

# Visualizing changes over time

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# Tools

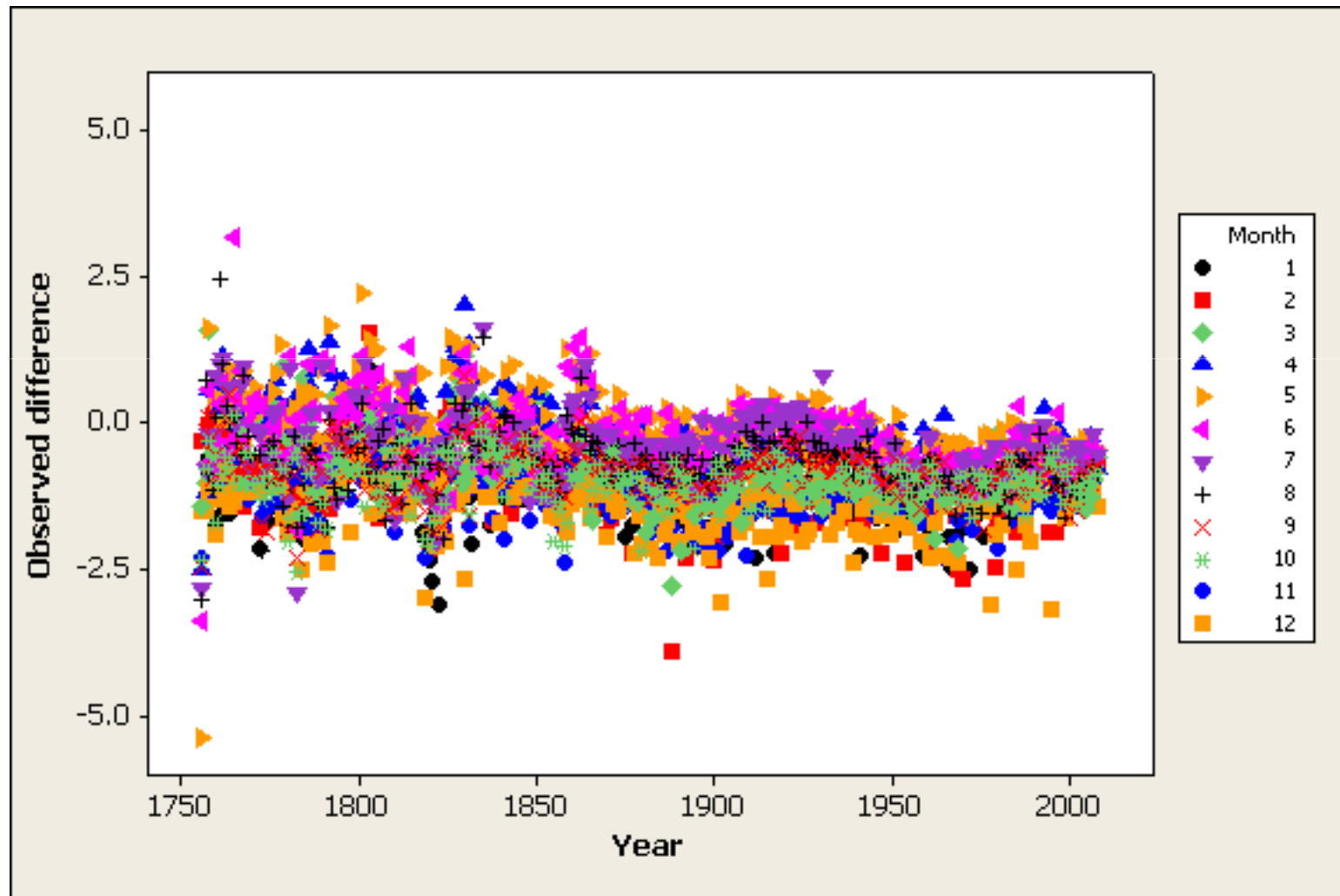
- **Interactive linked diagrams ([www.ggobi.org](http://www.ggobi.org))**
- **Animated scatter charts ([www.gapminder.org](http://www.gapminder.org), Google gadget, Visual Basic macros for Excel 2007)**

# Some milestones in data visualization

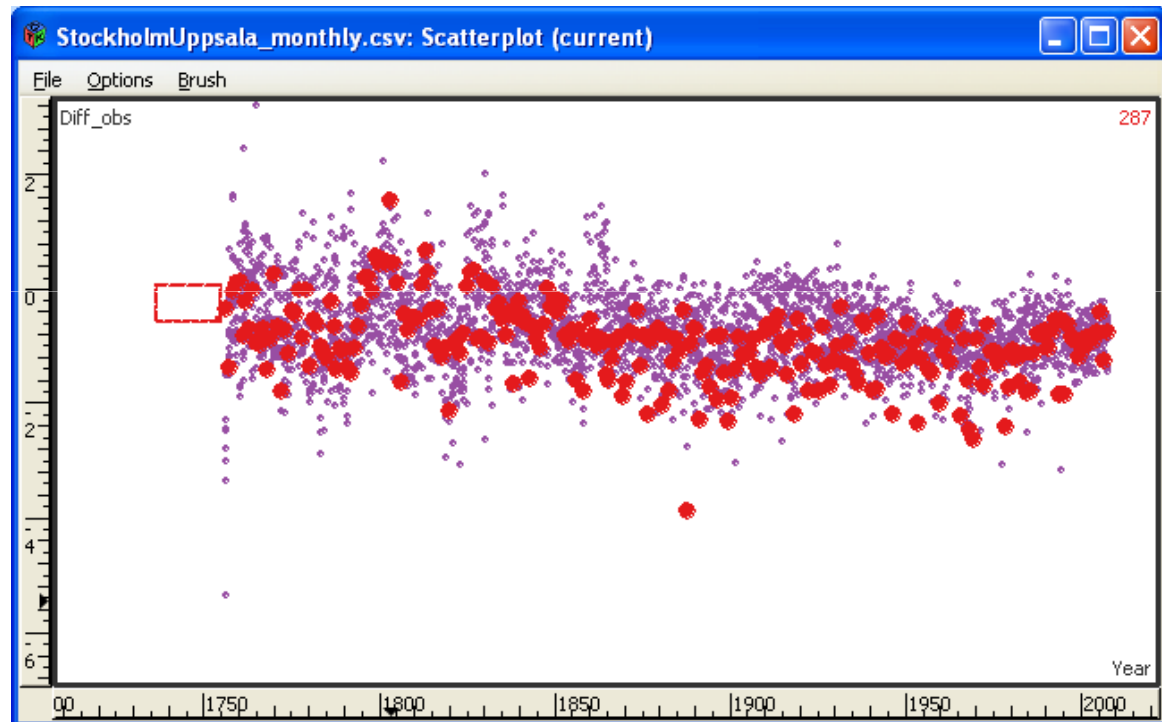
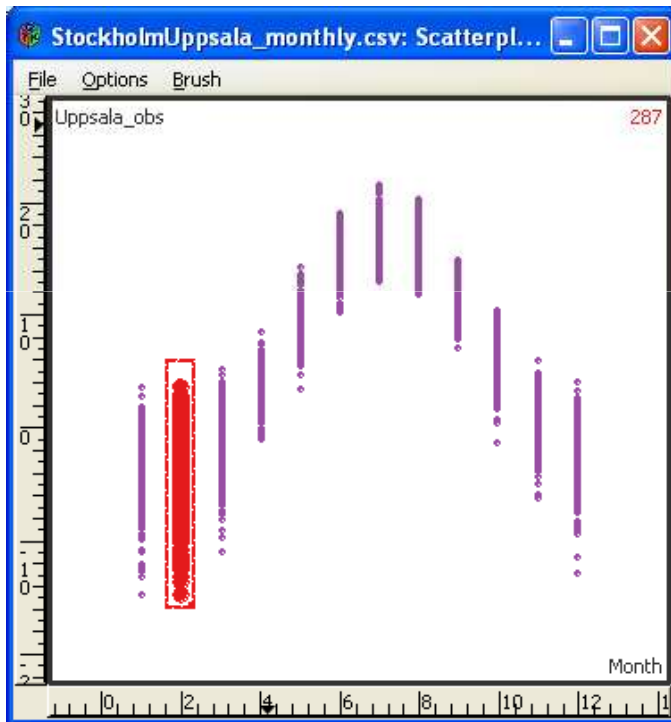
- **Original invention of linked brushing, i.e. highlighting of observations selected in one display in another display of the same data (Newton, 1978)**
- **Grand tour, for viewing high-dimensional data sets via a structured progression of 2D projections (Asimov, 1985)**
- **Interactive statistical graphics, systematized: allowing brushing, linking, other forms of interaction (Becker & Cleveland, 1987)**
- **Interactive graphics for multiple time series with direct manipulation (zoom, rescale, overlaying, etc.) (Unwin & Wills, 1988)**
- **Motion charts of interdependent time series (Rosling, 2005)**

# Temperature difference Uppsala – Stockholm

## Mean monthly records

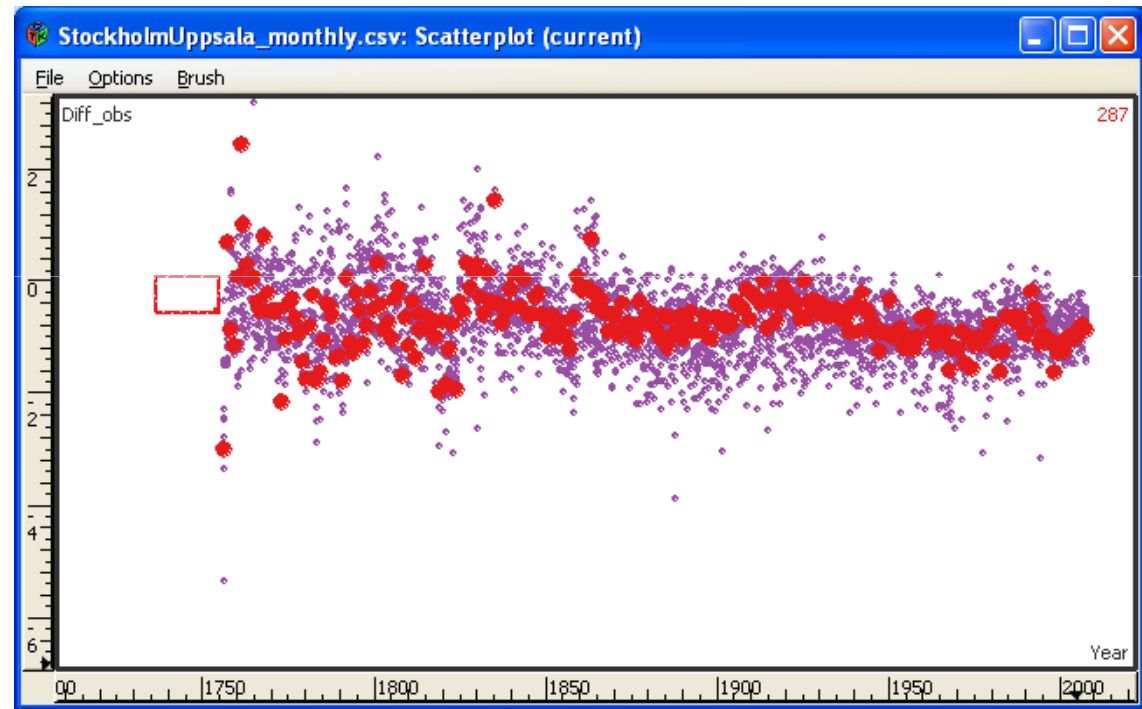
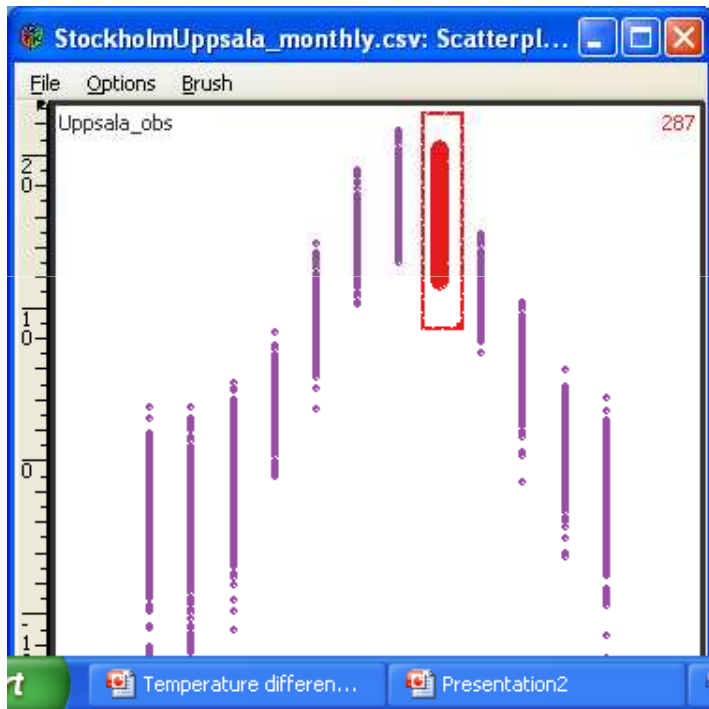


# Temperature difference Uppsala – Stockholm, February records high-lighted



Level shift around 1860?

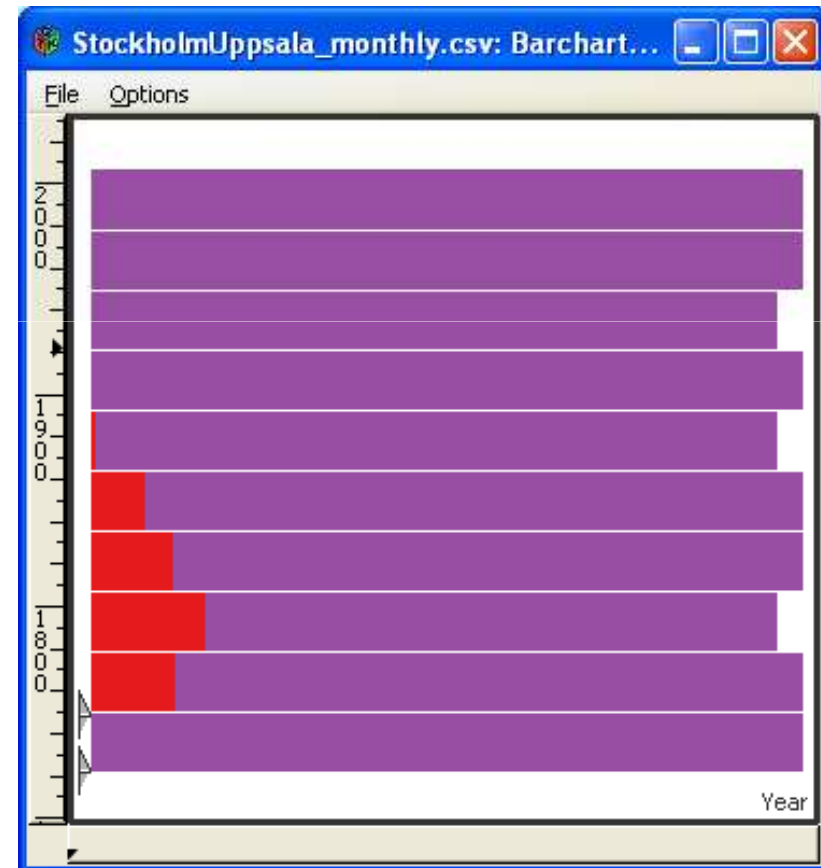
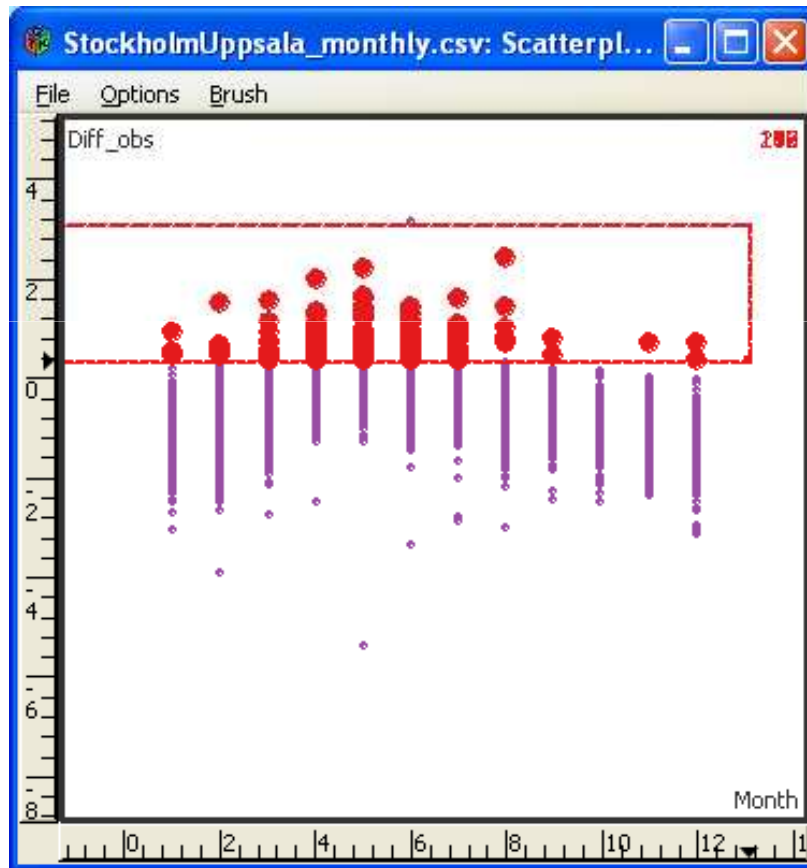
# Temperature difference Uppsala – Stockholm, August records high-lighted



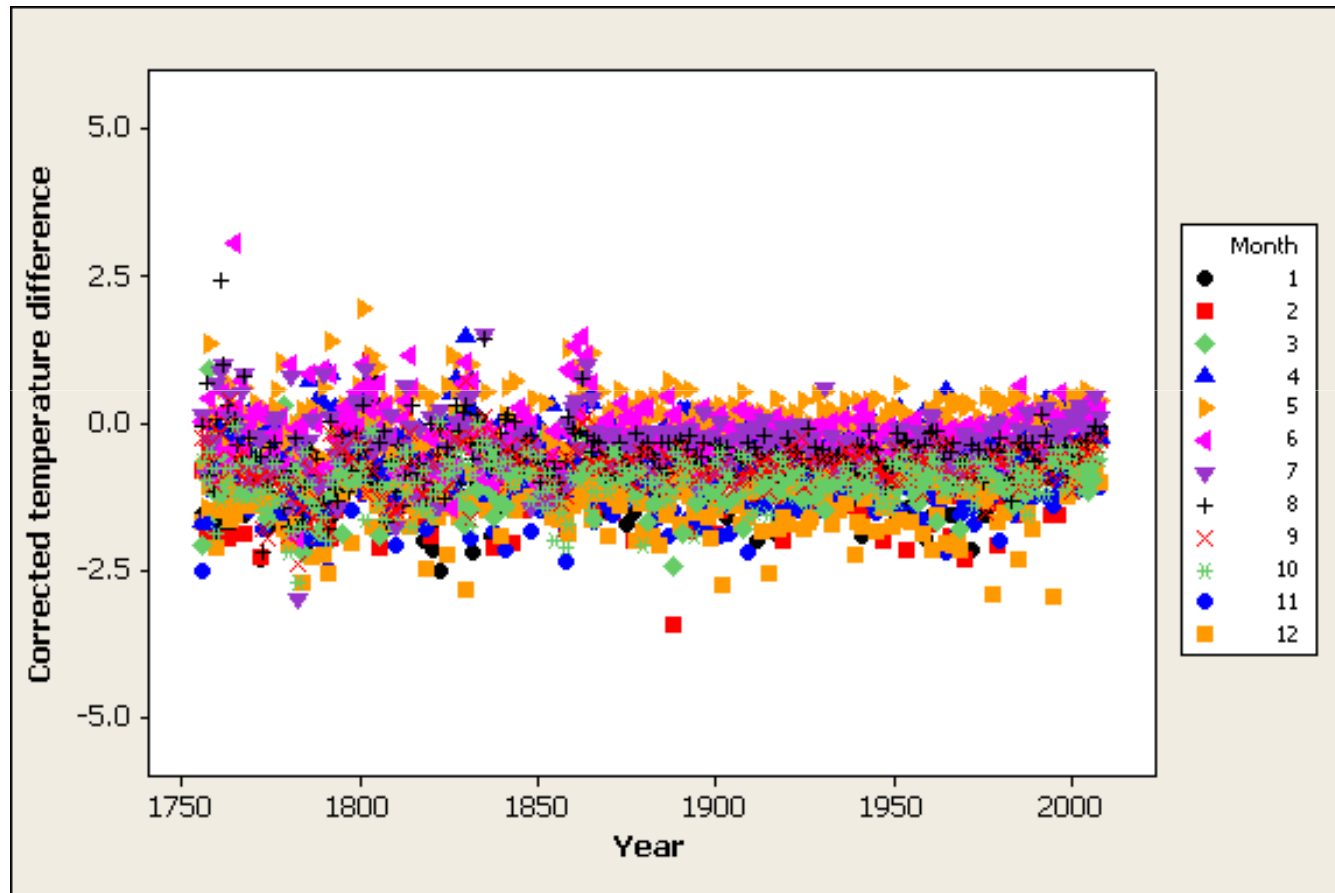
Shift in dispersion  
around 1860

Level shift around 1905

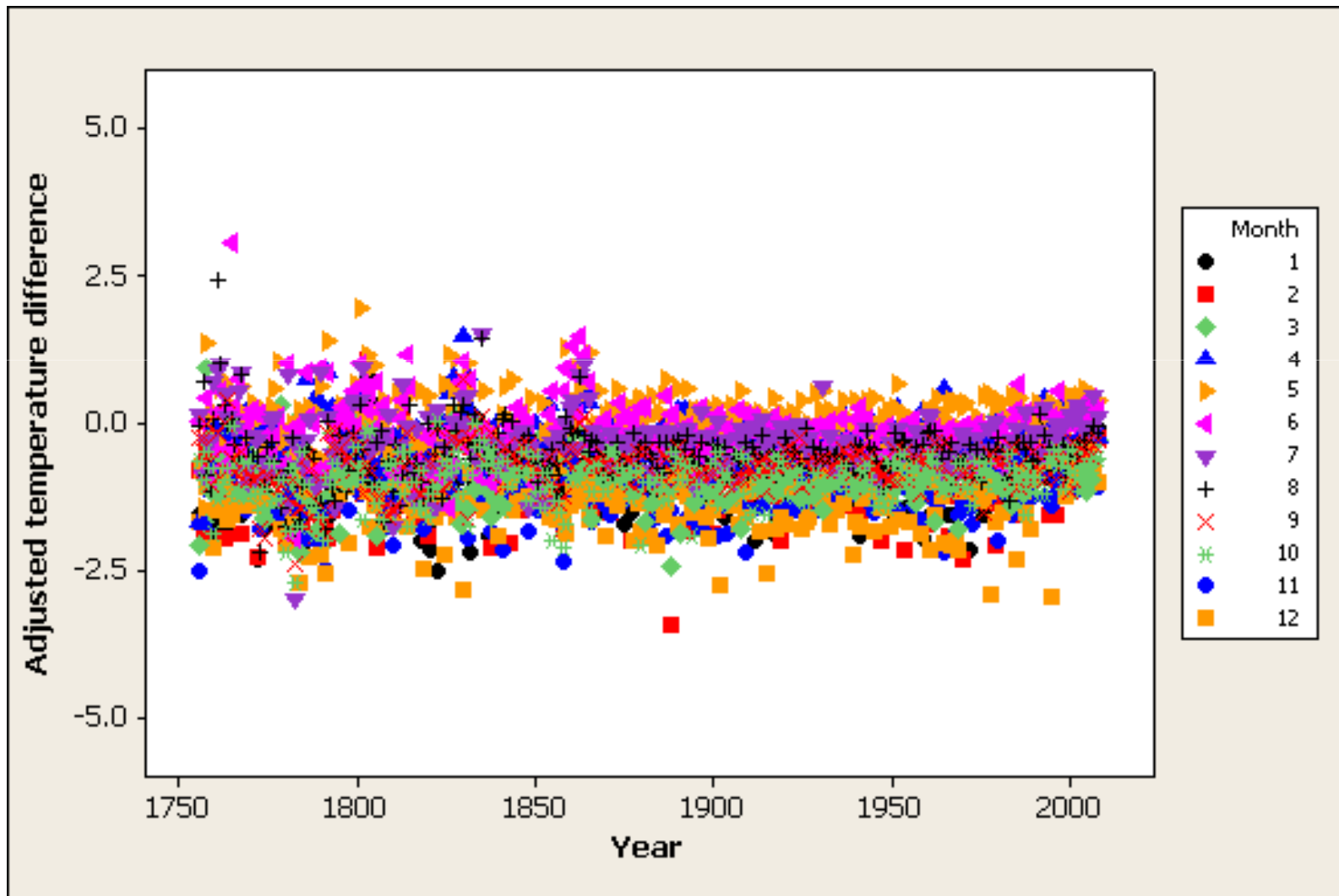
# Temperature differences Uppsala – Stockholm exceeding 0.4°C disappeared around 1860



# Corrected temperature difference Uppsala - Stockholm



# Adjusted temperature difference Uppsala - Stockholm



# Simulation experiment for estimation of a level shift at an unknown time point

Data were generated as pure noise (standard deviation = 1) with a level shift of 0.5 units at  $t=30$

