Simulation of Neighborhood-Scale Air Quality Over the Washington D.C. Metropolitan Area

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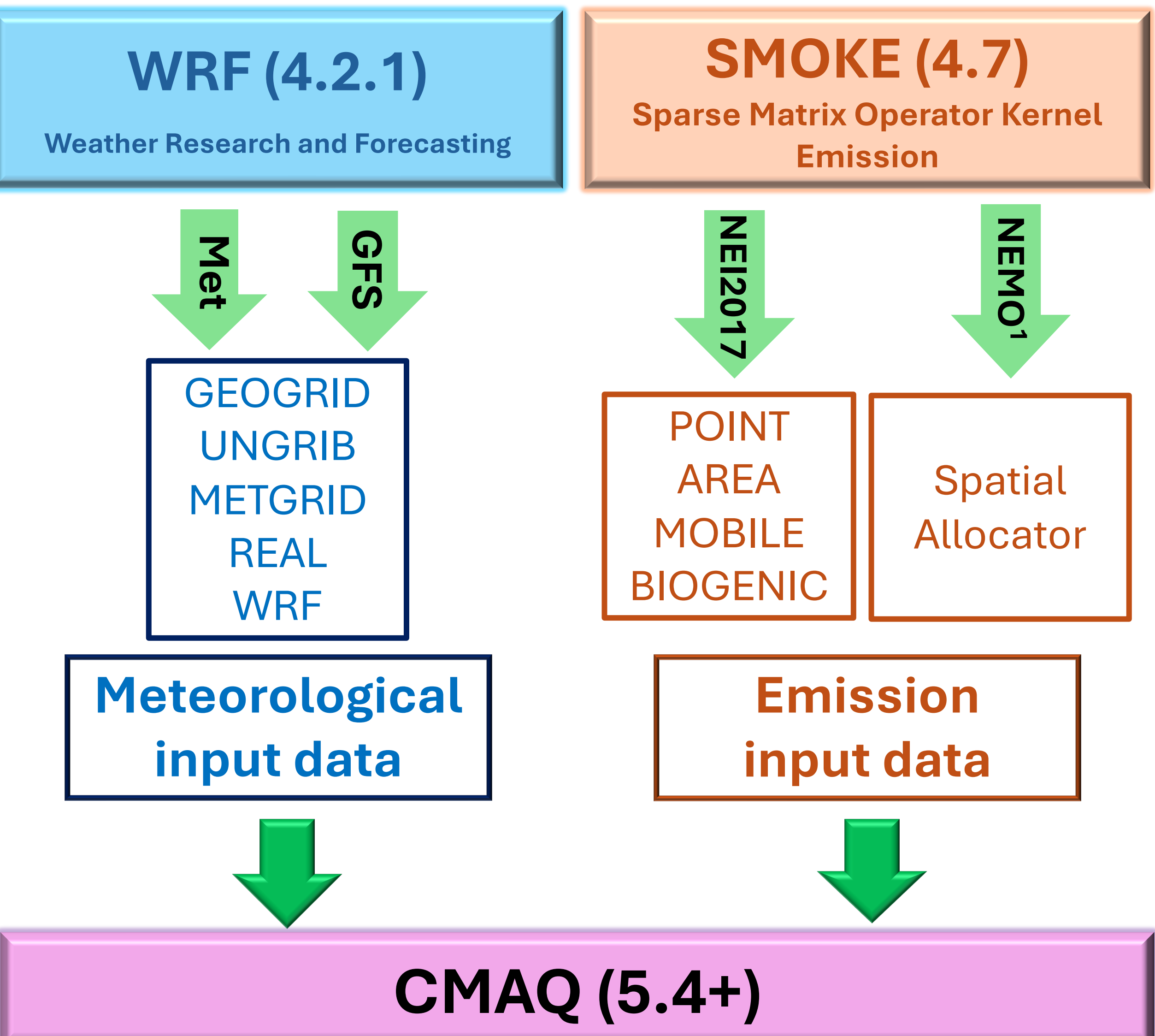
BACKGROUND AND MOTIVATION

➤ Improving neighborhood air quality is vital for public health in dense urban areas.

➤ Fine-scale models help identify pollution patterns and support targeted health and equity policies.

➤ New NIH-funded REACH Climate and Health Center will bridge big data with climate solutions that advance health and environmental justice

➤ Multiple strategies, including air quality and transportation policies, are essential for reducing emissions and improving urban air quality.
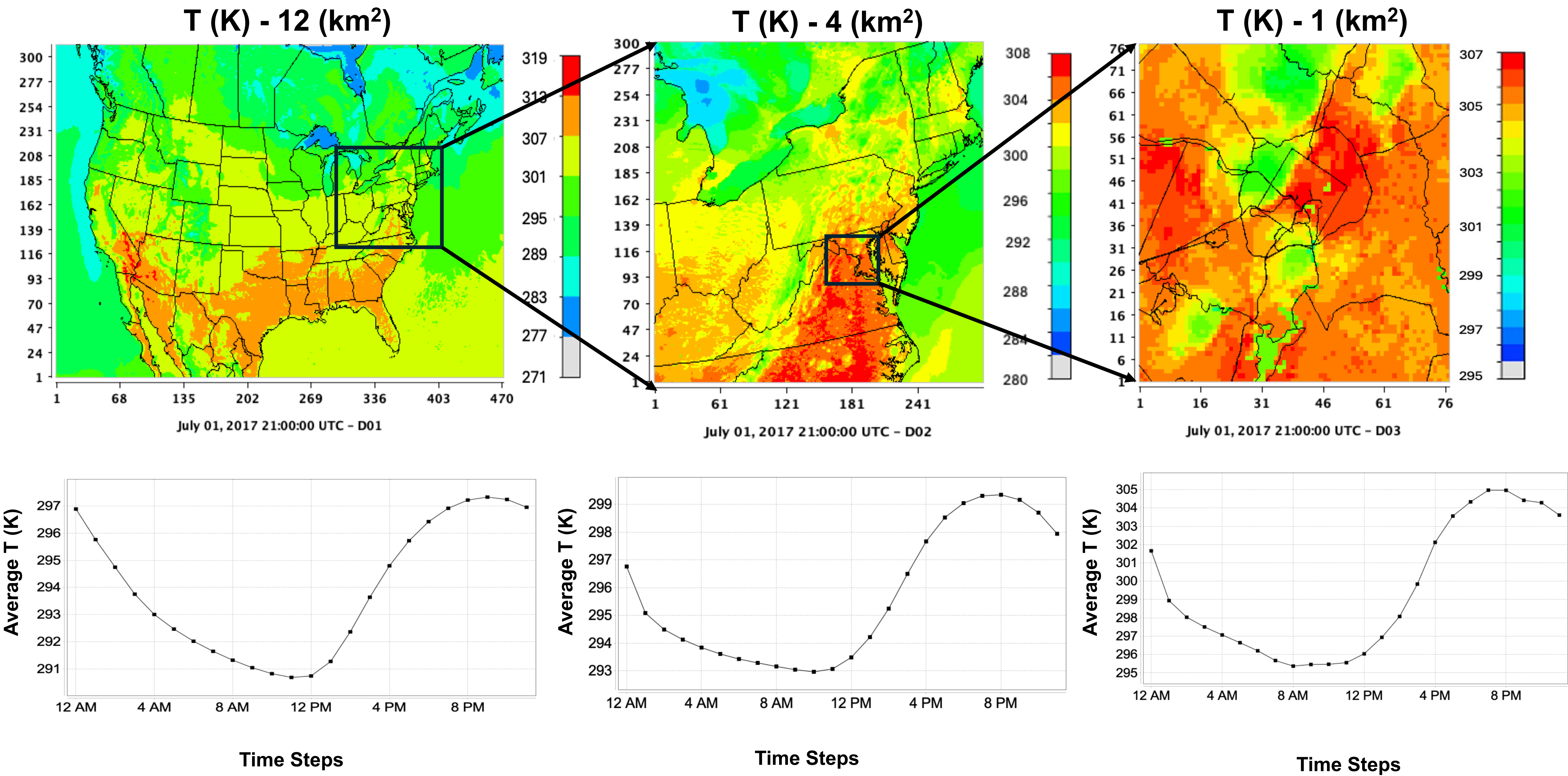
OBJECTIVE

• Quantify air quality, exposure, health, and equity implications of proposed road pricing strategies in Washington, DC

• Assess road pricing impacts at various geopolitical scales important to policymakers

• Work closely with community stakeholders on project planning, implication and results.

WORKFLOW

WRF (4.2.1) — Weather Research and Forecasting

SMOKE (4.7) — Sparse Matrix Operator Kernel Emission

Met, GFS → GEOGRID UNGRIB METGRID REAL WRF → **Meteorological input data**

NEI2017, NEMO[1] → POINT AREA MOBILE BIOGENIC, Spatial Allocator → **Emission input data**
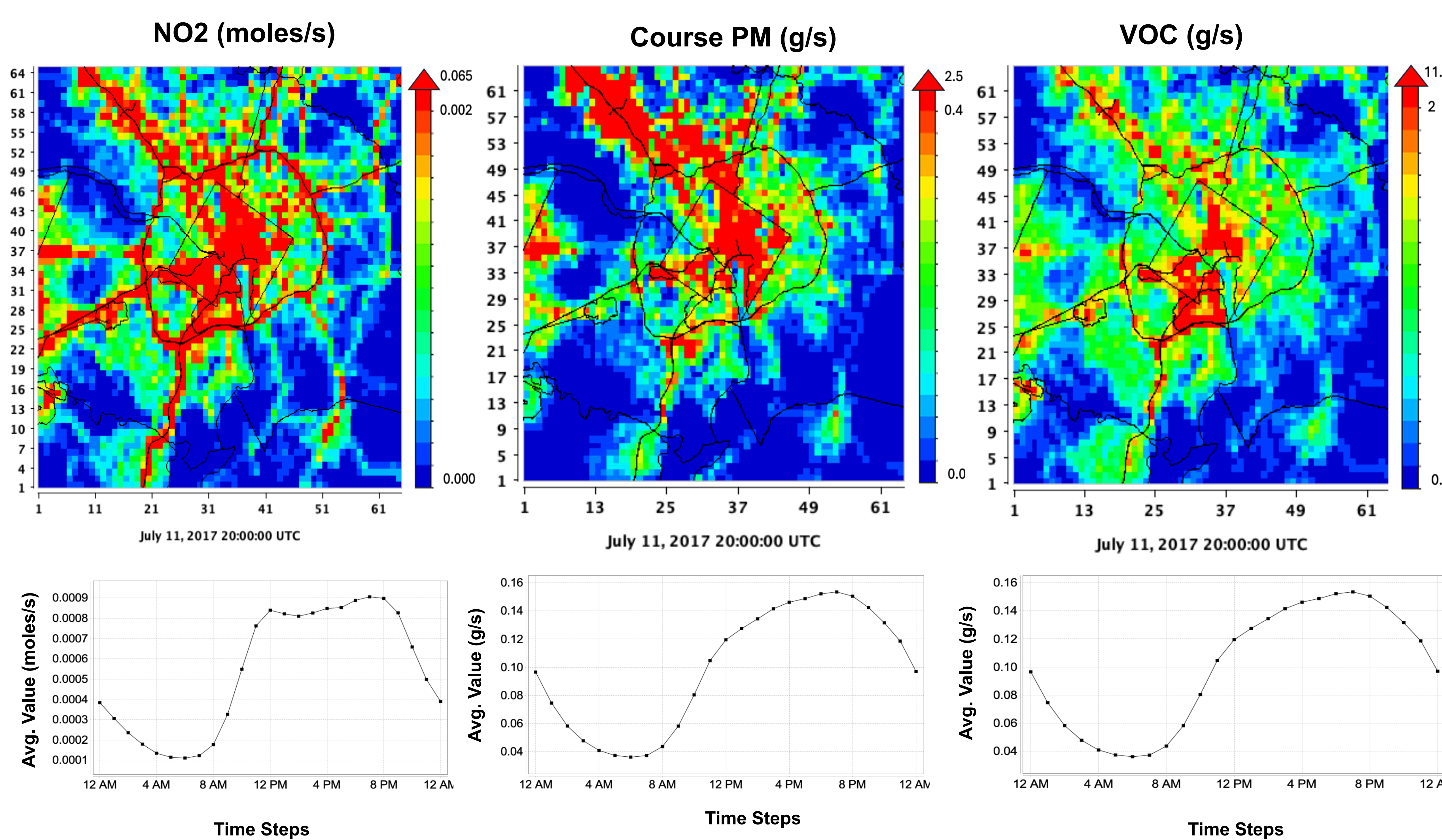
→ **CMAQ (5.4+)**

[1] Ma, Siqi, and Daniel Q. Tong. "Neighborhood Emission Mapping Operation (NEMO): A 1-km anthropogenic emission dataset in the United States." *Scientific Data* 9, no. 1 (2022): 680.

METEOROLOGICAL DATA

T (K) - 12 (km²) — July 01, 2017 21:00:00 UTC – D01

T (K) - 4 (km²) — July 01, 2017 21:00:00 UTC – D02

T (K) - 1 (km²) — July 01, 2017 21:00:00 UTC – D03

❖ The fine-scale meteorological data captures the local dynamics crucial for accurately simulating air quality at the neighborhood level.

1 (km²) EMISSION DATA

NO2 (moles/s) — July 11, 2017 20:00:00 UTC

Course PM (g/s) — July 11, 2017 20:00:00 UTC

VOC (g/s) — July 11, 2017 20:00:00 UTC

Emissions Sources Classification

point								nonpoint								mobile	biogenic
airports	cmv_c1c2	cmv_c3	ptagfire	ptegu	ptfire_rx	ptfire_wild	ptnonipm	pt_oilgas	afdust	fertilizer	livestock	nonpt	nonroad	np_oilgas	np_solvent	rail	rwc	onroad	BEIS

Legend: NEMO (green), NEI2017 (pink), CMAQ (blue)

RESULTS CONTINUED

✓ Nested domains (12, 4, and 1 (km²)) captured neighborhood-level meteorological variations in Washington D.C.

✓ NEMO, provides a 1 (km²) resolution anthropogenic emission dataset for the U.S. It includes hourly and annual emissions from nine sectors. Used NEMO combined with the NEI 2017 to generate high-resolution vehicular and industrial emissions for air quality models.

✓ The 1 (km²) resolution identified pollutant hotspots near roadways and industrial zones, supporting evaluation of localized policy impacts.

NEXT STEPS

➤ Traffic and Emissions Impact Analysis:
Apply travel demand modeling to quantify traffic changes and use the MOVES model to estimate emissions impacts under different road pricing scenarios.

➤ Model Validation:
Compare model outputs with observed air quality data from monitoring stations to ensure accuracy at the 1 (km²) resolution.

ACNOWLEDMENT

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