PRODUCING THE BEST GLOBAL MOSAIC OF TITAN'S SURFACE ALBEDO USING CASSINI IMAGES. E. Karkoschka[1], A. McEwen[1], J. Perry[1], [1]University of Arizona, Tucson, AZ 85721

Introduction: Cassini's Imaging Science Subsystem (ISS) has acquired almost 20,000 images of Titan in the CB3 (938 nm) filter, which is the best methane window available to ISS for detecting the surface. Previous global mosaics with the ISS data typically use just 3 summed images (acquired in rapid sequence) over each patch of surface. They suffer from low signal-to-noise (SNR) and resolution and brightness mismatches at the image seams [1]. In principle, the full dataset contains sufficient information to create a global mosaic of Titan's surface with a resolution of a few kilometers and SNR of surface albedo variations >20:1. Although no single image shows features at similar resolution because Titan's atmosphere reduces the contrast of small scale features at this wavelength by ~60 times, these features can be made detectable by averaging many images. Unfortunately, averaging images taken from different photometric angles has not been successful because uncertainties in the correction for atmospheric scattering were many times larger than the tiny signal. We describe and demonstrate a solution to this limitation.

New method: We created a method for combining images in the 938 nm filter that is based on recent publications, describing scattering of light in Titan's haze [2], latitudinal and seasonal variations of the haze [3], bidirectional surface reflection in mostly diffuse illumination [4], Titan image navigation [5] and mosaicking methods [6], and detecting features of 0.01 % intensity variation through stacking of >1000 images [7].

Our first test of this method is over the Adiri region of Titan's surface. It uses ~25 times as many images per location as used before, improving the SNR and spatial resolution by about a factor of 5. Fig. 1 shows a comparison between the best previous mosaic and our new one for a 300 km wide area in northern Adiri.

We had to improve the geometric registration of images to build up signal of small scale features. A high-pass filter was used previously to crudely deconvolve the scattering; we improved the deconvolution to be consistent with the published haze model [2] based on our Monte Carlo work for scattered photons.

Our main improvement is a new photometric model that fits the observed data numbers to 0.3 %. The model uses a function with 12 parameters, seven atmospheric parameters such as the Minnaert Law exponent, phase coefficient, and parameters describing seasonal variations of Titan's haze. They were determined by a least square fit to 400 ISS images.

Four parameters are fitted for each image, describing changes such as slight flatfield variations of the camera. After all data were corrected for the first 11 parameters, averaging data at the same location determines the last parameter, which is the surface albedo. This method essentially removes all artifacts at image seams. It quantifies surface albedo while previous mosaics showed only relative brightness without information about surface albedo or contrast. Comparison to the mosaic produced from DISR images [4] demonstrates that the albedo corrections are accurate (Fig. 2). The method also records small atmospheric changes, such as variations of 1 % in the haze optical depth.

Outlook: We plan to combine all suitable images for a global mosaic. Care must be taken to produce separate local products before and after major surface changes [e.g., 8]. Statistical analysis will find outliers in the data set due to surface changes and occasional clouds. We will add further parameters to the model to distinguish variations of surface reflectivity with phase angle and emission angle, which will help to characterize and distinguish different terrains.

This effort will lead to new science results in three areas: (1) We expect to detect smaller temporal variations on Titan's surface, related to activity such as methane rainfall (and subsequent dryout), potential new evaporite deposits, shrinking and expanding lakes, and perhaps some new discoveries. (2) Correlation of observations by RADAR, VIMS, and DISR to the improved ISS global map will facilitate interpretation of the global distributions of key terrains such as dark dunes, lakes, large river channels, and tectonic structures. (3) The ISS map with quantitative albedo values at 938 nm provides a direct compositional constraint and can be compared to VIMS data [9] for improved mapping of compositional variations.

The evident success of this technique is good news for the future exploration of Titan [10, 11]. The atmospheric scattering is much reduced in longer-wavelength methane windows [12], so a high-resolution near-IR camera can acquire orbital or flyby images of Titan's surface comparable to the DISR mosaic over any well-illuminated area on Titan.

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Fig. 1: Best previous mosaic of a 300 km × 240 km area in northern Adiri and our mosaic using the new method.

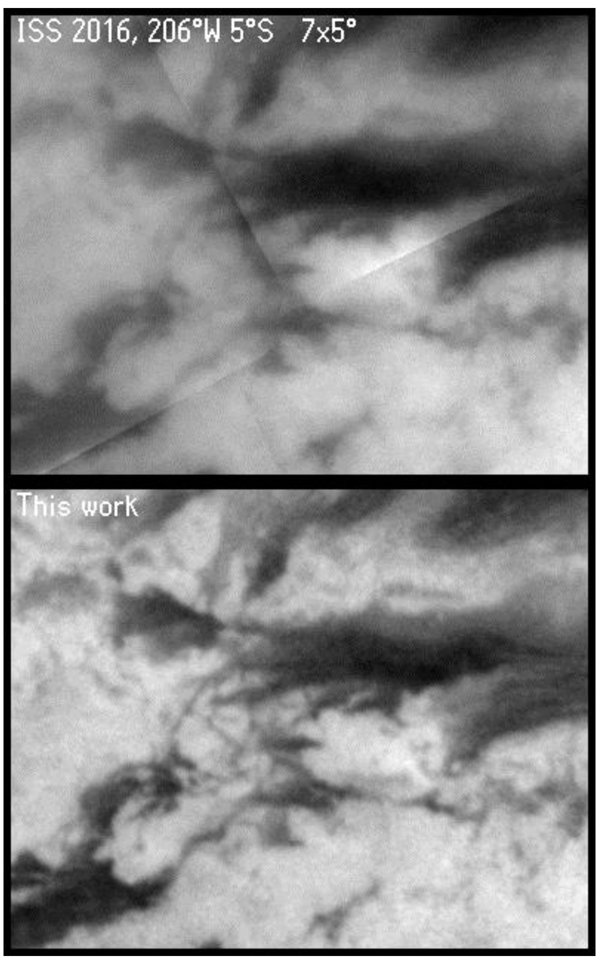

Fig. 2: Best previous ISS mosaic of the area within 65 km of the Huygens Landing Site compared with our new mosaic and the DISR mosaic, which comes with an accurate albedo scale. The two dark horizontal lines (dunes, above center) are 5 km apart and resolved in this work.