A Brief History of Student Sun Photometry

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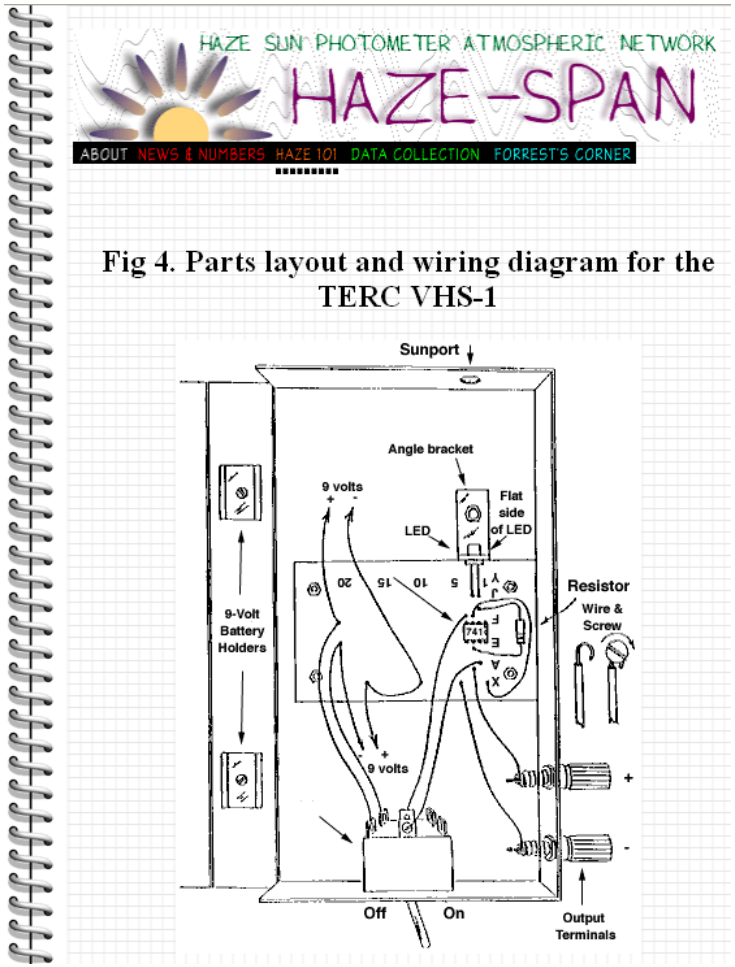
Handheld sun photometers: The early days

*Mims, Forrest M. III: Sun photometer with light-emitting diodes as spectrally selective detectors. Appl. Opt., **31**, 6965-6967, 1992.*

- Handheld sun photometers pioneered by Frederick Volz:

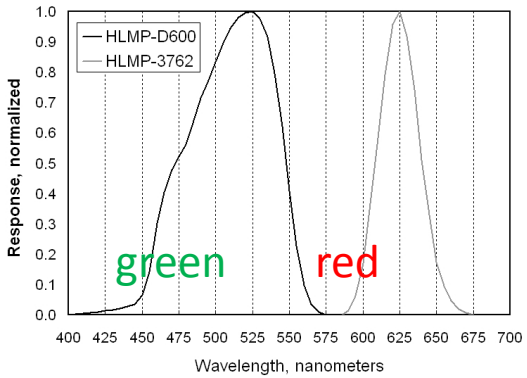
  Volz, F. E., Photometer mit Selen-photoelement zurspektralen Messung der Sonnenstrahlung und zer Bestimmung der Wallenlangenabhangigkeit der Dunsttrubun, *Arch. Meteor.Geophys. Bioklim.*, **B10**, 100-131, 1959
- The original LED-based"Visible Haze Sensor," built in a VHS tape case, was designed by Forrest Mims and developed by TERC in 1996, with support from NSF (the Concord Consortium, 1997).
- VHS-1 appeared in *Scientific American*'s *"The Amateur Scientist" column:*

  Carlson, Shawn. Hazy Skies are Rising, *Scientific American* **276**, 106-107, 1997.



Why bother with LED-based sun photometers?

- Historically, sun photometers used narrow-bandpass filters (a few nm?), but these filters are ***expensive, fragile, and subject to unpredictable failure***.
- LEDs have some disadvantages (their spectral bandpass is relatively large (a few tens of nm?), but they are ***cheap, virtually indestructible, and very stable over time***.
- A performance study of the two-channel LED sun photometer was published in 2002. This was the first sun photometer (and the first GLOBE instrument) to be designed for student use and subjected to peer review in a scientific journal.



Brooks, D. R., and Mims, F. M. III. Development of an inexpensive handheld LED-based Sun photometer for the GLOBE program. J. Geophys. Res., ***106****, D5, 4733-4740, 2002.*

Introducing Sun Photometry to the GLOBE Community, 1998

Mims' VHS-1 instrument was the basis for the sun photometer designed for the GLOBE Program. An important difference was that the spectral response of the LED detector used in this instrument was studied extensively so that the aerosol optical thickness (AOT) could be properly interpreted. This instrument was introduced, along with an Aerosols Protocol, at the 1998 GLOBE Annual Meeting.

Characterization of LED-Based Sun Photometers for Use as GLOBE Instruments

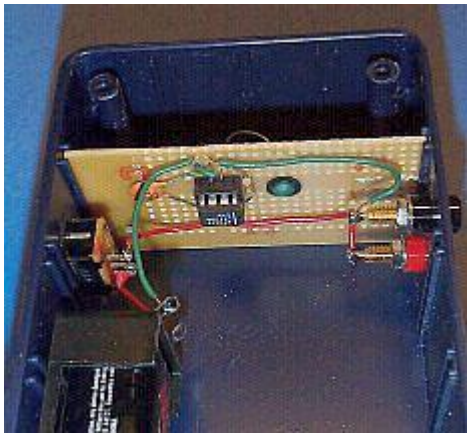
David R. Brooks, PD/PI for Science, Haze/Aerosol Monitoring Project, Drexel University

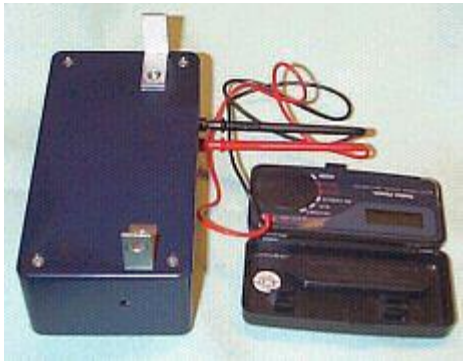
Forrest M. Mims III, Co-PI for Science, Haze/Aerosol Monitoring Project

Tran Nguyen, Research Assistant, Drexel University

Stephen Bannasch, Director of Technology, The Concord Consortium

GLOBE Third Annual Meeting, Snowmass, Colorado, August 3-7, 1998





Evolution of the GLOBE sun photometer

✓ Several design iterations and more than 900 hand-built instruments!

RG8	907	2	6	2012		1.5283	1.7623
RG8	908	2	6	2012		1.6854	1.7985
RG8	989	2	13	2012		1.6366	1.9450
RG8	910	2	8	2012		2.0397	1.9457

Plus:
~100 sun photometers for NASA's CALIPSO project
~150 water vapor sun photometers
~200 sun photometer kits

✓ Two channels (505 and 625 nm)

✓ Build-in digital panel meter

✓ Internal air temperature sensor

✓ Near-IR version for water vapor

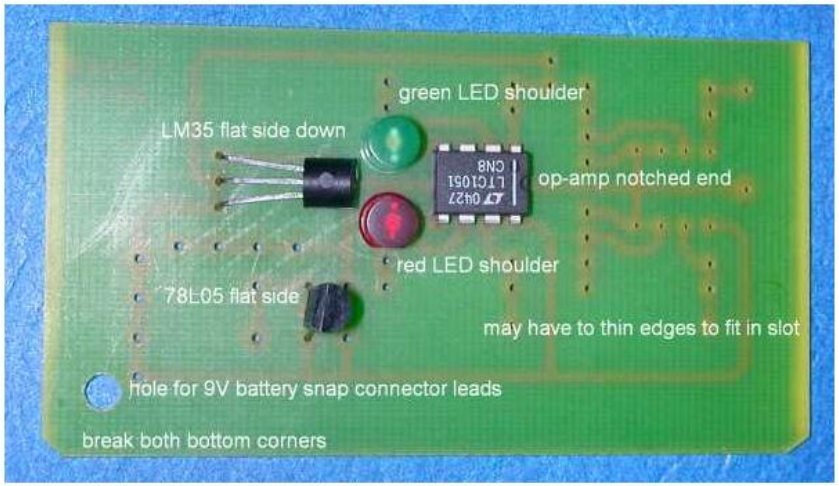
A kit version is still available…

Building a two-channel sun photometer

These photos show you how to build a two-channel sun photometer with a built-in temperature sensor and connections to a digital panel meter. These are minimum instructions for use by those who already have some electronic construction experience. Note that not all connections on the board are used. **Be sure to examine the photos carefully to make sure that you make connections as required!**

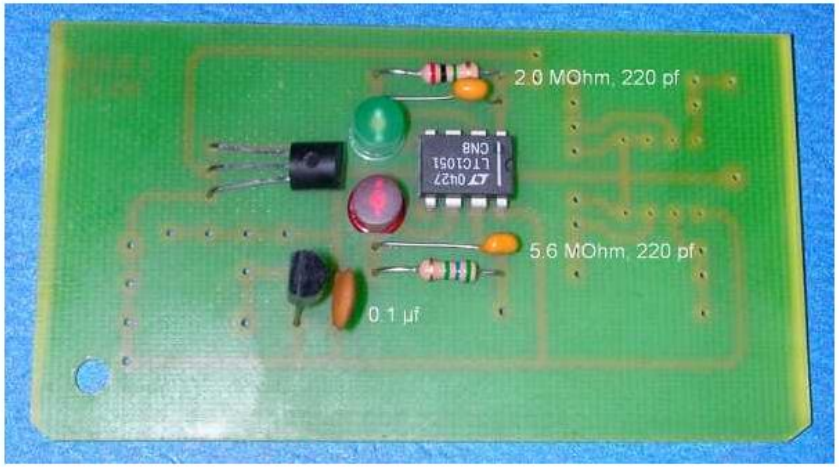
Components that must be oriented in a particular direction.

Note that the op-amp lettering is upside down in this view, but it is mounted correctly on the board.



Components that can be oriented in either direction.

The resistor values may be different. The capacitors, especially the 220 pf capacitors, may look different from the photo.



The first serious student aerosols monitoring program was started in the Netherlands, with science support from KNMI. That program continues to this day!

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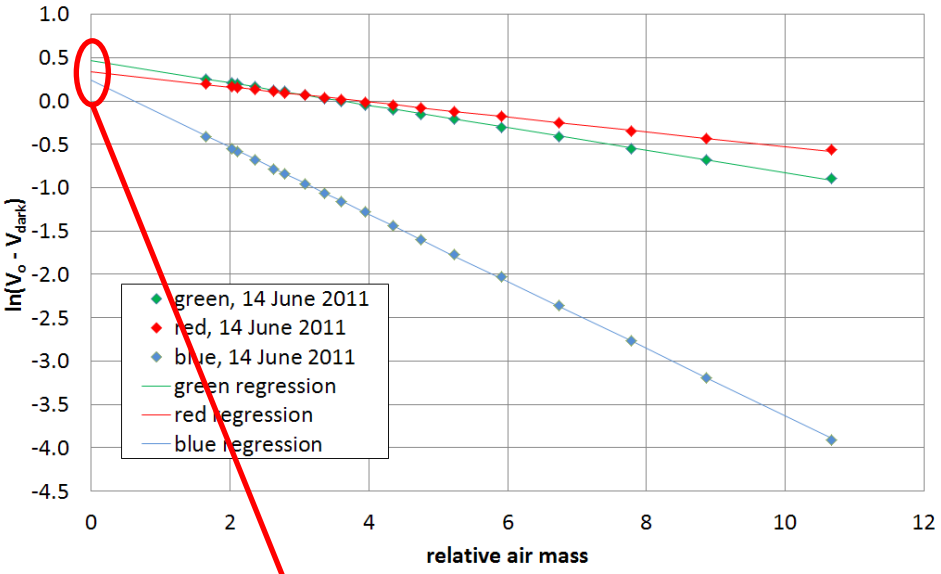
RGK-201, Nieuwentijt old: g=1.8466 r=1.3351?
1.7934 1.5526
52.3833 4.9333 0 505 625
//AA
AZ NLNLENQ5 01 20030313 RGK-201 X X X 121500 1.221 0.003 121700 1.094 0.004 121900 1.229 0.003 122100 1.079 0.004
122200 1.239 0.004 122400 1.081 0.003 X X X X X X X X X X X X X 0000010000 X X X SC X X LB CL X X X X X 1037 X 0
AZ NLNLENQ5 01 20030314 RGK-201 X X X 121000 1.346 0.003 121200 1.192 0.004 121400 1.351 0.003 121500 1.193 0.004
121800 1.336 0.003 122000 1.193 0.004 X X X X X X X X X X X X X 0000000000 X X X NC X X LB CL 9 X X X X 1040 X 0
```

Requirements for a successful student instrument:

- Simple design with high-quality electronic components.
- Testing the spectral response of LED detectors (*significantly* different from their spectral emission spectrum).
- Simple design and rugged construction.
- An ongoing program of calibration for reference instruments to ensure scientific credibility.

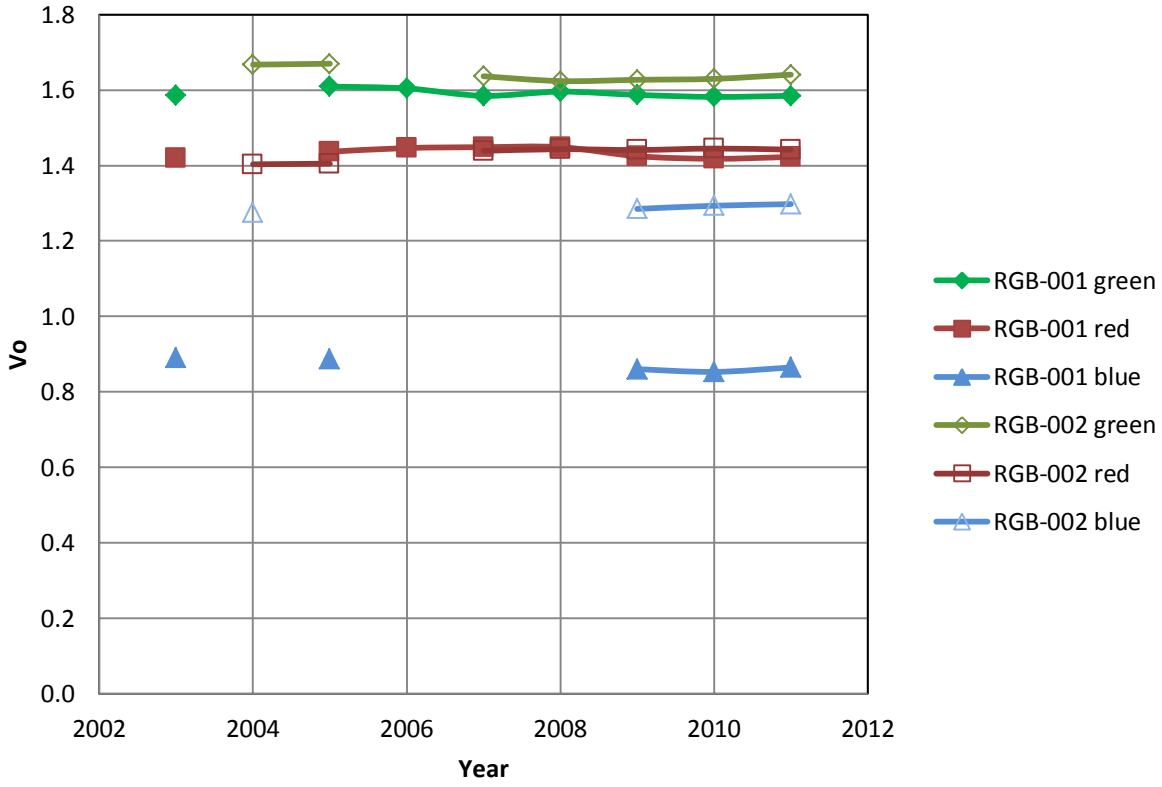
Calibrations at Mauna Loa Observatory – every year since 2003!

- An aggressive program of calibration is essential to the success of any aerosol monitoring program! Hawaii's Mauna Loa Observatory is the favored site for such work.
- Data collection (by Mims) is completely separated from data analysis (by Brooks). This ensures that the Langley plot data are analyzed objectively.



These intersections give the calibration constants (V_o) for this instrument, which are then corrected to an average Earth-sun distance of 1 AU.

MLO calibrations demonstrate the long-term stability of LED sun photometers



LED-based student sun photometry makes its way into the peer-reviewed scientific literature

Boersma, K.F., and J.P. de Vroom. "Validation of MODIS Aerosol Observations over the Netherlands with GLOBE Student Participation." Journal of Geophysical Research, Vol. III, p. D20311, doi. 10.1029/2006

Joris de Vroom, Folkert Boersma, and Pieternel Levelt. Can Dutch GLOBE schools validate MODIS Aerosol Optical Thickness measurements? KNMI, Presentation at the EOS/Aura Science Team Meeting, October 2003.

Vroom, Joris de. The Contribution of Dutch GLOBE Schools to Validation of Aerosol Measurements from Space. Master's Thesis, Vrije Universiteit Amsterdam, October 2003.

Geophysical Research Abstracts, Vol. 9, 00563, 2007 SRef-ID: 1607-7962/gra/EGU2007-A-00563 © European Geosciences Union 2007

The GLOBE-Aerosol monitoring Project at KNMI

T. Vlemmix [1], E.J. Brinksma [1], P.F. Levelt [1], R. Braak [1], B. Veihelmann [1], J.P. Veefkind [1]

*Brooks, David R., Forrest M. Mims III, Richard Roettger, Inexpensive Near-IR Sun Photometer for Measuring Total Column Water Vapor, Journal of Atmospheric and Oceanic Technology, **24**, 1268-1276, 2007.*

GLOBE students get international recognition

Brooks, D. R., F. Niepold, G. D'Emilio, J. Glist, G. Hatterscheid, S. Martin, K. Dede, I. Neumann. Scientist-Teacher-Student Partnerships for Aerosol Optical Thickness Measurements in Support of Ground Validation Programs for Remote Sensing Spacecraft. IAC-03-P.4.07, International Astronautical Federation, 54th International Astronautical Congress, Bremen, Germany, Sept. 28 - Oct. 3, 2003.

Scientist, teachers, and students, plus Dr. Adena Williams Loston, NASA Associate Administrator for Education (in center).

14 CUXHAVEN

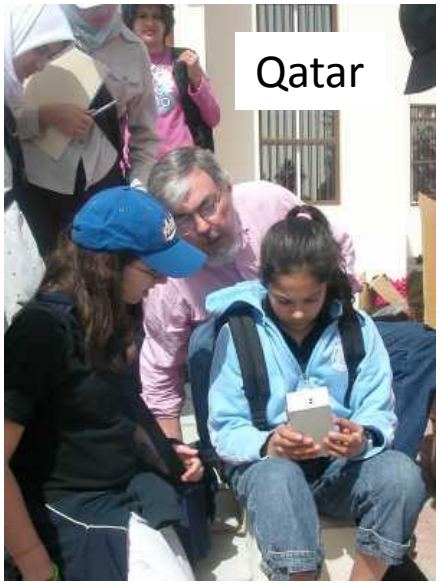
Dienstag 21. Oktober 2003

Ergebnis-Präsentation vor internationalem Publikum

Drei Cuxhavener Realschülerinnen waren sich in Bremen einig: „So macht Lernen Spaß"

The local newspaper in Cuxhaven published this article about their students' participation in the conference. (See English translation below.)

Student/teacher sun photometry around the world.



Today, there is encouraging and not so encouraging news…

- Student aerosol monitoring continues in the Netherlands and elsewhere in Europe, part of the Comenius project sponsored by GLOBE Europe/Eurasia, with scientific oversight from KNMI.
- Our colleagues in France are developing new versions of handheld sun photometers for student use.
- Worldwide, even though hundreds of sun photometers have been distributed to GLOBE schools, relatively little data have been reported. Only a few dozen schools have consistently reported aerosol data – notably schools in the Netherlands and a few other European countries.
- The scientific value of these measurements has been proven, but there is much work yet to be done!