主　論　文　の　要　旨

氏名　　Phan Anh

論文題目：**Estimating intervention-induced air pollution changes and tracking carbon neutrality progress employing the Digital Earth Systems Approach: Applications and Policy Implications**　（デジタル アース システムズ アプローチによる「介入事象がもたらした大気汚染の変化推定」と「カーボン ニュートラルの進捗状況の追跡」：その応用、政策への示唆）

Reducing air pollution and greenhouse gases is vital for climate change mitigation. This thesis focuses on three main topics to enhance understanding and monitor carbon neutrality progress at various scales. Firstly, it provides evidence and recommendations for regional air pollution mitigation policies, using multisource data to evaluate impact of intervention events in Japan and Ukraine. Secondly, it addresses the gap in terrestrial carbon fluxes estimates which is crucial for achieving carbon neutrality. Lastly, the thesis introduces a digital earth platform for carbon neutrality roadmaps and monitoring CO_2 emissions and forest sinks at a local scale, using Japan's municipalities as a case study. The key findings are as follows:

・I analyzed tropospheric NO_2 levels in Ukraine during the Covid-19 lockdown and the armed conflict with Russia. My findings suggest that the reduction in road transportation did not significantly decrease NO_2 levels in Ukraine, mainly due to limited reductions in coal power plants operation. In contrast to Europe, where road transport is a primary NO_2 contributor, my evidence suggests that future policies targeting NO_2 reduction from road transportation may not be as effective in Ukraine's populous cities.

・I examined the impact of NO_2 reduction on variations in O_3 and CH_4 across 14 metropolitan areas (MAs) in Japan in 2020. My results indicate an increase in O_3 levels after the Covid-19 lockdown in most MAs, suggesting a potential rise in O_3 levels under NO_2 reduction scenarios with sunny conditions. However, in MAs from Hiroshima to the southwest, I observed instances of NO_x-limited areas during the summer, indicating limited effectiveness in reducing O_3 levels through the reduction of anthropogenic non-methane volatile organic compounds (VOCs). Consequently, I recommend the simultaneous reduction of air pollutants, both anthropogenic VOCs and biogenic VOCs to mitigate adverse effects on both O_3 and CH_4.

・Using a multivariate time series Transformer-based model and a recently updated dataset of plant functional types, I generated a monthly global terrestrial carbon fluxes from 1990 to 2019 named FluxFormer. FluxFormer outperforms FLUXCOM, NIES, and MetaFlux datasets, exhibiting the highest positive trend in gross primary production from 2001 to 2019. It captures positive long-term trends that other datasets fail to replicate, providing reduced variations in deserts and semi-arid regions compared to NIES data. FluxFormer products are available at https://doi.org/10.5281/zenodo.10258644.

・I developed a digital earth platform focusing on carbon neutrality roadmaps at the municipal level in Japan. The platform monitors local CO_2 emissions and assesses the capacity of local forest sinks, incorporating energy-related data from major domestic power companies. The platform is accessible at: http://de14.digitalasia.chubu.ac.jp/.

My future work involves incorporating high-frequency temporal data from satellite-derived NO_2 observations to predict fossil fuel CO_2 emissions, enhancing continuous monitoring for achieving carbon neutrality at local and regional levels.