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ADVANCED MATHEMATICAL AND COMPUTATIONAL METHODS FOR SPACE SCIENCE AND TECHNOLOGY

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ABSTRACT

Space science and space technology present complex challenges that demand robust mathematical models, advanced numerical simulations, and highly efficient predictive tools. As observational datasets from space missions continue to grow exponentially in size and heterogeneity, there is a critical need to translate theoretical advances in applied mathematics into reliable, real-world solutions. This directly aligns with the core mission of the Math to Product congress, which seeks to bridge the gap between academic research and industrial workflows through quantitative predictive science.

This Invited Session explores the dynamic intersection of computational engineering, scientific machine learning, and space applications. We focus on innovative methodologies integrating deep physical modeling with data-driven techniques to analyze, reconstruct, and predict complex phenomena. Key topics include inverse problems and regularization methods for space-based imaging and remote sensing; numerical optimization and variational approaches for precise parameter estimation and data assimilation; and statistical learning frameworks designed for high-dimensional, multimodal observational data.

Special emphasis is placed on physics-informed learning, hybrid approaches combining numerical solvers with machine learning, uncertainty quantification, and interpretable, trustworthy artificial intelligence. These mathematical tools are vital for extracting actionable information across applications such as solar physics, space weather forecasting, and spacecraft dynamics. Furthermore, by addressing Earth observation and satellite data analysis, this session supports the broader goals of computational sustainability, environmental monitoring, and climate modeling.

We encourage contributions that go beyond the standard application of existing algorithms to highlight methodological advances, computational efficiency, and the strict integration of physical constraints into optimization frameworks. By fostering cross-fertilization among mathematicians, computational scientists, domain experts, and industrial stakeholders, this session aims to deliver robust, physically consistent computational tools that address emerging challenges in space engineering, thereby driving new paradigms in science, industrial innovation, and policy making.