Development of Mid-Century Anthropogenic Emissions Inventory in Support of Regional Air Quality Modeling under Influence of Climate Change

J. Woo, S. He, P. Amar
NESCAUM

E. Tagaris, K. Manomaiphiboon, K. Liao, A. G. Russell
Georgia Institute of Technology

EPA EI Conference, May, 2005, New Orleans

Overview

Purpose of work

*** Develop 2050 EI**

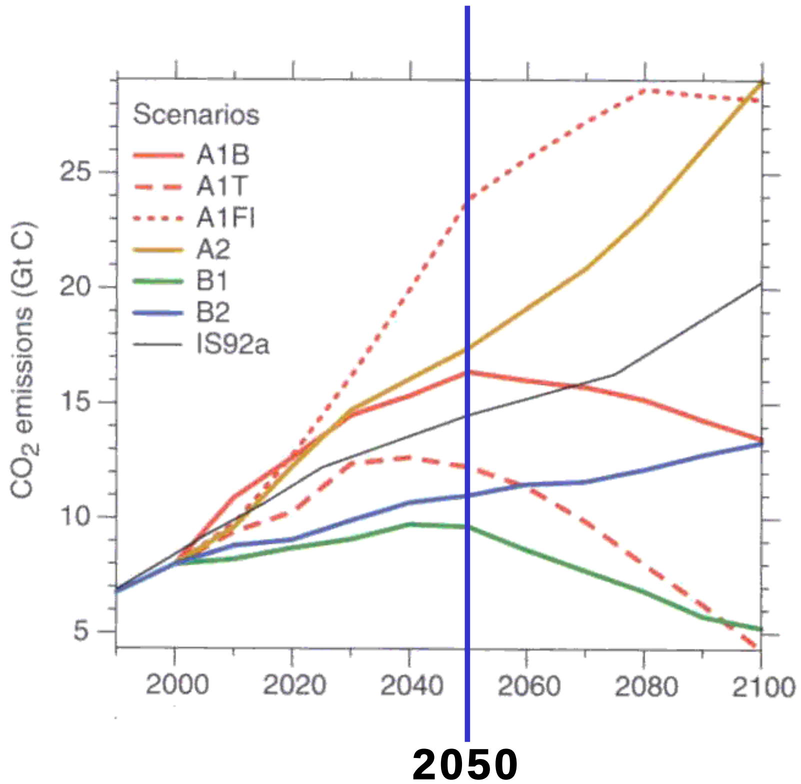
- Target year : Year 2050, Annual
- Format : SMOKE-ready
- Sector : Anthropogenic only
- Geographical domain : US/CAN/MX
- Projection approach :

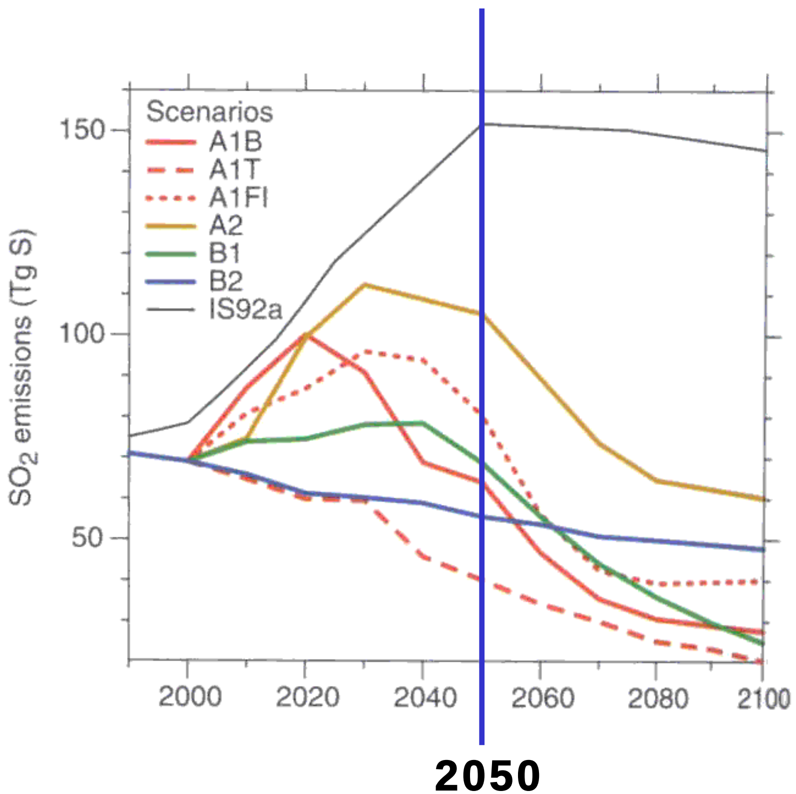
Two stage approach if any national projection is available

*** In support of modeling**

- Not creating new future energy/emissions scenario

Uncertain Future (Global CO_2 & SO_2)





Source : IPCC

Basic strategy

Future year EI development

- Try to get the best available future EI data possible
- Fill-up gaps from near/certain future to distant/uncertain future

Example : Use EPA projection until 2020 and use IPCC scenario from 2020-2050

Inter-comparison of Future EI development

Name	Base Year	Future Years	Geographical Domain	Scenario	Source sectors	Chemical species	Model	Availa bility
EPA CAIR	2001	2010 /2015 /2020	Continental US	EPA BASE /CAIR	EGUs, non-EGUs	NOx, VOCs, CO, NH3, SO2, PM	IPM /EGAS/ NMIM	Yes
EPA CSI	1996	2010 /2020	Continental US	EPA BASE /CSI	EGUs, Non-EGUs	NOx, VOCs, CO, NH3, SO2, PM	IPM /EGAS	Yes
RPO	2002	2009 /2018	Continental US	OTB/OTW	EGUs & non-EGUs	NOx, VOCs, CO, NH3, SO2, PM	IPM /EGAS	Partly
SAMI	1990	2040 (/10yrs)	38 States + DC	OTB/OTW/ BWC/BB	EGUs & non-EGUs	NOx, VOCs, CO, NH3, SO2, PM	SAMI	No
RIVM*	1995	~2100 (/yr)	World (17 regions)	IPCC SRES(A1, B1, A2, B2)	Energy sector/fuel combination	CO2, CH4, N2O, CO, NOx, SO2, NMVOC	IMAGE	Yes
NESCAUM /EPA	1999	~2029+ (/3yrs)	Units(EGUs), States(NE), Country	BAU, RGGI	Energy sector/fuel combination	NOx, VOCs, CO, NH3, SO2, PM	MARKAL	2007

Pros | Cons | Both

• RIVM : Netherlands's National Institute for Public Health and the Environment
• IMAGE : Integrated Model to Assess the Global Environment

Selected Method & Data

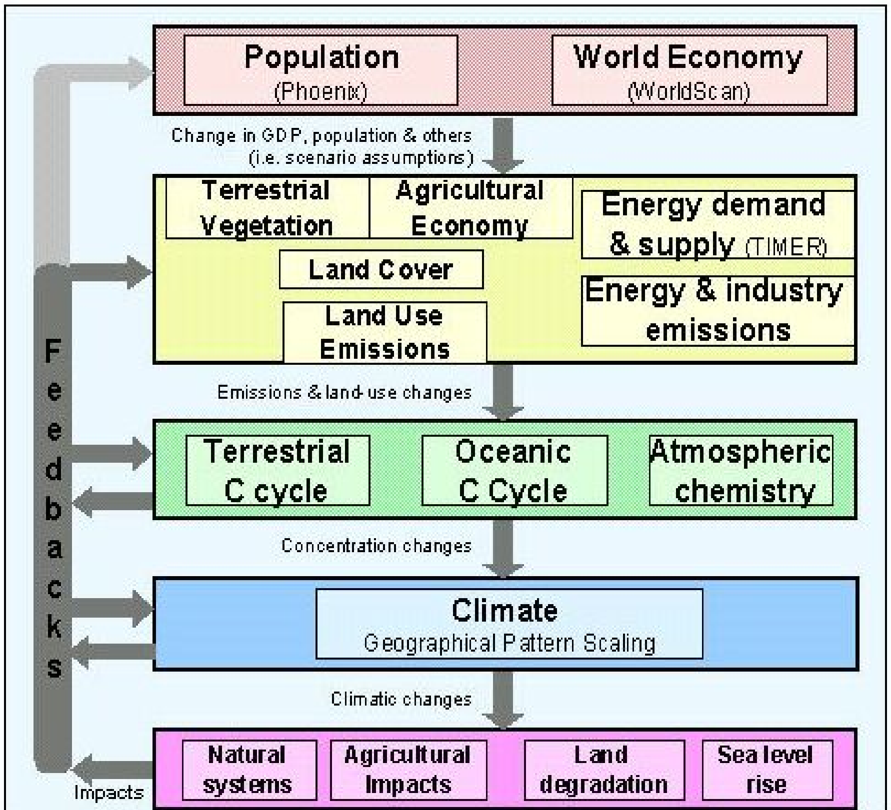
Near Future EI (EPA CAIR)

- Base Case
  - Current controls except CAIR
- **Control Case(Clean Air Interstate Rule)***
  - The same as base case except for EGUs
- Available for Y2001, Y2010, Y2015, Y2020
- Based on 1999 NEI
- Pollutant : NOx, CO, NMVOC, SO2, NH3, PM10, PM2.5
- Available as SMOKE/IDA format

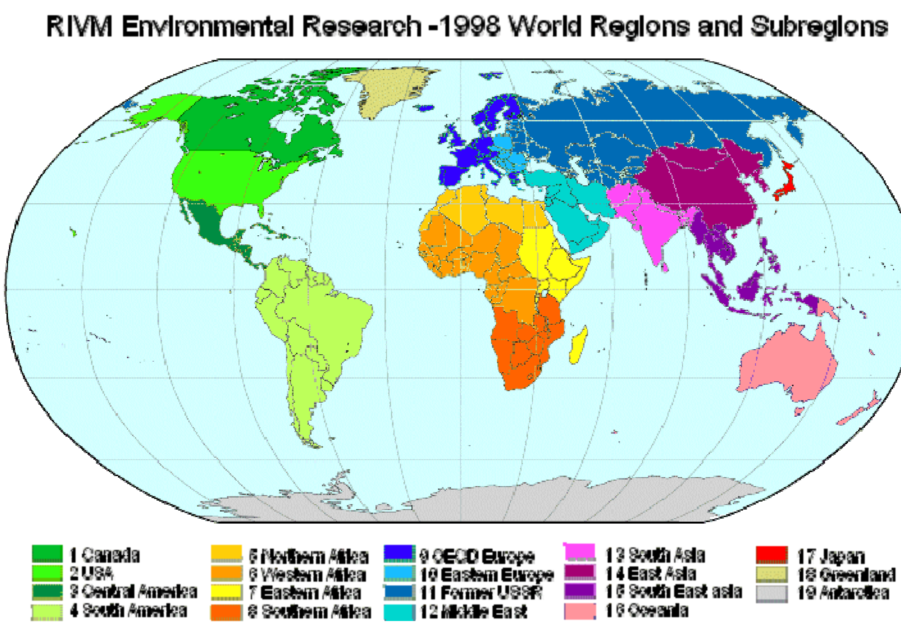
* CAIR region : AL, AR, CT, DE, DC, FL,GA, IL, IN, IA, KY, LA, MD, MA, MI, MN, MS, MO, NJ, NY, NC, OH, PA, SC, TN, TX,VA, WV, WI

Distant Future EI (RIVM IMAGE)

IMAGE：A dynamic integrated assessment modeling framework for global change



WorldScan(economy model), and PHOENIX (population model) feed the basic information on economic and demographic developments for 17 world regions into three linked subsystems (EIS, TES, and AOS*)



* EIS(Energy-Industry System), TES(Terrestrial Environment System), AOS (Atmospheric Ocean System)

Project emissions
- US -

- **Step #1 : Use national projection data available for the near future**
  - Use EPA CAIR Modeling EI
    (Point/Area/Nonroad, from Y2001 to Y2020)
  - Use RPO SIP Modeling EI
    (Mobile, from Y2002 to Y2018)

- **Step #2 : Get growth data for the distant future and develop cross-reference**
  - Use IMAGE model (IPCC SRES, A1B)
  - From Y2020(Y2018 for mobile activity) to Y2050
  - X-Ref : Sectors/Fuels combination to SCCs

- **Step #3 : Apply growth factors using cross-reference**
  - Use in-house Fortran software
  - From Y2020(Y2018 for mobile activity) to Y2050

Project emissions

- CANADA/MEXICO -

- **Step #1 : Use national projection data available for the near future or update base year inventory**

  - Use Y2020 Environmental Canada Future EI (Area/Mobile)

  - Use Y2002 Point source inventory (NYSDEC) scaled with Y2000 by-state point source summary from Environment Canada

  - Update base year Mexico inventory(BRAVO) using Mexico NEI for 6 US-Mexico Border states

- **Step #2 : Get simple growth data for the future and apply them**

  - Use IMAGE model (IPCC SRES, A1B)

  - From Y2020 to Y2050 (CAN, Area/Mobile)

  - From Y2000 to Y2050 (CAN, Point)

  - From Y1999 to Y2050 (MX, All)

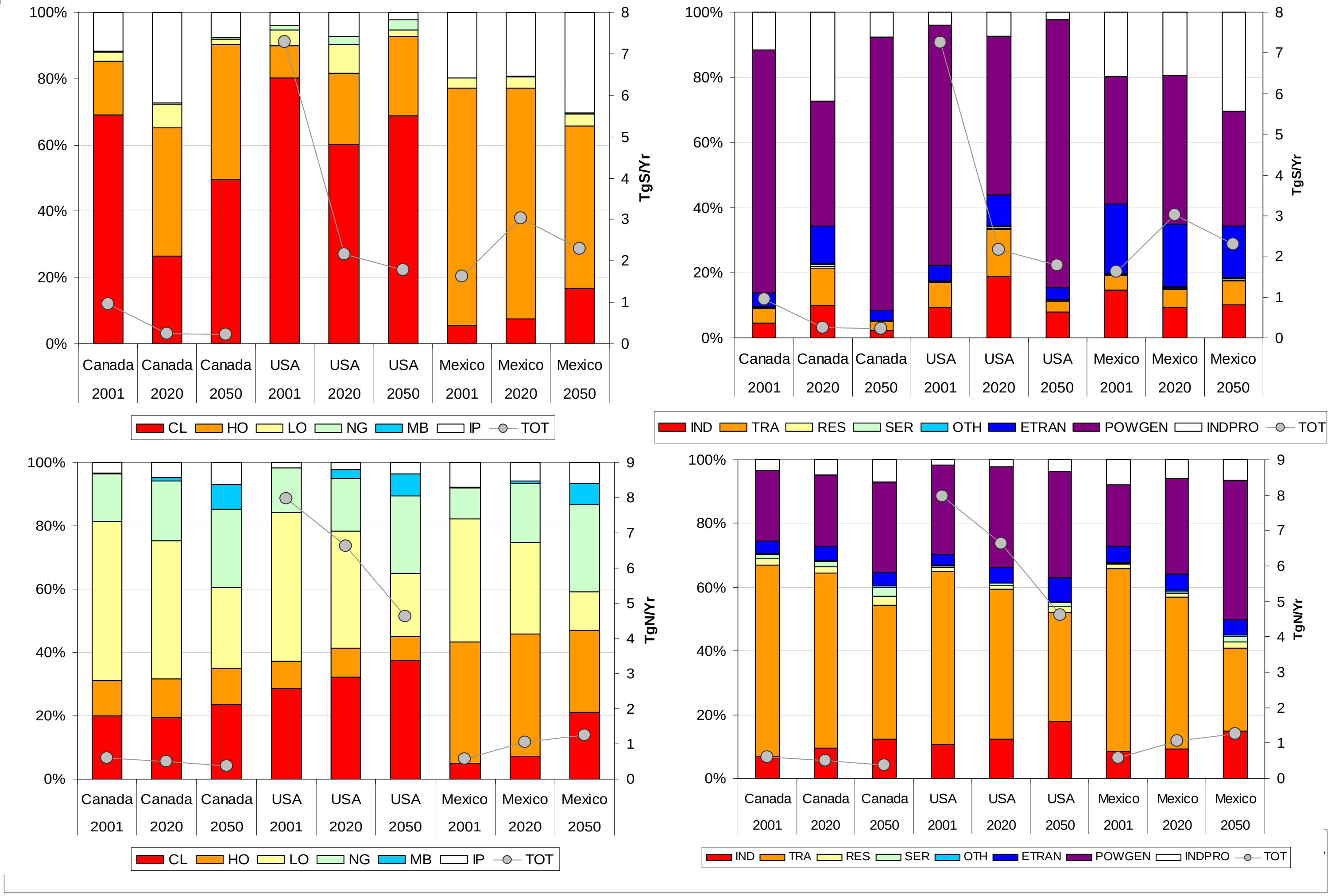
Result

Developing cross-reference (CAIR and IMAGE)

no	SCC	CO	NOx	VOC	NH3	SO2	PM10	PM2_5	sec	fuel	cntry	SCC_Description
407	10300101	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Anthracite Coal_Pulve
408	10300102	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Anthracite Coal_Trave
409	10300103	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Anthracite Coal_Hand-
410	10300203	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
411	10300205	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
412	10300206	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
413	10300207	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
414	10300208	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
415	10300209	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
416	10300214	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
417	10300216	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
418	10300217	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
419	10300218	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
420	10300222	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
421	10300223	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
422	10300224	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
423	10300225	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
424	10300226	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Bituminous/Subbitumi
425	10300309	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Commercial/Institutional_Lignite_Spreader Stok
426	10500202	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	External Combustion Boilers_Space Heaters_Commercial/Institutional_Coal *
427	2103001000	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	Stationary Source Fuel Combustion_Commercial/Institutional_Anthracite Coal
428	2103002000	2.08811	2.08811	2.08811	2.08811	0.522028	0.868927	0.868927	COM	COAL	USA	Stationary Source Fuel Combustion_Commercial/Institutional_Bituminous/Sub
539	10300601	0.55543	0.96362	0.55543	0.96362	1.03203	1.123573	1.123573	COM	GAS	USA	External Combustion Boilers_Commercial/Institutional_Natural Gas_> 100 Mi
540	10300602	0.55543	0.96362	0.55543	0.96362	1.03203	1.123573	1.123573	COM	GAS	USA	External Combustion Boilers_Commercial/Institutional_Natural Gas_10-100 M

5000+ SCCs

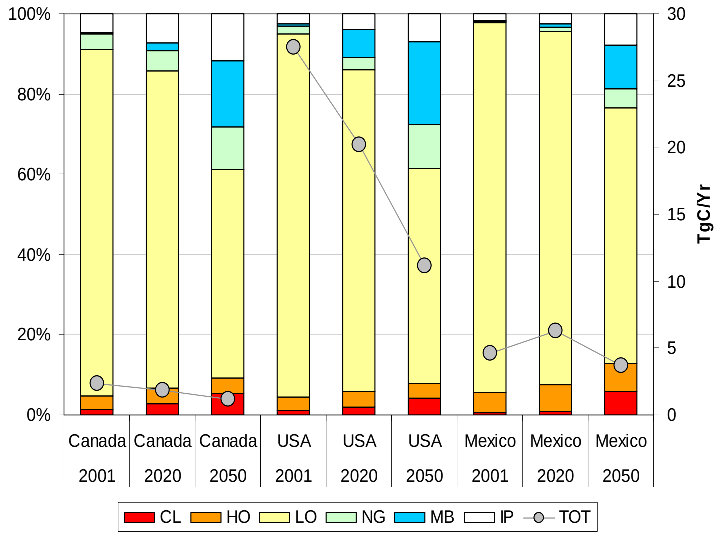
Growth (IMAGE – A1B)

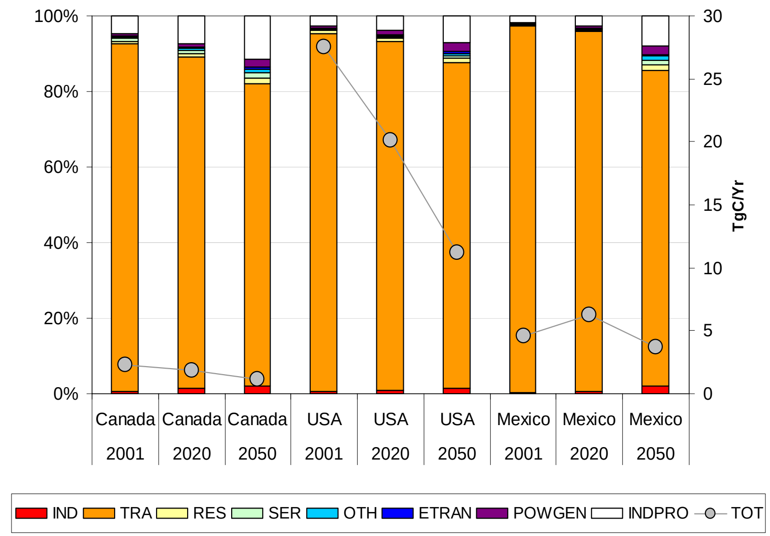


SO2(as S)

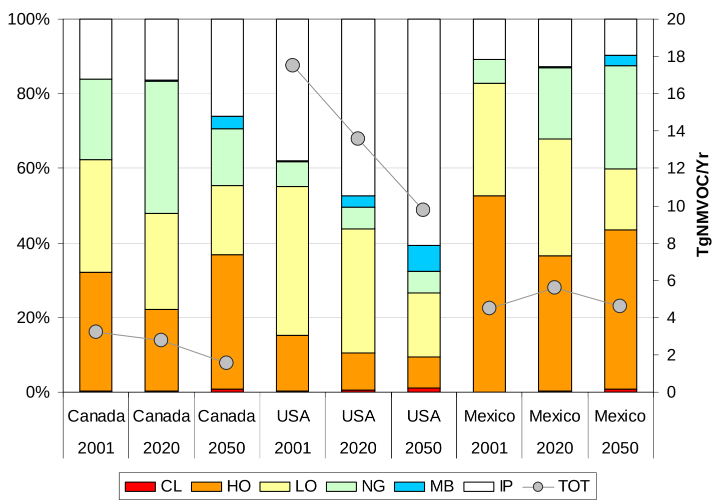
NOx(as N)

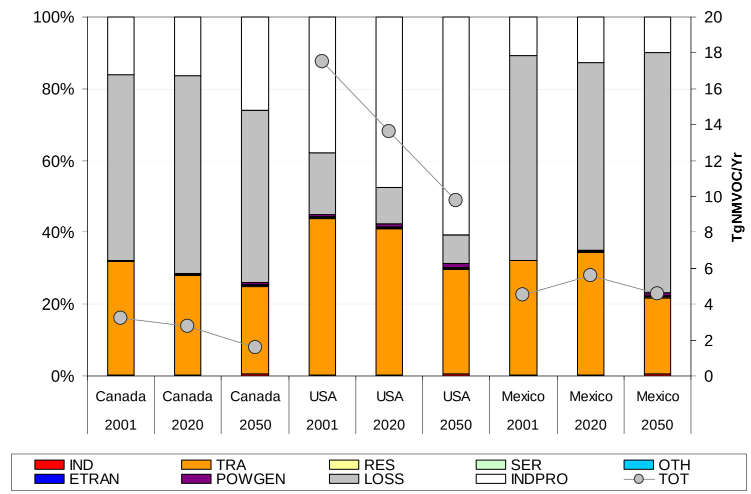
Growth (IMAGE – A1B)





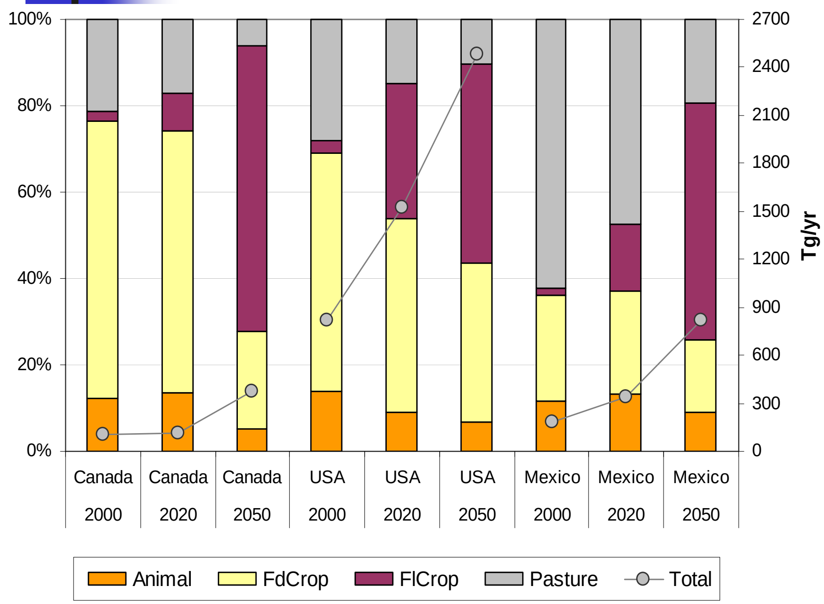
CO(as C)





NMVOC

Growth (IMAGE – A1B)

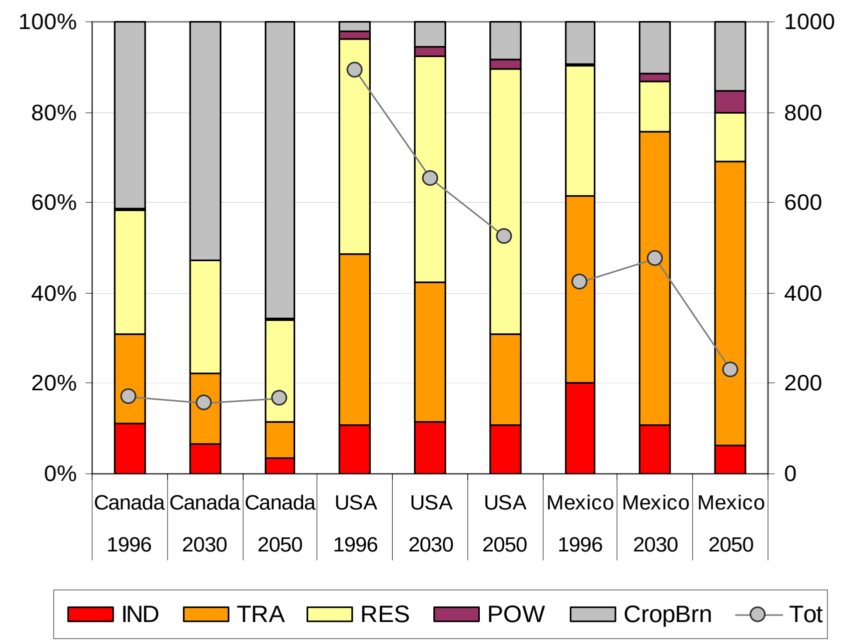


Agricultural Production

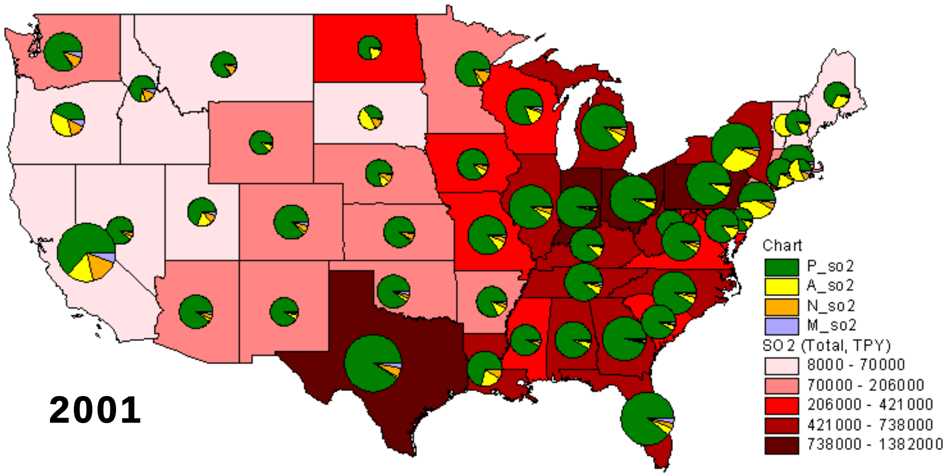
Surrogates for NH3 for OTH sector

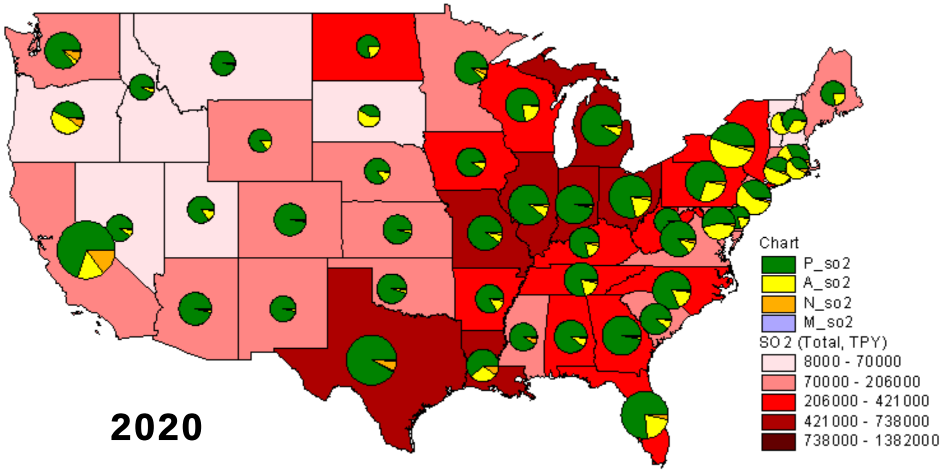
Surrogates for PM species

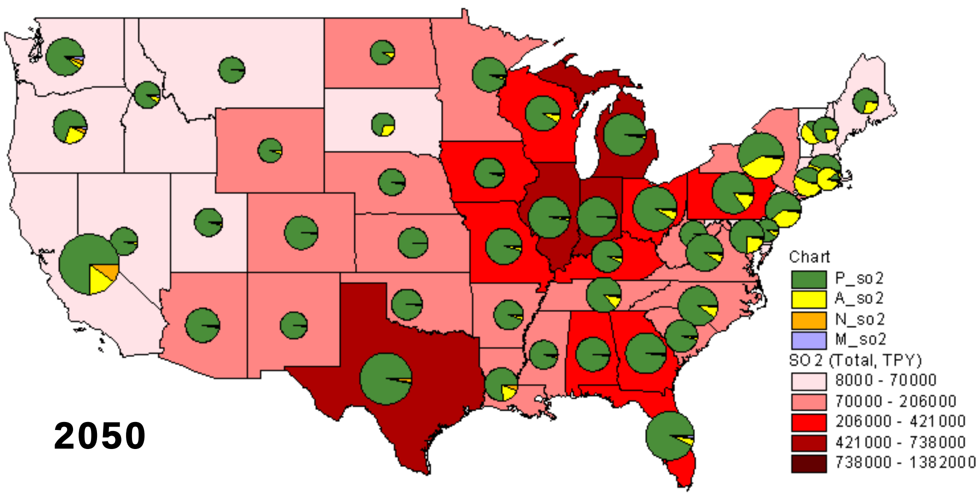
BC+EC
-Streets et al. (2004)

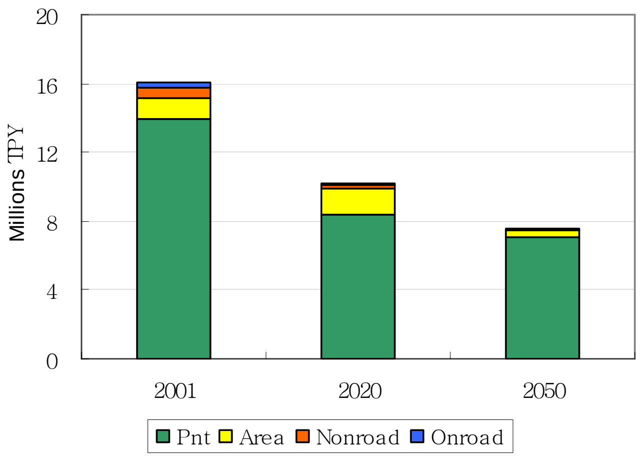


Spatial Distribution of Emissions
(SO2)

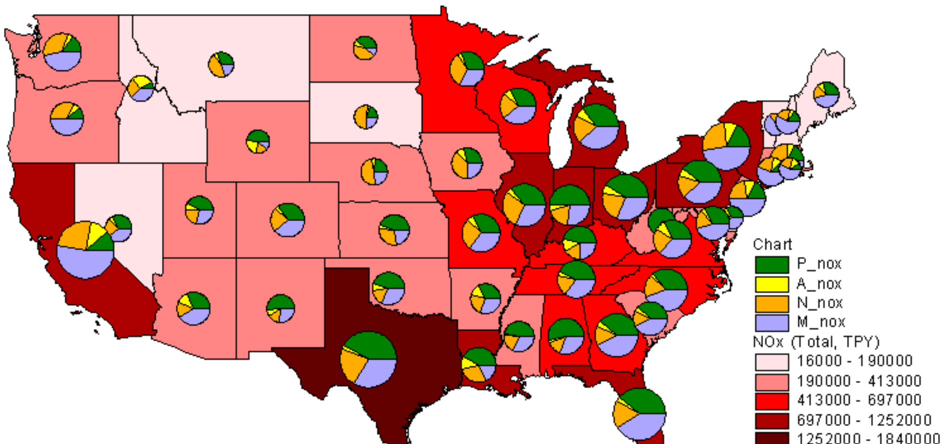




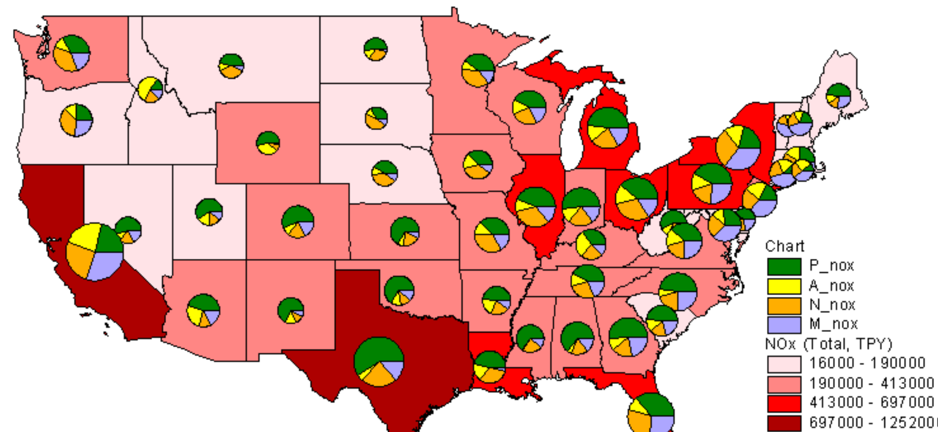




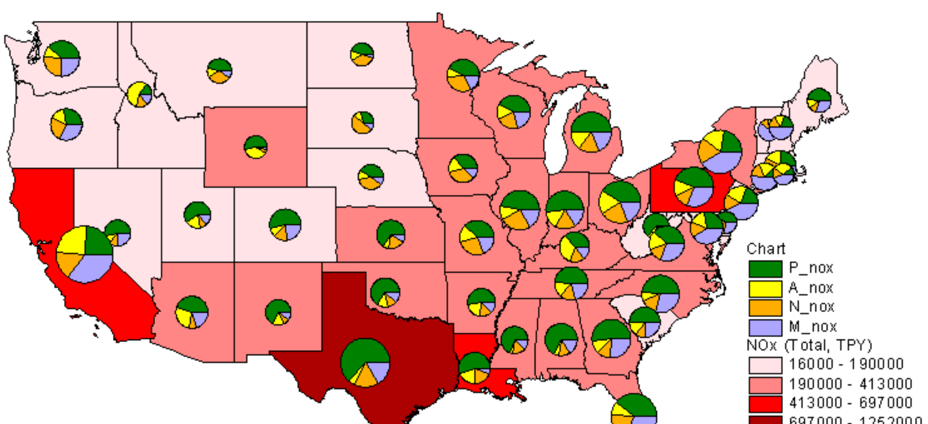
Spatial Distribution of Emissions
(NOx)



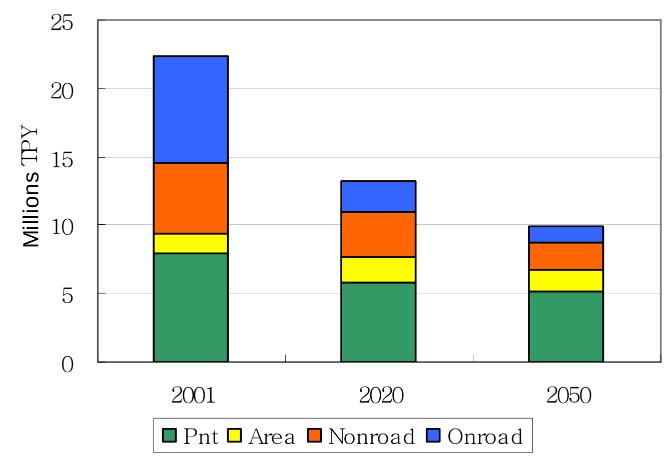
2001



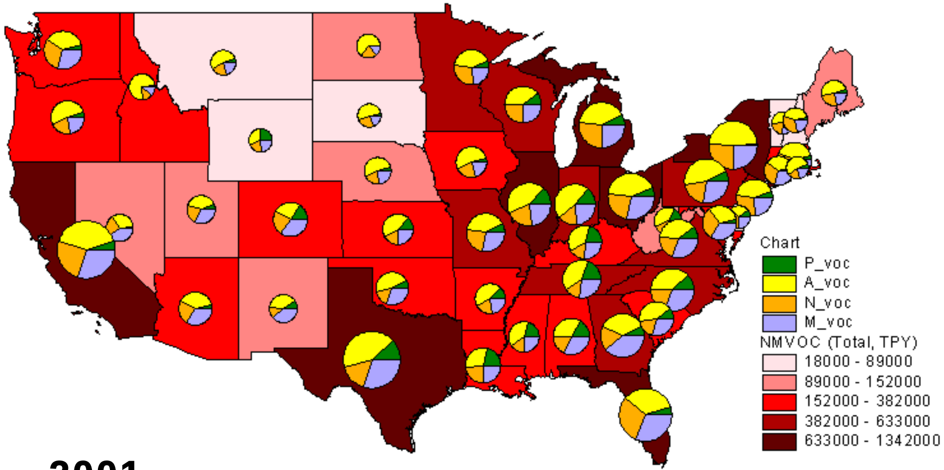
2020



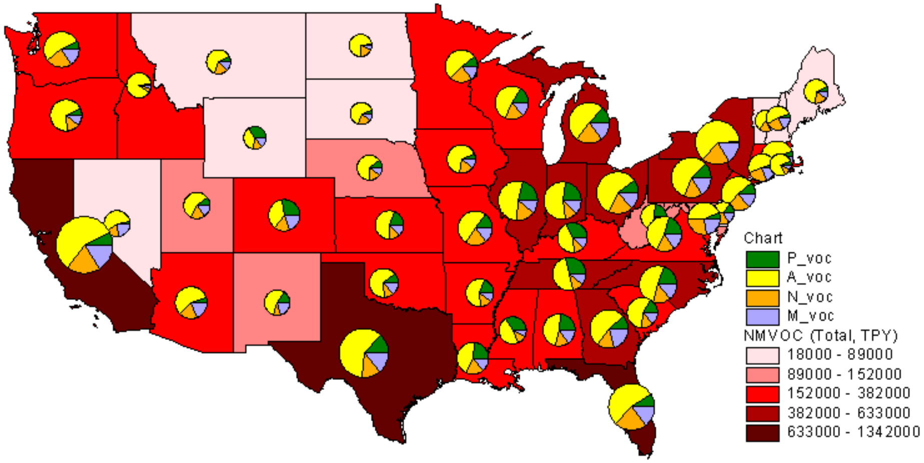
2050



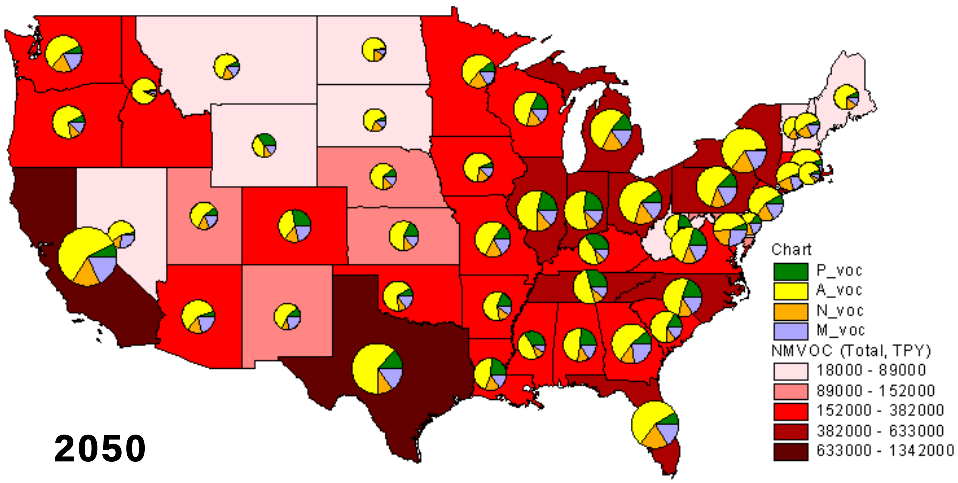
Spatial Distribution of Emissions
(NMVOC)



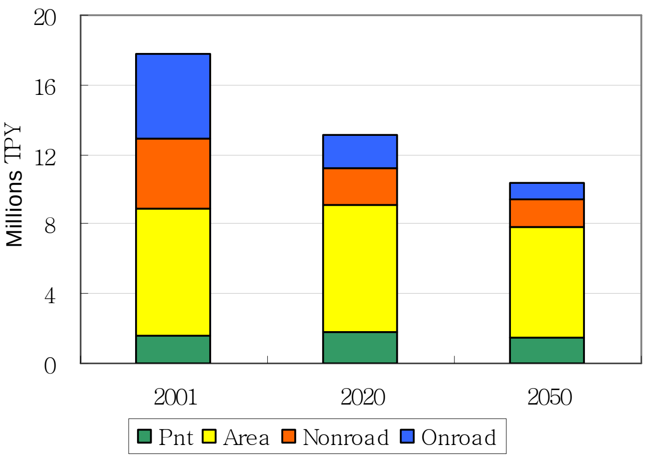
2001



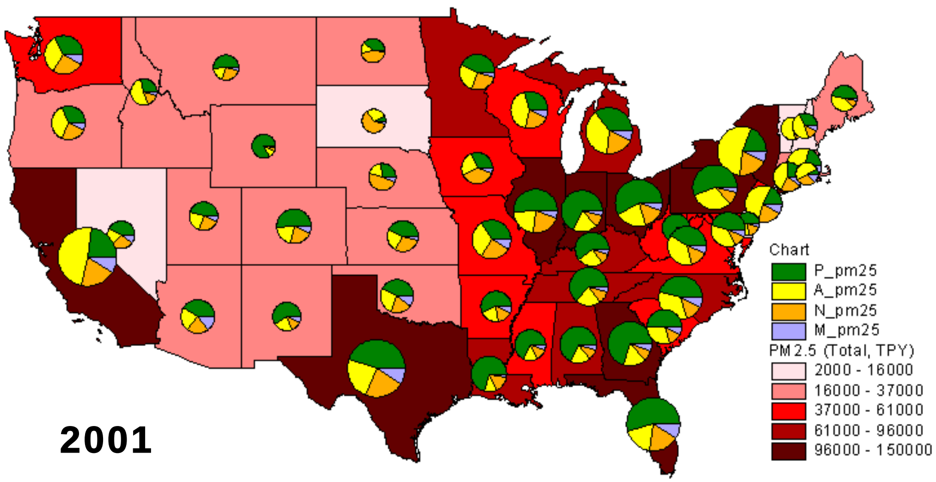
2020

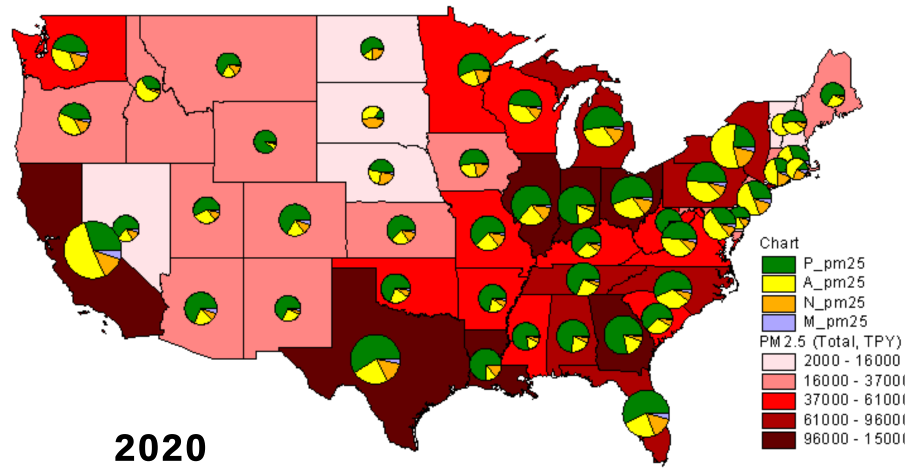


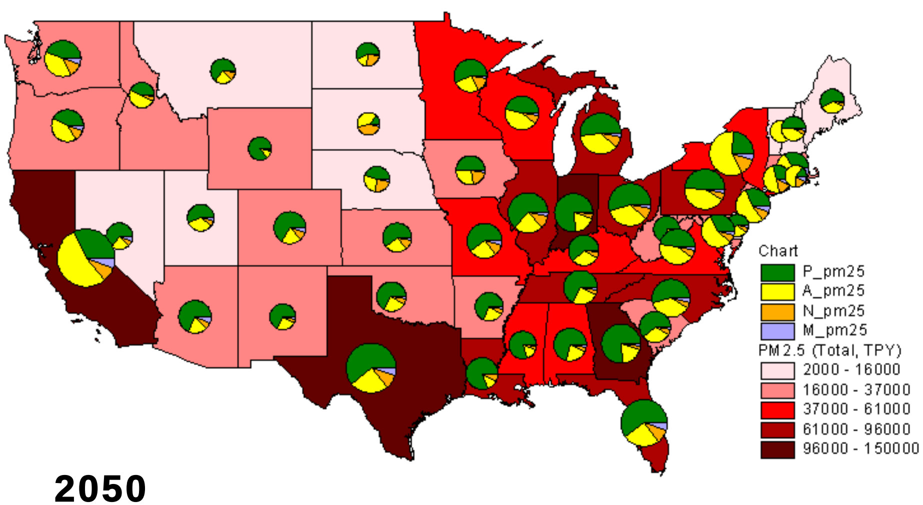
2050

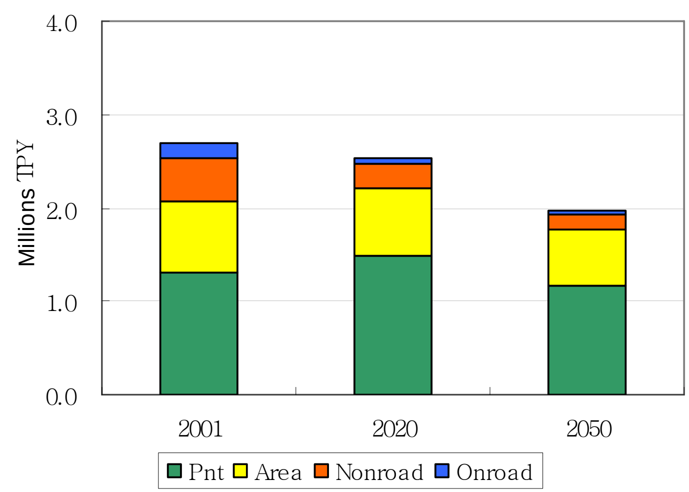


Spatial Distribution of Emissions
(PM2.5)

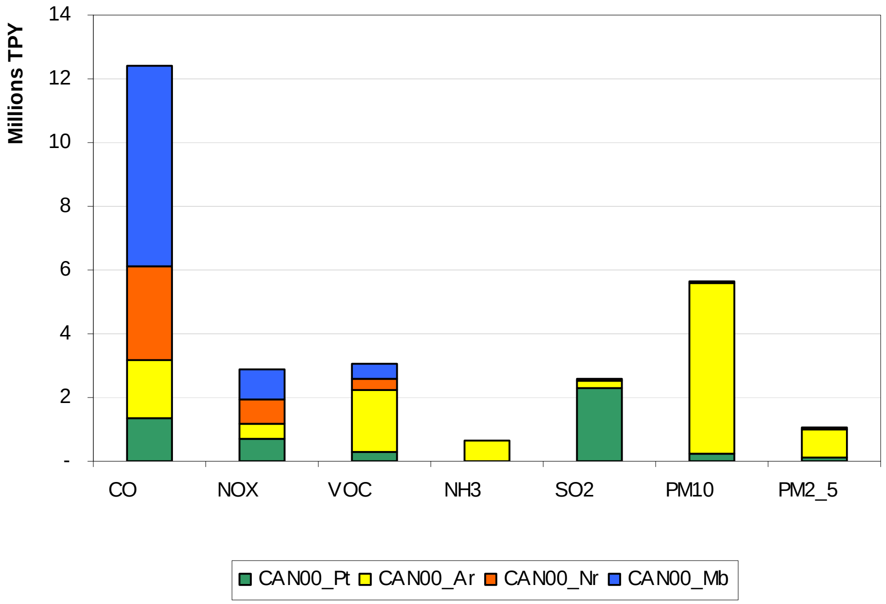


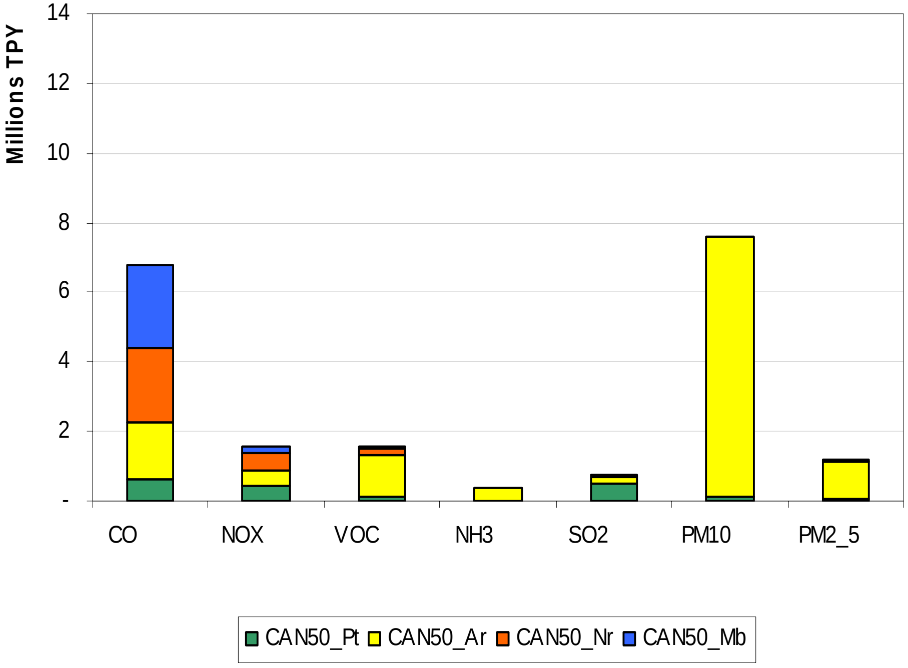




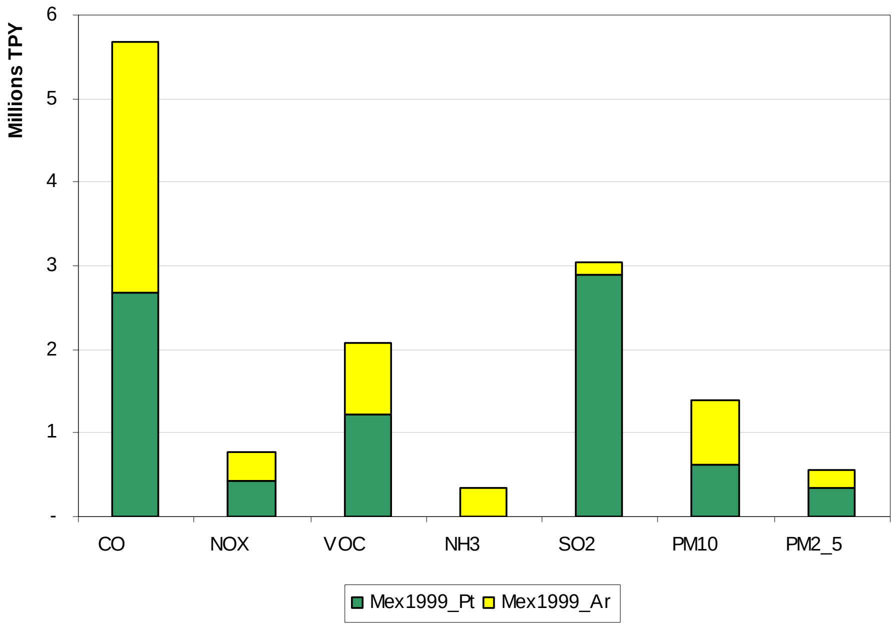


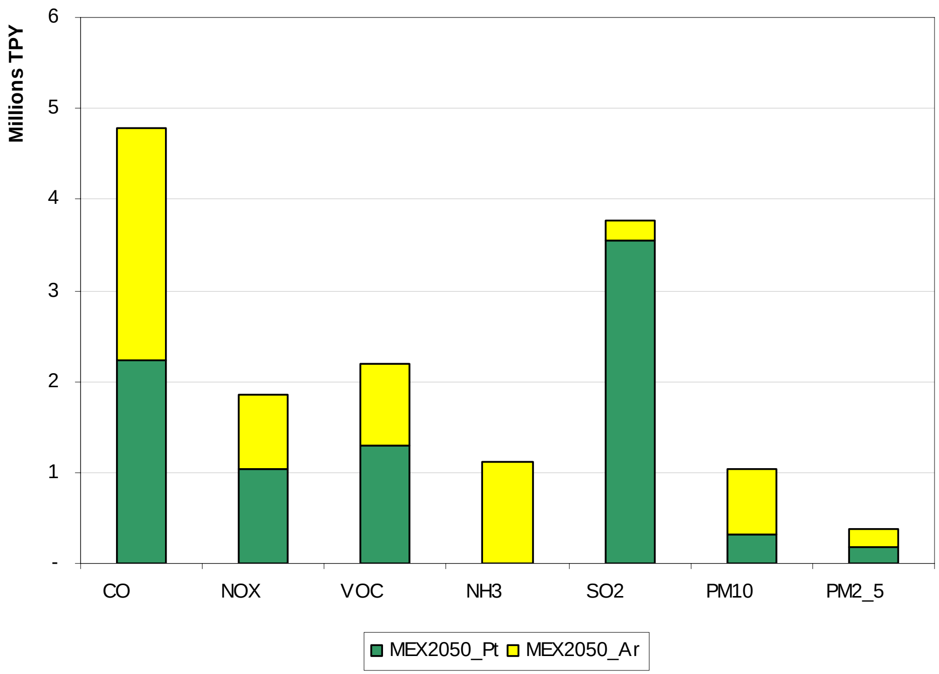
Future Emissions (CANADA)



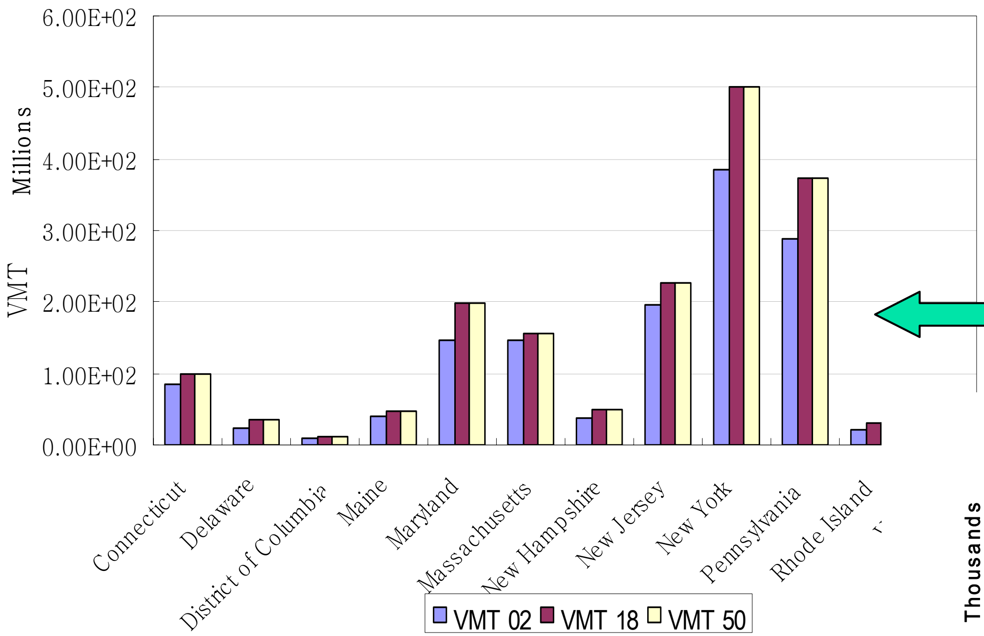


Future Emissions (Mexico)





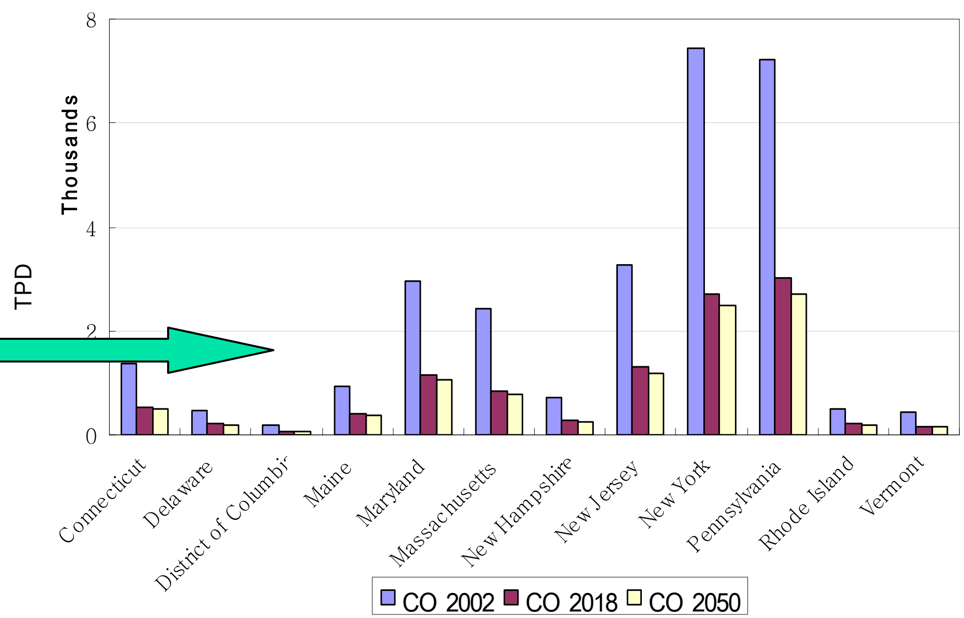
Mobile source (VMT vs. Emission)



Three SMOKE/M6 runs(2002/2018/2050) for MANE-VU states

VMT increases (about 1%/year) for the future years (Y2050 = Y2018 yet)

In spite of VMT increase, emission (CO) decrease dramatically because of controls for the future years. Much less effect of controls after 2018.



Conclusion

- US emissions in the future (Y2050) are estimated to decrease by 2.5 times (NOx) to 25% (PM2.5)
- Canadian EI shows decrease of gaseous pollutants but increase of particle emissions because of fugitive dust
- For Mexico, emissions of NOx, SO2, NH3, and VOC are estimated to increase but CO, PM10, and PM2.5 will decrease
- For US onroad mobile source, post 2018 emissions will not decrease significantly without activity change or even increase with just VMT growth. The IMAGE model, however, projects decrease of this source sector.

On-going work

- Air quality modeling using CMAQ-DDM for three cases

  - Base year emissions with base year meteorology

  - Base year emissions with future year (2050) meteorology

  - future year (2050) emissions with future year (2050) meteorology

Thank you for your attention!

Mobile source (VMT vs. Emission)

National emissions of VOCs from light-duty vehicles expected to remain flat post 2015 and begin to rise post 2020.

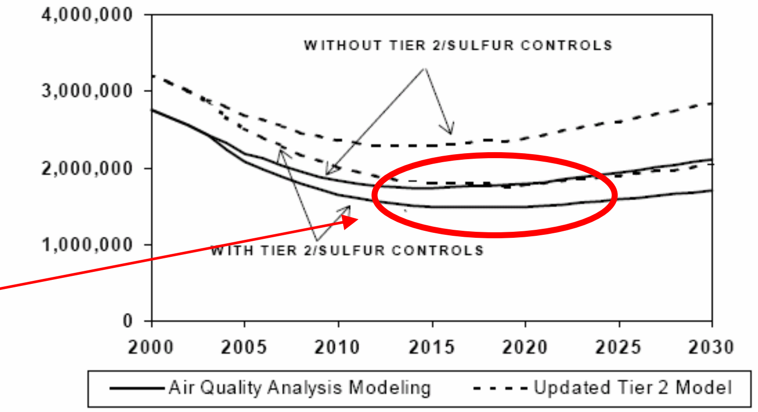


Figure III.A-10. 47-State Light-Duty VOC Emissions With Tier 2/Sulfur (Annualized Summer Tons)

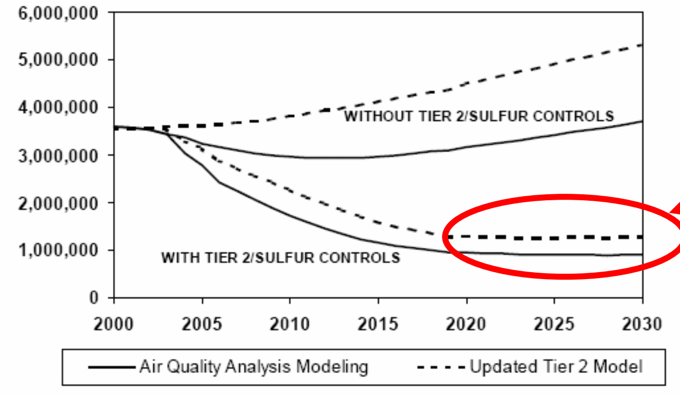


Figure III.A-4. 47-State Light-Duty NOx Emissions With Tier 2/Sulfur (Annualized Summer Tons)

III-11

NOx to remain flat post 2020 and begin to rise sometime post 2030.

Source: US EPA, Tier 2 Regulatory Impact Analysis; NRDC, 2005

Combining two futures (CAIR and IMAGE)

Calculate combined factor of growth/control from EPA base year(2001) vs. future year (2020) emissions inventory

Use EPA 2020 CAIR-case inventory

Calculate growth factor for Y2020-Y2050 (A1B) from IMAGE

Calculate growth factor for Y2001-Y2050 for Canada/Mexico from IMAGE

RPO 2018 Activity data (On-road mobile)

Compare EPA CAIR vs. IMAGE for Y2001-Y2020

Develop SCC to IMAGE fuel/sector x-reference

Update cross-references

Check/apply growth factors to 2020 EPA CAIR EI to get 2050 EI

SMOKE/M6-ready activity data for 2050

Combining two futures
(CAIR and IMAGE)

- **EPA CAIR inventories for year-2001 and year-2020 were processed with SMKINVEN and SMKREPORT** to ensure consistency in data formatting and generate emissions summary by each SCCs

- **Emissions from IMAGE and other research [Streets et. al., 2004] were estimated for USA/Canada/Mexico and for Y2001/Y2020/Y2050** to get growth factors for these periods

- **The cross-references from US Source Classification Code (SCC) to IMAGE sector/fuel combination were developed**

Developing cross-reference
(CAIR and IMAGE)

IMAGE

Sector	Fuel
IND	COAL
TRA	HO
RES	LO
COM	GAS
POW	OTH
OTH	
PRO	

CAIR

5000+
US
SCCs