INITIAL MODELING OF THE ATMOSPHERIC PHYSICS OF A TRANSIENT LUNAR ATMOSPHERE ON THE ANCIENT MOON.

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Introduction: Recently, Needham and Kring (2017) proposed that early in lunar history increased volcanic activity may have created a substantial, collisional lunar atmosphere [1]. During peak mare formation and outgassing, which occurred ~3.5 Ga, the lunar atmosphere may have reached surface pressures as high as ~1 kPa [1]. This surface pressure is comparable to the current surface pressure of Mars. Such an atmosphere would have required around 70 million years to dissipate, which may have allowed this transient atmosphere to sequester volatiles in the permanently-shadowed regions of the lunar poles [1].

Using the volatile production estimates from Needham and Kring (2017) [1], we have begun to investigate the atmospheric physics associated with a putative, ancient, and transient lunar atmosphere. We are particularly interested in how the dynamics of such a transient atmosphere may have mixed volatiles from the equatorial and mid-latitude regions to the poles, where cold-trapping in permanently-shadowed regions may have been possible.

Modeling Transport in a Lunar Atmosphere: An ancient lunar atmosphere with surface pressures comparable to Mars is a new and exciting area of study. There are a number of possible areas of investigation, including but not limited to: the dynamical transport of water vapor, the photochemical stability of the lunar atmosphere, the radiative-convective conditions, and the formation of winds and possible aeolian surface features. We have chosen to first look at how the atmospheric dynamics of a collisional, "thick" lunar atmosphere controls the transport and deposition of water vapor.

Needham and Kring (2017) determined that lunar volcanism would create a lunar atmosphere dominated by carbon monoxide (CO) and sulfur (S) atmosphere with a non-negligible amount of water vapor (H_20). The transport of this water vapor will depend on the latitudinally-dependent, vertical temperature profile, the strength of meridional mixing, and the surface energy balance. The meridional mixing, in turn, will depend on the strength and extent of the development of a Hadley circulation and baroclinic eddies, which are ultimately controlled by the rotation rate and Rossby deformation radius, respectively.

As a first step in modeling the dynamics of this lunar atmosphere, we are using a model framework designed for idealized modeling at various levels of complexity [2]. The model, called Isca, provides a flexible framework for investigating scenarios, like an ancient, collisional lunar atmosphere, where observation constraints are limited. We are exploring the dynamics of the lunar atmosphere using a range of physics parameterizations. This process allows us to identify dynamical transport features that are independent of model assumptions while also exploring possible climate conditions that warrant future exploration.

We will present our initial modeling results and discuss future directions in studying an ancient, collisional lunar atmosphere.

References: [1] D. H. Needham and D. A. Kring, EPSL, 478 (2017), pp. 175 – 178. [2] G. K. Vallis, et al., Geosci. Model Dev., 11, 843–859, 2018