

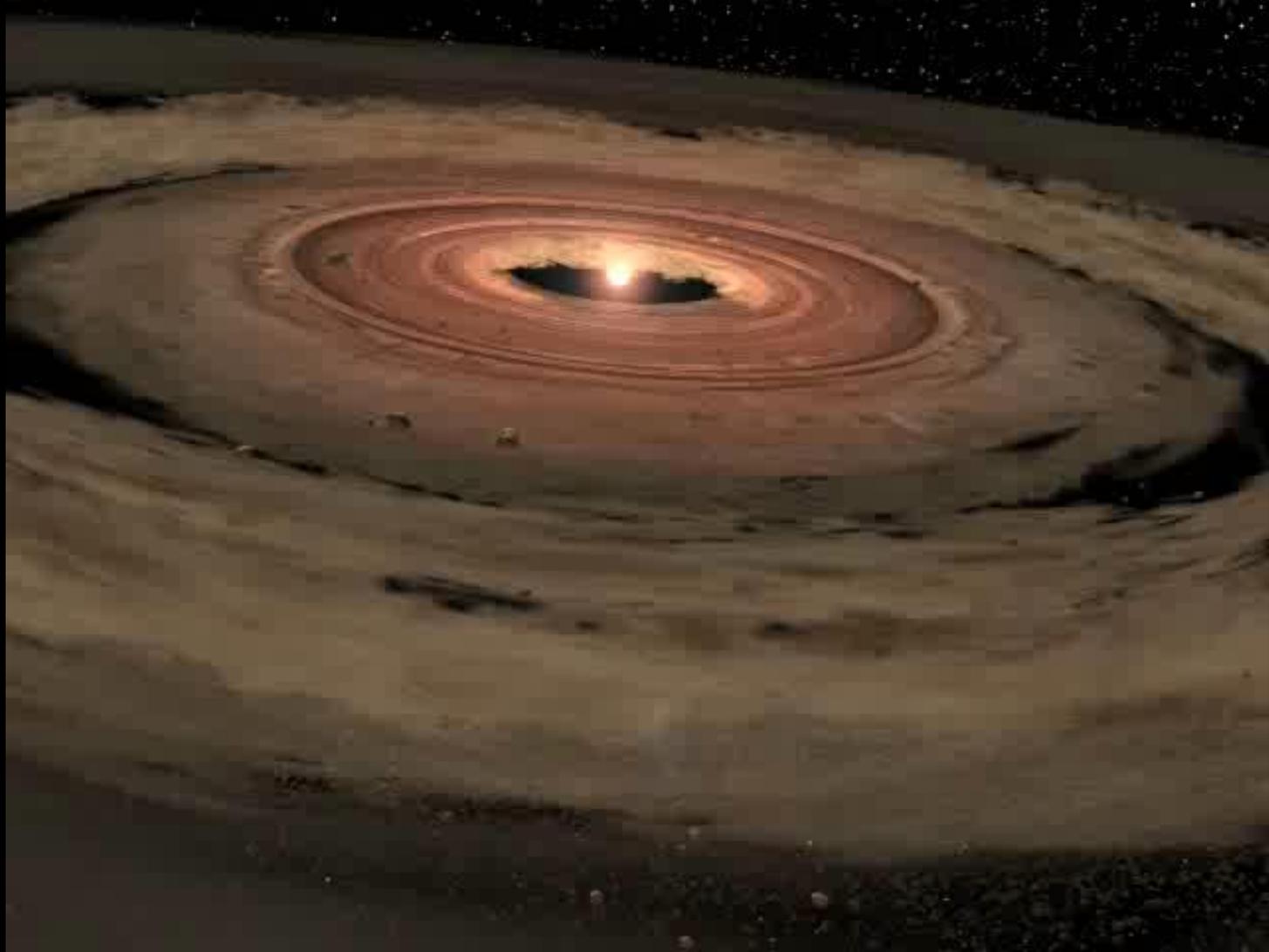


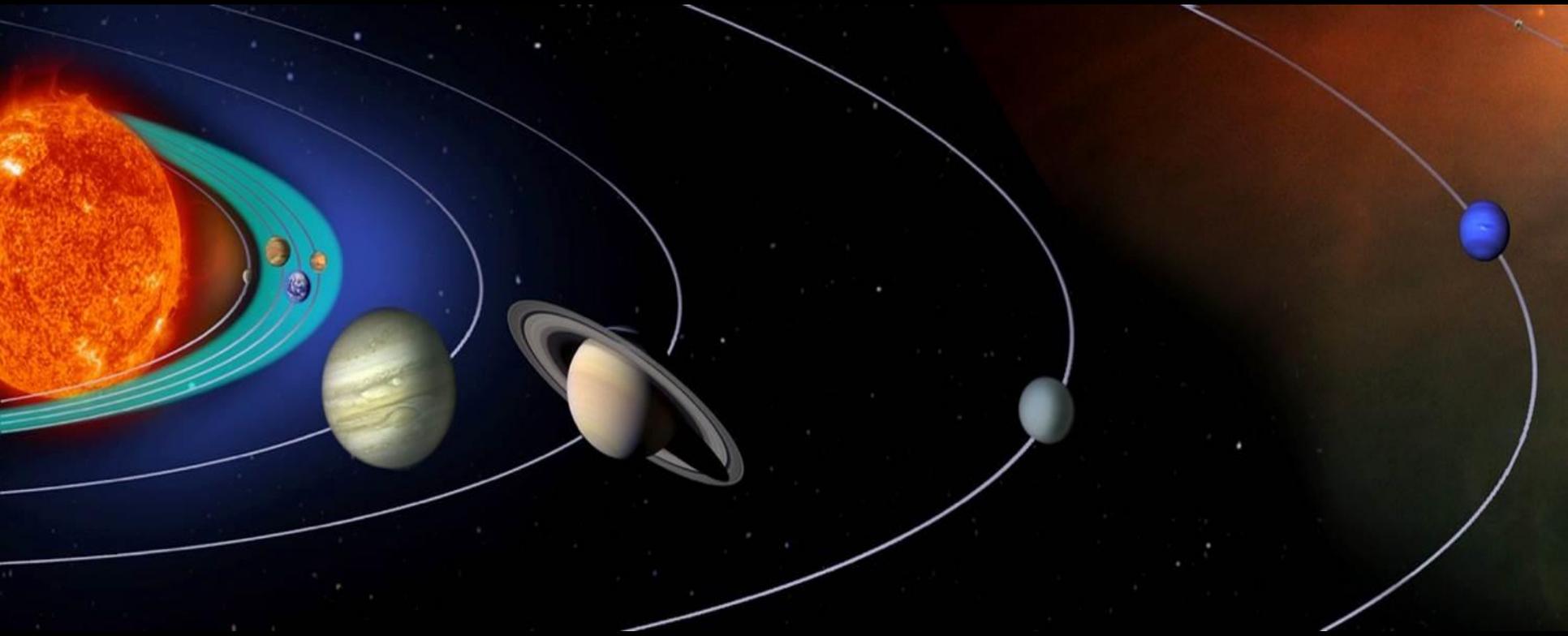
# Exploring the Solar System and Beyond

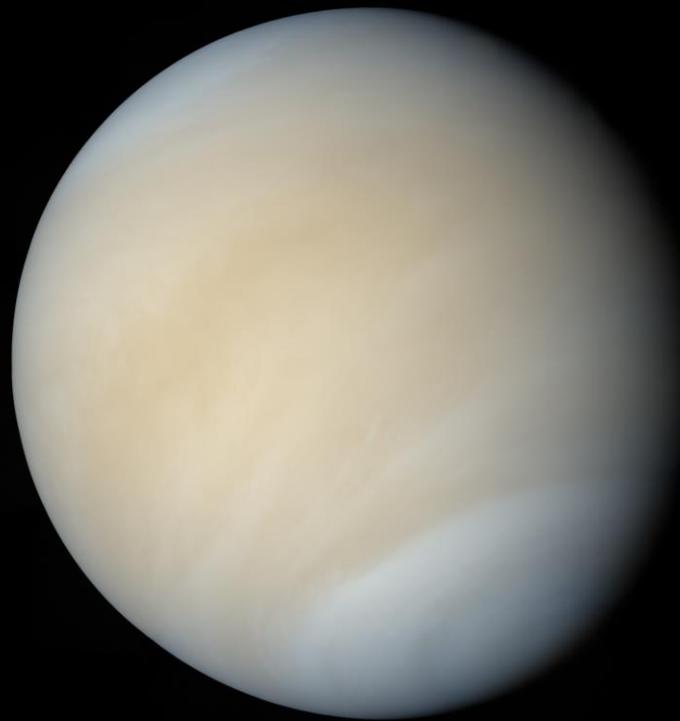


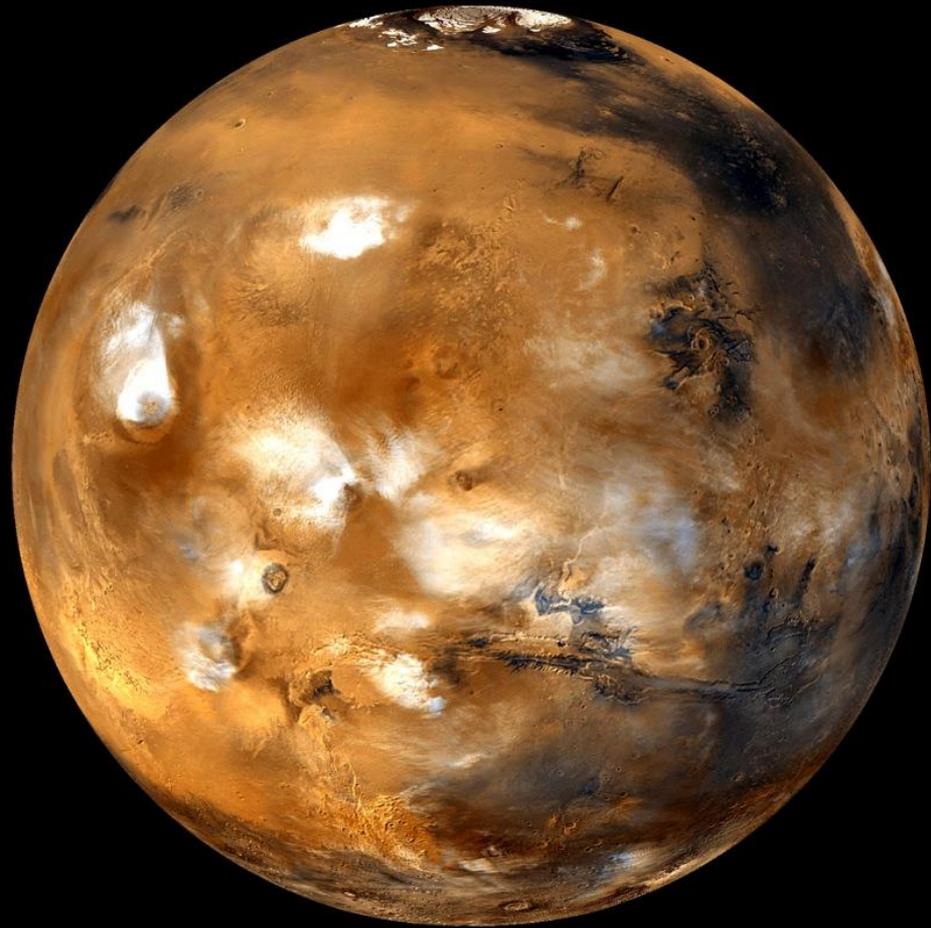
**Jet Propulsion Laboratory**  
California Institute of Technology

**Dr. Jakob van Zyl**  
Director: Solar System Exploration

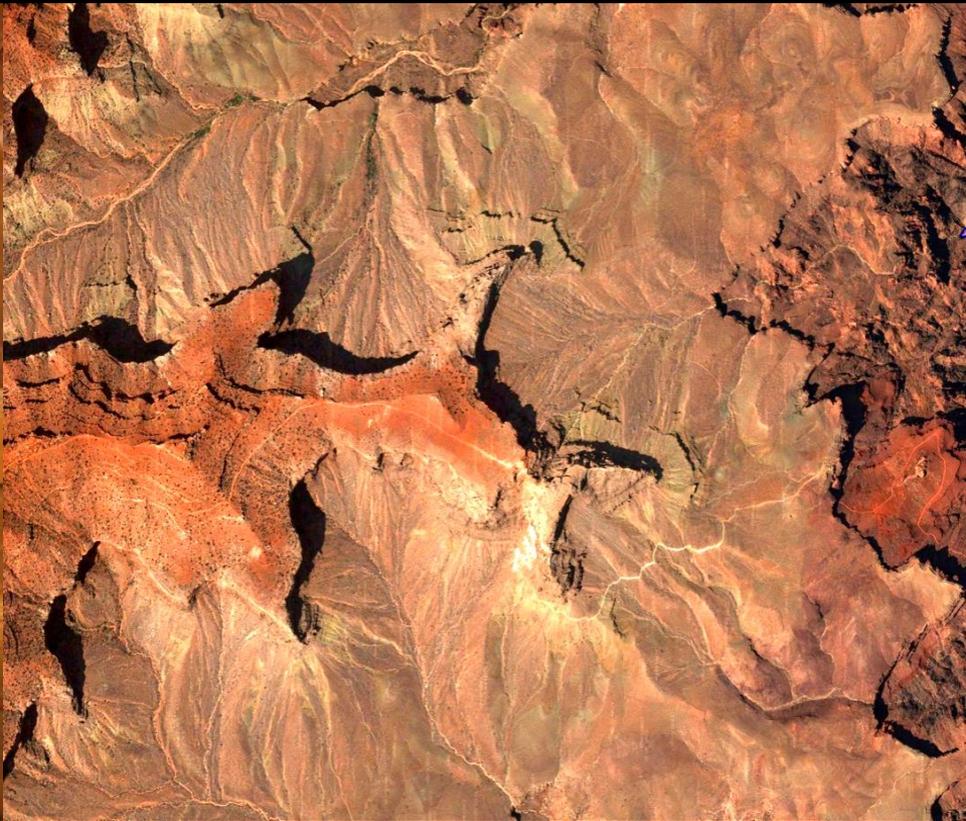




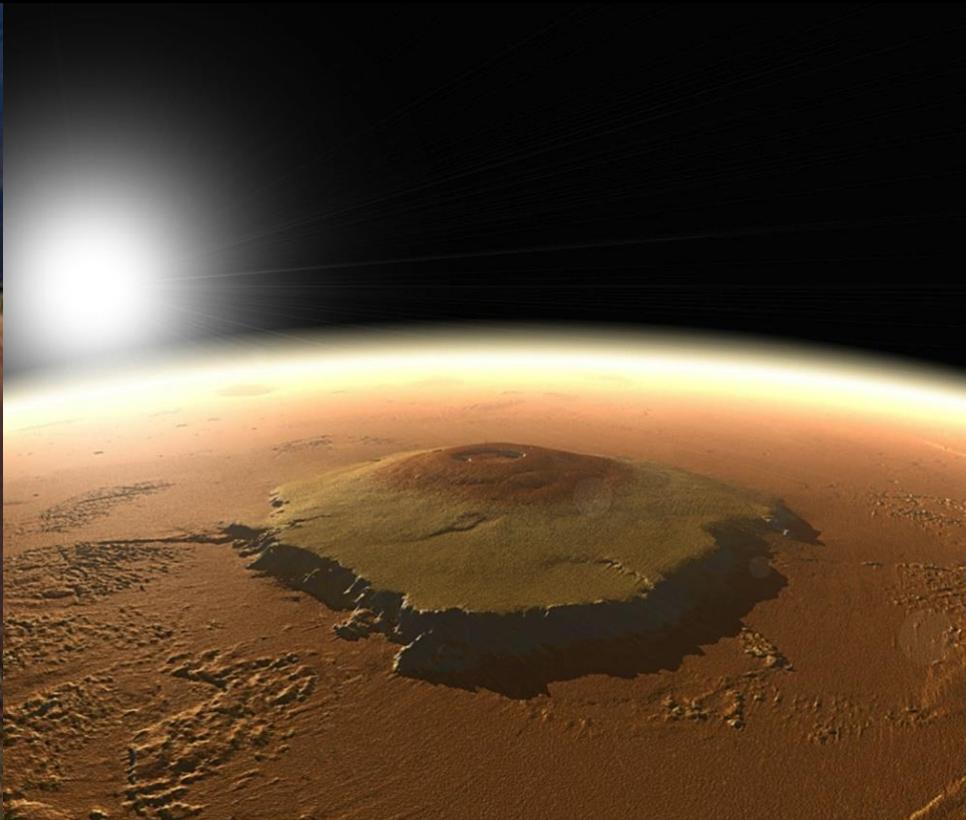




# Grand Canyons



# Great Volcanoes



# Geology



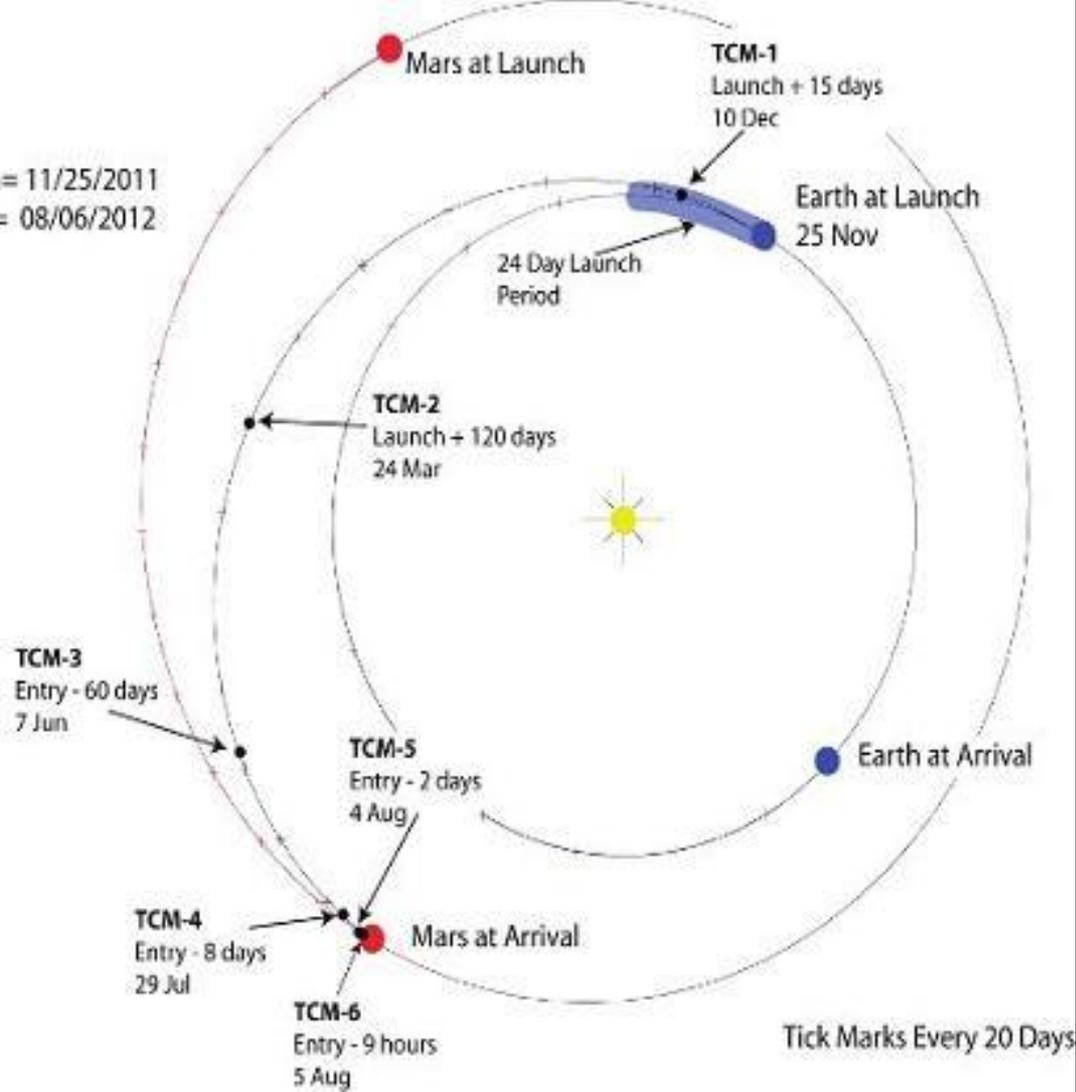
**You are here**



# First mobility test: *Curiosity*



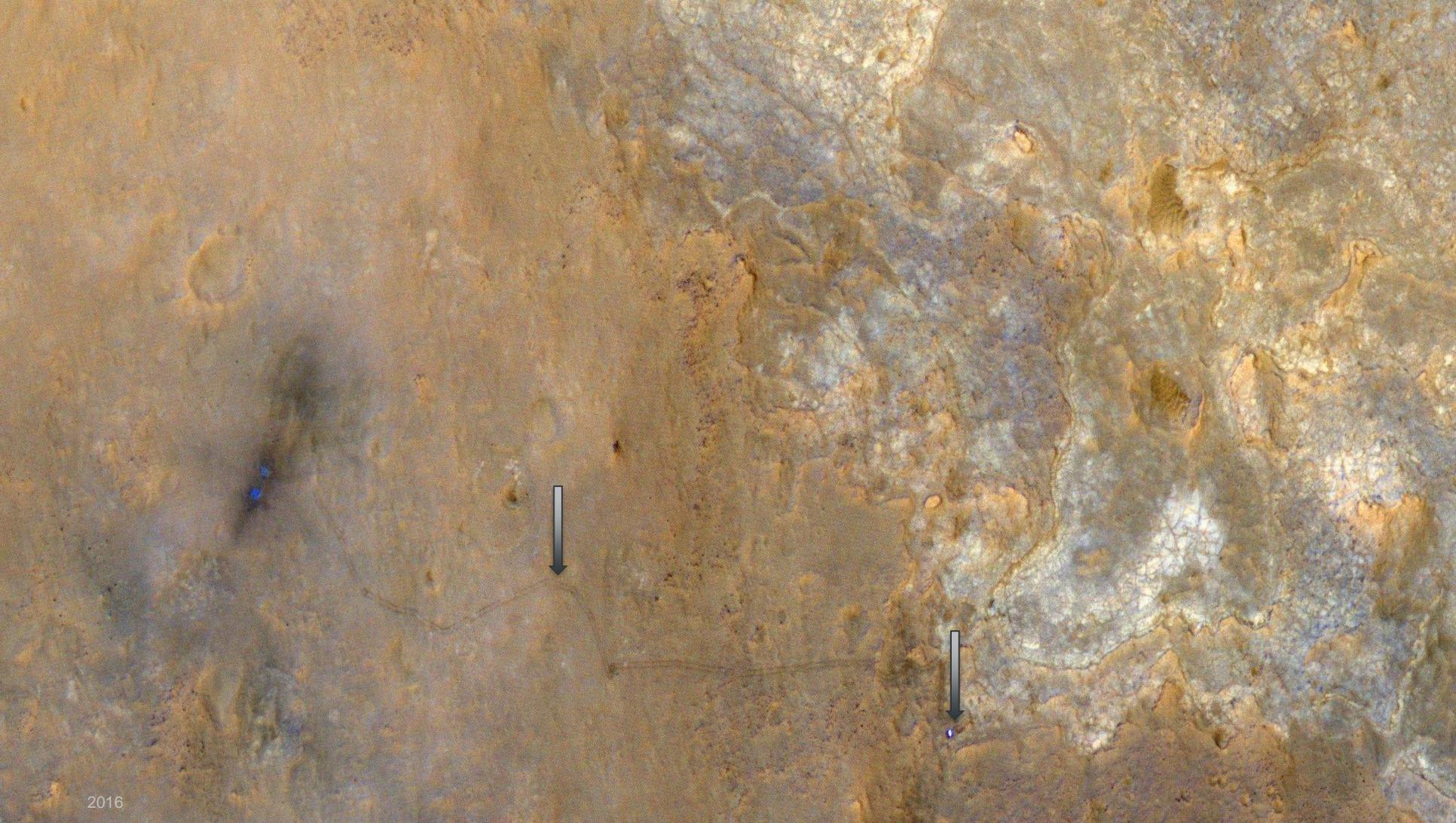
Launch= 11/25/2011  
Arrival= 08/06/2012





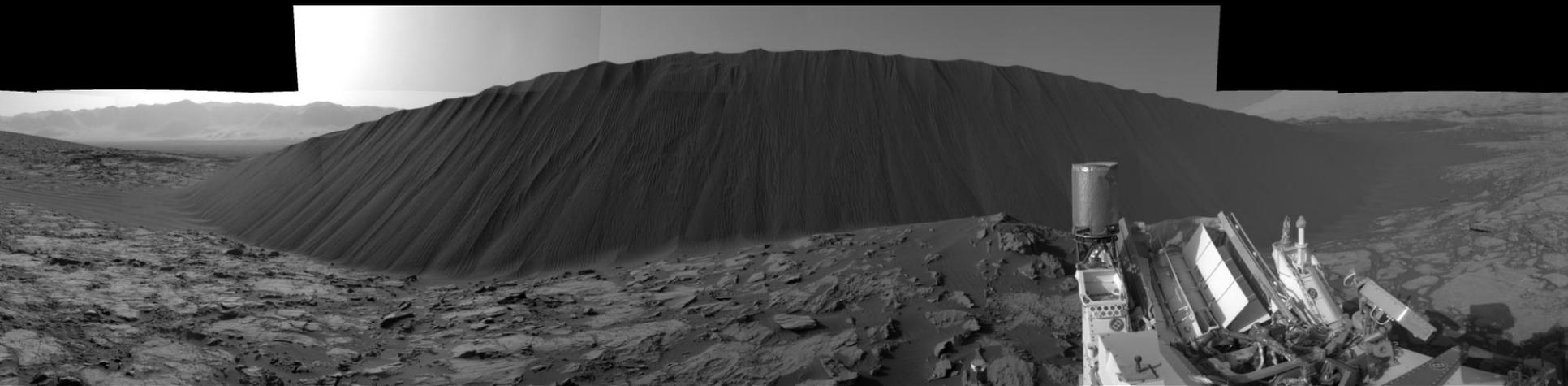


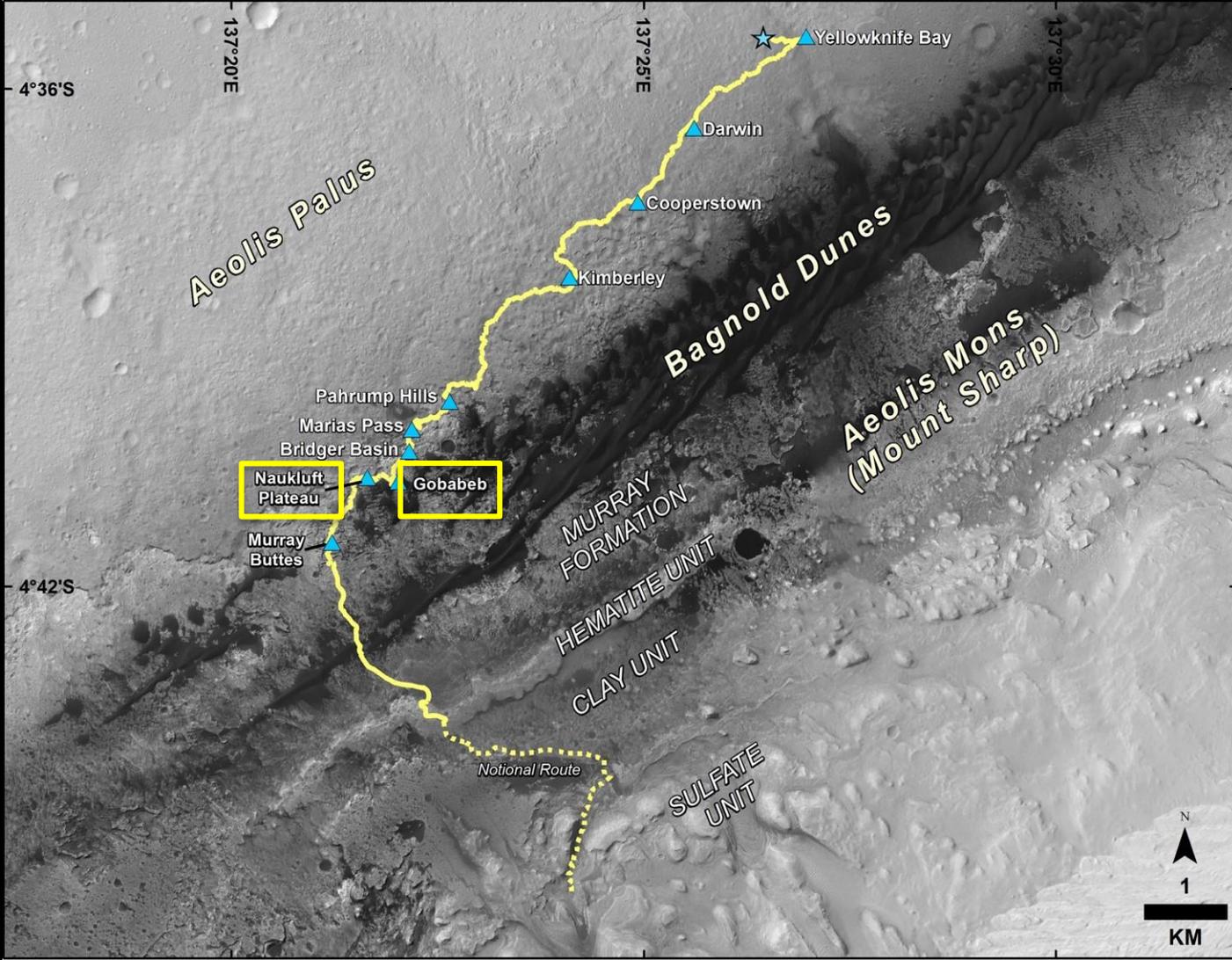
1 cm

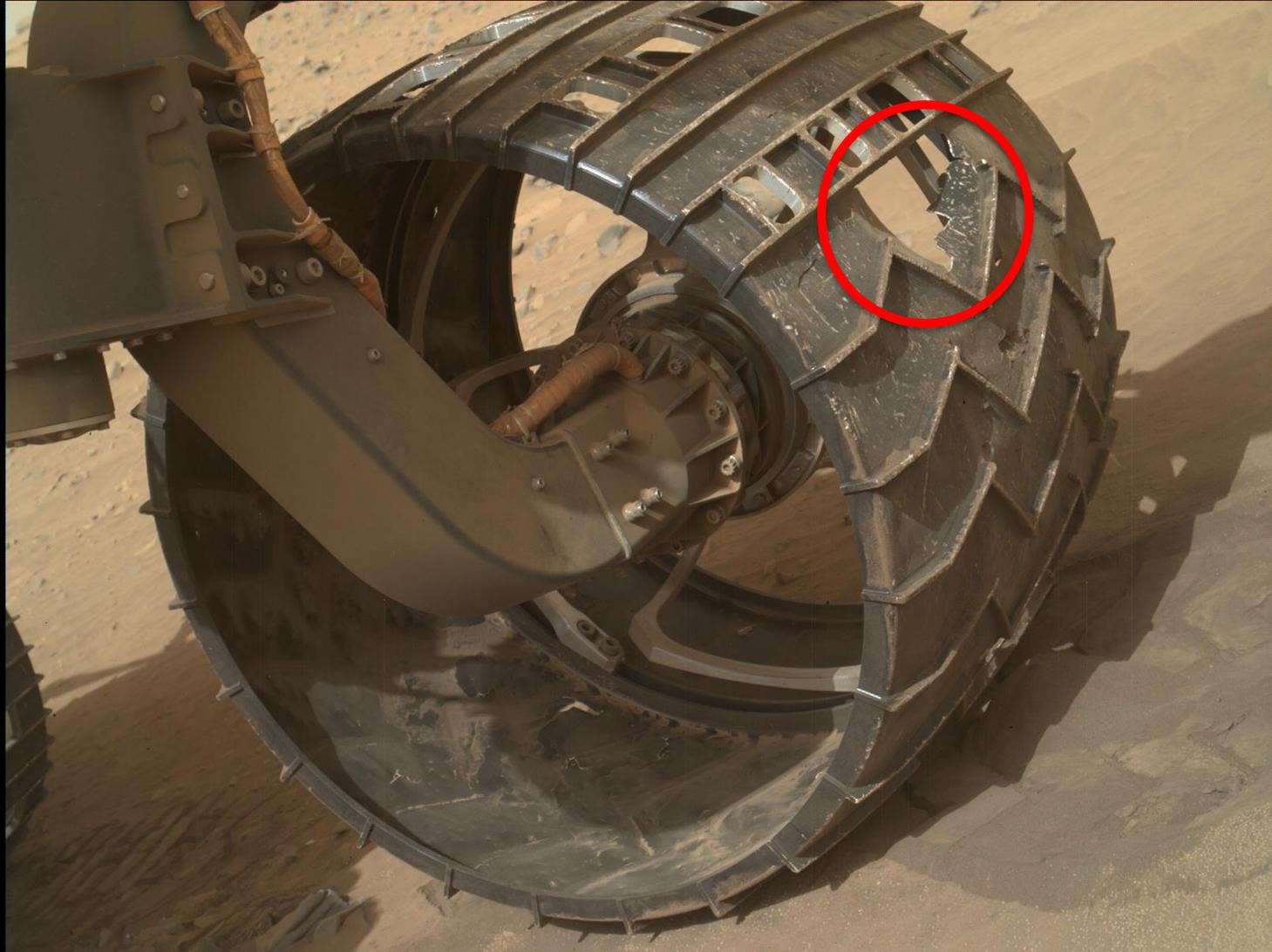




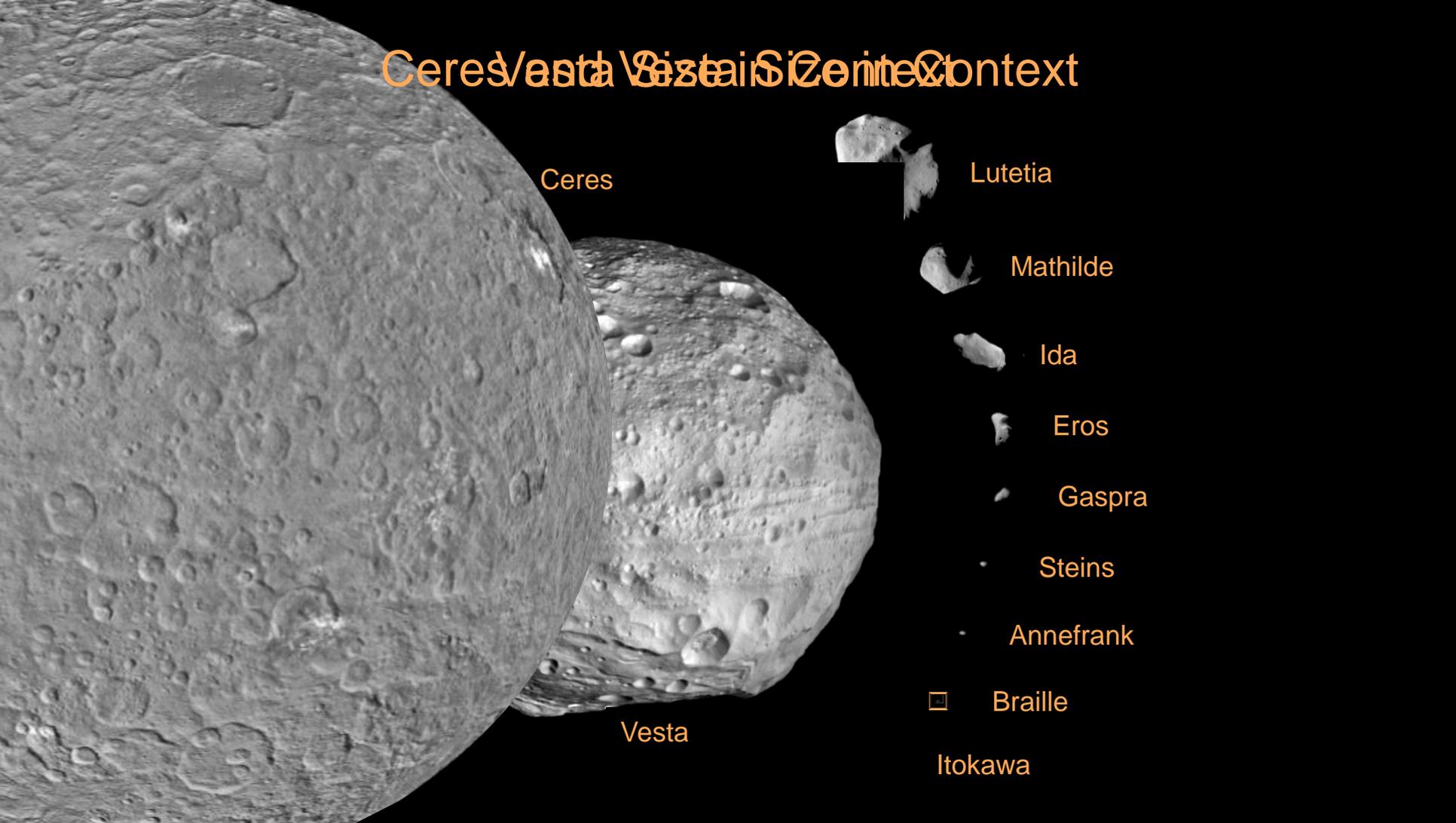








# Ceres/Vesta Size Comparison



Ceres

Lutetia

Mathilde

Ida

Eros

Gaspra

Steins

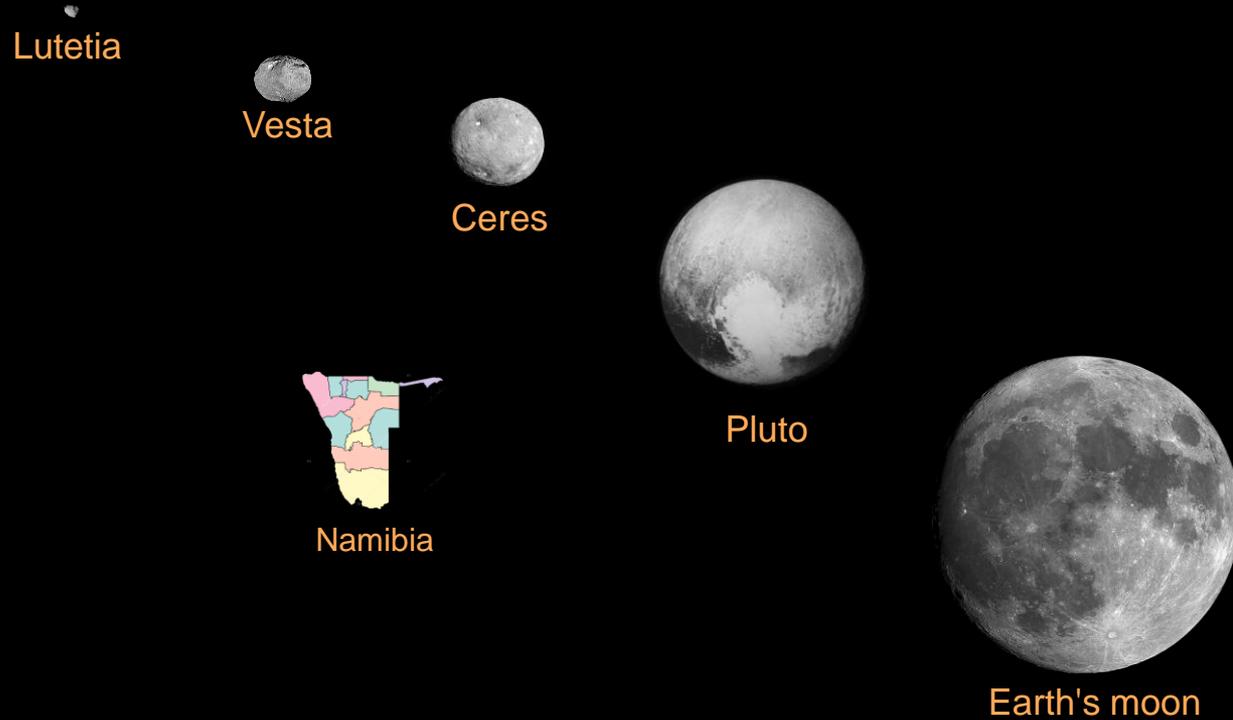
Annefrank

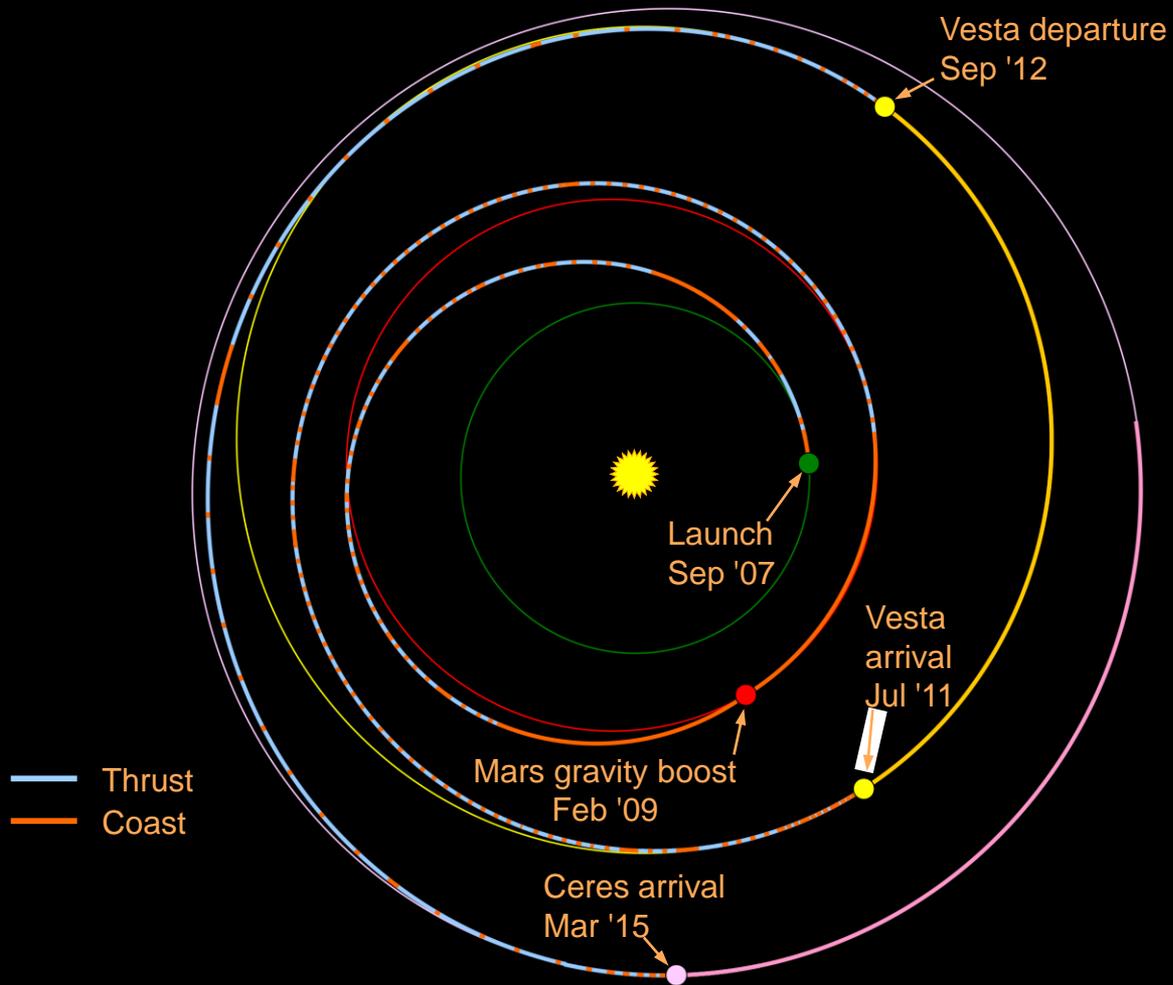
Braille

Itokawa

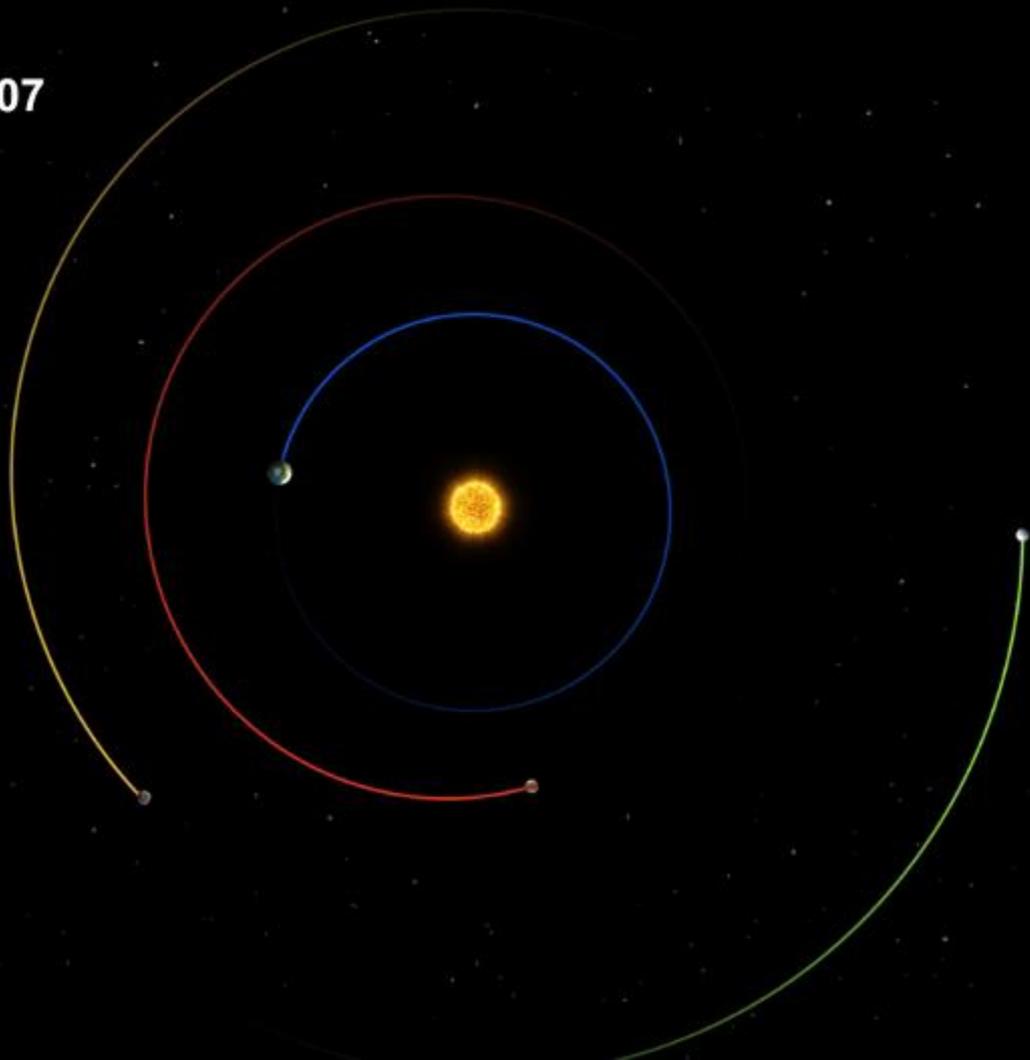
Vesta

# Ceres and Vesta Size in Context





Mar 2007



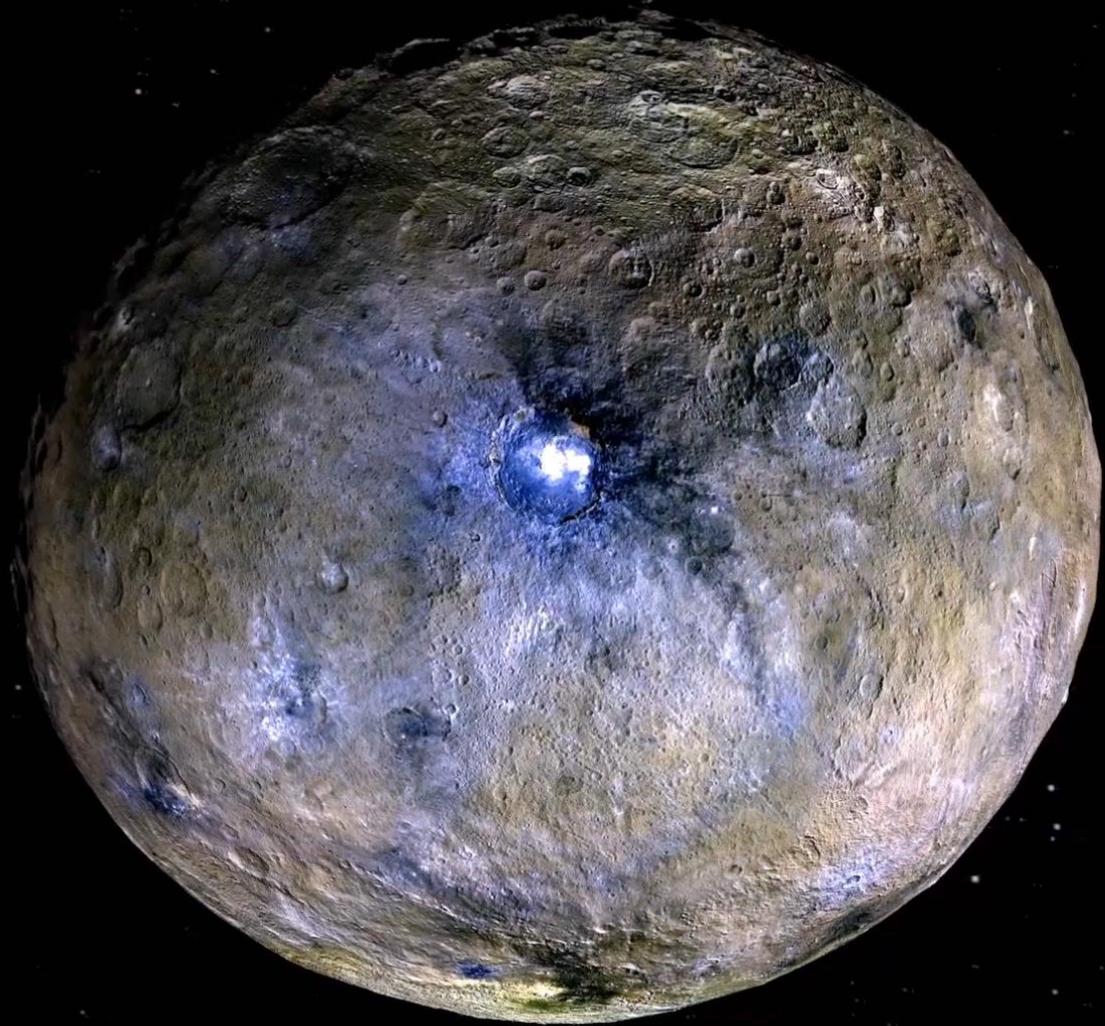


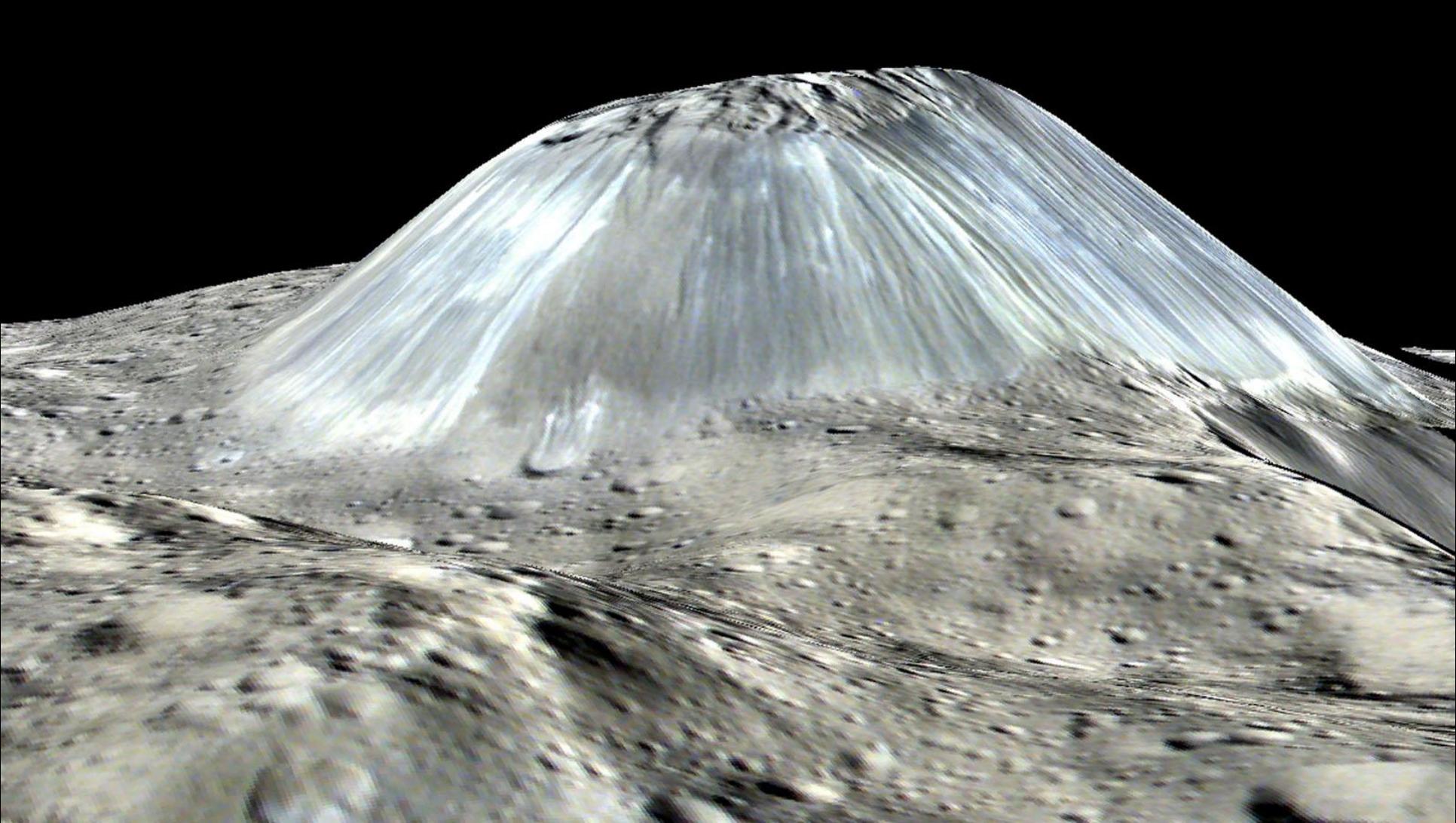
# Dawn at Ceres

2015 JAN 04

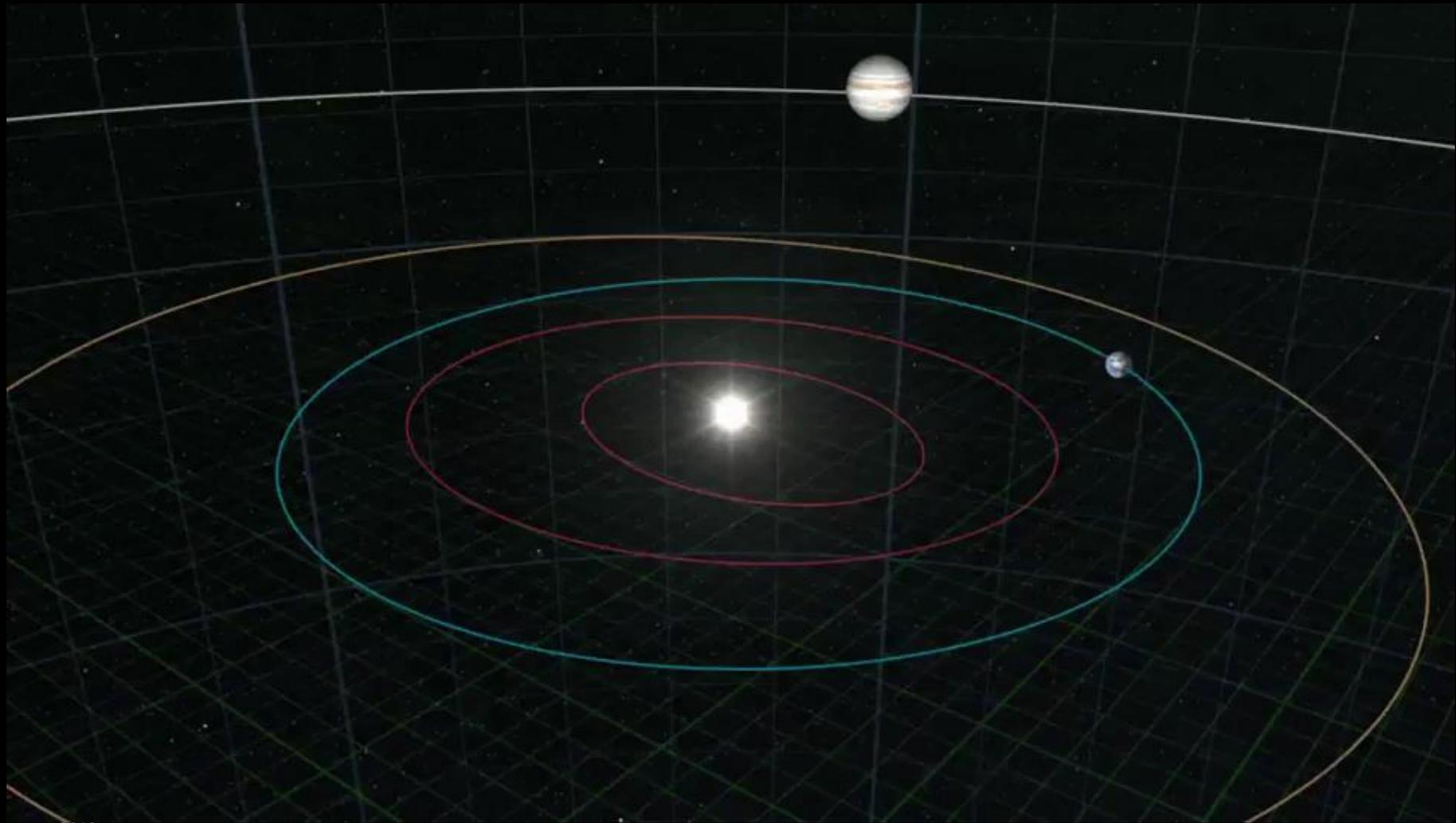
Maneuver to circular orbit at 13,600  
km

Piloting a spaceship with ion propulsion

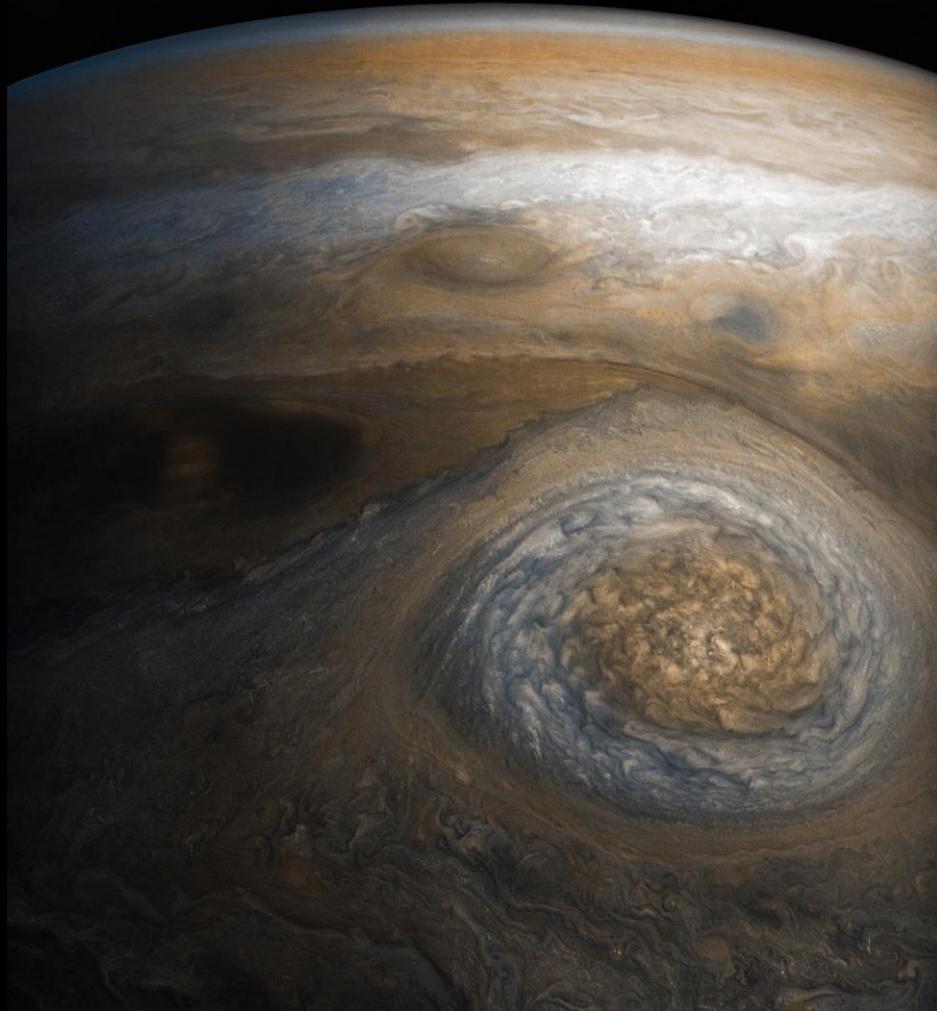






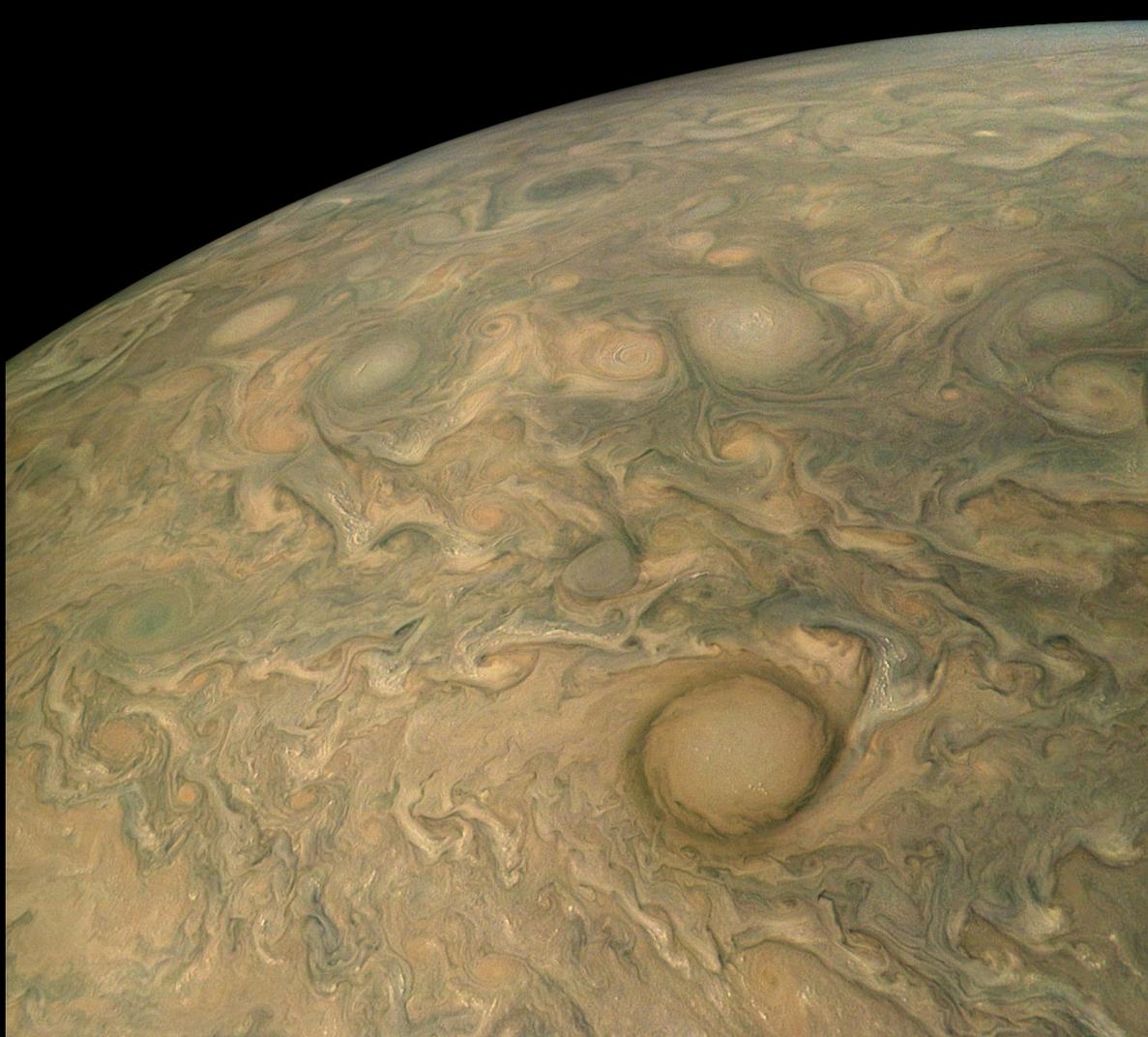


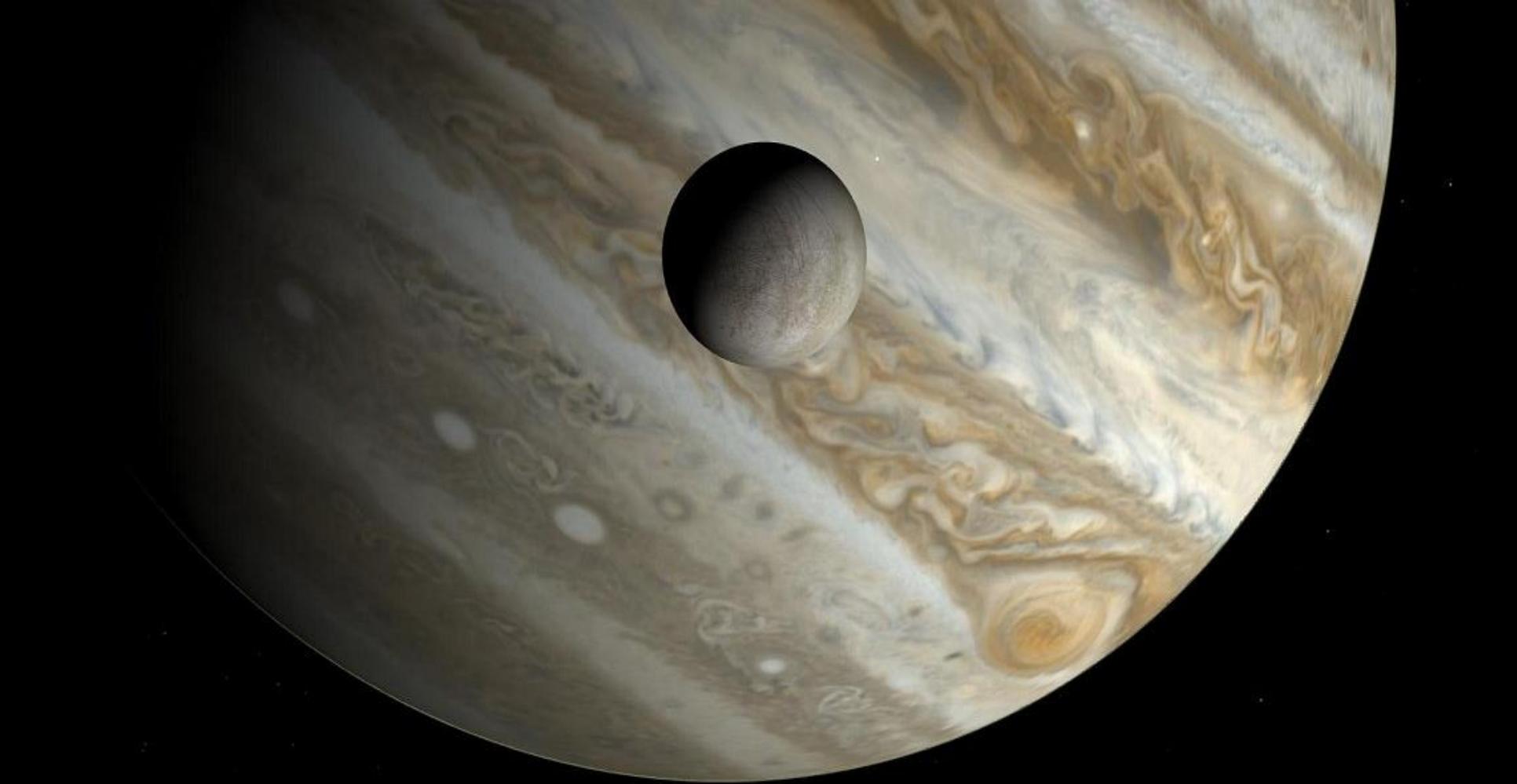


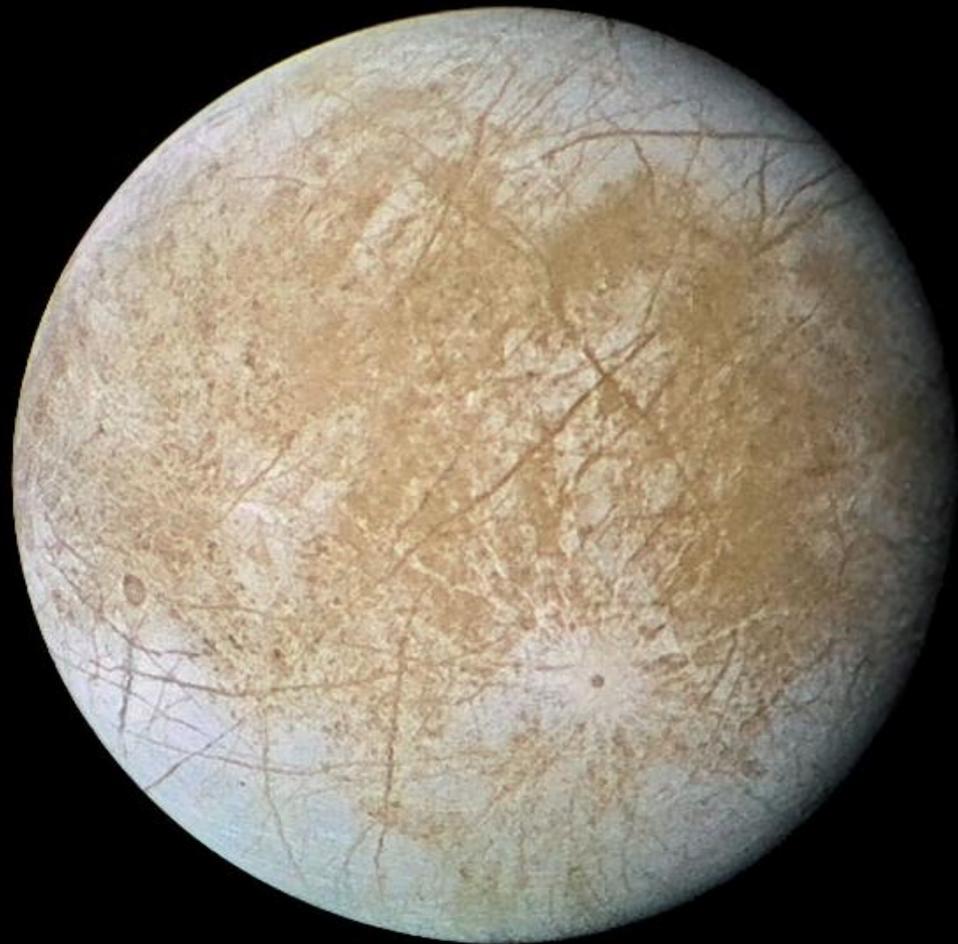


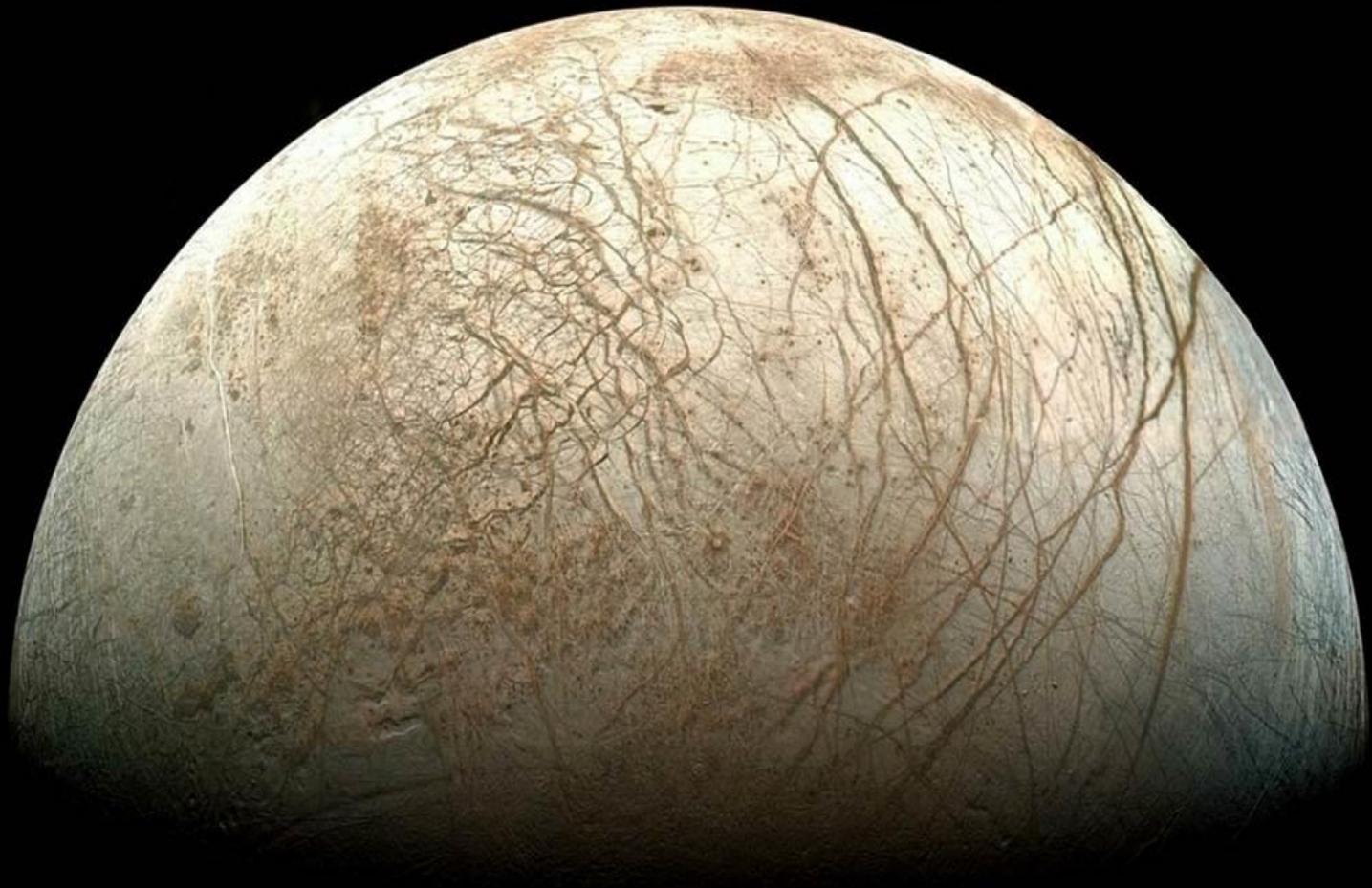




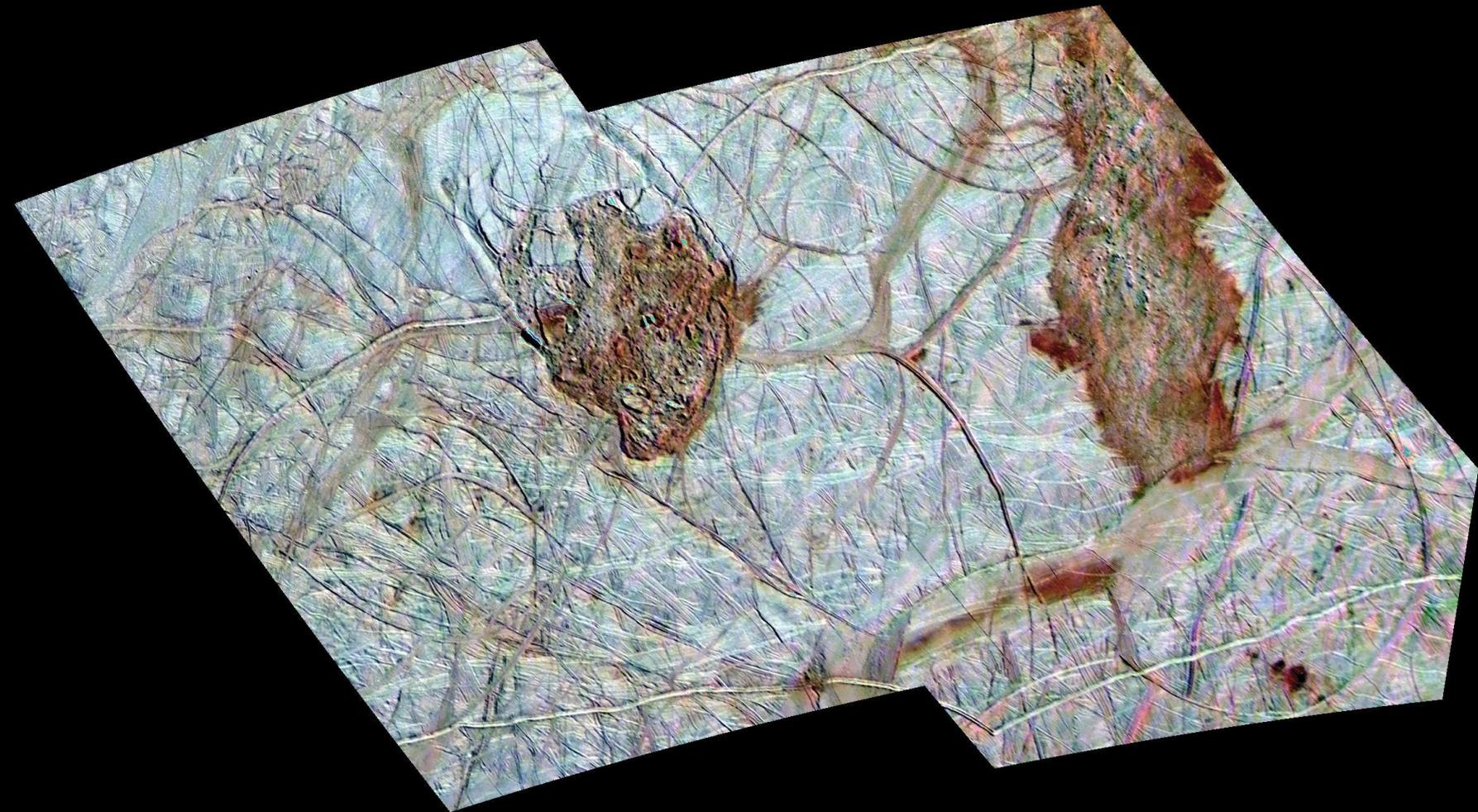


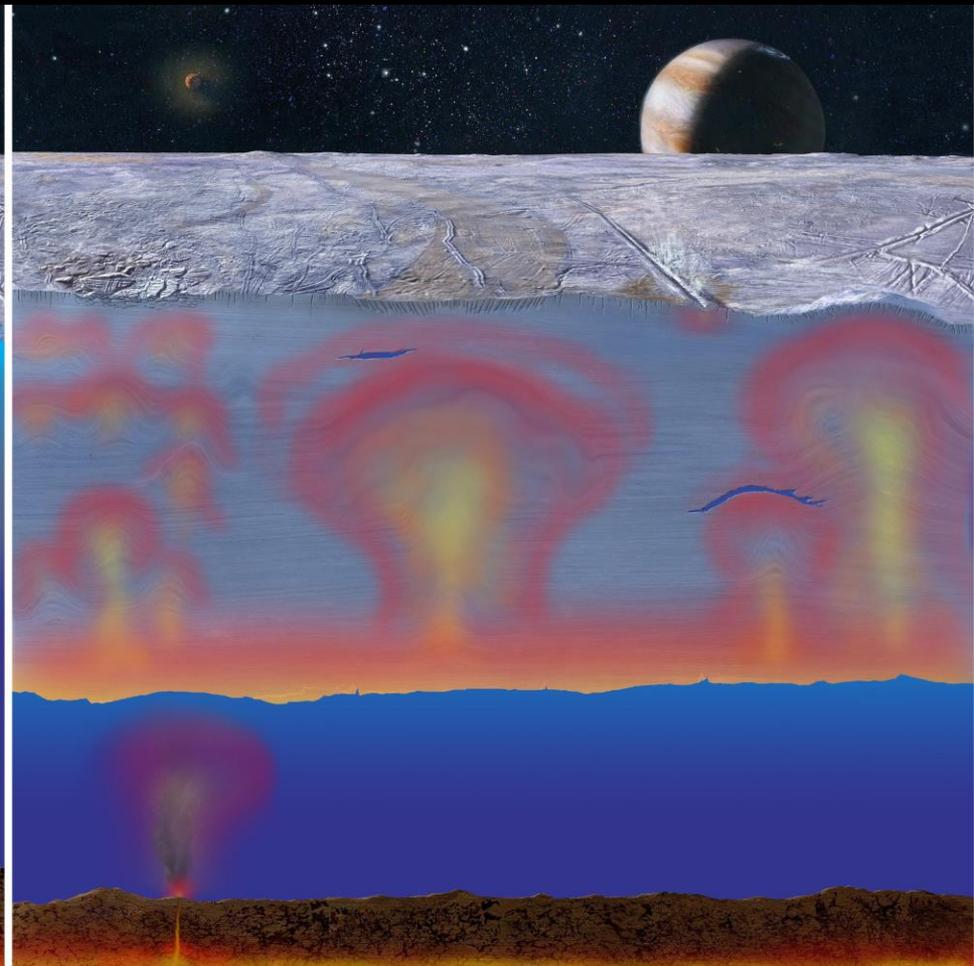
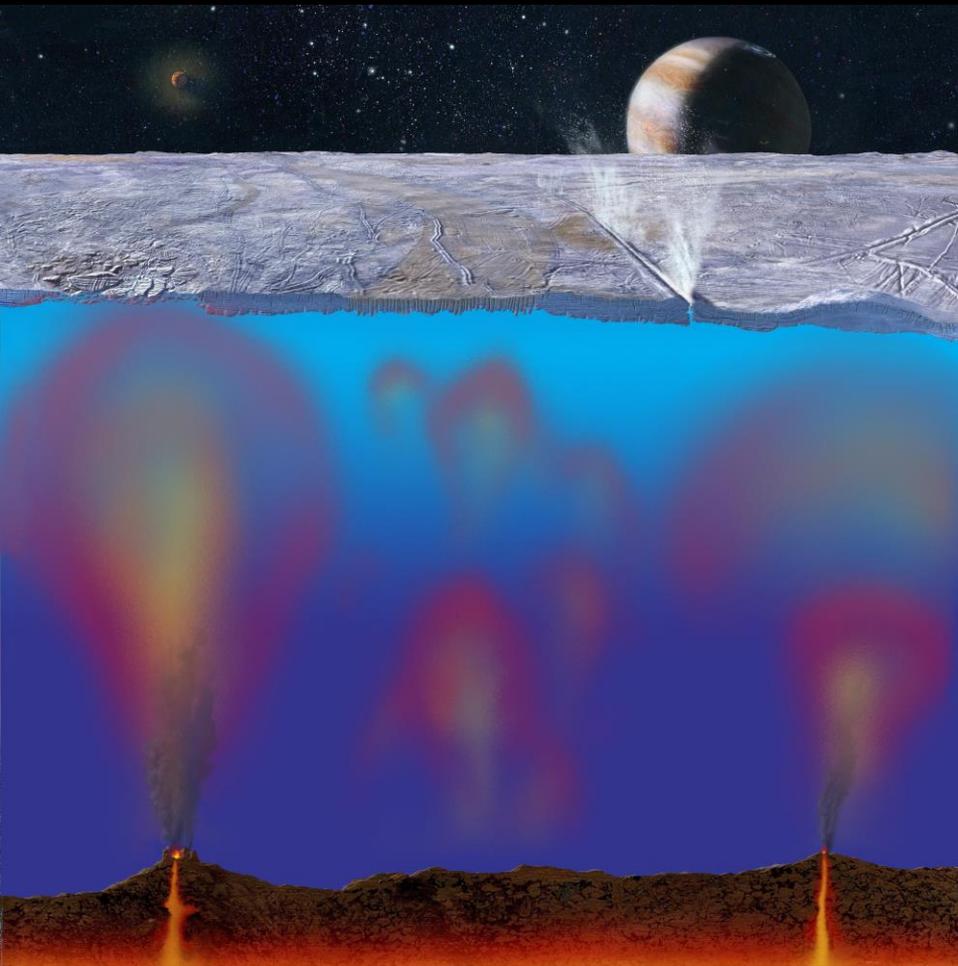


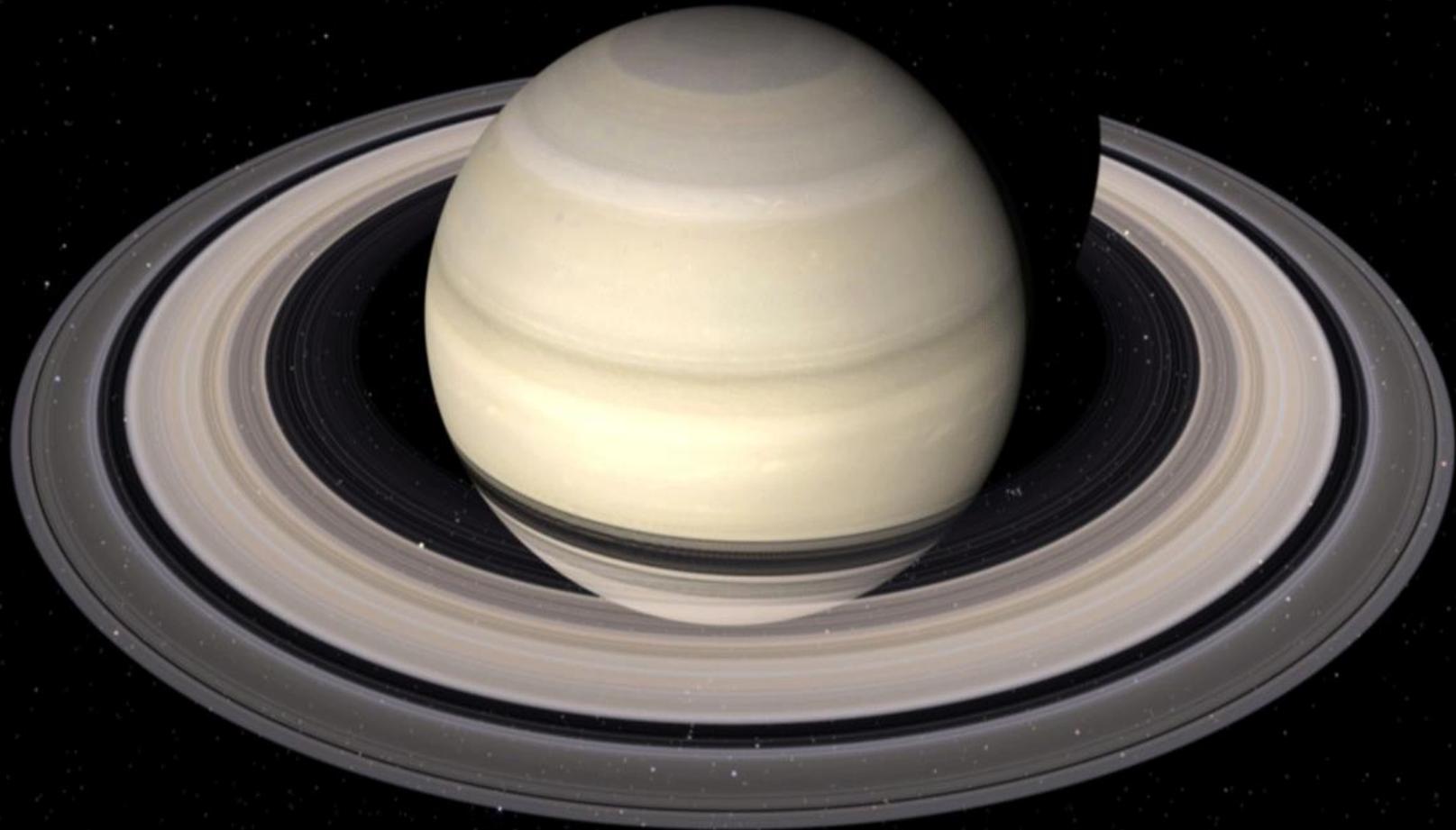




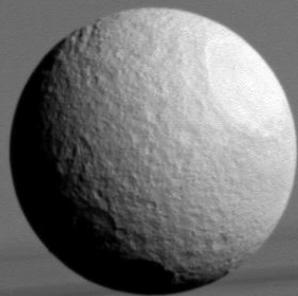












Atlas



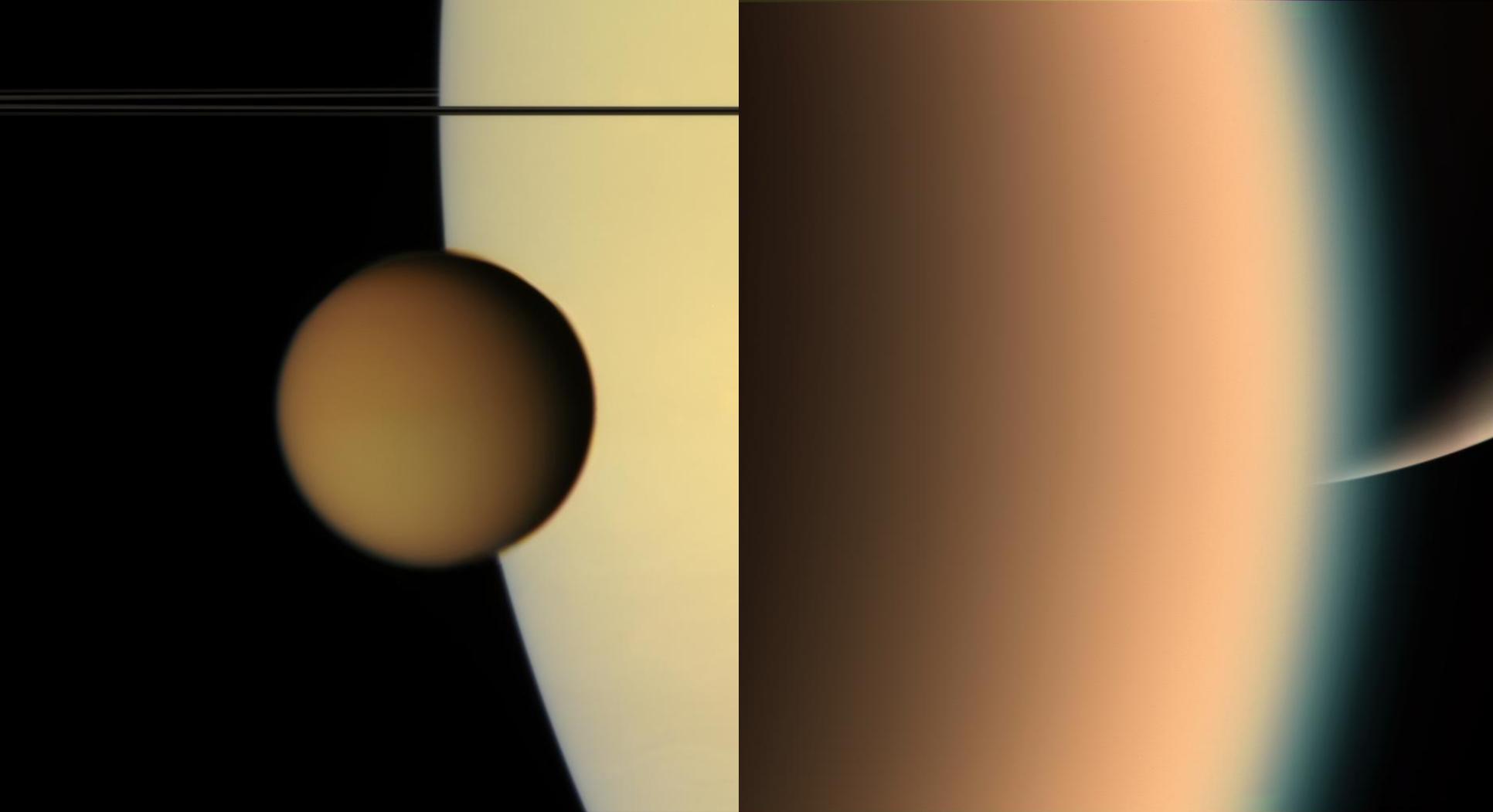
Daphnis

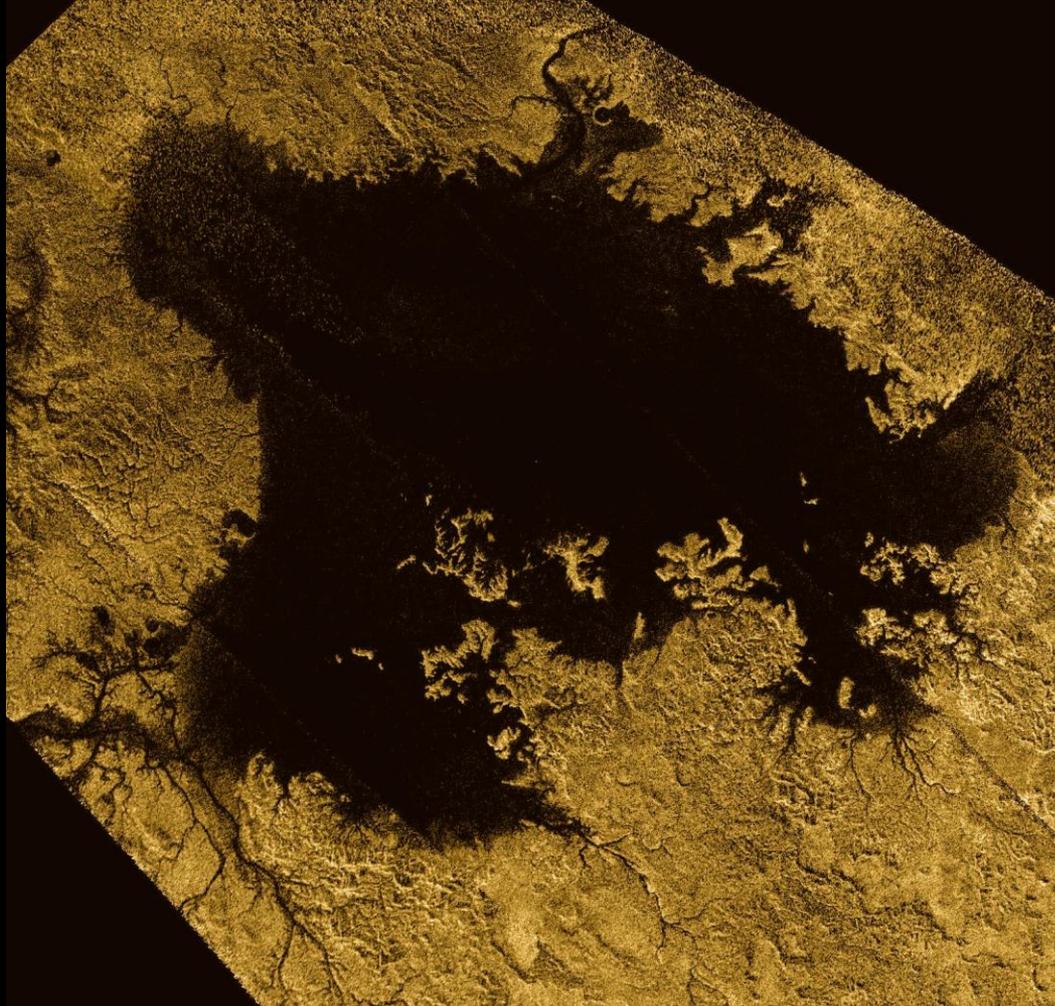


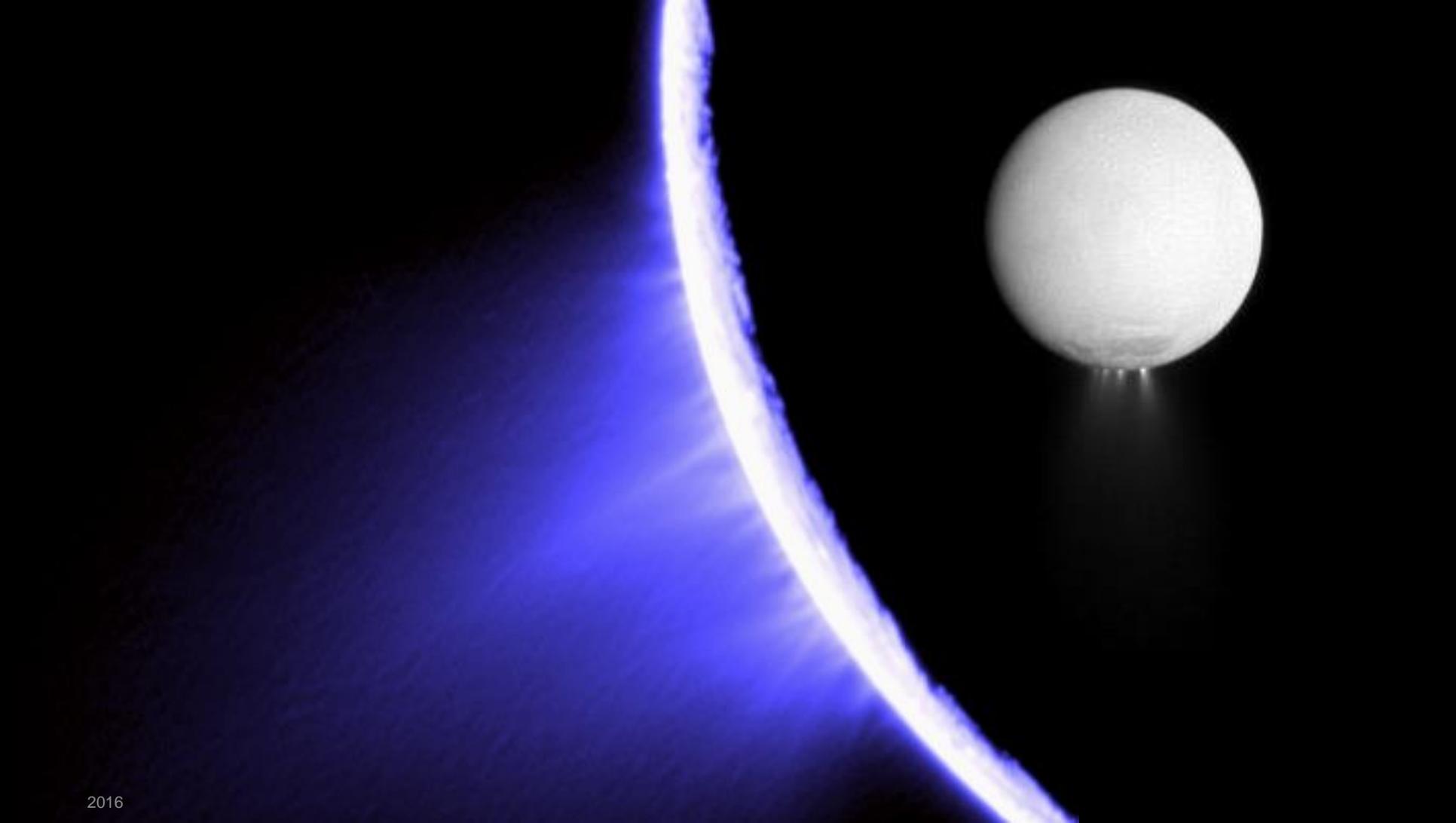
Pan

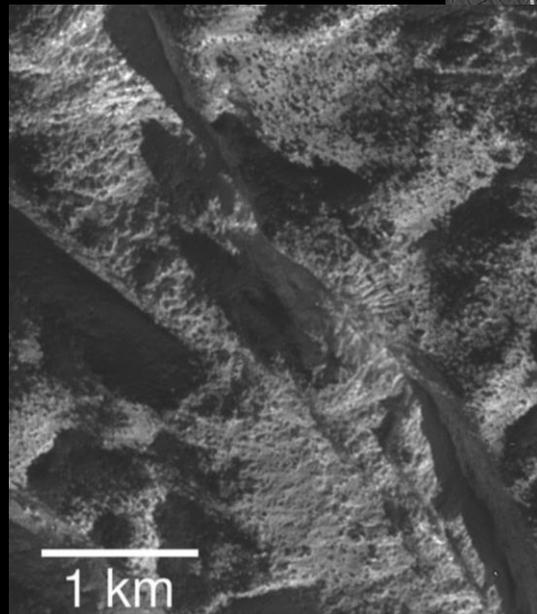
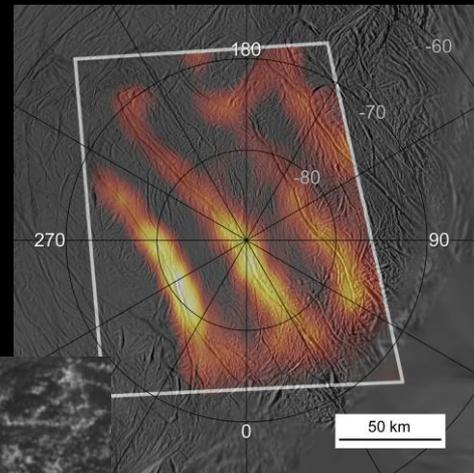
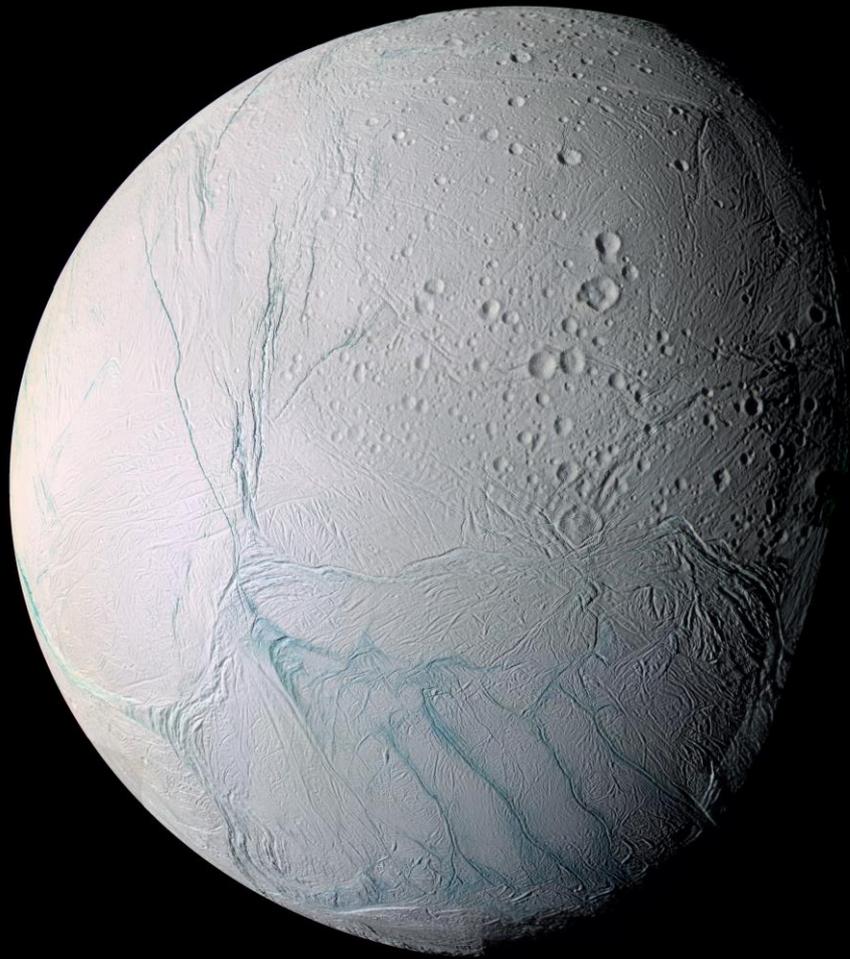


6 miles  
(10 kilometers)











Is there life elsewhere in the Universe?

# Current Potential Habitable Exoplanets

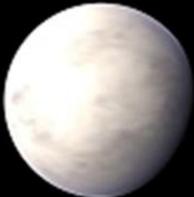
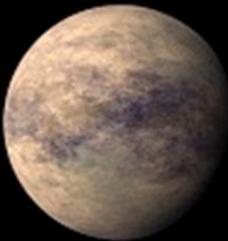
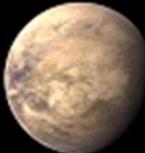
Compared with Earth and Mars and Ranked in Order of Similarity to Earth



Earth  
1.00



Mars  
0.66

| #1  | #2  | #3  | #4   | #5  | #6  | #7  |
|---|---|---|--|---|---|---|
| Earth Similarity Index  |   |   |  |   |   |   |
| 0.92  | 0.85  | 0.81  | 0.79   | 0.77  | 0.73  | 0.72  |
|  |  |  |  |  |  |  |
| Gliese 581 g*   | Gliese 667C c   | Kepler-22 b   | HD 40307 g*  | HD 85512 b  | Gliese 163 c  | Gliese 581 d  |
| Discovery Date  |   |   |  |   |   |   |
| Sep 2010  | Nov 2011  | Dec 2011  | Nov 2012   | Sep 2011  | Sep 2012  | Apr 2007  |

\*unconfirmed planets

CREDIT: PHL @ UPR Arcibo (phl.upr.edu) Nov 7, 2012

# More than a dozen ocean worlds within reach

## Ocean Relicts



Mars



Ceres

## Jovian icy moons



Europa



Ganymede



Callisto

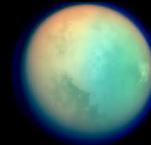
## Saturnian icy moons



Enceladus



Dione



Titan

## Kuiper Belt Objects



Triton



Pluto

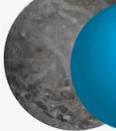


Charon

# HOW THE SOLAR SYSTEM'S LARGEST OCEAN WORLDS COMPARE IN SIZE



Earth has a surprisingly small amount of water compared to other worlds in the Solar System. Each measurement is the spherical radius of the world and its water (including ice):

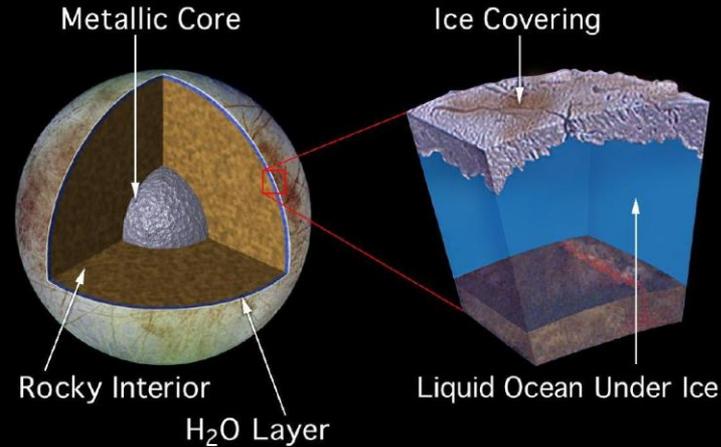
| ENCELADUS  | DIONE   | EARTH   | EUROPA  | PLUTO   | TRITON  | CALLISTO  | TITAN   | GANYMEDE  |
|--|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |
| Water radius:<br><b>140 mi./<br/>220 km.</b>                                     | Water radius:<br><b>300 mi./<br/>480 km.</b>                                      | Water radius:<br><b>430 mi./<br/>690 km.</b>                                      | Water radius:<br><b>550 mi./<br/>880 km.</b>                                      | Water radius:<br><b>630 mi./<br/>1010 km.</b>                                     | Water radius:<br><b>730 mi./<br/>1170 km.</b>                                       | Water radius:<br><b>1,120 mi./<br/>1,800 km.</b>                                    | Water radius:<br><b>1,180 mi./<br/>1,890 km.</b>                                    | Water radius:<br><b>1,460 mi./<br/>2,350 km.</b>                                    |
| World radius:<br><b>157 mi./<br/>252 km.</b>                                     | World radius:<br><b>349 mi./<br/>561 km.</b>                                      | World radius:<br><b>3,959 mi./<br/>6,371 km.</b>                                  | World radius:<br><b>972 mi./<br/>1,565 km.</b>                                    | World radius:<br><b>738 mi./<br/>1,187 km.</b>                                    | World radius:<br><b>840 mi./<br/>1,352 km.</b>                                      | World radius:<br><b>1,498 mi./<br/>2,410 km.</b>                                    | World radius:<br><b>1,601 mi./<br/>2,576 km.</b>                                    | World radius:<br><b>1,635 mi./<br/>2,631 km.</b>                                    |

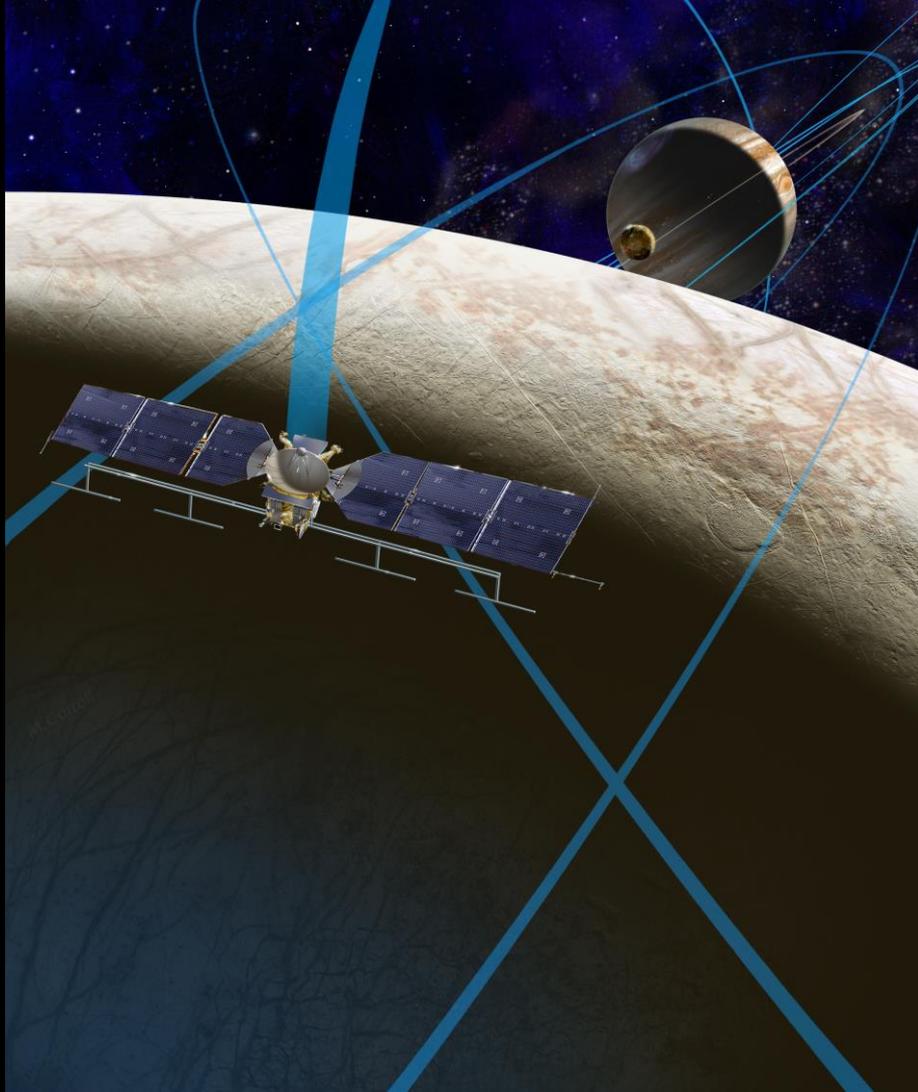
SOURCE: Steve Vance; NASA/JPL-Caltech

BUSINESS INSIDER

# Europa: best place for life?

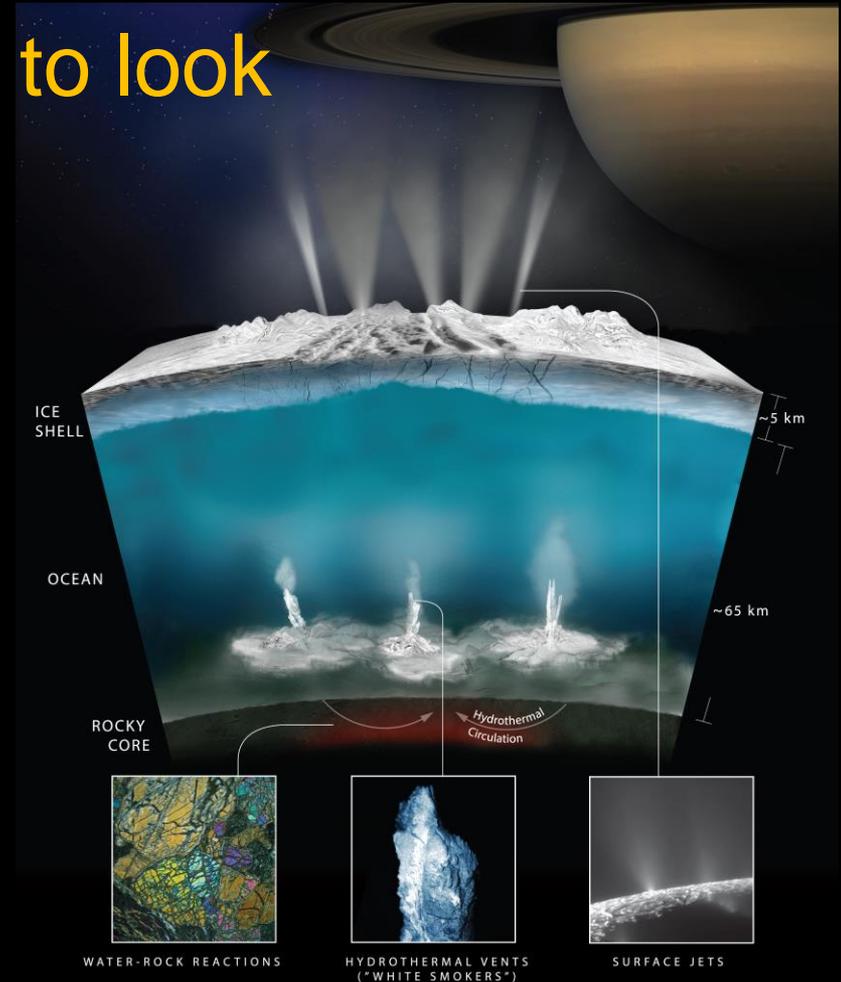
- Almost as large as Earth's Moon
- Ocean in contact with silicate rock
- Possible mechanism to sustain redox disequilibrium





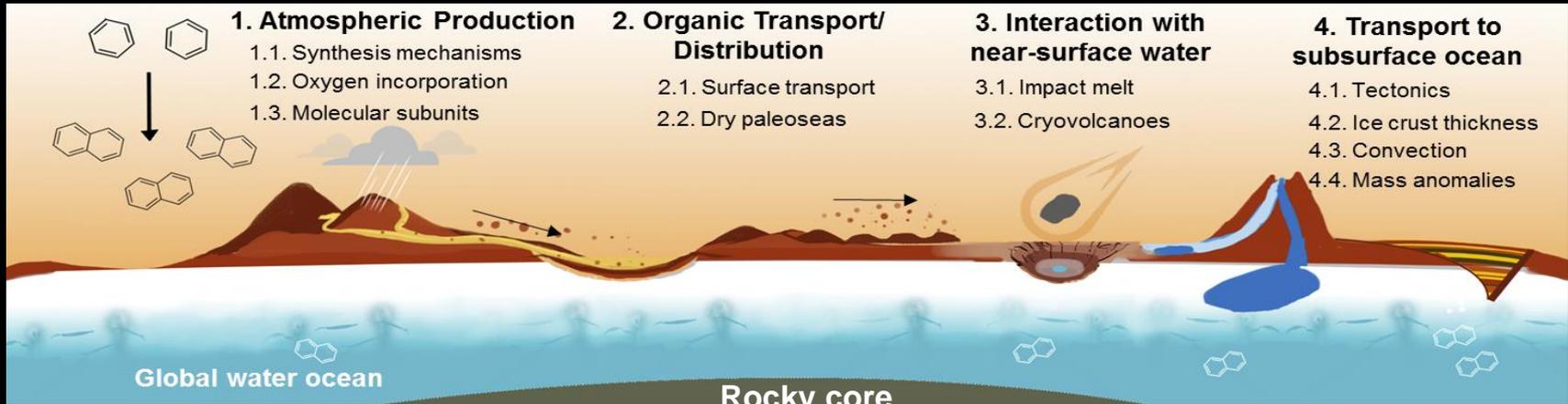
# Enceladus: easiest place to look

- Salt-water ocean with hydrothermal activity
- Predictably expressed into space by a big plume, ripe for sampling
- By today's standard, the most habitable place known off Earth



# Titan is a glimpse of early Earth

- Before Earth was a “pale blue dot” it was a pale orange dot
- A world of two oceans...





Do not go where  
the path may  
lead, go instead  
where there is  
no path and  
leave a trail.

- Ralph Waldo Emerson



*Sterre en Planete* is 'n voortvloeisel uit Hennie Maas se gewilde radioprogram met dieselfde naam wat weekliks op RSG uitgesaai word. Een van die uitstaande kenmerke van die radioprogram is dat die vier kundige deelnemers, prof. Matie Hoffman, Willie Koorts, Kobus Olckers en dr. Japie van Zyl, dit op 'n eenvoudige, lekker geselstrant doen. Die boek *Sterre en Planete* poog om tussen die akademiese, sterrekundige wetenskap en sterrekunde vir die leek 'n brug te slaan. Hierdie boek sal ongetwyfeld 'n groter gehoor as net die radioprogram trek. En met die astronomiese ontwikkeling op die gebied van ruimtewetenskap sal 'n volgende boek binnekort nodig wees!

"Sterrekunde is waarskynlik dié dissipline wat vanweë die visuele kontak die maklikste as konkreet eerder as abstrak ervaar word. In Eerste blootstelling aan 'n donker nag se verskeidenheid, prag en misterie, verkieslik onder leiding van 'n kundige, laat altyd 'n onuitwisbare indruk en herinnering. Dit verdiep maklik tot 'n groter bewondering van 'n begrip vir die onmeetlike omvang van die heelal in al sy ervaringsfasette: geskiedkundig, mitologies, observasioneel, fotografies, spektroskopies, astrofisies, kosmologies en nog meer.

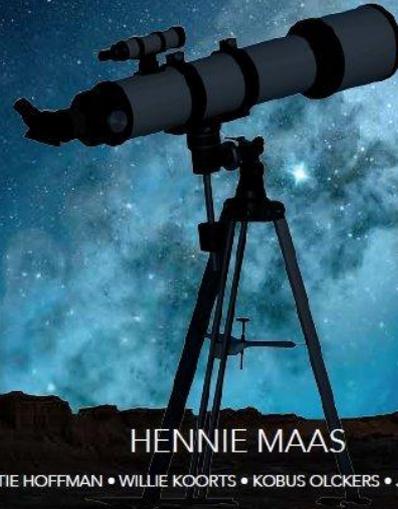
Dit is in hierdie konteks dat sowel *RSG Sterre & Planete* se radioprogram as hul Facebook-blad een van dié belangrikste blootstellings aan 'n breë spektrum van sterrekunde bied wat bykans intyds deur vakkundige gesaghebbendes gegee word. Die gevolglike bevordering van 'n belangstelling in sterrekunde gee daarmee uitvoering aan die Sterrekundige Vereniging van Suidelike Afrika (ASSA) se missie om die studie en praktyk van sterrekunde aan te moedig en te stimuleer.

"Dankie vir julle wesenlike verrykking van so baie se lewens. Doet so voort!"  
Pierre de Villiers, President: ASSA

Sterre en Planete

HENNIE MAAS  
MATIE HOFFMAN • WILLIE KOORTS •  
KOBUS OLCKERS • JAPIE VAN ZYL

# Sterre en Planete



HENNIE MAAS

MATIE HOFFMAN • WILLIE KOORTS • KOBUS OLCKERS • JAPIE VAN ZYL

www.naledi.online



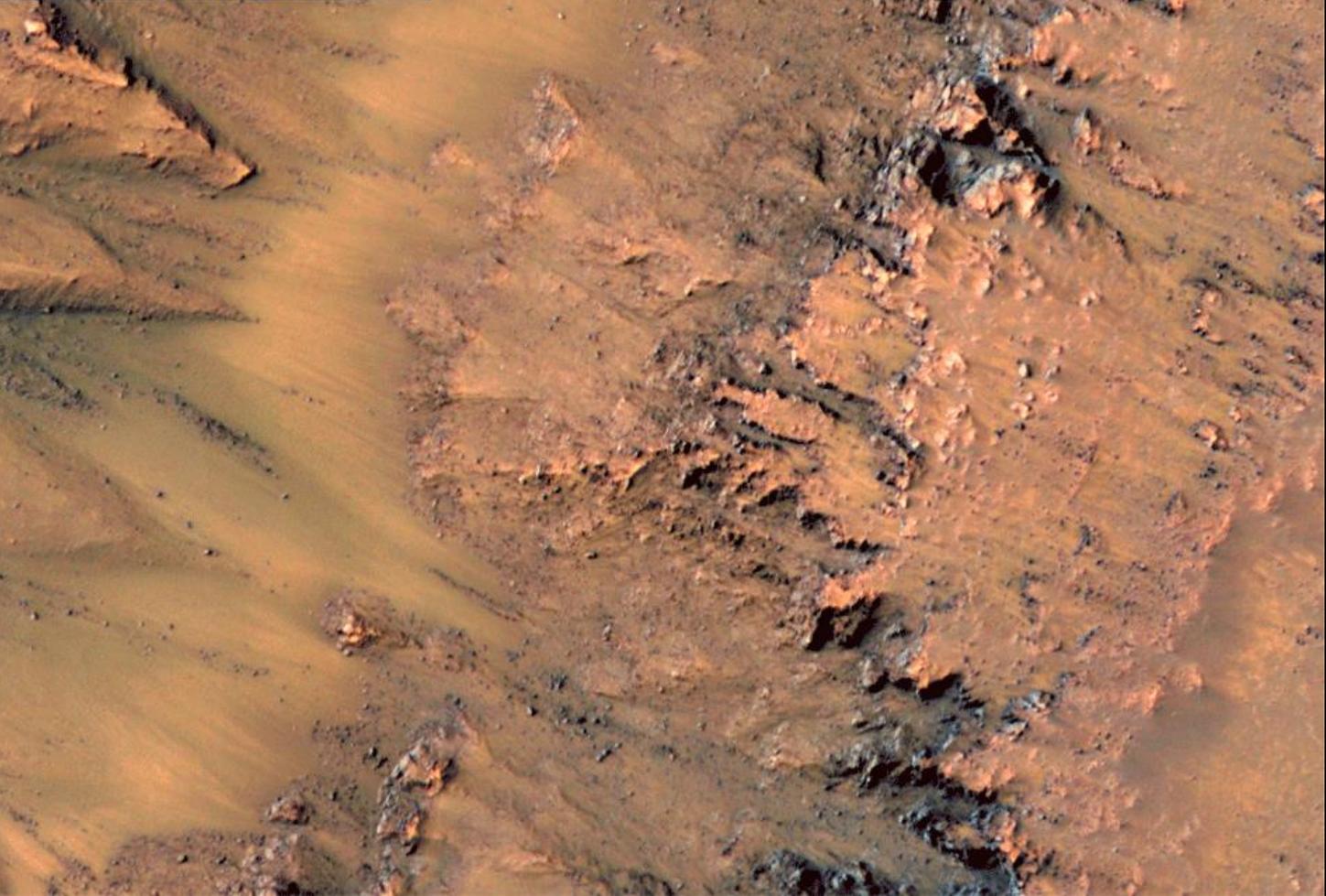
naledi\*

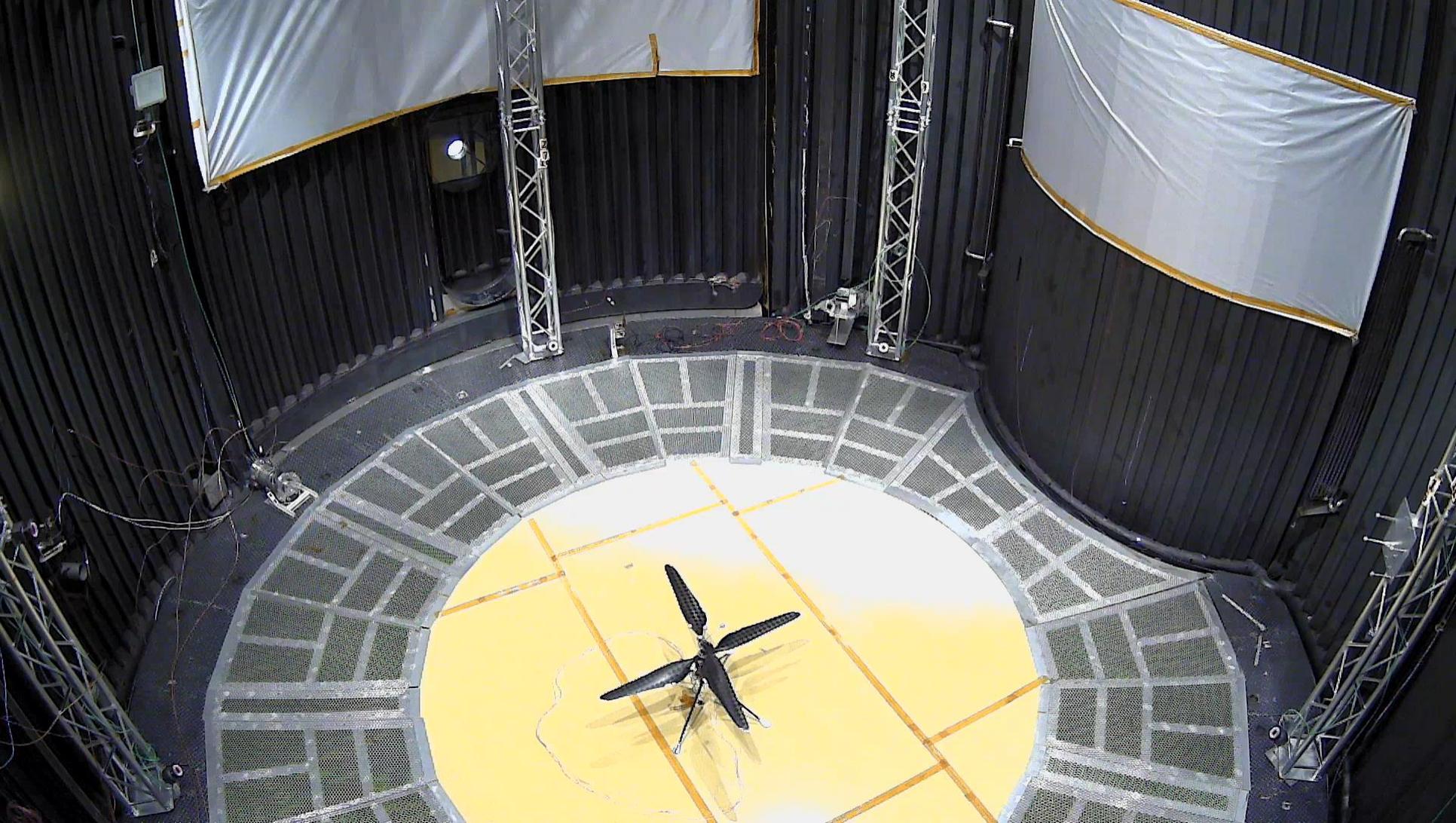


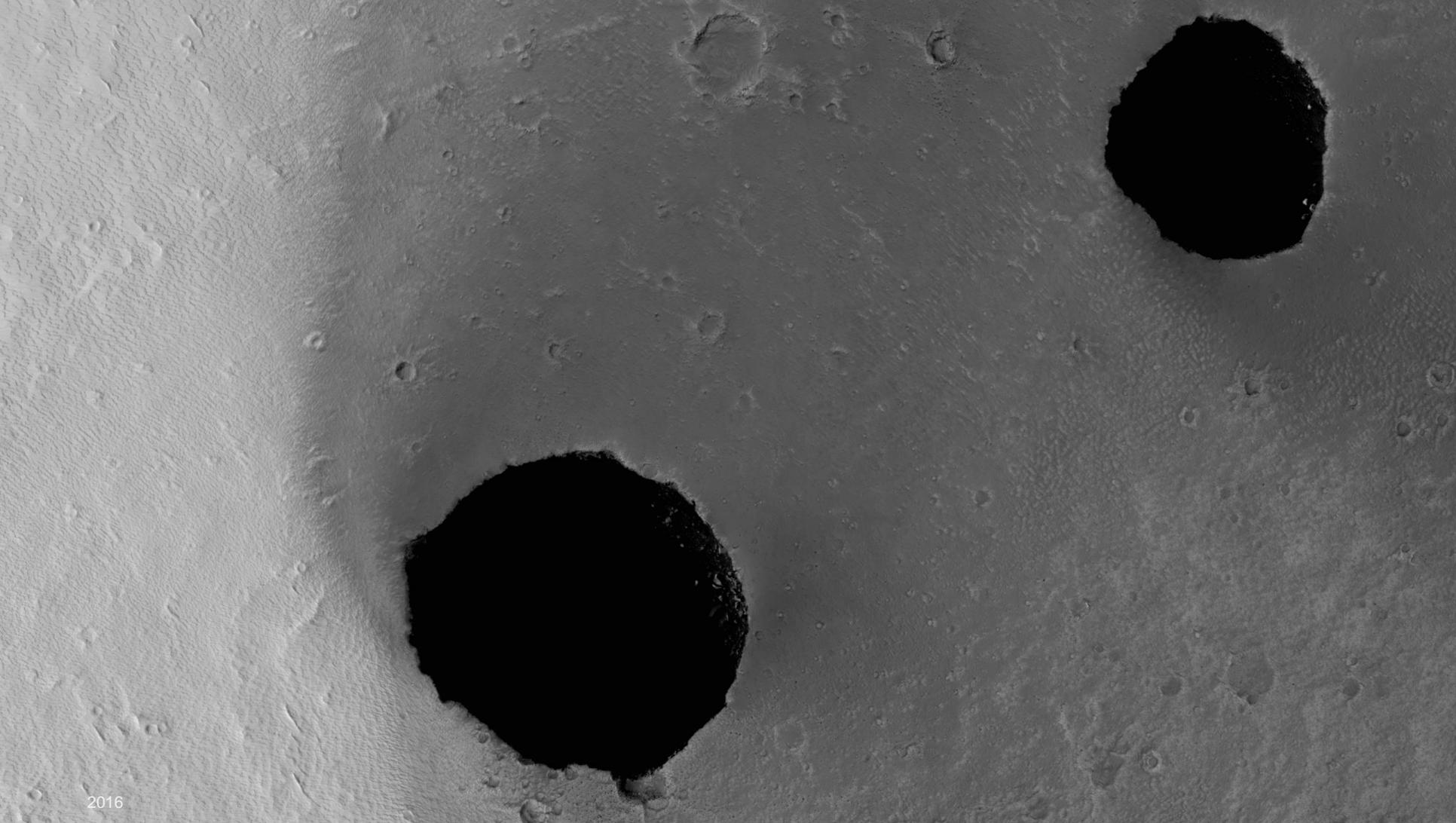


**Jet Propulsion Laboratory**  
California Institute of Technology

MY 29  
MY 30  
L\_s 0 autumn 90 winter 180 spring 270 summer 360  
ESP\_011428\_1380









Free Climbing 15 deg overhang  
Video Speed Increased