Local Climatic Effects of Coal Fires:
Modeling the Impacts of Subsurface Heating on Temperature and Precipitation

Collapsing coal seam in NW China
Anumpa Prakash- www.ehpnet1.niehs.nih.gov

Global Climate Change and Society (GCCS)
Final Presentation – August 8, 2003
1. This summer I did research with the assistance of John Bergman at NOAA’S Climate Diagnostic Center. The goal of my research was to develop a better understanding of the uncertainties associated with climate modeling. Towards this end, I examined the effect of the subsurface heating of coal fires on local and regional climate. The climate modeling was done through the use of the National Center for Atmospheric Research’s (NCAR) Single Column Model (SCM). Two localities were examined one approximately 40km SE of Urumqi in Western China and another approximately 250km NW of Kolkata in NE India.
Lecture Outline

✔ Where do coal fires occur, what are there causes, and why are they important?

✔ What is the National Climate for Atmospheric Research (NCAR) Single Column Model (SCM) and how can it be used to model the local climatic effects of coal fires?

✔ What are the probable effects of coal fires on surface temperatures, atmospheric temperatures, and precipitation?

✔ What if any are the global impacts of the fires?

✔ How are coal fires similar to other phenomenon, and what useful information was obtained from this research?
2. In this presentation, I will first provide a brief introduction of coal fires including their origins, distribution, costs, and associated hazards. Next, I will describe the two localities and describe some of the ongoing monitoring and fire fighting projects in the areas. Then, I will describe the SCM, and how it was used to model coal fires. In discussing the results of the research, uncertainties in the modeling process will be analyzed. In conclusion, I will briefly address how coal fires are a similar phenomenon to land-use changes, and provide my interpretation of the resulting implications for anthropogenic climate change.
3. Coal fires are a global phenomenon, with fires burning in virtually all areas that have coal deposits. While evidence of coal fires has been found in the geologic record, the magnitude and number of coal fires has increased dramatically since the beginning of coal mining operations. Coal fires can start by spontaneous combustion, by they are often caused by illegal mining in India and China. The famous coal fire of Centralia, PA was started when a trash dump burst on fire. The United States, including Colorado, have dozens of fires that are continuing to burn, and coal fires often burn for decades and even centuries. The fire last summer near Glenwood Springs that destroyed nearly 100 homes, and resulted in over 6 million dollars in damage was caused by a burning coal seam. Coal fires in China alone release more CO2 per year, than all the vehicles in the United States combined. Costs of the China coal fires are on the order of $1.25 Billion USD a year in terms of lost coal reserves alone. The pollution caused by these fires affects air, water, and land. Smoke, from these fires contains poisonous gases such as oxides and dioxides of carbon, nitrogen and sulphur, which along with particulate matter are the causes of several lung and skin diseases. High levels of suspended particulate matter increase respiratory diseases such as chronic bronchitis and asthma.
Distribution of Coal Fires in China

Based on Kijk (1995, no. 8, p. 29)
Distribution of Coal Fires in India
Landsat TM Satellite Image of the Jharia Coal Field

The area of the image is approximately 38 km x 19 km
National Center for Atmospheric Research (NCAR)
Single Column Community Climate Model (SCM)
7. The Single Column Model is a one-dimensional time-dependent model where the local time-rate-of-change of the large-scale state variables depend on specified horizontal flux divergences, as well as a specified vertical motion field. The research goal was to attempt to parameterize circulation on space scales smaller than the width of the column. The SCM incorporates a grid size of approximately 24,000 km². The coal fires are no larger in area than a square kilometer, and it is unlikely that the SCM can handle the turbulent mixing of that extreme heating.

The strategy was to examine what happens as the dimensions of the SCM approach the dimensions of the coal fire. The goal is to see if the impact of coal fires can be determined from asymptotic behavior (limiting).
Use of the NCAR SCM Model

- A 1-D time-dependent model
- Local time-rate of change dependent on specified horizontal fluxes and vertical motion field
- The grid size is approximately 24,000 km²
- Coal fires are no larger than 1 km², unlikely to accurately model turbulent mixing
- Strategy to examine the effects of subsurface heating as the dimensions of the SCM approached the dimensions of the coal fire.
- Are coal fires limited by asymptotic behavior?
Sample Model Outputs

Surface Temp.

Total Precipitation.

Temperature Profile
India
Local Climatic Effects of Coal Fires

Change in Temp. (°C)

Coal Fire Area as Percentage of Column (%)

Soil Temperature
Air Temperature
Precipitation

Change in Rainfall (mm)
China Surface Temperatures

Percentage of Column per line (ascending)
0.3%, 2.5%, 4.17%, 5.83%, 8.5%, 8.83%, 9.17%, 11.67%, 13.33%
Soil Model Saturation

India
Local Climatic Effects of Coal Fires (0-15%)

Notice: lack of variability prior to .8%
China
Local Climatic Effects of Coal Fires

Soil Saturation Takes Place at ~8% of Column
Conclusions

1. Coal fires result in an increase in temperature and precipitation.
2. The rate of increase is dependent on local conditions, in India over 200,000 people live within 100 km² of the fires.
3. Preliminary results are:
   • India – Within 100 km² there would be an increase in temperatures on the order of 1-3 degrees C, and rainfall of 1-2 mm/day.
   • China – Within 10 km² there would be an increase in temperature on the order of 10 degrees C, and rainfall of 0.5-1.5 mm/day.
4. These results have a high degree of uncertainty due to the dissipation of heat away from the single column, which will most likely decrease the temperature increases and possibly decrease the increases in precipitation, as well as uncertainties in the model.
5. Global effects due to subsurface heating appear minimal although the release of green-house gases, primarily CO₂ has a considerable impact.
6. In comparison with the changes in temperature associated with urban heat islands, the results of this simulation model as a real world probe appear possible.
Urban Heat Island

http://employees.oneonta.edu/baumanpr/geosat2/Urban_Heat_Island/Urban_Heat_Island.htm
Landsat TM Imagery of Washington, DC

Urban Heat Island

Rock Creek Park: Three Color Composites

A  B  C

Red  Band 6 Not Stretched  Red  Band 6 Stretched  Red  Band 6 Stretched
Green Band 4 Not Stretched  Green Band 4 Stretched  Green Band 4 Not Stretched
Blue  Band 4 Not Stretched  Blue  Band 4 Stretched  Blue  Band 4 Not Stretched

Special Thanks:

John Bergman for all of his assistance this summer.

And to the mountains for existing.

“There are no defensible epistemological grounds for challenging reliance on climate modeling results in global-change policy deliberations. Models of data and simulation models are not mere heuristic devices.” (Norton and Suppe, 2001)