A global simulation of tropospheric ozone and related tracers: Description and evaluation of MOZART, version 2

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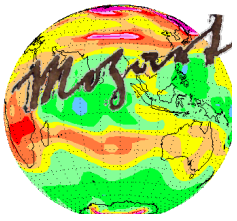
April 16, 2001

MOZART-2

- Model description
  - Overview
  - Recent modifications
- Comparison with observations
- O_3 budget



MOZART-2

Model resolution: 2.8° latitude × 2.8° longitude (≈T42), 20 min timestep, 34 vertical layers (hybrid), surface to ~35 km (5 mb)

Meteorology: Winds, T, P, humidity, surface fluxes
From MACCM-3 (truncated to 34 layers), every 6 hours

Surface emissions: NO_x (fossil fuel, biomass burning, soils)
CO, non-methane hydrocarbons (FF, vegetation, biomass burning, oceans)

Lightning: NO_x source based on convection [*Price et al.*, 1997; *Pickering et al.*, 1998]

Photochemistry: 58 chemical species, 132 kinetic + 31 photolysis reactions
Photolysis rates computed from lookup table

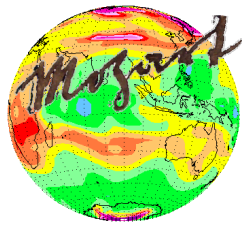
Advection: Flux-form semi-Lagrangian scheme [*Lin and Rood*, 1996]

Convection: Rediagnosed from MACCM-3 data using *Hack* [1994] and *Zhang and MacFarlane* [1995] schemes

Boundary layer diffusion: Based on *Holtslag and Boville* [1993]

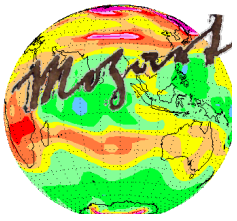
Dry deposition: Deposition velocities computed with *Wesely* [1989] scheme, using NCEP meteorology and *DeFries and Townshend* [1994] vegetation map

Wet deposition: Based on *Giorgi and Chameides* [1985]



MOZART-2

- Recent modifications
  - Emissions
  - Dry deposition velocities
  - New isoprene scheme
  - Lightning NO_x
  - “Flexible” architecture version
  - Updated reaction rates
  - Improved O_3 upper BC



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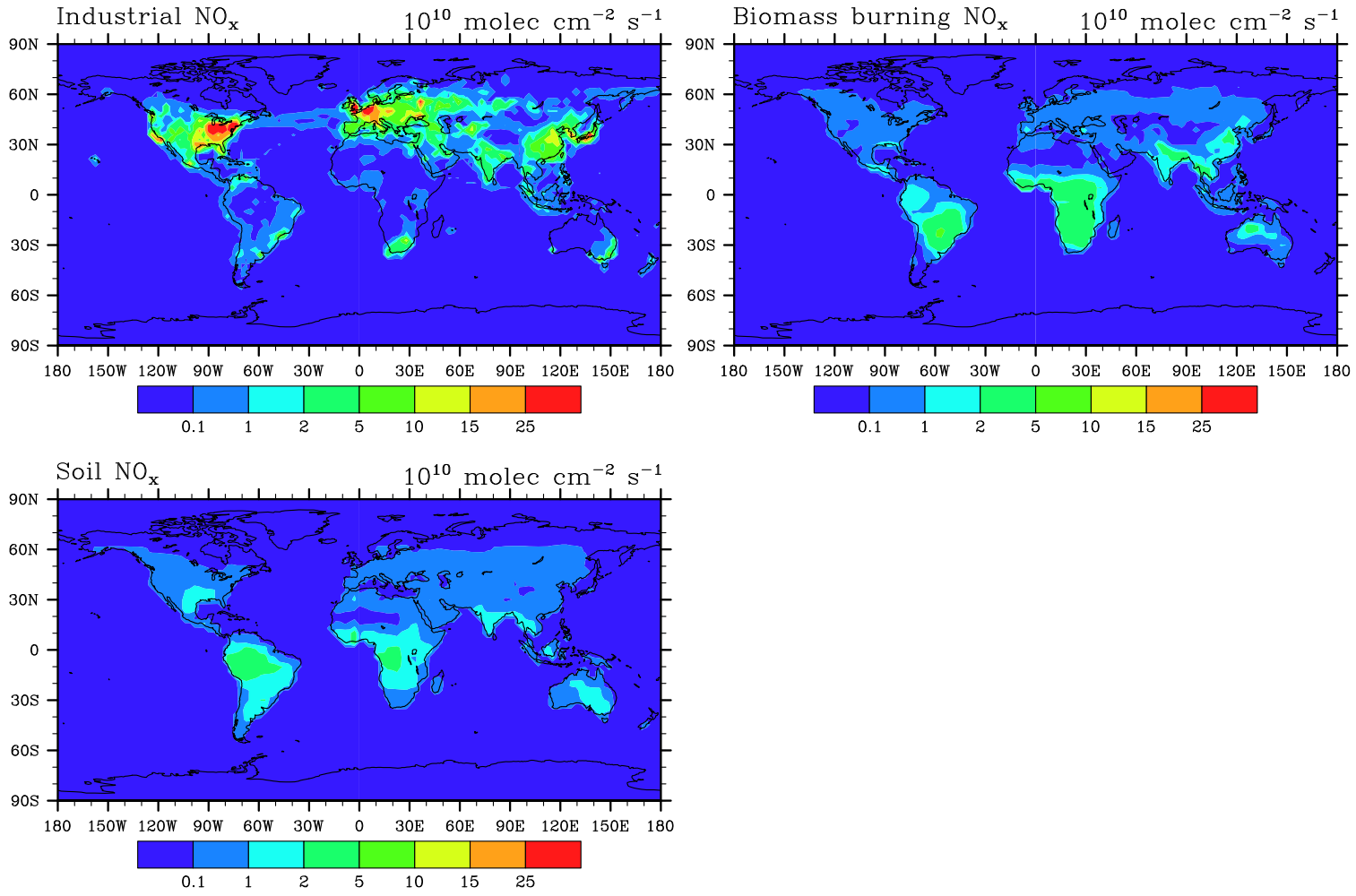
NO_x Emissions



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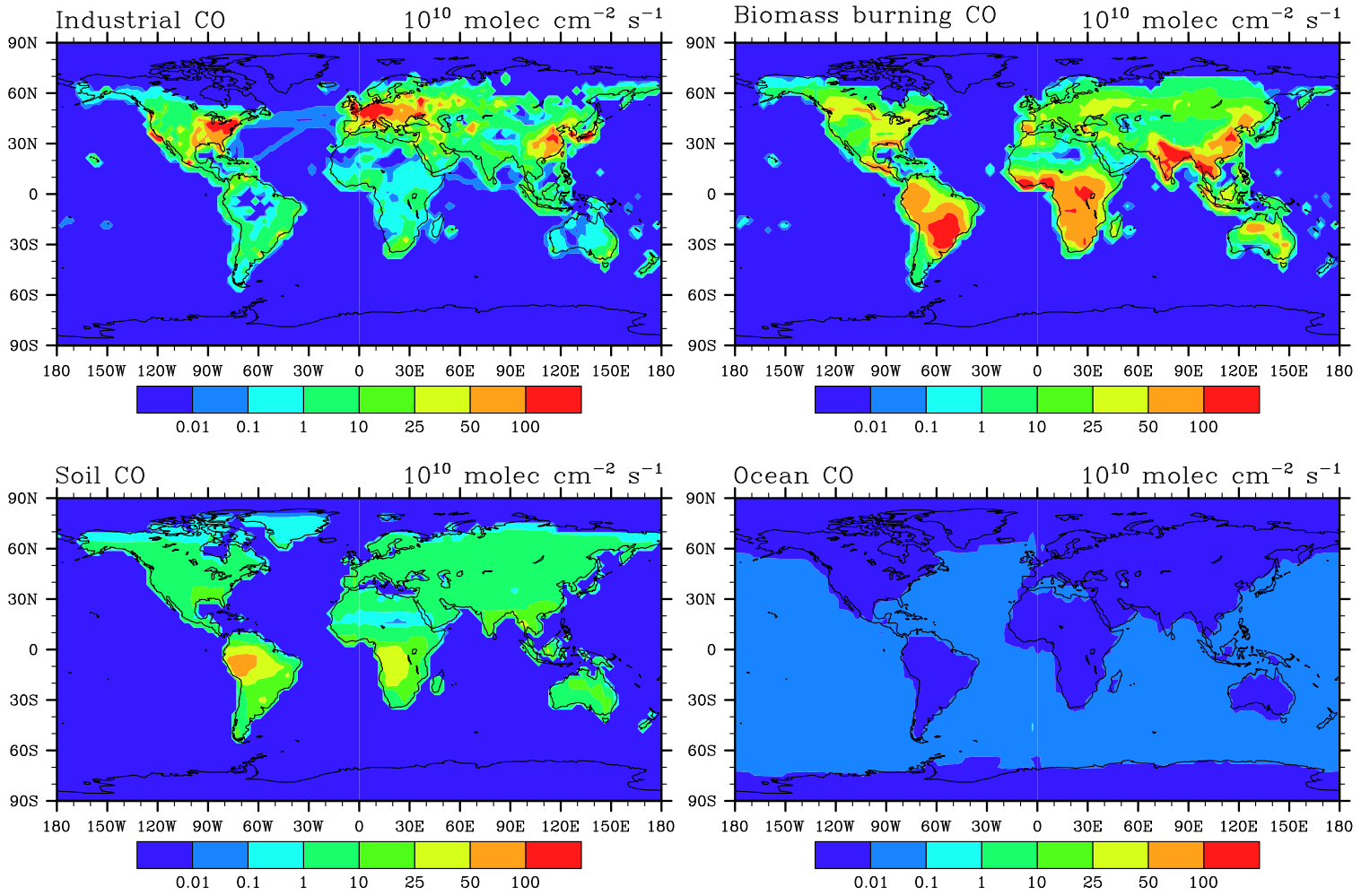
CO Emissions



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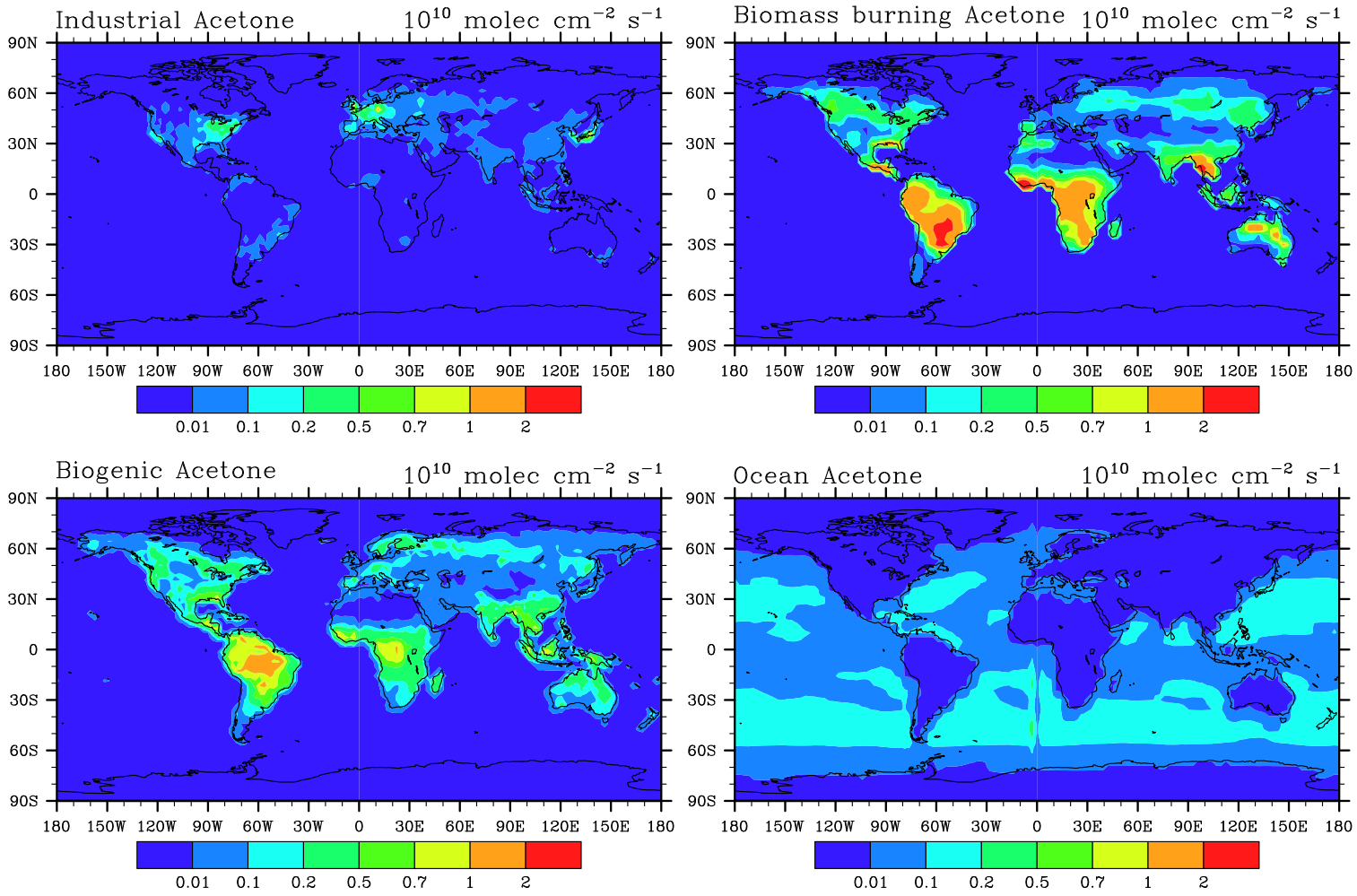
Acetone Emissions



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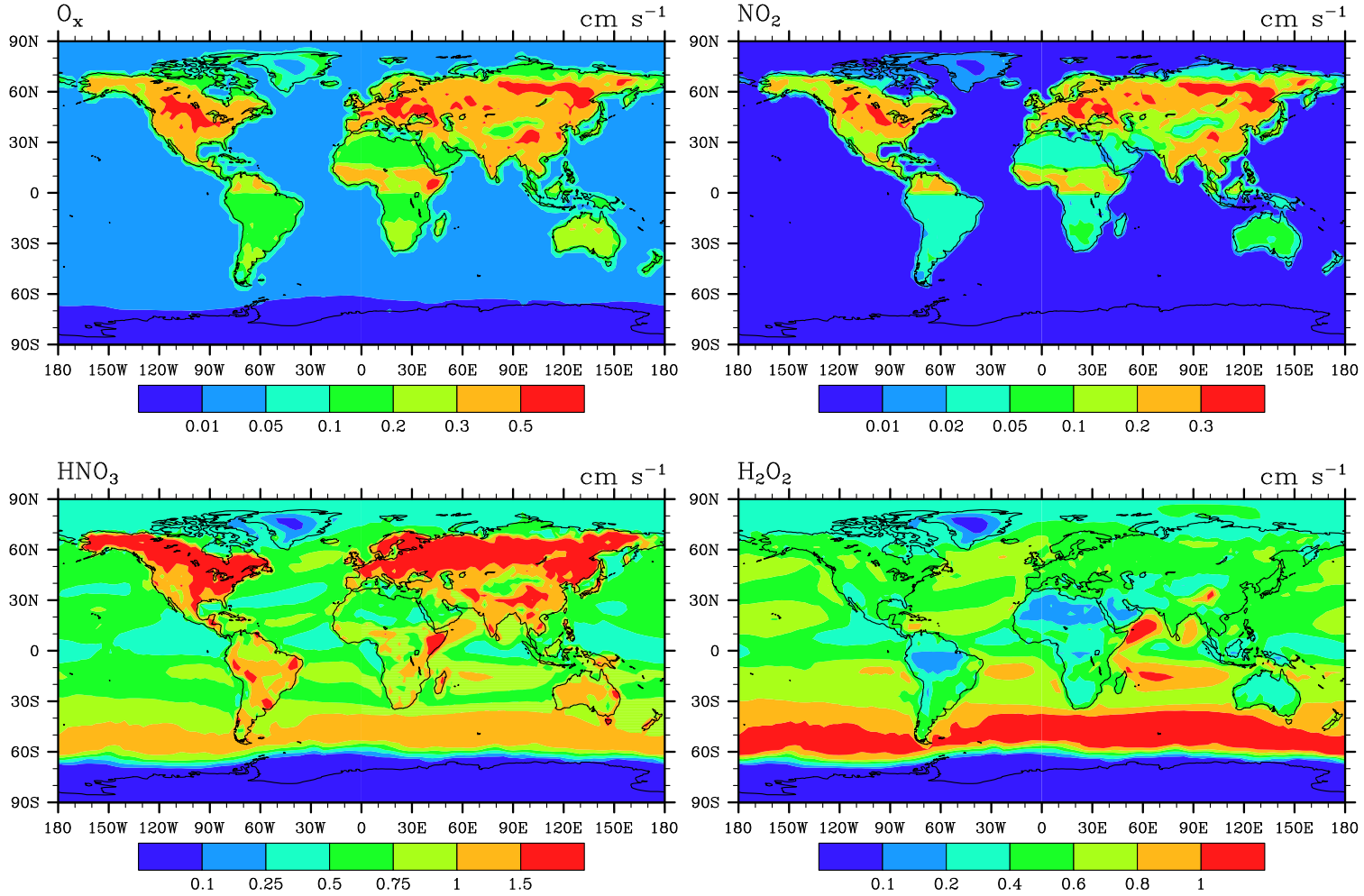
Deposition Velocities (July)



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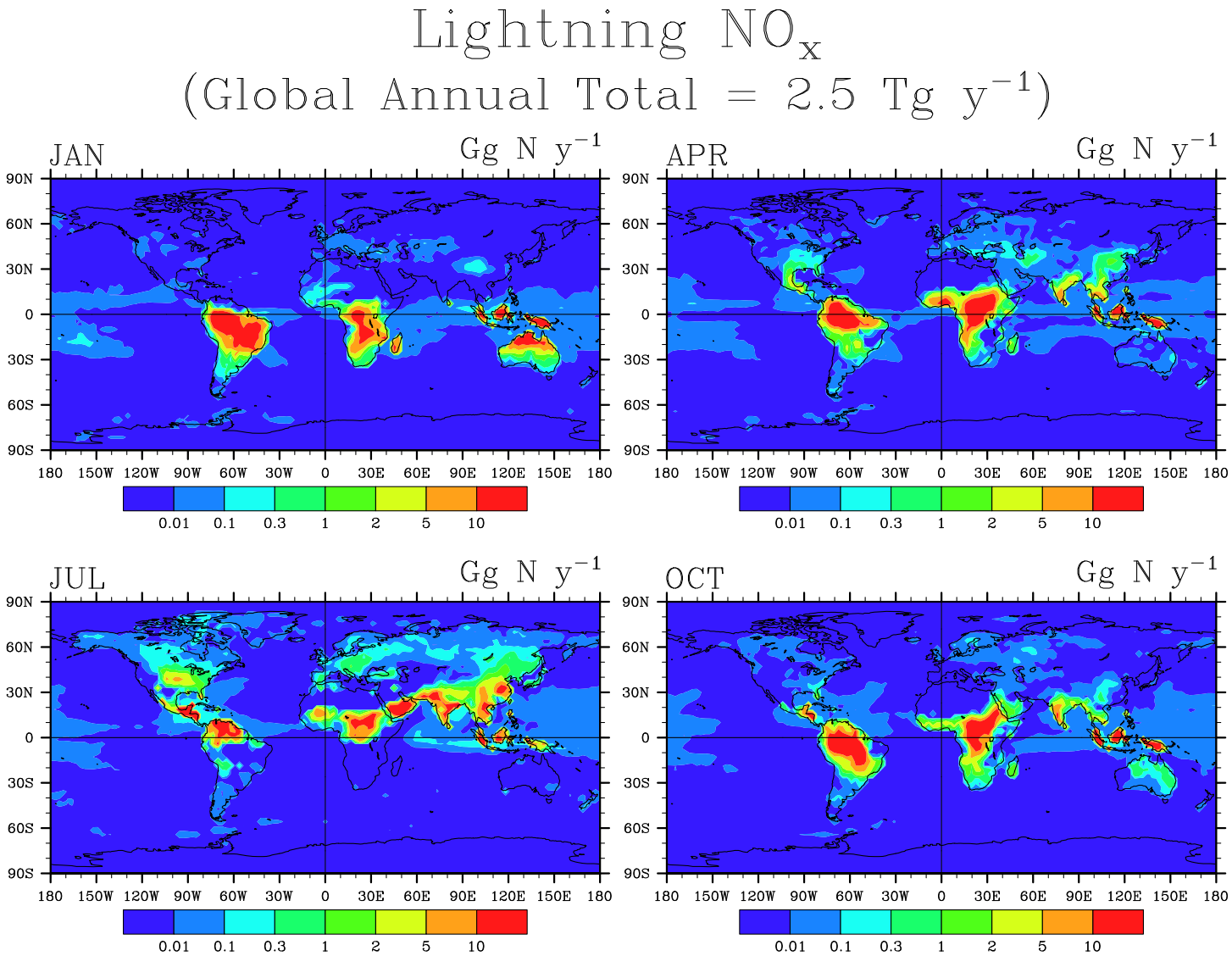
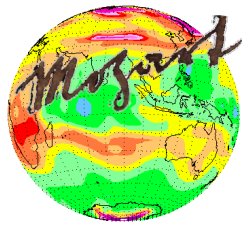

Lightning NO_x
(Global Annual Total = 2.5 Tg y^{-1})
JAN
APR
JUL
OCT
Gg N y^{-1}
90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
0.01 0.1 0.3 1 2 5 10

MOZART-2
Emissions

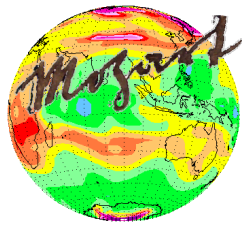
Species	Fossil fuel combustion	Biomass burning	Biogenic / Soil	Oceans	Total
NO (TgN/y)	23.1	8.7	6.6	0	38.4
CO (Tg/y)	306.9	711.2	181.0	2.0	1201.1
C_2H_6 (TgC/y)	6.4	4.5	0.8	0.1	11.7
C_3H_8 (TgC/y)	10.0	2.2	1.6	0.1	14.00
C_2H_4 (TgC/y)	2.0	12.3	4.3	2.1	20.7
C_3H_6 (TgC/y)	0.9	5.6	0.9	2.5	9.8
C_4H_{10} (TgC/y)	22.2	23.0	21.4	6.3	72.9
CH_3COCH_3 (Tg/y)	1.0	16.1	10.2	9.9	37.3
ISOP (TgC/y)	0	0	299.0	0	299.0
$C_{10}H_{16}$ (TgC/y)	0	0	129.1	0	129.1
CH_4 (Tg/y)	95.0	64.3	145.7	11.3	467.9
N_2O (Tg/y)	5.0	1.7	20.7	11.3	38.7
H_2 (Tg/y)	13.5	14.0	5.3	7.8	40.6



MOZART-2

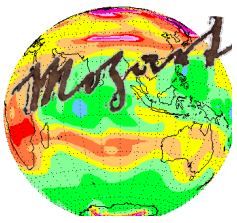
Emissions (new, old)

Species	Fossil fuel combustion	Biomass burning	Biogenic / Soil	Oceans	Total
NO (TgN/y)	23.1	8.7 10.0	6.6	0	38.4 39.5
CO (Tg/y)	306.9	711.2 858.4	181.0	2.0 20.1	1201.1 1353.8
C_2H_6 (TgC/y)	6.4 3.2	4.5 5.4	0.8	0.1 0.8	11.7 10.2
C_3H_8 (TgC/y)	10.0 5.0	2.2 2.6	1.6	0.1 1.1	14.0 10.2
C_2H_4 (TgC/y)	2.0	12.3 14.1	4.3	2.1 8.4	20.7 28.7
C_3H_6 (TgC/y)	0.9	5.6 6.4	0.9	2.5 10.2	9.8 18.3
C_4H_{10} (TgC/y)	22.2 44.0	23.0 39.5	21.4 214.3	6.3 63.2	72.9 186.7
Acetone (Tg/y)	1.0	16.1 15.1	10.2	9.9 0	37.3 26.1
Isoprene (TgC/y)	0	0	299.0 500.3	0	299.0 500.3



MOZART-2

- Comparison with observations
  - ~~- Ozonesondes~~
  - CMDL (CO)
  - Aircraft measurements
    - → DIAL O_3
    - → CO
    - → Acetone
    - → others?



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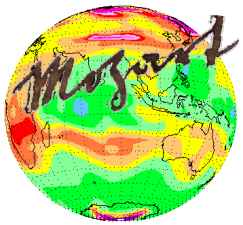
SUMMARY

- O_3, NO_x, CO, NMHCs, peroxides
  - very good agreement with obs
- PAN, CH_2O
  - good agreement at most locations
- HNO3, acetone
  - significant disagreement at some locations



MOZART-2

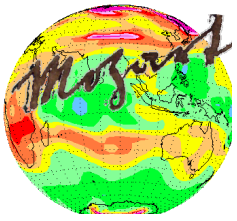
Ozone budget

Process	Production (Loss) [Tg O_3 / yr]		
	Global	**Northern Hemisphere**	**Southern Hemisphere**
Influx from stratosphere[a]	409[b]	267	142
Photochemical production	4671	2750	1921
Photochemical loss	-4238	-2463	-1775
Dry deposition	-847	-557	-290

For this budget, the tropopause is defined as the hybrid model level interface corresponding to approximately 100 hPa in the tropics (30°S-30°N) and 250hPa in the extratropics..

a. Includes advection, pressure consistency correction, and convection and vertical diffusion.

b. This term consists of advection (310 Tg/y), pressure consistency correction (91 Tg/y), and convection and vertical diffusion (8 Tg/y).



Ozone fluxes (Tg y^{-1})