Cimel Sunphotometers: Highlights from Recent Deployments and Instrument Advancements for Cloud Mode Observations for Ship-Based Deployments

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Cimel Sunphotometer Introduction & Measurements

Description and Uses

The Cimel Sunphotometer (CSPHOT) is a multi-channel, automatic sun-and-sky scanning radiometer that has been deployed at ARM sites starting in 1998 at the SGP site and is now deployed at all ARM sites. Each ARM deployment of this instrument is also part of NASA AERONET (AErosol RObotic NETwork) which provides stable and well characterized calibrations (Holben et al., 1998). ARM data users often rely on this calibration for instrument intercomparison, satellite retrieval validation, as well as aerosol research, for which the network was intended. Here we present some of the highlights from recent deployments and updates on advancements made to the instrument for ship-based deployments.

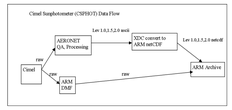
Measurements

- Direct solar irradiance and sky radiance at the Earth's surface
- Direct Sun Measurements every 15 Minutes at 340, 380, 440, 500, 675, 870, 1020, and 1640 nm
- Almucantar and Principal Planes up to 8 times per day

Derived Quantities:

- Aerosol optical depth (AOD) (Lev. 1.0, unscreened, 1.5 cloud screened, 2.0 cloud screened and quality assured)
- Size Distribution
- Phase Functions (coarse, fine)
- Cloud Optical Depth (provisional)
- PWV, Single scattering albedo, refractive index

L. Gregory: CSPHOT on top of Bldg. 490 at BNL doing a direct Sun observation during the 2011 Aerosol Life Cycle Field Campaign).



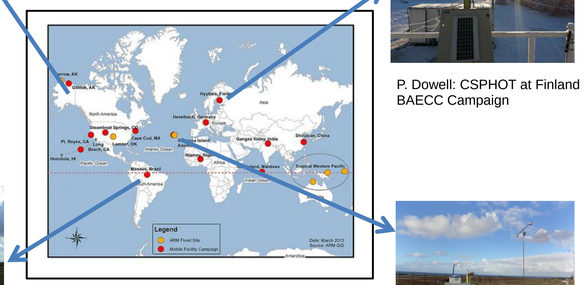
L. Gregory: Chart showing that the data flow path to both ARM and AERONET

AERONET: All AERONET sites

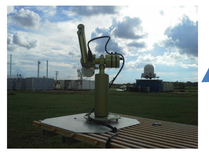
Deployments

The ARM CSPHOTs are now available at all ARM Sites. Recent deployments include Oliktok (OLI), Eastern North Atlantic in the Azores (ENA), Brazil for the GOAMAZON Campaign (MAO) and at Finland for the BAECC Campaign (TMP).

AMF3 site ops: CSPHOT installed at Oliktok, Alaska



P. Dowell: CSPHOT at Finland BAECC Campaign



V. Castro: CSPHOT at Brazil, GOAMAZON Campaign

C. Sousa : CSPHOT at ENA, Azores

Comparisons

Comparisons to Other Instruments

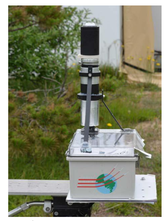
Here are some recent examples of validation and comparisons to newly developed instrumentation during recent ARM Field Campaigns

Validation for 4STAR instrument

- ARM CSPHOT was used to validate the AOD measurements for the newly developed 4STAR Spectrometer for Sky-Scanning Sun-Tracking Atmospheric Research (4STAR) instrument (Shinozuka et al., 2013)
- Tested during field campaign with ARM Aerial Facility & NASA Ames: "Two-Column Aerosol Project (TCAP): Ground based AOD measurements", PI's Phil Russell, Jens Redemann
- Data were compared from the CSPHOT, installed at Barnstable Airport at Cape Cod and the 4STAR, installed on DOE G-1 Aircraft, July 2012

Validation for AERODYNE TWST (Three-Waveband Spectrally-agile Technique)

- CSPHOT cloud optical depth measurements were compared to the TWST sensor, being developed by Aerodyne Research, Inc. (Niple et al., 2014)
- Tested at TCAP, Cape Cod
- TWST description: Real time Cloud Optical Depth Sensor, 1 sec temporal resolution, approx. 300 spectral resolutions
- Data compared with CSPHOT, MWR



MAGIC CSPHOT Deployment

MAGIC CSPHOT

For the Cimel Sunphotometer deployment on board the MAGIC Horizon Spirit, modifications were made to enable continuous zenith radiance measurements for cloud optical depth and cloud droplet size retrievals.

Motivation

- To increase understanding of feedback processes of marine boundary layer clouds the AMF2 MAGIC field campaign aimed to observe the transition from the stratocumulus to shallow trade-wind cumulus. These clouds pose great challenges for remote sensing techniques because of their highly inhomogeneous and fast evolving nature.
- We aimed to provide observations of cloud optical depth (COD) and effective droplet size at high temporal resolution using the ARM sunphotometer, which has a proper narrow field-of-view for observing broken clouds and the necessary narrow wavelength bands.

Cloud Mode, background and operational use in AERONET

- Cloud mode and cloud optical depth Retrievals were developed by ARM PI's C. Chiu and A. Marshak (Chiu et al., 2010)
- **Tested and developed at ARM sites**
- Now used operationally at many AERONET sites, making this the largest ground based network for cloud optical depth measurements
- Original retrievals relied on vegetated sites
- New retrieval (Chiu et al.,2012) developed to allow for COD measurements at marine sites

AERONET: Cloud Mode Sites

Instrument Advances

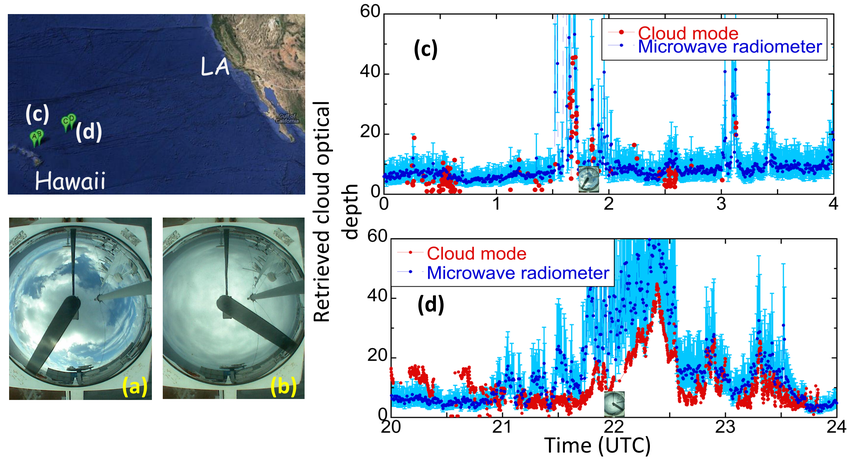
- Modifications to the CSPHOT EPROM were needed to add continuous cloud mode measurements.
- Changes coordinated between Cimel Electronique, ARM PI Christine Chiu at Univ. of Reading, and AERONET
- Updates allow for near continuous zenith radiance measurements, 12 measurements taken, lasting approx 10 seconds.
- Measurements are taken at wavelengths 340, 380, 440, 500, 675, 870, 1020, and 1640 nm
- New EPROM was installed into a newly calibrated instrument from AERONET and deployed as part of the ARM Magic deployment June-August, 2013

Changing out the EPROM in CSPHOT Control Box (Picture from Cimel Electronique)

CSPHOT on board the Horizon Spirit

Results using Cloud Optical Depth Retrievals (Chiu et al., 2013)

- Examples show a reasonably good agreement between retrievals from cloud mode and microwave radiometer obs.



Retrievals for 5/18/2013 (as shown on the map). (a) and (b) are cloud images taken at ~1:53 UTC and 22:00 UTC, respectively, while (c) and (d) are the corresponding time series of retrieved cloud optical depth. Microwave-based retrievals use an assumed cloud effective radius of 10 μm, with uncertainty estimated by changing size from 6 to 16 μm.

More Information:
Cimel (CSPHOT) Instrument Page:
http://www.arm.gov/instruments/csphot
Aeronet:
http://aeronet.gsfc.nasa.gov/
ARM eXternal Data Center (XDC):
http://www.xdc.arm.gov/, xdc_oper@arm.gov.
ARM Google:
http://google.arm.gov/ search for "Cimel OR CSPHOT OR CSPOT"

References:

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Chiu, J. C., A. Marshak, C-H. Huang, T. Várnai, Robin J. Hogan, D. M. Giles, B. N. Holben, Ewan J. O'Connor, Y. Knyazikhin, and W. J. Wiscombe. ", Cloud droplet size and liquid water path retrievals from zenith radiance measurements: examples from the Atmospheric Radiation Measurement Program and the Aerosol Robotic Network." *Atmospheric Chemistry & Physics Discussions* 12, No. 8 (2012).

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