

# Reflected Solar Radiation Near the Terminator

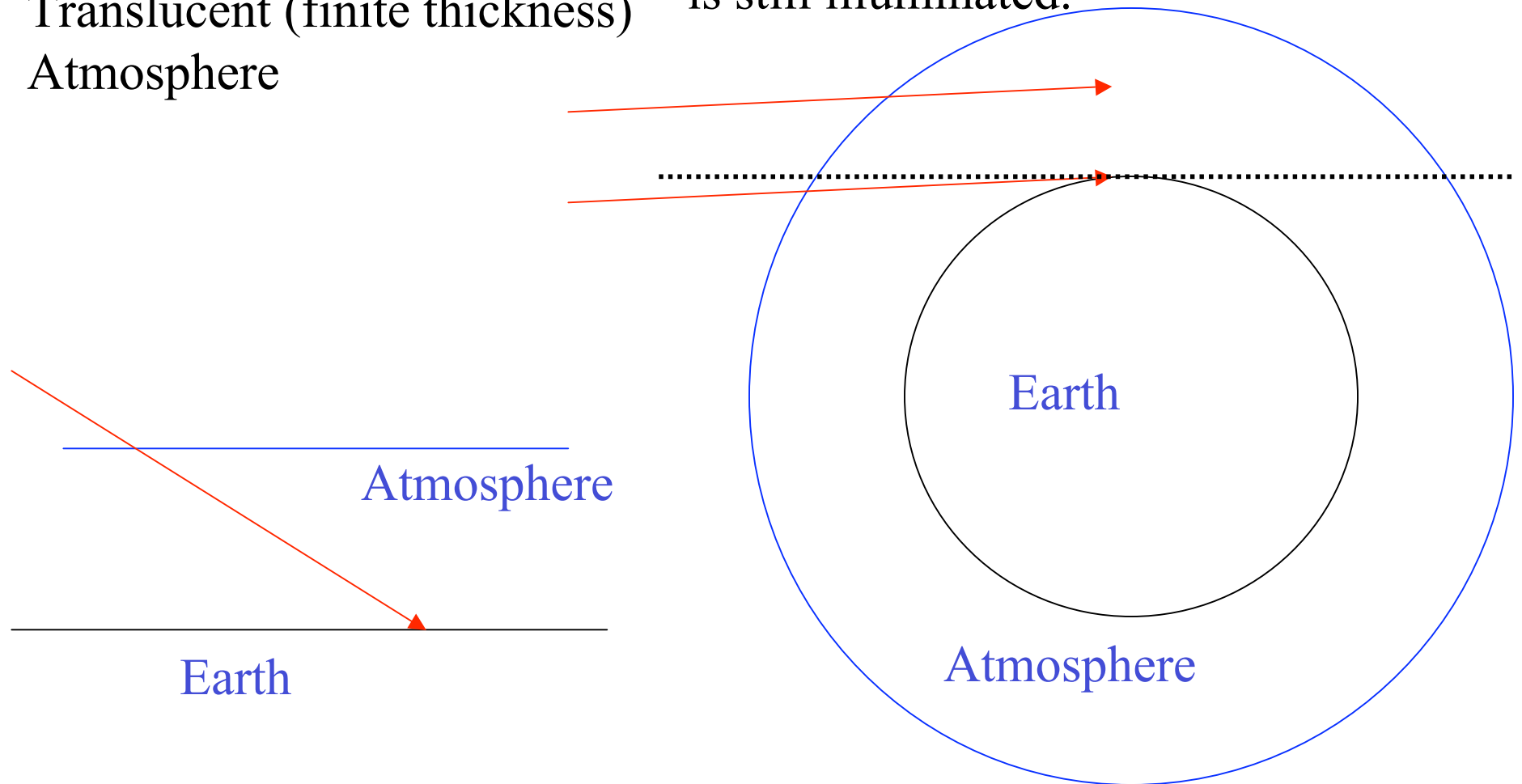
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According to Rozenberg (1966), at any given time approximately 20 to 25% of the surface area of the globe is in a twilight area where the sun is located within 5 to 10 degrees from the horizon.

# Flux near terminator

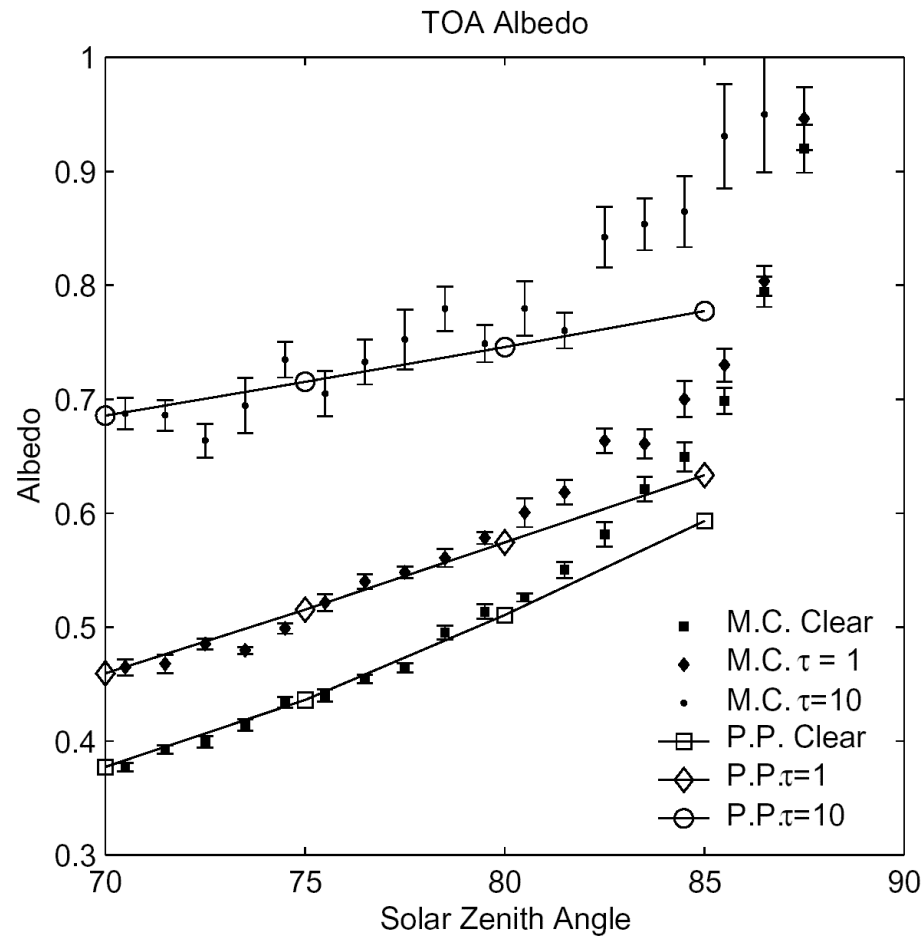
Spherical Geometry  
Translucent (finite thickness)  
Atmosphere

The atmosphere above a region where the sun is below the horizon is still illuminated.



# PP model vs. Monte Carlo

$$\text{Albedo} = F / (\_0 F_0)$$



Non-absorbing Atmosphere

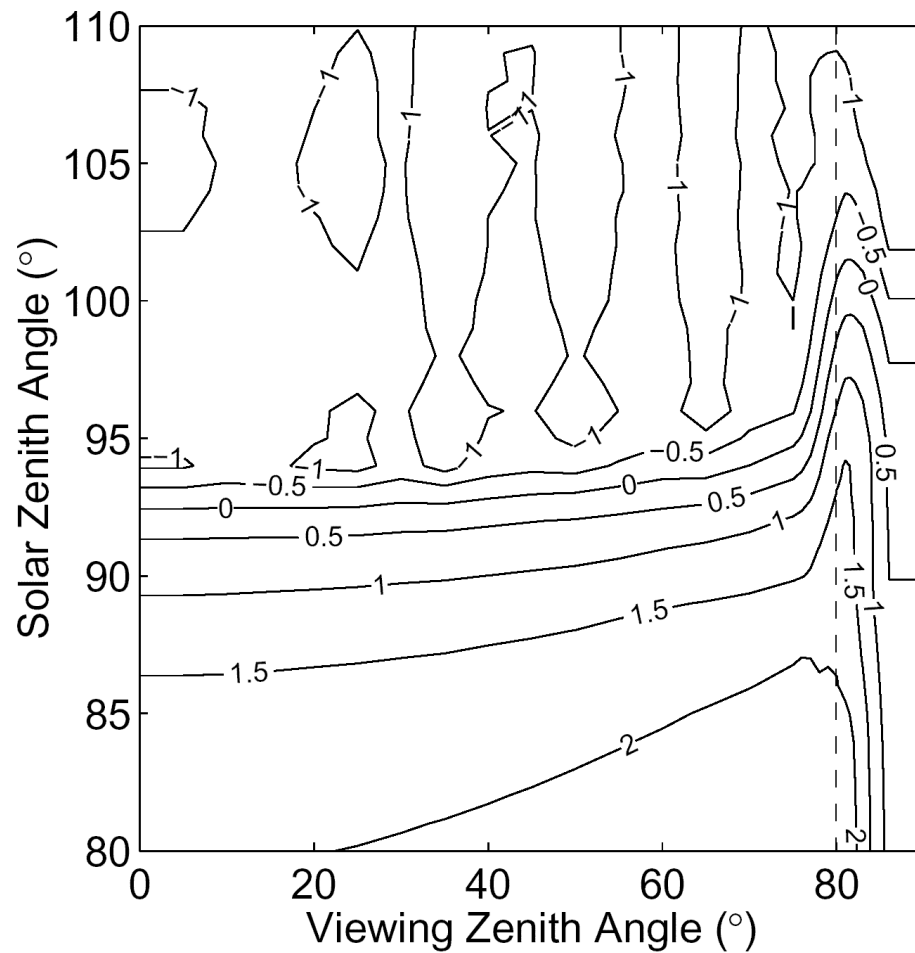
- How large is the SW TOA flux when the solar zenith angle is 90 degree or greater than 90 degree?

# Twilight Irradiance Estimate from CERES data

- Un-filter CERES radiances whose line-of-sight does not intercepts the earth (MODTRAN).
- Sort radiances as a function of viewing zenith, relative azimuth, and solar zenith angles.
- Integrate radiances to compute irradiance at satellite altitude (fill empty bins).
- Scale the irradiance to the reference altitude (20 km).

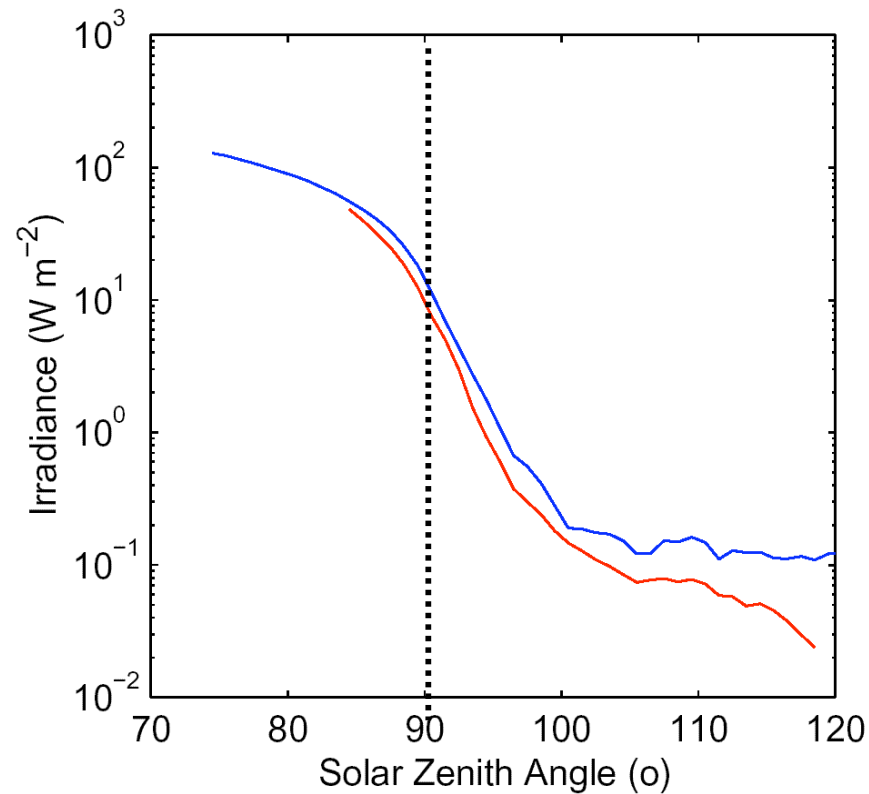
# CERES Observations (Radiance)

Log10 of azimuthally averaged un-filtered CERES radiance



# CERES Observations (Flux)

All-sky irradiances derived from TRMM as a function of Solar zenith angle



$5 \text{ w m}^{-2} \times 0.1/2$



# Twilight Flux

Solar Zenith Angle Greater than 90 degrees

	Lowest Flux (W m <sup>-2</sup> )	Highest Flux (W m <sup>-2</sup> )
Global Mean	0.22	0.29

# Further Uncertainty

- CERES ADM fluxes includes off-earth contributions.
- TISA directional models are based on ADM-derived albedo.
- But the flux at solar zenith greater than 85 degree depends on assumptions (linear extrapolation, spline fitting etc.).

## Sensitivity to Assumptions between 85 to 90 degree Solar Zenith Angle

	Global SW (W m <sup>-2</sup> ) March 2000	Difference (W m <sup>-2</sup> )
Scene Type Independent Flux	96.57	0.0
Scene Type Dependent Flux (Higher angular res.)	97.14 (96.92)	0.57
Linear Extrapolation of Directional Model	96.88	0.31
1 Hour Interval Linear Extrapolation	97.08	0.51

3-year mean with constant flux = 96.44 W m<sup>-2</sup>

TISA 3-year mean = 96.1 (96.7 with Rev1) W m<sup>-2</sup>

# Conclusions

- The global mean twilight flux is  $0.22 \pm 0.07 \text{ W m}^{-2}$ .
- The uncertainty in the global mean reflected SW flux due to assumptions between 85 and 90 solar zenith angles is  $0.57 \text{ W m}^{-2}$ .
- The lowest global mean flux from this study is  $0.1 \text{ W m}^{-2}$  lower than the corresponding TISA value (this could be due to other reasons).
- The global mean TISA flux can probably be higher by  $0.54 \text{ W m}^{-2}$ .