6. Is SNWD variation spatial or temporal

April 30, 2020

0.1 Analyze whether early or late snow changes more year to year or place to place.

- We know from previous notebooks that the value of `coef_2` corresponds to whether the snow season is early or late.
- We want to study whether early/late season is more dependent on the year or on the location.
- We will use RMS Error to quantify the strength of these dependencies.

[1]:
```
import pandas as pd
import numpy as np
import urllib
import math
```

[2]:
```
import findspark
findspark.init()

from pyspark import SparkContext
#sc.stop()
sc = SparkContext(master="local[3]",pyFiles=['lib/numpy_pack.py','lib/spark_PCA.
↪py','lib/computeStatistics.py'])

from pyspark import SparkContext
from pyspark.sql import *
sqlContext = SQLContext(sc)
```

[ ]:
```
%pylab inline
import numpy as np
from lib.numpy_pack import packArray,unpackArray
from lib.spark_PCA import computeCov
from lib.computeStatistics import *
```

[ ]:
```
### Read the data frame from pickle file

data_dir='../Data/Weather'
state='NY'
meas='SNWD'

from pickle import load
```

```
#read statistics
filename=data_dir+'/STAT_%s.pickle'%state
STAT,STAT_Descriptions = load(open(filename,'rb'))
print('keys from STAT=',STAT.keys())
```

[ ]:
```
#!ls -ld $data_dir/*.parquet

#read data
filename=data_dir+'/decon_%s_%s.parquet'%(state,meas)

df=sqlContext.read.parquet(filename)
print(df.count())
```

[ ]:
```
tmp=df.filter(df.Station=='USC00306411').toPandas()
tmp.head(1)
```

[7]:
```
#extract longitude and latitude for each station
feature='coeff_1'
sqlContext.registerDataFrameAsTable(df,'weather')
Features='station, year, coeff_2'
Query="SELECT %s FROM weather"%Features
print(Query)
pdf = sqlContext.sql(Query).toPandas()
pdf.head()
```

```
SELECT station, year, coeff_2 FROM weather
```

[7]:

	station	year	coeff_2
0	USW00014735	1939	-169.322319
1	USW00014735	1943	272.354092
2	USW00014735	1945	790.579389
3	USW00014735	1947	-216.302832
4	USW00014735	1948	1028.612179

[8]:
```
year_station_table=pdf.pivot(index='year', columns='station', values='coeff_2')
year_station_table.tail(5)
```

[8]:

```
station  USC00300015  USC00300023  USC00300047  USC00300055  USC00300063  \
year
2009             NaN          NaN          NaN          NaN          NaN
2010             NaN          NaN          NaN          NaN          NaN
2011             NaN          NaN          NaN  -120.642691   472.534062
2012             NaN          NaN          NaN          NaN          NaN
2013             NaN   149.013363          NaN          NaN     0.977231

station  USC00300077  USC00300085  USC00300090  USC00300093  USC00300159  \
```

```
year
2009                NaN           NaN           NaN   870.773867           NaN
2010                NaN           NaN           NaN   -31.805303           NaN
2011                NaN           NaN           NaN   907.925667           NaN
2012                NaN           NaN           NaN          NaN           NaN
2013                NaN     97.643753           NaN          NaN           NaN

station      …       USW00014786  USW00014797  USW00014798  USW00094704  \
year         …
2009         …               NaN          NaN          NaN          NaN
2010         …               NaN          NaN          NaN          NaN
2011         …               NaN          NaN          NaN          NaN
2012         …               NaN          NaN          NaN          NaN
2013         …               NaN          NaN          NaN          NaN

station  USW00094725  USW00094728  USW00094745  USW00094789  USW00094790  \
year
2009             NaN          NaN          NaN          NaN          NaN
2010             NaN          NaN          NaN          NaN          NaN
2011             NaN   806.258001          NaN          NaN          NaN
2012             NaN          NaN          NaN          NaN          NaN
2013             NaN          NaN          NaN          NaN          NaN

station  USW00094794
year
2009             NaN
2010             NaN
2011             NaN
2012             NaN
2013             NaN

[5 rows x 329 columns]
```

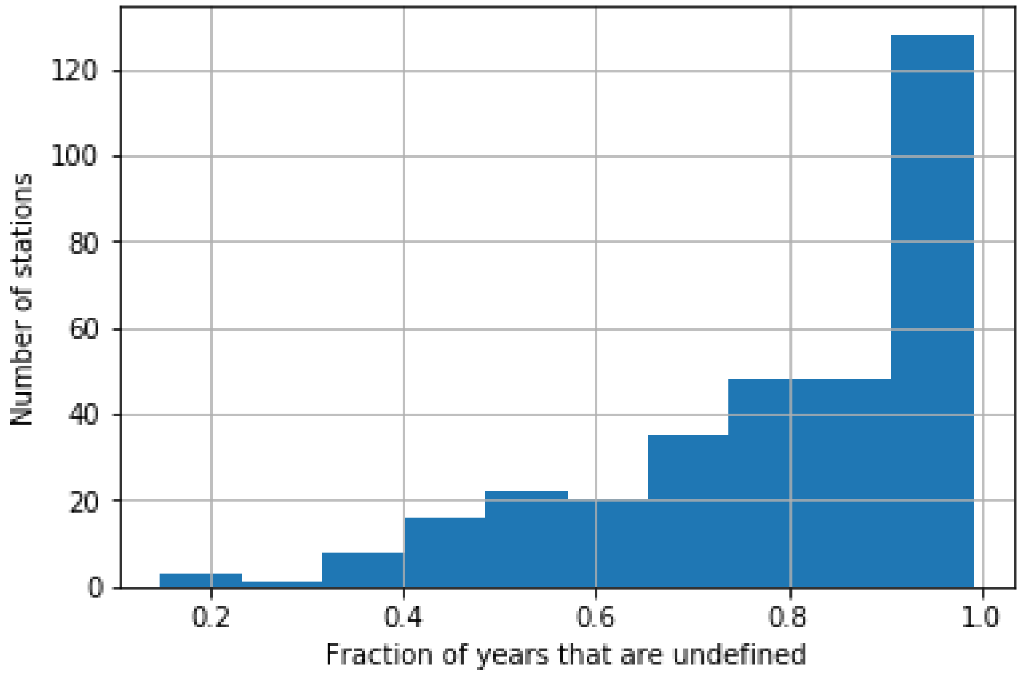
0.1.1 Data Cleaning

As can be seen in the table above, most of the values of coeff_2 are undefined.

We want to focus on a part where they are defined.

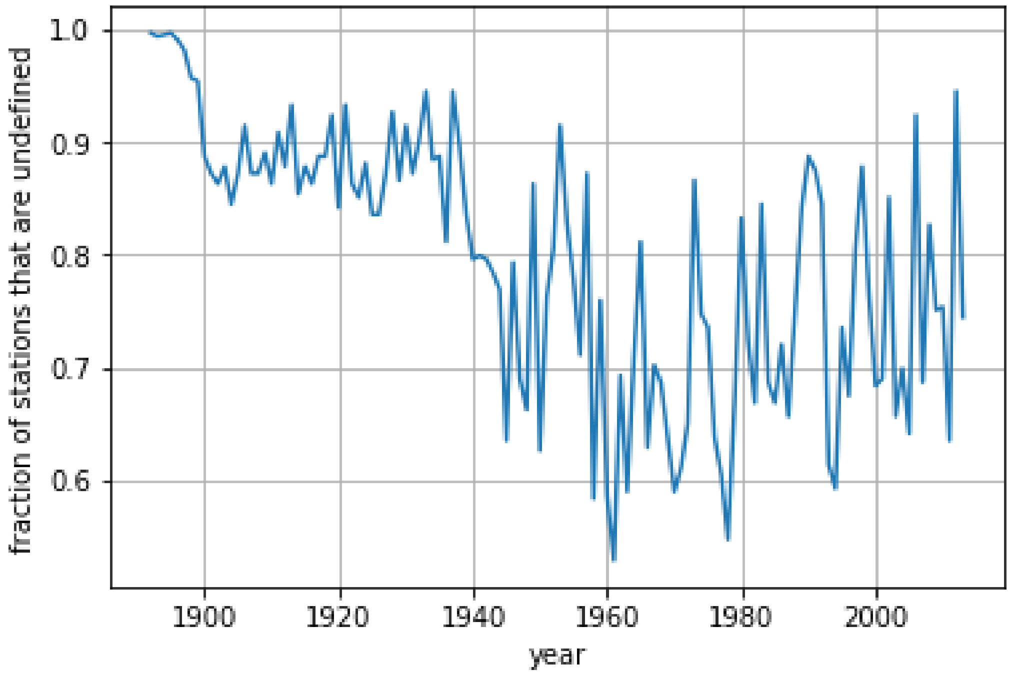
[9]:
```
station_nulls=pd.isnull(year_station_table).mean()
station_nulls.hist();
xlabel('Fraction of years that are undefined')
ylabel('Number of stations')
```

[9]:
```
Text(0,0.5,'Number of stations')
```



[10]:
```
year_nulls=pd.isnull(year_station_table).mean(axis=1)
year_nulls.plot();
grid()
ylabel('fraction of stations that are undefined')
```

[10]: Text(0,0.5,'fraction of stations that are undefined')

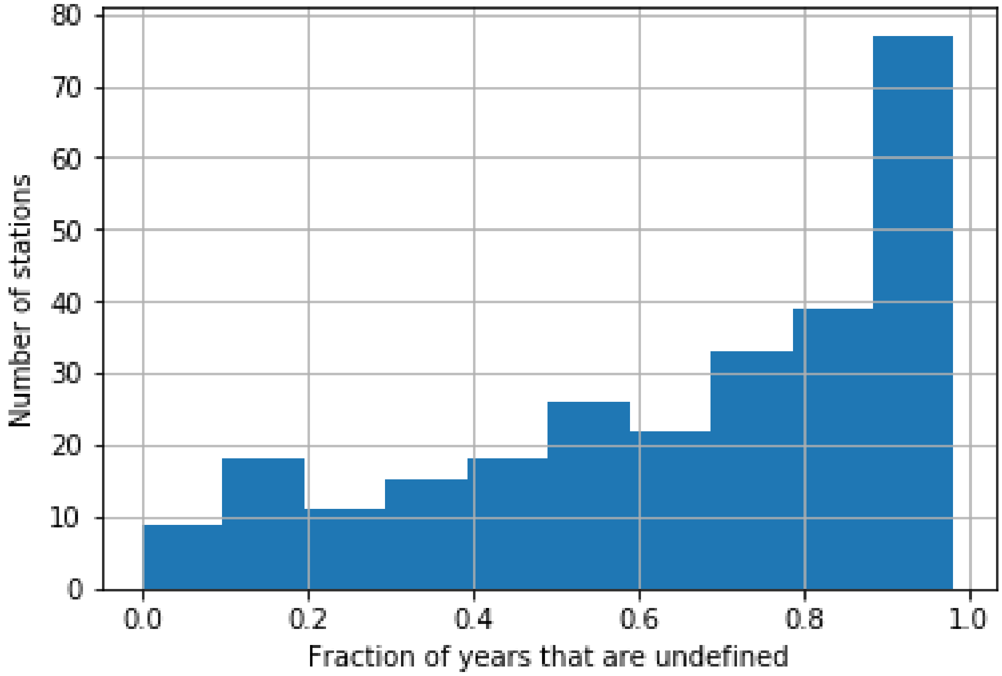


- The last figure shows that more data is available Since the 1960's
- Based on that we restrict our analysis to the years 1960 - 2012

[ ]:
```
pdf2=pdf[pdf['year']>1960]
year_station_table=pdf2.pivot(index='year', columns='station', values='coeff_2')
year_station_table.tail(5)
```

[12]:
```
station_nulls=pd.isnull(year_station_table).mean()
station_nulls.hist();
xlabel('Fraction of years that are undefined')
ylabel('Number of stations')
```

[12]:
```
Text(0,0.5,'Number of stations')
```



0.1.2 Estimating the effect of the year vs the effect of the station

To estimate the effect of time vs. location on the second eigenvector coefficient we compute:

- The average row: `mean-by-station`
- The average column: `mean-by-year`

We then compute the RMS before and after subtracting either the row or the column vector.

[13]:
```
def RMS(Mat):
    return np.sqrt(np.nanmean(Mat**2))

mean_by_year=np.nanmean(year_station_table,axis=1)
mean_by_station=np.nanmean(year_station_table,axis=0)
tbl_minus_year = (year_station_table.transpose()-mean_by_year).transpose()
tbl_minus_station = year_station_table-mean_by_station

print('total RMS                   = ',RMS(year_station_table))
print('RMS removing mean-by-station=
 ',RMS(tbl_minus_station),'reduction=',RMS(year_station_table)-RMS(tbl_minus_station))
print('RMS removing mean-by-year   =
 ',RMS(tbl_minus_year),'reduction=',RMS(year_station_table)-RMS(tbl_minus_year))
```

```
total RMS                   =  753.145449514645
RMS removing mean-by-station=  701.5445524111517 reduction= 51.60089710349325
RMS removing mean-by-year   =  531.4823870967629 reduction= 221.6630624178821
```

0.1.3 Conclusion Of Analysis

The effect of time is about four times as large as the effect of location.

0.1.4 Iterative reduction

- After removing one component, the other component can have an effect.
- We can use **alternating minimization** to remove the combined effect of location and time.

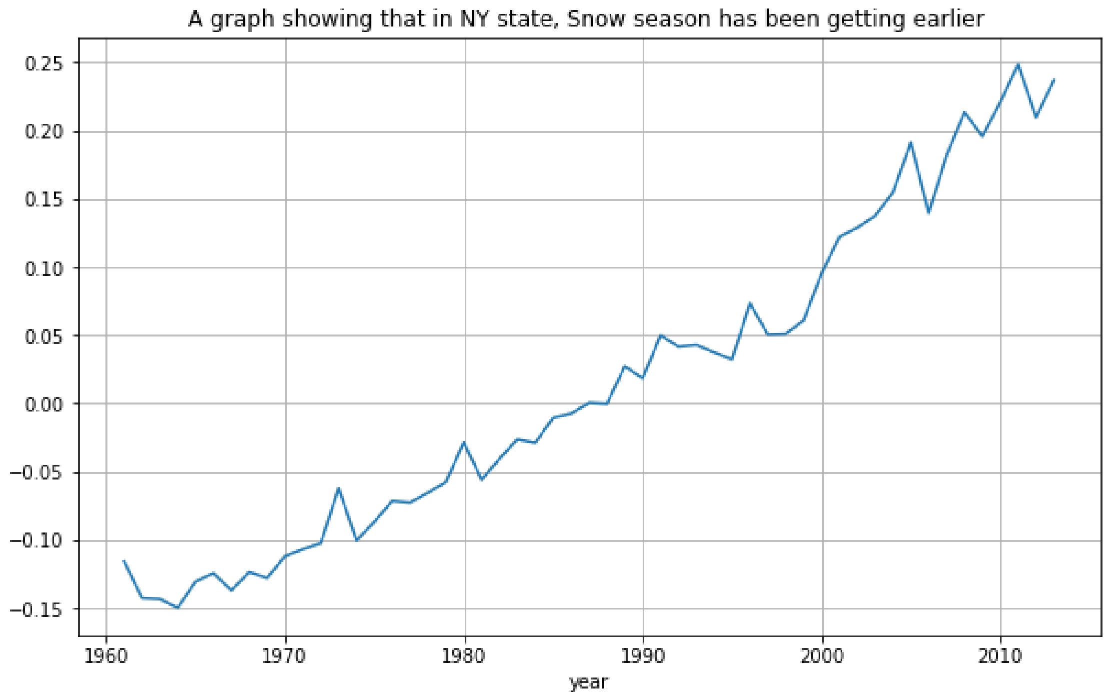
[14]:
```
T=year_station_table
print('initial RMS=',RMS(T))
for i in range(5):
    mean_by_year=np.nanmean(T,axis=1)
    T=(T.transpose()-mean_by_year).transpose()
    print(i,'after removing mean by year    =',RMS(T))
    mean_by_station=np.nanmean(T,axis=0)
    T=T-mean_by_station
    print(i,'after removing mean by stations=',RMS(T))
```

```
initial RMS= 753.145449514645
0 after removing mean by year    = 531.4823870967629
0 after removing mean by stations= 490.58111029852466
1 after removing mean by year    = 490.11149394795615
1 after removing mean by stations= 490.08333935027764
2 after removing mean by year    = 490.08010695597295
2 after removing mean by stations= 490.0794679008307
3 after removing mean by year    = 490.0793022334803
3 after removing mean by stations= 490.07925486768687
4 after removing mean by year    = 490.0792408655066
4 after removing mean by stations= 490.0792366758466
```

[15]:
```
T['mean_by_year']=mean_by_year
T['mean_by_year'].head()
```

[15]:
```
year
1961   -0.115733
1962   -0.142607
1963   -0.143292
1964   -0.149812
1965   -0.130511
Name: mean_by_year, dtype: float64
```

[16]:
```
figure(figsize=(10,6))
T['mean_by_year'].plot();
grid()
title('A graph showing that in NY state, Snow season has been getting earlier␣
 ↪');
```



0.2 Summary

- The problem of missing data is prevalent and needs to be addressed.
- RMS can be used to quantify the effect of different factors (here, time vs. space)
- The snow season in NY has been getting earlier and earlier since 1960.