Abstract of Doctoral Dissertation

Degree requested: Doctor of Science Applicant's name: Purwadi

Title of Doctoral Dissertation

On relationships between lightning and observed phenomena and activities in thunderstorms, typhoons and volcanoes
（雷放電と積乱雲、台風、および火山活動の関係に関する研究）

Thunderstorm clouds may cause hydro-meteorological hazards such as torrential rainfall causes flood, hail, tornadoes, and CG lightning stroke. However, the existing thunderstorms observation method, such as weather radar, cannot grasp the physics behind heavy precipitation. A previous study mentioned that lightning is a good proxy for thunderstorm clouds severe weather[4]. Zipser, 1994, mentions that the occurrence of lightning in a thunderstorm requires strong updraft (7 m/s) at a temperature colder than 0°C to -20°C[27]. Observing the early thunderstorms cloud evolution at a temperature colder than 0°C can be conducted from space and possible to use to predict the final result of thunderstorm clouds. So, the combination of ground-based lightning detection networks and thermal infrared sensor(TIS) sensor cameras from space is suggested. This study evaluates the correlation between lightning and other thunderstorm parameters and suggests a precise methodology for those combination thunderstorm observations.

During the Understanding of Lightning and Thunderstorm (ULAT) Project and e-Asia Joint research Project, 2017 to 2020 FSY, some VLF receiver called V-POTEKA has been manufactured by Meisei Company-Japan and developed together with Hokkaido University. During this period, V-POTEKA was deployed to observe cloud to ground (CG) lightning in Asian countries called AVON. Moreover, V-POTEKA was deployed in Philippines to cover lightning observation in that country called Nationwide Network. V-POTEKA networks has been test and operated and shows the ability to detect the lightning phenomena in the target area. The comparison of the lightning geolocation estimate by the V-POTEKA lightning detection networks and Blitzortung shows the relative distance 35km and 37 km for the Nationwide Network and AVON.

The relationship between lightning and other thunderstorm cloud characteristic such as cloud top temperature (CTT), cloud top height (CTH), and precipitation has been conducted using AVON lightning data and static grid method. The result shows that CTT, CTH, rain rate, and precipitation volume (PV) is logarithmic function of CG lightning event. The result also agree with the previous work which mention that the total lightning is exponential function of CTH. During the operation, the V-POTEKA Nationwide Network in Philippines detects the lightning produce by Taal Volcano eruption on January 12th, 2020. The development of Taal Volcano eruption cloud ash is detected using Himawari 8 band 15 (12µm) and performed in 2D and 3D. The temporal evolution of the cloud ash shows the maximum cloud growth speed is ~50 m/s at around 07:00 to 07:10 UTC which closed to big explosion time ~15:00LT (07:00 UTC). The first CG lightning detected by V-POTEKA Nationwide Network occur at 07:47:25.15725 UTC. 34 CG lightning are detected by V-POTEKA Nationwide Network during the Taal Volcano eruption on January 12th, 2020.

Moreover, The study of correlation between lightning and maximum sustainable wind speed has been conducted using new technique for the first time in the world. The lightning is assumed to be proportional to the energy and the wind to be the carrier of the energy input. We did the back-tracing of the 60 point in radius 100 km to the typhoon eye. The speed and direction is taken from the ERA5 reanalysis at the pressure level 1000 to 400 with spatial resolution 0.25°x0.25°. We calculate new point with interval time 30 minutes with the speed and direction updated to be the closest place and time. The lightning data detected by Blitzortung is counted using the back-tracing point windows with interval time 6 hours. The result of this study shows, the wind in level 900 Mb is to be the most reasonable path to carry the energy to the typhoon Trami from place with the distance-time 36 hours to 48 hours from the typhoon Trami eye. The lag time in the maximum cross-correlation value between reaching center time and increasing maximum wind speed is 6-12 hours, which is assumed to be the conversion time of energy from latent heat to the kinetics energy.

Thermal infrared sensor (TIS) camera has been developed by Hokkaido University and will be installed in LAPAN-A4 micro satellite. The LAPAN-A4 micro satellite is planned to be launched in third

quarter of 2020 and orbit the earth at 500 km height. In LAPAN-A4 orbit, the Hokkaido University (HU) TIS camera will have better earth surfaces spatial resolution than existing geostationary satellite and the early formation of thunderstorm cloud can be conducted more detail than before.