Review of the 2012 Smoke Pollution Fatalities Assessment

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- Summary of DS 2010 presentation
- Objectives of Johnston et al
- Methodology of Johnston et al
- Results of Johnston et al
- Technical challenges
- Conclusions

Summary of DS 2010 presentation

- Vegetation fires are a global problem
- Smoke from vegetation fires contain hundreds of chemical compounds
- Fine particles are major constituents of forest fires and the only ones that have been and are being studied
- Adverse health impacts of fine particulate matter include respiratory and cardiovascular ailments, increased emergency department visits and premature death
- Vegetation fire PM concentrations can exceed WHO guideline values by an order of magnitude
- Studies addressing the health effects of smoke from vegetation fires are urgently needed

Mortality attributable to smoke from vegetation fires

Estimated Global mortality Attributable to Smoke from Landscape Fires

Johnston FH, Henderson SB, Chen Y, Randerson JT, Marlier M, DeFries RS, Kinney P, Bowman DMJS, Brauer M

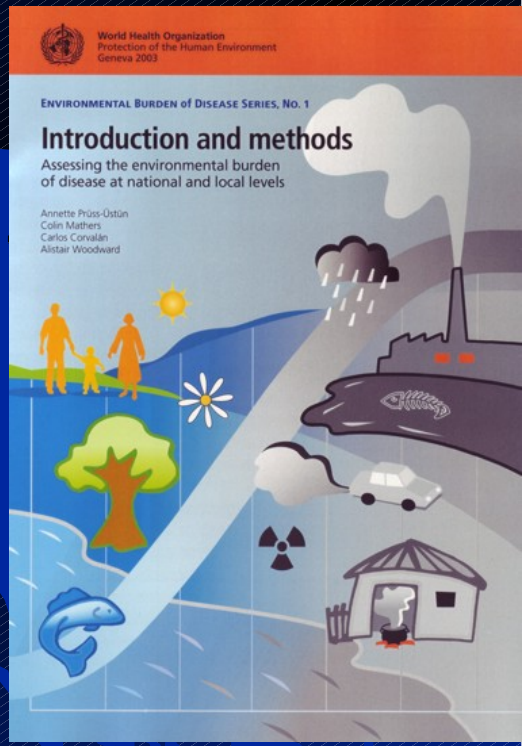
Environmental Health Perspectives 120(5): 695-701
and
Supplemental Material

Background and Objective of Johnston et al paper

- Vegetation fires emit approximately $2 \cdot 10^{15}$ g C annually
- Emissions from vegetation fires affect radiative forcing and hydrological cycles
- Emissions from vegetation fires cause episodes of severe air pollution that impact both in developed and developing countries
- Health impacts of vegetation fires are rarely assessed in quantitative terms
- The objective of the paper is to assess the annual global mortality attributable to vegetation fire events

Methodology of Johnston et al (1)

- WHO Global Burden of Disease Comparative Risk Assessment framework to evaluate the annual all-cause mortality attributable to PM
- Use of recent epidemiological evidence and exposure assessment methods
- Exposure estimates: global fire activity, geographic area burned, type of vegetation burned – GEOS 3-D chemical transport model



- Input of GEOS model: emissions from (1) all sources; (2) without vegetation fire emissions
- Combination of output from chemical transport model with measurements of aerosol optical thickness to estimate annual $PM_{2.5}$ emissions from vegetation fires
- Scaling of $PM_{2.5} = (2*GEOS + MODIS + MISR)/4$

Methodology of Johnston et al (2)

- Country-specific estimates from all-cause all-age mortality from WHO Global Health Observatory
- Emissions for BC (3.9 Tg/a) and OC (33 Tg/a) which are 40% above those quoted by Andrae & Merlet (2001), Bond et al (2004), van der Werf et al (2006) but below those of Chin et al (2009)
- Classification of WHO sub-regions according to pattern of exposure: short-term – "sporadically"; long-term – "chronically"
- Increase in all-cause mortality due to short-term exposure: 0.11% per 1 µg $PM_{2.5}/m^3$
- Increase in all-cause mortality due to long-term exposure: 0.64% per 1 µg $PM_{2.5}/m^3$
- Sensitivity analyses

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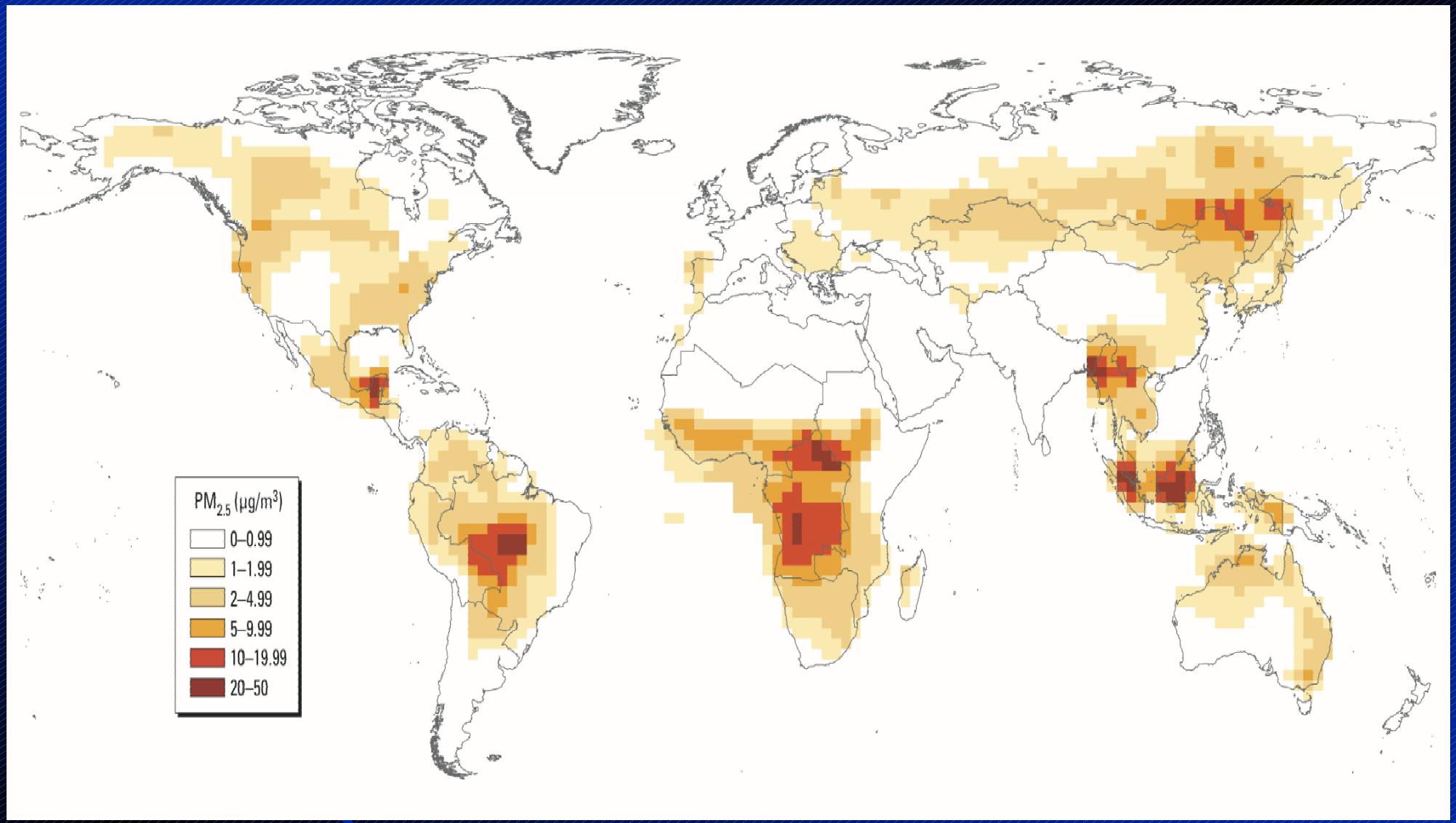
Results of Johnston et al

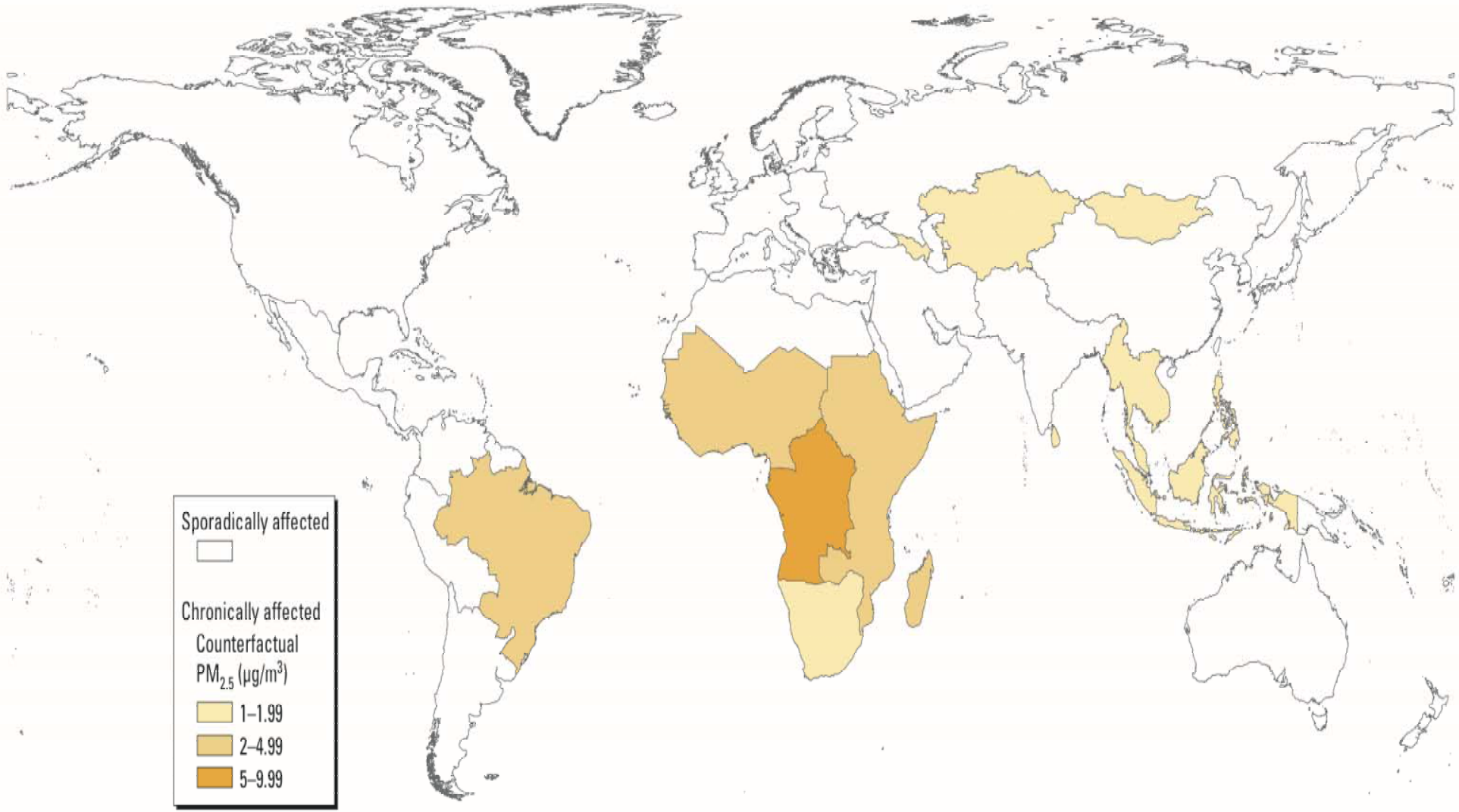
- Estimated annual $PM_{2.5}$ concentrations 0-45 µg $PM_{2.5}$ / m^3
- Population-weighted annual average range from 0.2 µg $PM_{2.5}$ / m^3 (Caribbean) – 12.2 µg $PM_{2.5}$ / m^3 (SSA)
- Population-weighted annual average of days over 5 µg $PM_{2.5}$ / m^3 range from 6 (Caribbean) to 141 (SSA)
- Annual deaths attributable to exposure to $PM_{2.5}$ from vegetation fires

Scenario	Global	Sub-Saharan Africa[a]	Southeast Asia[b]	South America[c]
Annual average (1997-2006)	339,000	157,000	110,000	10,000
EL Niño year (September 1997-August 1998)	532,000	137,000	296,000	19,000
La Niña year (September 1999-August 2000)	262,000	157,000	43,000	11,000

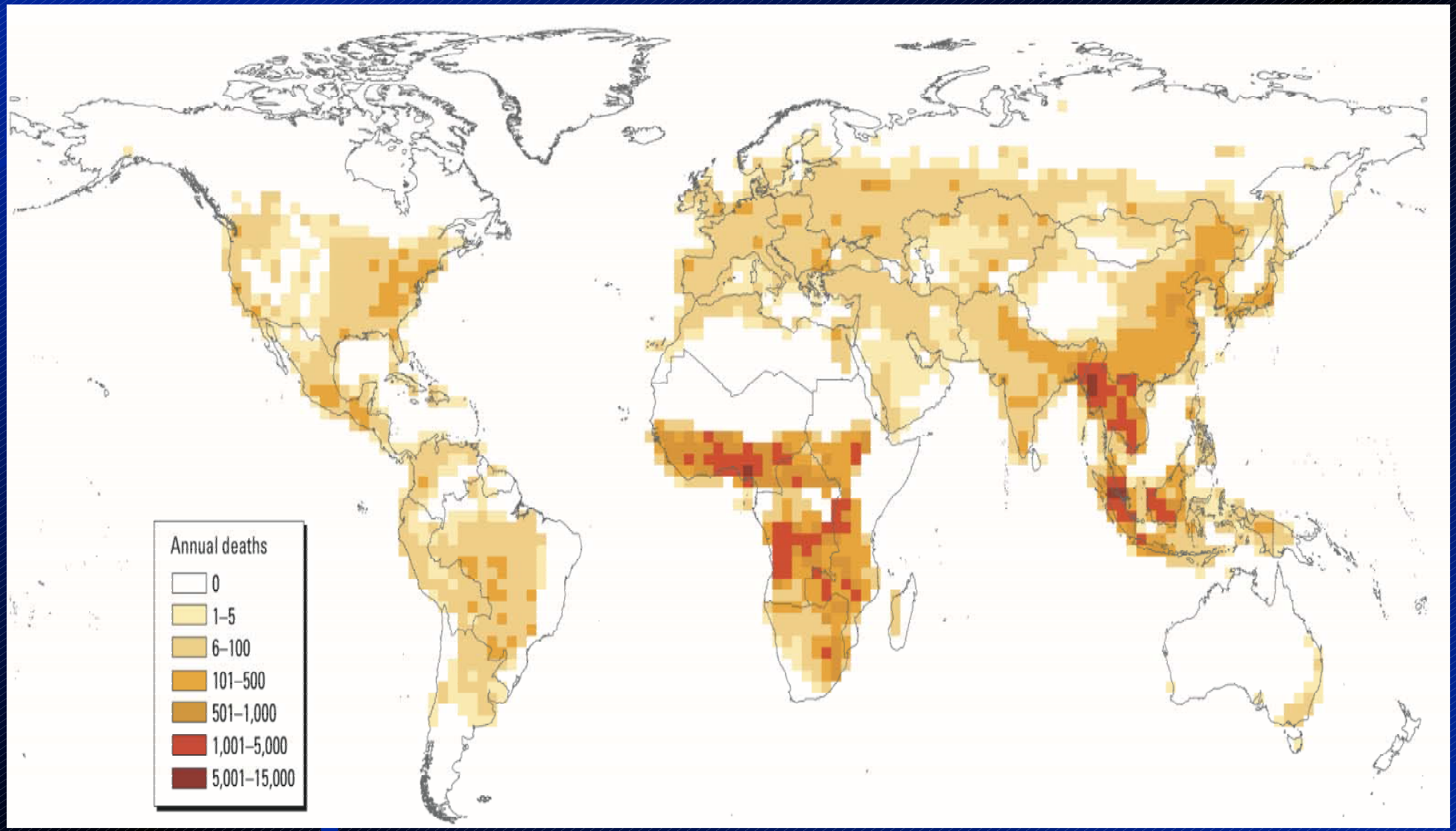
Estimates of annual $PM_{2.5}$ concentrations (GEOS-Chem, MODIS, MISR)



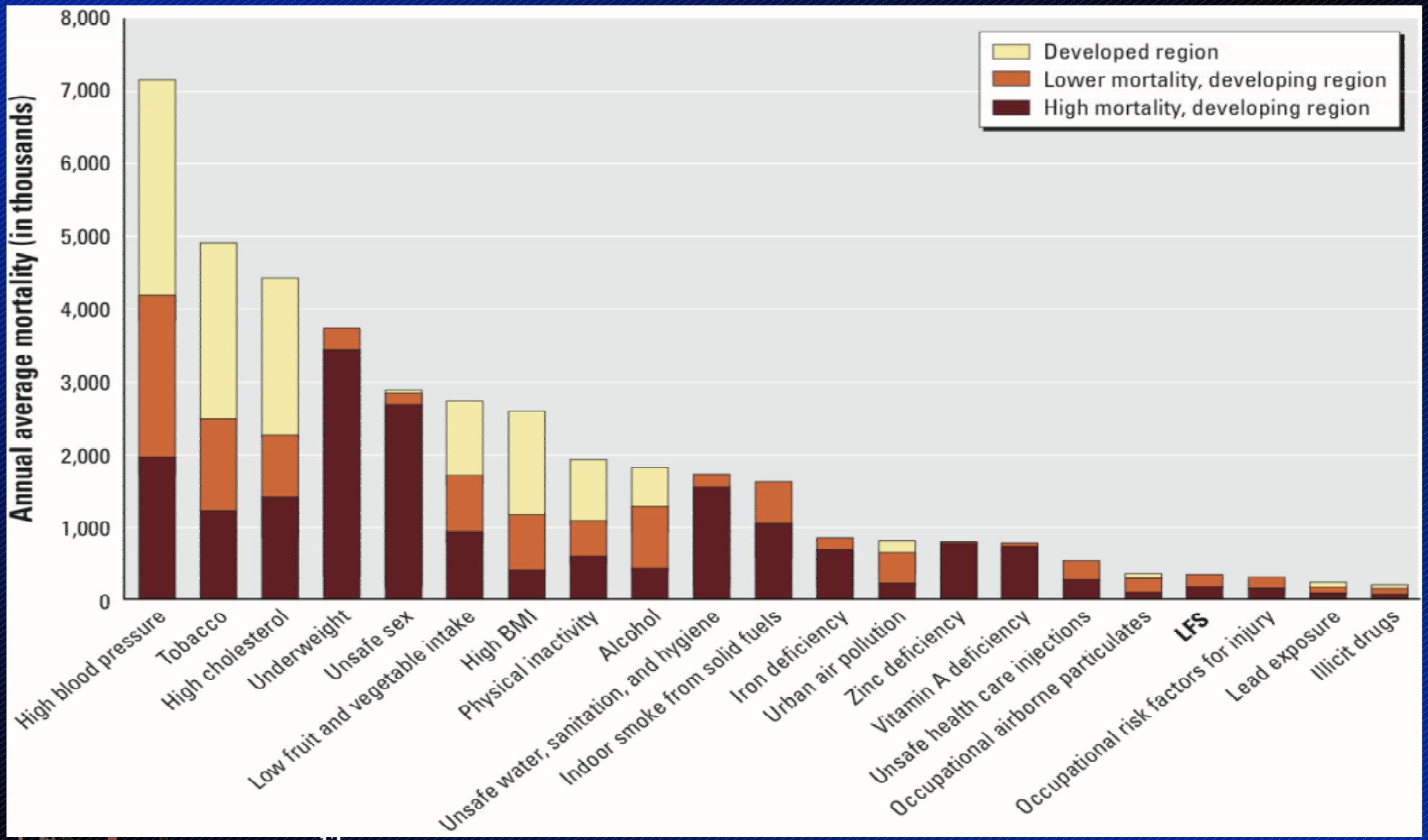
WHO sub-regions impacted by short-term and long-term exposure



Global annual mortality attributable to vegetation fire events



Comparison of mortality attributable to various risk factors



Comparison with WHO estimates for the global burden of disease due to air pollution

Scenario	Global	Sub-Saharan Africa[a]	Southeast Asia[b]	South America[c]
Annual average (1997-2006)	339,000	157,000	110,000	10,000
EL Niño year (September 1997-August 1998)	532,000	137,000	296,000	19,000
La Niña year (September 1999-August 2000)	262,000	157,000	43,000	11,000

Inter-quartile range: 260,000-600,000 per year

Outdoor air pollution: 800,000 per year (mostly urban, exposure throughout)

Indoor air pollution: 1,600,000 per year (mostly rural, women and infants, exposure throughout)

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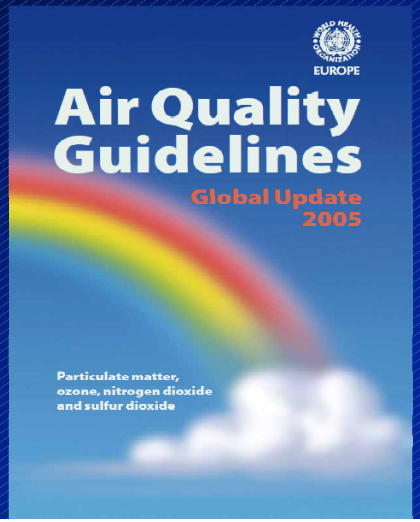
Technical challenges in studying health impacts

- Estimation of exposure to $PM_{2.5}$
- Selection of the most appropriate exposure-response function
- Consideration of theoretical minimum exposure values ("counterfactual exposure")
- Many uncertainties (models, limited health impact data, baseline death rates, composition of smoke)
- Vegetation fire PM concentrations can exceed WHO guideline values by an order of magnitude

Time Average	PM_{10} [µg/m³]	$PM_{2.5}$ [µg/m³]
24-hour	50	25
Annual	20	10



Conclusions

- Estimations are conservative with respect to exposure-response relationship between $PM_{2.5}$ and mortality
- Inter-quartile range of estimates is large: 260,000-600,000 death estimates
- Estimates depend decisively on reliability of vegetation fire BC, OC, $PM_{2.5}$ emission factors
- Models for $PM_{2.5}$ estimation currently cannot be validated by ground-level monitoring of $PM_{2.5}$
- Estimation does not consider
  - demographic statistics (e.g. gender, rural-urban)
  - age distribution of exposed people (including e.g. baseline child and adult mortality)

Thank you