

EARLIER WARNING ON GLOBAL WARMING

A new method for timely tracking and forecasting of global surface temperature change and accelerations

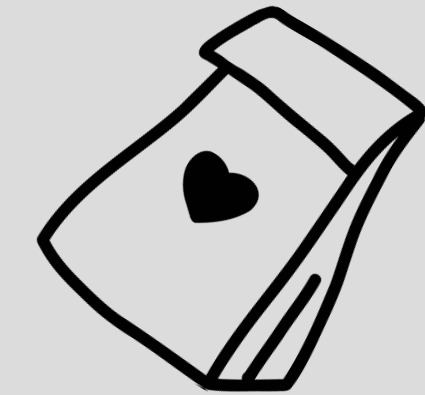
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Session ITS4.2 / CL0.12

Solicited poster

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TAKEAWAY BRAINFOOD



We can...

...extend the global surface temperature timeseries by an additional annual prediction value by mid-year using seasonal forecasts (Figs 1, 3, 4).

...compute the 20-year average global surface temperature up to the current year and 10 years ahead, co-estimating the rate and acceleration of change as well as uncertainties (Figs 1, 2).

...detect a statistically significant acceleration of global surface temperature change based on these data from 1990 to 2020 (at > 99% significance level; see Fig 2).

Ongoing work: We will...

...use this framework also for other key climate variables other than temperature.

...improve the annual prediction by further refined bias estimation in the seasonal forecast.

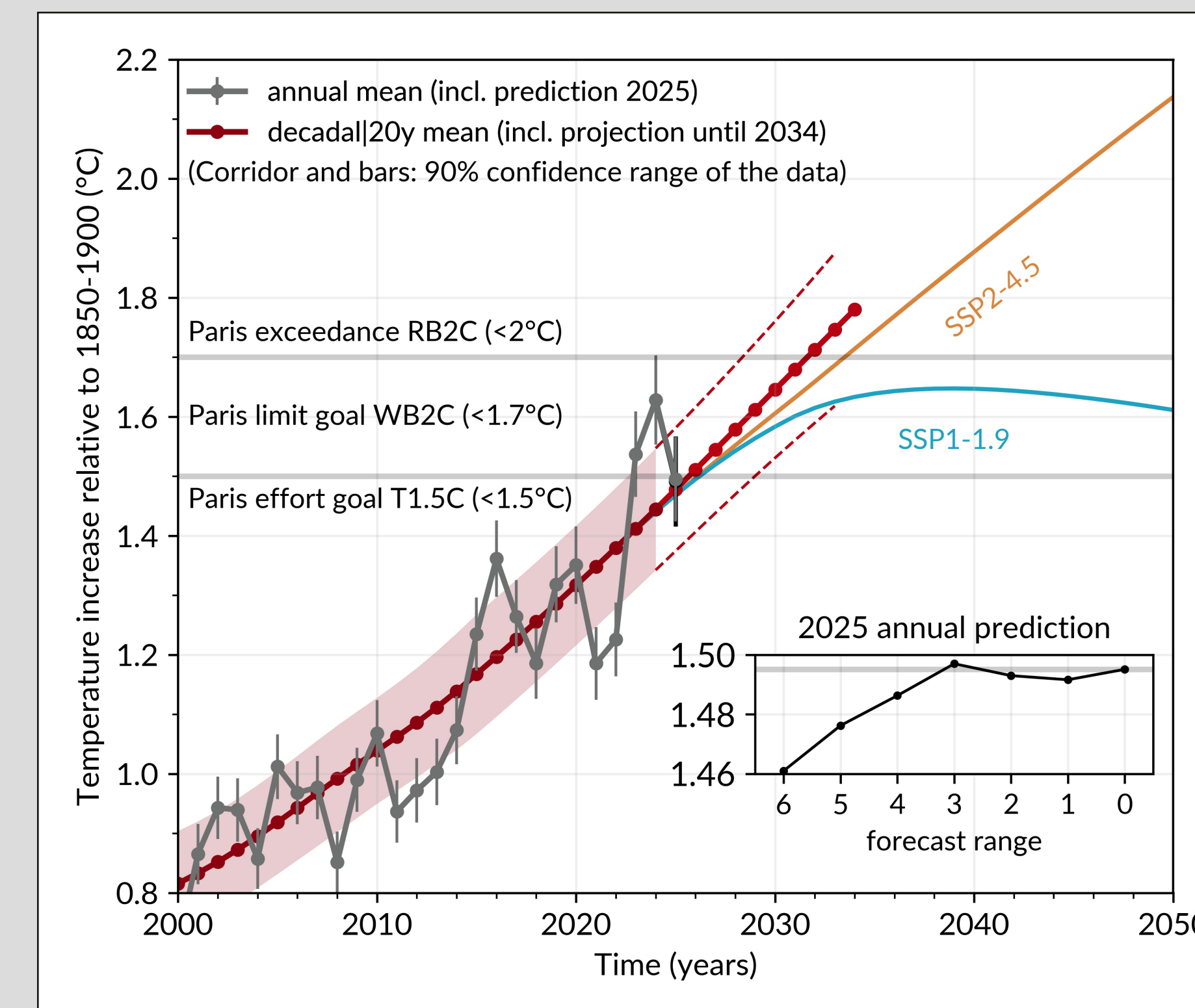
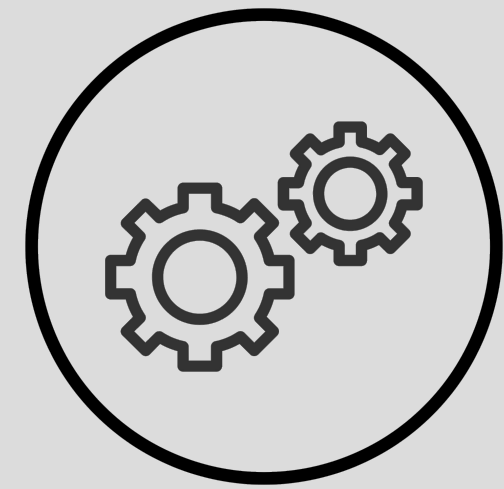


Figure 1: Global surface air temperature (GSAT) anomaly relative to the preindustrial (1850-1900) baseline. The gray line indicates observed annual temperature. The black dot is the prediction of the 2025 annual mean GSAT, four months in advance of the year's end; it is accurate to better than 0.02°C, which is well within the observational uncertainty. The inset plot shows the development of the annual mean GSAT prediction starting at 6 months advance. The red line shows the moving 20-year average GSAT as computed with a moving-window ensemble-of-trendlines fit, including a projection up to 2034 (see References for details). Selected illustrative scenarios to 2050 as well as uncertainty ranges are also shown.

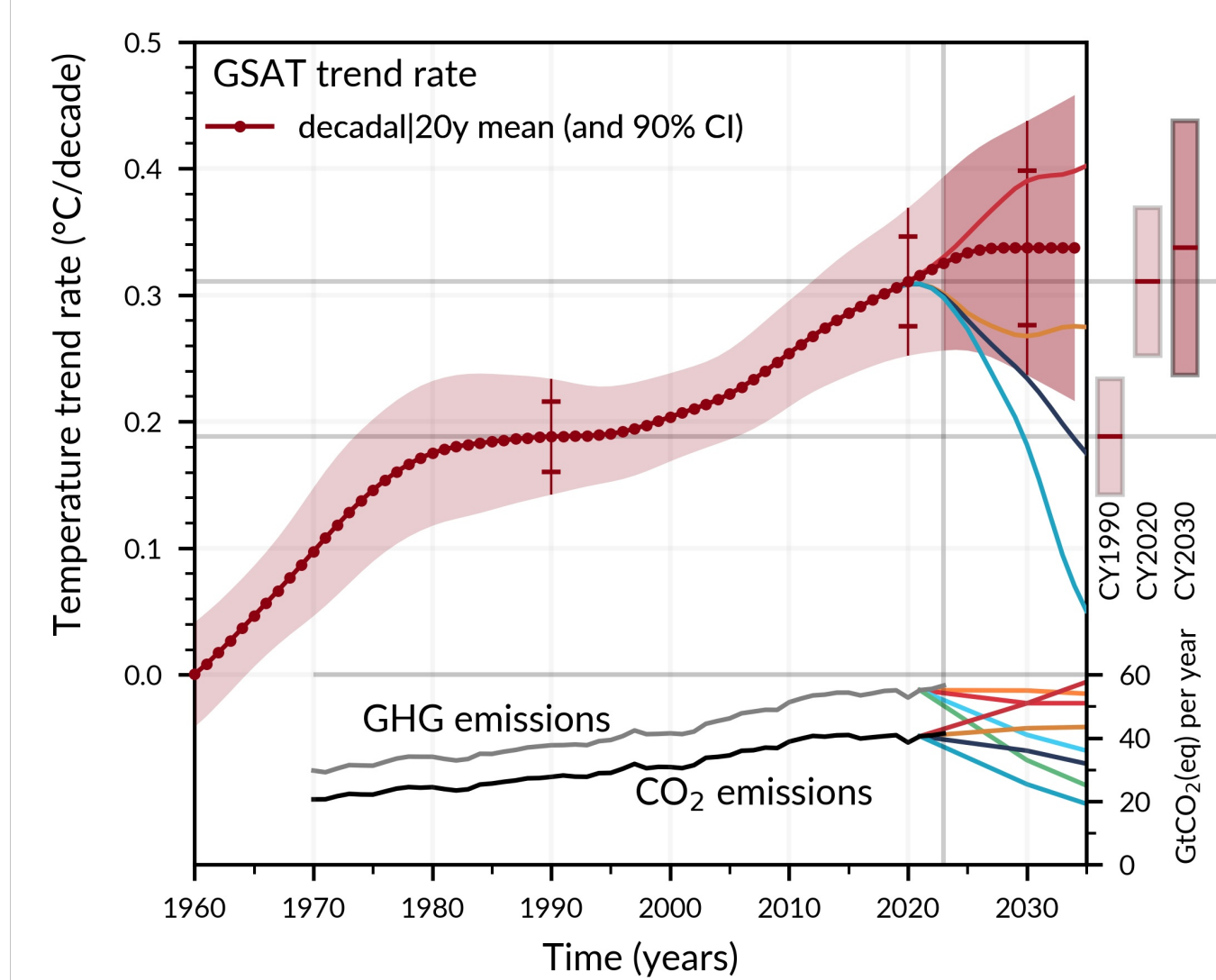


Figure 2: Decadal trend rate and concurrent annual greenhouse gas and carbon dioxide emission data (bottom), together with 90% uncertainty ranges (shaded corridor). Error bars and side bars mark the standard deviations and 90% uncertainty ranges for the years 1990 and 2020; these signal a statistically significantly 1990-2020 trend rate acceleration on a 99% confidence level.

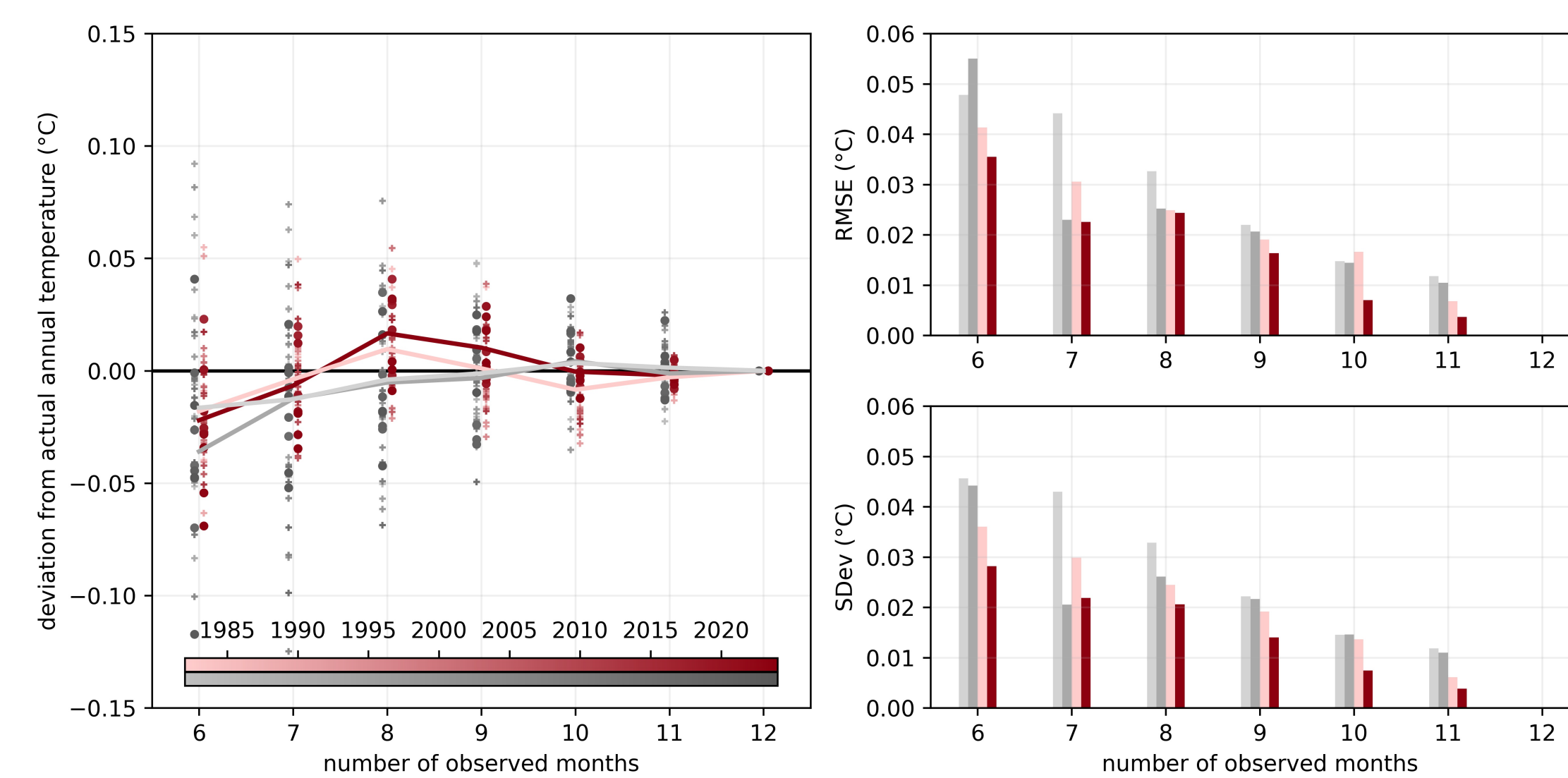


Figure 3: Left: Accuracy estimate of the prediction, depending on the number of already observed months of the year (red dots). In comparison, a "naive" approach of simply predicting the remaining months of the year based on the past 30-year climatology is plotted (grey dots). Average results are shown as red / grey lines. Right: Summary of root-mean-square error (top) and standard deviation (bottom) of the data. RMSE and StDev are consistently reduced for our prediction compared to the climatology approach.

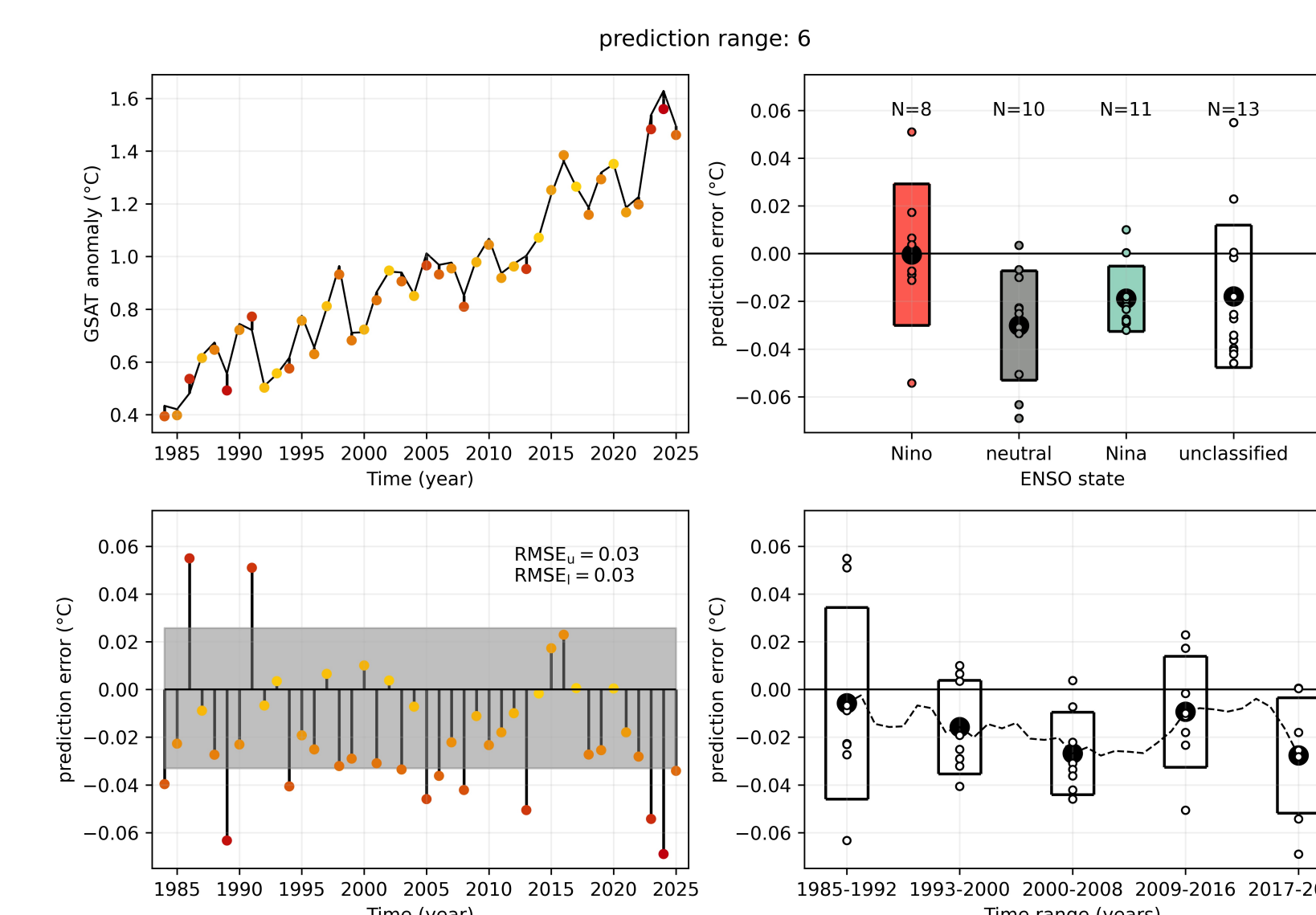


Figure 4: Prediction results for 6-months leadtime compared to the actual annual global surface air temperature (top left), additionally depicted as a deviation from the actual temperature (bottom left). The RMSE is independently assessed but comparable for positive and negative prediction errors. Prediction errors are also clustered according to prevailing ENSO conditions (top right) and exhibit a tendency towards better results under El Niño conditions compared to neutral and other states. Clustering into decadal bins (bottom right) indicates no clear improvement of prediction accuracy for more recent years despite improvements in input information.

ABSTRACT



DATA PORTAL



DATASETS USED

GMST (obs): HadCRUT5, NOAA GlobalTemp v6, BEST-Berkeley Earth (downl. 04/2026)
GSAT (reanalysis): ERA5; GSAT (forecast): SEAS5

REFERENCES

Kirchengast, G. & Pichler, M. A traceable global warming record and clarity for the 1.5 °C and well-below 2 °C goals. *Commun Earth Environ* 6, 402 (2025), doi: [10.1038/s43247-025-02368-0](https://doi.org/10.1038/s43247-025-02368-0)

ACKNOWLEDGEMENTS

We thank the providers of all datasets used for making their data accessible. The work was supported by GCCI | ClimateTracer funding of the University of Graz based on field-of-excellence funds from the Austrian Federal Ministry for Education, Science and Research.