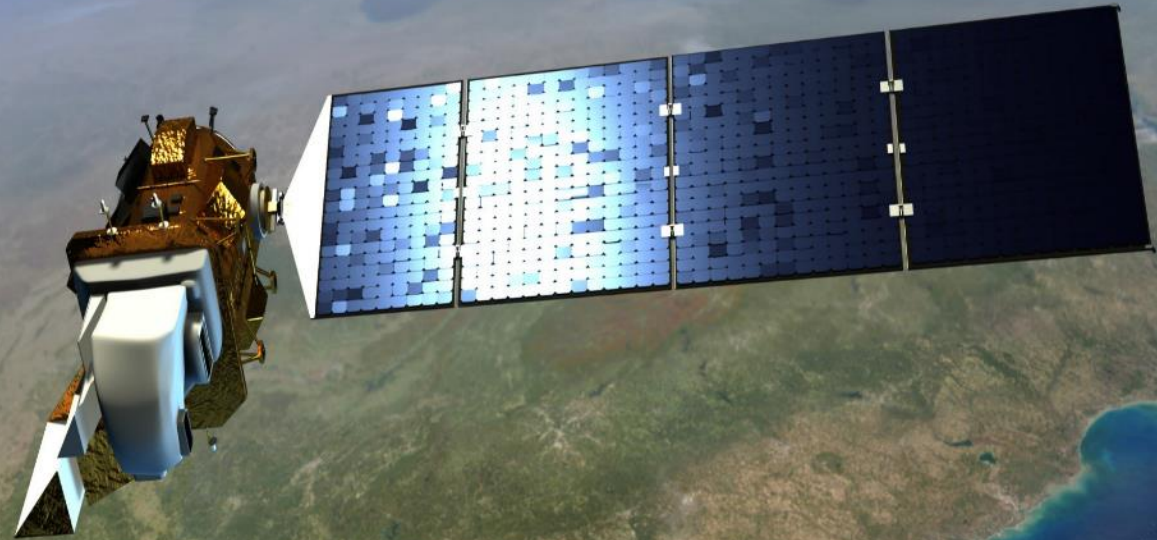


NOAA – Cooperative Science Center for Earth Systems Science and Remote Sensing Technologies



NOAA-CREST Center at ESRL

Reza Khanbilvardi
August 14, 2018



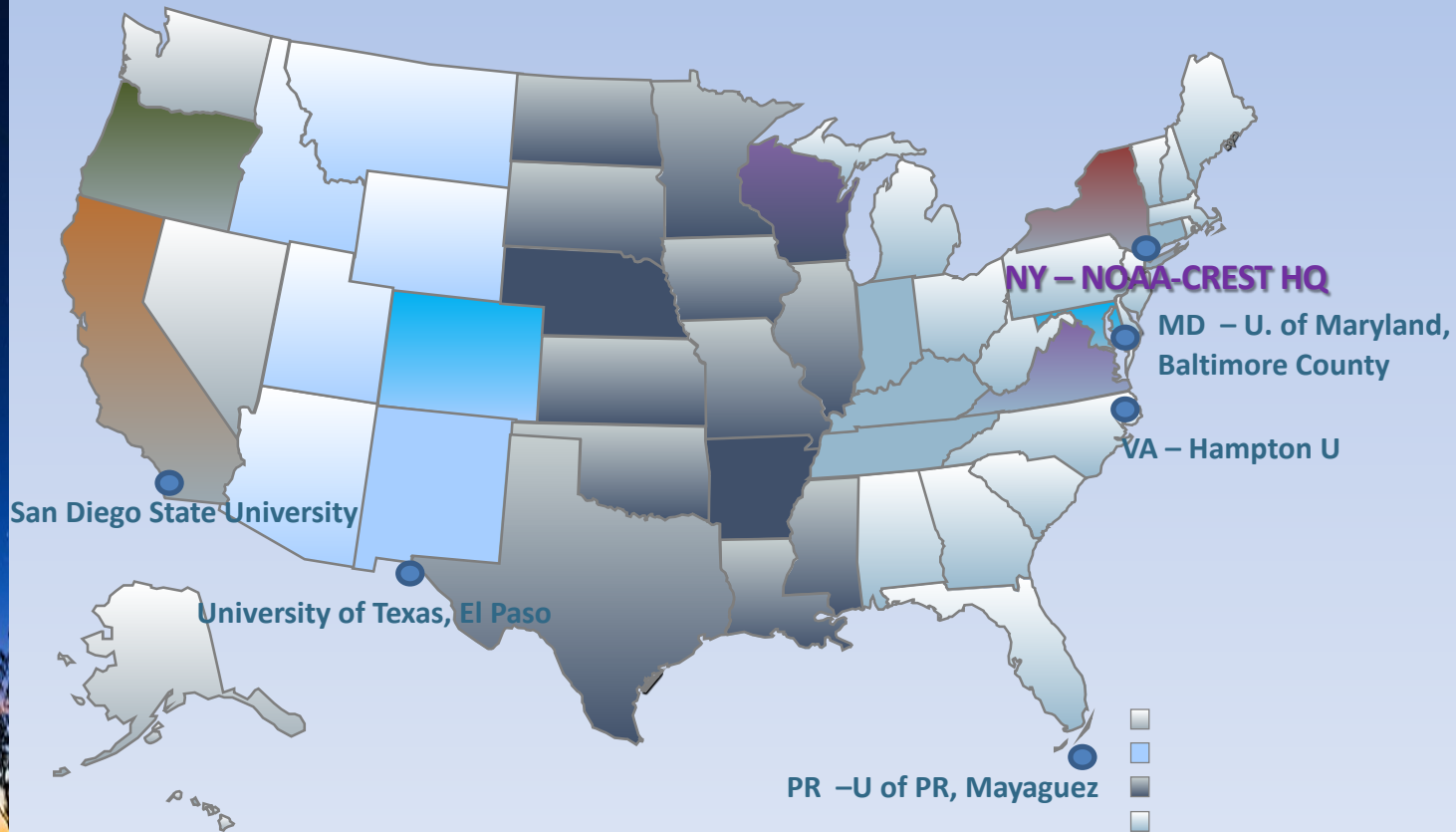
NOAA-CREST History

- **In existence** since 2001 through major funding by NOAA Educational Partnership Program (EPP)
- **Mission** - to increase number of educated, trained and graduated students especially from underrepresented communities in NOAA related sciences and advance NOAA sciences
- **Overarching Goals** – conduct **research** in NOAA related science in collaboration with NOAA line offices (NESDIS, NWS, NOS) , **recruit , train, educate and graduate** students and **public outreach** to help increase environmental literacy and help increase STEM workforce

CREST Industrial Partners

- Northrop Grumman Corporation (NCG)
- Raytheon
- Earth Research Technology, Inc. (ERT)
- Science Systems and Applications, Inc (SSAI)

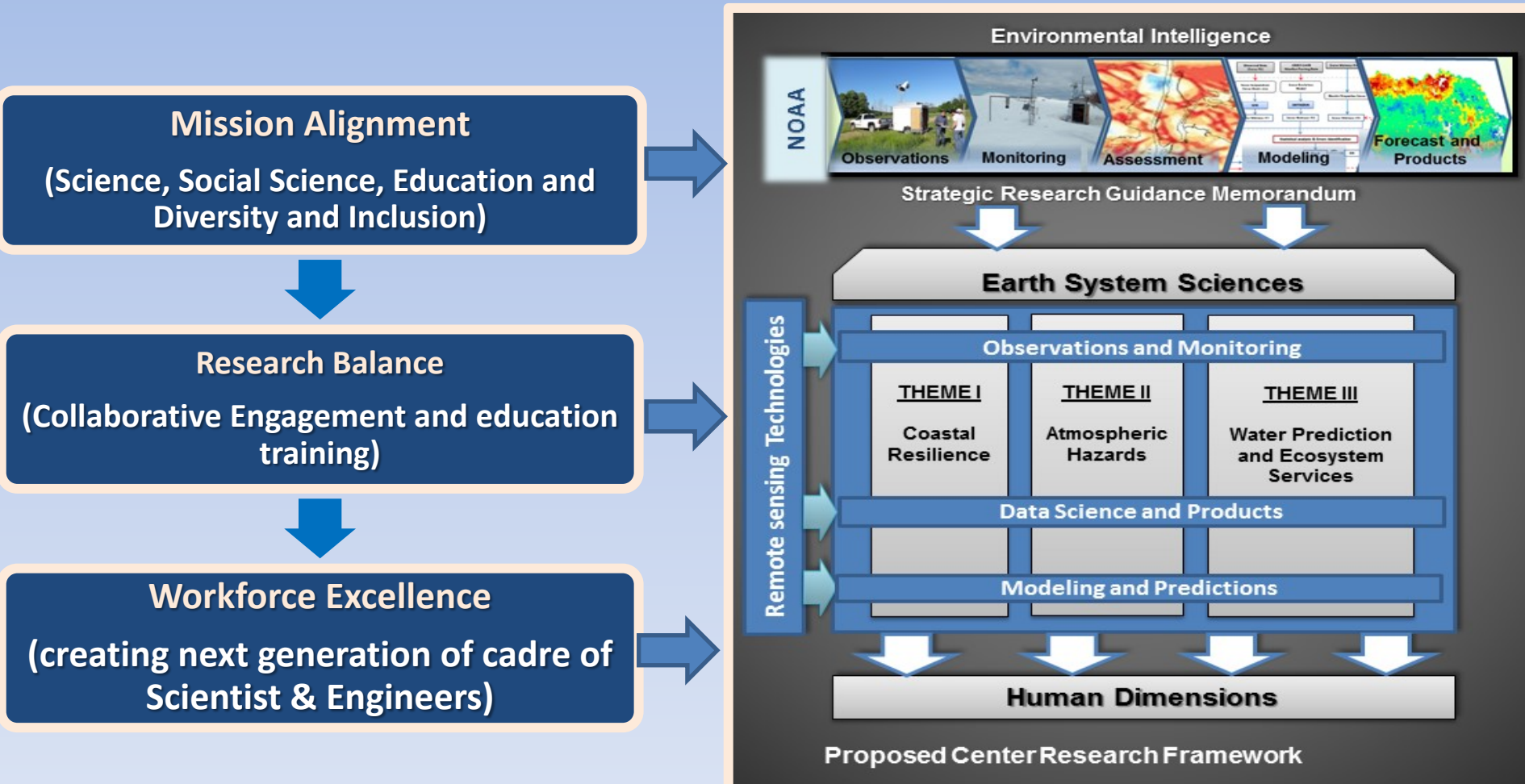
CREST Consortium across US Region



NOAA-CREST and its four Pillars

- CREST Sciences in line with NOAA's mission
- CREST Education
- CREST recruitment and outreach
- CREST capacity building – faculty, students, infrastructure

Research and Education Mapping



Examples of NOAA CREST Research



Photo Credit: Ohio Sea Grant

Monitoring and Assessing
Harmful Algal Blooms



Photo Credit: NOAA CREST

Hydrologic Extremes

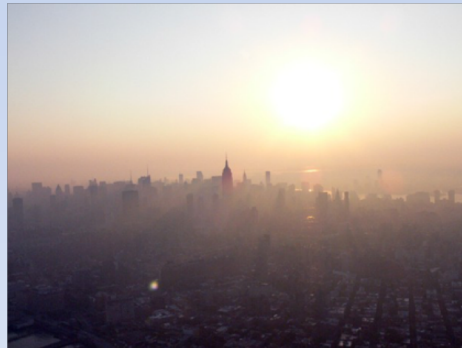


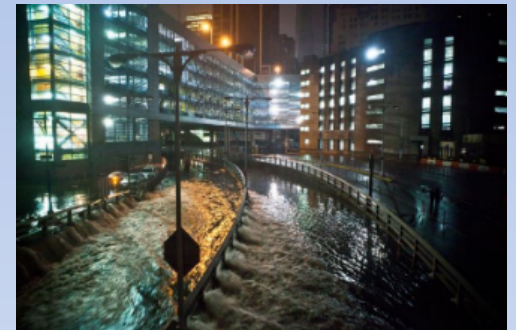
Photo Credit: NOAA CREST

Heat Stress and
Urban Modeling

Theme III - Water Prediction & Ecosystem Services

Hydrologic Extremes

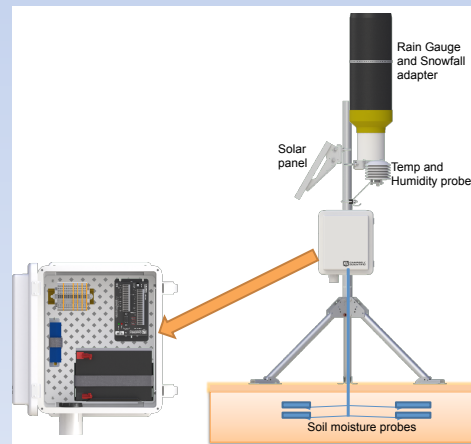
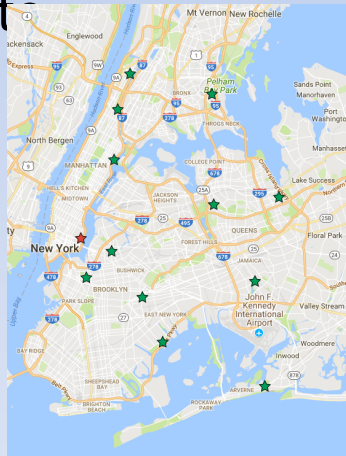
- Development of flood routing and inundation model using the Water Balance Modelplus (WBMplus) forced with appropriate hydrologic parameters and gridded river network.
- Development of high-resolution urban flood guidance and hazard warnings system by incorporating hydro-meteorological data from the New York Urban Hydrometeorology Test Bed; Ensemble flash flood models for Puerto Rico.
- Development of usable surface water drought indicator datasets for the major river basins, their changes, climate connectivity, and predictability assessment.



Theme III - Water Prediction & Ecosystem Services

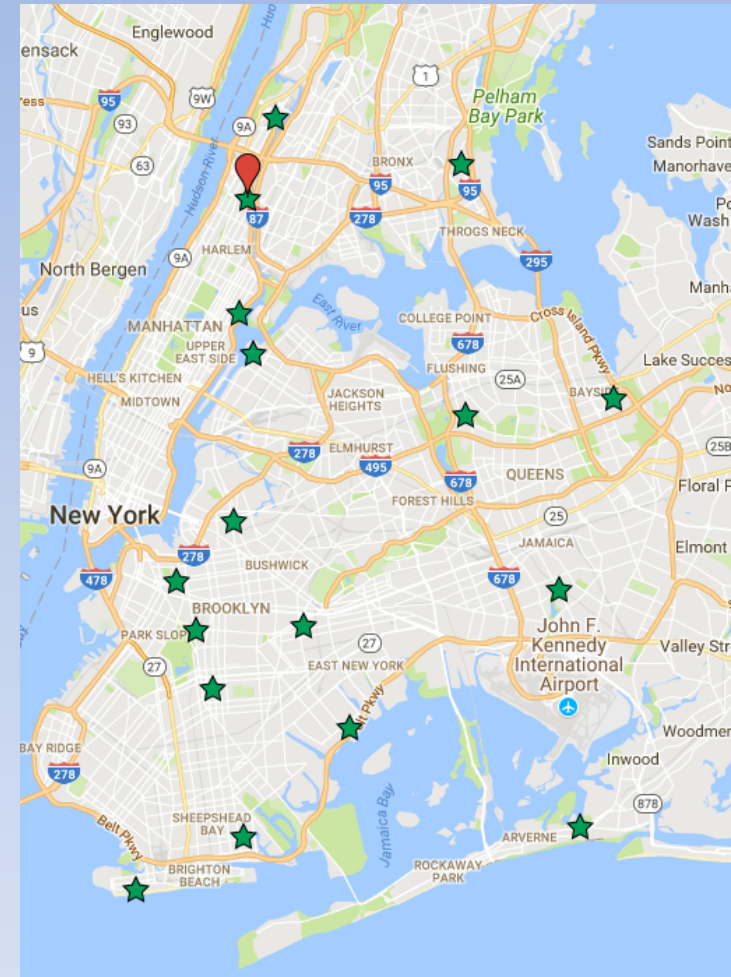
New Data

- Develop integrated near real time high-resolution mapping of weather parameters (temperature and precipitation).
- Integration of ground based in-situ observation with radar and uWRF model used to understand influence of urban heat island on urban climate



New York Urban Hydro-Meteorological Testbed (NY-uHMT)

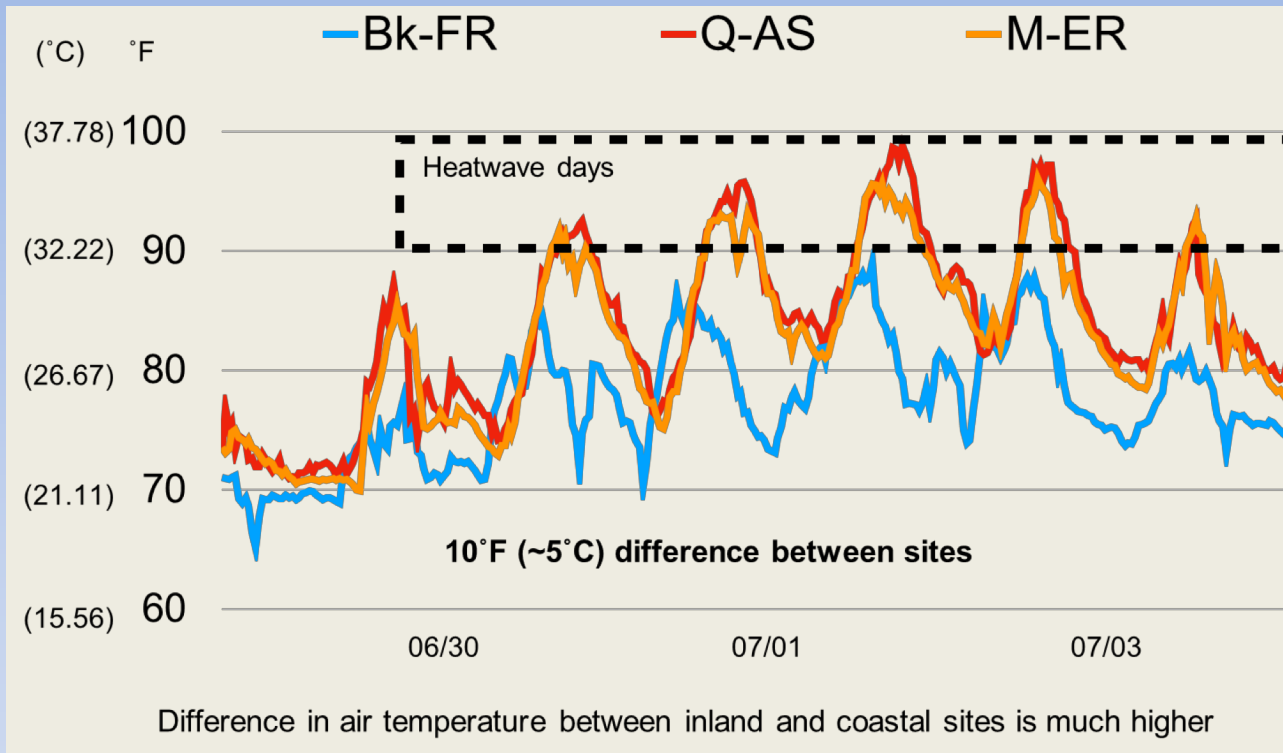
- To understand the **intra-urban variability** in hydro-meteorological properties
- To aid in designing **early warning systems** for heatwaves and storms
- To aid in developing **mitigation strategies** to combat extreme heat and flooding. (e.g. green infrastructure)
- To help urban climate **modeling framework**.
- Serve as an **educational platform** for the City and beyond.



<http://www.noaacrest.org/uHMT/>

Sites located in Schools, Botanical Gardens, and in NYCHA Properties.

NYC Heatwave (July 2018) Observed by NY-uHMT

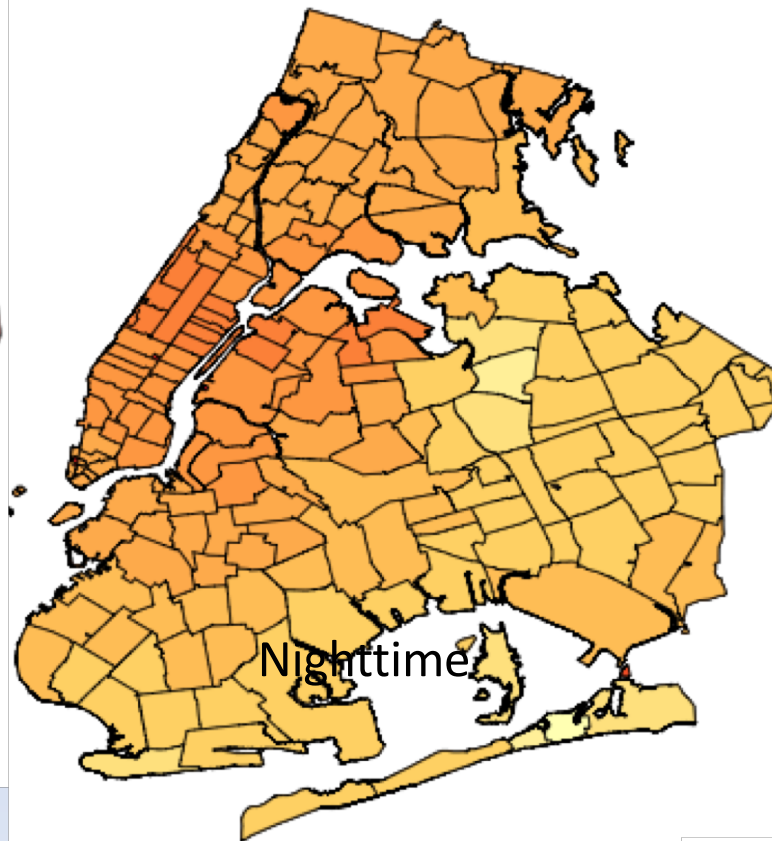
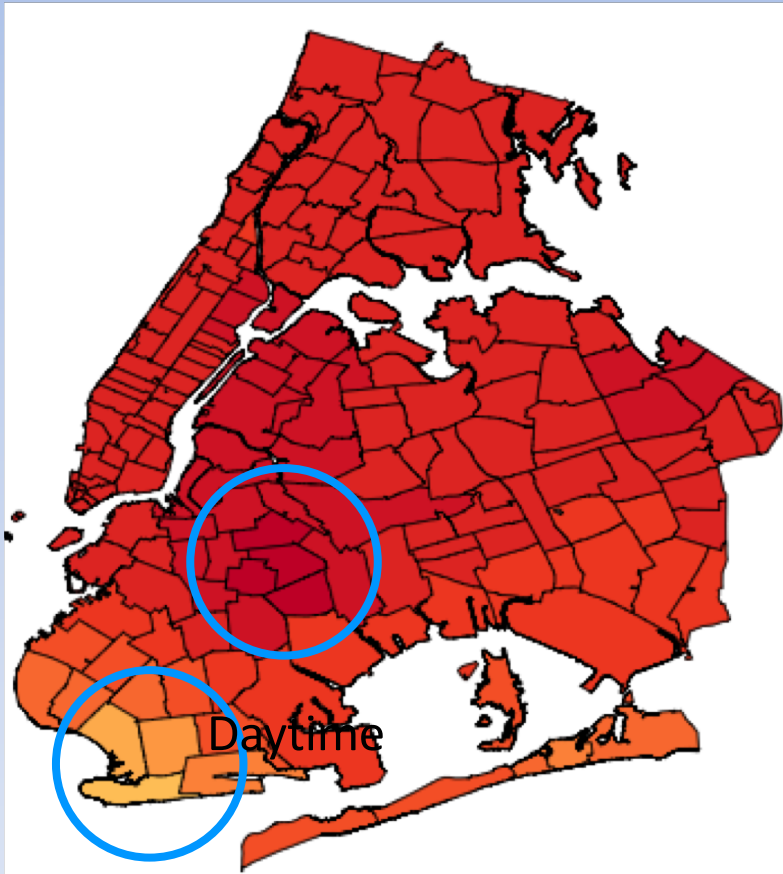


NY-uHMT **Weather Station location:**
ER- East River Houses, Manhattan, NYCHA
AS - Astoria Houses, Queens, NYCHA
FR - Far Rockaway, Brooklyn, NYCHA

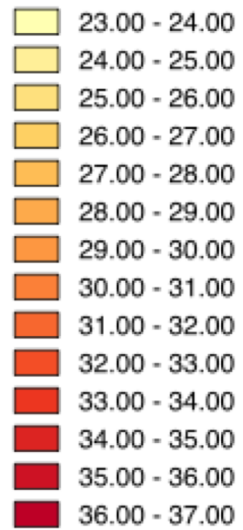


Heatwave: Air Temperature

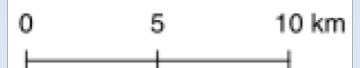
Clear spatial pattern even during heatwaves



T1 (C)

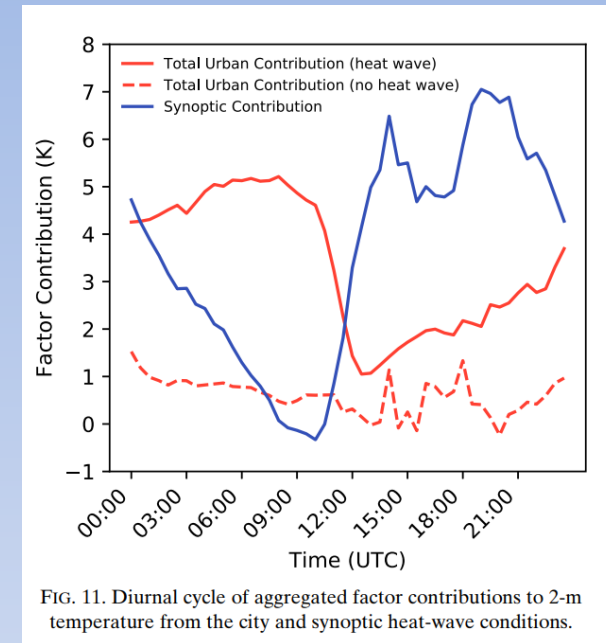


Densely populated LCZ 2/3 parcels experience higher air temperature.



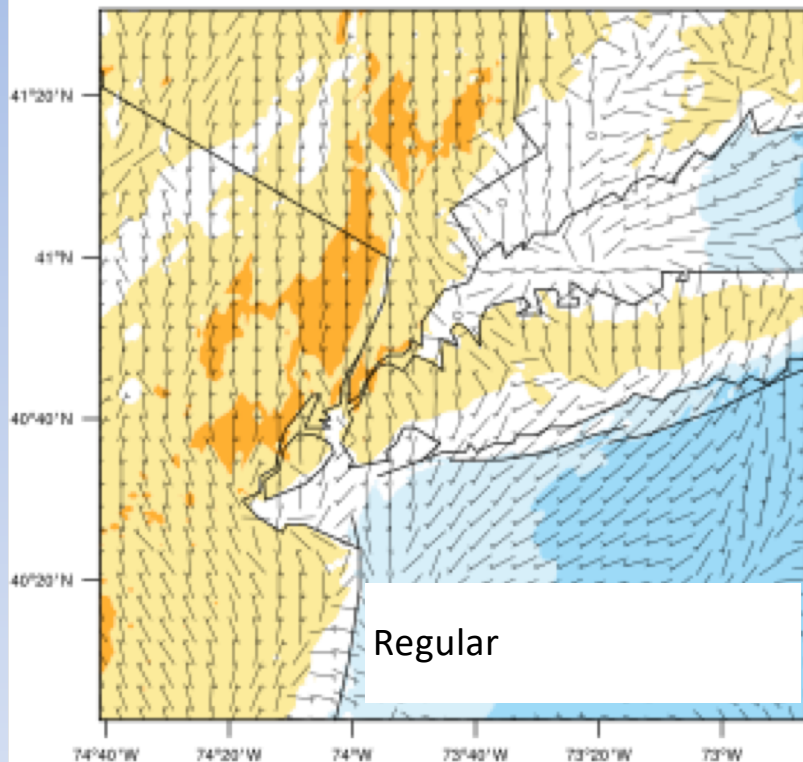
Weather Research and Forecasting (WRF) Model

- CREST Faculty and Students working on High-resolution simulations (1-km grid spacing) with an urbanized version of the Weather Research and Forecasting (WRF) Model for New York City.
- Recently, published work (See below citation) shows that factors behaved different throughout the day, with synoptic conditions dominating afternoon temperature contributions ($> 7^{\circ}\text{C}$).
- At night, combined urban surface factors contributed over 5°C during the heat wave and up to 1.5°C on non-heatwave days.



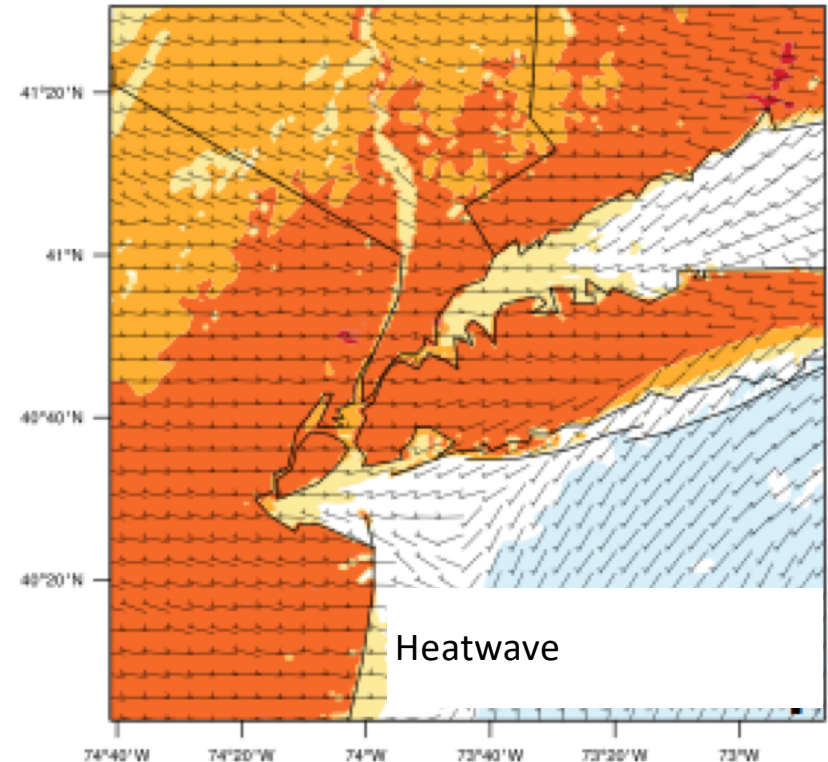
Current State of Urban WRF Model

WRF + UCM (1 km resolution)



Air temperature uniform across the urban parcels.

Unable to reproduce intra-city variability

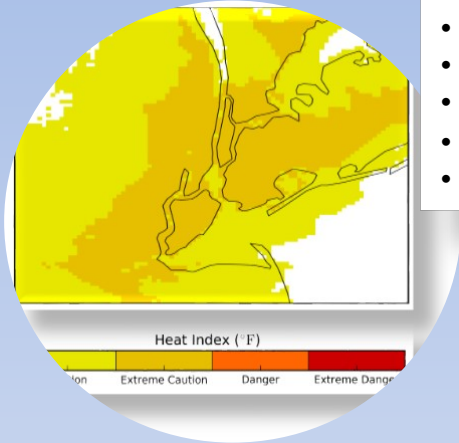


2-m air temperature (°C)

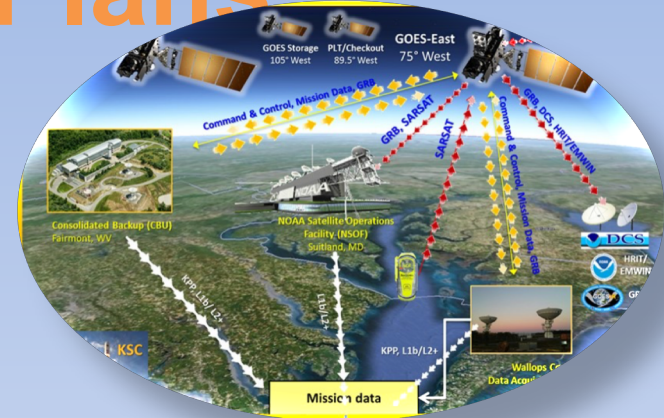
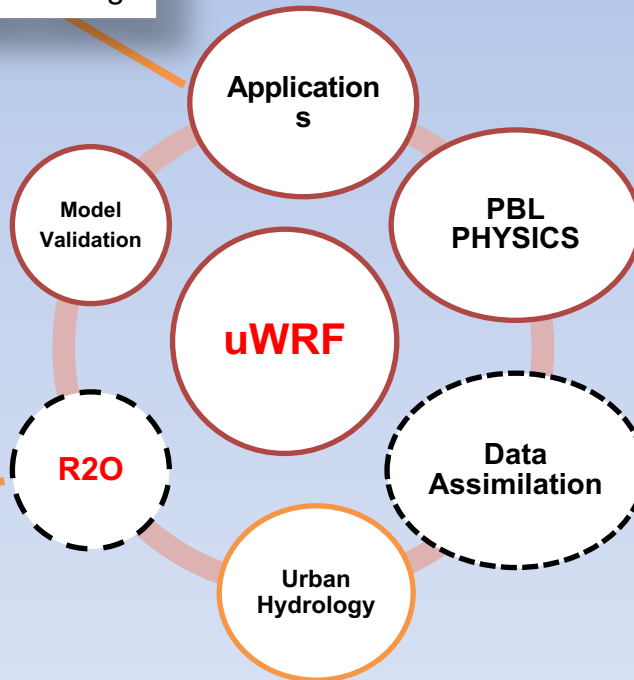


(Ramamurthy & Bou-Zeid JGR-A 2018)

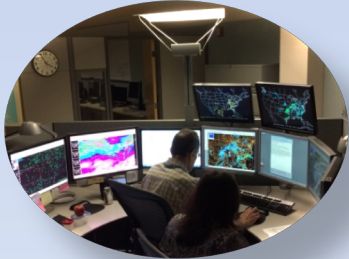
Potential Future Plans



- Weather
- Health
- Energy
- Transportation
- Urban Planning

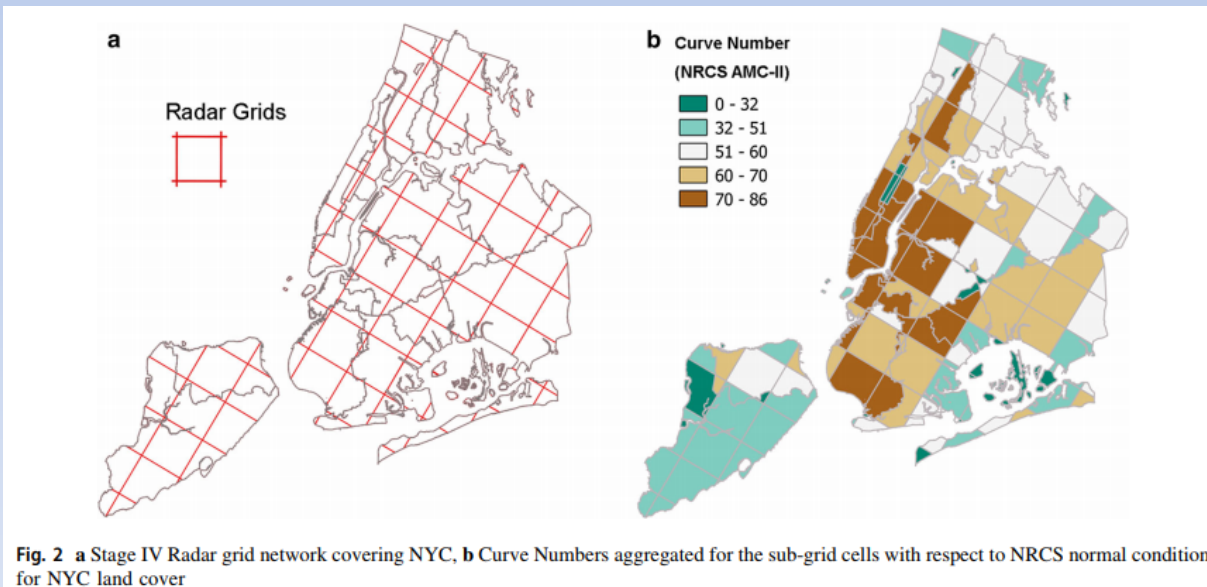
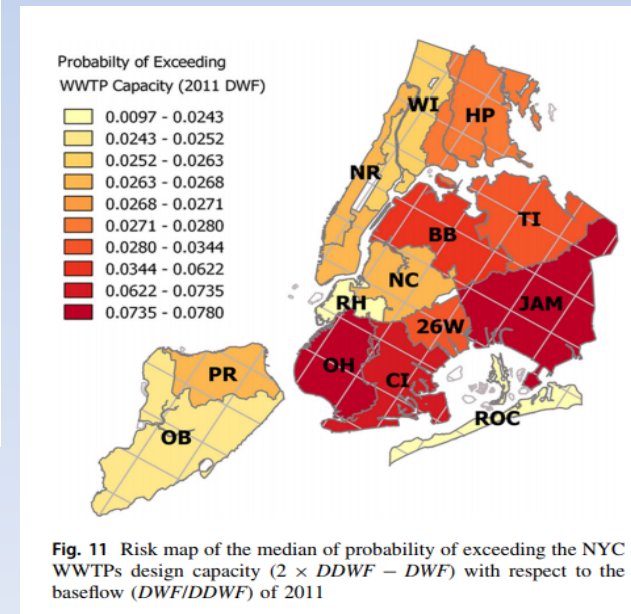
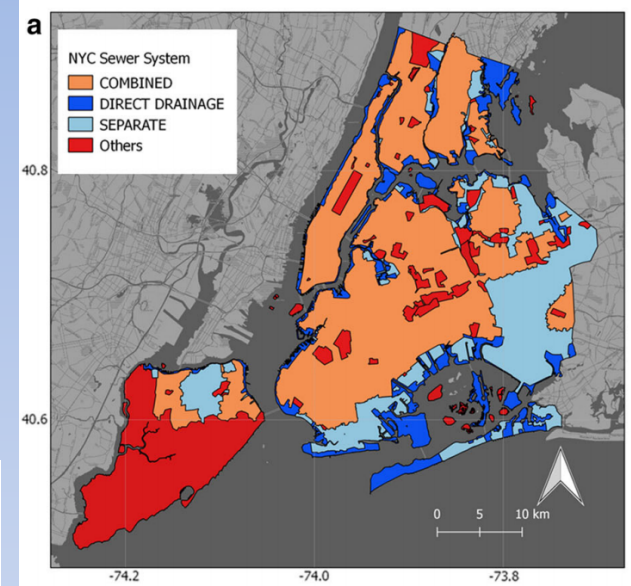


- PSD (GOES-16)
- Thermal surface properties (GOES-16+HysPIRI/GOES-R)
- SSTs (GOES-16)



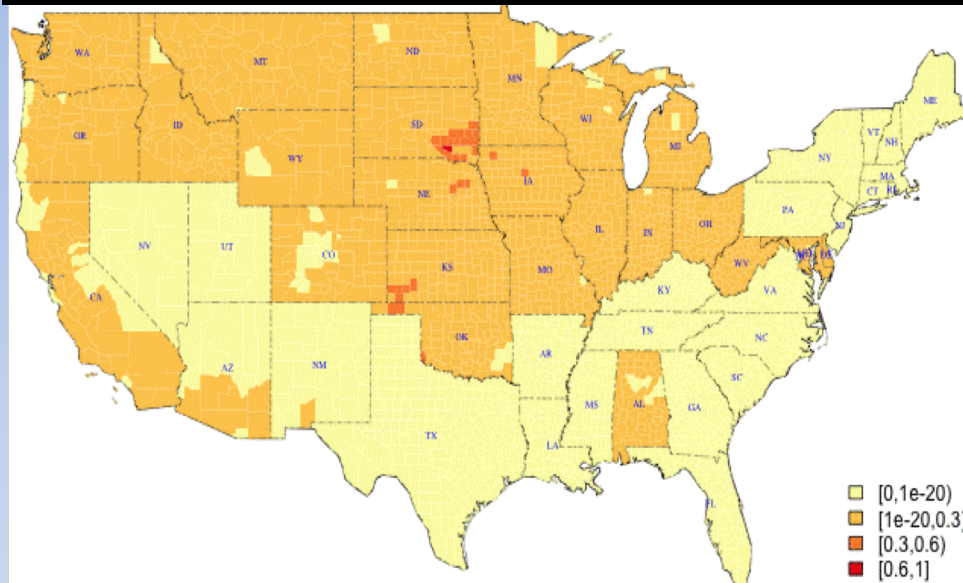
Uncertainty analysis of urban sewer system using radar rainfall data

- CREST Faculty and student (Naresh Devineni and Ali Hamidi) investigated the uncertainty of an urban sewer system's response under various rainfall and infrastructure scenarios by applying a recently developed nonparametric copula-based simulation approach to extreme rainfall fields.
- This study presented a strategy for city planners to investigate the effect of infrastructure change on stormwater runoff as a source control system.



Hamidi, A., Farnham, D.J. & R. Khanbilvardi (2018) Uncertainty analysis of urban sewer system using spatial simulation of radar rainfall fields: New York City case study, Stochastic Environmental Research and Risk Assessment (2018) 32: 2293.

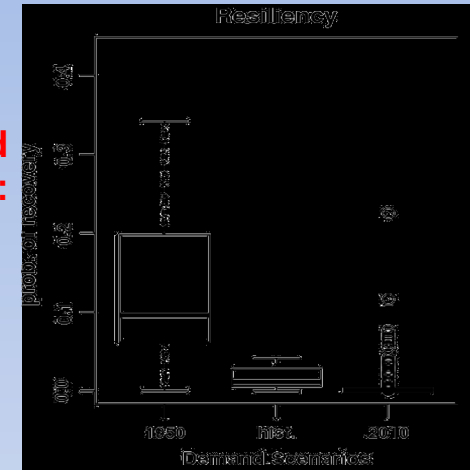
CREST COMPREHENSIVE DROUGHT INDEX



Development of Demand Sensitive Drought Index: Application to Major Field Crops in the Continental USA

County level agricultural drought index with resilience and recovery estimates

Journal of Hydrology 534 (2016) 219–229



Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol



Development of a Demand Sensitive Drought Index and its application for agriculture over the conterminous United States



Elius Etienne^{a,*}, Naresh Devineni^{a,*}, Reza Khanbilvardi^a, Upmanu Lall^b

^aDepartment of Civil Engineering, NOAA – Cooperative Remote Sensing Science and Technology Center, City University of New York (City College), 160 Convent Ave, New York, NY 10031, United States

^bDepartment of Earth and Environmental Engineering, Columbia Water Center, Columbia University, 500 Mudd, W 120th Street, New York, NY 10027, United States

River and Lake Ice Product

River and Lake Ice mapping using NPP/JPSS VIIRS sensor To support NOAA NWS

- **Product name:** River and Lake Ice mapping using NPP/JPSS VIIRS sensor To support NOAA NWS
- **Technical Readiness Level :** Eight (8). Prototype system, process, product, service or tool demonstrated in an operational or other relevant environment (functionality demonstrated in near-real world environment; subsystem components fully integrated into system).
- **Description of the product:** Run the ice detection methodology to additional rivers in Alaska and north central US operationally. Validation of River Ice product during 2014 ice breakup and ice onset periods.
- **Transition Plan:** Algorithm now runs routinely in Wisconsin and Alaska and NOAA/JPSS Team are in the process of making it a full operational product.
- **Benefits:** Satellite based Ice detection in river and lakes
- **Outcome:** Development of a new data product that provide information on inland ice precisely in lakes and major rivers which constitute principal components of hydrological processes in northern watersheds.
- **Project Milestone:** This project has progressed significantly (to a TRL8). It is part of the **JPSS River Ice and Flooding Initiative**. There are several Regional forecast Centers that use it as an additional tool (not operational yet). We are taking steps to improve on the Algorithm while a training module is already in place for RFC. The project's algorithm now runs routinely in Wisconsin and Alaska and NOAA/JPSS Team are in the process of making it a full operational product

Harmful Algal Bloom Detection Technique

Development of Red Band Difference (RBD) and *KB* bloom index (KBBI) algorithms for detecting and classifying toxic dinoflagellate *Karenia brevis* blooms from satellite imagery

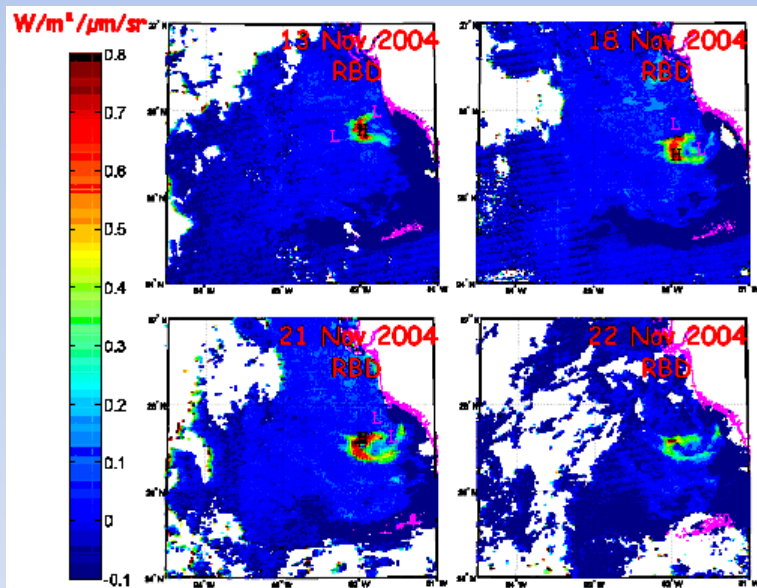
Pls Prof Sam Ahmed & Alex Gilerson (CREST CCNY)

Techniques developed by **Dr. Ruhul Amin – CREST Alumni and now a NOAA Physical Scientist at NMFS, Hawaii**

Developed detection-classification algorithms for positive *KB* identification

•**Detection:** $RBD = nLw(678) - nLw(667)$ condition: $RBD > 0.15 \text{ W/m}^2/\mu\text{m/sr}$

***Classification:** $KBBI = \frac{nLw(678) - nLw(667)}{nLw(678) + nLw(667)}$ condition: $KBBI > 0.3 * RBD$



Algorithms shown to be effective and are an example of successful R2O currently used by NOAA National Centers for Coastal Ocean Sciences as aid in detecting and classifying Harmful Algal Blooms.

Example of *K. brevis* blooms detected using the RBD technique on the WFS on (a) 17 Sep 2001, and (b) 21 Jan 2005. These blooms are classified as *K. brevis* blooms using the KBBI classification technique with appropriate thresholds applied on (c) 17 Sep 2001 and (d) 21 Jan 2005. The 17 Sep 2001 image is an example when *K. brevis* and *Trichodesmium* blooms were co-occurring spatially but only *K. brevis* bloom detected.



C



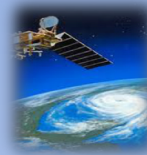
R



E



S



T



Integrated Data Products

- ISCCP – 2012
- CRIOS - 2012
- Upper Tropospheric Water Vapor (2013)
- Radiative Flux Profiles (2014)
- Land Inundation (2012)
- Snow Cover (2012)
- Cyclone Attributes and Dynamics (2013)
- Tropical Deep Convection (2013)
- Effective cloud emissivity (product of cloud fraction and the cloud emissivity) using CrIS/ATMS and NGAS-CrIMSS radiances
- A climatology of PSCs in the Arctic and Antarctic polar winter stratospheres (2013)
- MODIS AOD Urban Fusion Product (2014)
- In situ datasets for validation of ocean color satellites including JPSS-VIIRS (2012)
- Algal bloom data for West Florida Shelf (2013).

Cal/Val

- ISCCP Radiance Calibrations confirmed to 3% absolute (VIS) and 2% absolute (IR)
- ISCCP Cloud Properties confirmed to better than originally estimated uncertainty
- Microwave Snow Site – CREST SAFE
- Soil Moisture Advanced Radiometric Testbed and In-Site Network
- CREST LIDAR NETWORK (CLN) Assessment of Passive and Active Satellite Aerosol Products
- Long Island Sound Coastal Observatory (LISCO) with reflectance and atmospheric data products, matchups of multi and hyperspectral in-situ and Ocean Color satellite data

R2O

- ISCCP Cloud Product Processing will go operational 2012
- ISCCP Radiative Flux Profile Processing will go operational in summer 2014.
- Assist OMPS LP retrieval algorithms for ozone, aerosol, and NO2 profiles (2014)
- BRDF model for coastal waters (2014)

FLASH FLOODS: WEATHER READY NATION

Research: In the US, flash flooding is the number one killer among all weather-related hazards. The 30 Year Flood Loss **Averages** = \$7.82 Billion in damages, 94 deaths per year.

This project integrates **remote sensing satellite based soil moisture data** in current hydrological modeling to improve Gridded Flash Flood Guidance System.

Collaborators:

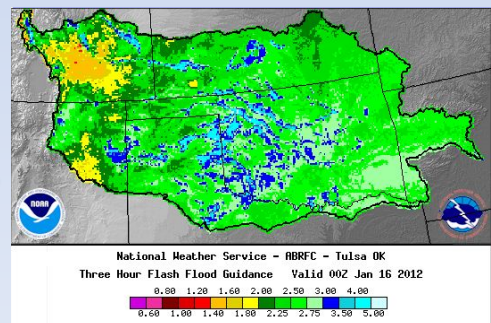
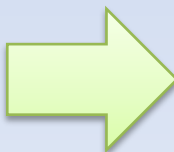
Office of Hydrological Development (OHD/NWS).

Regional Forecasting Center, National Weather Service (NWS), Tulsa OK.

National Environmental Satellite, Data, and Information Service (NESDIS).

End Users:

Weather Forecasting Offices; Local Emergency Management Offices; Federal Emergency Management Agency (FEMA) .



RIVER ICE: WEATHER READY NATION



- **Research:** The project introduces an operational new satellite based **river ice product to display ice conditions in major rivers in the northern watersheds**. Ice maps are updated on a daily basis and the product makes use of images from MODIS acquired in near real time by the CREST satellite receiving station.
- **Product:** Developed ice maps are made available online through a data portal superimposing the Google Earth
- **End-users:** like NOAA NWS River Forecast Centers and Weather Forecast Offices as well as reservoir managers in hydropower plants along the rivers.

SNOW STUDIES : WEATHER READY NATION

CREST-Snow Analysis and Field Experiment (CREST-SAFE)

As per NOAA/NOHRSC report, snowmelt provides over 70% of the water supply in the western USA. Accurate and timely snow forecasts and snowmelt forecasts are critical components in the management of rivers such as the Columbia and the Colorado. Snow also plays a significant role in the United States tourism economy, adds up to more than \$7.9 billion dollars a year.

Research:

The CREST-SAFE is being carried out to develop real time and forecasted gridded snowpack data by objectively merging in-situ stationed with satellite based VIS/NIR and microwave observation.

CREST-SAFE is setup in the backyard of the Weather Forecasting Office at Caribou, ME has equipped with: dual polarized microwave radiometers (37 and 89 GHz), Snow Pillows, ultrasonic snow depth sensor, Infrared Thermometer, Radiation Sensors, snow temperature profiler, snow grain size, density, Humidity/Temperature probe and network camera.

End users:

Modeling community: Improvement in Community Radiative Transfer Model (CRTM) by NOAA/NESDIS

River Forecasting Centers (for Snowmelt and discharge), Water Resources Managers (for Water Supply in spring and summer), Public Safety Managers, Department of Environment Protection (for Snowmelt and flood), Tourism Industry (Snow/Skiing).



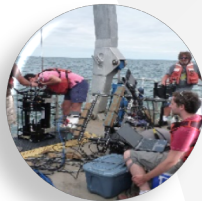
CREST Capacity Building



Facilities – Snow, Soil and Coastal observatories



**Faculty and scientists from 18 (2002) to 65 (2011)
to 75 (present)**



Students – from 1 to 650



Research and Publications/Data Products

CREST Facilities



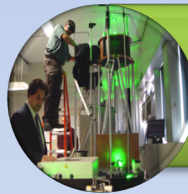
CREST Microwave Observation Unit



Coastal Measurement Platform



CREST Earth Observation Unit



CREST LIDAR Network (CLN)



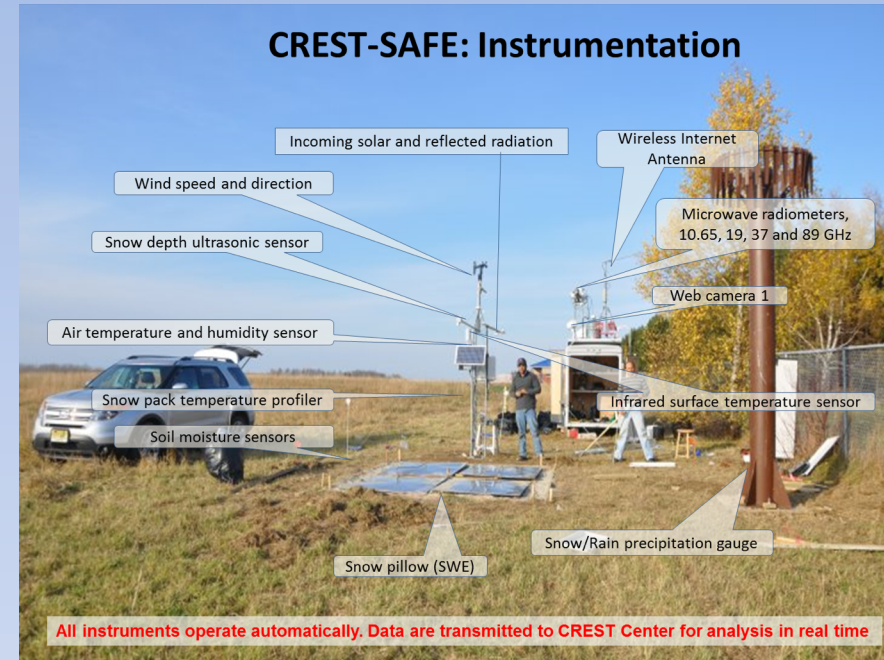
**Computational Labs (GIS, CALIPSO, Earth
System Research)**



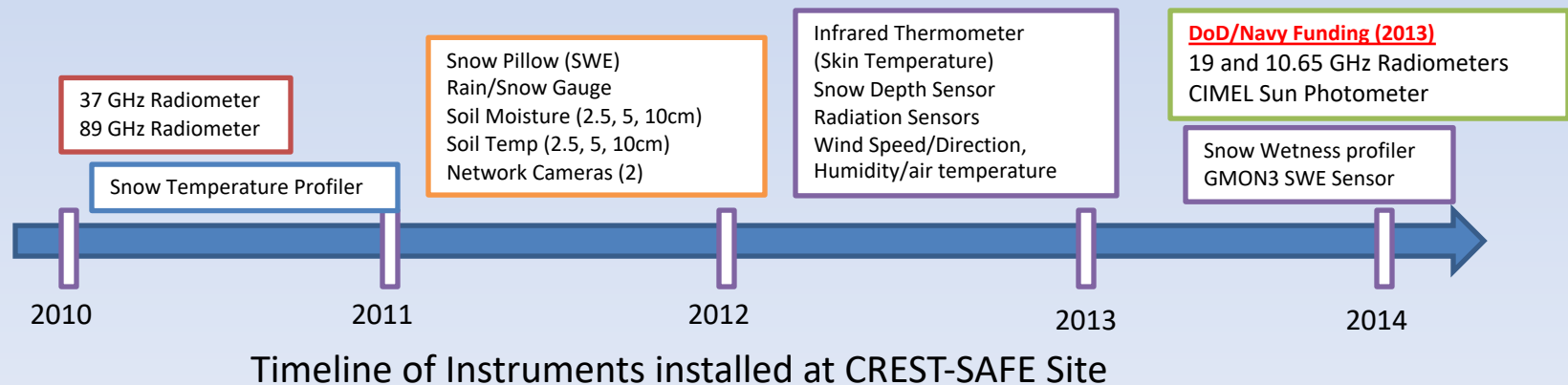
**Other Ground Instrumentations and Urban
Meteorological Observational Network**

Microwave Observation Unit – Snow in the Weather Forecast Office Site, Caribou, Maine

CREST-SAFE Experiment located on the premises of NWS Regional Forecast Office at Caribou Regional Airport, Caribou, ME



<http://crest.ccnv.cuny.edu/snow/index.html>



Snow Instrument at the Weather Forecast Office Site, Caribou, Maine



Snow Temperature Profiler



Microwave Radiometers



Trailer



Snow Wetness Sensors



Grain size and Density Instruments



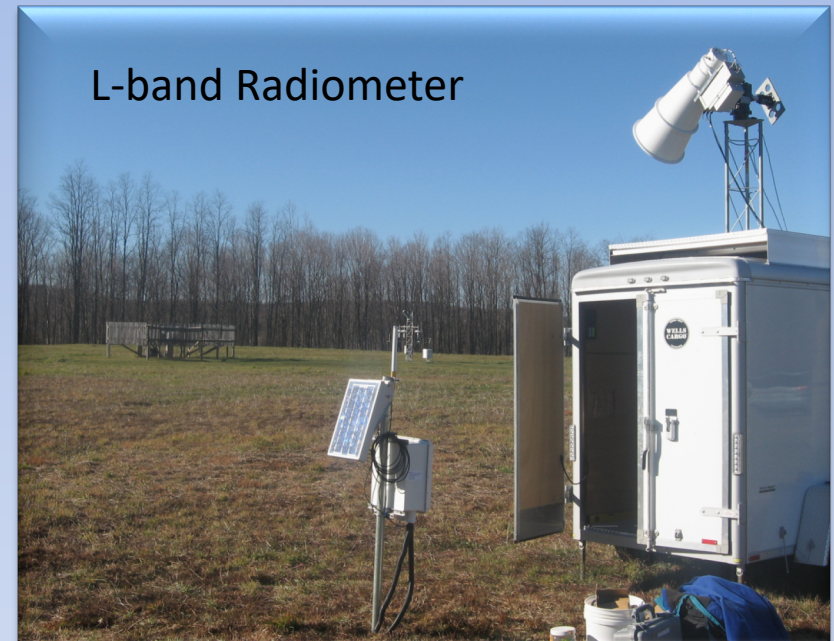
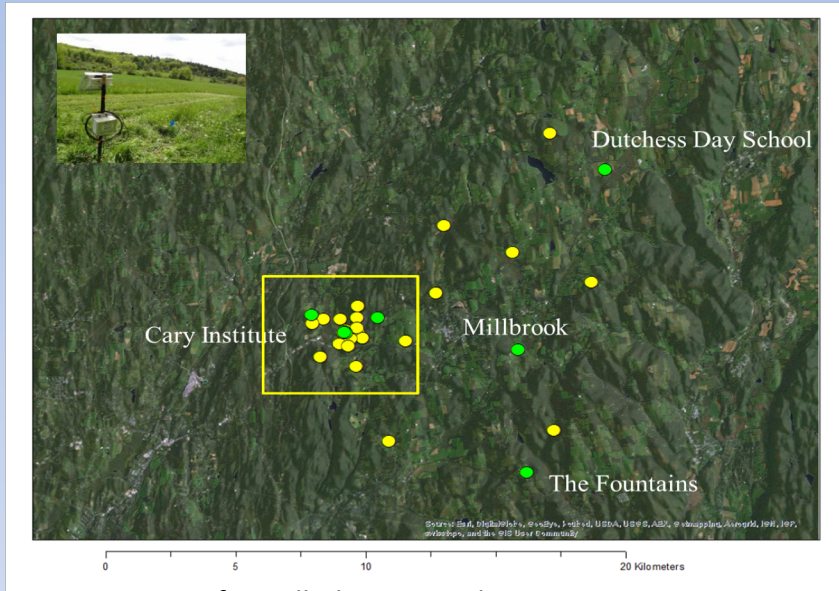
Snow Water Equivalent (SWE) Sensors



Microwave Observation Unit – Soil, Millbrook, NY

CREST-SMART: Soil Moisture Advanced Radiometric Testbed

The established network was selected by NASA for the Cal/Val of the SMAP mission



Joint Field Experiment in May 2012

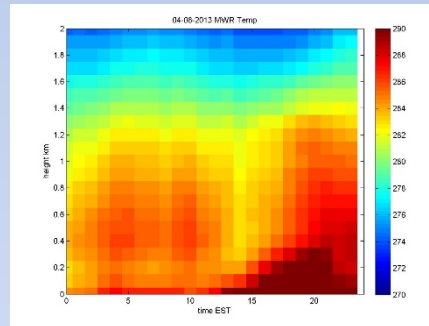


Microwave Observation Unit – Atmosphere

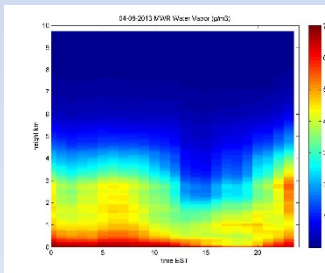
The Radiometrics Profiling Radiometer, model MP-3000A, produces vertical profiles from the surface to 10 km, producing high-resolution 1) temperature, 2) relative humidity and 3) water vapor profiles, and 4) low-resolution liquid profiles.

Applications include:

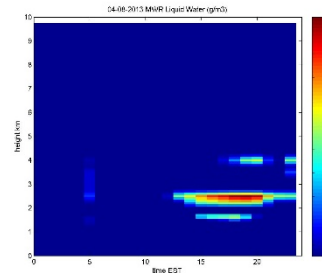
- validation of high resolution meteorological models
- Aerosol – Cloud Interactions
- Hygroscopic Aerosol Modeling.



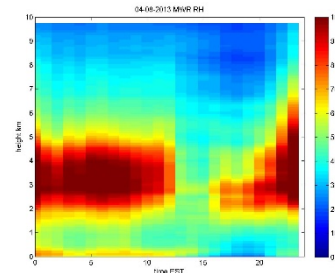
Temperature profiles



water vapor profiles



Liquid water profiles



Relative Humidity profiles



Microwave Radiometer Profile
located at Steinman Hall @ CCNY

Satellite Earth Observation System

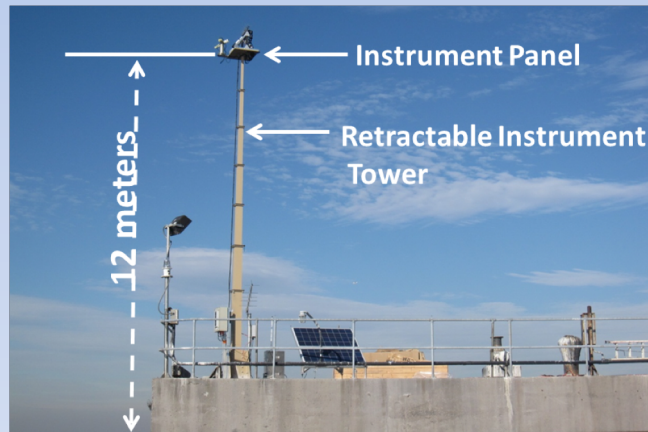
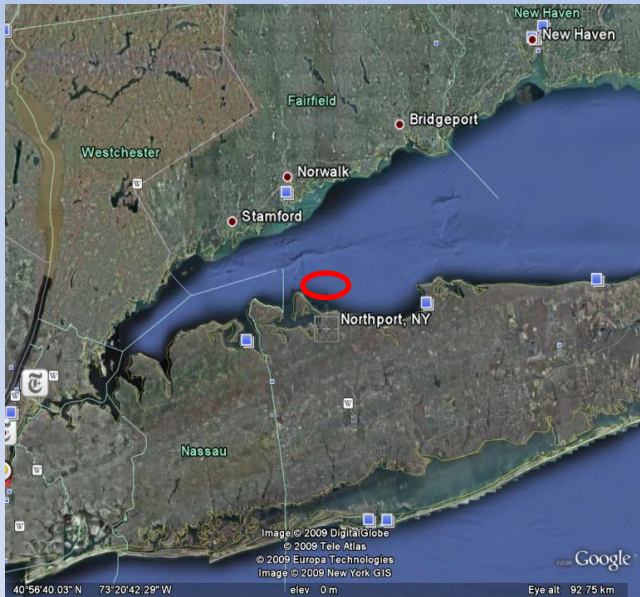


The Satellite Receiving Station is a key component of CREST research . SRS is primarily responsible to acquiring, storing and algorithm processing of all satellite related products.

The Receiving Station currently has 2 antenna and a vast array of data collecting equipment and algorithms for polar and geostationary satellite as well as ground-based field measurement and LIDAR networks.

Long Island Sound Coastal Observatory (LISCO)

Platform: Collocated multispectral **SeaPRISM** hyperspectral **HyperSAS** instrumentations Since October 2009



The platform combines an AERONET SeaPRISM radiometer and [CIMEL Electronique](#) as a part of AERONET Ocean Color Network, with a co-located [HyperSAS](#) set of radiometers capable of hyperspectral measurements of water-leaving radiance, sky radiance and down-welling irradiance. SeaPRISM data are transferred by the satellite link to NASA.

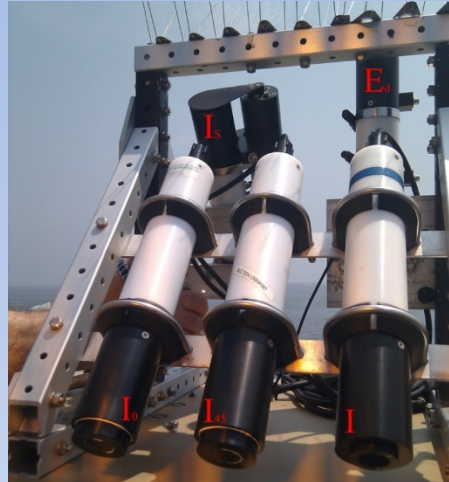
LISCO Instrumentation

SeaPRISM instrument



- Sea Radiance
- Direct Sun Radiance and Sky Radiance
- Bands: 413, 443, 490, 551, 668, 870 and 1018 nm

HyperSAS Instrument



- Sea Radiance
- Sky Radiance
- Downwelling Irradiance
- Linear Polarization measurements
- Hyperspectral: 180 wavelengths [305,900] nm

Water Quality Monitor (WQM)

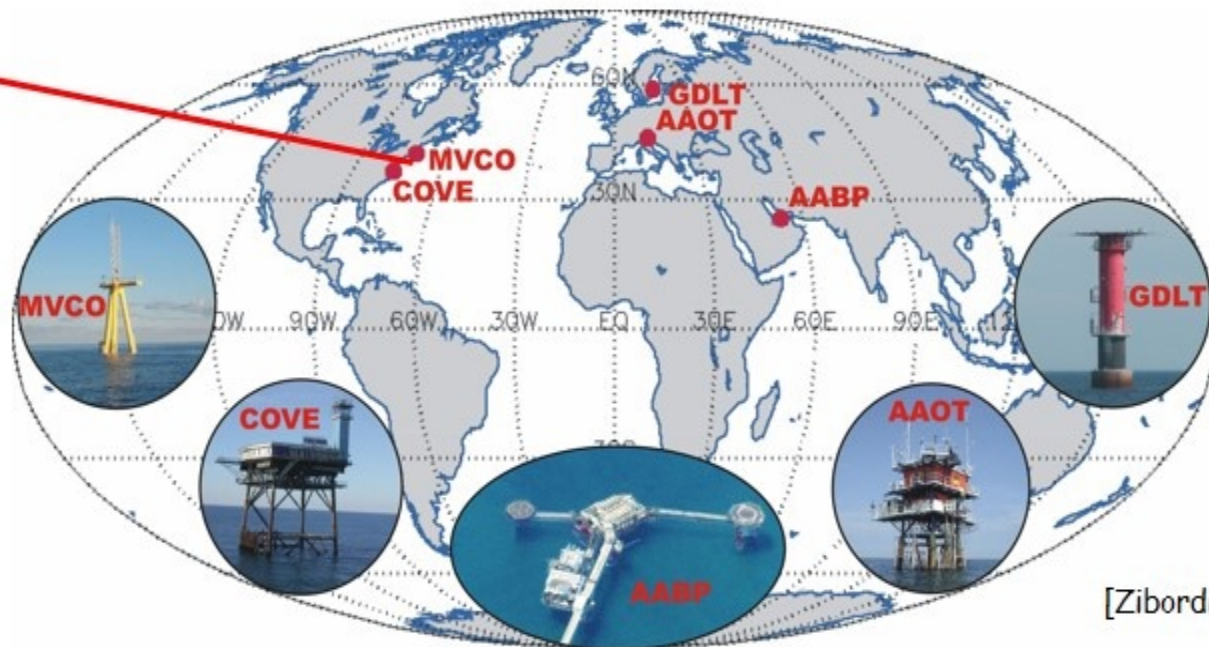


- Measure: temperature, salinity, depth, dissolved oxygen, chlorophyll, turbidity and attenuation data.

Data acquisition every 30 minutes for high time resolution time series

LISCO Site Characteristics

LISCO Multispectral SeaPRISM system as part of AERONET – Ocean Color network + HyperSAS



[Zibordi et al., 2006]

- Identical measuring systems and protocols, calibrated using a single reference source and method, and processed with the same code;
- **Standardized products of exact normalized water-leaving radiance and aerosol optical thickness**

Chesapeake Bay campaign: Aug 2013

Instrumentation: in-water and above water reflectance, water optical properties, POC, water samples, ALFA for underway measurements



CREST LIDAR Network (North East Corridor)

CREST LIDAR Network (NY, VA, MD, PR) studies the vertical profiling along the Atlantic Coast transect from NYC to Caribbean with applications to aerosol transport and air quality. It has been cooperated in founding the International GAW Aerosol LIDAR Observation Network.



@ UMBC



@ Hampton University



@ UPRM

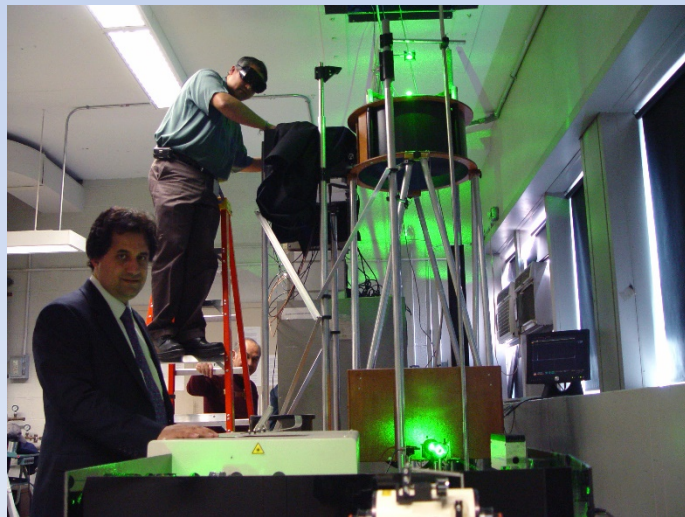
CREST LIDAR Facility at the City College of New York



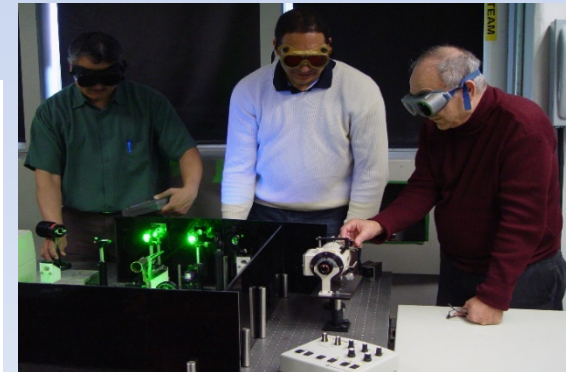
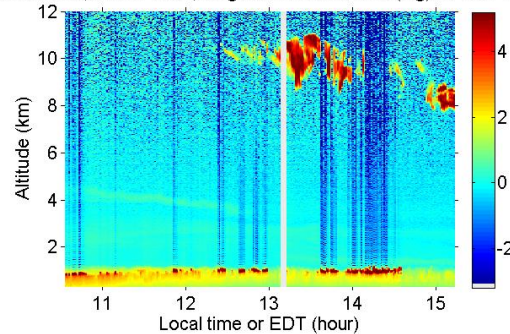
Mid-IR Lidar at 4.5 microns



Open-path Laser Measurements
at 7.8 microns



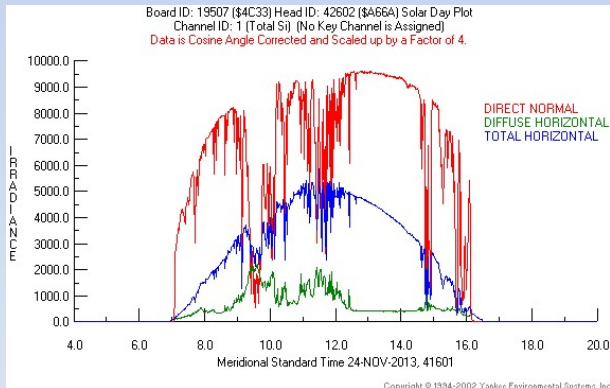
2012 Oct18, CCNY-Lidar, range-corrected returns (log) at 1064-nm



CREST LIDAR Facility at the City College of New York



MFR-7 Shadowband Radiometer (MFRSR)

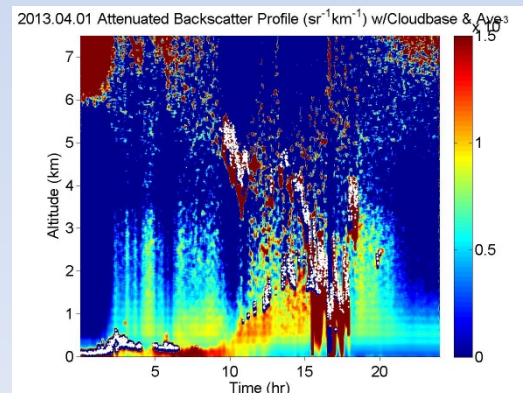


MFRSR measures total, diffuse, and direct irradiance at six wavelengths (415, 500, 615, 673, 870, and 940 nm, each 10 nm FWHM) in the visible/NIR spectrum.



Ceilometer

Ceilometer measures backscatter reflection from clouds, aerosols or precipitation is used to measure cloud base height and vertical visibility, and is particularly suited for low altitude measurements.



CREST Mobile Doppler LIDAR System

The mobile Doppler Lidar system was installed in MEMLAB (Mobile Environmental Measurements Lab) truck.

Transmitter		Receiver	
Laser	Q-Switched Nd: YAG Continuum Surelite II-10	Telescope Aperture	CM_1400 Schmidt-Cassegrian telescope 14 " (35.56 mm)
Wavelength	1064, 532, 355, 266 nm	Focal length	153.9 " (3910 mm)
Energy/pulse	650 mJ at 1064 nm 300 mJ at 532 nm 100 mJ at 355 nm	Detectors 532 nm 355 nm 1064 nm	Hamamatsu PMT: R758-10 PMT: R758-10 APD
Pulse Duration	7 ns at 1064 nm	Data acquisition	LICEL TR 40-160
Repetition rate	10 Hz	Photon Counter	LICEL TR 40-160
Harmonic Generator	Surelite Double (SLD) Surelite Third Harmonic (SLF)		



Project 2. CREST Observing Systems for Atmospheric Process and Air Quality Applications

The CREST Earth System Observing Network (CESON)

Satellite Research Products

High resolution regional AOD for VIRRS and GOES-R

Climatology of Planetary Boundary Layer (PBL) dynamics
and Smoke and Dust Transport

Validation of OMPS limb profiler

Validation of Chemical Transport Models



Observing System Technologies & Field Campaigns

ASOS ceilometer network aerosol products

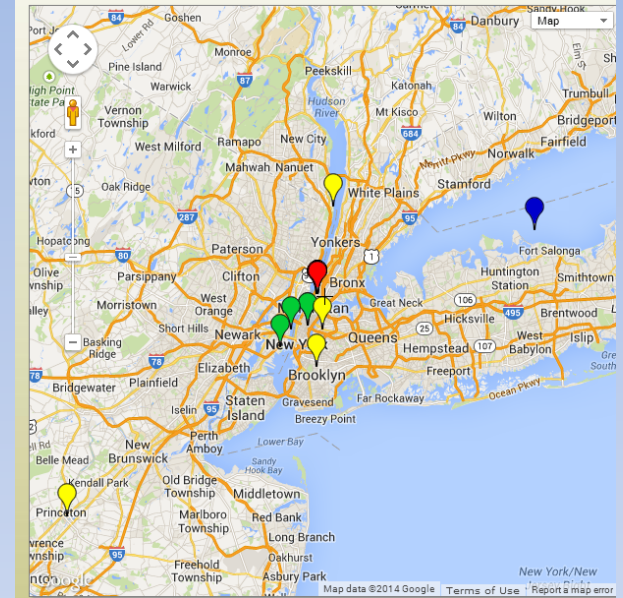
Lidar technology development

Field campaign data products



NYCMetNet, CCNY

- NYCMetNet provides latest meteorological observations in and around The New York metropolitan area (NYC).
- Observations are updated every 15 minutes to better characterize meteorological conditions within the NYC urban environment.
- Surface observations consist, in part, of near real-time atmospheric pressure, relative humidity, temperature, wind direction, wind speed, rain rate, and total rain accumulation measurements at building-top sites.



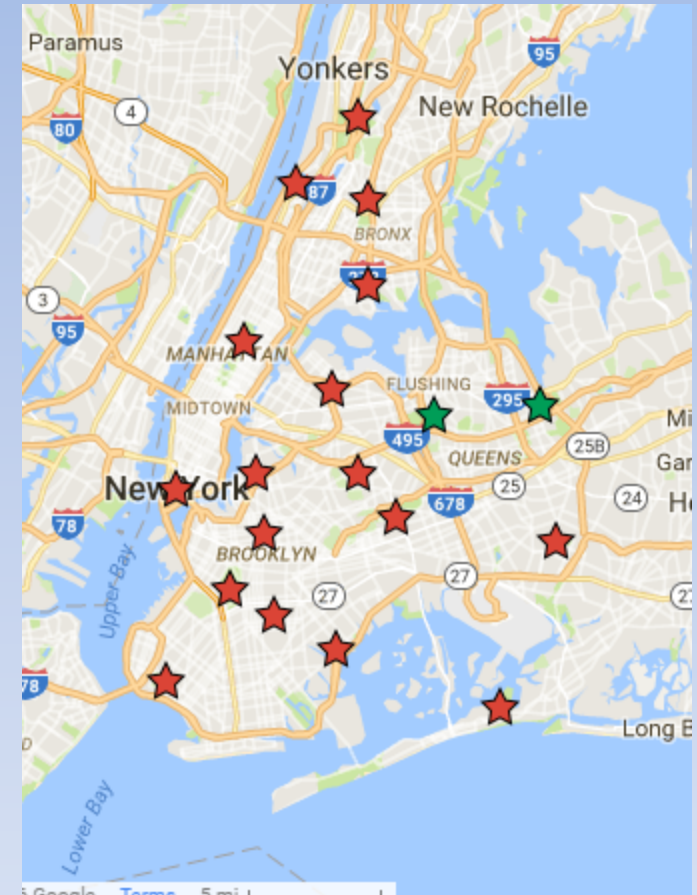
Location of Met Station



Sustained wind speed and direction

New York Urban Hydro-Meteorological Testbed (NY-uHMT)

- Develop integrated near real time high-resolution mapping of weather parameters (temperature and precipitation).
- Improve the accuracy and lead time of measuring and accessing the precipitation and providing Warn-on-flash flood forecasts and warnings in the New York City region.
- Create impacts-based, urban-scale flash flood and hazard warnings for a range of public and private decision-makers.
- Integrate of ground based in-situ observation with radar and uWRF model used to understand influence of urban heat island on urban climate.
- Establish collaborative models for federal/municipal/ private partnerships for education outreach to NYC schools with on-going interdisciplinary research at NOAA-CREST Center.



Green stars are installed sites.

Red stars are proposed sites.

All sites will be ready by end of summer 2016.

<http://www.noaacrest.org/uHMT/>

- New Infrastructure Initiatives
- Urban-HydroMet Net
- Microwave Radiometer Test Bed un UPRM
- Flux Towers in Alaska
- VIRS Data
- GOES-R Antenna
- Wind Lidar

- Expanding Partnership:

- At Federal Level

- * PMEL,
- * GFDL
- * NWC
- * ARL
- * ESRL

- At State Level

- * New York State (Lidar network)

- At Local Level

- * NYC Mayor Office,

- With Private Industries

- * (IMSG, ERT, in DC, AER in Boston, etc)



National Oceanic and Atmospheric Administration
NOAA-CREST
&
CUNY CREST Institute

Steinman Hall, City College of New York, 140th St. @ Convent Ave., NY 10031

Phone: 212-650-8099: Fax : 212-650-8097

Email: noaa-crest@ccny.cuny.edu

website: www.noaacrest.org