Geophysical Research Abstracts
Vol. 16, EGU2014-15246, 2014
EGU General Assembly 2014

The potential of hydrodynamic analysis for the interpretation of Martian fluvial activities

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After liquid water was identified as the agent of ancient Martian fluvial activities, the valley and channels on the Martian surface were investigated by a number of remote sensing and in-situ measurements. In particular, the stereo DTMs and ortho images from various successful orbital sensors are being effectively used to trace the origin and consequences of Martian hydrological channels. For instance, to analyze the Martian fluvial activities more quantitatively using the topographic products, Burr et al. (2003) employed 1D hydrodynamic models such as HEC-RAS together with the topography by MOLA to derive water flow estimates for the Athabasca Valles area on Mars [1]. Where extensive floodplain flows or detailed 2D bathymetry for the river channel exist, it may be more accurate to simulate flows in two dimensions, especially if the direction of flow is unclear a priori.

Thus in this study we demonstrated a quantitative modeling method utilizing multi-resolution Martian DTMs, constructed in line with Kim and Muller's (2009) [2] approach, and an advanced hydraulics model LISFLOOD-FP (Bates et al., 2010) [3], which simulates in-channel dynamic wave behavior by solving for 2D shallow water equations without advection. Martian gravitation and manning constants were adjusted in the hydraulic model and the inflow values were iteratively refined from the outputs of the coarser to the finer model. Then we chose the target areas among Martian fluvial geomorphologies and tested the effectiveness of high resolution hydraulic modeling to retrieve the characteristics of fluvial systems. Test sites were established in the Athabasca Valles, Bahram Vallis, and Naktong Vallis respectively. Since those sites are proposed to be originated by different fluvial mechanisms, it is expected that the outputs from hydraulics modeling will provide important clues about the evolution of each fluvial system. Hydraulics modeling in the test areas with terrestrial simulation parameters was also conducted to explore the different characteristics of two planets' fluvial activities.

Ultimately, this study proved the effectiveness of multi-resolution modeling using 150-1.2m DTMs and 2D hydraulics to study the Martian fluvial system. In future study, we will elaborate the hydrodynamic model to investigate the sediment transformation mechanism in Martian fluvial activities using hydrodynamic properties such as flow speed.

References: [1] Burr, D.M. (2003).Hydraulic modelling of Athabasca Vallis, Mars. Hydrological Sciences Journal, 48(4), 655-664. [2] Kim, J.R. & Muller, J-P.,(2009).Multi resolution topographic data extraction from Martian stereo imagery.Planetary and Space Science. 57, 2095-2112. [3] Bates, P.D., Horritt, M.S., & Fewtrell, T.J. (2010). A simple inertial formulation of the shallow water equations for efficient two-dimensional flood inundation modelling. Journal of Hydrology, 387(1), 33-45.