1.读取usgs_earthquakes.csv并命名为ds，创建大小为12：9、分辨率为200的画布，使用Robinson投影，并使图片中心位于经度180度。使用ax.stock_img()绘制地球阴影浮雕图（参考网页https://www.cnblogs.com/youxiaogang/p/14262751.html），最后绘制色彩条、添加标题。

2.本题使用的文件为MERRA2_400.tavgU_2d_aer_Nx.202309.nc4（与上次作业相同），使用变量DMS Column Mass Density和SO2 Column Mass Density画出全球变化图，标注网格线、x、y坐标、标题、注释、文本、图例等。DMS Column Mass Density显示出海洋高、陆地低的趋势，其中最大值出现在北美洲西北部的太平洋地区，而SO2 Column Mass Density则是陆地高、海洋低，最大值出现在中国东部沿海地区。
之后用同一个变量SO2 Column Mass Density绘制了中国南部区域图，同样地标注网格线、x、y坐标、标题、注释、文本、图例等。

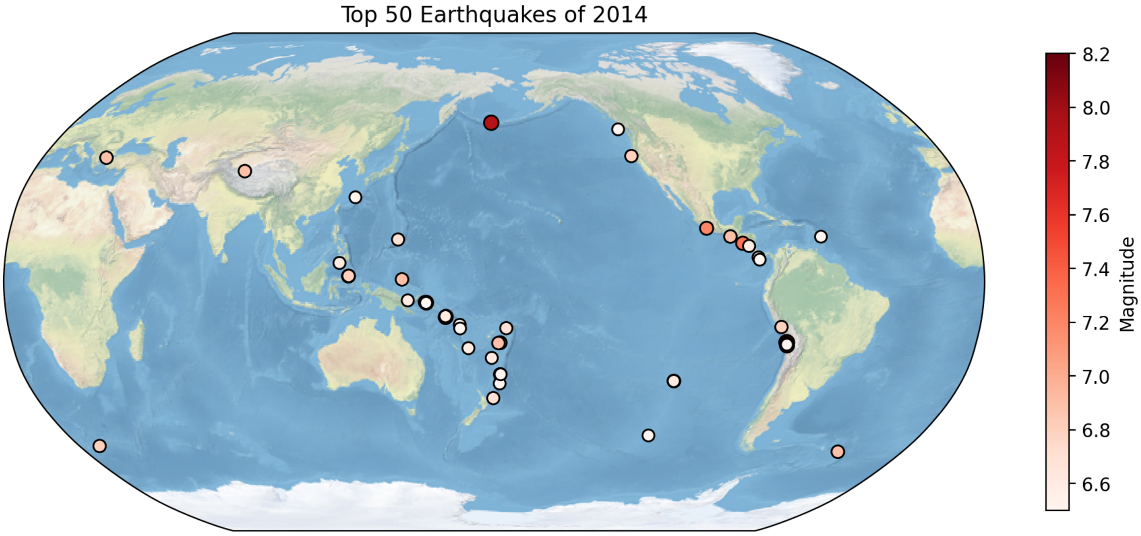
In [1]:
```
import netCDF4
import numpy as np
import xarray as xr
import pandas as pd
import matplotlib.pyplot as plt
import matplotlib.ticker as mticker
import cartopy.crs as ccrs
import cartopy.feature as cfeature
import cartopy.mpl.ticker as cticker
%matplotlib inline
```

In [2]:
```
# 1. Global Earthquakes
ds = pd.read_csv("usgs_earthquakes.csv")
ds.head()
```

Out[2]:

	time	latitude	longitude	depth	mag	magType	nst	gap	dmin	rms	ne
0	2014-01-31 23:53:37.000	60.252000	-152.7081	90.20	1.10	ml	NaN	NaN	NaN	0.2900	a
1	2014-01-31 23:48:35.452	37.070300	-115.1309	0.00	1.33	ml	4.0	171.43	0.34200	0.0247	n
2	2014-01-31 23:47:24.000	64.671700	-149.2528	7.10	1.30	ml	NaN	NaN	NaN	1.0000	a
3	2014-01-31 23:30:54.000	63.188700	-148.9575	96.50	0.80	ml	NaN	NaN	NaN	1.0700	a
4	2014-01-31 23:30:52.210	32.616833	-115.6925	10.59	1.34	ml	6.0	285.00	0.04321	0.2000	

In [6]:
```
plt.figure(figsize=(12, 9),dpi=200)
proj = ccrs.Robinson(central_longitude=180, globe=None)
ax = plt.axes(projection=proj)
ax.stock_img()
# got inspired in https://www.cnblogs.com/youxiaogang/p/14262751.html
ax.set_global()

top_50_earthquakes = ds.nlargest(50, 'mag')
lons = top_50_earthquakes['longitude'].values
lats = top_50_earthquakes['latitude'].values
magnitudes = top_50_earthquakes['mag'].values

sc = ax.scatter(lons, lats, s=magnitudes**2, c=magnitudes, edgecolor='black', cmap='

plt.colorbar(sc, label='Magnitude', shrink=0.5)
plt.title('Top 50 Earthquakes of 2014')
plt.show()
```



In [3]:
```
# 2.Explore a netCDF dataset
# 2.1
data = xr.open_dataset("MERRA2_400.tavgU_2d_aer_Nx.202309.nc4", engine="netcdf4")
data
```

Out[3]:

xarray.Dataset

▶ Dimensions: (**lon**: 576, **lat**: 361, **time**: 24)

▼ Coordinates:

lon	(lon)	float64	-180.0 -179.4 ... 178.8 179.4
lat	(lat)	float64	-90.0 -89.5 -89.0 ... 89.5 90.0
time	(time)	datetime64[ns]	2023-09-01T00:30:00 ... 2023-09-...

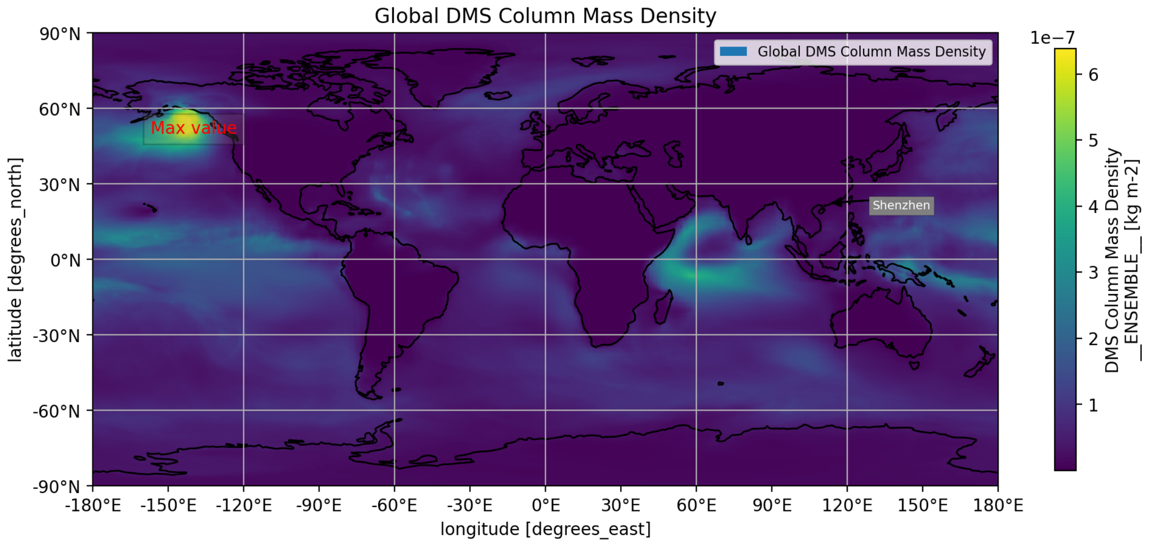
▶ Data variables: (50)

▶ Indexes: (3)

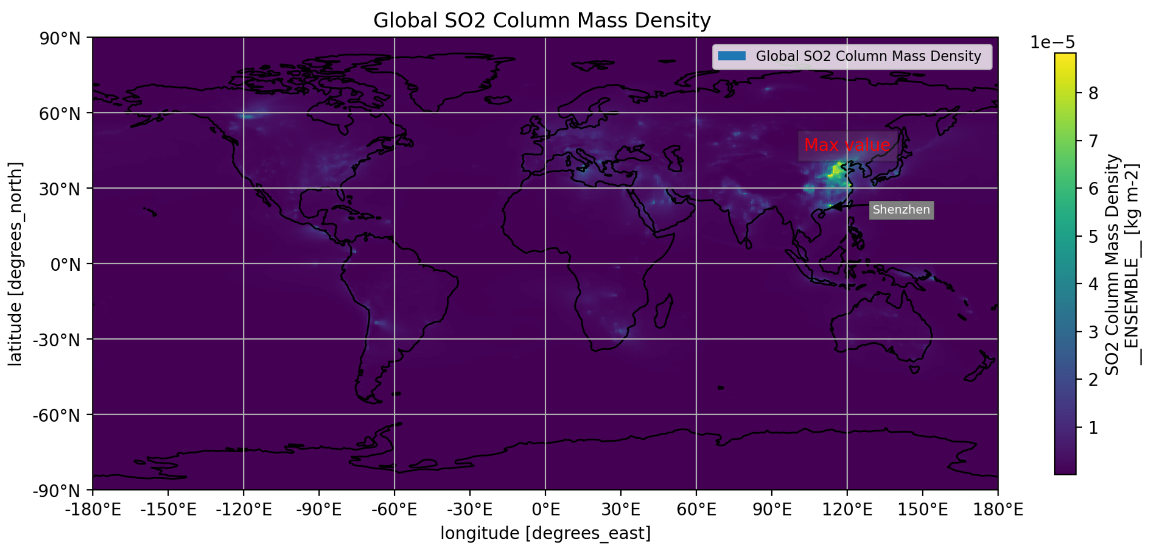
▶ Attributes: (30)

In [4]:

```python
plt.figure(figsize=(12, 9),dpi=200)
ax = plt.axes(projection=ccrs.PlateCarree())
ax.coastlines()

# Add projection
Value = data.DMSCMASS.groupby('time.month')
Value.mean(dim=['time']).plot(ax=ax, transform=ccrs.PlateCarree(),cbar_kwargs={'shrir

# Add gridlines, x label and ticks, y label and ticks
ax.gridlines()
ax.set_xticks(range(-180, 181, 30), crs=ccrs.PlateCarree())
ax.set_yticks(range(-90, 91, 30), crs=ccrs.PlateCarree())
ax.xaxis.set_major_formatter(plt.FixedFormatter(['{}° E'.format(i) for i in range(-18
ax.yaxis.set_major_formatter(plt.FixedFormatter(['{}° N'.format(i) for i in range(-9(

# Add title
plt.title('Global DMS Column Mass Density')

# Add annotate
ax.annotate('Shenzhen',xy=(114.06,22.54),xytext=(130,20),
            bbox=dict(boxstyle='square', fc='grey',linewidth=0.1),
            arrowprops=dict(facecolor='black', width=0.01,headwidth=5, headlength=5,
            fontsize=7, color='white', horizontalalignment='left',
            transform=ccrs.PlateCarree())
# Add text
plt.text(-140, 50, 'Max value', size = 10,
        horizontalalignment='center', color='red',
        bbox=dict(facecolor="grey",alpha=0.2),
        transform=ccrs.PlateCarree())

# Add legend
plt.legend(['Global DMS Column Mass Density'],loc='best',fontsize=8)

plt.show()
```

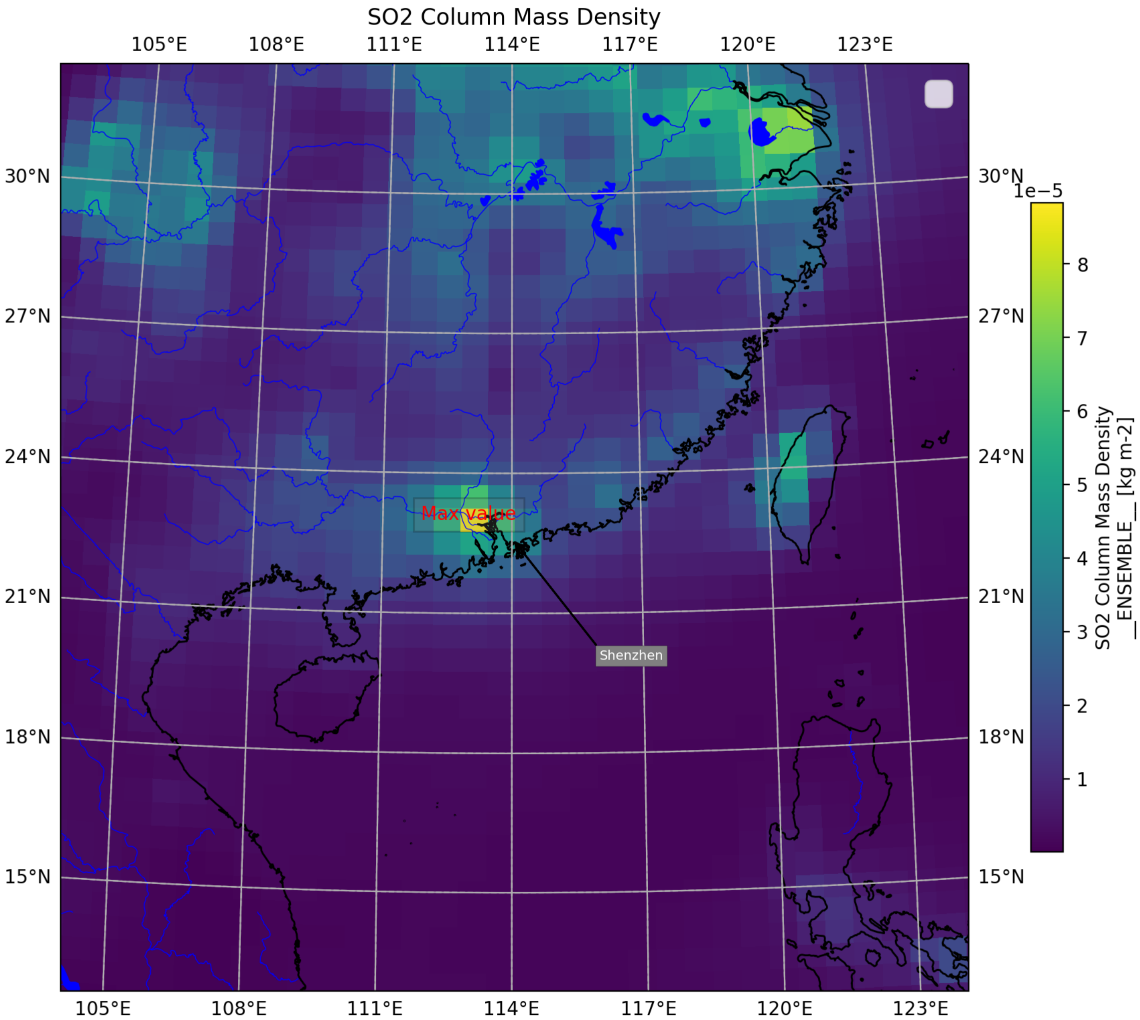


In [5]:
```
# use another variable

plt.figure(figsize=(12, 9),dpi=200)
ax = plt.axes(projection=ccrs.PlateCarree())
ax.coastlines()

# Add projection
Value = data.SO2CMASS.groupby('time.month')
Value.mean(dim=['time']).plot(ax=ax, transform=ccrs.PlateCarree(),cbar_kwargs={'shrir

# Add gridlines, x label and ticks, y label and ticks
ax.gridlines()
ax.set_xticks(range(-180, 181, 30), crs=ccrs.PlateCarree())
ax.set_yticks(range(-90, 91, 30), crs=ccrs.PlateCarree())
ax.xaxis.set_major_formatter(plt.FixedFormatter(['{}° E'.format(i) for i in range(-18
ax.yaxis.set_major_formatter(plt.FixedFormatter(['{}° N'.format(i) for i in range(-9(

# Add title
plt.title('Global SO2 Column Mass Density ')

# Add annotate
ax.annotate('Shenzhen',xy=(114.06,22.54),xytext=(130,20),
            bbox=dict(boxstyle='square', fc='grey',linewidth=0.1),
            arrowprops=dict(facecolor='black', width=0.01,headwidth=5, headlength=5,
            fontsize=7, color='white', horizontalalignment='left',
            transform=ccrs.PlateCarree())
# Add text
plt.text(120, 45, 'Max value', size = 10,
        horizontalalignment='center', color='red',
        bbox=dict(facecolor="grey",alpha=0.2),
        transform=ccrs.PlateCarree())

# Add legend
plt.legend(['Global SO2 Column Mass Density '],loc='best',fontsize=8)

plt.show()
```



In [6]:

```
# 2.2
rivers_10m = cfeature.NaturalEarthFeature('physical', 'rivers_lake_centerlines', '10m

# Create and define the size of a figure object
plt.figure(figsize=(12, 9), dpi=200)

# Set Orthographic projection style
central_lon, central_lat = 114.06, 22.54 # Shenzhen
proj = ccrs.Orthographic(central_lon, central_lat)

# Create an axes with Orthographic projection style
ax = plt.axes(projection=proj)

# Set a region and plot
extent = [central_lon-10, central_lon+10, central_lat-10, central_lat+10]
ax.set_extent(extent)

# Add gridlines, x label and ticks, y label and ticks
gl = ax.gridlines(draw_labels=True, linestyle='--')
gl.xlocator = cticker.LongitudeLocator()
gl.ylocator = cticker.LatitudeLocator()
gl.xformatter = cticker.LongitudeFormatter()
gl.yformatter = cticker.LatitudeFormatter()

# Add features to axes using cartopy.feature (cfeature)
ax.add_feature(cfeature.LAKES, edgecolor='blue', facecolor='blue', zorder=2)
ax.add_feature(rivers_10m, facecolor='None', edgecolor='blue', linewidth=0.5)

# Add features to axes using coastlines method
ax.coastlines(resolution='10m')
ax.gridlines()
Value2 = data.SO2CMASS.groupby('time.month').mean(dim=['time'])
Value2.plot(ax=ax, transform=ccrs.PlateCarree(),cbar_kwargs={'shrink': 0.7})

# Add title
plt.title('SO2 Column Mass Density')

# Add annotate
ax.annotate('Shenzhen',xy=(114.06,22.54),xytext=(116,20),
             bbox=dict(boxstyle='square', fc='grey',linewidth=0.1),
             arrowprops=dict(facecolor='black', width=0.01,headwidth=5, headlength=5,
             fontsize=7, color='white', horizontalalignment='left',
             transform=ccrs.PlateCarree())
# Add text
plt.text(113, 23, 'Max value', size = 10,
        horizontalalignment='center', color='red',
        bbox=dict(facecolor="grey",alpha=0.2),
        transform=ccrs.PlateCarree())

# Add legend
plt.legend(['SO2 Column Mass Density'],loc='best',fontsize=18)

plt.show()
```



SO2 Column Mass Density
105°E
108°E
111°E
114°E
117°E
120°E
123°E
30°N
27°N
24°N
21°N
18°N
15°N
Max value
Shenzhen
1e−5
8
7
6
5
4
3
2
1
SO2 Column Mass Density
__ENSEMBLE__ [kg m-2]