$$= \frac{D^M L^{10}}{\Omega^l_M \Omega_1^{2-l}} (\Omega_T/\Omega_M)^{2+k} \qquad \Omega_T < \Omega_M$$

where we have normalized to the standard magnetic diffusion coefficient at $\Omega_1 = \Omega_T(E{=}100\text{ keV}, L{=}7.5)$, and l, D^M, k, and Ω_M remain to be determined. For $\Omega_T > \Omega_M$ we obtain the standard form for the magnetic diffusion coefficient as given by *Fälthammer* [1965],

$$D^M_{LL} \propto L^{6+2l'} \mu^{2-l'} = L^{10} \qquad l' = 2 \tag{13}$$

Fälthammer [1966] also derived a result for fluctuations shorter than the drift period of the ions, ($\tau_M < \tau_T$, or equivalently, $\Omega_T < \Omega_M$) and found l'=0. This corresponds to our second case above with a resonant frequency below the peak in the power spectrum if we take k<<1. This choice of a small value for k which implies a very flat $H_1(\Omega_T)$ spectrum, is consistent with short pulses, since the narrower the pulsewidth, the broader the frequency spectrum. Thus our generalized spectrum is consistent with the two special cases considered by Fälthammer.

Modified electric diffusion. *Fälthammer* [1965] derives a relatively general result for the diffusion caused by electric fluctuations (his equation 3.10),

$$\langle(\Delta r)^2\rangle = \frac{1}{4B_d^2(r)} \sum_{n=1}^{N} G_n(r, n\Omega(\mu, r)) \tag{14}$$

where B_d is the equatorial dipole field, and G (analagous to the magnetic fluctuation power H_1 of (10)) is the cross correlation of the azimuthal electric field fluctuations. Only azimuthal fluctuations are considered here because the magnetic field is taken to be dipolar, without a cross-tail electric field, so that only azimuthal electric fields contribute to radial diffusion. In a real magnetosphere this is not entirely true, particularly for ring current energy ions below 100 keV, which because of their somewhat noncircular drift orbits can couple to the fluctuation power in the radial electric field component as well. Unfortunately, these complications are rather difficult to include in the azimuthally symmetric model used here, so we will treat the empirically calculated electric field power to be solely azimuthal fluctuations, recognizing that there is a radial fluctuation component to the diffusion also whose contribution depends on energy and location.

However the simplification of the G function to just the autocorrelation of azimuthal fluctuations does not survive intact. The assumption of large timescales, $\tau >> 1/\Omega_T$ (his equation A.17) is what justifies keeping only the autocorrelation of the electric field fluctuations. Without being able to make this simplifying assumption, which breaks down when the drift frequency approaches zero, we approximate with a parameterized spectral form composed of the sum of two power laws as above. This form is based on experimental measurements of the electric field power spectra made at L=6.2 [*Holzworth and Mozer*, 1979], L=2.3 [*Andrews*, 1980], and L=1 [*Earle and Kelley*, 1987], which all show

does not generally know the global mode or the phase of t electric field fluctuations, so we make the assumption t all the power is in the fundamental, and that all the phas are random. We are not so much interested in reconstru ing the modes of the electric field fluctuation as finding fluctuation power spectral form that will adequately expla the observed diffusion. Thus we assume that the elect fluctuation power can be written

$$P_E(r, \Omega) = \sum_i \langle \Delta E_i^2(r) \rangle H_1(\Omega_T) \qquad (1$$

where $\langle \Delta E_i^2 \rangle$ incorporates the radial dependence of the ele tric field fluctuations for each component i to allow for t possibility of multiple sources. As before, we model t electric fluctuation power by assuming there is some pe frequency in the spectrum, Ω_E with power law falloff both higher and lower frequencies. With these approxim tions we can write [e.g., *Cornwall*, 1968]

$$\begin{aligned} D^E_{LL} &= \frac{\sum_i \langle \Delta E_i^2 \rangle}{8B_d^2} (\Omega_T/\Omega_E)^{-n} \qquad \Omega_T \geq \Omega_E \ (1 \\ &= \frac{\sum_i \langle \Delta E_i^2 \rangle}{8B_d^2} (\Omega_T/\Omega_E)^{m} \qquad \Omega_T < \Omega_E \end{aligned}$$

where for simplicity we use the same spectral shape for components.

Modified Radial Gradients

The standard radial diffusion coefficient contains an e ternal L^6 radial dependence, $D^E_{LL} \propto L^6 \langle \Delta E^2_{ext} \rangle$, becaus nearly constant azimuthal ΔE_{ext} fluctuation combined w a radially varying B field causes an $\vec{E} \times \vec{B}$ radial deflecti of $\Delta E_\phi / B_d$. A radially dependent fluctuation amplitu $\langle \Delta E^2 \rangle$, could in principle produce any desired radial d pendence in the electric diffusion coefficient, which is n possible with magnetic fluctuations since currents produ global effects on the magnetosphere. That is, a sudden ons compression of the magnetosphere does not locally co press the magnetosphere but globally, and the ΔB fluctu tion created (and its induced electric field) does not poss any strong L dependence. Because magnetic field lines a considered equipotentials (no parallel currents), the situ tion is different for electrostatic fluctuations. The potent difference between neighboring field lines is only limit by the ionospheric conductances, so that strong radial longitudinal gradients in the electrostatic potential are pos ble. We suggest three possible mechanisms for such spat gradients: plasma shielding (space charge), divergence magnetic field lines, and latitude-dependent sources.

In the Volland-Stern shielded electric field model [*Vo land*, 1973; *Stern*, 1973] the ring current shields the extern (L>7.5) voltage source (via charge separation between t counterrotating energetic ions and electrons [*Vasyliuna* 1972]) so that this electric field weakens at lower altitude In this model, the external electric field is proportional radial distance, $E_{ext} \propto r$, so that fluctuations in this hig