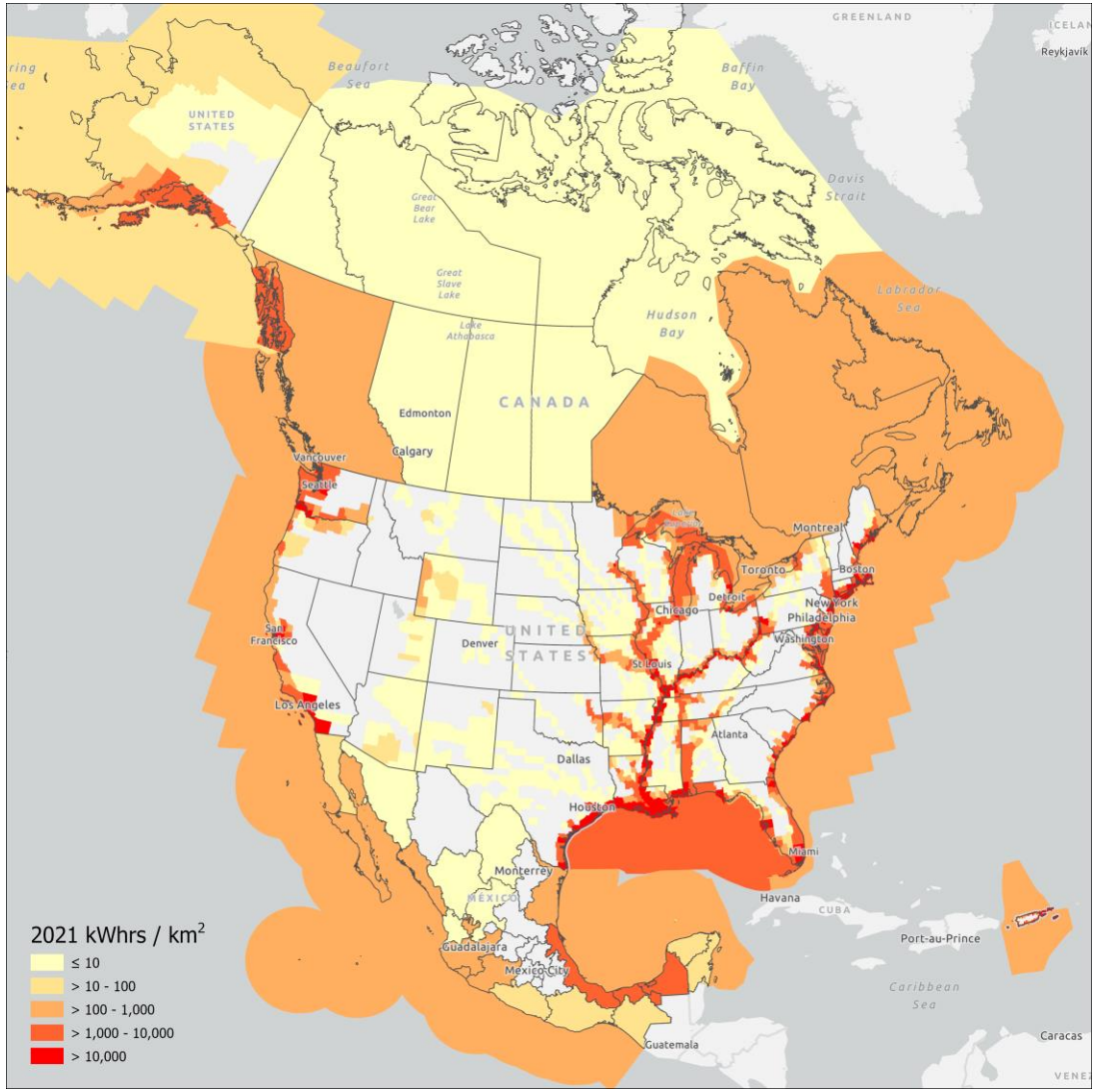
Updated 2021 vs 2020 CMV Emissions

February 2024

Development of 2021 CMV Emissions

- Data were requested from US Coastguard for the same boxes as were used for 2020 NEI – they cover our 36US3 grid AK, HI, and PR+VI
- Data were processed by EPA with C1C2 separated from C3
- ERG developed C1C2 emissions using methods similar to 2020 NEI
- EPA developed C3 emissions using methods similar to 2020 NEI
- Updates since 2020:
  - 22% more Automated Identification System (AIS) records received than 2020
  - More commercial fishing vessels have AIS transmitters
  - More satellite data was available to gap fill locations too far from VHS towers
  - Better gap filling method was used to address missing data
  - SCCs were refined to include ship type

Area Covered by Full 2021 Inventory



Decoder for new SCCs

2280	F	XX	Y	ZZ

Fuel Type	
1	-
2	Diesel
3	Residual
4	LNG
5	-
6	-

Vessel Type	
01	Barge
02	Offshore
03	Bulk Carrier
04	Fishing
05	Container Ship
06	Ferry
07	General Cargo
08	Government
09	Miscellaneous
10	Ro-Ro
11	Tanker
12	Tour Boat
13	Tug
14	Refrigerated
15	Cruise
16	Passenger Other

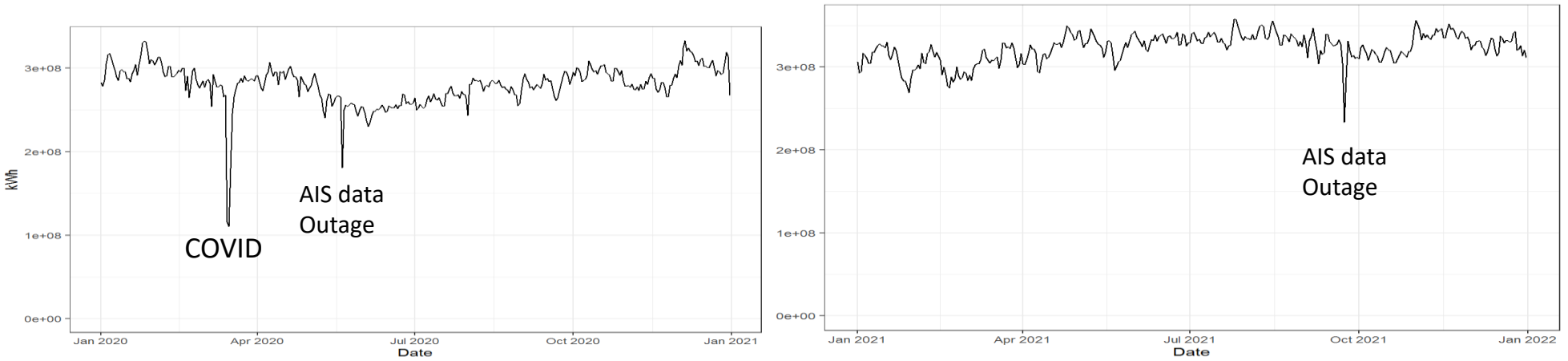
Category	
1	C1,C2
2	C3

Location	
1	Port
2	Underway

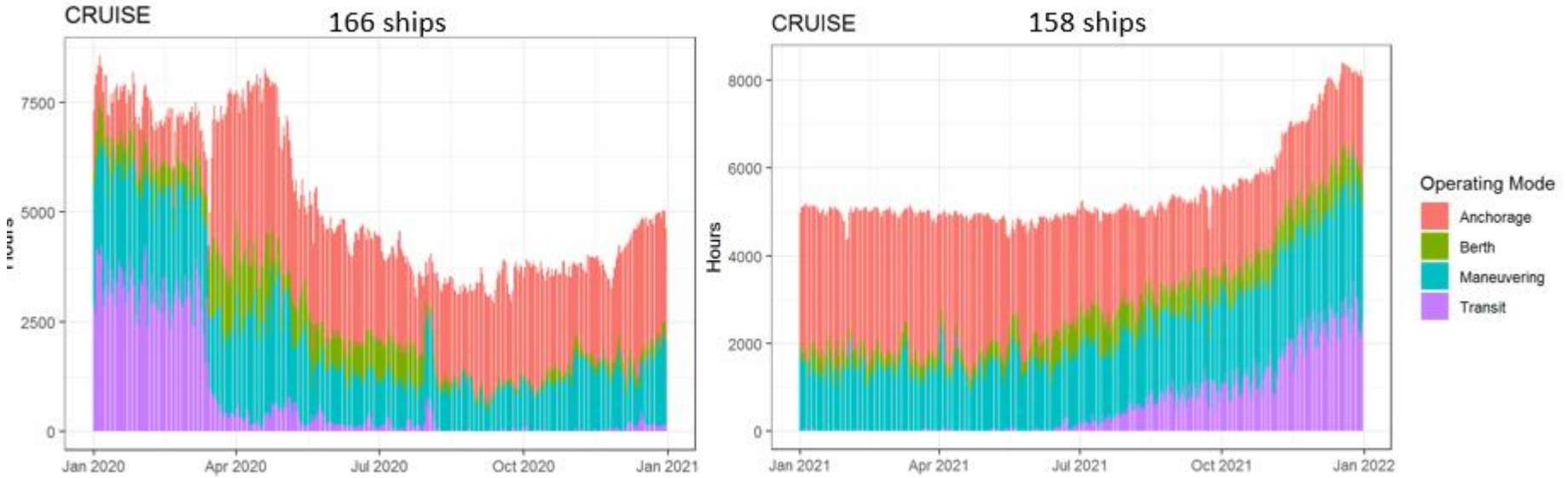
Engine	
3	Main
4	Aux

Recent year activity trends for C3

2020 and 2021 Fleet-wide Energy consumption

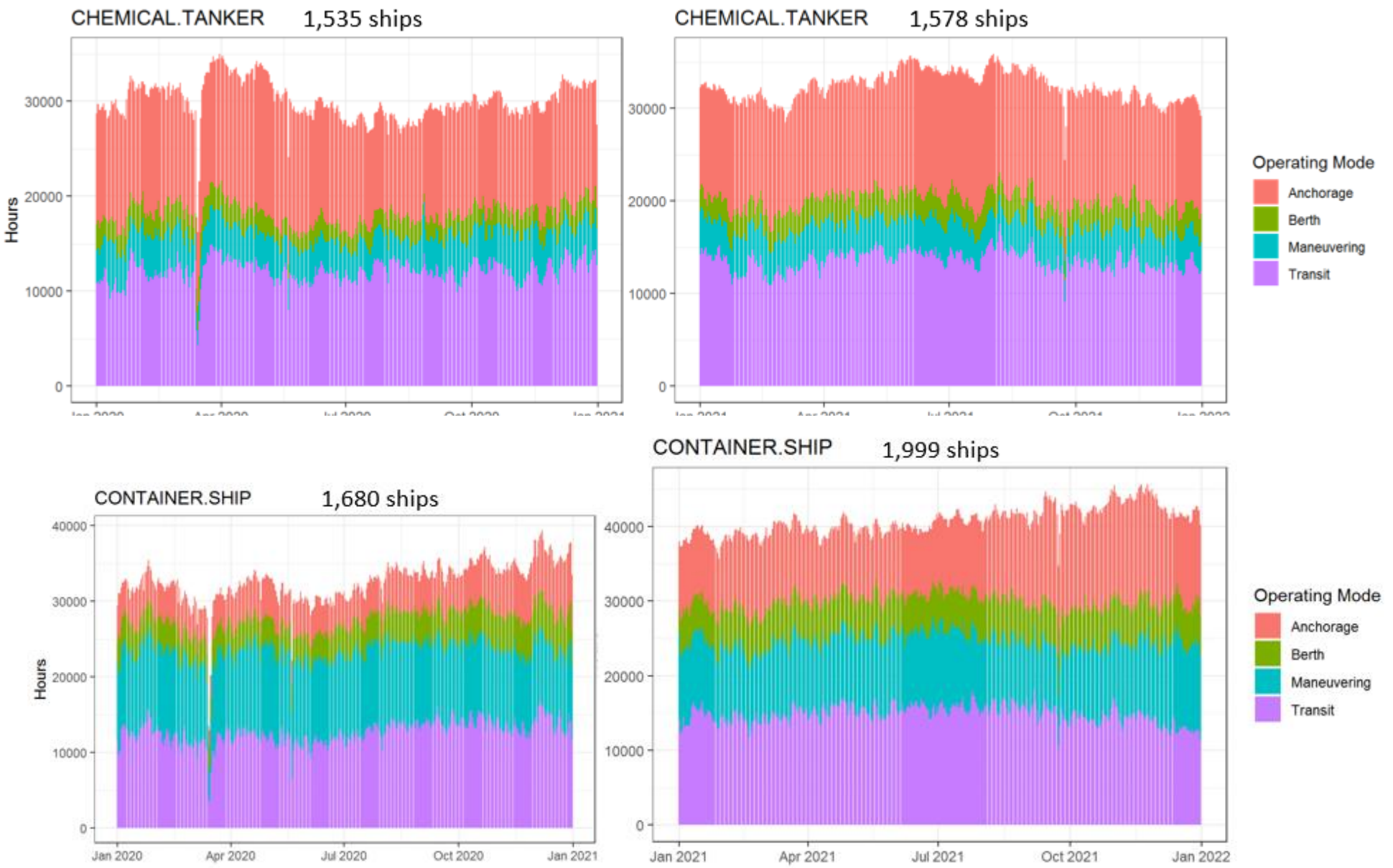


Overall energy consumption was a bit higher in 2021 vs 2020



Cruise ship activity rebounded in 2021 especially by the end of the year

Additional 2020 and 2021 C3 activity by operating mode



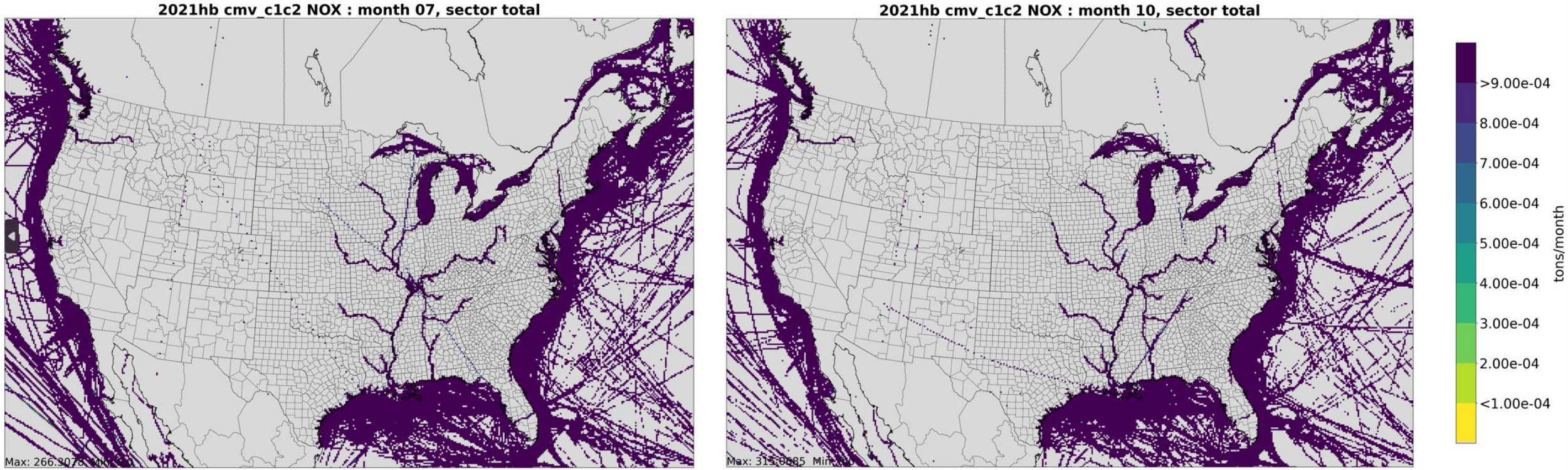
Tankers showed a little growth in 2021 vs 2020

Container ships grew by almost 20% in 2021 vs 2020

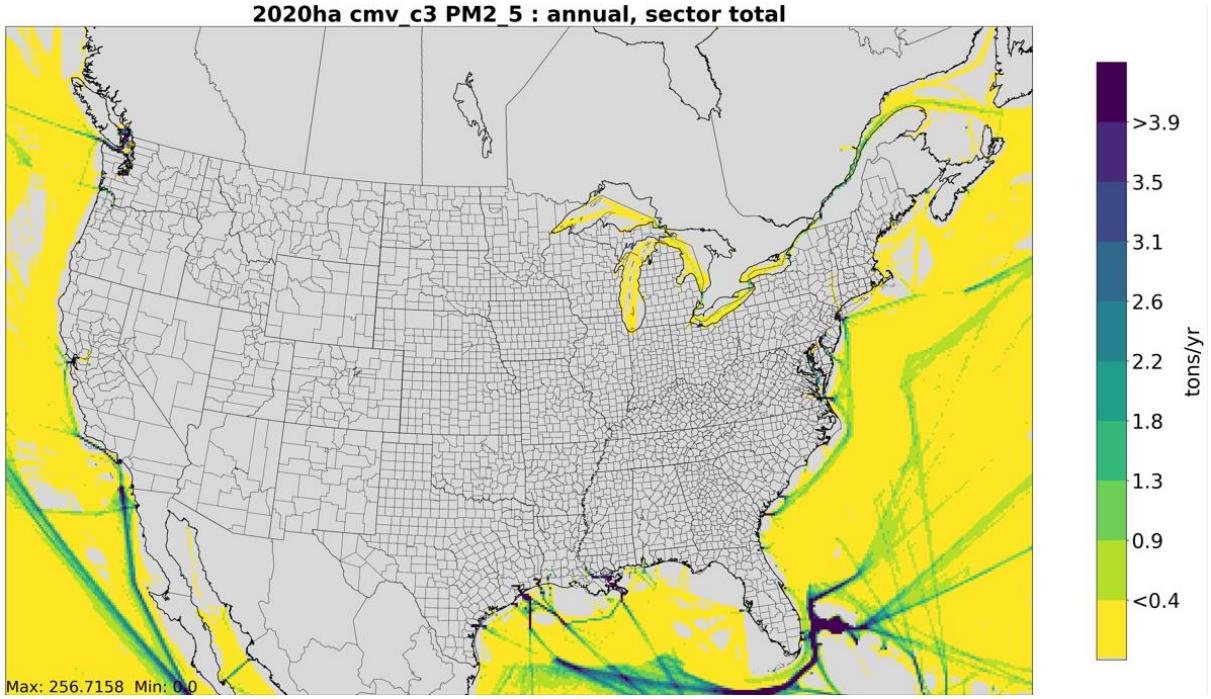
2021 and 2020 C1C2 Emissions and Activity Comparison (from the September call)

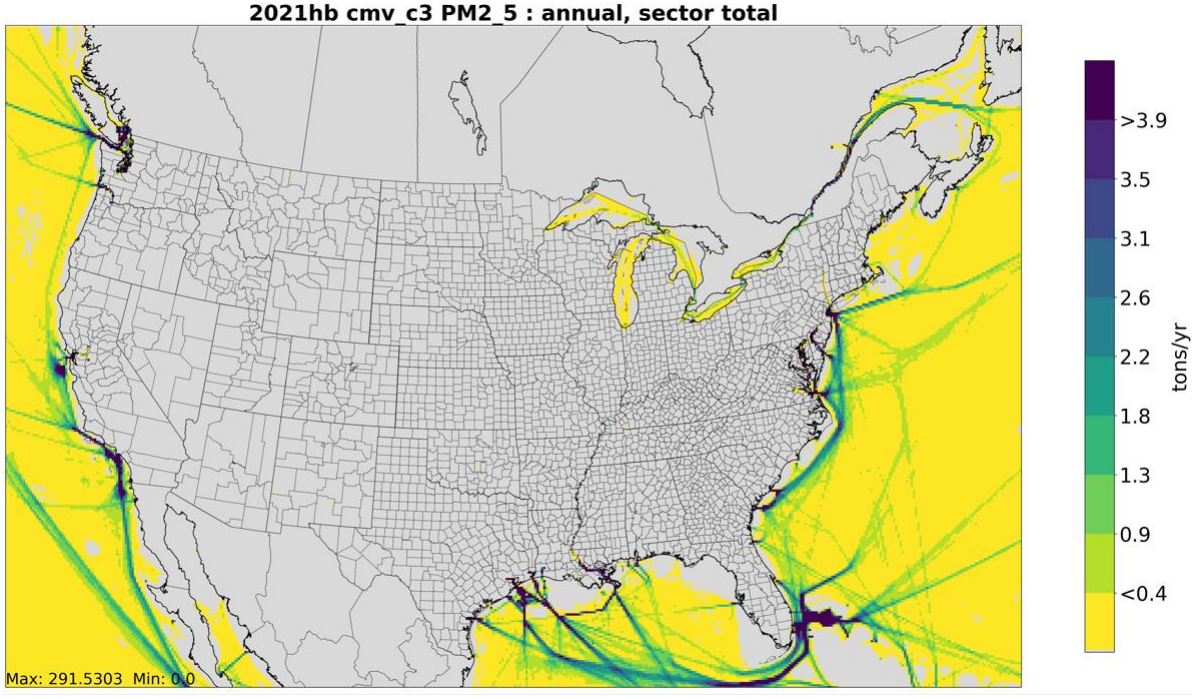
	2020	2021	Percent Change
kWhrs	17,595,918,350	20,529,263,68	16.671%
VOC	6,485	8,176	26.071%
CO2	13,477,847	15,703,352	16.512%
CO	27,466	32,347	17.773%
NOX	179,303	214,943	19.877%
PM25	4,632	5,599	20.881%
SO2	738	817	10.701%
PM10	4,779	5,777	20.871%
Avg_Daily_#_Vessels	6,355	6,561	3.251%

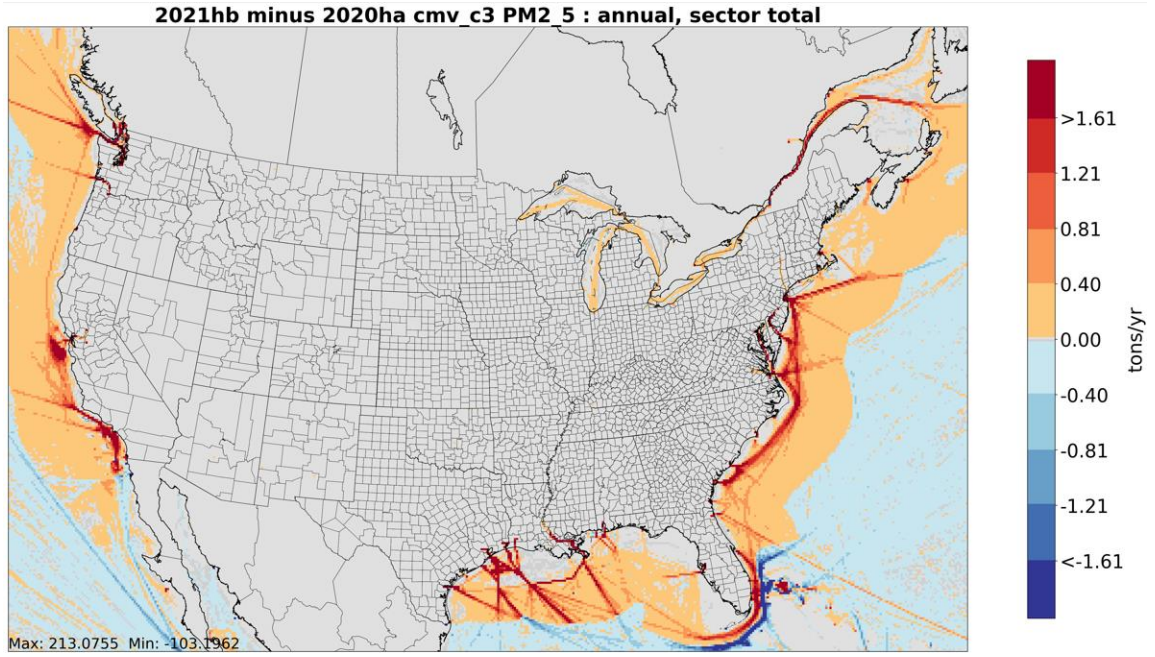
Issue from original version:
C1C2 Emissions in Unexpected States



It was determined that some stray transponder signals were provided with the 2021 AIS data – some are diagonal and others along lines of longitude. The emissions are small but these should be cleaned up before finalizing the data.

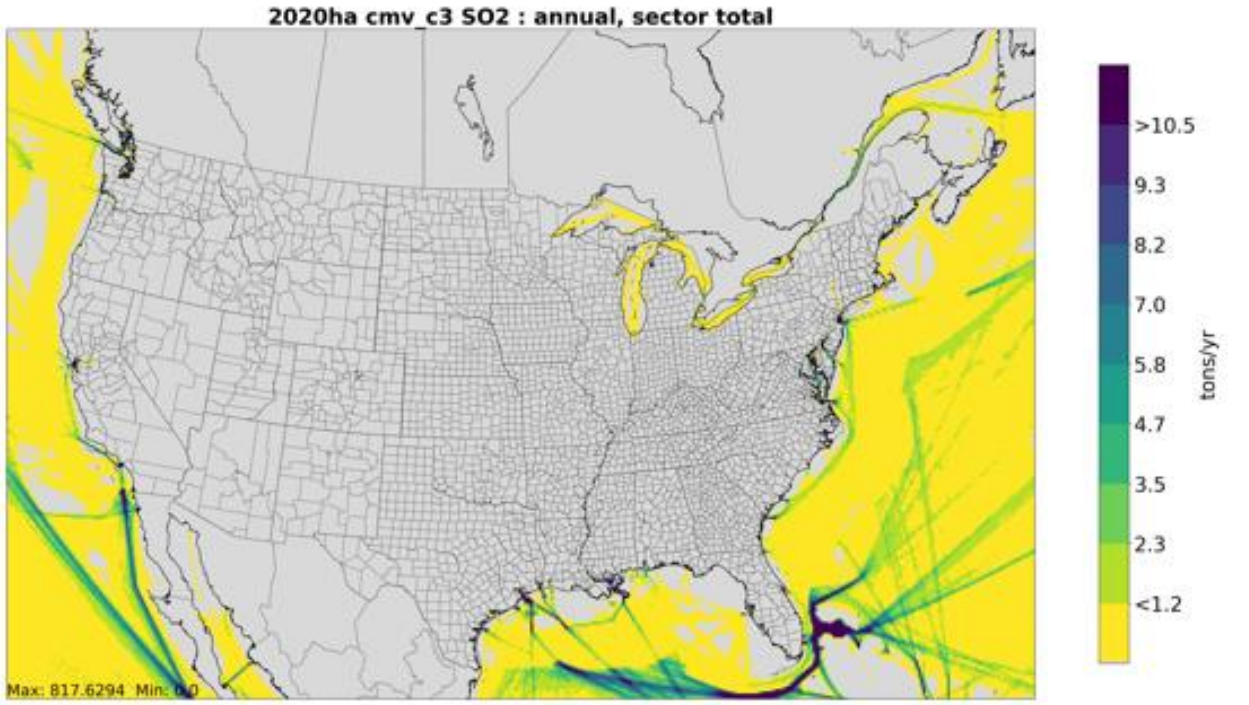


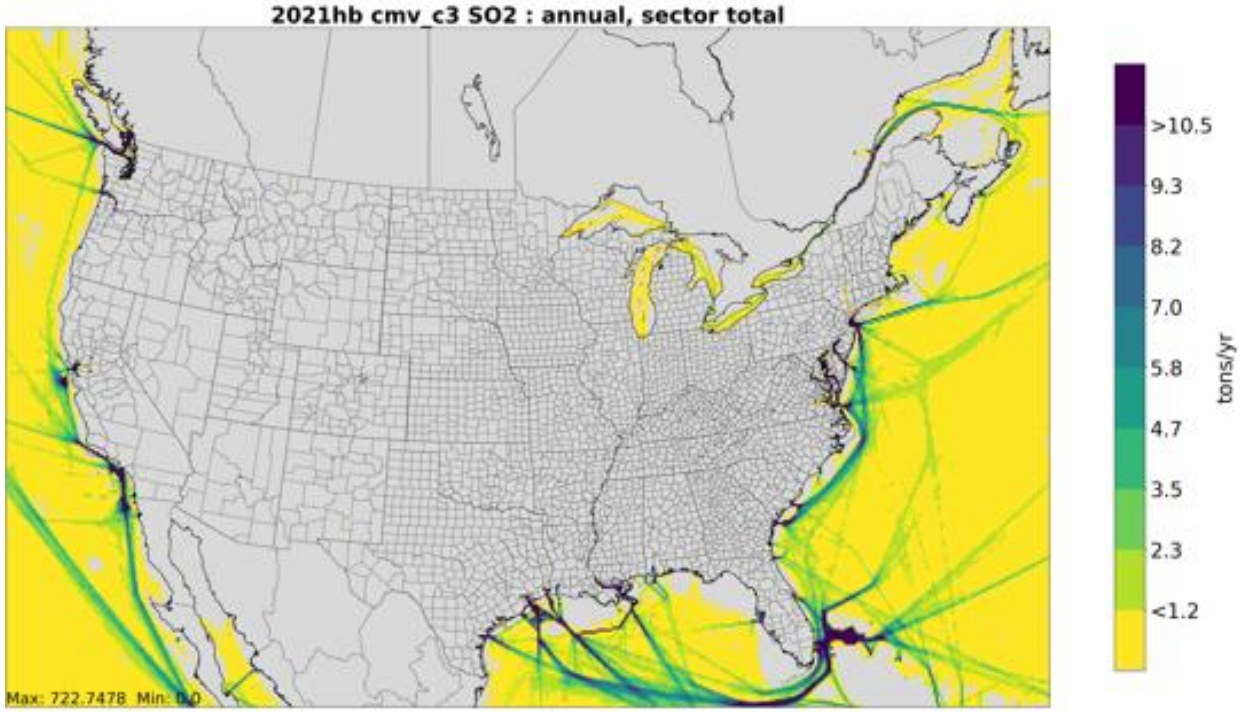


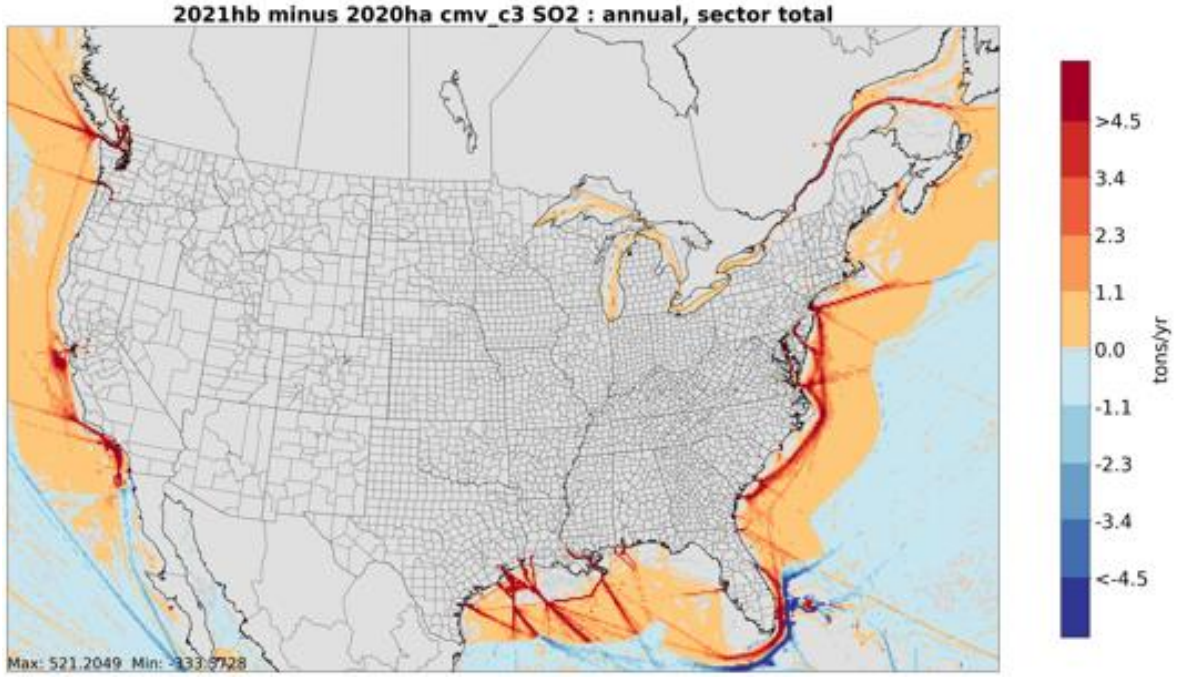


2020 and 2021 CMV C3 PM2.5 emissions – initial version

We note higher PM and SO2 emissions in the emissions control area (ECA)





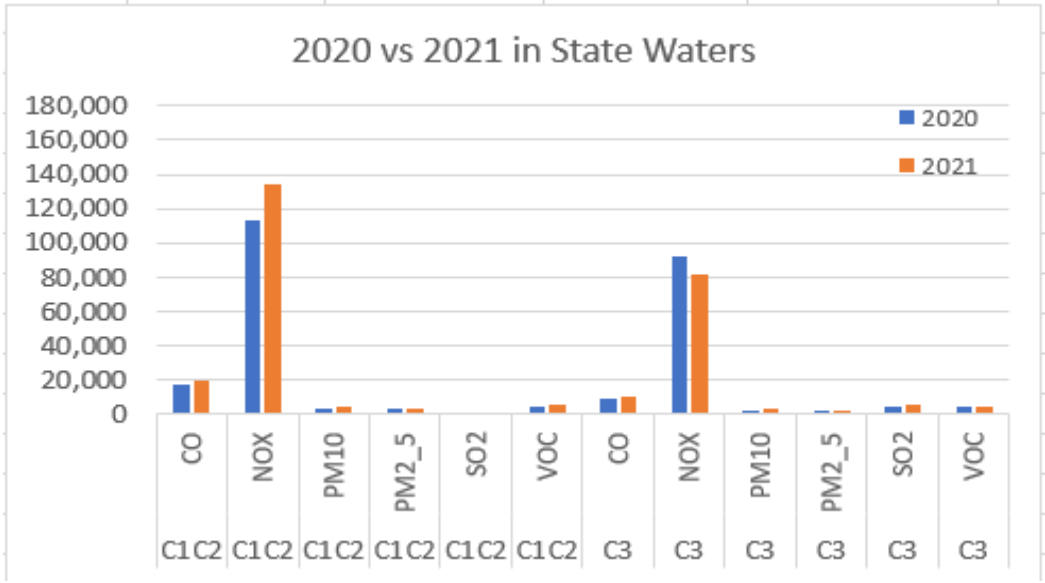


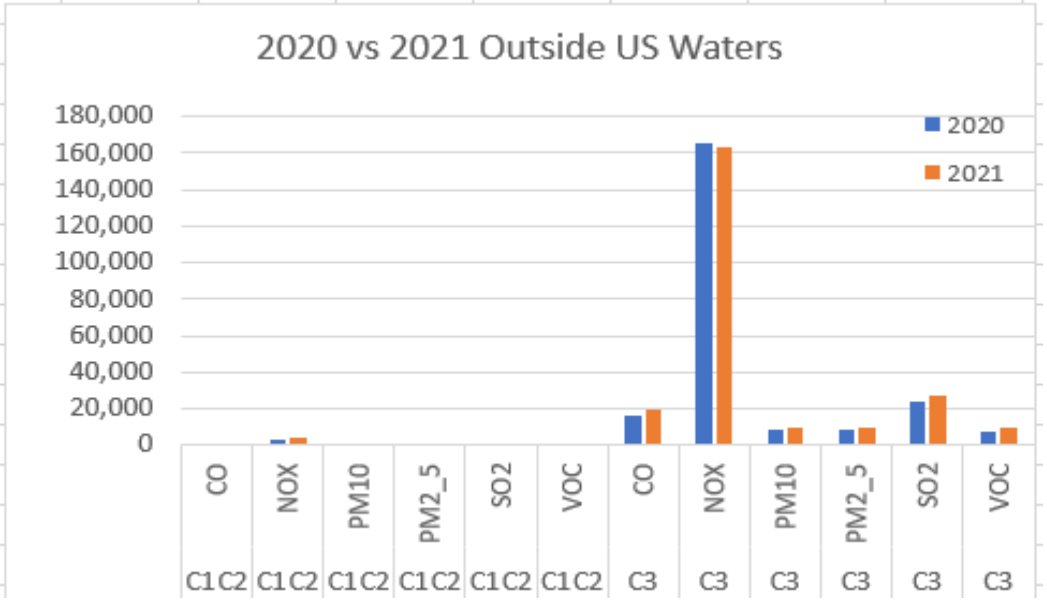
2020 and 2021 CMV C3 SO2 emissions – initial version

We see elevated emissions in the ECA as compared to 2020 in this version

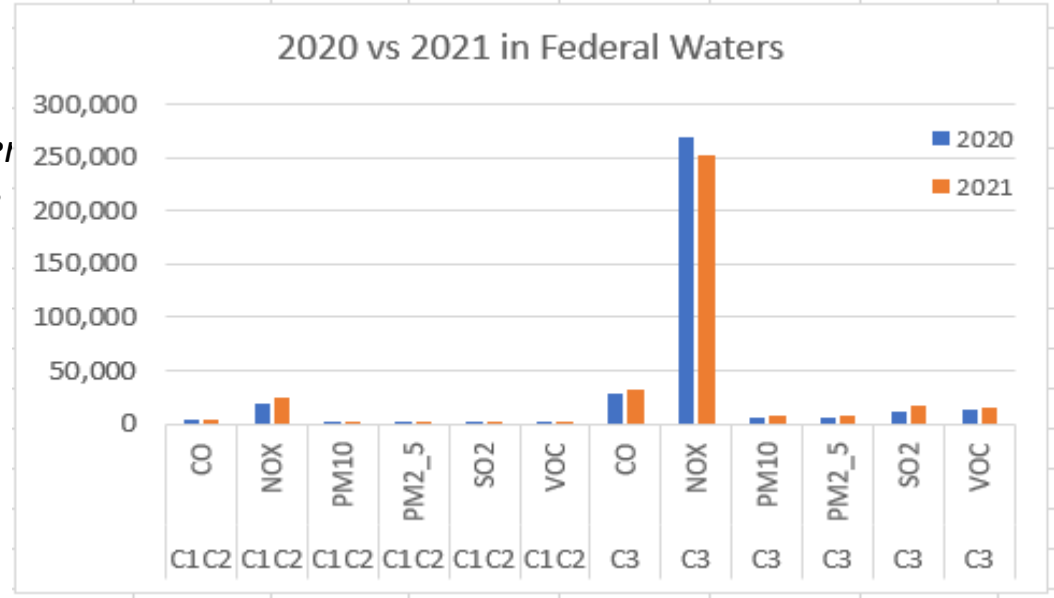
(Note there is no ECA around Mexico)

Updated Emissions for CONUS 12US1 Grid





Note larger scale



Observations:

- NOx is the dominant pollutant (and CO2 – not shown here)
- In state waters, there is more NOx from C1C2 than from C3
- Outside of state waters, more emissions are from C3
- In state and federal waters, NOx increased in 2021 (20%) for C1C2 but decreased for C3 (-19% state and -9% federal)
- C3 SO2 and PM increased over 100% within state and federal waters but decreased outside of US waters

Total 2021-2020 and New-old changes in state waters (tons)

Engine	Poll	2020	2021	2021-2020	% change	New-old
C1C2	CO	17,242	19,892	2,650	15%	-145
C1C2	NOX	113,213	134,167	20,954	19%	-1,095
C1C2	PM10	3,051	3,662	611	20%	-31
C1C2	PM2_5	2,956	3,548	592	20%	-30
C1C2	SO2	571	615	44	8%	-3
C1C2	VOC	3,973	5,116	1,143	29%	-54
C3	CO	9,216	10,252	1,036	11%	0
C3	NOX	91,850	81,846	-10,003	-11%	7,647
C3	PM10	1,640	2,507	868	53%	-1,918
C3	PM2_5	1,508	2,307	798	53%	-1,764
C3	SO2	3,690	5,767	2,078	56%	-4,578
C3	VOC	4,233	4,687	454	11%	0
C1C2	CO2	8,355,448	9,518,291	1,162,843	14%	-2,353,393
C3	CO2	6,014,674	6,859,059	844,386	14%	-24,293,319

Corrections:

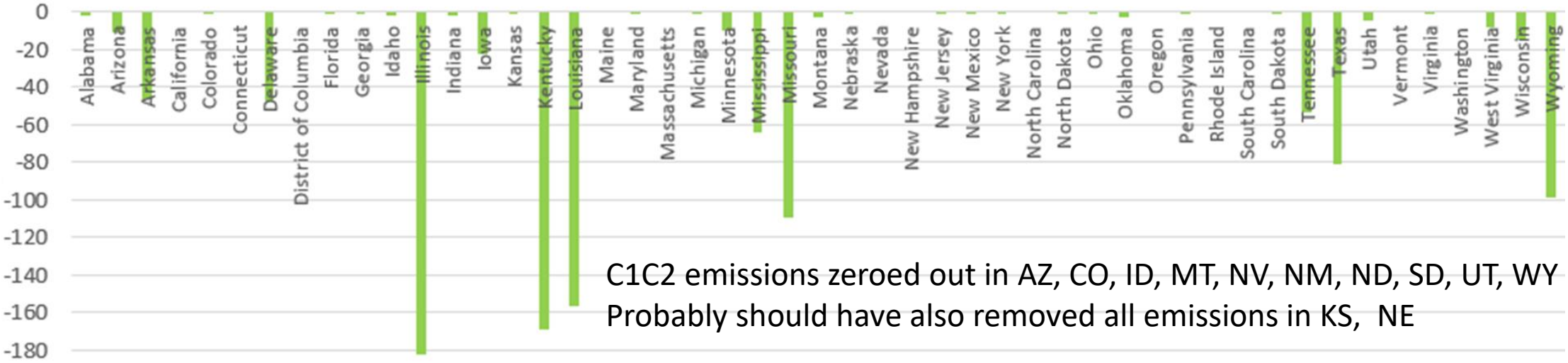
C1C2: stray tracks were removed

C3: recomputed with correction

- Total NOx higher
- PM and SO2 lower

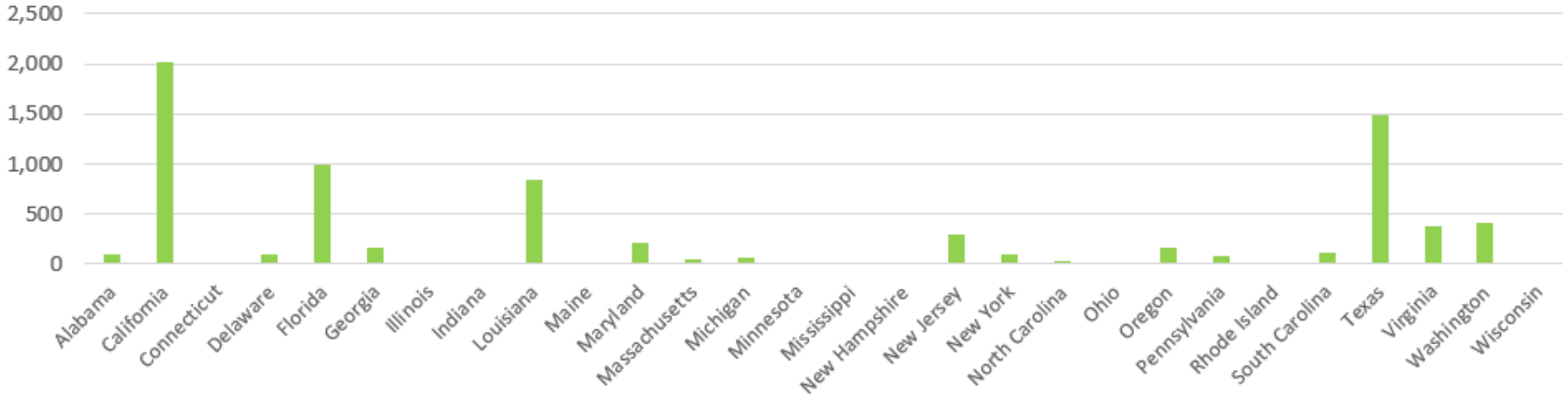
NOx Changes by State due to Corrections

C1C2

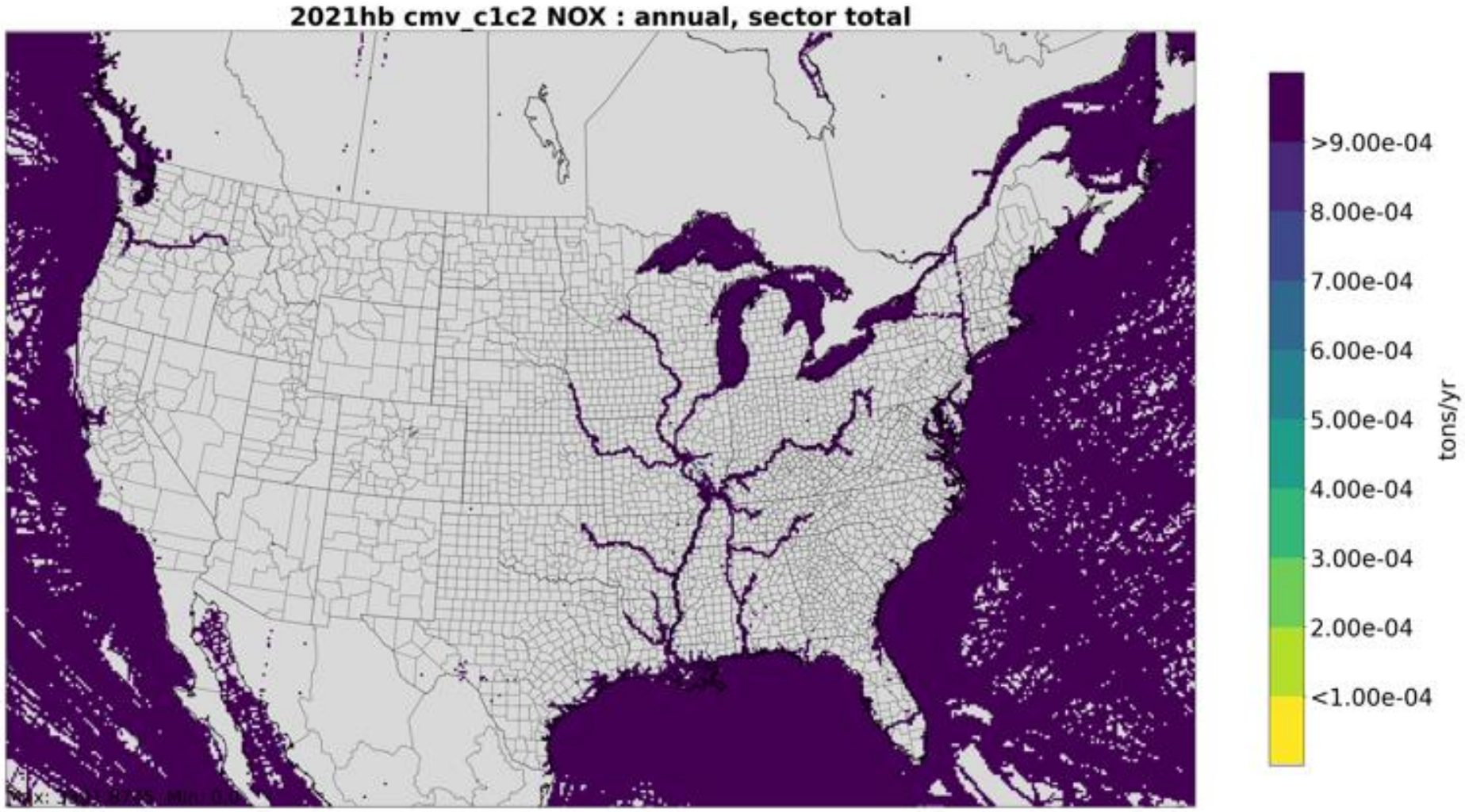


C1C2 emissions zeroed out in AZ, CO, ID, MT, NV, NM, ND, SD, UT, WY
Probably should have also removed all emissions in KS, NE

C3



Updated 2021 C1C2 CMV with low scale



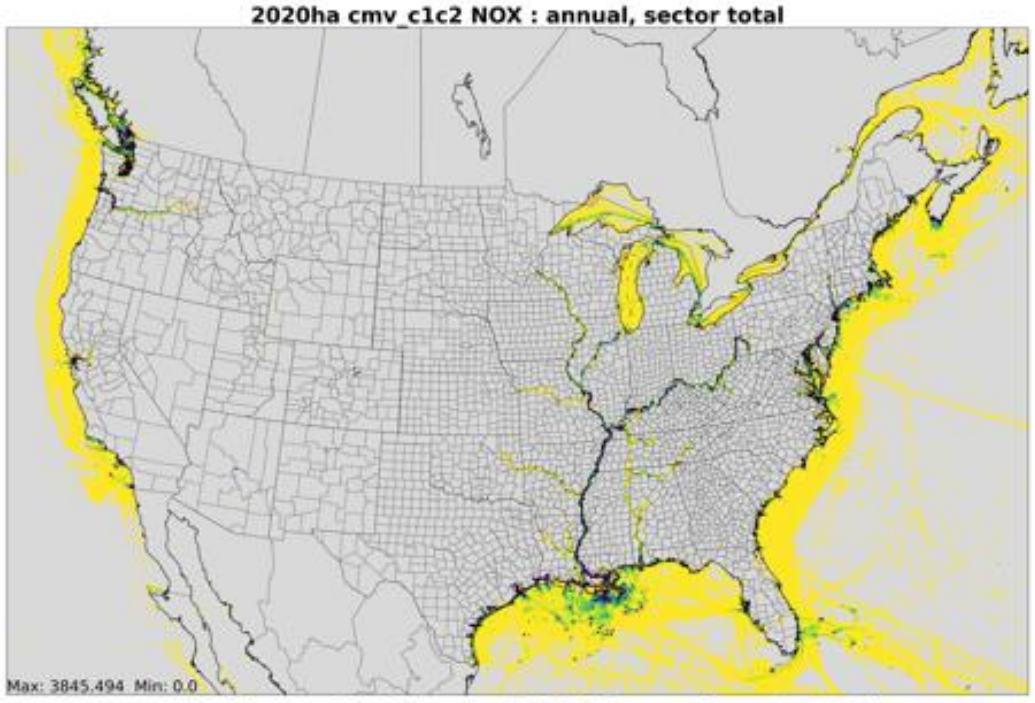
Many anomalies are removed, but there are a still a couple that show up in Canada, Mexico, Texas, and OH
We will need to do a more thorough job on removing these for 2022

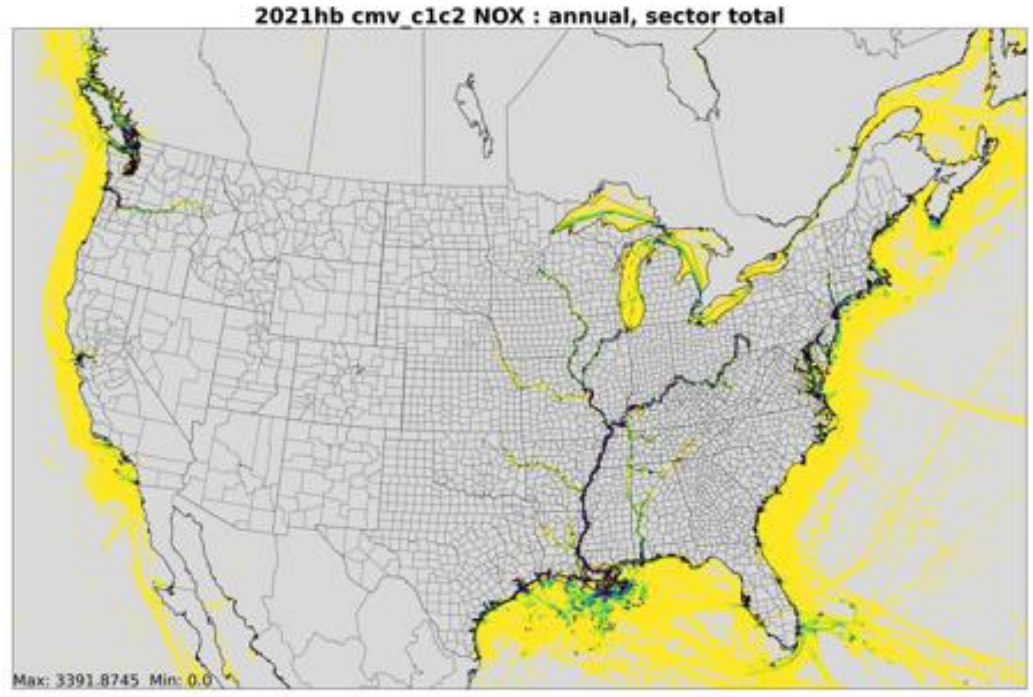
2021-2020 and new-old changes in Federal Waters (tons)

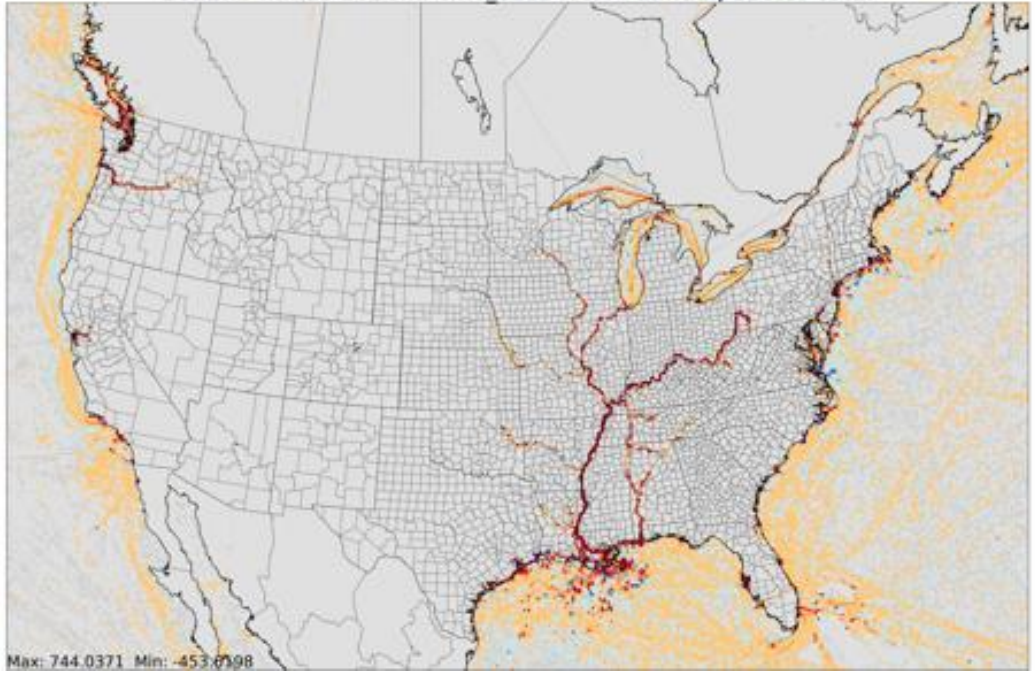
Engine	Poll	2020	2021	2021-2020	% change	New-old
C1C2	CO	3,075	3,683	607	20%	-2
C1C2	NOX	19,813	23,720	3,907	20%	-12
C1C2	PM10	516	619	103	20%	0
C1C2	PM2_5	501	600	100	20%	0
C1C2	SO2	45	63	18	40%	0
C1C2	VOC	759	900	141	19%	-1
C3	CO	27,481	32,139	4,658	17%	0
C3	NOX	269,175	252,068	-17,107	-6%	7,048
C3	PM10	5,338	7,430	2,093	39%	-3,527
C3	PM2_5	4,911	6,836	1,925	39%	-3,244
C3	SO2	12,096	17,264	5,168	43%	-9,301
C3	VOC	13,333	15,967	2,634	20%	0
C1C2	CO2	1,564,340	1,879,389	315,049	20%	-1,381
C3	CO2	12,355,726	14,721,438	2,365,712	19%	-71,638

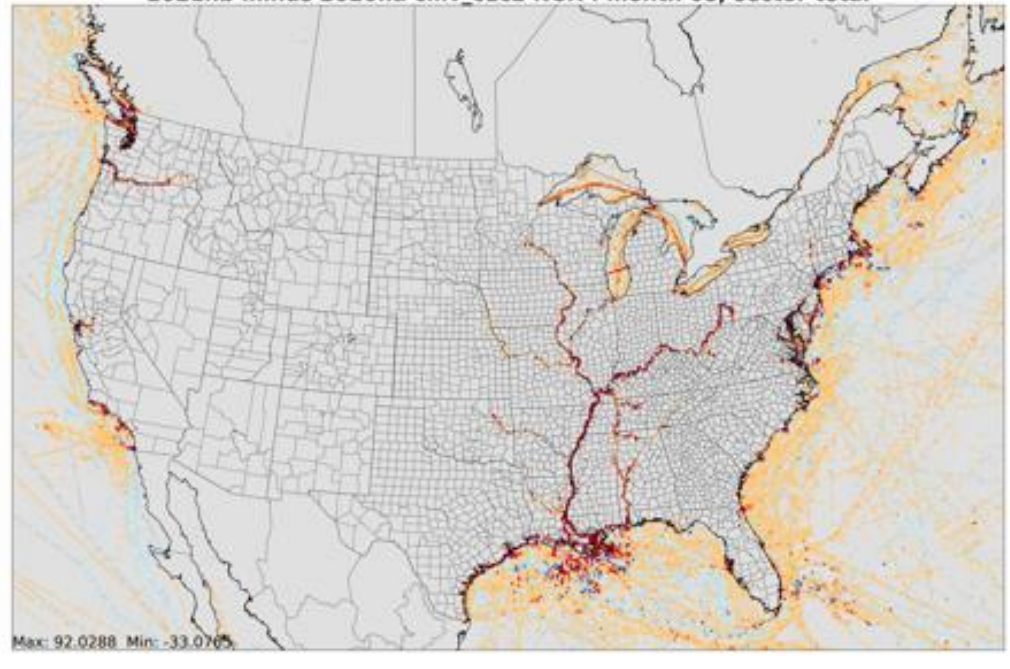
2021-2020 and new-old changes outside of U.S. Waters (tons)

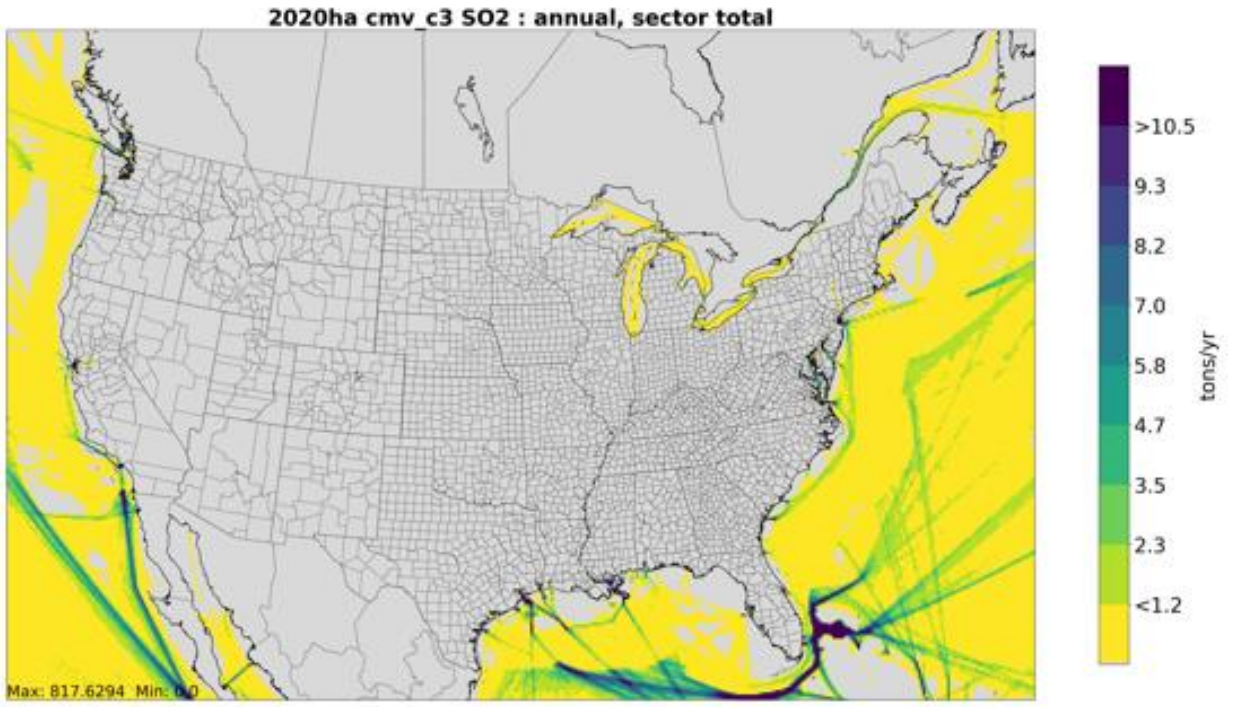
Engine	Poll	2020	2021	2021-2020	% change	New-old
C1C2	CO	571	765	194	34%	0
C1C2	NOX	3,477	4,672	1,195	34%	0
C1C2	PM10	93	124	31	33%	0
C1C2	PM2_5	90	121	30	33%	0
C1C2	SO2	20	25	6	28%	0
C1C2	VOC	125	166	40	32%	0
C3	CO	15,652	19,334	3,682	24%	0
C3	NOX	165,499	163,286	-2,213	-1%	1,659
C3	PM10	8,996	10,098	1,102	12%	3,103
C3	PM2_5	8,276	9,290	1,014	12%	2,854
C3	SO2	24,264	26,857	2,593	11%	8,705
C3	VOC	7,291	9,215	1,924	26%	0
C1C2	CO2	306,453	407,276	100,823	33%	-1
C3	CO2	7,730,611	9,544,042	1,813,431	23%	67,908

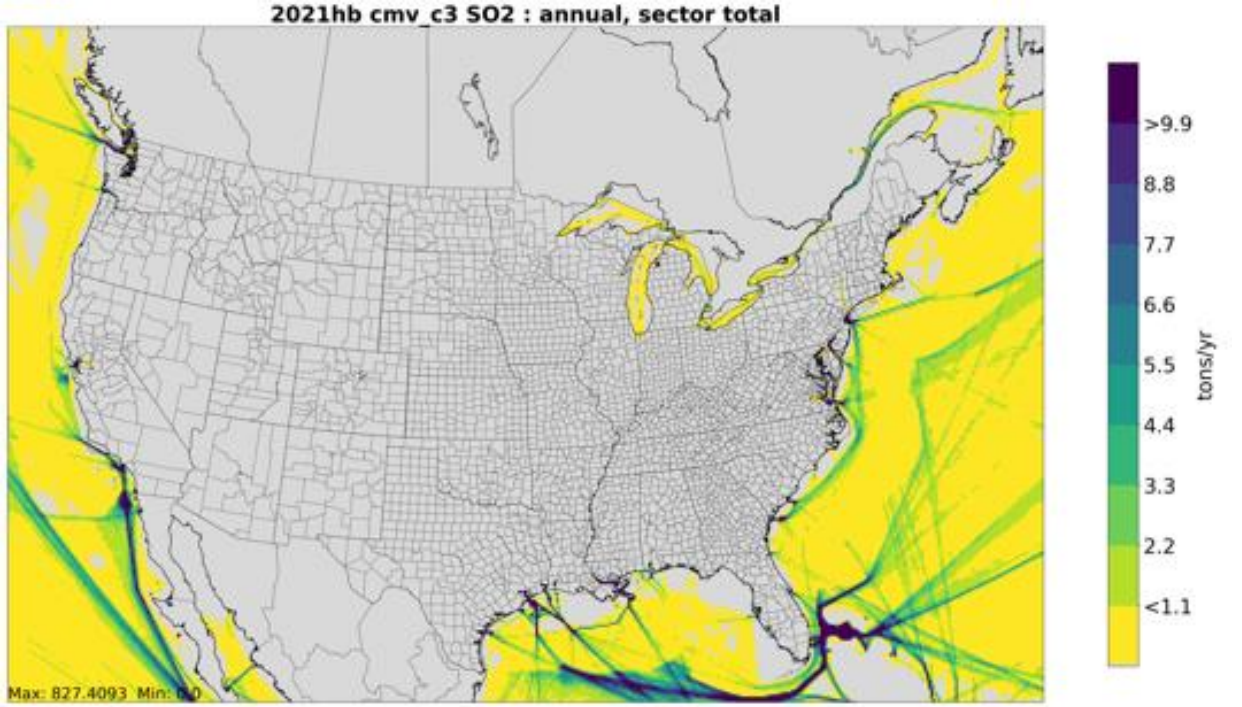

2020ha cmv_c1c2 NOX : annual, sector total
>44
39
34
29
24
19
14
9
<4
tons/yr
Max: 3845.494 Min: 0.0

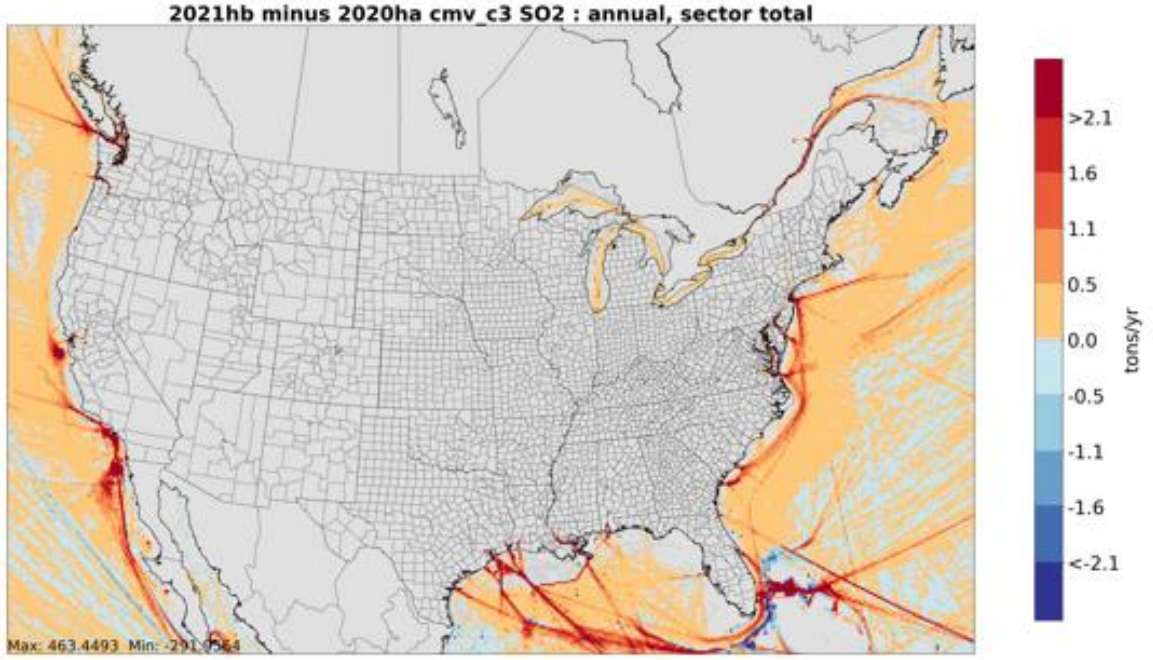

2021hb cmv_c1c2 NOX : annual, sector total
>44
39
34
29
24
19
14
9
<4
tons/yr
Max: 3391.8745 Min: 0.0


2021hb minus 2020ha cmv_c1c2 NOX : annual, sector total
>9.8
7.3
4.9
2.4
0.0
-2.4
-4.9
-7.3
<-9.8
tons/yr
Max: 744.0371 Min: -453.6198


2021hb minus 2020ha cmv_c1c2 NOX : month 05, sector total
>1.09
0.82
0.55
0.27
0.00
-0.27
-0.55
-0.82
<-1.09
tons/month
Max: 92.0288 Min: -33.0705



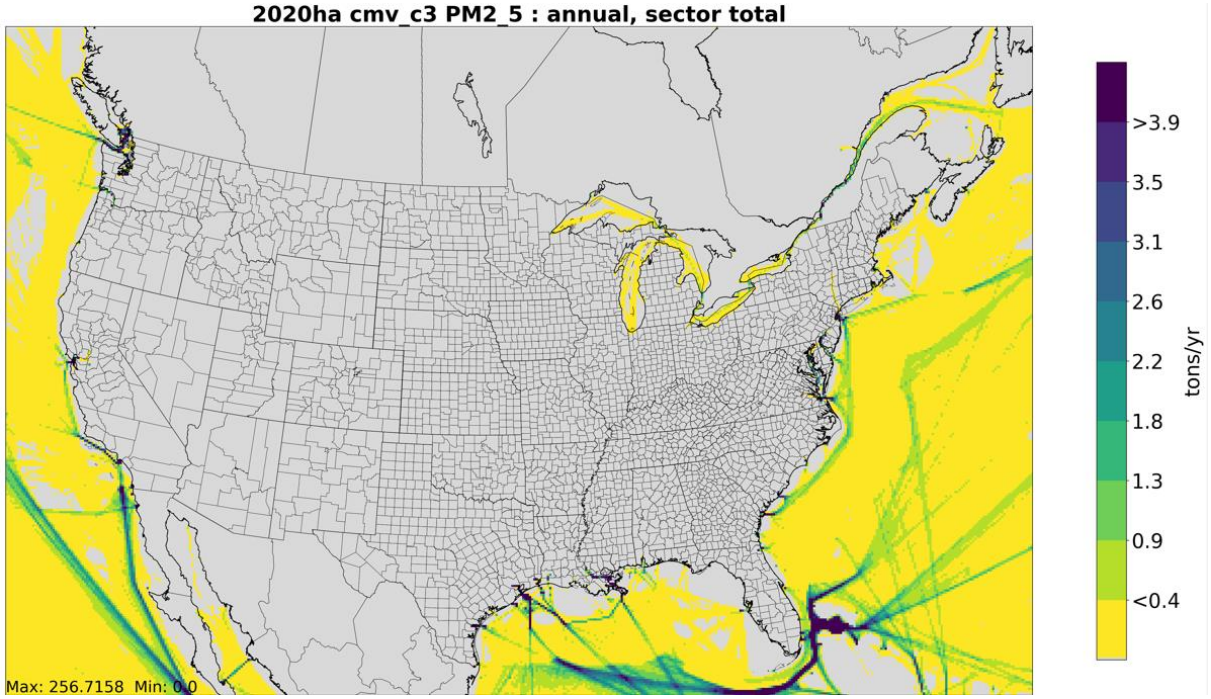


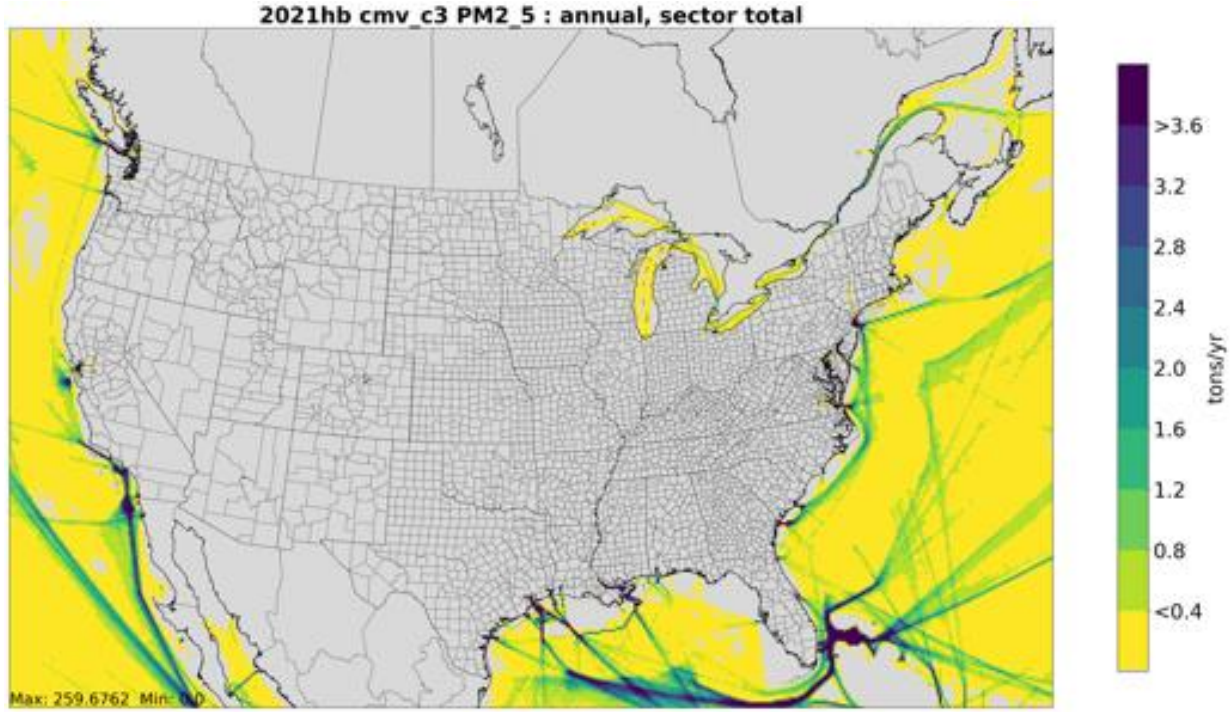


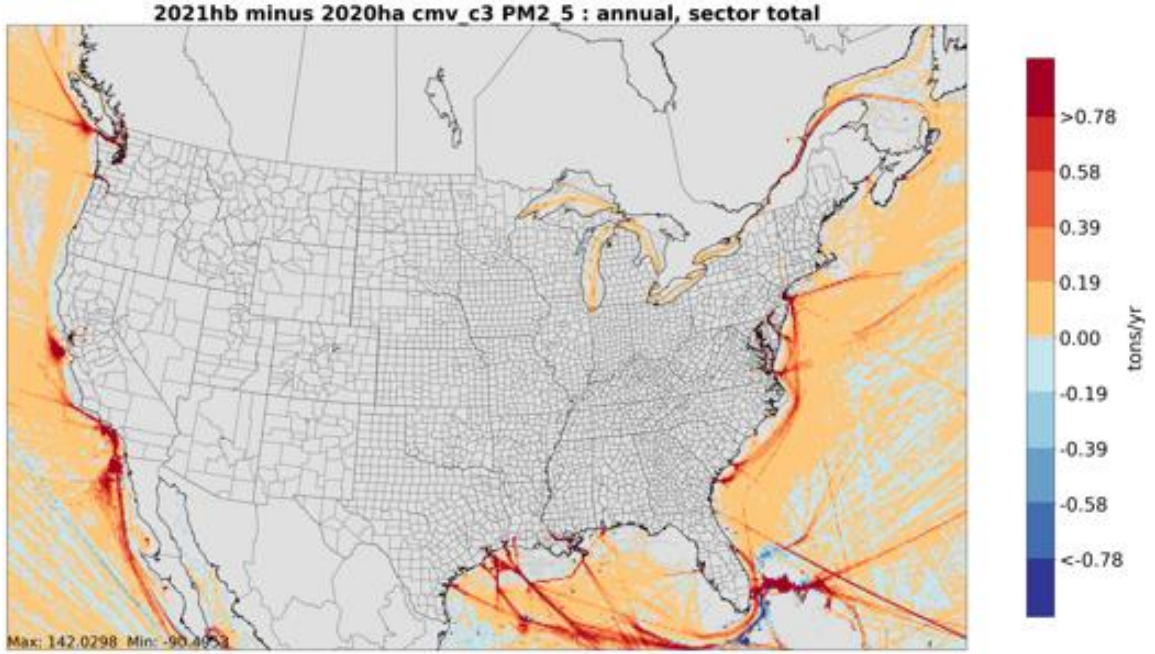
2020 and 2021 CMV C3 SO2 emissions – Updated version

Differences between ECA and outside ECA are substantially reduced. Scale is lower here than before: 4.5 vs 2.1.

(Note there is no ECA around Mexico)



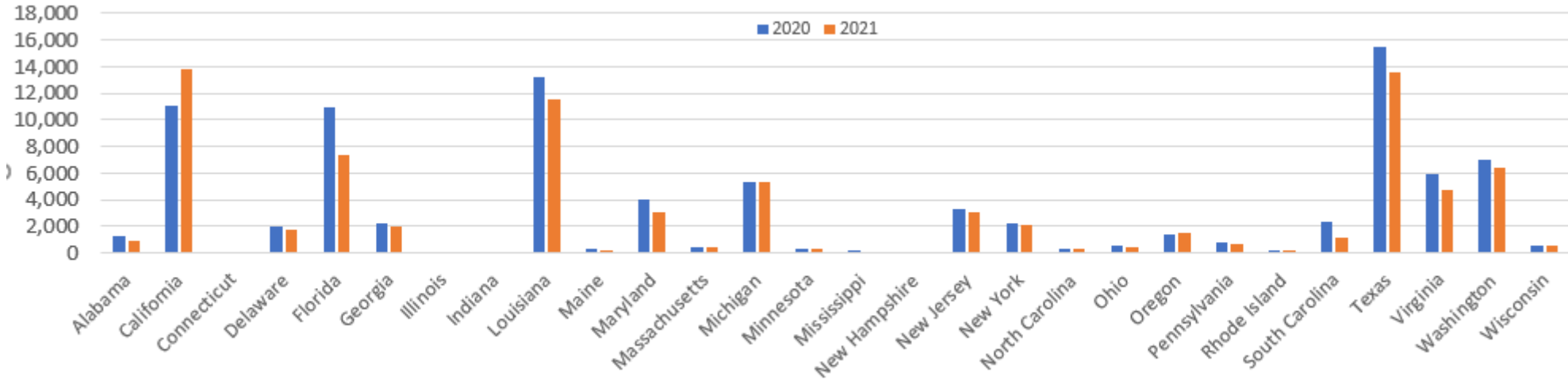




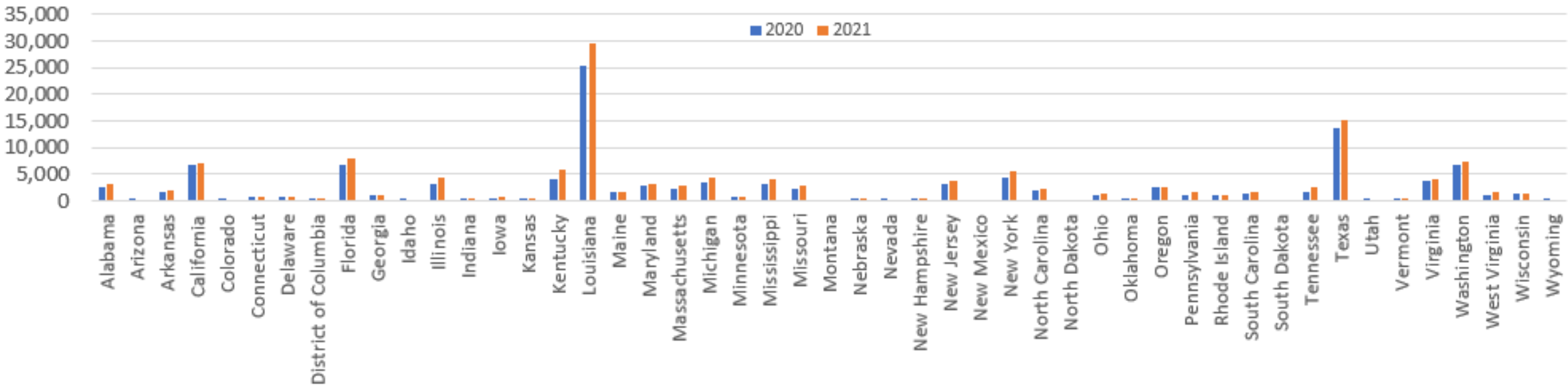
2020 and 2021 CMV C3 PM2.5 emissions – updated version

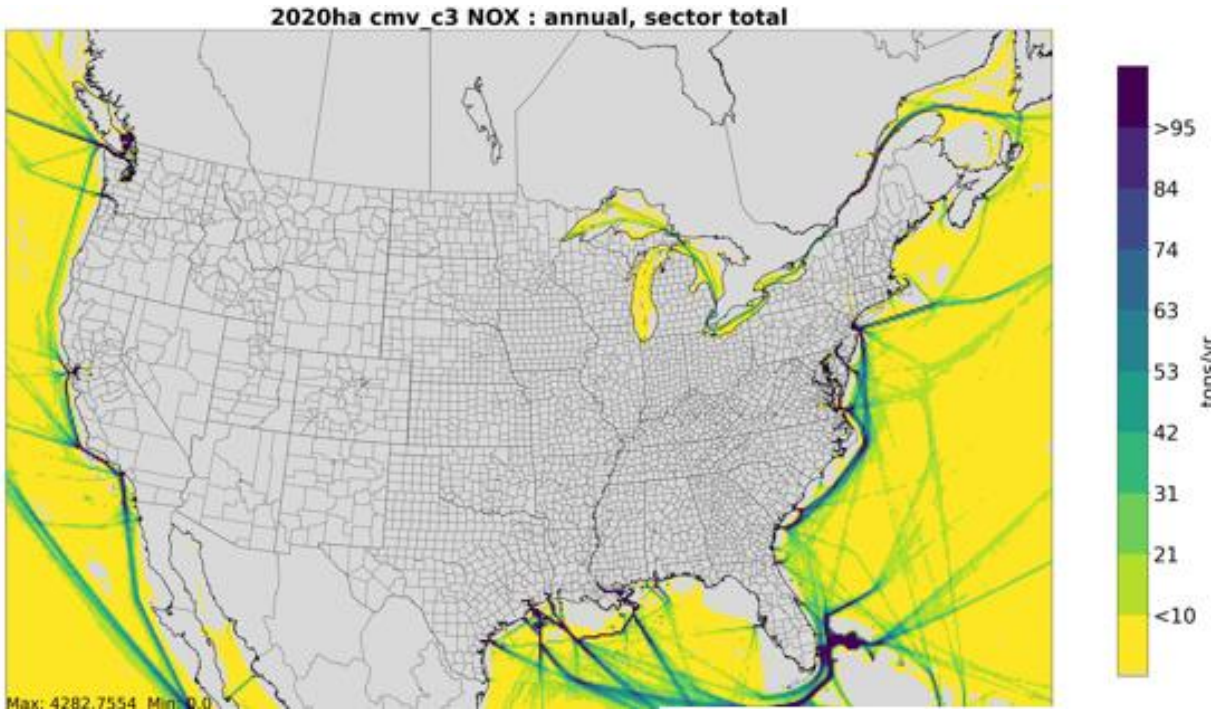
The differences in the ECA are significantly reduced (note smaller scale on map – 0.78 vs 1.6) and no big difference ECA vs outside ECA

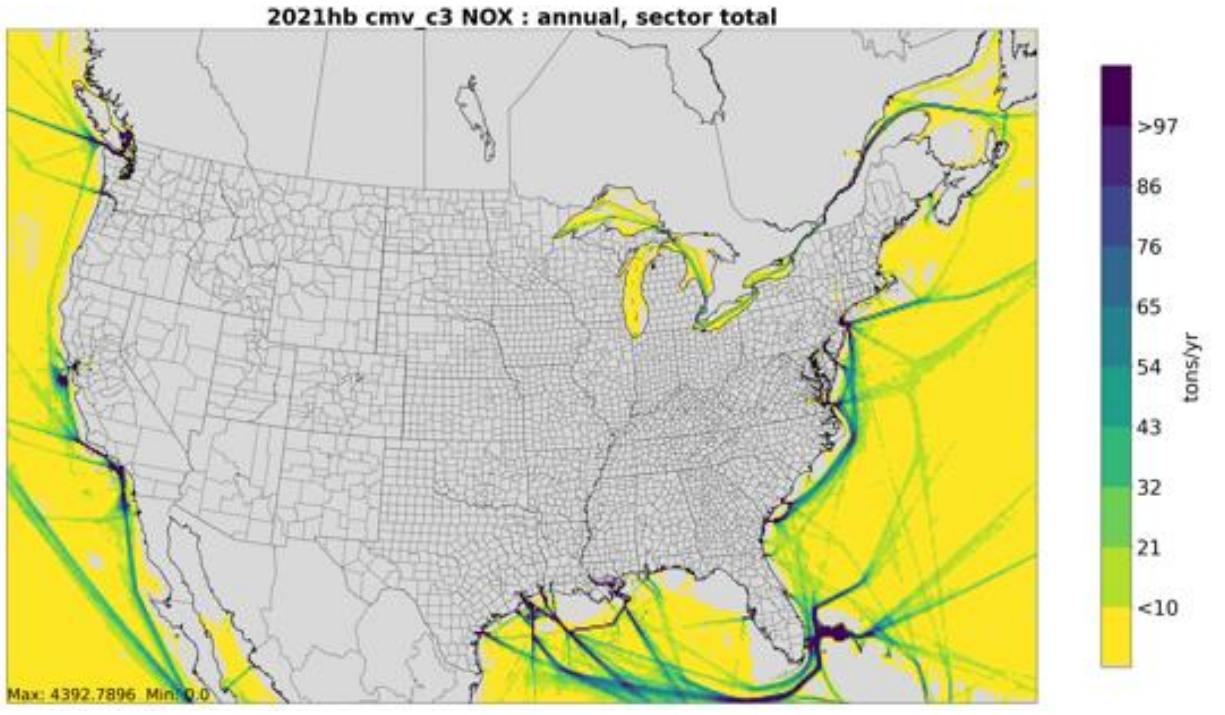
2020 vs Updated 2021 CMV C3 NOx Emissions by state

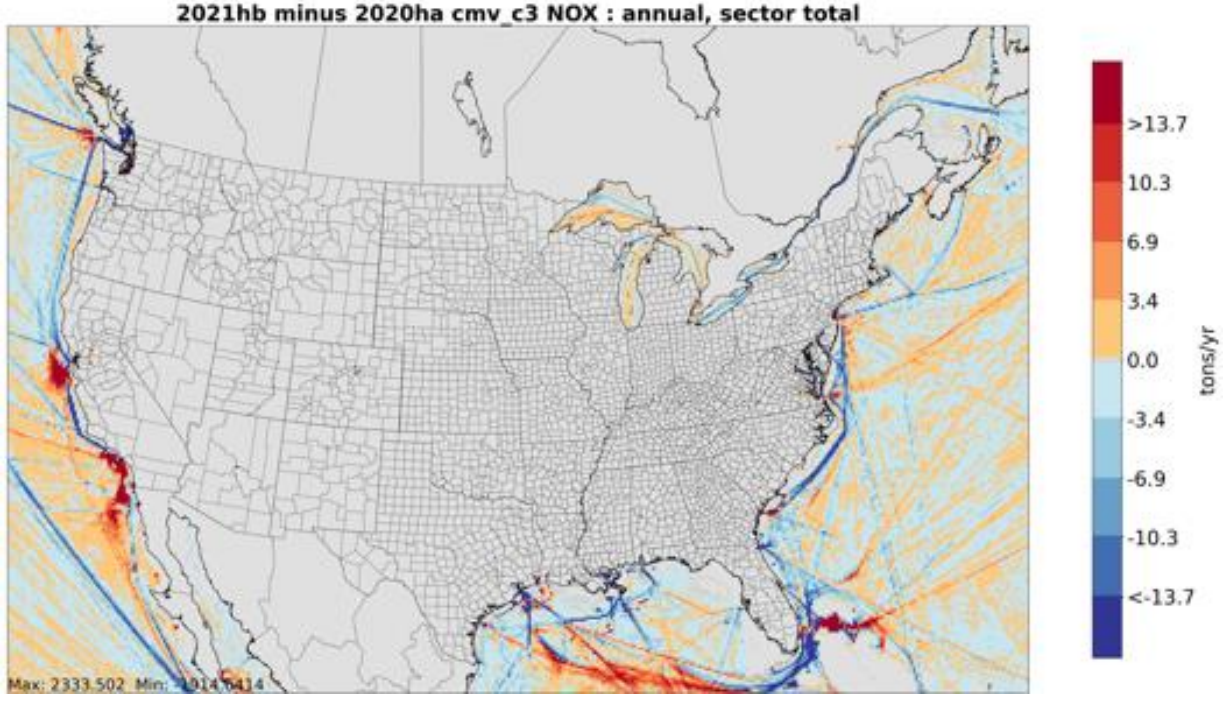


2020 vs Updated 2021 CMV C1C2 NOx Emissions by state





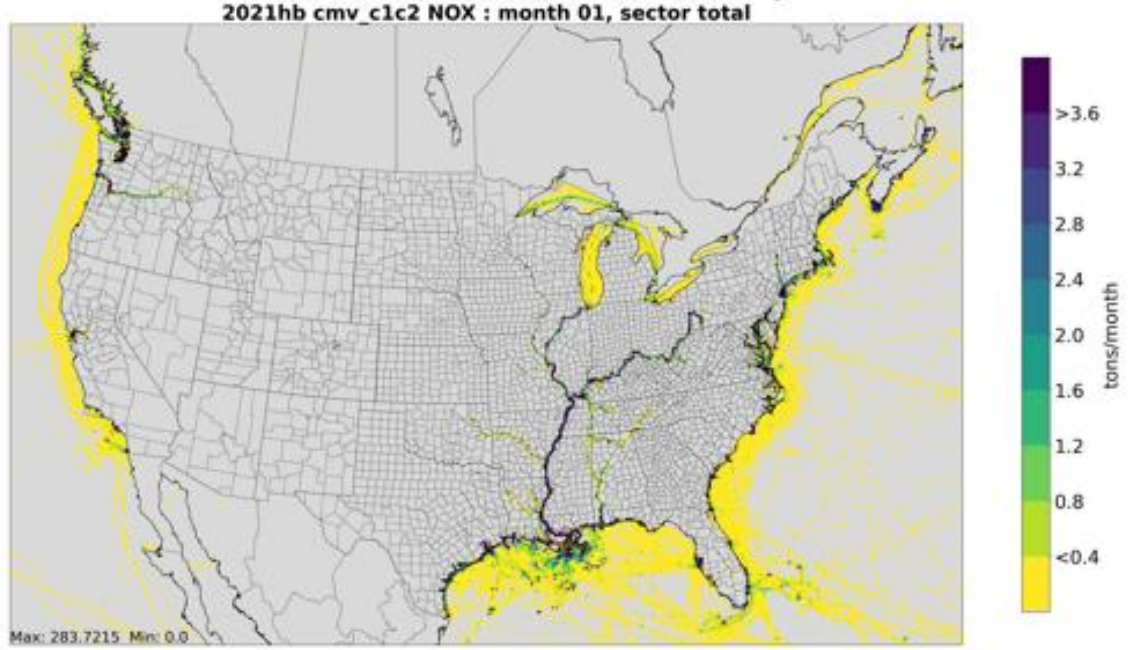


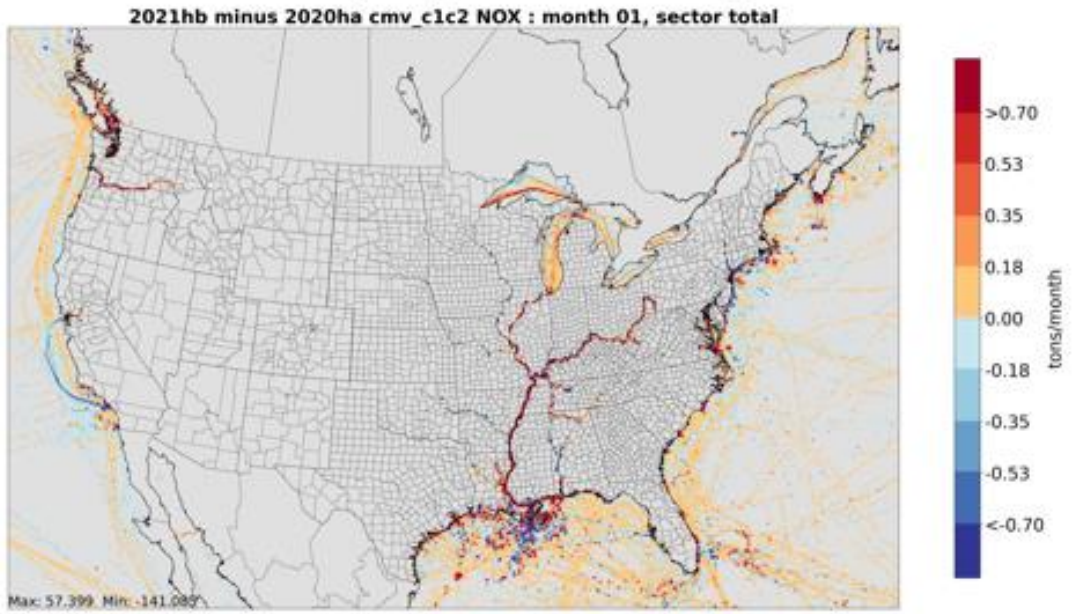


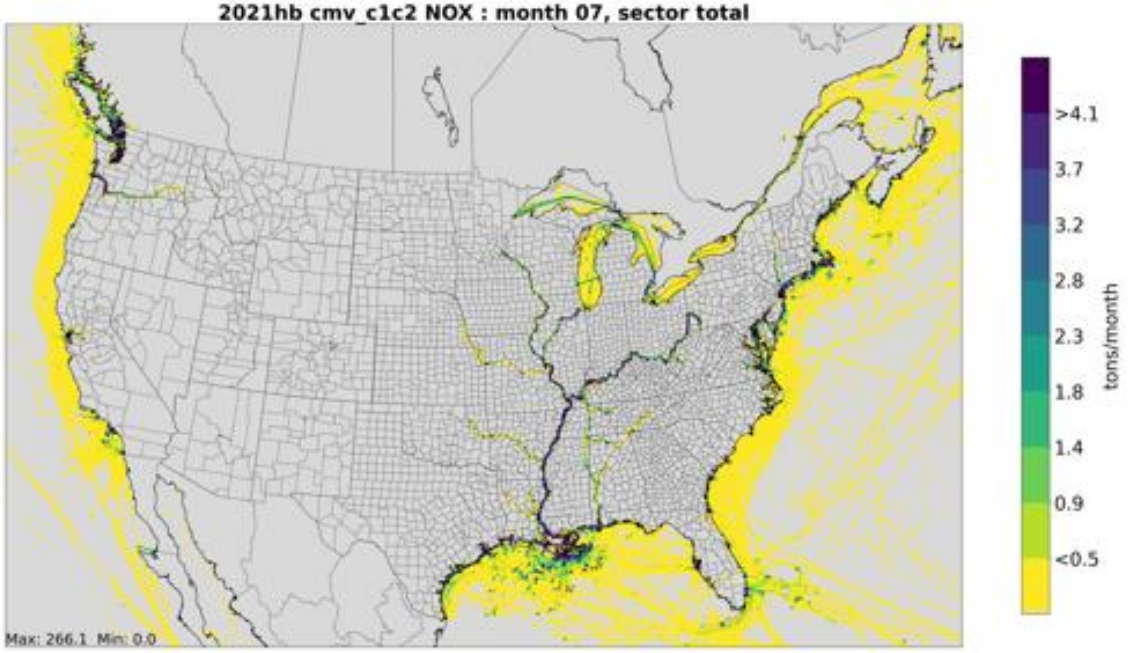
2020 and Updated 2021 CMV C3 NOx emissions

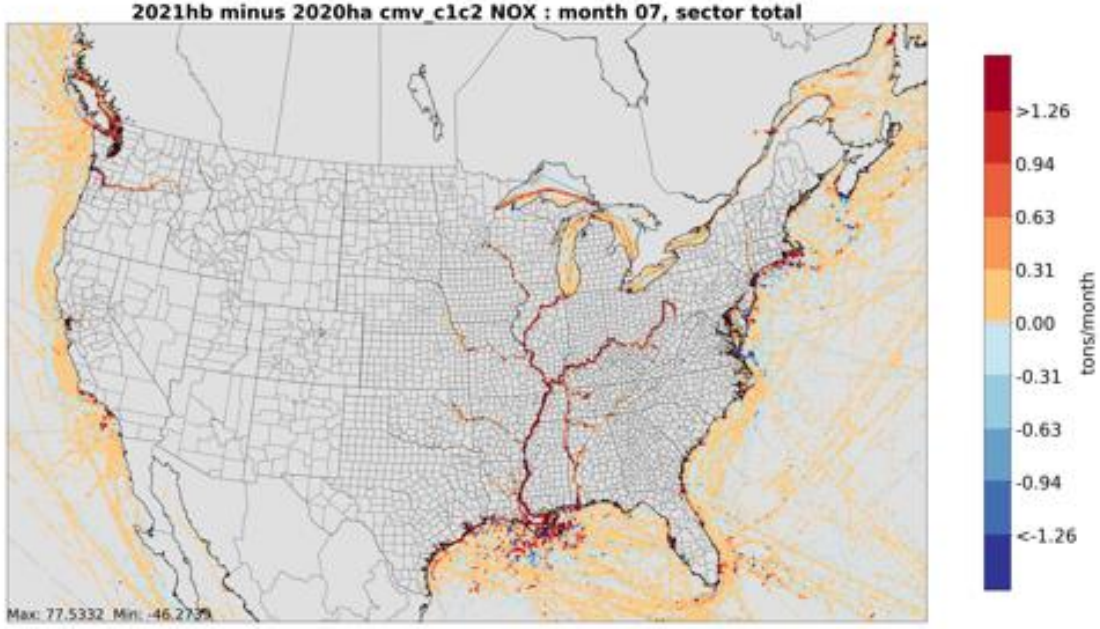
C3 NOx emissions grew in CA in 2021 but decreased in the Gulf of Mexico, south of Florida, ad off coast of Oregon

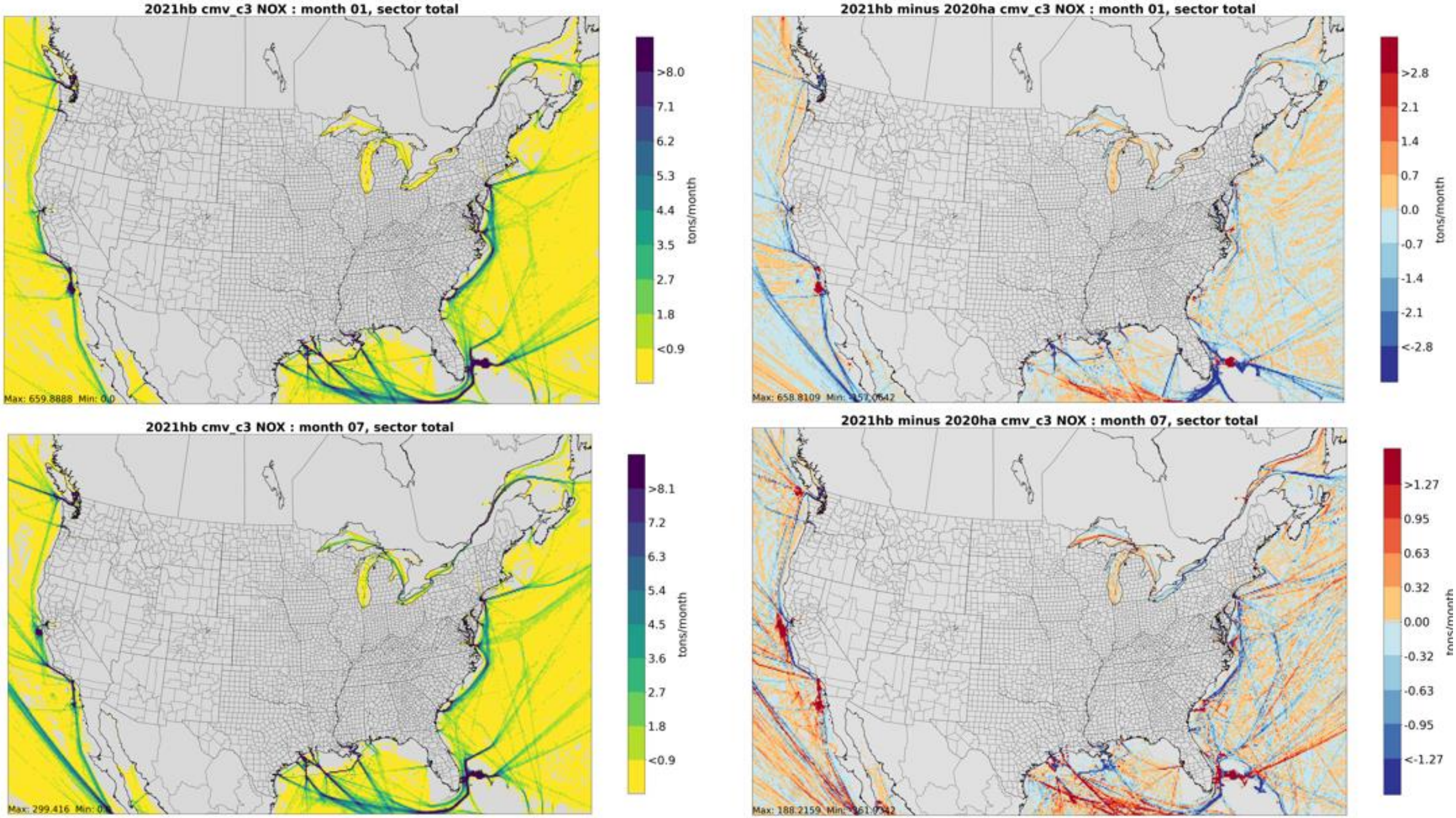
Monthly Plots are Available (updated)



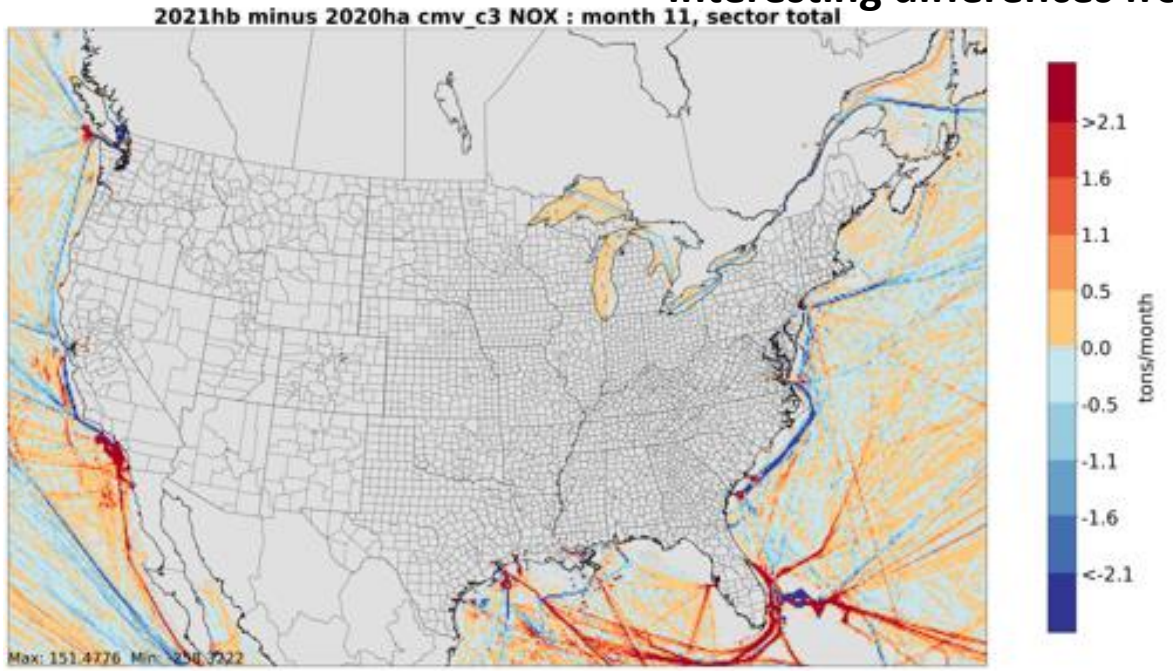


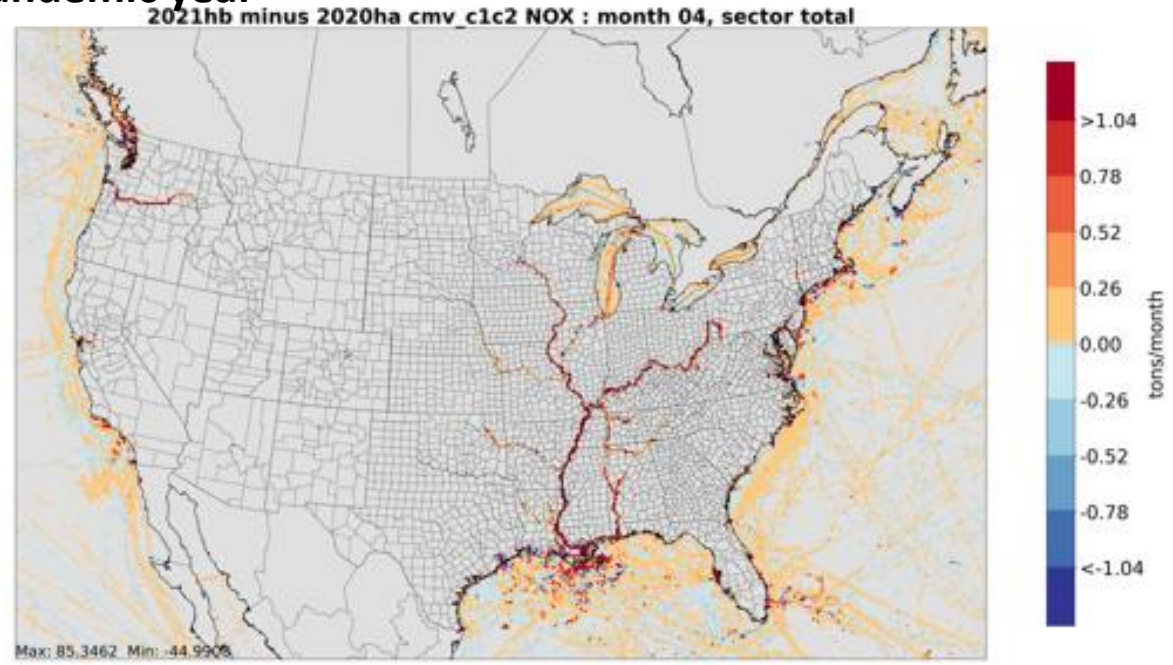


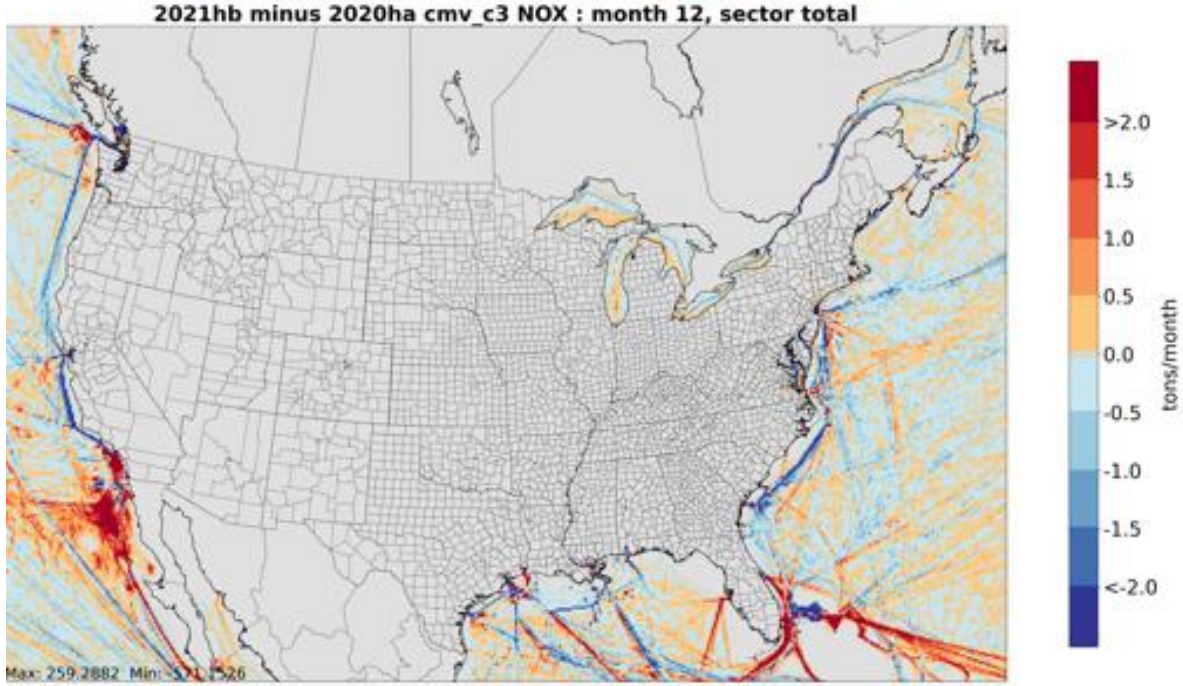


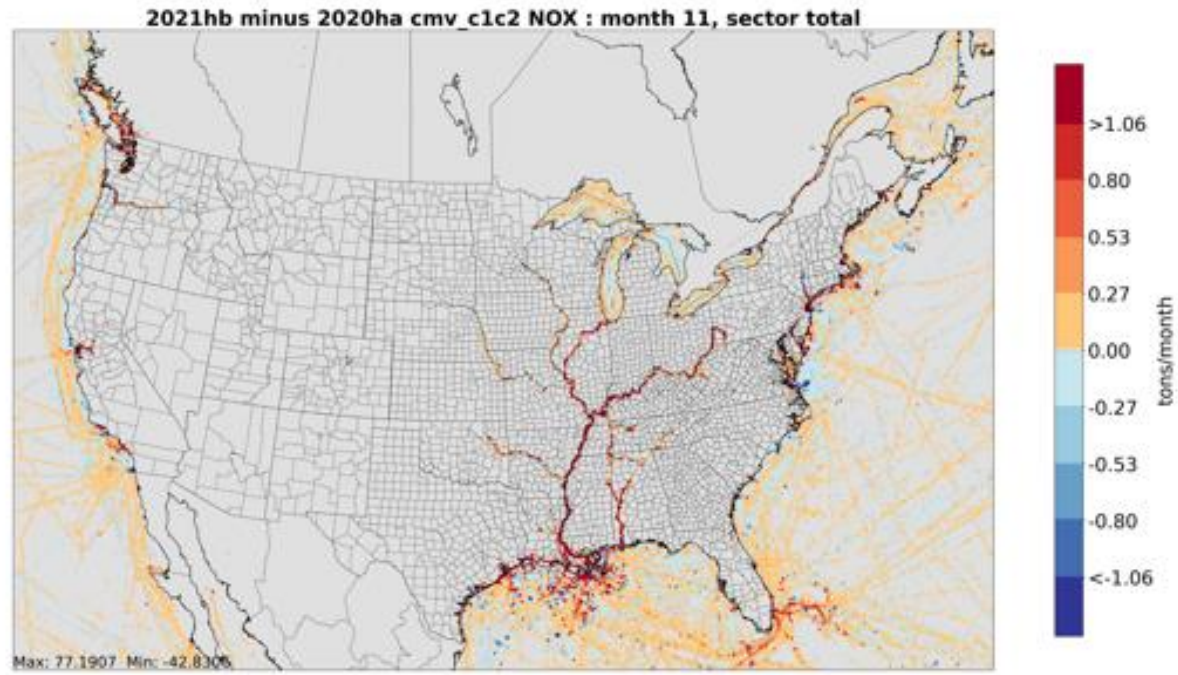

2021hb cmv_c3 NOX : month 01, sector total
>8.0
7.1
6.2
5.3
4.4
3.5
2.7
1.8
<0.9
tons/month
Max: 659.8888 Min: 0.0
2021hb minus 2020ha cmv_c3 NOX : month 01, sector total
>2.8
2.1
1.4
0.7
0.0
-0.7
-1.4
-2.1
<-2.8
tons/month
Max: 658.8109 Min: -357.0642
2021hb cmv_c3 NOX : month 07, sector total
>8.1
7.2
6.3
5.4
4.5
3.6
2.7
1.8
<0.9
tons/month
Max: 299.416 Min: 0.0
2021hb minus 2020ha cmv_c3 NOX : month 07, sector total
>1.27
0.95
0.63
0.32
0.00
-0.32
-0.63
-0.95
<-1.27
tons/month
Max: 188.2159 Min: -161.0342

Interesting differences from the pandemic year

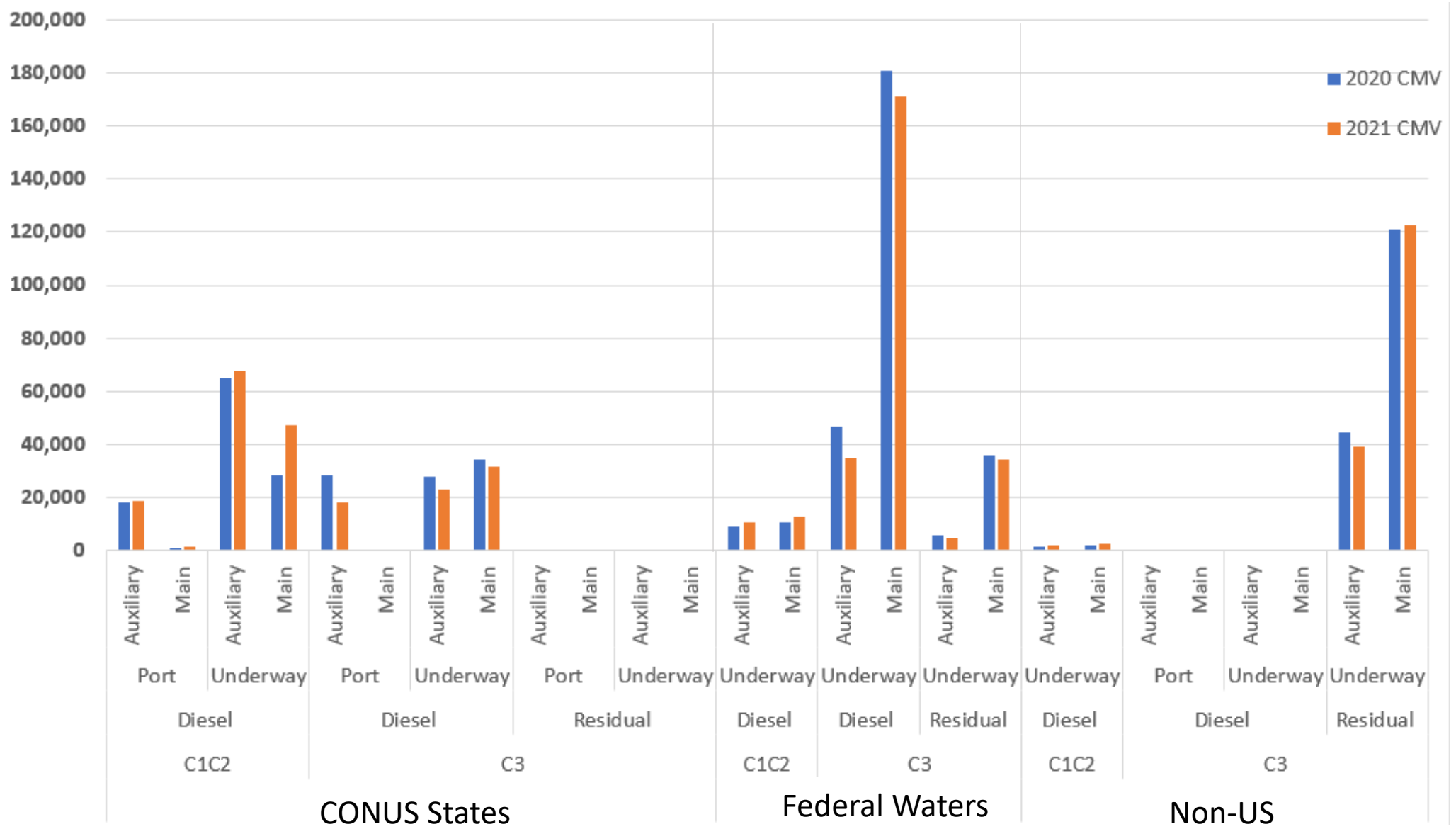




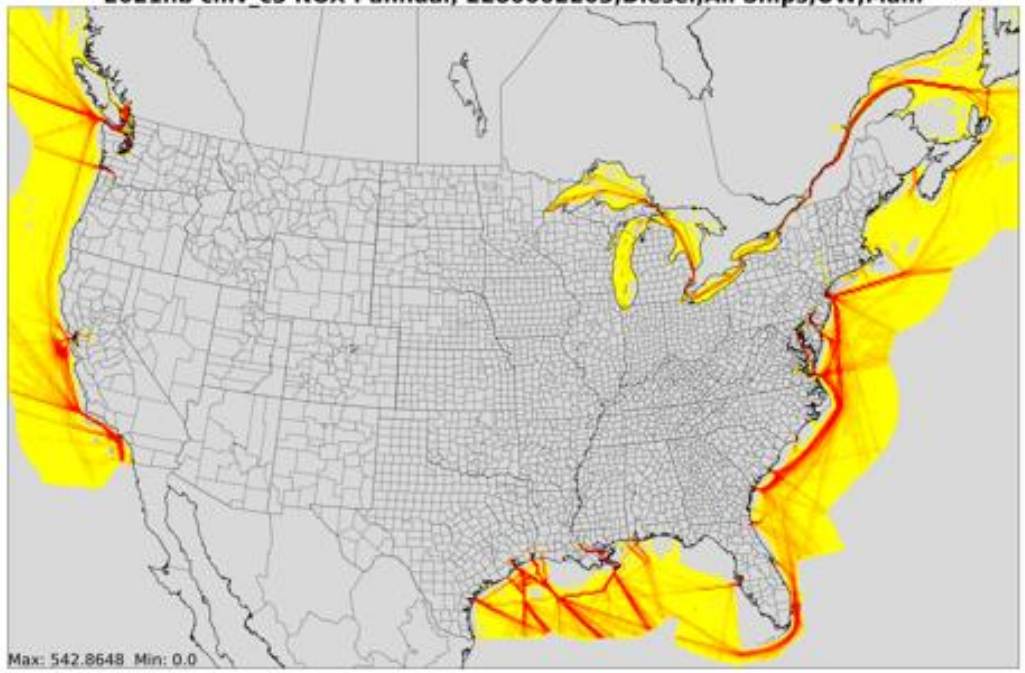


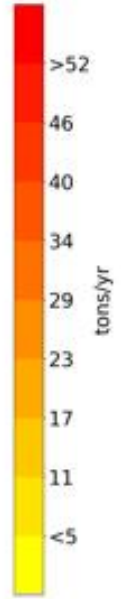


Where are most of the NOx emissions from? (not updated for corrected emissions)

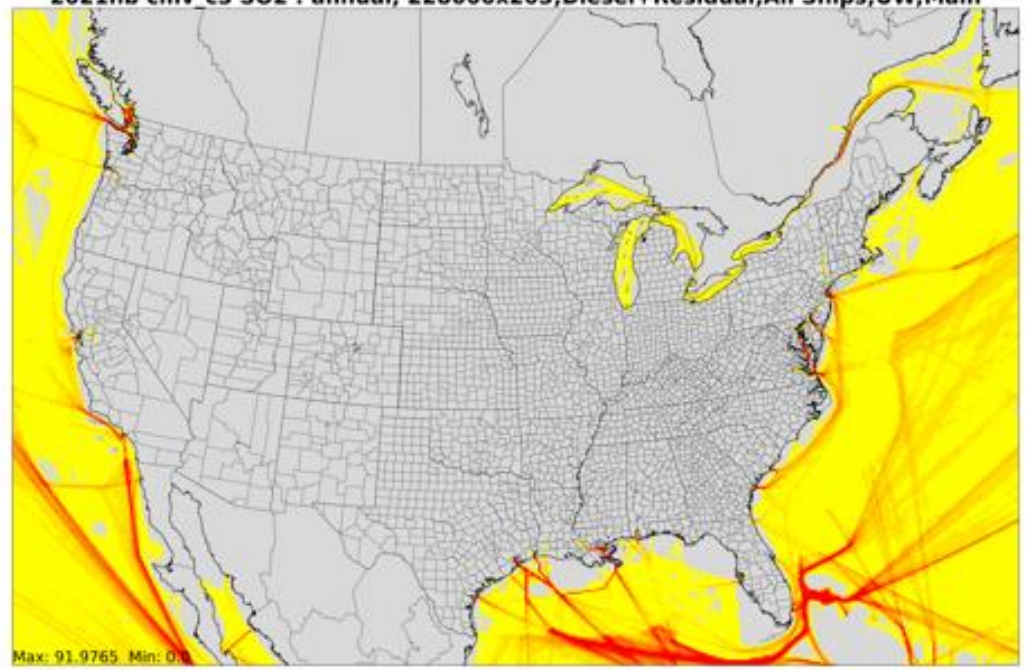


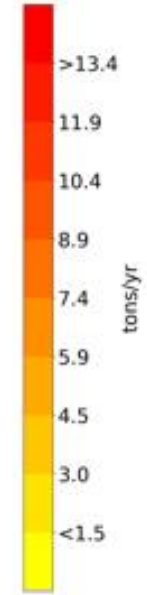
2021hb cmv_c3 NOX : annual, 2280002203;Diesel;All Ships;UW;Main



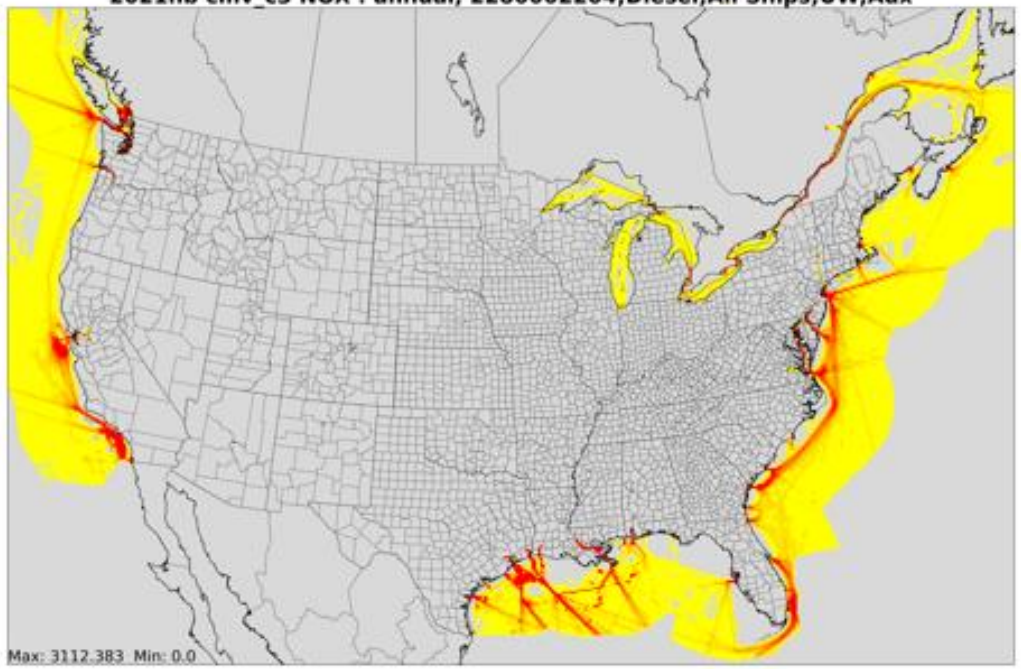


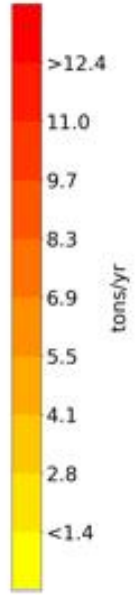
2021hb cmv_c3 SO2 : annual, 228000x203;Diesel+Residual;All Ships;UW;Main



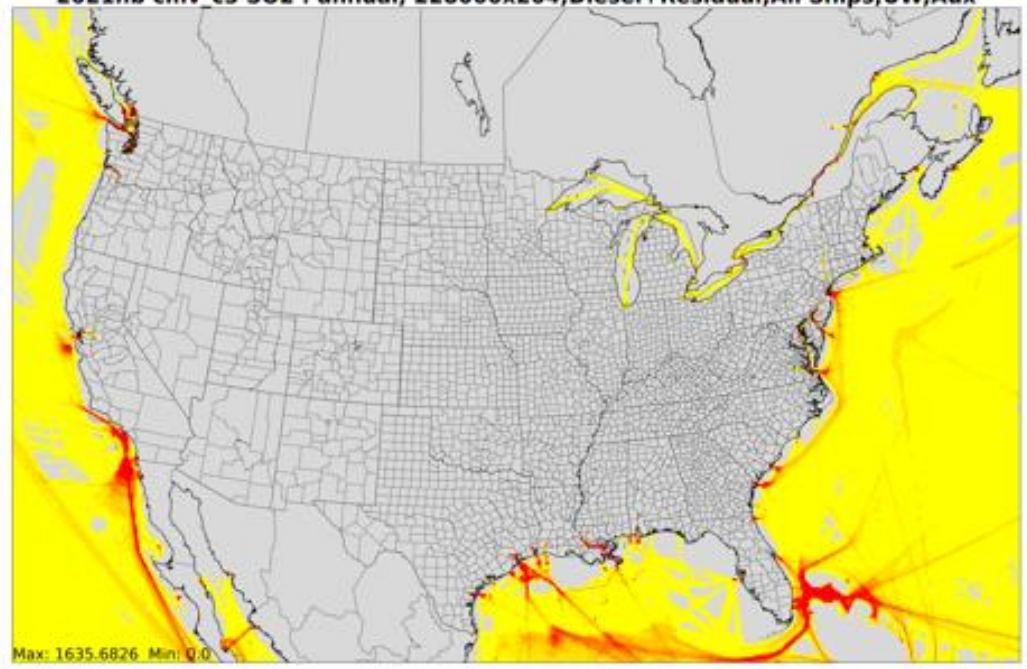


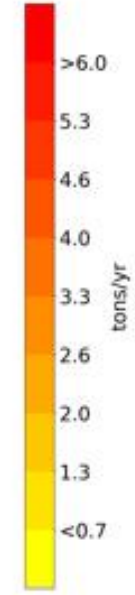
2021hb cmv_c3 NOX : annual, 2280002204;Diesel;All Ships;UW;Aux



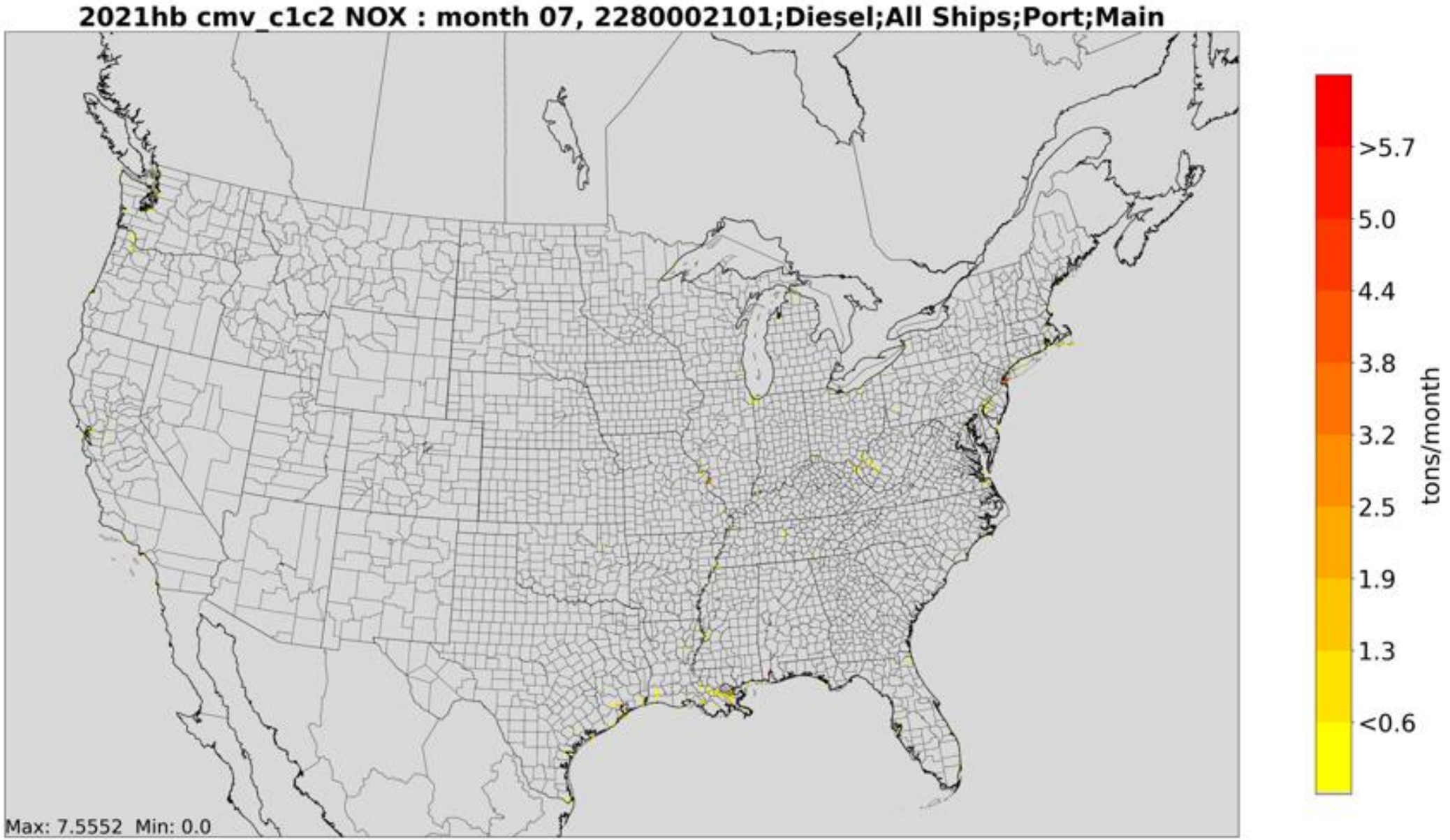


2021hb cmv_c3 SO2 : annual, 228000x204;Diesel+Residual;All Ships;UW;Aux

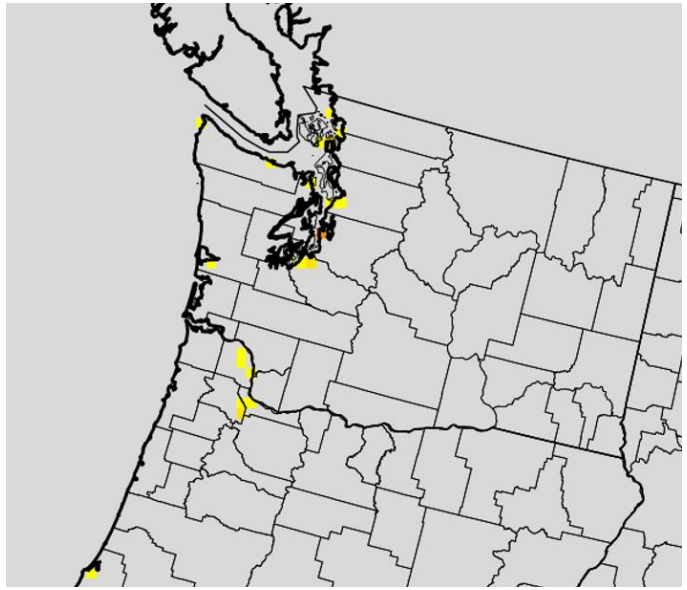


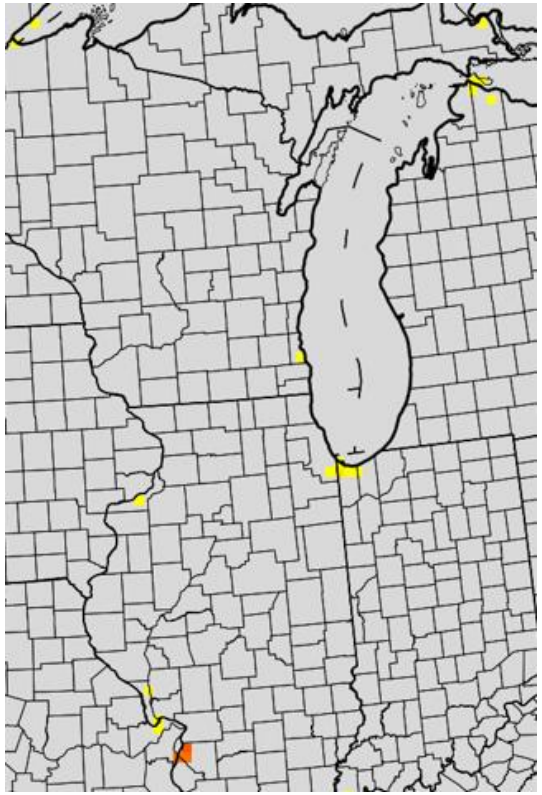


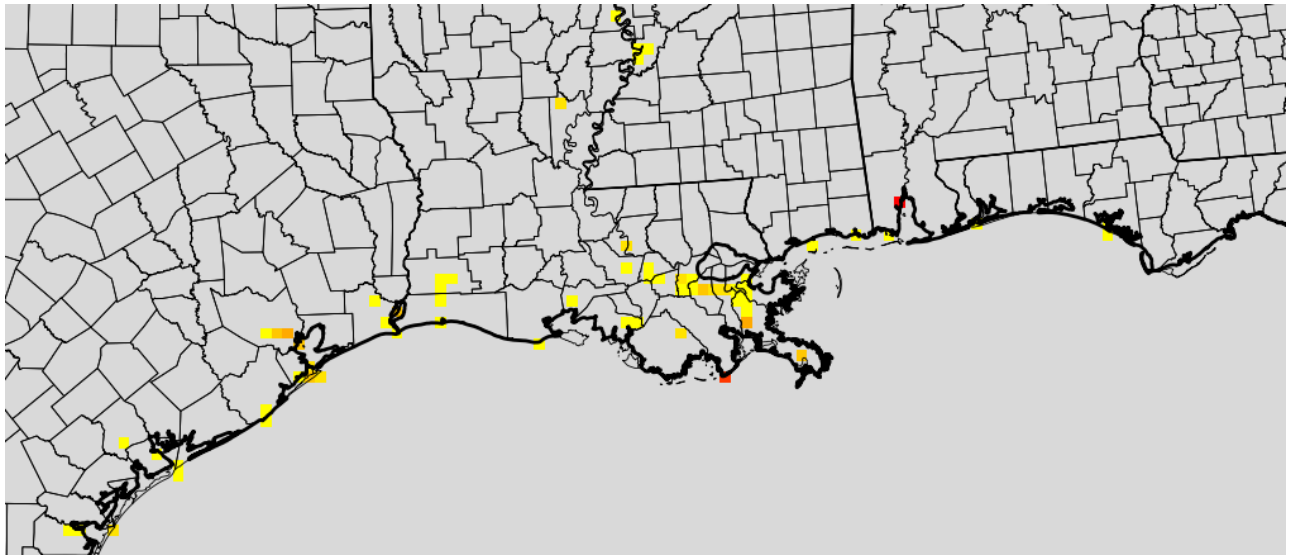
C1C2 Port emissions

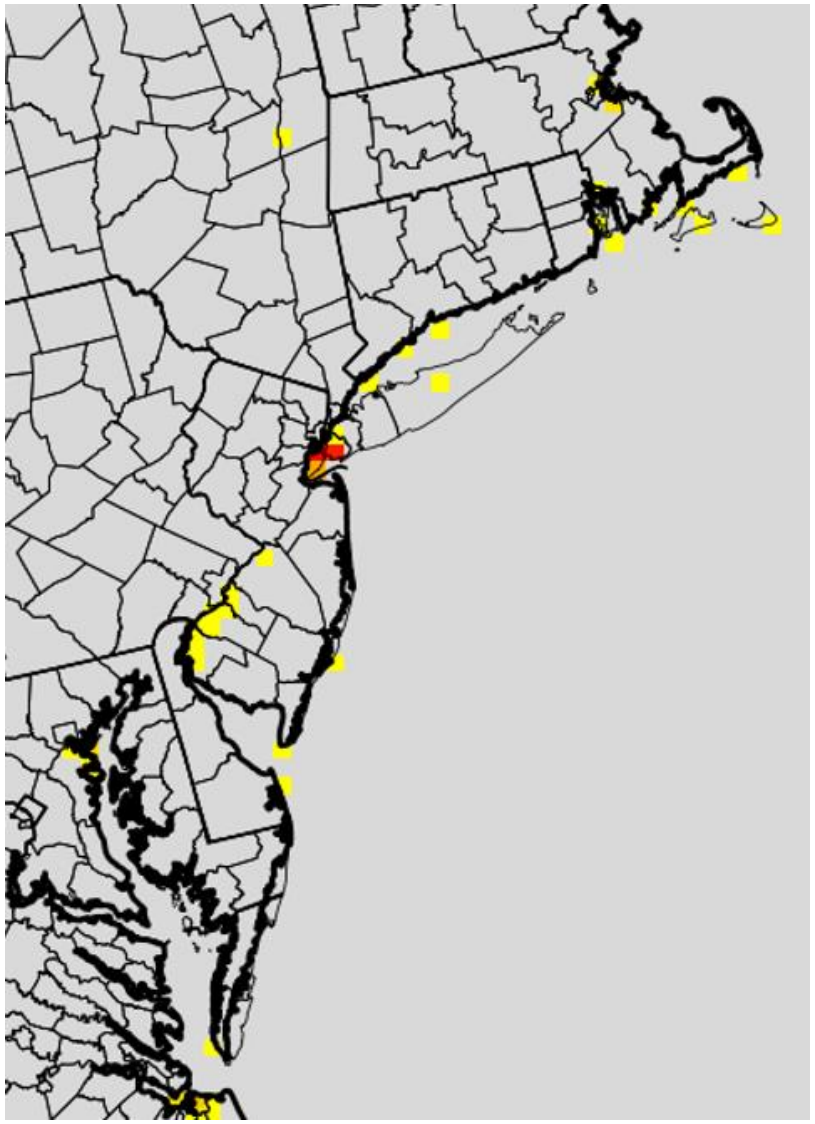


C1C2 Emissions at Key Ports

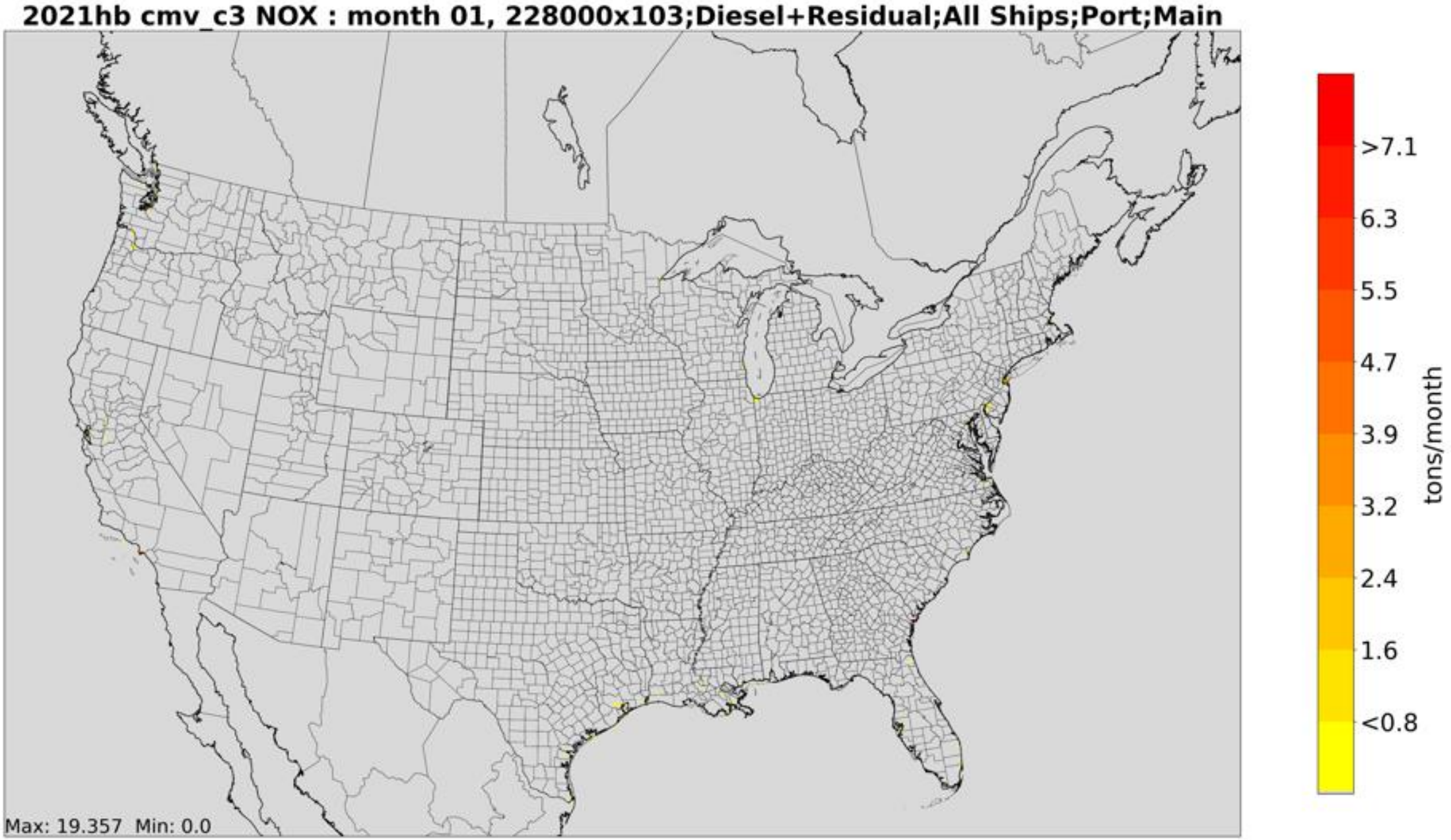




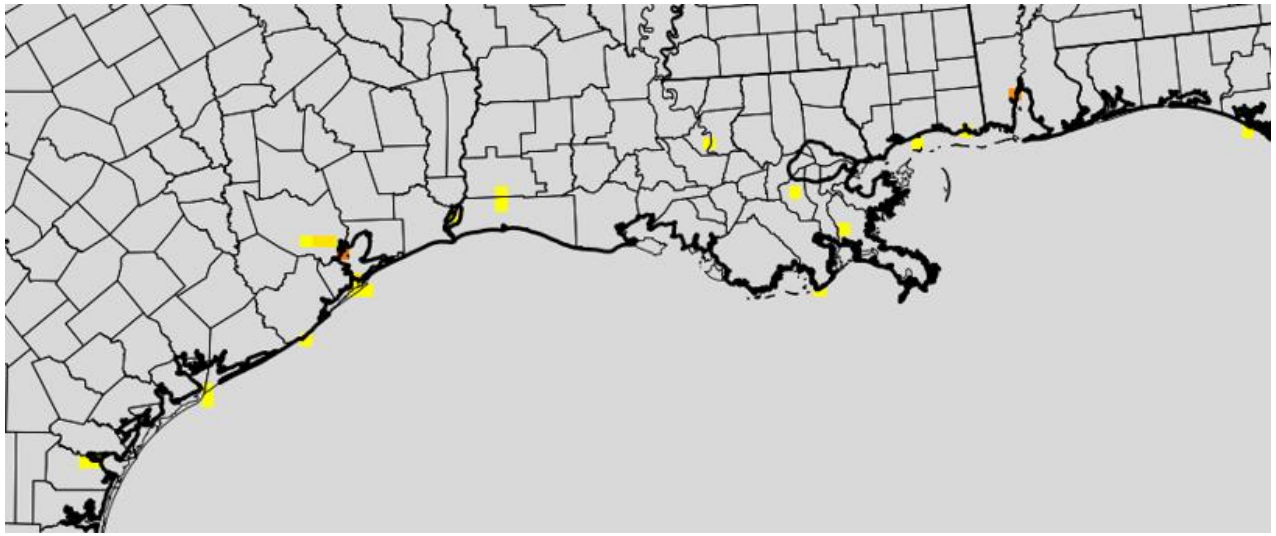


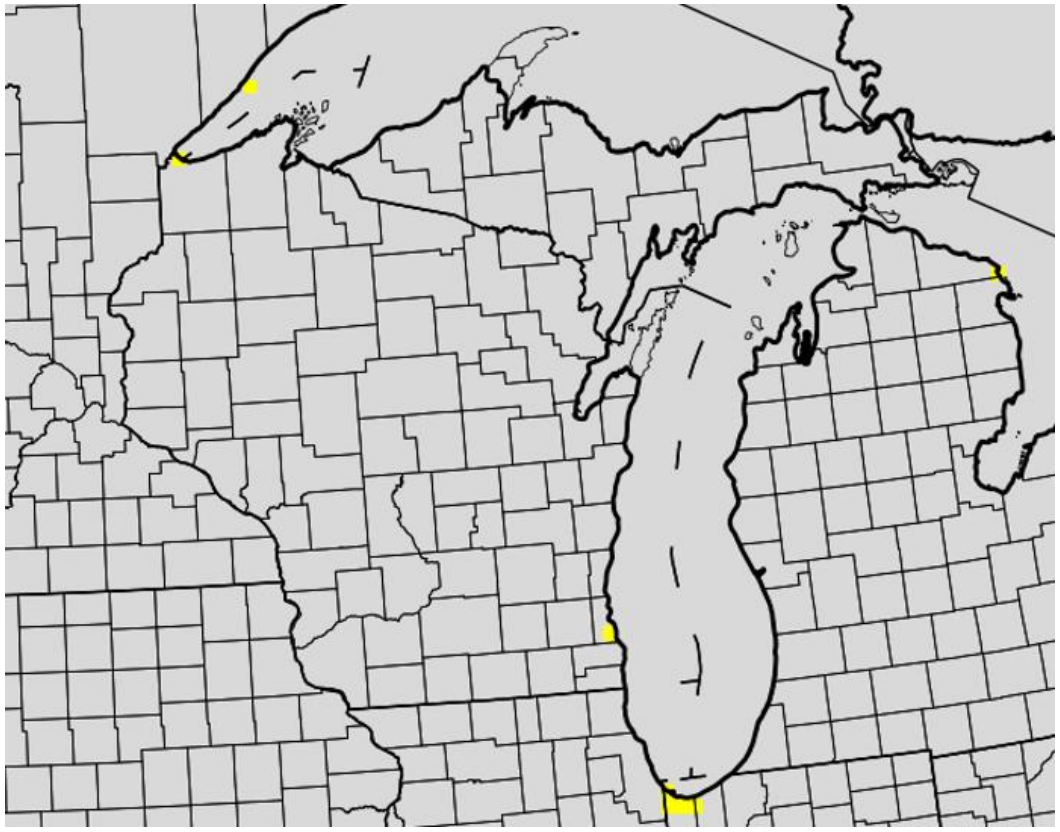


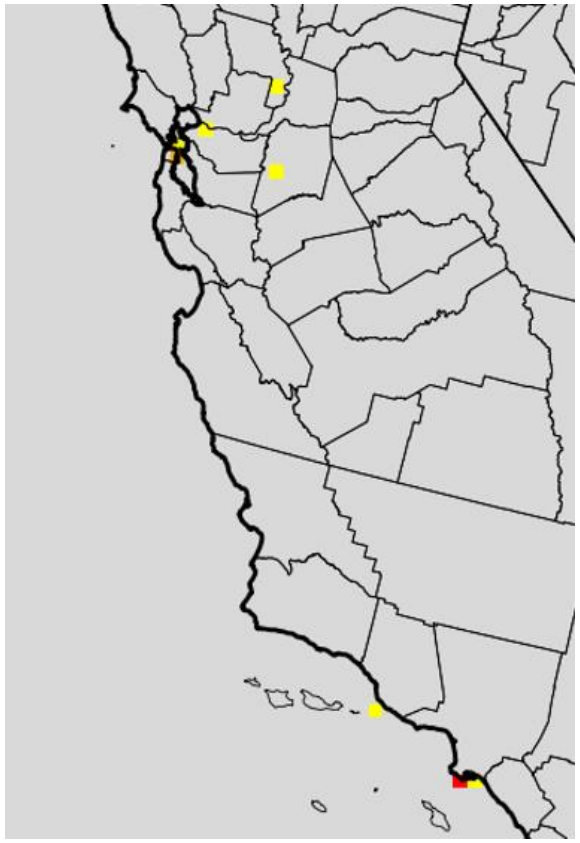
C3 Port Emissions

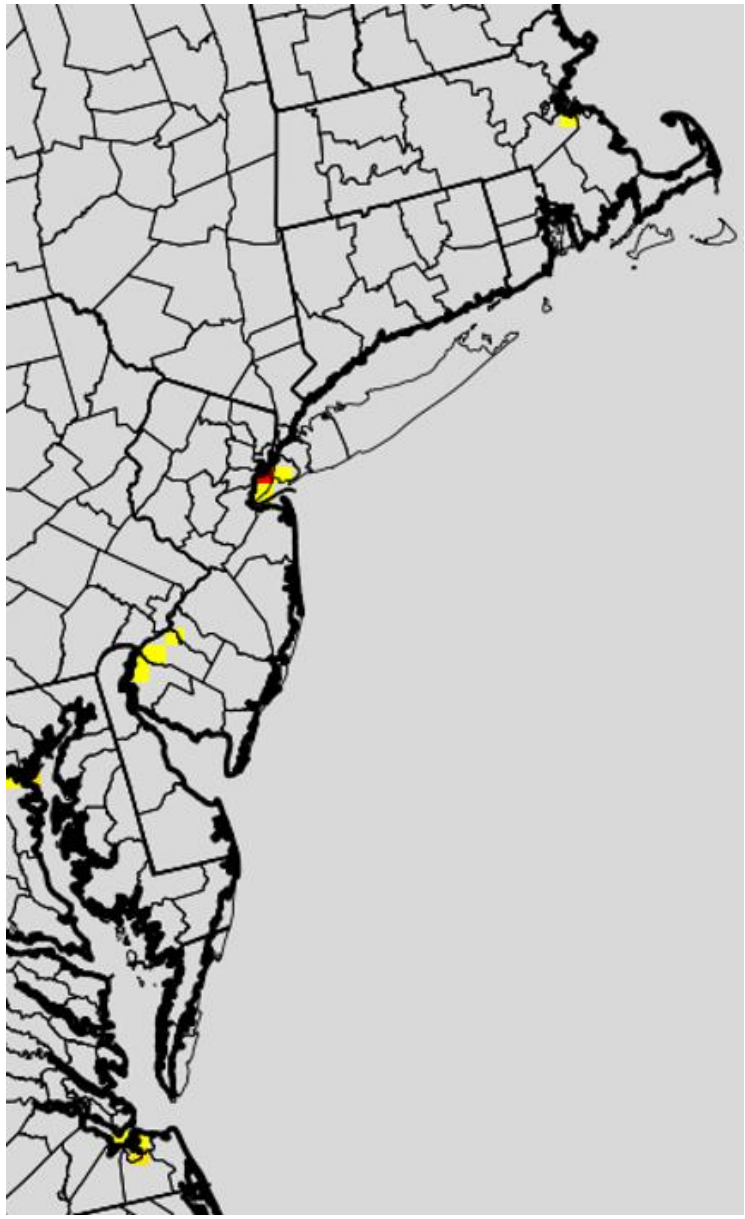


Emissions at Key C3 ports









Top SCCs of Emissions for 2021 – State and Federal Waters (Updated)

	2021 NOx St
l;Tug;Underway emissions: Class 1/2 Main Engine	30,953
l;General Cargo;Underway emissions: Class 1/2 Auxiliary Engine	16,719
l;Tug;Underway emissions: Class 1/2 Auxiliary Engine	14,796
l;Government;Underway emissions: Class 1/2 Auxiliary Engine	13,218
l;Bulk Carrier;Underway emissions: Class 3 Main Engine	11,736
l;Container Ship;Underway emissions: Class 3 Main Engine	8,569
l;Miscellaneous;Underway emissions: Class 1/2 Auxiliary Engine	7,513
l;Tanker;Underway emissions: Class 3 Auxiliary Engine	6,794
l;Offshore;Underway emissions: Class 1/2 Auxiliary Engine	6,511
l;Container Ship;Underway emissions: Class 3 Auxiliary Engine	6,285
l;Tanker;Underway emissions: Class 3 Main Engine	6,177
l;Cruise;Underway emissions: Class 3 Auxiliary Engine	6,087
l;Tanker;Port emissions: Class 3 Auxiliary Engine	6,044
l;Container Ship;Port emissions: Class 3 Auxiliary Engine	5,859
l;General Cargo;Underway emissions: Class 1/2 Main Engine	5,552
l;Bulk Carrier;Underway emissions: Class 3 Auxiliary Engine	5,401
l;Government;Port emissions: Class 1/2 Auxiliary Engine	4,829
l;Cruise;Port emissions: Class 3 Auxiliary Engine	4,379
l;Tour Boat;Underway emissions: Class 1/2 Auxiliary Engine	4,206
l;Offshore;Port emissions: Class 1/2 Auxiliary Engine	4,022
l;Fishing;Underway emissions: Class 1/2 Auxiliary Engine	3,187
l;General Cargo;Port emissions: Class 1/2 Auxiliary Engine	2,846
l;Tug;Port emissions: Class 1/2 Auxiliary Engine	2,836
l;Bulk Carrier;Port emissions: Class 3 Auxiliary Engine	2,807

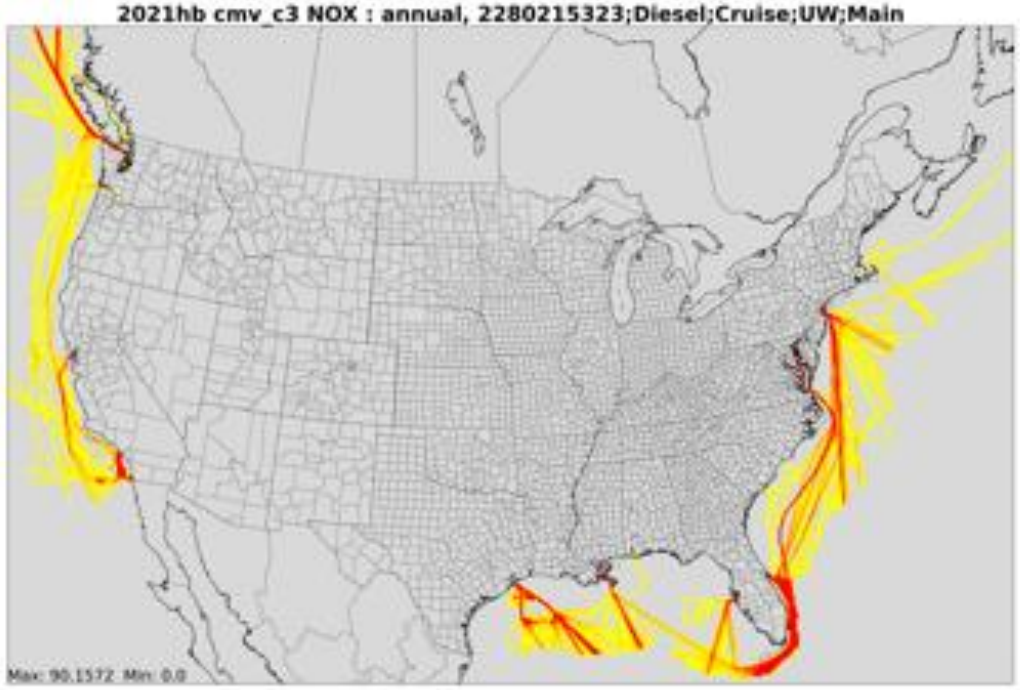
	2021 NOx st + fed
;Diesel;Container Ship;Underway emissions: Class 3 Main Engine	84,236
;Diesel;Tanker;Underway emissions: Class 3 Main Engine	52,349
;Diesel;Tug;Underway emissions: Class 1/2 Main Engine	36,181
;Diesel;Bulk Carrier;Underway emissions: Class 3 Main Engine	34,268
;Diesel;Container Ship;Underway emissions: Class 3 Auxiliary Engine	23,691
;Diesel;Tanker;Underway emissions: Class 3 Auxiliary Engine	18,007
;Diesel;General Cargo;Underway emissions: Class 1/2 Auxiliary Engine	17,415
;Diesel;Tug;Underway emissions: Class 1/2 Auxiliary Engine	15,112
;Diesel;Government;Underway emissions: Class 1/2 Auxiliary Engine	14,285
;Diesel;Ro-Ro;Underway emissions: Class 3 Main Engine	12,624
;Diesel;Cruise;Underway emissions: Class 3 Auxiliary Engine	12,423
;Diesel;Offshore;Underway emissions: Class 1/2 Auxiliary Engine	12,350
;Residual;Container Ship;Underway emissions: Class 3 Main Engine	11,411
;Residual;Tanker;Underway emissions: Class 3 Main Engine	10,937
;Diesel;Miscellaneous;Underway emissions: Class 1/2 Auxiliary Engine	8,683
;Diesel;Bulk Carrier;Underway emissions: Class 3 Auxiliary Engine	7,593
;Residual;Bulk Carrier;Underway emissions: Class 3 Main Engine	6,924
;Diesel;General Cargo;Underway emissions: Class 1/2 Main Engine	6,203
;Diesel;Tanker;Port emissions: Class 3 Auxiliary Engine	6,044
;Diesel;Offshore;Underway emissions: Class 3 Main Engine	6,036
;Diesel;Container Ship;Port emissions: Class 3 Auxiliary Engine	5,859
;Diesel;Cruise;Underway emissions: Class 3 Main Engine	5,547
;Diesel;Offshore;Underway emissions: Class 1/2 Main Engine	4,848
;Diesel;Government;Port emissions: Class 1/2 Auxiliary Engine	4,829

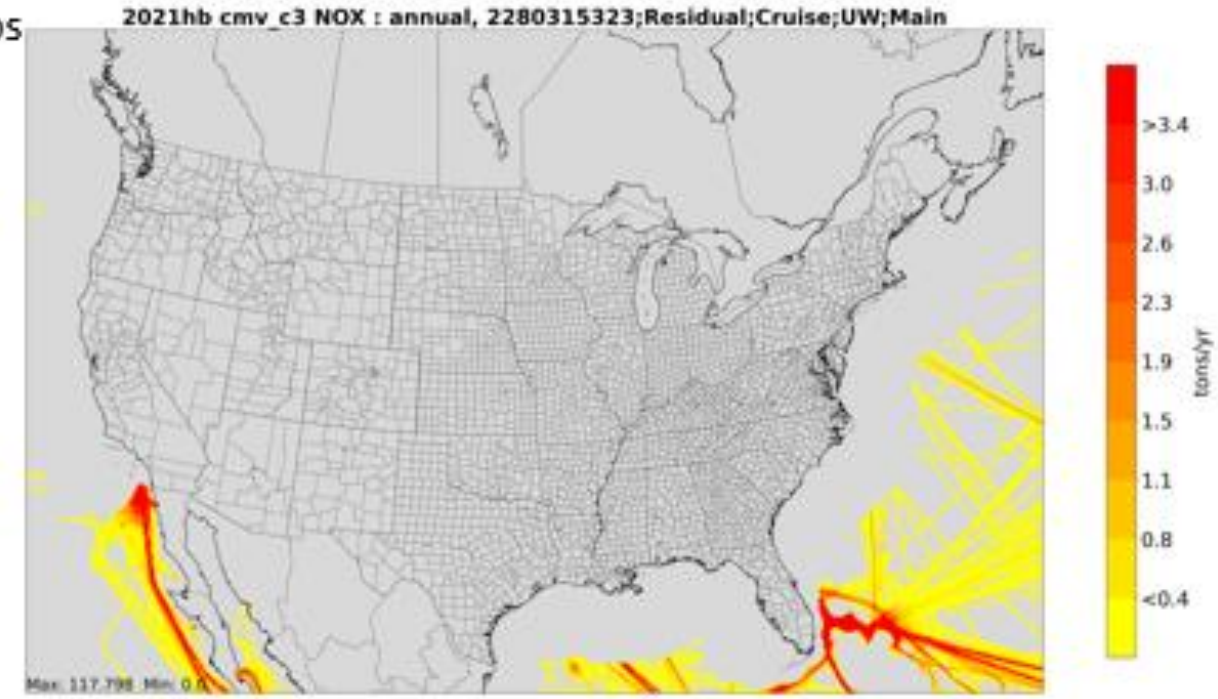
Plots of Emissions by SCC – now including ship type (not yet updated)

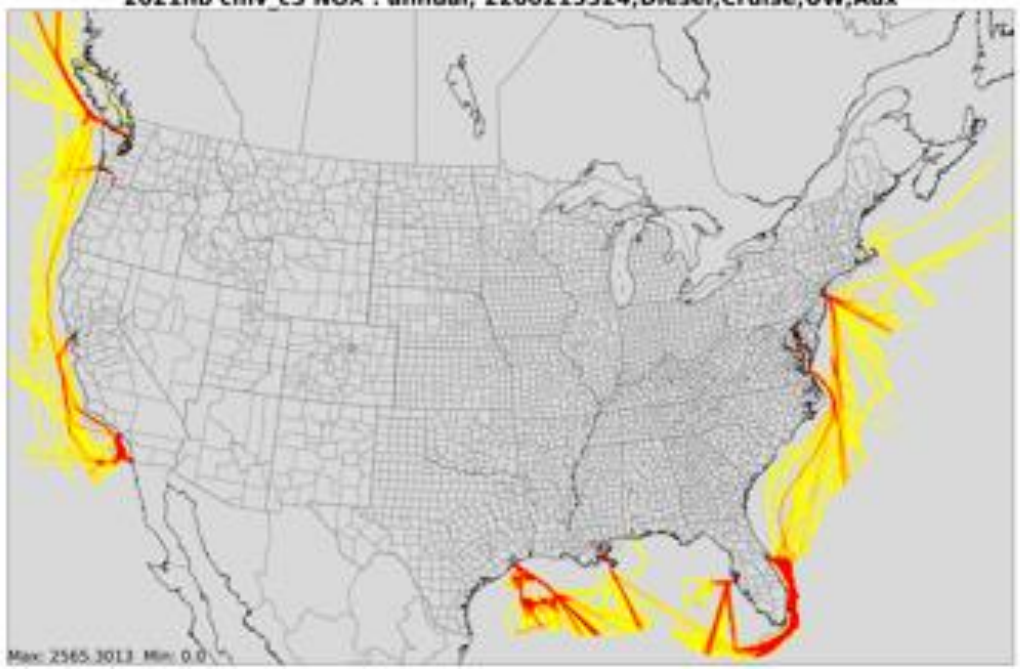
- With the new SCCs, it is possible to visualize where the emissions are occurring for each ship type, fuel type, and engine type
- Note that the scales vary on the following slide, depending on the magnitude of the emissions

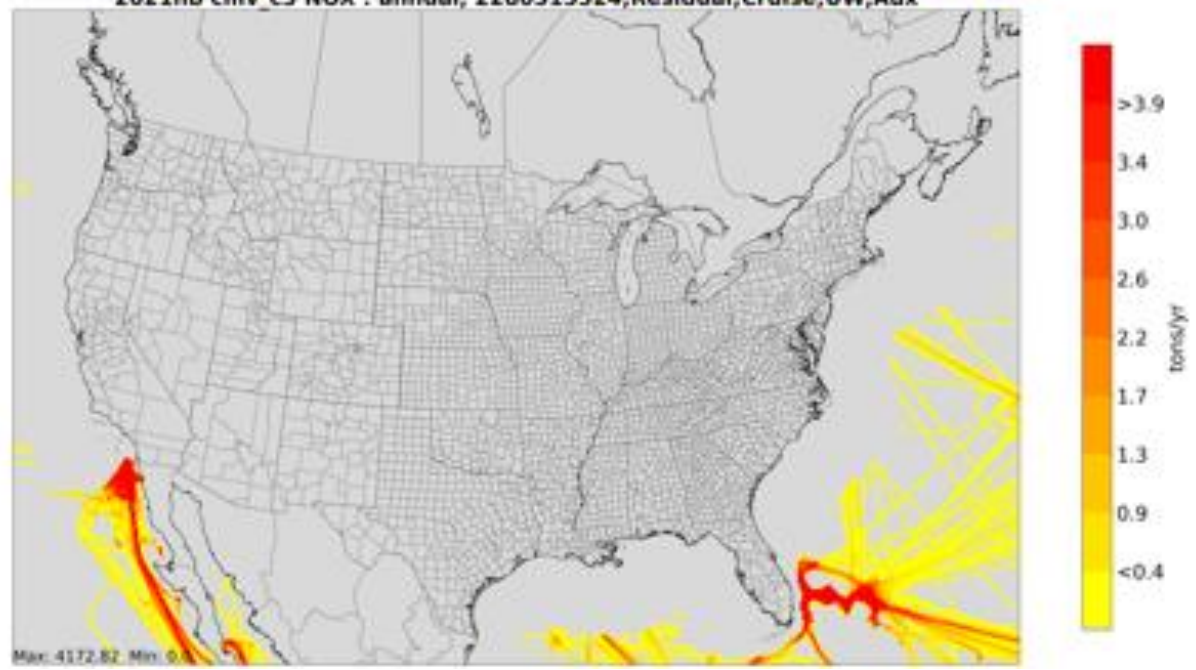
C3 examples by ship type, fuel, engine type

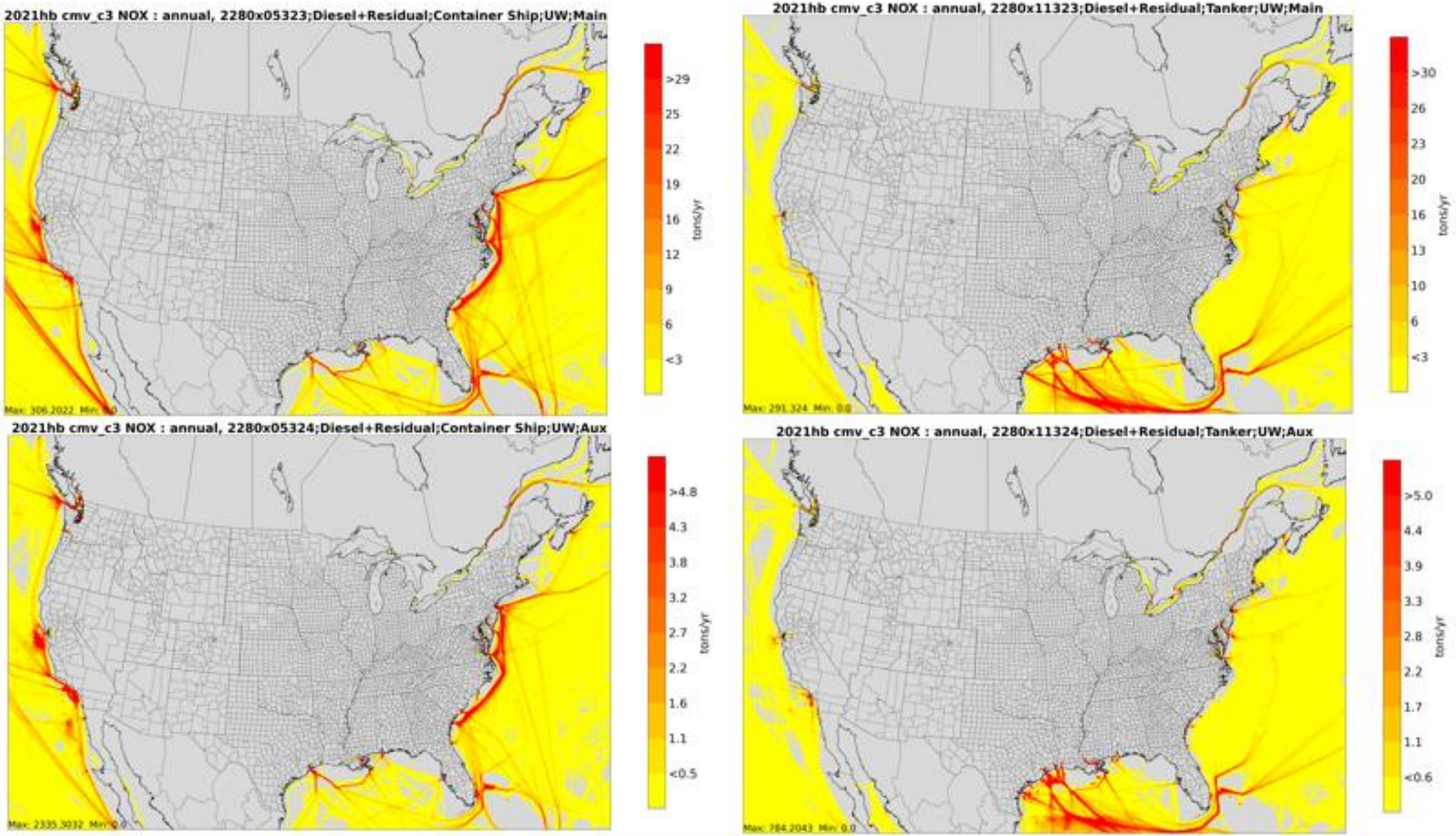
Cruise ships



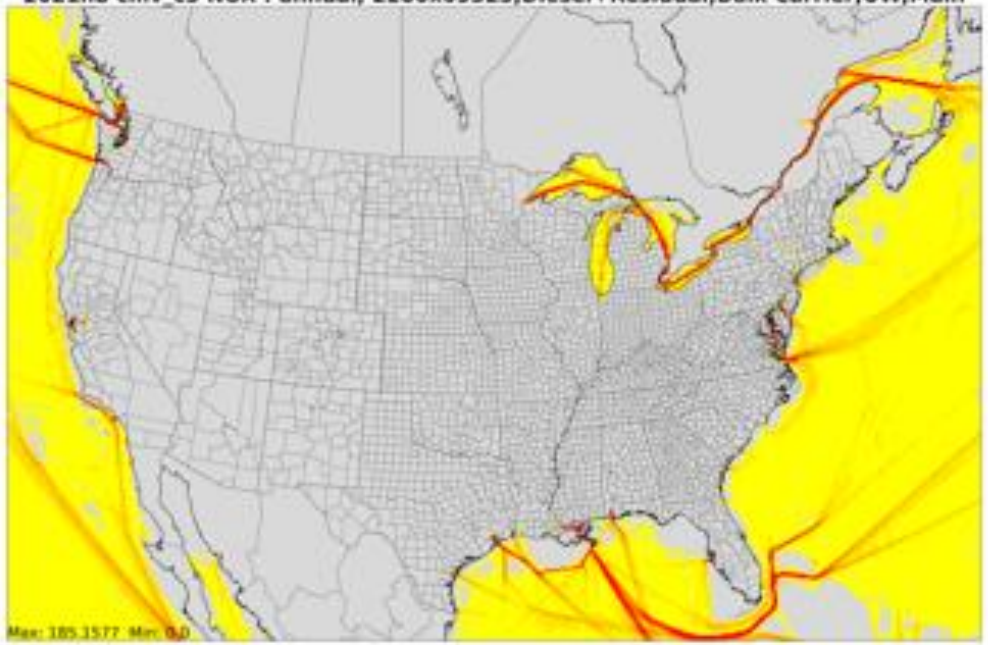


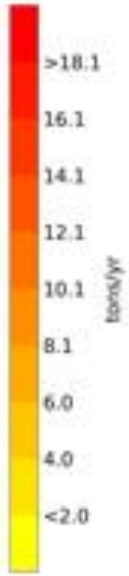




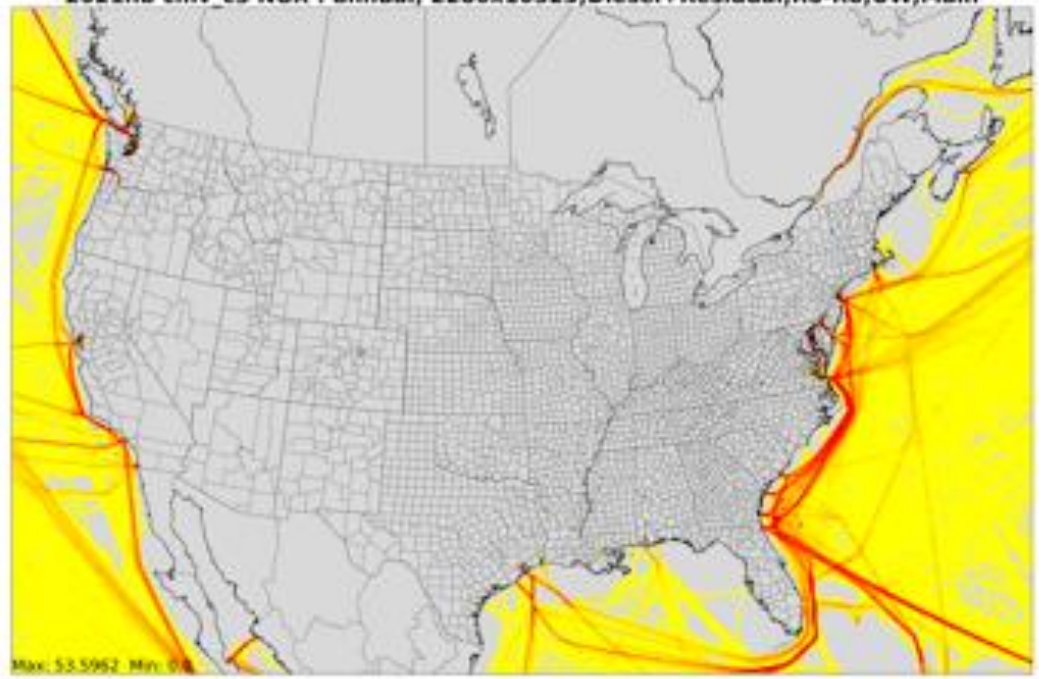

2021hb cmv_c3 NOX : annual, 2280x05323;Diesel+Residual;Container Ship;UW;Main
>29
25
22
19
16
12
9
6
<3
tons/yr
Max: 306.2022 Min: 0.0
2021hb cmv_c3 NOX : annual, 2280x11323;Diesel+Residual;Tanker;UW;Main
>30
26
23
20
16
13
10
6
<3
tons/yr
Max: 291.324 Min: 0.0
2021hb cmv_c3 NOX : annual, 2280x05324;Diesel+Residual;Container Ship;UW;Aux
>4.8
4.3
3.8
3.2
2.7
2.2
1.6
1.1
<0.5
tons/yr
Max: 2335.3032 Min: 0.0
2021hb cmv_c3 NOX : annual, 2280x11324;Diesel+Residual;Tanker;UW;Aux
>5.0
4.4
3.9
3.3
2.8
2.2
1.7
1.1
<0.6
tons/yr
Max: 784.2043 Min: 0.0

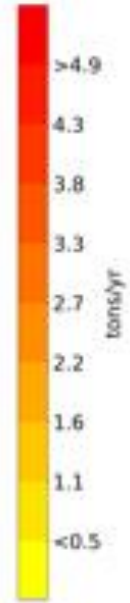
2021hb cmv_c3 NOX : annual, 2280x03323;Diesel+Residual;Bulk Carrier;UW;Main



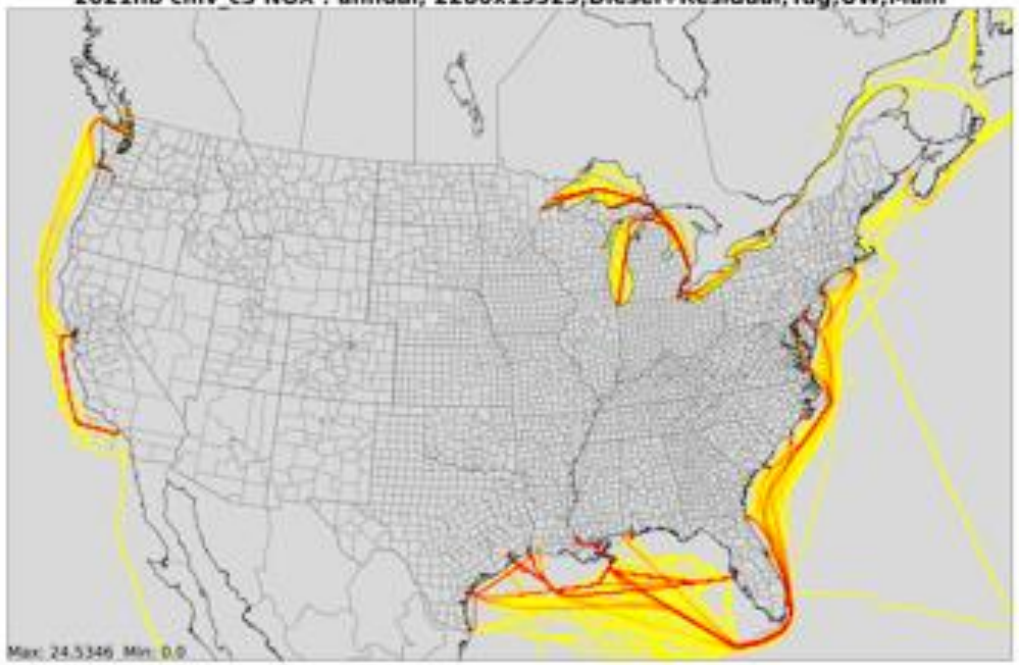


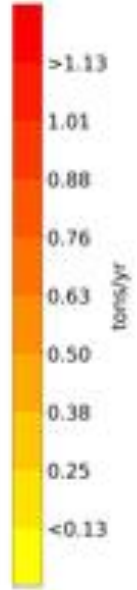
2021hb cmv_c3 NOX : annual, 2280x10323;Diesel+Residual;Ro-Ro;UW;Main



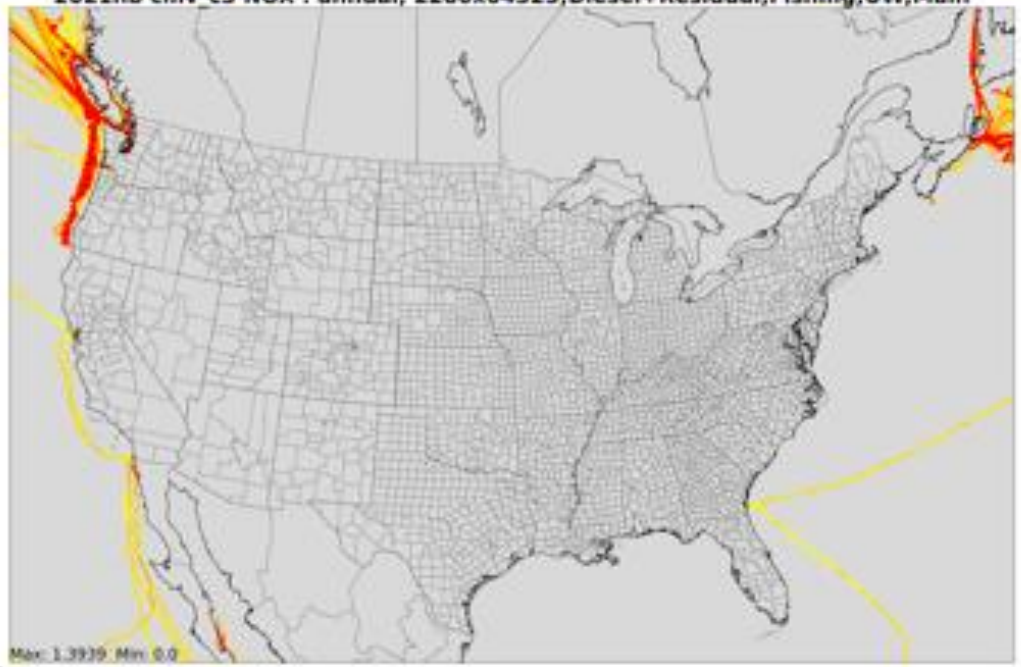


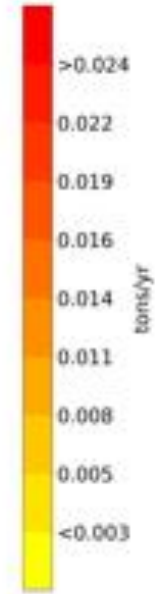
2021hb cmv_c3 NOX : annual, 2280x13323;Diesel+Residual;Tug;UW;Main



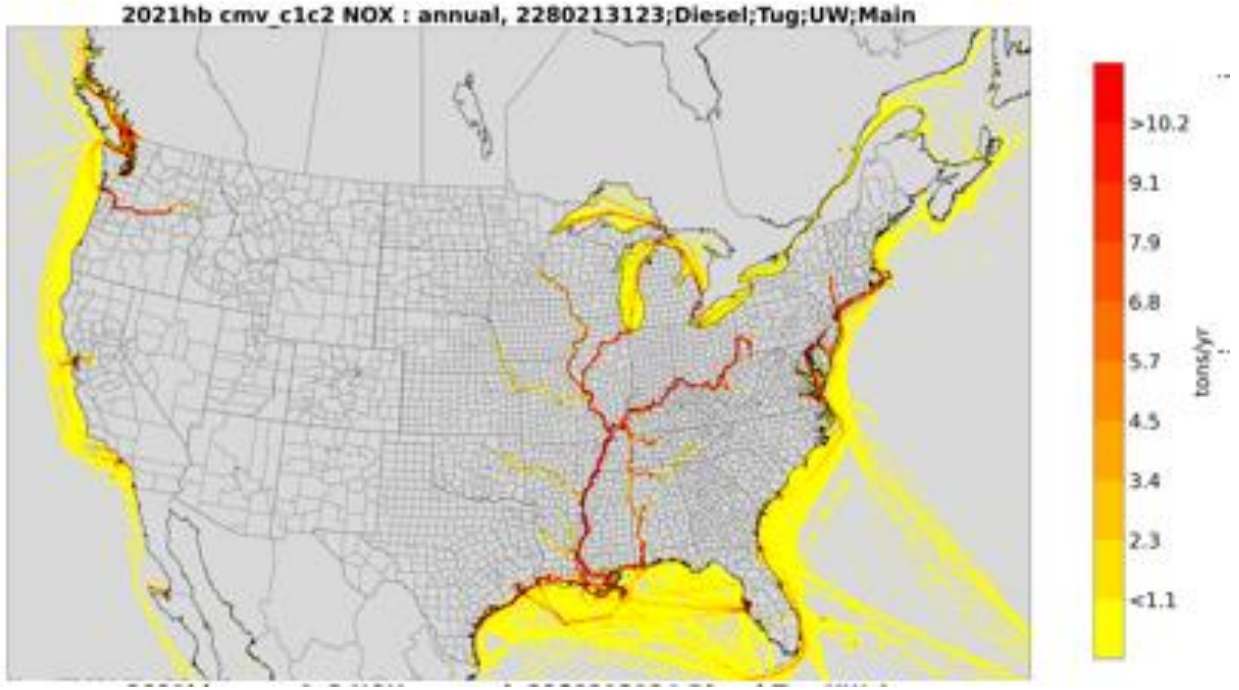


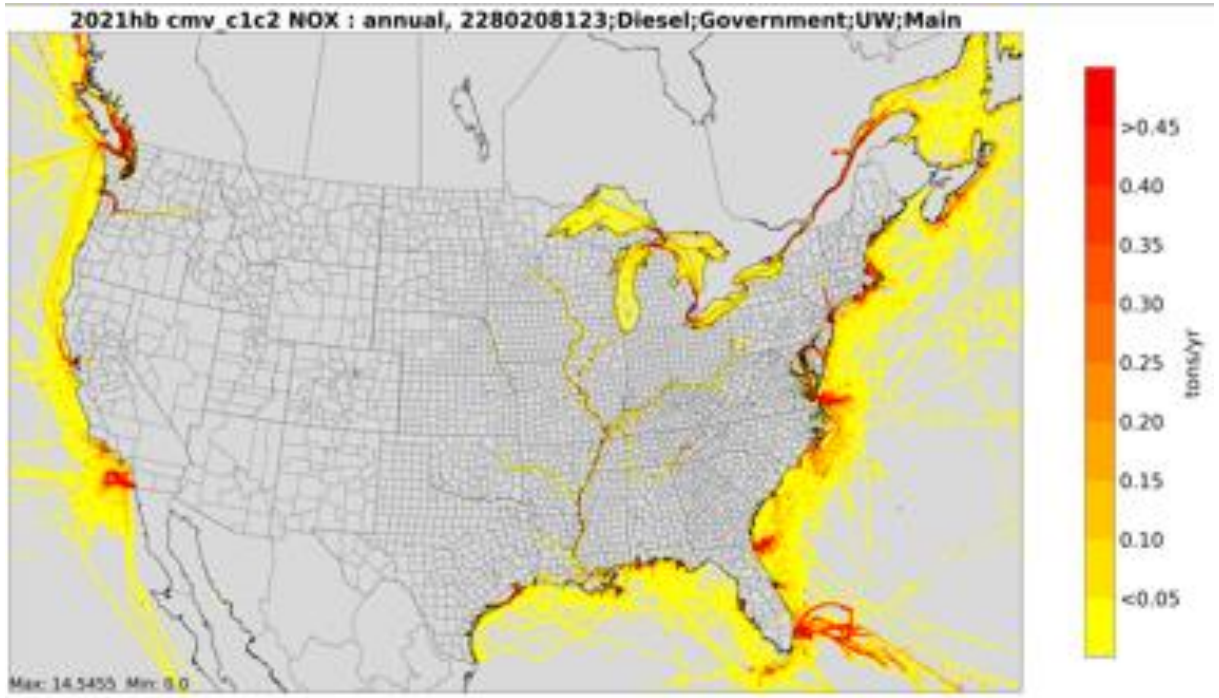
2021hb cmv_c3 NOX : annual, 2280x04323;Diesel+Residual;Fishing;UW;Main

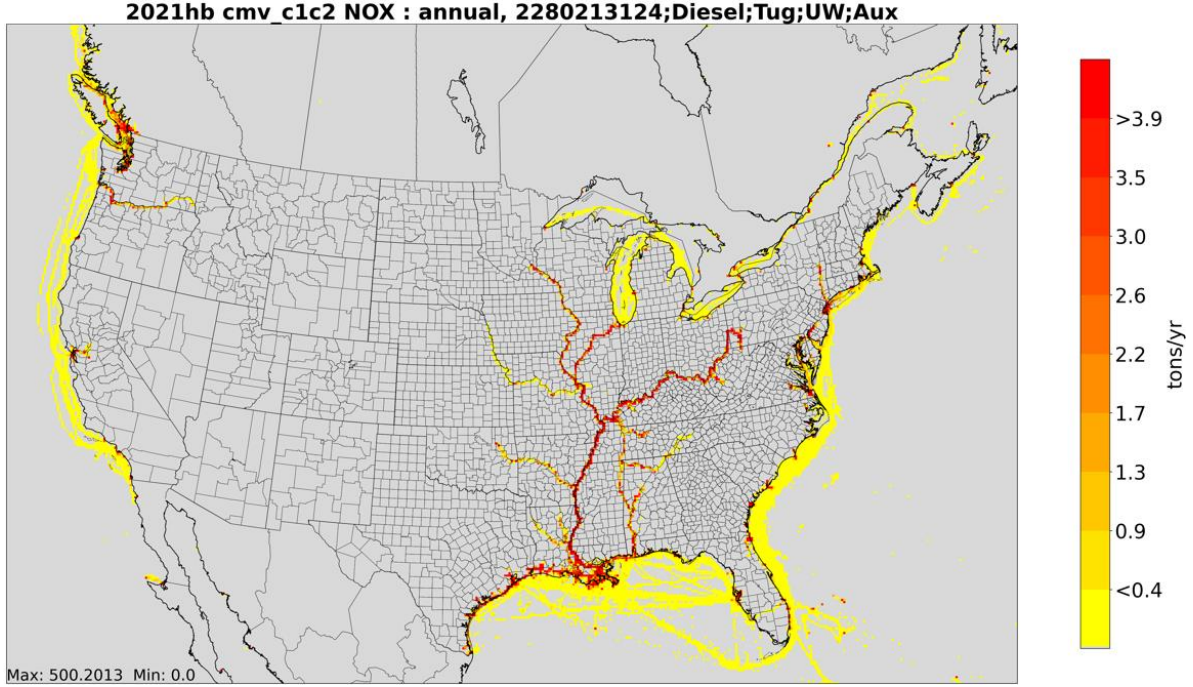


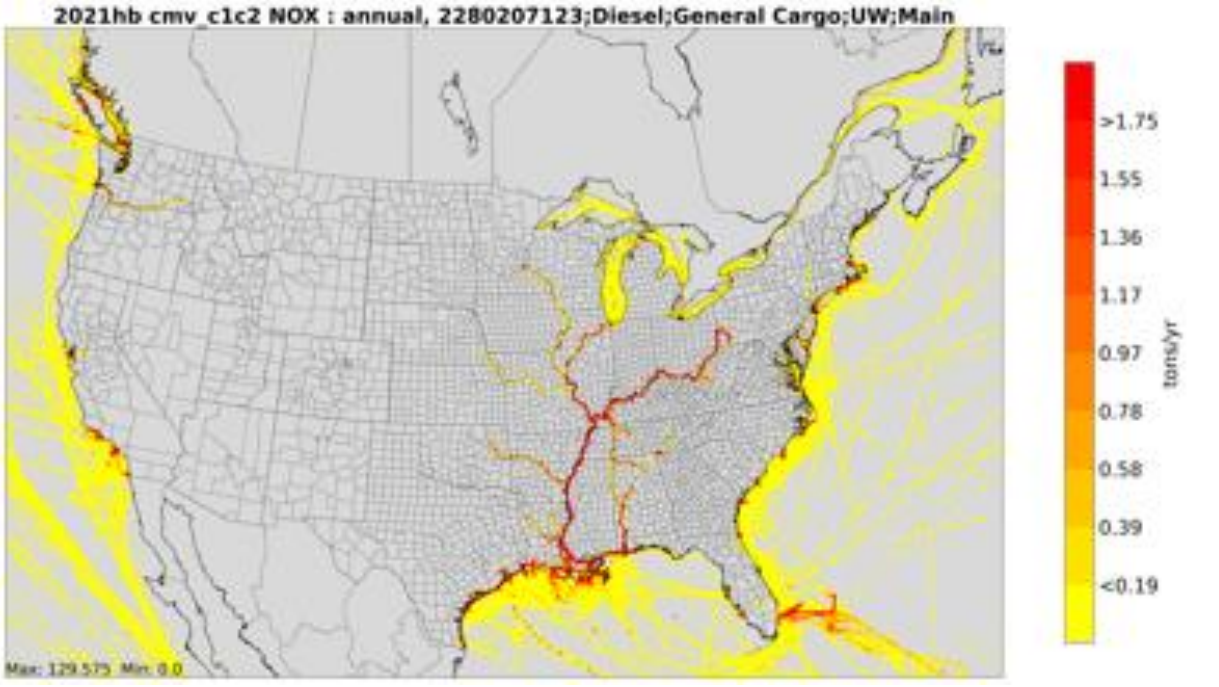


C1C2 by ship type

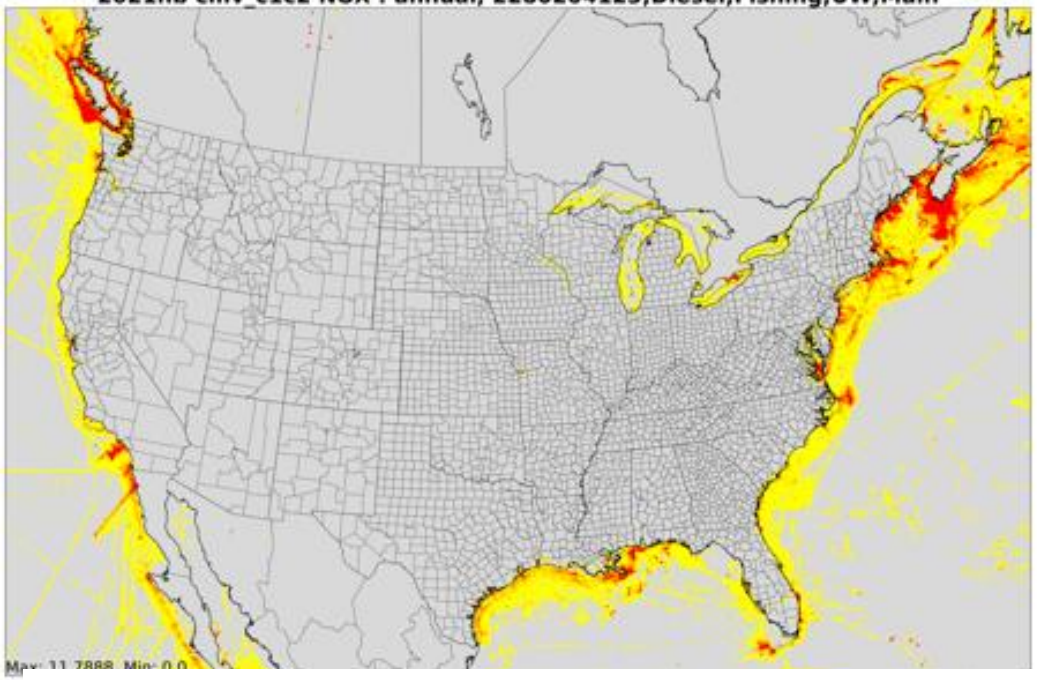

2021hb cmv_c1c2 NOX : annual, 2280213123;Diesel;Tug;UW;Main
>10.2
9.1
7.9
6.8
5.7
4.5
3.4
2.3
<1.1
tons/yr

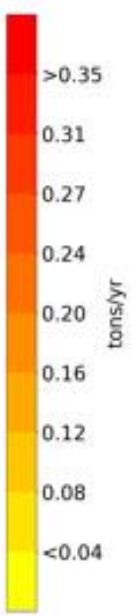

2021hb cmv_c1c2 NOX : annual, 2280208123;Diesel;Government;UW;Main
>0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
<0.05
tons/yr
Max: 14.5455 Min: 0.0


2021hb cmv_c1c2 NOX : annual, 2280213124;Diesel;Tug;UW;Aux
>3.9
3.5
3.0
2.6
2.2
1.7
1.3
0.9
<0.4
tons/yr
Max: 500.2013 Min: 0.0

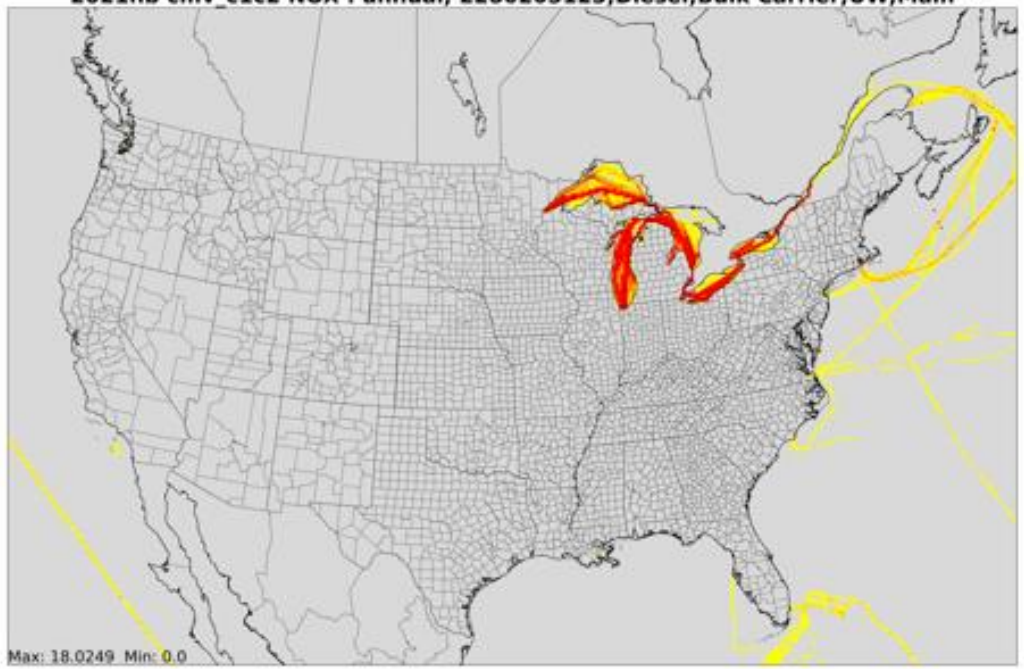

2021hb cmv_c1c2 NOX : annual, 2280207123;Diesel;General Cargo;UW;Main
>1.75
1.55
1.36
1.17
0.97
0.78
0.58
0.39
<0.19
tons/yr
Max: 129.575 Min: 0.0

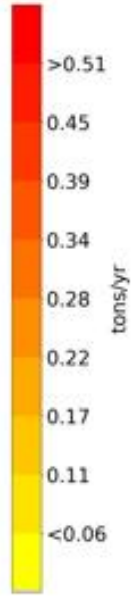
2021hb cmv_c1c2 NOX : annual, 2280204123;Diesel;Fishing;UW;Main



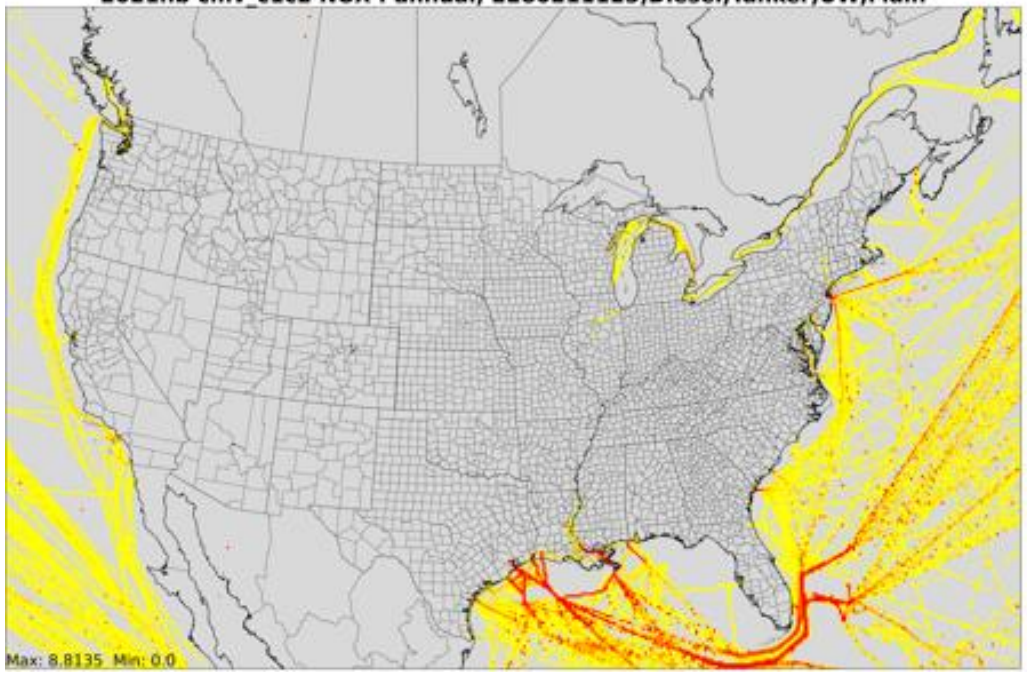


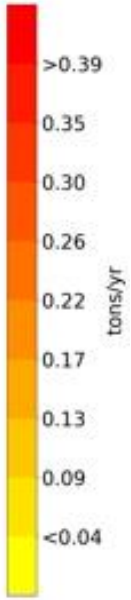
2021hb cmv_c1c2 NOX : annual, 2280203123;Diesel;Bulk Carrier;UW;Main



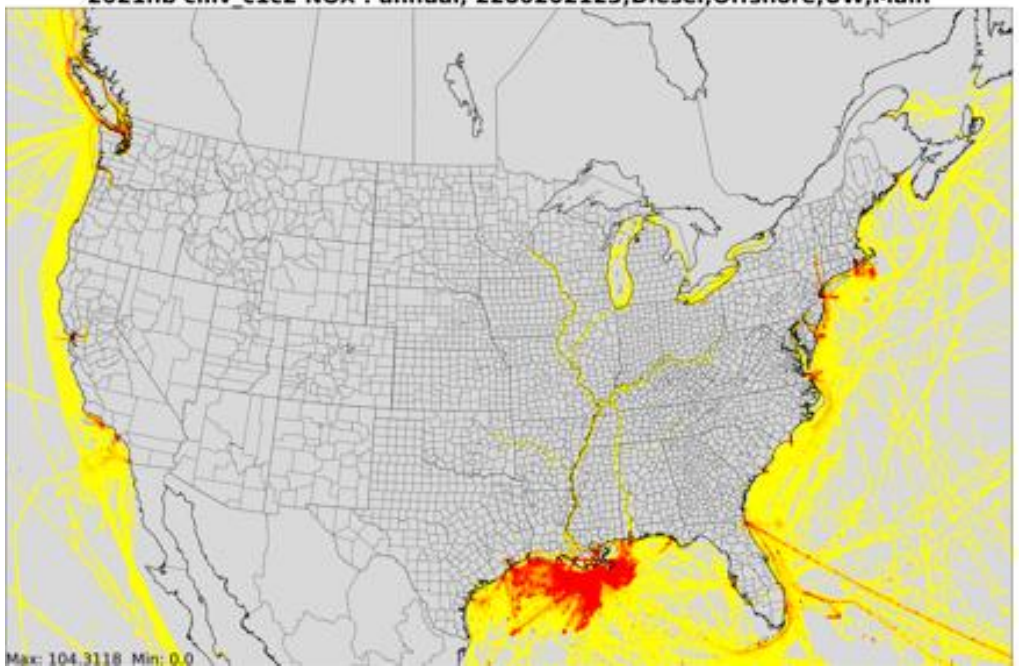


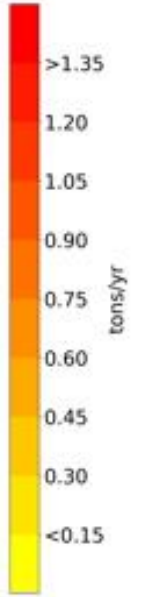
2021hb cmv_c1c2 NOX : annual, 2280211123;Diesel;Tanker;UW;Main



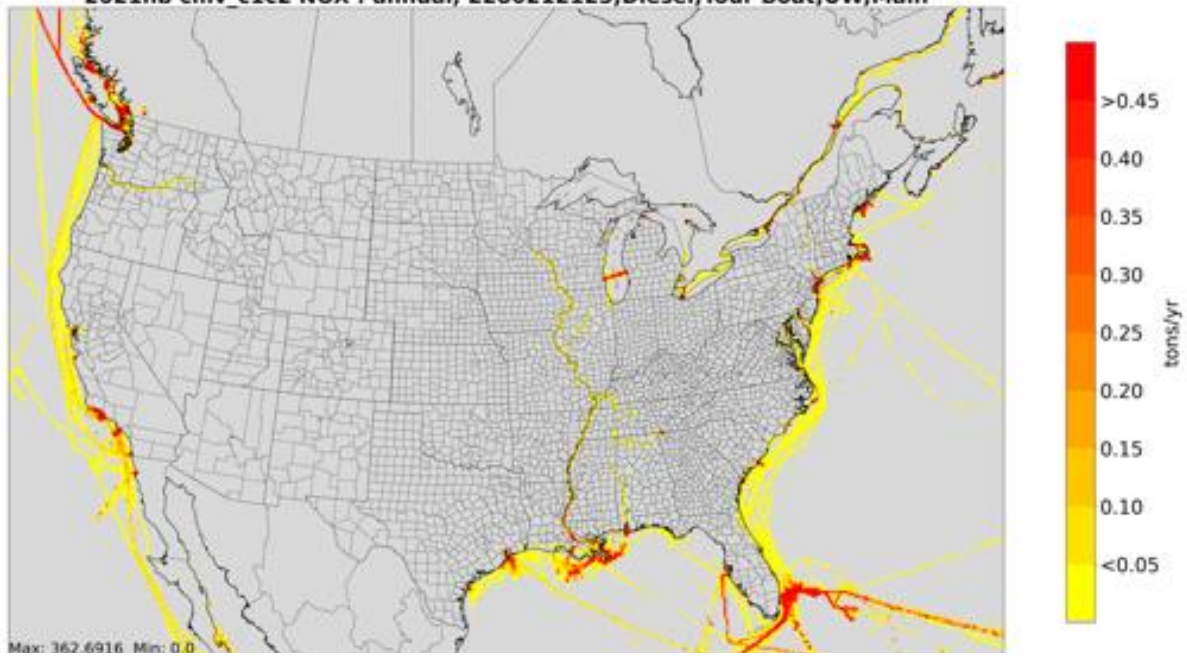


2021hb cmv_c1c2 NOX : annual, 2280202123;Diesel;Offshore;UW;Main

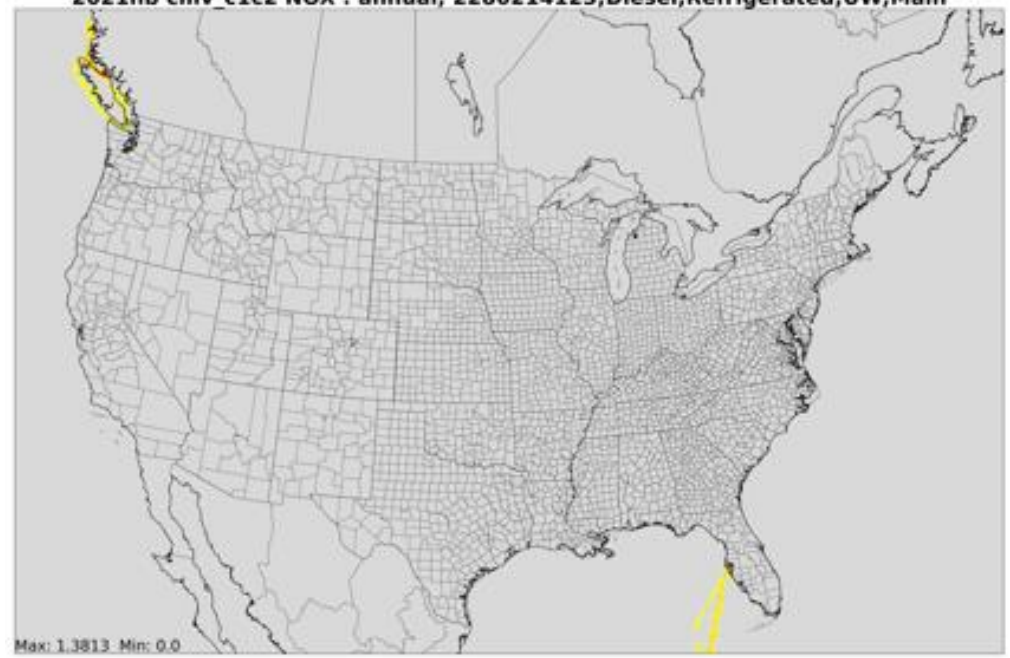


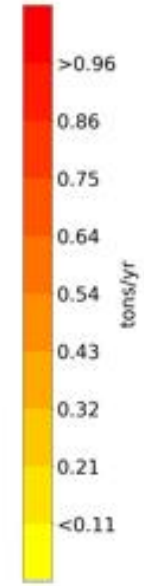


2021hb cmv_c1c2 NOX : annual, 2280212123;Diesel;Tour Boat;UW;Main

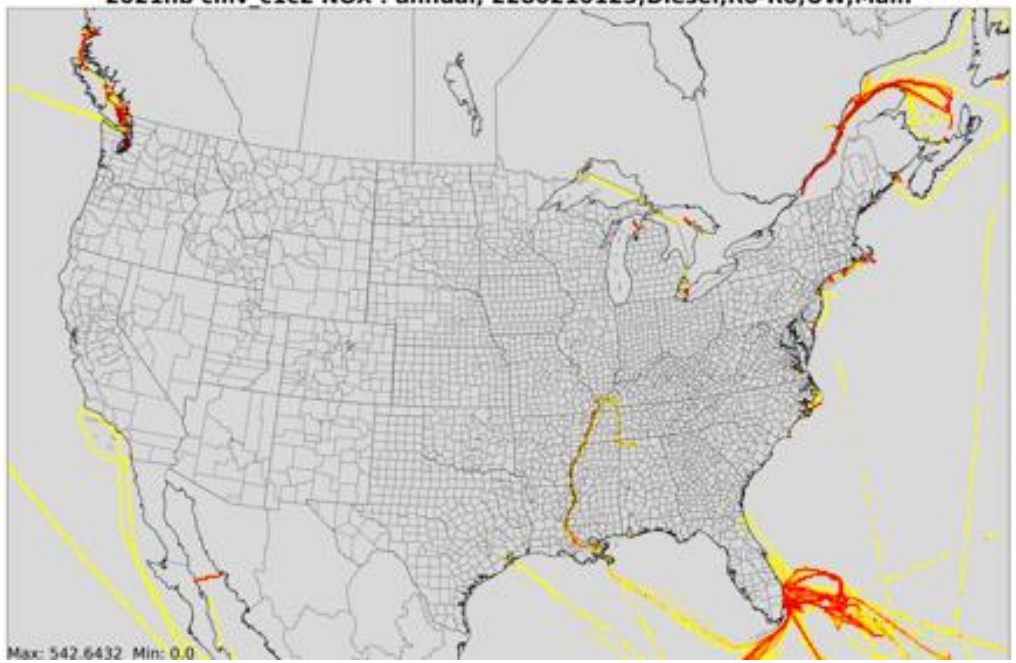


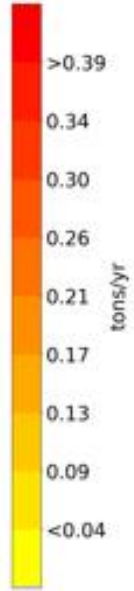
2021hb cmv_c1c2 NOX : annual, 2280214123;Diesel;Refrigerated;UW;Main



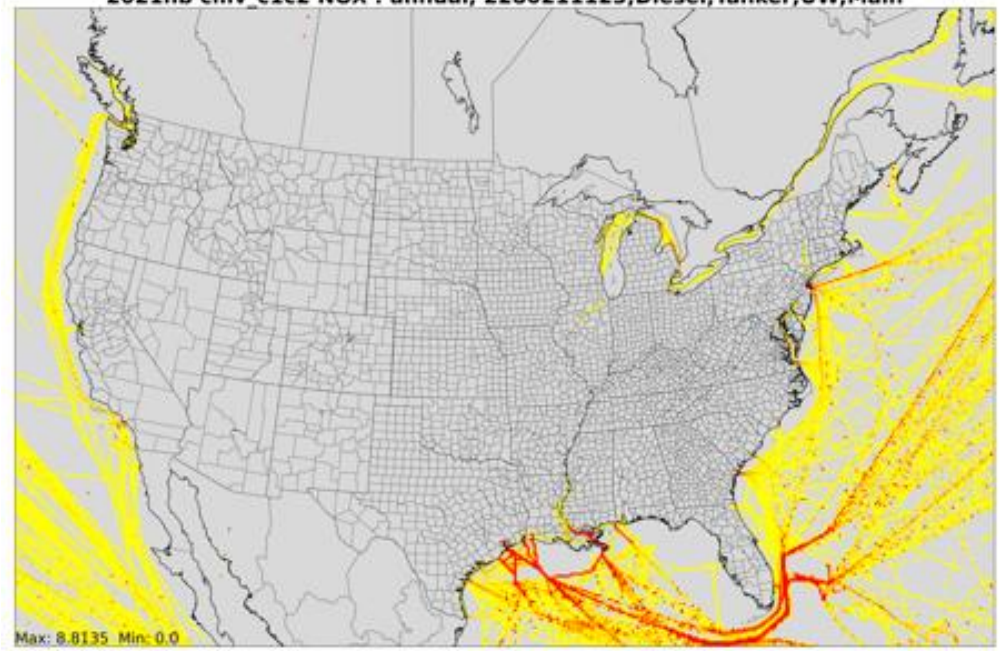


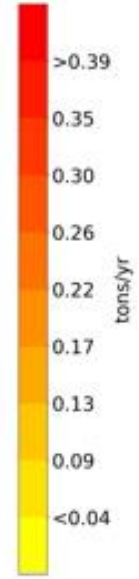
2021hb cmv_c1c2 NOX : annual, 2280210123;Diesel;Ro-Ro;UW;Main

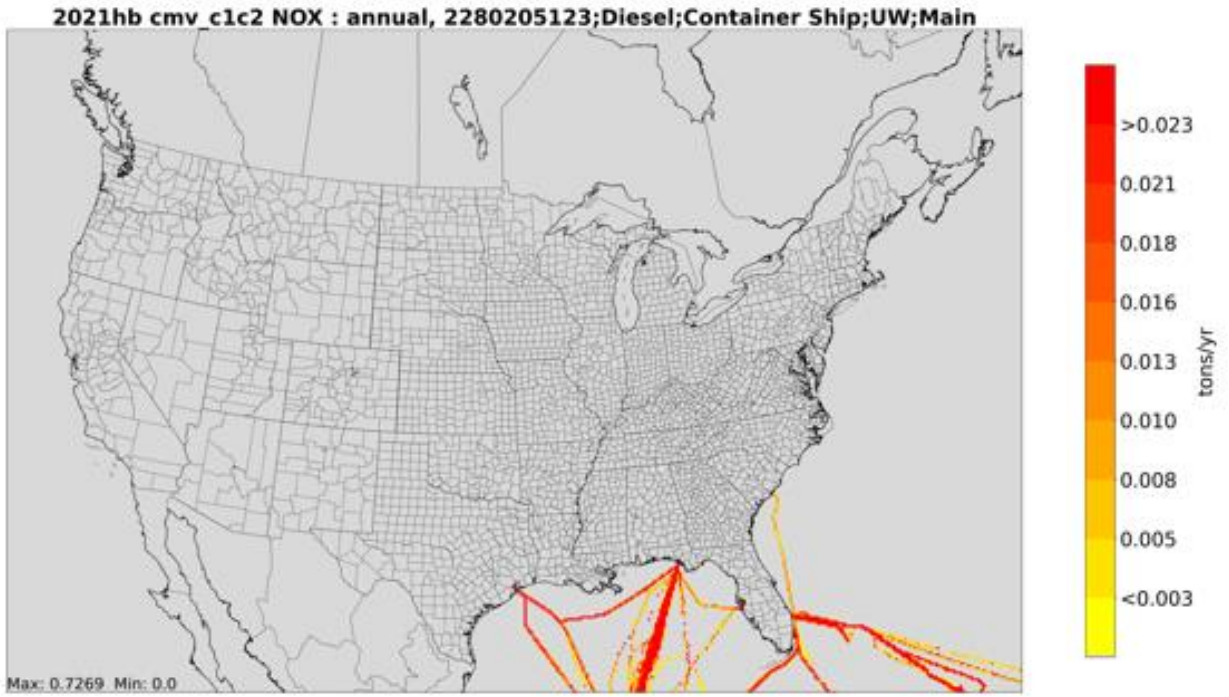


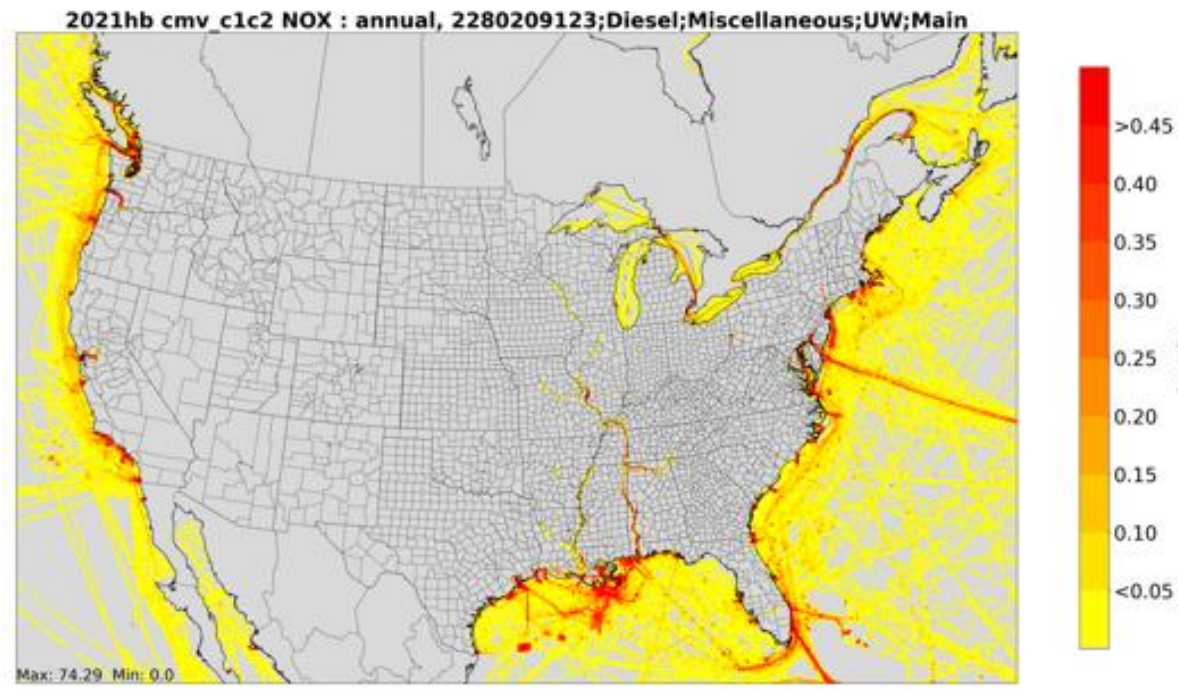


2021hb cmv_c1c2 NOX : annual, 2280211123;Diesel;Tanker;UW;Main






2021hb cmv_c1c2 NOX : annual, 2280205123;Diesel;Container Ship;UW;Main
>0.023
0.021
0.018
0.016
0.013
0.010
0.008
0.005
<0.003
tons/yr
Max: 0.7269 Min: 0.0


2021hb cmv_c1c2 NOX : annual, 2280209123;Diesel;Miscellaneous;UW;Main
>0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
<0.05
tons/yr
Max: 74.29 Min: 0.0

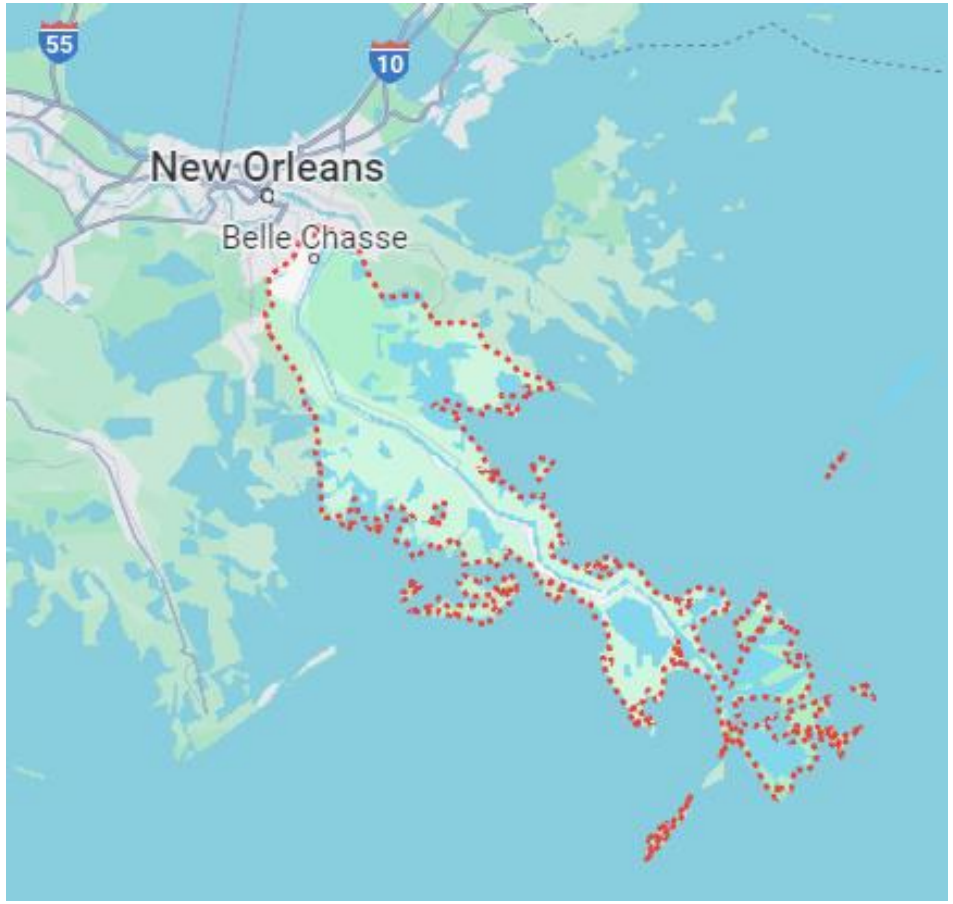
Counties with the most CMV NOx emissions in 2021

County	C1C2	C3	Tot NOx
Los Angeles Co	1,816	8,407	10,223
Plaquemines Par	3,707	5,553	9,260
Galveston Co	3,899	4,339	8,239
Harris Co	3,717	4,504	8,221
Lafourche Par	5,061	126	5,188
Jefferson Co	2,758	1,900	4,658
Miami-Dade Co	1,056	3,374	4,430
Mobile Co	2,060	933	2,993
Jefferson Par	2,164	816	2,979
Orleans Par	1,675	1,141	2,816
King Co	1,714	1,102	2,816
Nueces Co	1,335	1,401	2,736
Broward Co	948	1,650	2,598
Hudson Co	1,564	859	2,423
San Diego Co	1,274	1,138	2,412
Clallam Co	645	1,750	2,395
Chatham Co	606	1,785	2,391
St Charles Par	1,376	1,005	2,381
San Francisco Co	751	1,601	2,352
Charleston Co	1,223	1,074	2,297
Norfolk	1,058	1,089	2,146
St James Par	1,322	786	2,109
Anne Arundel Co	1,662	417	2,079
Orange Co	1,090	928	2,019

Total, C1C2, and C3 NOx emissions are shown here.

The new SCC assignments support analyses of the main ship types that contributing to the CMV emissions by county (*see next slide*)

SCCs with the most NOx for Plaquemines Parish



	poll	2021 ann
;Diesel;Bulk Carrier;Underway emissions: Class 3 Main Engine	NOX	1,818
;Diesel;Tanker;Underway emissions: Class 3 Main Engine	NOX	1,096
;Diesel;Bulk Carrier;Underway emissions: Class 3 Auxiliary Engine	NOX	830
;Diesel;Tug;Underway emissions: Class 1/2 Main Engine	NOX	614
;Diesel;Container Ship;Underway emissions: Class 3 Main Engine	NOX	593
;Diesel;General Cargo;Underway emissions: Class 1/2 Auxiliary Engine	NOX	578
;Diesel;Miscellaneous;Underway emissions: Class 1/2 Auxiliary Engine	NOX	391
;Diesel;Tug;Underway emissions: Class 1/2 Auxiliary Engine	NOX	337
;Diesel;Tanker;Underway emissions: Class 3 Auxiliary Engine	NOX	327
;Diesel;General Cargo;Underway emissions: Class 1/2 Main Engine	NOX	278
;Diesel;Offshore;Underway emissions: Class 1/2 Auxiliary Engine	NOX	226
;Diesel;Government;Underway emissions: Class 1/2 Auxiliary Engine	NOX	205
;Diesel;Offshore;Underway emissions: Class 3 Main Engine	NOX	188
;Diesel;General Cargo;Port emissions: Class 1/2 Auxiliary Engine	NOX	178
;Diesel;Offshore;Underway emissions: Class 1/2 Main Engine	NOX	162
;Diesel;Container Ship;Underway emissions: Class 3 Auxiliary Engine	NOX	139
;Diesel;Tug;Underway emissions: Class 3 Main Engine	NOX	136
;Diesel;Miscellaneous;Underway emissions: Class 1/2 Main Engine	NOX	116

Next Steps

- Finish updating SCC-specific plots
- Post summaries and plots on EPA ftp site as a preview to 2022: https://gaftp.epa.gov/Air/emismod/2021/