

Satellite-to-Surface Mapping of Ammonia over South Korea by Merging CrIS and IASI Satellites with In-Situ Validation

*Chisung Yun¹, Minho Kim¹, MinSuk Bae², Jung Min Park³, Yongjoo Choi¹

1. Hankuk University of Foreign Studies, Republic of Korea, 2. Mokpo National University, Republic of Korea, 3. National Institute of Environmental Research, Incheon, Republic of Korea

Ammonia (NH₃) is a key alkaline precursor that contributes to secondary inorganic aerosol formation through neutralization with sulfuric and nitric acids, thereby playing a significant role in PM_{2.5}. The lack of *in-situ* NH₃ measurements limits robust characterization of the spatio/temporal distribution and trends of NH₃. In contrast, satellite observations provide large spatial coverage and long-term measurement but are still associated with high uncertainties. In this study, we developed a satellite-to-surface estimation framework by integrating surface NH₃ concentration using nationwide passive-sampling, NH₃ total columns retrieved from two satellites (IASI and CrIS), ERA5 meteorological variables, livestock density from Gridded Livestock of the World, MODIS land-cover fractions. Then we evaluated three empirical models including multiple linear regression (MLR), random forest (RF), and an artificial neural network (ANN) to estimate surface NH₃ concentrations. Comparisons of NH₃ between columns and *in-situ* showed weak correlation (R=0.21), whereas the performance of three models significantly improved in terms of statistical parameters. RF exhibited the highest cross-validated performance (R=0.87, RMSE=4.24 ppbv), followed by ANN (R=0.78, RMSE=5.26 ppbv) and MLR (R=0.51, RMSE=6.42 ppbv). The RF converged with the monthly variation of *in-situ* NH₃, with monthly mean differences below 2 ppbv, both quantitatively and qualitatively, over the three-year period. These results demonstrate that the developed satellite-to-surface estimation framework can fill the gap between satellite retrievals and *in-situ* NH₃, providing reliable information for large-scale, long-term monitoring in regions with sparse *in-situ* observations.

Keywords: Ammonia, Passive Sampling, Satellite(CrIS, IASI), Random Forest, Multiple linear Regression, Artificial Neural Network