Emissions and chemistry simulations for AR5

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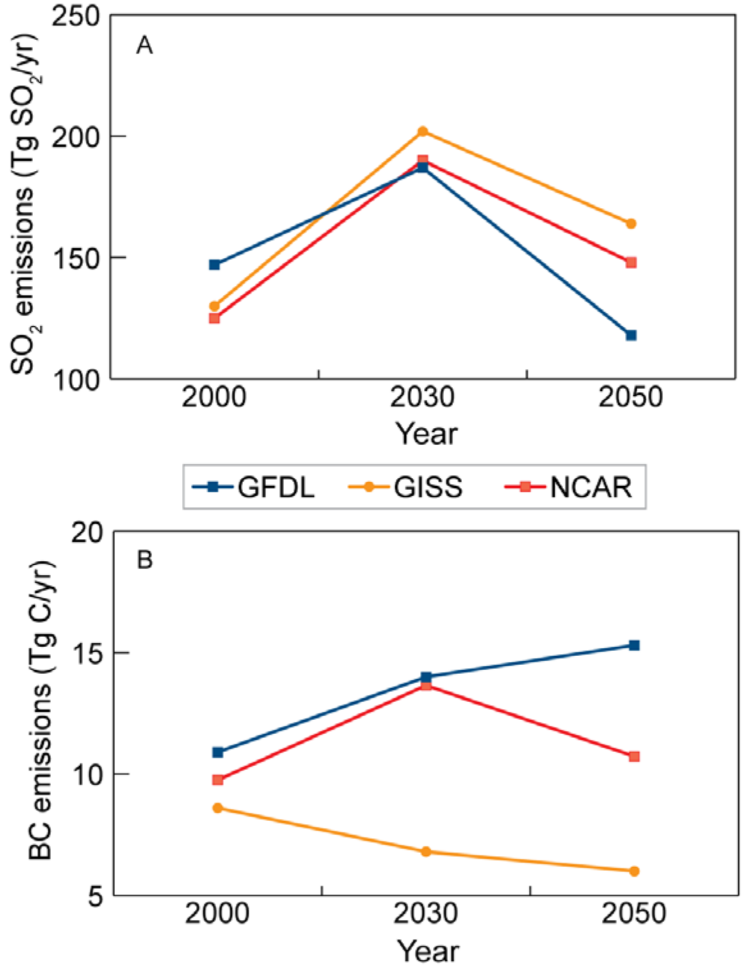
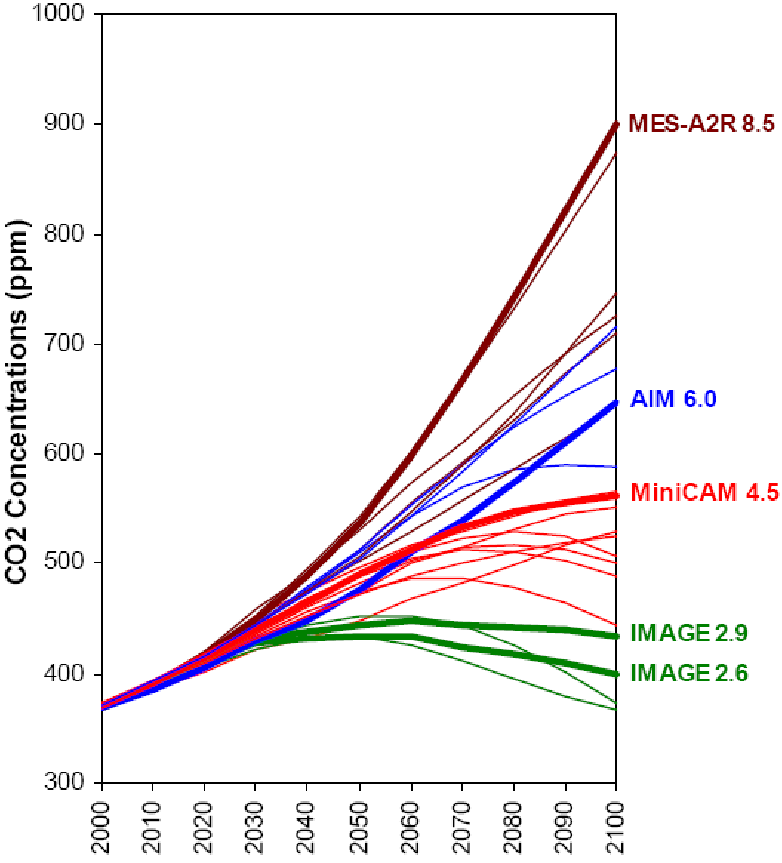
AR-4



Emissions from A1B scenario

From Shindell et al., JGR, 2008

Representative Concentration Pathways



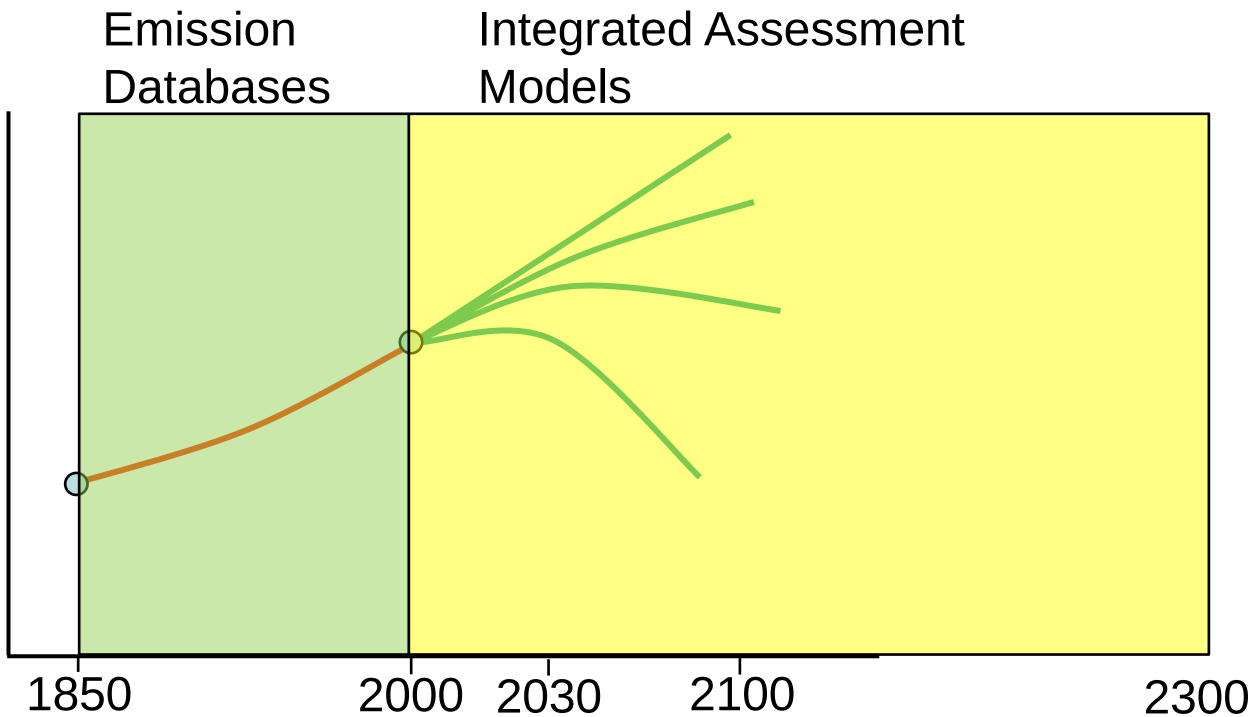
Requirements (Sept. 2007)

Variable	Units	Spatial scale	
		Concentrations	Regional and sectoral emissions
Greenhouse gases			
CO_2 (fossil fuel, industrial, land use change)	ppm and Pg/yr	Global average	Sum
CH_4	ppb and Tg/yr	Global average	Grid[1]
N_2O	ppb and Tg/yr	Global average	Sum
HFCs[2]	ppb and Tg/yr	Global average	Sum
PFCs[2]	ppb and Tg/yr	Global average	Sum
CFCs[2]	ppb and Tg/yr	Global average	Sum
SF_6	ppb and Tg/yr	Global average	Sum
Aerosols[2]			
Sulfur (SO_2)	Tg/yr	Generated by CM community[3]	Grid
Black Carbon (BC)	Tg/yr	Generated by CM community[3]	Grid
Organic Carbon (OC)	Tg/yr	Generated by CM community[3]	Grid
Chemically active gases			
CO	Tg/yr	Generated by CM community[3]	Grid
NO_x	Tg/yr	Generated by CM community[3]	Grid
VOCs[2]	Tg/yr	Generated by CM community[3]	Grid
NH_3	Tg/yr	Generated by CM community[3]	Grid

Grid is 0.5°

Emissions for AR5

International effort to provide decadal emissions 1850-2300, consistent across 2000, for anthropogenic (land, ship and aircraft) and biomass burning emissions of ozone precursors, aerosols and ODSs for each RCP

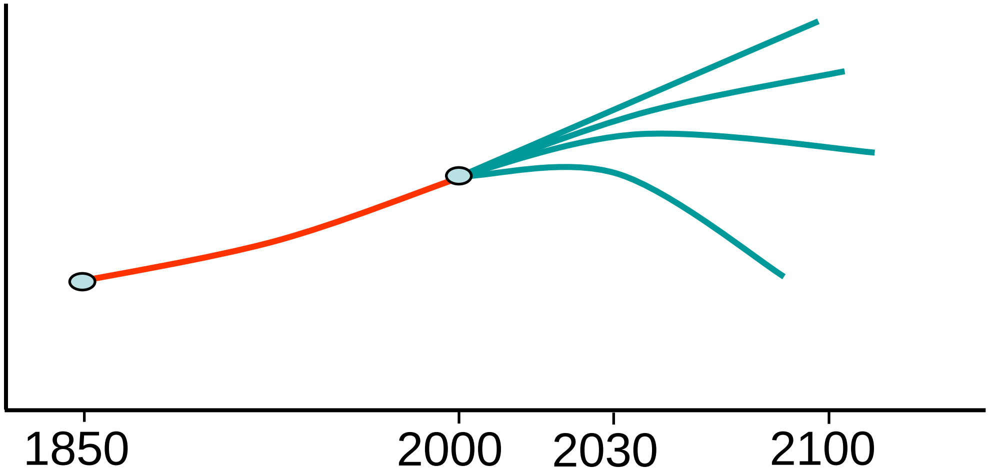


Process

- Workshop in May 2008 with representatives from global emission inventories and IAMs
- Focus on regional and sectoral analysis of existing inventories
- Use regional information where available (EPA/EMEP for example), global inventories otherwise
- Make emissions useful for variety of chemistry modeling efforts

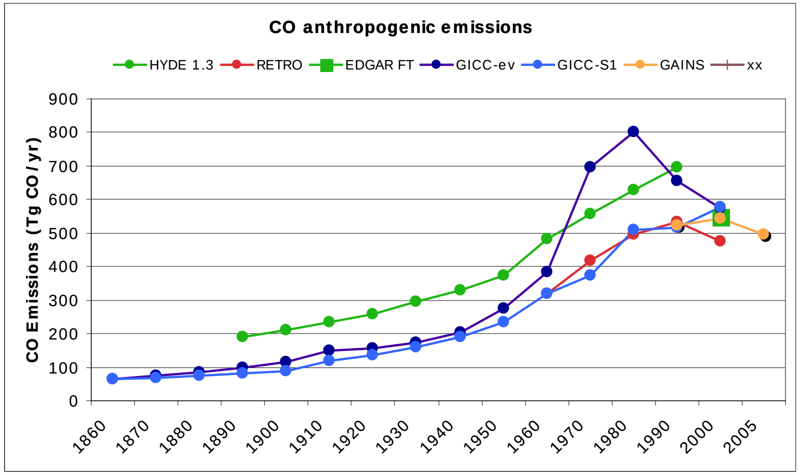
Anchor point in 2000

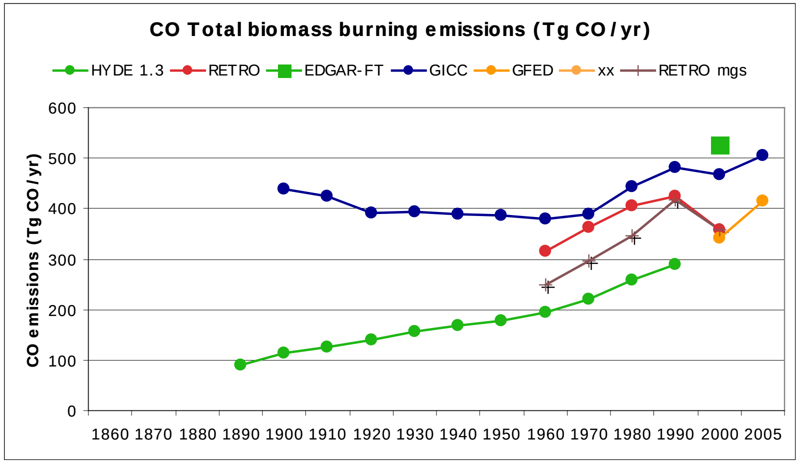
- Harmonization
  - ➢10 sectors
  - ➢40 regions

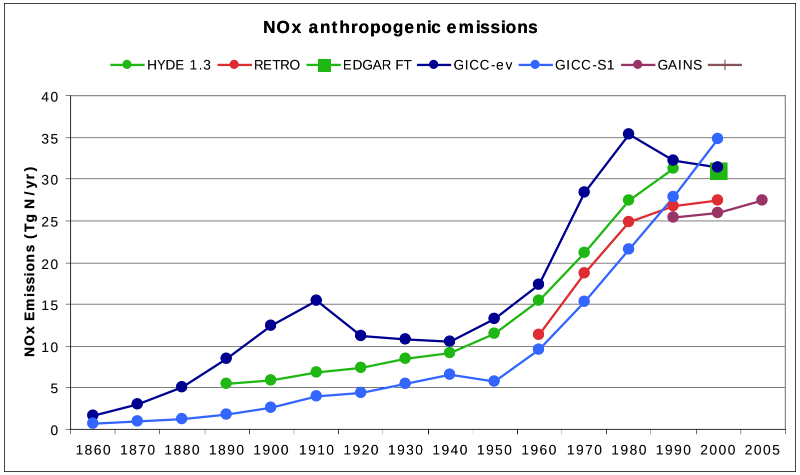


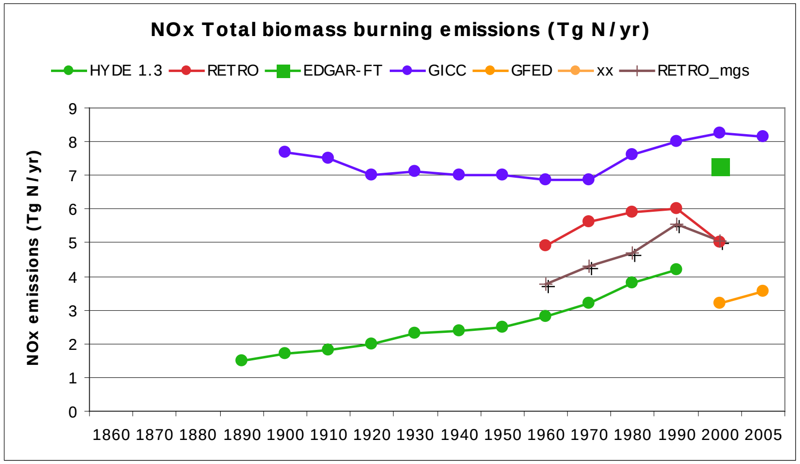
- Best estimate for 2000: combination of global and regional datasets
- Biomass burning: 1997-2006 Average from GFED

How sure are we about past trends in emissions?









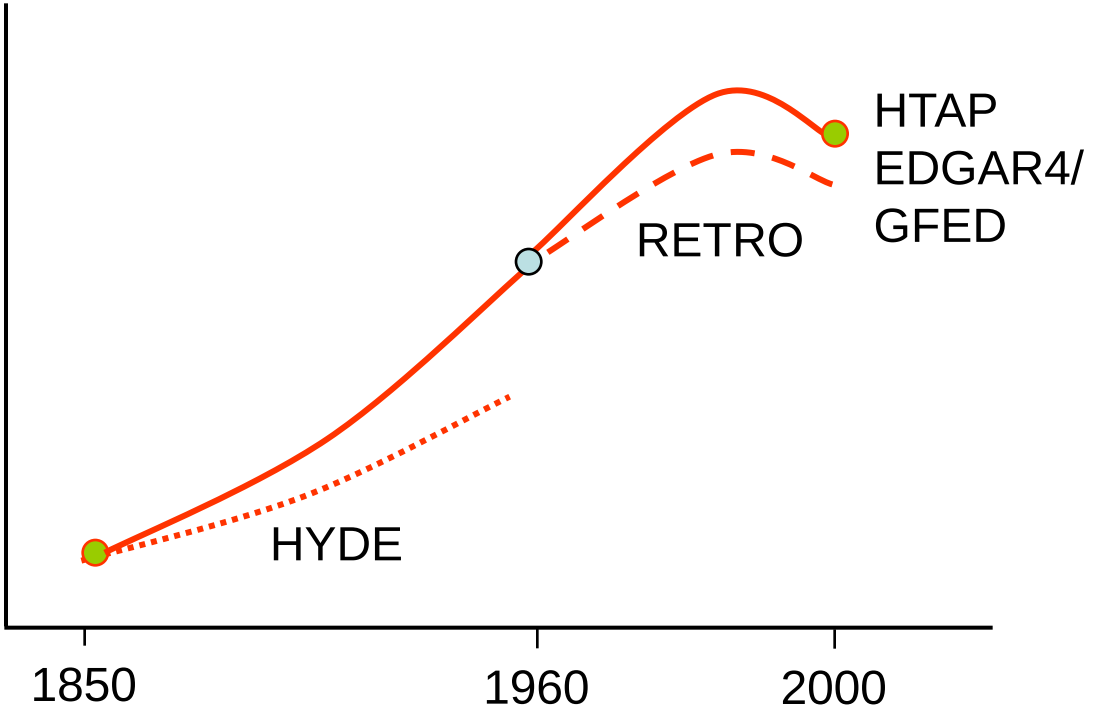
Method Summary

1) year 2000 handshake

Sector	Species									
	NOx	N2O	CO	NMVOC	SO2	BC	OC	NH3	CH4	CO2
ENE	HTAP	EDGAR4	HTAP	HTAP	Smith	B/L	B/L	---	HTAP	EDGAR4
IND	HTAP	EDGAR4	HTAP	HTAP	Smith	B/L	B/L	---	HTAP	EDGAR4
TRA	HTAP	EDGAR4	HTAP	HTAP	Smith	B/L	B/L	EDGAR4	HTAP	EDGAR4
DOM	HTAP	EDGAR4	HTAP	HTAP	Smith	B/L	B/L	---	HTAP	EDGAR4
SLV	HTAP	EDGAR4	HTAP	HTAP	---	---	---	---	HTAP	EDGAR4
AGR	HTAP	EDGAR4	HTAP	HTAP	---	B/L	B/L	EDGAR4	HTAP	EDGAR4
AWB	HTAP	EDGAR4	HTAP	HTAP	?	B/L	B/L	EDGAR4	HTAP	EDGAR4
WST	HTAP	EDGAR4	HTAP	HTAP	?	---	---	EDGAR4	HTAP	EDGAR4
ships	Eyring	---	Eyring	Eyring	Eyring	Eyring	Eyring	---	Eyring	Eyring
aviation	Lee	---	---	---	---	Lee	---	---	---	Lee
FOR	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED
WOD	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED
GRA	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED	GFED
plants	MEGAN?		MEGAN?	MEGAN?	---					
soils					---					
ocean					---					
wetlands										
volcanoes										

B/L = Bond / Liousse

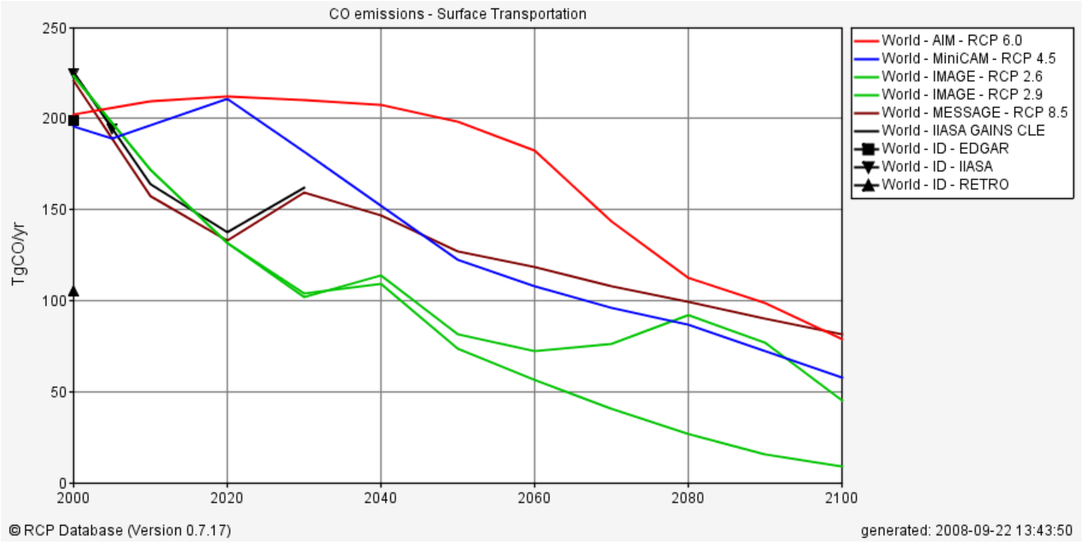
Proposed Methodology



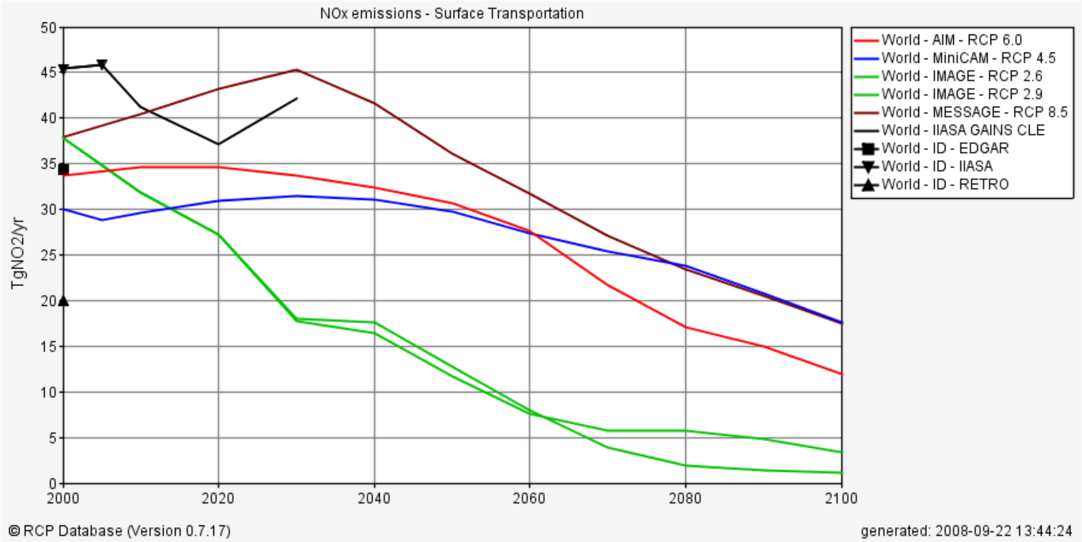
No inventory is perfect!

Preliminary Scenario Results: Transportation sector

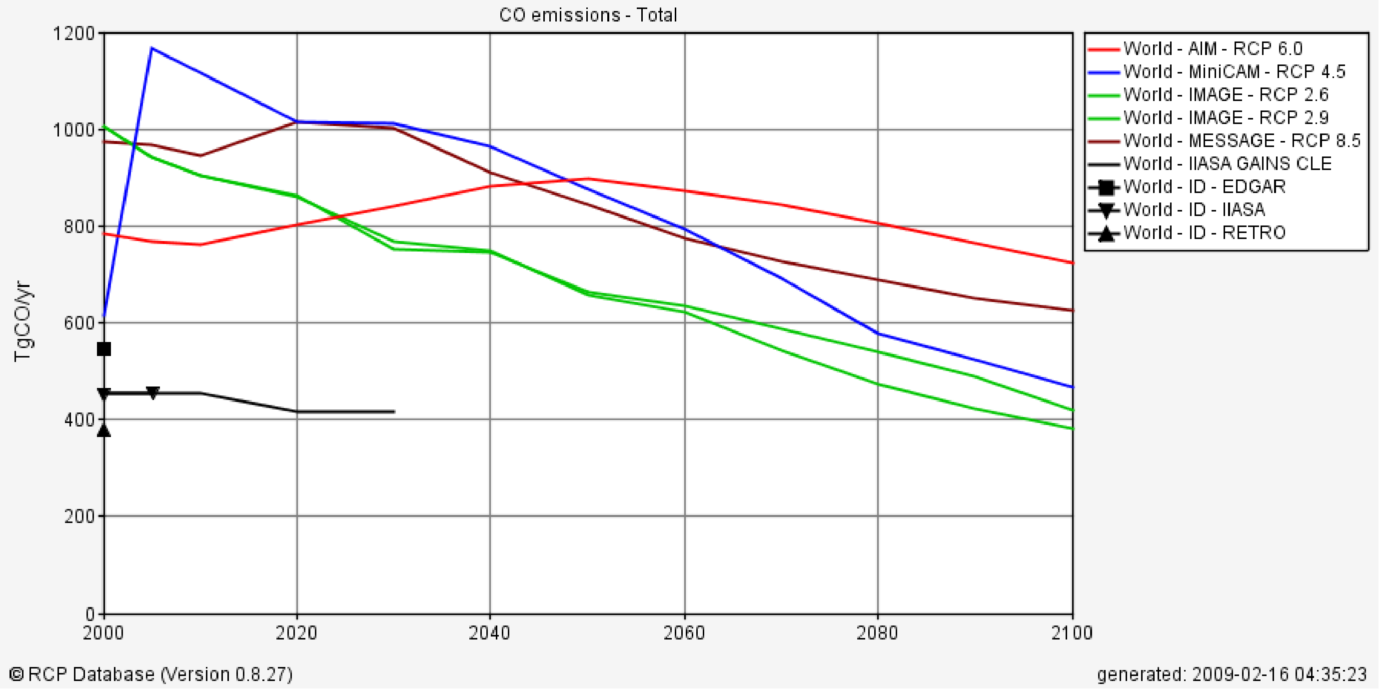
CO



NO_x



Emissions from RCPs



Status and schedule

- 2000 and 1850 emissions are available (only OC/BC AWB 1850 missing)
- 1850-2000 shipping, aircraft and biomass burning already available
- All other time periods in spring 09

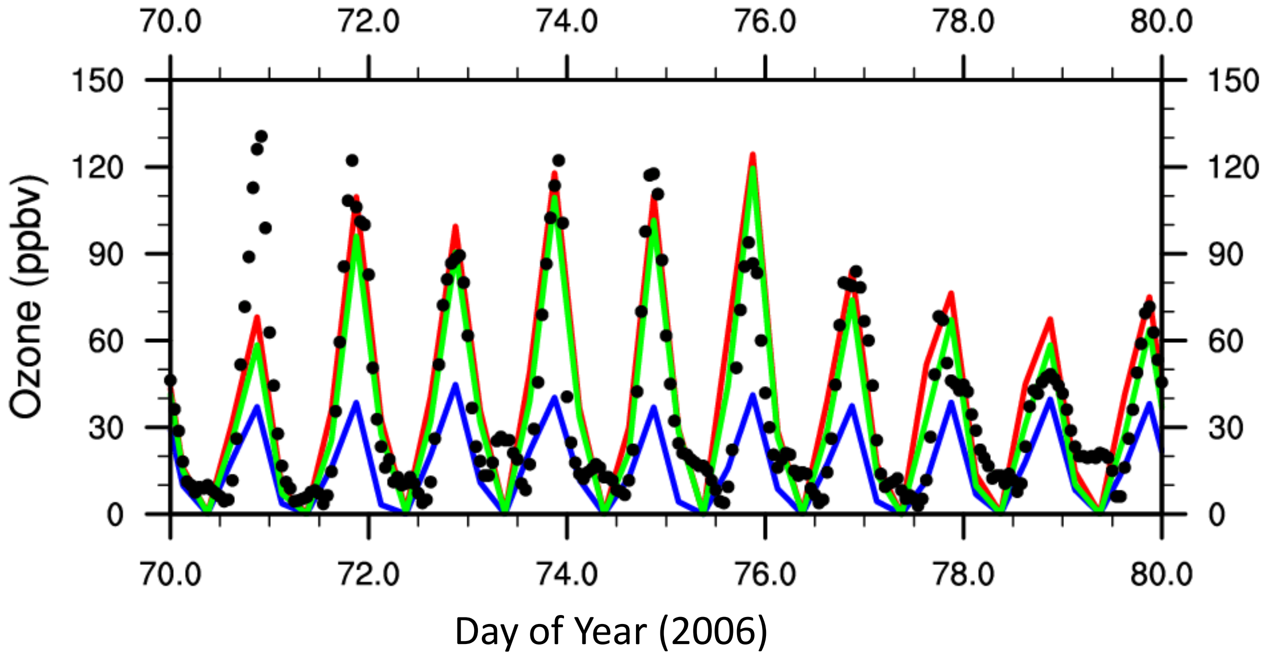
  Parallel tracks: 1850-2000
2000-2300

- Additional emissions from RCPs: summer 09 and beyond

Interactive chemistry simulations in AR5

- Long-term simulations: super-fast chemistry with LINOZ/PSC parameterization in stratosphere (see Philip’s talk):3+ ensemble members?
- Decadal projection: reduced NMHC

Air quality: Comparison with Mexico City surface observations



Red: Full mechanism
Green: Intermediate mechanism
Blue: Fast mechanism
Dots: observations

On most days, full and intermediate capture well the diurnal cycle and amplitude; the fast mechanism is much lower

Interactive chemistry simulations in AR5

- Long-term simulations: super-fast chemistry with LINOZ/PSC parameterization in stratosphere (see Philip's talk):3+ ensemble members?
- Decadal projection: reduced NMHC

Will start testing both options in Track 5 setup in the next few weeks

Plans for AR5 (historical and long-term simulations)

- Stratospheric ozone
  1. From reconstruction (SPARC activity)
  2. From online simulations (fast mechanism)
  3. From offline CAM simulations (reduced mechanism + strat)
- Tropospheric ozone
  1. From online simulations (fast mechanism)
  2. From offline CAM simulations (reduced mechanism + strat)
- Other gases (incl. methane)
  1. From online simulations (fast mechanism)
  2. From offline CAM simulations (reduced mechanism + strat)
  3. From observations/IAMs (surface concentrations)

Plans for AR5 (decadal prediction)

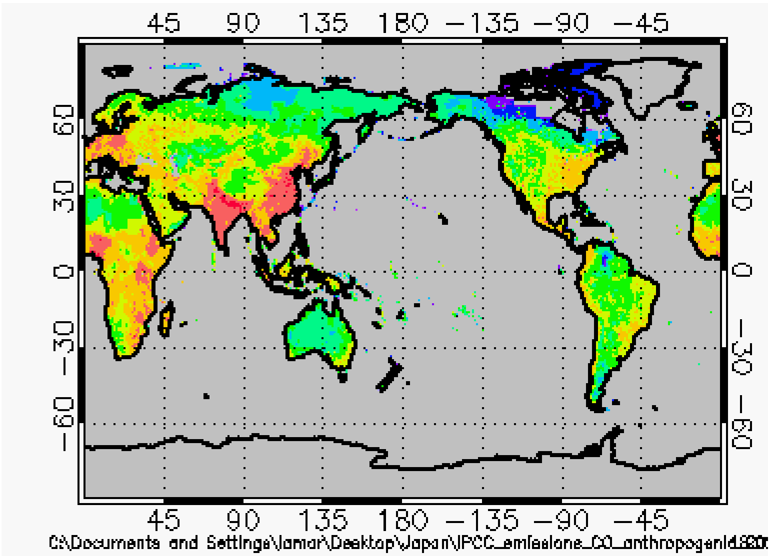
- Stratospheric ozone
  1. From CCMval (SPARC activity)
  2. From offline CAM simulations (reduced mechanism + strat)
  3. From online simulations (fast mechanism)
- Tropospheric ozone
  1. From online simulations (fast mechanism, not for AQ)
  2. From online simulations (reduced mechanism)
  3. From offline CAM simulations
- Other gases (incl. methane)
  1. From online simulations (fast mechanism)
  2. From online simulations (reduced mechanism)
  3. From offline CAM simulations
  4. From IAMs

Chemistry MIP for AR5

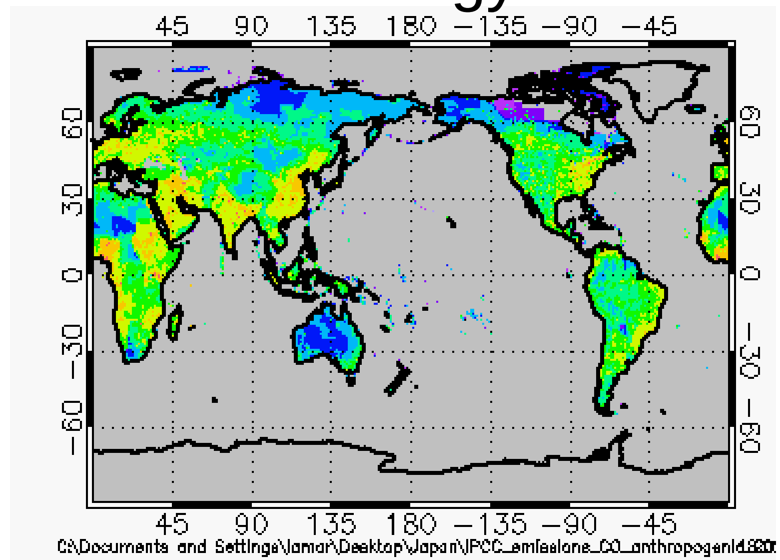
- Coordinated by D. Shindell (NASA/GISS) and myself (in contact with CCMval and AEROCOM)
- Will define science questions and necessary outputs
- Simulations scheduled to start in 09
- Define climatology (1850-2300) for AOGCMs
- Continuous (Phase 1) and time-slice experiments (Phase 2)
- Collaboration with hindcast (1960-present) intercomparison (AC&C Activity #1)

CO emissions for 2000

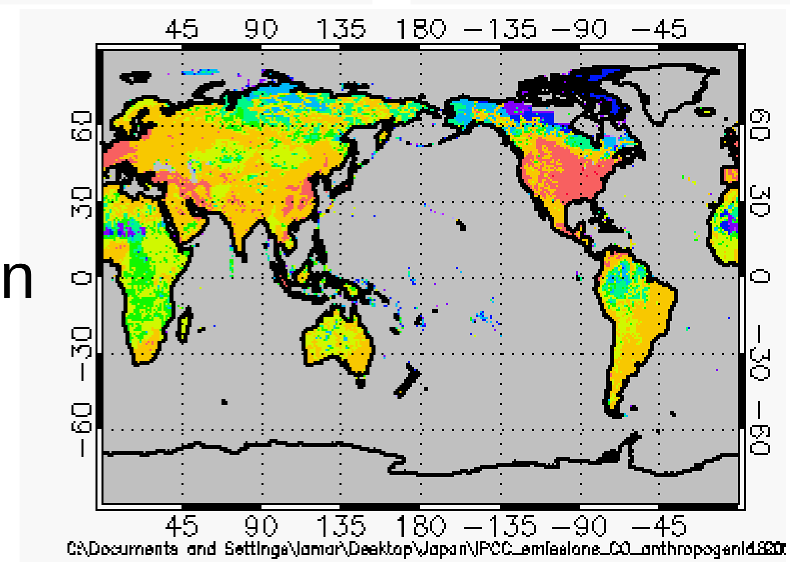
Domestic

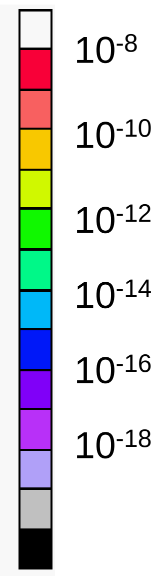


Energy



Transportation





$kg/m^2/s$

Chemistry simulations in AR5

- Emissions consistent with RCPs
- Tropospheric (and stratospheric) chemistry in offline simulations (long-term IPCC simulations)
- Tropospheric chemistry online in short-term simulations; possibly fast scheme for long-term
- Enough simulations to track tails of PDF (air quality)
- Enough simulations to identify the role of variations in emissions

Challenges

- Ensure correct trends in early 21st century emissions
- Gridding of future emissions is (mostly) linked to population scenarios
- No consistency with historical landuse
- No natural and future biomass burning emissions
- How to merge tropospheric and stratospheric ozone?
- How well are we simulating regional AQ? Who will use this information?
- No AQ focus on the development of the RCPs; can this be tackled by using emissions for each RCP from all the IAMs?
- Error estimate?

Why consider chemistry in a climate model?

1. Provides consistent distribution of radiatively-active greenhouse gases (troposphere and stratosphere)
2. Provides distribution of oxidants for aerosol production, including secondary-organic aerosols*
3. Provides distribution of constituents relevant to air quality
4. Provides interaction with biogeochemistry: black carbon deposition, nitrogen deposition, ozone damage

After the emissions are available

- Emissions will be centralized and publicly distributed
- Testing of emissions will table place in the latter part of the year to identify major issues
- Additional emission datasets will become available from IAMs to study the sensitivity of chemical composition to the trajectory used in the scenario

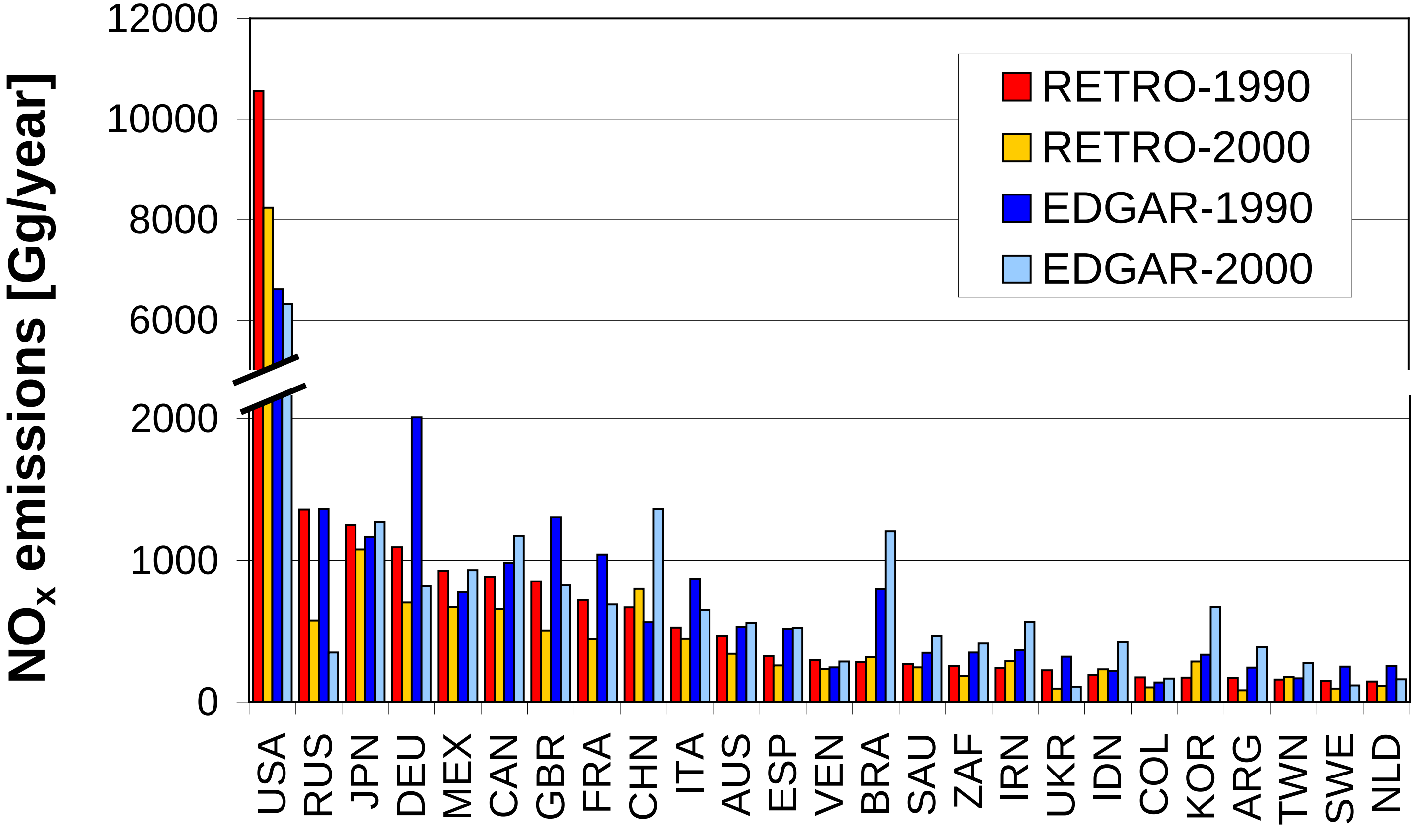
Recent development in CAM-chem:fast chemistry

- Minimal set of chemistry to reproduce mean and response to changes in emissions/climate for
  1. Ozone (methane chemistry and linearized stratospheric chemistry)
  2. Oxidants (for methane lifetime and for aerosol formation)
- Leads to a more consistent picture in main drivers of atmospheric composition and climate
- Additional cost of approx. 40%

  CAM with no chemistry = 6.7 years/day
  super-fast chemistry = 3.5 years/day

- Developed at LLNL by P. Cameron-Smith, M. Prather and collaborators

Country-level comparison of NO_x emissions from traffic



Method Summary

2) 1960-2000

Sector	**Species**									
	NOx	N2O	CO	NMVOC	SO2	BC	OC	NH3	CH4	CO2
ENE	RETRO	HYDE	RETRO	RETRO	Smith	B/L	B/L	---	HYDE	HYDE
IND	RETRO+ HYDE	HYDE	RETRO+ HYDE	RETRO+ HYDE	Smith	B/L	B/L	---	HYDE	HYDE
TRA	RETRO	HYDE	RETRO	RETRO	Smith	B/L	B/L	HYDE	HYDE	HYDE
DOM	RETRO	HYDE	RETRO	RETRO	Smith	B/L	B/L	---	HYDE	HYDE
SLV	HYDE	HYDE	HYDE	HYDE	---	---	---	---	HYDE	HYDE
AGR	HYDE	HYDE	HYDE	HYDE	---	B/L	B/L	HYDE	HYDE	HYDE
AWB	HYDE	HYDE	HYDE	HYDE	---	B/L	B/L	HYDE	HYDE	HYDE
WST	HYDE	HYDE	HYDE	HYDE	---	---	---	HYDE	HYDE	HYDE
ships										
aviation										
FOR	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO
WOD	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO
GRA	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO	RETRO
plants	MEGAN?		MEGAN?	MEGAN?	---					
soils					---					
ocean										
wetlands					---					
volcanoes										

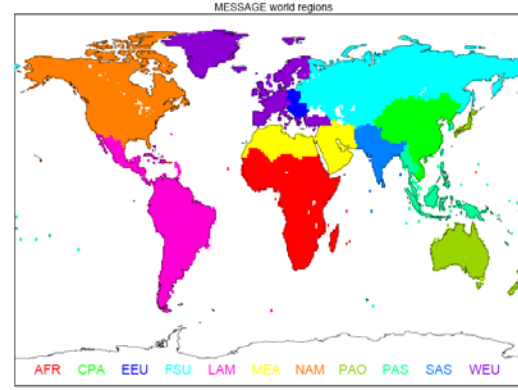
EDGAR4 goes back to 1970

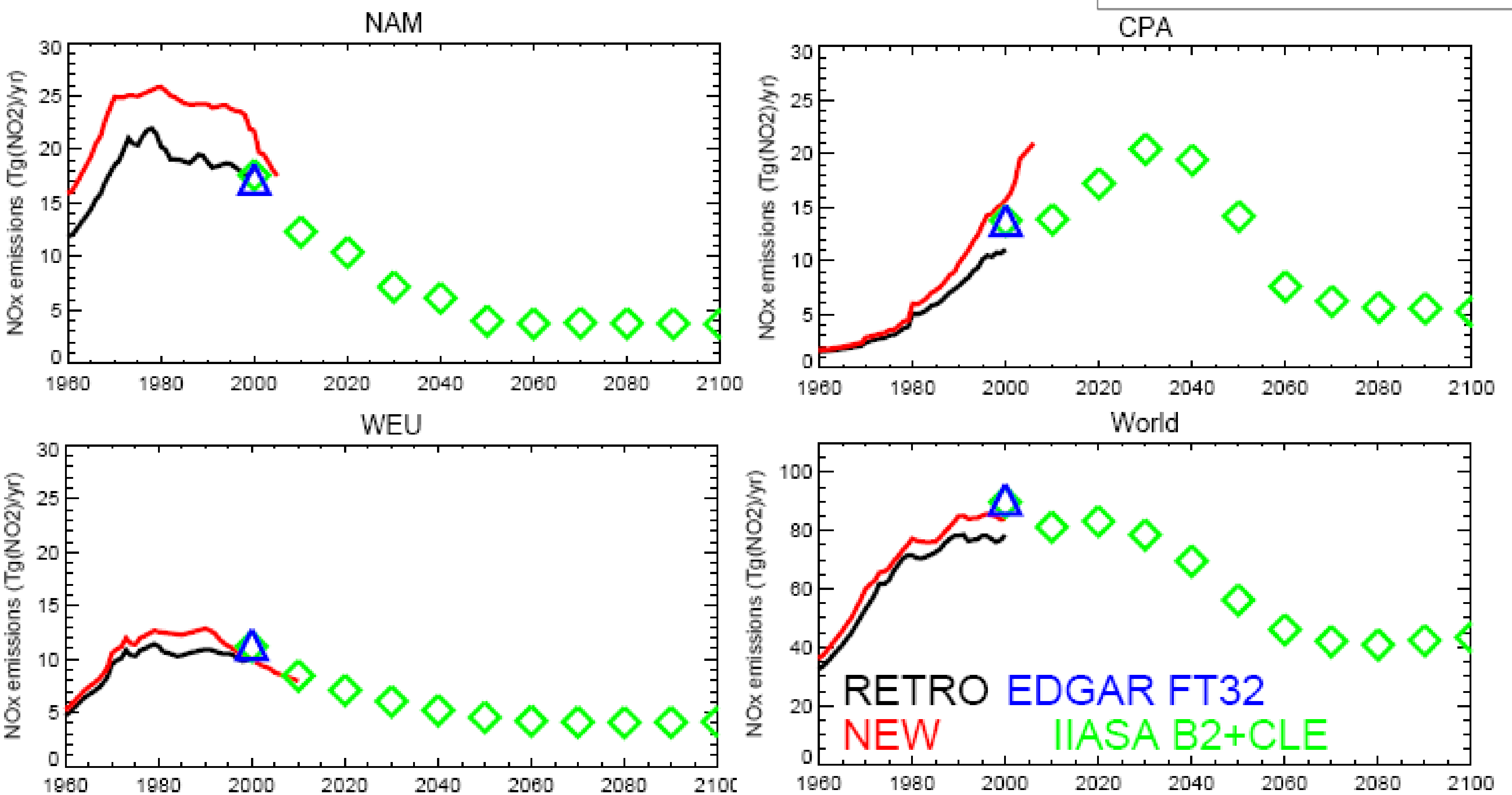
Method Summary

3) 1850-1960

Sector	Species									
	NOx	N2O	CO	NMVOC	SO2	BC	OC	NH3	CH4	CO2
ENE	HYDE	HYDE	HYDE	HYDE	Smith	B/L	B/L	HYDE	HYDE	HYDE
IND	HYDE	HYDE	HYDE	HYDE	Smith	B/L	B/L	HYDE	HYDE	HYDE
TRA	HYDE	HYDE	HYDE	HYDE	Smith	B/L	B/L	HYDE	HYDE	HYDE
DOM	HYDE	HYDE	HYDE	HYDE	Smith	B/L	B/L	HYDE	HYDE	HYDE
SLV	HYDE	HYDE	HYDE	HYDE	---	---	---	HYDE	HYDE	HYDE
AGR	HYDE	HYDE	HYDE	HYDE	---	B/L	B/L	HYDE	HYDE	HYDE
AWB	HYDE	HYDE	HYDE	HYDE	---	B/L	B/L	HYDE	HYDE	HYDE
WST	HYDE	HYDE	HYDE	HYDE	---	---	---	HYDE	HYDE	HYDE
ships										
aviation										
FOR	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**
WOD	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**
GRA	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**	**GICC**
plants										
soils										
ocean										
wetlands										
volcanoes										

Regional/World NOx 1960-2100





From D. Stevenson

Simulations in AR5

- Stratospheric ozone
    1. From CCMval (SPARC activity)
    2. From atmosphere-only model simulations (reduced mechanism + strat.)
    3. From online chemistry climate simulations (linearized ozone chemistry)
- Air quality
    1. From online chemistry climate simulations (reduced mechanism)
- Tropospheric ozone
    1. From atmosphere-only simulations (reduced mechanism)
    2. From online chemistry climate simulations (fast/reduced mechanism)
- Other gases (incl. methane)
    1. From atmosphere-only simulations (reduced mechanism)
    2. From online chemistry climate simulations (fast/reduced mechanism)
    3. From observations/IAMs

Long-term simulations

Decadal prediction simulations