



Temperatures of the Galilean Satellites

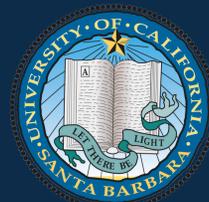
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College of Creative Studies



Abstract

In this research, we analyzed the published and the unpublished Galileo Photopolarimeter-Radiometer (PPR) data on the brightness temperatures of the Galilean satellites of Jupiter. We extended the previous thermal model for Europa and adapted it for the other Galilean satellites. By comparing the models and the PPR data, we were able to examine the **potential thermal anomalies**, obtain the **thermal inertia maps**, and characterize the **relations between data and the albedo variations**.

Prelude

Galilean Satellites



Galilean satellites in ascending order for distance from Jupiter
jpl.nasa.gov

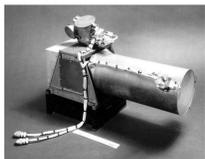
Galileo Mission



Artist's representation of the Galileo orbiter



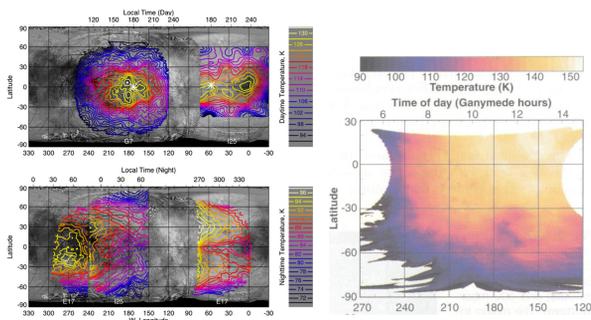
Galileo Mission Badge
jpl.nasa.gov



Photopolarimeter-Radiometer (PPR) instrument

- Photopolarimeter-Radiometer obtained data used for this research
- Observations were sent back since 1996

Previous Work



Composite of five Europa data sets (Rathbun et al. 2010)

One published Ganymede data set (Orton et al. 1996)

- **5 out of 92** available data sets on Europa brightness temperature were published
- **1 out of 51** available data sets on Ganymede brightness temperature was published
- Ganymede data set published but not analyzed

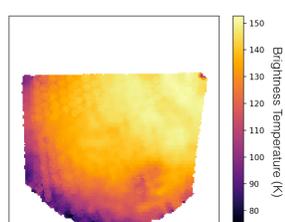
Significance and Goal

- Look through the PPR data set
- Analyze the **thermal properties** of Galilean satellites
- Examine **anomalies** in the data

Display Temperature



Projection of Ganymede



Corresponding daytime brightness temperature

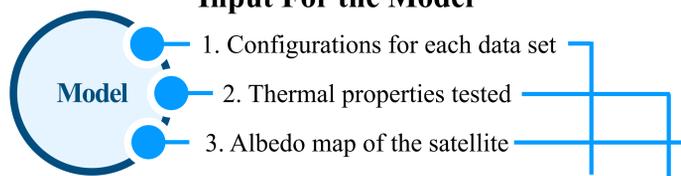
The daytime brightness temperature exhibits an anti-correlation with the albedo map
Data set: 1G1GDRTM_01

- **Albedo**: surface property; fraction of sunlight reflected

Thermal Model

- Extended from a previously developed **simple thermal model** for Europa (Trumbo et al. 2017)
- Kept model simple to grasp global features

Input For the Model



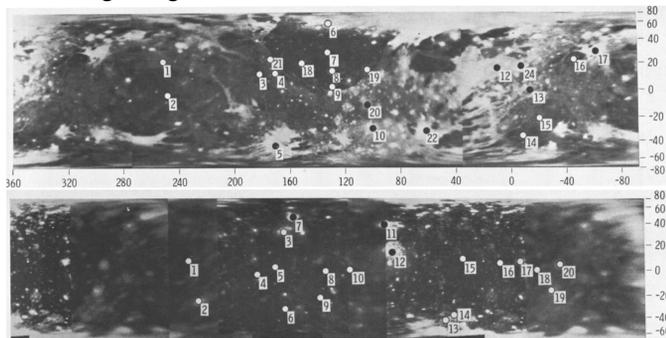
ID	Sub-solar Longitude	Sub-solar Latitude	Sub-spacecraft Longitude	Sub-spacecraft Latitude
Heliocentric Distance (AU)	Resolution (km)	Wavelength (μm)	Eclipse Start Longitude	Eclipse Duration (Hour)

Table 1. Parameters specific to each data set required by the simple thermal model

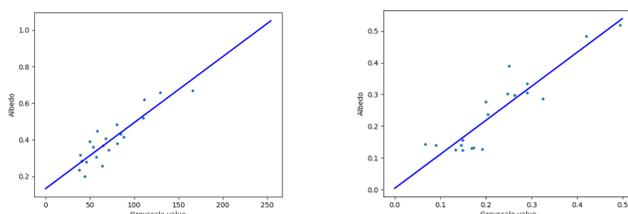
ID	Thermal Inertia ($\text{J m}^{-2} \text{K}^{-1} \text{s}^{-1/2}$)	Emissivity
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Table 2. Thermal properties assumed to be uniform throughout the globe

- Constructed the albedo maps from the Voyager measurements in four different wavelengths (Johnson et al. 1983)
- Weighted each measurement based on solar flux at each wavelength to get the albedo

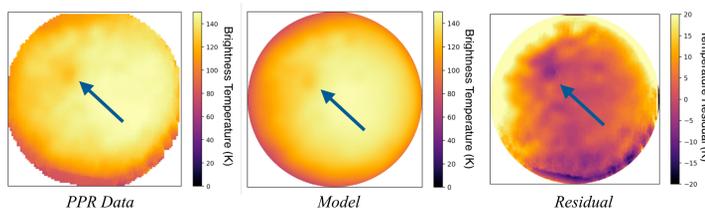


Numbered points have albedo measured in 4 difference wavelengths.
Top: Ganymede; Bottom: Callisto (Johnson et al. 1983)



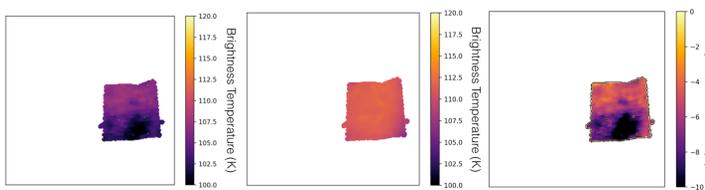
Best fit line for the correlation between albedo and greyscale values from the mosaic map
Left: Ganymede, $r^2 = 0.963$; Right: Callisto, $r^2 = 0.974$

Ganymede Data vs. Model



Unpublished daytime Ganymede data vs. model; Thermal inertia: $70 (\text{J m}^{-2} \text{K}^{-1} \text{s}^{-1/2})$; Emissivity: 0.9
Data set: 2G29GDGTM_01

- **Residual = Data - Model**
- **Dark spot** pointed by arrow is the **crater Tros** on Ganymede
- Residual map requires model **temperature to be lower** at Tros
- **Other variations of thermal properties** need to be included to account for such feature

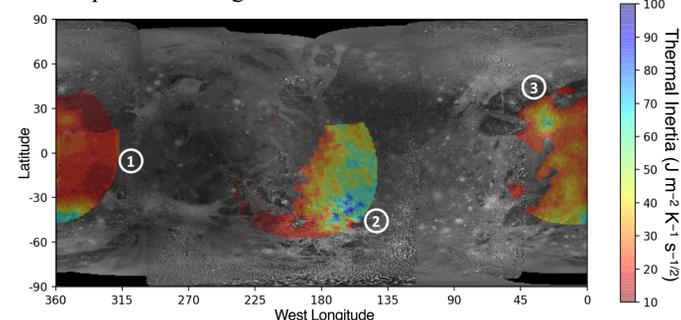


Unpublished noon Ganymede data vs. model; Thermal inertia: $30 (\text{J m}^{-2} \text{K}^{-1} \text{s}^{-1/2})$; Emissivity: 0.9
Data set: 2G29GNICECL01

- Model suggests the temperature **should be ~10 K higher**
- Model also does not exhibit the **dark spot** seen in the data
- Turns out this was **during eclipse** — Jupiter blocked all sunlight
- It is equivalent to night time, where **albedo variation is not the dominant thermal property for temperature variations**

Thermal Inertia

- **Thermal inertia**: property of surfaces; resistance in temperature change

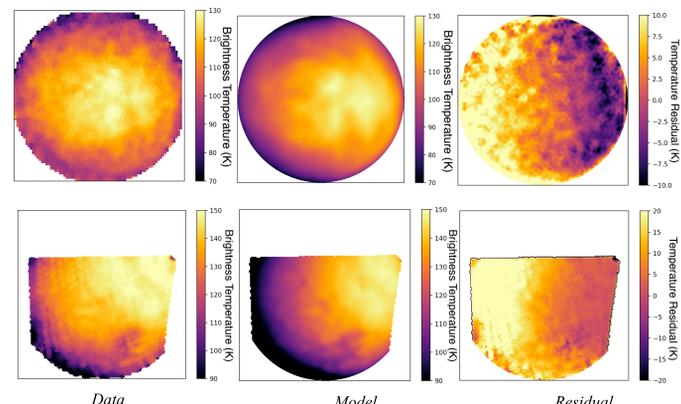


Thermal inertia map of Ganymede from three consistent data sets
Data sets: 2G29GDGTM_01, 1G1GDRTM_01, 2G29GNICECL01

- Obtained the map by fitting model to data at each point
- Region 1: eclipsed region
- Region 2&3: **locally high thermal inertia corresponding to the craters**, which is conclusion consistent with craters on other objects such as Mars (Mellon et al. 2000)

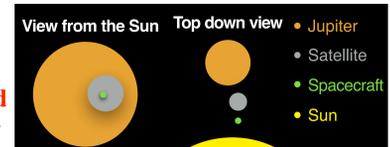
Noise and Artifact

Artifact #1



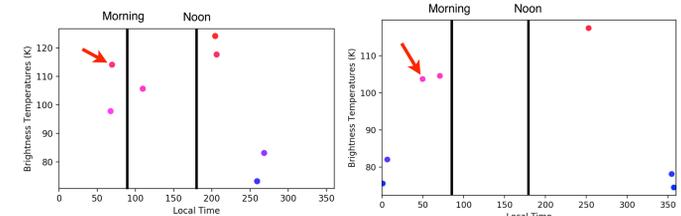
Residual map of certain files contain a stripe of high temperature. Top: Europa; Bottom: Ganymede
Data set: 1G7EDGTM_01, 1G1GDRTM_01

- These data sets share the **same configuration** as shown on the right
- Possible that PPR **picked up signals from Jupiter** in the background



Artifact #2

- Europa hotspot indicate **cryovolcanic activities** (e.g. ice volcano)
- Overall temperature is **~30K higher**
- Upper hotspot: **~20K higher** than another observation at the same time
- Lower hotspot: **~25K higher** at night **without sunlight**
- No sufficient to claim the hotspots



Diurnal brightness temperatures of the same region. Hotspots are pointed out by arrows. Left: upper hotspot; Right: lower hotspot.

References

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