MICHIGAN STATE UNIVERSITY

Project Plan Presentation

Wildfire Risks Forecasting Tool

The Capstone Experience

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From Students…
…to Professionals

Functional Specifications

The Problem

- Wildfires in the San Francisco Bay Area pose significant threats to life, property, and the environment
- Climate change is increasing temperatures and drought, leading to more frequent and intense wildfires
- Public understanding of wildfire risk lags science
- Existing wildfire simulations have a high barrier to entry

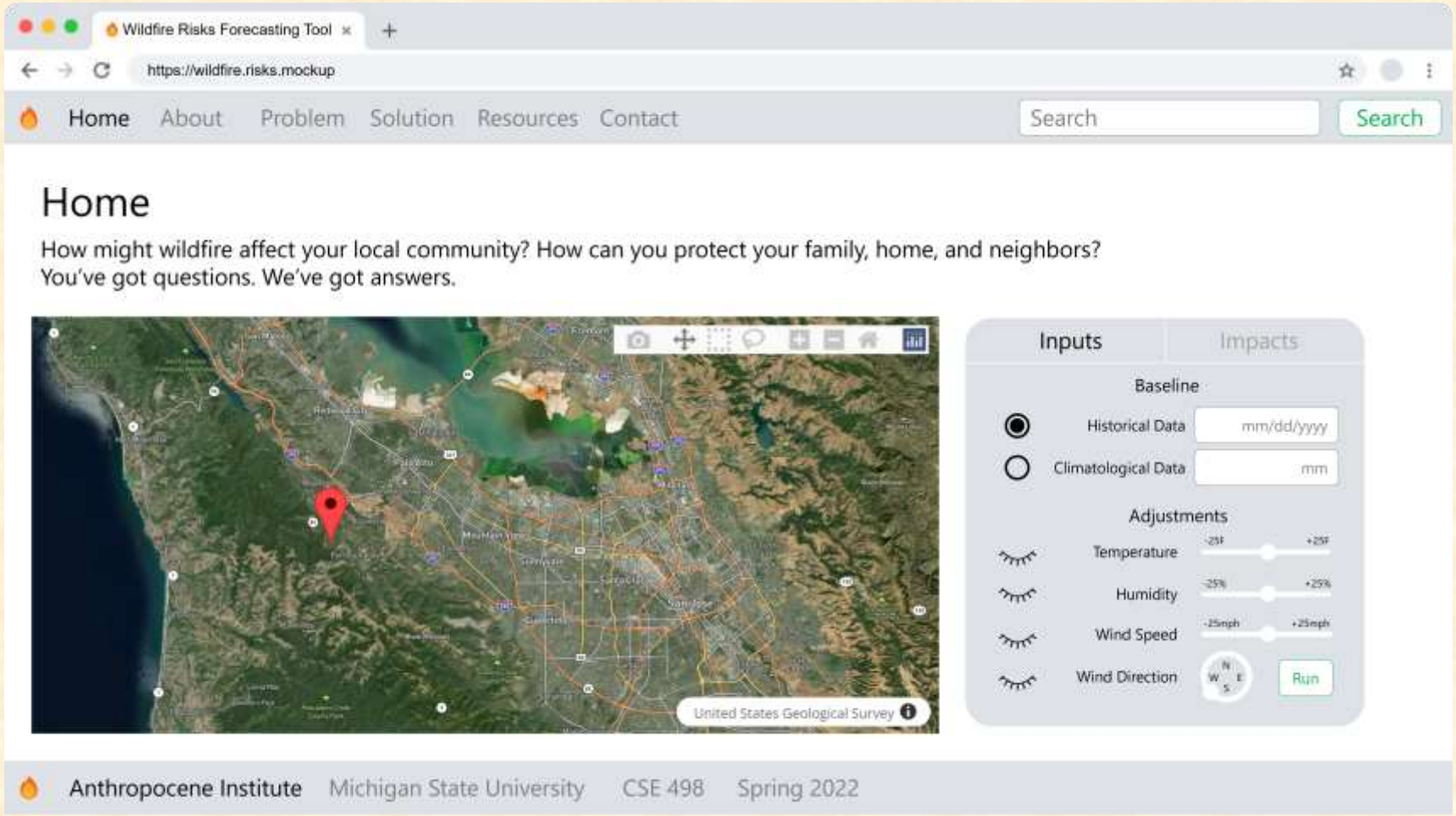
Our Solution

- Create an intuitive web app which simulates wildfires and predicts their impacts
- Target Bay Area residents of marginalized communities, communicating critical information to prevent wildfires and engage with policymakers

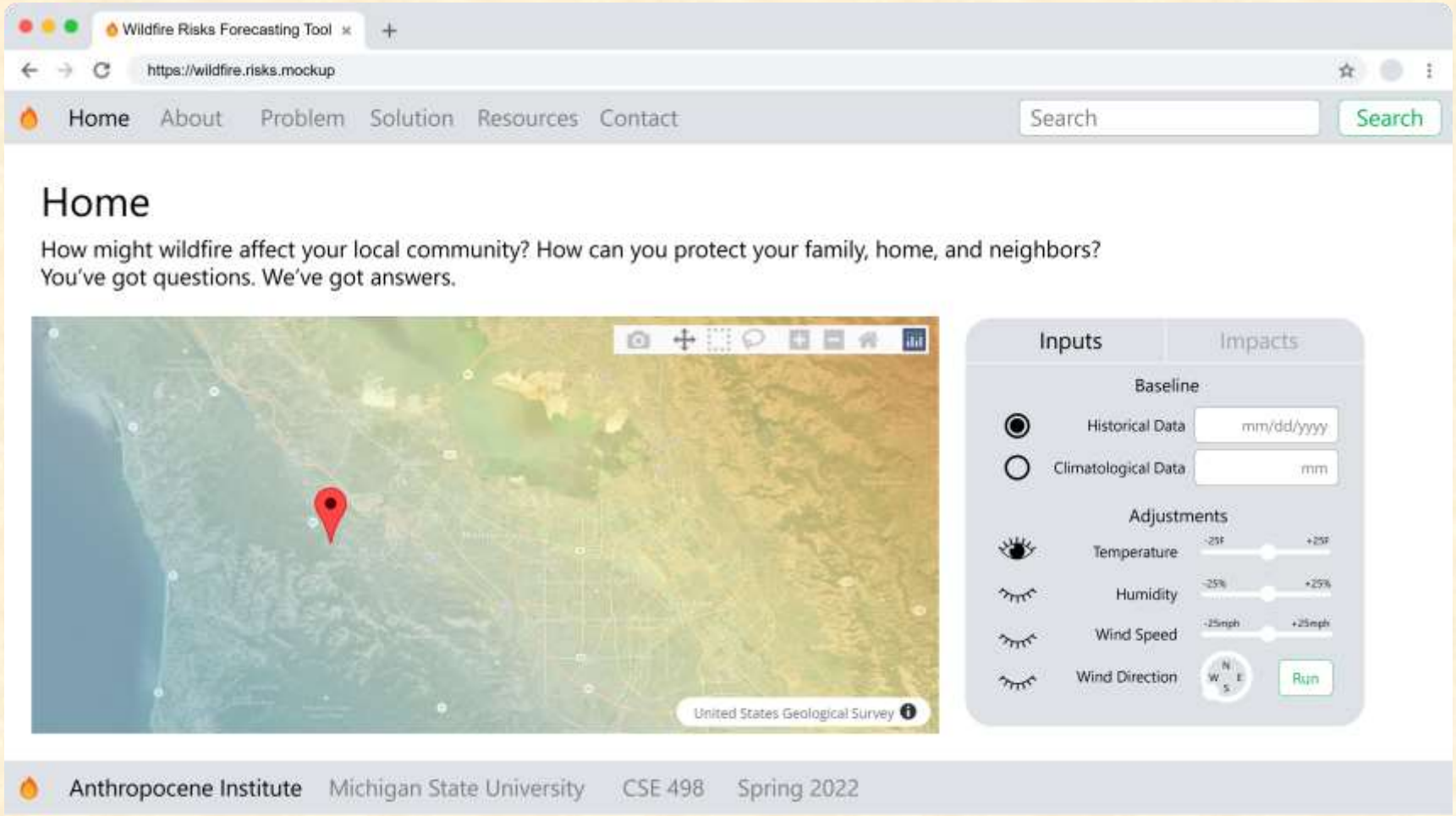
Design Specifications

- Accessible from any internet-connected computer, smartphone, or tablet
- Modern, minimalist, intuitive
- Homepage
  - Map-based interface for wildfire simulation & impact exploration
    - Fully interactive with satellite base
    - Toggleable translucent data layers
  - User-specified baseline simulation parameters
    - Live weather conditions
    - Historical weather conditions from a particular day
    - Climatological average conditions in a particular month
  - User-specified adjustments to baseline simulation parameters
    - Temperature, Humidity, Wind Speed, Wind Direction
    - Allows exploration of effects of climate change
  - Impact exploration by category
    - Economic: structures damaged or destroyed, firefighters needed, closures, evacuations, etc.
    - Health: injuries, deaths, hospital beds needed, hospital staff needed, etc.
    - Demographic: municipalities affected, breakdown by income level, education level, age, race, ethnicity, equity analysis, etc.
    - Environment: acres burned, smoke footprint, watershed footprint, CO_2e emissions, PM 2.5 emissions, etc.
- Supplementary Pages
  - About, Problem, Solution, Resources, Contact

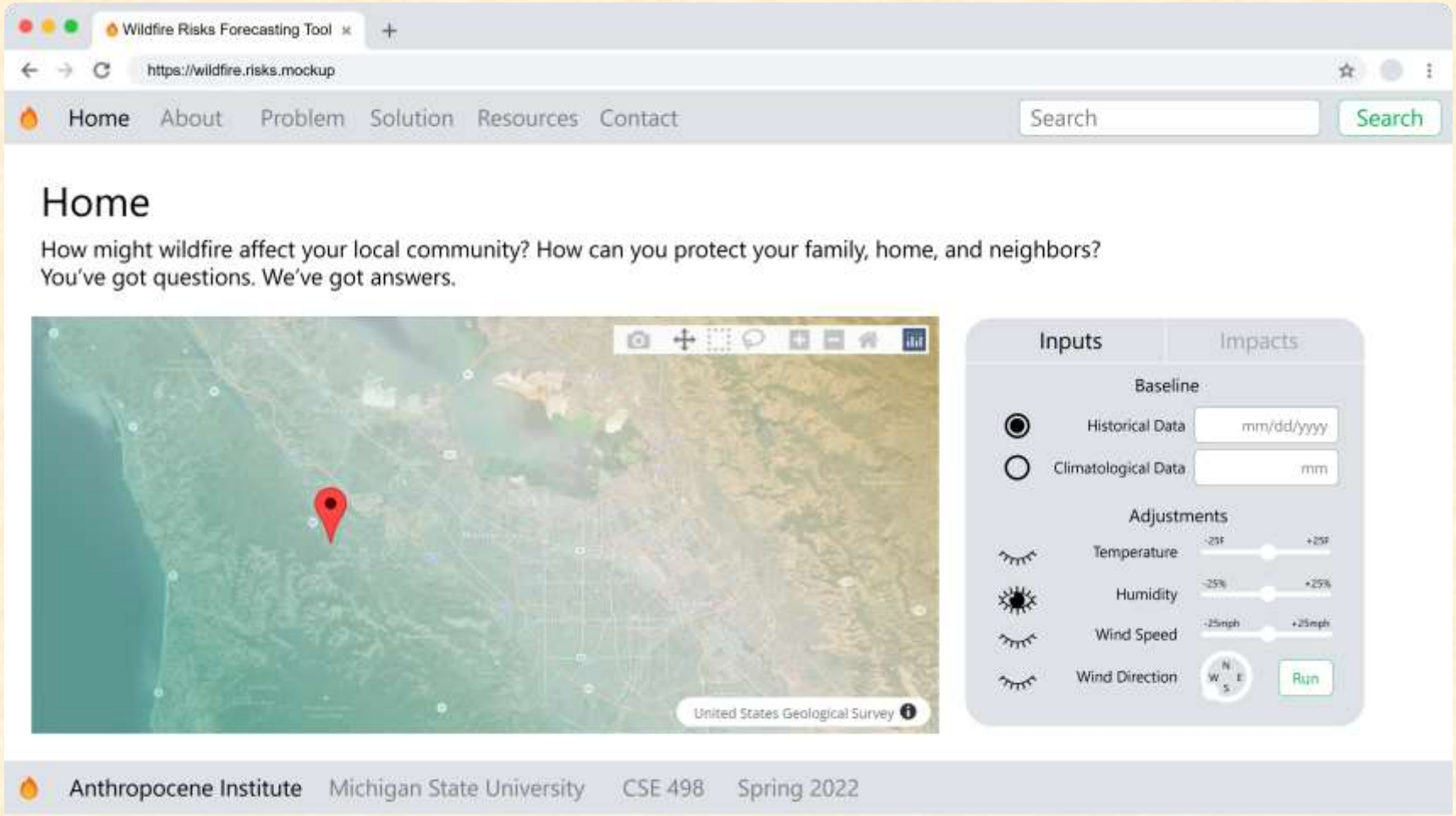
Screen Mockup: Simulator > Inputs > Base



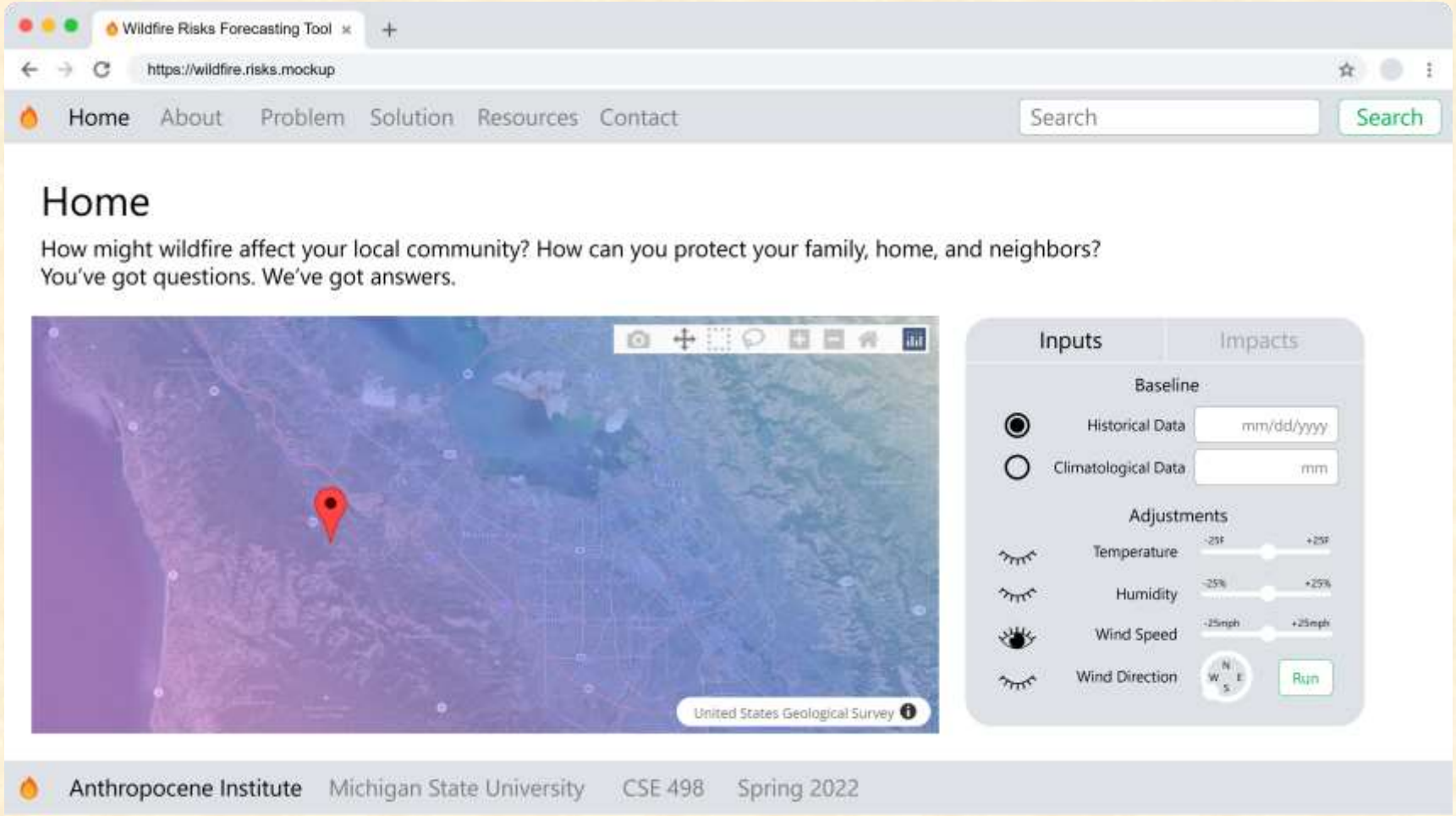
Screen Mockup: Simulator > Inputs > Temperature



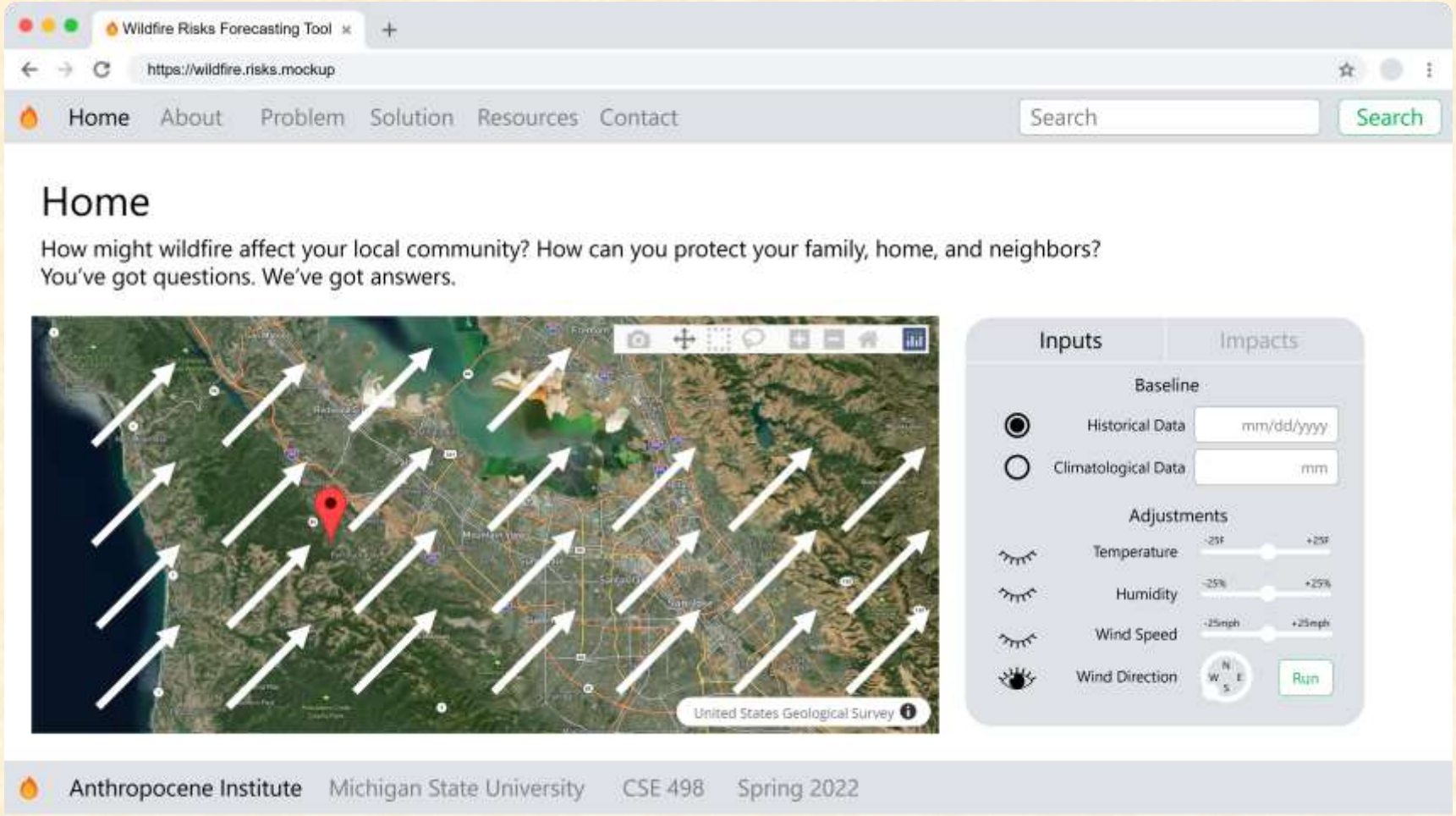
Screen Mockup: Simulator > Inputs > Humidity



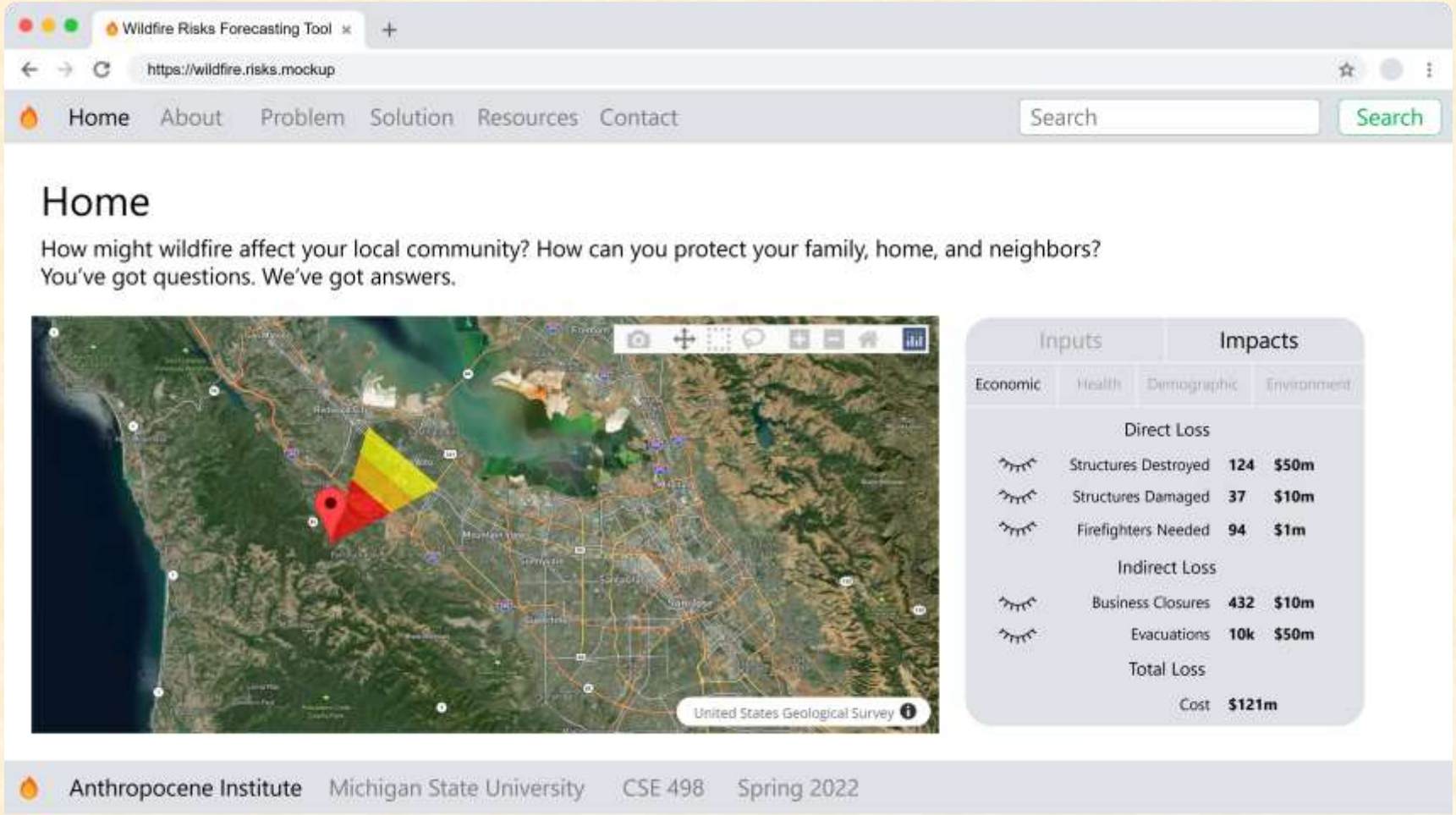
Screen Mockup: Simulator > Inputs > Wind Speed



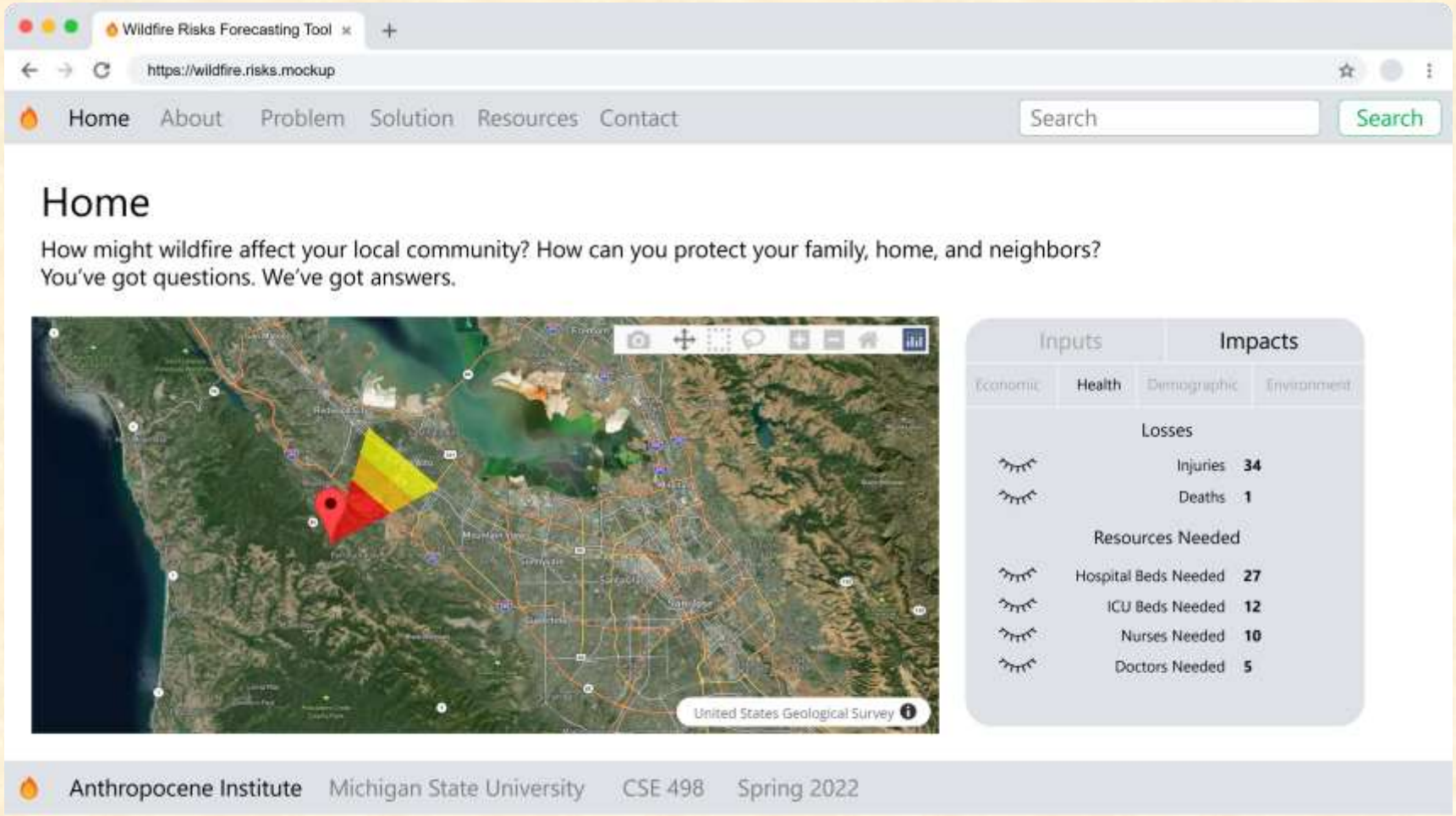
Screen Mockup: Simulator > Inputs > Wind Direction



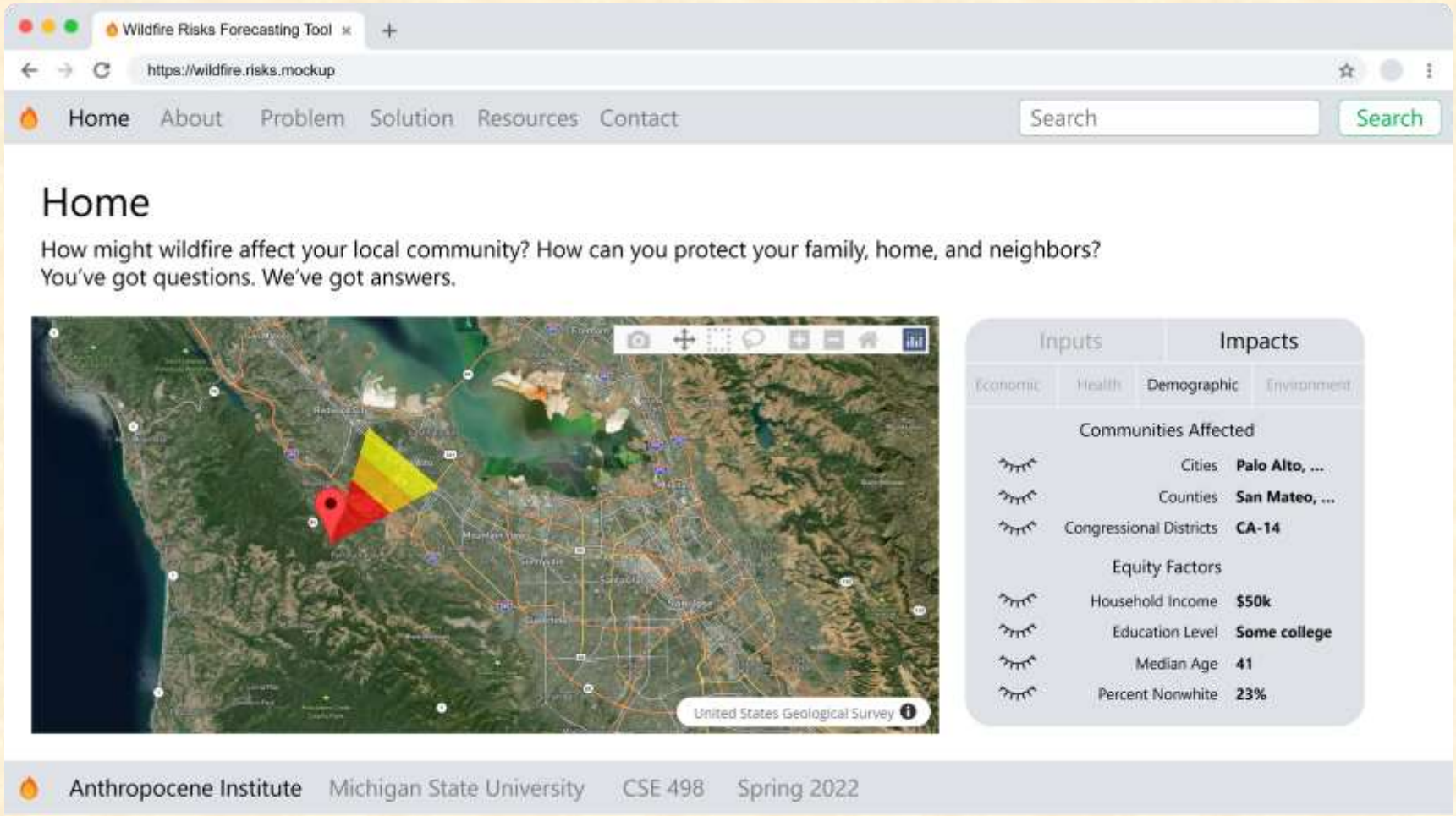
Screen Mockup: Simulator > Impacts > Economic



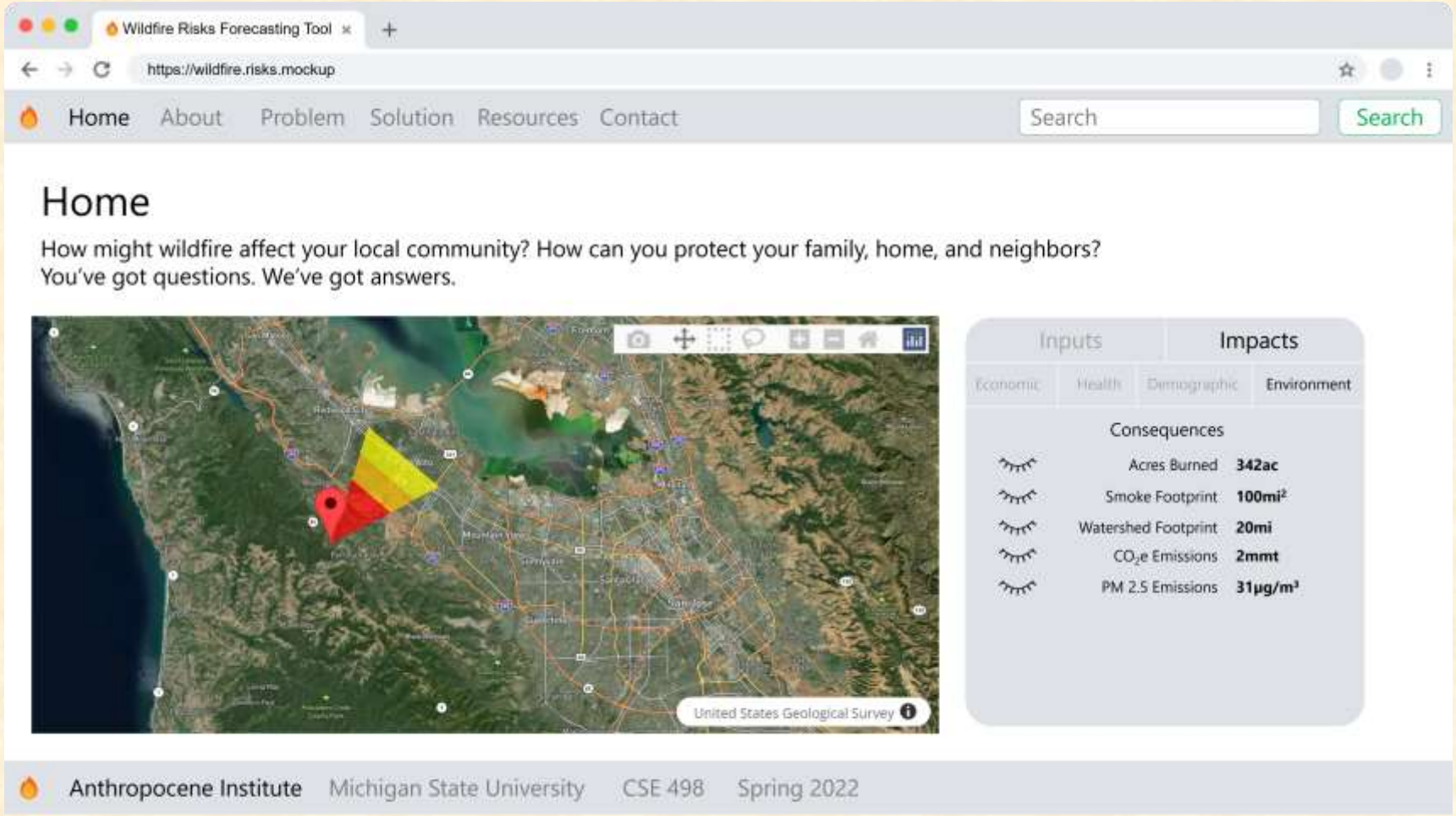
Screen Mockup: Simulator > Impacts > Health



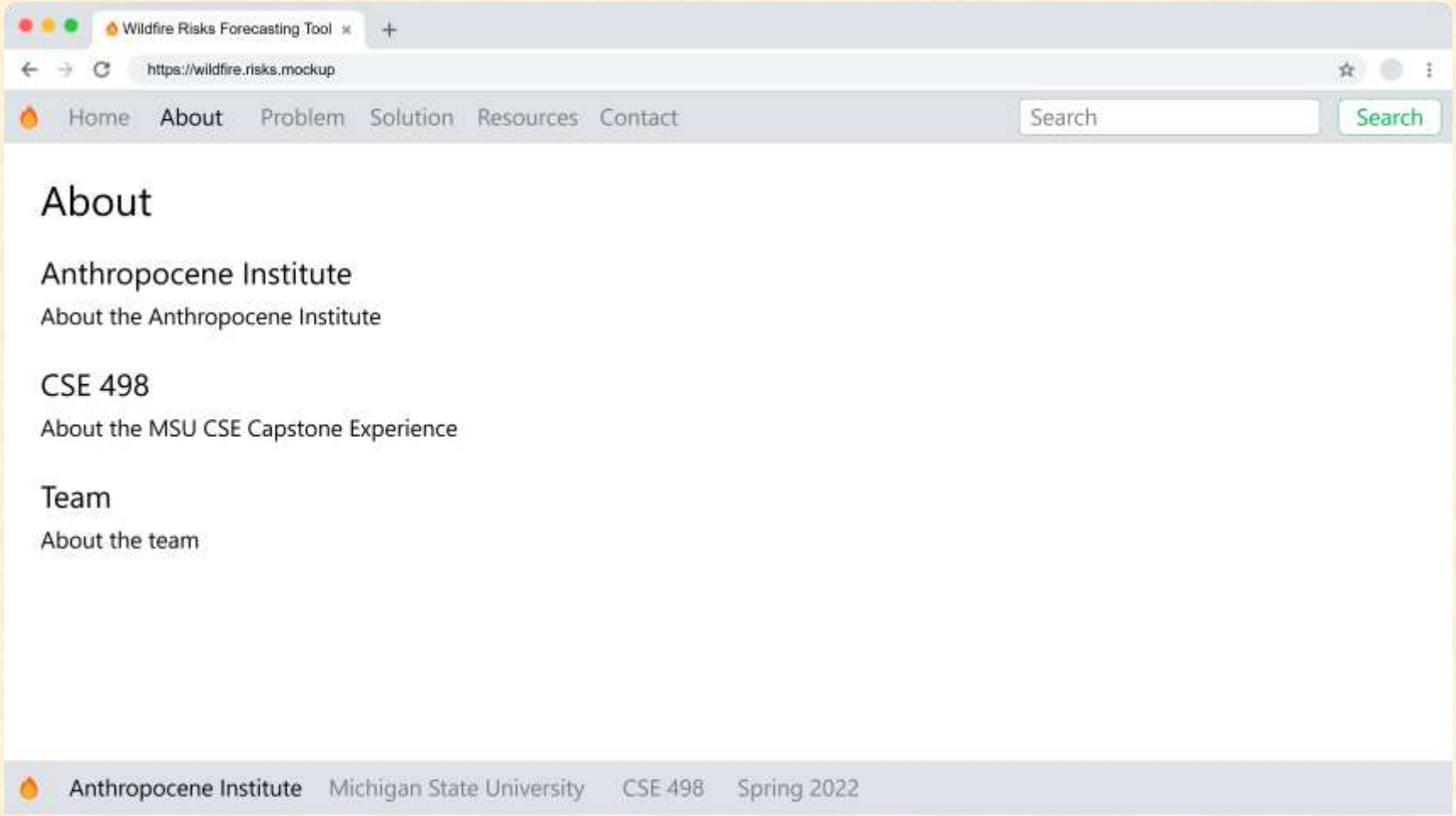
Screen Mockup: Simulator > Impacts > Demographic



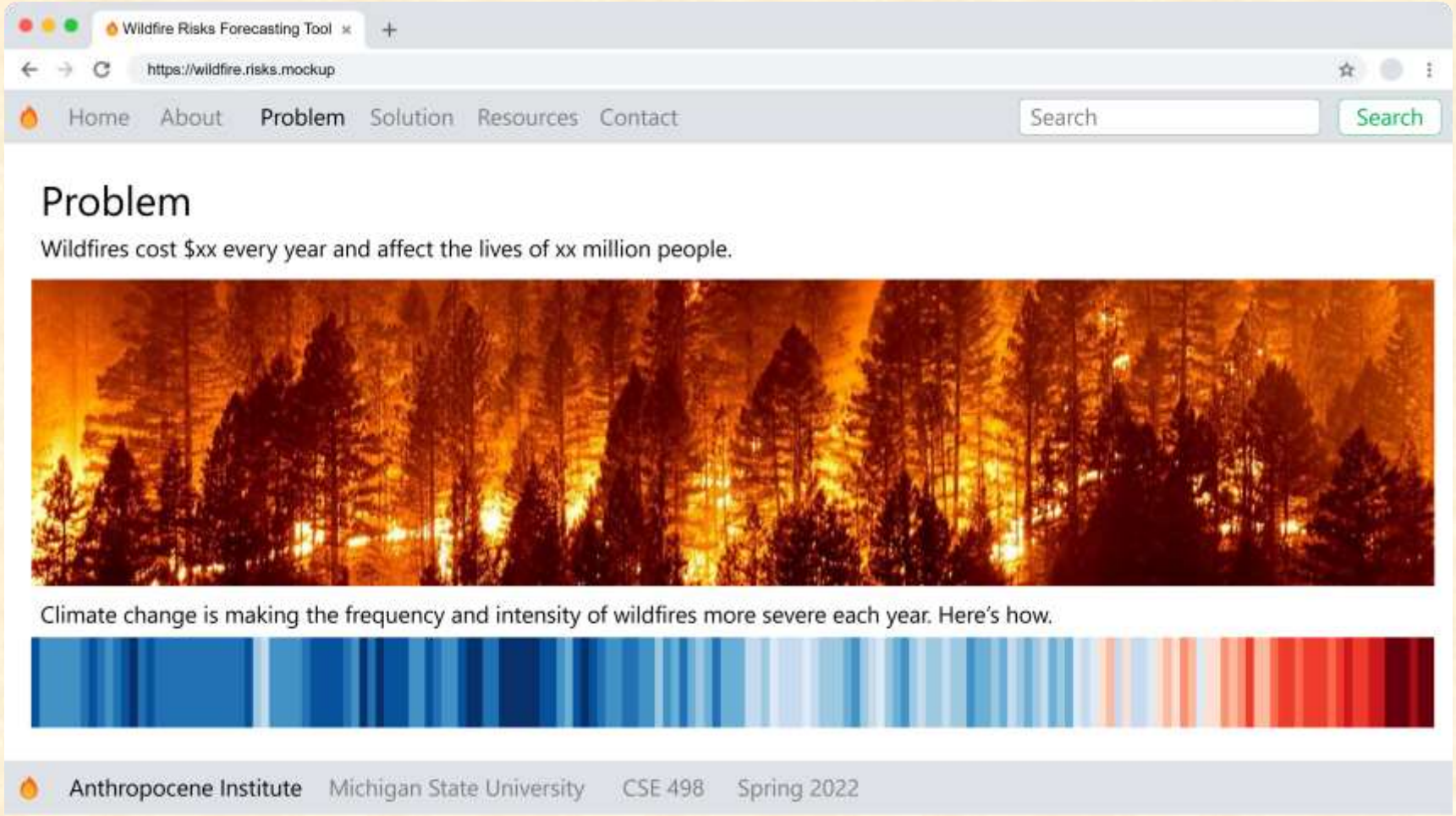
Screen Mockup: Simulator > Impacts > Environment



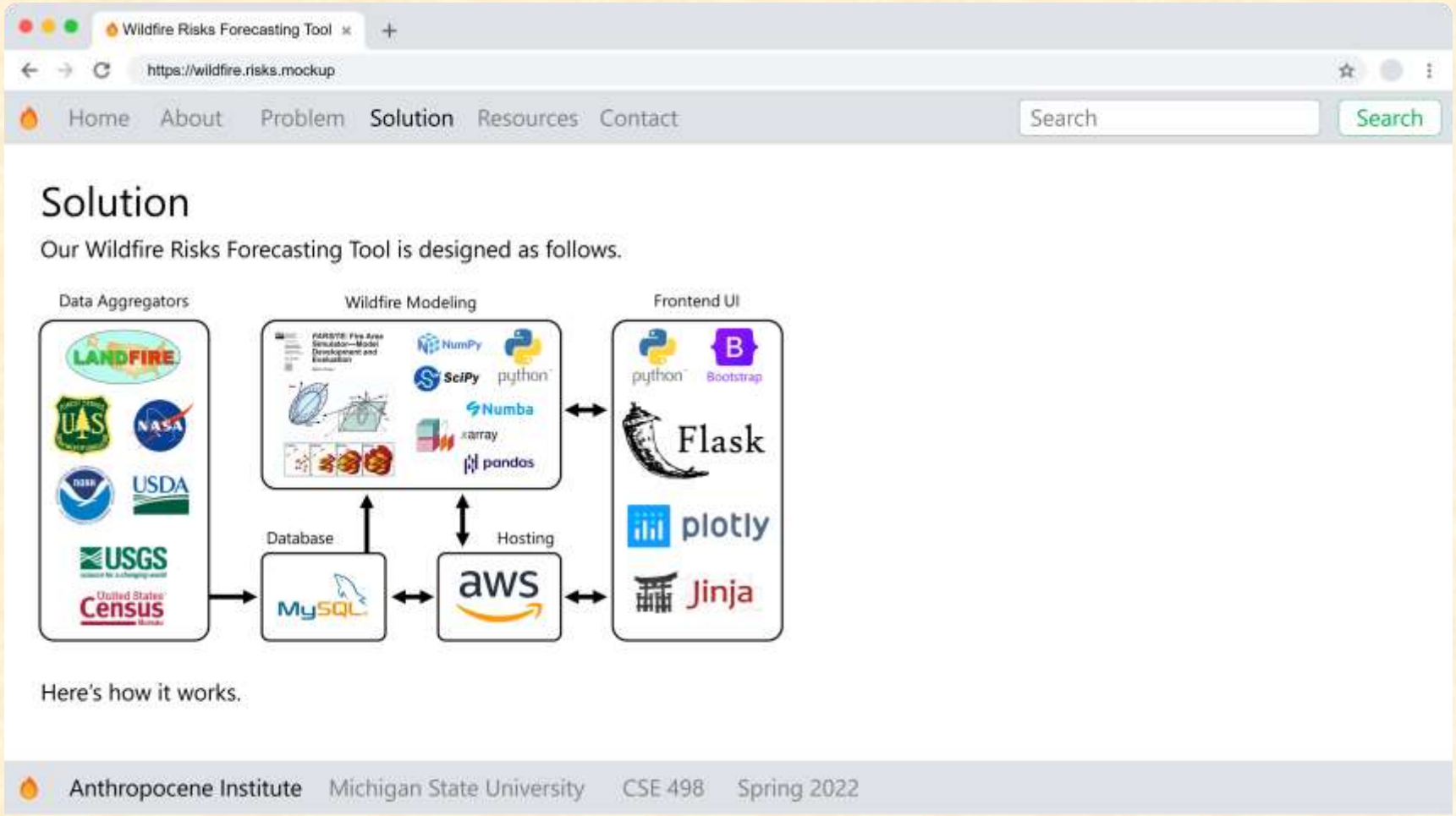
Screen Mockup: About



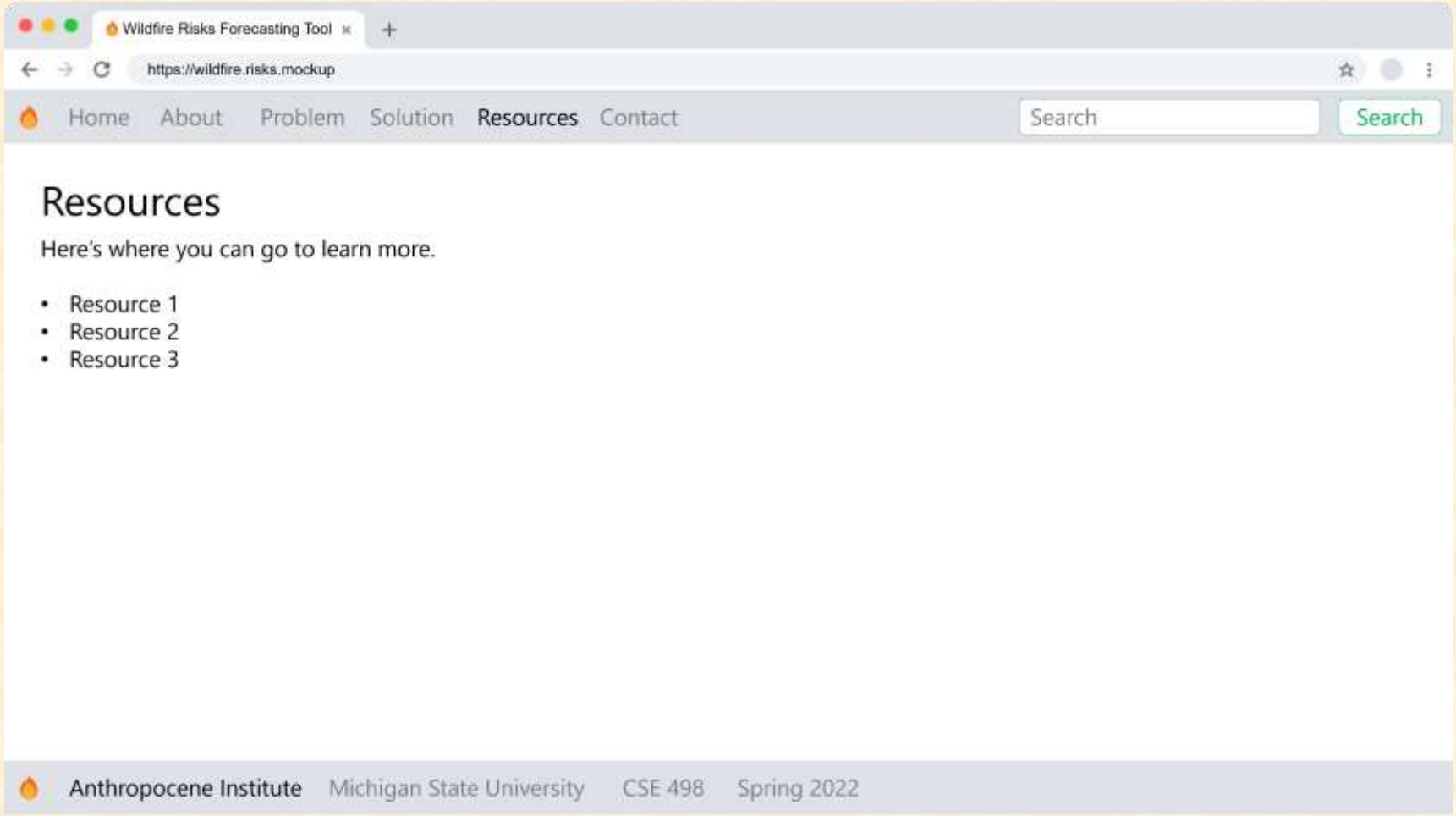
Screen Mockup: Problem



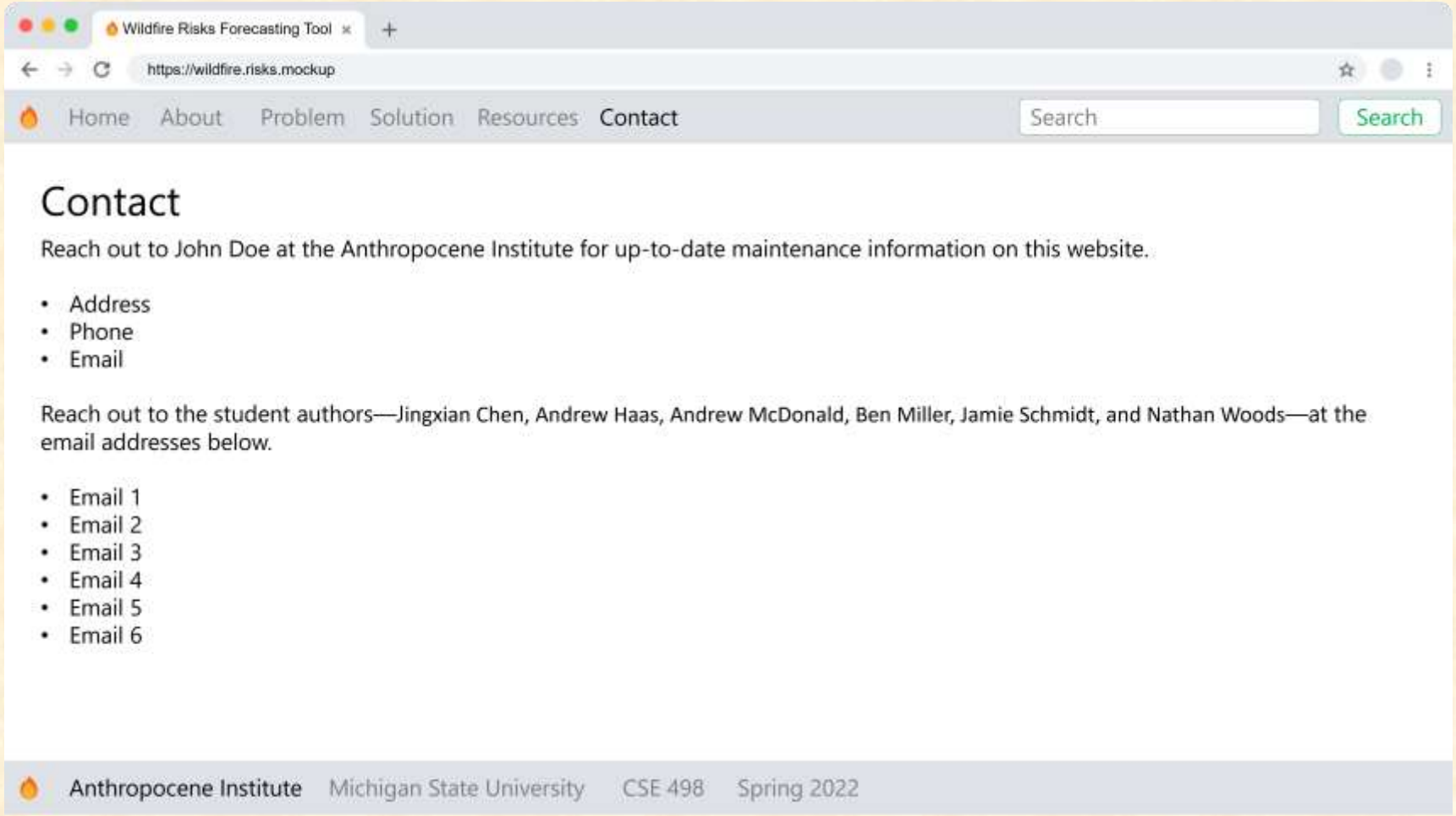
Screen Mockup: Solution



Screen Mockup: Resources



Screen Mockup: Contact

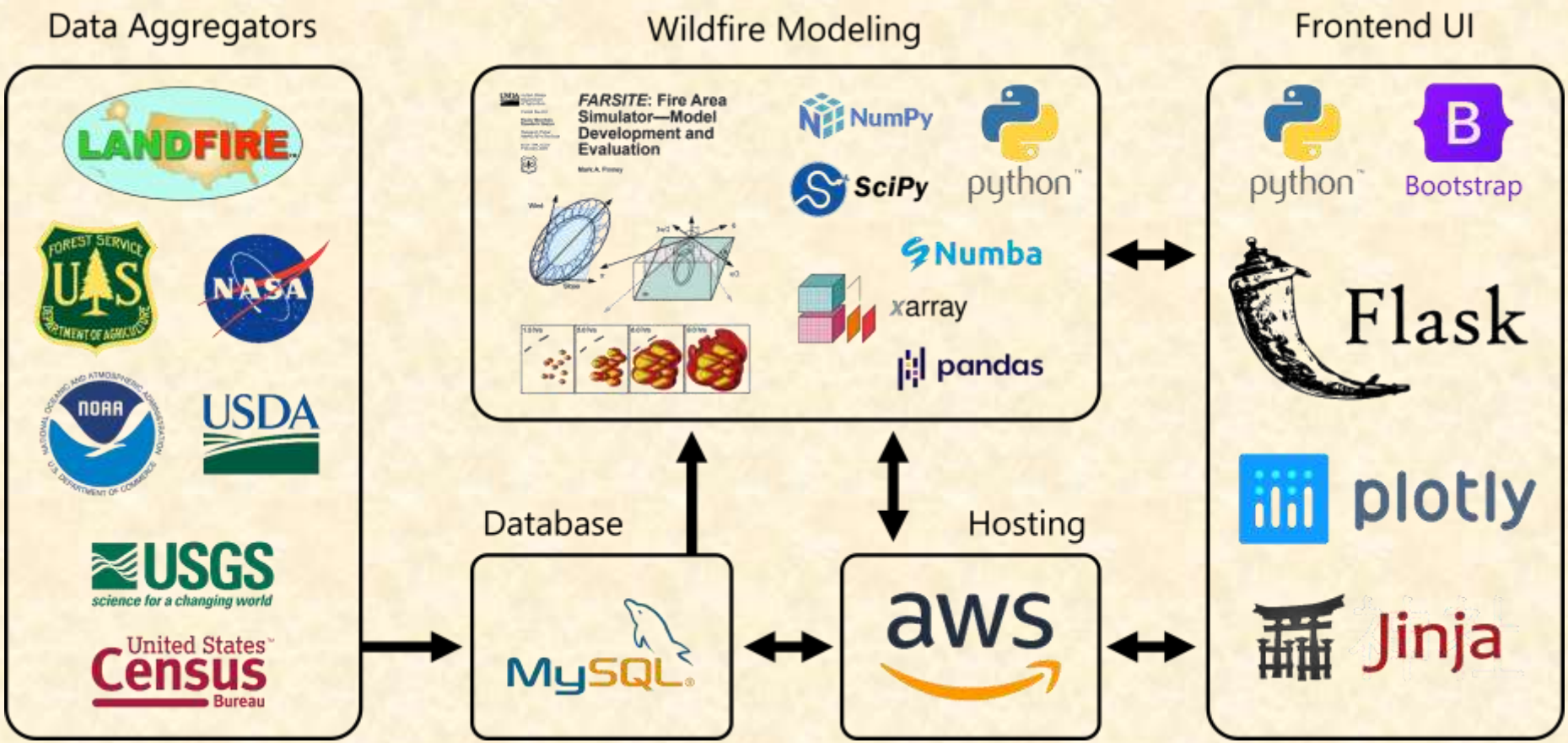


Technical Specifications

- Open-source on GitHub with conda package management for reproducibility
- Four major technical components with unit and integration tests throughout

1. Wildfire Modeling & Simulation
   - Gold-standard physics-based FARSITE model (Finney, USFS, 1998)
   - Standard Fire Behavior Fuel Models (Scott & Burgan, USFS, 2005)
   - Builds upon earlier Rothermel Surface Fire Model (Rothermel, USFS, 1972)
   - Implemented in Python, Numpy, and Scipy
   - Parallelization and acceleration with Numba
2. Data Pipeline
   - NOAA NCEI API for dynamic weather and climate data
   - LandFire database for static fuel and topography data
3. Infrastructure & Hosting Solutions
   - AWS hosting for web application and scalable computing resources
4. Frontend
   - Python Flask application with modern Bootstrap CSS
   - Data transfer to/from backend via Xarray, Pandas, and Numpy
   - Interactive map with toggleable data layers rendered by Plotly

System Architecture



System Components

- Hardware Platforms
  - End-User: Internet-connected computer, smartphone, or tablet
    - Accessible by any Bay Area resident, particularly in at-risk, marginalized communities
  - Server: Cloud
    - Simplifies handoff from student developers to long-term maintainer
    - Simplifies scaling with demand for computational resources
    - Stability and security
  - Maintainer: Internet-connected computer
    - Expect a non-wildfire-domain-expert software engineer at the Anthropocene Institute
- Software Platforms / Technologies
  - Development: GitHub, VS Code, PyCharm, Jupyter, Anaconda
  - Wildfire Modeling & Simulation: Python, Numpy, Scipy, Numba, Pandas
  - Infrastructure & Hosting Solutions: AWS / Azure / GCP with MySQL
  - Frontend: Python, Flask, Bootstrap, Xarray, Pandas, Numpy, Plotly
  - Quality Assurance: Python unittest, Postman, Google Lighthouse

Risks

1. Uncertainty of End-User
   - Client has left end-user up to our discretion
     - Need to balance specificity with breadth and marketability
     - Too narrow: (high impact)(small userbase) = low impact
     - Too wide: (low impact)(large userbase) = low impact
   - Mitigation: Consult with Bay Area fire agencies, governments, and residents
2. Data Sourcing & Maintenance
   - Fuel and climate data tend to be updated on an impractically slow timeline
     - May cause errors in our simulation
   - Mitigation: Download latest data and document data update procedures
3. Computational Complexity
   - Wildfire simulation across (h, w, t) is computationally expensive
     - Simulations may require several seconds to run and render
   - Mitigation: Implement parallelization and low-level acceleration using Numba
4. Storage Complexity
   - Budgetary constraints limit server storage space for climate and fuel data
   - Mitigation: focus on small geographic regions and downscale data resolution

Questions?