Holistic Process Analysis of Atmospheric Chloride Deposition: Modelling, Prediction, and Interpretation

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Abstract Atmospheric chloride deposition is a critical factor influencing metal atmospheric corrosion, and accurately estimating its spatial distribution is of great importance. Existing models for estimating atmospheric deposition rate often oversimplify the physical processes, leading to lower generalization performance and prediction accuracy. We compiled 544 records of atmospheric chloride deposition rates from six countries, including China and Australia. By analyzing the holistic physical process of atmospheric chloride deposition, 11 key environmental factors were identified. Based on the analysis, a genetic algorithm-optimized quantile regression forest (GA-QRF) method was proposed to quantitatively model the holisitc deposition process. The proposed model demonstrated superior predictive performance on the dataset, achieving a determination coefficient (R^2) of 0.935. Additionally, the model quantified the uncertainty of the predictions, achieving a 98.2% interval coverage rate at a 95% confidence level. To verify the generalization performance, three model interpretability methods were employed to ensure consistency between the black-box model and domain knowledge. Finally, using the proposed model, we constructed the first continental-scale dataset of atmospheric chloride deposition rates across mainland China which includes uncertainty quantification. This dataset can serve as a preliminary input for scholars in China for atmospheric corrosion prediction, maintenance protection, and material selection for equipment.

Keywords atmospheric corrosion; chloride deposition; holistic process; spatial distribution; uncertainty quantification.

Reference

[1] Chen, Q., Wang, H., Liu, Y., Shangguan, Y., Ma, X., & Cai, Y. (2024). Interpretable data-driven prediction methods for atmospheric chloride deposition rate. *Atmospheric Environment*, 334, 120687.