Project title: Development of high-resolution anthropogenic emission inventories (CINEIv2.1) and facilitation of atmospheric transport modeling

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Project Abstract: Anthropogenic emissions significantly influence atmospheric composition, air quality, and climate through complex interactions with meteorological processes. Current emission inventories often lack the spatial resolution and temporal accuracy needed for high-resolution Earth system modeling, particularly in rapidly changing industrial regions of East Asia, South America, and Africa. This limitation affects the reliability of both climate projections and air quality forecasting in these critical regions.

This project develops CINEI v2.1 (Coupled and Integrated Emission Inventory version 2.1), a next-generation high-resolution (0.1°) global anthropogenic emission inventory that integrates satellite observations (TROPOMI NO_2, HCHO) with ground-based measurements using machine learning techniques. Building upon our published CINEI v1.1 inventory (Zhang et al., 2025; DOI: 10.1594/PANGAEA.974347), the enhanced version will provide temporally resolved emission estimates with uncertainty quantification for eight major emission sectors.

The test project phase will establish the computational infrastructure on Levante and conduct preliminary development activities:

- Implementation of satellite data preprocessing workflows using TROPOMI Level-2 products
- Development of XGBoost-based emission adjustment algorithms incorporating meteorological variables
- Testing of conservative regridding procedures maintaining mass balance for integration with climate models
- Preliminary validation through WRF-Chem simulations over selected test regions

This work is conducted in collaboration with the Max Planck Institute for Meteorology (MPI-M) and supports the German climate modeling community (Zhang et al., 2025; Pachón et al., 2024), including ICON (ICOsahedral Nonhydrostatic) model development and applications (Pham et al., 2021). The enhanced inventory will enable more accurate representation of aerosol-cloud-climate interactions and atmospheric chemistry processes in coupled simulations, directly benefiting DKRZ's climate modeling activities and contributing to CMIP7 preparations.

The test project establishes the foundation for the comprehensive CINEI v2.1 development planned for submission during the September-October 2025 application period.

References:

Pham, T. V., Steger, C., Rockel, B., Keuler, K., Kirchner, I., Mertens, M., Rieger, D., Zängl, G., and Früh, B. (2021). ICON in Climate Limited-area Mode (ICON release version 2.6.1): a new regional climate model, Geoscientific Model Development, 14, 985–1005, https://doi.org/10.5194/gmd-14-985-2021

Pachón, J. E., Opazo, M. A., Lichtig, P., Huneeus, N., Bouarar, I., Brasseur, G., Li, C. W. Y., Flemming, J., Menut, L., Menares, C., Gallardo, L., Gauss, M., Sofiev, M., Kouznetsov, R., Palamarchuk, J., Uppstu, A., Dawidowski, L., Rojas, N. Y., Andrade, M. D. F., Gavidia-Calderón, M. E., Delgado Peralta, A. H., and Schuch, D. (2024). Air quality modeling intercomparison and multiscale ensemble chain for Latin America, Geoscientific Model Development, 17, 7467–7512, https://doi.org/10.5194/gmd-17-7467-2024

Zhang, Y., Brasseur, G., Kanakidou, M., Granier, C., Daskalakis, N., Panagiotis Poulidis, A., Qu, K., and Vrekoussis, M. (2025). Towards an integrated inventory of anthropogenic emissions for China, EGUsphere, 2025, 1–33, https://doi.org/10.5194/egusphere-2025-268