The Earth's gravity field undergoes continuous changes due to various natural and anthropogenic factors, including glacier melt, groundwater extraction, and atmospheric and oceanic processes. These changes can be precisely monitored using satellite gravimetry, particularly through the GRACE (Gravity Recovery and Climate Experiment) mission and its successor, the GRACE Follow-On mission. However, these missions have certain limitations, such as data gaps and lower accuracy in determining some components of the gravitational field. Satellite Laser Ranging (SLR), an alternative technique, offers a continuous and long-term data set that extends beyond the GRACE mission period, making it valuable for studying changes in the gravitational field over a longer timeframe.

Understanding long-term changes in the Earth's gravitational field is crucial for several reasons. The reduction in glacier mass, especially in Greenland and Antarctica, directly affects freshwater resources, impacting ecosystems and human societies. Accurate monitoring of these changes can support strategies for mitigating climate change effects and managing water resources. Additionally, phenomena such as El Niño and La Niña, which cause significant changes in precipitation and temperature patterns, can be better understood through detailed gravity field models. These models can provide insights into the underlying mechanisms driving these phenomena and their broader environmental impacts.

The research project aims to develop a comprehensive time-variable model of the Earth's gravity field using SLR data from 1995-2025, integrating various satellite data and advanced modeling techniques. This will enable understanding of the complex interactions between atmospheric and oceanic phenomena, particularly focusing on their impact on polar motion, length of day, and regional hydrological changes.

Expected outcomes of this study include the development of higher resolution gravitational field models compared to previously proposed SLR models. SLR observations will be processed using both long-arc and short-arc approaches, and various methods will be employed to handle non-gravitational orbital perturbations. The results will be integrated with other satellite data, enhancing the resolution of gravity field models for periods before the GRACE era.

Furthermore, based on 30 years of data, it will be possible to investigate whether changes in the gravitational field exhibit nonlinear behaviors, particularly in response to climate change and human activities, allowing for a deeper understanding of long-term environmental processes. The resulting models will be validated using altimetry data and hydrological models, ensuring their reliability and accuracy. The findings will be valuable to scientific communities and organizations involved in studying and managing the Earth's dynamic systems.

In summary, this project aims to leverage the potential of SLR data to create a long-term model of the Earth's gravity field, offering key insights into the environmental processes shaping our planet. Through this research, we strive to enhance our ability to monitor and respond to the challenges associated with climate change and ensure sustainable management of Earth's natural resources.