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Tracking Pollution to Help You Breathe: Data and Best Practices for Tracing the Health Impacts of Smoke for the Public Health Community

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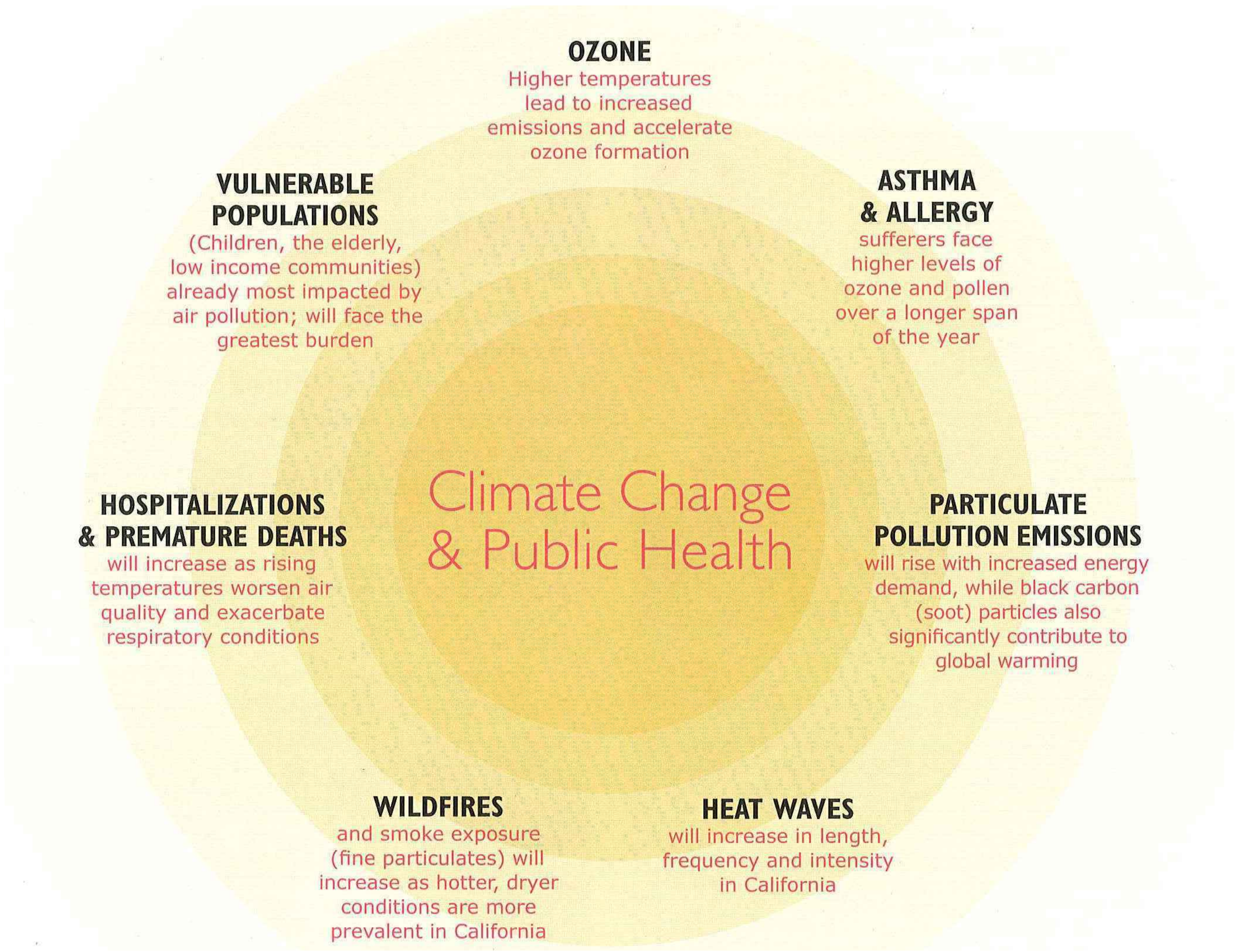
Climate Change Has Many Impacts on Respiratory Health



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Worsening Air Quality

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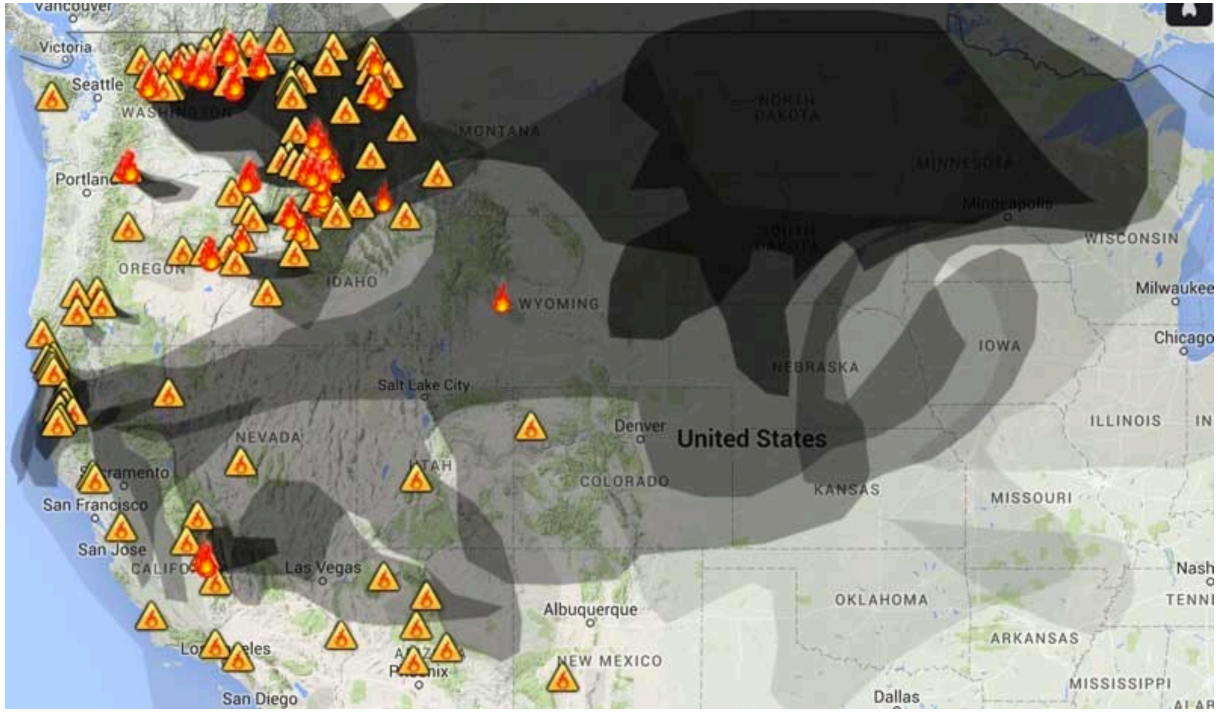
Wildfires

- More frequent and more severe
- Downwind effects
- Huge increases in particle pollution
- Ozone worse, too



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Wildfire Health Effects

- Fine particles deadly
- Difficulty breathing
- Need for more medical care
- Home evacuation, recovery needed
- Risk to health care services

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Wildfire Response

- Public information and health messaging
- Wildfire Smoke Shelters
- Expanded smoke management and public education

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NASA HEALTH AND AIR QUALITY APPLIED SCIENCES TEAM

Connecting NASA Data and Tools with Health and Air Quality Stakeholders

ABOUT PEOPLE PROJECTS NEWS TOOLS AND RESOURCES MEETINGS CONTACT

HAQAST is a collaborative team that works in partnership with public health and air quality agencies to use NASA data and tools for the public benefit. Here you can learn about our team, partnerships, and newsworthy achievements. You can also find short tutorials for NASA's open-access satellite tools.

What is “hay-kast”?

- Health and Air Quality Applied Sciences Team
- NASA-funded Applied Sciences Team
- ~~3~~ 4-year funded project (thru summer ~~’19~~ ‘20)
- 13 Members and 70+ co-investigators
- Mission: Connect NASA science with air quality and health applications
- ~ $15 Million Total Cost
- Three types of work:
  - Member projects
  - Tiger team projects (collaborative)
  - Outreach, engagement, rapid response

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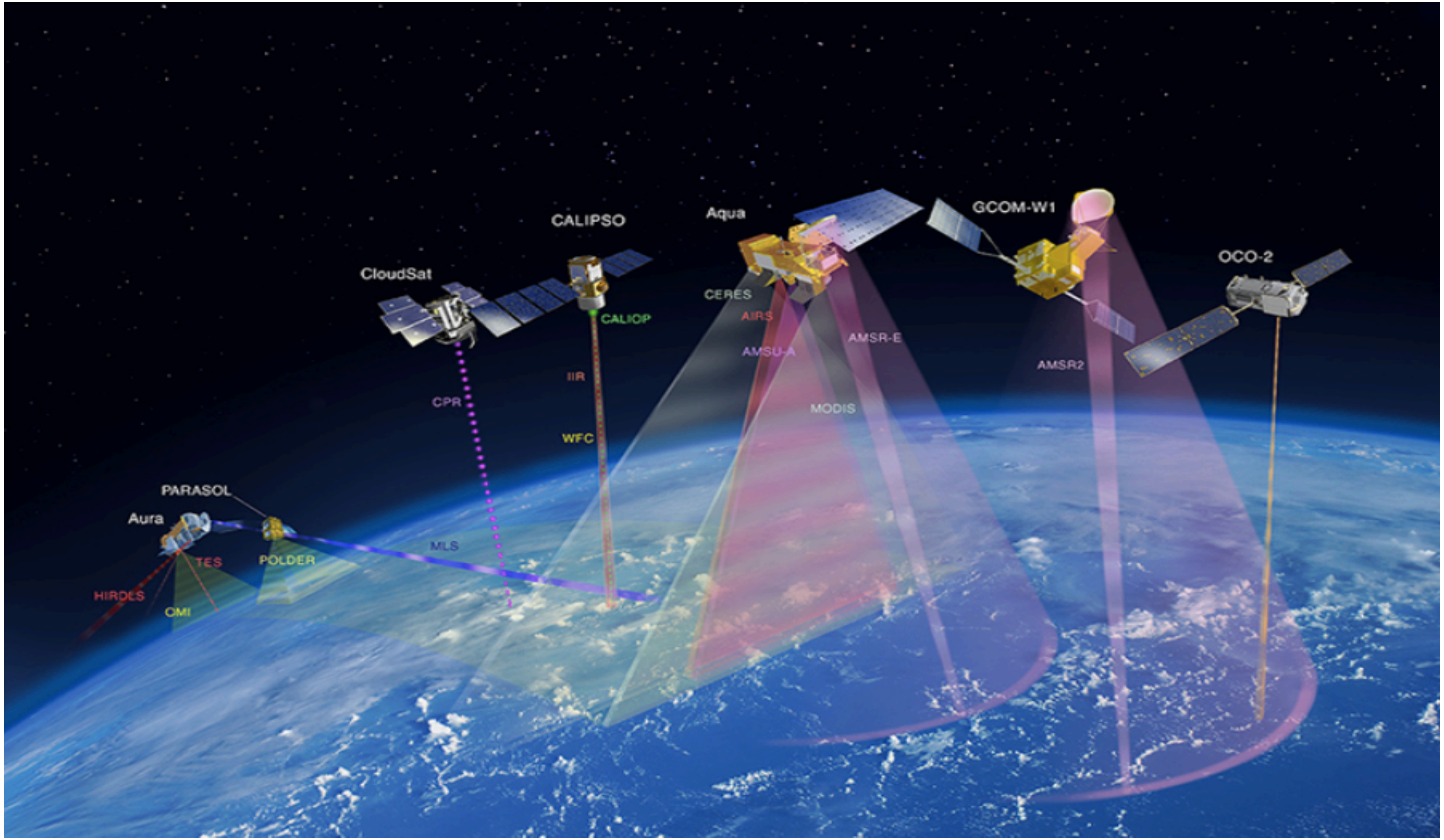
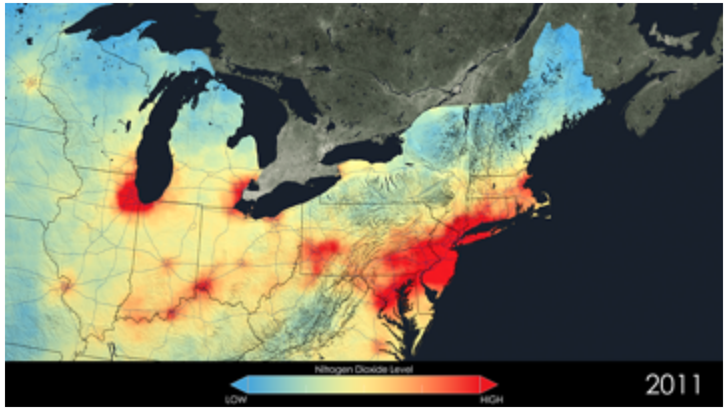


Potential Monitoring Site Purposes



A Role for Remote Sensing?

1. To Determine Compliance with National Ambient Air Quality Standards (NAAQS) — **Not Now**

2. To Develop Regional Pollution Trends in Urban and Rural Areas — **Yes**

3. To Evaluate the Effects of Population, Land Use and Transportation on Air Quality — **Yes**

4. To Evaluate Air Dispersion Models — **Yes**

5. To Provide Air Quality Information to the Public — **Yes**

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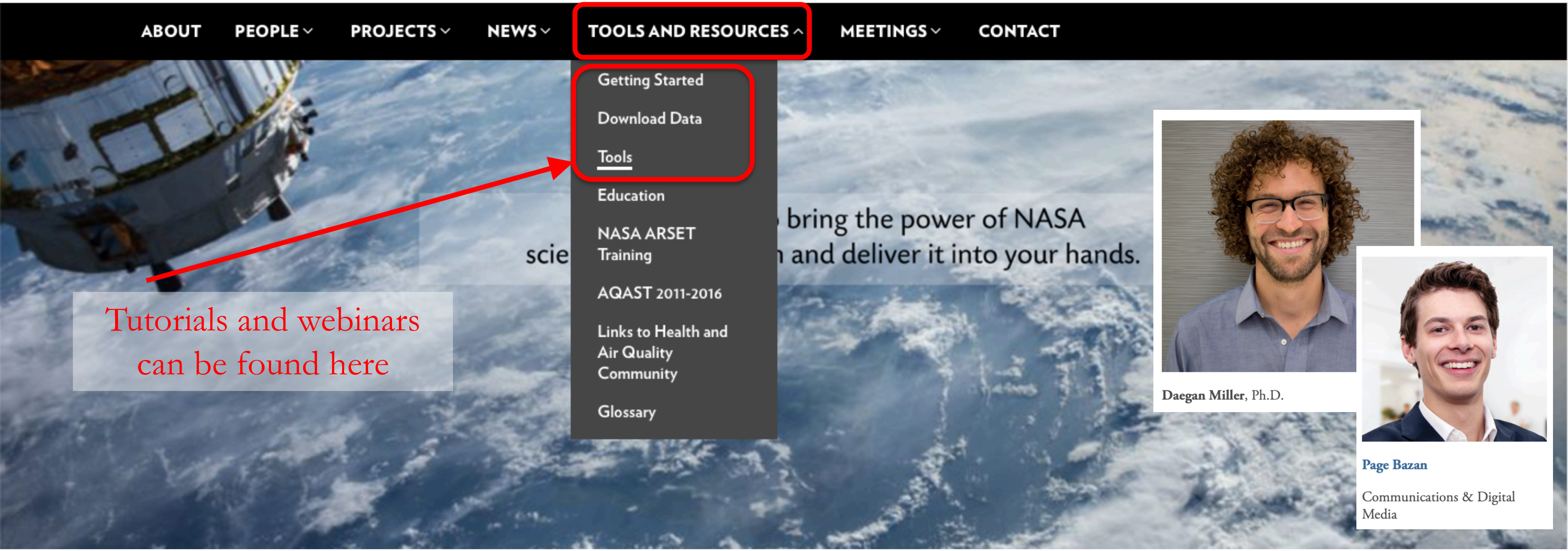
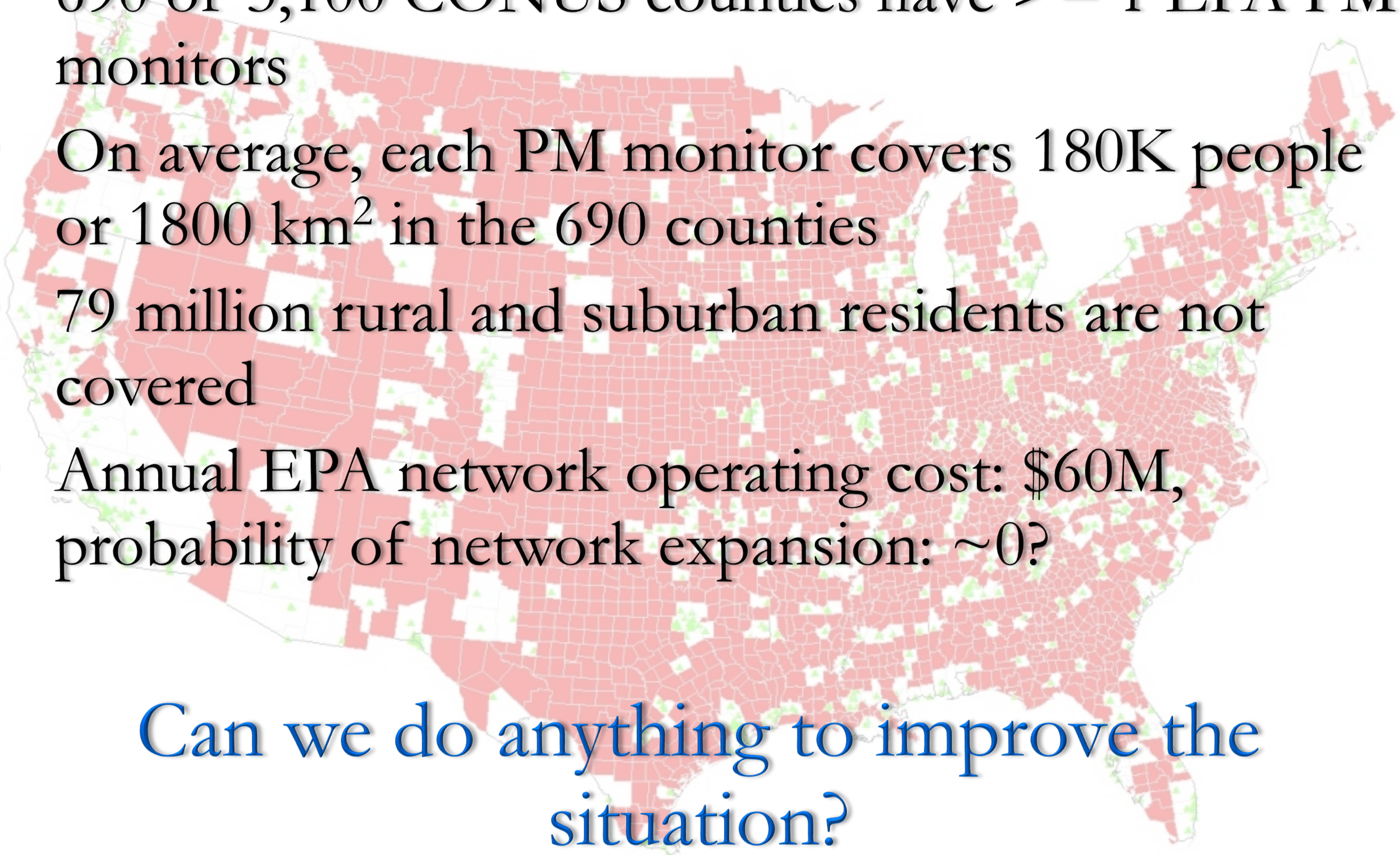


Why satellites?

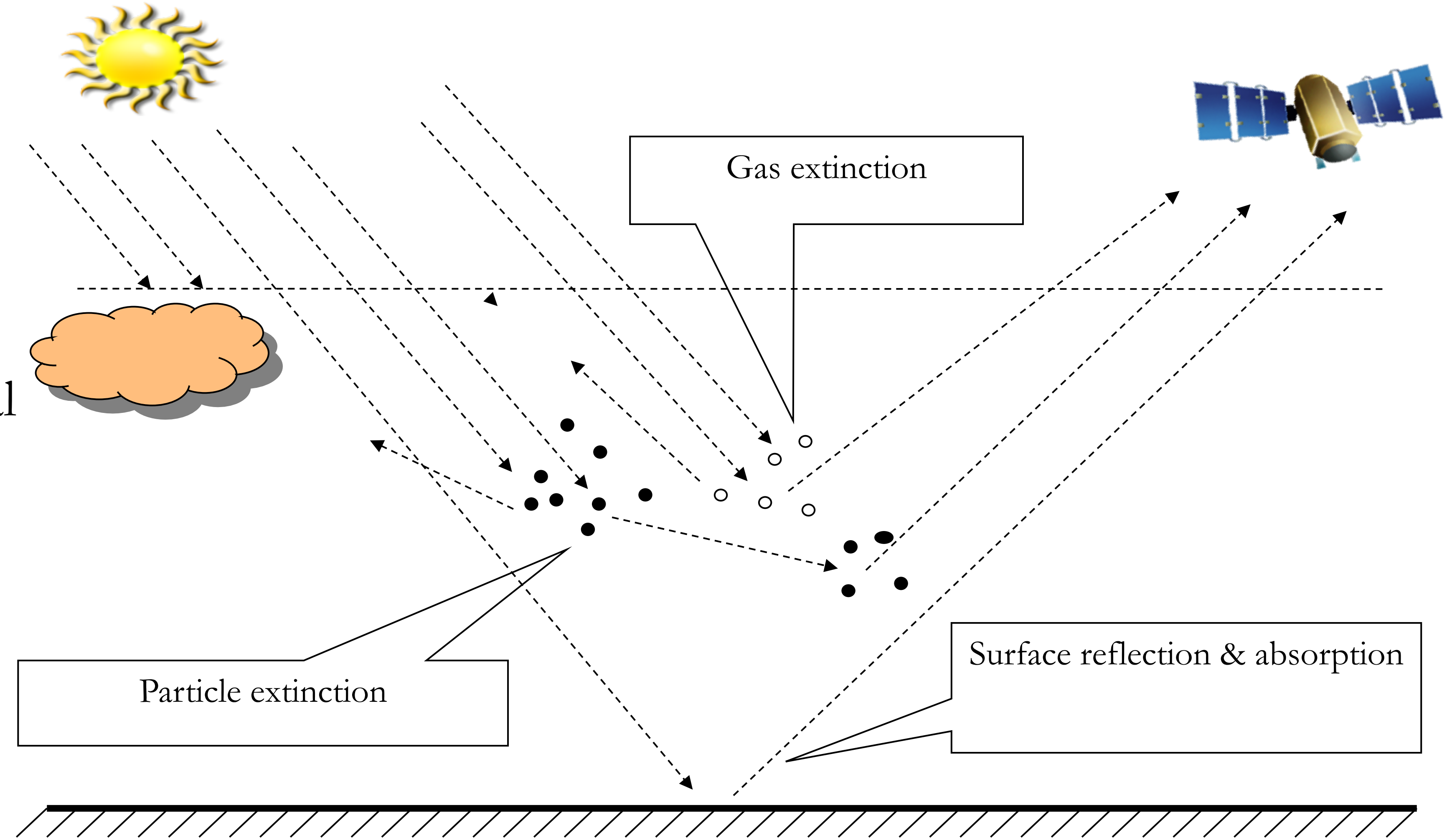


- 690 of 3,100 CONUS counties have >= 1 EPA PM monitors
- On average, each PM monitor covers 180K people or 1800 km^2 in the 690 counties
- 79 million rural and suburban residents are not covered
- Annual EPA network operating cost: $60M, probability of network expansion: ~0?

Can we do anything to improve the situation?

Satellite Aerosol Remote Sensing

- Satellite measures reflected sunlight
- Retrieval algorithms extract PM reflectance from total reflectance (PM + surface), and derive particle info



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Relevant Satellite-Retrieved Parameters

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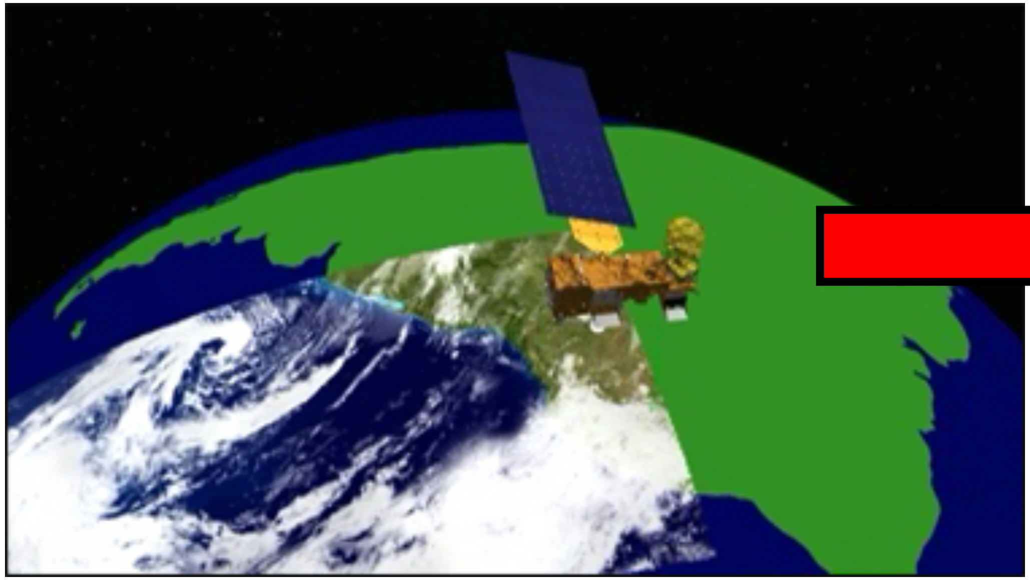
- Aerosol Optical Depth (AOD or τ)
- Fine mode fraction
- Angstrom Exponent (α)
- Single Scattering Albedo (ω)
- Particle Sphericity
- Particle type (e.g., dust vs. smoke)
- Vertical extinction profile (limited coverage)

If most particles are concentrated and well mixed in the lower troposphere, satellite AOD contains a strong signal of ground-level particle concentrations. Long-range transport events will introduce errors and outliers.

AOD and PM2.5 are different



AOD – Column integrated value (TOA to surface) - Optical measurement of ambient particle loading.

$PM_{2.5}$ – dry mass concentration for particles less than 2.5 µm in aerodynamic diameter at ground level

AOD – PM Relation

$$C = \frac{4\rho r_e}{3Q} \times \frac{f_{PBL}}{H_{PBL}} \times AOD$$

ρ – particle density

Q – extinction coefficient

Composition

r_e – effective radius

Size distribution

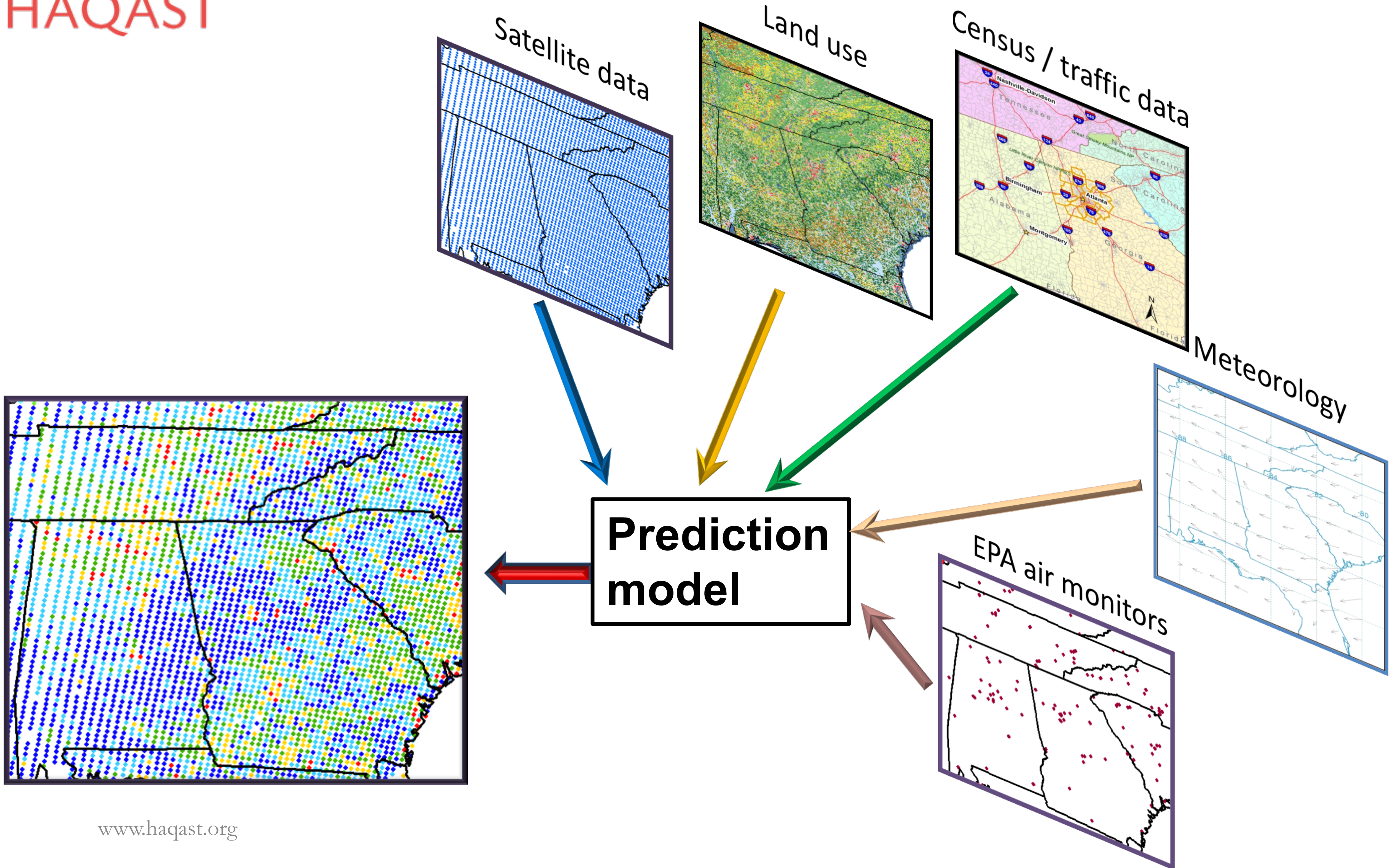
f_{PBL} – % AOD in PBL

H_{PBL} – mixing height

Vertical profile

These factors cause the AOD-$PM_{2.5}$ association to vary in time and space

Modeling Idea



Advanced PM Models

- Multiple linear regression (Liu et al. 2005)
- Linear mixed effects models (Lee et al. 2011)
- Geographically weighted regression (Hu et al. 2013)
- Generalized additive model (Liu et al. 2009, Strawa et al. 2014)
- Hierarchical models (Kloog et al. 2012, Shaddick et al. 2018)
- Bayesian models (e.g., Chang et al. 2013, Geng et al. 2018)
- Fusion models (e.g., van Donkelaar et al. 2015, Friberg et al. 2018)
- Machine learning models
  - Artificial neural network (e.g., Gupta et al. 2009, Di. et al. 2016)
  - Random forest (e.g., Hu et al. 2017, Meng et al. 2018)
  - Ensemble ML models (e.g., Xiao et al. 2018)

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The Use of Satellite Models

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- Currently
  - Spatial trends of $PM_{2.5}$ at urban to global level
  - Daily to interannual variability of $PM_{2.5}$
  - Exposure assessment for health effect studies
- In the near future
  - Improved coverage and accuracy
  - Pollution episodes (wildfires, dust storms, etc.)
  - Hourly variability of $PM_{2.5}$ and ozone
  - Environmental justice issues
- For regulation
  - Justification for exceptional events
  - Development and evaluation of emissions inventory
  - Evaluation of policy efficacy

Final Thoughts

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Questions?

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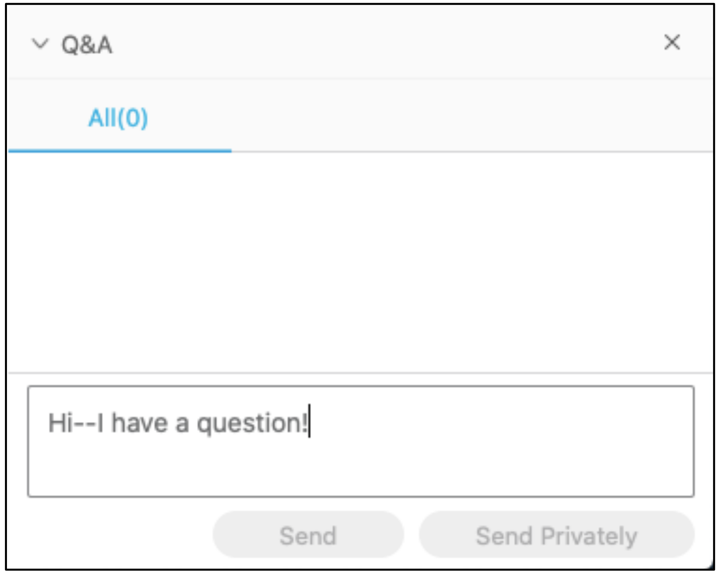

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