Taking the Temperature of Phoebe and Iapetus with Cassini's Composite Infrared Spectrometer (CIRS)

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CHARM Telecon, January 25th 2005

Black-body Radiation

- Any object warmer than absolute zero emits heat radiation
- The hotter the surface, the shorter the wavelength of the radiated light
  - Brightness and wavelength of the radiation gives the temperature
- Objects as cold as those in the Saturn system emit their radiation at long infrared wavelengths

Hot lava emits red and yellow light

Cooler lava emits red light

Even cooler lava emits only infrared light

Black-body Radiation, Continued

- Most solid or liquid surfaces emit similar radiation no matter what they are made of: “black body” radiation
  - It’s often hard to determine the composition of a surface from its thermal radiation
  - Some exceptions (e.g., discovery of hematite at Meridiani on Mars)

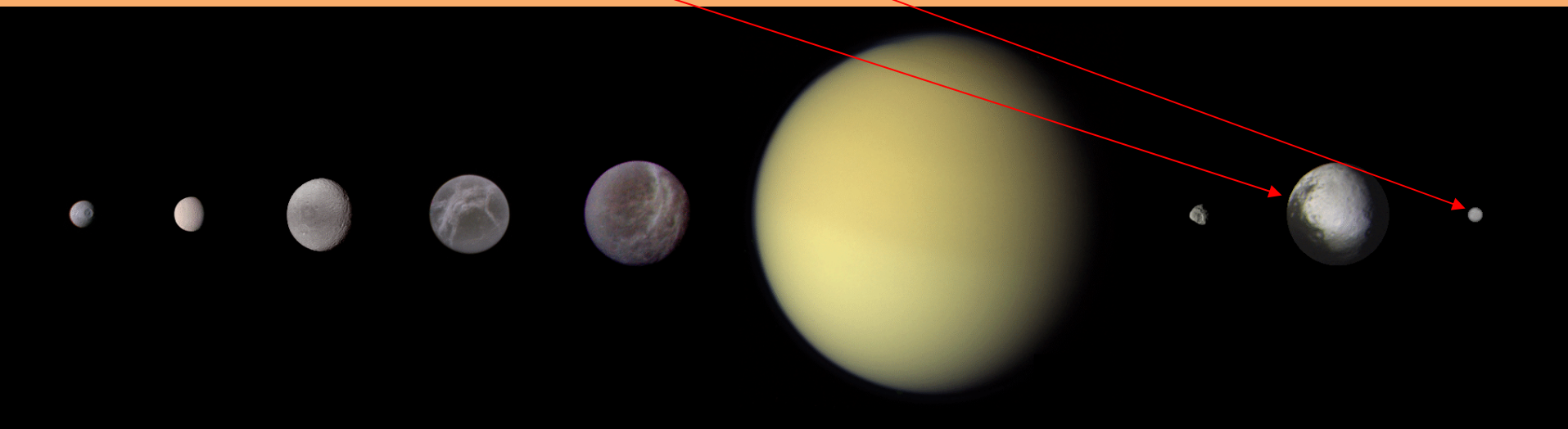
Heat radiation from hot rock looks the same as heat radiation from hot metal at the same temperature

CIRS: Composite Infrared Spectrometer

- Measures long-wavelength infrared (heat) radiation from Saturn, its rings, and moons.
- Sensitive to wavelengths between 7 and 300 microns (14 – 600 times longer wavelength than visible light)
- For objects with atmospheres (Saturn and Titan), CIRS provides detailed information on atmospheric composition and temperature.
- For objects without substantial atmospheres (Saturn's rings, and its smaller moons) CIRS provides mostly temperature information (though we might learn something about composition if we're lucky).

CIRS and Saturns's Small Satellites

- Extensive observations of most of the satellites are planned
  - Good data on only two so far (excluding Titan)
    - Phoebe, June 2004
    - Iapetus, Dec 2004 / Jan. 2005



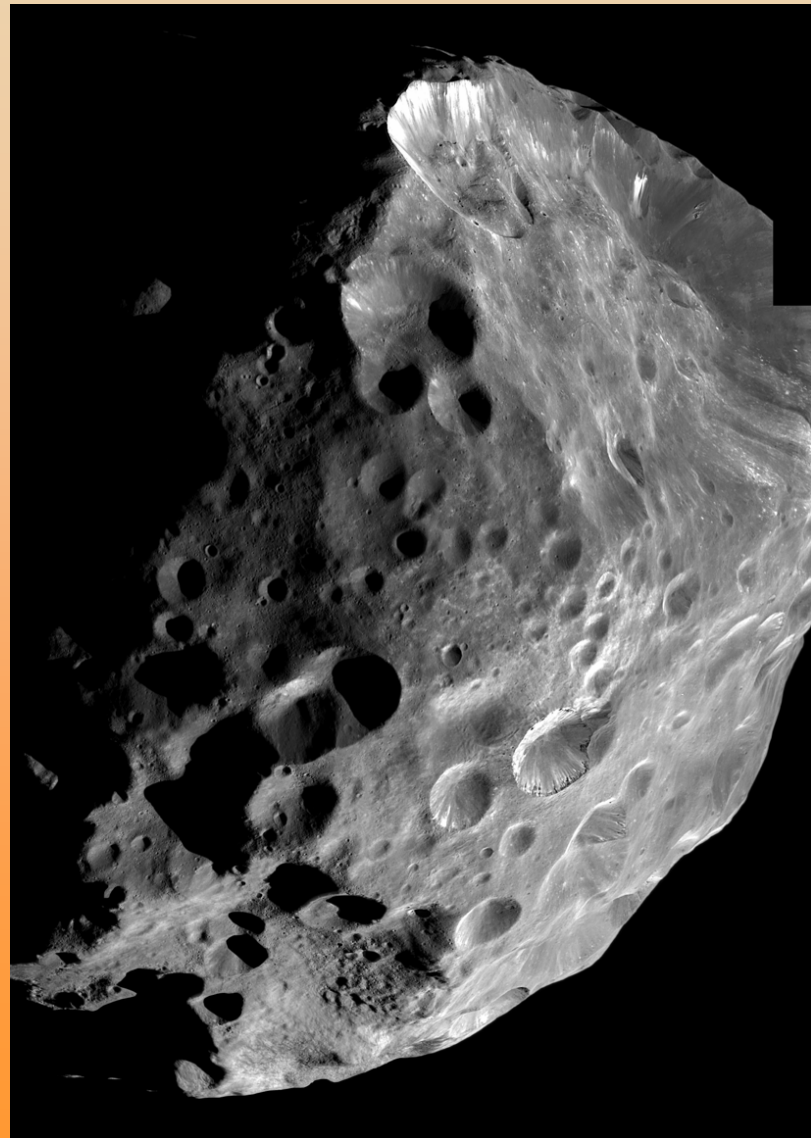
Phoebe: Outer “Irregular” Satellite of Saturn

Visited by Cassini before Saturn orbit insertion

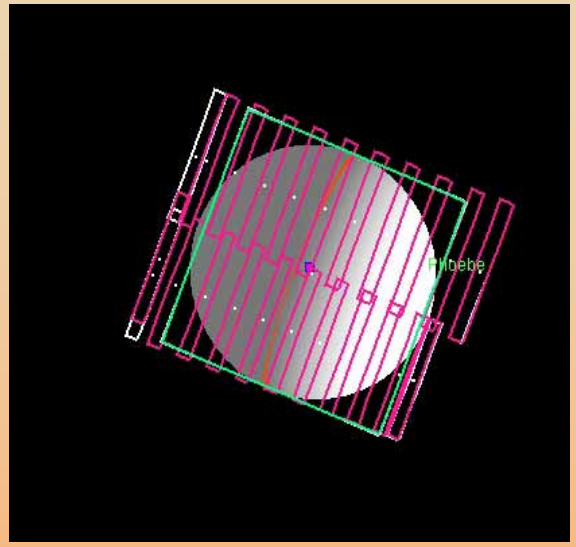
Phoebe is dark and therefore warm: its strong thermal radiation allows us to obtain detailed maps of surface temperatures

We measure temperature in Kelvin (K): degrees C above absolute zero.

100^{o} K = -173^{o} C = -279^{o} F



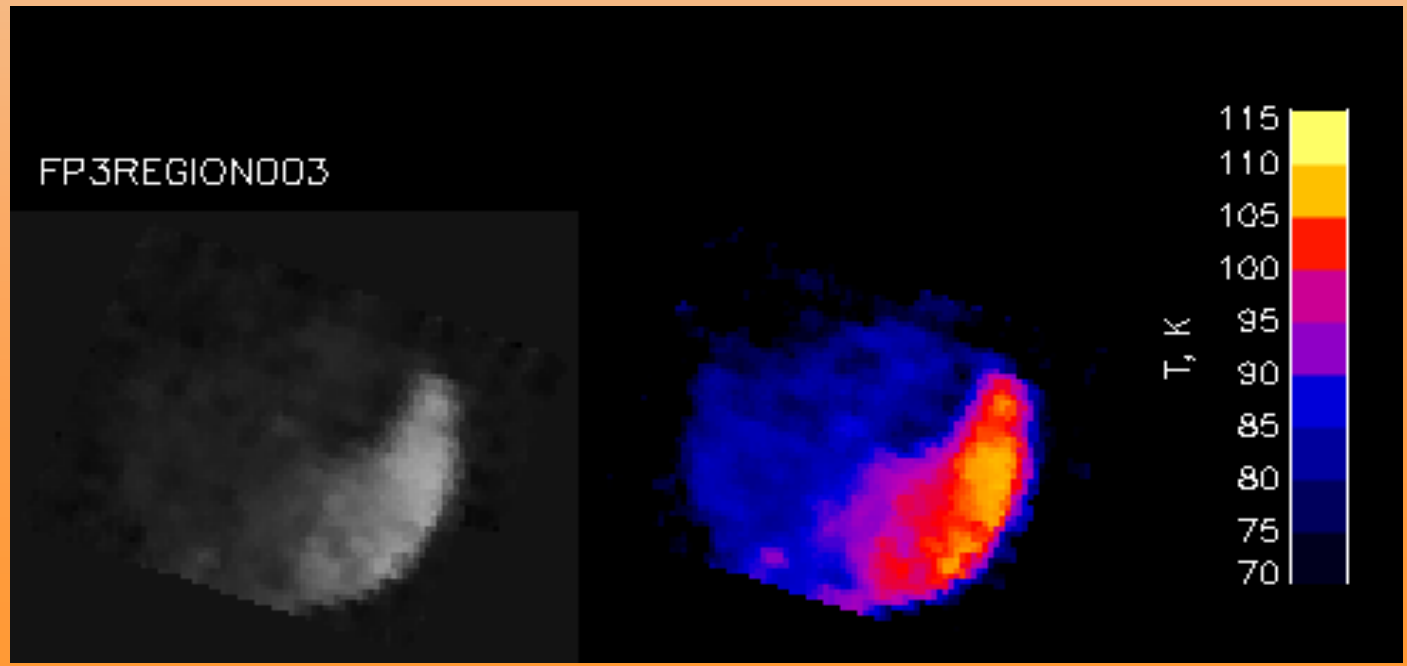
Approach to Phoebe



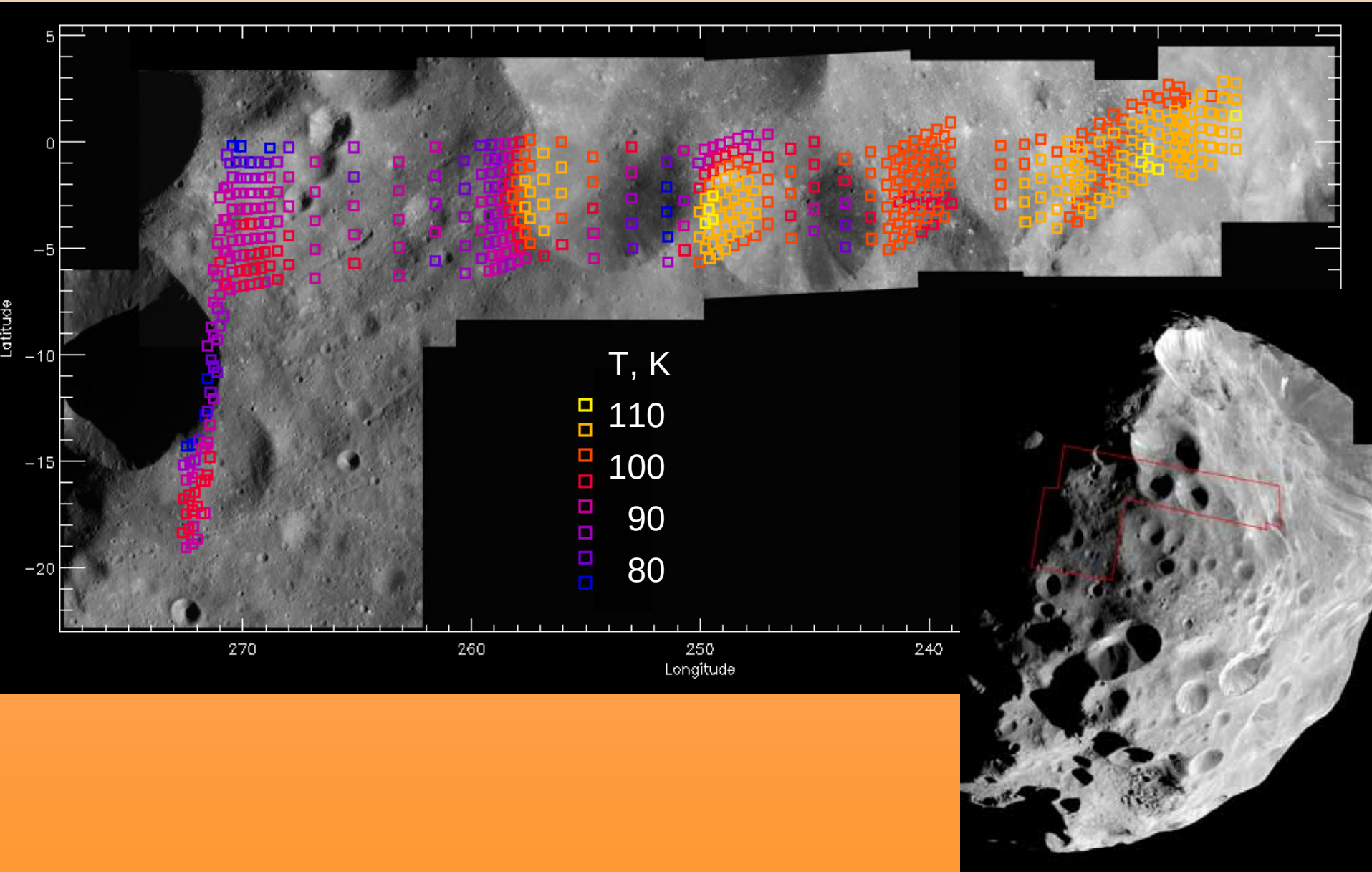
During sunrise on the big crater Jason

1:50h prior to close approach:
Range: 42,000 km

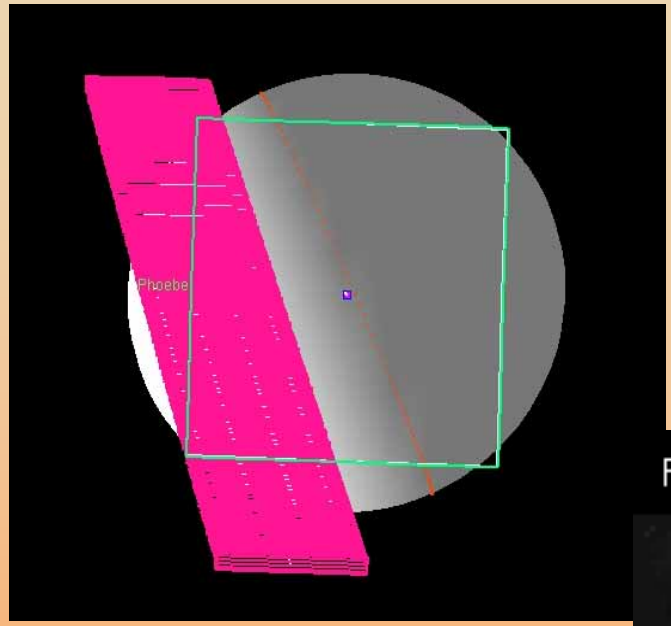
See night side before dawn: coldest time of day (~80 K)



Close approach ride-along



Departure from Phoebe

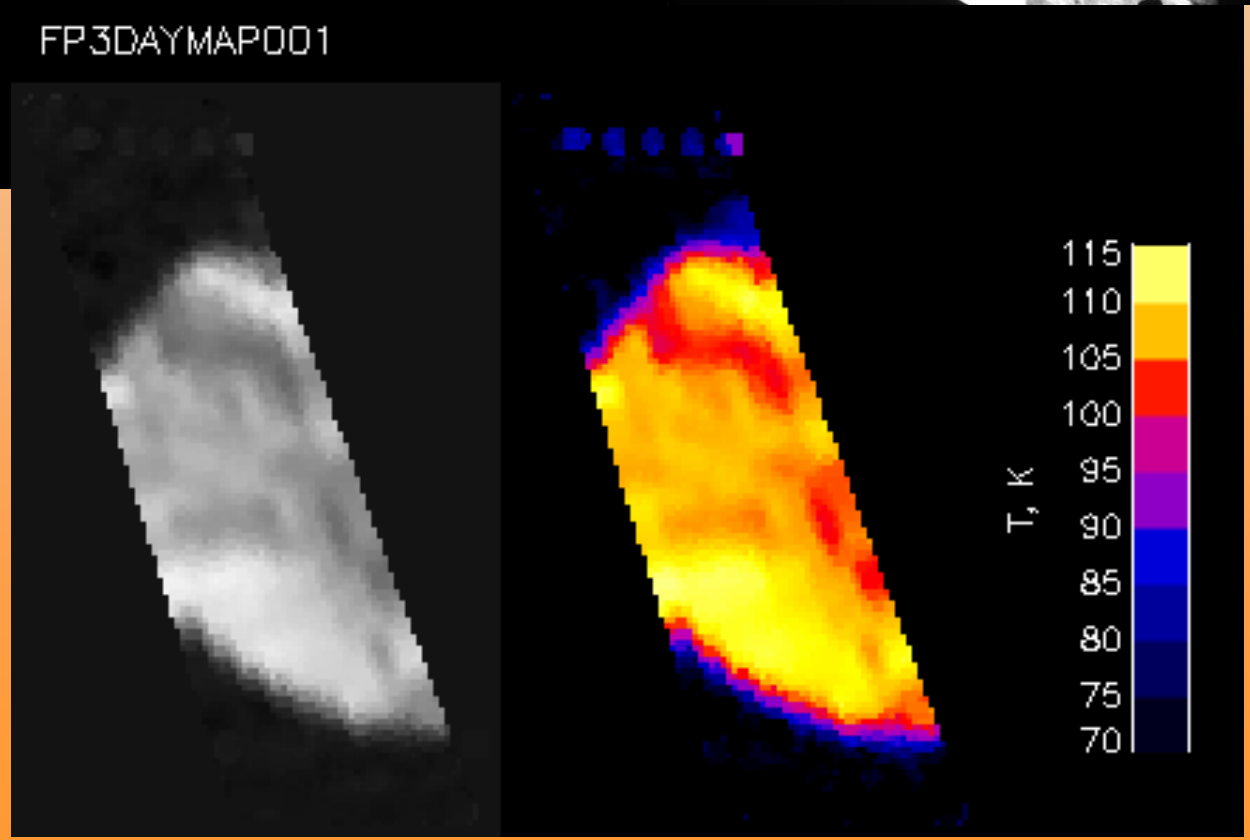


0:55h after close approach

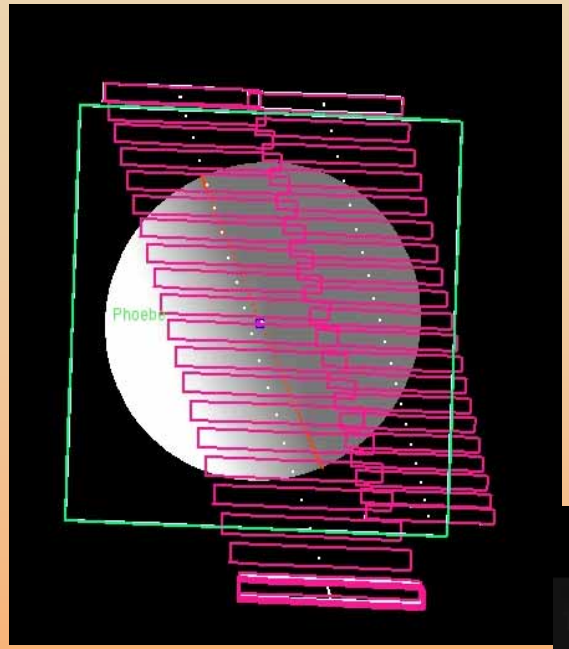
Range: 21,500 km

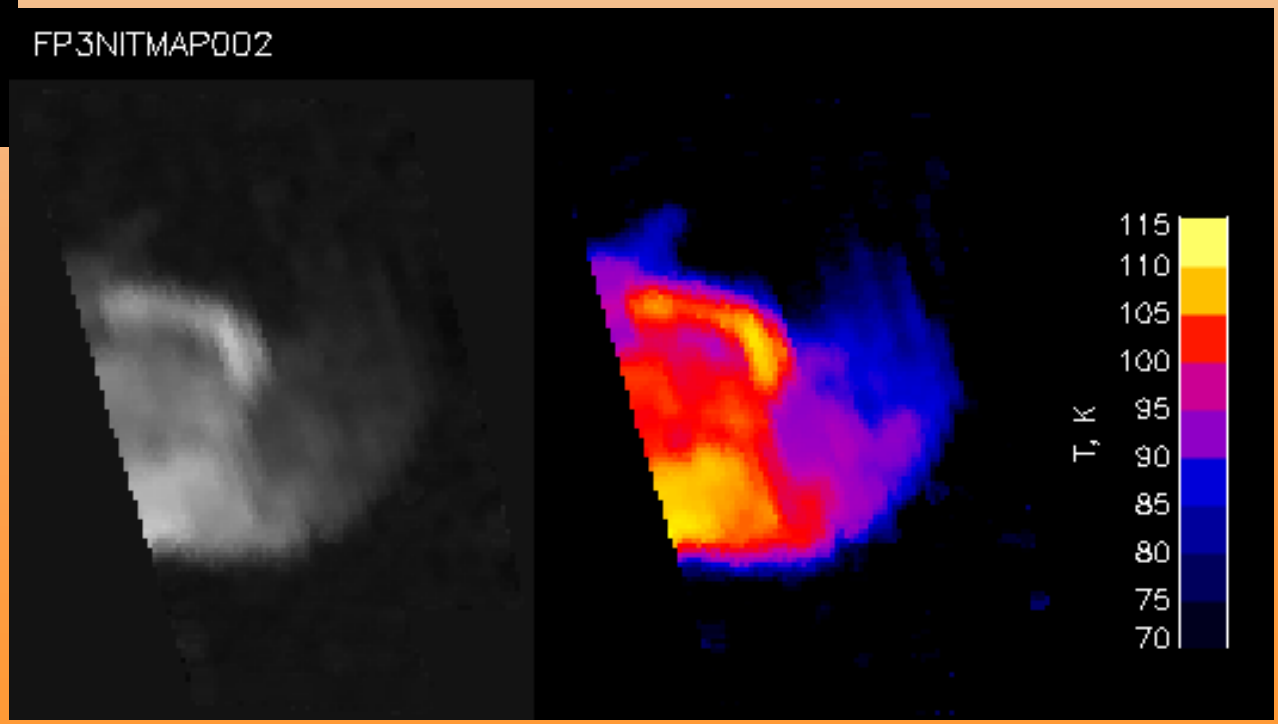
Early afternoon is the warmest time of day, ~112 K

Warmer than most Saturn satellites because Phoebe is dark and absorbs most of the available sunlight



Phoebe Departure: Early Evening Temperatures



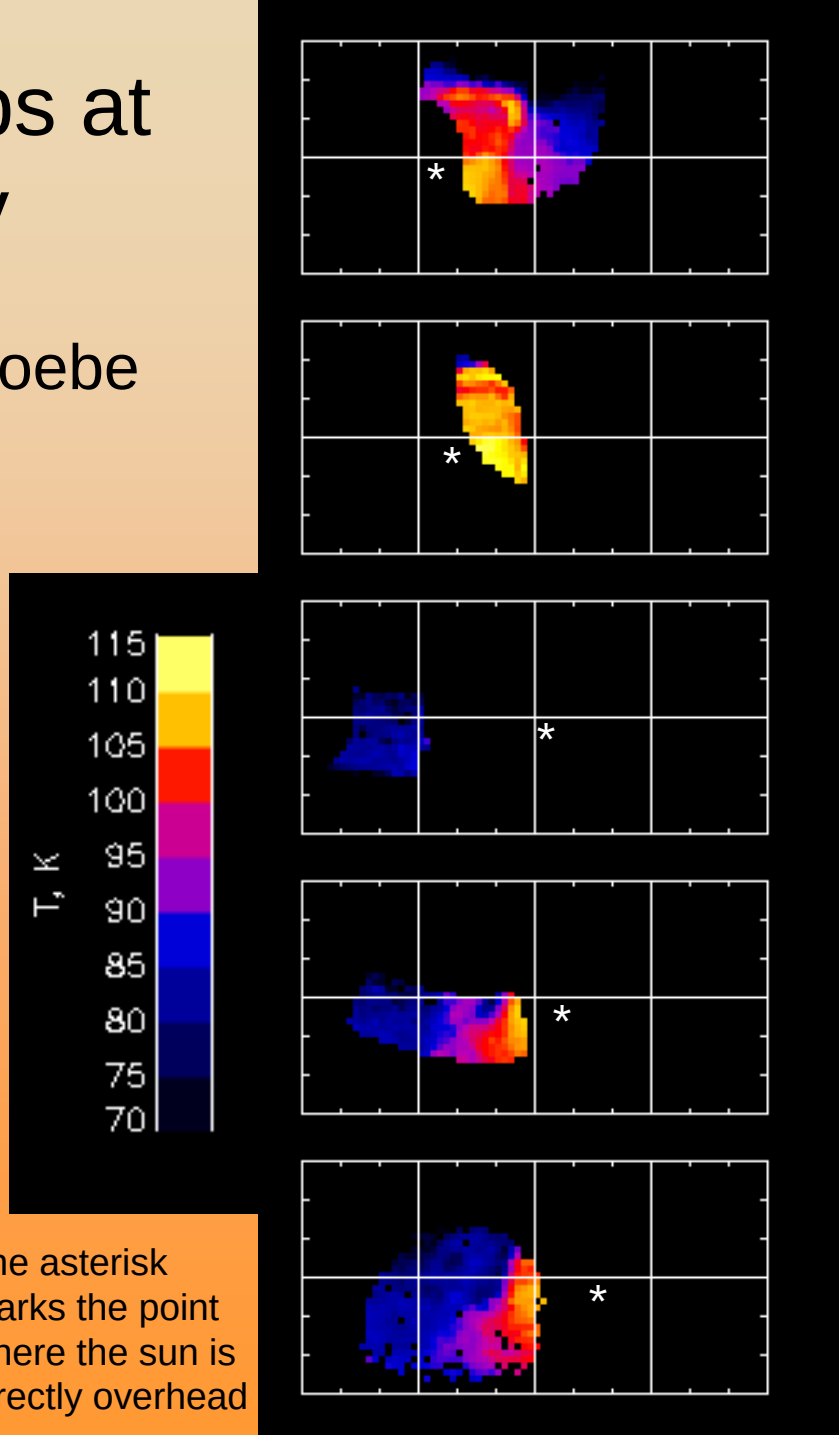


1:20h after close approach

Range: 30,945 km

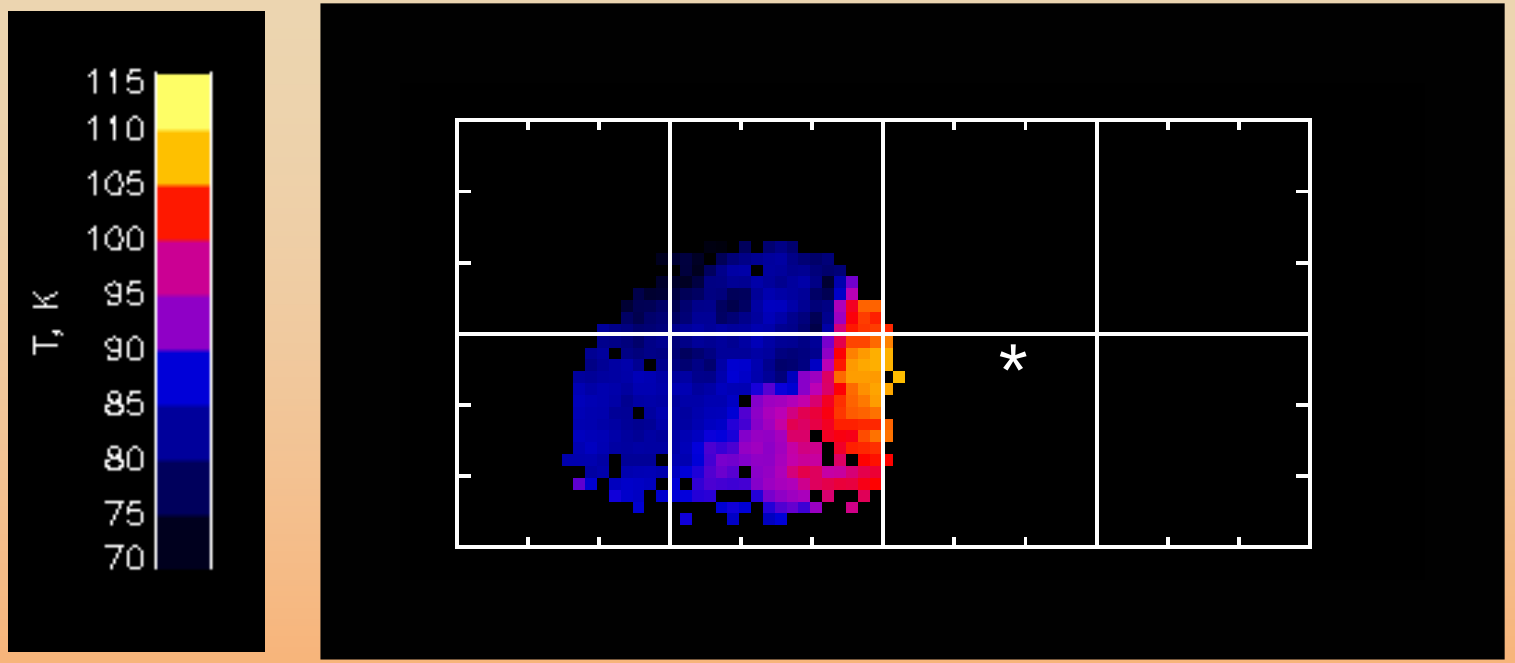
Phoebe Temperature Maps at Different Times of Day

- We followed same region on Phoebe (including the big crater Jason) through half a Phoebe day



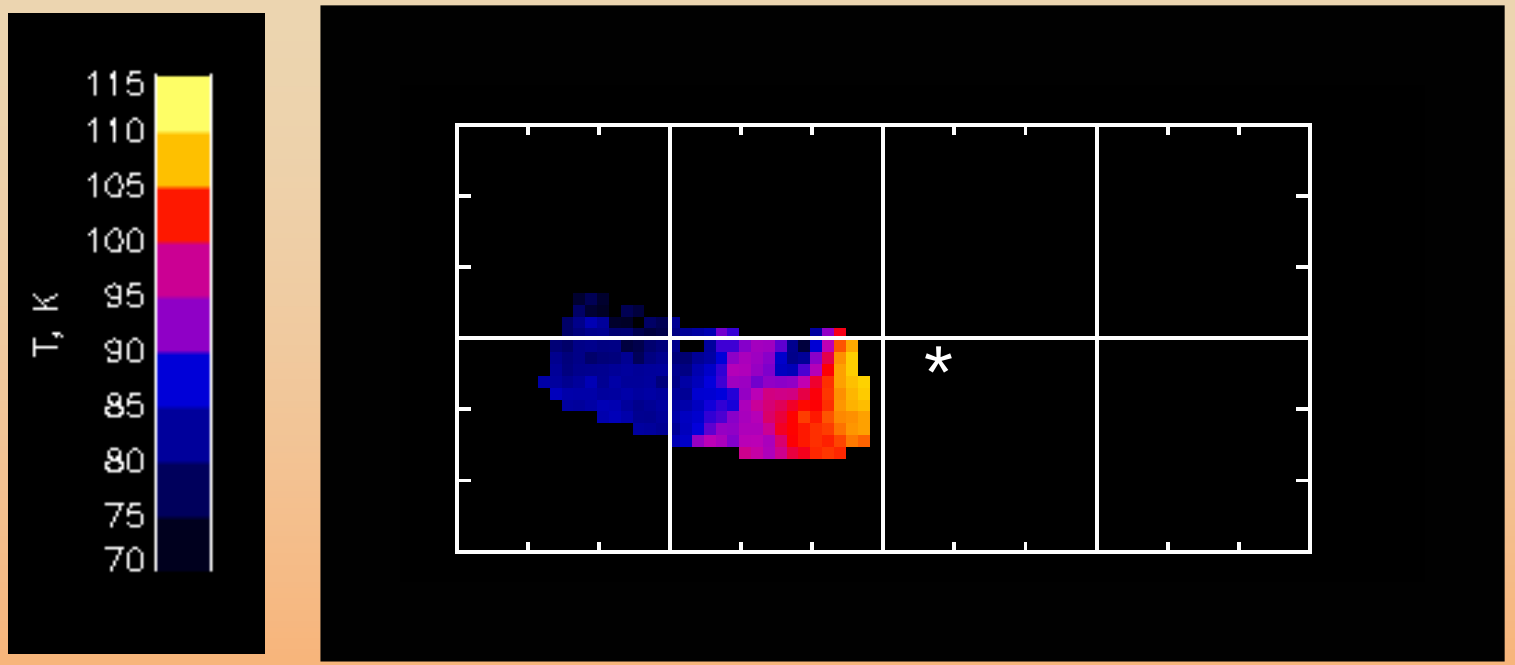
The asterisk marks the point where the sun is directly overhead

Phoebe Temperature Movie: Frame 1



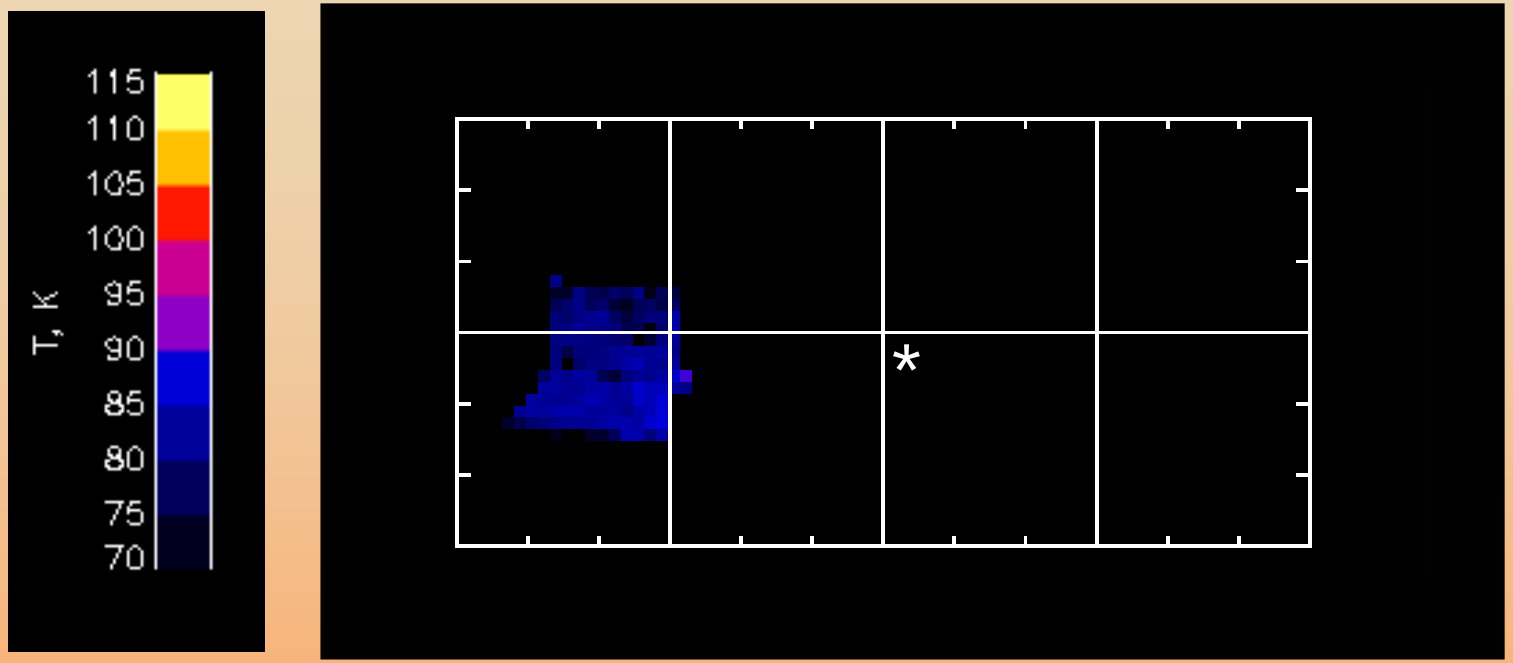
- Follow same region on Phoebe through half a day
- The asterisk marks the point where the sun is directly overhead

Phoebe Temperature Movie: Frame 2



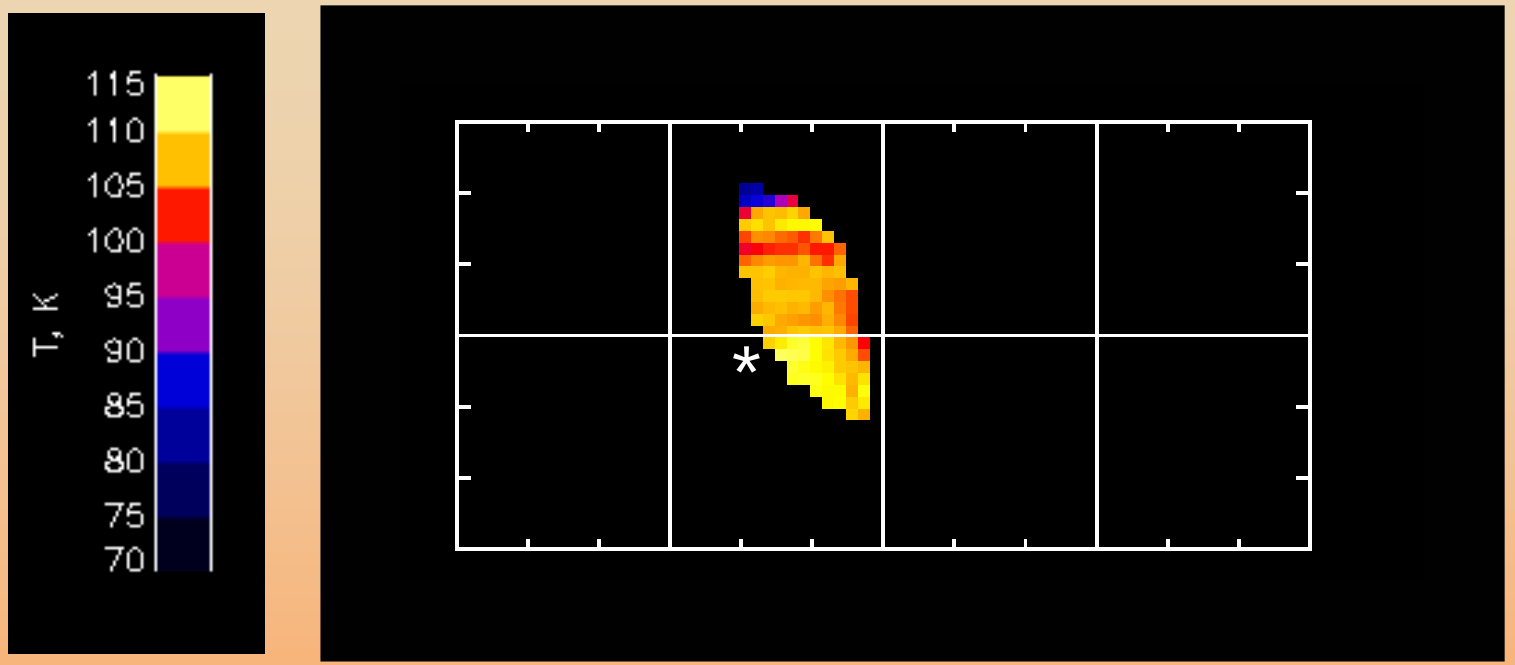
- Follow same region on Phoebe through half a day
- The asterisk marks the point where the sun is directly overhead

Phoebe Temperature Movie: Frame 3



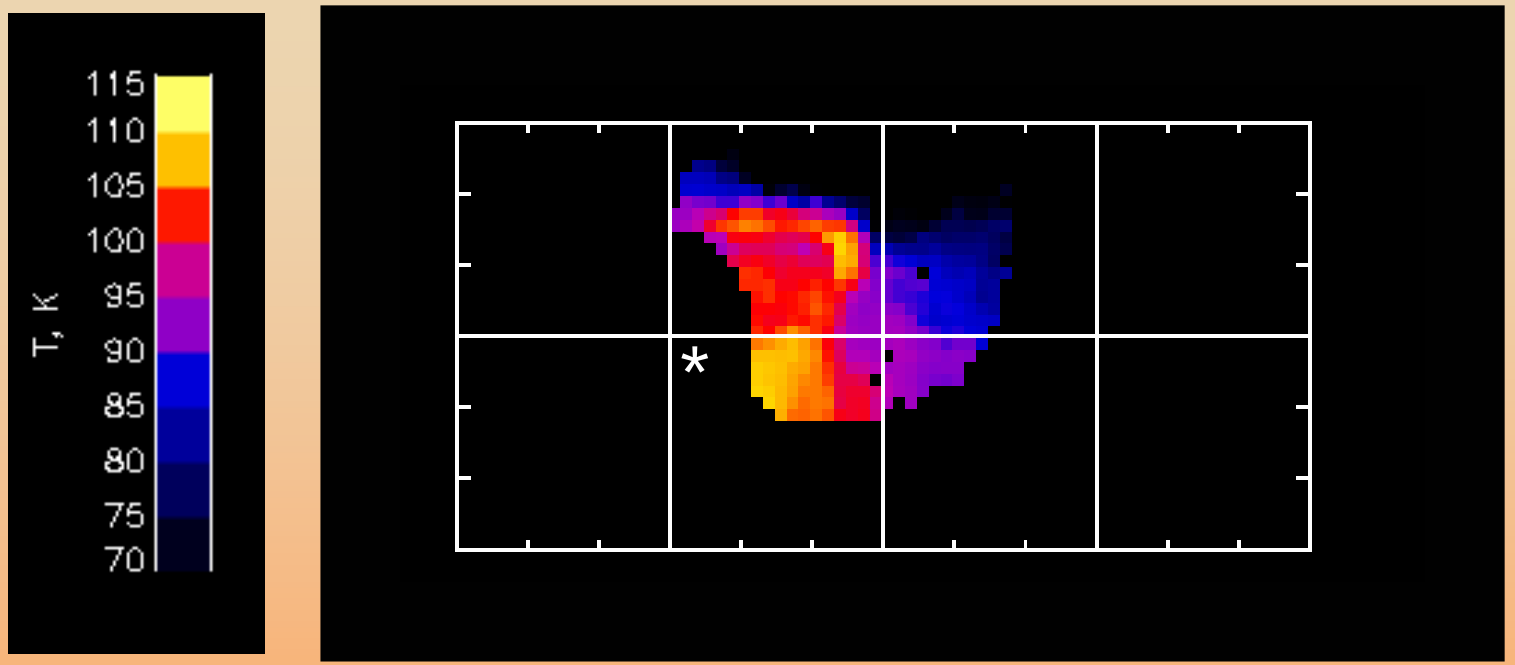
- Follow same region on Phoebe through half a day
- The asterisk marks the point where the sun is directly overhead

Phoebe Temperature Movie: Frame 4



- Follow same region on Phoebe through half a day
- The asterisk marks the point where the sun is directly overhead

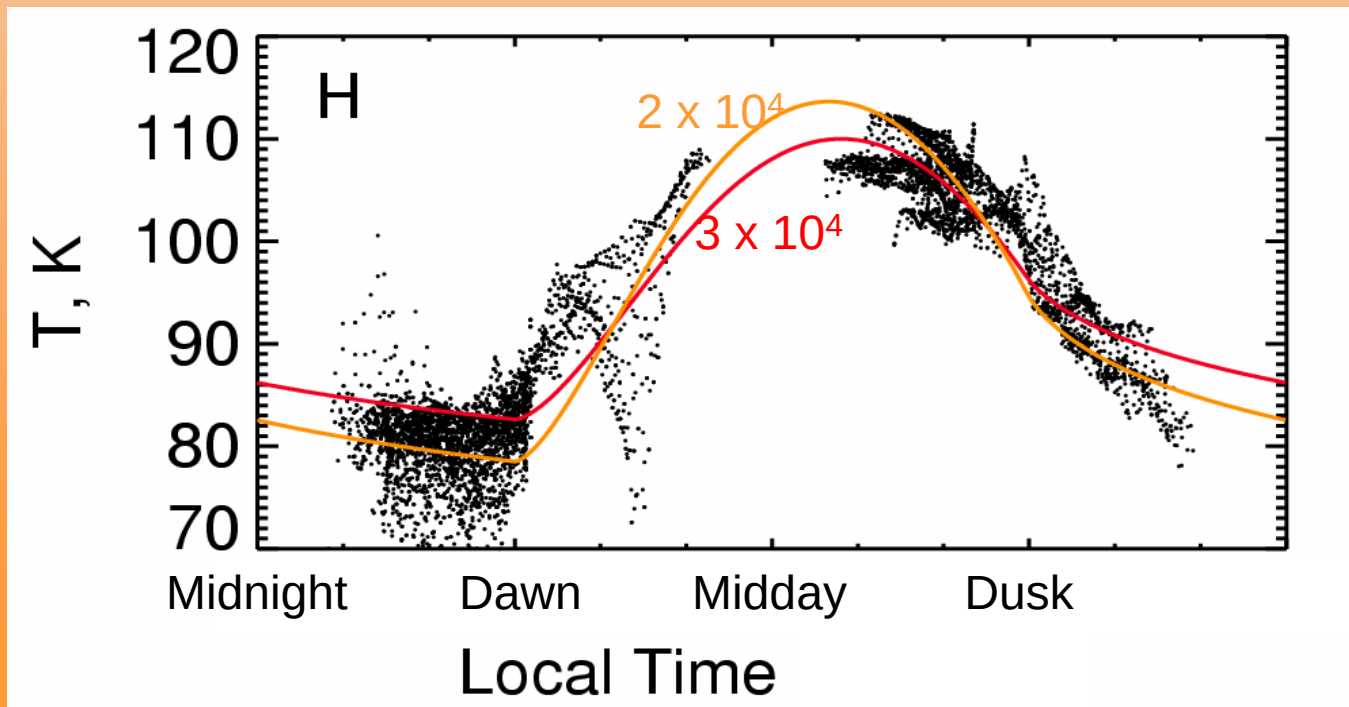
Phoebe Temperature Movie: Frame 5



- Follow same region on Phoebe through half a day
- The asterisk marks the point where the sun is directly overhead

Phoebe Diurnal Temperature Curve

- Allows determination of *thermal inertia*: how well the surface retains heat at night.
  - Solid rock and ice store heat efficiently, change temperature slowly (think of warm stone walls at the end of a summer day)
  - Fluffy, dusty, surfaces change temperature quickly when the heat source (sunlight here) goes away.
- Large diurnal variations in temperature on Phoebe mean that its surface is very dusty or fluffy: thermal inertia is 100x lower than for solid rock or ice.
- Pulverized by billions of years of impacts

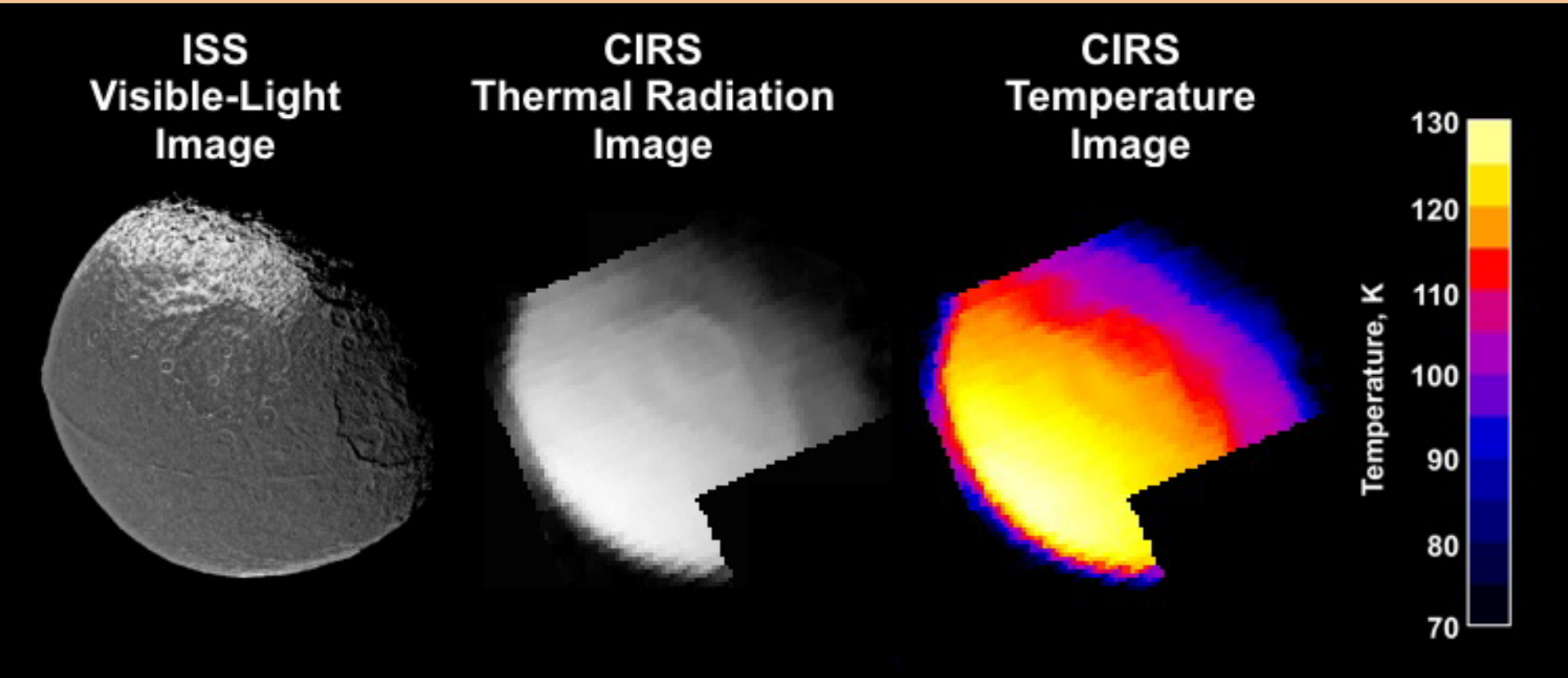


Iapetus

- Mysterious light/dark dichotomy
- Lots of CIRS measurements of its thermal radiation were obtained during the New Year 2005 flyby
- Very preliminary analysis so far…

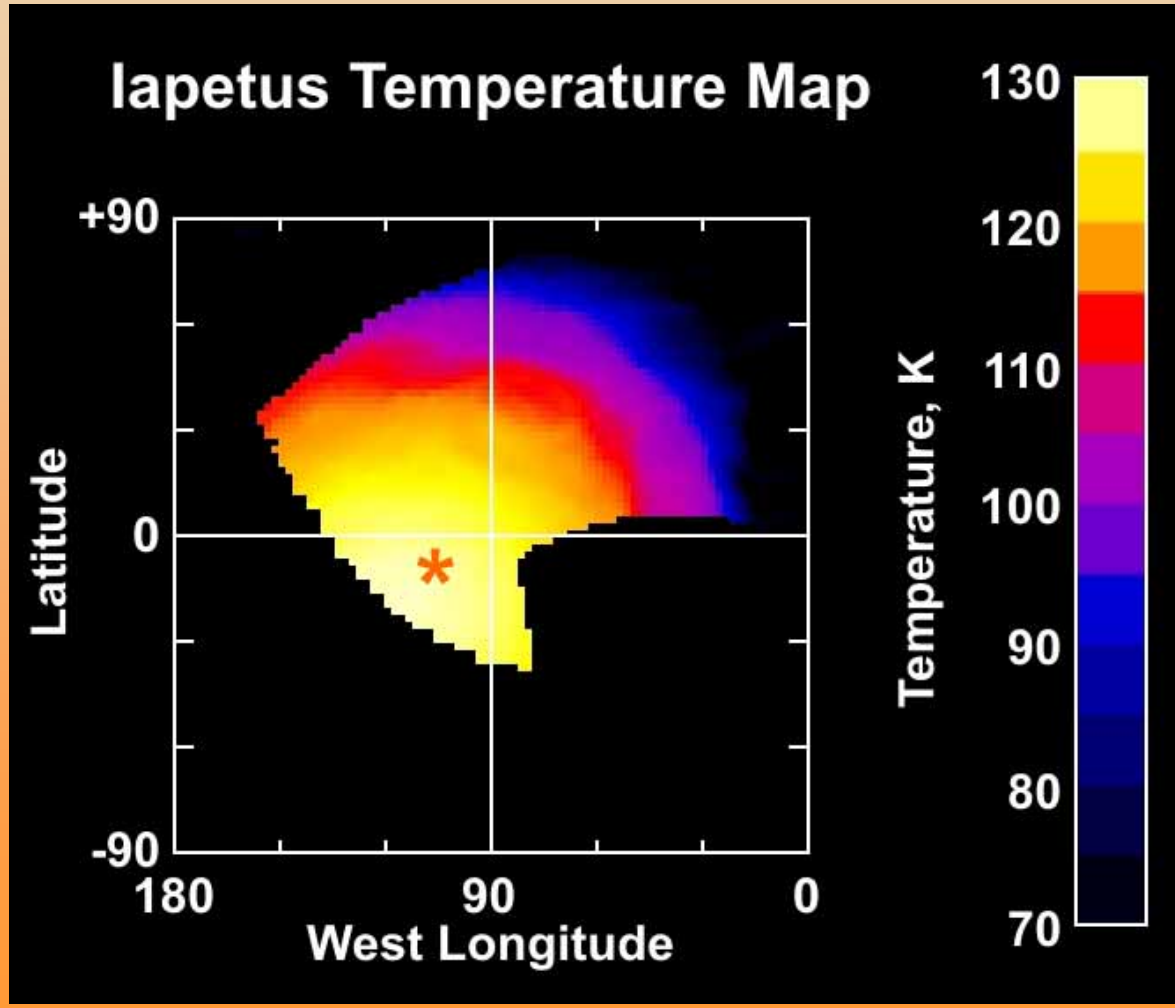
Iapetus Daytime Temperatures

- Temperature variations due to craters are visible: sun-facing slopes are warmer than slopes facing away from the sun



Iapetus Temperature Map

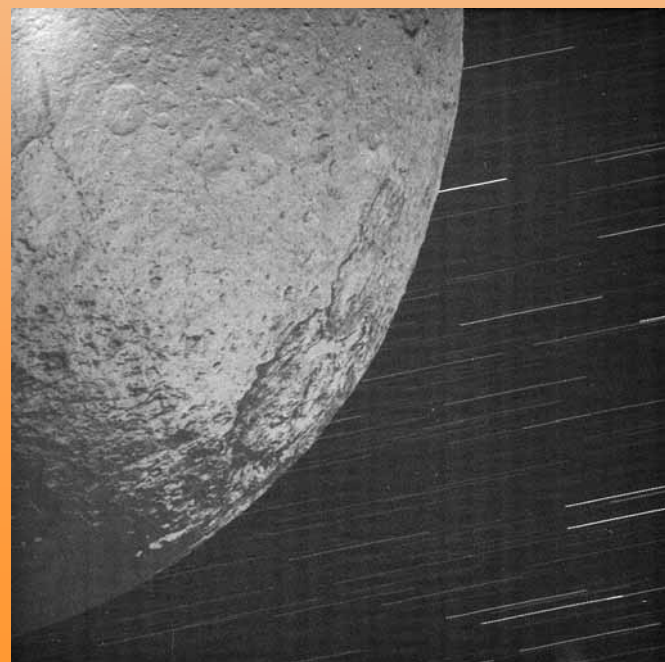
- Temperatures at noon in the dark terrain near the equator reach 130 K
- Probably warmer than any other surface in the Saturn system because:
  - Surface is dark and absorbs most of the available sunlight
  - Iapetus rotates very slowly (once every 79 days vs. 9 hours for Phoebe): lots of time to warm up each morning



The asterisk marks the point where the sun is directly overhead

Iapetus Nighttime Temperatures

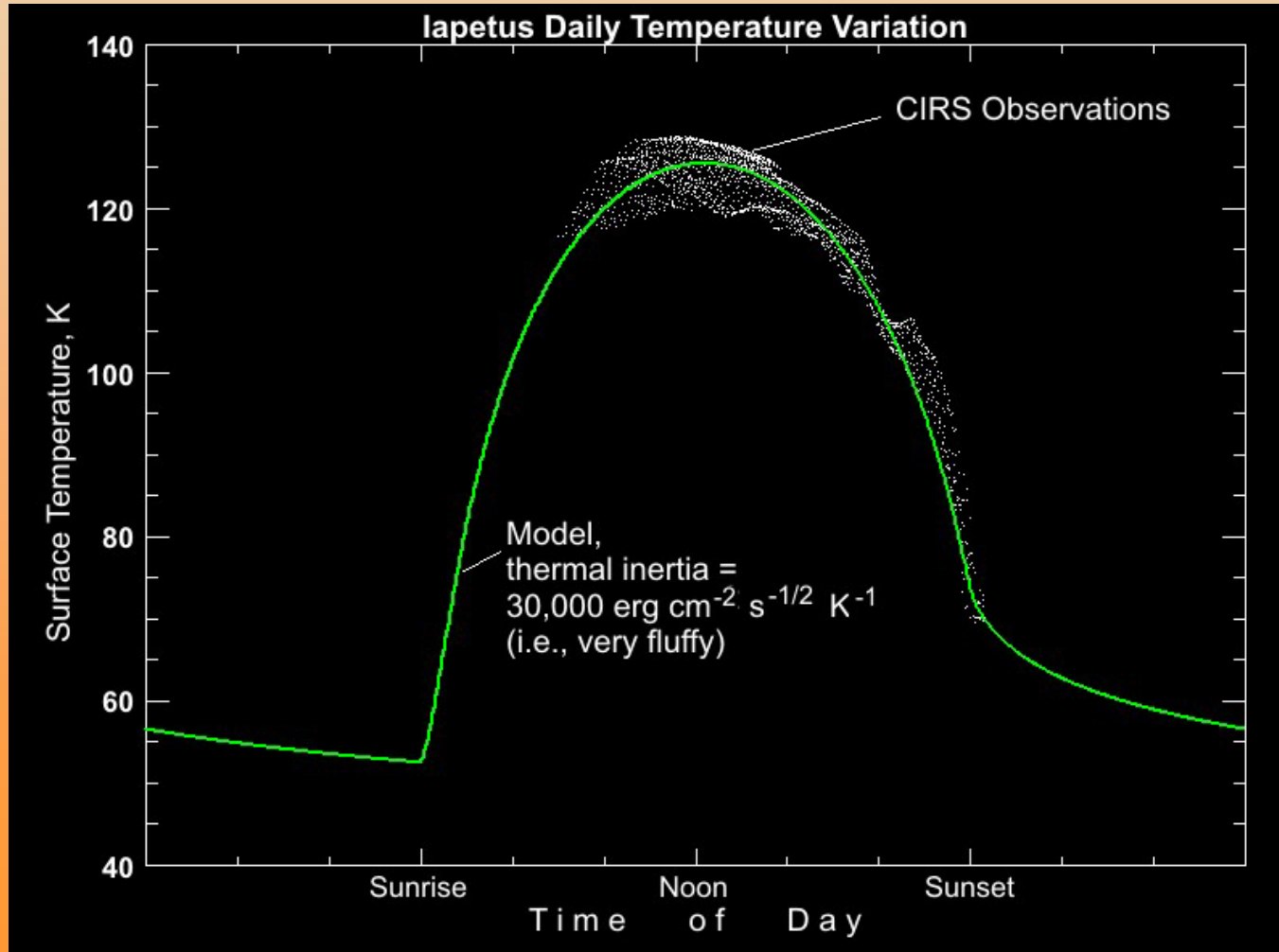
- Very cold, because:
  - Very slow rotation: lots of time to cool off at night
  - Much of night side during the New Year's flyby was bright terrain that is colder anyway, because it absorbs less sunlight
- CIRS measured nighttime temperatures as low as 40 K
- Iapetus is one of the warmest *and* coldest places in the Saturn system



Nighttime view of bright terrain on Phoebe

Iapetus Diurnal Temperatures

- Like Phoebe, very low thermal inertia: very fluffy or powdery surface



Coming Attractions

- Close flybys of Enceladus on February 17th and March 9th 2005
  - Very young, possibly active, surface
  - CIRS will be looking for evidence of hot spots from active eruptions (unlikely but not impossible)
  - CIRS will also be measuring surface temperatures to help estimate interior temperatures and understand why the surface is so young.