“Air Quality in Sichuan: A Comparative Analysis”

Preliminary Research Proposal

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I. Introduction

Since the late 1970's China has experienced rapid socioeconomic growth, industrialization, increased energy consumption, and urbanization. Coupled with this unprecedented growth has been an equally daunting increase in air pollution associated with the increased consumption of energy and increased vehicle use (The National Academies, 2004).

In 2003, China became the second largest consumer of energy in the world, second to the United States. Most of the energy consumed in China, approximately 70% comes from coal and as a result the ~~countries~~ country's air and overall environmental quality has suffered (The National Academies, 2004). Many research articles have pointed to SO_2, NO_x, TSP and ozone as the major pollutants present in the Chinese atmosphere that doesn't make it very different from anywhere else, does it? and have used measurements of these compounds' concentrations and decomposition pathways to forecast China's future air quality. These models were developed to help shape Chinese environmental policy decisions and understand the threats associated with each air quality forecast (Huebert et al, 2003 and Junling et al, 2001). However, many models have vastly under-estimated the growth of the Chinese economy in the past few years because they used a linear relationship to model yearly growth. Interesting observation. Is this your own critique or one that you read in the literature? Thus, energy consumption and associated air pollution have also been underrepresented. Several of the authors also pointed to a lack of field data for rural regions of China as a source of possible inaccuracy, focusing their field measurements on Beijing, Shanghai, Japan, Taiwan, and other heavily populated Eastern coastal regions. Computer and satellite imaging was used to collect data for other regions (Huebert et al, 2003). I get the point, but I think you need to make it clearer that Japan and Taiwan are not "heavily populated Eastern coastal regions" of China.

II. Problem Statement

This project aims to determine the accuracy of current models at identifying trends in China's air pollution concentrations and dispersion mechanisms, specifically in areas that have previously lacked in-situ measurements of pollutant levels. The field testing will be focused in South Central China in the city of Chengdu, Sichuan Province and surrounding rural areas. The combined data will be used identify trends with more current data, address the rural impact to and from air pollution, and to examine ways to address the problem locally, nationally, and globally. A really nice idea.

The project will aim to answer the following four (4) questions:

(1) What major air pollutants are present in the city of Chengdu and surrounding rural areas? I would try to concentrate on developing a rather detailed spatial model of the distribution on the Chengdu plain, and perhaps (though not necessarily) in nearby mountainous areas where the distribution might be different. As an anthropologist, I'm always interested in the *local* distribution of just about everything, and thus inherently suspicious of large-scale generalizations, even if it's about pollutants. But more than just that, I know that when I go to Liangshan, there are stars beyond number in the sky, and in Chengdu you could easily grow up and not have any concept of "star." So what's the point in talking about "China"?

(2) How do these concentrations compare with models developed in previous studies?

(3) How does this data compare with air pollution, economic growth, and environmental protection trends in the United States? Less important, unless you think that the US experience can serve as a direct model (positive or negative) for Chinese planners.

(4) What are the probable sources of the detected compounds and how can harmful levels best be addressed ~~es~~?

III. Background Information

(i) *Economic and Emission Trend Data.*

Since China's economic reform, which took place beginning in the late 1970s, it has achieved unprecedented socioeconomic growth, industrialization, increased energy consumption and urbanization. The total energy consumption has increased approximately 200% from 1980 t0 2004 (Yi et al, 2006). The major contributors to air pollution have been identified by Yu, Hao, and Tang (2006) as power sector emissions, mainly from power plants, and vehicular emissions. Since the late 1970's China's motor vehicle fleet has increased 10-fold and estimates by U.S. National Academy of Engineering and the Chinese Academy of Science (2003) show vehicle populations more than tripling in the next 25 years. China also has 5-10 times higher emissions factors (amount of pollution emitted per car) than in developed countries because of lower efficiency standards (Streets and Waldhoff, 2000). Yipes. But the good side is that this means there is a lot of room for fairly easy improvement. The real villains here, I suspect, are Volkswagenwerk A.G. and the Ford Motor Company, who won't listen to anything except coercion. This has lead to higher concentration of NOx and particulates (National Academy of Engineering, 2004). Unless steps are taken to address the pollution caused by vehicles, this increase in emissions will have drastic effects ~~of~~ on the

Chinese atmosphere. The combustion of fossil fuels, predominantly gasoline, diesel fuel, and coal, in automotive engines and coal-fired power plants releases a variety of toxic substances into the atmosphere. Among the most prevalent are: carbon monoxide (CO shouldn't be a problem as long as people run their cars outdoors), volatile organic compounds (VOCs), nitrogen oxides (NO_x), fine particulate matter (PM_{10} and $PM_{2.5}$), and nitrogen dioxide (NO_2) (An et al, 2001).

(ii) *Sulfur Compounds (SO_2 and SO_4^{2-})*

The main contributor to sulfur pollution, 85%, is sulfur dioxide (SO_2) emissions form coal combustion (Yi et al, 2006). High SO_2 concentrations lead to high aerosol sulfate (SO_4^{2-}) concentrations, as SO_4^{2-} is primarily produced through the oxidation of SO_2 through several different pathways, including gar-phase oxidation to sulfuric acid and aqueous-phase oxidation in cloud droplets. Sulfate concentrations are typically much higher than sulfur concentrations, which is a condition that is unique to the Asian situation (Xu and Carmichael, 1999). Aqueous phase, or wet, sulfur decomposition is the predominant pathway for sulfur removal. Aerosol sulfate has been identified as a major contributor to light scattering, cloud condensation nuclei, and as an acidifying agent leading to acid rain (Zhang et al, 2005). Acid rain, or washout, is the main removal pathway for aqueous-phase sulfur. Generally, surface sulfur concentrations are higher in the winter months and lower in the summer probably due to lower dispersion rates in winter (Xu and Carmichael, 1999). I'm guessing it has a lot more to do with higher consumption for heating in the winter. This would be a more-or-less nationwide trend, while dispersion rates would depend on local wind patterns. In some parts of Sichuan, the winter is dry and windy, and the summer wet and still, which would run contrary to the Xu and Carmichael hypothesis.

Levels of SO_2 emissions have decreased slightly since the mid-1990s. This has been a result of use of cleaner, low-sulfur coal and installation of flue-gas desulphurization technology now required of power plants. However, it is projected that sulfur emissions in Asia will exceed that of North America and Europe by 2010 without further controls on emissions (Xu and Carmichael, 1999).

(iii) *Nitrogen Oxides (NO_x).*

Nitrogen oxides (NO_x) are caused by both vehicle exhaust and coal burning. In recent years, the proportion of nitrate radical ion has increased in acid rain, indicating an increase in overall emissions of NO_x and NO_2. This is due to the sharp rise in vehicle ownership and the comparative lack in control mechanisms for NO_x, especially from stationary sources (Yi et al, 2006).

(iv) *Particulate Matter (TSP, PM_{10} and $PM_{2.5}$)*

For the past three years PM_{10} has been the predominant pollutant in most Chinese cities. Particulate matter is composed of a range of compounds. The larger PM_{10} is mainly sulfate, black soot, organic carbon and to a lesser extent, dust (Tie et al, 2006). In contrast, $PM_{2.5}$ is in large majority a secondary pollutant formed through transformations of gas-phase SO_2, NO_x, and VOCs (NAE, 2004).

(v) *Ozone (O_3)*

Ozone is a secondary pollutant that is caused by reaction of NO_x and VOCs in the presence of ultraviolet radiation. This ground level ozone is a major contributor to the visibility-obscuring smog prevalent in many of China's large cities. Exposure to ozone can cause eye irritation, plant damage, respiratory problems, and the deterioration of rubber and paint (NAE, 2004).

(vi) *Carbon Monoxide (CO)*

The main contributor to CO emissions is incomplete combustion of biofuels also coal, especially the coal briquettes known as *feng wo mei* (beehive coal) burned in many home stoves in inefficient stoves. This comprised approximately 64% of total CO emissions as calculated RAINS-ASIA and EDGAR models (Streets and Waldhoff, 2000). Thus, the CO concentrations in China are considerably higher in urban areas than in remote unpopulated areas because of the higher density of biofuel-burning stoves (Tie et al, 2006).

(vii) *Environmental Policy Trends*.

To attempt to mitigate some of the most severe air pollution China has begun to adhere to more strict environmental standards. As of July 2000 leaded gasoline was banned, starting in Beijing. In 2004 China adopted Euro II vehicle emission standards, allowing only 50ppm of what? on all new cars and trucks (NAE, 2004). China began to control small particulate emissions in the 1980s and has since seen a decrease in air pollution levels (Yi et al, 2006). Monitoring and control of particulate matter is now more stringent than in the United States. However, concentrations of many pollutants still exceed U.S. Environmental Protection Agency (EPA) and World Health Organization (WHO) standards and air pollution remains a pressing environmental and health concern and steps should continue to be taken to further decrease pollution and mitigate its effects, especially with the continued rapid growth of energy use(Yi et al, 2006).

V. Methods

(i) *Methodology*.

To obtain the data used for analysis I will monitor levels of sulfur dioxide, nitrous oxides, particulate matter, ozone, and carbon monoxide. This can be done through sampling and analysis of air and sometimes water or soil at each site. Sampling soil and water can further exhibit the effects of harmful pollutants on the ecosystem, by seeing how it affects soil and water composition.

(ii) *Equipment*.

Common laboratory instruments, chemicals, and supplies can be used to carry out these tests, as well as some simple industrial air monitoring devices.

VOC, TSP, filter??

(iii) *Procedure*.

I am in the process of designing exact laboratory techniques and identifying the equipment I will need. OK; this is important. Bharath and Yuh-chi never got the equipment, though apparently they may get it this week. For you, it would be nice to avoid this kind of run-around.

(iv) *Site Selection*.

The Chengdu Plain [and surrounding mountainous areas?] is an ideal location for these air quality measurements to occur because it is in a place that has not been heavily studied previously and will represent a countering data set to be compared to the test data of the models. The diversity in geography allows for sampling to occur in a range of altitudes and geographic situations. The close proximity of rural and suburban areas also allows for a range of data to be collected based on differing anthropogenic emission levels. Tests will be carried out in several different sites to be designated upon arrival in Chengdu. You might want to think ahead of time about a design for site selection, based on population density, distance from Chengdu itself, topography, prevailing winds, etc.

(v) *Minimizing Error.*

Each test will record the weather, temperature, barometric pressure, wind speed and direction at each sampling time span. You need to figure out the time span, also. This is where Yost and others might be able to provide very useful advice. The altitude, geographical features, and socioeconomic situation will also be recorded at each site. Acknowledging and recording the differences in site selection and conditions could lead to a greater diversification of data or could lead to greater error from a lack of continuity. However, only by allowing all these variables to change individually can each factor be accounted for in its effects on the greater air composition.

VII. References

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