HWRF

March 12, 2022

1 Local testing

I copied a nc file and track file to this directory.

[1]:
```
import numpy as np
import xarray as xr

import pandas as pd

from matplotlib import pyplot as plt
%config InlineBackend.figure_format = 'retina'
%matplotlib inline
```

2 Read one forecast file

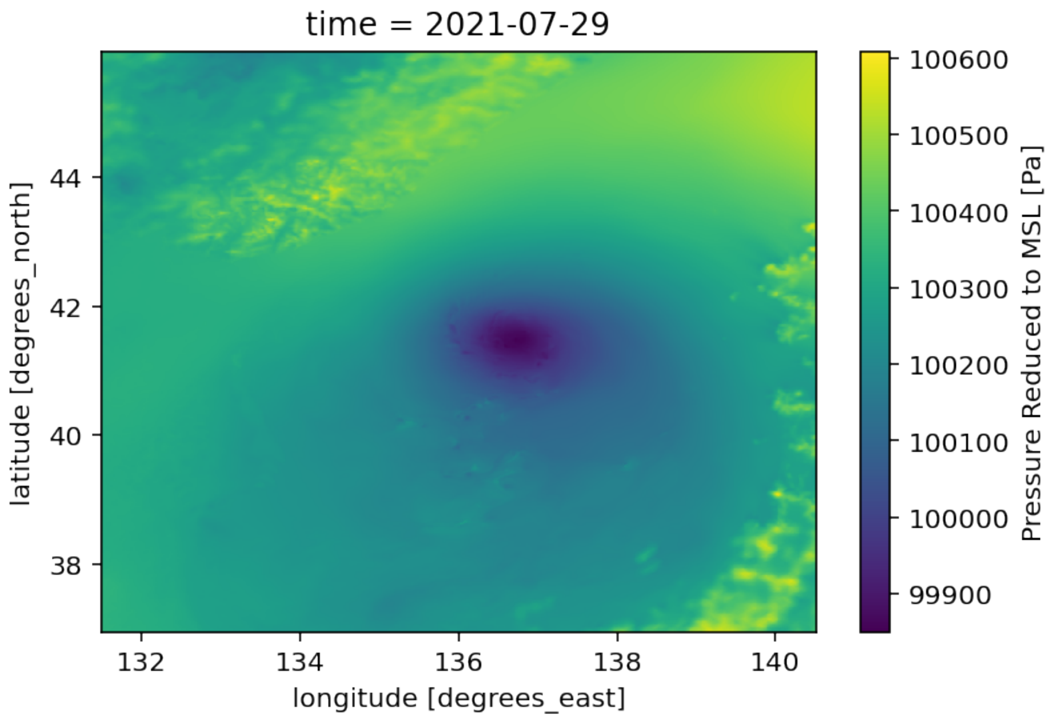
[2]:
```
#ds = xr.open_dataset('/data2/qy2216/HWRF_wind/hwrf.2021072718/nepartak11w/nc/
↪nepartak11w.2021072718.f030.nc')
ds = xr.open_dataset('nepartak11w.2021072718.f030.nc')
ds
```

[2]:
```
<xarray.Dataset>
Dimensions:               (latitude: 601, longitude: 601, time: 1)
Coordinates:
  * latitude              (latitude) float64 36.95 36.97 36.98 … 45.94 45.95
  * longitude             (longitude) float64 131.5 131.5 131.5 … 140.5 140.5
  * time                  (time) datetime64[ns] 2021-07-29
Data variables:
    PRMSL_meansealevel    (time, latitude, longitude) float32 …
    PRES_surface          (time, latitude, longitude) float32 …
    UGRD_10maboveground   (time, latitude, longitude) float32 …
    VGRD_10maboveground   (time, latitude, longitude) float32 …
    PRATE_surface         (time, latitude, longitude) float32 …
    APCP_surface          (time, latitude, longitude) float32 …
    ACPCP_surface         (time, latitude, longitude) float32 …
    NCPCP_surface         (time, latitude, longitude) float32 …
Attributes:
    Conventions:           COARDS
```

```
History:                created by wgrib2
GRIB2_grid_template:    0
```

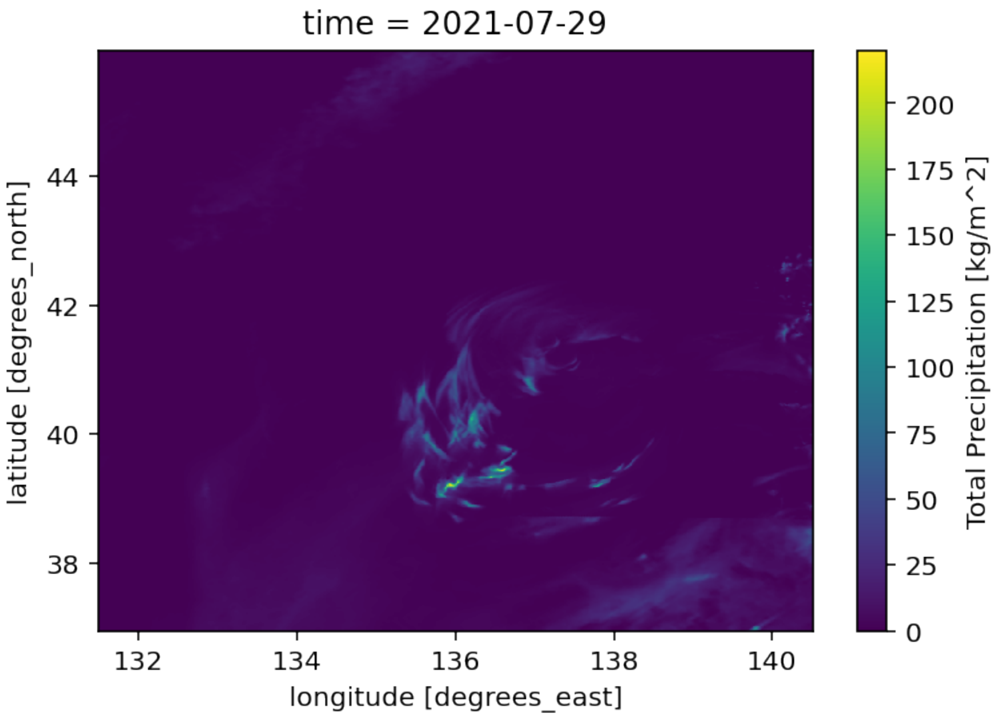
[3]:

```
ds.PRMSL_meansealevel.plot();
```



[4]:

```
ds.APCP_surface.plot();
```



3 Read tpc file

With center etc

```
0         1         2         3         4         5         6         7         8
9         0

0123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123

HOUR:   0.0  LONG:  142.00  LAT:  37.80  MIN PRES (hPa):  985.00   MAX SURF WIND
(KNOTS):  41.00
```

[5]:
```
import pandas as pd
colspecs = [(5, 10), (18, 25), (32, 38), (56, 63), (89, 95)]
# df = pd.read_fwf('/data2/qy2216/HWRF_wind/hwrf.2021072718/nepartak11w/track/
↪NEPARTAK11W.2021072718.stats.tpc',
df = pd.read_fwf('NEPARTAK11W.2021072718.stats.tpc',
                 colspecs=colspecs, header=None, skiprows=12, names=['hour',␣
↪'lon', 'lat', 'P', 'V'])
df = df[:41]
df.head()
```

[5]:

	hour	lon	lat	P	V
0	0.	142.0	37.8	985.0	41.0

```
1    3.  141.8  38.4  992.0  43.0
2    6.  141.6  38.9  994.0  39.0
3    9.  141.2  39.7  997.0  34.0
4   12.  140.7  40.4  997.0  29.0
```

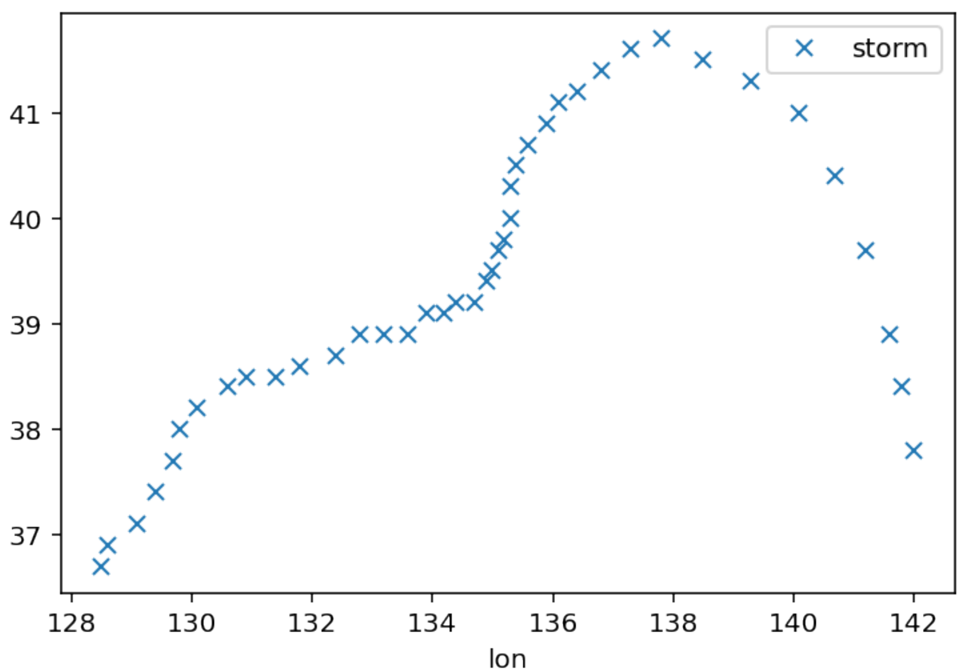
[6]:
```python
# they are strings, convert to float
df['hour'] = df['hour'].astype(float)
df['lat'] = df['lat'].astype(float)
df['lon'] = df['lon'].astype(float)

xcenter = df[df.hour == 30].lon.values[0]
ycenter = df[df.hour == 30].lat.values[0]

print(xcenter, ycenter)
```

```
136.8 41.4
```

[7]:
```python
df.plot(x='lon', y='lat', style='x', label='storm')
plt.show()
```



4 Start plotting

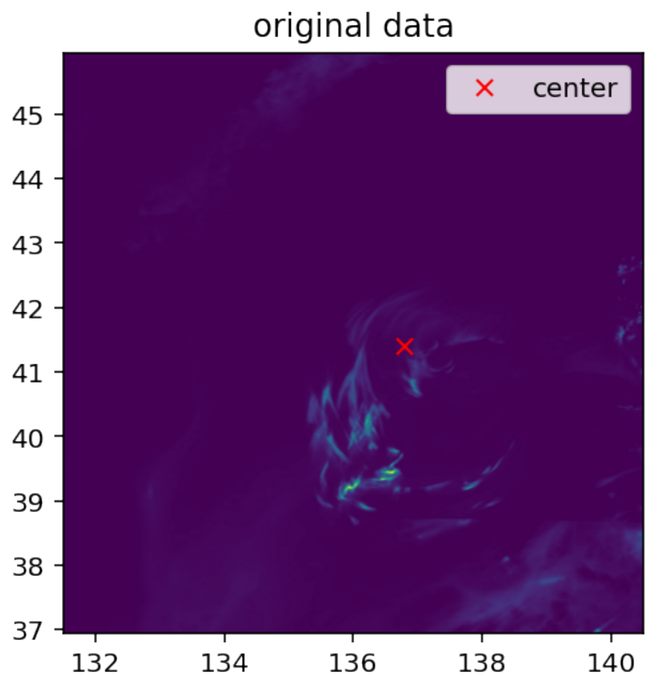
Strategy 1. Define storm-centered polar coordinate grid 2. Convert lat-lon to km - Use cosine of center lat value - Use cosine of lat values <- sensible - Use catopy

4.1 Original (lat-lon)

[8]:
```
#z = ds.PRMSL_meansealevel.isel(time=0).values
z = ds.APCP_surface.isel(time=0).values

lon = ds.longitude.values
lat = ds.latitude.values

plt.pcolormesh(lon, lat, z, shading='gouraud')
plt.title('original data')
plt.gca().set_aspect('equal')
plt.plot(xcenter, ycenter, 'rx', label='center')
plt.gca().set_aspect('equal')
plt.legend()
plt.show()
```



4.2 Storm-centered polar coordinate grid

[9]:
```
# new polar coordinates that are uniform in r and theta
# units of r are km

ntheta_pts = 201
nr_pts = 200
rmax = 300
```

```python
#FIX rmax name
r1 = np.linspace(0, rmax, nr_pts)
theta1 = np.linspace(-np.pi, np.pi, ntheta_pts)

theta2, r2 = np.meshgrid(theta1, r1)

# cartesian coordinates (in km) of the polar coordinates
polar_x2 = r2 * np.cos(theta2)
polar_y2 = r2 * np.sin(theta2)
polar_x2.shape
```

[9]: (200, 201)

4.3 Cosine lat weighting (center value)

[10]:
```python
np.cos(np.deg2rad(ycenter))
```

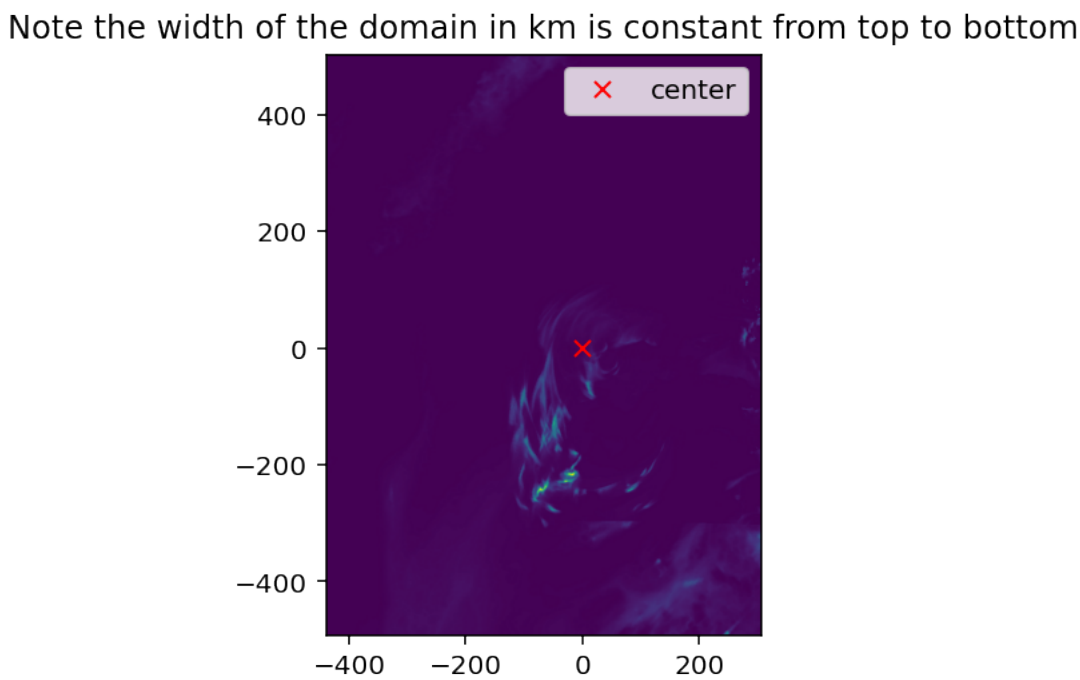
[10]: 0.7501110696304596

[11]:
```python
# uses one cos lat value for scaling
# units are km
x1 = (ds.longitude.values - xcenter) * np.cos(np.deg2rad(ycenter)) * 110.567
y1 = (ds.latitude.values - ycenter) * 110.567
x2, y2 = np.meshgrid(x1, y1)

# number of points X 2 matrix of x y
xy = np.stack((x2.flatten(), y2.flatten())).T
print('number of grid points', xy.shape, 601 * 601)

plt.pcolormesh(x1, y1, z, shading='gouraud')
plt.plot(0, 0, 'rx', label='center')
plt.gca().set_aspect('equal')
plt.legend()
plt.title('Note the width of the domain in km is constant from top to bottom')
plt.show()
```

```
number of grid points (361201, 2) 361201
```



[12]:
```
from scipy.interpolate import NearestNDInterpolator
#from scipy.interpolate import LinearNDInterpolator
#interp = LinearNDInterpolator(xy, z.flatten())
interp = NearestNDInterpolator(xy, z.flatten())
```

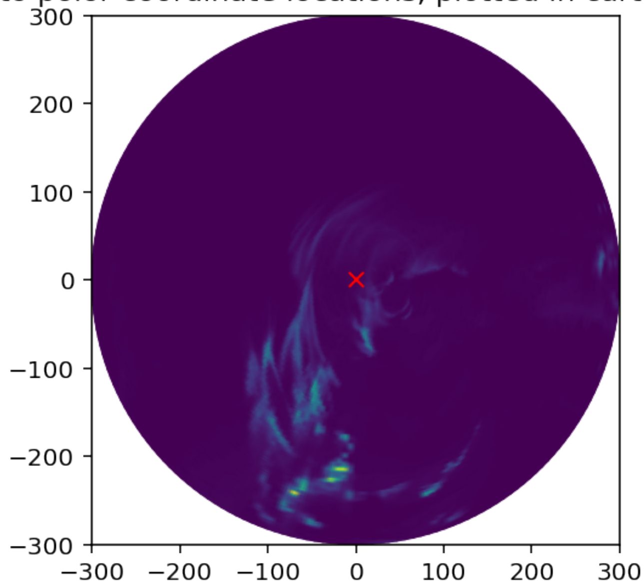
[13]:
```
# z interpolated to the uniform polar coordinate locations
Z = interp(polar_x2, polar_y2)
```

[14]:
```
Z.shape
```

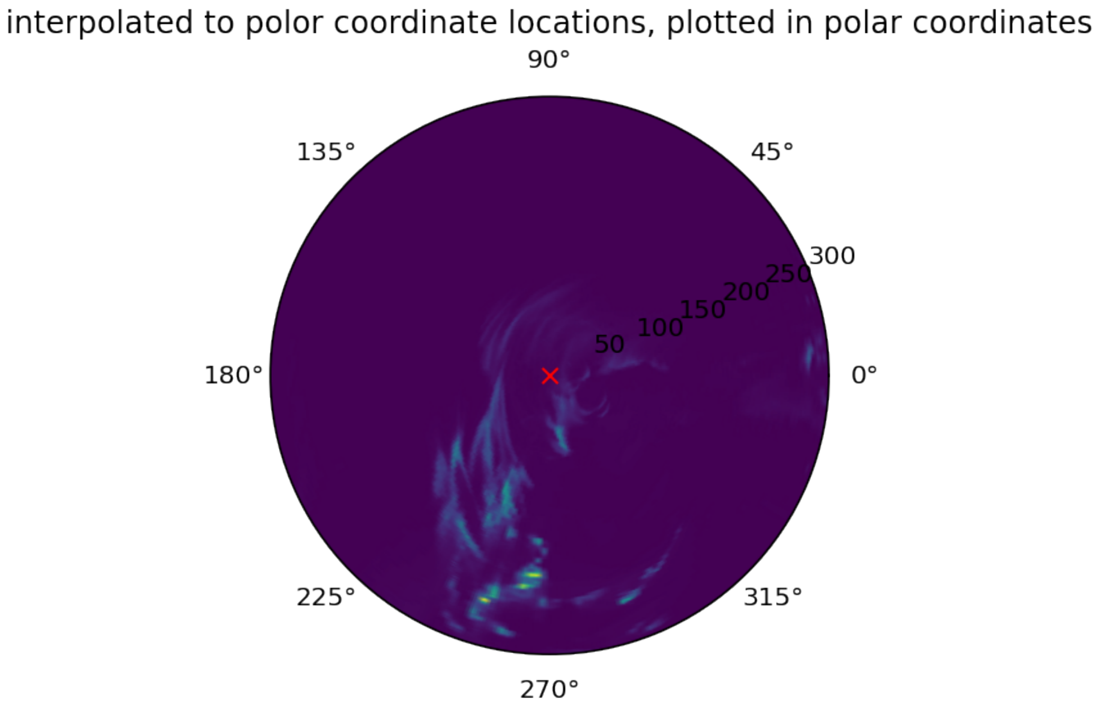
[14]: (200, 201)

[15]:
```
plt.pcolormesh(polar_x2, polar_y2, Z, shading='gouraud')
plt.plot(0, 0, 'rx', label='center')
plt.gca().set_aspect('equal')
plt.title('interpolated to polor coordinate locations, plotted in cartesian␣
 ↪coordinates');
```

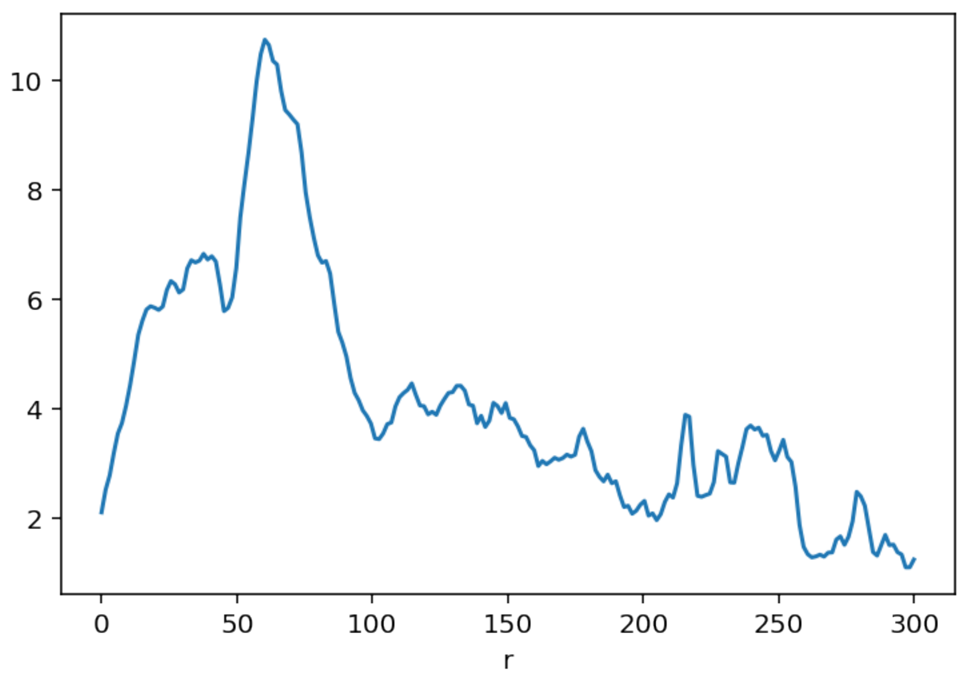
interpolated to polor coordinate locations, plotted in cartesian coordinates



[16]:
```
plt.subplot(projection="polar")
plt.pcolormesh(theta1, r1, Z, shading='gouraud')
plt.plot(0, 0, 'rx', label='center')
plt.title('interpolated to polor coordinate locations, plotted in polar␣
 ↪coordinates')
plt.show()
```

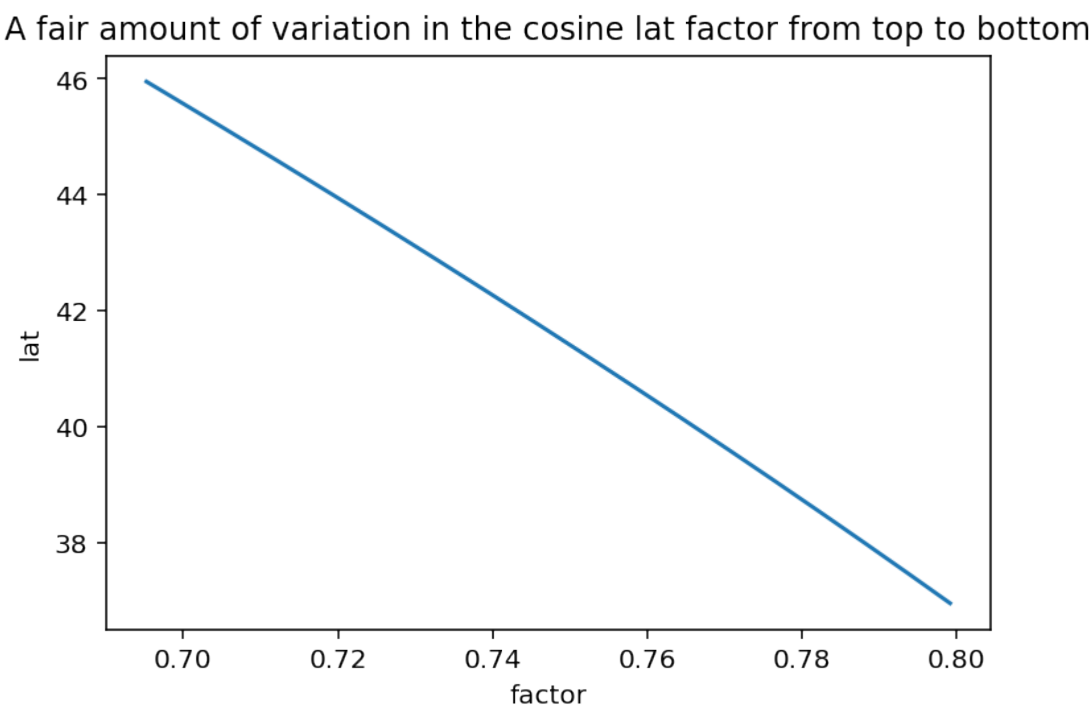


[17]:
```
plt.plot(r1, np.mean(Z, axis=1))
plt.xlabel('r')
plt.show()
```



[18]:
```
# rename result to compare latter
Z_center = Z
```

[19]:
```
plt.plot(np.cos(np.deg2rad(ds.latitude.values)), lat)
plt.title('A fair amount of variation in the cosine lat factor from top to␣
 ↪bottom')
plt.xlabel('factor')
plt.ylabel('lat')
plt.show()
```

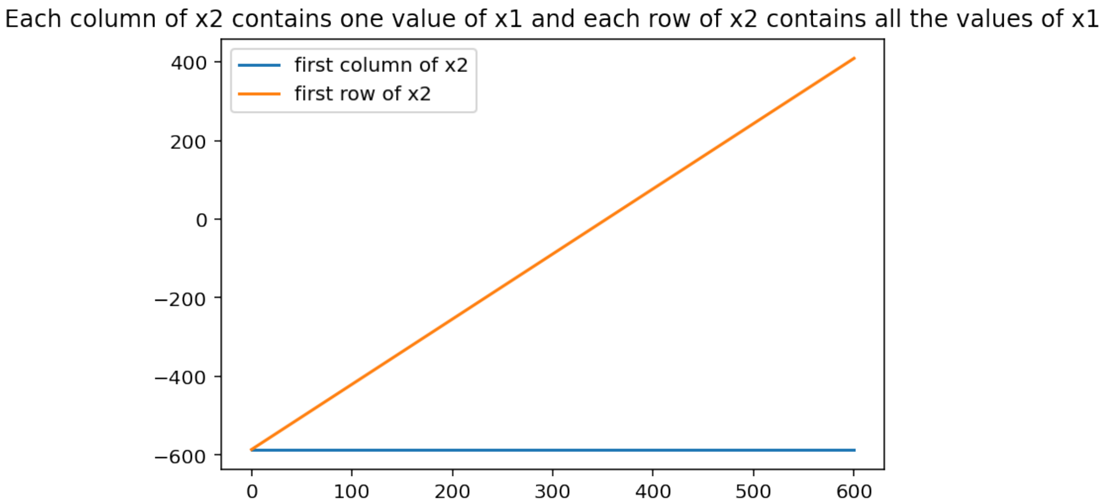


4.4 Cosine lat weighting (varying)

[20]:
```
# uses all the cos lat values km/deg = 110.567
x1 = (ds.longitude.values - xcenter) * 110.567
y1 = (ds.latitude.values - ycenter) * 110.567
x2, y2 = np.meshgrid(x1, y1)
```

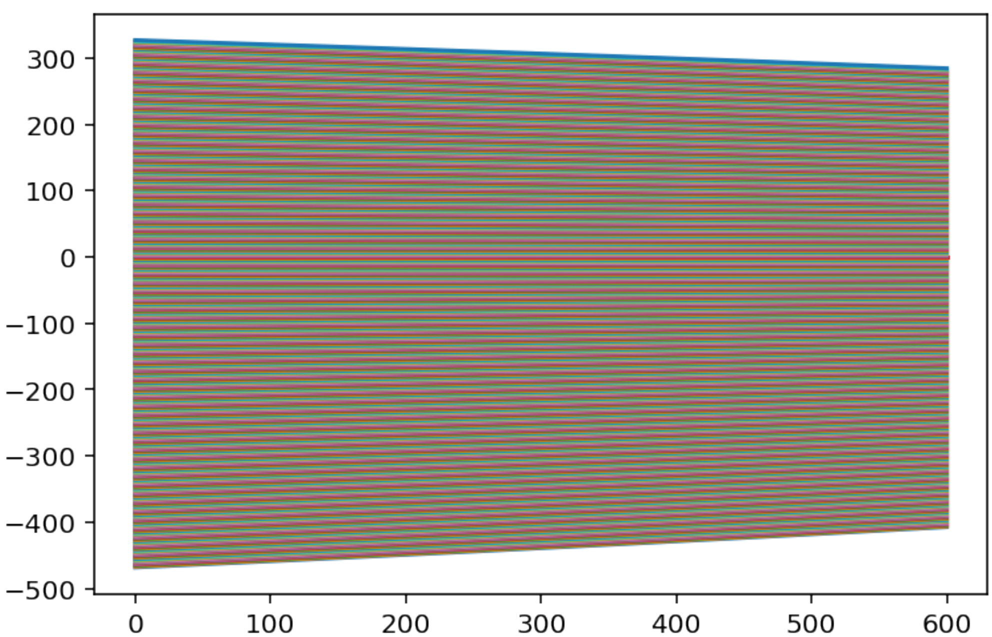
[21]:
```
plt.plot(x2[:, 0], label='first column of x2')
plt.plot(x2[0, :], label='first row of x2')
plt.title('Each column of x2 contains one value of x1 and each row of x2␣
 ↪contains all the values of x1')
```

```
plt.legend()
plt.show()
```

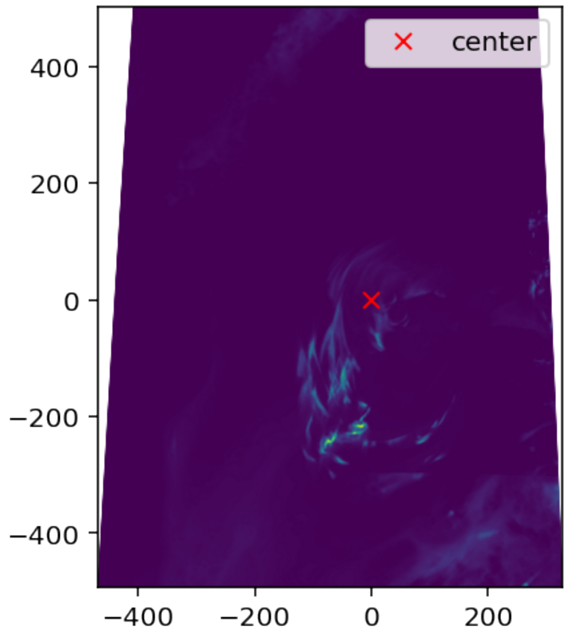


[22]:
```
# choose the shape of the factor to broadcast along the 2nd
cosine_factor = np.cos(np.deg2rad(ds.latitude.values)).reshape(-1, 1)
x2 = cosine_factor * x2
```

[23]:
```
plt.plot(x2);
```



[24]:
```
plt.pcolormesh(x2, y2, z, shading='gouraud')
plt.plot(0, 0, 'rx', label='center')
plt.gca().set_aspect('equal')
plt.legend()
plt.show()
```



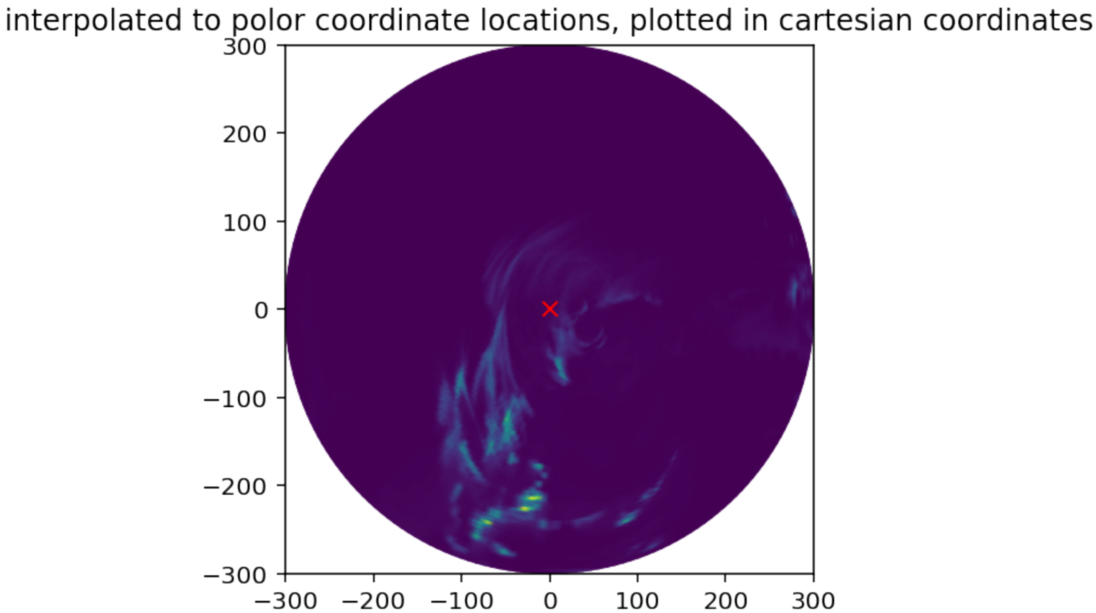
[25]:
```
# number of points X 2 matrix of x y
xy = np.stack((x2.flatten(), y2.flatten())).T
xy.shape
```

[25]: (361201, 2)

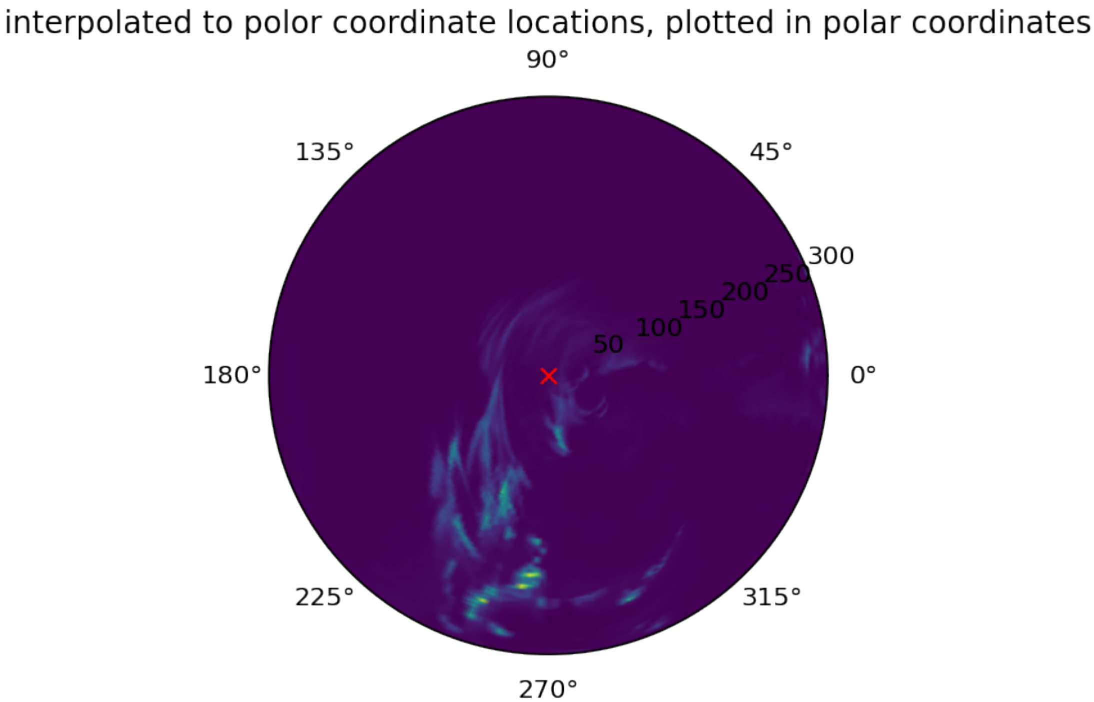
[26]:
```
from scipy.interpolate import NearestNDInterpolator
#from scipy.interpolate import LinearNDInterpolator
#interp = LinearNDInterpolator(xy, z.flatten())
interp = NearestNDInterpolator(xy, z.flatten())
```

[27]:
```
# z interpolated to the uniform polar coordinate locations
Z = interp(polar_x2, polar_y2)
```

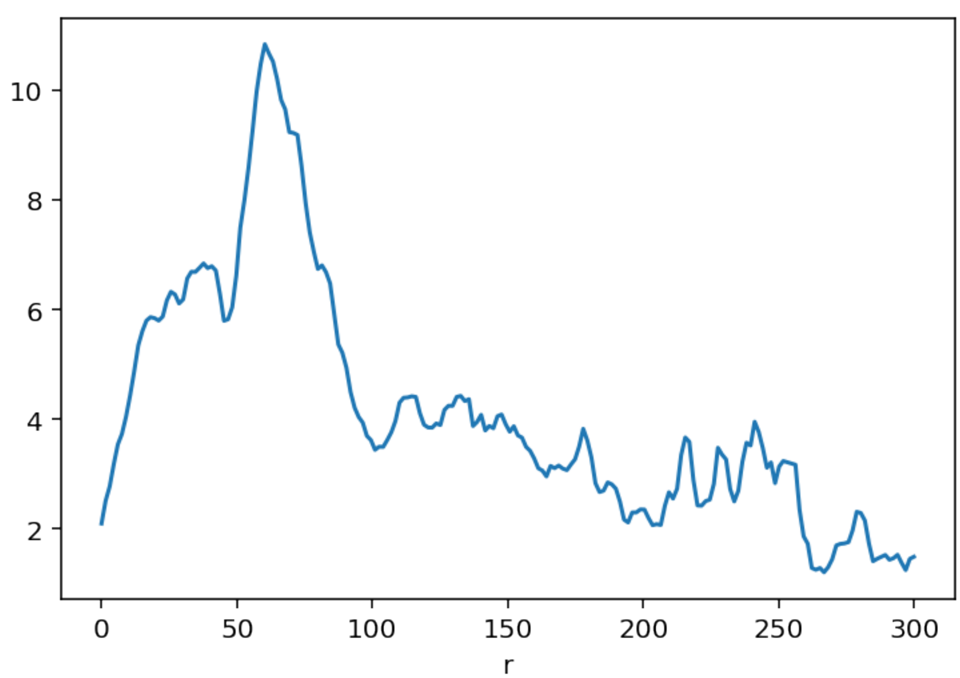
[28]:
```
plt.pcolormesh(polar_x2, polar_y2, Z, shading='gouraud')
plt.plot(0, 0, 'rx', label='center')
plt.gca().set_aspect('equal')
plt.title('interpolated to polor coordinate locations, plotted in cartesian␣
↪coordinates');
```



[29]:
```
plt.subplot(projection="polar")
plt.pcolormesh(theta1, r1, Z, shading='gouraud')
plt.plot(0, 0, 'rx', label='center')
plt.title('interpolated to polor coordinate locations, plotted in polar␣
 ↪coordinates')
plt.show()
```



[30]:
```
plt.plot(r1, np.mean(Z, axis=1))
plt.xlabel('r')
plt.show()
```



[31]:
```python
# rename result to compare latter
Z_varying = Z
```

4.5 Cartopy

[32]:
```python
import cartopy.crs as ccrs

proj_local = ccrs.TransverseMercator(central_longitude=xcenter,␣
 ↪central_latitude=ycenter, approx=False)
#proj_local = ccrs.AzimuthalEquidistant(central_longitude=xcenter,␣
 ↪central_latitude=ycenter)

proj_data = ccrs.PlateCarree()

# define point
p_data = (xcenter, ycenter)

# convert from data to cartesian coordinates
p_local = proj_local.transform_point(*p_data, src_crs=proj_data)

print(p_local)
```

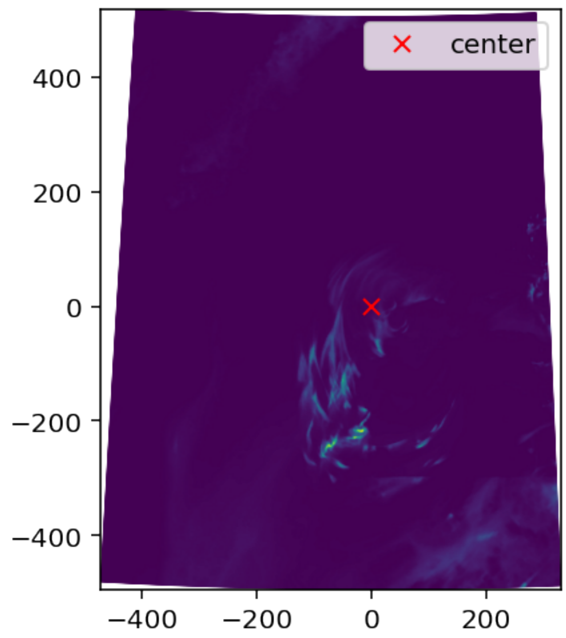
```
(0.0, 0.0)
```

[33]:
```python
# number of points X 2 matrix of x y
lon2, lat2 = np.meshgrid(lon, lat)
lonlat = np.stack((lon2.flatten(), lat2.flatten())).T
```

[34]:
```python
x2 = np.empty_like(lon2)
y2 = np.empty_like(lat2)

for ii in range(0, len(lon)):
    for jj in range(0, len(lon)):
        x2[ii, jj], y2[ii, jj] = proj_local.transform_point(lon2[ii, jj],␣
 ↪lat2[ii, jj], src_crs=proj_data)
# m -> km
x2, y2 = x2/1000, y2/1000
```

[35]:
```python
plt.pcolormesh(x2, y2, z, shading='gouraud')
plt.plot(0, 0, 'rx', label='center')
plt.gca().set_aspect('equal')
plt.legend()
plt.show()
```



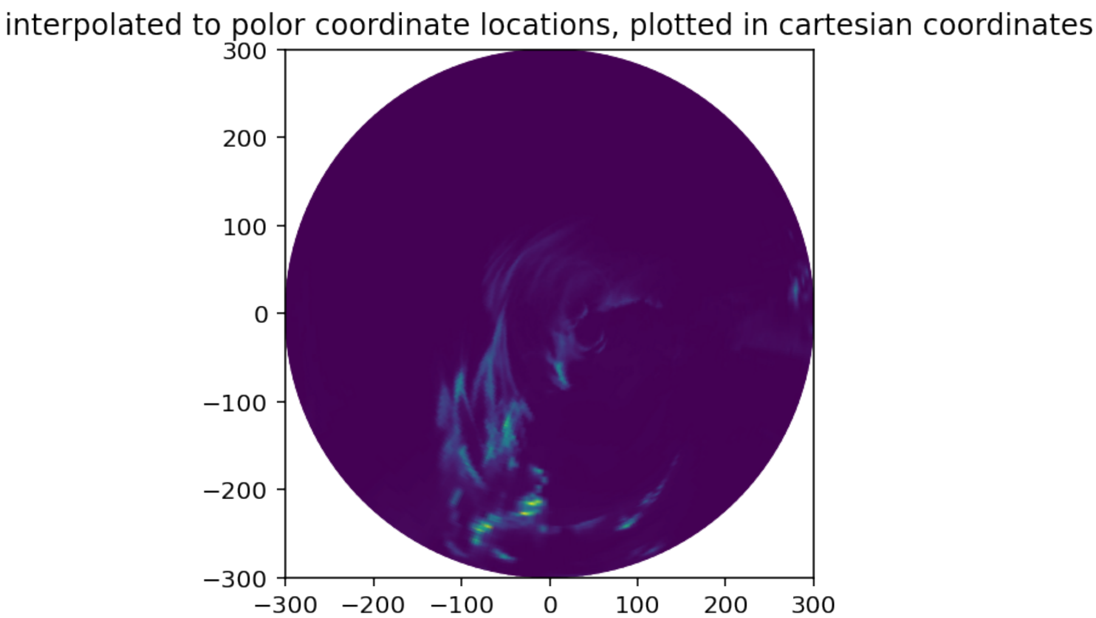
[36]:
```
# number of points X 2 matrix of x y
xy = np.stack((x2.flatten(), y2.flatten())).T
xy.shape
```

[36]: (361201, 2)

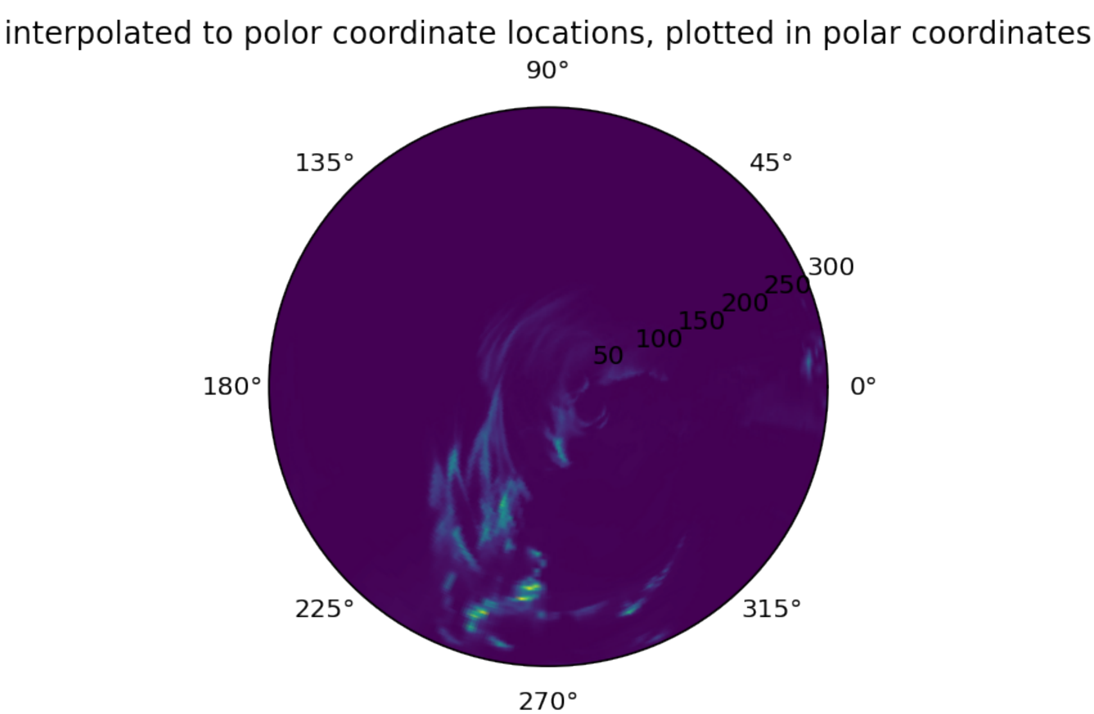
[37]:
```
#from scipy.interpolate import LinearNDInterpolator
#interp = LinearNDInterpolator(xy, z.flatten())
from scipy.interpolate import NearestNDInterpolator
interp = NearestNDInterpolator(xy, z.flatten())
```

[38]:
```
# z interpolated to the uniform polar coordinate locations
Z = interp(polar_x2, polar_y2)
```

[39]:
```
plt.pcolormesh(polar_x2, polar_y2, Z, shading='gouraud')
plt.gca().set_aspect('equal')
plt.title('interpolated to polor coordinate locations, plotted in cartesian␣
 ↪coordinates');
```



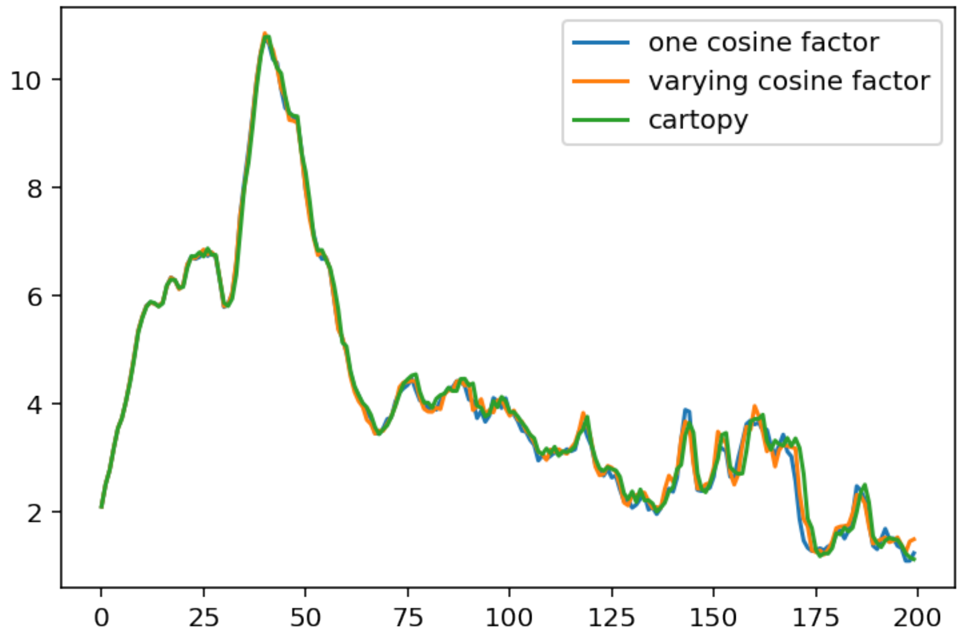
[40]:
```
plt.subplot(projection="polar")
plt.pcolormesh(theta1, r1, Z, shading='gouraud')
plt.title('interpolated to polor coordinate locations, plotted in polar␣
 ↪coordinates')
plt.show()
```



[41]:
```
# rename result to compare latter
Z_proj = Z
```

5 Compare

[42]:
```
plt.plot(np.mean(Z_center, axis=1), label='one cosine factor')
plt.plot(np.mean(Z_varying, axis=1), label='varying cosine factor')
plt.plot(np.mean(Z_proj, axis=1), label='cartopy')
plt.legend()
plt.show()
```

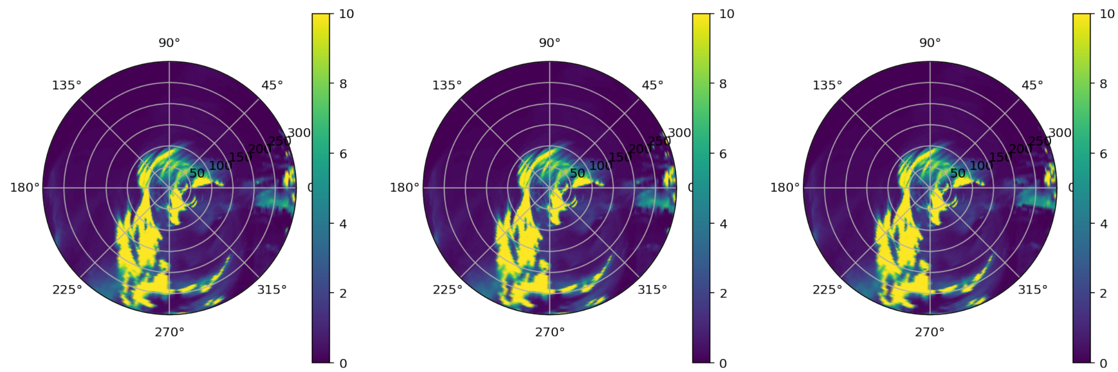


[43]:
```
fig, axs = plt.subplots(1, 3, figsize=(15, 5), subplot_kw=dict(polar=True))

ax = axs[0]
g = ax.pcolormesh(theta1, r1, Z_center, vmax=10, shading='gouraud')
plt.colorbar(g, ax=ax)
ax.grid()

ax = axs[1]
g = ax.pcolormesh(theta1, r1, Z_varying, vmax=10, shading='gouraud')
plt.colorbar(g, ax=ax)
ax.grid()
```

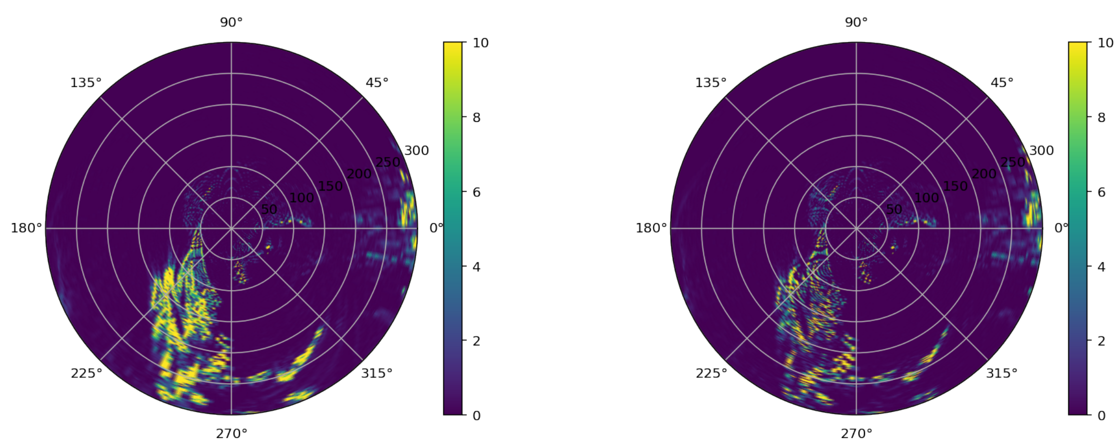
```
ax = axs[2]
g = axs[2].pcolormesh(theta1, r1, Z_proj, vmax=10, shading='gouraud')
plt.colorbar(g, ax=ax)
ax.grid()
```



[45]:
```
fig, axs = plt.subplots(1, 2, figsize=(15, 5), subplot_kw=dict(polar=True))

ax = axs[0]
g = ax.pcolormesh(theta1, r1, np.abs(Z_center - Z_proj), vmax=10,␣
 ↪shading='gouraud')
plt.colorbar(g, ax=ax)
ax.grid()

ax = axs[1]
g = ax.pcolormesh(theta1, r1, np.abs(Z_varying - Z_proj), vmax=10,␣
 ↪shading='gouraud')
plt.colorbar(g, ax=ax)
ax.grid()
```



```
[ ]:
```

```
[ ]:
```