A Site Atmospheric State Best Estimate of Temperature for Lauder, New Zealand

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Overview

Introduction: What are Site Atmospheric State Best Estimates?

Combining measurements to best estimate the temperature above Lauder

Calculating the components of the SASBE

Summary

Site Atmospheric State Best Estimates

Site Atmospheric State Best Estimates (SASBEs)

- combine measurements from multiple instruments to create the best-possible vertically resolved time series of target parameter above one site
- contain all available knowledge about the state of target variable at that site
- include an estimate of the uncertainty on every value
- useful for satellite/model validation and sensitivity studies

The temperature SASBE for Lauder

- A temperature SASBE for the distributed GCOS[1] Reference Upper-Air Network (GRUAN) site at Lauder is under development
- SASBE combines measurements from Lauder and Invercargill
- Available for 1996-2012
- Hourly temporal resolution
- Vertically resolved on standard pressure levels[2]

[1] Global Climate Observing System

[2] ground, 925 hPa, 850 hPa, 700 hPa, 500 hPa, 400 hPa, 300 hPa, 200 hPa, 150 hPa, 100 hPa, 70 hPa, 50 hPa, 30 hPa, 20 hPa, 10 hPa

The temperature SASBE for Lauder

The SASBE is calculated based on:

- radiosonde temperature profiles from Lauder and Invercargill
- surface measurements from automatic weather stations in Lauder and Invercargill
- ERA5 diurnal temperature cycles at Lauder and Invercargill

The temperature anomaly is calculated for both sites.
A regression model is used to best-estimate the temperature anomaly above Lauder from the temperature above Invercargill

The temperature SASBE for Lauder

The temperature SASBE is then calculated as

$$T_{Lau}(t) = T_{Diur}(t) + \alpha \cdot \sum_{i=1}^{n} \gamma_i \cdot T'_{Lau_i} + (1-\alpha) \cdot \sum_{i=1}^{m} \beta_i \cdot \widehat{T}'_{Lau_i} \quad (1)$$

Using:

- The diurnal cycle
- weights $\alpha = \exp\left(-\frac{(t_{Lau_1} - t)^2}{\tau_{Lau}^2}\right)$
- the weighted temperature anomaly from those Lauder radiosondes that are sufficiently close in time
- the weighted best-estimate of the temperature anomaly above Lauder obtained from radiosondes launched at Invercargill

Diurnal Cycle

- Diurnal cycle calculated from hourly ERA5 reanalysis for Lauder/Invercargill
- Fourier series accounting for day of year and hour of day is fit to temperature time series
- ERA5 includes uncertainties → uncertainties on the diurnal temperatures (see Bodeker and Kremser, 2015)

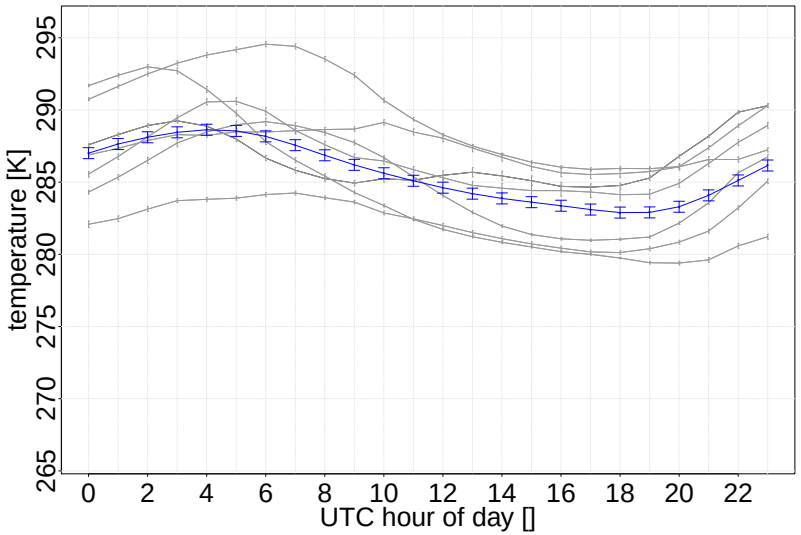

Figure 1: Diurnal cycle 925 hPa above Lauder at the 1st of January.

Enhancing the value of a distributed site

- Temperature anomalies above Lauder correlated with temperature anomalies above Invercargill
- This interdependence is used to estimate temperature anomaly above Lauder $\widehat{T}'_{Lau}$ from temperature anomaly above Invercargill T'_{Inv}
- The following regression model is used:

$$\widehat{T}'_{Lau} = \alpha + \beta \cdot T'_{Inv} + \eta \cdot \Delta SP + \kappa \cdot \Delta ST' + \epsilon \quad \text{Eq.(4)}$$

- β is expanded in a Fourier series to take the wind direction into account
- uncertainties propagated through the regression model

Example of the temperature SASBE (version2b)

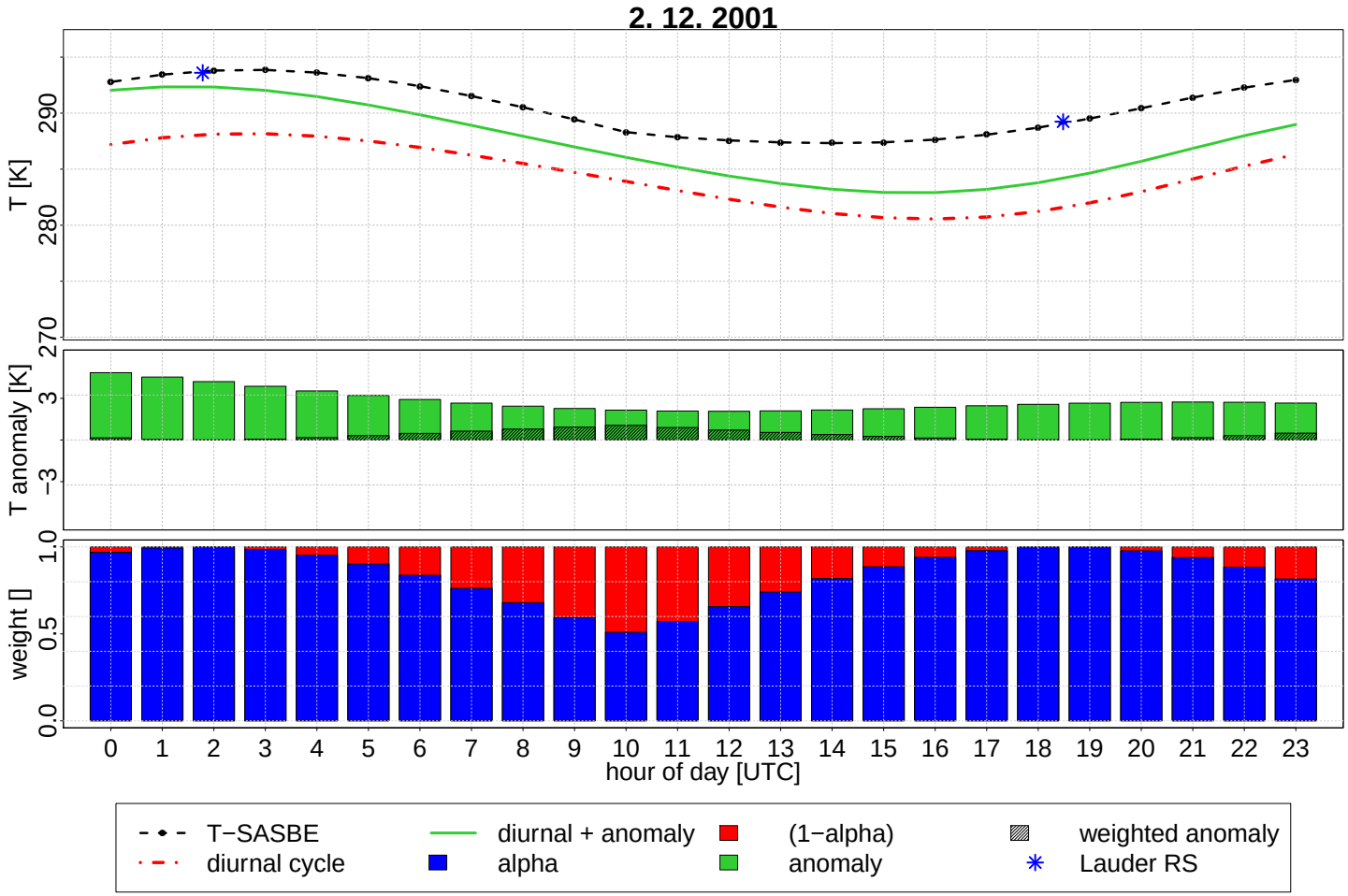

Figure 2: Temperature SASBE at 925 hPa.

Does using Invercargill data improve the SASBE?

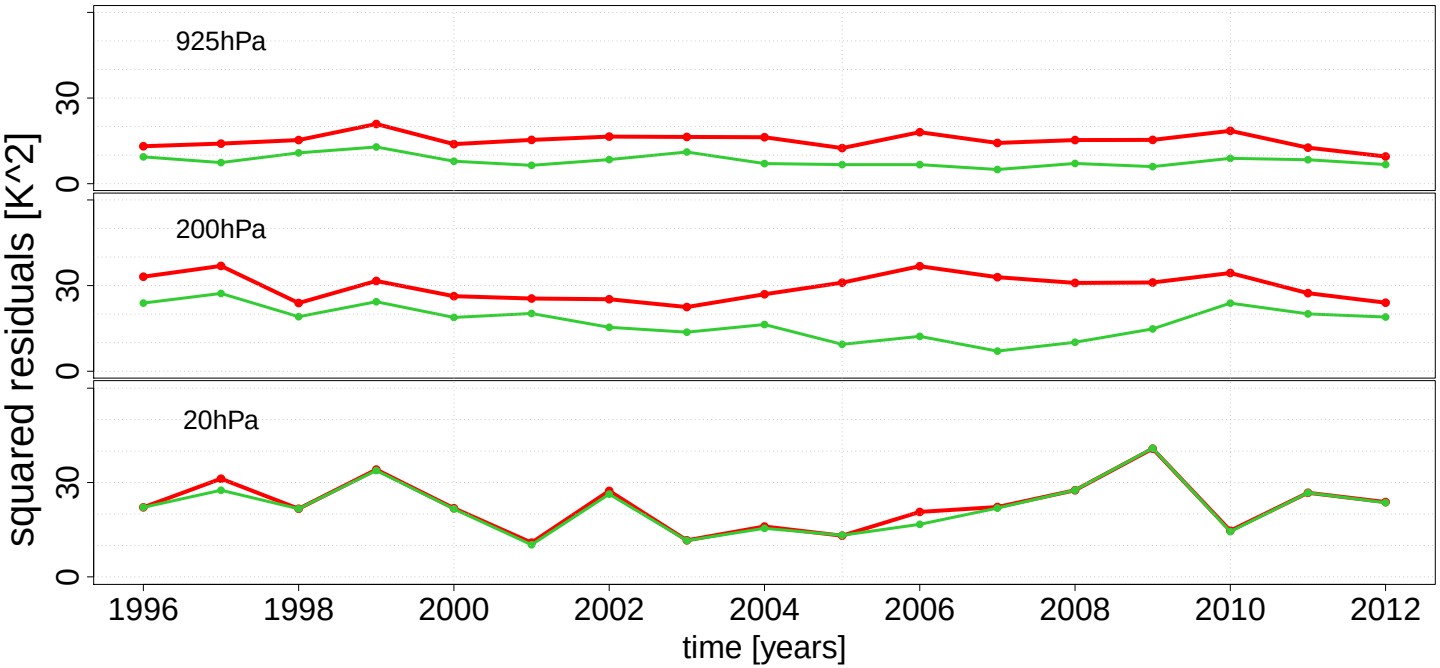

Figure 3: Normalized squared residuals between the Lauder RS measurements and (i) the diurnal cycle (red) and (ii) the diurnal cycle plus temperature anomalies retrieved from the regression model using the Invercargill RS (green).

Summary

- The final version of the SASBE for Lauder is under development
- It provides temperature profiles from 1996-2012 with hourly resolution at standard pressure levels
- The methodology will be published in *Earth System Science Data* (Manuscript in preparation)
- The data product will be added to the PANGAEA archive (including doi)
- Outlook: The SASBE can be used to calculate top-of-the-atmosphere radiances with traceable uncertainty estimates (see Tradowsky et al., 2016) $\rightarrow$ satellite validation and sensitivity study

References I

Bodeker, G. E. and Kremser, S. (2015). Techniques for analyses of trends in GRUAN data. *Atmos. Meas. Tech.*, 8:1673–1684. doi:10.5194/amt-8-1673-2015.

Tradowsky, J. S., Bodeker, G. E., Thorne, P. W., Carminaty, F., and Bell, W. (2016). GRUAN in the service of GSICS: Using reference ground-based profile measurements to provide traceable radiance calibration for space-based radiometers. *GSICS Quarterly Newsletter*, 10(2).

Thank you for your attention!