In [242]:

```
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np
from pydmd import DMD
```

In [243]:

```
import pandas as pd
train=pd.read_csv('emissions.csv')
train.head()
```

Out[243]:

	Country	ISO 3166-1 alpha-3	Year	Total	Coal	Oil	Gas	Cement	Flaring	Other	Per Capita
0	Afghanistan	AFG	1750	0.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1	Afghanistan	AFG	1751	0.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2	Afghanistan	AFG	1752	0.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
3	Afghanistan	AFG	1753	0.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
4	Afghanistan	AFG	1754	0.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

In [244]:

```
train1=train.drop(['ISO 3166-1 alpha-3','Coal','Oil','Gas','Cement','Flaring','Other','Per Capita'],axis=1)
```

In [245]:

```
train1.head()
```

Out[245]:

	Country	Year	Total
0	Afghanistan	1750	0.0
1	Afghanistan	1751	0.0
2	Afghanistan	1752	0.0
3	Afghanistan	1753	0.0
4	Afghanistan	1754	0.0

In [246]:

```
modtrain=train1[train1.Year>1999]
```

In [247]:

```
modtrain1=modtrain.sort_values('Year')
```

In [248]:

```
modtrain1.shape
```

Out[248]:

```
(5104, 3)
```

In [249]:

```
w=train1[train1.Country=='Albania']
q1=w[w.Year>1999].T
q1
q2=q1.drop(['Country','Year'])
q2
np.array(q2)
```

Out[249]:

```
array([[3.024926, 3.220656, 3.748272, 4.303499, 4.176684, 4.261413,
        3.910715, 3.94897, 4.397043, 4.406552, 4.783865, 5.314676,
        4.85006, 5.287466, 5.999658, 4.712137, 4.631977, 5.564149,
        4.984045, 4.947485, 4.728559, 4.619109]], dtype=object)
```

In [250]:

```
l4=train1.Country.unique()
dt=[]
for i in l4:
    w=train1[train1.Country==i]
    q1=w[w.Year>1999].T
    q2=q1.drop(['Country','Year'])
    q3=np.array(q2).flatten()
    dt.append(q3)
```

In [251]:

```
l4[-5:]
```

Out[251]:

```
array(['Yemen', 'Zambia', 'Zimbabwe', 'International Transport', 'Global'],
      dtype=object)
```

In [252]:

```
dt=np.array(dt)
dt.shape
```

Out[252]:

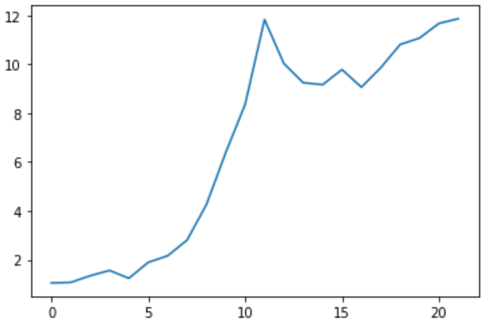
```
(232, 22)
```

In [253]:

```
plt.plot(dt[0])
```

Out[253]:

```
[<matplotlib.lines.Line2D at 0x27aa98be8e0>]
```



In [254]:

```
type(dt)
```

Out[254]:

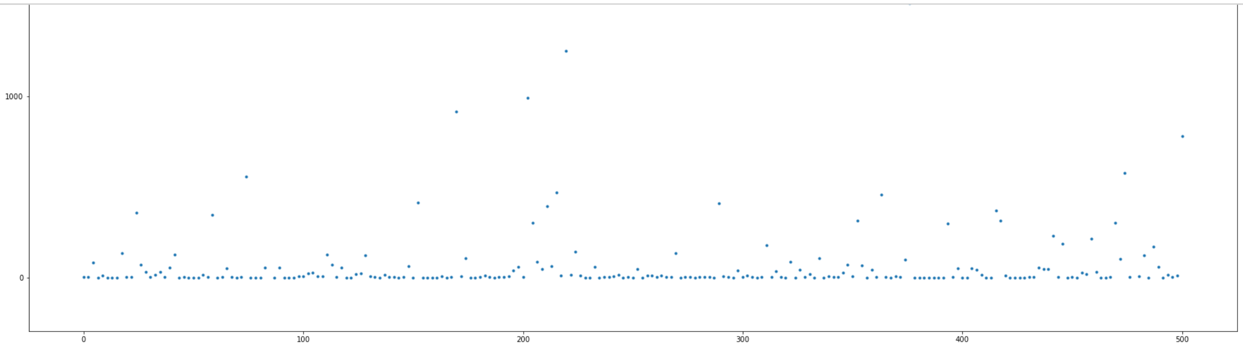
```
numpy.ndarray
```

In [255]:

```

import scipy


from matplotlib import animation
from IPython.display import HTML
```

In [256]:

```
x = np.linspace(0, 500,231)
#print(x[0:5])
snapshots = dt[:-1].T
f=snapshots
c=0

for i in snapshots:
    c+=1
    print(c)
    plt.figure(figsize=(30,30))
    plt.plot(x, i, '.')
    plt.show()
```



```
3
```

In [257]:

```
dt1=dt.astype(float)
```

In [258]:

```
hodmd = DMD(svd_rank=0, exact=True, opt=True).fit(dt1)
```

In [259]:

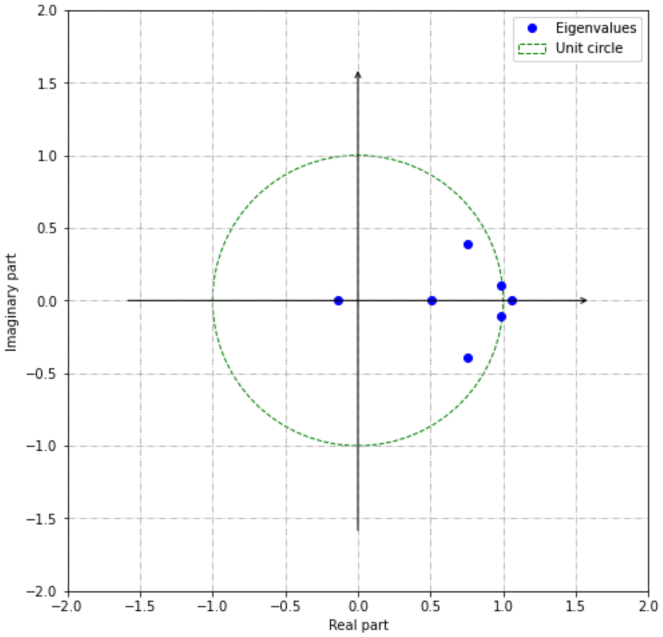
```
hodmd.reconstructed_data.shape
```

Out[259]:

```
(232, 22)
```

In [260]:

```
hodmd.plot_eigs()
```

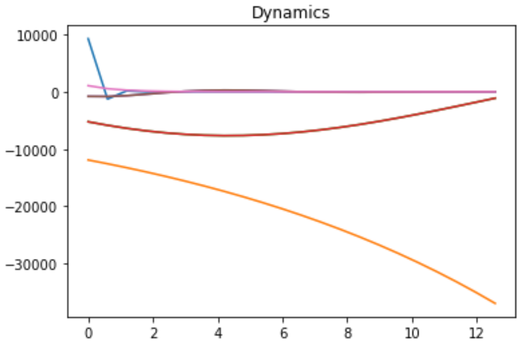


In [261]:

```
t = np.linspace(0, 4*np.pi, 22)
```

In [262]:

```
for dynamic in hodmd.dynamics:
    plt.plot(t, dynamic.real)
    plt.title('Dynamics')
plt.show()
```



In [263]:

```
print("Shape before manipulation: {}".format(hodmd.reconstructed_data.shape))
hodmd.dmd_time['dt'] *= .25
hodmd.dmd_time['tend'] *= 0.4
print("Shape after manipulation: {}".format(hodmd.reconstructed_data.shape))
```

```
Shape before manipulation: (232, 22)
Shape after manipulation: (232, 35)
```

In [264]:

```
fig = plt.figure()

dmd_states = [state for state in hodmd.reconstructed_data[:-2].T]
```

```
<Figure size 432x288 with 0 Axes>
```

In [272]:

```
dmd_states[10].shape
```

Out[272]:

```
(230,)
```

In [269]:

```
fig = plt.figure(figsize=(20,20))
b=17
for id_subplot, snapshot in enumerate(dmd_states[17:27], start=1):
    plt.subplot(4, 4, id_subplot)
    plt.plot(snapshot)
    plt.title(2000+b)
    b+=1
```

```
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
e imaginary part
  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
e imaginary part
  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
e imaginary part
  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
e imaginary part
  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
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  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
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  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
e imaginary part
  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
e imaginary part
  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
e imaginary part
  return np.asarray(x, float)
D:\Anaconda\lib\site-packages\matplotlib\cbook\__init__.py:1298: ComplexWarning: Casting complex values to real discards th
e imaginary part
  return np.asarray(x, float)
```
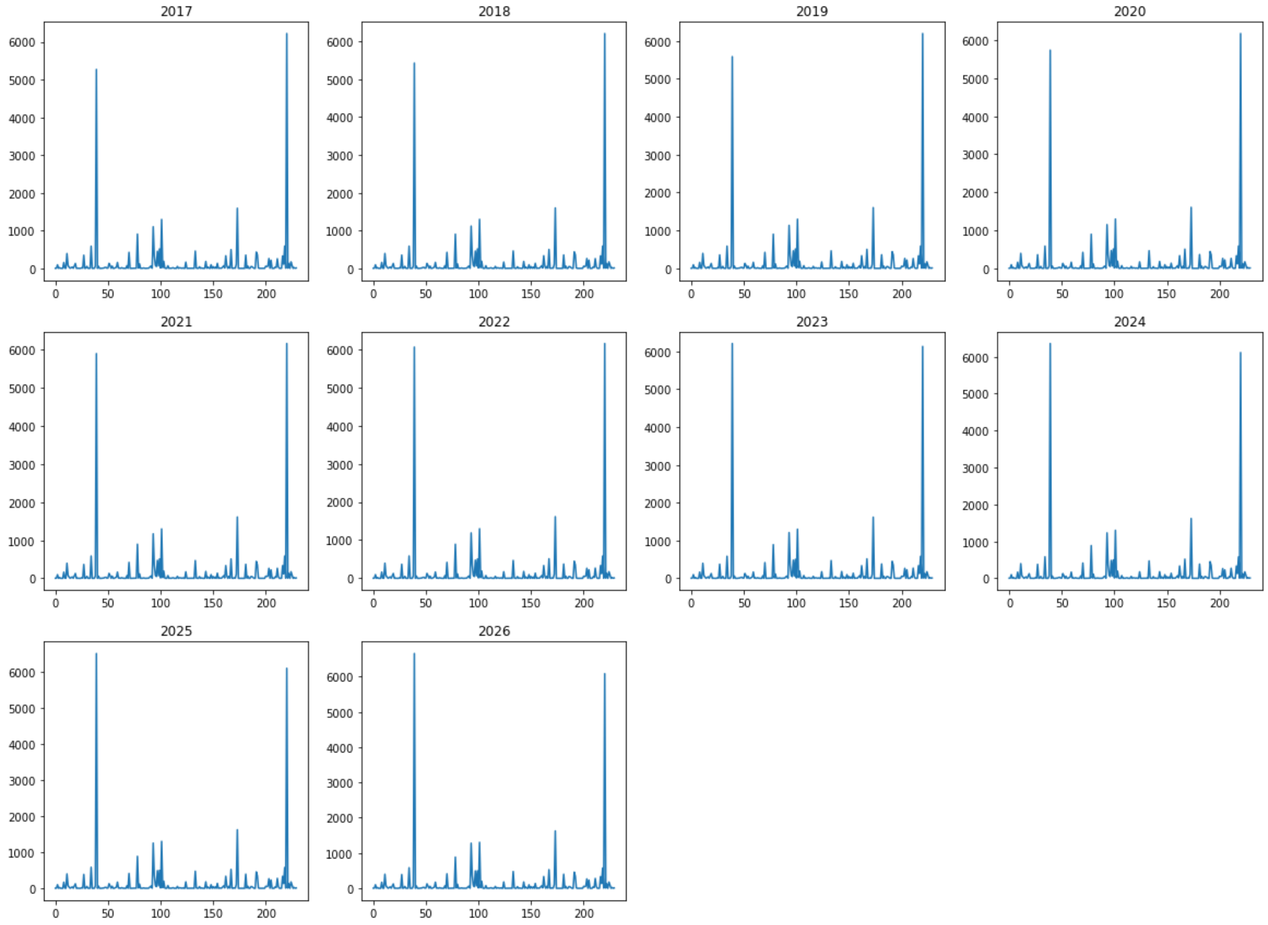
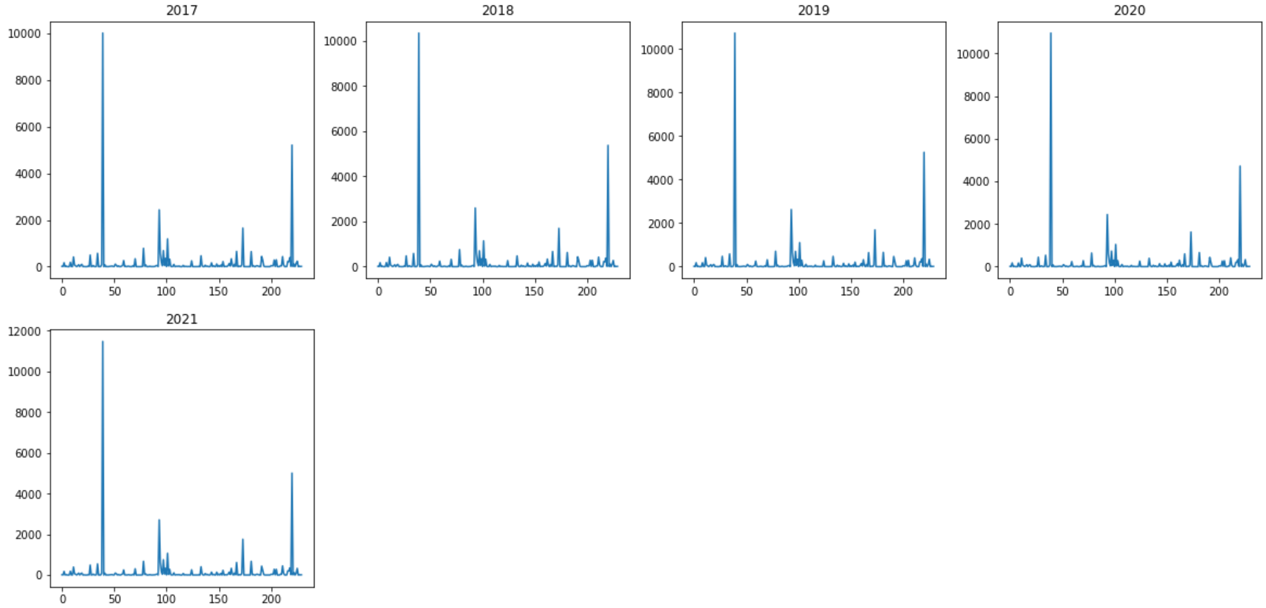



In [270]:

```
dt2=dt[:-2].T
fig = plt.figure(figsize=(20,20))
b=17
for id_subplot, snapshot in enumerate(dt2[17:], start=1):
    plt.subplot(4, 4, id_subplot)
    plt.plot(snapshot)
    plt.title(2000+b)
    b+=1
```



In [271]:

```
dt2[0].shape
```

Out[271]:

```
(230,)
```

In [227]:

```
dt.shape
```

Out[227]:

```
(232, 22)
```

In [228]:

```
x0=dt1[:,:21]
x1=dt1[:,1:22]
x0.shape
```

Out[228]:

```
(232, 21)
```

In [229]:

```
U, s, V = np.linalg.svd(x0,full_matrices=False)
```

In [230]:

```
s.shape
s1=np.diag(s)
s1.shape
s2=np.linalg.inv(s1)
```

In [231]:

```
s2.shape
```

Out[231]:

```
(21, 21)
```

In [232]:

```
Atil=U.T @ x1 @ V.T @ s2
```

In [233]:

```
Atil.shape
```

Out[233]:

```
(21, 21)
```

In [234]:

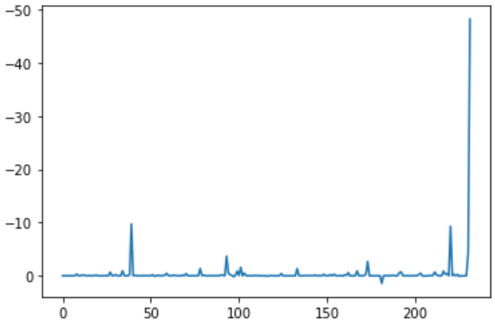
```
w,v=np.linalg.eig(Atil)
```

In [235]:

```
evec=x1 @ V.T @ np.linalg.inv(s1) @ w
```

In [236]:

```
plt.plot(evec.real)
plt.gca().invert_yaxis()
```



In [237]:

```
evec.shape
```

Out[237]:

```
(232,)
```

In [238]:

```
c1=dt1[:,1]
```

In [239]:

```
b=evec/c1
```

```
C:\Users\Sahil\AppData\Local\Temp\ipykernel_2580\2883851432.py:1: RuntimeWarning: divide by zero encountered in true_divide
  b=evec/c1
C:\Users\Sahil\AppData\Local\Temp\ipykernel_2580\2883851432.py:1: RuntimeWarning: invalid value encountered in true_divide
  b=evec/c1
```

In [240]:

```
m1=np.linalg.matrix_power(v,23)
evec.T.shape
```

Out[240]:

```
(232,)
```

In [241]:

```
newx=evec*m1*b
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
Input In [241], in <cell line: 1>()
----> 1 newx=evec*m1*b

ValueError: operands could not be broadcast together with shapes (232,) (21,21)
```

In [ ]:

```

```