In [1]:
```
# Import modules
import numpy as np
import xarray as xr
import pandas as pd
import matplotlib.pyplot as plt
import matplotlib.ticker as mticker
%matplotlib inline
import cartopy.crs as ccrs
import cartopy.feature as cfeature
```

In [3]:
```
# 1.Global Earthquakes
# Read the file "usgs_earthquakes.csv" and rename it "Usgs_Eqs"
Usgs_Eqs=pd.read_csv("usgs_earthquakes.csv")
# Observe each column and know that all the time data belongs to Year 2014
# No need to select rows with "time=2014"
Usgs_Eqs.head()
```

Out[3]:

	time	latitude	longitude	depth	mag	magType	nst	gap	dmin	rms	net	id
0	2014/1/31 23:53	60.252000	-152.7081	90.20	1.10	ml	NaN	NaN	NaN	0.2900	ak	ak11155107
1	2014/1/31 23:48	37.070300	-115.1309	0.00	1.33	ml	4.0	171.43	0.34200	0.0247	nn	nn00436847
2	2014/1/31 23:47	64.671700	-149.2528	7.10	1.30	ml	NaN	NaN	NaN	1.0000	ak	ak11151142
3	2014/1/31 23:30	63.188700	-148.9575	96.50	0.80	ml	NaN	NaN	NaN	1.0700	ak	ak11151135
4	2014/1/31 23:30	32.616833	-115.6925	10.59	1.34	ml	6.0	285.00	0.04321	0.2000	ci	ci37171541

In [4]:
```
# Use the function sort_values() to sequence "mag"
Equs_head50=Usgs_Eqs.sort_values("mag",ascending=False).head(50)# Get the head 50 rows
# The lowest and highest "mag" among top 50 earthquakes are equal to "6.5" and "8.2", respectively
Equs_head50
```

Out[4]:

	time	latitude	longitude	depth	mag	magType	nst	gap	dmin	rms	net	
37371	2014/4/1 23:46	-19.6097	-70.7691	25.00	8.2	mww	NaN	23.0	0.60900	0.66	us	usc000
50562	2014/6/23 20:53	51.8486	178.7352	109.00	7.9	mww	NaN	22.0	0.13300	0.71	us	usc00
36918	2014/4/3 2:43	-20.5709	-70.4931	22.40	7.7	mww	NaN	44.0	1.02900	0.82	us	usc00(
33808	2014/4/12 20:14	-11.2701	162.1481	22.56	7.6	mww	NaN	13.0	2.82800	0.71	us	usc000

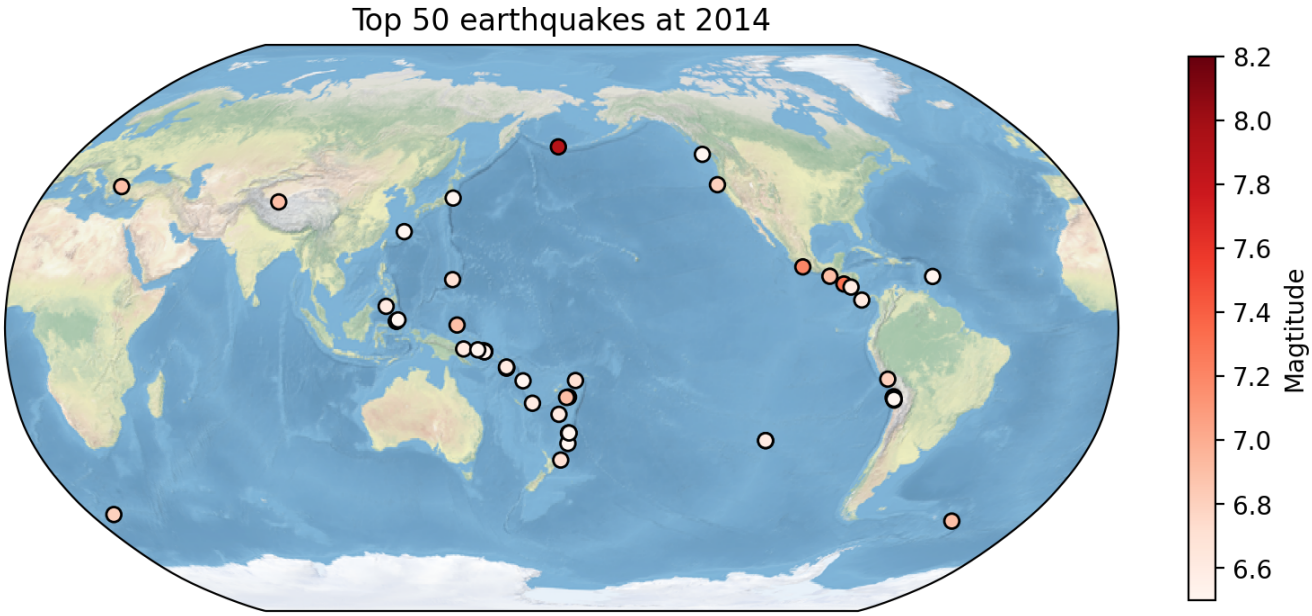
In [6]:
```
# Considering some earthquakes with mag = 6.5, but not listed in the top 50 earthquakes
List_Equs_Mag_largerorequal6_5=Usgs_Eqs.loc[Usgs_Eqs["mag"]>=6.5].sort_values("mag",
                                                                               ascending=False)
List_Equs_Mag_largerorequal6_5
```

Out[6]:

	time	latitude	longitude	depth	mag	magType	nst	gap	dmin	rms	net	
37371	2014/4/1 23:46	-19.6097	-70.7691	25.00	8.2	mww	NaN	23.0	0.60900	0.66	us	usc000
50562	2014/6/23 20:53	51.8486	178.7352	109.00	7.9	mww	NaN	22.0	0.13300	0.71	us	usc00
36918	2014/4/3 2:43	-20.5709	-70.4931	22.40	7.7	mww	NaN	44.0	1.02900	0.82	us	usc00(
33808	2014/4/12 20:14	-11.2701	162.1481	22.56	7.6	mww	NaN	13.0	2.82800	0.71	us	usc000

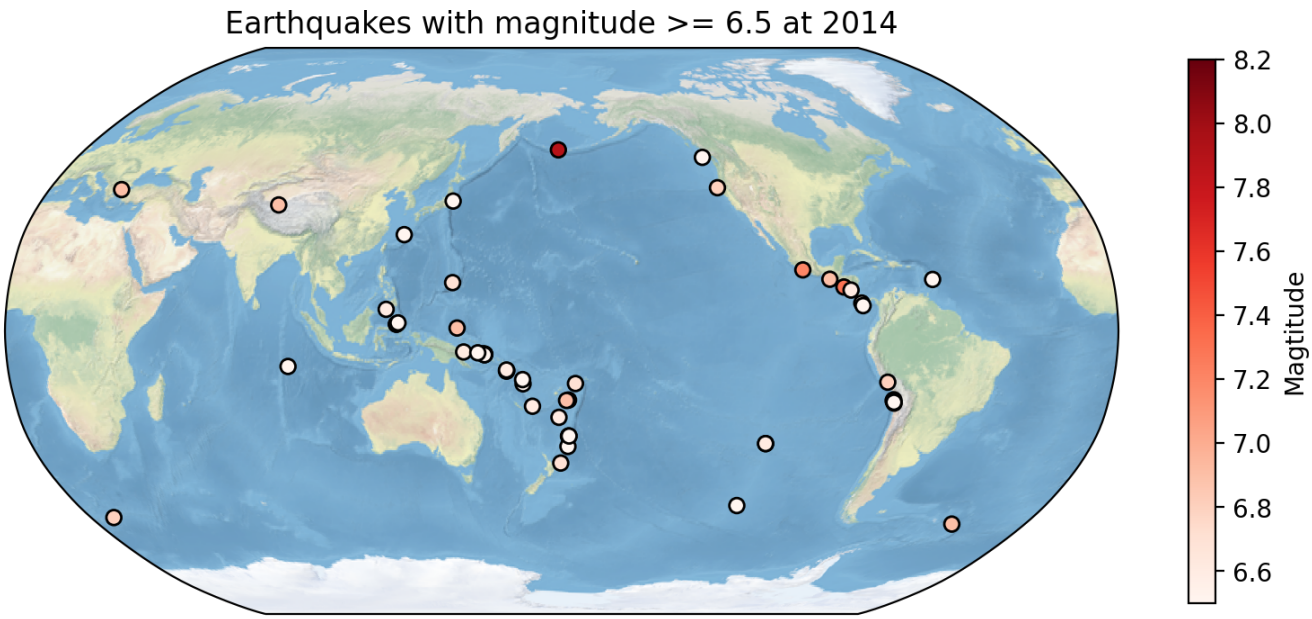
In [7]:
```
# Set the coordinate "longitude" and "latitude" as x and y, respectively
x=Equs_head50["longitude"]
y=Equs_head50["latitude"]
# Create a variable "Magtitude" based on column "mag"
Magtitude=Equs_head50["mag"]
# Create a plotting object
plotting=plt.figure(figsize=(10,8), dpi=200)
# Set the plotting projection "ccrs.Robinson"
proj=ccrs.Robinson(central_longitude=180)# According to Mr.zhu's requirements in this question,
                                         # the central longitude is 180.
ax=plotting.add_subplot(projection=proj)
# Add the map sticker to distingush the ocean and the land
ax.stock_img()# Inspired from https://blog.csdn.net/qq_40497403/article/details/119248198
# Plot the scatter figure of the top 50 earthquakes
plt.scatter(x,y,c=Magtitude,cmap="Reds",edgecolors="black",vmin=6.5,vmax=8.2,
            transform=ccrs.PlateCarree())
# Add the colorbar and set the title
plt.colorbar(shrink=0.5,label="Magtitude")
plt.title("Top 50 earthquakes at 2014",fontsize=12)
```

Out[7]: Text(0.5, 1.0, 'Top 50 earthquakes at 2014')



In [8]:
```
# Do the same orperations for "List_Equs_Mag_largerorequal6_5"
# Set the coordinate and create a variable "Magtitude2"
x2=List_Equs_Mag_largerorequal6_5["longitude"]
y2=List_Equs_Mag_largerorequal6_5["latitude"]
Magtitude2=List_Equs_Mag_largerorequal6_5["mag"]
# Create a plotting object and set the projection "ccrs.Robinson"
plotting2=plt.figure(figsize=(10,8), dpi=200)
proj=ccrs.Robinson(central_longitude=180)
ax=plotting2.add_subplot(projection=proj)
ax.stock_img()# Add the map sticker
# Plot the scatter figure of the earthquakes with mag >= 6.5
plt.scatter(x2,y2,c=Magtitude2,cmap="Reds",edgecolors="black",vmin=6.5,vmax=8.2,
            transform=ccrs.PlateCarree())
plt.colorbar(shrink=0.5,label="Magtitude")
plt.title("Earthquakes with magnitude >= 6.5 at 2014",fontsize=12)
```

Out[8]: Text(0.5, 1.0, 'Earthquakes with magnitude >= 6.5 at 2014')



In [9]:
```
# 2.Explore a netCDF dataset
# Open a dataset
ds = xr.open_dataset("CESM2_200001-201412.nc", engine="netcdf4")
# Select the data in 2008
Temp_2008=ds.tas.sel(time="2008")
# Compute the average Temp in 2008
Average_temp_2008=np.mean(Temp_2008,axis=0)
Average_temp_2008
```

```
D:\Users\60918\anaconda3\lib\site-packages\xarray\conventions.py:512: SerializationWarning: variable 'tas' has multiple fill values {1e+20, 1e+20}, decoding all values to NaN.
  new_vars[k] = decode_cf_variable(
```

Out[9]:

xarray.DataArray 'tas' (**lat**: 192, **lon**: 288)

```
array([[225.68904, 225.68904, 225.68904, ..., 225.68904, 225.68909,
        225.68909],
       [225.95027, 225.917  , 225.7666 , ..., 225.9668 , 225.96483,
        225.95796],
       [226.3095 , 226.27367, 226.26031, ..., 226.52269, 226.47725,
        226.41267],
       ...,
       [261.74112, 261.76352, 261.78543, ..., 261.68265, 261.70135,
        261.72   ],
       [261.73532, 261.74377, 261.75272, ..., 261.7092 , 261.7178 ,
        261.72668],
       [261.7146 , 261.71503, 261.71536, ..., 261.71317, 261.7137 ,
        261.71414]], dtype=float32)
```

▼ Coordinates:

lat	(lat)	float64	-90.0 -89.06 -88.12 ... 89.06 90.0	
lon	(lon)	float64	0.0 1.25 2.5 ... 356.2 357.5 358.8	

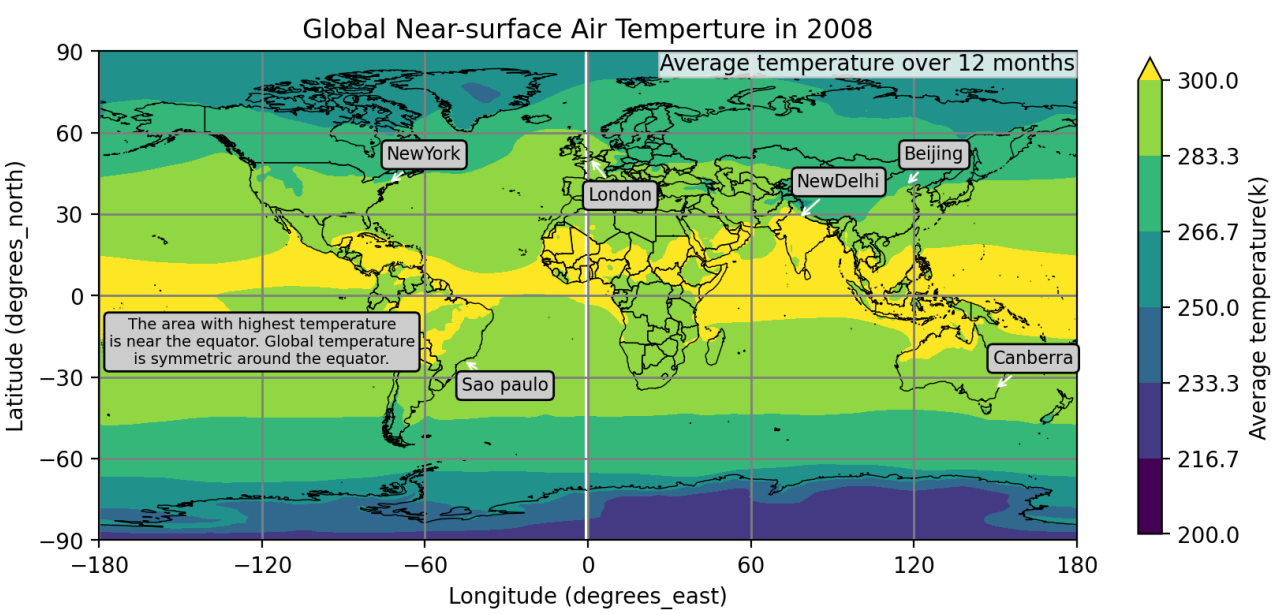
▶ Attributes: (0)

In [11]:
```
# 2.1 Make a global map of a certain variable
# Create a figure object
plt.figure(figsize=(10,8), dpi=200)
# Set a PlateCarree projection
proj = ccrs.PlateCarree(central_longitude=0)
# Create an axes with the projection set above
ax = plt.axes(projection=proj)
# Plot a contourf figure based on the DataArray "Average_temp_2008" and show its colorbar
Average_temp_2008.plot.contourf(ax=ax, transform=ccrs.PlateCarree(),vmin=200, vmax=300,
                                cbar_kwargs={"shrink": 0.5, "label":"Average temperature(k)"})
# Use the function add_feature() to add border lines over countries
ax.add_feature(cfeature.NaturalEarthFeature(category="cultural",
                                            name="admin_0_countries",
                                            scale="50m",
                                            facecolor="none",
                                            edgecolor="black",
                                            linewidth=0.5))
# Add gridlines
ax.gridlines(crs=ccrs.PlateCarree(),linewidth=1,color="gray")

# Show x/ylabel and x/yticks
plt.xticks(ticks=np.arange(-180,181,60),fontsize=10)
plt.yticks(ticks=np.arange(-90,91,30),fontsize=10)
plt.xlabel("Longitude (degrees_east)",fontsize=10)
plt.ylabel("Latitude (degrees_north)",fontsize=10)
# Show title
plt.title("Global Near-surface Air Temperture in 2008",fontsize=12)
# Add annotate
bbox = dict(boxstyle="round", fc="0.8")
arrowprops = dict(arrowstyle = "->",color="white")
plt.annotate("Beijing", xy=(116.5,39.9),xytext=(116.5,50),fontsize=8,bbox=bbox,
             arrowprops=arrowprops)
plt.annotate("NewYork", xy=(-74,40.7),xytext=(-74,50),fontsize=8,bbox=bbox,arrowprops=arrowprops)
plt.annotate("London", xy=(0.1,51.3),xytext=(0.1,35),fontsize=8,bbox=bbox,arrowprops=arrowprops)
plt.annotate("NewDelhi", xy=(77,28),xytext=(77,40),fontsize=8,bbox=bbox,arrowprops=arrowprops)
plt.annotate("Canberra", xy=(149,-35),xytext=(149,-25),fontsize=8,bbox=bbox,
             arrowprops=arrowprops)
plt.annotate("Sao paulo", xy=(-46.5,-23.5),xytext=(-46.5,-35),fontsize=8,bbox=bbox,
             arrowprops=arrowprops)
# Add textbox
plt.text(-120,-25,
         "The area with highest temperature\nis near the equator. Global temperature\nis symmetric
         fontsize=7,bbox=bbox,horizontalalignment="center")
# Add legend
plt.legend(title="Average temperature over 12 months",loc="best",fontsize=0.1)
```

```
No artists with labels found to put in legend.  Note that artists whose label start with an und
erscore are ignored when legend() is called with no argument.
```

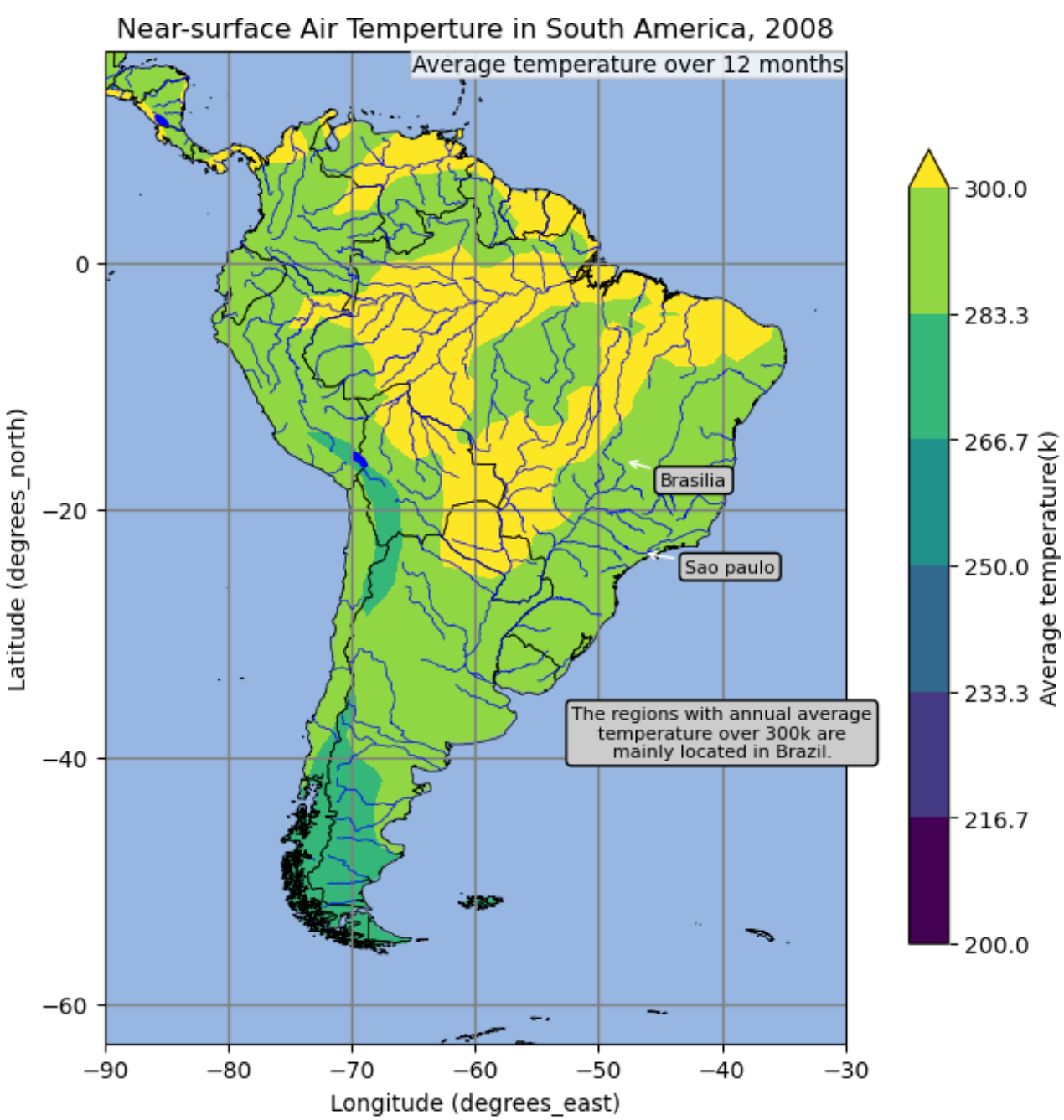
Out[11]:
```
<matplotlib.legend.Legend at 0x1d6b3f84bb0>
```


Global Near-surface Air Temperture in 2008
Average temperature over 12 months
NewYork
London
NewDelhi
Beijing
Canberra
Sao paulo
The area with highest temperature is near the equator. Global temperature is symmetric around the equator.
Latitude (degrees_north)
Longitude (degrees_east)
Average temperature(k)
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
300.0
283.3
266.7
250.0
233.3
216.7
200.0

In [12]:
```
# 2.2 Make a regional map of the same variable
# Create a figure object
plt.figure(figsize=(10,8),dpi=100)
# Set the coordinate of the plotting center
central_lon,central_lat = -60,-15
# Set a PlateCarree projection
proj2 = ccrs.PlateCarree()
# Create an axes
ax = plt.axes(projection=proj2)
# Frame the regional drawing area
extent = [central_lon-30, central_lon+30, central_lat-45, central_lat+30]
ax.set_extent(extent)
# Plot a contourf figure and show its colorbar
Average_temp_2008.plot.contourf(ax=ax, transform=ccrs.PlateCarree(),
                                vmin=200, vmax=300,
                                cbar_kwargs={"shrink": 0.8, "label":"Average temperature(k)"})
# Add border lines over countries
ax.add_feature(cfeature.NaturalEarthFeature(category="cultural",
                                            name="admin_0_countries",
                                            scale="50m",
                                            facecolor="none",
                                            edgecolor="black",
                                            linewidth=0.5))
# Add features of ocean, lakes and rivers
ax.add_feature(cfeature.OCEAN, zorder=1)
ax.add_feature(cfeature.LAKES, edgecolor="blue", facecolor="blue", zorder=2)
rivers = cfeature.NaturalEarthFeature("physical", "rivers_lake_centerlines", "10m")
ax.add_feature(rivers,facecolor="None", edgecolor="blue", linewidth=0.5, zorder=3)
# Add coastlines
ax.coastlines(resolution="10m", linewidth=0.5)
# Add gridlines
ax.gridlines(crs=ccrs.PlateCarree(),linewidth=1,color="gray")
# Show x/ylabel and x/yticks
plt.xticks(ticks=np.arange(-90,-29,10),fontsize=10)
plt.yticks(ticks=np.arange(-60,16,20),fontsize=10)
plt.xlabel("Longitude (degrees_east)",fontsize=10)
plt.ylabel("Latitude (degrees_north)",fontsize=10)
# Show title
plt.title("Near-surface Air Temperture in South America, 2008",fontsize=12)
# Add annotate
plt.annotate("Brasilia", xy=(-48,-16),xytext=(-45,-18),fontsize=8,bbox=bbox,
             arrowprops=arrowprops)
plt.annotate("Sao paulo", xy=(-46.5,-23.5),xytext=(-43,-25),fontsize=8,bbox=bbox,
             arrowprops=arrowprops)
# Add textbox
plt.text(-40,-40,
         "The regions with annual average\ntemperature over 300k are\nmainly located in Brazil.",
         fontsize=8,bbox=bbox,horizontalalignment="center")
# Add legend
plt.legend(title="Average temperature over 12 months",loc="best",fontsize=0.1)
```

```
No artists with labels found to put in legend.  Note that artists whose label start with an und
erscore are ignored when legend() is called with no argument.
```

Out[12]:
```
<matplotlib.legend.Legend at 0x1d6b42ad0d0>
```


Near-surface Air Temperture in South America, 2008
Average temperature over 12 months
Brasilia
Sao paulo
The regions with annual average temperature over 300k are mainly located in Brazil.
Latitude (degrees_north)
Longitude (degrees_east)
0
−20
−40
−60
−90
−80
−70
−60
−50
−40
−30
300.0
283.3
266.7
250.0
233.3
216.7
200.0
Average temperature(k)