EPSC Abstracts
Vol. 13, EPSC-DPS2019-683-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

A closer look at thermal data from Europa's surface at possible plume source locations near Pwyll Crater

Julie A Rathbun (1), and John R Spencer (2)
(1) Planetary Science Institute, Arizona, USA (Rathbun@psi.edu), (2) Southwest Research Institute, Colorado, USA

Abstract

Recent observations from the Hubble Space Telescope [1-3] and reanalysis of Galileo data [4] are consistent with the presence of water plumes erupting from Europa's surface. Here, we take a closer look at thermal data of the proposed surface source regions. We use temperatures measured with the Galileo PPR instrument and one observation from ALMA [5]. By fitting a diurnal thermal model to the observed temperatures, we find that they are consistent with passive reradiation of sunlight and do not require endogenic emission. The thermal anomaly near the plume site noted by [3] is likely due to high thermal inertia ejecta from the Pwyll impact crater.

1. Galileo PPR data and limits on endogenic emission

The Galileo Photopolarimeter-Radiometer (PPR) measured surface temperatures on Europa from 1996 through 1999 [6]. Daytime brightness temperatures correlate inversely with albedo, as expected from equilibrium with absorbed sunlight [7]. The same is true at night on a global scale, but not always on a smaller scale, particularly on the bright ejecta blanket around the impact crater, Pwyll, which is bright and warm at night.

The repeating plume source location proposed by [2-3] was noted to be nearly coincident with the highest nighttime temperatures measured by PPR (The source location found by [1] was not observed by

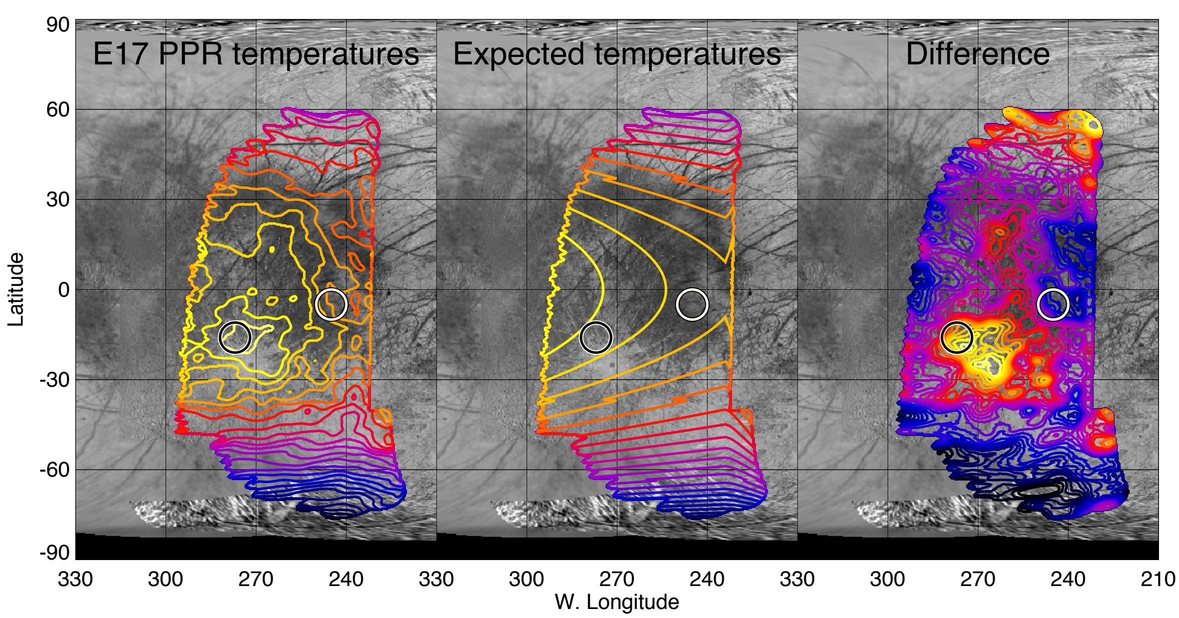

Figure 1: PPR nighttime observation from Galileo's 17th orbit (left), temperatures expected in that observation for a constant albedo of 0.55 and thermal inertia of 70 in MKS units (middle), and the difference between the two (right). In each panel the left circle indicates the source location from [3] and the right circle the source location from [4]. The circles are 5 degrees in radius, which is the approximate size of the field of view for the lowest resolution PPR observations used in this paper and the approximate uncertainty in the plume source locations. The background is a Galileo SSI basemap.

PPR). Figure 1, left panel shows the high resolution nighttime PPR observation that includes the [3] (left) and [4] (right) source locations. To better understand the extent of the warm region, we need to correct for latitude and time of day. To do this, we subtract the temperatures expected from a surface with constant albedo of 0.55 and thermal inertia of 70 in MKS units (center panel). The result (right panel) shows that the residual thermal anomaly including the [3] plume source is well correlated with the location of the Pwyll ejecta blanket . The [4] location is clearly not in the warmer region.

2. Modelling surface thermal properties

Another way to determine the presence of any endogenic emission on Europa's surface is to fit a diurnal temperature model to observed temperatures. If the temperatures can be fit by only changing the thermal inertial and albedo, and if the fitted albedos are consistent with other data, then endogenic emission is not required.

We found 5 PPR observations that include the [3] source location with local times ranging from early morning before dawn to mid-morning. We also include the ALMA daytime observation [5].

One complication when matching modelled diurnal temperatures with measurements at substantially

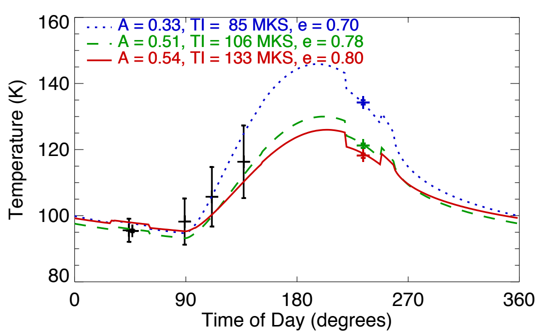

Figure 2: Diurnal model fits to measured temperatures (with error bars, plotted in black). Several different combinations of thermal properties are shown. The emissivity, in these cases, is set at 0.9 for infrared (PPR) wavelengths. In two cases (top and bottom), the emissivity at ALMA wavelengths is also set, while for the third (middle curve) it is allowed to vary. The jumps in the curve are due to observations being obtained at different solar distances.

different wavelengths is emissivity. Emissivity controls the efficiency of thermal radiation and thus surface temperature, and also the difference between the brightness temperature and the actual temperature of the surface. Constraints on the emissivity of icy satellites is limited, so Fig.2 shows diurnal fits made with different assumptions.

We find that, at neither source location is an endogenic source necessary to fit the observed temperatures, because fitted albedos are consistent with imaging data. This result was also noted by [5] for the [3] source.

References

[1] Roth, L., Sauer, J., Retherford, K. D., et al. Transient Water Vapor at Europa's South Pole, 2014, *Science*, 343, 171.

[2] Sparks, W. B., Hand, K. P., McGrath, M. A., et al. Probing for Evidence of Plumes on Europa with HST/STIS, 2016, *ApJ*, 829, 121

[3] Sparks, W. B., Schmidt, B. E., McGrath, M. A. Hand, K. P., Spencer, J. R., Cracraft, M., Deustua, S. E. Active Cryovolcanism on Europa? 2017, *ApJ Lett.,* 839, L18.

[4] Jia, X., Kivelson, M. G., Khurana, K. K., Kurth, W. S. Evidence of a plume on Europa from Galileo magnetic and plasma wave signatures, 2018, *Nature Astronomy*, https://doi.org/10.1038/s41550-018-0450-z

[5] Trumbo, S. K., Brown, M. E., Butler, B. J., ALMA thermal observations of a proposed plume source region on Europa, 2017, *AJ*, 154, 148.

[6] Rathbun, J. A., Rodriguez, N. J., Spencer, J. R. Galileo PPR observations of Europa: Hotspot detection limits and surface thermal properties, 2010, *Icarus*, 210, 763-769.

[7] Spencer, J. R., Tamppari, L. K., Martin, T. Z., & Travis, L. D. Temperatures on Europa from Galileo Photopolarimeter-Radiometer: Nighttime Thermal Anomalies, 1999, Science, 284, 1514.