Alejandro Soto

1050 Walnut Street, Suite 300, Boulder, CO 80302
(720) 240-0128, asoto@boulder.swri.edu, www.alejandrosoto.net

A planetary scientist and aerospace engineer involved in Solar System exploration.

Expertise

I have over a decade of experience developing and using atmospheric models to study the dynamics of terrestrial planets. I have used and help develop atmospheric models for Mars and Titan, including working with existing models such as NCAR's WRF, MarsWRF, TitanWRF, and GFDL's FMS. I also have experience in space instrument development and operations for planetary spaceflight missions, including the Mars Reconnaissance Orbiter and the Deep Impact mission.

Professional Appointments

- Oct. 2019 - present, Southwest Research Institute, Senior Research Scientist
- Jan. 2015 – Sept. 2019, Southwest Research Institute, Research Scientist
- Jan. 2013 – Dec. 2014, Southwest Research Institute, Postdoctoral Scholar
- Aug. 2012 – Dec. 2012, California Institute of Technology, Postdoctoral Scholar
- Feb. 2012 – July 2012, Colorado School of Mines, Postdoctoral Scholar
- Apr. 2000 – July 2004, NASA Jet Propulsion Laboratory, System Engineer
- Sept. 1997 – Sept. 1998, Lockheed Martin Missiles & Space, Technical Staff

Education

Ph.D., Planetary Science, **California Institute of Technology**, 2012.
Dissertation: *Dynamical Paleoclimatology of Mars.* (Defended Nov. 2011).

M.S., Aeronautics & Astronautics, **Stanford University**, 2000.

B.A., Physics & Astronomy, with Honors, **Dartmouth College**, 1997.
Senior Thesis: *A Kinematic Study of the Galactic Supernova Remnant 3C58.*

Vatican Observatory Summer School, Castel Gandolfo, Italy, 1997.
"Observations and Theoretical Understanding of Comets, Asteroids, and Meteorites".

Featured Papers

My scientific career started with studying the paleoclimate dynamics of Mars. In particular, I explored how the Martian atmosphere's tendency to "collapse" at lower obliquities generates pathways of meridional transport of energy that are more important on Mars, and possibly Pluto, than on Earth.

- **Soto, A.**, M.A. Mischna, T. Schneider, C. Lee, M.I. Richardson (2015), "Martian atmospheric collapse: Idealized GCM studies", *Icarus*, Volume 250, Pages 553-569, doi:10.1016/j.icarus.2014.11.028.

With collaborators E.G. Rivera-Valentin and V.F. Chevrier, I have been investigating the potential habitabilty of current Mars, with a focus on brine environments at a very localized scale. Our first two papers, for which I did all of the atmospheric modeling, looked at the global-scale habitability of surface brines. We are following up this research with investigations into the possible habitable conditions for brines at the smaller-scale (mesoscale), e.g., within craters like Jezero and Gale.

- Chevrier, V. F., E. G. Rivera-Valentín, **A. Soto**, T. S. Altheide. Global Temporal and Geographic Stability of Brines on Present-Day Mars. *Planetary Science Journal*, in press.
- Rivera-Valentín, E. G., V. F. Chevrier, **A. Soto**, and G. Martínez (2020). Distribution and habitability of (meta)stable brines on present-day Mars. *Nature Astronomy*, 4:756–761, doi:10.1038/s41550-020-1080-9.

I am also investigating the mesoscale atmospheric dynamics of Titan. My collaborator S.C.R. Rafkin and I have modeled the air-sea interactions over the lakes of Titan. I am continuing this work, as part of a Cassinia

Data Analysis project for which I am the Principal Investigator and in collaboration with J. Soderblom, J. Steckloff, and P. Corlies, where we are integrated the unique thermodynamics of the Titan lakes into our mesoscale modeling.

- Steckloff, J. K., Soderblom, J. M., Farnsworth, K. K., Chevrier, V. F., Hanley, J., **Soto, A.**, Groven, J. J., Grundy, W. M., Pearce, L. A., Tegler, S. C., and et al. (2020). Stratification Dynamics of Titan's Lakes via Methane Evaporation. The Planetary Science Journal, 1(2):26, doi:10.3847/PSJ/ab974e.
- Rafkin, S. C. and **Soto, A.** (2020). Air-sea interactions on Titan: Lake evaporation, atmospheric circulation, and cloud formation. *Icarus*, 351:113903, doi:10.1016/j.icarus.2020.113903.

Beyond the atmospheric and climate modeling, I am also involved in the development of novel instruments for future spaceflight missions. For example, I led the development of a semiconductor-based neutron spectrometer that will provide new capabilities for surface observations of thermal and epithermal neutrons on airless bodies, such as the moon and asteroids.

- **Soto, A.** R. G. Fronk, K. Neal, B. Ehresmann, S. L. Bellinger, M. Shoffner, D. S. McGregor (2020). "A semiconductor-based neutron detection system for planetary exploration", *Nuclear Instrument and Methods in Physics Research, A, in press*, doi:10.1016/j.nima.2020.163852.

Project Experience

- Co-Investigator on Project ESPRESSO, a SSERVI virtual institute. 2017 – present
- Payload Sys. Engineer, Phase A/B/C, Mars Reconnaissance Orbiter (MRO). 2001 – 2004.
- Instrument Sys. Engineer on the Terrestrial Planet Finder (TPF) program. 2003 – 2004.
- Science Sys. Engineer, Phase C/D, Deep Impact Mission. Launch: 2002 – 2004.
- Lead Instrument Engineer for JPL's MATMOS instrument. 2002 – 2004.
- Integration and Test Engineer, Phase C/D, Stanford's OPAL satellite. Launch: 1998 –1999.

Instrument Projects

Grain Velocimetry and Tomography Analysis System (GraVeTAS). As a member of Project ESPRESSO, a Solar System Exploration Virtual Institute (SSERVI) team, Dr. Soto is investigating the dynamical processes associated with impact ejecta formation and how impact ejecta processes affect the small body surface environment, with a focus on the consequences for robotic and human operations. Dr. Soto and his team are developing the Grain Velocimetry and Tomography Analysis System (GraVeTAS), an instrument to simultaneously measure the size, shape, 3D velocity, and optical-NIR spectrum of ejecta particles with sizes from 0.25 micron to 3 millimeter in free flight traveling at speeds up to a kilometer per second launched from laboratory impact experiments.

- **Soto, A.**, Nowicki, K., Whizin, A., Parker, A., Durda, D., Cintala, M., II, C. C., and Walsh, K. (2020). Development of Novel Instrumentation for Impact Experiments. In *NASA Exploration Science Forum*, number NESF2020-085.

Hura: An Integrated Anemometer, Nephelometer, and Tomographer to Study Planetary Atmospheres. Dr. Soto is the Principal Investigator leading the development of Hura, an *in situ* instrument designed to characterize dust and aerosols in a variety of planetary atmospheres, including Mars, Titan, and comet atmospheres. Dr. Soto is involved in developing the sciencne and system level requirements and in analyzing the performance of various prototypes of an optical instrument for in situ measurement of atmospheric properties. Currently, a field version of the instrument has been tested in a basaltic aeolian region in Iceland.

- **Soto, A.**, Nowicki, K., Pyke, B., and Shoffner, M. (2020). Hura: An Instrument for Atmospheric and Aeolian Science. In *Sixth International Planetary Dunes Workshop*, volume 2188, page 3046.

Flight Projects

Deep Impact. Dr. Soto was a science system engineer on the Deep Impact mission during Phase C & D. During that time, he helped develop the science operations sequences for the lunar flyby ob- servations as well

as the comet encounter observations. Dr. Soto also participated in the pre-launch science planning, balancing spacecraft resources with scientific objectives and requirements.

Mars Reconnaissance Orbiter. Dr. Soto was a payload systems engineer on the Mars Reconnais- sance Orbiter (MRO) during Phase A through C. He participated in designing the interfaces, both physical and operational, between the MRO spacecraft and the MCS, MARCI, and CTX instru- ments. As a member of the MRO engineering team, Dr. Soto was an advocate for the instruments.

Stanford's OPAL spacecraft. Dr. Soto was an integration and test engineer for Stanford's Orbiting Pico-satellite Automated Launcher (OPAL) during Phase C & D. OPAL launched in January 2000.

Funding as Principal Investigator

"Investigating Clouds on Titan", Grant No. 80NSSC18K0967, 05/22/2018 - 05/21/2021, role: Principal Investigator.

Funding as Co-Investigator

"The Role of Moist Convection in Titan's Hydrological Cycle and General Circulation", Grant No. 80NSSC17K0722, PI: Juan Lora.

"Exploration Science Pathfinder Research for Enhancing SS Observations (ESPRESSO)", a Solar System Exploration Research Virtual Institute (SSERVI) team, PI: Alex Parker.

"The biologic potential of the martian subsurface via brine production through atmosphere-regolith interactions", Grant No. 80NSSC17K0742, PI: Edgard Rivera-Valentin.

"Environmental Consequences of Asteroidal Bombardment on Early Mars", Grant No. NNX16AR87G, PI: Simone Marchi.

"The Hydrology, Climate, and Sedimentary Deposits of Meridiani Planum and Gale Crater", Grant No. NNX15AH34G, PI: Jeffrey Andrews-Hanna.

"Climatic control of explosive volcanism on Mars", Grant No. 80NSSC17K0059, PI: Jeffrey Andrews-Hanna.

Service to the Science Community

- Reviewer for articles in Icarus, Journal of Atmospheric Science, Journal of Geophysical Research, Geophysical Research Letters, Nature Geoscience, Science, and Space Science Reviews.
- Served on various NASA ROSES and NSF review panels in 2014, 2015, 2016, 2018, and 2020. Also provided external reviews to a variety of review panels from 2014 to the present.
- Member of the science organizing committee for the Mars Workshop on Amazonian and Present-Day Climate held in Denver, CO in June 2018.
- Co-Chair for the Comparative Climatology of Terrestrial Planets III conference held in Houston, TX in August 2018.
- Member of the Division for Planetary Science (DPS) Prize Subcommittee, 2018-2019.
- Member of MEPAG's Ice and Climate Evolution Science Analysis Group (ICE-SAG), 2018-2019.
- Member of the science organizing committee for the Division of Planetary Science meeting, virtual meeting in October 2020.
- Member of the American Astronomical Society Sustainability Committee, 2018-2020.
- Member of the Division for Planetary Science Professional Culture & Climate Subcommitee, 2018-2020.

Memberships

- Division of Planetary Science (DPS) of the American Astronautical Society (AAS).
- American Institute of Aeronautics and Astronautics (AIAA).
- American Geophysical Union (AGU).
- American Meteorological Society (AMS).

Science Communication and Outreach

- From 2015 to 2020, I volunteered as a producer for KGNU's How on Earth science radio show, producing a number of shows on a variety of science topics, including planetary science.
- I was interviewed in Spanish and English as part of the MU69 observation campaigns in Mendoza, Argentina and Comodoro Rivadavia, Argentina, including an interview with ADN Sur - Agencia de Noticias de Comodoro Rivadavia y Chubut and an interview with Texas Public Radio.
- Wrote an article for the Planetary Society about the MU69 campaign.
- I participated in science outreach panels at the 2016 and 2017 Denver Comic Con, including a panel about the science of *The Martian* and a panel about pursuing a career in planetary science and exploration.
- In March 2019, I spoke at the San Antonio Astronomy on Tap event co-sponsored by the Witte Museum in San Antonio. As part of the "Mars Attacks!" event, I spoke about "Dust Storms on Mars".

Refereed Papers

Chevrier, V. F., E. G. Rivera-Valentín, **A. Soto**, T. S. Altheide. Global Temporal and Geographic Stability of Brines on Present-Day Mars. *Planetary Science Journal*, in press.

Rafkin, S. C. and **Soto, A.** (2020). Air-sea interactions on Titan: Lake evaporation, atmospheric circulation, and cloud formation. *Icarus*, 351:113903, doi:10.1016/j.icarus.2020.113903.

Rivera-Valentín, E. G., V. F. Chevrier, **A. Soto**, and G. Martínez (2020). Distribution and habitability of (meta)stable brines on present-day Mars. *Nature Astronomy*, 4:756–761, doi:10.1038/s41550-020-1080-9.

Soto, A. R. G. Fronk, K. Neal, B. Ehresmann, S. L. Bellinger, M. Shoffner, D. S. McGregor (2020). "A semiconductor-based neutron detection system for planetary exploration", *Nuclear Instrument and Methods in Physics Research, A, in press*, doi:10.1016/j.nima.2020.163852.

Steckloff, J. K., Soderblom, J. M., Farnsworth, K. K., Chevrier, V. F., Hanley, J., **Soto, A.**, Groven, J. J., Grundy, W. M., Pearce, L. A., Tegler, S. C., and et al. (2020). Stratification Dynamics of Titan's Lakes via Methane Evaporation. The Planetary Science Journal, 1(2):26, doi:10.3847/PSJ/ab974e.

Farnsworth, K. K., Chevrier, V. F., Steckloff, J. K., Laxton, D., Singh, S., **Soto, A.**, and Soderblom, J. M. (2019). Nitrogen Exsolution and Bubble Formation in Titan's Lakes. Geophysical Research Letters, doi:10.1029/2019gl084792.

McDonald, G. D., A. G. Hayes, R. C. Ewing, J. M. Lora, C. E. Newman, T. Tokano, A. Lucas, **A. Soto**, G. Chen, "Variations in Titan's dune orientations as a result of orbital forcing", *Icarus*, Volume 270, Pages 197-210, doi:10.1016/j.icarus.2015.11.036.

Soto, A., M.A. Mischna, T. Schneider, C. Lee, M.I. Richardson (2015), "Martian atmospheric collapse: Idealized GCM studies", *Icarus*, Volume 250, Pages 553-569, doi:10.1016/j.icarus.2014.11.028.

Guo, X., M. I. Richardson, **A. Soto**, and A. Toigo (2010), "On the mystery of the perennial carbon dioxide cap at the south pole of Mars", *Journal of Geophysical Research*, 115, E04005, doi:10.1029/2009JE003382.

Fesen, R., G. Rudie, A. Hurford, and **A. Soto** (2008), "Optical Imaging and Spectroscopy of the Galactic Supernova Remnant 3C 58 (G130.7+3.1)." *The Astrophysical Journal Supplement Series*, 174:2, pages 379-395, doi:10.1086/522781.

Anderson, M.S., J.M. Andringa, R.W. Carlson, P. Conrad, W. Hartford, M. Shafer, **A. Soto**, A.I. Tsapin, J.P. Dybwad, W.Wadsworth, and K. Hand (2005), "Fourier Transform Infrared Spectroscopy for Mars Science." *Review of Scientific Instruments*, volume 76, doi:10.1063/1.1867012.