HW 6 Problem 1

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The goal of this problem is to take publicly available methane data and fit it to an exponential function. We also need to compare the goodness of the fit for several year ranges.

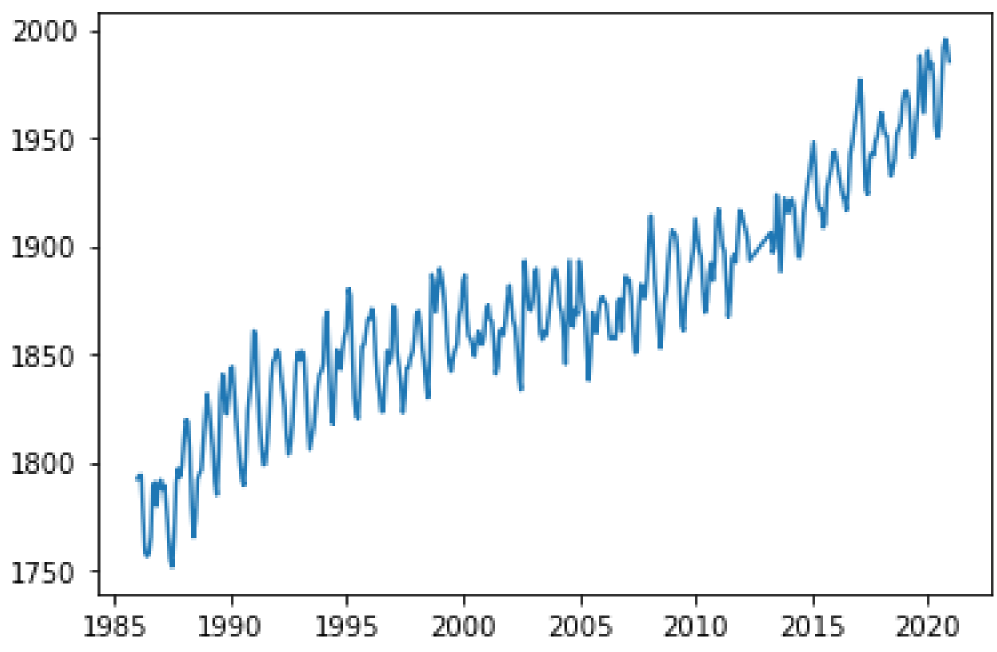
First, our import statements.

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
from chi_square_fit import chi_square_fit
from fitting_file import fitting
```

Next, read in the text file provided from the website https://gml.noaa.gov/ccgg/trends_ch4/ The detector gives values of -999.99 for 10 measurements. We need to drop these data points.

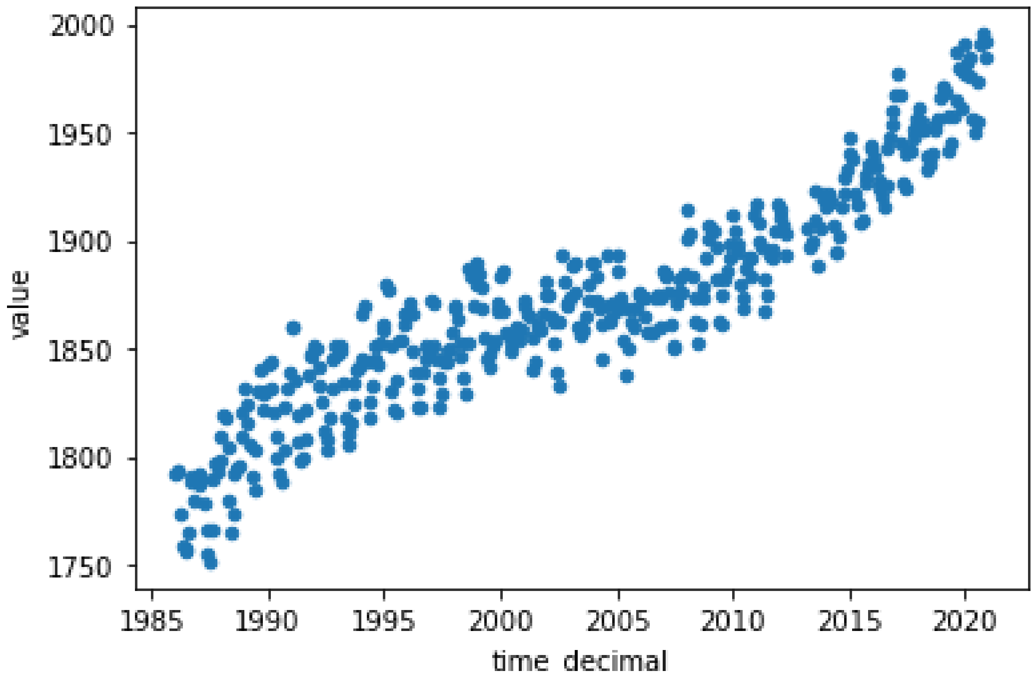
```
filename = "Month.txt"
data2 = pd.read_csv(filename,skiprows = 139, sep = " ",na_values = [-999.99,-99.99])
# Dropping both na_values is not necessary, because -99.99 only occurs in the rows where -999.99 occurs
# and those values are dropped.
data = data2.dropna()
plt.plot(data["time_decimal"], data["value"])
```

```
[<matplotlib.lines.Line2D at 0x7fc108994220>]
```




```
data.plot(kind = 'scatter', x = 'time_decimal', y = 'value')
```

```
<AxesSubplot:xlabel='time_decimal', ylabel='value'>
```




```
#data.drop( data[ data['value'] == -999.99 ].index , inplace=True)
```

It will be easier to manipulate the data if they are `numpy` arrays.

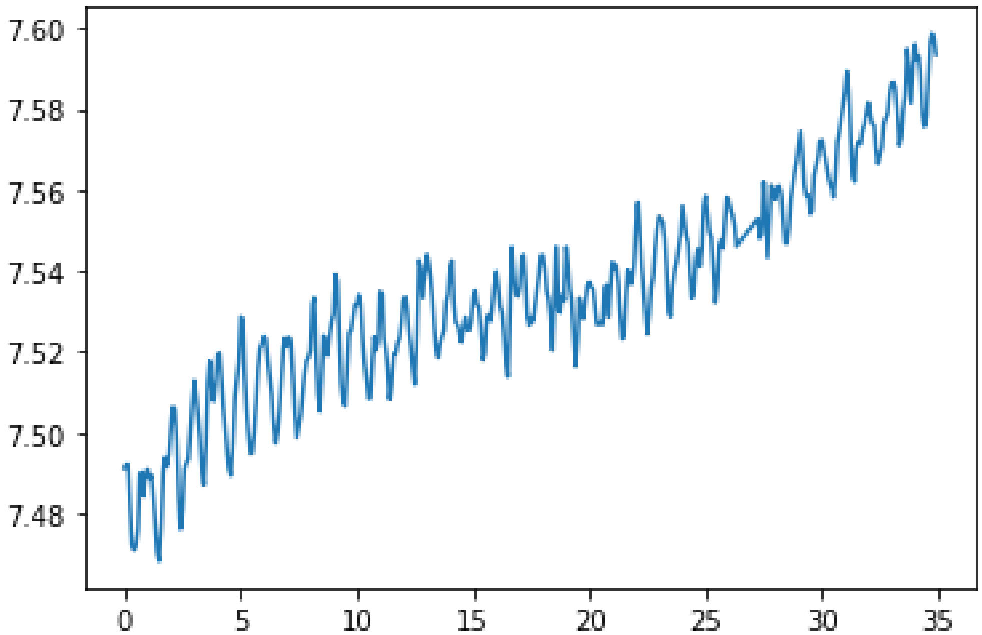
Additionally, if we want to fit the original data to an exponential, we should take the log of the y values and fit log(y) to a line. By error propogation, the standard deviation σ needs to be taken as $\frac{1}{\sigma}$, since $\frac{\partial}{\partial\sigma}\ln(\sigma) = \frac{1}{\sigma}$

```
graph_value = data['value'].to_numpy()
graph_time = data['time_decimal'].to_numpy()
graph_dev = data['value_std_dev'].to_numpy()

graph_value = np.log(graph_value)
graph_dev
graph_dev = graph_dev/graph_value
print(graph_time[0])
graph_time = graph_time - 1986.0
```

```
1986.0
```

```
plt.plot(graph_time, graph_value)
```

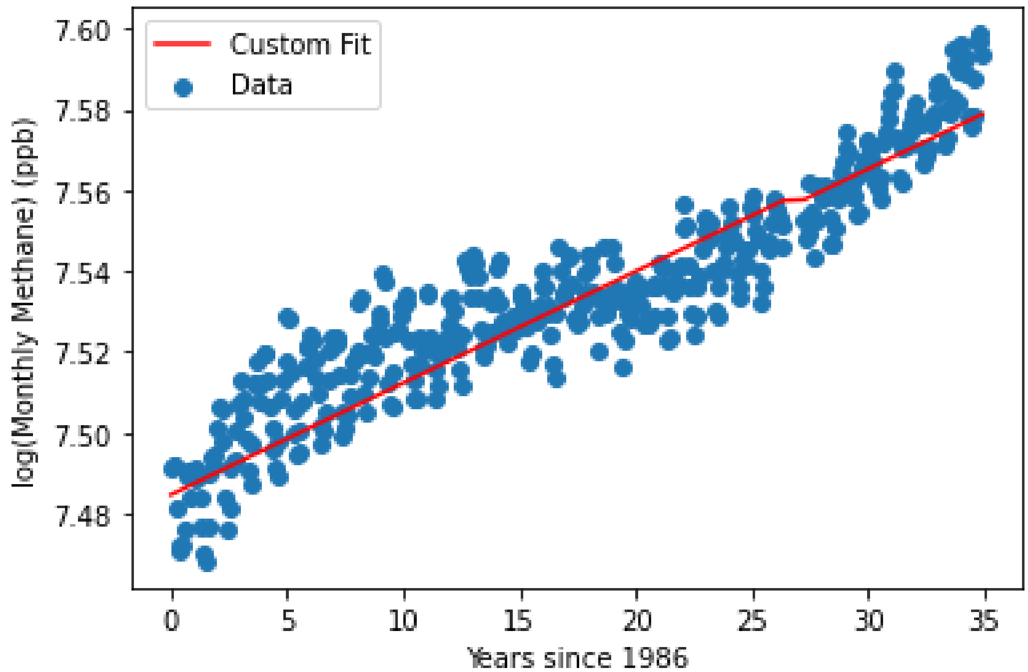
```
[<matplotlib.lines.Line2D at 0x7fc10878be80>]
```



Use the `chi_square_fit.py` for this section. This will give us the fitline and the scatter plot for the data.

```
fit = chi_square_fit(graph_time,graph_value,graph_dev)
print(fit)
print (' slope =', fit[1], ' +- ', fit[3])
print (' intercept =', fit[0], '+-', fit[2])
if len(data) - 2 > 0 :
    print (' chi-square/d.o.f. = ', fit[4]/(len(data)-2))
else :
    print (' chi-square/d.o.f. undefined')
data_val = np.linspace(0,35,410)
fitline = fit[0] + fit[1] * data_val

plt.scatter(graph_time, graph_value, label = "Data")
plt.plot(graph_time,fitline, 'r', label = "Custom Fit")
plt.xlabel("Years since 1986")
plt.ylabel("log(Monthly Methane) (ppb)")
plt.legend()
plt.show()
```

```
(7.48464197159303, 0.002690268609430559, 0.11692699029280375, 0.005205092340129078, 0.0319796167751688)
 slope = 0.002690268609430559  +-  0.005205092340129078
 intercept = 7.48464197159303 +- 0.11692699029280375
 chi-square/d.o.f. =  7.838141366462941e-05
```



We can do this same analysis for different years to see how the fit is at smaller segments.

```
def take_years(yr):
    """
    Takes data from a select year and centers it as years from 1985.

    Args: yr - takes in a year between 1986 and 2021.

    Returns: returns a list -- first entry being a list of time values in floats
                            -- second entry being list of values in floats
                            -- third entry being list of standard deviation in floats
    """
    diff = yr - 1985
    mon = 12*diff
    back = mon - 12
    va = graph_value[back:mon]
    ti = graph_time[back:mon]
    de = graph_dev[back:mon]
    print(va)
    print(ti)
    print(de)
    return [ti,va,de]
```

```
take_years(1986)
```

```
[7.49122151 7.492125   7.49217517 7.48102598 7.47208565 7.47098168
 7.47184675 7.47603627 7.48945121 7.49025019 7.48421695 7.489753  ]
[0.         0.08493151 0.16164384 0.24657534 0.32876712 0.41369863
 0.49589041 0.58082192 0.66575342 0.74794521 0.83287671 0.91506849]
[1.47372494 4.5674625  2.55199586 0.73519328 0.91005381 1.81636103
 2.78512136 3.22764619 5.16993821 4.27489058 1.65281152 2.2030099 ]
```

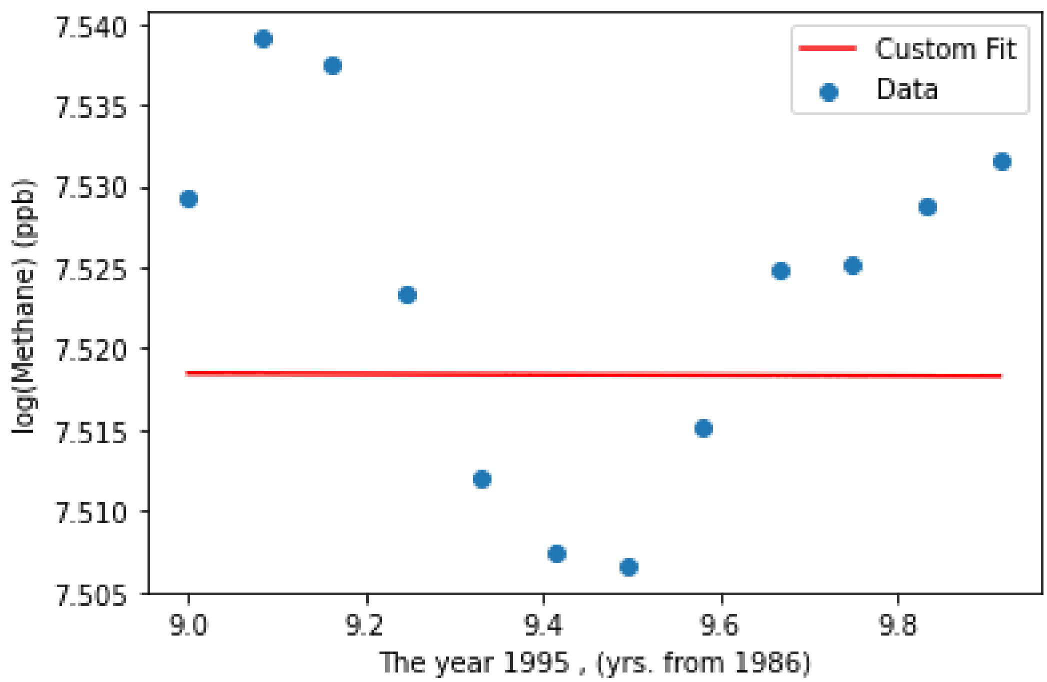
```
[array([0.        , 0.08493151, 0.16164384, 0.24657534, 0.32876712,
```

```
        0.41369863, 0.49589041, 0.58082192, 0.66575342, 0.74794521,
        0.83287671, 0.91506849]),
 array([7.49122151, 7.492125  , 7.49217517, 7.48102598, 7.47208565,
        7.47098168, 7.47184675, 7.47603627, 7.48945121, 7.49025019,
        7.48421695, 7.489753  ]),
 array([1.47372494, 4.5674625 , 2.55199586, 0.73519328, 0.91005381,
        1.81636103, 2.78512136, 3.22764619, 5.16993821, 4.27489058,
        1.65281152, 2.2030099 ])]
```

```
def yr_fit(yr):
    """
    Fits the data for a specific year.

    Args: yr must be an int.

    Returns: Plot returned, value returned is chi^2, which is a float.

    """
    dat = take_years(yr)
    fit = chi_square_fit(dat[0],dat[1],dat[2])
    print (' slope =', fit[1], ' +- ', fit[3])
    print (' intercept =', fit[0], '+-', fit[2])
    if len(data) - 2 > 0 :
        print (' chi-square/d.o.f. = ', fit[4]/(len(data)-2))
    else :
        print (' chi-square/d.o.f. undefined')
    data_val = np.linspace(0,1,12)
    fitline = fit[0] + fit[1] * data_val
    plt.scatter(dat[0], dat[1], label = "Data")
    plt.plot(dat[0],fitline, 'r', label = "Custom Fit")
    plt.xlabel("The year " + str(yr)+ " , (yrs. from 1986)")
    plt.ylabel("log(Methane) (ppb)")
    plt.legend()
    plt.show()
    return None
```

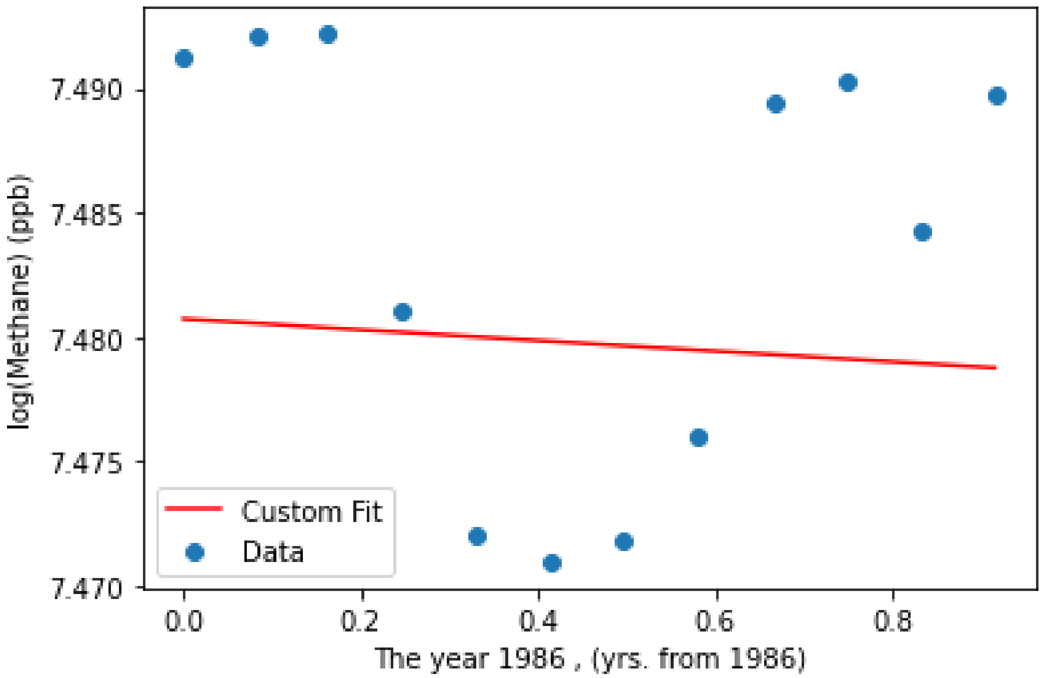
```
a = yr_fit(1995)
```

```
[7.52936349 7.53911216 7.537462   7.52344349 7.51203846 7.50734424
 7.50660277 7.51511579 7.52477707 7.52524097 7.52874029 7.53166492]
[9.         9.08493151 9.16164384 9.24657534 9.32876712 9.41369863
 9.49589041 9.58082192 9.66575342 9.74794521 9.83287671 9.91506849]
[1.9656376  8.79413897 1.56816711 2.59854414 0.6629359  1.69567288
 1.3841148  1.90948488 6.20749287 3.21584386 2.94870047 1.77118873]
 slope = -0.00017451636561359853  +-  2.1610518955799294
 intercept = 7.518471277293825 +- 20.30533221300021
 chi-square/d.o.f. =  1.1287567310423056e-06
```




```
yr_fit(1986)
```

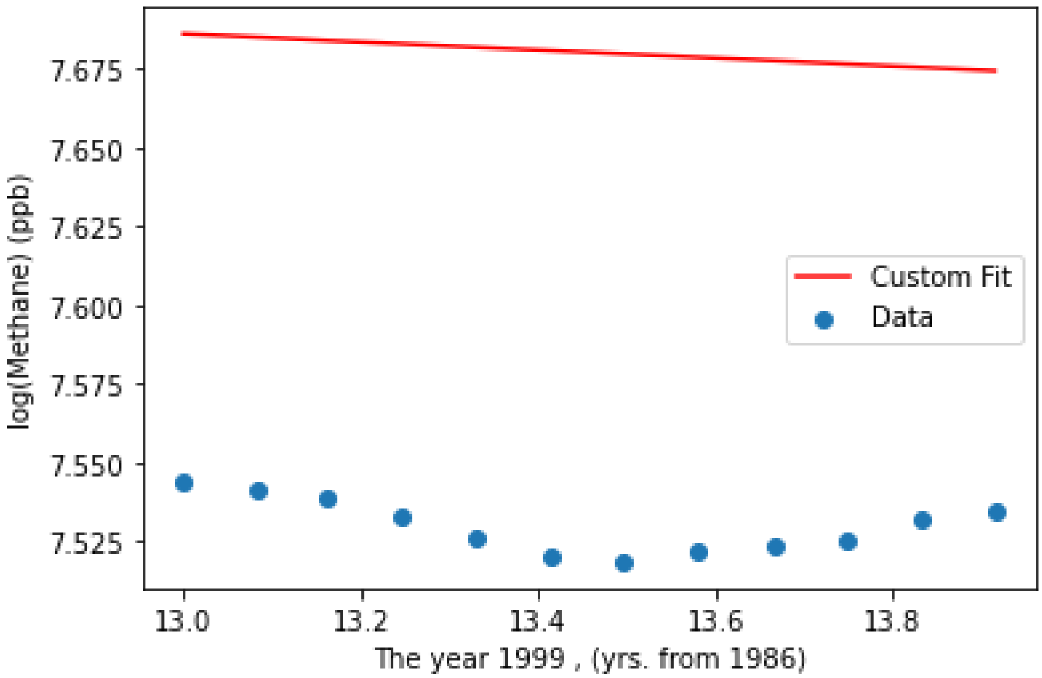
```
[7.49122151 7.492125   7.49217517 7.48102598 7.47208565 7.47098168
 7.47184675 7.47603627 7.48945121 7.49025019 7.48421695 7.489753  ]
[0.         0.08493151 0.16164384 0.24657534 0.32876712 0.41369863
 0.49589041 0.58082192 0.66575342 0.74794521 0.83287671 0.91506849]
[1.47372494 4.5674625  2.55199586 0.73519328 0.91005381 1.81636103
 2.78512136 3.22764619 5.16993821 4.27489058 1.65281152 2.2030099 ]
 slope = -0.0019603636199659862  +-  1.9688830339552965
 intercept = 7.480726444310829 +- 0.8127529241214292
 chi-square/d.o.f. =  5.742387504415295e-07
```



There appears to be some fits that are moderate given the data, but the fits do not seem to be proper. Take for example the year 1999.

```
yr_fit(1999)
```

```
[7.54410986 7.54181041 7.53861208 7.53330326 7.52581247 7.52063014
 7.51863436 7.52185925 7.52399442 7.52519783 7.53232914 7.53432453]
[13.         13.08493151 13.16164384 13.24657534 13.32876712 13.41369863
 13.49589041 13.58082192 13.66575342 13.74794521 13.83287671 13.91506849]
[1.70994329 1.29544492 1.48701112 0.60265727 0.62983233 0.9733227
 2.04558425 3.72381336 2.38702995 0.607293   4.34261427 1.13480644]
 slope = -0.011669830546741715  +-  1.1449287394595877
 intercept = 7.685994117761191 +- 15.386629657472655
 chi-square/d.o.f. =  8.809607019470402e-07
```



Clearly this fit is off based on the intercept, but the general trendline appears okay. This would require further analysis of the `chi_square_fit` function.

As for comparing the goodness for each curve, we can compare the values of χ^2 for the years.

- 1986: $\chi^2 = 5.742387504415293e - 07$
- 1995: $\chi^2 = 1.1287567310423052e - 06$
- 1999: $\chi^2 = 8.809607019470668e - 07$

```
def uncert_yr(yr):
    """
    Calculates the uncertainty of the data given a year.

    Args: yr must be an int.

    Returns: fi[2] is a float.


    """
    ret = take_years(yr)
    dat = []
    for entry in ret:
        ent = [ret[0],ret[1]]
        dat.append(ent)
    fi = fitting([dat[0],dat[1]])
    return fi[2]
```

From the `fitting` function we made in class, we can find the uncertainty, or the "goodness" of the fit also. However, I could not get the fitting function to give me anything returnable that I could construct points out of, and then determine the uncertainty. This is likely a minor issue. If I run `uncert_yr(1986)`, I cannot generate the pdf unfortunately. I get some text errors.