Data Visualization

BBM 101 - Introduction to Programming I

Hacettepe University
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Fuat Akal, Aykut Erdem, Erkut Erdem, Vahid Garousi

Today

A Little Bit on Data Science

- What is Data Science?
- Why learn Data Science?
- How do we learn Data Science?

Plotting with Matplotlib

- How to read data from a file?
- How to work with that data?
- How to graphically display facts about that data using numpy and pyplot?

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20th Century Innovation

Engineering and Computer Science played key role

- Cars
- Airplanes
- Power grid
- Television
- Air conditioning and central heating
- Nuclear power
- Digital computers
- The internet

For more:

http://camdp.com/blogs/21st-century-problems

But how about these 20th Century questions?

Does fertilizer increase crop yields?

Does Streptomycin cure Tuberculosis?

Does smoking cause lung-cancer?

What is the difference

Deterministic versus random

Deductive versus empirical

 Solutions deduced mostly from theory versus solutions deduced from mostly from data

Data

- Does fertilizer increase crop yields? Answer: Collect and analyze agricultural experimental data
- Does Streptomycin cure Tuberculosis? Collect and analyze randomized trials data
- Does smoking cause lung-cancer? Collect and analyze observaLonal studies data
- Analyzing these was the job of: boring ol' statisticians

21st Century





21st Century

"I keep saying the sexy job in the next ten years will be statisticians. People think I'm joking, but who would've guessed that computer engineers would've been the sexy job of the 1990s?"

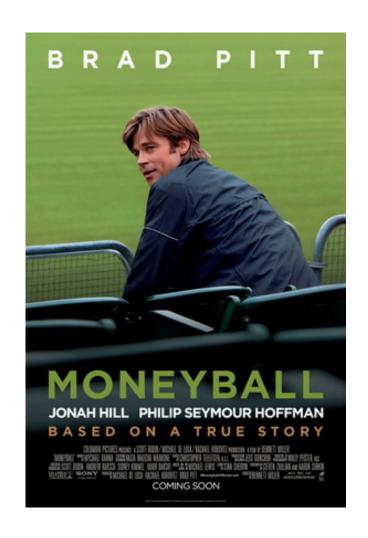
- Hal Varian, Google's Chief Economist

Hal Varian Explains...

"The ability to take **data** – to be able to **understand** it, to process it, to extract value from it, to visualize it, to communicate it's going to be a hugely important skill in the next decades, not only at the professional level but even at the educational level for elementary school kids, for high school kids, for college kids. Because now we really do have essentially free and ubiquitous data."

Hal Varian

Data Science Success Stories

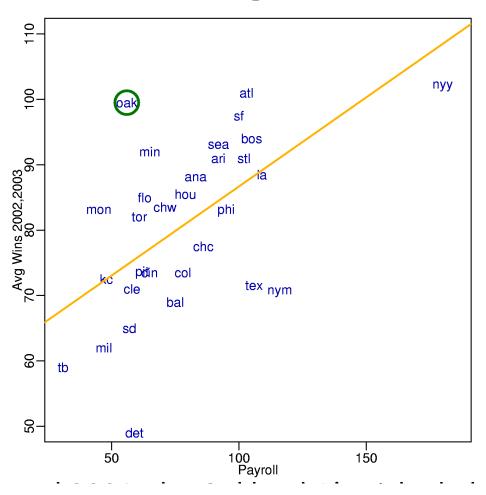


The Data Scientist

Actual Hollywood

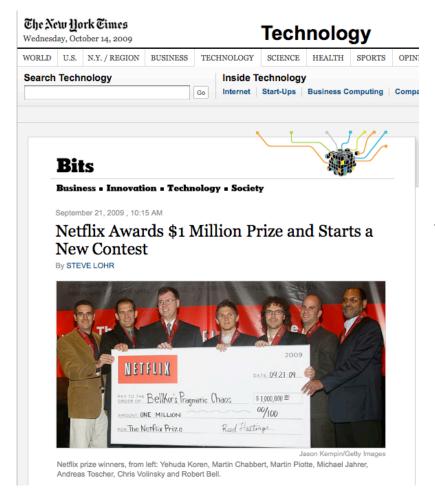


Money Ball



Start around 2001, the Oakland A's picked players that scouts thought no good but data said otherwise

Netflix Challange



In Sept 2009 a team lead by Chris Volinsky from Statistics Research AT&T Research was announced as winner!

Ad-targeting





Making Sense of Big Data

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www.tableausoftware.com/big-data

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How do we do Data Science?

- Science: determining what questions can be answered with data and what are the best datasets for answering them
- Computer programming: using computers to analyze data
- Data wrangling: getting data into analyzable form on our computers
- Statistics: separating signal from noise
- Machine learning: making predictions from data
- **Communication:** sharing findings through visualization, stories and interpretable summaries

Today

A Little Bit on Data Science

- What is Data Science?
- Why learn Data Science?
- How do we learn Data Science?

Visualization

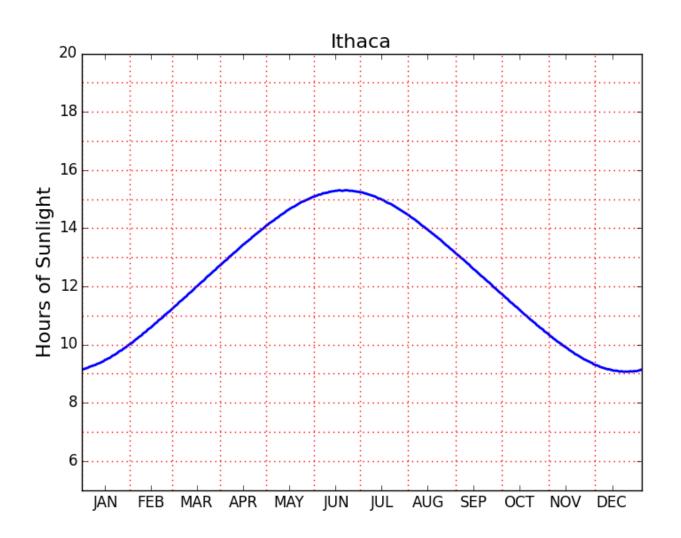
- How to read data from a file?
- How to work with that data?
- How to graphically display facts about that data using numpy and pyplot?

The Problem

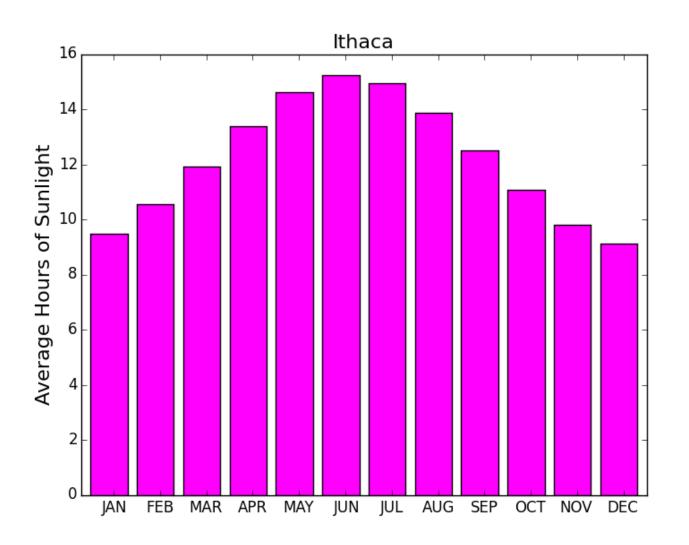
- For various cities around the world, we would like to examine the "Sun Up" time throughout the year.
- How does it vary from day to day?
- What are the monthly averages?

Sun Up Time = Sunset Time – Sunrise Time

How Does Sun-Up Time Vary Day-to-Day?



How Does Sun-Up Time Vary Month-to-Month?



The Task Before Us...

- 1. Find a website where the data can be found.
- 2. Get that data into a file on our computer.
- 3. Understand how the data is laid out in the file.
- 4. Write python code that gets that data (or some aspect of it) into your Python environment.

Where Do We Get the Data?

• Lots of choices. Google "Sunset Sunrise times"

 We will use the U.S. Naval Observatory data service:

• Visit:

http://www.usno.navy.mil/

From the Website...

Astronomical Applications

Data Services

Sun and Moon rise and set times, Moon phases, eclipses, seasons, positions of solar system objects, and other data

Complete Sun and Moon Data for One Day
Sun or Moon Rise/Set Table for One Year
Phases of the Moon
more...

We Downloaded Rise/Set Data For a Number of Cities

Anaheim Baltimore Boston Cleveland Ithaca LosAngeles Moscow Philadelphia Phoenix SanFrancisco Seattle Teheran

Anchorage Bangkok BuenosAires Denver Johannesburg MexicoCity NewDelhi Tokyo

Arlington Beijing Cairo Detroit KansasCity Miami NewYork Pittsburgh Seoul Toronto

Athens Berlin Chicago Honolulu Lagos Milwaukee Oakland RiodeJaneiro Sydney Washington

Atlanta Bogata Cincinnati Houston London Minneapolis Paris Rome Tampa Wellington

One .dat File Per City

RiseSetData

Anaheim.dat Anchorage.dat Arlington.dat

•

Toronto.dat Washington.dat Wellington.dat We put all these files in a directory called RiseSetData

.dat and .txt files
are common ways
to house simple
data. Don't worry
about the difference.

.txt and .dat Files have Lines

```
abcd
123 abc d fdd
xyz
3.14159 2.12345
```

There is an easy way to read the data in such a file line-by-line

Read and Print the Data in Ithaca.dat

```
FileIO.py
FileName = 'RiseSetData/Ithaca.dat'
f = file(FileName, 'r')
for s in f:
    print s
f.close()
```

RiseSetData and FileIO.py must be in the same folder.

Ithaca.dat

There are 33 lines

```
Ithaca
W07629N4226
     R S
               R S
                     R S
                          R S
          R S
                                R S
                                     R S
                                          R S
                                                R S
                                                     R S
                                                          R S
                                                                R S
               RS
                    R S
    R S
          R S
                          R S
                                R S
                                     R S
                                          R S
                                                R S
                                                     R S
                                                           R S
                                                                R S
     R S
               R S
                     R S
                          R S
                                     R S
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                                                R S
                                                     R S
                                                           R S
                                                                R S
28
               R S
                     R S
                          R S
                                                                R S
                                R S
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                                               R S
                                                     R S
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29
                                                     RS
     R S
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                                                RS
                                                     R S
                                                          R S
31
                          R S
     R S
          R S
               R S
                     R S
                                R S
                                     R S
```

The provider of the file typically tells you how the data is structured

From the Naval Observatory Website

 The first line names the city and the second line encodes its latitude and longitude, e.g.,

> Ithaca W07629N4226

and ...

From the Naval Observatory Website

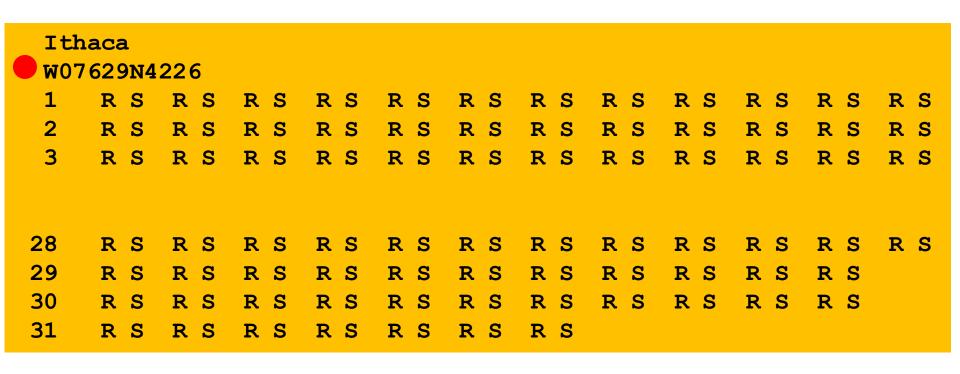
- The rise and set times are then specified day-byday with the data for each month housed in a pair of columns.
- In particular, columns 2k and 2k+1 have the rise and set times for month k (Jan=1, Feb = 2, Mar = 3, etc.)
- Column 1 specifies day-of-the-month, 1 through 31. Blanks are used for nonexistent dates (e.g., April 31).

The Data for a Particular City is Housed in a 33-line .dat file

```
Ithaca
 W07629N4226
     R S
          R S
                R S
                      R S
                           R S
                                 R S
                                      R S
                                            R S
                                                 R S
                                                       R S
                                                            R S
                                                                  R S
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                     R S
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28
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                                            R S
                                                       R S
                                                            R S
31
     R S
          R S
                R S
                      R S
                           R S
                                 R S
                                      R S
```

Line 1 has the name of the city

The Data for a Particular City is Housed in a 33-line .dat file



Line 2 encodes its longitude and latitude

Helper Function: LongLat

A latlong string has length 11, e.g. W08140N4129

```
def LongLat(s):
    """ Returns a tuple (Long, Lat) of floats that are the
    equivalent (in degrees) of the longitude and latitude
    encoded by s.
    PredC: s an 11-character string of the form 'cdddmmCDDMM'
    where cdddmm specifies longitude in degrees and minutes with
    c = 'W' or 'E' and CDDMM species latitude in degrees and
    minutes with C = 'N' or 'S'
    11 11 11
    Long = float(s[1:4])+float(s[4:6])/60
    if s[0]=='E':
        Long = -Long
    Lat = float(s[7:9])+float(s[9:11])/60
    if s[6]=='S':
        Lat = -Lat
    return (Lat, Long)
```

The Data for a Particular City is Housed in a 33-line .dat file

```
Ithaca
W07629N4226
                R S
                    R S
                         R S
            R S
                             R S
                                 R S
                                      R S
                                          R S
                                              R S
                                                  R S
   R S
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    R S
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    R S
                R S R S
30
       RS RS
                         RS RS RS RS
                                              R S
31
    R S
        R S
                R S
                         R S
                             R S
```

The remaining lines house the rise-set data.

Each R and S is a length-4 string: '0736'

Helper Function: ConvertTime

def ConvertTime(s): Returns a float that is the equivalent (in hours) of the time encoded by s. '2145' means 9:45 pm. PredC: s a 4-character string of the form hhmm that specifies time. ** ** ** x = float(s[:2]) + float(s[2:]) / 60

- In comes a length-4 string and back comes a float that encodes the time in hours
- '0736' ----> 7 + 36/60 hours ----> 7.6

return x

The Data for a Particular City is Housed in a 33-line .dat file

```
Ithaca
W07629N4226
             R S
                 R S
                      R S
                          R S
                               R S
                                   R S
                                        R S
                                            R S
                                                     R S
    R S
       R S
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            R S
                 R S
                      R S
                          RS
                               RS RS RS RS
                                                 R S
31
        R S
             R S
                 R S
                               R S
```

Day -Number followed by 12 rise-set pairs, one pair for each month

The Data for a Particular City is Housed in a 33-line .dat file

```
Ithaca
W07629N4226
               R S
                    R S
                         R S
                              R S
                                   R S
                                        R S
                                             R S
                                                   R S
                                                        R S
                                                             R S
    R S
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                                                        R S
31
     R S
         R S
              R S
                         R S
                                   R S
                    R S
                              R S
```

Day -Number followed by 11 rise-set pairs, one pair for each month except February

The Data for a Particular City is Housed in a 33-line .dat file

```
Ithaca
W07629N4226
    R S
                             R S
         R S
              R S
                   R S
                        R S
                                  R S
                                       R S
                                            R S
                                                       R S
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    R S
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30
    R S
        RS RS
                                                      R S
31
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         R S
              R S
                   R S
                        R S
                             R S
                                  R S
```

Day -Number followed by 7 rise-set pairs, one pair for each 31-day month

Recall the Motivating Problem

 For various cities around the world, we would like to examine the "Sun Up" time throughout the year.

How does it vary from day to day?

What are the monthly averages?

Daylight

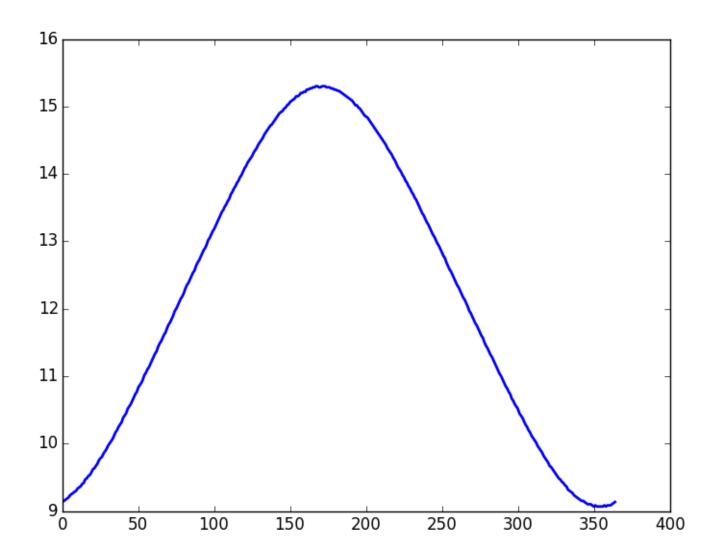
```
def SunUp(CityName):
    FileName = 'RiseSetData/'+CityName+'.dat'
    f = file(FileName, 'r');
    lineNum = 0
                                Recall how split works...
    for s in f:
                                s = '1\ 0535\ 0816\ 0542\ 0713'
         parts = s.split()
                               x = s.split()
                               print x
         lineNum+=1
                                ['1','0535','0816','0542','0713']
         if lineNum == 1:
             City = parts[0]
         elif lineNum == 2:
             Lat, Long = LatLong(parts[0])
         else:
              Code that builds the RiseTime and SetTime arrays
   f.close()
   return (City, Lat, Long, SetTime - RiseTime)
```

Building RiseTime and SetTime arrays

```
# Remaining lines have rise/set pairs
day = int(parts[0])
# Get all the rise and set times
RiseTimeList = ConvertTime(parts[1:len(parts):2])
SetTimeList = ConvertTime(parts[2:len(parts):2])
p = len(RiseTimeList)
for k in range(p):
    if day<=28:
        # All months have at least 28 days
        starts = [0,31,59,90,120,151,181,212,243,273,304,334]
        dayIndex = day + starts[k] - 1
    elif day==29 or day==30:
        # All months except February have a day 29 and a day 30
        starts = [0, 59, 90, 120, 151, 181, 212, 243, 273, 304, 334]
        dayIndex = day + starts[k] - 1
    else:
        # Only January, March, May, July, August, October, and December have
        # a day 31.
        starts = [0,59,120,181,212,273,334]
        dayIndex = day + starts[k] - 1
    RiseTime[dayIndex] = RiseTimeList[k]
    SetTime[dayIndex] = SetTimeList[k]
```

```
# Plot a 1-dim numpy array
City, Lat, Long, D = SunUp('Ithaca')
plot(D)
show()
```

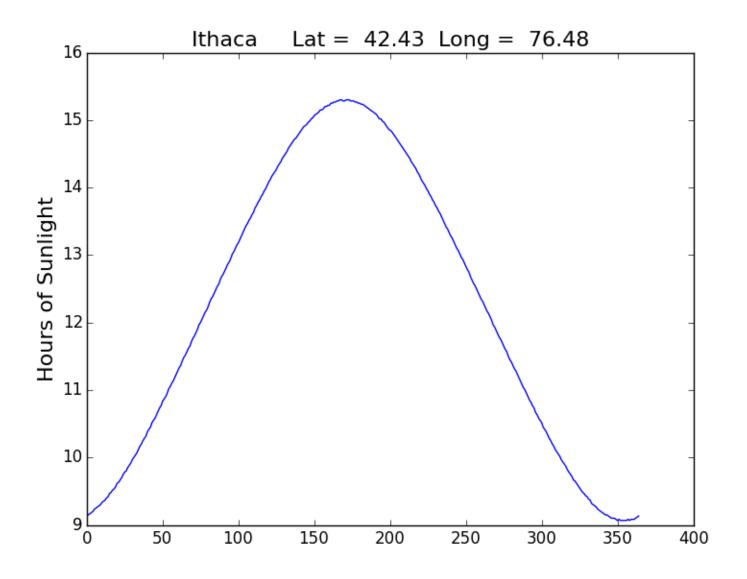
This is how you display the values in a numpy array like D.



How about a title and a labeling of the y-axis?

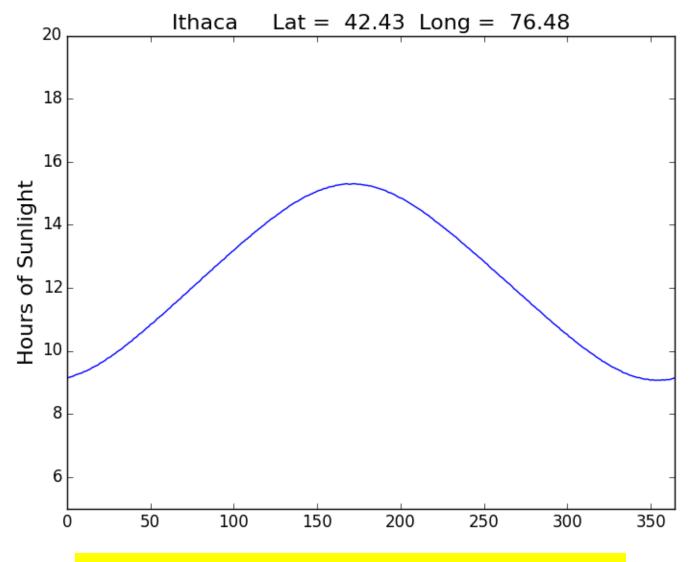
```
# Plot a 1-dim numpy array
City, Lat, Long, D = SunUp('Ithaca')
plot(D)

# The title
titlestr = '%s Lat = %6.2f Long = %6.2f' % (City,Lat,Long)
title(titlestr,fontsize=16)
# Label the y-axis
ylabel('Hours of Sunlight',fontsize=16)
show()
```



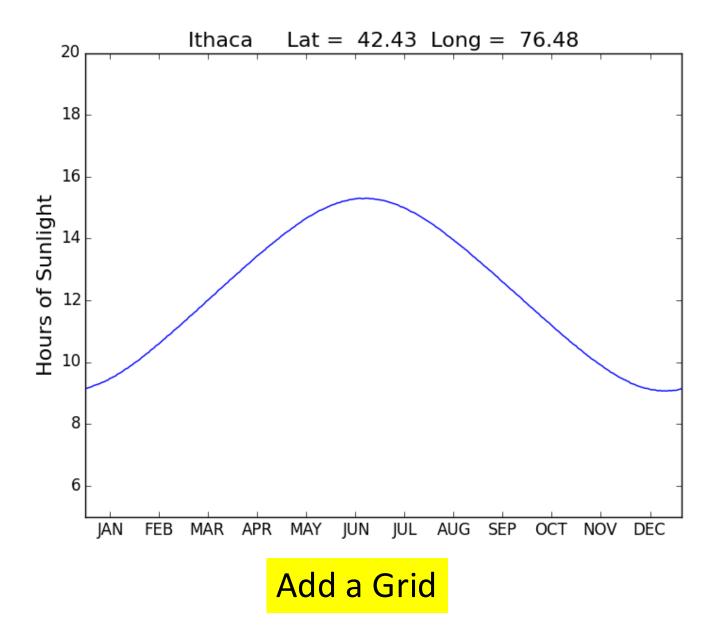
Modify the x range and the y range

```
# Plot a 1-dim numpy array
City, Lat, Long, D = SunUp('Ithaca')
plot(D)
# The title
titlestr = '%s Lat = %6.2f Long = %6.2f' % (City,Lat,Long)
title(titlestr,fontsize=16)
# Label the y-axis
ylabel('Hours of Sunlight',fontsize=16)
# set the range of x and the range of y
xlim(0,364)
ylim(5,20)
show()
```



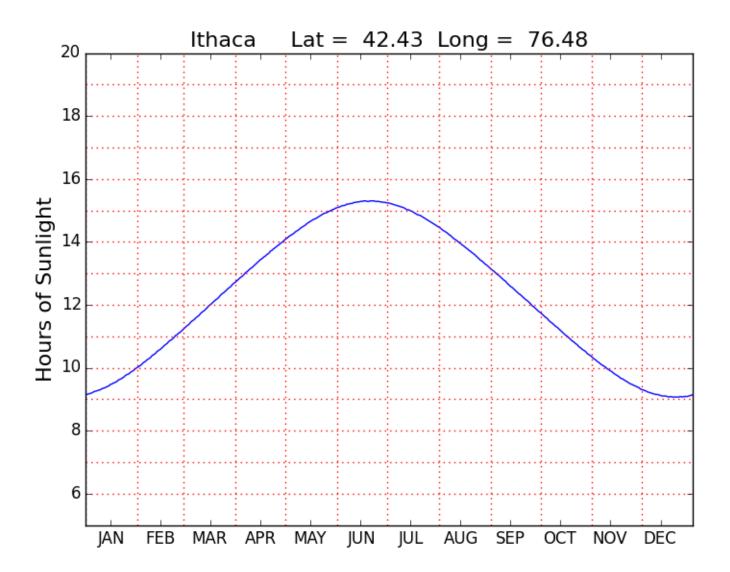
Label the x-axis with month names

```
# Plot a 1-dim numpy array
City, Lat, Long, D = SunUp('Ithaca')
plot(D)
# The title
titlestr = '%s Lat = %6.2f Long = %6.2f' % (City, Lat, Long)
title(titlestr,fontsize=16)
# Label the y-axis
ylabel('Hours of Sunlight',fontsize=16)
# set the range of x and the range of y
xlim(0,364)
ylim(5,20)
# Position ticks along the x-axis and label them
c = ['JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC']
t = [15, 45, 75, 105, 135, 165, 195, 225, 255, 285, 315, 345]
xticks( t,c)
show()
```



```
# Plot a 1-dim numpy array
City, Lat, Long, D = SunUp('Ithaca')
plot(D)
# The title
titlestr = '%s Lat = %6.2f Long = %6.2f' % (City, Lat, Long)
title(titlestr,fontsize=16)
# Label the y-axis
ylabel('Hours of Sunlight',fontsize=16)
# set the range of x and the range of y
xlim(0,364)
vlim(5,20)
# Position ticks along the x-axis and label them
c = ['JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC']
t = [15, 45, 75, 105, 135, 165, 195, 225, 255, 285, 315, 345]
xticks( t,c)
# Draw a grid
for k in range (6,20):
    # Draw horizontal line from (0,k) to (65,k)
    plot(array([0,365]),array([k,k]),color='red',linestyle=':')
for k in [0, 31, 59, 90, 120, 151, 181, 212, 243, 273, 304, 334]:
    # Draw vertical line from (k,5)) to (k,20))
    plot(array([k,k]),array([5,20]),color='red',linestyle=':')
```

show()



Monthly Averages

```
def MonthAverages(CityName):
    x = zeros((12,1))
    City, Lat, Long, D = SunUp(CityName)
    start = [0, 31, 59, 90, 120, 151, 181, 212, 243, 273, 304, 334]
    finish = [30, 58, 89, 119, 150, 180, 211, 242, 272, 303, 333,364]
    for k in range(12):
        z = D[start[k]:finish[k]]
        x[k] = sum(z)/len(z)
    return x
```

A Bar Plot

```
M = MonthAverages('Ithaca')
bar(range(12), M, facecolor='magenta')
xlim(-.2,12)
ylabel('Average Hours of Sunlight')
title(A.City, fontsize=16)
show()
```

