AEROSOLS IN THE SOLAR SYSTEM AND BEYOND.

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Abstract: Every planet with a significant atmosphere in the Solar System has an aerosol layer of some kind, be it thick or thin, permanent or transient. The types of aerosol can arise from a variety of sources. These sources include, mechanically produced dust aerosols on Mars, meteoritic smoke particles in Earth's mesosphere, and photochemically produced organic hazes of Saturn's moon Titan,.

On any of these bodies, aerosols have a significant influence on the climate, affecting (and being affected by) radiation, dynamics, cloud formation, and chemistry. This results in many possible feedback mechanisms that are not yet fully understood. Even on our home planet, aerosols are the climate change driver that contributes the largest uncertainty to estimates of net anthropogenic radiative forcings [1]. Atmospheric aerosols arise from a variety of sources, and they influence the climate through effects that are both direct (*i.e.* scattering and absorbing radiation) and indirect (*e.g.* as cloud condensation nuclei and sites for heterogeneous chemistry). The microphysical processes governing the presence, growth, physical, and chemical properties of aerosols are strongly linked to the nature of the sources and the chemistry of the atmosphere. Thus the characterization of the aerosols in a planetary atmosphere provides insight into that environment, with implications for habitability. Several such thought exercises have been undertaken with respect to the early Earth. These studies on early Earth have examined the possible role an extensive aerosol layer may have had on the surface climate as it relates to the "Faint Young Sun Paradox," as well as habitability and chemistry implications from the amount of UV radiation reaching the surface [*e.g.,* 2-10].

In searching for habitable exoplanets, the characterization of the atmospheric gases is not trivial. Further, it has been noted that the presence of clouds and hazes can strongly influence the detectability of exoplanet atmospheres [11 and references therein]. In this vein, the effects of aerosols and hydrated particulate hazes on exoplanet observations is beginning to be explored. Much of this work leverages our knowledge of the aforementioned hazes in our home system. For example, recent demonstrations of transmission spectra of Titan reveal the challenges and opportunities that might exist in detecting 'hazy' exoplanets and characterizing the nature of the atomspheric aerosol [12]. As these capabilities improve, we will need a comprehensive understanding of the types of aerosols that can form in diverse atmospheres, the role different types of aerosols play in climate, and the influence of aerosol on the exoplanets spectra.

We will review the current treatment of aerosols in General Circulation Models (GCMs) for planetary bodies. Using familiar Solar System case studies, we will explore the connections between the aerosol properties that can be sensed remotely and their potential impacts on climate. Particular focus will be given to the chemical composition of aerosols and the nature of the environments in which they form, and the degree to which aerosols can serve as indicators of habitability. Finally, we will speculate on the future potential for GCM implementation of interactive chemistry and aerosols to advance our understanding of the effects of aerosols on the climate and chemical environment of exoplanets.

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