Imports

In [1]:
```
import numpy as np
import pandas as pd
import netCDF4 as nc
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
import scipy.signal as sig
```

Open dataset

In [2]:
```
had = nc.Dataset("E:/science_research/obs_data/HadISST_sst.nc")
ersst = nc.Dataset("E:/science_research/obs_data/ersst_sst.nc")
cesm = nc.Dataset("E:/science_research/CMIP6/historical/tas/CESM2/r2i1p1f1/gn/tas_Amon_CESM2_historical_r2i1p1f1_gn_185001-201412.nc")
```

In [3]:
```
giss1 = nc.Dataset("E:/science_research/CMIP6/historical/tas/GISS-E2-1-G/r1i1p1f1/gn/tas_Amon_GISS-E2-1-G_hist-GHG_r1i1p1f1_gn_190101-195012.nc")
giss2 = nc.Dataset("E:/science_research/CMIP6/historical/tas/GISS-E2-1-G/r1i1p1f1/gn/tas_Amon_GISS-E2-1-G_hist-GHG_r1i1p1f1_gn_195101-200012.nc")
giss3 = nc.Dataset("E:/science_research/CMIP6/historical/tas/GISS-E2-1-G/r1i1p1f1/gn/tas_Amon_GISS-E2-1-G_hist-GHG_r1i1p1f1_gn_200101-201412.nc")
```

Extract Niño 3.4 average

In [4]:
```
had_nino = np.average(np.average(had.variables["sst"][360:360+1368,85:95,10:60], axis = 1), axis = 1)
ersst_nino = np.average(np.average(ersst.variables["sst"][552:552+1368,42:48,95:125], axis = 1), axis = 1)
cesm_nino = np.average(np.average(cesm.variables["tas"][600:600+1368,90:101,152:192], axis = 1), axis = 1)-273
```

```
C:\Users\bg502257\AppData\Local\Continuum\anaconda3\lib\site-packages\ipykernel_launcher.py:3: UserWarning: WARNING: missing_value not used since it
cannot be safely cast to variable data type
  This is separate from the ipykernel package so we can avoid doing imports until
```

In [5]:
```
giss1_nino = np.average(np.average(giss1.variables["tas"][:,42:47,75:95], axis = 1), axis = 1) - 273
giss2_nino = np.average(np.average(giss2.variables["tas"][:,42:47,75:95], axis = 1), axis = 1) - 273
giss3_nino = np.average(np.average(giss3.variables["tas"][:,42:47,75:95], axis = 1), axis = 1) - 273
```

In [6]:
```
giss_nino = np.concatenate((giss1_nino, giss2_nino, giss3_nino))
```

Smooth Nino index with 5-month running mean

In [7]:
```
had_nino_smooth = pd.DataFrame(had_nino).rolling(5).mean()
ersst_nino_smooth = pd.DataFrame(ersst_nino).rolling(5).mean()
cesm_nino_smooth = pd.DataFrame(cesm_nino).rolling(5).mean()
giss_nino_smooth = pd.DataFrame(giss_nino).rolling(5).mean()
```

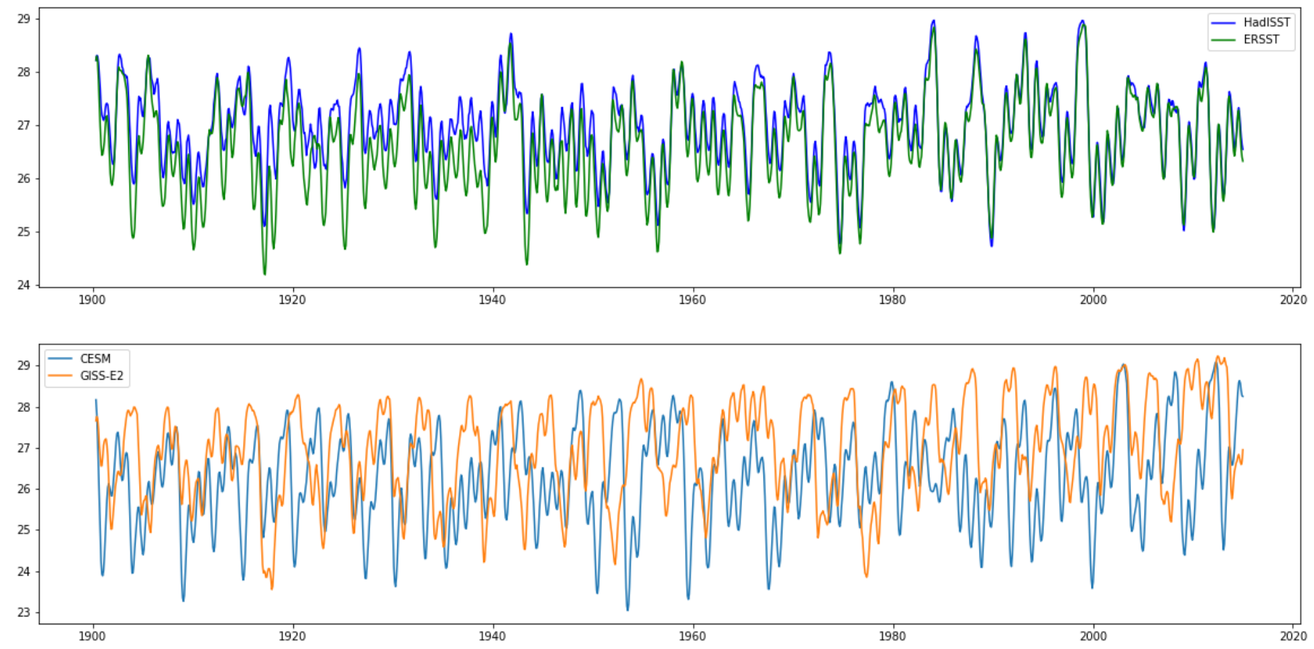
Construct date axis for plotting

In [8]:
```
nino_date = np.linspace(1900, 2015, 1368)
```

Plot Nino 3.4 index

In [9]:
```
plt.figure(figsize = (20,10))
plt.subplot(2,1,1)
plt.plot(nino_date, had_nino_smooth, "b")
plt.plot(nino_date, ersst_nino_smooth, "g")
plt.legend(["HadISST", "ERSST"])
plt.subplot(2,1,2)
plt.plot(nino_date, cesm_nino_smooth)
plt.plot(nino_date, giss_nino_smooth)
plt.legend(["CESM", "GISS-E2"])
```

Out[9]: <matplotlib.legend.Legend at 0x20e5a327c08>



Detrend nino

In [10]:
```
had_nino_detrend = sig.detrend(had_nino)
ersst_nino_detrend = sig.detrend(ersst_nino)
cesm_nino_detrend = sig.detrend(cesm_nino)
giss_nino_detrend = sig.detrend(giss_nino)
```

Calculate 20-year running variance

In [11]:
```
had_nino_var_20y = pd.DataFrame(had_nino_detrend).rolling(20*12).var().to_numpy()
ersst_nino_var_20y = pd.DataFrame(ersst_nino_detrend).rolling(20*12).var().to_numpy()
cesm_nino_var_20y = pd.DataFrame(cesm_nino_detrend).rolling(20*12).var().to_numpy()
giss_nino_var_20y = pd.DataFrame(giss_nino_detrend).rolling(20*12).var().to_numpy()
```

In [12]:
```
plt.figure(figsize = (20,10))
plt.subplot(2,1,1)
plt.plot(nino_date, had_nino_var_20y, "b")
plt.plot(nino_date, ersst_nino_var_20y, "g")
plt.legend(["HadISST", "ERSST"])
plt.subplot(2,1,2)
plt.plot(nino_date, cesm_nino_var_20y)
plt.plot(nino_date, giss_nino_var_20y)
plt.legend(["CESM", "GISS-E2"])
```

Out[12]: <matplotlib.legend.Legend at 0x20e5a39edc8>