1. Global methane levels from 2002

In [1]:
```
import netCDF4
import xarray as xr
```

In [2]:
```
ds = xr.open_dataset("200301_202006-C3S-L3_GHG-PRODUCTS-OBS4MIPS-MERGED-v4.3.nc", en
```

In [3]:
```
ds
```

Out[3]: xarray.Dataset

► Dimensions: (**time**: 210, bnds: 2, **lat**: 36, **lon**: 72, pressure: 10)

▼ Coordinates:

time	(time)	datetime64[ns]	2003-01-16T12:0...
lat	(lat)	float64	-87.5 -82.5 -77.5 ....
lon	(lon)	float64	-177.5 -172.5 ... 1...

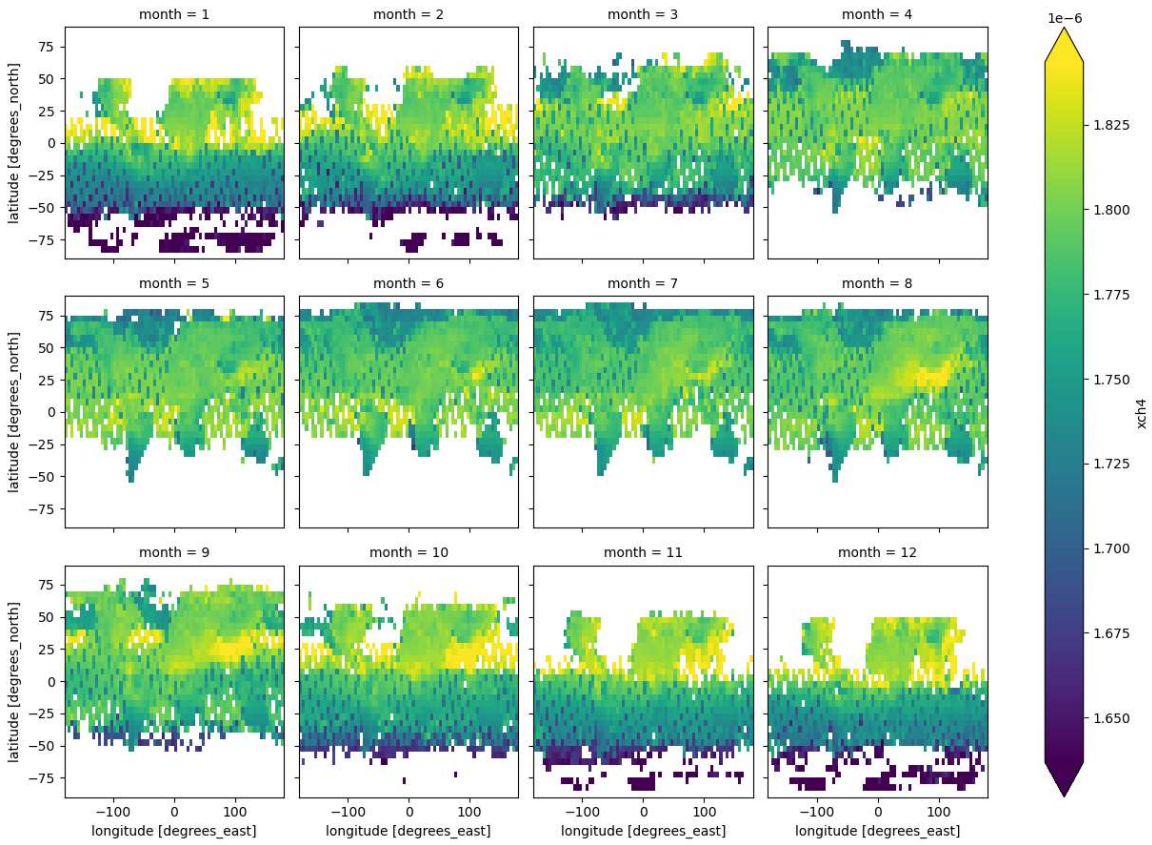
▼ Data variables:

time_bnds	(time, bnds)	datetime64[ns]	...
lat_bnds	(lat, bnds)	float64	...
lon_bnds	(lon, bnds)	float64	...
pre	(pressure)	float64	...
pre_bnds	(pressure, bnds)	float64	...
land_fraction	(lat, lon)	float64	...
xch4	(time, lat, lon)	float32	...
xch4_nobs	(time, lat, lon)	float64	...
xch4_stderr	(time, lat, lon)	float32	...
xch4_stddev	(time, lat, lon)	float32	...
column_averagin...	(time, pressure, lat, lon)	float32	...
vmr_profile_ch4_...	(time, pressure, lat, lon)	float32	...

► Attributes: (28)

In [4]:
```
# 1.1
# 参考了申涵同学的代码
ds.xch4.groupby('time.month').mean().plot(col="month",
          col_wrap=4,
          robust=True)
```

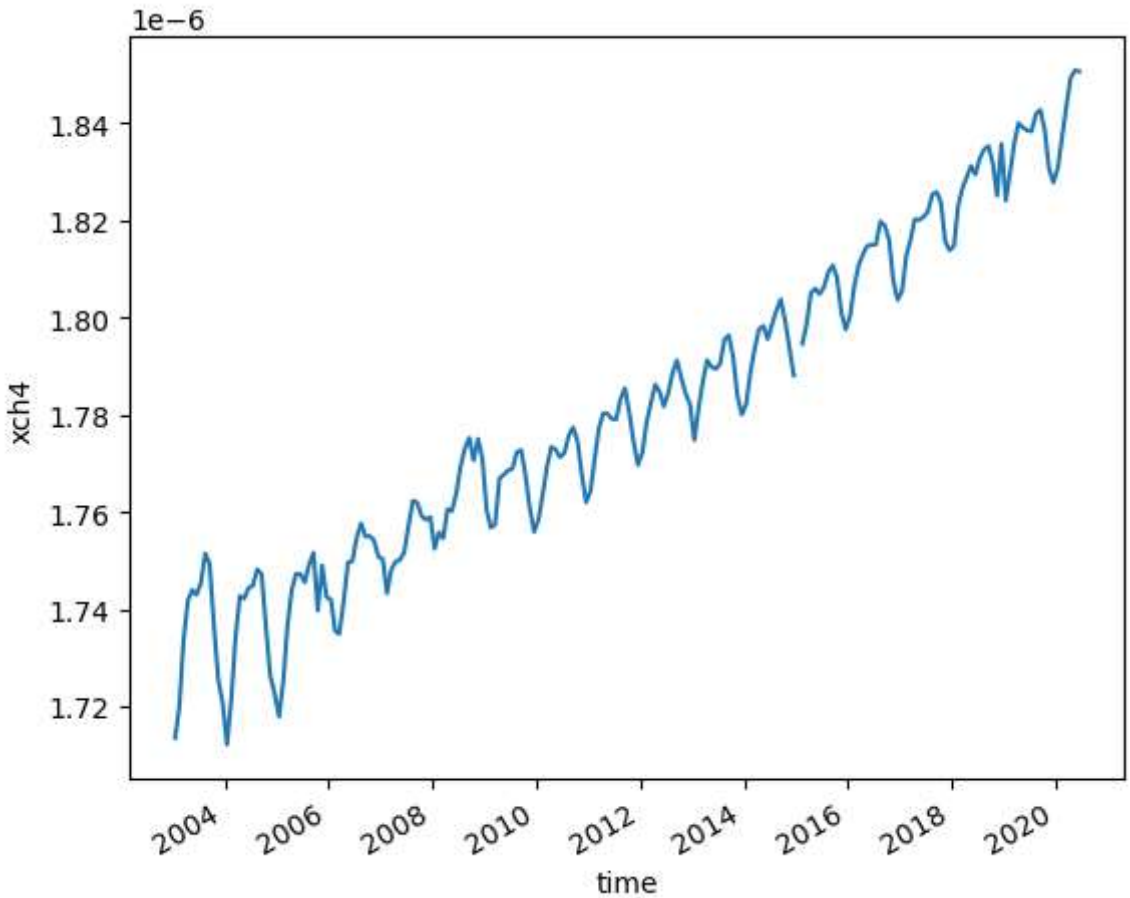
Out[4]:
```
<xarray.plot.facetgrid.FacetGrid at 0x1633be49fa0>
```



In [5]:
```
import numpy as np
```

In [6]:
```
# 1.2
weights = np.cos(np.deg2rad(ds.lat))
ds.xch4.weighted(weights).mean(dim=('lon', 'lat')).sel(time=slice("2003-01","2020-0
```

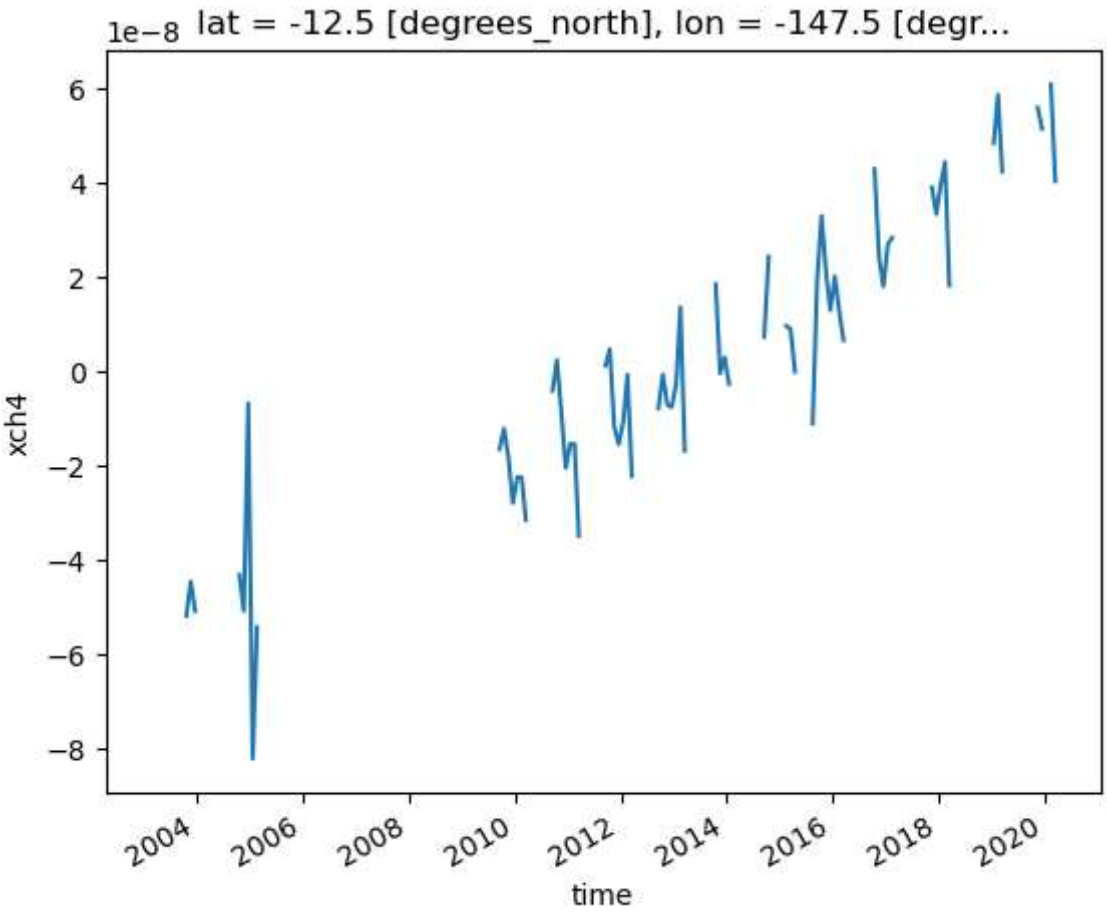
Out[6]:
```
[<matplotlib.lines.Line2D at 0x1633d7c5520>]
```



In [7]:
```
#1.3
sst=ds.xch4.sel(time=slice("2003-01", "2020-06")).groupby('time.month')
anom=sst-sst.mean(dim='time')
anom.sel(lat=-15.0,lon=-150.0,method='nearest').plot()
```

```
D:\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning: Passing me
thod to Float64Index.get_loc is deprecated and will raise in a future version. Use i
ndex.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
D:\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning: Passing me
thod to Float64Index.get_loc is deprecated and will raise in a future version. Use i
ndex.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
```

Out[7]:
```
[<matplotlib.lines.Line2D at 0x1633cb2bee0>]
```



In [8]:
```
anom
```

Out[8]: xarray.DataArray 'xch4' (**time**: 210, **lat**: 36, **lon**: 72)

```
array([[[nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        ...,
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan]],

       [[nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        ...,
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan]],

       [[nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        ...,
...
        ...,
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan]],

       [[nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        ...,
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan]],

       [[nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        ...,
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan],
        [nan, nan, nan, ..., nan, nan, nan]]], dtype=float32)
```

▼ Coordinates:

time	(time)	datetime64[ns]	2003-01-16T12:00:00 ... 2020-06-16
lat	(lat)	float64	-87.5 -82.5 -77.5 ... 82.5 87.5
lon	(lon)	float64	-177.5 -172.5 ... 172.5 177.5
month	(time)	int64	1 2 3 4 5 6 7 8 ... 12 1 2 3 4 5 6

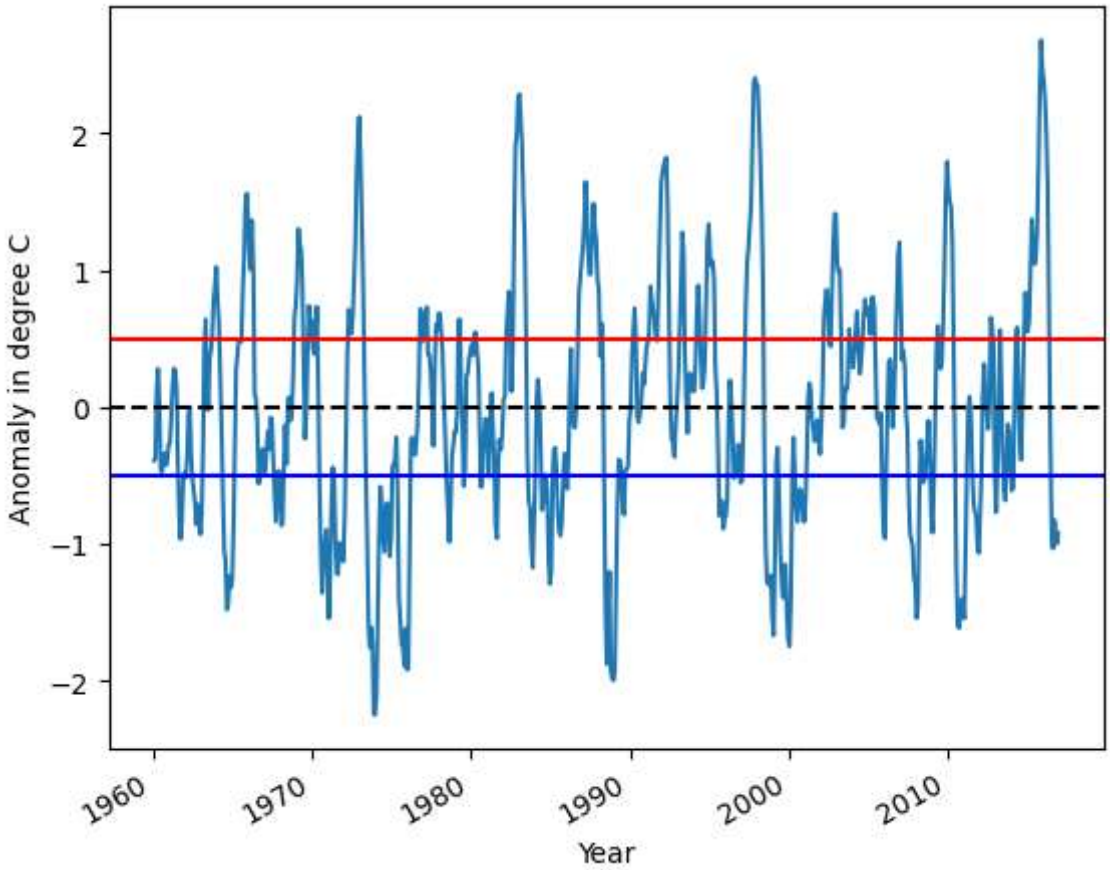
► Attributes: (0)

2. Niño 3.4 index

In [9]:
```
# 2.1
# 参考了申涵同学的代码
nino = xr.open_dataset("NOAA_NCDC_ERSST_v3b_SST.nc", engine="netcdf4")
weights = np.cos(np.deg2rad(nino.lat))
nino_sst=nino.sst.sel(lat=slice(-5.0,5.0),lon=slice(190,240)).weighted(weights).mea
nino3_4=nino_sst.rolling(time=3).mean().isel(time=slice(2,684))
climatology=nino3_4.groupby('time.month').mean()
anomaly=nino_sst.groupby('time.month')-climatology
```

In [10]:
```
import matplotlib.pyplot as plt
```

In [11]:
```
# 2.2
# 参考了申涵同学的代码
anomaly.plot()
plt.axhline(y=0,color="black",ls="--",lw=1.5)
plt.axhline(y=0.5,color="red",lw=1.5)
plt.axhline(y=-0.5,color="blue",lw=1.5)
plt.xlabel('Year')
plt.ylabel('Anomaly in degree C')
plt.show()
```



3. Explore a netCDF dataset

In [12]:
```
BC=xr.open_dataset("BC-em-anthro_input4MIPs_emissions_CMIP_CEDS-2017-05-18_gn_200001
BC_emiss=BC.BC_em_anthro.sel(sector=2)
BC_emiss
```

Out[12]: xarray.DataArray 'BC_em_anthro' (**time**: 180, **lat**: 360, **lon**: 720)

[46656000 values with dtype=float32]

▼Coordinates:

lon	(lon)	float64	-179.8 -179.2 ... 179.2 179.8
lat	(lat)	float64	-89.75 -89.25 ... 89.25 89.75
sector	()	int32	2
time	(time)	object	2000-01-16 00:00:00 ... 2014-12-...

▼Attributes:

units :	kg m-2 s-1
long_name :	BC Anthropogenic Emissions
cell_methods :	time: mean

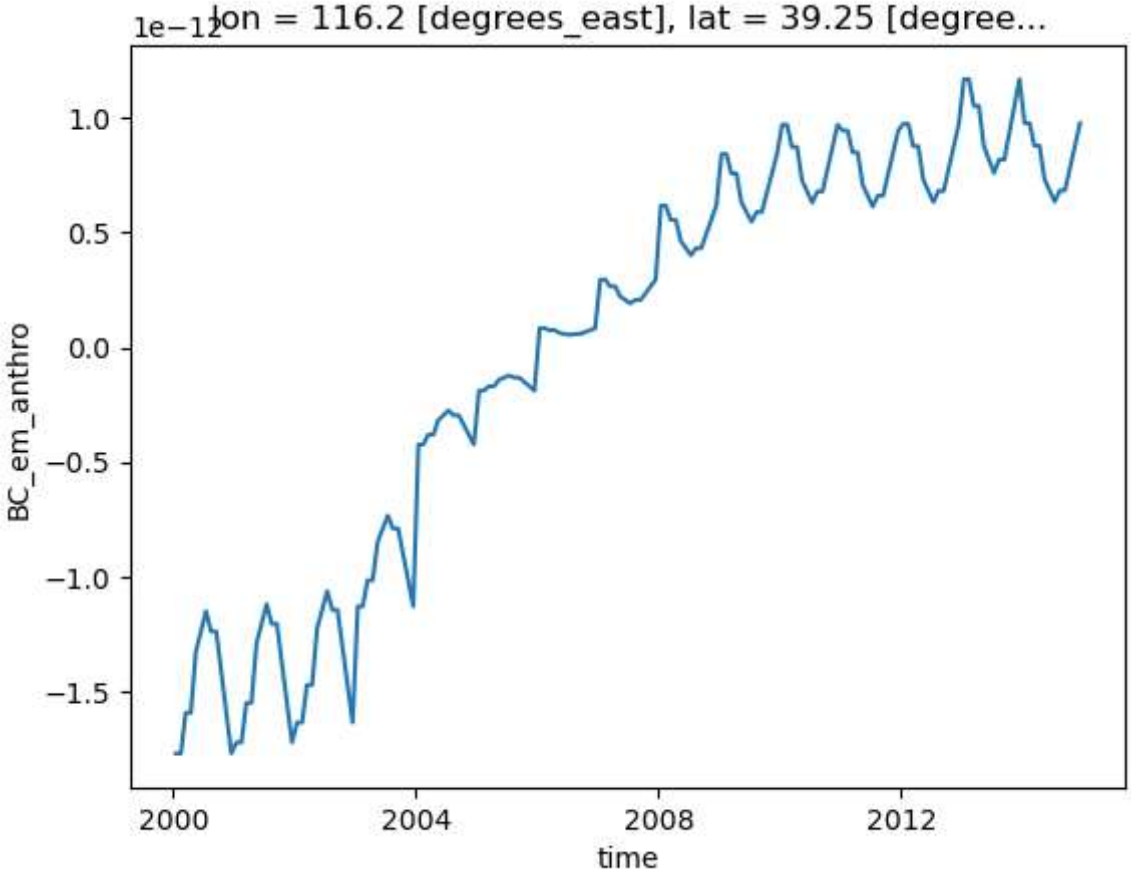
In [13]:

```
# 3.1
# 北京附近的deseasonalized data
group_data=BC_emiss.groupby('time.month')
BC_deseason=group_data-group_data.mean(dim='time'))
BC_deseason.sel(lon=116,lat=39,method='nearest').plot()
```

```
D:\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning: Passing me
thod to Float64Index.get_loc is deprecated and will raise in a future version. Use i
ndex.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
D:\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning: Passing me
thod to Float64Index.get_loc is deprecated and will raise in a future version. Use i
ndex.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
```

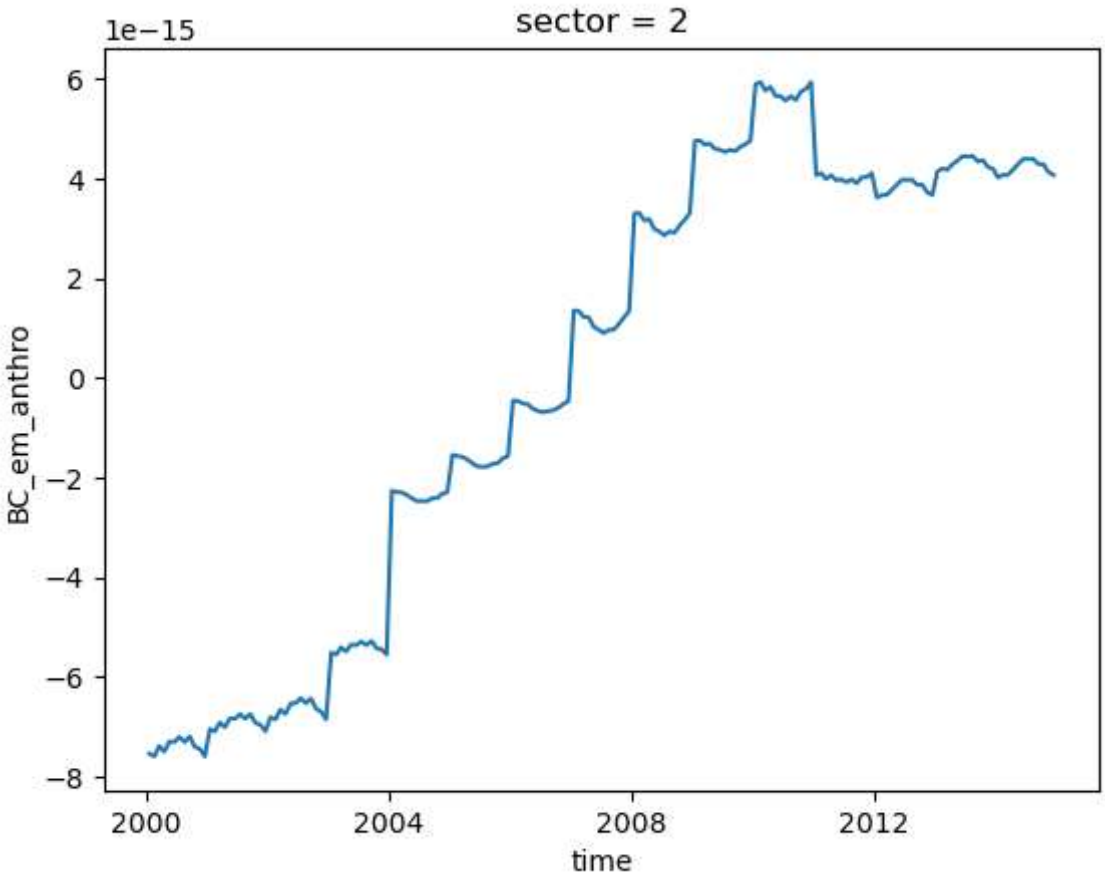
Out[13]:

```
[<matplotlib.lines.Line2D at 0x1633cc16d60>]
```



In [14]:
```
# 全球平均的deseasonalized data
BC_deseason.mean(dim=('lat','lon')).plot()
```

Out[14]:
```
[<matplotlib.lines.Line2D at 0x1633d4741c0>]
```



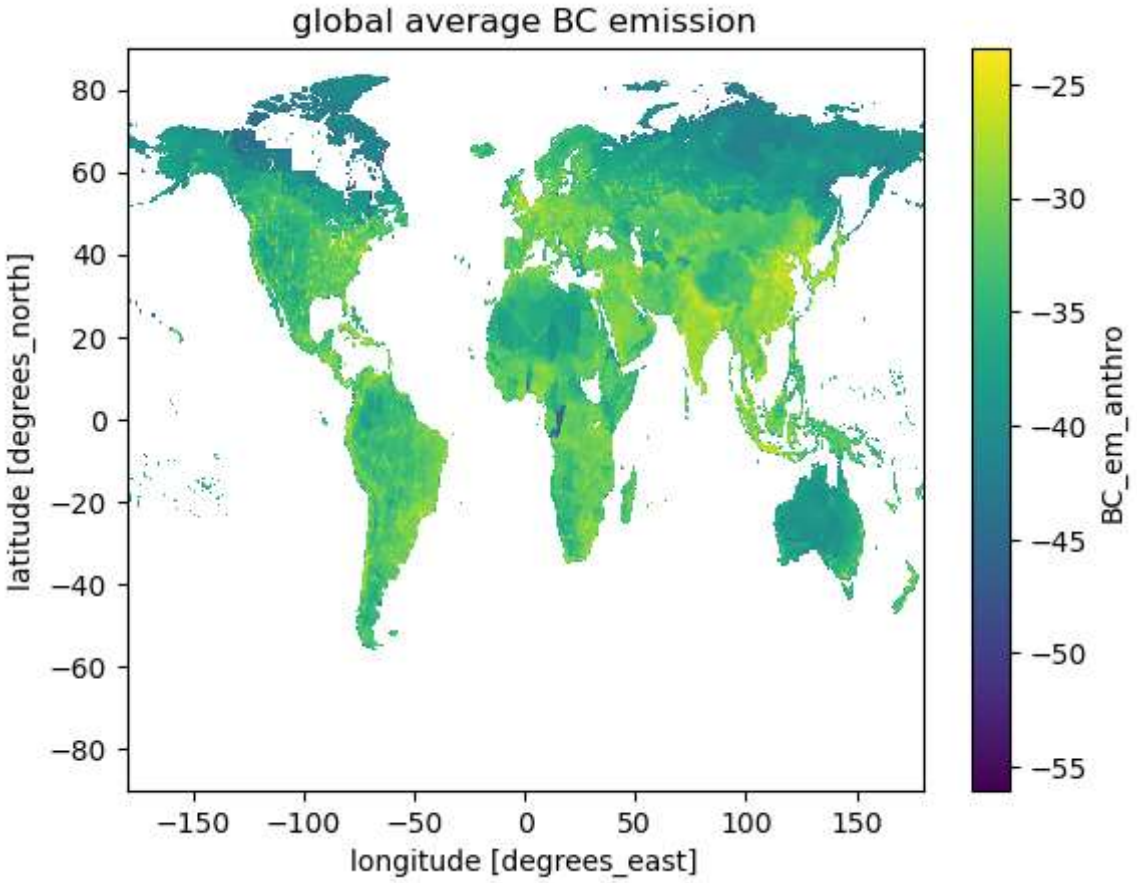
In [22]:
```
# 3.2
```

```
# 整个时间段的黑炭的全球排放，因为数值太小，所以取了对数值
np.log(BC_emiss.mean(dim='time')).plot()
plt.title('global average BC emission')
```

```
D:\anaconda3\lib\site-packages\xarray\core\computation.py:733: RuntimeWarning: divid
e by zero encountered in log
  result_data = func(*input_data)
```

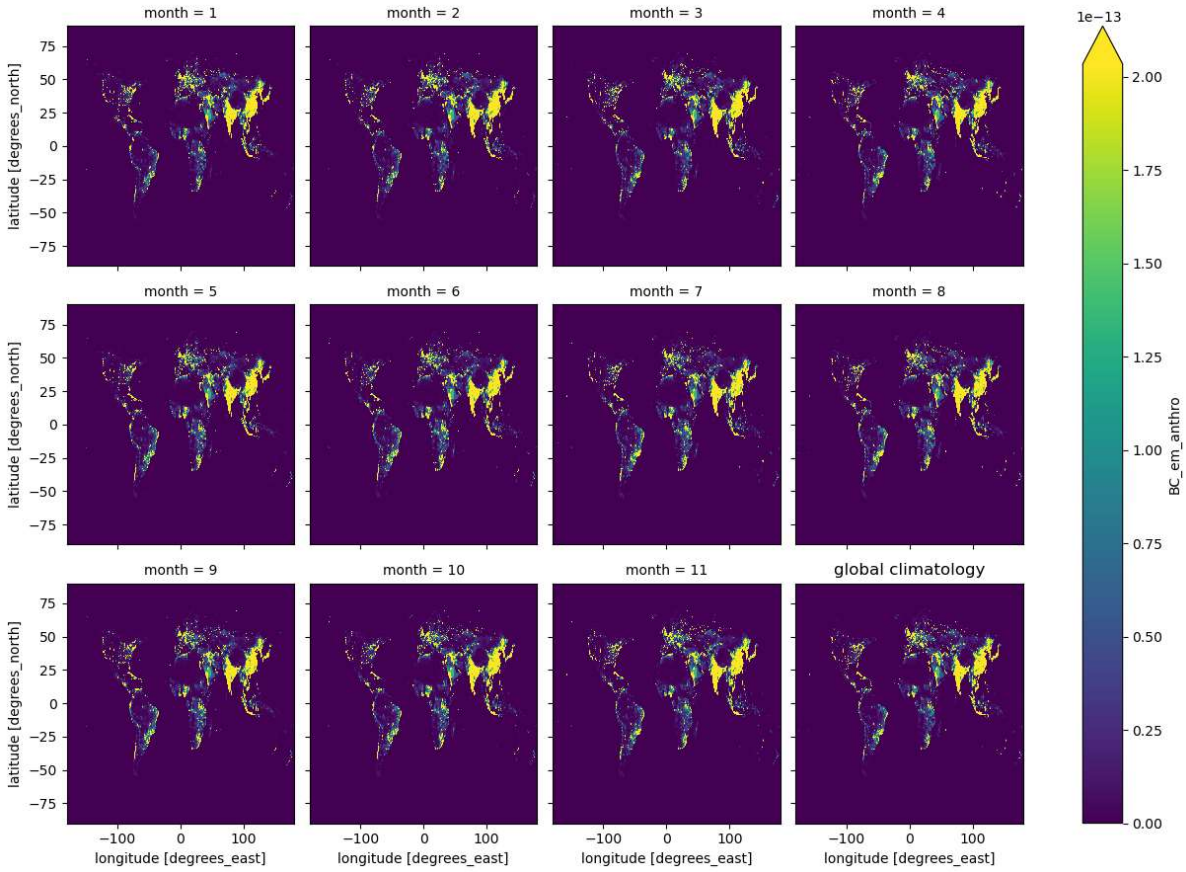
Out[22]:

```
Text(0.5, 1.0, 'global average BC emission')
```



In [21]:

```
# 3.2
# 全球每个月的climatology
BC_emiss.groupby('time.month').mean().plot(col="month",
          col_wrap=4,
          robust=True)
plt.title('global climatology')
plt.show()
```

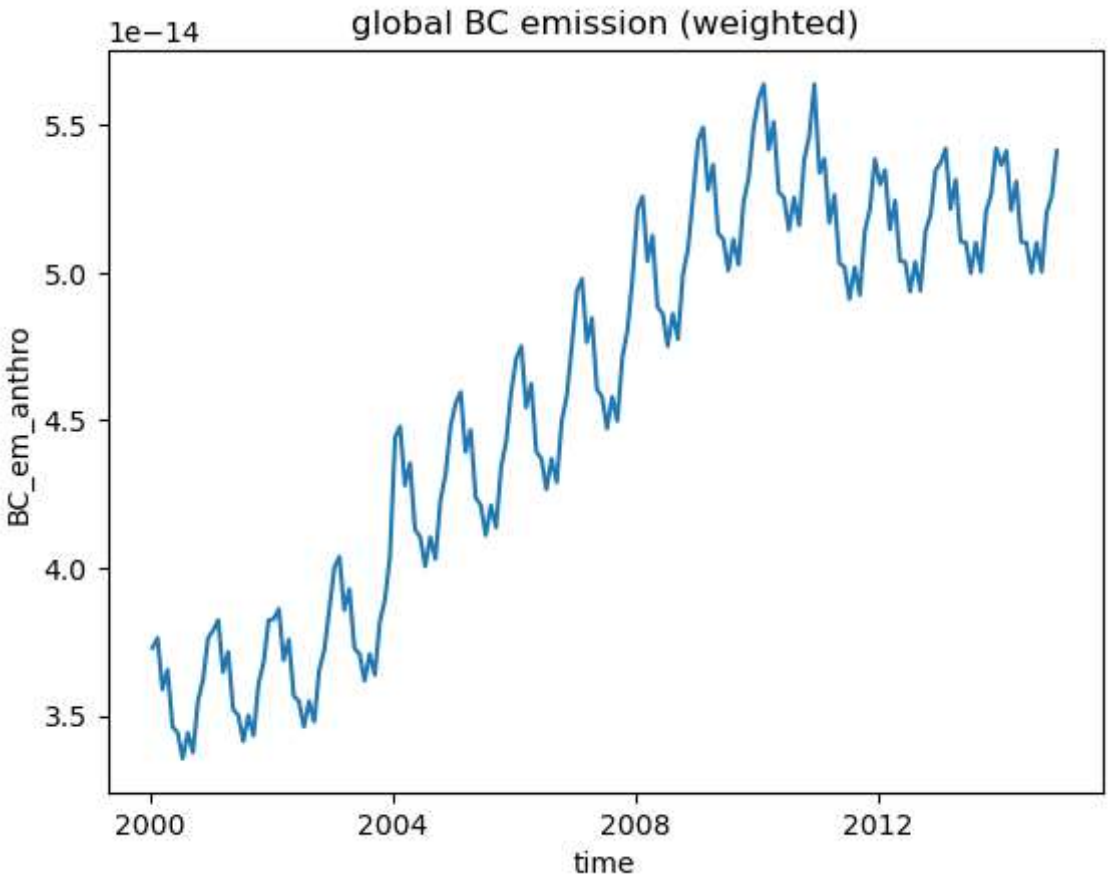


In [19]:

```
# 3.2
# 全球的黑炭平均排放时间序列
weights = np.cos(np.deg2rad(BC_emiss.lat))
BC_weighted = BC_emiss.weighted(weights)
BC_weighted.mean(dim=('lon','lat')).plot()
plt.title('global BC emission (weighted)')
```

Out[19]:

```
Text(0.5, 1.0, 'global BC emission (weighted)')
```



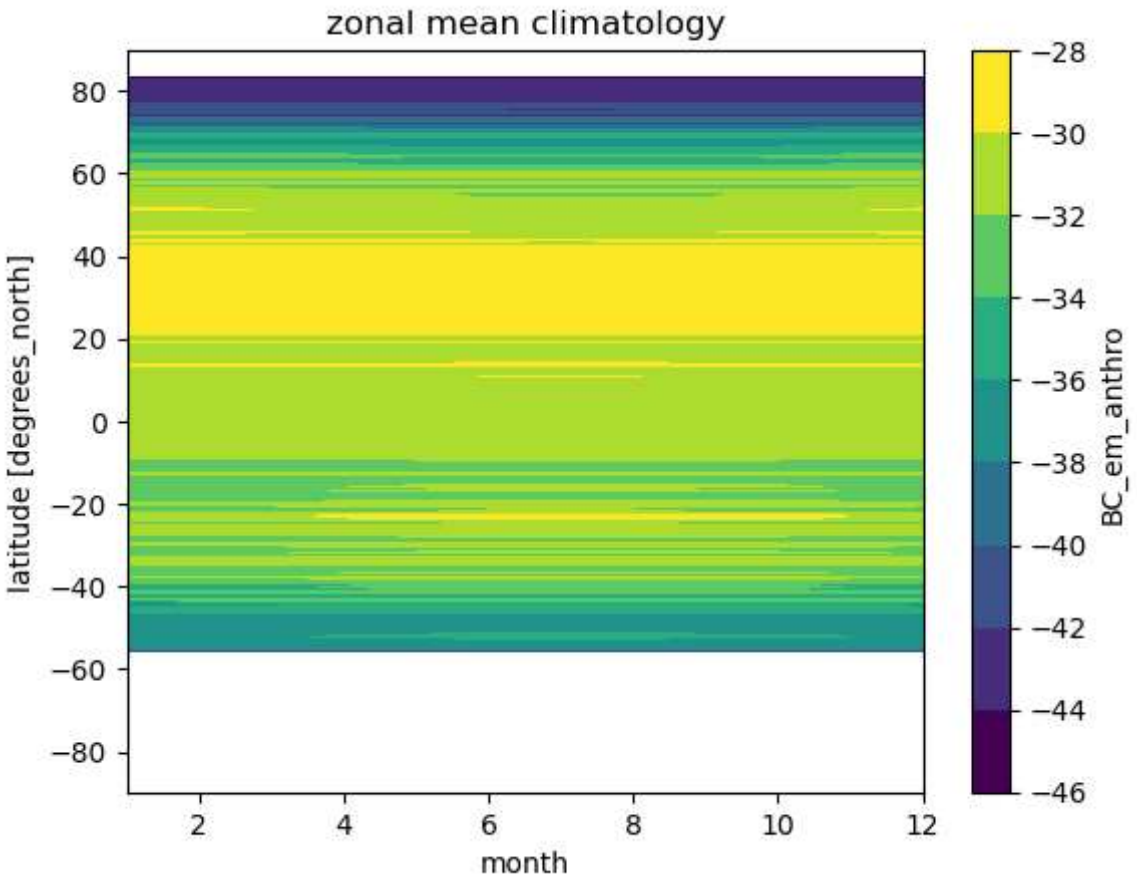
In [32]:

```
# 3.2
# zonal mean climatology
BC_clim=group_data.mean()
np.log(BC_clim.mean(dim='lon')).plot.contourf(x='month',
                                              levels=12)
plt.title('zonal mean climatology')
```

```
D:\anaconda3\lib\site-packages\xarray\core\computation.py:733: RuntimeWarning: divid
e by zero encountered in log
  result_data = func(*input_data)
```

Out[32]:

```
Text(0.5, 1.0, 'zonal mean climatology')
```



In [36]:
```
# 3.2
import hvplot.xarray
BC_emiss.hvplot(groupby="time", clim=(BC_emiss.min(), BC_emiss.max()), cmap='turbo')
```

Out[36]:

In [ ]: