A Climate-Energy Modeling Framework - Projecting Energy Demand & Infrastructure Resilience

Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

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BNL Community Advisory Council

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BNL Clean Energy and Climate Initiative

- New Frontiers in Climate Science
- Cleaner Fuel Sources
- Renewable Energy Technology
- Energy Storage and Grid Modernization
- Energy Efficiency
- Advanced in Nuclear Energy

Project Team

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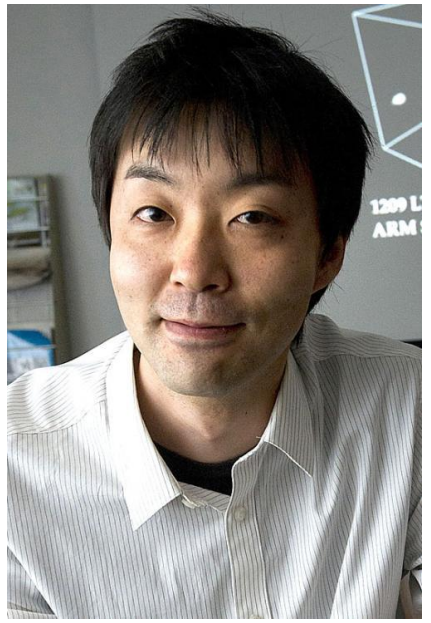

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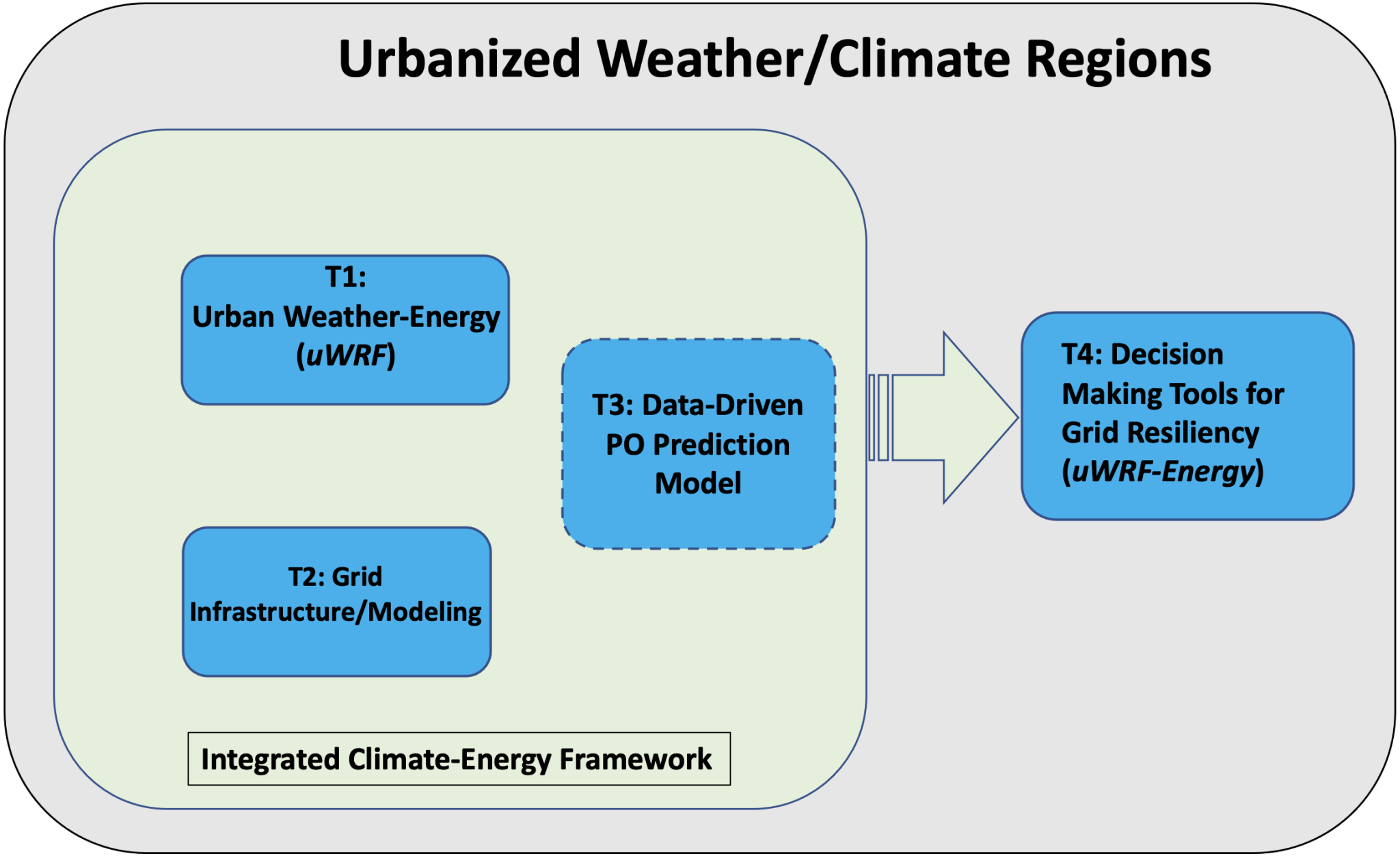
Project Motivation

- Increasing frequency of extreme weather events with climate change
- Impacts on energy infrastructure are becoming disruptive to society and economy
- Need for a strong, adaptable, and flexible energy infrastructure
- Generation and distribution can continue providing energy services
- **Urgent need for research that provides better understanding, and a predictive capability, of the relationship between climate-change-driven extreme weather events and the existing and future energy infrastructure.**

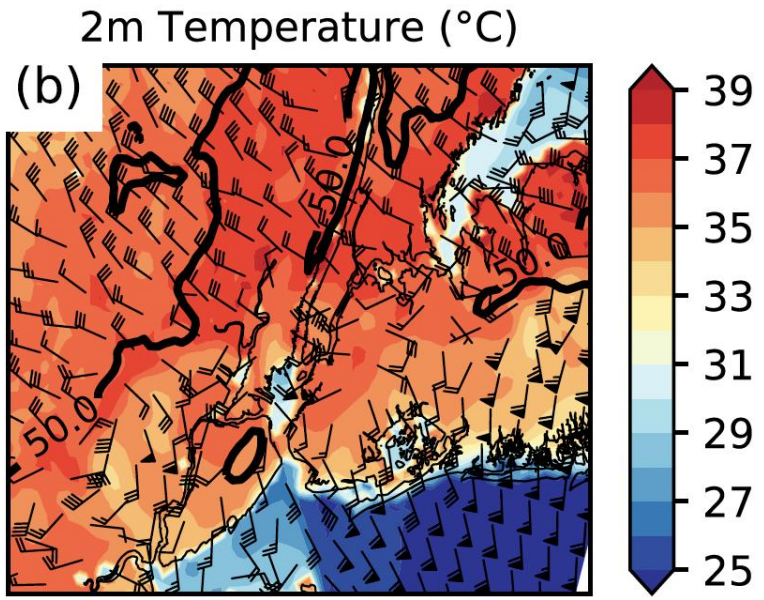
Overall Project Goals

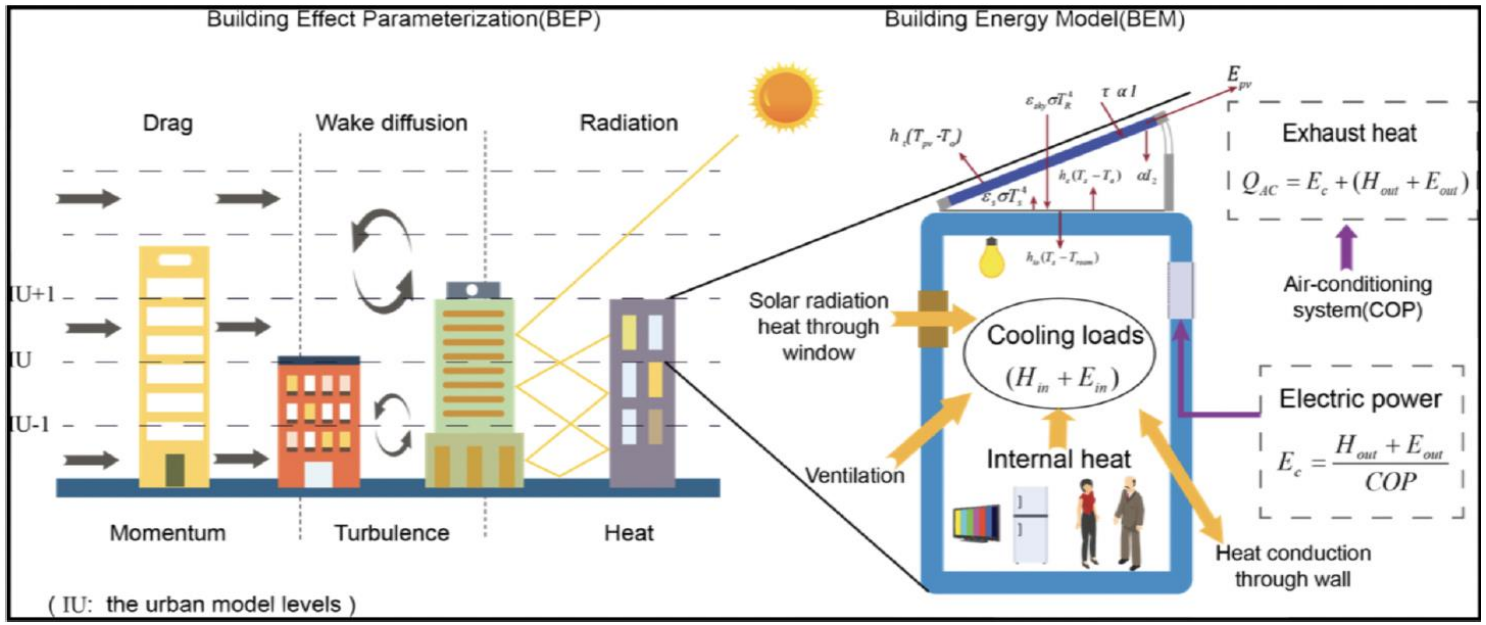
Build an integrated modeling framework for future risk mitigation analysis of the energy infrastructure in areas of high energy demand resulting from extreme weather under warming climate scenarios

- Link existing urbanized weather/climate community models with electric grid and power outage prediction models for impact assessment and mitigation development.
- Creating Urbanized Weather Research and Forecasting (WRF) model for Energy Applications (*uWRF-Energy*)
- Model offers long-term planning tool for grid energy and resiliency under climate change scenarios


Urbanized Weather/Climate Regions
T1:
Urban Weather-Energy
(uWRF)
T2: Grid
Infrastructure/Modeling
T3: Data-Driven
PO Prediction
Model
T4: Decision
Making Tools for
Grid Resiliency
(uWRF-Energy)
Integrated Climate-Energy Framework

Urbanized Climate-Energy Model

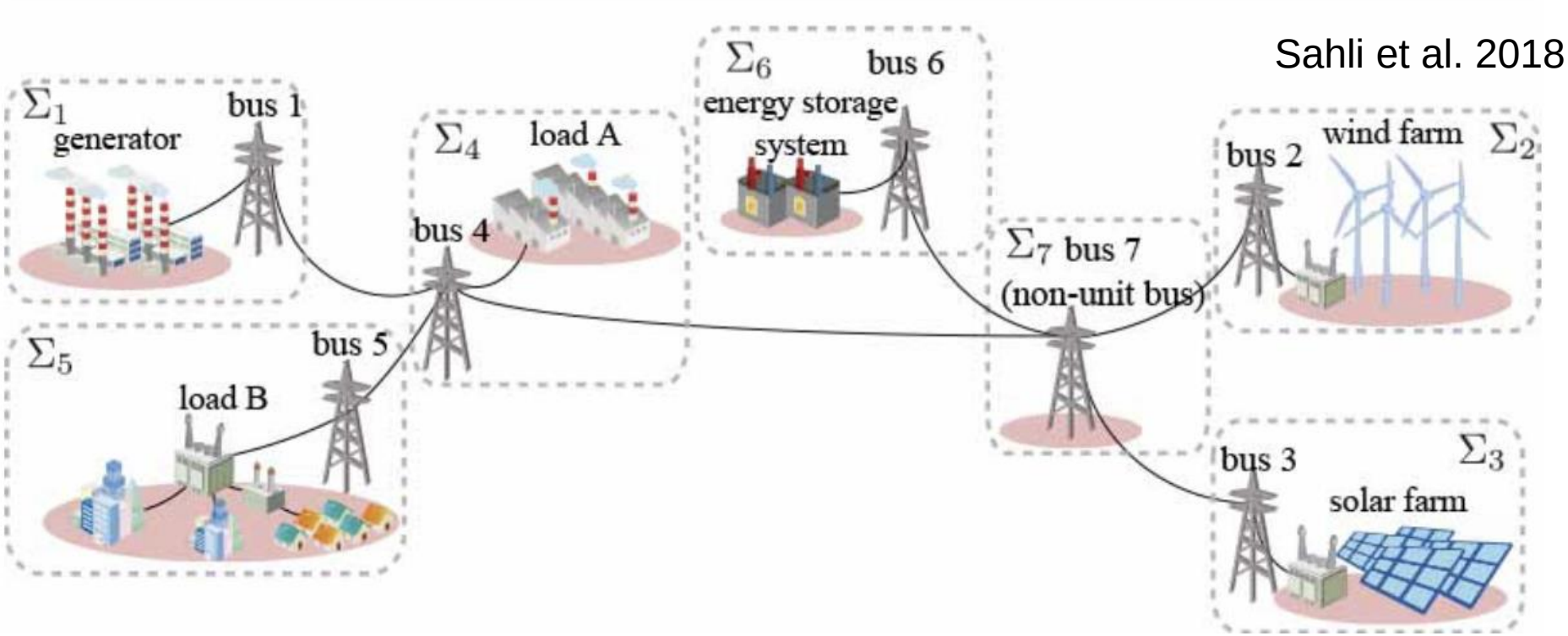




- Climate and urban environment impact energy demand, renewable generation and grid resilience
- Latest models capture interactions between the built and natural environments
- Provide high-resolution (< 1 km) forecasts of weather/climate and the associated energy demands

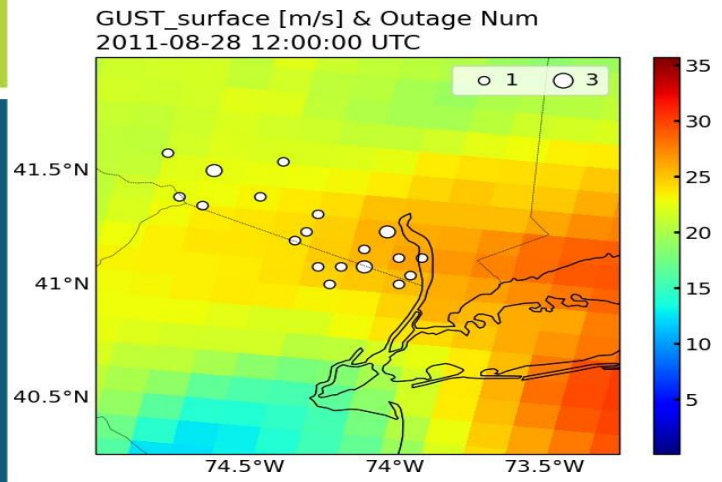
Grid Modeling for Resiliency Impact Analysis

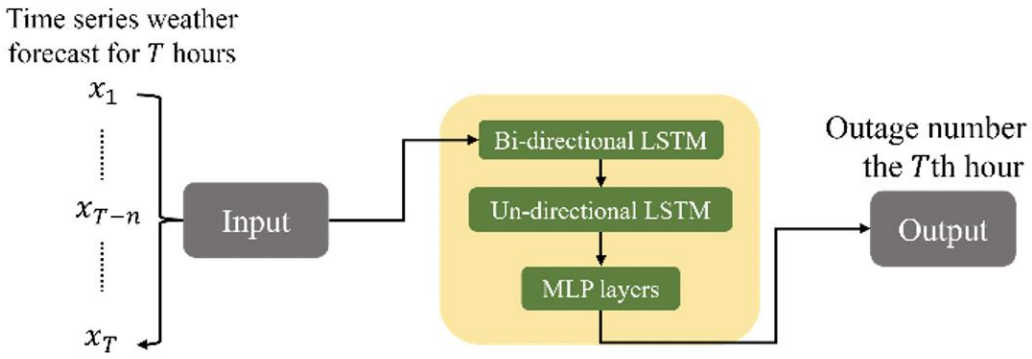
Sahli et al. 2018

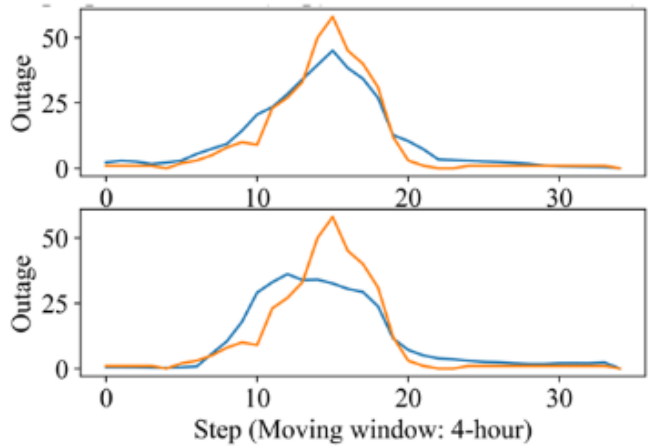


- Evaluate infrastructure resistance and recoverability for demand and generation
- Build on existing grid planning models for the NYC region
- Future planning scenarios considered based on projected generation and load
- Different contingencies can be considered and evaluated

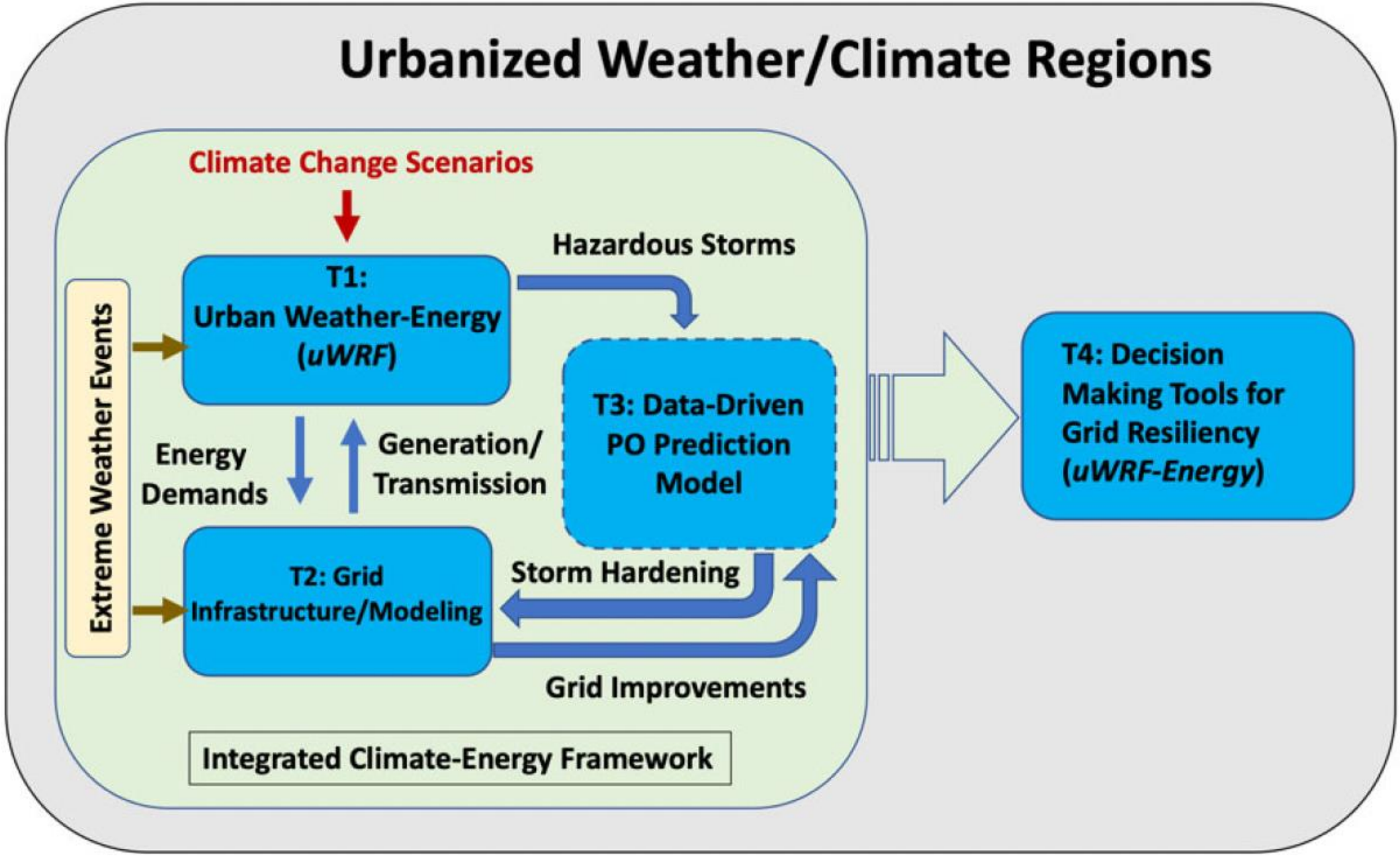
Data-Driven Power Outage Modeling







- Power grid is vulnerable to hazardous weather events that are becoming more frequent
- Grid operators need tools for weather-related outage estimation for decision making
- Machine-learning based algorithm relating historical weather and reported outages
- Approach must account for nonlinear relationships and spatial-correlation/temporal-accumulation of the inputs.


Urbanized Weather/Climate Regions
Climate Change Scenarios
Hazardous Storms
T1:
Urban Weather-Energy
(uWRF)
Extreme Weather Events
Energy
Demands
Generation/
Transmission
T3: Data-Driven
PO Prediction
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T4: Decision
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T2: Grid
Infrastructure/Modeling
Storm Hardening
Grid Improvements
Integrated Climate-Energy Framework

Project Research Questions

0. What ARE the (magnitude of) weather/climate-related hazards that challenge the operation of the energy grid?

1. What will be the frequency and intensity of weather/climate-related hazards that challenge the operation of the energy grid in heavily populated regions?

2. What technological, infrastructure and policy interventions may be required to mitigate these risks?

3. What will the new energy demand and generation capacity be that result from population growth, technological changes, and proliferation of renewables?

4. How can these new demands be serviced with sufficient reliability and resiliency when exposed to extreme weather/climate-related hazards?

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Take Home Messages

- We need better tools for assessing grid vulnerability and resiliency to hazardous weather and extreme climate

- Research requires a cross-directorate collaboration between the Environment, Biology, Nuclear Science and Nonproliferation and Energy Photon Sciences directorates

- We will develop an innovative modeling framework that includes:
  - Urbanized climate/weather model
  - Physical energy infrastructure
  - Data driven machine learning approaches

- Outcome is a unified, adaptable energy-environment modeling framework that can be used for planning of the power grid of the future

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