

Vishnu Viswanathan, Ph.D.

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I am a scientist at NASA's Goddard Space Flight Center. I led several NASA R&D projects and founded the Goddard Lunar Data Analysis Center. I am an expert in the high-precision modeling of dynamic physical systems, and I use various tracking data like laser, radio, images, and their derivatives to optimize these models. I bring a wealth of knowledge from working and leading multi-year, multi-disciplinary projects, with experience across five countries in Asia, Europe, and North America. I have a strong presence in the scientific community as a scientific reviewer for top-tier academic journals, a panelist for NASA R&D grant programs and have represented NASA on live interactive panels communicating complex scientific concepts to a broad audience.

EDUCATION

Ph.D., Astronomy & Astrophysics, Paris Observatory/Paris, Science & Letters, France | 2017

M.S., Aeronautical & Space Systems Engineering, ISAE-SUPAERO, France | 2013

B.Tech., Electronics & Communication Engineering, NIT Trichy, India | 2011

EXPERIENCE

Research Scientist, NASA GSFC/UMBC/CRESST, Greenbelt-MD, USA | 2019-present

- Secured ~\$1M in funding from NASA HQ by developing R&D proposals, each by defining and scoping scientific objectives, complex task breakdown, onboarding a team of experts, setting realistic project milestones, overall timeline, and budget.
- Founded the Goddard Lunar Data Analysis Center, an internationally affiliated hub for collaborative, scientific endeavors focused on the analysis of lunar laser ranging (LLR) data, critical for multi-year geospatial research on the Moon.
- Served as scientific advisor for next-generation LLR on a NASA/GSFC IRAD (Internal Research and Development) program.
- Initiated an international collaboration between scientific teams based in France and Germany via the development of a Franco-German scientific grant (ANR-DFG; ~\$0.5M).
- Served as a panelist & reviewer on several NASA/NSF R&D programs.
- Invited by NGA's Office of Geomatics to join the Lunar Geodetic System Working Group and develop a reference system for the Moon through an interagency collaboration strategy laid out by the White House National Science & Technology Policy Council.
- Selected as the keynote speaker for NASA's Public Engagement Team on multiple live events requiring wide public dissemination of complex scientific knowledge.
- Executed research involving modeling of physical systems, data analysis, and model fits, with results published in peer-reviewed journals and selected for feature in NASA press releases and other major media outlets, *e.g.*, NYTimes, CNN and Scientific American.

Postdoctoral Researcher, Paris Observatory, IMCCE/PSL, Paris, France | 2017-2018

- Improved the state-of-the-art dynamical model of the Moon that resulted in the tightest constraints known for the shape and size of the lunar fluid core.
- Published results in a top-tier peer-reviewed journal of geophysics and presented findings at international conferences.

Doctoral Researcher, Géoazur, Nice Observatory, Sophia-Antipolis, France | 2014-2017

- Improved the orbital-rotational dynamical model of the Moon in the European ephemeris software, bringing it to one of three primary references worldwide by developing a high-accuracy LLR data reduction and ephemeris fitting pipeline.

- Identified and resolved mission-critical bugs within the orbit-determination package (GINS) of the French space agency (CNES).
- Fitted over five decades of global lunar laser ranging data along with gravity field constraints from the NASA GRAIL mission and developed a dynamical model predicting the Moon's position with an accuracy of ~1cm in range.
- Published results in top-tier journals of Astronomy and Astrophysics and presented them at international conferences.

RELEVANT EXPERTISE

Project leadership, effective communication, high-emotional intelligence, cultural competence, media relations, rapid prototyping, proposal writing, proposal development, government contracts, negotiations, problem-solving, decision making, scientific research, scientific methods, physical system modeling, geospatial data processing, image processing, radio data processing, laser data processing, time series data processing, statistics, calculus, linear algebra.

LEADERSHIP ROLES

- Founder, ILRS Lunar Data Analysis Center at UMBC/GSFC | 2022-present
- Project Lead, Development of a High-Precision Dynamical Model of the Moon | 2022-2023
- Project Lead, Measuring Saturn's Dissipation using Cassini Astrometric Data | 2021-2024
- Project Lead, Analysis of LLR Data and Modeling of Lunar Interior | 2019-2022
- Project Lead, Retracing the Reorientation and Tidal History of the Moon | 2021-2023

GRANTS AWARDED

- NASA grant, ROSES Cassini Data Analysis Program, USA | 2021-2024
- NASA grant, GSFC ISFM Planetary Geodesy, USA | 2022-2023
- NASA grant, GSFC ISFM Planetary Geodesy, USA | 2021-2023
- NASA grant, GSFC ISFM Planetary Geodesy, USA | 2019-2022
- Postdoctoral grant, Space Exploration of Planetary Environments, France | 2017-2019
- Doctoral grant, Ministry of Higher Education, Research and Innovation, France | 2014-2017

PRESS RELEASES ON RESEARCH OUTPUT

- 2022 "Small Craters Add Up to Wandering Poles on Moon" <https://tinyurl.com/pole-wander>
Selected for a NASA/GSFC press release on the article published in *The Planetary Science Journal*.
- 2020 "Laser Beams Reflected Between Earth and Moon Boost Science" <https://tinyurl.com/y3f43sut>
Selected for a NASA/GSFC press release on the article published in *Earth, Planets and Space*.
- 2019 "New estimate of the size of the Moon's core using laser ranging" <https://tinyurl.com/yxonerss>
Selected for a press release by the National Centre for Scientific Research, France (CNRS) on the article published in *Geophysical Research Letters*.; Work cited by NYTimes
<https://tinyurl.com/moon-laser>
- 2018 "Testing the universality of free fall with lunar laser" (translated; originally in French)
A feature article in the French scientific magazine "La Recherche" about the article published in the *Monthly Notices of the Royal Astronomical Society*. <https://tinyurl.com/moon-free-fall>

OTHER PROPOSAL INVOLVEMENT

- Co-Investigator, Observation of Lunar Node using National Radio Astronomy Observatory's Very Long Baseline Array (VLBA) network ~ 18h | 2022
- Collaborator, Apache Point Lunar Laser Ranging Station, NASA/GSFC, USA | 2021-present
- Collaborator, Next-generation LLR, Internal R&D, NASA/GSFC, USA | 2019-present
- International Collaborator, Lunar Tidal Deformation from Earth-based and Orbital Laser Ranging, Bilateral Agreement: French National Research Agency/German Science Foundation | 2019-2022

MEMBERSHIPS

- Member, International Astronomical Union, Div-A/D/F | 2022-present
- Associate member, International Laser Ranging Service | 2022-present
- Science Team member, Lunar Geophysical Network Mission - NASA NF5 AO | 2021-present
- Affiliate, International Association of Geodesy | 2022-present
- Affiliate, Division for Planetary Sciences of the American Astronomical Society | 2021-present
- Affiliate, American Geophysical Union | 2019-present
- Affiliate, European Geophysical Union | 2017-present

PROFESSIONAL AND COMMUNITY SERVICE

- Scientific Committee, Lunar Laser Ranging Workshop, Grasse, France | 2023
- Session Chair, “Moon”, 53rd Meeting of the AAS Division for Planetary Sciences | 2021
- Reviewer for international scientific journals: *Astronomy & Astrophysics* (2), *Advances in Space Research* (3), *Celestial Mechanics and Dynamical Astronomy* (1), *Earth and Space Science* (2), *Icarus* (1), *Journal of Geodesy* (1), *Journal of Geophysical Research: Planets* (3), *Remote Sensing* (1), *The Astrophysical Journal Letters* (1), *The Planetary Science Journal* (3), *Universe* (2)
- Reviewer for NASA HQ’s ROSES program [3 as Panelist (’21, ’20, ’19) and 1 as External Reviewer (’20); Total of 38 research proposals]; EONS program: [1 as Panel Chair/Panelist (’24) and 1 as External Reviewer (’24); Total of 8 institutional-level proposals ~\$40M]

PUBLIC OUTREACH

- Interviewee, “Total Solar Eclipses Are Cosmic Coincidences That Won’t Last Forever”, *Scientific American* | 03/2024 <https://tinyurl.com/sci-am-eclipse>
- Scientific Advisor, Article on “Tides” hosted on NASA website | 06/2023 <https://science.nasa.gov/moon/tides/>
- Panelist, “NASA’s Exploration of the Moon: Past, Present, and Future”, *Awesome Con DC* | 06/2023
- Keynote Speaker, “How bouncing lasers off the Moon paves the road to lunar science and exploration”, *NASA GSFC Visitor Center* | 04/2023
- Author, Auxillary data to the article “The Contribution of Small Impact Craters to Lunar Polar Wander”, *NASA Planetary Geodesy Data Archive* | 10/2022 <https://pgda.gsfc.nasa.gov/products/86>
- Lead Scientist, “Lunar Polar Wander”, *NASA Scientific Visualization Studio* | 09/2022 <https://svs.gsfc.nasa.gov/5023>
- NASA expert, “Episode 42 – Watch a Total Lunar Eclipse”, *NASA Science Live* | 05/2022 https://images.nasa.gov/details-GSFC_20220515_NSL_Ep42 <https://www.youtube.com/watch?v=vGIaEIIICs>
- Scientific Advisor, Public Engagement Team, *NASA GSFC* | 2021-present
- Volunteer, 50th Anniversary: Apollo Moon Landing, National Mall, DC | 07/2019

PUBLICATIONS

(Refereed)

- **Viswanathan, V.**, Mazarico, E., Gramling, C., “Recommendations on the Data, Models and Parameterization for Planning a Unified Lunar Geodetic System”, *NASA GSFC* (under review).
- Ray, R.D., **Viswanathan, V.**, Chao, B.F., “Is there a six-year ocean tide?”, *Nature Scientific Reports* (under review)
- Briaud, A., and 10 co-authors (incl. **Viswanathan, V.**) 2023, “Constraints on the lunar core viscosity from tidal deformation”, *Icarus*, 115426. doi: 10.1016/j.icarus.2023.115426
- Smith, D.E., **Viswanathan, V.**, Mazarico, E., et al. 2022, “The Contribution of Small Impact Craters to Lunar Polar Wander”, *The Planetary Science Journal*, 3(9), 217. doi:10.3847/PSJ/ac8c39
- Ermakov, A., and 15 co-authors (incl. **Viswanathan, V.**) 2021, “A Recipe for Geophysical Exploration of Enceladus”. *The Planetary Science Journal*, 2(4), 157. doi:10.3847/PSJ/ac06d2

- Mazarico, E., and 19 co-authors (incl. **Viswanathan, V.**) 2020, “First Two-way Laser Ranging to a Lunar Orbiter: infra-red observations from the Grasse station to LRO’s retro-reflector array”. *Earth Planets Space* 72, 113; doi:10.1186/s40623-020-01243-w
- **Viswanathan, V.**, Rambaux, N., Fienga, A., Laskar, J., Gastineau, M. 2019, “Observational Constraint on the Radius and Oblateness of the Lunar Core-Mantle Boundary”. *Geophysical Research Letters* 46, 7295–7303; doi:10.1029/2019GL082677
- **Viswanathan, V.**, Fienga, A., Minazzoli, O., Bernus, L., Manche, H., Laskar, J., Gastineau, M. 2018, “The new lunar ephemerides INPOP17a and its application to fundamental physics”. *Monthly Notices of the Royal Astronomical Society* 476, 1877–1888; doi:10.1093/mnras/sty096
- Courde, C., and 10 co-authors (incl. **Viswanathan, V.**) 2017, “Lunar laser ranging in infrared at the Grasse laser station”. *Astron. Astrophys.* 602, A90; doi:10.1051/0004-6361/201628590

(Books/Technical Notes)

- Fienga, A., Deram, P., Ruscio A. Di., **Viswanathan, V.**, Camargo, J. I. B., Bernus, L., Gastineau, M., Laskar, J. 2021, “INPOP21a planetary ephemerides”. *Notes Scientifiques et Techniques de l’Institut de Mécanique Céleste*, ISBN 978-2-910015-84-8, 110, 19 pp.
- Fienga, A., Deram, P., **Viswanathan, V.**, Ruscio A. Di., Bernus, L., Durante, D., Gastineau, M., Laskar, J. 2019, “INPOP19a planetary ephemerides”. *Notes Scientifiques et Techniques de l’Institut de Mécanique Céleste*, ISBN 978-2-910015-81-7, 109, 35 pp.
- **Viswanathan, V.**, Fienga, A., Manche, H., Laskar, J., Gastineau, M. 2017, “INPOP17a planetary ephemerides”. *Notes Scientifiques et Techniques de l’Institut de Mécanique Céleste*, ISSN 1621-3823, ISBN 2-910015-79-3, 108, 39 pp.

(Community white papers)

- Cremons, D. et al. (incl. **Viswanathan, V.**) 2022, “The Contribution of Active Spectroscopy to Orbital Remote Sensing of Lunar Volatiles”, *LEAG Continuous Lunar Orbital Capabilities Specific Action Team (CLOC-SAT)*
- **Viswanathan, V.**, Mazarico, E., Merkowitz, S., Williams, J. G., Turyshev, S. G., Currie, D. G., et al. (2021). “Extending Science from Lunar Laser Ranging”. *Bulletin of the AAS*, 53(4); doi:10.3847/25c2cfcb.3dc2e5e4
- Porcelli, L., and 40 co-authors (incl. **Viswanathan, V.**) 2021, “Next Generation Lunar Laser Retroreflectors for Fundamental Physics and Lunar Science”, *White paper submitted to Decadal Survey on Biological and Physical Sciences Research in Space 2023-2032*, NTRS ID: 20210025424
- Ermakov, A.I., Castillo-Rogez, J.C., Park, R.S., Sotin, C., Lazio, J., Howell S.M., Keane, J.T., Hemingway., Nimmo, F., Kite, E., **Viswanathan, V.** et al. (2021) “A recipe for geophysical exploration of Enceladus”. *Bulletin of the AAS*, 53(4); doi:10.3847/25c2cfcb.b65f2c4c
- **Viswanathan, V.**, Mazarico, E., Merkowitz, S., Sun, X., Eubanks, T. M., & Smith, D. E. (2020). “Next-Generation Geodesy at the Lunar South Pole: An Opportunity Enabled by the Artemis III Crew”. *Artemis III Science Definition Team Whitepaper #2077*.

(Proceedings)

- Mao, D., Barker, M. K., Mazarico, E., Bertone, S., Cascioli, G., Sun, X., Neumann, G. A., **Viswanathan, V.**, Cremons, D., Tomio, H., Smith, D. E., Zuber, M. T. (2023). Two-way laser ranging from LRO-LOLA to Apollo laser retro-reflector arrays on the lunar surface, In AGU Fall Meeting # P11D-2762
- Colmenares, N. R., Battat, J. B. R., Gonzales, D. P., Hoffman, E. D., Lemoine, F. G., McMillan, R., Merkowitz, S. M., Murphy Jr., T. W., Sabhlok, S. S., **Viswanathan, V.** (2023). Data Reduction and Calibration of the Apache Point Observatory Lunar Laser-ranging Operation. In *1st Lunar Laser Ranging Meeting 2023*

- Blase, W. P., Eubanks, T. M., Bills, B., Petrov, L., **Viswanathan, V.**, King, S. (2023). The Lunar Ground Segment: Lunar Geodesy with LLR and VLBI Beacons. In *Annual Meeting of the Lunar Exploration Analysis Group #2917*
- Mazarico, E., Barker, M. K., **Viswanathan, V.**, Goossens, S. (2023). Constraining the Lunar Paleopole from Past PSR Existence at Multiple Artemis Regions. In *Artemis III Candidate Landing Regions Workshop (LPI Contributions Vol. 2989, p. 2008)*
- **Viswanathan, V.**, Mazarico, E., Barker, M. K. (2023). Cold, Earth-Visible Spots for Lunar Retroreflectors at Artemis Sites. In *Artemis III Candidate Landing Regions Workshop #2031*
- **Viswanathan, V.**, Mazarico, E., Goossens, S., Smith, D. E. (2023). Limits on Lunar Reorientation From Small(er) Craters, In NASA Exploration Science Forum.
<https://ntrs.nasa.gov/citations/20230010191>
- **Viswanathan, V.**, Mazarico, E., Smith, D. E., Goossens, S., Head, J. W., Neumann, G. A., & Zuber, M. (2022). Reorientation of the Moon from its Bombardment History. In *Division for Planetary Sciences, Bulletin of the AAS*, 54(8). <https://baas.aas.org/pub/2022n8i310p01>
- Baguet, D. et al. (incl. **Viswanathan, V.**) 2022, “Introduction of tidal models in lunar ephemerides”, *Europlanet Science Congress 2022, Granada, Spain*, doi:10.5194/epsc2022-978
- **Viswanathan, V.**, Smith, D. E., Mazarico, E., Goossens, S., Head, J. W., Neumann, G. A., Zuber, M. T. (2022). Small Impact Craters Steered the Early Moon’s Pole Along the Earth-Moon Direction. In *European Lunar Symposium*
- **Viswanathan, V.**, Liounis, A. J., Mazarico, E., Goossens, S., Neveu, M. (2022). Astrometric Reduction of Phoebe using a Digital Shape Model. In *Lunar and Planetary Science Conference* (p. 2224)
- Smith, D. E., **Viswanathan, V.**, Mazarico, E., Goossens, S., Head, J. W., Neumann, G. A., Zuber, M. T. (2022). A Geodetic Approach to Estimate the Contribution of Impact Craters and Basins to the Moon’s Low-Degree Gravity Field. In *Lunar and Planetary Science Conference* (p. 1283)
- **Viswanathan, V.**, Mazarico, E., Barker, M. K., Cremons, D. R., & Smith, D. E. (2021). The Case for a Retroreflector in a Lunar South Polar Shadowed Region. In *Lunar Surface Science Workshop: Landing Sites and Capabilities for Future CLPS deliveries* (#8026)
- **Viswanathan, V.**, Mazarico, E., & Goossens, S. (2021). A Simulation Study for Extending Lunar Laser Ranging Science. In *Lunar and Planetary Science Conference* (p. 2651).
- **Viswanathan, V.**, Mazarico, E., Goossens, S., Rambaux, N., & Smith, D. E. (2020). Estimating the Lunar Core Equatorial Ellipticity Using Lunar Laser Ranging. In *Lunar and Planetary Science Conference* (p. 2031).
- **Viswanathan, V.**, Mazarico, E., Cremons, D., Merkowitz, S., Sun, X., & Smith, D. E. (2020). Scientific Exploration of the Lunar South Pole with Retro-Reflectors. *LPI Contributions, 2241*(Lunar Surface Science Workshop), 5070.
- Fienga, A., **Viswanathan, V.**, Deram, P., Di Ruscio, A., Bernus, L., Laskar, J., et al. (2020). INPOP new release: INPOP19a. *Astrometry, Earth Rotation, and Reference Systems in the GAIA Era*, 293–297.
- Rambaux, N., **Viswanathan, V.**, Fienga, A., Laskar, J., & Gastineau, M. (2020). A New Dynamical Model of the Lunar Core and Improved Observational Constraints from Lunar Laser Ranging. In C. Bizouard (Ed.), *Astrometry, Earth Rotation, and Reference Systems in the GAIA era* (pp. 303–307).
- Rambaux, N., **Viswanathan, V.**, Fienga, A., Laskar, J., & Gastineau, M. (2019). Dynamical Model of Lunar Core and Observational Constraint from Lunar Laser Ranging. In *EPSC-DPS Joint Meeting 2019* (Vol. 2019, p. EPSC--DPS2019).
- Chen, H., Gastineau, M., Hestroffer, D., **Viswanathan, V.** 2018, Parallel High-fidelity Trajectory Optimization with Application to CubeSat Deployment in an Earth-moon Halo Orbit. *Proc. of the 7th Interplanetary CubeSat Workshop*, Paris, France, May 29-30.

- Courde, C., Torre, J.M., Samain, E., Martinot-Lagarde, G., Aymar, M., Albanese, D., Maurice, N., Mariey, H., Viot, H., Exertier, P., Fienga, A., and **Viswanathan, V.** 2017, Satellite and Lunar Laser Ranging in Infrared. *Proc. SPIE 10229, Photon Counting Applications*, doi:10.1117/12.2270573;
- Minazzoli, O., Bernus, L., Fienga, A., Hees, A., Laskar, J., **Viswanathan, V.** 2017, Universality of Free Fall versus Ephemeris. *Proc. of the 52th Rencontres de Moriond*
- **Viswanathan, V.**, Fienga, A., Manche, H., Courde, C., Torre, J.M., Exertier, P., Laskar, J. 2016, Updates from INPOP ephemerides: Data Reduction Model and Parameter Estimation using IR LLR data from OCA”. *20th International Workshop on Laser Ranging*.

TALKS

- Invited by the National Geospatial-Intelligence Agency’s Office of Geomatics (Space Branch) to present work as part of the Lunar Reference System Working Group:
 - o “GRAIL-LLR Principal Axes Reference Frames” | 10/2023
 - o “Interactive Q&A with NGA on Lunar Laser Ranging Data Analysis” | 06/2023
 - o “Lunar Laser Ranging Data Analysis” | 03/2023
- “Integrated time difference using ephemeris data”, LunaNet Interoperability, NASA-ESA Lunar Reference Time Meeting (invited by C. Gramling, Assoc. Chief for Tech. GSFC/MESA) | 06/2023
- “Cold, Earth-Visible Spots for Lunar Retroreflectors at Artemis Sites”. Artemis III Candidate Landing Regions Workshop #2031 | 04/2023
- “Orientation of the Moon using Lunar Laser Ranging data & GRAIL gravity field”, ESI-Solid Earth Team Meeting (invited by NASA/HQ) | 11/2022
- “Reorientation of the Moon from its Bombardment History”
 - o AGU Fall Meeting, U25B-0501 | 12/2022
 - o 54th Annual DPS Meeting, #310.01 | 10/2022
 - o NASA/GSFC Early Career Scientist Forum, #O606 | 10/2022
 - o Planetary Geodesy ISFM Flash Talk | 10/2022
 - o LRO Project Science Working Group | 10/2022
 - o European Lunar Symposium | 08/2022
- “Extending Science from Lunar Laser Ranging data”, Joint Seminar: Geodesy & Geophysics Lab.; Planetary Geology, Geophysics & Geochemistry Lab. at NASA GSFC (invited) | 04/2021
- “Scientific Exploration of the Lunar South Pole with Retro-Reflectors”, Lunar Surface Science Workshop, LPI #2241, id. 5070 | 04/2020
- “Updates from INPOP ephemeris: From fundamental physics tests to lunar interior probe”, 42nd COSPAR Scientific Assembly, H0.5-0006-18 | 07/2018
- “Recent updates from the INPOP lunar and planetary ephemeris team”, Journées Scientifiques du Programme National GRAM, #215219 | 06/2018
- “LLR data analysis and impact on lunar dynamics from recent developments at OCA LLR Station”, EGU General Assembly Conference, Vol. 18, p. 13995 | 04/2016
- “Recent developments in INPOP planetary ephemerides”, IAU GA, 22, p. 27116 | 8/2015