DATA VISUALIZATION

UNIT - IV (PART - II)

Variation and Uncertainty

- It's good to feel confident when armed with a bit of data, but it's crucial to stay humble.
- The world is complex and ever-changing.
- If our data is unreliable or our conclusions are questionable, we should be cautious.

- When sharing data, honesty is key.
- Clearly communicate what we know, what we don't, and represent reality as accurately as possible.
- If data has high variation or is from a limited sample, be transparent to avoid misleading our audience.

Variation and Uncertainty

- Variation refers to how much individual observations differ within a group.
- Example: Students in a class may have different heights because of factors like genetics and nutrition.

- Uncertainty is the lack of confidence in making inferences about a population from data collected in samples.
- Example: It's hard to be completely sure about the average income of a city when relying on a small survey.

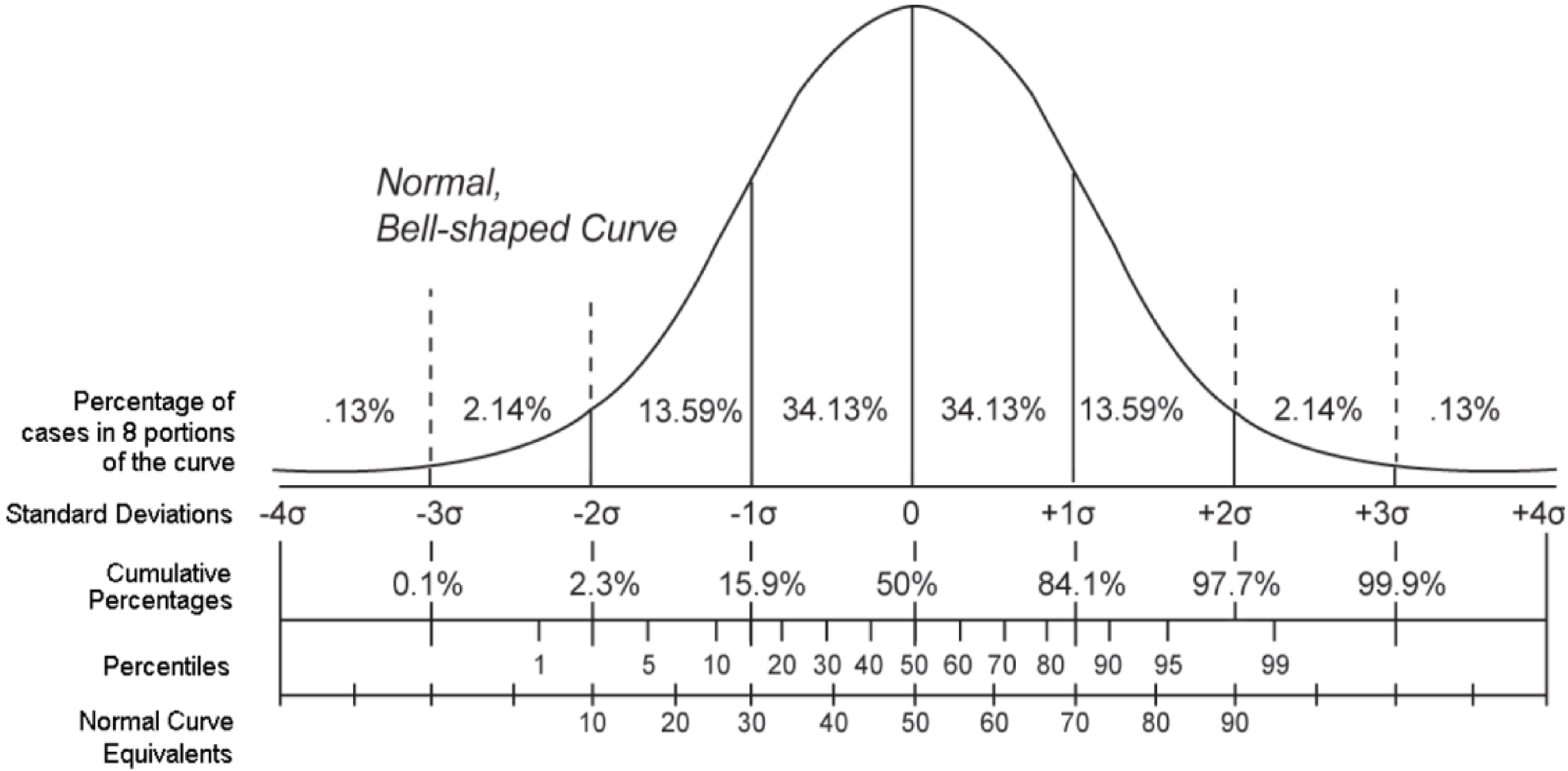
Variation and Uncertainty

1. Respecting variation
2. Variation over time-Control charts
3. Understanding uncertainty

Respecting variation

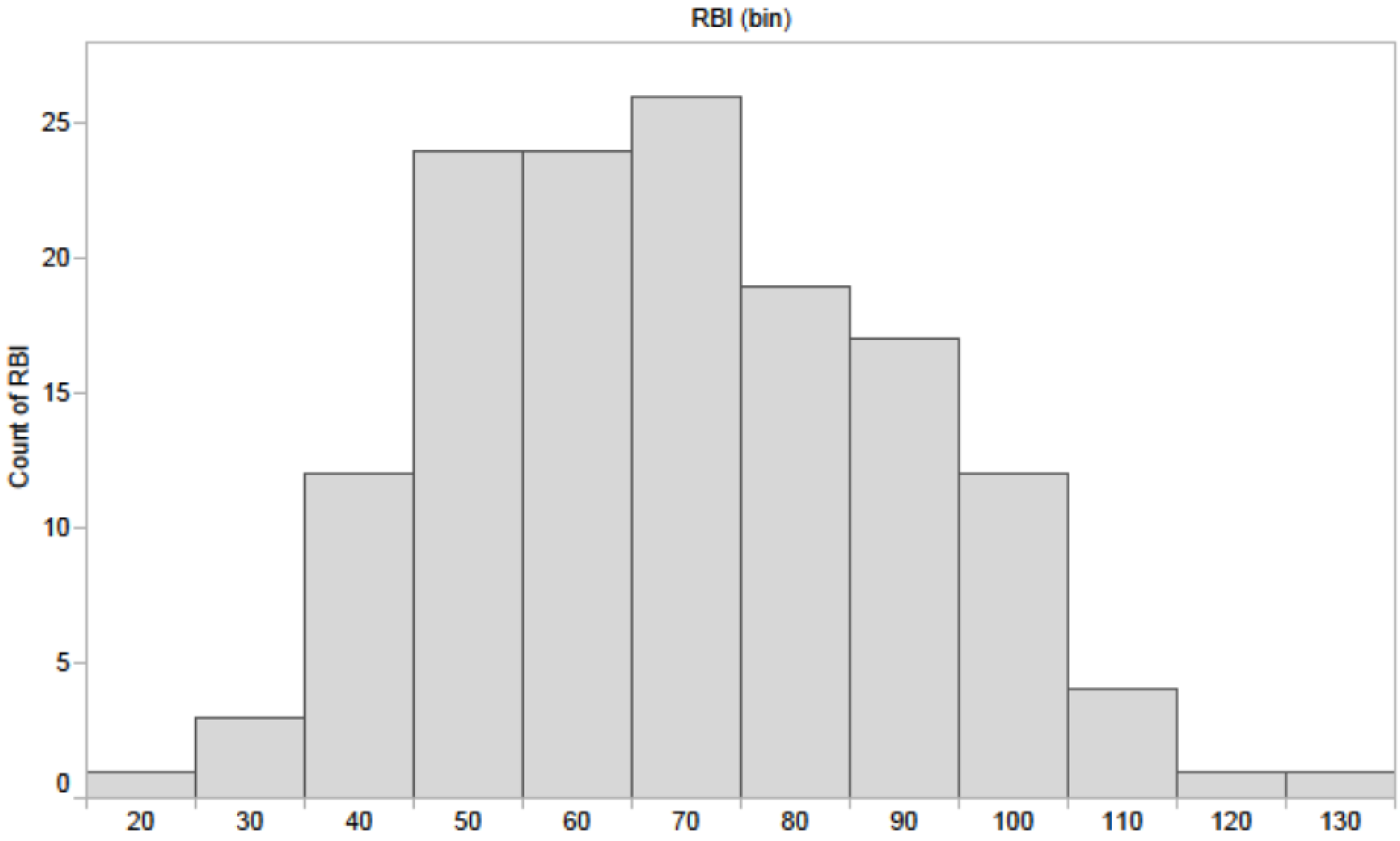
- In the previous chapter, we explored central tendency measures, such as the mean and median.

- This discussion also included fundamental measures of variation, like standard deviation and the interquartile range, as illustrated in Figure 7-1.

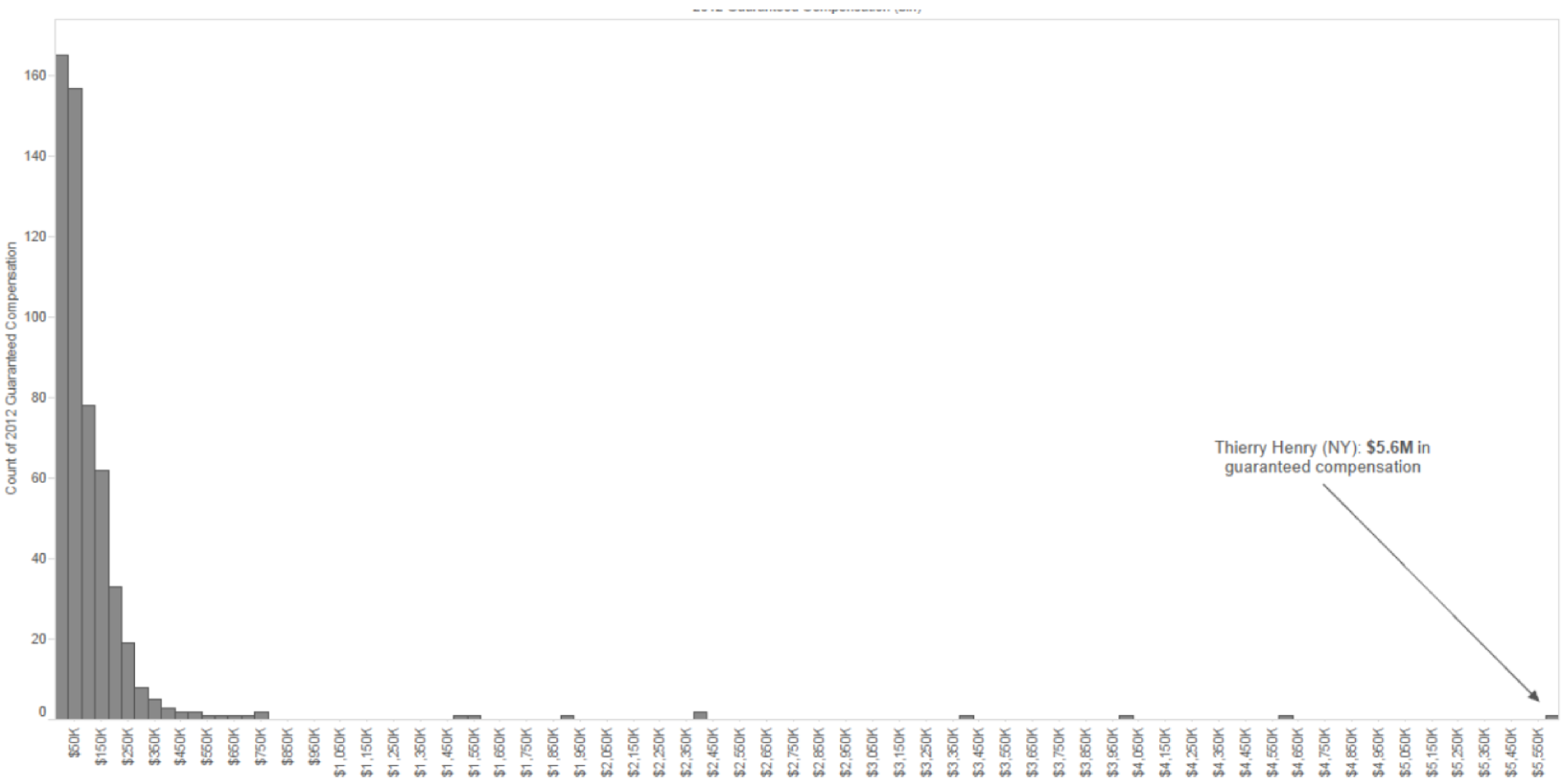

Normal,
Bell-shaped Curve
Percentage of cases in 8 portions of the curve
.13%
2.14%
13.59%
34.13%
34.13%
13.59%
2.14%
.13%
Standard Deviations
-4σ
-3σ
-2σ
-1σ
0
+1σ
+2σ
+3σ
+4σ
Cumulative Percentages
0.1%
2.3%
15.9%
50%
84.1%
97.7%
99.9%
Percentiles
1
5
10
20
30
40
50
60
70
80
90
95
99
Normal Curve Equivalents
10
20
30
40
50
60
70
80
90

Respecting variation

- In the previous chapter, we examined two distinct types of variables in the realm of sports: baseball batting statistics (RBI) and soccer players' salaries, depicted in Figure 7-2.



2012 Guaranteed Compensation (bin)



Count of 2012 Guaranteed Compensation
0
20
40
60
80
100
120
140
160
$50K
$150K
$250K
$350K
$450K
$550K
$650K
$750K
$850K
$950K
$1,050K
$1,150K
$1,250K
$1,350K
$1,450K
$1,550K
$1,650K
$1,750K
$1,850K
$1,950K
$2,050K
$2,150K
$2,250K
$2,350K
$2,450K
$2,550K
$2,650K
$2,750K
$2,850K
$2,950K
$3,050K
$3,150K
$3,250K
$3,350K
$3,450K
$3,550K
$3,650K
$3,750K
$3,850K
$3,950K
$4,050K
$4,150K
$4,250K
$4,350K
$4,450K
$4,550K
$4,650K
$4,750K
$4,850K
$4,950K
$5,050K
$5,150K
$5,250K
$5,350K
$5,450K
$5,550K
Thierry Henry (NY): **$5.6M** in guaranteed compensation

Respecting variation

Visualizing Variation:

- To honor the inherent variation in our data, it's essential to display it.
- Presenting only averages creates a too simple view of the world.
- Just as not every person in a country shares the most common physical traits, not every data point aligns with the mean, median, or mode.

- If we consider once again the number of strikeouts per nine innings in professional baseball over the past 100 years, we can show a simple line plot of average strikeouts per nine innings, as shown in Figure 7-3

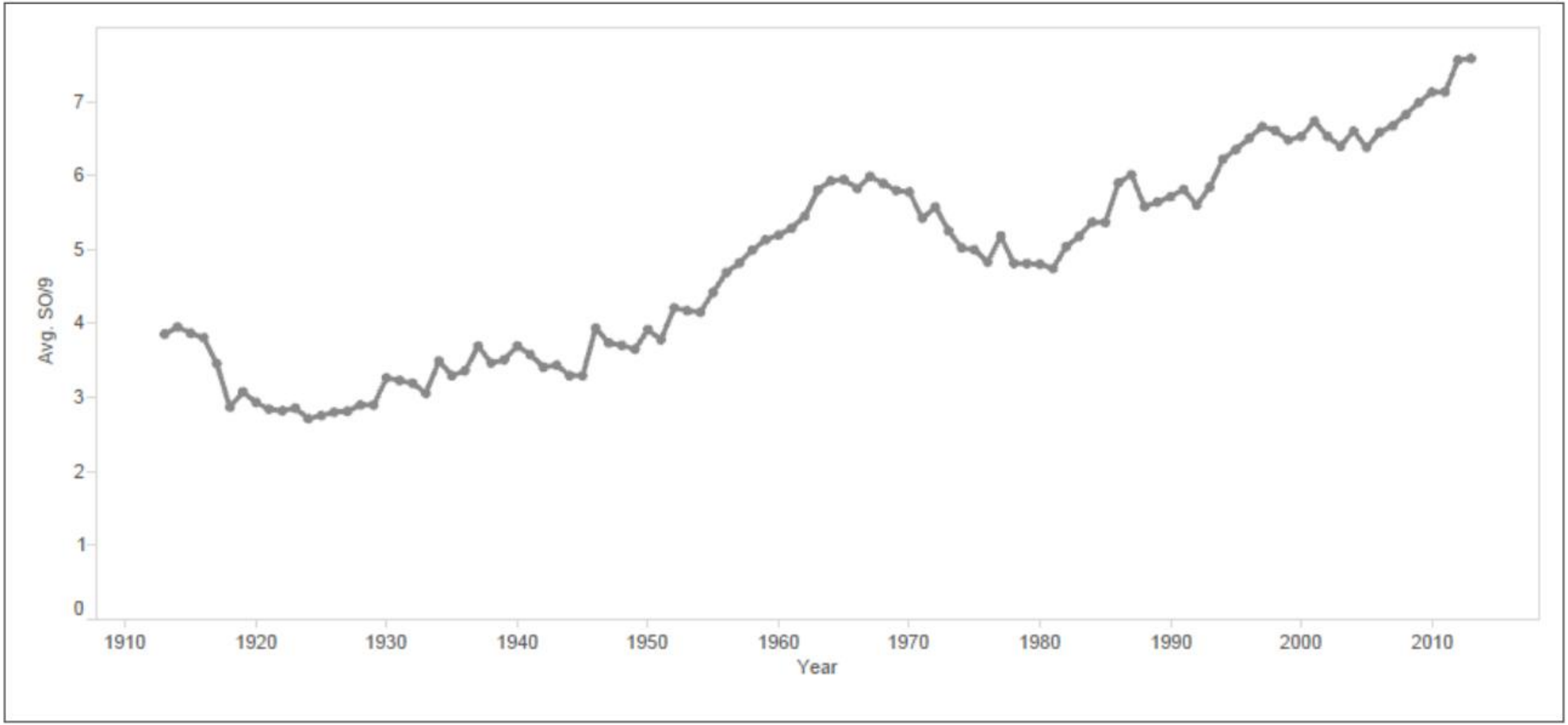


Figure 7-3. Average number of strikeouts per nine innings

Respecting variation

<u>Visualizing Variation:</u>

- However, this chart doesn't reveal how the strikeout rates varied among different teams in the league each year.
- We're left in the dark about the contrast between the team with the highest strikeout rate and the one with the lowest rate annually.

- To capture the inherent variation in the data, we can represent it in various ways, as depicted in Figure 7-4

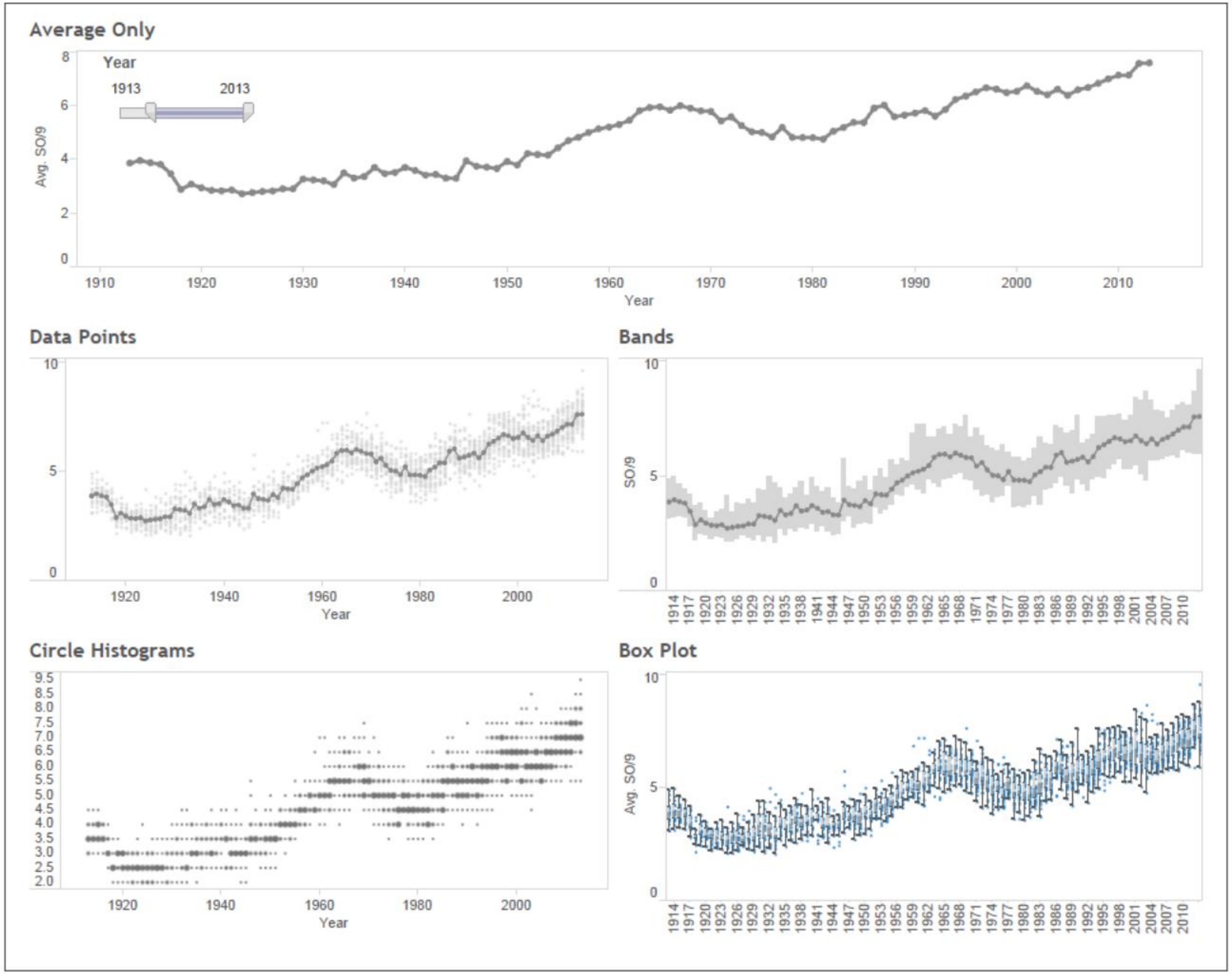


Figure 7-4. Four different ways of showing variation in a time series

Respecting variation

Data points:

- Each team is represented by its own circle in each year.

Bands:

- Includes reference bands from the minimum to the maximum for each year.

Circle Histograms:

- Consists of circle histograms, where the area of each circle is proportional to the number of teams in each bin.

Box-Plots

- Displays a series of box plots for each year.

Variation and Uncertainty

1. Respecting variation
2. Variation over time-Control charts
3. Understanding uncertainty

Variation over time-Control charts

- Control charts help determine if data collected over time contains statistically significant signals or if the variation is just noise.
- Walter Shewhart developed them in the 1920s at the Western Electric Company for industrial quality control.

- The Six Sigma movement has popularized these charts, with "black belts" using them to measure process behavior and reduce variation to enhance quality.

Variation over time-Control charts

- The idea is that reducing variation leads to fewer defects.
- This concept is particularly applicable in manufacturing and any scenario where a consistent output is essential.
- For instance, when ordering a burger from a fast-food chain or starting a new car, we expect a standardized product.
- In such cases, variation would likely be undesirable.

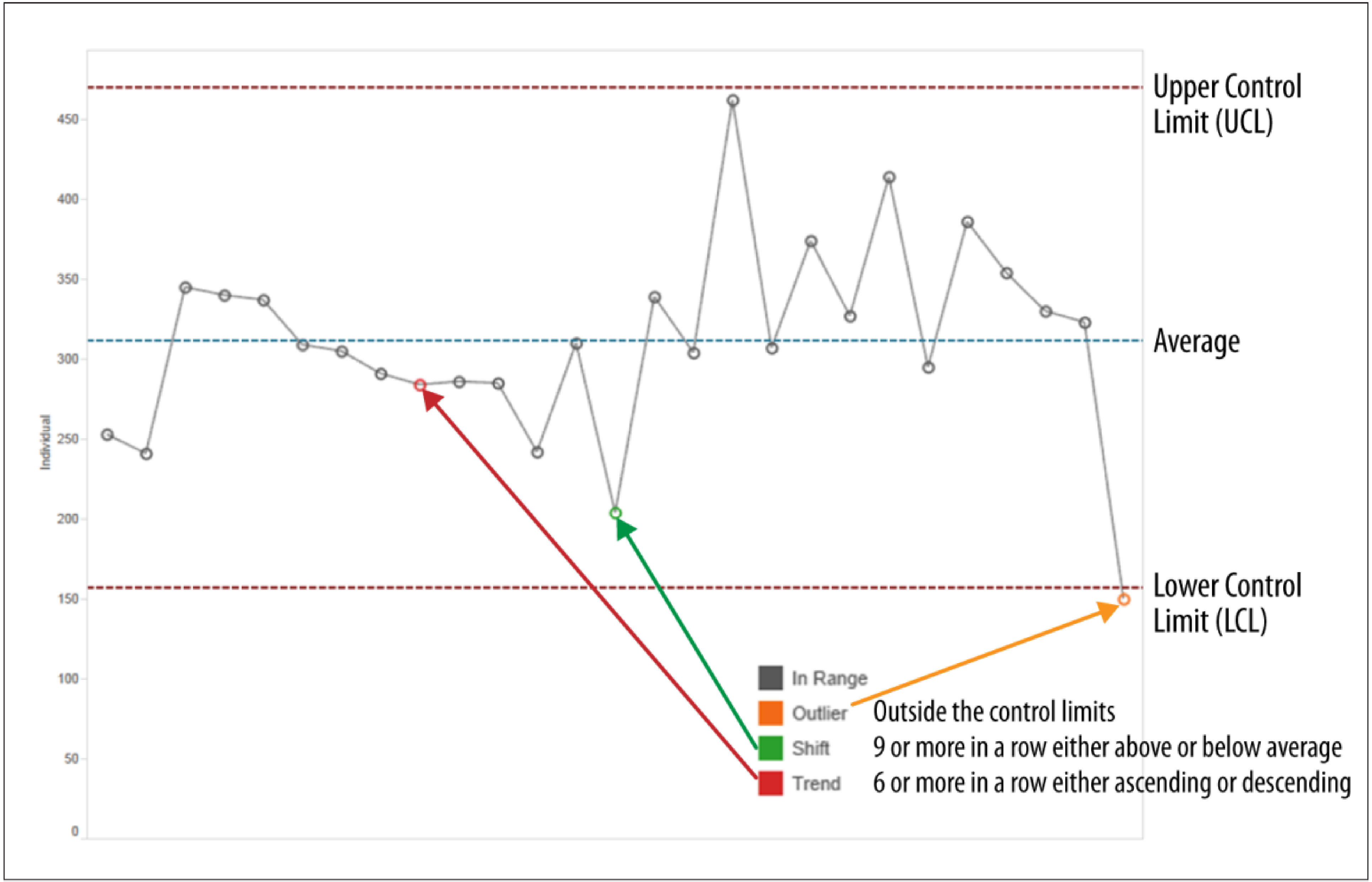


Figure 7-5. The elements of a Shewhart Control Chart

Variation over time-Control charts

Anatomy of a Control Chart:

- A control chart contains the following basic elements:
    1. The time series data itself
    2. The average line
    3. The control limits: UCL (the upper control limit) LCL (the lower control limit)
    4. Signals:
        - Outliers (data points either above the UCL or below the LCL)
        - Trends (six or more points either all ascending or all descending)
        - Shifts (nine or more points either all above or all below the average line)

Variation over time-Control charts

How to Create a Control Chart in Tableau

- Let's explore two methods for control chart analysis: the quick method and the rigorous method.
- The main distinction lies in how the control limits are determined.

- The quick method employs a global measure of dispersion, specifically the standard deviation of all data points.
- The rigorous method utilizes a local measure of dispersion known as Sigma(x), derived from the differences between successive data points.

Variation over time-Control charts

Example:

- Consider the total number of earthquakes recorded worldwide that registered magnitude 6.0 or higher on the Richter scale from 1983 through 2013.

- The source for the data is the USGS Earthquake Archive Search website.
- There were 4,136 such events recorded, and Figure 7-6 gives a view of the most recent records in the data set

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Date & Time	latitude	longitude	depth	mag	magType	nst	gap	dmin	rms	net	id	updated	place	type
2	2013-12-17 23:38:06	20.7727	146.7903	9	6.2	mww		14	4.162	0.81	us	usc000lmmc	2014-02-27T21:49:52.353Z	198km E of Farallon de Pajaros, Northern Mariana Islands	earthquake
3	2013-12-08 17:24:54	44.4438	149.1667	28	6	mww		26	4.726	0.99	us	usb000lds9	2014-02-15T02:35:45.869Z	134km SE of Kuril'sk, Russia	earthquake
4	2013-12-01 06:29:57	2.044	96.8261	20	6	mww		27	1.049	0.89	us	usb000l8pb	2014-02-12T02:20:23.821Z	69km SE of Sinabang, Indonesia	earthquake
5	2013-12-01 01:24:13	-7.0269	128.3791	9.87	6.4	mww		11	3.046	0.7	us	usb000l8mb	2014-02-12T02:20:47.278Z	Kepulauan Barat Daya, Indonesia	earthquake
6	2013-11-25 07:21:18	-53.8708	-53.9107	14.83	6	mwc		58	3.346	0.76	us	usb000l633	2014-02-11T02:22:33.206Z	South Atlantic Ocean	earthquake
7	2013-11-25 06:27:33	-53.9451	-55.0033	11.78	7	mww		31	2.935	1.08	us	usb000l5zn	2014-02-11T02:25:27.101Z	Falkland Islands region	earthquake
8	2013-11-25 05:56:50	45.5613	151.0047	34	6	mww		26	5.885	0.66	us	usb000l5z1	2014-02-11T02:32:38.383Z	247km E of Kuril'sk, Russia	earthquake
9	2013-11-23 07:48:32	-17.1171	-176.5449	371	6.5	mww		22	5.194	0.83	us	usb000l51g	2014-02-11T02:22:07.739Z	Fiji region	earthquake
10	2013-11-19 17:00:44	18.4753	145.2041	511	6	mww		10	1.848	1.05	us	usb000l25i	2014-02-11T02:29:01.431Z	58km WSW of Agrihan, Northern Mariana Islands	earthquake
11	2013-11-19 13:32:51	2.6403	128.4339	38	6	mww		19	2.14	1.01	us	usb000l219	2014-02-11T02:36:43.624Z	111km NNE of Tobelo, Indonesia	earthquake
12	2013-11-17 09:04:55	-60.2738	-46.4011	10	7.7	mww		23	8.05	1.33	us	usb000l0gq	2014-01-31T21:29:01.439Z	Scotia Sea	earthquake
13	2013-11-16 03:34:31	-60.2627	-47.0621	9.97	6.9	mww		17	8.284	0.84	us	usb000kznc	2014-01-31T21:32:02.803Z	Scotia Sea	earthquake
14	2013-11-13 23:45:47	-60.2814	-47.1233	11.07	6.1	mww		23	8.319	1.19	us	usb000kxhr	2014-01-31T21:26:05.362Z	Scotia Sea	earthquake
15	2013-11-12 07:03:51	54.6859	162.3024	43	6.4	mww		20	2.73	0.87	us	usb000kw1x	2014-01-31T21:35:40.466Z	172km S of Ust'-Kamchatsk Staryy, Russia	earthquake
16	2013-11-02 18:53:46	-19.1711	-172.6411	10.05	6.2	mww		21	5.297	0.72	us	usb000krlz	2014-01-10T13:04:16.196Z	152km ESE of Neiafu, Tonga	earthquake
17	2013-11-02 15:52:46	-23.6357	-112.5956	9.98	6	mww		35	4.558	0.81	us	usb000krjt	2014-01-10T13:03:30.639Z	Easter Island region	earthquake
18	2013-10-31 23:03:59	-30.2921	-71.5215	27	6.6	mww		31	0.636	1.28	us	usb000kqnc	2014-01-10T13:06:12.899Z	41km SSW of Coquimbo, Chile	earthquake
19	2013-10-31 12:02:08	23.5904	121.4366	10	6.3	mww		15	0.234	1.29	us	usc000ksdy	2014-01-10T13:05:25.588Z	46km SSW of Hualian, Taiwan	earthquake
20	2013-10-30 02:51:47	-35.314	-73.395	41.5	6.2	mww				1.68	us	usc000kr9k	2014-01-10T13:04:41.053Z	88km W of Constitucion, Chile	earthquake
21	2013-10-25 17:10:19	37.1557	144.6611	35	7.1	mww		10	3.968	1.01	us	usc000kn4n	2014-01-03T00:48:15.801Z	Off the east coast of Honshu, Japan	earthquake
22	2013-10-24 19:25:10	-58.153	-12.7964	22.87	6.7	mww		53	13.711	0.99	us	usc000kmfw	2014-01-03T00:40:15.133Z	East of the South Sandwich Islands	earthquake
23	2013-10-23 08:23:30	-23.0067	-177.1425	160	6	mwb		19	6.252	0.84	us	usb000kj1z	2014-02-21T19:59:38.000Z	283km SW of Vaini, Tonga	earthquake

Figure 7-6. Sample of global earthquakes data set, registering magnitude 6.0 or greater

Variation over time-Control charts

Quick Method:

- Create a simple timeline with a YEAR (Date & Time) on the Columns shelf, and SUM (Number of Records) on the Rows shelf, fit to width as shown in Figure 7-7.
- Right-click on the y-axis, select Add Reference Line, and add an average line by filling out the resulting dialog box.
- Then right-click on the y-axis, select Add Reference Line again, and this time add a distribution of +3 and −3 times the standard deviation, with dotted red lines and no fill.
- Both reference line dialog boxes are shown in Figure 7-8

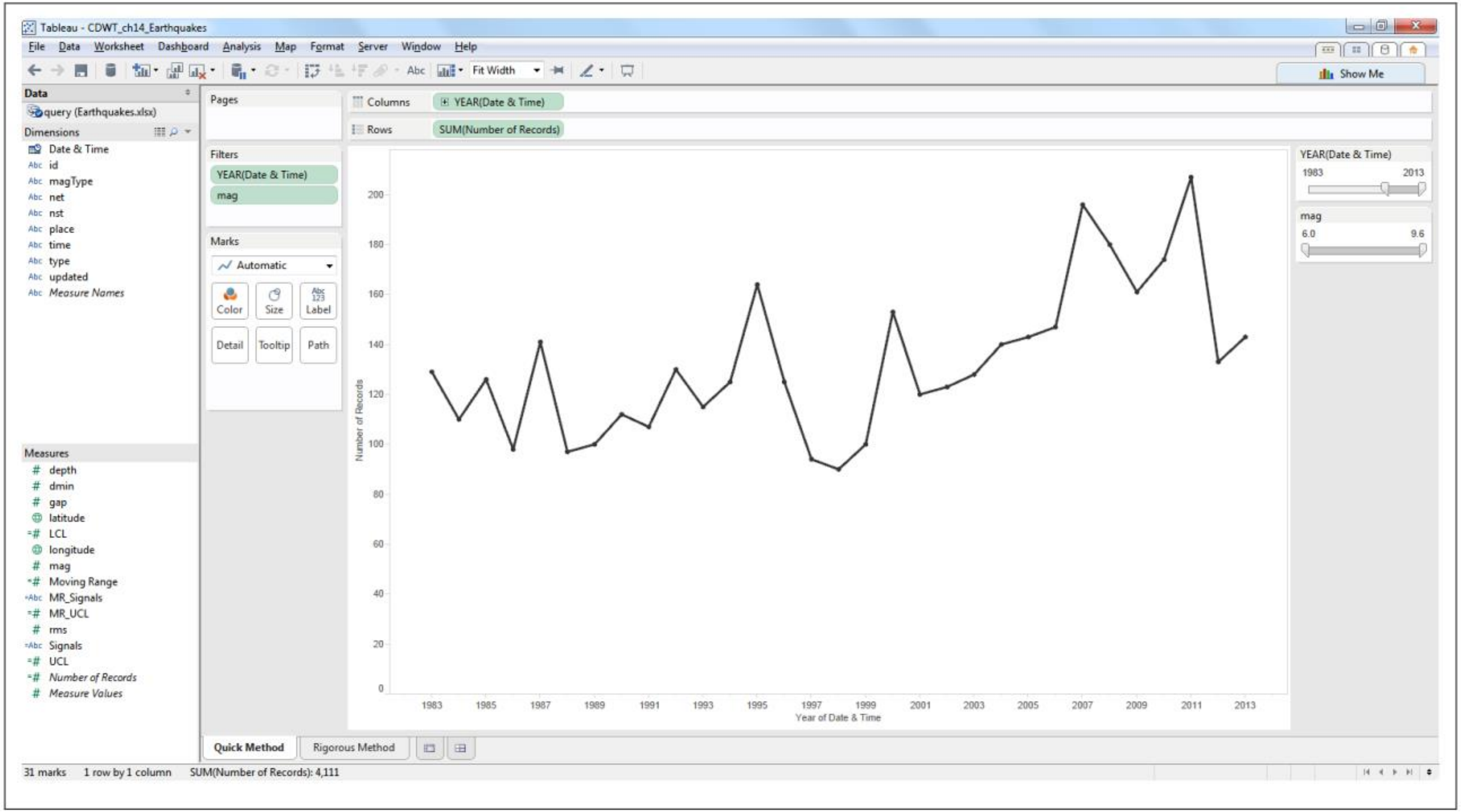


Figure 7-7. A simple timeline of the number of annual earthquakes

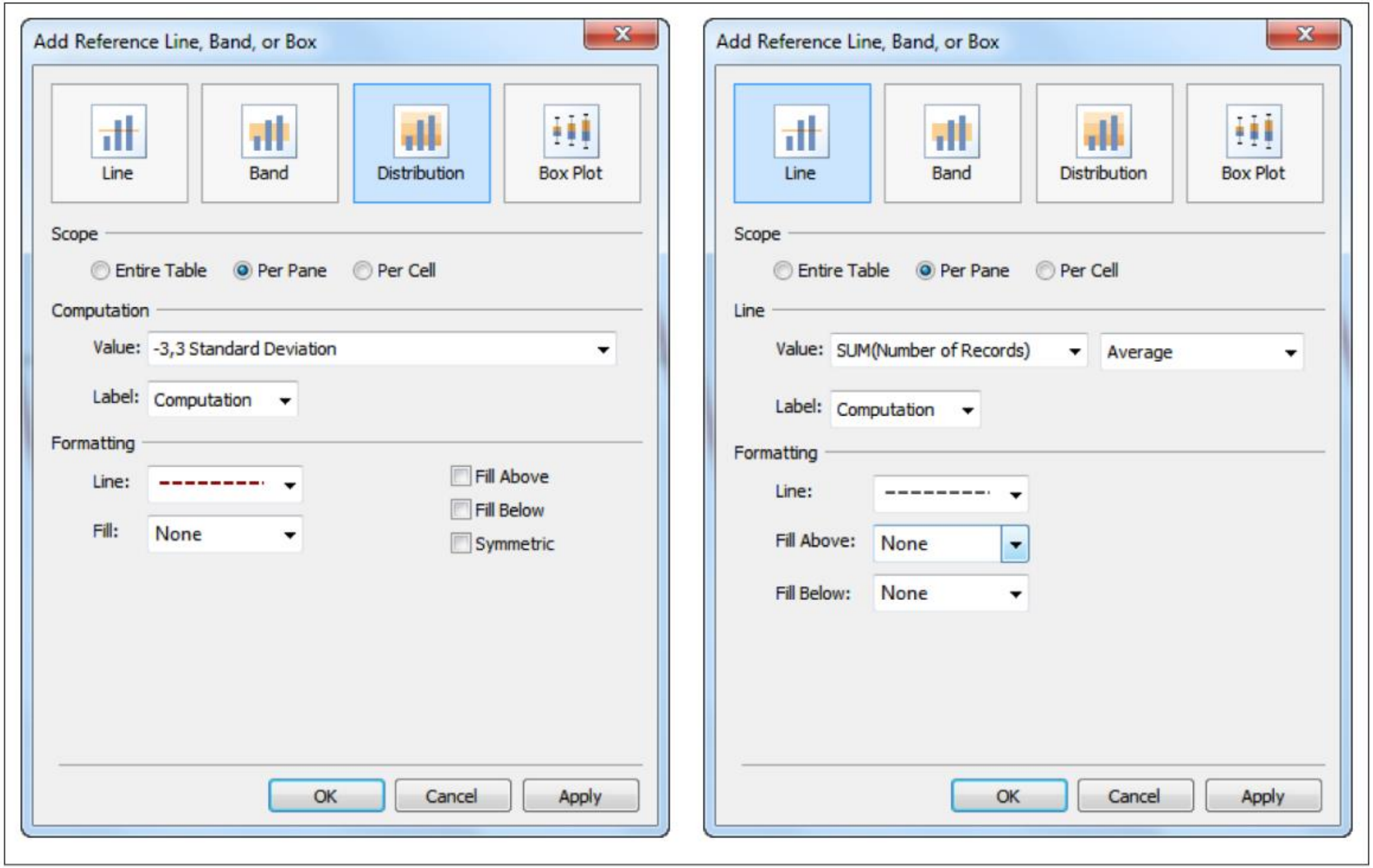


Figure 7-8. Adding reference lines to the line chart

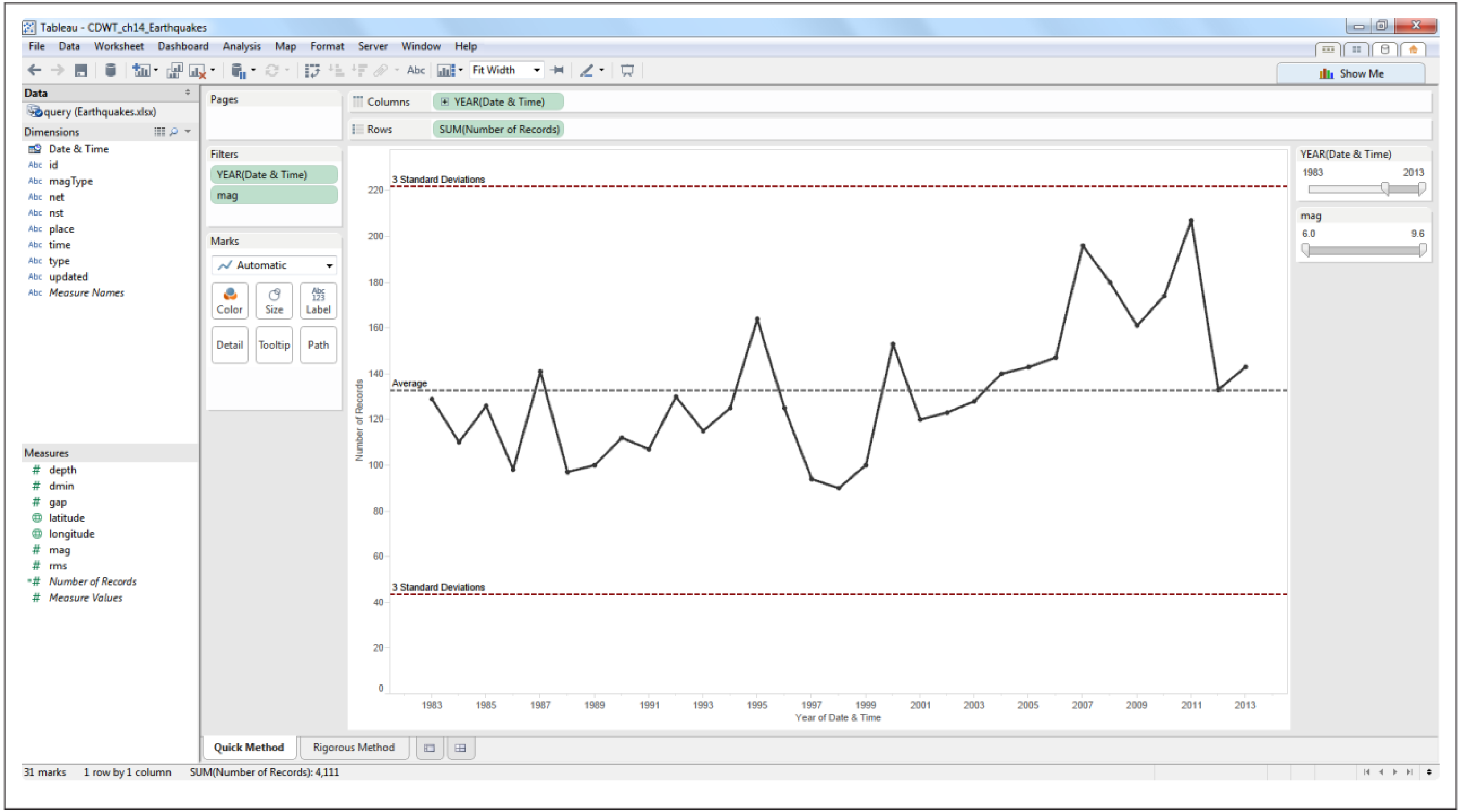


Figure 7-9. Simple control chart of annual earthquakes of magnitude 6.0 or greater

Variation over time-Control charts

- If we change from YEAR to MONTH, then the control chart changes to show several points above the 3-sigma line, including a sharp outlier in March 2011 corresponding to the Great East Japan earthquake, as shown in Figure 7-10

- Also note that the lower limit is not real. It's below 0, and it's not possible to have a negative number of earthquakes recorded

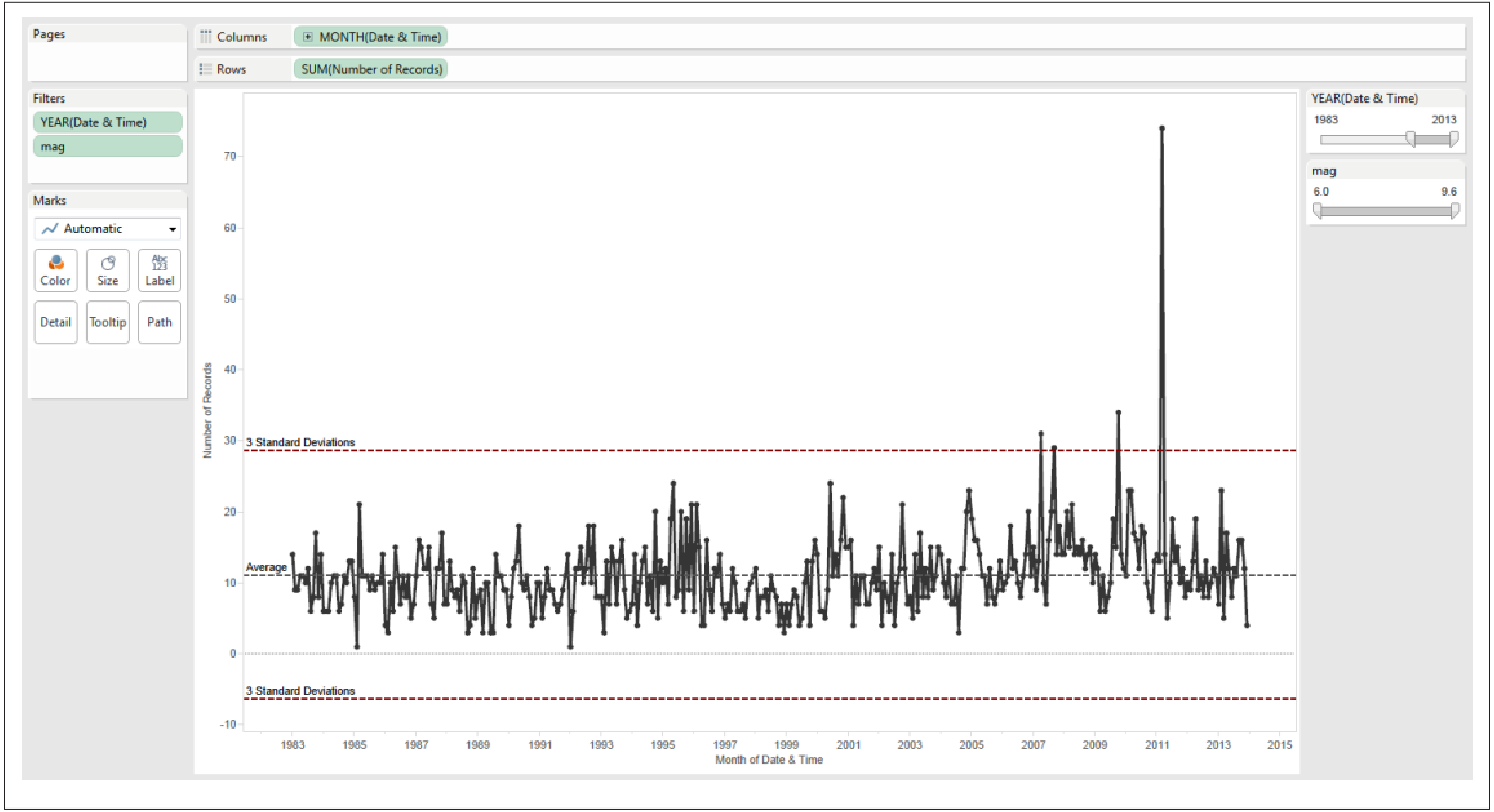


Figure 7-10. The simple control chart showing monthly counts of worldwide earthquakes

Variation over time-Control charts

The rigorous method:

- Create a new sheet and begin with Step 1 of the quick method outlined in the previous section to establish a basic timeline.
- Duplicate the SUM(Number of Records) and generate a dual-axis plot with synchronized axes.
- Represent the first set of marks as a line and the second set as circles, as illustrated in Figure 7-11.
- Additionally, introduce extra elements like a "Moving Range" timeline, which displays the absolute value of the change from one quake to another.

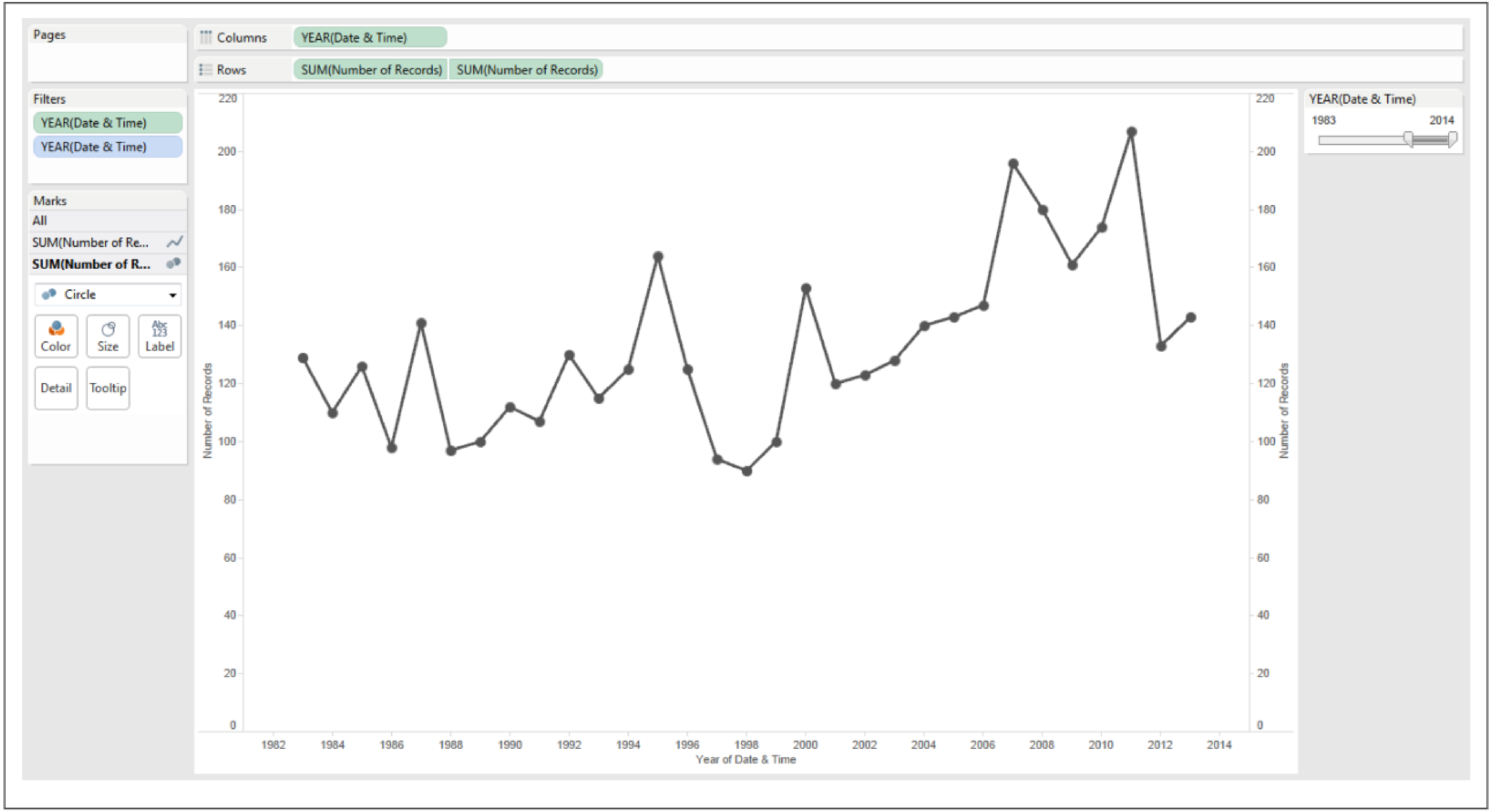


Figure 7-11. Dual-axis timeline of annual earthquake count

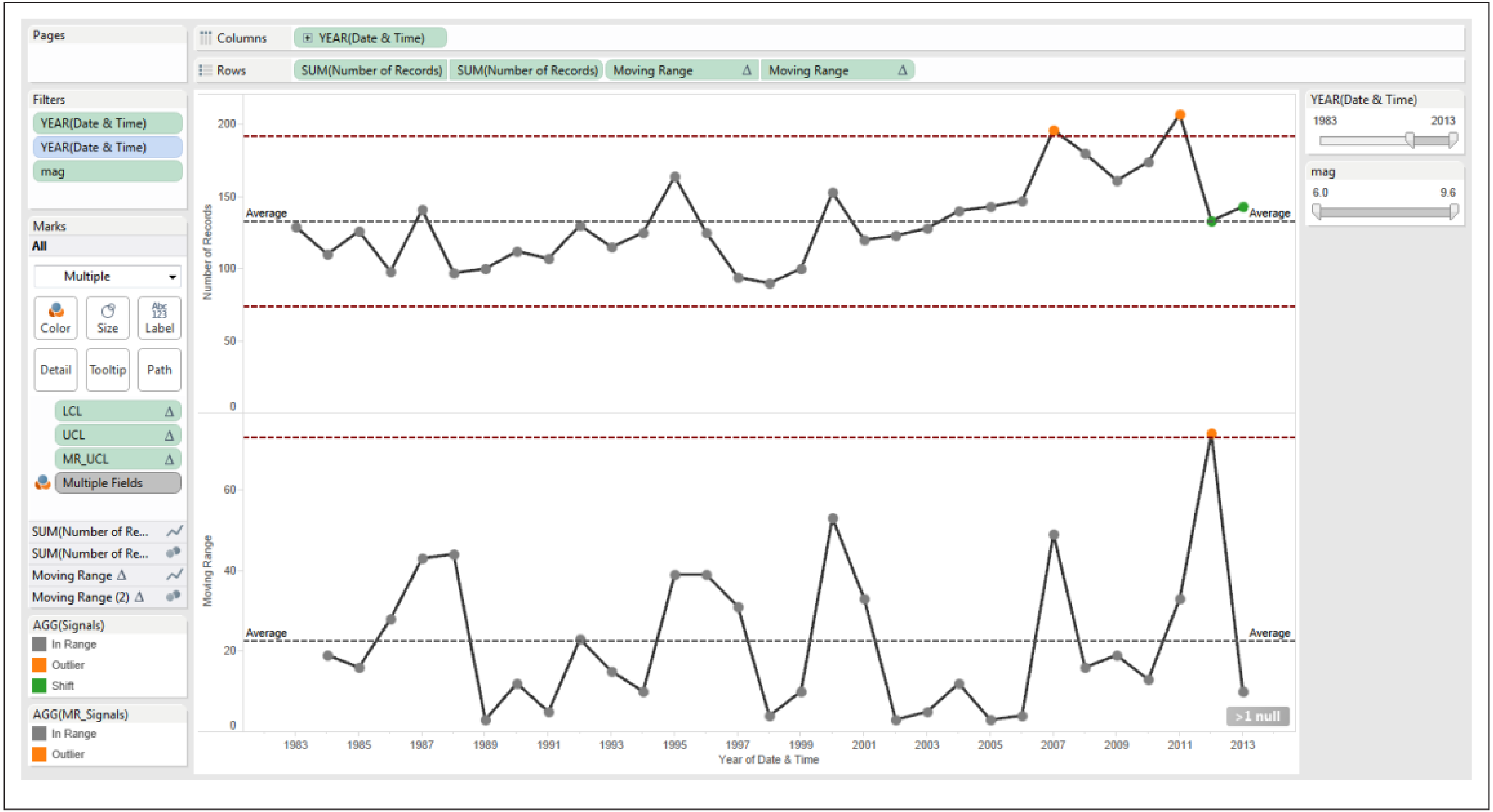


Figure 7-15. The rigorous control chart showing worldwide earthquake count by year

Variation and Uncertainty

1. Respecting variation
2. Variation over time-Control charts
3. Understanding uncertainty

Understanding uncertainty

The rigorous method:

- Create a new sheet and begin with Step 1 of the quick method outlined in the previous section to establish a basic timeline.
- Duplicate the SUM(Number of Records) and generate a dual-axis plot with synchronized axes.
- Represent the first set of marks as a line and the second set as circles, as illustrated in Figure 7-11.
- Additionally, introduce extra elements like a "Moving Range" timeline, which displays the absolute value of the change from one quake to another.