Atmospheric Propagation Effects relevant to UV Communications

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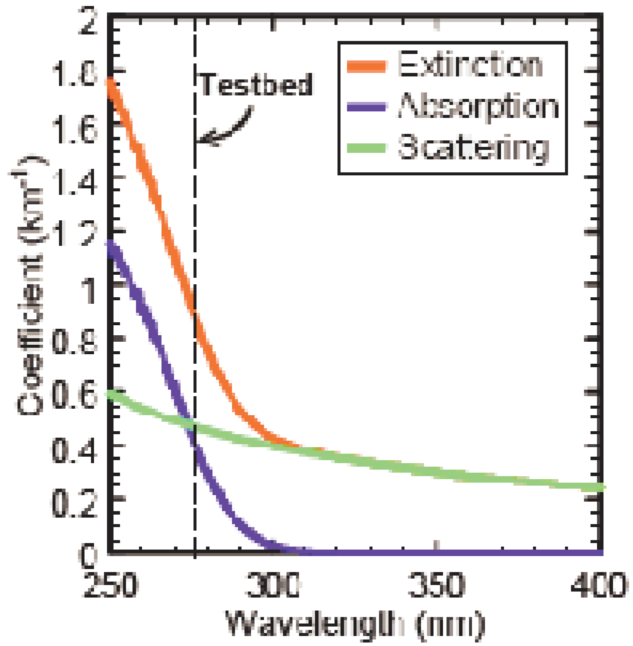
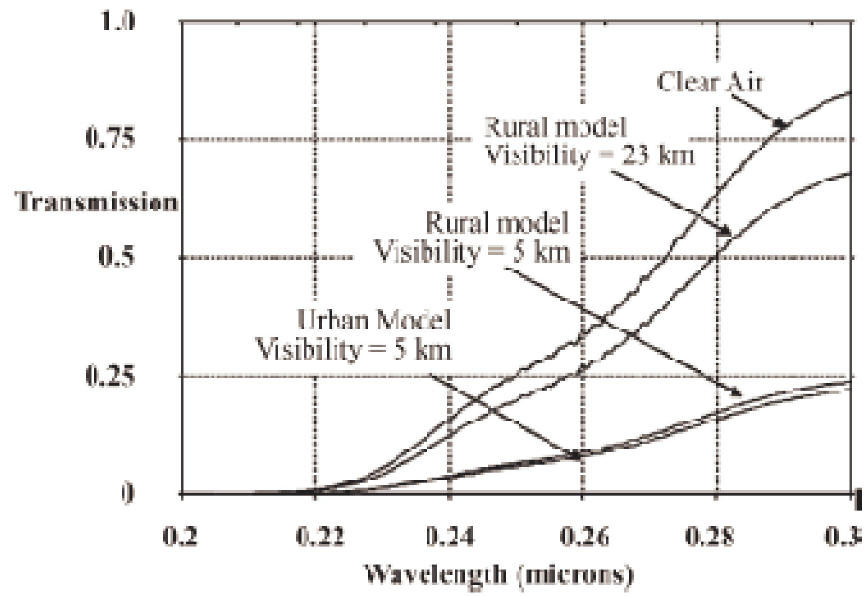
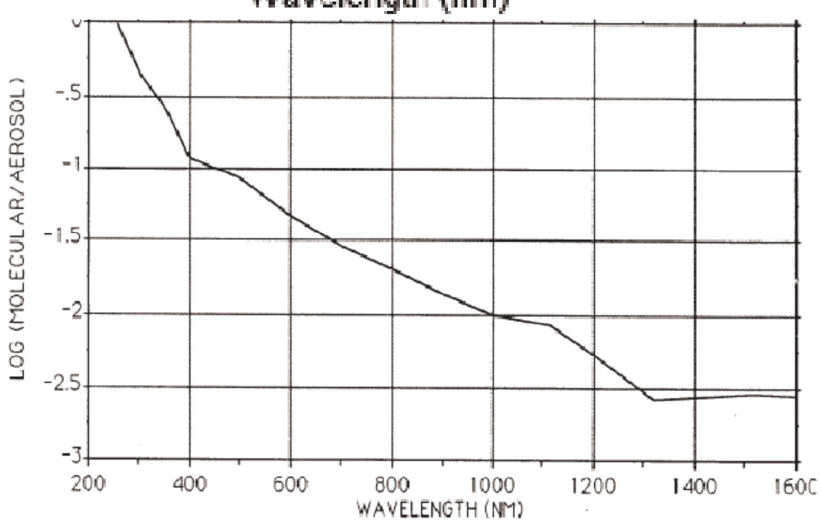
Attenuation/Scattering Effects in UV region







Gary Shaw, et al: Proc.SPIE Vol. 6231,62310C(2006)

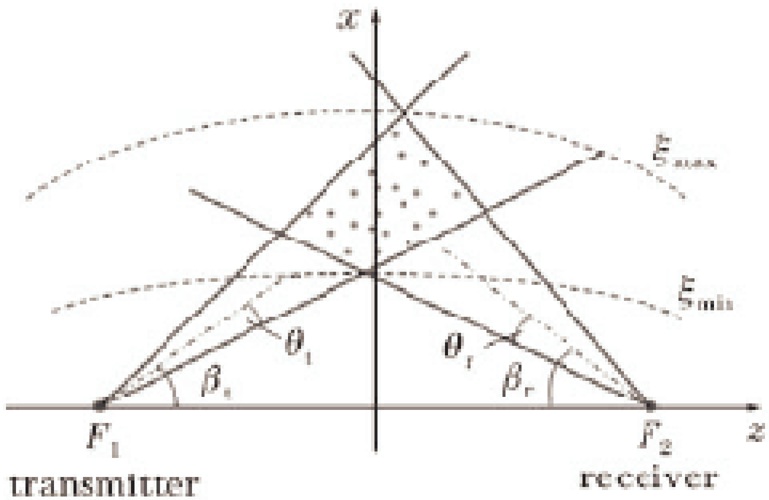
Jeffery Puschel & Robert Bayse:

http://ieeexplore.ieee.org/iel2/172/4485/00177806.pdf

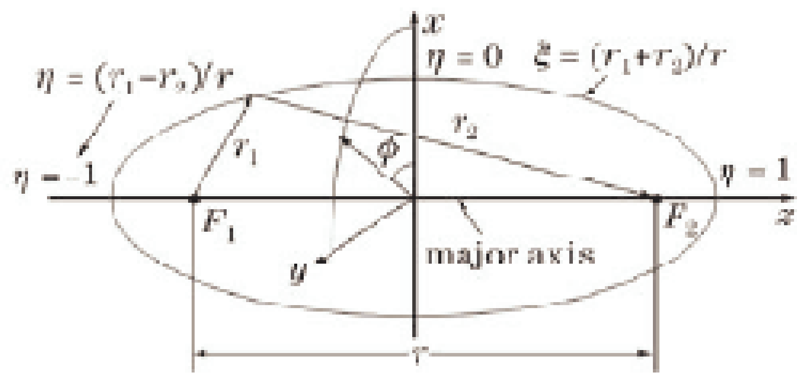
Debbie Kedar & Shlomi Arnon, Applied Optics, Vol. 45, No.33, 20 Nov. 2006

Effect of optical scattering channel relevant to communication

Multipath dispersion of pulse signals in a NLOS due to multipath propagation causes pulse broadening and consequently limit the available bandwidth of the channel : Important as the data rate is increased.



NLOS optical Scattering geometry

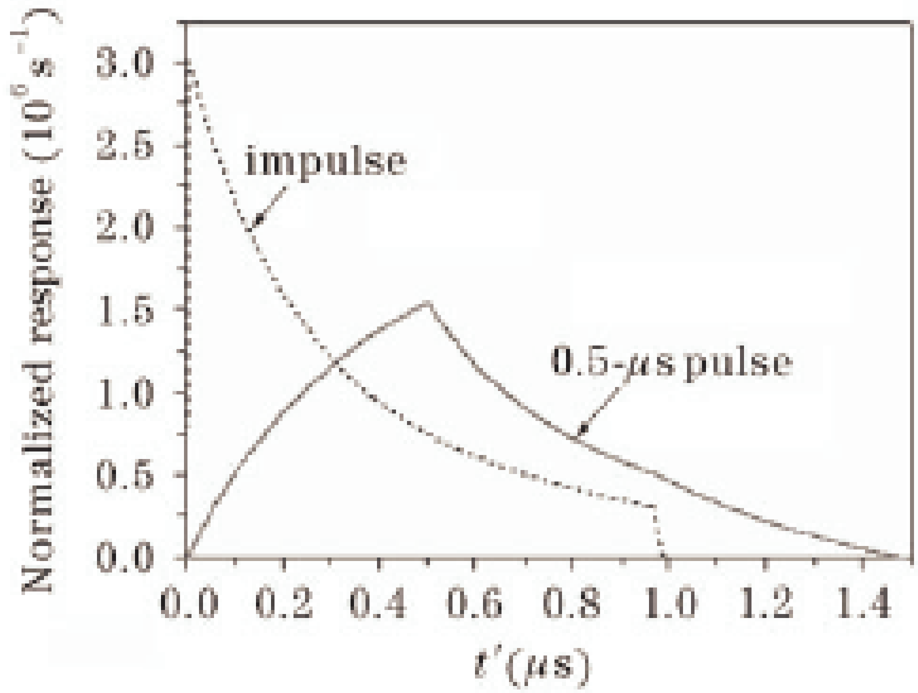


Prolate-spheroidal coordinates

Tao Feng,et al, Chinese Optics Letters, Vol.4,No.11, Nov.10, 2006

- **Effects on optical communications**

Normalized response of the NLOS optical scattering channel



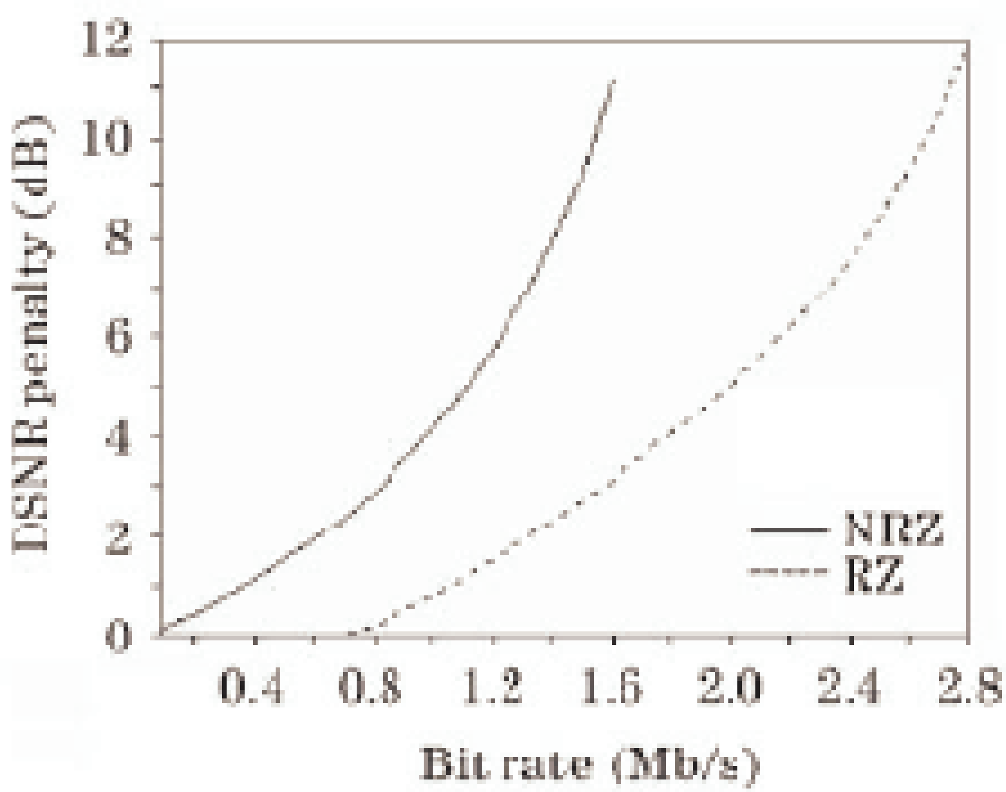
$$h(t) = \frac{Q_t A_r c k_s \exp(-k_e c t)}{2\pi \Omega_t r^2}$$

$$\times \int_{\eta_1(ct/r)}^{\eta_2(ct/r)} \frac{2G[\phi(ct/r,\eta)]\, p(\theta_s)}{(ct/r)^2 - \eta^2} \mathrm{d}\eta,$$

$$\mathrm{BER} = \frac{1}{2}\mathrm{erfc}\left(\frac{\mathrm{DSNR}}{\sqrt{2}}\right).$$

$$h_k = h_{\mathrm{TR}}(t) \otimes h_{\mathrm{N}}(t) \otimes h_{\mathrm{RE}}(t)\big|_{t=kT},$$

$$\mathrm{BER} = \frac{1}{2^{M+1}}\sum_{a}\mathrm{erfc}\left[\frac{\mathrm{DSNR}}{\sqrt{2}}\left(1 - 2\sum_{i\neq k} a_i h_{k-i}\right)\right],$$



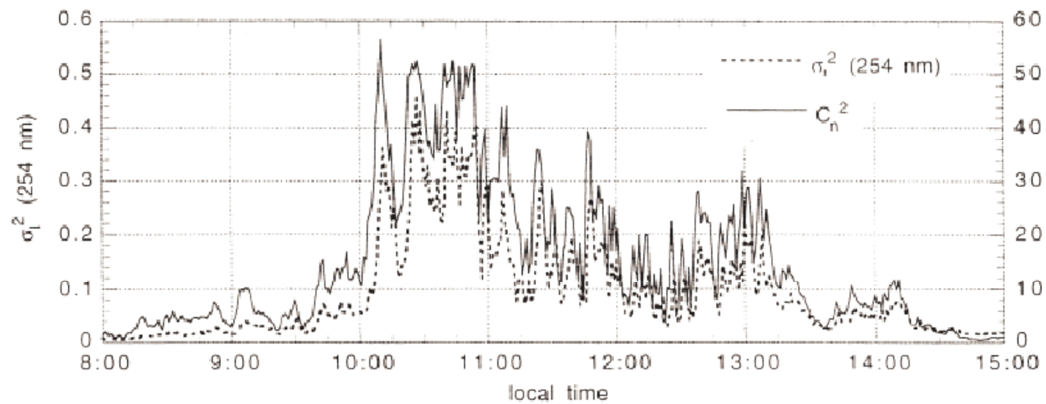
Atmospheric Turbulence Effects in the Solar blind Ultraviolet (SBUV)region

- Research Data not easily available in the literature, specifically in this wavelength region (most work on the effects of optical turbulence has been done for visible or near-infrared wavelengths)
- But, the effects of atmospheric turbulence can severely degrade performance of UV systems
- Can be a limiting factor for UV systems operating near the Ground where turbulence is greatest
- Rytov solution to the wave equation: log-amplitude variance scales as wavelength to the -7/6 power, which implies that the effects of scintillation are two to three times greater in the SBUV than in the visible
- Also implies that the log-amplitude variance in the SBUV would become saturated at levels of turbulence approximately half those required to cause saturation of visible light
- Thus, UV radiation should be much susceptible to turbulence effects than visible light

Some turbulence results at SBUV

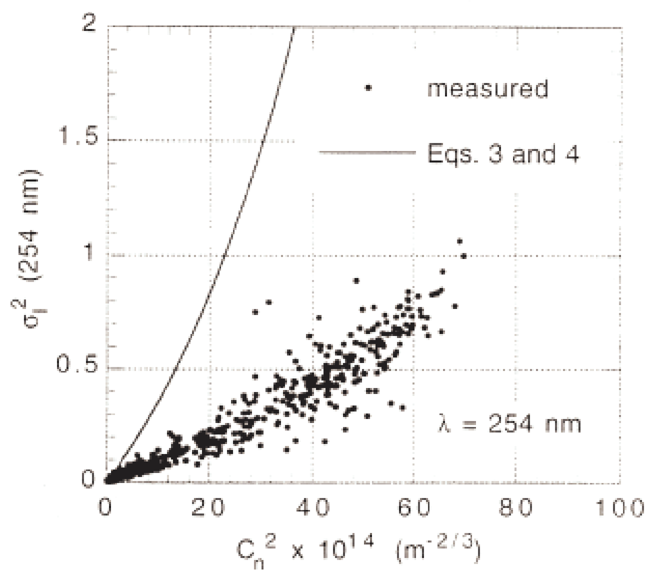
Daniel Hutt & David Tofsted, Optics & Laser Technology,vol.32, 39-48 (2000)

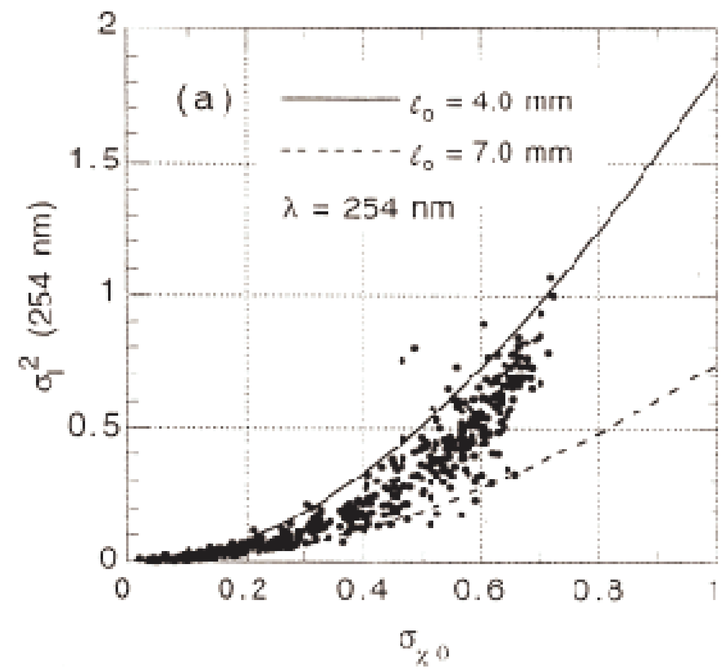
Time plot of turbulence structure parameter C_n^2 and UV scintillation index σ_I^2



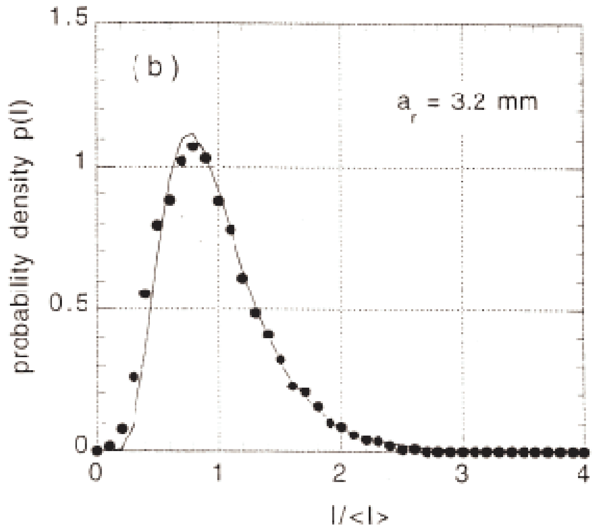
UV scintillation vs. log-amplitude variance

Measured UV scintillation vs. Cn2



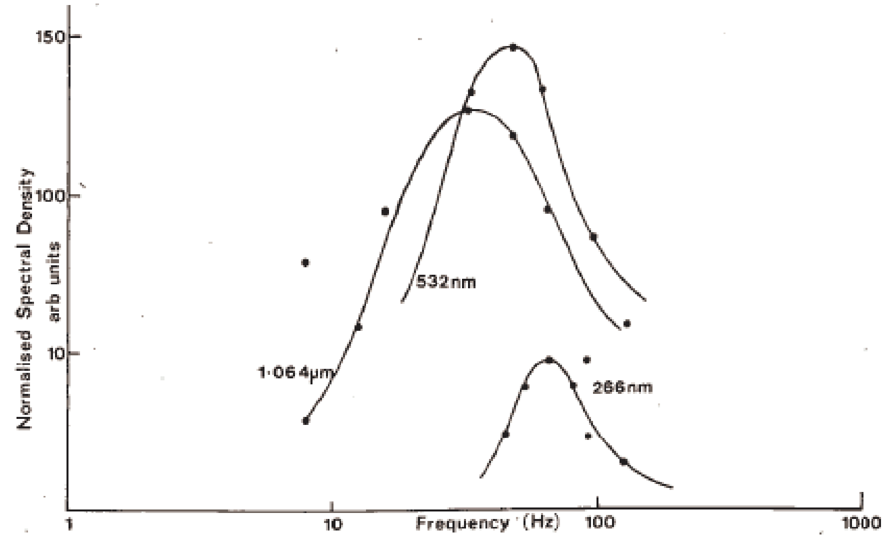


Probability density function for intensity



Tatarskii's Normalized intensity fluctuations spectrum

D.W.Goodwin and A.J.Lindop, OPTICA ACTA, Vol.23, no.4, 257-263 (1976)



Conclusion

- Scattering effects for high data-rate laser communications in the SBUV can cause pulse broadening, and consequently limit the available bandwidth.
- The effects of atmospheric turbulence can be a limiting factor for SBUV systems operating near the ground where turbulence is greatest.
- Depending on the scenario (such as slant path, range, operating platforms, etc.), the combined effects of scattering and turbulence must be taken into account to evaluate the communications performance.