

# Solar Flare Forecast Operation by Deep Flare Net and Future Prospects

\*Naoto Nishizuka<sup>1</sup>, Yuki Kubo<sup>1</sup>, Komei Sugiura<sup>2</sup>, Mitsue Den<sup>1</sup>, Mamoru Ishii<sup>1</sup>

1. National Institute of Information and Communications Technology, 2. Keio University

Complex systems, such as space weather, meteorological phenomena, and life phenomena, are a collection of diverse phenomena, and it is difficult to understand them only by clarifying elementary processes. In recent years, machine learning has been attracting attention as a method that encompasses multidisciplinary data and attempts to derive rules and essence from the data. We have developed a deep learning-based prediction model, Deep Flare Net (DeFN), as a method for predicting solar flares, which are the source of space weather phenomena. We have been operating it for forecasting since 2019. Since 2021, solar activity has been increasing and greater than M-class flares has been observed more frequently. In 2021, Deep Flare Net's predictions were successful in predicting 13 out of 14 events of greater than M-class flares. These forecast results are also used in the daily space weather forecast meetings, contributing to the efficiency and accuracy of the 24-hour space weather forecast. In addition, the magnetic neutral line and magnetic shear of the sunspot magnetic field, which are the focus of DeFN, are visualized so that people can visually check them in the forecast meeting. In one case where the DeFN failed to predict, we found that the hypothesis that there is a strong magnetic field gradient in the magnetic neutral line in the active region where flares greater than M-class are generated did not apply. Finally, now that the solar flare forecasting operation is stable and the accuracy has been improved, we will discuss the next prospects. We would like to discuss the development of machine learning and AI applications for the extension to SEP forecasting, which has been a longstanding issue, ionospheric storm forecasting, and the long-term forecasting of solar activity.

Keywords: Solar Flares, Space Weather Forecasting, Machine-learning