Global Surface Temperatures of the Moon

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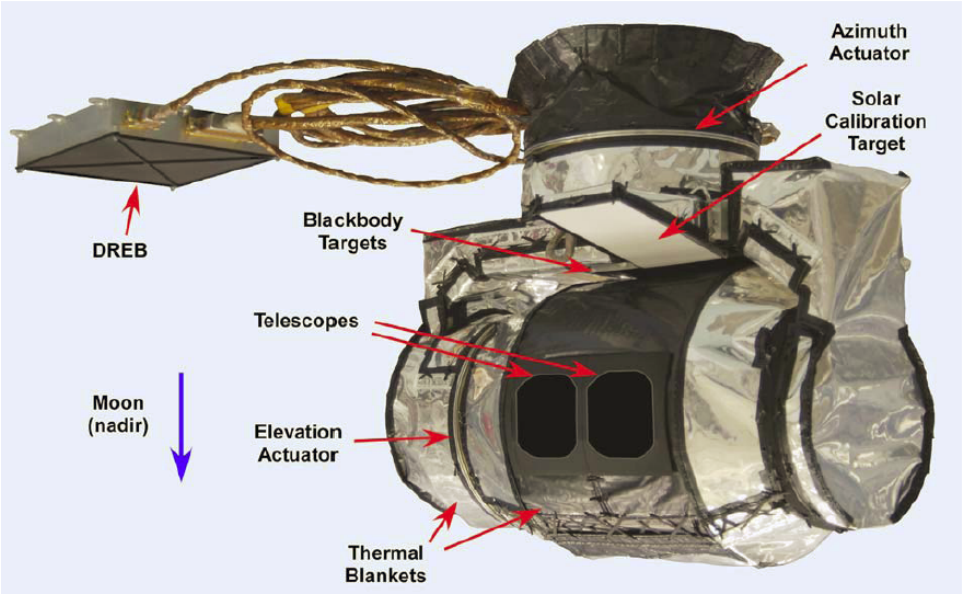
NASA Exploration Science Forum 2014

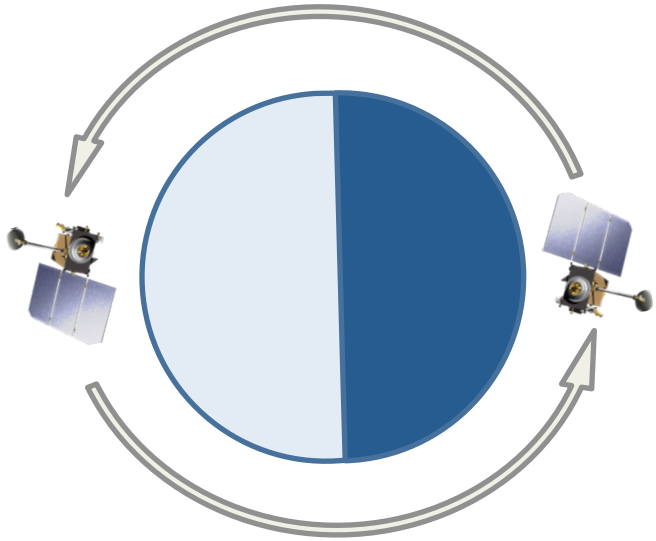
Overview

- What Diviner does:
  - Measure reflected solar and emitted infrared radiation.
  - Nine spectral channels with wavelengths ranging from 0.3 to 400 microns.

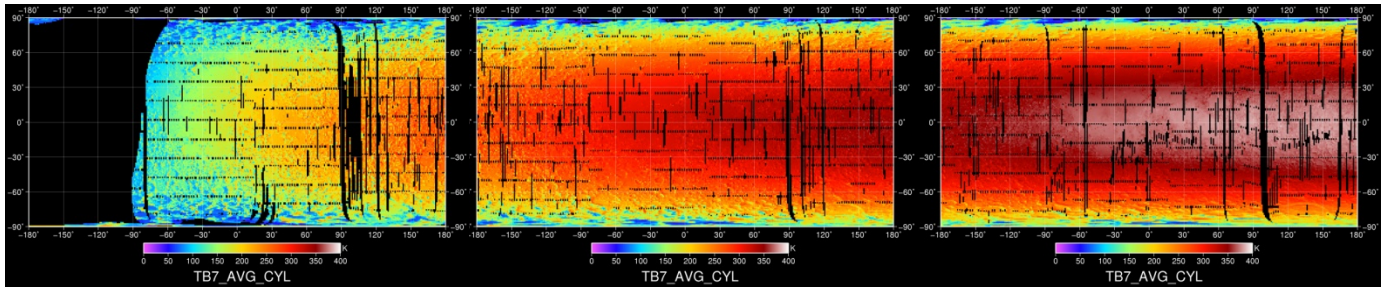


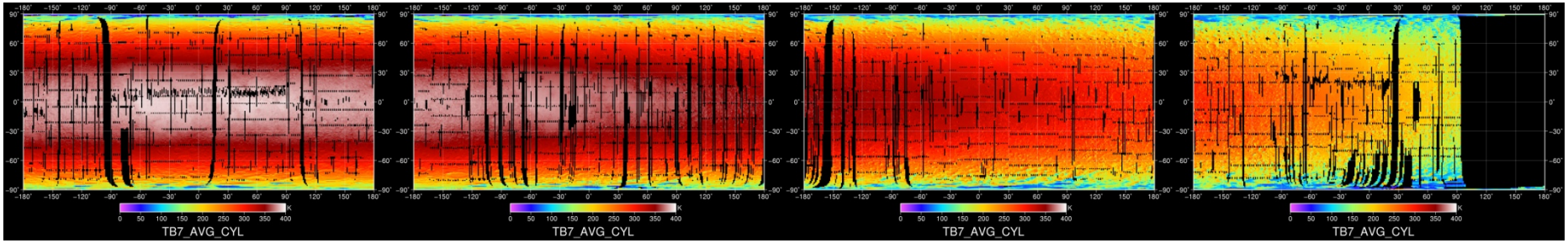
- Five years of data → global diurnal temperatures can be adequately resolved to create global maps of surface temperatures.
- Bolometric brightness temperatures from radiance from the 7 infrared spectral channels
  - measure of the spectrally integrated flux of infrared radiation emerging from the surface (*Paige et al.*, 2010).

- Sub-spacecraft longitude cycles between -180° and 180° every ~27 days
- Sub-spacecraft local time cycles between 0 and 24 hours once every Earth year
- Daytime and nighttime observations on alternate hemispheres in a single orbit
  - two different local times separated by 180° longitude.



Dawn





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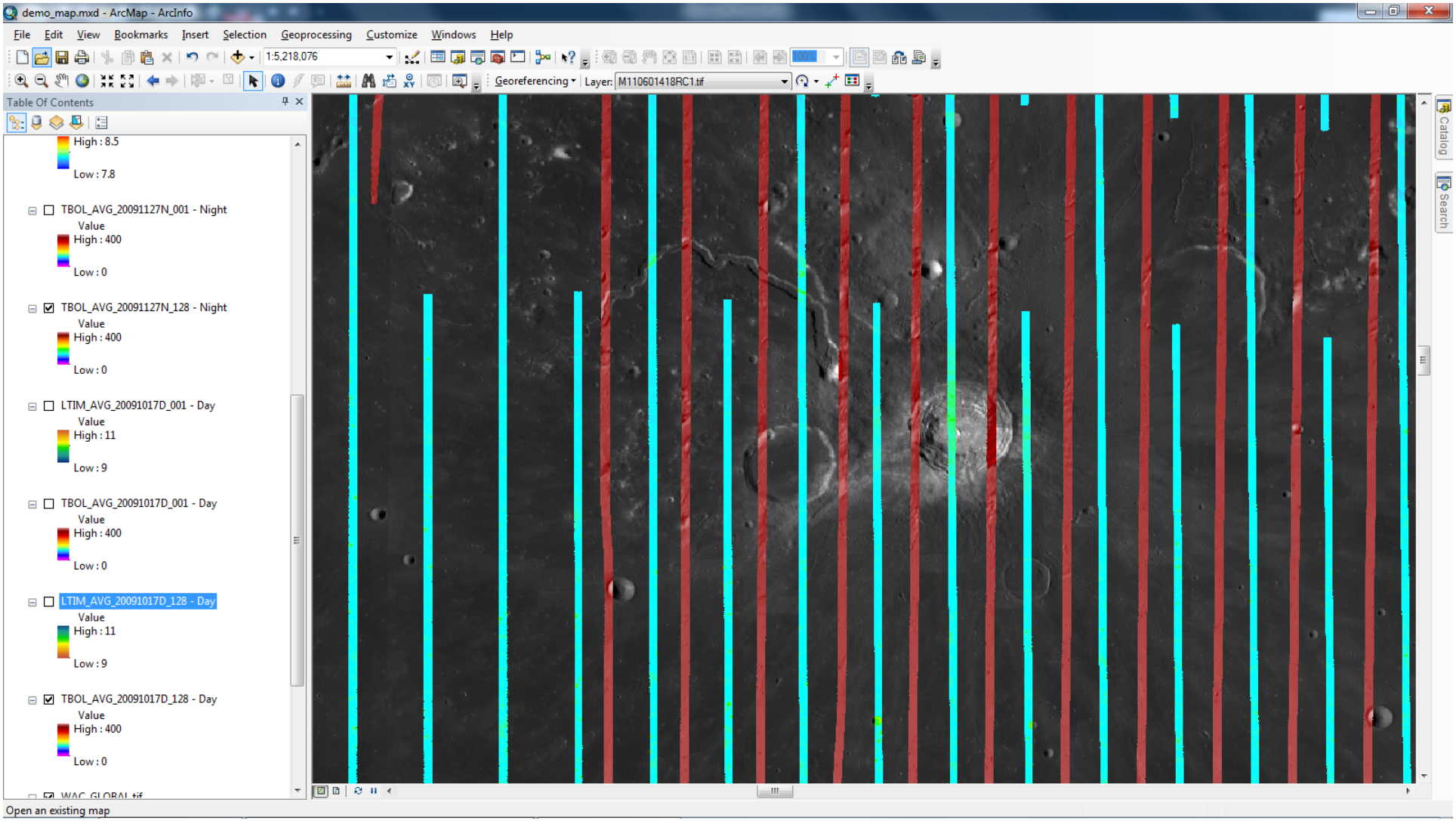
First light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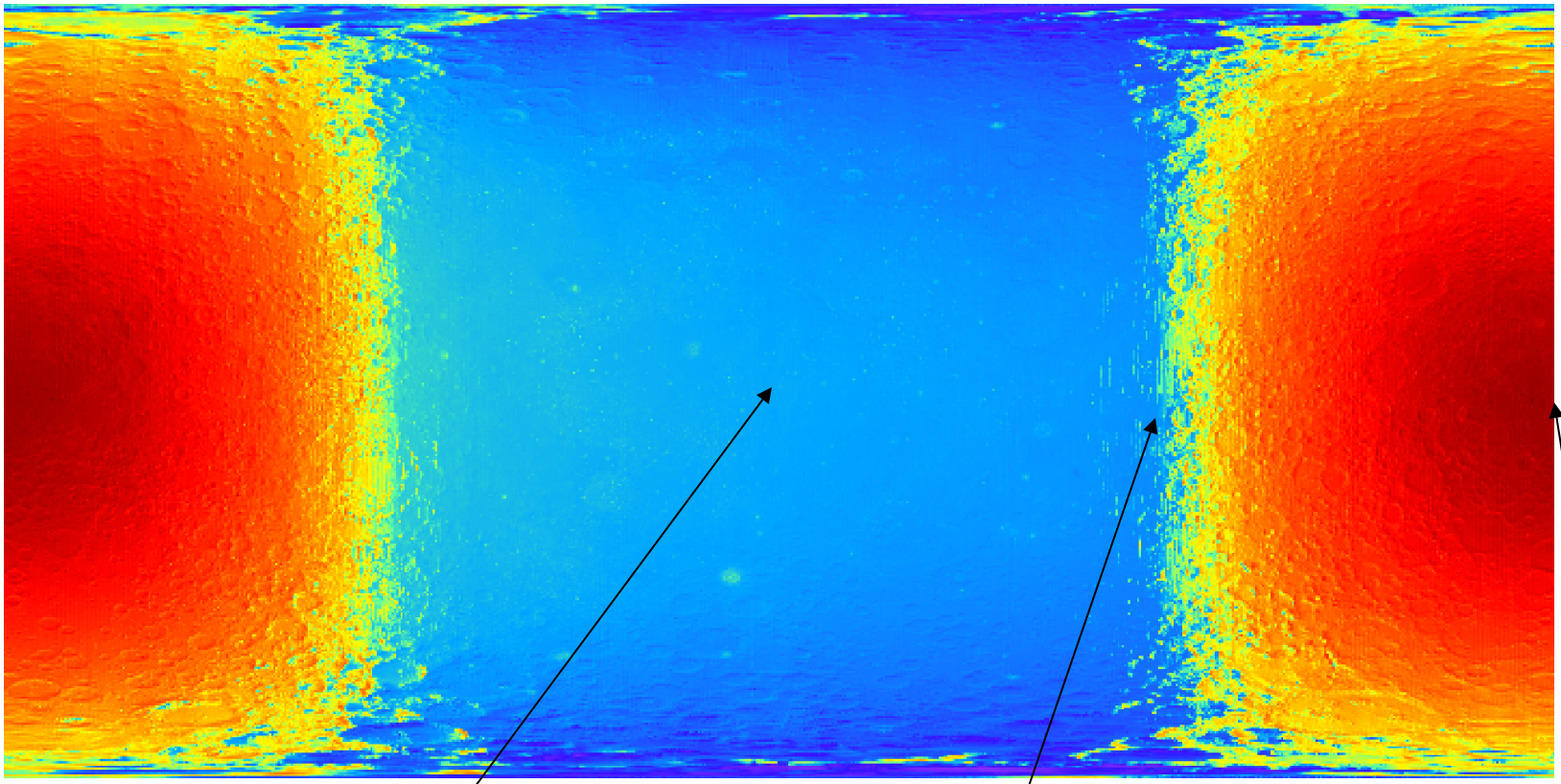
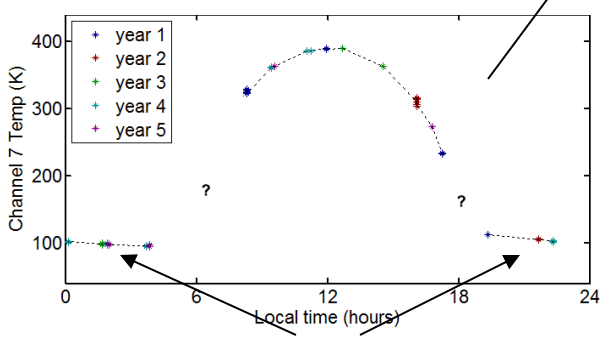
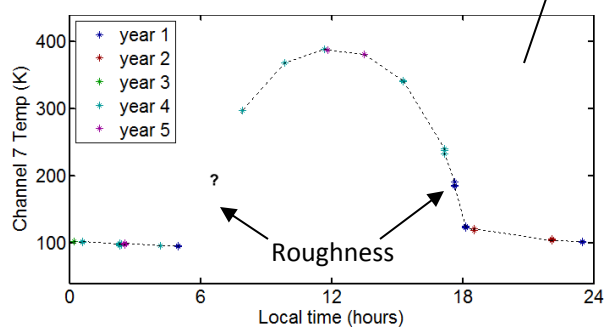
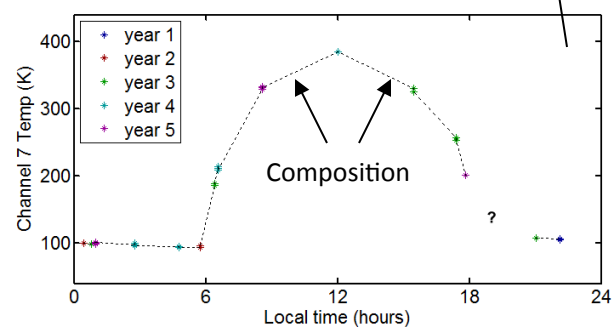
Catalog
Search
Open an existing map

Diviner Global Diurnal Bolometric Temperature Coverage





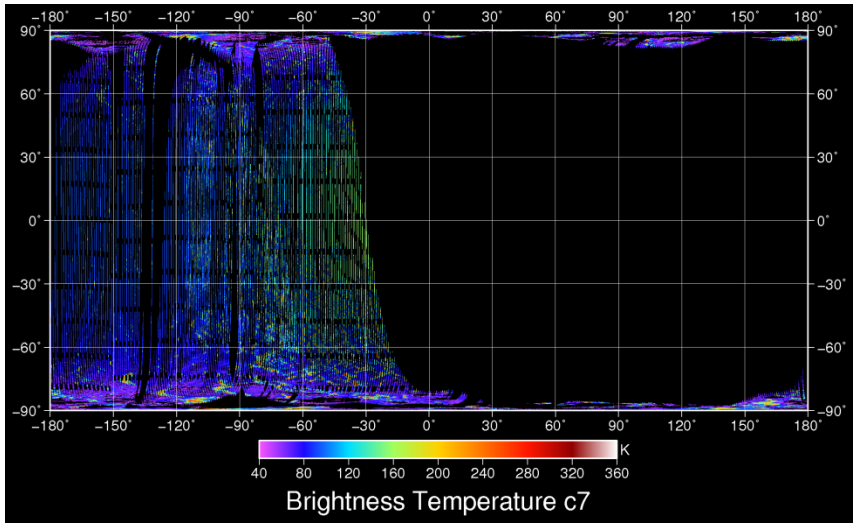




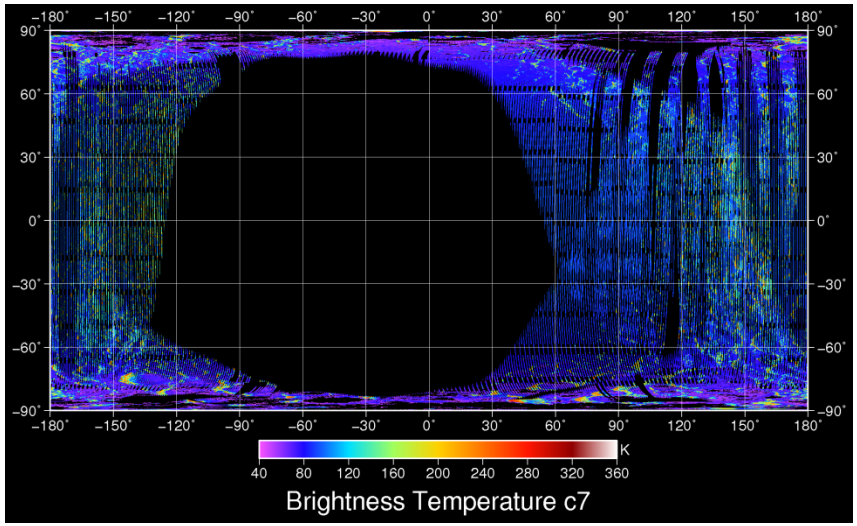
Rocks, Regolith Thermophysical Properties and Vertical Structure

Diviner Global Coverage at 64ppd: 5:45 AM – 6:15 AM

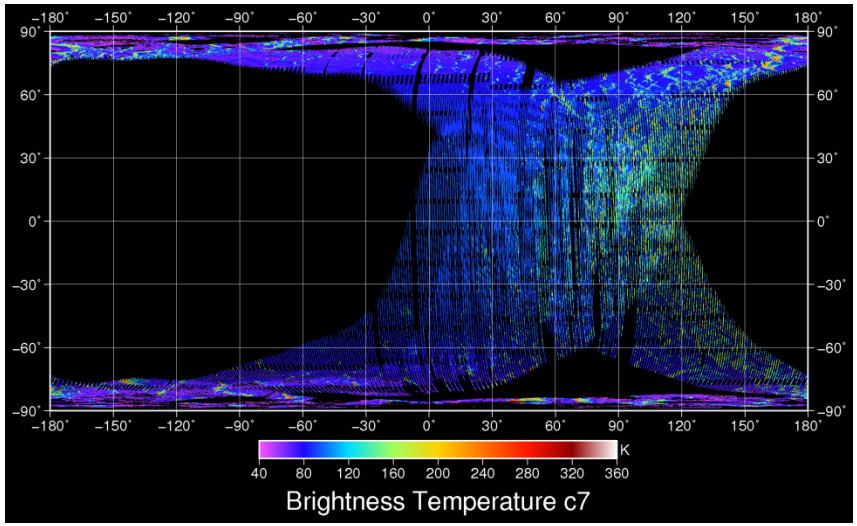
ESMD Mission: 16%



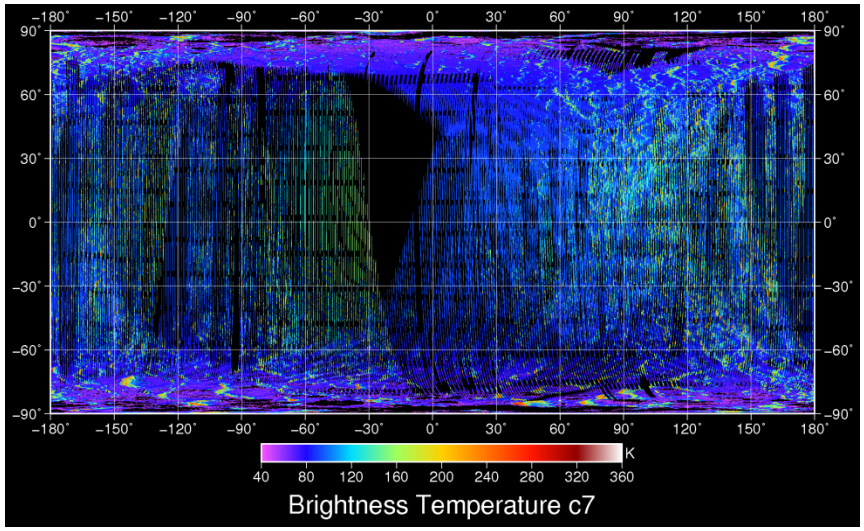
SMD Mission: 32%



ESM1 Mission: 27%



Combined: 55%



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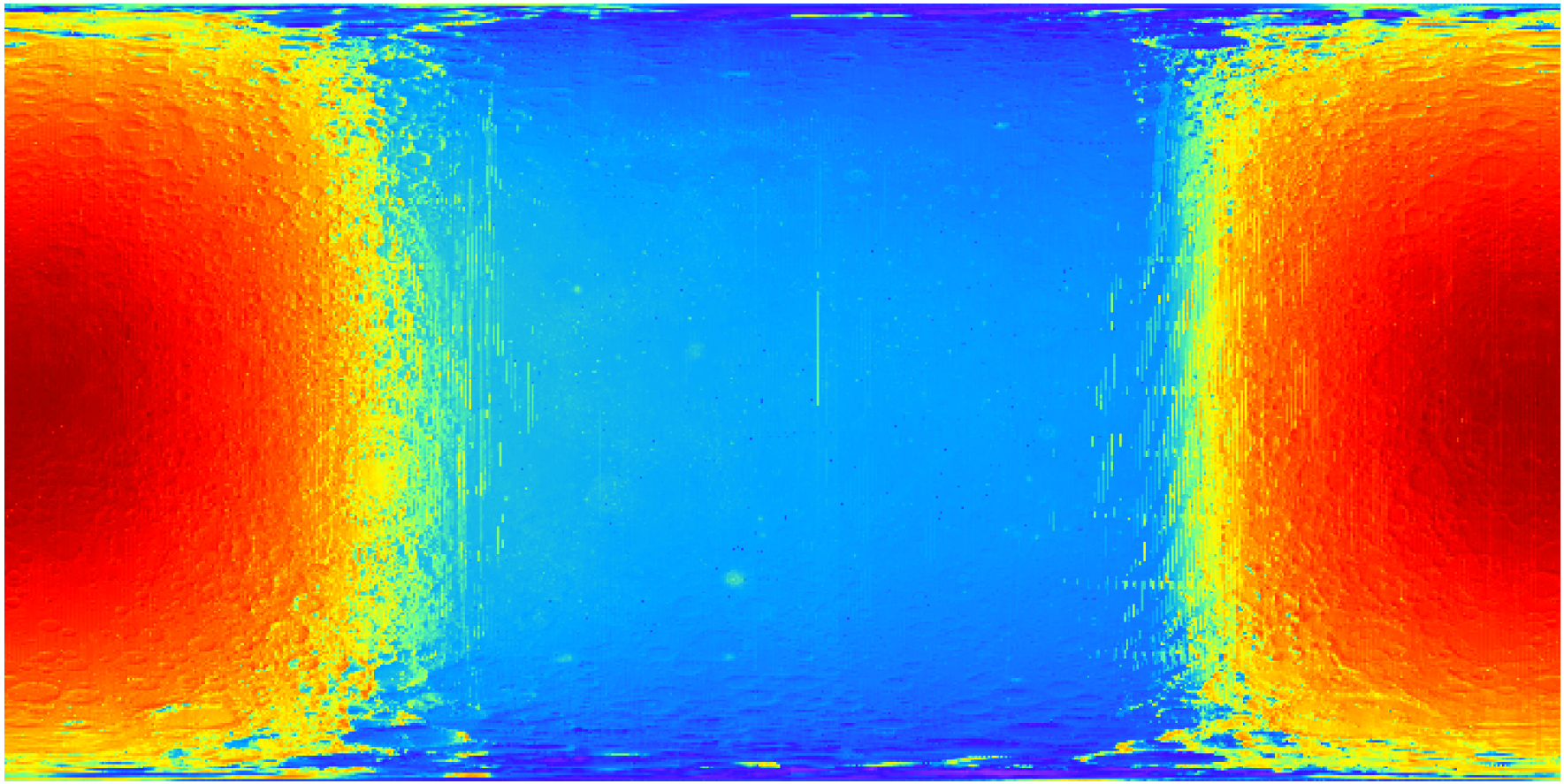
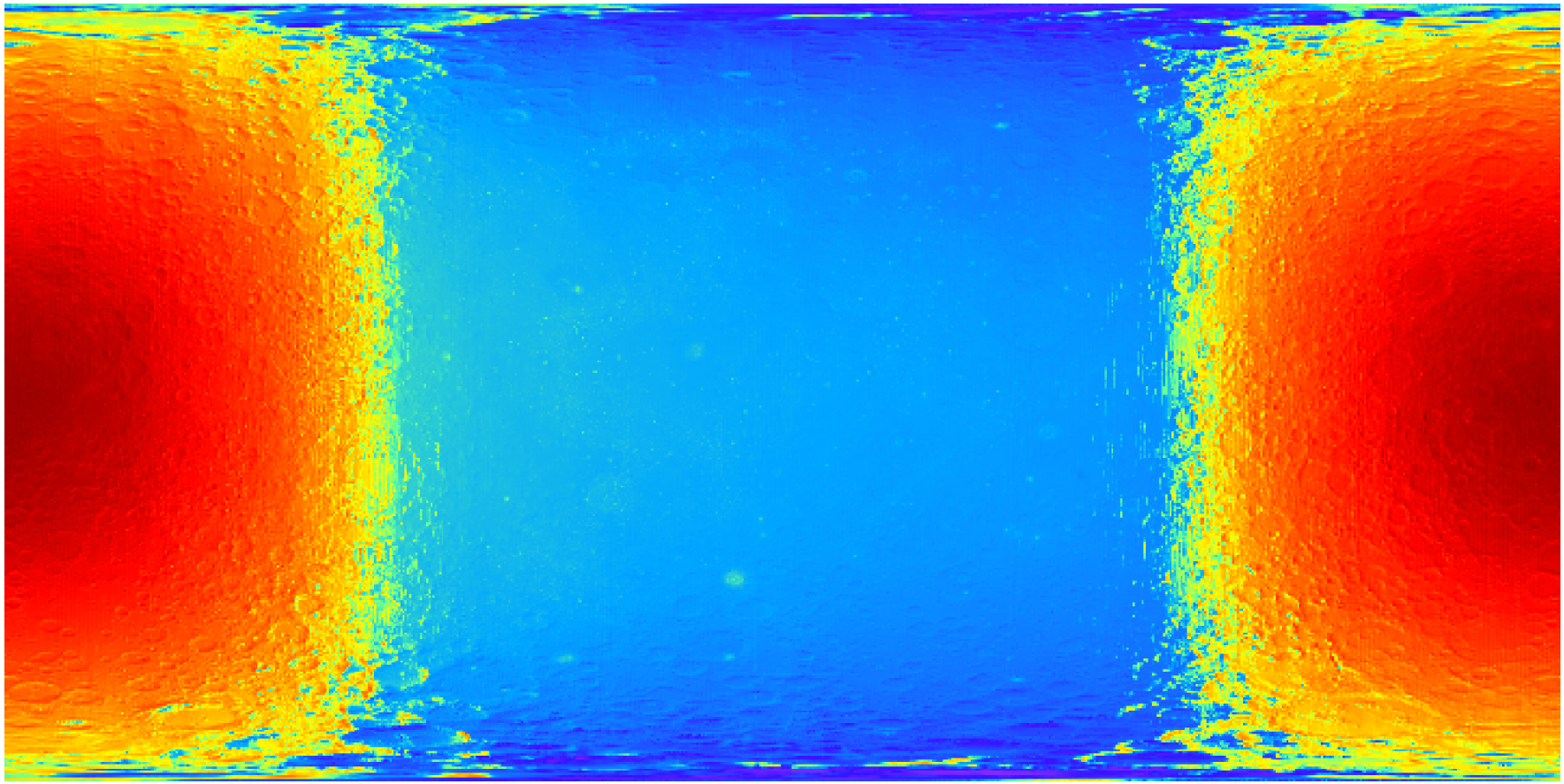
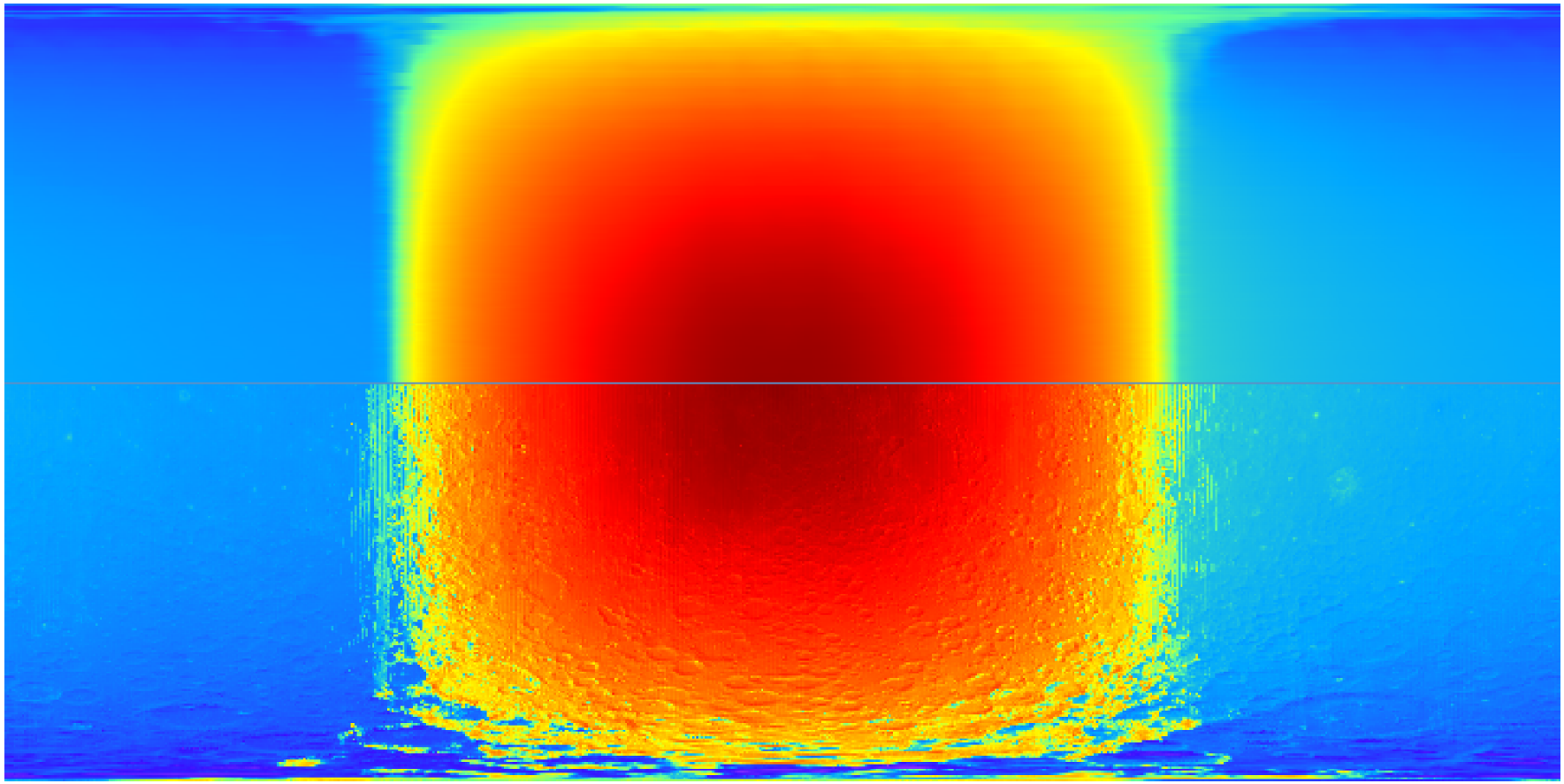
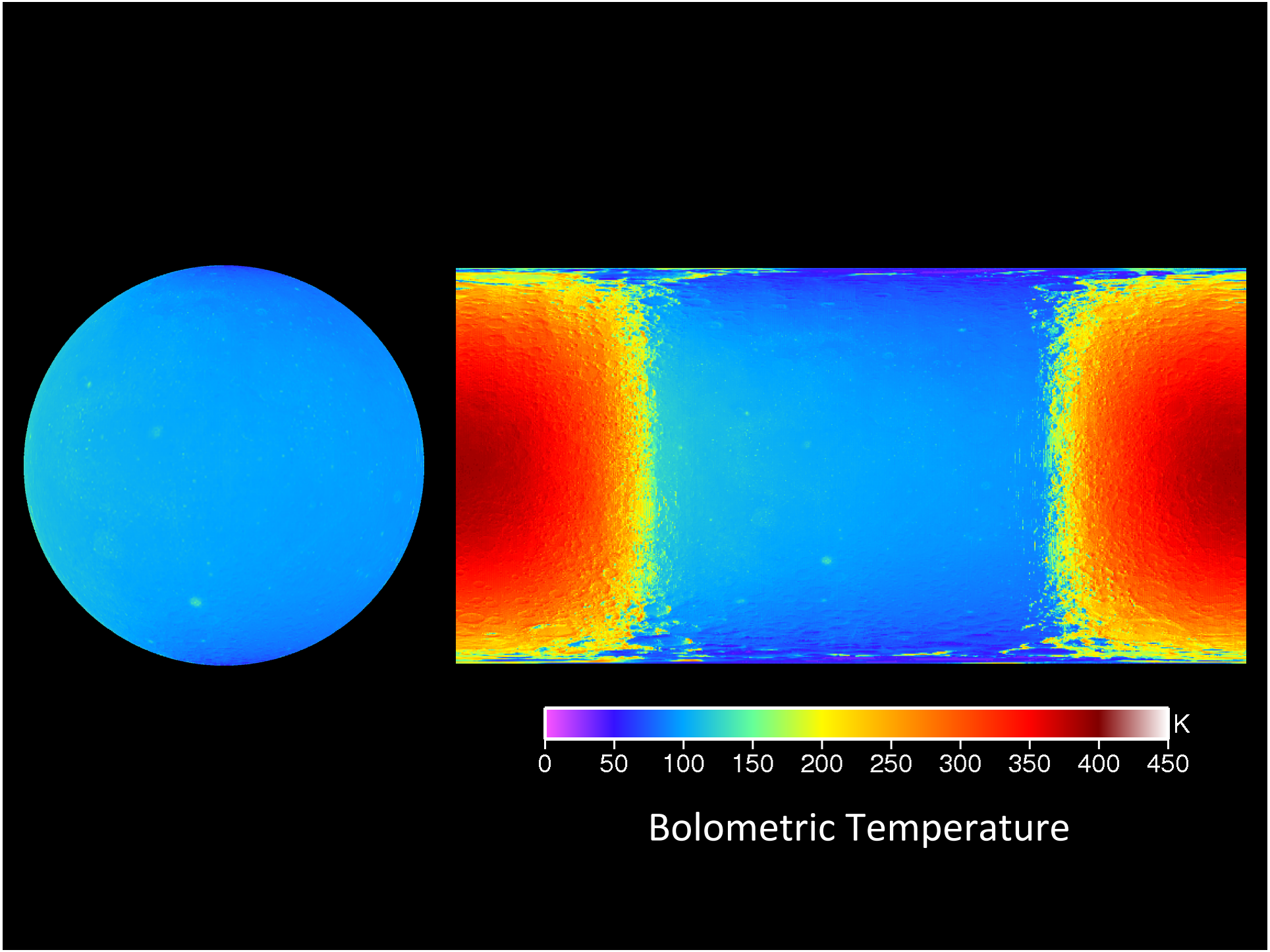


July 2009 – June 2014



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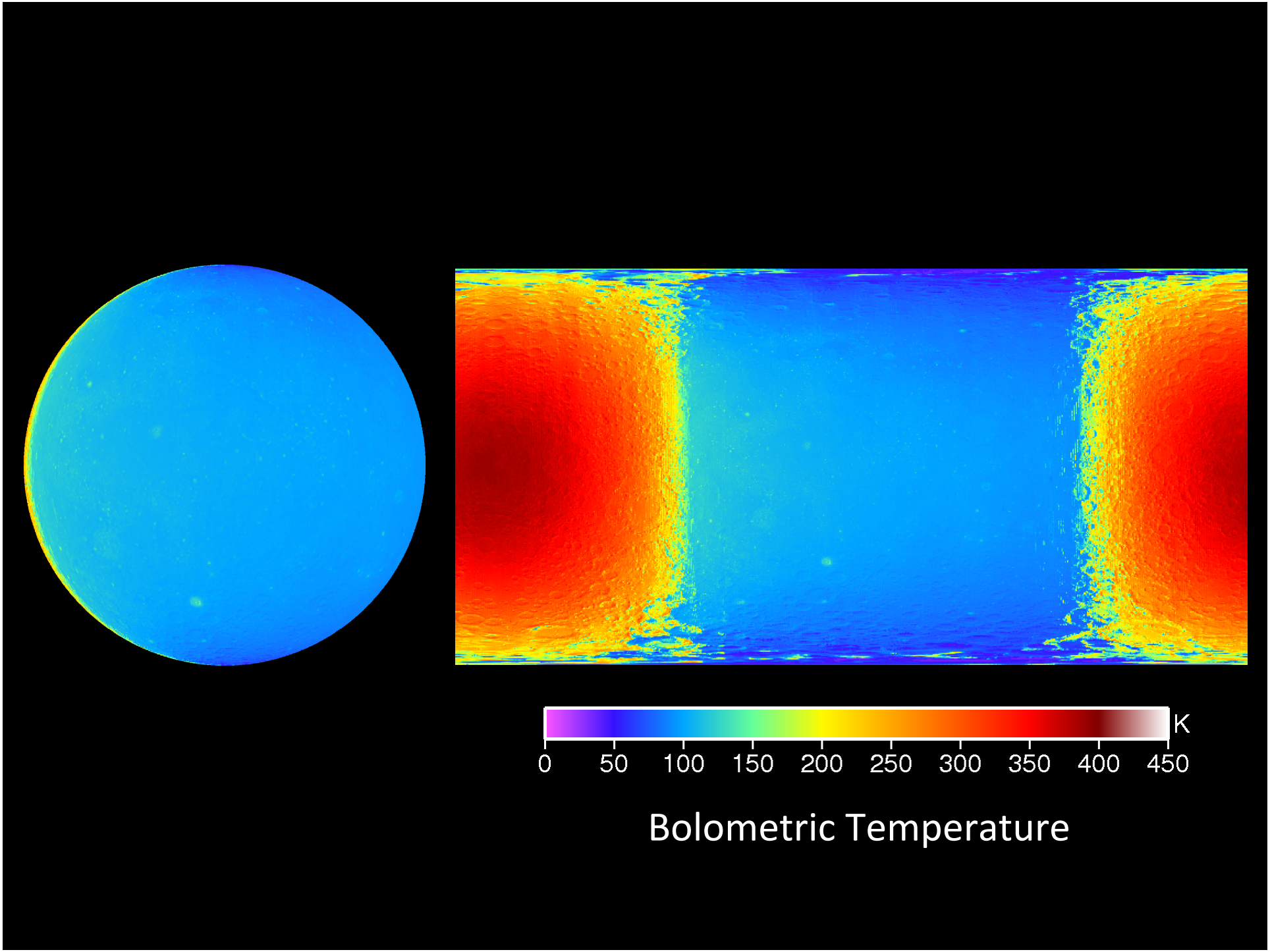
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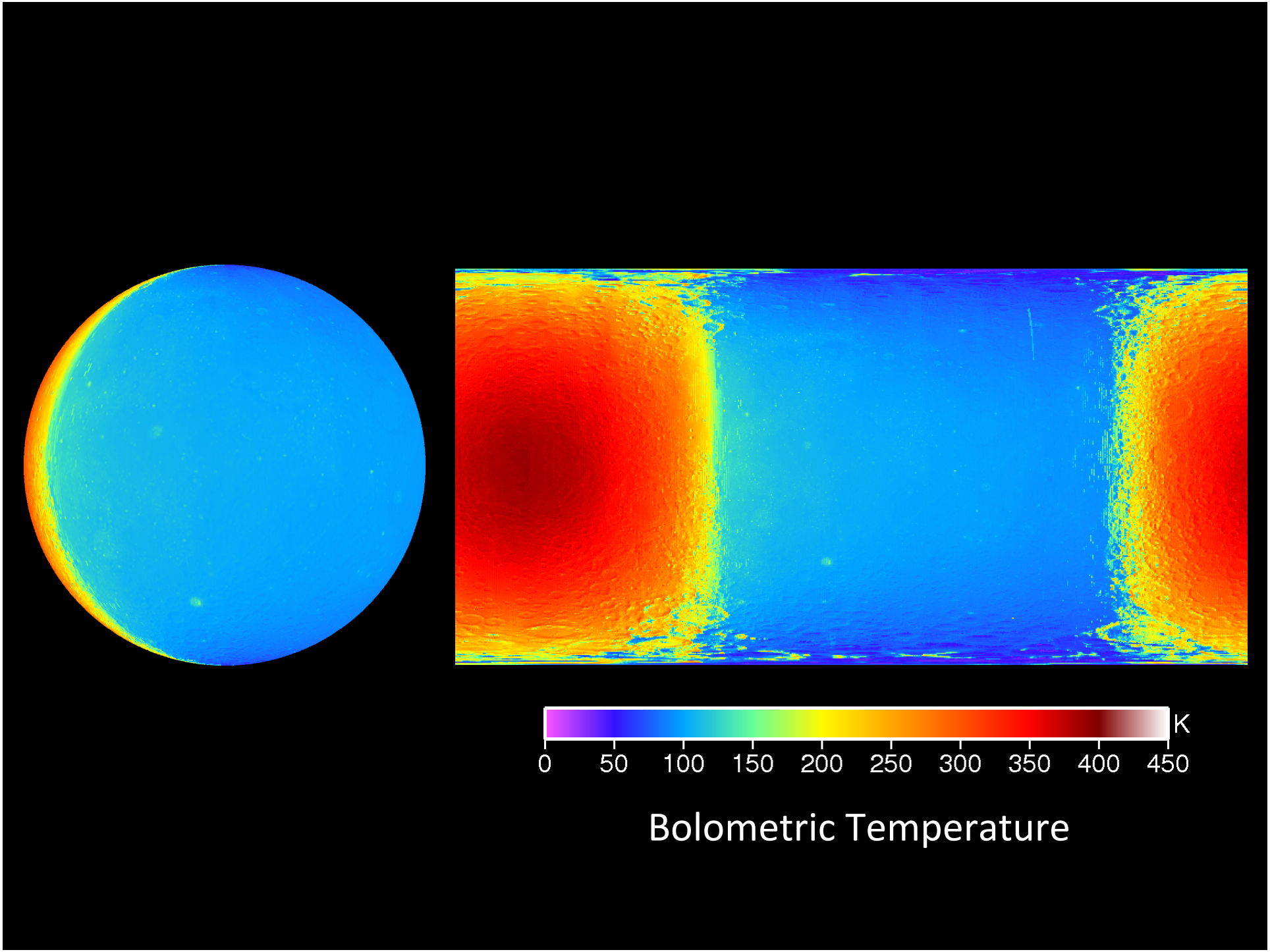
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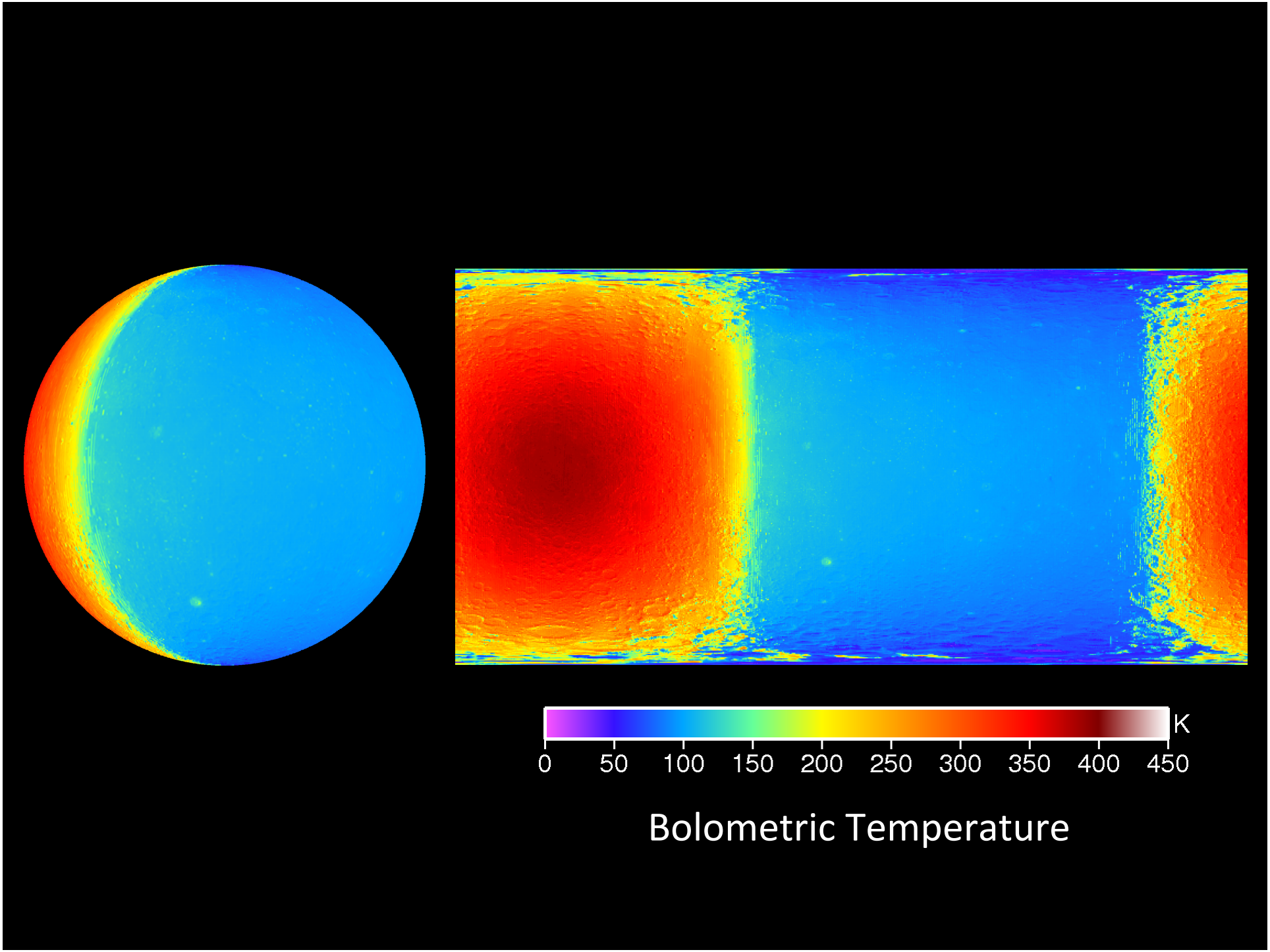
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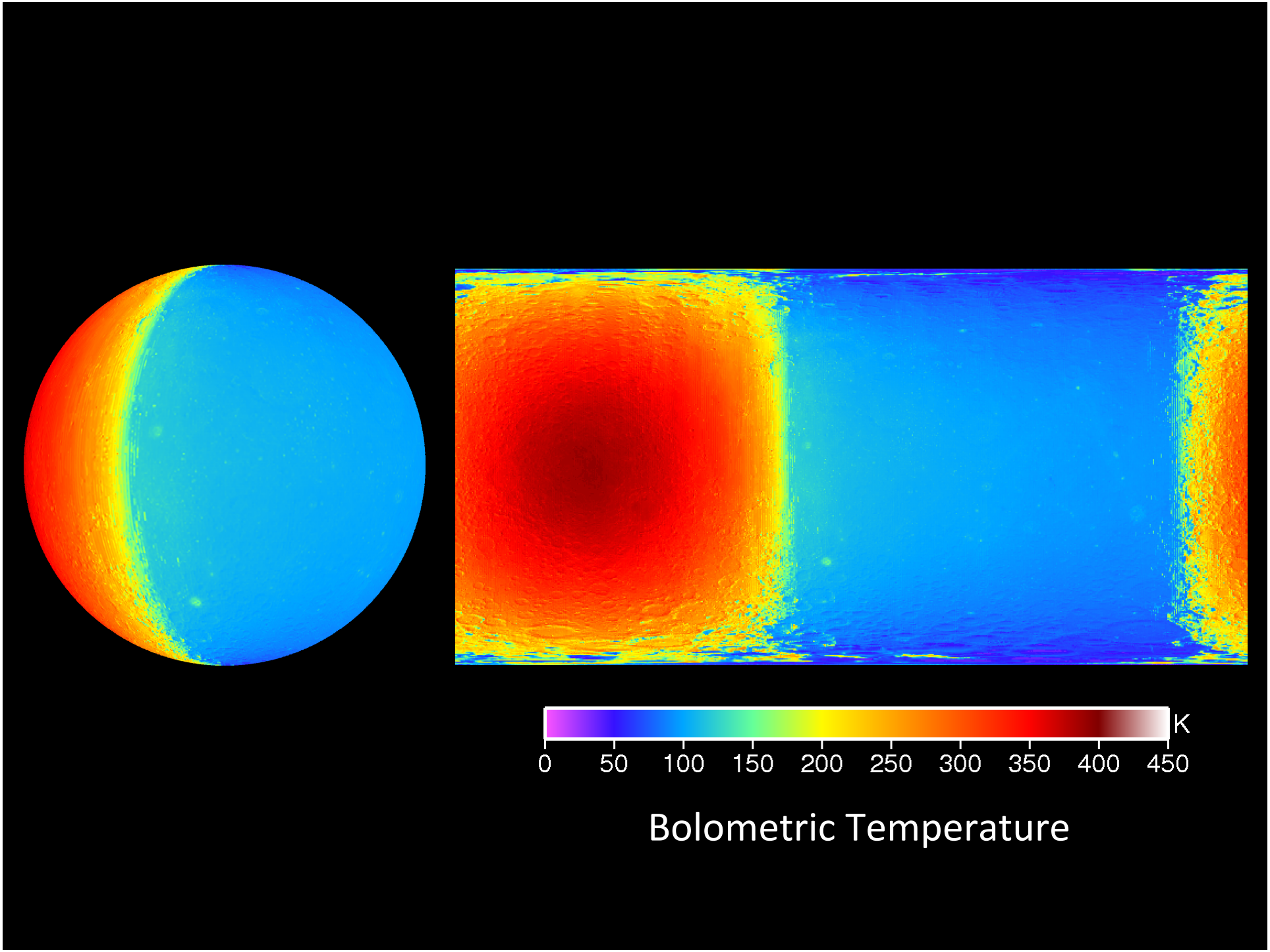
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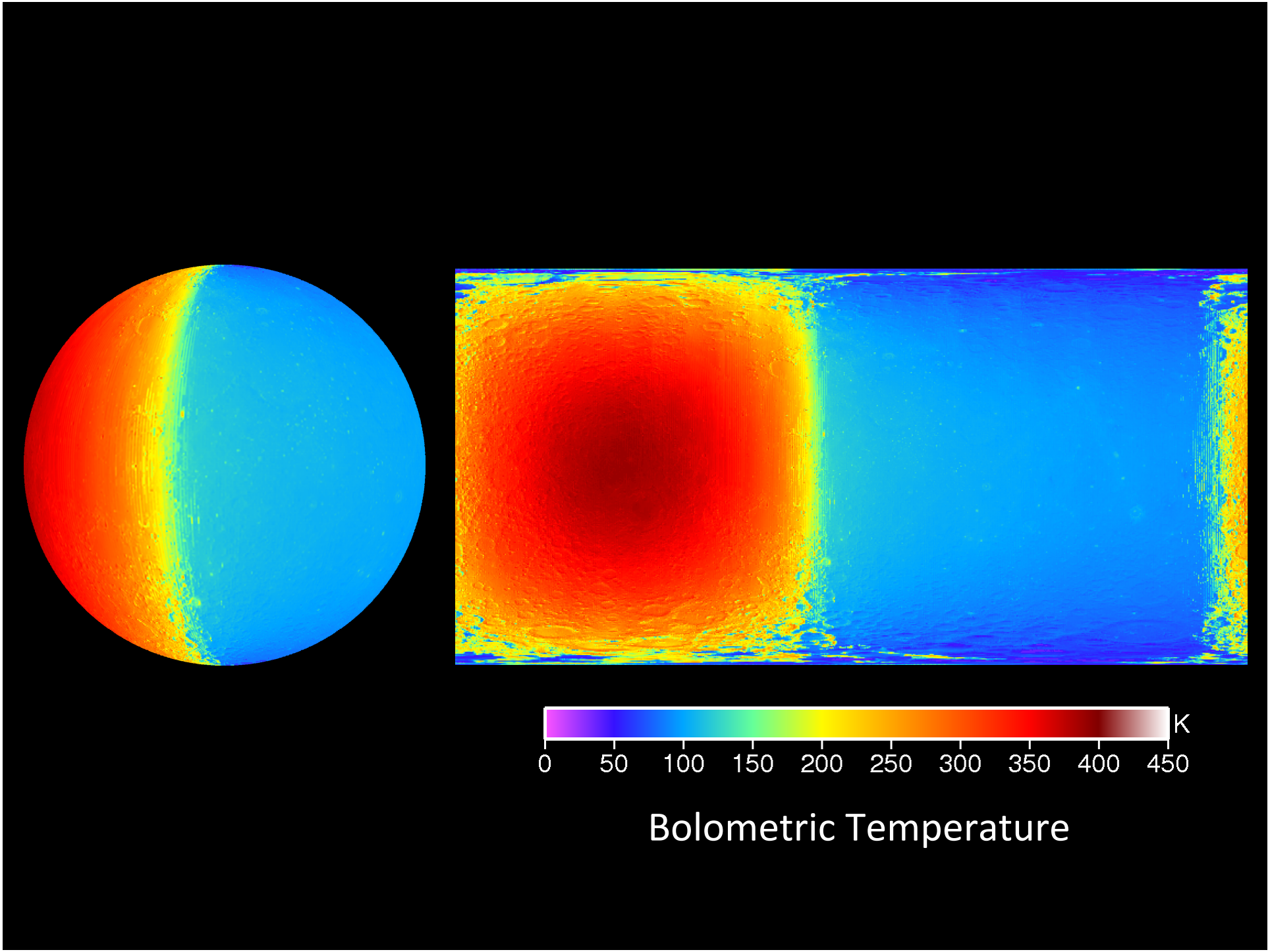
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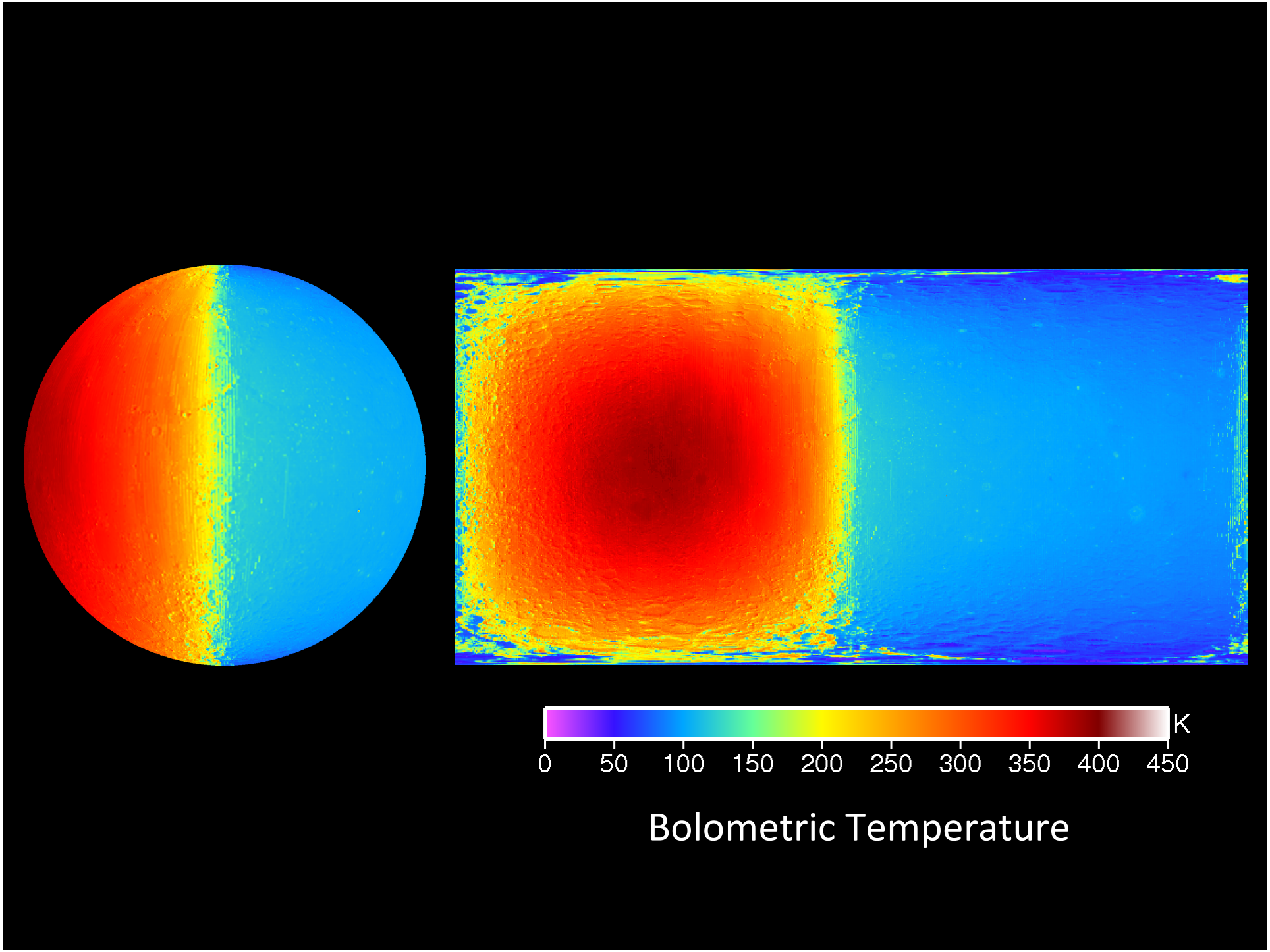
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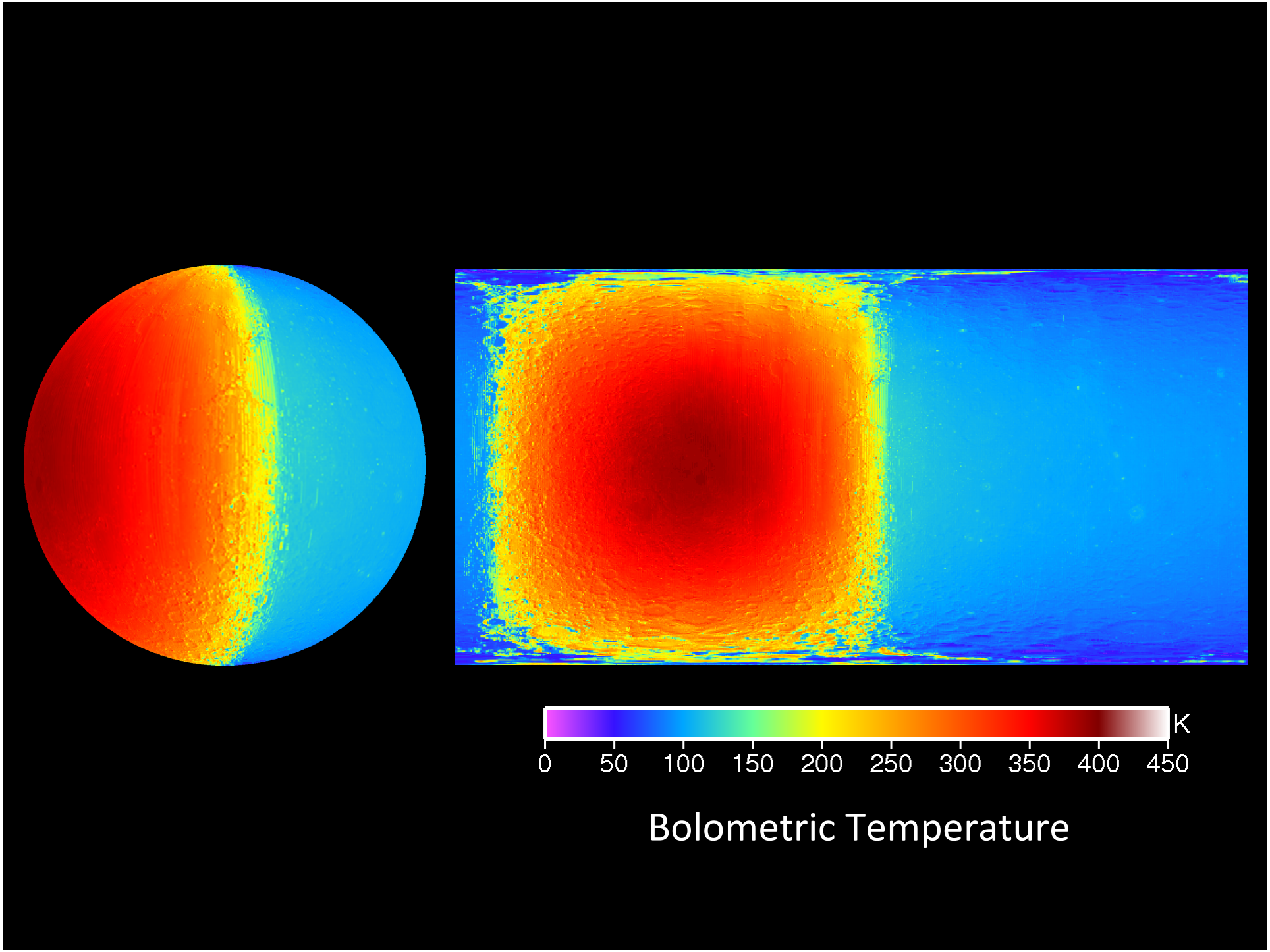
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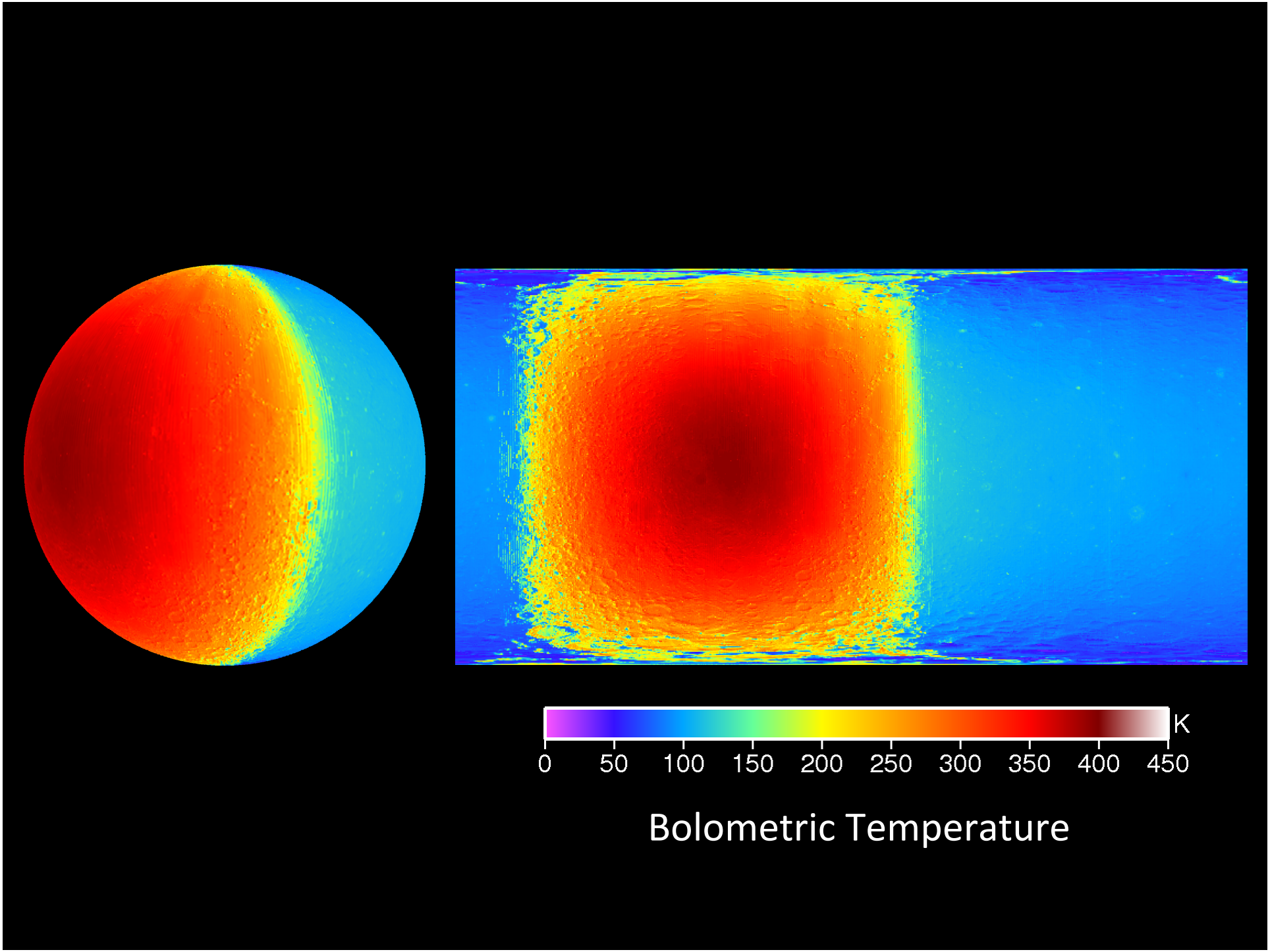
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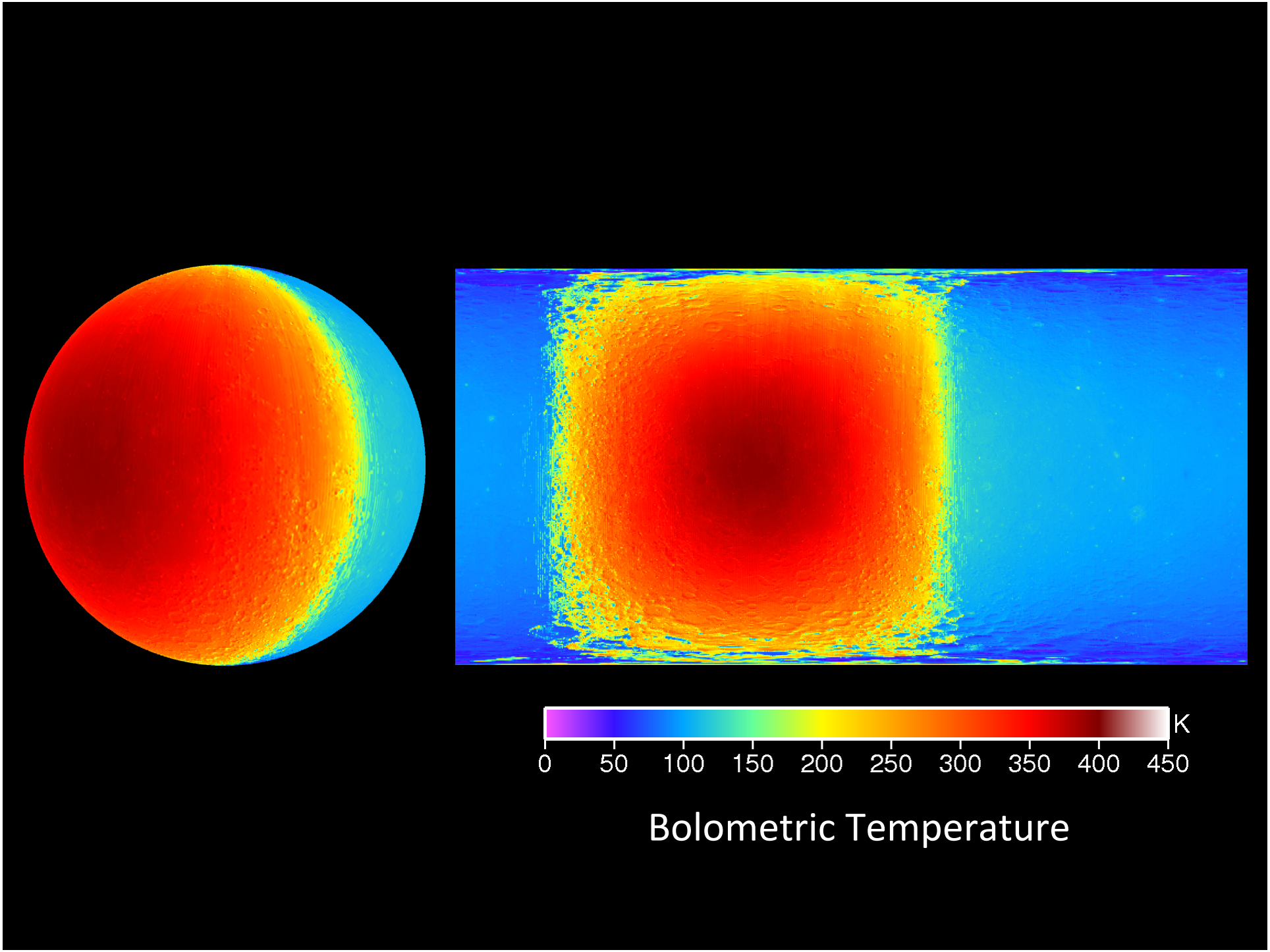
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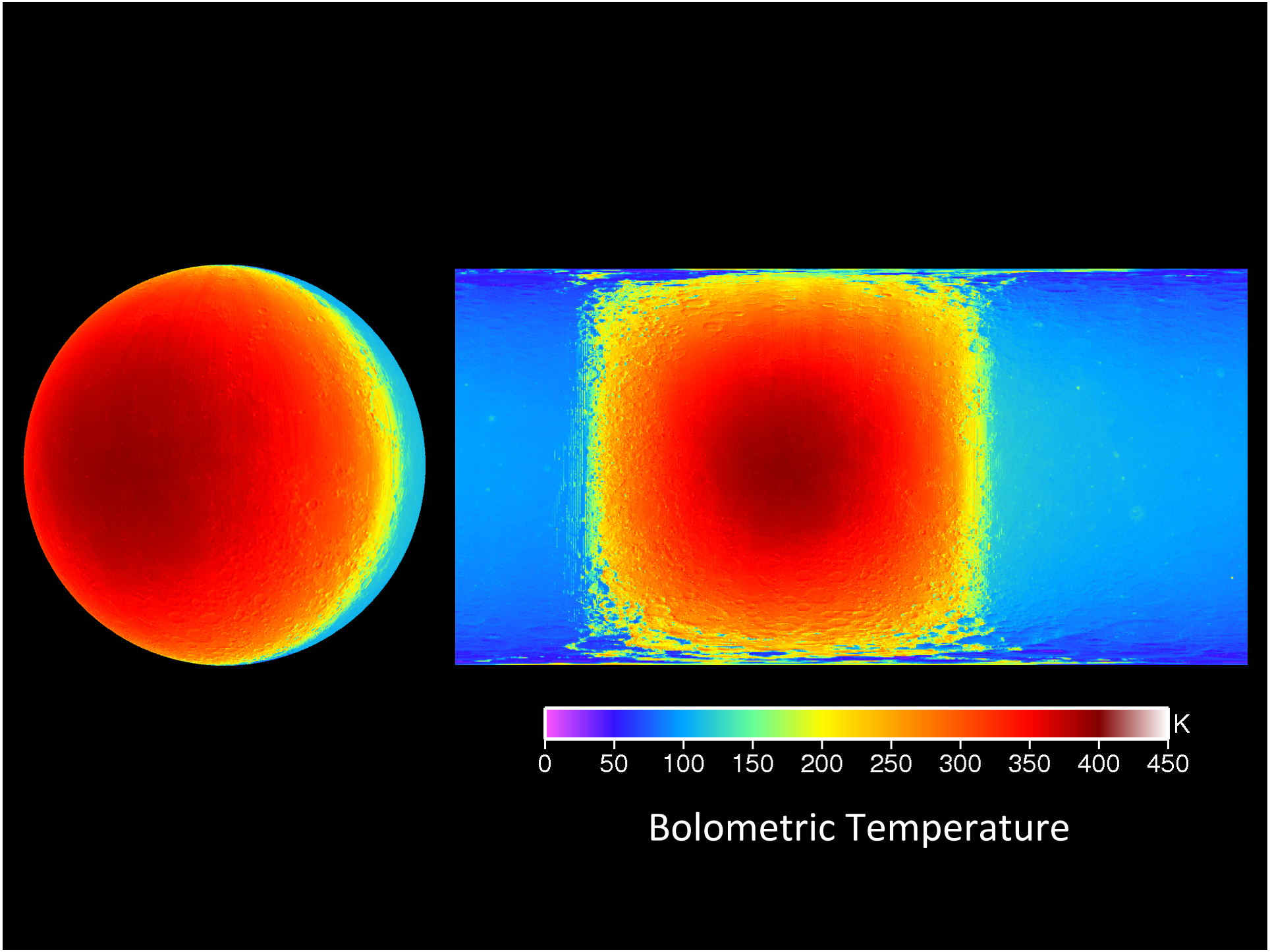
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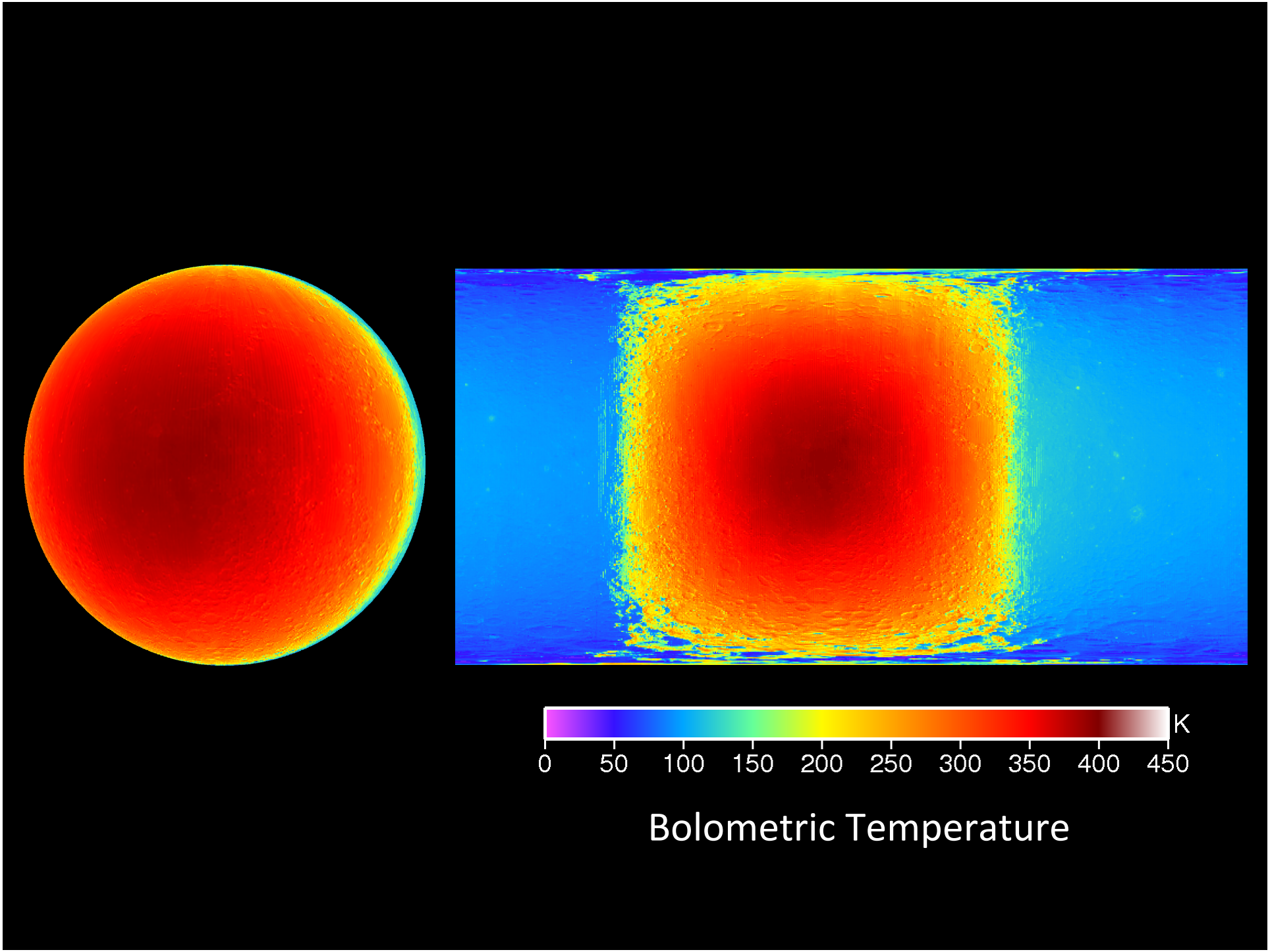
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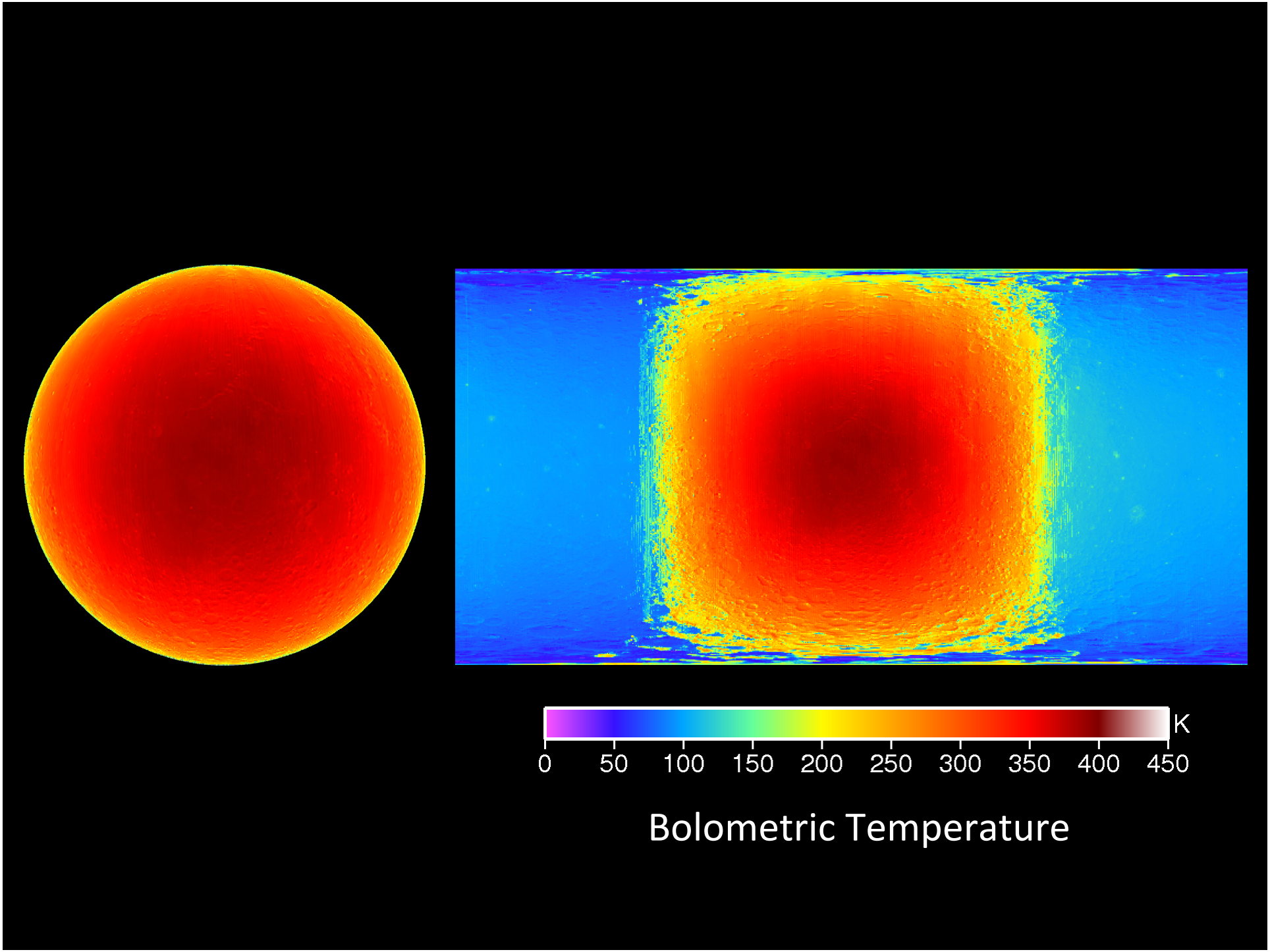
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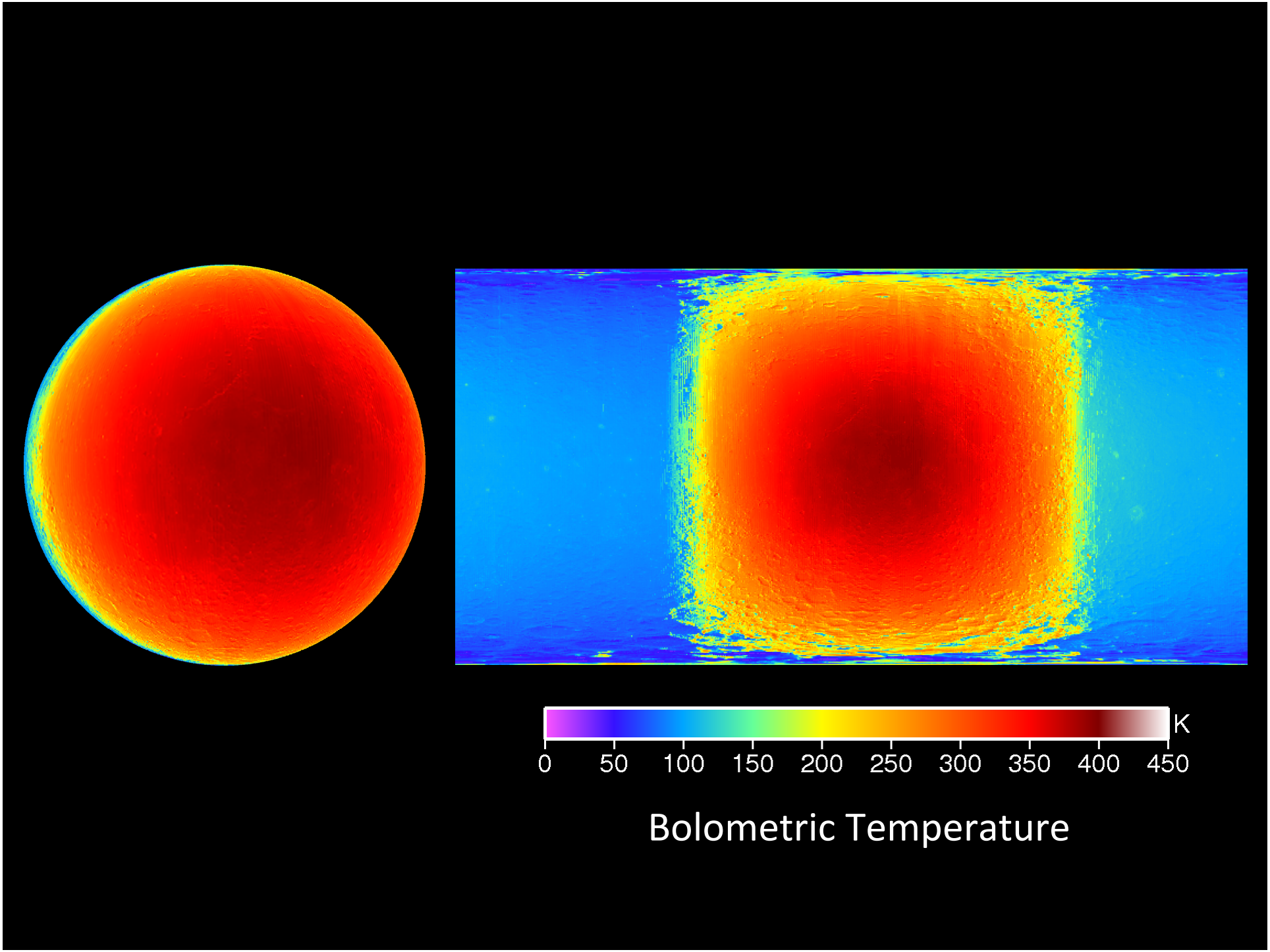
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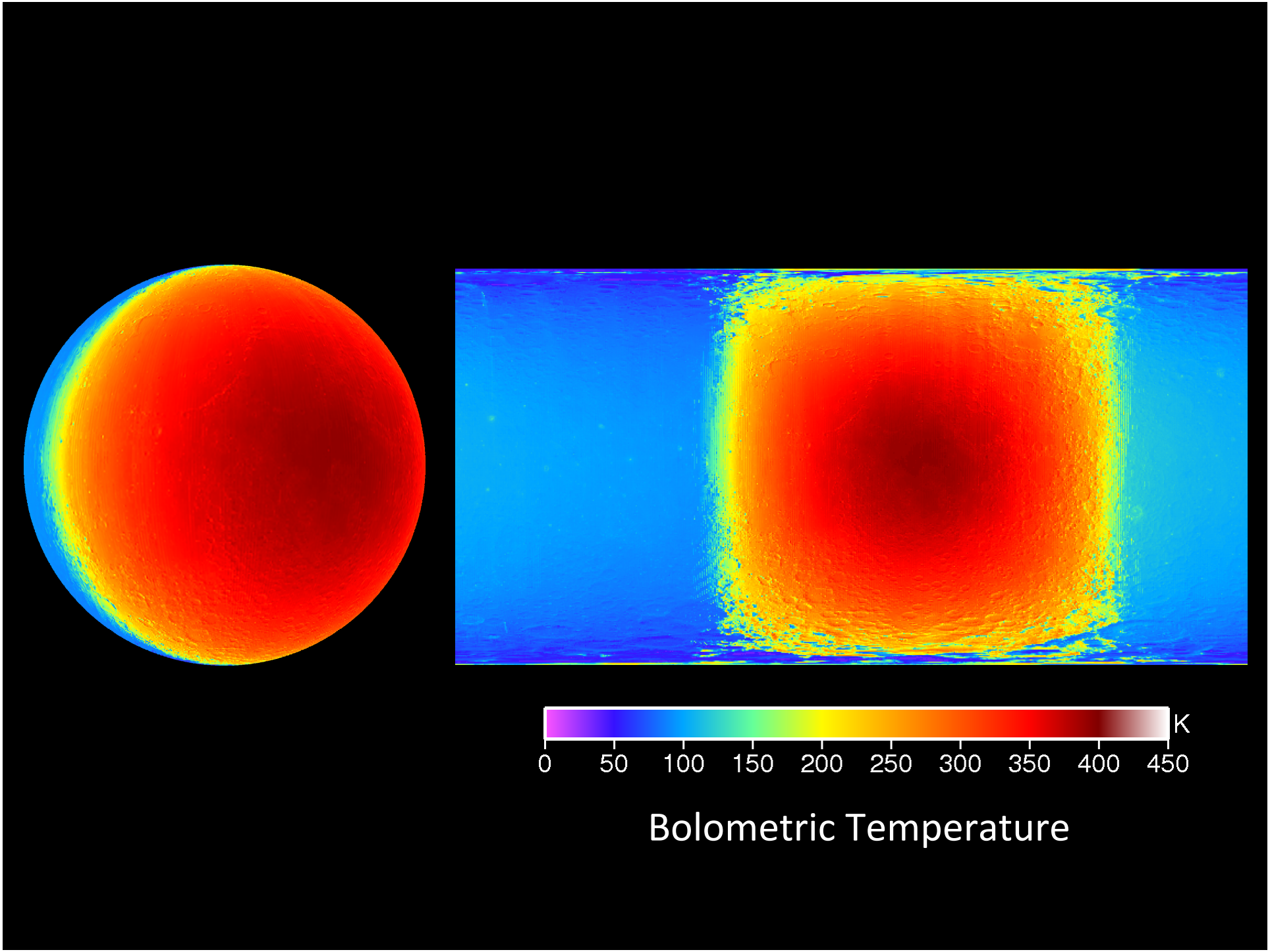
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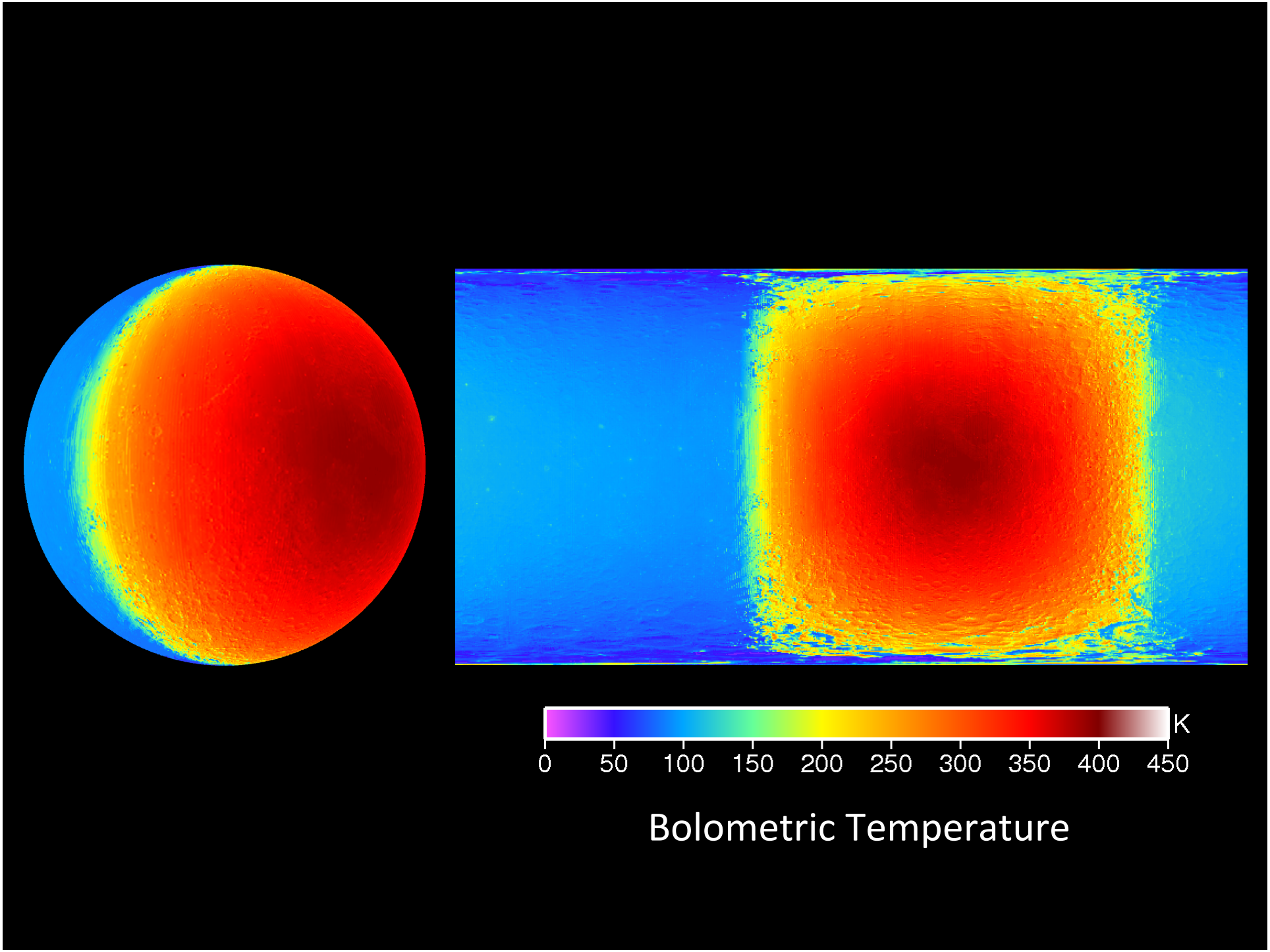
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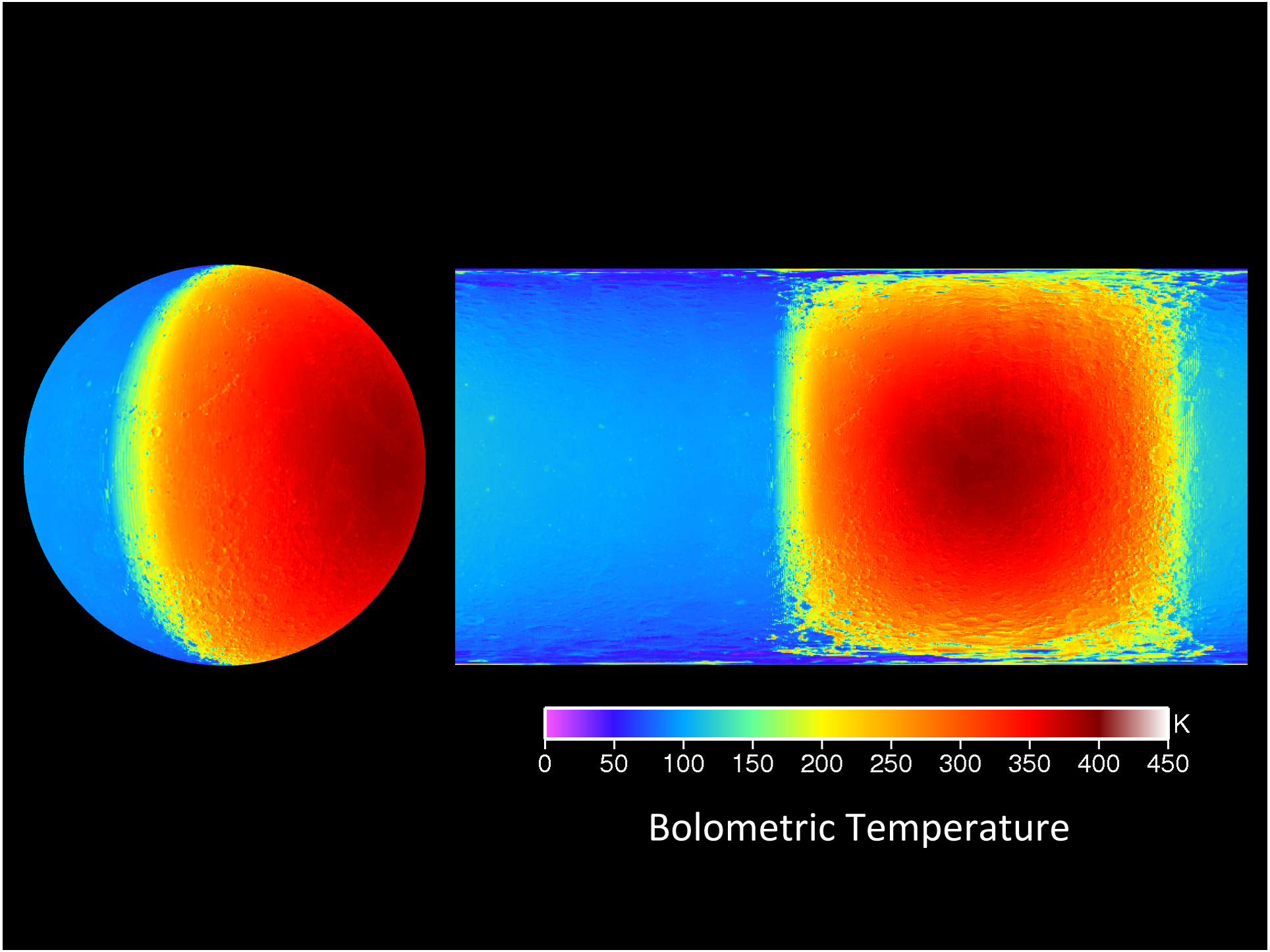
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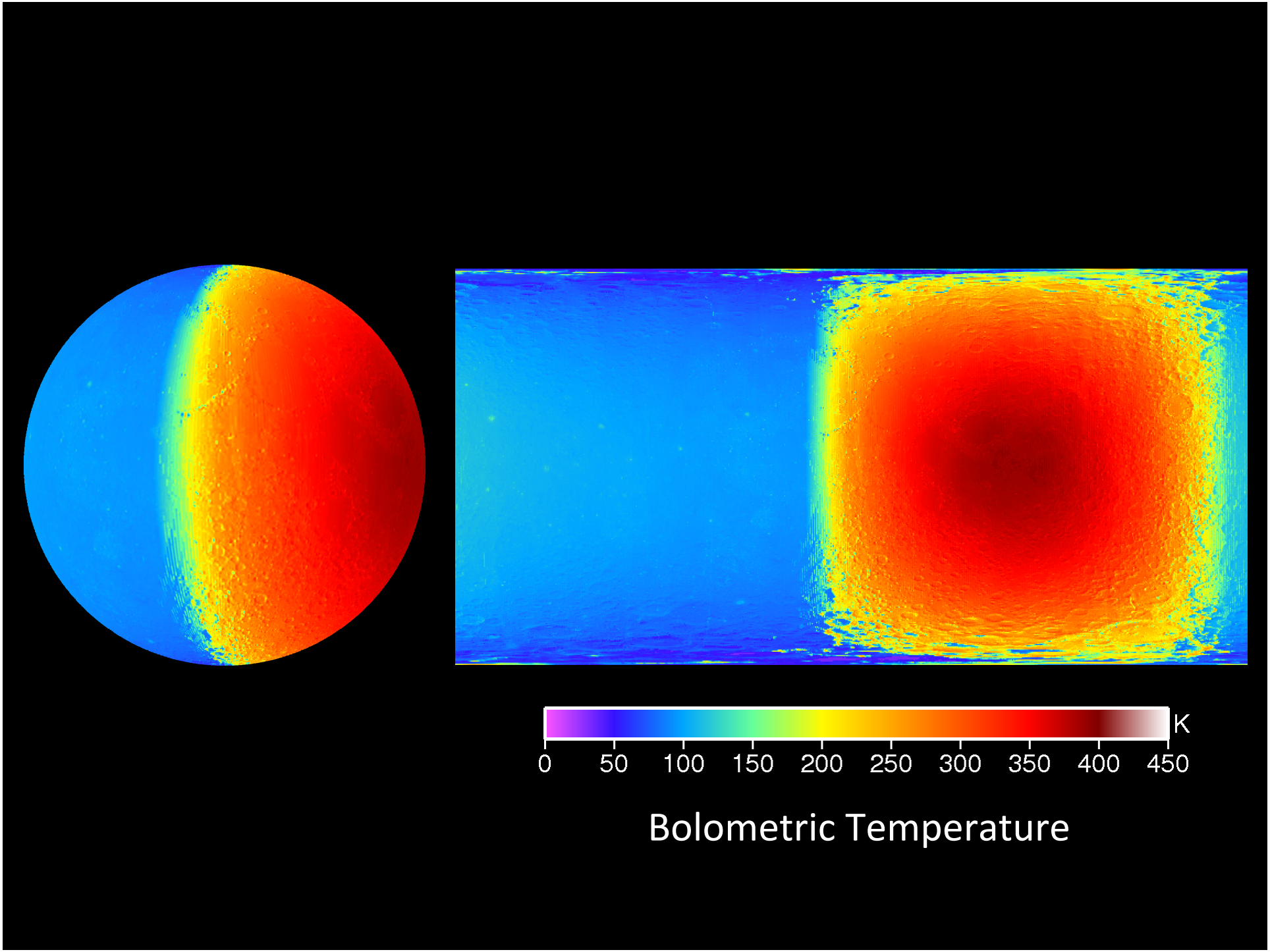
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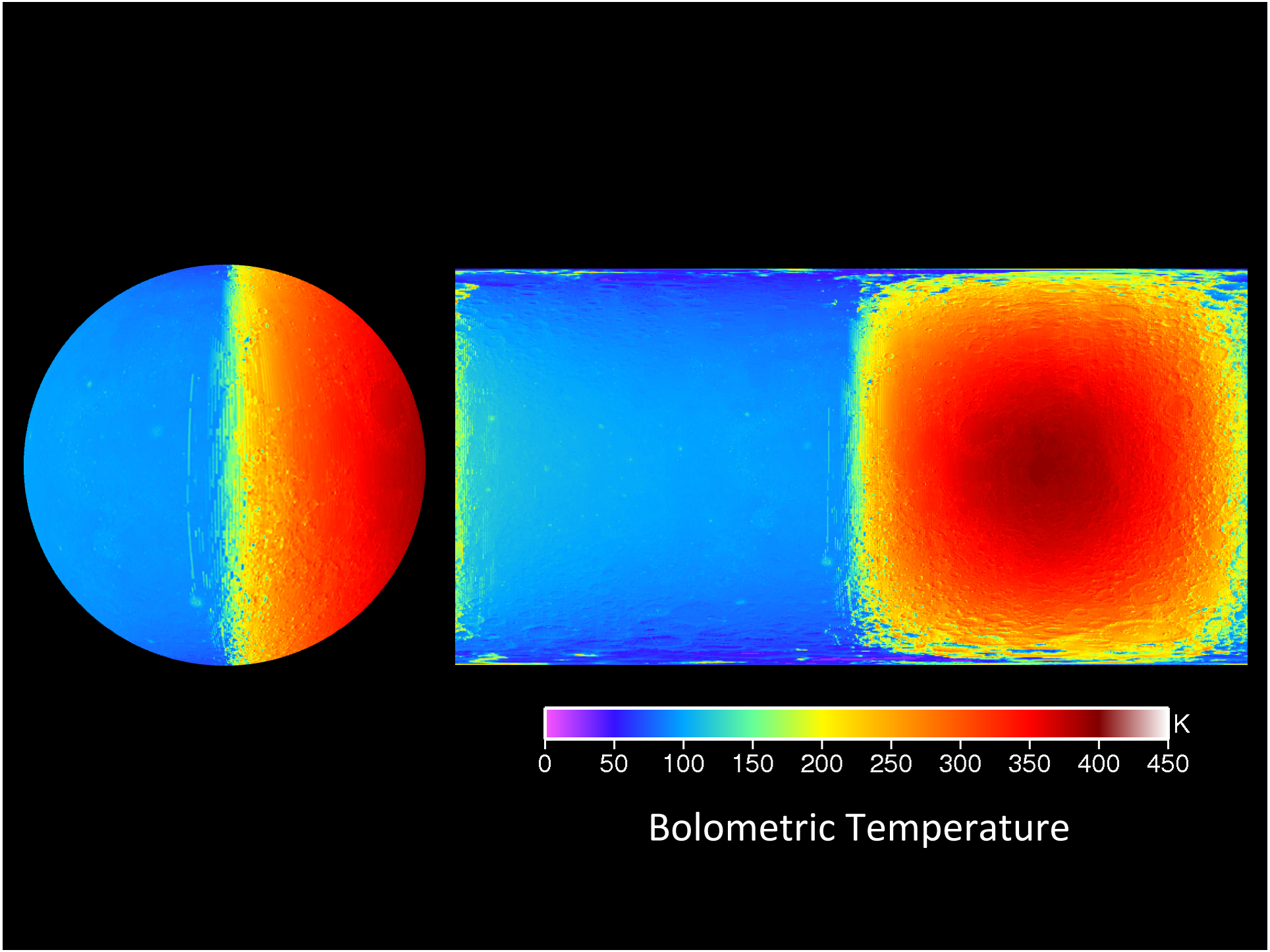
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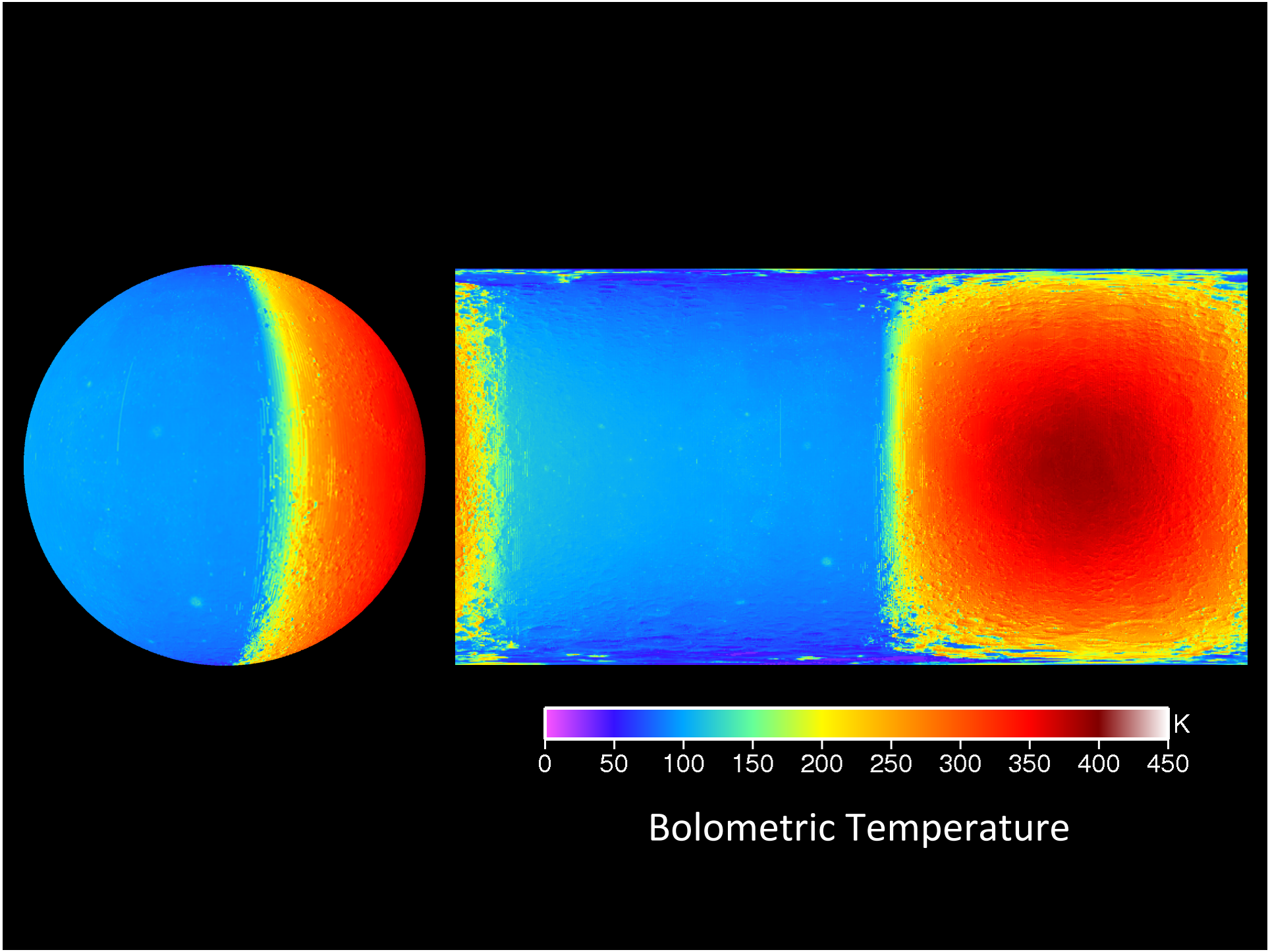
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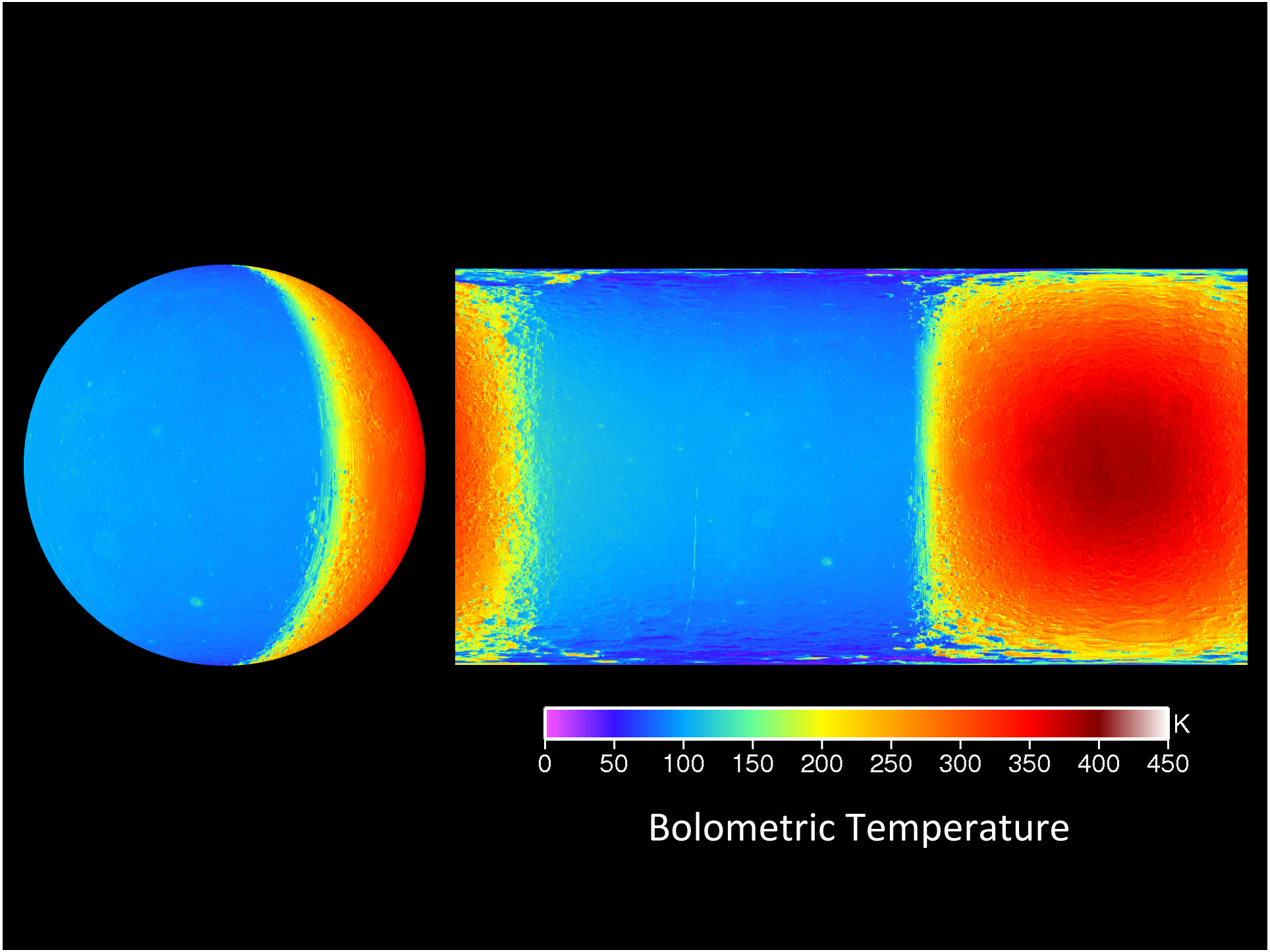
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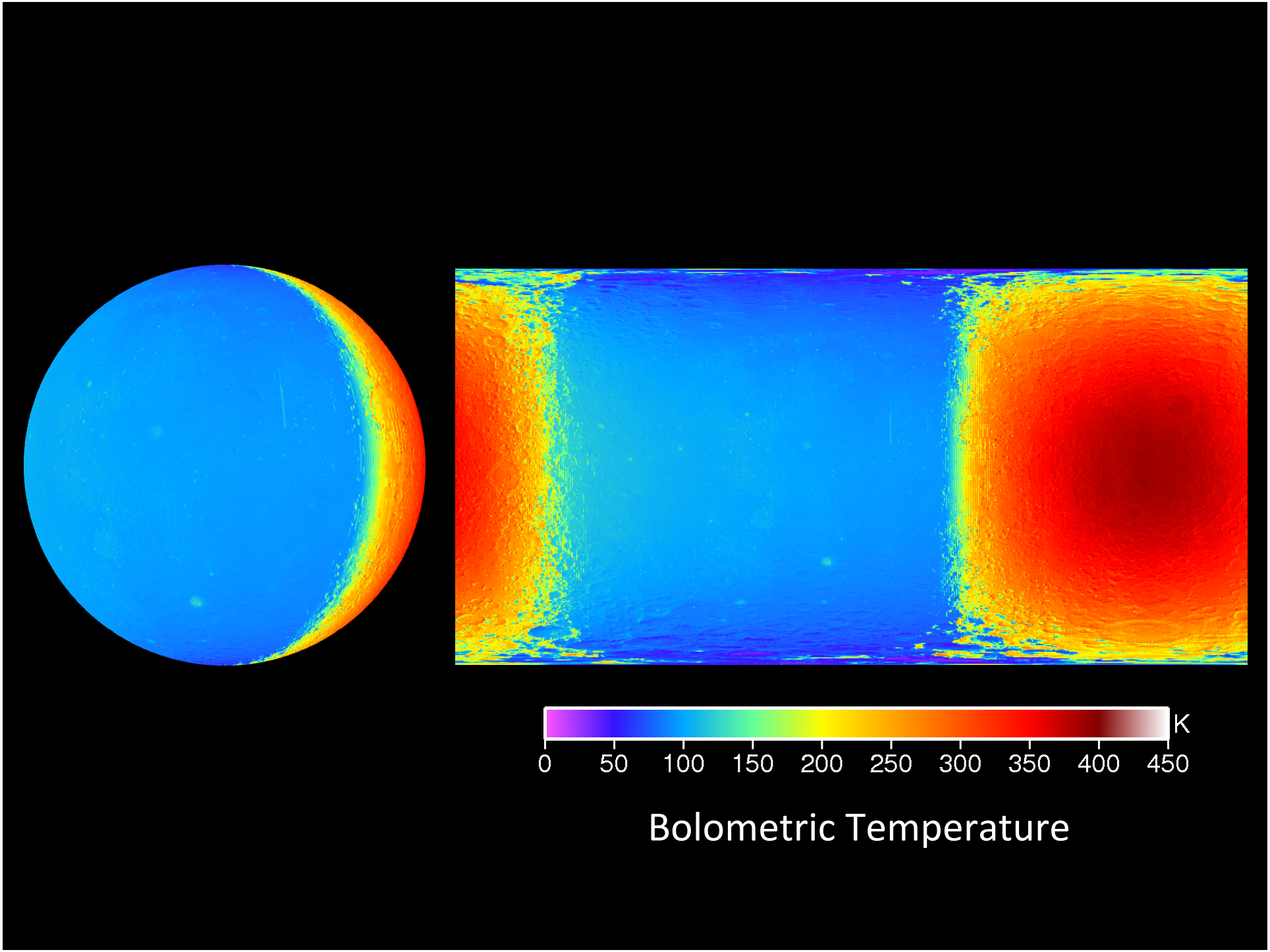
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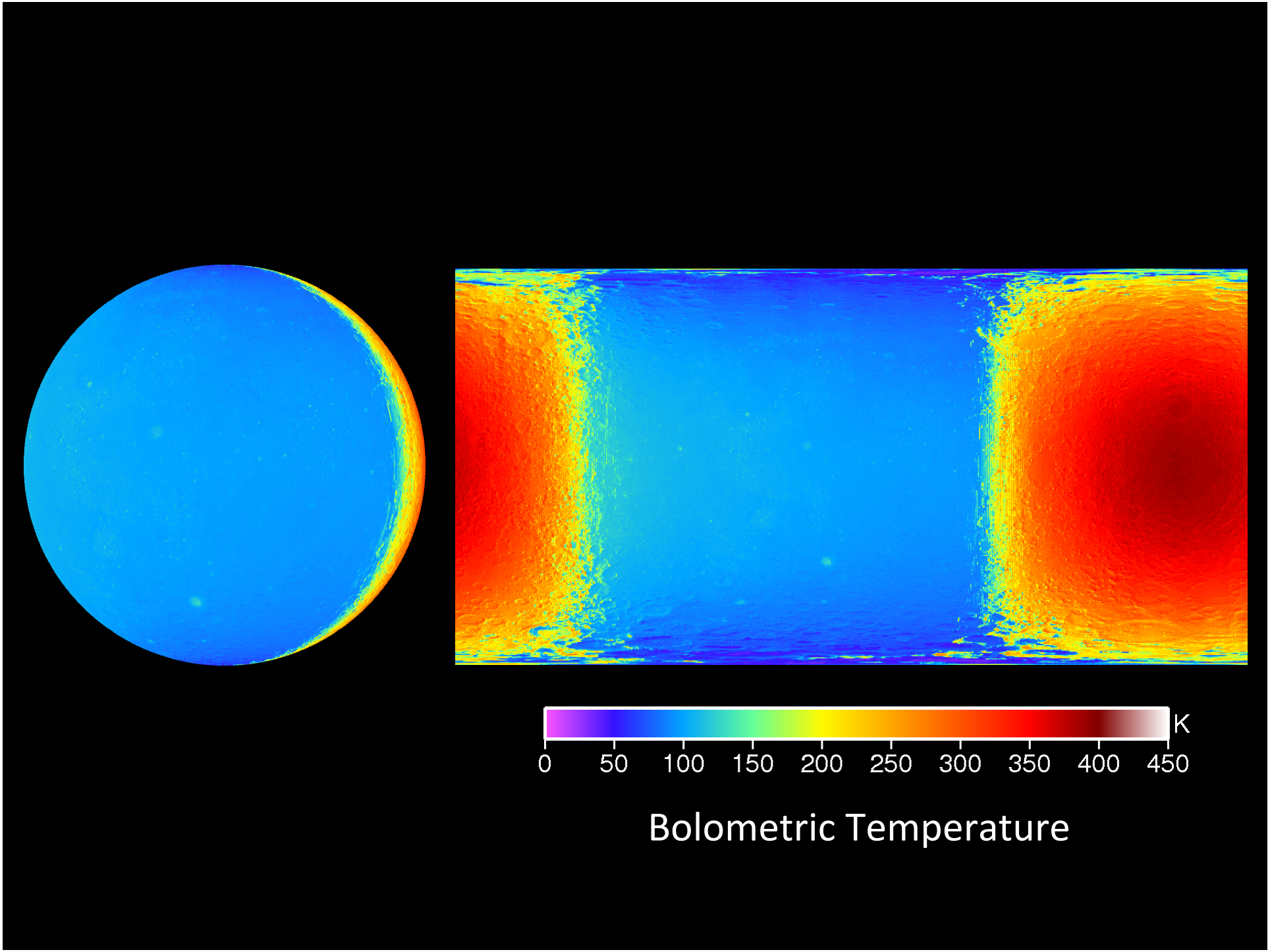
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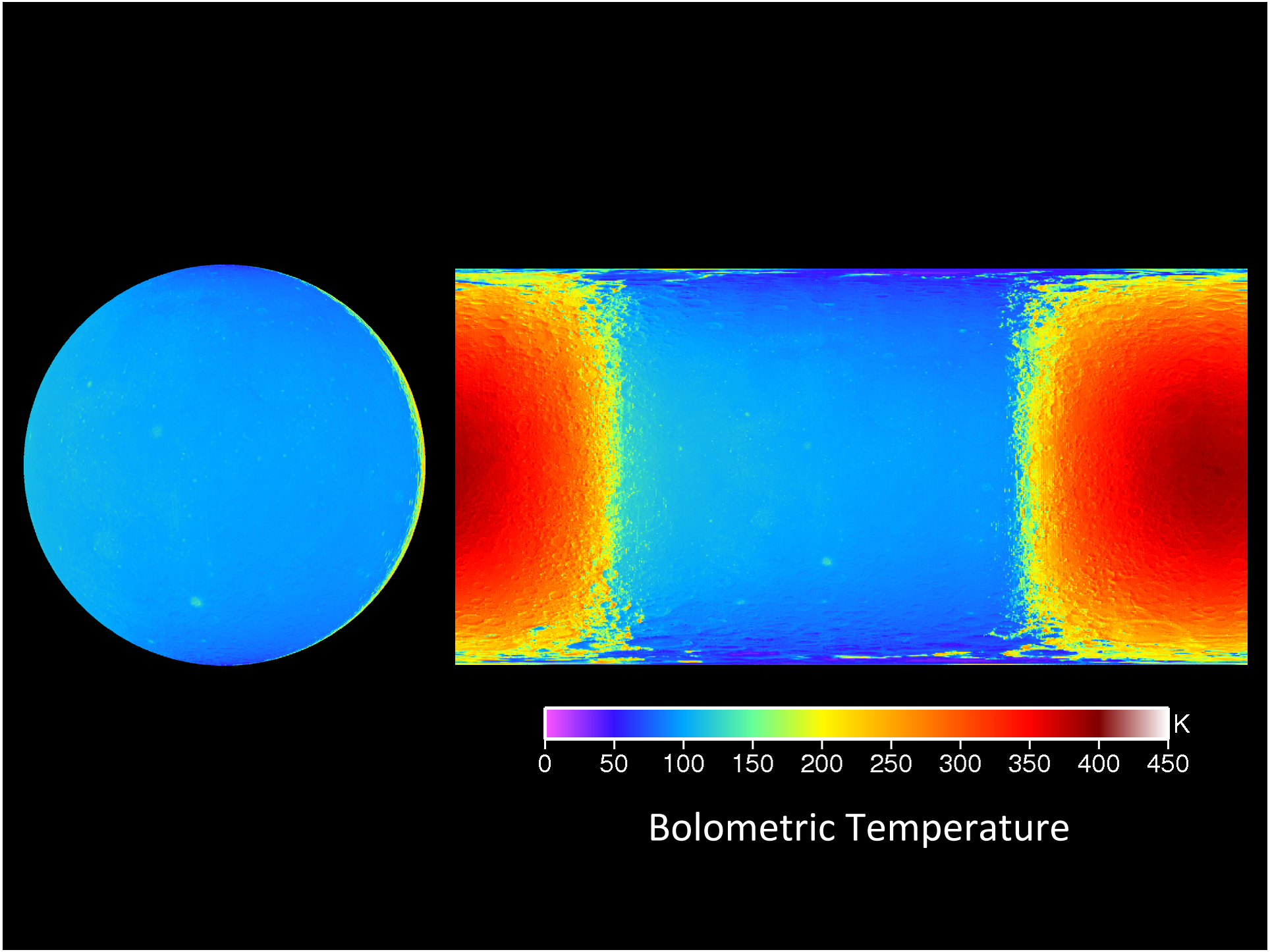
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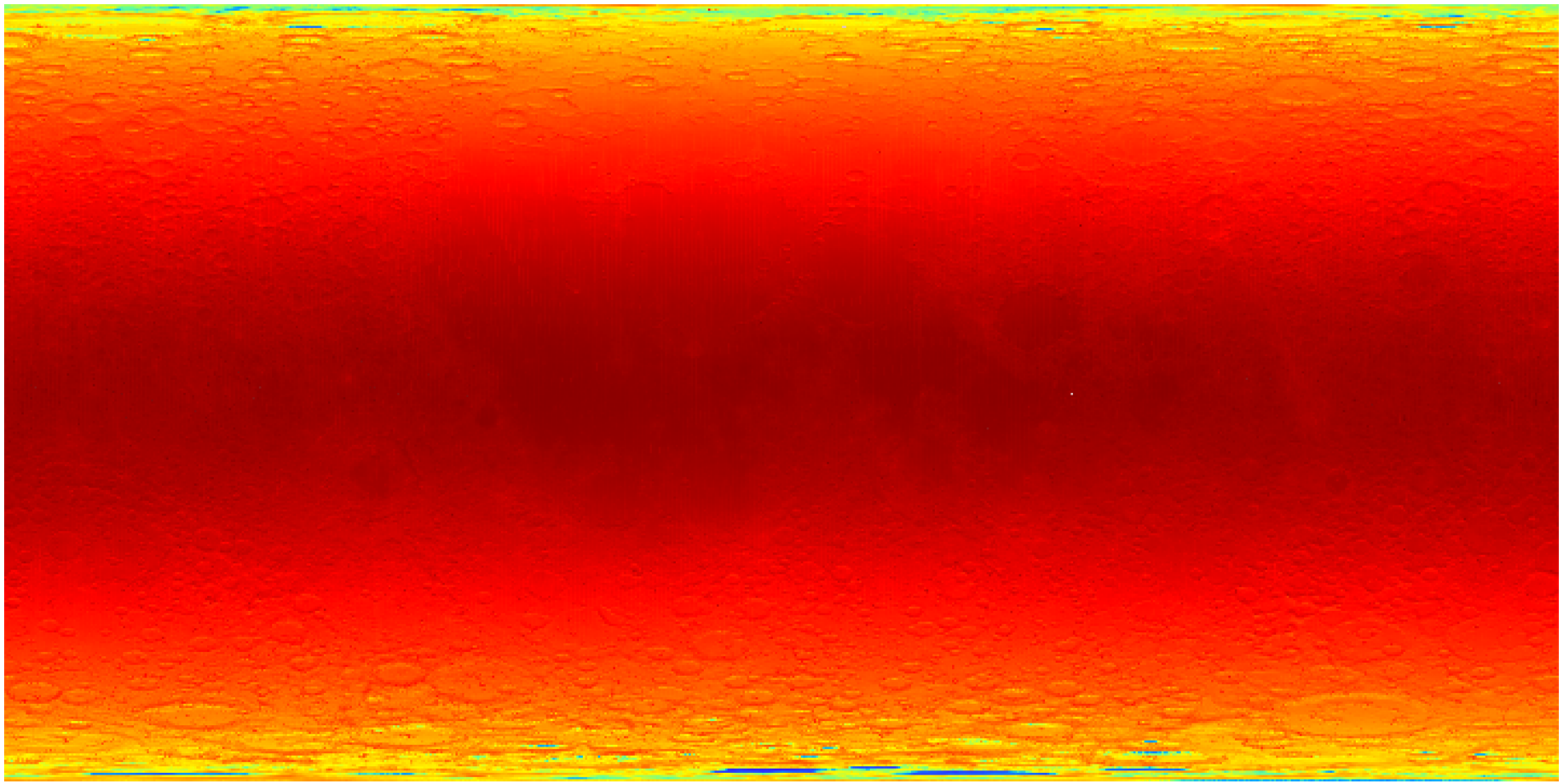
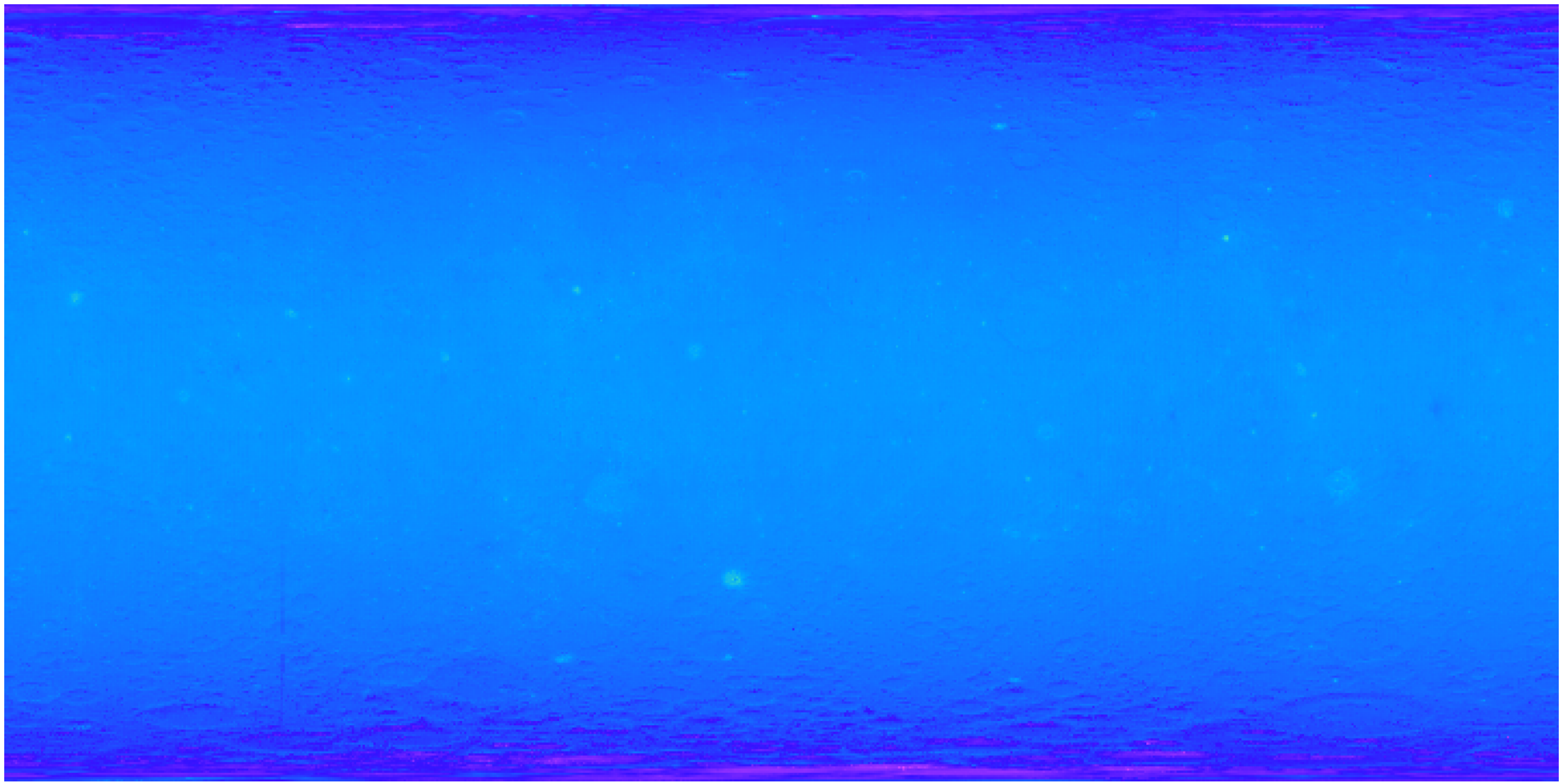
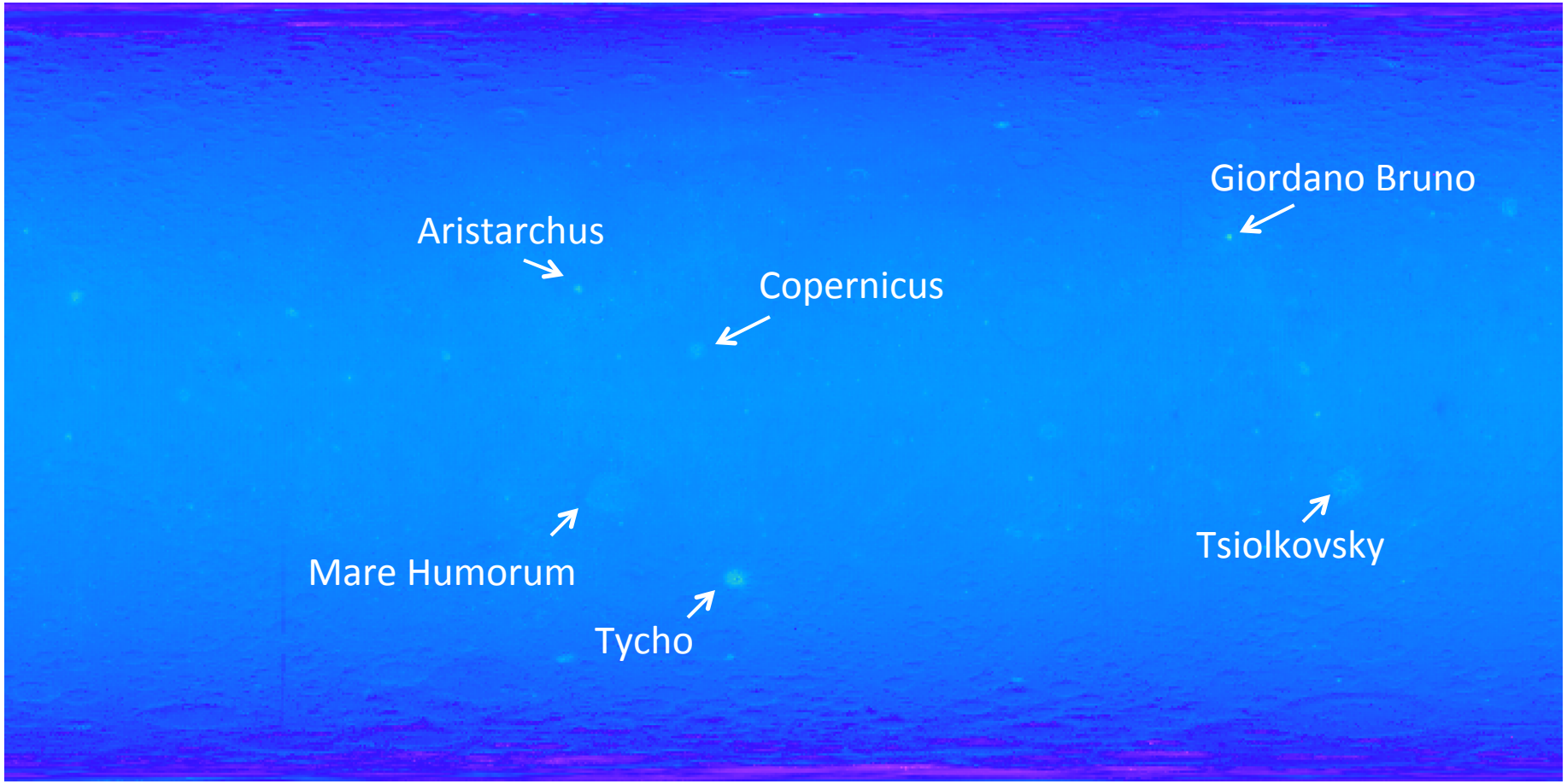
Maximum Global Temperatures

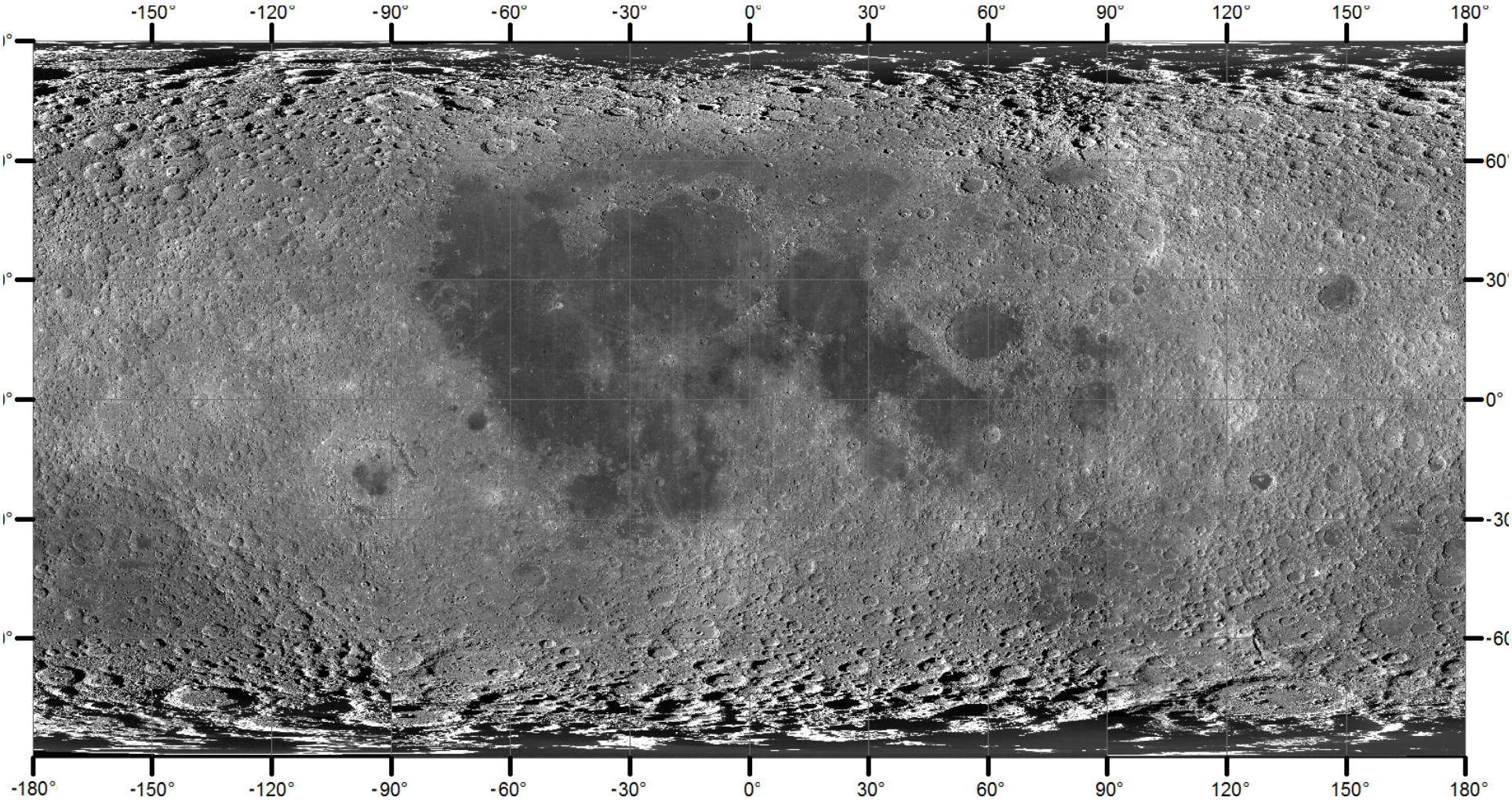


Minimum Global Temperatures



Minimum Global Temperatures

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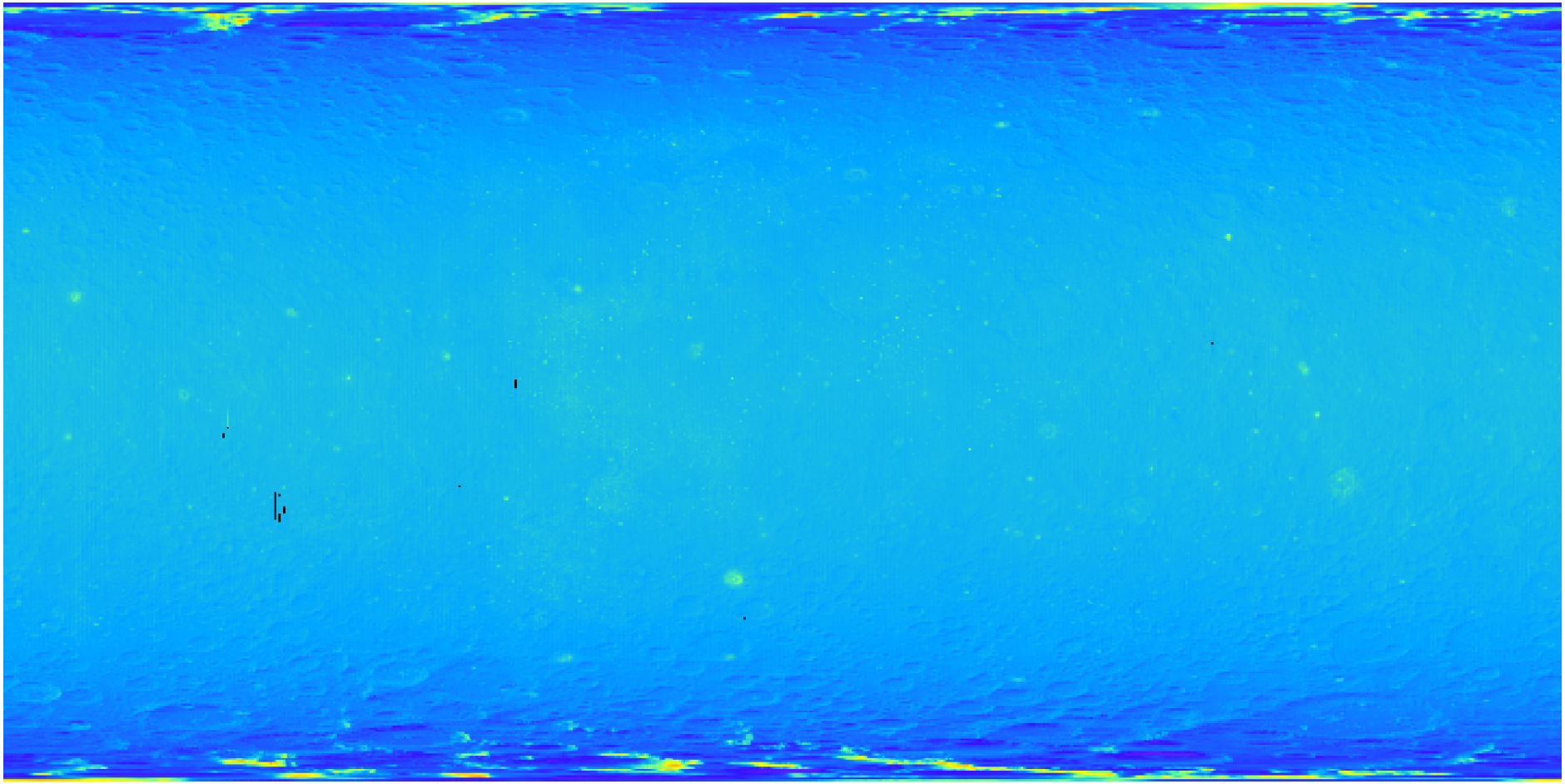

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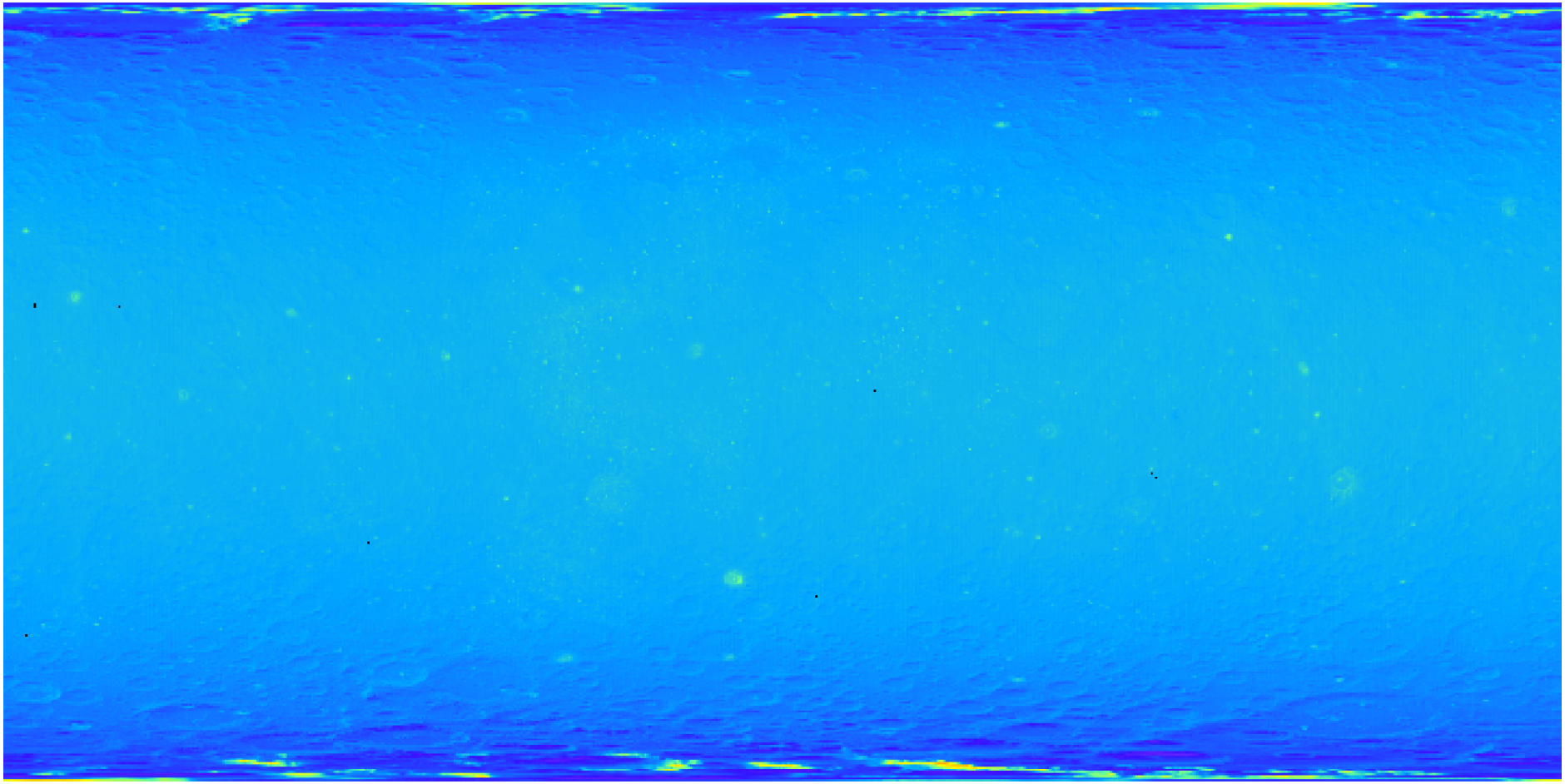

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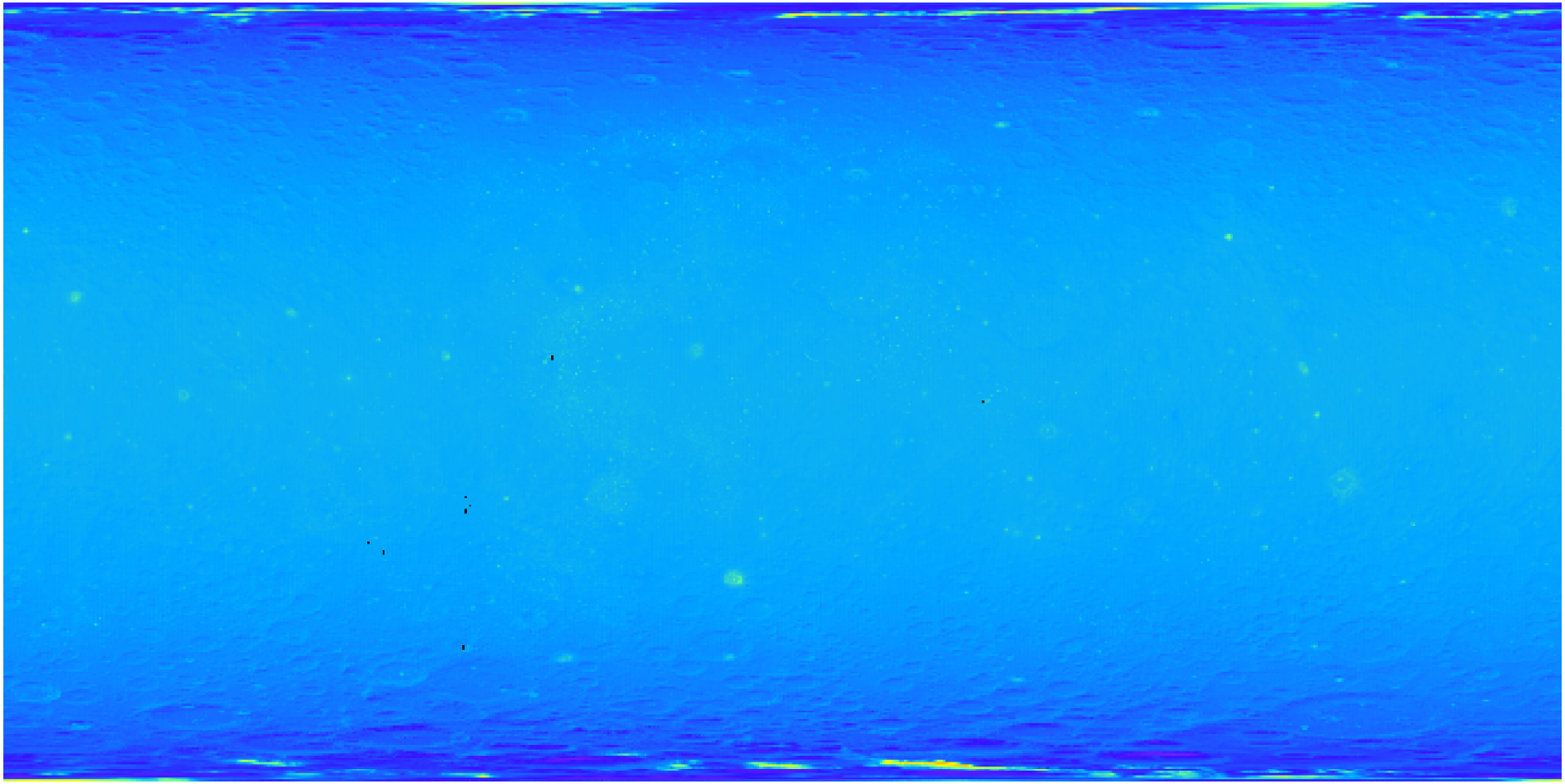

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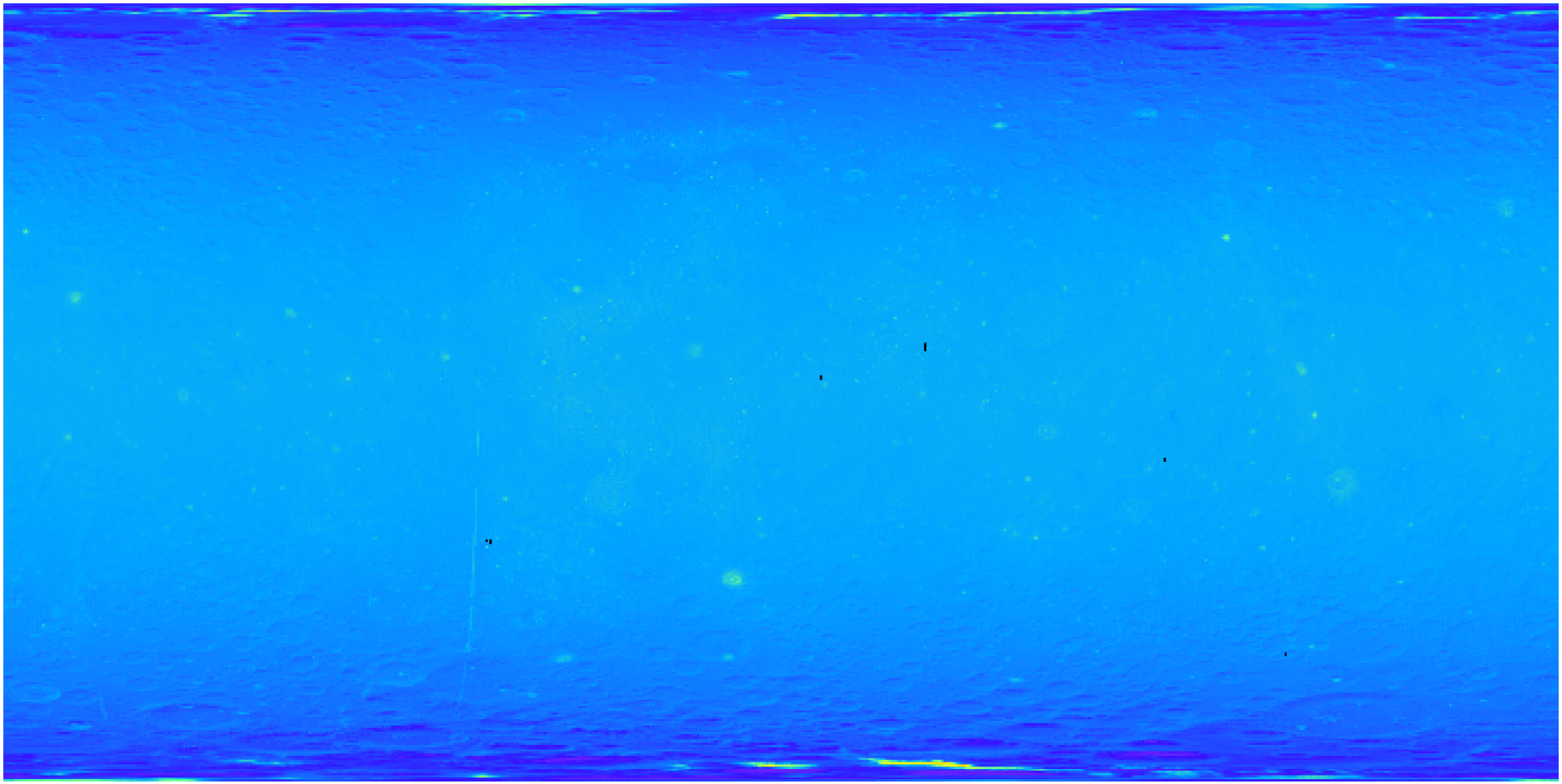

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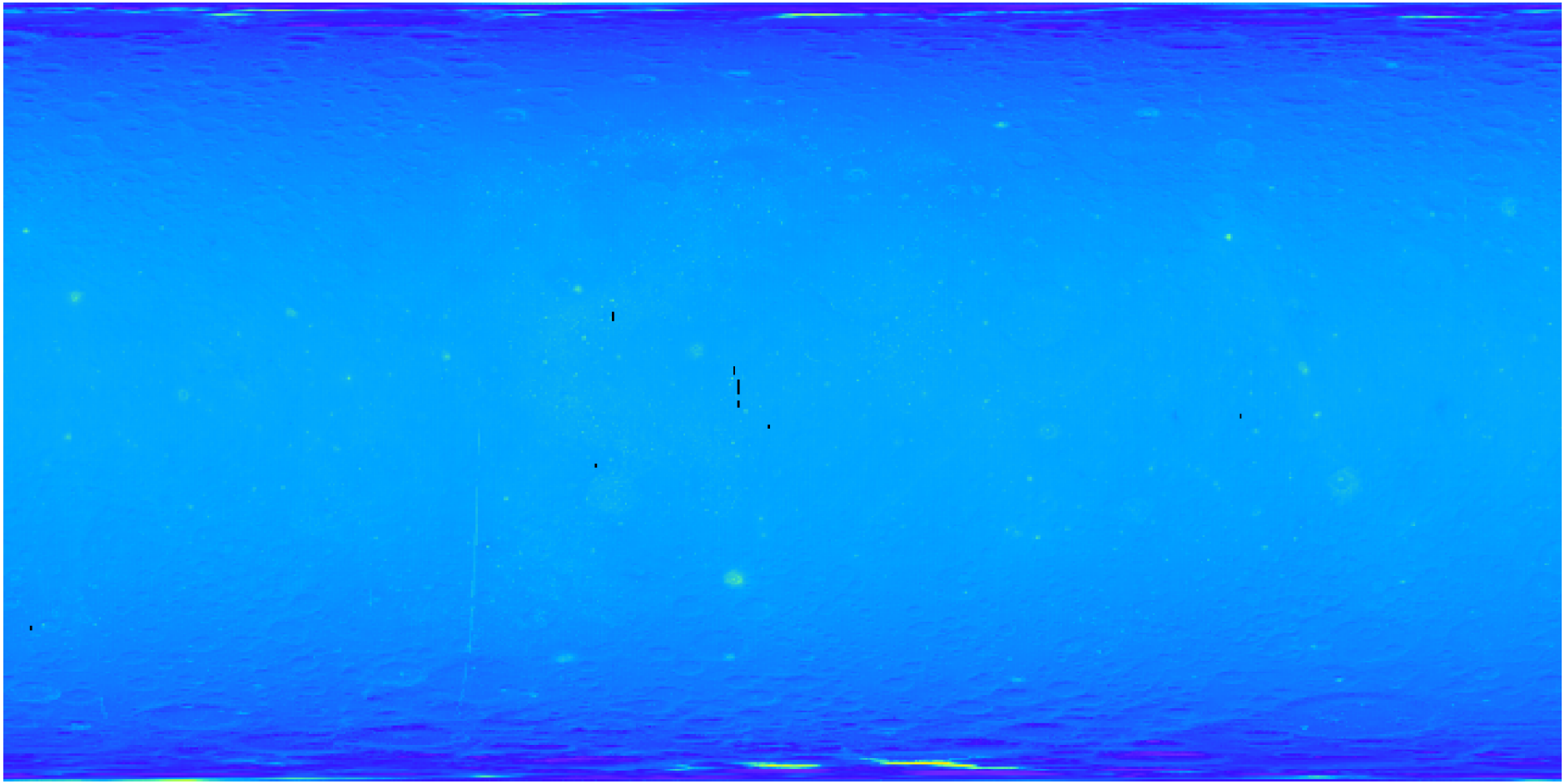

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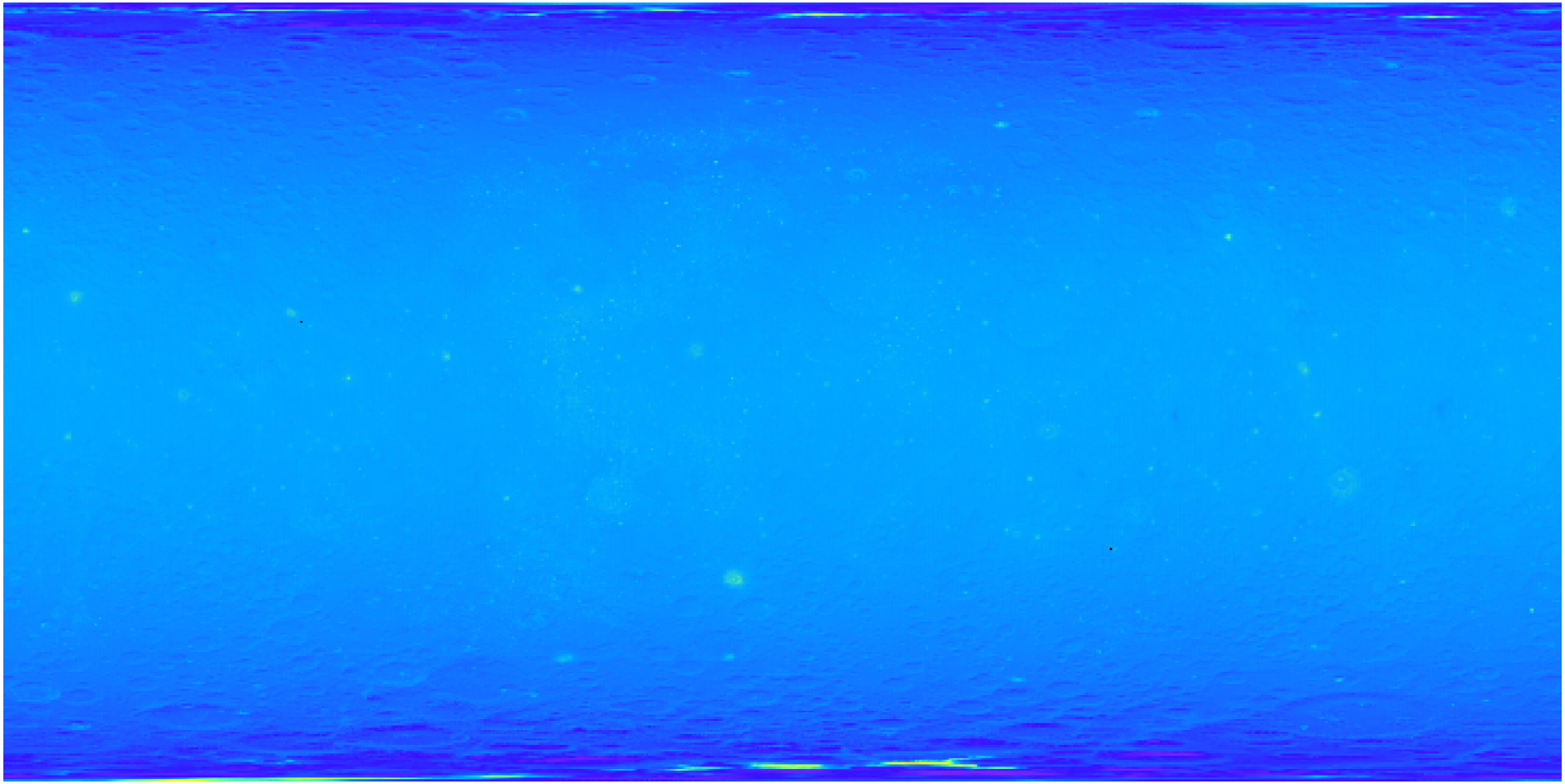
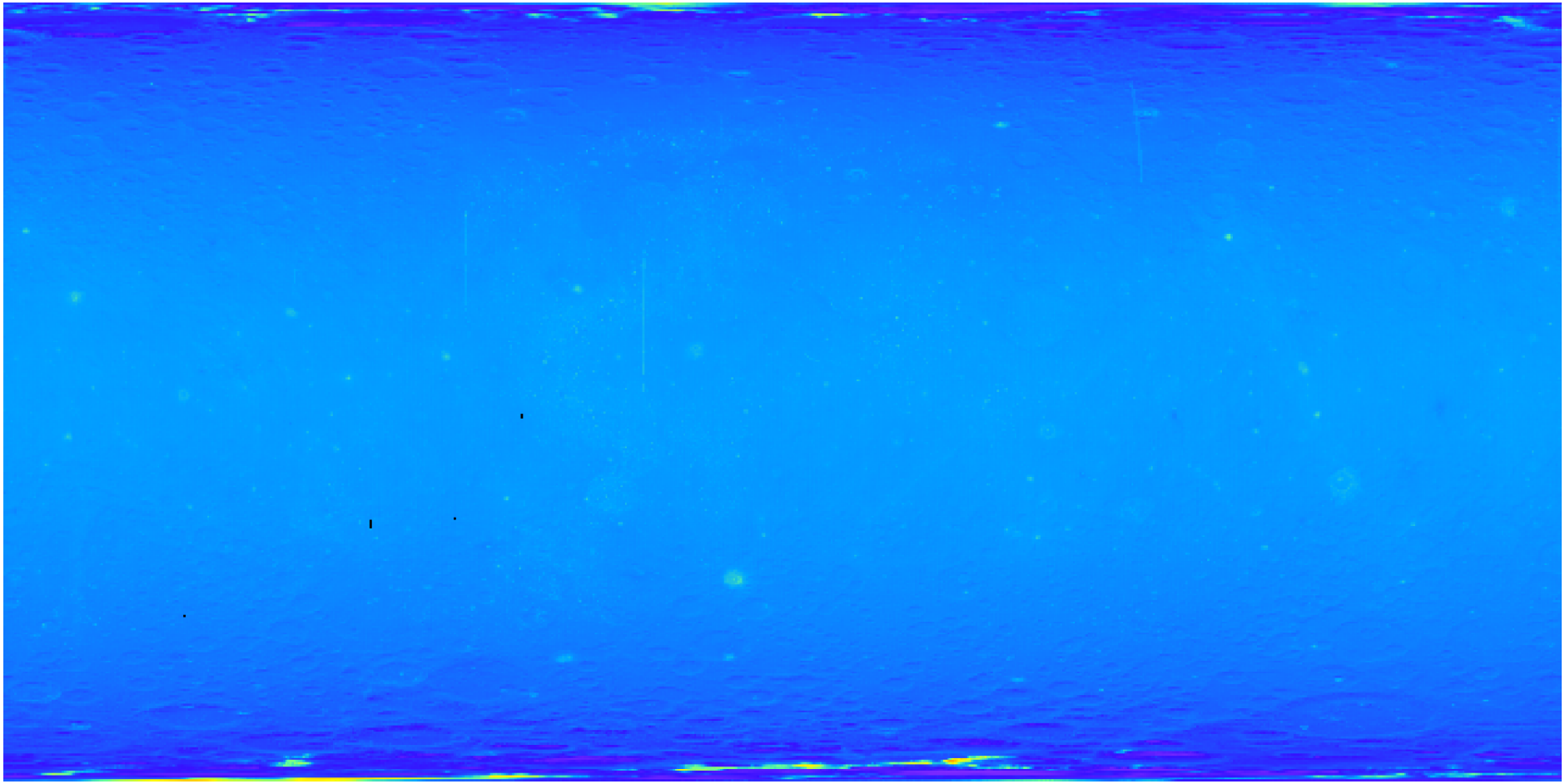
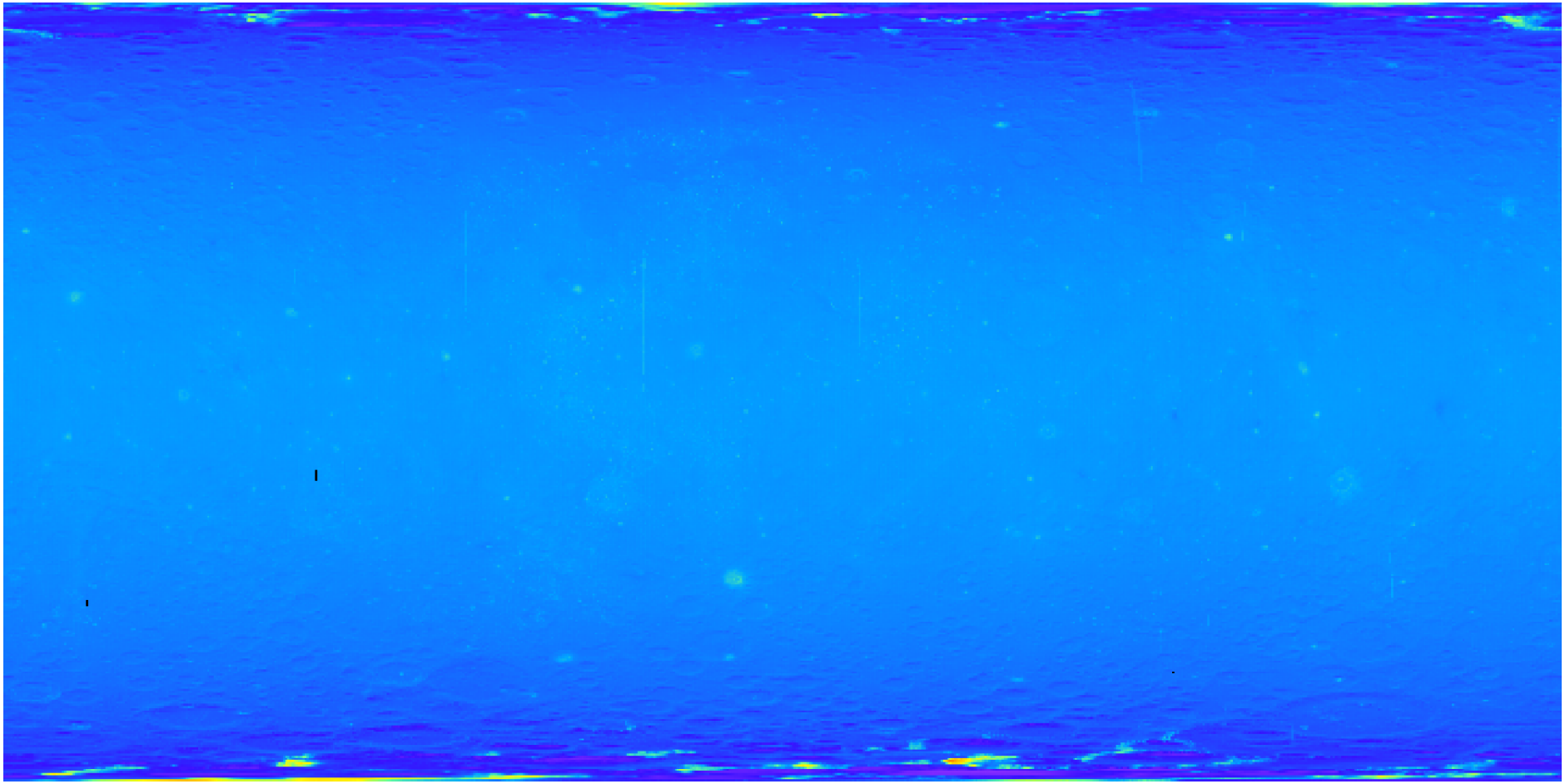


Local time: 1 hr

Local time: 2 hr

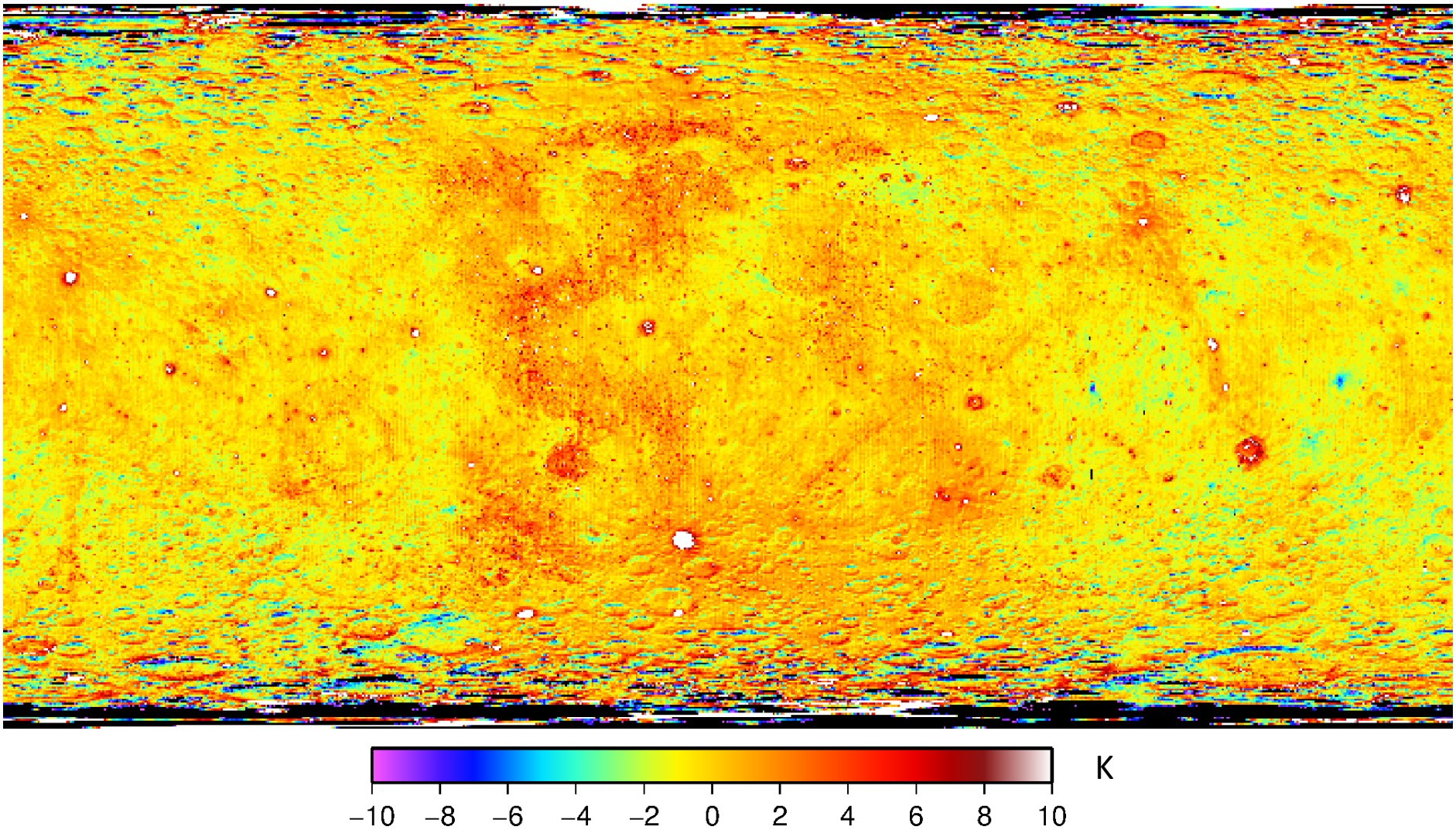


Local time: 3 hr



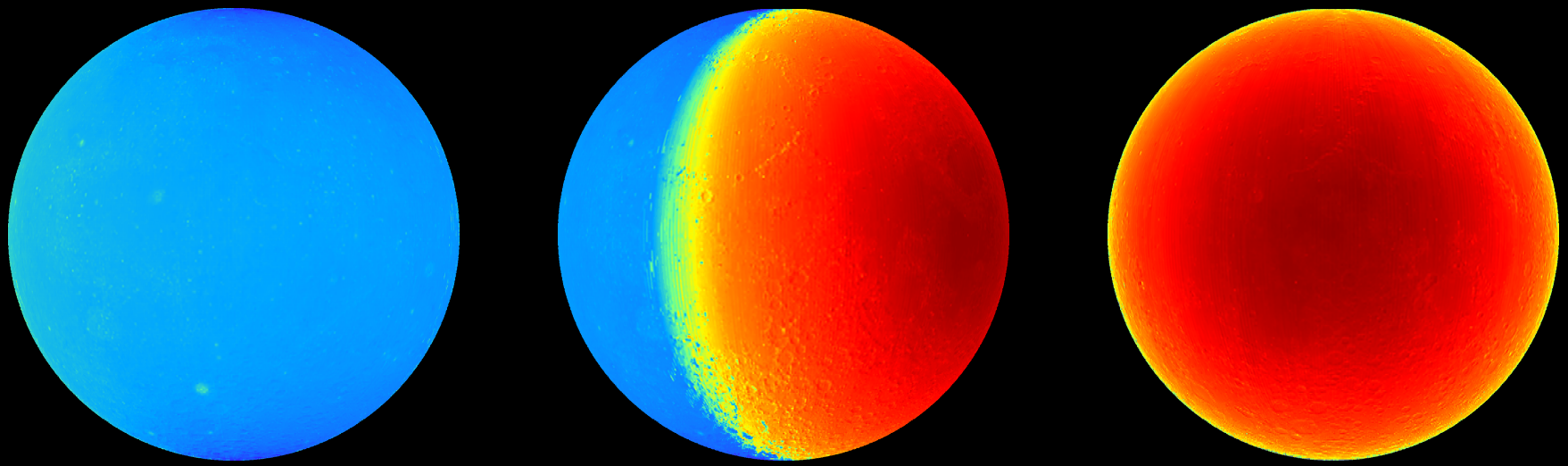
Local time: 4 hr

Nighttime T_{bol} – Nighttime Averaged T_{bol}



Summary

- Systematic observations of the global thermal state of the Moon
- Mapping global diurnal variability
- Characterize the surface energy balance
  - How does the lunar regolith stores and exchanges heat.
- Extremely complex thermal environment
  - Highly insulating surface
  - Lack of an appreciable atmosphere to buffer surface temperatures
  - Slow rotation
- Terminators and at high latitudes topography dominates the surface temperatures.
- Hottest temperatures, which are in near-equilibrium with the solar flux, are influenced by radiative properties of the surface.
- Nighttime temperatures determined by the radiation of sensible heat stored in the subsurface during the day and are sensitive to the thermophysical properties of the regolith.



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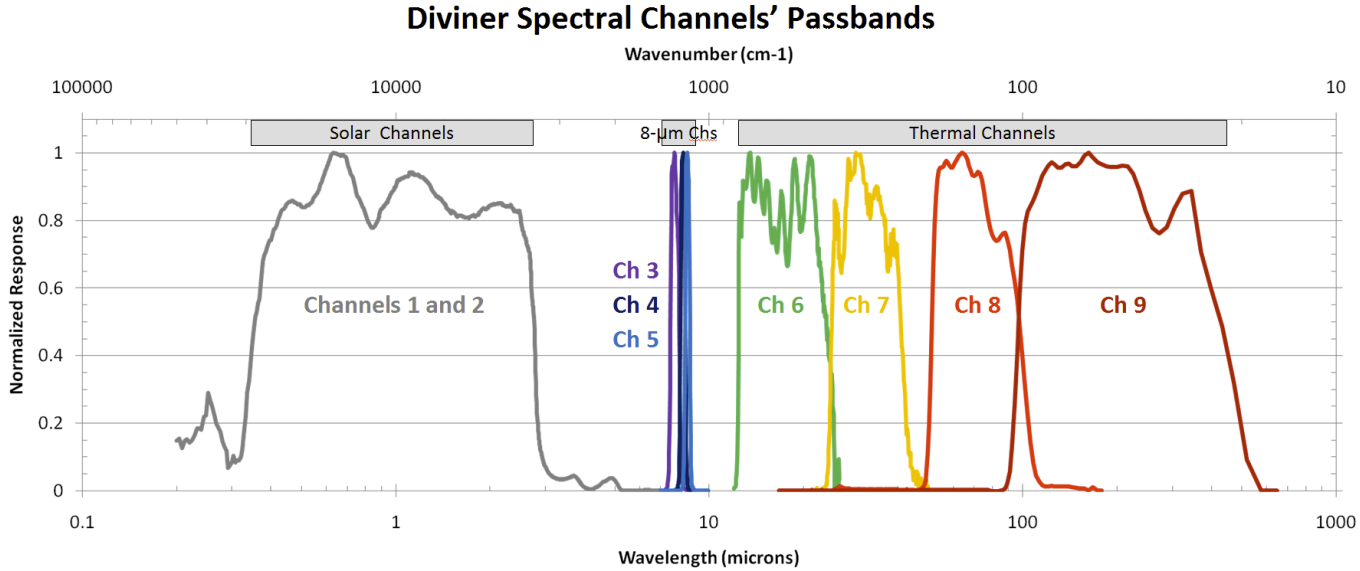
Diviner Spectral Channels



Channel Number	Channel Type	Channel Name	Passband µm	Measurement Function	Minimum Detectible Temperature (K)
1	Solar	High Sensitivity Solar	0.35-2.8	Reflected solar radiation, high sensitivity	-
2	Solar	Reduced Sensitivity Solar	0.35-2.8	Reflected solar radiation, reduced sensitivity	-
3	8 µm	7.8 µm	7.55-8.05	Christiansen feature	150
4	8 µm	8.25 µm	8.10-8.40	Christiansen feature	150
5	8 µm	8.55 µm	8.38-8.68	Christiansen feature	150
6	Thermal	13-23 µm	13-23	Surface Temperature (most sensitive channel for >178 K)	856
7	Thermal	25-41 µm	25-41	Surface Temperature (most sensitive channel for 69-178K)	55
8	Thermal	50-100 µm	50-100	Surface Temperature (most sensitive channel for 43-69 K)	40
9	Thermal	100-400 µm	100-400	Surface Temperature (most sensitive channel for <43 K)	30

Bolometric Brightness Temperature (TBOL)

- Measure of spectrally integrated flux of infrared radiation from the surface
- TBOL more directly related to heat balance of the surface
- Individual Diviner channels can exhibit anisothermality

In radiative equilibrium, the surface heat balance can be expressed as:

$$\sigma T_{BOL}^4 = \pi \int_0^\infty \varepsilon(\lambda) B(\lambda, T_s) = S_0(1 - A)$$

$$\sigma T_{BOL}^4 = \sum_{i=3}^{9} \sigma T_i^4 f(T_i, \lambda_1, \lambda_2) \qquad f(T_i, \lambda_1, \lambda_2) = \frac{\int_{\lambda_1}^{\lambda_2} B(\lambda, T) d\lambda}{\int_0^\infty B(\lambda, T) d\lambda}$$

For detailed description see:
Paige et al., *Diviner Lunar Radiometer Observations of Cold Traps in the Moon's South Polar Region*, *Science*, Vol 330, p479-482, 2010