OCCULTATION LIGHT CURVES OF IO'S HOT SPOTS IN 2014. S. Gutierrez[1], K. de Kleer[2], I. de Pater[1,3], J. Rathbun[4], [1]Astronomy Department, UC Berkeley, Berkeley, CA (s.gutierrez@berkeley.edu); [2]Division of Geological and Planetary Science, California Institute of Technology, Pasadena, CA; [3]Institute of Earth Observation and Space Systems, Delft University of Technology, Delft, The Netherlands; [4]Physics Department, University of Redlands, Redlands, CA.

Introduction: Groundbased observations in the infrared complement spacecraft images of Io. Until adaptive optics was developed, occultation photometry was the only technique to resolve individual hot spots with groundbased observations. First applied to Io in 1990, the method uses the regular occultation of Io by Jupiter and light curves to find candidates for active hot spots [7, 9, 11,12]. This method measures Io's total brightness and uses known hot spot positions and occultation models to determine the occultation phase for individual hotspots [11]. The steps in the lightcurves correspond to the reappearance or disappearance of a hotspot. Our eight nights of data are all in-eclipse occultation reappearances. With the known occultation phases for Loki Patera and Janus Patera/Kanehekili Fluctus, we have deduced the individual brightnesses of these hot spots over Spring 2014, and compare them to Gemini N observations taken at the same time period [2]. This analysis contributes to the decadal timelines of Loki Patera's and Janus Patera/Kanehekili Fluctus's volcanic variability.

Loki Patera, Io's most powerful volcano, has been observed for 30 years, during which time it regularly has undergone brightening events [6]. Rathbun and Spencer [9, 10] proposed an overturning lava lake with varying overturn propagation speeds. de Kleer and de Pater [1] find that a modified version of the Matson et al. [8] overturning lake model fits all three decades of reported data. Recent mapping of Loki Patera indicates that this resurfacing process has multiple phases as different velocity waves move around an anchored island and converge in the eastern part of the lake [3].

Janus Patera and Kanehekili Fluctus are close together on Io's surface, and cannot be separated by occultation observations such as those presented here. Their combined radiance has been recorded since the 1990's, while their individual timelines have been measured over time from spatially-resolved adaptive optics observations [4]. Observations of Janus Patera over the last two decades demonstrate relatively steady radiant fluxes between 2 and 8 Gw/sr/micron; the stable fluxes along with the spectrum shape support the presence of an active lava lake [5]. Kanehekili Fluctus' thermal emissions are more variable and are consistent with insulating crust lava flows [5].

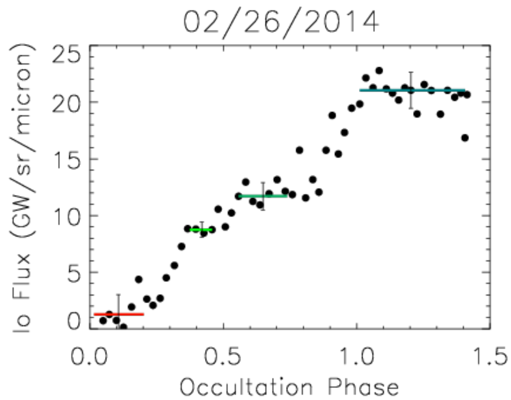

Figure 1: Lightcurve of the 02/26/2014 occultation reappearance. Flux is plotted as a function of Occultation Reappearance Phase, defining the beginning of the reappearance as 0 and Io completely coming into view as 1.0. Every step signifies at minimum one active hot spot appearing at the reappearance phase. Every night of observation has an active hot spot consistently at the occultation phases .27 and .93, most likely being Janus Patera /Kanehekili Fluctus and Loki Patera respectively.

Methods: All of the observations were taken with the CSHELL CCD camera at NASA's Infrared Telescope Facility. Images of Io were taken during reappearance from Jupiter's occultation into eclipse, therefore the derived fluxes originate entirely from hot spot volcanism. We plot the total observed radiance of Io as it reappears from behind Jupiter, as a function of reappearance phase for each date (Figure 1.) Since Io is in Jupiter's shadow the entire time, all of the radiance measured is directly from its hot spots, not reflected radiance from the Sun.

Results and Discussion: *Loki Patera.* After determining the individual hot spot fluxes from the lightcurves, we construct time lines for the individual hot spots. Figure 3 plots Loki Patera's eight radiance values (circles) from our analysis and five radiance values (crosses) from [2]. Although, it may appear that we observe a relative brightening event in February, in the context of Loki Patera's periodic time line, our points are steady and at a low-activity period [6]. The Gemini N. and Keck data also depict this trend.

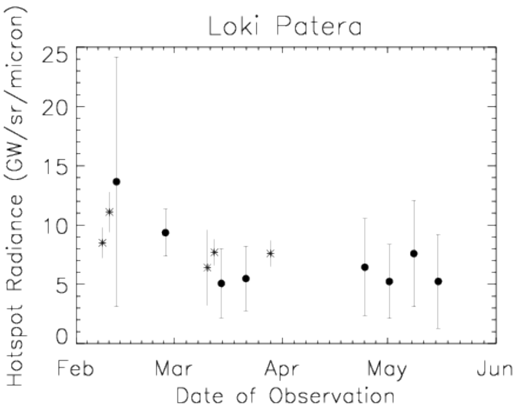

Figure 2: Radiance values (circles) of the individual hot spot Loki Patera over the eight nights of observations in Spring 2014. The Gemini N data from [2] are plotted as stars for comparison. During this time, Loki Patera was fading following a brightening event in Fall 2013. All radiance values were obtained in L' band (3.8 micron).

These observations occurred during a dim period between brightening events measured by [2] and indicate that the overturning lava lake is thickening and cooling in this time period. In August 2013 Loki Patera reached radiance values of 136 ± 20 GW/sr/micron and then gradually decreased to a range of 6 to 15 Gw/sr/micron, which we observed [2]. In October 2014 another brightening event occurred at 128 ± 19 Gw/sr/micron [2]. The observed flux of this dim period are similar in range for dim periods observed in Spring 2015, between 6 to 11 Gw/sr/micron.

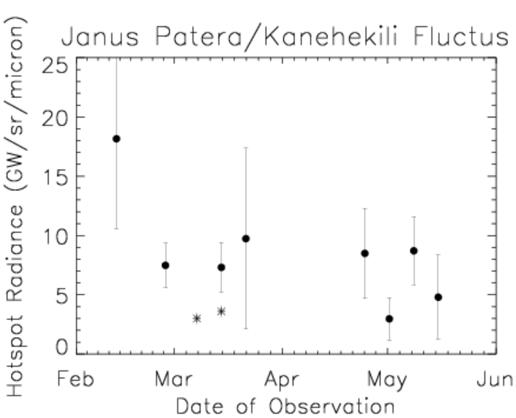

Figure 3: Radiance values (circles) of the volcanoes Janus Patera/ Kanehekili Fluctus. The Gemini N data from [2] are plotted as crosses for comparison.

Janus Patera/ Kanehekili Fluctus. The eight radiance values (circles) of Janus Patera/ Kanehekili Fluctus are plotted along with two data points (crosses) from [2] however the Gemini N points are only from Janus Patera (Figure 3). The two observations from [2] did not detect any radiance from Kanehekili Fluctus, constraining its thermal emission to at or below 3 Gw/sr/micron at a wavelength of 3.8 micron, the detection limit of the Gemini N observations. With our error bars, the observed radiances are relatively regular and within the range that Janus Patera has been observed at for decades [4]. More recently, in Fall 2013 Janus Patera's radiant flux ranged from 3 to 10 Gw/sr/micron, and in Fall 2014 throughout 2015 it was also consistently between 2 to 9 Gw/sr/micron at 3.8 micron [2]. These observations support the active lava lake model for Janus Patera [4].

References: [1] de Kleer, K., de Pater, I., (2017) *Icarus,* 289, 181-198**.** [2] de Kleer, K. , de Pater, I., (2016) *Icarus,* 280, 378-404. [3] de Kleer, K. *et al.,* (2017) *Nature,* 545, 199-202. [4] de Pater, I. *et al.,* (2004) *Icarus,* 169, 250-263. [5] de Pater, I. *et al.,* (2014b) *Icarus,* 242, 379–395. [6] de Pater, I. *et al.,* (2017) *Icarus* 297, 265-281. [7] Howell, R. R. et al., 2001. *J. Geophys. Res.,* 106, 33129–33139. [8] Matson, D.L. *et al.,* (2006) *J. Geophys. Res.,* doi:10.1029/2006JE002703. [9] Rathbun, J.A. *et al.,* (2003) *34th LPSC,* abstract no. 1375. [10] Rathbun, J.A., Spencer, J.R., (2006) *Geophys. Res. Lett.* 33, L17201. doi:10.1029/2006GL026844. [11] Rathbun, J., Spencer, J.R., (2010). *Icarus* 290, 625-630. [12] Spencer, J.R. *et al.,* (1990). *Nature* 348, 618-621.