

# A Geophysical Planet Definition

K.D. Runyon<sup>1</sup>, S.A. Stern<sup>2</sup>, T.R. Lauer<sup>3</sup>, W. Grundy<sup>4</sup>, M.E. Summers<sup>5</sup>, K.N. Singer<sup>2</sup>, Philip Metzger<sup>5</sup>. <sup>1</sup>Johns Hopkins University, Dept. of Earth and Planetary Sciences, Baltimore, MD, USA (kirby.runyon@gmail.com), <sup>2</sup>Southwest Research Institute, Boulder, CO, USA, <sup>3</sup>National Optical Astronomy Observatory, Tucson, AZ, USA, <sup>4</sup>Lowell Observatory, Flagstaff, AZ, USA <sup>5</sup>George Mason University, Dept. of Physics and Astronomy, Fairfax, VA, USA, <sup>5</sup>University of Central Florida, Orlando, FL, USA.

- “Why did you send *New Horizons* to Pluto if it’s not a planet anymore?” is a question we receive from the public, and it reflects an unfortunate perception. It is illuminating that the word “planet” carries a significant connotation.
- **A planet is a sub-stellar mass body that has never undergone nuclear fusion and that has enough gravitation to be round due to hydrostatic equilibrium regardless of its orbital parameters.**
- Emphasizes **intrinsic** as opposed to **extrinsic** properties.
- More appropriate scientific nomenclature for geoscience-aligned planetary scientists. The definition may evolve slightly with new discoveries. Uncertainty & debate (“making judgement calls”) is appropriate in borderline cases for smaller objects.
- Paraphrased for young students: “Round objects in space that are smaller than stars.” See Figure 1.
- More engaging to the public and more easily captures their support for planetary science & exploration.
- No one should memorize 110 planets! Teach the Solar System’s zones and why different planet types formed at their respective Solar distances. See Figure 2.
- As a *geophysical* definition, this does not fall under the domain of the International Astronomical Union [1] and is an alternate and parallel definition that can be used by different scientists. It is “official” without IAU approval, partly via usage (Table 1).
- Nomenclature reflects common professional usage. Referring to Titan, [2] writes, “A **planet**-wide detached haze layer occurs 300-350 km above the surface.” At least 27 other papers specifically refer to Titan as a planet. See Table 1.

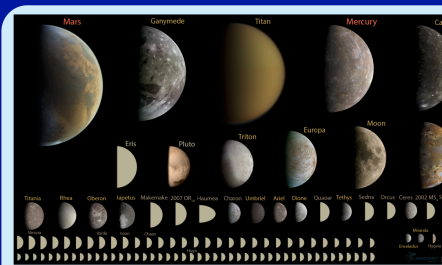


Figure 1. Every known Solar System planet 10,000 km in diameter or smaller. With the geophysical definition, there are at least 110 planets in our Solar System. Image credit: Modified from Emily Lakdawalla, The Planetary Society. <http://www.planetary.org/multimedia/space-images/charts/every-round-object-under-10k-2015.html>

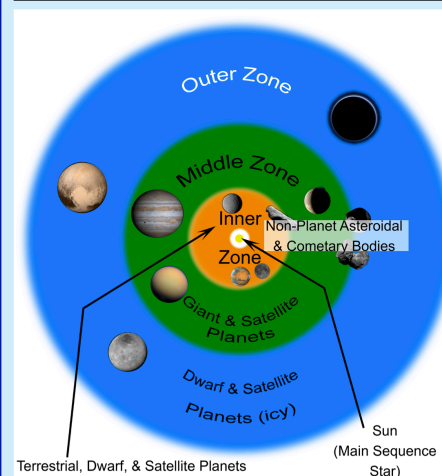


Figure 2. Teach zones, not planet names. Rocky and metallic inner planets (Mercury, Venus, Earth, Moon, Mars, Ceres) formed in the Inner Zone where heavier elements concentrated closer to the Sun during Solar System formation. Gaseous and mainly icy planets (Jupiter, Saturn, Uranus, Neptune, and their satellite planets) formed in the Middle Zone. Icy planets, most of which are probably dwarf planets (which are “full-fledged” planets) formed in the outer zone where lighter elements remained during Solar System formation.

Table 1. Peer-reviewed papers referring to Titan & Europa as planets, both pre- & post-IAU planet decision.

<p>1. M. G. J. Casanova, et al. "Hydrocarbon lakes on Titan." <i>Science</i> 316 (2005): 385-386.</p> <p>2. B. J. Brice, et al. "The Titan atmosphere: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1021-1024.</p> <p>3. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1025-1028.</p> <p>4. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1029-1032.</p> <p>5. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1033-1036.</p> <p>6. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1037-1040.</p> <p>7. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1041-1044.</p> <p>8. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1045-1048.</p> <p>9. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1049-1052.</p> <p>10. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1053-1056.</p> <p>11. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1057-1060.</p> <p>12. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1061-1064.</p> <p>13. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1065-1068.</p> <p>14. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1069-1072.</p> <p>15. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1073-1076.</p> <p>16. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1077-1080.</p> <p>17. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1081-1084.</p> <p>18. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1085-1088.</p> <p>19. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1089-1092.</p> <p>20. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1093-1096.</p>	<p>21. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1097-1100.</p> <p>22. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1101-1104.</p> <p>23. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1105-1108.</p> <p>24. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1109-1112.</p> <p>25. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1113-1116.</p> <p>26. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1117-1120.</p> <p>27. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1121-1124.</p> <p>28. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1125-1128.</p> <p>29. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1129-1132.</p> <p>30. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1133-1136.</p> <p>31. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1137-1140.</p> <p>32. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1141-1144.</p> <p>33. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1145-1148.</p> <p>34. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1149-1152.</p> <p>35. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1153-1156.</p> <p>36. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1157-1160.</p> <p>37. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1161-1164.</p> <p>38. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1165-1168.</p> <p>39. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1169-1172.</p> <p>40. S. K. Atreya, et al. "The atmosphere of Titan: A review." <i>Journal of Geophysical Research</i> 114 (2009): 1173-1176.</p>
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- The geophysical definition is already in use, taught, and included in planetological glossaries [e.g., 3].
- Nomenclature is important as it affects how we compare, think, and communicate about objects in nature.
- Examples of classroom usage: “In the 2020s, NASA will send a spacecraft to study the planet Europa, which orbits the planet Jupiter as one of its many moons.” “Earth and Io are the only solar system planets where ongoing silicate volcanism has been directly imaged.” “The aeolian planets of Venus, Earth, Mars, and Titan have surfaces shaped by wind.”

References: [1] International Astronomical Union (2006) <https://www.iau.org/public/themes/pluto/>. [2] C.P. McKay et al., 2001, *Plan. Space Sci.*, 49, [http://dx.doi.org/10.1016/S0032-0633\(00\)00051-9](http://dx.doi.org/10.1016/S0032-0633(00)00051-9). [3] University of Hawaii Planetary Science Research Discoveries (2017) <http://www.psr.d.hawaii.edu/PSRDglossary.html#planet>.