http://visibleearth.nasa.gov/view.php?id=5772

Predicting Future CO2 Amounts and Monitoring Seasonal CO2 Fluctuations

QUANTIFYING CO2 ANNUAL INCREASE

Aguilera, Kimberly | GEO 3276: GIS & GPS Applications in Earth Sciences | November 20, 2015

Introduction

The Keeling curve was originated by Charles Keeling to measure increasing global scale CO_2 levels. Over the past several decades, his research continues to thrive and has led to two important conclusions. The first hypothesis confirms that CO_2 levels are increasing annually and the second one affirms that CO_2 concentration is season dependent contingent on which hemisphere data is gathered from. The notion is that the northern hemisphere contains more vegetation than the southern hemisphere. Therefore, CO_2 levels will deviate more in the northern hemisphere, depending on the season, because the amount of vegetation available directly affects the amount of CO_2 present. In particular, May proves to have the highest CO_2 concentration while October records the lowest. For my project, I wanted to map out the highest and lowest levels of CO_2 recorded annually from 2005-2010 to see how much the concentrations fluctuate seasonally with different vegetation amounts. I will do this using the spatial analysis tool to create rasters for May and October. Additionally I would like to know how much CO_2 concentration will be expected for the year 2020.

Data Collection

I collected CO_2 data from NASA's AIRS (atmospheric infrared sounder) OPeNDAP server dataset. AIRS collects greenhouse gas, humidity, and temperature data using infrared channels. I downloaded AIRS/ Aqua Level 3 Monthly CO_2 in the free troposphere (AIRS+AMSU)(AIRX3C2mM) which contains CO_2 data collected at an altitude where local topography does not affect the concentrations.

NASA AIRS: http://airs.jpl.nasa.gov/data/get_data

Monthly vegetation imaging was gathered for May and October from NASA's NEO (NASA earth observations) database as a .5 degree GeoTIFF file. The images are known as Normalized Difference Vegetation Indices (NDVI) and are produced from moderate resolution imaging spectroradiometers (MODIS).

NASA NEO: http://neo.sci.gsfc.nasa.gov/view.php?datasetId=MOD13A2_M_NDVI

The world country outline was gathered from ArcGIS online shapefiles.
Esri, DeLorme Publishing Company, CIA World Factbook

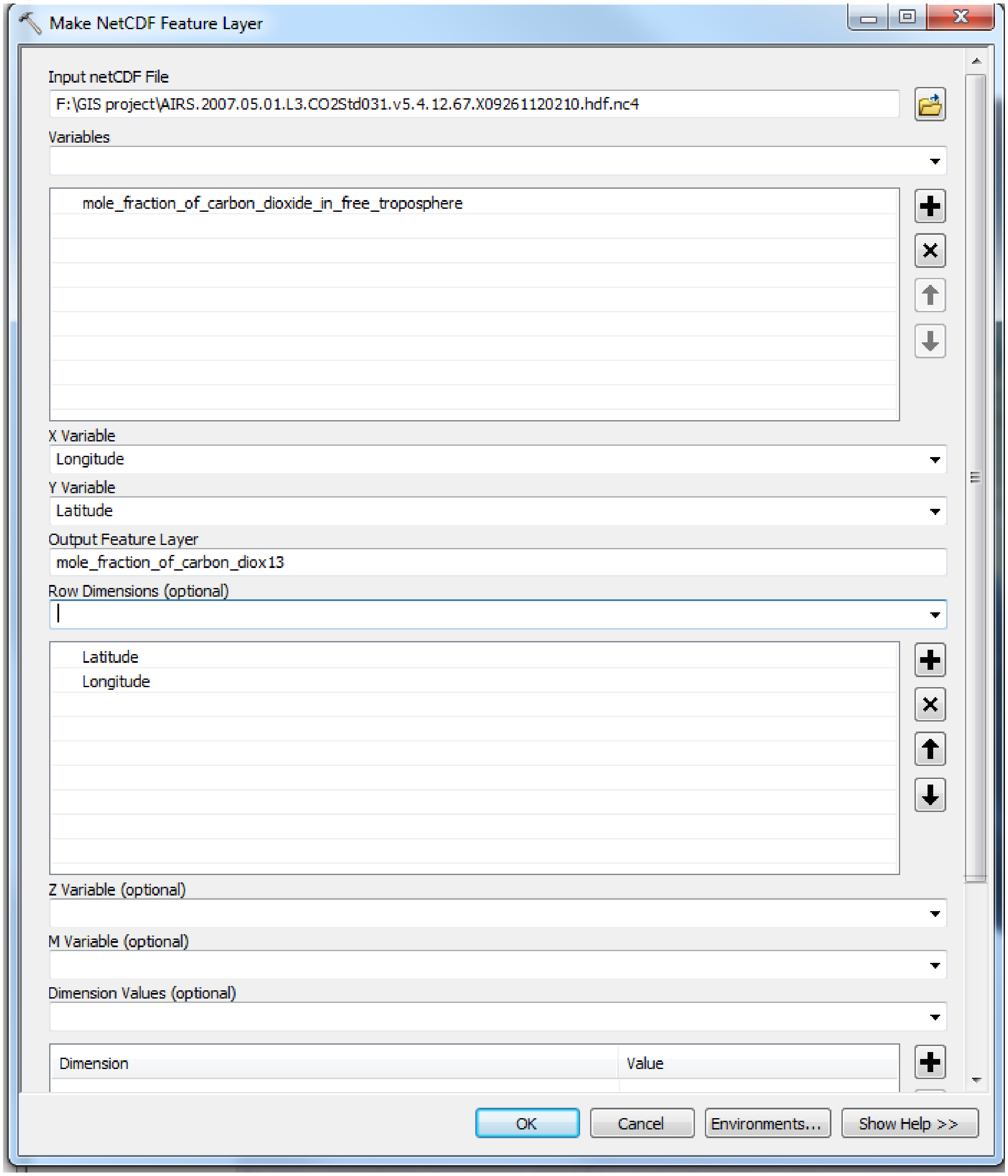
http://www.arcgis.com/home/item.html?id=3864c63872d84aec91933618e3815dd2

ArcGIS Processing

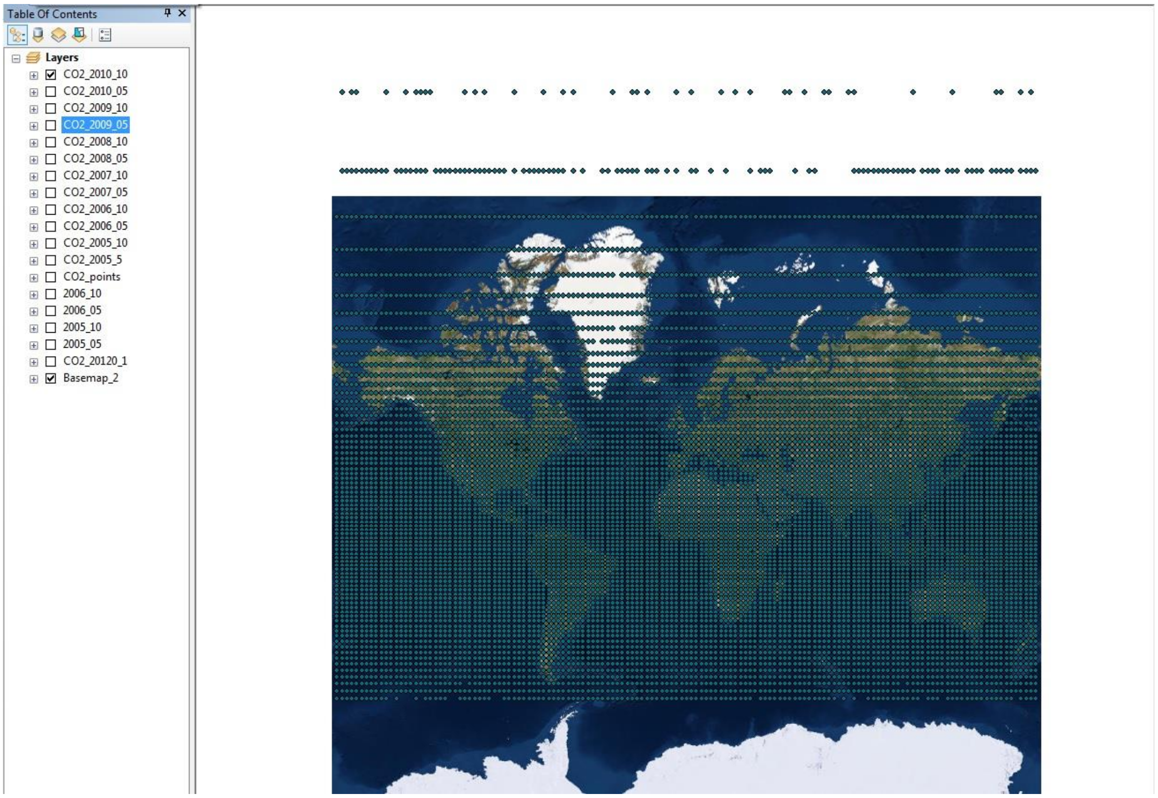
Making CO_2 Rasters

Before making a raster, the AIRS monthly data needed to be converted from a NetCDF (network common data form) to a point shapefile layer. This was done by using the Make NetCDF Feature

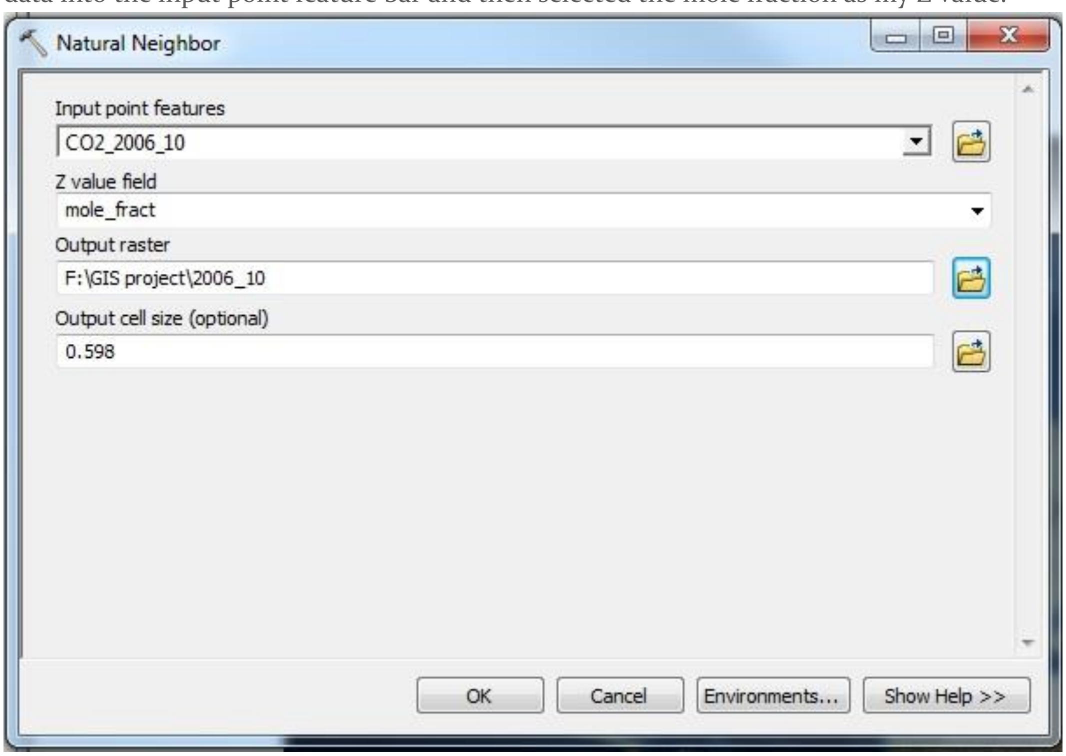
Layer tool in ArcMap.



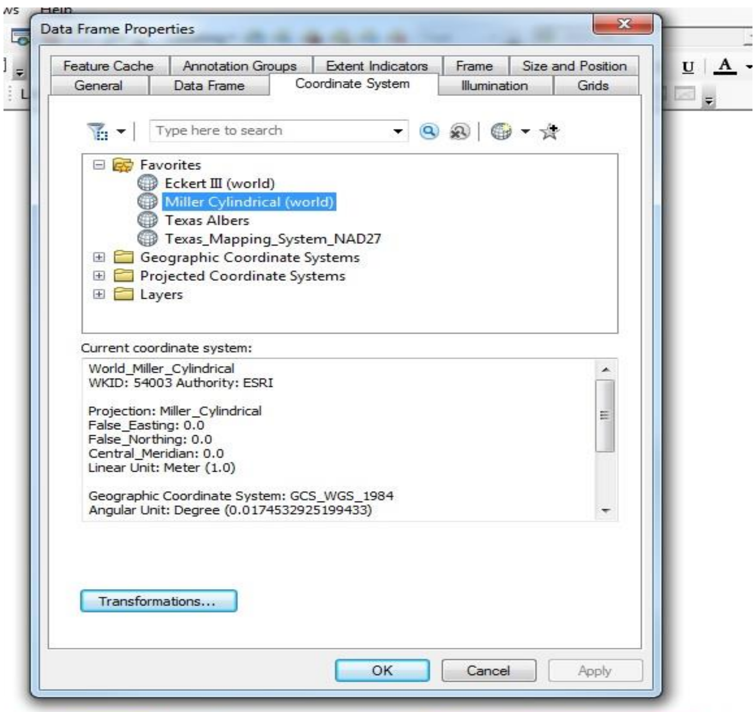
I set the variables to mole fraction of carbon dioxide in free troposphere with the X and Y variable set to longitude and latitude respectively. The mole fraction of CO_2 reports as a fraction of air molecules present. The row dimensions were also set to latitude and longitude, this will make the feature layer create a point for each cell value.

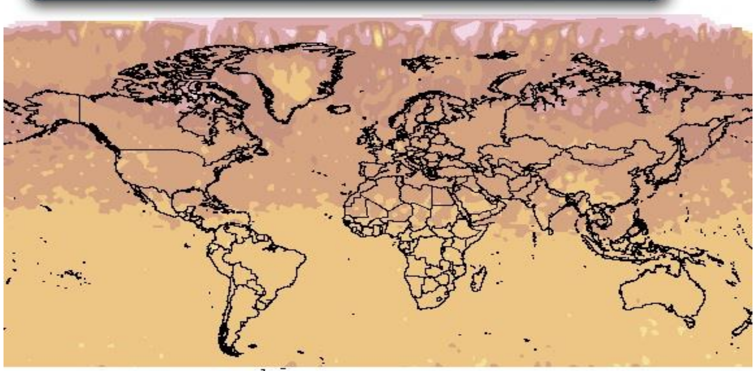


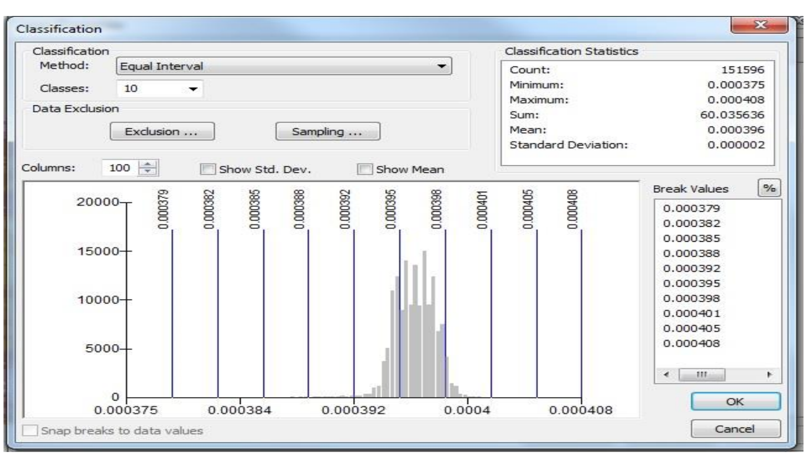
I exported the feature layer data as a shapefile to be interpolated using spatial analysis. Using the natural neighbor tool I was able to make a raster of interpolated point. I inputted each month's data into the input point feature bar and then selected the mole fraction as my Z value.



The resulting rasters were changed to the World Miller Cylindrical projection with 10 classes of equal intervals to effectively display the data. The raster displays data as in mole fraction but can be interpreted in ppm by multiplying the value by 1,000,000.





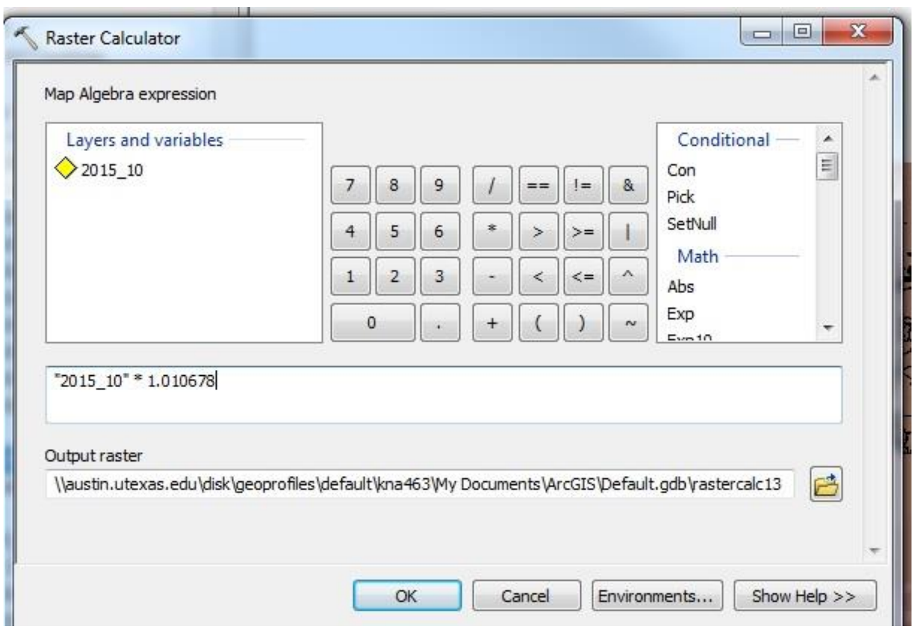


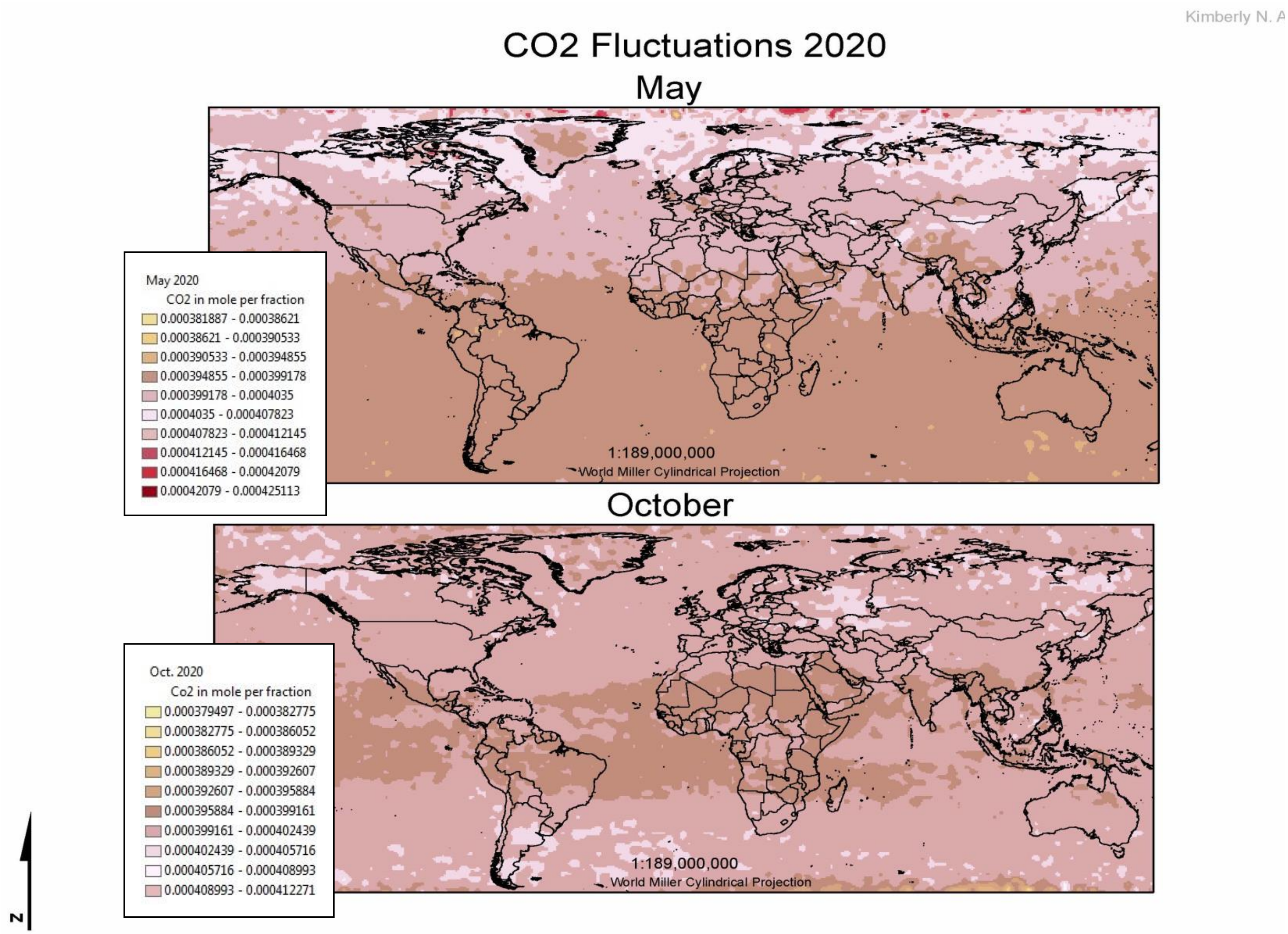
Importing GeoTIFF

I downloaded a .5X.5 GeoTIFF resolution images from NASA's NEO website and changed the projection to Eckert III since the files were already georeferenced when I loaded them into AcrMap. The lighter beige and darker green regions on the NDVI maps represent little to no growing vegetation and active vegetation growth, respectively.

2020 Prediction Results

I was able to calculate future 2020 CO2 concentrations by multiplying the 2010 May and October rasters by the rate between 2005 and 2010, 1.010678 mole fraction product increase over five years. Assuming the same rate for the next five years, I multiplied the 2015 May and October rasters again by 1.010678.





The average increase in ppm from 2005 to 2020 for May and October was around 19.58 ppm and 21.37 ppm, respectively. The information was found by looking at the mean classification stats.

May 2005

Classification Statistics

Count:	148982
Minimum:	0.000369913
Maximum:	0.000405438
Sum:	56.605259855
Mean:	0.000379947
Standard Deviation:	0.000002919

May 2020

Classification Statistics

Count:	148874
Minimum:	0.000381887
Maximum:	0.000425113
Sum:	59.47901174
Mean:	0.000399526
Standard Deviation:	0.000003546

Oct. 2005

Classification Statistics

Count:	149401
Minimum:	0.000363899
Maximum:	0.00038864
Sum:	56.605390857
Mean:	0.000378882
Standard Deviation:	0.000001364

Oct. 2020

Classification Statistics

Count:	151596
Minimum:	0.000379497
Maximum:	0.000412271
Sum:	60.67669526
Mean:	0.000400253
Standard Deviation:	0.000001552

The total increase is about 20.47 ppm [(19.58 ppm + 21.37 ppm)/2] resulting in an overall amount of ~420.47 ppm by 2020.

Seasonal Interpretation

As the Keeling Curve predicted, densely vegetated regions influence CO_2 data amounts. The Northern hemisphere progressively shows higher CO_2 mole fraction amounts from 2005-2010 for May months vs. October. This trend is due to the steady increase of CO_2 from lack of vegetation growth in the winter months. Contrary, October months show a lower amount than May due to the spring and summer vegetation growth absorbing CO_2. The lighter regions indicate no vegetation growth, while the darker areas indicate growth. The table below displays the average CO_2 amount per year found from the raster classification table.

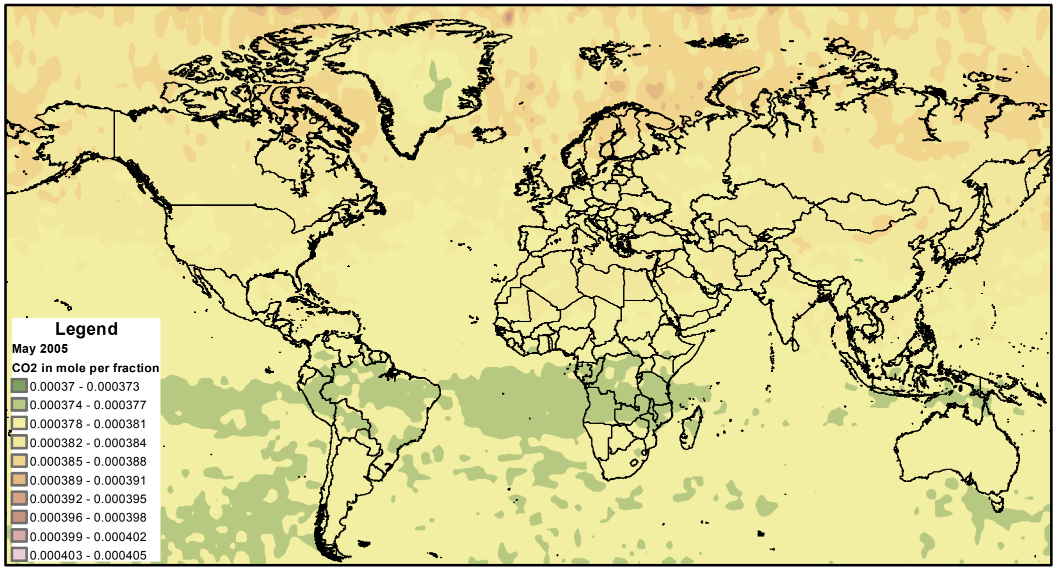
Year	2005	2006	2007	2008	2009	2010	Total increase
May (ppm)	379.9	382.25	383.81	386.70	388.14	391.12	11.22
October (ppm)	378.8	380.86	383.25	385.07	387.62	389.86	11.06

Conclusion:

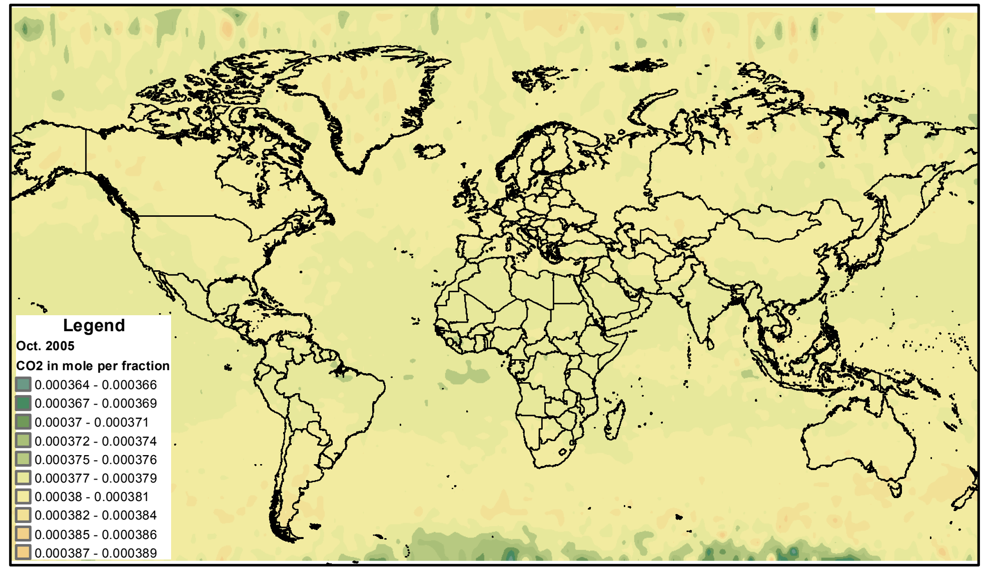
Vegetation growth proved to have significant effects on global average CO_2 levels with an increase of about 11 ppm from 2005 to 2010. Progressively, each raster map displayed higher CO_2 concentrations in the northern hemisphere for May months and more evenly distributed amounts in October months. Overall, the current rate of CO_2 increase will lead to highs of 425.11 ppm and 400.25 ppm levels in 2020 for the May and October months, respectively.

CO2 Fluctuations 2005

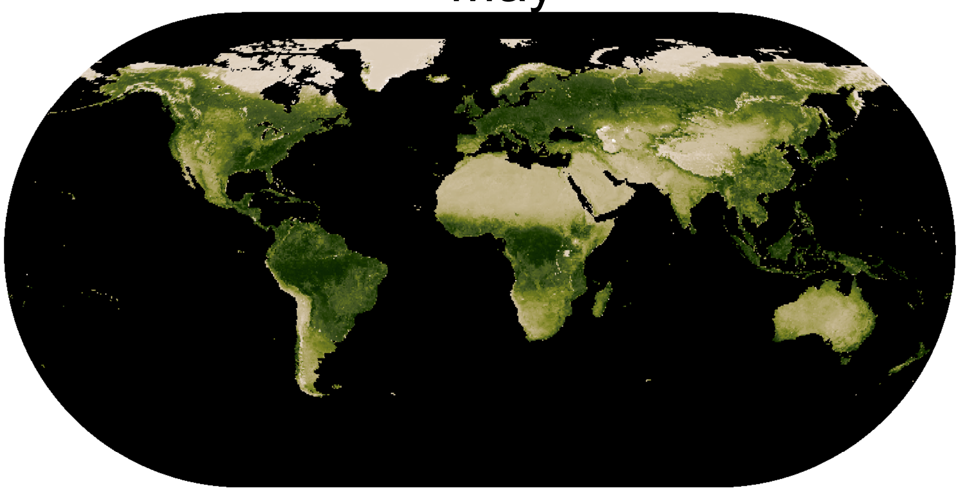
May



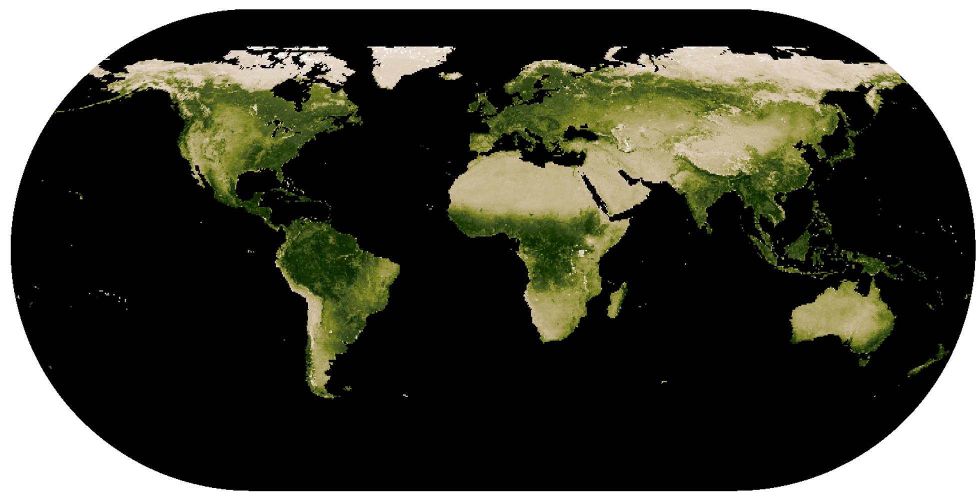
October



May

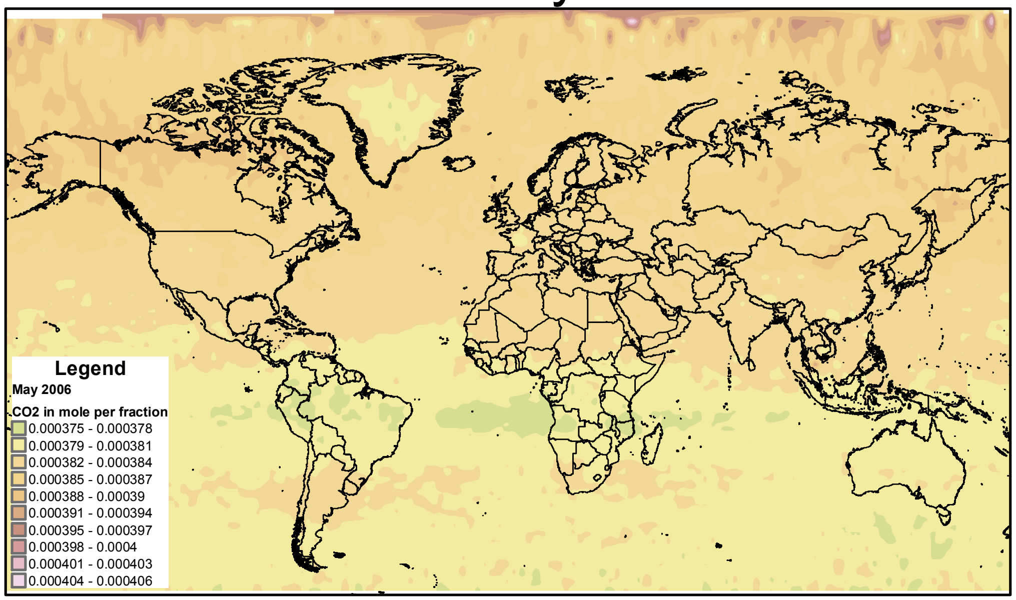


October

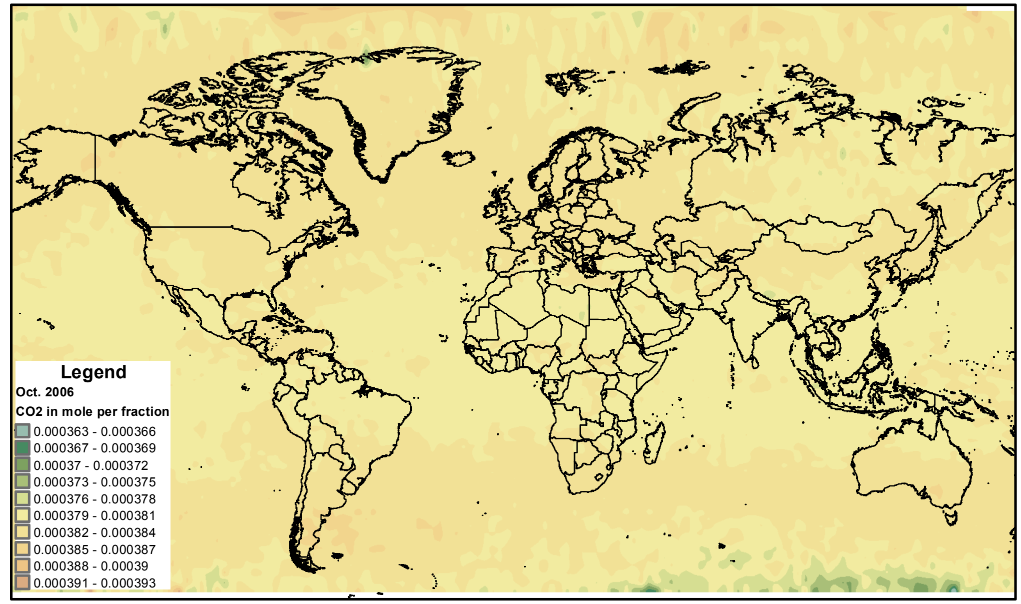


CO_2 Fluctuations 2006

May



October



May

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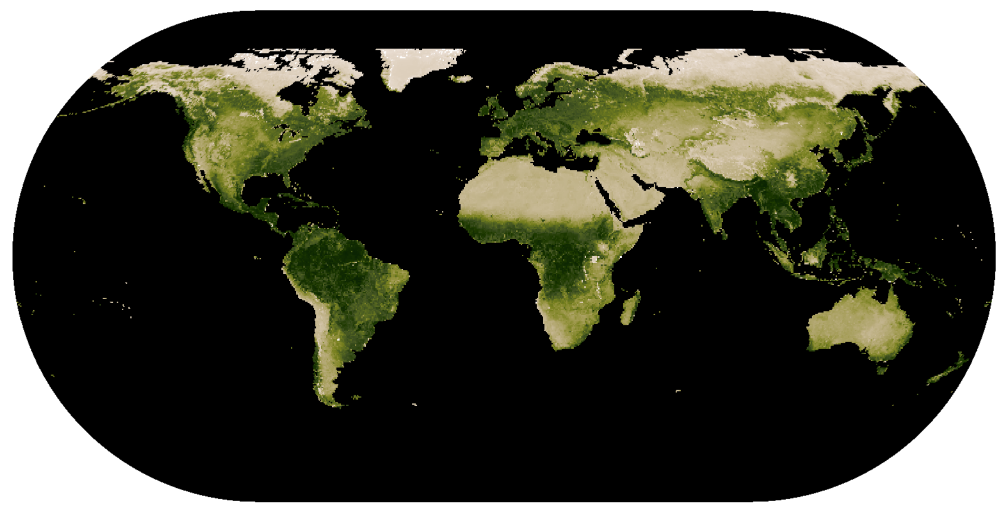
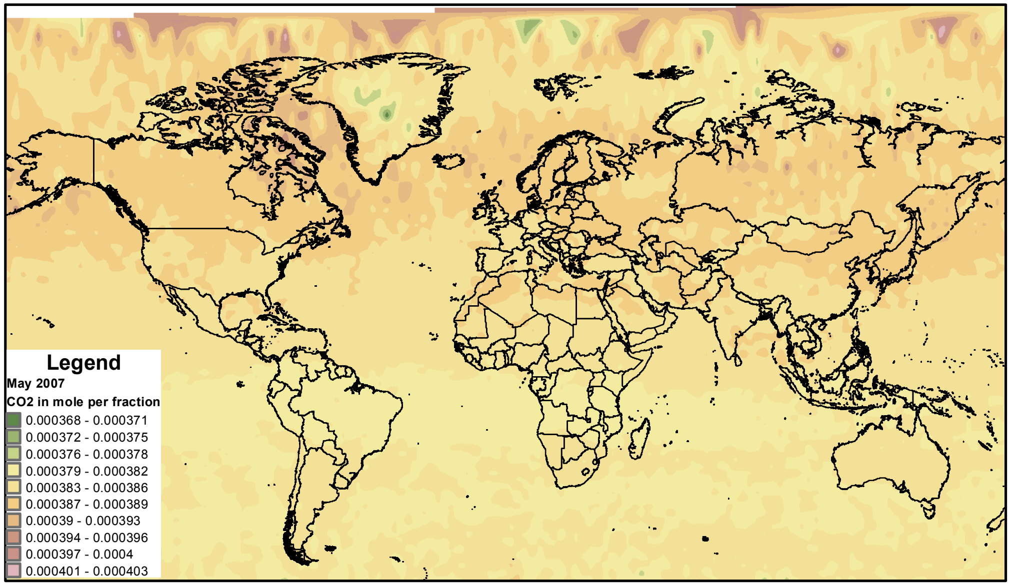


CO2 Fluctuations 2007

May



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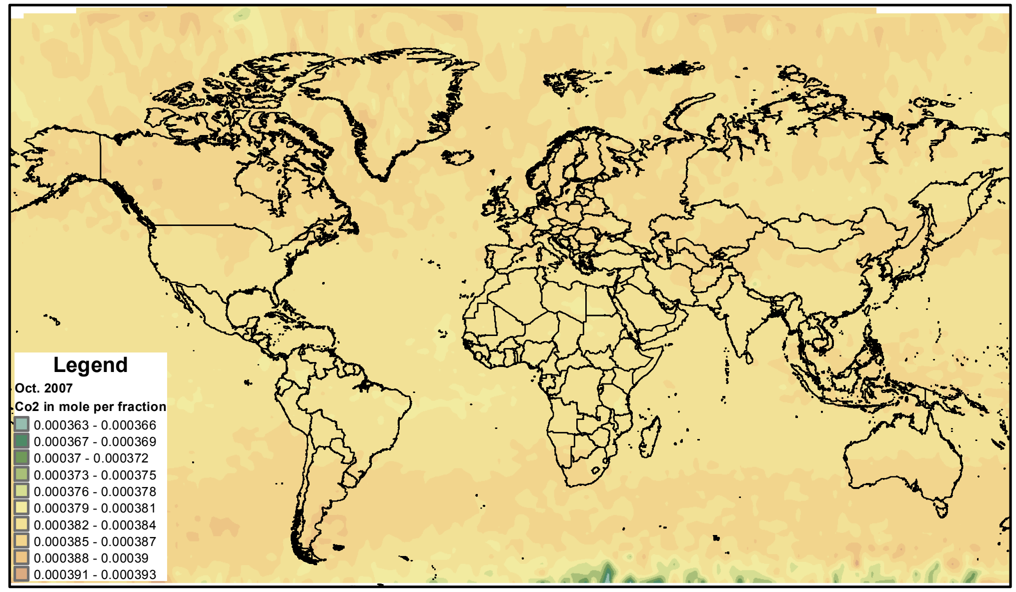

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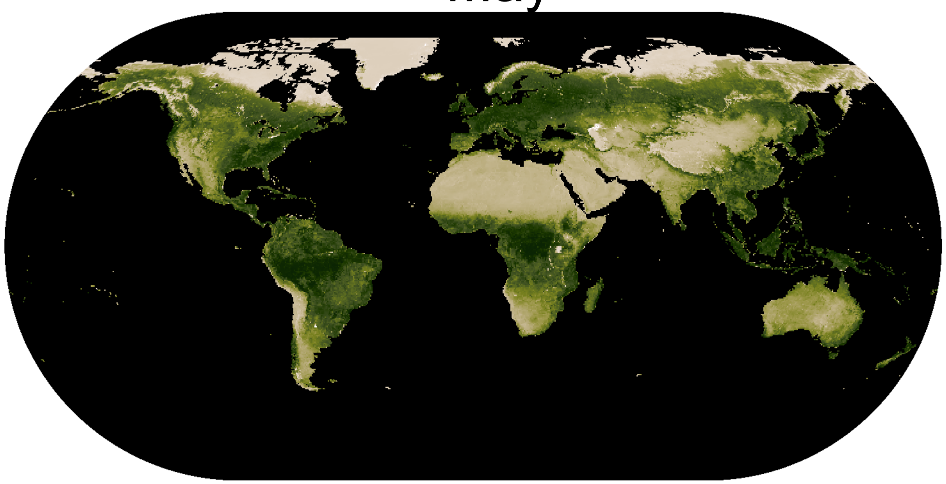

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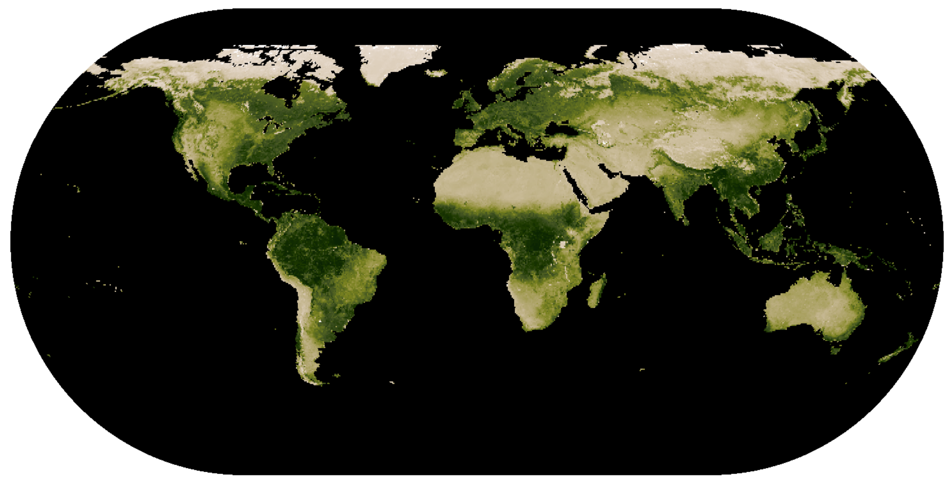
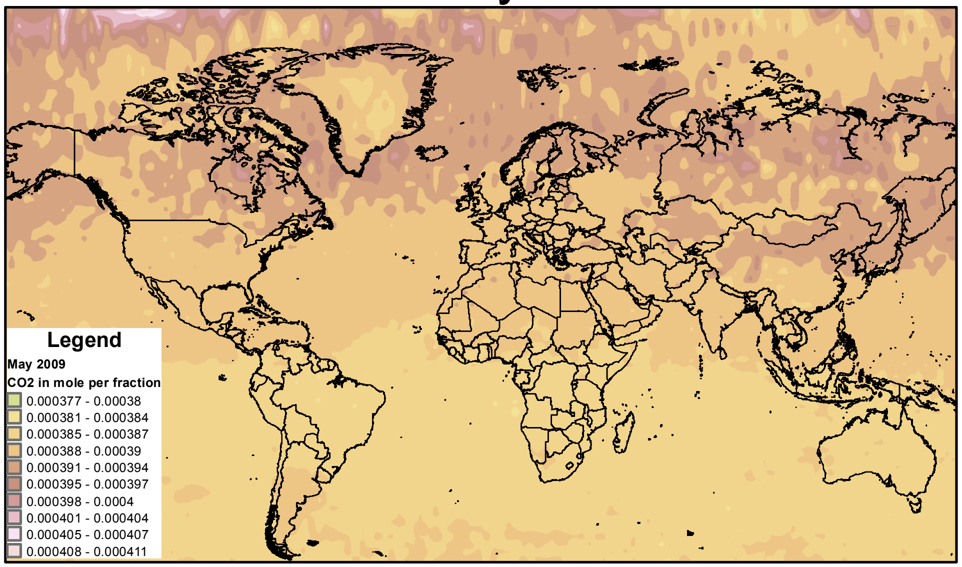
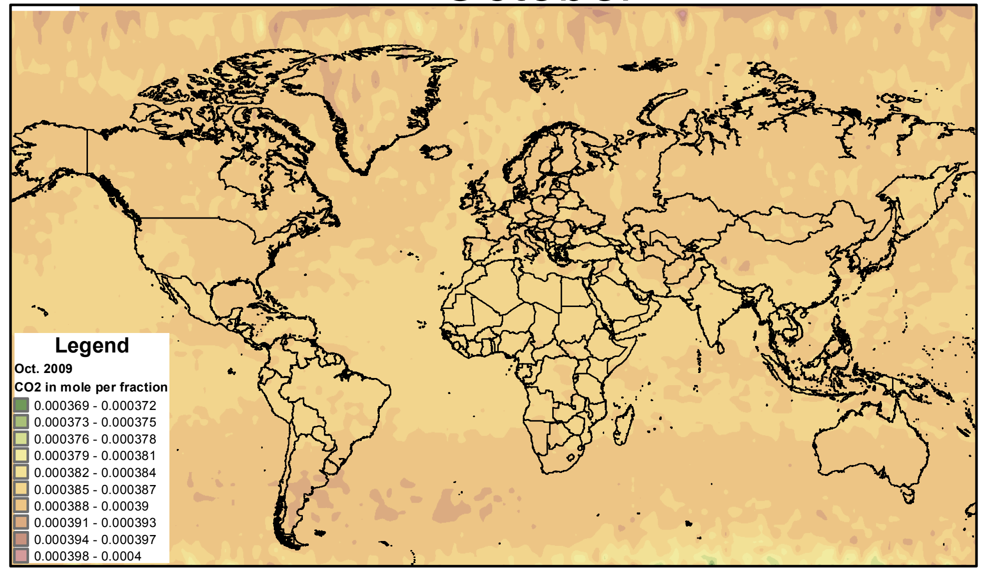


CO_2 Fluctuations 2009

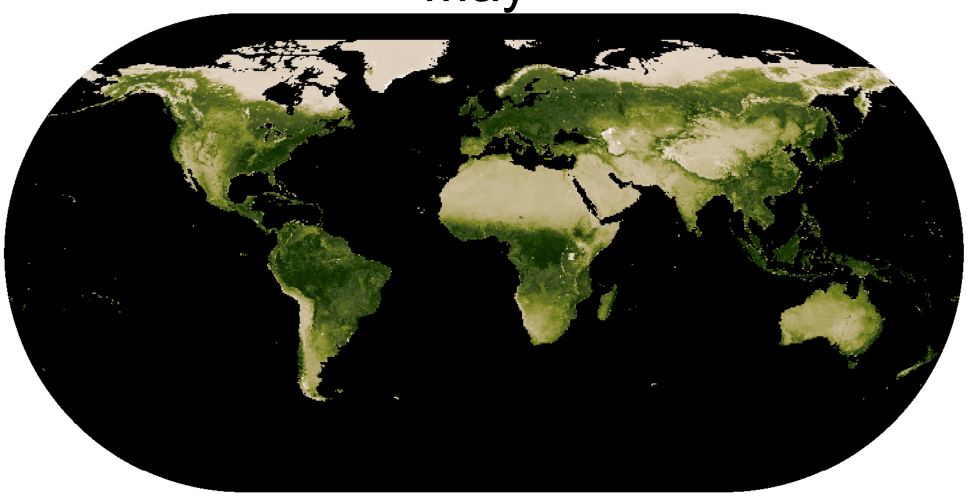
May



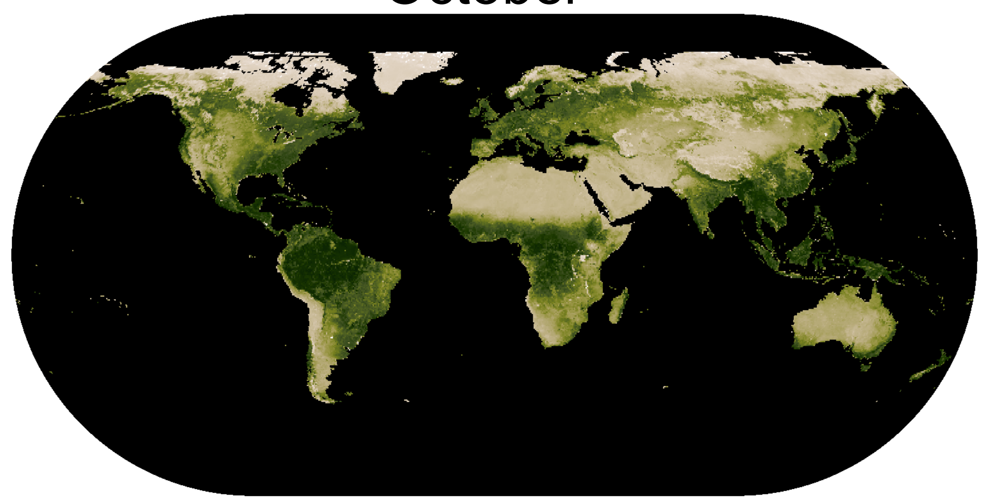
October



May



October



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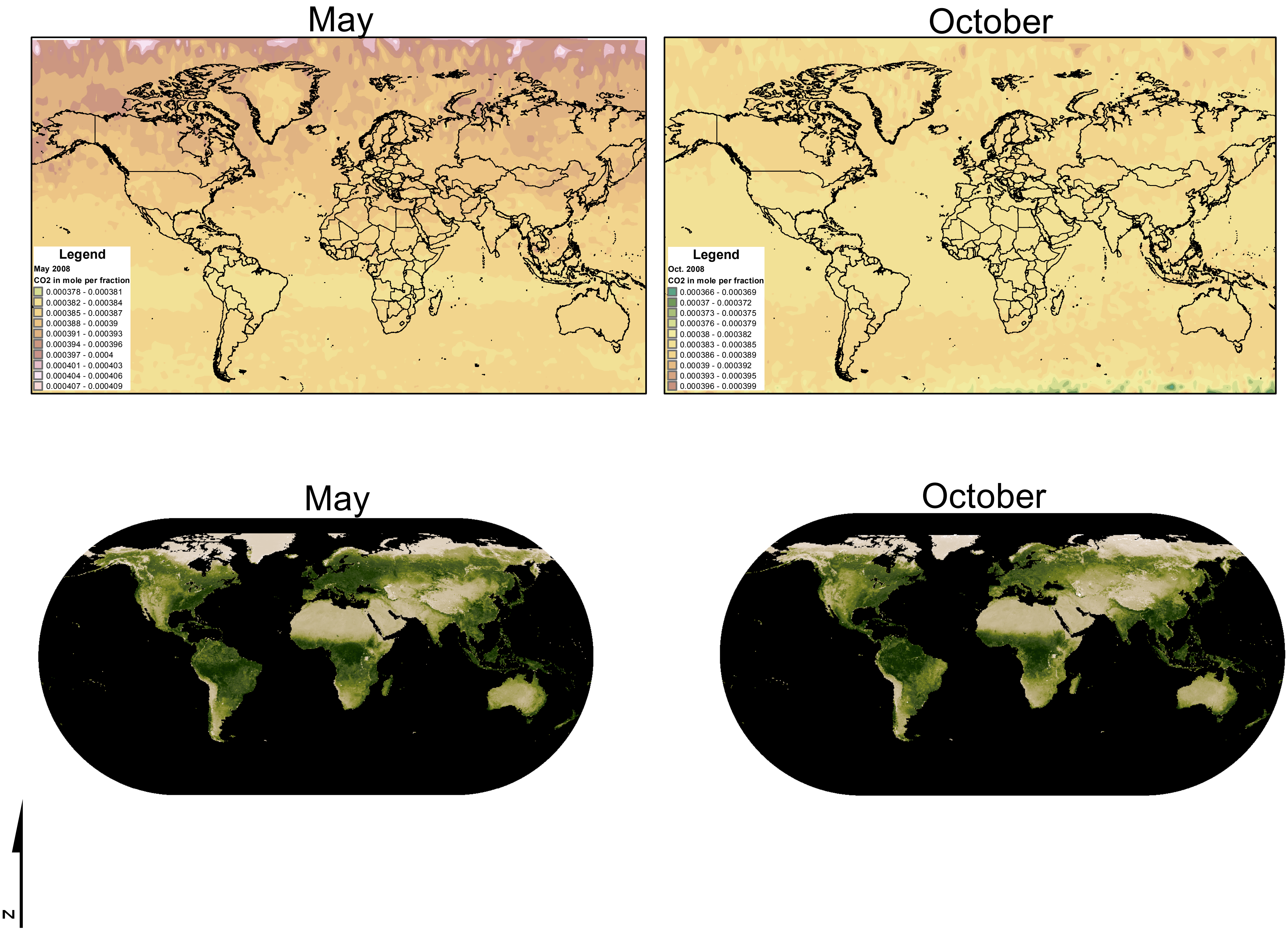
CO2 Fluctuations 2008



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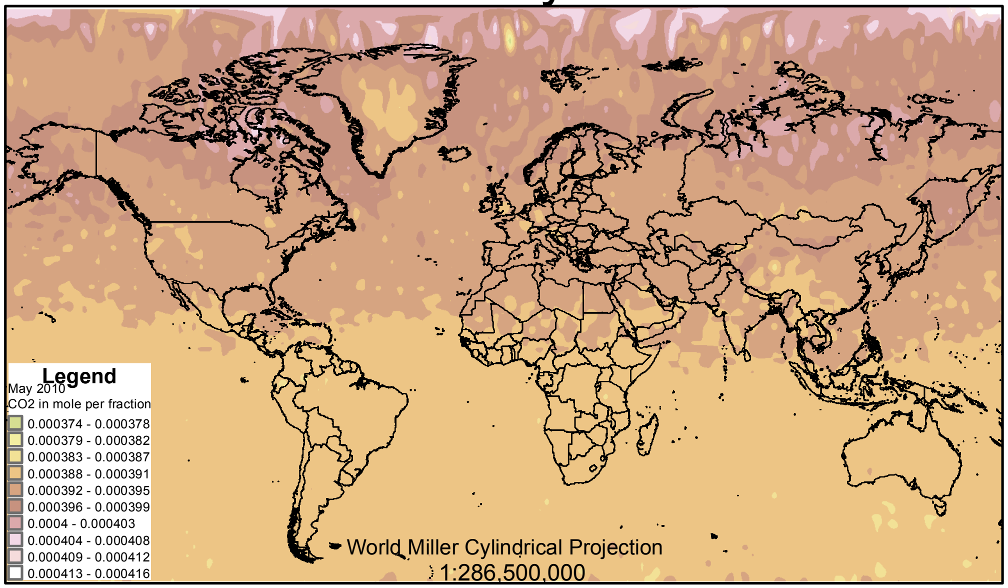
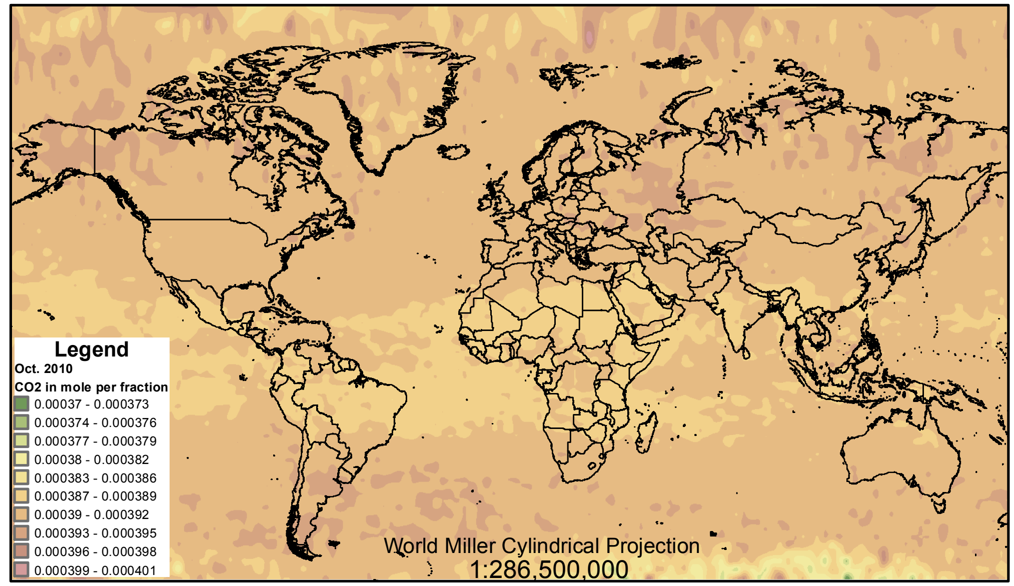
CO2 Fluctuations 2010

May



October



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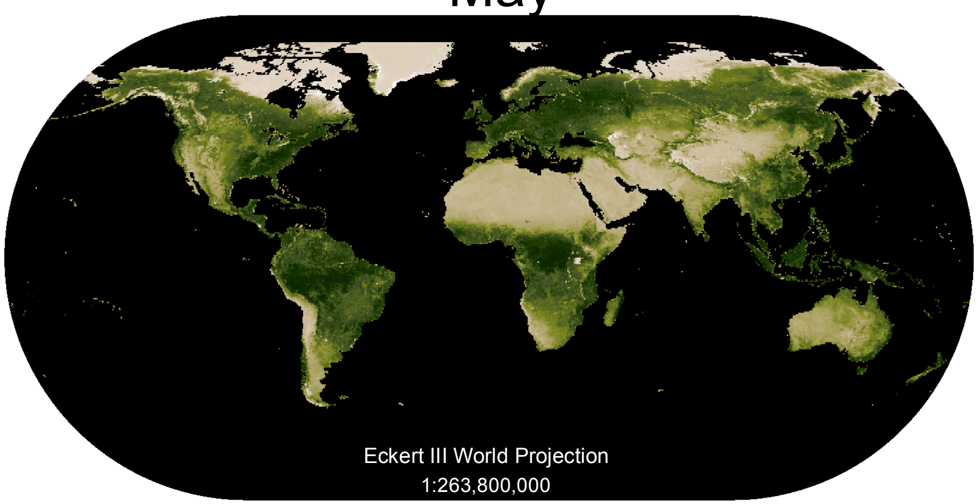
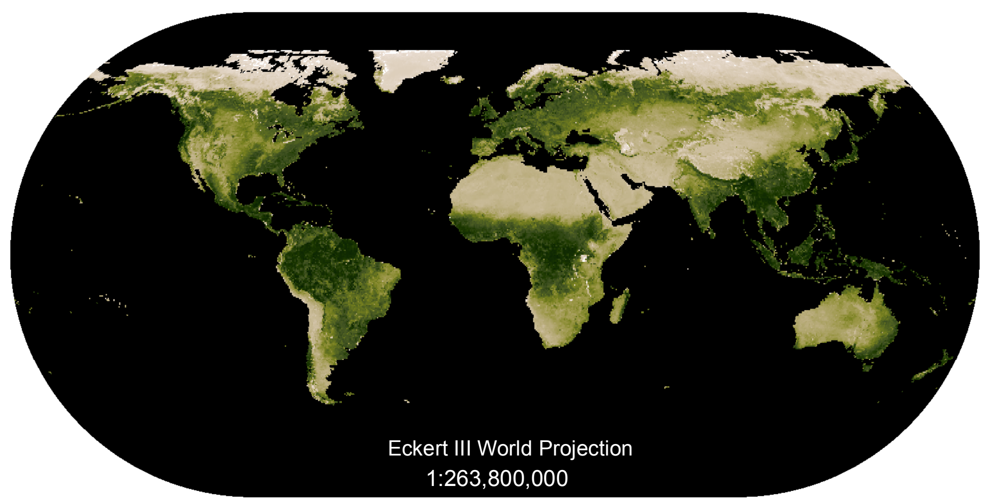


October



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