An Empirical Method for Estimating Visible Thin Cloud Optical Thickness (using data from TWP-ICE)

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Problem:

How do we estimate thin cloud optical thickness, τ_c, using ground-based shortwave irradiance measurements?

Possible Solutions:

Shortwave measurement	means of finding τ_c
direct beam irradiance (415 nm) from the MFRSR	Min algorithm (2004)
total broadband downwelling irradiance	Broadband algorithm to find visible τ_c ; lots of computation
total broadband downwelling irradiance	☞ **Simple empirical method (look right)**

☞ Simple empirical method:

From Barnard and Long (2004):

$$\tau_c = \frac{1.16/r - 1}{(1-A)(1-g)}$$

A = broadband surface albedo, 0.12,

g = asymmetry parameter = 0.77, (ice), and …

$$r = \frac{T}{C\mu_0^{1/4}}$$

T = total downwelling shortwave irradiance

C = clear sky total downwelling irradiance (from Long [2000] algorithm)

μ_0 = cosine(SZA)

But …

Designed only for $\tau_c/\mu_0 > 5$

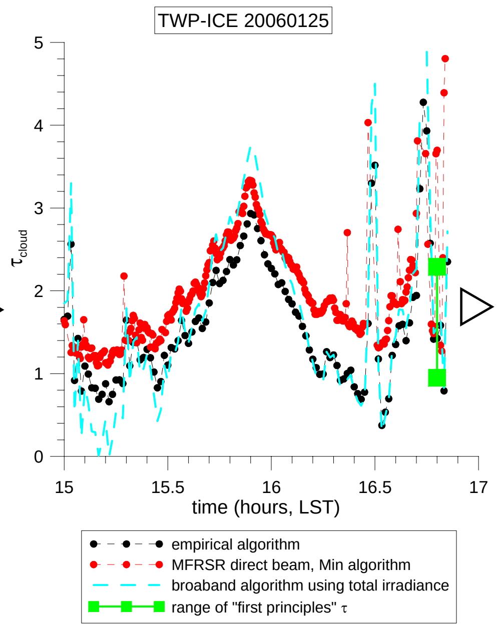
&

Designed only for completely overcast skies; finds "effective" τ_c

Question: Will it work for thin clouds and with less-than-full sky cover?

Let's find out … *see below left*

Total sky image, 1600 hours (LST) 01/25/2006 (Darwin); fairly uniform high cloud overcast



Four optical depth retrievals over 2 hour period; note "first principles" retrieval

Notes:

The "first principles" optical thickness was obtained from size distributions measured as an airplane descended through the cloud; the range in τ_c (about 1) depends on the ice habit assumed for the particles.

Increasing *g* from 0.77 to 0.81 in the empirical algorithm improves the agreement between this algorithm and the Min algorithm

Conclusions:

1) All three methods provide results that are about the same; **good!**

2)The three methods are roughly consistent with the "first principles" optical thickness