Aerosol Optical Depth in GAW Trial Network

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- Goals of trial network
- Network extend
- Calibration scheme and Quality Control
- Results from selected stations
- Comparison with other networks

WORCC mandate

Subsequent to the AOD fiasco in BAPMon, a *World Optical depth Research and Calibration Center* was proposed and established in 1996 at Davos and sponsored by Switzerland.

WORCC Tasks

- Implement AOD measurements at 12 global observatories with new instrumentation, calibration scheme, data quality control and protocols.
- Test and verify new instruments and methods under operational network conditions.
- Train station operators in AOD measurements.

WORCC *is assisted by a international group of experts and works in cooperation with GAW QA/SAC* SAG/Aerosols assumes these roles.

WMO initiated contacts between potential stations and WORCC for placement of instruments donated by MeteoSwiss. Host stations are to provide tracking facility and limited manpower.

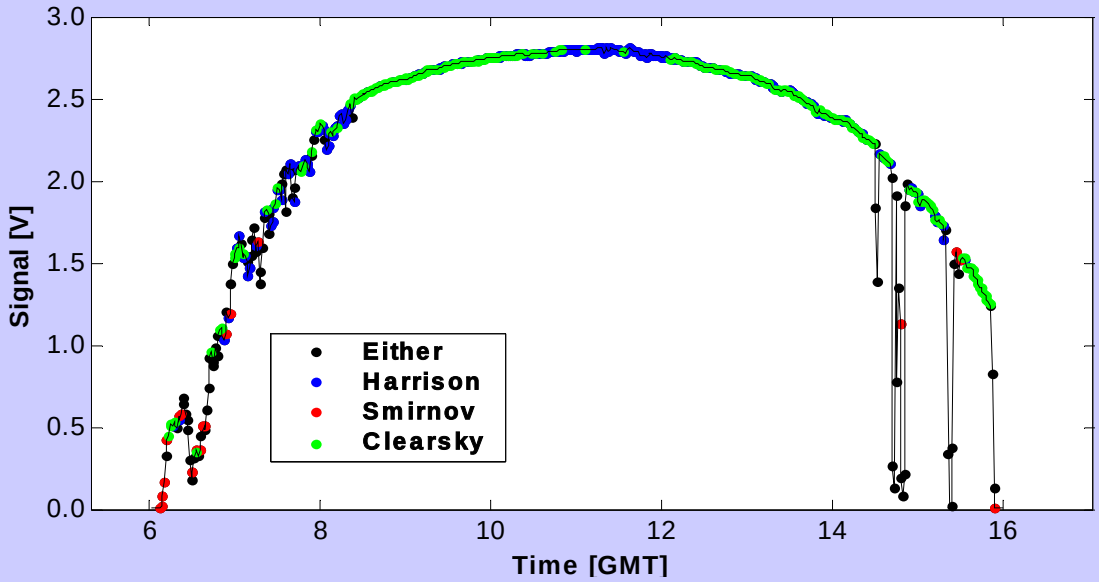
What is measured and how?

- Classic sunphotometer measurements at 4 WMO wavelengths 368, 415, 500 and 862nm ⇨ Optical depth, Ångström exponent
- Identical, precision filter radiometers (manufactured at PMOD/WRC)
- Continuous sampling at 1 (2) minute cadence by automated system
- Monthly data transfer to WORCC for centralized evaluation
- Quality control flags added, pointing, objective cloud filtering, …
- *Hourly means to be archived at WDCA, Ispra.* Currently available at WORCC upon request

Cloud Filtering

3 different cloud flags are determined for individual samples

1. Harrison & Michalsky algorithm, modified for air masses <2
2. Aeronet algorithm applied as moving filter on continuous samples
3. Optically thick (OD>3) clouds



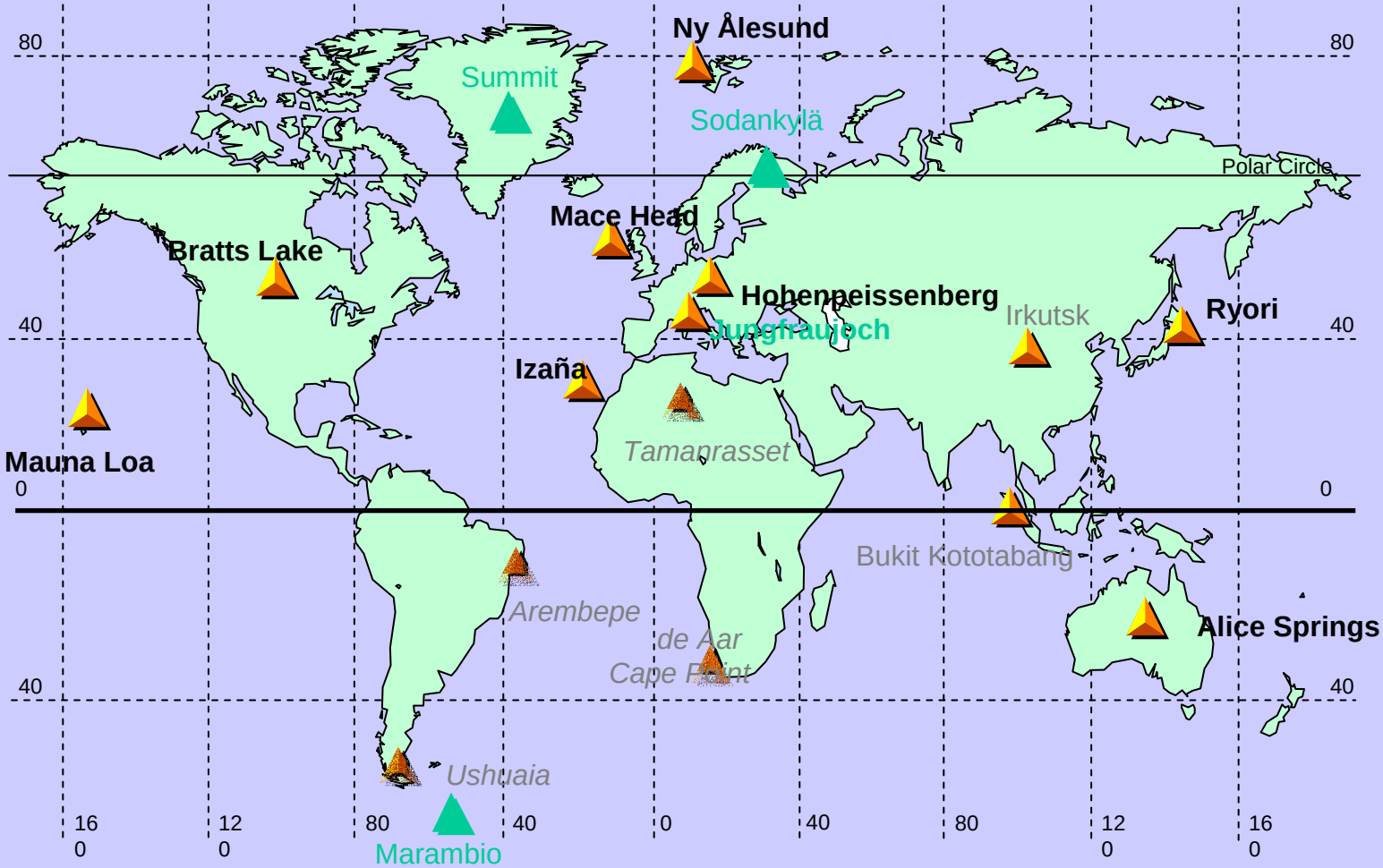
Precision Filter Radiometer

PFR N21 at Ryori, Japan.

PFR specifications

- Automated, solar spectral radiometer
- 4 WMO channels at 862, 500, 412, 368nm using IAD interference filters
- Field of View: ±2.5° , slope angle 0.7°
- Dimensions: Ø90 x L300mm, Mass 3 kg
- Sensor at 20±0.1°C in range –25 ÷ 35°C internal shutter; N_2 purged, airtight case
- High cadence measurements
- built-in pointing sensor
- Data logger with 30 day storage capacity
- Simultaneous barometric measurements

GAW / PFR network sites



PFR Station List

Location	Since	Altitude
Davos, Switzerland (PMOD)	10/1995	1590
Hohenpeissenberg, Germany	06/1999	995
Mace Head, Ireland	07/1999	10
Mauna Loa, Hawaii	11/1999	3397
Jungfraujoch, Switzerland (PMOD)	03/1999	3580
Bratt‘s Lake, Canada	04/2001	586
Izaña, Tenerife	06/2001	2370
Ryori, Japan	06/2001	230
Alice Springs, Australia	07/2001	547
Ny Ålesund, Spitzbergen	05/2002	17
Summit, Greenland (ETH Zürich)	2001, 2002	3150

PFR's at Work

Mace Head

Hohenpeissenberg

Bratt's Lake

Tenerife

WORCC Calibration Hierarchy

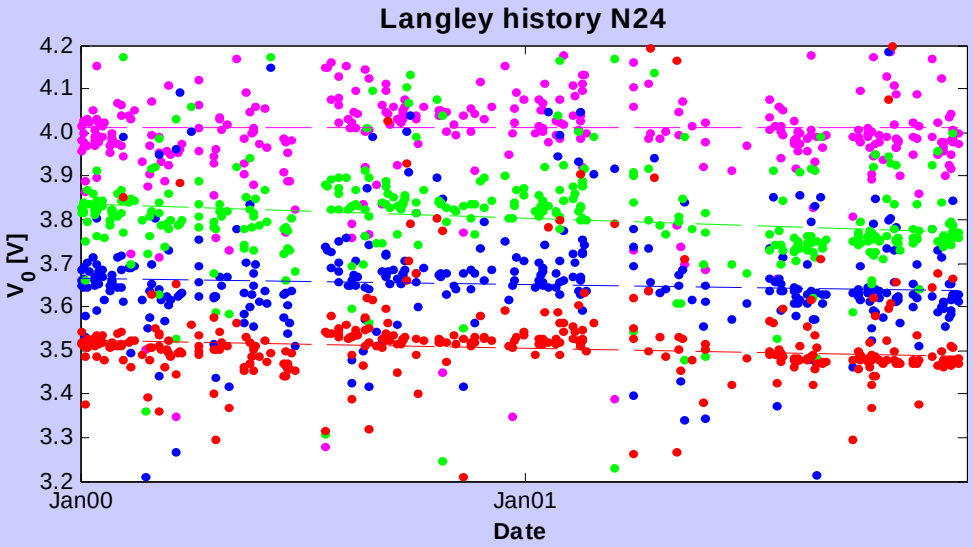
- Standard instruments are calibrated at high altitude stations (Jungfraujoch, Mauna Loa) by atmospheric extrapolation methods.
- One instrument was calibrated in 1998 from stratospheric balloon at 40km height.
- Working standards are calibrated by comparison with WORCC standards at Davos or Jungfraujoch.
- Stability of standard instruments is monitored by spectral comparison with a metrologically traceable absolute detector.
- Station instruments are linked to WORCC reference by travelling standards or exchange of sensors.
- Performance is tested through intercomparison of field instruments with other co-located networks.

Launch of SIMBA98 experiment in Aire sAdours, F

High Altitude Calibration

Sphinx Research Station at Jungfraujoch

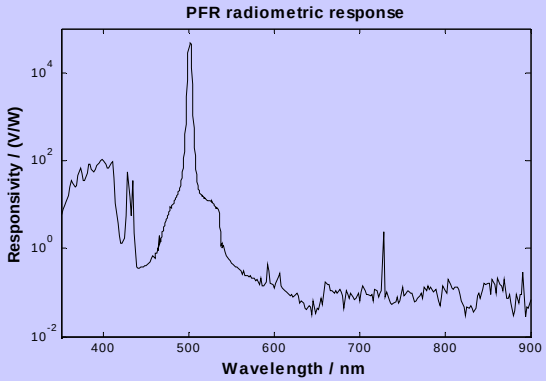
Altitude 3580m
Latitude 46°32'55" N
Longitude 7°59'11" E
Automated solar dome of MS



- Objective, daily Langley calibrations
- Robust, statistical analysis for V_0
- Annual drift <1±0.15%/y

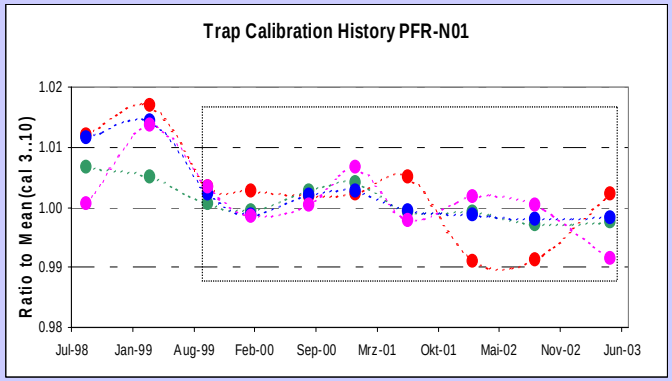
Radiometeric Calibration

- Spectral irradiance scale based on cryogenic radiometer of PTB (Berlin) transferred via calibrated trap detector
- Radiometric response determined every 6 months by spectral comparator facility.



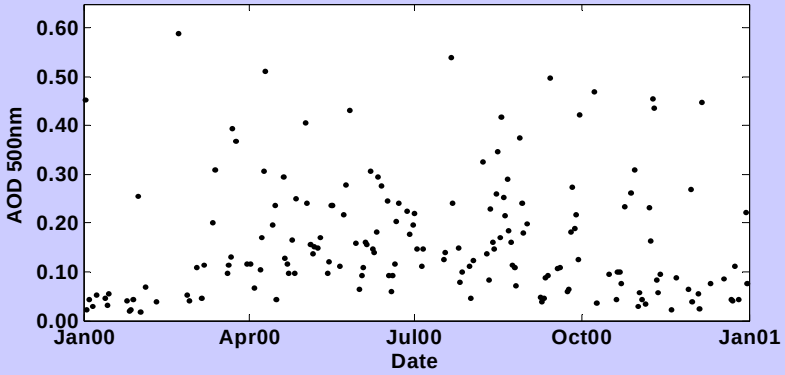
➢Reference instrument N01 is assumed to be radiometrically stable to <±0.5%

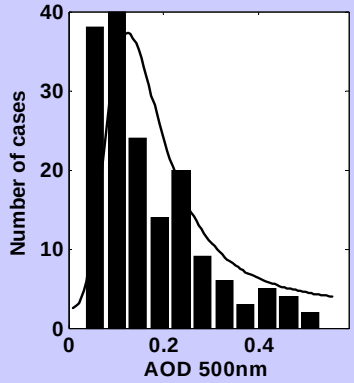
➢*Top_of_Atmosphere constant V_0 could be determined in the laboratory if an accurate extraterrestrial solar spectrum was available.*

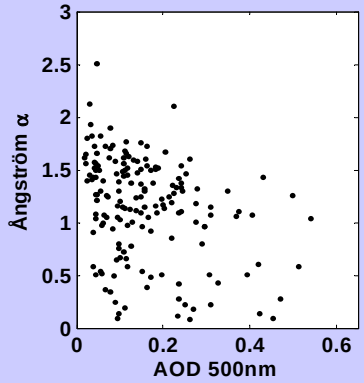


Annual Statistics 2000

Hohenpeissenberg 2000







172 selected clear days
Avg(τ) =0.165±0.122; Median(τ)=0.127
Avg(α) =1.12 ±0.517; Median(α)= 1.22
Gmean(τ)=0.125*2.2^±1

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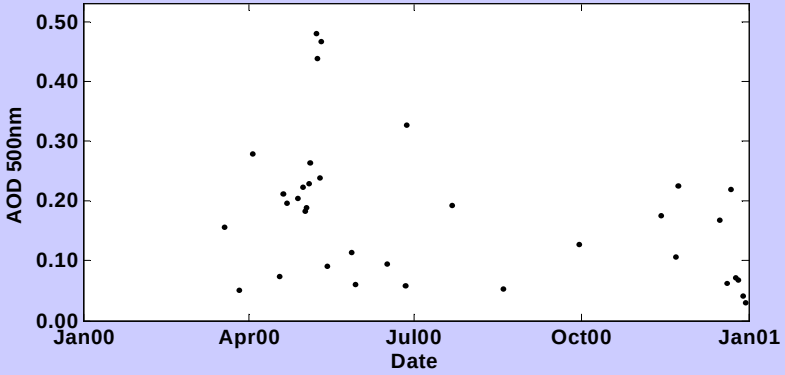
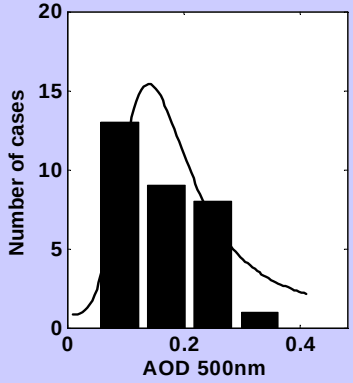
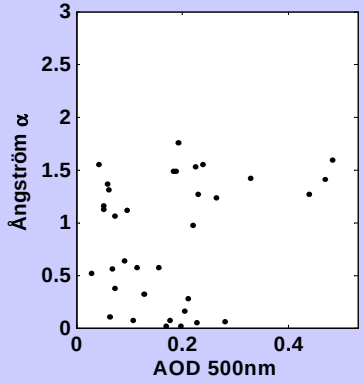
Mace Head 2000







35 selected clear days
Avg(τ) =0.177±0.118; Median(τ)=0.176
Avg(α) =0.86 ±0.586; Median(α)= 1.06
Gmean(τ)=0.140*2.1^±1
Filter: α>0 & β<0.3 & 0.00<τ<0.65

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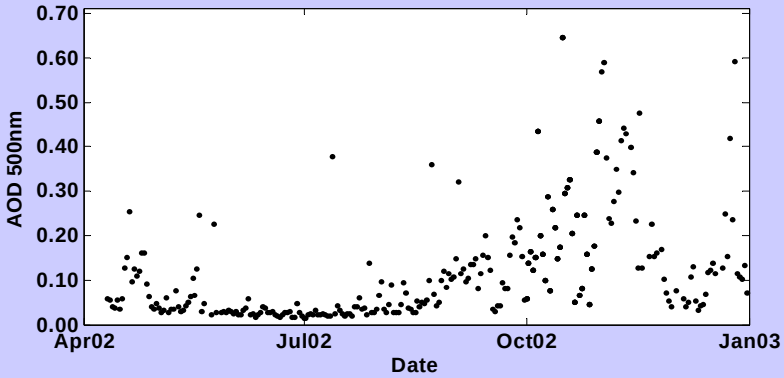
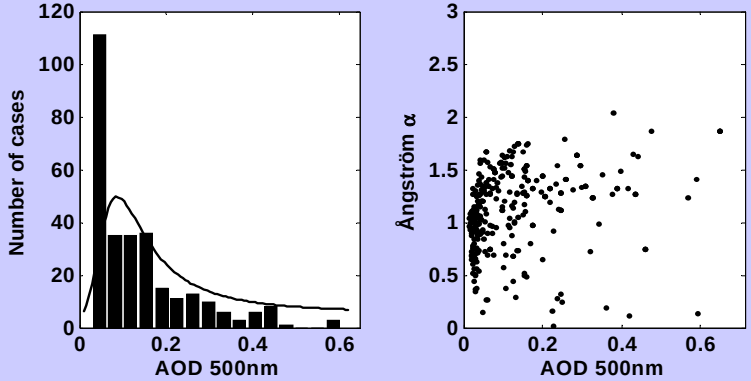
Annual Statistics 2002

Alice Springs 2002





315 selected clear days
Avg(τ) =0.133±0.128; Median(τ)=0.094
Avg(α) =1.12 ±0.379; Median(α)= 1.20
Gmean(τ)=0.086*2.6$^{\pm 1}$

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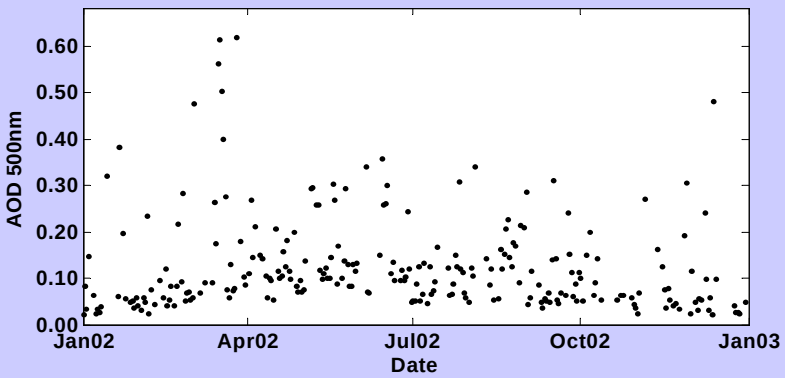
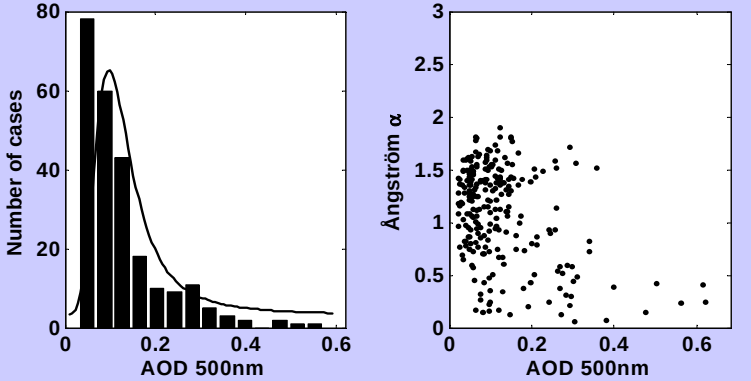
Bratt's Lake 2002





247 selected clear days
Avg(τ) =0.126±0.103; Median(τ)=0.095
Avg(α) =1.08 ±0.468; Median(α)= 1.20
Gmean(τ)=0.097*2.0$^{\pm 1}$

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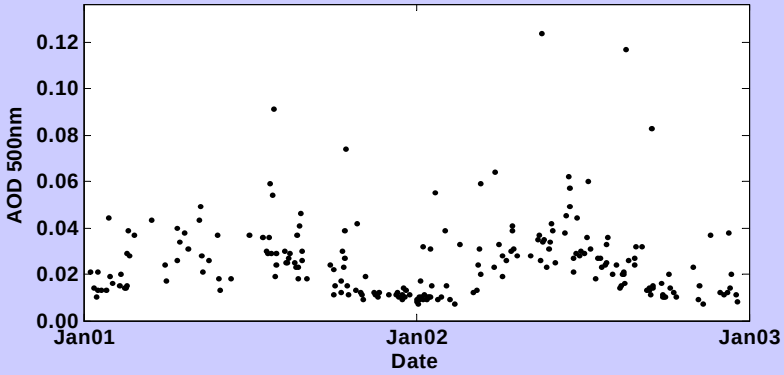
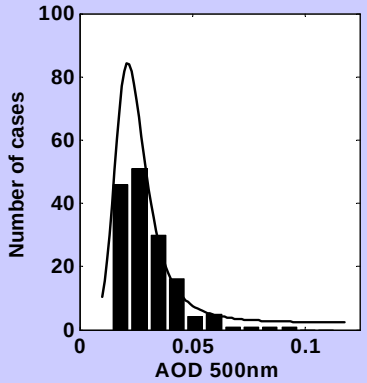
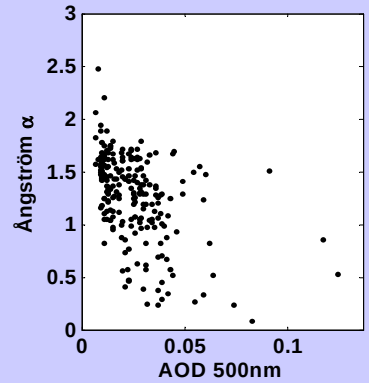
More Stations 2001÷2002

Jungfraujoch 2001÷2002







218 selected clear days
Avg(τ) =0.025±0.017; Median(τ)=0.023
Avg(α) =1.26 ±0.408; Median(α)= 1.32
Gmean(τ)=0.021*1.8^±1

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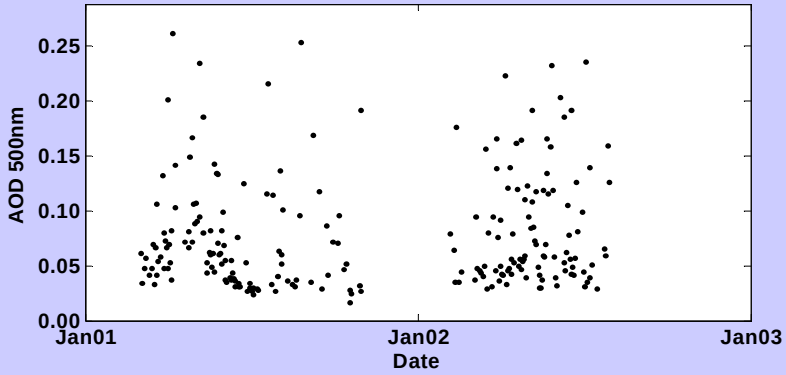
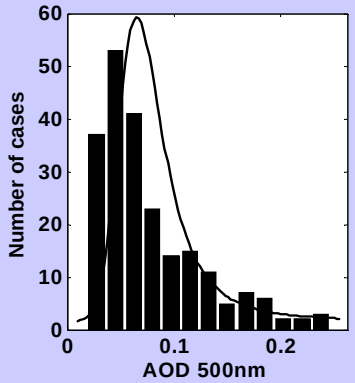
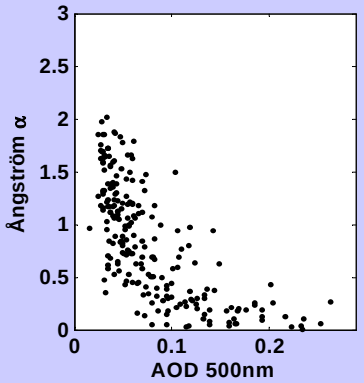
Summit 2001÷2002







222 selected clear days
Avg(τ) =0.078±0.051; Median(τ)=0.059
Avg(α) =0.84 ±0.538; Median(α)= 0.82
Gmean(τ)=0.065*1.8^±1
Filter: α>0 & β<0.3 & 0.00<τ<0.27

file: AODstat2.m Date: 28-May-2003 ChW

MLO Comparison 2000: Methodology

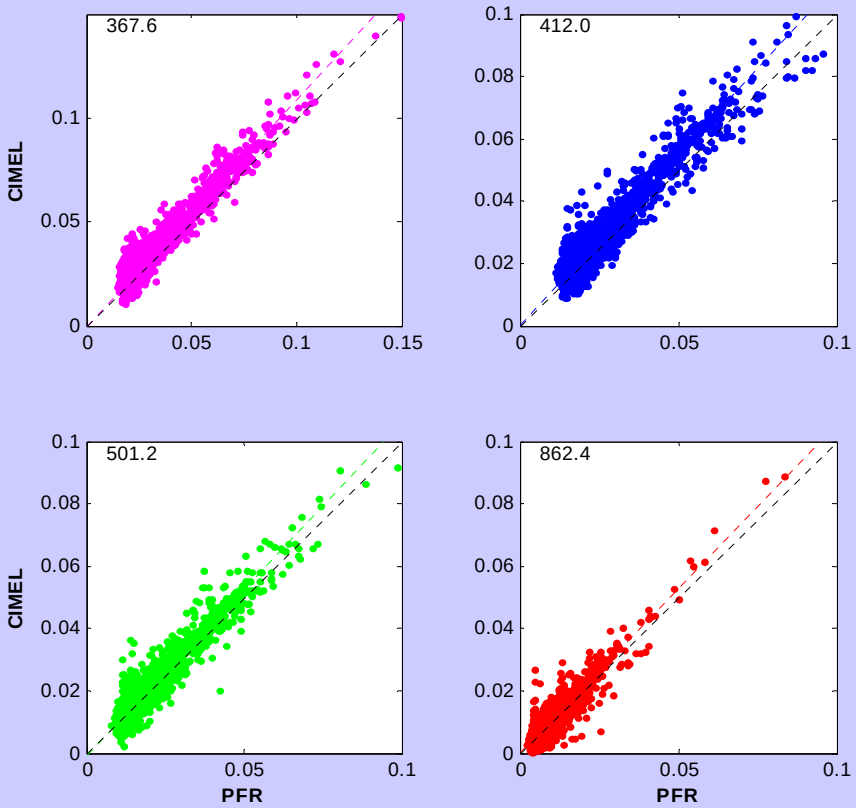
Mauna Loa co-location site for Aeronet and GAW/PFR

- AERONET/CIMEL and GAW/PFR data compared at individual samples level
- Aeronet Level2 data (380, 440, 500, 870nm) as published on internet †
- GAW/PFR with interpolated calibration (drift <0.25%/year)

- ➢ CIMEL channels are interpolated to WMO wavelengths of PFR by Ångström's law using instantaneously derived wavelength exponents.
- ➢ PFR one minute samples are interpolated in time to CIMEL observation scheme

† with kind permission of Dr. Brent Holben, Aeronet PI, NASA/GSFC

MLO Comparison 2000: Optical Depths

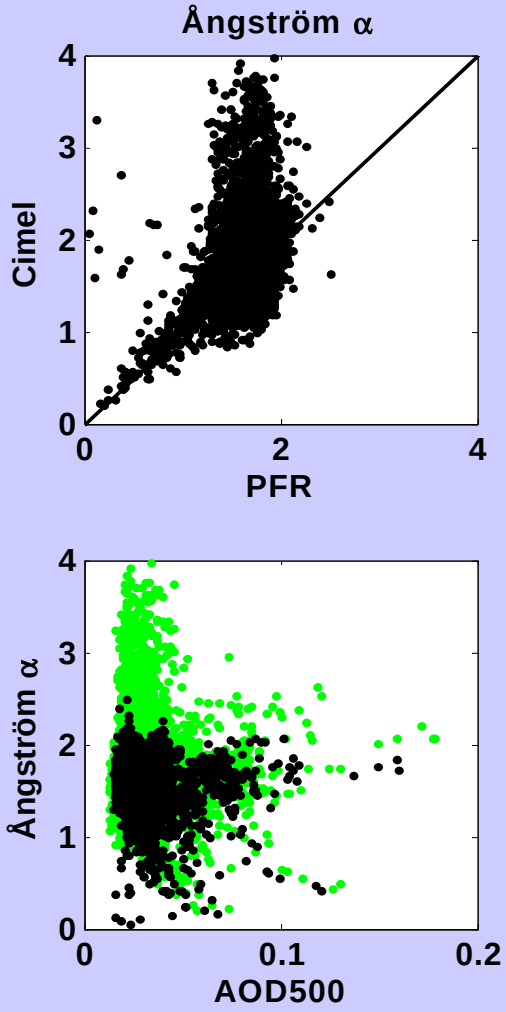


N = 4705 cloudfree samples compared

Wavelength:	367.6	412.0	501.2	862.4
Mean slope:	1.0941	1.1056	1.0678	1.0531
Mean bias :	-0.0002	0.0001	-0.0005	0.0002
RMS diff. :	0.0055	0.0043	0.0030	0.0026
Mean AOD :	0.0203	0.0163	0.0114	0.0049

➢ **Excellent agreement within 0.005 OD at calibration site!**

MLO Comparison 2000: Ångström



Averages

Alpha(Cimel): 1.81±0.5; Aeronet(2000) : 1.83±0.3

Alpha(PFR) : 1.63±0.26; Aeronet(climat): 1.69±0.24

- Marked differences between both radiometers, although they agree well in optical depth.
- Ångström exponent α is a less reliable parameter for satellite ground truthing or model verification.

BLO Comparison 2001

Five instruments operating under 4 network protocols co-located at Bratt's Lake were compared during 3 months in summer 2001:

Cimel (Aeronet); PFR(GAW); SP01 (MSC), 2 MFRSR (MSC and USDA)

- 3 direct pointed radiometers agreed within ±0.01 (2σ) optical depths
- Significant improvements were obtained through cloud screening algorithms
- Difference between 2 MFRSR were almost as large as optical depths
- Large differences in derived Ångström α parameters were found

McArthur, B.L.J., Halliwell, D.H., Neibergall, O.J. O'Neill, N.T., Slusser, J.R. and Wehrli, C.; Field comparison of network sunphotometers JGR 2002JD002964R

Conclusions

- A new network of AOD measurements is under construction within the WMO Global Atmosphere Watch program, that includes a calibration and data quality control concept.
- Data are available since 1999 with ≈ 10 stations in operation now.
- Uncertainty is ≈0.01 optical depths as estimated from comparisons.