Ground-based Cloud and Aerosol Sensing

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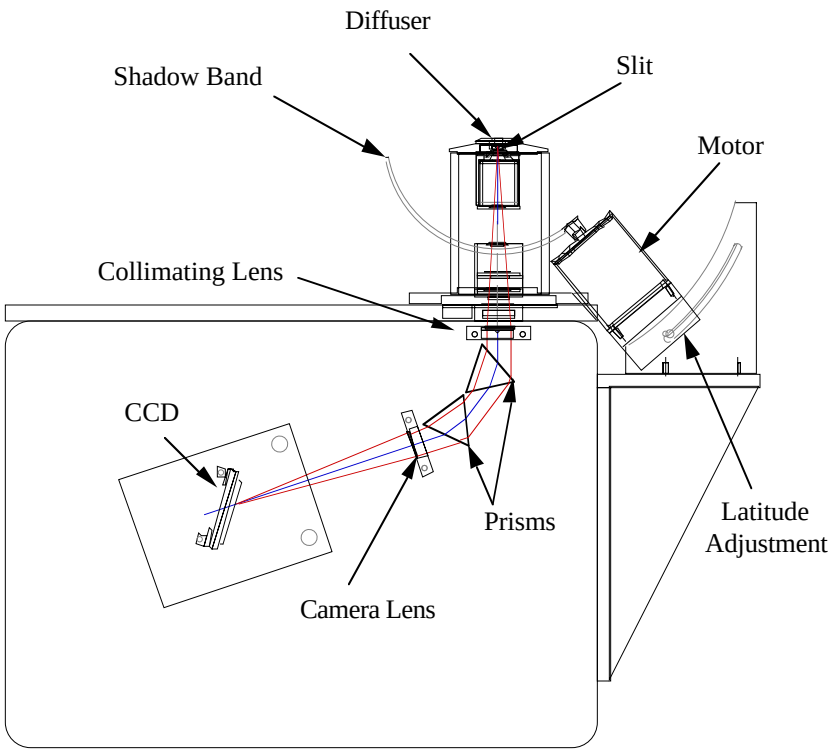
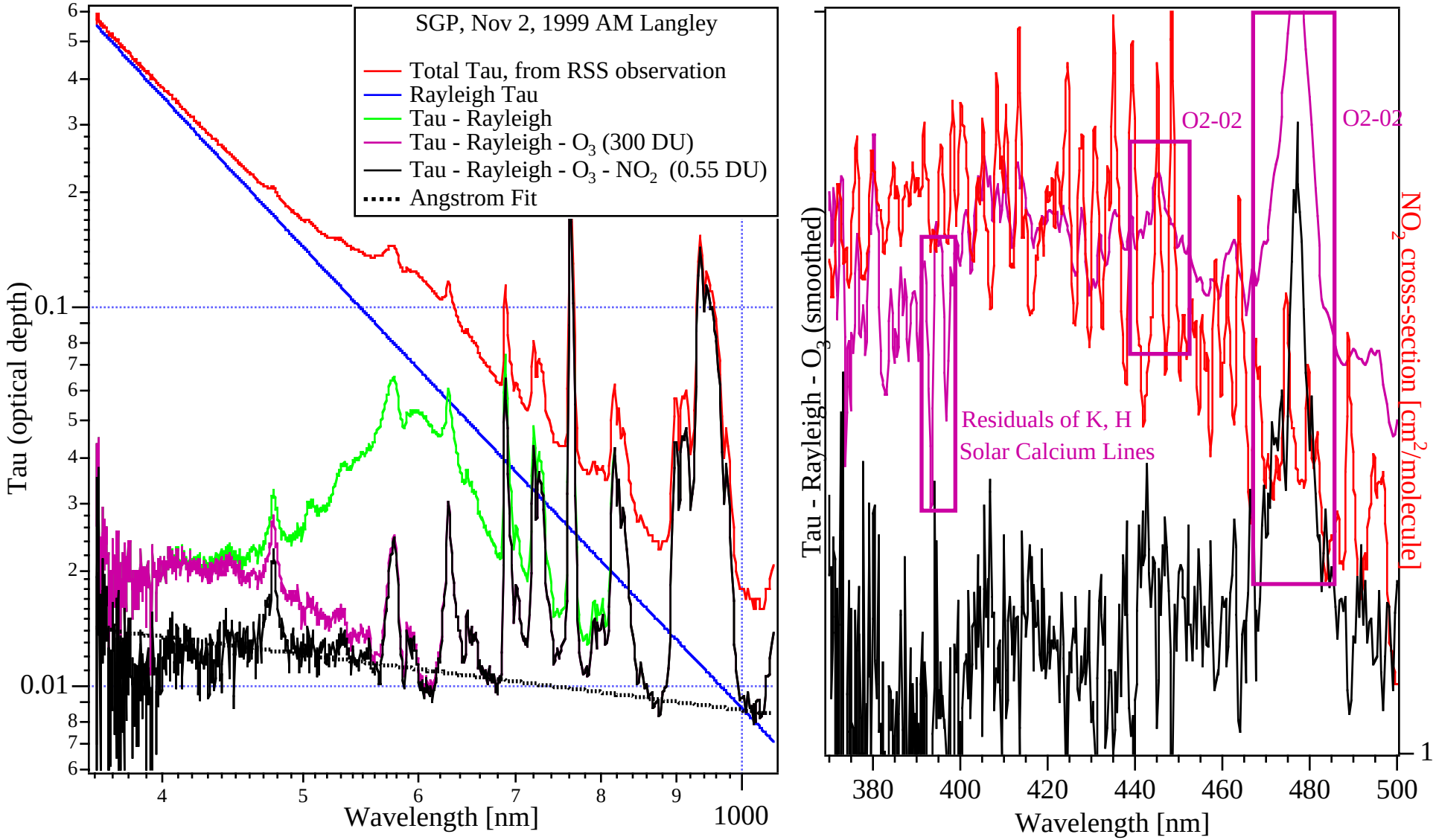
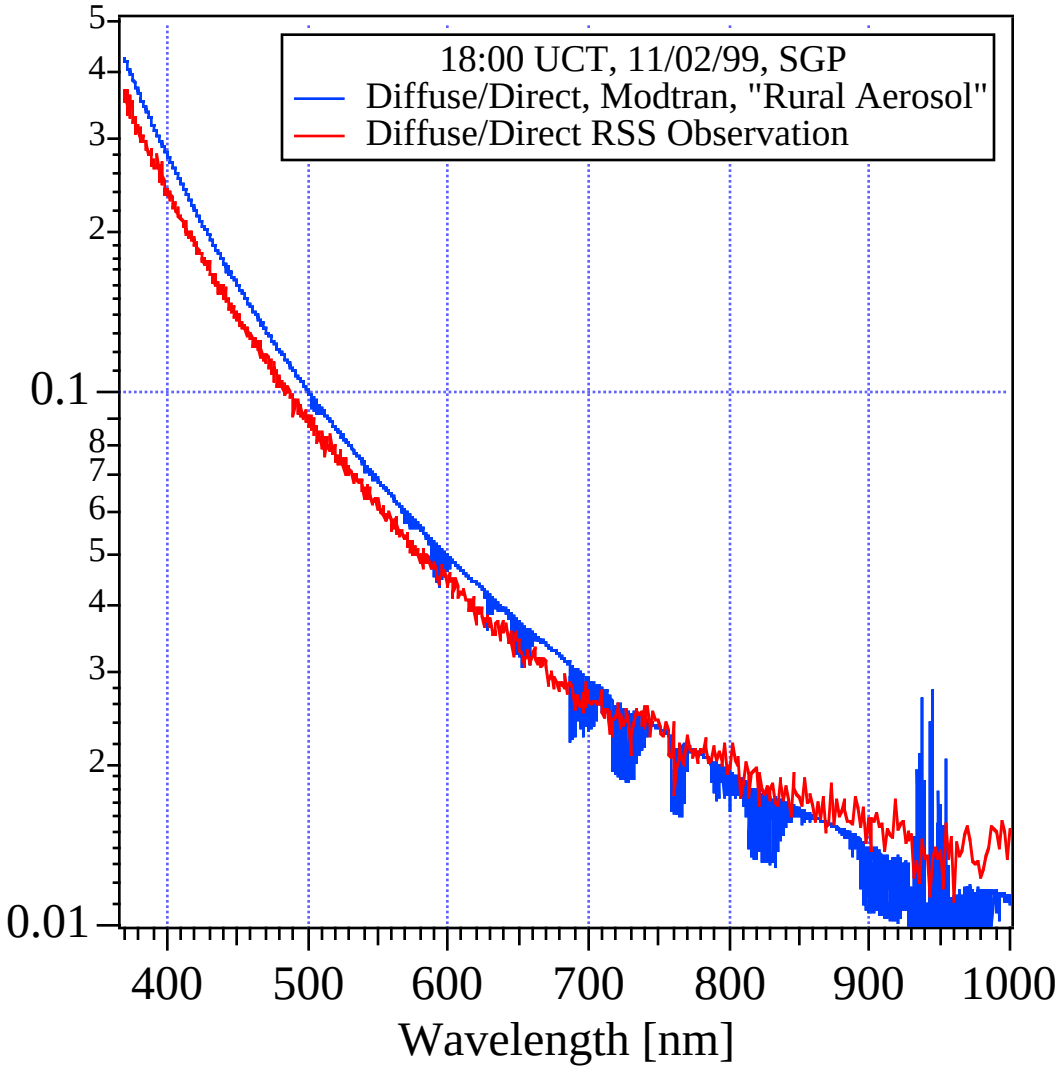


Rotating Shadowband Spectroradiometer (RSS)

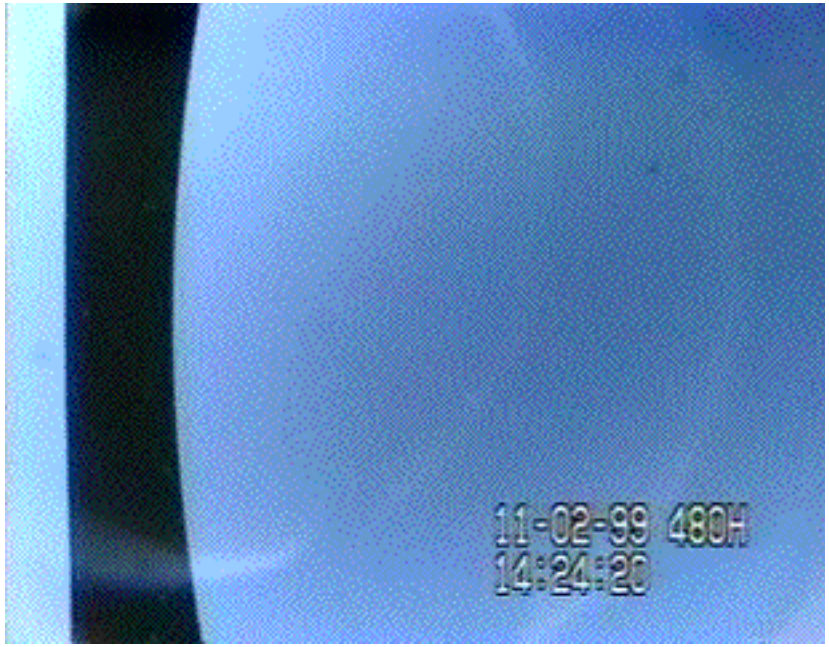
Two 1st - Generation RSS instruments at the Southern Great Plains (SGP) ARM field site - 1996



Clear-Sky Optical Depth Spectrum from RSS data at SGP

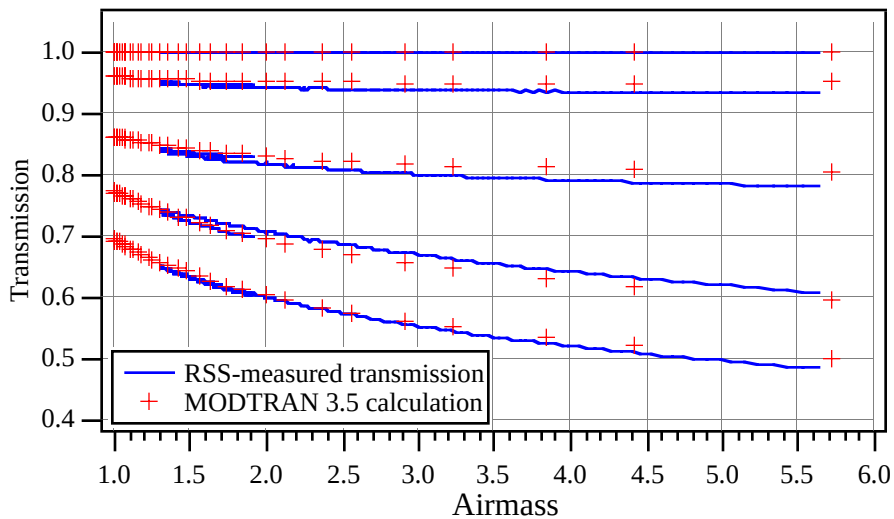


Diffuse/Direct Ratio vs. Wavelength



The clearest day ever seen at SGP

Photon Pathlengths from O_2 A-Band



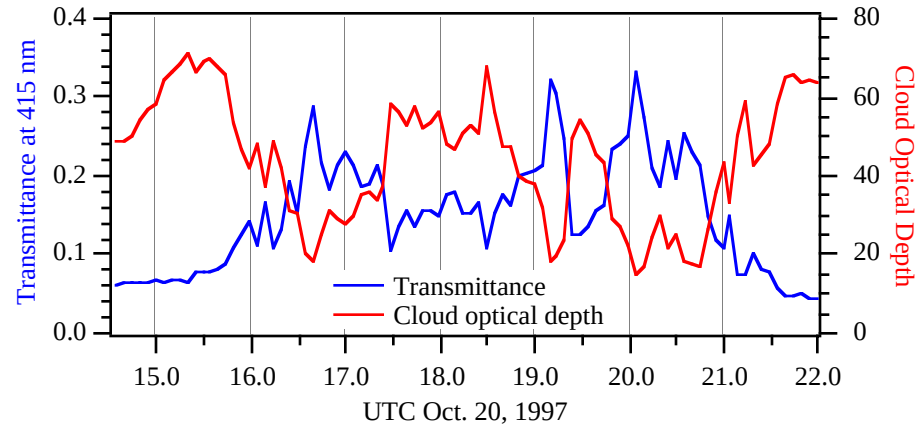
Direct-Beam Transmissions, 4 Pixels in the O_2 Band

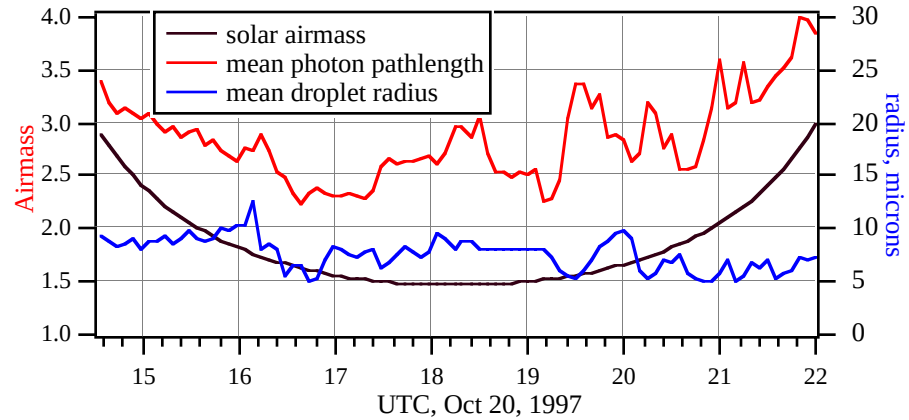
The RSS has sufficient resolution that we can obtain a measurement of the "mean" photon pathlength using the O_2 A-band absorption as described by Harrison and Min (1996). Optical measurements can retrieve only a particular mean , and it's precise definition is the mean of the first moment of the geometric pathlength with respect to pressure, and the inverse 1/2-power moment with regard to temperature, arising from the Lorentzian line-profile

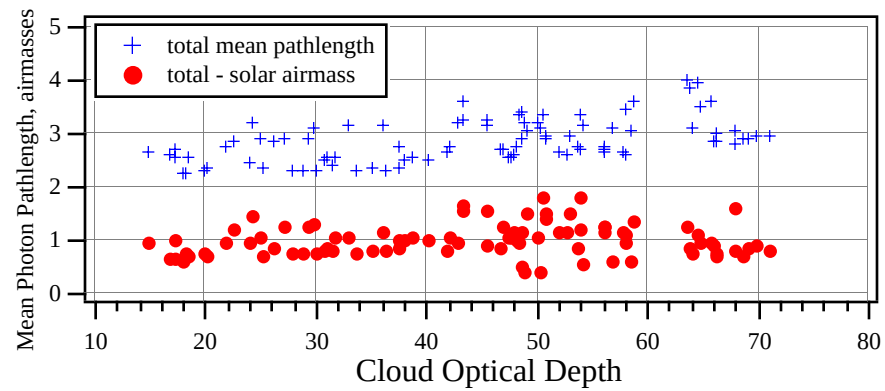
$$k_i = \frac{S_i}{\pi} \frac{\alpha_i}{(\upsilon - \upsilon_i)^2 + \alpha_i^2} \quad where \;\; \alpha_i = \alpha_i^0 \frac{p}{p^0} \left(\frac{T^0}{T}\right)^{1/2}$$

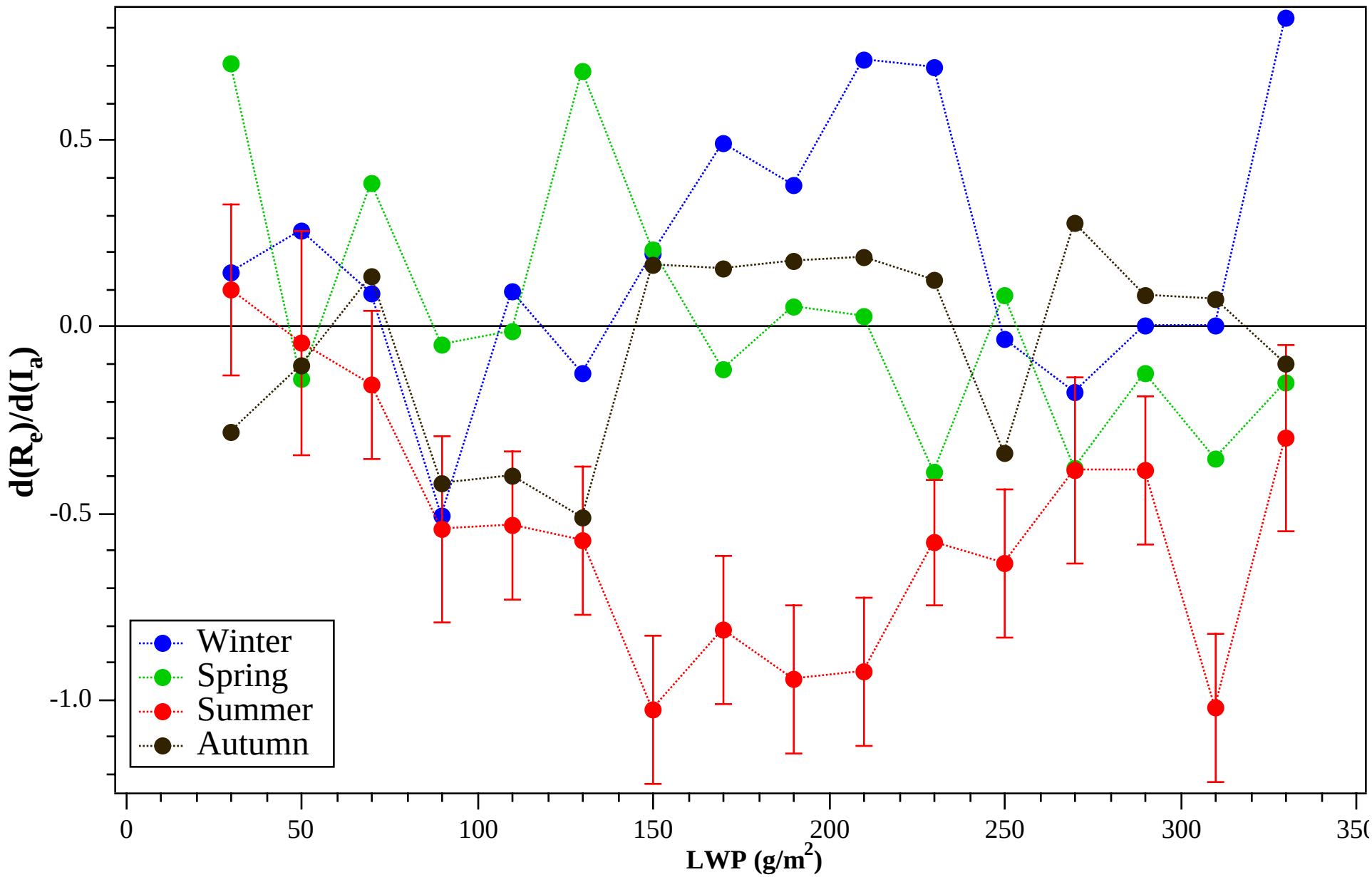
The result is naturally expressed in atmospheres. These data serve as an *empirical* calibration for RSS-derived photon pathlengths.

The photon pathlength, together with the cloud optical depth and mean effective droplet radius, describe the optical properties of a warm cloud system and provide strong constraints on geometric properties that may otherwise be unknown. Cloud optical depths and mean droplet radii can be obtained from either MFRSR or RSS data, and a Microwave radiometer (Min and Harrison, 1996), but only with the RSS can we obtain an estimate of the photon pathlength.









Detection of the Indirect Aerosol Effect (Twomey Effect) from 12 years of SGP Data

Discussion:

Our results leave us with the obvious question(s) of why can't we observe any effect in the other seasons; what is going on he

1) Summer is when updrafts are significant and Twomey theory most robust. The mechanisms which control the dr populations in stratus are less well understood. Perhaps there is not be a significant effect for low-updraft stratus? I hypothesis turns out to be correct, it is very important climatologically.

2) In more stratified systems the aerosol column integral we measure may be a poorer estimate for the clould level.

3) At low (to zero) updraft velocities, small local supersaturations and very long system life-times make the very supersaturation tail of the CCN distribution dominant. Our aerosol inference from the optical turbidity may not capture moment effectively.

A Gratuitous Phillipic? *A few comments about ASP goals for indirect-affect assessment:*

As we see it, the key observables are cloud optical depth, mean effective droplet radius (R_e), CCN properties, and up velocities. The first two of these we know how to do and are well done (indeed best done) from ground-based op measurements (R_e requires a H_2O column constraint, coming from microwave radiometry). These measurements are affordable for short or long-term measurements, and are cloud-scale and column-integral (not point) measurements.

What the optical measurements are not yielding are aerosol/CCN properties in and near the clouds, and updraft velocities. Air borne aerosol measurements are thus an obvious and necessary goal. Unfortunately the vertical velocities are particularly cr to any attempt to understand the processes analytically, and not easy to measure. Vertical velocity measurements with accurac about 5 cm/s are needed.

Analyses ([articularly for the second aersosol indirect effect) are intrinsically Lagrangian with long time-scales, and so measurements become useful only with implicit ergodic hypotheses.

And that drives us back to needing to have many more events, and ensemble statistics, than we can feasibly afford from inte aircraft studies. Put in simplest terms, we need something between "IOPs" and the limited continuous dataset we have from Traditional campaign-style large-aircraft omnibus field experiments cannot be afforded to obtain the event statistics needed.