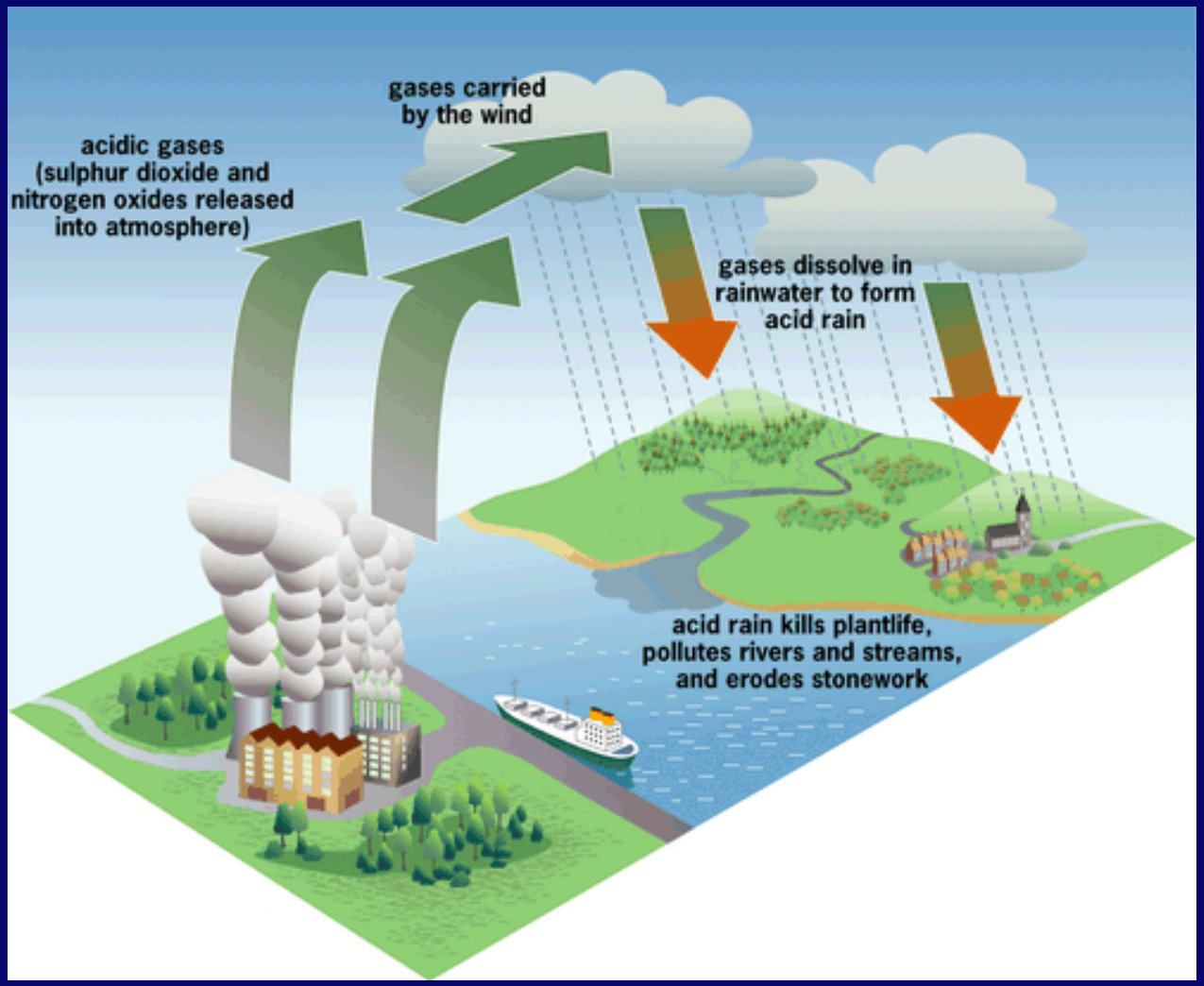
Air Pollution and Ancient Cultures: Is Acid Rain Melting Mexico's Pyramids?

Jon Kahl - Atmospheric Science Group, UW-Milwaukee

2001:	Family vacation to Mexico City
2002:	Humberto Bravo in Cincinnati; applied for Fulbright grant
2003:	Sabbatical in Mexico City
2004-2005:	Began teaching workshops in Monterrey
2006:	Taught first full course in Monterrey
2007 – now:	Taught courses in Monterrey, Campeche, Cd. del Carmen



Emissions ⇒ vertical mixing
horizontal transport
horizontal dispersion
chemical conversion
scavenging by clouds ⇒ wet deposition
dry deposition
fog deposition

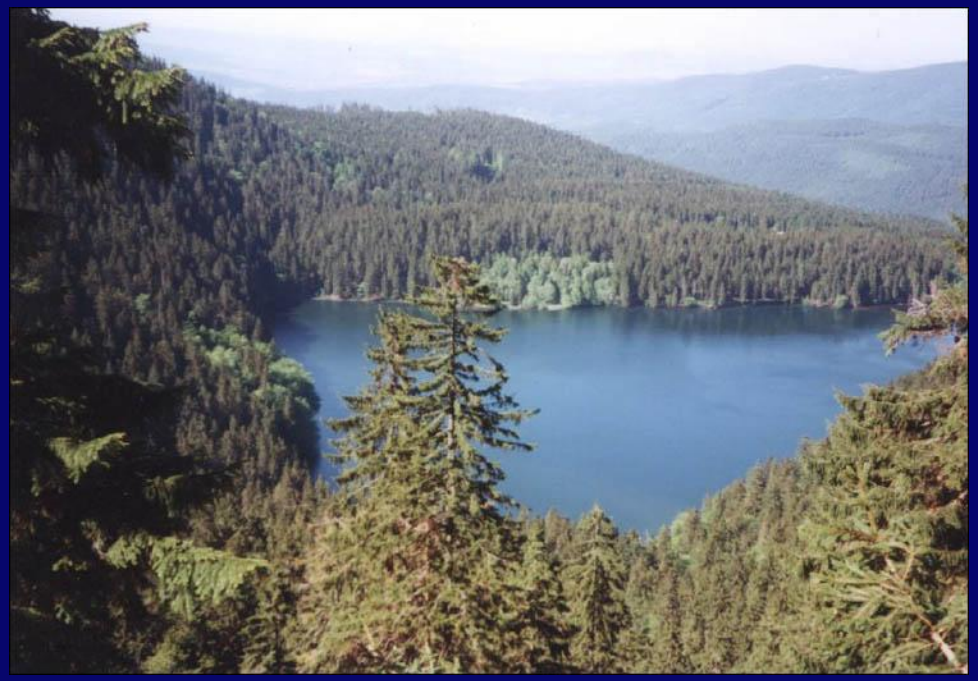
Acid Rain Effects

Healthy lake trout.

Lake trout dying from the effects of acidity.

When acid rain or acid snow falls or rolls into a lake or stream, aluminum and other minerals are drawn out of rocks and sediment at the bottom of the water. These minerals are toxic to the plants that live in the water. The minerals also kill fish by causing their gills to clog with mucus.

Acid Rain Effects



More than 20,000 lakes in North America have been harmed by acid rain. Surprisingly, acidified lakes often look strangely beautiful, with water so crystal clear that you can see through it to the bottom. But don't be fooled by this false beauty – the water is clear because nothing is alive in it, not even the tiny plants called algae that darken the color of healthy lakes.

Acid Rain Effects

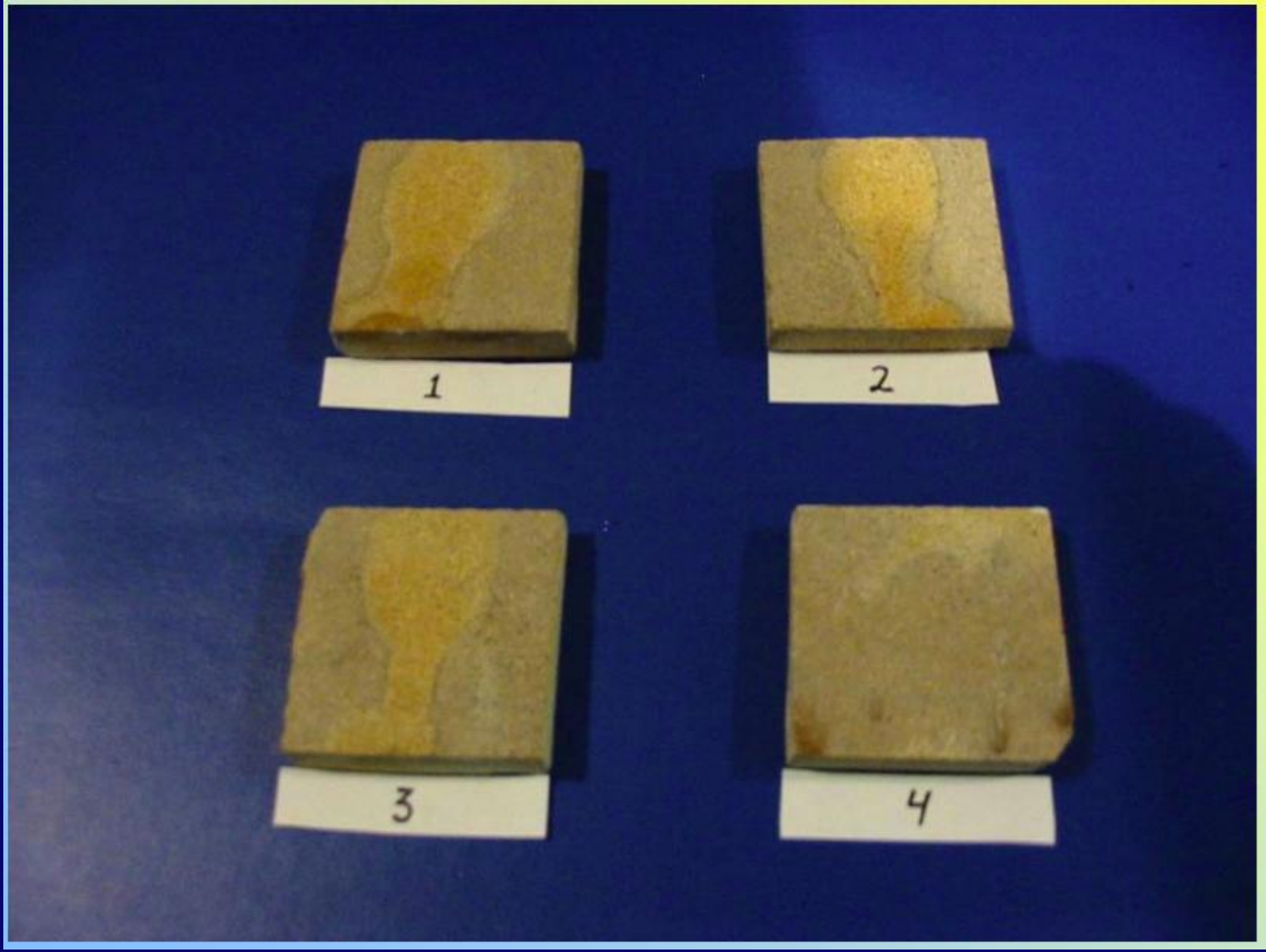
Acid rain corrodes metals and deteriorates paint and stone, causing damage to buildings, bridges, statues, monuments, tombstones and other cultural artifacts.

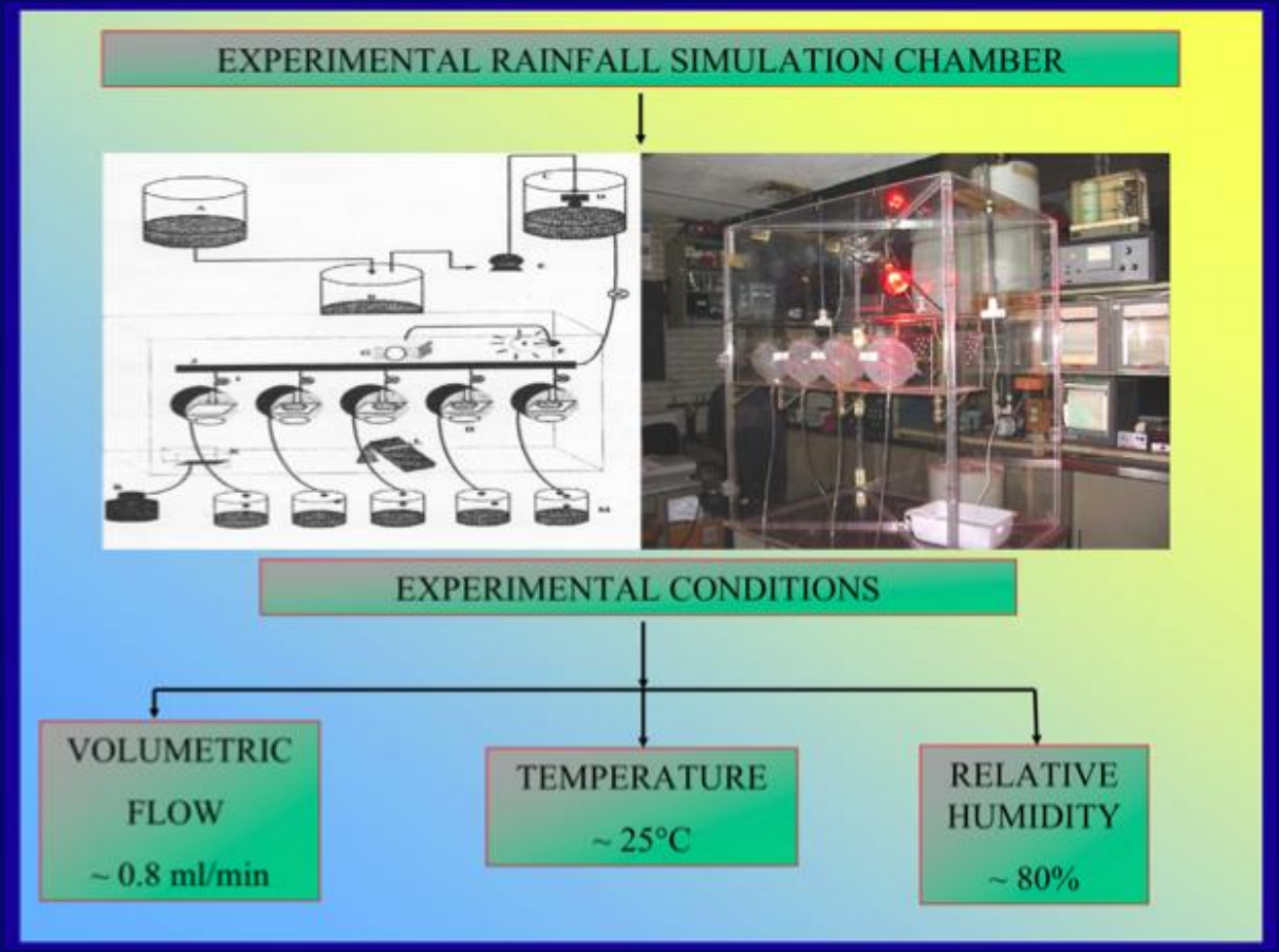
Acid Rain Effects

Acid rain erodes limestone in the same way that water dissolves an Alka Seltzer tablet. The process occurs very slowly, but the most important parts, like the painting pigments, are in the top few millimeters. Once eroded, they are lost forever.

Acid rain collector

Acid rain and Mesoamerican Heritage sites





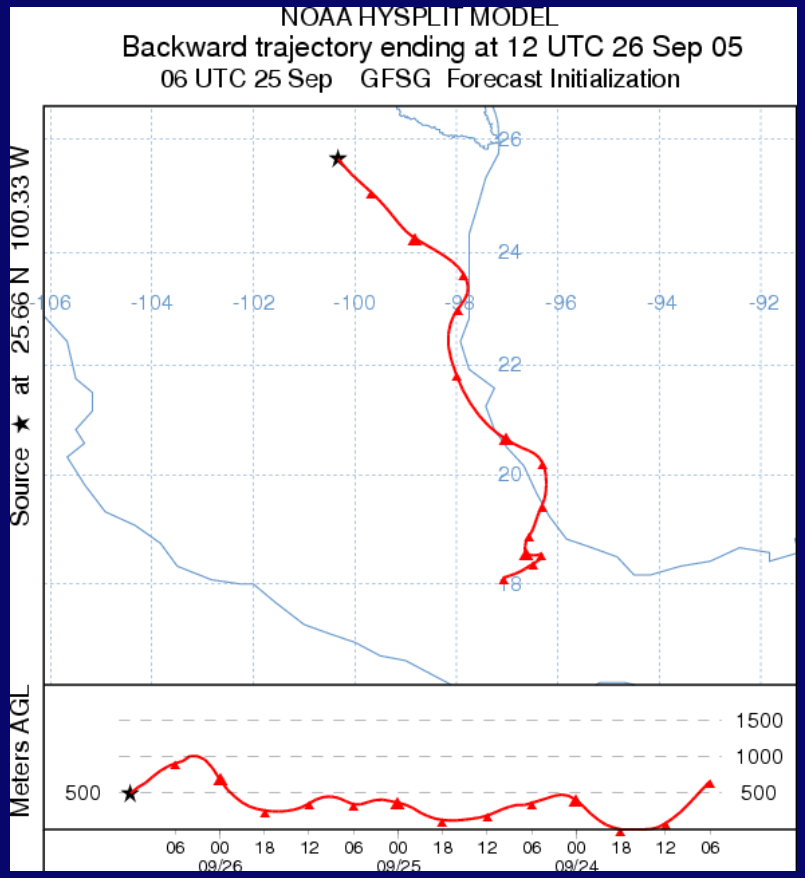
Surface recession rates: 8 – 45 μm yr^{-1} (0.8 – 4.5 mm $century^{-1}$)

Bravo, H., Soto, R., Sosa, R., Sanchez, P., Alarcon, J., Kahl, J. and Ruiz, B., 2006: Effects of acid rain on building material of the El Tajin archaeological zone. Environmenal Pollution, 144(2), 655-660.

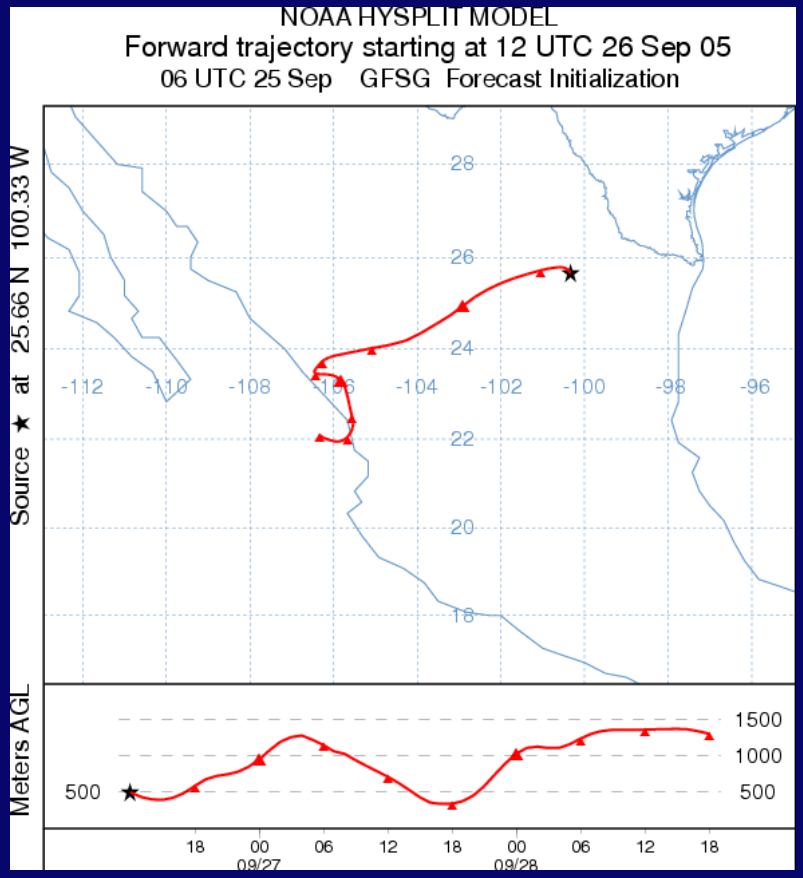
Air Trajectory Models

$$\vec{x}(t) = \int \vec{u}\, dt$$

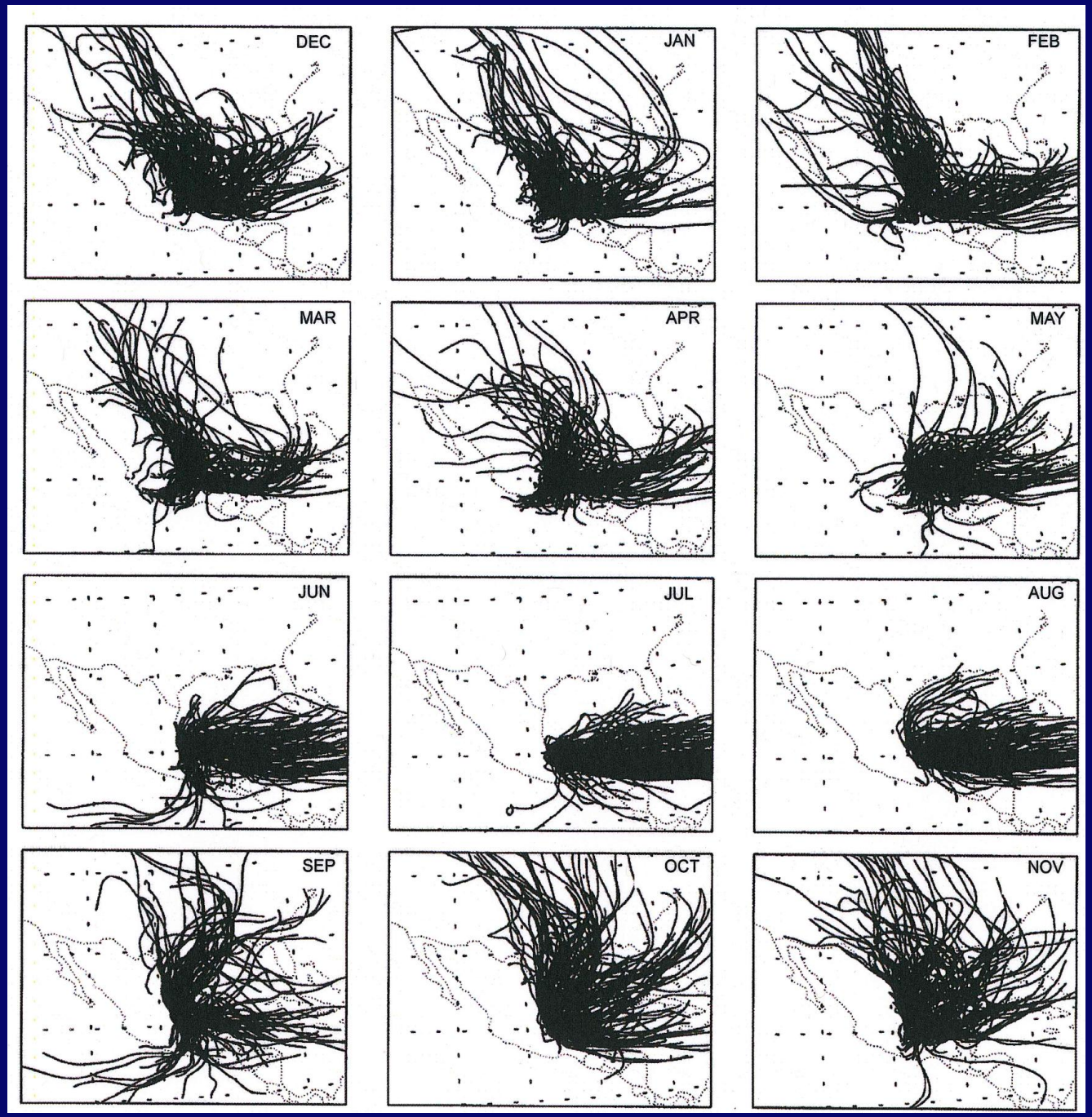
Backward trajectory



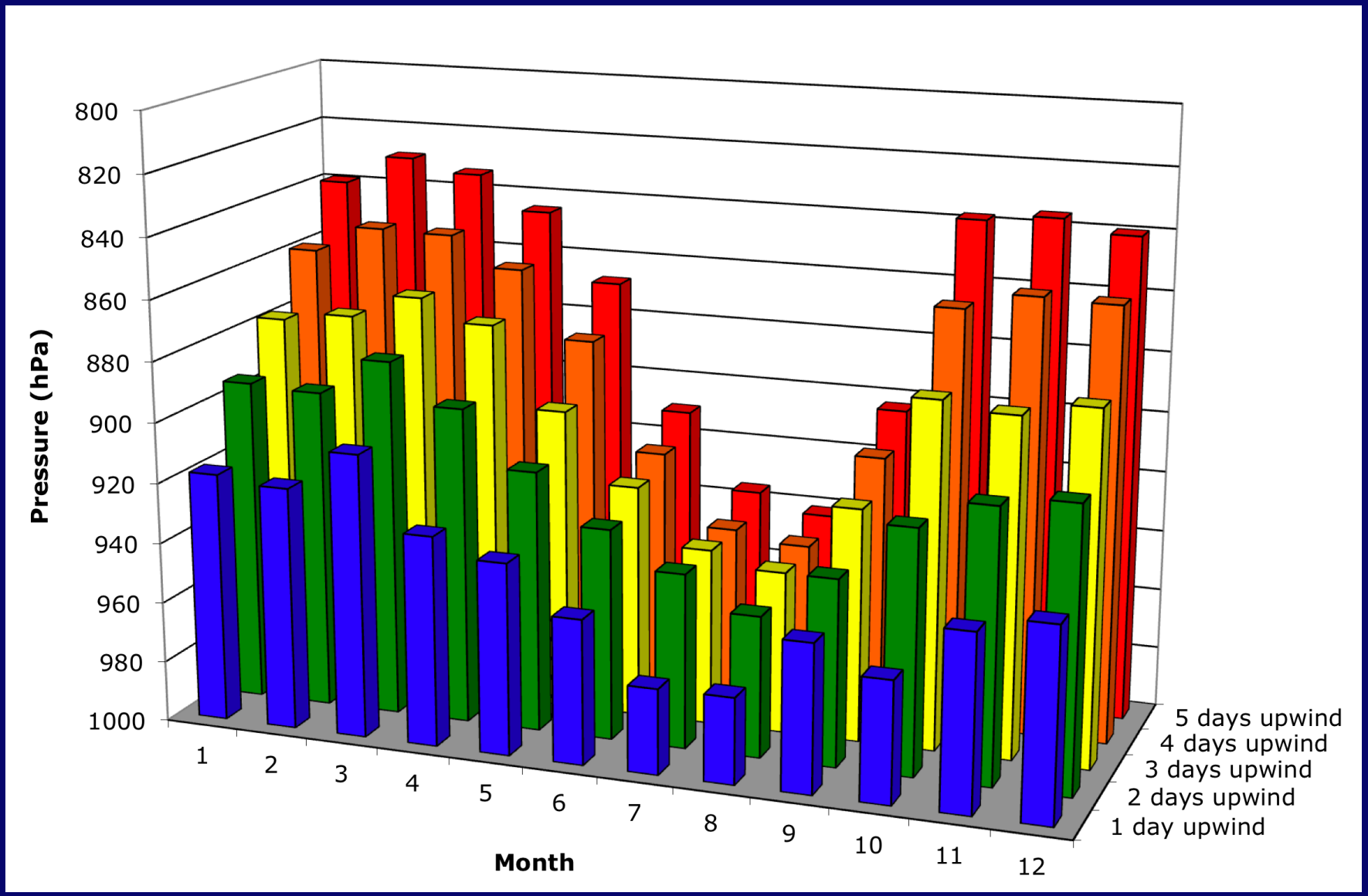
Forward trajectory



Daily trajectories to El Tajín, Veracruz



Pressure (altitude) of El Tajín Trajectories

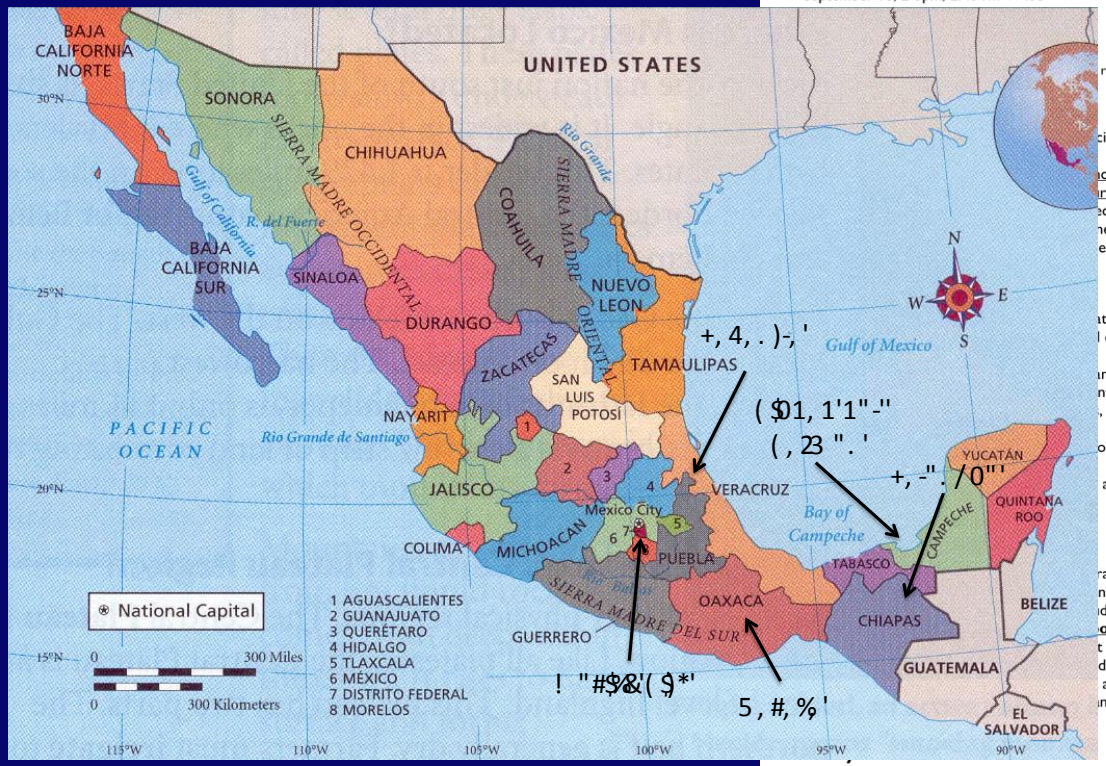



U.S.
Cantarell complex
Kutz
Akal
Nohoch
Chac
Natural gas compression facility
Gulf of Mexico
Monterrey
MEXICO
Cantarell oil field complex
Nitrogen complex
Bay of Campeche
Guadalajara
Mexico City
Pacific Ocean
Ciudad del Carmen
BELIZE
GUATEMALA
Gulf of Tehuantepec
EL SALVADOR
HONDURAS
Oil field
Planned gas pipeline
Planned liquids pipeline

Offerings so far:

2010 2013

2011 2014



center for international education
University of Wisconsin–Milwaukee

Department of Mathematical Sciences

MEXICO
AIR POLLUTION AND ANCIENT CULTURES

Tentative Dates:
In Milwaukee: January 3-4, 2013
In Mexico: January 5-18, 2013

Program Leaders:
Professor Jon Kahl, Atmospheric Sciences, kahl@uwm.edu
Yomarie Castellano, Program Assistant

Information Session:
September 18, 2-3pm, EMS rm W435

registration,

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application.
n be found here:

September13, 2012
9 a.m. – 2 p.m. (Union Concourse)

In the third offering of this exciting course, students will travel to five exotic locations in southern Mexico. We'll visit amazing archaeological sites, world-class museums, and universities.

We begin in Teotihuacán (The City of the Gods) just outside Mexico City, home to the third largest pyramid in the world. (Yes, you can climb it!) From there we travel to El Tajín, an impressive Gulf Coast site where ancient ballgames ended in human sacrifice. Next up is Monte Alban, where the ancient Zapotec civilization flattened an entire mountaintop using only hand tools. Monte Alban is just outside Oaxaca, an unforgettable city where you'll see women carrying baskets of fried grasshoppers and dried chili peppers on their heads. We'll finish the course in the jungle alongside toucans and howler monkeys, at the ancient Mayan city of Palenque.

We are going to these amazing places to study the effects of acid rain on cultural heritage sites. Ancient structures such as pyramids and their colofrul stucco coverings are easily corroded by acid rain. In the developing countries of Latin America, efforts to protect these sites from environmental corrosion are in their early stages. Students will examine firsthand the relationships between meteorology, air pollution, and cultural heritage. Joint activities with Mexican university students will increase the value (and fun) of the experience.

Scholarships:
Based on eligibility, UWM undergraduate students may apply for a WI Study Abroad Grant. The award amount is up to $500. Please see our website for details.

Students may also apply for the Center for Latin American and Caribbean Studies Donald R. Shea Undergraduate Scholarship. More information is available at: http://www4.uwm.edu/clacs/students/scholarship.cfm

Financial Aid, Scholarships & Grants can be used for this program!

APPLY ONLINE: WWW.STUDYABROAD.UWM.EDU

University of Wisconsin-Milwaukee
CIE Study Abroad Office
P.O. Box 413/Pearse Hall 166
Milwaukee, WI 53201

www.studyabroad.uwm.edu
overseas@uwm.edu

Phone: 414.229.5182
Fax: 414.229.4858
Toll Free: 800.991.5564

Main program goal:

Help students investigate and understand the complex relationships between air pollution and the environmental degradation of Mesoamerican heritage sites.

Academic content delivered via:

- Lectures & labs at UWM
- Guided tours of museums and archaeological sites
- Visits to Mexican universities

Lectures & labs at UWM

- Meteorological Aspects of Acid Rain
- Environmental Corrosion of Stone
- Precipitation Collection and Measurement
- Pollution Source Attribution Using Atmospheric Trajectory Models
- Spanish for Travelers

Guided tours of archaeological sites

Teotihuacan*, Plaza Mayor* (Mexico City)

El Tajín* (Papantla)

San Juan de Ulúa (Veracruz)

Monte Albán*, Mitla* (Oaxaca)

Calakmul* (Campeche state)

Palenque (Chiapas)

* 2015 program destinations

Guided tours of museums

National Museum of Anthropology and History*, Plaza Mayor* (Mexico City)

Museum of Oaxacan Culture* (Oaxaca)

Archaeological Museum of Campeche

* 2015 program destinations

University visits

University of Mexico (UNAM) (Mexico City)

University of Campeche

University of Carmen* (Ciudad del Carmen, Campeche)

* 2015 program destinations

Meteorology Lab Exercise

Sample Journal Questions

The buildings at Teotihuacan were once vibrantly colored with painted stucco. If their original appearance could accurately be determined via historical accounts, do you think the buildings should be restored to their natural appearance? Why or why not?

At El Tajín, as at many other archaeological sites in Latin America, there are numerous unexcavated mounds. The natural turf covering of unexcavated mounds protects the artifacts within from the corrosive effects of air pollution and acid rain. New archaeological finds thus present an interesting dilemma. Should they be excavated to reveal their clues about past civilizations? If so, they will begin to deteriorate instantly as they become exposed to air pollutants and acid rain. Or, should they remain unexcavated and protected, at the expense of failing to reveal the secrets within? Can you suggest a solution to this dilemma?

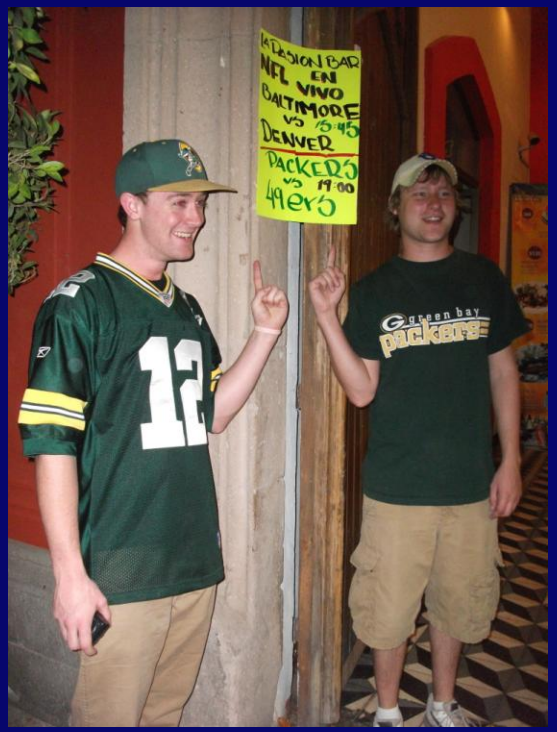
Like all expenditures of limited public funds, funding for archaeological restoration/preservation necessarily means that the expended funds will not be directed toward other public programs. Large projects, such as the excavation and restoration of the huge temples at Palenque, are extremely expensive. Do you feel such expenses of public funds are justified? Why or why not?

Please ask one of the University of Carmen students about their background:

- What is his/her name?
- What is his/her major (in Spanish: 'carrera')?
- What coursework and/or work experience is necessary for this major?
- What types of job does he/she expect to get after graduating?
- Why did he/she choose this major?
- What are his/her hobbies?
- Does he/she often get the chance to talk with people from other countries?

Program History

Year	# students	#Atm Sci majors	#grad students
2010	8	5	1
2011	10	4	1
2013	8	2	0
2014	8	2	0



Program Evaluation

FACULTY-LED STUDY ABROAD IN ATMOSPHERIC SCIENCE EDUCATION

BY JONATHAN D. W. KAHL AND JULIA G. CERÓN

In the faculty-led study abroad program *Mexico: Air Pollution and Ancient Cultures*, students gain cultural competency and life-changing experiences while learning about the effects of acid deposition on Mesoamerican heritage sites.

Bulletin of the American Meteorological Society, 95(2), 283-292, 2014

Program Evaluation

From course evaluations:

I _____ recommend this course to other students.

a. would not
b. would
c. would enthusiastically

Answer b: 4%
Answer c: 96%
(25 out of 26 students responding)

From course evaluations: comments related to personal growth.

"The trip was so diverse in its life lessons - it had academic, social, linguistic, touristic, and many other benefits."

From course evaluations: comments related to depth of learning.

"I've learned more in the past two weeks than I have in a long time."

"I enjoy going out and experiencing everything firsthand rather than sitting in a classroom. "

Comments related to intercultural competence.

"I can't think of a better way to earn college credit. It incorporates lessons and research as well as cultural experience."

"Experiencing a different country and people just gives you a better respect for what you have and what you don't need."


Thank you!