Marine Emissions Inventory Development for Modeling

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Presented at the HGB Air Quality Technical Information Meeting on July 28, 2022
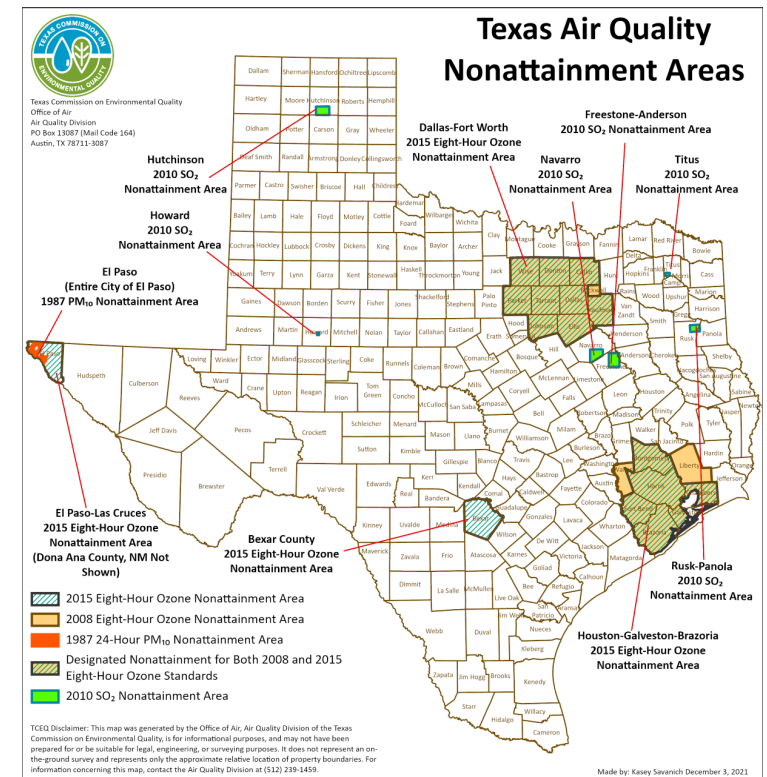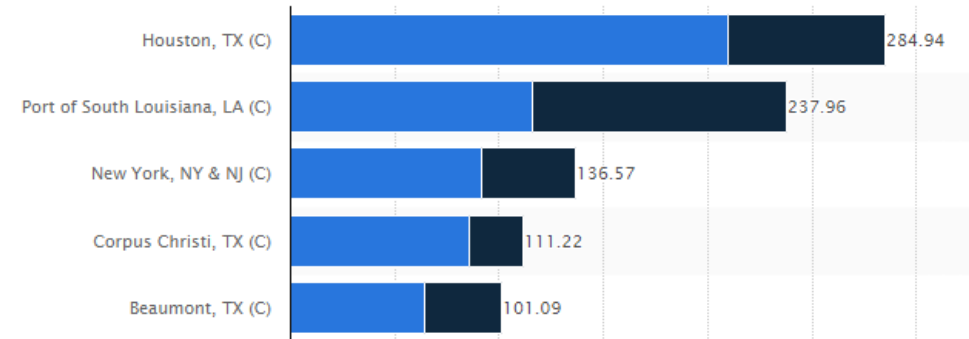
Marine Emissions: Purpose

Texas and Gulf Coast are home to busy shipping lanes and nation's busiest ports.

The Houston-Galveston-Brazoria (HGB) ozone nonattainment area has significant shipping activity.

Commercial Marine Vehicle (CMV) emissions essential to quantify, understand, and project in future years.

Leading ports in the United States in 2019, by tonnage
(in million tons)

Port	Tonnage
Houston, TX (C)	284.94
Port of South Louisiana, LA (C)	237.96
New York, NY & NJ (C)	136.57
Corpus Christi, TX (C)	111.22
Beaumont, TX (C)	101.09

Texas Air Quality Nonattainment Areas

Texas Commission on Environmental Quality
Office of Air
Air Quality Division
PO Box 13087 (Mail Code 164)
Austin, TX 78711-3087

Hutchinson 2010 SO₂ Nonattainment Area

Howard 2010 SO₂ Nonattainment Area

El Paso (Entire City of El Paso) 1987 PM₁₀ Nonattainment Area

Dallas-Fort Worth 2015 Eight-Hour Ozone Nonattainment Area

Freestone-Anderson 2010 SO₂ Nonattainment Area

Navarro 2010 SO₂ Nonattainment Area

Titus 2010 SO₂ Nonattainment Area

El Paso-Las Cruces 2015 Eight-Hour Ozone Nonattainment Area (Dona Ana County, NM Not Shown)

Bexar County 2015 Eight-Hour Ozone Nonattainment Area

Rusk-Panola 2010 SO₂ Nonattainment Area

Houston-Galveston-Brazoria 2015 Eight-Hour Ozone Nonattainment Area

Legend:
- 2015 Eight-Hour Ozone Nonattainment Area
- 2008 Eight-Hour Ozone Nonattainment Area
- 1987 24-Hour PM₁₀ Nonattainment Area
- Designated Nonattainment for Both 2008 and 2015 Eight-Hour Ozone Standards
- 2010 SO₂ Nonattainment Area

TCEQ Disclaimer: This map was generated by the Office of Air, Air Quality Division of the Texas Commission on Environmental Quality, is for informational purposes, and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative location of property boundaries. For information concerning this map, contact the Air Quality Division at (512) 239-1459.

Made by: Kasey Savanich December 3, 2021

Marine Emissions: CMVs

Ocean-Going Vessels (OGVs)

- Container Ships, Cruise Ships, etc.
- Bigger C3 engines
- Move into and out of port

Harbor Craft

- Tugboats, Barges, Dredges, etc.
- Smaller engines (C1/C2)
- Remain in port
- Much more activity
- Less available ship data

Marine Emissions: Activity Types

- Transit/Underway: Vessels moving outside of restricted speed zone, electricity drawn from propulsion engine

- Maneuvering: Getting into and out of docked position, going slower, often with tugs, more auxiliary use

- Hotelling: Vessels docked or waiting to dock, propulsion engine is off, all needs met by auxiliary

Engine Function

- **Propulsion** engines (main engines) supply power to move the vessel

- **Auxiliary** engines supply power for non-propulsion (e.g., electrical) loads

- **Boilers** provide heat and steam on vessels for a variety of purposes

Activity Types: Houston
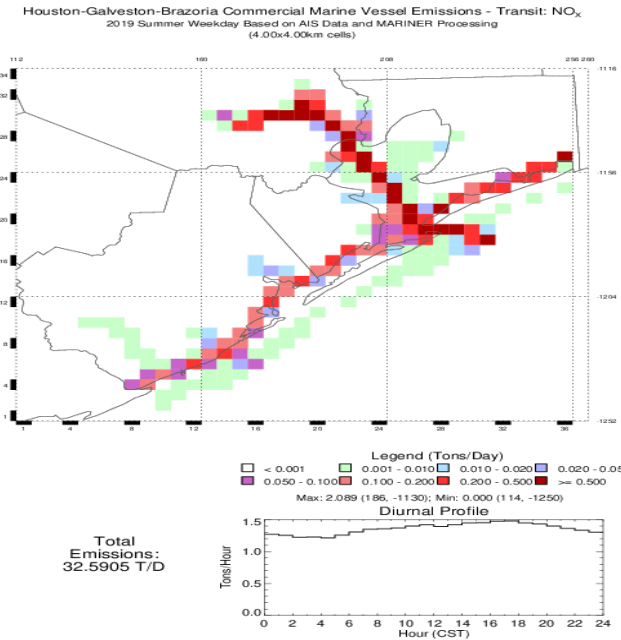
Transit Emissions (HGB)
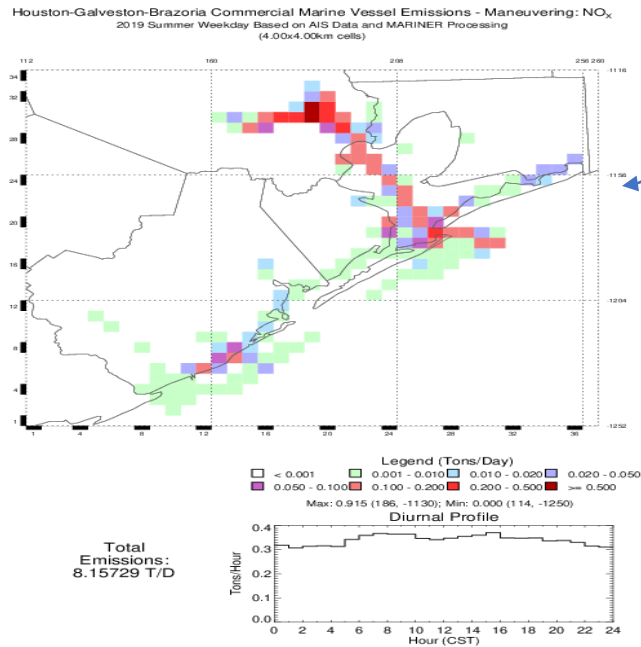
Maneuvering Emissions (HGB)
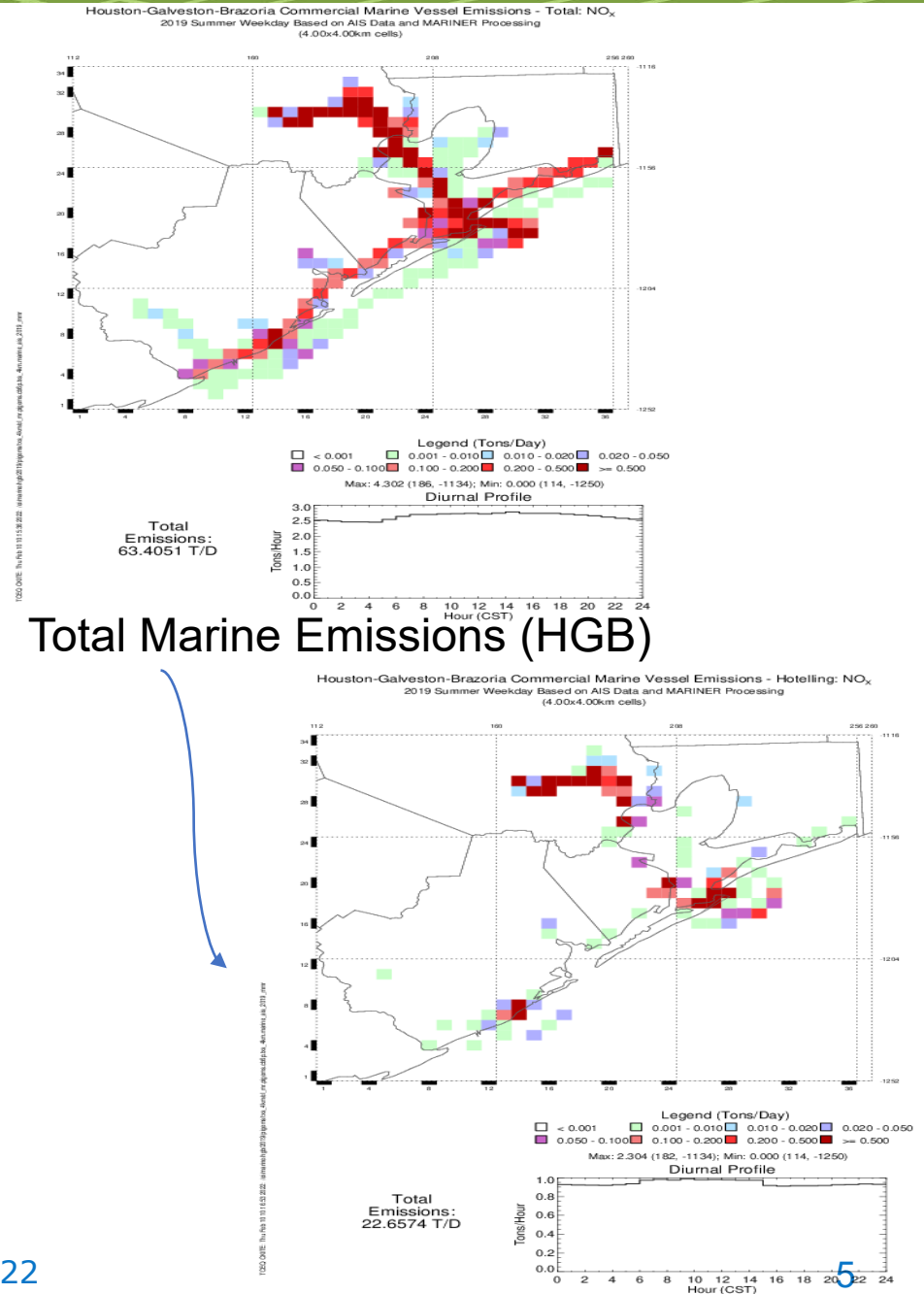
Total Marine Emissions (HGB)

Hotelling Emissions (HGB)

Marine Emissions: In the dark ages...

- Inventories required dedicated marine emissions studies, done periodically for different areas.

- Different areas had studies for different years.

- Most recent had to be projected to base year, patched together, then projected to future years.

- Until along came...

APPENDIX B

EMISSIONS MODELING FOR THE DFW AND HGB
ATTAINMENT DEMONSTRATION SIP REVISIONS FOR THE
2008 EIGHT-HOUR OZONE STANDARD

DALLAS-FORT WORTH SERIOUS CLASSIFICATION
ATTAINMENT DEMONSTRATION STATE IMPLEMENTATION
PLAN REVISION FOR THE 2008 EIGHT-HOUR OZONE
NATIONAL AMBIENT AIR QUALITY STANDARD

PROJECT NUMBER 2019-078-SIP-NR

Adoption
March 4, 2020

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Automatic Identification System (AIS)

- Real-time tracking system used for navigation

- Required on CMVs (C1, C2, C3) starting 2016

- Fine-scale location and speed data on all commercial vehicles every few minutes

- Used in US and international waters
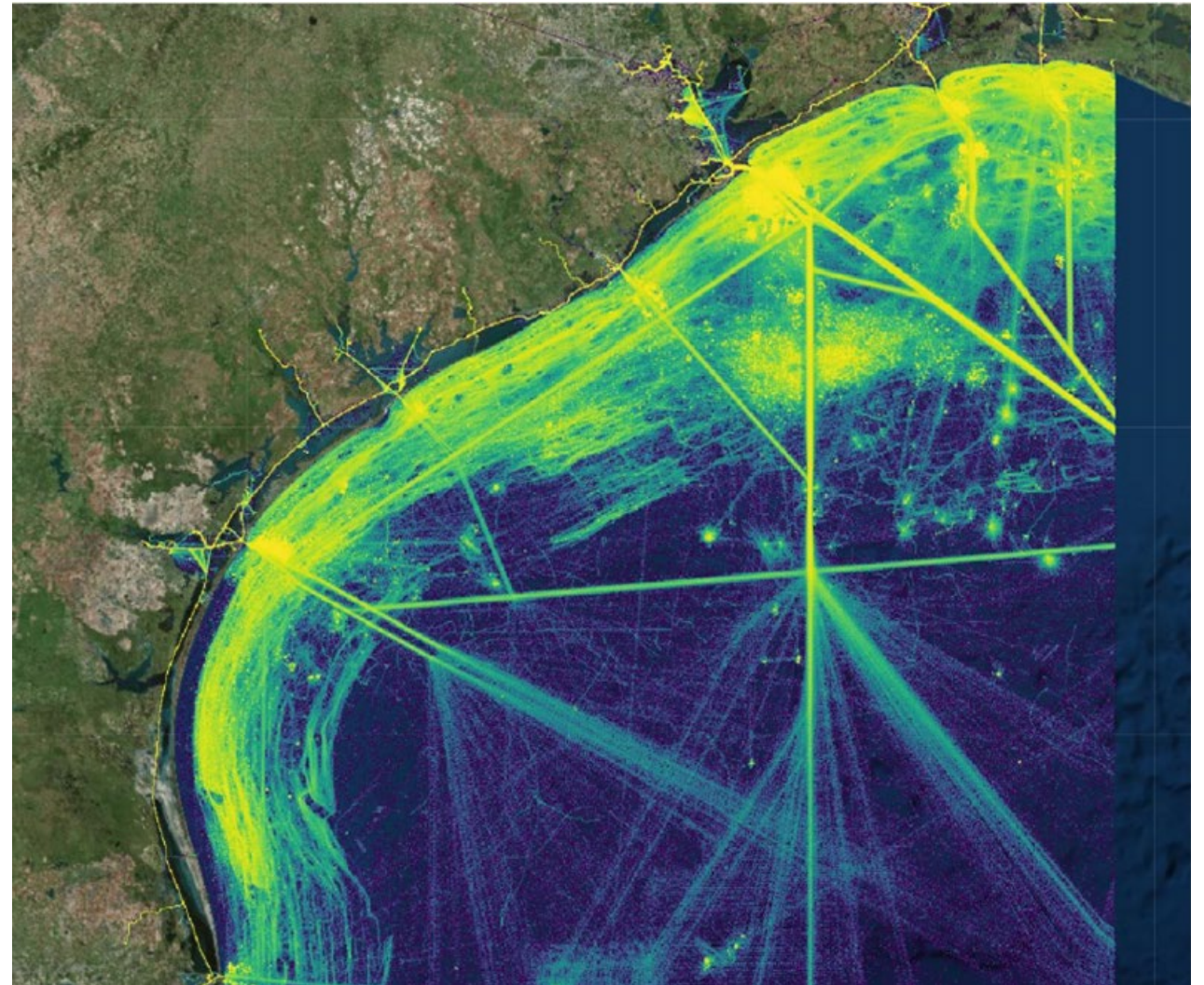
Image Courtesy of Ramboll

MARINER (Post-2020)

- FY2018 - Ramboll (nee Environ) generate marine EI for TCEQ using AIS data

- FY2020 - Ramboll contracted again to create a tool to automatically generate marine EIs from AIS data
  - Project manager: Chris Kite
  - **Marin**e **E**missions **R**esolver (MARINER) python tool created
  - Design follows the 2020 EPA draft guidance (EPA, 2020) on estimating port and marine emissions

- FY2022 – New project with Ramboll expands capabilities of MARINER and provides important updates
 - Project manager: Beata Czader
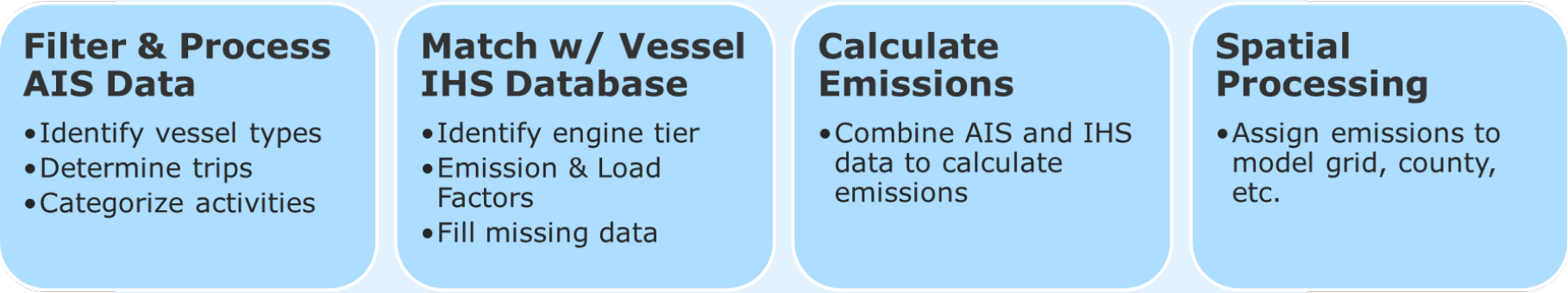
IHS Database

- World's largest maritime ships database
- **Over 200,000** vessels characterized
- Vessel size, age, type of cargo, and total capacity
- Fuel and exhaust scrubber types
- Main engine, auxiliary engine, and boiler specifications

Calculating Emissions

$$E = P \times A \times EF \times LLAF$$

Where
- E = per vessel emissions (g)
- P = engine operating power (kW)
- A = engine operating activity (h)
- EF = emission factor (g/kWh)
- $LLAF$ = low load adjustment factor, a unitless factor that reflects increasing propulsion emissions during low load operations (always 1 for auxiliary engines and boilers)

MARINER outputs

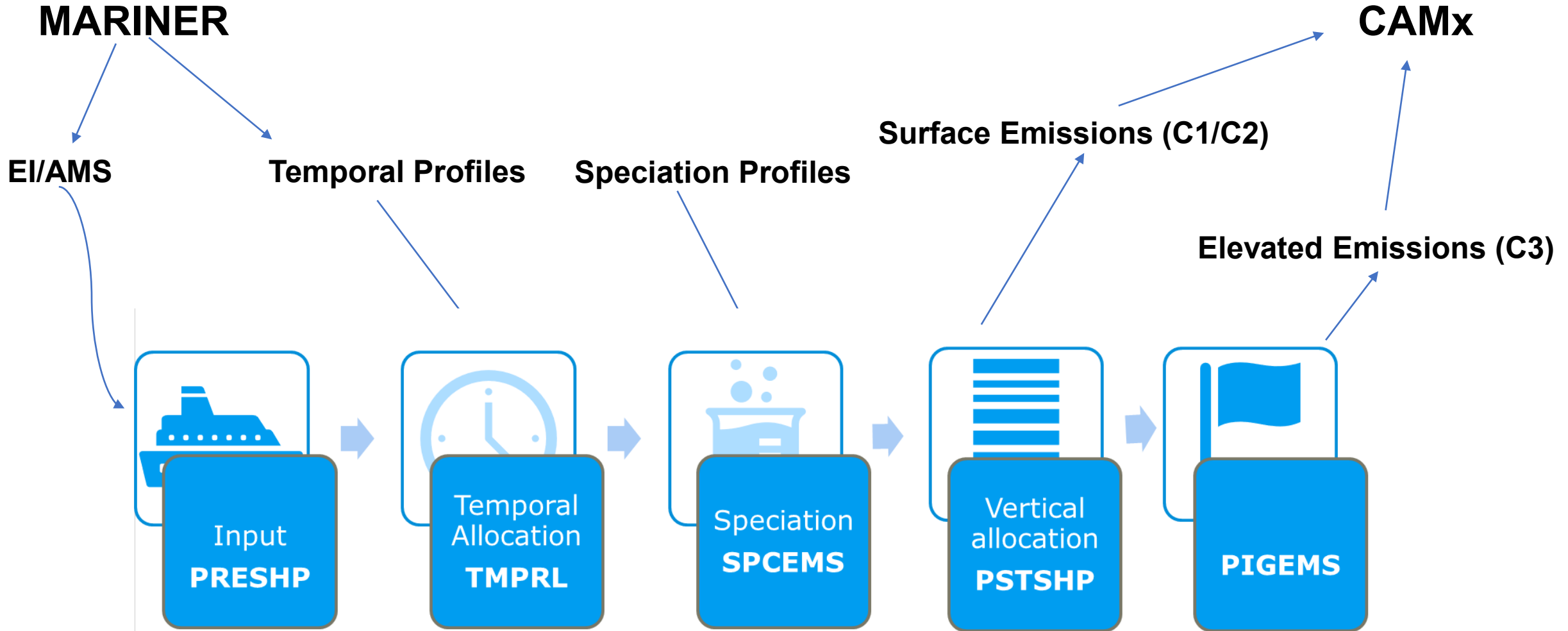Gridded output ready for PRESHP/EPS3
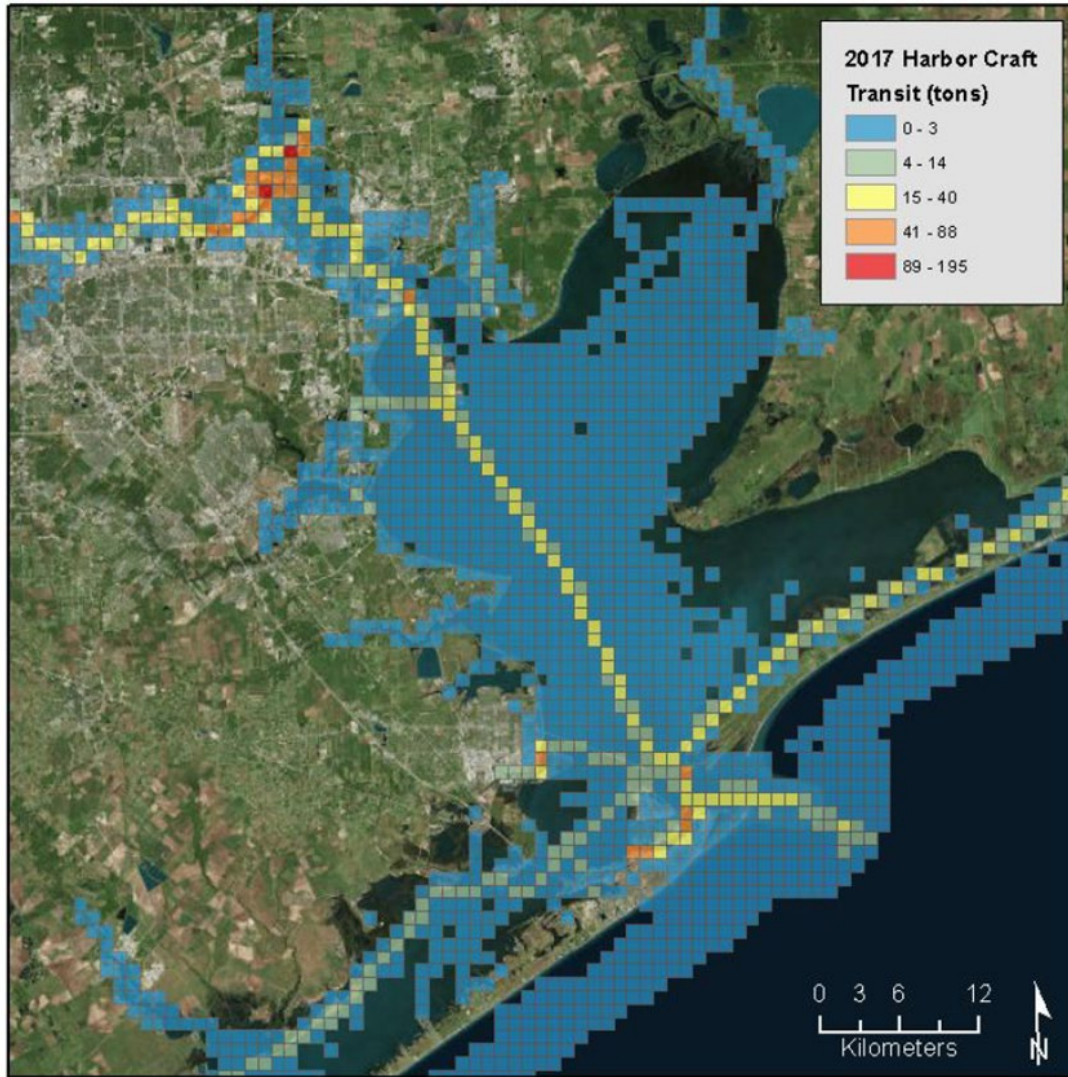
4-km Gridded Harbor Craft NOx Transit Emissions

- Capable of every ship, every hour, every day activity reports of actual emissions (below)
- For now, EPS3 modeling needs only aggregated gridded emissions (left) as a preshp file.

	A	B	C	D	E	F	G
1	VesselType	EPAShipType	VesselClass	SpeedBin	FIPS	Hour	NauticalMile
2	79	Container Ship	C3	3	85000	3.777222	54.36132
3	71	Container Ship	C3	1	48201	7.639444	0.450231
4	71	Container Ship	C3	2	48201	0.191667	0.451571
5	71	Container Ship	C3	3	48071	0.633611	7.7737
6	71	Container Ship	C3	3	48167	1.904444	27.83773
7	71	Container Ship	C3	3	48201	1.730556	14.18205
8	71	Container Ship	C3	3	85000	7.415556	151.8126
9	81	Chemical Tanker	C3	1	85000	23.89972	2.170933
10	52	Tug Boat	C1C2	1	22000	48.40778	1.842608
11	52	Tug Boat	C1C2	1	48007	4.665556	0.087026
12	52	Tug Boat	C1C2	1	48167	19.7575	0.929964
13	52	Tug Boat	C1C2	1	48201	35.91222	2.599125
14	52	Tug Boat	C1C2	1	48245	0.233056	0.056523
15	52	Tug Boat	C1C2	1	48355	47.94417	3.655926
16	52	Tug Boat	C1C2	1	48361	24.29333	1.714928
17	52	Tug Boat	C1C2	2	22000	1.374444	2.234892

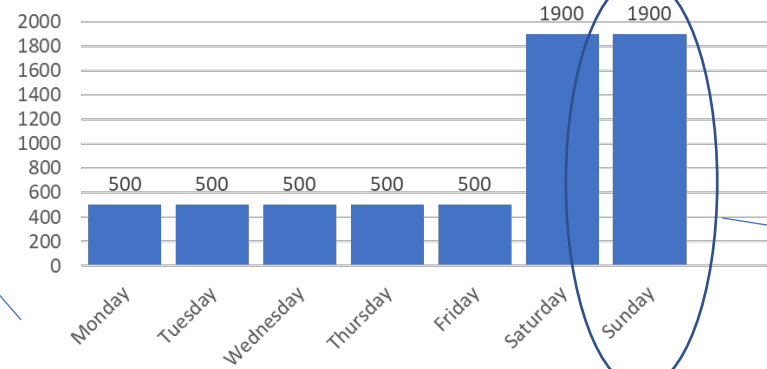Daily Activity Report summarized by FIP (county) and Ship Type

EPS3

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Outputs: Temporal Profiles

1000 tpd

Seasonal Profile

700 ❄

900 🍁

1300 ☀

1100 ✿

Weekly Profile

Day	Value
Monday	500
Tuesday	500
Wednesday	500
Thursday	500
Friday	500
Saturday	1900
Sunday	1900

Daily Profile

Series 1
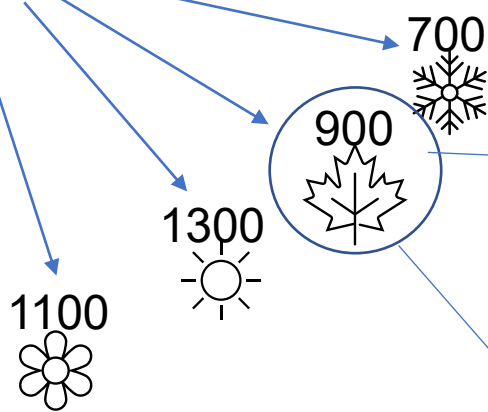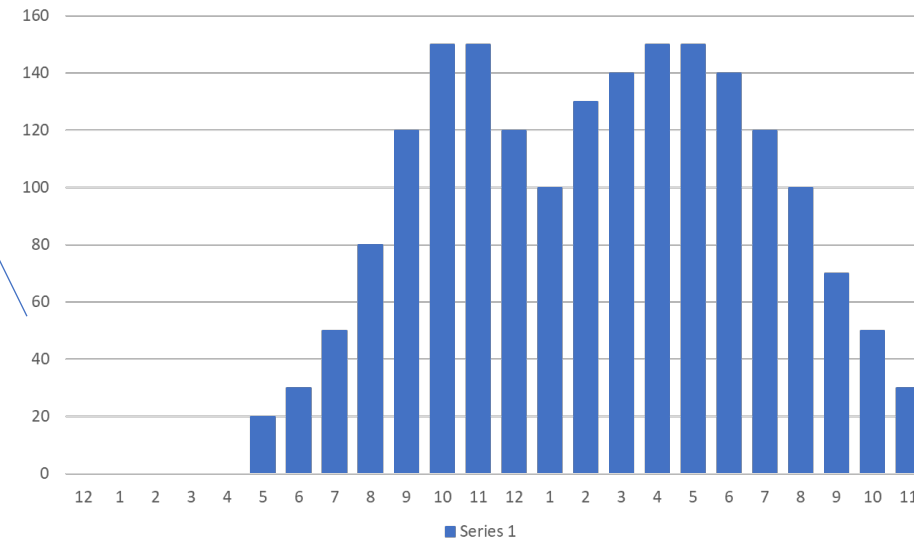
Simulating future years

Year	All C2 Vessels	Container	Solid Bulk	Cruise	All Others
2019	1.000000	1.000000	1.000000	1.000000	1.000000
2023	0.939208	1.097158	1.181150	1.089570	1.060376
2026	0.947661	1.209225	1.301796	1.200862	1.168686

Activity Projections Relative to 2019

- EPS3 cntlem module

- Base year (2019) is multiplied by 'adjustment factors' based on expected changes over time.

- Adjustment factors estimate changes in activity and lower emission rates from newer ships.

Year	NOx	SO2	PM - Main	PM - Auxiliary
2019	100.00%	100.00%	100.00%	100.00%
2023	80.80%	100.00%	100.00%	100.00%
2026	66.70%	100.00%	100.00%	100.00%

C3 Emissions Factors relative to 2019

- Can also be altered based on specific planned events...

Future Year Simulations: Houston Ship Channel Sensitivity

Image Courtesy of www.expandthehoustonshipchannel.com

- Port of Houston's 'Projected Emissions Reductions for Houston Ship Channel Expansion Channel Improvement Project' (2019)

- Anticipated emissions reductions due to fewer larger ships, reduced hoteling

- Changes applied to:
  - 2026 future year
  - Harris, Chambers, Galveston Counties;
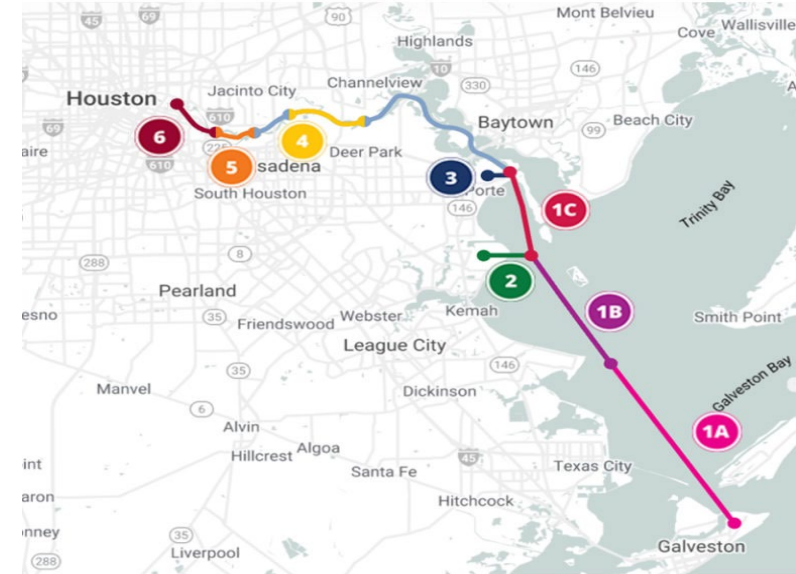 - 9 C3 ship types;
  - Only Hotelling and Transit.

Period	NOx	VOC
Annual Reductions (tpy)	147.20	3.35
Daily Reductions (tpd)	0.40	0.01
Daily Unadjusted Emissions (tpd)	16.71	2.18
Daily Adjusted Emissions (tpd)	16.31	2.17
Daily Adjustment Factor	0.9759	0.9958

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Geographic Scope

- AIS data used all over US and internationally

- However, computing demands limit MARINERs range
  - Currently using EPA data for larger modeling domains

North American Category 3 Commercial Marine Vessel Emissions: NOₓ

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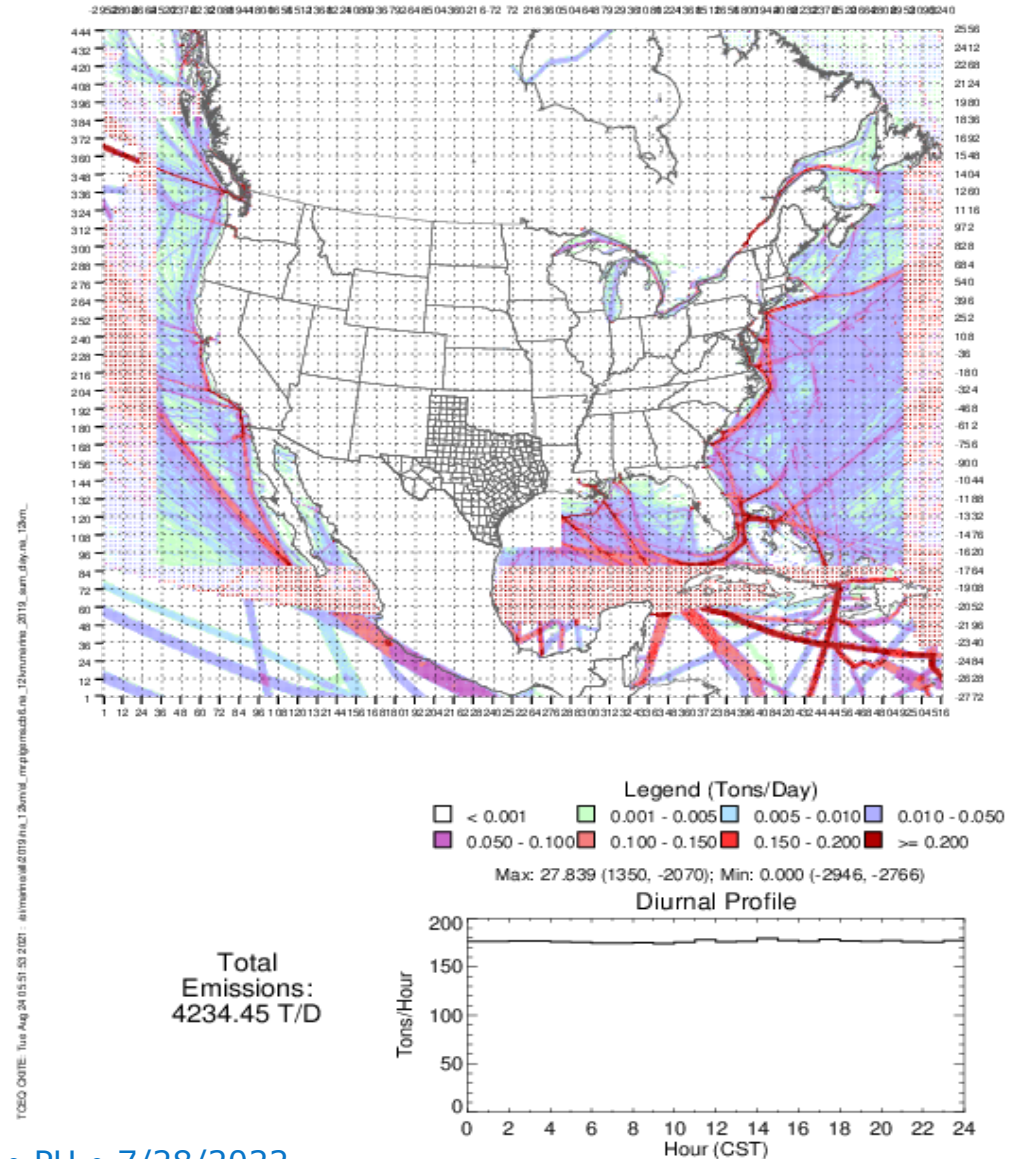
What's Up Next for MARINER?

- FY2022 contract with Ramboll (Proj. Manager: Beata Czader)
  - Faster processing time
    - 2019 processing slow, exclusive usage of Linux server
    - Faster MARINER can be used in more areas
  - Gap-fill missing data with Texas-specific averages
  - Update IHS data and new variables
  - New outputs (temporal profiles, activity reports)
- Future updates?
  - Run independent of IHS database
  - Expand further to Atlantic and Pacific modeling domains

Questions?

Marine Emissions Team:

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- Peter Hoholick peter.hoholick@tceq.texas.gov