EXPLORING SPATIAL RELATIONSHIP BETWEEN DOMES AND IMPACTS ON CERES. A. W. Zitnik and J. M. Hurtado, Jr., The University of Texas at El Paso, 500 West University Avenue, El Paso, TX 79968, azitnik@miners.utep.edu.

Introduction: The dwarf planet (1)Ceres is the largest object in the asteroid belt and contains interesting topographic rises which are the subject of continuing research [1]. When NASA's Dawn spacecraft arrived in 2014, images captured the presence of large domes found scattered across the surface of the dwarf planet [2]. Competing models suggest that the domes are either the result of cryovolcanism or the surface manifestation of diapiric flow in a subsurface briny ice mixture [3,4,5]. One such dome, Ahuna Mons, has been modeled as an anomalous concentration of mass (referred to as a "mascon") in the subsurface [6]. Lunar mascons originate from impact events which create craters exceeding 30 km in diameter [7], leaving the possibility that the formation of domes on Ceres may also be spatially connected to impact events.

We demonstrate the use of automated crater detection algorithms applied to images taken during the Dawn mission. The resulting images will be used in tandem with spatial analysis tools to explore meaningful relationships among craters and domes. The purpose of detecting craters is to interpret relationships between the formation of these domes and impact events. To that end, craters larger than 30 km are chosen as candidates for likely mascon formation [7]. Since mascons can be observed or inferred using gravity data on Ceres and other planetary objects, further work will constrain the formation processes of these domes using Bouguer gravity data which was also recorded by the Dawn spacecraft.

Methodology: The input image data are version 2 of the Ceres LAMO (Low Altitude Mapping Orbit) Clear Filter Mosaic and made available via the NASA PDS system. The mosaic has a resolution of approximately 35 m/pixel [8]. Preprocessing of the image data included removal of a brightness gradient in which equatorial pixels are anomalously bright. This non-uniform illumination would have otherwise caused difficulty in further processing steps [9]. A second preprocessing step segments the image into 4000x4000 pixel sub-images to decrease RAM usage and improve performance.

We implement two methods for detecting large-scale features on the surface of Ceres. These two methods are designed to focus on low spatial frequency features (>30 km). The output of these algorithms is then used as an input to a multidirectional Sobel edge detection filter for detecting craters.

The first technique convolves a Gaussian blur function with the image to act as a low-pass filter. Kernel sizes of 1000x1000 and 1500x1500 pixels were both tested with Gaussian 1-standard deviation widths of 500 and 700 pixels. The initial kernel sizes were picked based on the 30 km crater size being targeted. The kernel size and width of the Gaussian will be adjusted to determine the optimal values.

The second technique applies a median filter to the segments of the image. The median filter used employs a kernel size of 1000x1000 pixels such that features smaller than those being targeted for this study are smoothed out along with any noise.

The Sobel filter is applied to both techniques for ease in detecting edges and is set to operate in a multidirectional manner. A multidirectional approach is used to ensure edges along both image axes are detected. After passing through the Sobel filter, the resulting images contain only black pixels and white pixels, representing no edges and detected edges respectively.

Following the output of the Sobel filter, a qualitative assessment is applied to choose which technique returned the best fits for crater detection. Techniques are judged based on how closely their shape resembles the crater and the proximity of the detected edge to the topographic edge.

The best fitting Sobel edge detector results will then be transformed into polygons utilizing the Raster to Polygon tool. By teaching the program that white pixels are of interest, ArcMap can then convert the contour lines into geo-referenced polygons.

Polygons for domes on the surface of Ceres will need to be manually created. Domes will then be spatially grouped to the nearest crater polygons with the Spatially Constrained Multivariate Clustering (Spatial Statistics) tool in the Spatial Statistics toolbox.

Preliminary Results:. Comparing this result to the original image reveals promising circular patterns of that closely approximate large craters (Fig 1). Additional adjustments to the kernel size and width are planned to fine-tune the best parameters for identifying the target craters.

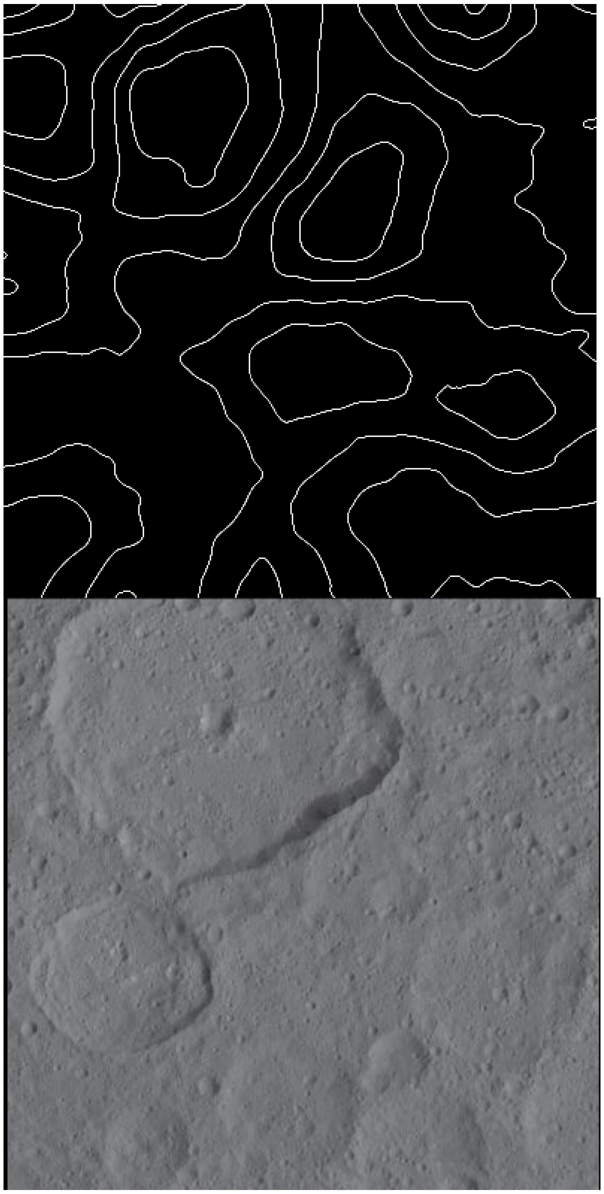

Fig 1. (Top) Sobel edge detector applied to Gaussian blur filtered image. The Gaussian used a kernel size of 1000x1000 and a standard deviation of 500 pixels. (Bottom) The original image segment. Contours closely relate to topographic features but are not yet ideal fits.

References: [1] McCord et al., (2006) *Eos Trans. AGU, 87,* 105-109; [2] Buczkowski et al., (2016) *Science, 353,* aaf4332; [3] Wyrick et al., (2019) *LPSC L*, #3239; [4] Ruesch et al., (2019) *Nature Geosci., 12,* 505-509; [5] Bland et al., (2019) *Nature Geosci., 12,* 797-801, [6] Ermakov et al., (2017) *JGR:Planets, 122,* 2267-2293; [7] Melosh et al., (2013) *Science, 340,* 1552-1555; [8] Roatsch et al., (2016) *DAWN FC2 DERIVED CERES MOSAICS V1.0,* NASA PDS; [9] Cao et al., (2020) *IEEE, 8,* 109989-110002.