A Description of the "Global Experiment" Visualization, Using Data from a Worldwide Citizen-Science Project of Visitors at Science Centers and Science Museums

Between October 1 and October 22, NASA asked museums and science centers around the world to participate in a global experiment collecting observations of clouds while NASA satellites were overhead. As part of the part of International Science Center and Science Museum Day (ISCSMD), the experiment built upon UNESCO's theme of "Science for Peace and Development."

The goal was to create new ways for museums and science centers worldwide to proactively address global sustainability while reaching increasingly diverse audiences. More than 900 cloud observations, including more than 5,500 photos, came in. The white dots on this map show each observation submitted through the app in that period. The red dots represent science centers participating in the global experiment. The observations are distributed internationally.

Several of the observations lined up with satellite overpasses, and this video shows three examples (from September 2016) from the early afternoon overpasses of Aqua, CALIPSO, and CloudSat, NASA satellites that fly together in formation as part of the A-train constellation of satellites. CALIPSO is a joint U.S. (NASA)/French (Centre National d'Etudes Spatiales/CNES) mission.

By taking ground-based cloud observations at the same time, citizen scientists are helping NASA scientists interpret the satellite data. Through the GLOBE Observer app, a person can report what kind of clouds are in the atmosphere, estimate how high the clouds are, and indicate how much of the sky is cloudy. Satellites can do some of the same things, but see clouds from above. By combining both citizen and satellite observations, scientists get a much more complete understanding of what is happening in the atmosphere. This will help address questions about changes in the water cycle and freshwater availability.

The first satellite example (starting at about 35 seconds) shows an overpass over North America on September 7. Dots represent citizen science observations taken at or near the same time as the overpass. Blue dots represent a report of clear skies, while white dots are cloudy skies. Partially blue dots are partially cloudy skies.

The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on NASA's Aqua satellite provides a natural color view of clouds over a broad swath of the continent. This view shows the clouds as a person might see them from space. Tiny clouds are scattered across the southern United States corresponding to areas where citizen scientists reported clear skies.

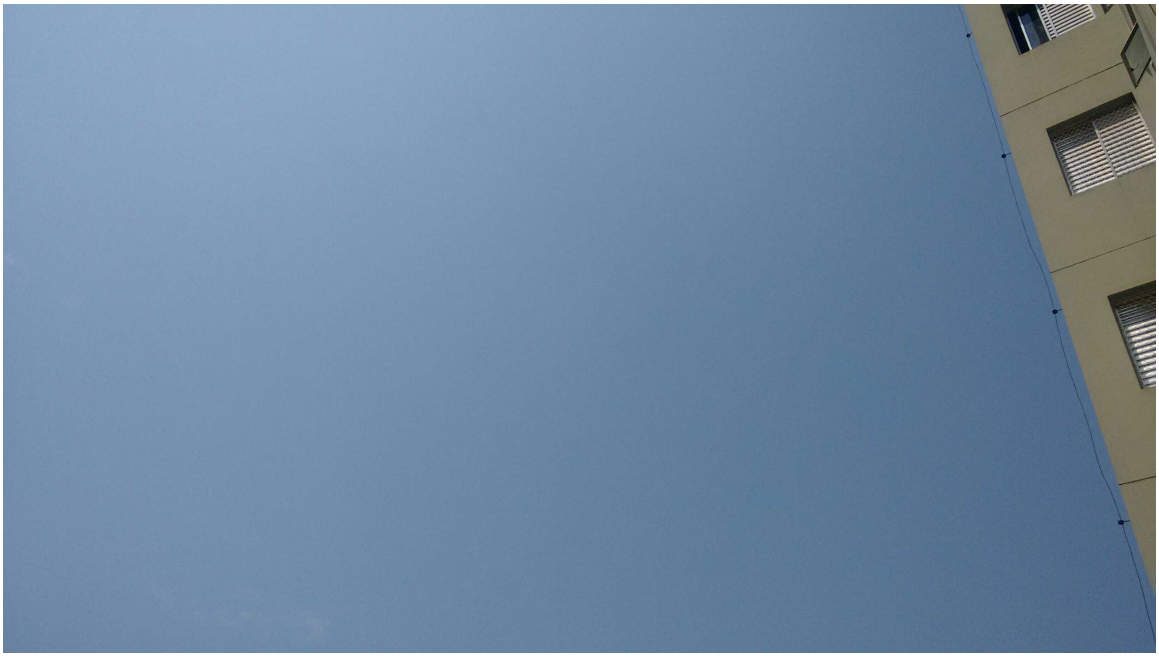
The vertical band shows CALIPSO data from the ground to 30 kilometers into the atmosphere. CALIPSO carries a lidar instrument that uses a laser to measure the vertical structure of thin clouds and aerosols (particles in the atmosphere like pollution, smoke, dust, sea salt, and so forth). Thin clouds and aerosols are difficult to see with other satellites and from the ground. The laser bounces off these features, making it possible to detect them. The scattered yellow band indicates that there were thin clouds and/or aerosols in the atmosphere, even though citizen scientists reported clear skies.

Toward the north of the swath, over the Chicago region, the laser is bouncing off a high, band of clouds (the dark red and yellow line), probably high-level cirrus clouds. Citizen scientists reported overcast or partially overcast skies. One citizen photo from that time shows low stratocumulus clouds. Why is CALIPSO measuring high cirrus clouds, while the person on the ground sees low clouds?

Citizen science observation of stratocumulus clouds over Illinois on September 7, 2016.

The question is answered by adding CloudSat data. As the camera pans around the swath, the CloudSat data fades in at about 47 seconds. CloudSat carries a radar instrument that measures the vertical structure of thick clouds—clouds that CALIPSO's laser can't see through. The reds and pinks indicate strong radar reflection, which indicate ice or rain in the clouds. This is a storm system, and CALIPSO recorded clouds above the top of the towering clouds, while the citizen scientist saw the base of the system. CloudSat sees inside the system to provide the full picture of the storm.

The second example begins at 58 seconds and shows Brazil on September 18, 2016. The broader MODIS scene shows hazy skies with scattered clouds. (MODIS detected extensive fires in the Amazon rainforest, shown as red dots at http://go.nasa.gov/2fx163H.) CALIPSO detected what is probably smoke particles (aerosols) as represented by yellow and red band. The uneven blips in the band are little cumulus clouds. CloudSat also picks up the small cumulus clouds when it fades in at about 1:09. The nearest citizen scientist observation shows clear skies not far from a convective boundary (storm system) to the west.



A GLOBE Observer noted cloudless skies over Brazil on September 18, 2016.

The final example starts at 1:23 and shows clouds over Turkey and eastern Europe. MODIS reveals widely cloudy skies. In CALIPSO, a solid white line hangs near the ground. These are likely low-level stratus clouds. CloudSat (1:36) shows little bright red or pink, indicating that these clouds probably aren't producing rain. The citizen science observation from Warsaw, Poland indicates stratocumulus clouds.

Stratocumulus clouds over Warsaw, Poland on September 21, 2016.

As the animation concludes (1:41), the camera pans around to show an interesting feature in the lower right over the Mediterranean Ocean. CALIPSO shows a band of red, meaning big particles were in the atmosphere. Elsewhere, that color is associated with rainfall, but CloudSat shows no reflectivity and MODIS shows no clouds here. Instead, there is a hint of brown color. This is a dust storm from the Sahara Desert blowing north over the Mediterranean Sea. We have no GLOBE Observer observations to confirm the storm from the ground, but the report would probably have been obscured skies due to dust.

By looking at three different satellites along with citizen science observations, scientists can learn about the structure of cloud systems and better understand what the satellites are measuring. Why do clouds matter so much? Clouds are a key mechanism in distributing fresh water around the planet. In a changing climate, scientists are uncertain how clouds might change, and as a result, how access to fresh water might change.

Clouds also affect climate in different ways. High thin clouds act like a greenhouse gas, trapping heat and amplifying warming. Such clouds carry little water. Low clouds shade Earth's surface, cooling the planet and re-distributing water. Which will become more common as temperatures warm, and what does that mean for warming and water availability? By tracking clouds, citizen scientists can help scientists monitor changes and begin to address these questions.