TITAN THROUGH TIME : A PROXY FOR THE EARLY EARTH E. H. Hébrard[1,2] and S. D. Domagal-Goldman[1], [1]NASA Goddard Space Flight Center, Greenbelt, MD, United States (eric.hebrard@nasa.gov), [2]NASA Postdoctoral Program, Oak Ridge Associated Universities, TN, United States.

It has been hypothesized that the Earth's atmosphere once contained an organic haze similar to that of Titan well before widespread oxygenation about 2.45 Gyr ago ([1-3]). This prediction arose from the fact that, because the Sun was fainter by 20–30% than today, and because there is no evidence in the geological record for a very high P_{CO_2} in the Archean, another greenhouse gas had to be present in the ancient atmosphere to counter-balance the lower solar energy and prevent global glaciation (e.g., [4], and references therein). This led to the identification of methane (CH_4) as a potential greenhouse gas, and the realization that high CH_4 concentrations could lead to accumulation of a Titan-like haze..

The occurrence of kerogens with extremely low-^{13}C in late Archean sediments were first argued as an indirect evidence for the occurrence of an organic haze, mediated by biological CH_4 production [5]. Sulfur isotope records were further used to conclude that early to mid-Archean conditions were anoxic [6] and that the size of that signal could be modulated by the thickness of an organic haze [7]. Multiproxy geochemical analyses of sediments from the 2.65- to 2.5-Ga-old Ghaap Group in South Africa, have indicated the presence at that time of a reduced atmosphere that was periodically rich in methane, consistent with the prediction of a hydrocarbon haze [8]. It was recently suggested that the temporal trend exhibited by xenon isotope composition of the primitive atmosphere trapped into Archean samples involved the presence of a primitive organic haze as well [9]. Overall, as limited as they are, ground-truth evidences from 3.5- to 2.5-Ga-old geological records suggest that methane was indeed an important component of the atmosphere throughout the Archean, which might have driven the formation of a hydrocarbon haze.

The Sun was significantly more active in its past. This early activity for Sun-like stars has been shown in the X-ray/EUV range [10] and in the UV range [11]. These emissions might have had an impact on the early evolution of Earth's atmosphere. It was indeed suggested that such enhanced UV light emission might have triggered a peculiar chemistry in the atmosphere of the early Earth and might even have helped the in-situ synthesis of complex prebiotic molecules [11, 12].

Numerical simulations of the responses of an organic haze formation to early Earth's atmosphere conditions and solar EUV temporal variations are therefore worth performing. In that frame, we present the results of a state-of-the-art photochemical model of Titan's atmosphere [13,14] that has been run in appropriate conditions for an organic haze to be formed - obviously - and at different times along the course of the Sun's evolution.

Because Archean Earth's atmosphere had conditions that were anoxic but not as O-poor as Titan's atmosphere, these two sets of simulations will "bound" the anoxic/reduced region of the chemical phase space for anoxic atmospheres. By running these end-member cases, and then intermediate cases, we will substantially expand our ability to use conditions on Archean Earth as a proxy for what we might eventually observe on extrasolar planets. The evolution of the organic haze formation in Titan's atmosphere over time will be re-evaluated in the light of the enhanced UV emission of the young Sun and of the peculiar atmospheric chemistry that such enhancement presumably triggered.

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