Environmental Modeling and Applications

(Led by Charlie Vorosmarty and Jorge Gonzalez)

Broad array of domains and themes, modeling approaches

Applications to Protecting Water Resources & Ecosystems: (Led by Vorosmarty)

- **Predictive Coastal Modeling (*Tang**)**
- **EaSM Regional Ecosystem Modeling (*Vorosmarty**)**
- **Algorithm Development for Merged Land Surface - Sea Ice Cryosphere Freeze/Thaw Product (*McDonald/Steiner*)**

Applications t-Health & Energy: (Led by Vorosmarty)

- **Air Quality Impact Applications on Health (*Maantay*)**
- **City scale energy analysis (*Ramamurthy*)**

Weather Ready-Nation: (Led by Gonzalez)

- **Development of NWPMs for Urbanized Regions (*Gonzalez – et al.*)**
- **Integrated Research at California State University, LA (*LaDochy et al*)**
- **Rainfall extremes at urban scales (*Devineni/Khanbilvardi*)**
- ***Drought indicators (Devineni/Khanbilvardi)***
- **Data assimilation of snowpack information for runoff simulations (*Lakhankar/Khanbilvardi***
- ***Satellite based soil moisture for gridded flash flood guidance (Lakhankar/Khanbilvardi)***
- ***Operational global flood mapping using NPP ATMS data (Tesfagiorgis/Temimi/Khanbilvardi)***
- **Assessment of assimilating ATMS land surface sensitive observations (*Tesfagiorgis/Temimi/McDonald*).**

*** Leveraged projects**

NOAA CREST

Project-V:/Theme II

Numerical Weather Prediction Model Development for Dense Urban Environments

Jorge Gonzalez, Mark Arend, Fred Moshary

Students/Post-Docs: Nathan Hosannah, Estatio Gutierrez, Luis Ortiz, David Melecio,

Collaborators: Jeffrey Tongue (NOA/NWS), Graham Feingold (NOAA/OAR/ESRL), Reggina Cabrera (NOAA/NWS), Daniel Comarazamy (NOAA/NESDIS), Fei Chen (NCAR), Bob Borstein (SJSU), Alberto Martilli (CIEMAT/Spain)

Funding Sources: NOAA CREST; NSF ; USDOE, & US ED

Objectives:

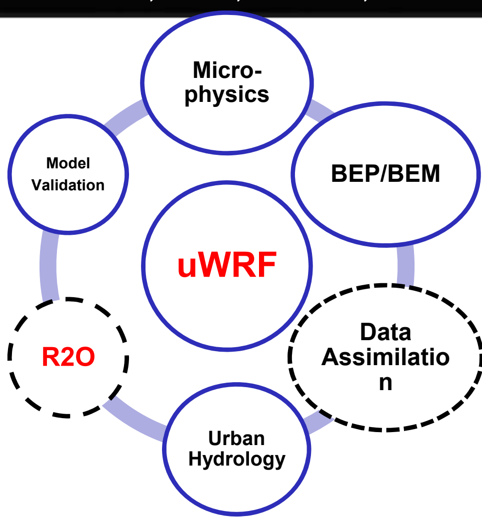
Coupling of NCAR-WRF to urban parameterization schemes (uWRF)

Configuration, parameterization, model development testing and validation of uWRF for **NY-NJ & PR** urban areas at high resolutions (<=1km)

Coupling of uWRF to micro-physics of clouds for in-situ data ingestions.

NOAA Relevance: A Weather Ready Nation

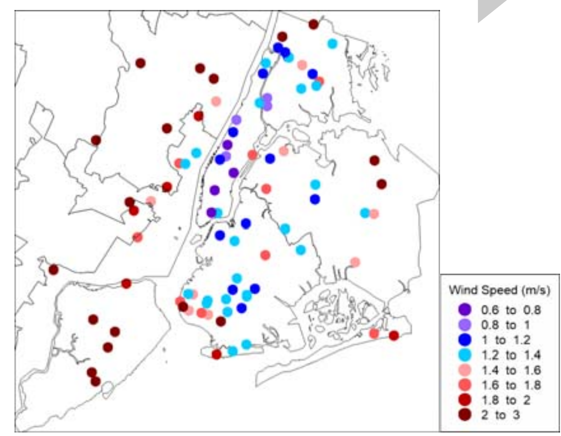
Methods: Improved urban parameterization by including hydrology elements (currently missing), develop data ingestion techniques for aerosol PSD into microphysics schemes, model testing, R20.



EXPECTED OUTCOMES:

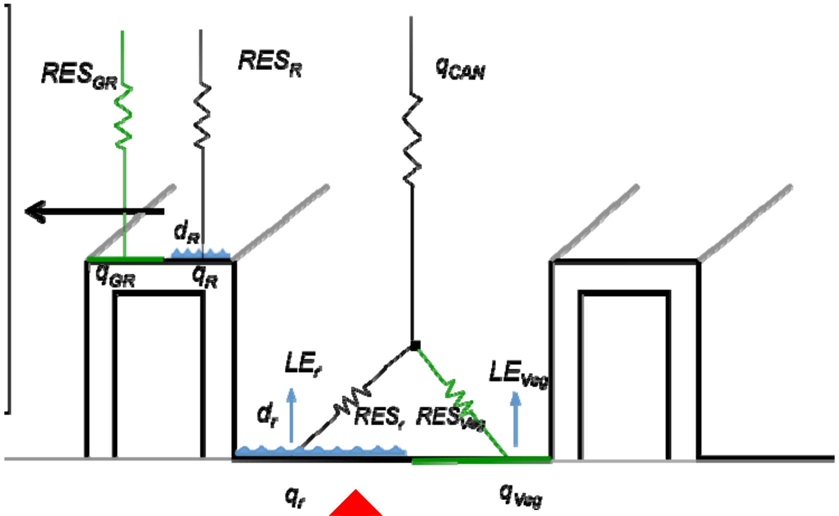
-high resolution (<=1km) NWP optimized for urban environments.

-with applications to: Weather, climate, energy, air quality.

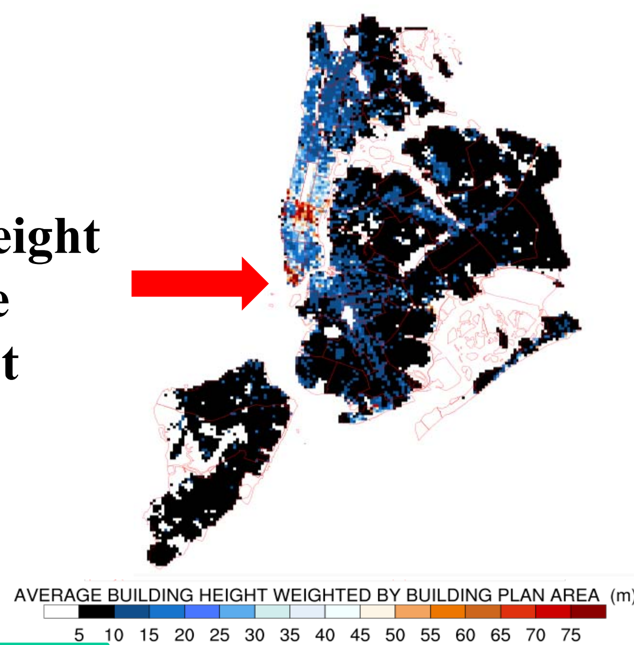


Average Wind Speed (m/s) with new Cdrag Formulation (Summer 2010)

New Urban Parameterizations



Average Building height PLUTO (over entire city) at 250 m (Right



(a) Urban hydrology
(b) Building data assimilation
(c) drag coefficients schemes.

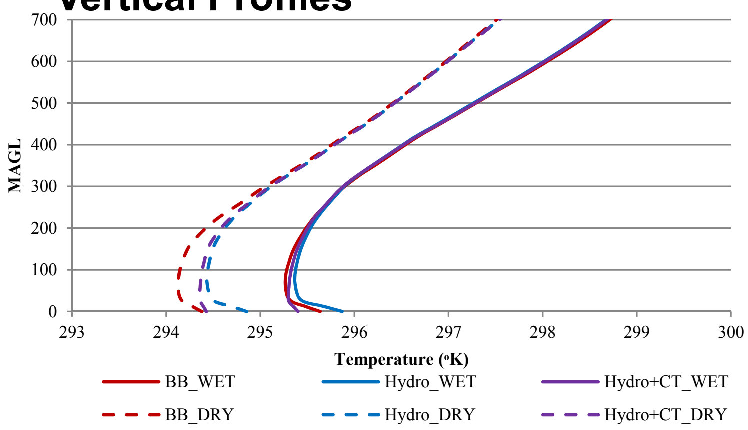
Sectional drag coefficient (Default) = 0.4

Drag coefficient as a function of the building packing density (Santiago and Martilli 2010):

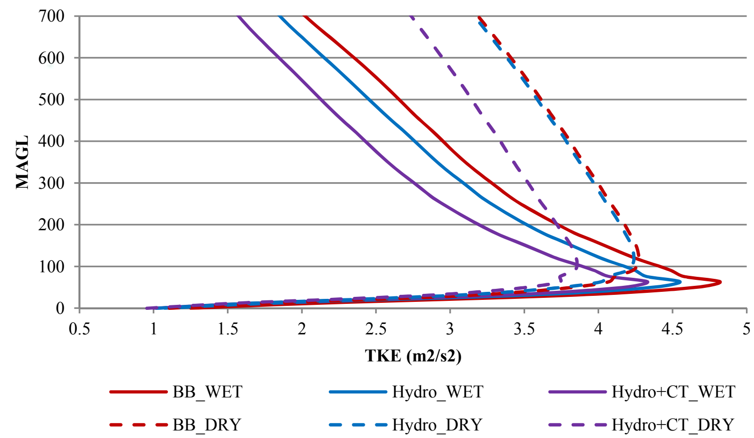
$$C_{deq}(\lambda_p) = \begin{cases} 3.32x\lambda_p{}^{0.47} & for\ \lambda_p \leq 0.29 \\ 1.85 & for\ \lambda_p > 0.29 \end{cases}$$

Major Finding: Planetary Boundary Layer

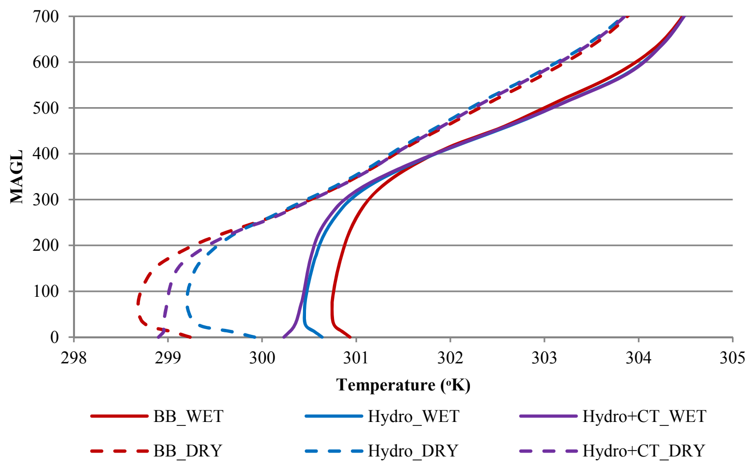
Vertical Profiles



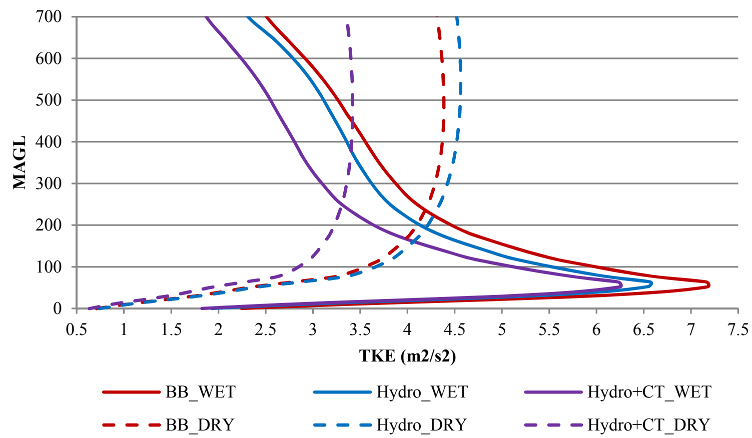
Potential Temperature at 0600 LST for Commercial Areas.



TKE at 1500 LST for Commercial Areas.

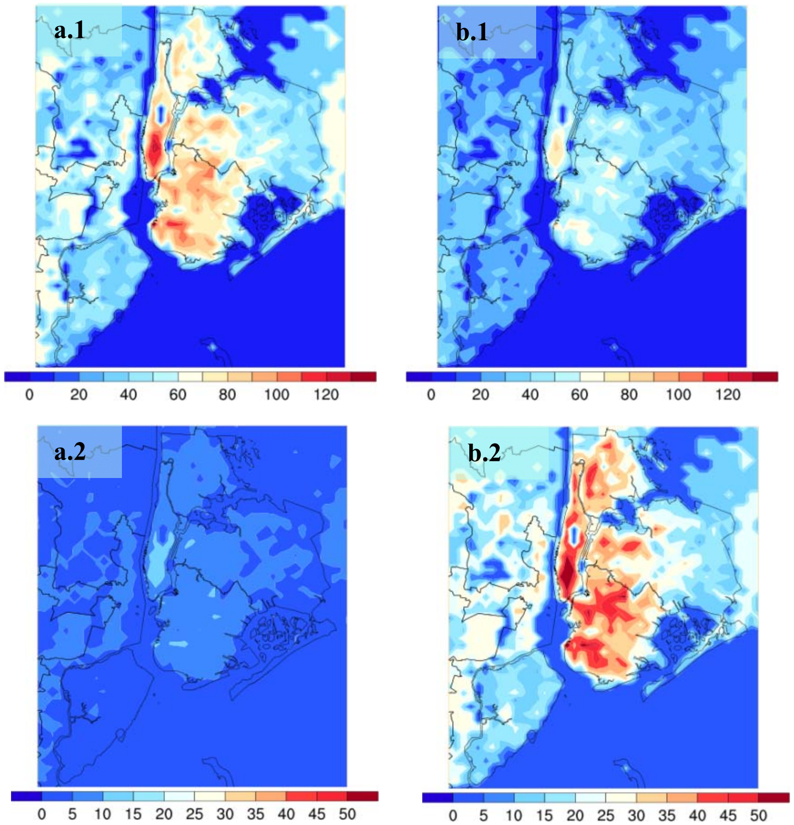


Potential Temperature at 1500 LST for Commercial Areas durin Extreme Events.

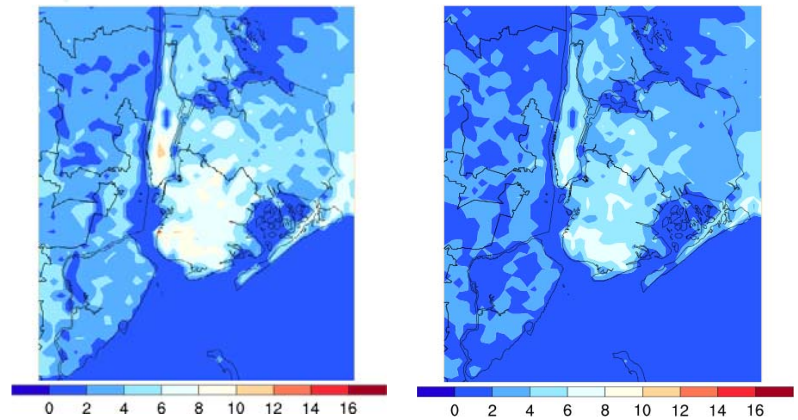


TKE at 1500 LST for Commercial Areas during Extreme Events .

Mitigation Strategies for NYC:
Heat-Partition (Sensible/Latent) Spatial Distribution (W/m²)



Average Daytime Roof Sensible (1) and Latent (2) Heat Flux for Hydro (a) and GR (b).

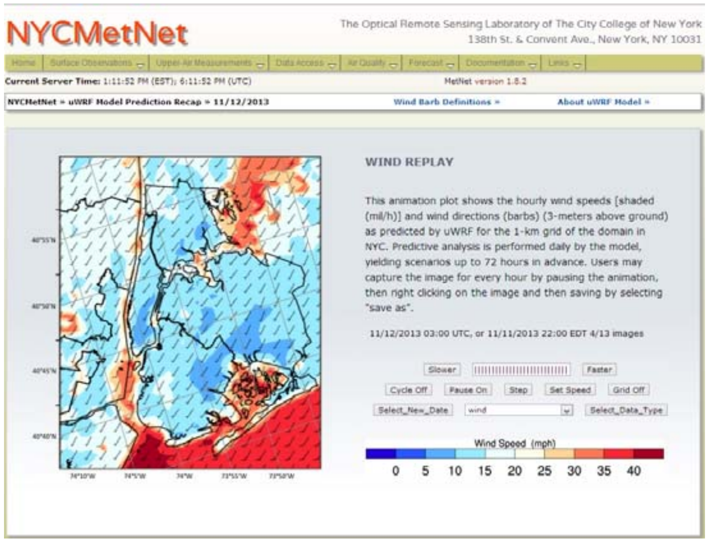


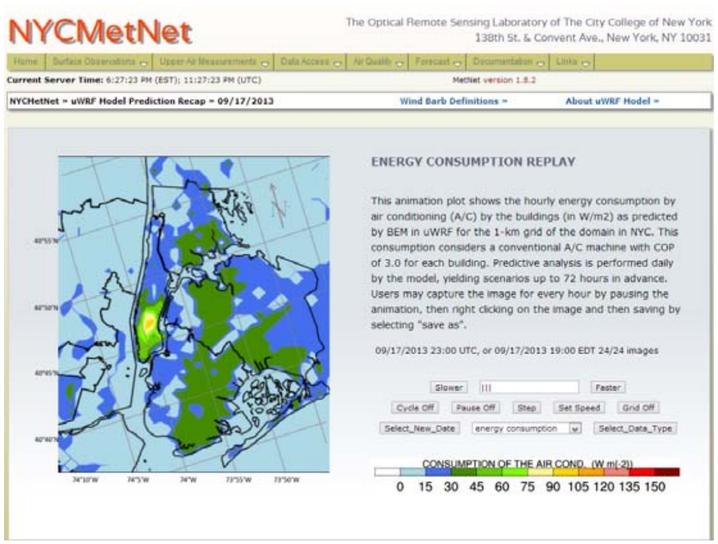
Average Daytime White Roof Sensible Heat Flux During Dry (Left) and Wet (Right) Days

R2O: Operational uWRF for NYC

- WRF-BEP/BEM daily real-time 72h simulations for NYC.
- Surface temperature, winds, hourly accumulated rainfall, snow cover, and energy consumption products are available daily at 9:00 AM ELT.
- An automated assessment system has been implemented and will be further improved

http://air.ccny.cuny.edu/ws/wrfn/thindex.wrfmetnet.php?initial=1





Project-V:/Theme II
Assessment of regional impacts of urban centers in the Northeast United States

Luis E. Ortiz, Jorge Gonzalez

Collaborators: Jeffrey Tongue (NOAA, NWS), Wei Wu (BNL), Bob Bornstein (SJSU), Bereket Lebassi-Habtezion (LLNL)

Funding Source: NOAA CREST; US DoE

Objectives:

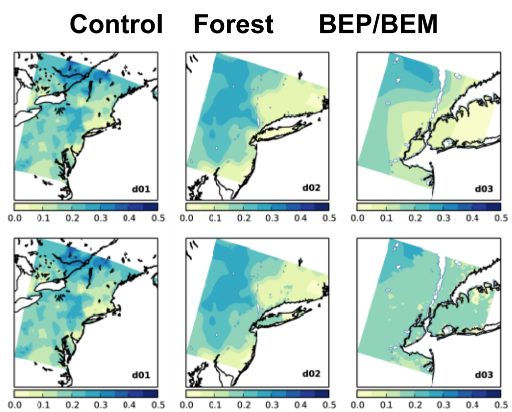
Scaling of the urban WRF (uWRF) for use at the regional level.

Quantify the impacts of urban centers to regional weather and climate using uWRF coupled to urban parameterization schemes

Regional-scale high resolution weather and climate simulations, using the U.S. Northeast as a case study

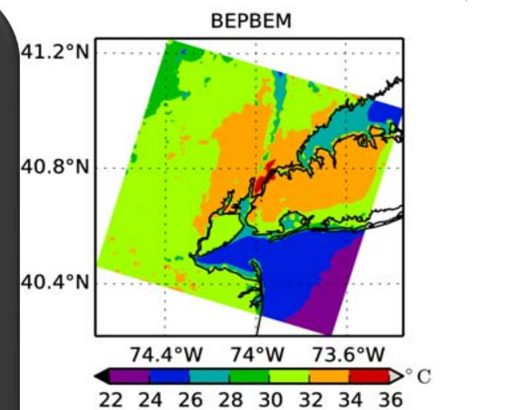
NOAA Relevance: A Weather Ready Nation

Methods: WRF and uWRF simulations with varying urban land cover leading to analysis of effects of urban centers in neighboring areas and at regional level. Design of urban sprawl scenarios for simulations leading all the way to 2100.



EXPECTED OUTCOMES:

- <=1 km resolution regional-scale simulation products for the U. S. Northeast
- Analysis of regional and local impacts in the long-term and during extreme events (heat waves, storms).



Tmax °C for Summer 2010 Heat Wave

Project-V:/Theme II

Catalogue of Observations of the Urban Planetary Boundary Layer (PBL)

David Melecio, Jorge Gonzalez, Mark Arend, James Booth

Collaborators: Jeffrey Tongue (NOA/NWS), Fei Chen (NCAR), Bob Borstein (SJSU), Alberto Martilli (CIEMAT/Spain)

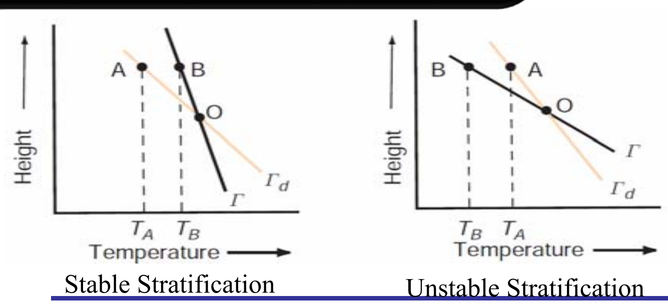
Funding Source: NOAA CREST; NSF and US ED

Objectives:

Use ground-based remote-sensing to characterize the atmospheric boundary layer under different stability conditions.

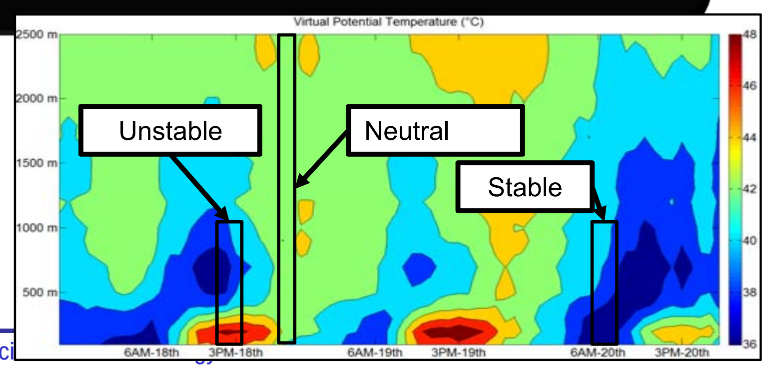
NOAA Relevance: Weather Ready Nation

Methods:
Create a catalog of the static stability. The static stability is being defined by the average of the vertical gradient of the virtual potential temperature up to the height of the boundary layer. Boundary layer heights will be determined from vertical gradients of other derived quantities (minimum relative humidity gradient, and maximum potential temperature gradient.



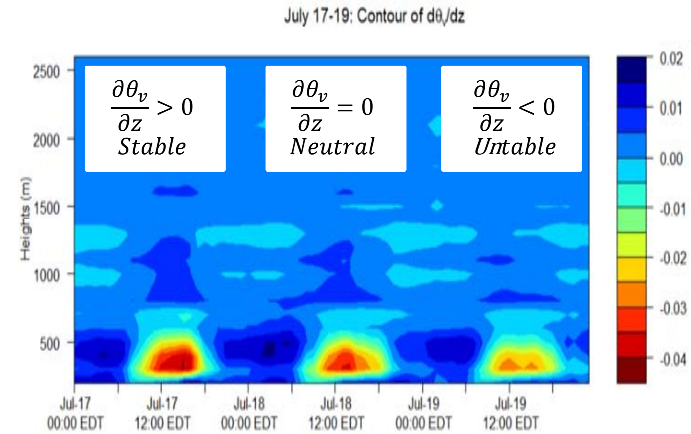
EXPECTED OUTCOMES:

- The creation of a catalogue from which an ensemble of particular static stability conditions can be assembled.
- This will enable testing of turbulence parameterizations within models for urban environment.

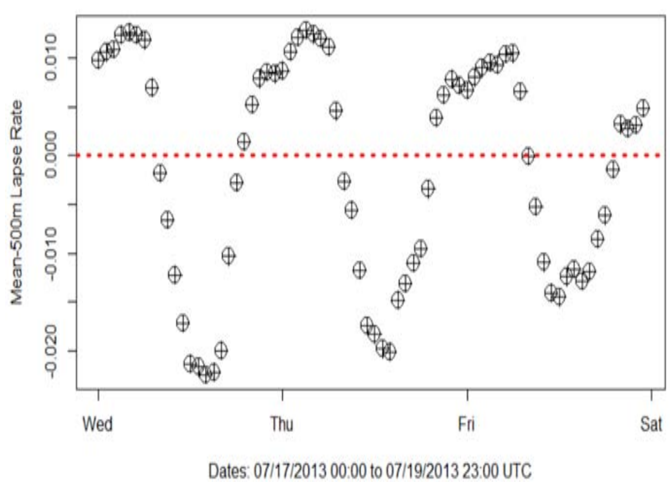


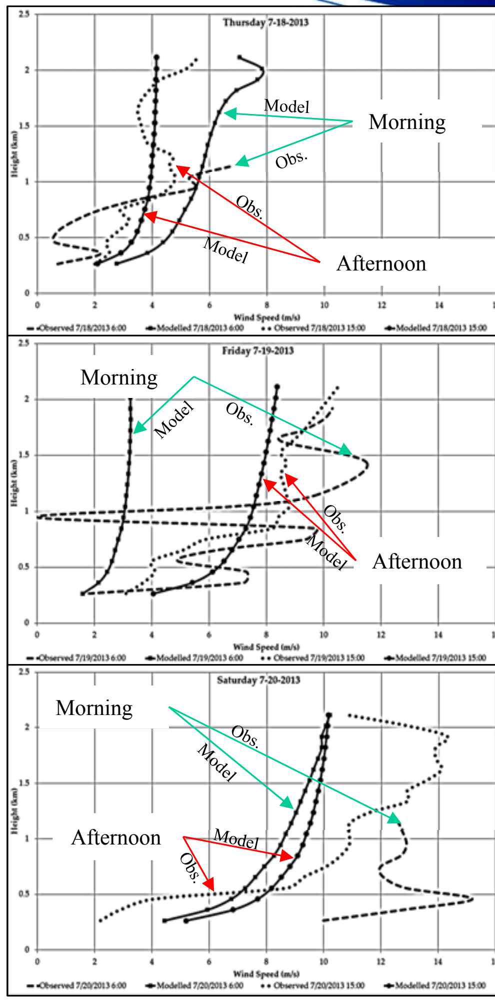
Static Stability Cataloged Events

Static stability is a measure of the capability for buoyant convection and it is determined from the virtual potential temperature profile, $\overline{\theta_v}$, over the whole BL . Using the value of the vertical gradient of $\overline{\theta_v}$, the static stability is determined based on its sign.



Static Stability





Methodology: From Instrument Data to Static Stability

1. Measurements of the temperature, relative humidity, water vapor density, and liquid water densities from a microwave radiometer.
2. Calculate the virtual potential temperature gradient.
3. Boundary layer height is calculated from the average of the boundary layer heights measured from the methods employed.
4. Static stability is determined from value of the vertical gradient of the virtual potential temperature.

Correct determination of the static stability is a crucial first step in determining the type of turbulence closure scheme to be implemented.

Once a catalog based on the static stability is assembled, a more focused, event-based approach can be used to test modeling techniques. An example of a comparison between the modeled and observed winds is given (far-left figure).

Project-5/Theme II: PSD Data Ingestion for Improved Precipitation Forecasting

Nathan Hosannah, Hamed Parsiani, Jorge Gonzalez

Collaborators: Daniel Comarazamy (NESDIS), Graham Feingold (NOAA/OAR/ESRL)

Funding Sources: NOAA CREST & NSF

Objectives:

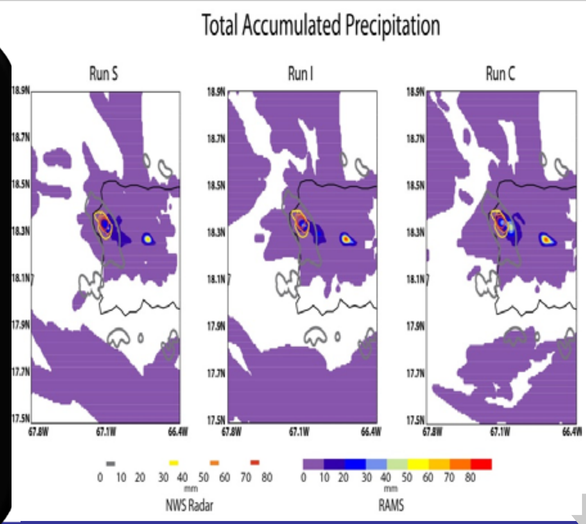
1. To improve PSD ingestion techniques in Cloud-Resolving models
2. To determine the effects of aerosols from varying sources on precipitation
3. 1 Short term extreme events, and long term studies.

Methods:

-Field campaigns in Puerto Rico (Summer 2014 & 2015) & NYC (Continuous) for PSD and BL.

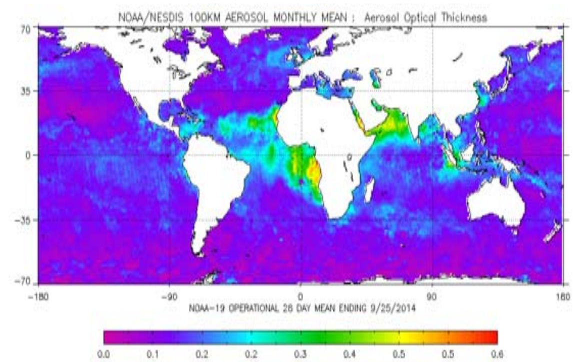
-Ingest PSD into NWP (RAMS) microphysics schemes to test skills.

-Build 4D distributions for forecasting improvements



Future Goals:

To be on a team geared towards producing a gridded PSD satellite product for Global and Cloud-Resolving models.



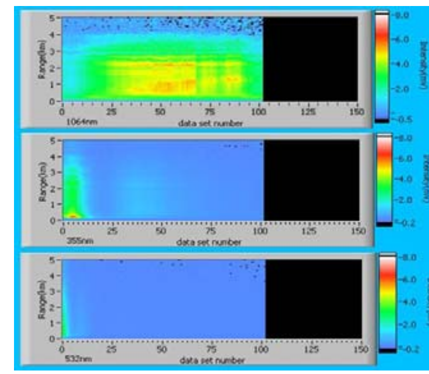
THE IMPORTANCE OF THIS WORK

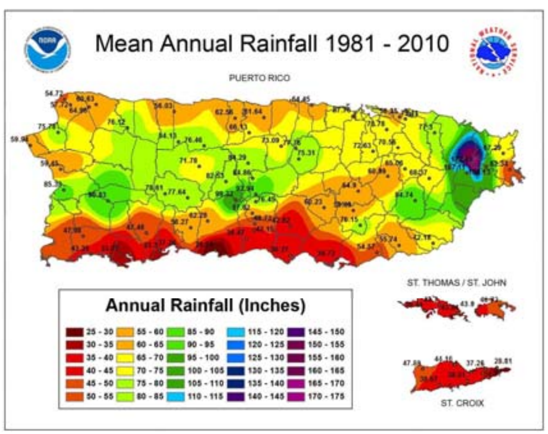
Understanding the aerosol impact on **convective storms** is necessary for precipitation forecasting analysis (Comarazamy et al. 2006; Rosenfeld et al. 2008; Carrio et al. 2010; Hosannah and Gonzalez 2014).

The Caribbean- a tropical environment where precipitation varies by season, tropical storms initiate, and is in the path of Dust storms which originate in the African Sahara (Jury 2009; Angeles et al. 2010; Enfield 1997; Gamble and Curtis 2008; Kim 2005).

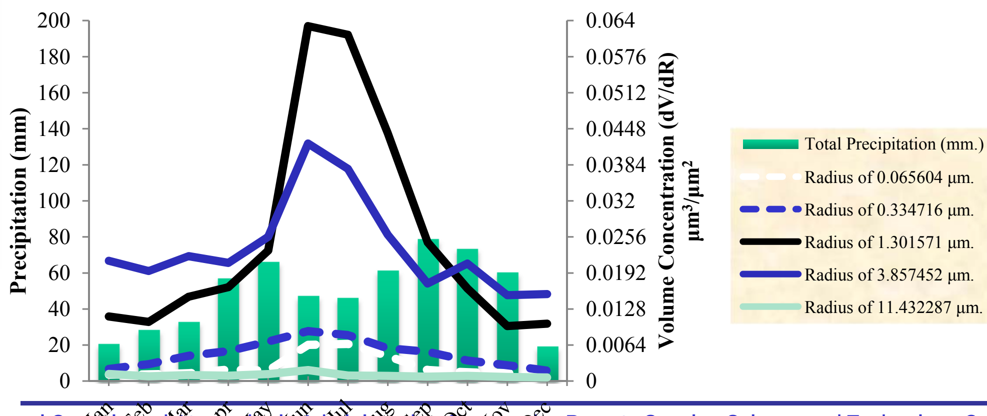
Puerto Rico- A tropical coastal environment frequently blanketed by Saharan dust (SD) that is subjected to varying dynamics across its span (e.g. **Mayaguez** is a sea-breeze/tradewind convergence zone, the central mountains are subject to orographic cloud Formation, and **San Juan** is a highly urbanized coastal environment).

Sample LIDAR returns, and skew-T plot from during Summer 2014 Radiosonde campaign.

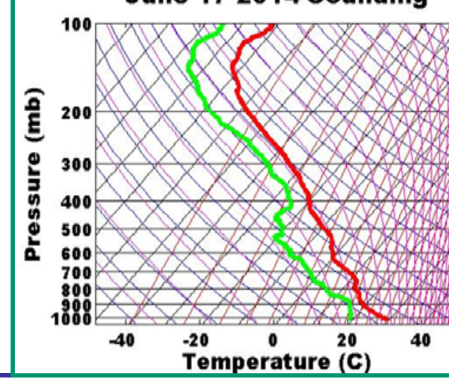




Average Monthly Precipitation and Aerosol Volume Concentration at La Parguera, Puerto Rico (2001 - 2013)



June 17 2014 Sounding



Project-I:/Task-3

Studies for Changing Coastal Climate in Southern California

Pedro Sequera & Jorge Gonzalez

Collaborators: Kyle MacDonald(NOAA/CREST), Daniel Comarazamy (NOAA/NESDIS), Steve LaDochy (Cal State LA), Bob Borstein (SJSU),

Funding Source: NOAA CREST and NSF

Objectives:

Determine the spatial and temporal variability of California summer coastal-climate

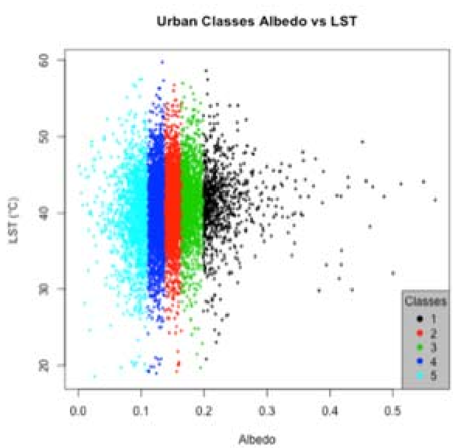
Assess the individual and/or combined contributions of large-scale, regional and local effects on coastal-cooling and forecast this signal in the future

NOAA Relevance: A Weather Ready Nation

Methods:

-Derive a new land-cover classification from NASA HyspIRI preparatory

-Numerical modeling (WRF) with different scenarios of land-covers and climate conditions.

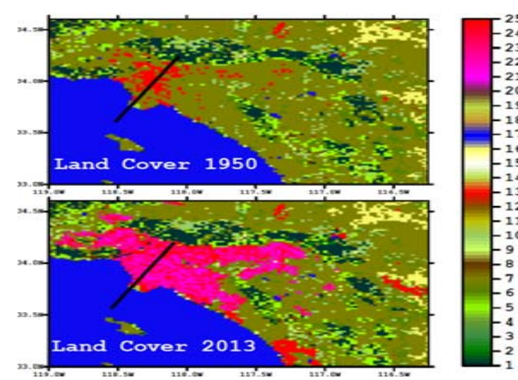


EXPECTED OUTCOMES/Results:

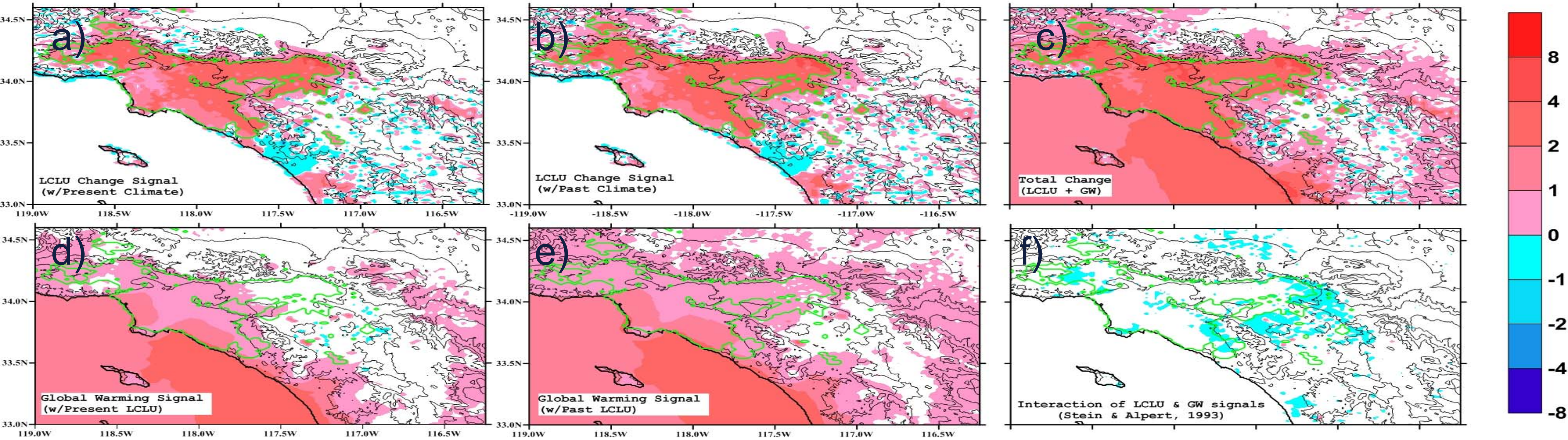
Updated land-cover classifications (2013).

Numerical simulation outputs that will allow to assess the most influential factors on coastal climate

With applications to: Weather, climate, energy, air quality.



Changes in Tmax for Southern California 1950-54 to 2009-13 (Global Warming vs Changes in LCLU) (Urban areas in green; white areas are non-significant Tmax Changes at the 5% significance level)



- **LARGE-SCALE EFFECTS:** overall regional warming (panels c and d). Most intense warming (up to 2°C/60 years) occurs in coastal areas.
- **LCLU EFFECTS:** Clear warming trends (up to 8°C/60 years) in urban areas (panels a and b). UHI-induced temperature gradient not enough to promote regional coastal-cooling.
- **TOTAL CHANGE** (panel c): both factors contribute to the warming, but Global Warming is more dominant.

Integrated Research at California State University, LA

CREST Researchers: Steve LaDochy, Pedro Ramirez, Hengchun Ye, Jorge Gonzalez

CREST Students: Freddy Hsu, Tania Torres, Alissa Magana, Arquimidez Hernandez, Pedro Sequera

Collaborators: William Patzert (NASA JPL), David Bruno (NOAA)

Funding Source NOAA CREST and LaKretz Environmental Research Grant

Objectives: Investigate the characteristics of an evolving urban heat island (UHI) in the Los Angeles metro area, using surface met data, land use change and aircraft remote sensing.

Integration of GIS maps, climatic and oceanic coastal data, demographics and social-economic variables.

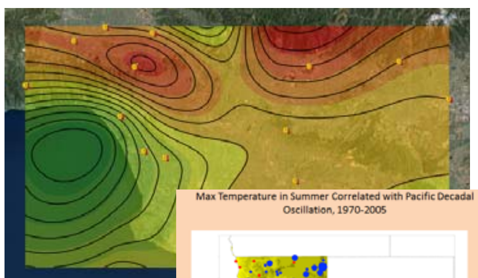
NOAA Mission Relevancy: Weather Ready-Heat Waves

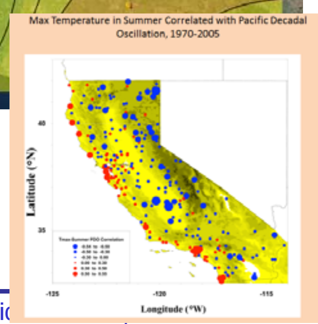
Methods:

Developing integrated model of ocean-land-atmosphere interactions over a changing coastal urban landscaped;

Creating unique sets of GIS maps.

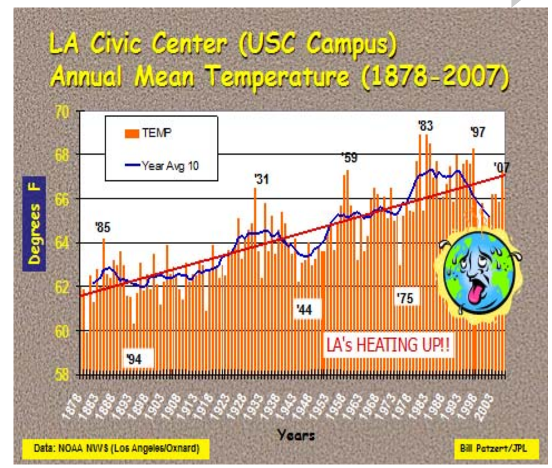
Identifying urban hot spots, mitigation schemes.





EXPECTED OUTCOMES

Create unique data set for urban climate models showing LA UHI characteristics and heat wave mitigation strategies



Rainfall Extremes at Urban Scales

CREST Participants: Naresh Devineni, Reza Khanbilvardi

CREST Students: Ali Hamidi (Leveraged)

NOAA Collaborators: Ralph Ferraro(NOAA)

Funding Sources: NOAA-EPP, and leveraged

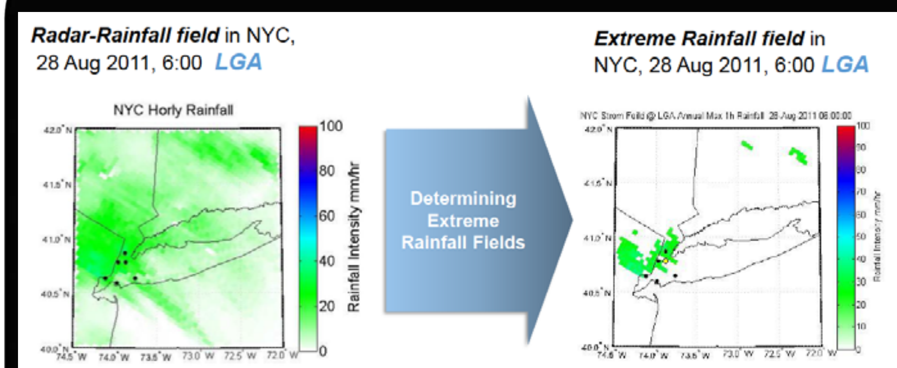
Objectives

→ Develop simultaneous exceedance of rainfall fields.

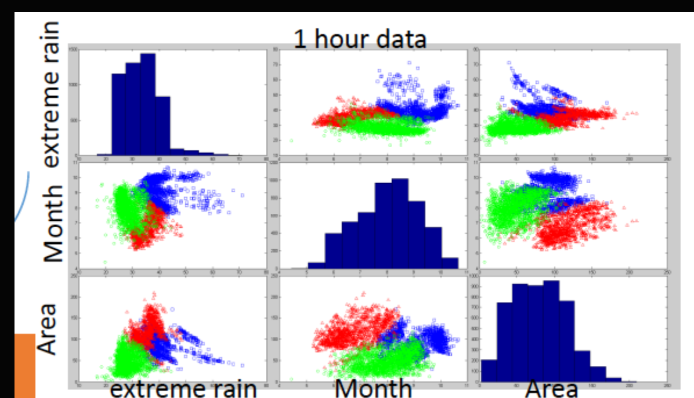
→ Data fusion strategy for regional risk estimation and identification of potential exposure zone at New York City.

NOAA Mission Relevancy: Climate Adaptation; Weather Ready Nation.

Conceptualization



CREST'S Urban Flood Risk Model



Demand Sensitive Drought Indicators (Water Resources)

CREST Researchers: Naresh Devineni, Reza Khanbilvardi

CREST Students: Elius Etienne (Leveraged)

NOAA Collaborators: Felix Kogan (NOAA STAR)

Funding Sources: CUNY Leveraged, NOAA-CREST

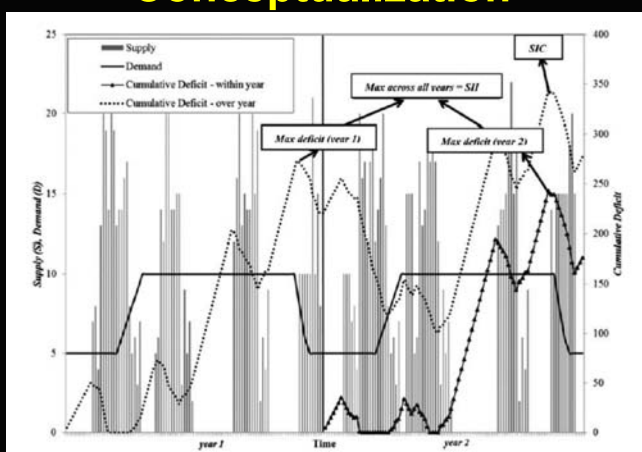
Objectives

→ Develop an index that considers the differences in regional **sectorial water demands** (sometimes markedly different in the same climatic regime)

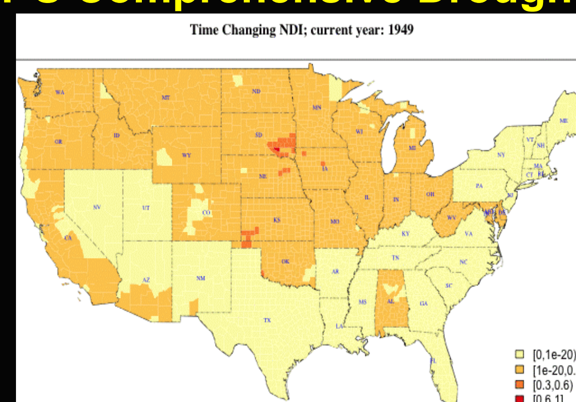
→ Develop a demand sensitive drought index (TDI) that (**operates on a daily scale**) and could be spatially disaggregated to **county level**.

NOAA Mission Relevancy: Weather Ready Nation, Resilient Communities and Economy.

Conceptualization



CREST'S Comprehensive Drought Index



Assimilating merged remote sensing and ground based snowpack information for runoff simulation using hydrological models

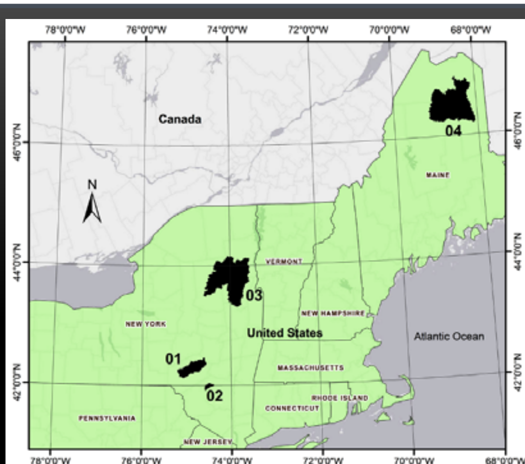
CREST Researchers: Tarendra Lakhankar, Reza Khanbilvardi
CREST Students: Jose Infante (PhD) (leveraged)
NOAA Collaborators: Al Powell (NOAA)
Other Collaborators: Elliot Schneiderman (NYC-DEP)

Objectives:

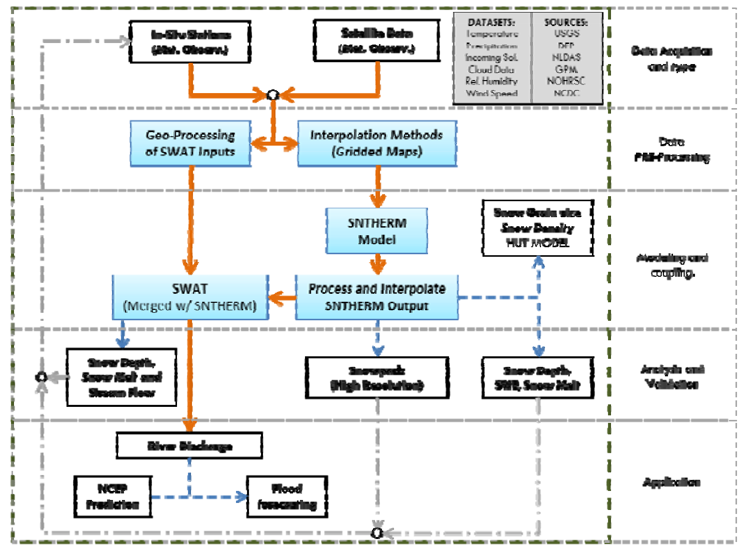
- Improve streamflow simulation by introducing spatially distributed meteorological data and a more robust snowpack simulation into hydrological modeling

NOAA Mission Relevancy

Weather-Ready Nation, Ow2: Improved water resource management



Study area: West Delaware (NYCDEP), **West Neversink** (Small basin), **Upper Hudson** (Snow Amount), **Caribou** (CREST-SAFE data comparison).



Potential End-users: (1) DEP/NYC for Snowpack Modeling (3) National Weather Service

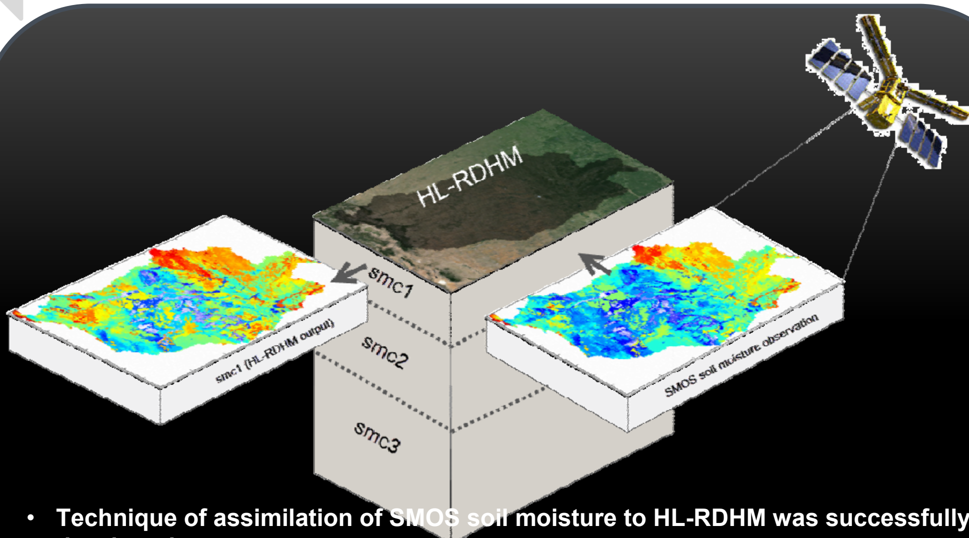
Toward Satellite Based Soil Moisture for Gridded Flash Flood Guidance

CREST Researchers: Tarendra Lakhankar, Reza Khanbilvardi
CREST Students: Dugwon Seo (Graduated)
NOAA Collaborators: Brian Cosgrove, Mike Smith (NWS/OHD), Xiwu Zhan (NOAA/NESDIS)

Objectives:

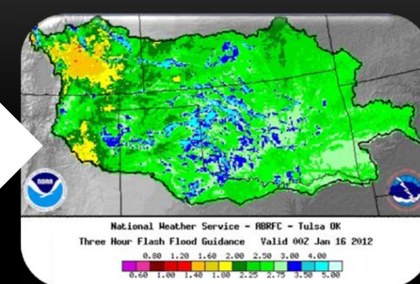
- The motivation of this project to integrate remote sensing satellite based soil moisture data in current hydrological modeling to improve NWS Gridded Flash Flood Guidance System.
- The data from Soil Moisture and Ocean Salinity (SMOS) mission is being used as a proxy to NASA's SMAP mission's soil moisture data.
- A methodology is being developed to employ the direct soil moisture data from SMOS to replace the model-calculated soil moisture state which is based on the soil water balance.

NOAA Mission Relevancy
Weather-Ready Nation, **Ow2:** Improved water resource management



- **Technique of assimilation of SMOS soil moisture to HL-RDHM was successfully developed.**
- **The discrepancy of upper zone saturation ratio proved the potential improvement of flash flood forecast with satellite based soil moisture.**

End Users: River Forecasting Centers, Water Resources Managers and Public Safety Managers.



Operational Global flood mapping using NPP ATMS data

CREST Researchers: Kibre Tesfagiorgis, Marouane Temimi, and Reza Khanbilvardi.

NOAA Collaborators: Mitch Goldberg

Funding Source: Leveraged (Non-EPP NOAA funds)

Objective:

Automated detection and mapping of flooding across the globe.

The system posts markers on Google API at locations where flooding have occurred.

Improve global flood monitoring to **support NOAA's goal of achieving a weather ready nation**

Methods:

ATMS/AMSU include window channels (23.8, 31.4, 50.3 and 89.0 GHz) to monitor surface features, such as soil moisture.

A combination of two or more of these channels can be used for a qualitative soil wetness estimation

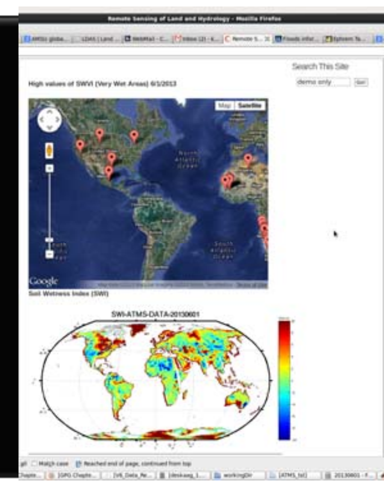
There are two well established methodologies to monitor inundation/flood using Microwave BT measurements.

PRVI (Polarization Ratio Variational Index)

SWVI (Soil Wetness Variational Index)

Operational global flood mapping system

http://water.ccny.cuny.edu/research-product/inundation/



Assessment of assimilating ATMS land surface sensitive observations in the NOAA data assimilation system

CREST Researchers: Kibre Tesfagiorgis, Marouane Temimi, and Kyle McDonald.

NOAA Collaborators: Weishong Zhang and Mike Ek (NOAA-NCEP); Sid Boukabara (NOAA-JCSDA)

Funding Source: Leveraged (Other Non-EPP NOAA funds)

Assimilating land sensitive microwave observations into Global Forecast Systems

Precisely; the assimilation of Freeze/Thaw data is being tested. Also, ATMS widow channel data are being tested.

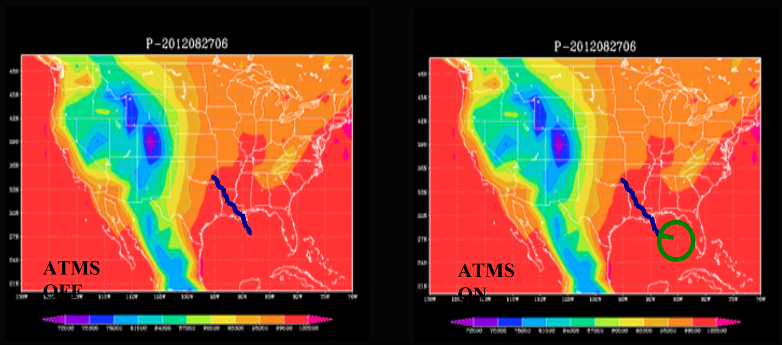
Improve global weather forecasts to **support NOAA's goal of achieving a weather ready nation**

Methods:

Currently NOAA's operational forecast system does not account for radiances observed in window channels which are highly sensitive to surface parameters.

We used S4 suit to assess the assimilation of land surface Freeze/Thaw data with NCEP team (led by Mike Ek)

First tests with synthetic F/T estimates were successfully conducted.



Hurricane track simulated with and without ATMS window channel data being assimilation into GFS

Multiscale and Multiphysics Model Development for High-Fidelity Simulation of Coastal Ocean flows

CREST Researchers: Hansong Tang

NOAA Collaborator: Yong Wei (NOAA/Pacific Marine Environmental Laboratory)

Funding Source: NSF

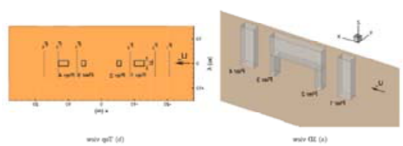
Objective: Establishment of an unprecedented and urgently needed modeling system to handle emerging problems, such as storm surge impact on bridge and oil spill at seabed, and provide necessary a tool for efforts in research on mitigation of coastal hazards and development of resilient coast.

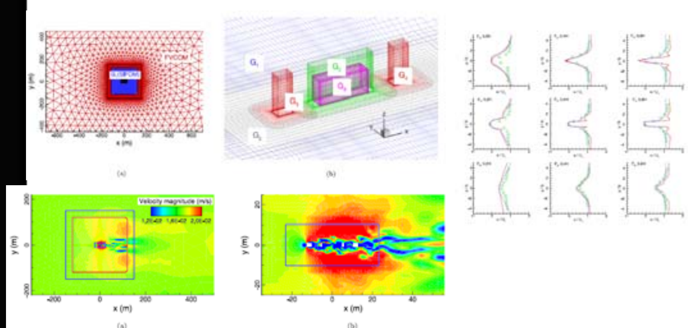
NOAA Mission Relevancy – Resilient Ecosystem and Coastal Communities

Formulation of SIFOM-FVCOM coupling system.

Code development and validation.

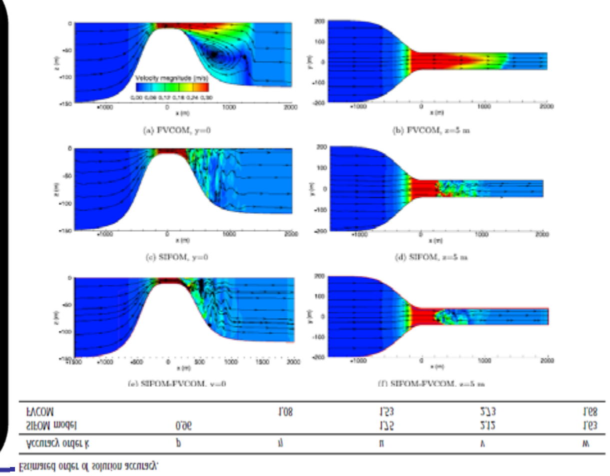
Flow past bridge piers





Expected outcome: a working modeling system for small-scale flows problems of NOAA mission

Flow over sill

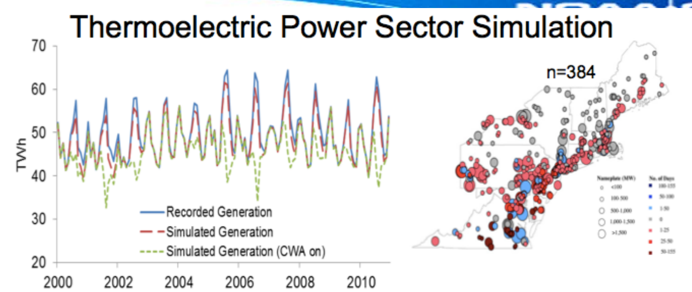


LEVERAGED PROJECT:

A Regional Model of the Northeast Corridor: Analyzing 21st Century Climate and Environment

C. Vörösmarty, B. Rosenzweig, A. Miara, N. Ehsani, F. Moshary, B. Gross, M. Arend, J. Gonzalez, Kyle McDonald (Students: A. Miara, N. Ehsani, K. Shikmacheva)

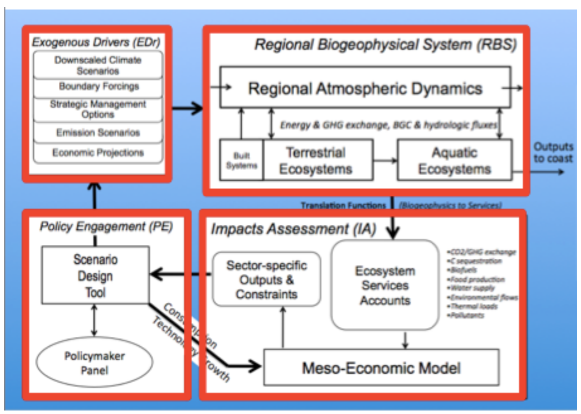
Funding Source: NSF & NOAA CREST



Objectives: Move from retrospective to prospective and potential operational system for assessing water quantity, quality, carbon balances, energy system secutiry, and economic impacts of climate/weather and environmental stressors

NOAA Mission Relevancy: Climate Adaptation & Mitigation and creating a Weather-Ready Nation

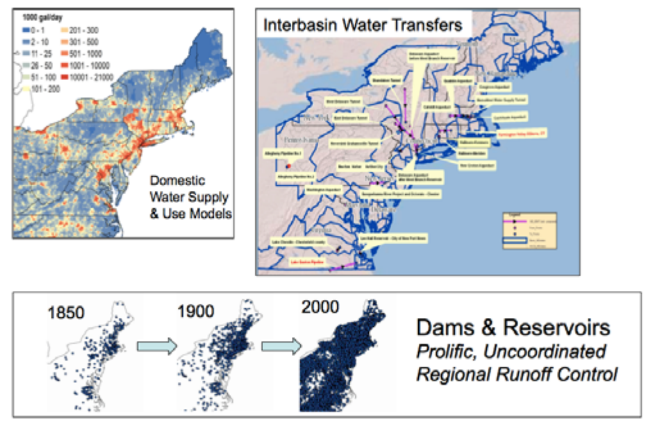
Development of multi-sectoral, multi-environmental subsystem assessment systems for climate and weather and direct human-induced stresses



EXPECTED OUTCOMES

Operational system to integrate regional earth system observation and modeling for sector-specific applications

Strategies to Optimize Water Use and Infrastructure Management under Climate and Development Scenarios



Algorithm Development for Merged Land Surface - Sea Ice Cryosphere Freeze/Thaw Product

CREST Mentors: Kyle McDonald, Nicholas Steiner, **CREST Students:** Cassandra Calderella (partially funded)

Collaborators: Benjamin Holt (NASA JPL)

Funding Source NOAA CREST and NASA Earth Science

Objectives: Development of unified datasets of unified datasets of daily land surface freeze/thaw state and ocean ice freeboard extent and melt/freeze condition over the Arctic land and sea ice domains to enhance environmental modeling.

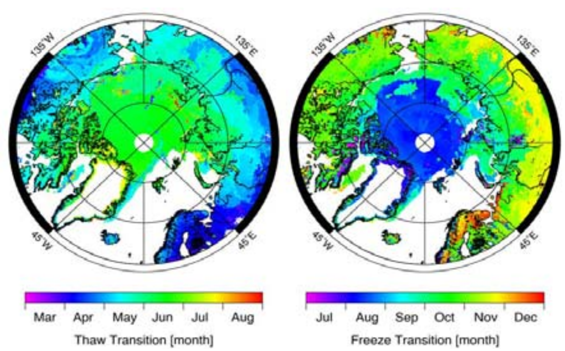
Integration of SMAP datasets w for operational characterization of cryosphere processes across the north polar land-ocean domain

NOAA Mission Relevancy

Development of wavelet-based approach to map transition events on sea ice and land.

Prototyping with ASCAT and QuikSCAT.

Operatoinalization with SMAP



EXPECTED OUTCOMES

Enhance use of NRL environmental model for operational ice monitoring and climate studies

Climate Change and Public Health (Theme 1)

CREST Researcher: Juliana Maantay;

CREST Students: Lesley Patrick, PhD Candidate;

Zakkiyyah Shah, MS-GISc

NOAA Collaborator: Ralph Ferraro

Assessing the "Riskscape" – Exposure and Vulnerability from Current and Projected Coastal Flooding

Objectives:

1.) Health Exposure and Infrastructure Vulnerability to Projected Coastal Flooding in New York City: Constructing a Risk Index

2.) Climate Change and Public Health Impacts on Two Coastal Cities: New York and San Juan, Puerto Rico

Methods:

Advanced GISc and geostatistical techniques for combining large-area data products with micro-extent human conditions and activities for urbanized coastal regions.

This research has potential benefits for public policy–making, regarding planning, management and mitigation strategies, and resilience-building.

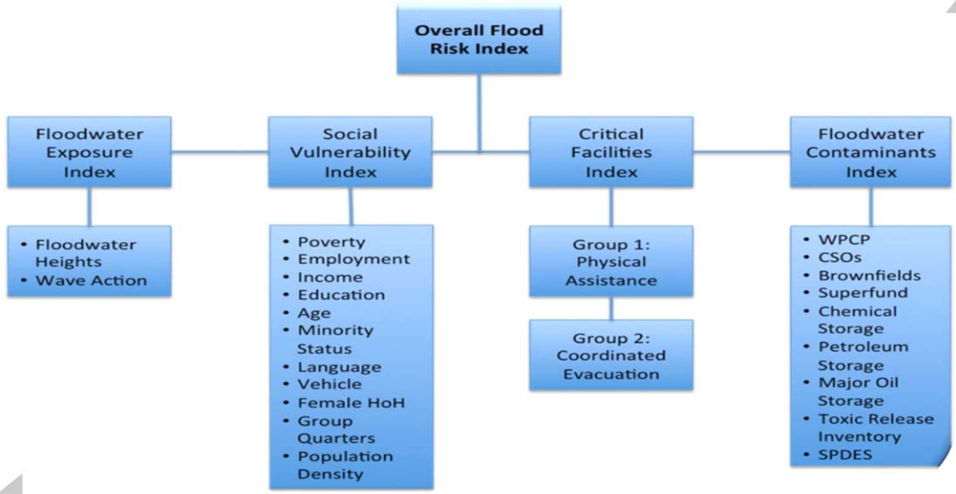
Outcomes and Significant Contributions:

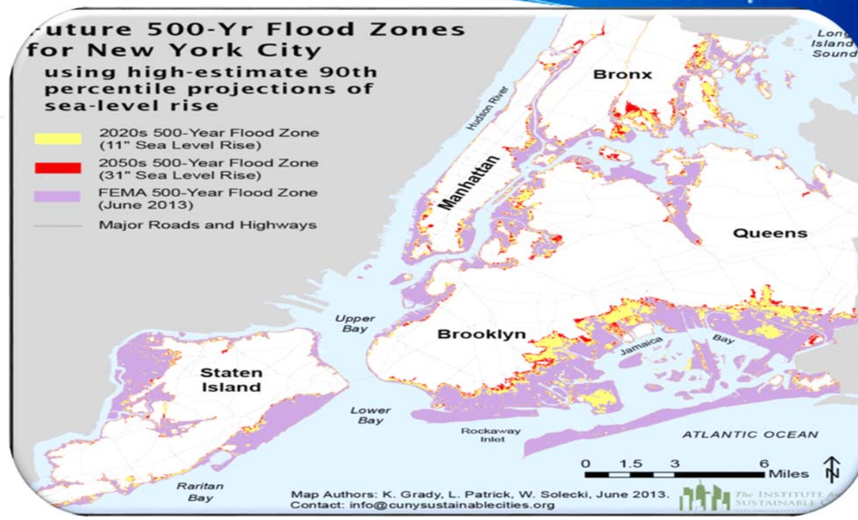
Publications: 5 (4 w/students)

Conference Presentations: 6

Risk Index and Results Useful to Policy- and Decision-makers

NOAA CREST





Lower Vulnerability

Higher Vulnerability

Rank 1 - Projected 500-Year Flood, 2050s

Rank 2 - Projected 500-Year Flood, 2020s

Rank 3 - Projected 100-Year Flood, 2050s

Rank 4 - Projected 100-Year Flood, 2020s

Rank 5 - FEMA Shaded X Zones

FEMA Shaded X areas are located between the limits of the current 100-Year and 500-Year floods. High velocity wave action is not a factor.

Rank 6 - FEMA AE and AO Zones, BFE < 10 ft

FEMA AE Zones are subject to shallow flooding (average depths between 1 and 3 feet) in the current 100-Year flood. High velocity wave action is not a factor. The base flood elevations in these tax lots are less than 10 feet.

Rank 7 - FEMA AE Zones, BFE 10 ft

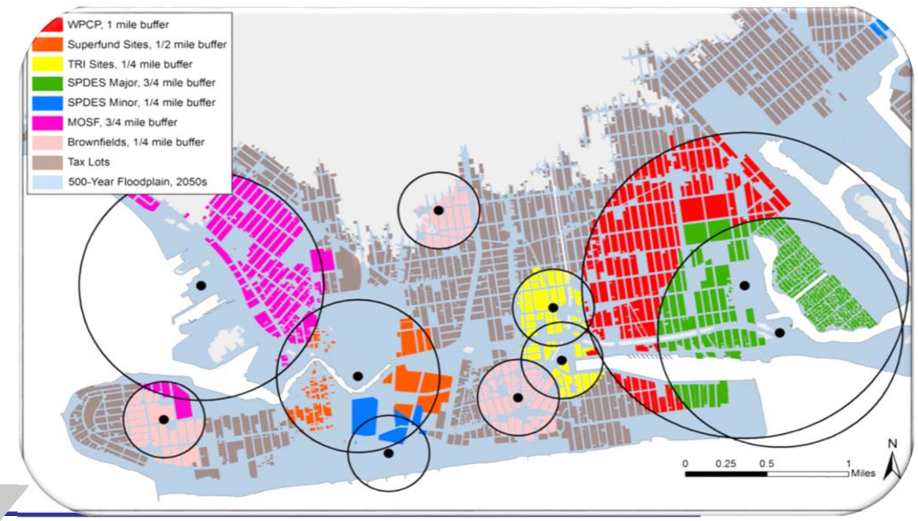
FEMA AE Zones are subject to the current 100-Year flood. High velocity wave action is not a factor. The base flood elevations in these tax lots are equal to 10 feet.

Rank 8 - FEMA AE Zones, BFE > 10ft

FEMA AE Zones are subject to the current 100-Year flood. High velocity wave action is not a factor. The base flood elevations in these tax lots are greater than 10 feet.

Rank 9 - FEMA VE Zones

FEMA VE Zones are subject to the current 100-Year flood and also exposed to storm-induced breaking waves greater than 3 feet in height (high velocity wave action).



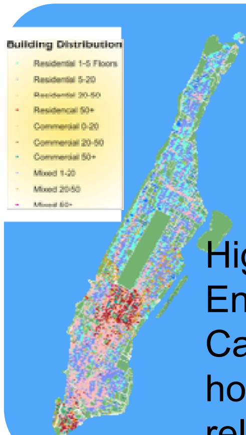
Figures by L. Patrick, 2015

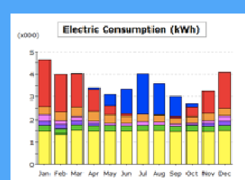
Coupled Framework to Map Building Energy Use in NYC

Prathap Ramamurthy, Yori Baldis*

Funding Source: NOAA CREST
Collaborators: NYC Mayor's Office

Project Objectives: 1- Facilitate urban climate simulation at high resolution**. 2-** Estimate anthropogenic contribution to urban heat at block-scale. **3-** Improve NYC Climate Preparedness





High-Res LULC + Building Energy Model + Urban Canopy Model to estimate hourly energy use & energy release

Expected Outcome: Citywide building energy contribution to urban surface energy budget at multiple temporal resolution. Impact of various UHI mitigation strategies on reducing anthropogenic heat release.