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Interactive comment on "Combining Data from the Distributed GRUAN Site Lauder-Invercargill, New Zealand, to Provide a Site Atmospheric State Best Estimate of Temperature" *by* Jordis S. Tradowsky et al.

Anonymous Referee #2

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This paper describes a statistical method for computing a best estimate of the atmospheric state over Lauder, New Zealand, using a combination of observational data sources: weekly sonde launches at Lauder and twice daily sonde launches from Invercargill, New Zealand; and model/data assimilation data from the ERA5 reanalysis.

The method used is the Site Atmospheric Best Estimate (SASBE) technique, here specialized to observational data obtained from spatially disparate locations. The method computes a diurnal climatology for Lauder from the ERA5 reanalysis, and the computed atmospheric profile converges to this climatology in the absence of data. The

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Discussion paper

model uses a regression approach to compute the temperature anomaly at Lauder with respect to the Invercargill observations. A weighting scheme utilizing computed temporal autocorrelations is used to weight Invercargill- and Lauder-derived observational anomalies with respect to the diurnal cycle. Uncertainties for measurements, the diurnal cycle climatology, and uncertainties in regression parameters are propagated through to the atmospheric state estimate via standard techniques.

This paper is definitely within the scope of the journal, and should be publishable after attention to some issues.

The first significant issue is that a key issue for the SASBE approach investigated here is how useful a site based on spatially distributed measurements is. It seems that in the process of preparing the manuscript, the authors have developed the appropriate quantitative framework for answering this question, but the manuscript as written does not directly address this essential point. In particular, lines 2-5 of p. 14 note that the residuals between the Lauder radiosonde measurements and the diurnal climatology plus the Invercargill regression anomalies and the residuals using the diurnal climatology suggest that there is added value for adding the spatially distant Invercargill measurement. However, the figures that support this analysis are not shown. It seems that this could be one of the most significant findings from this manuscript: how much are the uncertainties in the atmospheric state estimate improved, as a function of seasonal, atmospheric level, and time of day.

Some of the technical aspects of the paper could use better elaboration. For example, it is important to note that in eq. (1) on p.5, the diurnal cycle climatology includes the higher harmonics of the diurnal cycle. These are an important part of the temporal variability of the upper troposphere and stratosphere due to atmospheric tides, and are undersampled by sounders in sun-synchronous orbit. Another example is the Fourier series expansion of the wind direction in eq. (6) on p. 8. What is the purpose of this Fourier expansion? Is it meant to capture some kind of lead/lag behavior between the temperature anomalies at Invercargill and Lauder as a function of wind direction? It

was unclear to me what vertical and temporal dependence the regression coefficients have. I assume they are computed independently for each vertical level, but are fixed in time. In general, I think the values of the regression coefficients, and their standard errors, are an important part of the paper.

Revisions that address these issues, and a careful proofreading, should lead to a manuscript that will be appropriate for publication.

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