

Downscaling to high-resolution and correcting air temperature from the ERA5-Land over Ethiopia

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Open access gridded daily 2-m air temperature for Ethiopia (1981-2010)

- Enhanced spatial resolution and accuracy of ERA5-Land (ERA5L)
- Compatible with the high resolution precipitation dataset (e.g., CHIRPS)

Challenges and solutions:

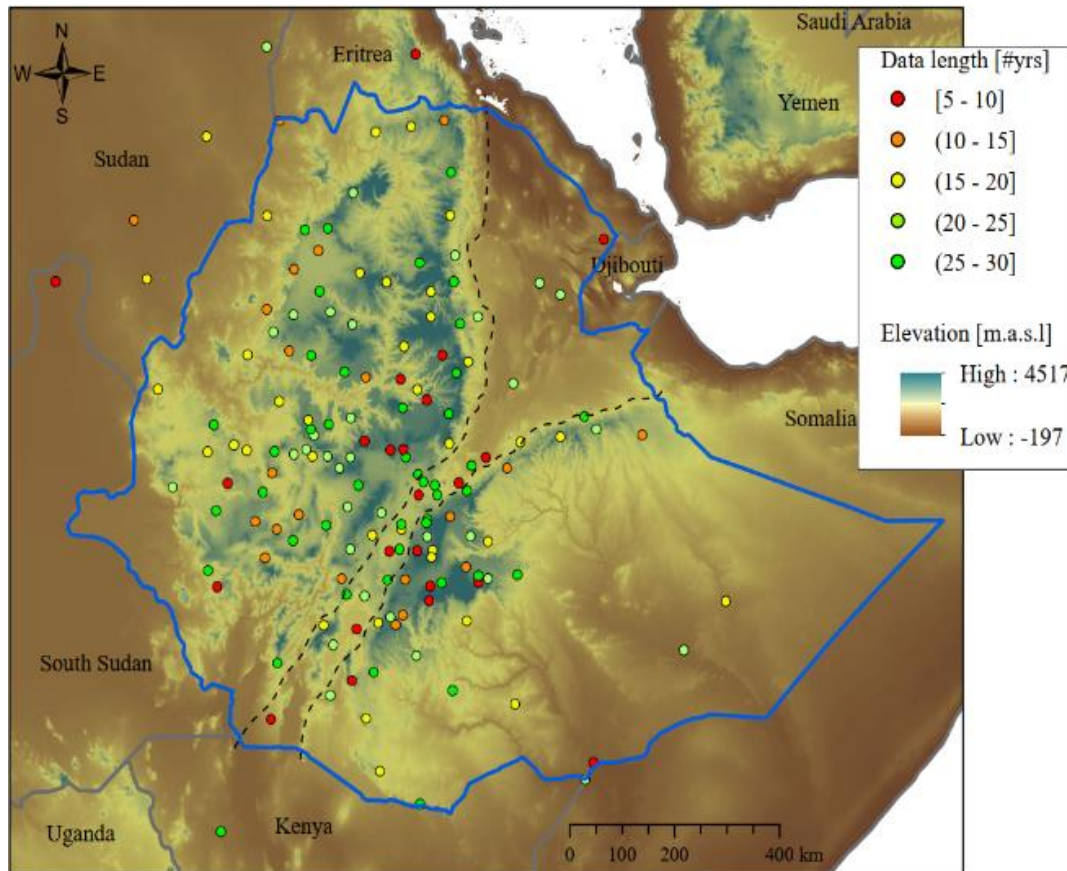
- Limited availability and quality of the in-situ observation (IOBS)
- Temperature statistics used instead of complete time series

Methodology

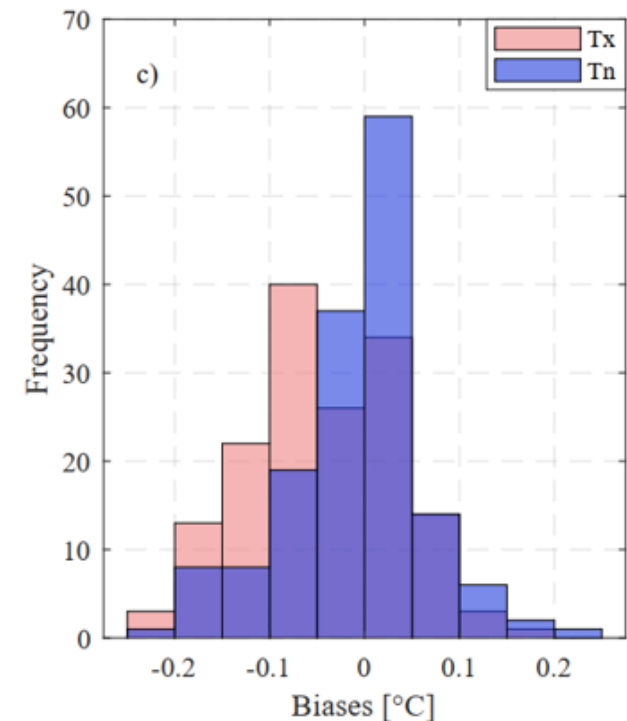
Data gap-filling and homogenization

Quality controlled in-situ observed (IOBS) temperature statistics

- 154 stations
- 5 – 30 years (1981-2010)
- Mean (μ) and standard deviation (σ) for...
- Monthly climatologies and annual cycles of ...
- Maximum (Tx) and minimum (Tn) temperatures



Sampling uncertainties due to differences in record length



Methodology

Spatial interpolation of μ and σ

Hybrid interpolation ($0.05^\circ \times 0.05^\circ$)

$$\mu = \mu_{\text{background}} + \mu_{\text{residual}}$$

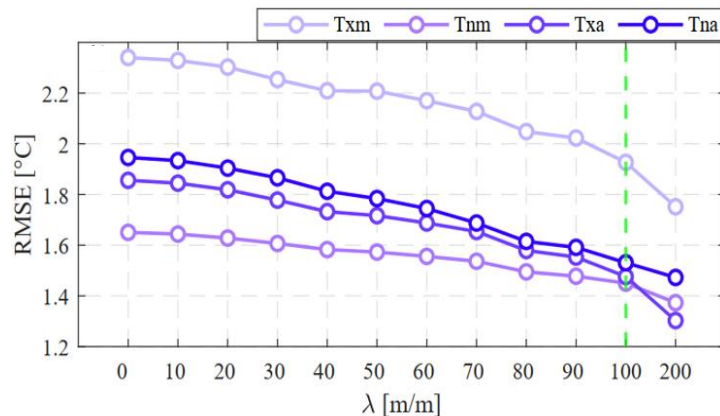
$$\sigma = \sigma_{\text{background}} + \sigma_{\text{residual}}$$

Background statistics: multivariate linear regression with elevation and location predictors

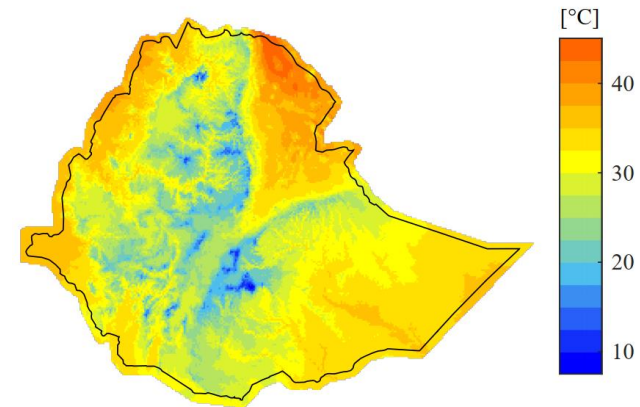
Residual statistics: inverse generalized distance (D_λ) weighting (IGDW) interpolation (Frei, 2014)

$$D_{\lambda, (s_1 \rightarrow s_2)} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (\lambda \cdot (z_1 - z_2))^2}$$

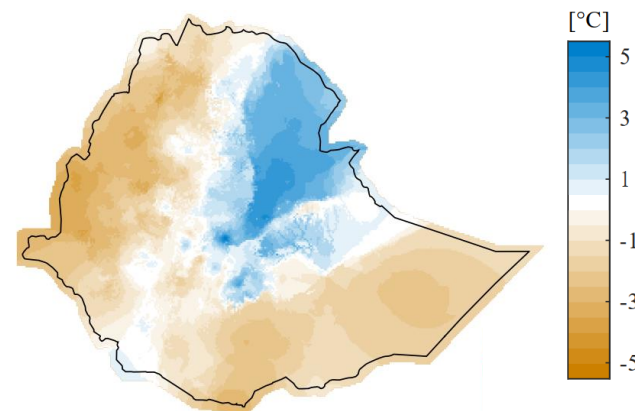
λ is distance penalty per meter of elevation difference



Background mean of Tx (June)



Residual mean of Tx (June)



ERA5L ($0.1^\circ \times 0.1^\circ$)
disaggregated to
 $0.05^\circ \times 0.05^\circ$

IOBS distribution is
nearly Gaussian

Quantile mapping

Step 1:

- Correction for monthly climatology
- Stationarity
- Calibration with monthly statistics



Step 2:

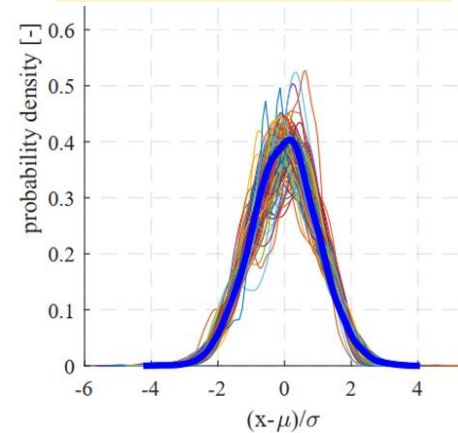
- Correction for annual cycles
- Non-stationarity in time
- Calibration with annual statistics



**Bias-corrected ERA5L Tx and Tn
(BCE5)**



Leave-Out-One Cross-Validation
(LOOCV)

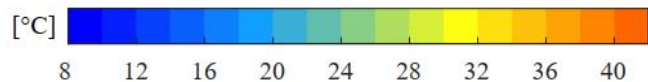
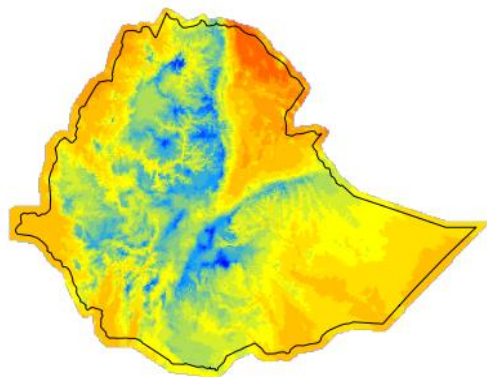


Kernel densities of IOBS Tx
at 154 stations

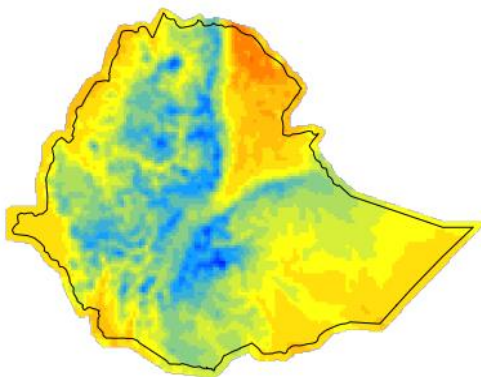
Results

Comparison of the corrected and raw ERA5L datasets

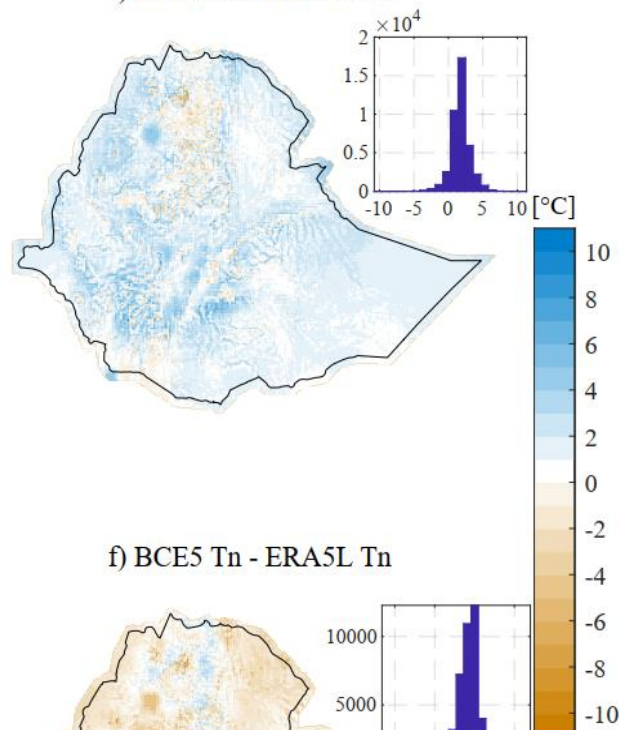
a) BCE5 mean Tx



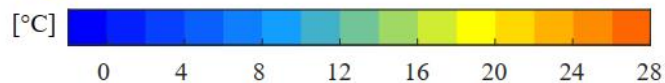
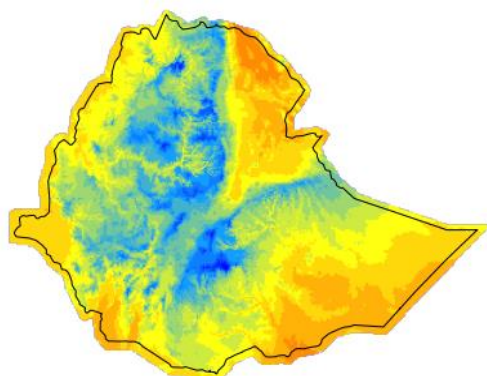
b) ERA5L mean Tx



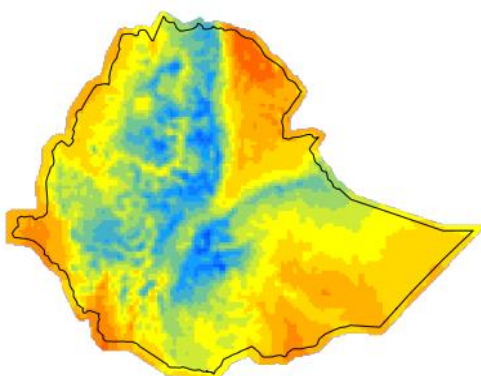
c) BCE5 Tx - ERA5L Tx



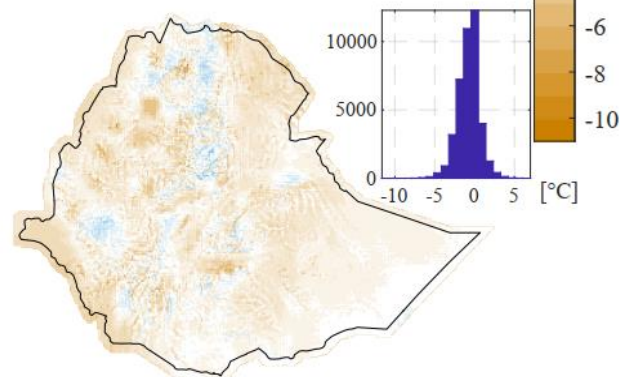
d) BCE5 mean Tn



e) ERA5L mean Tn



f) BCE5 Tn - ERA5L Tn

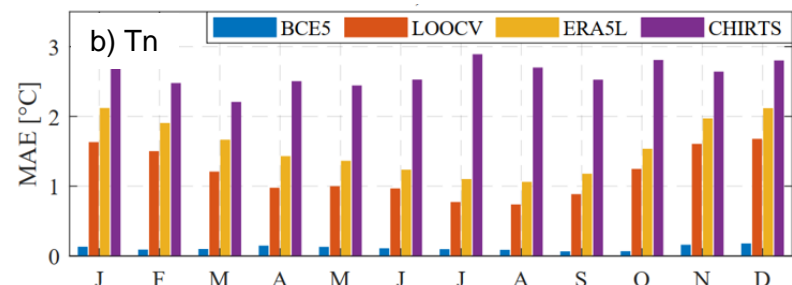
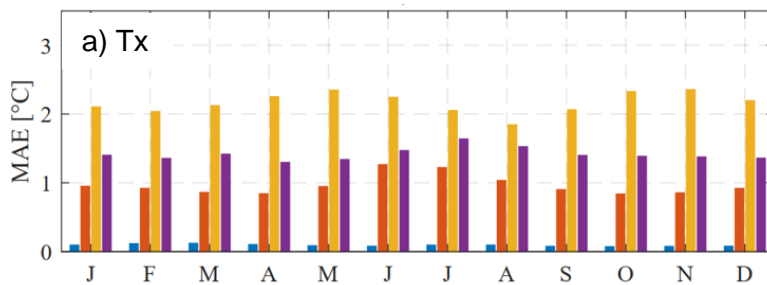


Daily climatology

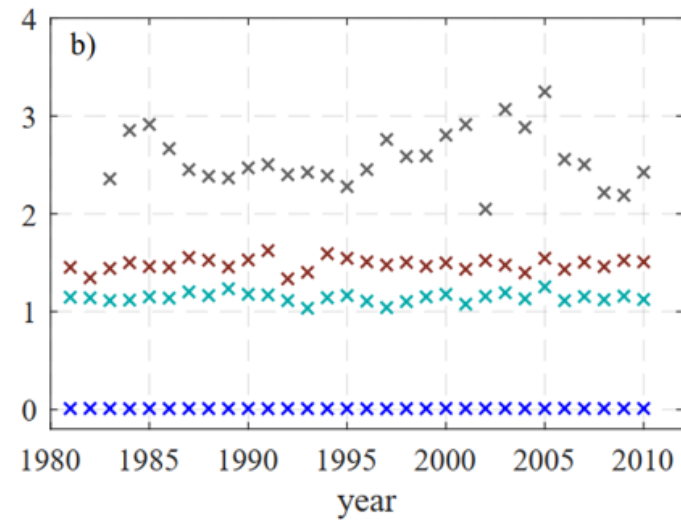
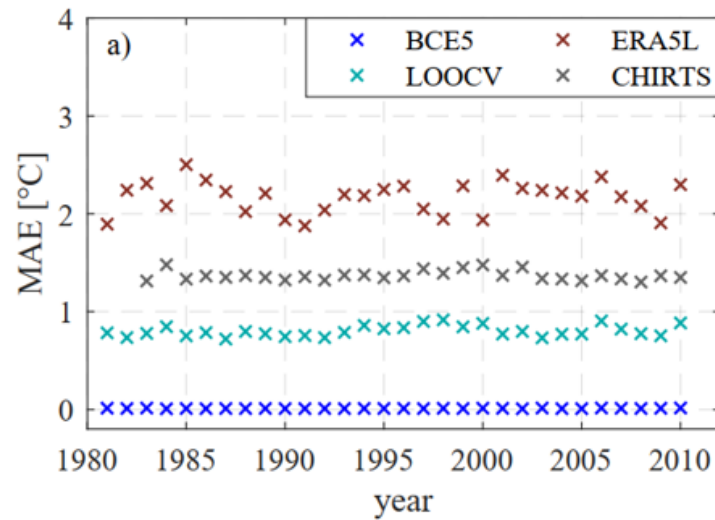
	Tx				Tn			
	Mean		Std		Mean		Std	
Dataset	MAE (°C)	RMSE (°C)	MAE (°C)	RMSE (°C)	MAE (°C)	RMSE (°C)	MAE (°C)	RMSE (°C)
BCE5	0.05	0.07	0.07	0.11	0.01	0.02	0.08	0.10
LOOCV	0.68	0.91	0.27	0.37	1.07	1.27	0.48	0.63
ERA5L	2.14	2.55	0.26	0.33	1.43	1.77	0.64	0.86
CHIRTS*	1.30	1.64	0.40	0.50	2.53	2.94	0.56	0.73

*CHIRTS (Verdin et al., 2020) is a daily temperature dataset available at 0.05°x0.05° resolution and it is considered here for comparison

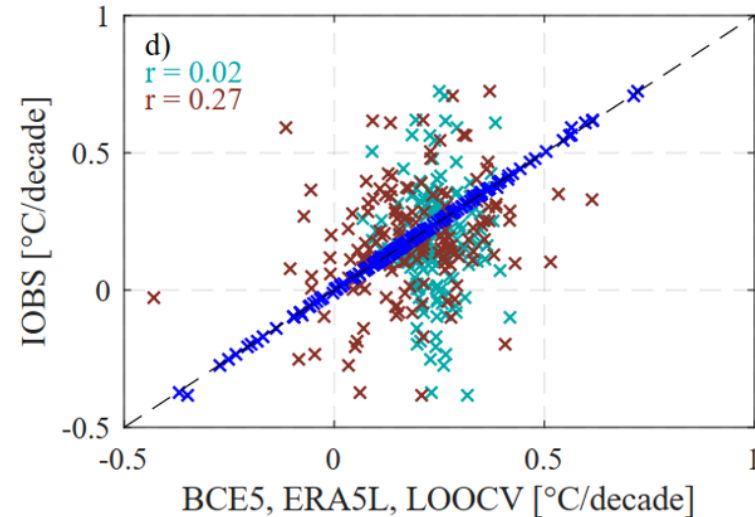
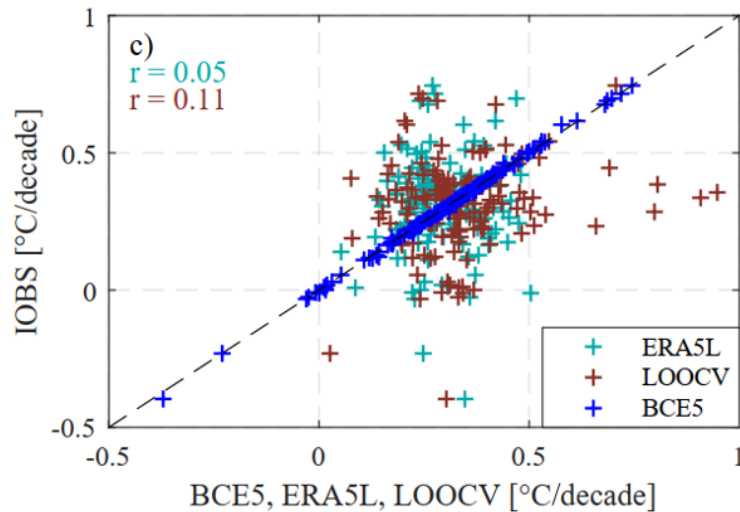
Monthly climatology



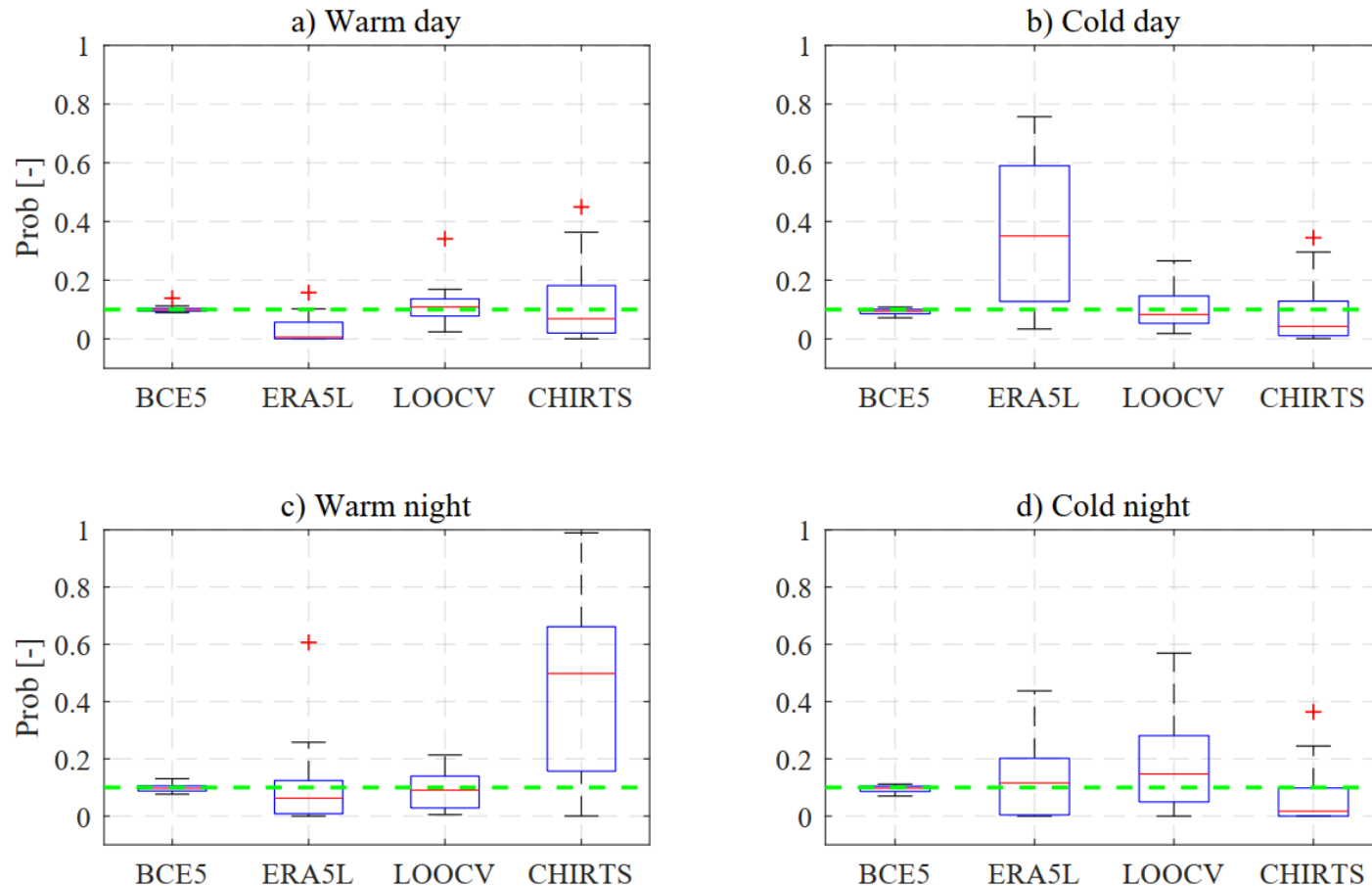
Annual cycle



Trends



Extreme temperature



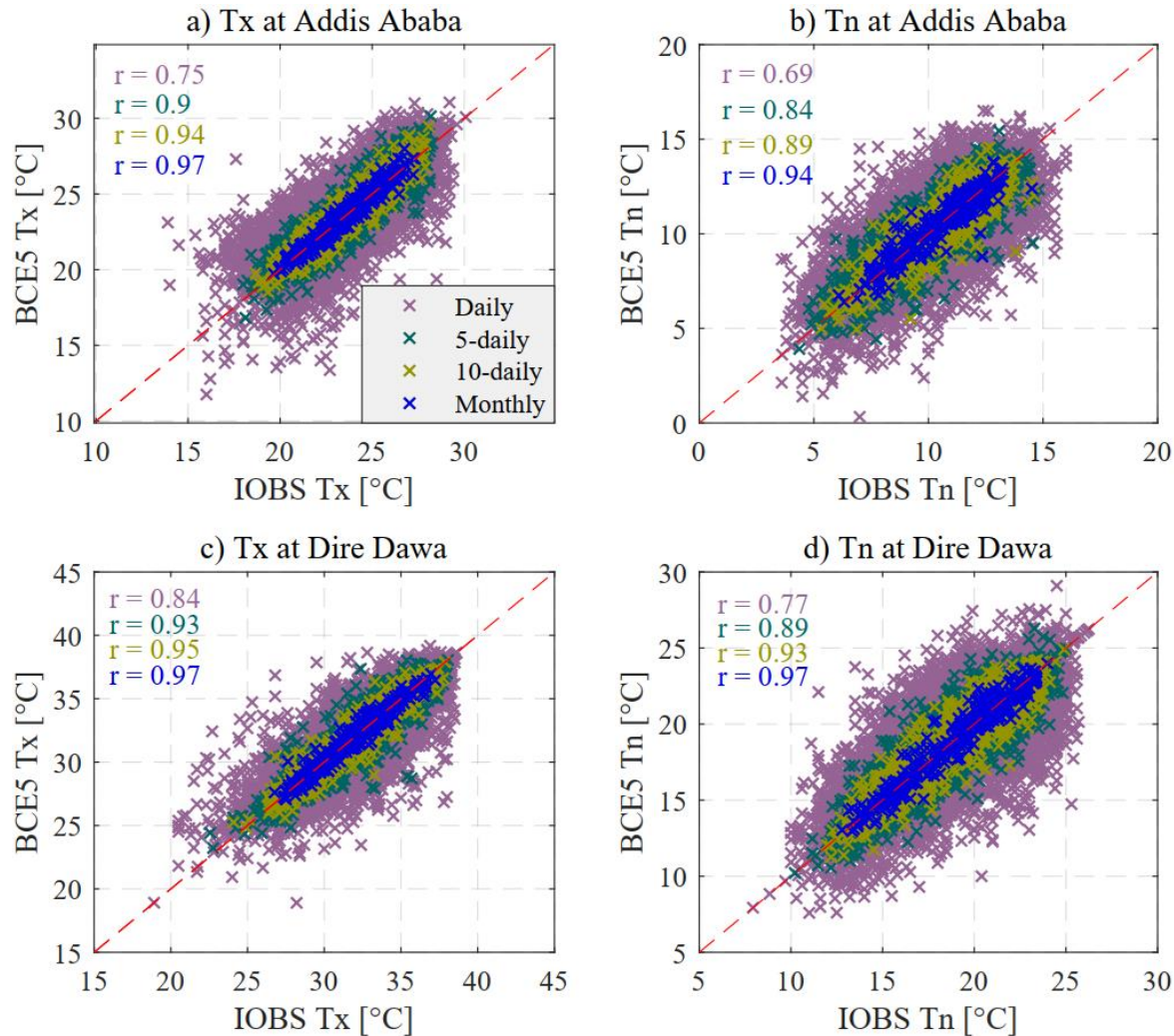
Definitions (e.g., Donat et al., 2013)

- Warm day ($T_x > 90^{\text{th}}$ ile of T_x)
- Warm day ($T_x > 90^{\text{th}}$ ile of T_n)
- Cold day ($T_x < 10^{\text{th}}$ ile of T_x)
- Cold night ($T_n < 10^{\text{th}}$ ile of T_n)

Results

Performance at different aggregation times

Scatterplots of the IOBS and corrected time series at Addis Ababa and Dire Dawa stations at different aggregation times: use of the data at coarser aggregation time is suggested for a better accuracy



Summary

Dataset information:

- Variables: maximum temperature, minimum temperature (°C)
- Spatial resolution: ~5km x 5km
- Temporal resolution and coverage: Daily, 1981-2010
- Spatial coverage: Ethiopia and areas within 20 – 30 km outside the boundary of Ethiopia
- Coordinate system: WGS 84
- File format: NetCDF
- Data availability: can be accessed freely at: <https://doi.org/10.3929/ethz-b-000546574>
- Full article is under preparation to be submitted to the Earth Systems Science Data journal.

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