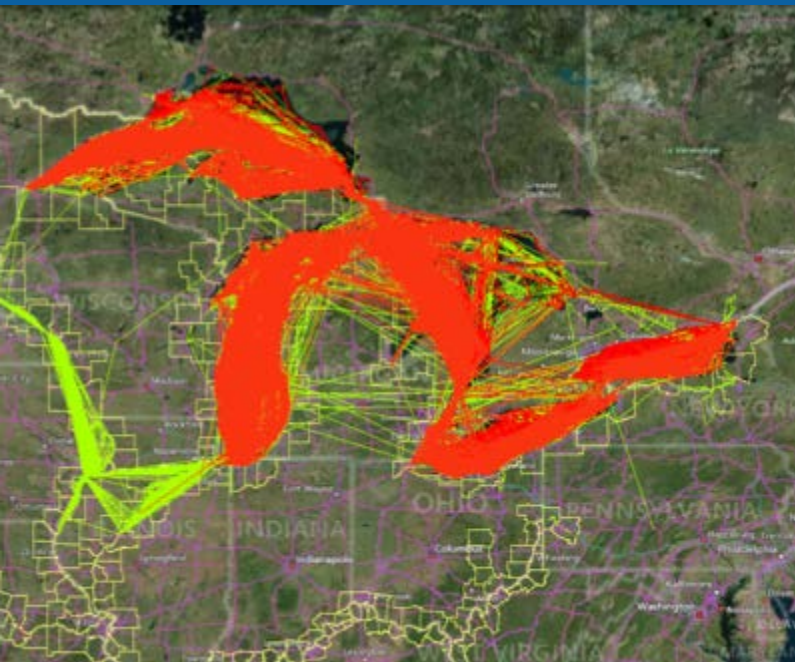# Simulating Emissions from Commercial Marine Vessels: An Approach for Using Transponder Data in Emissions Modeling

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Commercial Marine Vessels (CMV) in the Great Lakes

- Air quality modeling shows that CMV sources are large contributors to local and regional ozone around the Great Lakes

- CAMx source apportionment indicates CMV sources can contribute > 10 ppb ozone locally and 2-4 ppb ozone regionally on an hourly basis

- Motivation for improving how CMV emissions are represented in PGMs
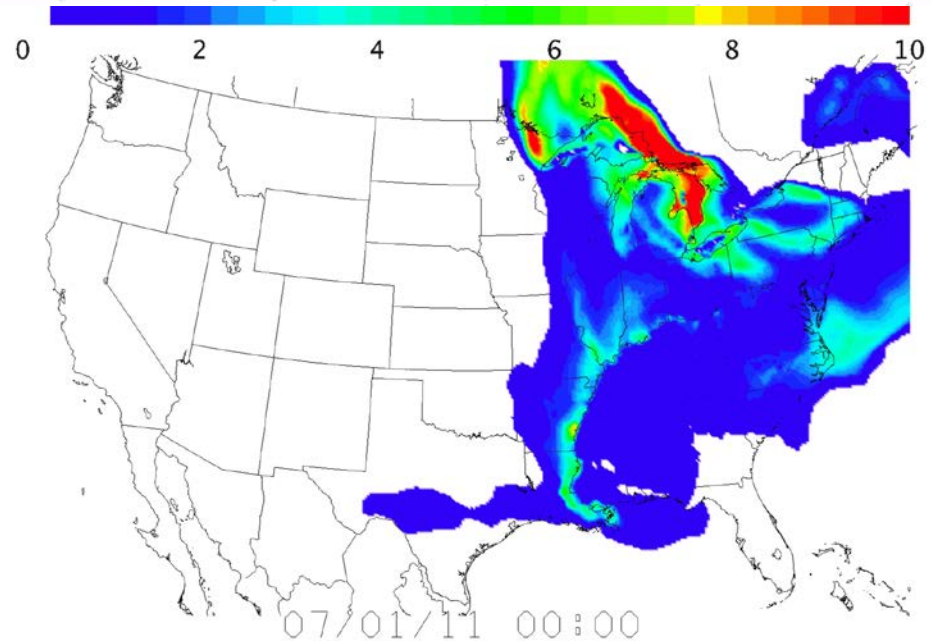
**CAMx OSAT Hourly Ozone (ppb) from Great Lakes and Midwest Rivers CMV**

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Background on CMV Inventories

- NEI uses nonpoint and point inventories to represent CMV sources

  - Nonpoint inventories use spatial surrogates of shipping lanes to place annual, county total inventories in modeling grids

  - Point inventories are based on 3D gridded data of ship locations

  - Flat temporal profiles

- GIS Transponders on ships provide an opportunity to improve spatial and temporal characterization of CMV emissions

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Transponder Data for CMV Sources

❑ Automatic Identification Systems (AIS) are supplemental collision avoidance equipment that broadcast real-time ship identity, type, position, speed, and course

❑ Most commercial marine vessels (CMV) are required to use AIS

❑ Archived broadcast data for vessels with AIS transponders
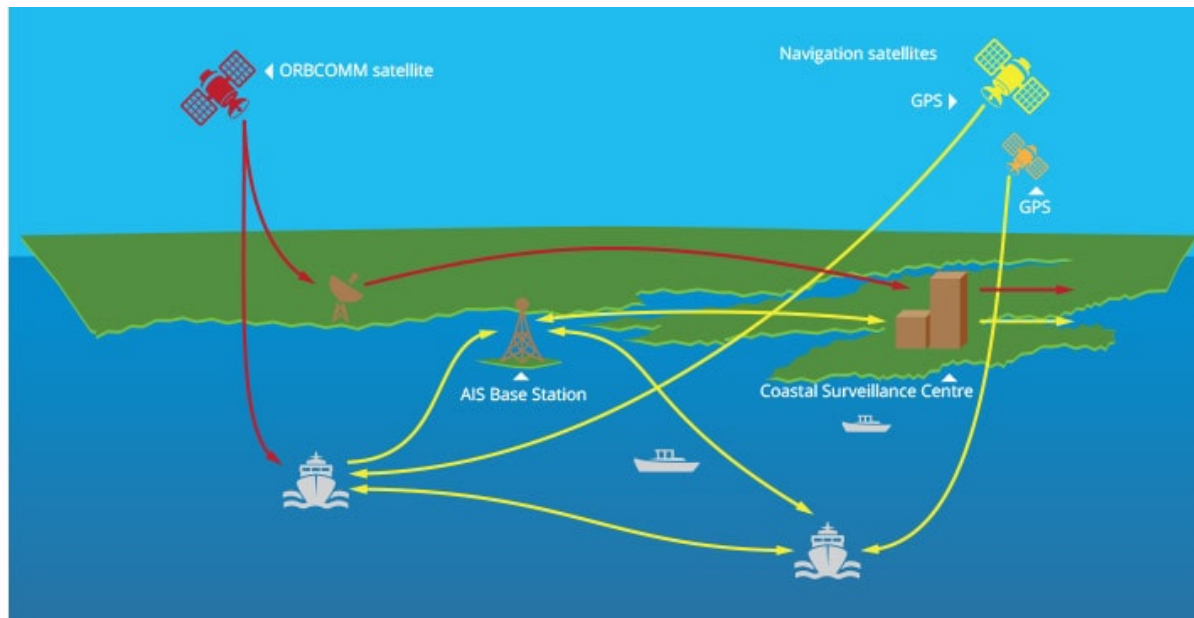
Project Approach

- Lake Michigan Air Directors Consortium (LADCO) used 2014 AIS data from marinetraffic.com to develop an inventory of CMV sources in the Great Lakes
  - Emissions estimated using vessel gross tonnage, engine rating, fuel consumption, and pollutant-specific emissions factors
- **Objective**: Process the 2014 CMV inventories for photochemical grid modeling that preserves as much of the spatial and temporal resolution of the AIS data as possible

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2014 CMV Inventory

- CMV sources binned into three operating modes
  - Hoteling (operations while stationary) at ports/docs
  - Maneuvering at ports
  - Underway/Cruising
- AIS data → linked line sources
- Data scrubbing performed to identify and eliminate bad vessel tracks (e.g. tracks traversing land)
- SCCs assigned to 48 vessel-mode combinations (e.g. cargo-cruise, fishing-maneuver, tanker-hotel)
  - Plume top/bottom assigned to elevated CMV sources
- New data format developed for link-level inventory

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Link Data Inventory Format

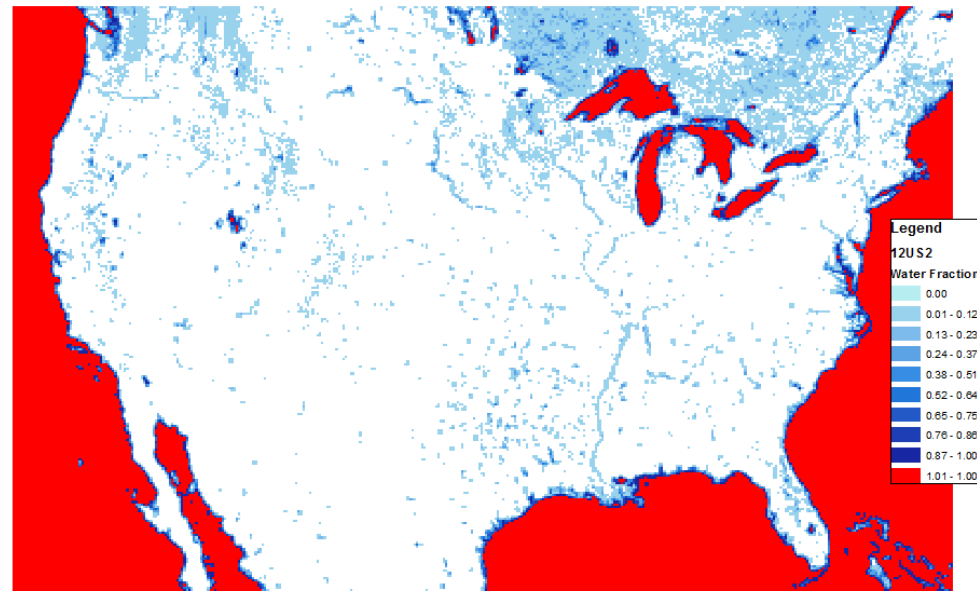| Field	Units	Description
Country Code	Character (2)	Two-digit country code: Default to "US"
FIPS	Character (5)	Five-digit FIPS code for state and county
SCC	Character (10)	Source Category Code
Vessel ID	Character (15)	Vessel Identification number
Segment ID	Character (15)	Sequential number for each segment (link)
STKHGT	Real	Stack Height (ft) (optional)
STKDIAM	Real	Stack Diameter (ft) (optional)
STKTEMP	Real	Stack Temperature (^{o}F) (optional)
STKFLOW	Real	Stack Gas Flow Rate (ft3/sec) (optional)
STKVEL	Real	Stack Gas Exhaust Velocity (ft/sec) (optional)
SEGMENT_MONTH	Integer	Month at the beginning of the Segment
SEGMENT_DAY	Integer	Day at the beginning of the Segment
SEGMENT_YEAR	Integer	Year at the beginning of the Segment
SEGMENT_HOUR	Integer	Hour at the beginning of the Segment (GMT)
SEGMENT_MIN	Integer	Minute at the beginning of the Segment (GMT)
SEGMENT_SEC	Integer	Second at the beginning of the Segment (GMT)
SEGMENT_TIME	Integer	Segment travel duration in unit of second
TRACK_DISTANCE	Miles	Total Ground Projected Track Distance (optional)
LATITUDE	Degrees	Latitude at the beginning of the Segment
LONGITUDE	Degrees	Longitude at the beginning of the Segment
ALTITUDE	Meters	Altitude MSL of fleet stack
CO	Grams	Mass of CO
TOG	Grams	Mass of TOG
...	Grams	...

- New SMOKE inventory format
- Time-resolved (down to the second)
- Emissions links with start/end coordinates
- Plume rise: "Stack" height and parameters
- Unique vessel IDs

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Linkproc

- New SMOKE processor to convert inventory to PGM-ready emissions
- Single step processing: reads inventory and outputs CMAQ-formatted netCDF file.
- Reporting capabilities
- Scaling factor functionality
  - By FIPS, SCC, Pollutant
- Water mask functionality
  - If the water fraction in a grid cell is less than a threshold, the emissions for that cell will optionally be moved to the nearest cell that is above the threshold
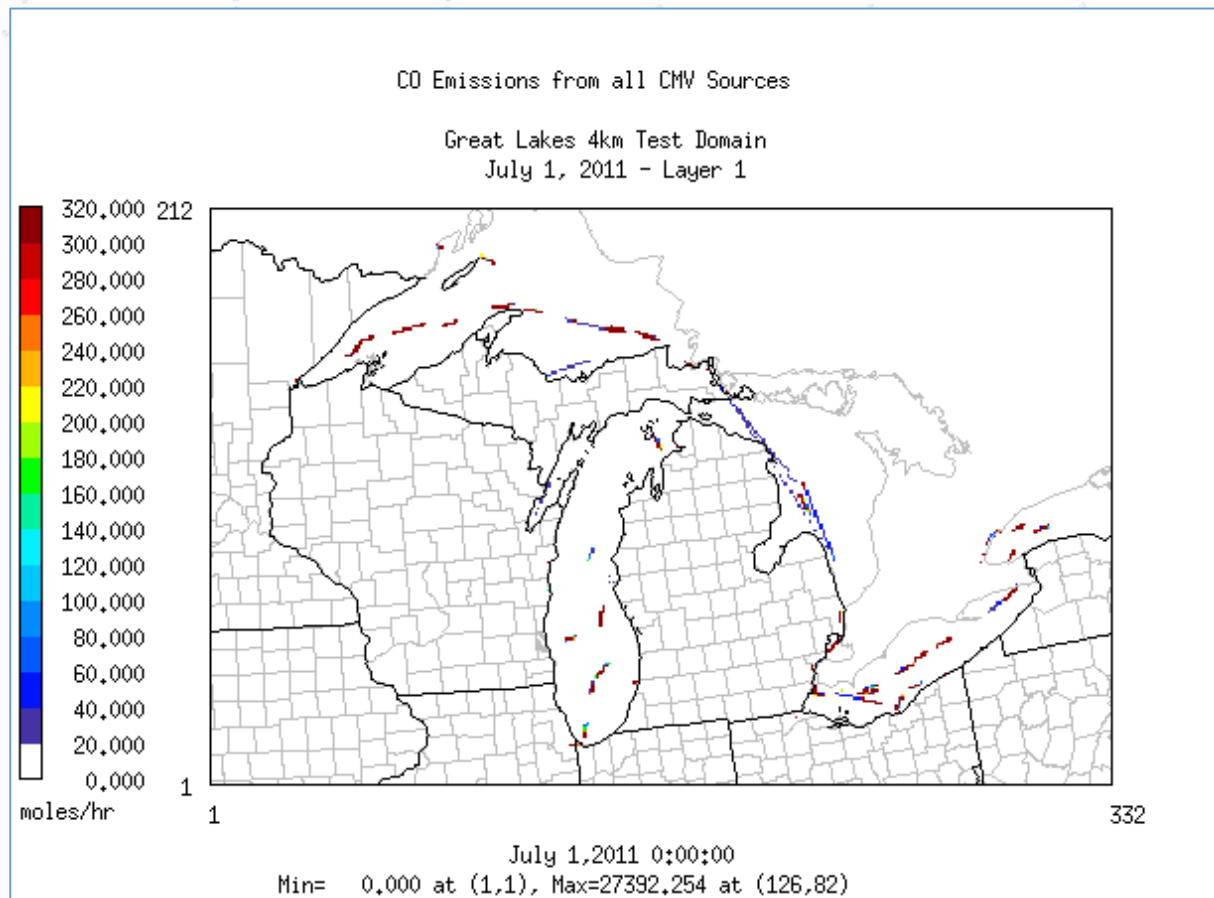
12km CONUS Water Fraction

Legend
12US2
Water Fraction
0.00
0.01 - 0.12
0.13 - 0.23
0.24 - 0.37
0.38 - 0.51
0.52 - 0.64
0.65 - 0.75
0.76 - 0.86
0.87 - 1.00
1.01 - 1.00

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Example Hourly Emissions July 1, 2011 CO @ 4km

Results and Future Work

❑ Hourly, gridded CONUS12 km 2014 Great Lakes and Midwest Rivers CMV emissions delivered to LADCO

❑ Documentation describes how to prepare and process data through Linkproc, including how to create a water mask for a new domain

❑ Future work will add vertical allocation process into Linkproc (currently needs to be done with a separate processor: Layalloc)

❑ Other sources with AIS tracking (rail) or link-level inventory (onroad mobile) could be simulated with Linkproc

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Acknowledgements

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❑ <u>Ramboll Environ</u>: Provided guidance on layer heights for different ship types and comments on the proposed approach to model these sources

❑ <u>ENERCON</u>: Developed the CMV inventory for LADCO

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