# p_clim

March 15, 2020

## 1 Paleo-Current Climate Study

A comparison of Atmospheric Surface Temperature (ATS) and CO2 for two time periods: 1. 800kyr to 1950 (i.e. before present) 2. 18800 to 2019

The paleo data are taken from the EPICA Dome C and Vostok ice cores. These data are composite from several analyses: - 0-22 kyr Dome C (Monnin et al. 2001) https://science.sciencemag.org/content/291/5501/112 - 22-393 kyr Vostok (Petit et al. 1999; Pepin et al. 2001; Raynaud et al. 2005) measured at LGGE in Grenoble - 393-416 kyr Dome C (Siegenthaler et al. 2005) measured at LGGE in Grenoble - 416-664 kyr Dome C (Siegenthaler et al. 2005) measured at University of Bern - 664-800 kyr Dome C (Luethi et al. 2008) https://www.nature.com/articles/nature06949

The current temperature and co2 data were obtained from NOAA on-line databases. - https://www.ncdc.noaa.gov/cag/global/time-series - ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_annmean_mlo.txt

#### 1.0.1 Required Files

- edc3_dt_jouzel2007.txt [] add link to original file
- edc3_co2_composite.txt [] add link to original file
- noaa_co2_annmean_mlo_1959to2019.txt, copy of co2_annmean_mlo file above
- noaa_temp_landsea_1880to2019.txt, from time-series link above

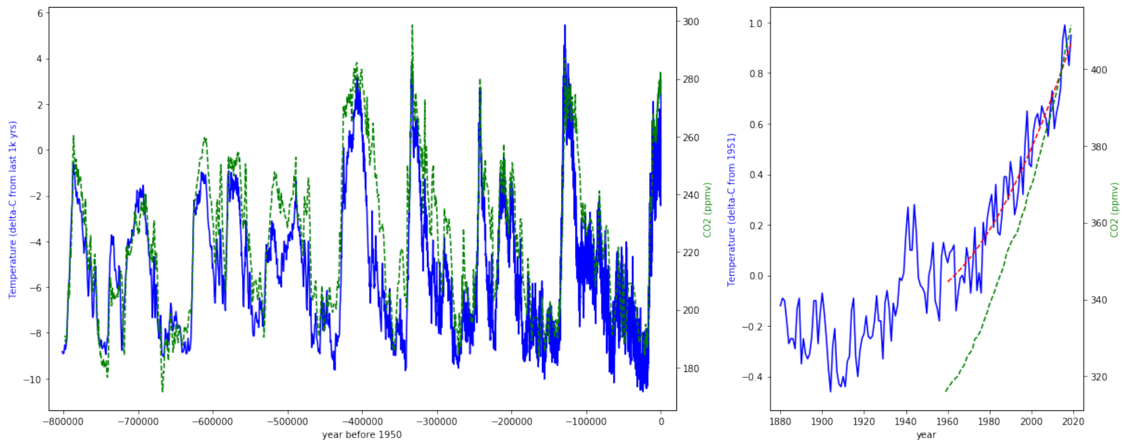
#### 1.0.2 Motivation

The goal of this study is to determine recent rise in temperature and co2 are or are not consistent with paleo-climate trends. To explore this issue we plot both time dependent variations during the two eras as well as time-derivates for both temperature and CO2.

```
In [2]: %matplotlib inline

        import numpy as np
        import matplotlib.pyplot as plt
        from matplotlib import gridspec
        # set a large default for figure size
        plt.rcParams["figure.figsize"] = (20,8)

        #
```

```
ptmp_data = np.genfromtxt('edc3_dt_jouzel2007.txt',skip_header=75)
ptmp_age = -ptmp_data[:,2]
ptmp_deu = ptmp_data[:,3]
ptmp_t   = ptmp_data[:,4]

pco2_data = np.genfromtxt('edc3_co2_composite.txt',skip_header=108)
pco2_age = -pco2_data[:,0]
pco2_ppm = pco2_data[:,1]

ntmp_data = np.genfromtxt('noaa_temp_landsea_1880to2019.txt',skip_header=5)
ntmp_age = ntmp_data[:,0]
ntmp_t   = ntmp_data[:,1]

nco2_data = np.genfromtxt('noaa_co2_annmean_mlo_1959to2019.txt',skip_header=57)
nco2_age = nco2_data[:,0]
nco2_ppm = nco2_data[:,1]
nco2_sig = nco2_data[:,2]

# plot to check
fig1 = plt.figure(1)
gs = gridspec.GridSpec(1, 2, width_ratios=[2, 1])
ax1 = fig1.add_subplot(gs[0])
ax1.set_xlim(-820000,20000)
ax2 = ax1.twinx()
ax1.set_xlabel('year before 1950')
ax1.set_ylabel('Temperature (delta-C from last 1k yrs)', color='b')
ax2.set_ylabel('CO2 (ppmv)', color='g')
ax1.plot(ptmp_age,ptmp_t,'b-')
ax2.plot(pco2_age,pco2_ppm,'g--')

ax3 = fig1.add_subplot(gs[1])
ax3.set_xlim(1875,2025)
ax4 = ax3.twinx()
ax3.set_xlabel('year')
ax3.set_ylabel('Temperature (delta-C from 1951)', color='b')
ax4.set_ylabel('CO2 (ppmv)', color='g')
ax3.plot(ntmp_age,ntmp_t,'b-')
ax4.plot(nco2_age,nco2_ppm,'g--')

# Fit and plot temperature to 3rd degree polynomial
min = 1960-1880
par = np.polyfit(ntmp_age[min:],ntmp_t[min:],2)
poly = np.poly1d(par)
ax3.plot(ntmp_age[min:],poly(ntmp_age[min:]),'r--')

#plt.show()
```

Out[2]: [<matplotlib.lines.Line2D at 0x1171c0a58>]




## 1.1 Figure 1 discussion

The left panel shows the paleo-climate temperature changes determined from changes in deuterium extracted from the EPICA Dome C and Vostok ice-cores in blue, and CO2 concentrations in parts-per-million by volume (ppmv) in dashed-green. The right panel shows the average land-see mean global temperatures per year reported by NOAA in blue, and CO2 concentrations measured at Manua Loa.

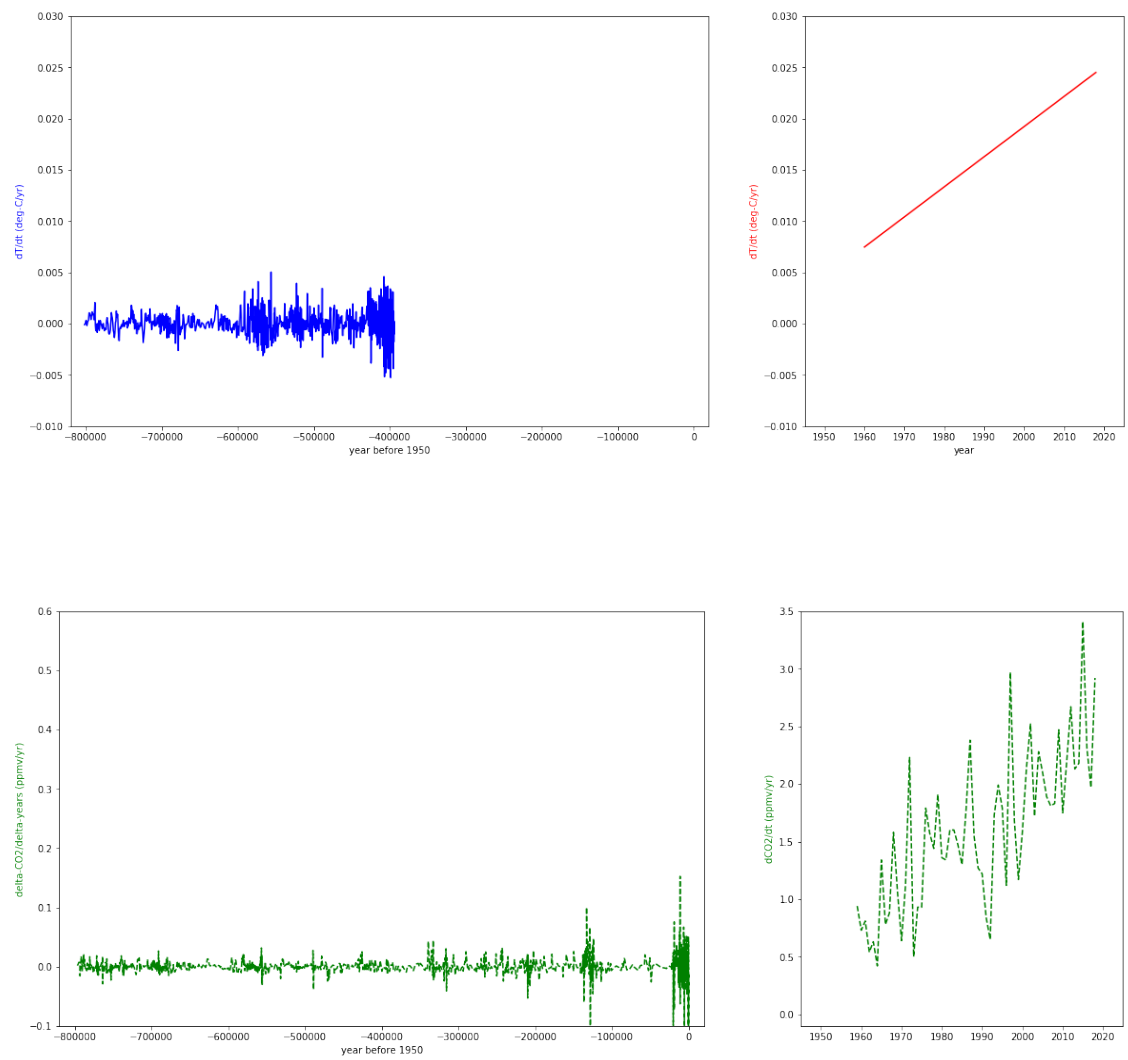
While not readily apparent from the ice-core figure, the rising temperatures usually preceed the rising CO2 levels by ~200 years, as determined in https://science.sciencemag.org/content/339/6123/1060. This value is less than was initially measured due to corrections for gas diffusion within the top layers of the ice. The explanation for this is that rising temperatures cause CO2 to be released from the ice when it melts. Note that this mechanisms could not be responsible for the near simulataneous rise in both CO2 and termperature, and it does not rule out the possibility of CO2 release leading to additional warming in a positive feedback loop during glacial melting.

Although the CO2 concentrations are now at last 100 ppmv higher than observed in the ice-core data over the last 800,000 years, the termperature scales from the antarctic (paleo) and global mean (current) are only shown relative to the last 1,000 years for paleo, and to 1950 for the current data. It is more meaningful to compare the time derivatives.

```
In [6]: plt.rcParams["figure.figsize"] = (20,8)

        # Use np.diff(a) = a[i+1]-a[i] to calculate derivative

        ptmp_age_diff = np.diff(ptmp_age)
        ptmp_tmp_diff = np.diff(ptmp_t)
        ptmp_deriv = ptmp_tmp_diff/ptmp_age_diff
        #print(ptmp_age_diff)
        #print(ptmp_tmp_diff)

        pco2_age_diff = np.diff(pco2_age)
        pco2_ppm_diff = np.diff(pco2_ppm)
```

```
pco2_deriv = pco2_ppm_diff/pco2_age_diff
#print(pco2_deriv)

fig2 = plt.figure(2)
# reuse same gs[] ratio from above
ax5 = fig2.add_subplot(gs[0])
#ax5.set_xlim(-820000,-390000)
ax5.set_xlim(-820000,20000)
ax5.set_ylim(-0.01,0.03)
ax5.set_xlabel('year before 1950')
ax5.set_ylabel('dT/dt (deg-C/yr)', color='b')
ax5.plot(ptmp_age[-895:],ptmp_deriv[-895:],'b-')
#ax5.plot(ptmp_age[:-1],ptmp_deriv,'g--')

ntmp_deriv = np.diff(poly(ntmp_age[min:]))
ax6 = fig2.add_subplot(gs[1])
ax6.set_xlim(1945,2025)
ax6.set_ylim(-0.01,0.03)
ax6.set_xlabel('year')
ax6.set_ylabel('dT/dt (deg-C/yr)', color='r')
ax6.plot(ntmp_age[min:-1],ntmp_deriv,'r-')

fig3 = plt.figure(3)
ax7 = fig3.add_subplot(gs[0])
ax7.set_xlim(-820000,20000)
ax7.set_ylim(-0.1,3/5)
ax7.set_xlabel('year before 1950')
ax7.set_ylabel('delta-CO2/delta-years (ppmv/yr)', color='g')
#ax7.set_ylim(0.4,3.5)
#ax7.plot(pco2_age[-895:],pco2_deriv[-895:],'g--')
ax7.plot(pco2_age[:-1],pco2_deriv,'g--')

nco2_deriv = np.diff(nco2_ppm)
ax8 = fig3.add_subplot(gs[1])
ax8.set_xlim(1945,2025)
ax8.set_ylim(-0.1,3.5)
ax8.set_ylabel('dCO2/dt (ppmv/yr)', color='g')
ax8.plot(nco2_age[:-1],nco2_deriv,'g--')
```

```
Out[6]: [<matplotlib.lines.Line2D at 0x1178e6a90>]
```




## 1.2 Figure 2

This figure compares time derivatives for temperature (top) and CO2 (bottom) for paleo- (left) and current (right) climate data. Both paleo-climate time derivatives to be significantly lower than recent data. For the temperature derivates we are showing only the Dome C data. The Vostok ice-core data exhibit larger variation above and below zero and further investigation into sources of stochastic error are warranted.