

NOAA Center for Earth System Sciences and Remote Sensing Technologies 2016-2021



Reza Khanbilvardi Center Director CICS Science Meeting November 6, 2017





Lead Institution: City College of New York

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Bronx Community College, CUNY; LaGuardia Community Colleges, CUNY; Hostos Community College, CUNY; Queensborough Community College, CUNY; Borough of Manhattan Community College, CUNY; Columbia University, NY (CU); New York University, NY (NYU); University of California, Irvine (UCI)

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San Diego State University, CA Other Affiliates:

- San Diego City College and Southwestern, CA
- University of California, San Diego (UCSD)
- Scripps Oceanographic Institution (SIO)

University of Maryland Baltimore County, MD <u>Other Affiliates:</u>

 Community College of Baltimore County, MD University of Puerto Rico, Mayaguez, PR

University of Texas, El Paso, TX Other affiliates: El Paso Community College, TX



Earth System Sciences and Remote Sensing Technologies

Thinking Forward

NOAA Strategic Research Framework Mission Alignment . Research Balance . Workforce Excellence **CREST KEY Strategic Framework for Collaborative Engagement**





CREST Program Performance (five) Priorities



- **1. Increase the number students** particularly from underrepresented minority community trained and graduated in NOAA Sciences.
- 2. Increase NOAA Collaboration and Early Engagement to conduct research to help advance NOAA mission sciences.
- 3. Generate Leveraged funding.
- 4. Inter-CSC and Cis collaboration.
- 5. Postdoctoral opportunities for recent graduates.

Mission Alignment

(Science, Social Science, Education and Diversity and Inclusion)

(Collaborative Engagement and education training)

Research Balance

Workforce Excellence

(creating next generation of cadre of Scientist & Engineers)







NOAA CREST Theme I: Coastal Resilience

CREST Faculty: M. Tzortziou (Lead), A. Gilerson, S. Ahmed, J. Cherrier, K. McDonald, R. Armstrong, R. Rodriguez, J. Munoz

Improving coastal resilience depends critically on coastal intelligence and developing a deeper understanding of coastal processes, dynamics, and vulnerability to anthropogenic and natural stressors.

Theme I addresses this high research priority for NOAA through a combination of coastal observations, advanced modeling, development of new remotes sensing tools, and assessment of environmental and socioeconomic efficacy of developed approaches for mitigating these stressors.

Coastal environments are among the most vulnerable yet economically valuable ecosystems on Earth. Comprehensive integration of social science into research is a key priority in Theme I.



NOAA CREST Theme I: Coastal Resilience

NOAA-CREST



Project I: Understanding the complexity of coastal ecosystems from space and improving our ability to manage our coastal natural resources requires advanced observational infrastructure. CREST will contribute to NOAA's efforts to develop integrated coastal ocean observing systems and networks with advanced measurement capabilities in urban temperate and tropical coastal waters

Project II: Supporting NOAA's leading role in coastal ecosystem management towards sustainability, CREST will apply in-situ and satellite observations to develop remote sensing tools for monitoring and assessment of physicochemical and biological indicators relevant to **coastal water-quality and ecosystem health**.

Theme 2 Atmospheric Hazards

Project 1. Weather Hazards

Storm & Strom Surge Prediction

Improved P-ETSS storm surge modeling system GOES-R Storm Now Casting: Validation of GFDL GCM Lightning Simulations with GOES-R Convective initiation products in coastal processes

Heat Stress and Urban Modeling

Heat indexes now-cast Urban thermal storage product

Improved urbanized numerical weather forecasting product with representation for urban land-surface processes

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

NOAA CREST Theme I: Coastal Resilience

- Theme III is focused on developing a unified water prediction system and ecosystem services using remote sensing of earth systems.
- Unified water diagnosis, prediction and modeling methodologies are being created to aid the development of operational products and services.
- Assess climate-informed water and ecosystems modeling, socioeconomic impacts analyses, and vulnerability assessments.
- Our team includes hydrologists, water systems analysts, remote sensing and instrumentation specialists.

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Tarendra Jonathan Lakhankar Munoz

Indrani Pal

Shakila Merchant

Nir Krakauer

Naresh r Devineni

Water Sustainability /Drought Risk

- Accounting long-term variability in spatially distributed water risk measures.
- Water stress maps to make decisions on new infrastructure investments.
- River low flow and water deficit maps for ecosystem stress assessment.

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 hydrometeorological 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.

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.

Policy and Economy

- Understand water system performance considering linkages between water supply, competing demands, economy and political/institutional constraints.
- Quantitative and qualitative frameworks designed for exploring how institutional decisions determine regional water availability and system resilience.
- Trade network analyses to understand impacts of extreme events on the food system.

With National Water Center Potential Science and Social Science Collaboration

- Integration of Snow Products (Snow Water Equivalency and Depth) Data into the land surface components of the existing National Water Model
- Hydrological assessment and predictions for coastal urban areas using existing CREST uWRF model.
- Seasonal predictions of low-flows and high-flows for the continental United States. (aligns with the Weather Bill Act – Title II - Sub-Seasonal and Seasonal Forecasting Innovation – Improving Sub-seasonal and seasonal forecasting).
- Ensemble flash flood models for Puerto Rico. (aligns with the Weather Bill Act, Title I – STATES WEATHER RESEARCH AND FORECASTING IMPROVEMENT Public Service Priority, of the new Weather Bill Act)

Assimilation of soil moisture and snow into WRF-Hydro

- Assimilation of Soil moisture (SMAP) and Snow Cover and Snow Water Equivalent (CREST Snow Product) into NWM for improving flood outlooks.
- We will compare the effectiveness of different assimilation methods and component couplings.

http://www.noaacrest.org/snow/products/

(NCAR 2017)

Integration of uWRF (urban-Weather Research Forecasting) model as applicable into the National Water Model

Possible research on coupling uWRF to WRF Hydro for urban areas – including coastal urban areas.

- Data Availability: Product is available to forecasters via CCNY Servers (web-portal). Data can be directly made available to users for their own display and use.
- **R2O Process:** The goal is to transition this product to operations under the NWS for major metro regions, by entering to the proper testing protocols for model improvements and transitions.
- Current Client: NWS/Upton Offices.
- Next Steps: Transition to headquarters is the next logical step. We need definition for this process, and man power to complete protocols for New York Metro Region, and for other cities. Continuous computational resources, currently academic, are always a limitation, that can be improved to include redundancy.

Flash flood model for Puerto Rico based on remote sensing data products

Develop an ensemble operational flood forecasting system coupling WRF Hydro with satellite data (JPSS & GOES-R) and NOAA numerical weather and climate models for Puerto Rico.

Anticipated results:

- 1. New flash flood guidance for tropical urban and coastal areas.
- 2. Downscale of satellite products taking into account highly variable topographic and land cover patterns.
- 3. Improve current flash flood lead time to forecasters.
- 4. Improve current geospatial resolution and area coverage.

Low flow prediction using local daily precipitation information

Annual q7 is significantly correlated (negative) with total number of dry days from precipitation at the nearest location (except for the southwest, where the correlation wasn't statistically significant)

Improved parameterization for flow estimation and routing using Gridded River Network Framework

Improved parameterization for flow estimation and routing using Gridded River Network Framework

Afshari et. al. (2017) computed an estimate for geometrical shape of riverbed assuming a powerlaw relation for **4472 USGS monitoring stations.**

NOAA-CREST Infrastructure Research Field Sites

- CREST-Snow Analysis and Field Experiment, (CREST-SAFE) Location: Caribou, ME
- CREST-Soil Moisture Advanced Radiometric Testbed (CREST-SMART) Location: Millbrook, NY and Mayaguez, PR
- New York Urban Hydro-meteorological Testbed (NY-uHMT)
 Location: Distributed in New York City
- Long Island Sound Coastal Observatory (LISCO)
 Location: New York City
- NYCMetNet

Location: Distributed in New York City

- CREST LIDAR Facility Location: The City College of New York
- Satellite Earth Observation System Location: The City College of New York

CREST-Snow Analysis and Field Experiment (CREST-SAFE), Caribou, ME

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

http://crest.ccny.cuny.edu/snow/index.html

Timeline of Instruments installed at CREST-SAFE Site

Instruments at the CREST-SAFE, Caribou, Maine A-CREST

Microwave Radiometers

Trailer

Snow Wetness Sensors

Grain size and Density Instruments

Snow Water Equivalent (SWE) Sensors

CREST-Soil Moisture Advanced Radiometric Testbed (CREST-SMART), NOAA-CREST

Location: Millbrook, NY and Mayaguez PR

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

Location of installed In-situ Soil Moisture Stations around Radiometer Site

Joint Field Experiment in May 2012

Ground Equipment used for Research and Education Outreach activities at Millbrook Site

New York Urban Hydro-meteorological **Testbed (NY-uHMT)**

- CREST NY-uHMT will be having ground Location: 20 weather stations evenly based 20 weather stations providing realtime data located in 5 boroughs (Bronx, Manhattan, Brooklyn, Staten Island Queens, and 2 stations at long island) of New York City.
- Each weather station includes instrumentations to measure soil moisture, Rainfall/snowfall, Temperature and humidity probe.
- The objective of this tested is to 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 for a range of public and private decisionmakers that result in measureable benefit for public safety and the economy.

distributed 5 borough of New York City

Long Island Sound Coastal Observatory NOAA-CREST (LISCO)

Tower

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 downwelling irradiance. SeaPRISM data are transferred by the satellite link to NASA.

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

CREST LIDAR Facility at the City College of New York

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.

6

11

Local time or EDT (hour)

Open-path Laser Measurements at 7.8 microns

NOAA CREST R&D Products

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

NOAA-CREST River Ice Mapping System (CRIOS)

NOAA-CREST

Based on SNPP VIIRS data, operational since 2016

Covers major rivers in Alaska and Conterminous US with the width of over 300-400 m Provides daily updates on the status of the river ice cover (yes/no and ice concentration) Monthly briefings are conducted for Regional River Forecast Centers and US Coast Guard Product is displayed on AWIPS II and SSEC Real Earth:

North Central: http://realearth.ssec.wisc.edu/?products=RVER-ICEC-NC North East: http://realearth.ssec.wisc.edu/?products=RVER-ICEC-NE Missouri Basin: http://realearth.ssec.wisc.edu/?products=RVER-ICEC-MB Alaska Pacific: http://realearth.ssec.wisc.edu/?products=RVER-ICEC-AP

River and Lake Ice Product

- 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

Techniques developed by Dr. Ruhul Amin – CREST Alumni and now a NOAA Physical Scientist at MEAAii CREST

Developed detection-classification algorithms for positive KB identification • **Detection:** RBD = nLw(678) - nLw(667) condition: RBD > 0.15 W/m²/µm/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.

IDEA <u>Infusing satellite Data into</u> <u>Environmental air quality Applications</u>

<u>Migration of NOAA IDEA: CIMSS → CREST/UMBC</u> → NESDIS

IDEA: Infusing satellite Data into Environmental air quality Applications)

- <u>NASA-EPA-NOAA</u> partnership to improve air quality assessment, management, and prediction by infusing (NASA) satellite measurements into (EPA, NOAA) analyses for public benefit.
- In the Summer of 2003, researchers form NASA, EPA, NOAA and academics prototyped the fusion, analysis and visualization of <u>NASA</u> <u>ESE</u> and US EPA data as AIRNow PM_{2.5} Forecast Tools.
- After a successful demonstration, EPA and NASA transferred IDEA to the Cooperative Institute for Meteorology and Satellite Studies (CIMSS), through their support until 2007.
- In 2007 IDEA was transferred to the University of Maryland Baltimore County and eventually to NOAA NESDIS. Since 2008, IDEA has been running at NOAA Center of Satellite Applications and Research (STAR) and has been hosted by its web server.
- Galvanized efforts parties involved allowed for transparent transition.

CREST Lidar Network (CLN)

CREST lidar (Elastic-Raman lidar / ceilometer)
City College of New York, NY (2004)
Univ. of MD, Baltimore County, MD (2001)
Hampton University, Hampton, VA (2008)
Univ. Of Puerto Rico, Mayagüez, PR (2008)

Observation, product, research activities

Wildfire smoke and dust plumes transport

(Verify satellite remote sensing of air quality)

Mixing layer height (MLH) dynamics

(Verify and validate the forecasts and models.

□ Aerosol extinction, Angstrom exponent profile

Cloud base height

UWRF Urban- Weather Research Forecast Model

R2O: Operational uWRF Jorge Gonzalez, NOAA CREST at City College of New York

• What: Weather Forecast Model for Cities

- WRF-BEP/BEM/Hydro (1 km) 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 ET.
- An automated assessment system has been implemented <u>http://air.ccny.cuny.edu/ws/wrfn/thindex.wrfmetnet.php?initial=1</u>

Model Performance

Surface Winds

Wind Speed RMSE
 0.6 to 0.8 0.8 to 1
 1 to 1.2 1.2 to 1.4 1.4 to 1.6
1.4 to 1.6 1.6 to 1.8
2 to 5

- Timing of the heatwave event is captured, with several locations reaching 39°C
- Maximum differences between the cases are in nighttime minimum temperatures.
- Long Island (Suffolk County) temperatures show differences with the urbanized simulations of up to 1 °C at night.

Average wind speed (m s⁻¹) (b) difference between variable drag C_{deq} minus constant C_d and wind sped RMSE for C_d (c) and C_{deq} (d) during June 2010. The dots represent locations of the surface weather stations.

R2O: Operational uWRF for NYC

- Intended Customers: NWS regional offices, NCEP, and local stakeholders such as environmental departments/agencies (i.e. NYC/DEP; Cal/CARB).
- Data Availability: Product is available to forecasters via CCNY Servers (web-portal). Data can be directly made available to users for their own display and use.
- R20 Process: The goal is to transition this product to operations under the NWS for major metro regions, by entering to the proper testing protocols for model improvements and transitions.
- Current Client: NWS/Upton Offices.
- Next Steps: Transition to headquarters is the next logical step. We need definition for this
 process, and man power to complete protocols for New York Metro Region, and for other
 cities. Continuous computational resources, currently academic, are always a limitation, that can
 be improved to include redundancy.

ISCCP

International Satellite Cloud Climatology Product

Data Processing Codes Delivered to NOAA William Rossow, Emeritus Scientist, NOAA CREST

- <u>ISCCP CLOUD PRODUCTS</u> -- 6 products from 7 satellites, global at 10 and 100 km, will be 35+ yrs. at 3 hr.
- <u>NNHIRS</u> atmospheric temperature-humidity profiles, global at 100 km, will be 35+ yrs. at 3hr.
- OZONE total ozone abundance, global at 100 km, will be 35+ yrs. daily
- <u>SNOICE</u> land snow cover w permanent glaciers and sea ice cover with permanent ice shelves at 100 km, will be 35+ yrs. daily
- <u>ISCCP-FH</u> 4 radiative flux products including profiles, global at 100 km, will be 35+ yrs. at 3hr

ECCA Ensemble Canonical Correlation Analysis

As NOAA's Climate Prediction Center (CPC) Operational Model for long-term Climate Outlook

ECCA

Theory developers: Sam Shen, Bill Lau and K.-Y. Kim NOAA operation developer: Kingtse Mo

Operational development of ECCA (2003-2005) Sam Shen, Professor at SDSU & NOAA CREST affiliate CREST

- Kingtse Mo of NOAA CPC turned ECCA (ensemble canonical correlation analysis) theory into an operational model in 2003-2005: ECCA is one of CPC's six operational models for 3-month climate outlook
 http://www.cpc.ncep.noaa.gov/ products/predictions/long_rang e/ecca.php?lead=1
- Mo, K.C., 2003: Ensemble canonical correlation prediction of surface temperature over the United States. J. Climate, 16, 1665-1683.

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Institution	Degree	
The City University of New York (CUNY)		
The City College of New York	· Civil Engineering (MS/PhD)	Link
	Computer Science (BS)	Link
	· Earth and Atmospheric Sciences (MS)	Link
	· Earth System Science and Environmental Engineering (BS/MS)	Link
	• Electrical Engineering (MS)	Link
	Mechanical Engineering (BS/MS/PhD)	Link
	Sustainability in the Urban Environment (MS)	Link
The City College of Technology	Construction Management and Civil Engineering Technology (AAS)	Link
CUNY Graduate Center	· Earth and Environmental Sciences (PhD)	Link
	Physics (PhD)	Link
Hampton University (HU)		
	Atmospheric Science (MS/PhD)	Link
	Mathematics (BS)	<u>Link</u>
	Physics (BS)	Link
San Diego State University (SDSU)		
	Applied Mathematics (MS)	Link
	• Biology (MS)	Link
	• Ecology (MS)	Link
University of Maryland, Baltimore County (UMBC		
	Mechanical Engineering (BS)	Link
	• Physics (BS)	<u>Link</u>
University of Puerto Rico Mayaguez Campus (UPI	RM)	
	• Electrical Engineering (MS)	Link
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