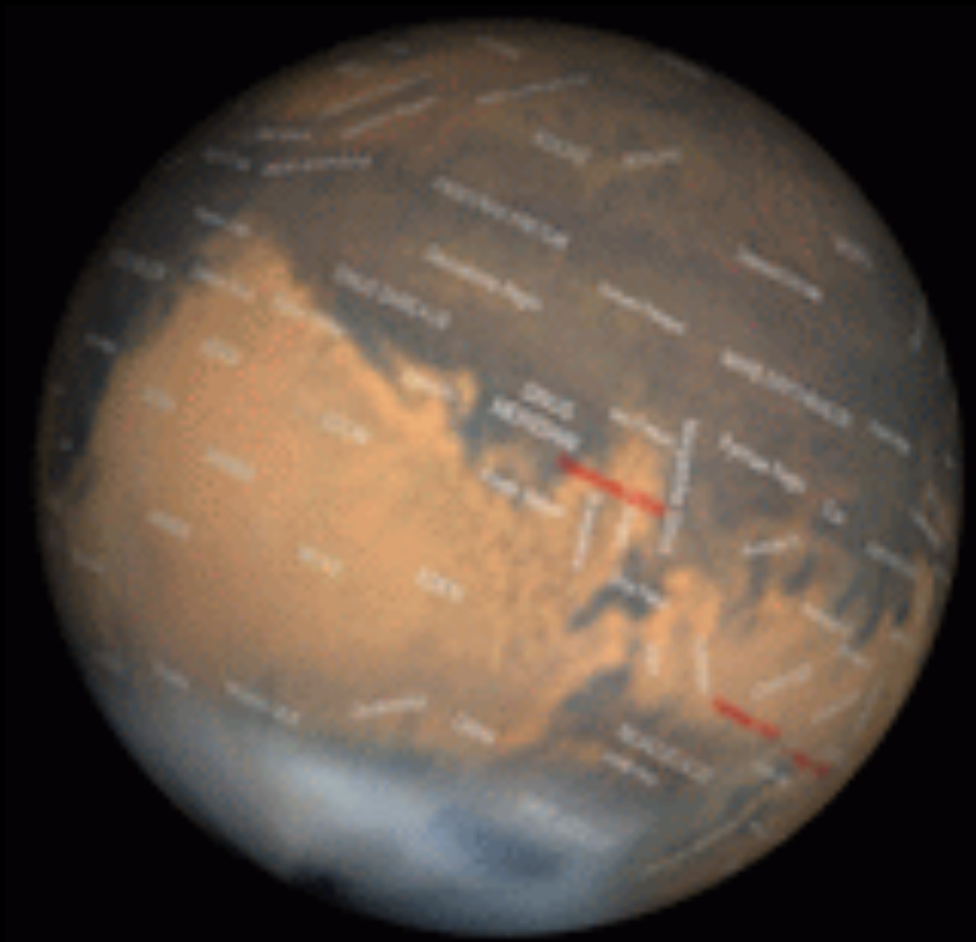
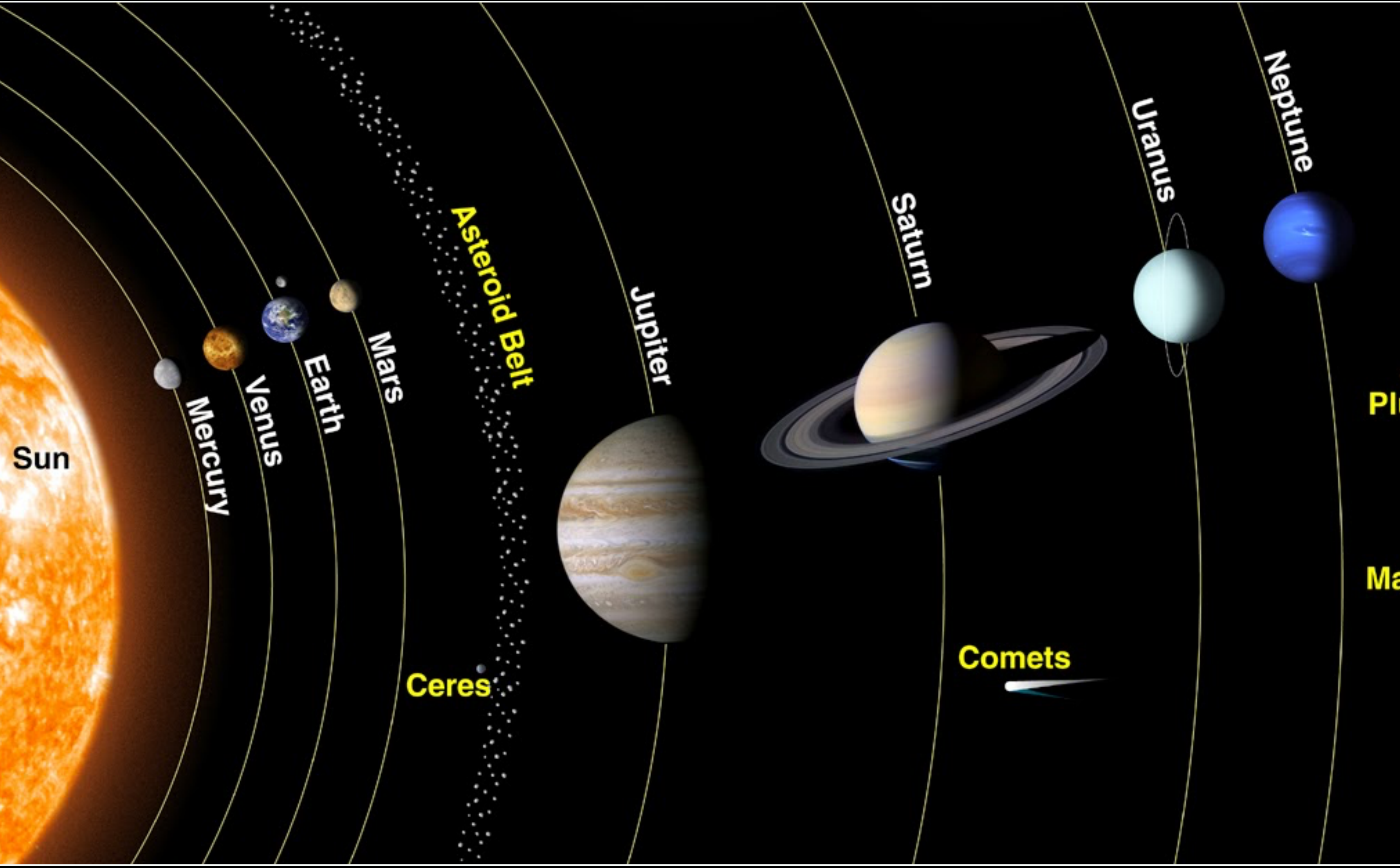
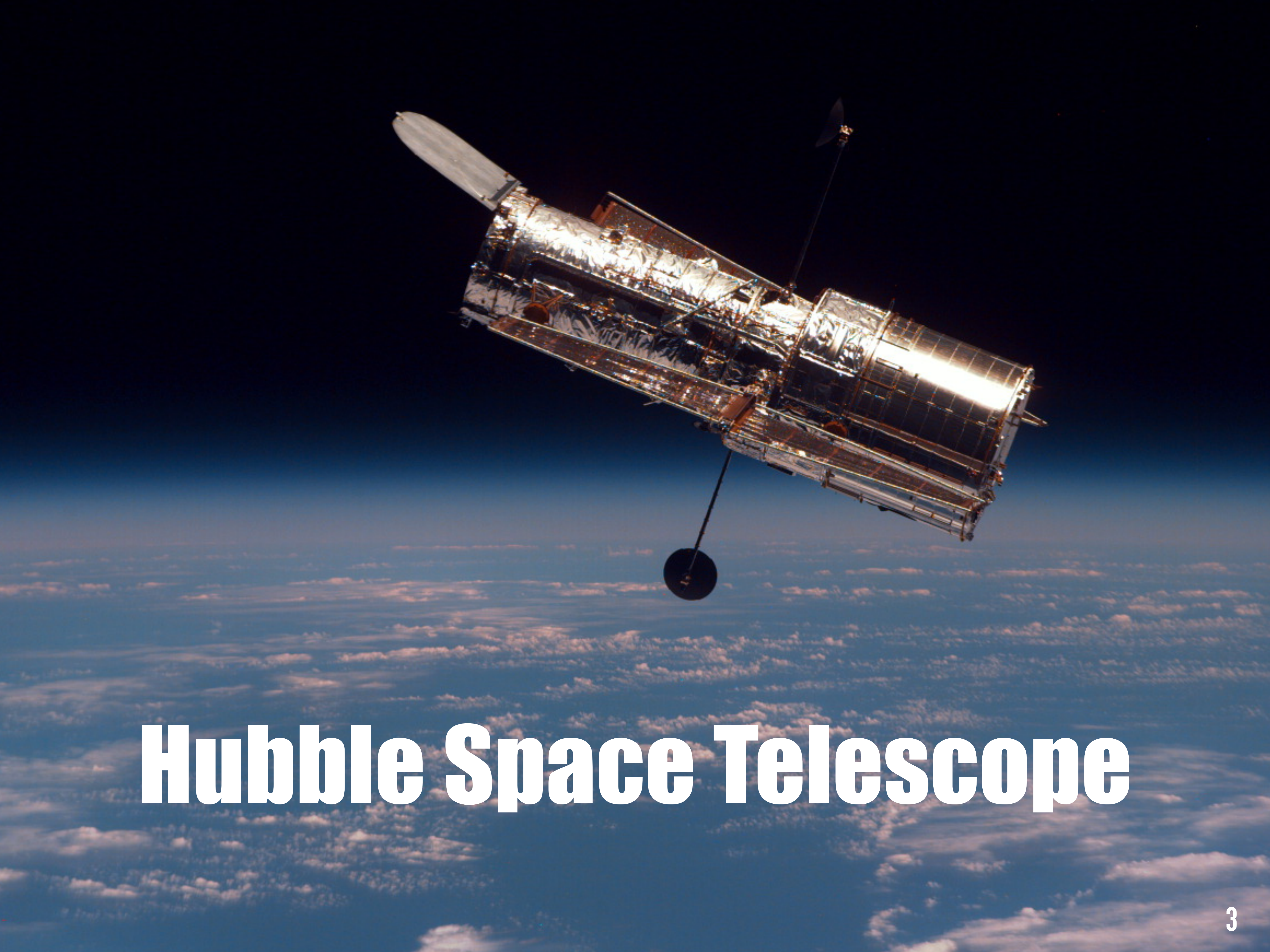


An incredible journey into space

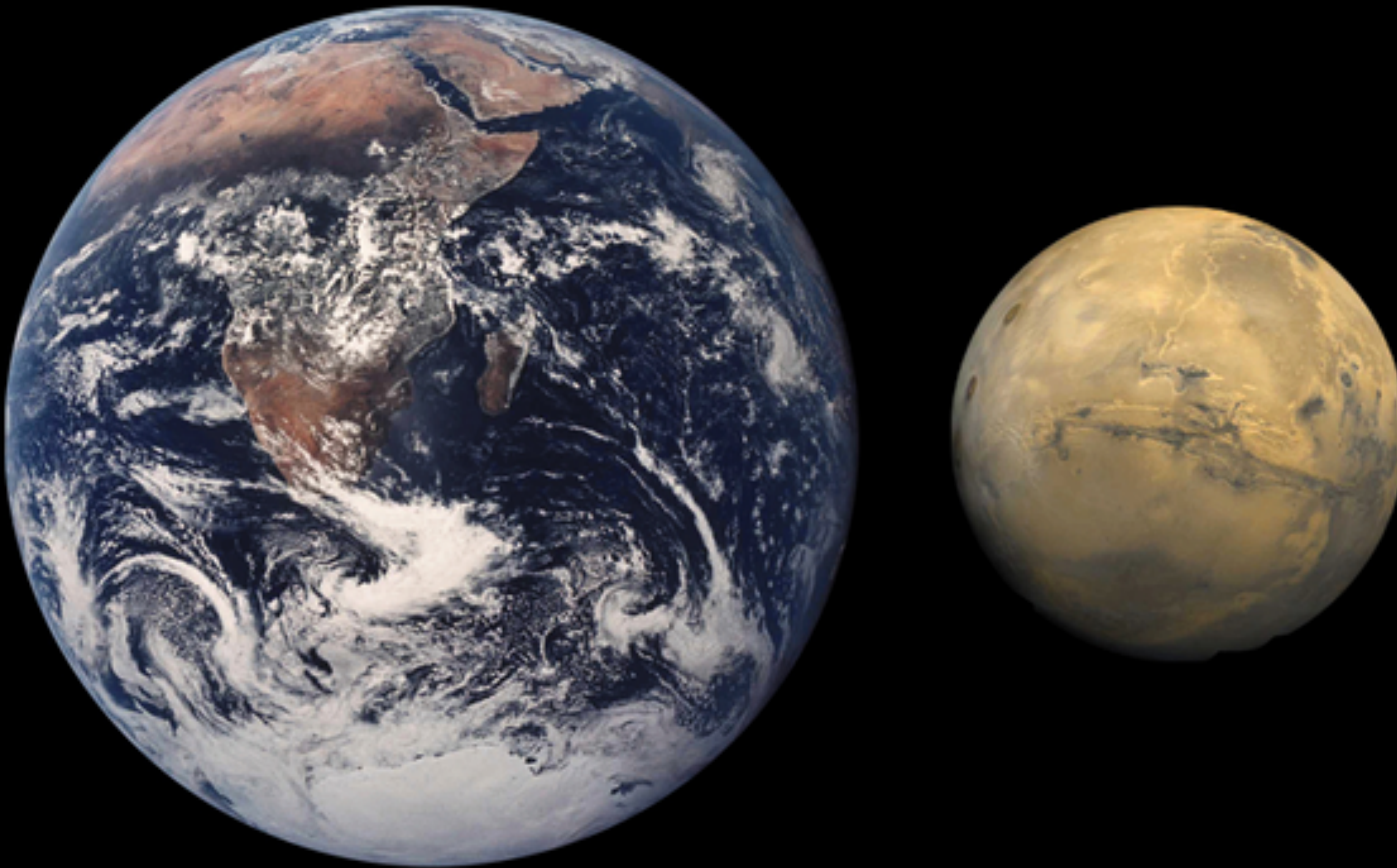
The Weather on Mars

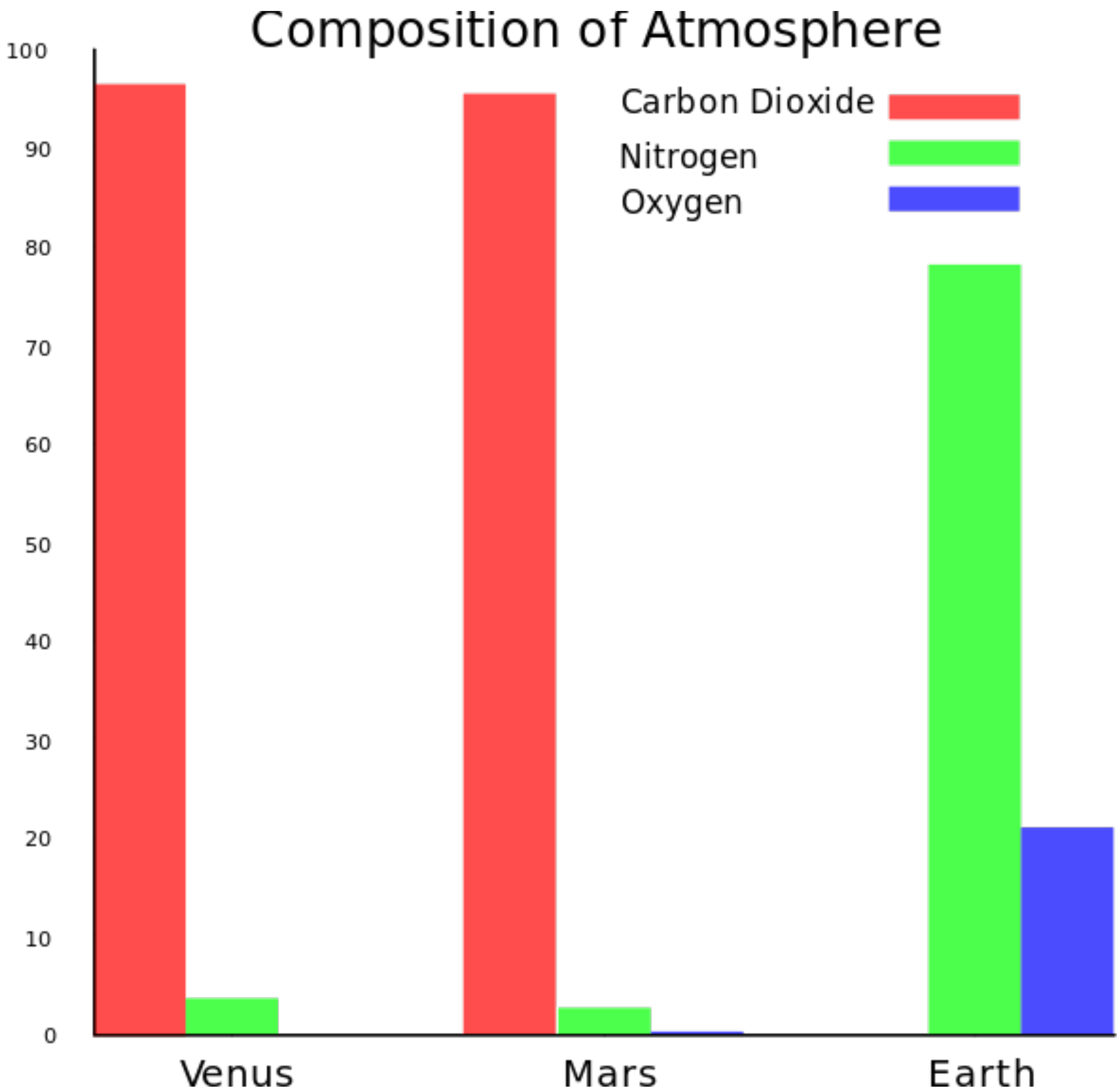

Sun
Mercury
Venus
Earth
Mars
Asteroid Belt
Ceres
Jupiter
Saturn
Comets
Uranus
Neptune


A trip to Mars



Hubble Space Telescope




Composition of Atmosphere
Carbon Dioxide
Nitrogen
Oxygen
100
90
80
70
60
50
40
30
20
10
0
Venus
Mars
Earth

an atmosphere has certain characteristics which are very different to those
esence of regular travelling baroclinic waves occur.

Physical Parameters	**Earth**	**Mars**
Radius	6378 km	3397 km
Surface gravity	9.8 ms^{-2}	3.72 ms^{-2}
Mean distance from sun	1.49 x 10^8 km	2.28 x 10^8 km
Inclination of Equator to orbit	23.45^o	25.2^o
Rotation Period	24 h (1 day)	24 h 39.5 m (1 sol)
Length of year	365.25 days	669 sols
Surface pressure	1000 mb	5-10 mb
Surface Temperature	250-300 K	150-300 K
Scale Height	8 km	10 km

Table 3.1: Characteristics of Earth and Mars.

ugh there is a basic similarity in the values of relevant parameters for l
or Mars and the Earth, Martian meteorology has some unique aspects (Le

Travel time to the red planet

Mariner 4, the first spacecraft to go to Mars (1964 flyby): 228 days

Mariner 6 (1969 flyby): 155 days

Mariner 7 (1969 flyby): 128 days

Mariner 9, the first spacecraft to orbit Mars (1971): 168 days

Viking 1, the first U.S. craft to land on Mars (1975): 304 days

Viking 2 Orbiter/Lander (1975): 333 days

Mars Global Surveyor (1996): 308 days

Mars Pathfinder (1996): 212 days

Mars Odyssey (2001): 200 days

Mars Express Orbiter (2003): 201 days

Mars Reconnaissance Orbiter (2005): 210 days

Mars Science Laboratory (2011): 254 days

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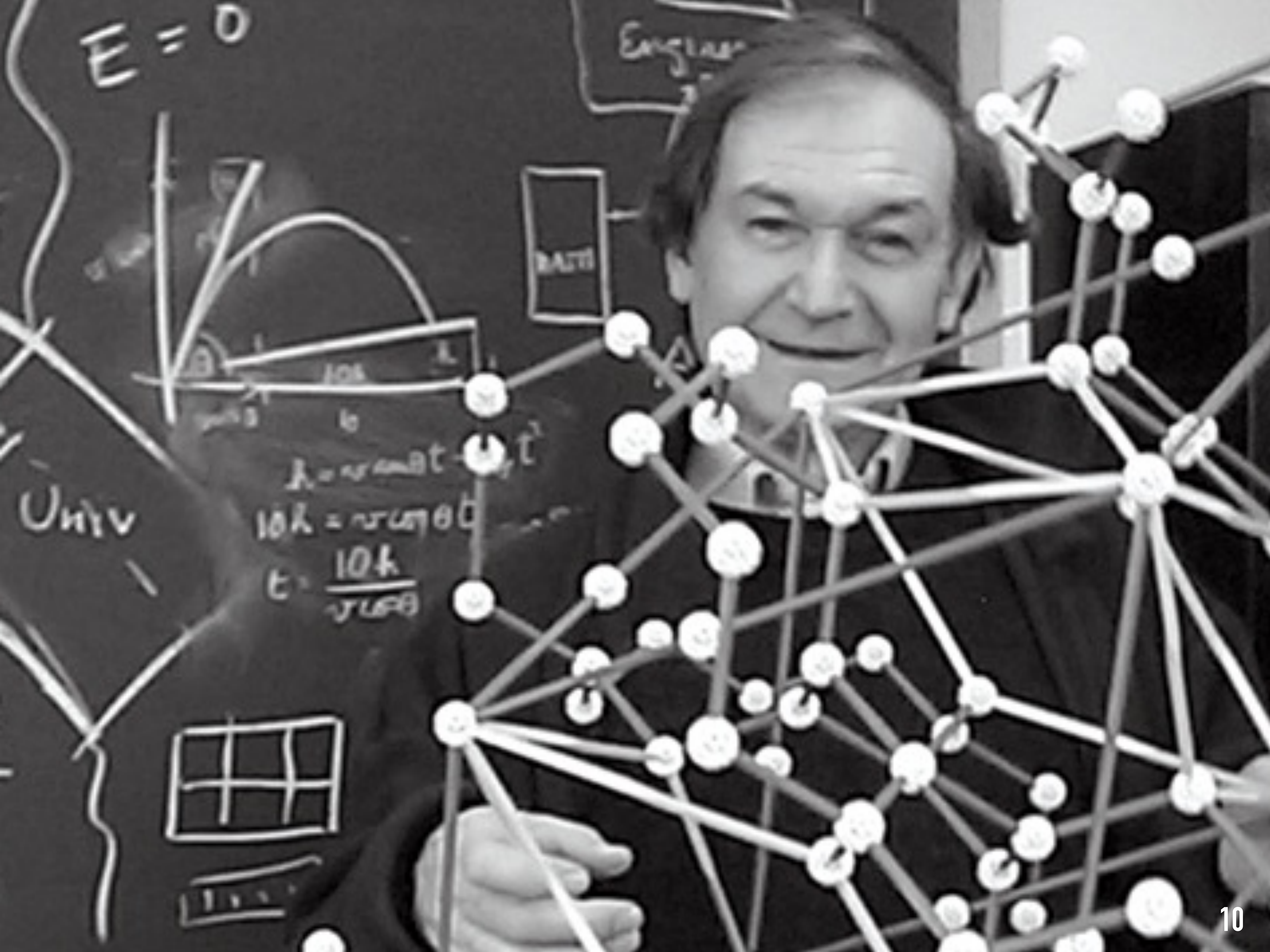
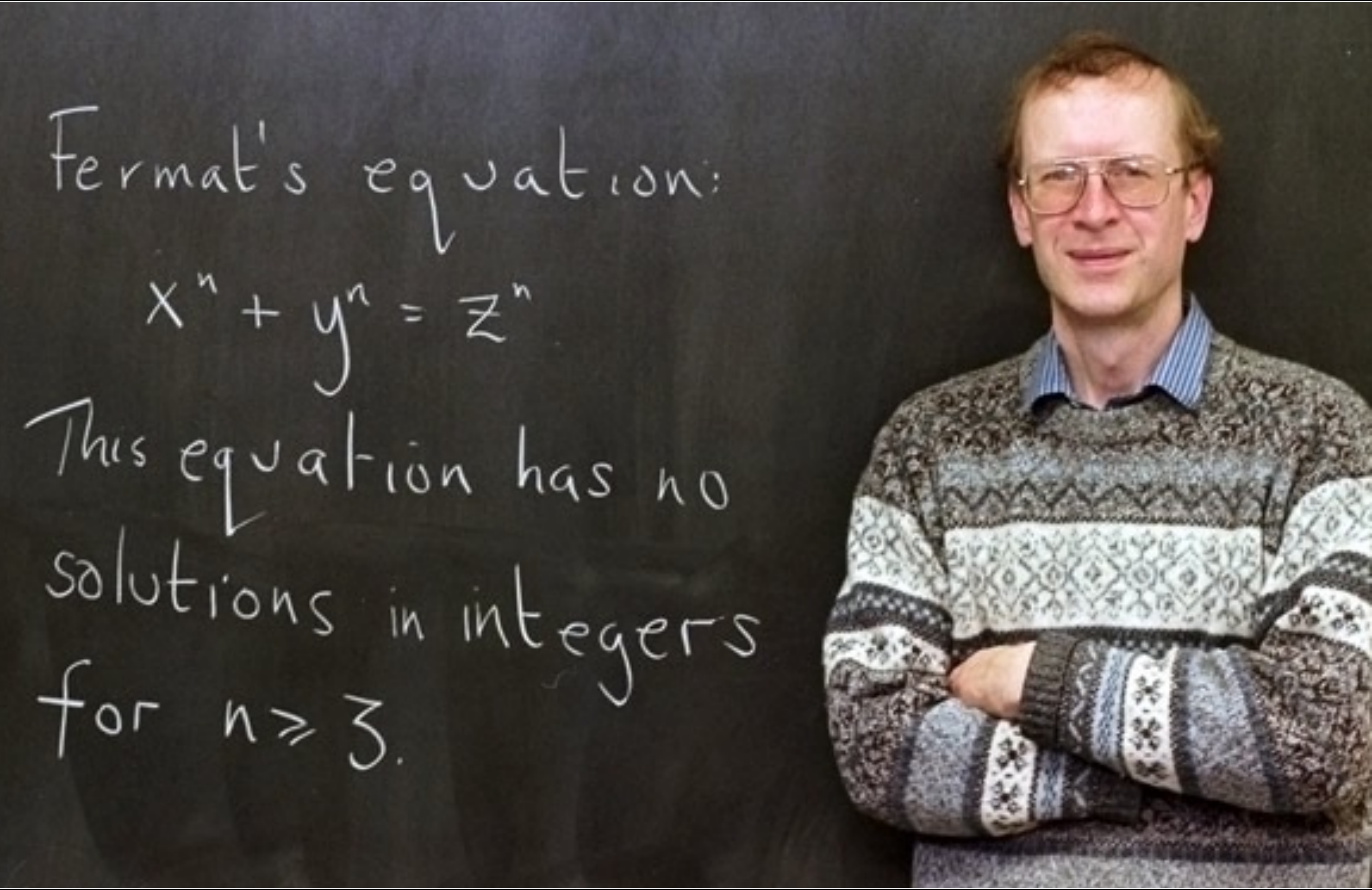
The Pathfinder Project


E = 0
Univ


Fermat's equation:
x^n + y^n = z^n
This equation has no
solutions in integers
for n ≥ 3.

The challenge (by end of week):

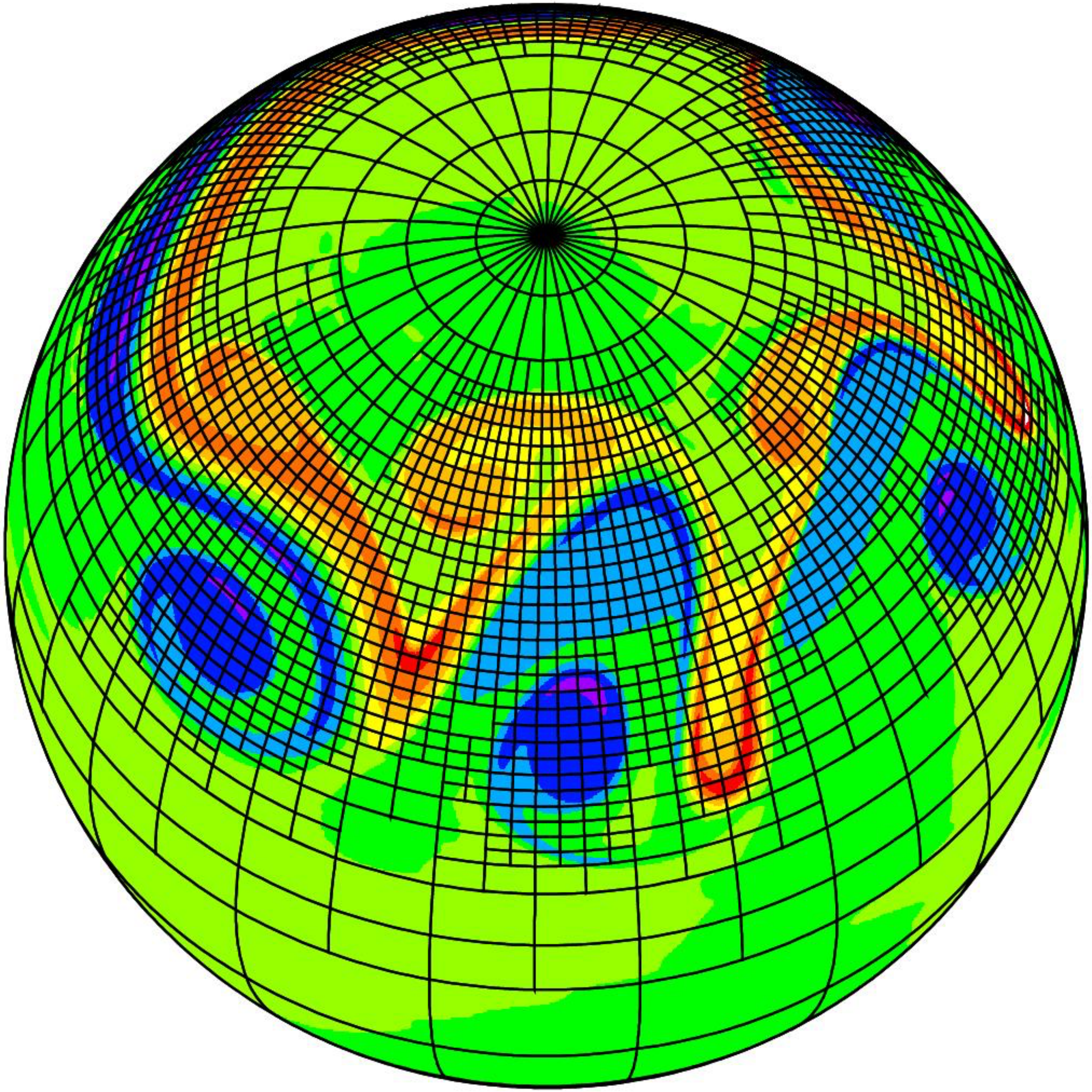
- $x^n + y^n = z^n$
- Solution has no real numbers for n greater than or equal to 3
- For n=2: you find me the largest x, y and z

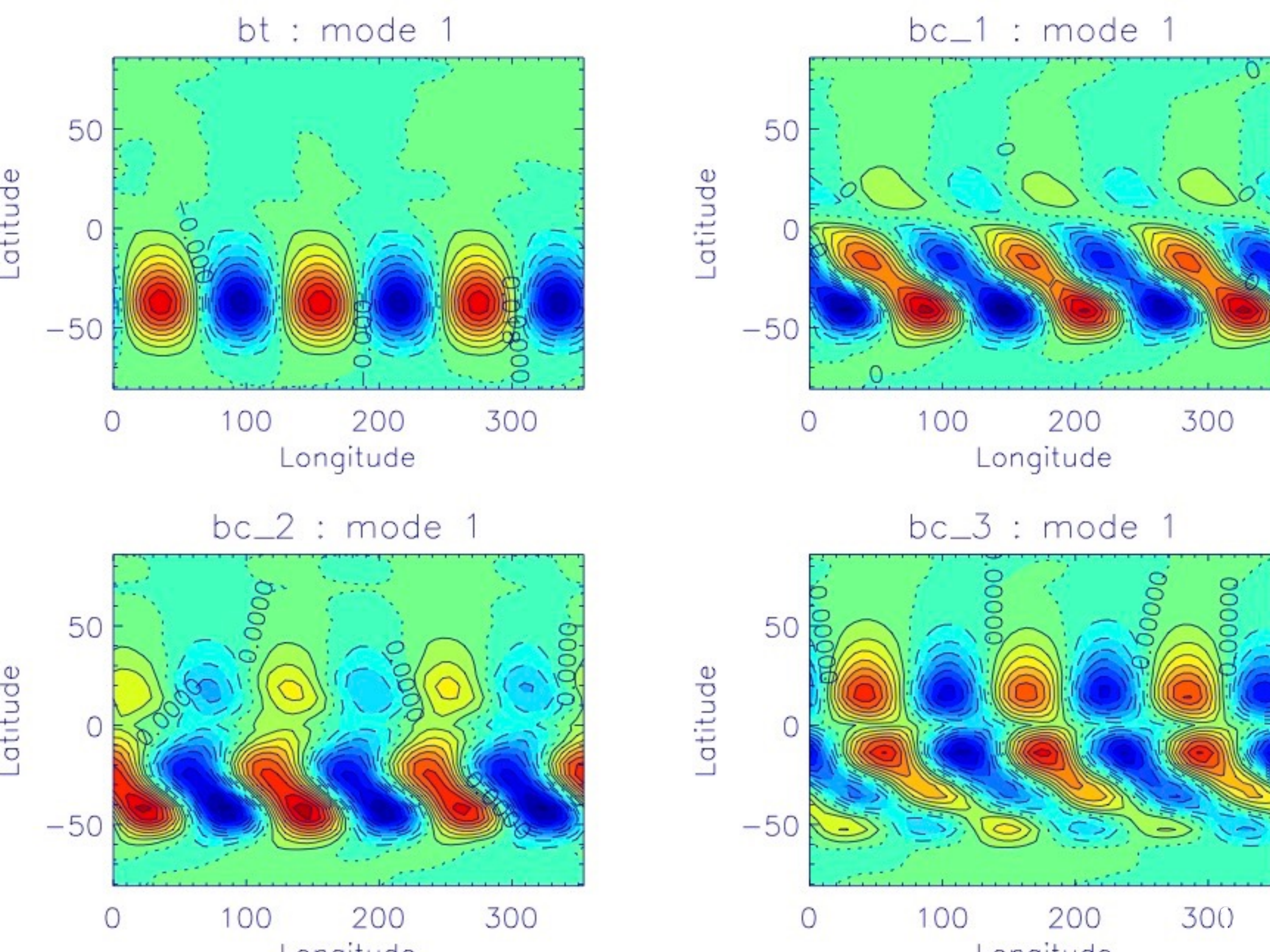
der (θ, ϕ, z) to be the coordinate axes, where ϕ is longitude, θ latitude, z the ve
ce above the surface of the planet and $\mathbf{U} = (u, v, w)$ to be the relative velocity.
ce to the centre of the planet is r where $r = a + z$ (a is the radius of the planet).
for the regions of the atmosphere which are meteorologically relevant, we take $r =$
approximation. If the Coriolis force $2\mathbf{\Omega}$ is expressed in components and the frict
to be $\mathbf{F}_r = (F_x, F_y, F_z)$, then the equations of motion on a sphere are :

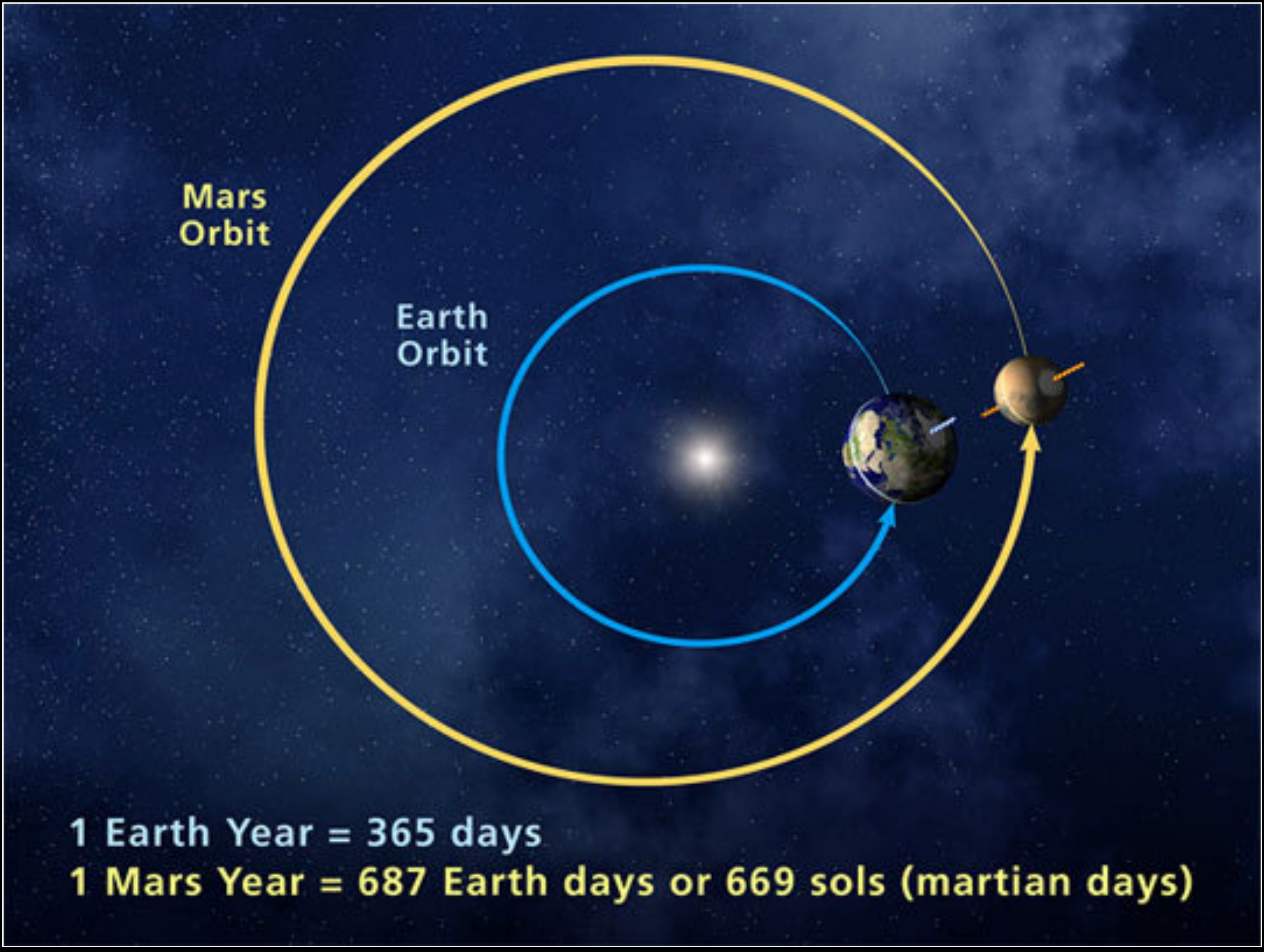
$$
\begin{aligned}
\frac{du}{dt} - \frac{uv\tan\theta}{a} + \frac{uw}{a} &= -\frac{1}{\rho}\frac{\partial p}{\partial x} + 2\Omega v\sin\theta - 2\Omega w\cos\theta + F_x, \\
\frac{dv}{dt} + \frac{u^2\tan\theta}{a} + \frac{uw}{a} &= -\frac{1}{\rho}\frac{\partial p}{\partial y} - 2\Omega u\sin\theta + F_y, \\
\frac{dw}{dt} - \frac{u^2+v^2}{a} &= -\frac{1}{\rho}\frac{\partial p}{\partial z} - g + 2\Omega u\cos\theta + F_z.
\end{aligned}
$$

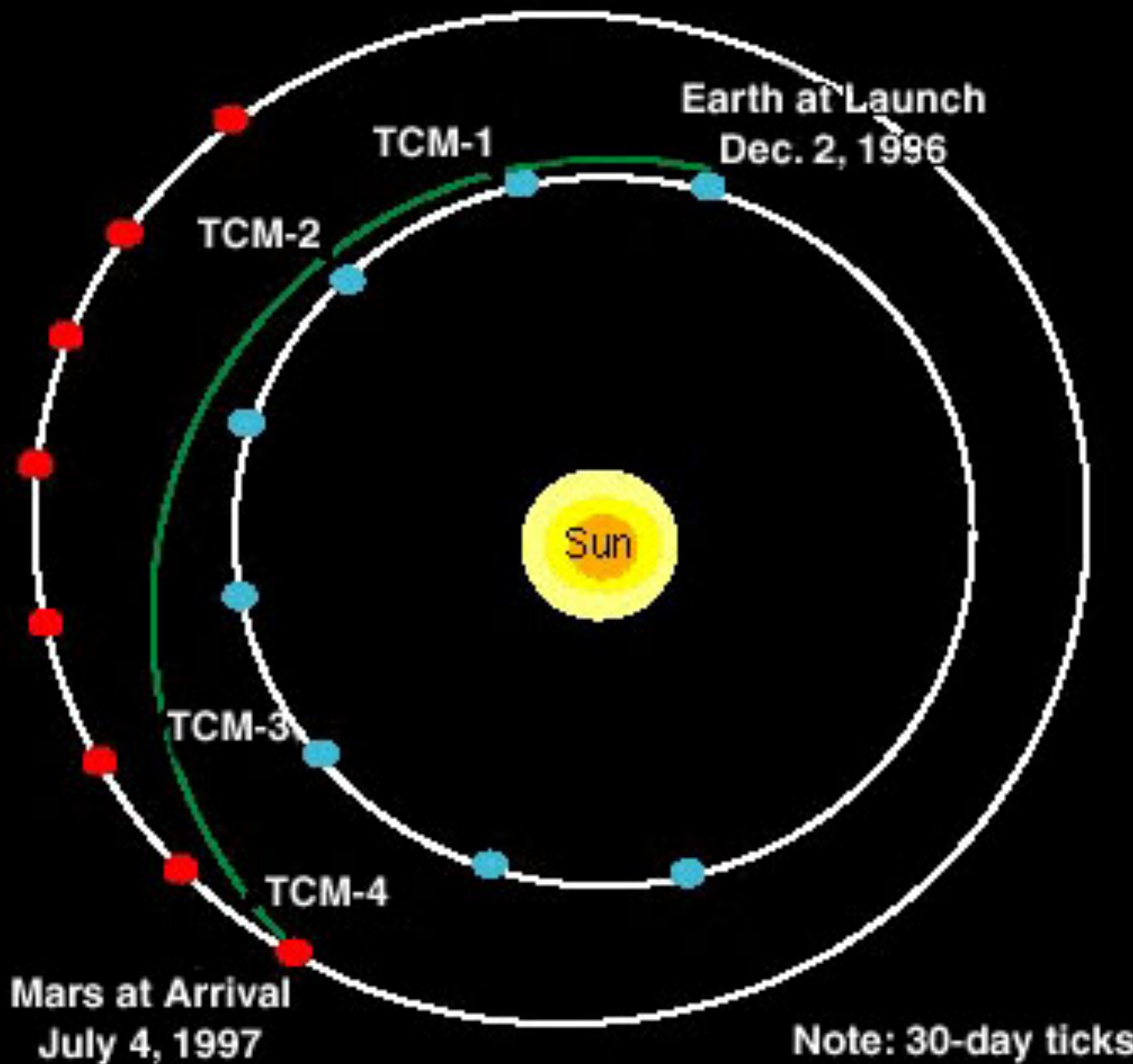
James (1994), the pressure derivatives in spherical coordinates become $\frac{\partial p}{\partial x} \rightarrow$
$\frac{\partial p}{\partial y} \rightarrow \frac{1}{a}\frac{\partial p}{\partial \theta}$. The terms proportional to $\frac{1}{a}$ on the left hand sides of (1.14) - (1.16) a
ure terms. In this process r has been replaced by a which means that the Coriolis
are proportional to $\cos\theta$ in (1.14) and (1.16) must be neglected if the equations

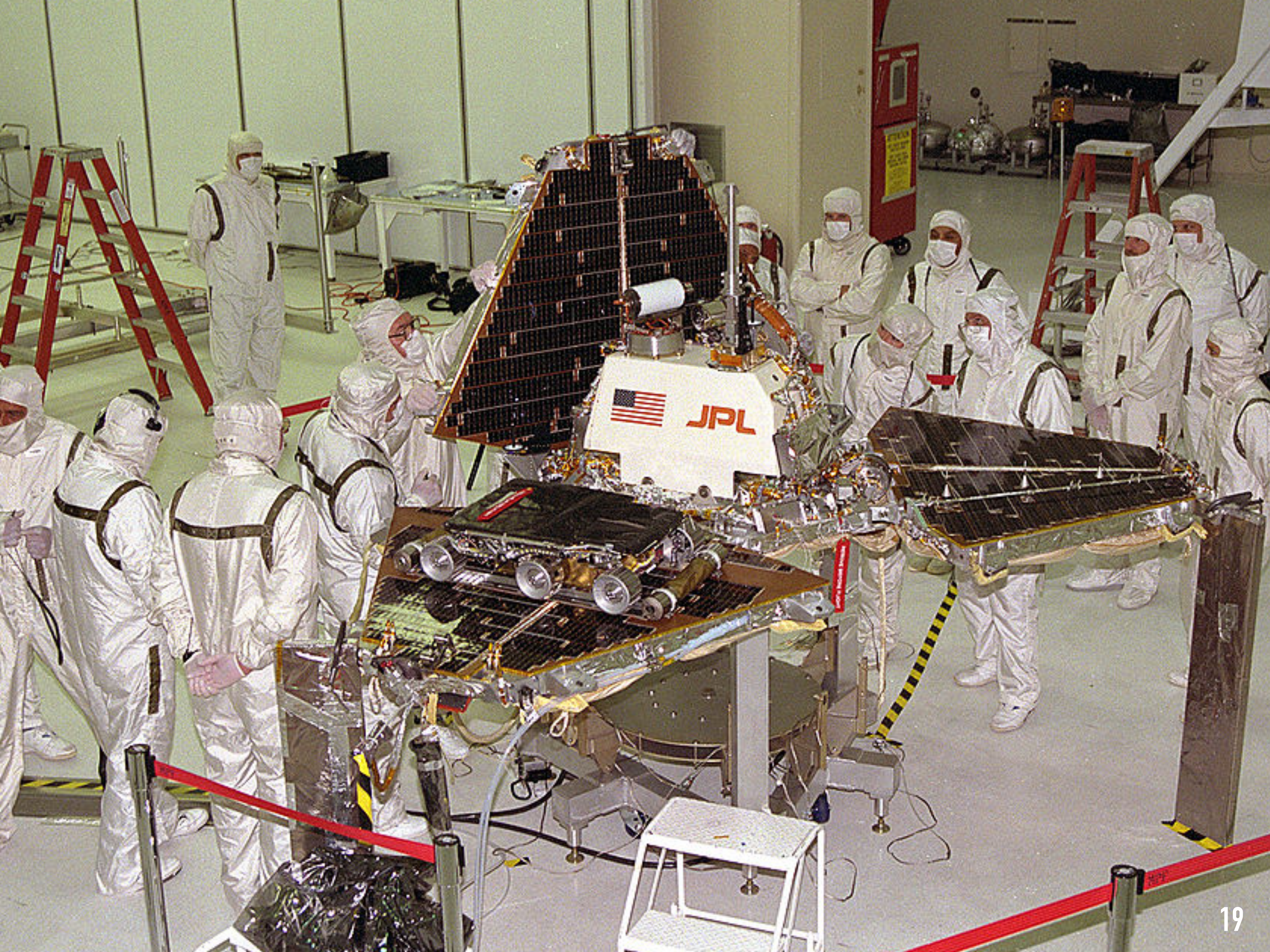
$$
\begin{aligned}
&\sum_{p=0}^{N-1} \left(\sum_{i=1}^{n} \dot{a}_i (\bar{\Phi}_k^p, \nabla^2 \bar{\Phi}_i^p) + \sum_{i=1}^{m} \dot{b}_i (\bar{\Phi}_k^p, \tilde{\Phi}_i^p) - \sum_{i=1}^{n} \lambda_p \dot{a}_i (\bar{\Phi}_k^p, \bar{\Phi}_i^p) - \sum_{i=1}^{m} \lambda_p \dot{b}_i (\bar{\Phi}_k^p, \tilde{\Phi}_i^p) \right) \\
&\quad = \sum_{p=0}^{N-1} \Bigg(- \sum_{i=1}^{n} \sum_{j=1}^{n} a_i a_j (\bar{\Phi}_k^p, J(\bar{\Phi}_i^p, \nabla^2 \bar{\Phi}_j^p)) - \sum_{i=1}^{n} \sum_{j=1}^{m} a_i b_j (\bar{\Phi}_k^p, J(\bar{\Phi}_i^p, \nabla^2 \tilde{\Phi}_j^p)) \\
&\qquad - \sum_{i=1}^{n} a_i (\bar{\Phi}_k^p, J(\bar{\Phi}_i^p, \nabla^2 \hat{\Phi}^p)) + \sum_{i=1}^{n} \sum_{j=1}^{n} a_i a_j \lambda_p (\bar{\Phi}_k^p, J(\bar{\Phi}_i^p, \bar{\Phi}_j^p)) \\
&\qquad + \sum_{i=1}^{n} \sum_{j=1}^{m} \lambda_p a_i b_j (\bar{\Phi}_k^p, J(\bar{\Phi}_i^p, \tilde{\Phi}_j^p)) + \sum_{i=1}^{n} \lambda_p a_i (\bar{\Phi}_k^p, J(\bar{\Phi}_i^p, \hat{\Phi}^p)) \\
&\qquad - \sum_{i=1}^{n} a_i (\bar{\Phi}_k^p, J(\bar{\Phi}_i^p, f)) - \sum_{i=1}^{m} b_i (\bar{\Phi}_k^p, J(\tilde{\Phi}_i^p, f)) - (\bar{\Phi}_k^p, J(\hat{\Phi}^p, f)) \\
&\qquad - \sum_{i=1}^{m} \sum_{j=1}^{n} b_i a_j (\bar{\Phi}_k^p, J(\tilde{\Phi}_i^p, \nabla^2 \bar{\Phi}_j^p)) - \sum_{i=1}^{m} \sum_{j=1}^{m} b_i b_j (\bar{\Phi}_k^p, J(\tilde{\Phi}_i^p, \nabla^2 \tilde{\Phi}_j^p)) \\
&\qquad - \sum_{i=1}^{m} b_i (\bar{\Phi}_k^p, J(\tilde{\Phi}_i^p, \nabla^2 \hat{\Phi}^p)) + \sum_{i=1}^{m} \sum_{j=1}^{n} \lambda_p b_i a_j (\bar{\Phi}_k^p, J(\tilde{\Phi}_i^p, \bar{\Phi}_j^p))
\end{aligned}
$$

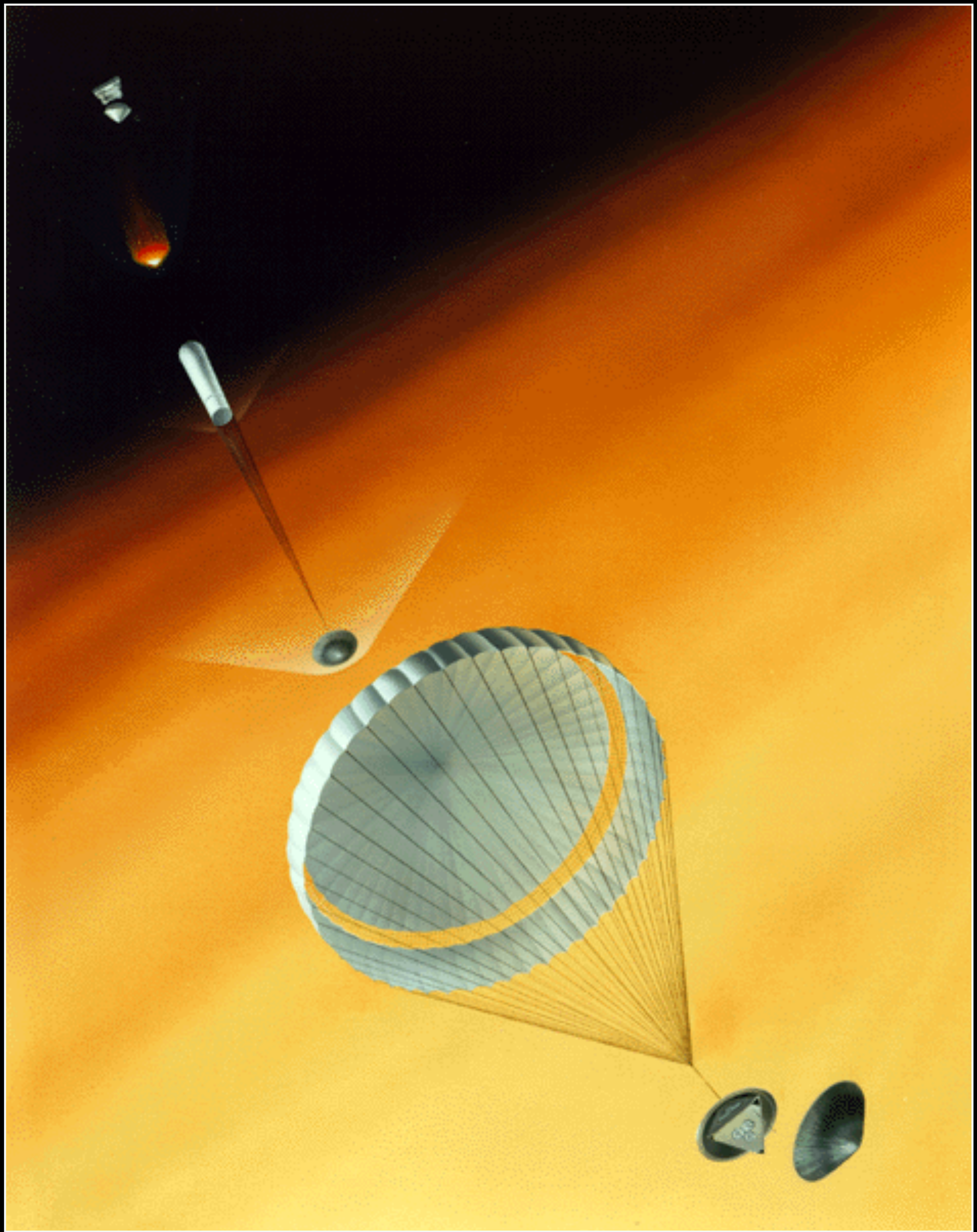



bt : mode 1
bc_1 : mode 1
bc_2 : mode 1
bc_3 : mode 1
Latitude
Longitude
50
0
−50
0
100
200
300


Mars
Orbit
Earth
Orbit
1 Earth Year = 365 days
1 Mars Year = 687 Earth days or 669 sols (martian days)


Earth at Launch
Dec. 2, 1996
TCM-1
TCM-2
Sun
TCM-3
TCM-4
Mars at Arrival
July 4, 1997
Note: 30-day ticks

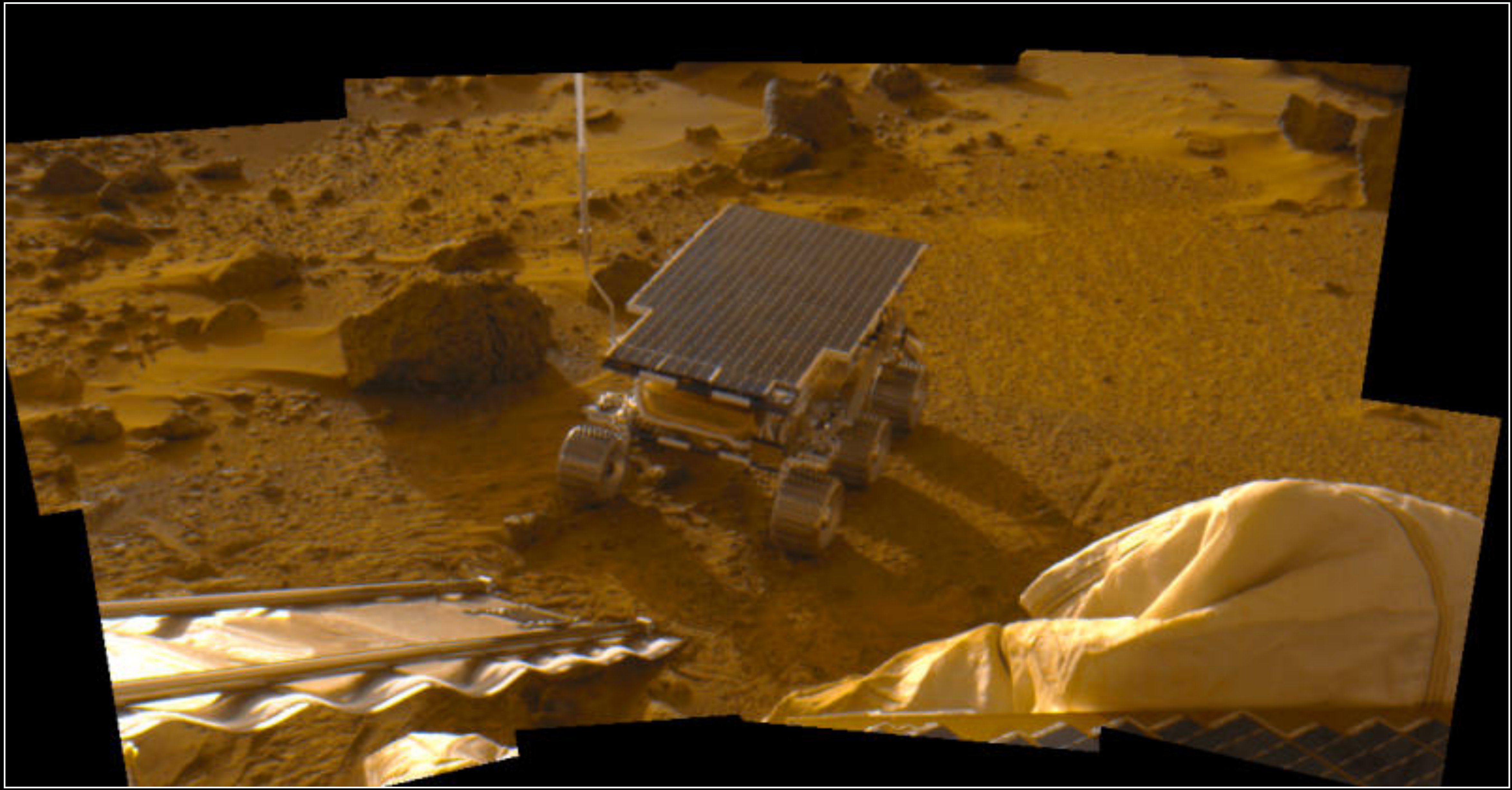

JPL

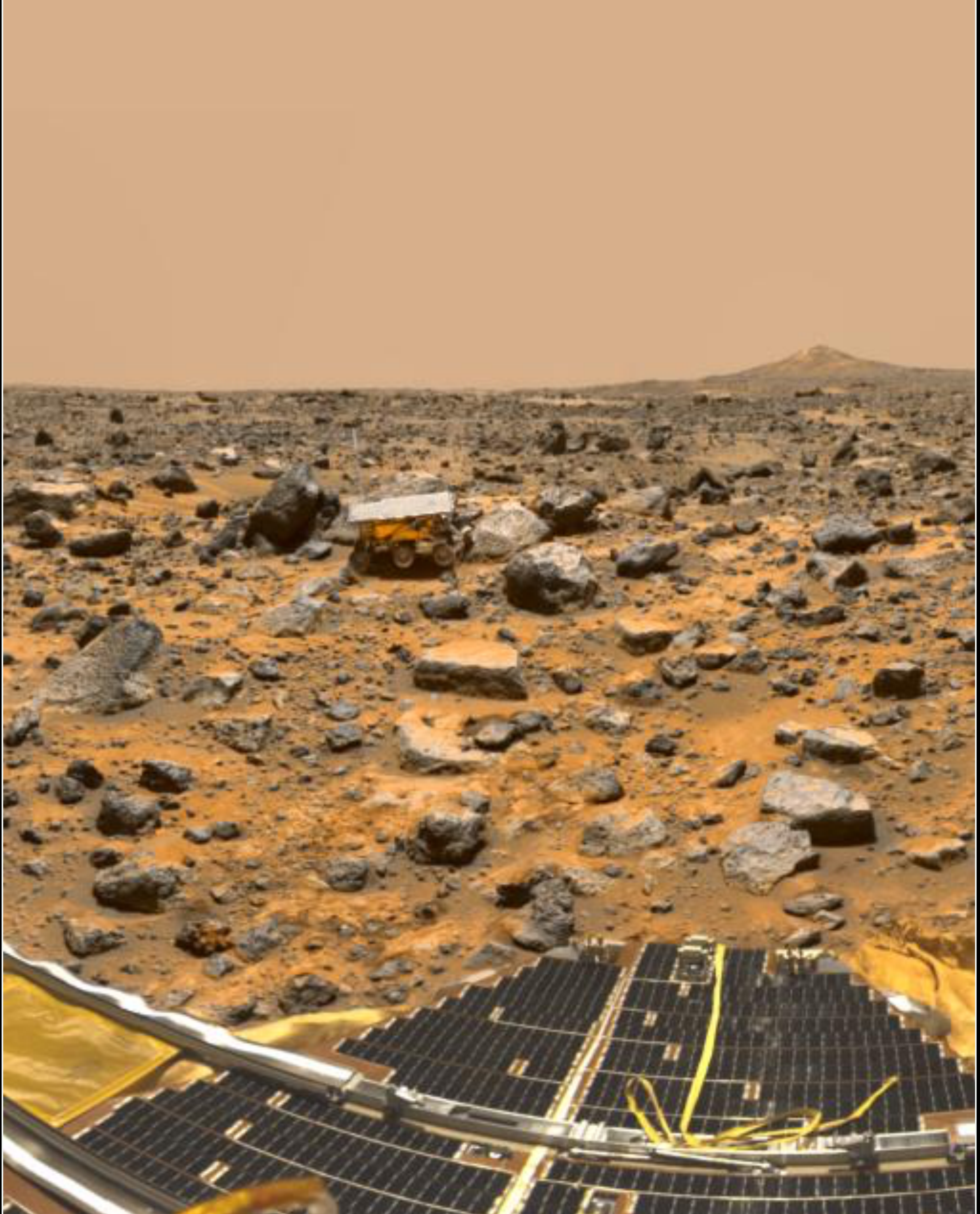


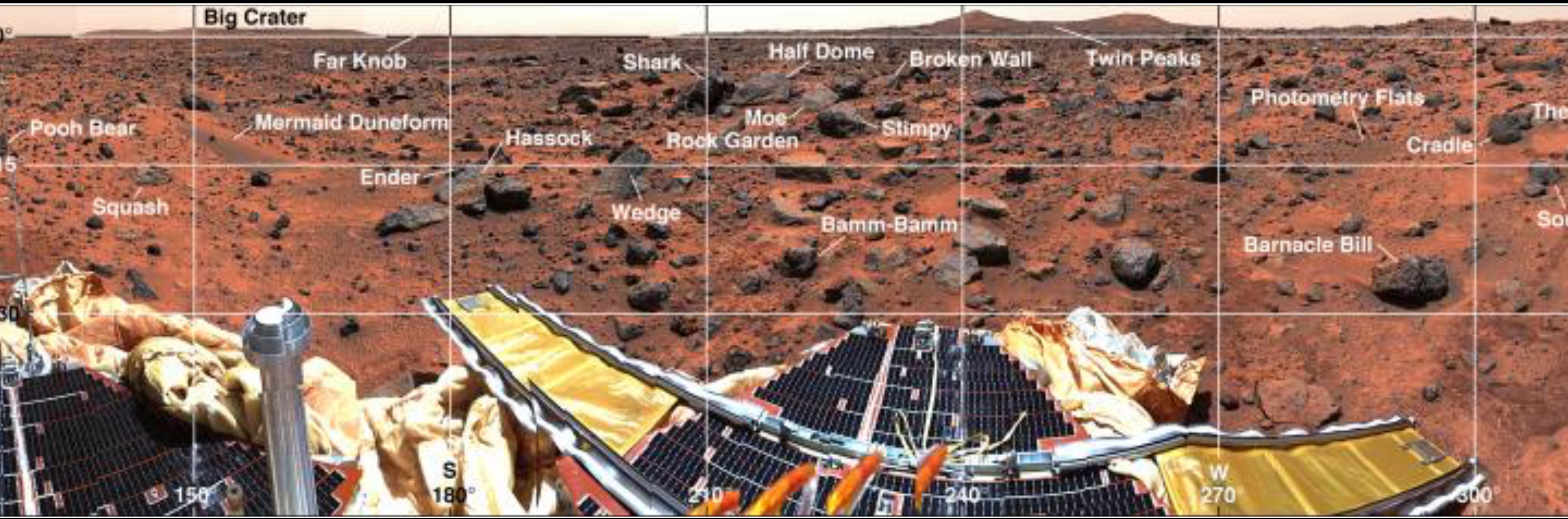

4D
4E


Ares Vallis (‘the valley of Ares’)

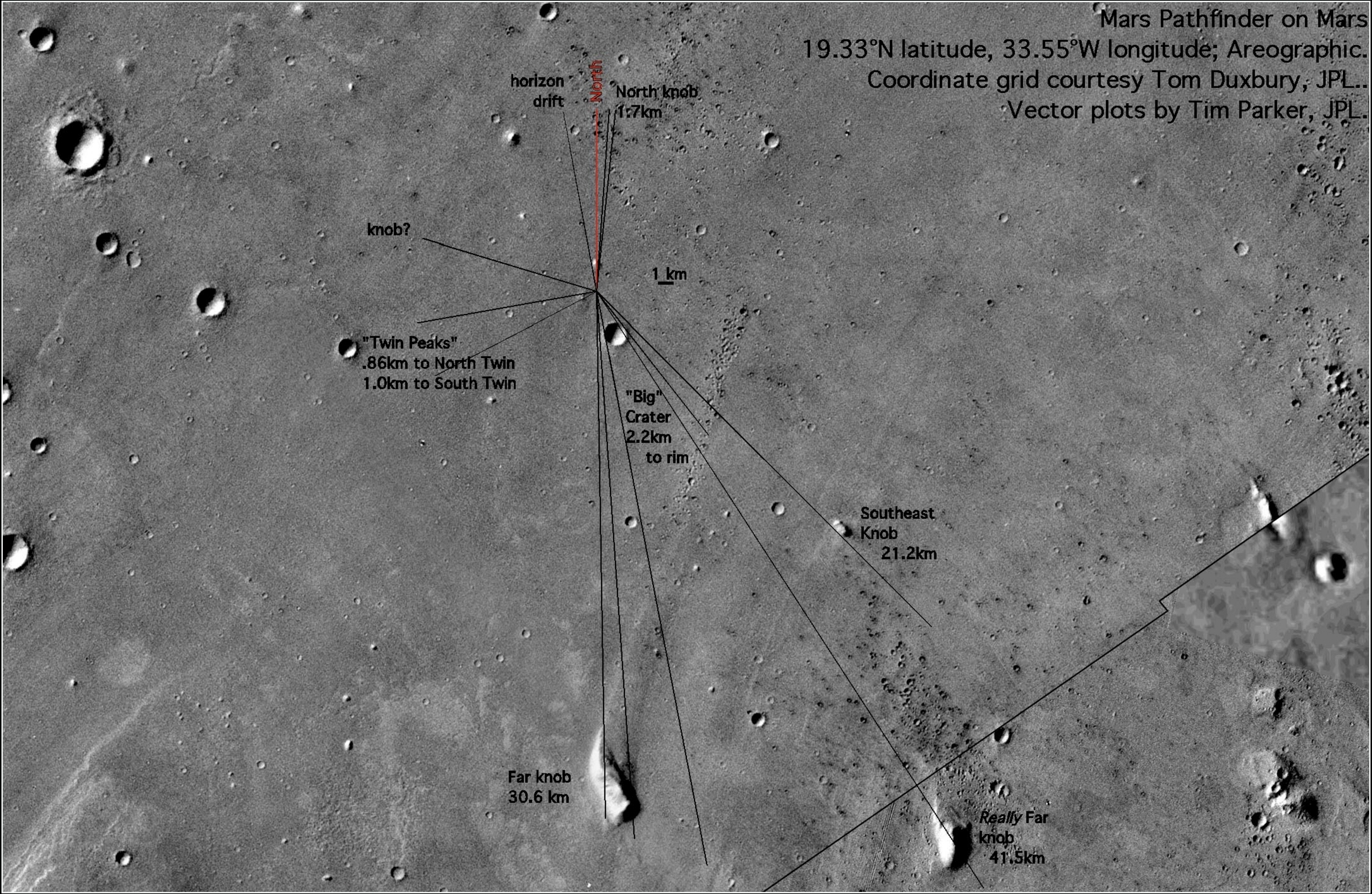
Pathfinder pictures - Rover





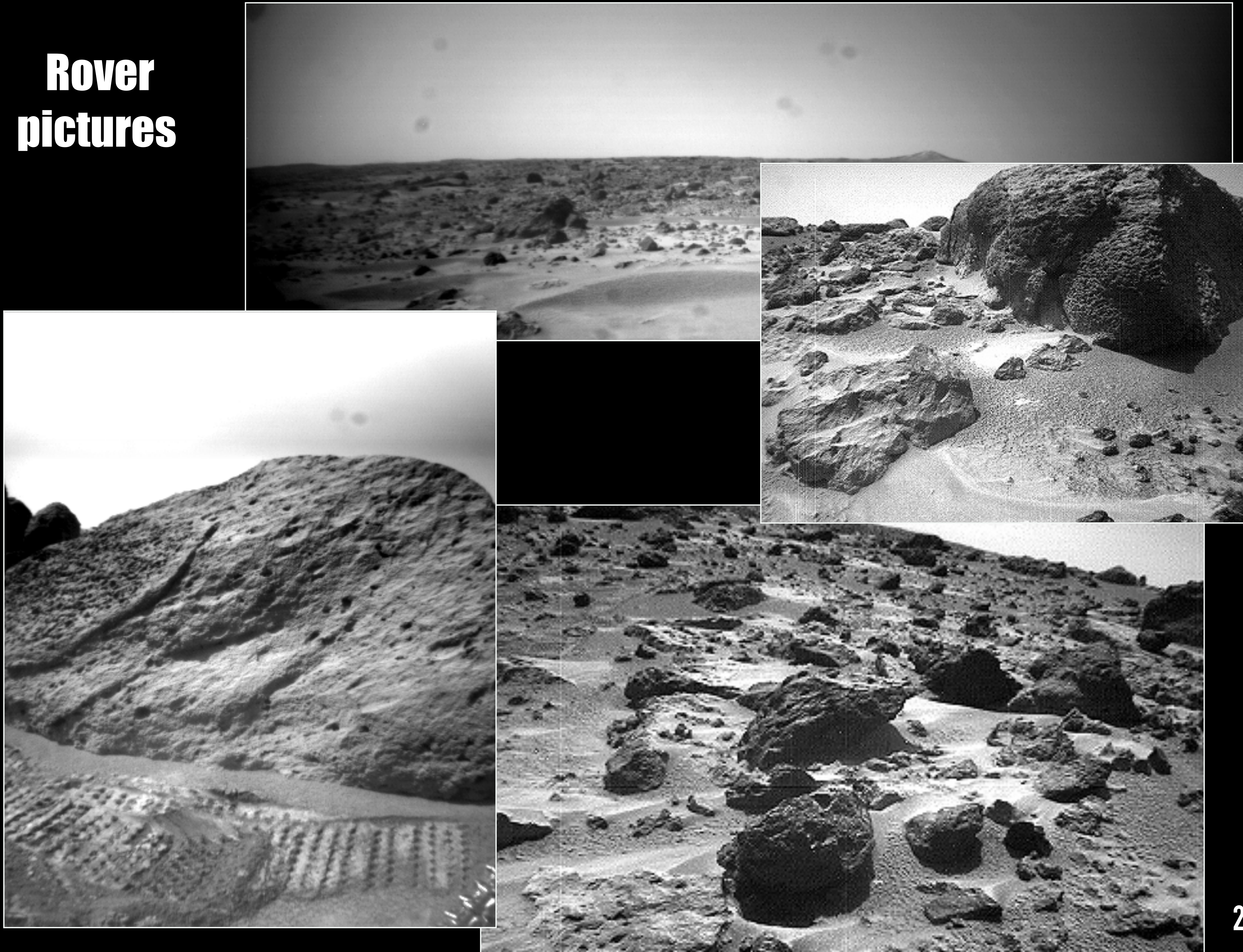


Big Crater
Far Knob
Shark
Half Dome
Broken Wall
Twin Peaks
Photometry Flats
Pooh Bear
Mermaid Duneform
Hassock
Moe
Rock Garden
Stimpy
Cradle
Ender
Squash
Wedge
Bamm-Bamm
Barnacle Bill
150°
S
180°
210°
240°
W
270°
300°

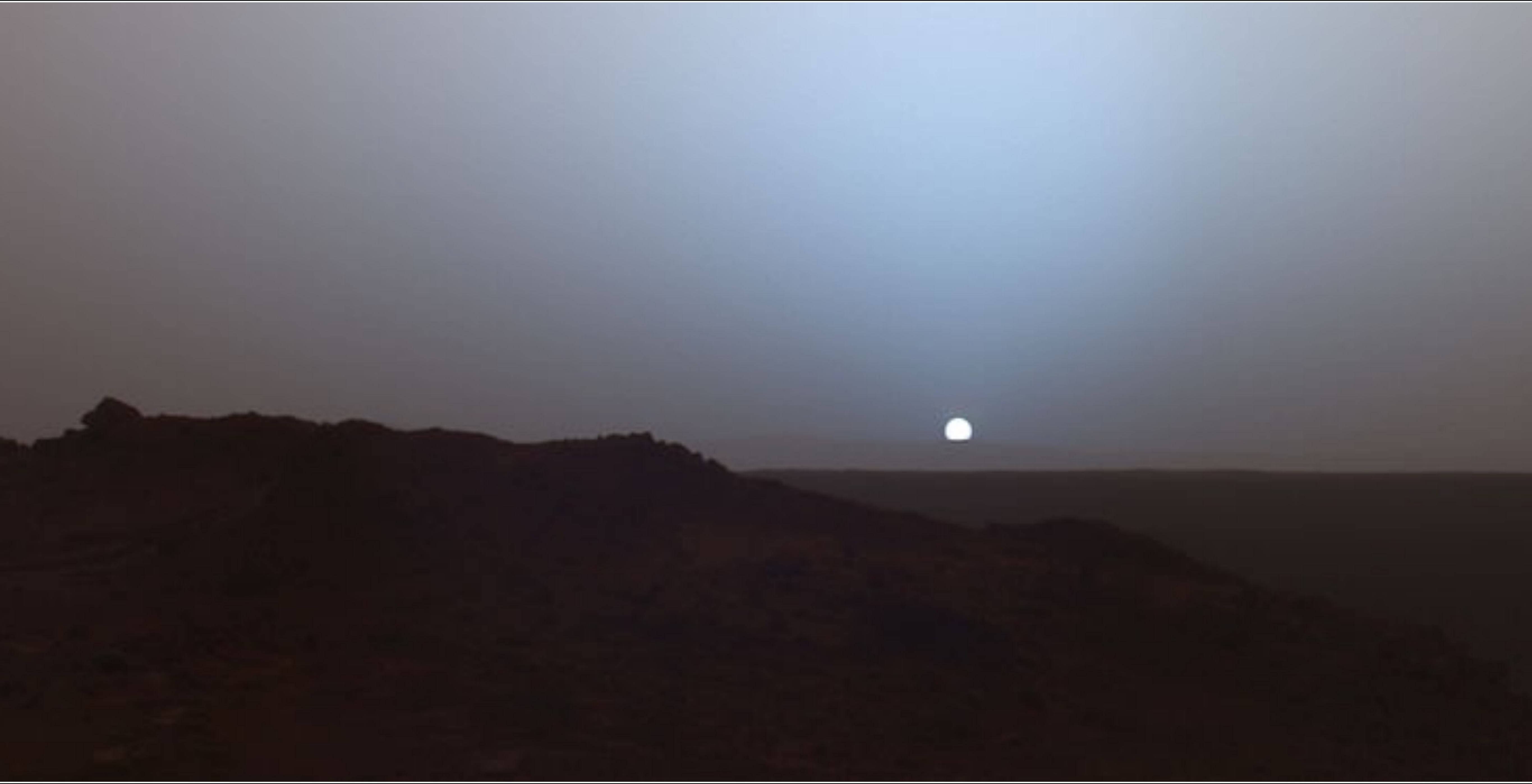

Mars Pathfinder on Mars
19.33°N latitude, 33.55°W longitude; Areographic.
Coordinate grid courtesy Tom Duxbury, JPL.
Vector plots by Tim Parker, JPL.
North
horizon drift
North knob 1.7km
knob?
1 km
"Twin Peaks" .86km to North Twin 1.0km to South Twin
"Big" Crater 2.2km to rim
Southeast Knob 21.2km
Far knob 30.6 km
Really Far knob 41.5km

Twin peaks

Rover pictures



Sunrise



Sunset

“It is he that sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers; that stretcheth out the heavens as a curtain, and spreadeth them out as a tent to dwell in”

(Isaiah 40:22)

“When I consider thy heavens, the work of thy fingers,
The moon and the stars, which thou hast ordained;
What is man, that thou art mindful of him? …”

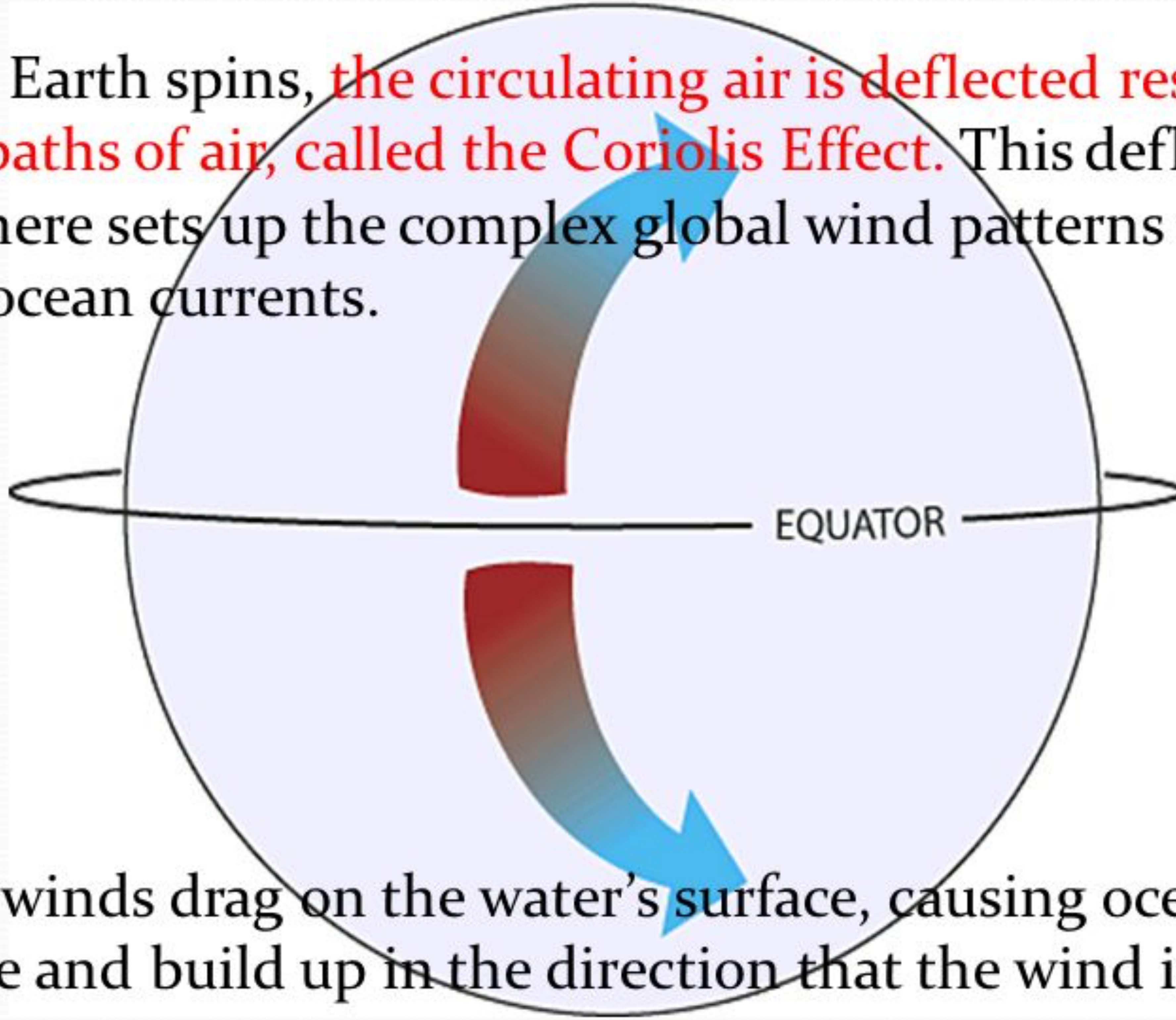
(Psalm 8:3-4)

“I will bless thee, and in multiplying I will multiply thy seed as the stars of the heaven …”
(Genesis 22:17)


Security

What is the Coriolis Effect?

Because Earth spins, the circulating air is deflected resulting in curved paths of air, called the Coriolis Effect. This deflection of the atmosphere sets up the complex global wind patterns which drive surface ocean currents.



Global winds drag on the water's surface, causing ocean water to move and build up in the direction that the wind is blowing.