Science Report: Atmosphere

GLOBE Takes the A-Train: NASA CloudSat, CALIPSO and Aura Satellite Missions

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Abstract

GLOBE students around the world have the opportunity to assist NASA scientists in their research on Earth's atmosphere by participating in the CloudSat, CALIPSO and Aura satellite missions. They are part of the A-Train, a succession of six satellites that will fly together in a sun-synchronous polar orbit. Among the ways to participate, the CloudSat, CALIPSO and Aura education programs have teamed up with GLOBE to help teachers in the United States better understand the atmosphere through a series of lead educator workshops. Internationally, the CloudSat mission has created a CloudSat Education Network that GLOBE schools around the world can join. Mission scientists will compare GLOBE data on clouds, aerosols, ozone, precipitation, water vapor and UV among other measurements to data collected by the three satellites.

Introduction

GLOBE students around the world have the opportunity to assist NASA scientists in their research on Earth's atmosphere. For the first time, NASA will fly six satellites in a tight formation like the cars on a train (Figure 1). Officially known as the Afternoon Constellation, the formation was quickly nicknamed the A-Train after the famous jazz tune. The mission of the A-train is to study the Earth's atmosphere in order to improve weather forecasting and climate prediction among many other advances. NASA's Earth Science Enterprise has many such missions to tell us more about our home. Each mission places a high priority on education. GLOBE students can support the satellites and their scientists and engineers.

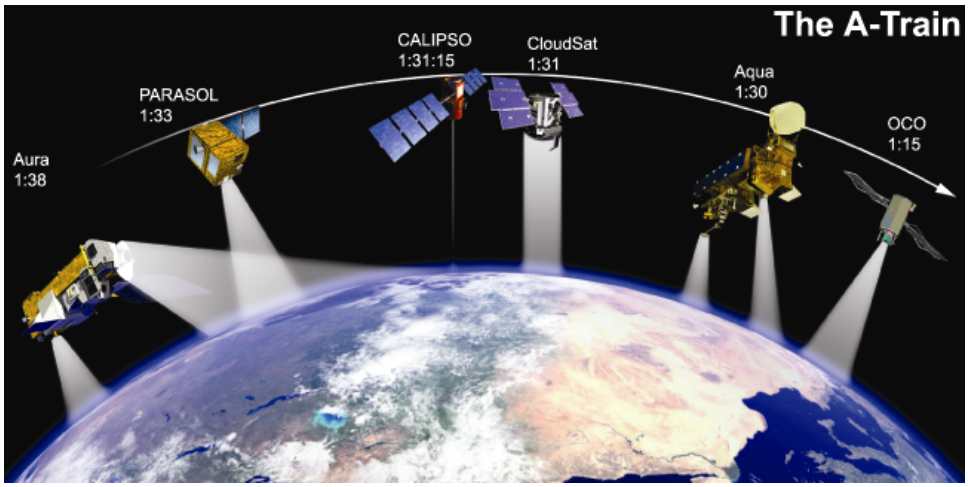

Figure 1. The "A-Train" will consist of six satellites flying in formation for the purpose of studying Earth's atmosphere (NASA Facts, 2003).

The NASA A-Train

The A-Train is an international effort just like The GLOBE Program. Table 1 lists the six satellites, their primary research areas, approximate launch dates and affiliations. These A-Train satellites travel around the poles ("polar-orbiting") 705 kilometers above the Earth's surface in a sun-synchronous orbit. In a sun-synchronous orbit, the satellite passes over the same part of the Earth at roughly the same local time each day.

SPACECRAFT	MISSION	INTERNATIONAL PARTNERS	LAUNCH DATE
Aqua	Synergistic instrument package studies global climate with an emphasis on water in the Earth's atmosphere system including its solid, liquid and gaseous forms	France, Australia, Italy, Brazil	May 2002
CloudSat	Cloud Profiling Radar will allow for most detailed study of clouds to date and should better characterize the role clouds play in regulating the Earth's climate	Canada, Japan, Germany, United Kingdom, The Netherlands, France	April 2005
CALIPSO	Observations from space-based lidar will lead to improved understanding of the roles aerosols and clouds play in regulating the Earth's climate	France	April 2005
PARASOL	Polarized light measurements will allow better characterization of clouds and aerosols in the Earth's atmosphere, in particular distinguishing natural from man-made aerosols	France	October 2004

Aura	Synergistic instrument package studies atmospheric chemistry, focusing on the horizontal and vertical distribution of key atmospheric pollutants and greenhouse gases	The Netherlands, United Kingdom, Finland	July 2004
OCO	Will make global space-based observations of the column integrated concentration of CO_2, a critical greenhouse gas	France, Germany, New Zealand, Australia, The Netherlands	August 2007

Table 1. Summary of A-Train missions.

Lead Educator Workshops

The CloudSat, CALIPSO and Aura education programs have teamed up with GLOBE to help teachers in the United States better understand the atmosphere through a series of lead educator workshops. The first workshop was held at Colorado State University in Fort Collins, Colorado, in July, 2004. Colorado State University is the home institution of the CloudSat Principal Investigator, Dr. Graeme Stephens who is also a GLOBE Atmospheric Science Principal Investigator. The workshops bring together long-time GLOBE teachers and trainers with teachers new to the program (including teachers from NASA Explorer Schools). The educators are also brought together with NASA mission scientists and GLOBE science principal investigators.

The workshops have three primary goals. The first goal is to allow the educators to hear directly from the NASA and GLOBE scientists about the value of student-collected data and student-based research. Second, the workshops provide instruction in areas such as the electromagnetic spectrum, Earth's atmosphere, clouds and cloud radar, aerosols and methods of detection, ultra-violet radiation and the difference between "good" and "bad" ozone through hands-on inquiry-based learning activities and resources. Finally, through The GLOBE Program, the educators are trained in atmosphere protocols and in data entry which will allow their students the opportunity to participate directly in the NASA missions by collecting genuine scientific data.

CloudSat Education Network

The CloudSat Education Network is part of the CloudSat Education and Public Outreach team. The goal of the Network is to provide the opportunity for schools to partner with the CloudSat Science and Education Teams. The Network will use proven science and education programs, to partner scientists, teachers, students and the communities where they live to give students meaningful, authentic and contemporary educational experiences. Student activities and learning outcomes are being designed to meet both general education outcomes and specific standards or objectives from school curricula. The main focus of the knowledge development component of the project is to help students better understand long-term climate change and the climatic processes that maintain the Earth's Energy balance.

With the launch of the CloudSat satellite anticipated for early 2005, the CloudSat Education Network will begin supporting the Science mission beginning midyear 2004 and continue

through early 2007. Participation in the network throughout the duration of the project will be monitored and schools will need to maintain levels of participation in order to maintain 'Membership' in the network. The base level of participation is the reporting of cloud cover, cloud type, temperature and precipitation data every 16 days, coinciding with the satellite overpass.

Participation in the CloudSat Education Network can give teachers the tools to provide students the opportunity to:

- Develop basic numeracy skills by gathering and processing environmental information that can be used by scientists to compliment the measurements taken by the CloudSat satellite (Scientists will benefit from this ground-based reference data).
- Develop practical science skills by measuring, recording and analyzing local environmental measurements.
- Communicate and learn with other students from around the world using appropriate information and communications technologies.
- Interface with the CloudSat Education Network Website which will offer student friendly materials and ideas to support the educational goals of member schools.
- Liaise with, ask questions and offer ideas to the CloudSat Science Mission team.

The network will be international in nature targeting up to 100 schools. Currently we have schools from Australia, New Zealand, Ghana, Cameroon, Croatia, Germany and the United States prepared to participate. Existing and new contacts are being pursued in Malaysia, Thailand, Taiwan, South Africa, the United Kingdom and Pakistan. Schools through existing networks have been targeted and contacts are being made in Russia, Iceland, Sweden, Finland, Estonia, Canada and China.

The Players

CloudSat

First in line after the Aqua satellite which was launched in May, 2002, is CloudSat. As its name implies, CloudSat will collect data on clouds with an instrument known as a Cloud Profiling Radar (or CPR). Clouds are one of the least understood elements of climate and the hydrological cycle. Yet without an understanding of clouds, weather forecasting and climate modeling become nearly impossible. For millennia, humans have studied clouds from the ground. Over the last century, it has become possible to study clouds from above. Until now, though, there was no good way to study the insides of clouds. The A-Train will make this possible, especially through the NASA CALIPSO and CloudSat missions. CALIPSO and CloudSat will use different types of remote sensing instruments for atmospheric data collection. CloudSat will use a special type of active microwave radar (94 GHz) to provide a global survey of cloud properties to aid in improving cloud models and the accuracy of weather forecasts, with the long-term goal of improving global climate models (Figure 2). This cloud-profiling radar (CPR) will provide vertical distribution of cloud physical properties including liquid water content, ice content, and

cloud optical depth (Stephens et al., 2002). The CloudSat mission is a cooperative effort that includes its international partner, Canada, and its industry partner, Ball Aerospace and Technologies Corporation. Among CloudSat's other partners are Colorado State University, Jet Propulsion Laboratory, Canadian Space Agency, the U.S. Air Force, U.S. Department of Energy, Goddard Space Flight Center and scientists from France, United Kingdom, Germany, Japan and Canada. The CloudSat website is: http://cloudsat.atmos.colostate.edu/.

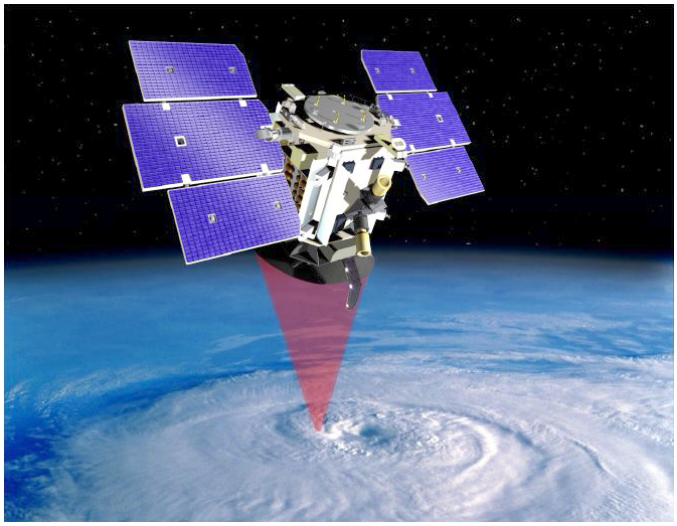

Figure 2. NASA ESSP satellite CloudSat (courtesy of Ball Aerospace).

CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations)

Flying in tandem with CloudSat will be CALIPSO. In addition to gases, clouds contain liquid droplets and solid particles known as aerosols. CALIPSO stands for **Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations** (Figure 3). CALIPSO will use **LI**ght **D**etection **A**nd **R**anging (LIDAR) to provide an opportunity for more comprehensive atmospheric data collection on aerosols. Lidar uses pulses of light generated by a laser to pass through the atmosphere, where a fraction is then scattered back by aerosols and cloud particles to a receiver. The CALIPSO satellite will fly in a polar orbit to vertically profile aerosols and clouds using the first satellite lidar dedicated to atmospheric sensing (Winker et al., 2002). The lidar will observe the vertical distribution of aerosols and provide information on particle size and phase, improving our understanding of the role aerosols play in Earth's climate system. The CALIPSO mission is a cooperative effort led by NASA's Langley Research Center and includes the French Space Agency CNES, Hampton University, Ball Aerospace and Technologies Corporation, and the French Institut Pierre Simon Laplace. The CALIPSO website is: http://www-calipso.larc.nasa.gov/.

Figure 3. NASA satellite CALIPSO (http://www-calipso.larc.nasa.gov/).

Aura

Earth Observing System (EOS) Aura is a NASA mission to study the Earth's ozone, air quality and climate (Figure 4). This mission is designed exclusively to conduct research on the composition, chemistry and dynamics of the Earth's upper and lower atmosphere employing multiple instruments on a single satellite. EOS Aura is the third in a series of major Earth observing satellites to study the environment and climate change and is part of NASA's Earth Science Enterprise. The first and second missions, Terra and Aqua, are designed to study the land, oceans, and the Earth's radiation budget. Aura's chemistry measurements will also follow up on measurements which began with NASA'S Upper Atmospheric Research Satellite and continue the record of satellite ozone data collected from the TOMS missions.

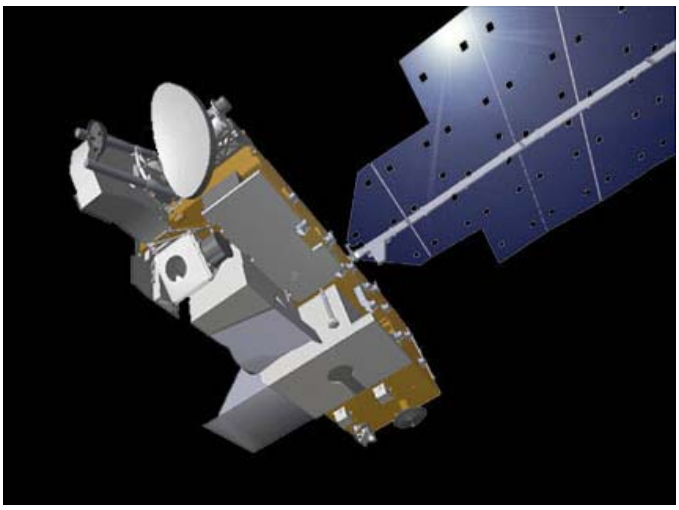

Figure 4. NASA EOS satellite Aura (http://eos-chem.gsfc.nasa.gov/index.html).

The Aura mission is designed to attack several science questions: (1) Is the ozone layer recovering as expected? (2) What are the sources and processes that control tropospheric pollutants? (3) What is the quantitative impact of aerosols, upper tropospheric water vapor and ozone on climate change? Aura will answer these questions by globally measuring a comprehensive set of atmospheric constituents at high vertical and horizontal resolution. The Aura website is: http://eos-chem.gsfc.nasa.gov/index.html.

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