



Modeling Ship Emissions

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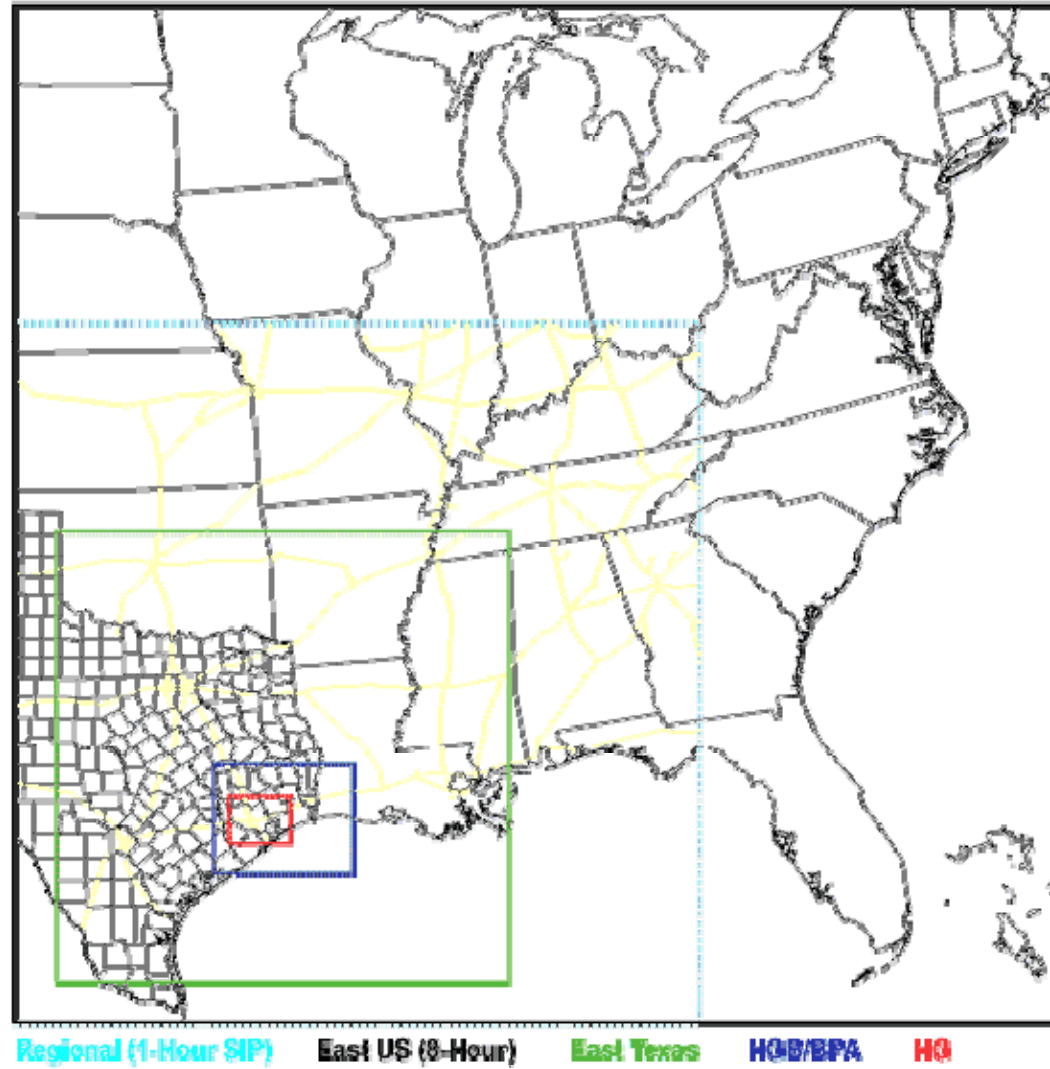


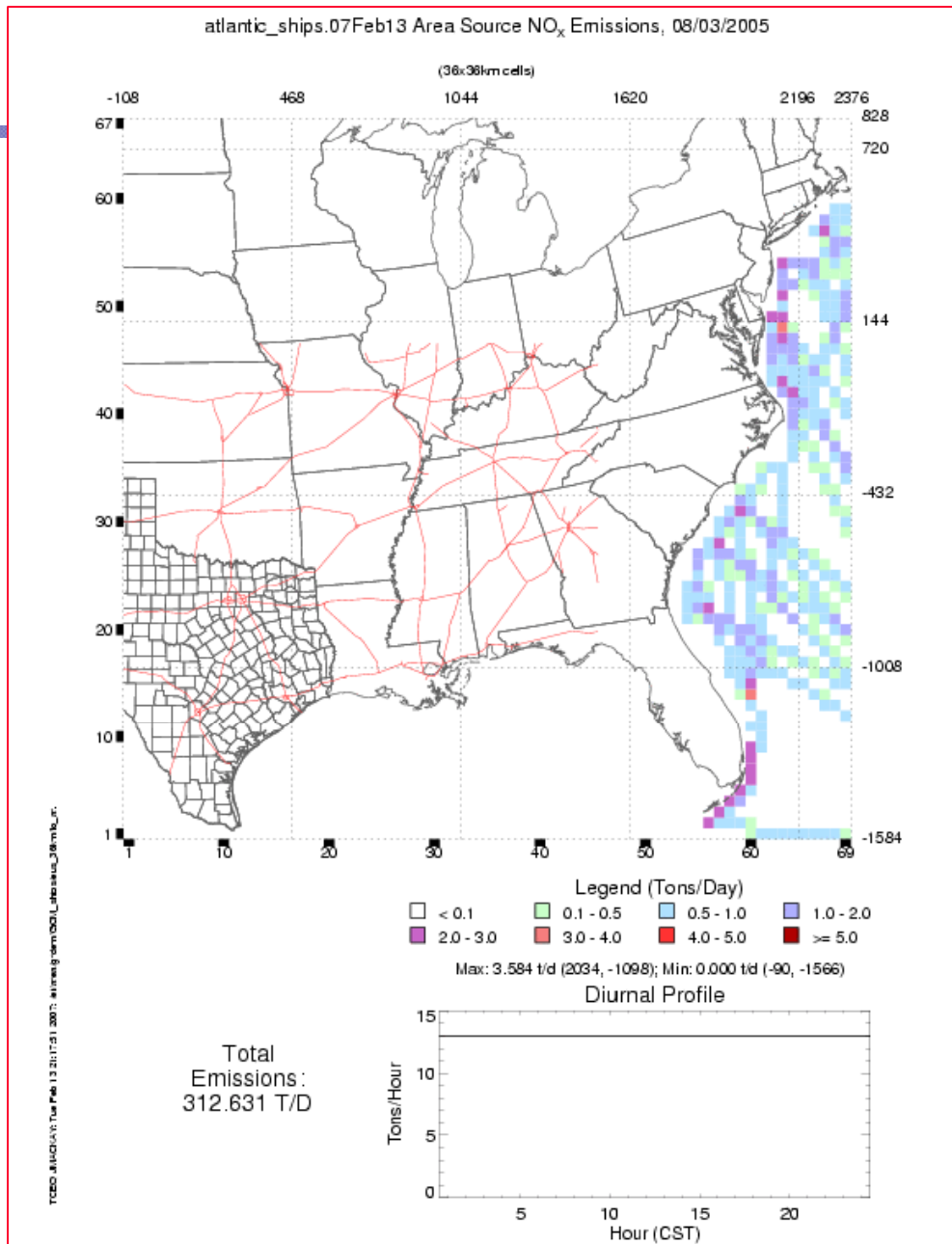
Typical Ship Modeling

- Low-level files
- Surrogates
- Emissions by county or shipping lane distance
- Estimates better than nothing

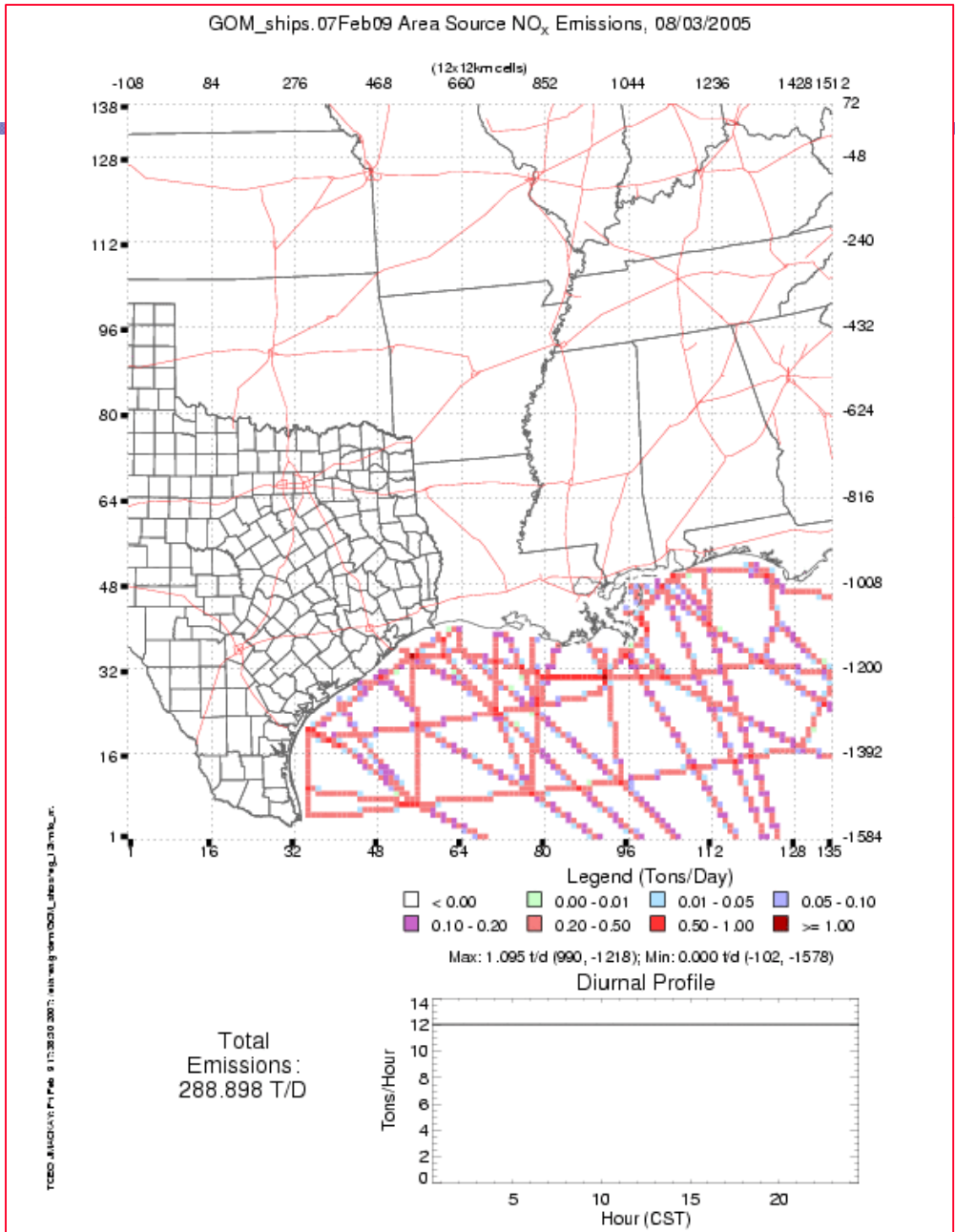


Original OGV Ship EI





Obsolete Atlantic Ships



Obsolete GOM ships reg-12km



Improvements

- Shipping lanes via GPS
- VMT-like or Trip-based spatial distribution
- Realistic plume rise



Current Ship Modeling

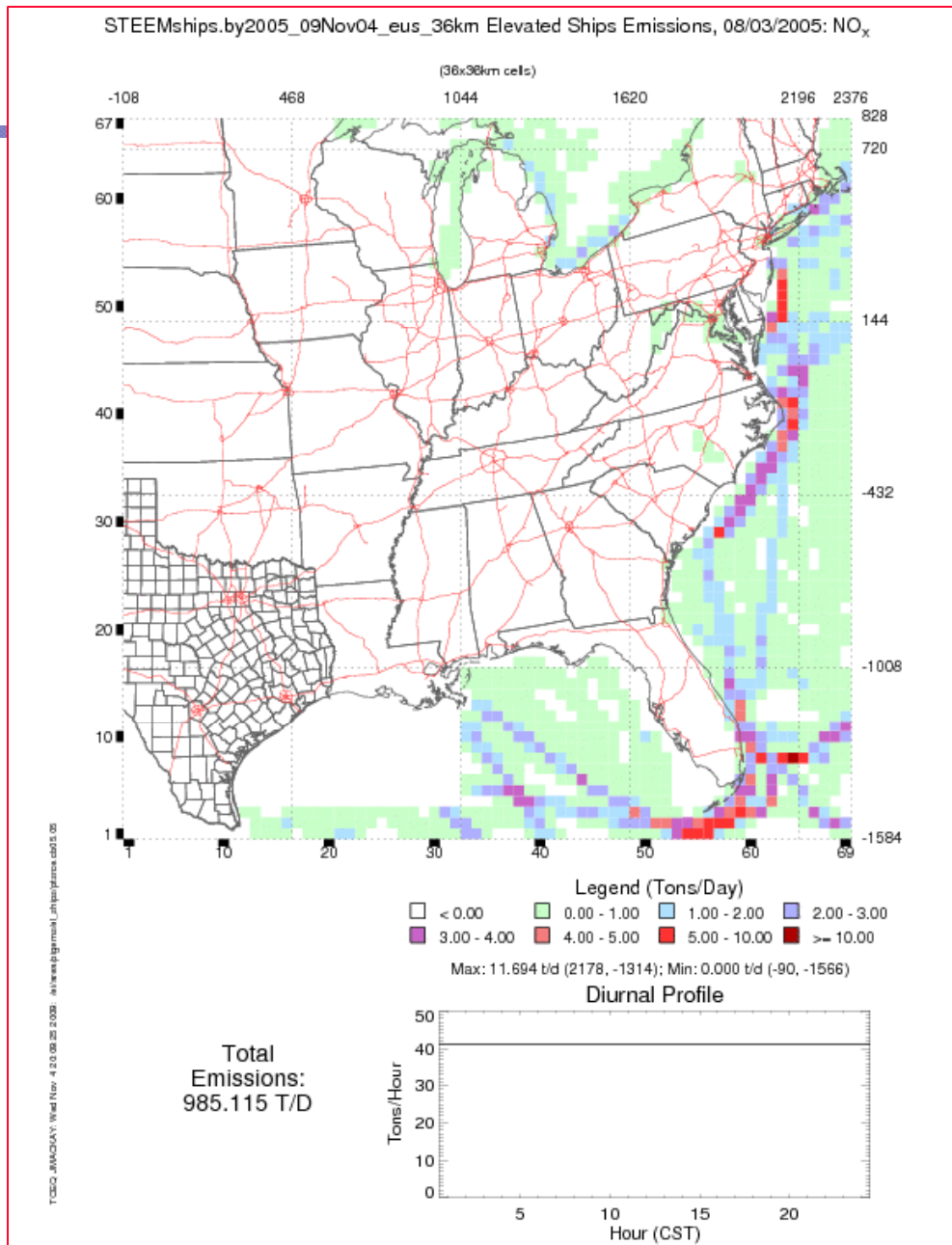
- Ships mostly modeled as “elevated links”
 - Trips from Sea Buoy
 - New EPS module pstshp
 - Allows link “width” – including trapezoids
- Synthesis of several sources
 - HGB ships – Starcrest c.2007 ship movements
 - BPA ships – Starcrest c.2000 ship movements
 - EPA nearport
 - Ship Traffic, Energy, and Environmental Model (STEEM) EI developed by the University of Delaware
- Complete, but no overlap



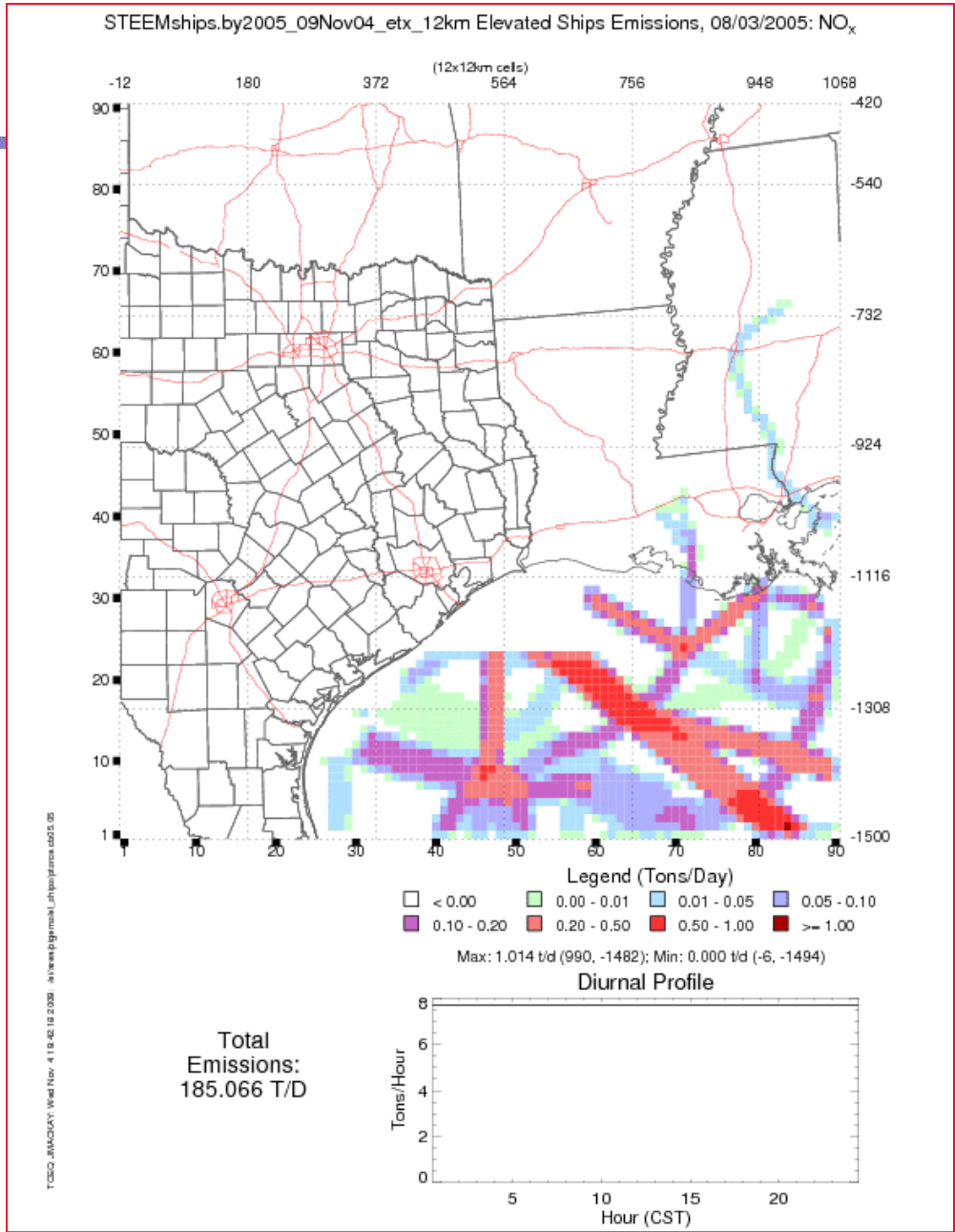
Shipping Component Files

bl06.eus_36km.bline06.reg2

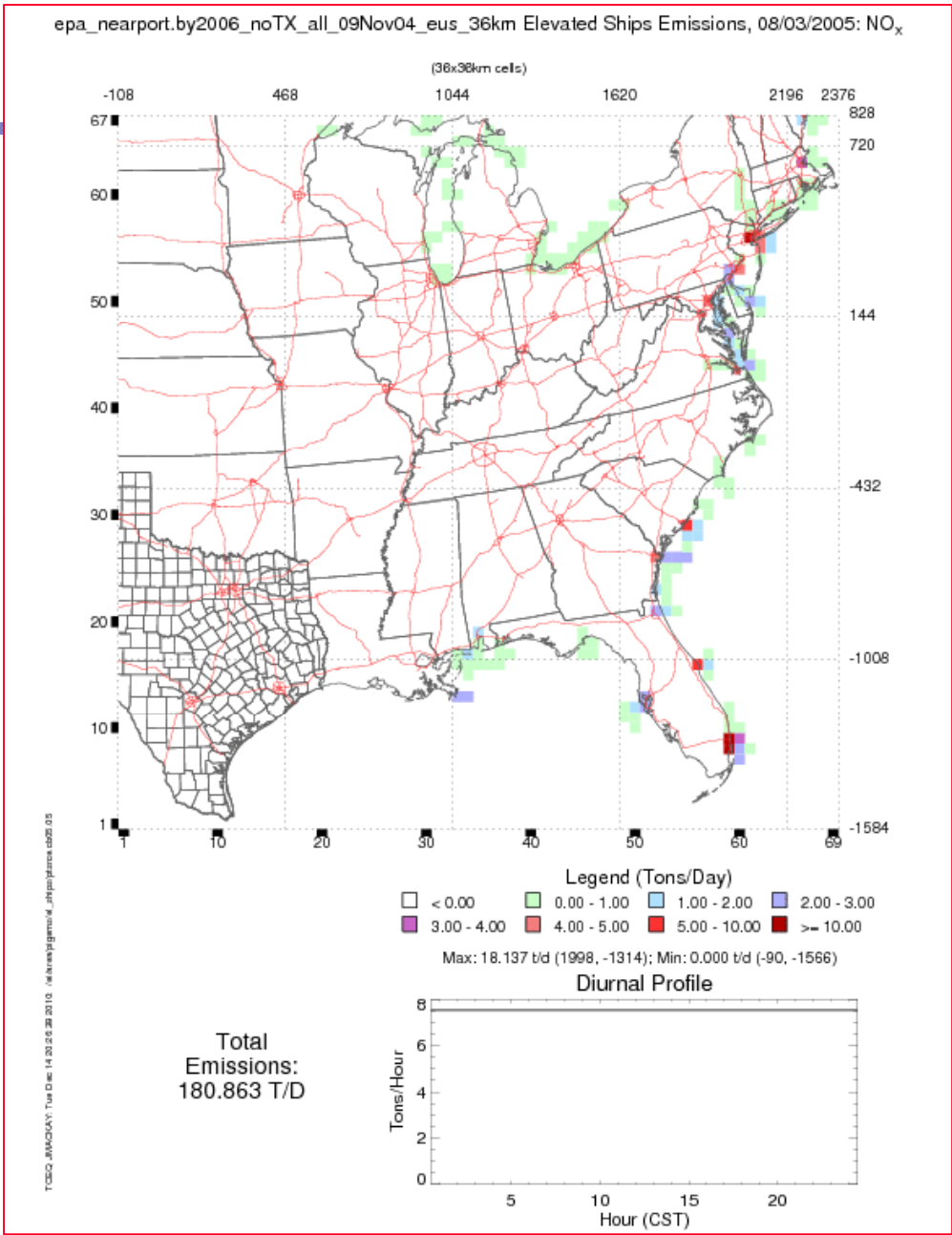
Component Files	NOx	VOC	CO
-----	-----	-----	-----
el_pstshp.hg_02km.HGB_2007.by2006.10Aug17	30.0318	1.3848	4.1657
pstpnt.eus_36km.bpa_ships.by2006.07Aug14	11.0692	0.4169	1.6467
el_pstshp.hg_02km.epa_nearport.by2006_TX_CRUSM.09Nov04	7.6861	0.2647	0.5950
el_pstshp.hg_04km.epa_nearport.by2006_TX_CRUSM.09Nov04	6.0521	0.2081	0.4683
el_pstshp.etx_12km.epa_nearport.by2006_TX_CRUSM.09Nov04	2.5800	0.0887	0.1999
el_pstshp.eus_36km.epa_nearport.by2006_TX_CRUSM.09Nov04	0.1171	0.0040	0.0091
el_pstshp.hg_04km.epa_nearport.by2006_noTX_all.09Nov04	2.8518	0.1242	0.8105
el_pstshp.etx_12km.epa_nearport.by2006_noTX_all.09Nov04	51.0349	1.7211	4.0779
el_pstshp.eus_36km.epa_nearport.by2006_noTX_all.09Nov04	180.8629	6.3196	15.3851
el_pstshp.hg_04km.STEEMships.by2006.09Nov04	28.8718	0.9932	2.2538
el_pstshp.etx_12km.STEEMships.by2006.09Nov04	190.4342	6.5514	14.8656
el_pstshp.eus_36km.STEEMships.by2006.09Nov04	1013.6830	34.8723	79.1304



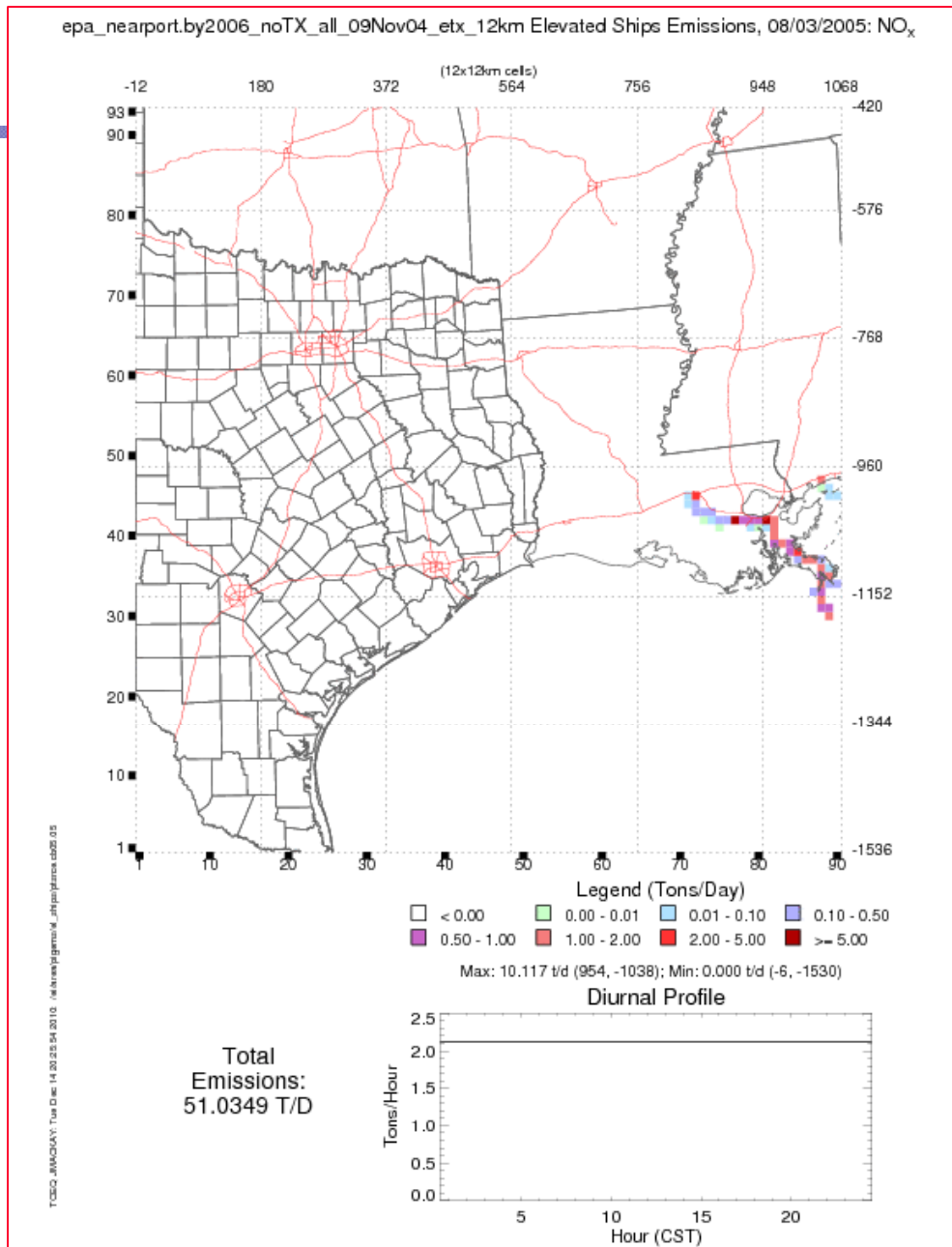
2005 STEEM SHIPPING at 36km



Model-ready STEEM Ships at
etx_12km



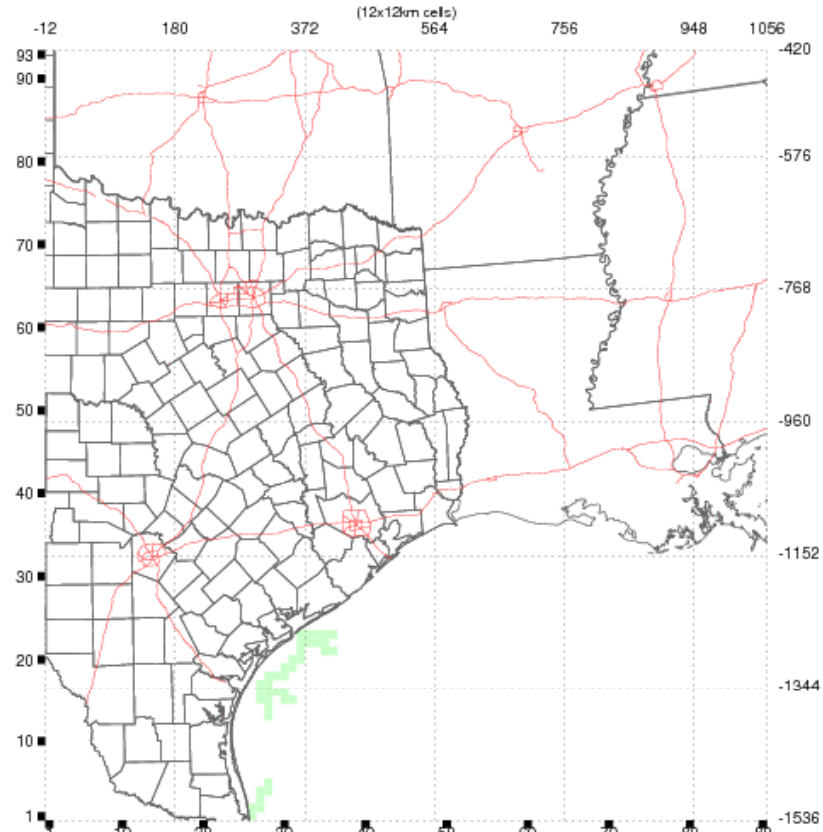
Epa_nearport 2006 eus_36km



Epa_nearport_2006_etx_12km

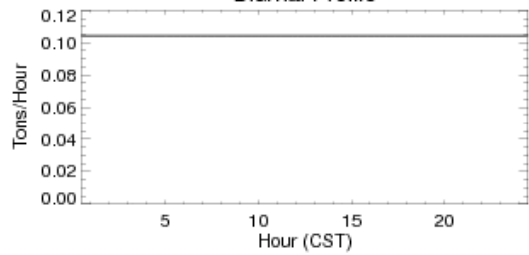


epa_nearport.by2005_TX_CRUSM_09Nov04_etx_12km Elevated Ships Emissions, 08/03/2005: NO_x



Max: 0.290 t/d (318, -1338); Min: 0.000 t/d (-6, -1530)

Diurnal Profile



Total Emissions: 2.50731 T/D

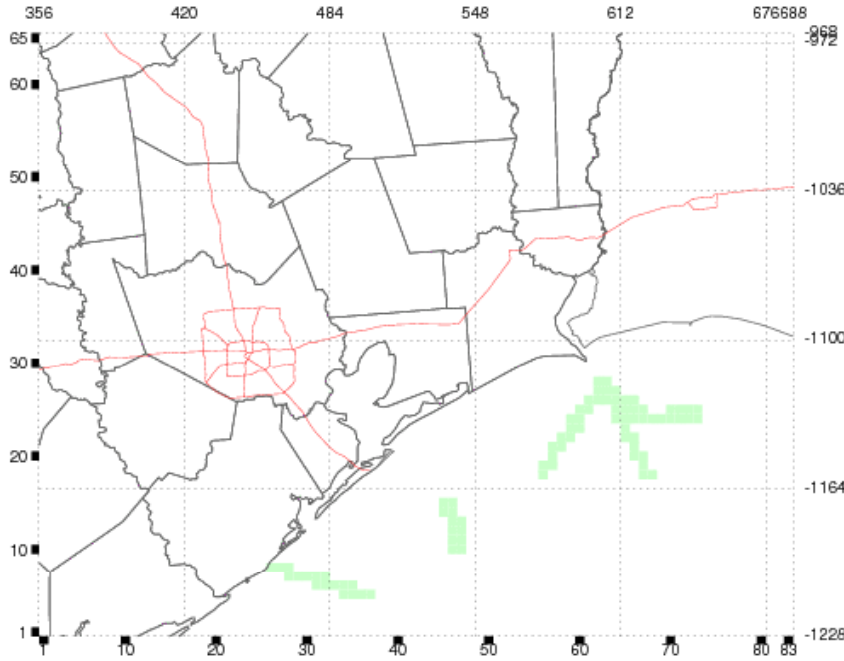
TCEQ_AIRQUALY: Wed Nov 4 11:00:34 2005: \\hwsas01\airqual\shipporssas05_05

Epa_nearport_2005_etx_12km



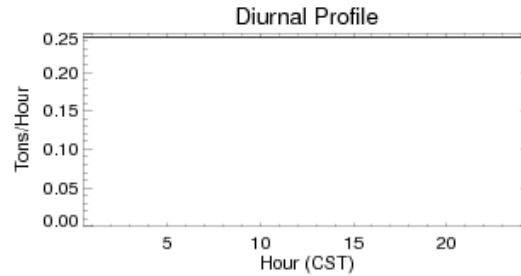
epa_nearport.by2005_TX_CRUSM_09Nov04_hg_04km Elevated Ships Emissions, 08/03/2005: NO_x

(4x4km cells)



Max: 0.402 t/d (538, -1178); Min: 0.000 t/d (358, -1228)

Total Emissions:
5.88154 T/D

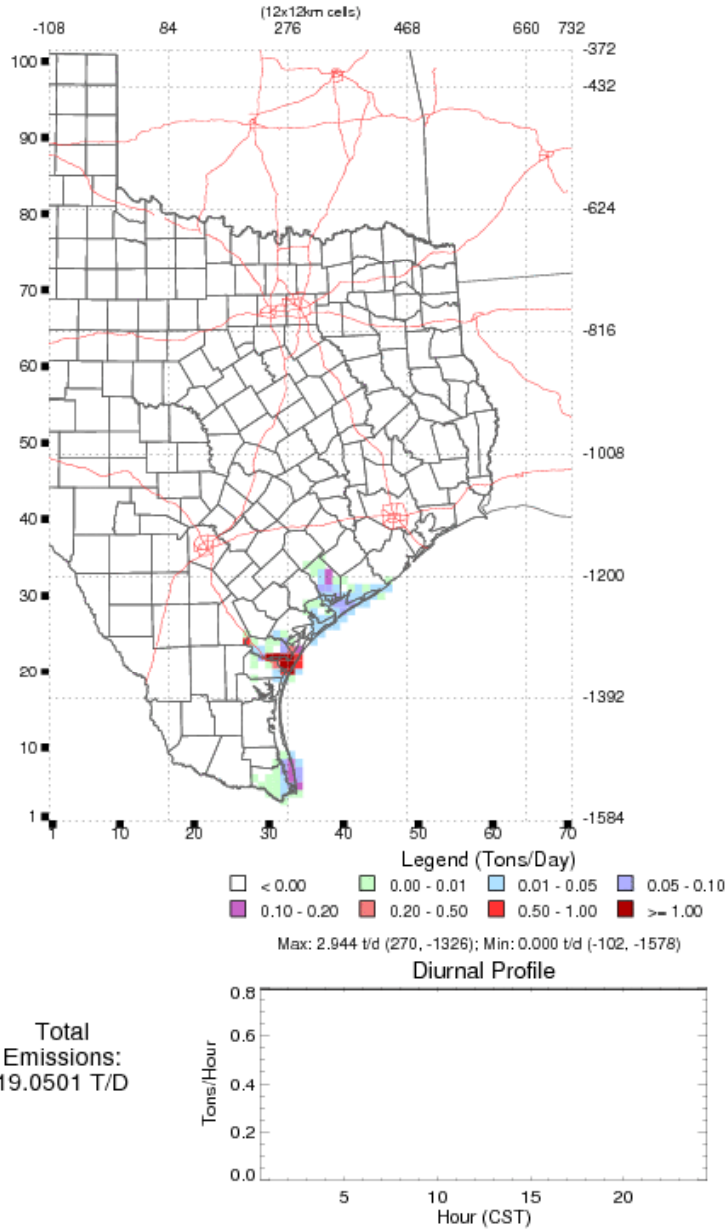


TCEQ_AIRQUAL: Wed Nov 4 12:40:38 2005: a:\www\egis\maki_ghip\james.dad05.05

Epa_nearport_TX_CRUSM_4km



ships.bc06.OFFR06_b7d_ships.hg_12km All Low Level Emissions, 08/03/2005: NO_x



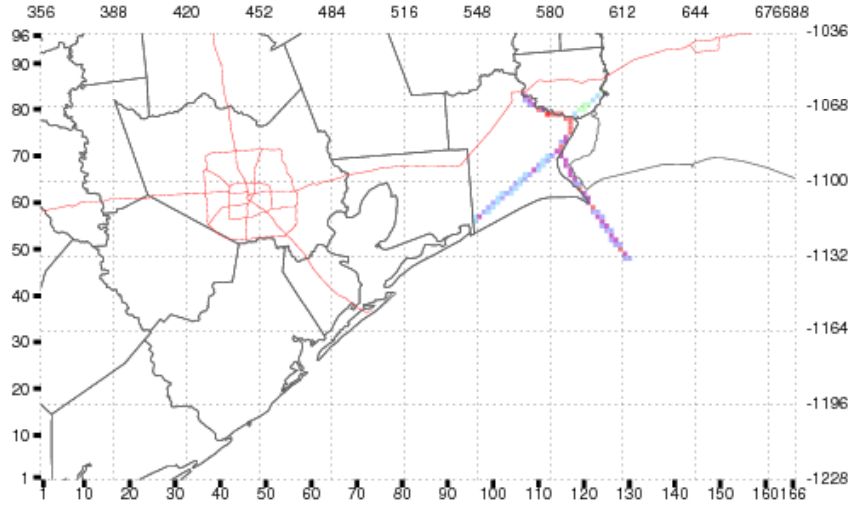
TCEQ_AIRQUAL: Mon Jul 27 18:53:24 2005: \\s:\www\gdam\OFFR\hg_12km\bc_06\pda

TEXASER SHIPPING EIT



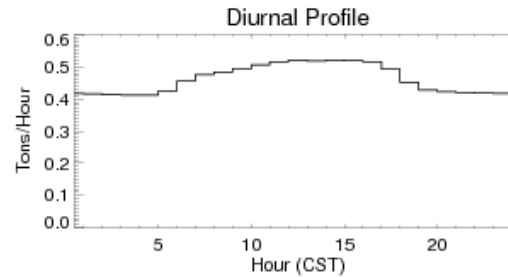
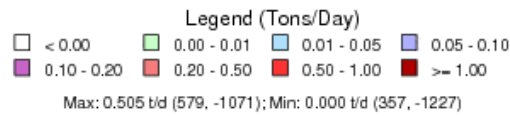
bpa_ships.bpa_ships.by2006.hgbpa_02km Elevated Ship Emissions, 08/30/2000: NO_x

(2x2km cells)

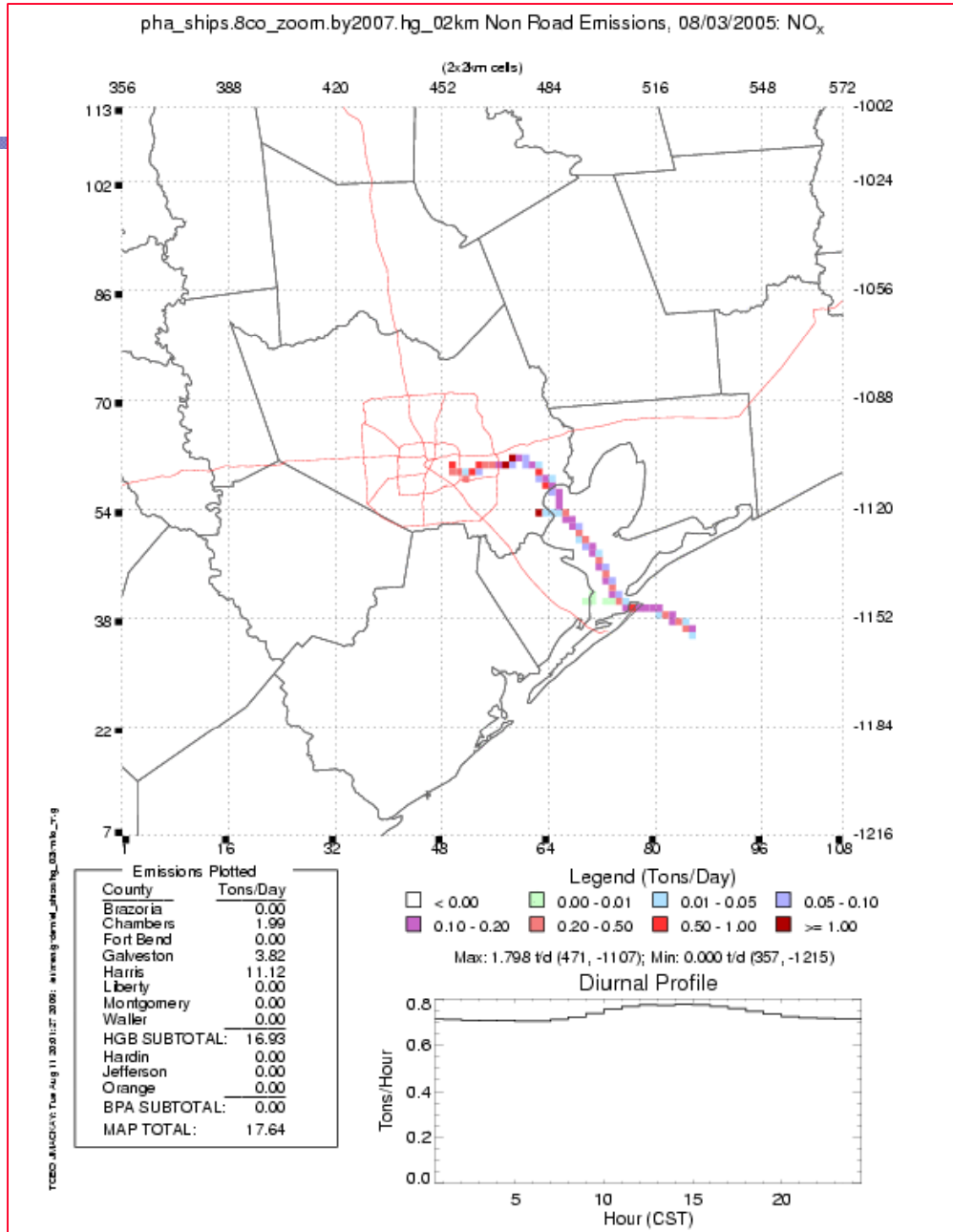


TCEQ, JIMOUAY, Wed Oct 18 14:02:30 2010, \\www.epg\maki_ghip\james.sab02.000

Emissions Plotted	
County	Tons/Day
Brazoria	0.00
Chambers	0.01
Fort Bend	0.00
Galveston	0.00
Harris	0.00
Liberty	0.00
Montgomery	0.00
Waller	0.00
HGB SUBTOTAL:	0.01
Hardin	0.00
Jefferson	7.31
Orange	0.88
BPA SUBTOTAL:	8.19
MAP TOTAL:	11.07



BPA ships

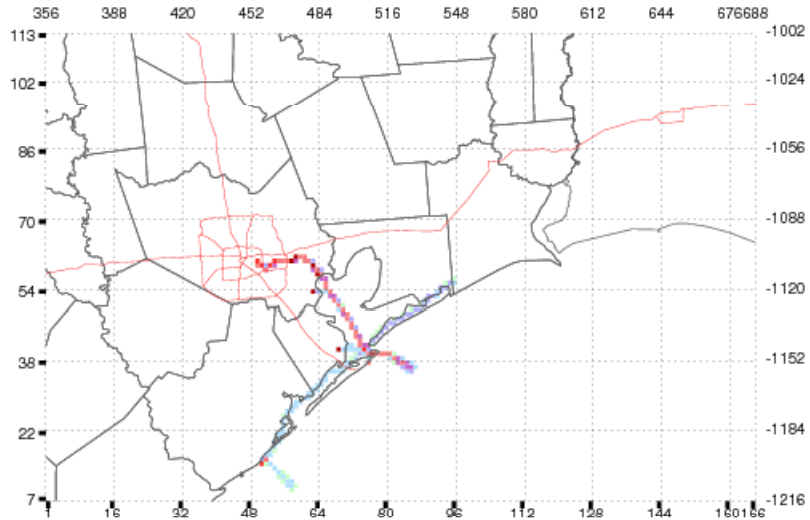


PHA Ships



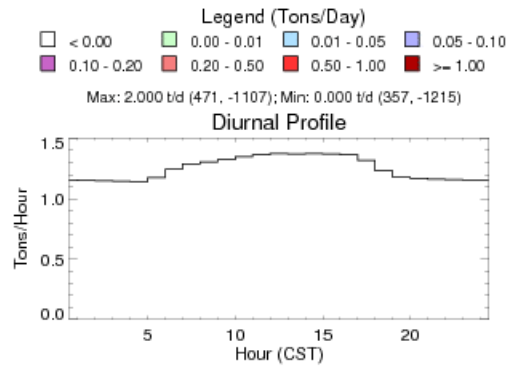
HGB_2007.by2006_10Aug17_hg_02km Elevated Ships Emissions, 06/06/2007: NO_x

(2x2km cells)

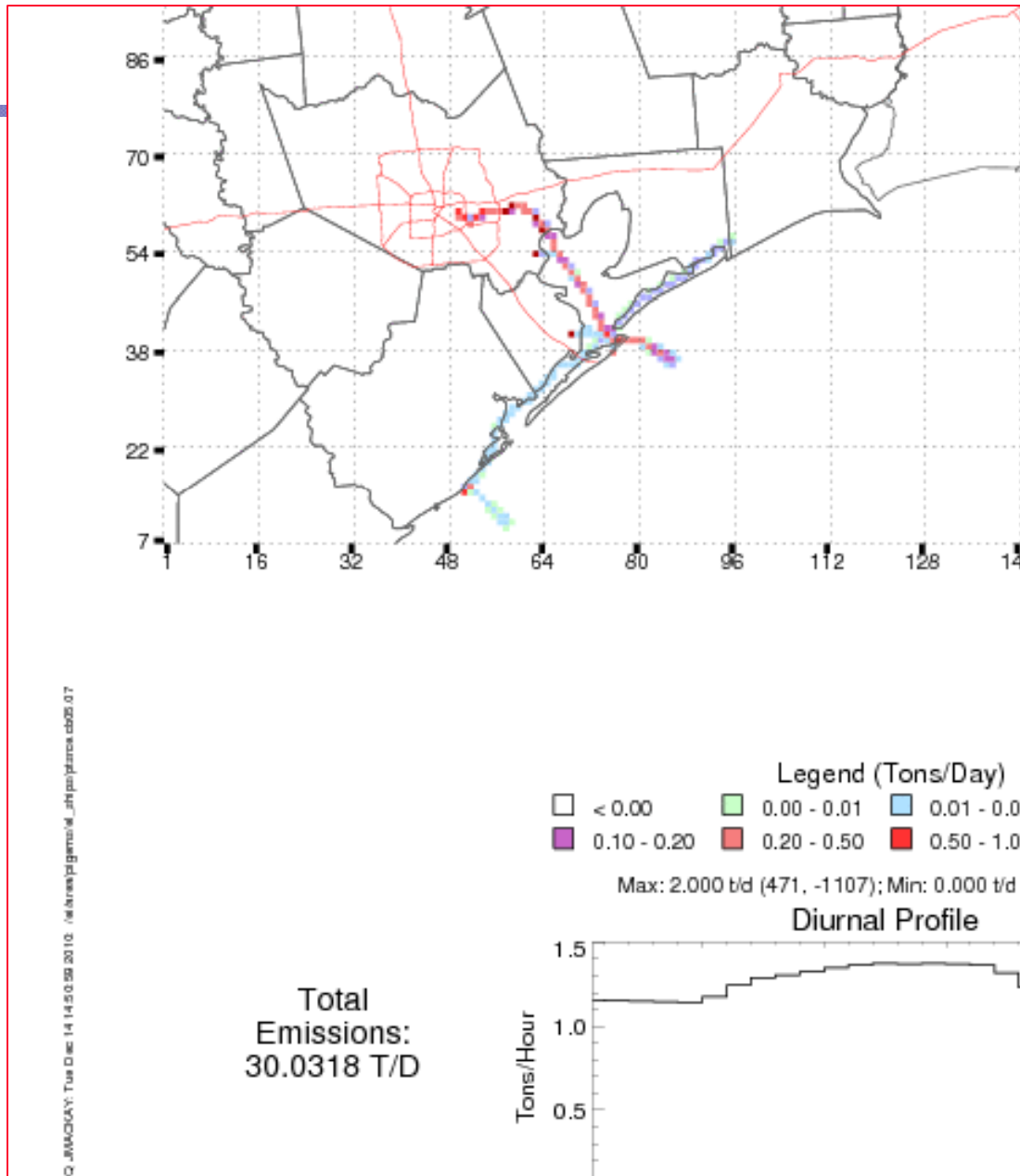


TCEQ_AIRQUALY: Tue Dec 14 14:50:59 2010: /s/n/ney/g/m/ol_j/p/p/par/ma/ab06.07

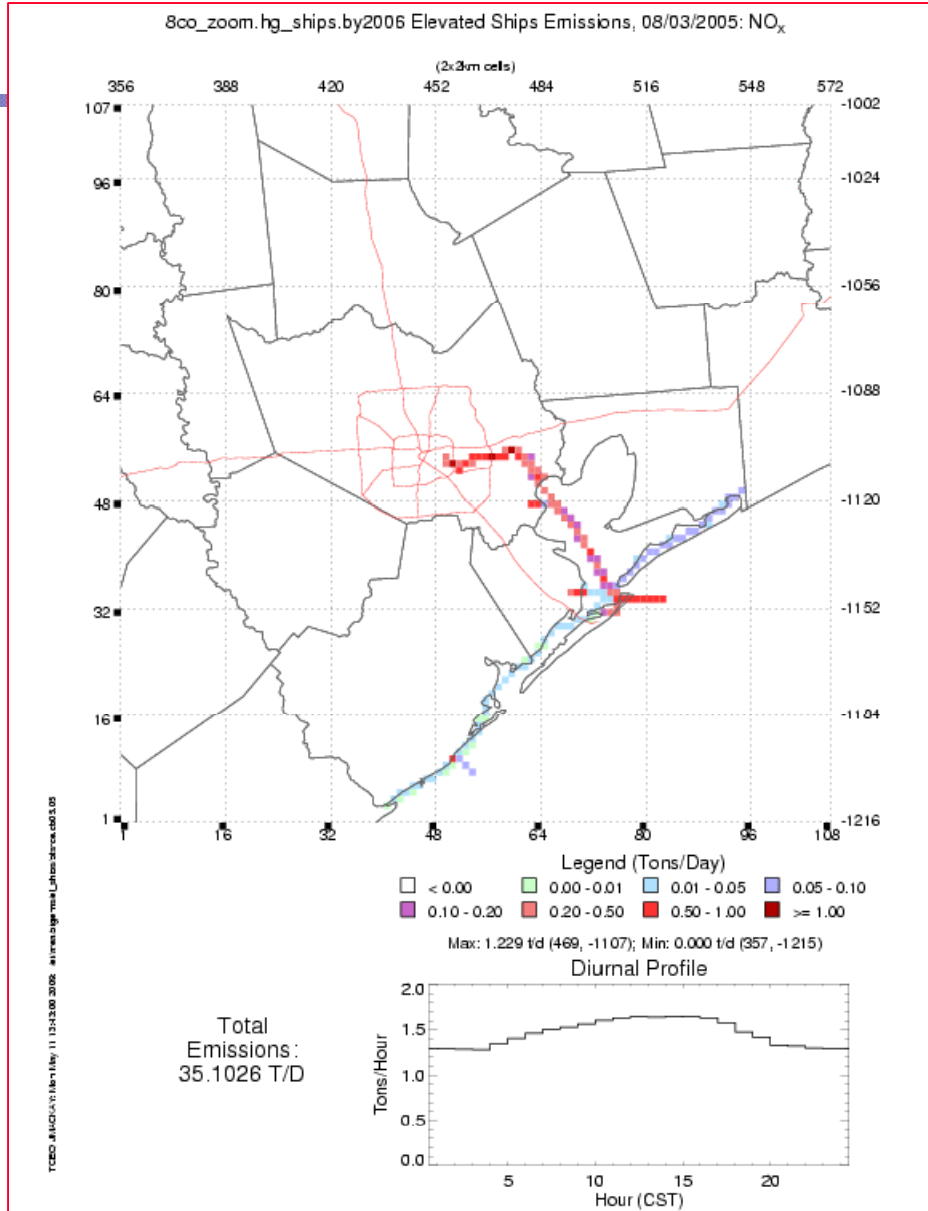
Total Emissions:
30.0318 T/D



Latest 2006 Ships



Latest 2006 Ships Zoomed



Older HGB Ships



Various Details

- EI's from various years for various years
- Some EI's have great detail
- NO_x-H₂O correction
- TxLED
- Harbor Vessel rules
- MARPOL et al



“Recession” Modified EPA growth and control clip used for non-HGBPA

yyyy	growth	factor	control
2002	0	1.0000	1.00
2003	2.9	1.0290	1.00
2004	2.9	1.0588	1.00
2005	2.9	1.0895	1.00
2006	2.9	1.1211	1.00
2007	2.9	1.1537	1.00
2008	1	1.1652	1.00
2009	0	1.1652	1.00
2010	0	1.1652	1.00
2011	1.5	1.1827	1.00
2012	2.9	1.2170	1.00
2013	2.9	1.2523	1.00
2014	2.9	1.2886	1.00
2015	2.9	1.3259	1.00
2016	2.9	1.3644	1.00
2017	2.9	1.4040	0.9526
2018	2.9	1.4447	0.9051
2019	2.9	1.4866	0.8577
2020	2.9	1.5297	0.8102
2021	2.9	1.5740	0.7627
2022	2.9	1.6197	0.7153
2023	2.9	1.6667	0.6679



Confusing HGB 2007 Growth clips

yyyy	growth	Growth factor
2002		
2003		
2004		
2005		0.9465
2006		0.9937
2007	0	1.0000
2008	0	1.0000
2009	0	1.0000
2010	0	1.0000
2011	2	1.0200
2012	2	1.0404
2013	2.2	1.0633
2014	2.2	1.0867
2015	2.2	1.1106
2016	2.2	1.1350
2017	2.2	1.1600
2018	2.2	1.1855
2019	2.2	1.2116
2020	2.2	1.2382
2021	2.2	1.2655
2022	2.2	1.2933
2023	2.2	1.3218

growth figure 3-15; longterm trend (year 2020 growth rate)

Calls by Port Region			
Port	Y2007	Y2006	Y2005
Freeport	806	743	760
Gal-Tex	1686	1541	1571
Houston	6195	6348	5891
	8687	8632	8222

Adjustment Factors by Port Region			
Port	Y2007	Y2006	Y2005
Freeport	1	0.921836	0.942928
Gal-Tex	1	0.913998	0.931791
Houston	1	1.024697	0.950928
	1	0.993669	0.946472

% per year	
Container	4.85
Other	2.85
General Cargo	2.15
Chemicals	1.85
Dry Bulk	1.30
Crude Oil	1.30
Petroleum	1.30
Natural Gas	0.60
Passenger	-0.75

figure 3-13; longterm trend (year 2020 growth rate)

Container		
yyyy	growth	factor
2002		
2003		
2004		
2005		0.0000
2006		0.0000
2007	0	1.0000
2008	0.011982	1.011982
2009	0.003671	1.015697
2010	4.85	1.0650
2011	4.85	1.1166
2012	4.85	1.1708
2013	4.85	1.2275
2014	4.85	1.2871
2015	4.85	1.3495
2016	4.85	1.4150
2017	4.85	1.4836
2018	4.85	1.5555

<http://www.epa.gov/otaq/regs/nonroad/420r09019-chp03.pdf>



2006 HGB Ship EI by Vessel Type

el_pstshp.HGB_2007.by2006.10Aug17

ASC	Vertical	Layer	NOX	Vessel Type
2280002021	2	33.9	0.0255	Assist Tugboats
2280002023	2	33.9	8.4493	Towboats
2280003011	3	84.9	1.6919	Bulk Cargo
2280003012	3	84.9	2.2023	General Cargo
2280003013	3	84.9	1.9367	Container Ships
2280003014	3	84.9	1.3285	Liquified Gas Carriers
2280003015	3	84.9	13.2131	Oil/Chemical Tankers
2280003017	3	84.9	0.3336	Cruise Ships
2280003019	3	84.9	0.7118	
2280003020	3	84.9	0.1352	
2280003023	3	84.9	0.0018	
Total			30.0298	(tons/day)



References and contact info

- [Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling](#)
- Jim MacKay 512.239.1485
- jmackay@tceq.state.tx.us
- Jim.MacKay@tceq.texas.gov