Operational wind speed forecasts for Chile's electric grid using multi-layer perceptrons and graph neural networks

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Supplementary Information

Supplementary Information

Operational changes in Chile's electric power sector

Mean hourly generation and standard deviation for wind, solar and thermal generation by year from 2019 through 2023 is shown in Figure S1. Generation from wind and solar has grown markedly over the five-year period, while ramps in thermal generation have become increasingly evident. Variability in generation (measured by the standard deviation in the shaded region) has increased across all three generation sources. An alternate measure of variability by hour of day is hourly capacity factor for wind and solar shown in Figure S2.
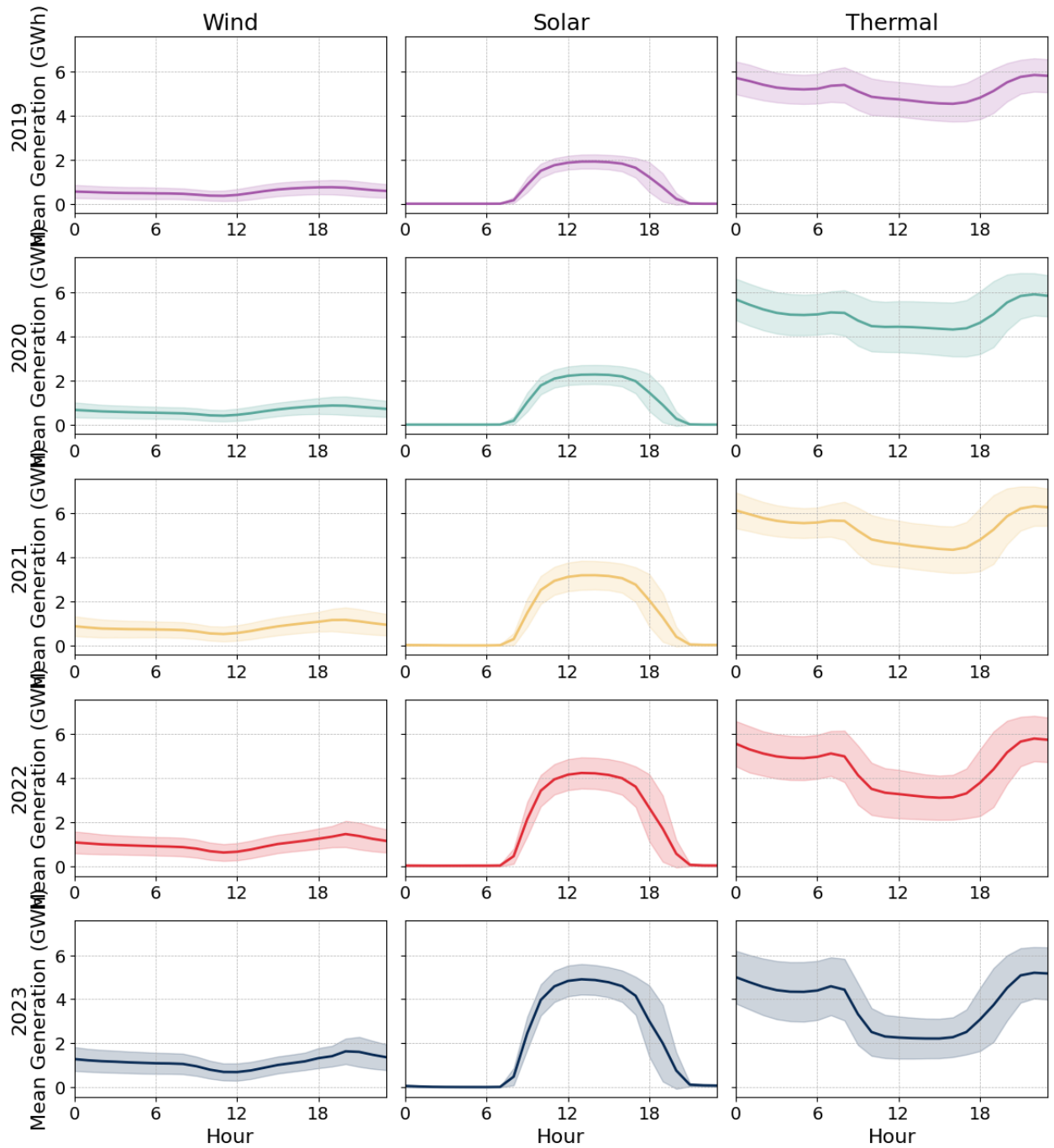
Figure S1 | **Mean hourly generation and standard deviation for wind, solar, and thermal power plants in Chile from 2019 to 2023**. Each row corresponds to a different year, and each column represents a different technology (Wind, Solar, and Thermal). The solid lines indicate the mean generation in gigawatt-hours (GWh), and the shaded areas represent the standard deviation across all hours. The x-axis denotes the hour of the day.

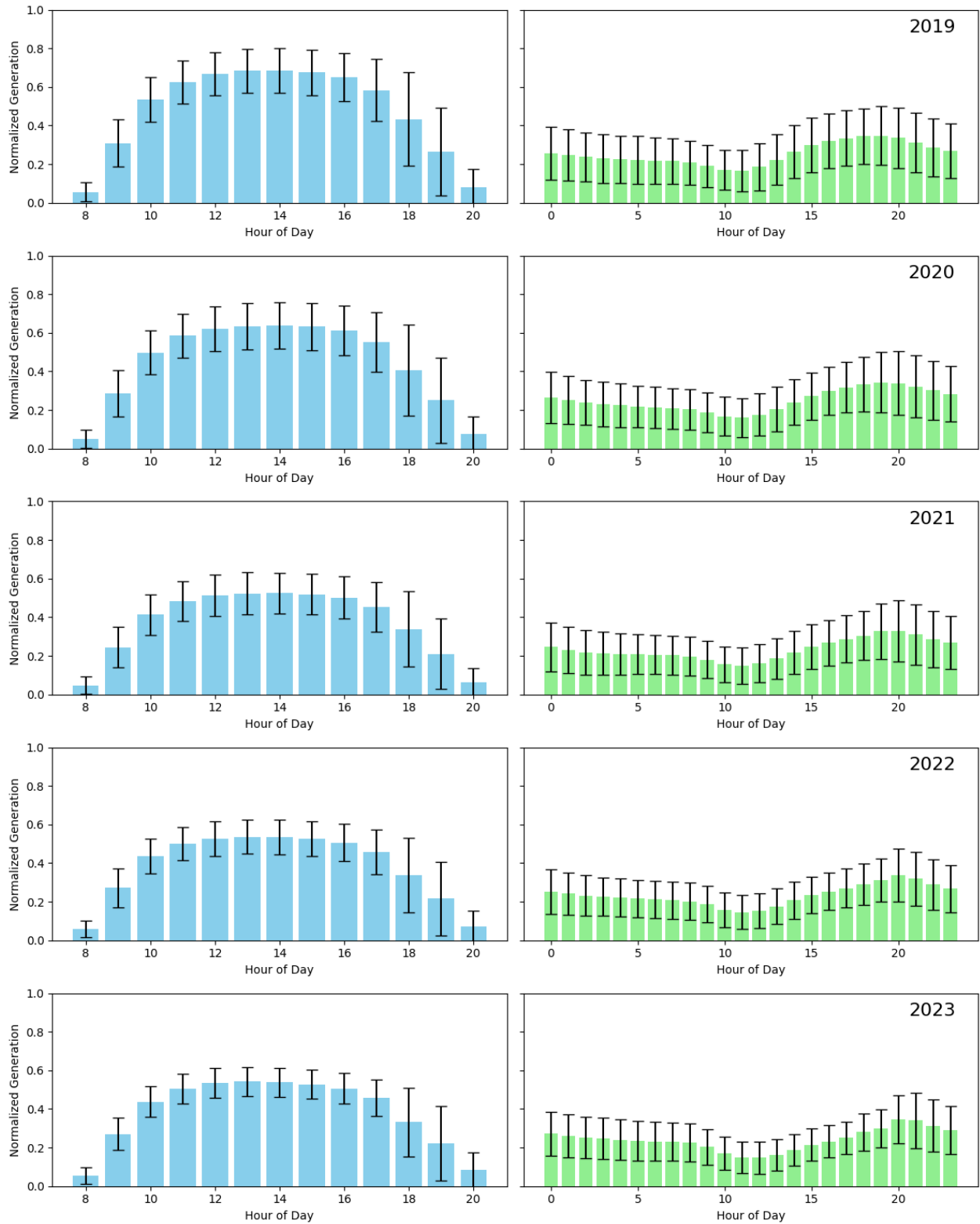**MLWP models for long-term forecasts**

Figure S2 | **Hourly solar and wind generation (2019-2023)**. Solar (left) and Wind (right). The colored bars represent mean generation normalized by installed capacity by source and year. The bars indicate the standard deviation of hourly normalized generation by source.
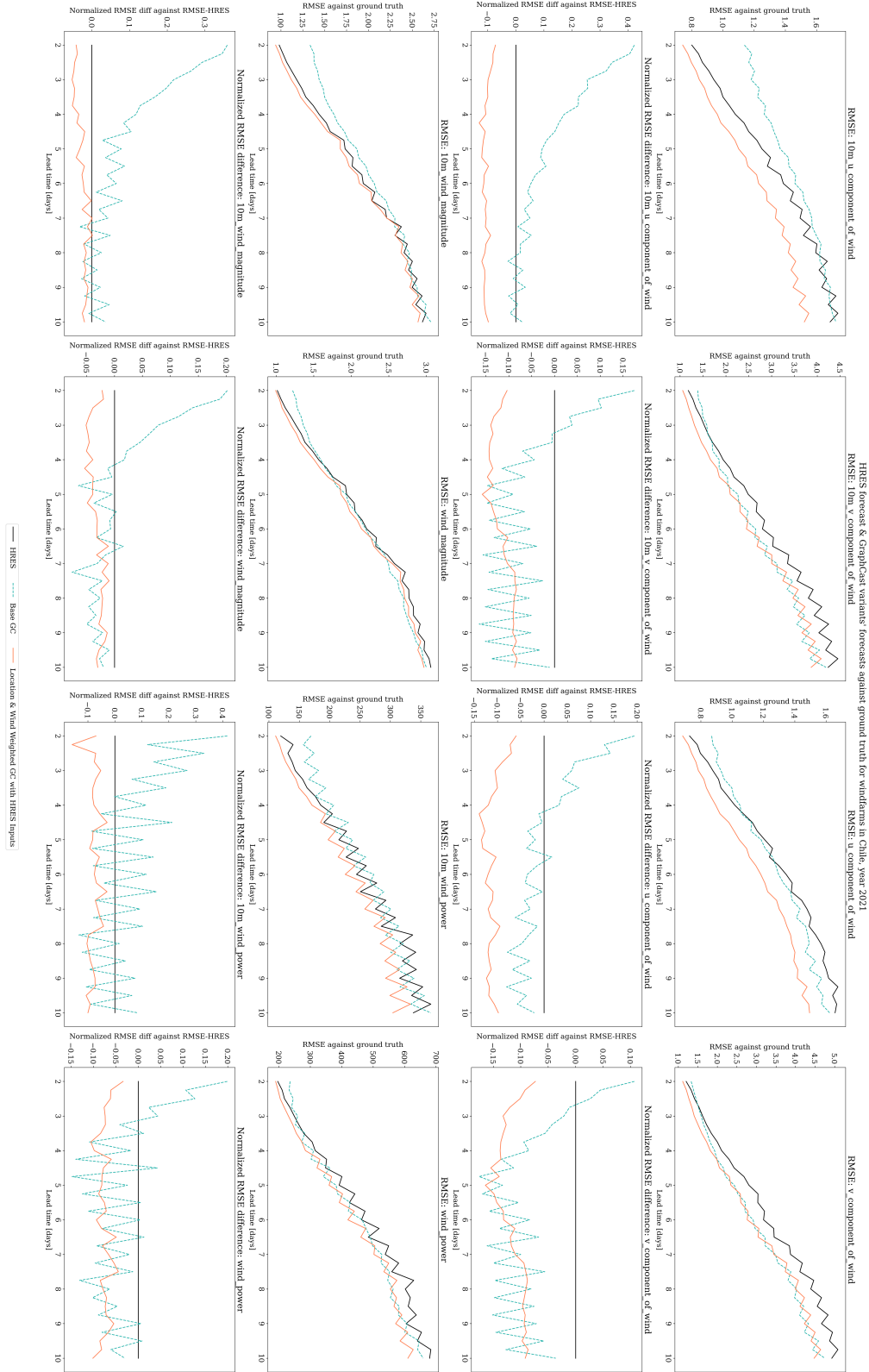
Figure S3 | **Performance comparison of HRES forecasts and tuned GraphCast variants for predicting wind characteristics at Chilean wind farms in 2021.** The plots depict the normalized RMSE difference between each GraphCast configuration and the HRES (High Resolution) forecast as well as the raw RMSE metrics for each model including HRES. Lower values indicate superior GraphCast skill. Visualizations of these metrics are provided for the u and v wind components, wind magnitude, and wind power, measured at 10m above ground level and at pressure level 1000. GraphCast models include a base configuration (dotted teal/turquoise), and a variant with location and/or wind weighting incorporating HRES inputs (orange).
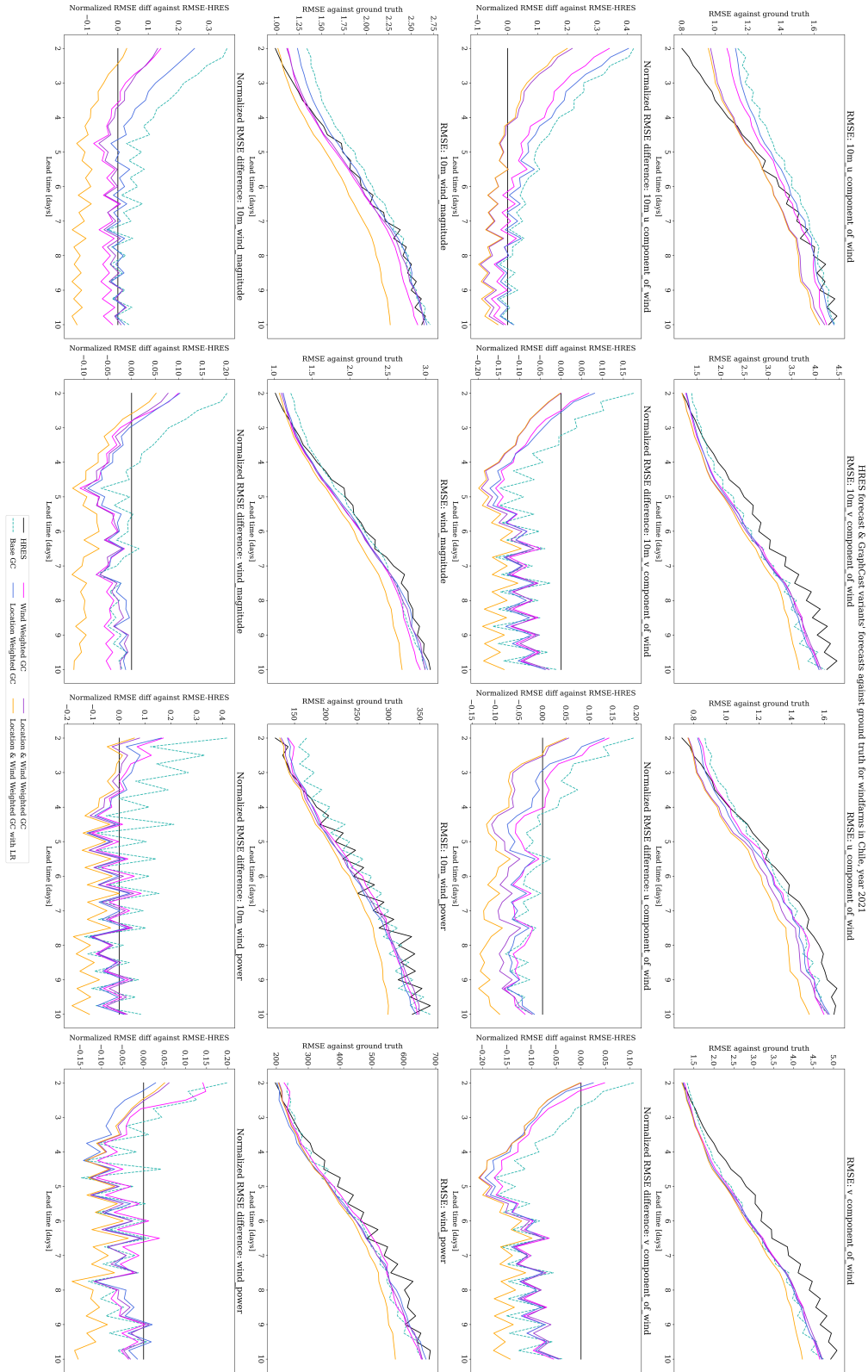
Figure S4 | **This figure compares the performance of HRES forecasts and tuned GraphCast variants in predicting wind characteristics at Chilean wind farms in 2021. Similar to the figure above, this figure extends the comparison to other Graphcast variants.**