Computation of Domain-Averaged Irradiance Using Satellite-Derived Cloud Properties

Seiji Kato[1], Fred Rose[2],

and

Thomas P .Charlock[3]

[1]Hampton University

[2]Analytical Service &materials, Inc.

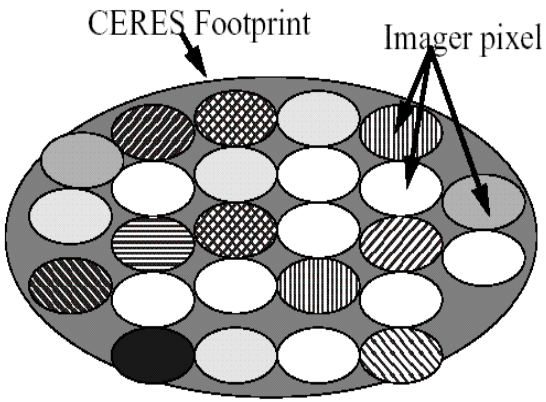
[3]NASA Langley Research Center

Objectives

- To understand errors in the modeled irradiance by the gamma-weighted two-stream approximation and effective thickness approximation when they are used for estimating global radiation budget.

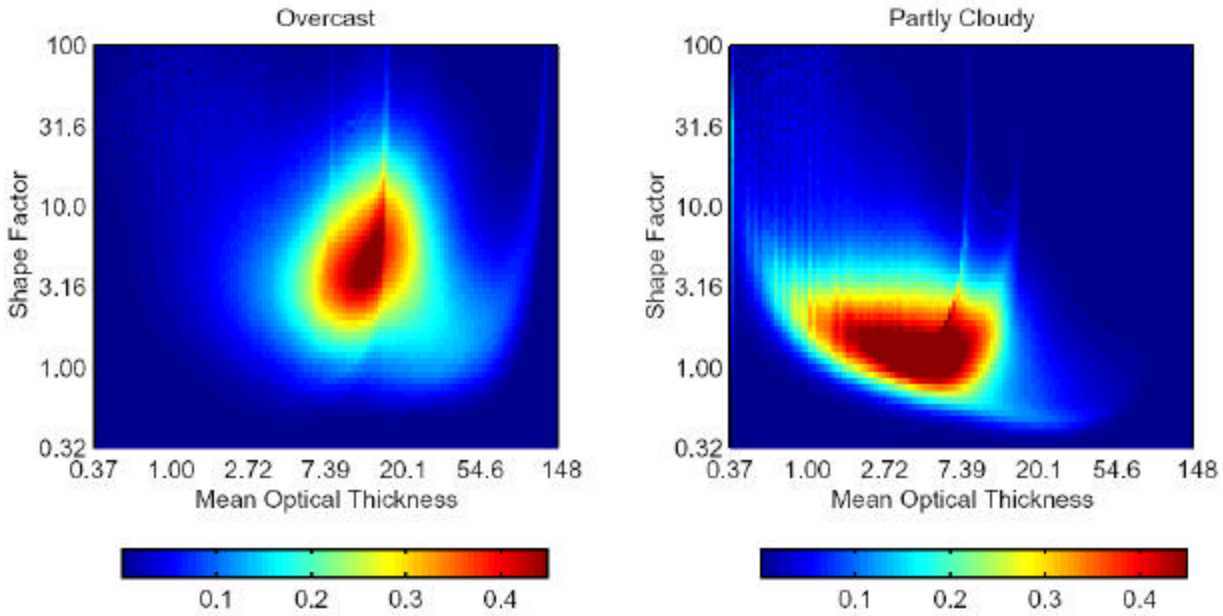
Methods of Estimating Error

- Use cloud optical thickness from SSF
- Domains are CERES footprints (20 to 170 km) and a footprint contains $\approx$ 200 to $\approx$30000 pixels (1km).
- IPA provides the truth.

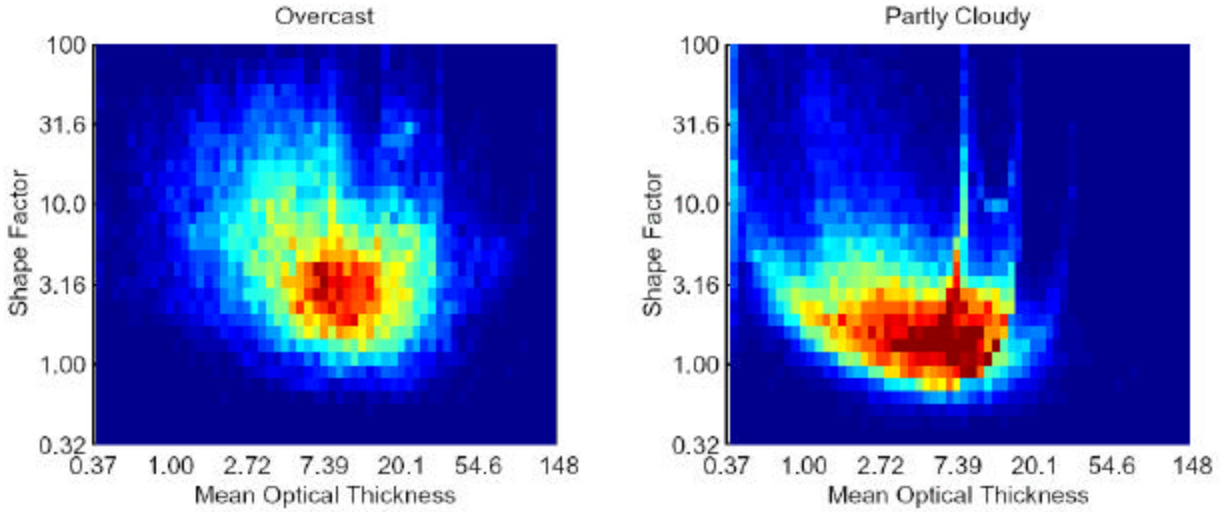


Cloud Properties over CERES footprints

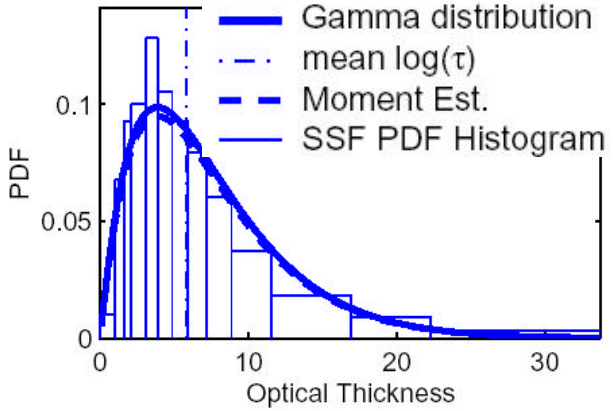
30 months of DATA

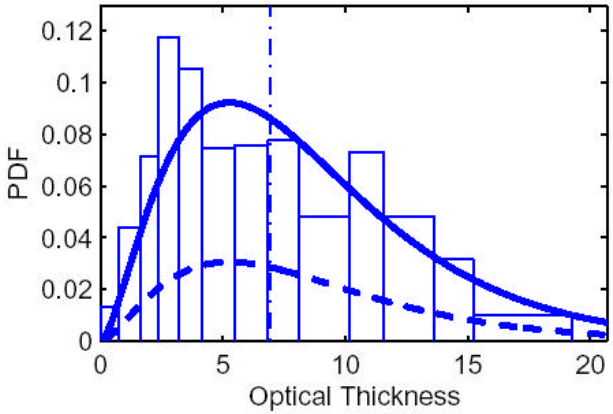


Data used in the study



MLE by Greenwood and Durand (1960)

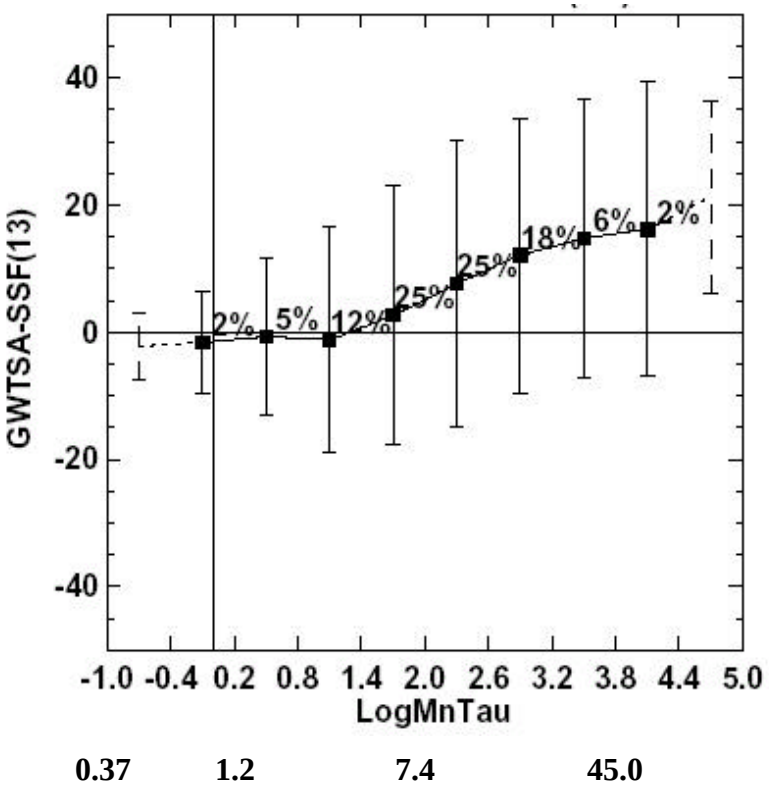




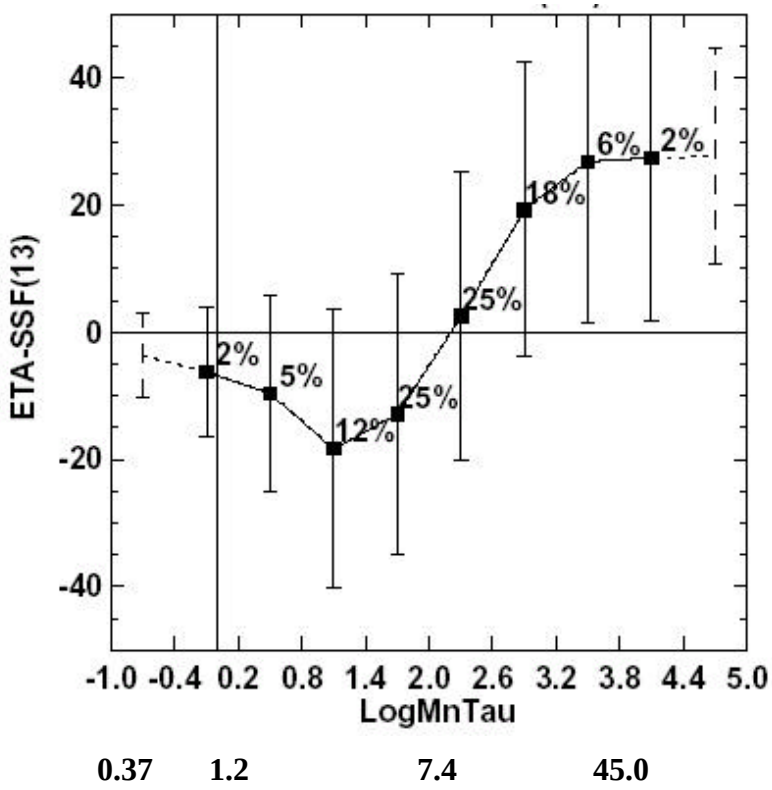
$$P = \frac{1}{\Gamma(n)}\left(\frac{n}{\bar{t}}\right)^{n} t^{n-1} e^{-nt/\bar{t}}$$

Overcast Clouds
30 degree solar zenith angle

Error by GWTSA (Wm^2)



ERROR by ETA (Wm^2)

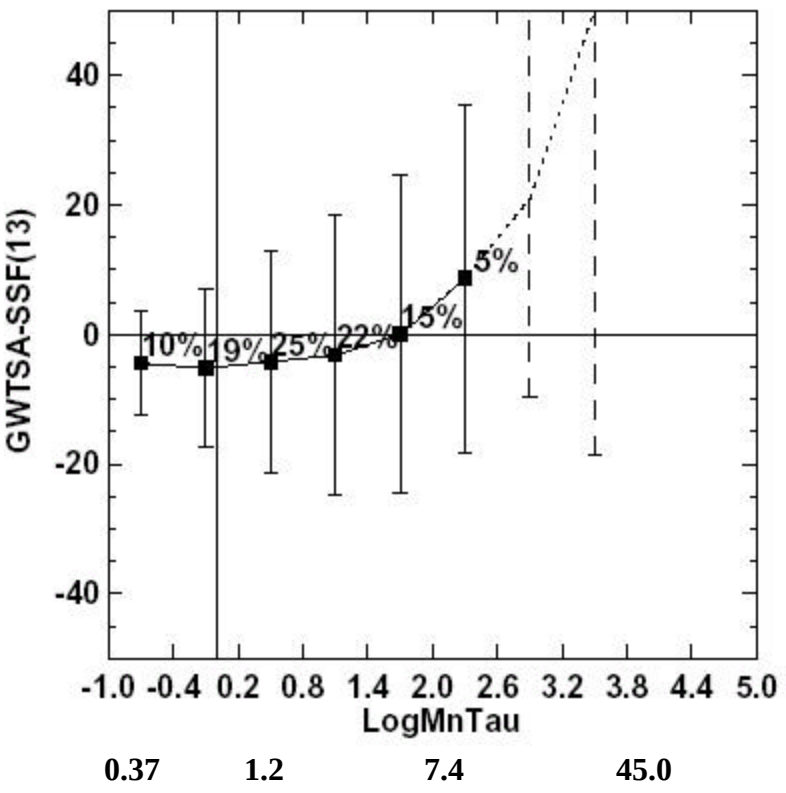


Gamma distribution and max t

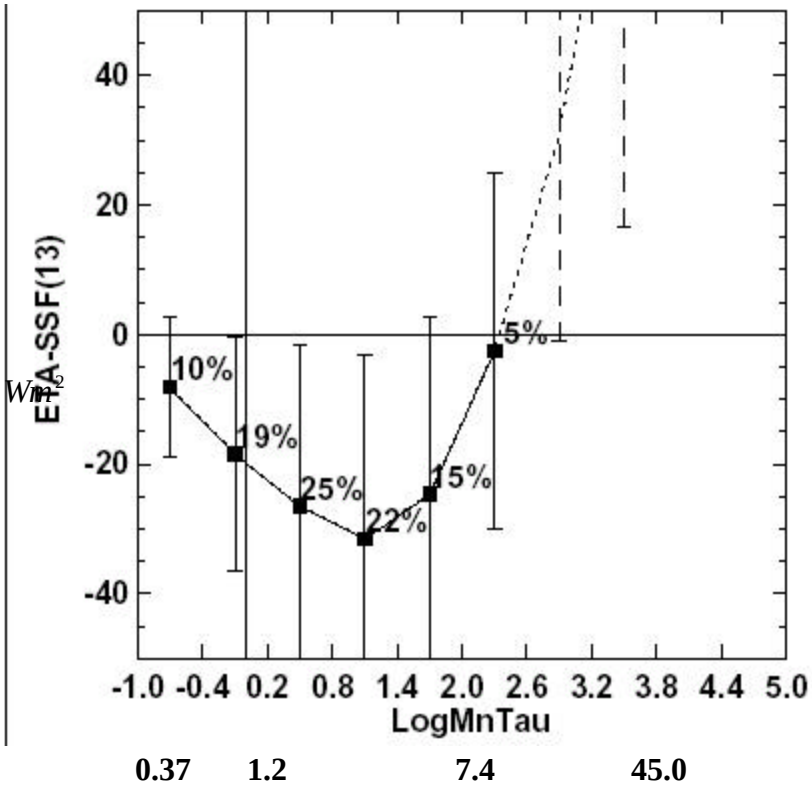
$$\frac{\partial^2}{\partial \ln t^2} \frac{gt/m_0}{1+gt/m_0} \propto 1-gt/m_0$$

Partly Cloudy

Error by GWTSA (Wm^2)



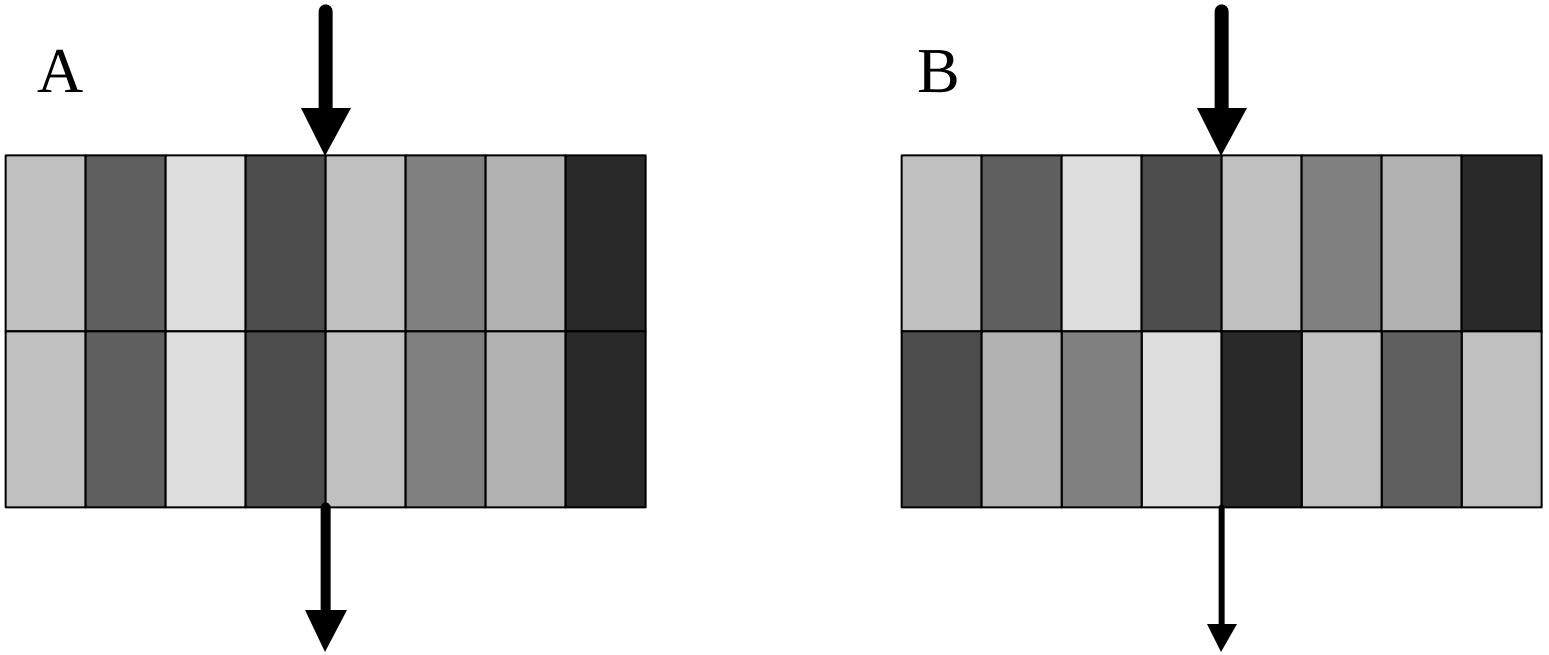
ERROR by ETA (Wm^2)



30 degree solar zenith angle

Fluxes are for 100% cloud cover

Dividing Cloud Layer for Computations

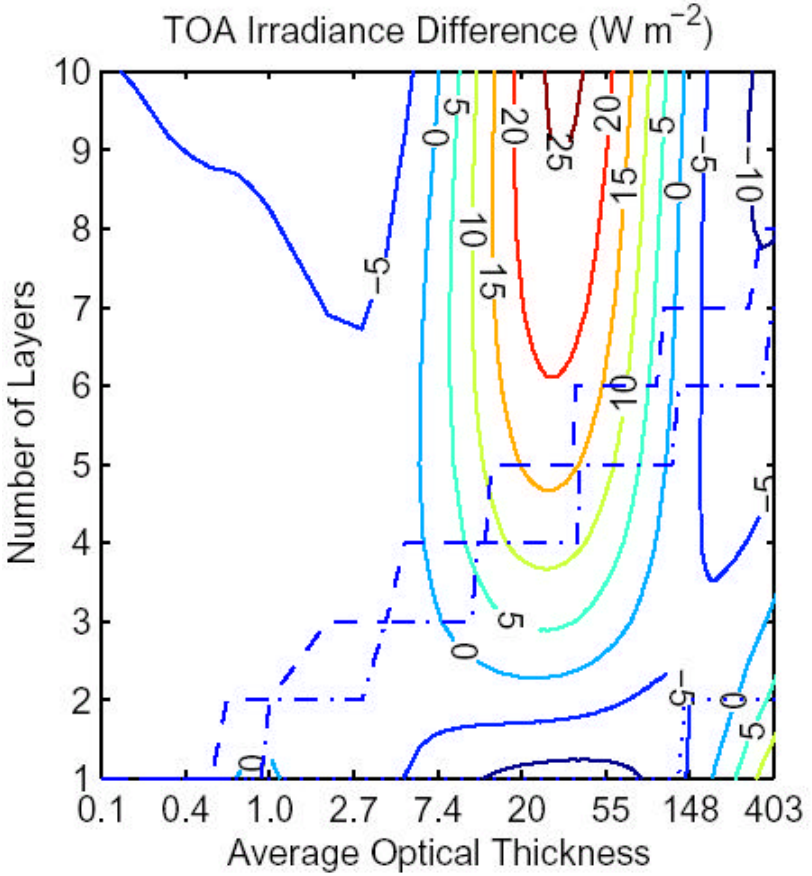


Transmittance of A is not the same as transmittance of B (Oreopoulos and Barker 1999)

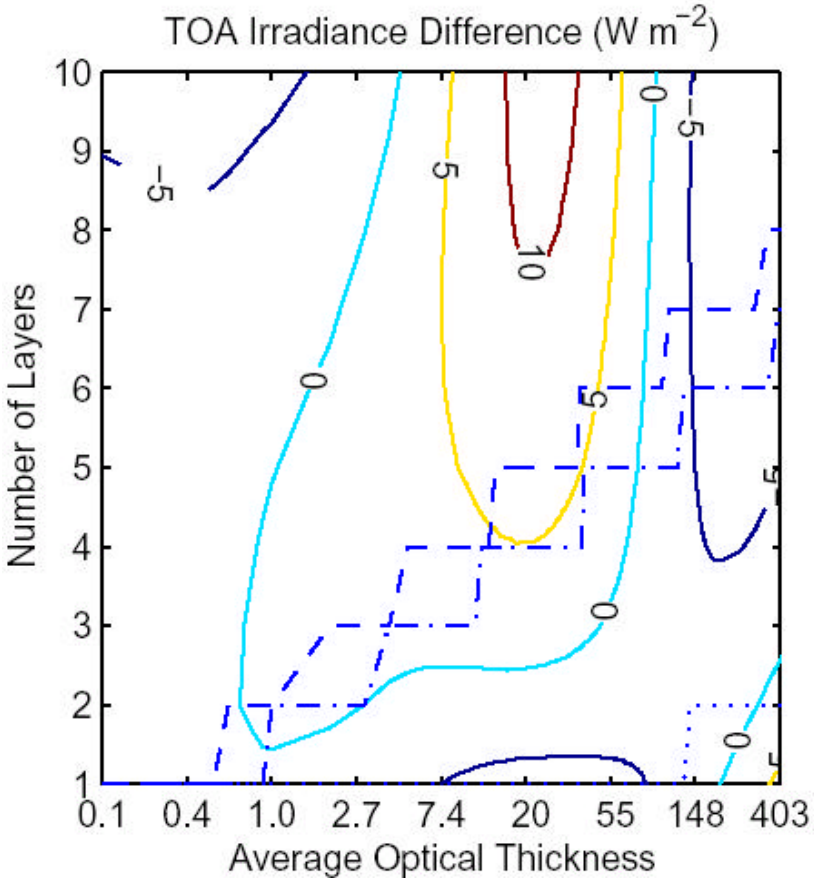
$$\overline{(T_1 + \Delta T_1)(T_2 + \Delta T_2)} = \overline{T_1}\,\overline{T_2} + \overline{\Delta T_1 \Delta T_2}$$

Effect of Cloud Layers on GWTSA

Solar Zenith Angle = 30°



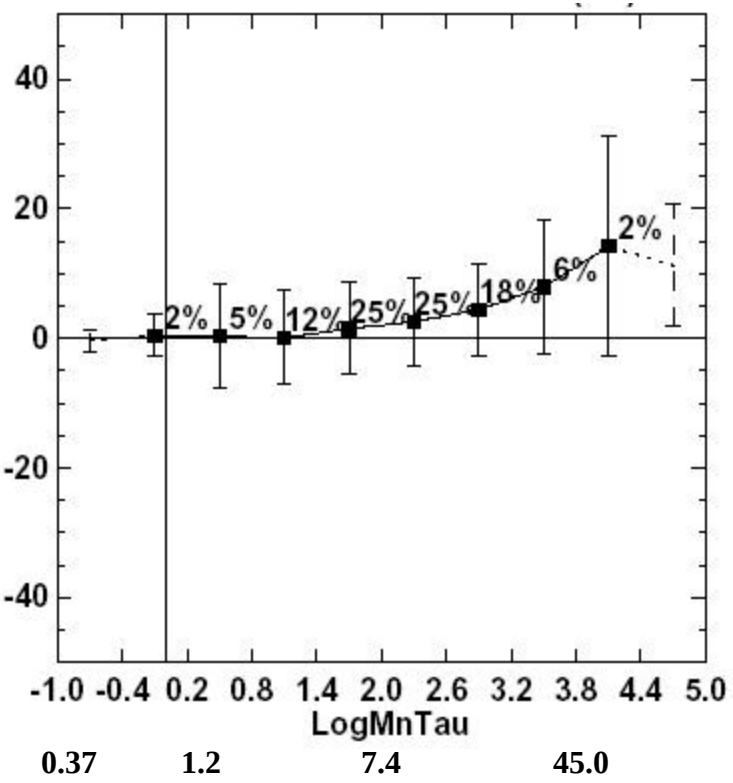
Solar Zenith Angle = 60°



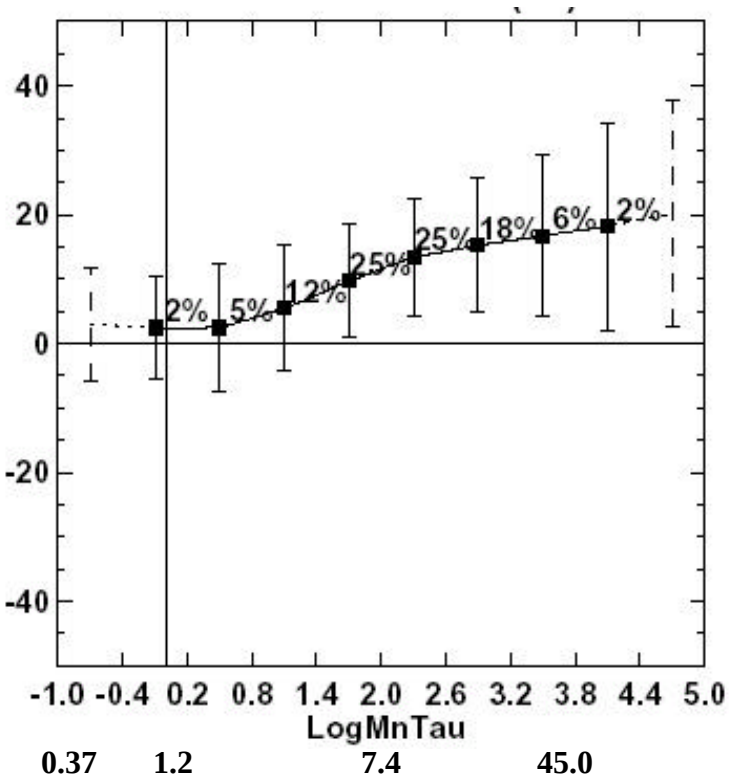
Shape parameter = 1

Error by GWTSA with 4-layer overcast clouds

1-layer (Wm^2)



4-layer (Wm^2)



30 degree solar zenith angle

Flux Error (W m^{-2}) at ?。=30°

	Gamma	Max t	4-layer	ETA
Overcast 32%	3.3 (21)	2.8 (8)	8.4 (11)	0.5 (27)
Partly Cloudy 68%	-2.3 (19)	-0.1 (6)	3.6 (9)	-21.5 (27)

Summary

- GWTSA works better for partly cloudy scene and overcast clouds with one computational layer. It needs some improvements for multi-layer clouds.
- ETA works well when $t/\mu_{\circ} \approx 10$.