Module 1.2
Examples of Time Series

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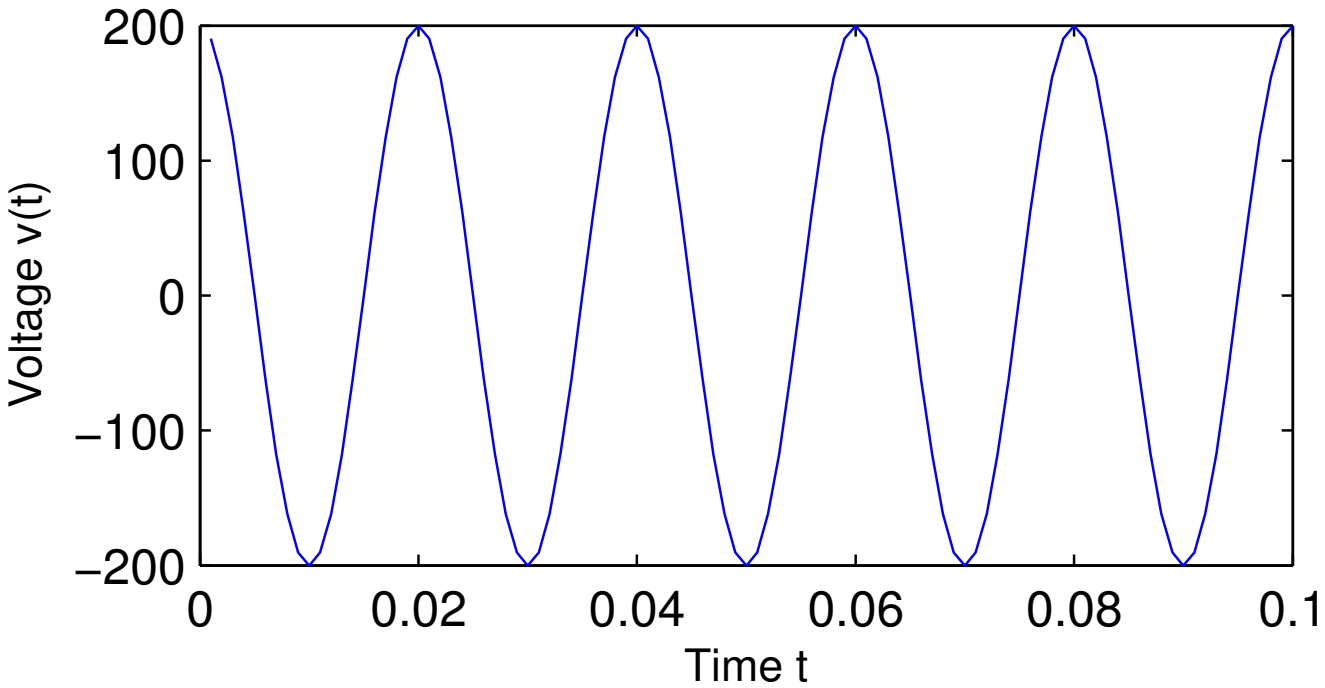
Deterministic Time Series

- Let $v(t) = 200\cos(2\pi ft)$ denote the AC voltage source of amplitude 200 volts and frequency $f = 50\frac{\text{cycles}}{\text{sec}}$.
- Let $v_0, v_1, v_2, \ldots v_{100}$ denote the observations of this voltage source at time $t = 0, \Delta t, 2\Delta t, \ldots k\Delta t, \ldots 100\Delta t$ when $\Delta t = 0.001$.
- A plot of this series is given below



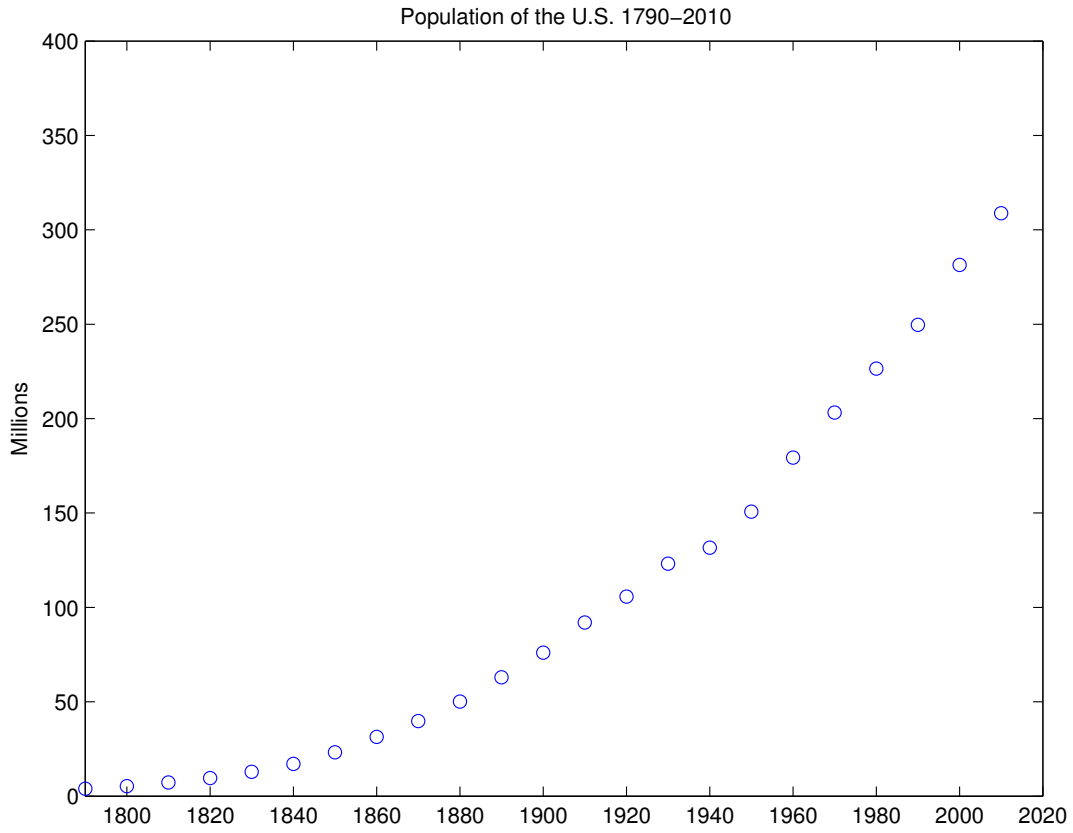
US Population data from 1790 - 2010

- The table of values of US population obtained from the US Census Bureau in units of million.

Year	US Population
1790	3,929,214
1800	5,308,483
1810	7,239,881
1820	9,638,453
1830	12,866,020
1840	17,069,453
1850	23,191,876
1860	31,443,321
1870	39,818,449
1880	50,155,783
1890	62,947,714
1900	75,994,575
1910	91,972,266
1920	105,710,620
1930	122,775,046
1940	131,669,275
1950	150,697,361
1960	179,323,175
1970	203,302,031
1980	226,545,805
1990	248,709,873
2000	281,421,906
2010	308,745,538

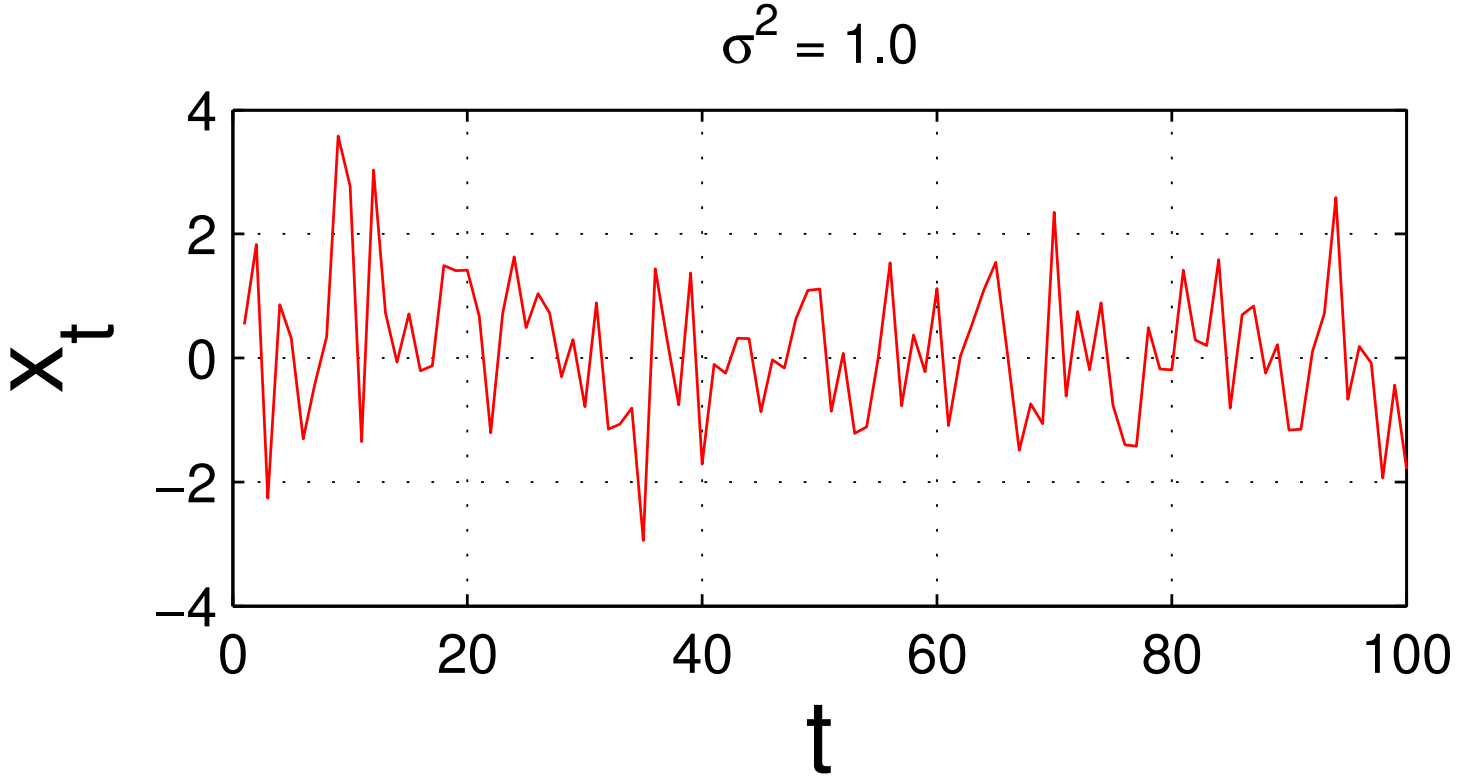
US Population data from 1790 - 2010

- A plot of this time series is given below.



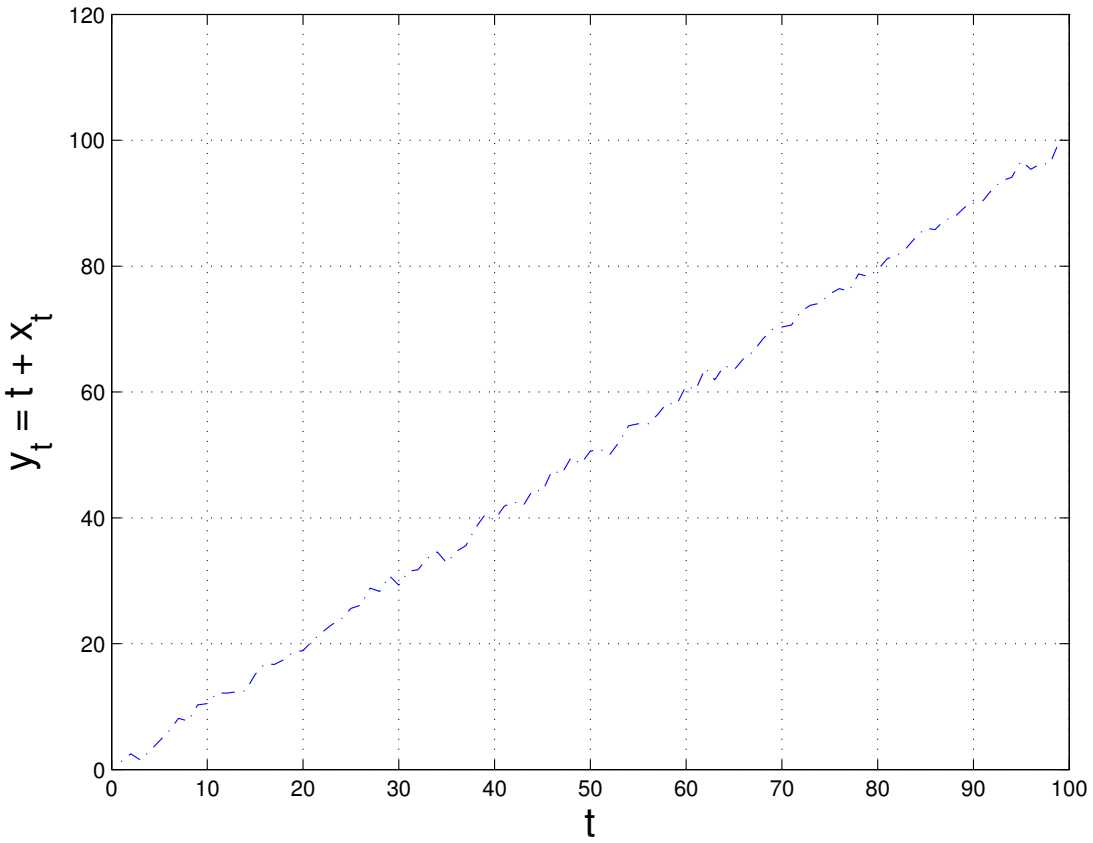
Gaussian Random Sequence

- Let $x_t \sim N(0, \sigma^2)$ be the mean zero Gaussian process.
- A plot of $\{x_t\}$ for $0 \leq t \leq 100$ for $\sigma^2 = 1.0$ is given below.



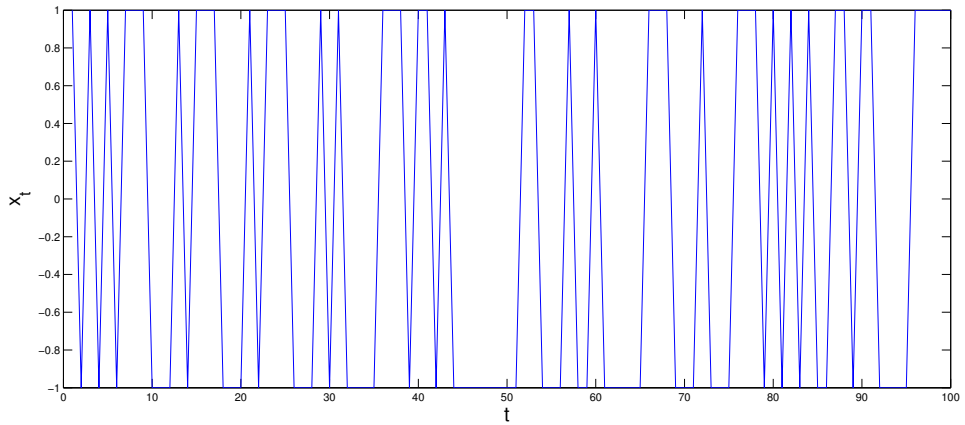
Gaussian Random Sequence

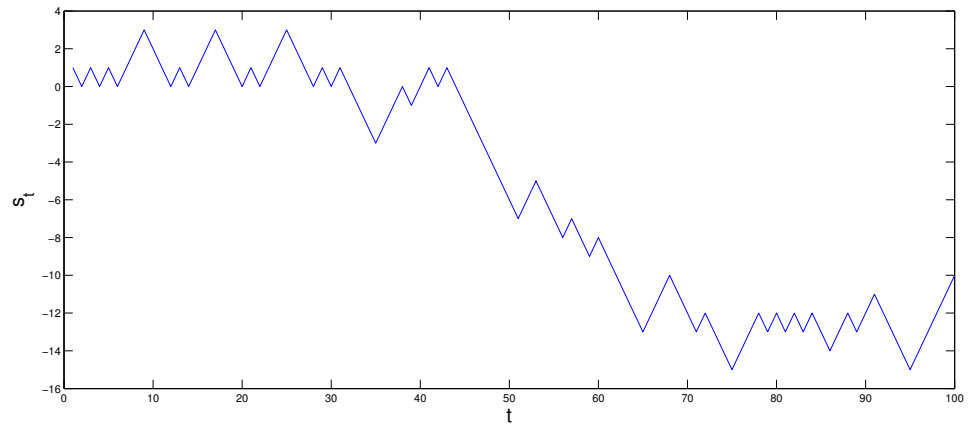
- Let $x_t \sim N(0, \sigma^2)$ be the mean zero Gaussian process.
- Plots of $y_t = t + x_t$ for $x_t \sim N(0, 1)$ and $0 \leq t \leq 100$ is given below.



Random Walk

- Let $x_t = 1$ with probability $1/2$
  and $x_t = -1$ with probability $1/2$
- Define $s_t = \sum_{t=1}^{t} x_t$ for $0 \leq t \leq 100$ for $s_0 = 0$.
- Plots of x_t and s_t and $0 \leq t \leq 100$ are given below.





Deadly Accidents in the USA

- The table of number of deaths resulting from automobile collisions on the road in each month from January to December in 2010

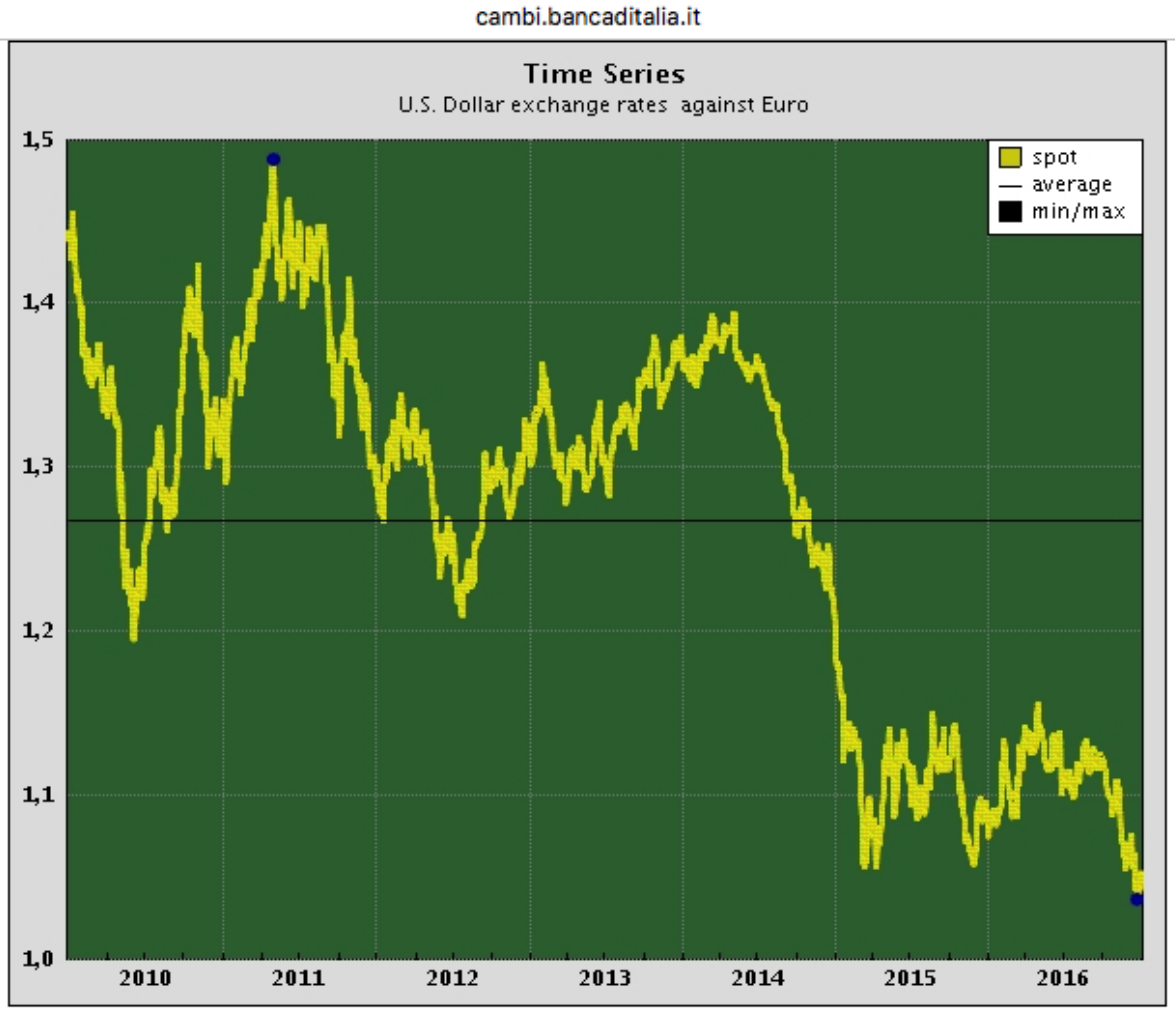
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2290	2016	2423	2777	2934	2795	3095	3083	3024	3056	2795	2597

- A plot of this time series is given below

https://en.wikipedia.org/wiki/List_of_motor_vehicle_deaths_in_U.S._by_year

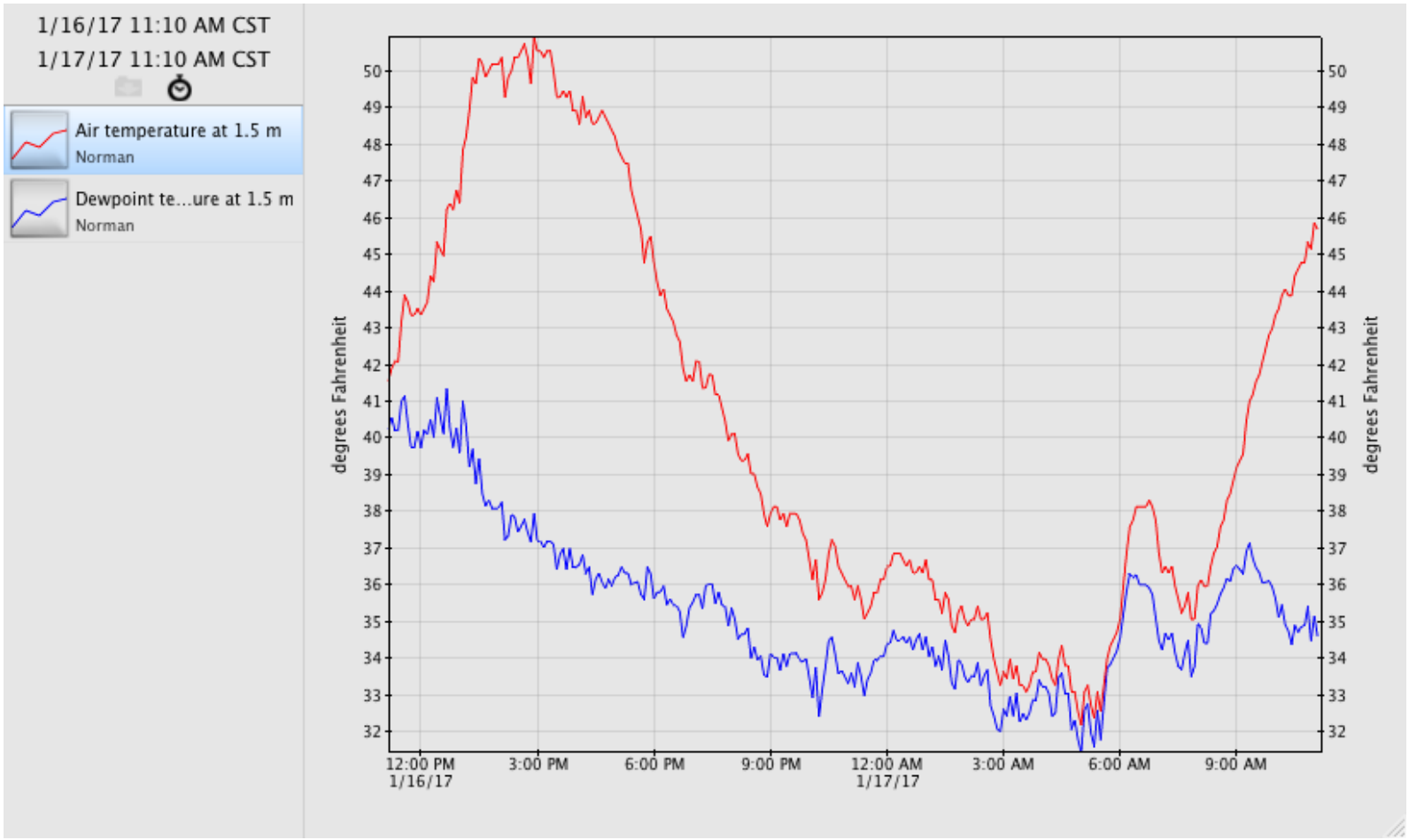
Foreign Exchange Rate - $ vs. Euro

- The table of foreign exchange rate between the US dollar and Euro.
- A plot of this time series is given below



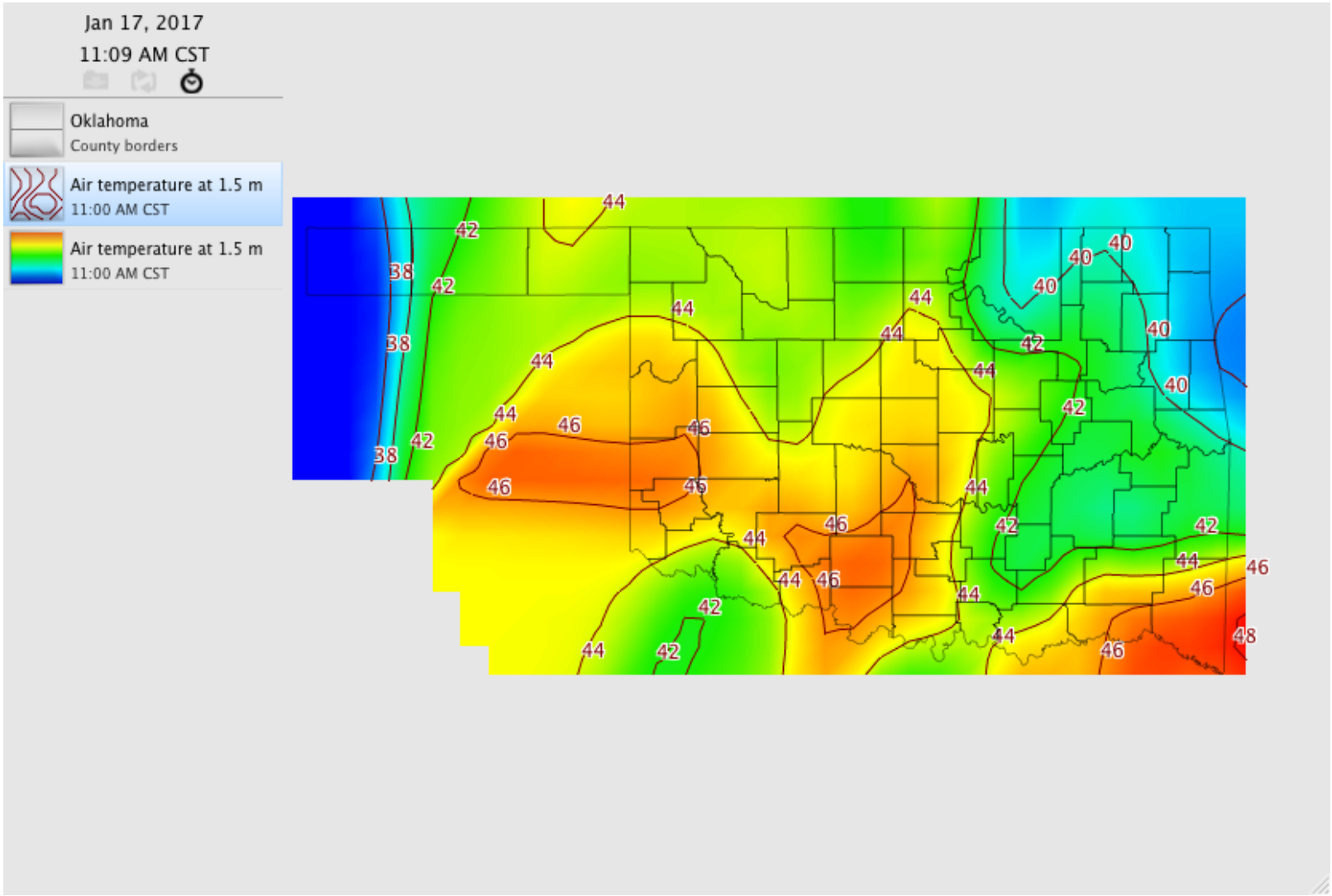
Temperature distribution - Mesonet data

- A plot of temperature variation in Oklahoma City is given below



Spatial variation of temperature - Mesonet data

- Contours of constant temperature across Oklahoma are given below - an example of spatial variation



Summary - 1

- A picture is worth a million words
- Real world time series can be decomposed into different components
  - A trend component - μ_t
  - A seasonal component s_t
  - A random component x_t
- Thus, y_t is an observed series, then $y_t = \mu_t + s_t + x_t$

Summary - 2

- We need to develop methods to estimate the trend $\hat{\mu}$ and seasonal part $\hat{s}_t$
- Then extract the random part as $x_t = y_t - \hat{\mu}_t - \hat{s}_t$
- It is assumed that the residual random part x_t can be modeled by a discrete time, stationary stochastic process

Problem

- From the data available from the US Government, compute the per capita deaths per 100,000 instead of the gross number of deaths in every month. Plot and comment at the behavior of this time series data.