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Recent SMOKE Enhancements and More

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Outlines

- Recent SMOKE v4.0 and 4.5 Release Updates
- Upcoming SMOKE and related Emissions Modeling updates
- Q&A

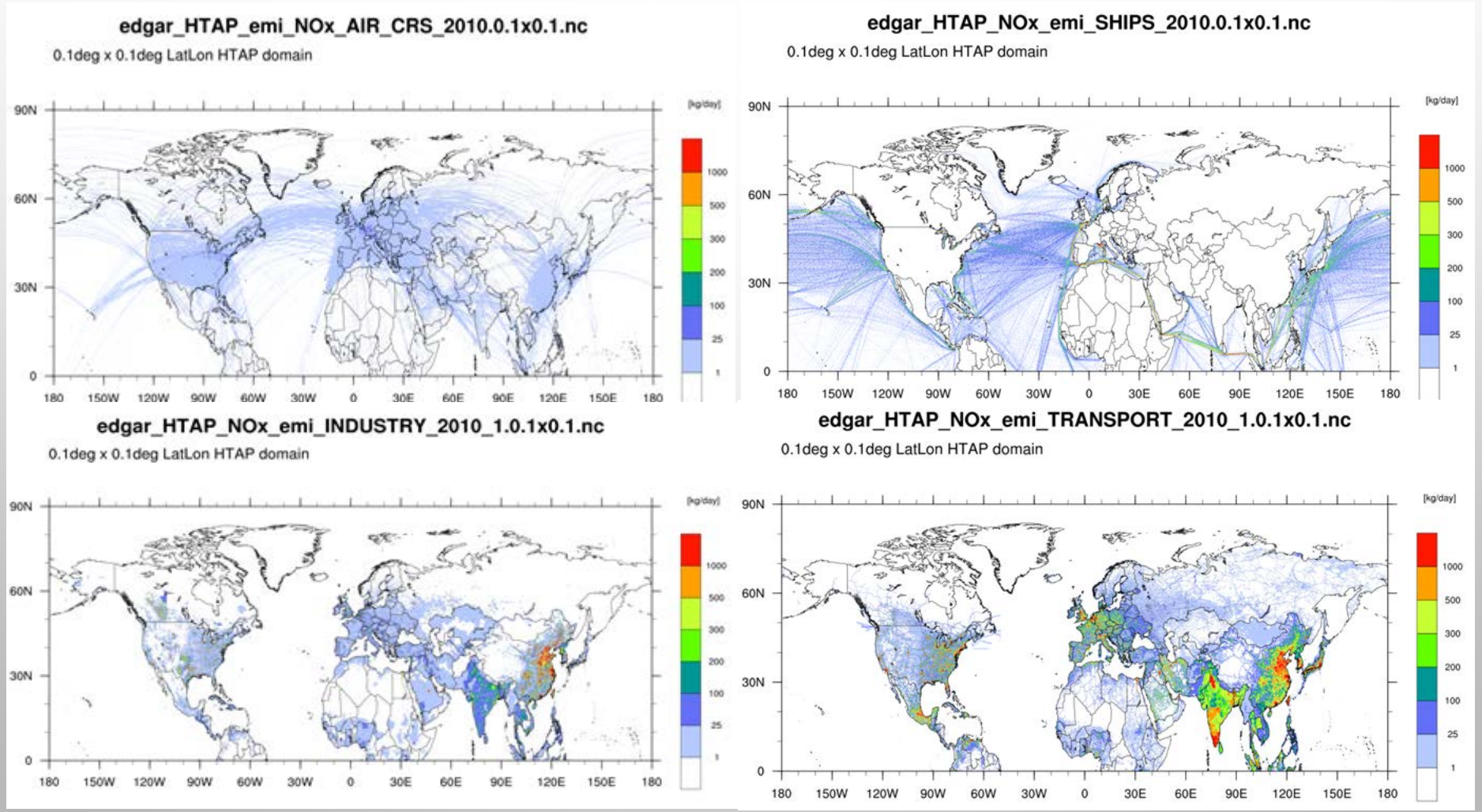
SMOKE v4.0 and v4.5 Updates

- SMOKE v4.0 released on September 2016
  - Support Global Gridded Inventories (i.e., EDGAR, HTAP,,,) Processing
  - Parallelization of SMOKE Programs using OpenMP
- SMOKE v4.5 released on April 2017
  - SMOKE4AERMOD Development
- New Link-level Inventory dataset Processing
  - Annual Link Inventory format: FF10_LINK
  - Hourly Link Inventory format: FF10_LINK_HOURLY

Global Gridded HTAP Emissions

Sectors: aircraft, shipping, industry, energy, transportation, residential, and agriculture

Pollutants: CO, NMVOC, NO_x, SO_2, NH_3, PM_{10}, $PM_{2.5}$,BC and OC

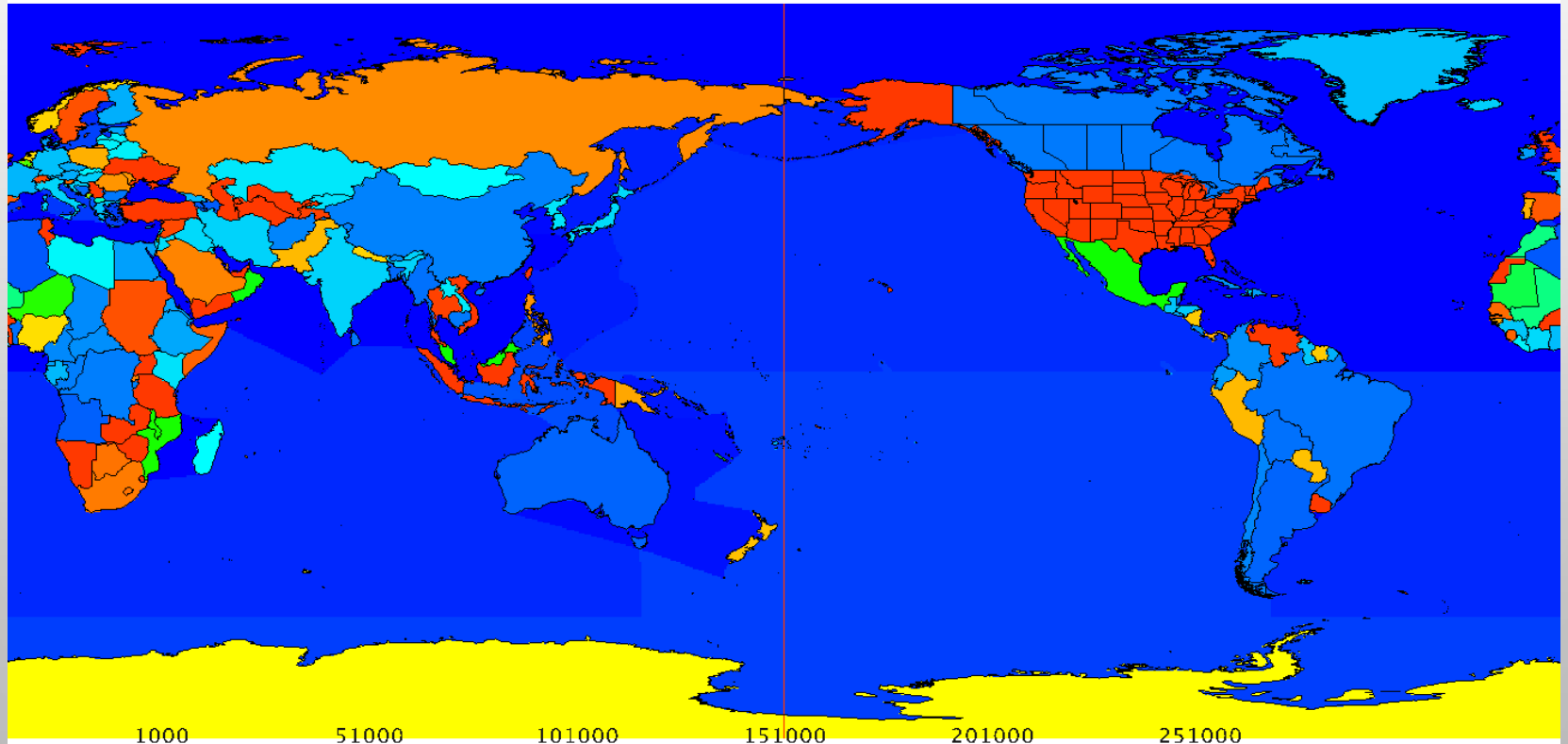


EPA's Hemispheric Modeling Challenges

- Consistent Emissions Processing across various sectors from various sources/countries.
  - Temporal Allocation
  - Horizontal and Vertical Spatial Allocation
- Accurate country-specific Time Zone handling
  - Local time to GMT as well as holidays
- Accurate horizontal spatial allocations without any spatial surrogates
- Zeroing out option to mix US and Global gridded emissions to avoid any possible double counting
- Optional vertical allocations for aircraft emissions (Taxi-in/out, LTO, Cruise) using **Layalloc** program

EPA Northern Hemispheric Modeling

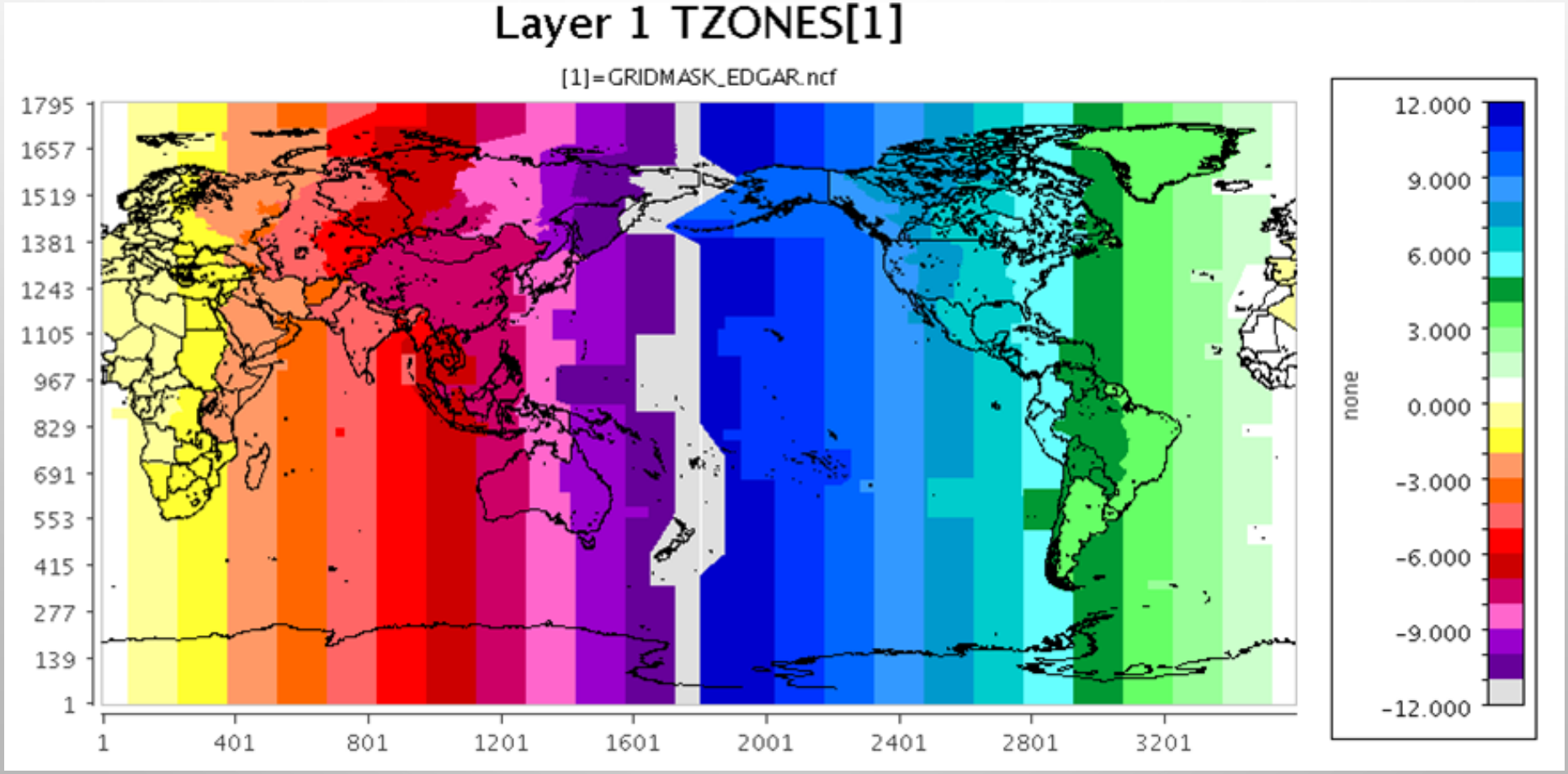
- **GRIDMASK** file that includes both the country and time zone by grid cell
  : used Arcmap zonal statistics to calculate the majority coverage in the cell



EPA Northern Hemispheric Modeling

- **GRIDMASK** file maps grid cells to time zones

: Finer time zones/country assignment? Required to update the GRIDMASK



SMOKE v4.0 for Hemispheric Modeling

- **Grid Cell = Inventory Source** (6.48 millions sources : 1600*3600)
- **Smkinven** Updates to read and process the native NetCDF-formatted pregridded emissions inventory files (i.e., HTAP, EDGAR,,,,)
  - ***IMPORT_GRDNETCDF_YN*** : Process the native NetCDF pregridded Inventory files
  - ***NETCDF_INV_YEAR*** : Required to provide the year of emissions
  - ***NETCDF_POL_UNIT*** : Required to specify the modeling the unit of each pollutant

ARINV: Area Inventory List File

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#LIST GRID

#SCC, Pollutant, Variable_Name, Month, File_location_name

SOLVENT,VOC,emis_nmvoc,0,/nas/EDGAR/solvent/nmvoc/v42_2010.nc

SOLVENT,CH4,emis_ch4,0,/nas/EDGAR/solvent/ch4/v42_2010.nc

ENERGY,NOX ,emis_nox,0,/nas/EDGAR/energy/nox/v42_2010.nc

ENERGY,PM25,emis_pm25,0,/nas/EDGAR/energy/pm2.5/v42_2010.nc

ENERGY,NOX,emis_nmvoc,0,/nas/EDGAR/energy/nmvoc/v42_2010.nc

…,…,…,…,…

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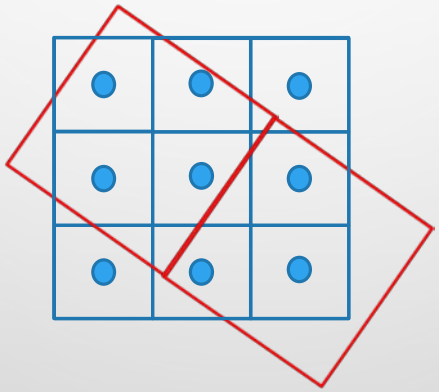
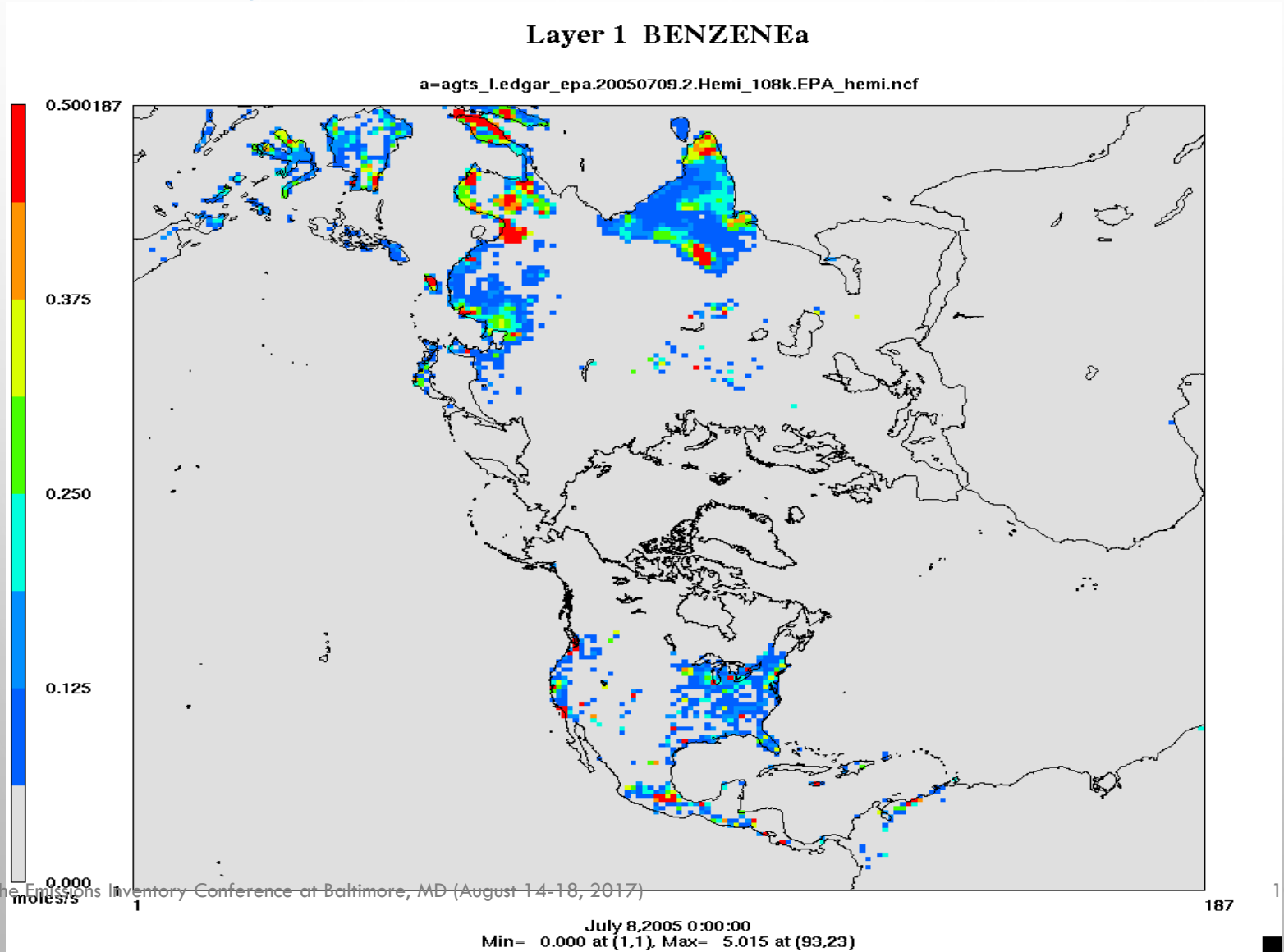
SMOKE v4.0 for Hemispheric Modeling

- **Grdmat** Updates to regrid the pregridded emissions into the output modeling domain without any spatial surrogate.
  - Built a new function to disaggregate the grid cell into multiple point and the regrid them into the new modeling domain.



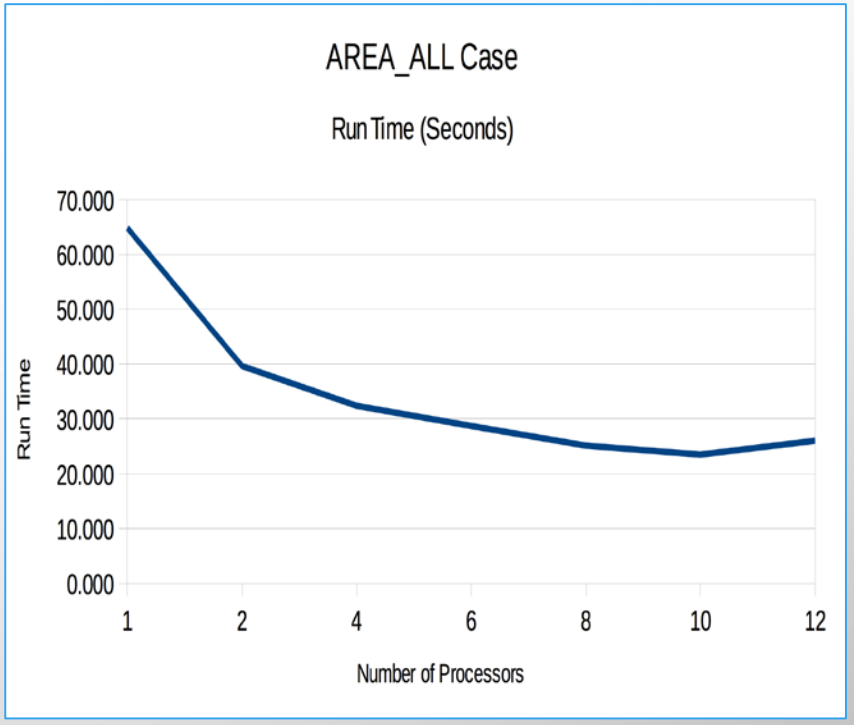
- **Spcmat** used to assign a single chemical speciation profile by grid cell
- **Cntlmat** used to zero-out US emissions by Country-level

Example of Gridded HTAP Emissions



Parallelization of SMOKE

- **Open MP Parallelization in SMOKE**
  - **Smkreport** and **Smkmerge**
  - Upto 2-2.5x Speed up
  - Requires a complete restructuring



SMOKE v4.5 Updates

- **SMOKE4AERMOD** System Development
  - Generating a set of AERMOD ready input files based on the NEI inventories used in for air quality modeling.
  - Designed for NATA 2014 Studies to be consistent with air quality model ready emissions input.
  - **Point Sources:**
    - Point-EGU
    - Point-NonEGU
    - Airports with Runway (w/o Runway)
  - **Nonpoint Sources:**
    - CMV, RWC,,,
  - **Nonroad Sources**
  - **Onroad Mobiles Source**s:
    - RPD, RPV, RPP, RPH

U.S. EPA OTAQ Aircraft Emissions

- Supports from OTAQ and OAQPS offices
- New NEI platform sector for aircraft with a fully trajectory emissions
- Landing-Take-off (LTO) and Cruising Altitude Treatment
- Altitude Cut-Off Method to control the maximum height of aircraft emissions (NEI aircraft inventory is based on up to 3,000ft)
- Converting MSL to AGL Altitudes Handling
- Annual Link Inventory format: **FF10_LINK**
- Hourly/seconds Link Inventory format: **FF10_LINK_HOURLY** (Optional)
  - Requires a new program called **Lnkmerge** to process Temporally and Spatially highly resolved link-level aircraft emissions inventory
- Based on several link-level inventory processing tools development from FAA and LADCO.

FF10_LINK: OTAQ Link-level Inventory Format

Column	Variable	Type	Description
1	COUNTRY	Chars (3)	Country code; default to "US" (required)
2	FIPS	Chars (6)	Geographical code to represent geographical location of aircraft [ex: 0NC001 for Alamance County in NC, CURISE for aircraft crusing mode,,,,]
3	TRIBAL	Chars (3)	Tribal code (optional)
4	LINK_ID	Chars (15)	Link Identification Code (required)
5	SCC	Chars (20)	Source Category Code (SCC) (required)
6	DEPART_ID	Chars (15)	Link-specific Departure ICAO Airport Code (required)
7	ARRIVAL_ID	Chars (15)	Link-specific Arrival ICAO Airport Code (required)
8	EXH_HGT	Real	Link-specific Exhaust Height from the ground (ft) (optional)
9	EXH_DIAM	Real	Link-specific Exhaust Diameter (ft) (optional)
10	EXH_TEMP	Real	Link-specific Exhaust Gas Exit Temperature (°F) (optional)
11	EXH_FLOW	Real	Link-specific Exhaust Flow Rate (ft3/sec) (optional; automatically calculated by **Smkinven** from velocity and diameter if not given in file)
12	EXH_VEL	Real	Link-specific Exhaust Gas Exit Velocity (ft/sec) (optional)
13	STR_LON	Real	Starting Link ID Longitude (degrees) (optional)
14	STR_LAT	Real	Starting Link ID Latitude (degrees) (optional)
15	END_LON	Real	Ending Link ID Longitude (degrees) (optional)
16	END_LAT	Real	Ending Link ID Latitude (degrees) (optional)
17	POL_NAME	Chars (16)	Pollutant Code (CAS) (required)
18	EMIS_VALUE	Chars (16)	Total emissions per link ID in unit of short tons per year (required)
19	Comments	Chars (256)	Comments

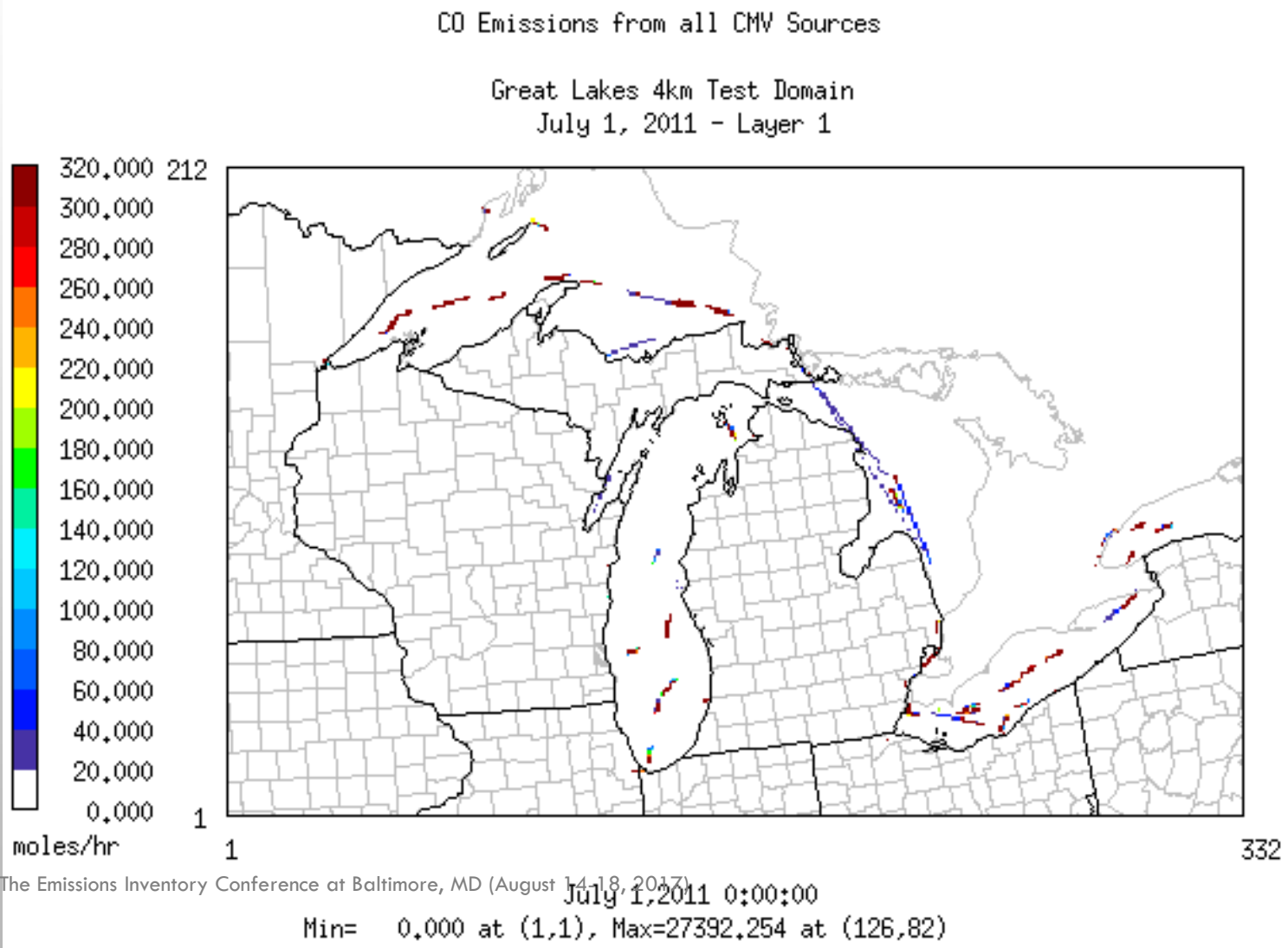
FF10_HOURLY_LINK: OTAQ Aircraft Link-level Format

Column	Variable \\	Type	Description
1	COUNTRY	Chars (3)	Country code; default to "US" (required)
2	FIPS	Chars (6)	Geographical code to represent geographical location of aircraft [ex: 037001 for Alamance County in NC,,,,,] (required)
3	TRIBAL	Chars (3)	Tribal code (optional)
4	LINK_ID	Chars (15)	Link Identification Code (required)
5	SCC	Chars (20)	Source Category Code (SCC) (required)
6	SEGMENT_ID	Chars (15)	Link-specific Segment ID [Taxi_out,,,,,Taxi_in] (required)
7	SEG_YEAR	Integer	Year of Segment ID (required)
8	SEG_MON	Integer	Month of year (required)
9	SEG_DAY	Integer	Day of month (required)
10	SEG_HOUR	Integer	Hour (required)
11	SEG_MIN	Integer	Minutes (required)
12	SEG_TZONE	Chars (3)	Link-specific time zone [ex: GMT,,,,,] (required)
13	SEG_DURATION	Integer	Segment Duration Time (seconds) (required)
14	SEG_DISTANCE	Integer	Segment Distance (feet) (optional)
15	STR_LON	Real	Starting Segment ID Longitude (degrees) (required)
16	STR_LAT	Real	Starting Segment ID Latitude (degrees) (required)
17	STR_ALT	Real	Starting Segment ID Altitude above MSL (feet) (optional)
18	END_LON	Real	Ending Segment ID Longitude (degrees) (required)
19	END_LAT	Real	Ending Segment ID Latitude (degrees) (required)
20	END_ALT	Real	Ending Segment ID Altitude above MSL (feet) (optional)
21	POL_NAME	Chars (16)	Pollutant Code (CAS) (required)
22	EMIS_VALUE	Chars (16)	Total emission in unit of short tons per segment ID (required)
23	Comments	Chars (256)	Comments

CMV Link-Level Emissions Processing

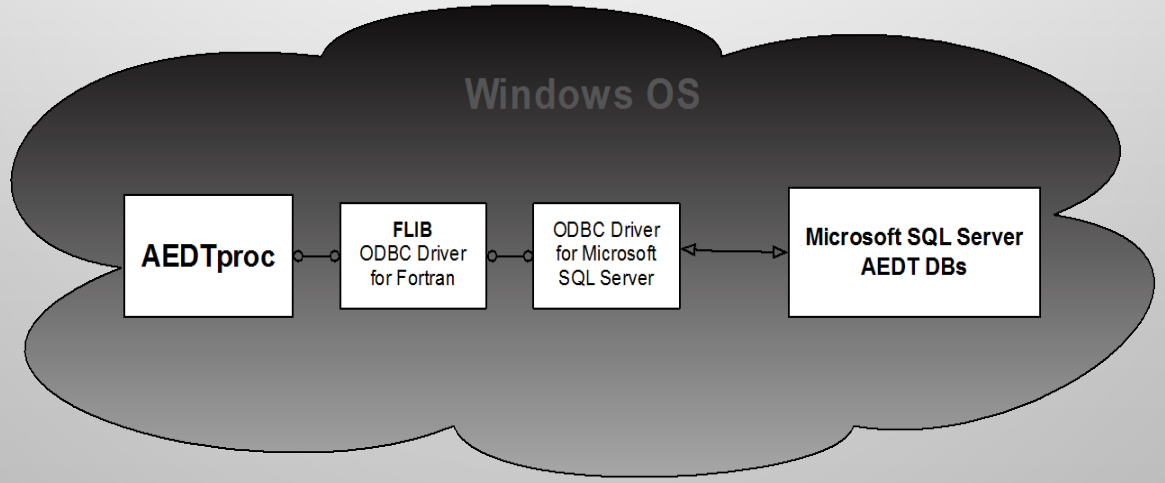
- LADCO's Commercial Marine Vessels (CMV) Link-Level Emissions
  - Real-time CMV Transponder Data measured by Automatic Identification System (AIS)
    - Vessel identity, type, position, course, speed, navigational status, and other
  - LADCO developed an AIS-based 2014 CMV Inventory
    - Processes: Cruising, Maneuvering and Hoteling
    - Link-level (starting and ending coordinates)
    - Temporal Resolution: Few seconds to Months
- **LinkProc** is a stand-alone Emissions Modeling Processor
  - Generates gridded/speciated/hourly emissions for AQ models
  - No multiple steps like SMOKE programs

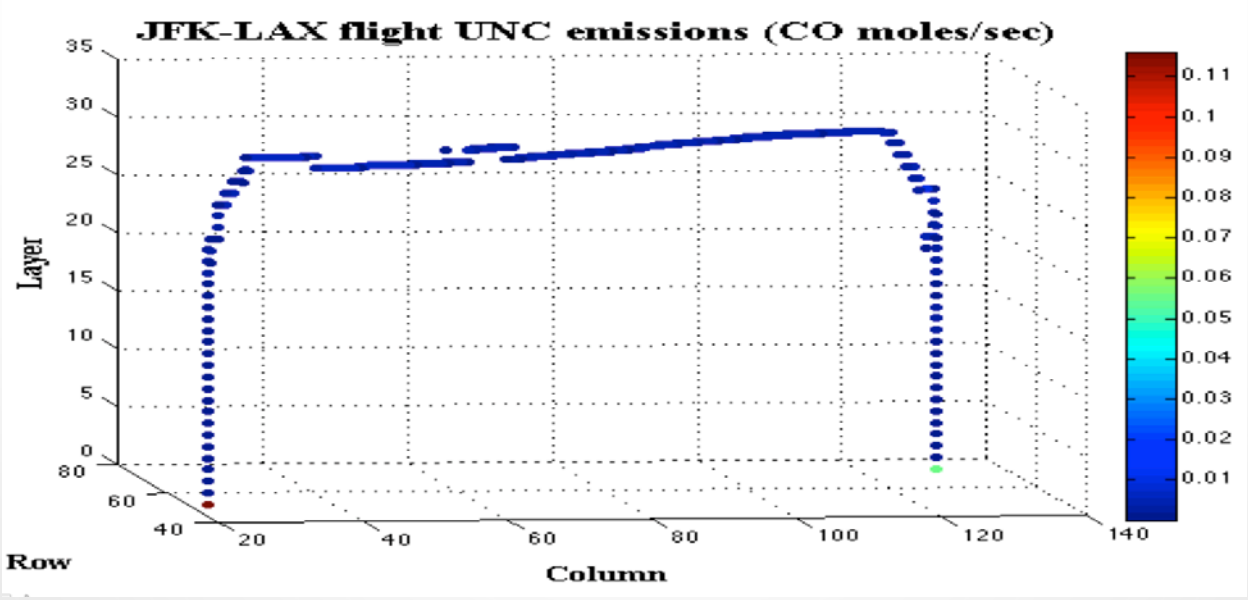
LADCO CMV Link-level Emissions

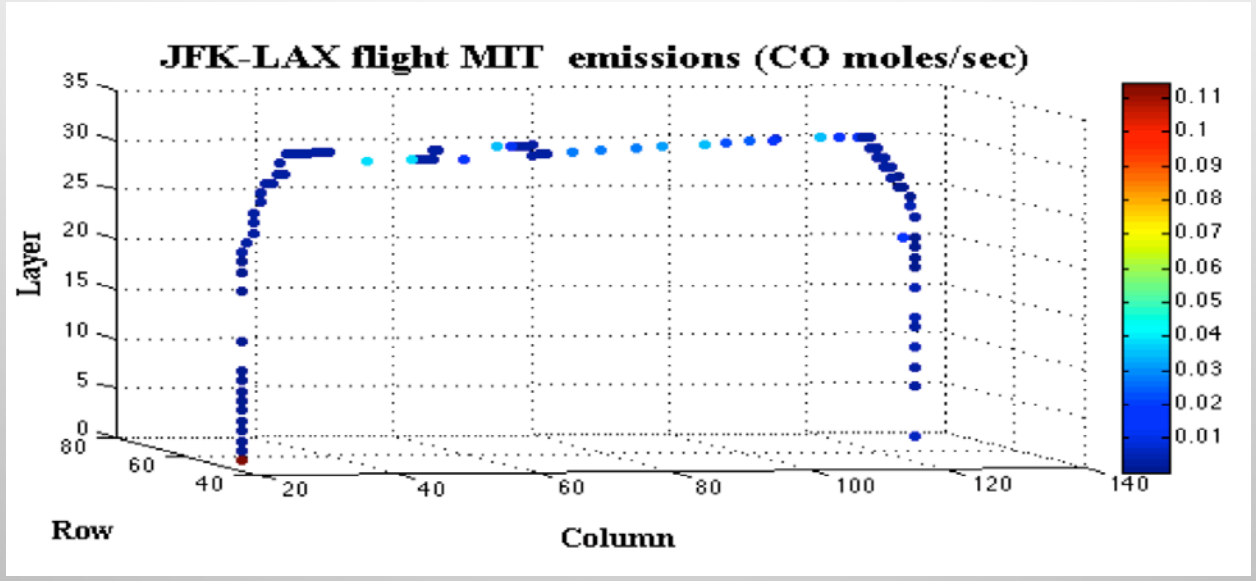


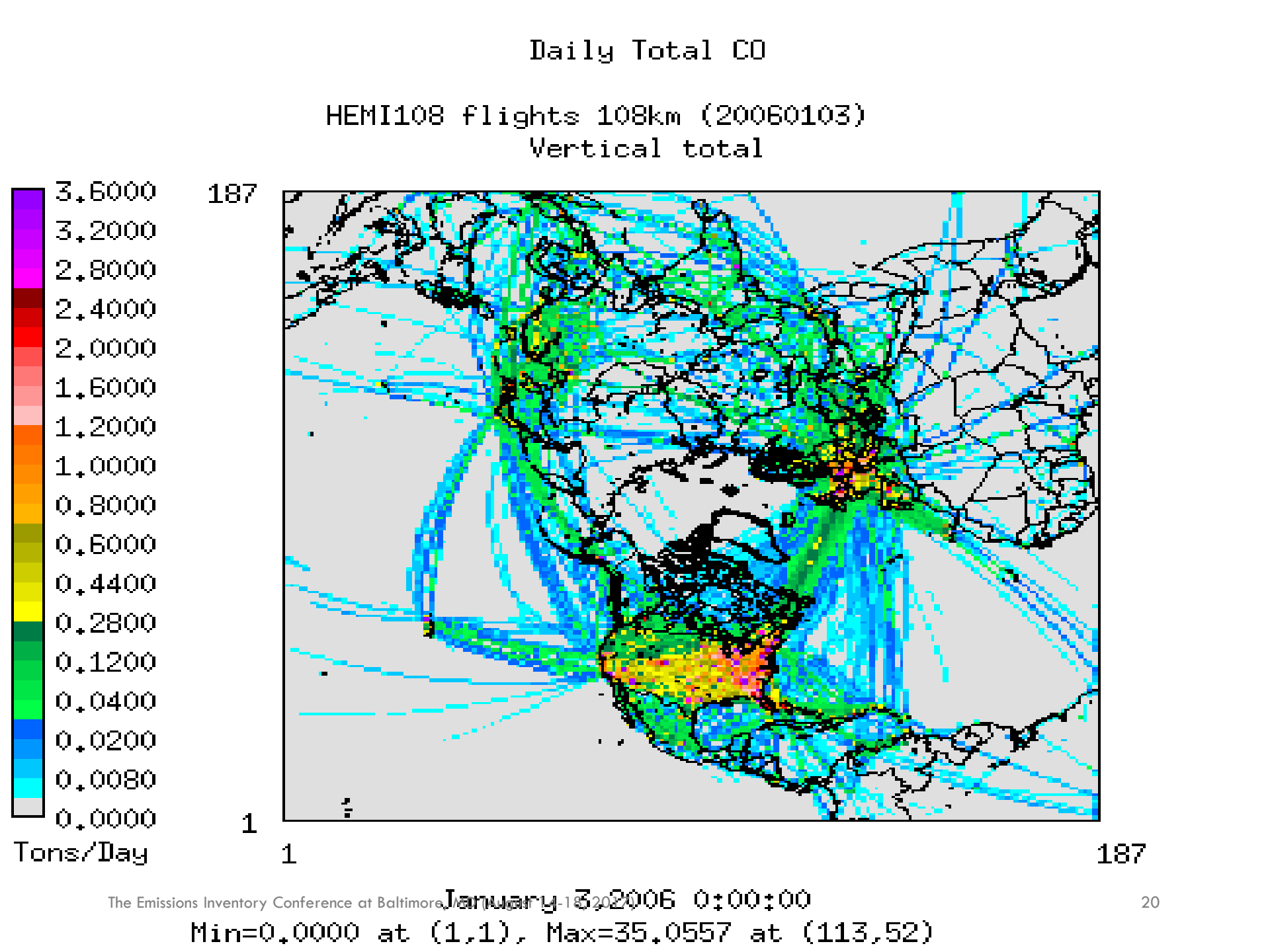
FAA AEDT Gridder Development

- FAA Aviation Environmental Design Tool (AEDT) version 2.0
  - Full trajectory link-level aircraft emissions in realtime
- **AEDTProc** was developed on 2010 and currently used to generate the 3-D aircraft emissions for air quality models
- New AEDT-Gridder Development:
  - Direct connection to MS SQL DBs Server to retrieve the aircraft emissions from SQL DBs using FLIB library that allows Fortran to talk to the DBs
  - Expanding to support global climate models (CamChem, Geos-Chem,,,) and the next generation air quality platform MPAS (Model for Prediction Across Scale)




JFK-LAX flight UNC emissions (CO moles/sec)
Layer
Row
Column
0
5
10
15
20
25
30
35
80
60
40
20
40
60
80
100
120
140
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01


JFK-LAX flight MIT emissions (CO moles/sec)
Layer
Row
Column
0
5
10
15
20
25
30
35
80
60
40
20
40
60
80
100
120
140
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01


Daily Total CO
HEMI108 flights 108km (20060103)
Vertical total
3.6000
3.2000
2.8000
2.4000
2.0000
1.6000
1.2000
1.0000
0.8000
0.6000
0.4400
0.2800
0.1200
0.0400
0.0200
0.0080
0.0000
Tons/Day
187
1
1
187
January 3, 2006 0:00:00
Min=0.0000 at (1,1), Max=35.0557 at (113,52)

Ongoing SMOKE Updates

- New Spatial Allocator Based on PostgreSQL/PostGIS
  - Easier, Faster and Simpler
- Improving Fire-related plume algorithms for a better vertical and horizontal allocations
  - New fires grouping for a better horizontal allocation
  - New Fire plume algorithms for a better vertical allocation
- The Integration of the SMOKE setup structures between NEI Modeling Platform and CMAS SMOKE release versions
  - Restructuring the current CMAS version of SMOKE system
  - NEI platform updates are needed.

Acknowledgement

- **U.S. EPA**
  - Office of Air Quality Planning and Standards (**OAQPS**)
  - Office of Transportation and Air Quality (**OTAQ**)

- **LADCO (Lake Michigan Air Director Consortium)**

- **FAA (Federal Aviation Administration)**