PS3　第一题

先进行初始化，导入一些模块

1.1

首先，读取文件并且将需要研究的区域挑选出来（5S-5N,170W-120W）。由于这里经度是0°-360°，所以切片的时候需要注意，应该是（190-240）

1.1 Compute monthly climatology for SST from Niño 3.4 region, and subtract climatology from SST time series to obtain anomalies.

In [15]:
```
# open the source of the dataset
ds  = xr.open_dataset("NOAA_NCDC_ERSST_v3b_SST.nc", engine="netcdf4")
# choose nino 3.4 region
ds_re = ds.sel(lat=slice(-5,5),lon=slice(190,240))
```

其次，利用 groupby 函数，把数据按照月份整合归类，就能求月平均的海平面温度。 用原来的数据减去月平均数据就能得到“异常”值。

```
group_data = ds_re.sst.groupby('time.month')
month_mean = ds_re.sst.groupby('time.month').mean(dim='time')
s_anom = group_data - month_mean


print(s_anom.data)
```

```
[[[-0.43157768 -0.41846275 -0.39795303 ... -0.2116642  -0.23776245
   -0.24401474]
  [-0.41259003 -0.4067192  -0.3875141  ... -0.52064896 -0.5346451
   -0.51997185]
  [-0.40932274 -0.39743805 -0.36237717 ... -0.6373882  -0.6171951
   -0.583725  ]
  [-0.4140854  -0.37909317 -0.3215618  ... -0.43292618 -0.38404274
   -0.3352623 ]
  [-0.5043678  -0.43894005 -0.3710251  ... -0.17453575 -0.11044502
   -0.06918144]]

 [[-0.5374584  -0.52739716 -0.50823593 ... -0.40254593 -0.44382668
   -0.45287704]
  [-0.55093956 -0.539135   -0.51673317 ... -0.6660595  -0.7127285
   -0.710968  ]
```

1.2

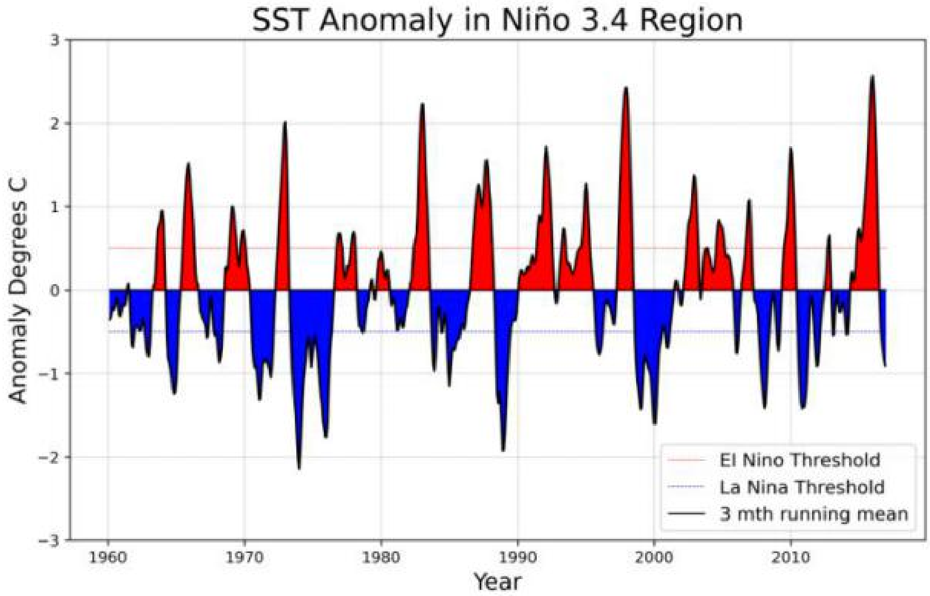
利用 rolling.mean 函数对 1.1 求出来的异常值求滑动平均，跨度为 3（即 3 个月）， 求滑动平均能把曲线调整的更加平滑，再创建一个新的画布，后面可以对 ax 进行修饰

1.2 Visualize the computed Niño 3.4. Your plot should look similar to this one.

In [33]:
```
anom_line= s_anom.rolling(time=3,center=True).mean()
line_anom =np.nanmean(anom_line.values,axis=(1,2))
fig,ax = plt.subplots(1,1,figsize=[10,6])
t = pd.date_range(start='1960-01',periods=684,freq='m')

ax.plot(t,line_anom,color='k')
# set xlabel, ylabel and title
ax.set_ylabel('Anomaly Degree C',color='k',fontsize=15)
ax.set_xlabel('Year',color='k',fontsize=15)
ax.set_title('SST Anomaly in Nino 3.4 Region(5N-5S,120-170W)',fontsize=20)

ax.grid(linestyle='--',linewidth=0.5,color='k')

ax.hlines(y=0.5,xmin=t[0],xmax=t[-1],color='r',ls='--',lw=1,label='EI Nino Threshold')
ax.hlines(y=-0.5,xmin=t[0],xmax=t[-1],color='b',ls='--',lw=1,label='La Nina Threshold')
ax.hlines(y=0,xmin=t[0],xmax=t[-1],color='k',ls='solid',lw=1,label='3 mth running mean')
# set ylabel limitation
ax.set_ylim(-3,3)
# put legend into the figure
ax.legend(loc=4,fontsize=12)

ax.fill_between(t,line_anom,where=(line_anom>0),color='r')
ax.fill_between(t,line_anom,where=(line_anom<0),color='b')
```

```
<ipython-input-33-19566400318b>:2: RuntimeWarning: Mean of empty slice
  line_anom =np.nanmean(anom_line.values,axis=(1,2))
```

现在我们绘制图片，并绘制尽可能类似于老师给出的图像。事实上，老师的图像情况是不同的，所以我选择了 1960 年至 2016 年的图像情况。创建子块；将变量放入绘图（x 轴=时间，y 轴=异常）；下面是一些详细操作：设置 ylabel、xlabel 和 title；绘制网格线；在图中加上高线；设置标签限制；在图形中添加图例；在图形中填充不同的颜色。最后，图形输出如下：



2.Earth's energy budget

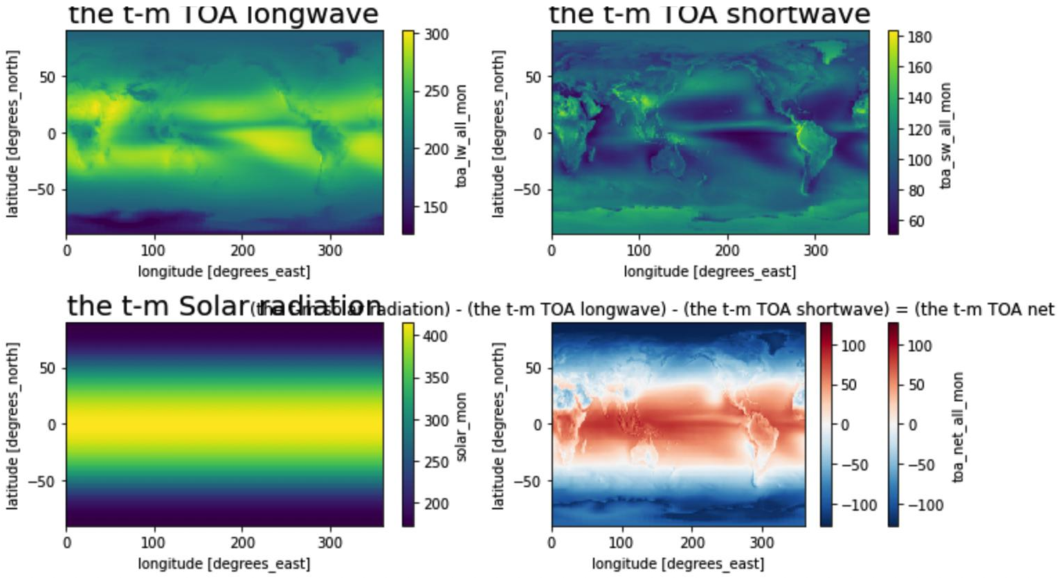
In [35]:
```
import numpy as np
import xarray as xr
import matplotlib as mpl
import matplotlib.gridspec as gridspec
from matplotlib import pyplot as plt

%matplotlib inline

import netCDF4
```

In [36]:
```
# open dataset
ds = xr.open_dataset("CERES_EBAF-TOA_200003-201701.nc")
```

2.1 Make a 2D plot of the time-mean TOA longwave, shortwave, and solar radiation for all-sky conditions. Add up the three variables above and verify (visually) that they are equivalent to the TOA net flux

```
dalw = ds.toa_lw_all_mon
dasw = ds.toa_sw_all_mon
dasolar = ds.solar_mon
danet = ds.toa_net_all_mon
fig, axes = plt.subplots(2,2, figsize=(10,6), sharex=False, sharey=False)
dalw.mean(dim='time').plot(ax=axes[0,0])
dasw.mean(dim='time').plot(ax=axes[0,1])
dasolar.mean(dim='time').plot(ax=axes[1,0])
danet.mean(dim='time').plot(ax=axes[1,1])

axes[0,0].set_title('the t-m TOA longwave',fontsize = 20)
axes[0,1].set_title('the t-m TOA shortwave',fontsize = 20)
axes[1,0].set_title('the t-m Solar radiation',fontsize = 20)
axes[1,1].set_title('the t-m Netflux',fontsize = 20)


plt.tight_layout()

plt.rcParams['figure.dpi'] = 120
da_total = dasolar - dalw - dasw
da_total.mean('time').plot()
plt.title('(the t-m solar radiation) - (the t-m TOA longwave) - (the t-m TOA shortwave) = (the t-m TOA net Flux) ')
```

创建了 4 个不同的数据阵列，包括 TOA 长波、TOA 短波、太阳辐射和 netwave。创建 4 个子图，并将 4 幅不同的图片绘制成子图，包括 TOA 长波、TOA 短波、solar radiation and netwave。然后输出如下图所示



2.2 Calculate and verify that the TOA incoming solar, outgoing longwave, and outgoing shortwave approximately match up with the cartoon above.

```
weights = np.cos(np.deg2rad(ds.lat))
toa_weighted_solar = dasolar.weighted(weights)
toa_weighted_lw = dalw.weighted(weights)
toa_weighted_sw = dasw.weighted(weights)


print('solar radiations:',toa_weighted_solar.mean(dim=('lon', 'lat','time')).values,'(Wm-2)')
print('long wave outgoing:',toa_weighted_lw.mean(dim=('lon', 'lat','time')).values,'(Wm-2)')
print('short wave outgoing:',toa_weighted_sw.mean(dim=('lon', 'lat','time')).values,'(Wm-2)')
```

```
solar radiations: 340.28326598091286 (Wm-2)
long wave outgoing: 240.2669337478465 (Wm-2)
short wave outgoing: 99.13805276923081 (Wm-2)
```

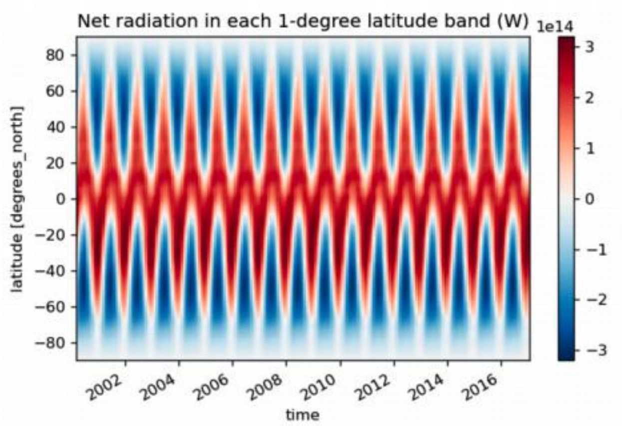
老师上课时有提到过计算 solar radiation 和 TOA 长波和 TOA 短波的加权平均值
并输出其值。

2.3 Calculate and plot the total amount of net radiation in each 1-degree latitude band. Label with correct units.

这题我自己没太搞明白，找同学询问了一下，回头再好好复习

```
#龚国庆同学向我解释了此题，但是前面和他编写的不一样，所以变量设置上有些问题，此题仍需研究研究
R=6371.4e3

equator_s = 2*np.pi**2*R**2/180
equator_s_weighted= equator_s * weights

nf = net_flux.mean(dim=('lon','time'))

total_amount = nf * equator_s_weighted
total_amount.plot(figsize=(10,6))
plt.title('Net radiation in each 1-degree latitude band ',fontsize = 18)
plt.ylabel('Net radiation(W)',fontsize = 15)
```

将权重 netwave 设置为正确的值。计算净辐射总量：净辐射总量=（每个纬度的净辐射）x（地球表面积）绘制正确的 TOAnet 和正确的 correct units，放置标题。输出图如下所示：



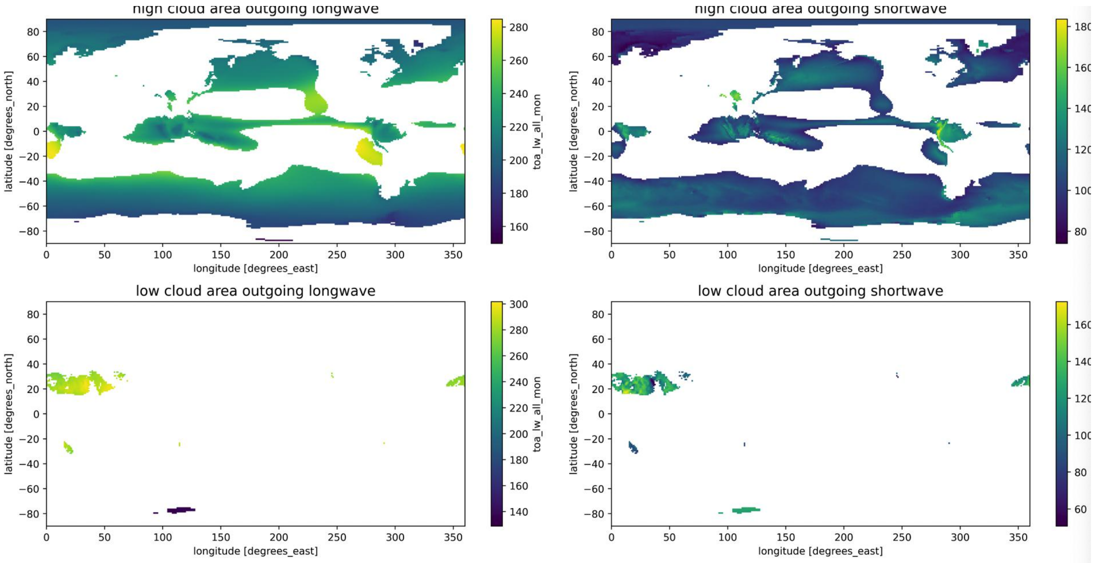
2.4 Calculate and plot composites of time-mean outgoing shortwave and longwave radiation for low and high cloud area regions. Here we define low cloud area as ≤25% and high cloud area as ≥75%. Your results should be 2D maps.

In [55]:
```
# open dataset and dataarray of TOA longwave, shortwave
ds = xr.open_dataset("CERES_EBAF-TOA_200003-201701.nc")


# Choose the area of low cloud area and high cloud area
arrclda = ds.cldarea_total_daynight_mon.mean(dim='time').values
high_cloud_area = (arrclda>=75)
low_cloud_area = (arrclda<=25)
```

In [56]:
```
hc_lw = ds.toa_lw_all_mon.mean(dim='time')
hc_sw = ds.toa_sw_all_mon.mean(dim='time')
lc_lw = ds.toa_lw_all_mon.mean(dim='time')
lc_sw = ds.toa_sw_all_mon.mean(dim='time')
```

In [58]:
```
# Create Figure and Subplots
fig,axes = plt.subplots(2,2,figsize=(16,8),dpi=500)
# Plot each axes
hc_lw.where(high_cloud_area).plot(ax=axes[0,0])
hc_sw.where(high_cloud_area).plot(ax=axes[0,1])
lc_lw.where(low_cloud_area).plot(ax=axes[1,0])
lc_sw.where(low_cloud_area).plot(ax=axes[1,1])
axes[0,0].set_title('high cloud area outgoing longwave',fontsize = 14)
axes[0,1].set_title('high cloud area outgoing shortwave',fontsize = 14)
axes[1,0].set_title('low cloud area outgoing longwave',fontsize = 14)
axes[1,1].set_title('low cloud area outgoing shortwave',fontsize = 14)
plt.tight_layout()
```

这里也是需要打开数据集然后选择 low cloud area 和 high cloud area 然后再去计算 high cloud longwave、high cloud shortwave 、low cloud longwave 和 low cloud shortwave



2.5 Calculate the global mean values of shortwave and longwave radiation, composited in high and low cloud regions. What is the overall effect of clouds on shortwave and longwave radiation?

```
In [60]: print('high cloud long wave:',np.nanmean(hclw),'(W/m2)')
         print('high cloud short wave:',np.nanmean(hcsw),'(W/m2)')
         print('low cloud long wave:',np.nanmean(lclw),'(W/m2)')
         print('low cloud short wave:',np.nanmean(lcsw),'(W/m2)')

         high cloud long wave: 224.75517 (W/m2)
         high cloud short wave: 102.30433 (W/m2)
         low cloud long wave: 224.75517 (W/m2)
         low cloud short wave: 102.30433 (W/m2)
```

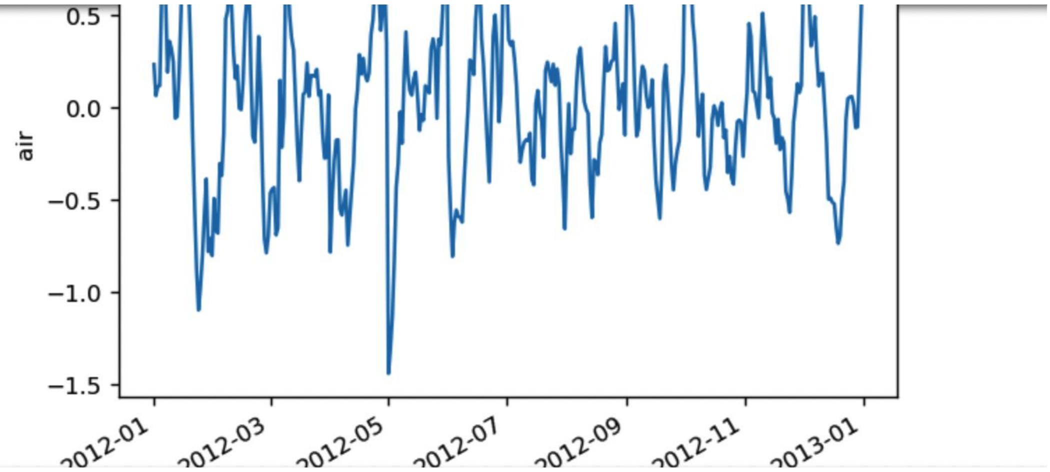
计算短波和长波辐射的全球平均值

3.Explore a netCDF dataset

浏览美国宇航局戈达德地球科学数据和信息服务中心（GES DISC）网站。搜索并下载您感兴趣的数据集。也欢迎在本习题集中使用您所在小组的数据。但数据集应为 netCDF 格式，并具有时间信息。Browse the NASA's Goddard Earth Sciences Data and Information Services Center (GES DISC) website. Search and download a dataset you are interested in. You are also welcome to use data from your group in this problem set. But the dataset should be in netCDF format, and have temporal information

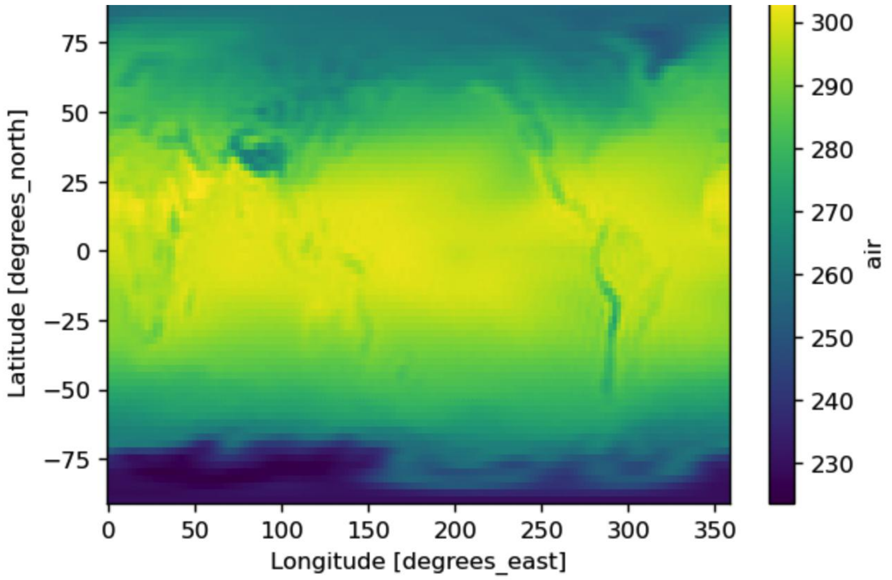
3.1 Plot a time series of a certain variable with monthly seasonal cycle removed.

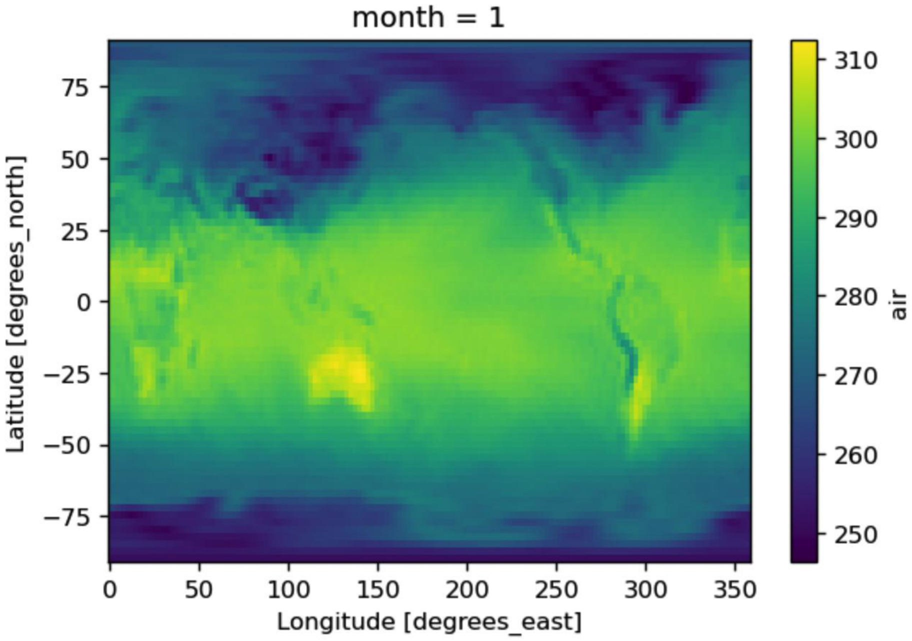
```
In [61]: #3.1
dt = xr.open_dataset("air.sig995.2012.nc", engine="netcdf4")
group_data = dt.air.groupby('time.month')

# Apply mean to grouped data, and then compute the anomaly
tas_anom = group_data - group_data.mean(dim='time')
tas_anom
tas_anom.mean(dim=['lat', 'lon']).plot()
```

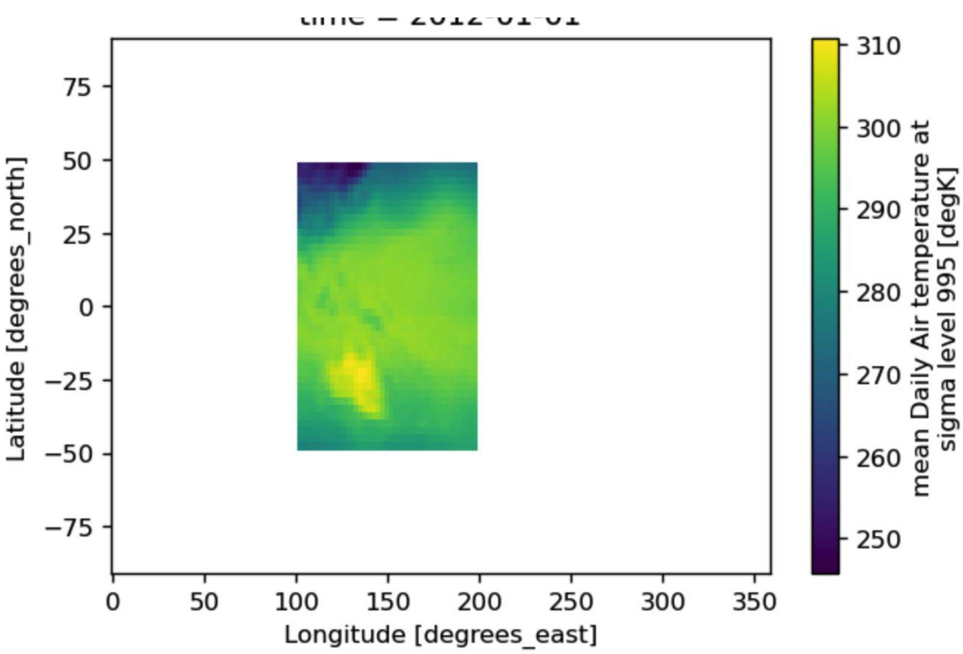


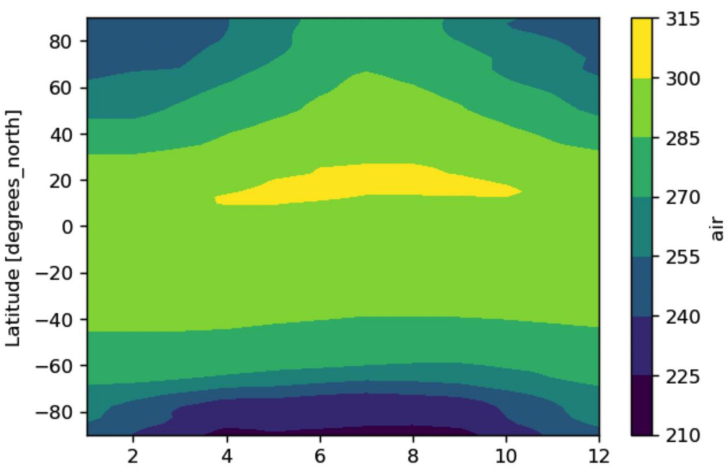
3.2 Make at least 5 different plots using the dataset.

```
In [63]:
dt.air.mean(dim='time').plot()
plt.show()

dt.air.groupby('time.month').max().sel(month=1).plot()
plt.show()

sample = dt.air.isel(time=0)
sample
masked_sample = sample.where(sample < 10)
masked_sample.plot()
plt.show()

sample.where((sample.lat < 50) & (sample.lat > -50) & (sample.lon > 100) & (sample.lon < 200)).plot()
plt.show()

dt.air.groupby('time.month').mean().mean(dim='lon').transpose().plot.contourf()
plt.show()
```




month = 1
Latitude [degrees_north]
75
50
25
0
−25
−50
−75
0
50
100
150
200
250
300
350
Longitude [degrees_east]
310
300
290
280
270
260
250
air


Latitude [degrees_north]
75
50
25
0
−25
−50
−75
0
50
100
150
200
250
300
350
Longitude [degrees_east]
310
300
290
280
270
260
250
mean Daily Air temperature at
sigma level 995 [degK]


Latitude [degrees_north]
80
60
40
20
0
−20
−40
−60
−80
2
4
6
8
10
12
315
300
285
270
255
240
225
210
air