In [1]:

```
import gc, argparse, sys, os, errno
%pylab inline
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
#from beakerx import *
import seaborn as sns
#import h5py
import os
from tqdm import tqdm_notebook as tqdm
import scipy
import sklearn
from scipy.stats import pearsonr
import warnings
warnings.filterwarnings('ignore')
from scipy.io import loadmat
from matplotlib.mlab import griddata
from ipywidgets import interact, FloatSlider,IntSlider, RadioButtons,Dropdown,Tab,Tex
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt
from matplotlib import cm
from matplotlib.ticker import LinearLocator, FormatStrFormatter
import numpy as np
from mpl_toolkits.mplot3d.axes3d import *
import matplotlib.pyplot as plt
from matplotlib import cm
from sklearn.preprocessing import MinMaxScaler,RobustScaler,StandardScaler
from IPython.core.display import HTML,Image
from functools import reduce
from bokeh.io import output_notebook, show
output_notebook()
from sklearn.decomposition import PCA
from sklearn.manifold import TSNE
from sklearn.metrics import roc_curve,roc_auc_score,auc,precision_recall_curve,averag
from sklearn.preprocessing import RobustScaler,MinMaxScaler,StandardScaler
from sklearn.neighbors import NearestNeighbors
from bokeh.palettes import Category20c
```

```
Populating the interactive namespace from numpy and matplotlib
```

(https://bokeh.pydata.org) BokehJS 0.13.0 successfully loaded.

In [2]:

```
cd /Users/james/NS_model
```

```
/Users/james/NS_model
```

In [3]:

```
# setup figure template
figure_template_path = 'bin/'
if figure_template_path not in sys.path:
    sys.path.append(figure_template_path)
from importlib import reload
import figure_template
# force reload of the module
reload(figure_template)
from figure_template import std_plot,display_dataframe, embed_pdf_figure, embed_pdf_p
fontlegend = {'family':'Arial',
                  'weight' : 'normal',
              #'linewidth':0.5,
                  'size' : 6.5*1}
```

In [4]:

```
FRB_H15_table = pd.read_table('data/FRB_H15.csv',sep=',',index_col=0).dropna()
frb_index = FRB_H15_table.index
time_arr = np.array([i.split('-') for i in frb_index[5:] ]).astype('int')

select_table = FRB_H15_table.iloc[np.concatenate((np.zeros([5]),(time_arr[:,0] >=2009
nan_ind = np.where(np.isin(np.array(FRB_H15_table.index),np.array(select_table.iloc[n

select_table.iloc[np.unique(np.where(select_table=='ND')[0])] = np.array(FRB_H15_tabl
```

FRB_H15_table = pd.read_table('data/FRB_H15.csv',sep=',',index_col=0).dropna().iloc[:,:-1] frb_index = FRB_H15_table.index time_arr = np.array([i.split('-') for i in frb_index[5:]]).astype('int')

select_table = FRB_H15_table.iloc[np.concatenate((np.zeros([5]),(time_arr[:,0] >=2002)&(time_arr[:,0] <=2010)&(time_arr[:,2] ==6))).astype('bool')] nan_ind = np.where(np.isin(np.array(FRB_H15_table.index),np.array(select_table.iloc[np.unique(np.where(select_table=='ND'[0])]].index))==1)[0] if nan_ind.shape[0] >0: select_table.iloc[np.unique(np.where(select_table=='ND')[0])] = np.array(FRB_H15_table.iloc[nan_ind+1])

tmp = np.unique(time_arr[:,2],return_counts=1)[1] plt.plot(tmp) np.argmax(tmp)

In [5]:

```
select_table=select_table.astype('float')
revise_columns = np.array([i.split(' ')[7] for i in np.array(select_table.columns)]).
select_table.columns = revise_columns
select_arr = np.array(select_table).astype('float')
month_ind = np.array([0,2,5,11,23,35,59,83,119,239,359])
resize_arr = np.zeros([select_arr.shape[0],360])
for i in range((select_arr.shape[0])):
    resize_arr[i] = np.interp(np.arange(360),month_ind,select_arr[i])
```

In [6]:

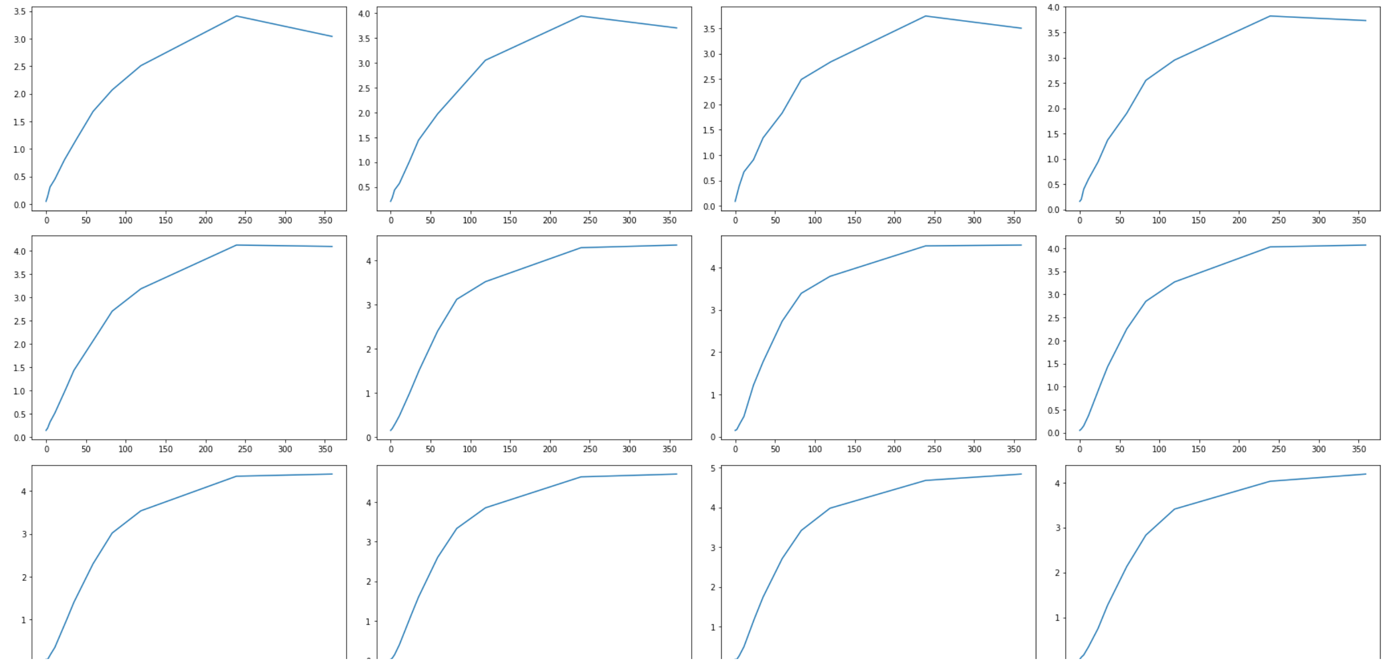
```
month_ind
```

Out[6]:

```
array([  0,   2,   5,  11,  23,  35,  59,  83, 119, 239, 359])
```

select_arr = np.array(select_table).astype('float') month_ind = np.array([0,2,5,11,23,35,59,83,119,239]) resize_arr = np.zeros([select_arr.shape[0],240]) for i in range((select_arr.shape[0])): resize_arr[i] = np.interp(np.arange(240),month_ind,select_arr[i])

In [7]:
```
plot_num = 4
fig,ax = plt.subplots(plot_num,4,figsize=(24,4*plot_num))
for i in range(plot_num):
    for j in range(4):
        ax[i,j].plot(resize_arr[i*4+j])
fig.tight_layout()
#embed_pdf_figure()
```

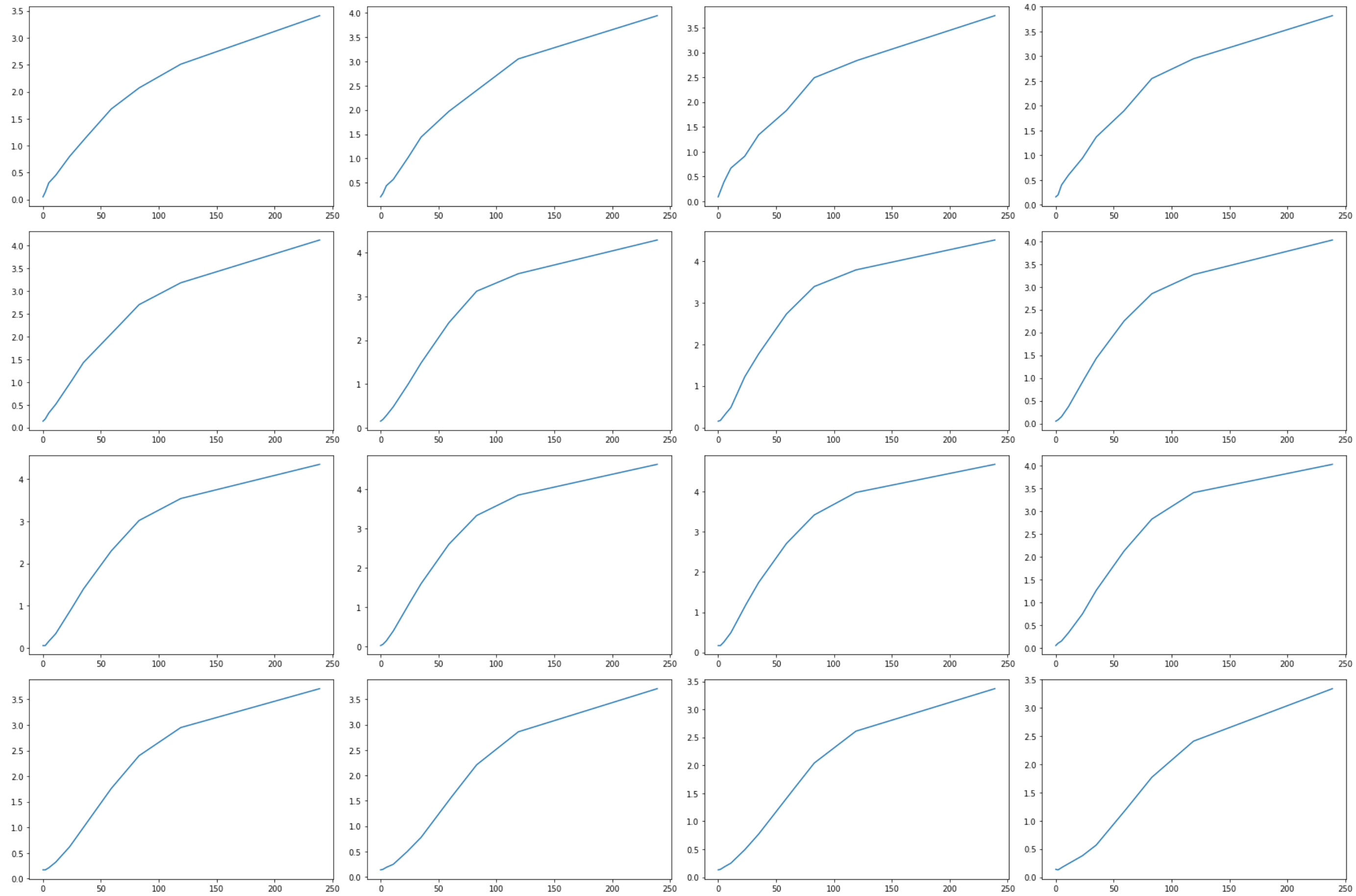


In [ ]:

In [8]:
```
time_start = 0
time_end = 89
start_point = 30
end_point = 240
Zs = resize_arr[time_start:time_end,start_point:end_point]
Zs = Zs.ravel()
Ys = np.repeat(np.arange(time_start,time_end),end_point-start_point)
Xs= np.repeat(np.arange(start_point,end_point),time_end-time_start).reshape(-1,time_e
```

In [9]:

```
plot_num = 4
fig,ax = plt.subplots(plot_num,4,figsize=(24,4*plot_num))
for i in range(plot_num):
    for j in range(4):
        ax[i,j].plot(resize_arr[time_start:time_end,:end_point][i*4+j])
fig.tight_layout()
#embed_pdf_figure()
```



In [10]:

```
# creation of a 2D grid
def plot_3d_grid_surface(width,height,azim,elev,contextind,styind,featureind,savefig
    fig = plt.figure(figsize=(width,height))
    X = Xs
    Y = Ys
    Z = Zs
    x = X.ravel()
    y = Y.ravel()
    z = Z.ravel()
    xi = np.linspace(min(x), max(x))
    yi = np.linspace(min(y), max(y))
    X, Y = np.meshgrid(xi, yi)
    Z = griddata(x, y, z, xi, yi,interp='linear')

    ax = Axes3D(fig)
    #ax.scatter3D(x,y,z,c=z,cmap=plt.cm.jet)
    surf = ax.plot_surface(X, Y, Z, rstride=1, cstride=1, cmap='jet',linewidth=1, an
    ax.xaxis.set_pane_color((1.0, 1.0, 1.0, 0.0))
    ax.yaxis.set_pane_color((1.0, 1.0, 1.0, 0.0))
    ax.zaxis.set_pane_color((1.0, 1.0, 1.0, 0.0))
    # make the grid lines transparent
    ax.xaxis._axinfo["grid"]['color'] =  (1,1,1,0)
    ax.yaxis._axinfo["grid"]['color'] =  (1,1,1,0)
    ax.zaxis._axinfo["grid"]['color'] =  (1,1,1,0)



    fig.colorbar(surf, shrink=0.5, aspect=5)
    ax.view_init(azim=azim,elev=elev)  # 50 20
    #ax.set_title('3D surface using feature '+'{:2}'.format(str(featureind)))
    ax.invert_xaxis()
    ax.invert_yaxis()
    ax=std_plot(ax,'month','year','rate','3D plot',fontscale=4,
                xticklabel=np.array([str(i) for i in range(50,250,50)]),
               yticklabel = np.array([str(i) for i in range(2009,2019,2)]))
    fig.tight_layout()
    #embed_pdf_figure()
    if savefig=='save':
        #fig.savefig('3D_surface_of_feature_'+'{:2}'.format(str(featureind)))
        fig.savefig('output/3D_surface.eps')
    else:
        plt.show()
interact(plot_3d_grid_surface,
    contextind=FloatSlider(min=0,max=3,step=1,value=2),
         styind=FloatSlider(min=0,max=2,step=1),
    width =FloatSlider(min=4,max=40,step=1,value=25),
         featureind=IntSlider(min=0,max=30,step=1,value=0),
    height= FloatSlider(min=4,max=30,step=1,value=16),
    azim= FloatSlider(min=0,max=180,step=2,value=45),
         savefig= RadioButtons(options=['show','save']),
    elev= FloatSlider(min=0,max=180,step=1,value=32))
```

width 25.00

height 16.00

azim 45.00

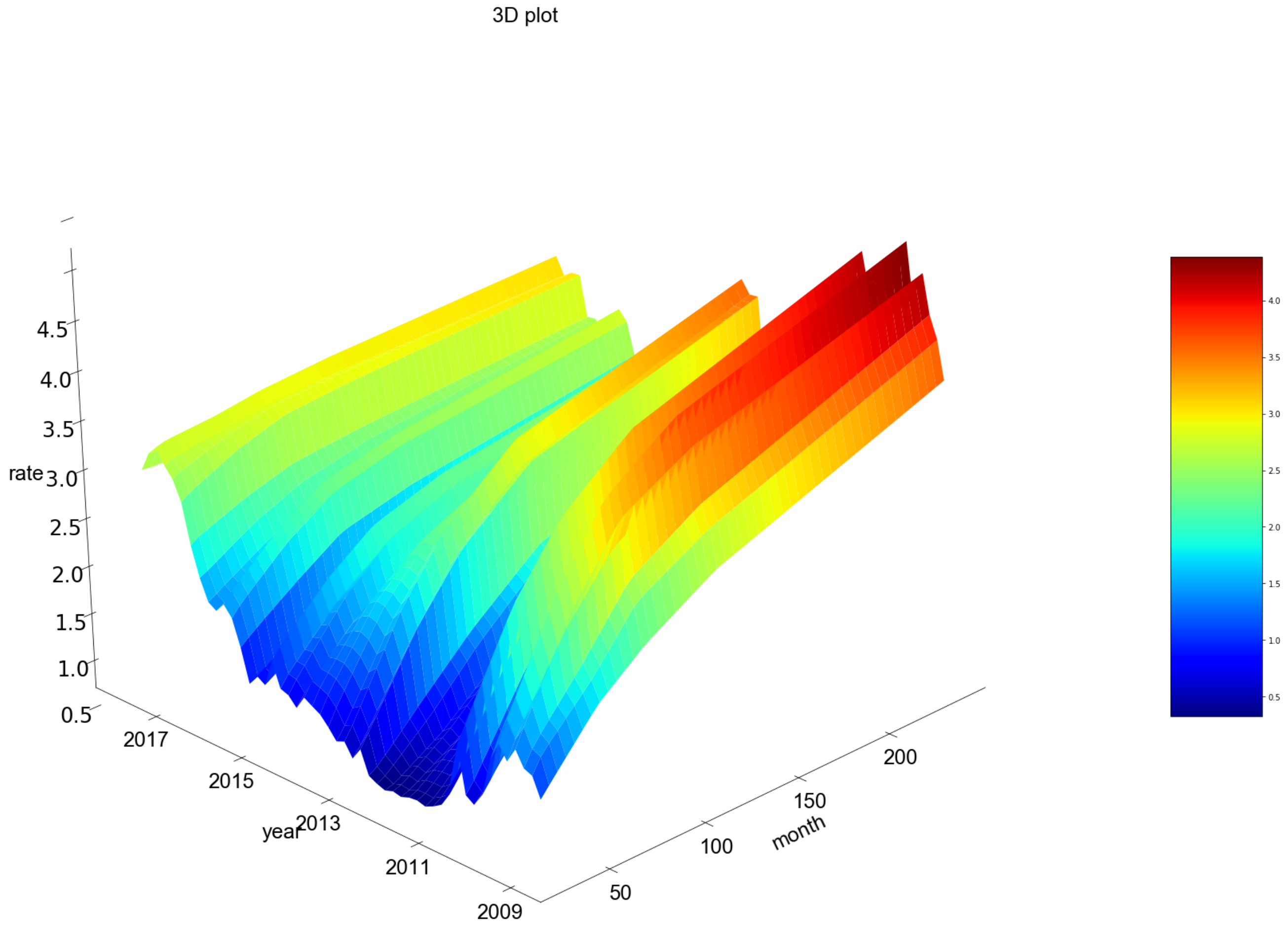
elev 32.00

contextind 2.00

styind ○ 0.00

featureind ○ 0

savefig ● show
○ save

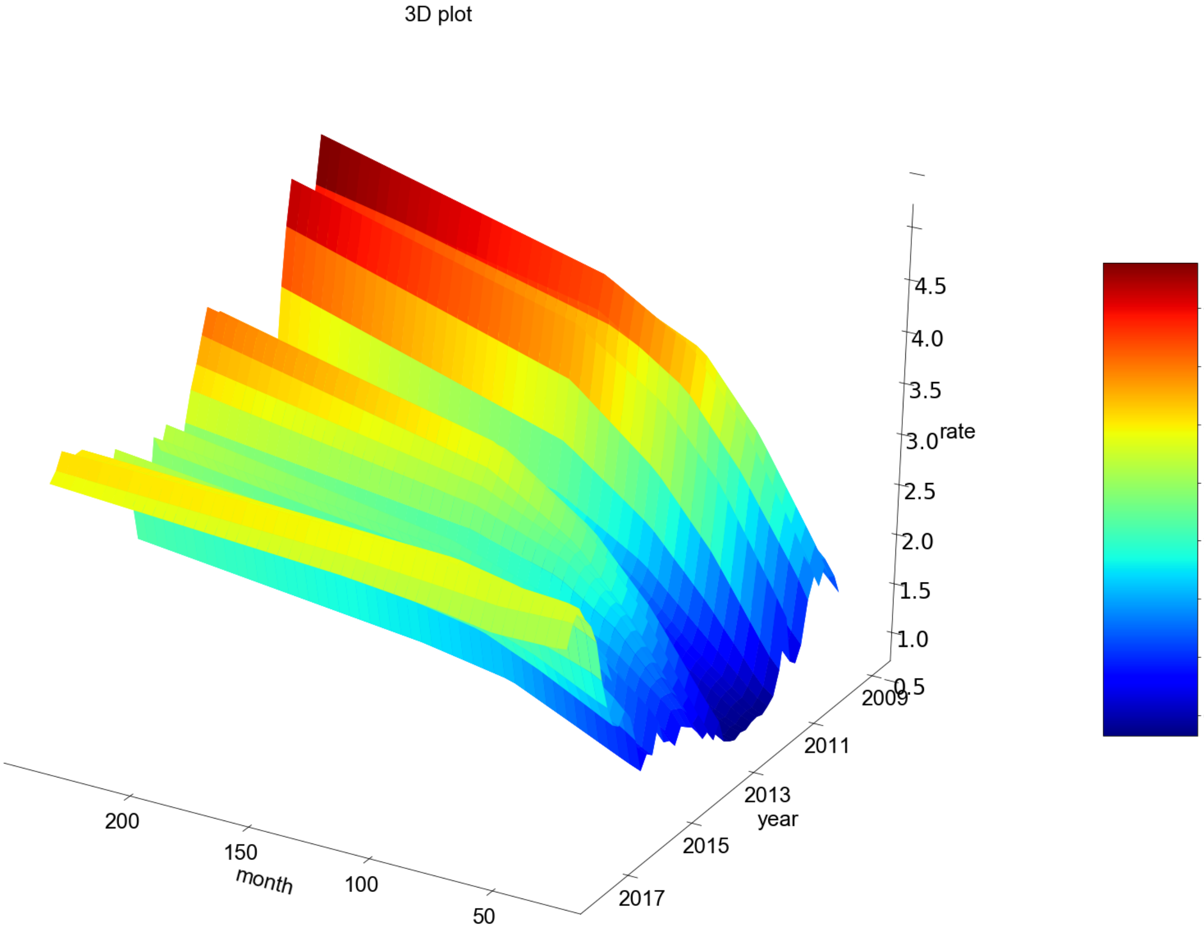


```
Out[10]: <function __main__.plot_3d_grid_surface(width, height, azim, elev, contextind, sty
         ind, featureind, savefig)>
```

```
In [11]: from matplotlib import animation
         from IPython.display import HTML
```

In [12]:

```
width=25
height=16

fig = plt.figure(figsize=(width,height))
ax = Axes3D(fig)
X = Xs
Y = Ys
Z = Zs
x = X.ravel()
y = Y.ravel()
z = Z.ravel()
xi = np.linspace(min(x), max(x))
yi = np.linspace(min(y), max(y))
X, Y = np.meshgrid(xi, yi)
Z = griddata(x, y, z, xi, yi,interp='linear')

surf = ax.plot_surface(X, Y, Z, rstride=1, cstride=1, cmap='jet',linewidth=1, antial
fig.colorbar(surf, shrink=0.5, aspect=5)
#fig.tight_layout()

def init():
    ax.plot_surface(X, Y, Z, rstride=1, cstride=1, cmap='jet',linewidth=1, antialias

    return fig,

def animate(i):
    ax.view_init(elev=32, azim=i)
    return fig,

ax.xaxis.set_pane_color((1.0, 1.0, 1.0, 0.0))
ax.yaxis.set_pane_color((1.0, 1.0, 1.0, 0.0))
ax.zaxis.set_pane_color((1.0, 1.0, 1.0, 0.0))
ax.xaxis._axinfo["grid"]['color'] =  (1,1,1,0)
ax.yaxis._axinfo["grid"]['color'] =  (1,1,1,0)
ax.zaxis._axinfo["grid"]['color'] =  (1,1,1,0)
ax.invert_xaxis()
ax.invert_yaxis()
ax=std_plot(ax,'month','year','rate','3D plot',fontscale=4,
                xticklabel=np.array([str(i) for i in range(50,250,50)]),
               yticklabel = np.array([str(i) for i in range(2009,2019,2)]))

# Animate
anim = animation.FuncAnimation(fig, animate, init_func=init,
                               frames=180,interval=20, blit=True)
```



anim.save('basic_animation1.mp4', fps=10, extra_args=['-vcodec', 'libx264'])

1 PCA

and ICA,CCA?

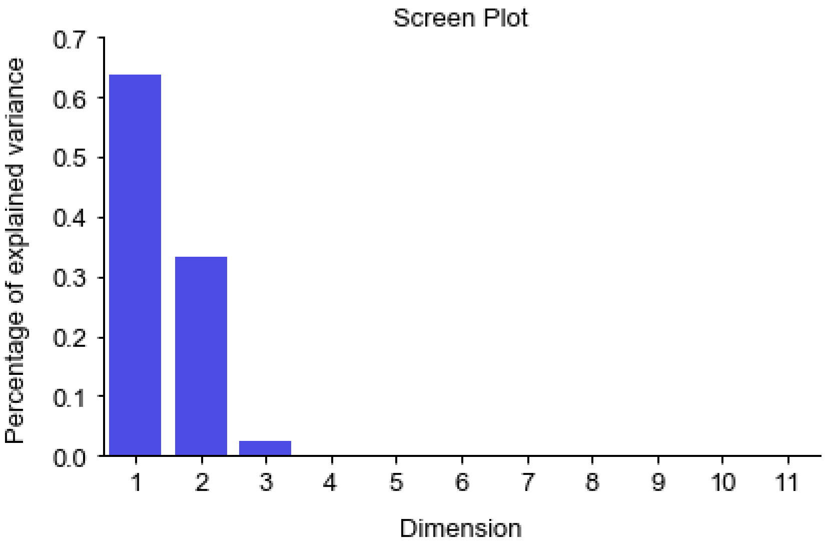
In [13]:

```
input_mx = select_arr[time_start:time_end]
input_table = select_table.iloc[time_start:time_end]

year_class = pd.DataFrame(np.concatenate((np.array(input_table.index).reshape(-1,1),
                                input_table.index]).reshape(-1,1)),axis=1),columns=[
year_class = year_class.set_index('sample').astype('str')
month_class = pd.DataFrame(np.concatenate((np.array(input_table.index).reshape(-1,1)
                                input_table.index]).reshape(-1,1)),axis=1),columns=[
month_class = month_class.set_index('sample').astype('str')
```

In [ ]:

In [14]:

```
svd_solver = ['auto','full','arpack','randomized']
pca = PCA(svd_solver=svd_solver[0])
input_mx_ = StandardScaler().fit_transform(input_mx) #scale for columns
pca.fit(input_mx_)
#loadings = np.dot(np.diag(pca.singular_values_), pca.components_)
#how to reverse back: (X - np.mean(X, axis=0).reshape((1, -1))).dot(pca.components_.

fig,ax=plt.subplots(figsize=(6,4))
plot_data = pd.DataFrame(np.concatenate((np.arange(1,pca.explained_variance_ratio_.s
                                         pca.explained_variance_ratio_.reshape(-1,1)
sns.barplot(data=plot_data,x='Dimension',y='Percentage of explained variance',color=
ax=std_plot(ax,'Dimension','Percentage of explained variance',None,'Screen Plot',xti
fig.tight_layout()
#embed_pdf_figure()
```



In [15]:

```
def zeroMean(dataMat):
    meanVal=np.mean(dataMat,axis=0)      #按列求均值，即求各个特征的均值
    newData=dataMat-meanVal
    return newData,meanVal

def pca_own(dataMat,n=None):
    if n==None:
        n = dataMat.shape[1]
    newData,meanVal=zeroMean(dataMat)
    covMat=np.cov(newData,rowvar=0)    #求协方差矩阵,return ndarray；若rowvar非0，一列代

    eigVals,eigVects=np.linalg.eig(np.mat(covMat))#求特征值和特征向量,特征向量是按列放的,
    eigValIndice=np.argsort(eigVals)            #对特征值从小到大排序
    n_eigValIndice=eigValIndice[-1:-(n+1):-1]   #最大的n个特征值的下标
    n_eigVect=eigVects[:,n_eigValIndice]        #最大的n个特征值对应的特征向量
    lowDDataMat=newData*n_eigVect               #低维特征空间的数据
    reconMat=(lowDDataMat*n_eigVect.T)+meanVal  #重构数据
    return lowDDataMat,reconMat,n_eigVect
```

In [16]:

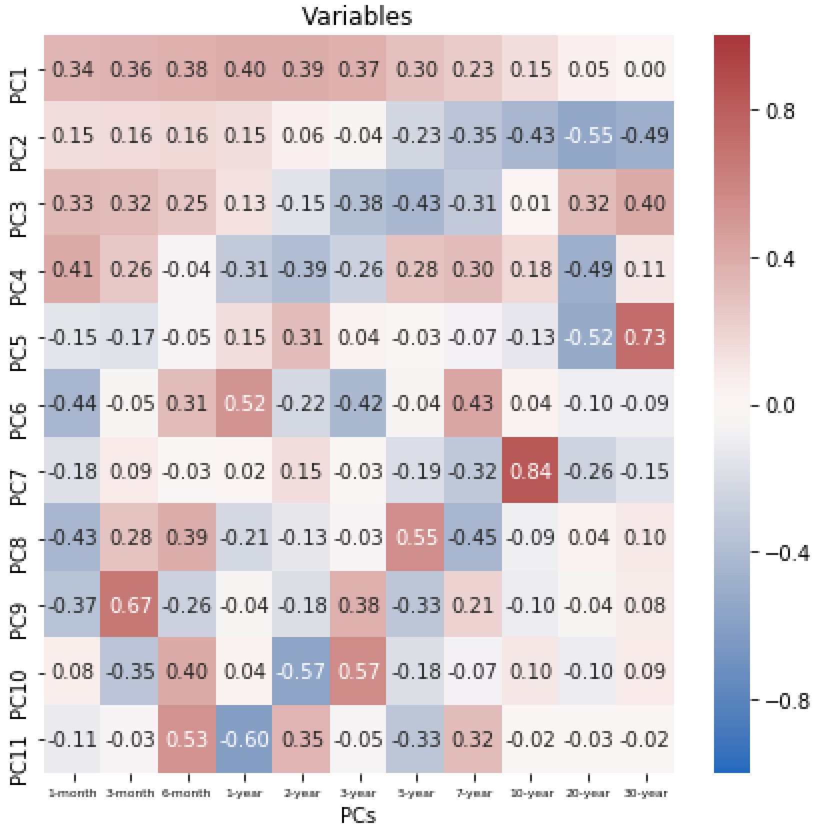
```
_,pca_mx,loadings = pca_own(input_mx)
```

fig,ax=plt.subplots(figsize=(6,18))

#loadings_test = pca.components_*np.sqrt(pca.singular_values_) sns.heatmap(input_mx_,ax=ax,vmin=-2, vmax=5, annot=True, fmt='.2f', cmap='vlag')

In [17]:

```
fig,ax=plt.subplots(figsize=(6,6))
#loadings_test = pca.components_*np.sqrt(pca.singular_values_)
sns.heatmap(loadings.T,ax=ax,vmin=-1, vmax=1, annot=True, fmt='.2f', cmap='vlag')
ax.set_title('PCA loading matrix')
ax.set_xlabel('PCs')
ax.set_title('Variables')
ax.set_xticklabels(revise_columns,fontsize=6)
ax.set_yticklabels(np.array(['PC'+ str(i) for i in range(1,12)]))
fig.tight_layout()
#embed_pdf_figure()
```



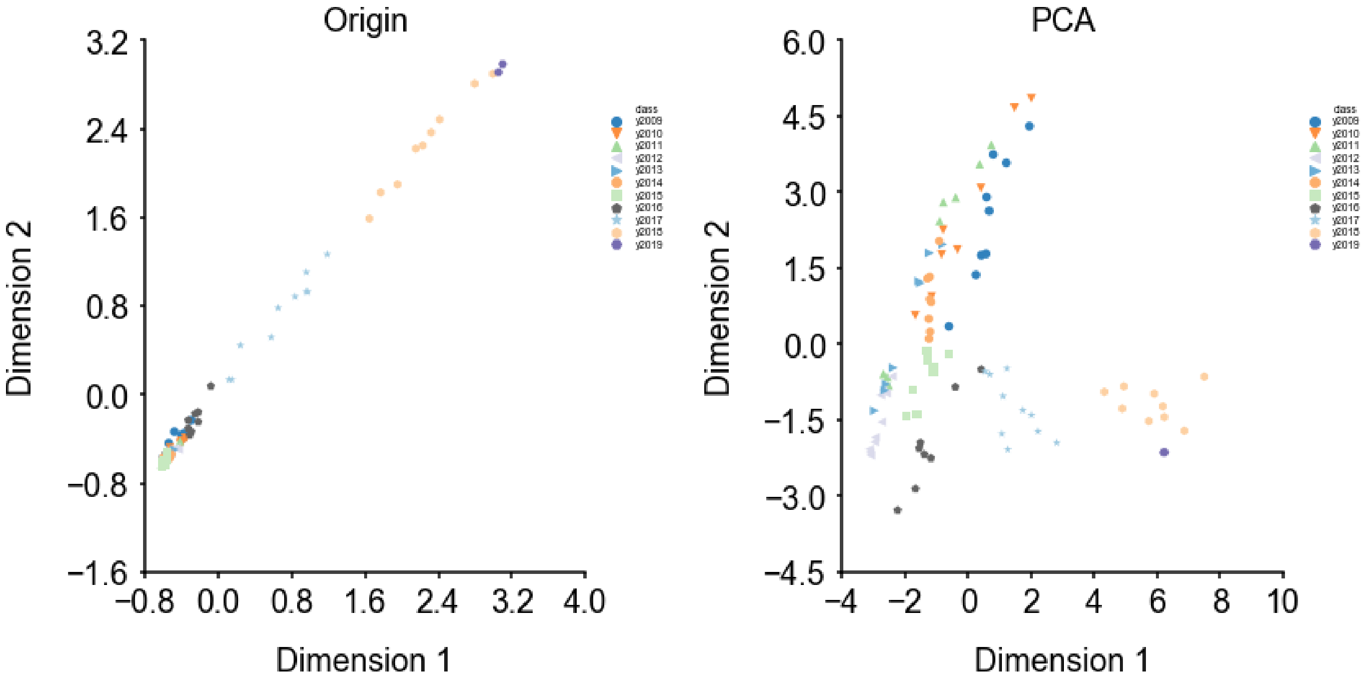
	1-month	3-month	6-month	1-year	2-year	3-year	5-year	7-year	10-year	20-year	30-year
PC1	0.34	0.36	0.38	0.40	0.39	0.37	0.30	0.23	0.15	0.05	0.00
PC2	0.15	0.16	0.16	0.15	0.06	-0.04	-0.23	-0.35	-0.43	-0.55	-0.49
PC3	0.33	0.32	0.25	0.13	-0.15	-0.38	-0.43	-0.31	0.01	0.32	0.40
PC4	0.41	0.26	-0.04	-0.31	-0.39	-0.26	0.28	0.30	0.18	-0.49	0.11
PC5	-0.15	-0.17	-0.05	0.15	0.31	0.04	-0.03	-0.07	-0.13	-0.52	0.73
PC6	-0.44	-0.05	0.31	0.52	-0.22	-0.42	-0.04	0.43	0.04	-0.10	-0.09
PC7	-0.18	0.09	-0.03	0.02	0.15	-0.03	-0.19	-0.32	0.84	-0.26	-0.15
PC8	-0.43	0.28	0.39	-0.21	-0.13	-0.03	0.55	-0.45	-0.09	0.04	0.10
PC9	-0.37	0.67	-0.26	-0.04	-0.18	0.38	-0.33	0.21	-0.10	-0.04	0.08
PC10	0.08	-0.35	0.40	0.04	-0.57	0.57	-0.18	-0.07	0.10	-0.10	0.09
PC11	-0.11	-0.03	0.53	-0.60	0.35	-0.05	-0.33	0.32	-0.02	-0.03	-0.02

```
In [18]: def legendhandle(lists,porm=True,order=0):
             '''
                 input: array,porm palette or marker
                 palettesorder=0 dataset Category20c
                 palettesorder=1 batch

                 return a dic mapping levels of the hue variable to colors
                 or return a dic mapping levels of the style variable to markers
                 when use sns function, set palette=dic or markers=dic

             '''
             tableau10m = np.array([(114,158,206),(255,158,74),(103,191,92),(237,102,93),(173
                                   (168,120,110),(237,151,202),(162,162,162),(205,204,93),(109,2
             if porm == True:
                 if order == 0:
                     palette = np.array(Category20c[20]).reshape(4,-1).T.ravel() #
                 if order == 1:
                     palette = Pastel2[8]
                 lists.sort()
                 dic={}
                 for i in range(len(lists)):
                     dic[lists[i]]=palette[i]
                 return dic
             else:
                 markerlist1 = ['v','^','<','>'] #triangle_down triangle_up triangle_left tri
                 markerlist2 = ['P','o','X','s'] #plus (filled) circle x (filled) square
                 #markerlist3 = ['$CPM$','$CPM_top$','$RLE$','$TMM$']
                 markerlist3 = ['$f$','$g$','$h$','$l$']
                 markerlist3.sort()
                 if order == 0:
                     markers = markerlist2
                 if order == 1:
                     markers = markerlist1
                 if order == 2:
                     markers = markerlist3

                 lists.sort()
                 dic={}
                 for i in range(len(lists)):
                     dic[lists[i]]=markers[i]
                 return dic
```

In [19]:

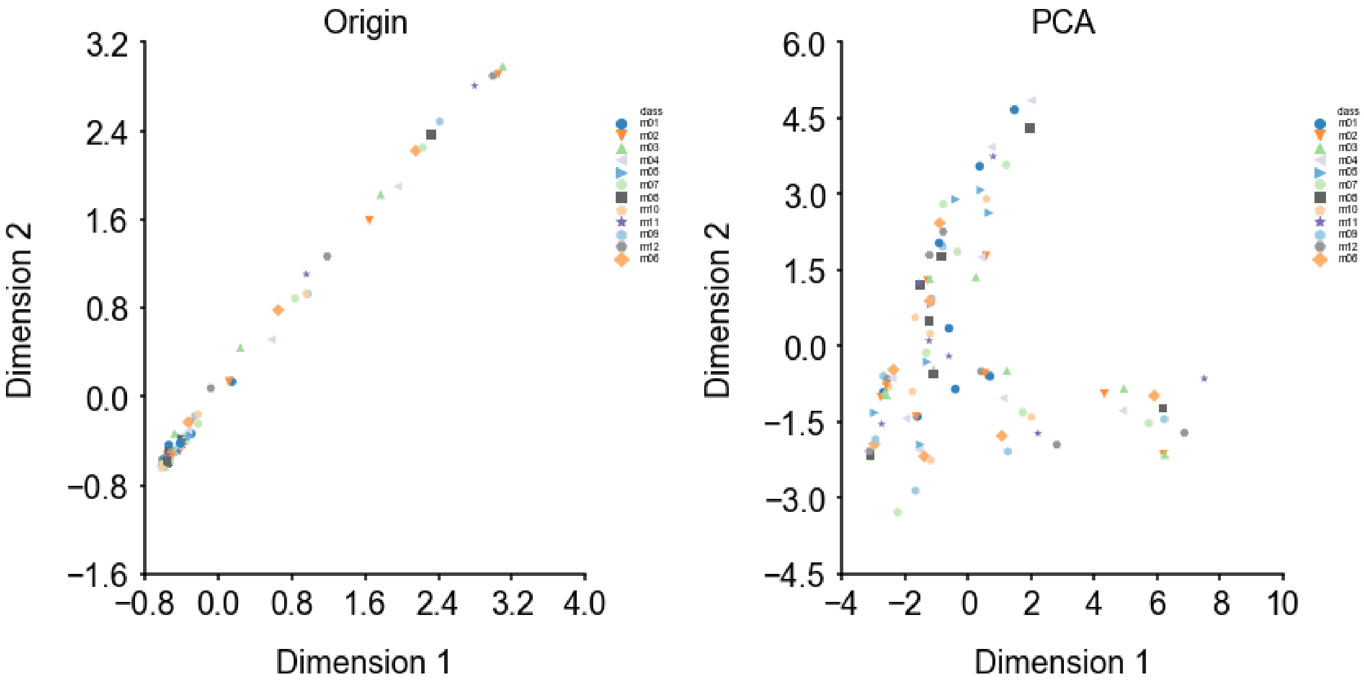
```
filled_markers = ('o', 'v', '^', '<', '>', '8', 's', 'p', '*', 'h', 'H', 'D', 'd', '
def PCA_plot_sns(ax,data,sampleclass,method = 'Origin'):
    #X = log_transfrom(data).T
    X = StandardScaler().fit_transform(data.T)
    if method=='Origin':
        X_pca=X
    if method == 'PCA':
        transform = PCA()
        X_pca = transform.fit_transform(X)
    elif method == 'tSNE':
        transform = TSNE()
        X_pca = transform.fit_transform(X)

    plot_table = pd.DataFrame(X_pca[:,:2])
    plot_table.index = data.columns
    plot_table = pd.concat((plot_table,sampleclass.loc[plot_table.index]),axis=1)
    plot_table.columns = ['dimension_1','dimension_2','class']
    classnum = np.unique(plot_table.iloc[:,2]).shape[0]

    #plot_table=plot_table.astype('float')
    #plot_table.iloc[:,2]  = plot_table.iloc[:,2].astype('str')
    #plot_table.iloc[:,0] = pd.to_numeric(plot_table.iloc[:,0])
    #plot_table.iloc[:,1] = pd.to_numeric(plot_table.iloc[:,1])

    sns.scatterplot(ax=ax,data=plot_table,x="dimension_1", y="dimension_2",markers=f
                    palette=legendhandle(np.unique(plot_table['class'])), hue="class

    std_plot(ax,'Dimension 1','Dimension 2',None,
             title=method, legendtitle='class',legendsort=False
             ,xbins=6,ybins=6
            )
    legend = ax.legend(prop=fontlegend,
     bbox_to_anchor=(1.2,0.9),framealpha=0,labelspacing=0.24)
    ax.legend_.get_frame()._linewidth=0
    fig.tight_layout()
    fig.savefig('output/'+method+'_plot.eps')
```

In [29]:
```
fig, ax = plt.subplots(1,2,figsize=(12,6))
PCA_plot_sns(ax[0],input_table.T,year_class,'Origin')
PCA_plot_sns(ax[1],input_table.T,year_class,'PCA')

#embed_pdf_figure()
```



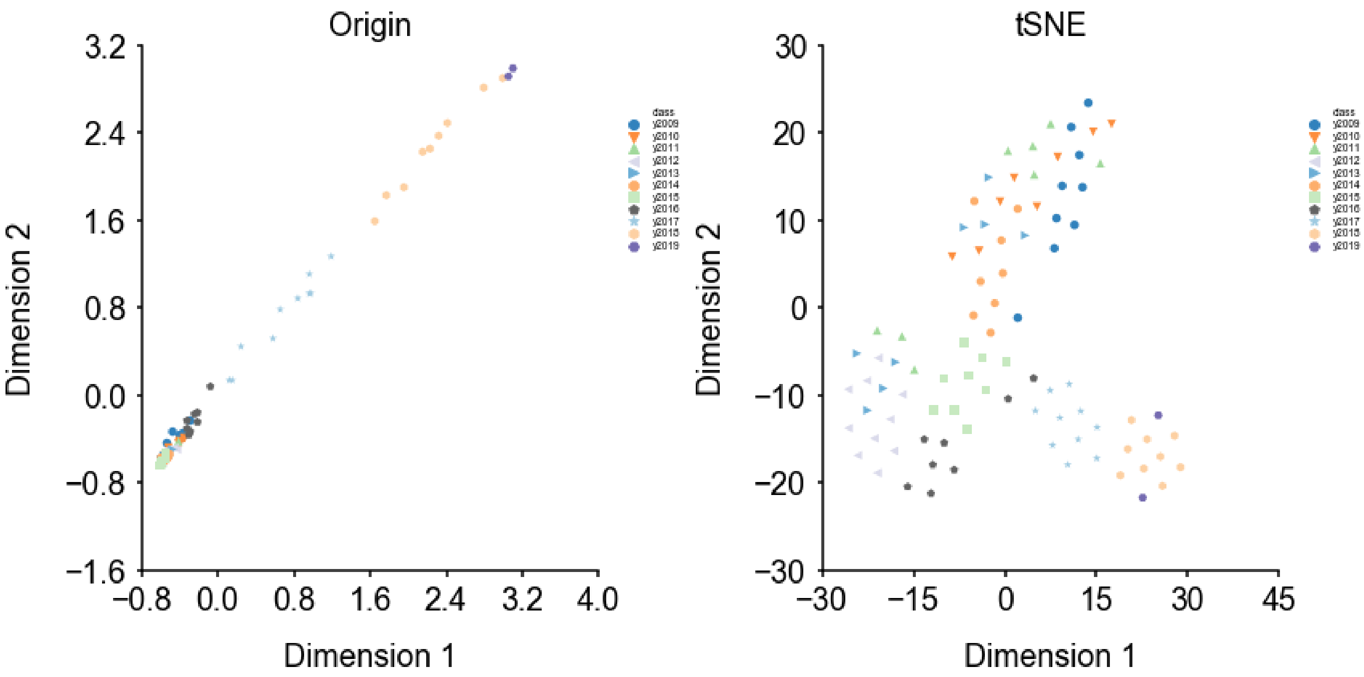
In [28]:

```
fig, ax = plt.subplots(1,2,figsize=(12,6))
PCA_plot_sns(ax[0],input_table.T,month_class,'Origin')
PCA_plot_sns(ax[1],input_table.T,month_class,'PCA')

#embed_pdf_figure()
```

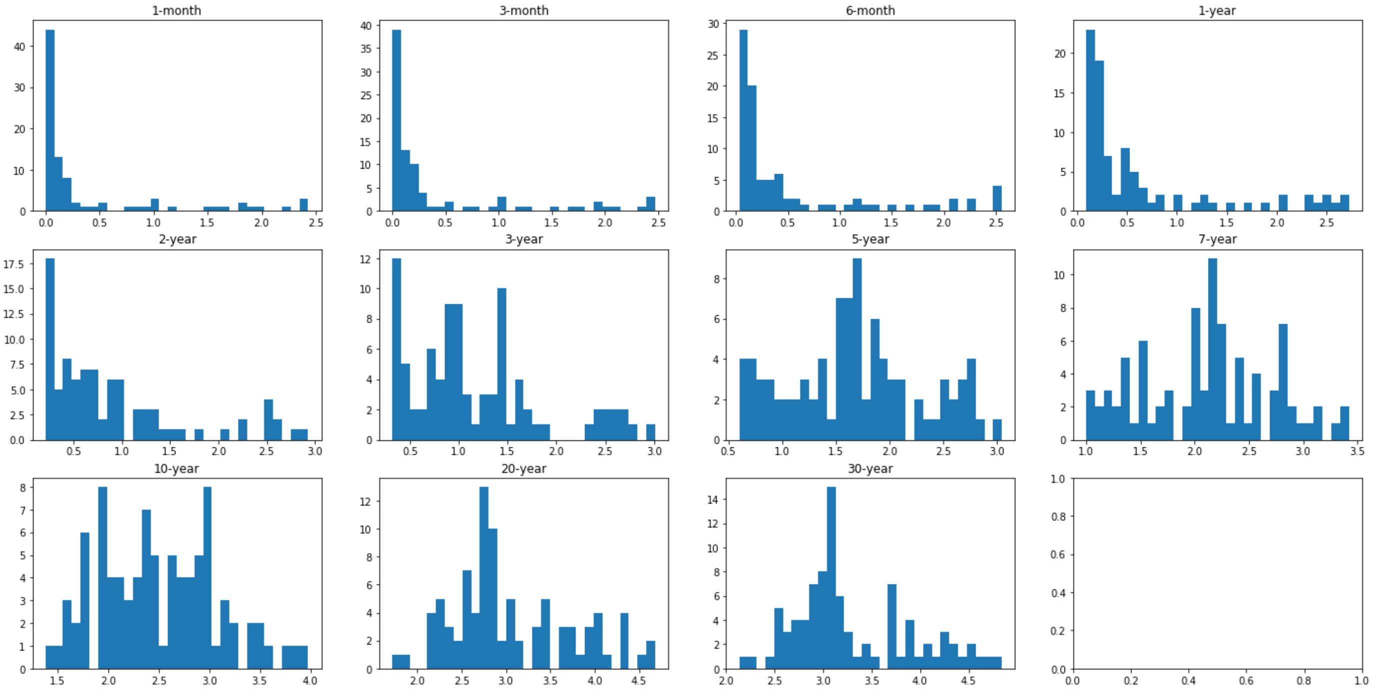


In [27]:

```
fig, ax = plt.subplots(1,2,figsize=(12,6))
PCA_plot_sns(ax[0],input_table.T,year_class,'Origin')
PCA_plot_sns(ax[1],input_table.T,year_class,'tSNE')
fig.tight_layout()
#embed_pdf_figure()
```



In [23]:
```
fig,ax = plt.subplots(3,4,figsize=(24,12))
for i in range(3):
    for j in range(4):
        if i*4+j<=10:
            ax[i,j].set_title(revise_columns[i*4+j])
            ax[i,j].hist(np.array(select_table.iloc[:,i*4+j]),bins=30)
#embed_pdf_figure()
```



In [24]:
```
from scipy.stats import skew
from scipy.stats import kurtosis
```

In [25]:
```
metrics_sum = pd.DataFrame(index=revise_columns,
                          columns=['mean','std','skewness','kurtosis'])
for i in range(11):
    metrics_sum.iloc[i,0] = np.mean(select_table.iloc[:,i])
    metrics_sum.iloc[i,1] =np.std(select_table.iloc[:,i])
    metrics_sum.iloc[i,2] =skew(select_table.iloc[:,i])
    metrics_sum.iloc[i,3] =kurtosis(select_table.iloc[:,i])
```

In [26]:

```
metrics_sum
```

Out[26]:

	mean	std	skewness	kurtosis
1-month	0.401236	0.654478	1.8917	2.29938
3-month	0.43809	0.680783	1.82375	2.00894
6-month	0.526404	0.71215	1.74099	1.71952
1-year	0.64618	0.735068	1.64643	1.45589
2-year	0.902135	0.706565	1.39284	0.99007
3-year	1.16674	0.677206	0.936489	0.210825
5-year	1.67764	0.614855	0.178631	-0.694048
7-year	2.11348	0.595711	0.0498472	-0.67209
10-year	2.49921	0.581905	0.331212	-0.459034
20-year	3.05966	0.672841	0.598109	-0.423001
30-year	3.29483	0.606408	0.707068	-0.299371

select_table.columns = np.array(['time-'+i for i in np.array(select_table.columns)]).astype('str')
select_table.to_csv('data/select_table.txt')