OUTFLOW CHANNELS INFLUENCING MARTIAN CLIMATE: GLOBAL CIRCULATION MODEL SIMULATIONS WITH EMPLACED WATER D. L. Santiago[1], A. Colaprete[2], R.M. Haberle[2], L.C. Sloan[1], E.I. Asphaug[1], [1]Department of Earth Sciences, University of California Santa Cruz (1156 High Street, Santa Cruz, California 95064, santiago@es.ucsc.edu) [2] NASA Ames Research Center, Moffett Field, MS245-3, Mountain View, CA 94035, tony@freeze.arc.nasa.gov).

Introduction: The existence of surface water on Mars in past geologic epochs is inferred on the basis of geomorphologic interpretation of spaceflight images, and is supported by the recent Mars Odyssey identification of ice-rich soils [1]. The Mars Exploration Rovers have provided further chemical evidence for past surface hydrologic activity [2]. One issue is whether this water-rich climate ever existed in a steady state, or whether it was triggered by catastrophic events such as large impacts [3], and/ or catastrophic outburst floods, the topic of consideration here.

The Martian outflow channels are thought to have been formed by water rapidly released from the subsurface. Most are Hesperian in age, and have discreet starting points for the flow [4]. In the late 1970's, Viking Orbiter captured the images of many outflow channels on Mars, including the region of Chryse-Acidalia. Since the imaging of these features, scientists have embarked upon determining the rate of water flow from these channels, and estimating the flow rate and total volume of water released. Early studies of Ares Valles, located in the Chryse basin, estimated water flowing at $7x10^7$ m^3/s [5], and a total volume of $3x10^5$ km^3 of water [4]. *Komatsu & Baker* [6] later estimated the peak discharge rate of Ares Valles to be as high as 10^9 m^3/s. *Carr et al* [7] estimates the total volume of water from the Chryse basin to be around 6×10^6 km^3.

While recent work by *Wilson et al* [8], shows that flow velocities may have been overestimated by a factor of ~2, resulting in volume overestimates by a factor of ~25, the volume of water released from outflow channels would still have involved volumes much larger than any catastrophic discharge seen on Earth. This water, suddenly emplaced upon the Martian surface, is expected to have significantly influenced climate, at least episodically, and to perhaps have played an important role in global geomorphic evolution by triggering a hydrologic cycle.

Approach: Our goal is to use the NASA Ames Mars General Circulation Model (MGCM) to examine the climatic consequences of the sudden burst of water from outflow channels on Mars. The immediate release of water has been postulated to result in huge climatic consequences. However, a three-dimensional general circulation model has not yet been used to study this type of event. The use of the MGCM to study outflow channels is a unique approach to studying the effects of outflow channels on the evolution of climate on Mars.

Presently, MGCM's have attained the necessary level of sophistication to address these issues. Physical processes defined in the model include sublimation, evaporation, condensation, and freezing.

Modeling Strategy: In our first, most simple model case, water is placed on the surface, within the cell or cells defining the outflow channel, with increasing amount of water at each time step until the specified discharge volume is attained (Figure 1). Our first model run simulates, within the existing Ames MGCM, an outflow channel in the Chryse basin, approximately the size and location of Ares Valles. Our initial assumption for the rate of water flow is 10^8 m^3/s with a total volume of 10^6 km^3. This is an upper estimate based on outflow rates and volumes discussed above.

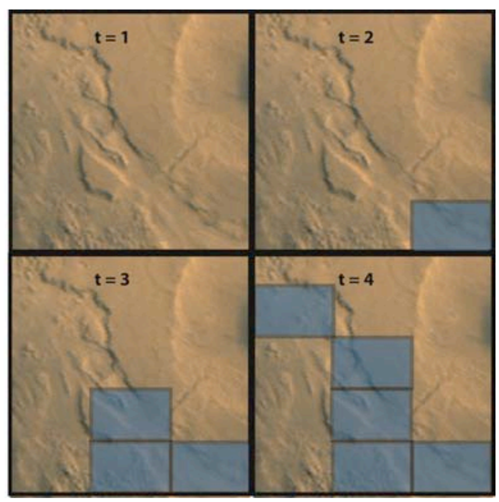

Figure 1: Example of how water will be emplaced on the surface on Mars at Ares Valles at different time intervals. Water grid cell size represents typical GCM resolution. (Mars Pathfinder photo).

The climate model is run during the outburst, and continues to steady state after the discharge terminates. A full hydrologic cycle is included, with full cloud physics, first without and later including full radiative transfer effects. This includes the radiative effects of water vapor, thus assessing the strength of possible water-vapor greenhouse feedback.

This first model assumes pure water composition, and temperatures slightly above freezing. The version of the MGCM used will approximate the present epoch of Mars, with a cold, dry atmosphere (30 millibars will be assumed). A resolution of 7½° x 9° is used.

Hypotheses Testing: Results will be presented to address the questions of 1) How far does water flow before it freezes? 2) What does the water do, and where does it go? The results from these questions will determine future climate modeling efforts to study the effects of outflow channels. Because the hydrologic cycles associated with channel outbursts may trigger related, observable global geomorphic evolution, it is conceivable that this modeling can eventually constrain the mechanisms of outflow channel formation, although that remains a secondary goal.

Several hypotheses exist for the fate of water from the outflow channels. First, *Kreslavsky & Head* [9] suggest that outflow channel water froze and sublimed quickly, as evidenced by the Vastitas Borealis Formation, which they interpret to include outflow channel sediment deposits. The sublimed water was possibly transported to the poles. A second hypothesis is that outflow channels may have triggered a (warm?) climate that included precipitation, suggested by *Mangold et al.* [10], which identifies valley networks likely formed in the Late Hesperian, likely from precipitation. A third possible outcome of outflow channel water is that the water froze rapidly, sublimed, and re-deposited locally, causing local features similar to those caused by terrestrial glaciers [11].

Issues and Considerations: The goal here is not study outflow channel formation, but to study outflow channel- atmosphere interactions, with a detailed look at what happens once large volumes of surface water are present in the atmosphere-hydrologic system. While the physics of a warm or frozen ocean on Mars is important to the questions we are addressing, that is not in the scope of this study.

A more important issue is the analysis of how water freezes on the surface. In our first order model presented here, water will be assumed to be on the surface as a liquid until it cools below the freezing point, at which time it becomes a solid (e.g. a one-layer lake model). In reality, an outflow channel forms a lake or a sea that will first form surface ice, depending on more factors including lake circulation and geothermal heat flow. The study of the freezing behavior of lake, with implications for Mars ([12], see also Barnhart et al. in this volume) will eventually be considered in this modeling effort.

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