AUDIT_BBP

November 25, 2020

BBP AUDIT - Raphaëlle Sauzède - November 2020

BGC-ARGO BBP AUDIT FROM SOCA-BBP CMEMS PRODUCT

How to flag bad bbp profiles from a reference database?

---

1 Import libraries

First, for avoiding the warning messages during the execution and installation process, at first remove them:

[1]:
```
import warnings
warnings.filterwarnings('ignore')
```

Import all libraries and functions that we need for the program:

[2]:
```
import os
#import os.path
from os import path
import numpy as np
import pandas as pd
import wget
import itertools
import matplotlib.pyplot as plt
from matplotlib.colors import ListedColormap, BoundaryNorm
from mpl_toolkits.basemap import Basemap
from datetime import date
from datetime import datetime
from datetime import timedelta
from netCDF4 import Dataset as NetCDFFile
from netCDF4 import num2date
from sklearn.metrics import mean_squared_error
from scipy.stats import ttest_ind, mannwhitneyu, bartlett, ks_2samp
```

2 Define working paths

[3]:
```
path_data_home="/home/sauzede/Documents/R/DATA/"
path_bbp_clim_data="/media/sauzede/MyPassport/DATA/FOR_SOCA_PRODUCT/
↪WEEKLY_FIELDS/CLIMATO/SOCA-BBP/"
path_argo_data="/home/sauzede/ARGO_DATA/"
#path_argo_data="/media/sauzede/MyPassport/ARGO_DATA/"
path_plot="/home/sauzede/PYTHON/ml4ocean/AUDIT_BBP/PLOT/"
```

3 Load synthetic Argo index file from coriolis and get dac/wmo/n_cycle for each NecCDF file from the BGC-Argo database

Download the synthetic Argo index file (with information on Real Time/ Adjusted and Delayed mode parameters for Synthetic NetCDF files) from coriolis for the date of today.

[4]:
```
#date_today=str(date.today())
# Stop the 23th of November to present the BBP audit during ADMT
date_audit_pres_ADMT=str("2020-11-23")

# Download file if it was not doine already for today
if not path.exists(path_data_home + "/index_bio_synth_" + date_audit_pres_ADMT␣
↪+ ".txt"):
    print('Beginning file download with wget module')
    url='ftp://ftp.ifremer.fr/ifremer/argo/argo_synthetic-profile_index.txt'
    wget.download(url, path_data_home + "/index_bio_synth_" + date_today + ".
↪txt")
```

[5]:
```
# Read this file
INDEX_SYNTH=pd.read_table(path_data_home + "/index_bio_synth_" +␣
↪date_audit_pres_ADMT + ".txt", skiprows=8, sep=",", encoding='utf8')
```

[6]:
```
INDEX_SYNTH.columns
```

[6]:
```
Index(['file', 'date', 'latitude', 'longitude', 'ocean', 'profiler_type',
       'institution', 'parameters', 'parameter_data_mode', 'date_update'],
      dtype='object')
```

Get dac/WMO/n_cycle/measured variables associated to each NetCDF file:

[7]:
```
files = INDEX_SYNTH['file'] #pathways of all profiles
file=files.str.split("/", expand=True).rename(columns={0:'dac', 1:'wod', 3:
↪'ncdf'})
INDEX_SYNTH['dac']=file.dac
```

```
INDEX_SYNTH['wod']=file.wod
INDEX_SYNTH['ncdf']=file.ncdf
# print(file)
nc_cycle=file.ncdf.str.split("_",expand=True)[1].str.split(".",expand=True)[0]
INDEX_SYNTH['nc_cycle']=nc_cycle
# print(nc_cycle)
variable = INDEX_SYNTH['parameters'] #contains parameters measured by the float
variables=variable.str.split()
variables=variables.astype(str)
INDEX_SYNTH['variables']=variables
# print(variables)
ref_date = "19500101000000"
INDEX_SYNTH['datetime'] = pd.
 ↪to_datetime(INDEX_SYNTH['date'],format='%Y%m%d%H%M%S', errors='ignore') #␣
 ↪convert date column to datetime
#INDEX_SYNTH.head()
```

4 Compute the statistics between CMEMS weekly climatologies of bbp and bbp measured from floats

First, get all climatological dates (every week) from the name of clim files:

[8]:
```
# Directory of bbp climatological data :
nc_file_chemin_bbp_clim=os.listdir(path_bbp_clim_data)
# Get all dates for clim: split the name of the NetCDf file to retrieve the date␣
 ↪into it:
dates_of_clim=[nc_file_chemin_bbp_clim[i].split("_")[6] for i in␣
 ↪range(len(nc_file_chemin_bbp_clim)-1)]
# And remove T00000Z from the date:
dates_of_clim=[dates_of_clim[i].split("T")[0] for i in␣
 ↪range(len(dates_of_clim)-1)]
# Transform the string in date formats:
dates_of_clim = [datetime.strptime(str(dates_of_clim[i]),'%Y%m%d') for i in␣
 ↪range(len(dates_of_clim)-1)]
```

[9]:
```
print("There are " + str(len(nc_file_chemin_bbp_clim)) + " weekly␣
 ↪climatological dates")
```

```
There are 53 weekly climatological dates
```

Then, initialize the statistical variables to fill in the INDEX_SYNTH dataframe and varibales to retrieve the number of bbp profiles compared to the bbp climatologies:

[10]:
```
# QC for profile
INDEX_SYNTH['PROF_QC']=np.nan
```

```
# Stats variables computed from difference between Argo and clim ref
# Median Absolute Percent Difference - MAPD
INDEX_SYNTH['MAPD']=np.nan
# Median Percent Difference - MPD
INDEX_SYNTH['MPD']=np.nan
# Median Difference - MD
INDEX_SYNTH['MD']=np.nan
# Median Gain -MG
INDEX_SYNTH['MG']=np.nan
# Root Mean Squared Difference - RMSD
INDEX_SYNTH['RMSD']=np.nan

# Results of p-value from different stats tests
#INDEX_SYNTH['Chi2']=np.nan
#INDEX_SYNTH['Wilcoxon']=np.nan
INDEX_SYNTH['T-test_ind']=np.nan
#INDEX_SYNTH['T-test_rel']=np.nan
#INDEX_SYNTH['Welch']=np.nan
INDEX_SYNTH['Kolomogorov-Smirnov']=np.nan
INDEX_SYNTH['Mann-Whitney']=np.nan
INDEX_SYNTH['Bartlett']=np.nan

# Index of bbp profiles
i_bbp=[]
i_bbp_good_profile=[]
i_bbp_good_profile_clim=[]
```

[11]:
```
print("Total of " + str(len(files)) + " files")
```

```
Total of 210895 files
```

[14]:
```
for i in range(len(files)-1):

    if i in [50000,100000,150000,200000]:
        print(str(i) + "/" + str(len(files)))

    # We want only open Argo files when bbp has been measured from the float
    if not "BBP700" in variables[i]:
        # Pass if BBP not measured
        continue

    # Get full path name of the NetCDF file
    path_bbp_argo_file=path_argo_data + files[i]

    # Verify that the file exists (sometimes problem between the index file and␣
↪files in the database
    # because the update is not finished in files available)
```

```python
    if not path.exists(path_bbp_argo_file):
        # Pass if the file does not exist
        continue

    # Put the i in the bbp_i vector to store indices of files that exist with␣
↪BBP700 measured
    i_bbp.append(i)

    # Open the Argo NetCDF file
    bgc_data=NetCDFFile(path_bbp_argo_file)
    # Get bbp/pres and geolocation variables and their associated QC
    bbp_argo=bgc_data.variables['BBP700'][:][0]
    bbp_argo_qc=bgc_data.variables['BBP700_QC'][:][0]
    # The QC variables has to be decoded
    bbp_argo_qc=[np.array(bbp_argo_qc)[i].decode('utf-8') for i in␣
↪range(len(bbp_argo))]

    # Get pressure
    pres_argo=bgc_data.variables['PRES'][:][0]
    pres_argo_qc=bgc_data.variables['PRES_QC'][:][0]
    # Decode the QC of pressure
    pres_argo_qc=[np.array(pres_argo_qc)[i].decode('utf-8') for i in␣
↪range(len(pres_argo))]

    # Get lon/lat/juld and QC associated
    lon_argo=bgc_data.variables['LONGITUDE'][:]
    lat_argo=bgc_data.variables['LATITUDE'][:]
    position_qc=bgc_data.variables['POSITION_QC'][:]
    position_qc=str(position_qc[0].decode('utf-8'))

    juld=bgc_data.variables['JULD']
    # Transfor the juld date in date format
    datetime_juld=num2date(juld[:],juld.units)
    juld_qc=bgc_data.variables['JULD_QC'][:]
    juld_qc=str(juld_qc[0].decode('utf-8'))

    # Get month and day from the date
    month=datetime_juld[:][0].strftime('%m')
    day=datetime_juld[:][0].strftime('%d')

    # Remove Fillvalues of bbp in pres and bbp variables
    pres_argo=pres_argo[bbp_argo.mask==False]
    pres_argo_qc=np.array(pres_argo_qc)[bbp_argo.mask==False]
    bbp_argo_qc=np.array(bbp_argo_qc)[bbp_argo.mask==False]
    bbp_argo=bbp_argo[bbp_argo.mask==False]
```

```python
    # Verify that there are some data of bbp and that the position and date are␣
↪not bad QC flagged data
    if (len(bbp_argo)<1) or (not position_qc in ['1','2']) or (not juld_qc in␣
↪['1','2']):
        # If no bbp data or bad position and/or date:
        # Close the NetCDF file
        bgc_data.close()
        # And pass to next iteration
        continue

    # Increment i_bbp_good_profile if bbp profile with at least one value is␣
↪available with good position and date available
    i_bbp_good_profile.append(i)

    # Get the QC from bbp profile
    prof_qc=bgc_data.variables['PROFILE_BBP700_QC'][:]
    if not prof_qc.mask:
        prof_qc_str=str(prof_qc[0].decode('utf-8'))
    if prof_qc.mask:
        prof_qc_str=np.nan

    # Put the prof QC in the dataframe
    INDEX_SYNTH['PROF_QC'][i]=prof_qc_str

    # Close the Argo NetCDF file
    bgc_data.close()

    # Get the closest date of climatology available
    # For that, get the date of the profile (month/day) but for year 2018
    # If wrong date (i.e.29/02) --> change in 28/02
    if month=='02' and day=="29":
        day='28'
    else:
        new_date=datetime.strptime(str('2018'+month+day),'%Y%m%d')

    # Compute the time difference between the date of float (in 2018) and each␣
↪climatological date (in 2018)
    delta=[abs(dates_of_clim[i]-new_date) for i in range(len(dates_of_clim)-1)]
    # Retrieve the minimum of the time difference
    i_min=np.argmin(delta)
    # Get the path of the NetCDF file associated to the climatological data for␣
↪the minimum time difference
    path_bbp_clim_data_w = path_bbp_clim_data + nc_file_chemin_bbp_clim[i_min]
    # Open the climatological NetCDF file
    nc_bbp_clim=NetCDFFile(path_bbp_clim_data_w)
    # Get pres/bbp and location from the climatological product
    bbp_clim=nc_bbp_clim.variables["bbp"][:]
```

```
    pres_clim=nc_bbp_clim.variables["depth"][:]
    lon_clim=nc_bbp_clim.variables["longitude"][:]
    lat_clim=nc_bbp_clim.variables["latitude"][:]
    # Close climatological NetCDF file
    nc_bbp_clim.close()

    # Get the closest pixel associated to the float profile
    # Compute the difference between each lon/lat and position of the float to␣
↪retrieve the position of the minimum
    delta_lon=[abs(lon_clim[i]-lon_argo) for i in range(len(lon_clim)-1)]
    iii=np.argmin(delta_lon)
    delta_lat=[abs(lat_clim[i]-lat_argo) for i in range(len(lat_clim)-1)]
    jjj=np.argmin(delta_lat)
    # Get the bbp values (at 19 depths) value for the minimum of difference for␣
↪lon and lat
    bbp_clim_comp=bbp_clim[0,:,jjj,iii]

    # Verify that the climatological bbp profile is not empty
    if not bbp_clim_comp.mask.all():
        # Interpolate the bbp climatological values to Argo pressure
       bbp_clim_comp_approx=np.interp(x=pres_argo,xp=pres_clim,fp=bbp_clim_comp)

        # Compute statistics between bbp clim and bbp from Argo
        # Median Absolute Difference
        MAPD=np.median(abs((bbp_argo - bbp_clim_comp_approx)/
↪bbp_clim_comp_approx))*100
        # Median Percent Difference
       MPD=np.median((bbp_argo - bbp_clim_comp_approx)/bbp_clim_comp_approx)*100
        # Median Difference
        MD=np.median(bbp_argo - bbp_clim_comp_approx)
        # Median gain
        MG=np.median(bbp_clim_comp_approx/bbp_argo)
        # Mean Squared Difference
        msd = mean_squared_error(y_true=bbp_clim_comp_approx,y_pred=bbp_argo)
        # Root Mean Squared Difference
        RMSD = np.sqrt(msd)

        # Put these statistics in the dataframe
        INDEX_SYNTH['MAPD'][i]=MAPD
        INDEX_SYNTH['MPD'][i]=MPD
        INDEX_SYNTH['MD'][i]=MD
        INDEX_SYNTH['MG'][i]=MG
        INDEX_SYNTH['RMSD'][i]=RMSD

        if len(bbp_argo)>5:
            # Statistics tests --> Get p-value
```

```
            INDEX_SYNTH['T-test_ind'][i]=ttest_ind(bbp_argo,␣
↪bbp_clim_comp_approx)[1]
            INDEX_SYNTH['Kolomogorov-Smirnov'][i]=ks_2samp(bbp_argo,␣
↪bbp_clim_comp_approx)[1]
            INDEX_SYNTH['Mann-Whitney'][i]=mannwhitneyu(bbp_argo,␣
↪bbp_clim_comp_approx)[1]
            INDEX_SYNTH['Bartlett'][i]=bartlett(bbp_argo,␣
↪bbp_clim_comp_approx)[1]

        # Increment i_bbp_good_profile_clim if bbp climatology available with␣
↪bbp Argo profile
        i_bbp_good_profile_clim.append(i)
```

```
50000/210895
100000/210895
150000/210895
200000/210895
```

[12]:
```
INDEX_SYNTH.shape
```

[12]:
```
(210895, 26)
```

[13]:
```
INDEX_SYNTH.columns
```

[13]:
```
Index(['file', 'date', 'latitude', 'longitude', 'ocean', 'profiler_type',
       'institution', 'parameters', 'parameter_data_mode', 'date_update',
       'dac', 'wod', 'ncdf', 'nc_cycle', 'variables', 'datetime', 'PROF_QC',
       'MAPD', 'MPD', 'MD', 'MG', 'RMSD', 'T-test_ind', 'Kolomogorov-Smirnov',
       'Mann-Whitney', 'Bartlett'],
      dtype='object')
```

5 Results

5.1 Some numbers

[14]:
```
print("BBP700 is measured for " + str(len(i_bbp)) + " files / " +␣
↪str(len(files)) + " available")
```

```
BBP700 is measured for 73262 files / 210895 available
```

[19]:
```
print(str(len(i_bbp_good_profile)) +
      " good BBP700 profiles available (with at least one value and with good QC␣
↪flagged position and date)")
```

```
73262 good BBP700 profiles available (with at least one value and with good QC
flagged position and date)
```

[20]:
```
print(str(len(i_bbp_good_profile_clim)) + " climatological profiles of bbp␣
↪available to make the comparison")
```

```
60096 climatological profiles of bbp available to make the comparison
```

Plot the geolocation of profiles without climatological data:

[21]:
```
i_without_clim = np.setdiff1d(i_bbp_good_profile,i_bbp_good_profile_clim)
```

[22]:
```
print(str(len(i_without_clim)) + " climatological profiles of bbp not available␣
↪to make the comparison")
```

```
13165 climatological profiles of bbp not available to make the comparison
```

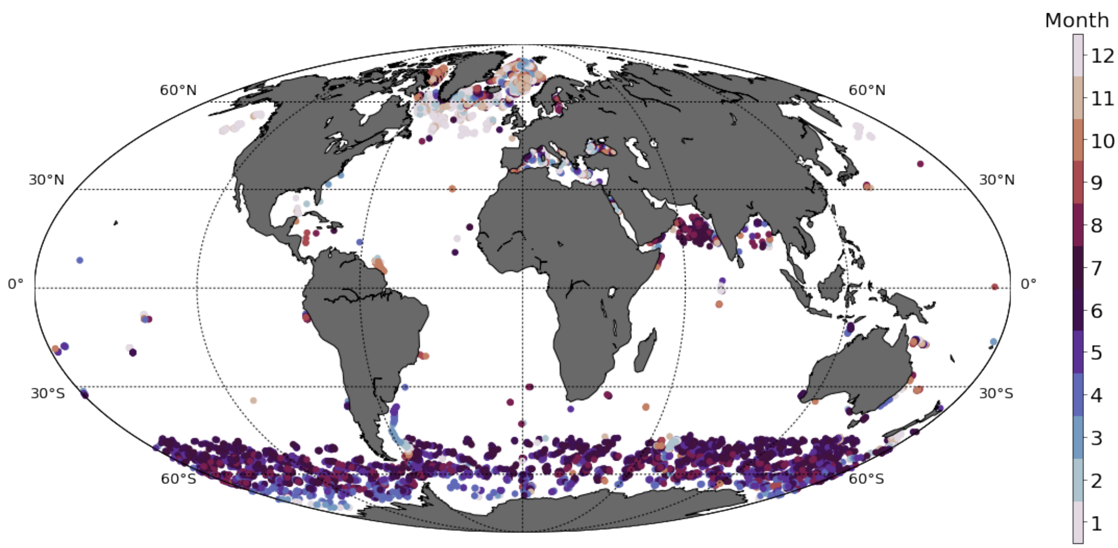
5.2 Plot the geographical distribution of the climatological weekly bbp profiles not available

Global Ocean:

[23]:
```
fig = plt.figure(figsize=(21,9)) # set figure environemnt
m = Basemap(projection="moll",lon_0=0,resolution='c') # Plot geographical map␣
↪and define projection

# Get date  of data that we want to plot
juld = INDEX_SYNTH['date'][i_without_clim]
# Transform the juld date in date format
datetime_juld=[datetime.strptime(str(int(juld[i_without_clim[i]])),␣
↪"%Y%m%d%H%M%S") for i in np.arange(len(i_without_clim))]

# Get month and day from the date
month=[int(datetime_juld[:][i].strftime('%m')) for i in np.
↪arange(len(datetime_juld))]

# Get lon/lat of data that we want to plot:
lon = INDEX_SYNTH['longitude'][i_without_clim].tolist()
lat = INDEX_SYNTH['latitude'][i_without_clim].tolist()

LON,LAT = m(lon,lat) #transform lon/lat in the basemap environment

cmap = plt.cm.twilight
norm = BoundaryNorm(np.linspace(start=0.5,stop=12.5,num=13), cmap.N)
sc = plt.scatter(LON, LAT, s=30, c=month, facecolors="none",cmap=cmap,norm=norm)␣
↪#facecolors = "none" to have circles (empty)

#plot continents/coastlines...
```

```
m.drawcoastlines()
m.drawmapboundary(fill_color='white')
m.fillcontinents(color='dimgrey',lake_color='white')
m.drawparallels(np.arange(-90.,90.,30.
 ↪),labels=[True,True,False,False],dashes=[2,2], fontsize='x-large')
m.drawmeridians(np.arange(-180.,180.,60.
 ↪),labels=[False,False,False,True],dashes=[2,2])
cbar = plt.colorbar(sc, aspect=50, ticks=[1,2,3,4,5,6,7,8,9,10,11,12])
cbar.ax.set_yticklabels(["1","2","3","4","5","6","7","8","9","10","11","12"],␣
 ↪fontsize=20)
cbar.ax.set_title("Month", fontsize=20) #Add a title to the colorbar

plt.savefig('%s/MAP_DATA_MISSING_CLIMATO_GLOBAL.png' %str(path_plot), dpi=300)␣
 ↪#Save the figure as png
```

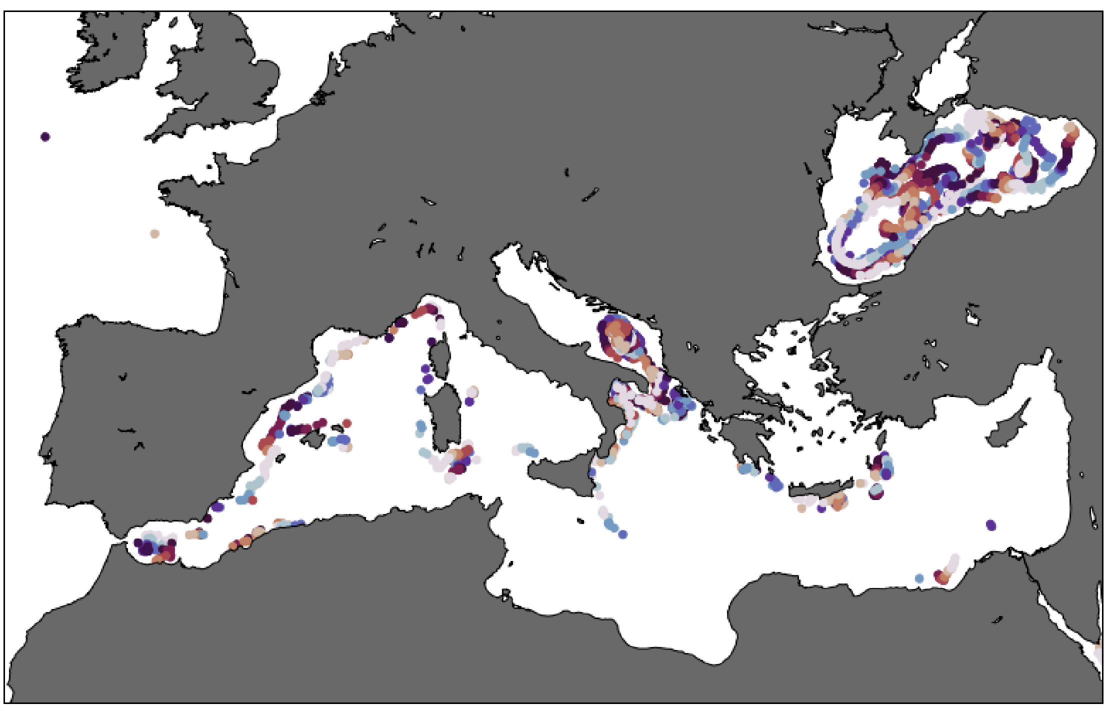
```
Warning: Cannot label meridians on Mollweide basemap
```



Zoom Mediterranean Sea:

```
[24]: fig = plt.figure(figsize=(15,9)) # set figure environemnt
m = Basemap(projection="cass",lon_0=0, lat_0 = 39.5, resolution='i',
            llcrnrlon=-10,llcrnrlat=30,urcrnrlon=45.,urcrnrlat=45.) # Plot␣
 ↪geographical map and define projection

# Get date  of data that we want to plot
juld = INDEX_SYNTH['date'][i_without_clim]
# Transform the juld date in date format
datetime_juld=[datetime.strptime(str(int(juld[i_without_clim[i]])),␣
 ↪"%Y%m%d%H%M%S") for i in np.arange(len(i_without_clim))]
```

```
# Get month and day from the date
month=[int(datetime_juld[:][i].strftime('%m')) for i in np.
 ↪arange(len(datetime_juld))]

# Get lon/lat of data that we want to plot:
lon = INDEX_SYNTH['longitude'][i_without_clim].tolist()
lat = INDEX_SYNTH['latitude'][i_without_clim].tolist()

LON,LAT = m(lon,lat) #transform lon/lat in the basemap environment

cmap = plt.cm.twilight
norm = BoundaryNorm(np.linspace(start=0.5,stop=12.5,num=13), cmap.N)
sc = plt.scatter(LON, LAT, s=30, c=month, facecolors="none",cmap=cmap,norm=norm)␣
 ↪#facecolors = "none" to have circles (empty)

plt.xlim(-10.5,  45)
plt.ylim(30, 45)
# plot continents/coastlines...
m.drawcoastlines()
m.drawmapboundary(fill_color='white')
m.fillcontinents(color='dimgrey',lake_color='white')
#m.drawlsmask(land_color='dimgrey',ocean_color='white',lakes=True)

plt.savefig('%s/MAP_DATA_MISSING_CLIMATO_MED_SEA.png' %str(path_plot), dpi=300)␣
 ↪#Save the figure as png
```



5.3 Find statistics for BBP Audit

Save the dataframe:

[25]:
```
INDEX_SYNTH.to_csv("INDEX_SYNTH_BBP_ALL.csv", index=False)
```

Get data:

[15]:
```
INDEX_BBP_ALL=pd.read_csv("INDEX_SYNTH_BBP_ALL.csv")
```

[16]:
```
INDEX_BBP_ALL.columns
```

[16]:
```
Index(['file', 'date', 'latitude', 'longitude', 'ocean', 'profiler_type',
       'institution', 'parameters', 'parameter_data_mode', 'date_update',
       'dac', 'wod', 'ncdf', 'nc_cycle', 'variables', 'datetime', 'PROF_QC',
       'MAPD', 'MPD', 'MD', 'MG', 'RMSD', 'T-test_ind', 'Kolomogorov-Smirnov',
       'Mann-Whitney', 'Bartlett'],
      dtype='object')
```

[17]:
```
print(str(len(INDEX_BBP_ALL['MAPD'].dropna())) + " profiles have been compared␣
↪to a reference bbp climatological profile")
```

```
60096 profiles have been compared to a reference bbp climatological profile
```

Remove data without bbp (when MAPD has not been computed so is NaN:

[18]:
```
INDEX_BBP=INDEX_BBP_ALL.dropna(subset=['MAPD'])
```

[19]:
```
INDEX_BBP.shape
```

[19]:
```
(60096, 26)
```

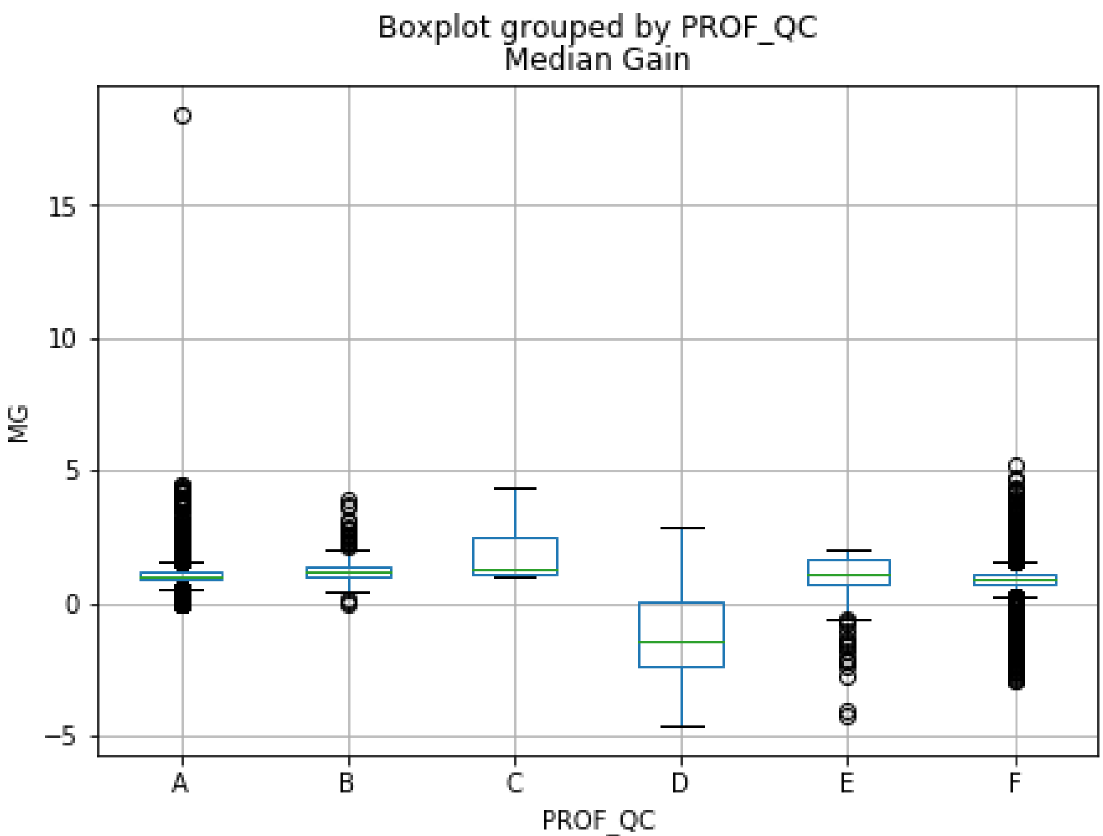
5.4 Boxplots of statistics against profile QC

Profile QC:

Profile QC	Meaning
" "	No QC performed
A	**N**=100%; All profile levels contain good data
B	75% <= **N** < 100%
C	50% <= **N** < 75%
D	25% <= **N** < 50%
E	0% < **N** < 25%
F	**N** = 0%; No profile levels have good data

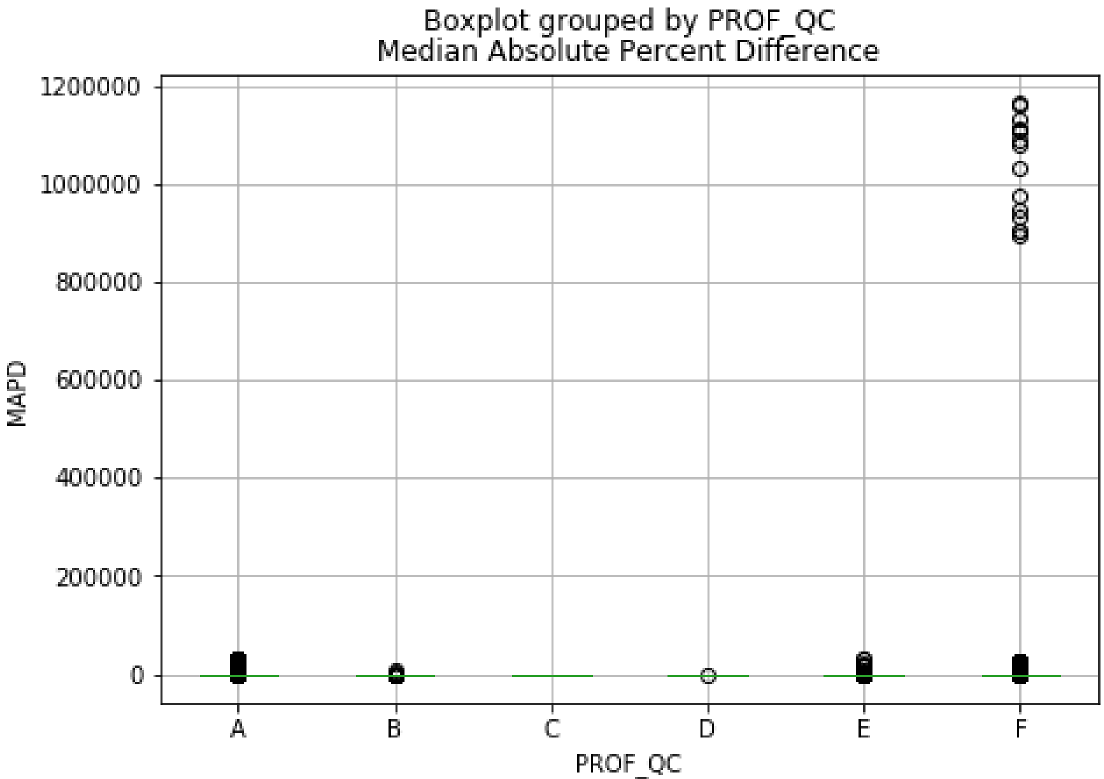
Boxplots:

[20]:
```
boxplot = INDEX_BBP.boxplot(column='MG',by='PROF_QC', figsize=(7,5))
title_boxplot = 'Median Gain'
plt.title( title_boxplot )
boxplot.set_ylabel('MG')
plt.savefig('%s/BOXPLOT_MG.png' %str(path_plot), dpi=300) #Save the figure as png
```



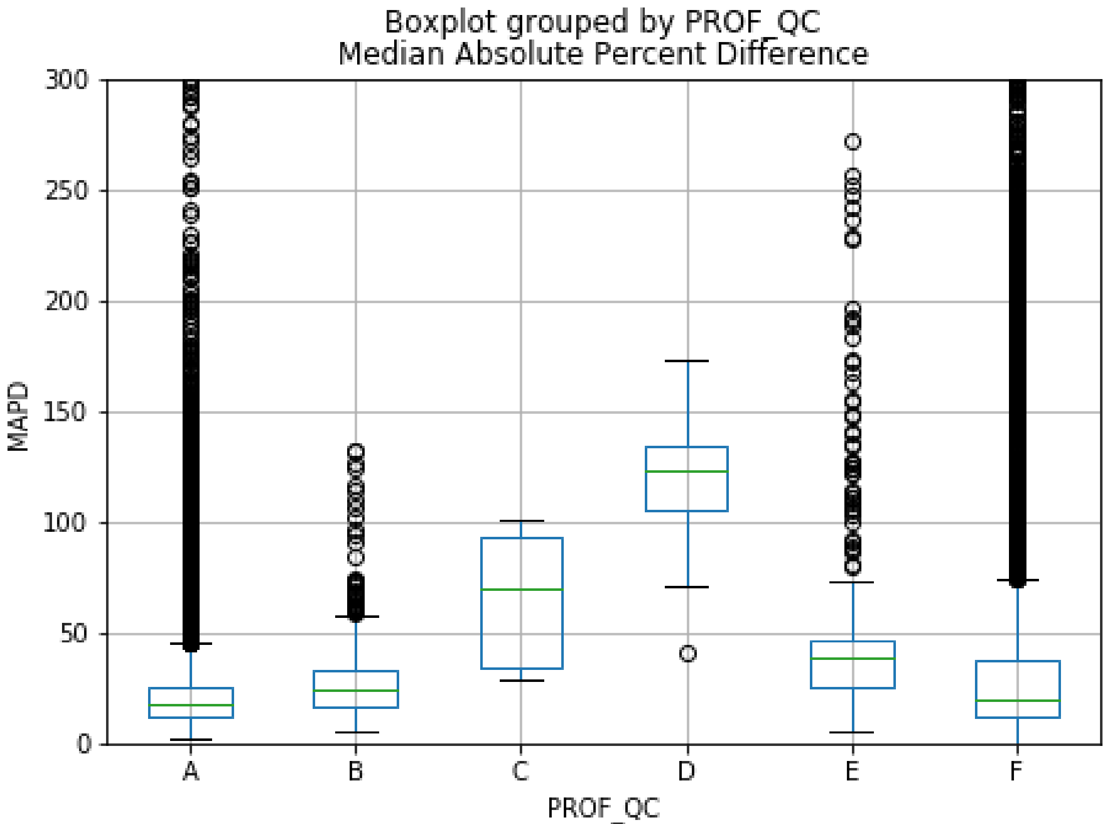
[21]:
```
boxplot = INDEX_BBP.boxplot(column='MAPD',by='PROF_QC', figsize=(7,5))
title_boxplot = 'Median Absolute Percent Difference'
plt.title( title_boxplot )
boxplot.set_ylabel('MAPD')
```

[21]: Text(0, 0.5, 'MAPD')



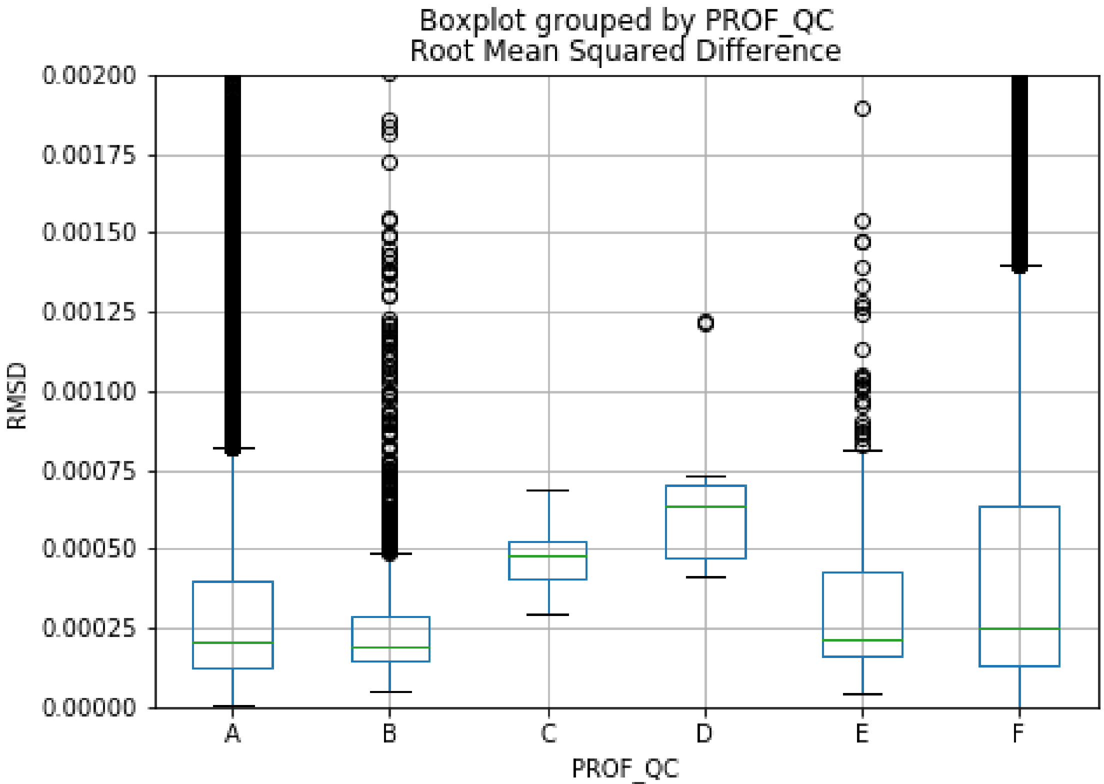
[22]:
```
boxplot = INDEX_BBP.boxplot(column='MAPD',by='PROF_QC', figsize=(7,5))
title_boxplot = 'Median Absolute Percent Difference'
plt.title( title_boxplot )
boxplot.set_ylabel('MAPD')
plt.ylim(0,300)
```

[22]: (0, 300)



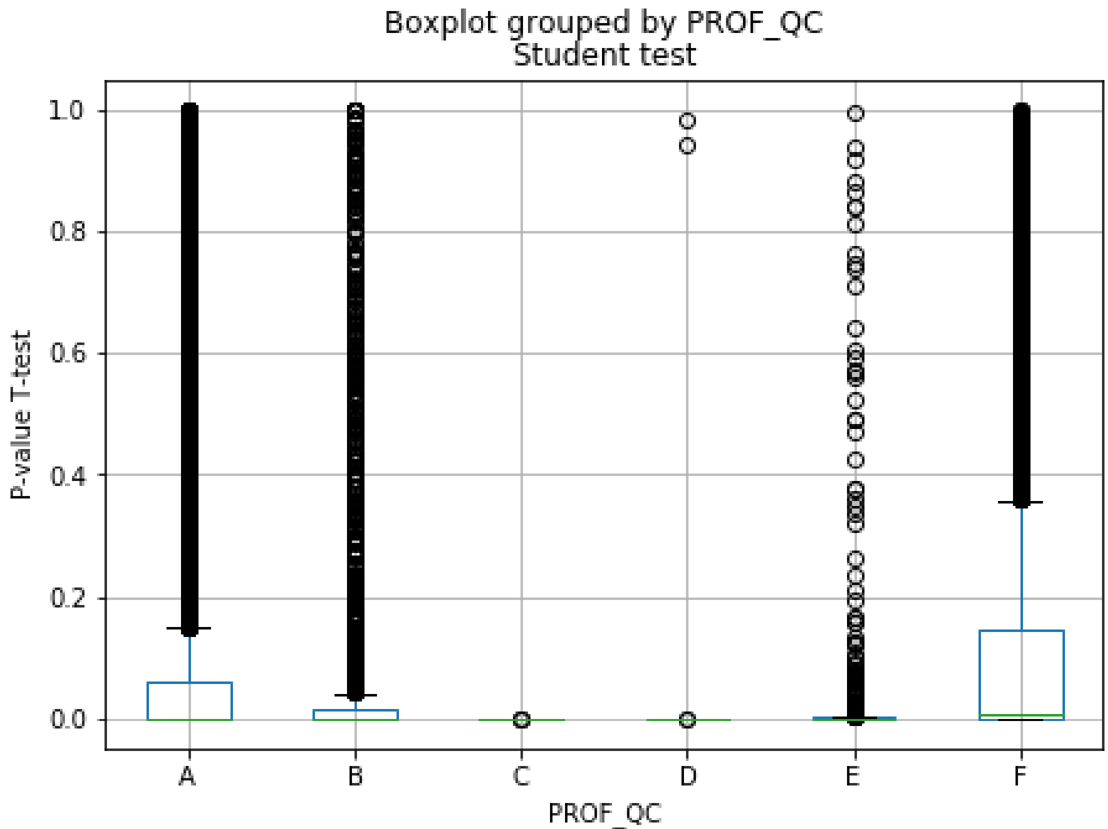
[23]:
```
boxplot = INDEX_BBP.boxplot(column='RMSD',by='PROF_QC', figsize=(7,5))
title_boxplot = 'Root Mean Squared Difference'
plt.title( title_boxplot )
boxplot.set_ylabel('RMSD')
plt.ylim(0,0.002)
```

[23]: (0, 0.002)

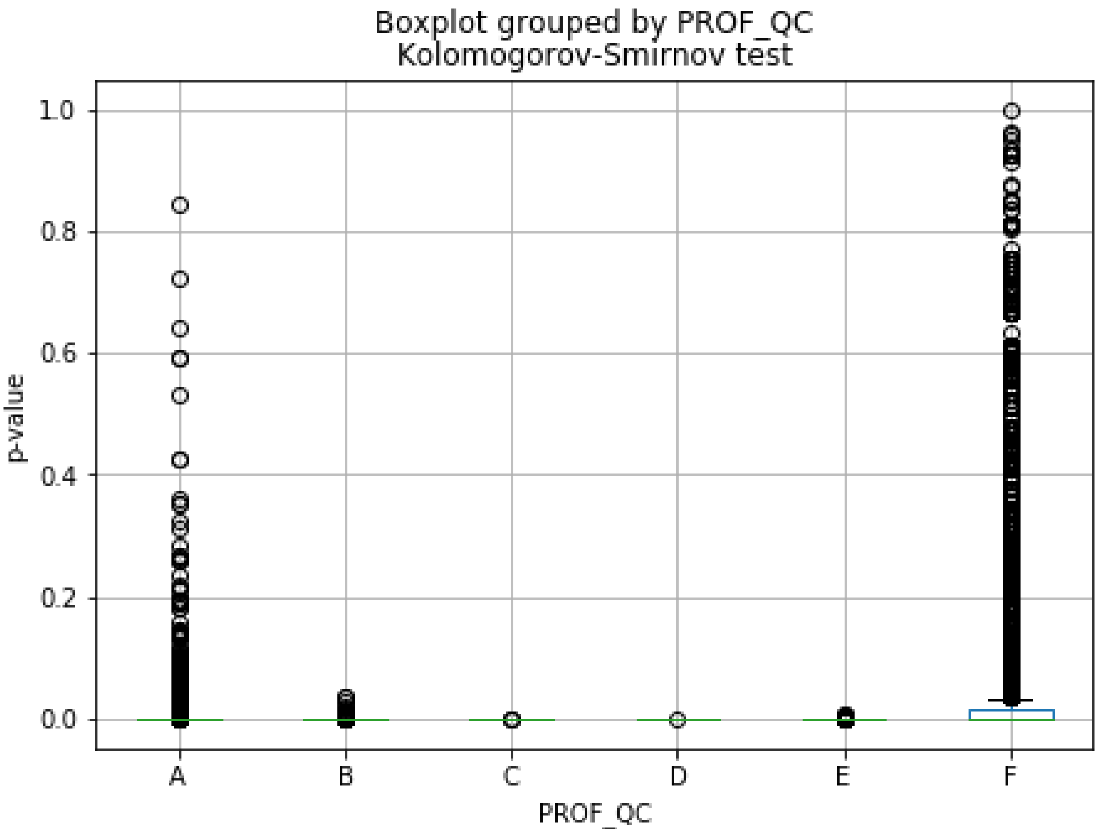



```
[24]: boxplot = INDEX_BBP.boxplot(column='T-test_ind',by='PROF_QC', figsize=(7,5))
      title_boxplot = 'Student test'
      plt.title( title_boxplot )
      boxplot.set_ylabel('P-value T-test')
```

```
[24]: Text(0, 0.5, 'P-value T-test')
```

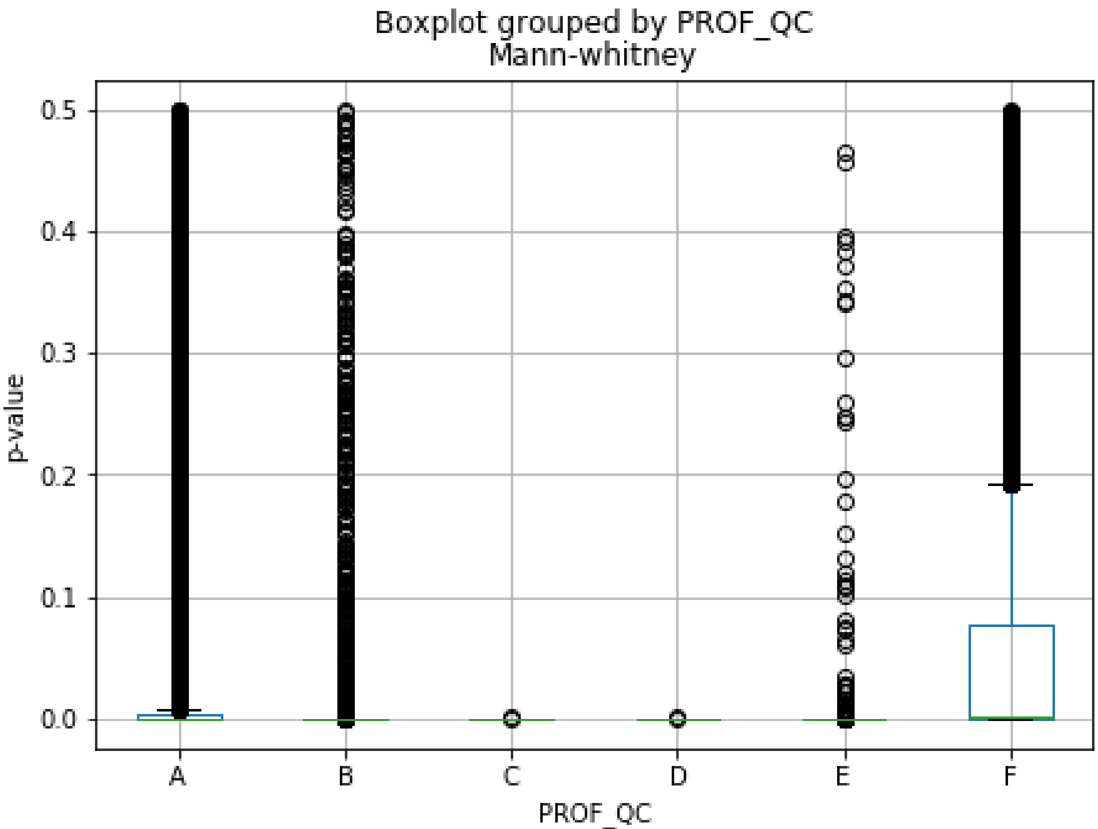


[25]:
```
boxplot = INDEX_BBP.boxplot(column='Kolomogorov-Smirnov',by='PROF_QC',␣
 ↪figsize=(7,5))
title_boxplot = 'Kolomogorov-Smirnov test'
plt.title( title_boxplot )
boxplot.set_ylabel('p-value')
plt.savefig('%s/BOXPLOT_KOLOMOGOROV.png' %str(path_plot), dpi=300) #Save the␣
 ↪figure as png
```



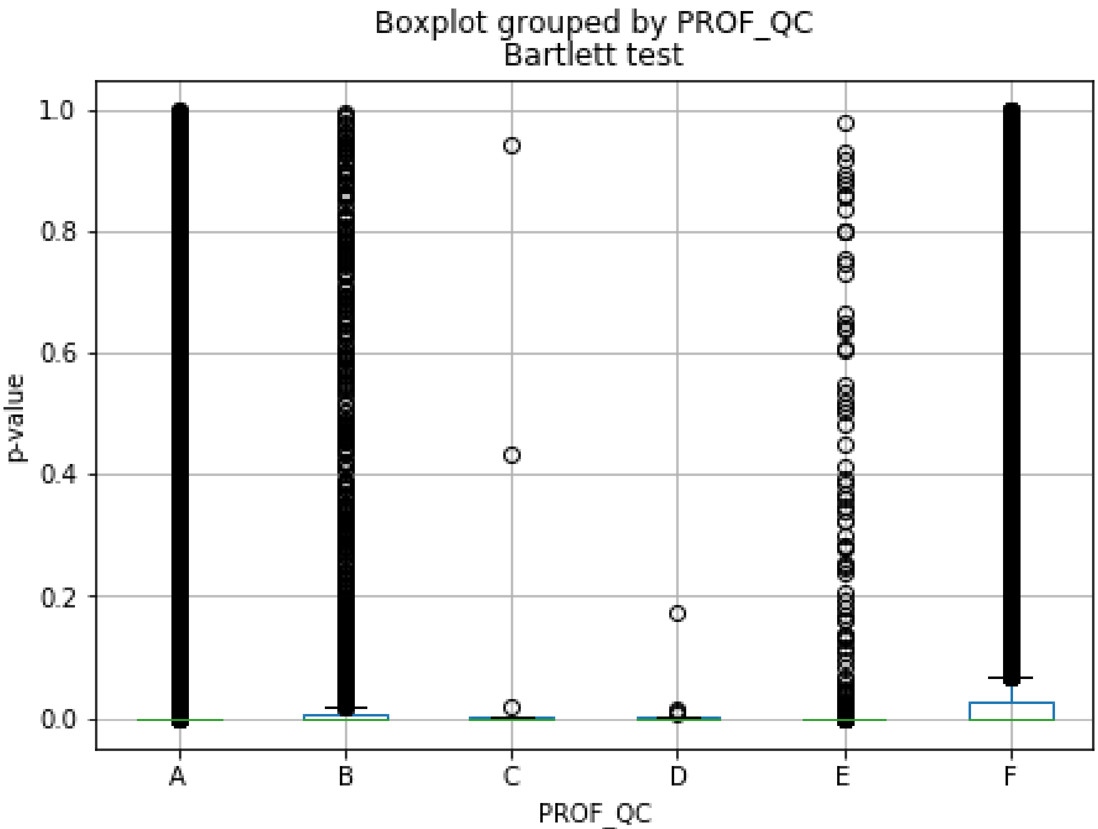
[26]:
```
boxplot = INDEX_BBP.boxplot(column='Mann-Whitney',by='PROF_QC', figsize=(7,5))
title_boxplot = 'Mann-whitney'
plt.title( title_boxplot )
boxplot.set_ylabel('p-value')
```

[26]: `Text(0, 0.5, 'p-value')`



[27]:
```
boxplot = INDEX_BBP.boxplot(column='Bartlett',by='PROF_QC', figsize=(7,5))
title_boxplot = 'Bartlett test'
plt.title( title_boxplot )
boxplot.set_ylabel('p-value')
```

[27]:
```
Text(0, 0.5, 'p-value')
```



5.5 Compute the Median Absolute Deviation (MAD, DOXY AUDIT inspiration)

Define the stats used to check “bad?” bbp profiles

First with MAPD:

[30]:
```
M = np.median(INDEX_BBP['MAPD'])
Manom = np.abs(INDEX_BBP['MAPD'] - M)
MAD = np.median(Manom*1.4826)
print("With MAPD M+5*MAD is equal to :", M+5*MAD)
```

```
With MAPD M+5*MAD is equal to : 86.95314545303506
```

Second with Median Gain:

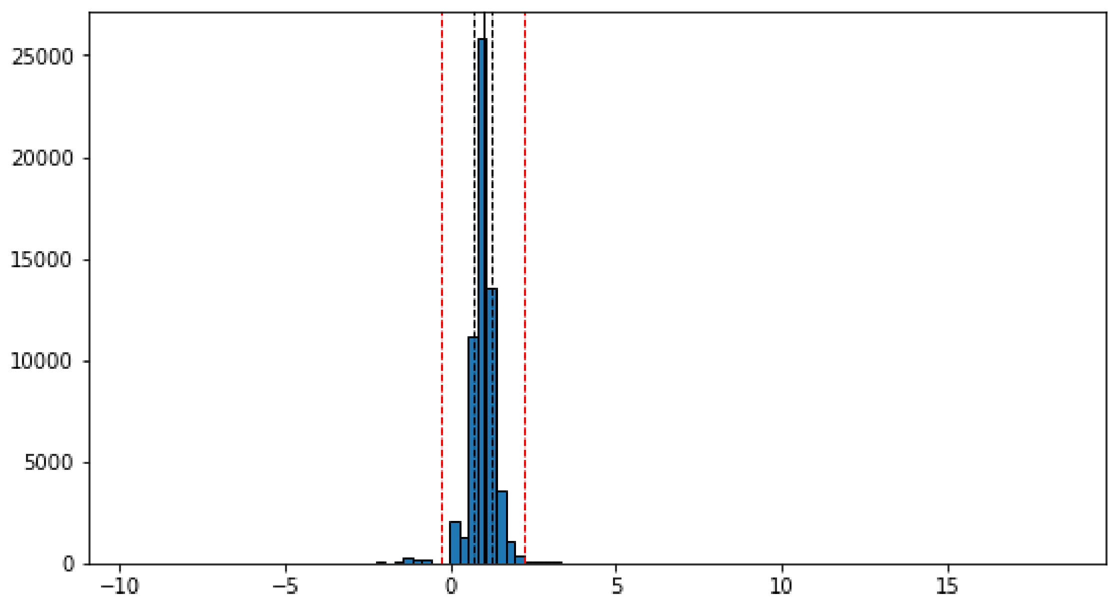
[31]:
```
M = np.median(INDEX_BBP['MG'])
Manom = np.abs(INDEX_BBP['MG'] - M)
MAD = np.median(Manom*1.4826)
Z = Manom/MAD
```

```
print("With MG M+5*MAD is equal to :", M+5*MAD, "and M-5*MAD is equal to :",␣
    ↪M-5*MAD)
```

```
With MG M+5*MAD is equal to : 2.204091426693074 and M-5*MAD is equal to :
-0.27091488430772825
```

[32]:
```
fig = plt.figure(figsize=(9,5)) # set figure environemnt
plt.hist(INDEX_BBP['MG'], bins=100, edgecolor="black")
plt.axvline(M, color="black", linewidth=1)
plt.axvline(M-MAD, color="black", linewidth=1, linestyle='--')
plt.axvline(M+MAD, color="black", linewidth=1, linestyle='--')
plt.axvline(M-5*MAD, color="red", linewidth=1, linestyle='--')
plt.axvline(M+5*MAD, color="red", linewidth=1, linestyle='--')
```

[32]:
```
<matplotlib.lines.Line2D at 0x7fef0d75f160>
```



–> I checked the results with MAPD and MG and it was not conclent –> a lot of false positive anomalous profiles

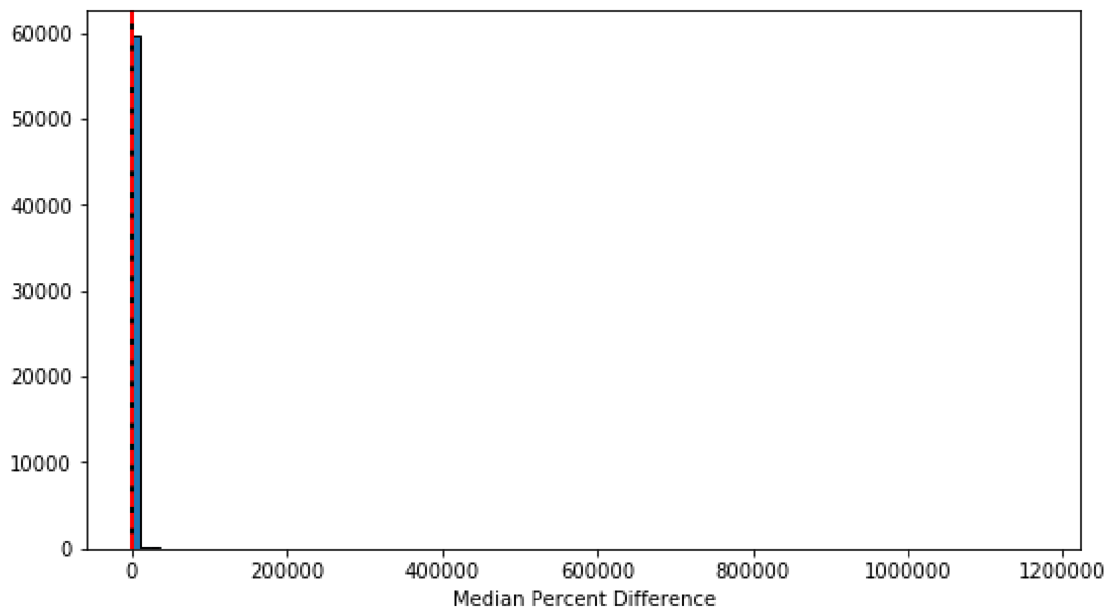
With Median percent difference:

[33]:
```
M = np.median(INDEX_BBP['MPD'])
Manom = np.abs(INDEX_BBP['MPD'] - M)
MAD = np.median(Manom*1.4826)
Z = Manom/MAD
INDEX_BBP['Z'] = Z
```

Histogram:

[34]:

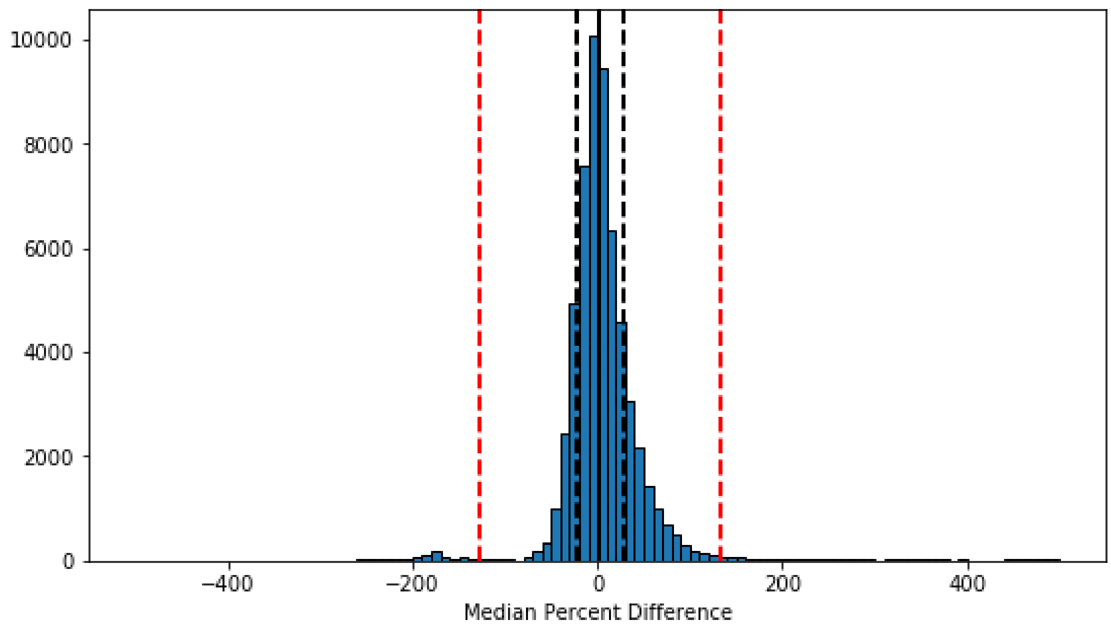
```
fig = plt.figure(figsize=(9,5)) # set figure environemnt
plt.hist(INDEX_BBP['MPD'], bins=100, edgecolor="black")
plt.xlabel('Median Percent Difference')
plt.axvline(M, color="black", linewidth=2)
plt.axvline(M-MAD, color="black", linewidth=2, linestyle='--')
plt.axvline(M+MAD, color="black", linewidth=2, linestyle='--')
plt.axvline(M-5*MAD, color="red", linewidth=2, linestyle='--')
plt.axvline(M+5*MAD, color="red", linewidth=2, linestyle='--')
plt.savefig('%s/HIST_MPD_ALL_RANGE.png' %str(path_plot), dpi=300) #Save the␣
↪figure as png
```



Zoom:

[35]:

```
fig = plt.figure(figsize=(9,5)) # set figure environemnt
plt.hist(INDEX_BBP['MPD'], range=(-500, 500), bins=100, edgecolor="black")
plt.xlabel('Median Percent Difference')
plt.axvline(M, color="black", linewidth=2)
plt.axvline(M-MAD, color="black", linewidth=2, linestyle='--')
plt.axvline(M+MAD, color="black", linewidth=2, linestyle='--')
plt.axvline(M-5*MAD, color="red", linewidth=2, linestyle='--')
plt.axvline(M+5*MAD, color="red", linewidth=2, linestyle='--')
plt.savefig('%s/HIST_MPD.png' %str(path_plot), dpi=300) #Save the figure as png
```



[36]:
```
print("With MPD M+5*MAD is equal to :", M+5*MAD, "and M-5*MAD is equal to :",␣
↪M-5*MAD)
```

```
With MPD M+5*MAD is equal to : 132.18398862607077 and M-5*MAD is equal to :
-127.0805010519011
```

[37]:
```
INDEX_BBP_TO_CHECK=INDEX_BBP[(INDEX_BBP['MPD']<M-5*MAD) |␣
↪(INDEX_BBP['MPD']>M+5*MAD)]
```

[38]:
```
INDEX_BBP_TO_CHECK.describe()
```

[38]:

	date	latitude	longitude	profiler_type	date_update	\
count	3.424000e+03	3424.000000	3424.000000	3424.000000	3.424000e+03	
mean	2.015954e+13	-0.520538	26.534041	840.379089	2.020108e+13	
std	2.722193e+10	40.634336	70.702454	7.576814	4.055391e+07	
min	2.010101e+13	-70.517000	-174.763000	835.000000	2.020103e+13	
25%	2.014022e+13	-45.457750	-25.766250	836.000000	2.020103e+13	
50%	2.016042e+13	9.767500	6.383500	836.000000	2.020110e+13	
75%	2.018111e+13	31.084750	95.986750	846.000000	2.020111e+13	
max	2.020112e+13	72.642000	179.581000	869.000000	2.020112e+13	

	wod	MAPD	MPD	MD	MG	\
count	3.424000e+03	3.424000e+03	3.424000e+03	3424.000000	3424.000000	
mean	5.738707e+06	8.292154e+03	8.206388e+03	0.022763	-0.192127	
std	1.748926e+06	6.884859e+04	6.885887e+04	0.146733	0.643338	
min	1.901329e+06	1.270904e+02	-3.329768e+02	-0.001538	-3.096541	

```
25%    3.902123e+06  1.919717e+02  1.408113e+02     0.000462     0.003611
50%    6.901152e+06  5.887699e+02  5.887699e+02     0.002099     0.029084
75%    6.901646e+06  4.148851e+03  4.148851e+03     0.015280     0.157637
max    7.900562e+06  1.164383e+06  1.164383e+06     2.202066     0.456795

              RMSD    T-test_ind  Kolomogorov-Smirnov   Mann-Whitney  \
count  3424.000000   3.175000e+03         3.175000e+03   3.175000e+03
mean      0.025886   2.623921e-04         1.428843e-06   3.904544e-06
std       0.178573   1.415080e-02         4.315662e-05   5.110115e-05
min       0.000302   0.000000e+00         0.000000e+00   0.000000e+00
25%       0.000920   0.000000e+00        3.185299e-287  2.175391e-159
50%       0.002453  3.861635e-245        4.291412e-150   6.692086e-89
75%       0.018803   2.712232e-68         1.334852e-39   4.133016e-24
max       5.857028   7.971948e-01         2.164502e-03   1.729802e-03

             Bartlett             Z
count    3.175000e+03   3424.000000
mean     2.459769e-02    319.779074
std      1.190830e-01   2655.529928
min      0.000000e+00      5.000381
25%     5.632613e-300      7.459116
50%      1.431741e-53     22.610815
75%      8.254180e-09    159.925441
max      9.721947e-01  44910.903276
```

[39]:
```python
# When adding MG and Kolomogorov test:
INDEX_BBP_TO_CHECK=INDEX_BBP[(INDEX_BBP['MPD']<M-5*MAD) |␣
 ↪(INDEX_BBP['MPD']>M+5*MAD) | (INDEX_BBP['Kolomogorov-Smirnov']>=0.9) |␣
 ↪(INDEX_BBP['MG']<0)]
```

[40]:
```python
INDEX_BBP_TO_CHECK.shape
```

[40]: (3496, 27)

[42]:
```python
print("Significant Kolomogorov-Smirnov test and negative Median Gain add",␣
 ↪3496-3424, "profiles")
```

```
Significant Kolomogorov-Smirnov test and negative Median Gain add 72 profiles
```

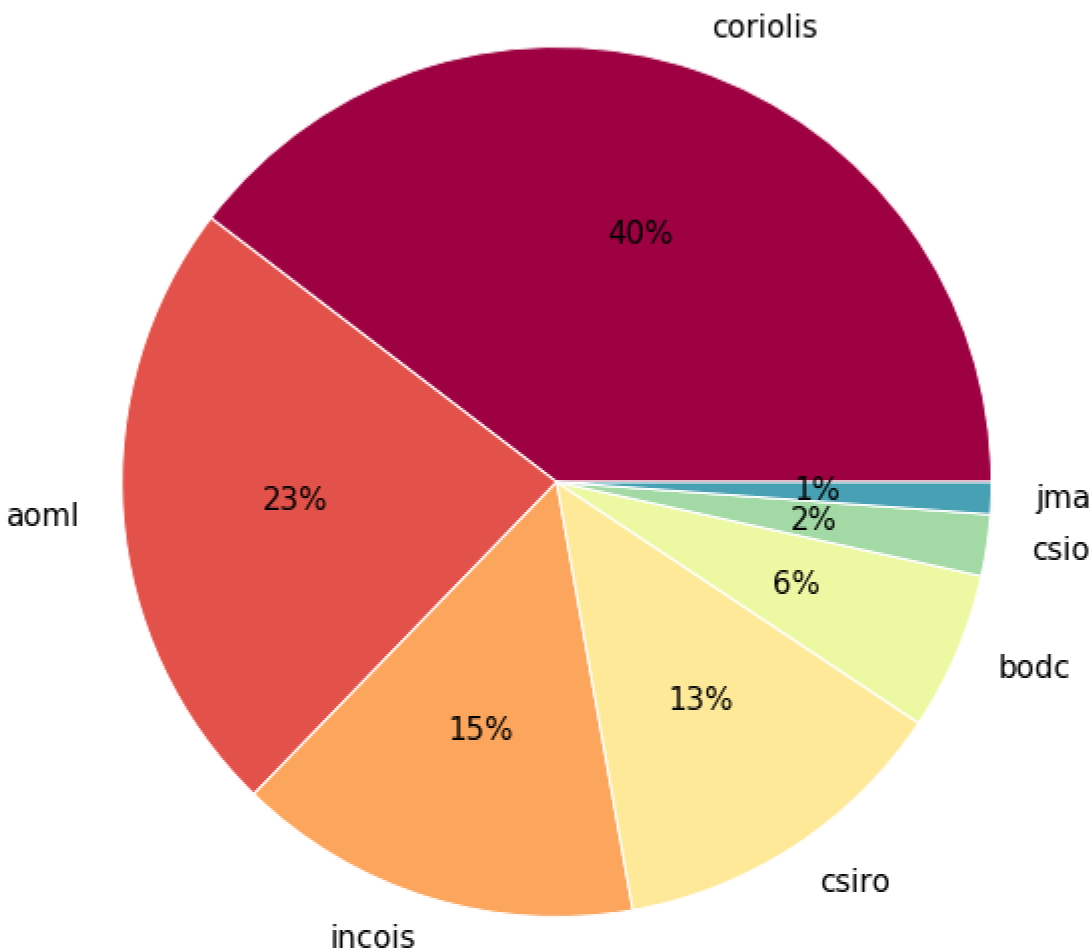
5.6 Pie plots for anomalous bbp profiles found per dac + time series of anomalous profiles per year for each dac

First, pie plots of all bbp profiles per dac:

[43]:
```python
fig = plt.figure(figsize=(10,10)) # set figure environemnt
dac_counts = INDEX_BBP['dac'].value_counts()
labels = INDEX_BBP['dac'].value_counts().index.tolist()
```

```
print(dac_counts)
cmap = plt.get_cmap('Spectral')
colors = [cmap(i) for i in np.linspace(0, 1, 8)]
plt.rcParams['font.size'] = 15

plt.pie(dac_counts, labels = labels, colors = colors, autopct='%.0f%%',␣
↪wedgeprops = {"linewidth": 1, "edgecolor": "white"})
plt.savefig('%s/PIE_PLOT_BBP_PROFILES.png' %str(path_plot), dpi=300) #Save the␣
↪figure as png
```

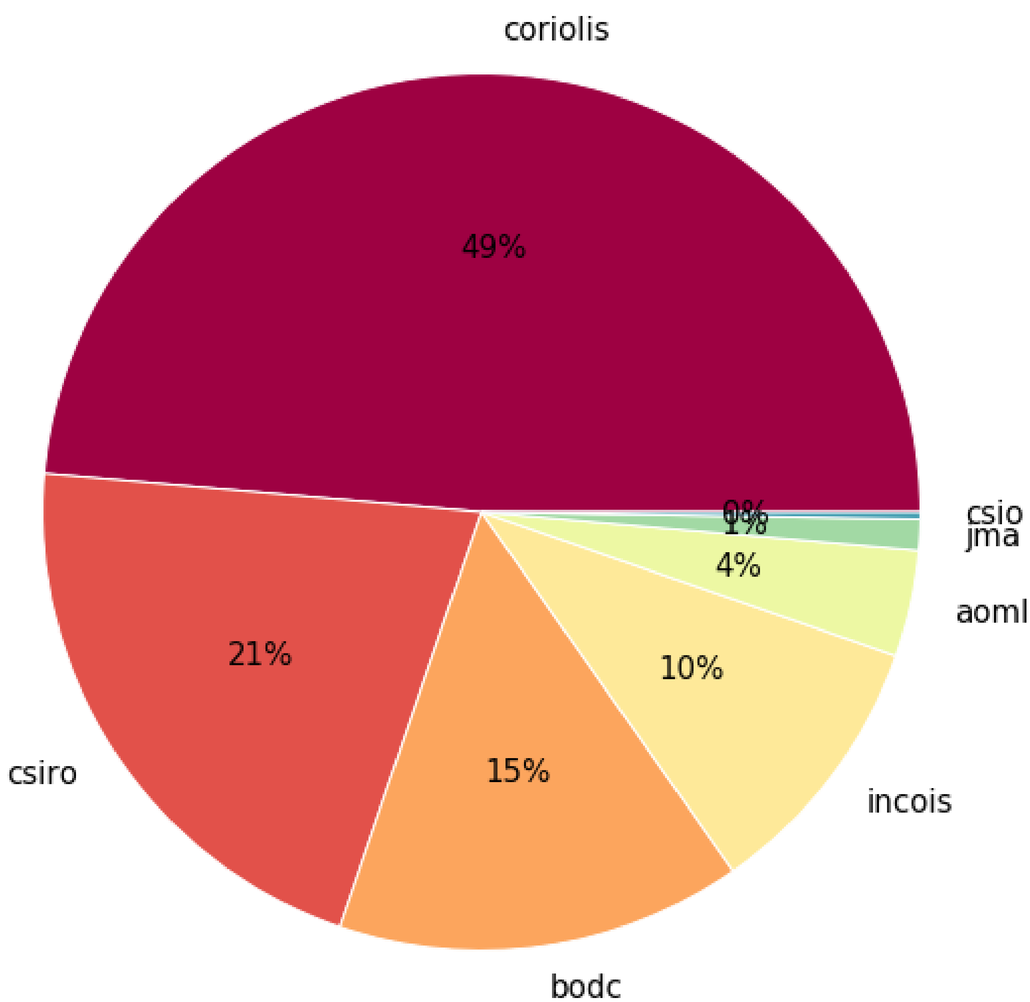
```
coriolis    23816
aoml        13888
incois       9051
csiro        7721
bodc         3534
csio         1371
jma           715
Name: dac, dtype: int64
```



Second, all anomalous profiles for all the database:

[44]:
```
fig = plt.figure(figsize=(10,10)) # set figure environemnt
dac_counts = INDEX_BBP_TO_CHECK['dac'].value_counts()
labels = INDEX_BBP_TO_CHECK['dac'].value_counts().index.tolist()
print(dac_counts)
cmap = plt.get_cmap('Spectral')
colors = [cmap(i) for i in np.linspace(0, 1, 8)]
plt.rcParams['font.size'] = 15
plt.pie(dac_counts, labels = labels, colors = colors, autopct='%.0f%%',␣
↪wedgeprops = {"linewidth": 1, "edgecolor": "white"})
plt.savefig('%s/PIE_PLOT_BAD_PROFILES.png' %str(path_plot), dpi=300) #Save the␣
↪figure as png
```

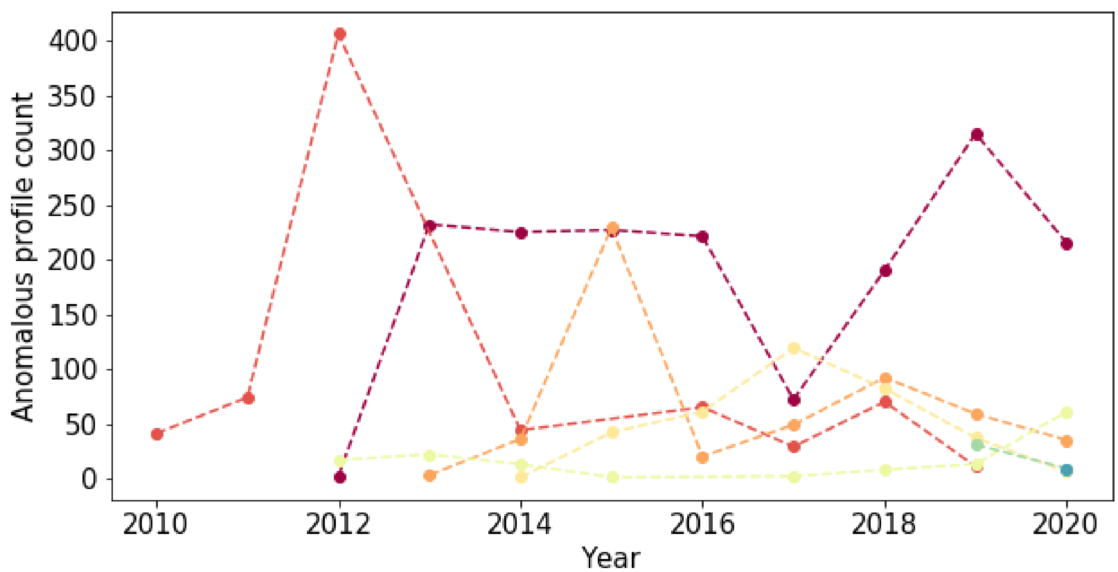
```
coriolis    1699
csiro        740
bodc         523
incois       348
aoml         137
jma           40
csio           9
Name: dac, dtype: int64
```



[45]:
```
# Get date of data that we want to plot
juld = INDEX_BBP_TO_CHECK['date']
# Transform the juld date in date format
```

```
datetime_juld=[datetime.strptime(str(int(juld[i])), "%Y%m%d%H%M%S") for i in␣
↪juld.index.values]

# Get year from the date
year=[int(datetime_juld[:][i].strftime('%Y')) for i in np.
↪arange(len(datetime_juld))]
# Put it in the dataframe
INDEX_BBP_TO_CHECK['Year']=year

fig = plt.figure(figsize=(10,5)) # set figure environemnt
dac_year_counts = INDEX_BBP_TO_CHECK.groupby(["dac", "Year"]).size()
i=0
for d in INDEX_BBP_TO_CHECK['dac'].value_counts().index.tolist():
    print(d)
    plt.plot(dac_year_counts[d], color=colors[i], linestyle='--', marker='o')
    plt.ylabel("Anomalous profile count")
    plt.xlabel("Year")
    i+=1
plt.savefig('%s/YEAR_ANOMALOUS_BAD_PROFILES.png' %str(path_plot), dpi=300)␣
↪#Save the figure as png
```

```
coriolis
csiro
bodc
incois
aoml
jma
csio
```



[46]:
```
print(str(INDEX_BBP_TO_CHECK[(INDEX_BBP_TO_CHECK['PROF_QC']=='D') |␣
↪(INDEX_BBP_TO_CHECK['PROF_QC']=='E') | (INDEX_BBP_TO_CHECK['PROF_QC']=='F')].
↪shape[0])
      + " are bad profiles FOR SURE on a total of " + str(INDEX_BBP_TO_CHECK.
↪shape[0]) + " profiles")
```

```
2058 are bad profiles FOR SURE on a total of 3496 profiles
```

[47]:
```
print(str(round(2058/3496*100)) + " % of profiles are bad FOR SURE")
```

```
59 % of profiles are bad FOR SURE
```

Validation of the method: Removal of all already bad flagged profiles to set up the BBP audit

[48]:
```
INDEX_BBP_GOOD = INDEX_BBP[~((INDEX_BBP['PROF_QC']=='D') |␣
↪(INDEX_BBP['PROF_QC']=='E') | ( INDEX_BBP['PROF_QC']=='F'))]
M = np.median(INDEX_BBP_GOOD['MPD'])
Manom = np.abs(INDEX_BBP_GOOD['MPD'] - M)
MAD = np.median(Manom*1.4826)
Z = Manom/MAD
INDEX_BBP_TO_CHECK_GOOD=INDEX_BBP_GOOD[(INDEX_BBP_GOOD['MPD']<M-5*MAD) |␣
↪(INDEX_BBP_GOOD['MPD']>M+5*MAD) |
                                       (INDEX_BBP_GOOD['Kolomogorov-Smirnov']>=0.
↪9) | (INDEX_BBP_GOOD['MG']<0)]
print("With MPD for good flagged profiles M+5*MAD is equal to :", M+5*MAD, "and␣
↪M-5*MAD is equal to :", M-5*MAD)
```

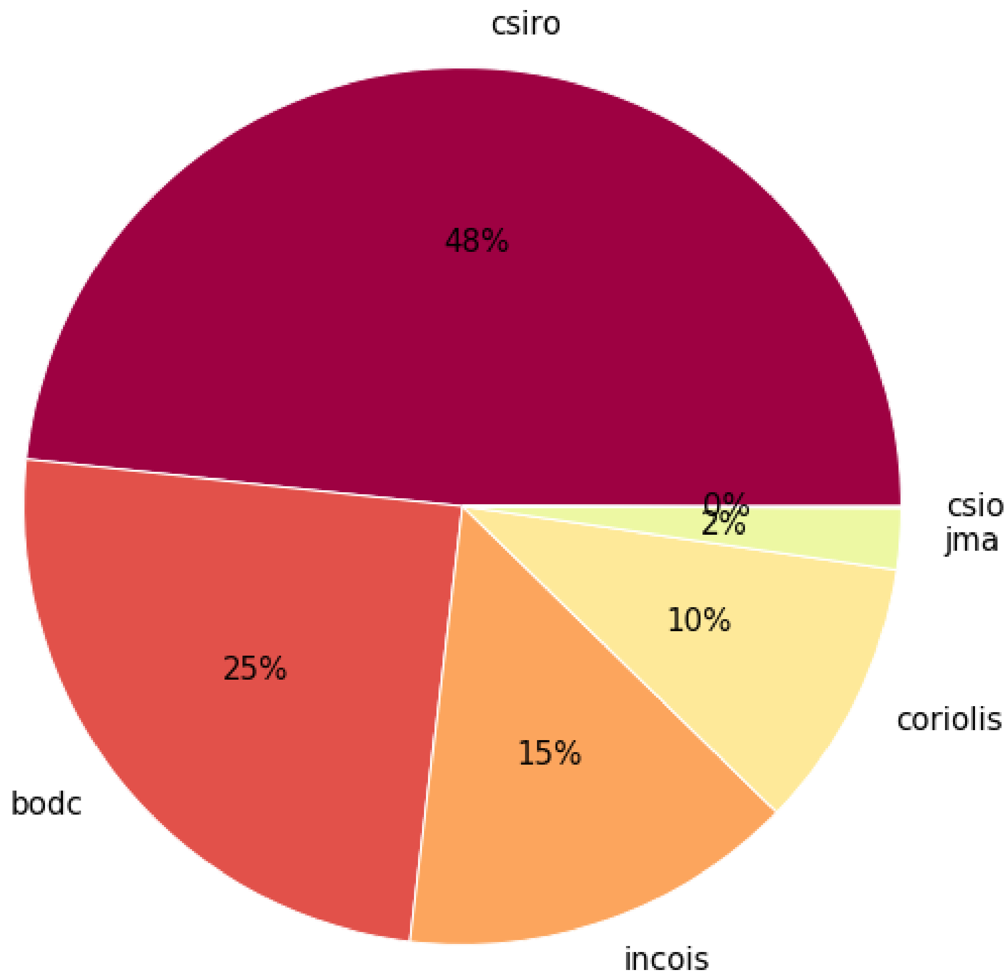
```
With MPD for good flagged profiles M+5*MAD is equal to : 128.72805440947667 and
M-5*MAD is equal to : -125.88349346834237
```

Pie plot for these new bad profiles:

[49]:
```
fig = plt.figure(figsize=(10,10)) # set figure environemnt
dac_counts = INDEX_BBP_TO_CHECK_GOOD['dac'].value_counts()
labels = INDEX_BBP_TO_CHECK_GOOD['dac'].value_counts().index.tolist()
print(dac_counts)
cmap = plt.get_cmap('Spectral')
colors = [cmap(i) for i in np.linspace(0, 1, 8)]
plt.rcParams['font.size'] = 15
plt.pie(dac_counts, labels = labels, colors = colors, autopct='%.0f%%',␣
↪wedgeprops = {"linewidth": 1, "edgecolor": "white"})
plt.savefig('%s/PIE_PLOT_NEW_BAD_PROFILES.png' %str(path_plot), dpi=300) #Save␣
↪the figure as png
```

```
csiro       707
bodc        363
incois      214
coriolis    146
jma          33
```

```
csio          1
Name: dac, dtype: int64
```

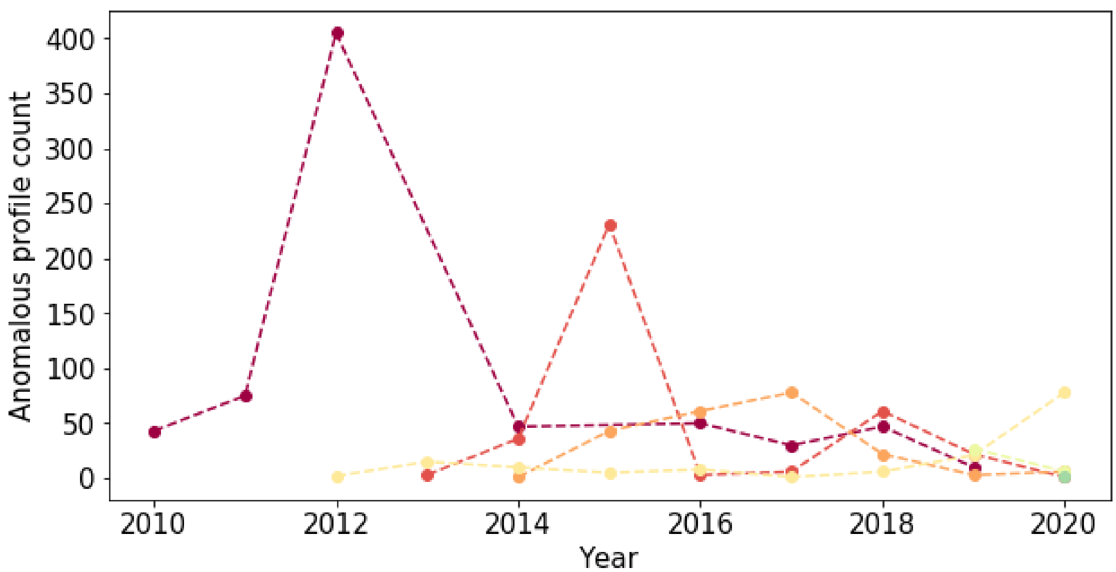


Plot time series of number of bad profiles per year for each dac:

[50]:
```
# Get date of data that we want to plot
juld = INDEX_BBP_TO_CHECK_GOOD['date']
# Transform the juld date in date format
datetime_juld=[datetime.strptime(str(int(juld[i])), "%Y%m%d%H%M%S") for i in␣
↪juld.index.values]

# Get year from the date
```

```
year=[int(datetime_juld[:][i].strftime('%Y')) for i in np.
 ↪arange(len(datetime_juld))]
# Put it in the dataframe
INDEX_BBP_TO_CHECK_GOOD['Year']=year

fig = plt.figure(figsize=(10,5)) # set figure environemnt
dac_year_counts = INDEX_BBP_TO_CHECK_GOOD.groupby(["dac", "Year"]).size()
i=0
for d in INDEX_BBP_TO_CHECK_GOOD['dac'].value_counts().index.tolist():
    print(d)
    plt.plot(dac_year_counts[d], color=colors[i], linestyle='--', marker='o')
    plt.ylabel("Anomalous profile count")
    plt.xlabel("Year")
    i+=1
plt.savefig('%s/YEAR_ANOMALOUS_BAD_NEW_PROFILES.png' %str(path_plot), dpi=300)␣
 ↪#Save the figure as png
```

```
csiro
bodc
incois
coriolis
jma
csio
```



6 Save the data

[51]:
```
INDEX_BBP_TO_CHECK.columns
```

[51]:
```
Index(['file', 'date', 'latitude', 'longitude', 'ocean', 'profiler_type',
       'institution', 'parameters', 'parameter_data_mode', 'date_update',
       'dac', 'wod', 'ncdf', 'nc_cycle', 'variables', 'datetime', 'PROF_QC',
       'MAPD', 'MPD', 'MD', 'MG', 'RMSD', 'T-test_ind', 'Kolomogorov-Smirnov',
       'Mann-Whitney', 'Bartlett', 'Z', 'Year'],
      dtype='object')
```

[52]:
```
INDEX_BBP_TO_CHECK_TO_SAVE=INDEX_BBP_TO_CHECK[['file', 'date', 'latitude',␣
↪'longitude', 'institution', 'parameters', 'parameter_data_mode',␣
↪'date_update',
       'dac', 'wod', 'ncdf', 'nc_cycle', 'variables', 'MPD', 'MG',␣
↪'Kolomogorov-Smirnov', 'PROF_QC']]
```

[126]:
```
#INDEX_BBP_TO_CHECK_TO_SAVE.to_csv("INDEX_SYNTH_BBP_TO_CHECKv2.csv",␣
↪index=False)
INDEX_BBP_TO_CHECK_TO_SAVE.to_csv("INDEX_SYNTH_BBP_TO_CHECK_MAD_MPD.csv",␣
↪index=False)
```