

Nuclear Science Research Division Astro-Glaciology Laboratory

1. Abstract

Our Astro-Glaciology Laboratory promotes both experimental and theoretical studies to open up the new interdisciplinary research field of astro-glaciology, which combines astrophysics, astrochemistry, glaciology, and climate science.

On the experimental side, we measure isotopic and ionic concentrations in ice cores drilled at Dome Fuji station, Antarctica, in collaboration with the National Institute of Polar Research (NIPR, Tokyo). Here, the ice cores are time capsules that preserve atmospheric information of the past. In particular, the ice cores obtained around the Dome Fuji site are very unique because they contain much more information on the stratosphere than any other ice cores obtained from elsewhere on Earth. This supports that we have significant advantages in using Dome Fuji ice cores when we study the Universe, since UV photons, gamma-rays, and high-energy protons emitted by astronomical phenomena affect the stratosphere.

Our principal aim is thus to acquire and interpret information preserved in ice cores regarding:

- Signatures of past volcanic eruptions and solar cycles;
- Relationship between climate change and solar activity;
- Traces of past supernovae in our galaxy, in order to understand better the rate of galactic supernova explosions.

Moreover, we are promoting experimental projects on:

- Development of “RIKEN-LMS” (Laser Melting Sampler) for analyzing ice cores with high depth resolution;
- Development of precise analytical techniques of high sensitivity for analyzing ice cores;
- The application of analytical methods for measuring isotopes in ice cores to archaeological artifacts;
- The evolution of molecules in space.

On the theoretical side, we are simulating numerically:

- Chemical effects of giant solar flares and supernovae on the Earth’s atmosphere;
- The explosive and the *r*-process nucleosynthesis in core-collapse supernovae;

Combining our experimental evidence and theoretical simulations, we are promoting the research mentioned above. These all will contribute to understanding relationships between the Universe and Earth. In particular, climate change is the most critical issue facing the world in the 21st century. It is also emphasized that the frequency of supernova explosions in our galaxy has not yet been fully understood, and it is crucial to understanding the *r*-process nucleosynthesis.

Members

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List of Publications & Presentations

Publications

[Original Papers]

- S. Katsuda, H. Shinagawa, H. Fujiwara, H. Jin, Y. Miyoshi, Y. Miyoshi, Y. Motizuki, M. Nakajima, K. Nakazawa, K. K. Nobukawa, Y. Otsuka, A. Shinbori, T. Sori, C. Tao, M. S. Tashiro, Y. Wada, and T. Yamawaki, "X-raying neutral density disturbances in the mesosphere and lower thermosphere induced by the 2022 Hunga-Tonga volcano eruption," *Geophys. Res. Lett.* Published Online, *Geophys. Res. Lett.* **51**, 20, e2024GL112025, (2024) DOI: 10.1029/2024GL112025.
- N. -E. Sie, M. Tsuge, Y. Nakai, and N. Watanabe, "Photodesorption efficiency of OH radical on the ice surface in the wavelength range from ultraviolet to visible," *Chem. Phys. Lett.* **848**, 141384, 1–7 (2024) DOI: 10.1016/j.cplett.2024.141384.
- K. Kitajima, Y. Nakai, M. Tsuge, and N. Watanabe, "Signature of proton-hole transfer in hydrogen-bonded solids at 10 K," *Phys. Chem. Lett.* **15**, 11701–11708 (2024) DOI: 10.1021/acs.jpclett.4c02812.

[Books]

- 望月優子, 「シリーズ現代の天文学第1巻 人類の住む宇宙」, (第2版第4刷改訂), pp. 99–144, (「第3章 元素の起源」), pp. 147–149, (「第4章 太陽系 4.1.2 節 太陽の現在」), 岡村定矩他編, 日本評論社, 2024年6月 ISBN 978-4-535-60751-4.

Presentations

[International Conferences/Workshops]

- Y. Motizuki (invited), "Relationship between climate and solar activity suggested by Dome Fuji ice cores and RIKEN AGDF Project," ISEE Symposium "Frontier of Space-Earth Environmental Research as Predictive Science," Nagoya, Japan, March 5–7, 2025.
- N. Watanabe (poster), Y. Nakai, W. M. C. Sameera, K. Furuya, H. Hidaka, and A. Ishibashi, "Reactions of low-energy ions with an ice surface at low temperature conditions," Symposium on Next Generation Astrochemistry, Tokyo, Japan, November 19–22, 2024.
- Y. Motizuki, Y. Nakai, K. Takahashi, T. Imamura, and H. Motoyama, "Multidecadal solar cycles embedded in nitrate concentrations in Antarctic Dome Fuji ice cores," Joint Symposium of Space Climate 9 Symposium and ISEE Symposium, Nagoya, Japan, October 1–4, 2024.
- S. Katsuda (poster), S. Hirasedo, Y. Motizuki, Y. Hasebe, C. Y. Cullens, Y. Nakai, H. Akiyoshi, and T. Imamura, "Key ionic reactions affecting stratospheric O₃ and HNO₃, changes caused by solar proton events," Joint Symposium of Space Climate 9 Symposium and ISEE Symposium, Nagoya, Japan, October 1–4, 2024.
- M. Morikawa and Y. Motizuki, "A grand journey of pink noise in the solar-terrestrial system," Joint Symposium of Space Climate 9 Symposium and ISEE Symposium, Nagoya, Japan, October 1–4, 2024.
- N. Watanabe (poster), Y. Nakai, W. M. C. Sameera, K. Furuya, H. Hidaka, and A. Ishibashi, "Reactions via irradiation of an ice surface with low-energy ions at low temperature conditions," CPLT2024 Chemistry and Physics at Low Temperatures, Niseko, Japan, July 6–11, 2024.
- N. -E. Sie, M. Tsuge, Y. Nakai, and N. Watanabe, "The photodesorption efficiency of OH radical on ice from ultraviolet to visible range," CPLT2024 Chemistry and Physics at Low Temperatures, Niseko, Japan, July 6–11, 2024.
- Y. Motizuki (invited), Y. Nakai, K. Takahashi, J. Hirose, Y. V. Sahoo, M. Yumoto, M. Maruyama, M. Sakashita, K. Kase, S. Wada, H. Motoyama, and Y. Yano, "First application of laser melting method to ice core sampling to study climate change," Int. Conference on Laser Solutions for Space and Earth (LSSE2024), Yokohama, Japan, April 22–26, 2024.

[Domestic Conferences/Workshops]

- 望月優子, 「水同位体比分析と新開発 "RIKEN-LMS" を用いた『雪氷データファクトリー』計画」, ドームふじアイスコアに関する研究集会・ICC 集会, 立川市, 2025年3月27–28日.
- 望月優子, 「ドームふじアイスコアからさぐる太陽活動周期・気候変動・銀河系内超新星の痕跡」, 極地研究集会「南極 12 m テラヘルツ望遠鏡で明らかにする銀河とブラックホールの形成と進化」, 立川市, 2025年3月13–14日.
- 森川雅博, 望月優子, 「太陽-地球系における 1/f 揺らぎの伝播とその痕跡」, 2024年度 ISEE 共同研究集会名大 ISEE 共同研究集会「太陽地球環境と宇宙線モジュレーション」, 名大 ISEE 共同研究集会「太陽圏・宇宙線関連の共同研究成果報告会」, 名古屋市, 2025年2月20–21日.
- 望月優子 (招待講演), 「『テラ・アストロノミー』: 南極の氷と天体現象をつなぐ学際横断研究」, 日本物理学会オンライン物理講話, 2024年11月30日.
- 中井陽一, 日高宏, 渡部直樹, 「低エネルギーイオンと氷表面との反応実験 III」, 日本物理学会第79回年次大会, 札幌市, 2024年9月16日–19日.
- 望月優子 (招待講演), 「南極の氷からひもとく地球と宇宙とのつながり」, 日本天文学会 2024年秋季年会公開講演会, 三田市, 2024年9月14日.
- 林左絵子, 片岡章雅, 日下部晴香, 小松英一郎, 新永浩子, 野村英子, 望月優子, 「日本天文学会の規範とハラスメント防止ガイドラインを作ろう」, 日本天文学会 2024年秋季年会, 三田市, 2024年9月11–13日.
- 山脇鷹也, 勝田哲, 田代信, 森浩二, 鶴剛, 望月優子, 「X線天文衛星『すざく』の昼地球観測データを用いた地球超高層大気の長期変動調査」, 日本天文学会 2024年秋季年会, 三田市, 2024年9月11–13日.
- 望月優子, 中井陽一, 高橋和也, 今村隆史, 本山秀明, 「Solar activity cycles embedded in nitrate concentrations in Dome Fuji ice cores」, 日本地球惑星科学連合 (JpGU) 2024年大会, 美浜区 (幕張メッセ、現地+オンライン), 2024年5月26日–31日.
- 平瀬戸爽, 望月優子, 長谷部憂磨, 中井陽一, 秋吉英治, 今村隆史, 勝田哲, 「ハロウィン太陽プロトンイベントが引き起こす成層圏

大気中の化学種濃度変動におけるイオン反応の重要性」, 日本地球惑星科学連合 (JpGU) 2024 年大会, 美浜区 (幕張メッセ、現地+オンライン), 2024 年 5 月 26 日-31 日.