Project: **1554**

Project title: **High-Resolution Integrated Anthropogenic Emission Inventories (CINEI v2.1) for Next Generation Kilometer-Scale Earth System Models**

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Report period: **2025-11-01 to 2026-10-31**

Progress

The project builds a satellite-informed, 5 km (0.05°) anthropogenic emission inventory for China (CINEI v2) and uses it to drive ICON-ART at 5 km (Figure 1). The chain is orchestrated from Levante: satellite processing is dispatched to Google Earth Engine cloud computing and its results stream back to /work automatically, ERA5 is read from the DKRZ pool, and only machine learning, the emission product and ICON-ART run on Levante.

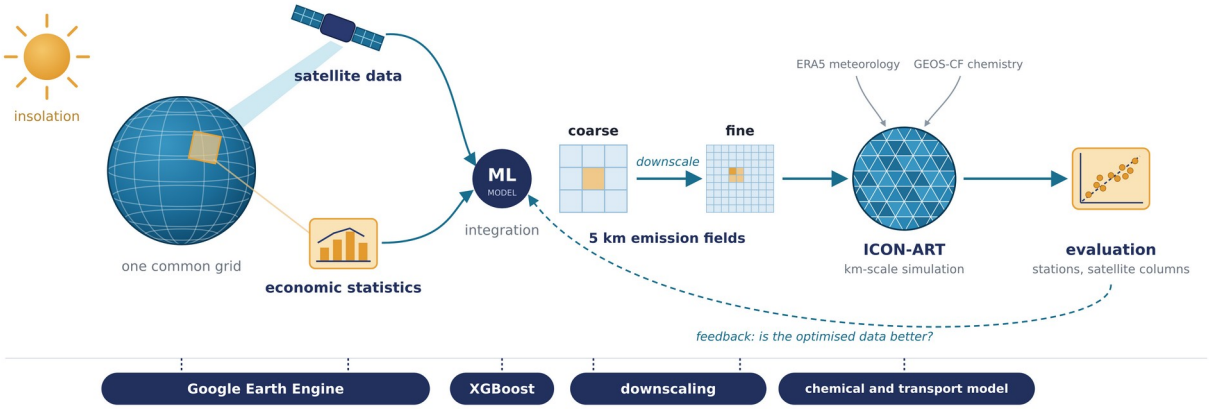


Figure 1. Workflow: satellite data (TROPOMI, VIIRS, MODIS, Sentinel and Landsat land cover) and statistics on one 0.05° grid, machine-learning downscaling to 5 km emission fields, ICON-ART km-scale simulation with ERA5 and GEOS-CF, and evaluation feeding back into the emission model The bar below names the tool used at each step: Google Earth Engine for the satellite data, XGBoost for the machine learning, downscaling to 5 km, and ICON-ART as the chemistry and transport model.

Emissions. A 43-feature stack (2019 to 2025, monthly) feeds XGBoost models validated with provincial cross-validation. The 2020 NOx product (six sectors) is mass-closed to provincial totals (closure 1.000000, 20.97 Tg) and recovers the power-plant share (14.1 %, MEIC 15.5 %). A transport-aware TROPOMI feature (DDf) places plant emissions in the correct 5 km cell for 83 catalogue-blind plants (mean weight 0.68 against 0.25 by chance), and the out-of-sample prediction ranks 117 plants against satellite top-down estimates better than its training target (Spearman +0.61 against +0.53). NMVOC (2021 to 2023) and CO companions exist; the **5 km NOx data are ready for delivery now**.

ICON-ART. ICON 2025.10 with ART runs as a 5 km limited-area model over China (1,008,236 cells, 80 levels) with a 50 km twin, ERA5 and GEOS-CF boundaries and CINEI emissions through OEM; meteorology agrees with 379 stations (2 m temperature r = 0.956). Four input pitfalls were documented (e.g. an 8 h UTC shift of diurnal profiles). Two tracer-advection defects at jet-level Courant numbers were diagnosed; the defect is weather-dependent, and two fixes (beta_fct = 1.0, ihadv = 22) are being confirmed. A pre-registered test against TROPOMI NO2 reached its SUCCESS band. Members with identical totals separate emission resolution, inventory pattern and model resolution (Figures 2 and 3).

Chemistry. The simplified ART OH reaches only about 5 % of GEOS-CF OH in winter, so a reduced mechanism was derived in CAABA/MECCA with its developer: 34 species and 91 reactions reproduce the 641-species MOM mechanism (score 0.24, MOZART 0.72), and a first ICON-ART coupling at 50 km conserves nitrogen to 0.03 %.

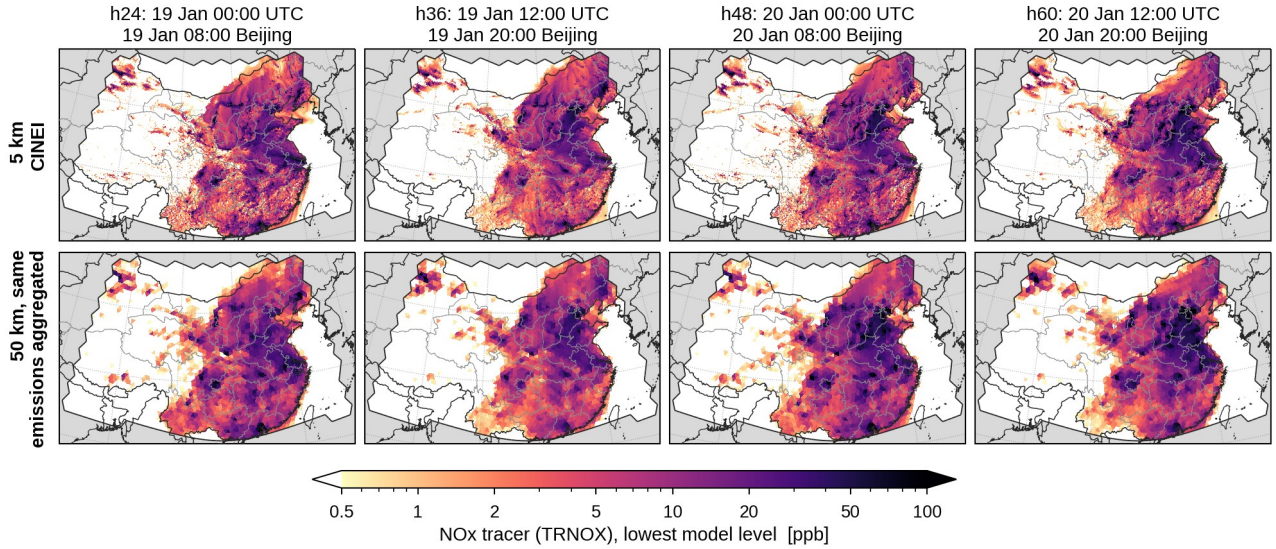


Figure 2. ICON-ART near-surface NOx tracer at 5 km with CINEI emissions (top) and in the 50 km twin with the same emissions aggregated (bottom), forecast hours 24 to 60, 19 to 20 January 2021.

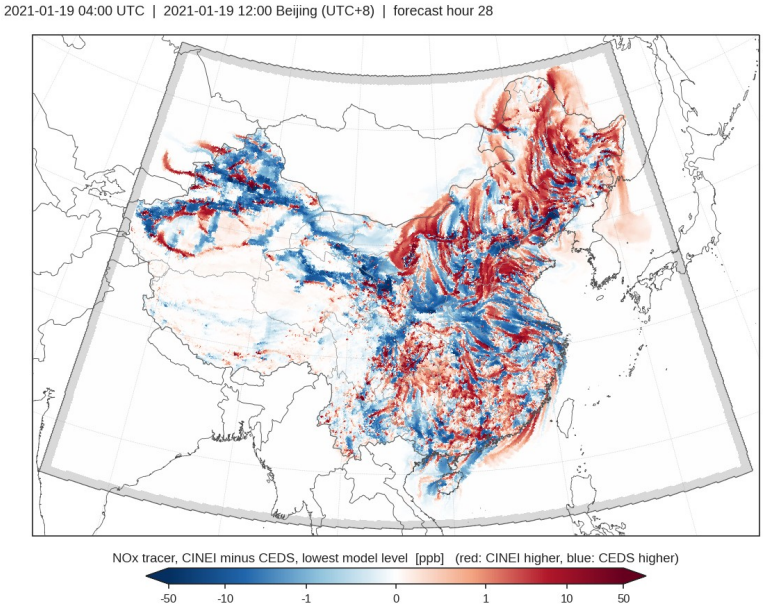


Figure 3. CINEI minus CEDS near-surface NOx at 5 km with identical sector totals (red: CINEI higher, blue: CEDS higher).

Use of resources

CPU: 5,304 of 7,308 node-hours used (73 %; 4,560 were added on 1 July). GPU: 197 of 322 (61 %); ICON-ART chemical tracers are not GPU-enabled. Disk: 5 of 46 TiB; archive not yet used. Under-use came from building the chain with short gated test runs, a limited-area grid dependency outside DKRZ that delayed 5 km production to September, the transport defects, and the inadequate simplified chemistry, which made long chemistry runs pointless until the reduced mechanism existed. Satellite processing ran in the cloud at practically no Levante cost.

Delivery, collaboration and publication

The 5 km NOx data will be published through the DKRZ data centre (WDCC) and delivered, with the simulation protocol and results, to the global km-scale modelling hackathon. The seamless satellite, emission and modelling workflow (Earth Engine exports, XGBoost downscaling, emission products, ICON-ART set-up and analysis) is recorded in GitHub repositories, currently private, and will be delivered to the DKRZ data centre together with the data. In collaboration with G. A. Hoshyaripour (KIT, ICON-ART), R. Sander (MPIC, CAABA/MECCA), L. Constantin (Empa, emiproc), the POMINO team (Peking University) and BIRA-IASB. Planned: a paper on the seamless satellite to emission to ICON-ART km-scale simulation (GMD or JAMES) and one on the reduced mechanism (GMD). Published: CINEI v1.1, GMD 19, 217, 2026.