The Pale Orange Dot: Lessons from Hazy Archean Earth Applied to Exoplanets

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In the near future, we will begin to characterize potentially habitable exoplanets. Modern Earth provides a useful starting point for understanding the remote observables of a habitable (and inhabited) world. However, the diversity of exoplanets already discovered warns us that we should anticipate a diversity of habitable environments elsewhere. A useful period of Earth history for considering "alien" yet habitable planetary states is hazy Archean Earth. Geochemical evidence suggests Archean Earth may have occasionally been enshrouded by a methane-based organic haze with major climatic, photochemical, and spectral consequences. I will discuss the putative Archean haze in the context of past environments of Earth that can be used to understand and characterize exoplanets. I argue that organic haze is not an impenetrable barrier to information about the lower atmosphere and surface environments of similarly enshrouded exoplanets. Organic hazes themselves may reveal much more than they conceal because photochemical haze layers can constrain important planetary processes and characteristics such as atmospheric redox state, surface gas source fluxes, planetary habitability, and possibly even point to signs of life. Because they are both produced by biology (in the form of biologically-generated methane) and because they produce environmental consequences for life, hazes must also be considered in the context of biological feedbacks in planetary environments and may serve as a type of biosignature.