Gradient Descent on European Temperature Data

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This study evaluates gradient descent performance on daily mean temperature data from three European weather stations: Stockholm (1960), Basel (1990), and Gdansk (2019). The goal is to observe temperature trends and verify that gradient descent converges reliably across different climates.

Gradient Descent Implementation and Dataset Overview

For each station/year, daily mean temperatures were modeled using a simple linear function. Gradient descent was applied with a learning rate of 0.1 and 500 iterations, starting from θ0 = 0 and θ1 = 0. Loss function tracking confirmed convergence.

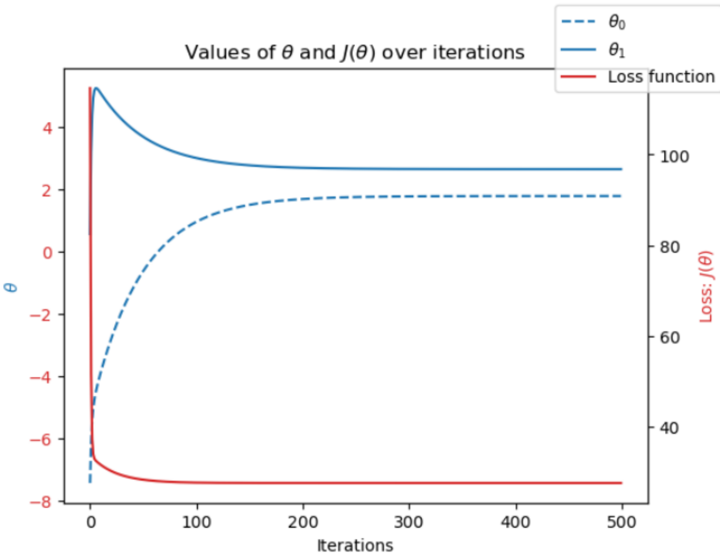
The following outputs were recorded: final θ0 and θ1, temperature range, and convergence status. Loss function plots and gradient descent profiles were generated for visualization.

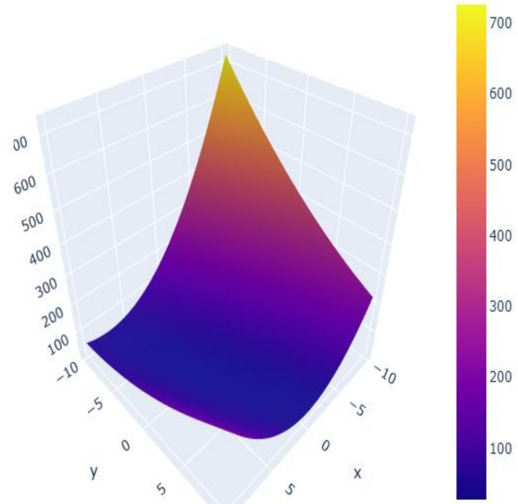
Station-Specific Results

Stockholm, 1960

- Final θ0: 1.78
- Final θ1: 2.64
- Temperature range: -11.6 °C to 20.9 °C
- Convergence: Successful

Stockholm shows the coldest minimum temperature among the three stations, consistent with its northern latitude. Gradient descent converged smoothly, with the loss function steadily decreasing to the minimum within 500 iterations.

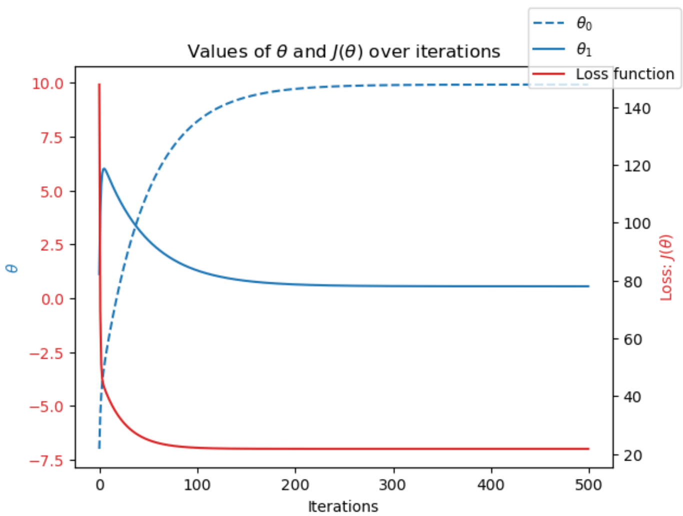


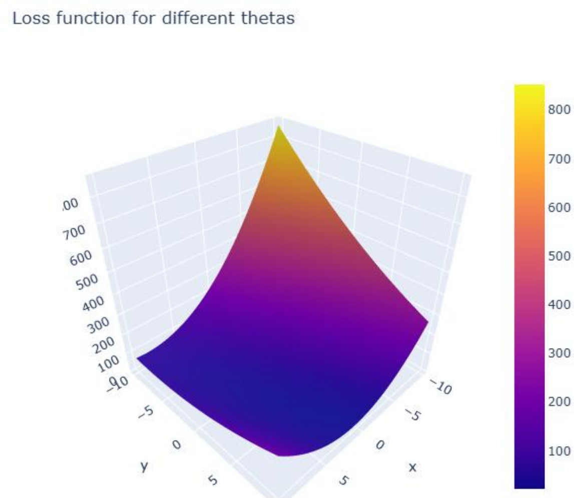


Basel, 1990

- Final θ0: 9.91
- Final θ1: 0.55
- Temperature range: -3.0 °C to 25.1 °C
- Convergence: Successful

Basel has a higher baseline temperature due to its central European location. Gradient descent behaved predictably, confirming robustness across climates.

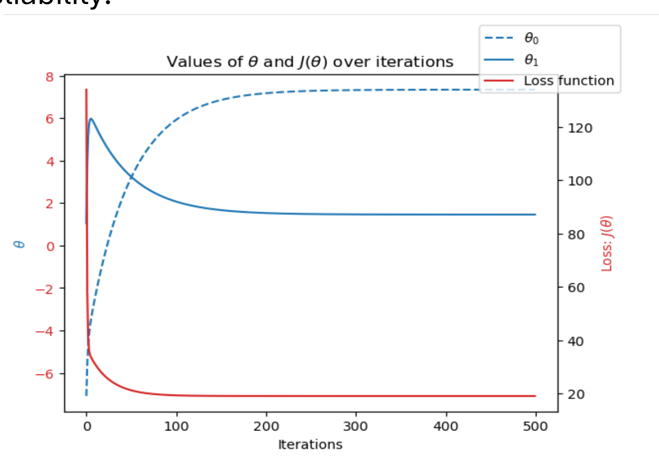


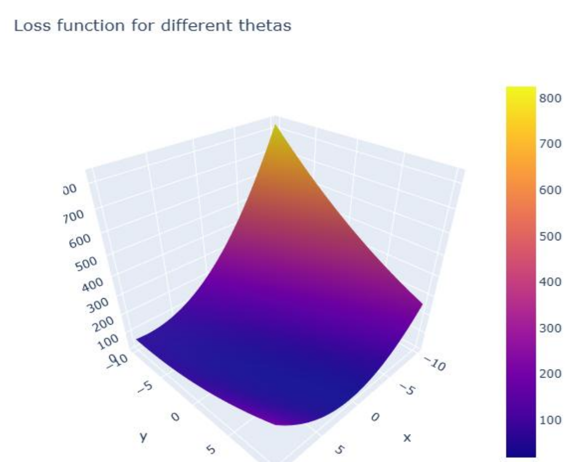


Gdansk, 2019

- Final θ0: 7.33
- Final θ1: 1.45
- Temperature range: -2.4 °C to 24.0 °C
- Convergence: Successful

Gdansk 2019 shows warmer minimum temperatures than Stockholm 1960, highlighting long-term warming trends. The gradient descent algorithm efficiently reached the minimum, confirming its reliability.





Insights Across Stations

Over the three datasets, a clear pattern emerges. Winter minimum temperatures have generally increased over the decades: Stockholm in 1960 recorded -11.6 °C, Basel in 1990 -3.0 °C, and Gdansk in 2019 -2.4 °C, illustrating a consistent upward trend in colder periods. Baseline temperatures, as indicated by θ_0, reflect geographic and climatic differences. Basel's central European location results in the highest baseline temperature (9.91), Stockholm the lowest (1.78), and Gdansk falls in between (7.33), consistent with its Baltic coastal position. Across all stations, gradient descent converged reliably within 500 iterations, and the loss function plots confirm the optimization effectively finds the minimum regardless of the station or year. Overall, the analysis demonstrates both the long-term warming trends across Europe and the robustness of gradient descent for modeling historical temperature data.

Key Results Summary

Station	Year	Final θ_0	Final θ_1	Min Temp	Max Temp	Convergence
Stockholm	1960	1.78	2.64	-11.6	20.9	Yes
Basel	1990	9.91	0.55	-3.0	25.1	Yes
Gdansk	2019	7.33	1.45	-2.4	24.0	Yes