to modulate the total insolation of the Earth by 1%. In the following, we shall provide some details regarding specific possibilities, ones selected to illustrate basic features of each of the major classes of scattering systems.

Sub-Microscopic Oxide Particulates. During the present decade, the eruption of Mt. Pinatubo in the Philippines induced a transient drop in the global mean temperature of ~0.5˚ K, apparently due to insolation modulation by volcanic particulates.[26] It is believed that this cooling was induced predominantly by scattering of sunlight by SO_2-based particulates of sub-micron scale, ones which may have grown into more effective scatterers by scavenging residual stratospheric water and cations, resulting in myriad still-sub-micron droplets of high-concentration sulfur acids and salts. Indeed, it has been suggested that the advent of marked greenhouse effects due to CO_2 emissions has been delayed through the present time by the simultaneous emission of large quantities of sulfate particulates (primarily arising from the ~2±1% sulfur content by weight of typical fuel-grade coal), resulting in significant tropospheric scattering of sunlight.[27] To these extents, the case of dielectric scattering-based insolation modulation already has some empirical basis.

It may well be feasible to transport and disperse enough SO_2 (or SO_3 or H_2SO_4) into the stratosphere to produce the desired insolation modulation effect[28,29] – and even to do so partly on the

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[26]Trepte CR and Hitchman MH, Tropical stratospheric circulation deduced from satellite aerosol data, *Nature* **355**, 626-8 (1992); Trepte CR, Veiga RE, and McCormick MP, The Poleward Dispersal of Mount Pinatubo Volcanic Aerosol, *J. Geophys. Res.* **98**, 18563-73 (1993); Grant WB et al, Use of volcanic aerosols to study the tropical stratospheric reservoir, *J. Geophys. Res.* **101**, 3973-88 (1996).

[27]See, e.g., Taylor KE and Penner JE, Response of the climate system to atmospheric aerosols and greenhouse gases, *Nature* **369**, 734-7 (1994); Chuang CC, et al, An Assessment of the Radiative Effects of Anthropogenic Sulfate, *J. Geophys. Res.* **102**, 3761-78 (1997); and Intergovernmental Panel on Climate Change, Climate Change 1995: The Science of Climate Change, JT Houghton, et al, eds. (Cambridge Univ. Press, Cambridge, 1996).

[28]See, e.g., Dyson FJ and Marland G, Technical fixes for the climatic effects of CO_2. *Workshop on the Global Effects of Carbon Dioxide from Fossil Fuels*. USDoE Report CONF-770385 (USDoE, Washington DC, 1979); Budyko MI, The Earth's Climate: Past and Future. (Academic Press, New York, 1982); Broecker WS, How to Build a Habitable Planet (Eldigio Press, Palisades, NY, 1985).

[29]In this approach, advantage is taken of the stronger Rayleigh scattering of the shorter wavelengths of optical sunlight as compared to those of terrestrial thermal emissions. A performance-optimized *scattering system* of present interest consists of a world-wide, ultra-thin cloud of dielectric particles, each of 0.05-0.1 μm diameter, deployed in the Earth's stratosphere. The Rayleigh scattering cross-section Σ of a particle of volume V whose polarizability $\alpha=3(\varepsilon-1)/4\pi(\varepsilon+2)$ for photons of angular frequency ω is $\Sigma = (8\pi/3)(\omega/c)^4\alpha^2V^2$. [See, e.g., Landau LD and Lifshitz EM, Electrodynamics of Continuous Media (Pergamon, Oxford, 1984).] For such a spherical particle whose diameter is equal to a quarter-wavelength of 0.5 μm radiation which has a dielectric coefficient ε~1.7 (e.g., a water-rich microdrop of refractive index ~1.3), Σ may be estimated to be ~5×10^{-12}