Regression using Support Vector Machines (SVM)

- What is SVM?
- How does it work?
- Kernel trick for non-linear data
- Regression with SVM

Common Applications of SVM

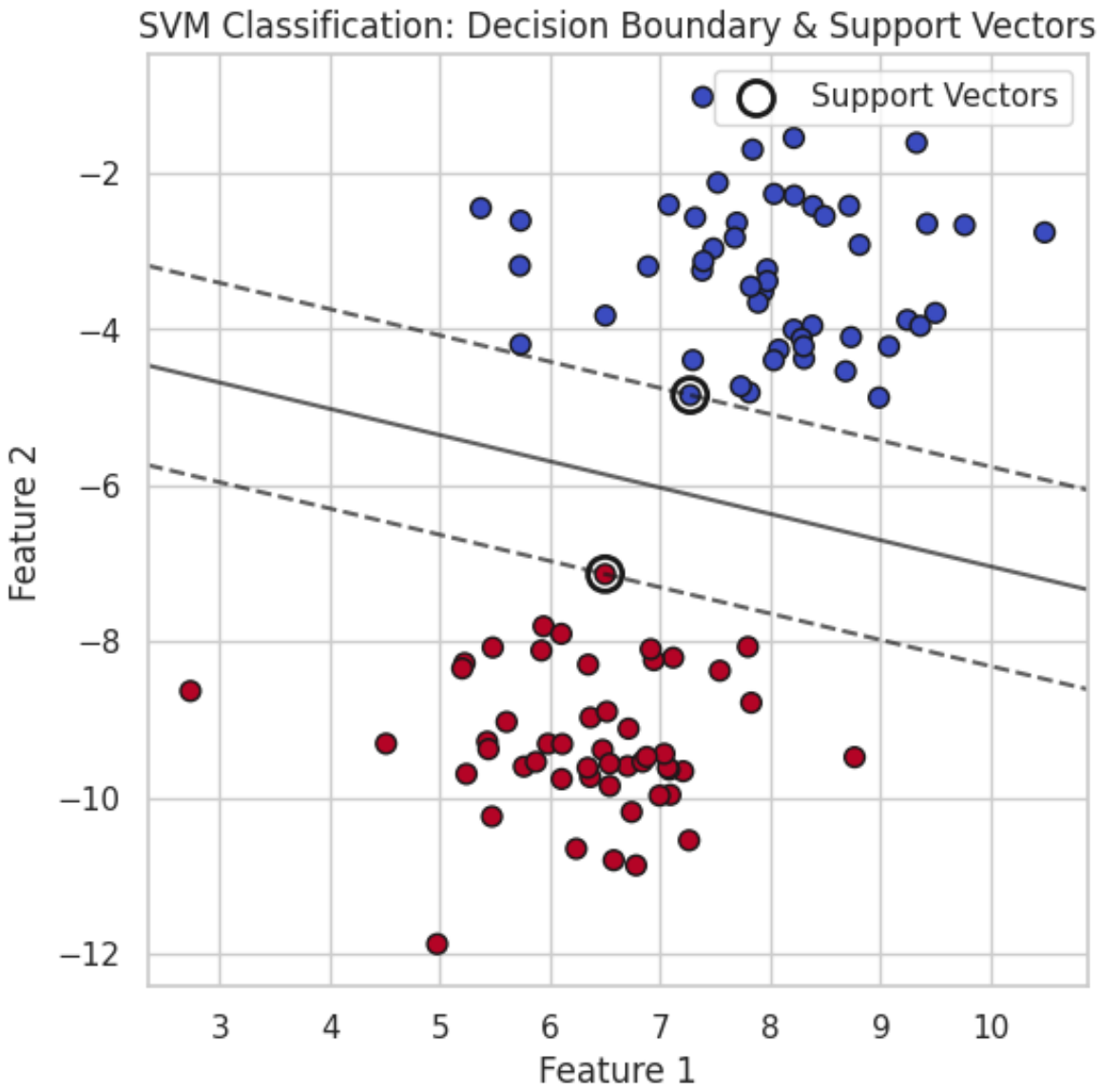
- **Classification**: Separating data into categories (e.g., spam detection, image recognition)
- **Regression**: Predicting continuous values (e.g., stock prices, house prices)

What is Support Vector Machine (SVM) ?

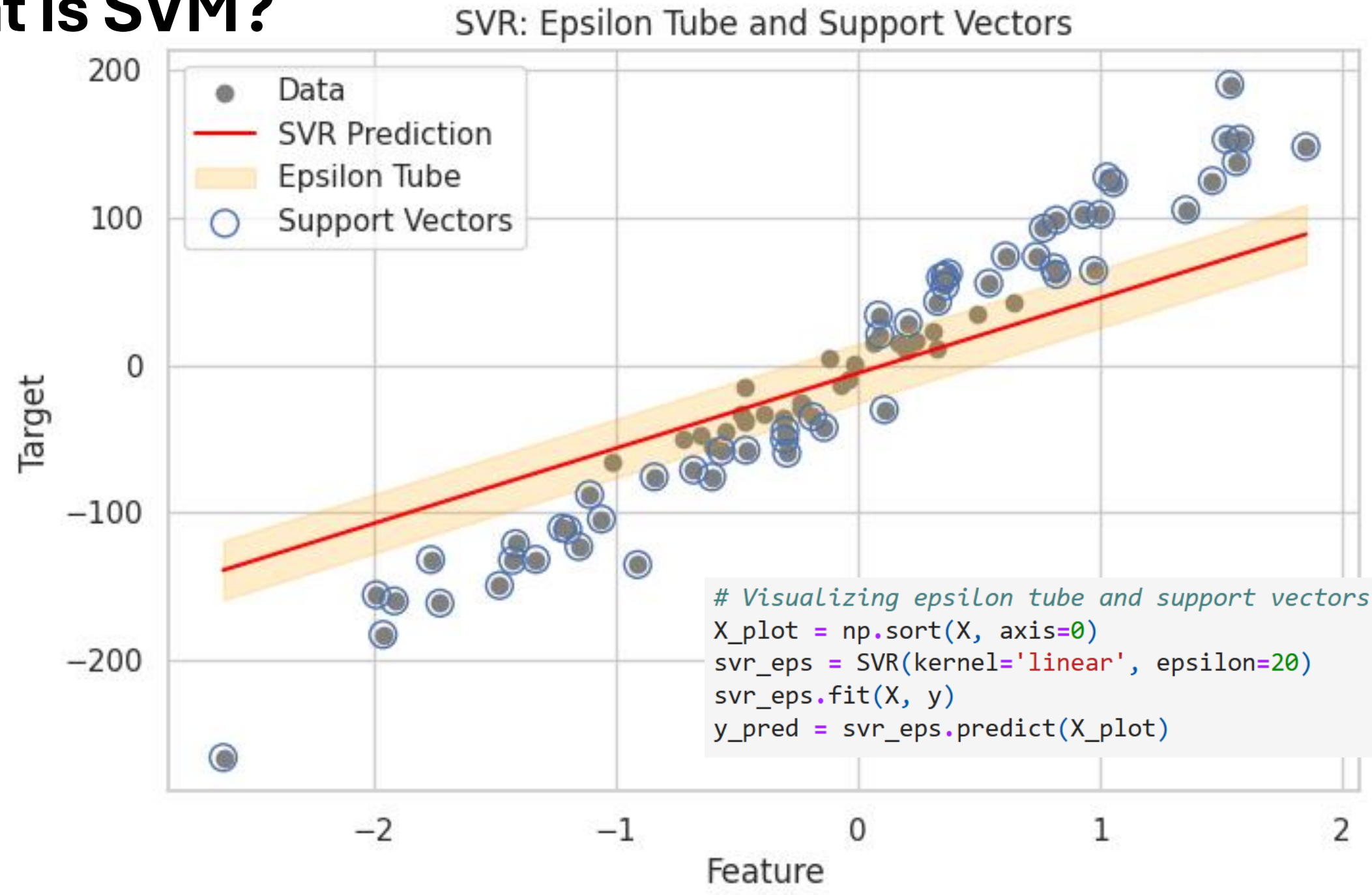
What is SVM?

- Hyperplane
- Margin
- Support Vectors

SVMs are powerful because they focus on the most critical data points (support vectors) and can handle both linear and non-linear problems.



What is SVM?



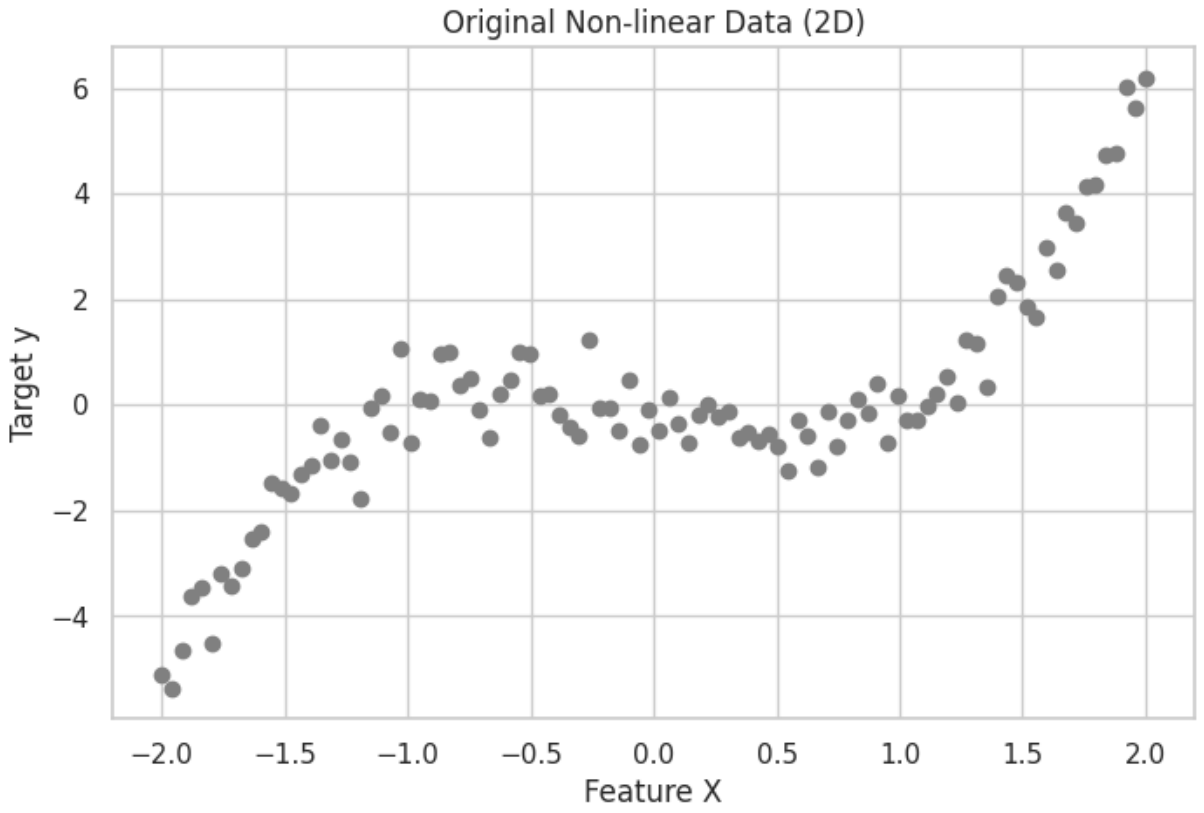

```python
# Visualizing epsilon tube and support vectors in SVR
X_plot = np.sort(X, axis=0)
svr_eps = SVR(kernel='linear', epsilon=20)
svr_eps.fit(X, y)
y_pred = svr_eps.predict(X_plot)
```

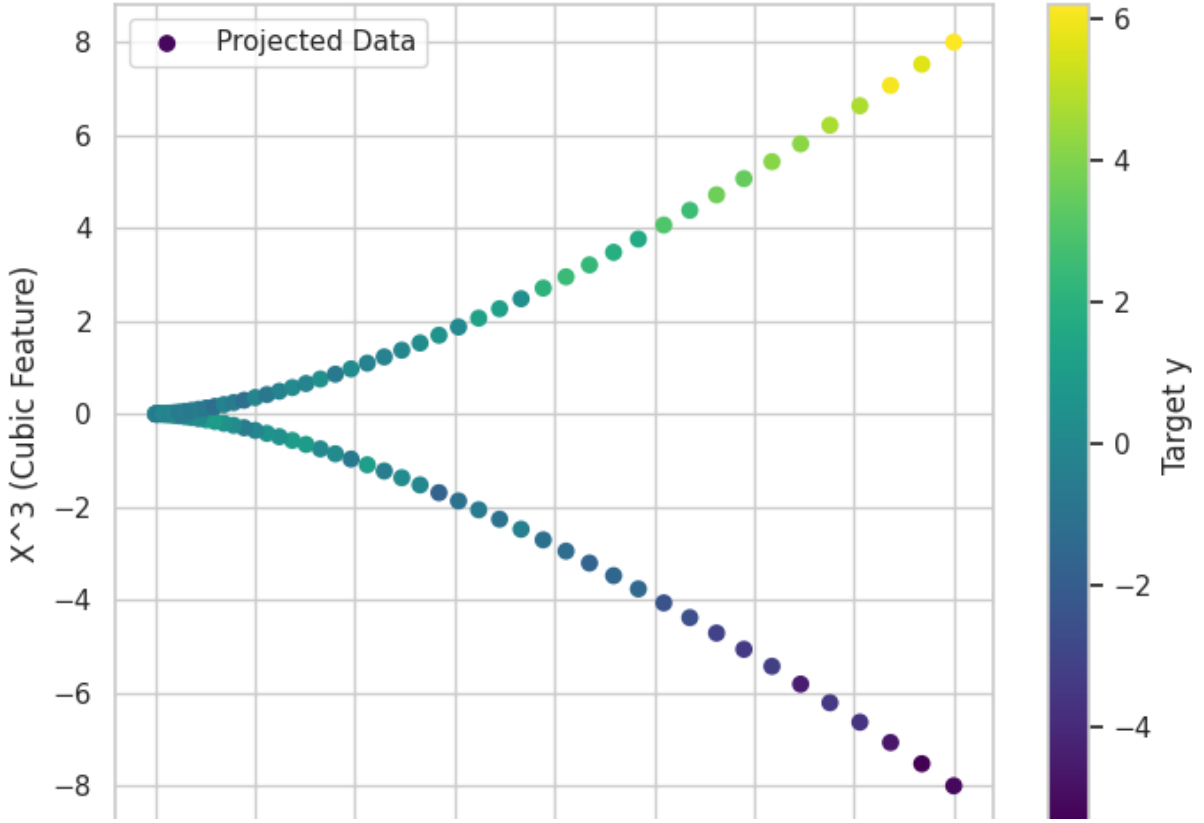
Kernel Trick

Kernel trick – project non-linear data in higher dimension space

```python
# Simple non-linear data
np.random.seed(0)
X_poly = np.linspace(-2, 2, 100).reshape(-1, 1)
y_poly = X_poly[:, 0] ** 3 - X_poly[:, 0] + np.random.normal(0, 0.5, X_poly.shape[0])
```

```python
# 2. Project data into 2D using polynomial features
from sklearn.preprocessing import PolynomialFeatures
poly = PolynomialFeatures(degree=3, include_bias=False)
X_poly_proj = poly.fit_transform(X_poly)
```



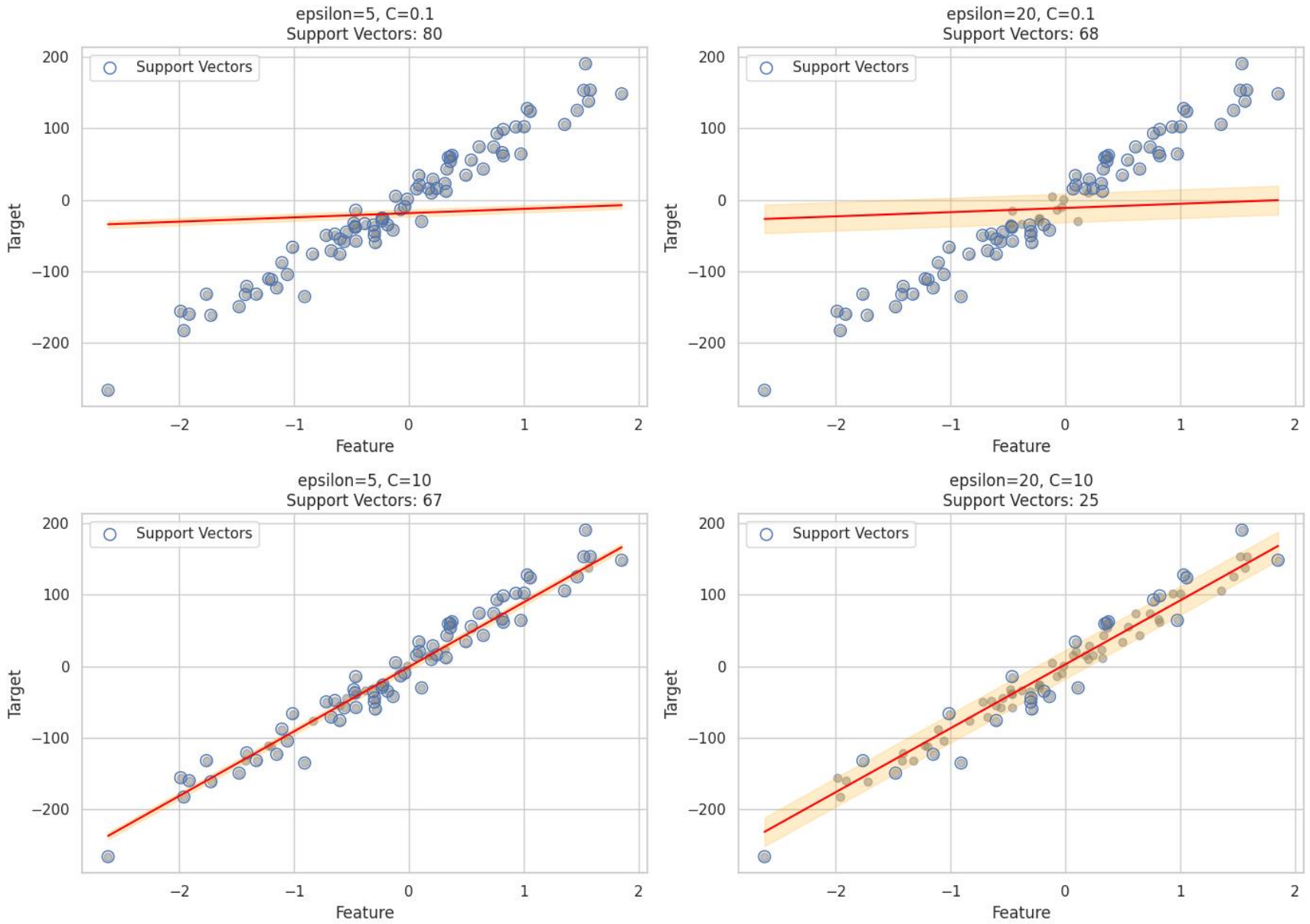


Support Vector Machine Regression (SVR)

SVM regression (**SVR**)

The goal is to find a function that deviates from the actual targets by a value no greater than epsilon (ε) for each training point, while being as flat as possible. The points that lie on or outside the epsilon tube are called **support vectors**.

SVR - Effect of Support Points, Epsilon, C



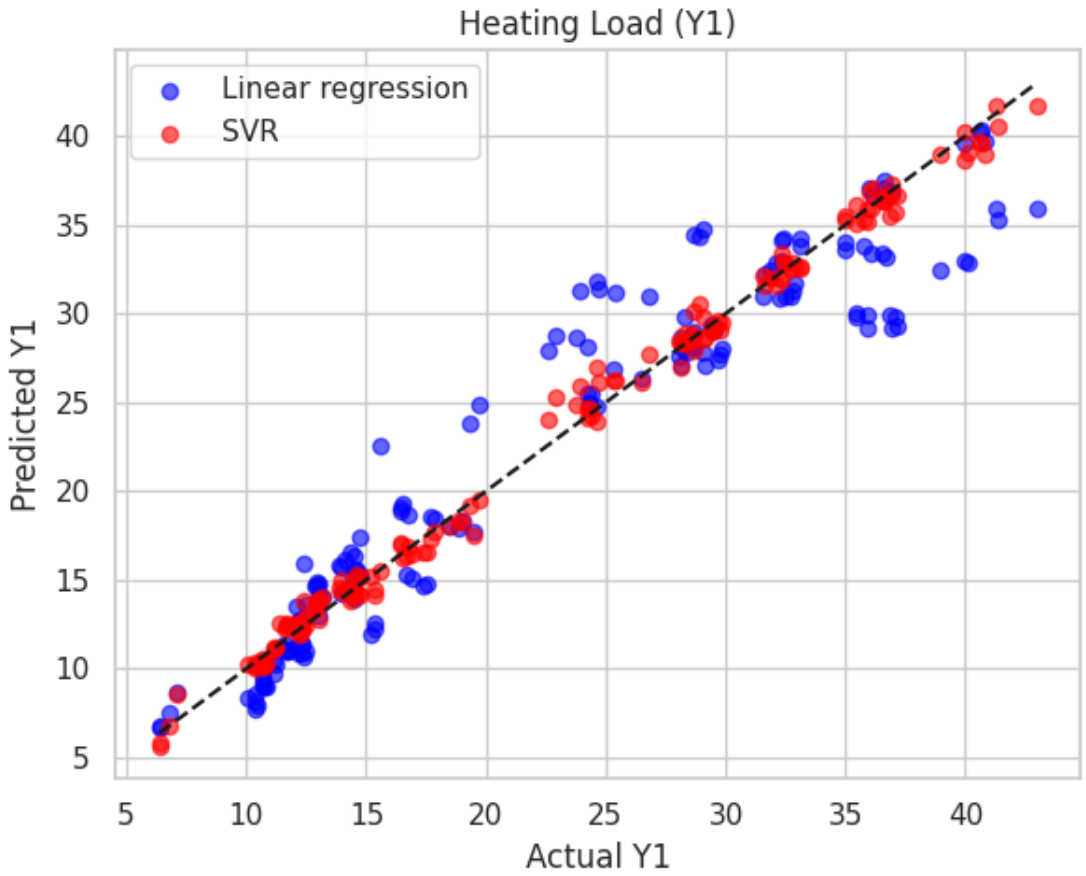
Examples

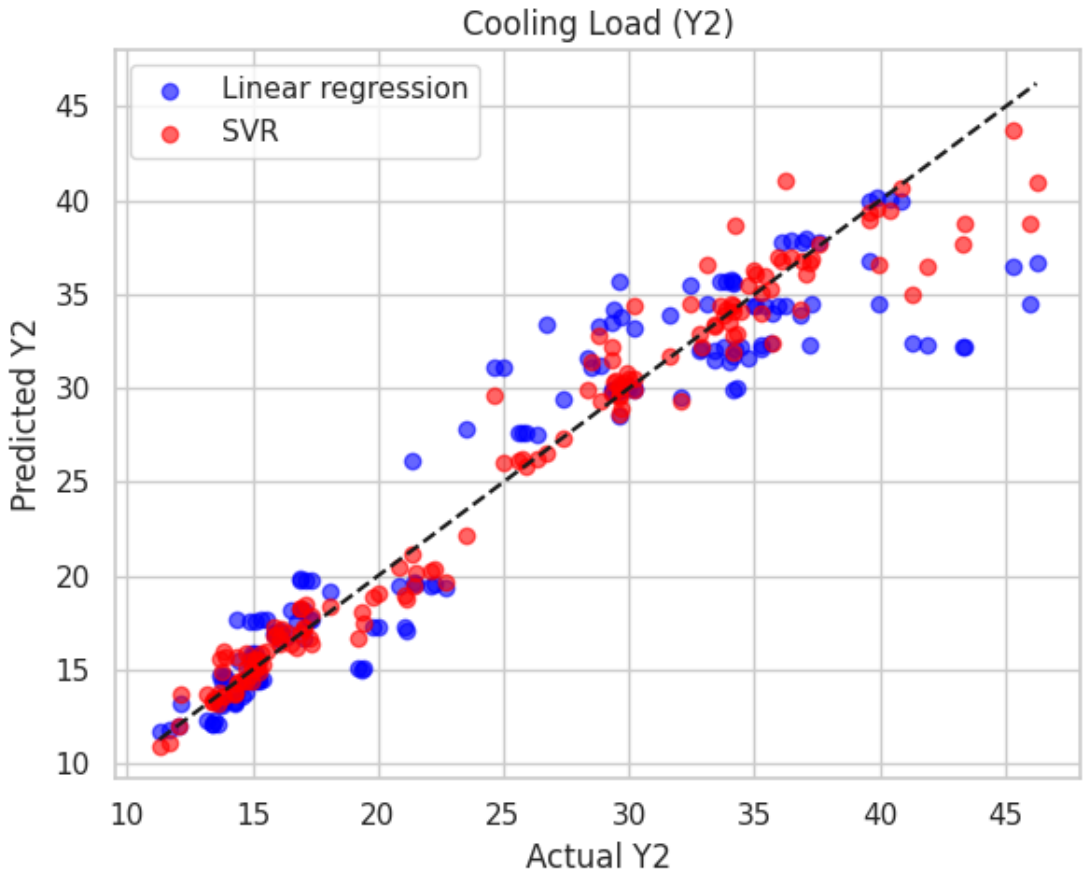
Example 1: Predict heating and cooling load on buildings

Variable Name	Tole	Type	Description	Units	Missing Values
X1	Feature	Continous	Relative Compactness	empthy	no
X2	Feature	Continous	Surface Area	empthy	no
X3	Feature	Continous	Wall Area	empthy	no
X4	Feature	Continous	Roof Area	empthy	no
X5	Feature	Continous	Overall Height	empthy	no
X6	Feature	Integer	Orientation	empthy	no
X7	Feature	Continous	Glazing Area	empthy	no
X8	Feature	Integer	Glazing Area Distribution	empthy	no
Y1	Target	Continous	Heating Load	empthy	no
Y2	Target	Continous	Cooling Load	empthy	no

Example 1: Predict heating and cooling load on buildings

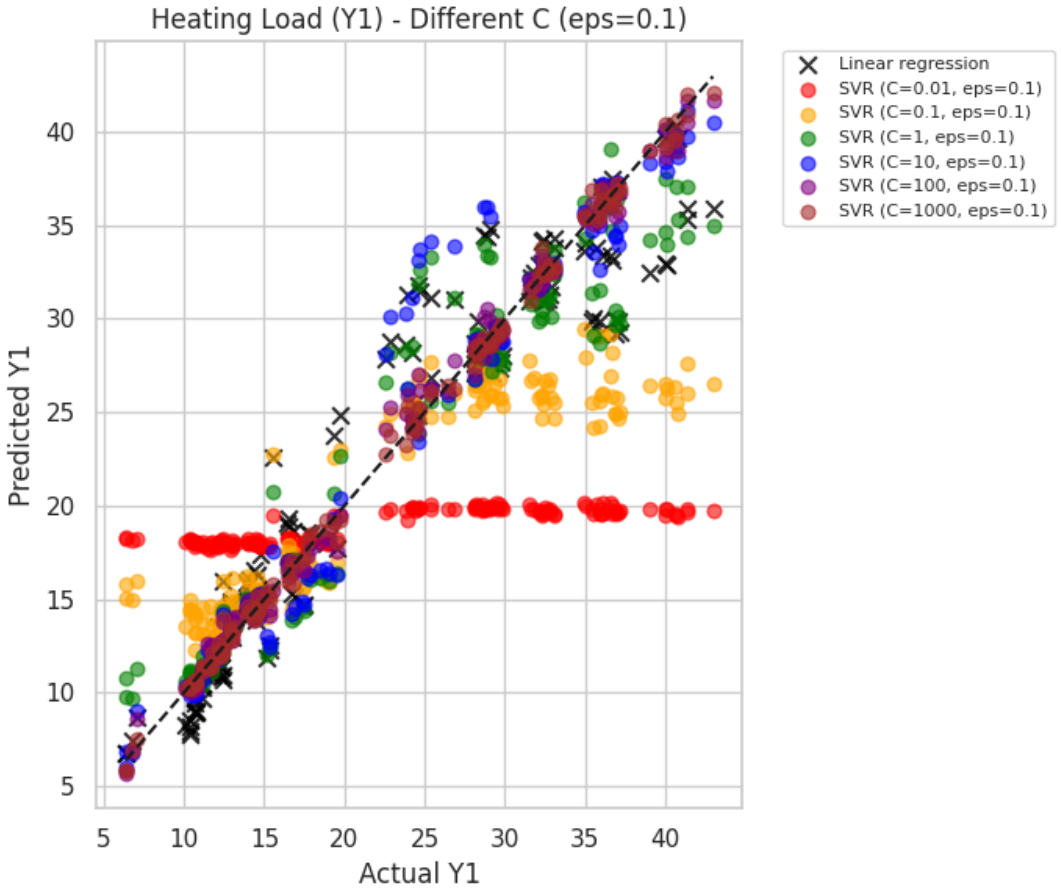
Linear regression vs Support Vector Regression

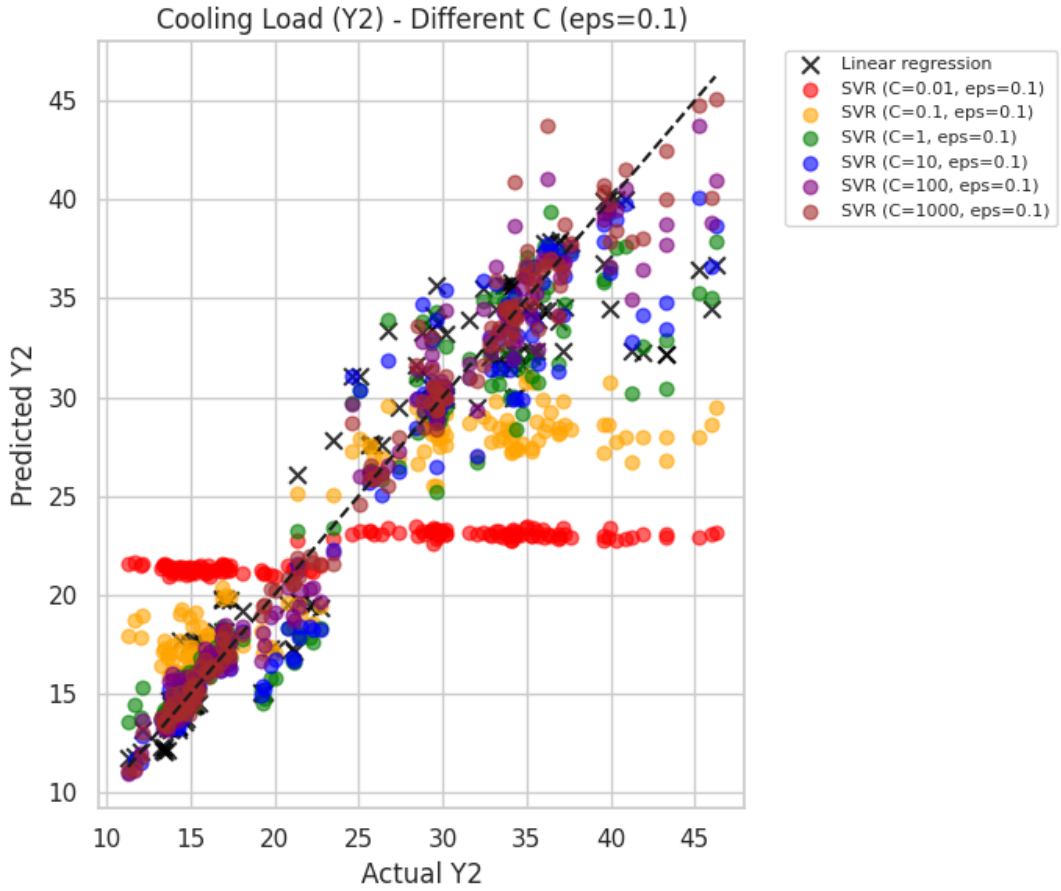




Example 1: Predict heating and cooling load on buildings

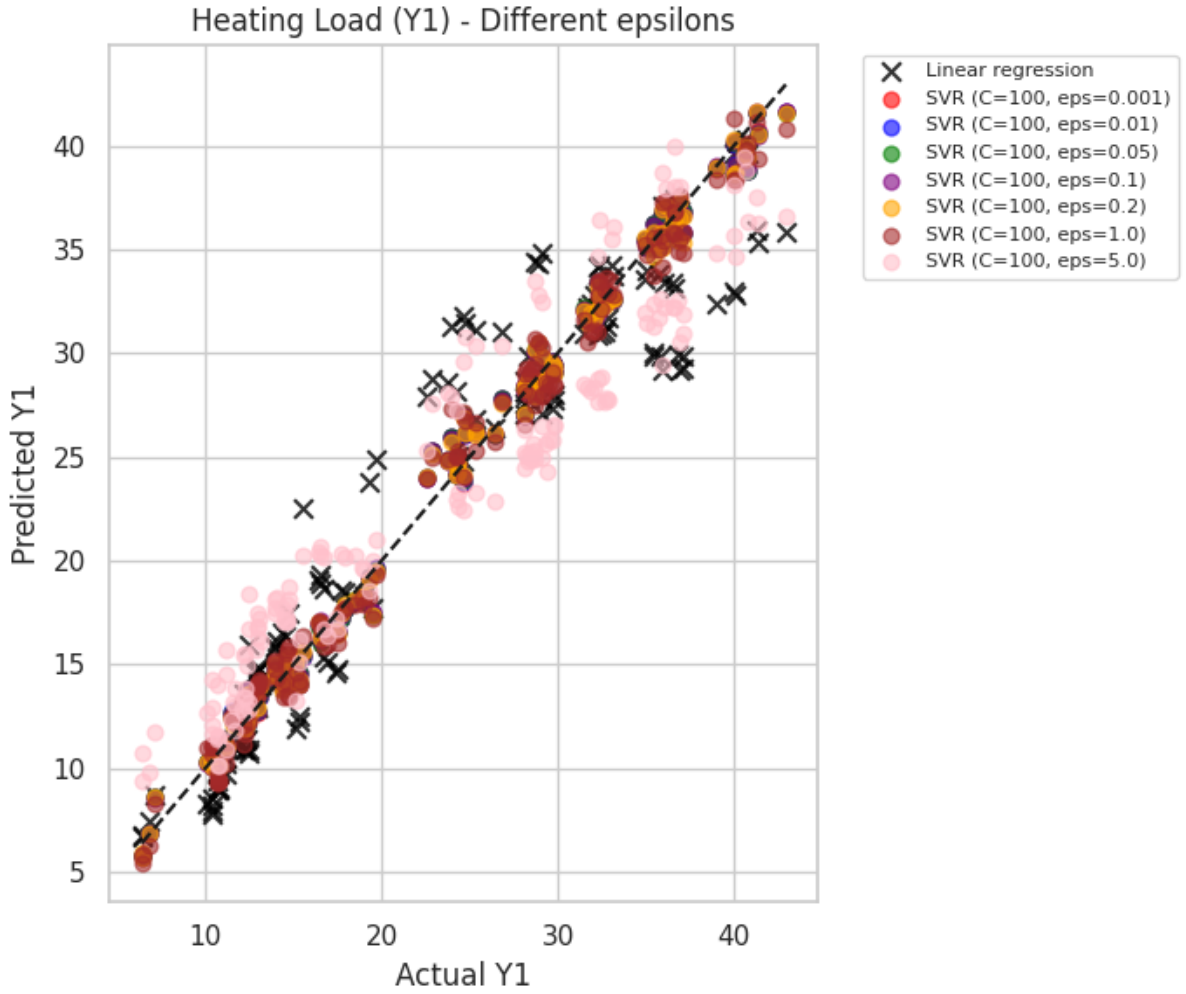
Twick C

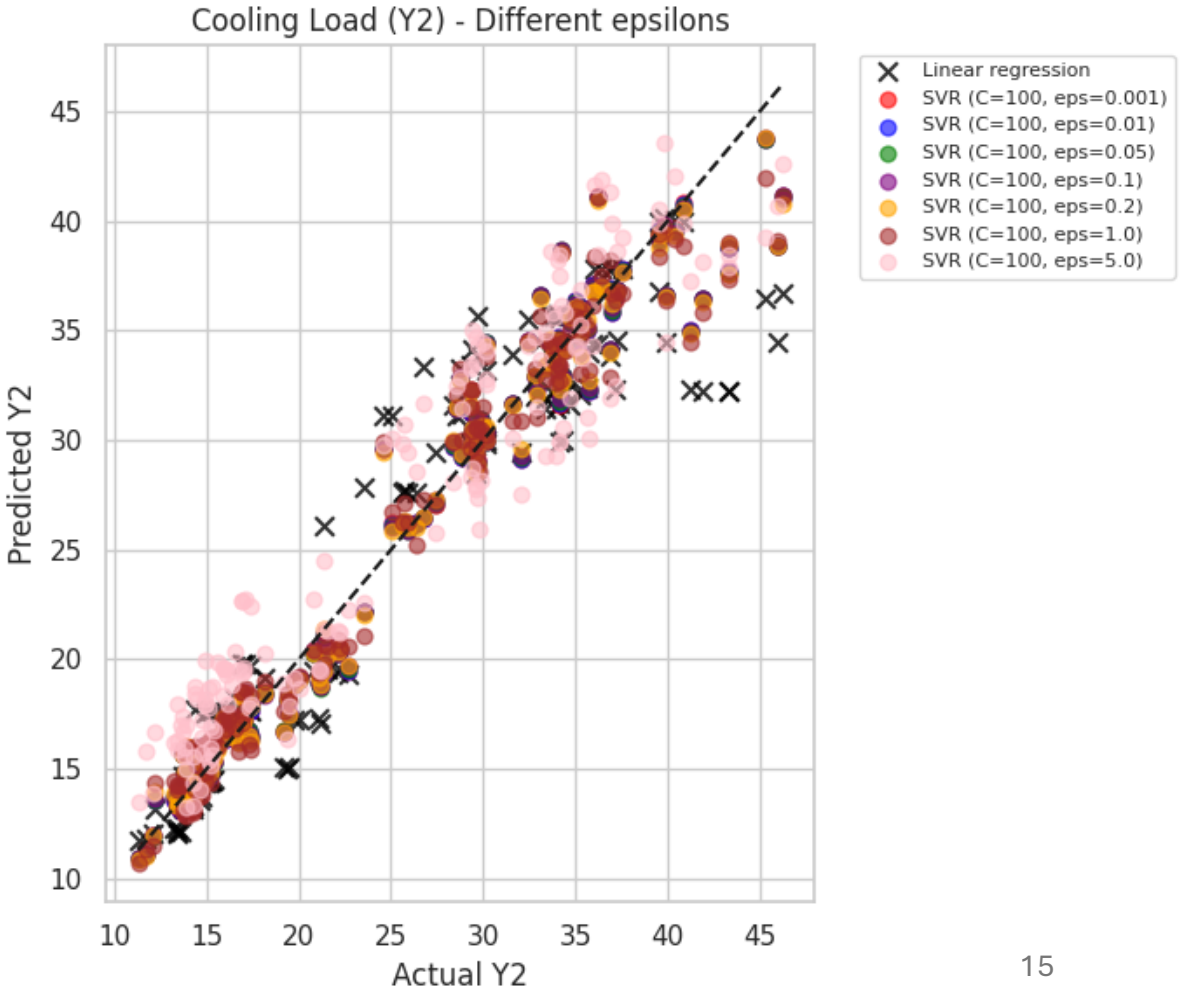




Example 1: Predict heating and cooling load on buildings

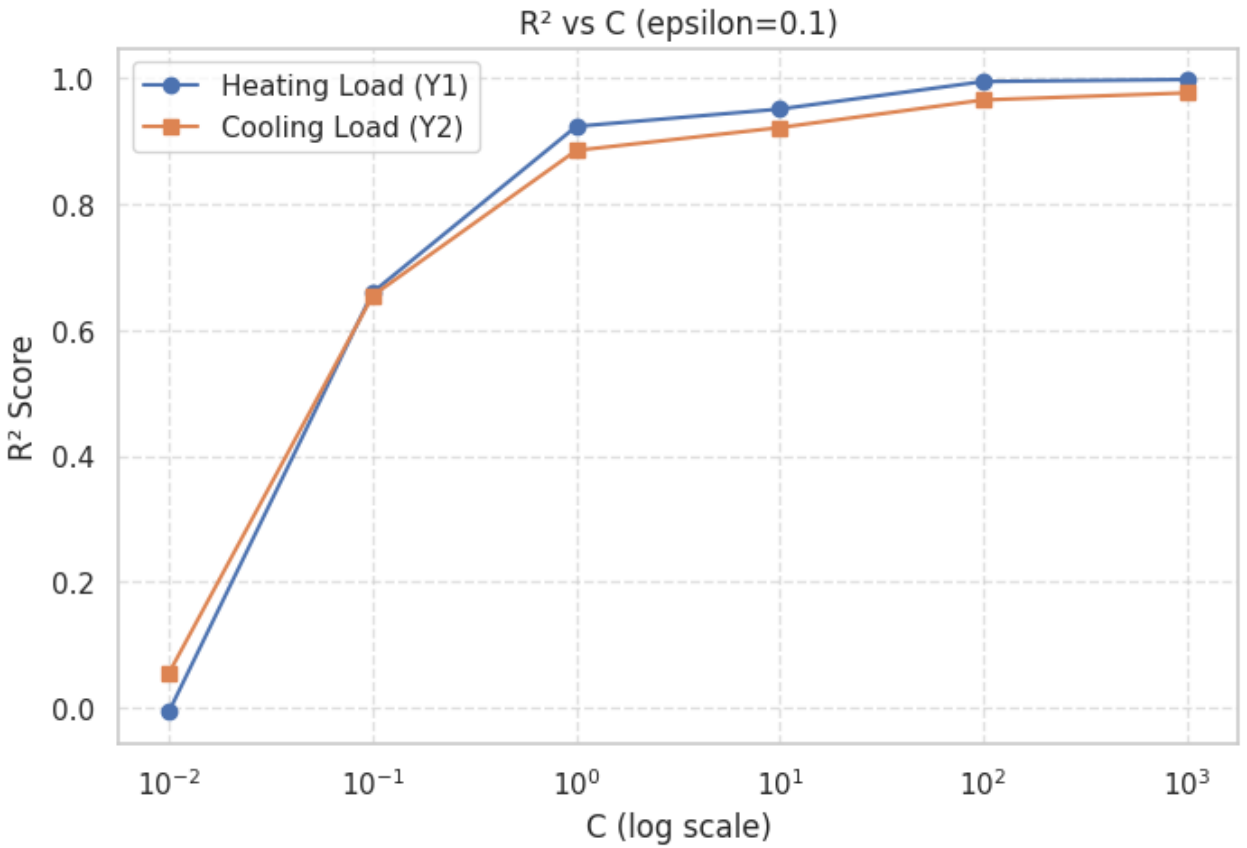
Twick epsilon

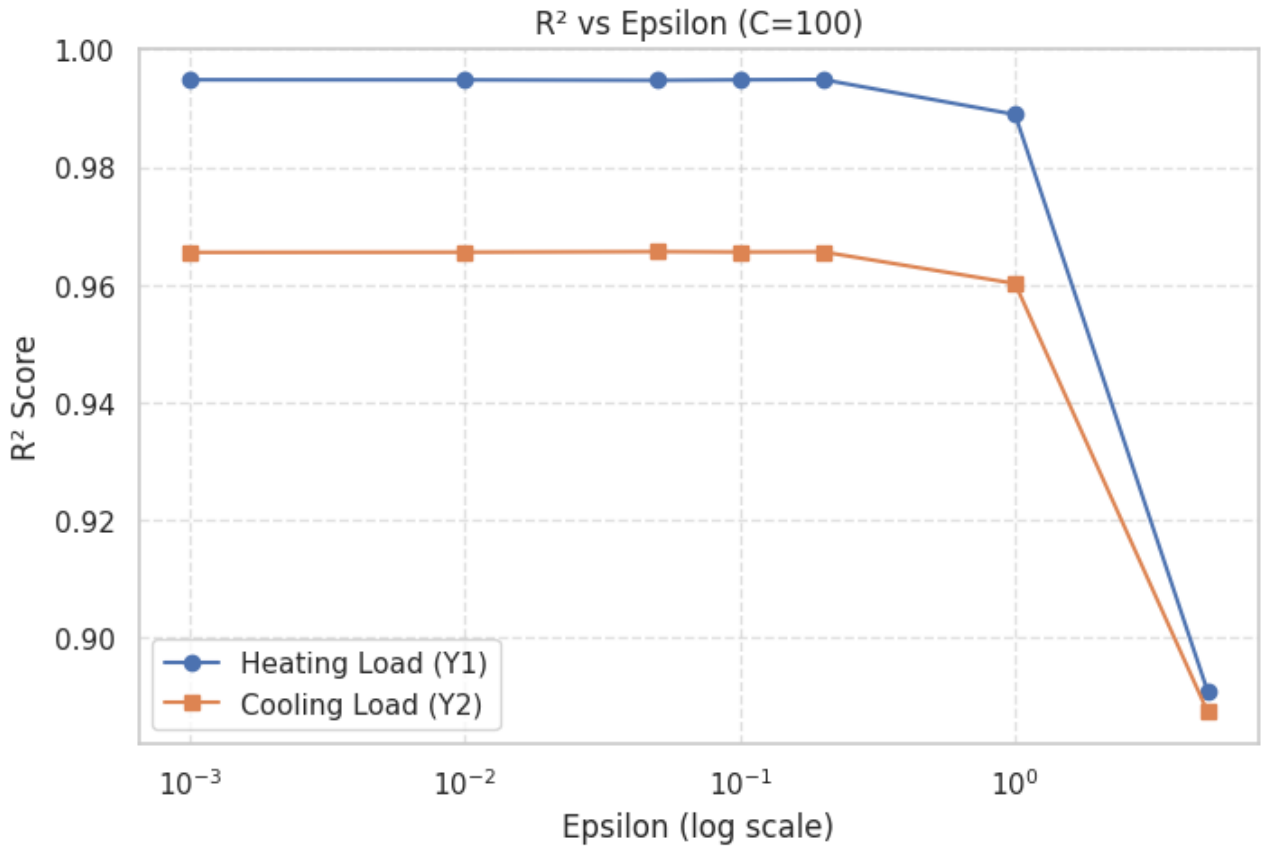




Example 1: Predict heating and cooling load on buildings

Comparison with R^2





Benefits of SVR

- Handles high-dimensional data
- Models non-linear relationships
- Robust to small noises and outliers
- Good generalization

Limitations of SVR

- Training time complexity
- Complexity in choosing hyperparameters
- Not scalable to large dataset
- Not easily interpretable

Summary

- SVMs powerful for classification and regression.
- In regression, SVR uses the concept of an epsilon tube and support vectors to fit the data.
- Kernel functions allow SVMs to handle non-linear data.
- The parameters epsilon and C control the flexibility and tolerance of the SVR model.