

Laboratory 3 of ATMS 121 Introduction to Climate Change and its Environmental Impacts

“How to respond to the question, was the last big weather event caused by climate change?”

Introduction:

The atmosphere and oceans have complex fluid motions ultimately due to the chaotic nature of fluid flow in energetic systems like the Earth. However, certain regularities exist even in chaotic systems as “islands of stability in an ocean of chaos”. The solar energy surplus at the equator and deficit at the poles forces the atmosphere and oceans into motion to equilibrate this energy imbalance. Jet streams form in the upper troposphere (from 4 to 10 miles above the surface) as rivers of air moving at speeds up to about 250 miles per hour. Jet streams steer regions of low and high pressure around the Earth, causing storms and heat waves. So when someone asks, “Was that last heat wave or hurricane or flood or wind event caused by global warming?”, one can answer glibly that “gee, atmospheric motions are chaotic and complex so who knows, maybe global warming caused it.”

Global warming and climate change science are about understanding the longer term weather. However, the atmosphere has what are called “teleconnection patterns” as regular behaviors of the climate system. A list of these patterns (from <http://www.cpc.ncep.noaa.gov/data/teledoc/teleintro.shtml>) includes:

Prominent patterns over the North Atlantic

- North Atlantic Oscillation (**NAO**), exists in all months
- East Atlantic Pattern (**EA**), exists in all months

Prominent patterns over Eurasia

- East Atlantic/Western Russia pattern (**EATL/WRUS**), exists in all months
- Scandinavia pattern (**SCAND**), exists in all months
- Polar/Eurasia pattern , exists in all months

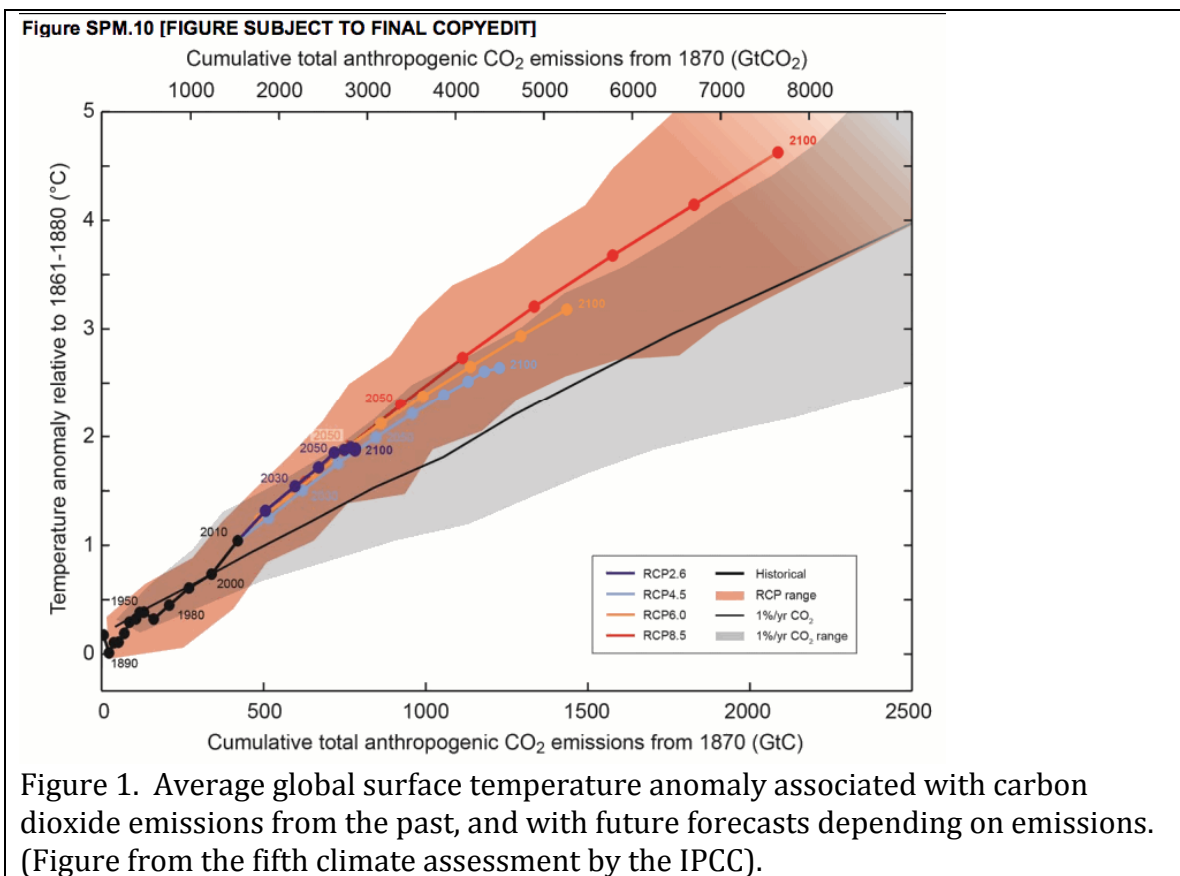
Prominent patterns over North Pacific/North America

- West Pacific pattern (**WP**), exists in all months
- East Pacific - North Pacific pattern (**EP-NP**), exists in all months
- Pacific/North American pattern (**PNA**), exists in all months
- Tropical/Northern Hemisphere pattern (**TNH**), during December-February
- Pacific Transition pattern (**PT**), exists during August-September

Certain more or less regular behaviors can be expected during the positive and negative phases of these patterns. Seasonal forecasts are based mostly on these patterns. The time scales for these patterns are from weeks to months to years to decades. The El-Niño Southern Oscillation we studied in class is another example of these patterns. Why do these patterns exist and how are they related? These are

deeper questions than can be answered here, or can be answered at all. We can study these patterns as a possible explanation for extreme weather events. For example, maybe an extreme heat wave in Canada was associated with a strong positive oscillation of the Pacific North American (PNA) pattern.

The great dilemma of climate science is that we must acquire data over the course of a long time to average out 'mere' weather events or climate pattern behaviors before we can begin to understand for sure that anthropogenically caused climate change is causing the weather to change. Our simplistic and most direct method for analyzing anthropogenic climate change, linked with carbon dioxide emissions, is through monitoring of average global surface temperature, and future forecasts are for more of the same (more emissions, higher temperatures) as shown the Figure 1.



Researchers are also studying the likelihood of extreme weather in a warmer world.

Framework for studying the weather and climate change connection

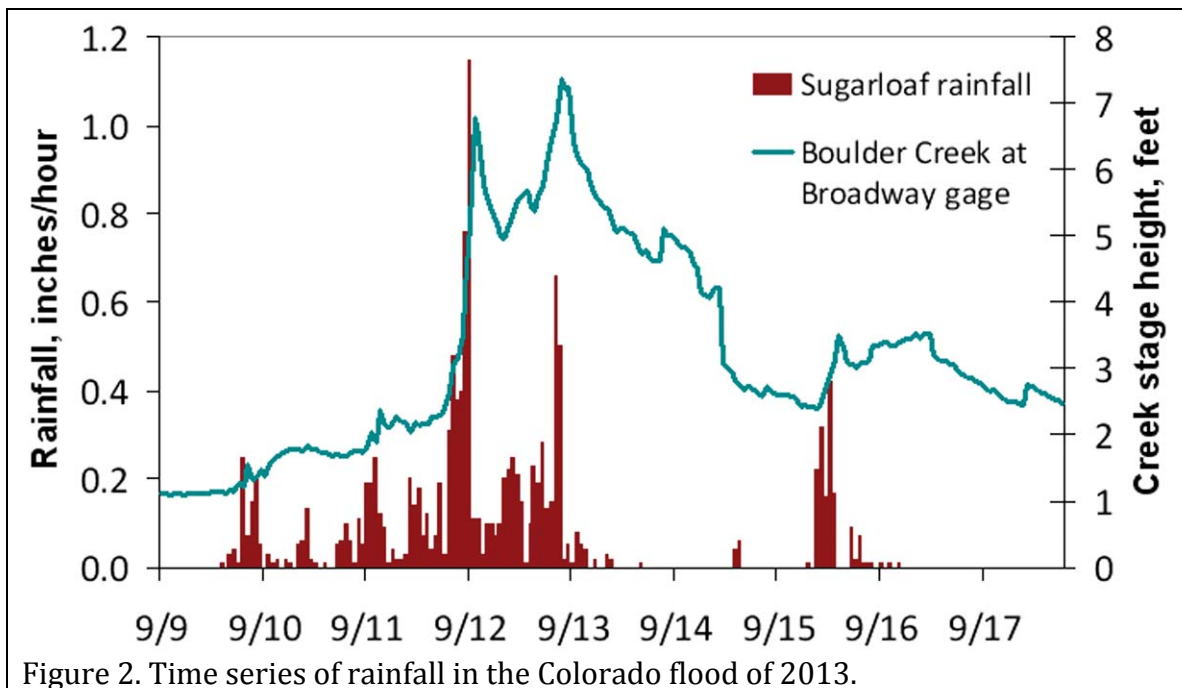
We'll use the Colorado flood to illustrate a framework for studying whether or not an extreme weather event was likely to be caused by global warming. Here is the plan.

1. Collect measurements describing the event
2. Compare the measurements with the previous record
3. Study the weather conditions surrounding the event*
4. Evaluate if the weather conditions were merely an extremely unlikely occurrence of contributing factors
5. Evaluate the parts of the weather conditions that seem common or emergent in other extreme weather events as perhaps a new mode of interaction of the atmosphere

* We will focus on this step in the lab

We will work with the rainfall time series at Sugarloaf Colorado, (Fig. 2),
40.017 degrees north latitude
-105.407 degrees west longitude

We will calculate and evaluate the back trajectory analysis (where the air was at before it arrived at Sugarloaf).



LAB PROCEDURE:

1. Go to the HYSPLIT model website.
<http://ready.arl.noaa.gov/HYSPLIT.php>
2. Choose "Run HYSPLIT Trajectory Model"
3. Choose "Compute archive trajectories"
4. Choose the "EDAS" model. Enter the latitude and longitude of Sugarloaf CO. See Fig. 3. Click "next" when done.

Meteorology & Starting Location(s)

Trajectory Calculation

Meteorology: EDAS 40km (U.S., 2004-present) [More info ▶](#)

Source Location (enter using **one** of the following methods):

Decimal Degrees Latitude: 40.017 N Longitude: 105.407 W

[Get Lat/Long from Google Maps](#)

DDD/MM/SS Latitude: [] [] [] N Longitude: [] [] [] W

City (Country or State: name: lat: lon): []

Airport or WMO ID (i.e., dca): [] [ID Lookup](#)

Figure 3. Meteorology and location setup for running the HYSPLIT model.

5. Choose the meteorology file as shown in Fig. 4. Click next when done.

Meteorology File

Meteorology: Archived EDAS40

Source Location: Lat: 40.017000 Lon: -105.407000

Choose an archived meteorological file

Archive File: edas.sep13.001

[Next>>](#)

Figure 4. Meteorology file choice for running the HYSPLIT model.

6. Set up the model as in Figures 5 and 6.

Model Run Details

The archived data file (EDAS40) has data beginning at 09/ 1/13 0000 UTC.

Model Parameters

Trajectory direction: Forward Backward (Change the default start time!) [More info ▶](#)

Vertical Motion: Model vertical velocity Isobaric Isentropic [More info ▶](#)

Start time (UTC): year month day hour [More info ▶](#)
Current time: 07:15

Total run time (hours): [More info ▶](#)

Start a new trajectory every: 0 hrs Maximum number of trajectories: 24 [More info ▶](#)

Start 1 latitude (degrees): 40.0170C [More info ▶](#)

Start 1 longitude (degrees): -105.407 [More info ▶](#)

Start 2 latitude (degrees): [More info ▶](#)

Start 2 longitude (degrees): [More info ▶](#)

Start 3 latitude (degrees): [More info ▶](#)

Start 3 longitude (degrees): [More info ▶](#)

Level 1 height: meters AGL meters AMSL [More info ▶](#)

Level 2 height:

Level 3 height:

Display Options

GIS output of contours? None Google Earth (kmz) GIS Shapefile [More info ▶](#)

Figure 5. Settings for the meteorological model, part 1.

Display Options

GIS output of contours? None Google Earth (.kmz) GIS Shapefile [More info](#) ▶

The following options apply only to the GIF, PDF, and PS results (not Google Earth or Google Maps)

Plot resolution (dpi): [More info](#) ▶

Zoom factor: 70 [More info](#) ▶

Plot projection: Default Polar Lambert Mercator [More info](#) ▶

Vertical plot height units: Pressure Meters AGL Theta [More info](#) ▶

Label Interval: No labels 6 hours 12 hours 24 hours [More info](#) ▶

Plot color trajectories? Yes No [More info](#) ▶

Plot source location symbol? Yes No [More info](#) ▶

Distance circle overlay: None Auto [More info](#) ▶

U.S. county borders? Yes No [More info](#) ▶

Postscript file? Yes No [More info](#) ▶

PDF file? Yes No [More info](#) ▶

Plot meteorological field along trajectory? Yes No [More info](#) ▶

Note: Only choose one meteorological variable from below to plot

Dump meteorological data along trajectory: [More info](#) ▶

- Terrain Height (m)
- Potential Temperature (K)
- Ambient Temperature (K)
- Rainfall (mm per hr)
- Mixed Layer Depth (m)
- Relative Humidity (%)
- Downward Solar Radiation Flux (W/m**2)

Figure 6. Settings for the meteorological model, part 2.

7. Request the trajectory (bottom of Fig. 6). Save the 'gif' file to disk. Save the 'Google Earth .kmz' file to disk. (See Fig. 7).

Click on text link to view images in a new window.

RESULTS	GIF Plots	PDF Plots	Google Earth	Google Maps
Trajectories	.gif	.pdf	.kmz	.kmz

Figure 7. Files to save to disk. Click on the link .kmz link to open the trajectory in Google Earth.

PREPARE A BRIEF REPORT USING MS WORD, INCLUDING THE FOLLOWING.

1. A brief description of the Colorado flood in September 2013.
2. Import your .gif file and describe it.
3. We will prepare and save a file from Google Earth too, showing more details than available on the .gif file. Import it and describe it.
4. Answer the question "Was the Colorado flood caused or affected by global warming?" You can look up discussion on the topic; be sure to reference anything you add from someone else.

Turn in your report using webCampus.

For reference, here are the 10.7 micron (IR) satellite images from around 06z on the 9th (Fig. 7) and 12th (Fig. 8) of September, 2013. They show a stream of mid level moisture from the Pacific, by the Baja California, in Colorado.

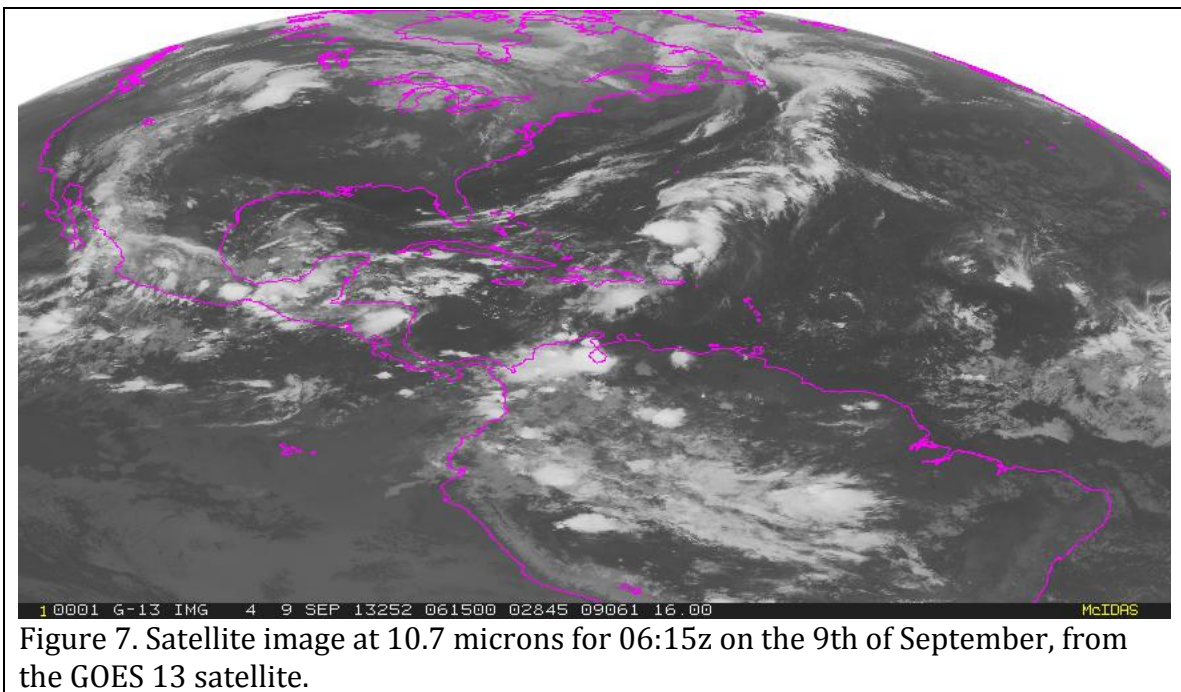


Figure 7. Satellite image at 10.7 microns for 06:15z on the 9th of September, from the GOES 13 satellite.

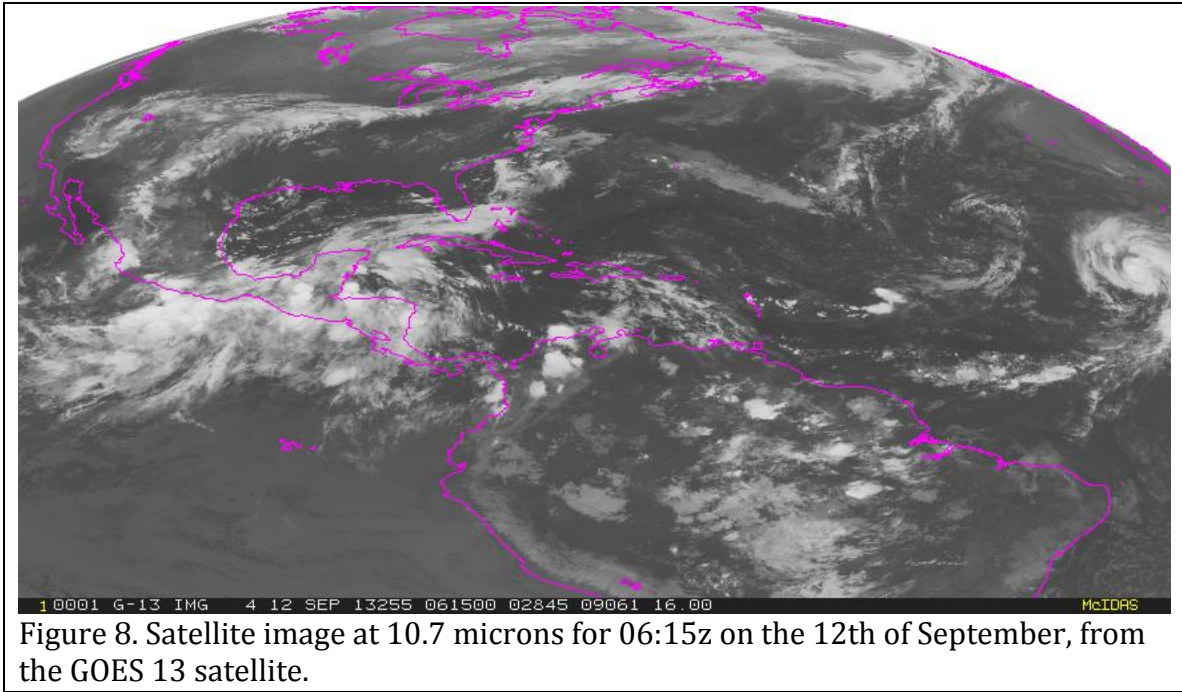


Figure 8. Satellite image at 10.7 microns for 06:15z on the 12th of September, from the GOES 13 satellite.