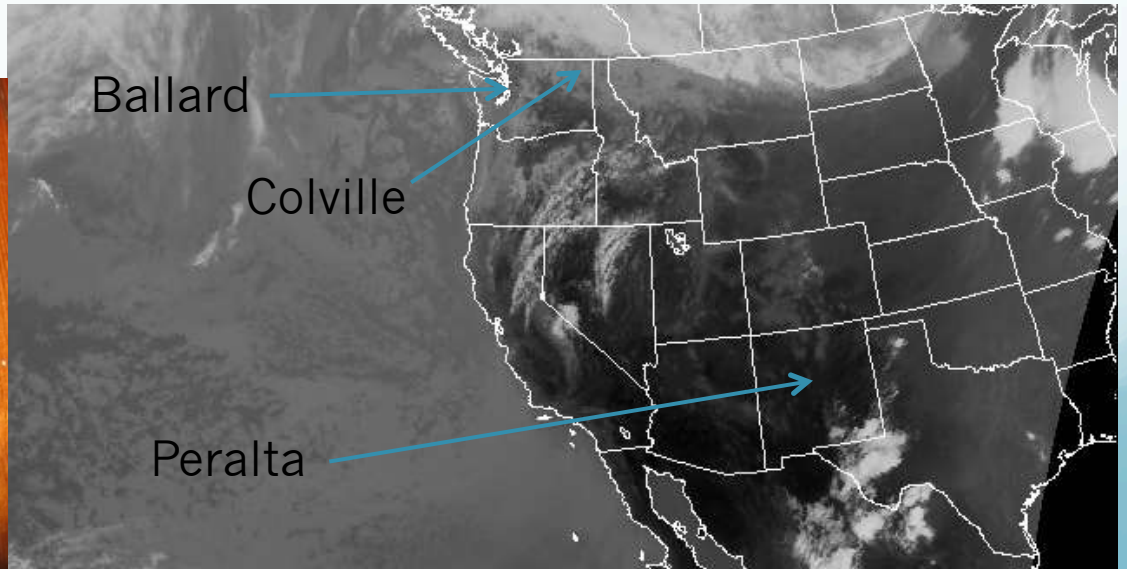
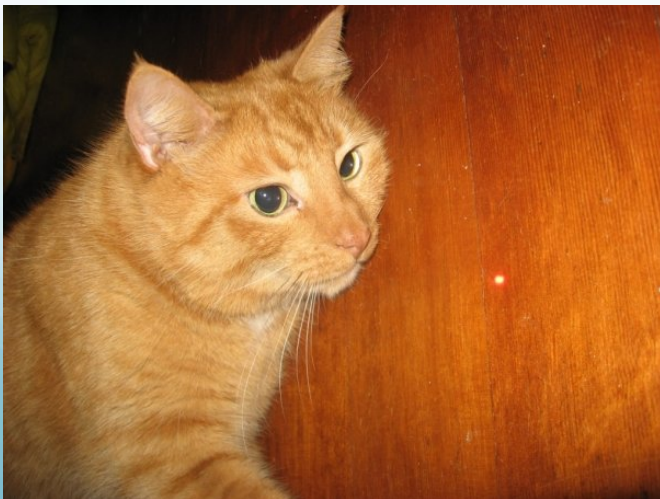


ATM S 111: Global Warming Class Overview

Jennifer Fletcher
Day 1: June 21 2010

About Me

- Jennifer Fletcher
- 4th year PhD student in atmospheric sciences
- Hometowns: Colville, WA; Peralta, NM; Seattle
- Currently live in Ballard with my husband and our cat



Class Info

- Office: Atmospheric Sciences/Geophysics (ATG) 724.
- Office Hours MW 1-2:30 or by appointment
- Nine week quarter: seven weeks on science, two weeks on debates and solutions.
 - Lecture M-Th, class discussion on Friday.
 - Six homework assignments during the science portion.
 - Comprehensive exam on the science August 5.
 - Paper on a topic of your choice due August 20.

Class Info

- Grading:
- Homework: 45%
- Class participation: 15%
- Exam: 20%
- Final paper: 20%

Goals of the Class

- We're going to learn about:
 - The science behind global warming
 - Impacts of global warming
 - How to critically evaluate what you hear about climate and global warming
 - The role of science in formulating effective societal responses
 - Related issues such as energy alternatives

Tentative Schedule

- Week 1 : Introduction, Solar Radiation and the Greenhouse Effect
- Week 2: Global Warming Forcings and Feedbacks
- Week 3: Global Warming Impacts: Extreme Heat, Floods, and Droughts.
- Week 4: Impacts: Ice, Snow, and Oceans.
- Week 5: Impacts: Hurricanes, Ecosystems, and Agriculture
- Week 6: Climate Records, Paleoclimate, and Climate Models.
- Week 7: Who's Responsible?
- Week 8: Debates and Solutions.
- Week 9: Solutions continued.

First...

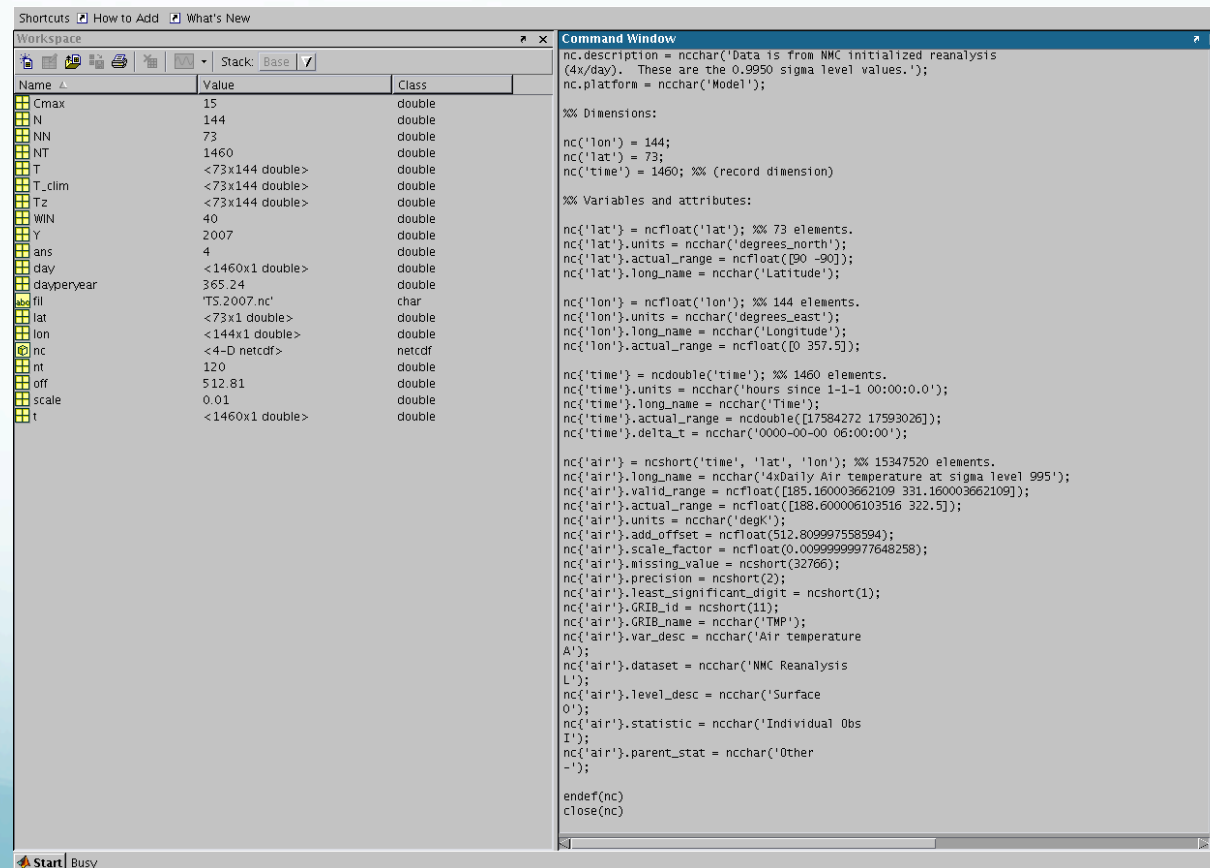
- A basic summary of the science of global warming
- Reading assignment for the summary:
 - *Rough Guide* pp. 3-19, “Climate Change: A Primer”
 - If it’s about restaurants in Prague, you’ve probably got the wrong *Rough Guide*

Weather versus Climate

- Weather varies from one day to the next
- Climate: averages of the weather over a longer period of time
- Examples:
 - Today was 60 and cloudy: weather
 - This winter was drier than usual: climate (not necessarily global warming, though)
 - Nine of the ten hottest years on record are the last nine years: climate (likely due to global warming!)
- Can we predict each of these examples?
 - Yes!

Weather versus Climate

- Weather varies a lot day-to-day
- Individual weather events should generally not be treated as evidence for or against global warming.



The screenshot shows the MATLAB environment. The workspace window on the left lists variables and their classes:

Name	Value	Class
Cmax	15	double
N	144	double
NN	73	double
NT	1460	double
T	<73x144 double>	double
T_clim	<73x144 double>	double
Tz	<73x144 double>	double
WIN	40	double
Y	2007	double
ans	4	double
day	<1460x1 double>	double
dayperyear	365.24	double
fil	'TS.2007.nc'	char
lat	<73x1 double>	double
lon	<144x1 double>	double
nc	<4-D netcdf>	netcdf
nt	120	double
off	512.81	double
scale	0.01	double
t	<1460x1 double>	double

The command window on the right displays the NetCDF variable definitions for the 'air' variable:

```
nc.description = ncchar('Data is from NMC initialized reanalysis  
(4x/day). These are the 0.9950 sigma level values.');
```

```
nc.platform = ncchar('Model');
```

```
%% Dimensions:  
nc('lon') = 144;  
nc('lat') = 73;  
nc('time') = 1460; %% (record dimension)
```

```
%% Variables and attributes:  
  
nc('lat') = ncfloat('lat'); %% 73 elements.  
nc('lat').units = ncchar('degrees_north');  
nc('lat').actual_range = ncfloat([90 -90]);  
nc('lat').long_name = ncchar('Latitude');
```

```
nc('lon') = ncfloat('lon'); %% 144 elements.  
nc('lon').units = ncchar('degrees_east');  
nc('lon').long_name = ncchar('Longitude');  
nc('lon').actual_range = ncfloat([0 357.5]);
```

```
nc('time') = ncdouble('time'); %% 1460 elements.  
nc('time').units = ncchar('hours since 1-1-1 00:00:0.0');  
nc('time').long_name = ncchar('Time');  
nc('time').actual_range = ncdouble([17584272 17593026]);  
nc('time').delta_t = ncchar('0000-00-00 06:00:00');
```

```
nc('air') = ncshort('time', 'lat', 'lon'); %% 15347520 elements.  
nc('air').long_name = ncchar('4xDaily Air temperature at sigma level 995');  
nc('air').valid_range = ncfloat([185.160003662109 331.160003662109]);  
nc('air').actual_range = ncfloat([188.600006103516 322.5]);  
nc('air').units = ncchar('degK');  
nc('air').add_offset = ncfloat(512.809997558594);  
nc('air').scale_factor = ncfloat(0.00999999977648258);  
nc('air').missing_value = ncshort(32766);  
nc('air').precision = ncshort(2);  
nc('air').least_significant_digit = ncshort(1);  
nc('air').GRIB_id = ncshort(11);  
nc('air').GRIB_name = ncchar('TMP');  
nc('air').var_desc = ncchar('Air temperature  
A');
```

```
nc('air').dataset = ncchar('NMC Reanalysis  
L');
```

```
nc('air').level_desc = ncchar('Surface  
0');
```

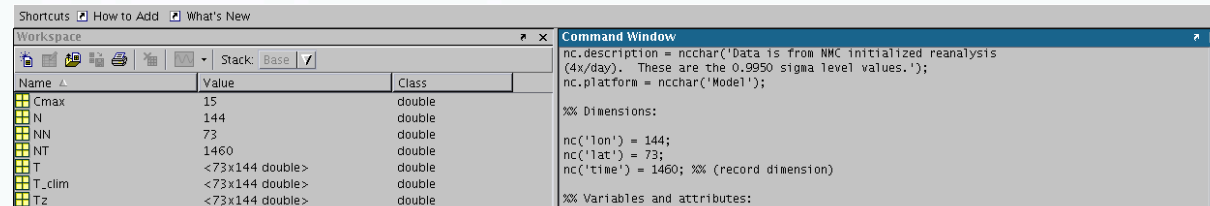
```
nc('air').statistic = ncchar('Individual Obs  
I');
```

```
nc('air').parent_stat = ncchar('Other  
-');
```

```
endef(nc)  
close(nc)
```

Weather versus Climate

- Weather varies a lot day-to-day
- Individual weather events should generally not be treated as evidence for or against global warming.



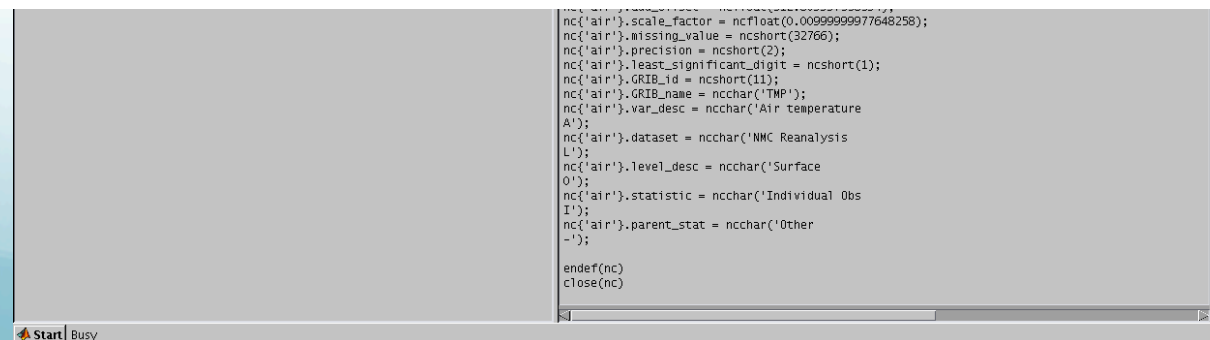
The screenshot shows the MATLAB workspace and command window. The workspace displays variables: Cmax (15, double), N (144, double), NN (73, double), NT (1460, double), T (<73x144 double>, double), T_clim (<73x144 double>, double), and Tz (<73x144 double>, double). The command window shows the following code:

```
nc.description = ncchar('Data is from NMC initialized reanalysis  
(4x/day). These are the 0.9950 sigma level values.');
```

Name	Value	Class
Cmax	15	double
N	144	double
NN	73	double
NT	1460	double
T	<73x144 double>	double
T_clim	<73x144 double>	double
Tz	<73x144 double>	double

```
nc.platform = ncchar('Model');  
  
%% Dimensions:  
nc('lon') = 144;  
nc('lat') = 73;  
nc('time') = 1460; %% (record dimension)  
  
%% Variables and attributes:
```

However, global warming can make some weather events more or less likely in a given region



The screenshot shows the MATLAB command window with the following code:

```
nc('air').scale_factor = ncfloat(0.00999999977648258);  
nc('air').missing_value = ncshort(32766);  
nc('air').precision = ncshort(2);  
nc('air').least_significant_digit = ncshort(1);  
nc('air').GRIB_id = ncshort(11);  
nc('air').GRIB_name = ncchar('TMP');  
nc('air').var_desc = ncchar('Air temperature  
A');  
nc('air').dataset = ncchar('NMC Reanalysis  
L');  
nc('air').level_desc = ncchar('Surface  
0');  
nc('air').statistic = ncchar('Individual Obs  
I');  
nc('air').parent_stat = ncchar('Other  
-');  
  
endef(nc)  
close(nc)
```

Weather versus Climate

- Climate: definitions?

Weather versus Climate

- Examples:
- Chicago is windy, with cold winters and hot summers. Summertime has the most precipitation.
- Seattle is cloudy, with relatively mild winters and summers. Very little precipitation falls during July and August. November is the rainiest month.
- *Climatology*: The average temperature, winds, etc in a given location. Seattle's climatological temperature on June 21st is 71°F, with 0.05 inches of rainfall.

Weather versus Climate

- Climate example: This winter was drier than usual.
- Natural variability can cause seasonal anomalies like this.
- El Nino tends to make warmer, drier than average winters in the PNW.
- La Nina tends to make cooler and wetter PNW winters than average.
- In comparison this winter was colder than average on the East Coast.
- So, is this evidence for/against global warming?

Weather versus Climate

- Climate example: This winter was drier than usual.
- Natural variability can cause seasonal anomalies like this.
- El Nino tends to make warmer, drier than average winters in the PNW.
- La Nina tends to make cooler and wetter winters than average.
- In comparison this winter was colder than average on the East Coast.
- So, is this evidence for/against global warming?
 - Not really, though global warming could **affect** El Nino and other sources of natural variability.

Weather versus Climate

- Another climate example: nine of the ten warmest years on record – averaged over the entire globe – were the past nine years.
- (The tenth was 1998, the year of the strongest El Nino on record.)
- Is **this** evidence for global warming?

Weather versus Climate

- Another climate example: nine of the ten warmest years on record – averaged over the entire globe – were the past nine years.
- (The tenth was 1998, the year of the strongest El Nino on record.)
- Is **this** evidence for global warming?
 - Yes!!

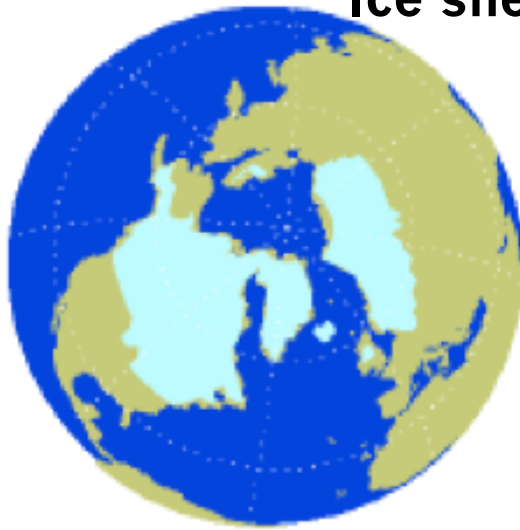
What Factors Influence Climate?

- Sunshine
 - And relatedly, latitude
- Topography/mountains
- Proximity to oceans and large lakes
- Ocean currents
- Presence of trees/vegetation
- Etc.

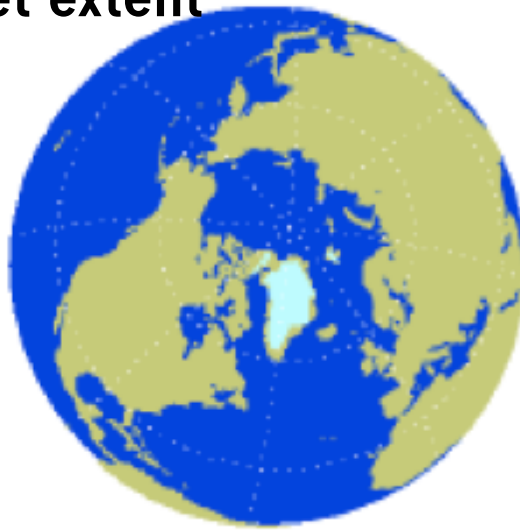
A Sampling of Future Topics

- “Paleoclimate”:
 - **Ice Ages** and hot climates of the past like the **Cretaceous**

Ice sheet extent



Last Glacial Maximum



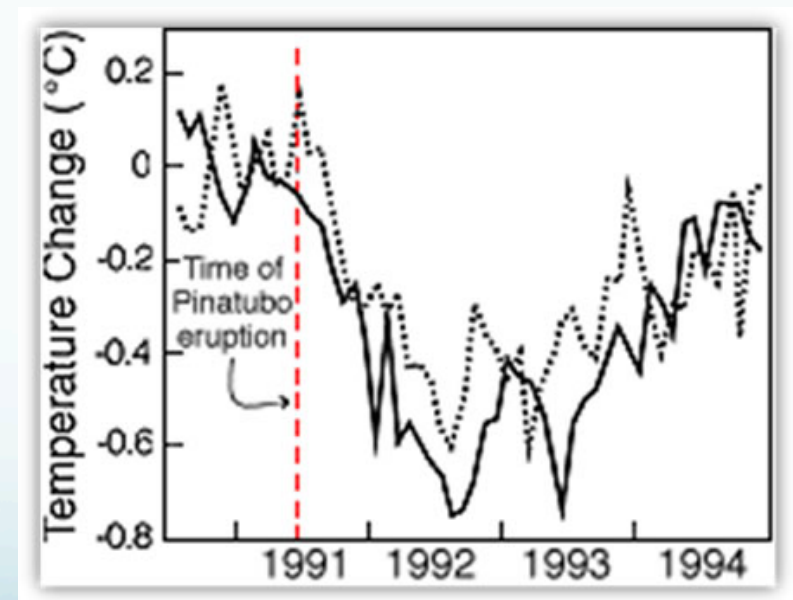
Present



The Cretaceous Seaway

Volcanoes and Climate

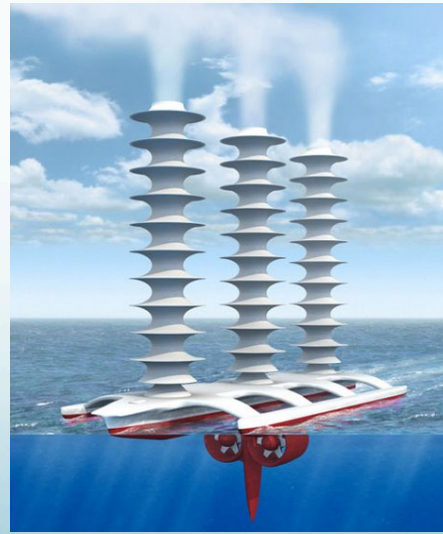
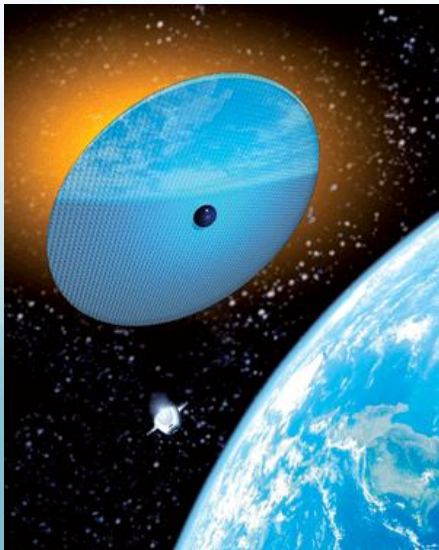
- How the Earth cools after certain types of volcanoes...



Eruption of Mount Pinatubo in June 1991 and its effect on global temperatures

And Human-Made Volcanoes!

- “Geoengineering”: using technology to cool the Earth
- People are considering things like
 - Putting volcanic-type particles into the stratosphere
 - Space mirrors
 - Cloud machines
 - Fake trees



Right picture from Rolling Stone article “Can Dr. Evil Save the World?”

The Effect of Climate on Nature

- Cute animal pictures!!



Climate and the Rainforests

- The effect of burning tropical rainforests on climate
- And the effect of climate change on rainforests



Rainforests burning over
the Brazil-Bolivia border

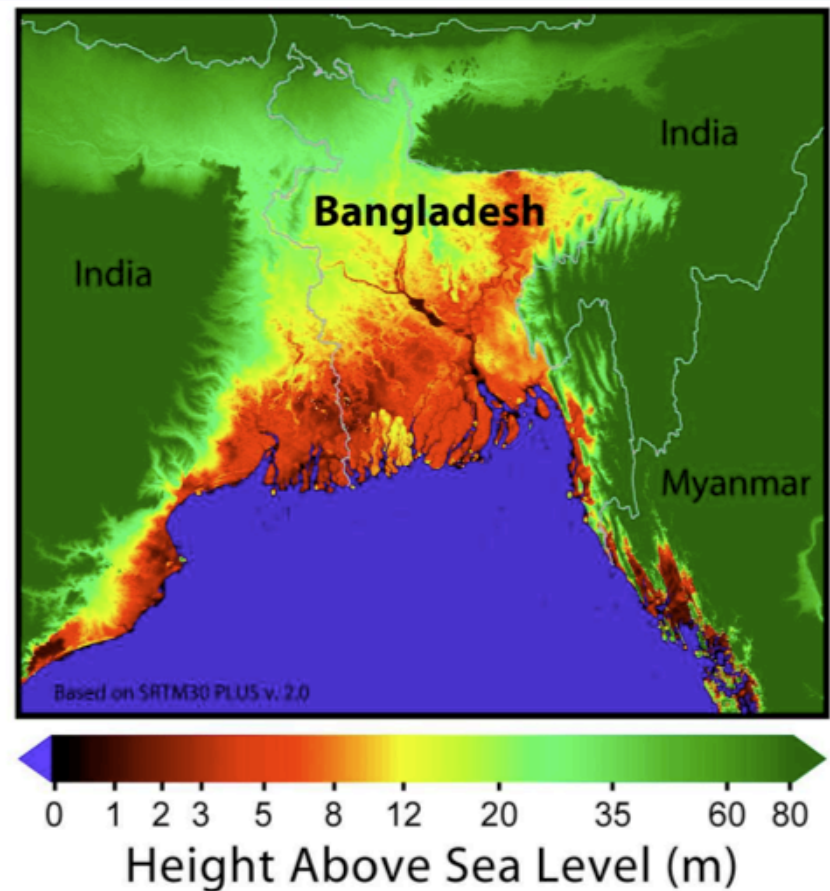
Satellite photo from NASA
(MODIS):
Locations of fires marked
by (enhanced) red dots

Winners and Losers

- Who will benefit...



- And who will it hurt the most?



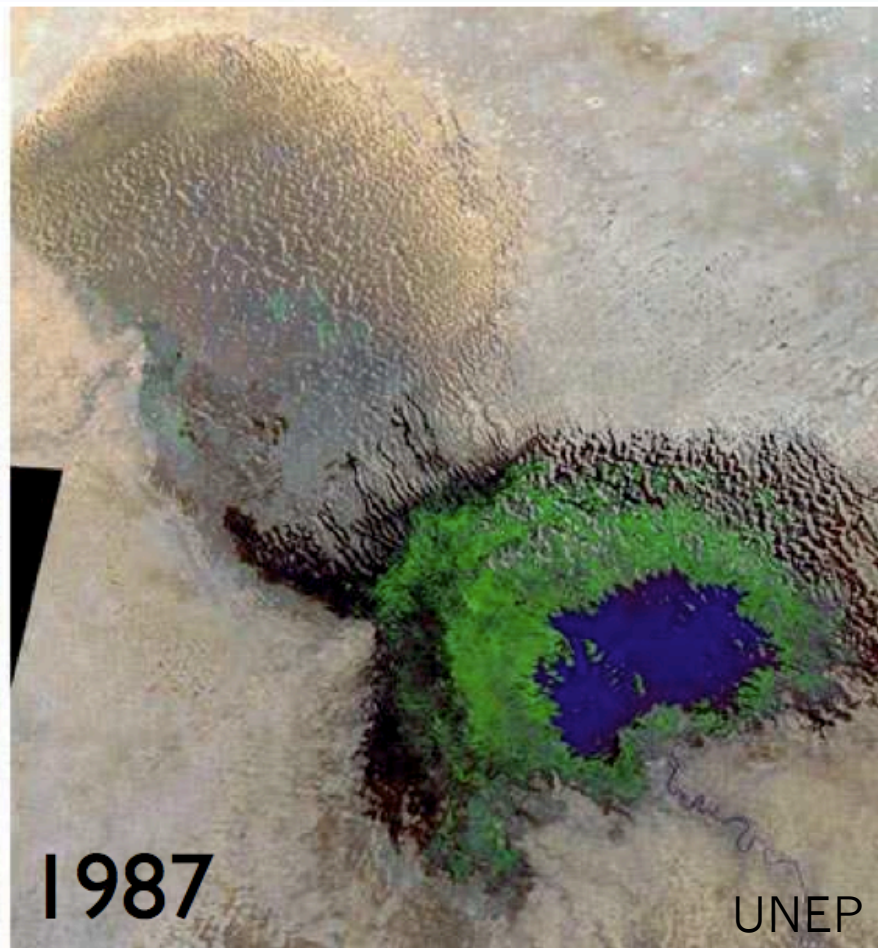
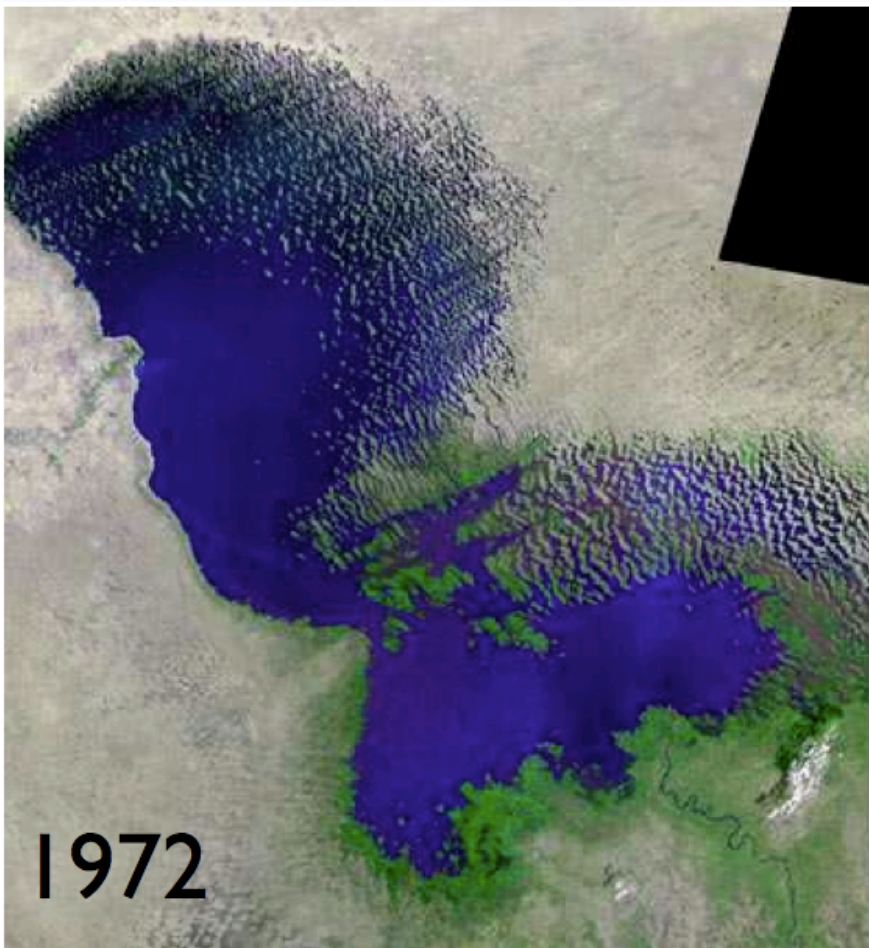
Floods

- Floods in Yemen, October 2008



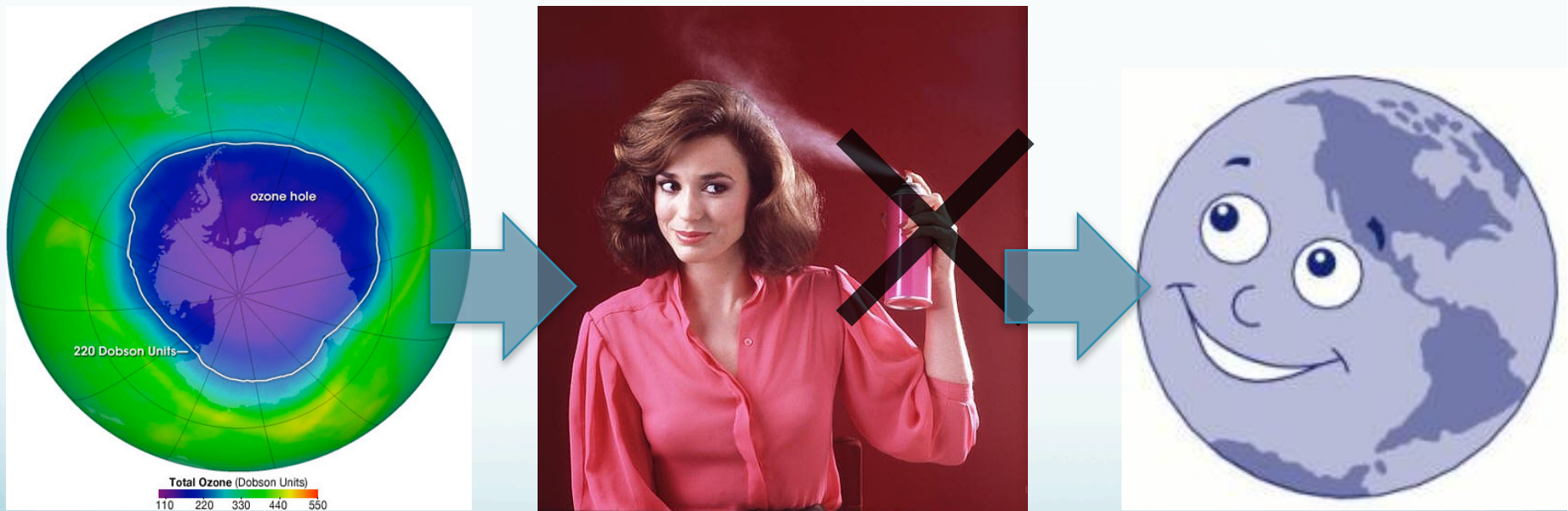
And Droughts...

- Lake Chad



Science and Policy

- The **ozone problem**
 - This was **solved** by the most efficient interaction between **science and policy** to date



Discovery of the ozone hole led to a ban on all CFCs

Why is global warming so much more difficult from a policy perspective?

Global Warming Solutions

