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We present theoretical and experimental results on spatial quantum correlations induced by multiple scattering of non-classical light. A continuous-mode quantum theory is derived that enables determining the spatial quantum correlation function from the fluctuations of the total transmittance and reflectance. Utilizing frequency-resolved quantum noise measurements, we observe that the strength of the spatial quantum correlation function can be controlled by changing the quantum state of an incident bright squeezed-light source. Our results are found to be in excellent agreement with the developed theory and form a basis for future research on, e.g., quantum interference of multiple quantum states in a multiple scattering medium.