Fires, Atmospheric Composition and Earth System Feedbacks

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JULES Science Meeting, Exeter, 28-29 June 2007

How Important are Fires for the Atmosphere?

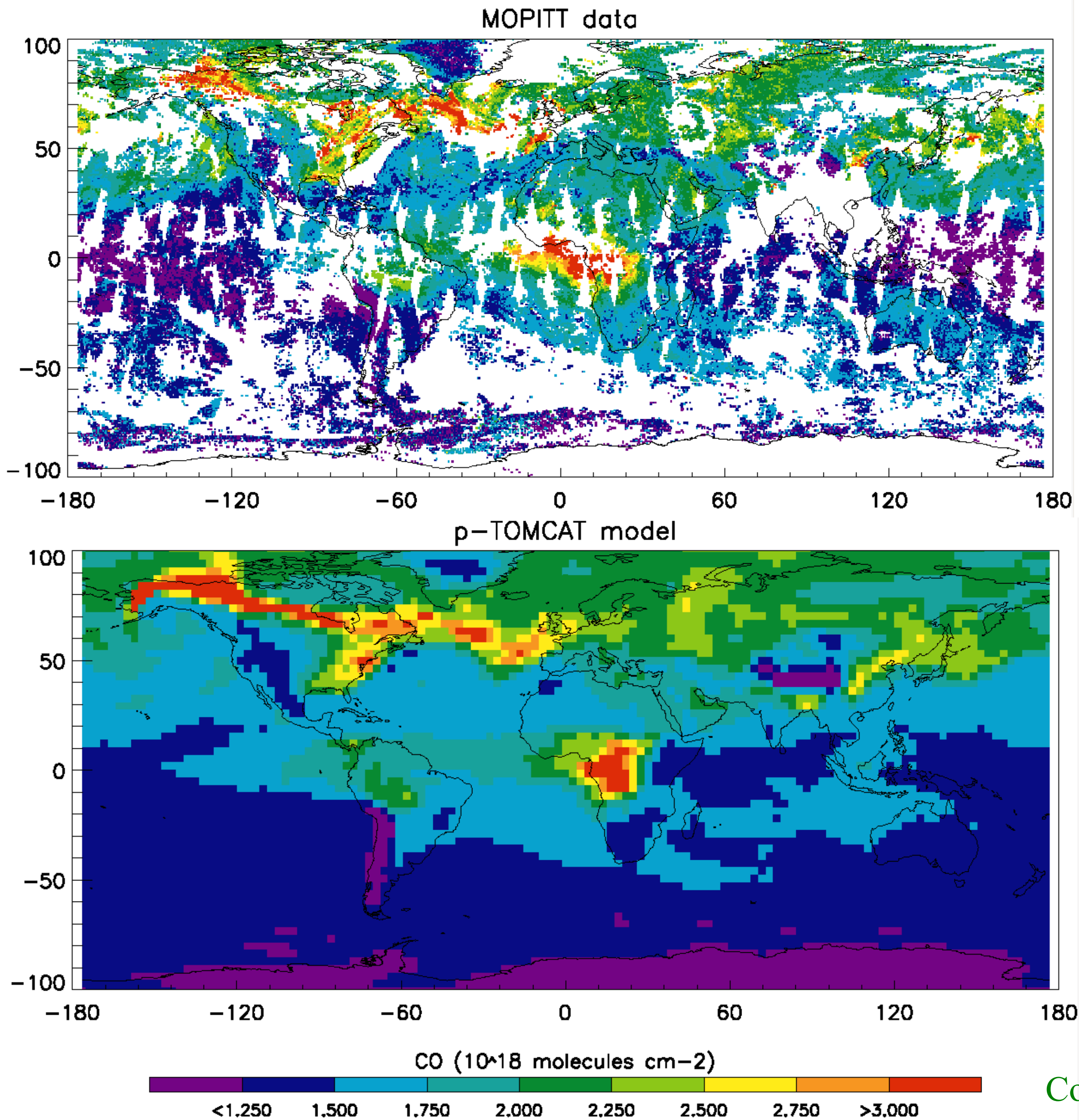
- Summary of Emission impacts

	Emissions	Percentage of Global Emissions
NO_x	6–10 TgN/yr	12–20%
CO	300–600 Tg/yr	30–45%
VOC	20–40 Tg/yr	10–20%
CH_4	15–30 Tg/yr	3–6%
H_2	5–15 Tg/yr	15–40%
BC	1–4 Tg/yr	
OC	10–30 Tg/yr	
SO_2	2–8 Tg/yr	2–8%

Data sources:

EDGAR, GEIA, RETRO, POET, GFED

– Fires have a large influence on tropospheric composition



CO columns from MOPITT during the ICARTT measurement campaign:

19-21 July 2004

CO features dominated by biomass burning

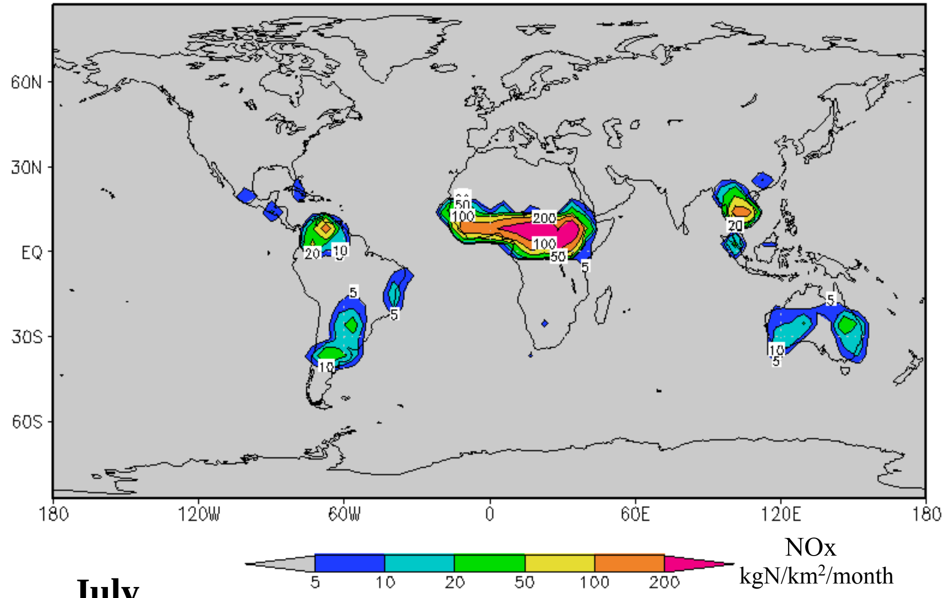
With meteorology from ECMWF and satellite-based emission estimates can reproduce features with CTMs

But how well do we understand the atmospheric impacts?

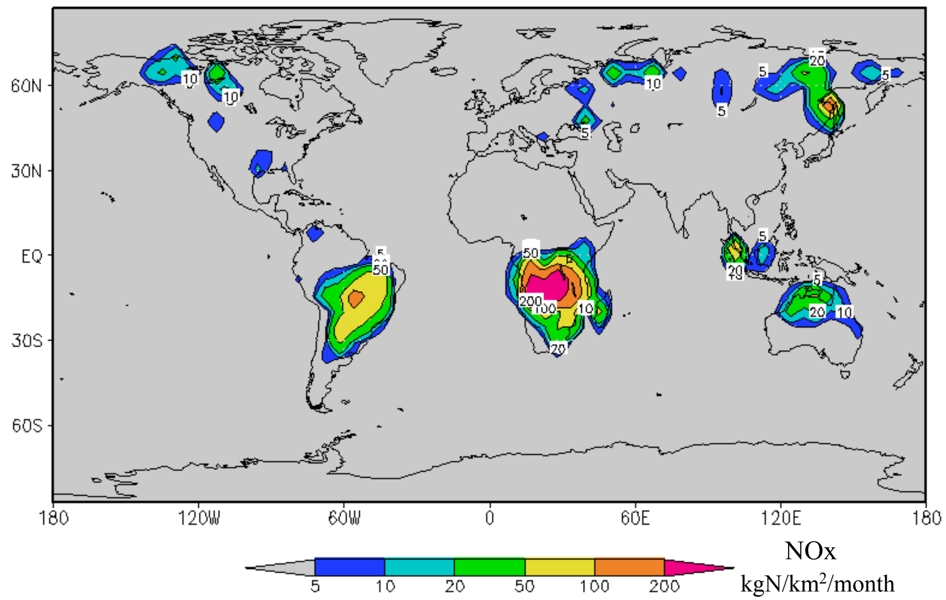
Cook et al., 2007

Mean Impact of Fires: Emissions

January



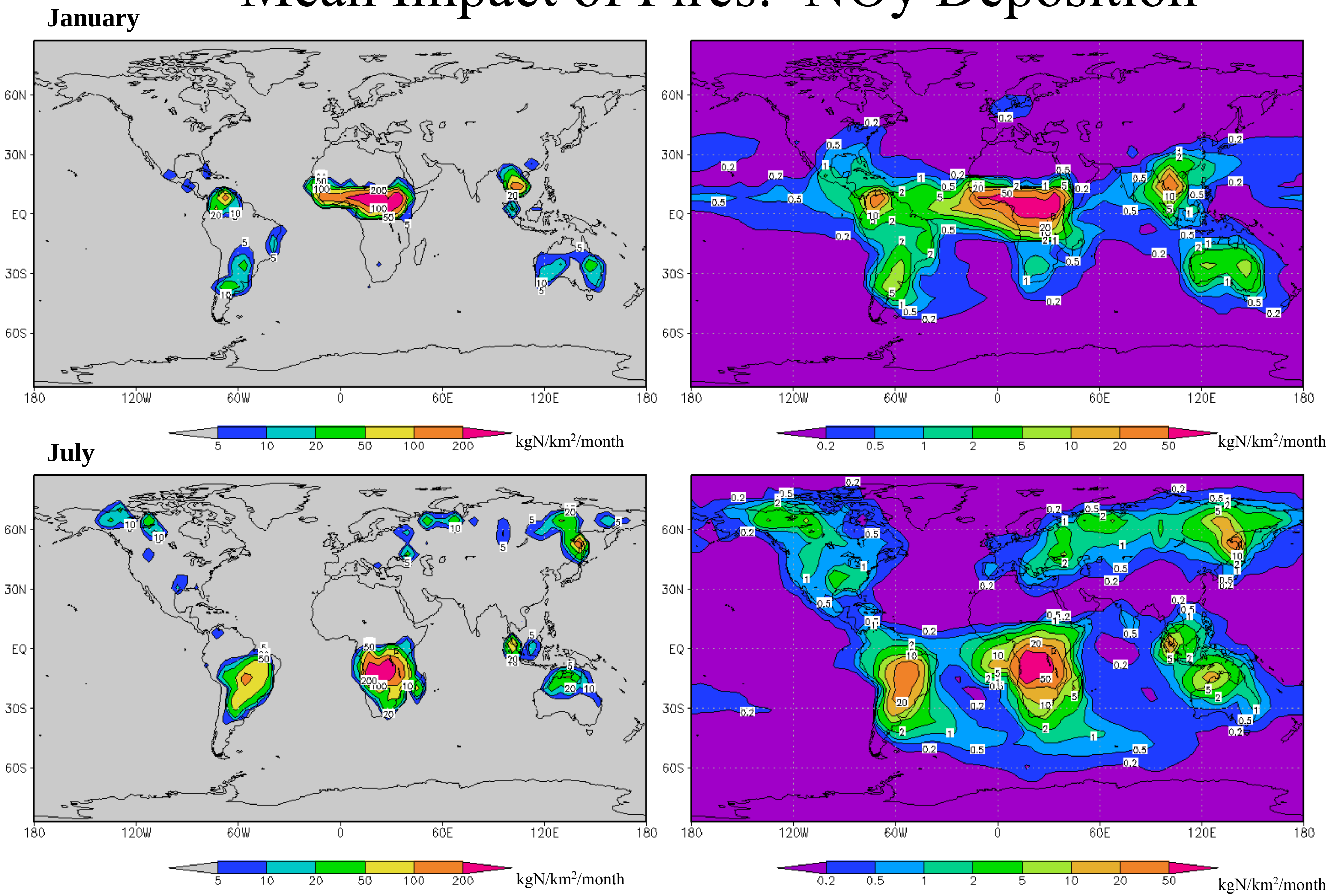
July



- Global CTM runs
  - FRSGC/UCI CTM
- Emissions from GFED v1.0
  - Satellite-derived (1997-2002)
  - van der Werf 2003
  - NO_x, CO, VOC

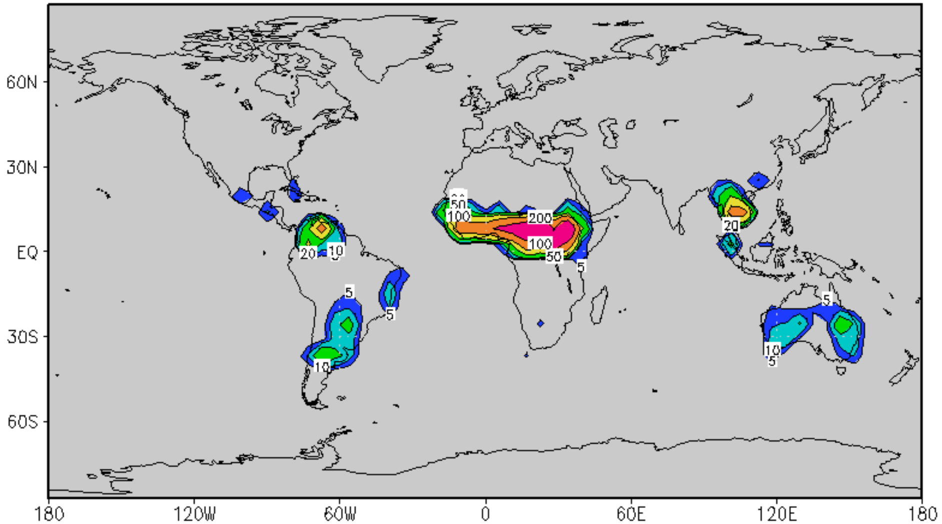
- January
  - Equatorial Africa
  - S.E. Asian agriculture
- July
  - Southern Africa, Amazon
  - Boreal forest fires

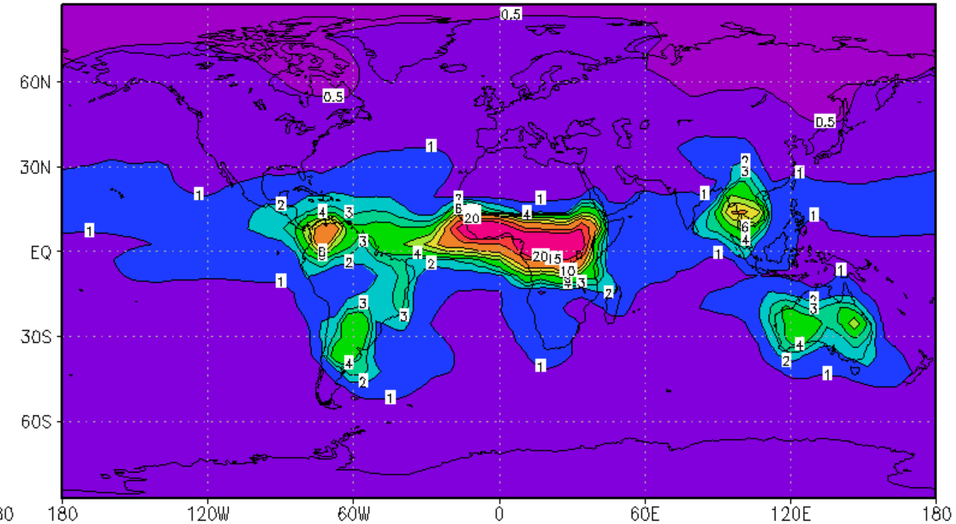
Mean Impact of Fires: NOy Deposition



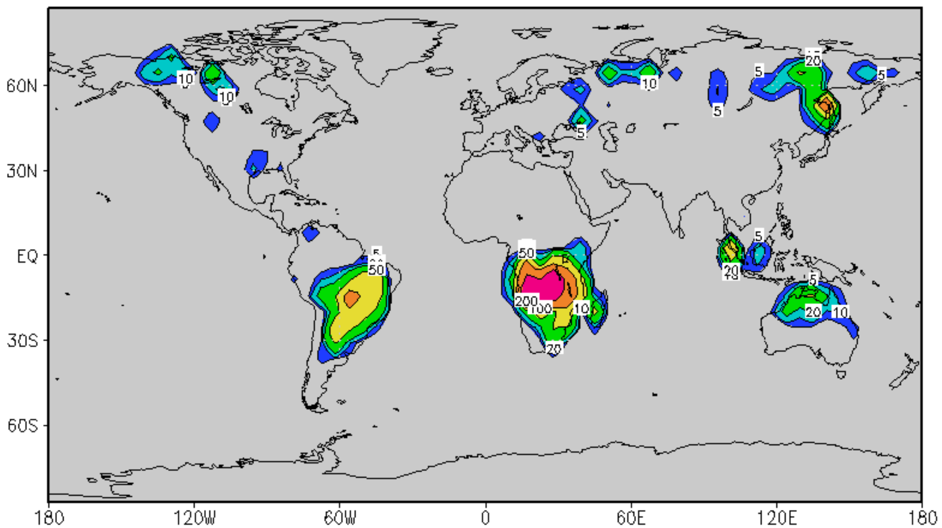
Mean Impact of Fires: Surface Ozone

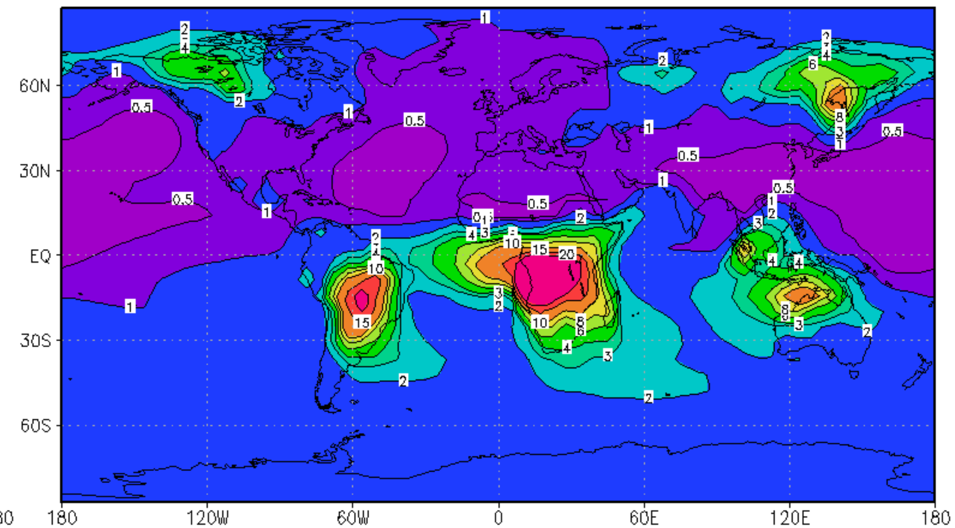
January





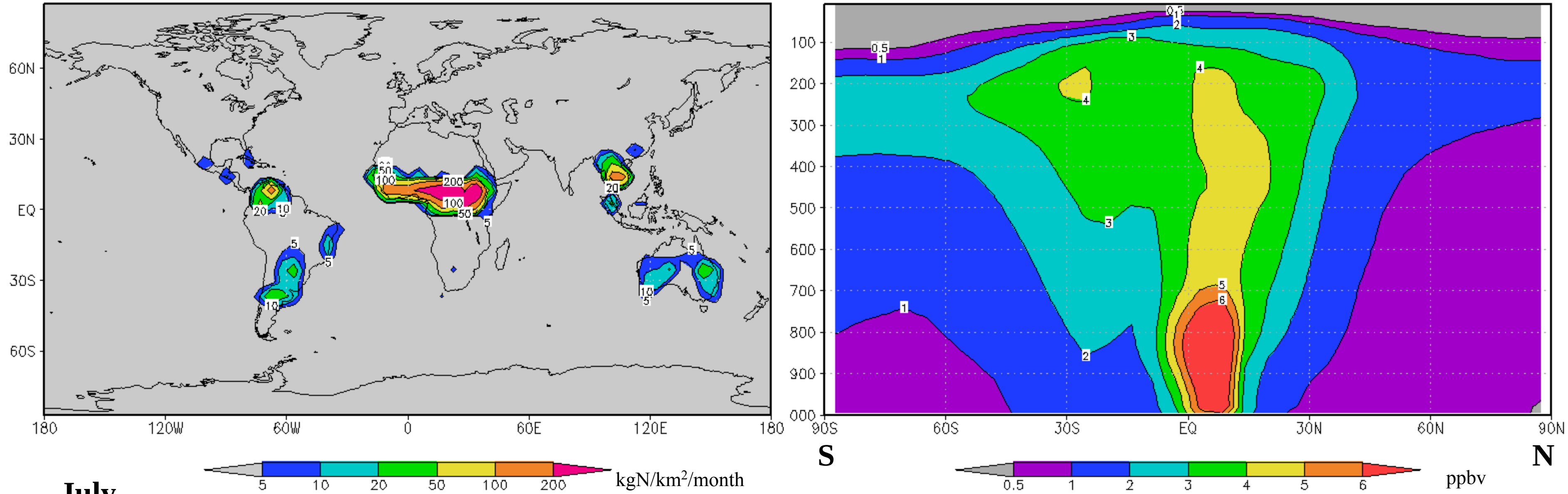
July



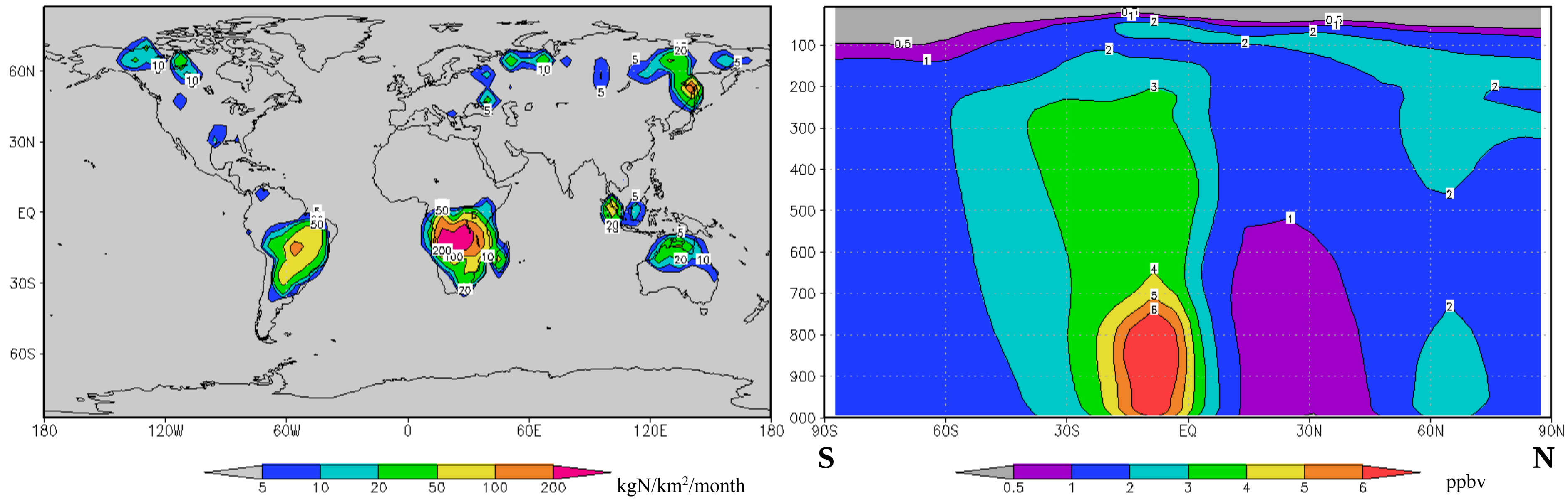


Mean Impact of Fires: Zonal Ozone

January



July



Global Response to Fires

- Impact on Tropospheric Budgets

	With Fires	Without Fires	Δ
O_3 Burden (Tg)	322	303	6%
O_3 Production (Tg/yr)	5070	4490	10%
Net O_3 Production (Tg/yr)	290	190	
O_3 Deposition (Tg/yr)	900	810	10%
NO_y Deposition (Tg/yr)	50.1	39.9	20%
CH_4 lifetime (yr)	8.4	8.5	

Features not included here…

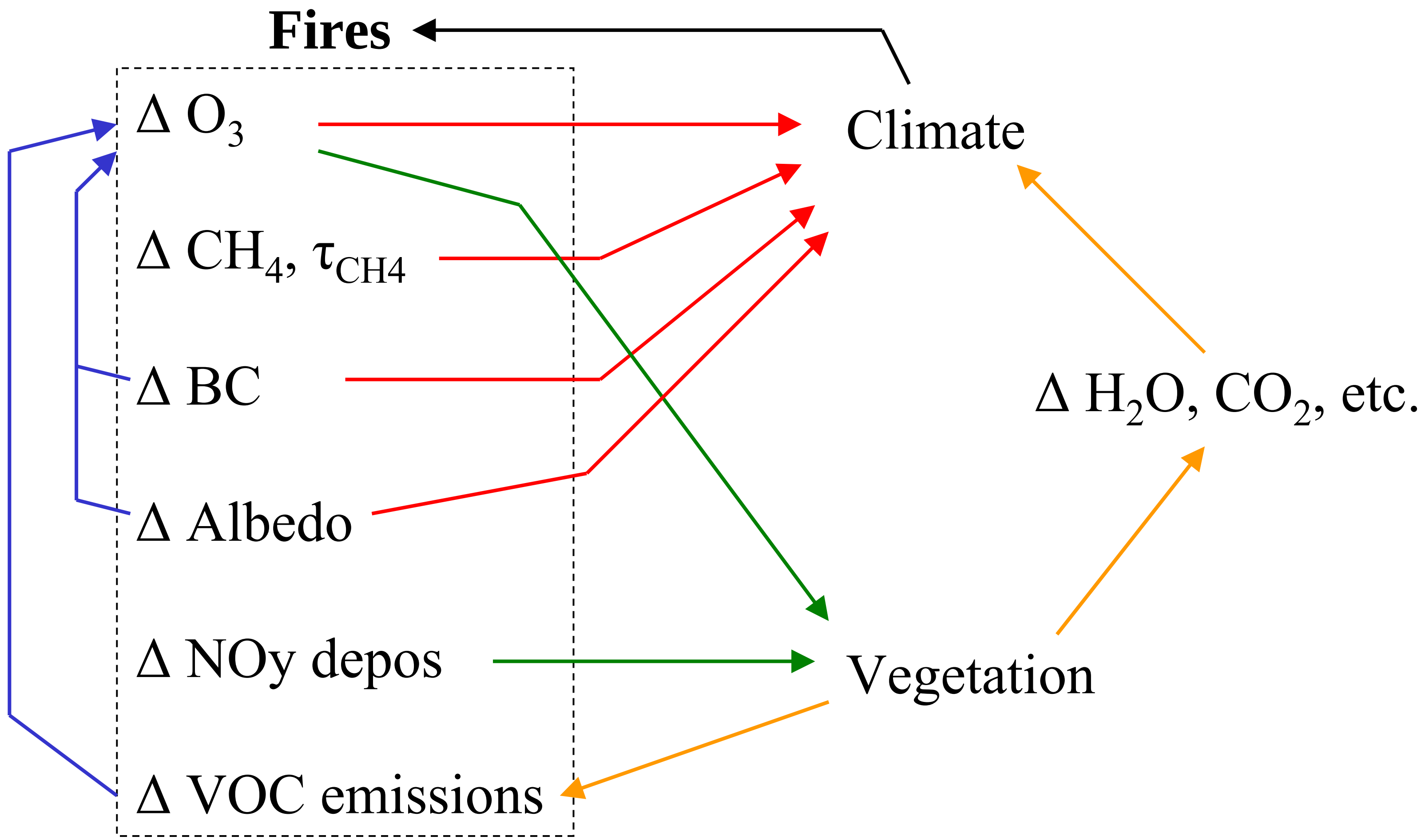
- Strongly episodic nature of fires
  - Mean emissions distributed over a month (overestimate influence)
- Self-lofting of emissions into free troposphere
  - Emissions only injected into boundary layer (underestimate extent)
- Surface changes following fires
  - Reduction in biogenic VOC emissions
  - Changes in deposition processes
  - Reduced albedo over burn scars affecting photolysis rates
  - Reduced albedo due to soot over snow/ice surfaces
- Chemistry-Aerosol interactions
  - Scattering/absorption effects associated with smoke plume
  - Heterogeneous chemistry on aerosol particles

Earth System Interactions

- Climate: radiative impacts
  - Increased O_3 and Aerosol, but reduced CH_4 lifetime
  - Albedo changes: effect radiation and chemistry

- Potential feedbacks through
  - Sensitivity of fire ignition to climate through drought, lightning
  - Surface O_3 – vegetation damage – VOC emissions, CO_2
  - NO_y deposition – fertilization effects – VOC emissions, CO_2

Earth System Interactions



Summary: Requirements for Fire Emissions

- Magnitude of emissions
  - NO_x, CO, VOCs, BC/OC and appropriate speciation
- Timing of emissions
  - Episodic in nature
  - Evolution in magnitude, intensity, speciation
- Injection height
  - Self-lofting, intensity-dependence

- Current chemistry-climate models use:
  - Monthly-mean emissions climatology (still typical)
    - But daily climatology for some periods (e.g. RETRO emissions)
  - Surface-based emissions, limited lofting
  - No albedo or vegetation interactions