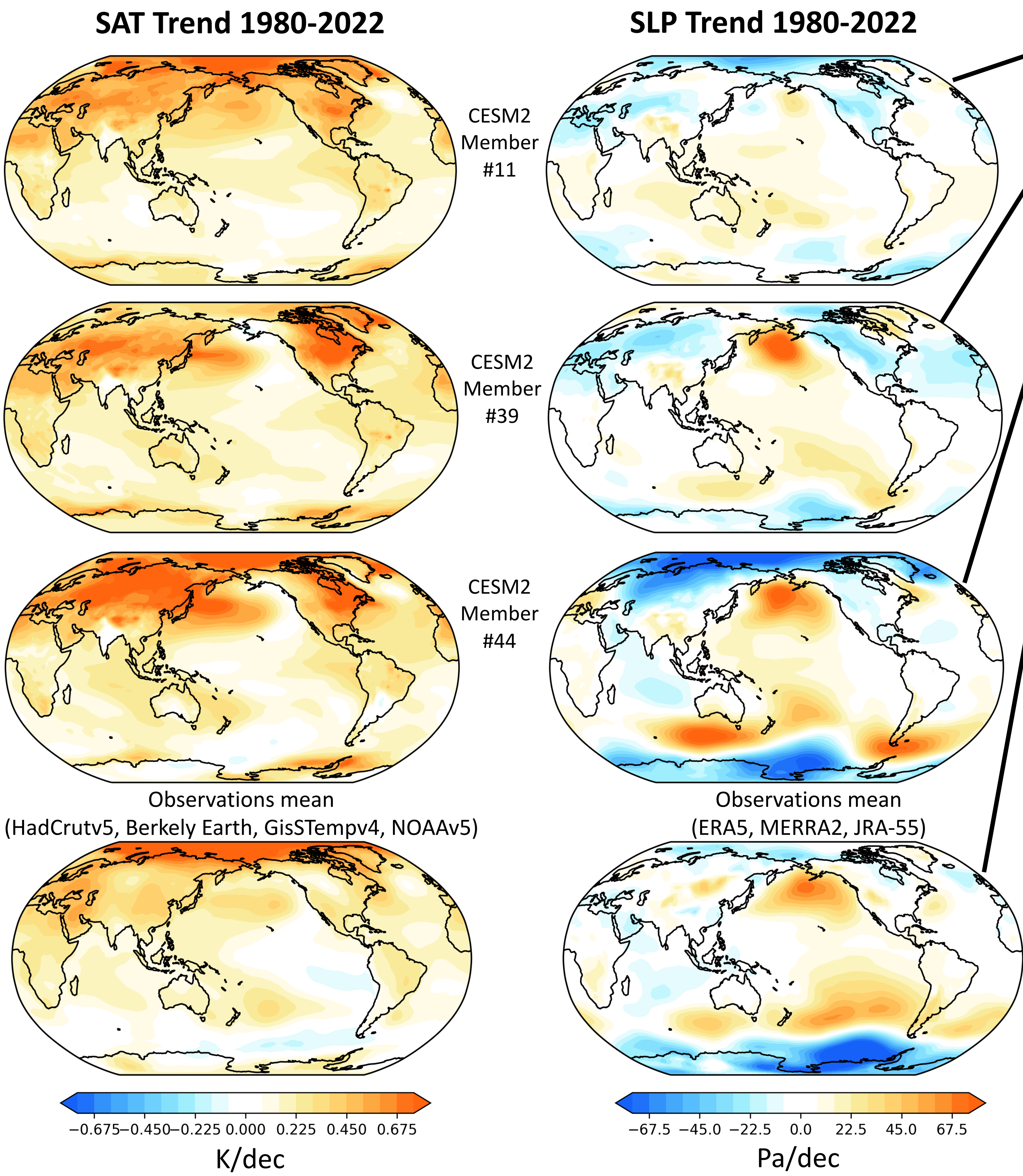
Internal Variability Enhanced Arctic Amplification During 1980-2022

Aodhan Sweeney[1], Qiang Fu[1], Stephen Po-Chedley[2], Hailong Wang[3], Muyin Wang[4,5]

[1]University of Washington, Department of Atmospheric Sciences, [2]Program for Climate Model Diagnosis and Intercomparison, LLNL, [3]Pacific Northwest National Laboratory, [4]Univeristy of Washington, CICOES, [5]Pacific Marine Environmental Laboratory, NOAA

Abstract Since 1980 the Arctic has warmed four times as quickly as the global mean[1,2], referred to as Arctic Amplification (AA). While climate models simulate AA, they struggle to replicate the observed magnitudes. This suggests either a gap in understanding the forced Arctic response, or a significant role of internal variability. Utilizing CMIP6 data and machine learning, we quantify internal variability's impact on Arctic and global warming trends[3,4]. While observed AA from 1980-2022 is 4.2, after removing internal variability AA is reduced to ~3.0[5] and agrees with climate model estimates.

References
[1]Rantanen et al., 2022
[2]Chylek et al., 2023
[3]Po-Chedley et al., 2022
[4]Barnes et al., 2019
[5]Sweeney et al., 2023



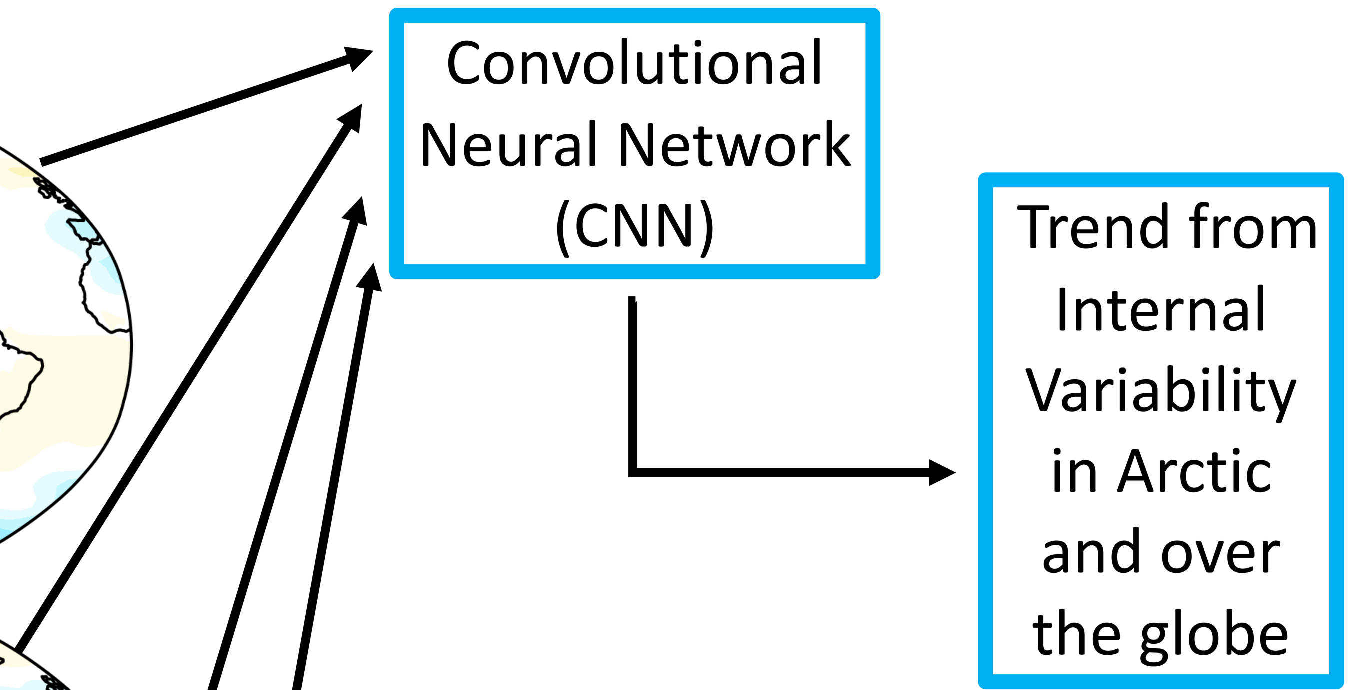
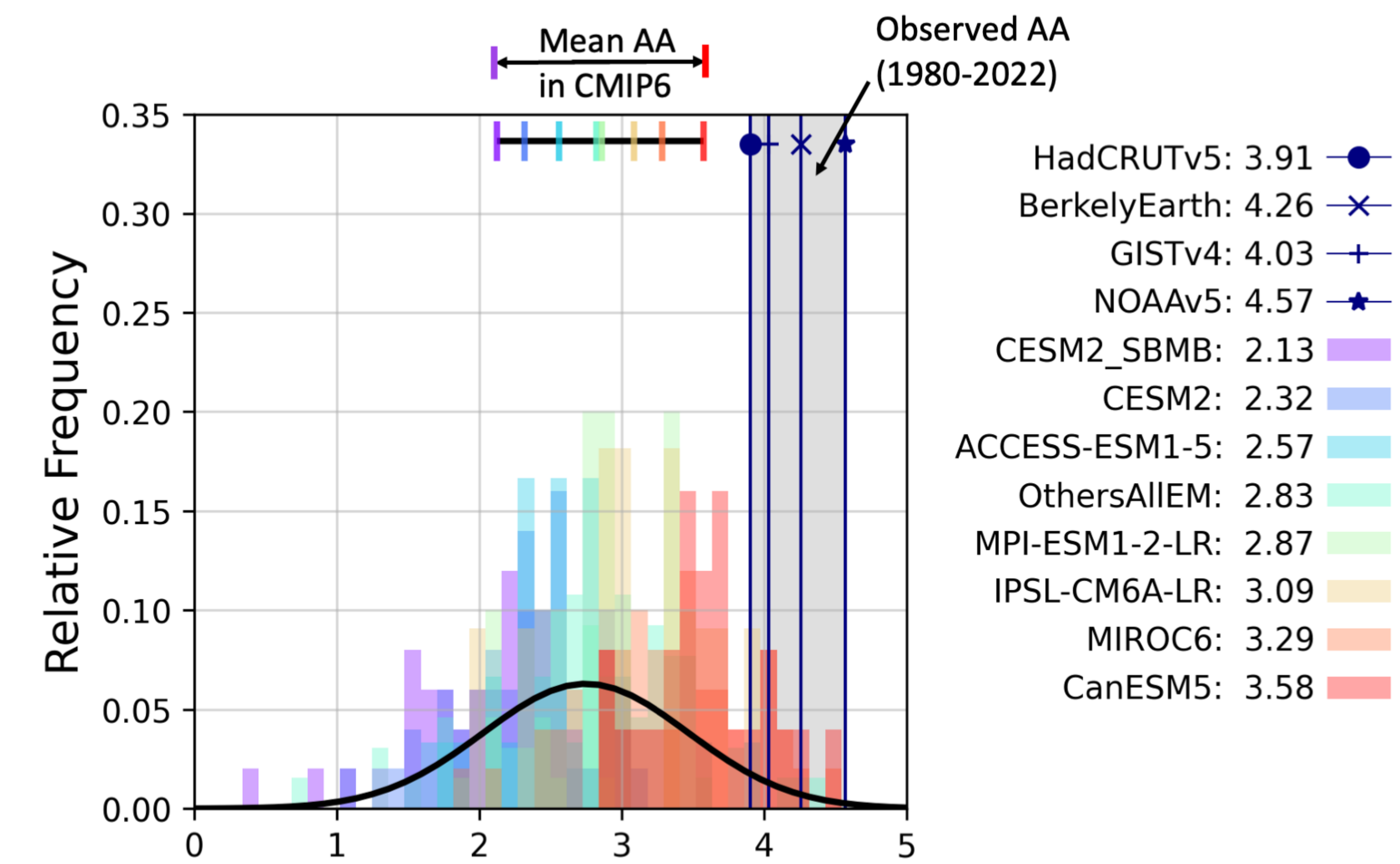


Figure 1: Diagram of CNN training to quantify the effect of internal variability on Arctic and global surface warming. Shown are SAT and SLP trend patterns from three CESM2 large ensemble members and observations from 1980-2022. Among CESM2 ensembles, the forced trend is the same in all members, so deviations are entirely due to internal variability. CNN inputs a set of 43-year SAT and SLP trend patterns and outputs the contribution of internal variability over the Arctic and the globe.

AA Before Removing Internal Variability



AA After Removing Internal Variability

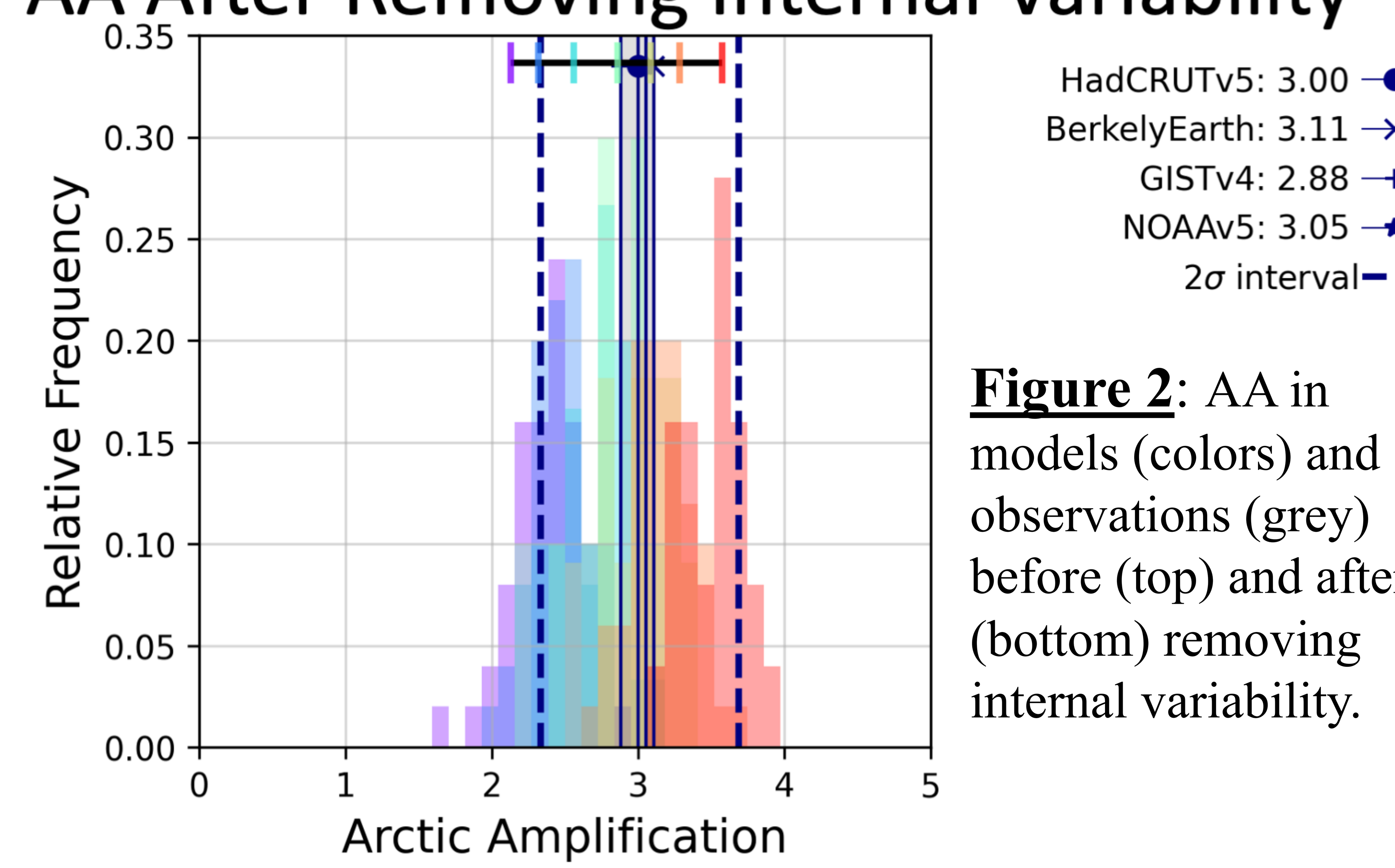


Figure 2: AA in models (colors) and observations (grey) before (top) and after (bottom) removing internal variability.

Methods Convolutional Neural Networks (CNNs) are used to partition the role of internal variability over both the Arctic (north of 70°), and globe individually. CNNs are trained using 43-year trend patterns of Surface Air Temperature (SAT) and Sea Level Pressure (SLP) from 11 large ensembles spanning 1900-2050. After training CNN, we apply it to observations of SAT and SLP trend patterns to quantify the role of internal variability for 1980-2022

Results

1. From 1980-2022 internal variability increased Arctic warming by 0.145 K/dec while decreasing global warming by -0.024 K/dec (not shown).
2. AA in observations is ~4.2, but after removing internal variability the AA is 3.0, in agreement with models which show a mean value of 2.8.