Paulo F Penteado

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Summary

Scientist / engineer with extensive experience in developing and implementing algorithms and pipelines, in applications from orbit determination and mission planning to geometric and radiometric processing, mining, fusion, building mosaics, archiving, analysis and visualization. A large fraction of my work relied on using SPICE to calculate accurate states, attitudes and FOV projections. Developed the MAIA Instrument Targeting Tool, for mission design and observation planning. Developed titanbrowse, a database, exploration, visualization and analysis tool for remote-sensing hyperspectral observations of Titan's surface and atmosphere, taken by Cassini VIMS, which led to the first discovery of tropical lakes on Titan. Extensive development of software for geometric and radiometric processing of solar observations by Parker Solar Probe (WISPR) and Solar Orbiter (SoloHI). Worked on extensive software development to process Earth hyperspectral observations by AIRS, including automated pipelines for volcano products and delivery of sets of all AIRS L2 products for GIBS / Worldview. Developed OMINAS pipelines for parsing and writing PDS files for multiple Cassini, Voyager and Galileo instruments. Reimplemented and extended parts of Plume Tracker, a toolkit for both interactive research and automated pipeline analysis of Earth remote sensing observations by MODTRAN radiative transfer retrievals. Applied radiative transfer models to VIMS reflected light observations, to derive Titan's methane, haze and cloud distributions.

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Key Skills

Instrument planning and data processing, archiving, exploration, mining, visualization and analysis
22 years experience developing algorithms to find what is interesting in existing dataset, process and visualize them. This includes:

- Development, implementation, deployment, and operation of automated pipelines to generate and deliver remote sensing products (AIRS, Parker Solar Probe, STEREO, SMAP, ESCDS, Cassini VIMS), for distribution to scientists, stakeholders, and the public, including through NASA's Worldview, GIBS, and Eyes on Earth.
- Algorithm development in research environments to create and test algorithms and strategies.
- Transition to production environments, needing systematic automated parallelized execution, to enable use of the entire set of available data - both real time streams as observations get downlinked, and entire archives since the beginning of mission.
- Radiative transfer modeling of remote sensing observations, including to derive physical methane abundances. Expert in MODTRAN and Discrete Ordinate algorithms.
- Orbital dynamics applied to observation geometry processing, including complex cases of observation planning optimization (ex: MAIA) and with observer flying through the observed structures (ex: WISPR, SoloHI). Expert in NAIF's SPICE.

Astronomy, Planetary, Earth and Solar Remote Sensing
Since graduate and postdoc research: Planning, acquisition, mining and analysis of astronomical and remote sensing observations: images, spectra and hyperspectral imaging. Experience with planning and acquisition of observations from Keck, Hubble Space Telescope and Cassini, mining Virtual Observatory resources and developing algorithms and databases to handle observations.

Programming:

- Developed projects using IDL, Python, Fortran, MATLAB, C, C++, SQL, Java, Git, Subversion, JIRA, NAIF SPICE, SEXtractor, Astrometry.net, GeoPandas, GDAL, xESMF, rioxarray, dask, scikit-image, Polars, scikit-learn, PyTorch, OpenCV, MODTRAN, HITRAN, DISORT, AWS EC2 and Lambda, Docker, CUDA, OpenMP, MPI, Cesium, handling a variety of file formats for ingestion and delivery, including netCDF, HDF, HDF-EOS, shapefile, GeoTIFF, GeoJSON, GeoCSV, KMZ, VICAR, FITS, WMTS, xlsx, and custom proprietary formats.
- Development of pipelines for automated bulk data processing, including parallelized execution and self-contained tool packages for other users to deploy on their environments.
- Expert in IDL, including collaboration the testing and definition of new language features and reviewed books. Curator of the IDL Coyote website and library, including an archive of the comp.lang.idl-pvwave newsgroup.
- Always interested in and quick to learn new tools to develop better software solutions.

Professional Experience

Jet Propulsion Laboratory Science Data and Instrument Visualization (398I) Pasadena

Data Visualization Developer 2016 – current

- Development of new algorithms and new implementations for Plume Tracker, a tool for both GUI-interactive and pipeline-automated atmospheric retrievals (such as human-made methane and volcanic SO_2 plumes) from radiative transfer modeling of remote sensing observations, both airborne (HyTES) and satellite-based (ASTER, MODIS, VIIRS, AIRS).
- Development and maintenance of the pipeline to create all L2 AIRS products delivered for public access through Worldview, GIBS, including efficient parallelization to enable quick reprocessing of all granules since beginning of mission (2002).
- Developed the visualizations of the AIRS volcano monitoring tool.
- Creation of new visualizations of AIRS Near-Real-Time data of transient phenomena (hydrological events and volcanoes).
- Maintenance and operation of pipelines for automated generation of products for SMAP and several instrument streams for Eyes on Earth (AIRS, SMAP, Jason, OCO-2, GRACE-FO, MLS, OMI, GPM).
- Developed software for mission design, science planning, strategy analysis and observation sequencing for the Multi-Angle Imager for Aerosols (MAIA).
- Developed algorithms and their parallelized implementation for radiometric and geometric mapping, visualization and analysis of solar observations taken by Parker Solar Probe (WISPR) and Solar Orbiter (SoloHI), including automated product generation, published through the SolarSoft library.
- Software development and data product generation for localization of Mars Exploration Rovers (Spirit and Opportunity) observations.
- Worked in the team developing OMINAS, a versatile toolkit to generate visualization products for Cassini and other planetary imaging missions.
- Worked on varied projects to create processing and visualization tools to inspect remote sensing observations and generate new data products, both automatic and interactive, for visible / infrared cameras and hyperspectral imagers, and for RADAR.
- Development of an online-accessible version of `titanbrowse`.

Northern Arizona University Department of Physics and Astronomy — Flagstaff
Postdoctoral researcher — 2013 – 2015

- Developed code to generate mosaics of remote-sensing observations, resulting in cartographically-correct representation of the extent of each spatial pixel.
- Support analysis of Cassini VIMS observations of Titan's surface and atmosphere, with a combination of PCA and radiative transfer models, to derive surface compositions and atmospheric parameters (PI: Caitlin Griffith, University of Arizona).
- Development databases of archived observations of Solar System bodies, to bring the possibilities of the Virtual Observatory into planetary science.
- Work on the maintenance and support of the Physics and Astronomy cluster; member of the NAU cluster committee.

Universidade de São Paulo Departamento de Astronomia — São Paulo
Postdoctoral researcher — 2008 – 2013

- Implemented a new version of `titanbrowse`, for improved performance and functionality.
- Collaborated on the use of `titanbrowse` to identify, for the first time, lakes on Titan's tropics, by mining Cassini VIMS observations.
- Started developing perceptually-uniform colormaps.

University of Arizona Department of Planetary Sciences — Tucson
Ph.D. research — 2003 – 2008

- Created `titanbrowse`.
- Created colormaps to visualize remote sensing observations of Titan which would show more structure, with less saturation, and to better show the structure in data over 2 bands.
- Analyzed VIMS observations to detect and characterize Titan's clouds and their evolution.
- Modified and used radiative transfer codes, implemented in Fortran, to reproduce VIMS spectra and derive Titan's methane and haze distributions.

Observatório Nacional — Brazil
Master's research — 2002 – 2003

- Applied the model developed on undergraduate research to analyze the rotation of asteroid fragments created in collisions.
- Created movies of 3D renderings of the collisions.

Universidade Federal do Rio de Janeiro Dept. de Astronomia — Brazil
Undergraduate research — 1998 – 2002

- Developed a model to simulate the dynamics of a rubble-pile asteroid during a collision, implemented in Fortran.

Education

University of Arizona — Tucson
Ph.D. in Planetary Sciences — 2003 – 2008
Thesis title: "Study of Titan's methane cycle"

Observatório Nacional — Brazil
M.Sc. in Astronomy — 2002 – 2003
Thesis title: "Study of the angular momentum after the fragmentation of a rubble-pile asteroid"

Universidade Federal do Rio de Janeiro Brazil
B.Sc. in Astronomy, *Magna cum Lauda* 1998 – 2002
Thesis title: "Interacting Ellipsoids: a model for the fragmentation of a rubble-pile asteroid"

Publications

- Google Scholar profile: http://scholar.google.com/citations?user=QWxVqrYAAAAJ
- Researcher ID: http://www.researcherid.com/rid/F-9081-2012
- Scopus profile: http://www.scopus.com/authid/detail.url?authorId=9532691100

1. *Synthetic Remote-sensing and In-situ Observations of Fine-scale Structure in a Pseudostreamer Coronal Mass Ejection through the Solar Corona.* BJ Lynch, PF Wyper, E Palmerio, L Casillas, JT Dahlin, LKS Daldorff, SE Guidoni, AK Higginson, P Kumar, A Liberatore, PC Liewer, O Panasenco, **P Penteado**, M Velli. arXiv preprint (2025) http://arxiv.org/pdf/2501.17298

2. *Analysis of CME Interactions in Solar Corona Combining Coronagraphic Observations with Wide-field Imagers from Solar Orbiter and Parker Solar Probe.* A Liberatore, PC Liewer, M Temmer, GM Cappello, Y De Leo, **P Penteado**. The Astrophysical Journal (2025) doi:10.3847/1538-4357/adbffd

3. *Structure of the Plasma near the Heliospheric Current Sheet as Seen by WISPR/Parker Solar Probe from inside the Streamer Belt.* PC Liewer, A Vourlidas, G Stenborg, RA Howard, J Qiu, **P Penteado**, O Panasenco, CR Braga. The Astrophysical Journal (2023). doi:10.3847/1538-4357/acc8c7

4. *Extracting the Heliographic Coordinates of Coronal Rays Using Images from WISPR/Parker Solar Probe.* PC Liewer, J Qiu, F Ark, **P Penteado**, G Stenborg, A Vourlidas, JR Hall, P Riley. Solar Physics (2022). doi:10.1007/s11207-022-02058-6

5. *Evolution of a streamer-blowout CME as observed by imagers on Parker Solar Probe and the Solar Terrestrial Relations Observatory.* PC Liewer, J Qiu, A Vourlidas, JR; Hall, **P Penteado**. Astronomy & Astrophysics (2021). doi:10.1051/0004-6361/202039641

6. *Tracking solar wind flows from rapidly varying viewpoints by the Wide-field Imager for Parker Solar Probe.* A Nindos, S Patsourakos, A Vourlidas, PC Liewer, **P Penteado**, .JR Hall. Astronomy & Astrophysics (2021). doi:10.1051/0004-6361/202039414

7. *Trajectory Determination for Coronal Ejecta Observed by WISPR/Parker Solar Probe.* PC Liewer, J Qiu, **P Penteado**, JR Hall, A Vourlidas, RA Howard. Solar Physics (2020). doi:10.1007/s11207-020-01715-y

8. *Near-Sun observations of an F-corona decrease and K-corona fine structure.* RA Howard, A Vourlidas, V Bothmer, RC Colaninno, CE DeForest, B Gallagher, JR Hall, P Hess, AK Higginson, CM Korendyke, A Kouloumvakos, PL Lamy, PC Liewer, J Linker, M Linton, **Penteado, P**, SP Plunkett, N Poirier, NE Raouafi, N Rich, P Rochus, AP Rouillard, DG Socker, G Stenborg, G. AF Thernisien, A. F, NM Viall. Nature (2019). doi:10.1038/s41586-019-1807-x

9. *Simulating White Light Images of Coronal Structures for WISPR/ Parker Solar Probe: Effects of the Near-Sun Elliptical Orbit.* P Liewer, A Vourlidas, A Thernisien, J Qiu, P Penteado,G Nisticò, R Howard, V Bothmer. Solar Physics (2019). doi:10.1007/s11207-019-1489-4

10. *A corridor of exposed ice-rich bedrock across Titan's tropical region.* CA Griffith, **P Penteado**, JD Turner, CD Neish, G Mitri, N Montiel, A Schoenfeld, RMC Lopes. Nature Astronomy (2019). doi:10.1038/s41550-019-0756-5

11. *Current paradigms in parallelization: a comparison of vectorization, OpenMP and MPI.* **P Penteado**. Journal of Computational Interdisciplinary Sciences (2015). doi:10.6062/jcis.2012.03.03.0057

12. *Software and cyber-infrastructure development to control the Observatorio Astrofísico de Javalambre (OAJ).* A Yanes-Díaz, JL Antón, S Rueda-Teruel, L Guillén-Civera, R Bello, D Jiménez-Mejías, S Chueca, NM Lasso-Cabrera, O Suárez, F Rueda-Teruel, AJ Cenarro, D Cristobal-Hornillos, A Marin-Franch, R Luis-Simoes, G López-Alegre, MAC Rodríguez-Hernández, M Moles, A Ederoclite, J Varela, H Vazquez Ramió, MC Díaz-Martín, R Iglesias-Marzoa, N Maicas, JL Lamadrid, A Lopez-Sainz, J Hernández-Fuertes, L Valdivielso, C Mendes de Oliveira, **P Penteado**, W Schoenell, A Kanaan. Proceedings of the SPIE, 9152, id. 915215 (2014). doi:10.1117/12.2054944

13. *Goals and strategies in the global control design of the OAJ Robotic Observatory.* S Rueda-Teruel, A Yanes-Díaz, JL Antón, F Rueda-Teruel, M Moles, AJ Cenarro, A Marín-Franch, A Ederoclite, N Gruel, J Varela, D Cristobal-Hornillos, S Chueca, MC Díaz-Martín, L Guillén, R Luis-Simoes, N Maícas, JL Lamadrid, AL López-Sainz, J Hernández-Fuertes, L Valdivielso, C Mendes de Oliveira, **P Penteado**, W Schoenell, A Kanaan. Highlights of Spanish Astrophysics VII, pp. 954-954. (2013). 2013hsa7.conf..954R

14. *Possible tropical lakes on Titan from observations of dark terrain.* Catilin A. Griffith, Juan Lora, Jake Turner, **Paulo F. Penteado**, Robert H. Brown, Martin G. Tomasko, Lyn Doose, Charles See. Nature 486, pp. 237-239 (2012). doi:10.1038/nature11165

15. *Goals and strategies in the global control design of the OAJ Robotic Observatory.* A.Yanes-Díaz, S. Rueda-Teruel, J.L. Antóna, F. Rueda-Teruel, M. Moles, A.J. Cenarro, A. Marin-Franch, A. Ederoclite, N. Gruel, J. Varela, D. Cristobal-Hornillos, S. Chueca, M.C. Díaz-Martín, L. Guillen, R. Luis-Simoes, N. Maicas, JL. Lamadrid, A. Lopez-Sainz, J. Hernández-Fuertes, L. Valdivielso, C. Mendes de Oliveira, **P. Penteado**, W. Schoenell, A. Kanaan. Observatory Operations: Strategies, Processes, and Systems IV. Proceedings of the SPIE, Volume 8448, id. 84481B-84481B-14 (2012). doi:10.1117/12.925665

16. *Radiative transfer analyses of Titan's tropical atmosphere.* Caitilin A. Griffith, Lyn Doose, Martin G. Tomasko, **Paulo F. Penteado**, Charles See. Icarus 218, 2, pp. 975-988 (2012). doi:10.1016/j.icarus.2011.11.034

17. *Latitudinal variations in Titan's methane and haze from Cassini VIMS observations.* **Paulo F. Penteado**, Caitlin A. Griffith, Martin G. Tomasko, Steffi Engel, Charles See, Lyn Doose, Kevin H. Baines, Robert H. Brown, Bonnie J. Buratti, Roger Clark, Phillip Nicholson, Christophe Sotin. Icarus 206, 1, pp. 352-365 (2010). doi:10.1016/j.icarus.2009.11.003

18. *Ground-based measurements of the methane distribution on Titan.* **Paulo F. Penteado**, Caitlin A. Griffith. Icarus 206, 1, pp. 345-351 (2010). doi: 10.1016/j.icarus.2009.08.022

19. *VIMS spectral mapping observations of Titan during the Cassini prime mission.* Jason W. Barnes, Jason M. Soderblom, Robert H. Brown, Bonnie J. Buratti, Christophe Sotin, Kevin H. Baines, Roger N. Clark, Ralf Jaumann, Thomas B. McCord, Robert Nelson, Stéphane Le Mouélic, Sebastien Rodriguez, Caitlin Griffith, **Paulo Penteado**, Federico Tosi, Karly M. Pitman, Laurence Soderblom, Katrin Stephan, Paul Hayne, Graham Vixie, Jean-Pierre Bibring, Giancarlo Bellucci, Fabrizio Capaccioni, Priscilla Cerroni, Angioletta Coradini, Dale P. Cruikshank, Pierre Drossart, Vittorio Formisano, Yves Langevin, Dennis L. Matson, Phillip D. Nicholson, Bruno Sicardy. Planetary and Space Science 57, 14-15, pp. 1950-1962 (2009). doi:10.1016/j.pss.2009.04.013

20. *Characterization of Clouds in Titan's Tropical Atmosphere.* Caitlin A. Griffith, **Paulo Penteado**, Sebastien Rodriguez, Stéphane LeMouélic, Kevin H. Baines, Bonnie Buratti, Roger Clark, Phil Nicholson, Ralf Jaumann, Christophe Sotin. The Astrophysical Journal Letters 702, 2, pp. L105-L109 (2009). doi:10.1088/0004-637X/702/2/L105

21. *Evidence for a Polar Ethane Cloud on Titan.* C. A. Griffith, **P. Penteado**, P. Rannou, R. Brown, V. Boudon, K. H. Baines, R. Clark, P. Drossart, B. Buratti, P. Nicholson, C. P. McKay, A. Coustenis, A. Negrao, R. Jaumann. Science, 313, 5793, pp. 1620-1622 (2006). doi:10.1126/science.1128245

22. *The Evolution of Titan's Mid-Latitude Clouds.* C. A. Griffith, **P. Penteado**, K. Baines, P. Drossart, J. Barnes, G. Bellucci, J. Bibring, R. Brown, B. Buratti, F. Capaccioni, P. Cerroni, R. Clark, M. Combes, A. Coradini, D. Cruikshank, V. Formisano, R. Jaumann, Y. Langevin, D. Matson, T. McCord, V. Mennella, R. Nelson, P. Nicholson, B. Sicardy, C. Sotin, L. A. Soderblom, R. Kursinski. Science 310, 5747, pp. 474-477 (2005). doi:10.1126/science.1117702

23. *Observations of Titan's Mesosphere.* C. A. Griffith, **P. Penteado**, T. K. Greathouse, H. G. Roe, R. V. Yelle. The Astrophysical Journal, 629, 1, pp. L57-L60 (2005). doi:10.1086/444533

24. *Measurements of CH_3D and CH_4 in Titan from Infrared Spectroscopy.* **P. F. Penteado**, C. A. Griffith, T. K. Greathouse, C. de Bergh. The Astrophysical Journal, Volume 629, Issue 1, pp. L53-L56 (2005). doi:10.1086/444353

25. *Interacting ellipsoids: a minimal model for the dynamics of rubble-pile bodies.* F. Roig, R. Duffard, **P. Penteado**, D. Lazzaro, T Kodama. Icarus, 165, 2, p. 355-370 (2003). doi:10.1016/S0019-1035(03)00216-1