Urban and Biomass Burning contribution to South American aerosols

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Some important issues

• **Brazil**: 90% hydroelectric power (5% nuclear; 5% coal). All cars run on gasohol, with 22% ethanol. 34 new natural gas power plants in construction.

• **São Paulo**: 16-18 million people, 36% of Brazil GDP; 6 million autos running on gasohol. Health effects: 35,000 excess deaths per year.

• **Santiago de Chile**: Very high PM$_{10}$ (200-300 µg/m$^3$) and O$_3$ levels (120-160 ppb). 40% Chilean GDP. Copper smelters nearby.

• **Amazonia**: 5.5 millions Km$^2$, 20 million inhabitants: 90% Urban. Aerosol concentrations: 10 to 600 µg/m$^3$. Ozone: 10-140 ppb. Deforestation rate: 20-35,000 km$^2$ per year. 14% of the original area deforested.
São Paulo metropolitan area
São Paulo equivalent black carbon aethalometer PM$_{2.5}$

![Graph showing PM$_{2.5}$ concentrations from Aug-Sep/97 to Sep/00. The x-axis represents the months, and the y-axis represents concentration in ug/m$^3$. There is a notable peak in Jan-Feb/98.]
AERONET Size Distribution

Size Distributions - AERONET

Particle Diameter (mm)

(dV/dLnR)

São Paulo  México  Santiago
São Paulo quantitative aerosol source apportionment

Coarse Mode
\( (2.5 < d_p < 10 \ \mu m) \)

- Vehicle Emissions: 28%
- Oil Combustion: 18%
- Industrial Emissions: 14%
- Sulfates: 23%
- Ressuspended Soil Dust: 5%
- Ressuspended Soil Dust: 20%

- CI: 11%
- PM\(_{2.5}\): 75%
Santiago de Chile: Dry, strong and shallow inversions, Andes nearby.
Santiago de Chile: PM$_{10}$ dominated by coarse aerosol
Chemical Composition of PM$_{2.5}$ Santiago, winter 1998

- Ammonium: 17%
- Sulfate: 19%
- Nitrate: 28%
- Resuspended Dust: 5%
- Other: 2%
- EC: 12%
- OC: 17%

Average mass = 35.97 $\mu$g/m$^3$
Santiago: High As, S, Pb, Cu, Soil dust
Deforestation rates in Amazonia

Total land use change area: 14% of the 5.5 million Km²

INPE data
Aerosol Concentrations in Amazonia changes from very low values of 5-12 µg/m³ to very high 500 µg/m³ in areas affected by biomass burning.
Biomass burning plume covers millions of km²
But Not Only Smoke and Dust Absorbs Light…

Histogram of $\omega_0$ values obtained in the wet season in the Amazon (Balbina), at $\lambda = 0.55 \, \mu m$.

- **Biogenic aerosol**
  - $\omega_0 = 0.92 \pm 0.02$

- **Biomass burning (SCAR-B)**
  - Average aerosol $\omega_0 = 0.83$
Equivalent black carbon concentration and ratio to FPM

Alta Floresta black carbon fine mode aerosol 1992-2001

Black carbon concentration (ng/m³)

Alta Floresta ratio black carbon to fine mode aerosol 1992-2001

Ratio EBC/FPM (%)
Role of Tropical Convection in Long Range Transport
Aerosol Optical Thickness in Amazonia

AOT at 500 nm

- Rio Branco: Oct 99 - Jul 01
- Balboa: Oct 99 - Jul 01
- Alta Floresta: Jan 99 - Jul 01
- Rondonia: Jan 1999 - Jul 2001

AOT at 500 nm:
- Manaus
- Trujillo
- Lima
- Bogota
- Caracas
- Cali
- Rio Branco
- Amazonas
- Roraima
- Amazonas
- Santarem
- Manaus
- Rio Branco
- Rondonia
- Trujillo
- Lima

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Aerosols and radiation in Amazonia
Instantaneous shortfall of 150-350 W/m²

<table>
<thead>
<tr>
<th>AOT (500 nm)</th>
<th>Fraction of background</th>
<th>Shortfall (W/m²)</th>
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<tbody>
<tr>
<td></td>
<td>Amazonia avg.</td>
<td>África avg.</td>
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<tr>
<td>0.5</td>
<td>0.91</td>
<td>0.87</td>
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<th>Single Scattering albedo (\omega_0)</th>
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<tr>
<td>Alta Floresta</td>
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<td>(\omega_0)</td>
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Joel Schaffer et al., 2002
Cloud-aerosol-mediated feedback loop on forest carbon uptake

Adapted from Jose Fuentes, 2002
Clear day

Visibility ~ ??? km
N_{CN} ~ 500 \text{ cm}^{-3}
CCN ~ 50-200 \text{ cm}^{-3}
BC ~ 0.1-0.2 \mu g \text{ m}^{-3}

Smoke day

Visibility ~ 800 m
N_{CN} ~ 10,000 \text{ cm}^{-3}
CCN~3,000-6,000 \text{ cm}^{-3}
BC ~ 7-20 \mu g \text{ m}^{-3}
Low cloud top height, warm rain, little ligniting, efficient precipitation mechanism
Amazon Basin Dry Season Cloud Structure

(Danny Rosenfeld, personal communication).
Are cloud properties changing in Amazonia because of the occupation process? 

Amazon Basin cloud effective radius (*)

Years: 1984 to 1996

Effective cloud particle radius (µm)

Wet Season

Dry Season

(*) AVHRR analysis by T. Nakajima