

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

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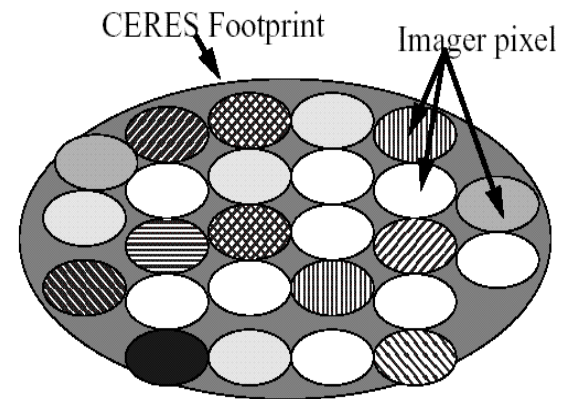
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Objectives

- 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.

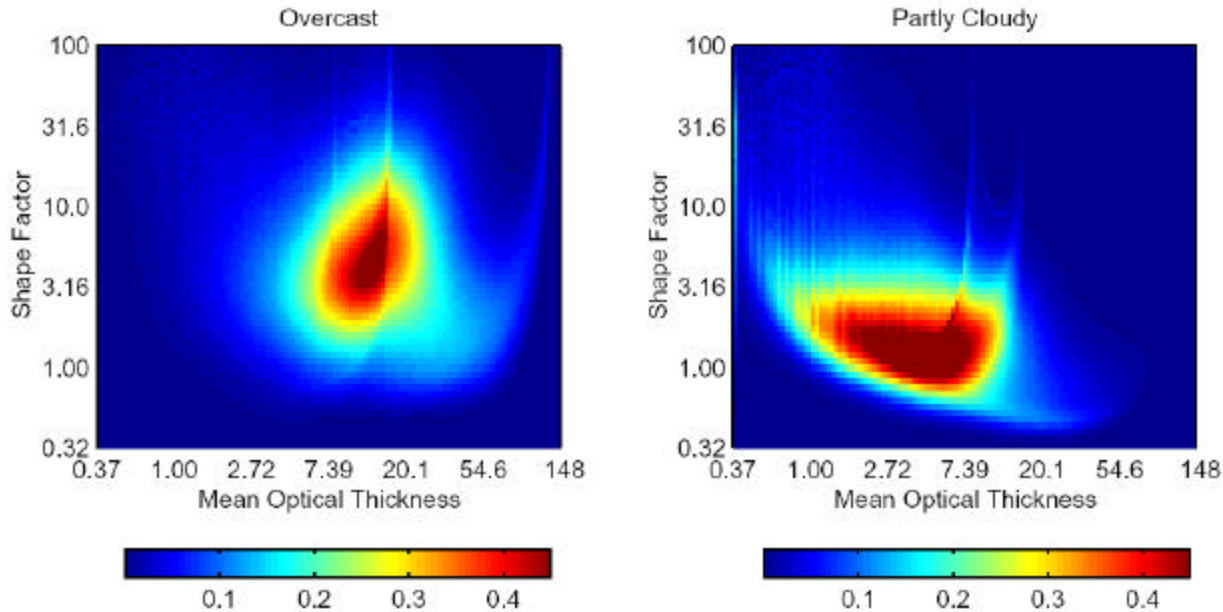
Methods of Estimating Error

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

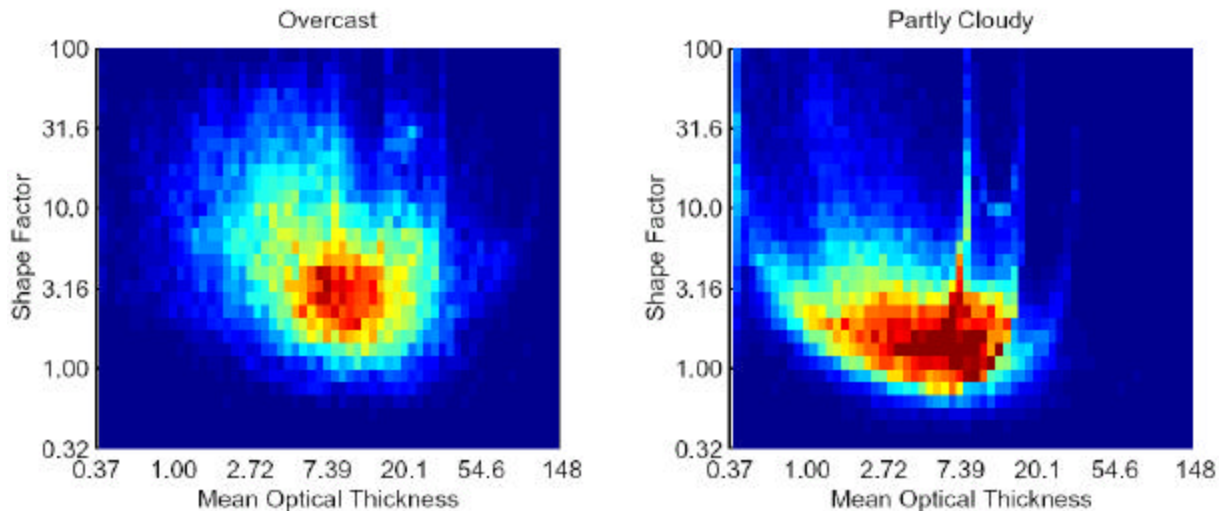


Cloud Properties over CERES footprints

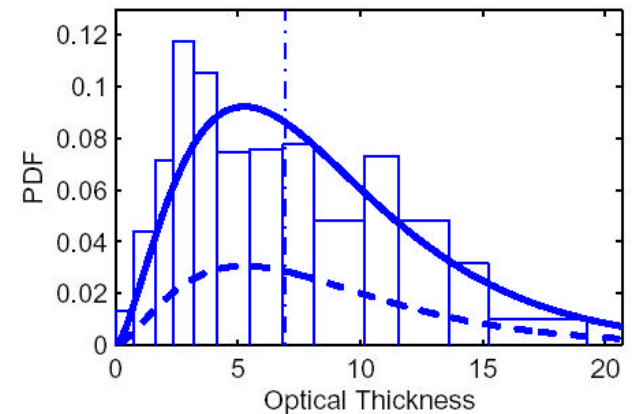
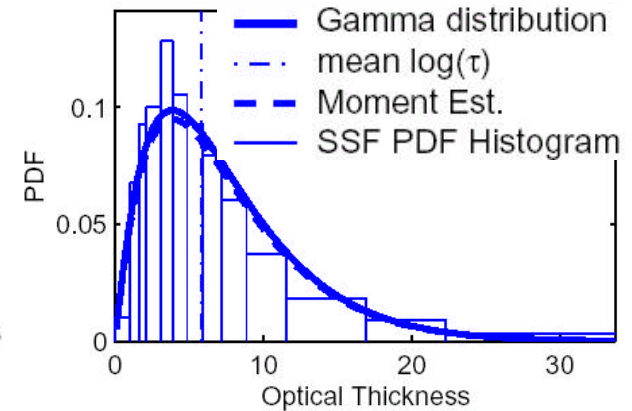
30 months of DATA



Data used in the study



MLE by Greenwood and Durand (1960)

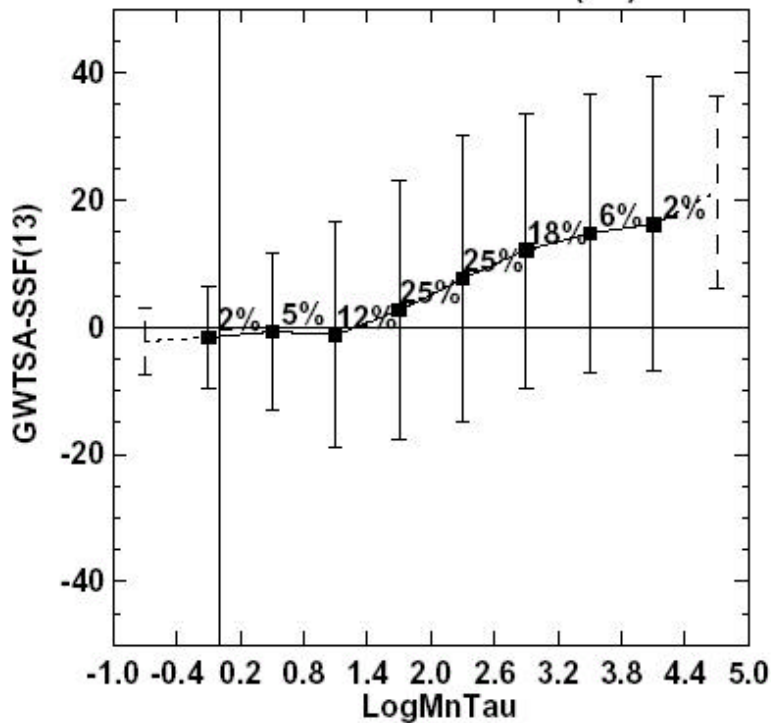


$$P = \frac{1}{\Gamma(\mathbf{n})} \left(\frac{\mathbf{n}}{\bar{t}} \right)^{\mathbf{n}} t^{\mathbf{n}-1} e^{-nt/\bar{t}}$$

Overcast Clouds

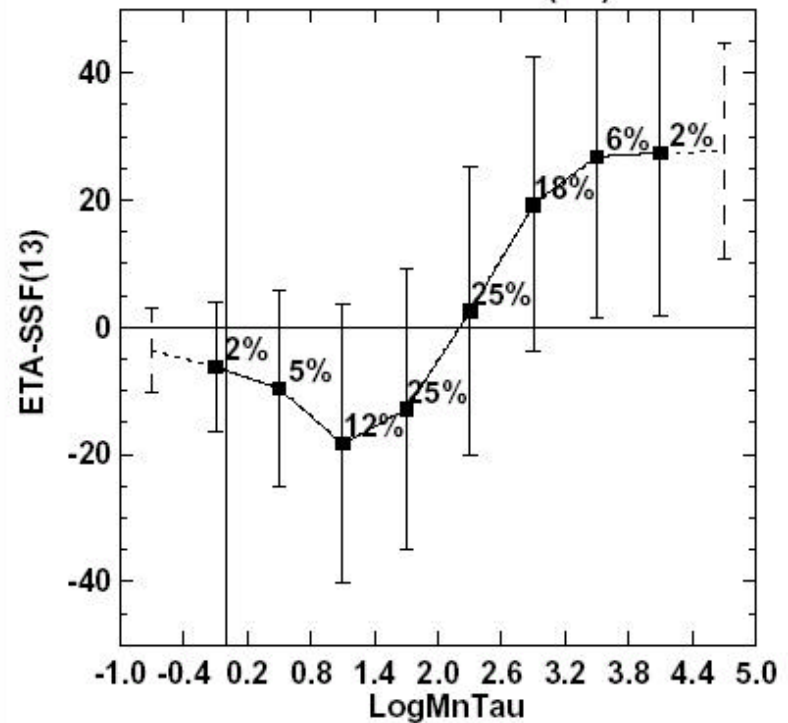
30 degree solar zenith angle

Error by GW TSA (Wm^2)



0.37 1.2 7.4 45.0

ERROR by ETA (Wm^2)



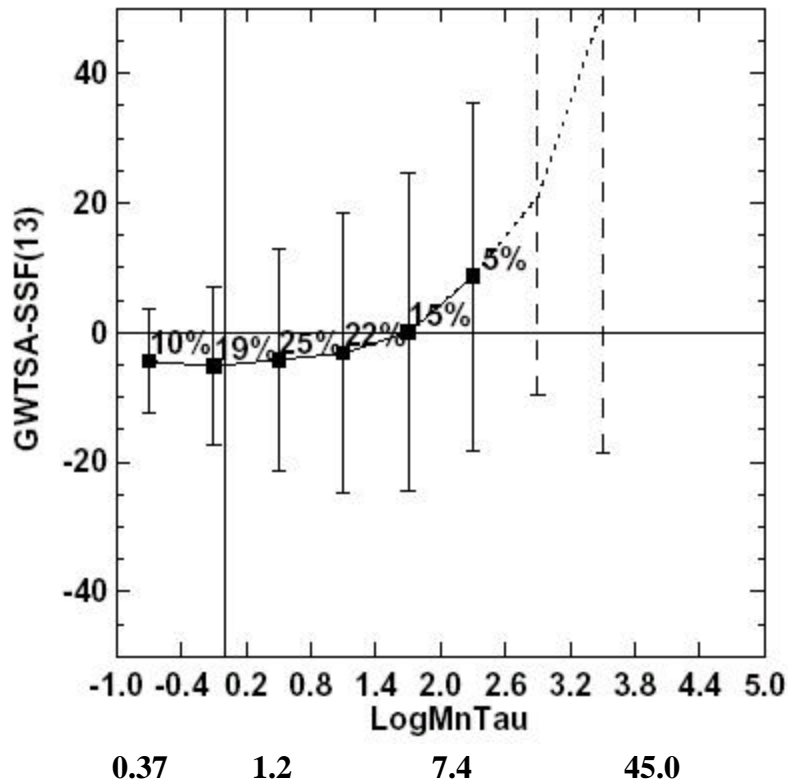
0.37 1.2 7.4 45.0

Gamma distribution and max t

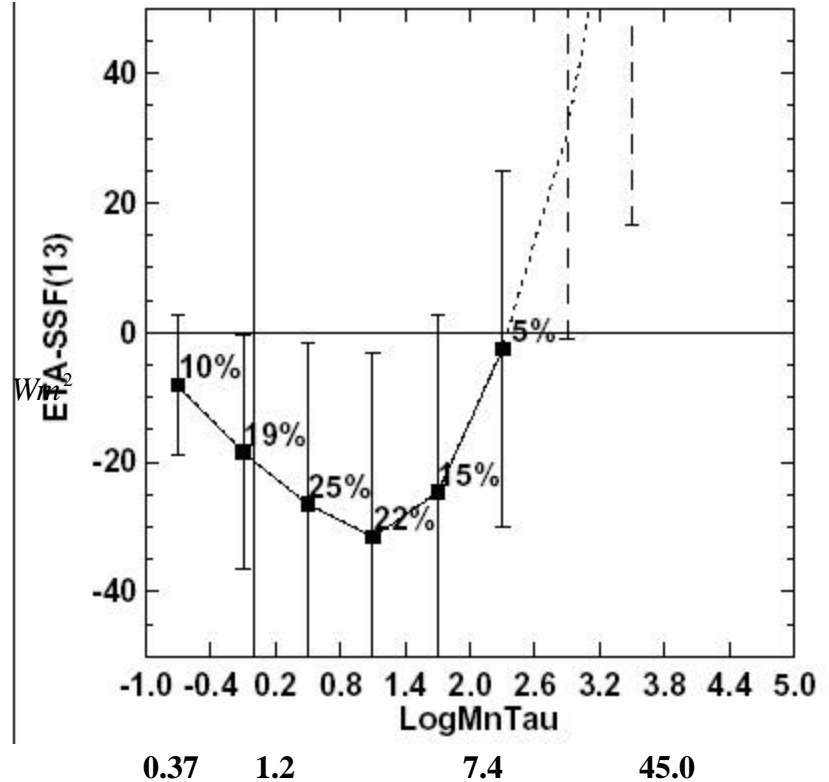
$$\frac{\partial^2}{\partial \ln t^2} \frac{gt / m_0}{1 + gt / m_0} \propto 1 - gt / m_0$$

Partly Cloudy

Error by GWTSA (Wm^2)



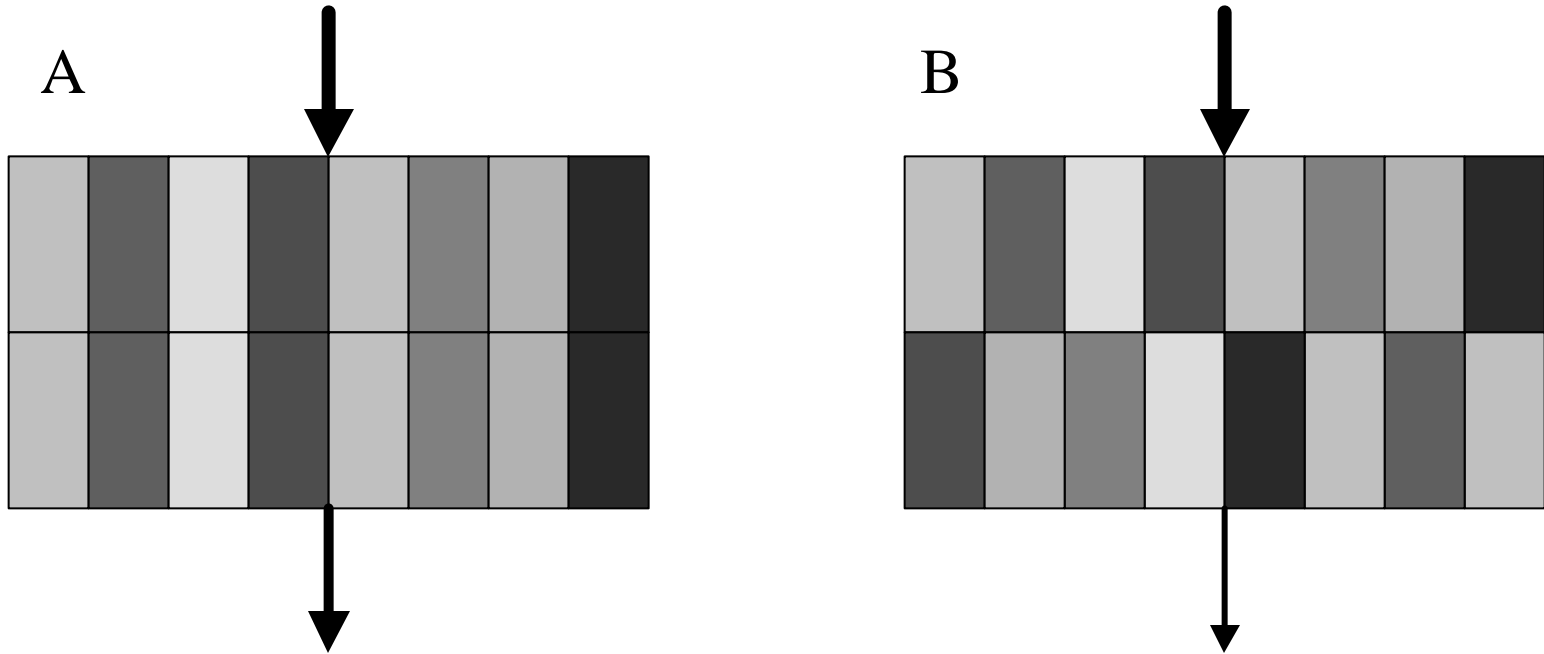
ERROR by ETA (Wm^2)



30 degree solar zenith angle

Fluxes are for 100% cloud cover

Dividing Cloud Layer for Computations

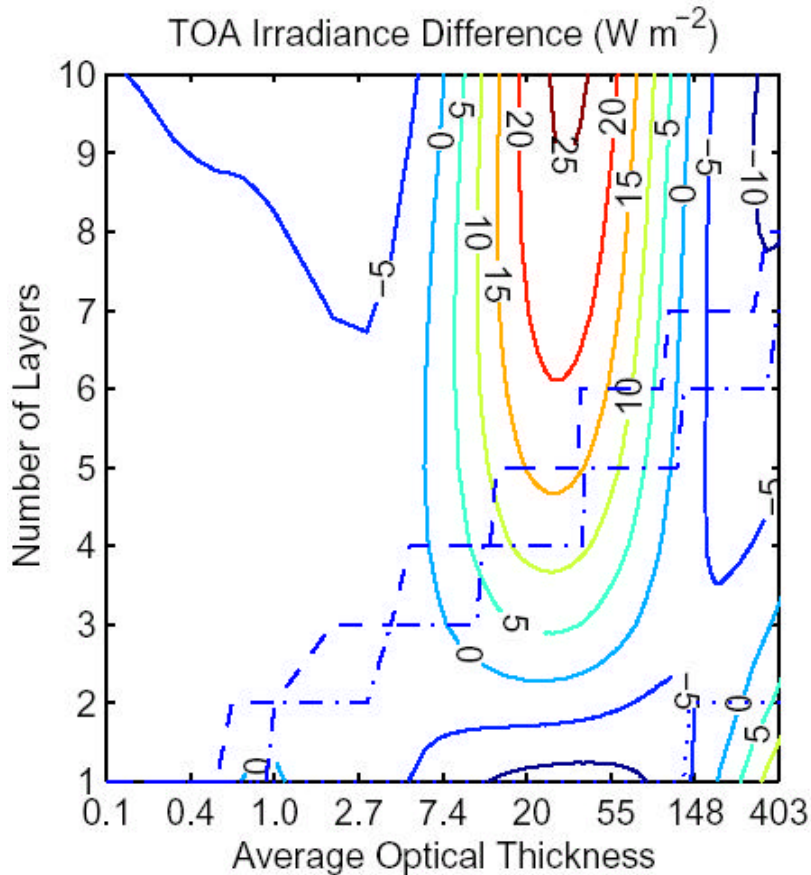


Transmittance of A is not the same as transmittance of B
(Oreopoulos and Barker 1999)

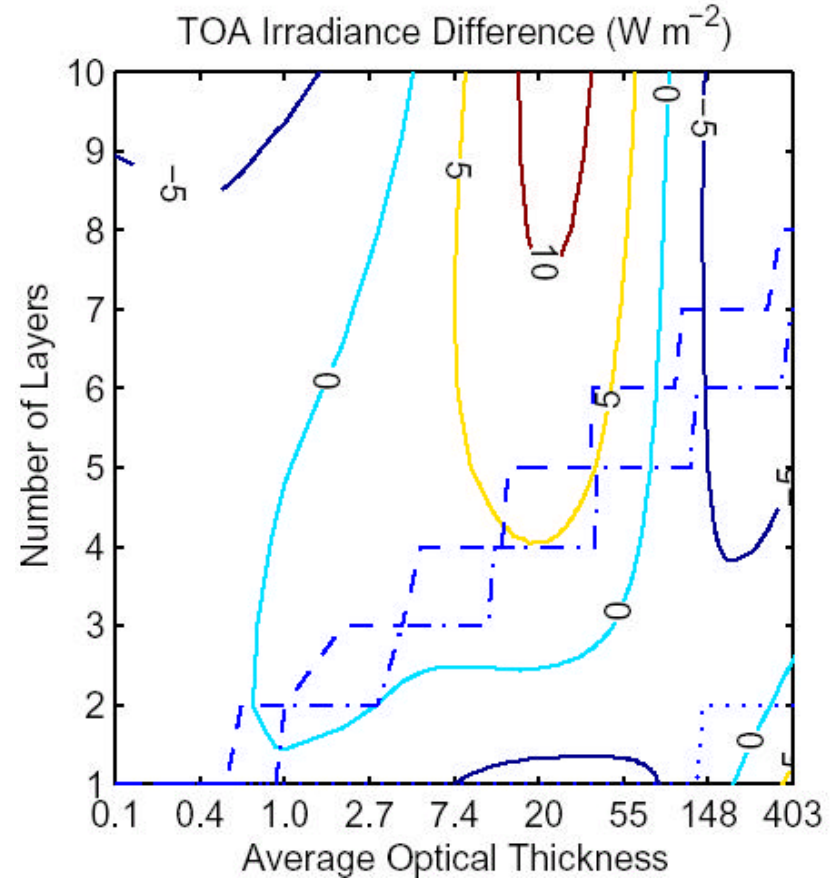
$$\overline{(T_1 + \Delta T_1)(T_2 + \Delta T_2)} = \overline{T_1 T_2} + \overline{\Delta T_1 \Delta T_2}$$

Effect of Cloud Layers on GW TSA

Solar Zenith Angle = 30°



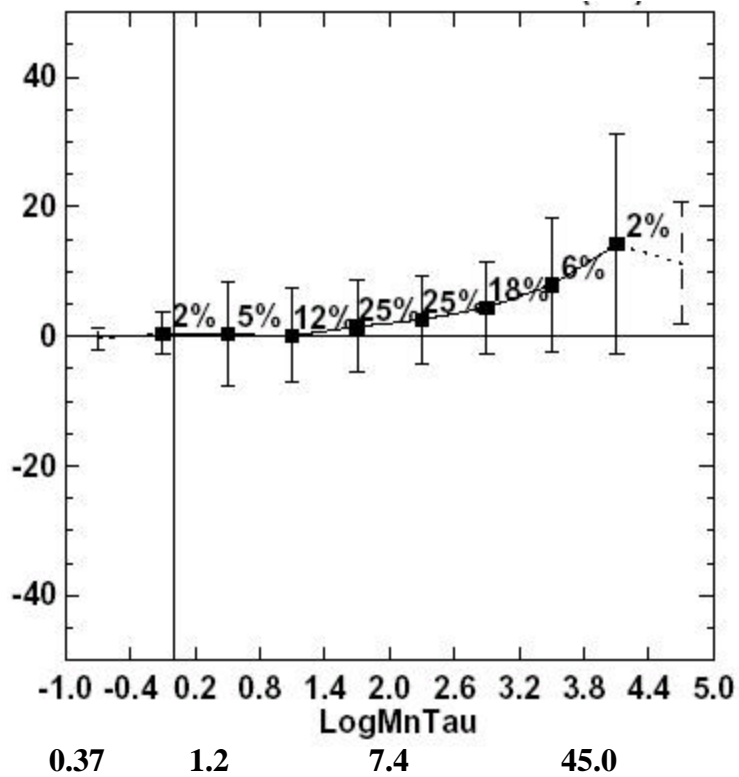
Solar Zenith Angle = 60°



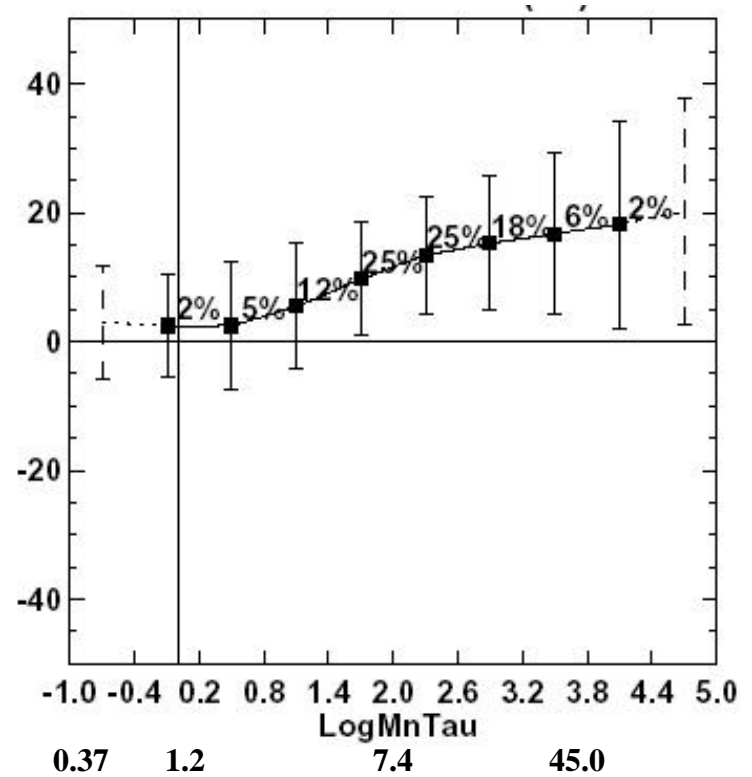
Shape parameter = 1

Error by GW TSA with 4-layer overcast clouds

1-layer (Wm^2)



4-layer (Wm^2)



30 degree solar zenith angle

Flux Error (W m^{-2}) at $\theta_0=30^\circ$

	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 $t/\mu_0 \approx 10$.