

Consecutive_wet-dry_days_rcp85

July 19, 2022

```
[1]: import cartopy.crs as ccrs # for geographic plotting
import cartopy.feature as cfeature
from IPython.display import Image
import xarray as xr
import xclim as xc
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns
import xclim as xc
import xarray as xr
from matplotlib.cm import get_cmap
```

```
[2]: #pr_file = '/lhome/cra2022/climriskdata/EUR-11/
↳MPI-M-MPI-ESM-LR_MPI-CSC-REMO2009_v1/historical/pr/
↳pr_EUR-11_MPI-M-MPI-ESM-LR_historical_r1i1p1_MPI-CSC-REMO2009_v1_day_19710101-20001231_LL.
↳nc'

pr_file_85 = '/lhome/cra2022/climriskdata/EUR-11/
↳ICHEC-EC-EARTH_CLMcom-CCLM4-8-17_v1/rcp85/pr/
↳pr_EUR-11_ICHEC-EC-EARTH_rcp85_r12i1p1_CLMcom-CCLM4-8-17_v1_day_20710101-21001231_LL.
↳nc'

ds_pr_85 = xr.open_dataset(pr_file_85).sel(lat=slice(30,45))

ds_pr_85

#ds_tas_current = xr.open_dataset(current_file).sel(time=slice('1996', '2000'),
#
lat=slice(44,48),
↳lon=slice(5,11))
```

```
[2]: <xarray.Dataset>
Dimensions:      (time: 10957, bnds: 2, lon: 471, lat: 151)
Coordinates:
  * time          (time) datetime64[ns] 2071-01-01T12:00:00 ... 2100-12-31T12:00:00
  * lon           (lon) float64 -10.0 -9.9 -9.8 -9.7 -9.6 ... 36.7 36.8 36.9 37.0
  * lat           (lat) float64 30.0 30.1 30.2 30.3 30.4 ... 44.7 44.8 44.9 45.0
Dimensions without coordinates: bnds
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Data variables:
    time_bnds    (time, bnds) datetime64[ns] ...
    pr           (time, lat, lon) float32 ...
Attributes: (12/31)
    CDI:         Climate Data Interface version ?? (http:/...
    history:     Tue Dec 03 10:30:57 2019: cdo mergetime /...
    source:      CLMcom-CCLM4-8-17
    institution: Climate Limited-area Modelling Community ...
    Conventions: CF-1.4
    institute_id: CLMcom
    ...
    project_id:  CORDEX
    table_id:    Table day (Sept 2013) 0cf1782745489246c9f...
    modeling_realm:  atmos
    realization:    12
    cmor_version:   2.9.1
    CDO:            Climate Data Operators version 1.9.3 (htt...
```

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[3]: pr_file = '/lhome/cra2022/climriskdata/EUR-11/
↳ICHEC-EC-EARTH_CLMcom-CCLM4-8-17_v1/historical/pr/
↳pr_EUR-11_ICHEC-EC-EARTH_historical_r12i1p1_CLMcom-CCLM4-8-17_v1_day_19710101-20001231_LL.
↳nc'

ds_pr = xr.open_dataset(pr_file).sel(lat=slice(30,45))

ds_pr
```

```
[3]: <xarray.Dataset>
Dimensions:    (time: 10958, bnds: 2, lon: 471, lat: 151)
Coordinates:
  * time       (time) datetime64[ns] 1971-01-01T12:00:00 ... 2000-12-31T12:00:00
  * lon        (lon) float64 -10.0 -9.9 -9.8 -9.7 -9.6 ... 36.7 36.8 36.9 37.0
  * lat        (lat) float64 30.0 30.1 30.2 30.3 30.4 ... 44.7 44.8 44.9 45.0
Dimensions without coordinates: bnds
Data variables:
    time_bnds    (time, bnds) datetime64[ns] ...
    pr           (time, lat, lon) float32 ...
Attributes: (12/31)
    CDI:         Climate Data Interface version ?? (http:/...
    history:     Tue Dec 03 12:33:45 2019: cdo mergetime /...
    source:      CLMcom-CCLM4-8-17
    institution: Climate Limited-area Modelling Community ...
    Conventions: CF-1.4
    institute_id: CLMcom
    ...
    project_id:  CORDEX
    table_id:    Table day (Sept 2013) 0cf1782745489246c9f...
```

```

modeling_realm:          atmos
realization:             12
cmor_version:            2.9.1
CDO:                     Climate Data Operators version 1.9.3 (htt...

```

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[4]: pr_mm_85 = xc.units.convert_units_to(ds_pr_85.pr, 'mm/day')

pr_mm = xc.units.convert_units_to(ds_pr.pr, 'mm/day')

```

```

[5]: #pr_mm
consec_dry_rcp85 = xc.indicators.icclim.CDD(pr_mm_85)

consec_dry = xc.indicators.icclim.CDD(pr_mm)

```

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[6]: #ROME, ITA
consec_dry_rome = consec_dry.sel(lat='41.893333',lon='12.482778',
    ↪method='nearest')
consec_dry_rcp85_rome = consec_dry_rcp85.sel(lat='41.893333',lon='12.482778',
    ↪method='nearest')

#MADRID, SPA
consec_dry_madrid = consec_dry.sel(lat='40.416667',lon='-3.7025',
    ↪method='nearest')
consec_dry_rcp85_madrid = consec_dry_rcp85.sel(lat='40.416667',lon='-3.7025',
    ↪method='nearest')

#CAIRO, EGY
consec_dry_cairo = consec_dry.sel(lat='30.044444',lon='31.235833',
    ↪method='nearest')
consec_dry_rcp85_cairo = consec_dry_rcp85.sel(lat='30.044444',lon='31.235833',
    ↪method='nearest')

```

```

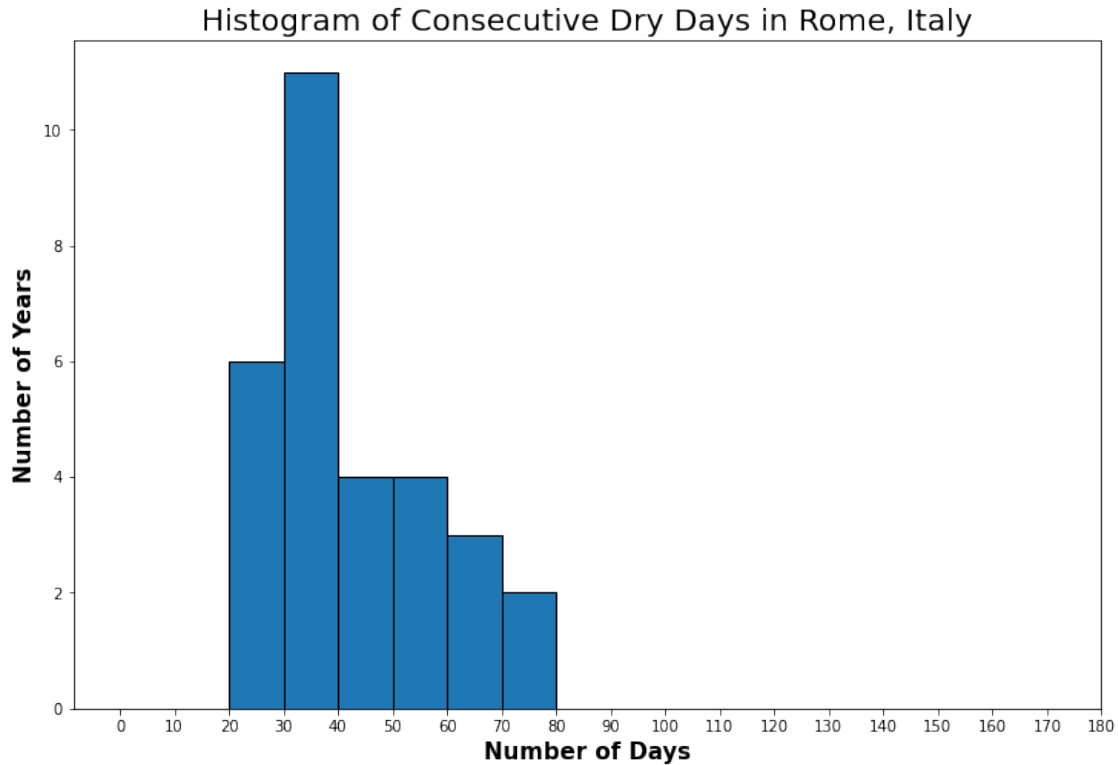
[27]: #ROME, ITA.

fig, axis = plt.subplots(figsize=(12, 8))

axis.hist(consec_dry_rome, bins = [0, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110,
    ↪120, 130, 140, 150, 160, 170], edgecolor= 'Black')

plt.xlabel('Number of Days', fontweight='bold', fontsize=15)
plt.ylabel('Number of Years', fontweight='bold', fontsize=15)
plt.xticks(ticks = range(0,190,10))
plt.title('Histogram of Consecutive Dry Days in Rome, Italy',fontsize=20)
plt.savefig("/lhome/cra2022/l.quirino.2_2022/Quirino_Leonardo/Project/
    ↪Histogram_Rome.png", dpi = 300, bbox_inches="tight",pad_inches=0)

```



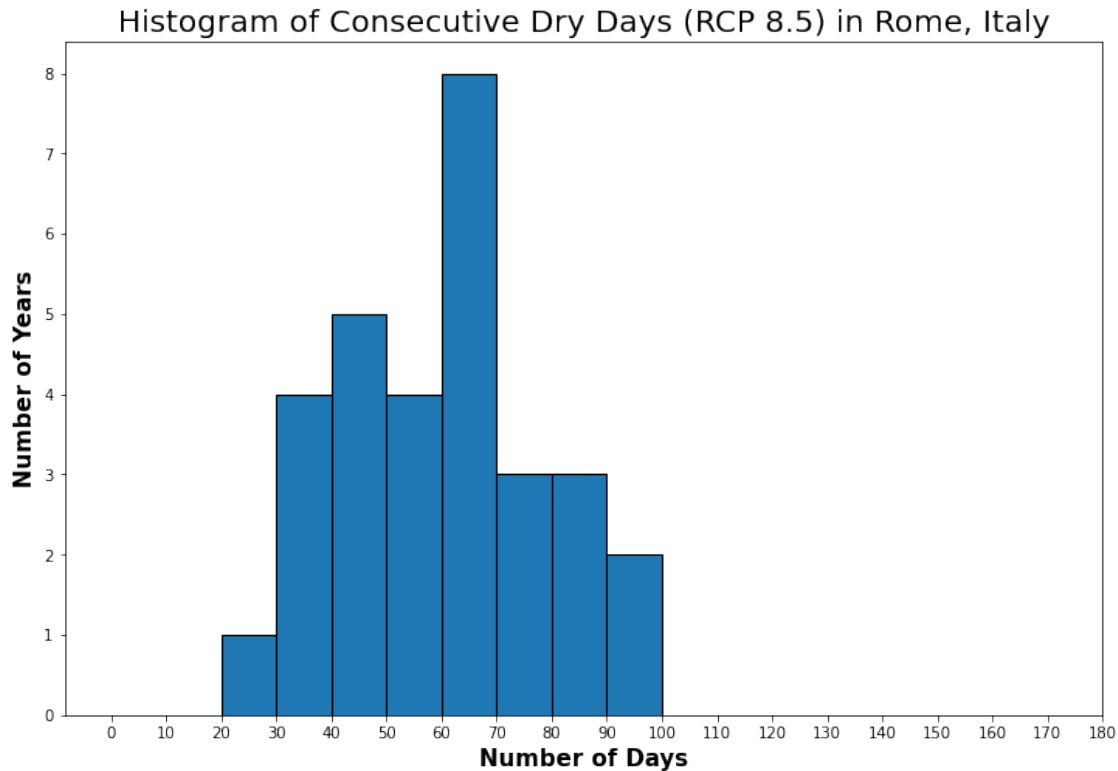
```
[8]: plt.close()
```

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[28]: #ROME, ITA. RCP 8.5

fig, axis = plt.subplots(figsize=(12, 8))

axis.hist(consec_dry_rcp85_rome, bins = [0, 20, 30, 40, 50, 60, 70, 80, 90,
↪100, 110, 120, 130, 140, 150, 160, 170], edgecolor= 'Black')

plt.xlabel('Number of Days', fontweight='bold', fontsize = 15)
plt.ylabel('Number of Years', fontweight='bold', fontsize = 15)
plt.xticks(ticks = range(0,190,10))
plt.title('Histogram of Consecutive Dry Days (RCP 8.5) in Rome,
↪Italy',fontsize=20)
plt.savefig("/lhome/cra2022/1.quirino.2_2022/Quirino_Leonardo/Project/
↪Histogram_rcp85_Rome.png", dpi = 300, bbox_inches="tight",pad_inches=0)
```



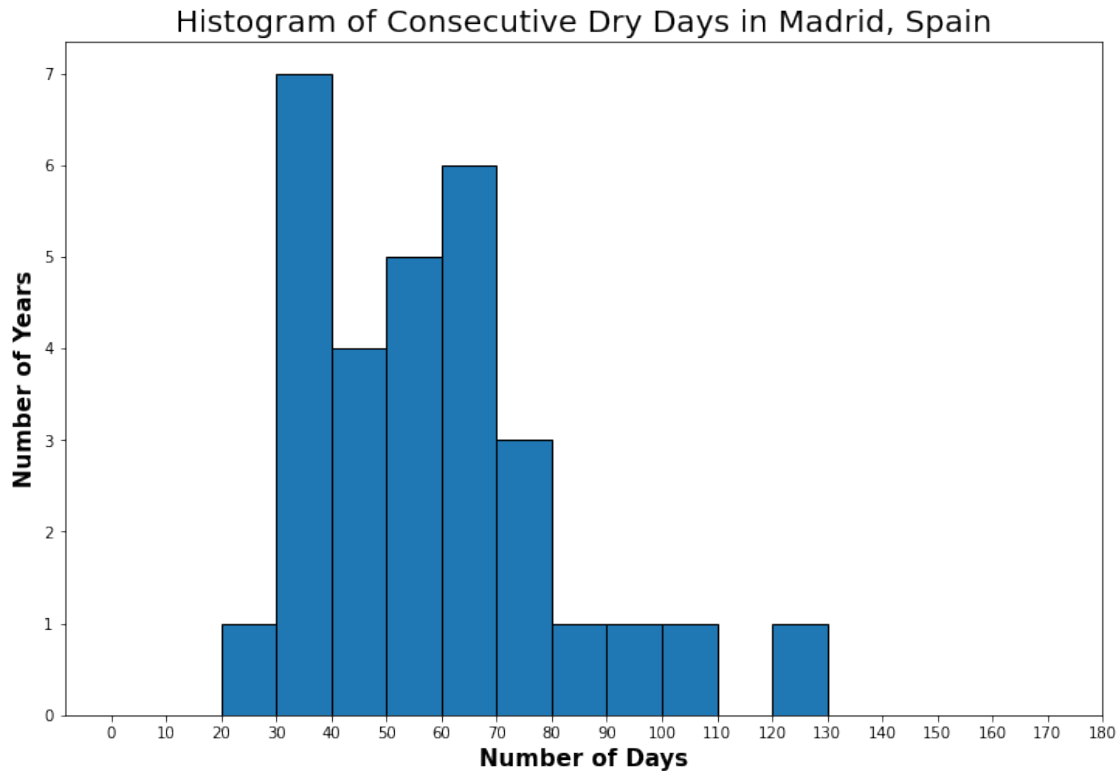
```
[10]: plt.close()
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[29]: #MADRID, SPA.
```

```
fig, axis = plt.subplots(figsize=(12, 8))

axis.hist(consec_dry_madrid, bins = [0, 20, 30, 40, 50, 60, 70, 80, 90, 100,
↪110, 120, 130, 140, 150, 160, 170], edgecolor= 'Black')

plt.xlabel('Number of Days', fontweight='bold', fontsize = 15)
plt.ylabel('Number of Years', fontweight='bold', fontsize = 15)
plt.xticks(ticks = range(0,190,10))
plt.title('Histogram of Consecutive Dry Days in Madrid, Spain',fontsize=20)
plt.savefig("/lhome/cra2022/l.quirino.2_2022/Quirino_Leonardo/Project/
↪Histogram_Madrid.png", dpi = 300, bbox_inches="tight",pad_inches=0)
```



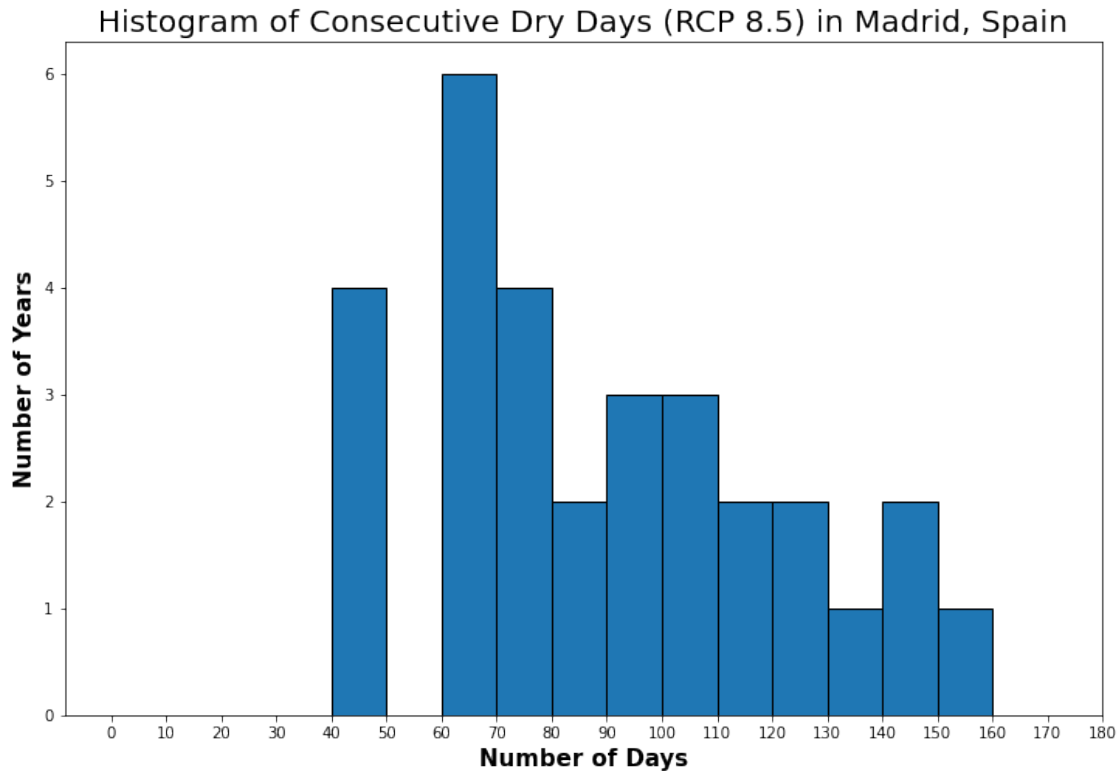
```
[12]: plt.close()
```

```
[30]: #MADRID, SPA. RCP 8.5

fig, axis = plt.subplots(figsize=(12, 8))

axis.hist(consec_dry_rcp85_madrid, bins = [0, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170], edgecolor= 'Black')

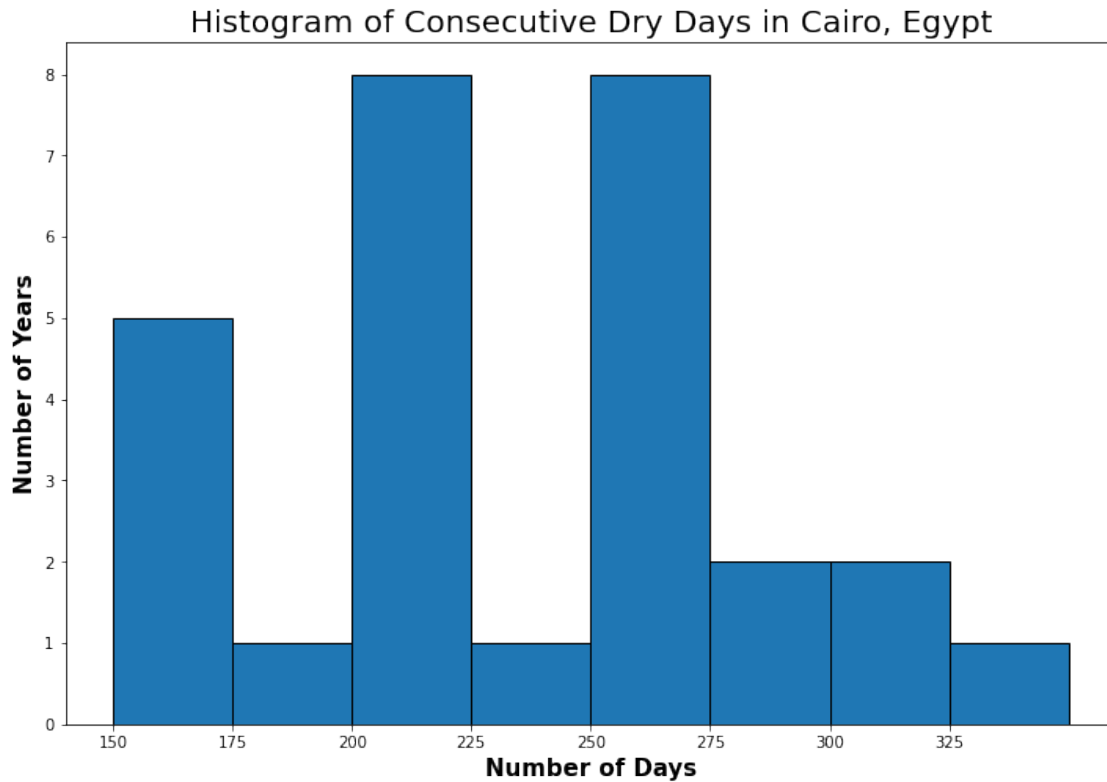
plt.xlabel('Number of Days', fontweight='bold', fontsize = 15)
plt.ylabel('Number of Years', fontweight='bold', fontsize = 15)
plt.xticks(ticks = range(0,190,10))
plt.title('Histogram of Consecutive Dry Days (RCP 8.5) in Madrid, Spain', fontsize=20)
plt.savefig("/home/cra2022/1.quirino.2_2022/Quirino_Leonardo/Project/Histogram_rcp85_Madrid.png", dpi = 300, bbox_inches="tight", pad_inches=0)
```



```
[14]: #CAIRO, EGYPT.
fig, axis = plt.subplots(figsize =(12, 8))

axis.hist(consec_dry_cairo, bins = [150, 175, 200, 225, 250, 275, 300, 325,
↪350], edgecolor= 'Black')

plt.xlabel('Number of Days', fontweight ='bold', fontsize = 15)
plt.ylabel('Number of Years', fontweight ='bold', fontsize = 15)
plt.xticks(ticks = range(150, 350, 25))
plt.title('Histogram of Consecutive Dry Days in Cairo, Egypt',fontsize=20)
plt.savefig("/lhome/cra2022/l.quirino.2_2022/Quirino_Leonardo/Project/
↪Histogram_Cairo.png", dpi = 300, bbox_inches="tight",pad_inches=0)
```

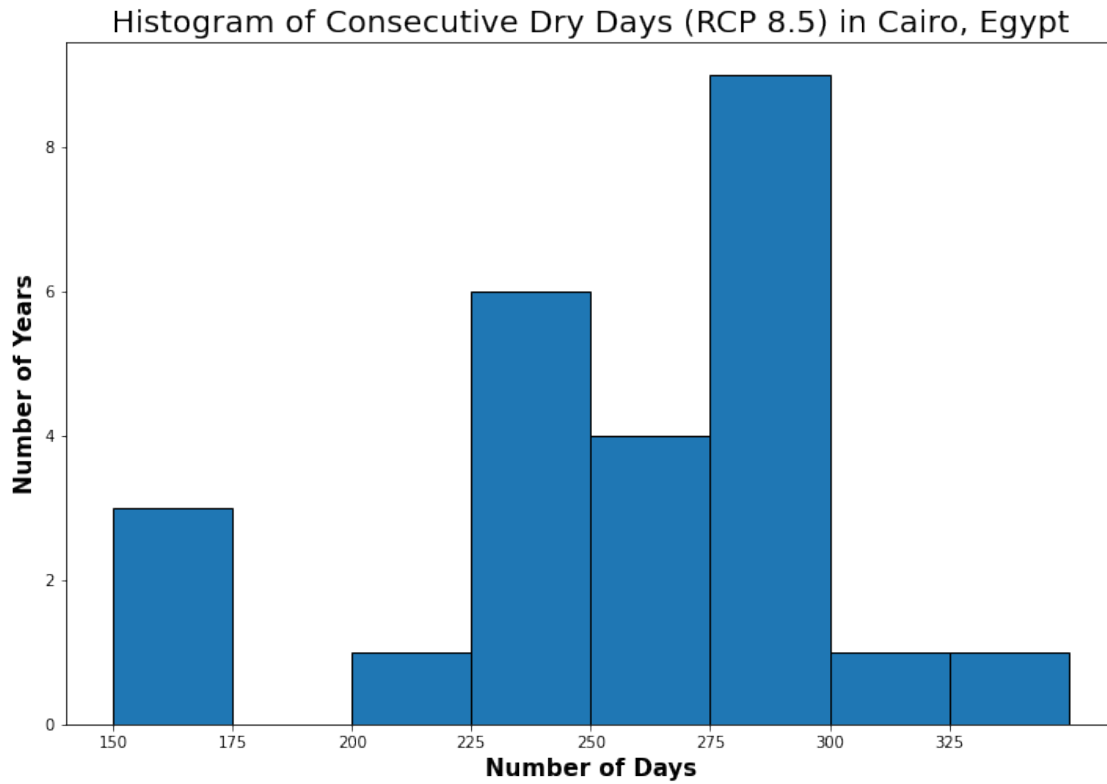


```
[15]: plt.close()
```

```
[16]: #CAIRO, EGYPT. RCP 8.5
fig, axis = plt.subplots(figsize=(12, 8))

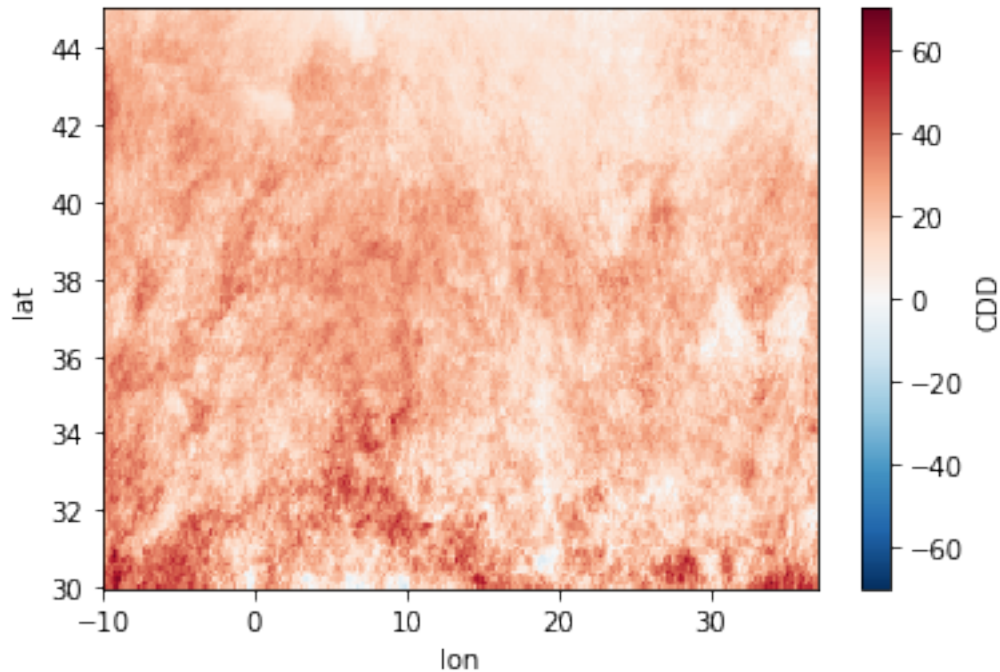
axis.hist(consec_dry_rcp85_cairo, bins = [150, 175, 200, 225, 250, 275, 300,
↪325, 350], edgecolor= 'Black')

plt.xlabel('Number of Days', fontweight='bold', fontsize = 15)
plt.ylabel('Number of Years', fontweight='bold', fontsize = 15)
plt.xticks(ticks = range(150, 350, 25))
plt.title('Histogram of Consecutive Dry Days (RCP 8.5) in Cairo,
↪Egypt', fontsize=20)
plt.savefig("/lhome/cra2022/1.quirino.2_2022/Quirino_Leonardo/Project/
↪Histogram_Cairo.png", dpi = 300, bbox_inches="tight", pad_inches=0)
```

```
[17]: mean_cdd_85 = consec_dry_rcp85.sum('time')/30  
  
mean_cdd = consec_dry.sum('time')/30  
  
anom_cdd = mean_cdd_85 - mean_cdd  
  
anom_cdd.plot()
```

```
[17]: <matplotlib.collections.QuadMesh at 0x7f22e6358910>
```



```
[18]: ds_pop_medi = xr.open_dataset('/lhome/cra2022/climriskdata/EUR-11S/
↳Estimated_population/Estimated_population_2093_LL.nc').sel(lat=slice(30,45))
#ds_pop_medi = ds_pop.sel(lat=slice(30,45))

ds_pop_medi
```

```
[18]: <xarray.Dataset>
Dimensions:      (lon: 471, lat: 151)
Coordinates:
  * lon          (lon) float64 -10.0 -9.9 -9.8 -9.7 -9.6 ... 36.7 36.8 36.9 37.0
  * lat          (lat) float64 30.0 30.1 30.2 30.3 30.4 ... 44.7 44.8 44.9 45.0
Data variables:
  population     (lat, lon) float32 ...
Attributes:
  CDI:           Climate Data Interface version 1.6.4 (http://code.zmaw.de/p...
  Conventions:   CF-1.4
  history:       Wed Feb 13 17:30:06 2019: cdo mul tmp1.nc Land_Surface_Mask...
  created_by:    R, packages ncdf and raster (version 2.0-12)
  date:          2012-11-08 14:48:18
  CDO:           Climate Data Operators version 1.6.4 (http://code.zmaw.de/p...
```

```
[19]: col_map = get_cmap("inferno_r").copy()
#col_map.set_under("white")
precip_levels = np.arange(25,200,25)
```

```

fig = plt.figure(figsize=(30,10))
ax = plt.axes(projection=ccrs.PlateCarree())

#Include a ready-to-use colormap with cmap=<colormap_name>
a = mean_cdd_85.plot.contourf(ax=ax, transform=ccrs.PlateCarree(),
    ↪cmap=col_map, levels = precip_levels, add_colorbar=False)
d = ds_pop_medi.population.plot.contourf(ax=ax, transform=ccrs.
    ↪PlateCarree(),levels=[0,500000], colors='none', hatches=['','+++'],
    ↪add_colorbar=False)

# Hatch color has to be changed afterwards has edgecolor
d.collections[1].set_edgecolor('Gray')

# Add a contour for clarity
ds_pop_medi.population.plot.contour(ax=ax, transform=ccrs.PlateCarree(),
    ↪levels=[500000], colors = 'Black', linewidths=1, add_colorbar=False)

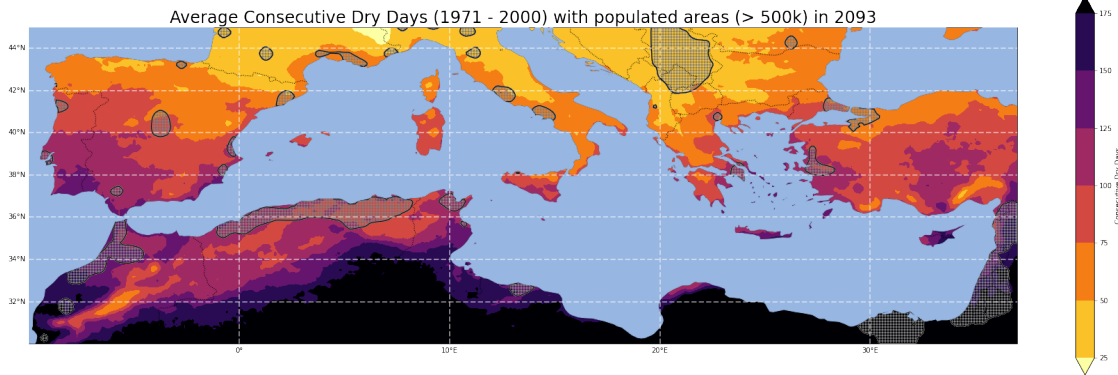
ax.add_feature(cfeature.COASTLINE, linestyle='-')
ax.add_feature(cfeature.BORDERS, linestyle=':');
ax.add_feature(cfeature.OCEAN, zorder=10)

cbar = fig.colorbar(a, ax=ax, fraction = 0.1, label=r'Consecutive Dry Days')

gl = ax.gridlines(crs=ccrs.PlateCarree(), draw_labels=True,
    ↪linewidth=2, color='white', alpha=0.5, linestyle='--',
    ↪zorder=11)
gl.top_labels = False # suppress gridline labels on the top
gl.right_labels = False # suppress gridline labels at the right edge

ax.set_title('')
#ax.set_title('Time:{}'.format(nice_time), loc='right');
ax.set_title('Average Consecutive Dry Days (1971 - 2000) with populated areas
    ↪(> 500k) in 2093', fontsize=24)
plt.savefig("/lhome/cra2022/1.quirino.2_2022/Quirino_Leonardo/Project/
    ↪CDD7100_Pop_2093.png", dpi = 300, bbox_inches="tight",pad_inches=0)

```



```
[20]: col_map = get_cmap("PuOr_r").copy()
#col_map.set_under("white")
precip_levels = np.arange(-5,30,5)

fig = plt.figure(figsize=(30,10))
ax = plt.axes(projection=ccrs.PlateCarree())

#Include a ready-to-use colormap with cmap=<colormap_name>
a = anom_cdd.plot.contourf(ax=ax, transform=ccrs.PlateCarree(), cmap=col_map,
    ↳levels = precip_levels, add_colorbar=False)
d = ds_pop_medi.population.plot.contourf(ax=ax, transform=ccrs.
    ↳PlateCarree(), levels=[0,500000], colors='none', hatches=['', '+++'],
    ↳add_colorbar=False)

# Hatch color has to be changed afterwards has edgecolor
d.collections[1].set_edgecolor('Black')

# Add a contour for clarity
ds_pop_medi.population.plot.contour(ax=ax, transform=ccrs.PlateCarree(),
    ↳levels=[500000], colors = 'Black', linewidths=1, add_colorbar=False)

ax.add_feature(cfeature.COASTLINE, linestyle='-')
ax.add_feature(cfeature.BORDERS, linestyle=':');
ax.add_feature(cfeature.OCEAN, zorder=10)

cbar = fig.colorbar(a, ax=ax, fraction = 0.1, label=r'Consecutive Dry Days')
cbar.ax.tick_params(labelsize=15)
cbar.set_label("Consecutive Dry Days", size=18)

gl = ax.gridlines(crs=ccrs.PlateCarree(), draw_labels=True,
    ↳linewidth=2, color='white', alpha=0.5, linestyle='--',
    ↳zorder=11)
```

```

gl.top_labels = False # suppress gridline labels on the top
gl.right_labels = False # suppress gridline labels at the right edge

ax.set_title('')
#ax.set_title('Time:{}'.format(nice_time), loc='right');
ax.set_title('Difference of Yearly Mean Consecutive Dry Days (1971 - 2000) and 2071 - 2100) with populated areas (> 500k) in 2093', fontsize=24)
plt.savefig("/lhome/cra2022/l.quirino.2_2022/Quirino_Leonardo/Project/ANOMCDD7100_Pop_2093.png", dpi = 300, bbox_inches="tight", pad_inches=0)

```

