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## Global warming rates and surface temperature patterns through 2023: A Green's function based investigation

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The rate of global surface warming has seemingly been steady since the 1970s. Any progress towards halting climate change will be heralded by a slowdown in the warming rate, but tracking it on sub-decadal timescales is challenging because of strong interannual-to-decadal variability.

Recently, we used a physics-based Green's function approach to filter out modulations to global mean surface temperature from sea-surface temperature (SST) patterns, and showed how this results in an earlier emergence of a discernible climate response to strong emissions mitigation. We have also shown how the filtered observations reveal a marked step-up in warming rate around 1990, consistent with known increases in ocean heat uptake. CMIP6 models are currently broadly unable to simultaneously capture the observed long-term warming rate, and such a step-up in rates over the last decades.

Here, we summarize these results, which were based on the CESM1 Earth System Model, and extend them to multiple, independently derived Green's functions. We discuss how this toolkit can be complementary to existing attribution techniques. Then we apply it to an investigation of the surprising SST patterns in 2023, and what they imply about the potential causes for the high global mean surface temperature. Finally, we discuss the prospects for rapid detection of a climate response to strong greenhouse gas emissions mitigation, modulated by one or more areas of strong aerosol emissions changes, using Green's functions or other techniques for reducing the influences of internal variability.

### Key references:

Samset, B.H., Zhou, C., Fuglestad, J.S. *et al.* Steady global surface warming from 1973 to 2022 but increased warming rate after 1990. *Commun Earth Environ* **4**, 400 (2023). <https://doi.org/10.1038/s43247-023-01061-4>

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