SUPPLEMENTARY TO: INSENSITIVITY OF GLOBAL TEMPERATURE RESPONSE TO THE MAGNITUDE OF VOLCANIC ERUPTIONS

In EGU session ***"Understanding volcano-climate impacts and the stratospheric aerosol layer"***

UiT The Arctic University of Norway

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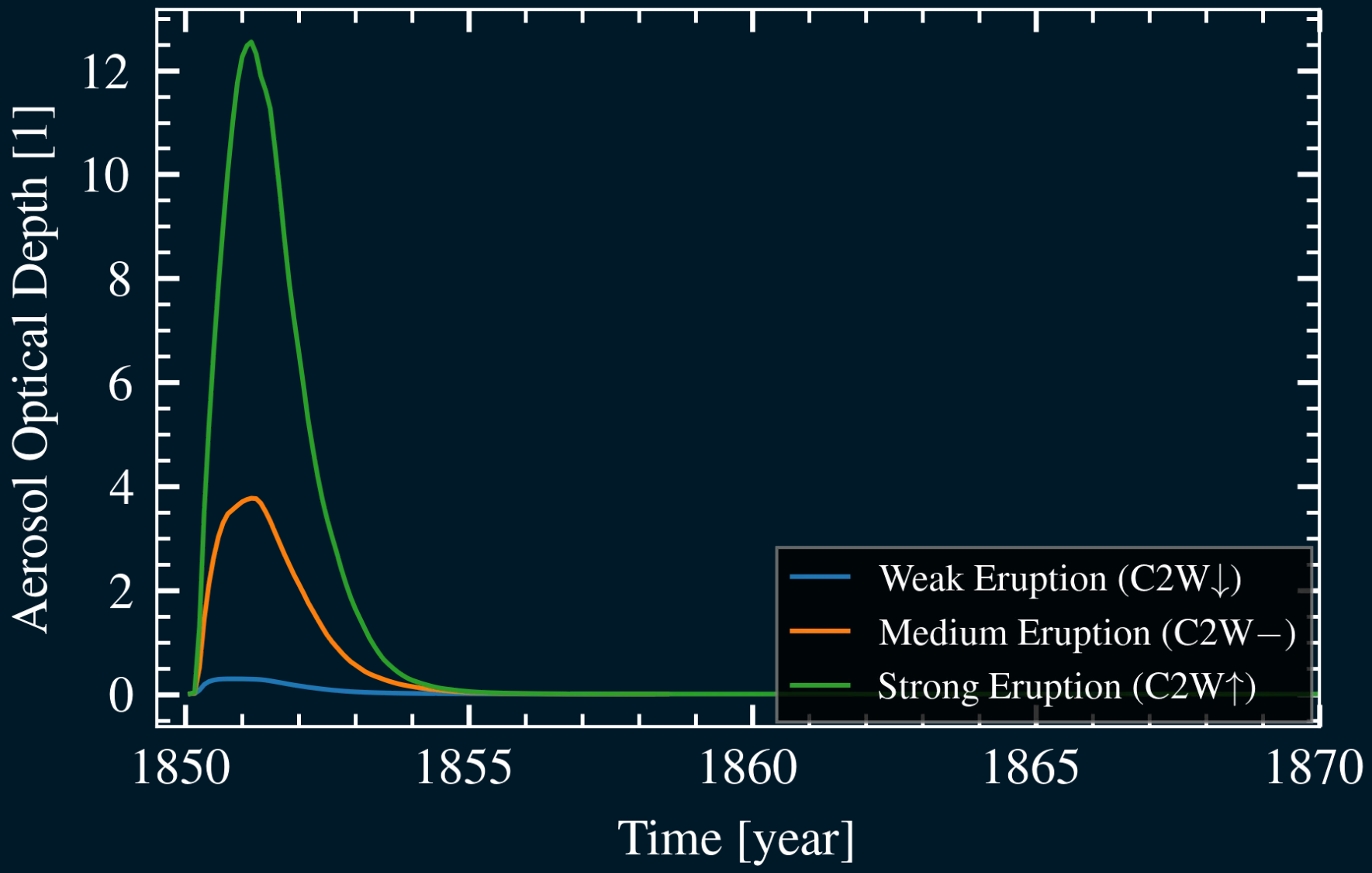
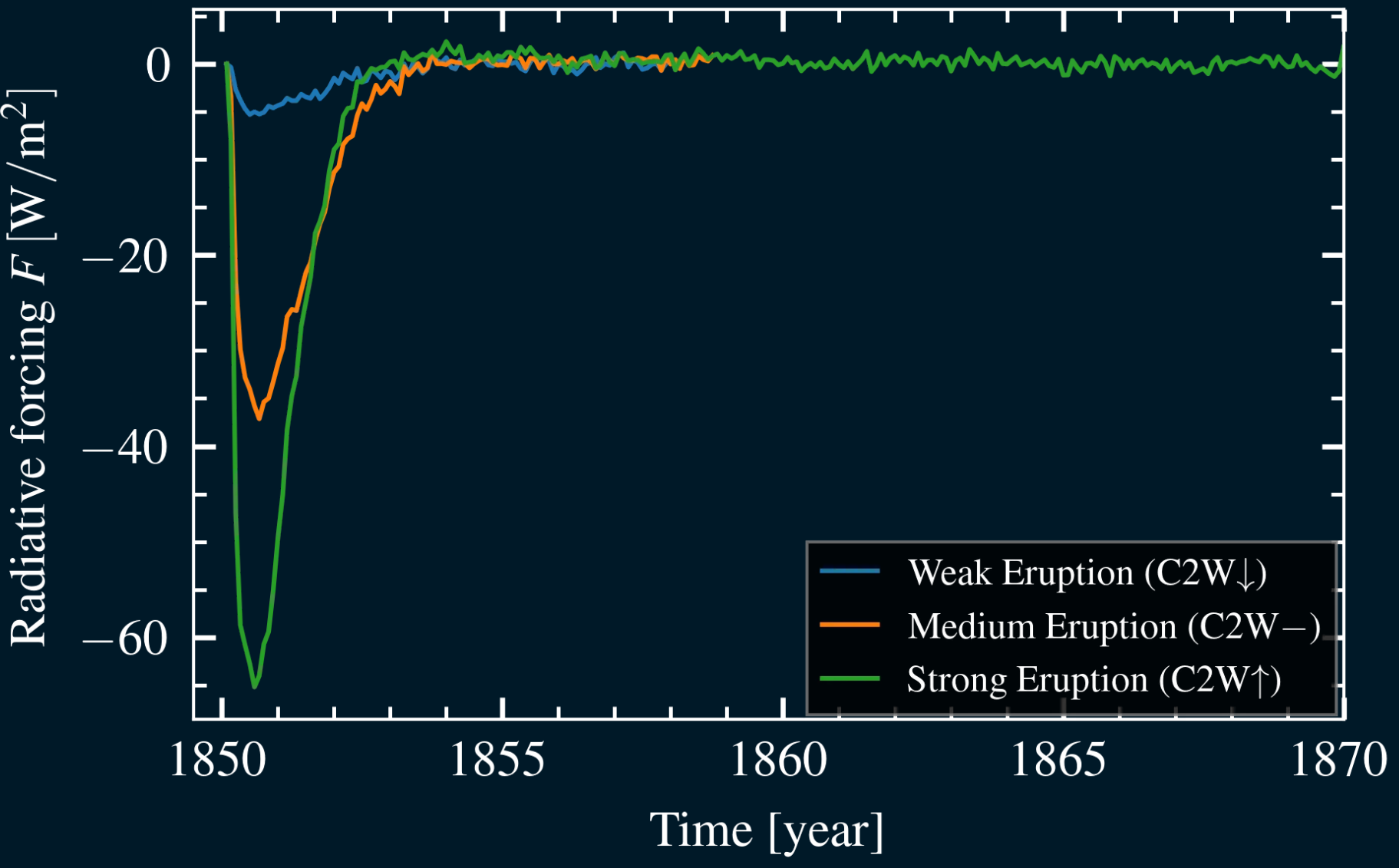

Aerosol Optical Depth [1]
0
2
4
6
8
10
12
1850
1855
1860
1865
1870
Time [year]
Weak Eruption (C2W↓)
Medium Eruption (C2W−)
Strong Eruption (C2W↑)


0
−20
−40
−60
Radiative forcing F [W/m^2]
1850
1855
1860
1865
1870
Time [year]
Weak Eruption (C2W↓)
Medium Eruption (C2W−)
Strong Eruption (C2W↑)

Using a linear operator to describe temperature fluctuations:

$$\Delta T(t) = \hat{L}[f_K(t)]$$

$$\Delta T(t) = \phi * f_K(t) = \phi * \sum_k A_k \delta(t - t_k)$$

Speaker notes

The first equation show the linear relation between some forcing $f(t)$ and the deterministic temperature fluctuation due to the forcing.

We wish to look further into the linearity assumption in relation to volcanoes over a large range of eruption magnitudes (total injected SO2).

Can we write up the temperature response to volcanic eruptions as a convolution between the forcing and some general shape function, here represented by the letter ϕ?

The forcing is here consisting only of forcing due to episodic volcanoes, where A represent the amplitude of a given volcanic event arriving at time t_k.

$$\Delta T(t) = \phi * f_K(t) = \phi * \sum_k A_k \delta(t - t_k)$$

$$A_k \begin{cases} \stackrel{?}{=} g(M_k^{\max}) \\ \stackrel{?}{=} M_k^{\max} \end{cases}, \; M = \begin{cases} \mathrm{SO_2}\,[\mathrm{Tg}] \\ \mathrm{AOD}\,[1] \\ \mathrm{TOA}\,[\mathrm{W/m^2}] \end{cases}$$

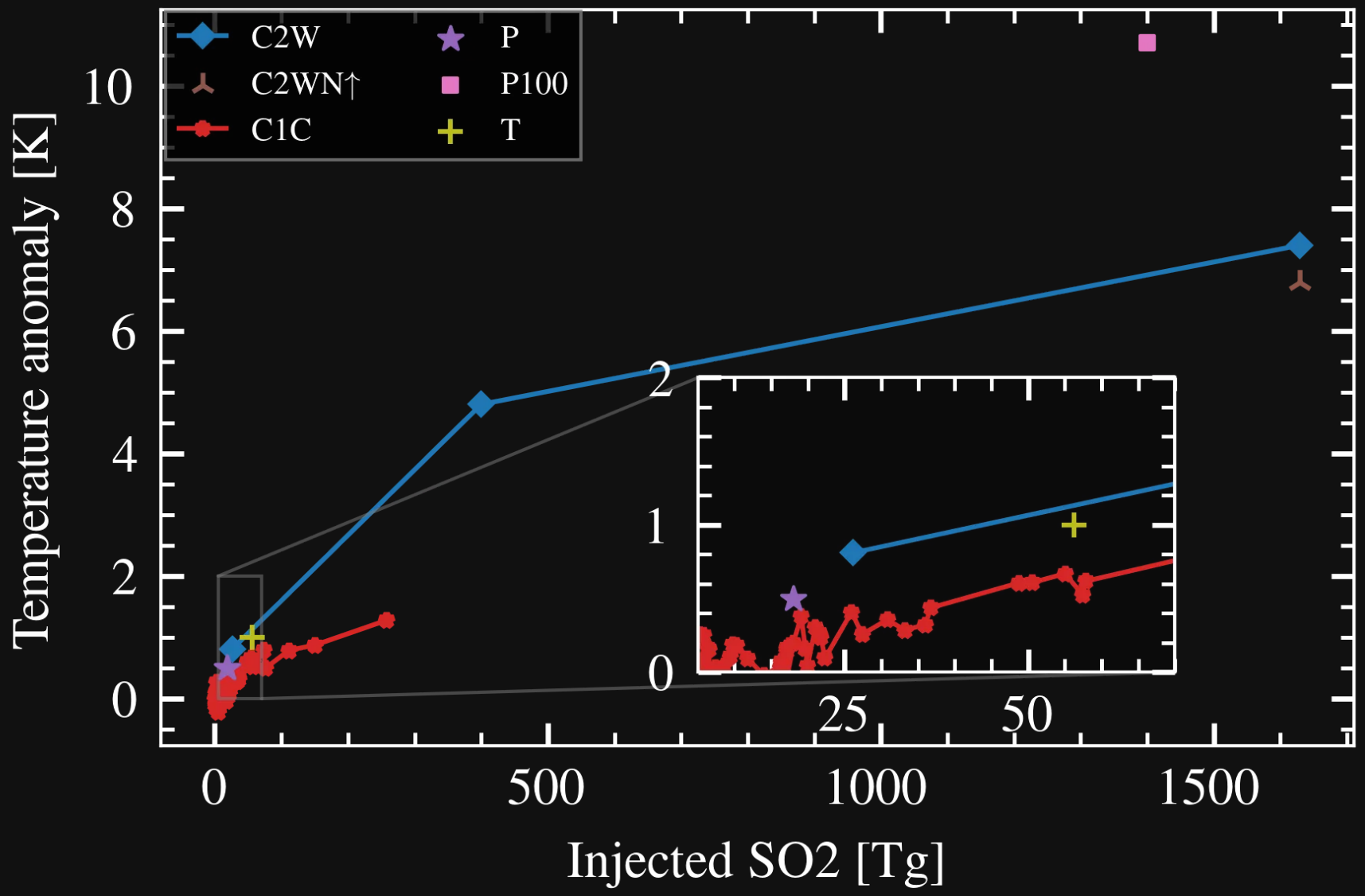
where $M_k^{\max}$ is the peak magnitude of event k.

Speaker notes

If so, what representation of the forcing should one use? Do we perhaps need a non-linear transformation ($g(\cdot)$) of the forcing to be able to get temperature from convolutions?

We consider three different sources to describe the forcing; total injected SO2 in Tg, the aerosol optical depth and forcing as top-of-the-atmosphere radiative forcing.

(Injected SO2 is used as model input to simulate the volcanoes, while both AOD and radiative forcing are output variables of the model.)

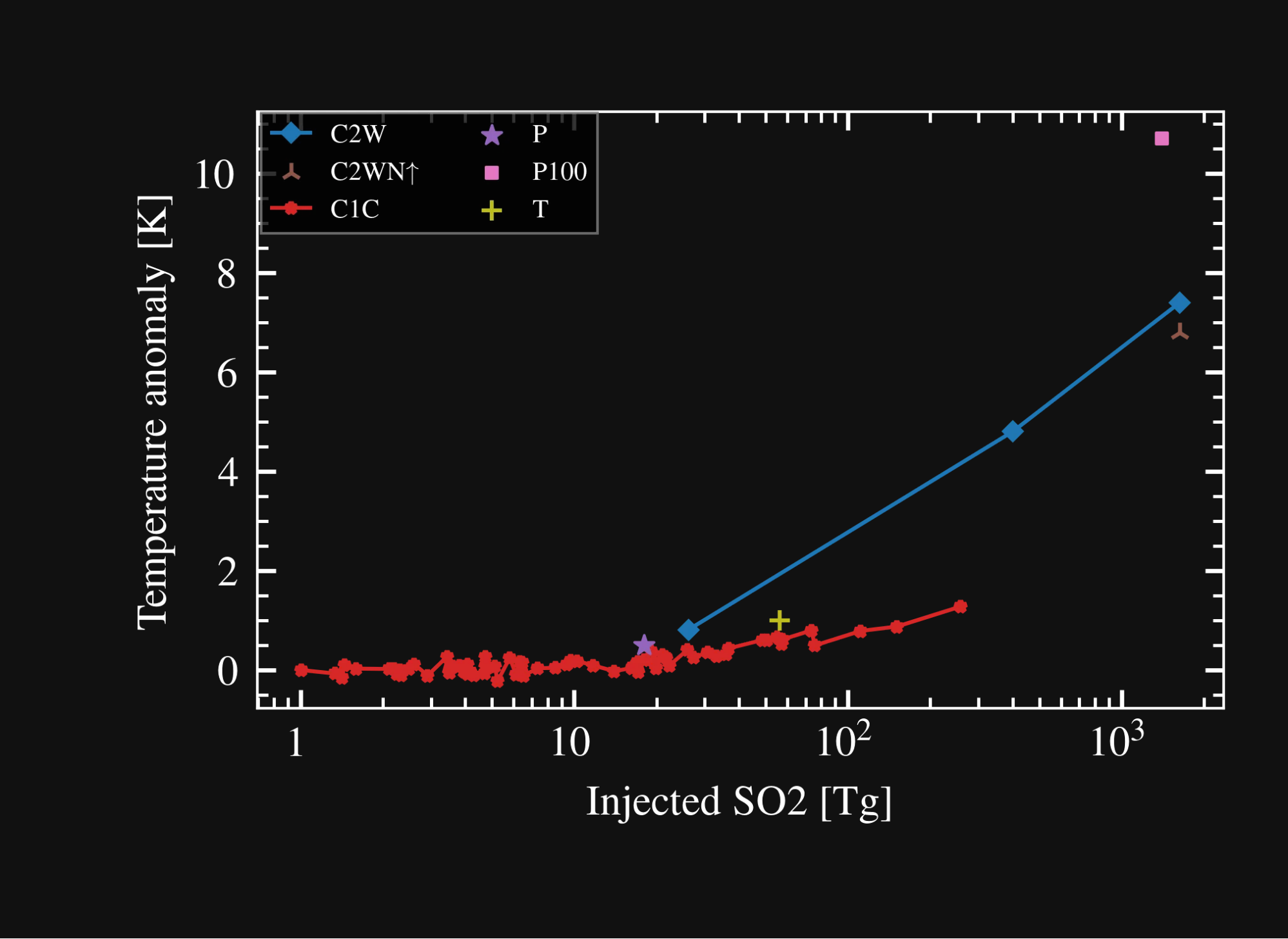

C2W
C2WN↑
C1C
P
P100
T
Temperature anomaly [K]
0
2
4
6
8
10
0
500
1000
1500
Injected SO2 [Tg]
0
1
2
25
50

Speaker notes

Temperature anomaly against injected SO2.

Short Name	Long Name
C2W	CESM2(WACCM6)
C2WN↑	CESM2(WACCM6), high latitude
C2C↑	CESM2(CAM6)
C1C	CESM1(CAM5)
P	Pinatubo
P100	Pinatubo times 100
T	Tambora

C1C data from Otto-Bliesner et al. (2016).


C2W
C2WN↑
C1C
P
P100
T
Temperature anomaly [K]
0
2
4
6
8
10
1
10
10^2
10^3
Injected SO2 [Tg]

Speaker notes

Temperature anomaly against injected SO2.

Short Name	Long Name
C2W	CESM2(WACCM6)
C2WN↑	CESM2(WACCM6), high latitude
C2C↑	CESM2(CAM6)
C1C	CESM1(CAM5)
P	Pinatubo
P100	Pinatubo times 100
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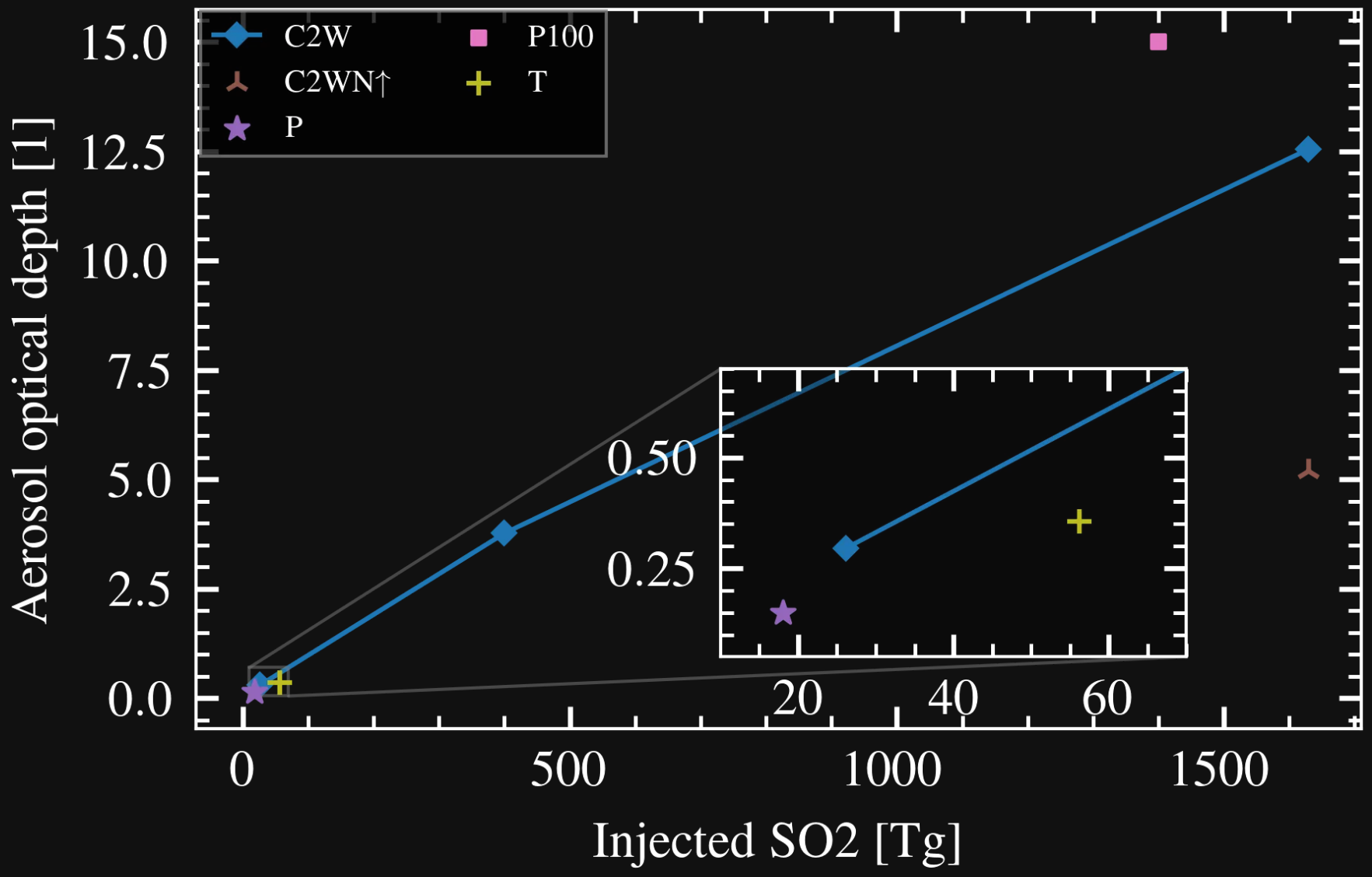
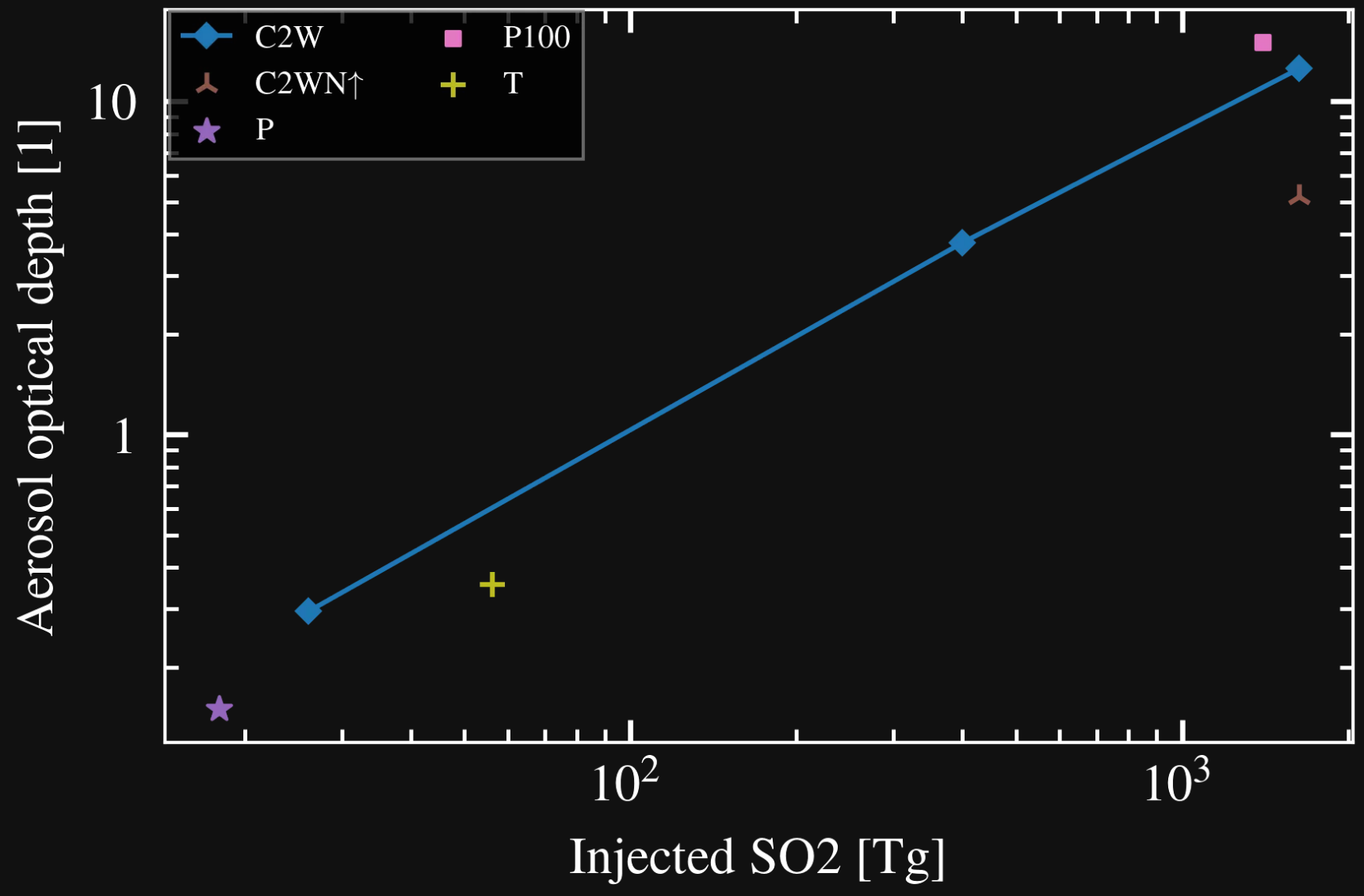
C1C data from Otto-Bliesner et al. (2016).


C2W
P100
C2WN↑
T
P
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Aerosol optical depth [1]
0.50
0.25
20
40
60
0
500
1000
1500
Injected SO2 [Tg]

Speaker notes

Aerosol optical depth versus injected SO2.

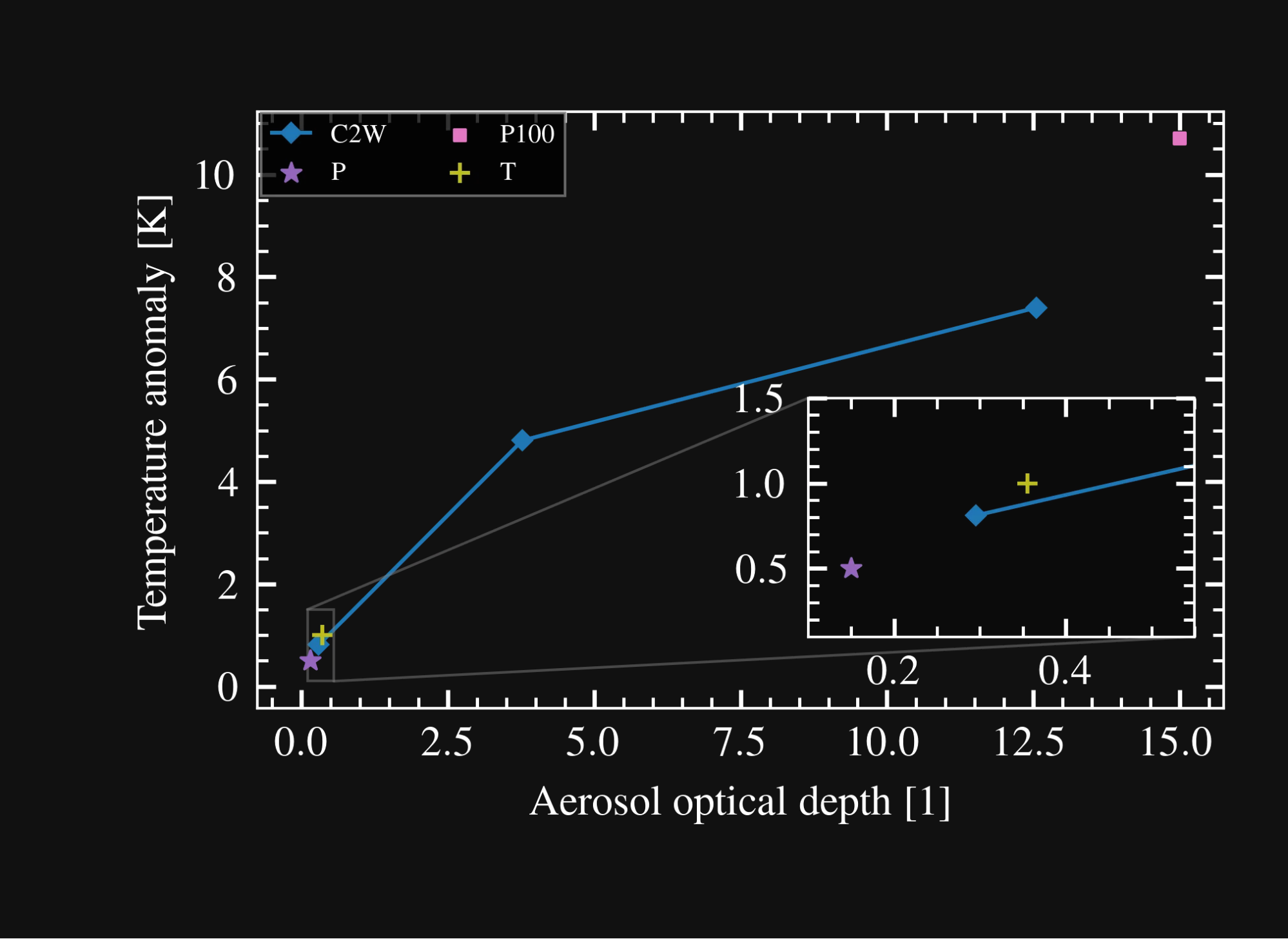
Short Name	Long Name
C2W	CESM2(WACCM6)
C2WN↑	CESM2(WACCM6), high latitude
C2C↑	CESM2(CAM6)
P	Pinatubo
P100	Pinatubo times 100
T	Tambora


C2W
C2WN↑
P
P100
T
10
1
Aerosol optical depth [1]
10^2
10^3
Injected SO2 [Tg]

Speaker notes

Aerosol optical depth versus injected SO2.

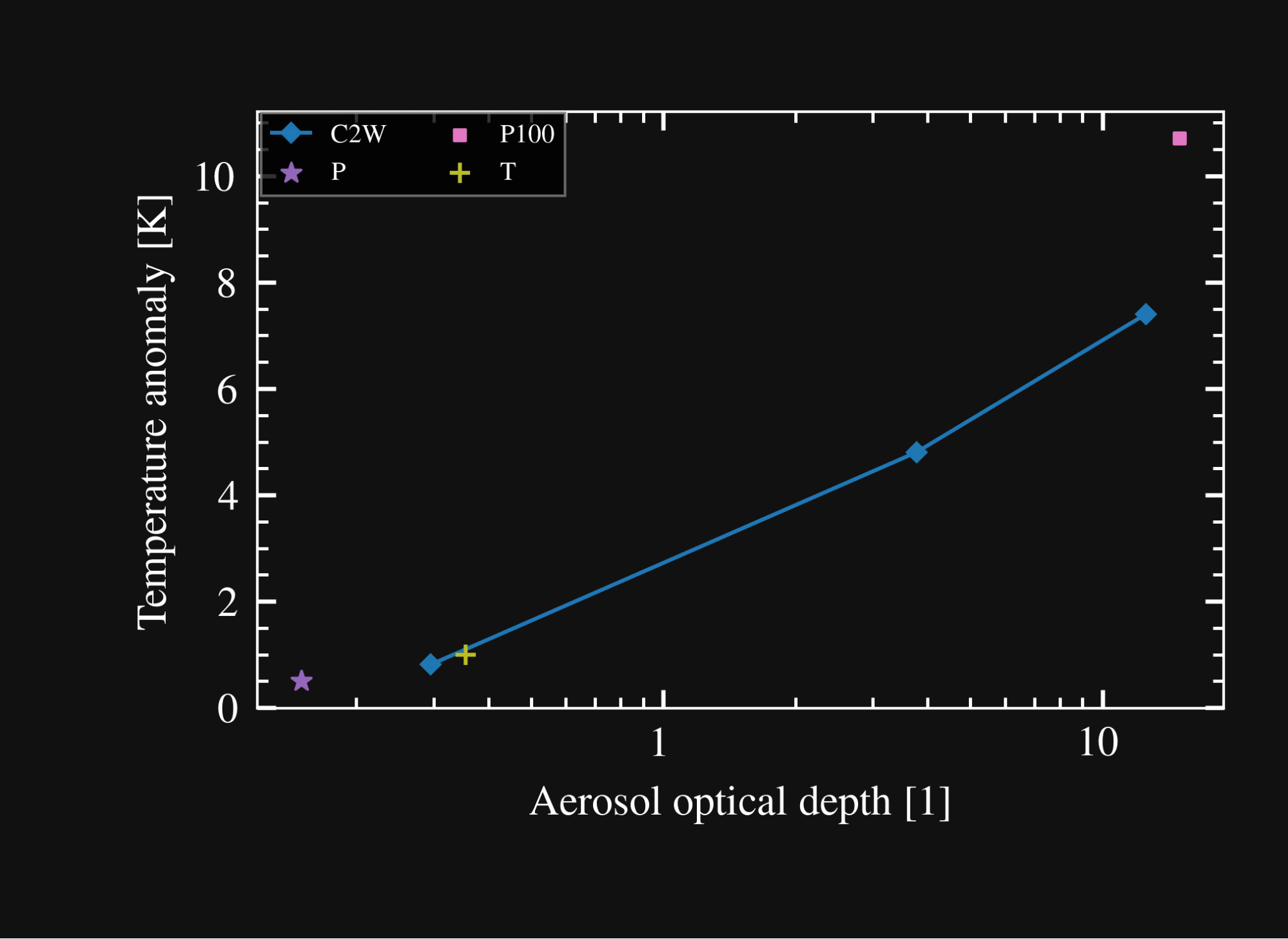
Short Name	Long Name
C2W	CESM2(WACCM6)
C2WN↑	CESM2(WACCM6), high latitude
C2C↑	CESM2(CAM6)
P	Pinatubo
P100	Pinatubo times 100
T	Tambora


C2W
P100
P
T
Temperature anomaly [K]
0
2
4
6
8
10
0.0
2.5
5.0
7.5
10.0
12.5
15.0
Aerosol optical depth [1]
1.5
1.0
0.5
0.2
0.4

Speaker notes

Temperature versus aerosol optical depth.

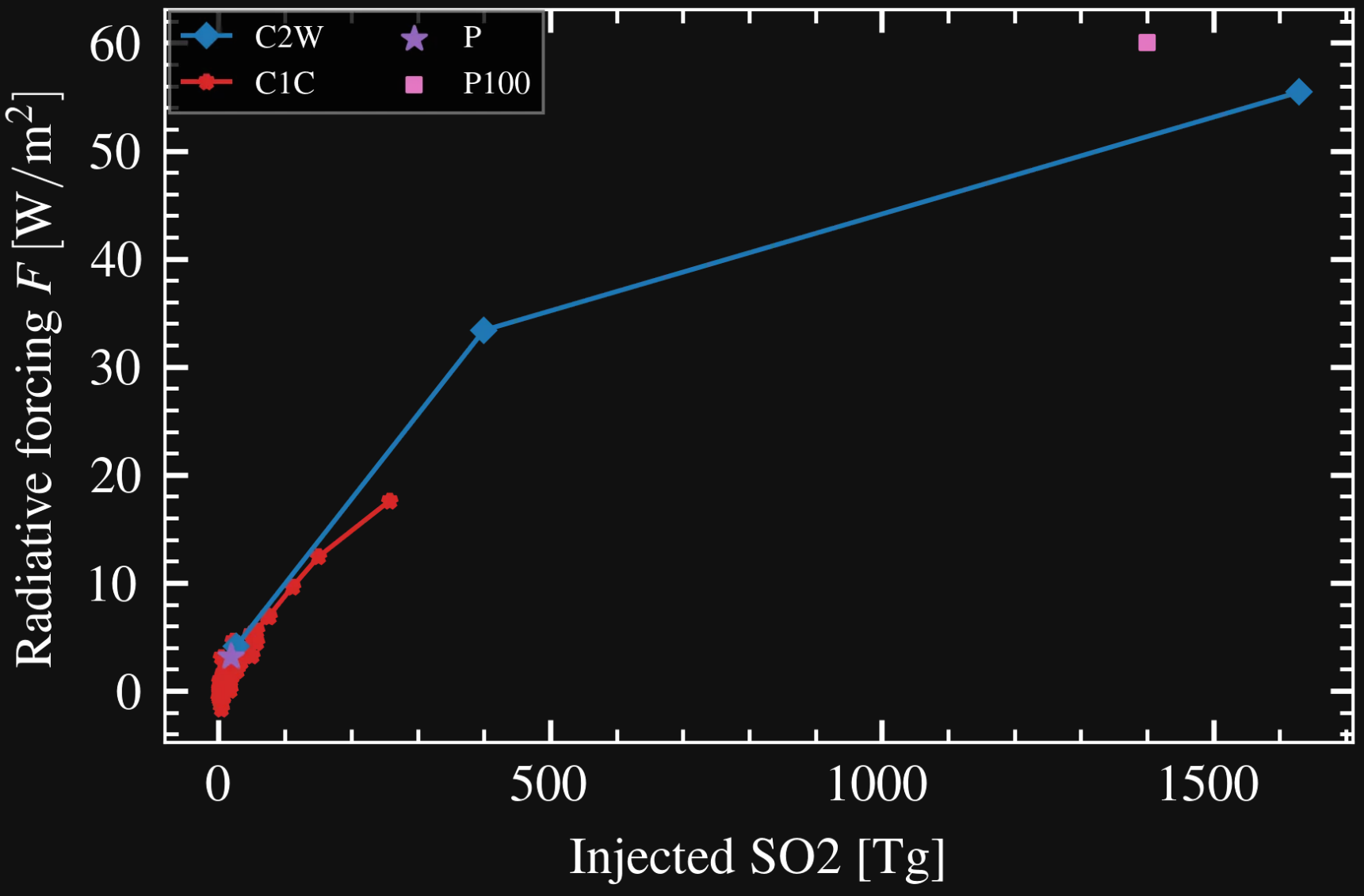
Short Name	Long Name
C2W	CESM2(WACCM6)
C2WN↑	CESM2(WACCM6), high latitude
P	Pinatubo
P100	Pinatubo times 100
T	Tambora


C2W
P100
P
T
Temperature anomaly [K]
0
2
4
6
8
10
1
10
Aerosol optical depth [1]

Speaker notes

Temperature versus aerosol optical depth.

Short Name	Long Name
C2W	CESM2(WACCM6)
C2WN↑	CESM2(WACCM6), high latitude
P	Pinatubo
P100	Pinatubo times 100
T	Tambora

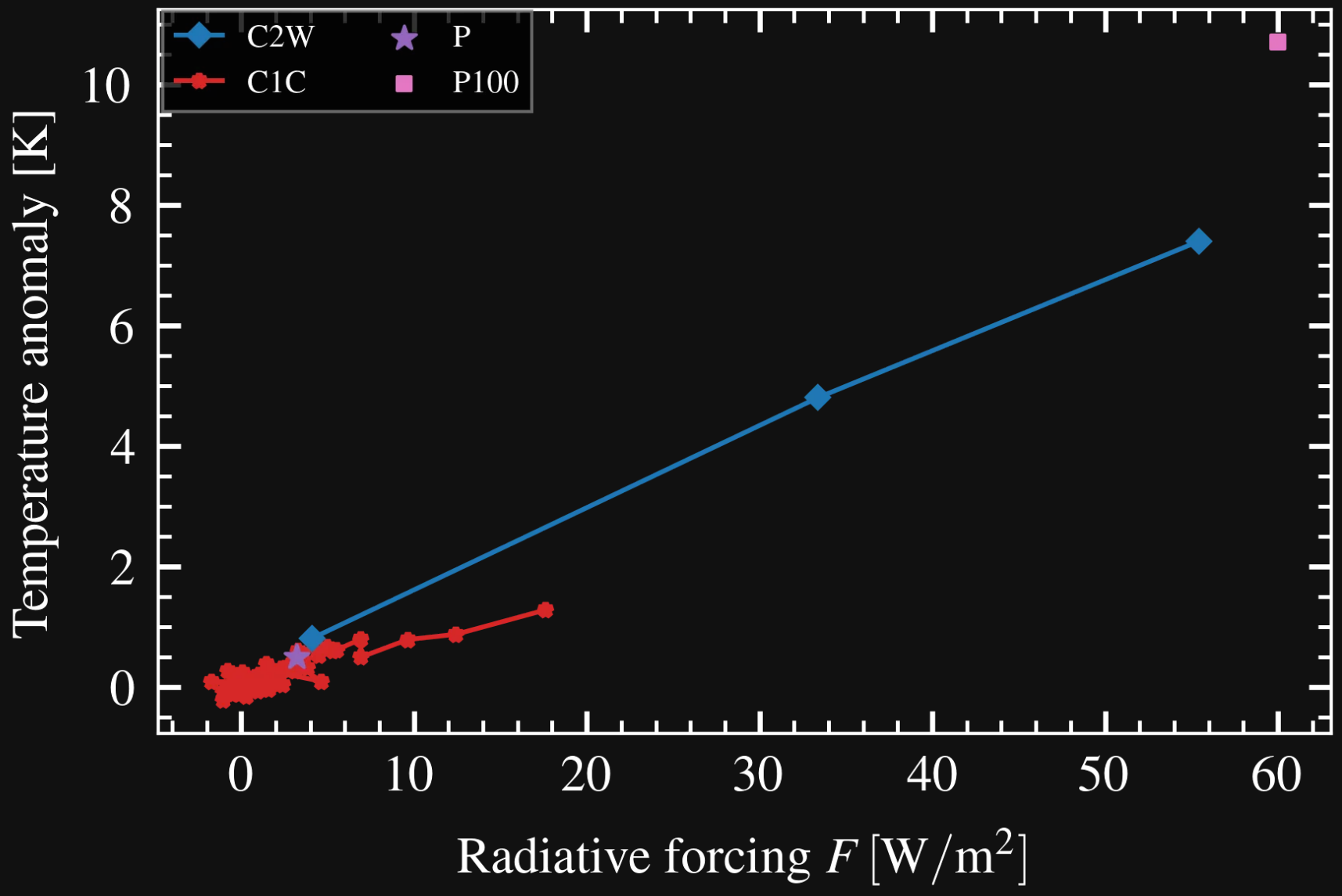

C2W
C1C
P
P100
Radiative forcing F [W/m^2]
60
50
40
30
20
10
0
0
500
1000
1500
Injected SO2 [Tg]

Speaker notes

Radiative forcing versus injected SO2.

Short Name	Long Name
C2W	CESM2(WACCM6)
C1C	CESM1(CAM5)
P	Pinatubo
P100	Pinatubo times 100

C1C data from Otto-Bliesner et al. (2016).

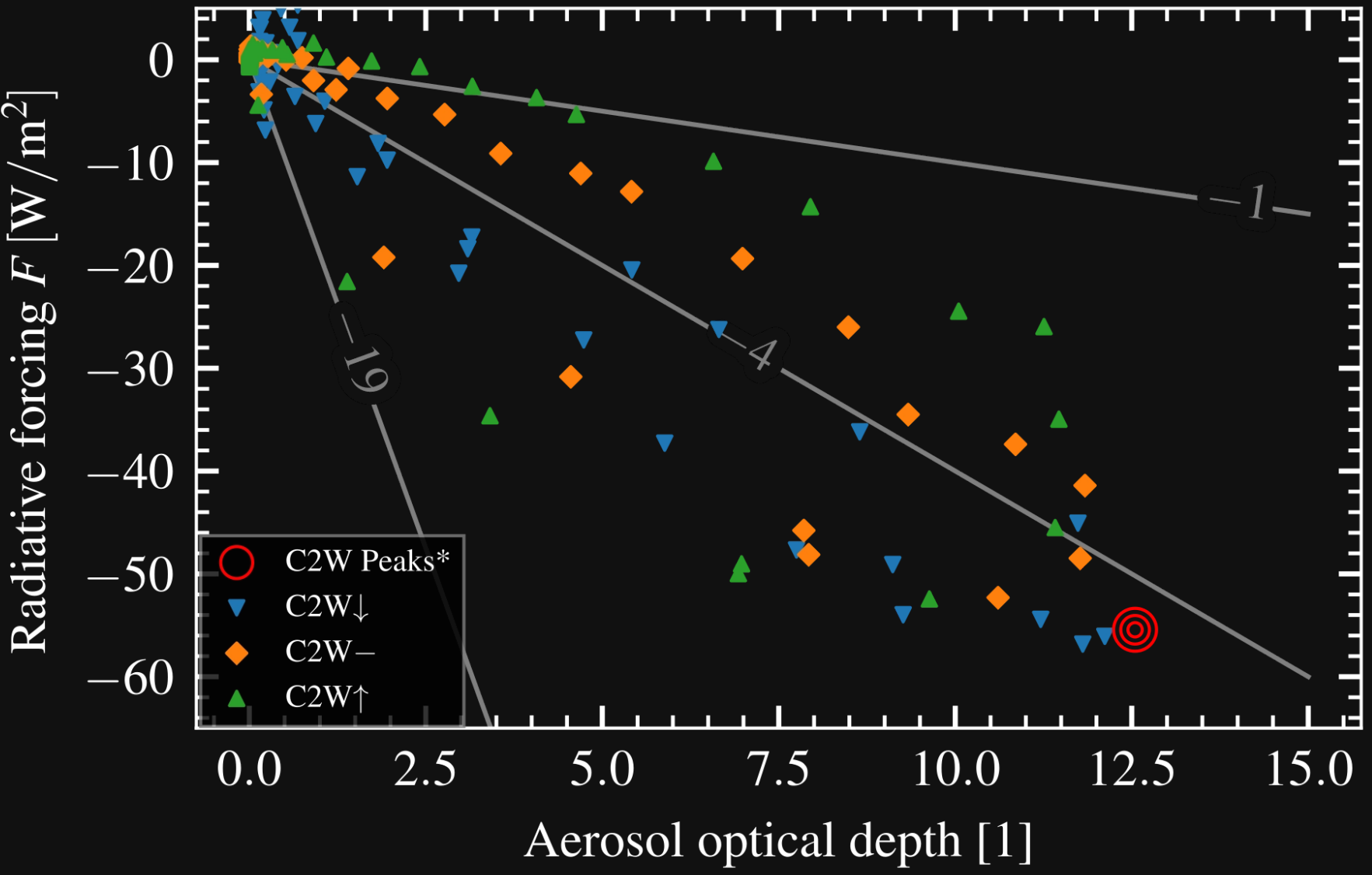

C2W
C1C
P
P100
Temperature anomaly [K]
0
2
4
6
8
10
0
10
20
30
40
50
60
Radiative forcing F [W/m^2]

Speaker notes

Temperature versus radiative forcing.

Short Name	Long Name
C2W	CESM2(WACCM6)
C1C	CESM1(CAM5)
P	Pinatubo
P100	Pinatubo times 100

C1C data from Otto-Bliesner et al. (2016).


Radiative forcing F [W/m^2]
0
−10
−20
−30
−40
−50
−60
0.0
2.5
5.0
7.5
10.0
12.5
15.0
Aerosol optical depth [1]
−1
−4
−19
C2W Peaks*
C2W↓
C2W−
C2W↑

Speaker notes

Scaled version of the two smaller eruption data points, such that the peak values coincide.

Short Name	Long Name
C2W Peaks*	CESM2(WACCM6), Peak values
C2W↓	CESM2(WACCM6), weak eruption
C2W—	CESM2(WACCM6), medium eruption
C2W↑	CESM2(WACCM6), strong eruption

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