As global surface temperatures continue to rise with increasing greenhouse gases, the warming pattern is projected to be most pronounced in polar regions. Additionally, the tropics show a local warming maximum. Yet, the shape and amplitude of these patterns vary greatly across climate models. This uncertainty has critical implications for anticipating regional adaptation needs to the projected climate change. For instance, the degree of polar amplification (i.e., faster polar warming relative to elsewhere) will determine melt rates of land ice and, thereby, influence sea-level rise and its impact on coastlines. As another example, the amount of projected equatorial warming will strongly influence future effects of El Niño on the global hydrological cycle, which could affect food production worldwide.

To improve understanding of projected regional climate change, I developed a modeling hierarchy with idealized spatially varying CO2-radiative forcing. This approach allows me to decompose the local radiative forcing patterns, individual physical feedbacks, as well as changes in the atmospheric and oceanic circulation, that control projected polar amplification and equatorial warming. I will show that polar amplification is mainly controlled by local polar radiative forcing and feedbacks, with the lapse rate feedback being the dominant factor. In contrast, I will demonstrate that equatorial warming is strongly controlled by off-equatorial forcing and an associated interactive feedback between the Hadley circulation, tropical clouds, and the shallow oceanic subtropical cell circulation in the Pacific. Importantly, ocean circulation adjustments and associated heat transport changes modulate the regional climate response to different radiative forcing patterns. These results lend to a number of broader implications and future research ideas, which I will discuss.