The Role of Satellite Observations in Assessing Impacts of Wildfire Occurrence on Respiratory Health of Population

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Outline

- Wildfire and human health
- Interdisciplinary work: all pieces of the puzzle
- Role of fire satellite data and information in emissions modeling
- Concluding thoughts
Wildfire and Health:
Wildfire PM toxicity

- Wildfire PM contains chemical components that are toxic to the lung and especially to alveolar macrophages.

- Wildfire PM appears to be more toxic to the lung than equal doses of PM collected from ambient air from the same region during a comparable season.
Study area: San Diego county, CA
Fire occurrence between 2003 and 2008
Wildland fire impacts large areas

Station Fire August 30, 2009 in Acton, California. (Justin Sullivan/Getty Images)
Smoke plumes and air quality

2007 fires on MODIS image

Wildfire and Health  Interdisciplinary work  Satellite data  Conclusions
Wildland fire: impact on air quality

A pyrocumulus cloud over Downtown Los Angeles (Michael Castillo)
Fire occurrence – Emissions - Health

Wildfire Activity → Particulate Emissions (PM$_{10}$ and PM$_{2.5}$) → atmospheric transport → Health Services Provider → Hospital Outcomes

Wildfire and Health  Interdisciplinary work  Satellite data  Conclusions
Doing Interdisciplinary Research: collecting all pieces of the puzzle
Fire occurrence – Emissions - Health

Wildfire Activity
Particulate Emissions (PM\textsubscript{10} and PM\textsubscript{2.5})
atmospheric transport
visits
Health Services Provider
Hospital Outcomes

Wildfire and Health  
Interdisciplinary work  
Satellite data  
Conclusions
Work and data flow

Burn area, Fuels, Fuel moisture, Emission factors

Emissions modeling
Location and amount of particulate matter emitted from wildland fires

WFEIS

Particulate emissions from wildfire

Meteorological data

HYSLIP

Atmospheric modeling
Where particulate emissions travel

Wildfire-related particulate emission concentrations w/in San Diego County

Day-of-week indicators
Subregional area indicators
Population age
Population income
Anthropogenic PM
Weather metrics

Explanatory variables

Stats model development

Predictive models connecting wildfire emissions to health

Statistical Modeling
Output model shows relative amount by which each variable influences the likelihood of seeking ED care

Syndromic surveillance
Number and location of emergency department visits w/ relevant symptoms

ED visits with wildfire-related symptoms

Response variable

Climate change scenarios

Interdisciplinary work

Wildfire and Health

Conclusions

Satellite data
Role of Satellite Fire Data
Quantifying wildfire emissions

- Burn area
- Fuels
- Fuel moisture
- Emission factors

Emissions modeling
Location and amount of particulate matter emitted from wildland fires

WFEIS

Particulate emissions from wildfire

Wildfire and Health  Interdisciplinary work  Satellite data  Conclusions
Decomposing fire events using MODIS data products

- MODIS active fires
  - FSR
    - Clustered detections
      - First day burning
      - Subsequent day burning
        - MODIS/Landsat burned area
          - Fire progression within a scar
          - Point source burning
          - Residual burning

Wildfire and Health  Interdisciplinary work  Satellite data  Conclusions
Information from active fires

MODIS active fire detections clustered by the FSR algorithm

Landsat ETM+ image path 122 row 16 from 08/19/02

- Fire detections
- Projections of fire detections on the respective axes

Wildfire and Health Interdisciplinary work Satellite data Conclusions
Characterizing burning process: point source burning

Mapped burned scars

- Fire detections without a corresponding burned scars
Characterizing burning process: fire progression in scars

2007 fire scars

Modeled date of burning

- Oct 21
- Oct 22
- Oct 23
- Oct 24
- Oct 25
- Oct 26
- Oct 27
- Oct 28
- Oct 29

0 20 km

Wildfire and Health  Interdisciplinary work  Satellite data  Conclusions
Characterizing burning process: residual burning

2007 fire scars

Modeled date of burning:
- Oct 21
- Oct 22
- Oct 23
- Oct 24
- Oct 25
- Oct 26
- Oct 27
- Oct 28
- Oct 29

Residual burning by date:
- Oct 22
- Oct 23
- Oct 24
- Oct 25
- Oct 26
- Oct 27
- Oct 28
- Oct 29
Spatially and temporally explicit emissions estimates (WFEIS)

Sample WFEIS output, showing PM-10 emissions from burn scars from October to November 2007 in San Diego County.

Wildfire and Health Interdisciplinary work Satellite data Conclusions
Atmospheric transport & dispersion modeling

- Example particulate concentrations estimated by HYSPLIT

- Red areas are fires in October 2003
- Modeled smoke plume is shown in blues & greens
- Red circles show locations of air quality stations

Wildfire and Health Interdisciplinary work Satellite data Conclusions
Modeling PM concentrations

The HYSPLIT model was run for 3 days after emission:

- In the dispersion mode
- Traced PM2.5 and PM10 particles
- No deposition allowed
Respiratory Related Encounters at Participating Emergency Departments*

August 1 to December 31, 2007

*San Diego Aberration Detection and Incident Characterization (SDADIC)

Wildfire and Health  Interdisciplinary work  Satellite data  Conclusions
Total Medical Examiner Deaths by Day of Death, 2003 (preliminary data)

Wildfire and Health
Interdisciplinary work
Satellite data
Conclusions
Modeling hospital visits in San Diego County for 2007

Wildfire and Health    Interdisciplinary work    Satellite data    Conclusions
Modeling hospital visits in San Diego County for 2007: sub regions
Concluding thoughts

- **We know:**
  - Wildfire releases strong toxins which affect respiratory health
  - Young people (< 24 years) are more sensitive to smoke impacts (in our study)

- **New research shows:**
  - wildfire impacts cardiovascular health
  - indoor concentrations of wildfire PM is near-equivalent to outdoor concentrations
Concluding thoughts II

- Satellite data provide critical and virtually unavailable from other sources information for tracking fire impacts.
- Studies of environmental impacts on health (present and future) involve multi-disciplinary teams of researchers.
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