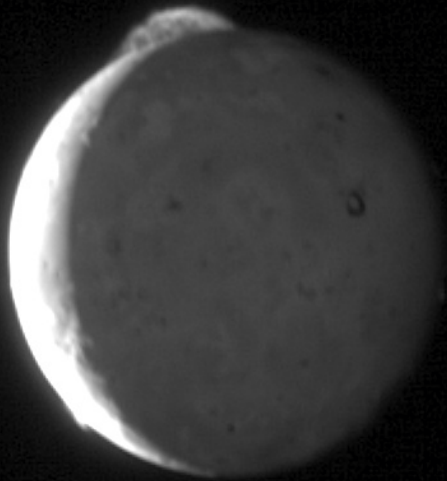


A closer look at Galileo Thermal data from a Possible Plume Source North of Pwyll, Europa

J. A. Rathbun (PSI, @LokiVolcano,
rathbun@psi.edu), J. R. Spencer
(SWRI)

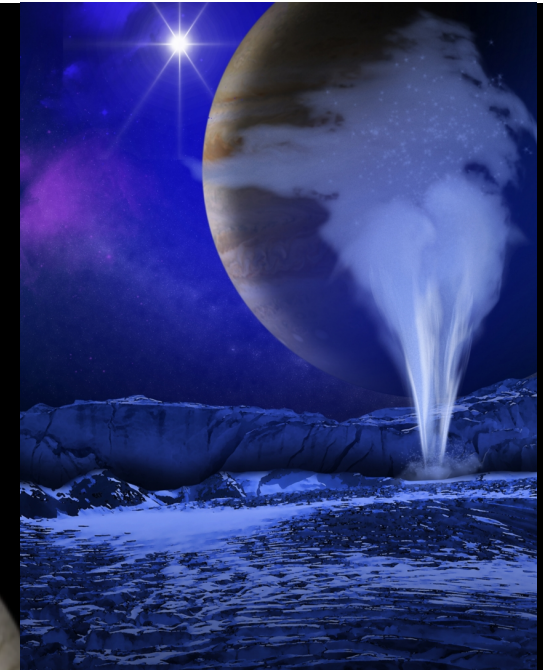
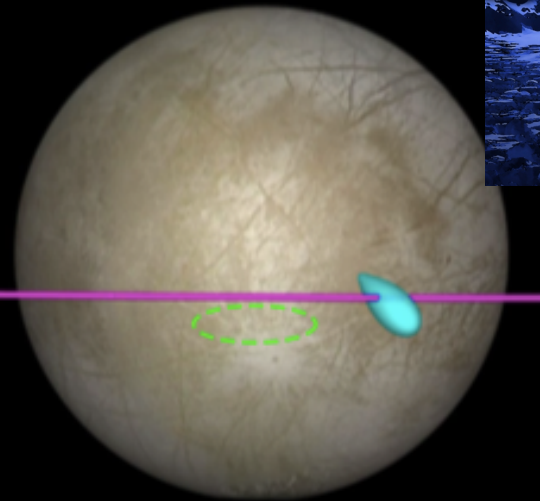
Plumes in the Solar System

- Many active worlds have plumes: Io, Enceladus, Earth

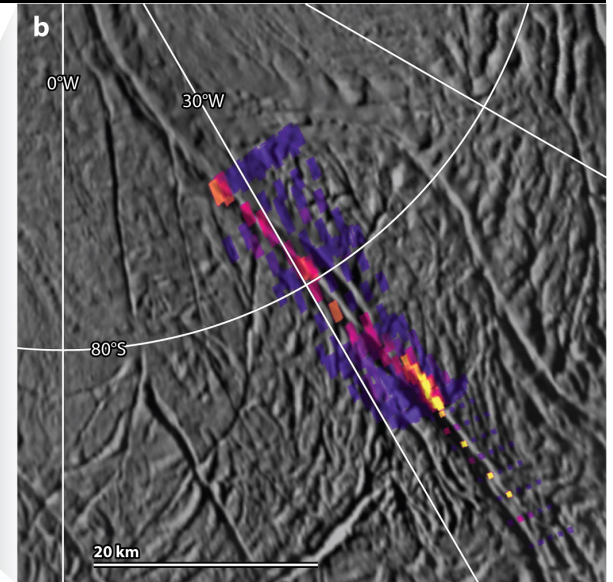
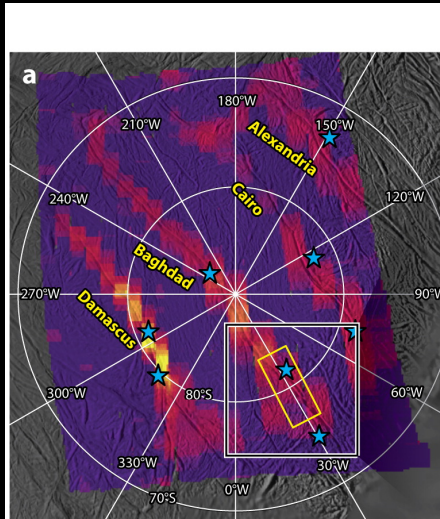
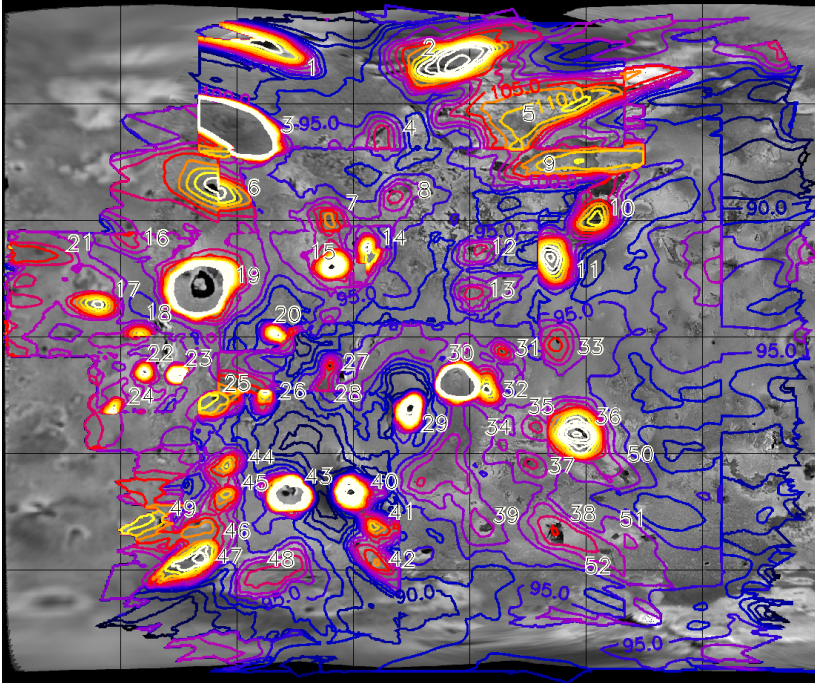


Plumes on Europa?

- None observed by spacecraft
- Expected due to geologic activity
- Recent observations by HST are **consistent** with a plume (Sparks et al., 2016, 2017)
- Reanalysis of Galileo magnetic and plasma wave data **consistent** with a plume ~1000 km away



Plumes come from “hot” areas



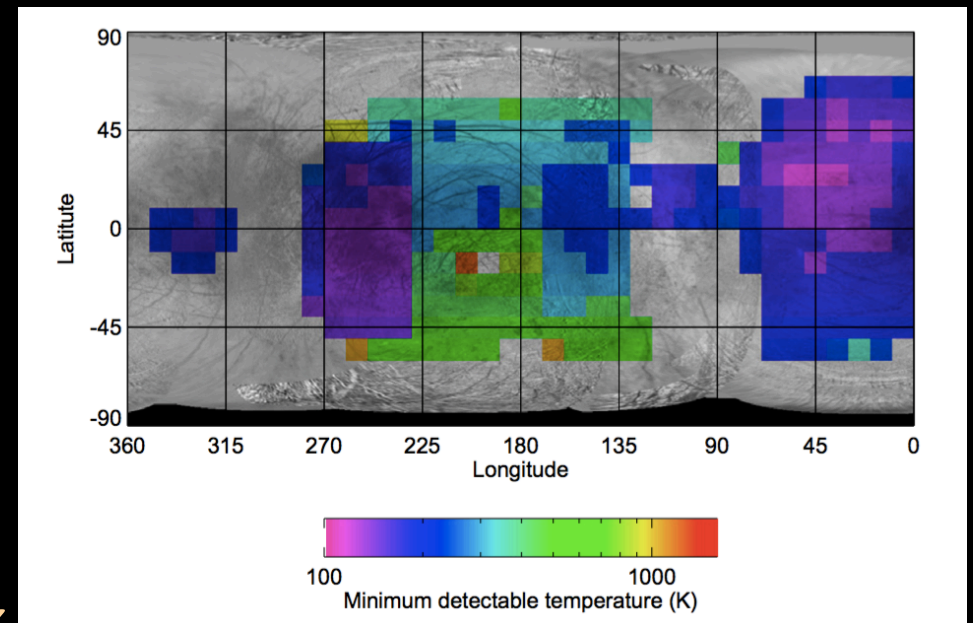
AR Spencer JR, Nimmo F. 2013.
Annu. Rev. Earth Planet. Sci. 41:693–717

“tiger stripes”

Is there a hot area at the source of Europa’s “plumes”?

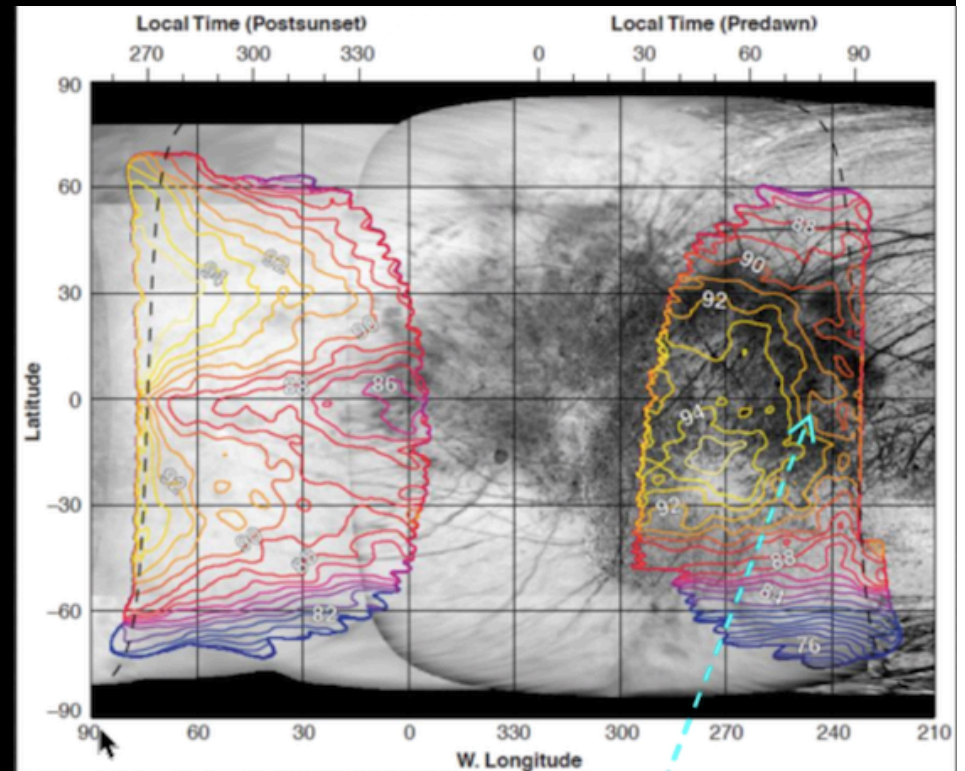
Hot spots on Europa?

- (Rathbun et al., 2010)
- Nothing obvious in a global search
- Depends on observation wavelength, resolution, etc.
- In some locations, a 1000 K small (100 km^2) feature could be on the surface and we would NOT have seen it



Model Thermal properties

- Observed temperatures are consistent with passive reaction to sunlight.
- Data used: Galileo PPR
 - ground-based ALMA data (Trumbo, et al, 2017)
- Model considers how surface responds to sunlight
- **Hotspots not required at either location of “plumes”**



Why no hotspots? Possibly:

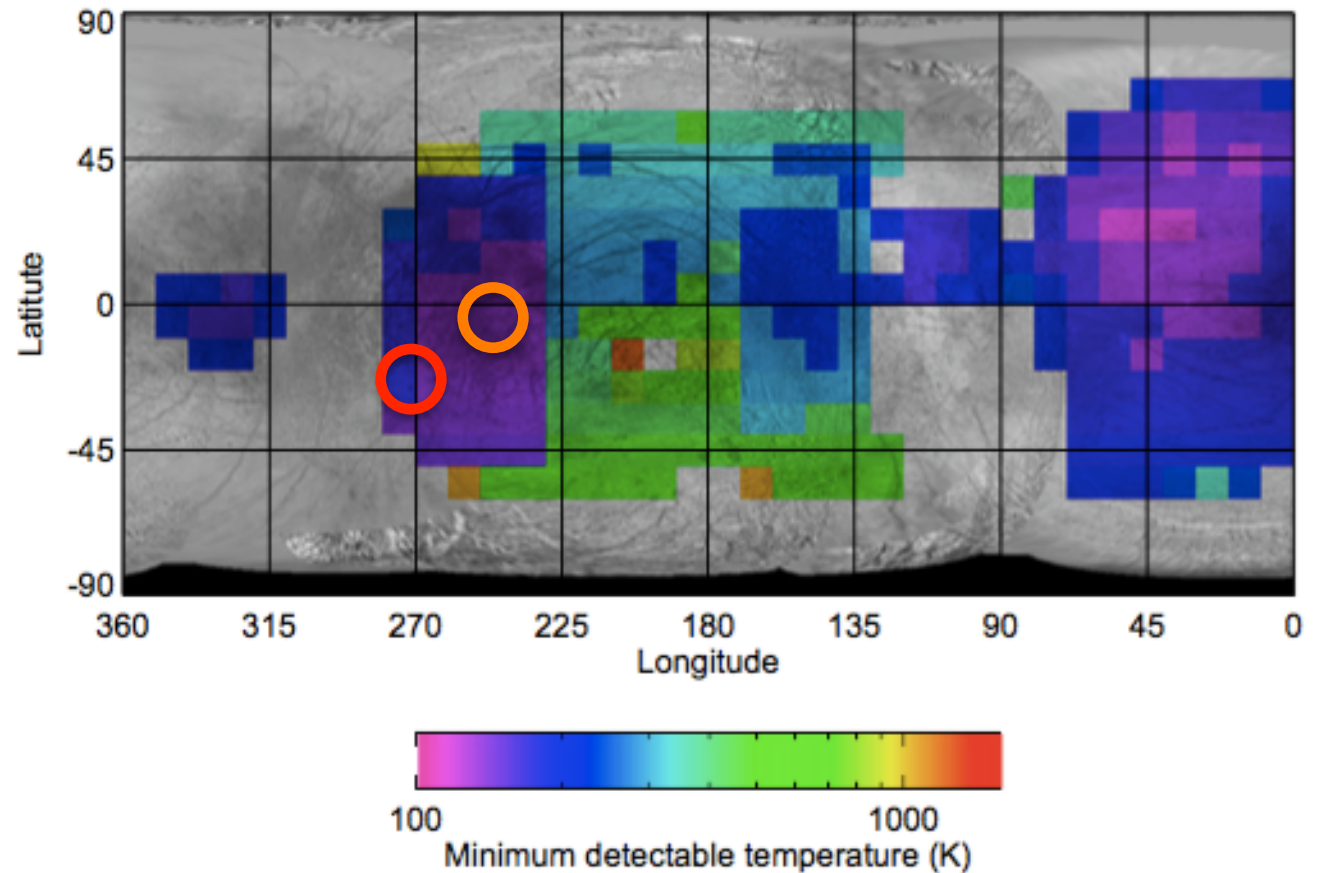
1. No plumes
2. Europa's plumes are not constant
3. Europa's plumes are different than others observed
4. Hotspots are smaller than we can detect with current data
 - A 100 km² feature 170K could be in either location and not be observed in either dataset. Not a “tiger stripe”.

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Back-up slides

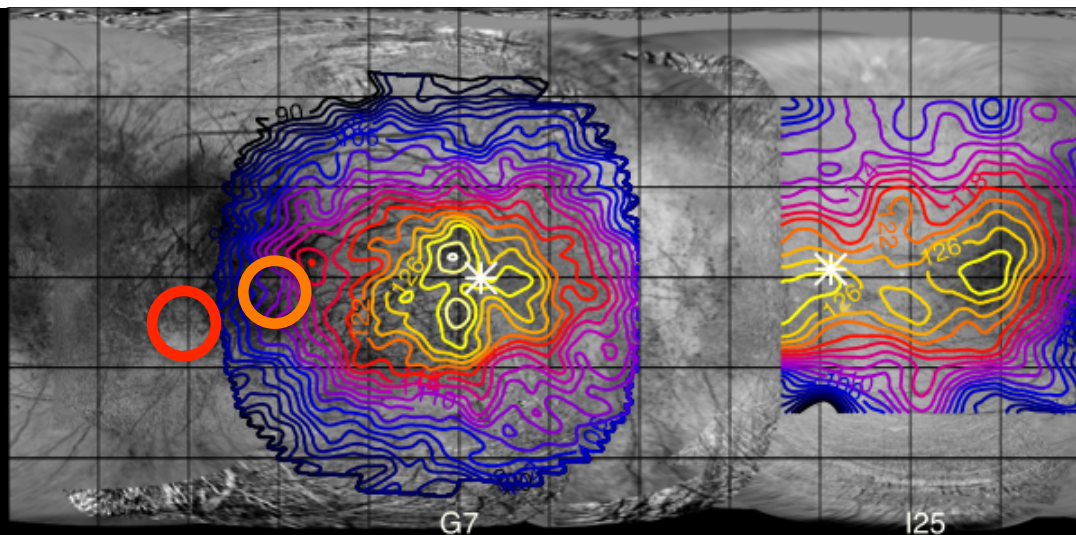
Hotspot limits from PPR data

- Rathbun et al. (2010)
- PPR would have detected a 100 km^2 hotspot if $T > \sim 170 \text{ K}$ (Sparks loc), $\sim 140 \text{ K}$ (Jia loc)

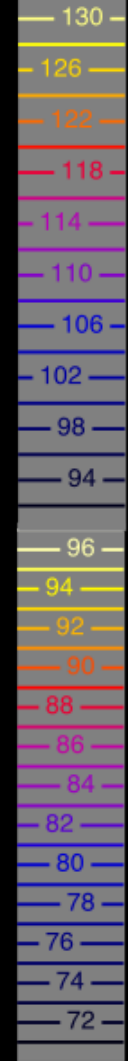
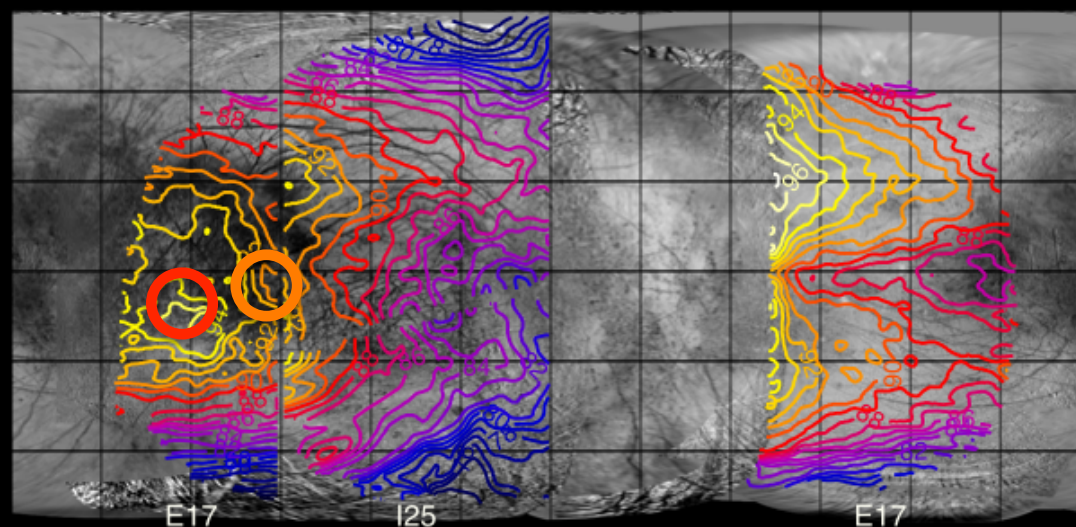


Best PPR

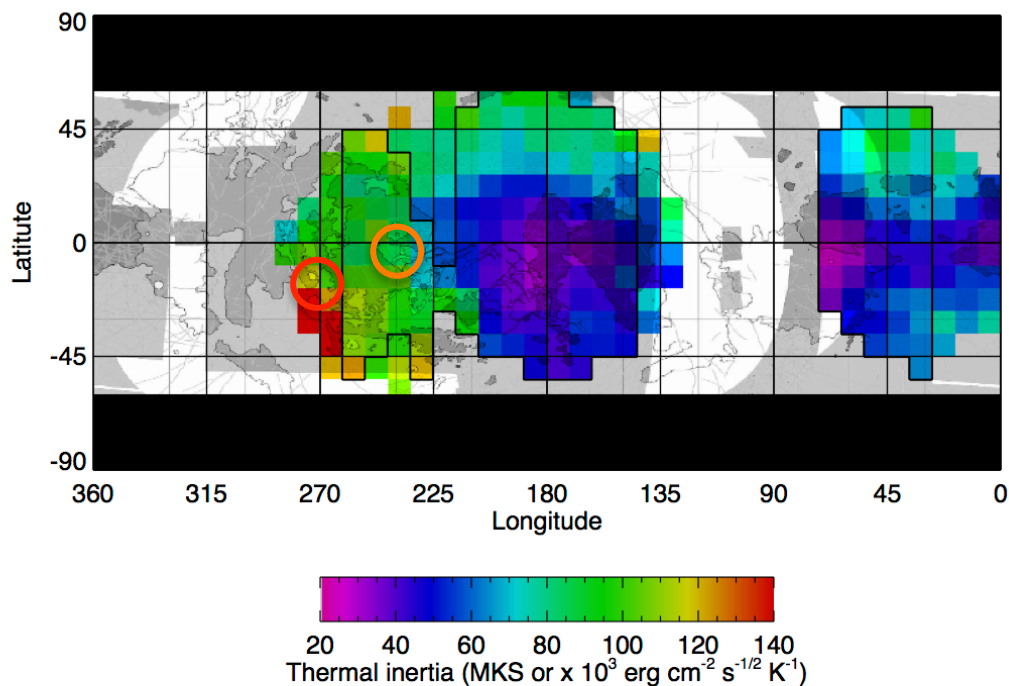
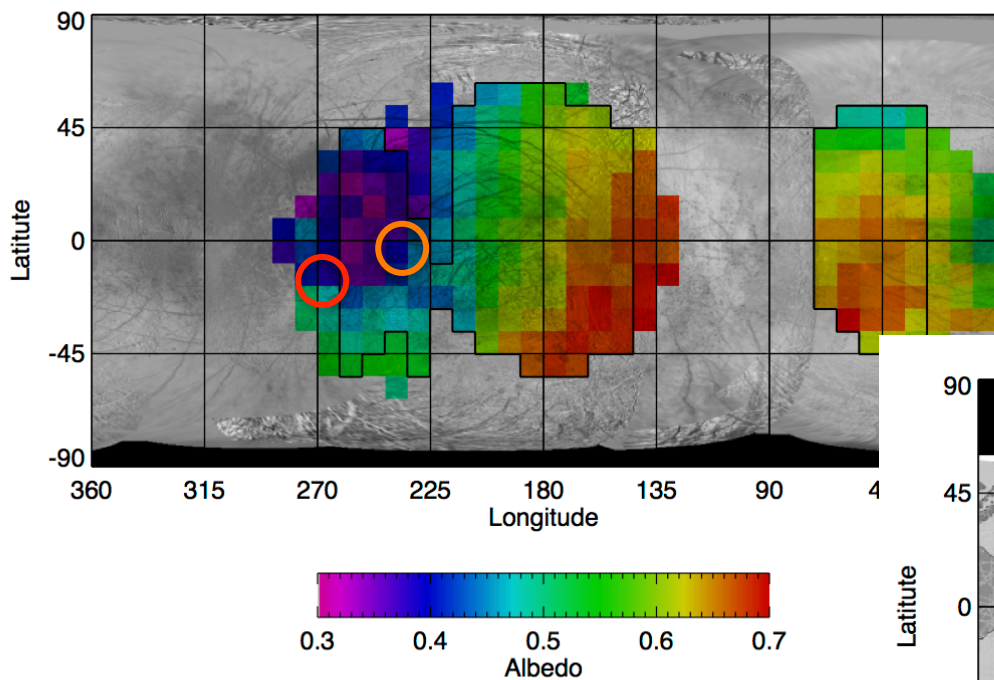
Daytime
temperatures



Nighttime
temperatures



Albedo & thermal inertia

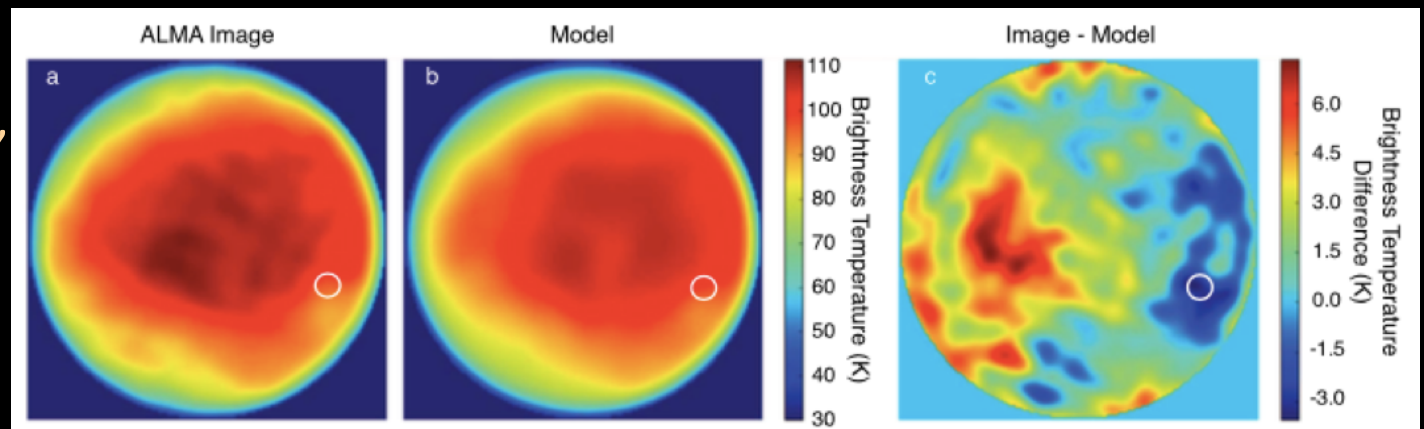


Rathbun and Spencer, 2014

- Jia location albedo ~ 0.4 , thermal inertia ~ 100 mks

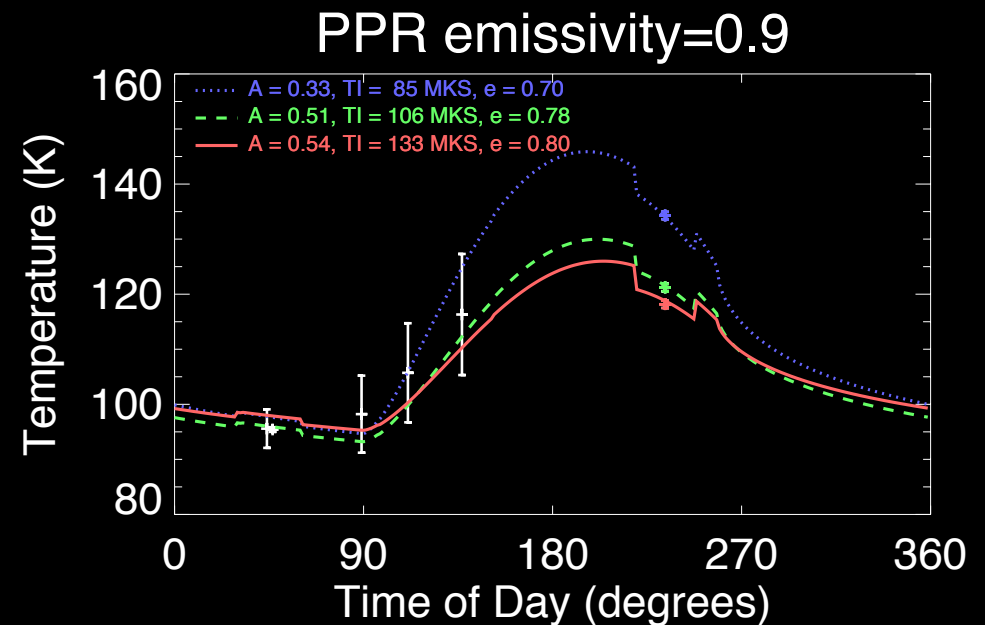
Sparks location – thermal model

- PPR observations at night and early-morning (3)
 - Early-morning in less sensitive filters: 27.5 (E6) & 35.5 μm
- No mid-day observations \rightarrow bad thermal model
- Trumbo et al. (2017) – observed location in daytime using ALMA (1.3 mm)
 - Colder \rightarrow thermal inertia $>$ surroundings, NOT endogenic heating



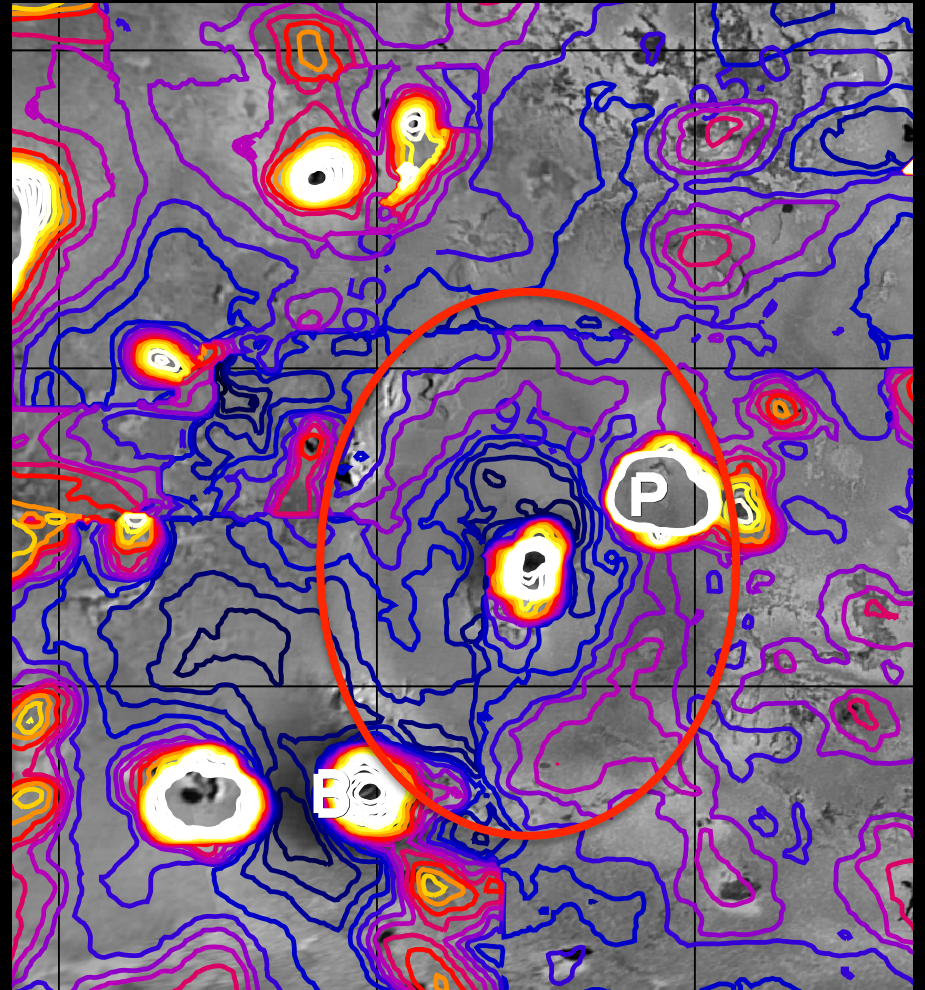
Favored model (Red line)

- Different emissivities, at PPR: 0.9 (Voyager value), at ALMA: 0.8 (Trumbo value)
 - Albedo: 0.54, thermal inertia: 133 MKS
 - similar to Trumbo, et al. (2017) and Rathbun and Spencer (2014) values
- Caveats
 - Different observing times
 - PPR: 12/1996 & 9/1998
 - ALMA: 11/2015
 - HST: 3/2014 & 2/2016
 - Different wavelengths
 - Probe to different depths



Plume?

- Nighttime temperatures of Io's Pele plume deposit higher than background
 - Different material
- Suggests higher thermal inertia in plume fallout
- No thermal inertia anomaly in the Jia location



Could a hotspot be hiding?

	Radius (km)	Area (km ²)	Temperature (K)	Brightness
ALMA data at 1.3 mm, Brightness in W/m/str				
background	156	2.4x10 ⁴	120 (emis corr.)	0.8
Hotspot	10	100	200	6x10 ⁻³
PPR data in open filter, Brightness in GW				
background	45	2.0x10 ³	95	9.2
Hotspot	10	100	170	4.7
“tigerstripe”	120 km long	86	133	1.5
PPR detection limits			2-5 GW	

Conclusions

Sparks location

- Endogenic heating not necessary
- Higher measured thermal inertias near Pwyll are consistent with higher thermal inertias in plume fallout from Io's Pele plume
- Need data from E-THEMIS on Europa Clipper
 - Multiple wavelengths simultaneously
 - Higher spatial resolution

Jia location

- Better observed by PPR
- Not located within PPR nighttime thermal anomaly
- Nothing in thermal data that suggests this location is special
- Seems too far from Sparks location (~1000 km) to be same plume source.