Supplementary Data: Examples of Modern Scientific Use Demonstrating What a Planet Is

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Preface

This documents that planetary scientists routinely call satellites, dwarf planets, and major planets all by the same term “planet”. Because automated search methods are unable to interpret how a word like “planet” is used in context, finding examples like these required opening and reading hundreds of manuscripts one-by-one. That limited how much of the literature we could search. Nevertheless, even our very incomplete search found many examples.

These examples do not include vast numbers of manuscripts that use the adjectival form “planetary” to describe satellites, dwarf planets, and major planets.

The Moon Is a Planet

G. Fielder, 1966

> Convection in the Moon: A Boundary Condition...Convective motion in a solid planet may be expected to produce surface configurations that are a consequence of, and to this extent characterize, the motion beneath the surface...Several authors have observed a pattern of lineaments, or ‘grid system’ on the Moon...

Fielder, G. "Convection in the Moon: a boundary condition." *Geophysical Journal International* 10.4 (1966): 437-443.

James W. Head, *et al.*, 1977

> The style and evolution of tectonics on the terrestrial planets differ substantially. The style is related to the thickness of the lithosphere and to whether the lithosphere is divided into distinct, mobile plates that can be recycled into the mantle, as on Earth, or is a single spherical shell, as on the moon, Mars, and Mercury.
>
> (…)
>
> Tectonics and thermal history are also closely related on planets that lack laterally mobile lithospheric plates (the moon, Mars, and Mercury)

Head, James W., Charles A. Wood, and Thomas A. Mutch. "Geologic Evolution of the Terrestrial Planets: Observation and exploration have yielded fundamental knowledge of planetary evolution and have given rise to an exciting new view of Earth as a planet." *American Scientist* 65.1 (1977): 21-29.

J. L. Warner and D. A. Morrison, 1978

> Essentially all thermal models for terrestrial planets which have been calculated since the first samples were returned from the Moon contain a stage early in each planet's history where at least the outermost few hundred km were molten...

Warner, J. L., and D. A. Morrison. "Planetary Tectonics i: the Role of Water." Lunar and Planetary Science Conference. Vol. 9. 1978.

Gerald Schubert, 1979

> Each of the terrestrial planets, Mercury, Venus, Earth, Moon and Mars...

Schubert, Gerald. "Subsolidus convection in the mantles of terrestrial planets." Annual review of earth and planetary sciences 7.1 (1979): 289-342

Sean C. Solomon, 1979

> The cores of the terrestrial planets Earth, Moon, Mercury, Venus and Mars differ...

Solomon, Sean C. "Formation, history and energetics of cores in the terrestrial planets." Physics of the Earth and Planetary Interiors 19.2 (1979): 168-182.

Roger J. Phillips and Kurt Lambeck, 1980

> We present a review of the long-wavelength gravity fields of the terrestrial planets, earth, moon, Mars, and Venus...

Phillips, Roger J., and Kurt Lambeck. "Gravity fields of the terrestrial planets: Long-wavelength anomalies and tectonics." Reviews of Geophysics 18.1 (1980): 27-7

James B.Pollack and Yuk L. Yung, 1980

This work generally separates planets from satellites. However:

> Thermal evolution of the interiors of the Moon (a), Mercury (b), Mars (c), and Venus (d) as a function of time from the completion of planetary formation (0 years). The curves in these figures are isotherms, with their associated numbers being temperatures in dc. In all cases, the model planets were assumed to have a homogeneous composition at the initial epoch"

Whenever it speaks of the general case (for all planets and satellites), it says "planet". Here's an example, where it shortly after includes the Moon:

Assuming solar wind sweeping operates at maximum efficiency, one may write this escape flux, Fs.w., as (Hunten & Donahue 1976) (Equation here), (6) where ¢, H, and r are the flux of solar wind protons, atmospheric scale height at the level of the solar wind, and distance from the center of the planet to the interface with the solar wind near the limb, respectively. Solar wind sweeping represents an important loss process for C and N from Mars (McElroy 1 972), for H from Venus (Kumar et al 1 978), and for all the constituents of the lunar atmosphere (Kumar 1976).

Pollack, James B., and Yuk L. Yung. "Origin and evolution of planetary atmospheres." Annual Review of Earth and Planetary Sciences 8, no. 1 (1980): 425-487.

Peter H. Cadogan, 1981

The Moon – Our Sister Planet.

Surveyor 5 lowered a box-like instrument on to the top of the [lunar] regolith to perform the first ever local chemical analysis of another planet.

…Surveyor 6 became the first spacecraft to take off from another planet.

But the time has now come to return to Earth and see what has now been learnt about the most tangible products of lunar exploration, the rocks and the soils. It is here that we have learnt the most about our sister planet.

And the general consensus of opinion here, in fact, is that this depletion must predate the formation of the Moon as a planet.

No, what is arguable is precisely when this extraction [of siderophile and chalcophile elements from lunar rocks] occurred. Some would say that it must have taken place even before the Moon became a planet.

But exactly how thin is the lunar atmosphere today? What does it consist of chemically, what can it tell us about the Moon as a planet?

So much, then, for the structure of the lunar interior, but what about the moonquakes themselves? How strong are they, whereabouts do they occur and what causes them, on a planet that is essentially dead?

As this central core is all that remains of the original molten zone, it is small wonder that the Moon is outwardly such a dead planet.

For having established that the Moon is just as old as the other planets it is now important to map out its subsequent history of bombardment and volcanism…

Cadogan, Peter H. *The Moon-Our Sister Planet*. Cambridge University Press Archive, 1981.

James W. Head and Sean C. Solomon, 1981

> "Tectonic evolution of terrestrial planets."

Includes an entire section on the Moon and extensive comparison of terrestrial planets including the Moon as "planets"

> The style and evolution of tectonics on the terrestrial planets differ substantially. The style is related to the thickness of the lithosphere and to whether the lithosphere is divided into distinct, mobile plates that can be recycled into the mantle, as on Earth, or is a single spherical shell, as on the moon, Mars, and Mercury. The evolution of a planetary lithosphere and the development of plate tectonics appear to be influenced by several factors, including planetary size, chemistry, and external and internal heat sources.
>
> Tectonics and thermal history are also closely related on planets that lack laterally mobile lithospheric plates (the moon, Mars, and Mercury).
>
> Fig. 3. Interiors of the terrestrial planets. For the moon, a 70-km-thick crust is indicated…
>
> …an early period of modest global expansion and lithospheric extension is confined to the first 1.0 billion years of lunar history. This extensional period is followed by a more extended period of modest planetary contraction and lithospheric compression lasting until the present…
>
> At least since the formation of a thick global crust the moon has been a one-plate planet.
>
> The Mariner 9 and Viking missions to Mars revealed a planetary surface more geologically complex than that of the moon or Mercury…
>
> Mars, like the moon and probably Mercury, is a differentiated planet…
>
> The deformation of Earth's lithosphere by volcanic loads is a direct analog to the loading of a planetary lithosphere by basalt fill in a large basin, as on the moon, or by a volcanic construct, as on Mars.
>
> The plate tectonic cycle has dominated the heat budget of the outer several hundred kilometers of Earth and has led to a level of volcanic activity which, when integrated through time, surpasses by a huge factor that seen on the moon, Mercury, or Mars. Earth shares with the other terrestrial planets, however, the concept of the lithosphere as an important governor of tectonic style. The vertical tectonics on Earth associated with volcanic loading, continental rifting, and

> subsidence of continental margins and plat- form basins has many direct analogs on the other planets.
>
> The influence of major changes in the interior and exterior environment of a planet are often readily visible on one-plate planets.

Head, James W., and Sean C. Solomon. "Tectonic evolution of terrestrial planets." Science 213, no. 4503 (1981): 62-76.

Bruce Murray, Michael C. Malin, and Ronald Greeley, 1981

> Earthlike planets: Surfaces of Mercury, Venus, earth, moon, Mars

Murray, Bruce, Michael C. Malin, and Ronald Greeley. "Earthlike Planets: Surfaces of Mercury, Venus, Earth, Moon, Mars." Research supported by the John Simon Guggenheim Memorial Foundation and California Institute of Technology. San Francisco, WH Freeman and Co., 1981. 402 p. 1 (1981).

Thomas R. Watters, 1988

> Wrinkle ridge assemblages on the terrestrial planets...Moon, Mars, and Mercury.

Watters, Thomas R. "Wrinkle ridge assemblages on the terrestrial planets." Journal of Geophysical Research: Solid Earth 93.B9 (1988): 10236-10254.

James Papike, Lawrence Taylor, and Steven Simon, 1991

> The major differences between the oxide minerals in lunar and terrestrial rocks arise from fundamental differences between both the surfaces and the interiors of these two planets.

Papike, James, Lawrence Taylor, and Steven Simon. "Lunar Minerals" In: *Lunar Sourcebook*, Heiken, Grant H., David T. Vaniman, and Bevan M. French. (Eds), Cambridge, England, Cambridge University Press, 1991,

Brent Sherwood, 2007

> ... A convenient taxonomy divides them into science of the Moon (history and evolution of the Moon as a planet), science on the Moon (including science underlying the activities discussed in the previous section), and science from the Moon (such as astronomy). ...

Sherwood, Brent. "What Will We Actually Do On the Moon?" AIP Conference Proceedings. Ed. Mohamed S. El-Genk. Vol. 880. No. 1. AIP, 2007.

Mark A. Wieczorek, 2007

> Gravity and Topography of the Terrestrial Planets...Earth, Venus, Mars, the Moon

Wieczorek, Mark A. "Gravity and topography of the terrestrial planets." Treatise on Geophysics.–2007.–10 5 (2007): 165-206.

T. V. Gudkova and S. N. Raevskii, 2013

> The model of the planet is considered as a sphere of equivalent volume...The amplitudes of these functions are normalized to unity at the surface of the Moon...Since the torsional oscillations are only associated with the solid planet's regions...The free oscillations have an important property: they move toward the surface of the planet as the oscillation number increases. Therefore, different frequency intervals of the free oscillations are determined by the properties of different regions of the Moon's interior.

Gudkova, T. V., and S. N. Raevskii. "Spectrum of the free oscillations of the Moon." Solar System Research 47.1 (2013): 11-19.

Titan Is a Planet

A. A. Kalinyak, 1966

> The discover of kuiper of an atmosphere on Titan provided definitive proof of the possible existence of gaseous envelopes in an equilibrium state on minor planets having masses of the order of the lunar mass. The mass ratio of Titan and the moon is 1.9. (new para.) The physical conditions prevailing on the surface of the planet impose certain requirements ont he chemical composition of their atmospheres...

Kalinyak, A. A. "Data on the Spectra of the Galilean Satellites of Jupiter." *Soviet Astronomy* 9 (1966): 824.

Donald M. Bunten, 1975

> Although Titan is a satellite of Saturn, it is appropriate to discuss it here as a planet. It is larger than Mercury and almost as large as Mars. It has an atmosphere that is deeper than that of Mars… [etc., describing planetary qualities]

Bunten, Donald M. "The outer planets." *Scientific American* 233, no. 3 (1975): 130-141.

W. Reid Thompson and Carl Sagan, 1984

> ...ray paths through the atmosphere, with atmospheric sphericity (and in fact emission from beyond the solid disk of the planet)...

Thompson, W. Reid, and Carl Sagan. “Titan: Far-infrared and microwave remote sensing of methane clouds and organic haze." *Icarus* 60.2 (1984): 236-259.

<u>Owen B. Toon, *et al.*, 1988</u>

> If optically thick methane clouds were present then one might expect to see their effects on the planet's radiation balance at visible wavelengths.

Toon, Owen B., *et al.* "Methane rain on Titan." *Icarus* 75.2 (1988): 255-284.

<u>F. Hourdin, *et al.*, 1992</u>

> A three dimensional General Circulation Model (GCM) of Titan's atmosphere is described...It appears that for a slowly rotating planet which strongly absorbs solar radiation, circulation is dominated by global equator to pole Hadley circulation and strong superrotation.

Hourdin, F., *et al.* "Numerical simulation of the circulation of the atmosphere of Titan." *Symposium on Titan*. Vol. 338. 1992.

<u>F. Raulin, 1992</u>

> Titan: a prebiotic planet?

Raulin, F. "Titan: a prebiotic planet?." *Frontiers of Life*. 1992.

<u>Anthony D. Del Genio, Wei Zhou, and Timothy P. Eichler, 1993</u>

> In principle, the simplest test of superrotation theories would be a direct simulation of the Venus and Titan atmospheres, with accurate specifications of atmospheric mass and composition,radiative heating, and planetary radius and surface properties for each planet.

Del Genio, Anthony D., Wei Zhou, and Timothy P. Eichler. “Equatorial superrotation in a slowly rotating GCM: Implications for Titan and Venus." *Icarus* 101.1 (1993): 1-17.

<u>Frédéric Hourdin, *et al.*, 1995</u>

> After 1.5 Titan years, the upper stratosphere rotates about 9 times faster than the solid planet and this superrotation still increases at the end of the simulation.

Hourdin, Frédéric, *et al.* "Numerical simulation of the general circulation of the atmosphere of Titan." *Icarus* 117.2 (1995): 358-374.

<u>J. I. Lunine and C. P. McKay, 1995</u>

> Therefore, study of Titan through the Cassini/Huygens mission, planned for launch in1997, primarily affords the opportunity to understand planet-wide surface-atmosphere interactions in the presence of fluids but in the absence of life.

Lunine, J. I., and C. P. McKay. "Surface-atmosphere interactions on Titan compared with those on the pre-biotic Earth." *Advances in Space Research* 15.3 (1995): 303-311.

Anthony D. Del Genio and Wei Zhou, 1996

> ...the eddy momentum effect of the prograde rotation of the solid planet will determine the sense of atmospheric rotation on Titan.

Del Genio, Anthony D., and Wei Zhou. "Simulations of superrotation on slowly rotating planets: Sensitivity to rotation and initial condition." *Icarus* 120.2 (1996): 332-343.

Frederic Hourdin, *et al.*, 1996

> ... performed with the Titan atmospheric GCM also produced a strong stratospheric superrotation with prograde winds of the order of 100 rn/s at the equator and an upper stratosphere rotating about 10 times faster than the solid planet (the rotation period of Titan, assumed to be ...

Hourdin, Frederic, *et al.*, "Numerical modelling of the circulation of superrotating atmospheres: Venus and Titan." *Environment Modeling for Space-Based Applications*. Vol. 392. 1996.

F. Forget, 1998

> As for Venus and Titan the atmosphere rotates much faster than the solid planet at most levels...

Forget, F. "Habitable zone around other stars." *Earth, Moon, and Planets* 81.1 (1998): 59-72.

Stephen H. Brecht, Janet G. Luhmann, and David J. Larson, 2000

> $180°$ is on the midnight side of the planet, and $270°$ is on the side of Titan where the E_{conv} is pointing into the surface of the planet.

Brecht, Stephen H., Janet G. Luhmann, and David J. Larson. "Simulation of the Saturnian magnetospheric interaction with Titan." *Journal of Geophysical Research: Space Physics* 105.A6 (2000): 13119-13130.

M. Banaszkiewicz, *et al.*, 2000

> In the case of Titan, the field lines pile up near the subram point on the leading side of Titan and then turn gently toward the flanks of the planet.

Banaszkiewicz, M., *et al*. "A Coupled Model of Titan's Atmosphere and Ionosphere" *Icarus* 147, 386-404 (2000).

V. Kerzhanovich, *et al.*, 2001

> ...makes Titan the almost ideal planet for studies with lighter-than-air aerial platforms...

Kerzhanovich, V., *et al.* "Titan airship surveyor." *Forum on Innovative Approaches to Outer Planetary Exploration 2001-2020*. Vol. 1. 2001.

Hall, Jeffery L., *et al.*, 2002

> On the other hand, the dense atmosphere and low temperature contrasts makes Titan almost an ideal planet for aerial vehicles.

Hall, Jeffery L., *et al*. "Titan airship explorer." *Aerospace Conference Proceedings*, 2002. IEEE. Vol. 1. IEEE, 2002

H. Luna, *et al*., 2003

> Titan's atmosphere is also unusually large due to its much smaller gravity. That is, the exobase altitude, the altitude above which escape occurs and below which the atmosphere is collisional, is about 60% of the planet's radius (~1500 km)

Luna, H., *et al*. "Dissociation of N2 in capture and ionization collisions with fast H+ and N+ ions and modeling of positive ion formation in the Titan atmosphere." *Journal of Geophysical Research: Planets* 108.E4 (2003).

Carlos Westhelle and James Masciarelli, 2003

> For the Titan aerocapture trajectory simulations, the planet and gravity model used are a spherical body of radius 2575 km with an inverse square gravity field with a gravitational parameter of 9.1420 × 103 km^3/s^2.

Westhelle, Carlos, and James Masciarelli. "Assessment of aerocapture flight at Titan using a drag-only device." *AIAA Atmospheric Flight Mechanics Conference and Exhibit*. 2003.

Ch Elachi, *et al.*, 2004

> The post-Voyager value of Titan’s density, 1.88 g cm^{-3} (Tyler et al., 1981; Lindal et al., 1983), allows for a silicate abundance comparable to or less than that of ices and organics together. The suspended aerosol particles represent one end state of the photolysis of methane, which also results in the escape of hydrogen from the planet.

Elachi, Ch, *et al*. "Radar: the Cassini Titan radar mapper." *Space Science Reviews* 115.1-4 (2004): 71-110.

M. B. Simakov, 2004

> The time of existence of the Titan's juvenile ocean was enough for arising of the first protoliving objects. As the planet developed through time several energetic processes (irradiation, lightnings, meteoritic and comet impacts) could produce different forms of fixed nitrogen...

Simakov, M. B. "Possible biogeochemical cycles on Titan." *Origins*. Springer Netherlands, 2004. 645-665

T. Kostiuk, *et al*. 2005

> The FOV shown in Figure 1 covers an extended portion of Titan with varying viewing angle and line-of-sight velocity projection...For the 0.5″ visible seeing profile, the effective beam width at 12 μm on the planet was ~ 0.4" FWHM.

Kostiuk, T., *et al*. "Titan's stratospheric zonal wind, temperature, and ethane abundance a year prior to Huygens insertion." *Geophysical Research Letters* 32.22 (2005).

R. Moreno, A. Marten, and T. Hidayat, 2005

> Since the planet rotation is slow (11.7 m/s), Titan's atmosphere is observed in superrotation, similar to that of Venus (Schubert 1983), the only other known case.

Moreno, R., A. Marten, and T. Hidayat. "Interferometric measurements of zonal winds on Titan." *Astronomy & Astrophysics* 437.1 (2005): 319-328.

Erika L. Barth and Owen B. Toon, 2006

> Titan's most visible feature is the optically thick haze layer enveloping the planet about 200 km above the surface.

Barth, Erika L., and Owen B. Toon. "Methane, ethane, and mixed clouds in Titan's atmosphere: Properties derived from microphysical modeling." *Icarus* 182.1 (2006): 230-250.

Giuseppe Mitri, *et al.*, 2007

> Cassini-Huygens observations have shown a somewhat dry planet.

Giuseppe Mitri, *et al.* "Hydrocarbon lakes on Titan." *Icarus* 186.2 (2007): 385-394.

<u>D. Snowden, et al., 2007</u>

> When the plasma flows near Titan the plasma that encounters Titan's ionosphere is slowed and the frozen-in field lines are forced to drape around the planet.

Snowden, D., *et al*. "Three-dimensional multifluid simulation of the plasma interaction at Titan." *Journal of Geophysical Research: Space Physics* 112.A12 (2007).

<u>Hervé Cottin, *et al.*, 2008</u>

> However, this planet offers an unique opportunity to study endogenous syntheses of exobiological interest since it has been shown that the hydrolysis of laboratory analogues of Titan's organic haze (Tholins) release amino acids (Khare et al., 1986).

Cottin, Hervé, *et al*. "Heterogeneous solid/gas chemistry of organic compounds related to comets, meteorites, Titan, and Mars: laboratory and in lower Earth orbit experiments." *Advances in Space Research* 42.12 (2008): 2019-2035.

<u>Xinhua Liu, Jianping Li, and Athena Cousteni, 2008</u>

> ... Firstly, since different planets have specific environments, changes were made to the model to adjust to these environments (eg, Mars, Titan and Venus): radius of the planet, acceleration of gravity, solar constant, components of the atmosphere, orbital elements...

Liu, Xinhua, Jianping Li, and Athena Coustenis. "A transposable planetary general circulation model (PGCM) and its preliminary application to Titan." *Planetary and Space Science* 56.12 (2008): 1618-1629.

<u>Christophe Sotin, *et al*., 2009</u>

> This paper also describes observations and interpretations which seem difficult to reconcile with our present understanding of Titan's interior structure and evolution such as the shape of the planet or the obliquity.

Sotin, Christophe, *et al*. "Titan's interior structure." *Titan from Cassini-Huygens*. Springer Netherlands, 2009. 61-73.

<u>Helmut Lammer, et al. 2009</u>

> All planets with substantial atmospheres (e.g., Earth, Venus, Mars, and Titan) have ionospheres which expand above the exobase.
>
> By synthesizing observations from the Earth, Venus, Mars, and Titan, we can qualitatively evaluate how the basic controlling parameters affect the various loss

mechanisms through the ionosphere for both magnetized and unmagnetized planets…

Lammer, Helmut, *et al*. "What makes a planet habitable?" *The Astronomy and Astrophysics Review* 17.2 (2009): 181-249.

<u>Yoav Yair, *et al*., 2009</u>

> Since lightning has been found in other planetary atmospheres, it seems reasonable to assume that some form of TLEs may also occur on those planets. Detailed calculations of the conventional breakdown parameters for various planetary atmospheres have been presented lately by Roussel-Dupré et al.[2008], for a range of external electric fields. Here we present initial calculations of the necessary lightning induced charge moment changes and possible atmospheric heights for the occurrence of sprites on Venus, Mars, Titan, and the gas giant Jupiter...We calculated the values of Ek over a wide range of pressures and temperatures in each planet's atmosphere...In order to compute the expected field above thunderclouds in other planets, we place a charge equivalent to the uppermost charge center expected in each cloud type...to account for the uncertainties in both charge locations and lightning discharge types in Venus, Titan and the giant planets... taken from the Planetary Atmospheres Node of the Planetary Data System (PDS) (http://atmos.nmsu.edu/) for Venus, Mars and Titan...

Yair, Yoav, *et al*. "A study of the possibility of sprites in the atmospheres of other planets." *Journal of Geophysical Research: Planets* 114.E9 (2009).

<u>R. M. C. Lopes, *et al.*, 2010</u>

> Planetary surfaces are shaped by the interplay of endogenic (volcanism, tectonism) and exogenic (impact cratering, erosion and surficial) processes. Understanding the distribution and inter- play of endogenic and exogenic processes on a planet is important for constraining models of the interior, surface–atmosphere interactions and climate evolution. Titan's atmosphere is the second densest in the Solar System and present day surface–atmosphere interactions make aeolian, fluvial, pluvial, and lacustrine processes important on a scale previously seen only on Earth.
>
> (…)
>
> All the major planetary geologic processes – volcanism, tectonism, impact cratering and erosion – have played a role in shaping Titan's complex surface.

Lopes, R. M. C., *et al.* "Distribution and interplay of geologic processes on Titan from Cassini radar data." *Icarus* 205.2 (2010): 540-558.

Mathieu Vincendon and Yves Langevin, 2010

> This approach is relevant when the solar zenith angle is small enough to neglect the curvature of the planet (typically less than 80° for Mars and 65° for Titan, which has a larger relative scale height).

Vincendon, Mathieu, and Yves Langevin. "A spherical Monte-Carlo model of aerosols: Validation and first applications to Mars and Titan." *Icarus* 207.2 (2010): 923-931.

Sarah Alice Drummond, 2012

> ... by Titan's low crater density (Lorenz et al. 2007, Wall et al. 2009, Wood et al. 2010, Neish and Lorenz 2012). For the purposes of this work external processes are defined as those for which the energy for surface modification is supplied externally to the planet's surface.

Drummond, Sarah Alice. "Structural control of fluvial network morphology on Titan." Masters Thesis, University of Tennessee, 2012. https://trace.tennessee.edu/utk_gradthes/1331.

S. Pascale, *et al.*, 2013

> ... a way to estimate the meridional heat transport of other planets, such as Mars and Titan (Lorenz et al., 2001; Jupp and Cox, 2010) and potentially to exoplanets too,…

Pascale, S., Ragone, F., Lucarini, V., Wang, Y. and Boschi, R.. Nonequilibrium thermodynamics of circulation regimes in optically thin, dry atmospheres. *Planetary and Space Science* 84 (2013), pp.48-65.

L. A. Amy and R. M. Dorrell, 2016

> …to have occurred on other planets (e.g., water on Mars and methane-ethane on Titan)"   "critical slopes for equilibrium flow are similar for planets. Compared to Earth, equilibrium slopes on Mars should be slightly lower whilst those on Titan will be higher or lower for organic and ice particle systems, respectively. Particle size distribution has a similar, order of magnitude effect, on equilibrium slope on each planet.

Amy, L. A., and R. M. Dorrell. "Equilibrium Conditions of Sediment Suspending Flows on Earth, Mars and Titan." In AGU Fall Meeting Abstracts. 2016.

David S. Stevenson, 2016

Generally careful to call Titan a moon, but it does not avoid saying the following:

> Titan has an atmosphere layered much like that of Earth .... The lowest 30 km contains most of the planet's true clouds.
>
> (…)
>
> Titan's low mass and its extended atmosphere should, therefore, make it vulnerable to escape, if we apply the same rules as we did to the other planets. As with the other planets, there are two main routes for escape of gases: thermal (or Jean's escape) and several non-thermal mechanisms.

In the following, "planet" is used for several bodies including Ganymede and Titan:

> All of these effects would have meant Ganymede remained largely airless while less massive Titan was able to maintain a rich, hazy firmament. There is one more factor worth considering: magnetic fields. Thinking back to Venus there is a perception that a planet must have a magnetic field if it is to retain an atmosphere against its star's stellar wind....Ganymede has its own, relatively strong field but this is embedded within Jupiter's enormous magnetized blanket. Titan is also within the field of Saturn, but it lies further out and Saturn's field is around 25–30 times weaker than Jupiter's...Under the auspices of Saturn's field Titan, by contrast, enjoys some protection from the solar wind. Yes, there is some erosion of its atmosphere from charged particles, but this effect is far less than experienced by Jupiter's satellites. Thus, a magnetic field may not be the protective, nourishing blanket it is always assumed to be. Venus does just fine without one, while Ganymede may have suffered because of one. Mars didn't lose its atmosphere so much for the lack of one, but for its proximity to the Sun and its low mass. Does Titan retain an atmosphere simply because it is further from the Sun than Ganymede? In part yes.

Also, Pluto is called a dwarf planet a few times, but there is also this:

> Here, the combination of greater insolation from the tilt and Pluto's closer position to the Sun ensure the planet can begin to warm up and, at least partially, thaw out.

In comparing three bodies it calls them "worlds" in most cases, but once it calls them "dwarf planets" even though two are satellites, showing that the root noun "planet" is not a dynamical category, and "dwarf" apparently means "small".

> Pluto, Triton and Titan form an intriguing triad of dwarf planets. While we think of Titan (quite rightly) as Saturn's greatest moon, it has rather a lot in common with further out Triton and Pluto.

Also, Titan's atmosphere is described as having a "planetary Hadley cell".

Stevenson, David S. "Ice Dwarves: Titan, Triton and Pluto." In: *The Exo-Weather Report*, pp. 329-362. Springer International Publishing, 2016.

Zac Liu, *et al*., 2016

> For example, the average slope of fold and thrust belts on terrestrial planets is commonly <15 (e.g., Yakima fold-and thrust belts in Washington, USA (Reidel, 1984) and lobate scarps on the Moon (Banks et al., 2012)).

Liu, Zac Yung-Chun, Jani Radebaugh, Ron A. Harris, Eric H. Christiansen, and Summer Rupper. "Role of fluids in the tectonic evolution of Titan." *Icarus* 270 (2016): 2-13.

M. J. Way, *et al*., 2017

> In simulating other planets, including early Earth, certain assumptions that are built into ModelE2 can become invalid, so updated or new parameterizations need to be developed for ROCKE-3D. This is especially the case for reduced atmospheres like those of Archean Earth, Titan and probably Pluto.

M. J. Way, Igor Aleinov, David. S. Amundsen, Mark Chandler, Thomas Clune, Anthony D. Del Genio, Yuka Fujii, Maxwell Kelley, Nancy Y. Kiang, Linda Sohl, Kostas Tsigaridis, "Resolving Orbital and Climate Keys of Earth and Extraterrestrial Environments with Dynamics 1.0: A General Circulation Model for Simulating the Climates of Rocky Planets" *Astrophys J Suppl Series* 231, no. 1. 2017.

K. J. Zahnle and D. C. Catling, 2017

> Constantly calls all round bodies including dwarf planets and moons "planets". Example: "It may be reasonable to expect a lower threshold for impact erosion from planets with well-defined surfaces (Melosh and Vickery 1989), yet the different fates of Titan and Callisto can be nicely accounted for by the same factor of 4−5.

Zahnle, K.J. and Catling, D.C., 2017. The cosmic shoreline: the evidence that escape determines which planets have atmospheres, and what this may mean for Proxima Centauri B. *Astrophysical Journal*, 843(2).

Juan M. Lora, Tiffany Kataria, and Peter Gao, 2018

> Our solar system's Titan is a prototypical hazy planet, whose atmosphere may be representative of a large number of planets in our Galaxy.

Lora, Juan M., Tiffany Kataria, and Peter Gao. "Atmospheric circulation, chemistry, and infrared spectra of Titan-like exoplanets around different stellar types." *The Astrophysical Journal* 853, no. 1 (2018): 58.

Kaylie Cohanim, *et al.*, 2018

> Titan, Saturn's largest moon, is home to many Earth-like planetary features that are still not thoroughly understood; lakes, rivers, clouds and precipitation of aqueous or frozen methane, extensive mountain ranges, as well as huge linear dunes that cover 15% of the planet.

Cohanim, Kaylie, Francis Alexander Turney, Jasper F. Kok, Kirby Runyon, Devon M. Burr, Nathan Bridges, Emily Nield, S. L. Sutton, and James K. Smith. "Properties of Wind-Blown Sand on Titan Obtained Through Calibrating Model to Laboratory Experiments." In *AGU Fall Meeting Abstracts*, vol. 2018, pp. EP23F-2381. 2018.

Sean Falk, 2018

> As the only body in the Solar System with an active hydrologic cycle other than Earth, Titan presents a valuable laboratory for studying principles of hydroclimate on terrestrial planets.
>
> Titan is the focus of this work, but it is not the heart of it. The heart of it is the question of what, fundamentally, forms a planet's climate.
>
> Seasonally shifting large-scale circulations, baroclinic storms, local convection and lake evaporation, runoff into river channels and lake networks, infiltration into subsurface aquifers, and phreatic zone flow all occur on Earth and almost definitely on Titan as well. The study of such processes, when combined with their impact on a planet's climate, can be generalized as a planet's hydroclimate. Earth's hydroclimate has been extensively studied, while Titan's, which is perhaps comparably complex, is just beginning to be explored.

Faulk, Sean. *Surface-Atmosphere Connections on Titan: A New Window into Terrestrial Hydroclimate*. PhD Dissertation, University of California, Los Angeles, 2018.

Javier Pelegrina, Carlos Osácar, and Amalio Fernández-Pacheco, 2021

> Brief Communication: Residence Time of Energy in the Atmospheres of Venus, Earth, Mars and Titan…The values of these fluxes for Venus, Mars and Titan have been deduced from Read et al. (2016). For each planet, F_i and F_o represent the inflow or outflow of energy absorbed or emitted by the atmospheres…. With the total energy values, E or S (in Table 1) and F (Table 2), we estimate the value of residence time of energy in the atmosphere of each planet… The residence time of energy in the atmospheres of Venus, Earth, Mars and Titan have been computed… The residence time of energy in a planetary atmosphere characterizes the planet, and is computed in a model independent way… In this expression, σ is the Stefan-Boltzmann constant, p is pressure, g, the gravity acceleration and T_{eff} the temperature corresponding to radiative equilibrium of the planet.

Pelegrina, Javier, Carlos Osácar, and Amalio Fernández-Pacheco. "Brief Communication: Residence Time of Energy in the Atmospheres of Venus, Earth, Mars and Titan." *Nonlinear Processes in Geophysics Discussions* (2021): 1-6.

Marco Gajeri, Paolo Aime, and Roman Ya Kezerashvili, 2021

> Titan's atmosphere is also unusually large due to its much smaller gravity. It is about 60% of the planet's radius whereas at the Earth it is 6%.

Gajeri, Marco, Paolo Aime, and Roman Ya Kezerashvili. "A Titan mission using the Direct Fusion Drive." *Acta Astronautica* 180 (2021): 429-438.

Neil Lewis and Peter Read, 2021

> Super-rotation is a phenomenon in atmospheric dynamics where the specific axial angular momentum of the wind (at some location) in an atmosphere exceeds that of the underlying planet at the equator…. The first approach utilises 'realistic', tailor-made models of Solar System atmospheres where super-rotation is present (e.g., Venus and Titan) to investigate the specific processes responsible for generating super-rotation on each planet. The second approach takes simple, 'Earth-like' models, typically dry dynamical cores with radiative transfer represented using a Newtonian cooling approach, and explores the effect of varying a single (or occasionally multiple) planetary parameters (e.g., the planetary radius or rotation rate) on the atmospheric dynamics. Notably, studies of this flavour have shown that super-rotation may emerge 'spontaneously' on planets with slow rotation rate or small radius (relative to the Earth's; Venus and Titan have these characteristics). However, the strength of super-rotation obtained in simulations of this type is far weaker than that observed in Venus' or Titan's atmospheres, or in tailored numerical models of either planet… This allows us to investigate how properties characteristic of the atmospheres of planets such as Venus and Titan combine to yield the strong super-rotation observed in their atmospheres (and realistic numerical models).

Lewis, Neil, and Peter Read. "Planetary and atmospheric properties leading to strong super-rotation in terrestrial atmospheres studied with a semi-grey GCM." In *EGU General Assembly Conference Abstracts*, pp. EGU21-4855. 2021.

D. Rose, *et al.*, 2021

> Linear dunes on Titan have the potential to reveal much about the planet's wind and atmosphere. This study focuses on creating a dataset for statistical analysis of dune length, orientation, and spacing in Titan's Shangri La sand sea.

Rose, D., J. Radebaugh, E. H. Christiansen, and B. Lake. "Length, Orientation, and Spacing of Linear Dunes in the Shangri La Sand Sea, Titan." In *Lunar and Planetary Science Conference*, no. 2548, p. 2568. 2021.

Europa Is a Planet

<u>A. A. Finnerty, *et al*., 1981</u>

> It is proposed that some of the surface features of Europa may be due to processes occurring within a planet in which hydrated silicates are stable.

Finnerty, A. A., *et al*. "Is Europa surface cracking due to thermal evolution." *Nature* 289 (1981): 24-27.

<u>Gregory W. Ojakangas, and David J. Stevenson, 1989</u>

> The problem is that of a planetary elastic lithosphere that is topographically loaded from below.
>
> (…)
>
> We describe one such scenario: that of a planet with an elastic lithosphere which is topographically loaded from below. We describe how this scenario applies to the question of polar wander of Europa,...

Ojakangas, Gregory W., and David J. Stevenson. "Polar wander of an ice shell on Europa." *Icarus* 81.2 (1989): 242-270.

<u>Paul M. Schenk and William B. McKinnon, 1989</u>

> ... across the wedge-shaped band rift zone is limited to a relatively small area, and may have been taken up planet-wide by ...

Schenk, Paul M., and William B. McKinnon. "Fault offsets and lateral crustal movement on Europa: Evidence for a mobile ice shell." *Icarus* 79.1 (1989): 75-100.

<u>Margaret G. Kivelson, et al., 2000</u>

> ... The Galileo magnetometer measured changes in the magnetic field predicted if a current-carrying outer shell, such as a planet-scale liquid ocean, is present beneath the icy surface. The evidence that Europa's field varies temporally strengthens the argument that a liquid ocean ...

Kivelson, Margaret G., et al. "Galileo magnetometer measurements: A stronger case for a subsurface ocean at Europa." *Science* 289.5483 (2000): 1340-1343.

Giuseppe Mitri and Adam P. Showman, 2000

> ... Structures and temperature profiles for two possible configurations of the ice shell of Europa. The heat generated in the interior of the planet might be shed by simple conduction through a relatively thin ice shell...

Mitri, Giuseppe, and Adam P. Showman. "Convective–conductive transitions and sensitivity of a convecting ice shell to perturbations in heat flux and tidal-heating rate: Implications for Europa." *Icarus* 177.2 (2005): 447-460.

Cynthia B. Phillips, *et al.*, 2000

> Figure 2b, with the bright limb at 7% of its full brightness, shifted off the planet by 16 pixels.

Phillips, Cynthia B., *et al*. "The search for current geologic activity on Europa*." Journal of Geophysical Research* 105.E9 (2000): 22579-22598.

Christophe Sotin, James W. Head, and Gabriel Tobie, 2002

> the viscous response of the planet is considered as a first order perturbation of the elastic response to the tidal potential

Sotin, Christophe, James W. Head, and Gabriel Tobie. "Europa: Tidal heating of upwelling thermal plumes and the origin of lenticulae and chaos melting." *Geophysical Research Letters* 29.8 (2002).

Giles M. Marion, *et al*., 2003

> Two aspects of time have a bearing on the possibility of life on Europa: (1) How much time is required for life to develop on a planet? (2) How long can life survive in the dormant stage in isolation from conditions normally considered vital for life such as cycling of liquid water, energy, and nutrients?

Marion, Giles M., *et al.* "The search for life on Europa: limiting environmental factors, potential habitats, and Earth analogues." *Astrobiology* 3.4 (2003): 785-811.

Jere H. Lipps and Sarah Rieboldt, 2005

> Clearly, an adequate assessment of life on another planet requires multiple instruments and techniques.

Lipps, Jere H., and Sarah Rieboldt. "Habitats and taphonomy of Europa." *Icarus* 177.2 (2005): 515-527.

<u>Giuseppe Mitri and Adam P. Showman, 2005</u>

> ... Structures and temperature profiles for two possible configurations of the ice shell of Europa. The heat generated in the interior of the planet might be shed by simple conduction through a relatively thin ice shell...

Mitri, Giuseppe, and Adam P. Showman. "Convective–conductive transitions and sensitivity of a convecting ice shell to perturbations in heat flux and tidal-heating rate: Implications for Europa." *Icarus* 177.2 (2005): 447-460.

<u>Timothy G. Leighton, Daniel C. Finfer, and Paul R. White 2008</u>

> To do so would be to assume a constant acceleration due to gravity, and to ignore the curvature of Europa's spherical geometry: vertical lines are not parallel on a small planet...
>
> …the sound speed calculated ignoring planet curvature and for a gravitational acceleration which is constant at a value of 1.31 m s-2 (the value at Europa's surface)...On a small planet...a planet resembling Europa...

Leighton, Timothy G., Daniel C. Finfer, and Paul R. White. "The problems with acoustics on a small planet." *Icarus* 193.2 (2008): 649-652.

<u>Michel Blanc, *et al*. 2009</u>

> ...All these topics relate to whether a planet immersed in a strong radiation environment can host complex compounds able to react chemically.

Blanc, Michel, *et al.* "LAPLACE: A mission to Europa and the Jupiter System for ESA's Cosmic Vision Programme." *Experimental Astronomy* 23.3 (2009): 849-892.

<u>Helmut Lammer, *et al*., 2009</u>

> Europa is probably unique in that it is the only satellite on which a large ocean can be in contact with the silicate layer. On the other moons, the existence of an ocean implies necessarily the occurrence of a very thick high pressure icy layer at the bottom which impedes the contact of the liquid with silicates. But one must keep in mind that, if the amount of water is large (roughly more than 5% wt of the planet), the liquid layer is still separated from the silicate by a thick high pressure icy layer (i.e., case 2).

Lammer, Helmut, *et al*. "What makes a planet habitable?" *The Astronomy and Astrophysics Review* 17.2 (2009): 181-249.

<u>Richard Greenberg, 2010</u>

> But information about the surface of Europa came from images taken of an alien planet using a telescope flying through space.
>
> (…)
>
> But there is a danger in unduly applying terrestrial experience to a planet that may be completely different. The initial considerations of Europa were based upon comparisons with the most similar types of familiar geological features on Earth.
>
> (…)
>
> This picture has emerged as we have come to know Europa as a planet. ... Unmasking Europa physical processes were actually responsible for the character of the planet.

Greenberg, Richard. *Unmasking Europa: The Search for Life on Jupiter's Ocean Moon*. Vol. 6. Springer Science & Business Media, 2010.

Triton Is a Planet

<u>J. A. Sansberry, 1989</u>

> ...fresh frost layer covering approximately the northern half of the planet.

Stansberry, J.A. “Albedo patterns on Triton.” *Geophys. Res. Lett.* 16 (1989), 961-964.

<u>L. A. Soderblom, *et al.*, 1990</u>

> These are projected onto a model of the planet's surface, in this case a sphere...

Soderblom, L.A., *et al*. “Triton's geyser-like plumes: Discovery and basic characterization.” *Science* 250 (1990), 410-415.

<u>A. P. Ingersoll, 1990</u>

> ...much less than Triton's tangential speed of rotation ... where Omega is the angular velocity of the solid planet." and "...solar heating at the equator is comparable to that for the planet as a whole.

Ingersoll, A.P. “Dynamics of Triton's atmosphere.” *Nature* 344 (1990), 315-317.

<u>J. R. Spencer, 1990</u>

> The model assumes a clear atmosphere overlaying a diffusely scattering uniform spherical planet. [The model is applied both to Pluto and Triton.]

Spencer, J.R., et al. "Solid methane on Triton and Pluto: 3- to 4-micron spectrophotometry." *Icarus* 88 (1990), 491-496.

<u>A. T. Bazilevskii, *et al.*, 1992</u>

> ...subsequent cooling of the planet interiors.

Bazilevskii, A.T., *et al*. "Geology of Triton and some comparative-planetological implications." *Adv. Space Res*. 12 (1992), 123-132.

<u>V. A. Krasnopolsky, *et al.*, 1993</u>

> The total escape flux from a planet is ... in the case of the atomic nitrogen escape from Triton when ...

Krasnopolsky, V.A., *et al*. "Temperature, N2, and N density profiles of Triton's atmosphere: Observations and model." *J. Geophys. Res.* 98 (1993), 3065-3078.

<u>C. B. Oikin, *et al.*, 1997</u>

Repeatedly uses the word "planet" when describing the modeling approach used for Triton's atmosphere.

Olkin, C.B., *et al*. "The thermal structure of Triton's atmosphere: Results from the 1993 and 1995 occultations." *Icarus* 129 (1997), 178-201.

<u>Jodi Gaeman, Saswata Hier-Majumder, and James H. Roberts, 2012</u>

> Ross and Schubert (1990) argue that during the circularization of Triton, enough heat was generated to melt the entire planet.

Gaeman, Jodi, Saswata Hier-Majumder, and James H. Roberts. "Sustainability of a subsurface ocean within Triton's interior." *Icarus* 220 (2012), 339-347.

<u>S. C. Tegler, *et al*., 2012</u>

Regularly uses the term "dwarf planet" for Pluto, Triton, and Eris.

Tegler, S.C., *et al*. "Ice mineralogy across and into the surfaces of Pluto, Triton, and Eris." *Astrophys. J*. 751 (2012), 76.1-10.

L. A. Trafton, 2015

Refers to Triton and Pluto as "these two dwarf planets".

Trafton, L.A. “On the state of methane and nitrogen ice on Pluto and Triton: Implications of the binary phase diagram.” *Icarus* 246 (2015), 197-205.

James A. Hall III, 2016

> Triton destroyed and further doomed other moons, and Neptune has in turn doomed Triton. The planet is expected to pass by the Roche limit or crash into Neptune's atmosphere in about 3.6 billion years...

Hall III, James A. "Neptune." In: *Moons of the Solar System*. Springer International Publishing, 2016. 171-184.

Other Satellites Are Planets

A. B. Binder. and D. P. Cruikshank, 1964

> Thus, if only 10% of the maximum available CH4 froze out during the eclipse over 20% of the planet, the resulting layer would be…

Binder, A.B. and Cruikshank, D.P., 1964. Evidence for an atmosphere on Io. *Icarus* 3.4, pp.299-305.

M. G. Kivelson, *et al.*, 1996

> It seems plausible that Io, like Earth and Mercury, is a magnetized solid planet.

Kivelson, M. G., *et al*. "A magnetic signature at Io: Initial report from the Galileo magnetometer." *Science* 273.5273 (1996): 337.

Gaël Cessateur, *et al*. 2012

> Photolysis in Ganymede's atmosphere... case 3 is when the spacecraft looks at the surface of the planet (limb viewing).

Cessateur, Gaël, *et al*. "Photoabsorption in Ganymede’s atmosphere." *Icarus* 218.1 (2012): 308-319.

Ceres Is a Planet

Vil'ev, Mikhail Anatol'evich 1916

“The Planet (1) Ceres”

Vil'ev, Mikhail Anatol'evich. "Absolyutnyia vozmushcheniia planety (1) Ceres ot IUpitera, Saturna i Marsa. The Absolute Peturbation of the Planet (1) Ceres from Jupiter, Saturn and Mars." *Mitteilungen der Nikolai-Hauptsternwarte zu Pulkowo* 7 (1916): 35-44.

G. M. Clemence 1948

> I have assumed that the planet Ceres was observed on half of the nights when the meridian transit occurred in darkness at Washington during the 5-year period 1938-1942.

Clemence, G. M. "The value of minor planets in meridian astronomy." *The Astronomical Journal* 54 (1948): 10.

Gerard P. Kuiper, 1950

> The largest asteroids, like Ceres, are regarded as such original condensations; they are in effect true planets [contrasted to the smaller asteroids, which are not true planets].

Kuiper, Gerard P. "On the origin of asteroids." *The Astronomical Journal* 55 (1950): 164.

Gerard P. Kuiper, 1951

> The total number of small proto-planets estimated to have formed in the region between Mars and Jupiter is between 5 and 10. They formed small planets, like Ceres...It is assumed that two of these collided sometime during the last 3.10^9 years, an event having a sufficiently large probability. Thereafter secondary collisions became increasingly frequent. The most recent of these collisions account for the Hirayama families. In this manner thousands of asteroids were formed, being the largest of the fragments, as well as billions of meteorites.

Kuiper, Gerard P. "On the origin of the solar system." *Proceedings of the National Academy of Sciences* 37, no. 1 (1951): 1-14.

S. Fred Singer, 1954

> Some four to five billion years ago a group of small protoplanets about 30 to more than 500 miles in diameter formed from collections of dust between Mars and Jupiter. After they condensed, their internal radioactivity heated them very

> rapidly. They melted, but soon thereafter began to solidify. During this slow solidification the planets' matter separated into the metallic and stony phases. Widmanstätten figures formed in the iron-nickel phase as it cooled under high pressure in the planet core. Eventually the protoplanets collided with one another and broke up into asteroids and meteorites. The new cosmic-ray studies allow us to date these catastrophes—some seem to have taken place around 300 million years ago. It is hoped that detailed laboratory study of other meteorites will eventually enable us to identify meteorites belonging to the same protoplanet and to date the break-up of individual planets.

Note: *protoplanet* literally means "first planet", whereas *protero-planet* would have meant "pre-planet". The term *protoplanet* became popular for large asteroids because they were literally classed as planets until the 1950s/60s. Singer here calls them both "protoplanets" and simply "planets". Note that Singer included bodies as small as 30 miles in diameter as protoplanets, whereas Kuiper had just published in 1950 that only the larger, round ones are "true planets", with updates to his theory in 1951 and 1953. Kuiper's view won out over the following decade as documented by Metzger, Philip T., Mark V. Sykes, Alan Stern, and Kirby Runyon. "The reclassification of asteroids from planets to non-planets." Icarus 319 (2019): 21-32.

Singer, S. Fred. "The origin of meteorites." *Scientific American* 191, no. 5 (1954): 36-41.

<u>Richard G. Hodgson, 1974</u>

> This problem has previously been discussed in relation to the planet Ceres

Hodgson, Richard G. "The Densities of Pallas and Vesta and their Implications." *Minor Planet Bulletin* 2 (1974): 17-20.

<u>V. N. Boiko, 1975</u>

> We have carried out several solutions for the planet Ceres, making the following changes in its orbital elements...

Boiko, V. N. "Improvement of the fundamental-catalog system for minor-planet observations." *Soviet Astronomy* 19 (1975): 261-266.

<u>Richard G. Hodgson, 1977</u>

> The writer would like to propose a different model for Ceres which would keep some or all of the interpretations of surface materials as live possibilities, and yet explain the low density of the planet.

Hodgson, Richard G. "Implications of Recently Published Diameters for 1 Ceres, 2 Pallas and 4 Vesta." *Minor Planet Bulletin* 5 (1977): 8-11.

Richard L. Branham, 1980

> ...shows the number of minor planets in the solution and the number in parentheses is the numerical designation of the planet...

Branham, Richard L. "Equinox and equator determinations from hypothetical minor planet observations." *Celestial Mechanics and Dynamical Astronomy* 22.1 (1980): 81-87

G. E. Taylor, 1981

> …the orbital latitude of the planet [Ceres].

Taylor, G. E. "Occultations of stars by the four largest minor planets, 1981-1989." *The Astronomical Journal* 86 (1981): 903-905.

Paul E. Johnson, *et al*., 1983

> POLARIMETRY OF CERES For a spherical planet the net polarization will increase asthe sphere is viewed at angles such that the subsolar point is seen closer to the limb,...

Johnson, Paul E., et al. "10 µm Polarimetry of Ceres." *Icarus* 56.3 (1983): 381-392.

N. Rambaux, F. Chambat, and J. C. Castillo, 1989

> …interpreting shape and gravity data in terms of interior structure and infer deviations from hydrostaticity that can bring information on the thermal and chemical history of the planet.

Rambaux, N., F. Chambat, and J. C. Castillo. "Third-Order Development of Shape, Gravity, and Moment of Inertia of Ceres." *AGU Fall Meeting Abstracts*. 2015.

E. Hantzsche, 1996

Title: “Planet Ceres”.

Discusses how Ceres has the characteristics of a planet.

> Ceres is also unlikely to be genetically different from other planets: it, too, is the end product of an accretion process from the early solar nebula... Let us accept Ceres, the largest planetoid, as one of the planets – as far as that makes sense: in considerations of planetary orbits and the structure of the solar system, and also in the context of comparative planetology and planetary cosmology. [transl. from German]

Hantzsche, E. "Planet Ceres." *Die Sterne* 72 (1996): 125-133.

T. B. McCord and C. Sotin, 2003

Title: "The Small Planet Ceres: Models of Evolution and Predictions of Current State"

McCord, T. B., and C. Sotin. "The small planet Ceres: Models of evolution and predictions of current state." *Bulletin of the American Astronomical Society*. Vol. 35. 2003.

T. B. McCord and C. Sotin, 2003

> Ceres orbits the sun and is large enough (1000 km diameter) to have experienced many of the processes normally associated with planetary evolution. Therefore, it should be called a planet even though it orbits in the middle of the asteroid belt.

Mccord, T. B., and C. Sotin. "The small planet Ceres: Predictions of current state." *EGS-AGU-EUG Joint Assembly.* 2003.

T. McCord and Dawn Team, 2003

> Dawn provides the missing context for both primitive and evolved meteoritic data, thus playing a central role in understanding terrestrial planet formation and the evolution of the asteroid belt.

McCord, T., and Dawn Team. "Dawn: A journey in space and time." *EGS-AGU-EUG Joint Assembly*. 2003.

T. McCord and C. Sotin, 2005

> Ceres orbits the Sun and is large enough in size to have experienced many of the processes normally associated with planetary evolution. Therefore it should be called a planet. Its location, in the middle of the asteroid belt, has caused it to be referred to as an asteroid. However, its size, orbit and general nature, as best we can discern it, suggest that it is much more interesting than the small pieces of larger objects (perhaps such as Ceres) that one normally thinks of when one refers to asteroids. Ceres' planet-like nature and its survival from the earliest stages of solar system formation, when its sister/brother objects probably became the major building blocks of the Earth and the other terrestrial inner planets, makes it an extremely important object for understanding the early stages of the solar system as well as basic planetary processes.

McCord, Thomas B., and Christophe Sotin. "Ceres: Evolution and current state." *Journal of Geophysical Research: Planets* 110, no. E5 (2005).

T. McCord, 2013

> Ceres likely contains considerable water, has differentiated, and has experienced major dimensional and chemical changes over its history, making it more a planet than asteroid.

McCord, T. "Ceres: Evolution and What Dawn Might Find." European Planetary Science Congress 2013, held 8-13 September in London, UK. Online at: http://meetings. copernicus. org/epsc2013, id. EPSC2013-129. Vol. 8. 2013.

T. McCord, 2014

> Ceres likely contains considerable water, has differentiated, possesses a silicate core and water mantle, and has experienced major dimensional, thermal and chemical changes over its history, making it more a planet than an asteroid.

McCord, T. "Ceres: Dawn visits a warm wet planet." *European Planetary Science Congress 2014*, *EPSC Abstracts*, Vol. 9, id. EPSC2014-96. Vol. 9. 2014.

T. McCord and Dawn Team, 2015

> Dawn provides the missing context for both primitive and evolved meteoritic data, thus playing a central role in understanding terrestrial planet formation and the evolution of the asteroid belt.

McCord, T., and Dawn Team. "Dawn: A journey in space and time." *EGS-AGU-EUG Joint Assembly*. 2003.

Christopher T. Russell, *et al*., 2015

> The first comprehensive survey of the planet is scheduled to commence in late April 2015...

Russell, Christopher T., *et al*. "First Results of the Exploration of Ceres by Dawn." *IAU General Assembly* 22 (2015): 21738.

Villarreal, M. N., et al., 2015

> The spikes were consecutively located closer to the planet as the spacecraft approached the subsolar point. The dramatic increase in electron counts could be explained by the acceleration of the electrons at a Ceres bow shock.

Villarreal, M. N., et al. "Evidence for a Bow Shock at Ceres?." *AGU Fall Meeting Abstracts*. 2015.

N, Rambaux, F. Chambat, and J. C. Castillo, 2015

> …interpreting shape and gravity data in terms of interior structure and infer deviations from hydrostaticity that can bring information on the thermal and chemical history of the planet.

Rambaux, N., F. Chambat, and J. C. Castillo. "Third-Order Development of Shape, Gravity, and Moment of Inertia of Ceres." *AGU Fall Meeting Abstracts*. 2015.

Pluto Is a Planet

Note: we limited this section to years beginning 2008 to show usage *after* the IAU's voted definition. Two years after the vote were allowed so papers already in peer review would clear the system.

M. D. Hicks, *et al*., 2008

> ... In order to constrain potential volatile transport on the surface of Pluto due to changing solarillumination geometry and heliocentric distance, we have recently measured (2007 October-2008 March) a Bessel R-band rotational lightcurve of the planet at TMO which exhibits a ...

Hicks, M.D., Buratti, B.J., Gillam, S.D., Young, J.W. and Somers, J.F., 2008, September. Support Observations For New Horizons: Pluto's Solar Phase Curve As Measured By The Cassini Spacecraft And A New Ground-based Optical Lightcurve. In: *Bulletin of the American Astronomical Society*, Vol. 40, p. 460.

J. K. Miller, *et al*., 2008

> Pluto/Charon/Hydra reduced optical imaging-sensitivity to planet ephemeris errors

Miller, J.K., Carranza, E., Stanbridge, D. and Williams, B.G. "New Horizons Navigation to Pluto." In: *AAS Guidance and Control Conference, 2008*.

P. A. Delamere, 2009

> Without an escaping atmosphere, the size of Pluto's obstacle to the solar wind (ie, planet + atmosphere), would be comparable to the upstream ion inertial length...

Delamere, P.A. "Hybrid code simulations of the solar wind interaction with Pluto." *Journal of Geophysical Research: Space Physics*, 114, no. A3 (2009).

O. V. Kalinicheva and V. P. Tomanov, 2009

> However, the closeness of the orbits of the comets and that of Pluto is insufficient for proving the connection between the comets and the planet. Even if the orbits cross, this does not mean that the comet and the planet will simultaneously end up in the cross point.

Kalinicheva, O. V., and V. P. Tomanov. "On the absence of an interrelation between cometary orbits and Pluto." *Solar System Research* 43.6 (2009): 500-503.

D. McComas, *et al.*, 2009

> ... Pluto's thick atmosphere escapes the planet's weak gravity and streams away as neutral particles. ... Pluto represents a possible intermediate case if the interaction region is limited to an area close to the planet since the solar wind proton inertial length is roughly 2 RP.

McComas, D., Allegrini, F., Bagenal, F., Casey, P., Delamere, P., Demkee, D., Dunn, G., Elliott, H., Hanley, J., Johnson, K. and Langle, J., 2009. “The solar wind around Pluto (SWAP) instrument aboard New Horizons.” In: *New Horizons*. Springer New York, pp. 261-313.

P. Rannou and G. Durry, 2009

> In this work, as in most of the publications concerning Pluto, we will refer to the altitude levels taken from the center of the planet since the real radius of the solid body is not well defined.

Rannou, P. and Durry, G. “Extinction layer detected by the 2003 star occultation on Pluto.” *Journal of Geophysical Research: Planets*, 114, E11 (2009).

D. P. Rubincam, 2009

> Pluto's south polar cap is a puzzle. The planet's southern cap may be brighter than the north, even though it was the south pole which faced the Sun on Pluto's recent approach to perihelion.

Rubincam, D.P. “Pluto Insolation and the South Polar Cap.” In: *AGU Spring Meeting Abstracts*, Vol. 1 (2009), p. 4.

B. Sicardy, et al., 2009

> …fit to the five Pluto occultation light curves obtained in Australia,using a ray tracing method and a standard atmospheric model for the planet, provides – among others – Pluto's offset with respect to it ex- pected DE413 ephemeris position.

Sicardy, B., Boissel, Y., Colas, F., Doressoundiram, A., Lecacheux, J., Roques, F., Widemann, T., Beisker, W., Andrei, A.H., Camargo, J.I.B. and Martins, R.V. “Constraints on Charon’s orbit from the stellar occultation of 22 June 2008.” In: *European Planetary Science Congress 2009*, Vol. 1, p. 164.

M Assafin, *et al.*, 2010

> Recall that our formula for insolation doesn’t depend on the precession angle. Note that the longitude of perihelion is determined by the precession angle (as the planet precesses, its line of equinoxes changes), so our results don’t depend on the longitude of perihelion. One area of concern could be that Pluto’s period of precession is in resonance with its orbital period. Dobrovolskis et al. show that the angle between Pluto’s perihelion and its vernal equinox have a period of about three million Earth years, or about 12,000 Pluto years [8]. Although this period is slightly faster than Earth’s precession, it is large enough so that Pluto’s precession is negligible in a Pluto year. Thus, we should have no influence from the precession angle (or longitude of precession) in the calculations of Pluto’s insolation.
>
> (…)
>
> It is important to note that because the mean annual insolation is symmetric across the equator, we have that any multi-year average must also be symmetric about the planet’s equator.

Assafin, M., Camargo, J.I.B., Martins, R.V., Andrei, A.H., Sicardy, B., Young, L., da Silva Neto, D.N. and Braga-Ribas, F. “Precise predictions of stellar occultations by Pluto, Charon, Nix, and Hydra for 2008–2015.” *Astronomy & Astrophysics* 515 (2010), p. A32.

H. Roe, 2010

> Further, these observations are important toward our long term understanding of Pluto's changing climate as the planet recedes from perihelion...

Roe, H. “Climate change and haze on Pluto.” *Keck Observatory Archive NIRSPEC N150NS*, 1 (2010), p. 295.

J. J. Rawal and B. Nikouravan, 2011

> Here, it is shown that a stable ring system consisting of small rocks having densities in the range (1–2.4) g cm-3 and diameters in the range (20–90) km along with fine dust and particles disrupted off these rocks, may exist around Pluto within the distance ~2500 km from the centre of the planet.

Rawal, J.J. and Nikouravan, B. “Are there rings around Pluto?” *International Journal of Fundamental Physical Sciences (IJFPS)* 1, no. 1 (2011), p. 6-10.

Leslie A. Young, 2012

> This model, like that of HP96, assumes that the volatile ice temperature is the same everywhere on the planet.

Young, Leslie A. "Volatile transport on inhomogeneous surfaces: I–Analytic expressions, with application to Pluto’s day." *Icarus* 221.1 (2012): 80-88.

Olivier Mousis, *et al*. 2013

> The formation on Pluto of clathrates rich in noble gases could then induce a strong decrease in their atmospheric abundances relative to their initial values. A clathrate thickness of order of a few centimeters globally averaged on the planet is enough to ...

Mousis, Olivier, *et al*. "On the possible noble gas deficiency of Pluto’s atmosphere." *Icarus* 225.1 (2013): 856-861.

A. Stern and J. Spencer, 2013

> The trans-Neptunian region, containing the binary planet Pluto–Charon and the myriad planetary embryos of the Kuiper Belt, is a scientific and intellectual frontier

Stern, A. and Spencer, J. “The First Decadal Review of the Edgeworth-Kuiper Belt” (2013), p.477.

Angela M. Zalucha, and Timothy I. Michaels, 2013

> This is unique versus other planetary atmospheres in the Solar System, such as Earth, Venus, Mars, Titan, and the giant planets. These planets have one or more overturning circulation patterns such as Hadley, Walker, or eddy driven circulations.
>
> (…)
>
> Fig. 12 shows a zonally and time averaged latitude-height temperature cross-section for Pluto...Fig. 13 shows the corresponding zonally and time averaged latitude-height cross section of mass stream function... at solstice there is a single planet-wide cell.

Zalucha, Angela M., and Timothy I. Michaels. "A 3D general circulation model for Pluto and Triton with fixed volatile abundance and simplified surface forcing." *Icarus* 223, no. 2 (2013): 819-831.

<u>D. P. Cruikshank, N. Pinilla-Alonso and R. P. Binzel, 2014</u>

> We propose to obtain the first ever high-precision spectra of Pluto in the region 0.3 to 0.9 nm at several disk-averaged positions on the planet's surface.

Cruikshank, D.P., Pinilla-Alonso, N. and Binzel, R.P. “Rotationally resolved spectrum of Pluto, ices and non-ice surface constituents.” NOAO Proposal, 1 (2014), p.272.

<u>K. M. Kratter and A. Shannon, 2014</u>

> The Pluto–Charon planet–satellite system consists of a binary orbited by four low-mass satellites.

Kratter, K.M. and Shannon, A. Planet packing in circumbinary systems. *Monthly Notices of the Royal Astronomical Society* 437, no. 4 (2014), pp.3727-3735.

<u>M. Nakajima, *et al*., 2014</u>

> This upper limit is a few Earth masses for a rocky planet, and about an Earth mass for an icy planet. These results are consistent with the models that Earth's and Pluto's satellites formed by impacts.

Nakajima, M., Genda, H., Asphaug, E. and Ida, S. “Constraints on Exomoon Formation.” In: *AAS/Division for Planetary Sciences Meeting Abstracts*, Vol. 46 (2014).

<u>M. R. Showalter, 2014</u>

> ... the mystery, Nix increased in absolute brightness by about 30% between 2010 and 2012, whereas Hydra was stable. I have developed a numeric integrator that tracks the position, velocity, orientation and rotation state of a moon as it orbits the Pluto-Charon "binary planet".
>
> ...However, both photometry and dynamical simulations support the notion that chaotic rotation is a natural state for irregularly-shaped bodies orbiting a binary planet, with Nix and Hydra as real-world examples.

Showalter M.R. “Chaotic Rotation of Nix and Hydra.” In: *AAS/Division of Dynamical Astronomy Meeting 2014*, Vol. 45.

<u>F. Bagenal, *et al.*, 2015</u>

> Pluto has a tenuous, extended atmosphere that is escaping the planet's weak gravity.

Bagenal, F., Delamere, P.A., Elliott, H.A., Hill, M.E., Lisse, C.M., McComas, D.J., McNutt Jr, R.L., Richardson, J.D., Smith, C.W. and Strobel, D.F. “Solar wind at 33 AU: Setting bounds on the Pluto interaction for New Horizons." *Journal of Geophysical Research: Planets*, 120, no. 9 (2015): 1497-1511.

<u>A. C. Correia, *et al*., 2015</u>

> ...Charon has an important fraction of the total mass (about 11%), and therefore the system is considered a binary planet rather than a planet and a moon.

Correia, A.C., Leleu, A., Rambaux, N. and Robutel, P. "Spin-orbit coupling and chaotic rotation for circumbinary bodies-Application to the small satellites of the Pluto-Charon system." *Astronomy & Astrophysics* 580 (2015): L14.

<u>D. P. Cruikshank, *et al*., 2015</u>

> ... laboratory by energetic processing of mixtures of the ices (N_2, CH_4, CO) known on Pluto's surface. We present results returned from the spacecraft to date obtained from the analysis of the high spatial resolution dataset obtained near the time of closest approach to the planet. ...

Cruikshank, D.P., Grundy, W.M., Stern, S.A., Olkin, C.B., Cook, J.C., Dalle Ore, C.M., Binzel, R.P., Earle, A.M., Ennico, K., Jennings, D.E. and Howett, C.J. "Pluto: Distribution of ices and coloring agents from New Horizons LEISA observations." In: *AAS/Division for Planetary Sciences Meeting Abstracts*, Vol. 47 (2015).

<u>D. P. Cruikshank, *et al.*, 2015</u>

> The shape of the reflectance spectrum of Plutorecorded with telescopes, 0.3-1.0 mum, shows the planet's yellow-red color (1)

Cruikshank, D.P., Imanaka, H., Dalle Ore, C., Sandford, S.A. and Nuevo, M. "Tholins as Coloring Agents on Pluto." In: *AGU Fall Meeting Abstracts*, 2015.

<u>D. P. Hamilton, 2015</u>

> We find that the annual average insolation is always symmetric about Pluto's equator and is fully independent of the relative locations of the planet's pericenter and equinoxes.

Hamilton, D. P. "The Cold and Icy Heart of Pluto." In: *AGU Fall Meeting Abstracts*, 2015.

<u>R. A. Jacobson, *et al.*, 2015</u>

> For the New Horizons encounter with the Pluto system, the initial satellite ephemerides (PLU043) and the initial planet and satellite masses were taken from the Brozović et al. analysis. During the New Horizons approach, the ephemerides and masses were periodically updated along with the spacecraft trajectory by the

New Horizons navigation team using imaging of the planet and satellites against the stellar background.

Jacobson, R.A., Brozovic, M., Buie, M., Porter, S., Showalter, M., Spencer, J., Stern, S.A., Weaver, H., Young, L., Ennico, K. and Olkin, C. “The Orbits and Masses of Pluto's Satellites after New Horizons.” In: *AAS/Division for Planetary Sciences Meeting Abstracts 2015*, Vol. 47.

Y. Sekine, *et al.*, 2015

Based on the satellite-to-planet mass ratio, the Pluto-Charon system is suggested to be of a giant impact origin

Sekine, Y., Genda, H. and Funatsu, T. “Can the Charon-forming giant impact generate elongated dark areas on Pluto?” In: *AGU Fall Meeting Abstracts 2015*.

M. R. Showalter, *et al*., 2015

Pluto and Charon comprise a ‘binary planet’—two bodies, similar in size, orbiting their common barycentre.

Showalter, M. R., and D. P. Hamilton. "Resonant interactions and chaotic rotation of Pluto/'s small moons." *Nature* 522.7554 (2015): 45-49.

S. A. Stern, S. Porter, and A. Zangari, 2015

Solar ultraviolet heating of Pluto's upper atmosphere drives escape, causing the planet to lose 10 27 to 10 28 N 2 s −1 (eg, Zhu et al., 2014, and references therein).

Stern, S.A., S. Porter, and A. Zangari. “On the roles of escape erosion and the viscous relaxation of craters on Pluto.” *Icarus* 250 (2015), pp.287-293.

K. Ennico, *et al.*, 2016

Pluto Colors: We determined the blue/red color ratio means and standard deviations averaged over 20° longitude bins for the six data sets...The comparison of the polar and the +50° to +70° region shows that this latitudinal banding does encircle the planet.

Ennico, K., A. Parker, C. A. J. Howett, C. B. Olkin, J. R. Spencer, W. M. Grundy, ... & S. A. Stern. “Hemispherical Pluto and Charon Color Composition from New Horizons.” In: *Lunar and Planetary Science Conference 2016*, no. 1903, p. 1775. 2016.

B. C. Huang, *et al.*, 2016

> In July 2015, the New Horizons (NH) spacecraft completed its flyby of Pluto and discovered flowing ice and an extended haze on the planet. Pluto exhibits a planetary geology that comprises flowing ice, exotic surface chemistry, mountain ranges, and vast haze.

Huang, B.C., S. W. Chou, J. M. Hong, and C. C. Yen. Global Transonic Solutions of Planetary Atmospheres in a Hydrodynamic Region---Hydrodynamic Escape Problem Due to Gravity and Heat. *SIAM Journal on Mathematical Analysis* 48, no. 6 (2016): 4268-4310.

W. B. McKinnon, *et al.*, 2016

> New Horizons has revealed the character and evolution of a small, icy binary planet, one born in a giant impact much closer to the Sun over 4 billion years ago.

McKinnon, W.B., Moore, J.M., Spencer, J.R., Grundy, W.M., Gladstone, G.R., Nimmo, F., Schenk, P.M., Howard, A.D., Stern, S.A., Weaver, H.A. and Young, L.A. “The Pluto-Charon system revealed: geophysics, activity, and origins.” In: *Lunar and Planetary Science Conference 2016*, Vol. 47, p. 1995.

F. Nimmo, *et al.*, 2016

> Here f is defined as f = 3m/(M + m), where m and M are the masses of the tide-raising body (Charon) and Pluto, respectively, such that for a synchronous satellite orbiting a massive planet f = 3 (yielding equation (39) of ref. 27) while for a purely rotationally distorted body f = 0.

Nimmo, F., Hamilton, D.P., McKinnon, W.B., Schenk, P.M., Binzel, R.P., Bierson, C.J., Beyer, R.A., Moore, J.M., Stern, S.A., Weaver, H.A. and Olkin, C.B., 2016. Reorientation of Sputnik Planitia implies a subsurface ocean on Pluto. *Nature* 540, no. 7631 (2016): 94-96.

R. P. Binzel, *et al.*, 2017

> Thus a consequence of Pluto's high obliquity is that most of the planet is both tropical and arctic during the course of the 2.8 million year obliquity cycle.

Binzel, R.P., Earle, A.M., Buie, M.W., Young, L.A., Stern, S.A., Olkin, C.B., Ennico, K., Moore, J.M., Grundy, W., Weaver, H.A. and Lisse, C.M. “Climate zones on Pluto and Charon.” *Icarus* 287 (2017): 30-36.

A. M. Earle, *et al.*, 2017

> This offers insight as to why the equatorial band of Pluto displays the planet's greatest albedo contrasts.

Earle, A.M., Binzel, R.P., Young, L.A., Stern, S.A., Ennico, K., Grundy, W., Olkin, C.B. and Weaver, H.A. “Long-term surface temperature modeling of Pluto.” *Icarus* 287 (2017): 37-46.

S. A. Stern, *et al.*, 2017

> …described how Pluto's high obliquity currently causes the planet's poles to receive more solar insolation than does the equator over the course of an orbit.

Stern, S.A., Binzel, R.P., Earle, A.M., Singer, K.N., Young, L.A., Weaver, H.A., Olkin, C.B., Ennico, K., Moore, J.M., McKinnon, W.B. and Spencer, J.R. “Past epochs of significantly higher pressure atmospheres on Pluto.” *Icarus*, 287 (2017): 47-53.

Other KBOs Are Planets

Scott J. Kenyon, and Benjamin C. Bromley, 2008

> PLANET FORMATION CALCULATIONS. Icy Planet Formation in Disks around 1 $M_\odot$ Stars.
>
> We begin with a discussion of planet formation in disks at 30–150 AU around a 1 $M_\odot$ star. For most disks around low mass stars, the timescale for planet formation is shorter than the main sequence lifetime. Thus, the growth of planetesimals into planets and the outcome of the collisional cascade depend more on the physics of solid objects than on stellar physics. Here, we review the stages in planet growth and describe the outcome of the collisional cascade. For a suite of calculations of planet formation in disks of different masses, we derive basic relations for the growth time and the maximum planet mass as a function of initial disk mass. We also show how the dust production rate and the mass in small objects depend on initial disk mass and time.

Kenyon, Scott J., and Benjamin C. Bromley. "Variations on Debris Disks: Icy Planet Formation at 30-150 AU for 1-3 M⊙ Main-Sequence Stars." *The Astrophysical Journal Supplement Series* 179.2 (2008): 451.

Hilke E. Schlichting, 2011

See the title. KBOs were made by "planet formation."

Schlichting, Hilke E. "Runaway growth during planet formation: Explaining the size distribution of large Kuiper Belt objects." *The Astrophysical Journal* 728.1 (2011): 68.

Earth Is a Planet

Nobody doubts that Earth is a planet, but these references using the phrase “Earth as a planet” give insight into what it is about Earth that the author considered to be the essence of Earth’s planethood. They paint the picture that to be a planet is to exist as a self-contained, geologically complex systems-of-systems, an island of complexity in the cosmos.

A. E. Basharinov, A. S. Gurvich, and S. T. Ego, 1974

> The title is “The Radio Emission of the Earth as a Planet.” It addresses these topics: microwave emissions, air humidity, cloud water content, glacier compactness, temperature of land masses.

Basharinov, A. E., A. S. Gurvich, and S. T. Egorov. "The radio emission of the earth as a planet." *Moscow Izdatel Nauka* (1974).

James E. Lovelock, James E., and Lynn Margulis, 1974

> We view the Earth as a planet whose surface physical and chemical state is in homeostasis at an optimum set by the contemporary biota and reexamine in this new context some questions on the past and present condition of the Earth.

Lovelock, James E., and Lynn Margulis. "Homeostatic tendencies of the Earth’s atmosphere." In: *Cosmochemical Evolution and the Origins of Life*. Springer Netherlands, 1974. 93-103.

Don L. Anderson, 1984

The title begins with "The Earth as a planet."

Snippets from the text showing the range of topics:

> ...how the interior of the earth works...Convection in the mantle.. Plate tectonics...deep subduction...polar wandering...Midocean ridge basalts... eruption. Hot spots and mantle plumes...Discontinuities in the mantle... bulk chemistry... lateral temperature gradients...phase change...reorient the mantle relative to the spin axis...Continents move ...sea-floor spreading...The whole mantle shifts...migration of the equatorial bulge... the mantle is chemically stratified...melting can only occur in the upper mantle... [etc.]

Anderson, Don L. "The Earth as a planet: paradigms and paradoxes." *Science* 223 (1984): 347-356.

<u>Hansen, James, *et al*., 1997</u>

> Considering the Earth as a planet seen from space, it is apparent that clouds are the dominant factor influencing both solar heating of the planet and thermal emission to space.

Hansen, James, *et al*. "The missing climate forcing." *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 352, no. 1350 (1997): 231-240

<u>S. T. Petsch, 2003</u>

> One of the key defining features of Earth as a planet that houses an active and diverse biology is the presence of free molecular oxygen (O2) in the atmosphere.

Petsch, S. T. "The global oxygen cycle." *Treatise on Geochemistry* 8 (2003): 682.

<u>Timothy E. Dowling and Adam P. Showman, 2007</u>

The title is: "Earth as a planet: atmosphere and oceans."

Dowling, Timothy E., and Adam P. Showman. "Earth as a planet: atmosphere and oceans." *Encyclopedia of the Solar System*, McFadden LA, Weissman PR, Johnson TV, (eds.) 2 (2007): 169-188.

<u>David J. Stevenson, 2008</u>

This gives a long review of all we know about earth's geology, then says,

> The remarkable advances over recent years and decades have been notable for their strongly interdisciplinary character, and some of this advance has come about through thinking of Earth as a planet and relating it to the environment in which it formed.

Stevenson, David J. "A planetary perspective on the deep Earth." *Nature* 451, no. 7176 (2008): 261-265.

<u>Esther Sanromá, and Enric Pallé, 2011</u>

The title includes "Earth as a planet."

> By utilizing satellite-based estimations of the distribution of clouds, we have studied Earth's large-scale cloudiness behavior according to latitude and surface types (ice, water, vegetation and desert). These empirical relationships are used here to reconstruct the possible cloud distribution of historical epochs of Earth's history such as the Late Cretaceous (90 Ma ago), the Late Triassic (230 Ma ago), the Mississippian (340 Ma ago), and the Late Cambrian (500 Ma ago), when the

landmass distributions were different from today's. With this information, we have been able to simulate the globally-integrated photometric variability of the planet at these epochs. We find that our simple model reproduces well the observed cloud distribution and albedo variability of the modern Earth. Moreover, the model suggests that the photometric variability of the Earth was probably much larger in past epochs.

Sanromá, Esther, and Enric Pallé. "Reconstructing the photometric light curves of Earth as a planet along its history." *The Astrophysical Journal* 744, no. 2 (2011): 188.

Habibullo I. Abdussamatov, 2012

From early 90s we observe bicentennial decrease in both the TSI and the portion of its energy absorbed by the Earth. The Earth as a planet will henceforward have negative balance in the energy budget which will result in the temperature drop in approximately 2014

Abdussamatov, Habibullo I. "Bicentennial decrease of the total solar irradiance leads to unbalanced thermal budget of the Earth and the Little Ice Age." *Applied Physics Research* 4, no. 1 (2012): 178.

E. Sanromá, E. Pallé, and A. García Munõz, 2013

The title includes "Earth as a planet."

Understanding the spectral and photometric variability of the Earth and the rest of the solar system planets has become of the utmost importance for the future characterization of rocky exoplanets. As this is not only interesting at present times but also along the planetary evolution, we studied the effect that the evolution of microbial mats and plants over land has had on the way our planet looks from afar. As life evolved, continental surfaces changed gradually and non-uniformly from deserts through microbial mats to land plants, modifying the reflective properties of the ground and most probably the distribution of moisture and cloudiness. Here, we used a radiative transfer model of the Earth, together with geological paleo-records of the continental distribution and a reconstructed cloud distribution, to simulate the visible and near-IR radiation reflected by our planet as a function of Earth's rotation. We found that the evolution from deserts to microbial mats and to land plants produces detectable changes in the globally averaged Earth's reflectance. The variability of each surface type is located in different bands and can induce reflectance changes of up to 40% in period of hours. We conclude that using photometric observations of an Earth-like planet at different photometric bands, it would be possible to discriminate between different surface types. While recent literature propose the red edge feature of vegetation near 0.7 μm as a signature for land plants, observations in near-IR bands can be equally or even better suited for this purpose.

Sanromá, E., E. Pallé, and A. García Munõz. "On the effects of the evolution of microbial mats and land plants on the Earth as a planet. Photometric and spectroscopic light curves of paleo-Earths." *The Astrophysical Journal* 766, no. 2 (2013): 133.

"Planet Earth"

Many other papers use "Planet Earth" in the title (rather than "Earth as a Planet"), which similarly emphasizes Earth's character as a planet – its planethood.

Adjectival Applications

There are far too many adjectival uses of *planet* or *planetary* applied to properties of moons to list the individual papers. It is probably found in the majority of manuscripts. Here we list some of the common uses:

Planet accretion
Planet development
Planet formation
Planetary albedo
Planetary astronomers
Planetary atmospheres
Planetary body
Planetary boundary layer
Planetary core
Planetary crust
Planetary environment
Planetary Hadley Cell
Planetary haze
Planetary interiors
Planetary interiors
Planetary mantle
Planetary protection
Planetary radiation budget
Planetary radius
Planetary scientists
Planetary waves
Planetary scale