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# Linking Climate, Environmental Exposure, and Health Data: Case Study and Data Ecosystem Development

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NASEM Action Collaborative Symposium on Disaster Data Science  
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## Primary Problem

*Timely and effective use of available **earth and atmospheric observations, environmental monitoring, and personal data sources** in combination with health data to improve response, recovery, and future preparedness.*



Satellite Data



Environmental &  
Exposure Data



SDOH and Neighborhood  
GIS data



Mobile & Digital Data



Electronic Health  
Records (EHRs)



Epidemiologic and  
Population Health Studies

# Science for Disaster Reduction (SDR): Geo and Health Data Integration Working Group

***Goal: Combining earth and atmospheric observations, stationary monitoring, personal monitoring, and health data to improve response, recovery, and future preparedness***

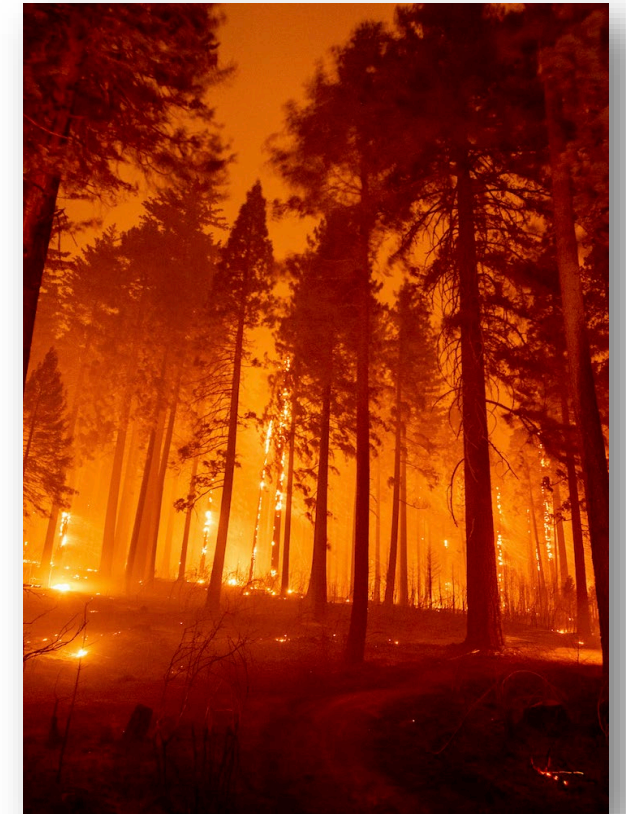
## **OSTP Interagency Working Group Chaired by NIEHS & NASA (8/21-6/22)**

- 48 participants from 16 agencies and partner organizations

### **Used a wildfire scenario in Sonoma County, CA to:**

- Evaluate capacity to collect, share, integrate, and communicate diverse data streams
- Strengthen data-focused collaborations to address priority issues
- Map out data gaps, challenges, and opportunities for reducing acute and longer-term health impacts

**SDR Publication *pending*: <https://www.sdr.gov/index.html>**



## Working Group Workflow and Products

- 1. Questions List**
- 2. Data Sources Roster**
- 3. Literature Review**
- 4. Conceptual Site Model**
- 5. Pilot Data Integration**



## 1. Questions List

*Goal: Identify high-priority questions and issues of concern from member agencies*

Example Questions / Concerns

### Geophysical Concerns

- Predicting fire airborne exposures and spread
- Drinking and surface water contamination
- Air exposures from surface to upper atmosphere
- Assessing impacts between weather and fire progression

### Health Concerns

- Risks from contaminated playgrounds and schools
- Food and crop hazards from ingestion
- Cardiorespiratory/mental health effects of wildfires
- Risk to workers and others involved in clean-up

## 2. Data Sources Roster: Exposure (45) and Health (39)

**Goal: Catalog known state and federal databases to answer high-priority questions**



USGS

- LandFire
- Monitoring Trends in Burn Severity
- Emergency Assessment of Postfire Debris Flow



NOAA

- National Digital Forecast Database
- National Weather Service Spot Forecast
- NOAA Operational Model Archive and Distribution System
- Wildfire Emission Factors
- Wildfire Air Quality Impacts



NASA

- Land Atmosphere Near Real Time Capability
- FIRMS
- Lance
- Disaster Portal



EPA

- EJ Screen
- Fire & Smoke Mapping Tool
- Air Quality System (AQS)



CDC

- Social Vulnerability Index
- Public Health Tracking Network
- WONDER

## 2. Data Sources Roster: Example Data Sources

Agency/Organization	Resource Name	Scale Level	Data Description	Variable Indicator Examples (But not limited to)	Timeframe	Frequency of Updates	Data Access
NASA	<a href="#">Global Wildfire Information System</a>	N/A	Joint Initiative of the GEO and the Copernicus Work Programs, aims at bringing together existing information sources at regional and national level in order to provide a comprehensive view and evaluation of fire regimes and fire effects at global level and to provide tools to support operational wildfire management from national to global scales.	Historical data, Forecast, Damage assessment	2001-Present	Varies	Public
NOAA	<a href="#">Meteorological Assimilation Data System (MADIS)</a>	N/A	The MADIS Application Program Interface (API) is a library of subroutines, callable from Fortran, which provides access to all of the observation and quality control (QC) information in the MADIS database (referred to as the "FSL database" in the API documentation), and/or other supported meteorological databases (i.e., the NWS AWIPS netCDF database).	N/A	Historical	N/A	Public/Requires DUA
Health - National Level							
AHRQ	<a href="#">Healthcare Cost and Utilization Project (HCUP)</a>	N/A	A family of databases, software tools and related products developed through a Federal-State-Industry partnership and sponsored by AHRQ. Derived from administrative data and contain encounter-level, clinical and nonclinical information including all-listed diagnoses and procedures, discharge status, patient demographics, and charges for all patients.	Adult and pediatric ICD-10-CM/PCS diagnosis, procedure, External cause of morbidity codes, and patient characteristics	1988-2019	Varies ; 1-3 years	Public/Requires DUA
CDC	<a href="#">National Syndromic Surveillance System (NSSP)</a> <a href="#">Biosense/ESSENCE</a>	N/A	Electronic health surveillance data integration platform. Patient encounter data received from ED, urgent and ambulatory care centers, inpatient healthcare settings, and labs. Secure data system- must request access as data is not publicly available.	Chief Complaint, Diagnosis Discharge, EMR data from disaster medical assistance team (DMAT) operation sites	2003-Present	Within 24 Hrs of Pt Visit	Private

### 3. Scoping Literature Review (77 papers identified 1/1/2016 - 7/31/22)

***Goal: Understand adverse health effects associated with wildfires and identify environmental exposures and health data sources used to wildfire-related health effects***

#### **Common Health Outcomes**

- Respiratory
- Cardiovascular
- Perinatal health
- Mental health

#### **Health Data Sources**

- **Data from government agencies**
  - Medicare and Medicaid Claims
  - Vital records
  - CDC (WONDER, Environmental Health Tracking)
- **Hospital admissions records**
  - Emergency Department (ED) visits, prescriptions
- **Interviews or surveys**

#### **Common Exposures**

- **Smoke pollutants** (e.g., PM<sub>2.5</sub>, PM<sub>10</sub>, NO<sub>2</sub>, ozone)
- **Wildfire event**

#### **Exposure Data Sources**

- **Surface monitors**
  - EPA Air Quality System (AQS), AirNow
- **Satellite remote sensing**
  - NASA MODIS satellite instruments
- **Wildfire event data**
  - NOAA Hazard Mapping System
  - USGS Geospatial Multi-Agency Coordination (GeoMAC)
- **Models/Forecasting systems**
  - Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model

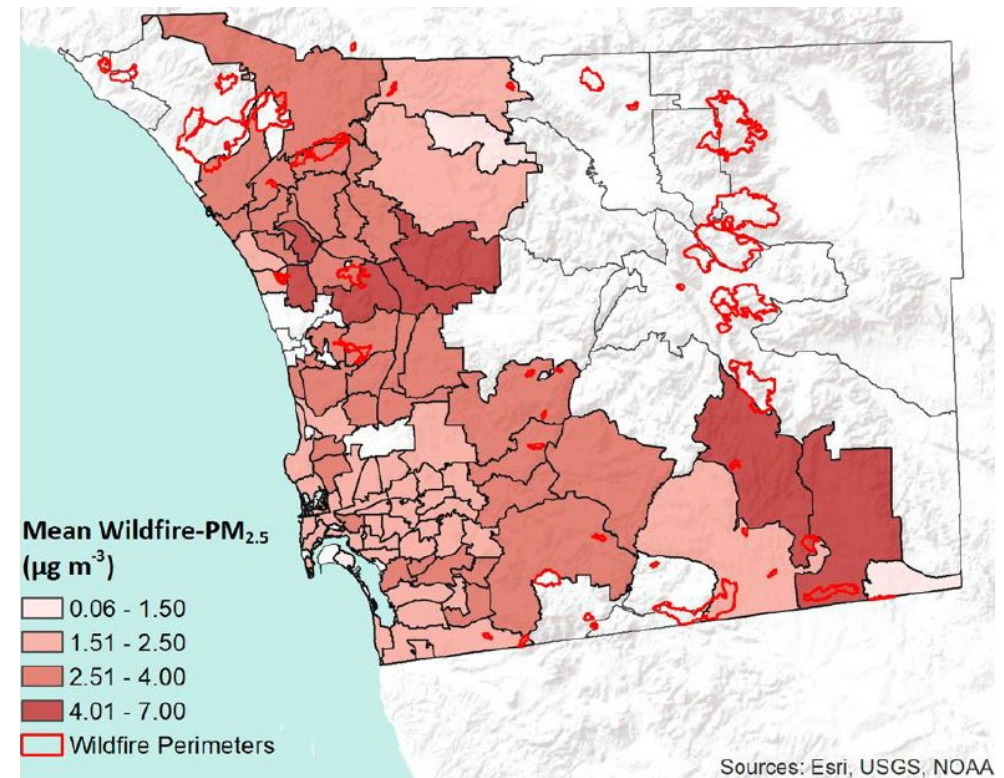
### 3. Literature Review Example: Study of Wildfire Exposures and Children's Respiratory Health in California

#### Exposure Data:

- **CA Department of Forestry and Fire Protection**
  - Wildfire events over a 7-year period
- **US EPA Air Quality System**
  - Daily zip code-specific PM<sub>2.5</sub>
- **NOAA Hazard Mapping System**
  - Daily exposure to wildfire PM<sub>2.5</sub>

#### Health Data:

- **Rady Children's Hospital Network**
  - ED and urgent care visits
  - Respiratory visits with chief complaints: difficulty breathing, respiratory distress, wheezing, asthma, or cough



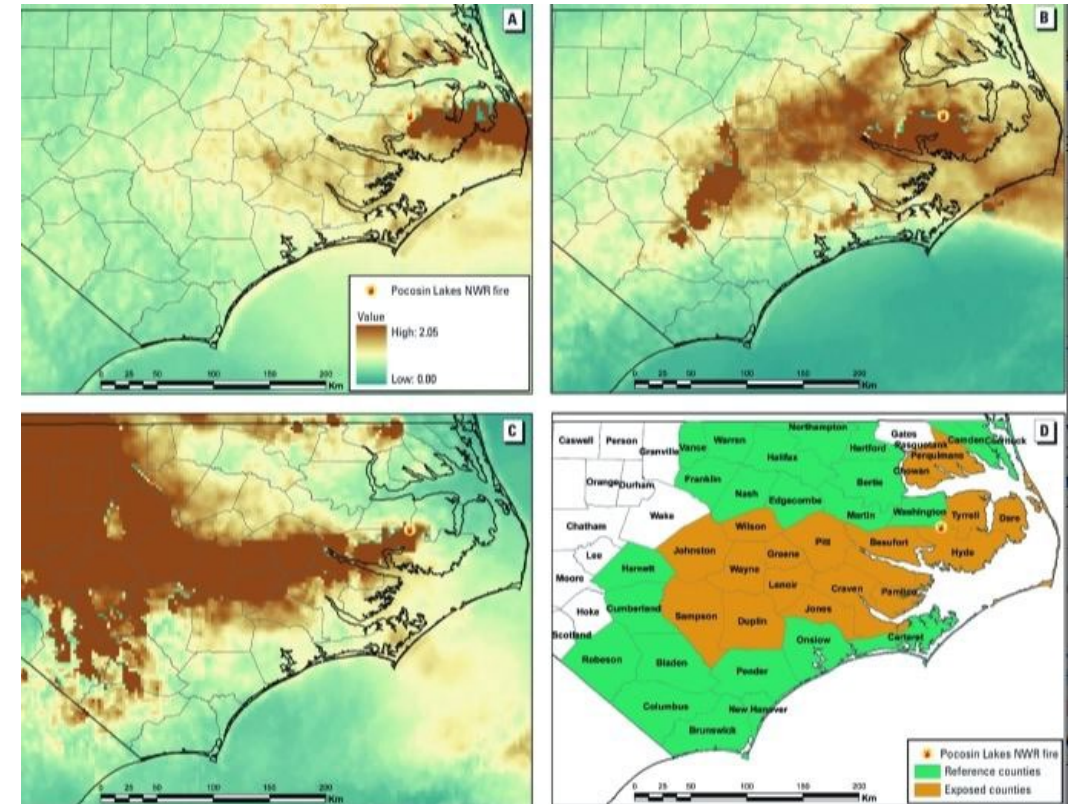
### 3. Literature Review Example: Wildfire-Related Exposures and Statewide Syndromic Surveillance Data

#### Exposure Data:

- **NOAA Geostationary Operational Environmental Satellite (GOES)**
  - Satellite measurements of aerosol optical depth (AOD)
  - 3-day window of dense smoke plume

#### Health Data:

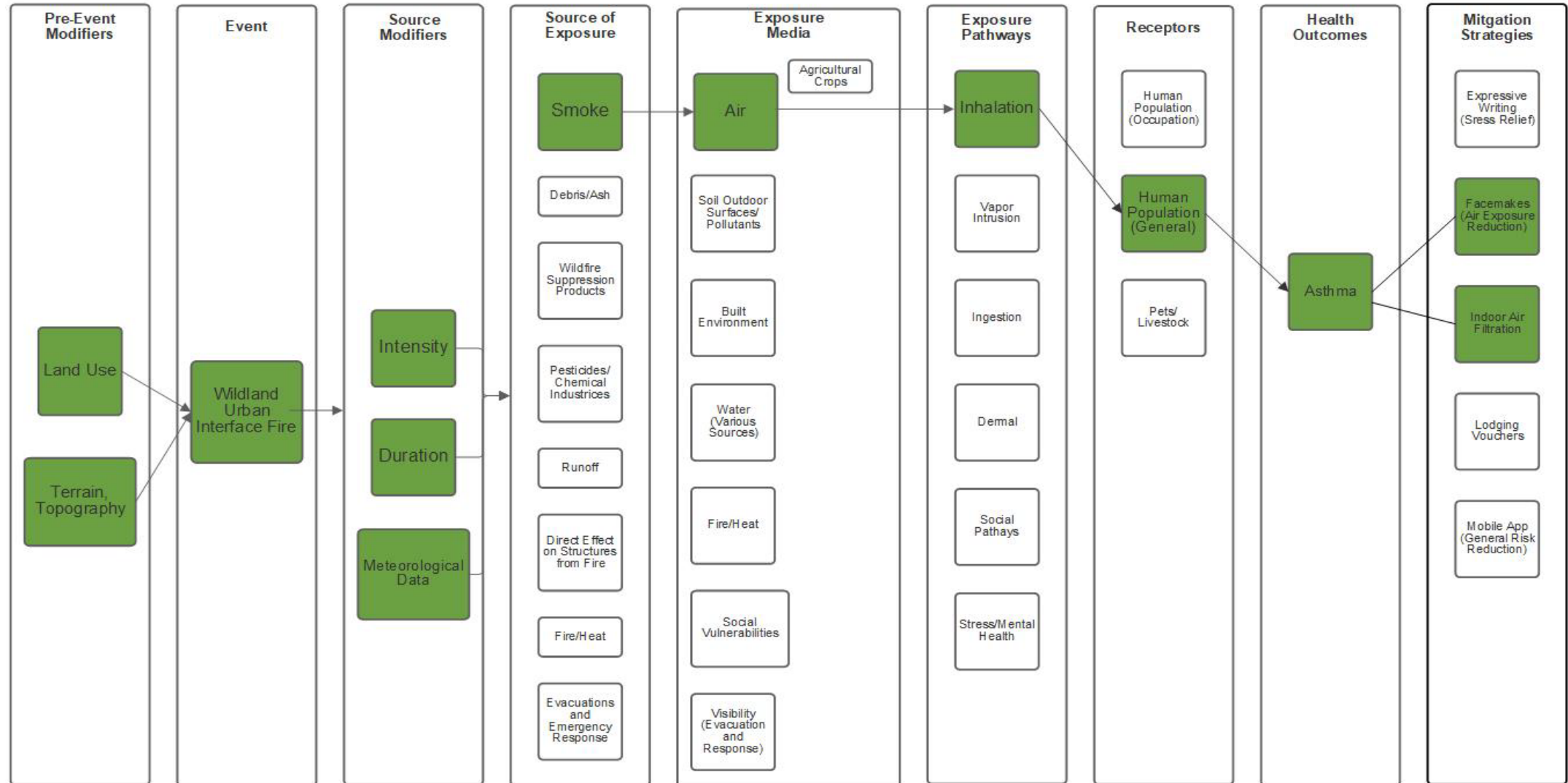
- **North Carolina Disease Event Tracking and Epidemiologic Collection Tool**
  - Syndromic surveillance program
  - Daily ED visit counts for:
    - Asthma, COPD, pneumonia, acute bronchitis and heart failure



## 4. Conceptual Site Model: Asthma Pathway

**Goal: Visualize data sources and needs over the disaster life cycle of a wildfire event**

### Conceptual Site Model



## 5. Pilot Integration of Geospatial Exposure and Health Data Streams

*Goal: Explore challenges associated with access, use, and integration of data sources*

### Legend

California 2020 Hospital Emergency Department -  
Characteristics by Facility



California 2020 Hospital Emergency Department -  
Respiratory dx

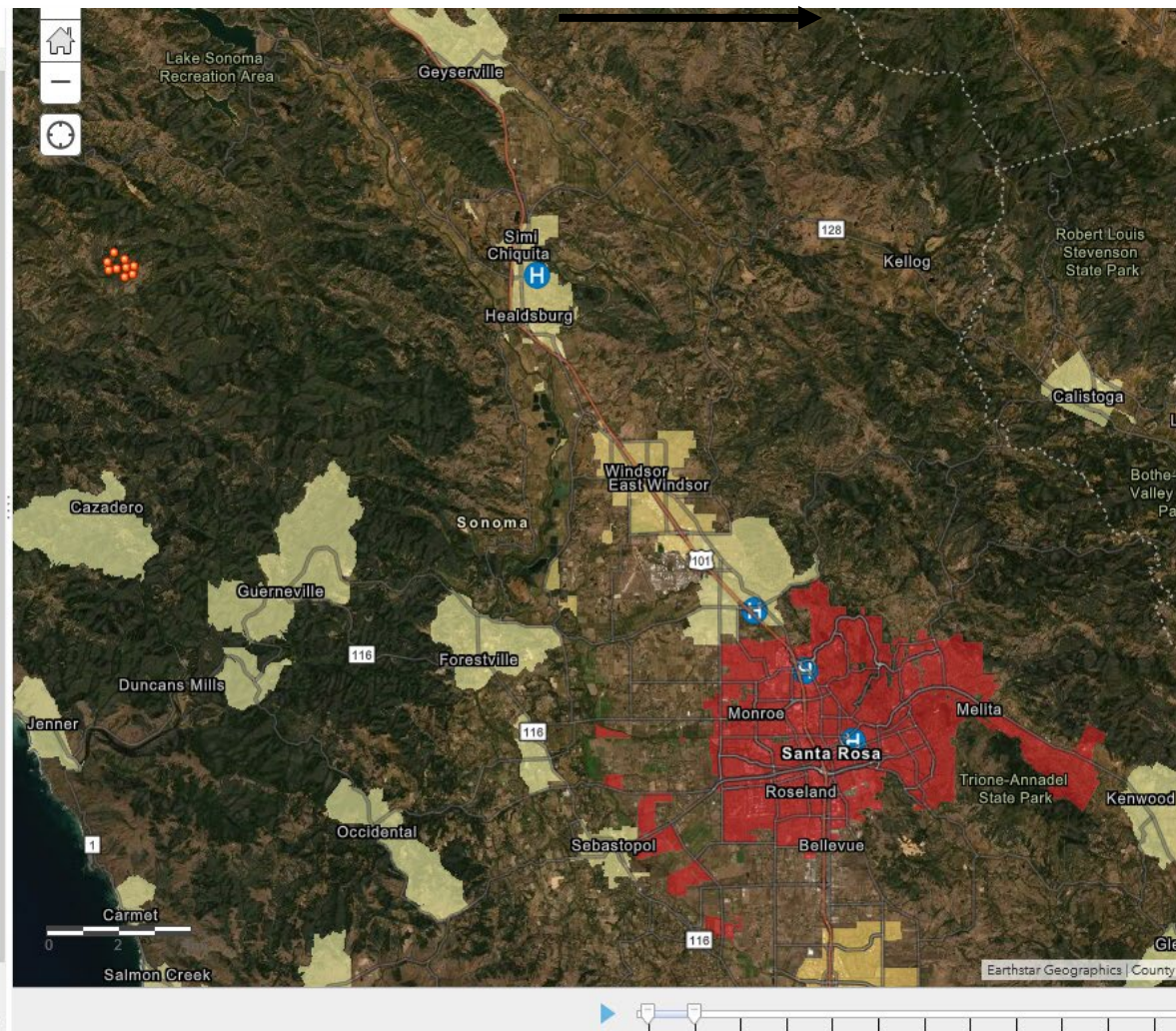
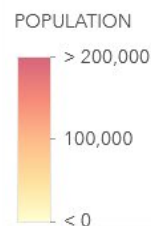
dx\_Respiratory



FIRMS Active Fire Points from 7/17/20 to 9/2/20 for the  
California Fires 2020



USA Census Populated Places



- Data streams entered into [NASA ArcGIS portal](#) for Walbridge Fire
  - Image includes Hospital ED visits with a respiratory ICD code overlaid
- Data included in Conceptual Site Model

## Barriers and Solutions for Health Research

- **Barriers**

- **Exposure data**

- Ability to use real-time wildfire smoke exposures and air pollutant data in a timely fashion
    - Little data: local/residential levels, non-air exposures, complex mixtures

- **Health data**

- Lack of real-time data
    - Challenges with data access to and sharing of electronic health records
    - Few studies using health data for longitudinal or interventions research

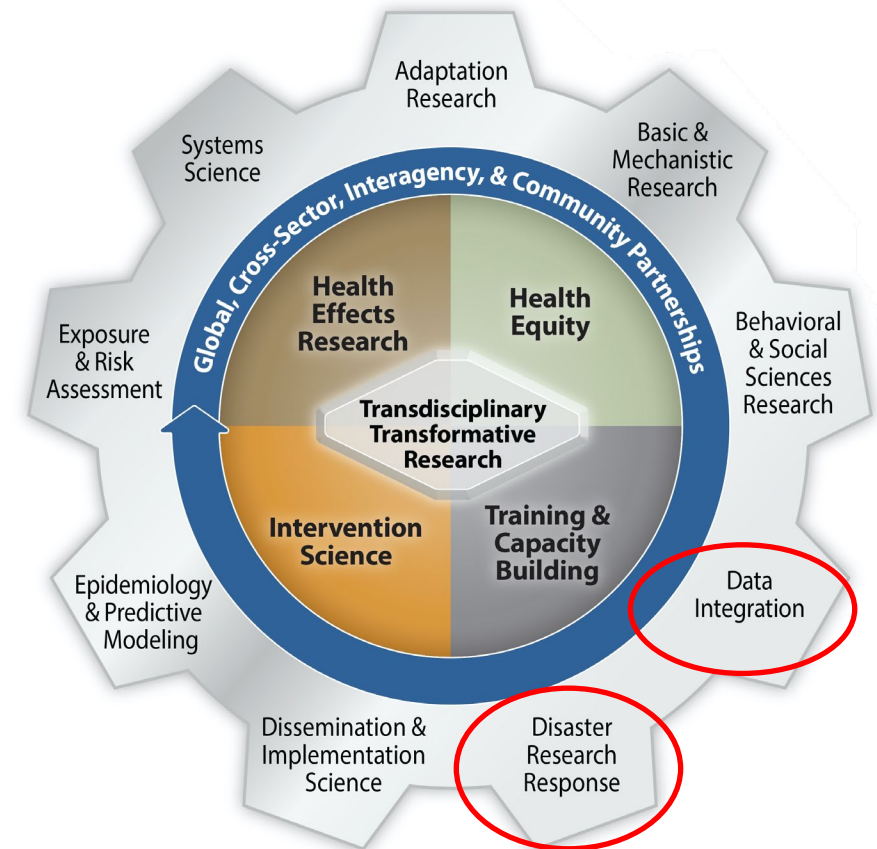
- **Solutions**

- Expand exposure assessment in the area of complex mixtures and all routes of exposure
  - Establish working relationships with data stewards for relevant data sources
  - Invest in integrating data sources for surveillance and research

# NIH Climate and Health Outcomes Research Data Systems (CHORDS) (March 2023)

## *Nexus of Climate Change & Extreme Weather Events Disasters & Data Integration*

- Funded by HHS Patient Centered Outcomes Trust Fund (PCORTF)
  - Portfolio of HHS projects that build data capacity for conducting patient centered outcomes research (PCOR)
- Path forward for the SDR efforts



## CHORDS Project Concept: Wildfire Focus

### Environmental Data Sources

PM 2.5  
VOCs  
PAHs  
Ozone  
AQI  
Temp  
Humidity  
Wind  
Trees  
Fires  
Smoke  
GPS data



Satellite Data



Environmental & Exposure Data



SDOH and Neighborhood GIS data



Mobile & Digital Data

### CHORDS DATA INTEGRATION

### Health Data Sources / Studies

All of Us

PEGS

HCUP

MESA

HHEAR

### Medical Records and Health Outcomes

Patient  
Demographics

Medical History  
Information

Medical Testing Info  
(X-rays and Labs)

Biomarkers  
Exposure and Effect

Genetic Testing

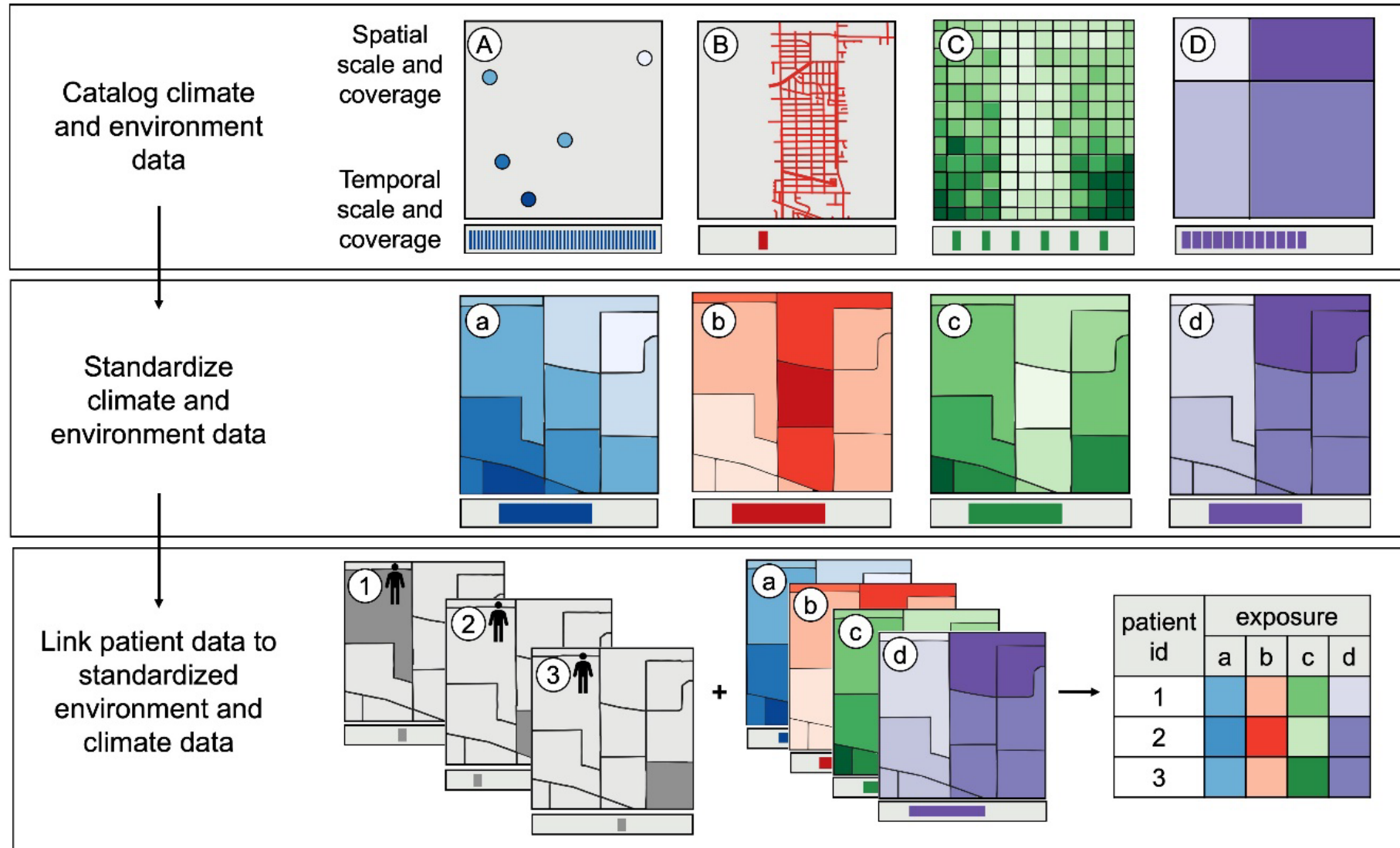
Lung Disease

CV Disease

Perinatal Health

Cancer

# Link Standardized Geographic-level Climate and Environment Data to Patient-level Data



# CHORDS Project Objectives and Deliverables

## Objective 1:

### Web-based catalog of available data resources

- Climate & health sources focused on wildfires
- Metadata & tools for use

## Objective 5:

### Addressing end user needs

Stakeholder engagement to ensure value!

## Objective 4:

### Evaluation use case

Resources for wildfire analysis of respiratory & other health outcomes

## Objective 2:

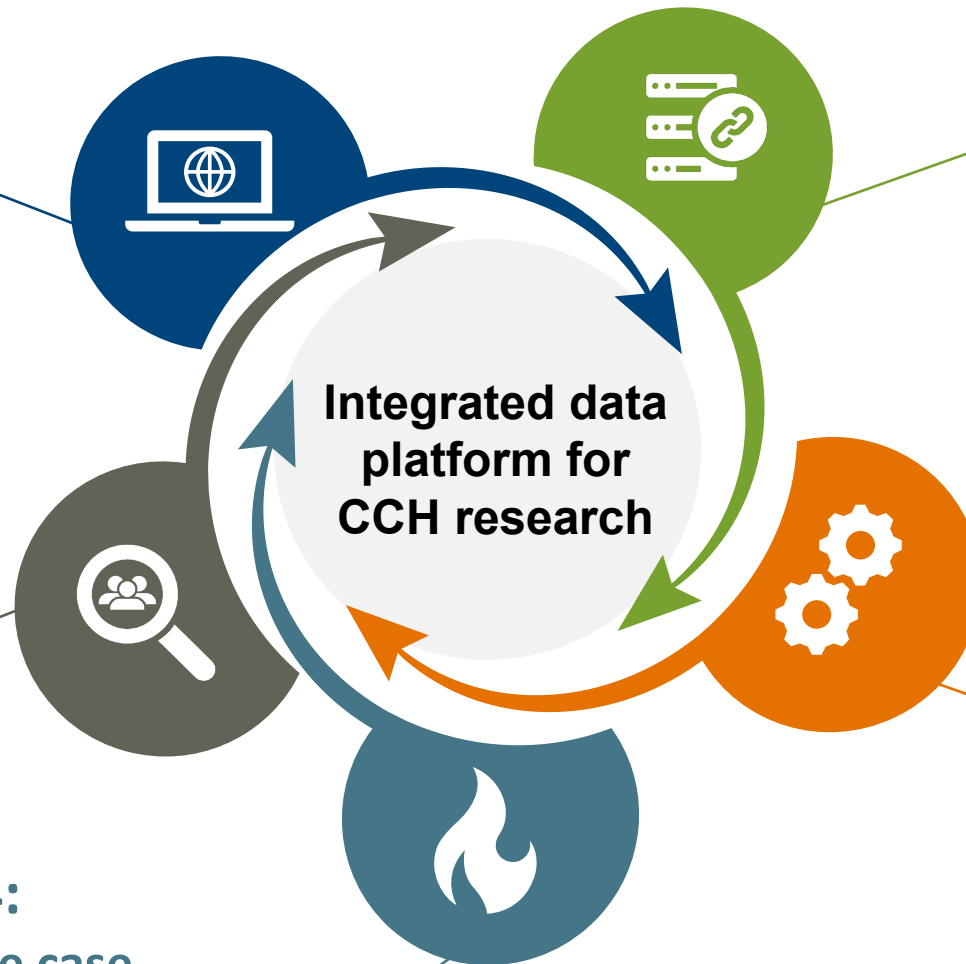
### Standardized, linked datasets

- Integrated climate, exposure and health datasets

## Objective 3:

### Toolkits for researchers

- Resources to enable those with health data to link to climate data and vice versa



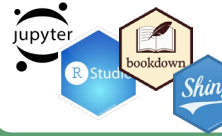
## CHORDS Platform and Catalog

- Climate and health data sources focused on wildfires
- Metadata and tools for public use



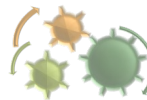
### FAIR platform

- Findable, Accessible, Interoperable, and Reproducible
- Github for code, tutorials, use cases, and walkthrough content
- CHORDS catalog for CHORDS generated datasets



### Dissemination Tooling

- R/Bookdown chapters, tutorials for different user types
- Jupyter notebooks for code walkthroughs and use cases
- Shiny applications for live applications



### Process

- SOPs for curation, review, build catalog, tools, and use cases
- Advisory input and review



### Glossary and Metadata Model

- Glossary to support common language and understanding
- Standardized terminology for cataloged resources



### Gen3

- Catalog supporting browsing, exploring, programmatic access
- Support for workspaces with Jupyter notebooks and RStudio

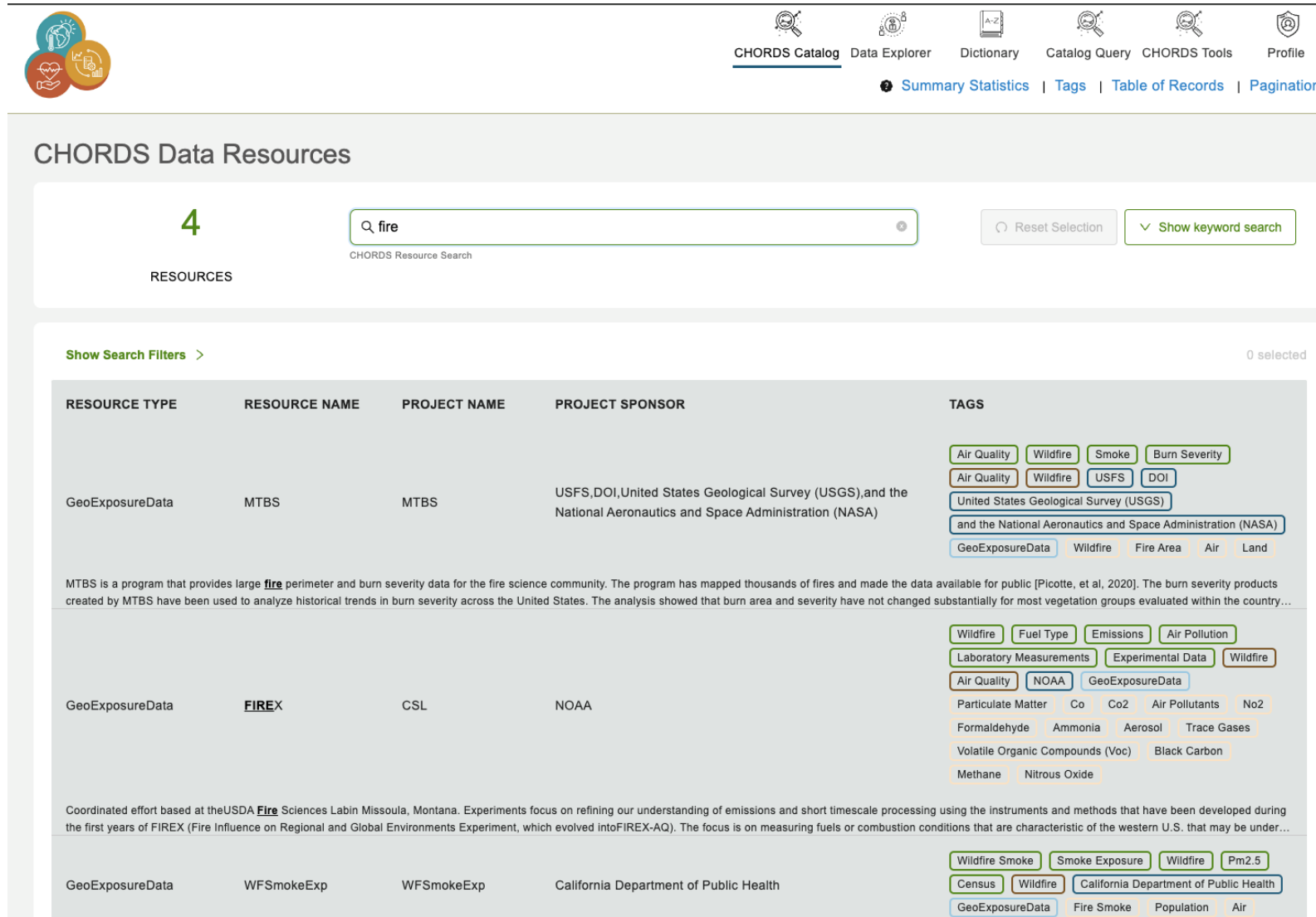


### Cloud-based

- Scalability, access, capabilities
- NIH Strides Initiative



# CHORDS Portal: Coming Soon!



The mockup shows a web interface for the CHORDS Portal. At the top, there is a navigation bar with icons and labels for 'CHORDS Catalog', 'Data Explorer', 'Dictionary', 'Catalog Query', 'CHORDS Tools', and 'Profile'. Below this is a secondary navigation bar with links for 'Summary Statistics', 'Tags', 'Table of Records', and 'Pagination'. The main content area is titled 'CHORDS Data Resources' and features a search bar with the text 'fire' and a 'Show keyword search' button. A '4 RESOURCES' indicator is shown. Below the search bar, there is a 'Show Search Filters' link and a '0 selected' indicator. The main table displays search results with columns for 'RESOURCE TYPE', 'RESOURCE NAME', 'PROJECT NAME', 'PROJECT SPONSOR', and 'TAGS'. The first row shows 'GeoExposureData' for 'MTBS' (Mountain Timber Burn Severity) by 'USFS, DOI, United States Geological Survey (USGS), and the National Aeronautics and Space Administration (NASA)'. The second row shows 'GeoExposureData' for 'FIREX' (Fire Influence on Regional and Global Environments Experiment) by 'NOAA'. The third row shows 'GeoExposureData' for 'WFSmokeExp' (Wildfire Smoke Exposure) by 'California Department of Public Health'. Each row includes a detailed description of the resource and a list of associated tags.

RESOURCE TYPE	RESOURCE NAME	PROJECT NAME	PROJECT SPONSOR	TAGS
GeoExposureData	MTBS	MTBS	USFS, DOI, United States Geological Survey (USGS), and the National Aeronautics and Space Administration (NASA)	Air Quality, Wildfire, Smoke, Burn Severity, USFS, DOI, United States Geological Survey (USGS), and the National Aeronautics and Space Administration (NASA), GeoExposureData, Wildfire, Fire Area, Air, Land
GeoExposureData	FIREX	CSL	NOAA	Wildfire, Fuel Type, Emissions, Air Pollution, Laboratory Measurements, Experimental Data, Wildfire, Air Quality, NOAA, GeoExposureData, Particulate Matter, Co, Co2, Air Pollutants, No2, Formaldehyde, Ammonia, Aerosol, Trace Gases, Volatile Organic Compounds (Voc), Black Carbon, Methane, Nitrous Oxide
GeoExposureData	WFSmokeExp	WFSmokeExp	California Department of Public Health	Wildfire Smoke, Smoke Exposure, Wildfire, Pm2.5, Census, Wildfire, California Department of Public Health, GeoExposureData, Fire Smoke, Population, Air

Data Catalog with manually curated attributes for search

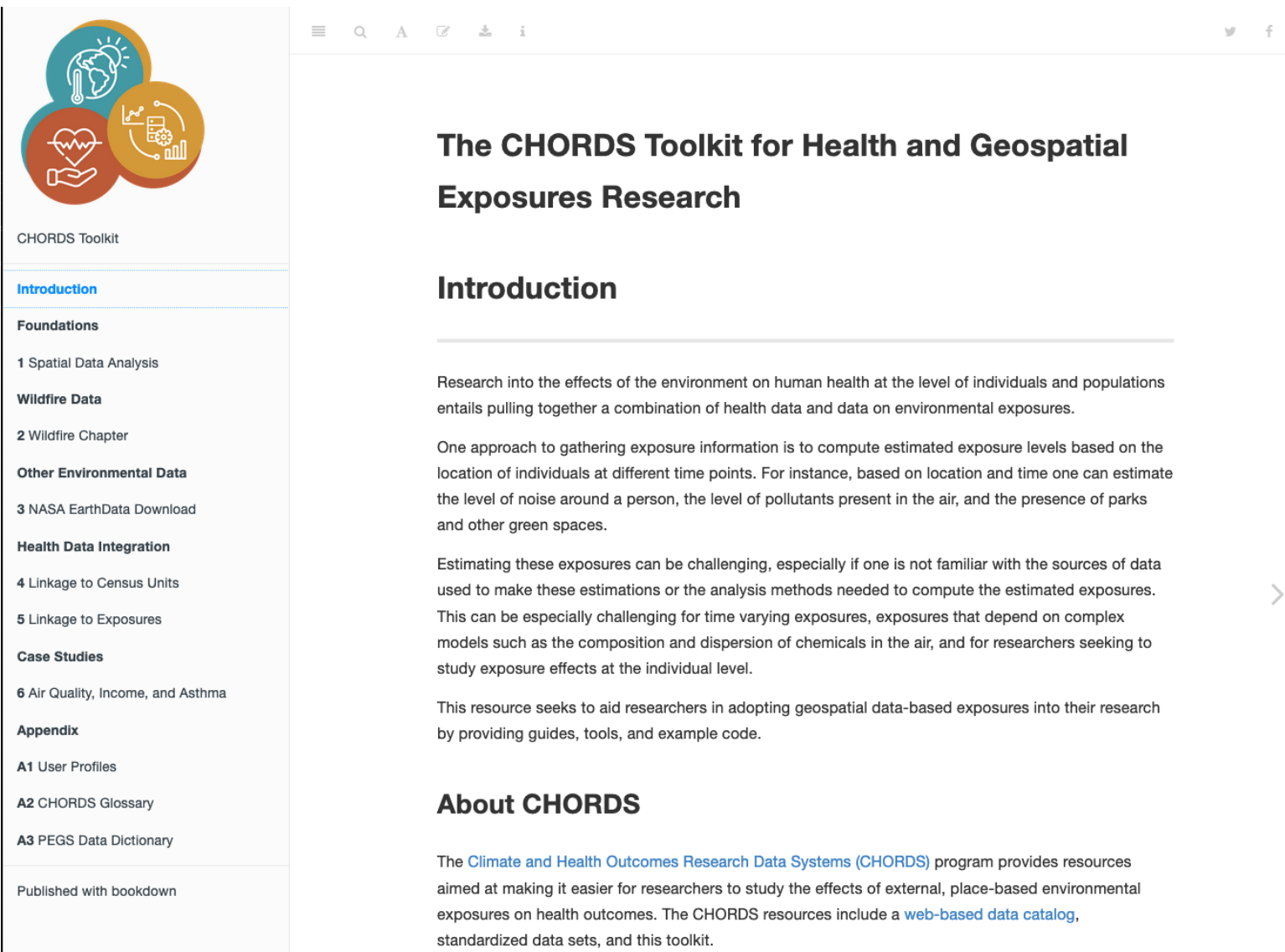
Information provided:

- Project information
- Measures
- Spatial characteristics
- Temporal characteristics
- Data access information
- Other details
  - Citation, publications, keywords

Hierarchical terminology/ application ontology for measures

- Expanding as needed

# CHORDS Toolkit



**CHORDS Toolkit**

**Introduction**

**Foundations**

- 1 Spatial Data Analysis

**Wildfire Data**

- 2 Wildfire Chapter

**Other Environmental Data**

- 3 NASA EarthData Download

**Health Data Integration**

- 4 Linkage to Census Units
- 5 Linkage to Exposures

**Case Studies**

- 6 Air Quality, Income, and Asthma

**Appendix**

- A1 User Profiles
- A2 CHORDS Glossary
- A3 PEGS Data Dictionary

Published with bookdown

## The CHORDS Toolkit for Health and Geospatial Exposures Research

### Introduction

Research into the effects of the environment on human health at the level of individuals and populations entails pulling together a combination of health data and data on environmental exposures.

One approach to gathering exposure information is to compute estimated exposure levels based on the location of individuals at different time points. For instance, based on location and time one can estimate the level of noise around a person, the level of pollutants present in the air, and the presence of parks and other green spaces.

Estimating these exposures can be challenging, especially if one is not familiar with the sources of data used to make these estimations or the analysis methods needed to compute the estimated exposures. This can be especially challenging for time varying exposures, exposures that depend on complex models such as the composition and dispersion of chemicals in the air, and for researchers seeking to study exposure effects at the individual level.

This resource seeks to aid researchers in adopting geospatial data-based exposures into their research by providing guides, tools, and example code.

### About CHORDS

The [Climate and Health Outcomes Research Data Systems \(CHORDS\)](#) program provides resources aimed at making it easier for researchers to study the effects of external, place-based environmental exposures on health outcomes. The CHORDS resources include a [web-based data catalog](#), standardized data sets, and this toolkit.

R Bookdown site (open-source platform for sharing code and data tools) of educational materials and tutorials

- Separate chapters on working with geospatial data, health data, and integration
- Tailored to user profiles
- Use case studies

## Value and Implications

- **Integrated climate and health data ecosystem**

- Data platform for wildfire-related data and analytical tools that facilitate patient-centered outcomes research for use by researchers, public health practitioners, educators, students, communities, etc.

- **Long-range goals**

- Convening data platform to engage and foster climate change and health research to inform policies and public health actions
- Facilitate beyond wildfires diverse areas of health research on climate change and disasters as well as energizing the incorporation of environmental risk factors into health systems activities

## CHORDS Team and Contributors

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\*New CHORDS Hires



## NIH Climate Change and Health Initiative

*An urgent, cross-cutting NIH effort to reduce health threats from climate change across the lifespan and build health resilience in individuals, communities, and nations around the world, especially among those at highest risk.*

### NIH Centers, Programs, and Projects

- Climate Change and Health Research Centers (Five (P20 Centers)
- Alliance for Community Engagement Hubs (Four)
- NIH-NSF Funded Center: U of Colorado Boulder Natural Hazards Center
- NIH-NSF Funded Center: U Washington RAPID Facility
- Climate Change and Health Research Coordinating Center (RCC)
- Climate and Health Outcomes Research Data Systems (CHORDS) Project



*Learn more*

### NIH Climate Change and Health Initiative

*Information on the Initiative, the Framework, and [funding opportunities](#)*



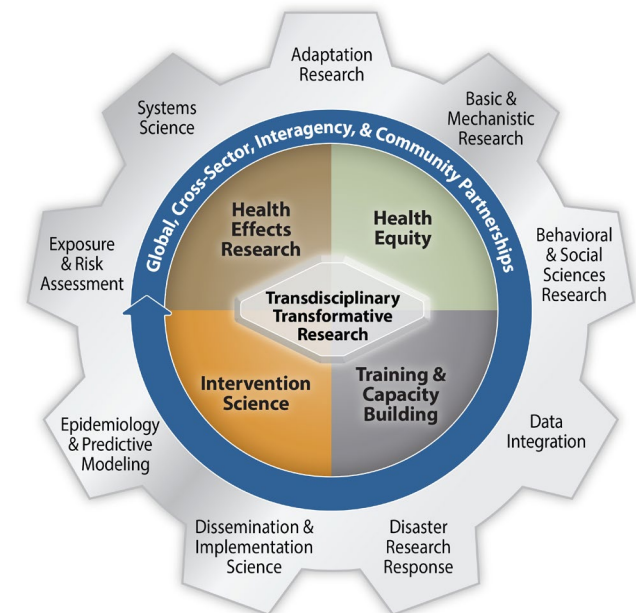
### Climate Change and Human Health Glossary

*A glossary of terms used to describe the science of climate change its impacts on human health*



### Climate Change and Human Health Literature Portal

*Searchable database to provide access to the most relevant scientific literature*



**Framework**



National Institutes of Health

# Climate Change and Health Initiative



Thank you!



CHORDS Team

National Institutes of Health • U.S. Department of Health and Human Services