Dutch Students Contribute to OMI Aerosol Validation

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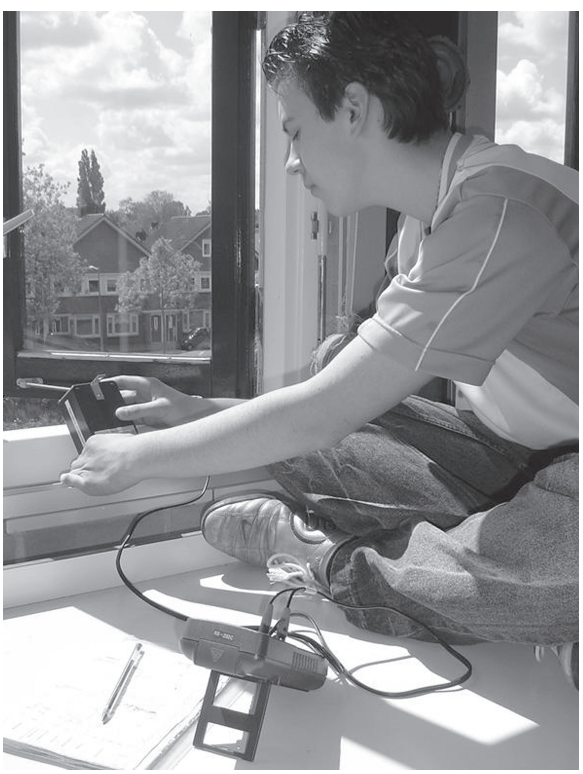
We've all been there. The sun is shining brightly outside but we are forced to stay inside for school or for our job. How we wish we could take our work or have our class outside! Well, some high school students in the Netherlands now have a legitimate reason to be outside on those bright sunny days. Their schools are participating in the GLOBE-aerosol project. Two or three students head outside a couple of minutes before NASA's Aura satellite is scheduled to pass over. Once outside, they take a measurement of the intensity of the sunlight using a hand-held Sun photometer, from which the amount of aerosols can be derived. The results are used for the validation of the aerosol retrieval of the Ozone Monitoring Instrument (OMI) on Aura.

OMI measures the aerosol concentrations (along with various trace gasses, and clouds) worldwide, on a daily basis. *Aerosols*—particles or droplets in the air with a typical diameter of 1 μm—scatter and absorb sunlight, and ultraviolet radiation from the surface of the Earth, and thus play an important role in the radiative balance of the atmosphere and impact the temperature of the atmosphere. Moreover, without aerosols it would be almost impossible for clouds to form in our atmosphere.



A student from Amsterdam takes an aerosol measurement out of the classroom window.

In order to understand climate and climate change, one obviously needs to investigate the role of aerosols. For this purpose, satellite observations are indispensable.

The students, who range in age from 14 to 17, use a simple hand-held Sun photometer to measure the direct sunlight. This instrument uses light emitting diodes (LED's) as photocells. **David Brooks** [Drexel University, Philadelphia, PA] and **Forest Mims** [Sun Photometer Atmospheric Network, Seguin, TX] developed the instruments that the students use. Although operating the instrument is not that difficult, the students have to make accurate measurements in order to have the lowest possible error due to misalignment of the instrument. From their measurement, the *total extinction* can be determined. [Following are details on how extinction is calculated.]

> ***Extinction*** of sunlight is caused by ***absorption*** and ***scattering*** of sunlight due to the various atmospheric constituents (clouds, water vapor, aerosols, other trace gases). In terms of physics, the ***total extinction*** is defined as the exponential factor by which the intensity of sunlight decreases as it propagates through the atmosphere. It is a product of the ***relative path length*** of the sunlight through the atmosphere (which is defined to be unity (1) when the sun is located directly above an observer) and the ***optical thickness***. The ***optical thickness*** can be decomposed in a contribution due to Rayleigh scattering (Rayleigh optical thickness), a part that is due to ozone absorption (ozone optical thickness) and a remaining part attributed to aerosols (aerosol optical thickness) which can only be measured in the absence of clouds. (The students measure aerosol optical thickness with the Sun photometers.)

Since aerosol extinction can only be measured under cloud-free conditions, the students must first observe the sky conditions and make a decision whether or not to take a measurement with the Sun photometer. Clouds are sometimes very difficult to detect with human eyes, so the largest source of potential error in the student's measurements is from cloud contamination.

Students fill in a data sheet with every measurement, making notes of the output voltages of the instrument, and also the meteorological conditions, e.g., cloud cover, cloud type, the number of contrails in the sky, etc.

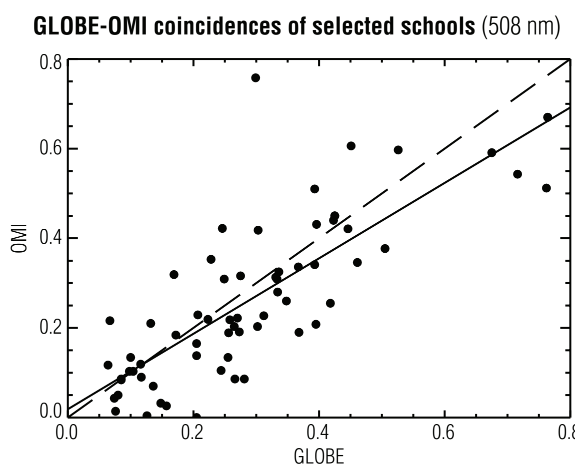
Four pairs of eyes keep a close watch on the instrument. The students lean on each other for support.

During Fall and Winter 2006 we noticed a sharp drop-off in the number of measurements coming from the schools. This is not surprising, since winter in the Netherlands tends to be very grey and overcast with very few cloud-free days to take observations. Sometimes during the winter the students have to wait for weeks to get a good day for making observations, and even those rare days where one could obtain a good measurement during an OMI overpass were often missed because the teachers and students had gotten out of the daily routine of taking measurements.

Students from Houten work together efficiently, bending over backwards to help one another.

To solve this problem, we introduced the *campaign format* this year. The main idea was to organize a shorter period (two months rather than the whole year) in which all the participating schools were on the alert all the time. We chose this period to start in the first week of March, and to end in the second week of May—that time of year tends to be sunny in the Netherlands. Twelve schools participated in the campaign.

We could not have chosen a better period for a campaign, since after some very good days in March, this year's April became a record breaking month in the Netherlands with lots of sunshine (280 hours of sun versus 162 normal). The schools were obviously ready this time, since we received lots of measurements that were taken right at the moment when OMI passed over (twice a day). At the moment we are in the process of analyzing the data and inspecting the calibration of the instruments that were used during the campaign. Preliminary results with well calibrated instruments



A scatter plot of coincident GLOBE [hand-held Sun photometers] and OMI [satellite] Aerosol Optical Thickness [AOT] measurements at 508 nm [the OMI AOT values have been extrapolated from 483.5 nm to this wavelength]. For points on the dashed line, there is no difference between the GLOBE and the OMI measurement. The skew line is the best linear fit through the points. The correlation coefficient of these 66 measurements is 0.80.

All students presented the results of their measurements during the campaign period on a poster at KNMI.

look very promising: there is a good correlation (0.80) between aerosol measurements from the ground—see graph on page 8—taken by the students, and measurements taken by OMI. This correlation is comparable to the results obtained by professional Sun photometers. It confirms the quality of the OMI-aerosol retrieval.

At the end of the campaign, the students and their teachers came to the Royal Netherlands Meteorological Institute (KNMI) to present a poster on which they showed what they had learned, and to understand from KNMI how they had contributed to the OMI aerosol validation research. It was a nice meeting and everybody was enthusiastic about the success of the campaign.

After the summer holidays, a new campaign will start to continue the research. Hopefully, we will have a lot of sunshine in September and October so we will be able to gather just as many valuable measurements. ■

ABOUT THE GLOBE PROGRAM

Global Learning and Observations to Benefit the Environment (GLOBE) is a worldwide hands-on, primary and secondary school-based science and education program. GLOBE's vision promotes and supports students, teachers, and scientists to collaborate on inquiry-based investigations of the environment and the Earth system, working in close partnership with NASA and the National Science Foundation's Earth System Science Projects (ESSPs) in study and research about the dynamics of Earth's environment. For more info please visit *www.globe.gov/*.

Internationally, GLOBE is implemented through bilateral agreements between the U.S. government and governments of partner nations. To date, 109 countries have signed GLOBE agreements, including the Netherlands. The GLOBE-aerosol project in the Netherlands started in 2002 with the scientific support of the Royal Netherlands Meteorological Institute [Koninklijk Nederlands Meteorologisch Instituut (KNMI)], and the organizational support of the Environmental Consultants Agency (SME-Advies). KNMI helps to train the teachers and students, calibrate the Sun photometers, and process the data that the schools submit. During the first couple of years of the project, the focus was on the validation of the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on NASA's Aqua satellite. The GLOBE measurements confirmed that MODIS aerosol retrieval was more accurate over land than over coastal areas. This finding resulted in a scientific article in the *Journal of Geophysical Research* (October 2006) by **Folkert Boersma** [Harvard University, Massachusetts] and **Joris de Vroom** [KNMI].