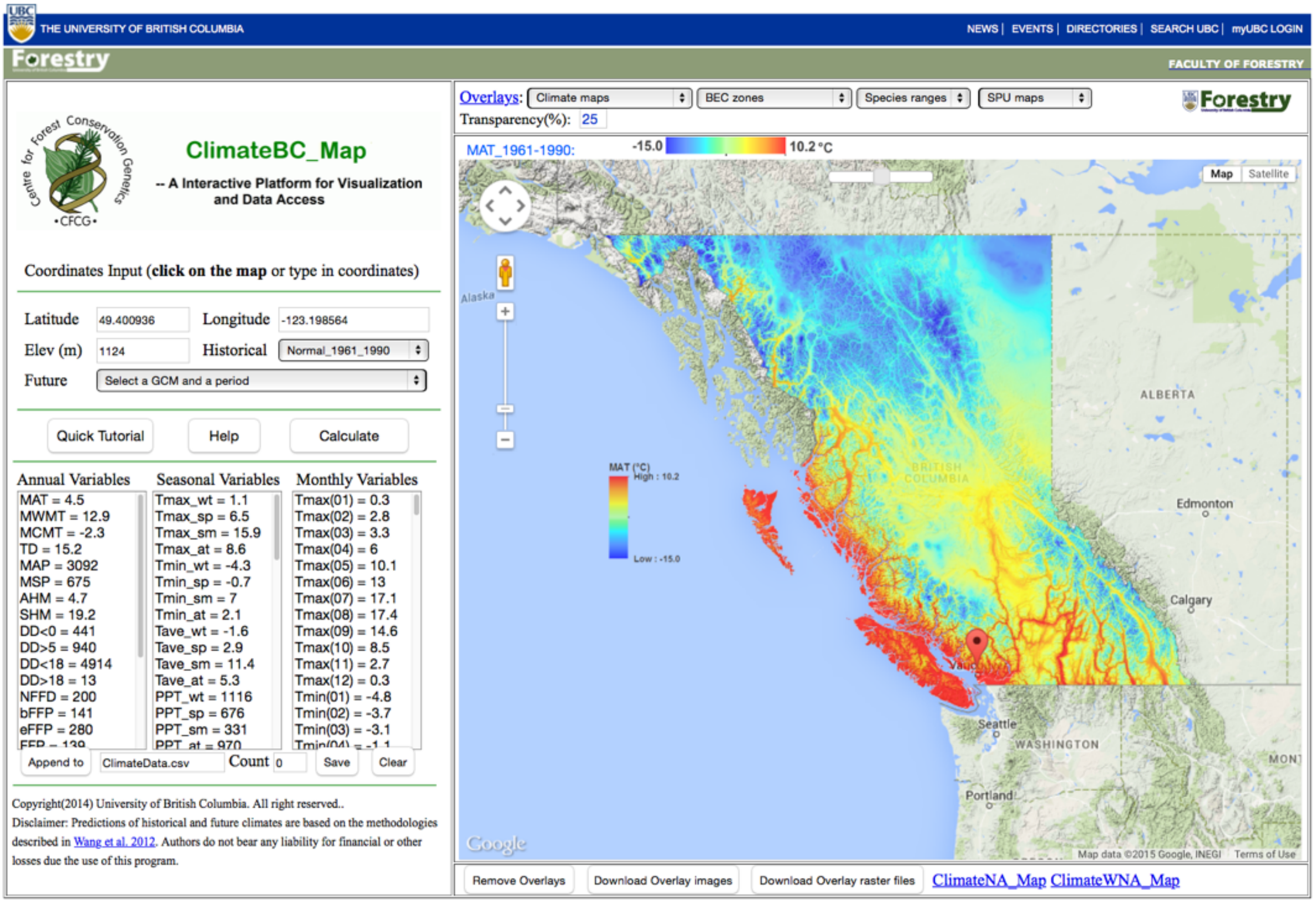
- **ClimateBC/NA** can create a ***virtual weather station*** for any location in western Canada.
- Generated data includes monthly precipitation, monthly snowfall, monthly mean temperature, annual precipitation, annual snowfall, annual mean temperature, degree days < 0°C, etc.
- Historical period covers 1901-2018.
- Future climates in 2025, 2055, and 2085 as generated by fifteen GCMs (IPCC AR5).

How does ClimateBC/NA work?

Grid-Cell Interpolation Spatially & by Elevation



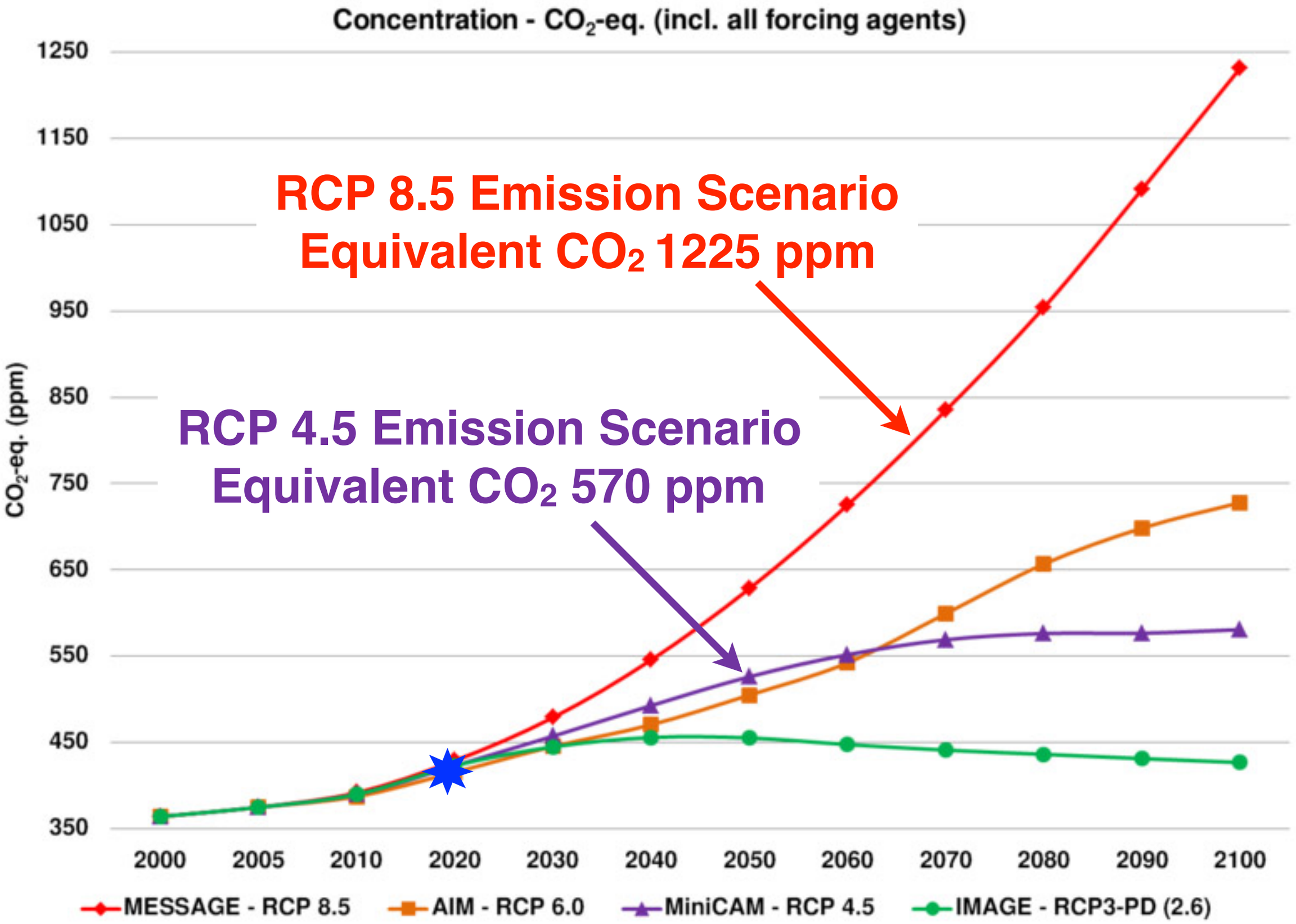
ClimateBC/NA Data



Note: Mismatchs between overlays and the map may occur if your browser is outdated. More spatial raster layers of climate variables are available for download.

Model Name	Country of Origin
ACCESS1-0	Australia
CanESM2	Canada
CCSM4	United States
CESM1-CAM5	United States
CNRM-CM5	France
CSIRO-Mk3-6-0	Australia
GFDL-CM3	United States
GISS-E2R	United States
HadGEM2-ES	Britain
INM-CM4	Russia
IPSL-CM5A-MR	France
MIROC-ESM	Japan
MIROC5	Japan
MPI-ESM-LR	Germany
MRI-CGCM3	Japan

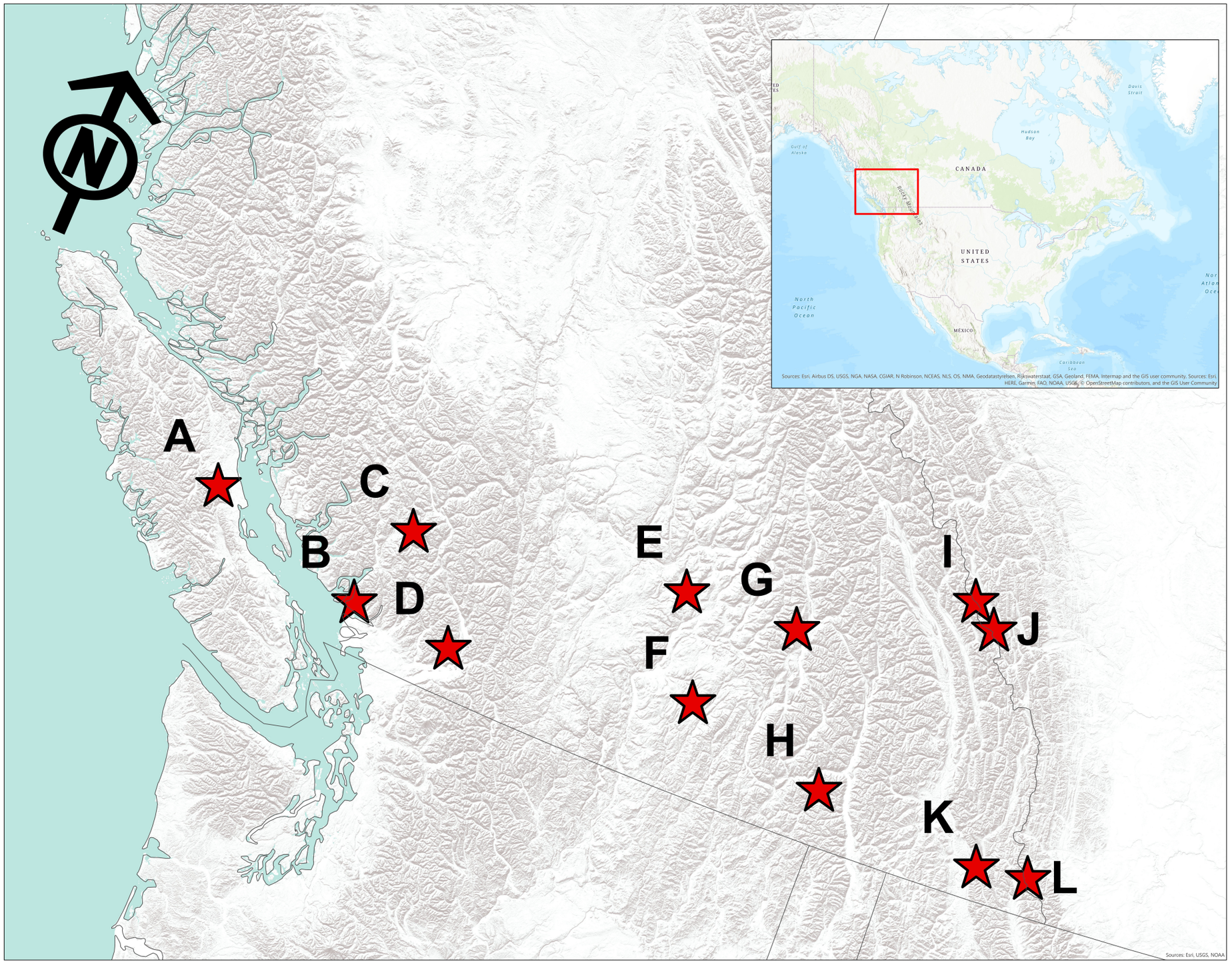
Time Period Emission Scenario	Carbon Dioxide (Parts Per Million)	Methane (Parts Per Billion)	Nitrous Oxide (Parts Per Billion)
1700	280	700	270
1985	345	1657	304
2019	410	1871	332
RCP4.5 2071-2100 Average Best-Case Scenario	532	1645	367
RCP8.5 2071-2100 Average Worst-Case Scenario	807	3566	415


Concentration - CO_2-eq. (incl. all forcing agents)
RCP 8.5 Emission Scenario
Equivalent CO_2 1225 ppm
RCP 4.5 Emission Scenario
Equivalent CO_2 570 ppm
CO_2-eq. (ppm)
1250
1150
1050
950
850
750
650
550
450
350
2000
2005
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
MESSAGE - RCP 8.5
AIM - RCP 6.0
MiniCAM - RCP 4.5
IMAGE - RCP3-PD (2.6)

Western Canada

Ski Resorts Studied

Future Climate Change - 12 Resorts Studied



A. Mt Washington

B. Cypress

C. Whistler

D. Sasquatch

E. Sun Peaks

F. Big White

G. Revelstoke

H. Whitewater

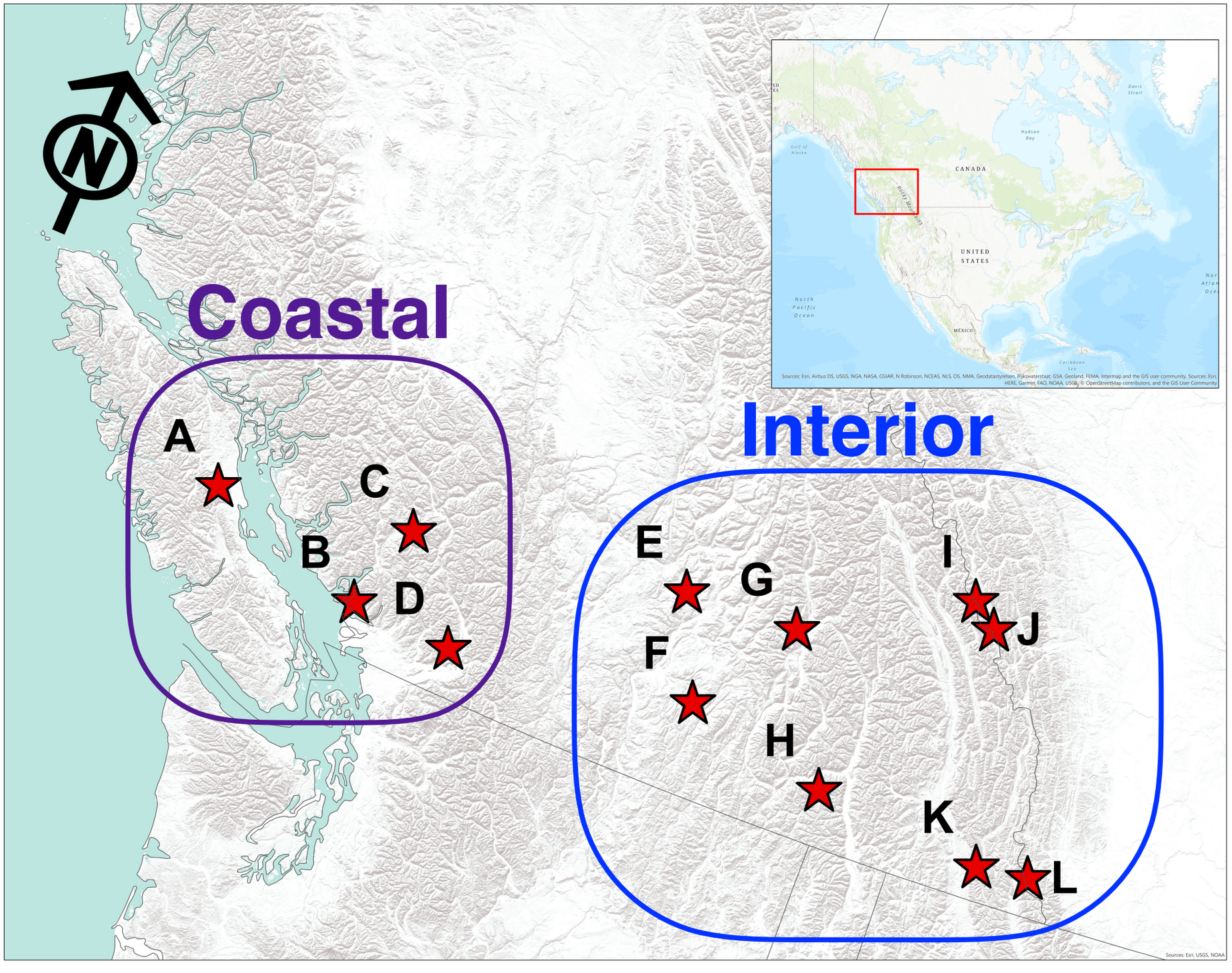
I. Lake Louise

J. Sunshine

K. Fernie

L. Castle Mountain

Future Climate Change - 12 Resorts Studied



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H. Whitewater
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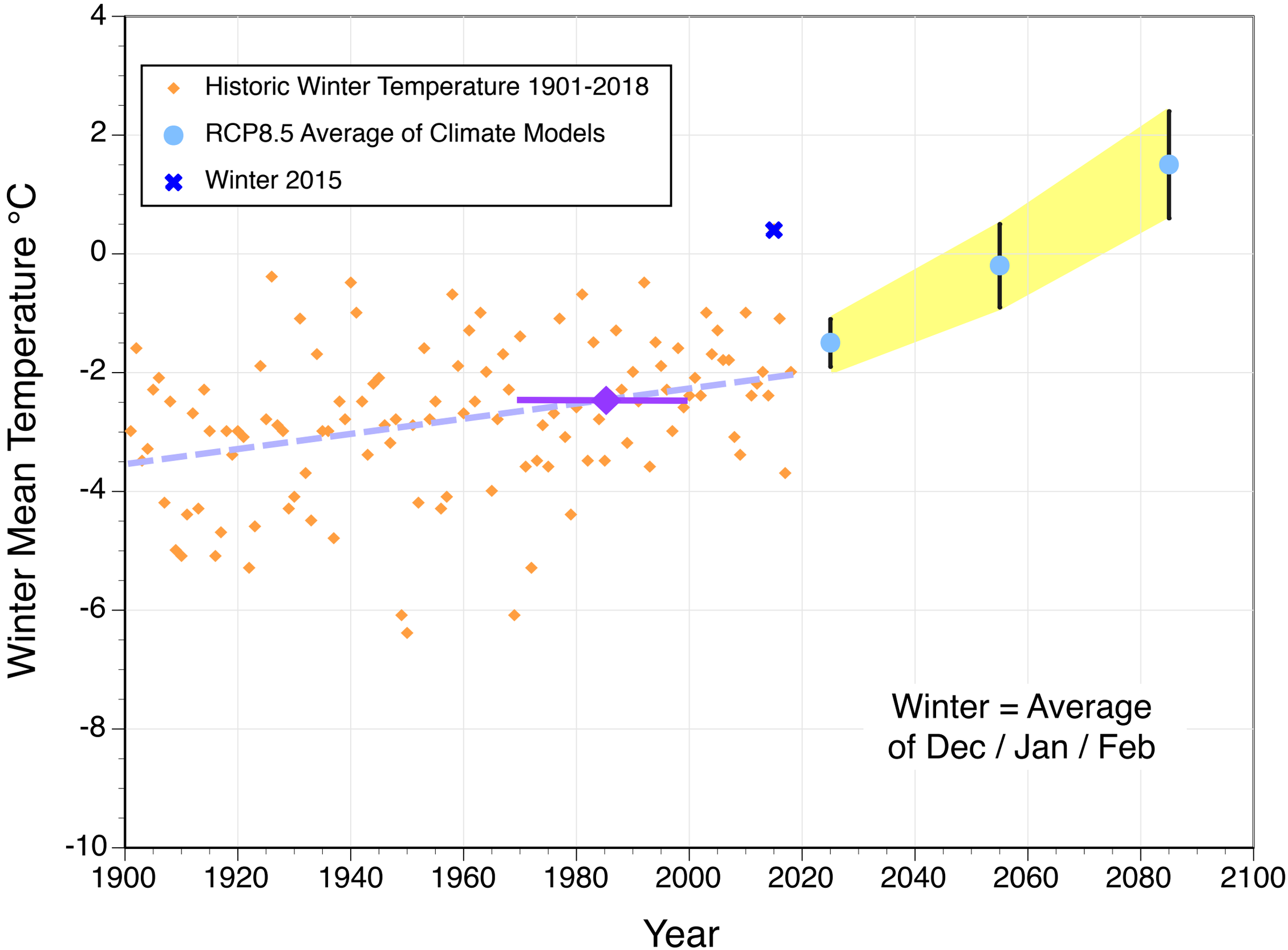
J. Sunshine
K. Fernie
L. Castle Mountain

Resort	Latitude (decimal)	Longitude (decimal)	Mid-Elevation (meters)
A. Mt. Washington	49.7469	-125.2992	1336
B. Cypress	49.4009	-123.1986	1124
C. Whistler	50.1038	-122.9136	1480
D. Sasquatch	49.3802	-121.9356	1174
E. Sun Peaks	50.8934	-119.8996	1639
F. Big White	49.7356	-118.9508	1930
G. Revelstoke	50.9558	-118.1299	1369
H. Whitewater	49.4396	-117.138	1728
I. Lake Louise	51.4476	-116.143	2142
J. Sunshine	51.0942	-115.7636	2207
K. Fernie	49.4606	-115.0936	1593
L. Castle Mt.	49.3128	-114.419	1842

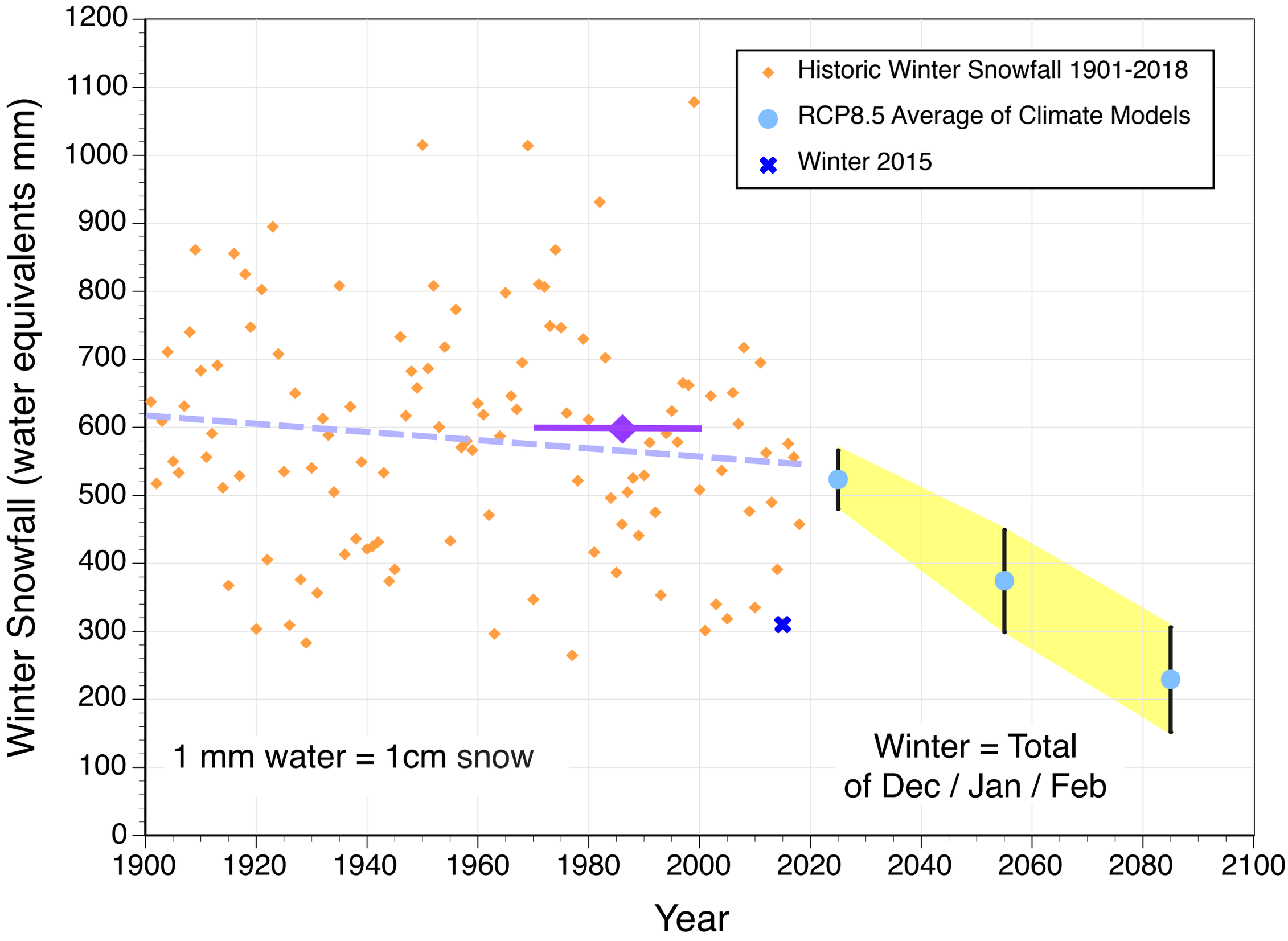
Western Canada Ski Resorts Mid-Elevation RCP8.5 Analysis

Coastal Ski Resorts
Mild Winters & Lots of Snow

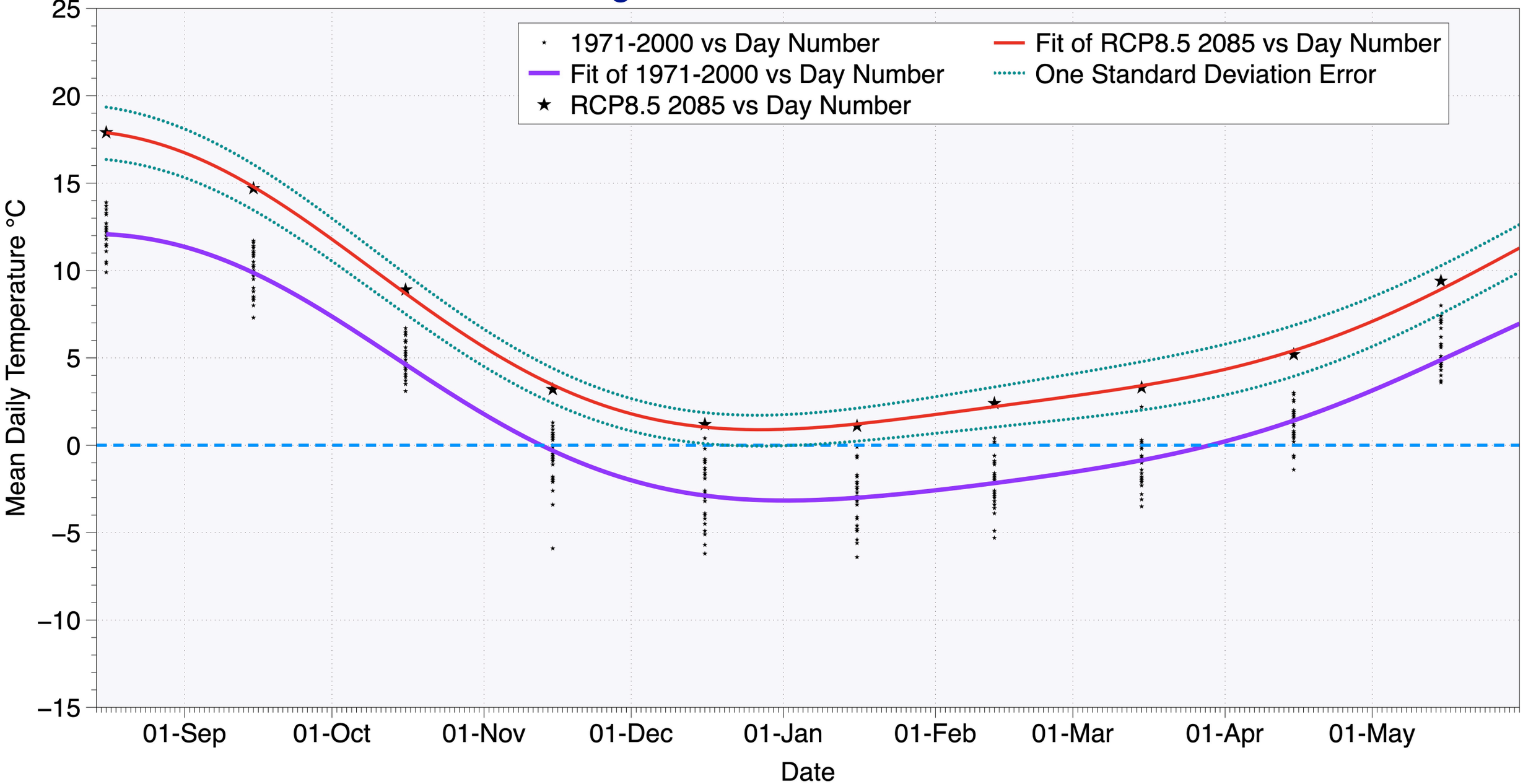
Mt. Washington Ski Resort - Mid-Elevation 1336 m



Mt. Washington Ski Resort - Mid-Elevation 1336 m

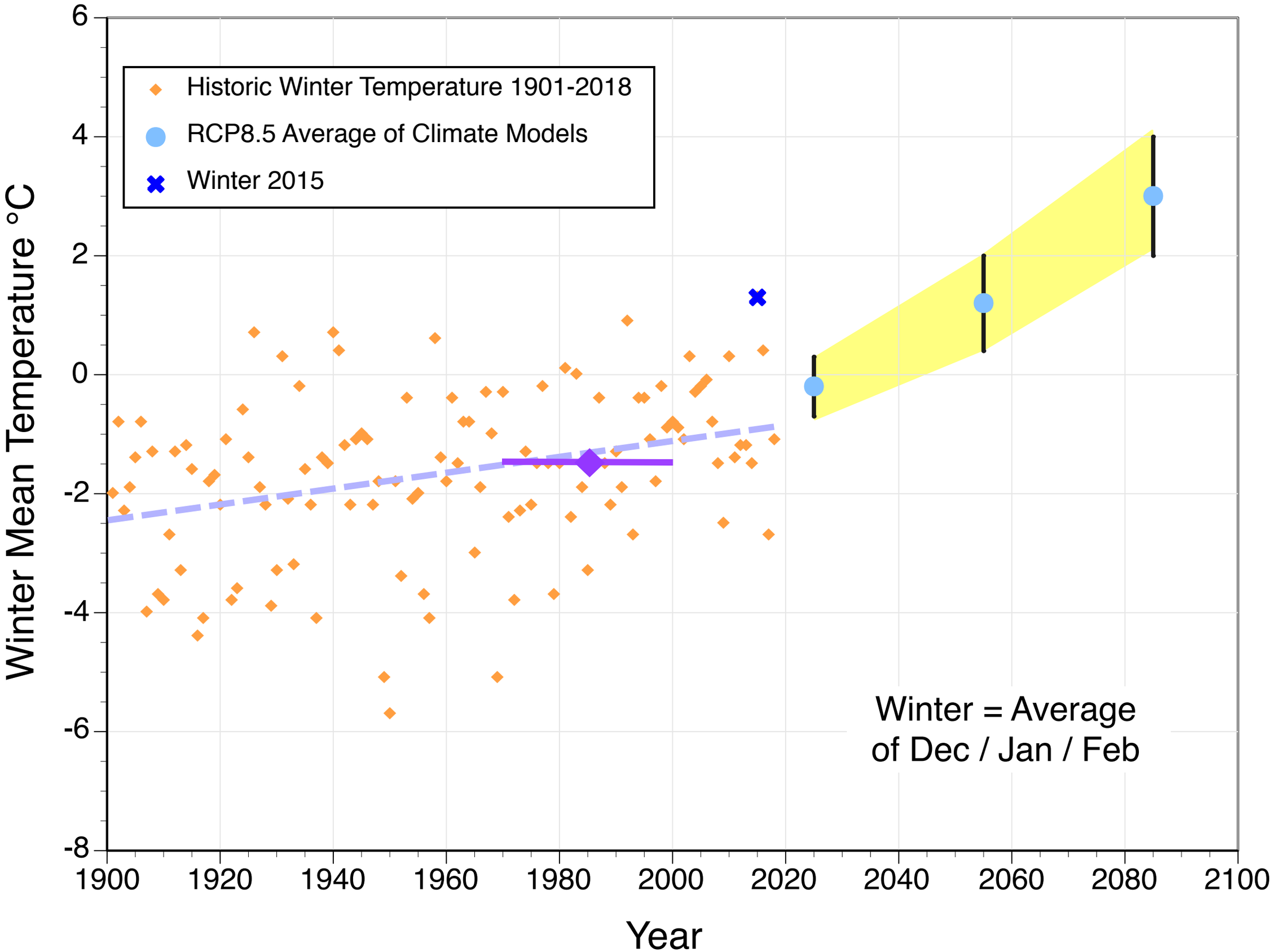


Mt Washington Ski Resort Elevation 1336 m

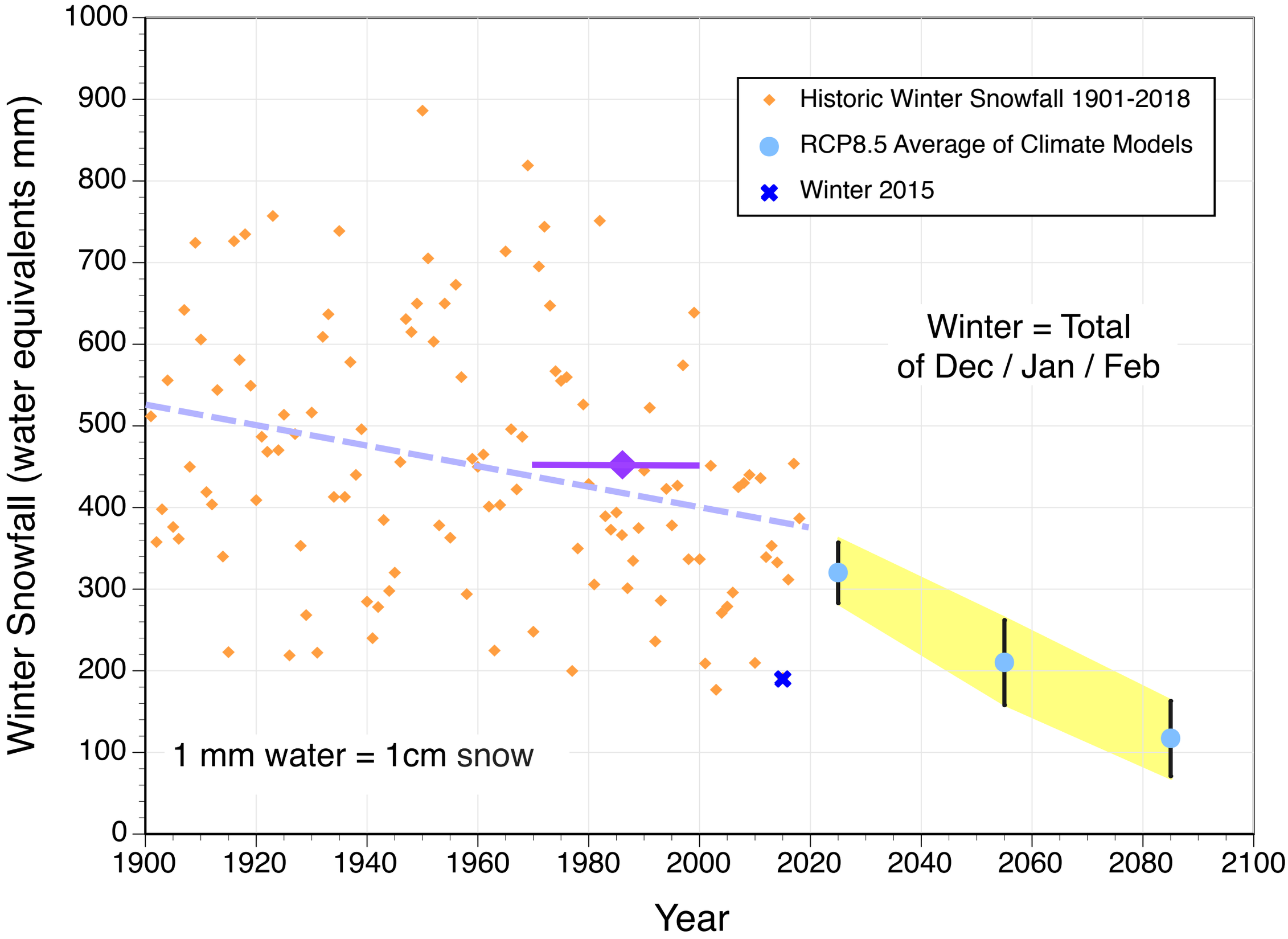


Ski Season Reduction 100%

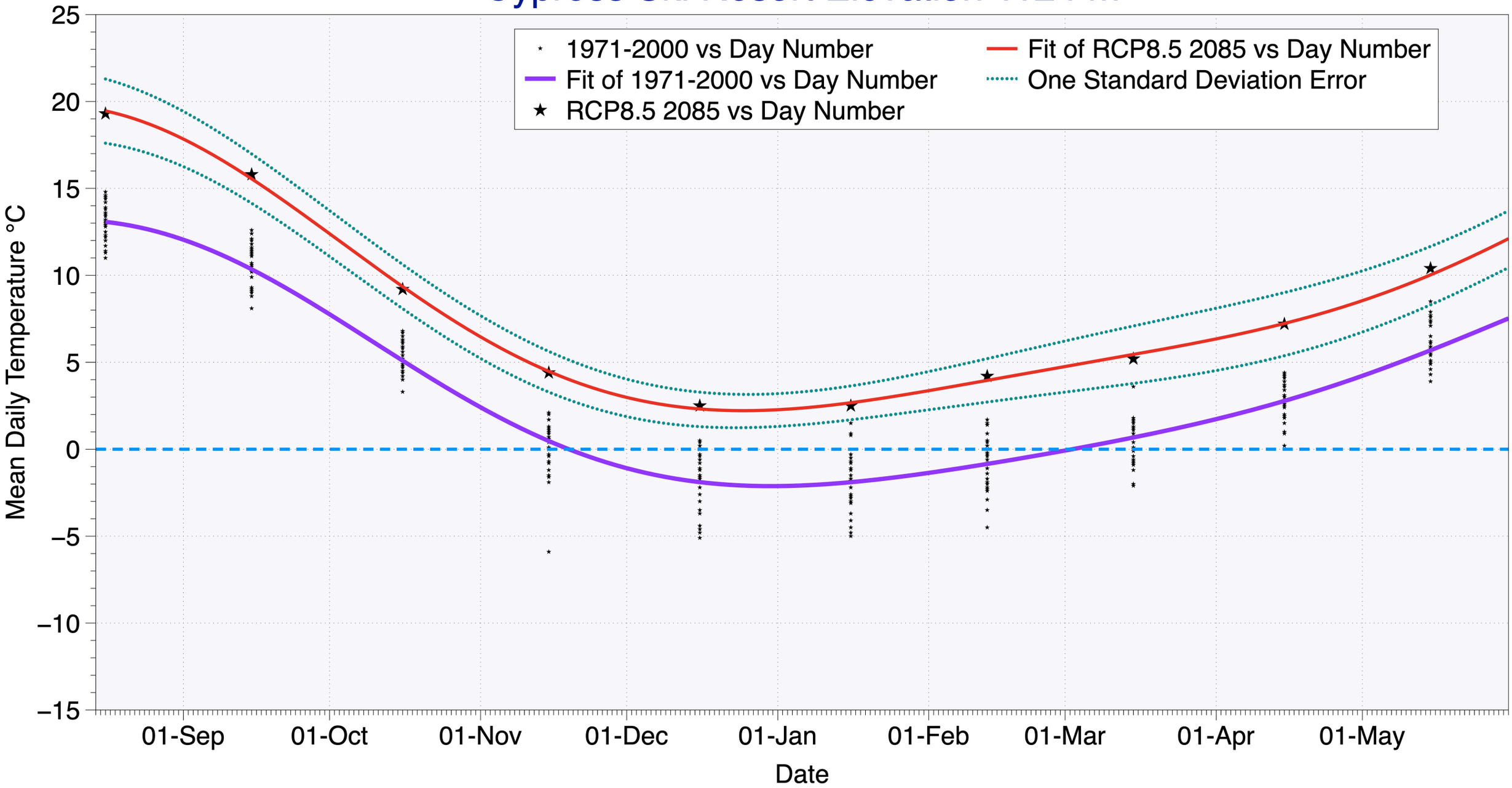
Cypress Ski Resort - Mid-Elevation 1124 m



Cypress Ski Resort - Mid-Elevation 1124 m

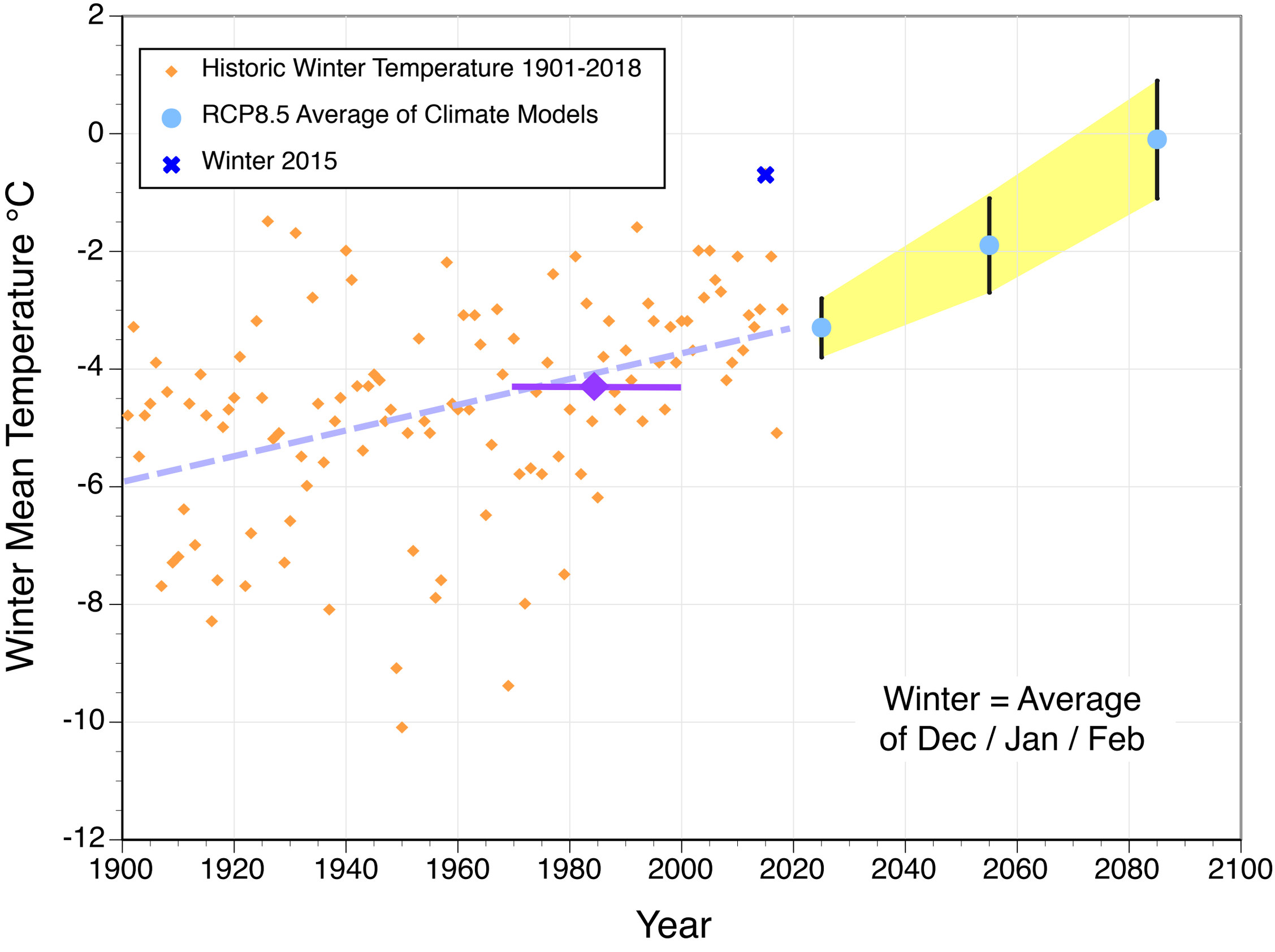


Cypress Ski Resort Elevation 1124 m

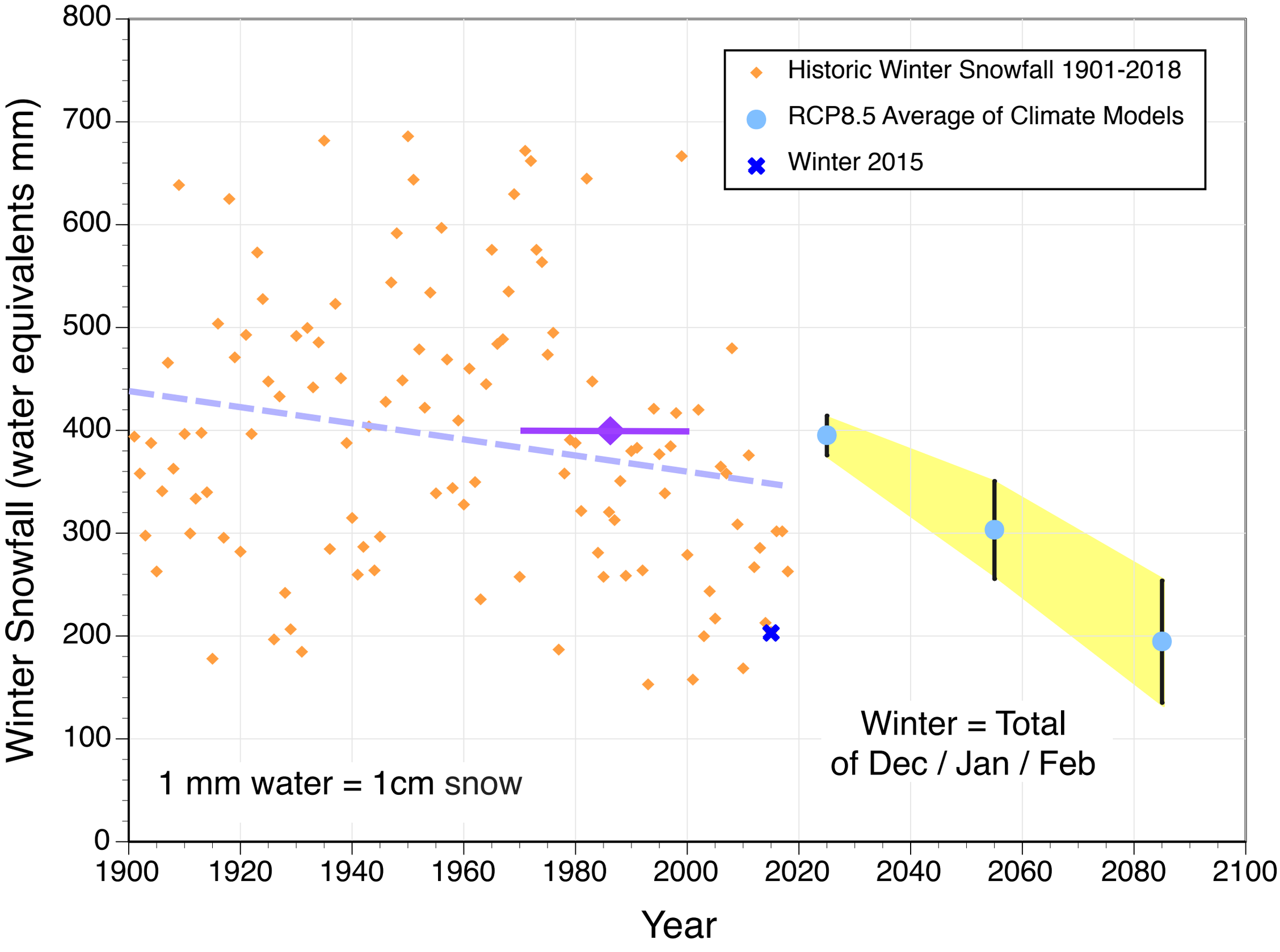


Ski Season Reduction 100%

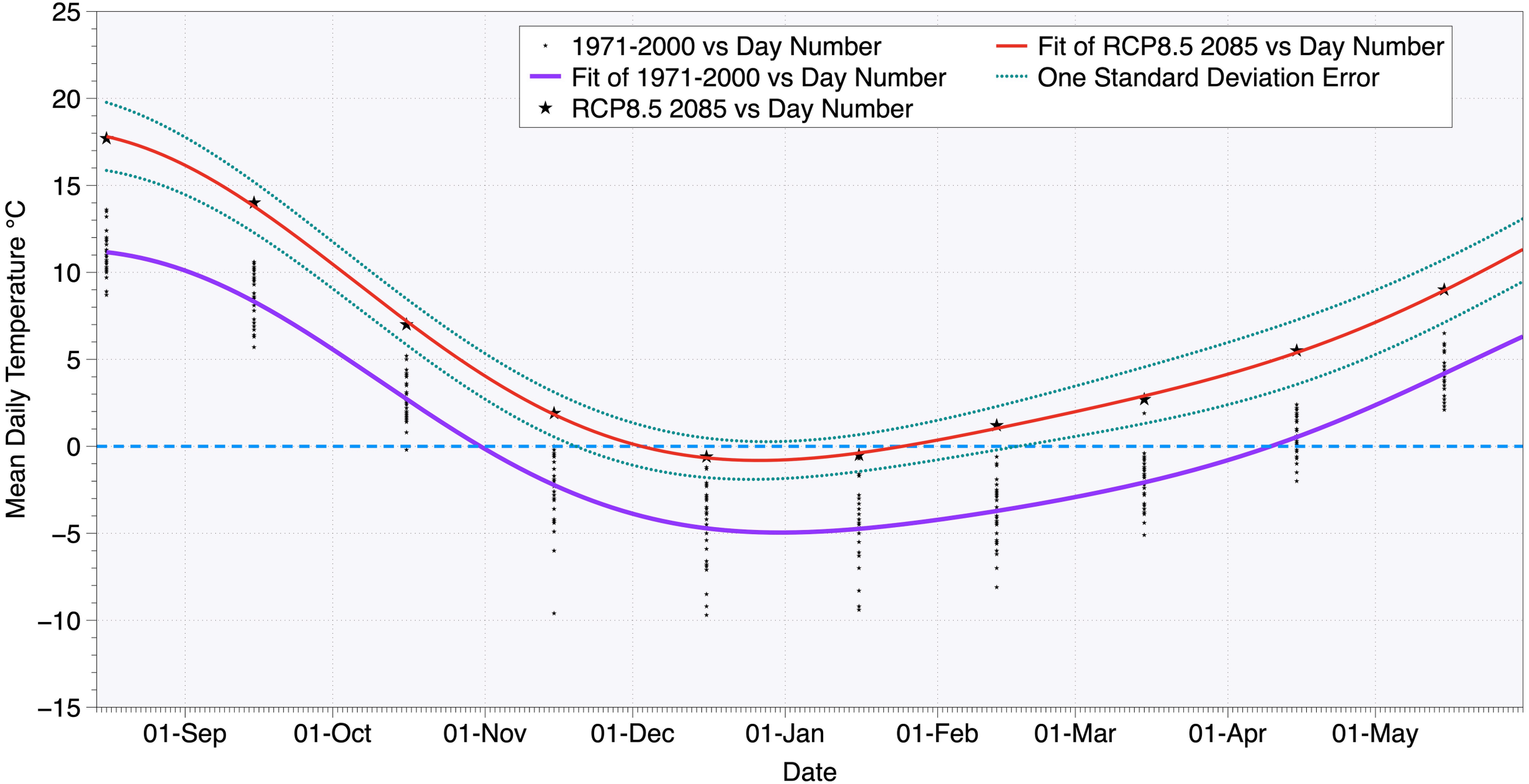
Whistler Ski Resort - Mid-Elevation 1480 m



Whistler Ski Resort - Mid-Elevation 1480 m

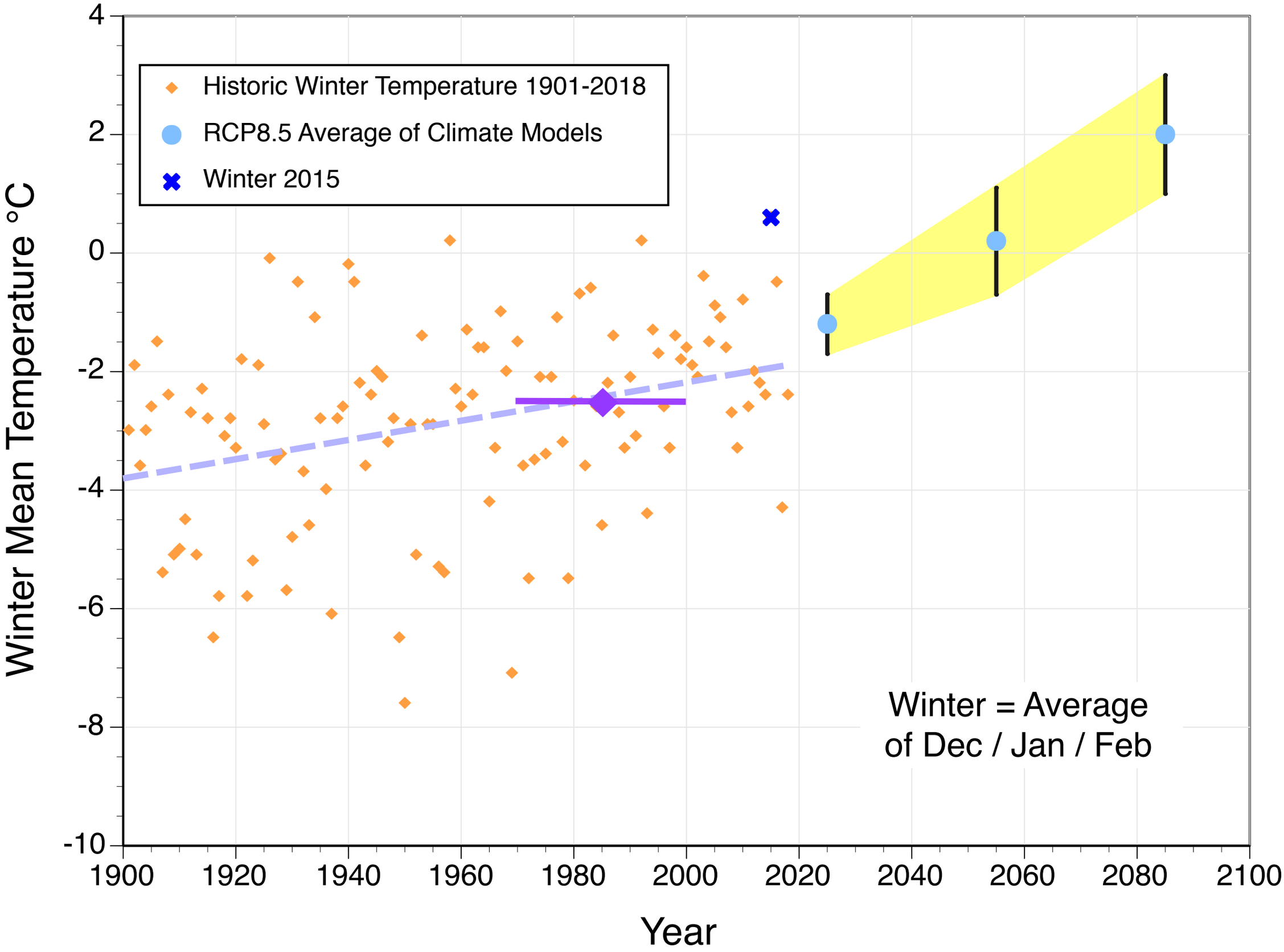


Whistler Ski Resort Elevation 1480 m

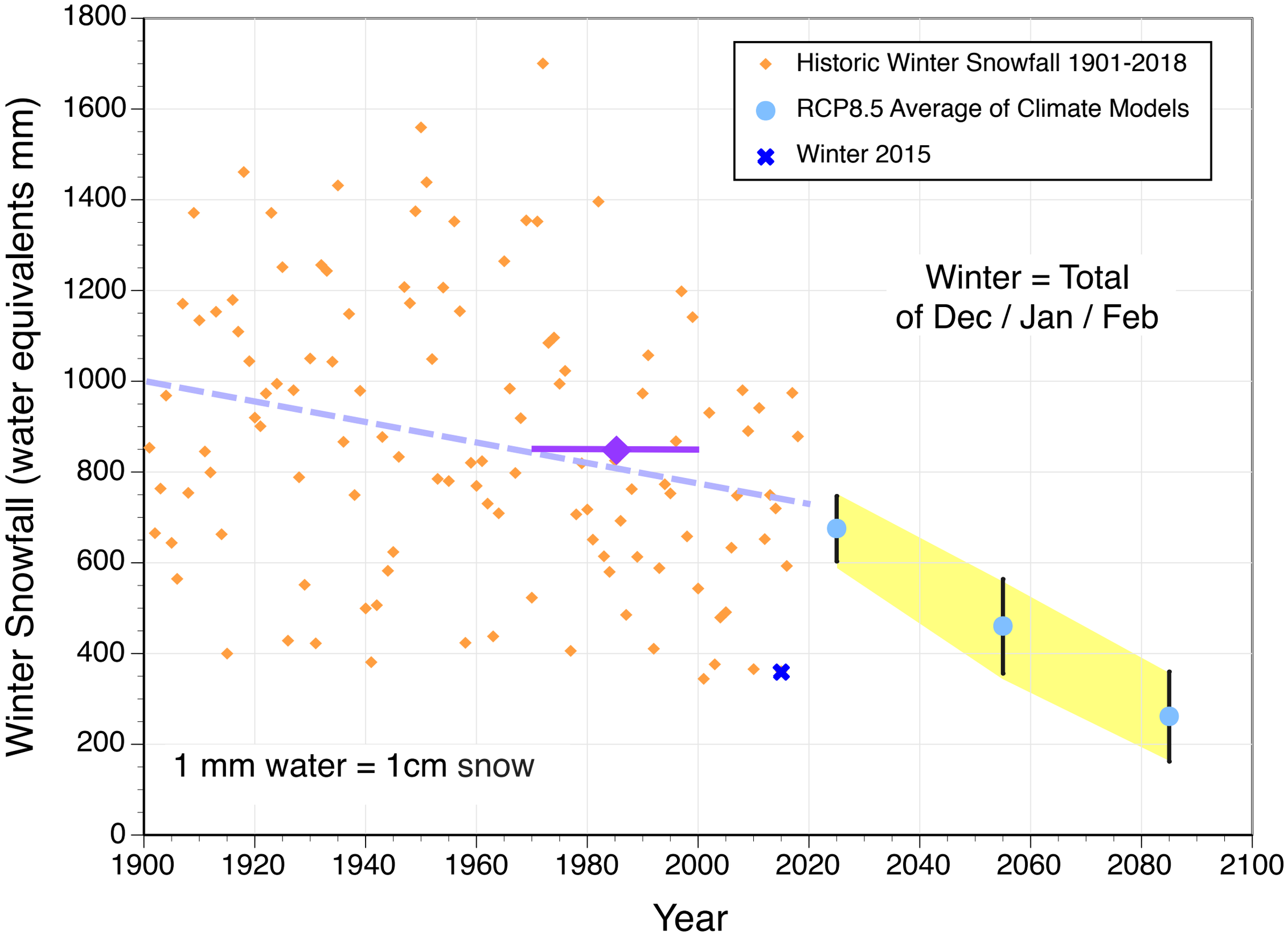


Ski Season Reduction 67%

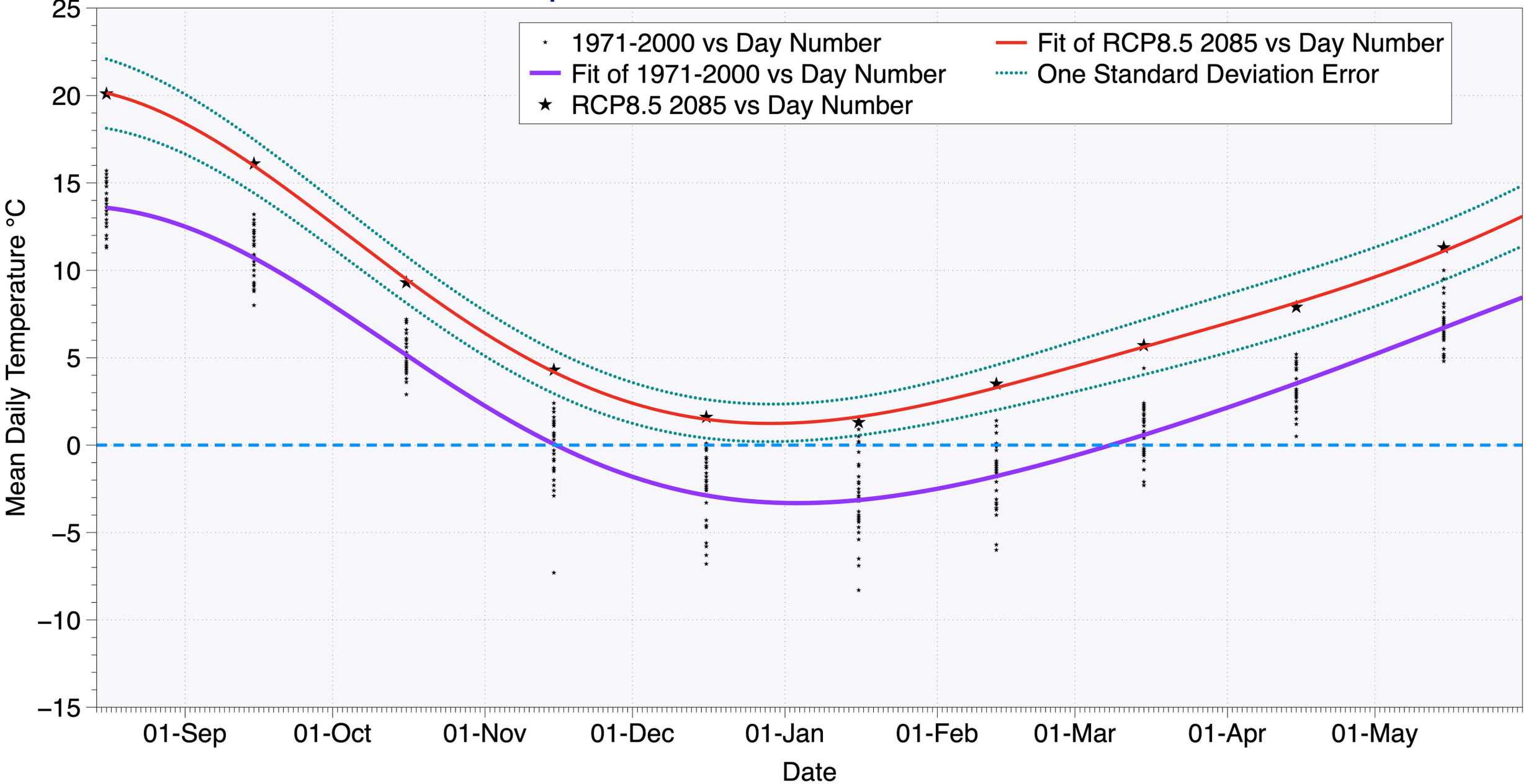
Sasquatch Mt. Ski Resort - Mid-Elevation 1174 m



Sasquatch Mt. Ski Resort - Mid-Elevation 1174 m



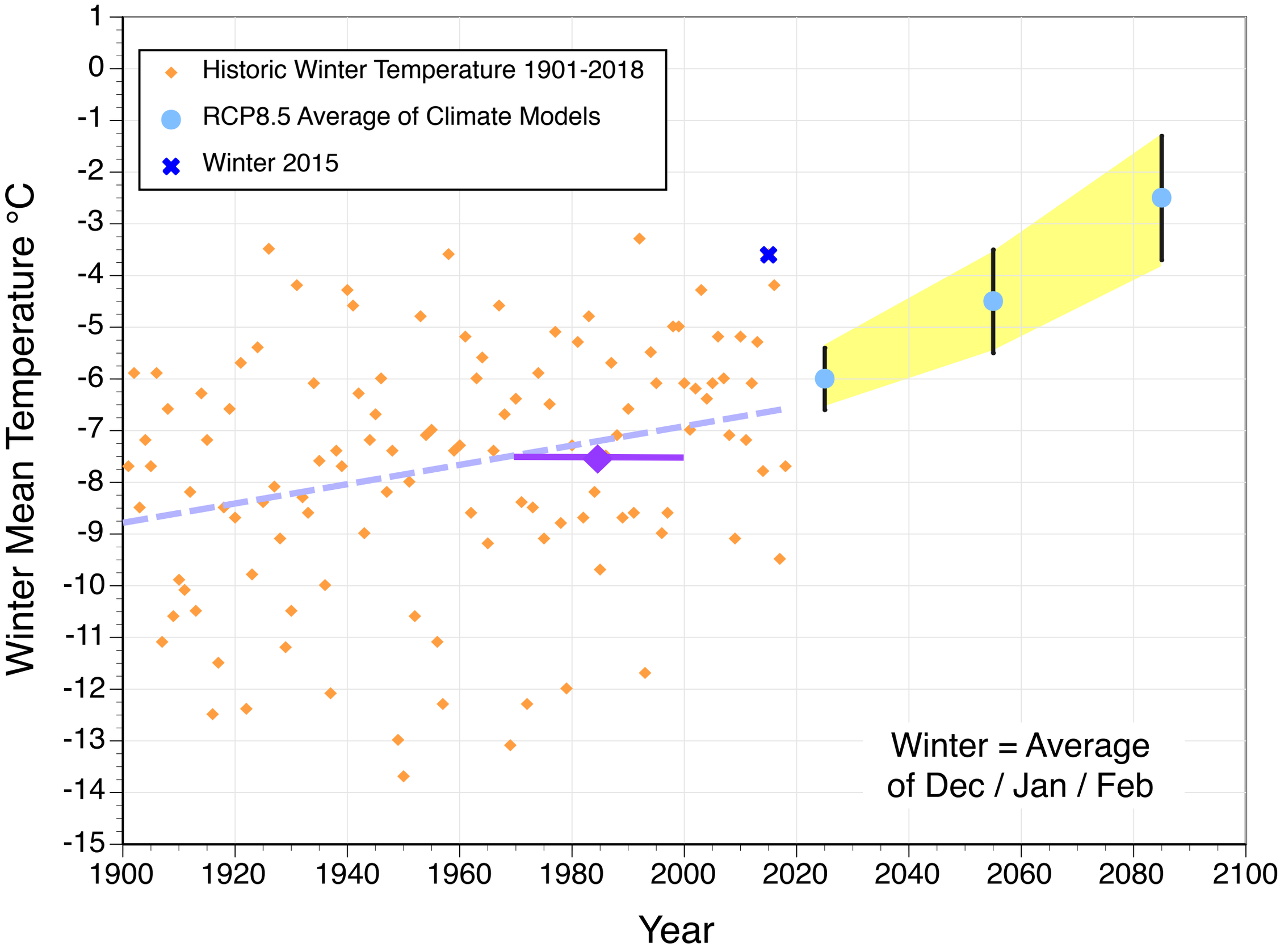
Sasquatch Ski Resort Elevation 1174 m



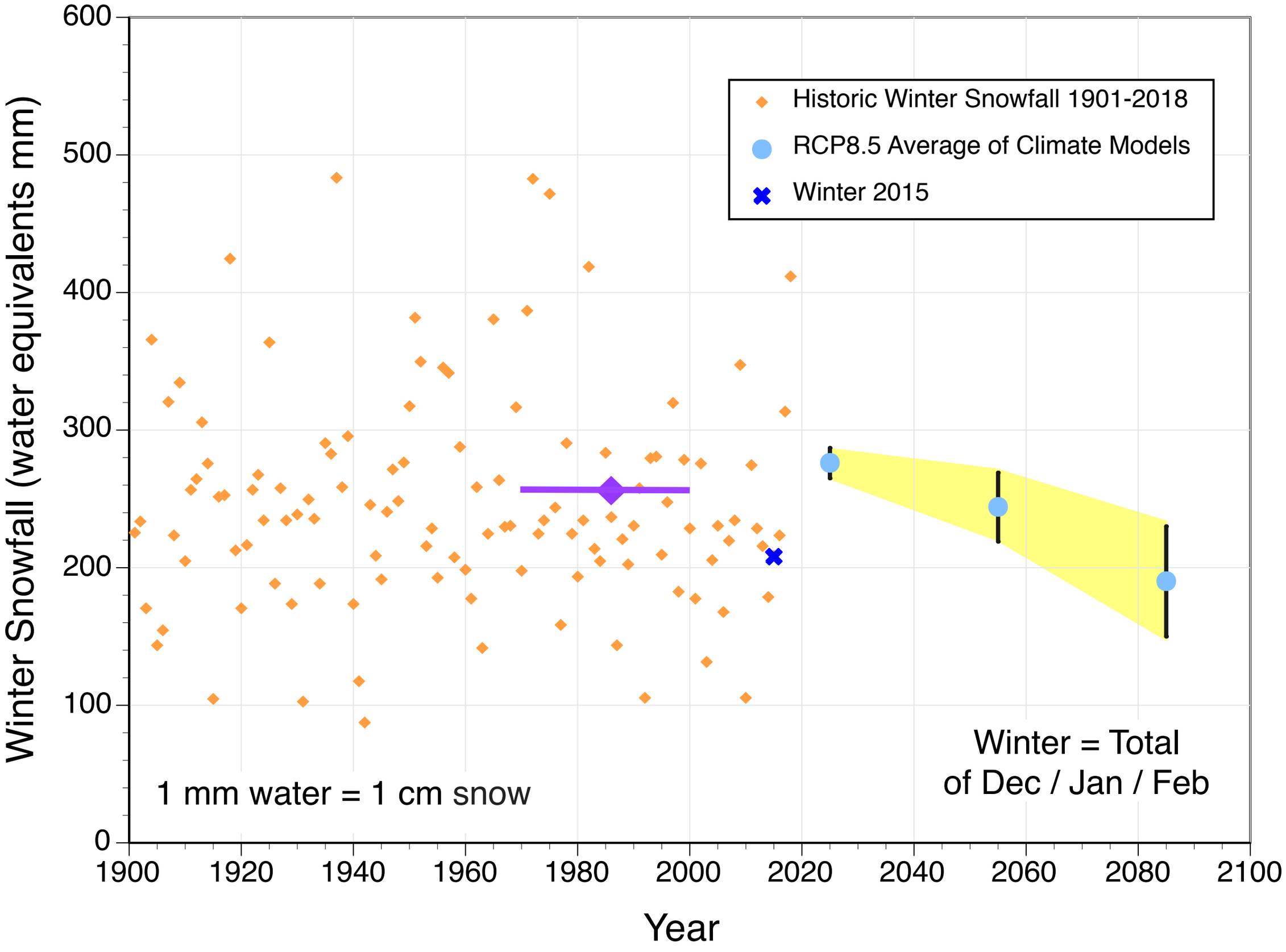
Ski Season Reduction 100%

Interior Ski Resorts
Cold Winters & Less Snow

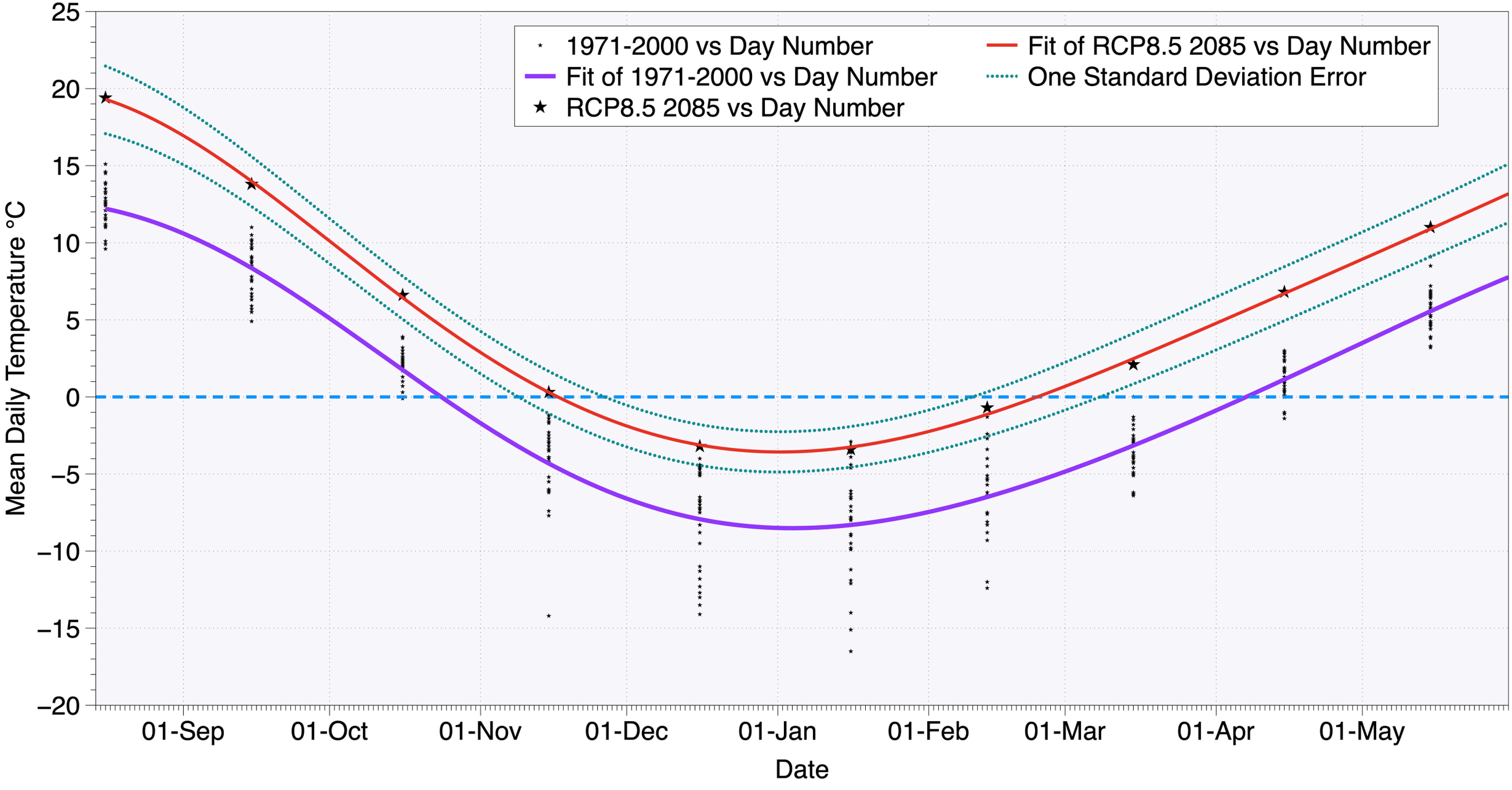
Sun Peaks Ski Resort - Mid-Elevation 1639 m



Sun Peaks Ski Resort - Mid-Elevation 1639 m

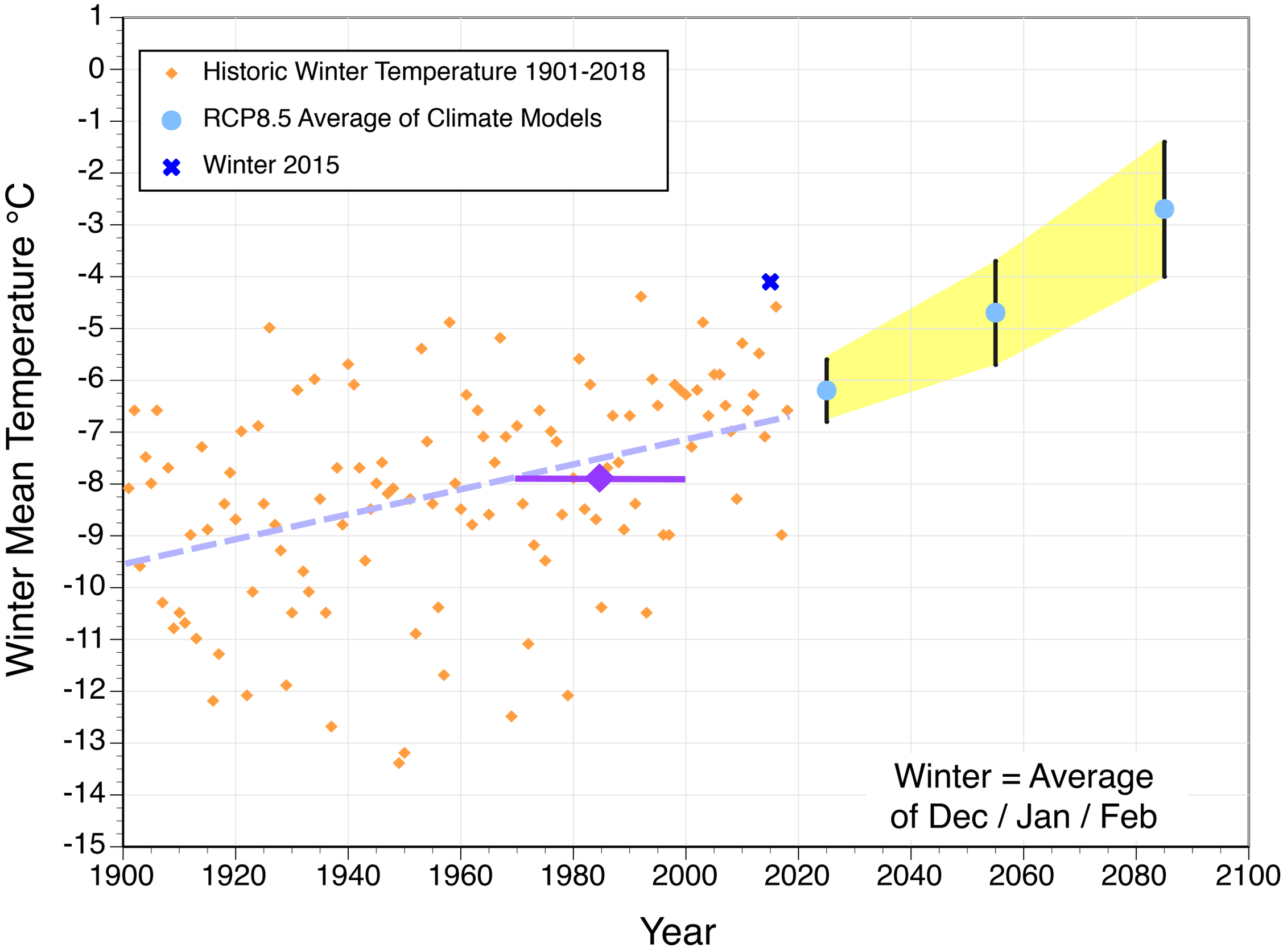


Sun Peaks Ski Resort Elevation 1639 m

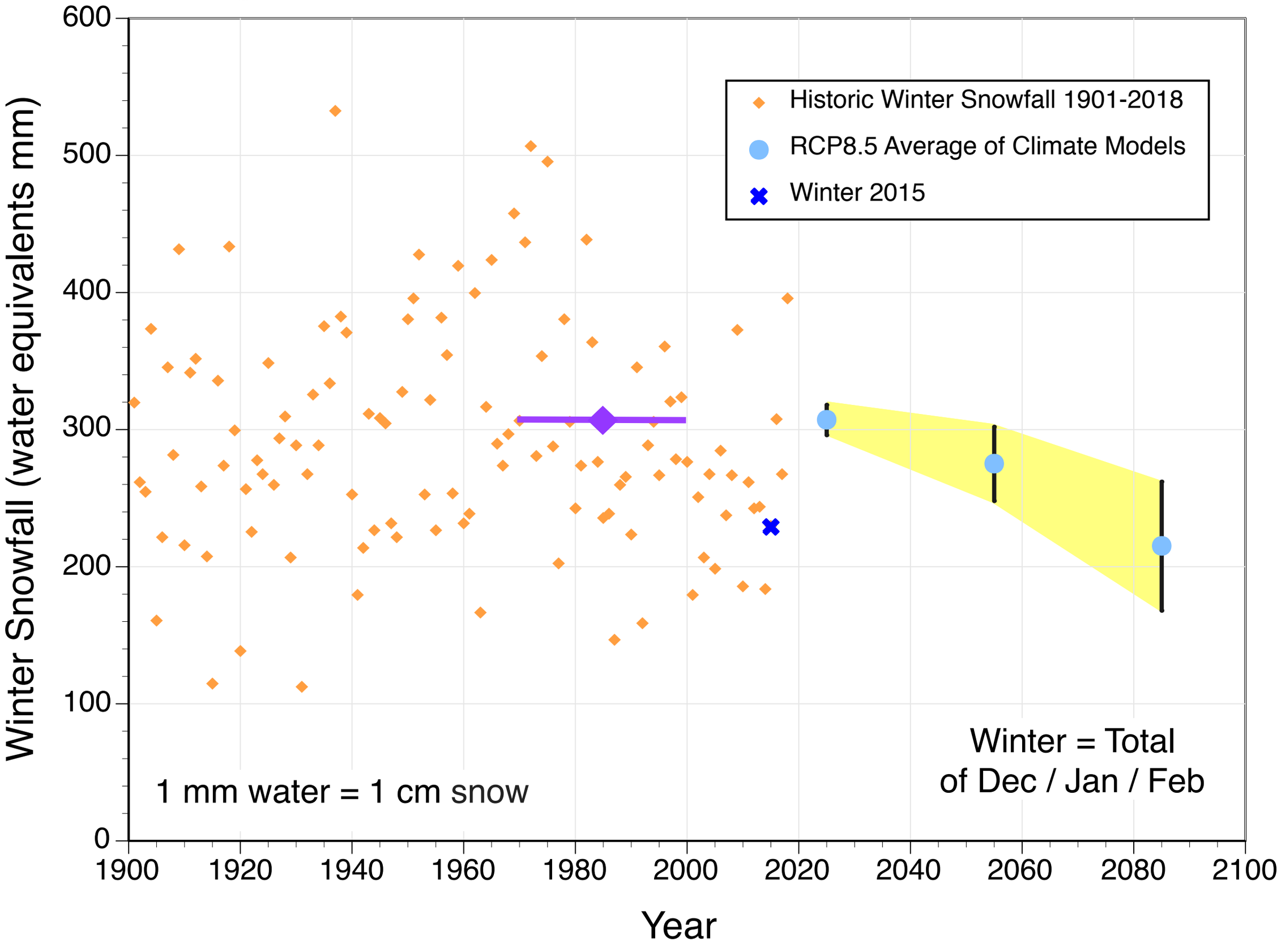


Ski Season Reduction 40%

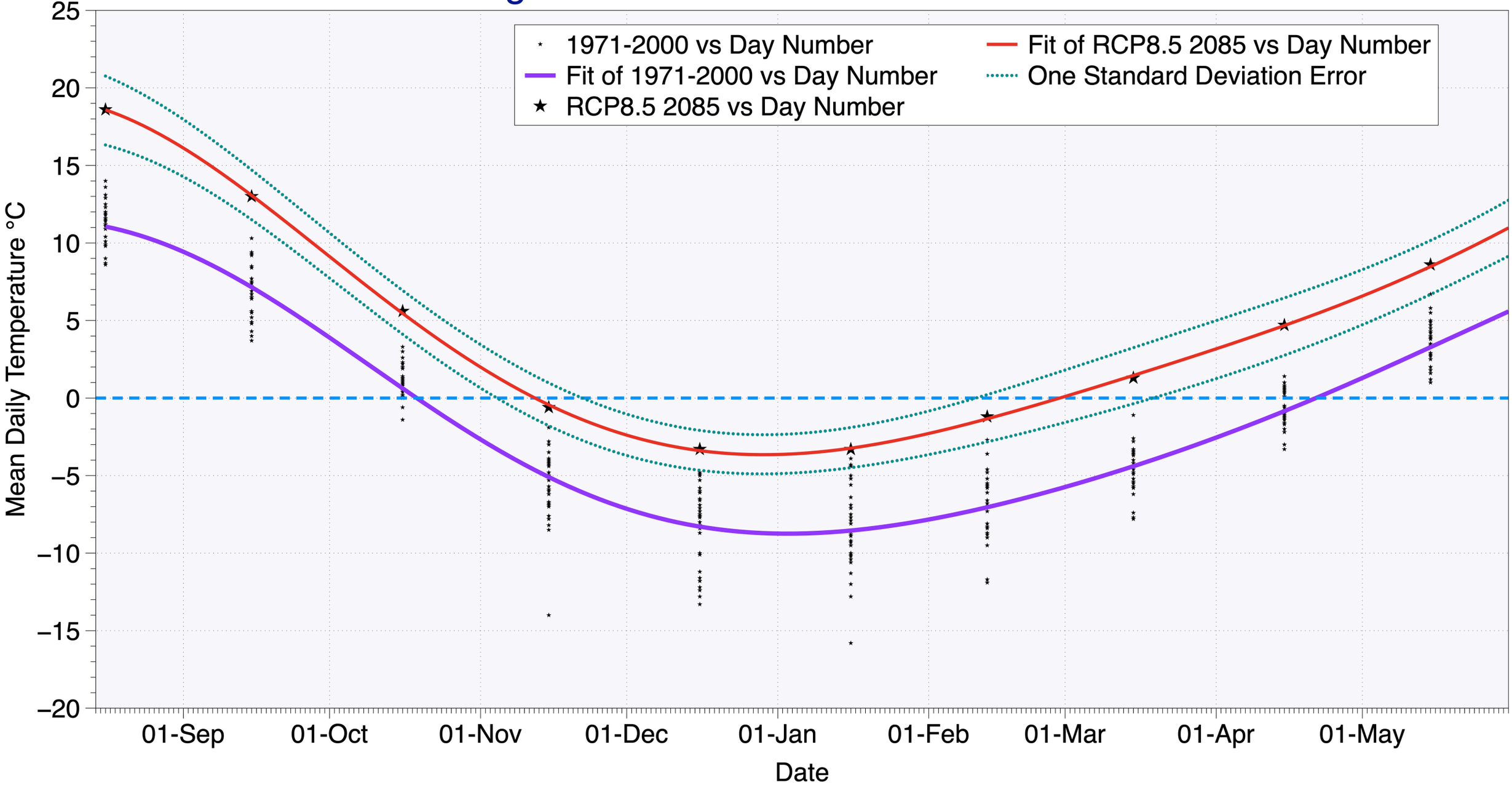
Big White Ski Resort - Mid-Elevation 1930 m



Big White Ski Resort - Mid-Elevation 1930 m

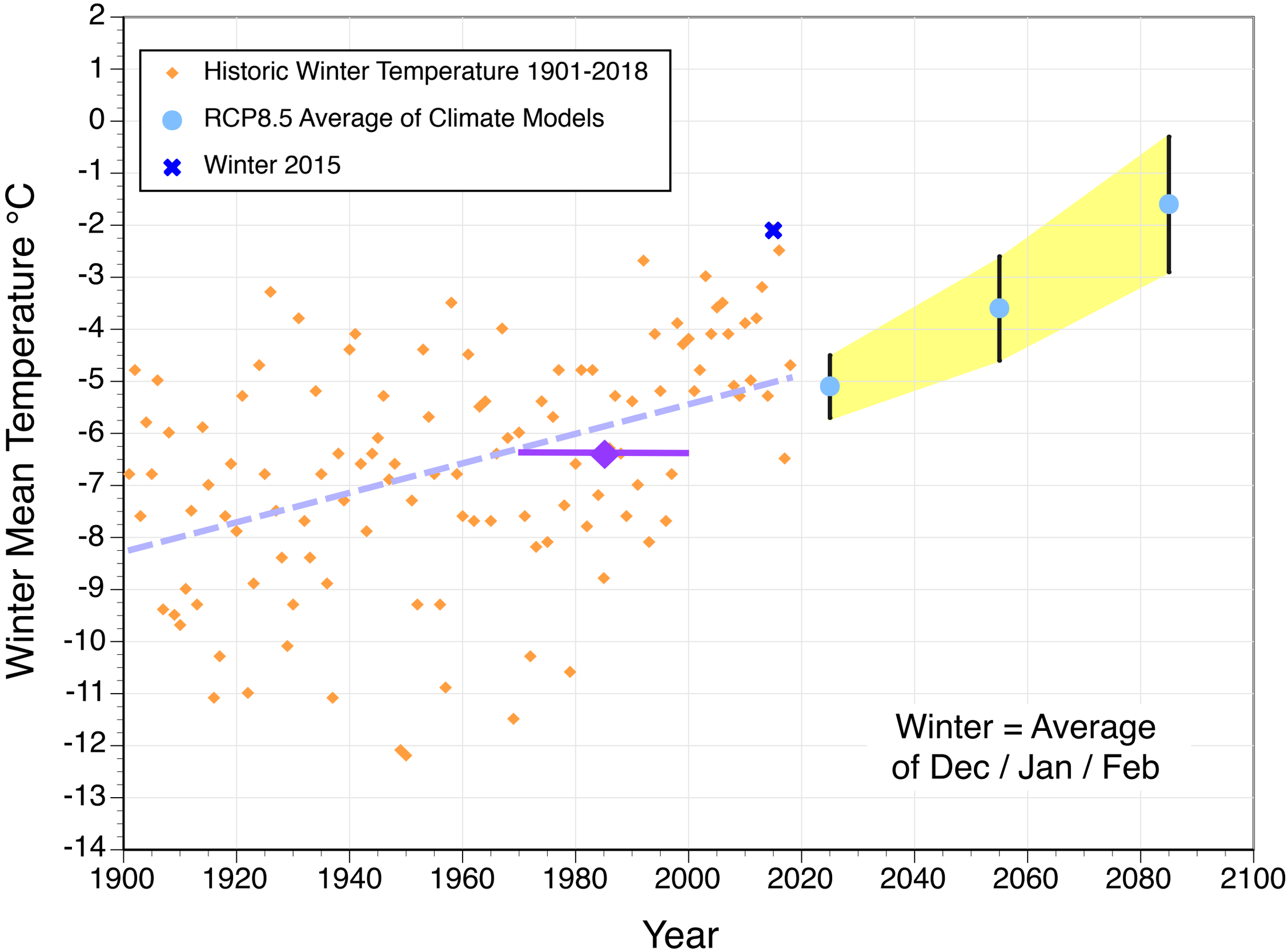


Big White Ski Resort Elevation 1930 m

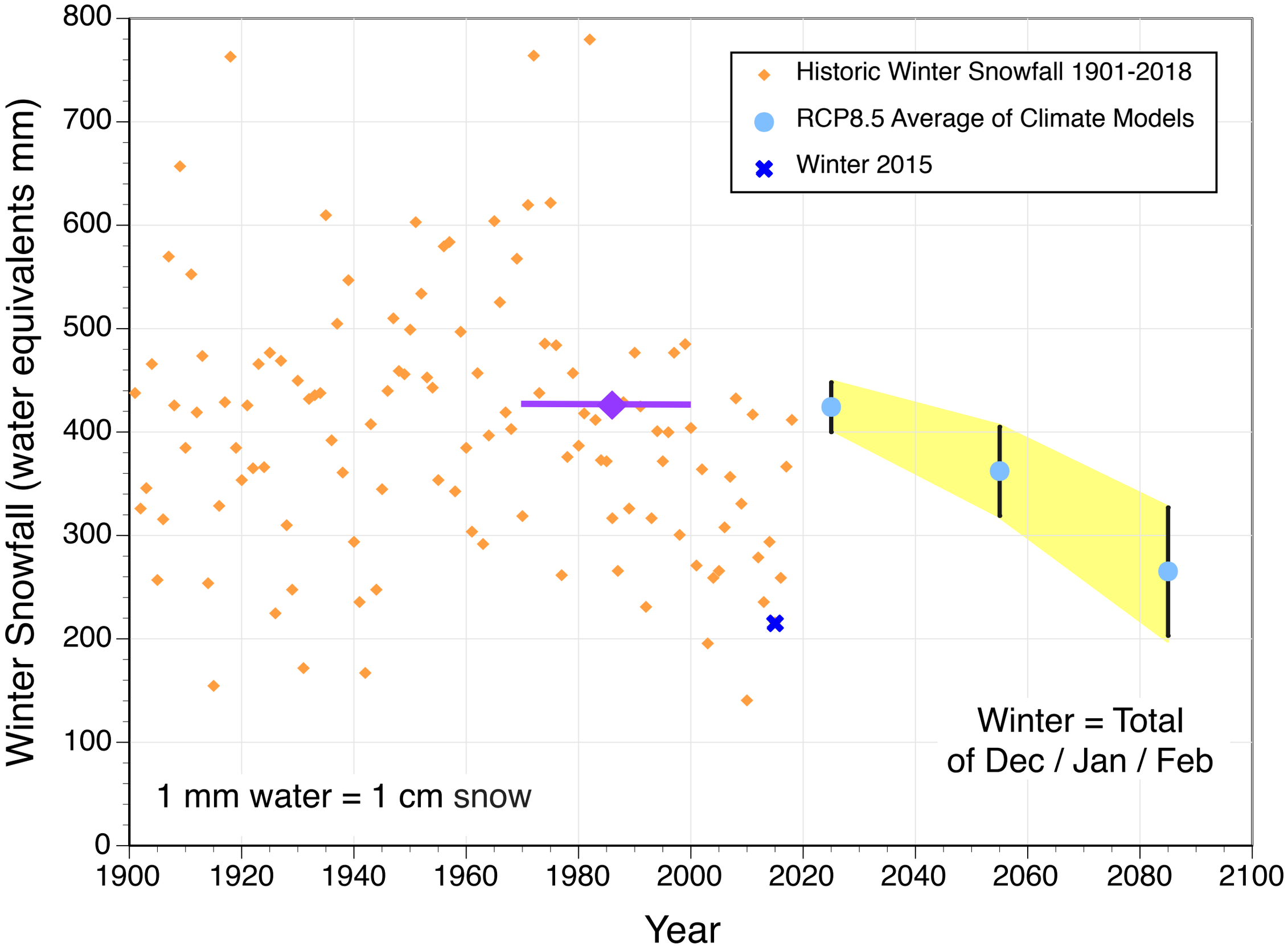


Ski Season Reduction 42%

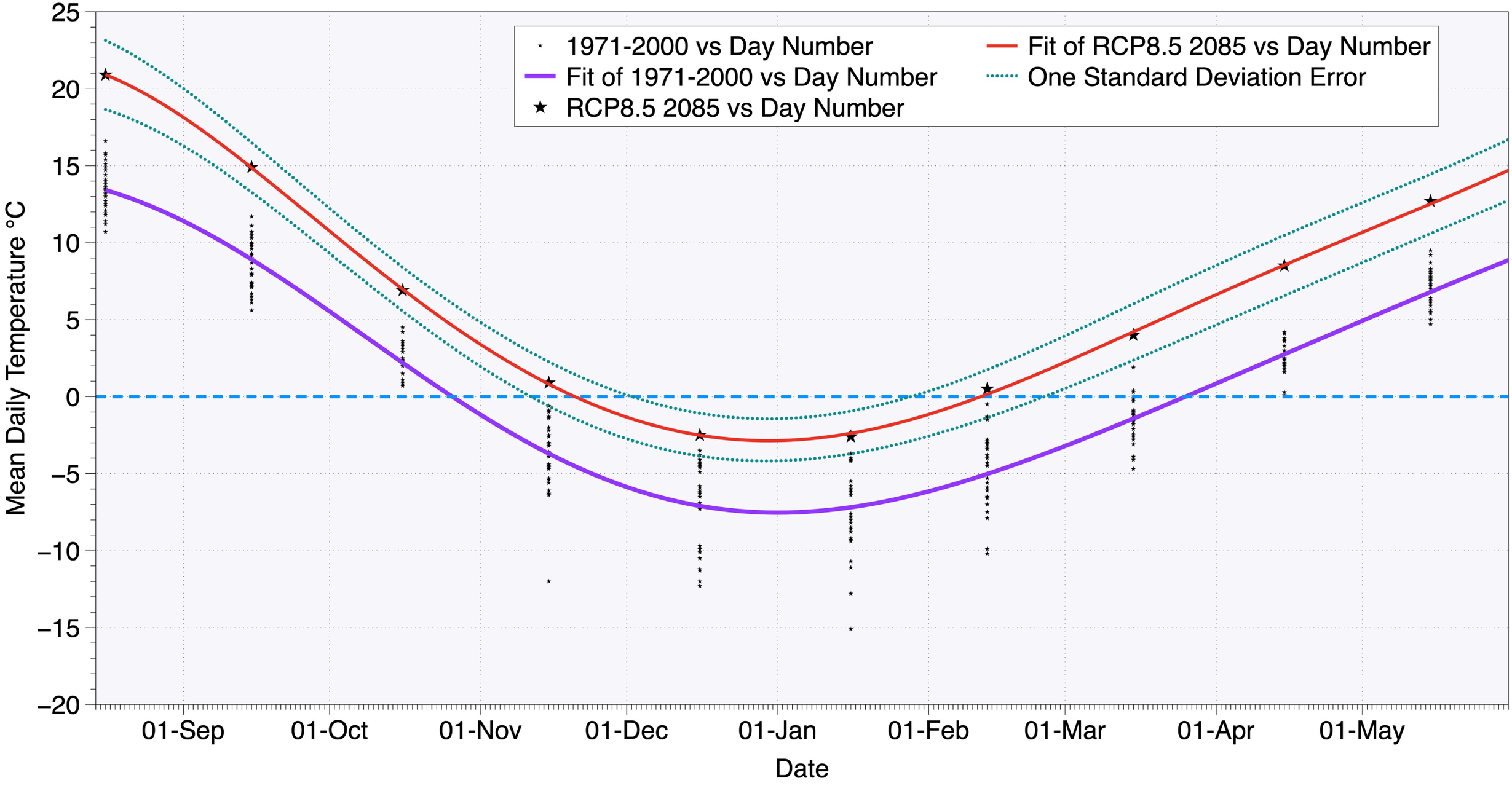
Revelstoke Ski Resort - Mid-Elevation 1369 m



Revelstoke Ski Resort - Mid-Elevation 1369 m

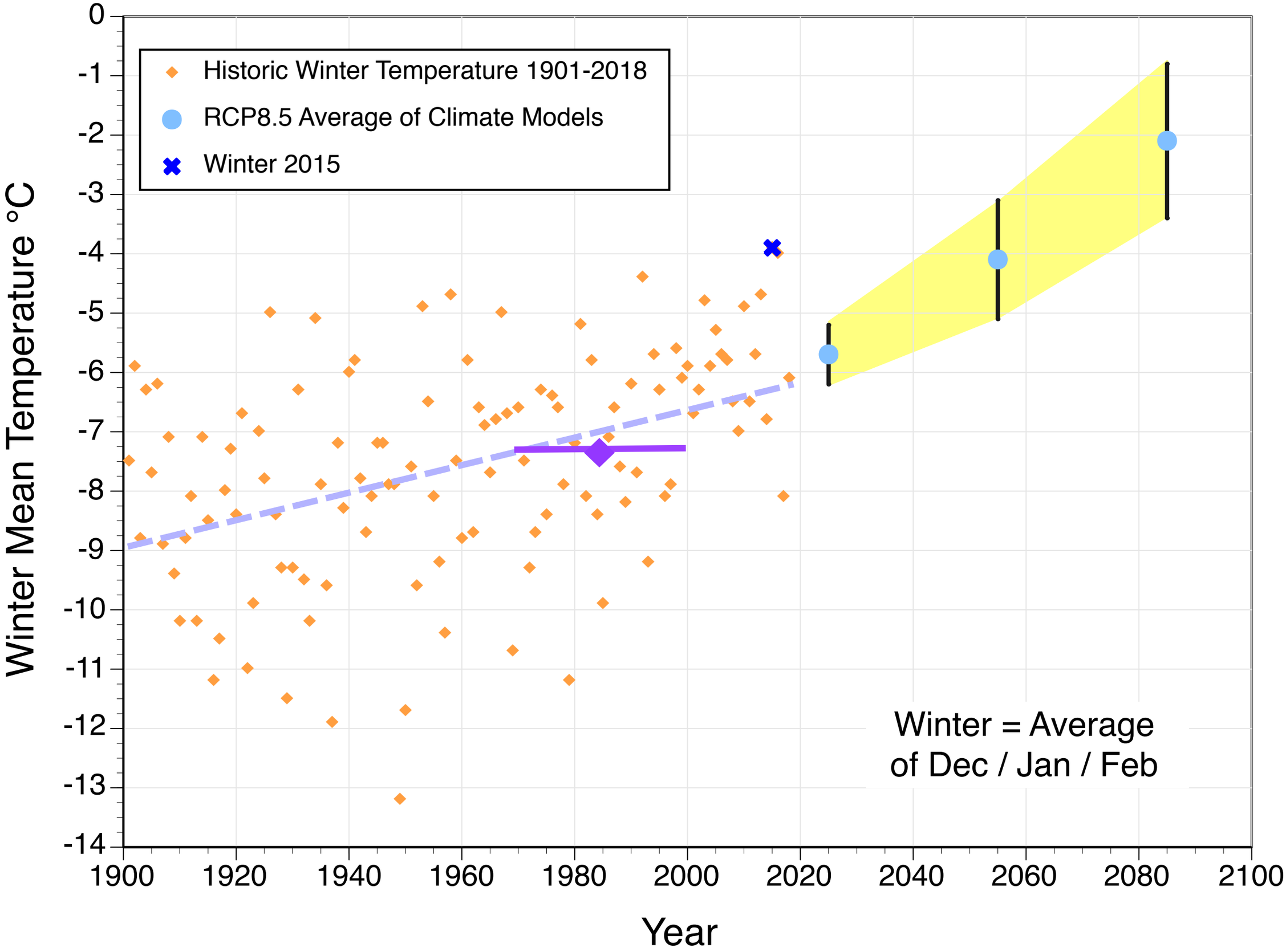


Revelstoke Ski Resort Elevation 1369 m

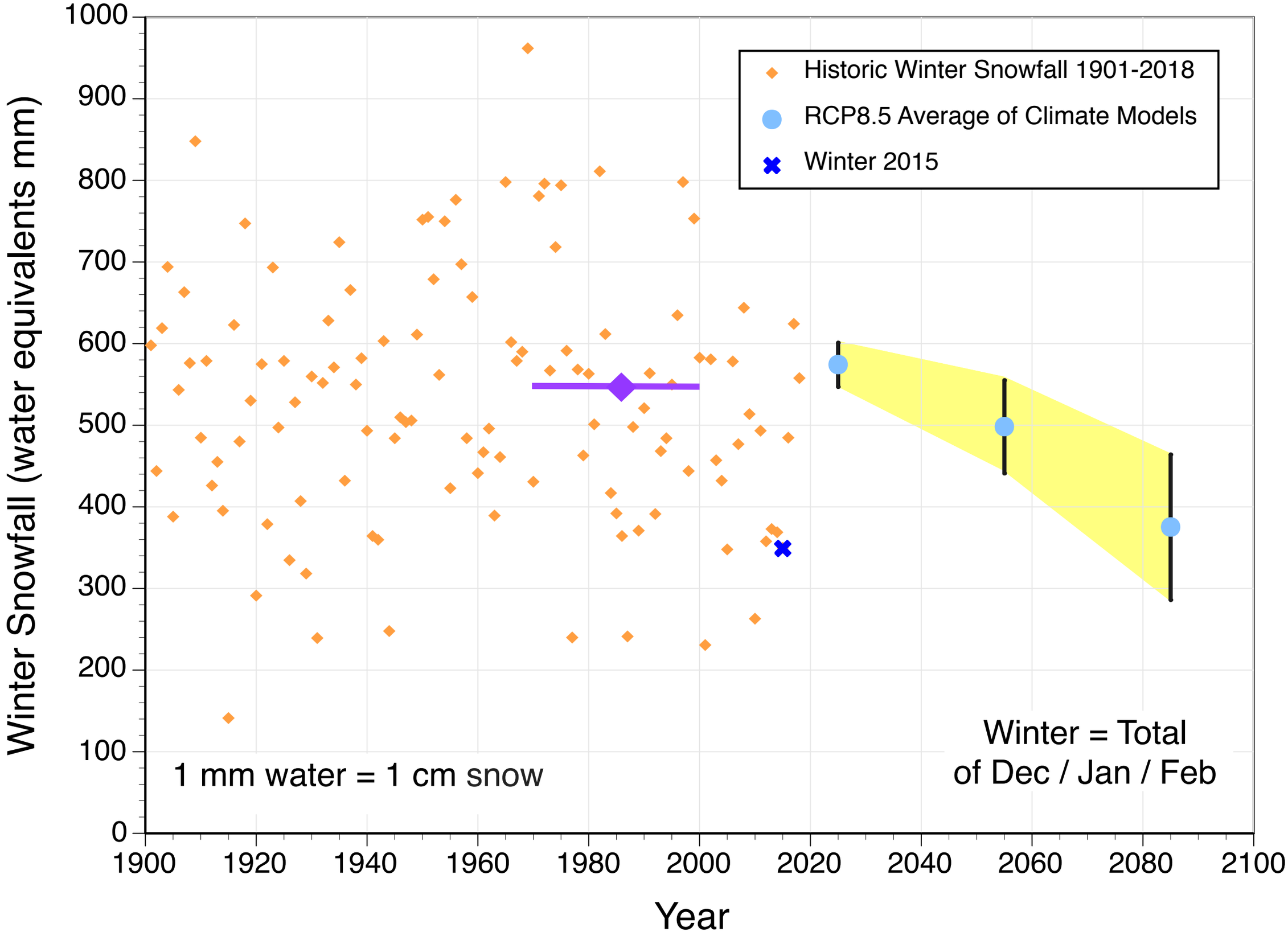


Ski Season Reduction 45%

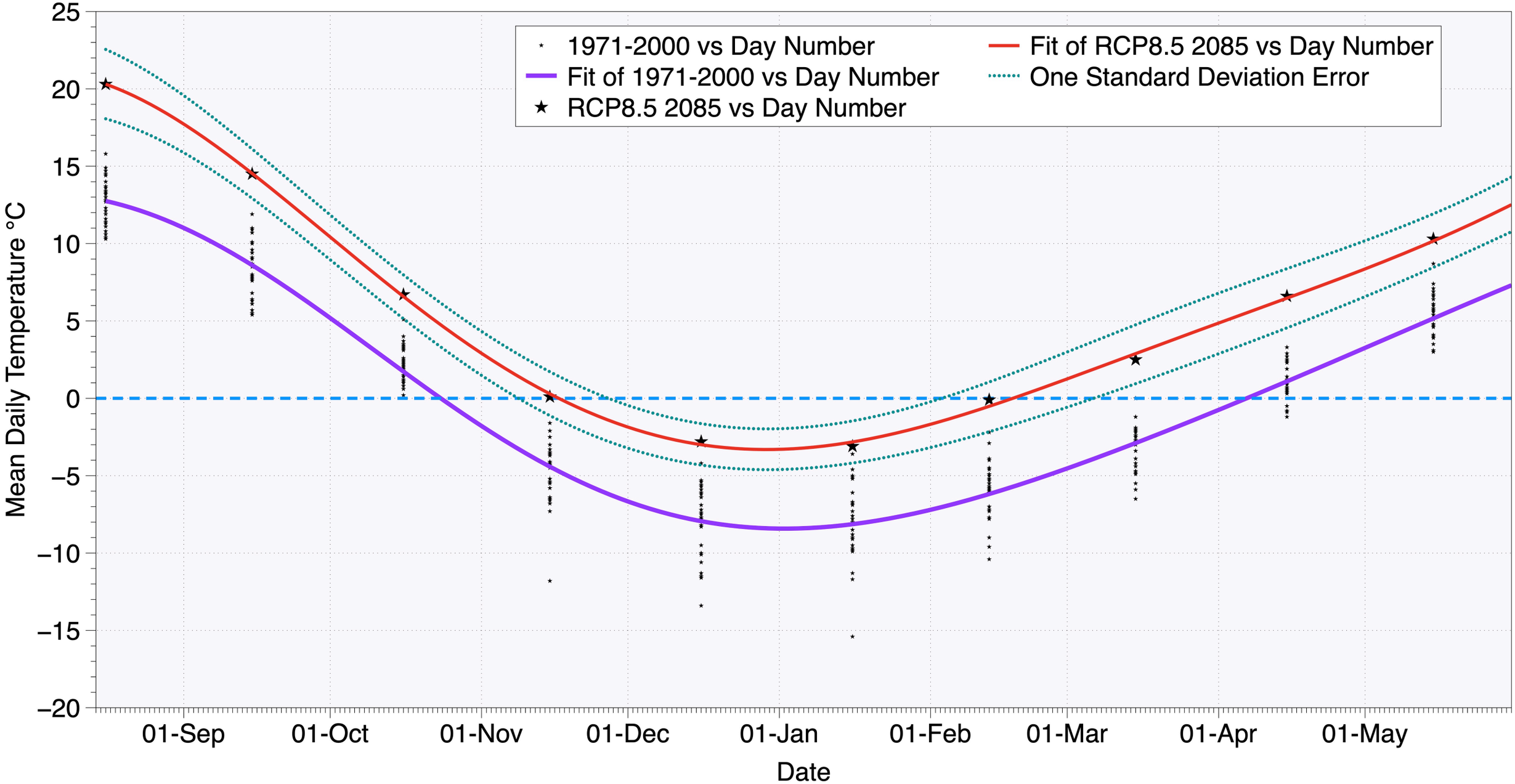
Whitewater Ski Resort - Mid-Elevation 1729 m



Whitewater Ski Resort - Mid-Elevation 1729 m

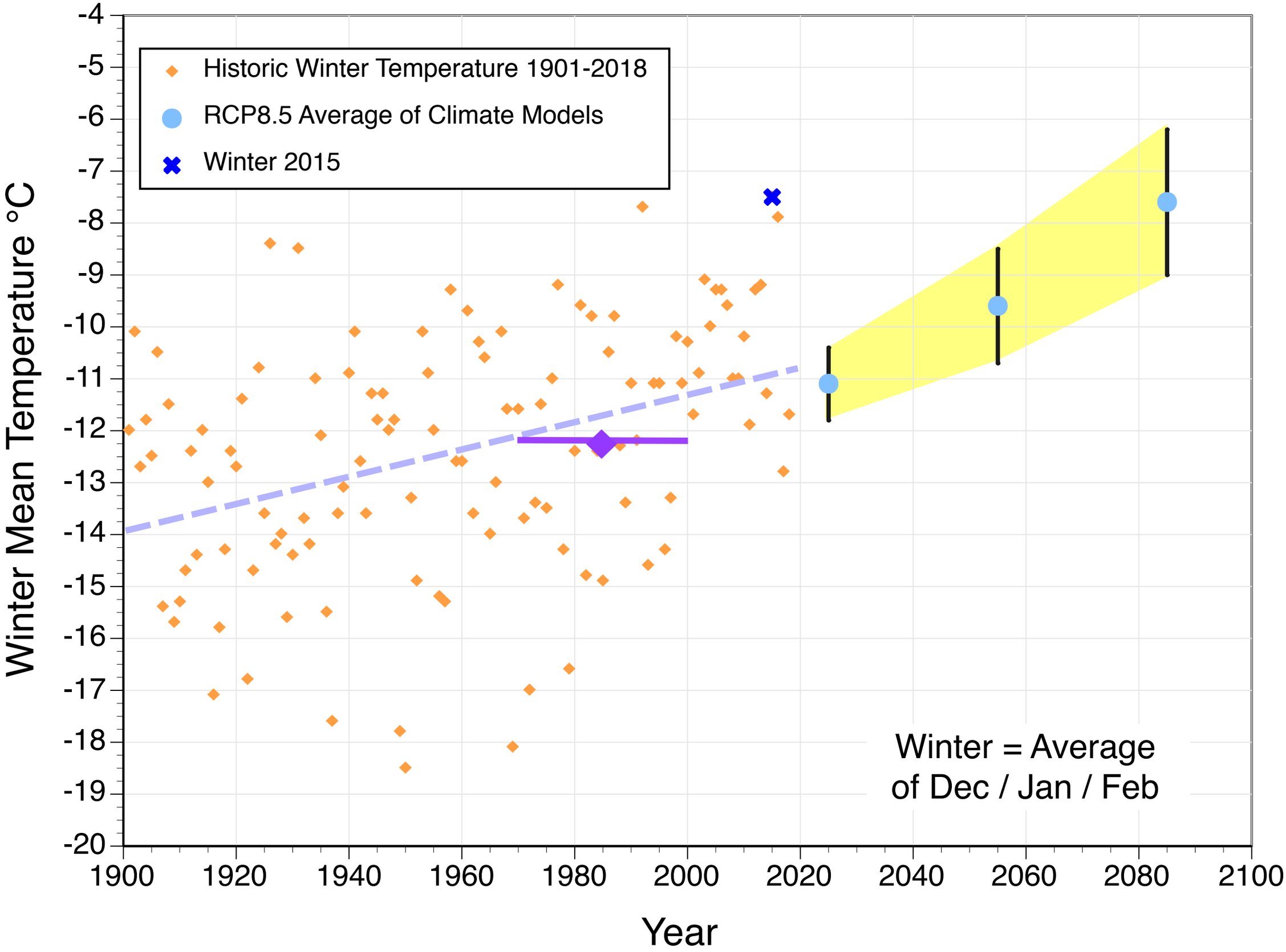


Whitewater Ski Resort Elevation 1729 m

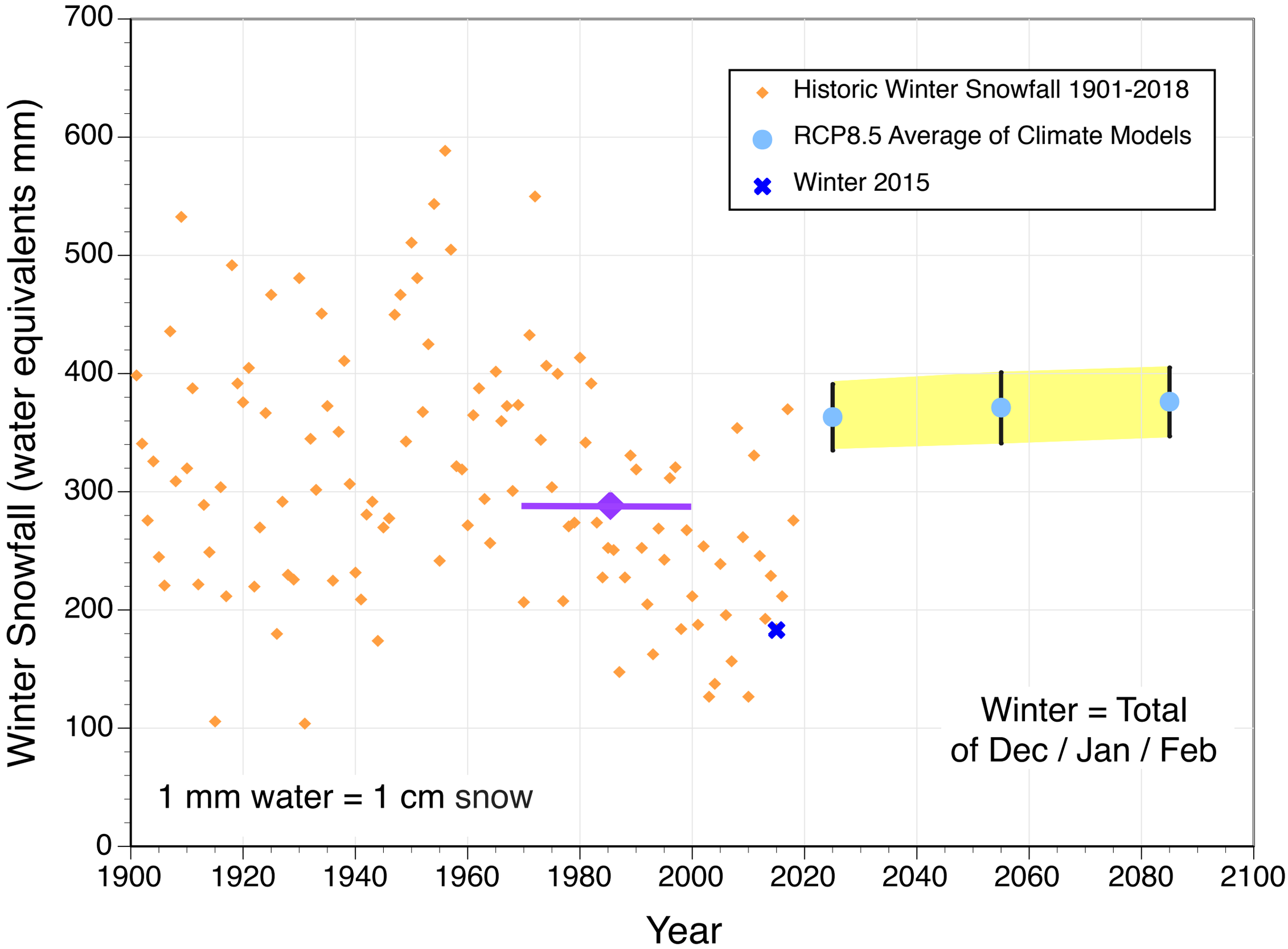


Ski Season Reduction 44%

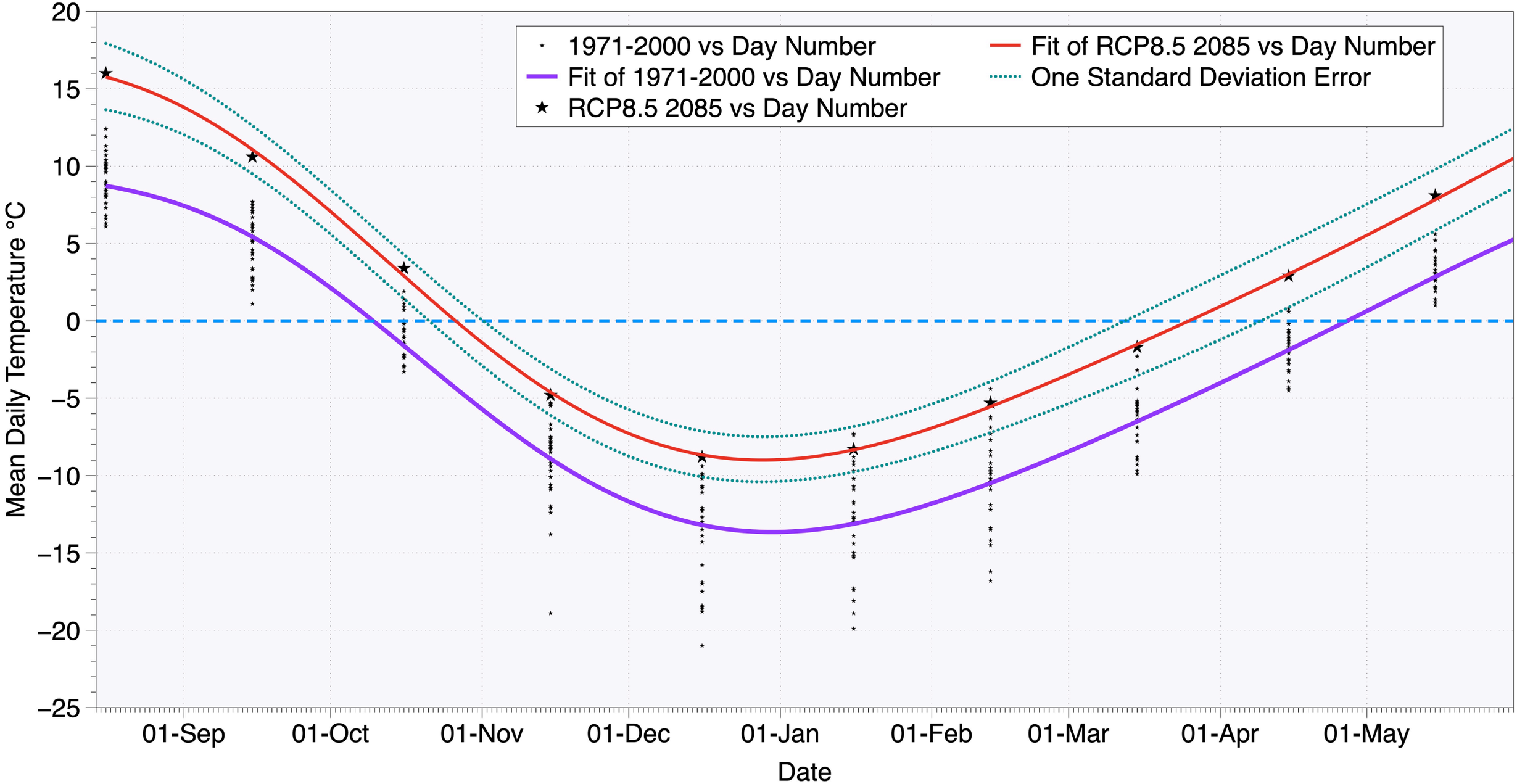
Lake Louise Ski Resort - Mid-Elevation 2142 m



Lake Louise Ski Resort - Mid-Elevation 2142 m

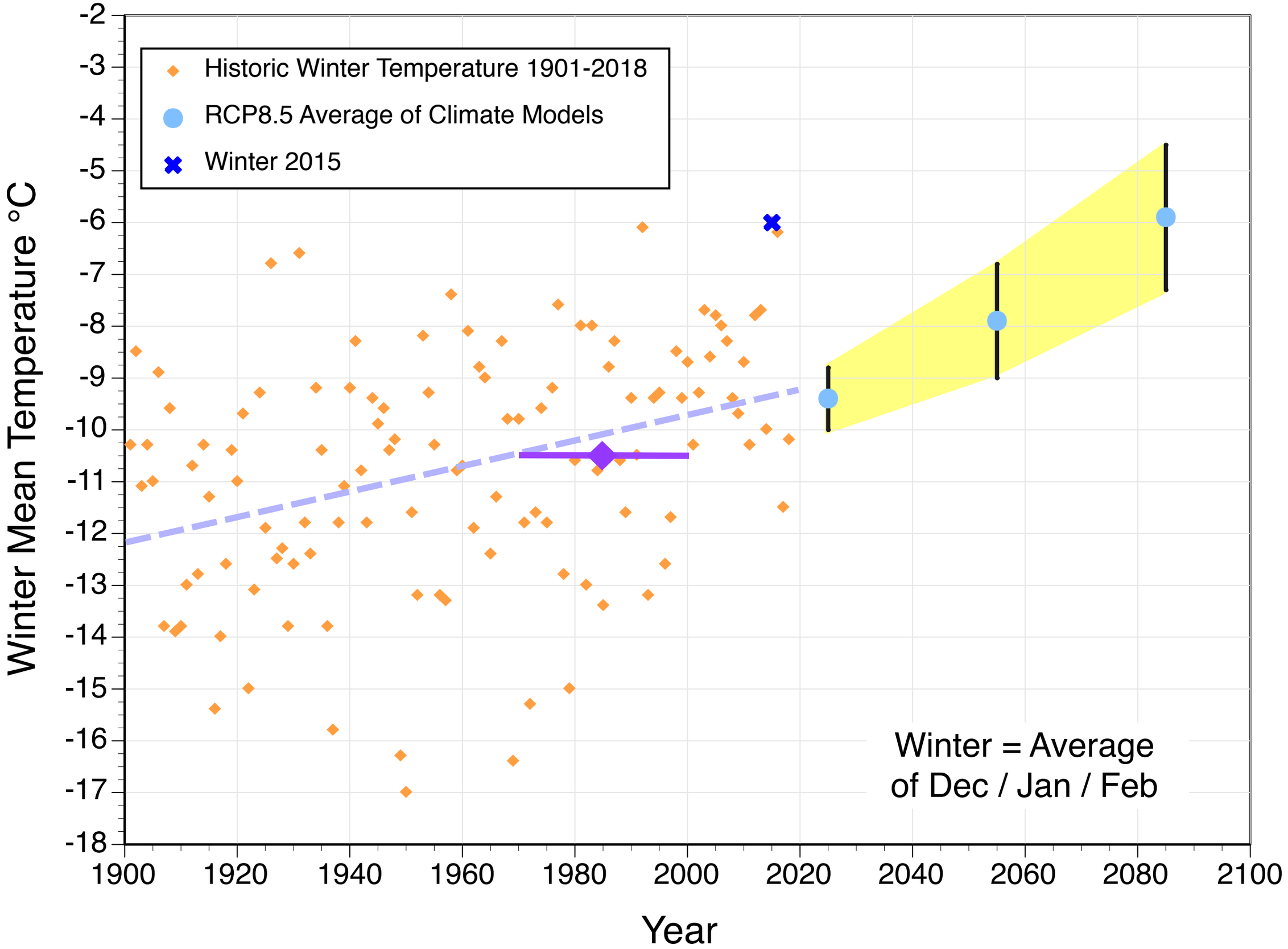


Lake Louise Ski Resort Elevation 2142 m

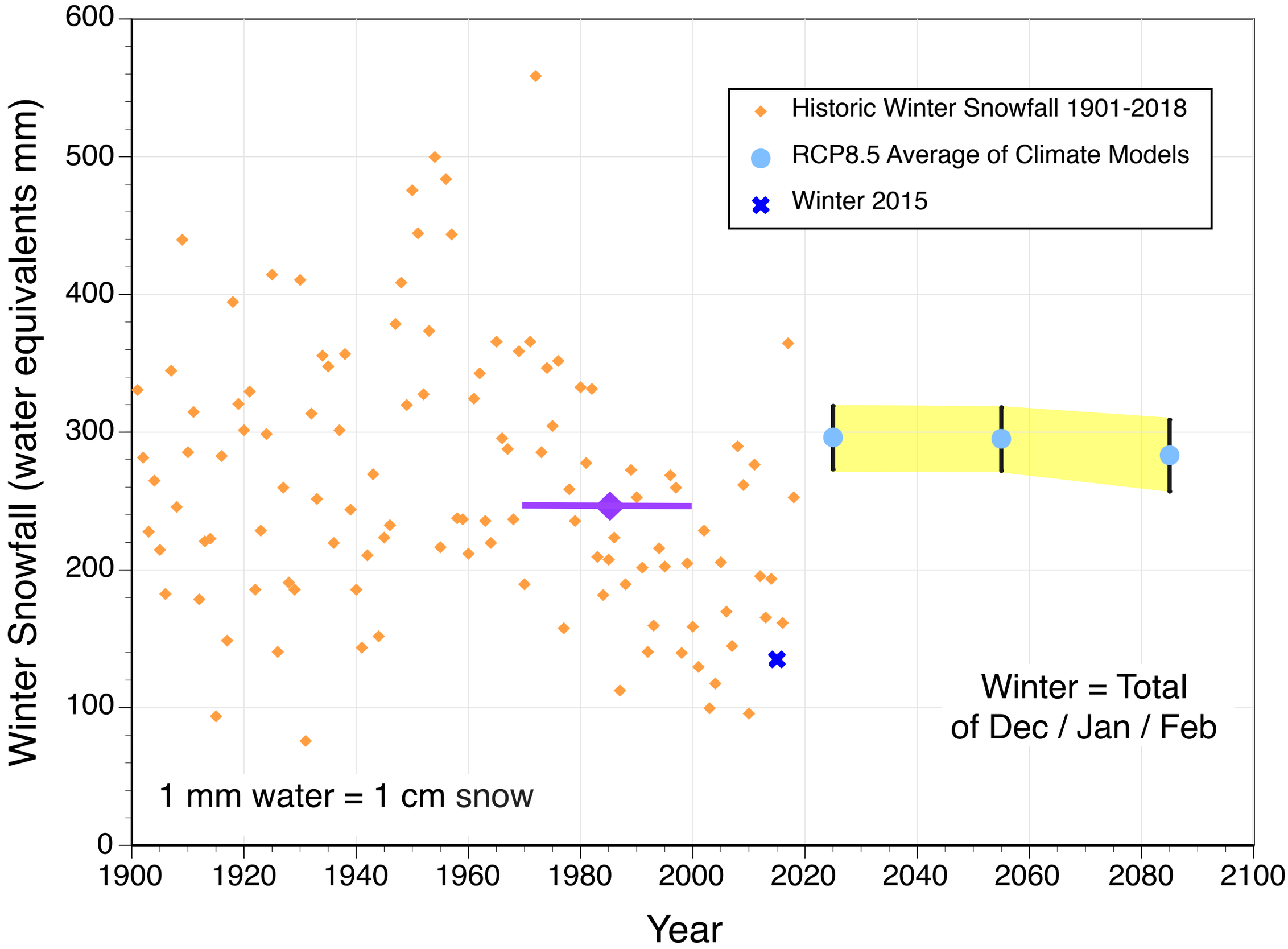


Ski Season Reduction 24%

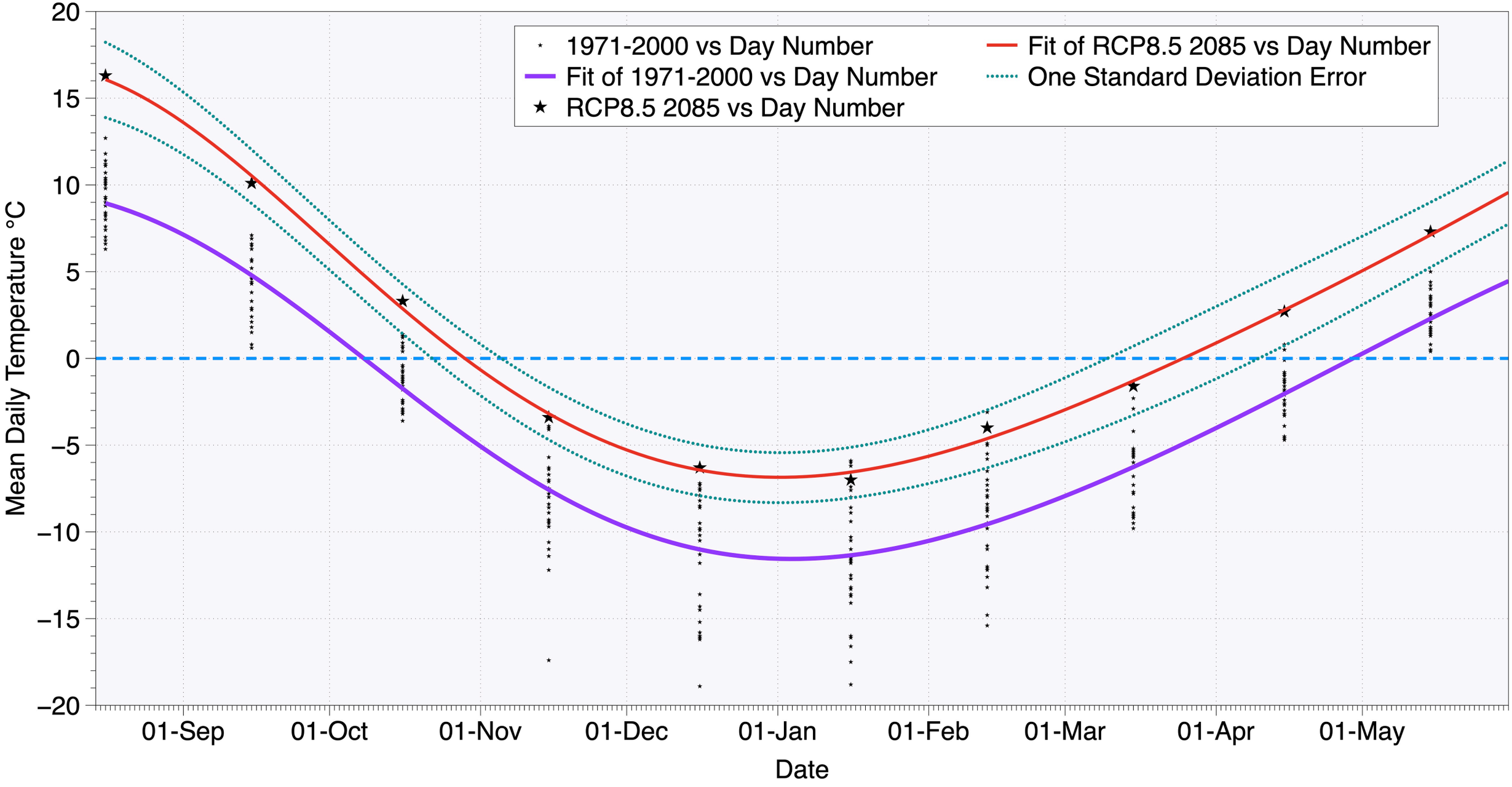
Sunshine Ski Resort - Mid-Elevation 2207 m



Sunshine Ski Resort - Mid-Elevation 2207 m

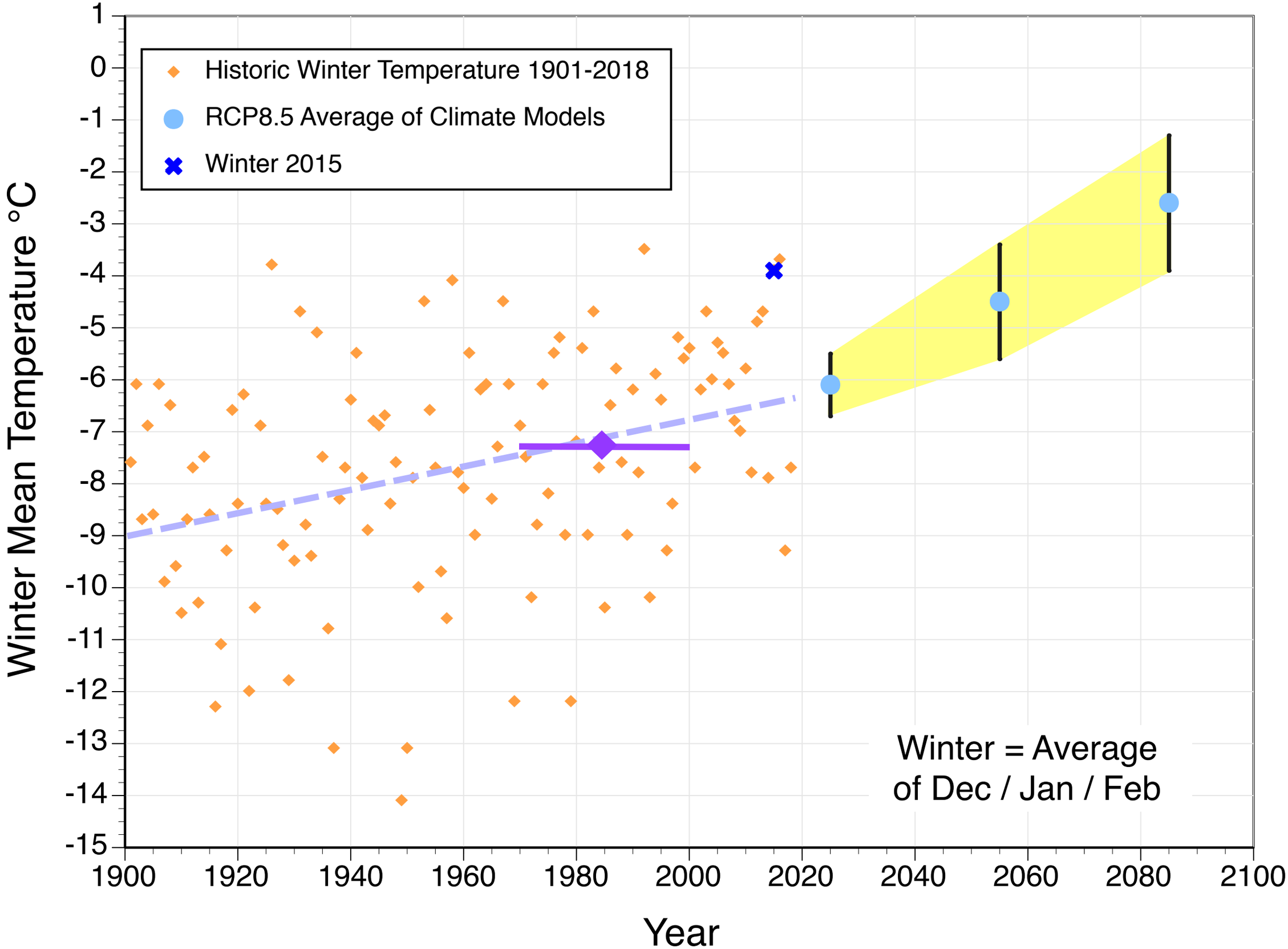


Sunshine Ski Resort Elevation 2207 m

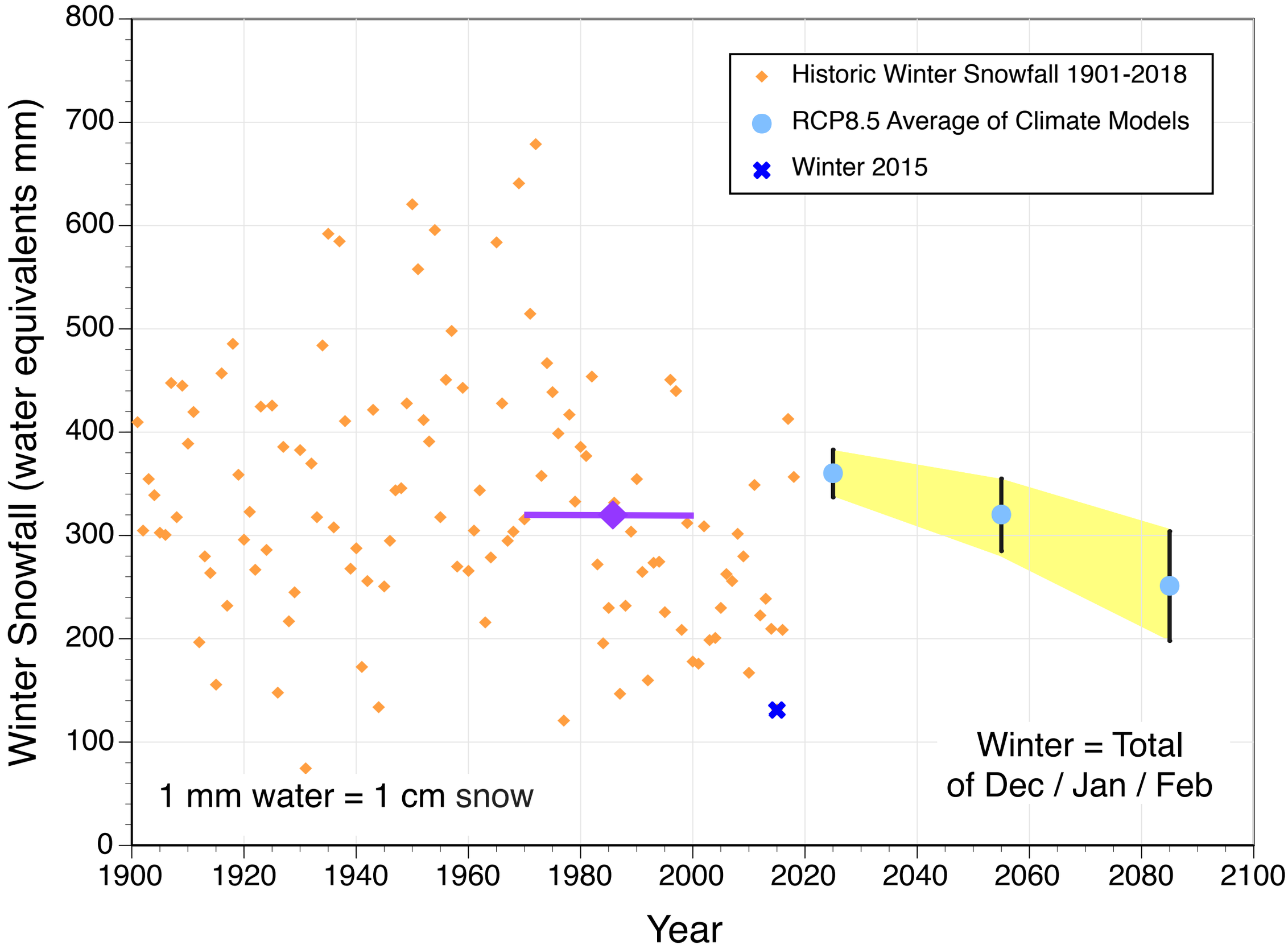


Ski Season Reduction 28%

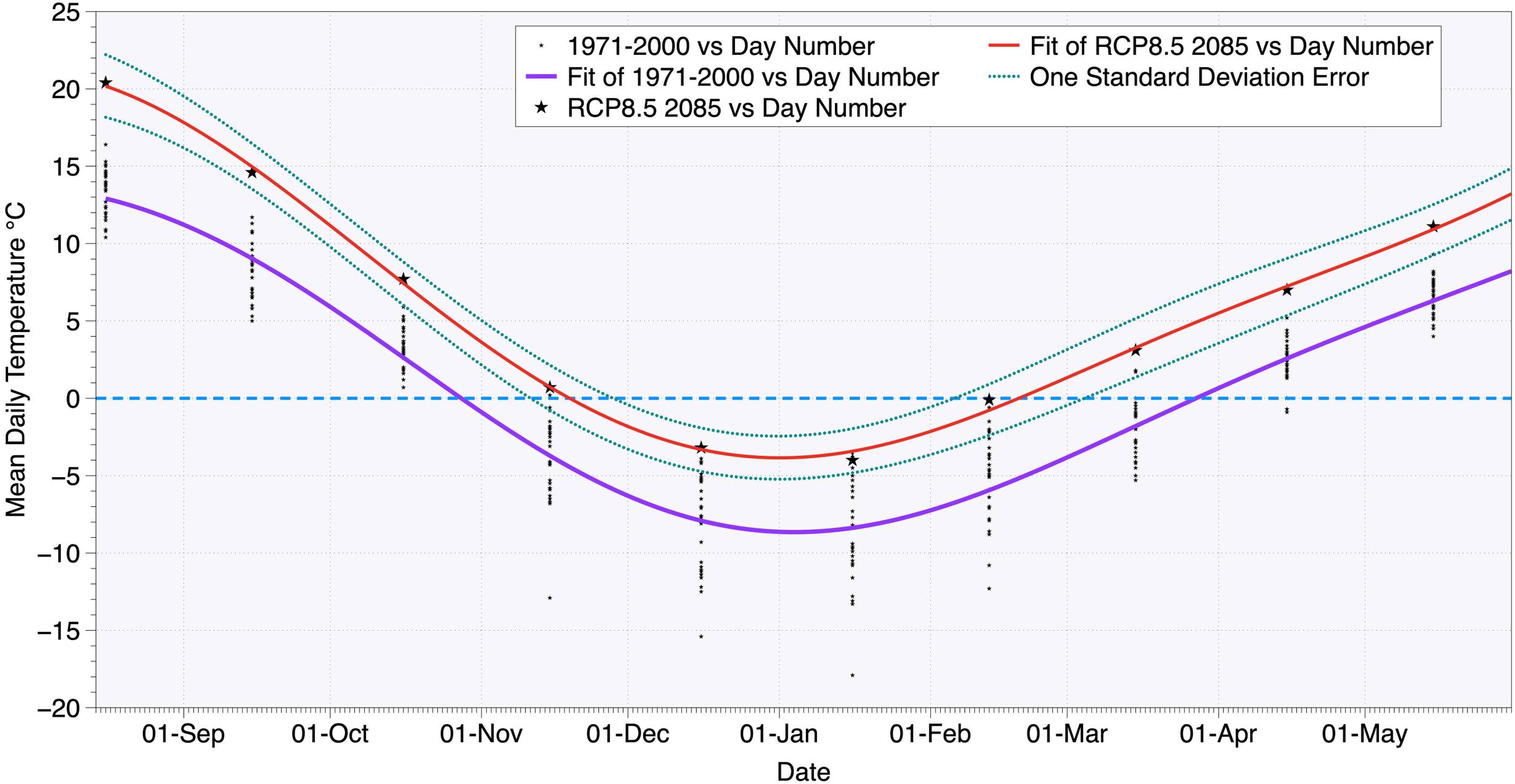
Fernie Ski Resort - Mid-Elevation 1593 m



Fernie Ski Resort - Mid-Elevation 1593 m

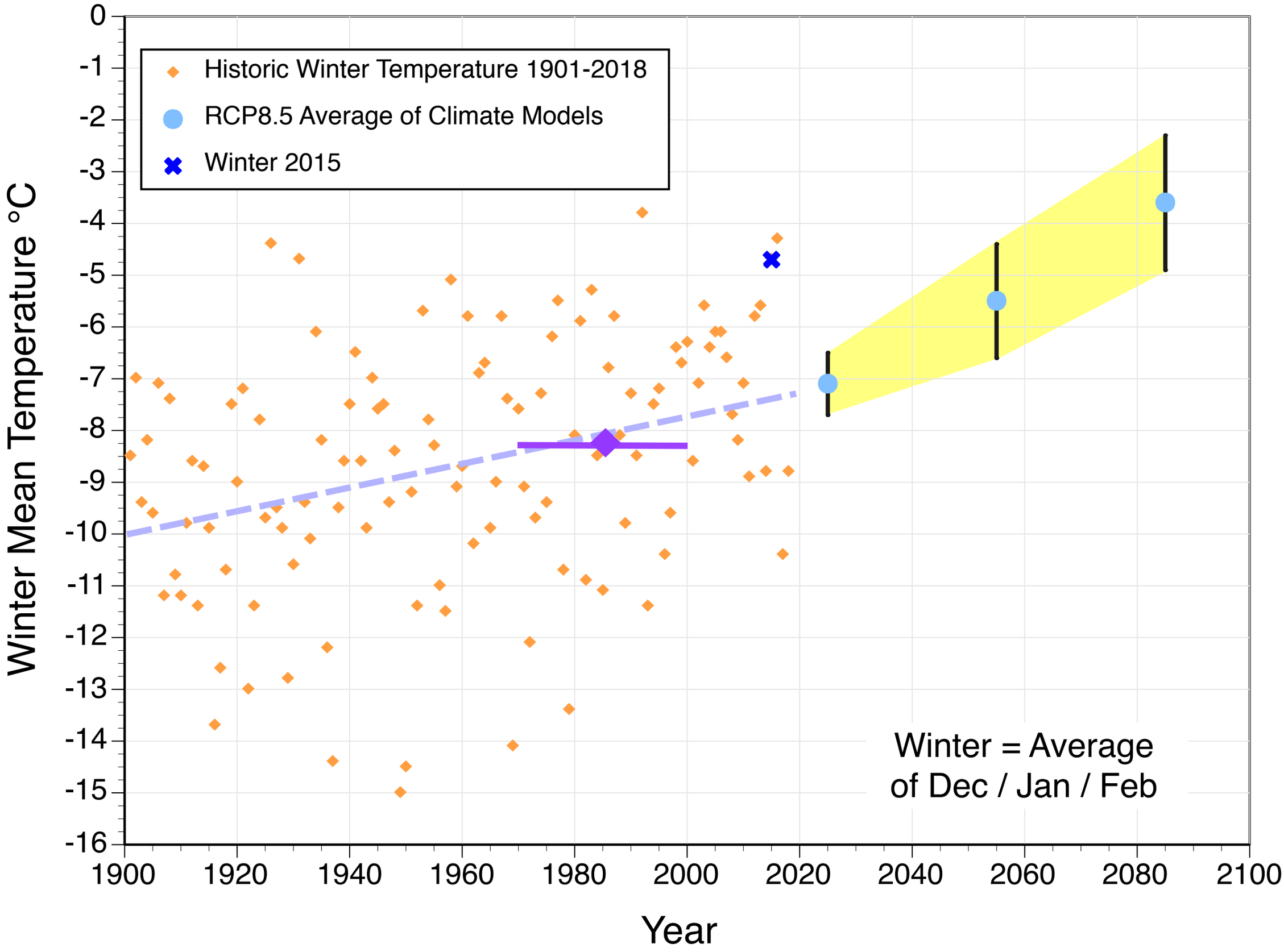


Fernie Ski Resort Elevation 1593 m

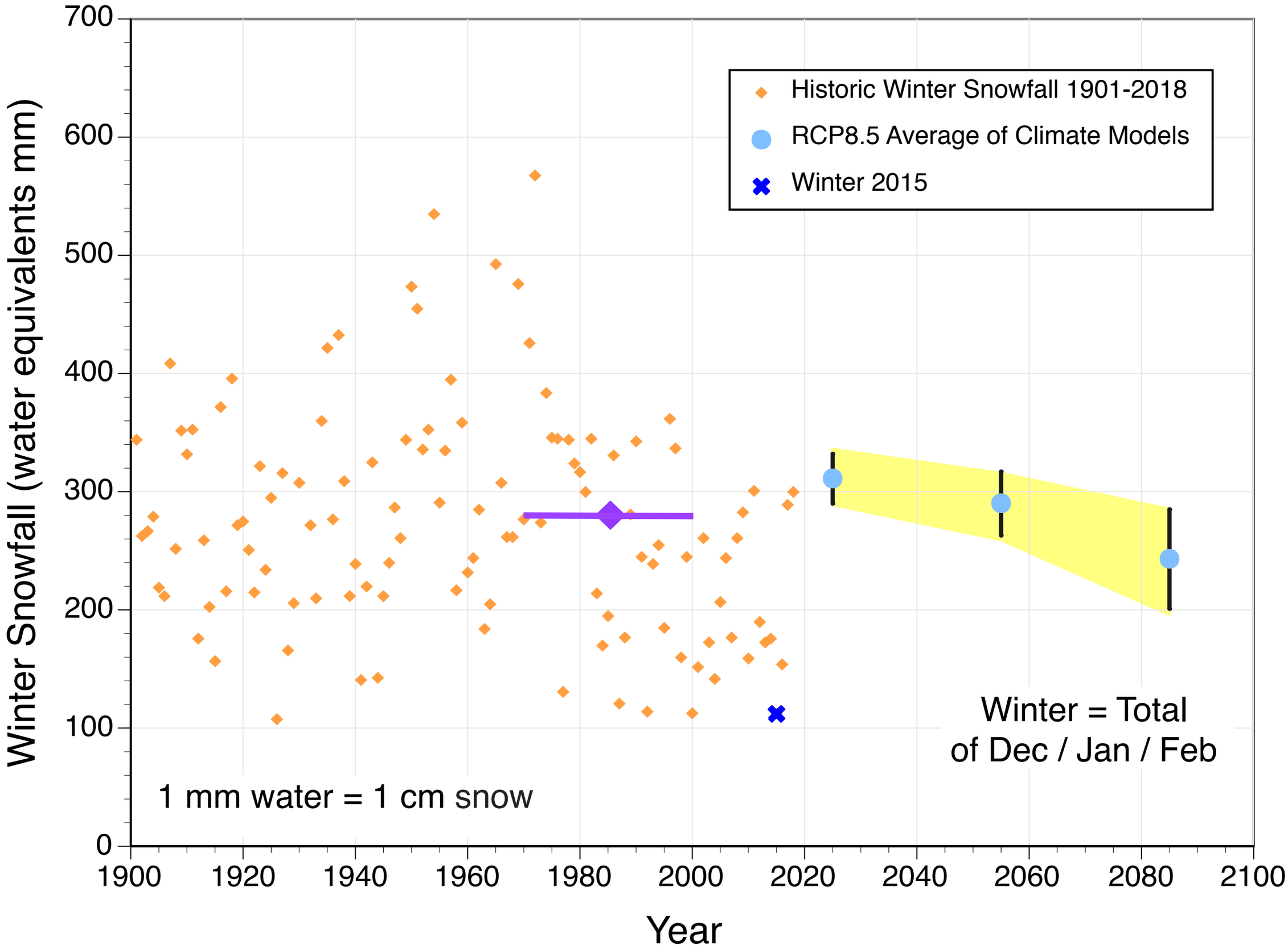


Ski Season Reduction 39%

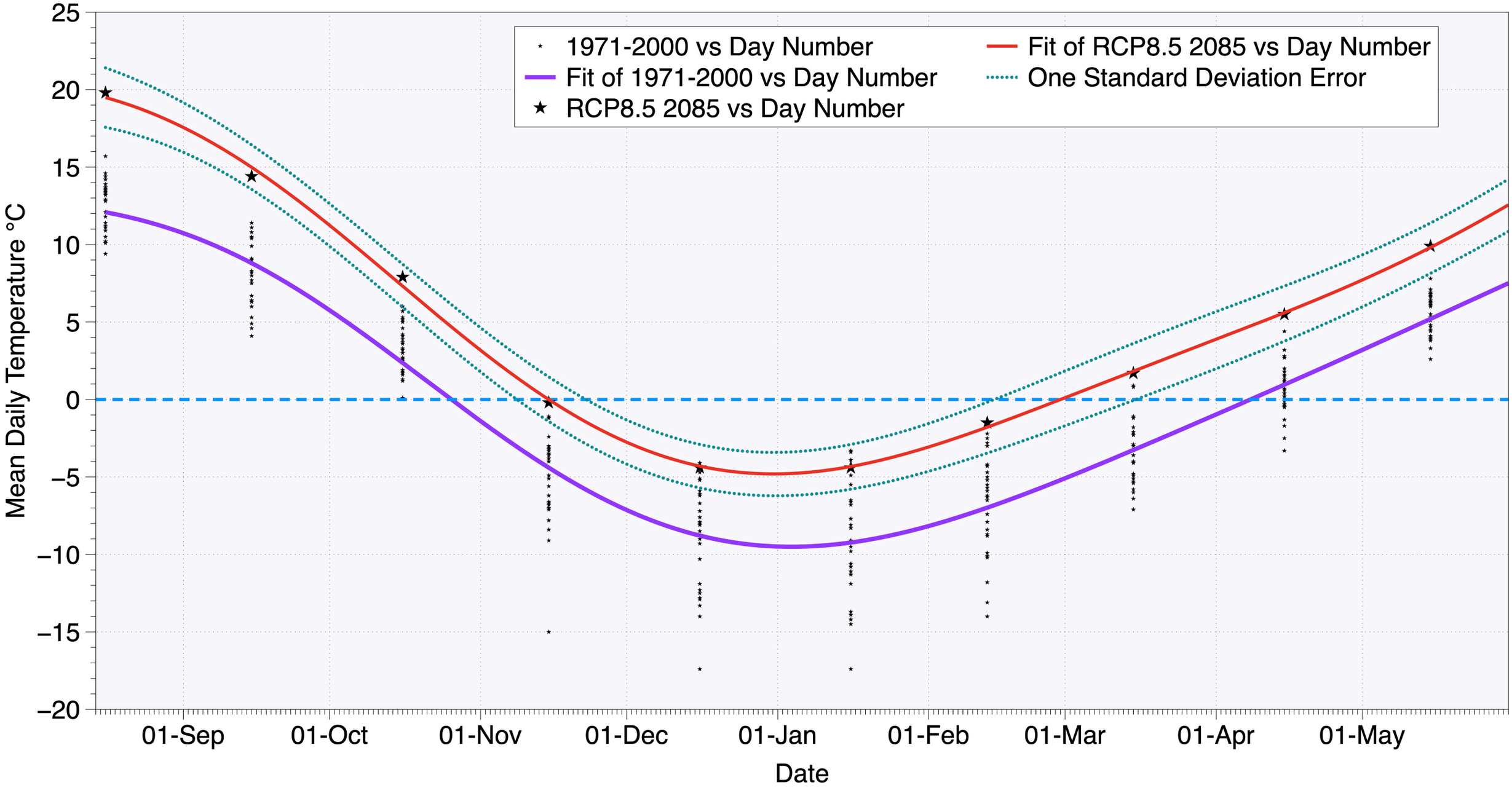
Castle Mtn Ski Resort - Mid-Elevation 1842 m



Castle Mtn Ski Resort - Mid-Elevation 1842 m



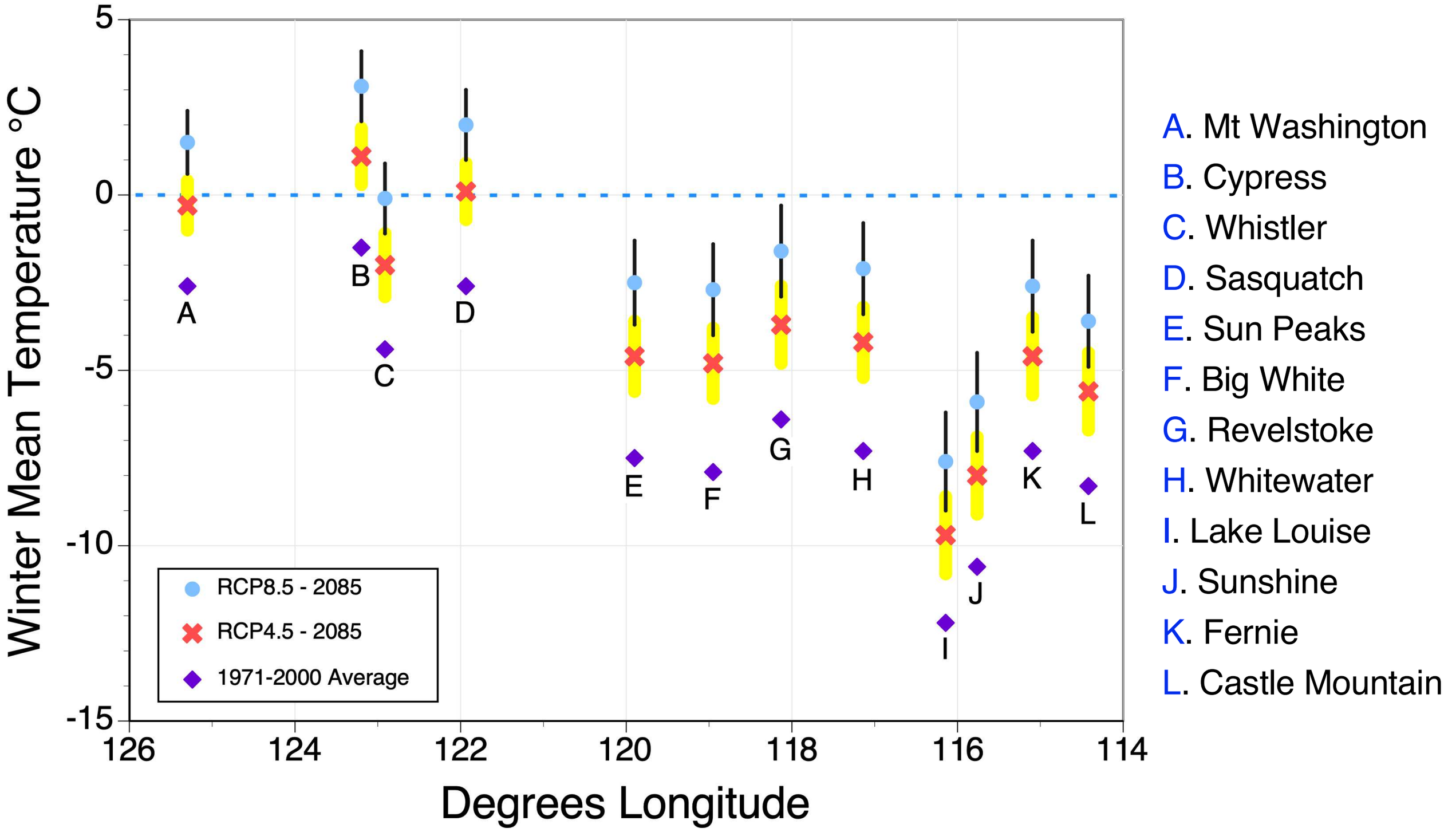
Castle Mt Ski Resort Elevation 1842 m



Ski Season Reduction 36%

Western Canada Ski Resorts Analysis Summaries RCP4.5 and RCP8.5

Winter Mean Temperature (°C)



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J. Sunshine
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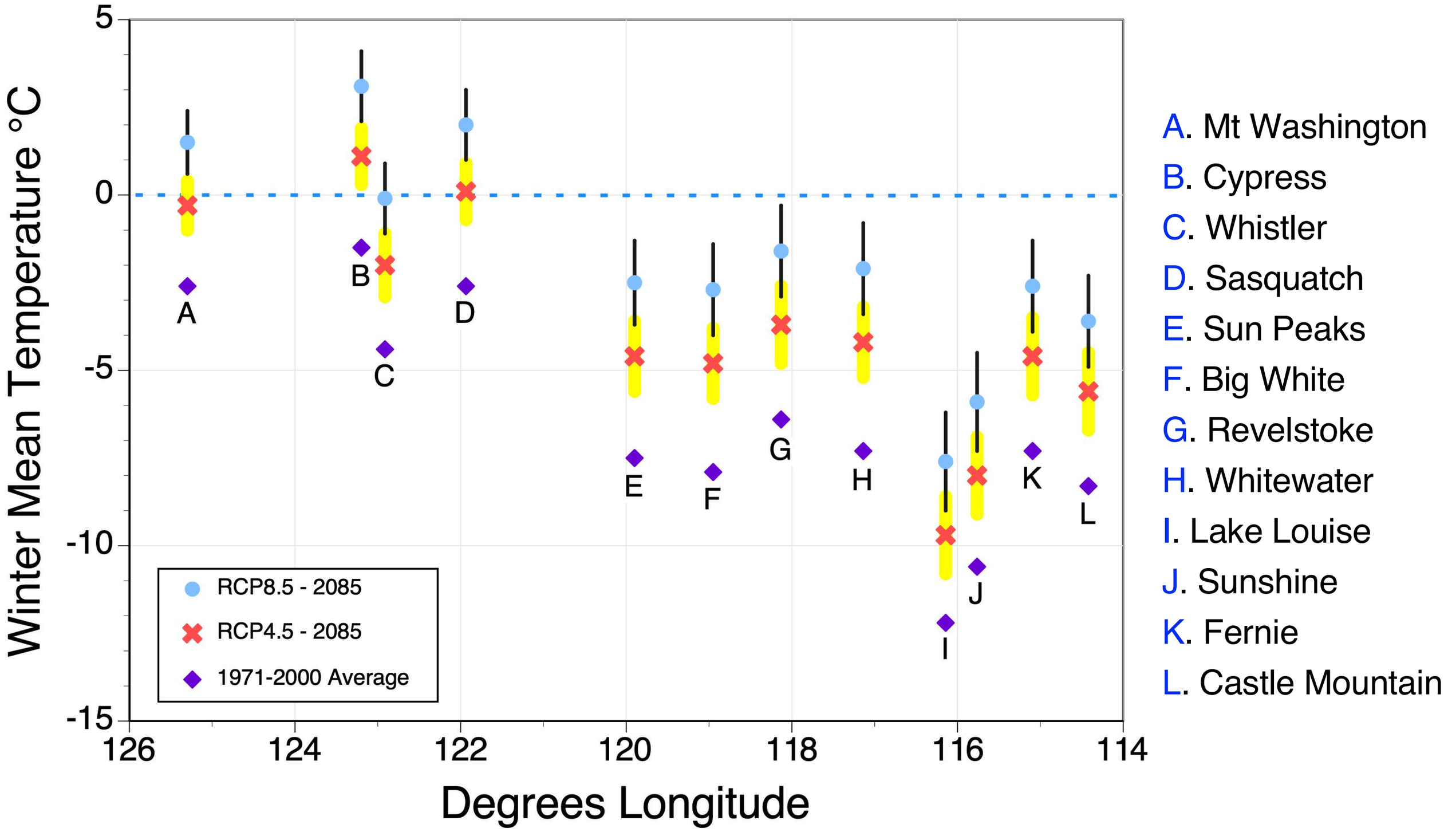
Coastal Resorts - Winter Mean Temperature (°C)

Resort	1971-2000	RCP4.5 - 2085	RCP8.5 - 2085
Mt. Washington	**-2.6**	**-0.3** ± 0.7	**1.5** ± 0.9
Cypress	**-1.5**	**1.1** ± 0.8	**3.1** ± 1.0
Whistler	**-4.4**	**-2.0** ± 0.9	**-0.1** ± 1.0
Sasquatch	**-2.6**	**0.1** ± 0.8	**2.0** ± 1.0

± 1 standard deviation from the 15 climate model results

Winter Mean Temperature (°C)



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Interior Resorts - Winter Mean Temperature (°C)

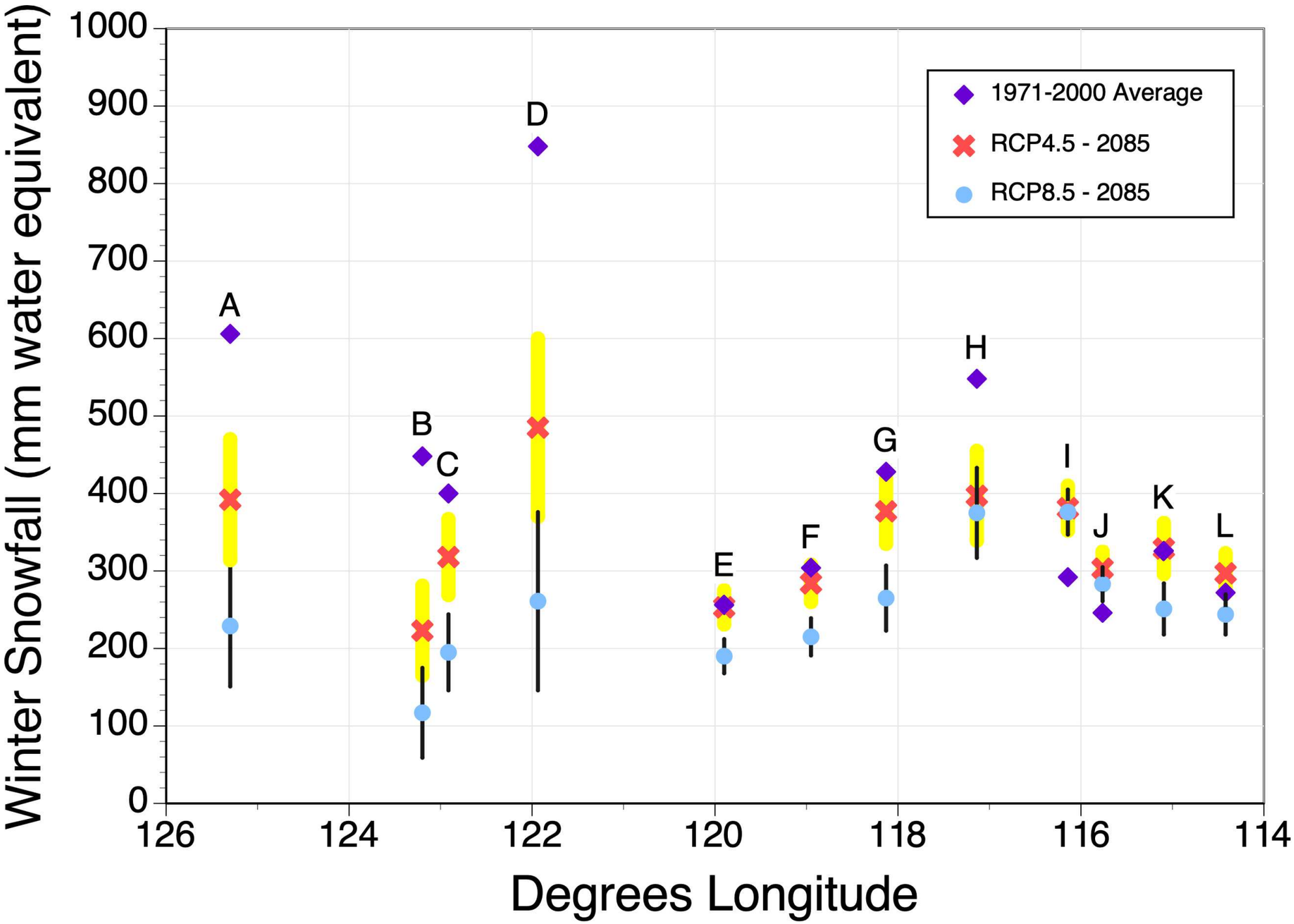
Resort	1971-2000	RCP4.5- 2085	RCP8.5 - 2085
Sun Peaks	**-7.5**	**-4.6** ± 1.0	**-2.5** ± 1.2
Big White	**-7.9**	**-4.8** ± 1.0	**-2.7** ± 1.3
Revelstoke	**-6.4**	**-3.7** ± 1.1	**-1.6** ± 1.3
Whitewater	**-7.3**	**-4.2** ± 1.0	**-2.1** ± 1.3
Sunshine	**-10.6**	**-8.0** ± 1.1	**-5.9** ± 1.4
Lake Louise	**-12.2**	**-9.7** ± 1.1	**-7.6** ± 1.4
Fernie	**-7.3**	**-4.6** ± 1.1	**-2.6** ± 1.3
Castle Mt	**-8.3**	**-5.6** ± 1.1	**-3.6** ± 1.3

± 1 standard deviation from the 15 climate model results

Take Aways - Winter Temperature

- Coastal resorts are warmer than interior resorts.
- Winter season warming under best-case scenario (RCP4.5) is about 2.3 to 3.1°C with the greatest increase seen in the resorts located in the central interior of British Columbia.
- Winter season warming under worst-case scenario (RCP8.5) is about 4.1 to 5.2°C depending on the resort with the greatest increase seen in resorts located in the central interior of British Columbia.

Winter Snowfall (mm water equivalent)



A. Mt Washington
B. Cypress
C. Whistler
D. Sasquatch
E. Sun Peaks
F. Big White
G. Revelstoke
H. Whitewater
I. Lake Louise
J. Sunshine
K. Fernie
L. Castle Mountain

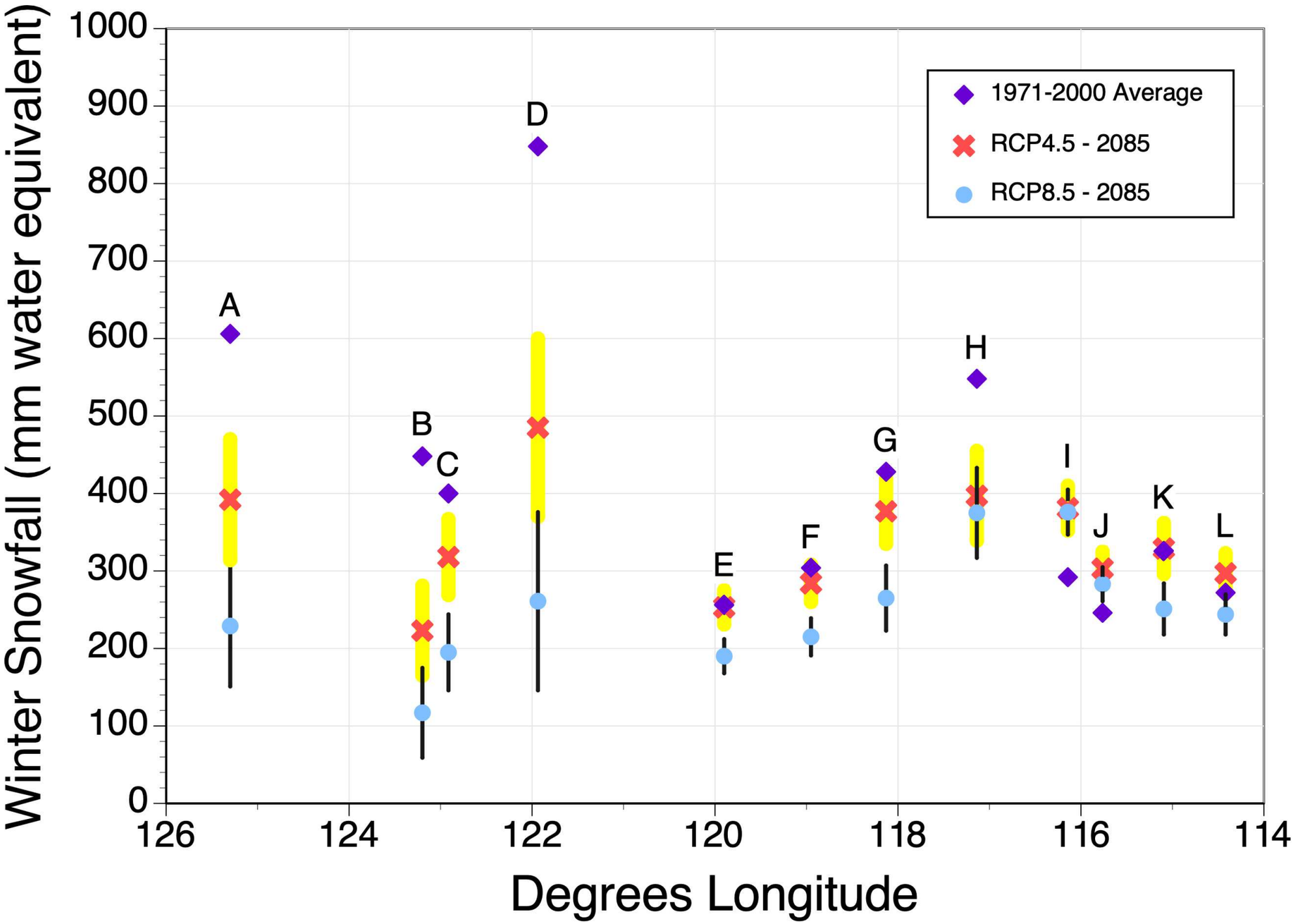
Coastal Resorts - Winter Snowfall

(mm water equivalent)

Resort	1971-2000	RCP4.5 - 2085	RCP8.5 - 2085
Mt. Washington	**606**	**392** ± 78	**229** ± 77
Cypress	**448**	**223** ± 58	**117** ± 46
Whistler	**400**	**318** ± 49	**195** ± 59
Sasquatch	**848**	**485** ± 115	**261** ± 99

± 1 standard deviation from the 15 climate model results

Winter Snowfall (mm water equivalent)



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Interior Resorts - Winter Snowfall

(mm water equivalent)

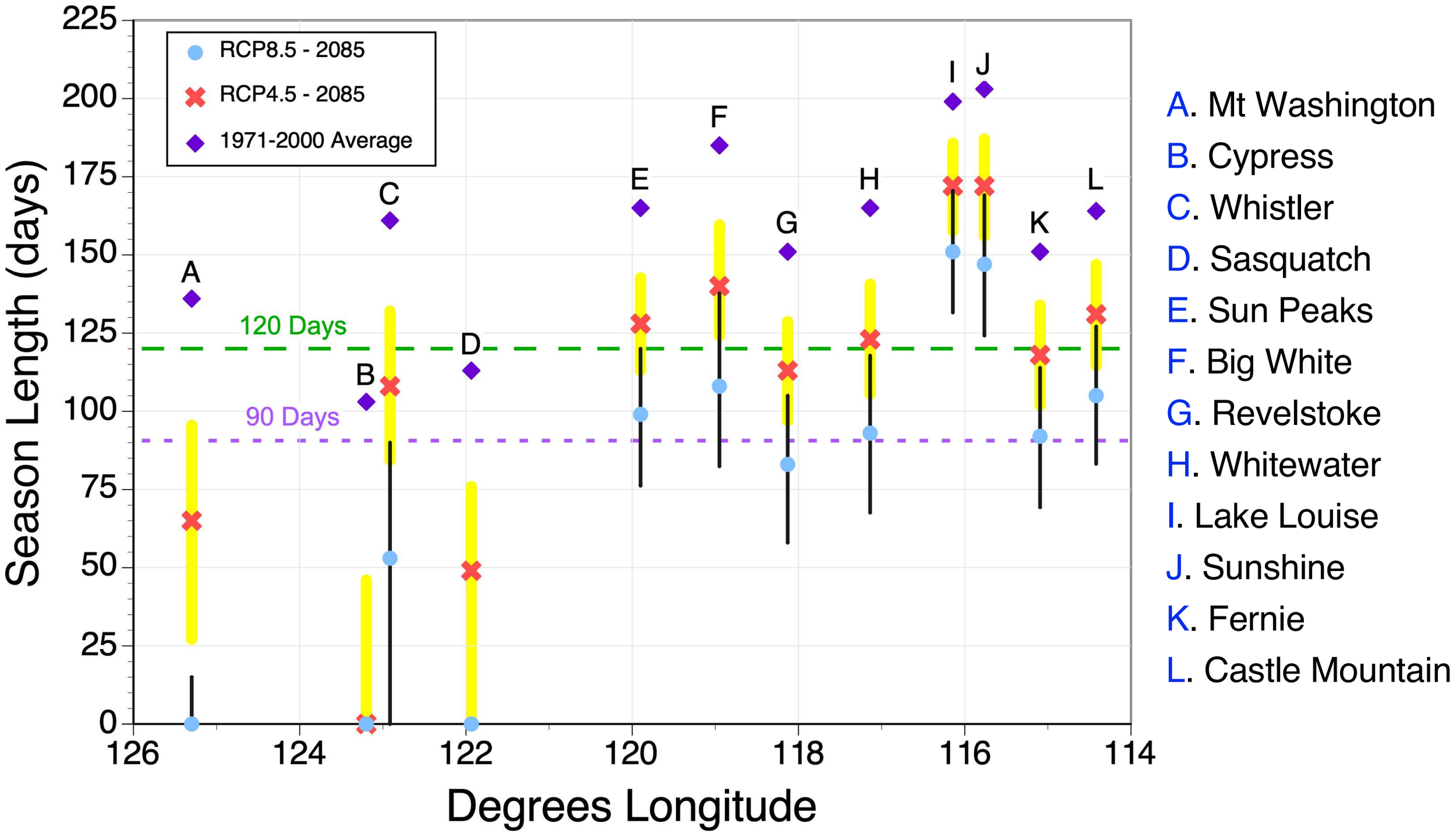
Resort	1971-2000	RCP4.5- 2085	RCP8.5 - 2085
Sun Peaks	**256**	**253** ± 22	**190** ± 40
Big White	**304**	**284** ± 24	**215** ± 47
Revelstoke	**428**	**377** ± 42	**265** ± 62
Whitewater	**548**	**397** ± 58	**375** ± 89
Sunshine	**246**	**303** ± 22	**283** ± 26
Lake Louise	**292**	**381** ± 29	**376** ± 29
Fernie	**326**	**329** ± 33	**251** ± 53
Castle Mt	**272**	**297** ± 26	**244** ± 42

± 1 standard deviation from the 15 climate model results

Take Aways - Winter Snowfall

- More snow falls on the coast compared to the interior.
- Under best-case scenario (RCP4.5) snowfall will increase by 1 to 31% at Fernie, Castle Mt., Sunshine and Lake Louise. Snowfall decrease by 1 to 28% for Sun Peaks, Big White, Revelstoke and Whitewater. Coastal resorts will see a large decrease between 21 to 50%.
- Under worst-case scenario (RCP8.5) snowfall will decrease 52 to 74% for coastal resorts. Sunshine and Lake Louise will see snowfall increase by about 15 and 29%, respectively. Decrease in snowfall of 26 to 38% for other interior resorts.

Ski Season Length (days)



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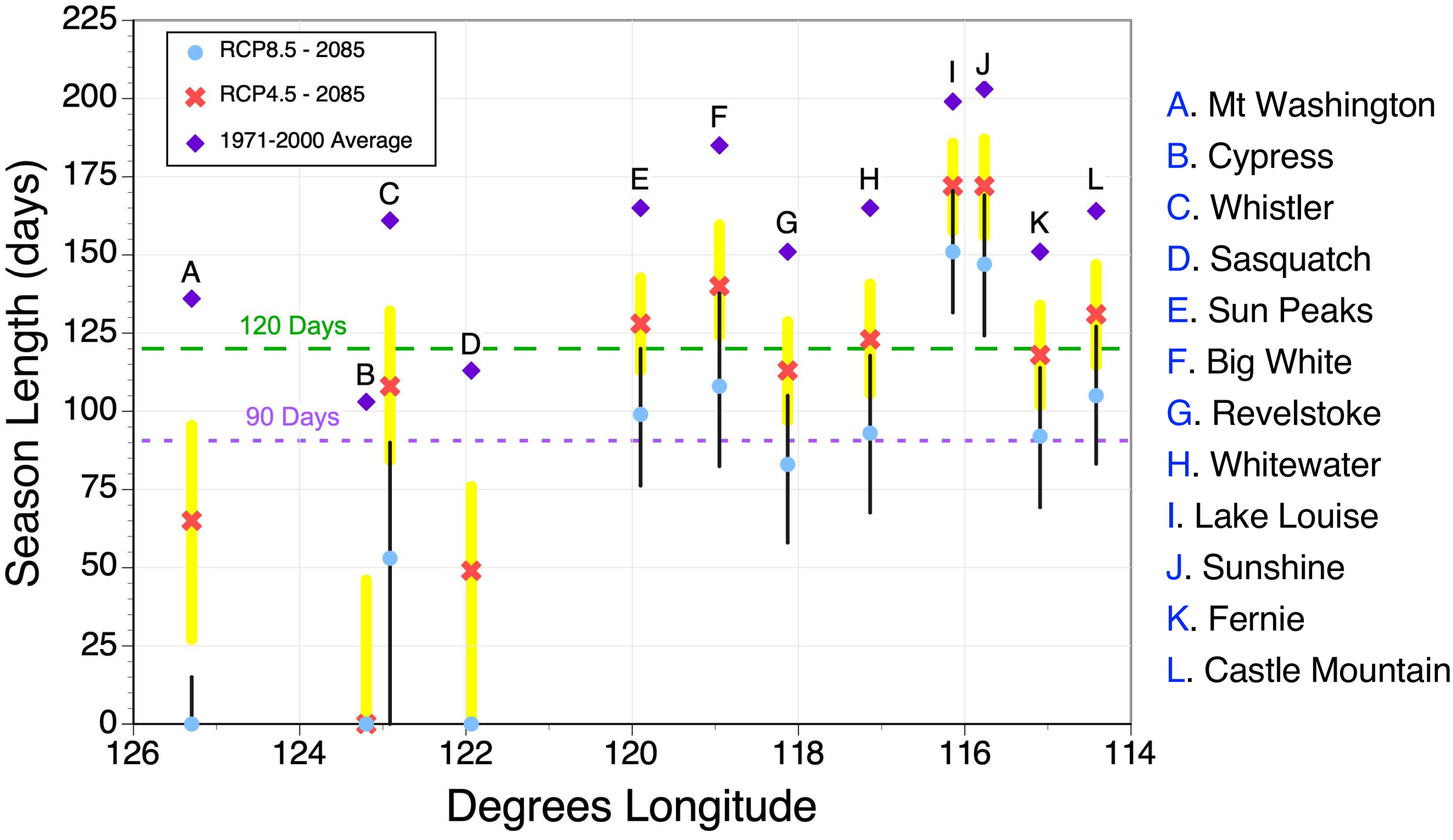
Coastal Resorts - Ski Season Length (days)

Resort	1971-2000	RCP4.5 - 2085	RCP8.5 - 2085
Mt. Washington	**136**	**65** (37,96)	**0** (0,15)
Cypress	**103**	**0** (0,46)	**0**
Whistler	**161**	**108** (84,132)	**53** (0,90)
Sasquatch	**113**	**49** (0, 76)	**0**

± 1 standard deviation from the 15 climate model results

Ski Season Length (days)



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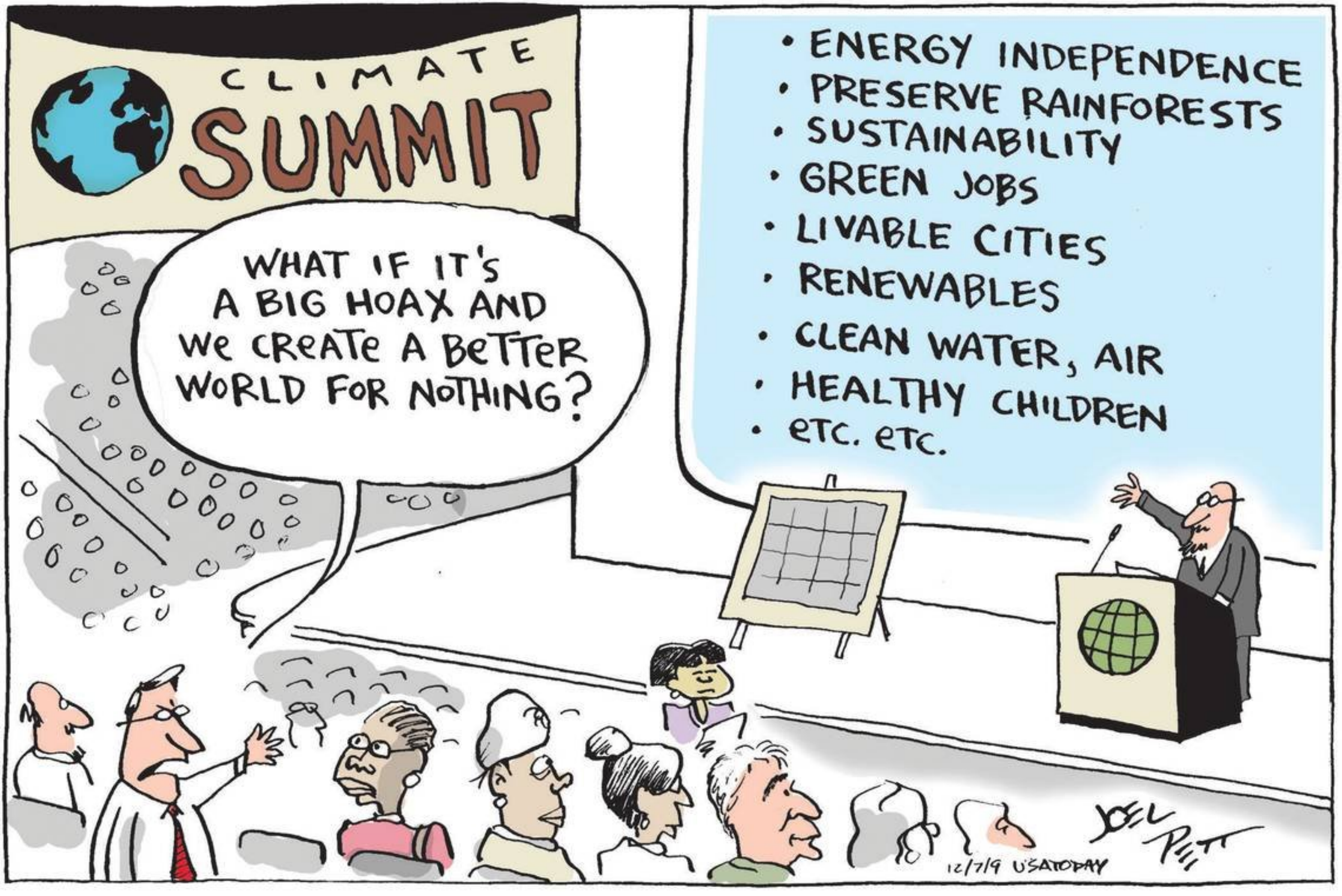
Interior Resorts - Ski Season Length (days)

Resort	1971-2000	RCP4.5- 2085	RCP8.5 - 2085
Sun Peaks	**165**	**128** (113,143)	**99** (76,120)
Big White	**185**	**140** (124,160)	**108** (82,138)
Revelstoke	**151**	**113** (97,129)	**83** (58,105)
Whitewater	**165**	**123** (106,141)	**93** (68,118)
Sunshine	**203**	**172** (156,187)	**147** (124,169)
Lake Louise	**199**	**172** (158,186)	**151** (132,171)
Fernie	**151**	**118** (102,134)	**92** (69,114)
Castle Mt	**164**	**131** (115,147)	**105** (83,127)

± 1 standard deviation from the 15 climate model results

Take Aways - Ski Season Length

- Ski season length generally increases inland because of colder temperatures (continentality).
- Under best-case scenario (RCP4.5) ski season will shrink by 27-45 days for interior resorts and 53-103 days for coastal resorts. Cypress no ski season under RCP4.5.
- Under worst-case scenario (RCP8.5) ski season will shrink by 48-77 days for interior resorts and 103-136 days for coastal resorts. Cypress, Mt. Washington, and Sasquatch will have no ski season under RCP8.5.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WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
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• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.
12/7/19 USATODAY
JOEL PETT

Questions?

michael.pidwirny@ubc.ca