Chemistry for decadal predictions

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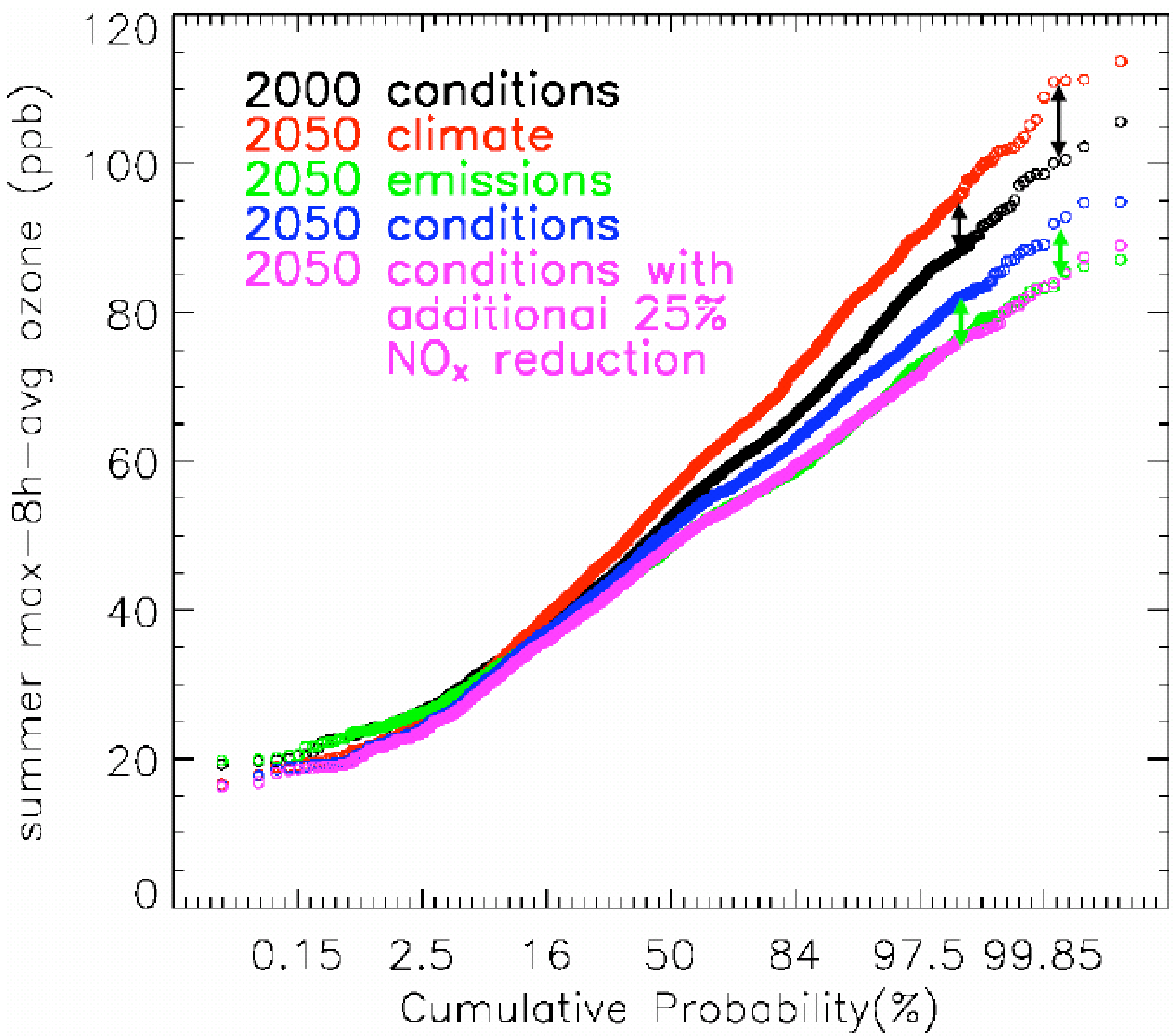
Importance of chemistry

- Climate forcing
  - Direct radiative forcing: ozone and methane
  - Aerosol indirect effects
- Air quality
  - Ozone and carbon monoxide
  - PM1, PM2.5
- Impact on vegetation
  - Ozone poisoning
  - Nitrogen deposition

Impact of climate on chemistry

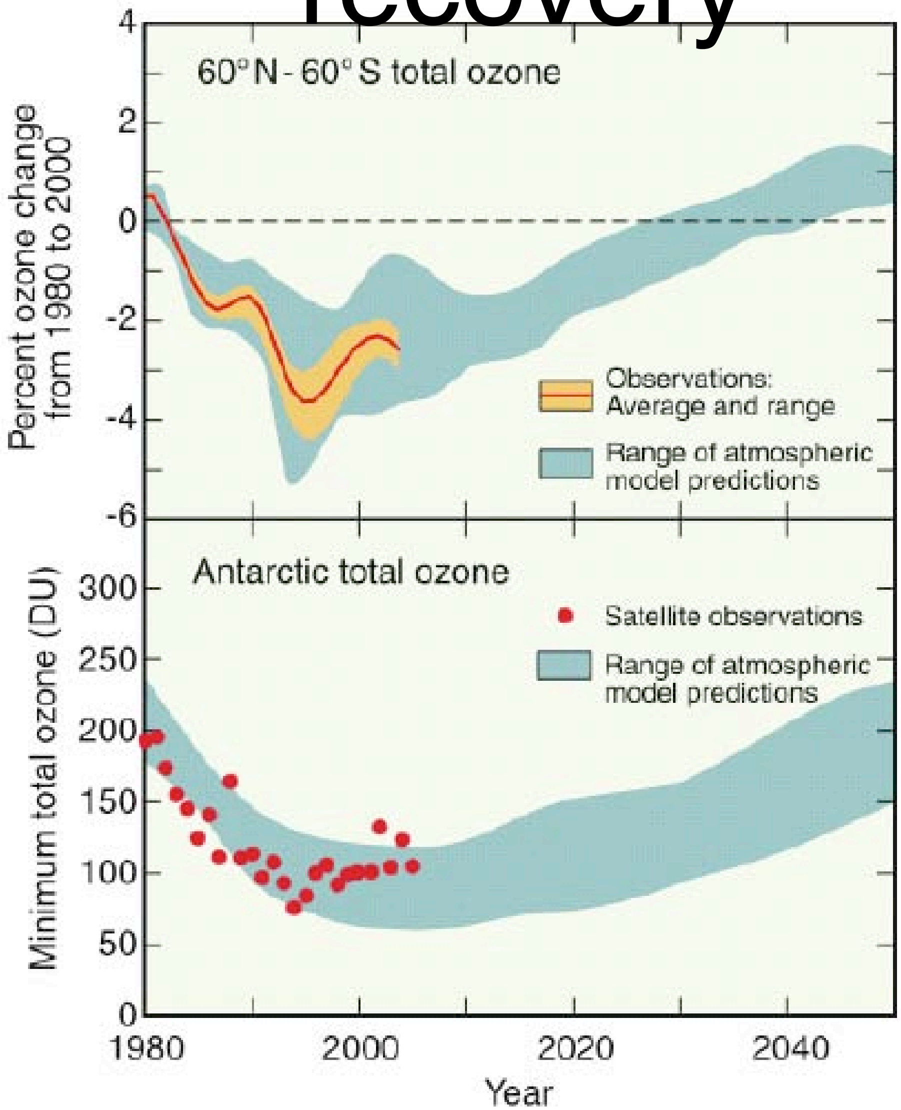
- Change in water vapor: link with OH
- Change in temperature: different reaction rates
- Change in surface temperature: biogenic emissions
- Change in precipitation: lifetime of soluble species
- Change in stratospheric circulation: STE
- Change in meteorological conditions: heat waves
- ….

Summer surface ozone



From Wu et al., JGR, 2007

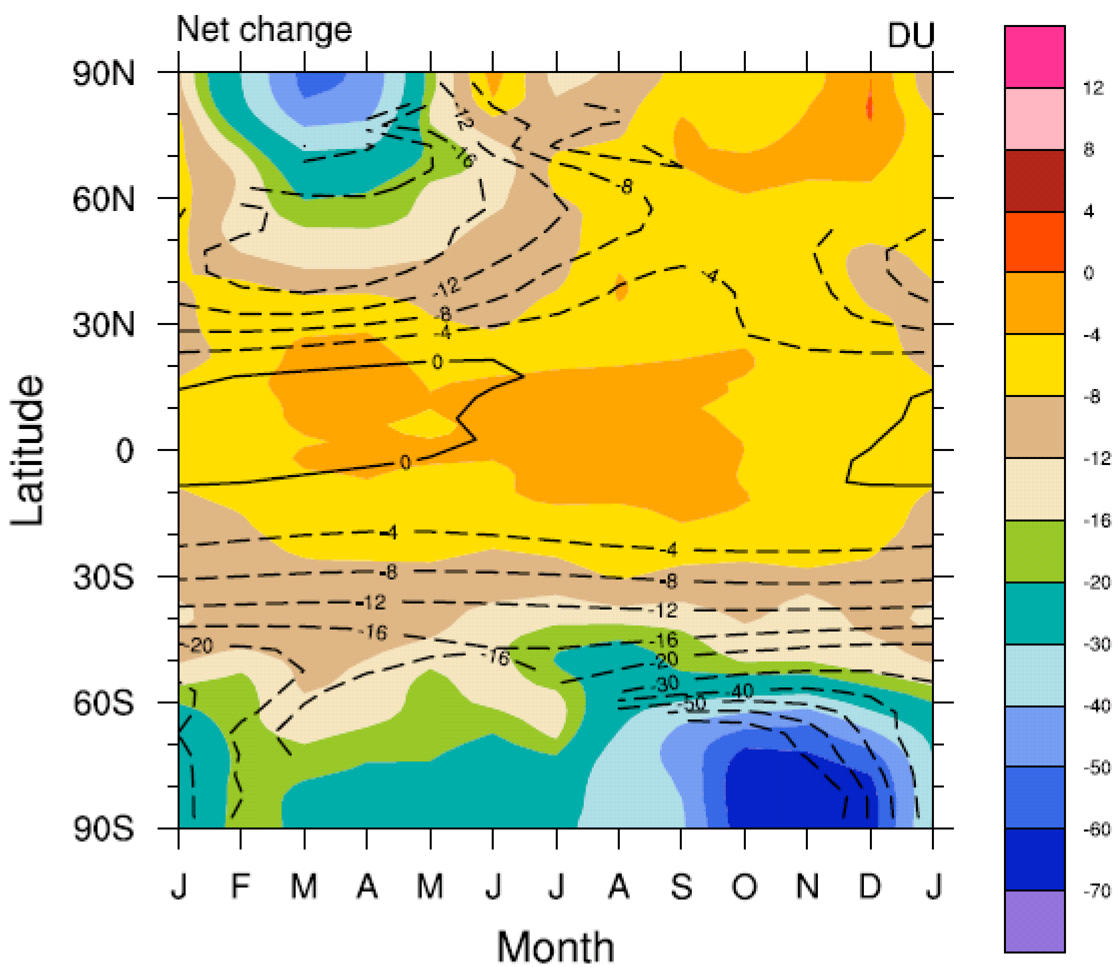
Stratospheric ozone and recovery



Fahey, 2007

Simulation with CAM3

Change in total ozone column 1979-2005



Lamarque et al., 2008

How much chemistry is needed?

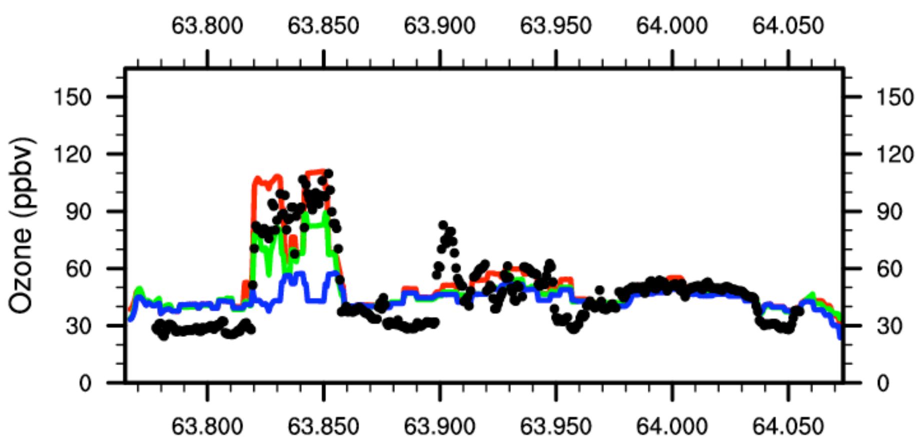
- Benchmarking for air quality questions

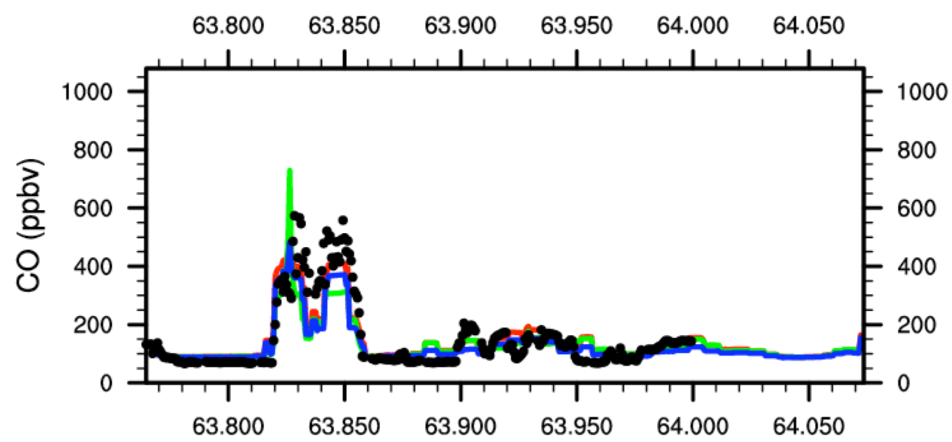
  Gas-phase tropospheric chemistry only

  - ➢Full mechanism: 79 species
  - ➢Intermediate mechanism: 39 species
  - ➢Fast mechanism: 28 species

- High-resolution simulations (0.5°) for Mexico City and comparison with observations

Air quality: Comparison with aircraft observations



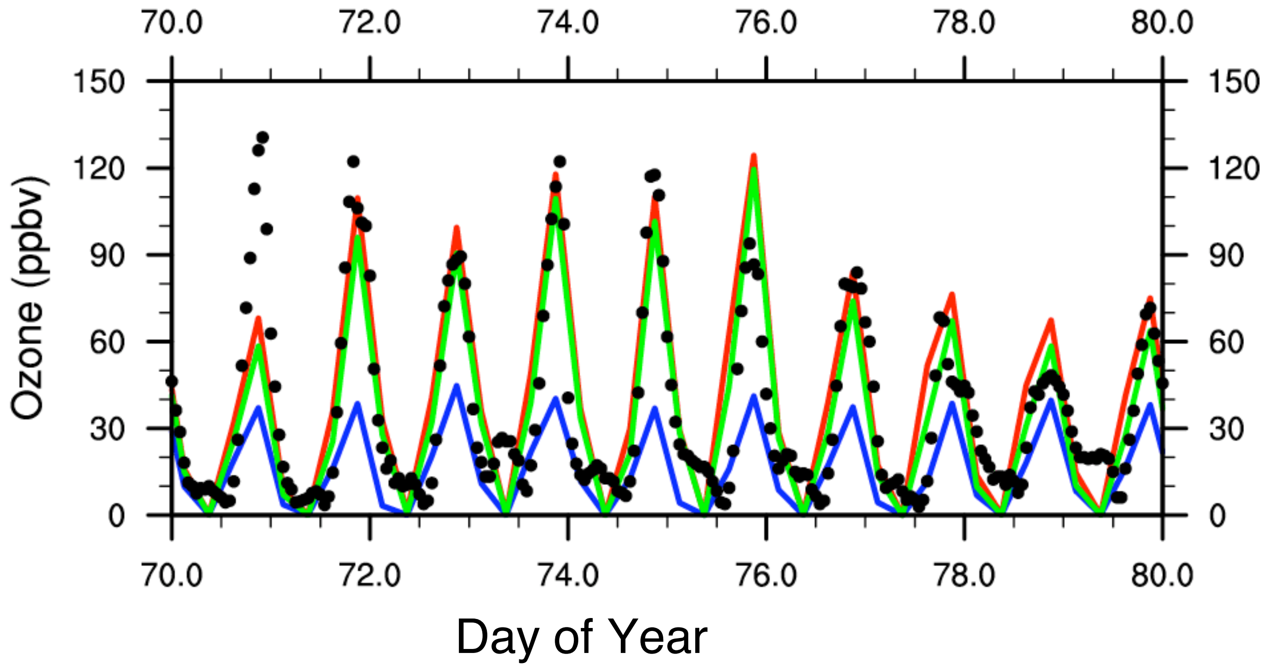


Day of Year (2006)

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

1. On most days, full and intermediate capture well the background and plume ozone; the fast mechanism captures well the background.
2. CO is will captured by all.

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

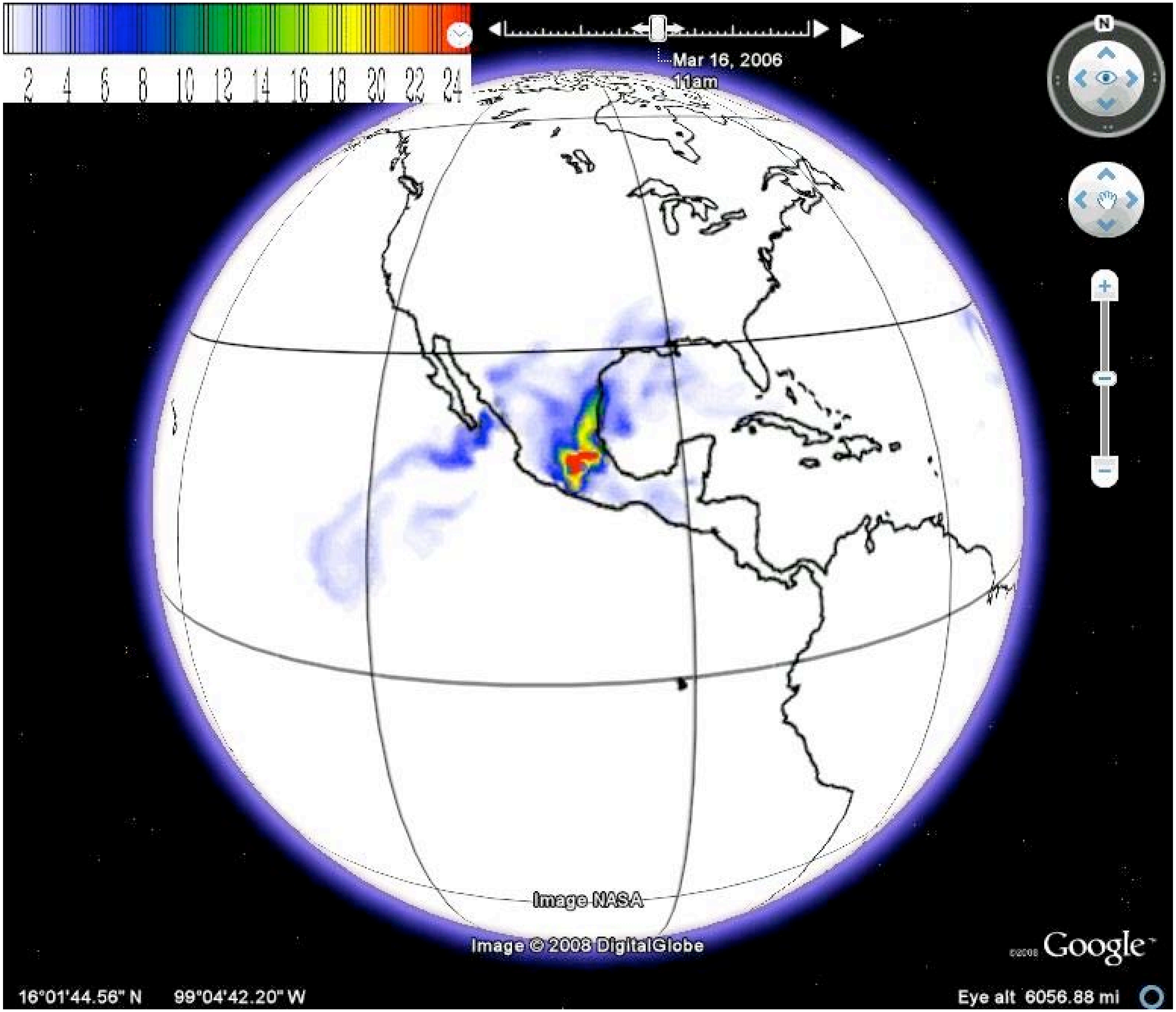

2 4 6 8 10 12 14 16 18 20 22 24
Mar 16, 2006
11am
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Image NASA
Image © 2008 DigitalGlobe
©2008 Google
16°01'44.56" N 99°04'42.20" W
Eye alt 6056.88 mi

Predictability of chemistry

- Decadal variability of tropospheric chemistry is strongly constrained by changes in emissions
- Except for
  - Change in OH
  - Occurrence of heat waves
  - Wildfires
  - Change in circulation pattern
- Challenges
  - Reasonable methane lifetime
  - Reasonable emissions

Proposal for chemistry

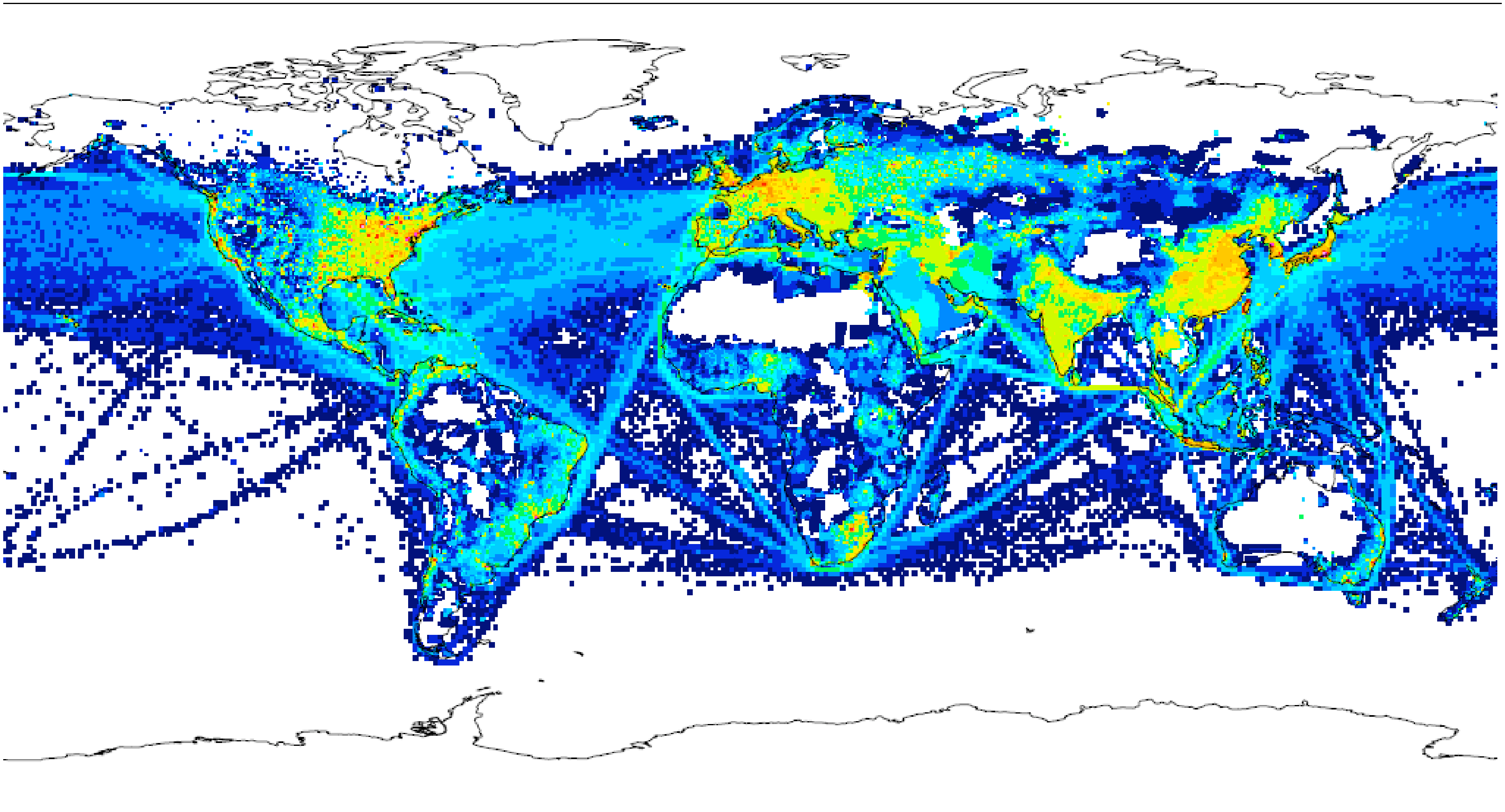
- Emissions consistent with RCPs
- Tropospheric (and stratospheric) chemistry for offline simulations (long-term IPCC simulations)
- Tropospheric chemistry for short-term simulations
- Aerosols
- Enough simulations to track tails of PDF
- Enough simulations to identify the role of variations in emissions

Requirements

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°

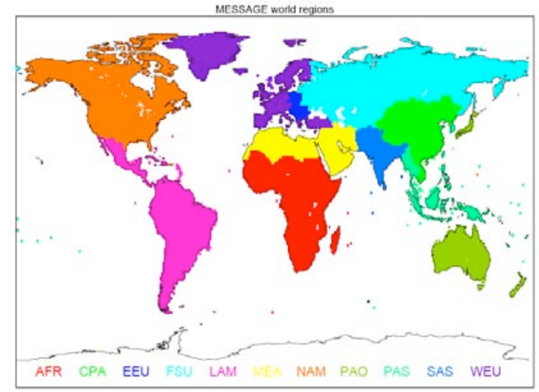
RETRO y2000 Anth NOx (Tg/yr) Total: 90.02 Tg/yr

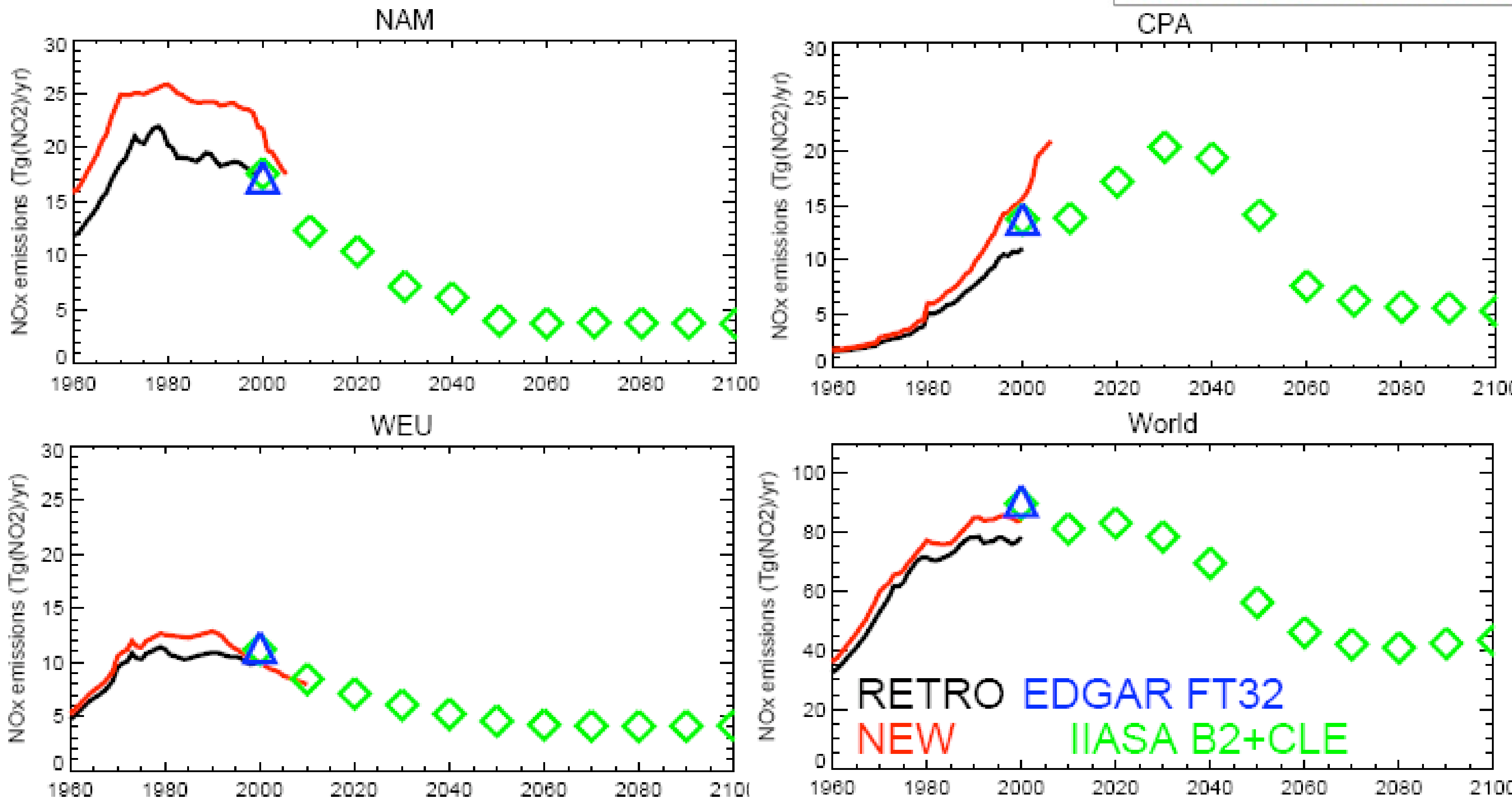


Process

- Workshop in May with representatives from global emission inventories and IAMs
- Define method (regional and sectoral analysis of existing inventories, including regional) to select (or build) inventory
- Harmonization (with past and future) emissions will be made with 2000 HTAP dataset

Regional/World NOx 1960-2100





From D. Stevenson

Expected outcome (October 2008)

- Gridded (0.5°) monthly emissions 1850-2300 (every 10 years) for anthropogenic (including ODSs, biomass burning and ships/aircraft) and natural emissions consistent with the scenarios
- VOC speciation will follow the RETRO procedure
- Much larger biomass burning emissions and black carbon emissions late 1800s-early 1900s
- Many of the natural emissions will be kept constant (not biogenic VOCs)

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

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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 for AOGCMs

  What to do about aerosols?
  Coordination with P. Ginoux (GFDL) for natural aerosols