TimeSeriesII.R

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Fri May 03 15:33:13 2019

Q. Build a timeSeries object with the data.

```
data("sunspots")
sunspots
```

```
##         Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov
## 1749   58.0  62.6  70.0  55.7  85.0  83.5  94.8  66.3  75.9  75.5 158.6
## 1750   73.3  75.9  89.2  88.3  90.0 100.0  85.4 103.0  91.2  65.7  63.3
## 1751   70.0  43.5  45.3  56.4  60.7  50.7  66.3  59.8  23.5  23.2  28.5
## 1752   35.0  50.0  71.0  59.3  59.7  39.6  78.4  29.3  27.1  46.6  37.6
## 1753   44.0  32.0  45.7  38.0  36.0  31.7  22.2  39.0  28.0  25.0  20.0
## 1754    0.0   3.0   1.7  13.7  20.7  26.7  18.8  12.3   8.2  24.1  13.2
## 1755   10.2  11.2   6.8   6.5   0.0   0.0   8.6   3.2  17.8  23.7   6.8
## 1756   12.5   7.1   5.4   9.4  12.5  12.9   3.6   6.4  11.8  14.3  17.0
## 1757   14.1  21.2  26.2  30.0  38.1  12.8  25.0  51.3  39.7  32.5  64.7
## 1758   37.6  52.0  49.0  72.3  46.4  45.0  44.0  38.7  62.5  37.7  43.0
## 1759   48.3  44.0  46.8  47.0  49.0  50.0  51.0  71.3  77.2  59.7  46.3
## 1760   67.3  59.5  74.7  58.3  72.0  48.3  66.0  75.6  61.3  50.6  59.7
## 1761   70.0  91.0  80.7  71.7 107.2  99.3  94.1  91.1 100.7  88.7  89.7
## 1762   43.8  72.8  45.7  60.2  39.9  77.1  33.8  67.7  68.5  69.3  77.8
## 1763   56.5  31.9  34.2  32.9  32.7  35.8  54.2  26.5  68.1  46.3  60.9
## 1764   59.7  59.7  40.2  34.4  44.3  30.0  30.0  30.0  28.2  28.0  26.0
## 1765   24.0  26.0  25.0  22.0  20.2  20.0  27.0  29.7  16.0  14.0  14.0
## 1766   12.0  11.0  36.6   6.0  26.8   3.0   3.3   4.0   4.3   5.0   5.7
## 1767   27.4  30.0  43.0  32.9  29.8  33.3  21.9  40.8  42.7  44.1  54.7
## 1768   53.5  66.1  46.3  42.7  77.7  77.4  52.6  66.8  74.8  77.8  90.6
## 1769   73.9  64.2  64.3  96.7  73.6  94.4 118.6 120.3 148.8 158.2 148.1
## 1770  104.0 142.5  80.1  51.0  70.1  83.3 109.8 126.3 104.4 103.6 132.2
## 1771   36.0  46.2  46.7  64.9 152.7 119.5  67.7  58.5 101.4  90.0  99.7
## 1772  100.9  90.8  31.1  92.2  38.0  57.0  77.3  56.2  50.5  78.6  61.3
## 1773   54.6  29.0  51.2  32.9  41.1  28.4  27.7  12.7  29.3  26.3  40.9
## 1774   46.8  65.4  55.7  43.8  51.3  28.5  17.5   6.6   7.9  14.0  17.7
## 1775    4.4   0.0  11.6  11.2   3.9  12.3   1.0   7.9   3.2   5.6  15.1
## 1776   21.7  11.6   6.3  21.8  11.2  19.0   1.0  24.2  16.0  30.0  35.0
## 1777   45.0  36.5  39.0  95.5  80.3  80.7  95.0 112.0 116.2 106.5 146.0
## 1778  177.3 109.3 134.0 145.0 238.9 171.6 153.0 140.0 171.7 156.3 150.3
## 1779  114.7 165.7 118.0 145.0 140.0 113.7 143.0 112.0 111.0 124.0 114.0
## 1780   70.0  98.0  98.0  95.0 107.2  88.0  86.0  86.0  93.7  77.0  60.0
## 1781   98.7  74.7  53.0  68.3 104.7  97.7  73.5  66.0  51.0  27.3  67.0
## 1782   54.0  37.5  37.0  41.0  54.3  38.0  37.0  44.0  34.0  23.2  31.5
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## 1783  28.0  38.7  26.7  28.3  23.0  25.2  32.2  20.0  18.0   8.0  15.0
## 1784  13.0   8.0  11.0  10.0   6.0   9.0   6.0  10.0  10.0   8.0  17.0
## 1785   6.5   8.0   9.0  15.7  20.7  26.3  36.3  20.0  32.0  47.2  40.2
## 1786  37.2  47.6  47.7  85.4  92.3  59.0  83.0  89.7 111.5 112.3 116.0
## 1787 134.7 106.0  87.4 127.2 134.8  99.2 128.0 137.2 157.3 157.0 141.5
## 1788 138.0 129.2 143.3 108.5 113.0 154.2 141.5 136.0 141.0 142.0  94.7
## 1789 114.0 125.3 120.0 123.3 123.5 120.0 117.0 103.0 112.0  89.7 134.0
## 1790 103.0 127.5  96.3  94.0  93.0  91.0  69.3  87.0  77.3  84.3  82.0
## 1791  72.7  62.0  74.0  77.2  73.7  64.2  71.0  43.0  66.5  61.7  67.0
## 1792  58.0  64.0  63.0  75.7  62.0  61.0  45.8  60.0  59.0  59.0  57.0
## 1793  56.0  55.0  55.5  53.0  52.3  51.0  50.0  29.3  24.0  47.0  44.0
## 1794  45.0  44.0  38.0  28.4  55.7  41.5  41.0  40.0  11.1  28.5  67.4
## 1795  21.4  39.9  12.6  18.6  31.0  17.1  12.9  25.7  13.5  19.5  25.0
## 1796  22.0  23.8  15.7  31.7  21.0   6.7  26.9   1.5  18.4  11.0   8.4
## 1797  14.4   4.2   4.0   4.0   7.3  11.1   4.3   6.0   5.7   6.9   5.8
## 1798   2.0   4.0  12.4   1.1   0.0   0.0   0.0   3.0   2.4   1.5  12.5
## 1799   1.6  12.6  21.7   8.4   8.2  10.6   2.1   0.0   0.0   4.6   2.7
## 1800   6.9   9.3  13.9   0.0   5.0  23.7  21.0  19.5  11.5  12.3  10.5
## 1801  27.0  29.0  30.0  31.0  32.0  31.2  35.0  38.7  33.5  32.6  39.8
## 1802  47.8  47.0  40.8  42.0  44.0  46.0  48.0  50.0  51.8  38.5  34.5
## 1803  50.0  50.8  29.5  25.0  44.3  36.0  48.3  34.1  45.3  54.3  51.0
## 1804  45.3  48.3  48.0  50.6  33.4  34.8  29.8  43.1  53.0  62.3  61.0
## 1805  61.0  44.1  51.4  37.5  39.0  40.5  37.6  42.7  44.4  29.4  41.0
## 1806  39.0  29.6  32.7  27.7  26.4  25.6  30.0  26.3  24.0  27.0  25.0
## 1807  12.0  12.2   9.6  23.8  10.0  12.0  12.7  12.0   5.7   8.0   2.6
## 1808   0.0   4.5   0.0  12.3  13.5  13.5   6.7   8.0  11.7   4.7  10.5
## 1809   7.2   9.2   0.9   2.5   2.0   7.7   0.3   0.2   0.4   0.0   0.0
## 1810   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
## 1811   0.0   0.0   0.0   0.0   0.0   0.0   6.6   0.0   2.4   6.1   0.8
## 1812  11.3   1.9   0.7   0.0   1.0   1.3   0.5  15.6   5.2   3.9   7.9
## 1813   0.0  10.3   1.9  16.6   5.5  11.2  18.3   8.4  15.3  27.8  16.7
## 1814  22.2  12.0   5.7  23.8   5.8  14.9  18.5   2.3   8.1  19.3  14.5
## 1815  19.2  32.2  26.2  31.6   9.8  55.9  35.5  47.2  31.5  33.5  37.2
## 1816  26.3  68.8  73.7  58.8  44.3  43.6  38.8  23.2  47.8  56.4  38.1
## 1817  36.4  57.9  96.2  26.4  21.2  40.0  50.0  45.0  36.7  25.6  28.9
## 1818  34.9  22.4  25.4  34.5  53.1  36.4  28.0  31.5  26.1  31.7  10.9
## 1819  32.5  20.7   3.7  20.2  19.6  35.0  31.4  26.1  14.9  27.5  25.1
## 1820  19.2  26.6   4.5  19.4  29.3  10.8  20.6  25.9   5.2   9.0   7.9
## 1821  21.5   4.3   5.7   9.2   1.7   1.8   2.5   4.8   4.4  18.8   4.4
## 1822   0.0   0.9  16.1  13.5   1.5   5.6   7.9   2.1   0.0   0.4   0.0
## 1823   0.0   0.0   0.6   0.0   0.0   0.0   0.5   0.0   0.0   0.0   0.0
## 1824  21.6  10.8   0.0  19.4   2.8   0.0   0.0   1.4  20.5  25.2   0.0
## 1825   5.0  15.5  22.4   3.8  15.4  15.4  30.9  25.4  15.7  15.6  11.7
## 1826  17.7  18.2  36.7  24.0  32.4  37.1  52.5  39.6  18.9  50.6  39.5
## 1827  34.6  47.4  57.8  46.0  56.3  56.7  42.9  53.7  49.6  57.2  48.2
## 1828  52.8  64.4  65.0  61.1  89.1  98.0  54.3  76.4  50.4  54.7  57.0
## 1829  43.0  49.4  72.3  95.0  67.5  73.9  90.8  78.3  52.8  57.2  67.6
## 1830  52.2  72.1  84.6 107.1  66.3  65.1  43.9  50.7  62.1  84.4  81.2
## 1831  47.5  50.1  93.4  54.6  38.1  33.4  45.2  54.9  37.9  46.2  43.5
## 1832  30.9  55.5  55.1  26.9  41.3  26.7  13.9   8.9   8.2  21.1  14.3
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## 1833  11.3  14.9  11.8   2.8  12.9   1.0   7.0   5.7  11.6   7.5   5.9
## 1834   4.9  18.1   3.9   1.4   8.8   7.8   8.7   4.0  11.5  24.8  30.5
## 1835   7.5  24.5  19.7  61.5  43.6  33.2  59.8  59.0 100.8  95.2 100.0
## 1836  88.6 107.6  98.1 142.9 111.4 124.7 116.7 107.8  95.1 137.4 120.9
## 1837 188.0 175.6 134.6 138.2 111.3 158.0 162.8 134.0  96.3 123.7 107.0
## 1838 144.9  84.8 140.8 126.6 137.6  94.5 108.2  78.8  73.6  90.8  77.4
## 1839 107.6 102.5  77.7  61.8  53.8  54.6  84.7 131.2 132.7  90.8  68.8
## 1840  81.2  87.7  55.5  65.9  69.2  48.5  60.7  57.8  74.0  49.8  54.3
## 1841  24.0  29.9  29.7  42.6  67.4  55.7  30.8  39.3  35.1  28.5  19.8
## 1842  20.4  22.1  21.7  26.9  24.9  20.5  12.6  26.5  18.5  38.1  40.5
## 1843  13.3   3.5   8.3   8.8  21.1  10.5   9.5  11.8   4.2   5.3  19.1
## 1844   9.4  14.7  13.6  20.8  12.0   3.7  21.2  23.9   6.9  21.5  10.7
## 1845  25.7  43.6  43.3  56.9  47.8  31.1  30.6  32.3  29.6  40.7  39.4
## 1846  38.7  51.0  63.9  69.2  59.9  65.1  46.5  54.8 107.1  55.9  60.4
## 1847  62.6  44.9  85.7  44.7  75.4  85.3  52.2 140.6 161.2 180.4 138.9
## 1848 159.1 111.8 108.9 107.1 102.2 123.8 139.2 132.5 100.3 132.4 114.6
## 1849 156.7 131.7  96.5 102.5  80.6  81.2  78.0  61.3  93.7  71.5  99.7
## 1850  78.0  89.4  82.6  44.1  61.6  70.0  39.1  61.6  86.2  71.0  54.8
## 1851  75.5 105.4  64.6  56.5  62.6  63.2  36.1  57.4  67.9  62.5  50.9
## 1852  68.4  67.5  61.2  65.4  54.9  46.9  42.0  39.7  37.5  67.3  54.3
## 1853  41.1  42.9  37.7  47.6  34.7  40.0  45.9  50.4  33.5  42.3  28.8
## 1854  15.4  20.0  20.7  26.4  24.0  21.1  18.7  15.8  22.4  12.7  28.2
## 1855  12.3  11.4  17.4   4.4   9.1   5.3   0.4   3.1   0.0   9.7   4.3
## 1856   0.5   4.9   0.4   6.5   0.0   5.0   4.6   5.9   4.4   4.5   7.7
## 1857  13.7   7.4   5.2  11.1  29.2  16.0  22.2  16.9  42.4  40.6  31.4
## 1858  39.0  34.9  57.5  38.3  41.4  44.5  56.7  55.3  80.1  91.2  51.9
## 1859  83.7  87.6  90.3  85.7  91.0  87.1  95.2 106.8 105.8 114.6  97.2
## 1860  81.5  88.0  98.9  71.4 107.1 108.6 116.7 100.3  92.2  90.1  97.9
## 1861  62.3  77.8 101.0  98.5  56.8  87.8  78.0  82.5  79.9  67.2  53.7
## 1862  63.1  64.5  43.6  53.7  64.4  84.0  73.4  62.5  66.6  42.0  50.6
## 1863  48.3  56.7  66.4  40.6  53.8  40.8  32.7  48.1  22.0  39.9  37.7
## 1864  57.7  47.1  66.3  35.8  40.6  57.8  54.7  54.8  28.5  33.9  57.6
## 1865  48.7  39.3  39.5  29.4  34.5  33.6  26.8  37.8  21.6  17.1  24.6
## 1866  31.6  38.4  24.6  17.6  12.9  16.5   9.3  12.7   7.3  14.1   9.0
## 1867   0.0   0.7   9.2   5.1   2.9   1.5   5.0   4.9   9.8  13.5   9.3
## 1868  15.6  15.8  26.5  36.6  26.7  31.1  28.6  34.4  43.8  61.7  59.1
## 1869  60.9  59.3  52.7  41.0 104.0 108.4  59.2  79.6  80.6  59.4  77.4
## 1870  77.3 114.9 159.4 160.0 176.0 135.6 132.4 153.8 136.0 146.4 147.5
## 1871  88.3 125.3 143.2 162.4 145.5  91.7 103.0 110.0  80.3  89.0 105.4
## 1872  79.5 120.1  88.4 102.1 107.6 109.9 105.5  92.9 114.6 103.5 112.0
## 1873  86.7 107.0  98.3  76.2  47.9  44.8  66.9  68.2  47.5  47.4  55.4
## 1874  60.8  64.2  46.4  32.0  44.6  38.2  67.8  61.3  28.0  34.3  28.9
## 1875  14.6  22.2  33.8  29.1  11.5  23.9  12.5  14.6   2.4  12.7  17.7
## 1876  14.3  15.0  31.2   2.3   5.1   1.6  15.2   8.8   9.9  14.3   9.9
## 1877  24.4   8.7  11.7  15.8  21.2  13.4   5.9   6.3  16.4   6.7  14.5
## 1878   3.3   6.0   7.8   0.1   5.8   6.4   0.1   0.0   5.3   1.1   4.1
## 1879   0.8   0.6   0.0   6.2   2.4   4.8   7.5  10.7   6.1  12.3  12.9
## 1880  24.0  27.5  19.5  19.3  23.5  34.1  21.9  48.1  66.0  43.0  30.7
## 1881  36.4  53.2  51.5  51.7  43.5  60.5  76.9  58.0  53.2  64.0  54.8
## 1882  45.0  69.3  67.5  95.8  64.1  45.2  45.4  40.4  57.7  59.2  84.4
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## 1883  60.6  46.9  42.8  82.1  32.1  76.5  80.6  46.0  52.6  83.8  84.5
## 1884  91.5  86.9  86.8  76.1  66.5  51.2  53.1  55.8  61.9  47.8  36.6
## 1885  42.8  71.8  49.8  55.0  73.0  83.7  66.5  50.0  39.6  38.7  33.3
## 1886  29.9  25.9  57.3  43.7  30.7  27.1  30.3  16.9  21.4   8.6   0.3
## 1887  10.3  13.2   4.2   6.9  20.0  15.7  23.3  21.4   7.4   6.6   6.9
## 1888  12.7   7.1   7.8   5.1   7.0   7.1   3.1   2.8   8.8   2.1  10.7
## 1889   0.8   8.5   7.0   4.3   2.4   6.4   9.7  20.6   6.5   2.1   0.2
## 1890   5.3   0.6   5.1   1.6   4.8   1.3  11.6   8.5  17.2  11.2   9.6
## 1891  13.5  22.2  10.4  20.5  41.1  48.3  58.8  33.2  53.8  51.5  41.9
## 1892  69.1  75.6  49.9  69.6  79.6  76.3  76.8 101.4  62.8  70.5  65.4
## 1893  75.0  73.0  65.7  88.1  84.7  88.2  88.8 129.2  77.9  79.7  75.1
## 1894  83.2  84.6  52.3  81.6 101.2  98.9 106.0  70.3  65.9  75.5  56.6
## 1895  63.3  67.2  61.0  76.9  67.5  71.5  47.8  68.9  57.7  67.9  47.2
## 1896  29.0  57.4  52.0  43.8  27.7  49.0  45.0  27.2  61.3  28.4  38.0
## 1897  40.6  29.4  29.1  31.0  20.0  11.3  27.6  21.8  48.1  14.3   8.4
## 1898  30.2  36.4  38.3  14.5  25.8  22.3   9.0  31.4  34.8  34.4  30.9
## 1899  19.5   9.2  18.1  14.2   7.7  20.5  13.5   2.9   8.4  13.0   7.8
## 1900   9.4  13.6   8.6  16.0  15.2  12.1   8.3   4.3   8.3  12.9   4.5
## 1901   0.2   2.4   4.5   0.0  10.2   5.8   0.7   1.0   0.6   3.7   3.8
## 1902   5.2   0.0  12.4   0.0   2.8   1.4   0.9   2.3   7.6  16.3  10.3
## 1903   8.3  17.0  13.5  26.1  14.6  16.3  27.9  28.8  11.1  38.9  44.5
## 1904  31.6  24.5  37.2  43.0  39.5  41.9  50.6  58.2  30.1  54.2  38.0
## 1905  54.8  85.8  56.5  39.3  48.0  49.0  73.0  58.8  55.0  78.7 107.2
## 1906  45.5  31.3  64.5  55.3  57.7  63.2 103.6  47.7  56.1  17.8  38.9
## 1907  76.4 108.2  60.7  52.6  42.9  40.4  49.7  54.3  85.0  65.4  61.5
## 1908  39.2  33.9  28.7  57.6  40.8  48.1  39.5  90.5  86.9  32.3  45.5
## 1909  56.7  46.6  66.3  32.3  36.0  22.6  35.8  23.1  38.8  58.4  55.8
## 1910  26.4  31.5  21.4   8.4  22.2  12.3  14.1  11.5  26.2  38.3   4.9
## 1911   3.4   9.0   7.8  16.5   9.0   2.2   3.5   4.0   4.0   2.6   4.2
## 1912   0.3   0.0   4.9   4.5   4.4   4.1   3.0   0.3   9.5   4.6   1.1
## 1913   2.3   2.9   0.5   0.9   0.0   0.0   1.7   0.2   1.2   3.1   0.7
## 1914   2.8   2.6   3.1  17.3   5.2  11.4   5.4   7.7  12.7   8.2  16.4
## 1915  23.0  42.3  38.8  41.3  33.0  68.8  71.6  69.6  49.5  53.5  42.5
## 1916  45.3  55.4  67.0  71.8  74.5  67.7  53.5  35.2  45.1  50.7  65.6
## 1917  74.7  71.9  94.8  74.7 114.1 114.9 119.8 154.5 129.4  72.2  96.4
## 1918  96.0  65.3  72.2  80.5  76.7  59.4 107.6 101.7  79.9  85.0  83.4
## 1919  48.1  79.5  66.5  51.8  88.1 111.2  64.7  69.0  54.7  52.8  42.0
## 1920  51.1  53.9  70.2  14.8  33.3  38.7  27.5  19.2  36.3  49.6  27.2
## 1921  31.5  28.3  26.7  32.4  22.2  33.7  41.9  22.8  17.8  18.2  17.8
## 1922  11.8  26.4  54.7  11.0   8.0   5.8  10.9   6.5   4.7   6.2   7.4
## 1923   4.5   1.5   3.3   6.1   3.2   9.1   3.5   0.5  13.2  11.6  10.0
## 1924   0.5   5.1   1.8  11.3  20.8  24.0  28.1  19.3  25.1  25.6  22.5
## 1925   5.5  23.2  18.0  31.7  42.8  47.5  38.5  37.9  60.2  69.2  58.6
## 1926  71.8  70.0  62.5  38.5  64.3  73.5  52.3  61.6  60.8  71.5  60.5
## 1927  81.6  93.0  69.6  93.5  79.1  59.1  54.9  53.8  68.4  63.1  67.2
## 1928  83.5  73.5  85.4  80.6  76.9  91.4  98.0  83.8  89.7  61.4  50.3
## 1929  68.9  64.1  50.2  52.8  58.2  71.9  70.2  65.8  34.4  54.0  81.1
## 1930  65.3  49.2  35.0  38.2  36.8  28.8  21.9  24.9  32.1  34.4  35.6
## 1931  14.6  43.1  30.0  31.2  24.6  15.3  17.4  13.0  19.0  10.0  18.7
## 1932  12.1  10.6  11.2  11.2  17.9  22.2   9.6   6.8   4.0   8.9   8.2
```

```
## 1933  12.3  22.2  10.1   2.9   3.2   5.2   2.8   0.2   5.1   3.0   0.6
## 1934   3.4   7.8   4.3  11.3  19.7   6.7   9.3   8.3   4.0   5.7   8.7
## 1935  18.9  20.5  23.1  12.2  27.3  45.7  33.9  30.1  42.1  53.2  64.2
## 1936  62.8  74.3  77.1  74.9  54.6  70.0  52.3  87.0  76.0  89.0 115.4
## 1937 132.5 128.5  83.9 109.3 116.7 130.3 145.1 137.7 100.7 124.9  74.4
## 1938  98.4 119.2  86.5 101.0 127.4  97.5 165.3 115.7  89.6  99.1 122.2
## 1939  80.3  77.4  64.6 109.1 118.3 101.0  97.6 105.8 112.6  88.1  68.1
## 1940  50.5  59.4  83.3  60.7  54.4  83.9  67.5 105.5  66.5  55.0  58.4
## 1941  45.6  44.5  46.4  32.8  29.5  59.8  66.9  60.0  65.9  46.3  38.3
## 1942  35.6  52.8  54.2  60.7  25.0  11.4  17.7  20.2  17.2  19.2  30.7
## 1943  12.4  28.9  27.4  26.1  14.1   7.6  13.2  19.4  10.0   7.8  10.2
## 1944   3.7   0.5  11.0   0.3   2.5   5.0   5.0  16.7  14.3  16.9  10.8
## 1945  18.5  12.7  21.5  32.0  30.6  36.2  42.6  25.9  34.9  68.8  46.0
## 1946  47.6  86.2  76.6  75.7  84.9  73.5 116.2 107.2  94.4 102.3 123.8
## 1947 115.7 113.4 129.8 149.8 201.3 163.9 157.9 188.8 169.4 163.6 128.0
## 1948 108.5  86.1  94.8 189.7 174.0 167.8 142.2 157.9 143.3 136.3  95.8
## 1949 119.1 182.3 157.5 147.0 106.2 121.7 125.8 123.8 145.3 131.6 143.5
## 1950 101.6  94.8 109.7 113.4 106.2  83.6  91.0  85.2  51.3  61.4  54.8
## 1951  59.9  59.9  59.9  92.9 108.5 100.6  61.5  61.0  83.1  51.6  52.4
## 1952  40.7  22.7  22.0  29.1  23.4  36.4  39.3  54.9  28.2  23.8  22.1
## 1953  26.5   3.9  10.0  27.8  12.5  21.8   8.6  23.5  19.3   8.2   1.6
## 1954   0.2   0.5  10.9   1.8   0.8   0.2   4.8   8.4   1.5   7.0   9.2
## 1955  23.1  20.8   4.9  11.3  28.9  31.7  26.7  40.7  42.7  58.5  89.2
## 1956  73.6 124.0 118.4 110.7 136.6 116.6 129.1 169.6 173.2 155.3 201.3
## 1957 165.0 130.2 157.4 175.2 164.6 200.7 187.2 158.0 235.8 253.8 210.9
## 1958 202.5 164.9 190.7 196.0 175.3 171.5 191.4 200.2 201.2 181.5 152.3
## 1959 217.4 143.1 185.7 163.3 172.0 168.7 149.6 199.6 145.2 111.4 124.0
## 1960 146.3 106.0 102.2 122.0 119.6 110.2 121.7 134.1 127.2  82.8  89.6
## 1961  57.9  46.1  53.0  61.4  51.0  77.4  70.2  55.9  63.6  37.7  32.6
## 1962  38.7  50.3  45.6  46.4  43.7  42.0  21.8  21.8  51.3  39.5  26.9
## 1963  19.8  24.4  17.1  29.3  43.0  35.9  19.6  33.2  38.8  35.3  23.4
## 1964  15.3  17.7  16.5   8.6   9.5   9.1   3.1   9.3   4.7   6.1   7.4
## 1965  17.5  14.2  11.7   6.8  24.1  15.9  11.9   8.9  16.8  20.1  15.8
## 1966  28.2  24.4  25.3  48.7  45.3  47.7  56.7  51.2  50.2  57.2  57.2
## 1967 110.9  93.6 111.8  69.5  86.5  67.3  91.5 107.2  76.8  88.2  94.3
## 1968 121.8 111.9  92.2  81.2 127.2 110.3  96.1 109.3 117.2 107.7  86.0
## 1969 104.4 120.5 135.8 106.8 120.0 106.0  96.8  98.0  91.3  95.7  93.5
## 1970 111.5 127.8 102.9 109.5 127.5 106.8 112.5  93.0  99.5  86.6  95.2
## 1971  91.3  79.0  60.7  71.8  57.5  49.8  81.0  61.4  50.2  51.7  63.2
## 1972  61.5  88.4  80.1  63.2  80.5  88.0  76.5  76.8  64.0  61.3  41.6
## 1973  43.4  42.9  46.0  57.7  42.4  39.5  23.1  25.6  59.3  30.7  23.9
## 1974  27.6  26.0  21.3  40.3  39.5  36.0  55.8  33.6  40.2  47.1  25.0
## 1975  18.9  11.5  11.5   5.1   9.0  11.4  28.2  39.7  13.9   9.1  19.4
## 1976   8.1   4.3  21.9  18.8  12.4  12.2   1.9  16.4  13.5  20.6   5.2
## 1977  16.4  23.1   8.7  12.9  18.6  38.5  21.4  30.1  44.0  43.8  29.1
## 1978  51.9  93.6  76.5  99.7  82.7  95.1  70.4  58.1 138.2 125.1  97.9
## 1979 166.6 137.5 138.0 101.5 134.4 149.5 159.4 142.2 188.4 186.2 183.3
## 1980 159.6 155.0 126.2 164.1 179.9 157.3 136.3 135.4 155.0 164.7 147.9
## 1981 114.0 141.3 135.5 156.4 127.5  90.0 143.8 158.7 167.3 162.4 137.5
## 1982 111.2 163.6 153.8 122.0  82.2 110.4 106.1 107.6 118.8  94.7  98.1
```

```
## 1983  84.3  51.0  66.5  80.7  99.2  91.1  82.2  71.8  50.3  55.8  33.3
##        Dec
## 1749  85.2
## 1750  75.4
## 1751  44.0
## 1752  40.0
## 1753   6.7
## 1754   4.2
## 1755  20.0
## 1756   9.4
## 1757  33.5
## 1758  43.0
## 1759  57.0
## 1760  61.0
## 1761  46.0
## 1762  77.2
## 1763  61.4
## 1764  25.7
## 1765  13.0
## 1766  19.2
## 1767  53.3
## 1768 111.8
## 1769 112.0
## 1770 102.3
## 1771  95.7
## 1772  64.0
## 1773  43.2
## 1774  12.2
## 1775   7.9
## 1776  40.0
## 1777 157.3
## 1778 105.0
## 1779 110.0
## 1780  58.7
## 1781  35.2
## 1782  30.0
## 1783  10.5
## 1784  14.0
## 1785  27.3
## 1786 112.7
## 1787 174.0
## 1788 129.5
## 1789 135.5
## 1790  74.0
## 1791  66.0
## 1792  56.0
## 1793  45.7
## 1794  51.4
## 1795  18.0
## 1796   5.1
```

```
## 1797   3.0
## 1798   9.9
## 1799   8.6
## 1800  40.1
## 1801  48.2
## 1802  50.0
## 1803  48.0
## 1804  60.0
## 1805  38.3
## 1806  24.0
## 1807   0.0
## 1808  12.3
## 1809   0.0
## 1810   0.0
## 1811   1.1
## 1812  10.1
## 1813  14.3
## 1814  20.1
## 1815  65.0
## 1816  29.9
## 1817  28.4
## 1818  25.8
## 1819  30.6
## 1820   9.7
## 1821   0.0
## 1822   0.0
## 1823  20.4
## 1824   0.8
## 1825  22.0
## 1826  68.1
## 1827  46.1
## 1828  46.6
## 1829  56.5
## 1830  82.1
## 1831  28.9
## 1832  27.5
## 1833   9.9
## 1834  34.5
## 1835  77.5
## 1836 206.2
## 1837 129.8
## 1838  79.8
## 1839  63.6
## 1840  53.7
## 1841  38.8
## 1842  17.6
## 1843  12.7
## 1844  21.6
## 1845  59.7
## 1846  65.5
```

```
## 1847 109.6
## 1848 159.9
## 1849  97.0
## 1850  60.0
## 1851  71.4
## 1852  45.4
## 1853  23.4
## 1854  21.4
## 1855   3.1
## 1856   7.2
## 1857  37.2
## 1858  66.9
## 1859  81.0
## 1860  95.6
## 1861  80.5
## 1862  40.9
## 1863  41.2
## 1864  28.6
## 1865  12.8
## 1866   1.5
## 1867  25.2
## 1868  67.6
## 1869 104.3
## 1870 130.0
## 1871  90.3
## 1872  83.9
## 1873  49.2
## 1874  29.3
## 1875   9.9
## 1876   8.2
## 1877   2.3
## 1878   0.5
## 1879   7.2
## 1880  29.6
## 1881  47.3
## 1882  41.8
## 1883  75.9
## 1884  47.2
## 1885  21.7
## 1886  12.4
## 1887  20.7
## 1888   6.7
## 1889   6.7
## 1890   7.8
## 1891  32.3
## 1892  78.6
## 1893  93.8
## 1894  60.0
## 1895  70.7
## 1896  42.6
```

```
## 1897  33.3
## 1898  12.6
## 1899  10.5
## 1900   0.3
## 1901   0.0
## 1902   1.1
## 1903  45.6
## 1904  54.6
## 1905  55.5
## 1906  64.7
## 1907  47.3
## 1908  39.5
## 1909  54.2
## 1910   5.8
## 1911   2.2
## 1912   6.4
## 1913   3.8
## 1914  22.3
## 1915  34.5
## 1916  53.0
## 1917 129.3
## 1918  59.2
## 1919  34.9
## 1920  29.9
## 1921  20.3
## 1922  17.5
## 1923   2.8
## 1924  16.5
## 1925  98.6
## 1926  79.4
## 1927  45.2
## 1928  59.0
## 1929 108.0
## 1930  25.8
## 1931  17.8
## 1932  11.0
## 1933   0.3
## 1934  15.4
## 1935  61.5
## 1936 123.4
## 1937  88.8
## 1938  92.7
## 1939  42.1
## 1940  68.3
## 1941  33.7
## 1942  22.5
## 1943  18.8
## 1944  28.4
## 1945  27.4
## 1946 121.7
```

```
## 1947 116.5
## 1948 138.0
## 1949 117.6
## 1950  54.1
## 1951  45.8
## 1952  34.3
## 1953   2.5
## 1954   7.6
## 1955  76.9
## 1956 192.1
## 1957 239.4
## 1958 187.6
## 1959 125.0
## 1960  85.6
## 1961  40.0
## 1962  23.2
## 1963  14.9
## 1964  15.1
## 1965  17.0
## 1966  70.4
## 1967 126.4
## 1968 109.8
## 1969  97.9
## 1970  83.5
## 1971  82.2
## 1972  45.3
## 1973  23.3
## 1974  20.5
## 1975   7.8
## 1976  15.3
## 1977  43.2
## 1978 122.7
## 1979 176.3
## 1980 174.4
## 1981 150.1
## 1982 127.0
## 1983  33.4
```

```
library(timeSeries)
```

```
## Warning: package 'timeSeries' was built under R version 3.5.3
```

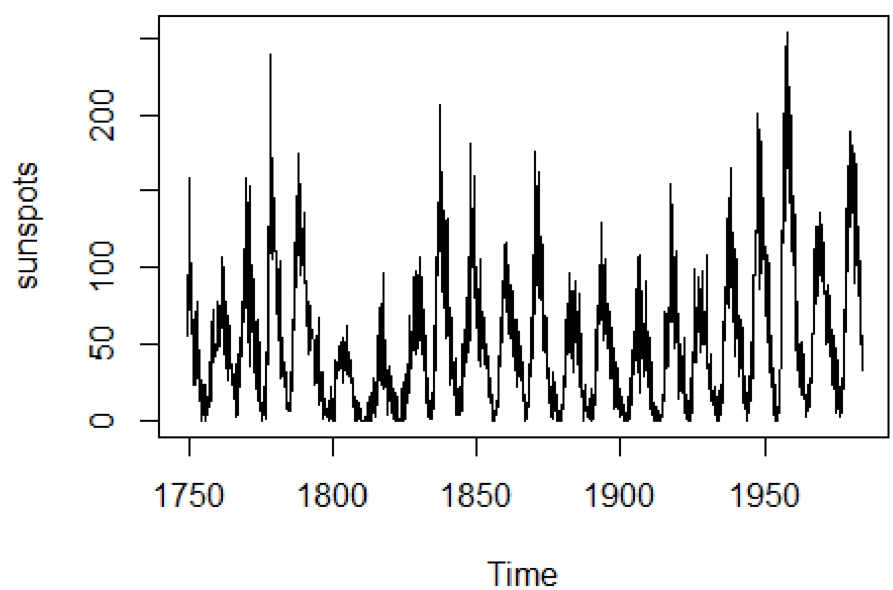
```
## Loading required package: timeDate
```

```
library(xts)
```

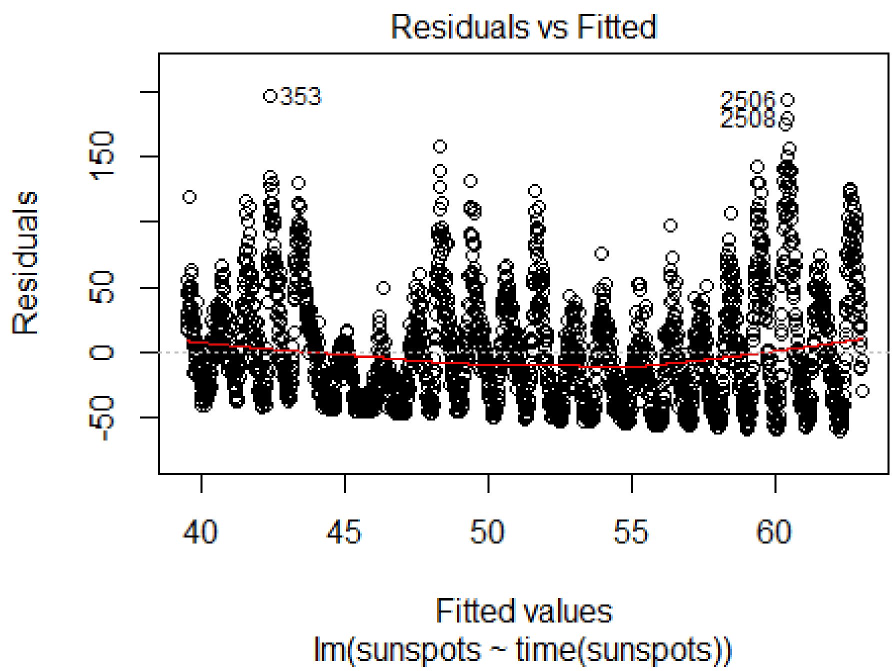
```
## Warning: package 'xts' was built under R version 3.5.3
```

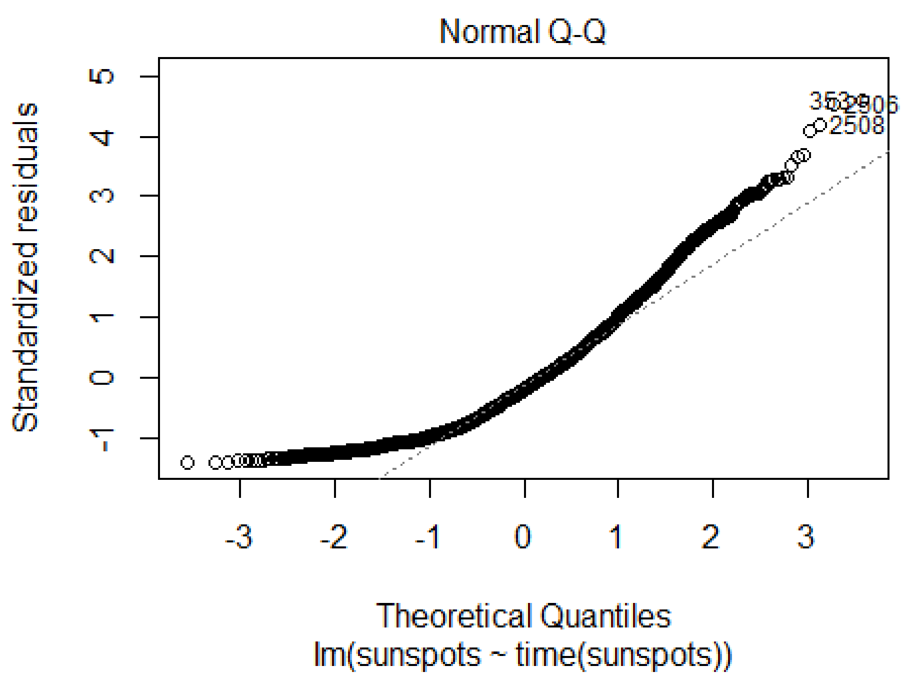
```
## Loading required package: zoo
```

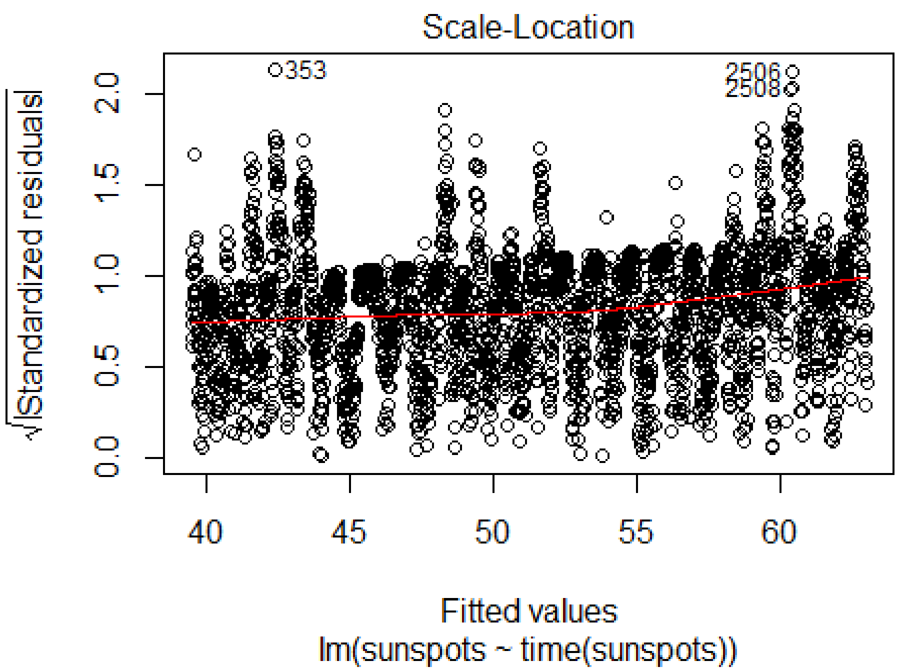
```
##
## Attaching package: 'zoo'

## The following object is masked from 'package:timeSeries':
##
##     time<-

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

library(forecast)

## Warning: package 'forecast' was built under R version 3.5.3

plot(sunspots)
```



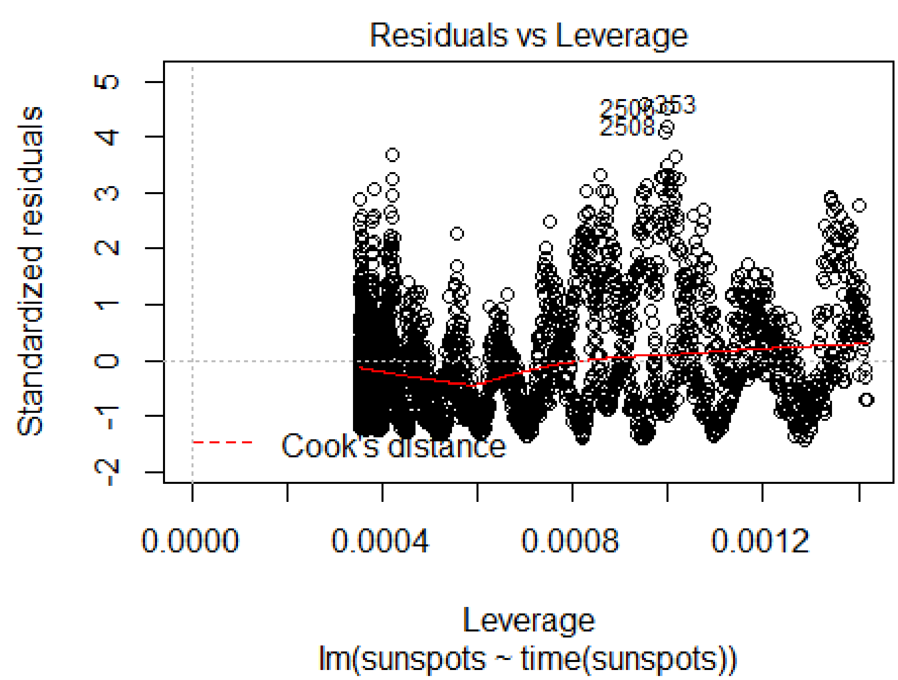

```
class(sunspots)

## [1] "ts"

#cycle(sunspots)

frequency(sunspots)

## [1] 12

m <- lm(sunspots ~ time(sunspots))
plot(m)
```


Residuals vs Fitted
Residuals
Fitted values
lm(sunspots ~ time(sunspots))
353
2506
2508
-50
0
50
150
40
45
50
55
60

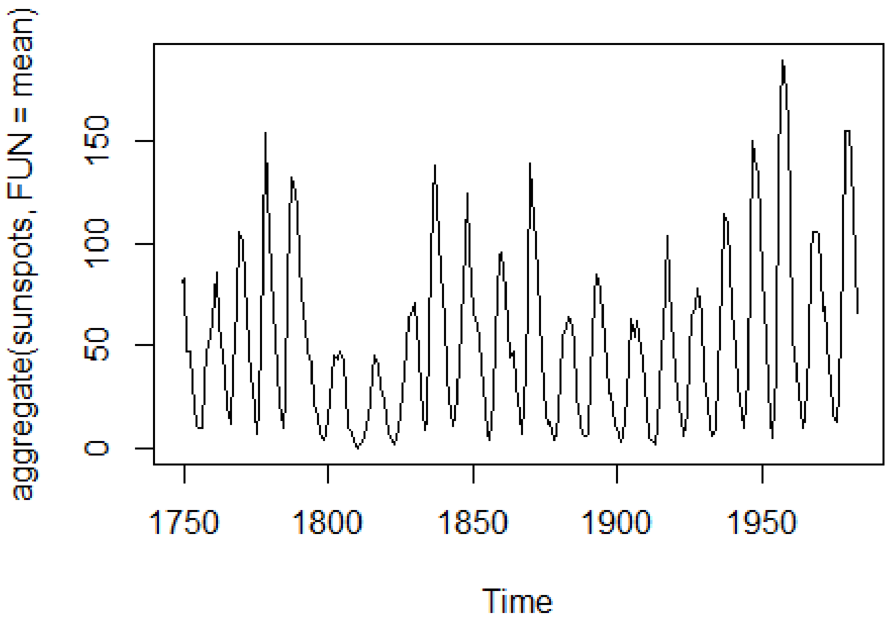

Normal Q-Q
Standardized residuals
Theoretical Quantiles
lm(sunspots ~ time(sunspots))
2508
-1
0
1
2
3
4
5
-3
-2
-1
0
1
2
3




```r
abline(m)
```

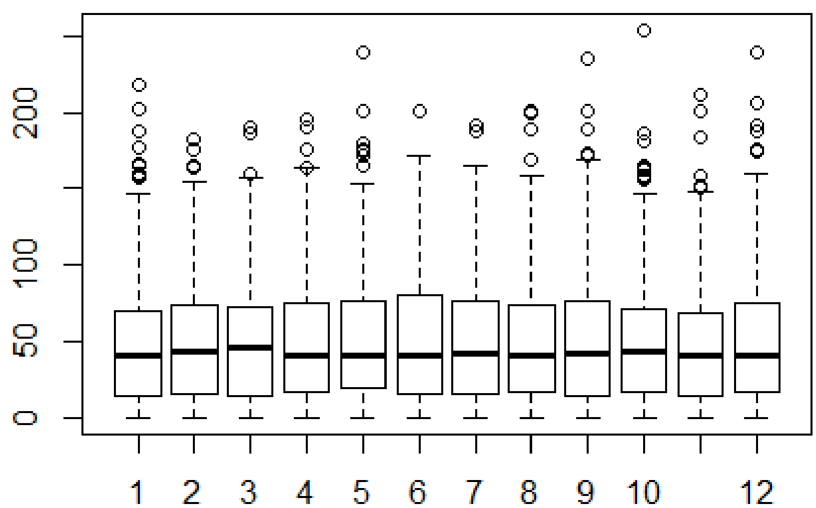



```r
plot(aggregate(sunspots, FUN = mean))
```



Q. Plot the monthly (or other suitable periodic) boxplots

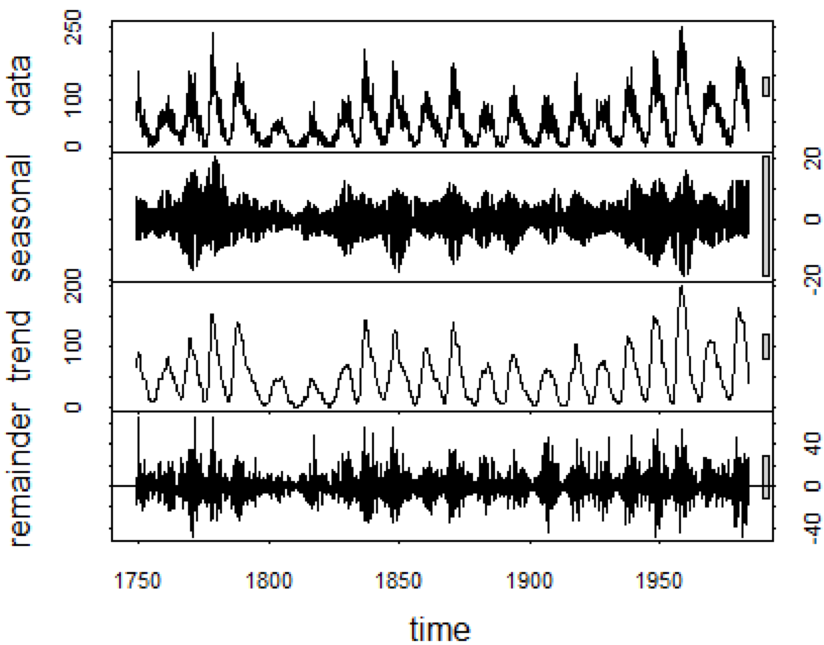
```
boxplot(sunspots ~ cycle(sunspots))
```



Q. Decompose the time series using the stl function. What type of trend does it show?

Answer: The plot is showing yearly seasonal trend.

```
d <- stl(sunspots, s.window = 12)

plot(d)
```



Q. What type of seasonality?

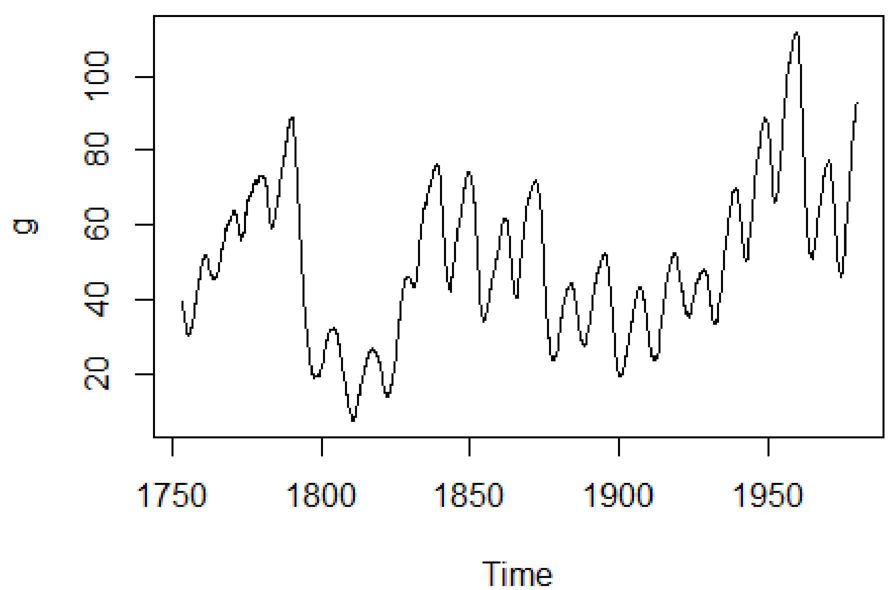
Answer: Seasonality is a characteristic of a time series in which the data experiences regular and predictable changes that recur every calendar year. Any predictable fluctuation or pattern that recurs or repeats over a one-year period is said to be seasonal.

Seasonal effects are different from cyclical effects, as seasonal cycles are observed within one calendar year, while cyclical effects, such as boosted sales due to low unemployment rates, can span time periods shorter or longer than one calendar year.

Q. How is the residue after you remove trend and seasonality?

Answer: It gives the graph with "remainder" which is basically showing noise. There are periodic ups and downs.

```
mean(sunspots)

## [1] 51.26596

g <- rollmean(sunspots, k = 100)
plot(g)
```



Q. Build a model of the data using the HoltWinters method for the period upto about 75% of the data (e.g., up to December 2015 if it were for the CO2 data set). Use suitable values of alpha, beta and gamma.

```
require(graphics)


library(zoo)
sunspots_zoo <- as.zoo(sunspots)
zoo_75 <- sunspots_zoo[1:2112]
zoo_25 <- sunspots_zoo[2113:length(sunspots)]

df_75 <- as.ts(zoo_75)
```

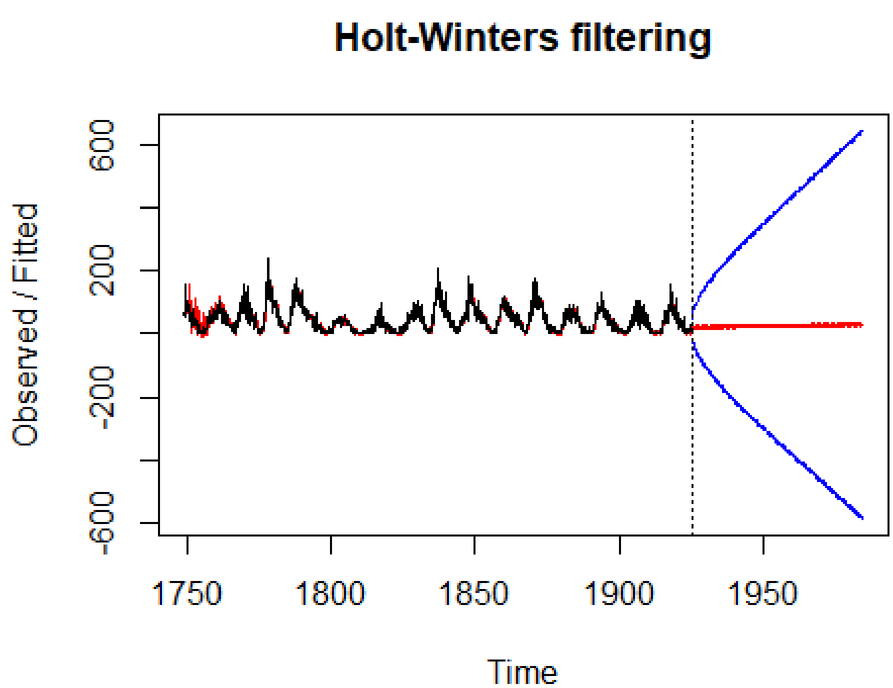
```r
df_25 <- as.ts(zoo_25)
#df_25
```

Q. Try to fine tune the model by changing alpha, beta and gamma. Are you able to improve the model (i.e., get a lower rms error)?

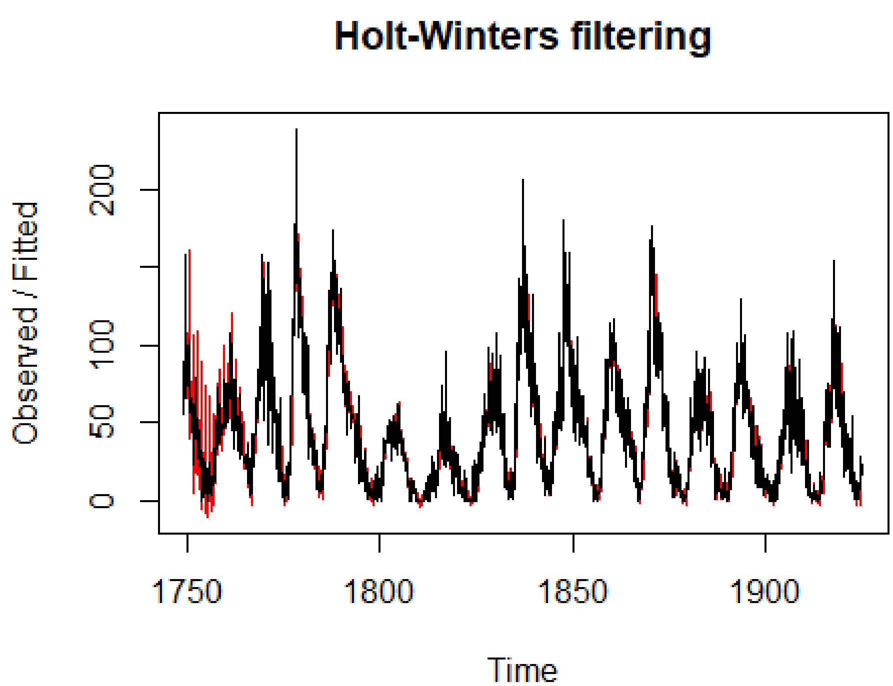
```r
sunspotsPredict <- HoltWinters(df_75, alpha = 0.4856207, beta = 0.001282363,
gamma = 0.1589522)
```

Q. Predict the values for the next 25% of the time (e.g., for the CO2 data set, all of 2016 and the first 3 months of 2017).

```r
p <- predict(sunspotsPredict, 708, prediction.interval = TRUE)
plot(sunspotsPredict, p)
```



```r
#p
p_zoo <- as.zoo(p)

p_df <- p[, 'fit']

#p_df <- subset(p, select = c(fit))
#p_df

class(p_df)

## [1] "ts"

plot(sunspotsPredict)
```



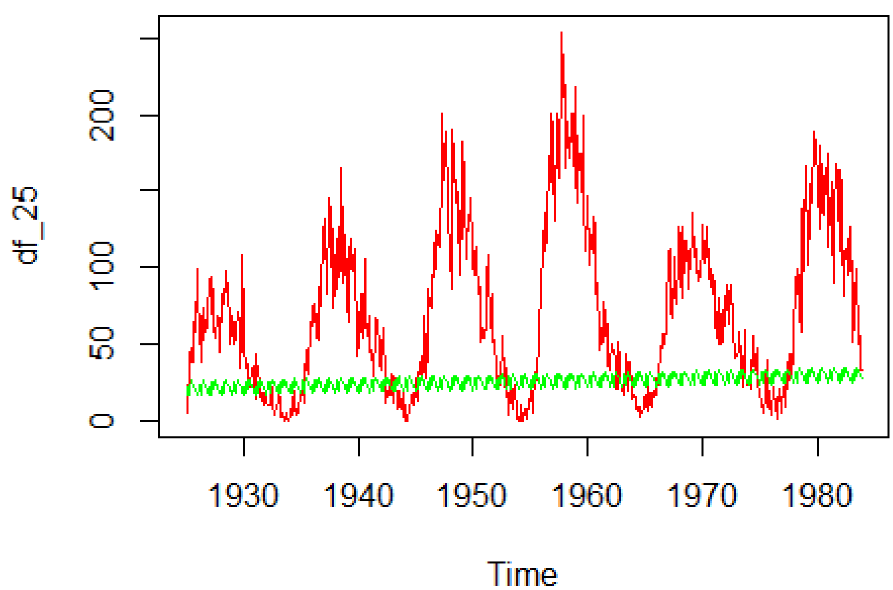
Q. Plot the predicted values along with the actual values to compare them.

```r
fitted <- matrix(p_df, ncol = 12, byrow = FALSE)
#fitted

matrix_df_25 <- as.matrix(df_25)
#matrix_df_25
actual <- matrix(matrix_df_25, ncol = 12, byrow = FALSE)
#actual
```

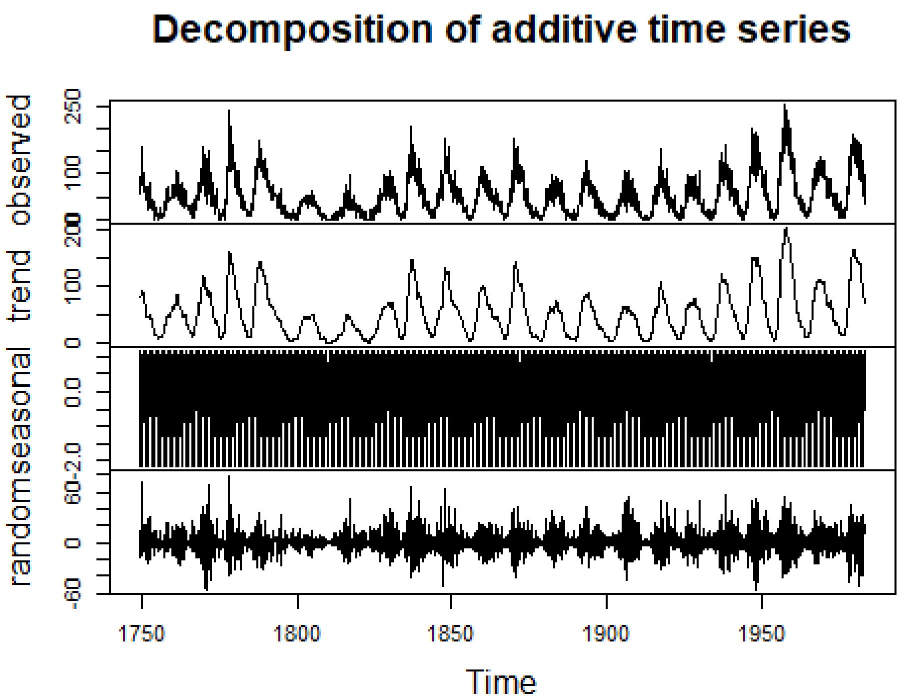
```
#rms <- actual - fitted
#rms
```

Q. Compute the rms error between the predicted and actual values.

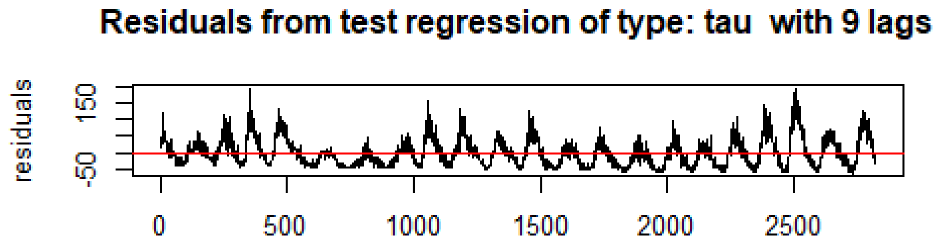
```
RMSE = function(fittd, actual){
  sqrt(mean((fitted - actual)^2))
}

RMSE(fiited, actual)

## [1] 68.75884

plot(df_25, col = "red")
lines(p_zoo$fit, col = "green")
```

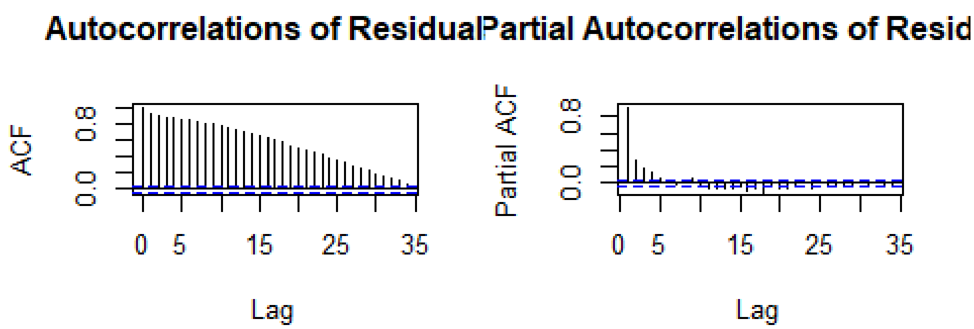



```
class(df_75)

## [1] "ts"

library(forecast)

components.ts = decompose(sunspots)
plot(components.ts)
```



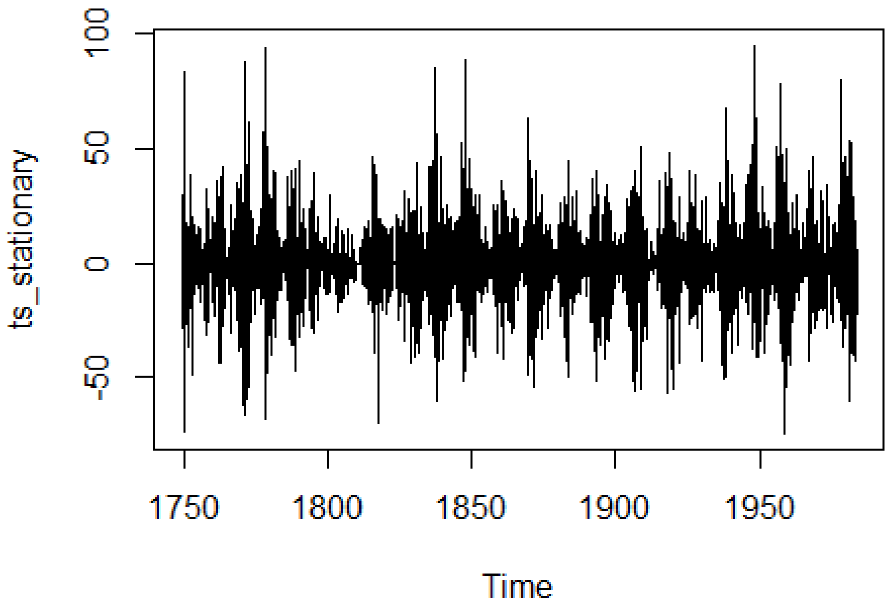

```r
library("fUnitRoots")

## Warning: package 'fUnitRoots' was built under R version 3.5.3

## Loading required package: fBasics

## Warning: package 'fBasics' was built under R version 3.5.3

urkpssTest(sunspots, type = c("tau"), lags = c("short"),use.lag = NULL,
doplot = TRUE)
```



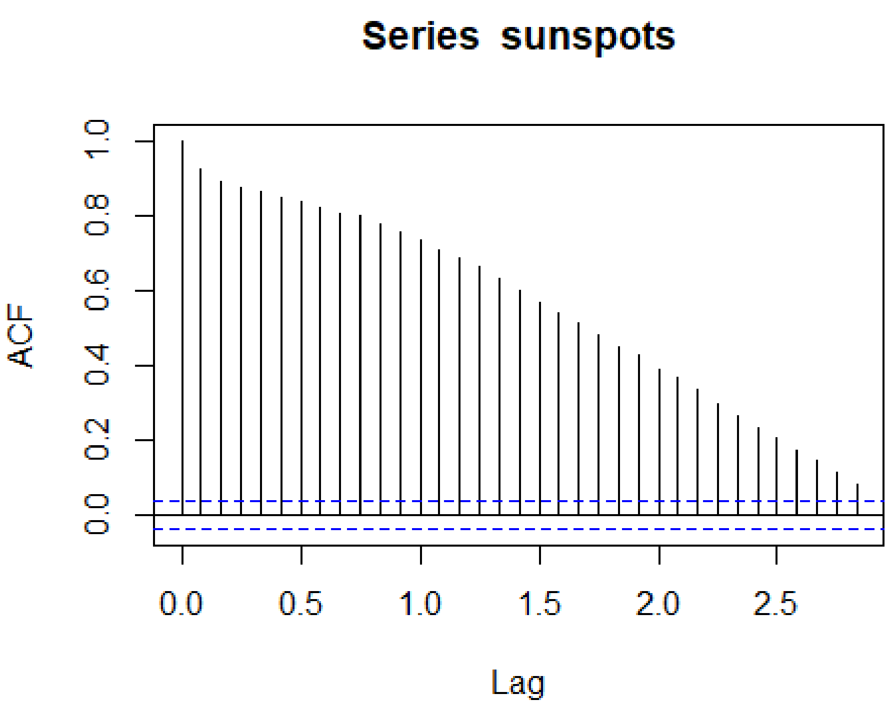



```
##
## Title:
##  KPSS Unit Root Test
##
## Test Results:
##   NA
##
## Description:
##  Fri May 03 15:33:17 2019 by user: IIIT
```

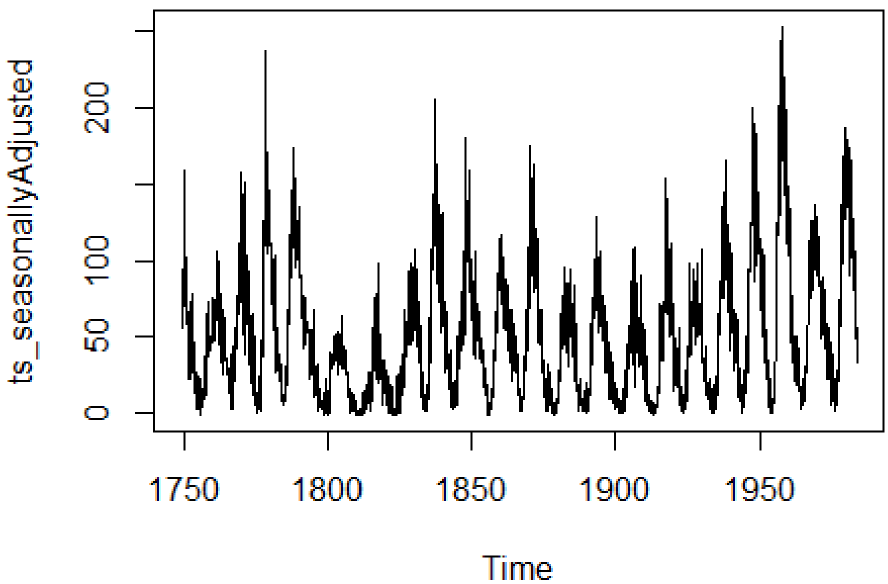
```
ts_stationary = diff(sunspots, differences=1)
plot(ts_stationary)
```



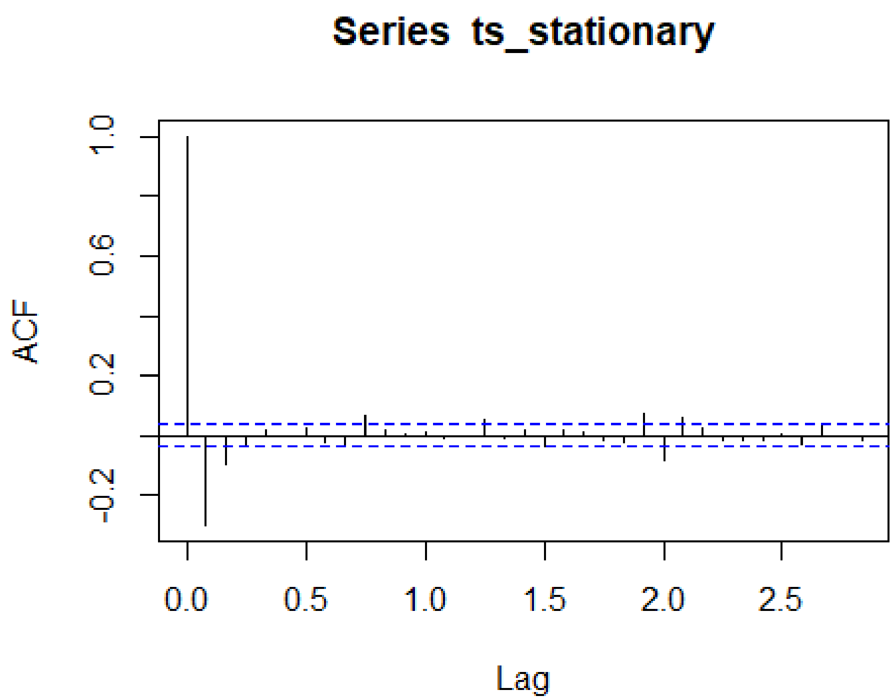

```r
#autoCorrelation : no linear association between observations separated by larger lags
acf(sunspots,lag.max = 34)
```



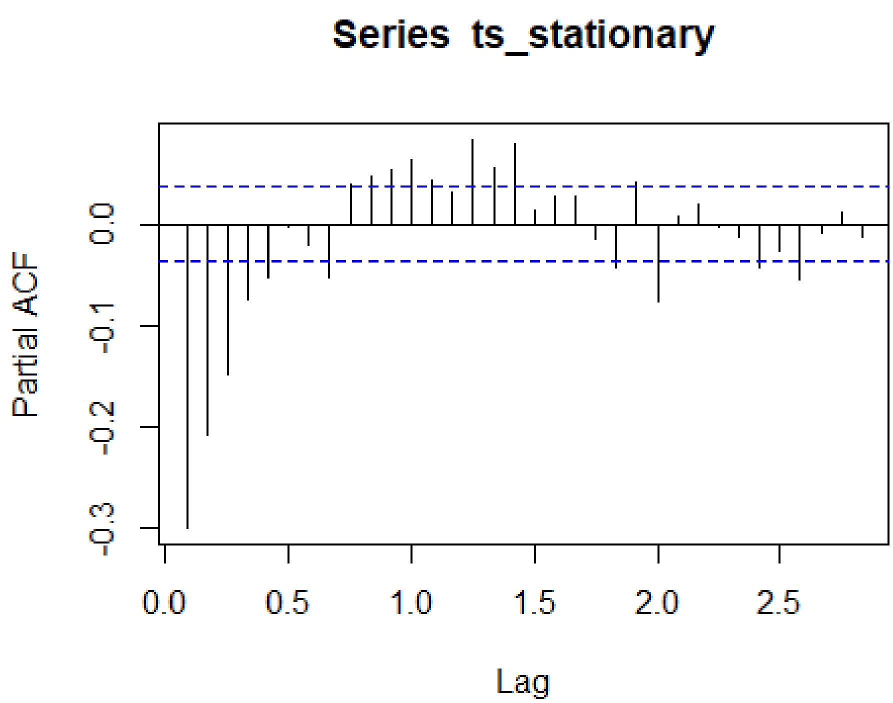
```r
#Remove seasonality from the original series
ts_seasonallyAdjusted <- sunspots- components.ts$seasonal
ts_stationary <- diff(ts_seasonallyAdjusted, differences=1)

plot(ts_seasonallyAdjusted)
```




```r
acf(ts_stationary, lag.max = 34)
```




```r
pacf(ts_stationary, lag.max = 34)
```



Q. Build an ARIMA model for the period up to about 75% of the data (e.g., for the CO2 data, up to December 2015) using auto.arima()

```
#order: non-seasonal part(p, d, q)
#seasonal: seasonal part of ARIMA
#method: fitting model
fitARIMA <- arima(df_75, order=c(1,1,1),seasonal = list(order = c(1,0,0),
period = 12),method="ML")
library(lmtest)
coeftest(fitARIMA)
```

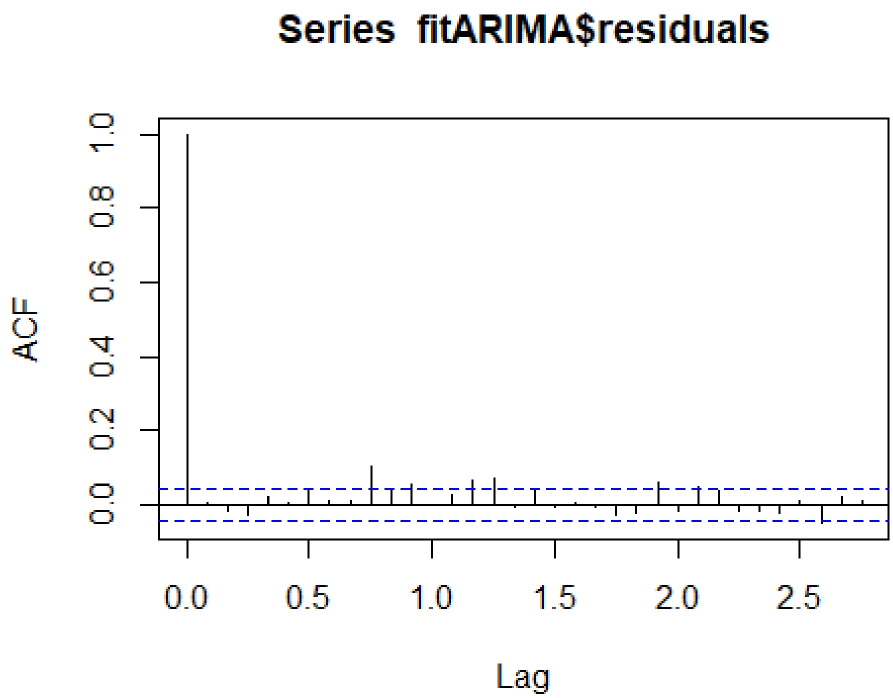
```
##
## z test of coefficients:
##
##       Estimate Std. Error  z value  Pr(>|z|)
## ar1   0.216614   0.035463   6.1082 1.007e-09 ***
## ma1  -0.666507   0.025750 -25.8839 < 2.2e-16 ***
## sar1  0.041316   0.022328   1.8504   0.06425 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
confint(fitARIMA)
```

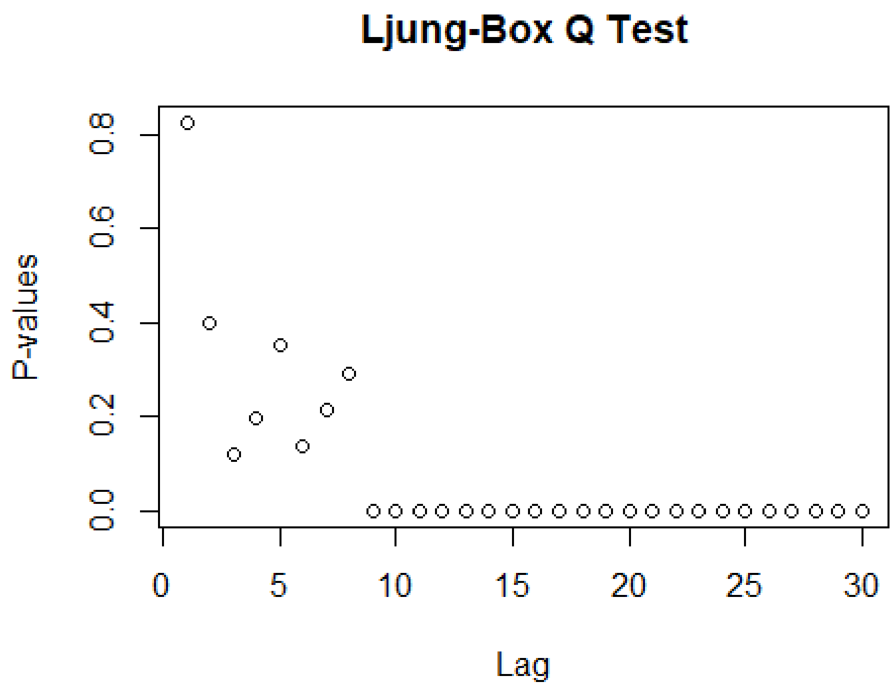
```
##             2.5 %      97.5 %
## ar1   0.147108523  0.28611988
## ma1  -0.716975463 -0.61603784
## sar1 -0.002445492  0.08507695
```

```
acf(fitARIMA$residuals)
```

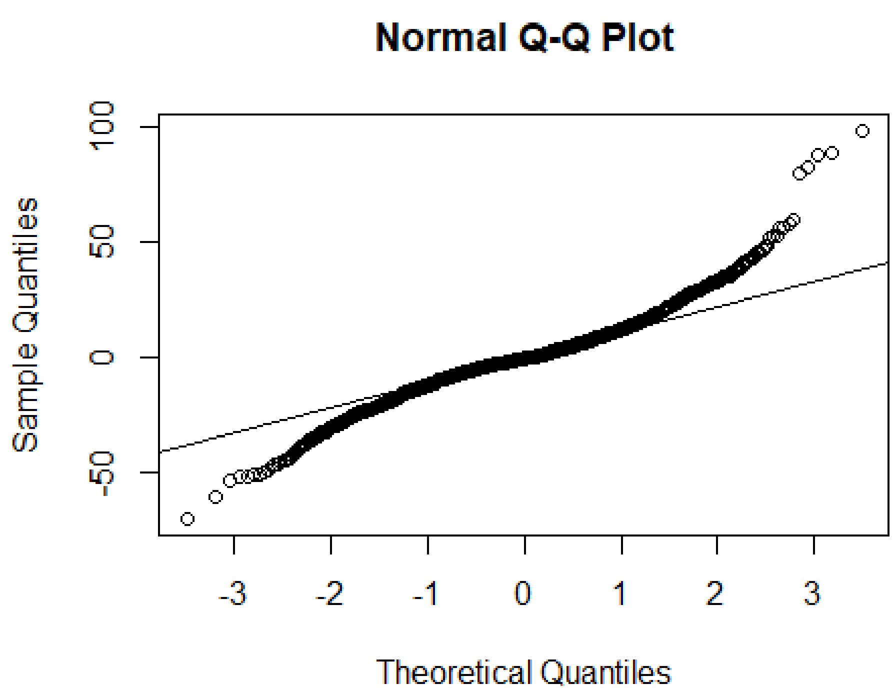
Q. Predict the values for the next 15 months (e.g., for the CO2 data, all of 2016 and the first 3 months of 2017).




```
library(FitAR)

## Warning: package 'FitAR' was built under R version 3.5.3

## Loading required package: lattice

## Loading required package: leaps

## Warning: package 'leaps' was built under R version 3.5.3

## Loading required package: ltsa

## Loading required package: bestglm

## Warning: package 'bestglm' was built under R version 3.5.3

##
## Attaching package: 'FitAR'

## The following object is masked from 'package:forecast':
##
##     BoxCox

boxresult<-LjungBoxTest (fitARIMA$residuals,k = 2, StartLag = 1)
plot(boxresult[,3],main= "Ljung-Box Q Test", ylab= "P-values", xlab= "Lag")
```




```r
qqnorm(fitARIMA$residuals)
qqline(fitARIMA$residuals)
```



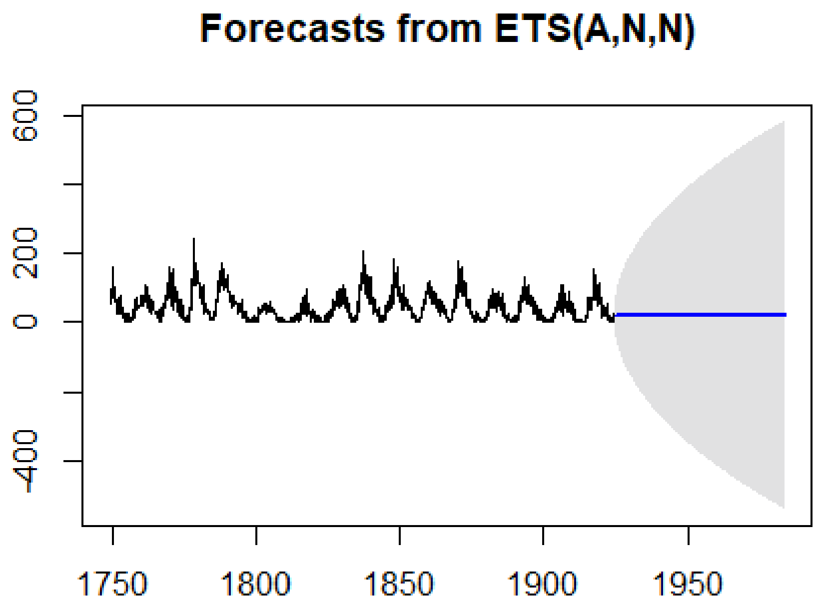
```r
auto.arima(df_75, trace=TRUE)
```

```
##
##  Fitting models using approximations to speed things up...
##
##  ARIMA(2,0,2)(1,0,1)[12] with non-zero mean : 17413.4
##  ARIMA(0,0,0)            with non-zero mean : 21324.77
##  ARIMA(1,0,0)(1,0,0)[12] with non-zero mean : 17715.03
##  ARIMA(0,0,1)(0,0,1)[12] with non-zero mean : 19186.54
##  ARIMA(0,0,0)            with zero mean     : 23183.14
##  ARIMA(2,0,2)(0,0,1)[12] with non-zero mean : 17445.62
##  ARIMA(2,0,2)(1,0,0)[12] with non-zero mean : 17412.53
##  ARIMA(2,0,2)            with non-zero mean : 17447.78
##  ARIMA(2,0,2)(2,0,0)[12] with non-zero mean : 17414.74
##  ARIMA(2,0,2)(2,0,1)[12] with non-zero mean : 17416.74
##  ARIMA(1,0,2)(1,0,0)[12] with non-zero mean : 17410.08
##  ARIMA(1,0,2)            with non-zero mean : 17445.4
##  ARIMA(1,0,2)(2,0,0)[12] with non-zero mean : 17414.76
##  ARIMA(1,0,2)(1,0,1)[12] with non-zero mean : 17411.24
##  ARIMA(1,0,2)(0,0,1)[12] with non-zero mean : 17443.33
##  ARIMA(1,0,2)(2,0,1)[12] with non-zero mean : 17416.18
##  ARIMA(0,0,2)(1,0,0)[12] with non-zero mean : 18537.75
##  ARIMA(1,0,1)(1,0,0)[12] with non-zero mean : 17437.63
##  ARIMA(1,0,3)(1,0,0)[12] with non-zero mean : 17411.74
##  ARIMA(0,0,1)(1,0,0)[12] with non-zero mean : 18964.08
##  ARIMA(0,0,3)(1,0,0)[12] with non-zero mean : 18351.77
##  ARIMA(2,0,1)(1,0,0)[12] with non-zero mean : 17411.83
##  ARIMA(2,0,3)(1,0,0)[12] with non-zero mean : 17413.13
##  ARIMA(1,0,2)(1,0,0)[12] with zero mean     : Inf
##
##  Now re-fitting the best model(s) without approximations...
##
##  ARIMA(1,0,2)(1,0,0)[12] with non-zero mean : 17444.48
##
##  Best model: ARIMA(1,0,2)(1,0,0)[12] with non-zero mean
```

```
## Series: df_75
## ARIMA(1,0,2)(1,0,0)[12] with non-zero mean
##
## Coefficients:
##          ar1      ma1      ma2    sar1     mean
##       0.9806  -0.4383  -0.1127  0.0454  44.7247
## s.e.  0.0046   0.0220   0.0205  0.0225   7.7248
##
## sigma^2 estimated as 225.3:  log likelihood=-8716.22
## AIC=17444.44   AICc=17444.48   BIC=17478.37
```

```r
arimaPred <- predict(fitARIMA,n.ahead = 708)
futurVal <- forecast(df_75,h=708, level=c(99.5))
```

```r
#forecast(futurVal)
plot(futurVal)
```




```r
#Arima RMSE
```

Q. Compute the rms error between the predicted and actual values.

```r
diffArima <- (sqrt(mean((df_25 - arimaPred$pred)^2)))
diffArima

## [1] 72.69348
```

Q. Based on your experiment, which method is better and why? HoltWinters or ARIMA?

Answer: In my case HoltWinters method has given better results than ARIMA. The rms error in HoltWinters was 68 whereas it was 72 in case of ARIMA.