

Paul O. Hayne

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Summary I am an assistant professor of astrophysical and planetary sciences at the University of Colorado, Boulder. My research focuses on the surfaces and atmospheres of icy planets and moons. I develop computational models and use the latest observational data to better understand these planetary bodies. Teaching, mentoring, and public engagement are also fundamental to my work.

Positions Held **University of Colorado, Boulder**
Assistant Professor, January 2018 – present
Astrophysical & Planetary Sciences Department, and
Laboratory for Atmospheric & Space Physics

NASA – Jet Propulsion Laboratory, California Institute of Technology
Research Scientist, 2012 – 2017

California Institute of Technology
Postdoctoral Scholar, 2011 – 2012
Division of Geological & Planetary Sciences (with Oded Aharonson)

Education **University of California, Los Angeles**
Ph.D., Geophysics & Space Physics, 2010 (Advisor: David A. Paige)

Stanford University
M.S., Geophysics, 2005 (Advisors: Norman H. Sleep & Jack J. Lissauer)
B.S., Geophysics, 2003

Mission Involvement **NASA Europa Clipper**
Co-Investigator (2017–present) and *Investigation Scientist* (2015–2018)
Europa Thermal Emission Imaging System (E-THEMIS)

NASA Mars Reconnaissance Orbiter
Co-Investigator (2017–present) and *Affiliate* (2007–2016)
Mars Climate Sounder

NASA Lunar Flashlight
Co-Investigator (2012–present)

NASA Lunar Reconnaissance Orbiter
Co-Investigator (2011–present)
Diviner Lunar Radiometer Experiment

Science Team Affiliate: NASA Dawn at Ceres (2016–present) and
NASA/ESA Cassini-Huygens Mission to Saturn (2006–2014)

Visiting
Appointments

Lawrence Livermore National Laboratory
Visiting Scientist (2017)
Planetary Defense Program / Weapons and Complex Integration (WCI)

Weizmann Institute of Science, Israel
Visiting Scientist (2015, 2016)
The Helen Kimmel Center for Planetary Science

Leadership
& Service

Keck Institute for Space Studies, California Institute of Technology
Study Co-Lead
2017–2018: [Unlocking the Climate Record Stored within Mars' Polar Layered Deposits](#)
2013–2014: [New Approaches to Lunar Ice Detection and Mapping](#)

American Astronomical Society, Division for Planetary Sciences
Member of the Federal Relations Subcommittee (2017–present)
Local Organizing Committee, Annual Meeting (2016)
Panelist, Annual Meeting (2015)

American Geophysical Union
Session Organizer (Mars Atmosphere), Annual Meeting (2014–2017)

Young Scientists for Planetary Exploration
Co-founder (2012) and *Co-leader* (2012–present)
World-wide advocacy organization for early-career planetary scientists

Ad Astra Academy
Co-founder and Co-leader, Ad Astra - Brazil (2015–2016)
Science and exploration program for school-aged students in developing countries

NASA Science Mission Directorate
Review Panel Member (2012–present)

National Research Council – Space Studies Board
Raconteur, Planetary Science Decadal Survey (2009–2010)

Earth & Space Sciences Student Organization, UCLA
President (2007–2008)

Stanford Astronomical Society
President (2002–2004)

Referee for major scientific journals:
Journal of Geophysical Research
Geophysical Research Letters
Icarus
Astrophysical Journal
Planetary & Space Science
Advances in Space Research
Space Science Reviews
Geology
Science Advances

Honors & Awards

2013	<i>NASA Group Achievement Award</i> , Diviner Lunar Radiometer science team
2011	<i>NASA Group Achievement Award</i> , Mars Climate Sounder science team
2010	<i>Best Student Paper Award</i> , NASA Lunar Science Forum
2010	<i>NASA Group Achievement Award</i> , Diviner Lunar Radiometer operations team
2010	<i>NASA Group Achievement Award</i> , Diviner Lunar Radiometer science team
2008	<i>Simon Latimer Award for Service</i> , UCLA
2006	<i>Graduate Fellowship</i> , Institute of Geophysics and Planetary Physics
2006	<i>Chancellor's Prize</i> , UCLA
2003	<i>Graduate Fellowship</i> , Dept. of Geophysics, Stanford University
2001	<i>Summer Research Fellowship</i> , Dept. of Physics, Stanford University

Teaching **University of Colorado, Boulder**
ASTR 3720: Planets and their Atmospheres (Spring, 2018)
 Professor for upper-division undergraduate course (84 students)

California Institute of Technology
Ge 151: Planetary Surfaces (2011)
 Guest Lecturer for graduate course (~6 students)

University of California, Los Angeles
ESS 10: Exploring Mars (2008)
 Teaching Assistant and Guest Lecturer for undergraduate course (60 students)

Stanford University
Geophysics 150: Physics of the Earth (2004, 2005)
 Teaching Assistant for graduate course (~6 students)
Physics 50: Observational Astronomy (2002, 2003)
 Teaching Assistant for undergraduate course (~20 students)

Mentoring **Laboratory for Atmospheric and Space Physics**
Mentor
 2018–present: Carlos Eytan Gary Bicas (U. Colorado)

Caltech Summer Undergraduate Research Fellows (SURF)
Mentor
 2017: James Haber (Cornell University)
 2015: Léa Bonnefoy (Cornell University)
 2014: Clifford Watkins (Carleton College)
 2011: Michael Lauria (Caltech)

Maximizing Student Potential (MSP)
Mentor
 2015–2018: Jose Martínez Camacho (Citrus College → Cal-Poly University)

Caltech Postdoctoral Fellows at JPL
Mentor
 2017–2018: Dr. Quentin Vinckier (*co-mentor* with Dr. R. Glenn Sellar)
 2016–2018: Dr. Catherine M. Elder

External Grants	<p>2018–2021 <i>Boulders on Bennu: Modeling Thermal Emission from Boulders for Yarkovsky Effect and Thermal Inertia Investigations</i> PI: P. Hayne (Science PI: C. Elder) NASA OSIRIS-REx Participating Scientist Program / \$346,000</p> <p>2013–2019 <i>Lunar Flashlight Science Investigation</i> PI: B. Cohen (Co-I: P. Hayne) NASA Advanced Exploration Systems / ~\$400,000 for P. Hayne</p> <p>2017–2018 <i>Unlocking the Climate Record Stored within Mars' Polar Layered Deposits</i> PI: P. Hayne W. M. Keck Institute for Space Studies / \$50,000</p> <p>2016–2018 <i>Lunar Reconnaissance Orbiter Extended Mission 3</i> PI: D. Paige (Co-I: P. Hayne) NASA Discovery Program / ~\$600,000 allocation for P. Hayne</p> <p>2016–2018 <i>Mars Reconnaissance Orbiter Extended Mission 4</i> PI: J. T. Schofield (Co-I: P. Hayne) NASA Mars Program / ~\$300,000 allocation for P. Hayne</p> <p>2015–2018 <i>Inter-seasonal and Inter-annual Surface Dust Fluxes on Mars</i> PI: P. Hayne (Science PI: S. Piqueux) NASA Mars Data Analysis Program / \$330,690</p> <p>2015–2018 <i>Europa Thermal Emission Imaging System</i> PI: P. Christensen (Co-I: P. Hayne) NASA Europa Clipper Mission / ~\$30,000 allocation for P. Hayne</p> <p>2013–2017 <i>Volatile Regolith Thermal Investigation Consortium for Exploration and Science (VORTICES)</i> PI: A. Rivkin (Co-I: P. Hayne) NASA Solar System Exploration Research Virtual Institute / ~\$120,000</p> <p>2014–2016 <i>Thermal Infrared Observations of the Moon during Lunar Eclipse</i> PI: P. Lucey (Co-I: P. Hayne) NASA Planetary Astronomy / \$142,810 allocation for P. Hayne</p> <p>2013–2014 <i>Development of Large Format Rad-Hard Focal Plane Arrays and Readouts for Thermal Radiometer for Europa Clipper Mission</i> PI: M. Kenyon (Co-I: P. Hayne) Instrument Concepts for Europa Exploration / \$16,460 allocation for P. Hayne</p> <p>2013–2014 <i>New Approaches to Lunar Ice Detection and Mapping</i> PI: P. Hayne W. M. Keck Institute for Space Studies / \$50,000</p>
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Invited Lectures	2018	Applied Physics Laboratory, Johns Hopkins University
	2017	Lawrence Livermore National Laboratory
	2017	University of Colorado, Boulder
	2016	Lunar & Planetary Institute
	2016	Weizmann Institute of Science (Israel)
	2015	International Space Exploration Coordination Group,
	2015	NASA Exploration Science Forum
	2015	University of California - Santa Cruz
	2014	SETI Institute
	2013	Lunar & Planetary Institute
	2012	California Institute of Technology
	2012	NASA – Jet Propulsion Laboratory
	Professional Affiliations	American Astronomical Society - Division for Planetary Sciences
American Geophysical Union		
European Geosciences Union		
Asia Oceania Geosciences Society		
Geochemical Society		
Sigma Xi		
Skills & Training	Remote sensing & spacecraft instrumentation	
	Spectroscopy (ultraviolet through submillimeter)	
	Thermal imaging and radiometry	
	Modeling and Numerical Simulation	
	Heat transfer (thermal modeling)	
	Radiative transfer for planetary atmospheres and surfaces	
	Geophysical inversion	
	Transient and stochastic phenomena	
	Computer programming languages	
	Proficient/expert: C/C++, Python, MATLAB, IDL, bash, c-shell	
	Familiar: Fortran 95/99, awk, javascript, etc.	
	Mission formulation experience	
	<i>Team-X</i> , NASA Jet Propulsion Laboratory	
	<i>Team-A</i> , NASA Jet Propulsion Laboratory	
	<i>Capture Lead Training</i> , NASA Jet Propulsion Laboratory	
	Co-I on proposals to NASA's <i>Discovery</i> and <i>New Frontiers</i> programs	
	PI on instrument proposals to NASA mission programs	
Additional training		
<i>Astrobiology Winter School and Field Course</i> (2011)		
NASA Astrobiology Institute and Hawaii Institute for Astronomy		
<i>International Astrobiology Summer School</i> (2008)		
NASA Astrobiology Institute and Universidad Internacional Menéndez Pelayo, Spain		
<i>PADI Open Water Diver</i> scuba certification (50+ dives)		
<i>Eagle Scout</i> (1998), BSA Troop 676, Issaquah, WA		

Publications: Refereed Journal Articles

Number of peer-reviewed papers: 31 (as of January, 2018)
h-index: 14 (Web of Science), 17 (Google Scholar)
Total citations: 594 (Web of Science), 987 (Google Scholar)

2018

1. Heavens, N. G., Kleinböhl, A., Chaffin, M. S., Halekas, J. S., Kass, D. M., **Hayne, P. O.**, McCleese, D. J., Piqueux, S., Shirley, J. H., & Schofield, J. T. (2018), Hydrogen escape from Mars enhanced by deep convection in dust storms, *Nature Astronomy*, *2*, 126–132. doi: [10.1038/s41550-017-0353-4](https://doi.org/10.1038/s41550-017-0353-4).

2017

2. **Hayne, P. O.**, Bandfield, J. L., Siegler, M. A., Vasavada, A. R., Ghent, R. R., et al. (2017), Global regolith thermophysical properties of the Moon from the Diviner Lunar Radiometer Experiment, *J. Geophys. Res.*, *122*, 2371–2400. doi: [10.1002/2017JE005387](https://doi.org/10.1002/2017JE005387)
3. Elder, C. M., **Hayne, P. O.**, Bandfield, J. L., Ghent, R. R., Williams, J.-P., Donaldson Hanna, K. L., & Paige, D. A. (2017), Young lunar volcanic Features: Thermophysical properties and formation, *Icarus*, *290*, 224–237. doi: [10.1016/j.icarus.2017.03.004](https://doi.org/10.1016/j.icarus.2017.03.004)
4. Mitri, G., Postberg, F., Soderblom, J. M., ..., **Hayne, P. O.**, et al. (2017), Explorer of Enceladus and Titan (E²T): Investigating ocean worlds' evolution and habitability in the solar system, *Planetary and Space Science*, doi: [10.1016/j.pss.2017.11.001](https://doi.org/10.1016/j.pss.2017.11.001)
5. Landis, M. E., Byrne, S., Schörghofer, N., Schmidt, B. E., **Hayne, P. O.**, Castillo-Rogez, J., ... Russell, C. T. (2017), Conditions for sublimating water ice to supply Ceres' exosphere, *J. Geophys. Res.*, *122*, 1984–1995. doi: [10.1002/2017JE005335](https://doi.org/10.1002/2017JE005335)
6. Davies, A. G., Gunapala, S., Soibel, A., Ting, D., Rafol, S., Blackwell, M., **Hayne, P. O.**, & Kelly, M. (2017), A novel technology for measuring the eruption temperature of silicate lavas with remote sensing: Application to Io and other planets, *J. Volcanology & Geothermal Res.*, *343*, 1–16. doi: [10.1016/j.jvolgeores.2017.04.016](https://doi.org/10.1016/j.jvolgeores.2017.04.016)
7. Fisher, E. A., Lucey, P. G., Lemelin, M., Greenhagen, B. T., Siegler, M. A., Mazarico, E., Aharonson, O., Williams, J.-P., **Hayne, P. O.**, Neumann, G. A., Paige, D. A., Smith, D. E., & Zuber, M. T. (2017), Evidence for surface water ice in the lunar polar regions using reflectance measurements from the Lunar Orbiter Laser Altimeter and temperature measurements from the Diviner Lunar Radiometer Experiment, *Icarus*, *292*, 74–85. doi: [10.1016/j.icarus.2017.03.023](https://doi.org/10.1016/j.icarus.2017.03.023)

2016

8. Piqueux, S., Kleinböhl, A., **Hayne, P. O.**, Heavens, N. G., Kass, D. M., McCleese, D. J., ... & Shirley, J. H. (2016), Discovery of a widespread low-latitude diurnal CO₂ frost cycle on Mars, *J. Geophys. Res.*, *121*, 1174–118. doi: [10.1002/2016JE005034](https://doi.org/10.1002/2016JE005034)
9. Greenhagen, B. T., Neish, C. D., Williams, J. P., Cahill, J. T., Ghent, R. R., **Hayne, P. O.**, ... & Bandfield, J. L. (2016), Origin of the anomalously rocky appearance of Tsiolkovskiy crater, *Icarus*, *273*, 237–247. doi: [10.1016/j.icarus.2016.02.041](https://doi.org/10.1016/j.icarus.2016.02.041)
10. Bennett, K. A., Horgan, B. H., Gaddis, L. R., Greenhagen, B. T., Allen, C. C., **Hayne, P. O.**, ... & Paige, D. A. (2016), Complex explosive volcanic activity on the Moon within Oppenheimer crater, *Icarus*, *273*, 296–314. doi: [10.1016/j.icarus.2016.02.007](https://doi.org/10.1016/j.icarus.2016.02.007)
11. Bonnefoy, L. E., A. G. Hayes, **P. O. Hayne**, et al. (2015), Compositional and spatial variations in Titan dune and interdune regions from Cassini VIMS and RADAR, *Icarus*, *270*, 222–237, doi:[10.1016/j.icarus.2015.09.014](https://doi.org/10.1016/j.icarus.2015.09.014)

2015

12. **Hayne, P. O.**, and Oded Aharonson (2015), Thermal stability of ice on Ceres with rough topography, *J. Geophys. Res.*, *120*, 1567–1584, doi: [10.1002/2015JE004887](https://doi.org/10.1002/2015JE004887)
13. Heavens, N. G., Cantor, B. A., **Hayne, P. O.**, et al. (2015), Extreme detached dust layers near Martian volcanoes: Evidence for dust transport by mesoscale circulations forced by high topography, *Geophys. Res. Lett.*, *42*, 10, 3730–3738. doi: [10.1002/2015GL064004](https://doi.org/10.1002/2015GL064004)
14. **Hayne, P. O.**, A. R. Hendrix, E. Sefton-Nash, P. G. Lucey, K. D. Retherford, J-P. Williams, et al. (2015), Evidence for exposed water ice in the Moon’s south polar regions from Lunar Reconnaissance Orbiter ultraviolet albedo and temperature measurements, *Icarus*, *255*, 58–69, doi:[10.1016/j.icarus.2015.03.032](https://doi.org/10.1016/j.icarus.2015.03.032)
15. Glotch, T. D., Bandfield, J. L., Lucey, P. G., **Hayne, P. O.**, et al. (2015), Formation of lunar swirls by magnetic field standoff of the solar wind, *Nature Communications*, *6*. doi: [10.1038/ncomms7189](https://doi.org/10.1038/ncomms7189)
16. Piqueux, S., Kleinböhl, A., **Hayne, P. O.**, Kass, D. M., Schofield, J. T., & McCleese, D. J. (2015), Variability of the Martian seasonal CO₂ cap extent over eight Mars Years, *Icarus*, doi:[10.1016/j.icarus.2014.10.045](https://doi.org/10.1016/j.icarus.2014.10.045)
17. Bandfield, J. L., **Hayne, P. O.**, Williams, J. P., Greenhagen, B. T., & Paige, D. A. (2015), Lunar surface roughness derived from LRO Diviner Radiometer observations, *Icarus*, *248*, 357–372. doi: [10.1016/j.icarus.2014.11.009](https://doi.org/10.1016/j.icarus.2014.11.009)

2014

18. **Hayne, P. O.**, McCord, T. B., & Sotin, C. (2014), Titan’s surface composition and atmospheric transmission with solar occultation measurements by Cassini VIMS, *Icarus*, *243*, 158–172. doi: [10.1016/j.icarus.2014.08.045](https://doi.org/10.1016/j.icarus.2014.08.045)
19. **Hayne, P. O.**, D. A. Paige, N. G. Heavens (2014), The role of snowfall in forming the seasonal ice caps of Mars: Models and constraints from the Mars Climate Sounder, *Icarus* *231*, 122–130. doi: [10.1016/j.icarus.2013.10.020](https://doi.org/10.1016/j.icarus.2013.10.020)
20. Ghent, R. R., **Hayne, P. O.**, Bandfield, J. L., Campbell, B. A., Allen, C. C., Carter, L. M., & Paige, D. A. (2014), Constraints on the recent rate of lunar ejecta breakdown and implications for crater ages, *Geology*, *42*(12), 1059–1062. doi: [10.1130/G35926.1](https://doi.org/10.1130/G35926.1)
21. Bandfield, J. L., E. Song, **P. O. Hayne**, B. D. Brand, R. R. Ghent, A. R. Vasavada, D. A. Paige (2014), Lunar cold spots: Granular flow features and extensive insulating materials surrounding young craters, *Icarus* *231*, 221–231. doi: [10.1016/j.icarus.2013.12.017](https://doi.org/10.1016/j.icarus.2013.12.017)
22. Ingersoll, R. V., Pratt, M. J., Davis, P. M., Caracciolo, L., Day, P. P., **Hayne, P. O.**, ... & Hendrix, E. D. (2014), Paleotectonics of a complex Miocene half graben formed above a detachment fault: The Diligencia basin, Orocopia Mountains, southern California, *Lithosphere*, *6*(3), 157–176. doi: [10.1130/L334.1](https://doi.org/10.1130/L334.1)

2013

23. Barnes, J. W., B. J. Buratti, E. P. Turtle, J. Bow, P. A. Dalba, J. Perry, R. H. Brown, S. Rodriguez, S. Le Mouelic, K. H. Baines, C. Sotin, R. D. Lorenz, M. J. Malaska, T. B. McCord, R. N. Clark, R. Jaumann, **P. O. Hayne**, et al. (2013), Precipitation-Induced Surface Brightenings Seen on Titan by Cassini VIMS and ISS, *Planetary Science*, *2*, p. 1. doi: [10.1186/2191-2521-2-1](https://doi.org/10.1186/2191-2521-2-1)

2012

24. **Hayne, P. O.**, D. A. Paige, J. T. Schofield, D. M. Kass, A. Kleinböhl, N. G. Heavens, and D. J. McCleese (2012), Carbon dioxide snow clouds on Mars: South polar winter observations by the Mars Climate Sounder, *J. Geophys. Res.*, *117*, E08014, doi: [10.1029/2011JE004040](https://doi.org/10.1029/2011JE004040)
25. Vasavada, A. R., J. L. Bandfield, B. T. Greenhagen, **P. O. Hayne**, et al. (2012), Lunar Equatorial Surface Temperatures and Regolith Properties from the Diviner Lunar Radiometer Experiment, *J. Geophys. Res.* *117*, E00H18. doi: [10.1029/2011JE003987](https://doi.org/10.1029/2011JE003987)

2010

26. **Hayne, P. O.**, B. T. Greenhagen, M. C. Foote, M. A. Siegler, A. R. Vasavada, and D. A. Paige (2010), Diviner Lunar Radiometer Observations of the LCROSS Impact, *Science*, *330*, 477. doi: [10.1126/science.1197135](https://doi.org/10.1126/science.1197135)
27. Paige, D. A., M. A. Siegler, J. A. Zhang, **P. O. Hayne**, et al. (2010), Diviner Observations of Cold Traps in the Lunar South Polar Region: Spatial Distribution and Temperature, *Science* *330*, 479. doi: [10.1126/science.1187726](https://doi.org/10.1126/science.1187726)
28. Greenhagen, B. T., P. G. Lucey, M. B. Wyatt, T. D. Glotch, C. C. Allen, J. A. Arnold, J. L. Bandfield, N. E. Bowles, K. L. Hanna, **P. O. Hayne**, E. Song, I. R. Thomas, and D. A. Paige (2010), Global Silicate Mineralogy of the Moon from the Diviner Lunar Radiometer, *Science* *329*, 1507. doi: [10.1126/science.1192196](https://doi.org/10.1126/science.1192196)
29. McCord, T. B., Hansen, G. B., Combe, J-P., & **P. O. Hayne** (2010), Hydrated minerals on Europa's surface: An improved look from the Galileo NIMS investigation, *Icarus* *209*, 639–650. doi: [10.1016/j.icarus.2010.05.026](https://doi.org/10.1016/j.icarus.2010.05.026)

2009

30. Barnes, J. W., ..., **P. O. Hayne**, et al. (2009), VIMS Spectral Mapping Observations of Titan during the Cassini Prime Mission, *Planet. and Space Sci.*, *57*, 1950–1962. doi: [10.1016/j.pss.2009.04.013](https://doi.org/10.1016/j.pss.2009.04.013)

2008

31. McCord, T. B., **P. Hayne**, et al. (2008), Titan's surface: Search for spectral diversity and composition using the Cassini VIMS investigation, *Icarus*, *194*, 212–242. doi: [10.1016/j.icarus.2007.08.039](https://doi.org/10.1016/j.icarus.2007.08.039)

Publications: Book Chapters & Reports

1. Aharonson, O., A. Hayes, **P. O. Hayne**, R. Lopes, A. Lucas, J. T. Perron, (2012), Titan's Surface Geology, in: C. G. Mueller-Wodarg, T. Cravens and E. Lellouch (Ed.), *Titan: Surface, Atmosphere and Magnetosphere*, Cambridge University Press, Cambridge, UK.
2. **Hayne, P. O.**, A. P. Ingersoll, D. A. Paige, & 32 co-authors (2014), "New approaches to lunar ice detection and mapping," *Keck Institute for Space Studies Report*. [[PDF](#)]

Publications: Commentaries

1. **Hayne, P. O.** (2013), Abandoned frontier, *Nature Geosci.*, *6(3)*, 155-156. doi: [10.1038/ngeo1753](https://doi.org/10.1038/ngeo1753)