CAN EXPLOSIVE VOLCANISM EXPLAIN HYDRATED REGOLITH PATTERNS ON MARS? T. Paladino[1], S.E.K. Nawotniak[1], L. Kerber[2], E. Millour[3], and S. Karunatillake[4]. [1]Department of Geosciences, Idaho State University, Pocatello, ID 83204, USA, (tylerpaladino@isu.edu), [2]Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109, USA, [3]Laboratoire de Meteorologie Dynamique, IPSL, Universite Pierre et Marie Curie, Paris 75005, France, [4]Department of Geology and Geophysics, Louisiana State University, Baton Rouge, LA 70803, USA

Introduction: Explosive volcanism was likely active for much of Mars's geologic history as evidenced by physical features as well as from one, two, and three dimensional numerical models [1]. Powerful explosive eruptions are theoretically capable of producing widespread ash deposits that could form observed explosive volcanic features such as the friable layered deposits and paterae [2].

H_2O hydration maps derived from Gamma Ray Spectrometer (GRS) data [3] show areas of hydrated regolith in the upper few decimeters of the Martian surface that remain difficult to explain. Here, we seek to understand what role explosive eruptions may have had on these patterns. Explosive volcanism, whether driven by external or internal volatiles, could result in concentration of water due to becoming trapped in vesicles, ash surface adsorption, or hydrated mineral phases, thereby contributing to elevated regolith hydration in areas with increased ash accumulation. We are interested in identifying possible primary ash accumulation zones on Mars through the use of physics-based plume and global circulation models.

The Martian Active Tracer High-resolution Atmospheric Model (MATHAM) [4], an adaptation to the terrestrial ATHAM [5], provides high-resolution 4-D simulations of an eruption column. We coupled MATHAM to the Laboratoire de Météorologie Dynamique General Circulation Model (LMD GCM) [6] to track ash deposition at regional- and planet-wide scales for eruptions from various proposed eruptive centers to create ash deposition maps that can be compared with existing hydrated regolith maps [3].

Based on the relationships between water and ash on Earth, we hypothesize that there will be a spatial correlation between modeled explosive eruption deposits and areas of hydrated regolith. If ash accumulation is a significant cause of local regolith hydration, it would suggest that these deposits might be much deeper than the view allowed by GRS and could be valuable for In Situ Resource Utilization in the future.

MATHAM: MATHAM [4] is a Martian specific module to the non-hydrostatic volcanic plume simulation, ATHAM [5]. It acts in a Eulerian reference frame and solves the Navier Stokes equation in three spatial dimensions and solves for turbulence using a large eddy simulation. It contains active tracers, meaning chemical species such as water go through phase changes, altering the overall plume dynamics by affecting the local energy budget. MATHAM differs from its terrestrial counterpart by actively solving for CO_2 thermodynamics and microphysics, as these become important for the energy balance in a martian plume due to the unique temperature/pressure conditions that exist on Mars. These conditions are not common on Earth and so can be safely ignored.

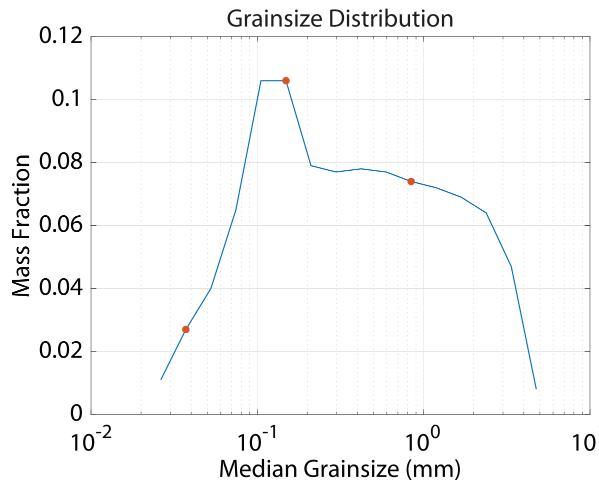

Figure 1: MATHAM grainsize distribution used in our MATHAM simulations, following Wilson and Head [7]. Red circles represent actual tracer values used in MATHAM.

Eruption Characteristics: The simulated eruption illustrated in figure 2 had a mass eruption rate of $8.04x10^4$ kg/s, with vent velocity of 100 m/s and vent radius of 100 m. Pyroclast density was set at 1500 kg/m^3, and the grainsize distribution 1 was based on the distribution estimated by Wilson and Head [7]. The magma temperature was 1450 K and the volatile content was 4% H_2O.

LMD GCM: The LMD GCM is a general circulation model of the atmosphere of Mars that solves for the dynamics and many physical processes that occur in the atmosphere, such as radiative transfer, phase changes of CO_2, and thermal surface interactions with the atmosphere [6]. The LMD GCM is capable of modeling modern Mars or early Martian conditions. Parameters such as obliquity and rotational velocity can also be changed.

We have modified the LMD GCM code to input ash data from MATHAM as an inactive tracer. Ash concentration in an established, quasi-steady plume is calculated in MATHAM, then used to provide the initial con-

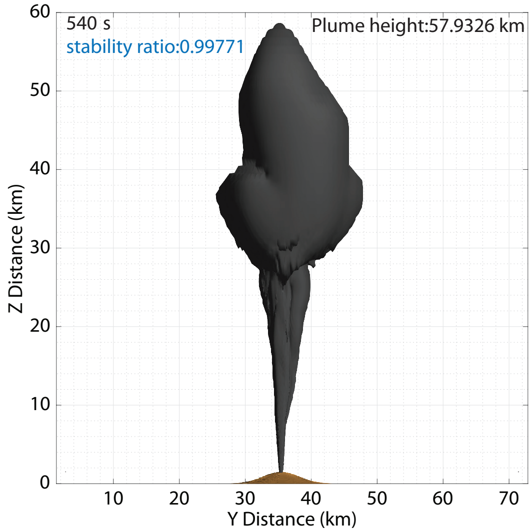

Figure 2: MATHAM eruption plume with a MER of 8.04x10^4 kg/s in a Martian atmosphere.

ditions for a vertical plume profile source in the LMD GCM. The simplification of the MATHAM plume when transferred to the GCM is due to the different spatial scales of the two models, where the GCM resolution is much coarser than that of MATHAM. This difference in spatial scales as well as the computation costs of the two models, is also why we chose to not fully integrate the two codes. Instead, output from the GCM is used to initialize the atmospheres for a range of MATHAM simulations, with the MATHAM ash concentrations in the plume used to initialize a subsequent GCM run.

The model outputs an ash surface over the entire planet. If the planar density at any grid point exceeds 100 kg/m^2, the surface is deemed ash covered; otherwise, the surface is deemed uncovered. This is done to reduce bias on ash deposit thickness which could be dependent on a variety of factor such as volcano simulation time.

Atmospheric Characteristics: Most large ($>10^5$ km^2) proposed explosive eruption deposits have been dated from the late Noachian to the early Amazonian [1]. As such, we use an atmosphere consistent with ancient Mars. We illustrate the results here from a cold and dry atmosphere, made up of 95% CO_2 and 5% H_2O, both of which are radiatively active. The surface pressure is 4.70x10^4 Pa, the surface temperature is -87.7 K, and the humidity at the surface is .3% (see fig. 3 for full profile). These parameters are mostly default parameters for the GCM. We plan to alter these to test a variety of different ancient atmospheres.

Results: Initial results from the coupled MATHAM-LMD GCM yielded plumes much taller than those expected[4, 8], extending well beyond 60 km high. This

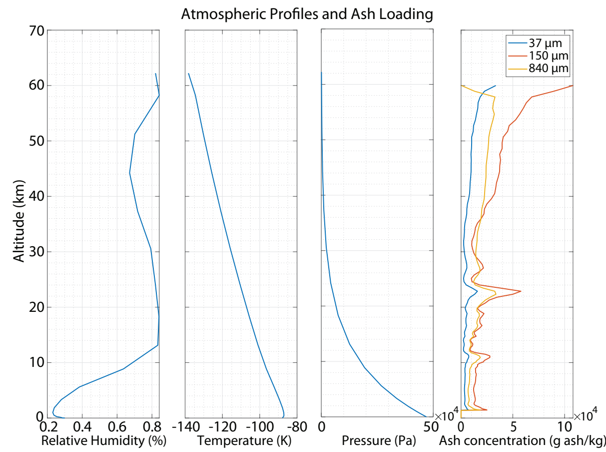

Figure 3: Atmospheric profiles sourced from the LMD GCM used in MATHAM (left 3 panels) along with the ash concentration loaded into the LMD GCM (rightmost panel)

is likely the result of our choice of atmosphere, particularly in comparison to the smaller MATHAM plumes generated in [4] in more humid Martian atmospheres. Interaction with the upper limits of the MATHAM domain space and subsequent accumulation of ash into a very top-heavy distribution means that we must be skeptical of depositional patterns generated from these plumes. While modeled ash deposits reached up to ~3450 km downwind and ~1200 km crosswind from the source location, we argue that these values are still underestimations of the expected ash distribution and are due to numerical artifacts. We are continuing to evaluate other atmospheric and eruptive conditions, as well as altering the means by which the atmospheric loading of the ash is transferred between models. Once these broader conditions and approaches have been studied, we will use biserial correlation to measure the relationship between modeled ash deposits and GRS regolith hydration data.

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