In [3]:
```
#1.1
# Import modules
import numpy as np
import pandas as pd
import xarray as xr
from matplotlib import pyplot as plt
%matplotlib inline
# Open a netCDF4 file
ds = xr.open_dataset("200301_202006-C3S-L3_GHG-PRODUCTS-OBS4MIPS-MERGED-v4.3.nc", en
# Show dataset
ds
```

Out[3]: xarray.Dataset

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

▼ Coordinates:

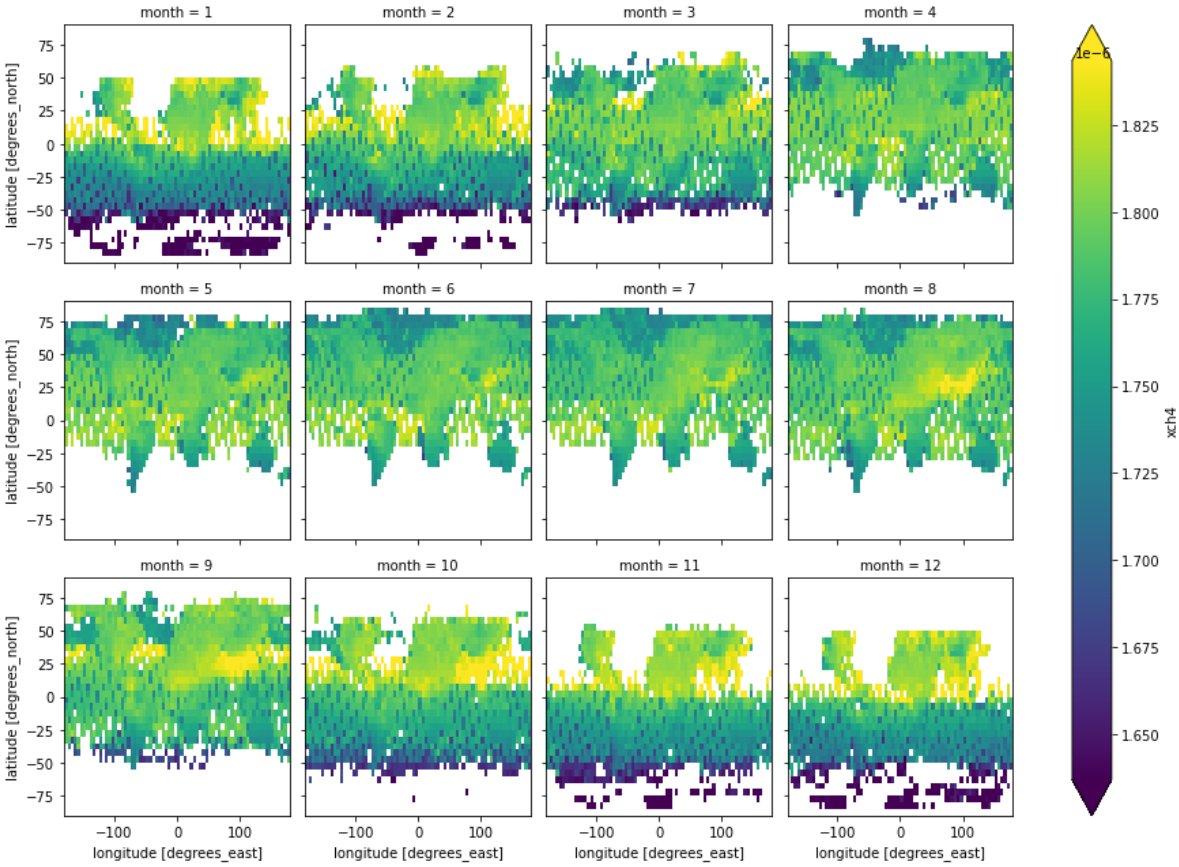
time	(time)	datetime64[ns]	2003-01-16T12:0...
lat	(lat)	float64	-87.5 -82.5 -77.5 ....
lon	(lon)	float64	-177.5 -172.5 ... 1...

▼ Data variables:

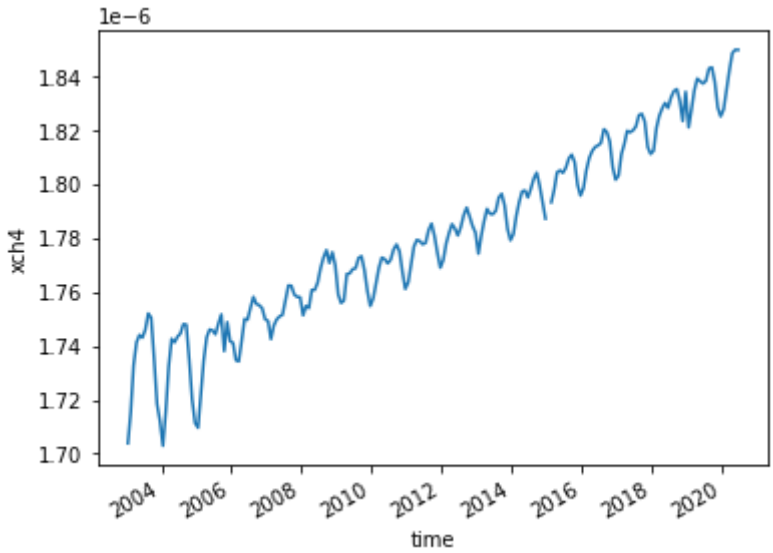
time_bnds	(time, bnds)	datetime64[ns]	...
lat_bnds	(lat, bnds)	float64	...
lon_bnds	(lon, bnds)	float64	...
pre	(pressure)	float64	...
pre_bnds	(pressure, bnds)	float64	...
land_fraction	(lat, lon)	float64	...
xch4	(time, lat, lon)	float32	...
xch4_nobs	(time, lat, lon)	float64	...
xch4_stderr	(time, 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]:
```
#Get the CH4 data
CH4 = ds.xch4
# Group data by month to get climatology
group_data = CH4.groupby('time.month').mean()
#Plot the data
#I didn't understand the meaning of this step,
#so I asked ShenHan how to draw and he taught me the easy way to plot
#Then I found we learn it in Section 7,https://zhu-group.github.io/ese5023/Section_0
group_data.plot(col="month",col_wrap=4,robust=True)
plt.show()
```



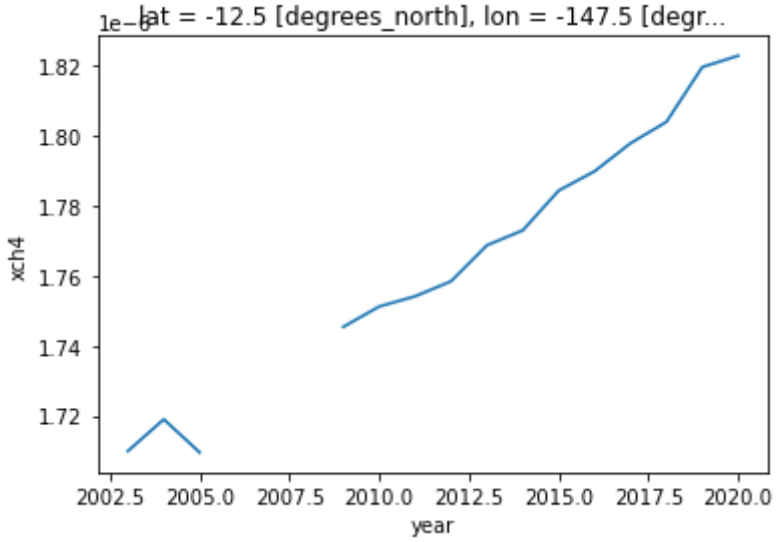
In [5]:
```
#1.2
#get the data from 2003-2020
CH4_Global=CH4.mean(dim=('lat', 'lon')).sel(time=slice("2003-01", "2020-06"))
#plot it
CH4_Global.plot()
plt.show()

#Describe the plot

#Methane concentration fluctuates dynamically over time,
#but the overall trend is upward and the concentration is getting higher and higher
```



In [7]:
```
#1.3
#I asked Shishao about the meaning of the question,and he told me that the teacher u
point_CH4 = CH4.sel(time=slice("2003-01", "2020-06")).sel(lon=-150, lat =-15, metho
point_CH4.groupby('time.year').mean().plot()
```

```
plt.show()
#There are some breakpoint in the figure, maybe some missing value in dataset. And t
```

```
C:\Users\dell\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning:
Passing method to Float64Index.get_loc is deprecated and will raise in a future vers
ion. Use index.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
C:\Users\dell\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning:
Passing method to Float64Index.get_loc is deprecated and will raise in a future vers
ion. Use index.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
```



In [12]:
```
#2.1
# Open a netCDF4 file
data = xr.open_dataset("NOAA_NCDC_ERSST_v3b_SST.nc", engine="netcdf4")
# Show dataset
data
```

Out[12]: xarray.Dataset

► Dimensions: (**lat**: 89, **lon**: 180, **time**: 684)

▼ Coordinates:

lat	(lat)	float32	-88.0 -86.0 -84.0 ... 86.0 88.0	
lon	(lon)	float32	0.0 2.0 4.0 ... 354.0 356.0 3...	
time	(time)	datetime64[ns]	1960-01-15 ... 2016-12-15	

▼ Data variables:

sst	(time, lat, lon)	float32	...

▼ Attributes:

Conventions :	IRIDL
source :	https://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCDC/.ERSST/.version3b/.sst/
history :	extracted and cleaned by Ryan Abernathey for Research Computing in Earth Science

In [18]:
```
#get the data of SST
SST=data.sst.sel(lon=slice(-170+360,-120+360), lat=slice(-5, 5)).mean(dim=('lon','
#Calculate 3-month running mean
```

```
SST_rol=SST.rolling(time=3,center=True).mean()
# Calculate the anomlies
group_data = SST_rol.groupby('time.month')
SST_anom = group_data - group_data.mean(dim='time')
SST_anom
```

Out[18]: xarray.DataArray 'sst' (**time**: 684)


```
array([           nan, -3.52058411e-01, -3.07853699e-01, -2.10880280e
-01,
       -2.40726471e-01, -2.25728989e-01, -1.61642075e-01, -9.31510925e
-02,
       -1.72449112e-01, -2.97628403e-01, -3.16455841e-01, -2.66429901e
-01,
       -1.87906265e-01, -1.88680649e-01, -1.86565399e-01, -1.24500275e
-01,
        3.54194641e-02,  7.36808777e-02, -8.31851959e-02, -4.22416687e
-01,
       -6.63099289e-01, -6.88962936e-01, -5.68630219e-01, -4.65534210e
-01,
       -4.49098587e-01, -4.45554733e-01, -4.52938080e-01, -4.89137650e
-01,
       -4.86087799e-01, -4.22689438e-01, -3.40246201e-01, -4.22336578e
-01,
       -5.52133560e-01, -7.18961716e-01, -7.83073425e-01, -8.07601929e
-01,
       -6.51060104e-01, -3.29572678e-01, -3.79734039e-02,  5.08155823e
-02,
        5.32474518e-02,  2.24658966e-01,  5.19973755e-01,  7.31996536e
-01,
        7.80866623e-01,  8.18628311e-01,  9.42928314e-01,  9.35924530e
-01,
        8.10529709e-01,  4.14836884e-01, -8.04691315e-02, -5.42263031e
-01,
       -8.14065933e-01, -8.64004135e-01, -9.41457748e-01, -1.04431534e
+00,
       -1.17953682e+00, -1.24540520e+00, -1.22883606e+00, -1.10599327e
+00,
       -7.95251846e-01, -4.21403885e-01, -1.85947418e-01,  2.64034271e
-02,
        2.60988235e-01,  5.57201385e-01,  8.80437851e-01,  1.10925293e
+00,
        1.34669876e+00,  1.46174431e+00,  1.51627159e+00,  1.38736725e
+00,
        1.16686630e+00,  1.02093124e+00,  8.11641693e-01,  4.65002060e
-01,
        1.96592331e-01,  8.32252502e-02,  6.71024323e-02, -7.60116577e
-02,
...
       -1.36054802e+00, -1.42088509e+00, -1.39449310e+00, -1.41278648e
+00,
       -1.30362320e+00, -1.12896538e+00, -8.00067902e-01, -4.95422363e
-01,
       -1.95692062e-01, -7.09781647e-02, -1.23596191e-01, -3.31645966e
-01,
       -5.43027878e-01, -7.74984360e-01, -9.15246964e-01, -9.12910461e
-01,
       -7.66300201e-01, -5.23027420e-01, -3.39998245e-01, -1.79428101e
-01,
       -5.36174774e-02,  5.45444489e-02,  2.09587097e-01,  4.63119507e
-01,
        6.14858627e-01,  6.53985977e-01,  2.47413635e-01, -2.06434250e
```

```
-01,
       -5.52478790e-01, -5.37473679e-01, -2.73836136e-01, -1.03874207e
-01,
       -5.97114563e-02, -1.80364609e-01, -2.66248703e-01, -2.59502411e
-01,
       -1.97811127e-01, -1.51571274e-01, -2.10556030e-01, -3.75471115e
-01,
       -5.43535233e-01, -5.30231476e-01, -3.43408585e-01,  1.84631348e
-03,
        1.98339462e-01,  2.20209122e-01,  9.81521606e-02,  1.13662720e
-01,
        2.57211685e-01,  5.44559479e-01,  7.00805664e-01,  7.22866058e
-01,
        6.20531082e-01,  5.86917877e-01,  6.80723190e-01,  8.33906174e
-01,
        1.01699257e+00,  1.18348122e+00,  1.40072823e+00,  1.65809822e
+00,
        1.96467781e+00,  2.31360245e+00,  2.51591873e+00,  2.54914284e
+00,
        2.36565018e+00,  2.07419014e+00,  1.63725281e+00,  1.07765770e
+00,
        5.00917435e-01, -7.18746185e-02, -4.42483902e-01, -6.18412018e
-01,
       -7.28170395e-01, -8.35844040e-01, -9.07592773e-01,
nan],
      dtype=float32)
```

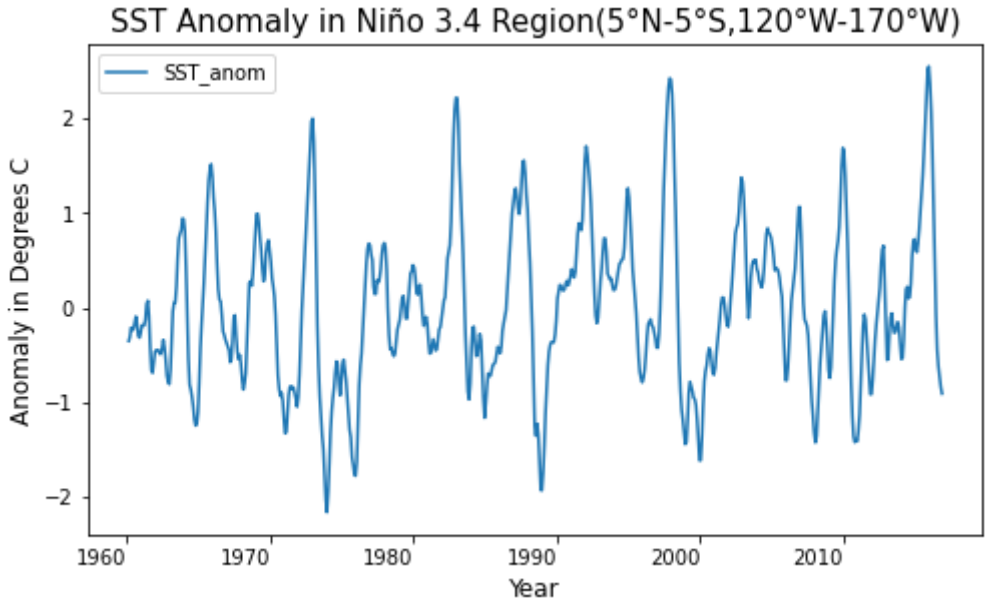
▼ Coordinates:

time	(time)	datetime64[ns]	1960-01-15 ... 2016-12-15
month	(time)	int64	1 2 3 4 5 6 7 ... 6 7 8 9 10 11 12

► Attributes: (0)

In [27]:

```
#2.2
#ShenHan told me that make a dataframe is easy to plot the figure, so I made a df.
#make a dataframe
df = pd.DataFrame(SST_anom,columns=['SST_anom'])
df['date'] = pd.DataFrame(SST_anom.time)
#plot the df
df.plot(x="date",y="SST_anom",figsize=(8, 5))
plt.xlabel('Year', color='k', fontsize=12)
plt.xticks(rotation=0)
plt.ylabel('Anomaly in Degrees C', color='k', fontsize=12)
plt.title('SST Anomaly in Niño 3.4 Region(5° N-5° S,120° W-170° W)',fontsize=15)
plt.show()
```



In [9]:
```
#3.1
# Open a netCDF4 file
# Import modules
import numpy as np
import pandas as pd
import xarray as xr
from matplotlib import pyplot as plt
%matplotlib inline

ds = xr.open_dataset("200001-201412.nc", engine="netcdf4")
# Show dataset
ds
```

```
C:\Users\dell\anaconda3\lib\site-packages\xarray\conventions.py:512: SerializationWa
rning: variable 'tas' has multiple fill values {1e+20, 1e+20}, decoding all values t
o NaN.
  new_vars[k] = decode_cf_variable(
```

Out[9]: xarray.Dataset

► Dimensions: (**time**: 180, **lat**: 192, **lon**: 288, nbnd: 2)

▼ 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
time	(time)	object	2000-01-15 12:00:00 ... 2014-12-...

▼ Data variables:

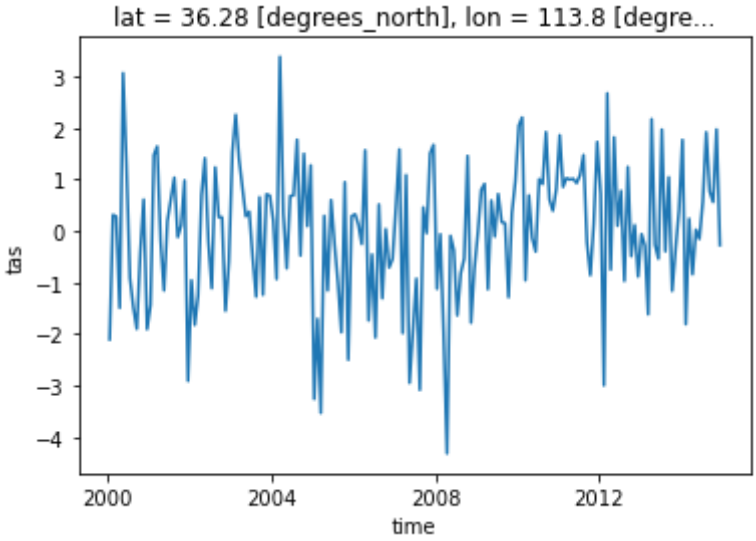
tas	(time, lat, lon)	float32	...
time_bnds	(time, nbnd)	object	...
lat_bnds	(lat, nbnd)	float64	...
lon_bnds	(lon, nbnd)	float64	...

► Attributes: (45)

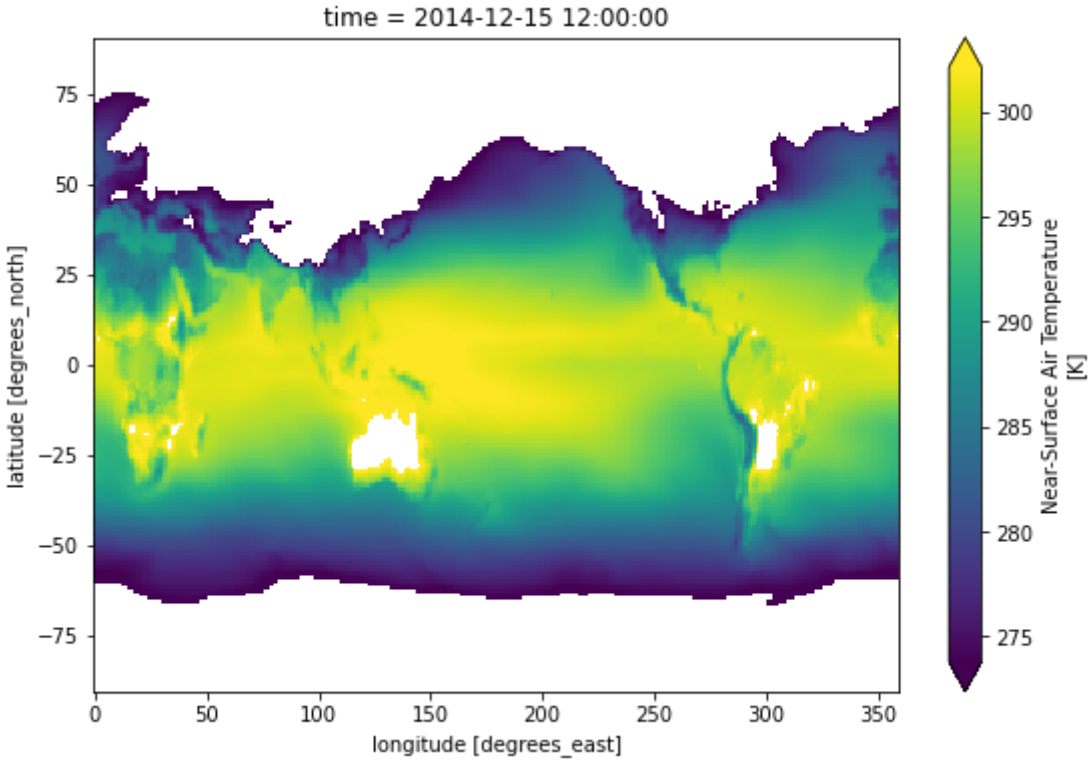
In [11]:
```
# Time series of the near surface temperature
# Group data by month
group_data = ds.tas.groupby('time.month')
# Apply mean to grouped data, and then compute the anomaly with monthly seasonal cyc
```

```
tas_anom = group_data - group_data.mean(dim='time')
tas_anom
# Plot anomaly at my hometown (Handan)
tas_anom.sel(lon=114.03, lat=36.20, method='nearest').plot()
plt.show()
```

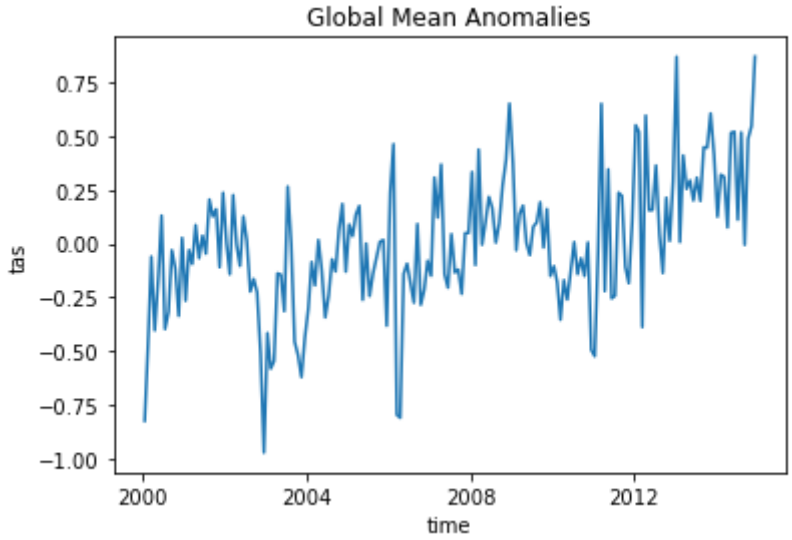
```
C:\Users\dell\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning:
Passing method to Float64Index.get_loc is deprecated and will raise in a future vers
ion. Use index.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
C:\Users\dell\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning:
Passing method to Float64Index.get_loc is deprecated and will raise in a future vers
ion. Use index.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
```



In [12]:
```
#3.2.1
#select the lateast data
l_data = ds.tas.isel(time=-1)
# plot the temperature where T>273 and T<303
l_data.where((l_data > 273) & (l_data < 303)).plot(size=6, robust=True)
plt.show()
```

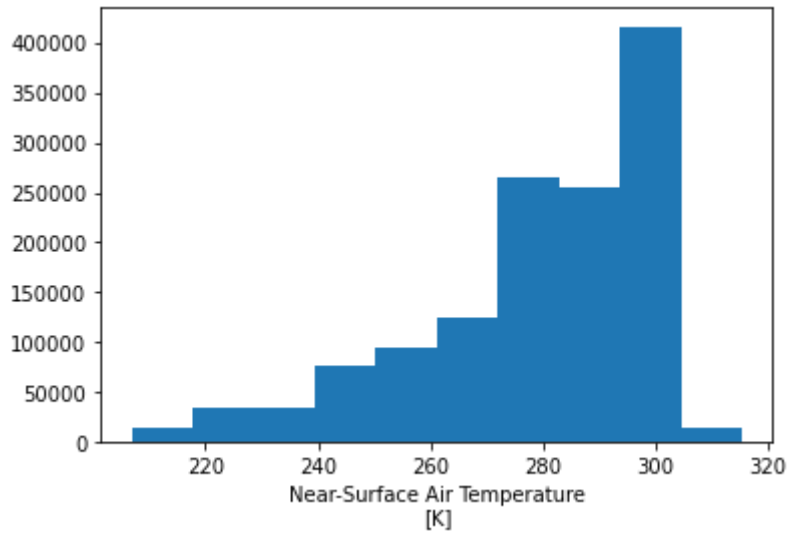


In [13]:
```
#3.2.2
# Plot global mean anomalies
tas_anom.mean(dim=['lat', 'lon']).plot()
plt.title('Global Mean Anomalies')
plt.show()
```



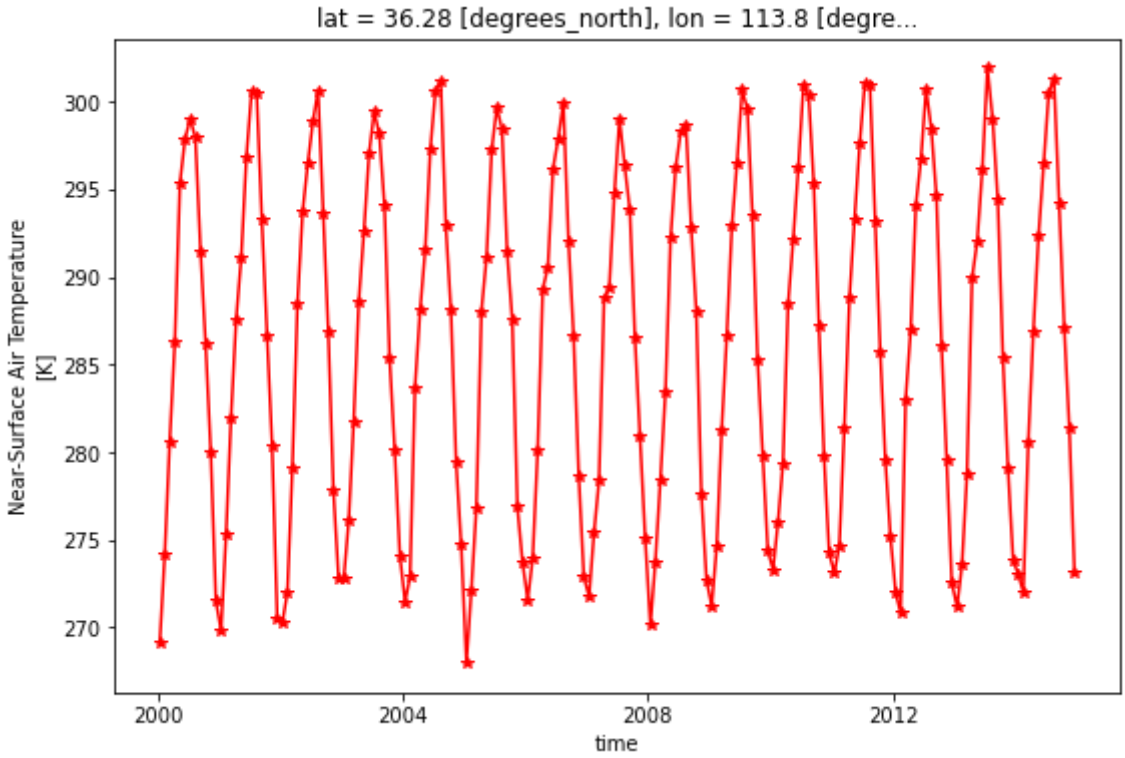
In [15]:
```
#3.2.3
#plot a part of data from 2013 to 2014
ds.tas.sel(time=slice("2013", "2014")).plot()
```

Out[15]:
```
(array([ 14782.,  33602.,  34180.,  75866.,  93803., 124627., 264117.,
        255807., 415203.,  15117.]),
 array([206.88835, 217.73865, 228.58893, 239.43921, 250.2895 , 261.1398 ,
        271.99008, 282.84036, 293.69067, 304.54095, 315.39124],
       dtype=float32),
 <BarContainer object of 10 artists>)
```

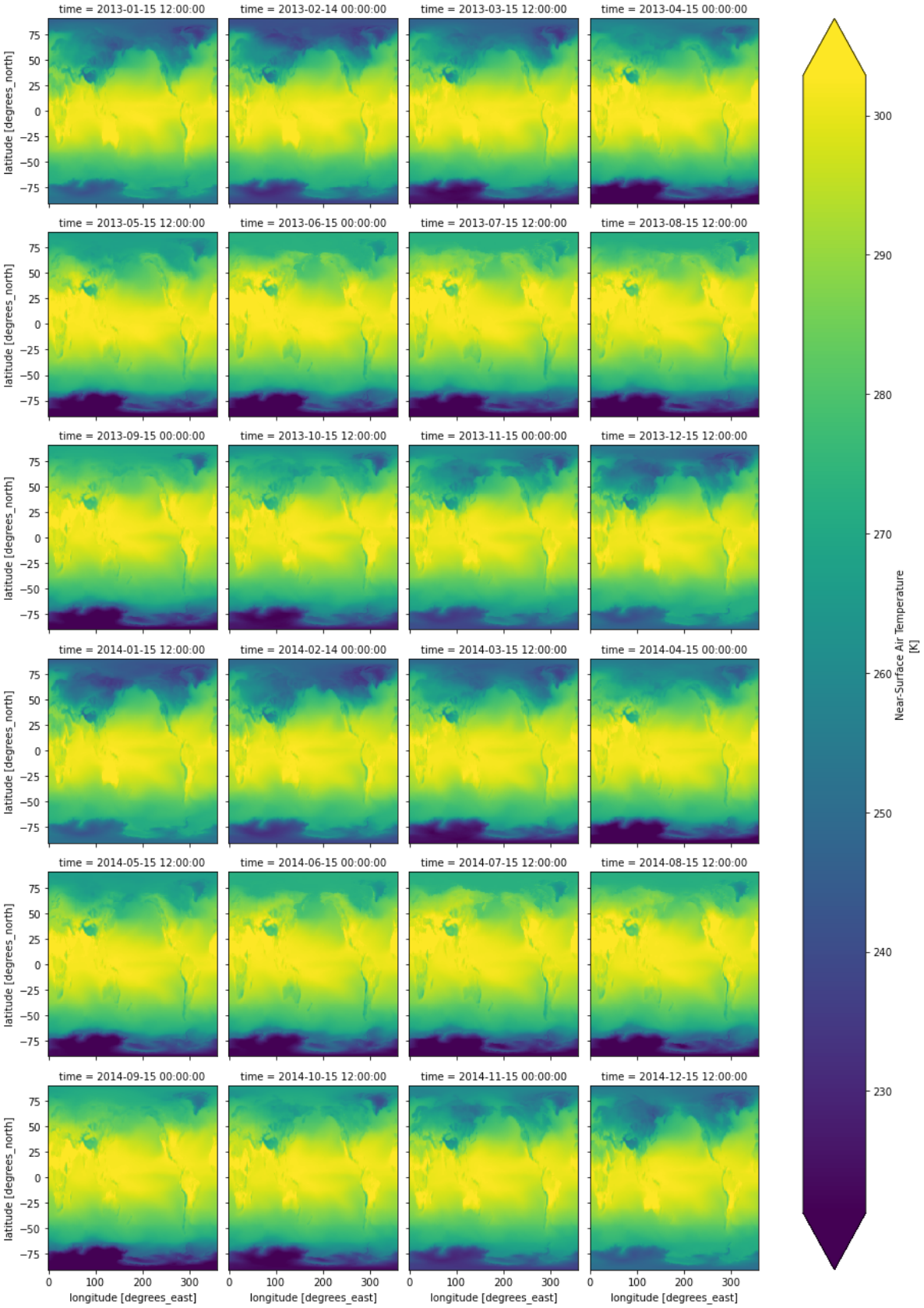


In [20]:
```
#3.2.4
# Time series of the near surface temperature at Handan
ds.tas.sel(lon=114.03, lat=36.20, method='nearest').plot(color='r', marker="*", siz
plt.show()
```

```
C:\Users\dell\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning:
Passing method to Float64Index.get_loc is deprecated and will raise in a future vers
ion. Use index.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
C:\Users\dell\anaconda3\lib\site-packages\xarray\core\indexes.py:234: FutureWarning:
Passing method to Float64Index.get_loc is deprecated and will raise in a future vers
ion. Use index.get_indexer([item], method=...) instead.
  indexer = self.index.get_loc(
```



In [22]:
```
#3.5
# Plot monthly mean near surface temperture in 2013 and 2014, one at a panel
ds.tas.sel(time=slice("2013", "2014")).plot(col="time", col_wrap=4, robust=True)
plt.show()
```


time = 2013-01-15 12:00:00
time = 2013-02-14 00:00:00
time = 2013-03-15 12:00:00
time = 2013-04-15 00:00:00
time = 2013-05-15 12:00:00
time = 2013-06-15 00:00:00
time = 2013-07-15 12:00:00
time = 2013-08-15 12:00:00
time = 2013-09-15 00:00:00
time = 2013-10-15 12:00:00
time = 2013-11-15 00:00:00
time = 2013-12-15 12:00:00
time = 2014-01-15 12:00:00
time = 2014-02-14 00:00:00
time = 2014-03-15 12:00:00
time = 2014-04-15 00:00:00
time = 2014-05-15 12:00:00
time = 2014-06-15 00:00:00
time = 2014-07-15 12:00:00
time = 2014-08-15 12:00:00
time = 2014-09-15 00:00:00
time = 2014-10-15 12:00:00
time = 2014-11-15 00:00:00
time = 2014-12-15 12:00:00
latitude [degrees_north]
75
50
25
0
−25
−50
−75
longitude [degrees_east]
0
100
200
300
Near-Surface Air Temperature [K]
300
290
280
270
260
250
240
230

In [ ]: