

"The Planets"

Astro/EPS C12 (CCN 17045 or 32505)

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LEC: 2 LeConte TWTh, 2:40–5:00pm
Office Hours: 419 Campbell Hall,
Mon 3–4 and Tue 5–6

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STAR PARTY

- 10PM TUES 12 AUG
- attendance optional (this is just for fun)
- meet at 10pm in front of Campbell Hall
- don't be late
- my cell 510-207-2236
- may be cancelled if weather is bad

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EARLY PLUTO STUDIES

- limited by technology:
 - instruments
 - computers
 - atmospheric absorption
 - "seeing"
- technology started improving rapidly in the 1970s

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PLUTO FACTS (review)

- satellites
- surface ices
- greenhouse effect
- sublimation/deposition cycle
- photochemistry
- temperature contrasts
- density

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NEW MOONS OF PLUTO



- grey like Charon, not pink like Pluto
- sizes 60–170 km

NASA, ESA, H. Weaver (JHU/APL), A. Stern (SwRI),
and the HST Pluto Companion Search Team

THE OCCULTATION LIGHTCURVE

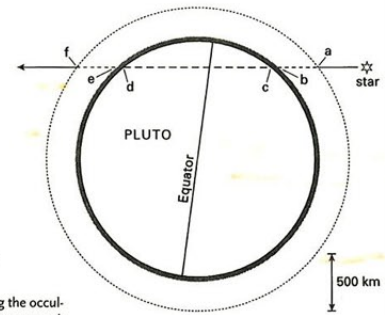
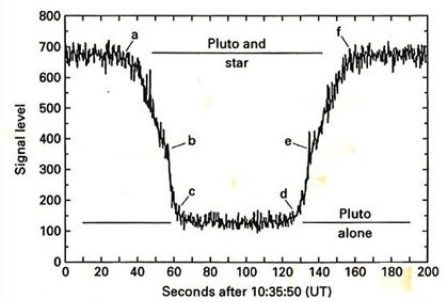


Fig. 4-7: The lightcurve obtained by the Kuiper Airborne Observatory during the occultation of a star by Pluto on June 9, 1988. The upper diagram shows the apparent track

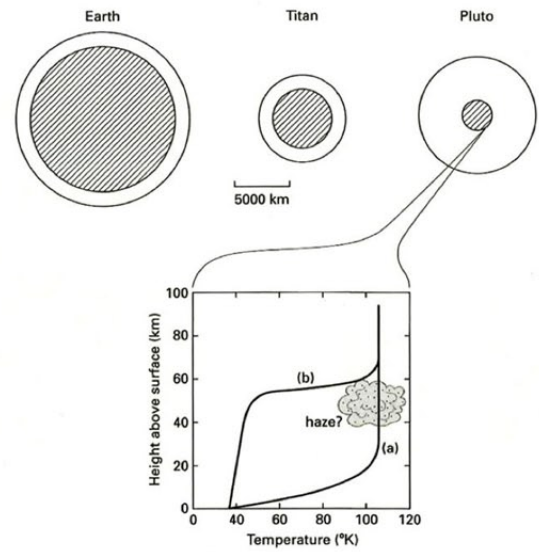
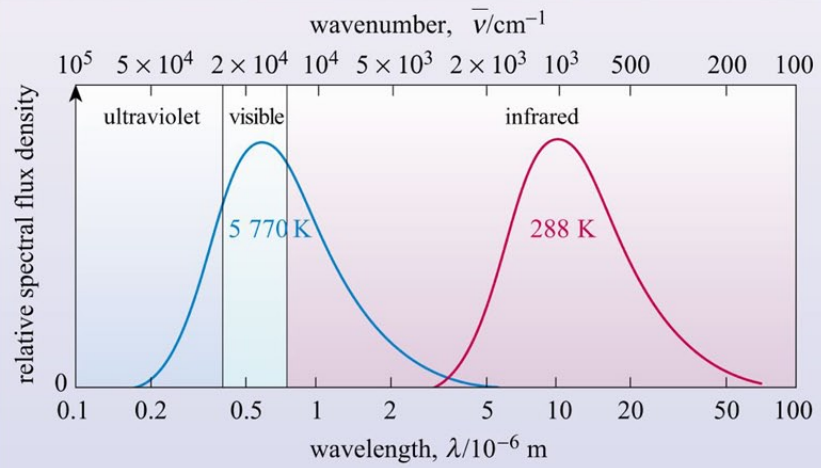
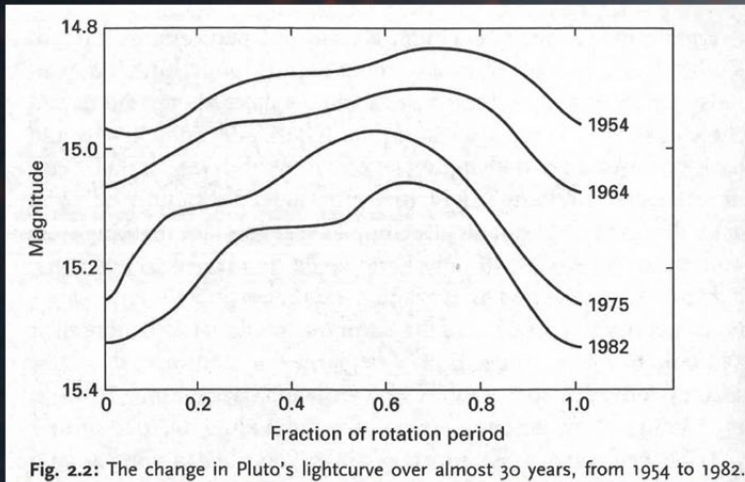


Fig. 4-9: Top: The extents of the atmospheres surrounding Earth, Titan, and Pluto are shown to scale for comparison. The limits shown represent in each case the upper stability limit, known as the exobase. Pluto's tenuous outer atmosphere is huge compared

THERMAL RADIATION

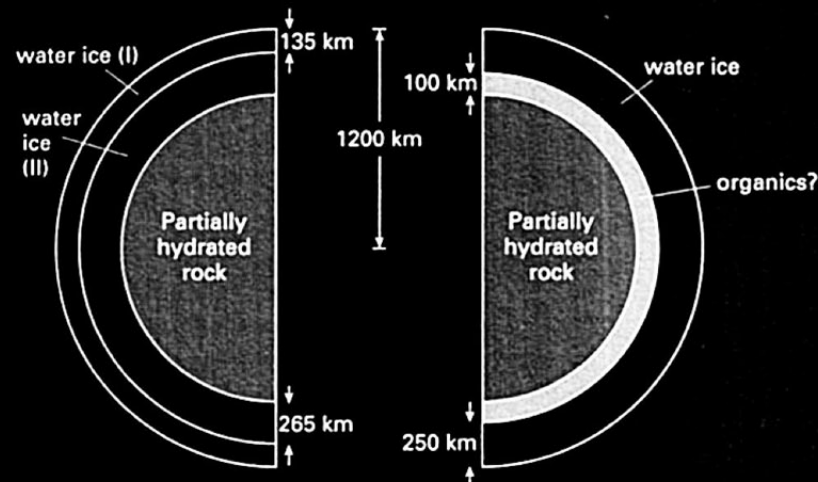


PLUTO'S LIGHTCURVES



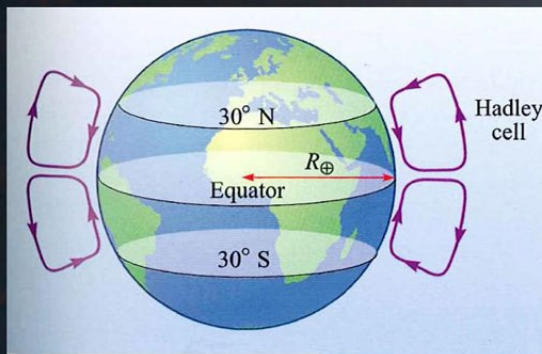
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DIFFERENTIATION



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HADLEY CELL



Large-scale convective heat transport by convection

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CHARON FACTS (review)

- grey, low contrast
- ices and hydrates on surface

Table 7.1: Some basic attributes of Pluto and Charon.

Parameter	Pluto	Charon
Rotation period (days)	6.3872	6.3872
Diameter (km)	2360	1200
Density (g/cm ³)	2.0	1.7–2.1
Surface reflectivity (%)	55	35
Lightcurve amplitude (%)	38	8
Known surface ices	N ₂ , CH ₄ , CO	H ₂ O
Atmosphere	Confirmed	Doubtful

NA3?

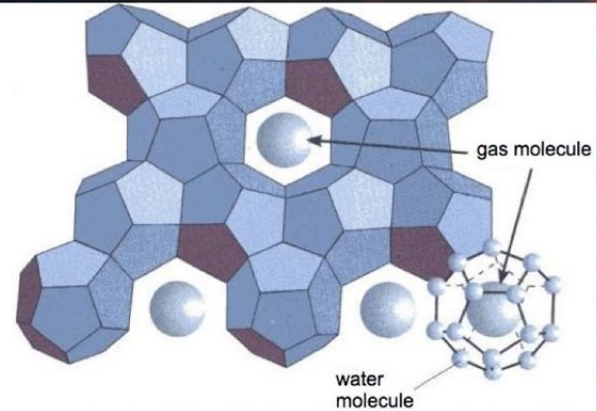
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ARIEL

- grey like Charon
- 70% ice, 30% rock

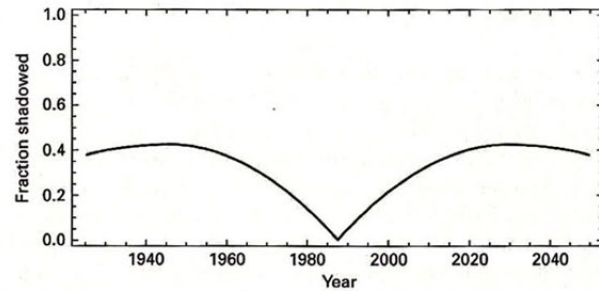
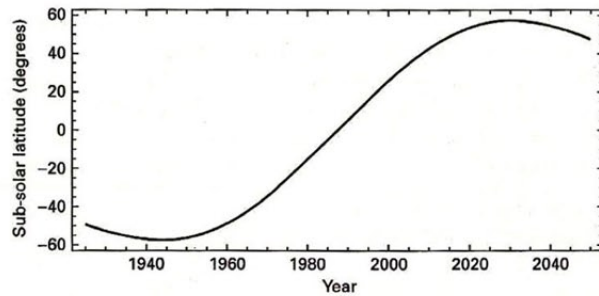
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HYDRATES



- solids containing water + other trapped gases

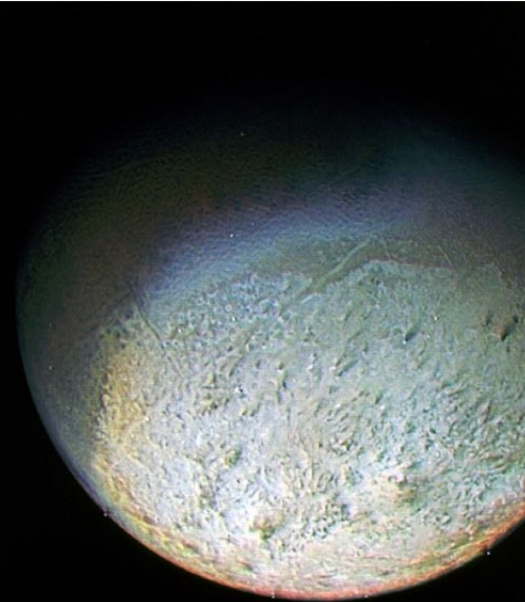
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TRITON

- surface composition similar to Pluto's
- signs of geologic activity

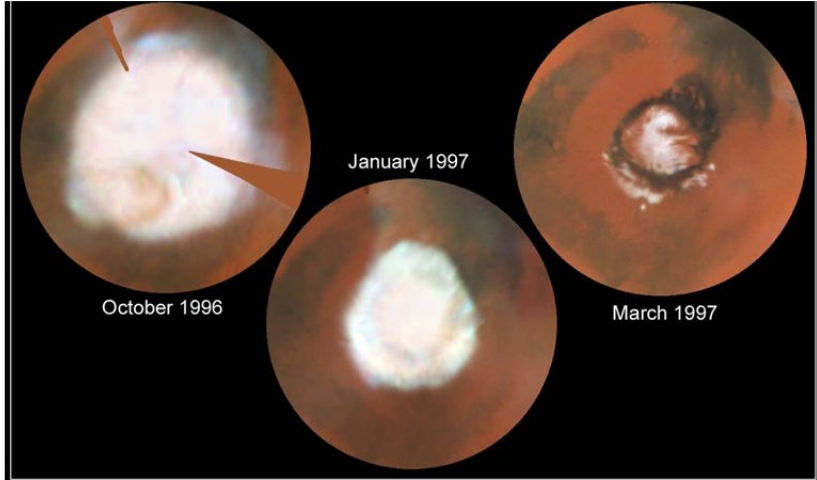


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VOLATILE CYCLES and related processes

- volatiles -- things that easily change state
- reservoirs of volatiles
- energy sources

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Mars • North Polar Cap
Hubble Space Telescope • WFPC2

PRC97-15b • ST ScI OPO • May 20, 1997 • P. James (Univ. Toledo), T. Clancy (Space Science Institute), S. Lee (Univ. Colorado) and NASA

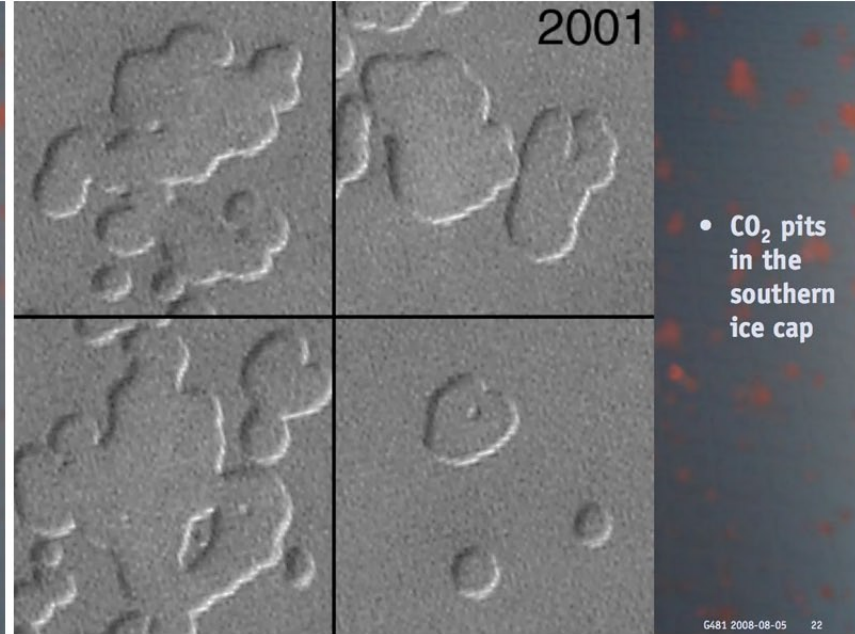
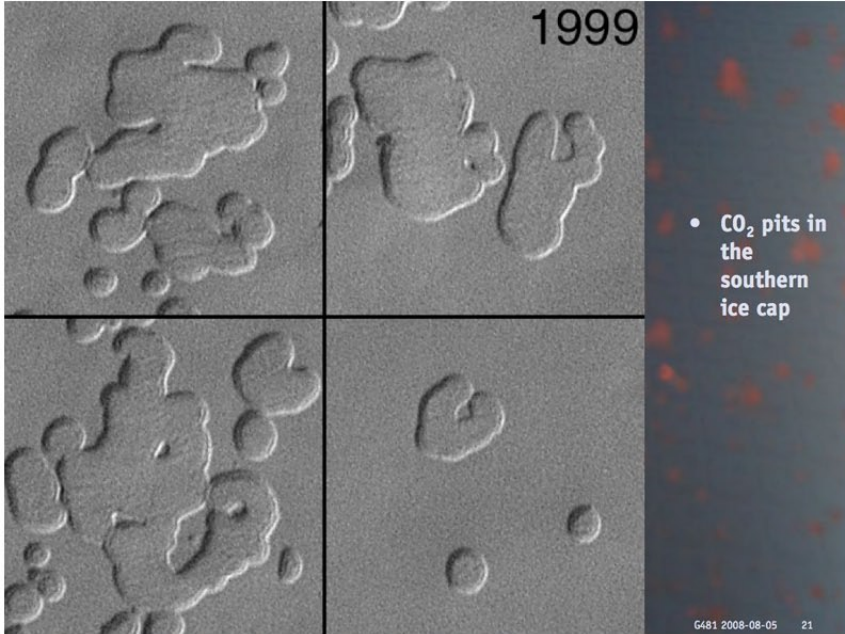
MARS

- small permanent polar caps
- large seasonal polar caps
- up to 1 meter of CO₂ ice in the seasonal caps at 70°+ latitude
- at Viking 1 lander position (23° N) pressure varied from 6.8 mbar to 9 mbar seasonally



MARS POLAR CAP

"vaporization erosion"
has some similarities
to "escape erosion"
on Pluto



MARS

solar radiation

condensed substances

- seasonal "condensation flow" on Mars
- temperature drives condensation/sublimation...
- pressure varies...
- gases flow in response

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MARS

- frost at the Viking 1 lander site

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**PINPOINT
FORECAST**
 cbs5.com

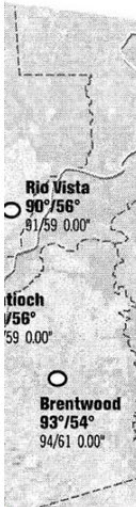
**ROBERTA
GONZALES**
 CBS 5
 Weather
 Anchor

A water cycle works like this: Warm air turns water from rivers, lakes and oceans into vapor rising into the air. That vapor forms clouds containing drops of water or ice crystals. As clouds rise, the air is cooler. The water vapor in the clouds becomes too heavy and falls back to earth as rain.

For weather info, visit www.cbs5.com.


Today

Morning fog then mostly sunny.
 Highs: 59° to 90°



WATER CYCLE

- also known as hydrological cycle
- Earth is the only planet with liquid water
- Titan has surface liquids of ethane and/or methane

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**PINPOINT
FORECAST**
 cbs5.com

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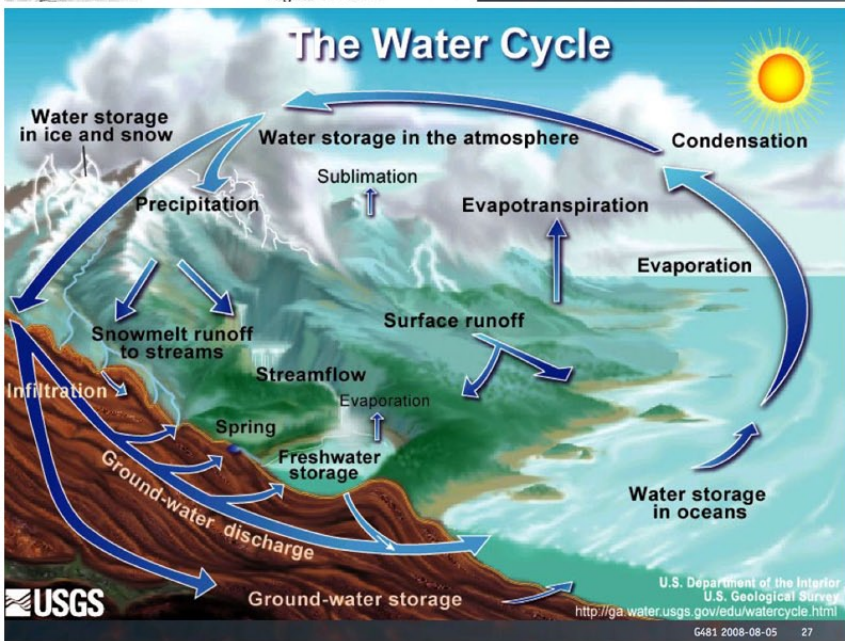


MENTAL EXERCISE

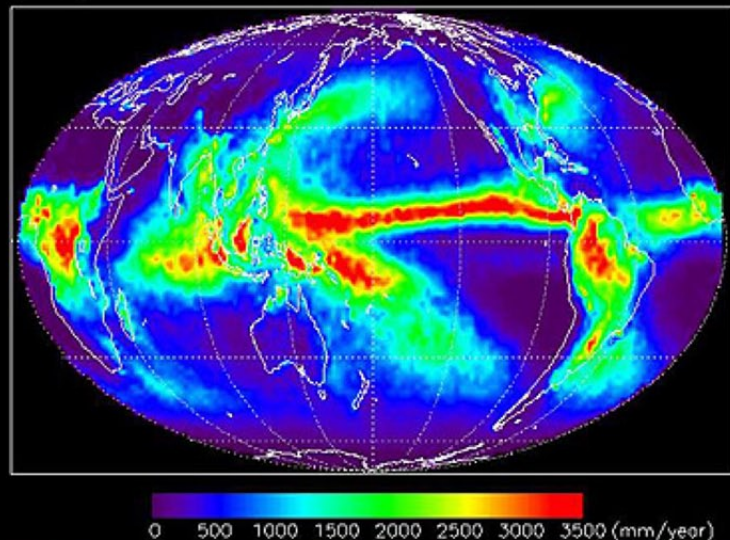
WHICH SENTENCE IS INCORRECT?

- Warm air...
- That vapor...
- As clouds rise...
- The water vapor...

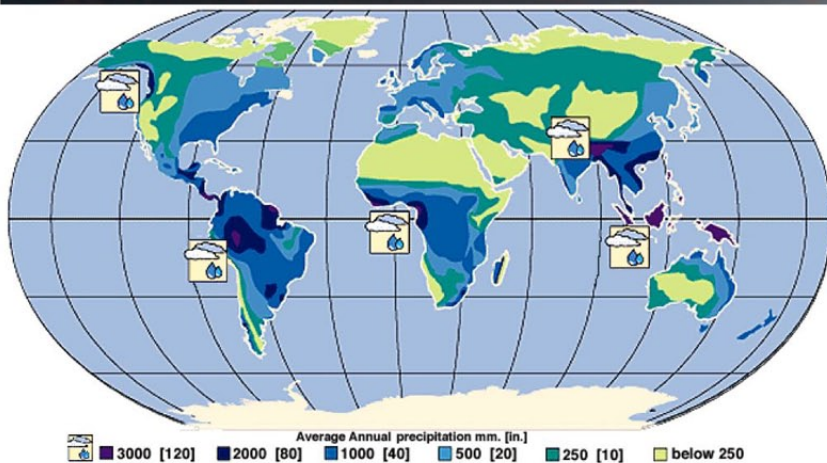
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SSM/I DERIVED GLOBAL ANNUAL RAINFALL

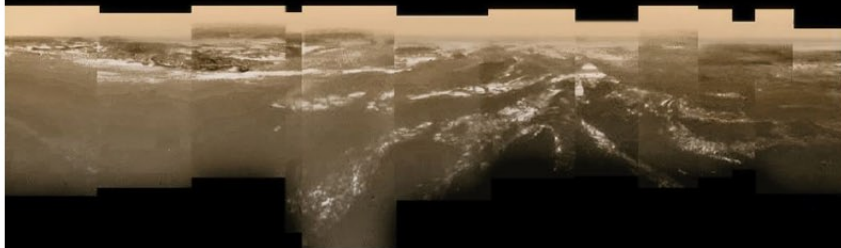


CLIMATE AND RAINFALL



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TITAN

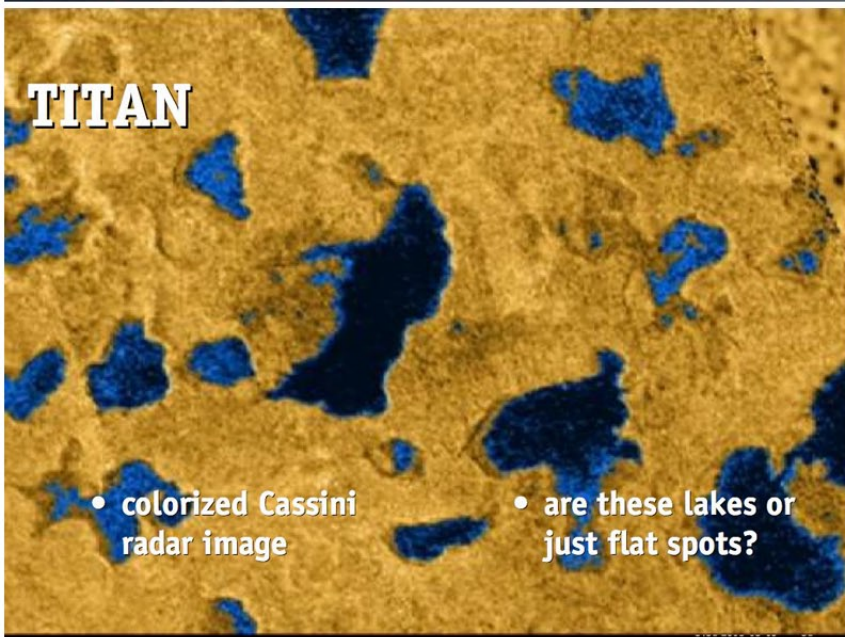


- colorized Huygens probe image

- Titan has surface liquids of ethane and/or methane

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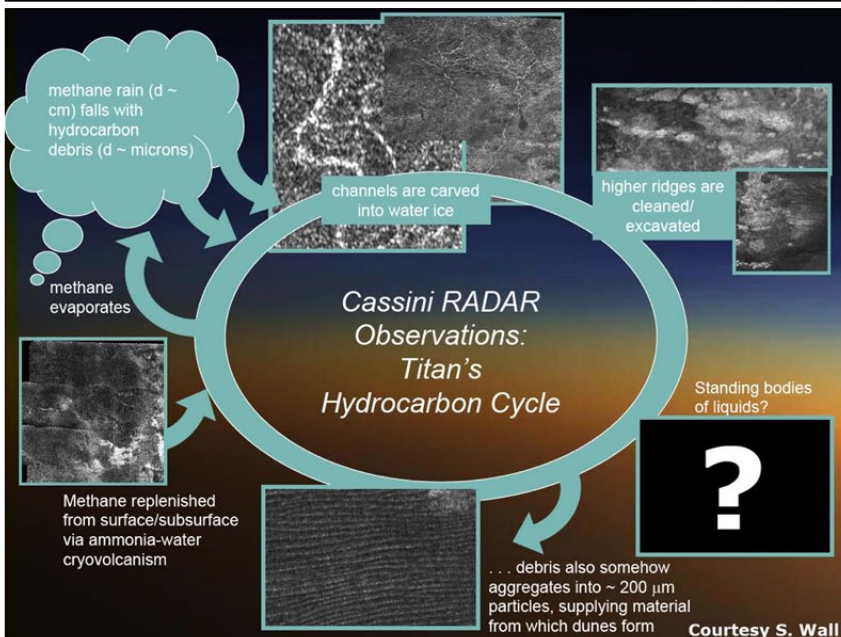
TITAN



- colorized Cassini radar image

- are these lakes or just flat spots?

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Courtesy S. Wall

TITAN



- artist's conception
- liquid hydrocarbons recently confirmed by spectroscopy

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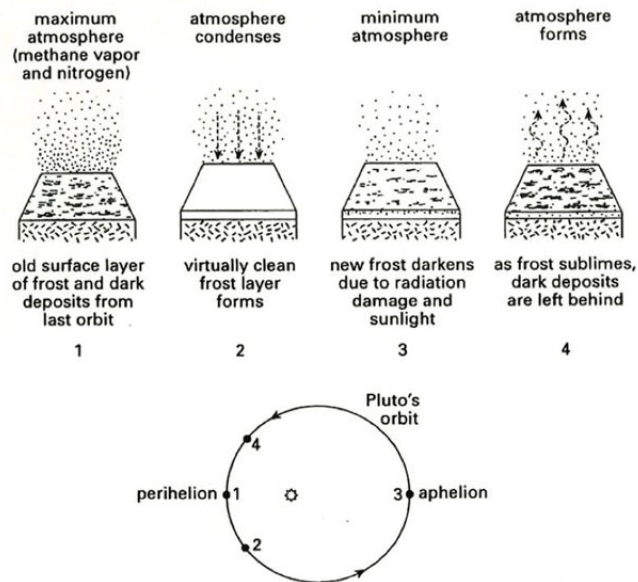
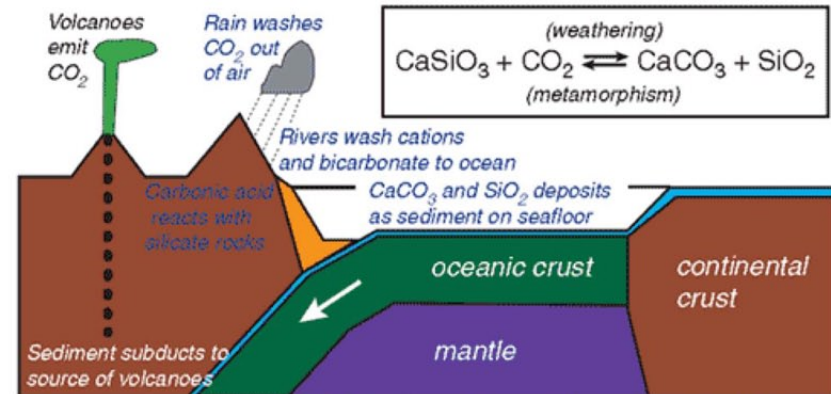


Fig. 4.1: The cycle of seasonal change and frost deposition affecting Pluto's surface.

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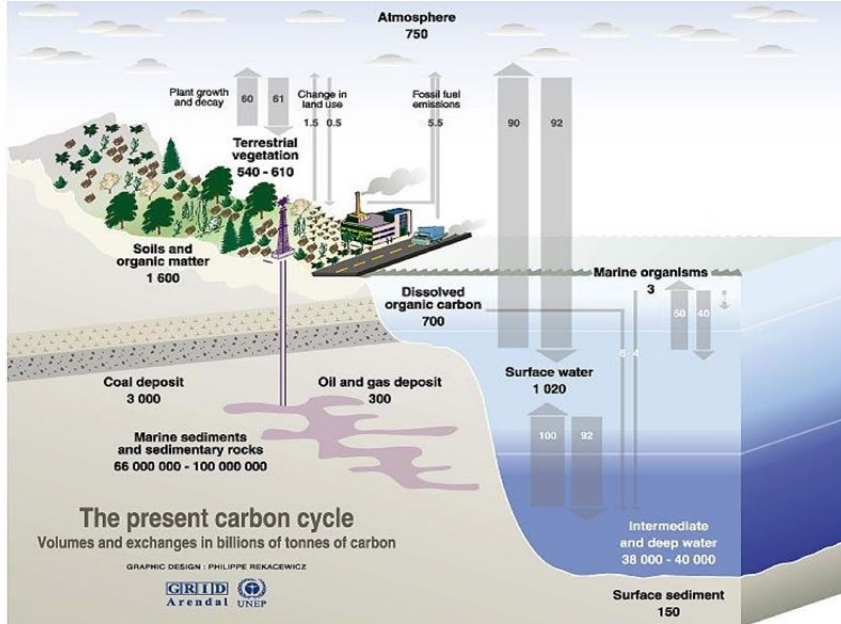
THE CARBON CYCLE



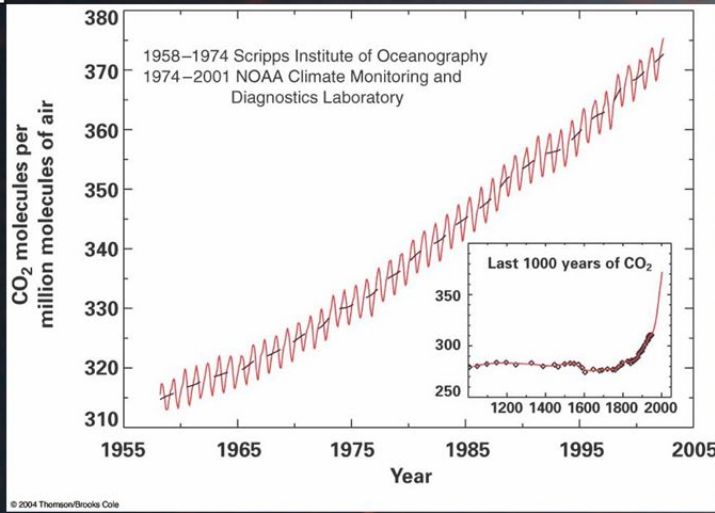
[Processes lettered in blue are absent in a snowball Earth]

From a lecture by Paul Hoffman & Daniel Schrag (1999)

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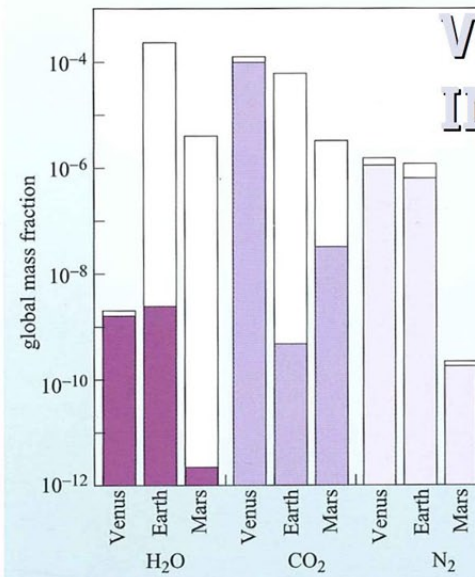


CO₂ INCREASE ON THE EARTH



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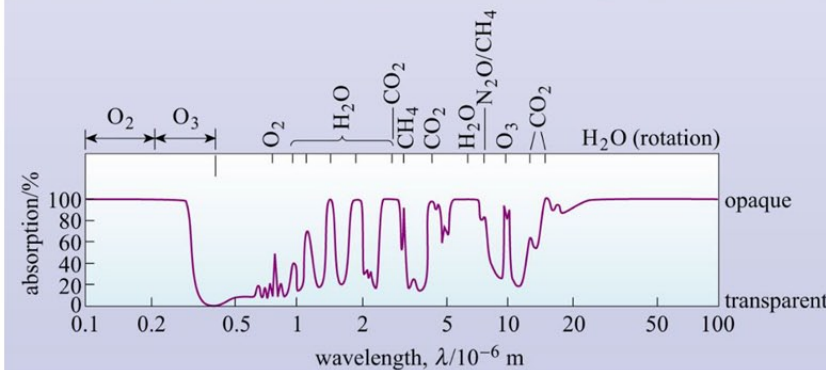
VOLATILE INVENTORIES



- white bar: amount of volatiles on planet, color: amount in the atmosphere
- Venus: no condensed volatiles

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ATMOSPHERIC ABSORPTION



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GREENHOUSE EFFECT

	Earth	Venus	Mars
average surface temperature	15°C (59°F)	460°C (860°F)	-55°C (-67°F)
surface temperature without greenhouse effect	-18°C (0°F)	-40° to 100°C (-40° to 215°F)	-60°C (-76°F)

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GREENHOUSE GASES

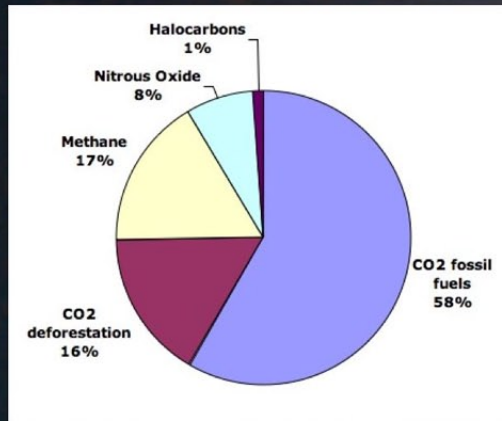


diagram of
the human-
produced
greenhouse
gases

also:

- ground-level ozone

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HYDRATES



- hydrate (white) from 708 meter depth in sea of okhotsk

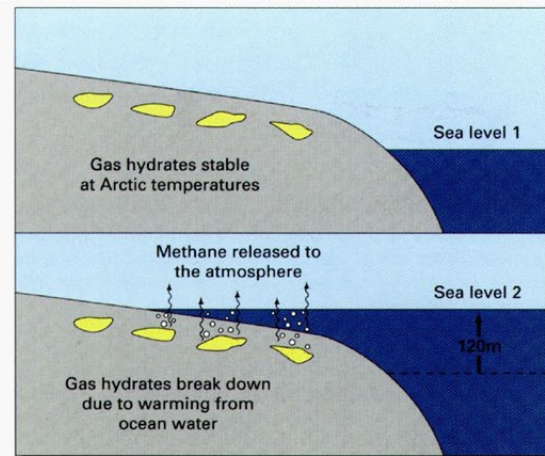
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SEA OF OKHOTSK



Сибирь
SIBERIA

HYDRATES

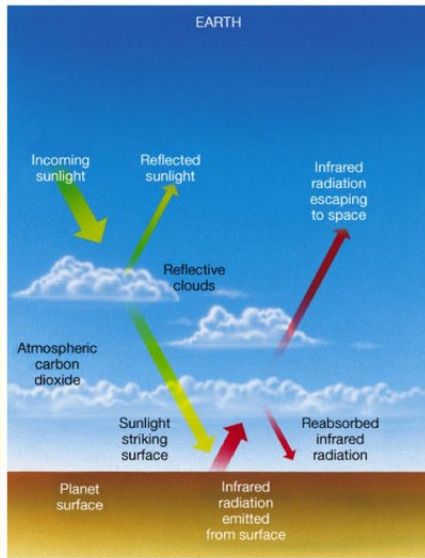
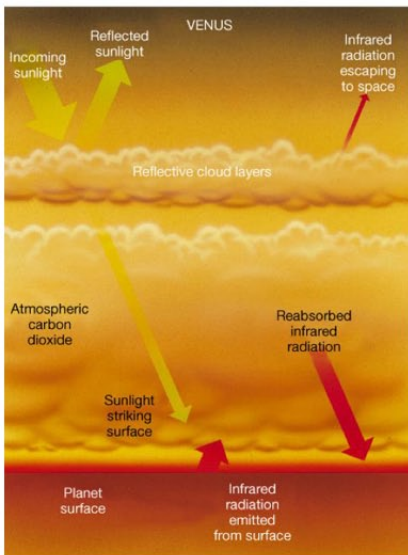


- may affect climate by releasing methane

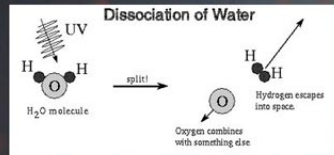
Sea-level rise causes relatively warm ocean water to cover cold Arctic strata. The resulting breakdown of stable gas hydrates within the sediment releases gas into the atmosphere.

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VENUS vs. EARTH



RUNAWAY GREENHOUSE



- higher temperature leads to more water in the atmosphere
- water acts as a greenhouse gas, increasing temperature on the planet
- eventually no oceans are left
- water at the top of the atmosphere is exposed to solar UV
- water is dissociated; hydrogen escapes