Sun Photometers

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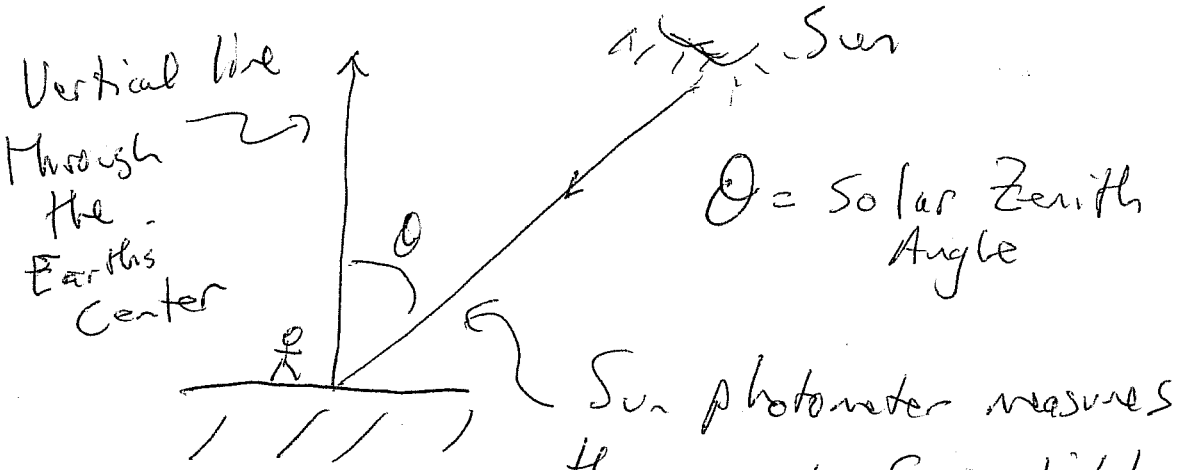
What are they? Instruments that use Wavelength Selective photometers to measure the amount of direct sunlight.

What can you measure?

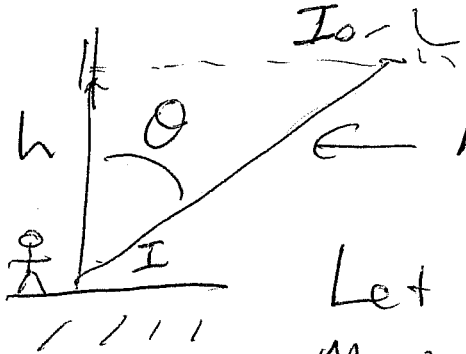
1) Extra Terrestrial Solar Irradiance, (how much Sunlight comes into the top of the atmosphere).
2) Ozone column amount.
3) Water Vapor column amount.
4) Spectral aerosol optical depth.
5) Perhaps Cirros cloud optical depth.



Sun Photometer Measurements

1) Make measurements
2) Plot the measurements on a Langley Plot.

Date	time	location	Solar Zenith Angle (θ) (calculated from 1st 3 items)	Sun Photometer Voltage (V)



h = height of the top of the atmosphere.

Let $m = 1/\cos\theta \equiv$ air mass.
$m = 1$, Sun is overhead,
$m \geq 1$.

I = Solar irradiance at the surface

I_o = Solar irradiance at the top of the atmosphere.

On a cloudless day,

$$I(\lambda) = I_o(\lambda)\, e^{-\tau(\lambda)}$$

λ = wavelength. τ = optical depth

Assuming the atmosphere is clear, or at least constant,

$$\tau(\lambda) = \tau_o(\lambda)/\cos\theta$$

(optical depth when the Sun is directly overhead.

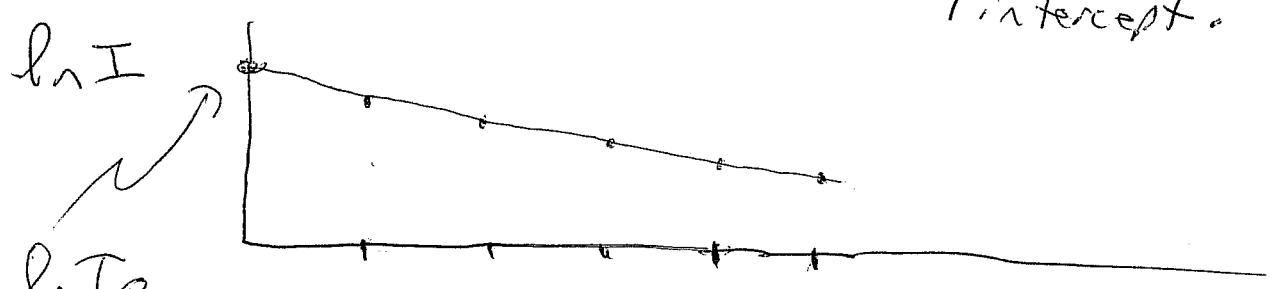
So ...

$$\ln I = \ln I_o - \tau_o(\lambda)/\cos\theta$$

or

$$\ln I = -\tau_o(\lambda)\frac{1}{\cos\theta} + \ln I_o$$

$$Y = -\text{Slope}\ X + Y\text{intercept}.$$



Varies during the day and is greatest at sunrise and sunset, smallest around noon.

The optical depth

τ is a dimensionless number.

$\tau = \tau_{\text{Rayleigh Scatter}} + \tau_{\substack{\text{gaseous} \\ \text{Absorption}}} + \tau_{\text{aerosol}} + \tau_{\text{clouds}}$

Since we'll work on relatively clear days we'll have no clouds.

$\tau_{\text{Rayleigh Scatter}}$ – Scattering by gases, N_2, O_2, etc, as dipole scatterers. (Reason why the sky is blue).

$\tau \approx a/\lambda^4$ ← Sky is blue, $\lambda = 450$ nm
weaker IR, $\lambda = 950$ nm

$\tau_{\text{gaseous absorption}}$ ⇒ Certain wavelengths are absorbed by certain gases, e.g. 950 nm and water vapor.

$\tau_{\text{aerosol}} \approx \frac{a}{\lambda^b}$, b might be 2 or 50.

Examples

λ (nm)	$\tau_{Rayleigh\ Scattering}(\lambda)$
430	0.226
470	0.156
530	0.096
660	0.0392
870	0.0128
950	0.009