SPECTROPHOTOMETRIC MODELING AND MAPPING OF CERES. Jian-Yang Li[1], L. Le Corre[1], V. Reddy[1], A. Nathues[2], M. Hoffmann[2], M. Schaefer[2], M. Ciarniello[3], S. Mottola[4], S. E. Schröder[4], C. A. Raymond[5], C. T. Russell[6], [1]Planetary Science Institute (jyli@psi.edu), [2]Max Planck Institute for Solar System Research, Germany, [3]Instituto di Astrofisica e Planetologia Spaziali, Instituto Nazionale di Astrofisica, Italy, [4]DLR, Germany, [5]Jet Propulsion Laboratory, California Institute of Technology, [6]IGPP, University of California Los Angeles.

Introduction: During the rendezvous with Ceres, Dawn Framing Camera (FC) collected images covering a wide range of illumination and viewing geometries of the surface of this inner most dwarf planet through seven color filters from 440 nm to 980 nm and a panchromatic filter. This dataset enables a comprehensive study of the photometric properties of Ceres. Preliminary modeling resulted in a geometric albedo of 0.09 at 550 nm, consistent with previous measurements [1]. The overall albedo variation on Ceres is about 15% [2], with many regions 10s km in size or smaller having geometric albedos up to 0.5 [2]. The geology on Ceres is highly complex [3] under its highly uncertain and unusual mineralogical composition and water ice content based on the current understanding [4,5]. The detailed mapping of the photometric properties across the whole surface of Ceres could therefore potentially reveals clues about the composition and geologic processes acting on the surface. Such maps could also be used to perform photometric corrections to imaging data to produce seamless mosaics. The objective of this work is to derive the globally averaged photometric parameters, as well as maps of the fundamental photometric properties of Ceres over all colors covered by the Dawn FC, including albedo, phase function, and roughness.

Data and methodology: We primarily use the imaging data collected during the Survey orbit, which is a polar orbit at an altitude of 4400 km, resulting in a pixel scale of 410 m on the surface of Ceres. These data cover a range of phase angle from ~7º to ~90º. We also used the data acquired during the initial approach to Ceres to increase the phase angle coverage to 155º in the panchromatic filter to enhance the modeling of phase function. We used the shape model of Ceres derived from images collected during the High Altitude Mapping Orbit (HAMO) at 135 m/pixel resolution [6], coupled with the spacecraft trajectory and pointing information in the NAIF SPICE data to calculate the scattering geometry and the latitude-longitude coordinate at each pixel.

For the global photometric modeling, we adopted a version of Hapke model [7], and a Lommel-Seeliger model with a linear-exponential phase function [8,9]. The Hapke model we adopted has six parameters, including single-scattering albedo (SSA), macroscopic

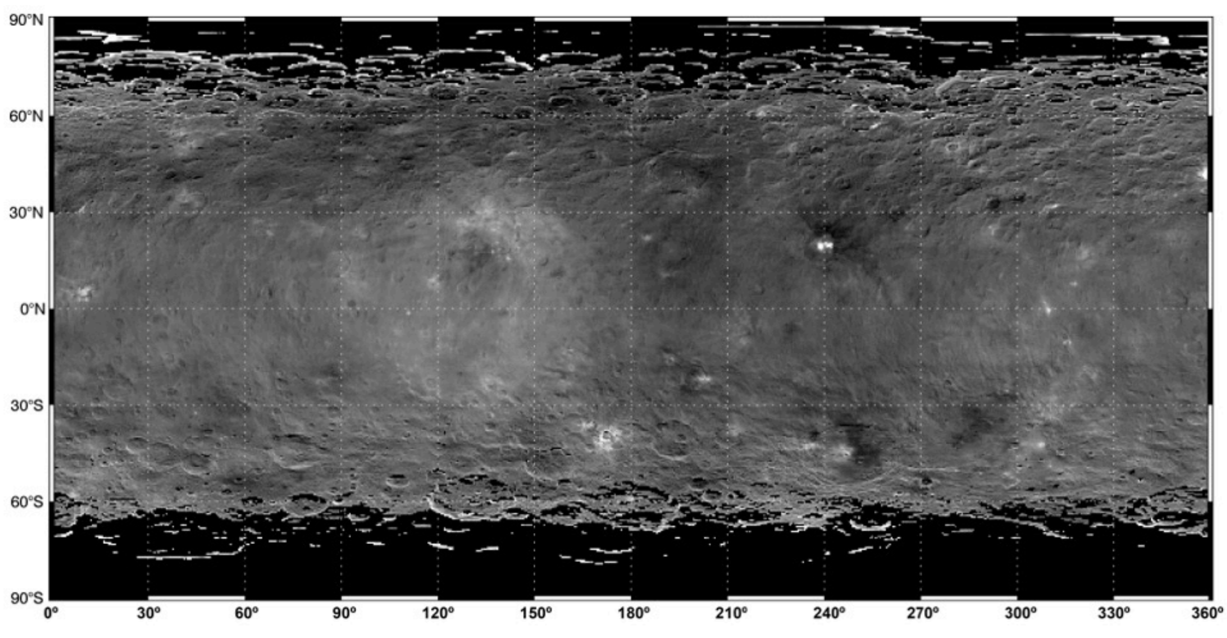

Fig. 1. Albedo mosaic of Ceres at 750 nm in equirectangular projection using the images from the Survey phase. The photometric corrections used the best-fit Hapke's parameters. The areas with incidence angle or emission angle greater than 80º are excluded in this map. The range of latitude is from -90º to +90º.

roughness, two parameters for the two-parameter Henyey-Greenstein single-scattering phase function, and two parameters for shadow-hiding opposition effect. For the Hapke modeling process, we followed the same procedure as in [10].

Results: For the global average photometric properties, the geometric albedo of Ceres is 0.085±0.005, with a weak dependence on wavelength mimicking Ceres' spectrum. The photometric roughness is 21º±2º, independent of wavelength. The phase function of Ceres shows a slight trend with wavelengths, with decreasing backscattering towards longer wavelength, consistent with phase reddening as previously observed from the ground [11]. Our data do not cover sufficiently small phase angles to allow us to model the opposition parameters. But an estimate of B_0=1.77 for the amplitude of opposition and h=0.15 for the width appears to be reasonable.

We used these photometric parameters to apply photometric corrections and generated albedo and color mosaics as shown in Figs. 1 and 2.

The next step is to subdivide the surface into longitude-latitude grid of 0.5º-1º wide, and apply photometric modeling with the empirical model, as well as Hapke model if possible (with sufficient coverage in scattering geometry). We expect to generate maps of photometric parameters, compare it with the maps generated with photometric corrections using the global average photometric parameters, and interpret these maps in the context of mineralogy and geology.

References: [1] Li, J.-Y., et al. 2006, Icar, 182, 143. [2] Li, J.-Y., et al., 2015, DPS #47, #103.04. [3] Jaumann, R., et al., 2015, EPSC2015-83. [4] Thomas, P.C., et al., 2005, Nature, 437, 224. [5] De Sanctis, M.C., et al., 2015, Nature, 528, 241. [6] Preusker, F., et al., 2016, LPSC. [7] Hapke, B., 2012, Theory of Reflectance and Emittance Spectroscopy. [8] Kaasalainen, S., et al. 2001, JQSRT, 70, 529. [9] Kaasalainen, S., et al. 2003, Icar, 161, 34. [10] Li, J.-Y., et al. 2013, Icar, 226, 1252. [11] Reddy, V., et al. 2015, Icar, 260, 332.

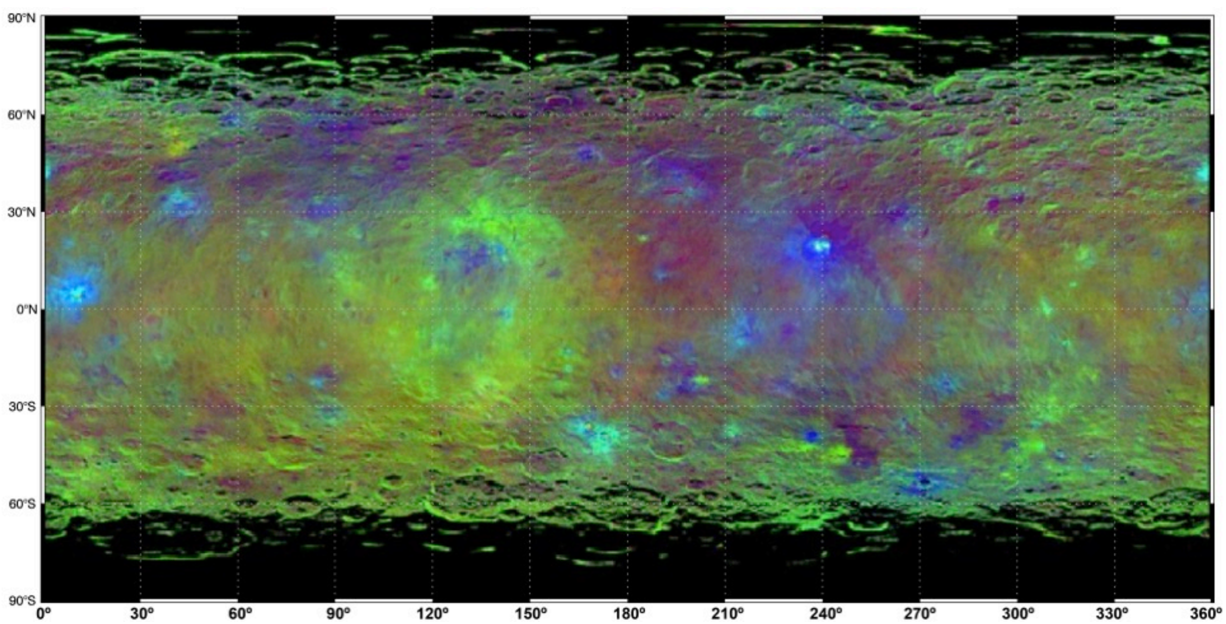

Fig. 2. The composite color mosaic of Ceres based on the Hapke photometric parameters derived in this work. In this color composite, red is the ratio of 980/750 nm, green is the albedo at 750 nm, and blue is the ratio of 440/750 nm.