# 10. Local Linear regression model

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One of the model explored in the paper is called **Local Linear Regression** . This method does not assume any functional form of the underlying non-linear relationship (polynomial, exponential, etc.). The idea of the approach is regardless of the non-linear relationship, it can always be approximately by a linear function for a small neighborhood near any data point (i.e., locally). Combining all local linear approximations together, we can obtain a prediction of the overall non-linear relationship.

More formally: for any data point $x_0$, we want to locally fit a linear model around $x_0$. We only want to fit this model in a small neighborhood $D$ containing data point $x_0$. The neighborhood $D$ is defined as:

$$D = \{x : \|x - x_0\| \leq h\}$$

within the neighborhood, we can use weighted ordinary least square to estimate the coefficients for the linear model:

$$\hat{\beta}_{x_0} = \arg\min_{\beta} \sum_{x_i \in D} w_i (y_i - \beta^T (x_i - x_0))^2$$

$w_i$ is the weight value for each data point $x_i$. Usually higher weight is assign to data points closer to $x_0$, and smaller weight when the data point is further from $x_0$. The weight $w_i$ is usually determined by some kernel function: $w_i = K\left(\frac{x_i - x_0}{h}\right)$

In the paper, the authors use the following model:

- Fit one model for each day of the year (shared across years) and grid point $g$
- The neighborhood $D$ is defined as the $\pm$ 56 days around target day of the year
- For each day of the year, they fit the following model

$$\hat{\beta}_g = \arg\min_{\beta} \sum_{t \in D} w_{t,g} (y_{t,g} - b_{t,g} - \beta^T x_{t,g})^2$$

- Weighting scheme: $w_{t,g}$ = 1 or $w_{t,g} = 1/\text{var}(\text{prediction}_t)$
- Offsets: $b_{t,g}$ = 0 or $b_{t,g}$ set up to take out the seasonality

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For each local linear model, we still need to determine what features to use to predict the weather variables. The paper used a backward regression approach to select the features:

- Start by using all features and remove features one by one
- Drop the feature that reduce the prediction accuracy the least, if below a tolerance threshold
- Prediction accuracy is determined by leave-one-year-out cross validation

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