The longwave effective cloud fraction derived from measurements with a comparison to shortwave cloud amounts for single layer clouds

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Introduction

This poster describes a comparison of the longwave effective cloud fraction (N_e) to shortwave cloud amounts: the cosine weighted cloud fraction from the Total Sky Imager (TSI), the cloud fraction from the shortwave flux analysis (swfan), and the Whole Sky Imager (WSI). These daytime comparisons are for single low cloud layers in 2000 and 2001 at the ARM SGP Central Facility as described in Ma and Ellingson (2005).

Longwave N_e

The average longwave surface over a large area can be expressed using (N_e) as:

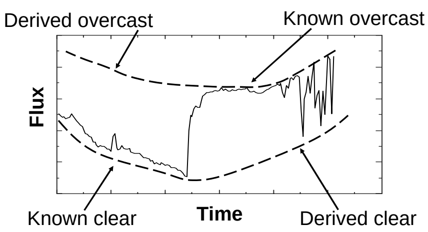
$$F = (1 - N_e)F_{clear} + N_e F_{overcast}$$

Where,

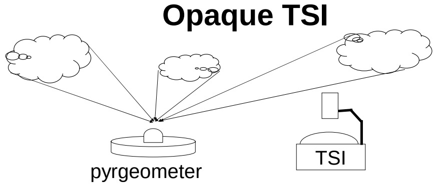
- F - Average flux of radiant energy at the surface.
- F_{clear} - Surface flux for the same atmosphere without clouds.
- $F_{overcast}$ - Surface flux for the same atmosphere but overcast
- N_e - Effective cloud fraction

Solving for N_e: $N_e = \dfrac{F - F_{clear}}{F_{overcast} - F_{clear}}$

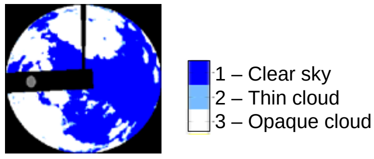
Since this method is based on longwave measurements, it is to be expected to work best on thicker, low level, single layer clouds.



Opaque TSI



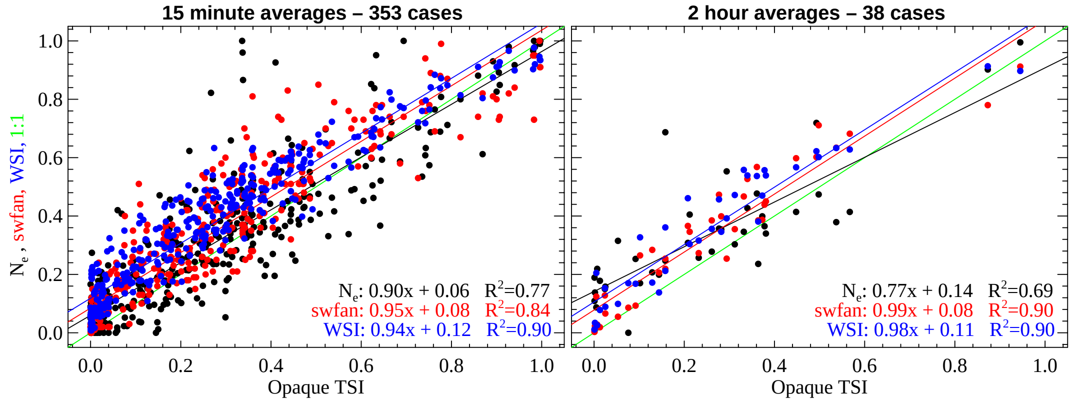
The TSI cloud mask shows which pixels are clear sky, thin or opaque cloud. To compare to the pyrgeometer flux, the sum of opaque cloud pixels is weighted by the cosine of the pixel's zenith angle.



Conclusions

- Twenty four days with daytime intervals of low, broken single cloud layers in 2000 and 2001 were taken from Ma and Ellingson (2005). The daytime intervals of interest were chosen by examining animations of TSI sky images and cloud masks. These clear/single layer intervals were 2-4 hours long.
- The scatter plots show very good agreement between the shortwave based cloud amounts from the cosine weighted TSI opaque cloud mask, shortwave flux analysis, and the WSI cloud fraction.
- The longwave N_e agrees with the TSI cloud amount, though not as well as the shortwave cloud amounts.
- The fits shown in the plots are relatively steady for various averaging times.
- The N_e outlier points may be due to small values of ($F_{overcast}$ - F_{clear}) which lead to inaccuracy in N_e, clouds that are optically thin in the longwave, or clouds that do not enter the AERI field of view.

Results



The scatter plots above shows 15 minute (left) and 2 hour (right) averages of the longwave effective cloud fraction (N_e), shortwave flux analysis cloud fraction (swfan), and WSI cloud fraction (WSI) versus the cosine weighted TSI opaque mask (Opaque TSI). The best fit lines are shown in their respective colors, the 1:1 line in green.

- The shortwave cloud amounts agree, with little bias and large R^2 values; as expected the two imagers agree best (Opaque TSI and WSI). The swfan agreement is good at 15 minutes and improves as the averaging time increases to two hours.
- Considering it is based on the longwave, the 15 minute averaged N_e shows good agreement. Its R^2 of 0.77 is quite close to the 0.84 of the swfan; which is also based on a measured flux. The agreement between N_e and the opaque TSI decreases as the averaging time increases to two hours.
- In general, the outlying N_e points are the result of $F_{overcast}$ that are too small. This leads to small values of ($F_{overcast}$ - F_{clear}), resulting in an inaccurate N_e. They may also be due to clouds that are not optically thick in the longwave or outside the AERI field of view.

Fits for the various averaging intervals

		N_e			swfan			WSI		
Interval	# cases	A	b	R^2	A	b	R^2	A	b	R^2
15 min	353	0.90	0.06	0.77	0.95	0.08	0.84	0.94	0.12	0.90
30 min	172	0.82	0.11	0.72	0.96	0.08	0.89	0.96	0.12	0.90
1 hour	80	0.77	0.14	0.68	0.98	0.08	0.90	0.97	0.12	0.90
2 hour	38	0.77	0.14	0.69	0.99	0.08	0.90	0.98	0.10	0.90

This table shows the line fit results for various averaging intervals from 15 minutes to 2 hours. The data shown is for the best fit line: y=Ax+b with a correlation factor of R^2. These fits show very little variation with averaging interval. This demonstrates that the agreement shown in the scatter plots above is quite robust.

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