ATMOSPHERIC CHEMISTRY:
FROM AIR POLLUTION TO GLOBAL CHANGE AND BACK

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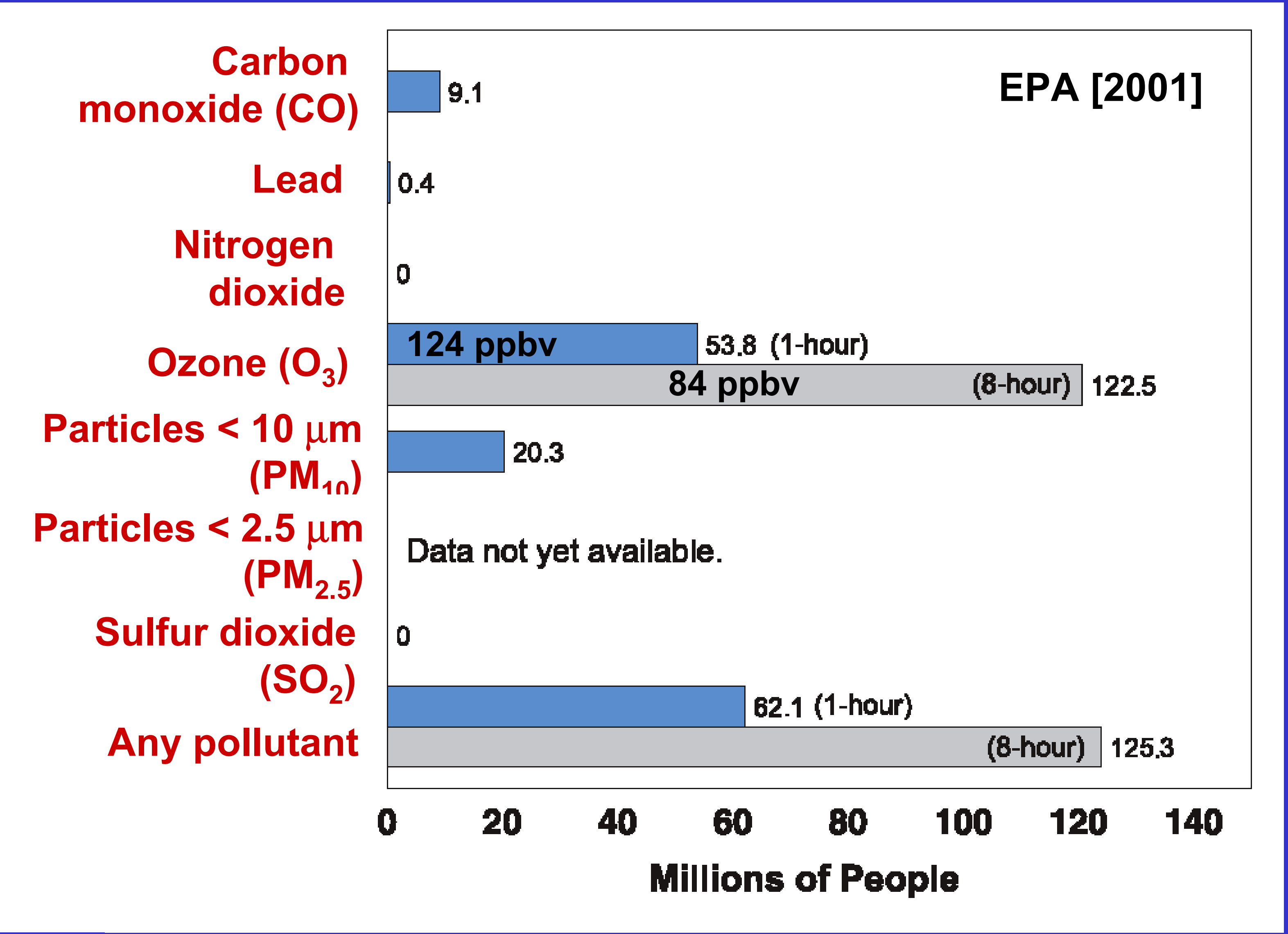
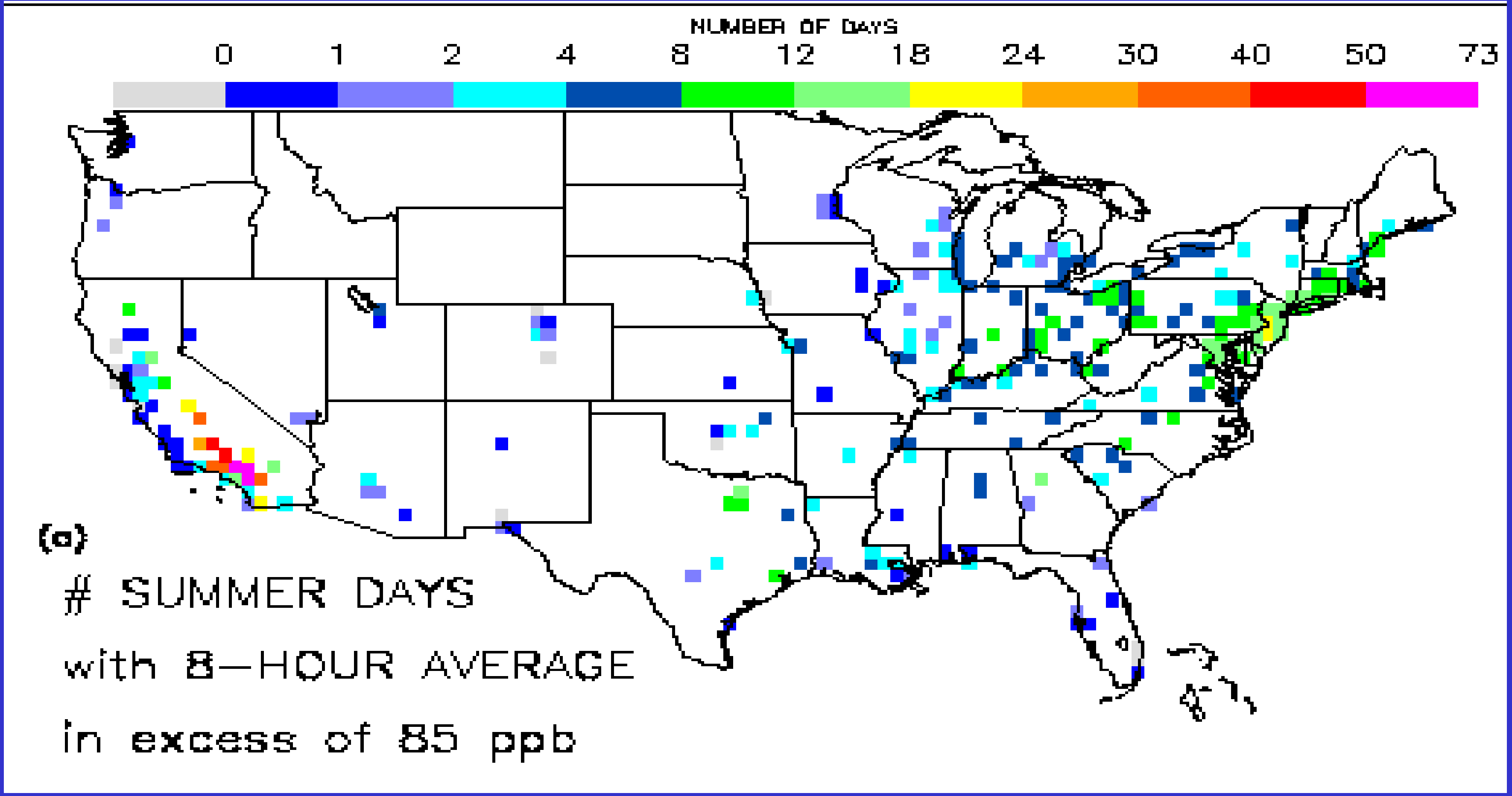
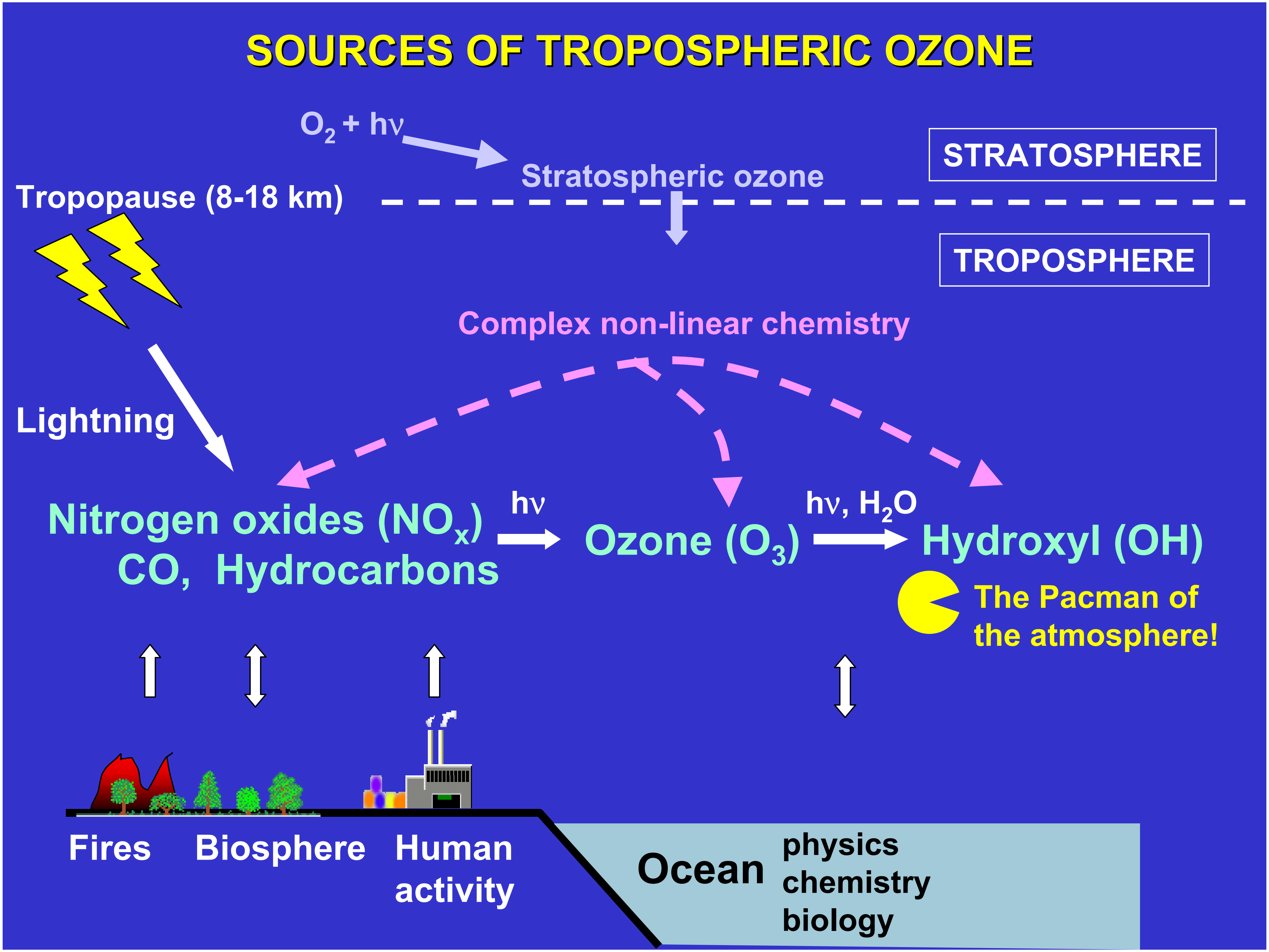
NUMBER OF PEOPLE LIVING IN U.S. COUNTIES VIOLATING NATIONAL AIR QUALITY STANDARDS, 1999



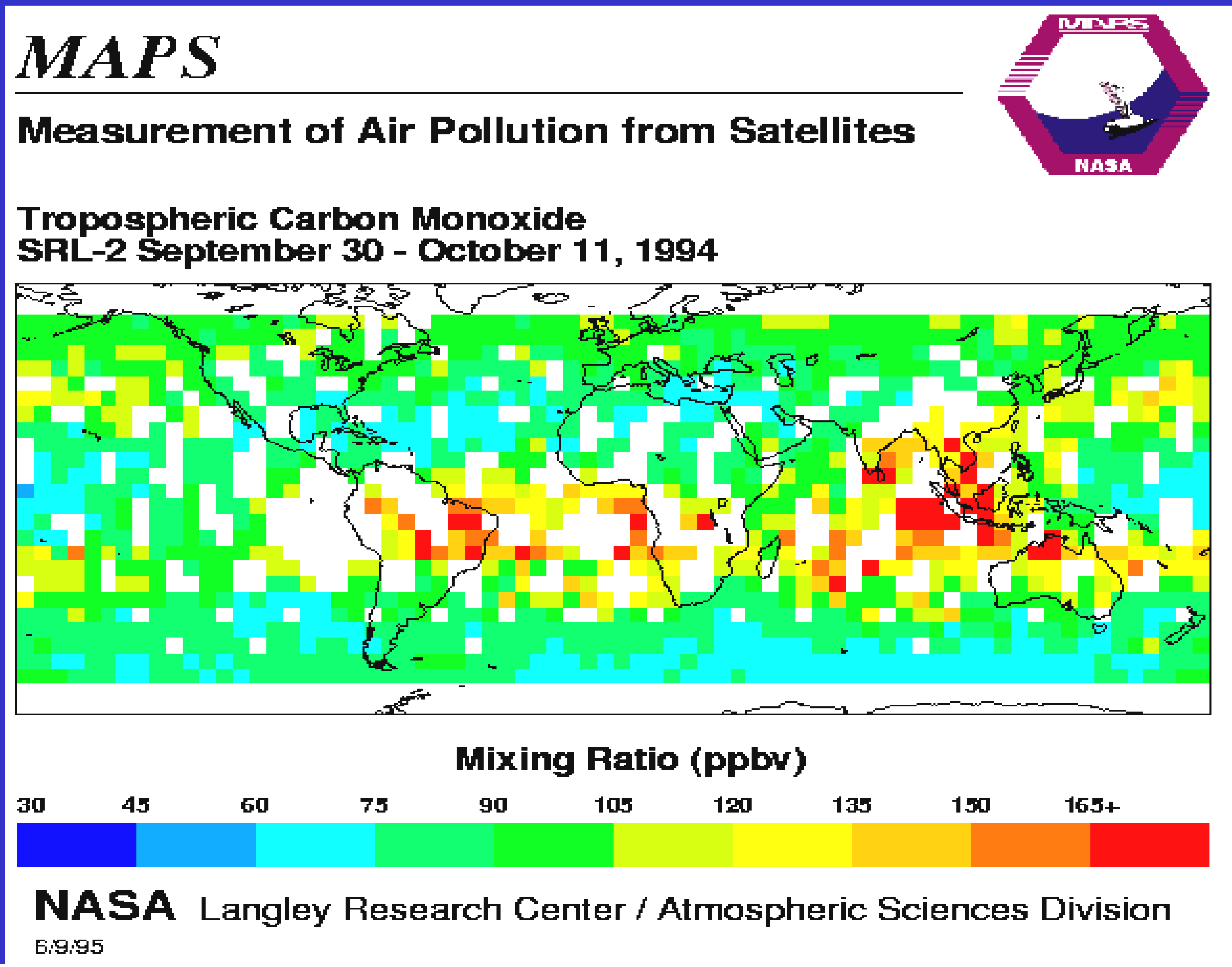
MEAN NUMBER OF SUMMER DAYS (1980-1998) EXCEEDING THE U.S. OZONE AIR QUALITY STANDARD (84 ppbv, 8-hour average)



EPA/AIRS data [Lin et al., 2001]

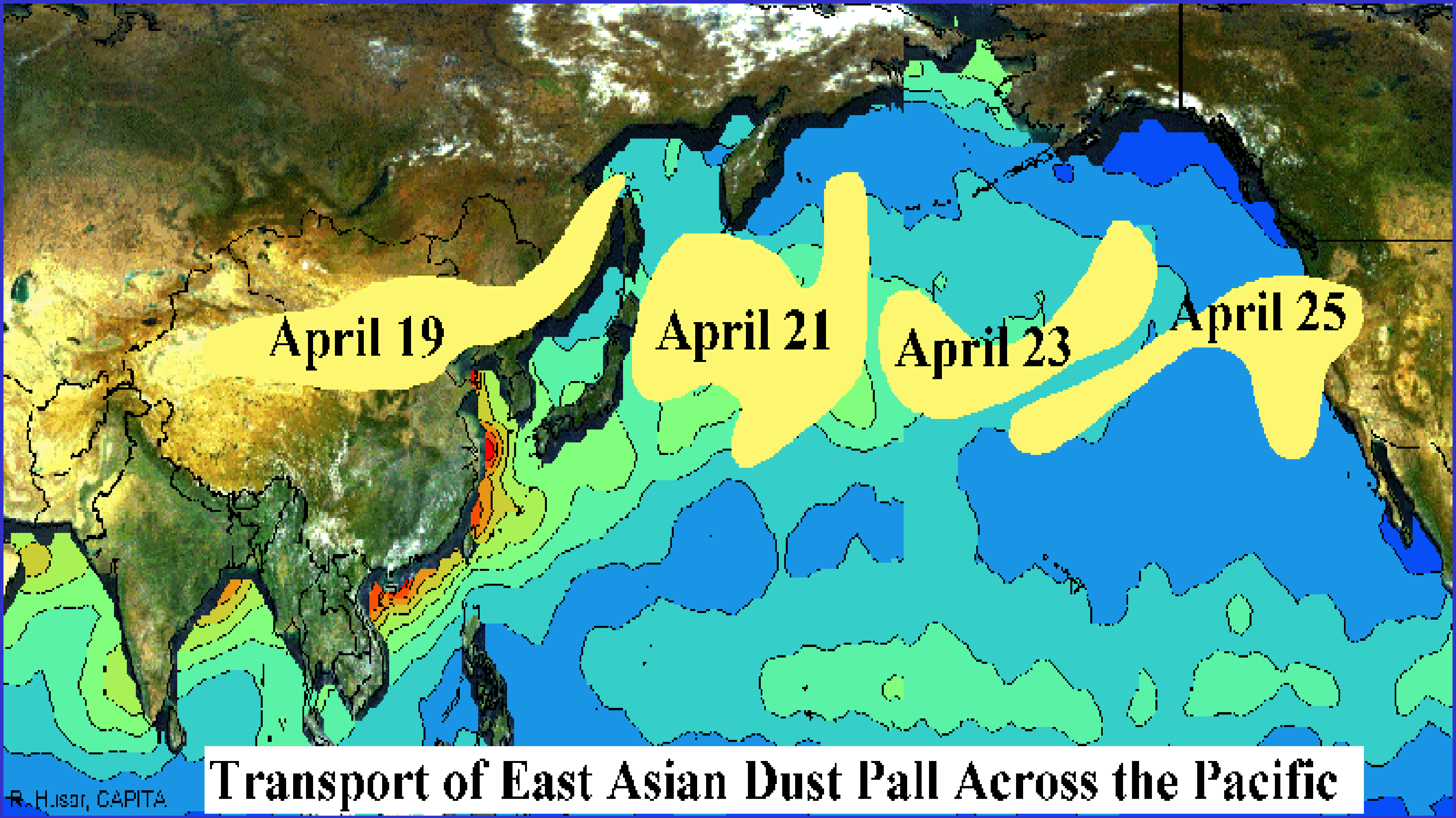

SOURCES OF TROPOSPHERIC OZONE
O_2 + hν
Stratospheric ozone
STRATOSPHERE
Tropopause (8-18 km)
TROPOSPHERE
Complex non-linear chemistry
Lightning
Nitrogen oxides (NO_x)
CO, Hydrocarbons
hν
Ozone (O_3)
hν, H_2O
Hydroxyl (OH)
The Pacman of the atmosphere!
Fires
Biosphere
Human activity
Ocean
physics
chemistry
biology

LARGE-SCALE POLLUTION IN THE TROPICS: BIOMASS BURNING



TRANSPACIFIC TRANSPORT OF ASIAN DUST

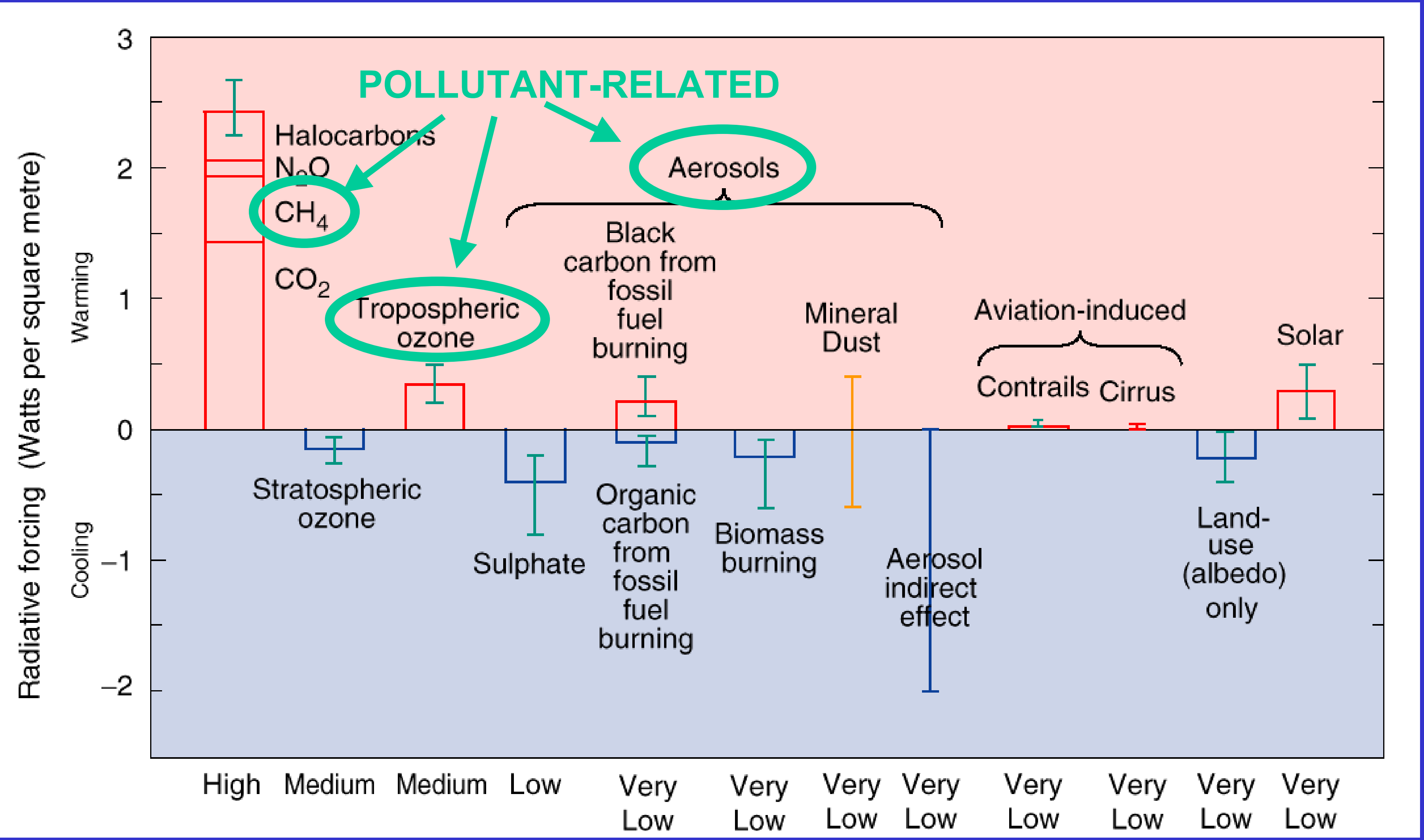
April 1998 event



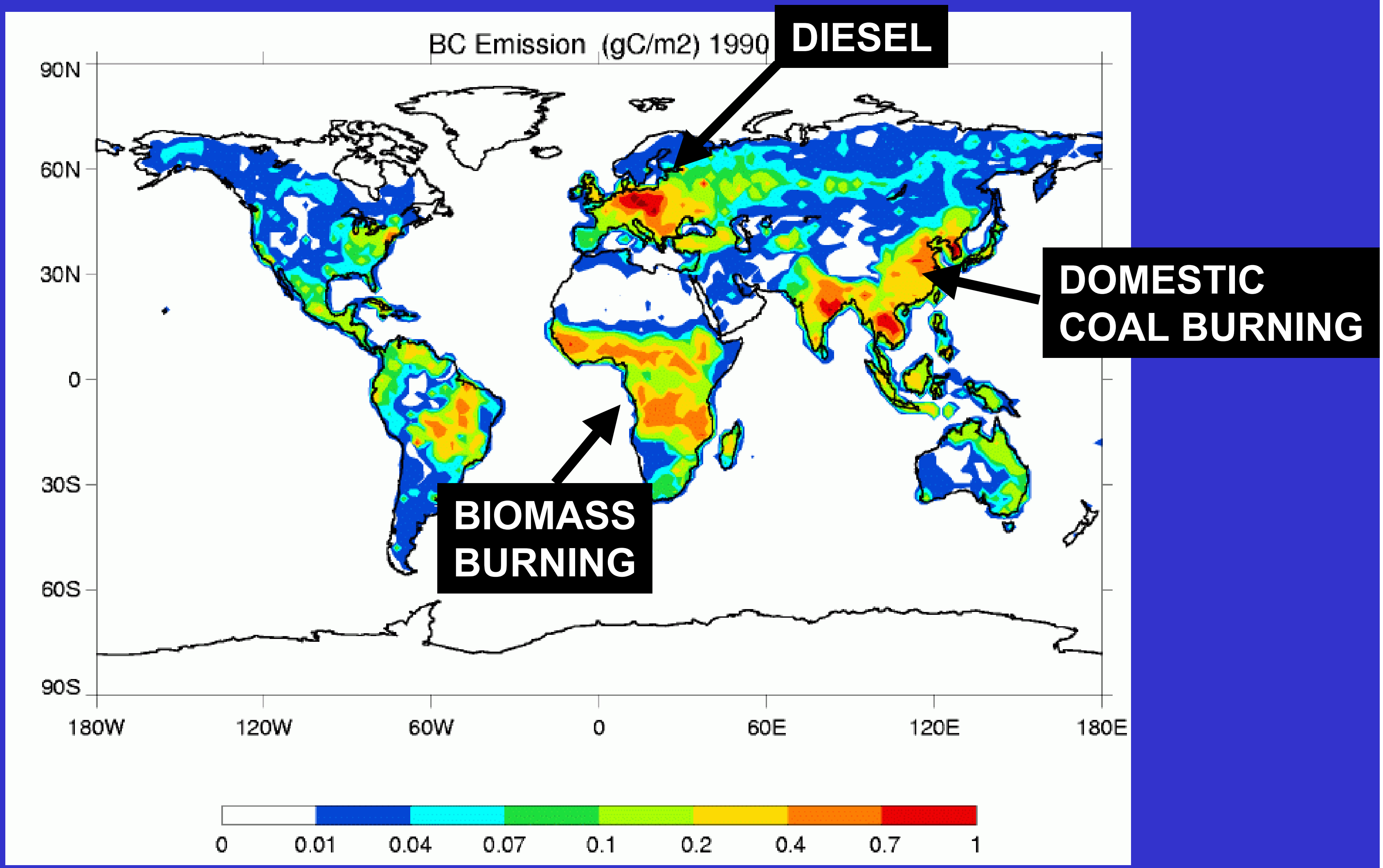
R. Husar

CLIMATE FORCING BY AIR POLLUTANTS

GLOBAL RADIATIVE FORCING OF CLIMATE, 1750-present [IPCC, 2001]



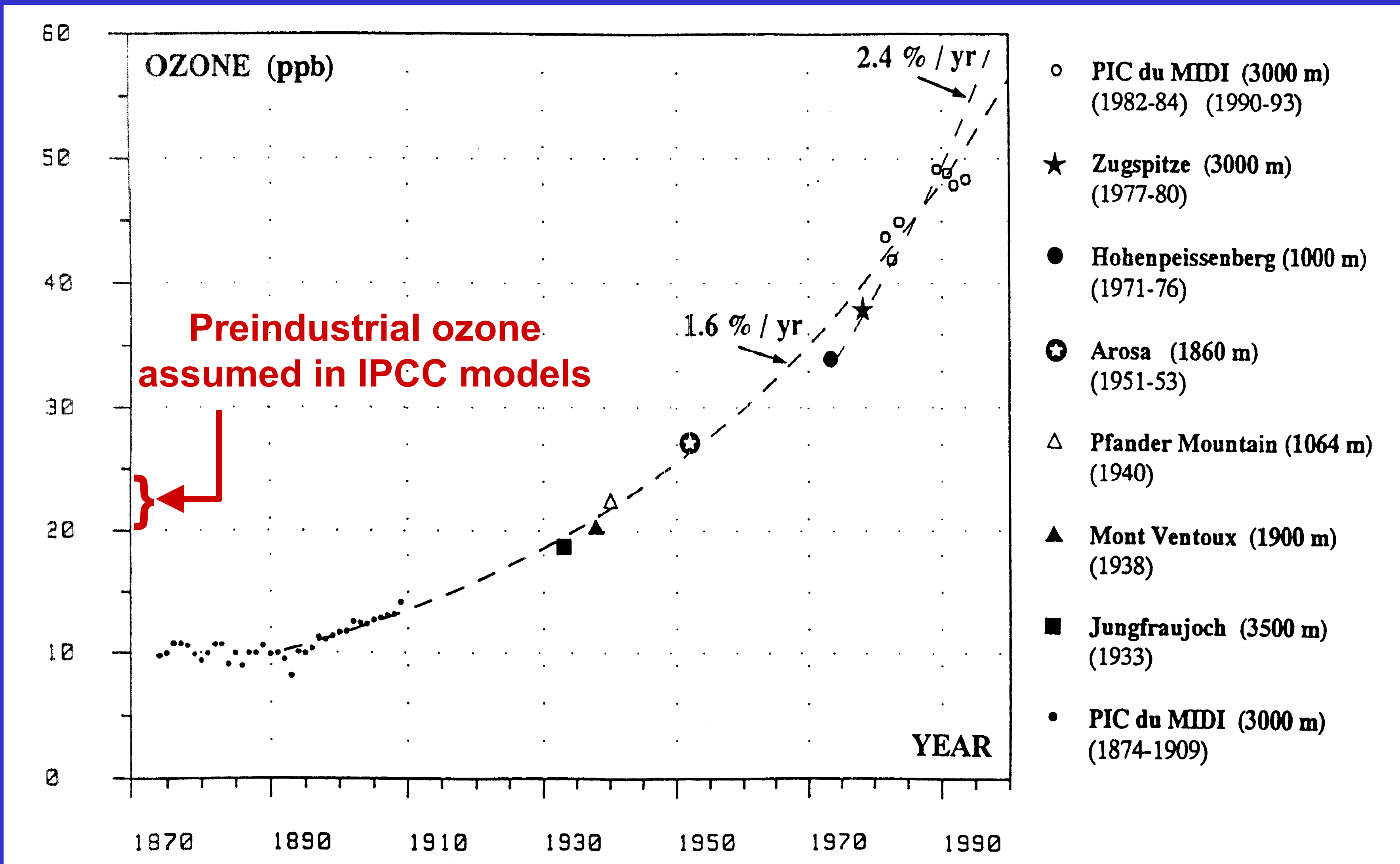
BLACK CARBON: A MAJOR "GREENHOUSE" AEROSOL



Chin et al. [2000]

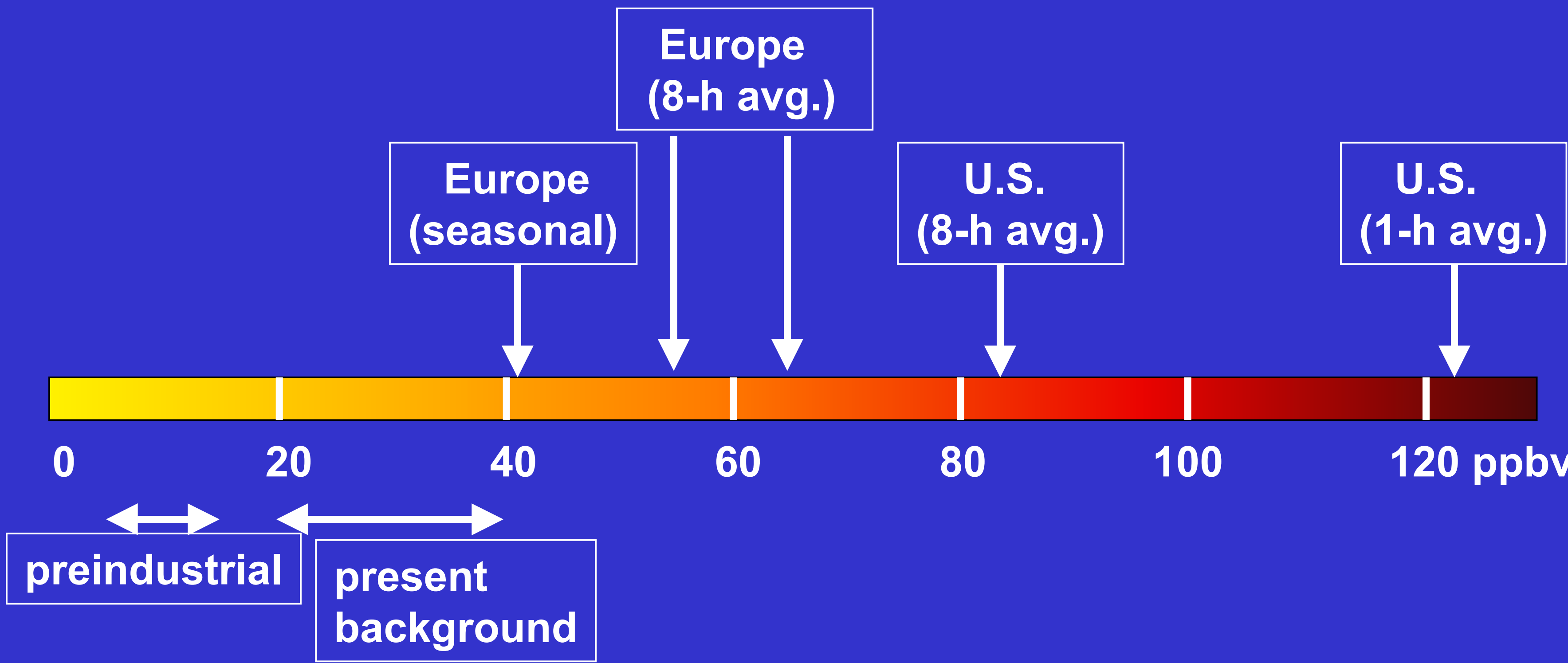
INCREASE IN TROPOSPHERIC OZONE BACKGROUND FROM INTERCONTINENTAL TRANSPORT OF POLLUTION

1870-1990 ozone trend at European mountain sites [Marenco et al.,1994]

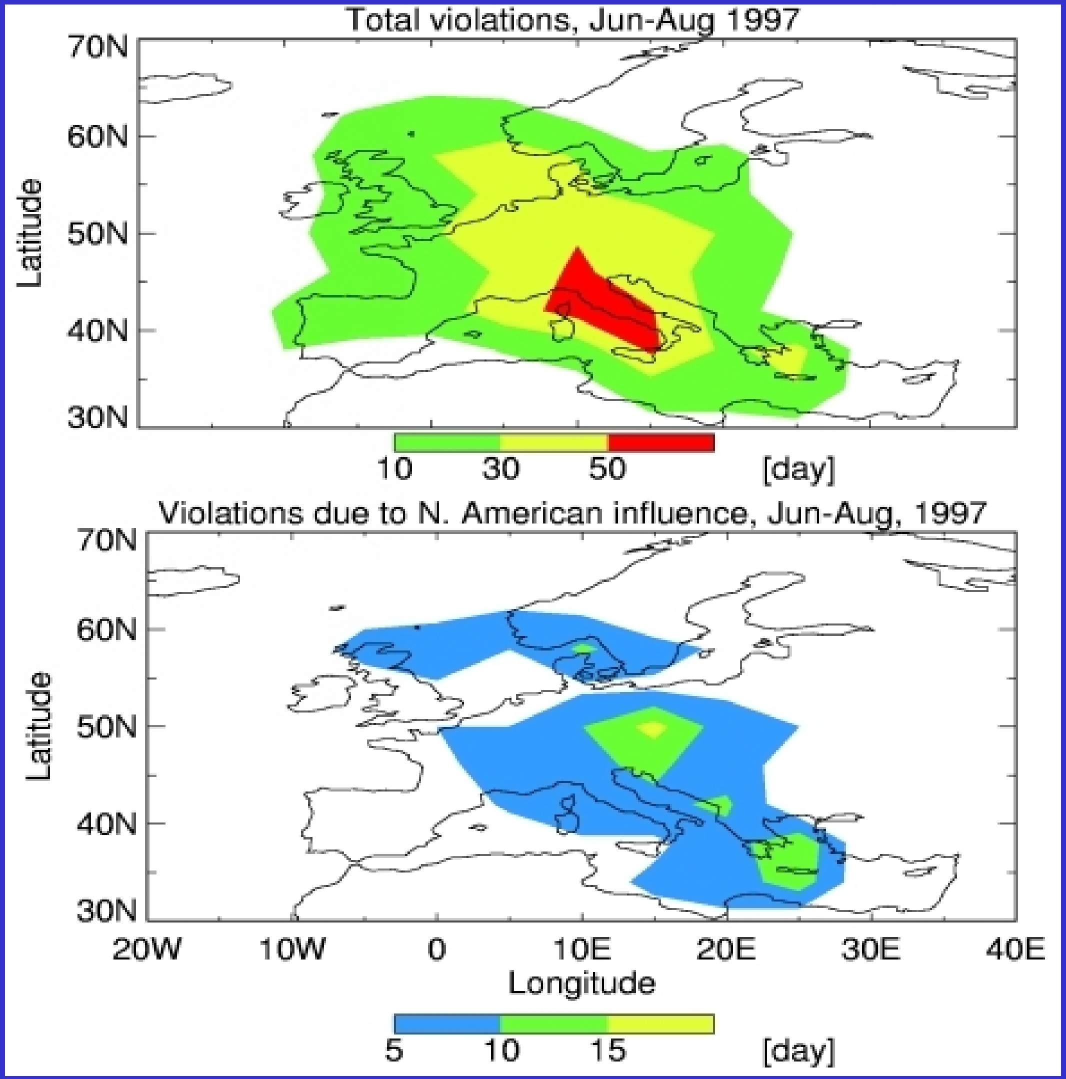


PRESENT OZONE BACKGROUND IS SIZABLE INCREMENT TOWARDS VIOLATION OF U.S. AIR QUALITY STANDARDS

(even more so in Europe!)



EFFECT OF NORTH AMERICAN SOURCES ON EXCEEDANCES OF EUROPEAN AIR QUALITY STANDARD (55 ppbv, 8-h average)



GEOS-CHEM model results, summer 1997

Number of exceedance days (out of 92)

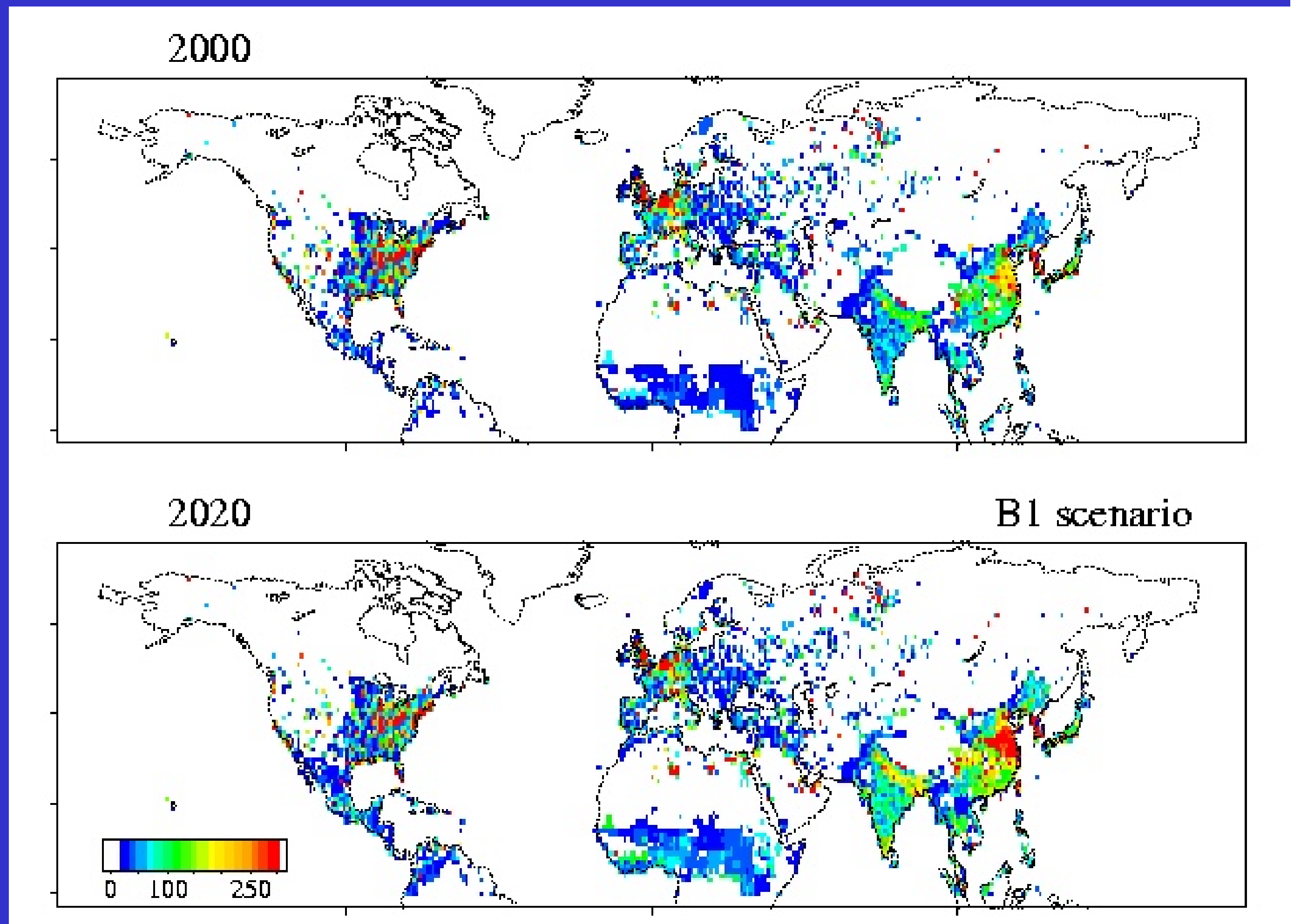
# of exceedance days that would not have happened in absence of U.S. emissions

Li et al. [2002]

Growth of Asian emissions over next decades will increase role of background for ozone air quality in U.S.

Anthropogenic NOx emissions [IPCC, 2001]

2000

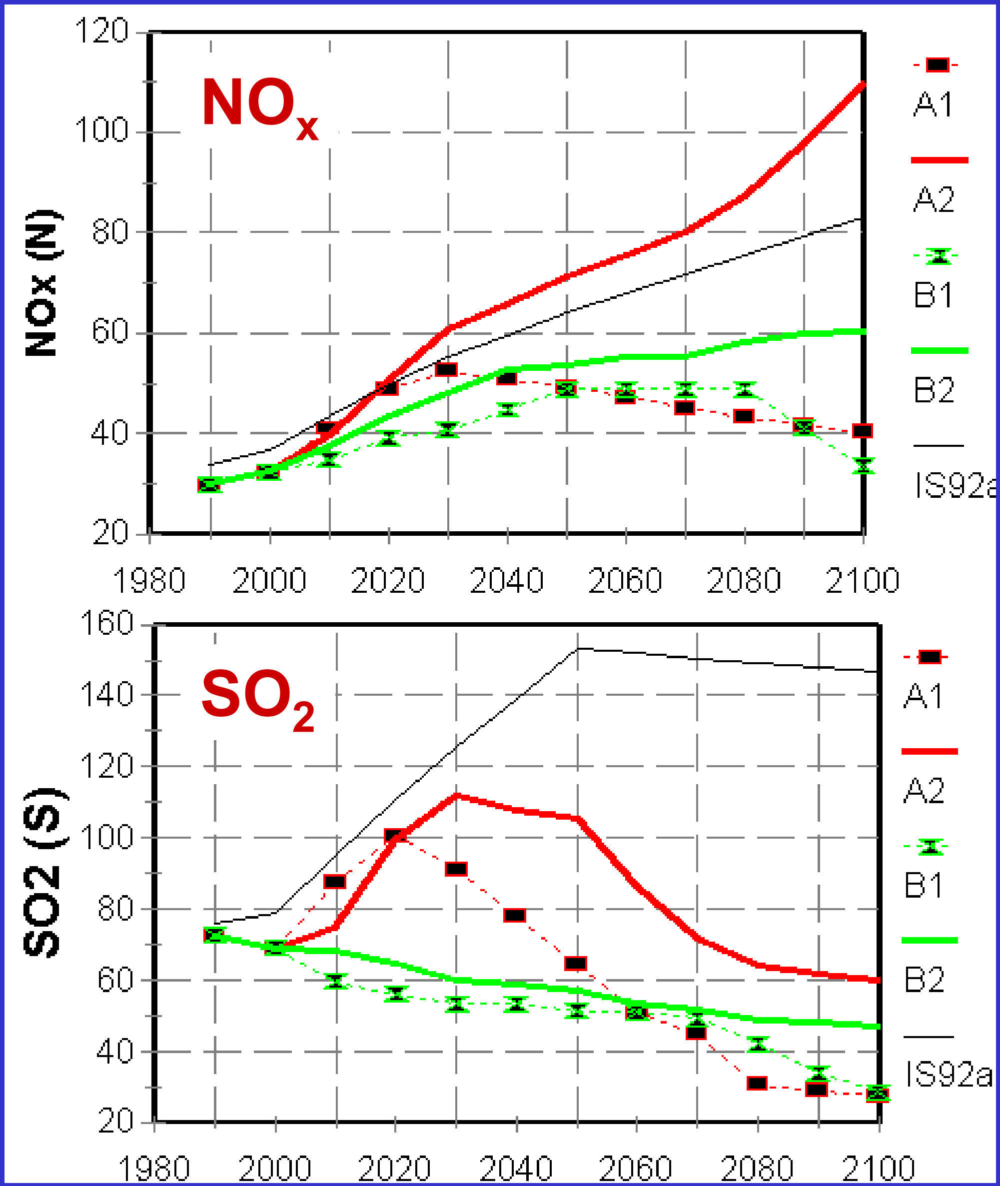


2020

"Optimistic" IPCC scenario:
OECD, U.S. down 20%
Asia up 50%

10^9 atoms N cm^{-2} s^{-1}

WHAT DOES THE FUTURE HOLD?
Future emission scenarios from IPCC [2001]

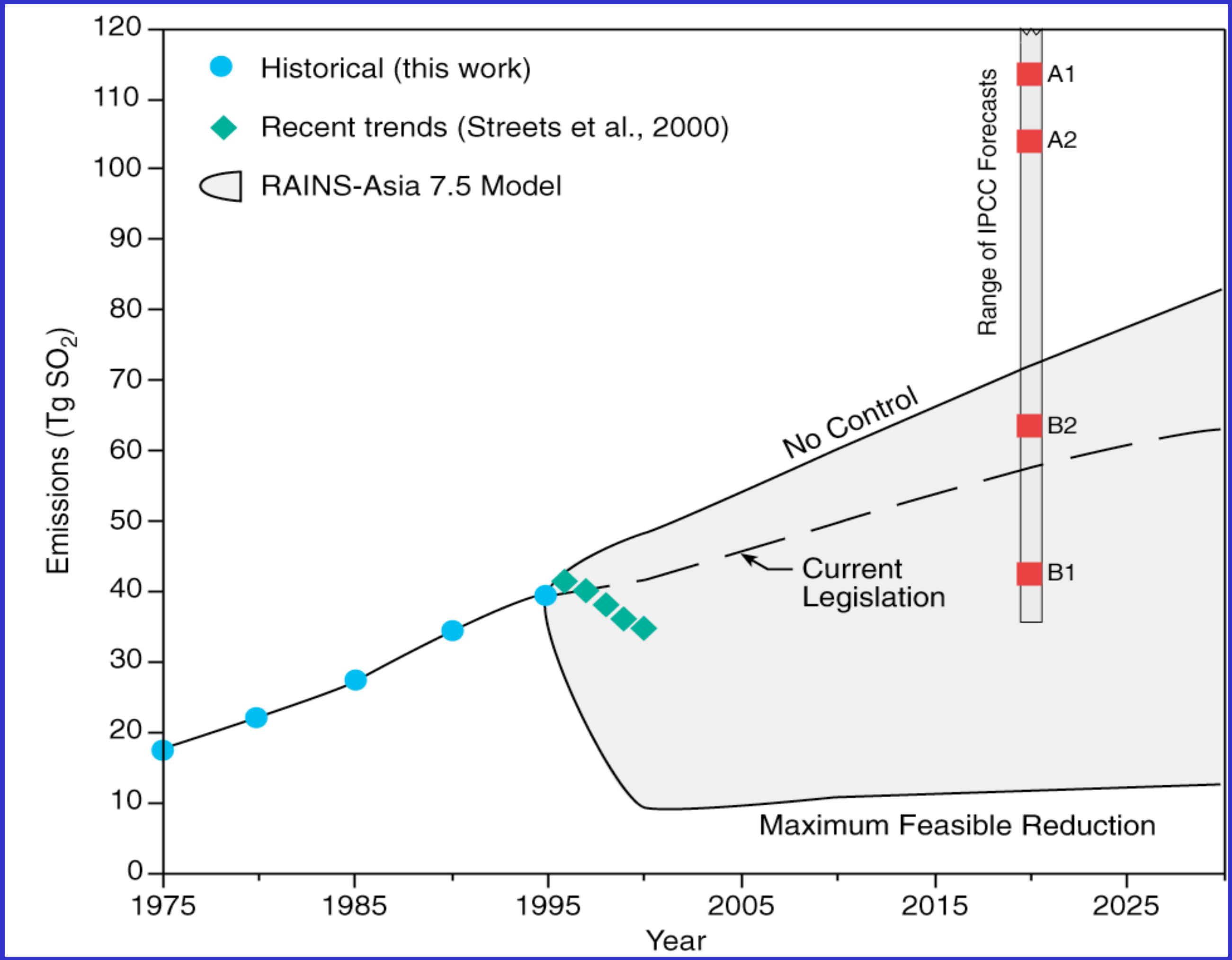


A1, A2, B1, B2: different socioeconomic story lines

A2: "dirty world"

B2: "clean world"

FUTURE EMISSIONS MAY BE LESS THAN PRESENT FORECASTS IF PUSH IS MADE FOR ENERGY EFFICIENCY AND AIR QUALITY IN DEVELOPING WORLD



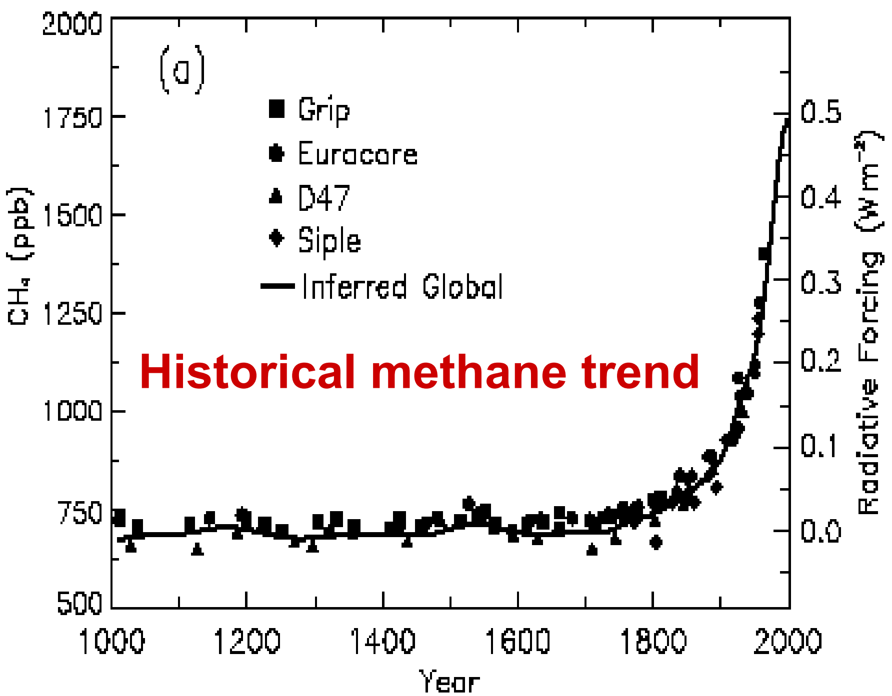
Streets et al. [2001]

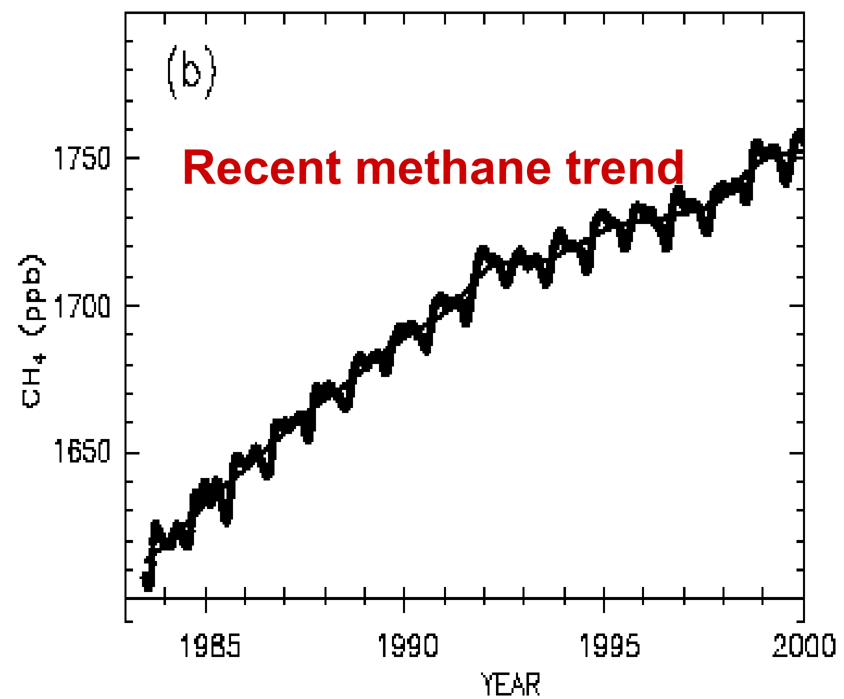
GETTING A BIG BANG FOR THE BUCK: controlling methane emissions

A 50% reduction in anthropogenic methane emissions would:

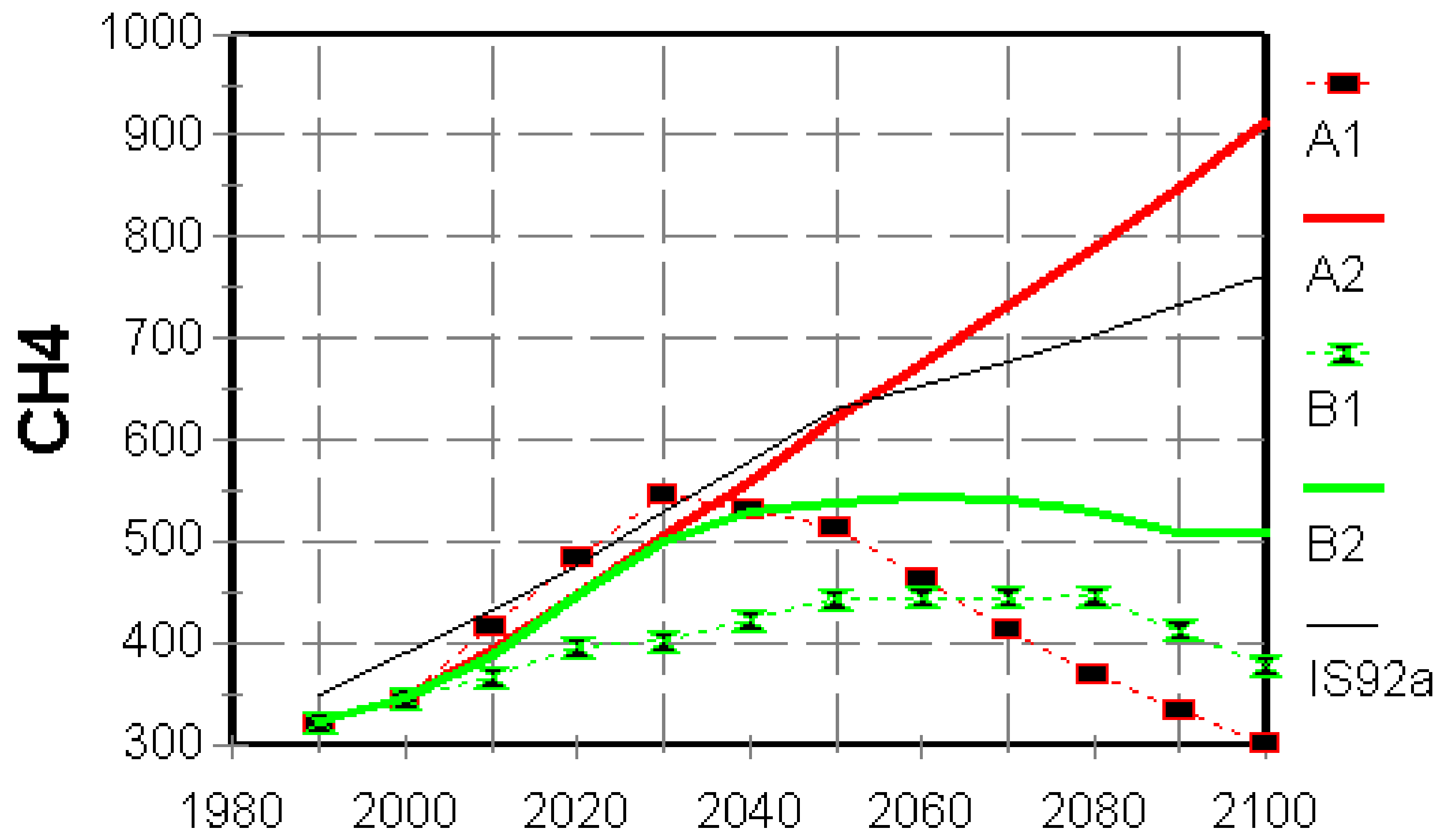
- **yield a fast negative global radiation forcing of 0.37 W m^{-2} (-0.30 W m^{-2} from methane, -0.07 W m^{-2} from ozone)**
- **decrease the incidence of ozone > 80 ppbv in surface air over U.S. by more than 50%**

[A.M. Fiore, GEOS-CHEM model results, 2002]



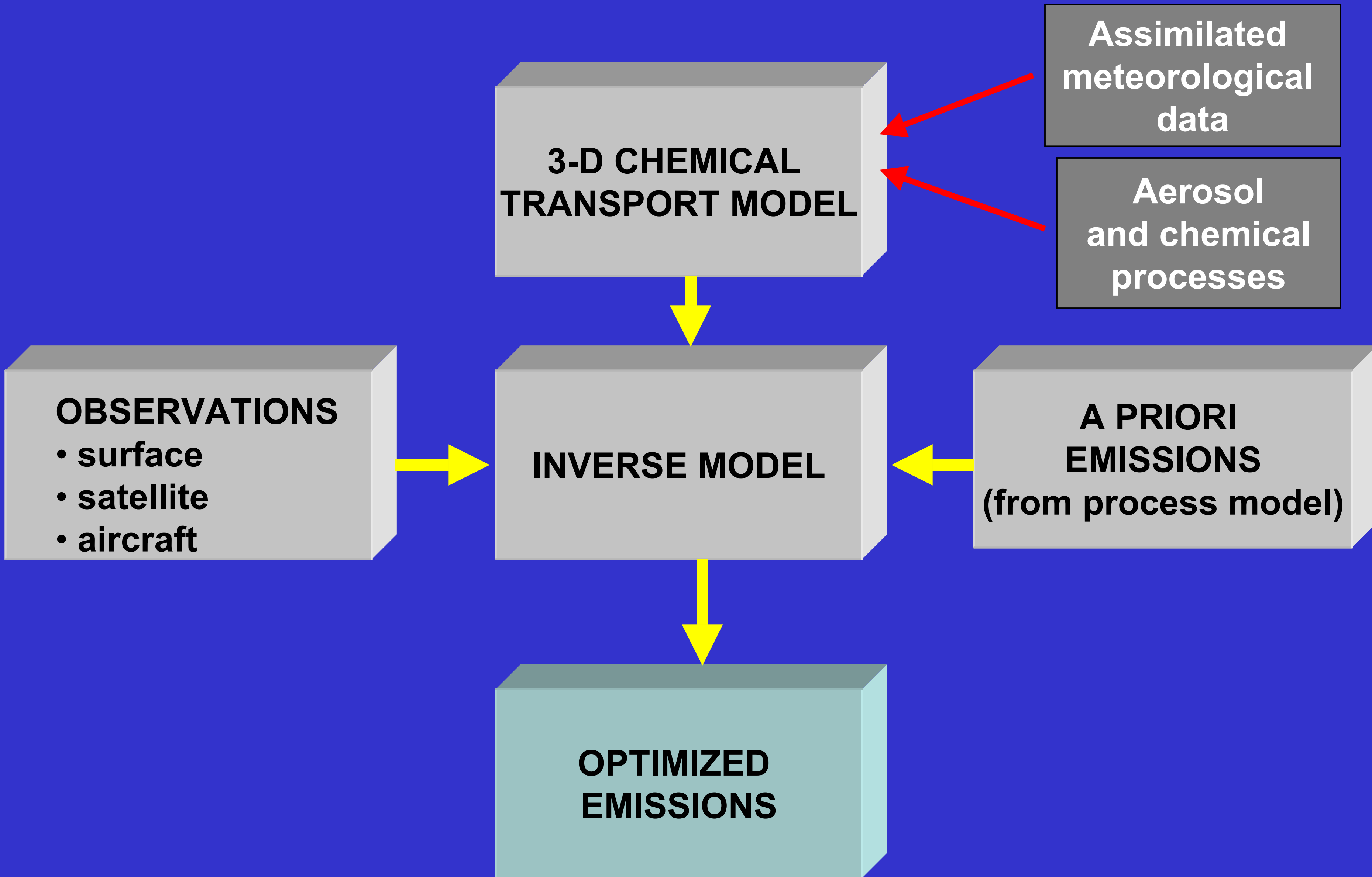


IPCC PROJECTION OF FUTURE METHANE EMISSIONS



Can we try to <u>decrease</u> methane emissions instead?

FUTURE MONITORING OF EMISSIONS BY INVERSE MODELING OF ATMOSPHERIC OBSERVATIONS

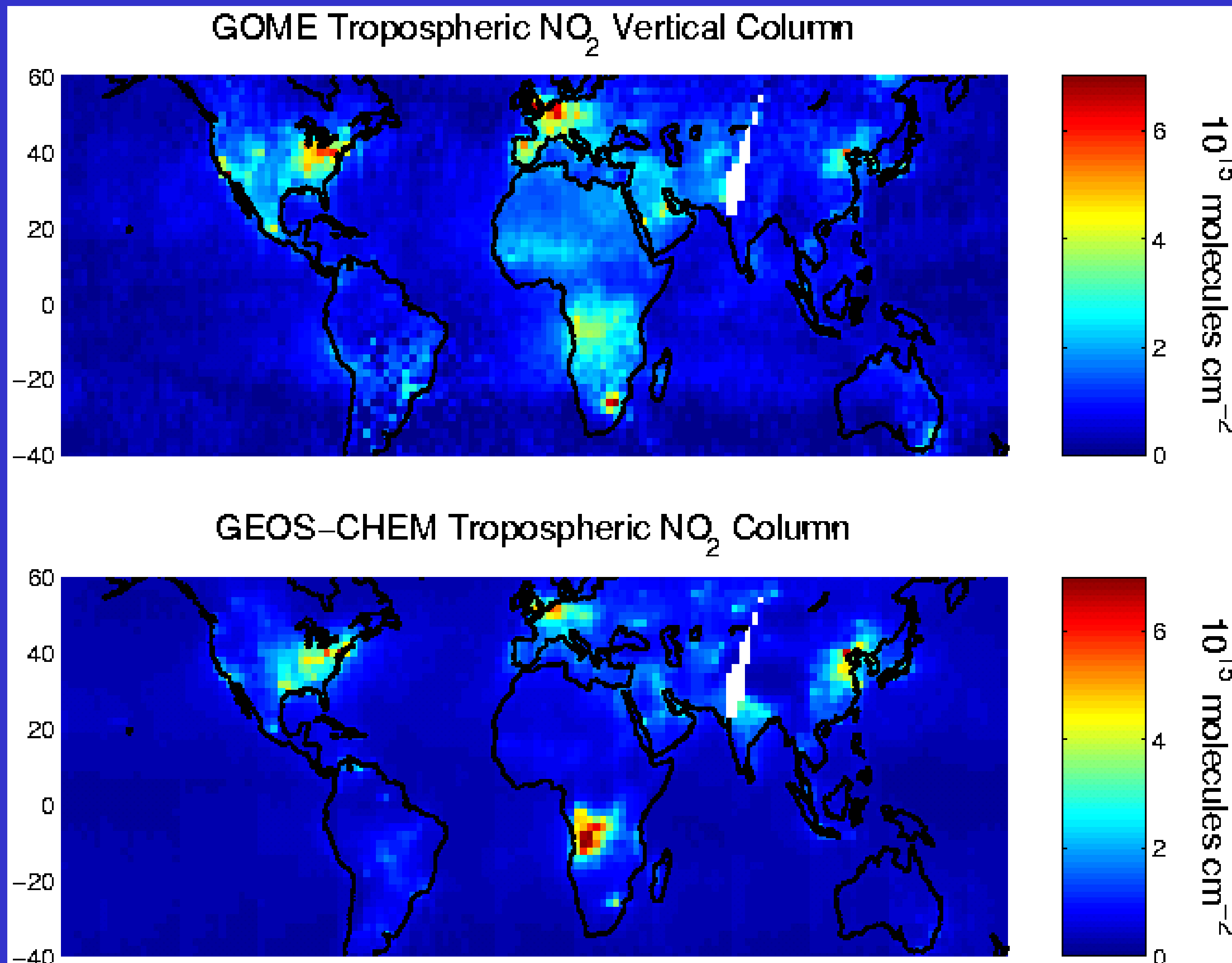


GLOBAL MAPPING OF NO_x EMISSIONS FROM SPACE: GOME observations of nitrogen dioxide (July 1996)

Martin et al. [2002]

GOME

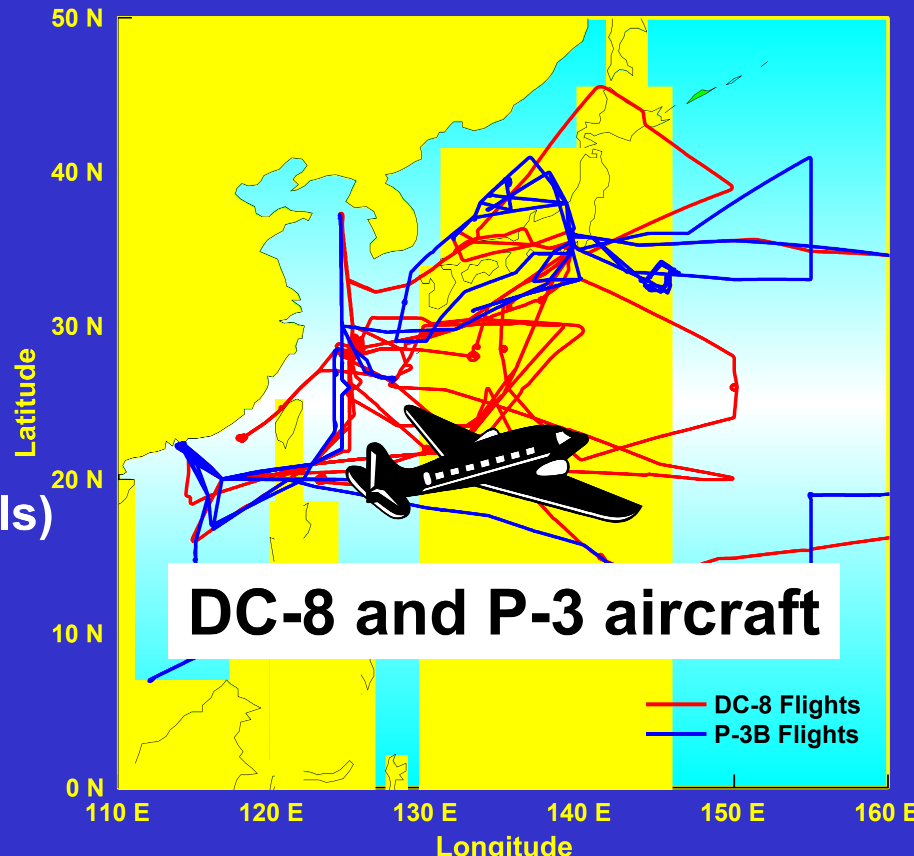
GEOS-CHEM model

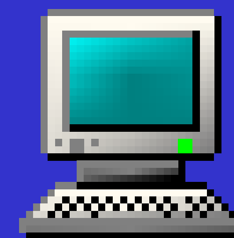


NASA/TRACE-P AIRCRAFT MISSION TO THE PACIFIC RIM (MARCH-APRIL 2001)

Quantifying the export of Asian pollution

Satellite data:
MOPITT (CO)
TOMS (ozone)
SEAWIFS,
TOMS (aerosols)





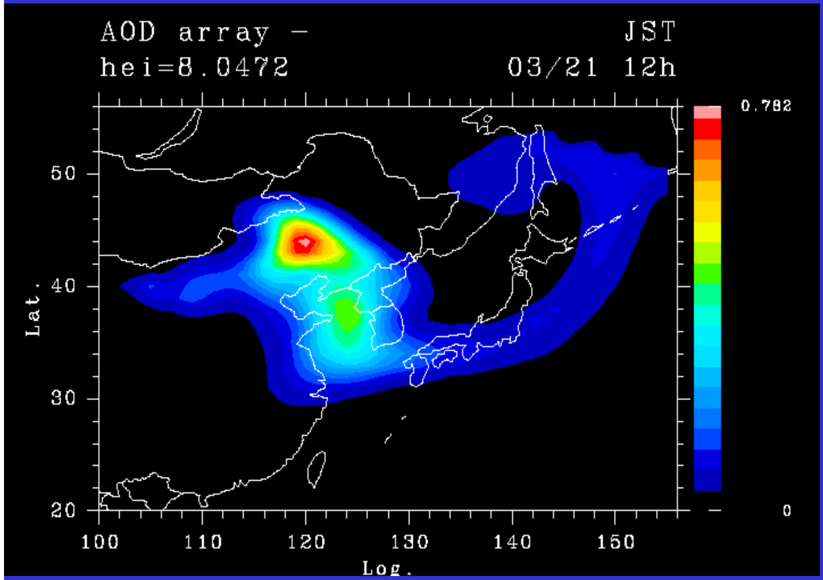
3-D chemical transport model forecasts

Flight tracks were designed to optimize model testing and satellite validation

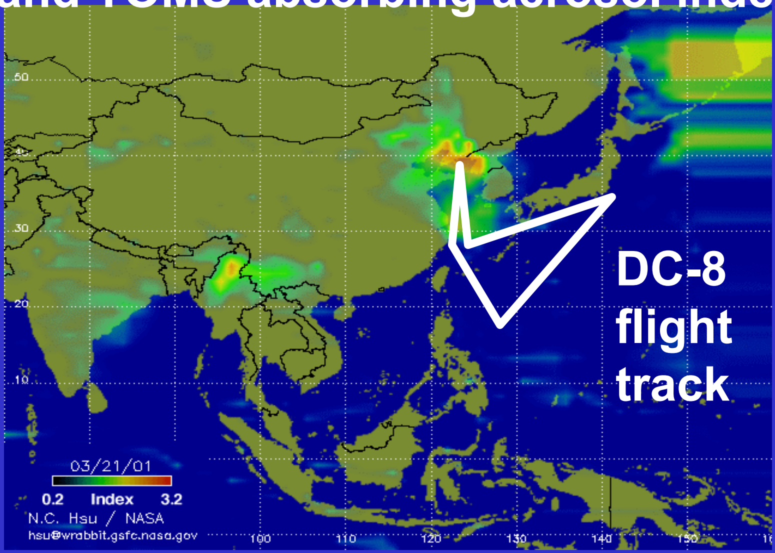
INTEGRATION OF AIRCRAFT, SATELLITES, AND MODELS:

quantifying the Asian dust source in TRACE-P

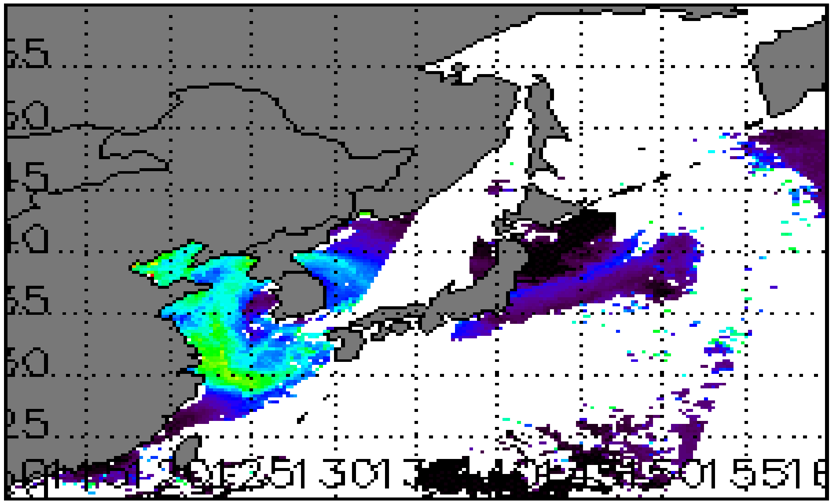
Dust forecast for 3/21/01 (Carmichael, U. Iowa)



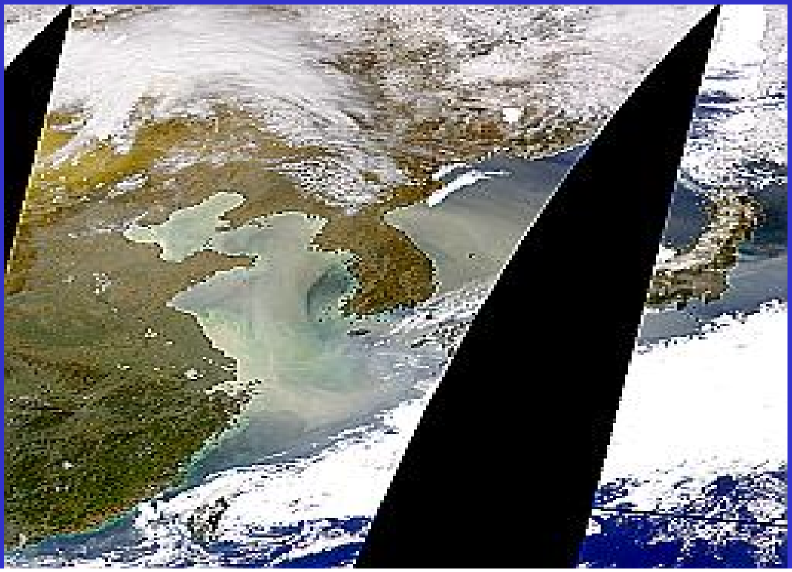
DC8 flight track and TOMS absorbing aerosol index



SEAWIFS aerosol optical depth



SEAWIFS visible image



FUTURE SATELLITE MEASUREMENTS OF TROPOSPHERIC CHEMISTRY

				TERRA		ENVISAT			AURA			
Sensor	TOMS/ TRIANA	AVHRR/ SEAWIFS	GOME	MOPITT	MODIS/ MISR	SCIA MACHY	MIPAS	SAGE III	TES	HRDLS	OMI	MLS
Launch	1979		1995	1999	1999	2002	2002	2004	2004	2004	2004	2004
O_3	col		col			col/limb	limb	limb	nadir/limb	limb	col	limb
H_2O	col					col/limb	limb	limb	nadir/limb	limb		limb
CO				nadir		col/limb	limb		nadir/limb			limb
NO									limb			
NO_2			col			col/limb					col	
HNO_3							limb		limb	limb		
CH_4				col		col/limb			col	limb		
CH_2O			col			col/limb					col	
SO_2						col			col		col	
CO_2						col/limb						
BrO			col			col					col	
HCN												limb
Aerosol	col	col			col	col/limb		limb		limb	col	