Atmospheric Radiation Measurement
Climate Research Facility
U.S. Department of Energy

Climate Education Update

NEWS AND INFORMATION ABOUT CLIMATE CHANGE STUDIES FOR TEACHERS AND STUDENTS

August 2006

The Department of Energy's Atmospheric Radiation Measurement (ARM) Climate Research Facility supports education and outreach efforts for communities and schools located near its sites. The mission of the Education and Outreach Program is to promote basic science education and community awareness of climate change research by focusing on three goals: student enrichment, teacher support, and community outreach.

ACRF Education and Outreach Director: Larry Jones

Editing and Layout:
Andrea Maestas
LALP-06-073

Where Does All the Heat Go?

by Dr. Mary Jane Bartholomew, ARM Scientist

When we stand in the shade of a tree, it is obvious that the tree blocks some heat from the sun from reaching us. When we stand in "direct" sunlight, some of the sun's heat is also blocked, but by invisible components of the atmosphere. The atmosphere consists of more than just gases (nitrogen, oxygen, carbon dioxide, ozone and others). It also has *water vapor* and small particles called *aerosols*. Even though we can't see the vapor, we all know water is there – especially when humidity is high. Even air with low humidity contains some water vapor. In the atmosphere, vapor often condenses to form water droplets and clouds. Clouds can cool the surface of the earth much like trees do when they block sunlight. Aerosol particles may be small, even microscopic, but our atmosphere has many teragrams of aerosol at any one instant in time. One teragram equals 1 trillion grams. Aerosols come from a variety of sources, both natural and man-made, including dust, sea spray, volcanic eruptions and soot. Soot is a product of forest fires, biomass (organic materials) burning and gas/oil combustion. Our atmosphere contains enough of these small particles to reflect sunlight back to space, keeping some sunlight from reaching the earth's surface and thus cooling the planet. (Keep in mind that all light is associated with heat, but not all heat is associated with light.)

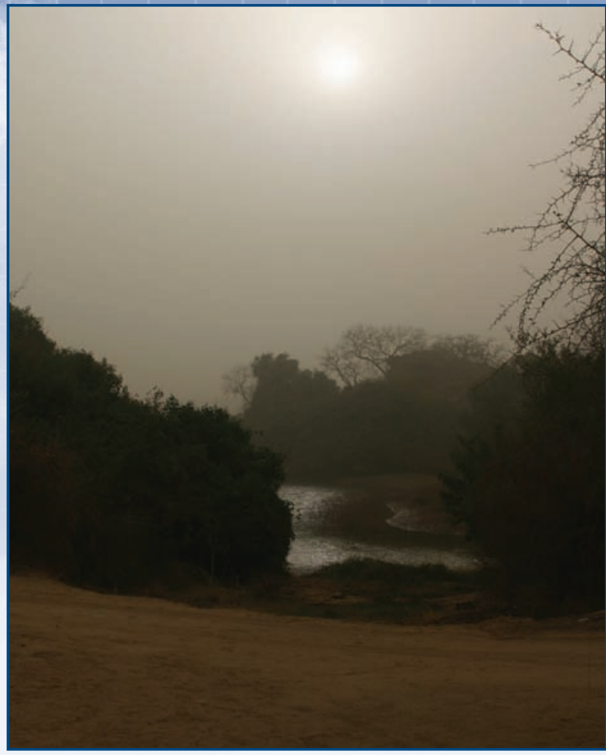
Our dilemma as scientists is that while we can measure the amount of light and heat coming from the sun, even with our best understanding of the nature of the atmosphere, when we try to calculate the amount of heat at the surface of the earth, we often get it wrong. Accurate calculations are needed to predict climate change, and we suspect our understanding of the interaction of sunlight with dust is incomplete. This is a particularly big problem in high dust areas like those near the Sahara Desert in northern Africa. RADAGAST is an experiment currently being conducted in the African country of Niger. It started in January 2006 and will continue through January 2007; scientists are collecting data that will help us improve our calculations of heat at the earth's surface.

Meteorological staff launch a weather balloon in Niger, Africa.

RADAGAST to the Rescue!

RADAGAST stands for RAdiative Divergence using AMF, GERB and AMMA STations. So it is actually an acronym that contains three other acronyms. Let's begin with the first two words. "Radiative" comes from the word "radiation," — the scientific term for sunlight. "Divergence" means to move in different directions, and in this case, refers to the way sunlight is absorbed, reflected, and scattered on its way to the earth. Only 5 percent of sunlight reaches the surface of the earth directly. The other 95 percent is reflected back into space, and/or absorbed, by gases, aerosols, clouds or water vapor in the sky. The processes that redirect sunlight and its associated heat have a general name: radiation divergence.

To study all of these reflecting and absorbing phenomena, scientists of the RADAGAST project will use data collected by the instruments in the ARM Mobile Facility (AMF), as well as data from the Geostationary Earth Radiation Budget (GERB) sensor located on the METEOSAT weather satellite. The AMF and GERB sensor are "participants" in the larger African Multidisciplinary Monsoon Analysis (AMMA), an on-going experiment to improve scientists' knowledge and understanding of the West African Monsoon and its variability. By combining local measurements from the AMF with the regional information available from the weather satellite and AMMA stations, a fuller understanding of these atmospheric phenomena can be reached.



The sun is barely visible in the dusty Niger sky.

More than Enough Dust

Work continues despite dusty conditions in Niger.

Imagine a dust blizzard big enough to close schools and airports. In Niger, these types of storms can last a few days at a time and are common occurrences. A dust blizzard is one example of atmospheric aerosols that can be clearly seen with the naked eye. The Sahara Desert is the world's biggest source of dust and is a growing dust source through the process of desertification. As farming practices in the areas bordering the desert turn semiarid land into arid land, the desert grows, and so does the potential for dust to have an impact on climate. Saharan dust has both reflective and absorbing properties, and therefore has a complex influence on the divergence of sunlight/heat.

Cloudy nights are warm, clear nights are cool. What about dusty nights?

A light bulb that has just been turned off can still be hot, even hot enough to burn. When the light bulb is on, it gives off light and heat. The heat comes from the infrared region of the radiation spectrum that lies at wavelengths just longer than the visible portion of the spectrum. Everything emits infrared radiation, but some more than others, like the light

(continued on page 6)

Teacher's Notes

The following is a segment from an article called "All the World's a Stage…for Dust," which was published in June 2001 by the National Aeronautics and Space Administration. It briefly describes the way dust is carried across continents by strong winds. Read this segment of the article with your students and facilitate a discussion using the questions provided at the end. The entire article and additional information about global dust scattering can be found on the Internet at the following address: http://www.thursdaysclassroom.com/26jun01/pdf/corner.pdf

All the World's a Stage…for Dust

Our planet's atmosphere provides a transcontinental highway for dust that has been stirred up from dry soils by strong winds. Because dust particles are so small -- often less than 0.002 mm across -- they can remain aloft for days as they ride global rivers of air. Larger sand grains don't get airborne as often or for as long, but they can be pushed along the ground by the wind or washed away by water erosion.

This constant reshuffling of the world's sand and dust ties the continents together and serves as a reminder that, in the natural world, there are no boundaries. Airborne microbes and pollen in Florida or Brazil might have come from Africa. Mineral dust in the soils of India could have blown over from Iran. In fact, over vast stretches of geologic time, the action of wind thoroughly mixes and re-mixes the world's dust. So the soil in your own backyard might contain some grains of dust from places all over the globe! While much of this reshuffling of earth can't be seen by satellites, dust often migrates in huge clouds that show up in satellite images.

For example, the Americas frequently inherit huge volumes of dust from Africa and Asia, while countries of the Far East like India and China get sprinkled with dust from the Middle East. African dust plumes begin their trans-Atlantic journey with storm activity in the Sahara Desert region. The dust, originating from fine particles in the arid topsoil, is transported into the atmosphere by winds and may be carried more than 10,000 feet high. Dust plumes cross the Atlantic Ocean and reach the Caribbean and the Americas in about 5 to 7 days. How much dust is transferred by the wind? One estimate places the number at about 13 million tons of dust each year drifting from Africa to the Northeastern Amazon Basin alone!

Discussion Questions:

- What effect does wind have on dust? (Wind lifts dust into the air and carries it long distances)
- What size are the traveling dust particles (As small as 0.002 mm)
- What mixes and remixes the world's dust? (The wind)
- Why do larger sand grains not become airborne? (They are too heavy for winds to pick up)
- How long does it take a dust plume to cross the Atlantic Ocean? (5 to 7 days)
- How much dust is transported by wind? (More than 13 million tons from Africa to the Amazon yearly)
- What do you think about the fact that the dust that you wipe off of your table might have originated on another continent? (Answers will vary)
- How long do you think this dust mixing has been going on? (Answers will vary)

Hands-on Learning

Migrating Dust

This hands-on activity is an interesting way of making the abstract content of the "All the World's a Stage...for Dust" article real and easily understood. It promotes comprehension and retention of the content.

Objective: Students will observe and map the migration of simulated dust on the classroom floor.

Materials: Each student will need a blank sheet of paper. The teacher will need lots of tiny circles of paper like those generated by a hole puncher. This activity will be more informative (even livelier!) if you have a mixture of circles of different colors.

Estimated Time: This lesson will require about 30 minutes at the beginning of the day and another 30 minutes towards the end of the day.

Procedure:

1. Before the school day begins collect about one cup of dots from a hole puncher and deposit on the floor inside the classroom near the door. If you do not have a hole puncher, use scissors to cut out paper squares roughly the size of a thumb nail.

2. Gather the students outside the classroom before the beginning of class and discuss the migration of dust across continents. Explain that they will have a chance to observe simulated dust migrate across the classroom floor. Their first task will be to draw a map of the classroom and the 'dust' as it appears when everyone first arrives at their desk.

3. Emphasize that the students are not to touch or blow on the 'dust' during the day. They should observe how the dust migrates without intentional interference.

4. Let students walk to their desks. Distribute the blank sheets of paper and instruct the students to draw a map of the classroom and the 'dust' spots as they are now. Monitor students as they work. Have students either save their maps or you may collect them for later use.

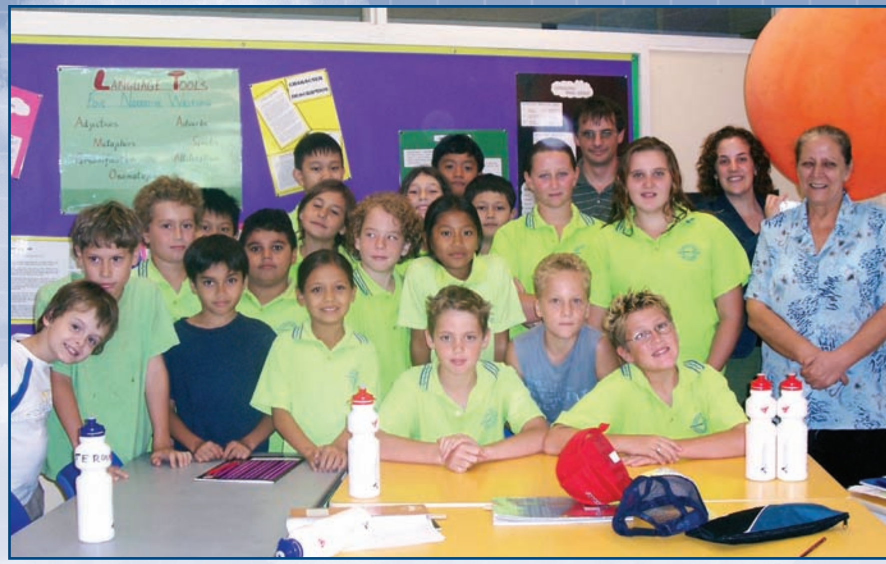
5. Continue with the normal class schedule, reminding students not to intentionally disturb the 'dust.'

6. At the end of the day, have students get their maps out. Ask them to use a different colored pencil or pen to indicate the current location of the 'dust' spots. Discuss the results. Was anyone surprised how far the dust went or where it traveled? Did the 'dust' spots travel beyond the classroom? What do they think would happen if the spots remained on the floor for another day? How is this related to the global travels of real dust clouds?

This lesson was reprinted courtesy of Thursday's Classroom: www.thursdaysclassroom.com

ARM Scientists Visit Northern Territory Schools

When ARM scientist Jim Mather brought out a weather balloon during his presentation at Wagaman Primary School, Margaret McPherson's students were filled with curiosity. "How high does the balloon go before it pops?" asked one student. "What if a weather balloon lands in my back yard?" asked another. Mather was impressed with the students' enthusiasm, especially because the purpose of his visit was to talk about the Tropical Warm Pool-International Cloud Experiment (TWP-ICE) happening in Darwin, Australia in January and February 2006. Mather was one of several scientists from the Atmospheric Radiation Measurement (ARM) Program who volunteered their time during the experiment to visit schools and talk science with Darwin students.



ARM Scientist Dr. Jim Mather with students at Wagaman Primary School

Students at Darwin High School piled into the school's auditorium for presentations by ARM Principal Investigator Courtney Schumacher to learn about the various instruments used at the ARM site in Darwin and during TWP-ICE. Not surprisingly, the weather balloons caught the interest of the high school students as well.

"This information will be useful for the year 12 physics students," said Rob Speirs, a teacher at Darwin High School. "They have two major projects: an Investigation Design, where they design an applied experiment, and an Information Search, where they research the application of some of their curriculum topics. There is great scope for students to latch on to material from these presentations."

The ARM TWP-ICE outreach effort concluded with a visit to Woolaning School, a small one-teacher Aboriginal school located in Litchfield National Park. ARM Education staff were welcomed by the school principal and teacher, Guna Deva, who last year was recognized as Teacher of the Year for the Northern Territory (Australia). After introductions were made, ARM staff gave presentations on the water cycle, cloud formation, and the ways in which ARM scientists were studying clouds during TWP-ICE. Using the information given during the presentations, the artistic students at Woolaning made beautiful drawings depicting the stages of the water cycle. Nanny Daisy, an elder from the Aboriginal community who works closely with the students on art projects, also made a beautiful painting about the traditional ways in which the Aborigines identify seasons. Two students read a story to explain what the painting was about. The day's activities ended with a "cloud reading" in the school yard; students estimated cloud cover and wind speed and identified cloud types.

Students listen to a traditional story about seasons called "Wangie and Miwangie"

More than Enough...

(continued from page 2)

bulb that has just been turned off. At night, the earth's surface emits infrared heat back into the atmosphere, but clouds may block this heat from reaching space. Often they reflect some of it back to the surface and the night stays "warm" compared to a clear night. (Nighttime temperatures are always cooler than daytime temperatures.) In the case of dusty nights, the same phenomenon happens. Less heat reaches outer space than during clear, dust-free conditions. One goal for the RADAGAST science team is to understand both the daytime light/heat exchange between the atmosphere and the earth's surface, as well as the nighttime heat exchange under dusty conditions.

Dust and Monsoons

Monsoon climates are characterized by seasons of onshore winds and tremendous rainfall. One reason monsoon conditions occur has to do with heating of the atmosphere. Any air that is locally hotter than the surrounding air will rise. One excellent way to heat air is to fill it with absorbing dust and let the sun shine on it. In the summer in Niger, this happens repeatedly for months at a time, and once significant uplift takes place, air from the moist Atlantic Ocean and Gulf of Guinea will flow in to take its place. Hence, a summer season of dust storms from the north is followed by a winter of heavy rain coming from the south. The hotter and dustier the summer, the easier it is for the monsoon to form, especially when sources of moisture are so close.

AMF instrument site in Niger

12 months for RADAGAST

Because these climate phenomena develop over 12 months, the RADAGAST experiment will continue for an entire year, or one full period of the entire dust/monsoon cycle. We hope to gain a better understanding of the details of the interaction of sunlight and the earth's atmosphere. We also hope to learn more about the formation of two severe weather events: dust storms and monsoon rains. Our overall goal is to learn if the changing climate will produce more of either of these severe weather events.

Atmospheric Radiation Measurement Climate Research Facility
U.S. Department of Energy

ACRF Education and Outreach
Los Alamos National Laboratory
PO Box 1663 MS J577
Los Alamos, NM 87545 USA

505-667-1186 (phone)
armeducation@lanl.gov (email)